Appendix A: Engineering

Attachment A: Hydrodynamic Modeling

LAKE WORTH INLET
Palm Beach Harbor

NAVIGATION STUDY FOR LAKE WORTH INLET, FLORIDA
DRAFT FEASIBILITY STUDY REPORT

APPENDIX A
ATTACHMENT A

ENGINEERING – Hydrodynamic Modeling

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HYDRODYNAMIC MODELING ATTACHMENT
PALM BEACH HARBOR GRR, WEST PALM BEACH, FLORIDA

INTRODUCTION

Background

Lake Worth Inlet and Palm Beach Harbor are located on the east coast of Florida in Palm Beach County. Lake Worth Inlet is the entrance to the Port of Palm Beach and is the northern most of two inlets that connect Lake Worth to the Atlantic Ocean.

Lake Worth Inlet is a man-made inlet. The USACE has maintained the Palm Beach Harbor Navigation Project since 1934, which includes the jetties, channel, turning basin, inlet revetments, and settling basin to the north of the entrance channel (See Figure 1). Palm Beach Harbor consists of an entrance channel 35 feet deep, 400 feet wide, merging with an inner channel (Cuts 1 & 2) 33 feet deep, 300 feet wide, then flaring into a turning basin with a 1,200 foot turning diameter and jetties on the north and south of the inlet. This project currently requires annual maintenance dredging. The Palm Beach Harbor navigation project also includes a settling basin on the north side of the entrance channel. The settling basin was designed to catch sediment moving from the north around the north jetty and into the channel. The dimensions of the settling basin are 200 feet (north-south) by 500 feet (east-west) with a depth of 35 feet.

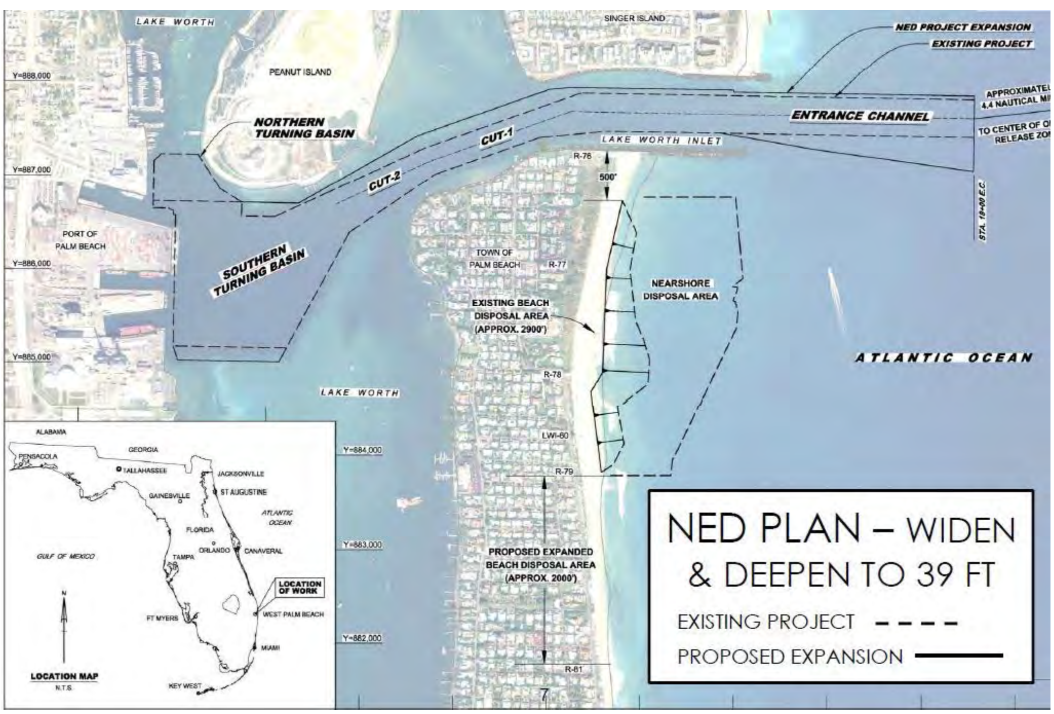

Figure 1. Lake Worth Inlet/ Palm Beach Harbor Navigation Study Area.

Objectives

The Palm Beach Harbor Navigation Project Management Plan (PMP) outlines a plan for identifying solutions for improving the navigation in federally maintained channels in the northern area of Lake Worth. Two critical elements, identified in the plan, for reaching that goal are the currents within the channels associated with each alternative and estimating project induced channel shoaling rates.

The objectives of the hydrodynamic modeling were as follows:

1) To provide the hydrodynamic inputs for use in the Ship Simulation Model. In order to meet this objective, a two-dimensional hydrodynamic model was developed that is capable of simulating complex flows in a large model domain. A two-dimensional hydrodynamic model was considered appropriate for comparison of current magnitude and direction between alternatives since the Lake Worth Lagoon is a well mixed estuary and the currents are primarily driven by tidal forcing. Also the Ship Simulator Model requires two-dimensional, depth averaged, currents and can not utilize three-dimensional currents.

2) To assess changes to circulation and shoaling patterns resulting from proposed channel geometry deepening modifications. The settling basin to the north of the entrance channel is an integral part of the sediment transport dynamics in the entrance channel area. The settling basin has been expanded several times to reduce shoaling in the entrance channel. Included in this investigation is an evaluation of the present and proposed settling basin as well as recommended modification for greater reduction of shoaling in the navigation channel. Evaluation of scour and hydrodynamic forces of the north jetty stabilization sheetpile wall would require a finer scale hydrodynamic model are not included in this modeling effort.

Technical Approach - Hydrodynamic Modeling

The technical criteria for selecting an appropriate hydrodynamic model are based primarily on the objectives of the navigation study, which are to optimize channel modifications and to assess impacts to channel shoaling.

The existing main channel is 400 ft wide and the alternatives under consideration include widening the channel to 500 ft. In order to represent these modifications in a hydrodynamic model, the horizontal grid resolution must be on the order of 50 ft. The Lake Worth Inlet/ Palm Beach Harbor Navigation Channel is about 1.7 nmi in length from the seaward limit to the port. Given the relatively small project area, it is feasible to represent the Palm Beach Harbor navigation and vicinity with a structured grid model.

To represent the Lake Worth Inlet/ Palm Beach Harbor Navigation Channel and vicinity hydrodynamics and the inlet system sediment transport and its response to wave action, circulation, and engineering alternatives, the Coastal Inlets Research Program (CIRP) Coastal Modeling System (CMS) (Sanchez, et.al. 2011) models were applied. CMS-FLOW, Version 4.00.00 Release 09/07/2011 was used for all model simulation in this report.

CMS is an integrated two-dimensional (2-D) numerical modeling package for simulating waves, current, water level, sediment transport, and morphology change at coastal inlets and entrances. The emphasis of the CMS is on navigation channel performance and sediment exchange between the inlet and adjacent settling basin area. The numerical wave and circulation models, CMS-WAVE and CMS-FLOW, were run in a coupled mode with information passed between the models at specified intervals.

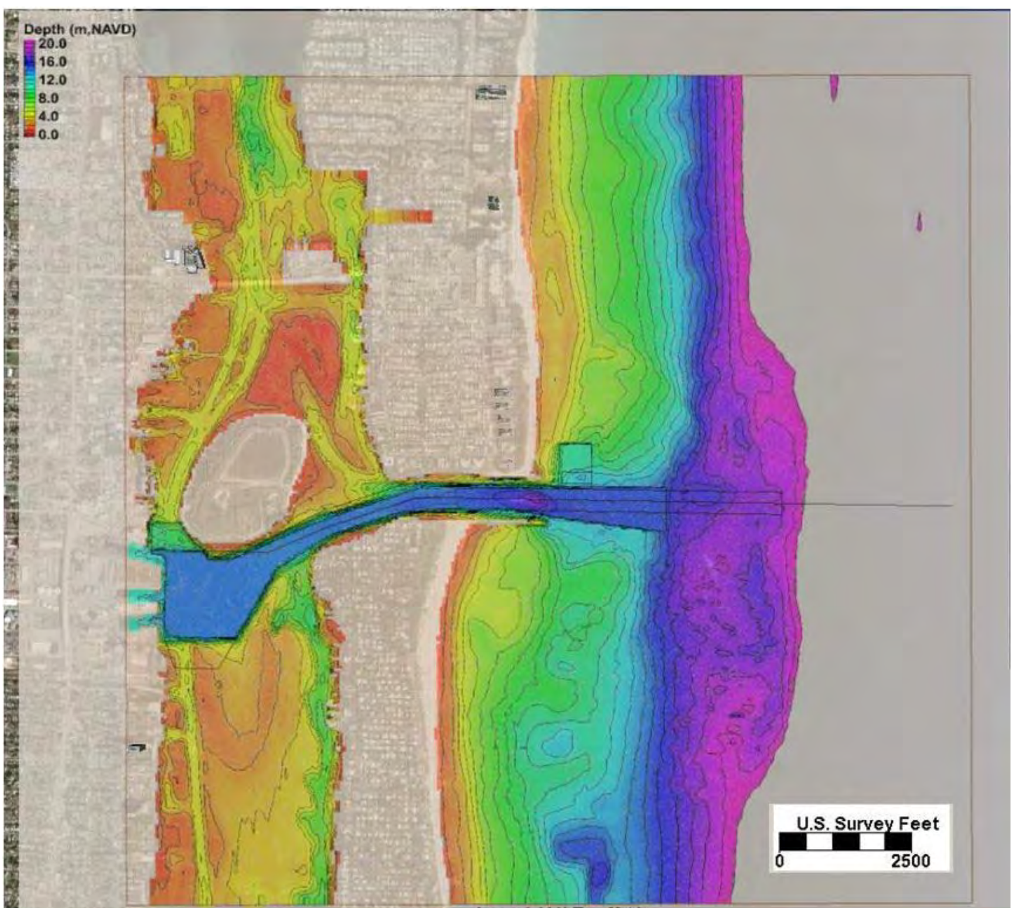

Figure 2. **Lake Worth Inlet/ Palm Beach Harbor hydrodynamic model grid domain and bathymetry. Model grid cells are 49.2 ft (15 m) on each side.**

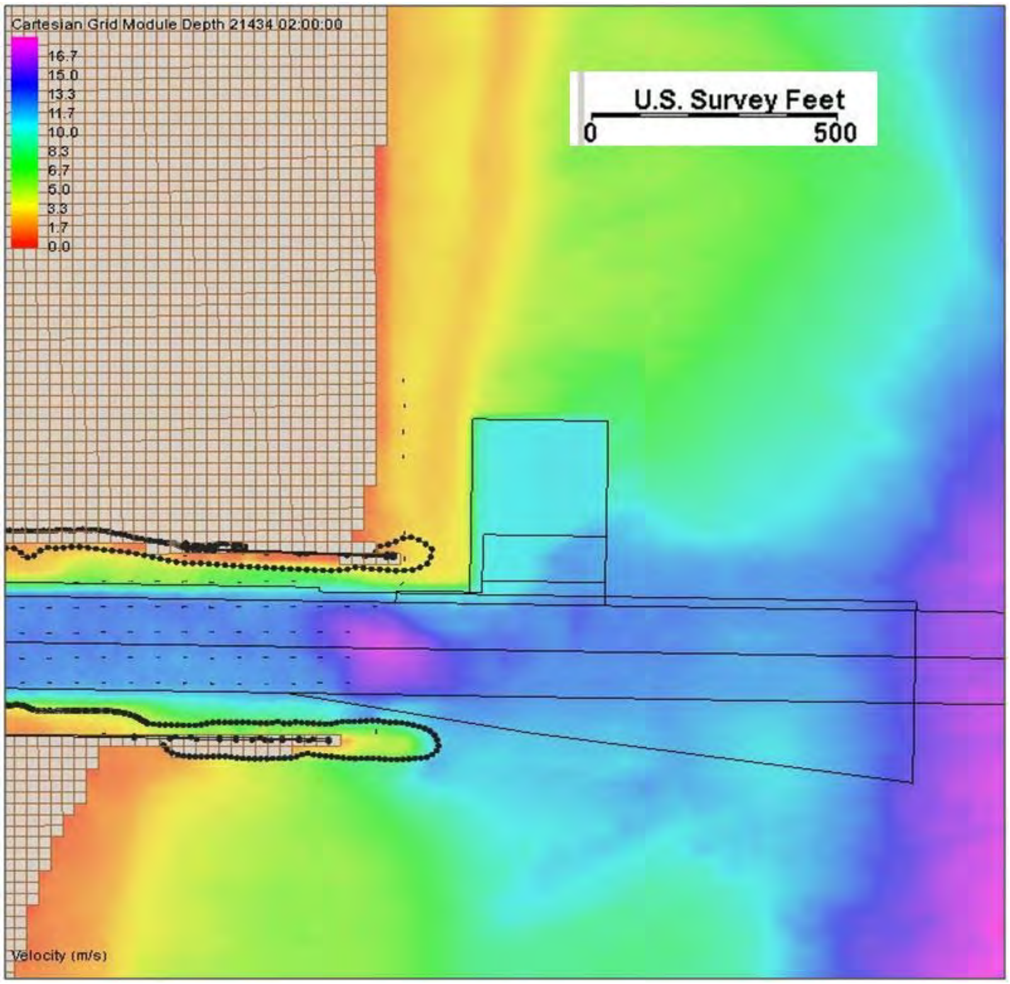

Figure 3. **Lake Worth Inlet/ Palm Beach Harbor hydrodynamic model grid cell resolution. Model grid cells are 49.2 ft (15 m) on each side.**

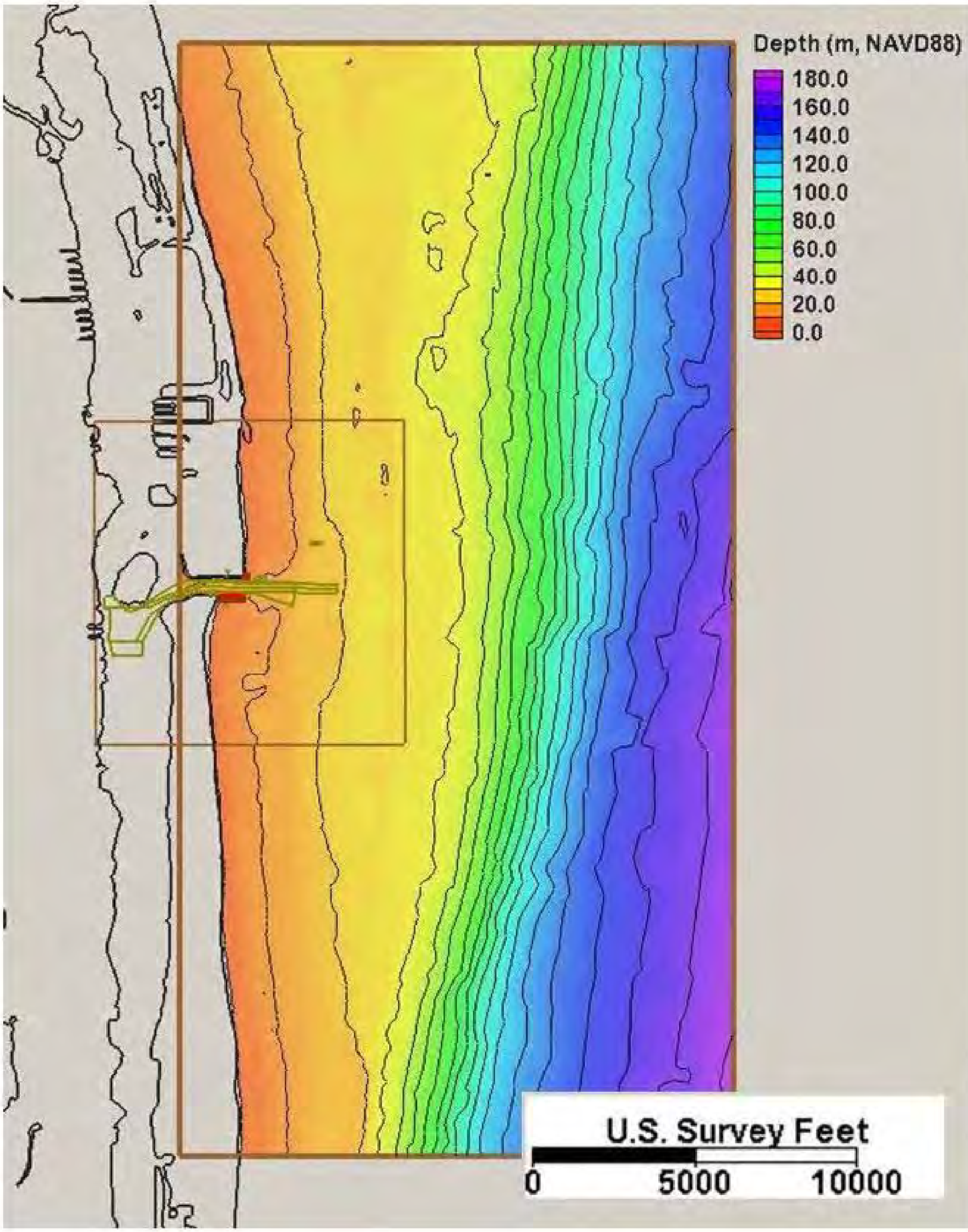

Figure 4. Lake Worth Inlet/ Palm Beach Harbor wave model grid domain. Model grid cells are 164 ft (50 m) on each side.

HYDRODYNAMIC MODEL APPLICATION

Hydrodynamic Model Setup

Numerical Grid Development

A variable rectilinear grid was used to accurately and efficiently represent the hydrodynamics of the Palm Beach Harbor Navigation Channel and Lake Worth area including the details of the navigation channel alternatives. Figure 2 shows the hydrodynamic model grid domain. Figure 3 shows the Palm Beach Harbor entrance channel model area.

The existing entrance channel is 400 ft wide and the proposed alternative width is 500 ft. The CMS-FLOW model consists of a variable rectilinear grid with 40,077 cells. Cell size ranges from 50 ft (15m) on a side within the navigation channel area to 240 ft (73 m) at the north and south limits of the grid. This resolution results in eight grid cells across the width of the existing entrance channel. This approach allows the model to represent the channel widening alternative of 500 ft. The CMS-FLOW model used the Implicit solution scheme and a wetting and drying threshold of 0.05 meters.

The CMS-WAVE grid, shown in Figure 4, extends 8.4 nmi along the coast and 4.3 nmi in the cross shore direction and was specified to have 164 ft (50 m) spacing over its domain. This spacing provides adequate resolution for sediment transport and shoal rate estimates. The wave model grid includes the entrance channels and surrounding coastal area.

Bathymetry

Bathymetry for the hydrodynamic model is based on USACE surveys of the navigation channel and the National Oceanic and Atmospheric Administration's (NOAA) LIDAR data in the project area. Figure 5 shows the base condition bathymetry used in the hydrodynamic model.

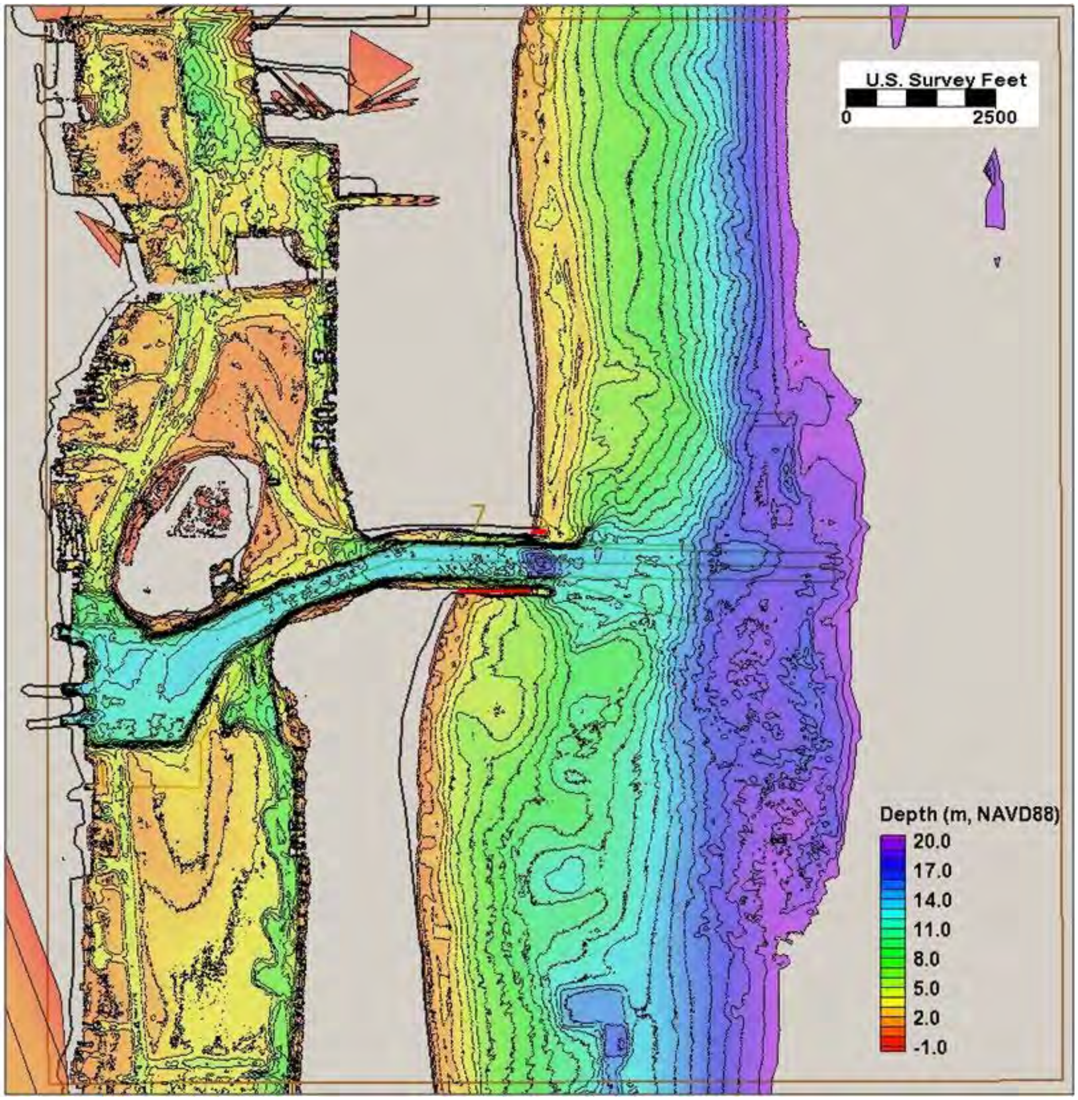

Figure 5. Palm Beach Harbor hydrodynamic model bathymetry (depth in meters). .

Boundary Conditions

The water level boundary condition is based on National Ocean Service (NOS) measured water level data in the Lake Worth inlet area. NOS stations used to construct the water level boundary condition include the Port of Palm Beach Harbor, Lake Worth Pier and PGA Blvd. Water level boundary conditions for the calibration of the CMS-FLOW model used for alternative optimization were constructed for the period 17 Dec 2008 to 22 Dec 2008. Alternative sediment transport simulations were based on the period 1 Sep to 30 Nov 2011.

Wave data for the sediment transport modeling was transformed in the CMS-WAVE from National Buoy Data Center (NDBC) Canaveral and Ft Pierce stations.

Hydrodynamic Model Calibration and Verification

Calibration and verification time periods were selected in order to make use of the physical oceanographic data collected in the Lake Worth Inlet area by NOS and the USACE, shown in Table 1. NOS data includes water-levels collected at the Port of Palm Beach Harbor station and ADCP currents collected at the inlet throat, Pier 3, and north of the turning basin from November 2008 to January 2009 (See Figure 7a & 7b). USACE data includes water-levels collected at stations north and south of the harbor area and offshore north of the inlet and ADCP currents collected at the inlet throat, Cut-2 from August 2008 to October 2008 (See Figure 6a & 6b).

An existing conditions CMS-FLOW model was developed and calibrated to match field-measured parameters such as velocities and water levels for the periods August 2008 to October 2008 and 9 to 23 December 2008.

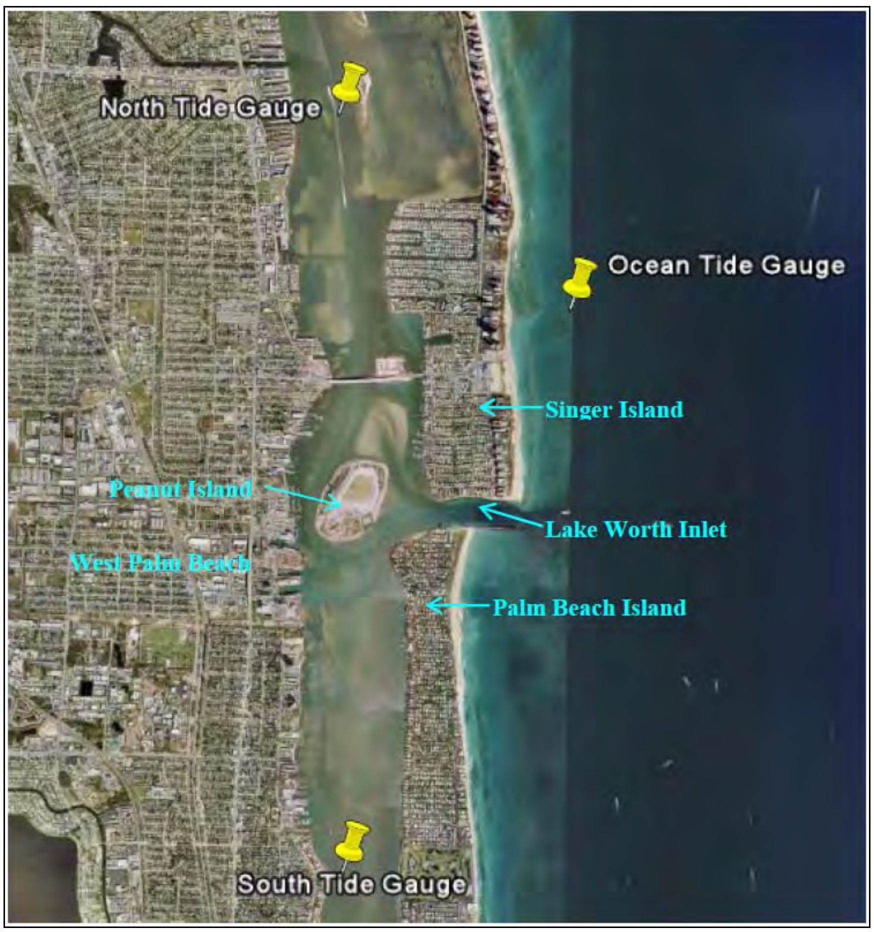

Figure 6a. USACE water-level data locations.

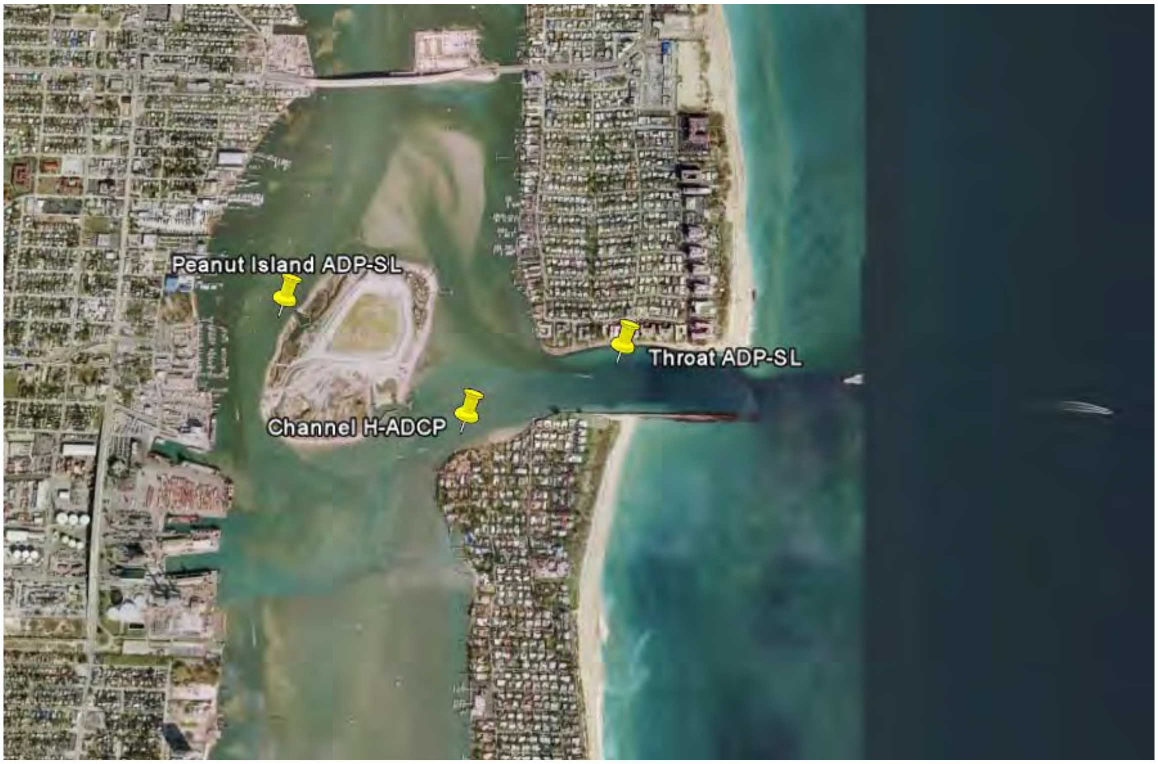

Figure 6b. USACE ADCP current stations.

Table 1. Observed Water Level and Current Gages

INSTRUMENT	Station No.	Latitude	Longitude	Observation Period
North Tide Gage		26° 48.266'	80° 02.839'	8/28 to 10/8/2008
South Tide Gage		26° 44.616'	80° 02.822'	8/28 to 10/8/2008
Ocean Tide Gage		26° 47.325'	80° 01.601'	8/28 to 10/8/2008
Throat ADP-SL		26° 46.296'	80° 02.084'	Aug 29-31 & Sep 22-24, 2008
Channel H-ADCP		26° 46.245'	80° 02.512'	Aug 29-31 & Sep 22-24, 2008
Peanut Is. ADP-SL		26° 46.484'	80° 02.933'	Aug 29-31 & Sep 22-24, 2008
NOS				
Port of West Palm Beach –Tide Gage	8722588	26° 46.2	80° 3.100	Jan 25, 2008 to Oct 20, 2010
Lake Worth ICW – Tide Gage	8722669	26° 36.8'	80° 2.8'	Jan 25, 2008 to Oct 18 2010
Lake Worth Pier – Tide Gage	8722670	26° 36.7'	80° 2.0'	Oct 27,2001 to Present
Lake Worth Inlet - ADCP	LWI0901	26° 46.379'	80° 2.172'	Dec17, 2008 to Jan 19, 2009
Pier 13 -ADCP	LWI0903	26° 46.022'	80° 3.008'	Nov14, 2008 to Jan 19, 2009
N. Turning Basin - ADCP	LWI0904	26° 46.276'	80° 3.024'	Nov14, 2008 to Jan 19, 2009

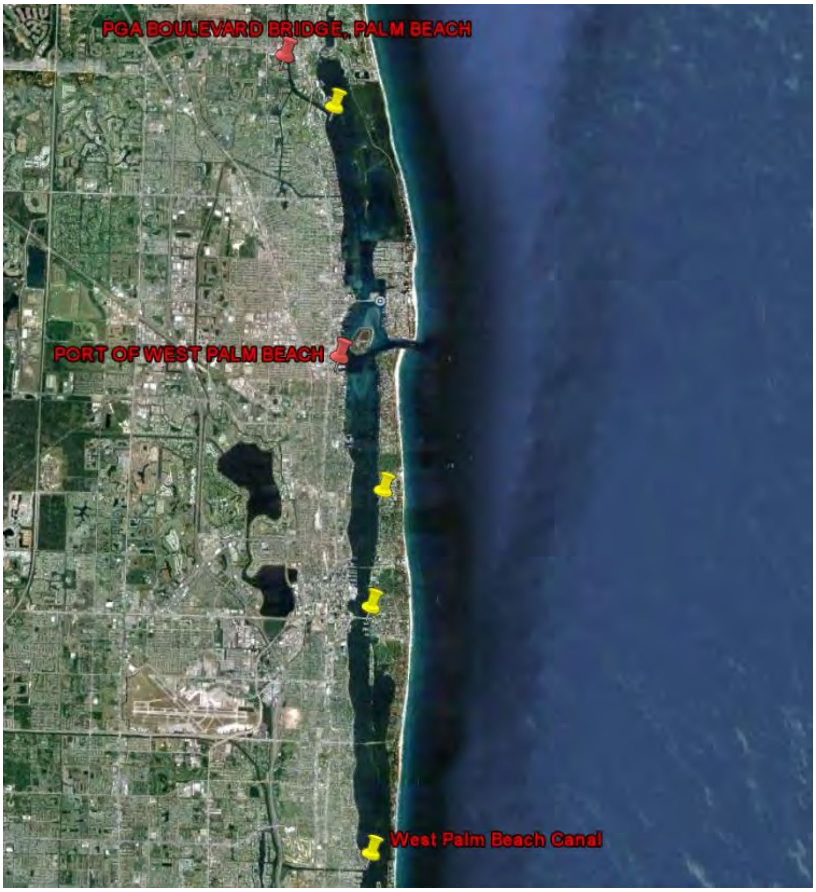

Figure 7a. NOS water-level stations.

Figure 7b. NOS ADCP current stations.

Waterlevels

CMS-FLOW waterlevels were calibrated at the 3 USACE stations (North, South , & OceanTide Gauges) and the NOS station number 8722588, Port of West Beach. Figure 8 shows the comparison between CMS-FLOW and NOS 8722588 water levels for the period December 9th to 23nd, 2008. Agreement between model and measured values are good, with an RMS error of 0.07 m.

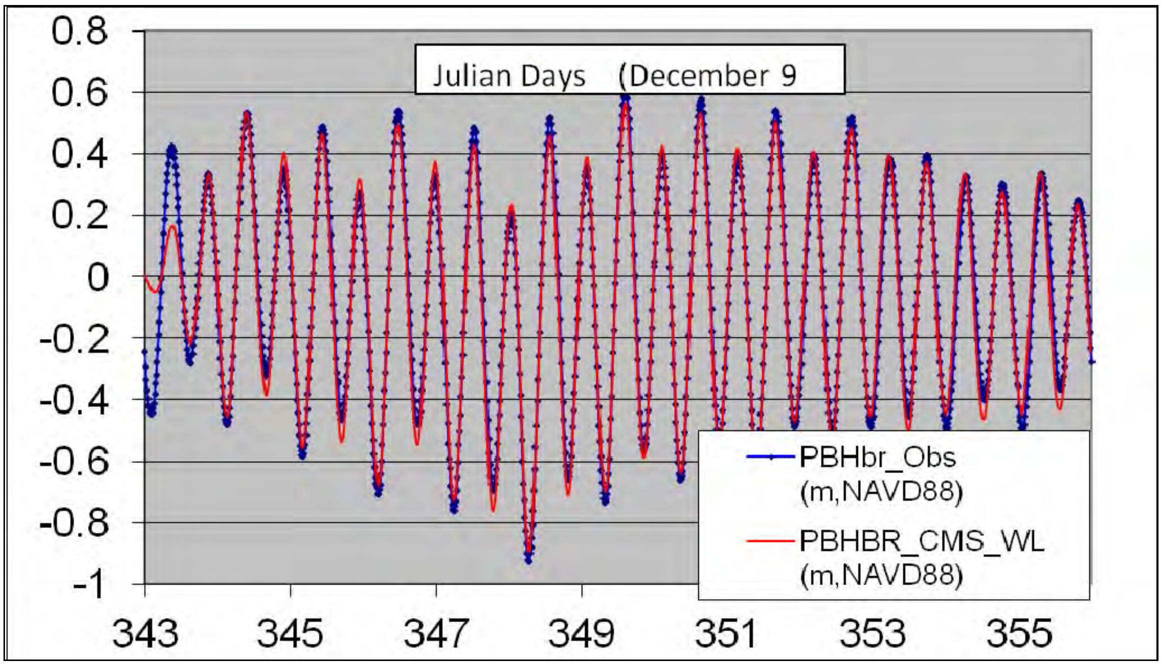

Figure 8. CMS-FLOW Port of West Palm Beach vs Measured Waterlevel (draft)

Currents

CMS-FLOW currents were calibrated at the NOS station LWI0901, in the inlet throat. Figure 9 shows the comparison between CMS-FLOW and NOS LWI0901 currents for the period December 17th to 22nd, 2008. Agreement between model and measured values are good, with an RMS error of 0.09 m.

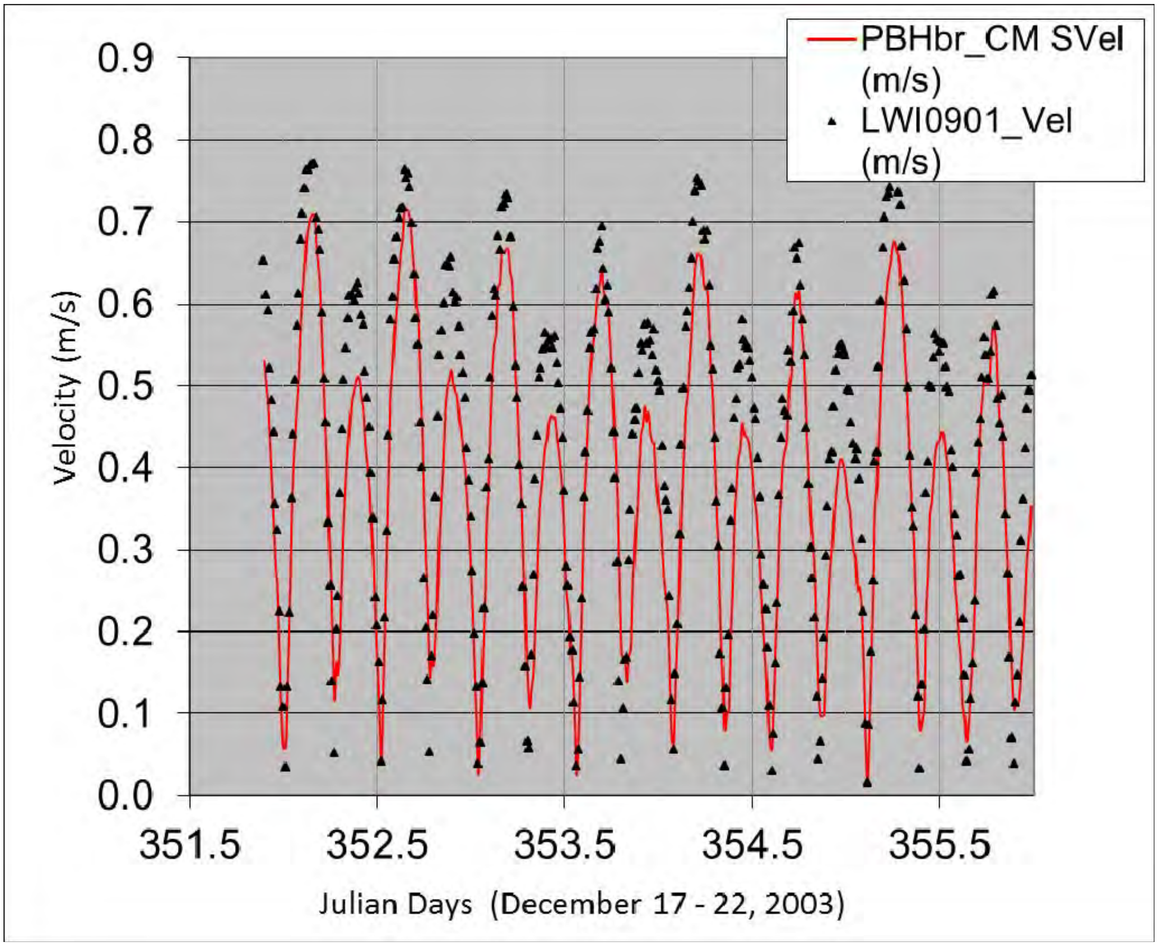

Figure 9. CMS-FLOW inlet throat vs Measured Depth averaged current velocities (m/s).

Hydrodynamic Modeling for Ship Simulation

Currents for Ship Simulation Validation

In order to provide currents for the validation of the Ship simulation model, the existing Palm Beach Harbor Navigation Channel configuration consisting of a 400 ft wide, 35 ft entrance channel project depth, a 33 feet deep, 300 feet wide inner channel and a 1,200 foot turning diameter turning basin as well as the 200 feet (north-south) by 500 feet (east-west), 35 ft existing settling basin was simulated.

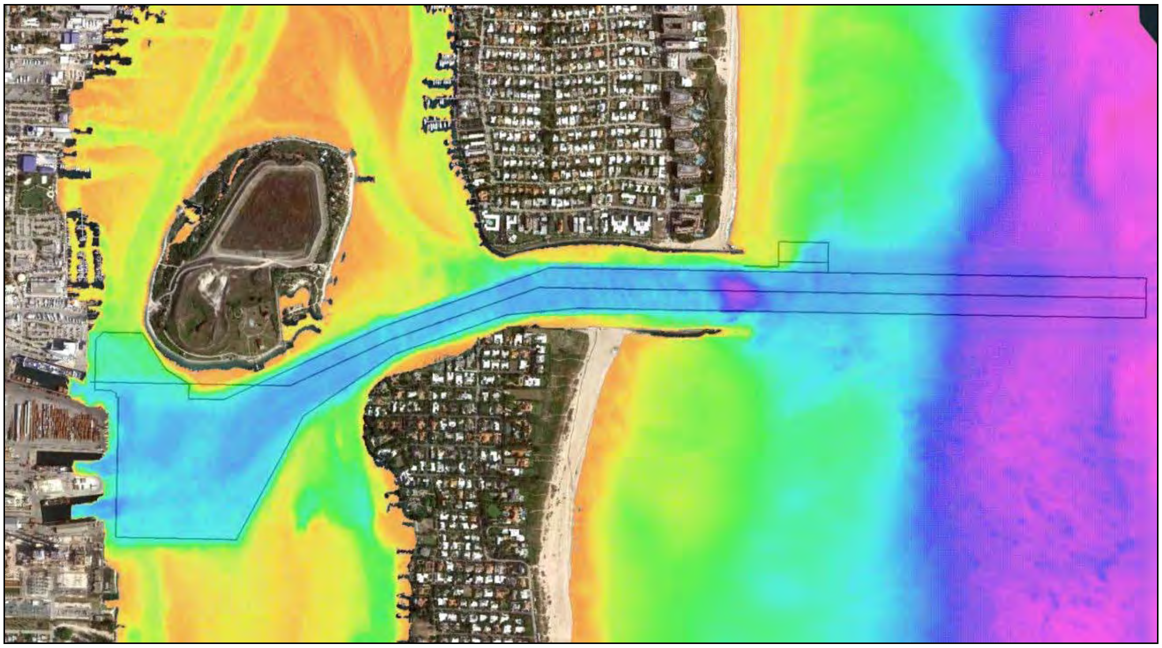

Figure 10. Existing Condition- Palm Beach Harbor

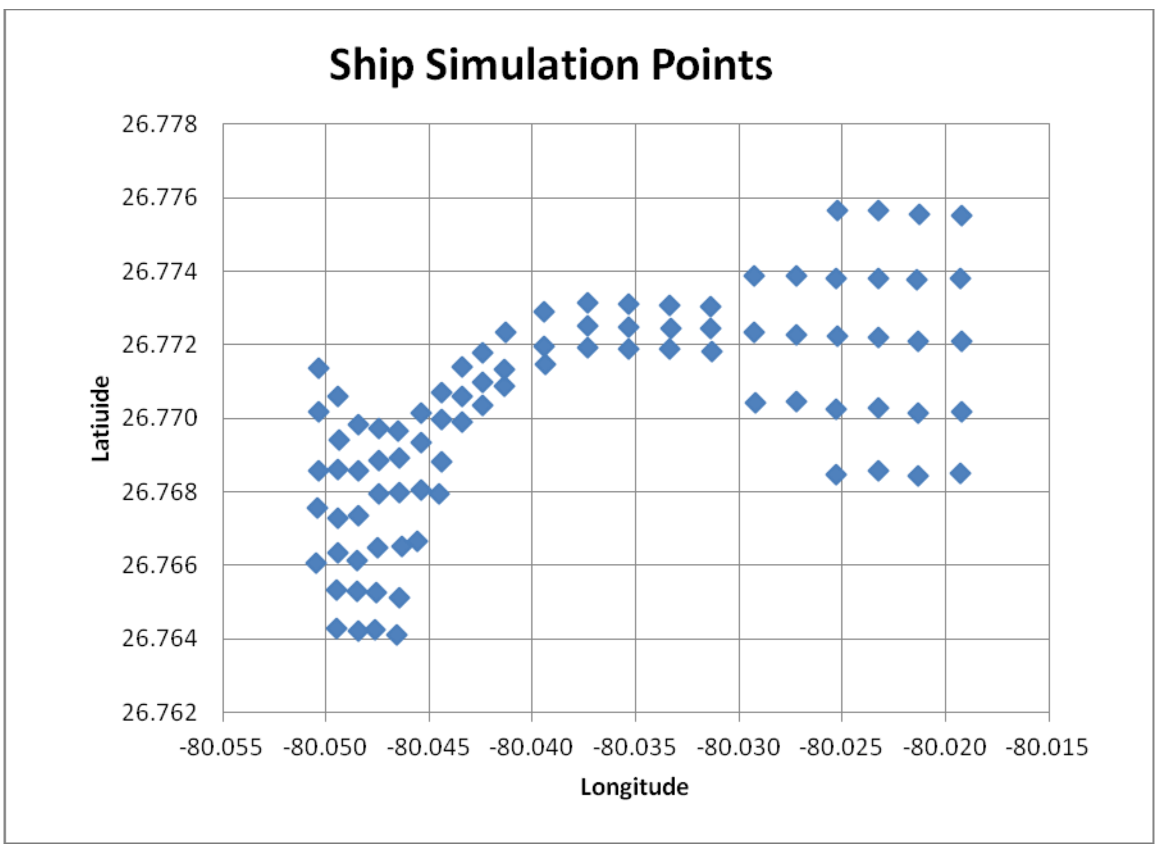

Figure 11. Ship Simulation Current Point Locations.

Plan1 Currents

CMS-FLOW hydrodynamic simulations provided currents for simulations of Alternative Plan 1 Ship Simulations. Alternative Plan 1 consists of an entrance channel flare (A-1), entrance channel widening (B-1, B-2), an inner channel widener (C), and expansion of the turning basin (D, F, & G).

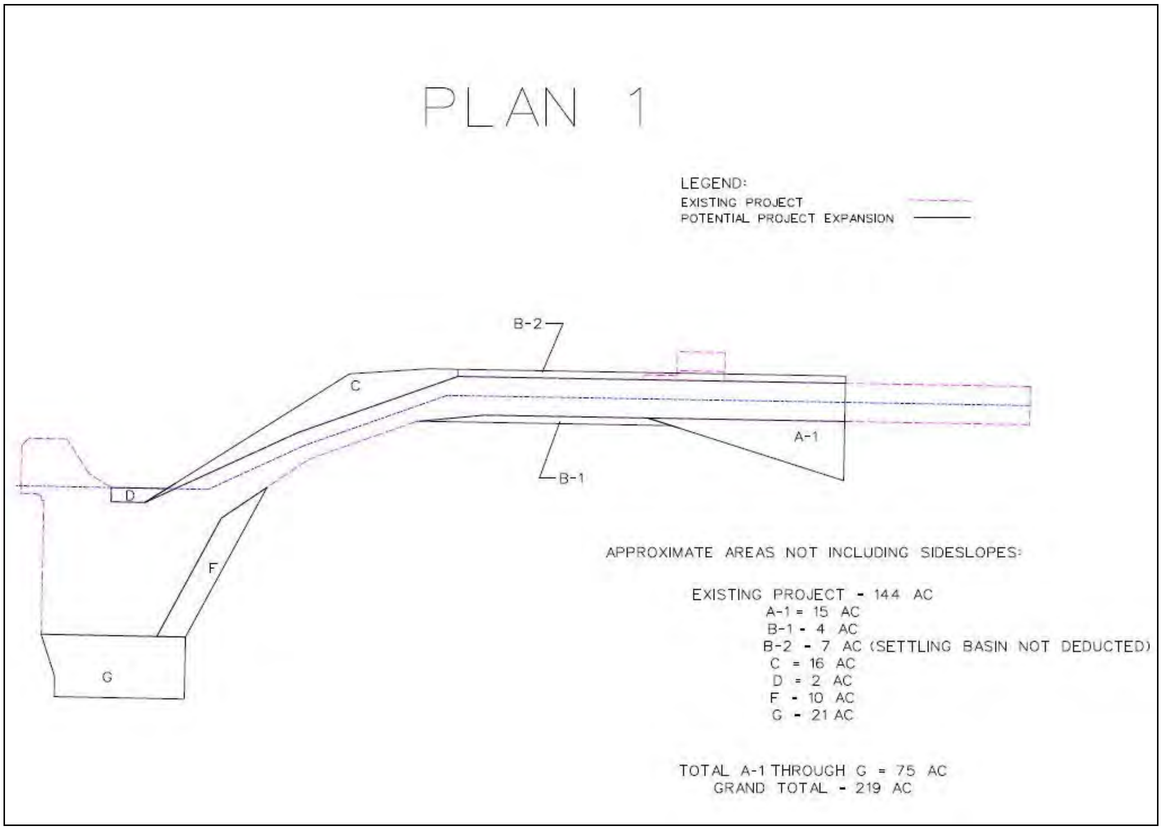

Figure 11. Ship Simulation- Alternative Plan1

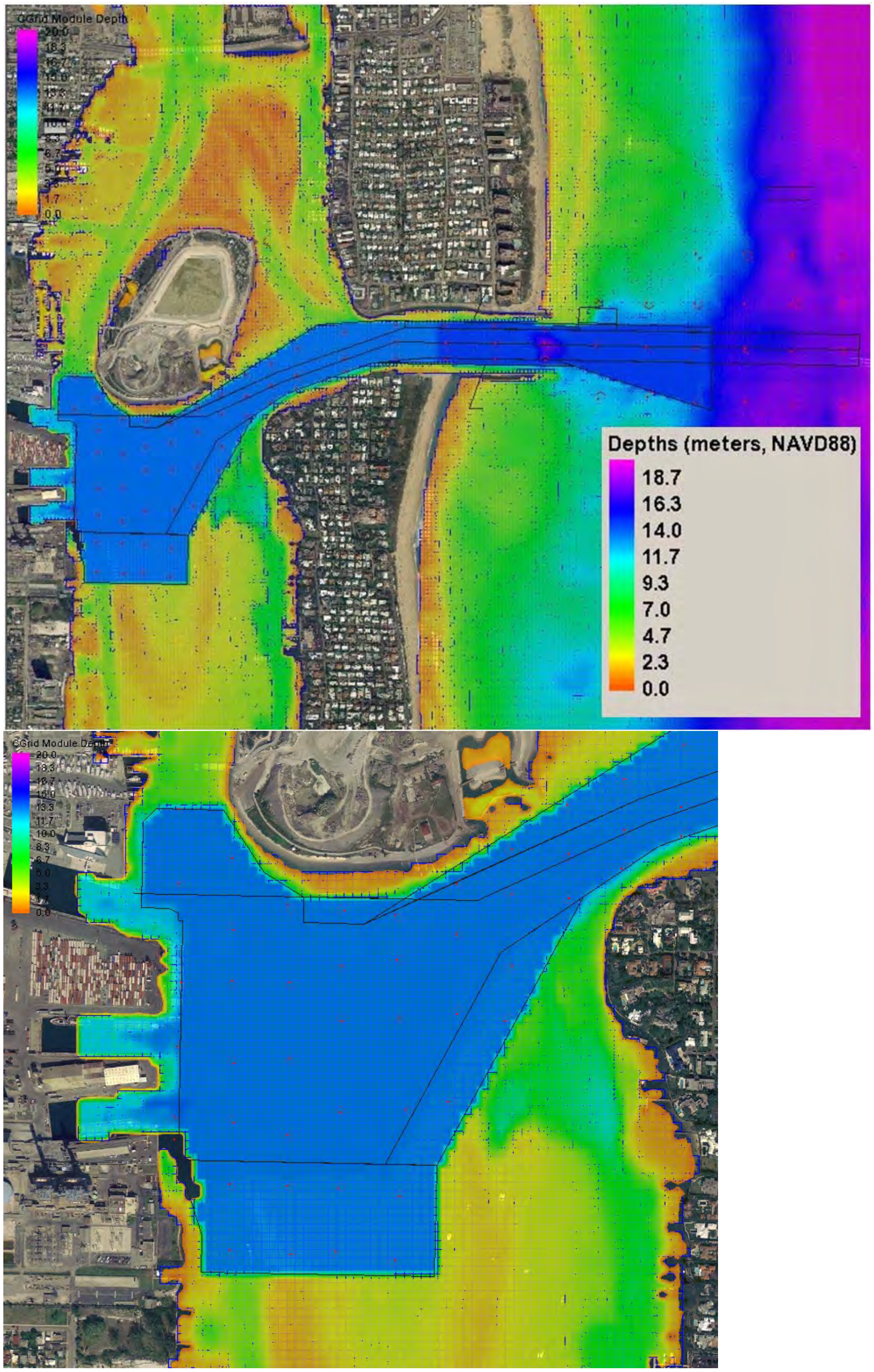

Figure 13. Ship Simulation – Plan 1 CMS-FLOW bathymetry and detail of Turning Basin.

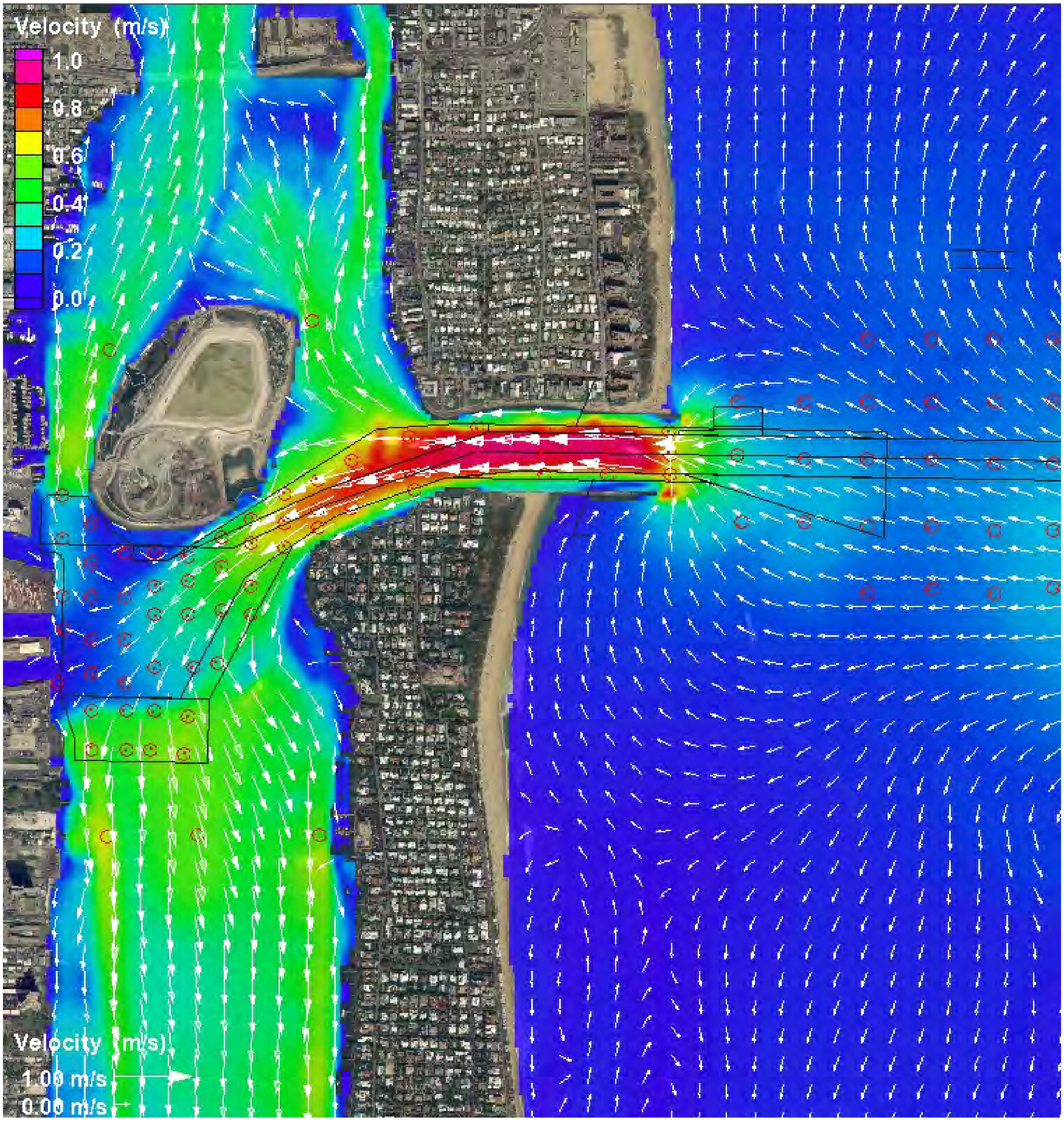

Figure 14. Existing Flow vectors for maximum spring flood tide.

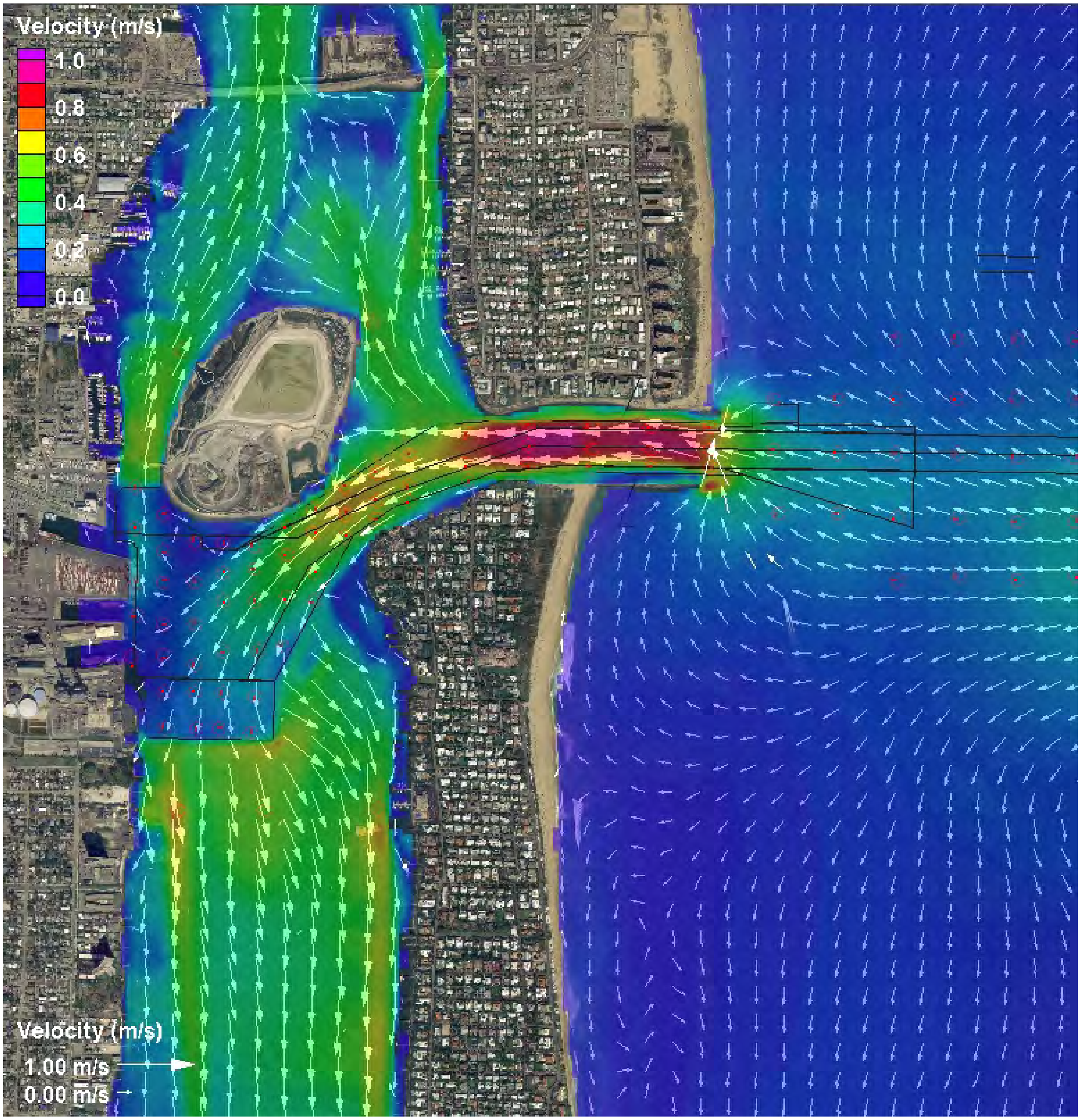

Figure 15. Plan1 Flow vectors for maximum spring flood tide.

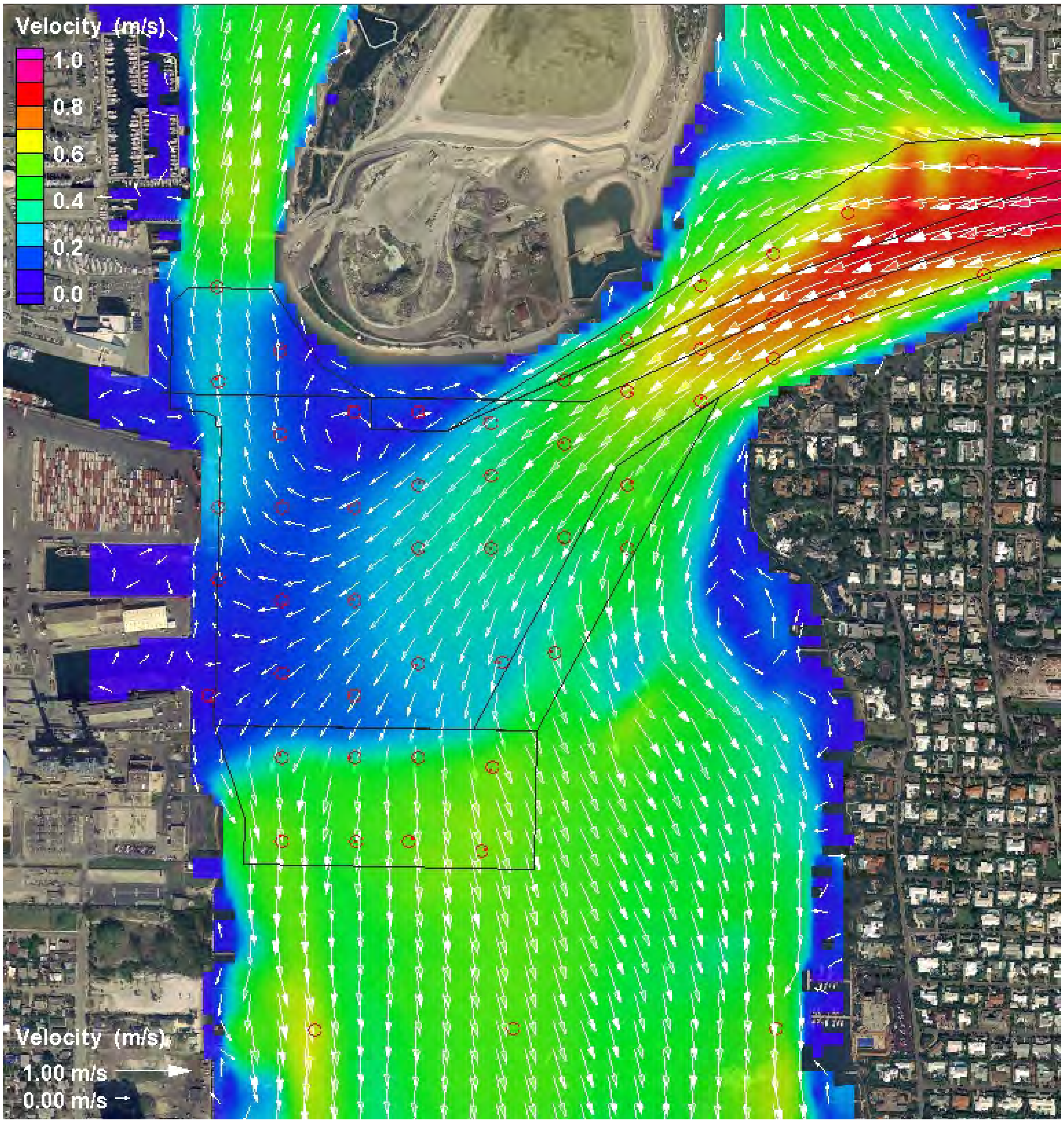

Figure 15. Existing Flow vectors for maximum spring flood tide.

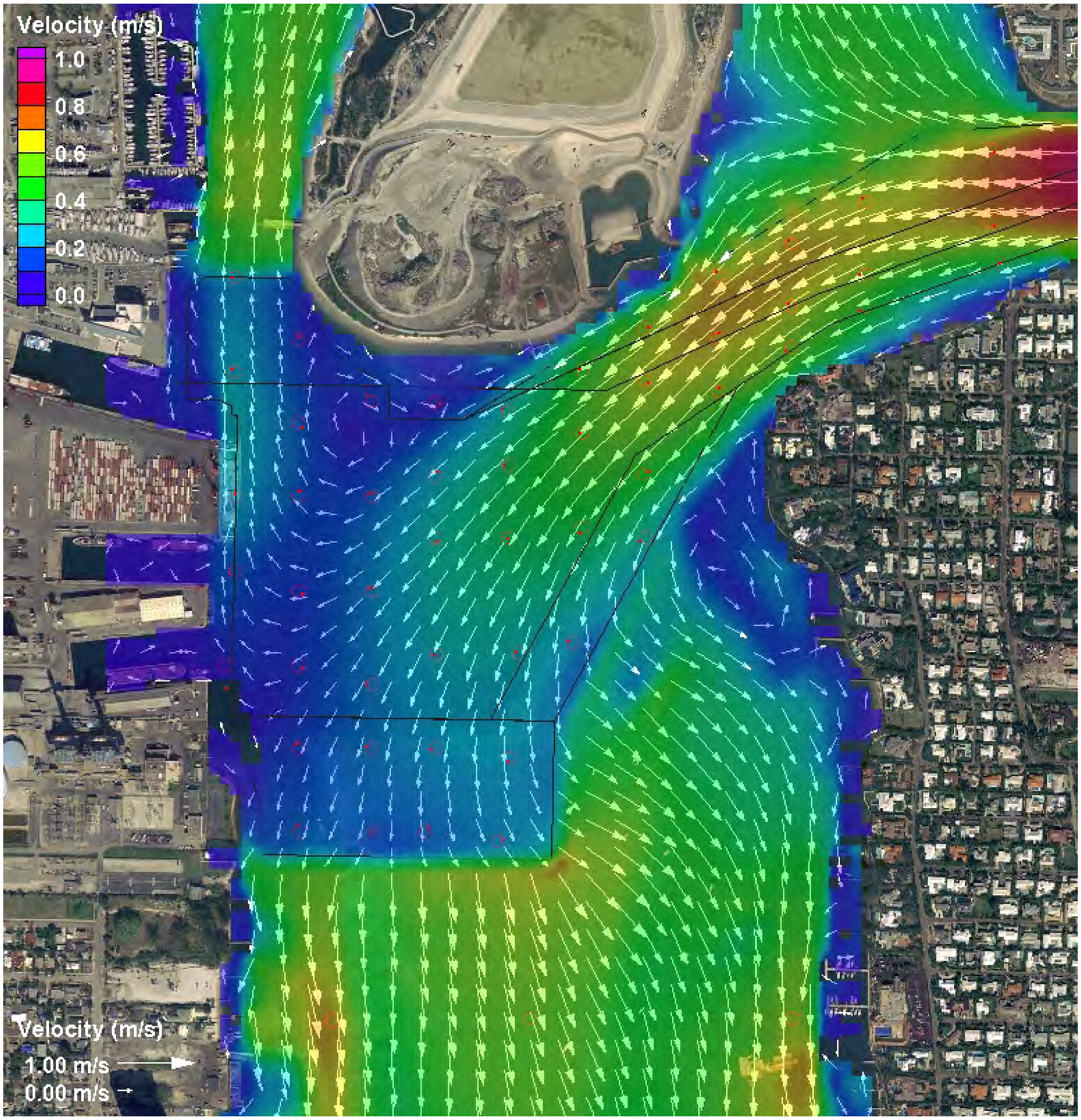

Figure 17. Plan1 Flow vectors for maximum spring flood tide.

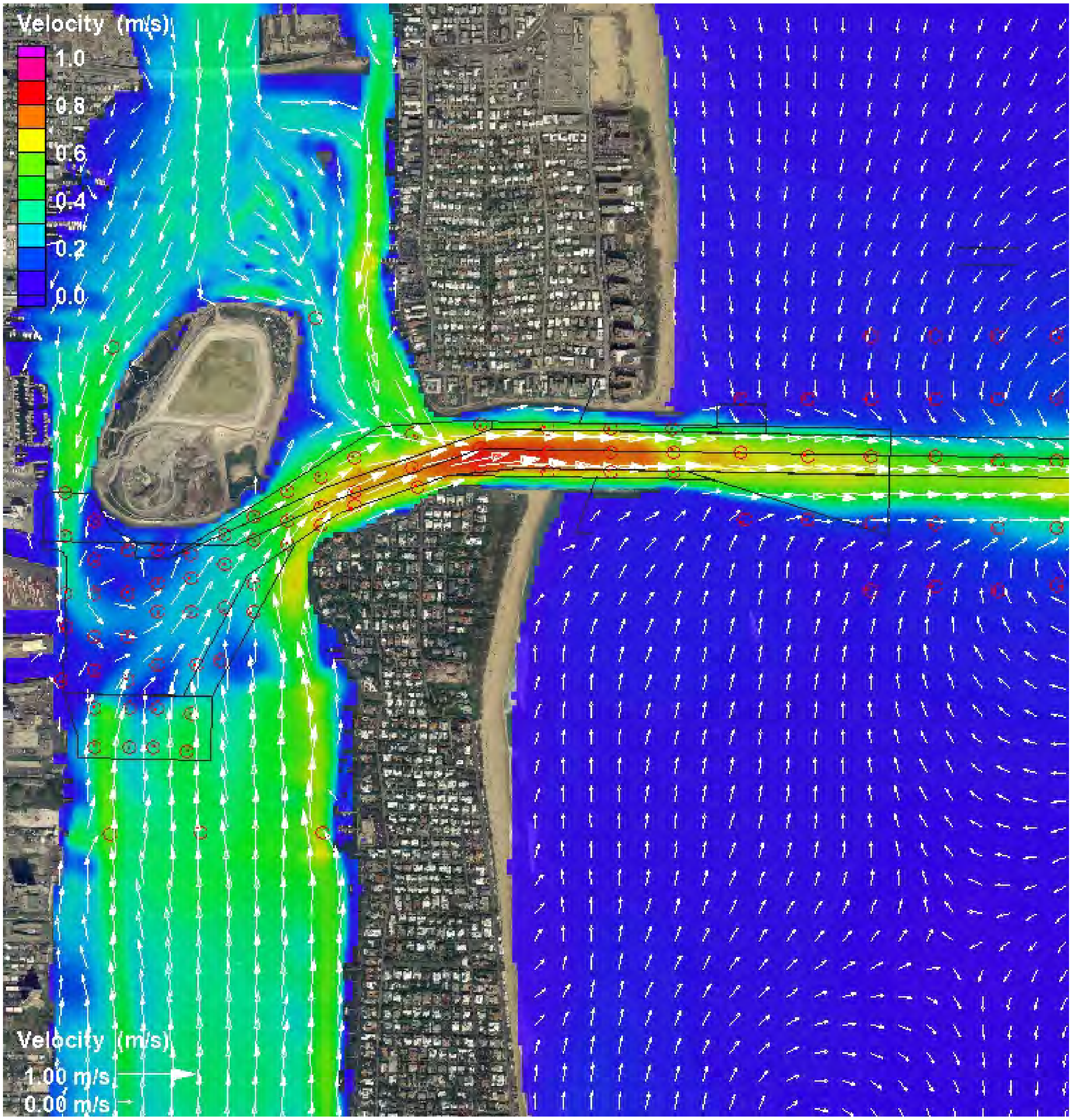

Figure 18. Existing Flow vectors for maximum spring ebb tide.

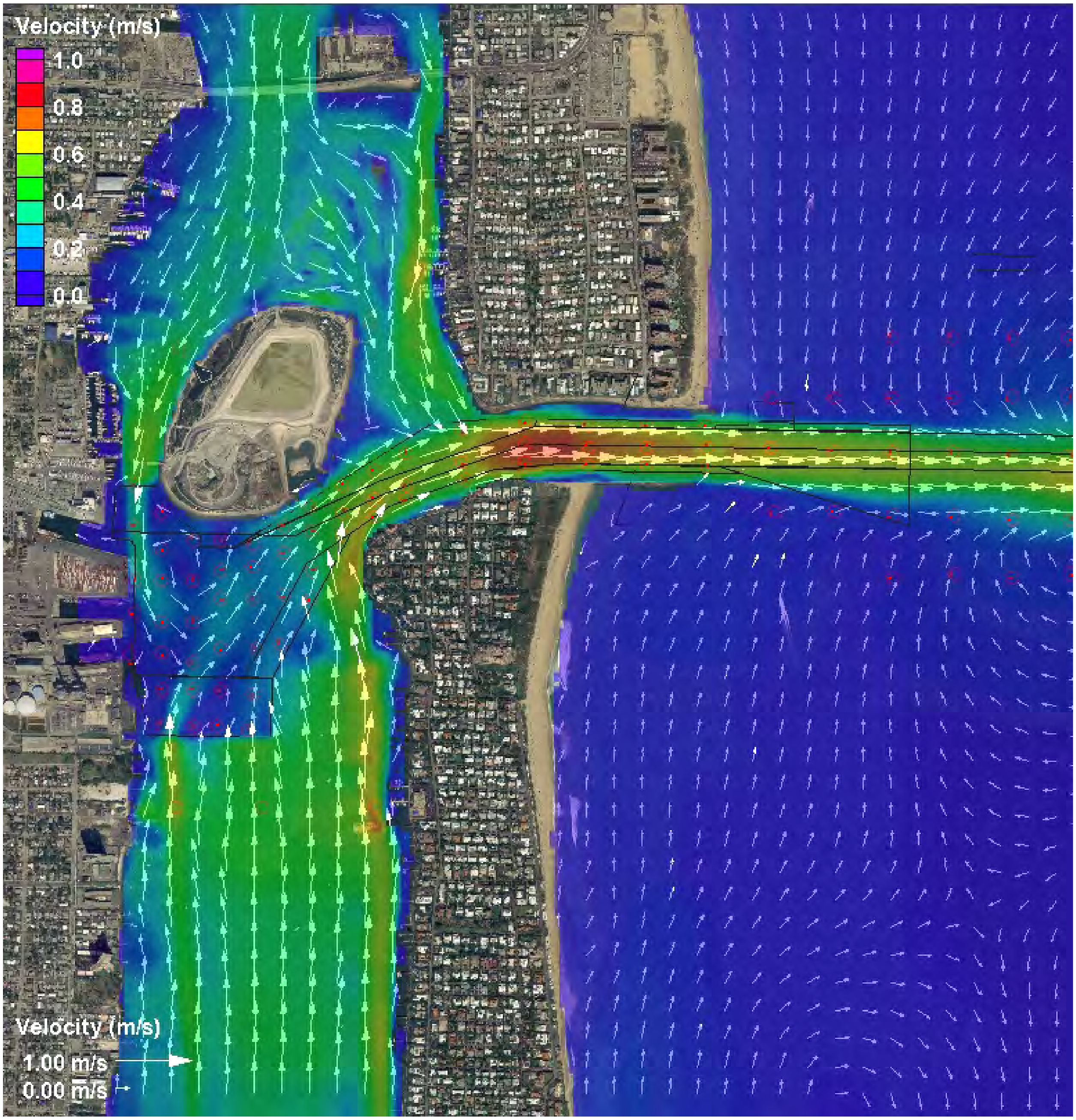

Figure 19. Plan1 Flow vectors for maximum spring ebb tide.

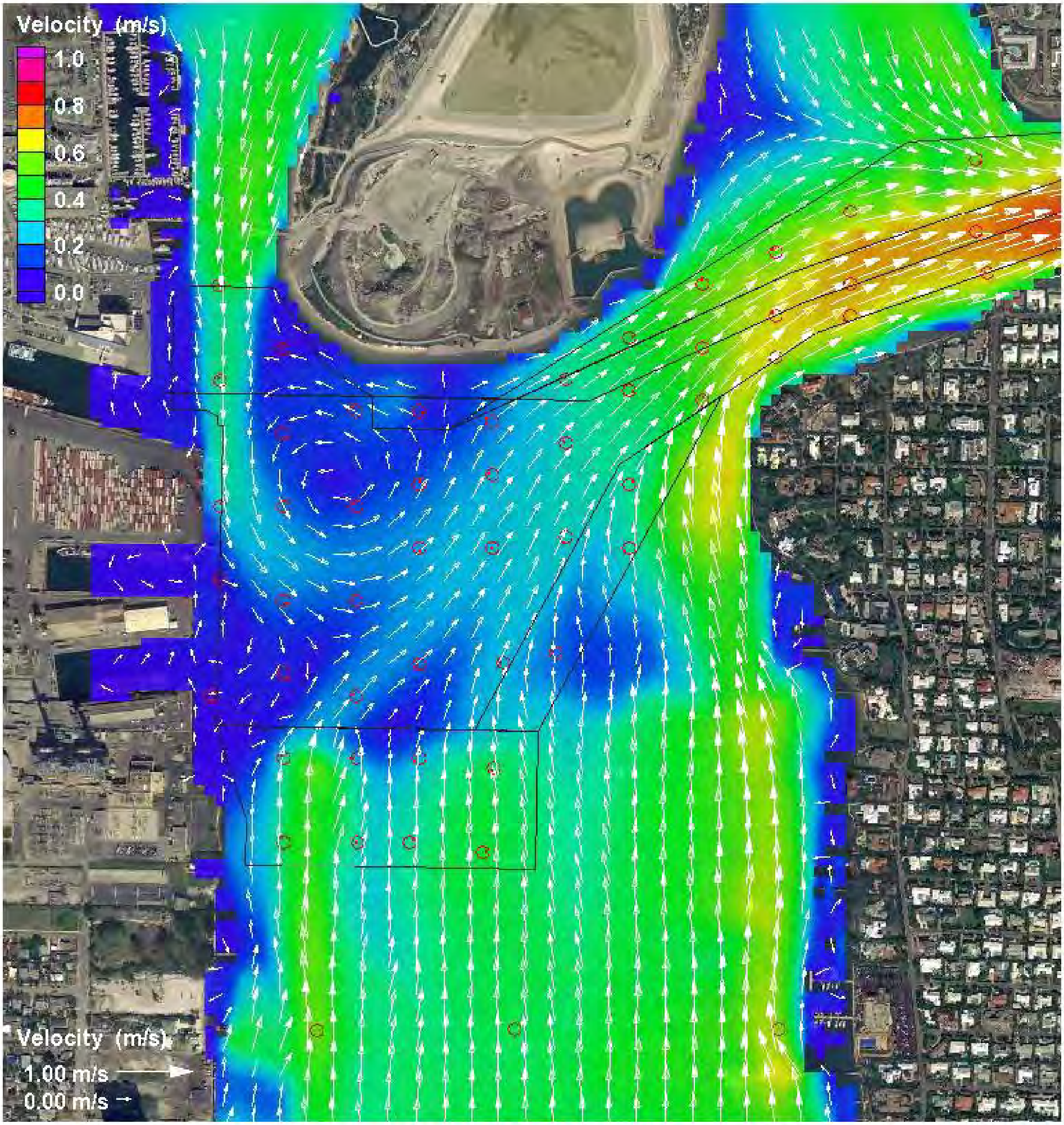

Figure 20. Existing Flow vectors for maximum spring ebb tide.

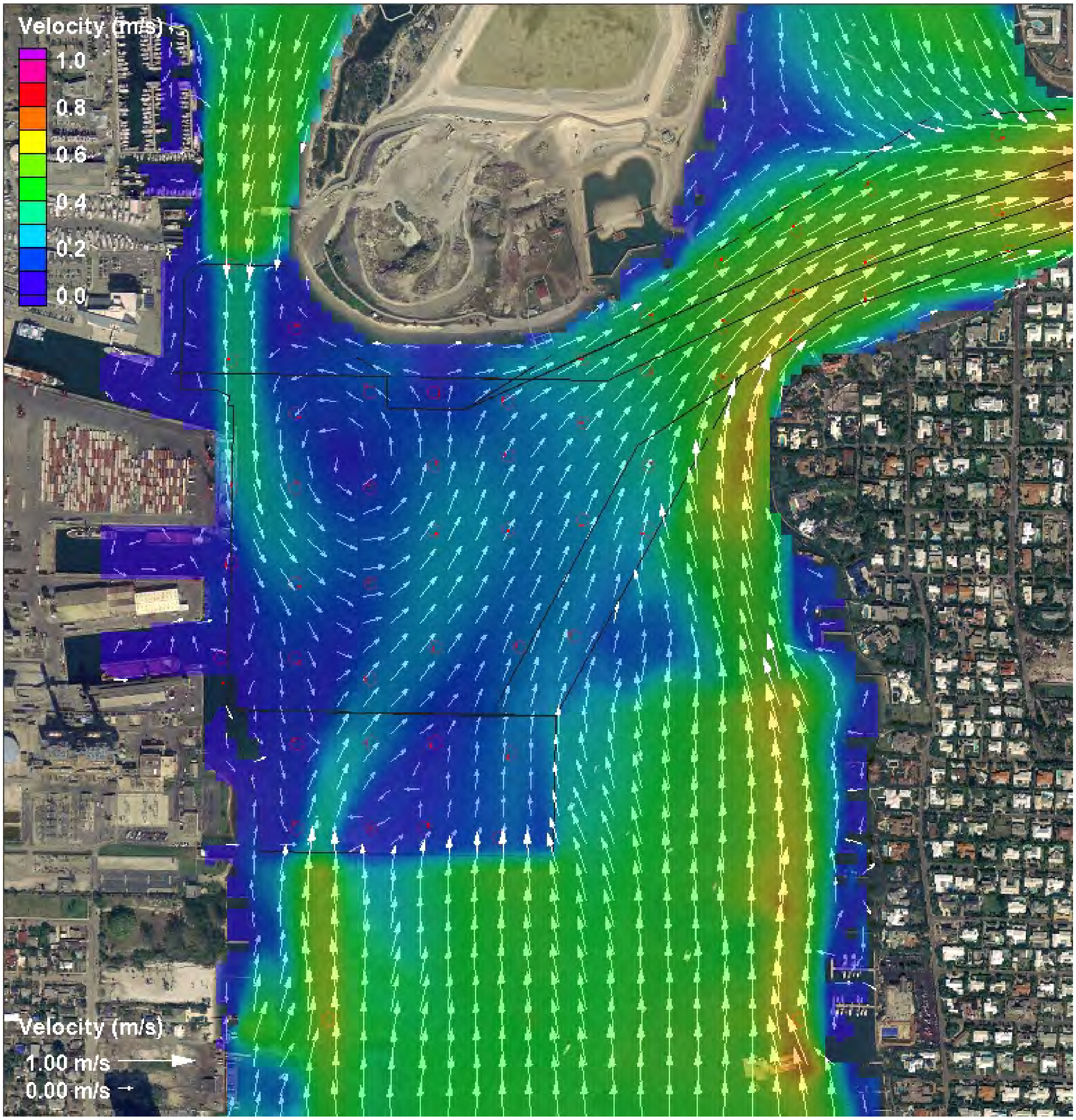

Figure 21. Plan 1 Flow vectors for maximum spring ebb tide.

Plan 2 Currents

CMS-FLOW hydrodynamic simulations provided currents for simulations of Alternative Plan 2 Ship Simulations. Alternative Plan 2 consists of a reduced entrance channel flare (A-1), entrance channel widening (B-1, B-2), a reduced inner channel widener (C), and reductions of areas F and G.

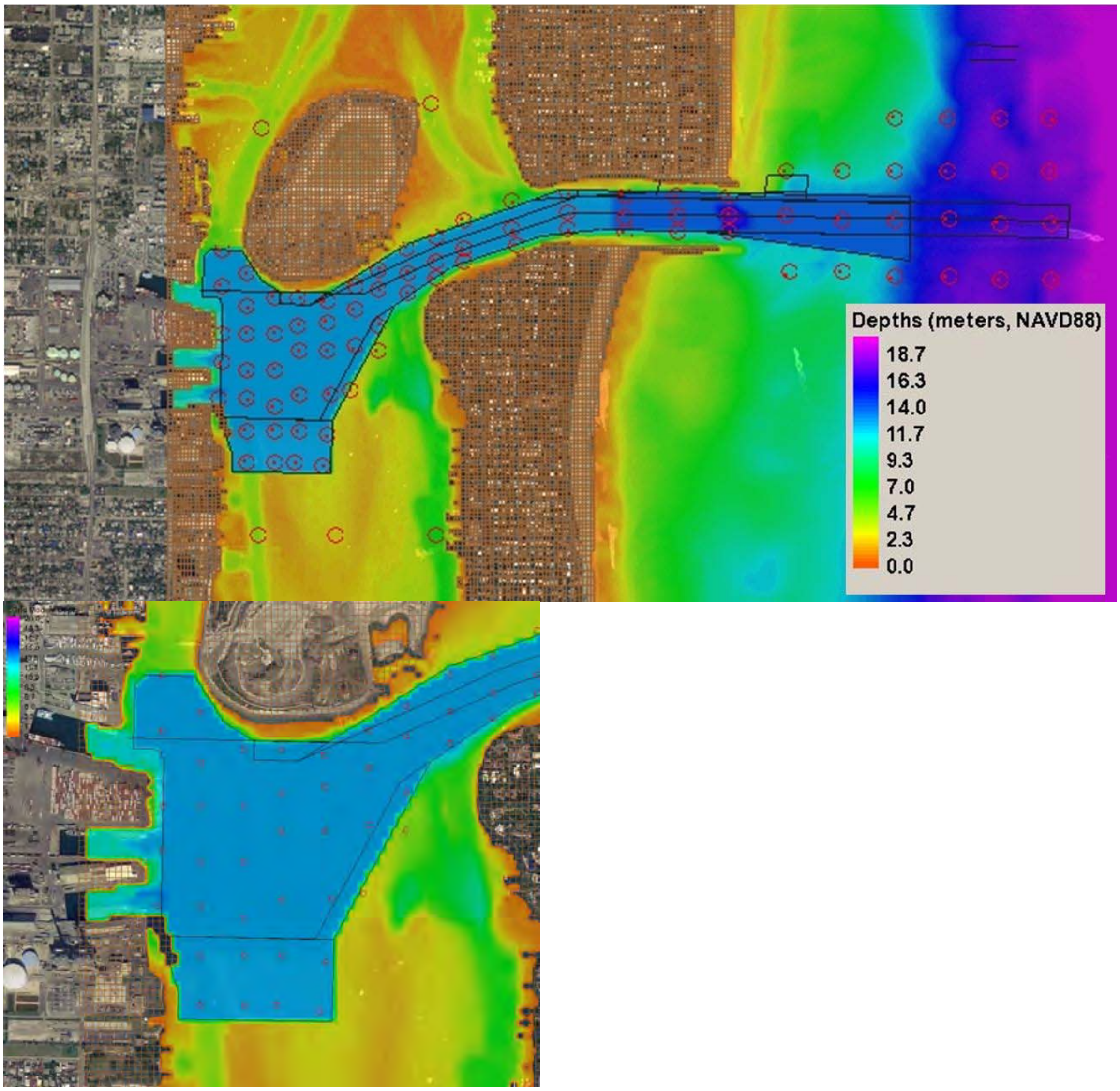

Figure 22. Alternative Plan 2 and detail of Turning Basin.

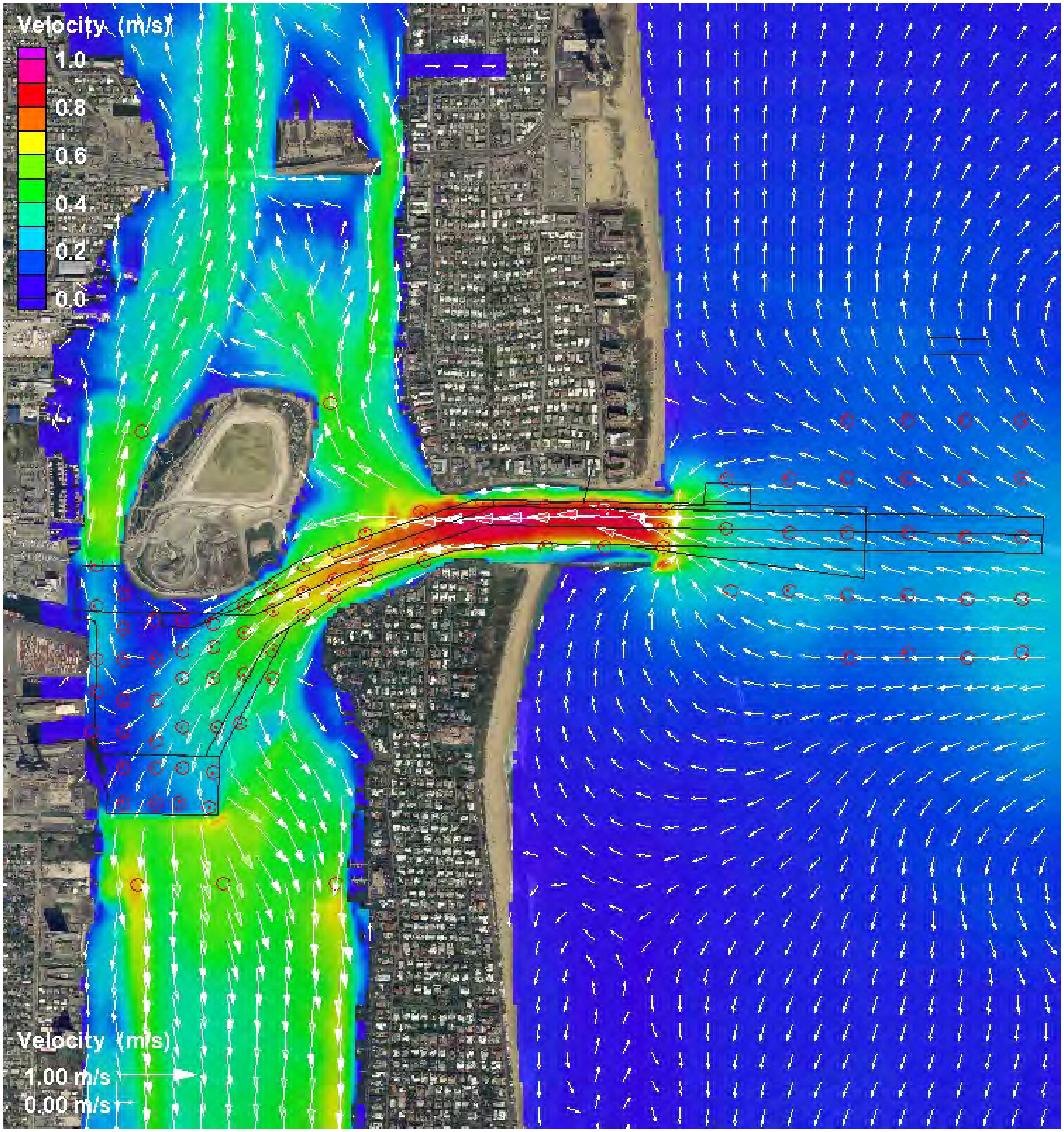

Figure 23. Plan 2 Flow vectors for maximum spring flood tide.

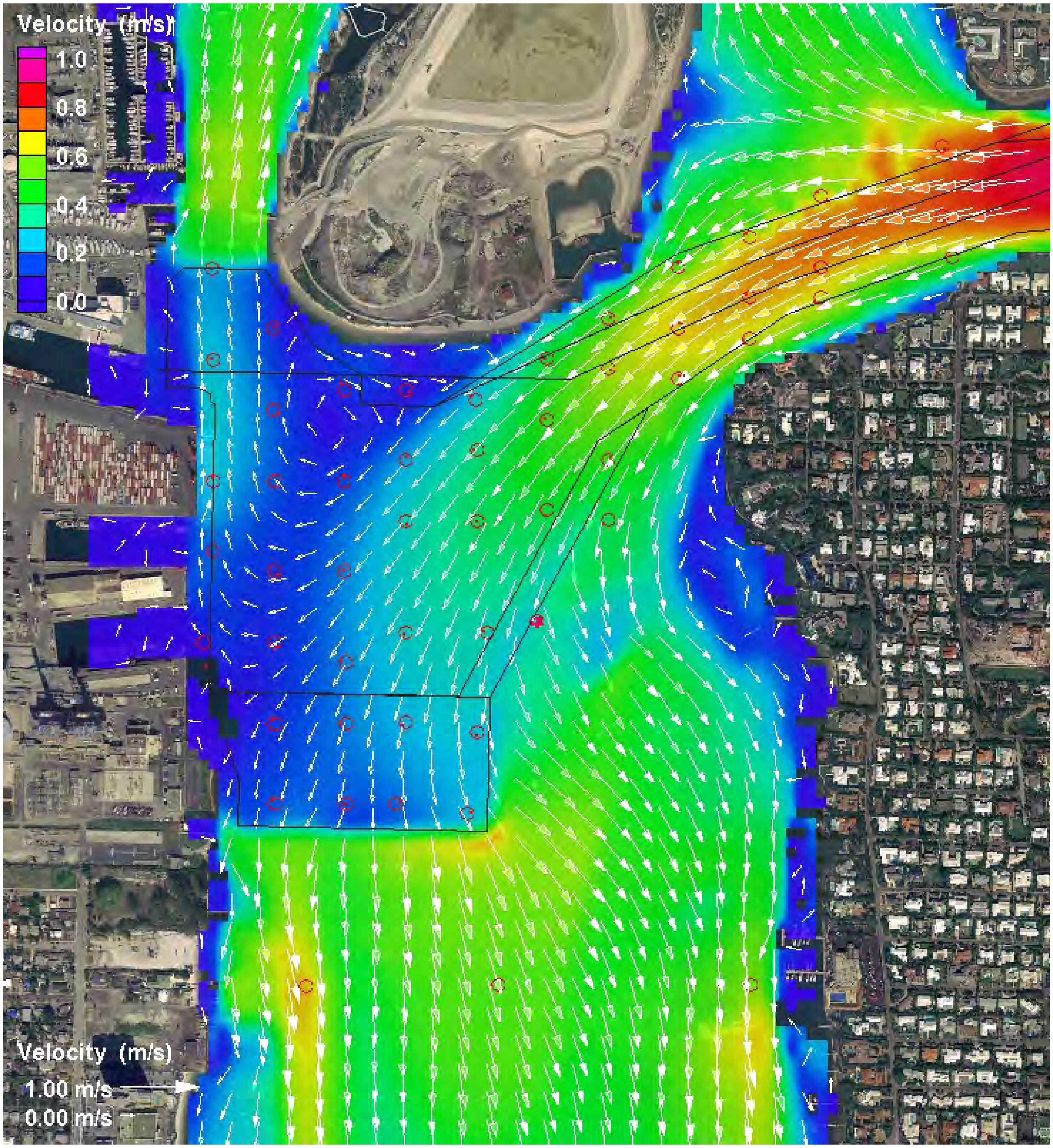

Figure 24. Plan2 Flow vectors for maximum spring flood tide.

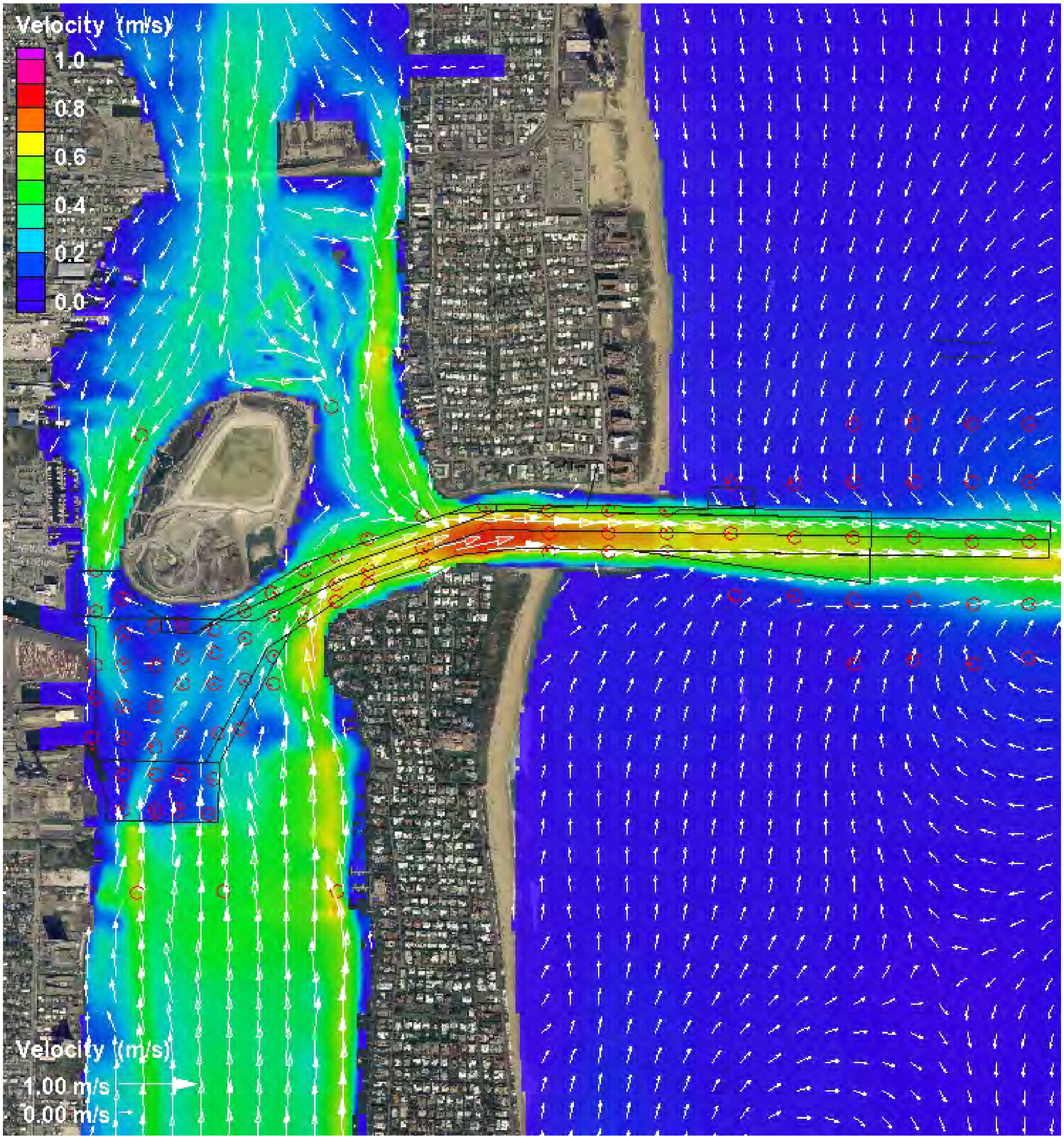

Figure 25. Plan 2 Flow vectors for maximum spring ebb tide.

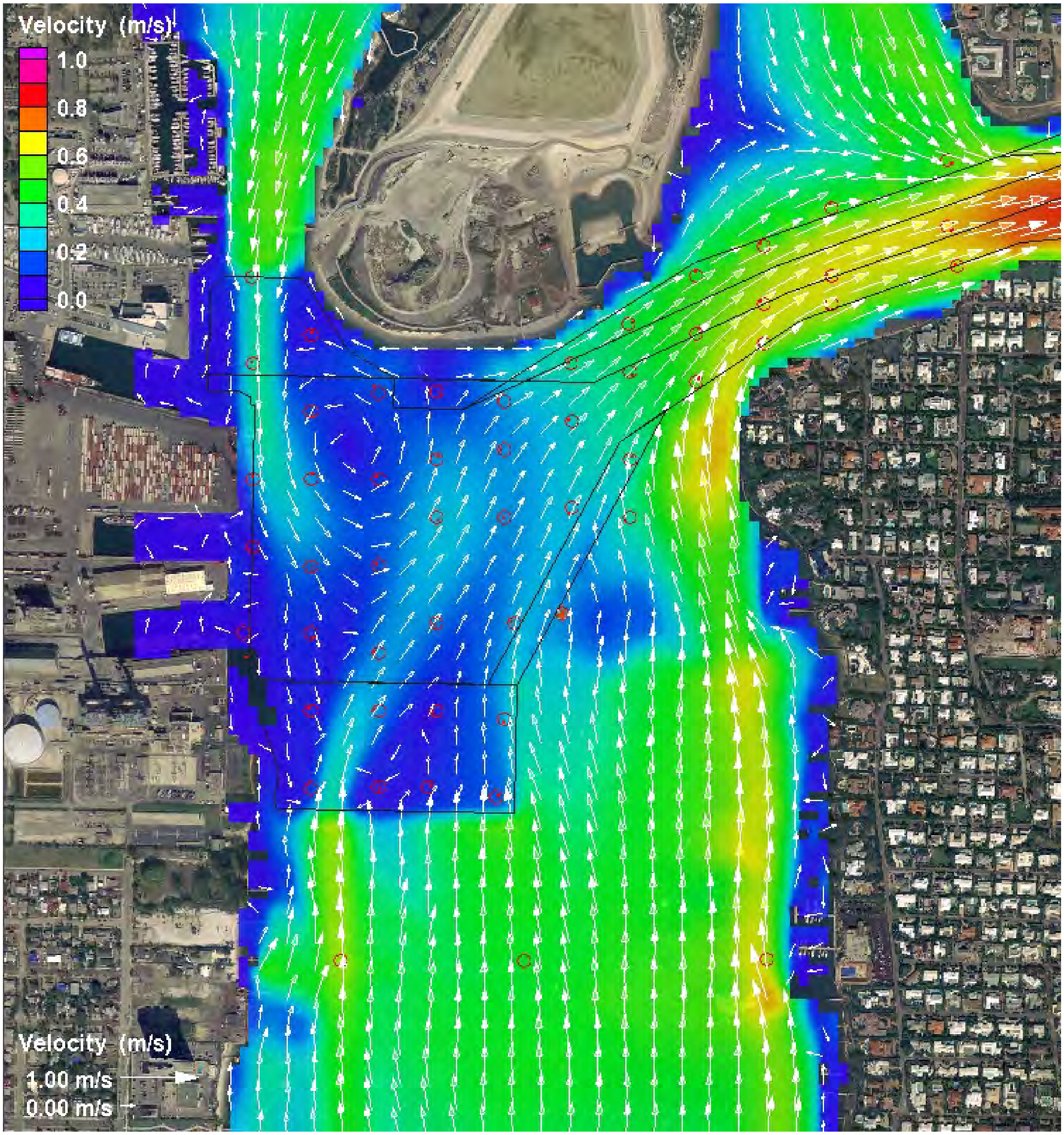

Figure 26. Plan 2 Flow vectors for maximum spring ebb tide.

Sediment Transport Modeling for Shoaling

CMS simulations conducted for this study included coupled CMS-FLOW and CMS-WAVE simulations of bed changes to estimate the shoaling rate for the project alternative as well as to optimize the settling basin design. The CMS sediment transport parameters used for this analysis are shown in Table 2.

Table 2. CMS-FLOW Sediment Transport Model Parameters

Sediment Transport Parameters	
Transport Method	Non-Equilibrium Transport
Transport Rate Time Step (s)	900.0
Morphologic Time Step (s)	900.0
Formulation	Advection-diffusion
Transport Capacity Formula	Lund-Cirp
Sediment Density (kg/m^3)	2650.0
Bed Load Scaling Factor	1.0
Suspended Load Scaling Factor	1.0
Morphologic Scaling Factor	1.0
Bed Slope Coefficient	1.0
Sediment Porosity	0.4
Transport Grain Size (mm)	0.25
Total load adaptation length method	Maximum of Bed & Suspended Sediment
Bed load adaptation length	Depth Dependent
Bed load adaptation factor	10.0
Suspended load adaptation length method	Armanini and Silvio

Sediment Transport Calibration

The simulation periods selected for this analysis span USACE bathymetry surveys conducted in September 2011, November 2011 and March 2012. The existing condition channel bathymetry in September 2011 was used as the initial condition for a 3 month calibration simulation which ends at the USACE November 2011 bathymetry survey (Figure 27). The simulation period used for calibration from September 1st to November 30th, 2011 represents an energetic wave climate with the mean Hs= 1.24 m during this period and four (4) storm events with two (2) exceeding Hs =3.0m. The calibration period mean Hs is similar to the Wave Information Study (WIS) mean Hs = 1.3 m for station 63459. Figure 28 shows the model results for existing condition channel shoaling and bed elevation change for the September to November 2011 time period. The shoaling volumes from the model were compared to the measured shoal volume based on the September to November 2011 surveys.

Sediment Transport Alternative Channel Depth and Settling Basin Optimization

Existing channel depths with the existing settling basin and the scheduled expanded settling basin were simulated and evaluated for channel shoaling volumes. Neither of these configurations results in channel shoaling volumes that would obviate the need for unscheduled maintenance dredging. Based on these results, simulations were conducted to optimize the expanded settling basin for both the existing channel depth (35/37 ft, MLLW) and the selected project alternative depth (47/ 50 ft, MLLW). Existing project feature constraints including the north and south jetties and beach area adjacent to the expanded settling basin limit both the alternative channel width and depth and the western extent of the settling basin. Figure 29 shows these features including the location of the jetty toe. Both the channel and settling basin are constrained by a minimum distance from the jetty toe due to potential jetty instability caused by foundation failure from channel or settling basin encroachment (See Geotechnical Attachment C).

After a number of iterative simulations an optimum settling basin configuration was determined that would trap enough sediment during storm events to reduce channel shoaling to allow for longer scheduled maintenance dredging cycles. Figure 30 shows the Existing Channel and Optimized Settling Basin shoaling. This combination reduces channel shoaling but not to the extent which would lengthen the dredging cycle. Figure 31 shows the Selected Project Channel Depth and Optimized Settling Basin Shoaling. This configuration reduces the channel shoaling enough to lengthen the dredging cycle to 2 years when combined with advanced maintenance. This configuration doesn't reduce the volume required to be dredged but does trap more of the volume in the settling basin rather than the channel and saves cost by reducing the number of required maintenance dredging events, on average, over the life of the project. Note that no significant shoaling was observed in the Inner Channel or Turning Basin. Therefore shoaling volumes estimates in these areas are based on historical rates and the increased area of the project features in these areas.

Advance Maintenance Zones and Annual Shoaling Volumes

In order to accommodate shoaling that occurs in the selected project alternative channel depth, advanced maintenance zones were established. Figure 32 and Table 4 shows the Advance Maintenance Zones and the corresponding annual shoal volumes and elevations. Future maintenance requirements based on model results and historical shoaling volumes for the Inner Harbor, which include the Inner Channel and Turning Basin is estimated to be a 17% increase of the historical volume of 17,224 cy, as shown in the historical dredging records in Table 3, which corresponds to the increase in project footprint. Since this area is not dredged as often as the Entrance Channel and Settling Basin, it should not affect the dredging frequency.

Future maintenance requirements based on model results for the Entrance Channel (including Adv. Maint.) predict a shoaling rate of 30,000 cy/yr and for the Settling Basins a rate of 70,000 cy/yr. That is similar to the current shoaling rate, however, a significant portion of the volume is trapped in the settling basin rather than the channel. The dredge cycle for the project is once every 2 years (it is 1 year currently) as the new capacity of these optimized features prevents the project from shoaling significantly above the project depth. Therefore, the total maintenance volume estimate is 200,000 cy/2 yr. This is based on an average basis, depending upon storm activity or lack thereof, where there may be periods when dredging is required dredge and others where dredging is not required until 3 years. The overall estimate is 24 Maintenance Dredging events over the 50-year project life.

Proposed Settling Basin and Sand Transfer Plant Operation

The Lake Worth Inlet sand transfer plant, a Federal project and locally maintained, is located on the west end of the north jetty and is operational year-round. Its purpose is to pump 160,000 cy of sand per year from the impounded area adjacent to the north jetty to three discharge points along the beach south of the inlet. The plant is fixed with an intake suspended from a rotating boom and can only transfer sand that is within (50 to 70 ft) reach of the intake structure. It has been recently upgraded with a new electrical service, pump, and intake structure but this does not affect the need for advance maintenance and an expanded settling basin in Lake Worth Inlet.

For, the Future Without-project (No Action Alternative) and With-Project Conditions (Tentatively Selected Plan), the sand transfer plant will continue to pump 160,000 cy of sand per year and may undergo future maintenance when necessary. The sediment transport modeling indicates that the proposed settling basin, which is 200 ft from the plant intake, will not reduce the volume of sand in the vicinity of the plant intake.

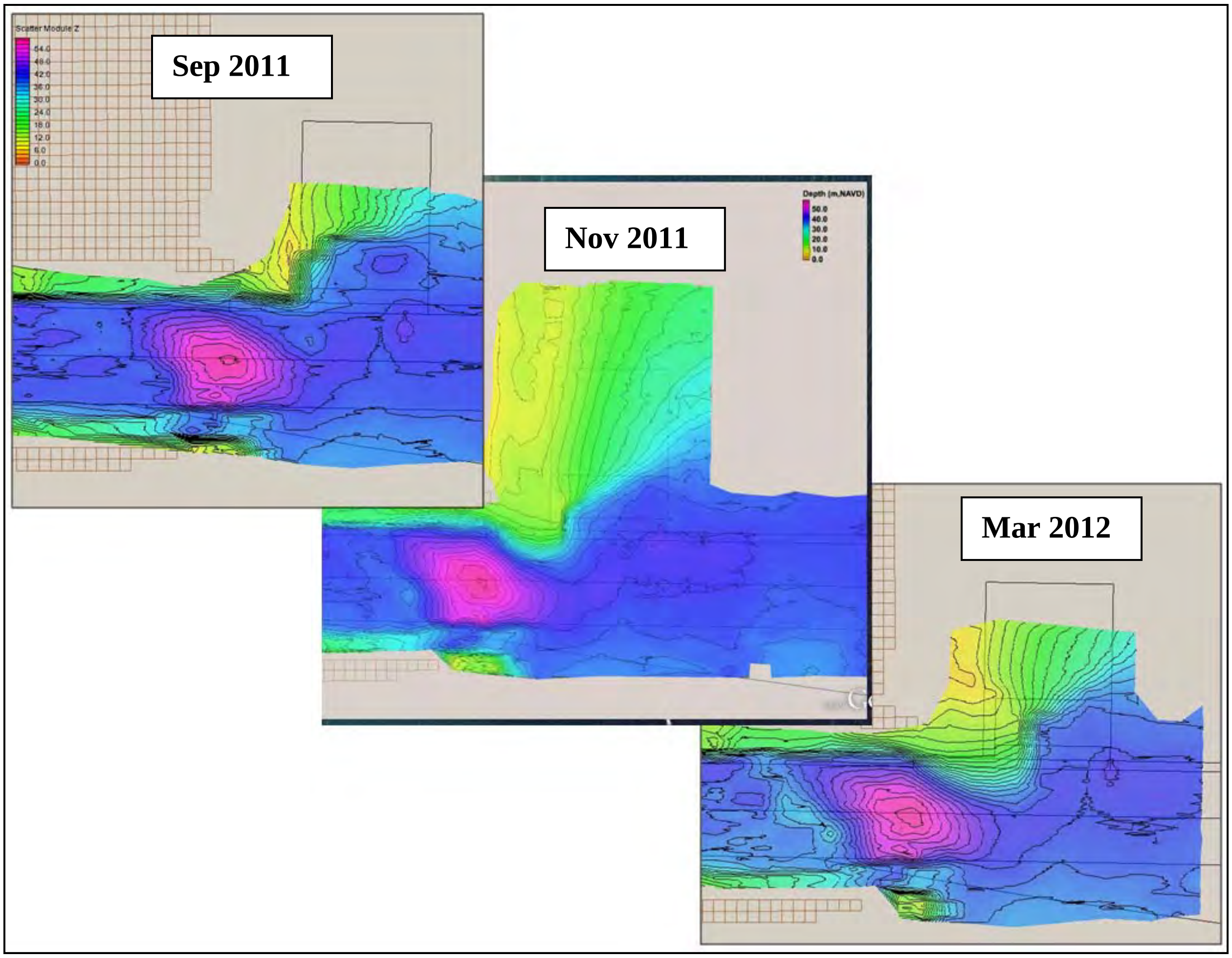

Figure 27. USACE bathymetry surveys used for calibration and shoaling rate estimates.

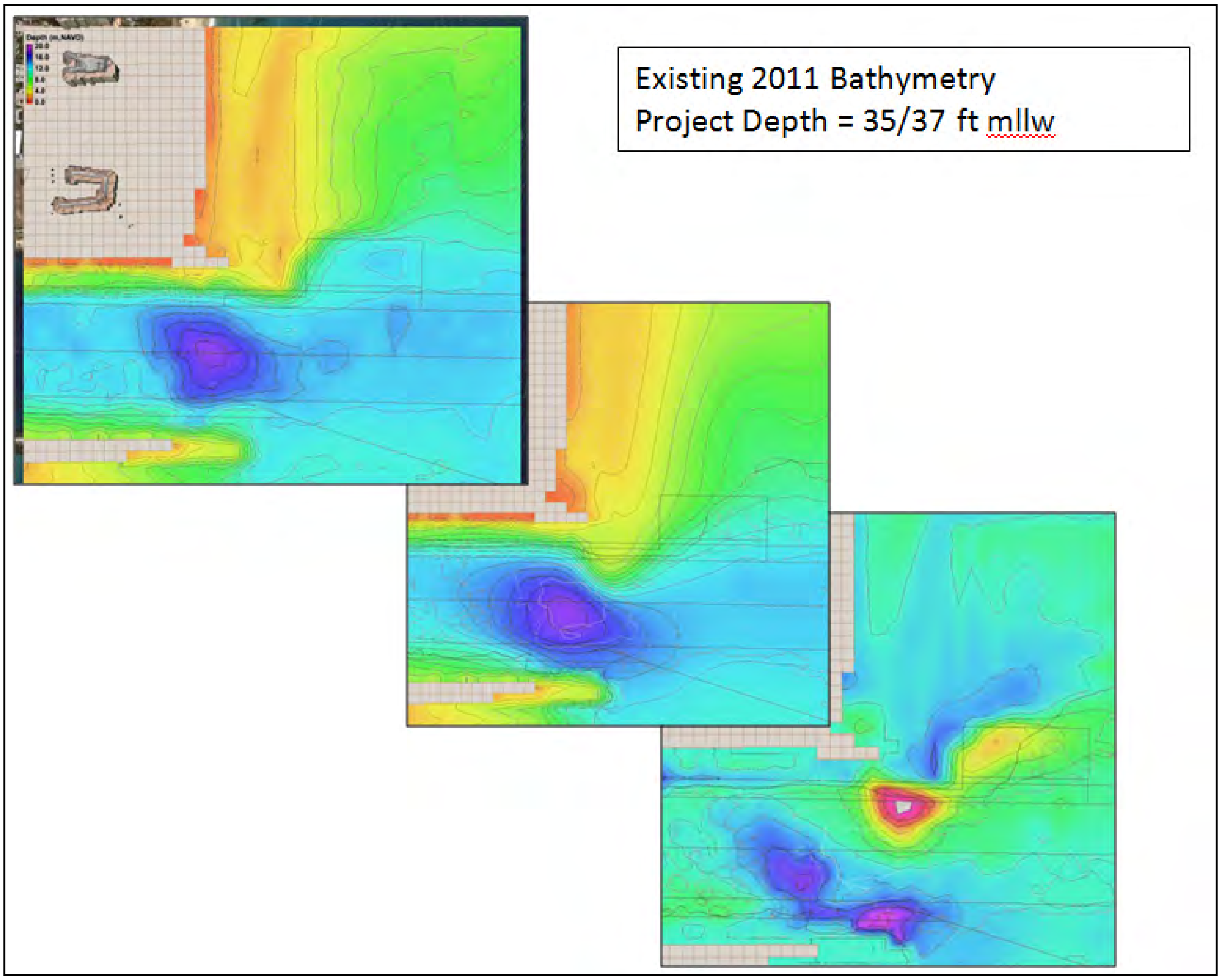

Figure 28. Existing Channel and Settling Basin Shoaling

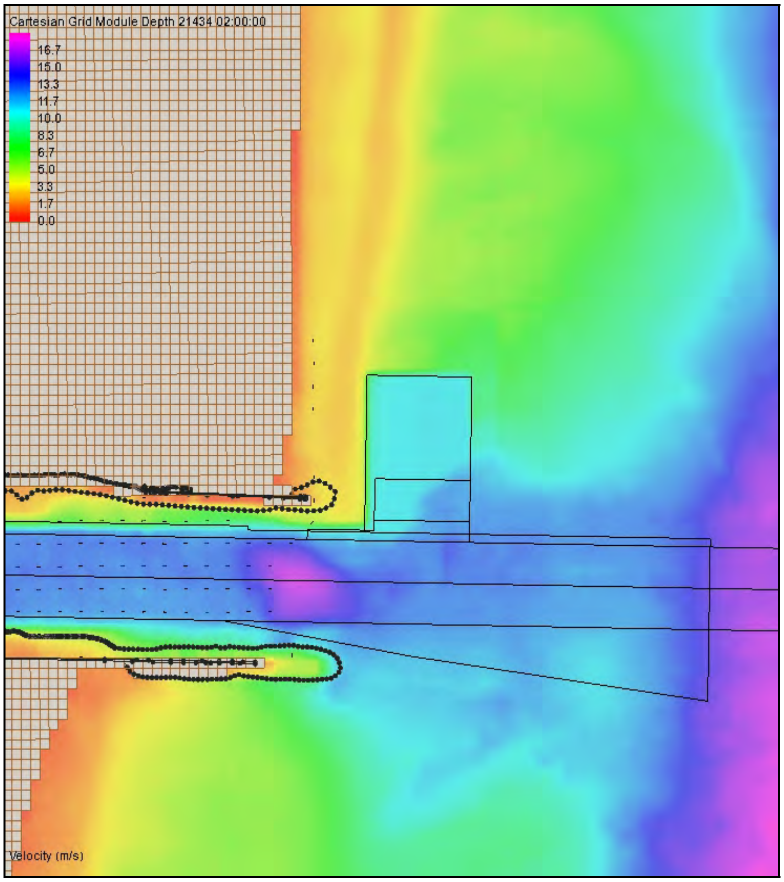

Figure 29.Project features- Existing Channel, Alternative channel geometry, Planned Expanded Settling Basin, and toe of jetty (black dotted line).

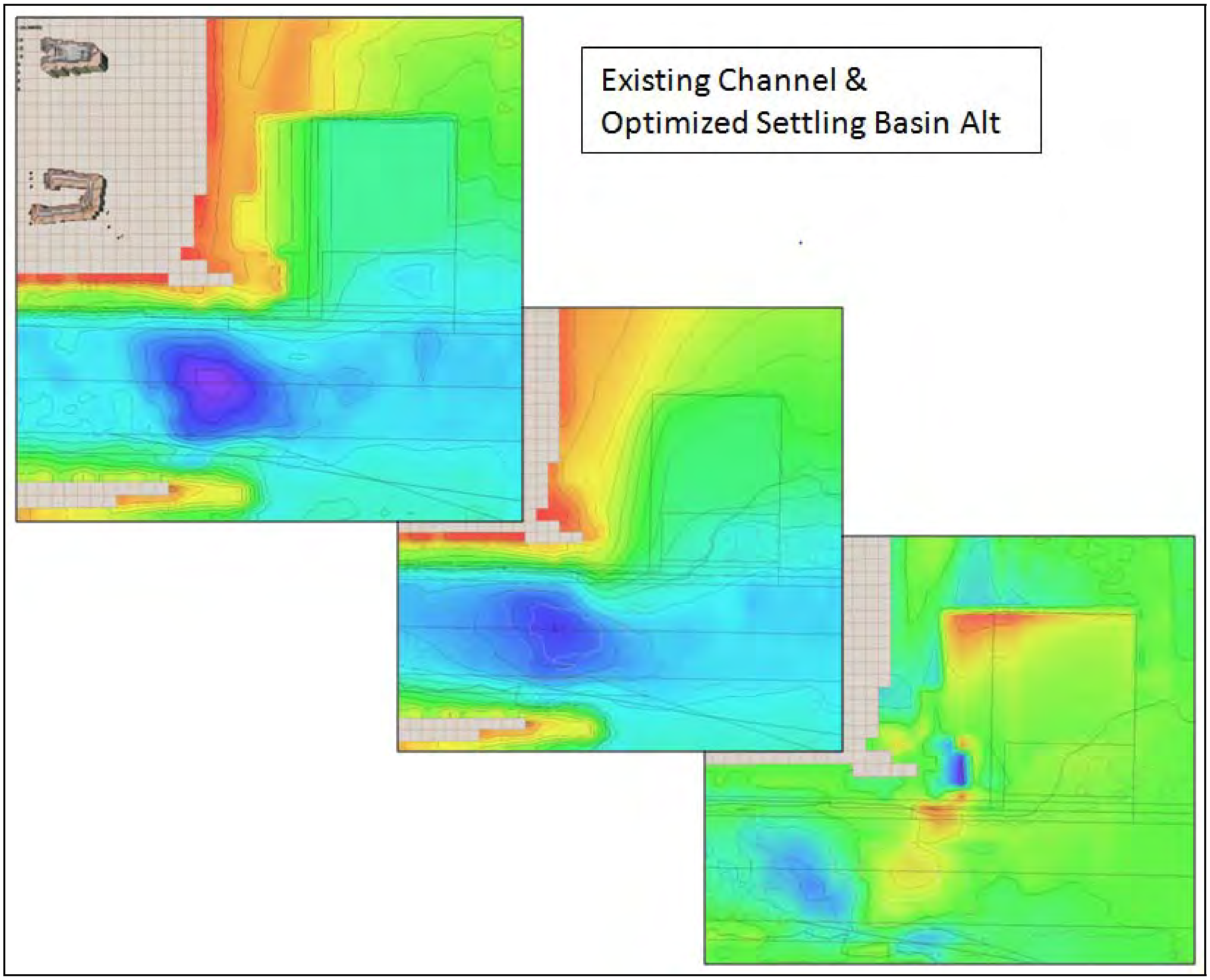

Figure 30. Existing Channel and Optimized Settling Basin Shoaling.

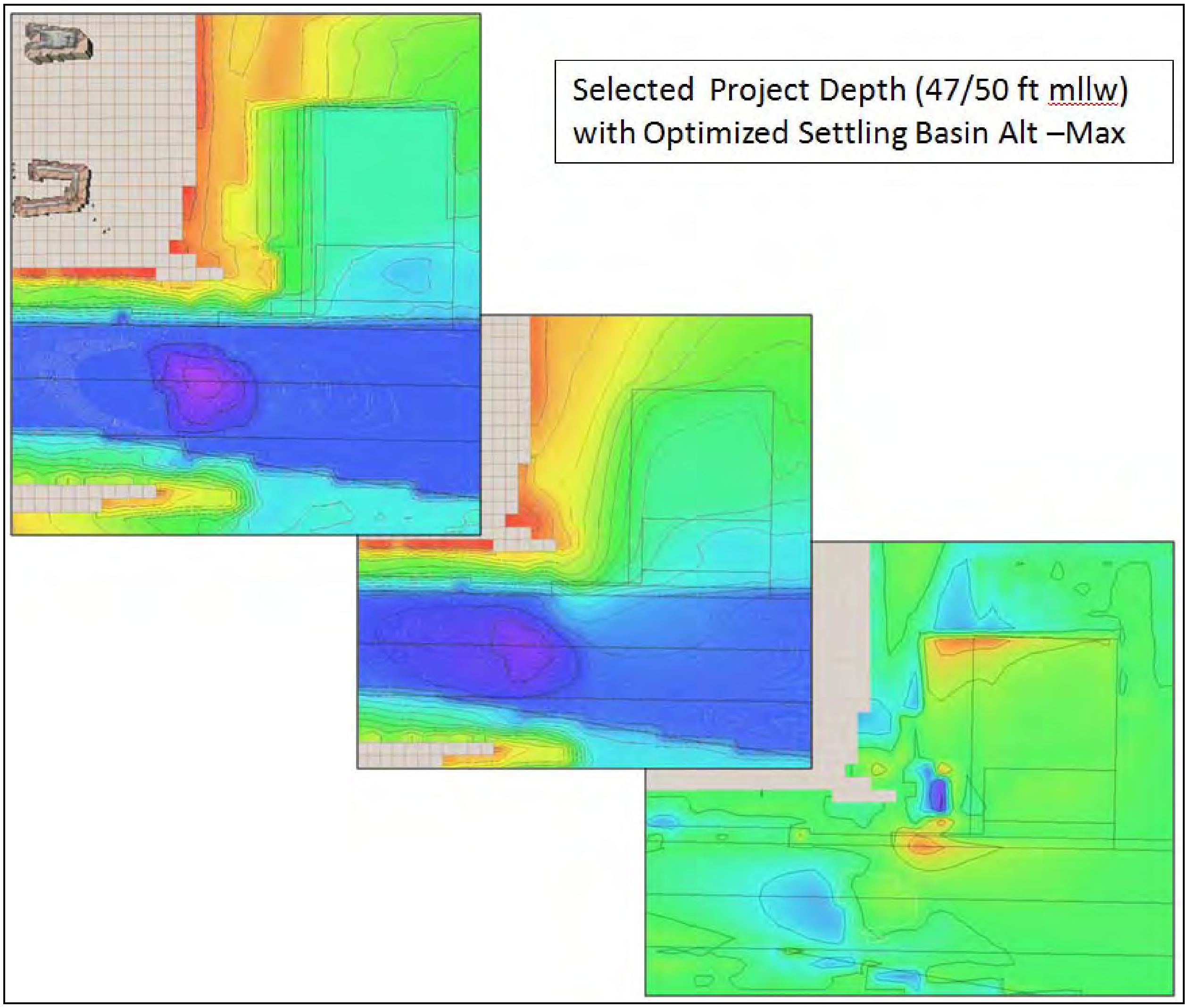

Figure 31. Selected Project Channel Depth and Optimized Settling Basin Shoaling.

Table 3. Historic Dredging Records

JOB KEY	JOB NAME	END DATE	VOLUME DREDGED (CY)	Volume (%)
00SAJ065	PALM BEACH HBR, '00	3/27/2000	124,000	
01SAJ160	Palm Beach Hbr, MD	1/11/2001	57,332	
02SAJ003	Palm Beach Hbr, MD	3/25/2002	118,450	
03SAJ002	Palm Beach Hbr-03, MD	4/29/2003	76,624	
04SAJ050	Palm Beach Harbor	5/7/2004	71,285	
04SAJ141	Palm Beach Hurricane Emer MD	10/2/2004	504	
05SAJ292	Palm Beach Harbor	7/28/2005	305,467	
06SAJ005	Palm Beach Harbor	12/9/2005	70,689	
06SAJ017	Palm Beach Harbor Emergency	10/3/2006	2,312	
07SAJ003	Palm Beach Harbor (FY 07)	4/20/2007	185,000	
08SAJ005	PALM BEACH HARBOR	5/20/2008	157,828	
09SAJ009	Palm Beach Harbor	12/30/2009	64,068	
10SAJ007	PALM BEACH HBR O&M	5/11/2011	144,340	
		Total CY =	1,377,899	
		Entrance Channel & Sediment Basins =	97,601	85%
		Turning Basins =	17,224	15%
		Annual Average Dredged Volume (CY) =	114,825	

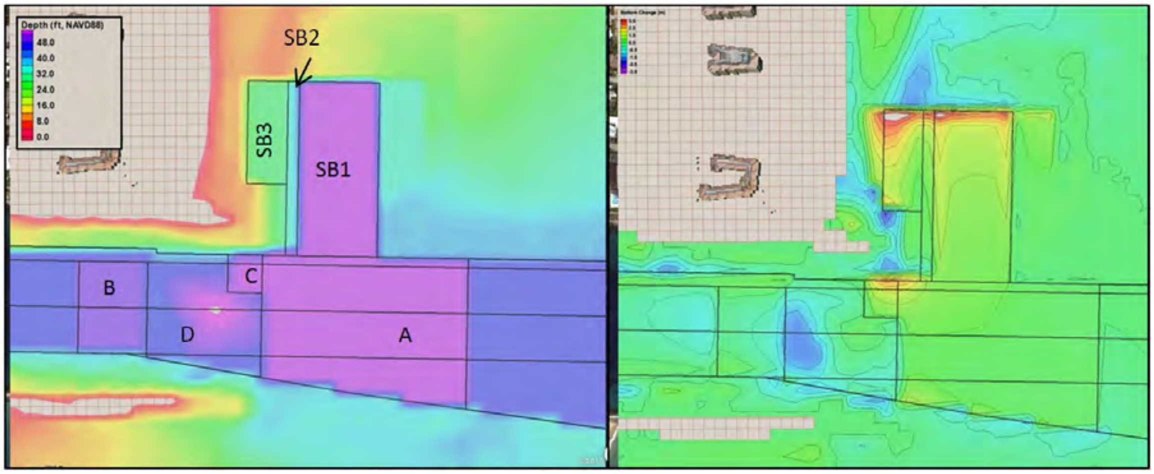

Figure 32. Selected Project Channel Alternative and Optimized Settling Basin advanced maintenance zones and shoaling elevations.

Table 4. Advance Maintenance Area Shoaling Volumes

Advance Maint. Areas	Max Shoal Height	Shoal Volume
	ft	cy
Inner Channel & Turning Basin	-	20,000
A	6.0	27,000
B	1.5	1,000
C	6.0	3,000
D	7.0	2,000
Entrance Channel Total		33,000
SB1	15.0	46,000
SB2	11.0	4,000
SB3	14.5	18,000
Settling Basin Total		68,000

Project Induced Changes to Wave Heights

In order to evaluate the changes to waves along the nearshore area north of the north jetty due to the Tentatively Selected Plan (TSP) navigation channel project depth and the Expanded and Proposed Settling Basins, CMS-WAVE simulations were conducted with a grid with 50 ft (15 m) cell spacing over its domain. The CMS-WAVE simulations include a representative storm event occurring in October 2011, with a maximum offshore significant wave height of 4.58 m (15 ft) (Figure 33.).

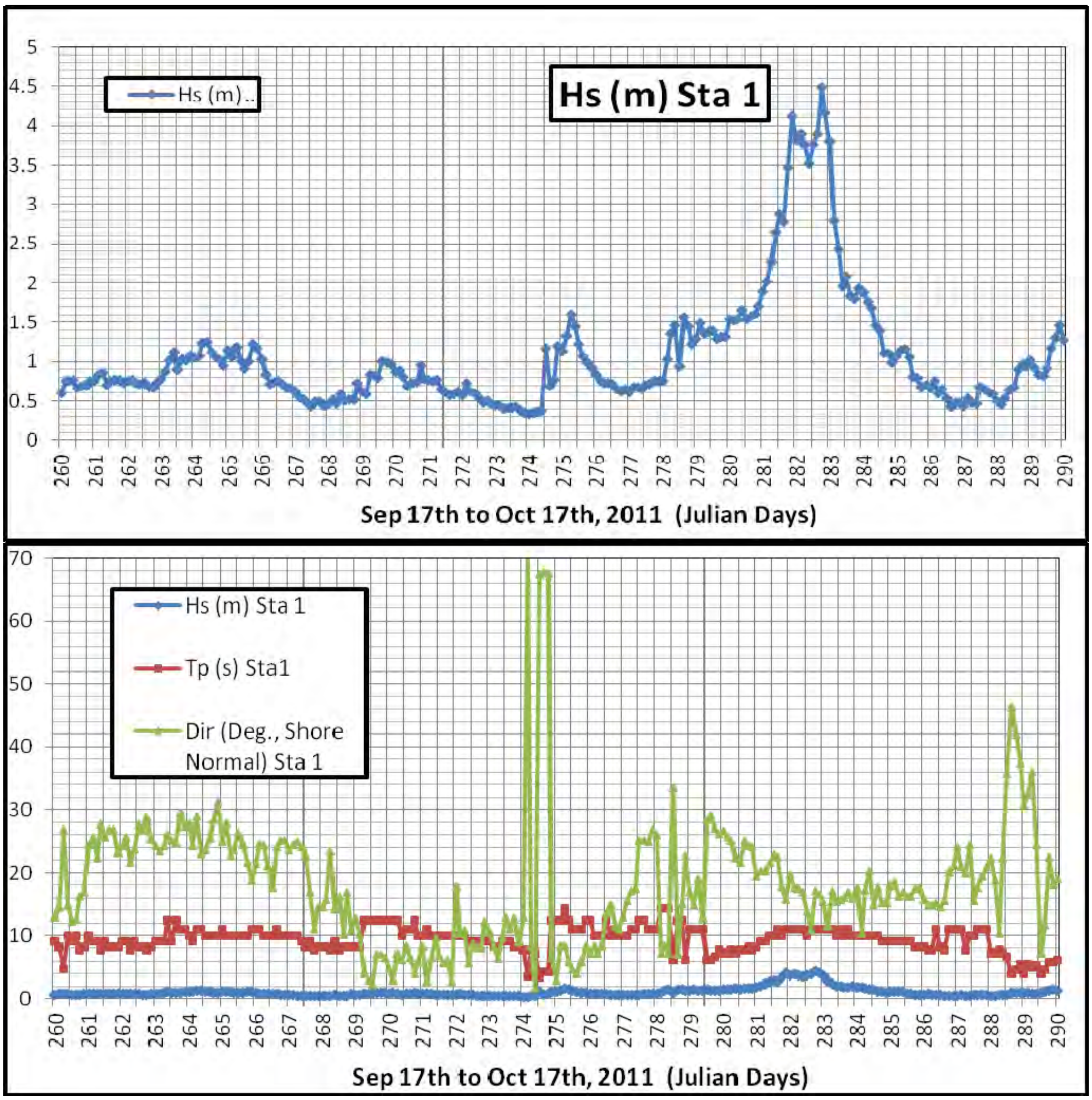

Figure 33. Simulated wave height, period, and direction at Station 1 (Depth = 8.8 m (29 ft)).

Three entrance channel and settling basin configurations are considered in this wave analysis. The Existing entrance channel and Pre-Expansion Settling Basin bathymetry, shown in Figure 34, includes the existing navigation channel and settling basin area (Existing Condition) as represented by the September 2011 Corps survey. Figure 34 also shows the CMS-WAVE output station locations 1 through 9, the toe of rubble apron of the north and south jetties, and the Sand Transfer Plant intake area. Figure 35 shows the existing channel and the Expanded Settling Basin (Expanded SB) which was constructed in the Fall of 2012. Figure 36 shows the TSP entrance channel and the Proposed Settling Basin (Proposed Channel and SB).

Wave heights for the October 2011 storm event are compared for each of the three scenarios, Existing Condition, Expanded Settling Basin, and Proposed Channel and Settling Basin at 3 output station locations, Station 5 (Depth = 1.9m), which is near the shore adjacent to the Settling Basin and 100 ft north of the Sand Transfer Plant intake area, Station 8 (Depth = 3.1m), which is located at the toe of the rubble apron of North Jetty, and Station 9 which is at the northeast corner of the Sand Transfer Plant intake area. Comparison of wave heights at Station 5, between the three scenarios, shows a maximum wave height 1.9 m for the Existing Condition and Expanded Settling Basin. The Proposed Channel and Settling Basin maximum wave height is 2.1 m, which is 20% higher than the Existing or Expanded maximum wave heights.

Comparison of wave heights at Station 8, between the three scenarios, shows a maximum wave height of 2.4 m for the Existing Condition and Expanded Settling Basin. The Proposed Channel and Settling Basin maximum wave height is 3.3 m , which is 0.9m or 38 % higher than the Existing or Expanded maximum wave heights.

Comparison of wave heights at Station 9, between the three scenarios, shows a maximum wave height of 1.6 m (5.3 ft) for the Existing Condition and Expanded Settling Basin at the time of maximum incident wave height.. The Proposed Channel and Settling Basin maximum wave height is 1.9 m (6.2 ft), which is 0.3 m (1.0 ft) higher than the Existing or Expanded maximum wave heights or a 19 % increase. The constant maximum wave height for the Proposed Channel and Settling Basin of 1.9 m (6.2 ft) from Julian Day 281 to 284 (Oct 8 to Oct 11) indicates that this is a depth limited wave condition and is the maximum wave height that can exist at this station.

This wave height comparison indicates that the Proposed TSP Channel and Settling Basin increases wave heights by 19 % in the vicinity of the Sand Transfer Plant and is not expected to significantly increase the risk of damage to the Sand Transfer Plant.

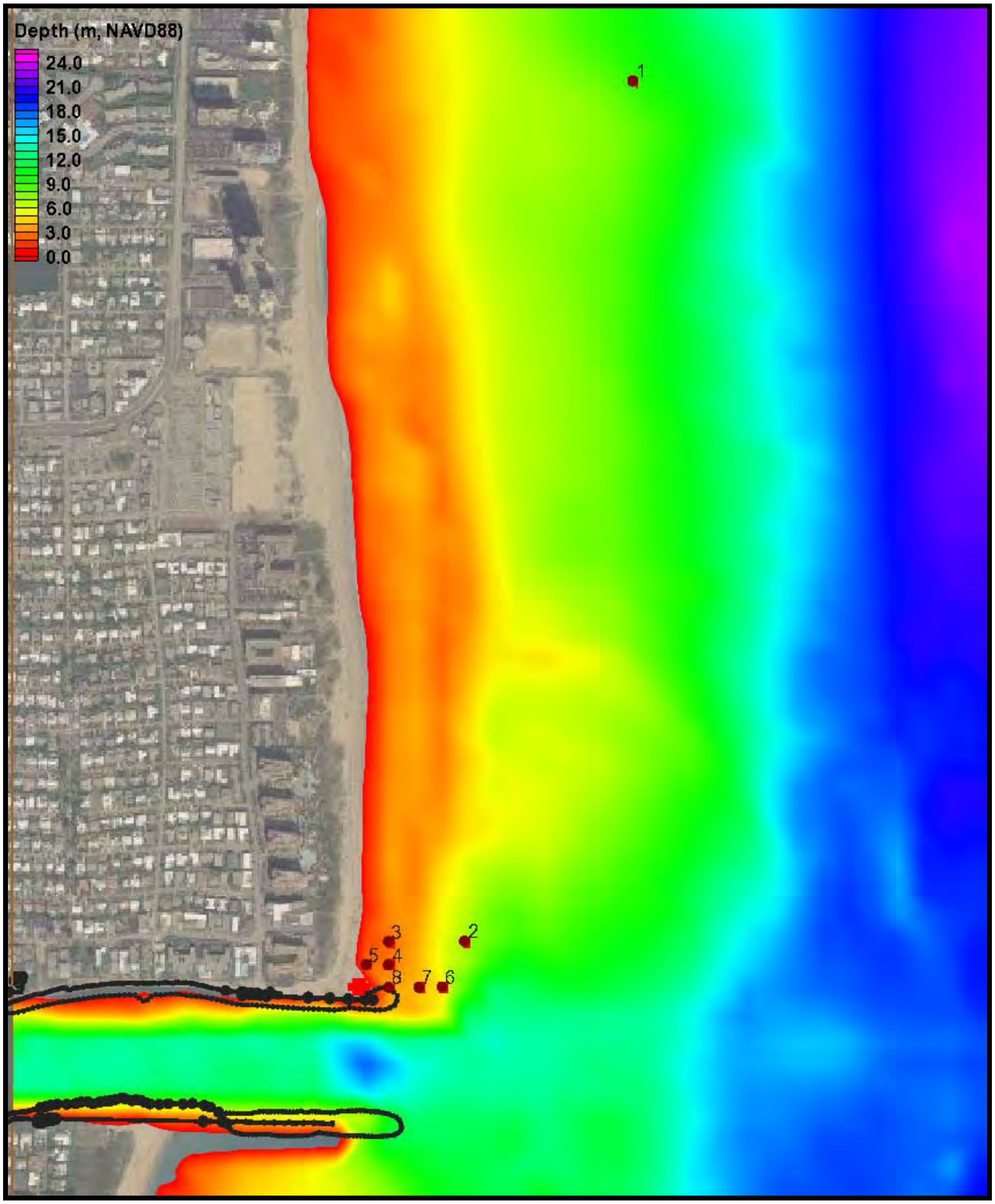

Figure 34. Wave Height comparison Station Locations with Existing channel and Pre-Expansion Settling Basin bathymetry (Existing Condition).

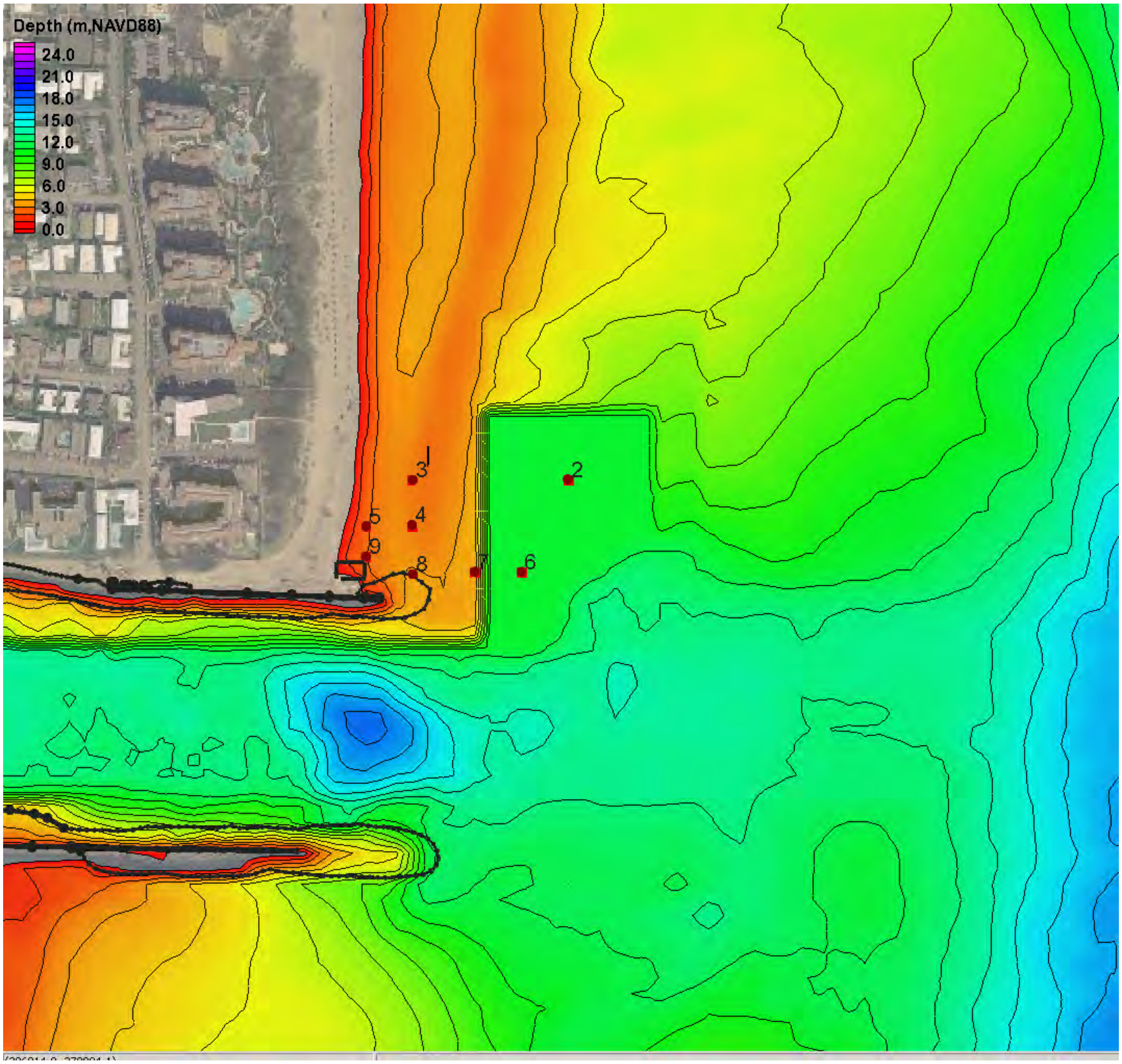

Figure 35. Existing channel and Expanded Settling Basin (Fall 2012) bathymetry (Expanded SB).

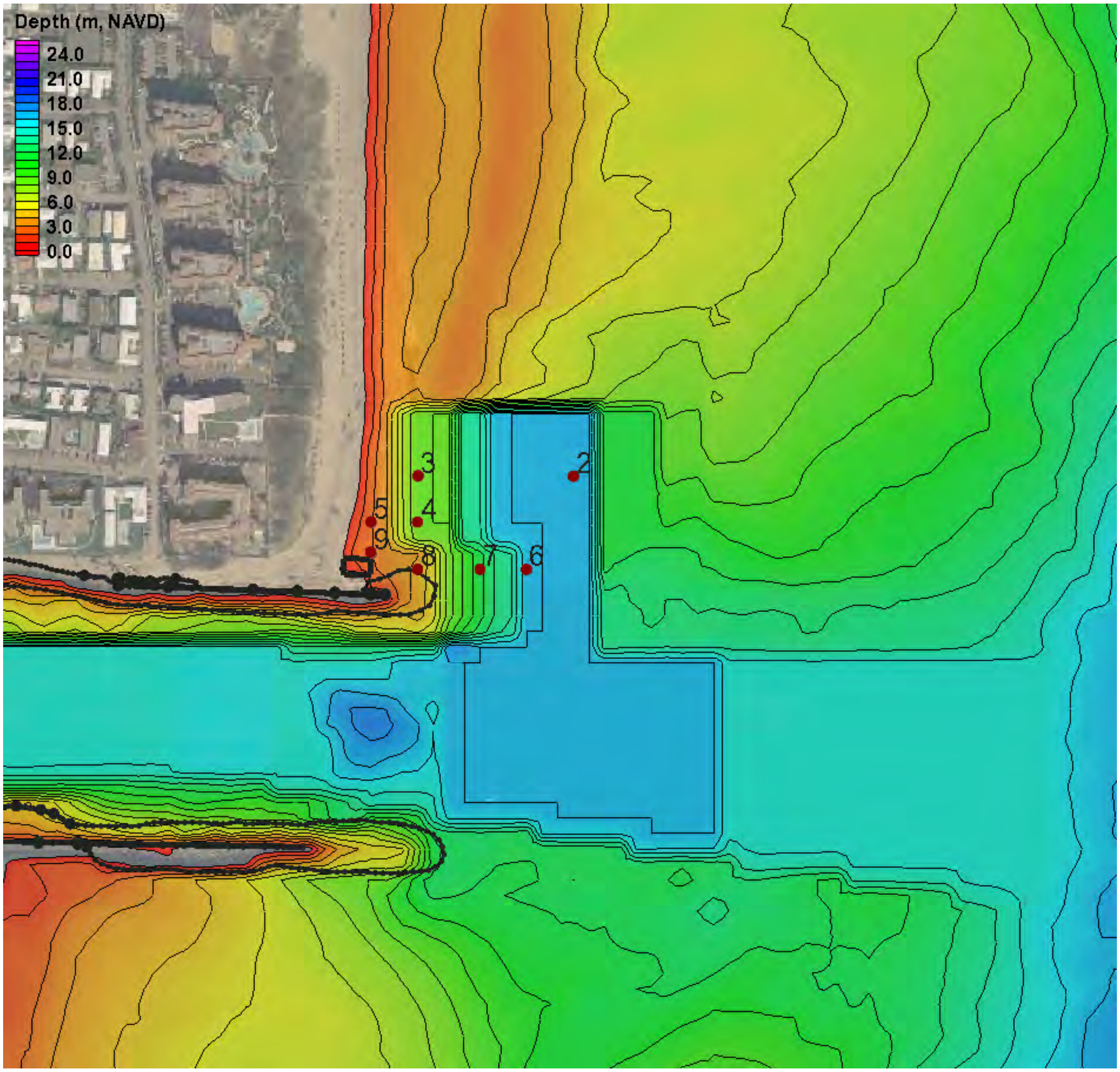

Figure 36. TSP channel and Proposed Settling Basin bathymetry (Prop_Channel_SB).

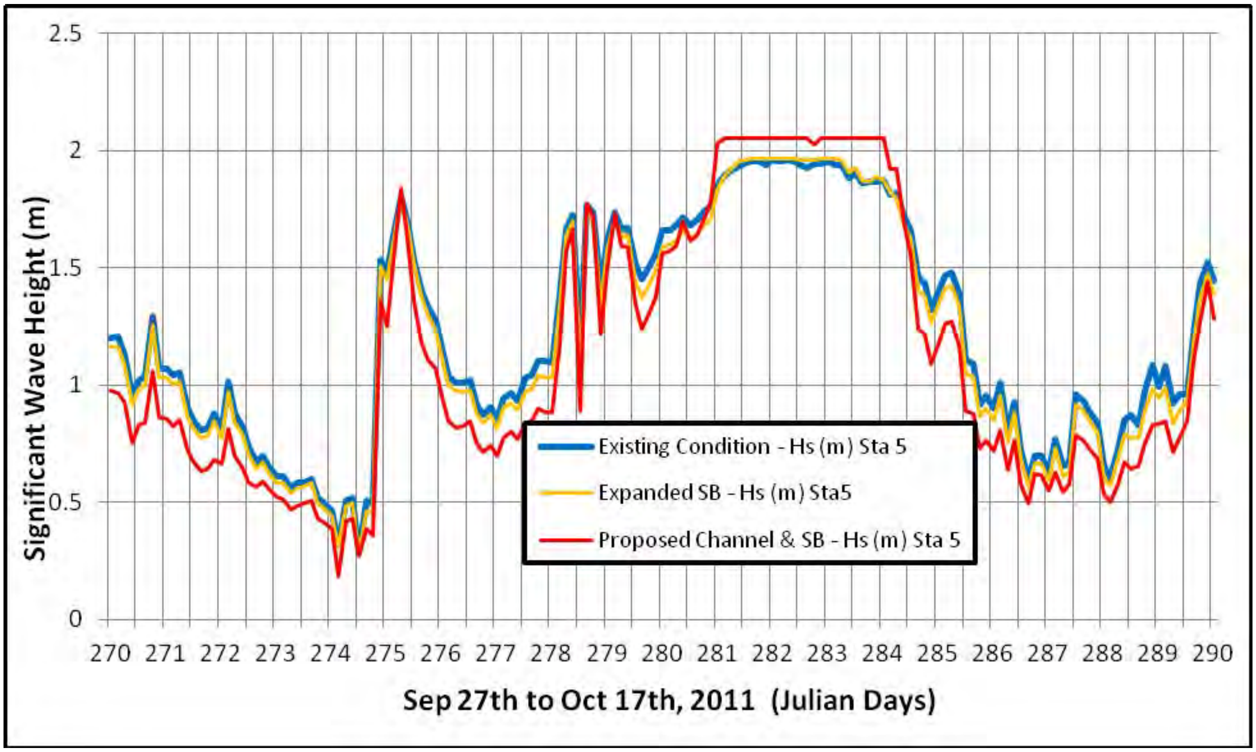

Figure 37. Station 5, Existing and Proposed Channel and Settling Basin wave heights.

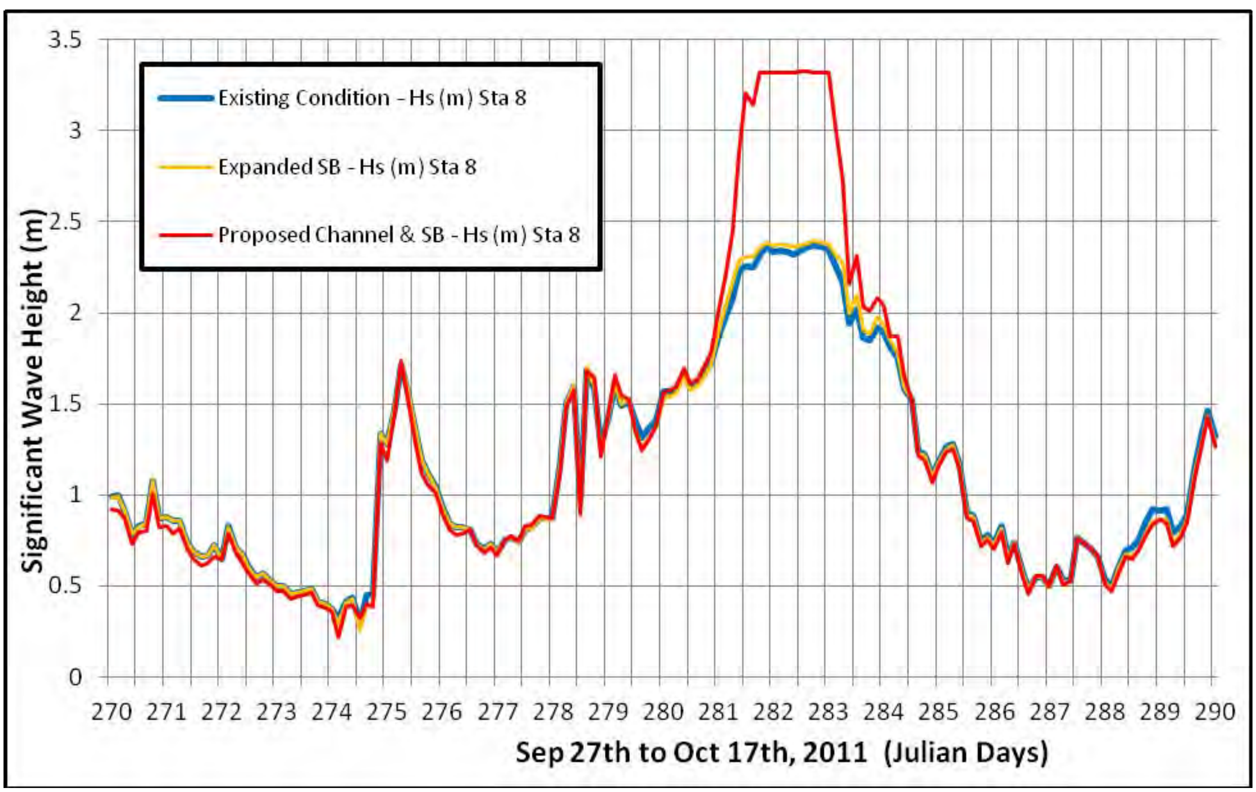

Figure 38. Station 8, Existing and Proposed Channel and Settling Basin wave heights.

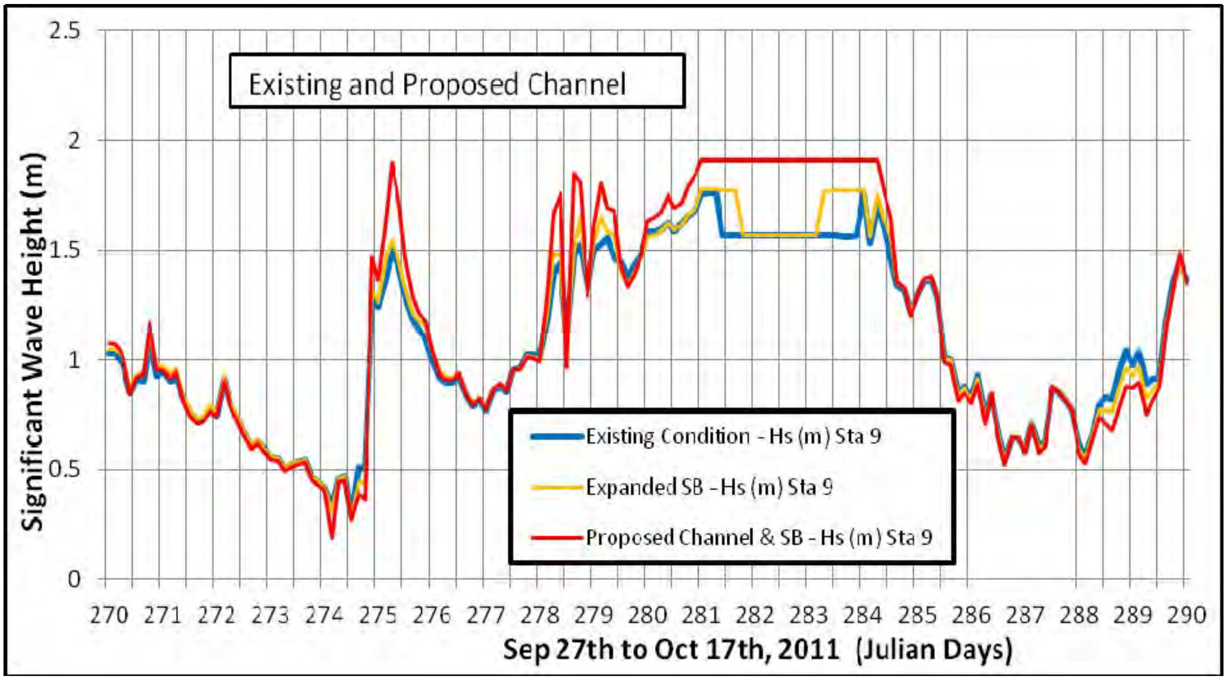

Figure 39. Station 9, Existing and Proposed Channel and Settling Basin wave heights.

Storm Surge Modeling

<u>Introduction</u>

An analysis was conducted to determine if there would be an impact to storm surge water levels at the project site due to proposed deepening of the Palm Beach Harbor Federal Navigation Project (Figure 1). The Coastal Modeling System (CMS) (Sanchez, et.al. 2011) was used to simulate a 100-year return interval total storm tide event on two different model grids representing the existing condition bathymetry and a future bathymetry representing the Federal project with all proposed deepening and widening of the channels and Harbor. The results of these numerical simulations are analyzed to determine any potential changes to total storm tide that might result from the proposed modifications to Palm Beach Harbor.

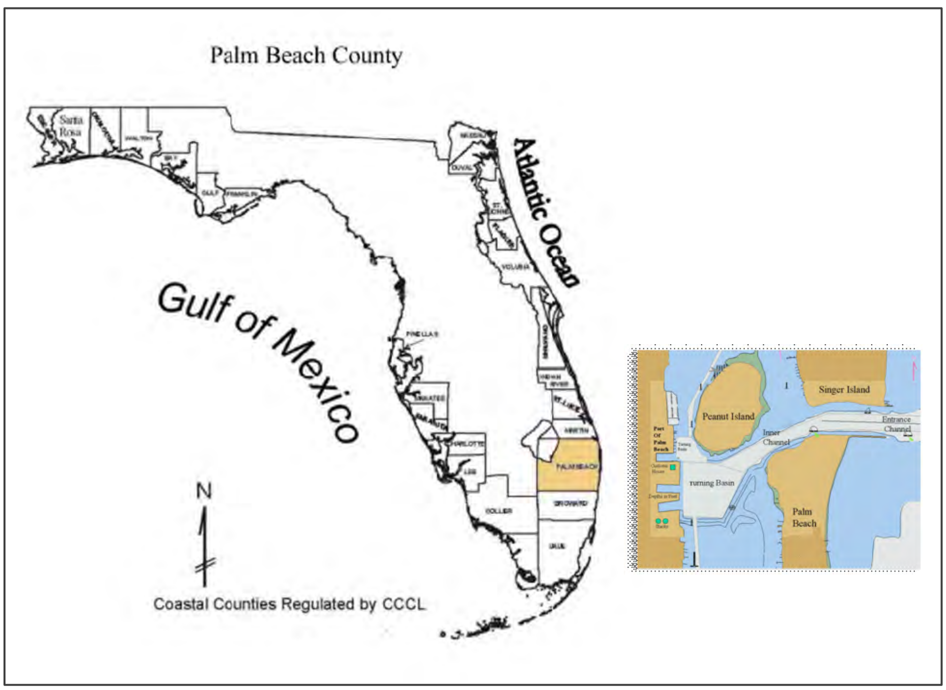

Figure 1: Study Location Map. Palm Beach County and Palm Beach Harbor

<u>Modeled Storm</u>

The 100-yr Storm was modeled using results from the published report, "Combined Total Storm Tide Frequency Analysis for Palm Beach County, Florida (Dean et al., 1992). The 100-yr Storm modeled was the Combined Total Storm Tide, which is the storm surge due to the astronomical tide, wind stress and barometric pressure effects combined with the dynamic wave set-up. All meteorological forcing and wave climate forcing are included in the calculation for the Combined Total Storm Tide. Available historical hurricane statistics were combined with a set of numerical models to simulate the storm tides at Palm Beach County. Available statistics included tidal recordings during the hurricanes of 1926, 1945, 1947 and September 1979 (Hurricane David). Values in the report were converted from NGVD to NAVD88 by subtracting -1.52 feet using the NOAA NOS gauge at Palm Beach, FL, Station ID: 8722607 (Figure 2). The Combined Total Storm Tide (Figure 3) was used for the storm surge model.

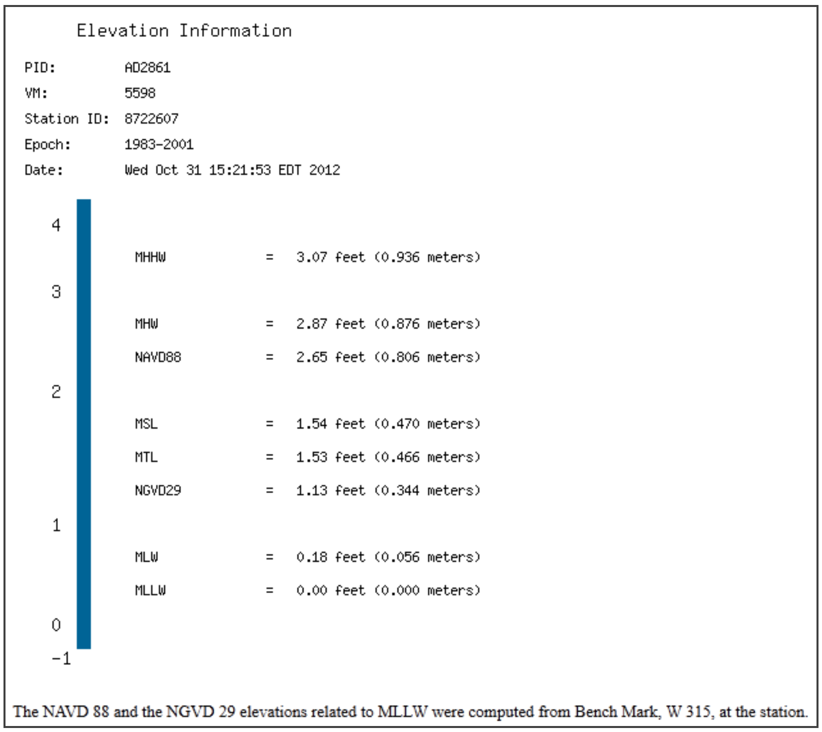

Figure 2: Datum Station 8722607 Palm Beach

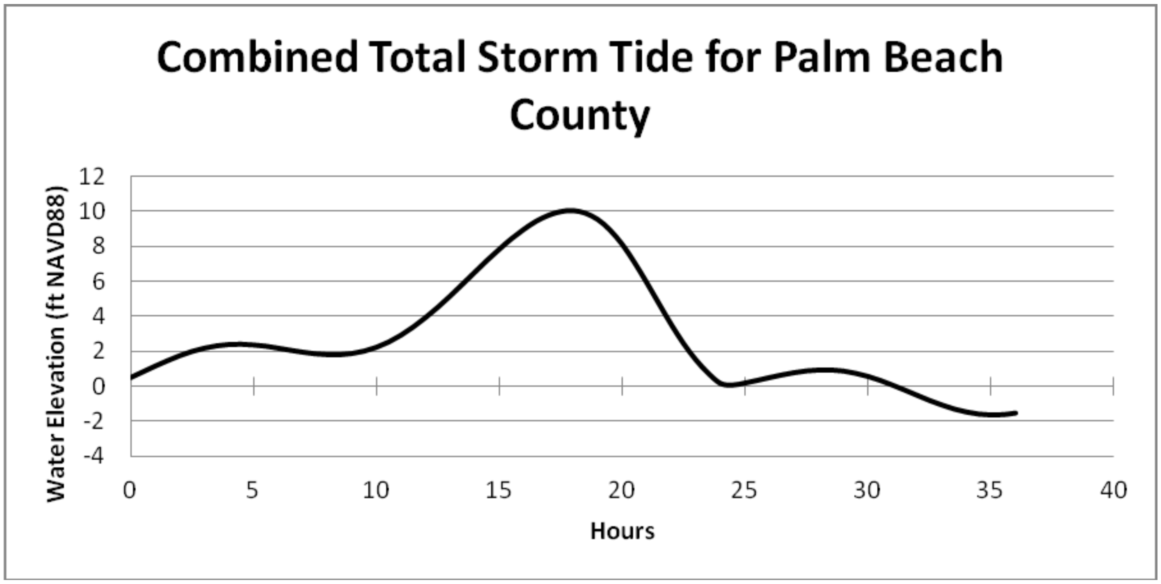

Figure 3: Total Storm Tide for Palm Beach County; 100-yr Storm

<u>Bathymetry Data</u>

The model grid was populated with LIDAR elevation data collected in 2006 and 2007 for the region. These data were also combined with NOS soundings for the regions including the entire navigation channel and inlet system, a 1-mile reach in the intracoastal waterway both north and south of the turning basin at the Harbor, and in the nearshore and offshore to deep water well beyond 100m depth. Areas where no LIDAR or NOS soundings exist were populated using the Coastal Relief Model, developed by and available from the NOAA National Geophysical Data Center (NGDC) (Figure 4).

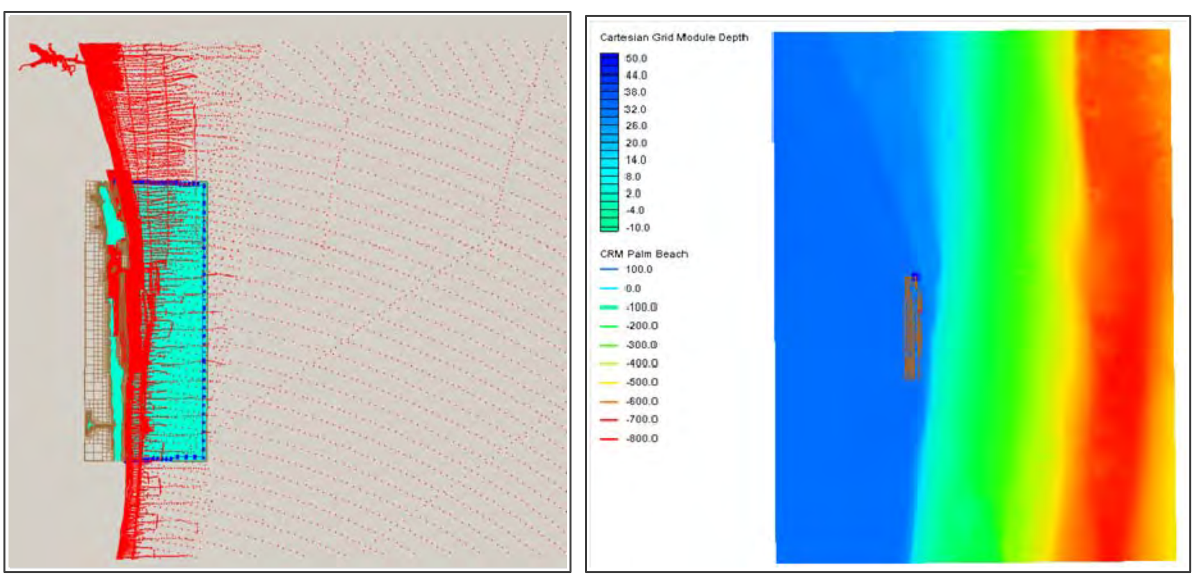

Figure 4: LIDAR and NOS data coverage (red dots) and NOAA CRM raster depths

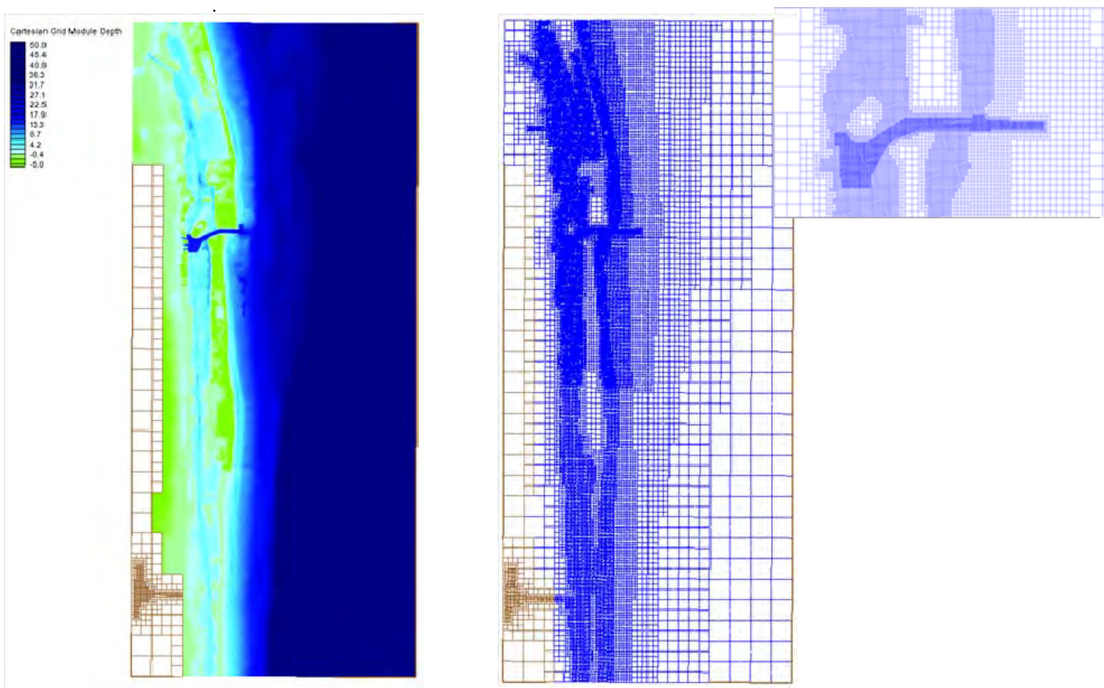

Figure 5: Model grid bathymetry mosaic of LIDAR, soundings and CRM model, the Combined Total Storm Tide was input as a boundary condition at the offshore boundary; model grid cells and detail of navigation channel and turning basin at Palm Beach Harbor (inset).

<u>CMS Storm Surge Modeling</u>

The CMS model was used to simulate the total storm tide at Palm Beach Harbor. This application included the implicit version of the depth-averaged hydrodynamic model, CMS (Sanchez, et.al. 2011).

<u>Water Elevation Boundary Condition</u>: The Combined Total Storm Tide (Figure 3) was used as the Surface Water Boundary Condition at the offshore boundary of the model (Figure 5).

<u>Model Grid</u>: The CMS model had 60081 cells, of which 59445 were ocean cells and 646 were land cells. The minimum cell size was 12.5m in the channel and turning basin for the Harbor. The maximum cell size was 800m on the offshore boundary. The maximum depth was 186m. The alongshore length of the model was 16 miles and the cross-shore length was 7 miles.

<u>CMS Storm Surge Model Run</u>

Current Velocities: The maximum flood and ebb currents for the with-project alternative are shown in Figure 6. Differences in the current structure between the with-project and the without-project alternatives were less than 0.3 m/s.

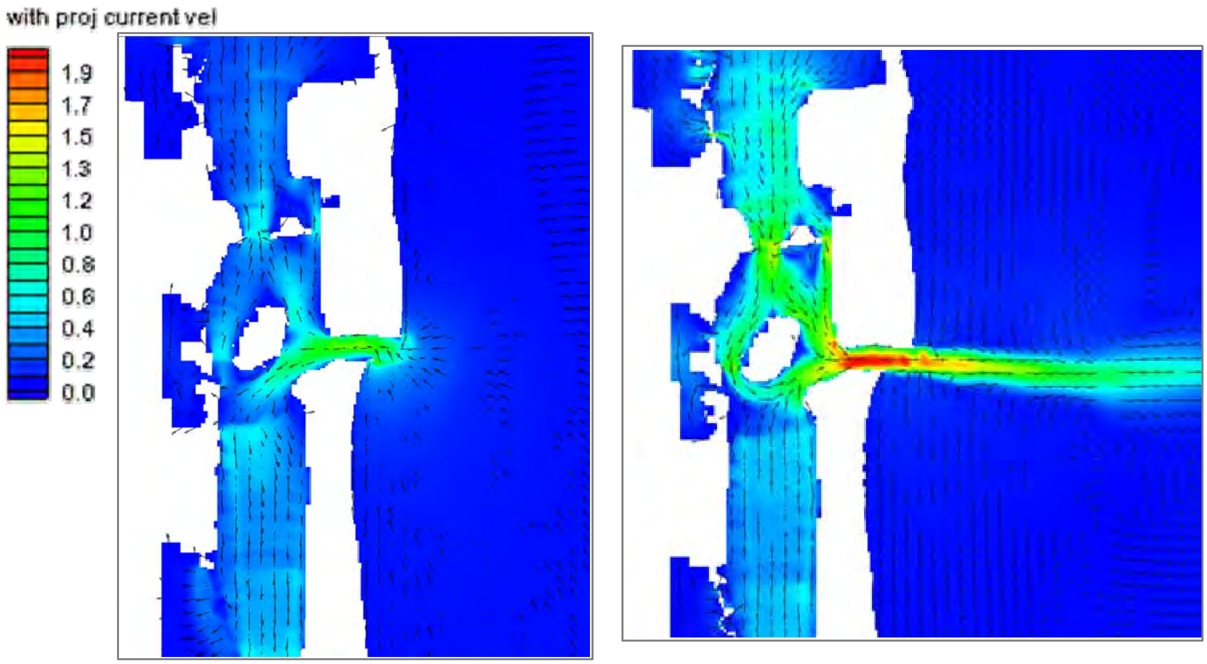

Figure 6: Maximum flood (left) and ebb (right) currents

Water Elevations: Water elevations were sampled within the model domain at four locations (Figure 7) in the Turning Basin (PT 1), the Navigation Channel (PT 2), in the ICW to the north of Peanut Island (PT 3) and in the ICW to the south of the Turning Basin (PT 4).

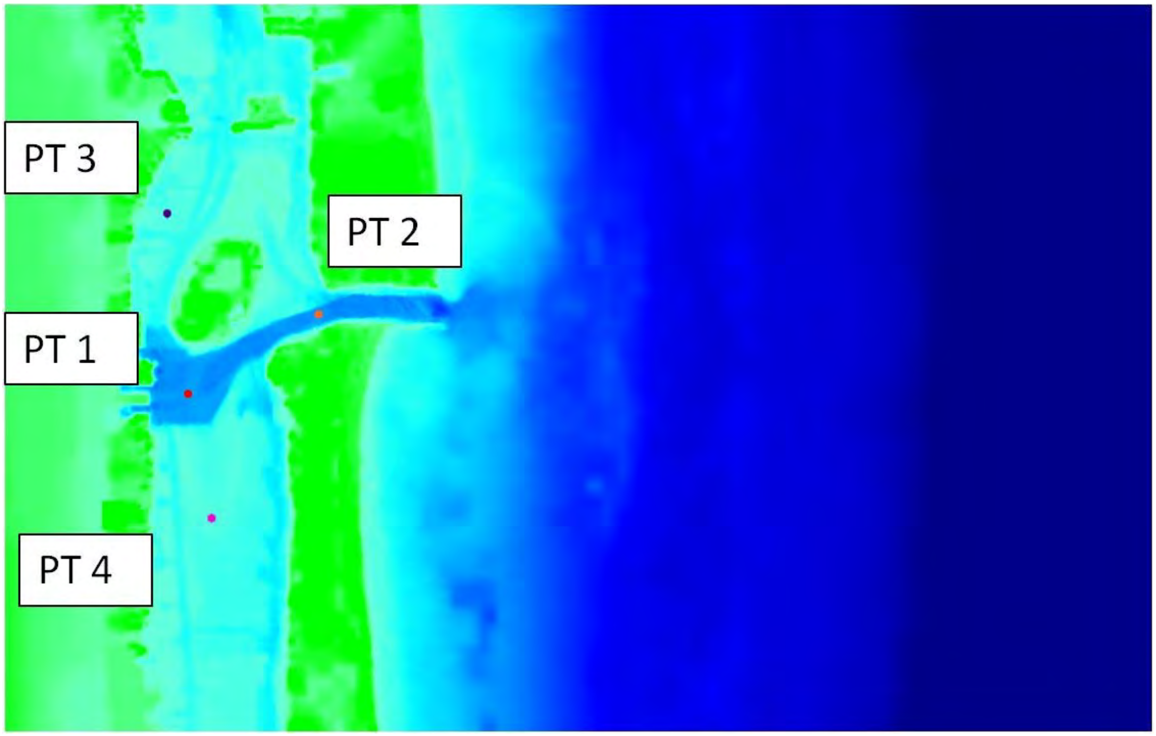

Figure 7: Sample locations for time-series analysis of water surface elevation

At the peak phase of the tide, when water levels offshore were maximum, the water level at the project site was the same for both alternatives, with and without the project (Figure 8; a,b,c&d). What was different between the scenarios was the phase of the water elevation; the phase for the with project alternative consistently lead the without project alternative both on the flood and ebb tides. This is due to the reduction in friction for the with-project scenario due to harbor deepening. Because the friction was reduced, the navigation channel, the turning basin and the ICW both filled with water sooner on the flood tide, and were emptied of water on the ebb tide sooner than the without-project scenario (Figure 8; a,b,c&d).

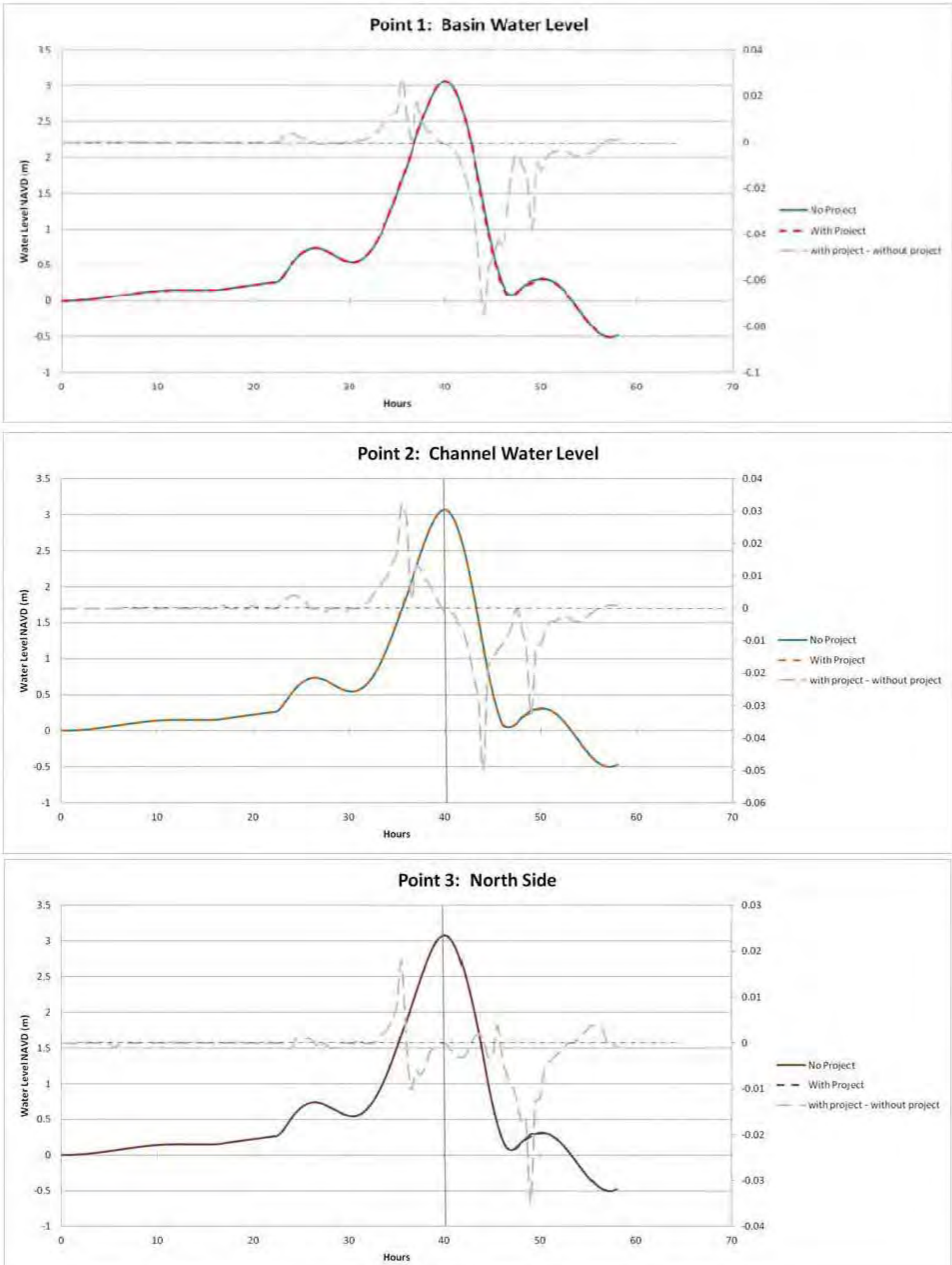

Figure 8 (a b & c): Water levels for the with and without project scenario. With project - without project water levels were subtracted (grey dashed line). Note the positive spike before hour 40 denoting the faster rate of flooding for the with project scenario and the negative spike after hour 40 denoting the faster rate of ebbing for the with project scenario.

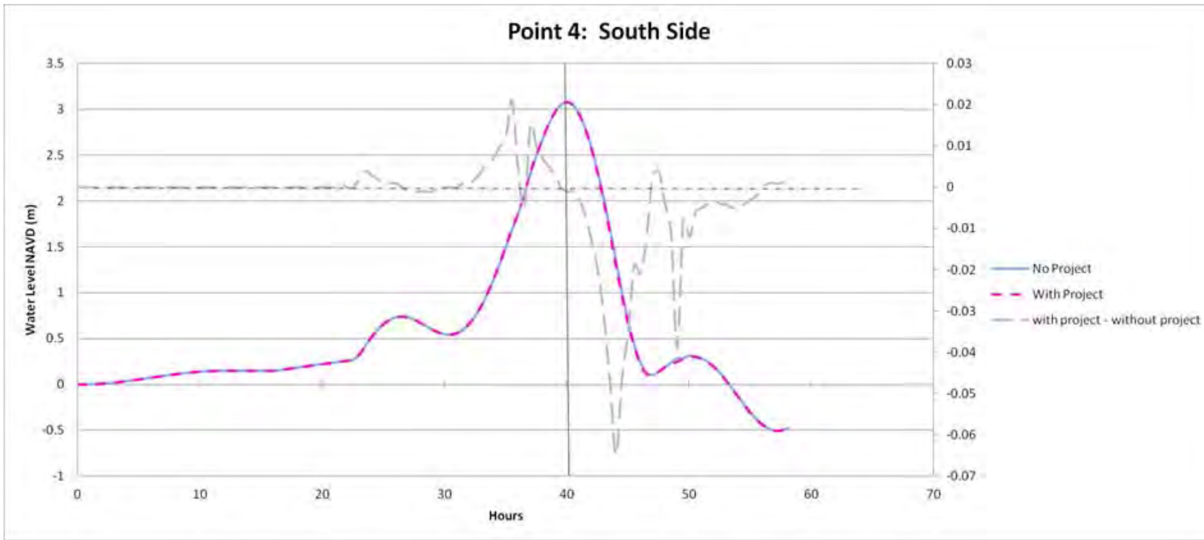

Figure 8d: Water levels for the with and without project scenario

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Dean, R.G., T.Y. Chiu, and S.Y. Wang. 1992. Combined Total Storm Tide Frequency Analysis for Palm Beach County, Florida. Beaches and Shores Resource Center, Institiute of Science and Public Affairs, Florida State University, Tallahassee, FL.

Sánchez, A., W. Wu, T.M. Beck, H. Li, J. Rosati, R. Thomas, J.D. Rosati, Z. Demirbilek, M. Brown and C. Reed. 2011. Validation of the Coastal Modeling System: Report III, Hydrodynamics. *Technical Report ERDC/CHL-TR-11-xx*. U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Sánchez, A., W. Wu, T.M. Beck, J.D. Rosati, Z. Demirbelik, H. Liand M.E. Brown. 2011. Verification, Calibration and Validation of the Coastal Modeling System: Report IV, Sediment Transport and Morphology Change. Tech. *Report ERDC/CHL-TR-11-xx*, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, MS.

Surfbreak Engineering Sciences, Inc, "Development of Water Level and Current Data in Support of the USACE's Palm Beach Harbor Navigation Project, Palm Beach County, Florida", November 18, 2008

Appendix A: Engineering

Attachment B: Ship Simulation Study

LAKE WORTH INLET

Palm Beach Harbor

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Simulation, Training, Assessment & Research
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LAKE WORTH FEASIBILITY STUDY

OVERVIEW

The U. S. Army Corp of Engineers (USACE) is considering port expansion in the port of Palm Beach, Florida. This expansion involves widening and deepening of the entrance channel, inner channel, and turning basin. Some modification of the vessels berthing areas may also be indicated, however, the pier areas were not part of our examination.

Two channel plans were submitted for consideration. In order to test the boundaries of these proposed plans, two bulk carrier vessels were selected as the design vessels, in addition to a cruise vessel. The goal of these plans is to enable safe transits, and ample maneuver room for these vessels, especially the bulk carrier vessels when in a fully loaded condition. Selecting the plan that best provides this access during wind and tidal current conditions normally experienced at the port is the focus of the study. STAR Center, located in Dania Beach, Florida, was tasked with accomplishing this evaluation. An existing geographic database of the Port of Palm Beach, already available in STAR Center's database library, was updated using USACE provided depth and tidal current information. This existing database was modified to represent the two proposed harbor expansion plans. These prospective plans are identified as Plan 1 and Plan 2, and along with the existing harbor configuration, provided the basis for our testing.

The project was conducted using STAR Center's 360 degree field of view, full mission simulator during the period 18 September through 2 October 2011. This report summarizes the methodology, results, and conclusions of that project.

PARTICIPANTS

Four experienced pilots from the Port of Palm Beach actively participated in the project and operated the bulk carriers and cruise vessel during all simulation exercises. In addition to the pilots, representatives from the U.S. Army Corp of Engineers (USACE), the client, observed simulation runs and provided valuable insight into design strategies and background information. The run matrix, which provided the general scope and details of the project, was provided by USACE, which also selected the design vessels used in simulations.

STAR provided a Senior Researcher to manage the project, a simulator operator to operate the equipment, and also monitor and record data, and a technician to ensure proper operation of the simulator. A bridge officer was provided to assist the pilot, carry out his steering and engine orders, and relay orders to assisting tug boats as necessary. A project facilitator observed and monitored simulations, noted conditions and results, briefed and debriefed the participating shiphandlers between simulation exercises.

GEOGRAPHIC DATABASE

The geographic database used in simulations was constructed from information based on C-Map electronic charts, NOAA Charts 11472 and 11466, up-to-date nautical publications, and tide and current tables. Digital photographs of the immediate area were included to provide an accurate and realistic visual reference for the shiphandlers. Details in these photographs included the pier area, shore installations, navigational aids, breakwaters, and shorelines.

Bathymetric information of area depths and currents was provided by USACE, and included in the database.

The Port of Palm Beach is accessed through Lake Worth Inlet using a 401.246 feet wide entrance channel. Charted depth in this channel, through the breakwaters is 39.370 feet, and continues at 36.089 feet in the inner channel and turning basin. These dimensions are represented in our existing channel database. The existing database is presented in **Figure 1 – Existing Channel** below.

FIGURE 1 – EXISTING CHANNEL

The existing database plan of the Port was modified to incorporate changes and modifications in depth and channel widths provided in design Plan 1.

While both proposed design plans offer the same entrance channel (46.259 ft.), inner channel and turning basin depths (42.979 ft.), Plan 1 offers the widest channel and turning basin options of either plan. The Plan 1 database is presented in **Figure 2 – Plan 1 Design** below.

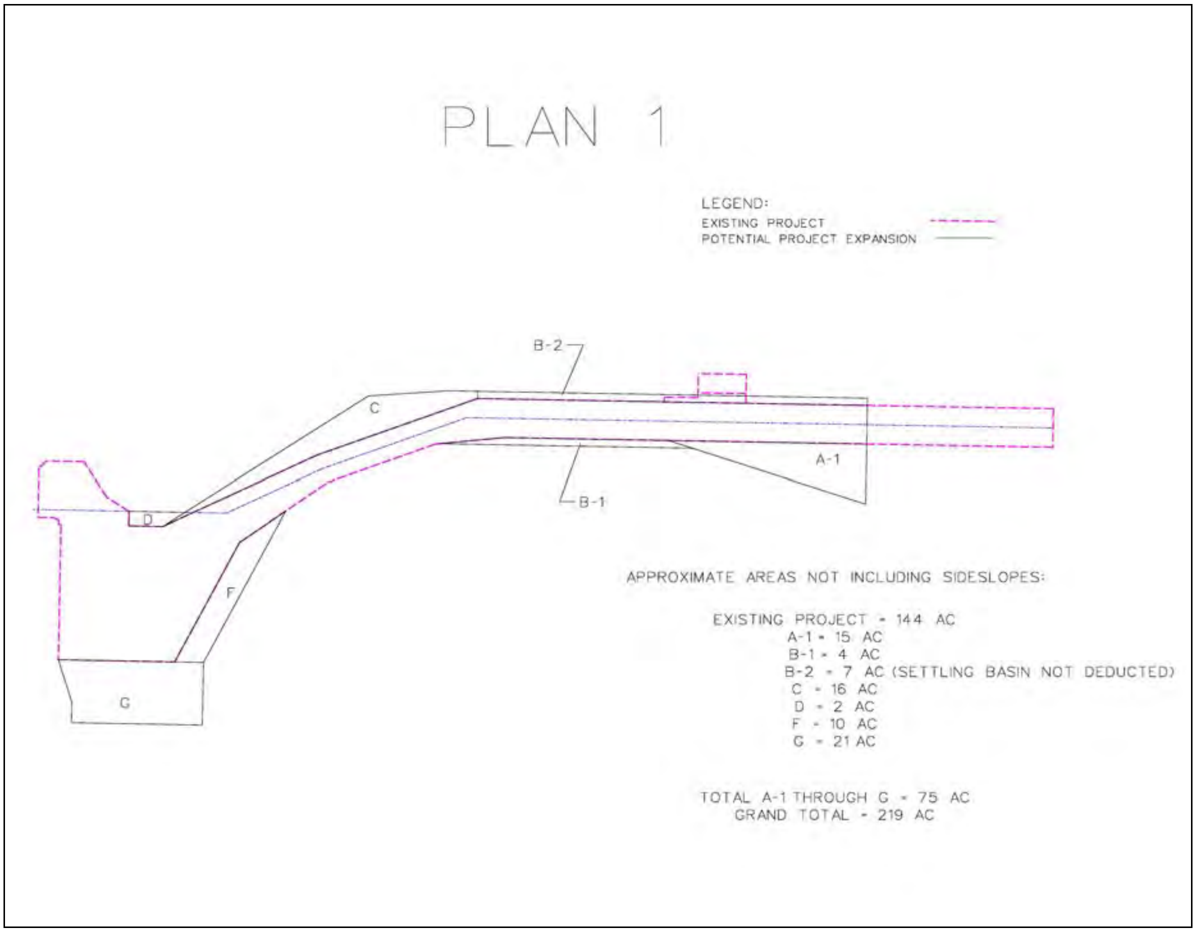

FIGURE 2 – Plan 1 Design

The existing database plan of the Port was also modified to incorporate changes and modifications in channel and turning basin design provided in design Plan 2. Channel and turning basin depths are the same as Plan 1; however, widening of those areas is less. The Plan 2 database is presented in **Figure 3 – Plan 2 Design** below.

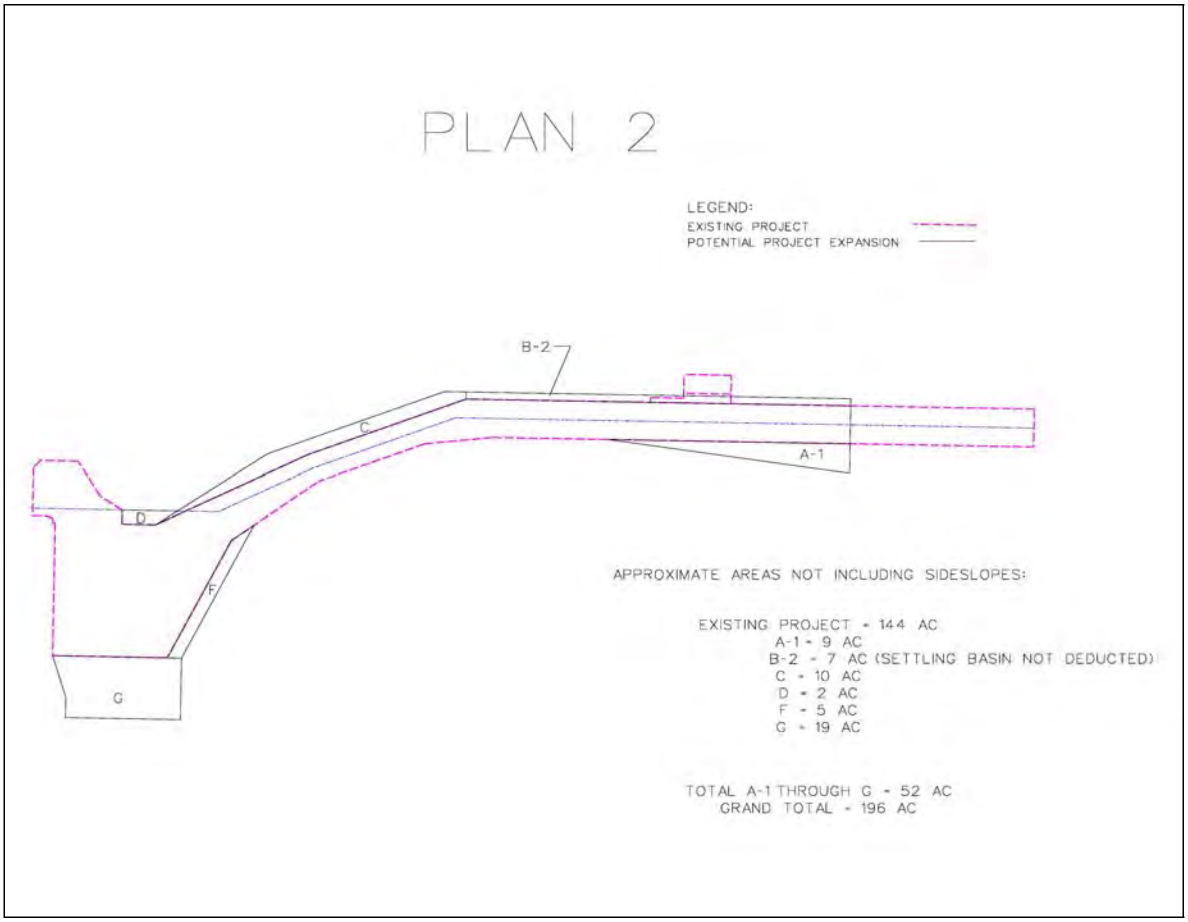

FIGURE 3 – Plan 2 Design

SHIP RESPONSE MODEL

The ship response hydrodynamic models provided for the study came from STAR's library of vessel models, or in the case of the "Palm Beach Brewer" were specifically constructed for this project. The bulk carrier vessels were selected as the design vessels as they represent vessels that may access the Port of Palm Beach in the future. The cruise vessel represents the same approximate size of a vessel now in use at the port, but would also benefit from an expanded channel and turning basin. Particulars for each vessel are presented in **Table 1 – Ship Particulars** below.

Table 1 – SHIP PARTICULARS

Ship Name	Palm Beach Brewer	Black Rose	Norwegian Sea	Black Rose
Condition	Loaded	Loaded	Design	Ballasted
Tonnage	62,820	65,085	19,810	33,140
LOA (ft)	656	707	710	707
Beam (ft)	106	105	93.2	105
Draft Fwd (ft)	40.02	40.02	22.3	18.4
Draft Aft (ft)	40.02	40.02	22.3	25
Propulsion	Diesel	Diesel	Diesel	Diesel
Bow Thruster hp	none	none	2,682	none
Stern Thruster hp	none	none	2,682	none
Shaft HP	13,357	13,512	14,161	13,512
Propeller	1 Fixed	1 Fixed	2 Variable	1 Fixed
Propeller Direction	CW	CW	Inward	CW
Max Rudder	35	35	35	35

SHIP ASSIST TUGBOATS

The Port of Palm Beach has at its disposal two conventional, twin propeller tug boats. The horsepower of these tugs is 2,000 and 900 respectively. The participating shiphandlers indicate that current practice is to augment these tugs when necessary, with the more powerful tugs available at nearby Port Everglades.

Bulk Carriers, with their deep draft, and minimum horsepower propulsion, are probably the least maneuverable vessels to visit the port. Their lack of maneuverability and sluggish steering capabilities at low channel transit speeds is amplified when the vessel is in a fully loaded condition. This fact dictates the use of reliable and powerful ship assist tug boats when in the entrance channel, the turning basin, and during docking and undocking maneuvers. Discussions conducted with the participating shiphandlers, prior to commencement of simulation exercises, stressed the need for more powerful tugs for use when maneuvering the bulk carriers. A 2,000 and a 3,000 horsepower tug boat configuration was tested. This 2,000/3,000 horsepower tug boat combination proved, in the opinion of the shiphandlers, to be inadequate in the conditions tested (runs 1 thru 9). It was decided, and was demonstrated in simulations, that the current 2,000hp tug when supplemented by a 5,000hp tug boat from Port Everglades, was adequate for all required transits and maneuvers. This 2,000/5,000 horsepower tug boat combination was used for all remaining simulations utilizing the bulk carriers.

Tug boat assistance is not normally required for arriving or departing cruise vessels due to their exceptional maneuverability, therefore, assist tugs were not used for the "Norwegian Sea".

ENVIRONMENTAL CONDITIONS

Wind

Wind direction and velocity used in simulations are those winds normally experienced in the area. Average light wind situations, generally Easterly, were incorporated in exercises involving both the "Palm Beach Brewer", and the "Black Rose". Wind effects are normally minimal for a loaded Bulk Carrier. Wind velocities were slightly higher when "Norwegian Sea" was used in simulations, because Cruise vessel susceptibility to wind effects is more pronounced. Winds from the North, Northeast, East, Southeast, and South were used.

Tidal Currents

The effects of tidal currents within the entrance channel, inner channel, and turning basin play an important roll in vessel performance. Current velocities up to or exceeding 1 knot in these areas, can be challenging, especially at the minimum transit speeds dictated for a laden bulk carrier. Current direction and velocities were supplied by USACE for inclusion in simulation exercises. They are generally described as Ebb or Flood currents, and the direction and velocity of their set adjusted accordingly. Slack water (no current) conditions were also used in simulations.

Prior to the start of our 14 day examination of the Port of Palm Beach, one additional day was devoted to adjustment of these currents. An experienced Palm Beach Pilot participated in this current validation effort by operating a "Black Rose" into and out of, the port during both ebb and flood conditions. His assessment as to the effects of the current on that vessel, were the basis of our validation. Slight current modifications dictated by that effort were accomplished during that one-day session, and were used throughout the project. Currents and their perceived effect on various vessels are subjective with each shiphandler. With this in mind, currents used were made to represent average conditions, accurate in direction of set, and based on USACE provided current data in their effect on vessels.

In addition to ebb and flood current, a slack current was also used within the confines of the harbor.

Gulf Stream Currents

Immediately outside the breakwater at the Lake Worth Inlet, the entrance channel is swept by the Gulf Stream Current. This current runs from South to North at varying velocities. Participating shiphandlers report that this Northerly current can be expected to run at between 1.0 and 2.5 knots immediately adjacent to the breakwaters. The challenge for the shiphandler when entering the channel is to maintain enough vessel speed, and enough course angle to overcome the effects of this current, and at the same time, immediately slow to safe channel transit speeds.

Tidal currents of ebb and flood within the channel blend with the Gulf Stream currents immediately outside, and duplicating these effects to the satisfaction of each shiphandler proved challenging. The effective simulated resultant current produced in simulations elicited shiphandler comments ranging from too strong, to too weak. In order to overcome this difficulty, it was decided to maintain the directionality, but decrease the Gulf Stream Current to 1.5 knots at the sea buoy and taper velocity to approximately 1 knot or less at the breakwater. This adjustment enabled the shiphandlers to continue their vessel course and speed strategies, with somewhat reduced effects.

In order that the full effect of this Gulf Stream current not be overlooked however, a brief series of exercises were included in simulations, and are identified as Gulf Stream currents.

Wind and Current conditions for each exercise are identified in **Table 2 – Run Matrix** see **Appendix B**.

TEST PROCEDURES

The shiphandler operated the vessel from the simulator pilot house, which is a replica of a vessel bridge. The bridge contains all the navigation and control equipment available to the shiphandler in actual practice. An additional display was made available to the shiphandler as part of this equipment. This display provided a bird's eye view of the vessel and its position in the channel/harbor. Its' inclusion was necessitated by the fact that the Electronic Chart Display (ECDIS) did not reflect changes made by dredge plans 1 and 2. Each shiphandler was assisted by a STAR Center provided mate to carry out his steering and engine orders, and relay verbal orders to the tugboats operated by the simulator operator, via VHF radio.

The general practice, followed throughout the simulation exercises, was to brief the shiphandler, identifying wind and current conditions used in each upcoming run. Also agreed upon, were the run start position and end point prior to the commencement of each run. The shiphandler selected the vessel's starting course, speed, and tug boat placement (if used) at that time.

At the completion of each exercise run, debriefing the just completed run included the completion of a "*Run Evaluation Form*". This form solicited his opinions and comments regarding the just completed exercise. It included questions relating to: adherence to intended track line, vessel controllability, adequacy of bow thrusters (if available), effectiveness of tug boats, and overall safety and task difficulty. Following completion of all exercises, participating shiphandlers were provided a "*Pilot's Final Evaluation*" form. This form solicited specific project related questions, and provided a forum for any additional comments or remarks participating shiphandlers wished to express.

Completed copies of both these forms are attached to this report.

All inbound exercises, for the bulk carriers and "Norwegian Sea", commenced outside the inlet breakwater, just south of the PB buoy (sea buoy), or just south of channel buoy number "2". Participants stated that the shortened starting point, South of buoy "2", was more practical, and in keeping with their strategy of entering the channel at, or just west of that point.

Bulk Carrier Inbound/Outbound Exercises

Inbound transits for "Palm Beach Brewer" and "Black Rose" ended when the vessel was parallel to Slip 3, slowed, and under comfortable control of the shiphandler. Both bow in and bow out approaches were examined. Shortened inbound runs concluded when the vessels cleared the inner channel turn at dredge Area C.

All outbound runs commenced in Slip 3 with mooring lines released, and ended at the entrance breakwaters. Both bow in and bow out departures were examined.**

Cruise Ship Inbound/Outbound Exercises

Inbound transits for "Norwegian Sea" ended when the vessel was parallel to Slip 1, slowed, and under comfortable control of the shiphandler. Both bow in and bow out approaches were examined. A number of shortened inbound runs were also conducted with "Norwegian Sea", and ended when the vessel cleared the Inner Channel turn at dredge Area C.

All outbound runs commenced in Slip 1 with mooring lines released, and ended at the entrance breakwaters. Both bow in and bow out departures were examined.

DATA COLLECTION

Track plots are a visual representation of vessel position, trajectory, and track history. After each simulation run a track plot was recorded. Also recorded and archived, was a parameter log, a numerical dataset listing items such as vessel heading, course and speed, information relating to control settings, and the resultant forces acting on the vessel.

STAR Center's staff maintained observation notes and discussed results with the participating shiphandlers after each test run. Simulator specific factors that might influence the interpretation of results were noted and taken into account when evaluating results.

These track plots and numerical dataset were used in post-project analysis, in conjunction with "Run Evaluation Forms", "Pilot Final Evaluations" and observation notes.

Copies of theses track plots, "Parameter Logs", "Run Evaluation Forms", and "Pilot Final Evaluations" are attached to this report.

**Note: One inbound and one outbound "special run" were conducted in the Existing Channel using "Black Rose" in a ballasted condition. With a maximum draft (aft) of 25.6 feet, these runs were completed successfully. These runs are identified as 55B and 56B in the Matrix table (see Appendix B). Their successful completion briefly demonstrates the fact that vessel draft, not vessel length, is the major limiting factor in safe access to the port.

FINDINGS

Dredge Depth

The fact that channel and harbor dredging would be required to provide safe access for "Palm Beach Brewer", and "Black Rose", each with a loaded draft of 40.02 feet, was apparent from the start of our examination given that the controlling depth of the channel is less than the deep draft of these ships. The depth of dredging would be dictated by the fact that approximately 3.28 feet of under-keel-clearance is normally accepted as the minimum clearance required for safe maneuvering when operating slower than approximately 5 knots of vessel speed. Common practice dictates that dredge depths should therefore be at least 43.3 feet, as per standard guidelines. Simulations indicate that a 43.3 feet depth proved to provide adequate and safe under-keel-clearance for vessel operations when in the turning basin and in the inner channel where slow speeds were maintained.

In the entrance channel however, shiphandlers use speed and drift angle[1] to overcome the North setting effects of the Gulf Stream current. Speeds of approximately 7 to 8 knots were used in simulations, and are considered conservative speeds to overcome these effects. These higher vessel transit speeds, with resultant squat[2], increase depth requirements. "Palm Beach Brewer", for instance, at a 7 knot speed would increase its draft by approximately 1.31 feet. "Black Rose" is in the same range. Depth in the entrance channel during simulations was 46.26 feet for this reason, and provided ample under-keel-clearance in all conditions tested.

Simulations involving the operation of "Norwegian Sea" contributed little to the determination of channel and turning basin depths. Its 22.31 feet draft easily maneuvered in the tested channel depths of 43 and 46 feet.

Channel and Turning Basin Widths

The limits of channel widening are determined by observation of usage of these areas, and the comments of the participating, experienced mariners.

Both **Plan 1** and, to a lesser extent, **Plan 2** provide widening in areas critical to vessel operations, as identified by planning engineers in consultation with participating shiphandlers.

The use of those areas in ebb, flood and slack water conditions, and the extent of that use, were examined here. Both of the bulk carrier vessels and the cruise vessel are affected by channel and turning basin widening and each contributed to our findings.

[1] Drift Angle – or crab angle, the angular difference between course steered and the course made good.
[2] Squat– is the increase of a vessels draft due to the effects of its speed through the water.

"Norwegian Sea" results demonstrated maneuvers unassisted by tug boats, but it cannot be stressed enough that both "Palm Beach Brewer" and "Black Rose" results depend heavily on maneuver assistance provided by the 2,000hp and the 5,000hp tug boats used in simulations. These tug boats are called into service, during average weather conditions, when an arriving vessel is inside the breakwaters. In the case of both bulk carriers, their first, and primary use, involves slowing the vessels speed prior to entering the turn at the inner channel.

The turning basin, after run 18, included the addition of moored vessels along the pier faces just south of slips 1 and 3. This was done in order to evaluate available maneuver room when these berths may be occupied, and as a worse-case scenario for shiphandlers.

RESULTS

Expansion Areas

Area A1 **–** Used in almost all simulation runs for all three vessels. Its' recommended dredging is based on the shiphandlers' preferred strategy for approaching the entrance channel at that point, as opposed to entering at or near the sea buoy. This area is subject to greater drift angle to overcome effects of the Gulf Stream Current. A 10 degree drift angle, seen in some simulations, can produce an increased swept path of as much as 230 feet wide for the bulk carriers.
Advantage: provides a much wider channel entrance. It adds maneuver room. It is consistent with shiphandlers entrance strategies.
Comment: Would remain unmarked as part of the channel. No visible navigation aid to identify this area.

Area B1 **–** Expands and widens the entrance channel areas Southern boundary adjacent to the south breakwater.
Advantage: Wider channel.
Comments: Rarely used for transits.

Area B2 **–** Widens the usable entrance channel area, especially in an area where Gulf Stream currents may set a vessel North of the intended center channel approach.
Advantage: Gives shiphandlers additional maneuver room for safety. Increased channel width (especially North side) provides additional maneuver room at a time when course angle, used to compensate for Gulf Stream set effects is most likely.
Comments: Any channel width increase in this area will improve the margin of safety.

Area C **–** Widens and provides needed maneuver room at a critical point in the inner channel to slow and turn the vessel. Provides maneuver room for attending tug boats to assist in this maneuver.

Advantage: Adds to overall safety. It is a necessity for inbound and outbound Bulk Carriers.
Comments: Most used area of the Plans. It is critical for vessel and tug boat maneuverability. Of the 38 inbound runs conducted with “Palm Beach Brewer”, 32 required the use of Area C.
Inbound and Outbound runs by “Black Rose” demonstrated similar run to area usage ratios.

Area D **–** Increases the approach and turning room for “Norwegian Sea” when using Slip 1 while docking or undocking.
Advantage: Added safety, especially when turning.
Comments: Of the 24 inbound and outbound runs conducted in plans 1 and 2, Area D was entered or brushed 19 times.

Area F **–** Increases the width of the turning basin by expanding the Eastern boundary.
Advantage: Added turning area maneuvering room.
Comments: This area was rarely used, even with the inclusion of moored vessels at the pier causing a further restriction of usable turning and maneuver space.

Area G **–** Used sparingly by inbound vessels to Slip 3 when arriving bow in. When backing from the slip in the bow in configuration, however, use of this area was most critical.
Advantage: Increased room to turn and increased tug boat maneuver room to assist, especially when backing from slip.
Comments: Backing from the slip in bow in configuration demonstrated a need for this area. Area G was used 5 of the 6 runs requiring backing out and turning. Representations of Area G usage are presented in **Figure 4 – Area G Usage** below.

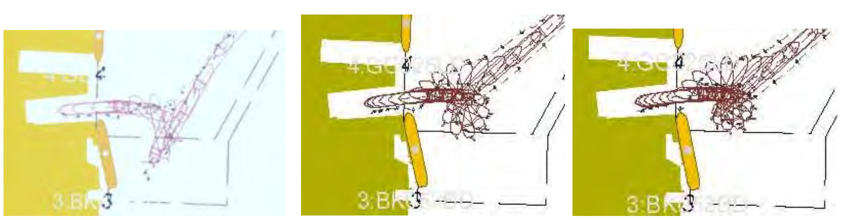

Image 1- Run 22 Image 2- Run 26 Image 3- Run 24

FIGURE 4 – Area G Usage

Image 1 depicts entry into G in run 22. Image 2 depicts slight entry in run 26, and finally, Image 3 depicts results of run 24, when the shiphandler was asked to avoid the area if possible.

The above areas are identified in Plan 1. Plan 2, however, presented a slightly less extensive scope to dredging in these areas, and eliminated completely Area B1 expansion. The advantages and brief comments presented with each area are the result of simulation observation and discussions with the participants.

Use of the expanded areas in Plans 1 and 2 was about the same. As can be expected, shiphandlers utilized the expanded area presented by Plan 1 when it was available, but their comments and simulator performance indicate that Plan 2 areas are adequate for all maneuvers, in the conditions tested. Evidenced in simulation, was the fact that no groundings, or unsuccessful transits were directly, or solely attributed to the reduced areas offered by Plan 2.

CONCLUSIONS

In this study we examined and evaluated the safe access of two bulk carrier vessels, and one cruise vessel to the Port of Palm Beach, via the Lake Worth Inlet channel modified by one of two prospective plans. The participation, cooperation, and patience of the Palm Beach pilots during the many simulation runs conducted during this project, ensured a practical look at plan impact on the mariner. Their comments and simulation results are the basis for the conclusions and recommendations expressed in this report.

Bulk Carriers

The modifications offered by both Plans 1 and 2 each provide the required elements of increased channel width to support "Palm Beach Brewer", and "Black Rose" safe access, during all conditions of wind and tidal currents tested. Both Plans were based on a dredged depth of 46 feet in the entrance channel, and 43 feet in the inner channel and turning basin. Simulations indicate that these depths do provide ample under-keel-clearance for safe transit and maneuvers of both vessels.

The locations selected as channel and turning basin widening points were obviously the result of thoughtful and appropriate pre-planning recommendations. As can be expected however, some areas were more important to the shiphandlers than others. Only two areas, identified in the plans as Areas B1 (Plan 1) and F (both Plans), were under-used and less critical for the participants in the exercise runs conducted.

Inbound transits, when transitioning from the Gulf Stream current to the entrance channel, are challenging for the shiphandler due to their pronounced effect on these vessels, but the assistance of powerful tug boats can ameliorate this situation.
There was little evidence in simulations that vessel transits and maneuvers were limited or adversely impacted by ebb, flood, or slack water conditions in either plan.

Cruise Vessel

"Norwegian Sea" took little advantage of plan designs, except in the area in both Plans 1 and 2, identified as Area D. The expansion of dredging at Area D would provide some measure of safety for this vessel. The shoal area represented by Area D, if eliminated, would allow maneuver room should a Northerly set of the current effect the docking and undocking vessel. Any widening of the entrance and inner channel, designed to accommodate the bulk carrier vessels, would benefit this vessel, but is not necessarily delineated by it.

RECOMMENDATIONS

Expanded dredge areas presented in Plan 2 are adequate to support safe access by "Palm Beach Brewer", "Black Rose", and "Norwegian Sea", in all conditions tested.

A depth of 46 feet in the entrance channel does support safe vessel maneuvers.
The 43 feet in the inner channel and turning basin did support adequate maneuvers for all three vessels, in the case of the bulk carriers however, 3 feet under-keel-clearance provided no margin for safety. It is noted that participating shiphandlers assert that 10% (4 ft.) under-keel-clearance is necessary for safe operations in the harbor. This is not an uncommon practice, or rule of thumb at many ports. We concur with an inner channel and turning basin depth of 44 feet.

Simulations indicate that Area F expansion, even with the presence in simulation of moored vessels (further restricting maneuver and turning room) be eliminated as unnecessary.

##

Appendix A: Engineering

Attachment C: Geotechnical

LAKE WORTH INLET
Palm Beach Harbor

USACE JACKSONVILLE DISTRICT

Attachment C
Geotechnical

NAVIGATION STUDY FOR
LAKE WORTH INLET, FLORIDA

INTEGRATED FEASIBILITY REPORT
AND ENVIRONMENTAL IMPACT STATEMENT

APPENDIX A
ENGINEERING

July 2013

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APPENDIX:

1 BACKGROUND

This section covers the historic and recent geotechnical information relevant to this project. Geotechnical investigations were conducted throughout the years for deepening projects as well as for maintenance dredging. Therefore a variety of historic data, such as boring logs and wash probe data are available and date as far back as 1962. Most historic borings reach below the recent maximum dredging depth, and are therefore viable data of the subsurface conditions of the proposed project. . In addition vibracore borings were advanced in June 2012. However, for the construction phase additional investigations will be required to characterize unknown areas and to define the material to greater depths in case blasting is needed.

This report includes a description of the regional and local geology, a description of the subsurface condition of the proposed widening and deepening design, and a jetty stability analysis. All borings included in this study are listed in **Table 1** and depicted in **Plates 1 through Plate 4**. Boring logs and laboratory results are attached in the **Appendix**.

The results of this geotechnical study are summarized and graphically depicted in **Plate 5.**

2 REGIONAL AND LOCAL GEOLOGY

Palm Beach County is made up of three physiographic areas: The Atlantic Coastal Ridge, the sandy flatlands and the Everglades. The formations exposed at the surface include sand, coquina and limestone deposited during the glacial epochs starting 1 to 2 million years ago.

Gray or white surface Pamlico sands mantle all of Palm Beach County east of the Everglades, except in the Loxahatchee marsh area where organic soils cover the surface. The surface sand is about 10 feet thick along the coastal ridge and the barrier beaches that are separated from the mainland by the Intracoastal Waterway. In the dune areas this sand attains a maximum thickness of about 50 feet.

Below the surface sands follows the Anastasia formation composed of sand, sandstone, limestone, coquina, and shell beds. The Anastasia Formation underlies all of eastern Palm Beach County from the beaches, where it can be up to 200 feet thick, to the edge of the Everglades, where it ranges from 40 to 50 feet.

Subsequent formations include the Tamiami, Hawthorne, Tampa, Suwannee limestone, Ocala Group and the Avon Park limestone.

3 MATERIALS ENCOUNTERED

3.1 Entrance Channel, Area A-1 and Area B-2

The Entrance Channel Area A-1 and Area B-2 analysis includes historic core borings from the 1960's and 1995, and nine (9) recent vibracore borings (VB-LWI12-01 through VB-LWI12-08, and VB-LWI12-20E). Due to the age of the historic borings, much of the material has been removed. However, they give indications of material in nearby areas that have not been dredged and have no core borings. In addition, the core borings extend below the current channel depth of -35 and -37(+2 ft allowable) MLW, usually to -42 or -43 MLW making them viable borings. Along with the borings taken in 1995, twenty-two (22) wash probes (WB-PBH95-1 through WB-PBH95-22) were taken to define the top of rock. Borings obtained by the Town of Palm Beach (sponsor supplied borings) were also used to characterize the materials encountered.

The Entrance Channel, Area A-1 and Area B-2 can be divided in two portions based on the materials encountered:

1. The Entrance Channel and Area B-2 up to Station 45 and Area A-1 consisting of unconsolidated sediments.
2. The Entrance Channel and B-2 from Station 45 to Cut 1 consisting of rock.

Both areas are described in the following chapters. Boring locations are depicted in **Plate 2 and Plate 3.**

3.1.1 Entrance Channel and B-2 up to Station 45 and Area A-1

Unconsolidated material is present in the Entrance Channel and Area B-2 from Station 00 to Station 45. The material is composed of clean, gray, fine to medium grained, poorly graded quartz sand with trace to some small shell fragments. The sand does pack tightly with depth making it dense. The sand is primarily material that has shoaled in from the adjacent beaches and has less than 5% silt and is beach quality. Wash probes which were advanced to a maximum depth of -52 ft, and the recent vibracore borings show that this type of material extends to a minimum depth of -51 ft MLW in this portion of the channel.

Area A-1 can be characterized through field results of the recent vibracore borings (VB-LWI12-01 and VB-LWI12-02) and the borings in the channel nearby but also by the jetty extension core borings CB-LWI-SJ01-3 and CB-LWI-SJ01-6 which were advanced to –61.9 feet MLW and –52.2 feet MLW respectively. Unconsolidated sediments were encountered to 58.9 ft. MLW followed by rock in boring CB-LWI-SJ01-3 and to the end of the boring at 52.2 ft. MLW in boring CB-LWI-SJ01-6. The unconsolidated sediments consist of fine to medium grained sand with shells and a silt content of less than 5%.

Rock appears to drop off from the barrier island rapidly as shown by CB-LWI-SJ01-3 where rock was encountered at -58.9 feet. However, gravel to cobble size rock fragments can be expected in the overdepth and advanced maintenance depths.

3.1.2 Entrance Channel and B-2 from Station 45 to Cut 1

Rock is encountered at approximately -41 MLW from Station 45 throughout the rest of the Entrance Channel to Cut 1. Near Station 45 the rock is initially present in thin layers as seen in CB-38, but increases in thickness rapidly to be massive throughout the rest of the Entrance Channel to Cut-1. Rock is shown in borings CB-2, CB-3, CB-4, CB-5, CB-14, CB-22, CB-23, CB-43 and CB-44 and also in the recent vibracore borings VB-LWI12-06, VB-LWI12-07, and VB-LWI12-08, and in various rock probes. The borings extend to approximately -43 MLW and it is not known what the lithology is below this depth. The rock is described as a limestone or sandstone being moderately hard to hard, fossiliferous, porous, permeable, very friable, shelly and sandy with 10% to 50% calcareous matrix. It is often referred to as "coquina" and is part of the Anastasia Formation. Although most of the rock shown on the boring logs has already been dredged from the channel without blasting to -36 to -40 ft. MLW, without additional deeper borings it can't be determined if this type of material continues..

The material encountered in the proposed widening area B-2 north of the entrance channel is represented in 2 sponsor supplied core borings (DM-3 and DM-4) which were performed in 1996 for the sand transfer plant by the Town of Palm Beach. The report includes a total of six borings (named B-1, B-

2, DM-3 DM-4, DM-5, and DM-6) and is included in the **Appendix**. Only descriptive locations were given for those borings therefore the plotted locations on **Plate 2** are approximate. These borings together with boring CB-4 and CB-43 located at the northern edge of the Entrance Channel verify the extension of the rock having a top elevation of approximately -25 ft. MLW. Unconfined compressive strength tests (UCS) performed on the rock from boring DM-3 ranging from 4545 pounds per square inch (psi) to 303 psi. The average strength for the boring was 1400 psi. The test with 4545 psi seems to be an anomaly from the rest of the area indicating an isolated dense layer at 30 feet and boring descriptions indicate it is only one foot thick. This layer may also occur in other areas, further supporting the allowance of blasting. All test results are included with the sponsor supplied boring logs in the **Appendix**.

3.2 Settling Basins

The current footprint of the Settling Basins is depicted in **Plate 5** and consisting of Settling Basin, Extended Settling Basin, and Expanded Settling Basin has currently an elevation of -10 to -30 ft. MLW. It is planned to dredge all Settling Basins to an elevation of -33 +2 ft MLW during the next dredging event in winter 2012.

Borings CB-LWI-PSB01-1 thru CB-LWI-PSB01-9, CB-LWI-SB01-1 thru CB-LWI-SB01-4, CB-PBH95-4 and CB-PBH95-5 are located in the footprint of the current Settling Basin Design. The borings were drilled to a depth of -35 ft. MLW. The material consists of sand and silty sand with a trace to some small shell fragments. In borings CB-LWI-PSB01-4, and CB-LWI-PSB01-7 through CB-LWI-PSB01-9, silty sand is encountered with silt contents as high as 22%. Wash probes were advanced in the Settling Basins showing no rock to -44.4 ft. MLW. The only rock encountered was in boring CB-LWI-PSB01-1, located in the upper northwest corner, where hard, vuggy, fossiliferous limestone was found at -30.9 MLW. The boring terminated in the rock at -35 MLW.

The material in the South-Eastern Portion of the Proposed Settling Basin (see Plate 5) consists of beach and nearshore compatible sands and silty sands to a depth of -35 ft. MLW.

No borings have been drilled in the North Western Portion of the Proposed Settling Basin (see Plate 5), and the character of materials is not known.

3.3 Cut-1, Cut-2 and Area C

All of the core borings in Cut 1 and Cut 2 are from 1962 and 1964. Due to the age of the borings, much of the material has been removed. However, they give indications of material in nearby areas such as Area C that have not been dredged and have no core borings. In addition, the core borings extend below the current channel depth of -35 (+2 ft allowable) MLW, usually ranging from -41 to -43 MLW making them viable borings for characterizing the material. Results from the recent vibracore borings in Cut-1, Cut-2 and Area C (VB-LWI12-09 through VB-LWI12-12) give additional information. All boring locations for Cut-1, Cut-2 and Area C are depicted in **Plate 3**.

3.3.1 Cut-1 and Cut-2

The unconsolidated material within Cut-1, Cut-2, and Area C consists of, gray, fine to medium grained, poorly sorted quartz sand with less than 5% silt passing the #200 sieve. The shell content varies from a trace to some small shell fragments. The sand is primarily material that has shoaled in from the adjacent beaches and is beach or nearshore quality.

With lower depths of Cut 1 and Cut-2 rock is present as a continuance of the Entrance Channel. The rock contains less shell and is primarily sandstone that is hard but very porous, permeable and friable with a low degree of cementation. The rock becomes less massive and is often layered with clean quartz sand as Cut-2 approaches the Turning Basin. Borings CB-18 and CB-20 show thick sand layers (> 5feet) underneath the rock at -35 and -38 ft MLW respectively and borings CB-19, CB-21, and VB-LWI2012-11 terminate in rock at the deeper depths but contained sand deposits above. This leads to the conclusion that the geology toward the turning basin changes from massive rock to interfingering layers of rock and unconsolidated sediments. Therefore excavation of the rock should become easier in Cut-2 due to a lower percentage of rock and influx of sand.

3.3.2 Area C

Area C is situated immediately north to Cuts 1 and 2. Three recent vibracores (VB-LWI12-09, VB-LWI12-10, and VB-LWI12-12) have been advanced to -24, -16, and -57 ft. MLW respectively. Borings VB-LWI12-09 and VB-LWI12-10 with shallow top elevations of -22 and -13 ft. MLW respectively, refused in rock after 2 to 3 feet. The rock is composed of hard to moderately hard sandstone and limestone. Vibracore boring VB-LWI2012-12 located closer to the turning basin with a top elevation of 38.5 feet MLW revealed the presence of sand, and silty sand underlain by rock at a depth of 51.9 feet. This supports the conclusion that the geology toward the turning basin changes from massive rock to interfingering layers of rock. Overall rock is predominant throughout Area C, resembling the conditions of Cut-1 and Cut-2 described above and may need blasting for removal pending equipment used.

3.4 Turning Basin, Area-D and Area-G

Seven (7) vibracore borings (VB-LWI12-13 through VB-LWI12-19) have been collected in 2012 in the Southern Turning Basin, Area-D and Area-G. In addition core borings from 1965 give viable information about the dredged materials, even though most of the surficial material has been removed the core borings extend below the current depth of the turning basin, usually ranging to -41 to -43 MLW. In addition, those borings give indications of the material still in place in Area D and Area G which never have been dredged. The 2011 hydro survey shows elevations between -33 to -39 ft. MLW in the Turning Basin, between -7 to -33 ft. MLW in Area D, and -5 to -30 ft. MLW in Area G. Boring locations for the Turning Basin, Area-D and Area G are depicted in **Plate 4.**

3.4.1 Turning Basin

The majority of the material in the Turning Basin is interfingering layers of sand and silty sand with limestone and calcareous sandstone layers throughout. The rock can be present in thin beds or in 1 to 2 foot thick layers and is usually moderately hard, highly fractured and filled with sand seams. Unconsolidated, beach compatible material composed of gray, fine to medium grained, poorly sorted quartz sand with trace to little silt and trace to some small shell fragments is present to -42 ft MLW in the north western portion of the Turning Basin (VB-LWI12-16, CB-29).

White milky turbidity plumes were observed in the water during vibracoring especially in the western portion of the Turning Basin.

3.4.2 Area D

Area D is located just south of Peanut Island and has never been dredged. One vibracore boring (VB_LWI12-14) was advanced to -42 ft. MLW in this area. Historical core borings CB-28, CB-31, and CB-

34 are located immediately adjacent of Area-D in the Turning Basin and extend vertical from approximately -17 ft. MLW to -41 ft. MLW. The material encountered consists of gray sand and silty sand to approximately -33 ft. MLW followed by interfingering layers of sand with rock similar to what was encountered in the rest of the Turning Basin.

3.4.3 Area G

Area G is located immediately south of the Turning Basin. Two vibracore borings VB_LWI12-18 and VB_LWI12-19 were advanced in Area G to -37.1 and 39.7. ft. MLW respectively. Nearby borings CB-30, CB-33 and CB-37 extending from -7 ft. MLW to -46 ft. MLW give additional information. The material encountered in vibracore boring VB-LWI12-19 consists of gray sand and silty sand to an approximate elevation of -38.5 ft. MLW, followed by soft limestone to the end of the boring at -39.7 ft. MLW. Vibracore boring VB-LWI12-18 located in the eastern portion of Area G encountered gray sand and silty sand to -27.1 ft. MLW followed by soft sandstone to the end of the boring at 37.1 ft. MLW. The rock layers are very soft and were easily penetrated by the vibracore unit.

4 BENEFICIAL USE OF DREDGE MATERIAL

4.1 Beach and Nearshore Placement

Dredged material from maintenance dredging of the entrance channel and the current settling basins has been continually place at the beach and in the nearshore. The unconsolidated material from the Entrance Channel, Area A-1, Area B-2 to STA 45 is composed of clean, gray, fine to medium grained, poorly graded quartz sand with trace to some small shell fragments and is also beach quality.

The material at the beach consists of sands composed of mostly fine to coarse grained sand-sized quartz and some medium sand sized sub angular shell fragments. Three core borings (CB-LWI99-1 thru CB-LWI99-3) advanced at the beach south of the Entrance channel provide additional information of the beach material. The material present in the Entrance Channel, Area A-1, Area B-2 to STA 45 as described above is compatible with that on the existing beach.

The logs and laboratory data of the beach borings are included in the **Appendix**.

4.2 Beneficial Use for Sea Grass Mitigation

A minimum of 45,000 cubic yards (cuyd) of sand and silty sand with less than <15% fines from Area G and the Turning Basin will be available for beneficial use as sea grass mitigation capping material.

5 JETTY STABILITY

Purpose
A slope stability analysis was performed for the Lake Worth Inlet project to determine if the proposed dredging design template would impact the stability of the existing jetties located to the north and south sides of the proposed dredging.

Slope Stability Analysis Software
The slope stability analysis was performed using SLOPE/W with models created using cross-sections taken along the channel stationing. The existing condition of both the north and south jetties were then analyzed for both the existing template and the proposed design template. SLOPE/W is a component of the software suite GeoStudio, created by Geo-Slope International. The version used in the analysis was, GeoStudio 2004 (Version 6.22).

Existing Jetty Conditions

Foundation Elevation: Per a letter titled "Town of Palm Beach 1986 CCMP Chapter 5 Lake Worth Inlet.pdf", the initial construction of the jetties is described as follows:

> Lake Worth Inlet was originally constructed in its present location between 1918 and 1925 by the Lake Worth Inlet District as part of the Port of Palm Beach development. Initially the inlet was 750 feet wide with a 300 foot wide dredged channel and a project depth of 15 to 18 feet MLW. Two rubble mound jetties 750 feet apart were constructed and extended to the 21-foot depth contour as it existed at that time. The North and South jetties were 1700 and 2150 feet long, respectively.
>
> In 1934 the Federal Government authorized funds to maintain a 16 foot inlet channel. The Corps of Engineers assumed responsibility for the maintenance of the inlet under the authorization of the River and Harbor Act of August 30, 1935.

Extending to the "21-foot depth contour" was interpreted to mean that the seaward extent of the jetty structure (i.e. the seaward toe of jetty) terminates at elevation -21.0 feet MLW (-23.5 NAVD88).

Archived USACE plans for proposed repairs to the north jetty dated 1934 depict raising the crest elevation, and consequently widening the cross-section of the existing jetties. Unfortunately, they do not note the jetty foundation elevation since the stone was placed on top of the existing jetty which was constructed between 1918 and 1925.

The models developed for slope stability analysis, assumed the foundation of the jetty to be at elevation -21.0 feet MLW (-23.5 feet NAVD88). All elevations for the purposes of the Geotechnical analysis herein are referenced to NAVD88. The final plans and specifications will be referenced in the project datum, MLLW.

Profile Geometry: The archived USACE plans for proposed repairs to the north jetty dated 1934 also show the north jetty side slopes at one foot vertical to two feet horizontal along alignment and one foot vertical to three feet horizontal at head of the jetty as the crest tapers down seaward, terminating at 21-foot (MLW) depth contour as stated in the referenced document above. The geometry for the channel and existing side slopes were determined by hydrographic and topographic surveys which were merged to display a complete surface of the channel as well as the north and south jetties. The initial mapping was submitted to the USACE on March 29, 2002 by Charley Foster and Associates, Inc. The survey length was approximately 4000 feet, extending to the east 200 feet of the jetties and terminating in the west where the north jetty turns to the north.

Existing Jetty Stability

A. South Jetty: The 2002 survey showed an area extending from approximately STA 42+50 (the jetty toe) to STA 45+50. This area contained existing side slopes steeper than one foot vertical to two feet horizontal. Since the exact elevation of the bottom of the jetty foundation at these locations was not defined by the survey or any other know documentation, SPT borings in the vicinity were used to estimate this material to be high blow count sand. Due to the unknown jetty foundation location as described above, the most conservative analysis was performed, assuming that between elevation -23.5 and -30.0 the material was high blow count sand and not jetty stone. The results indicated that at this isolated area, the south jetty in its current state has an inadequate factor of safety.

B. North Jetty: The 2002 survey indicated no specific areas of concern where slopes were less than 1 foot vertical to 2 feet horizontal. Analysis found that the jetty is stable in its current state.

With Project Conditions

Modeling Approach

Slope stability analysis was completed for Lake Worth Inlet to determine if the dredging limits would impact jetty stability. Model geometry was based on the survey data and historical records mentioned above.

Models were created at critical stationing for the north and south jetties. Critical stationing was defined as areas where the channel footprint would come closest to the jetties. Once models were completed, it was determined that an additional 15’ horizontal bench should be added to the toe of the jetty as an additional safety measure. This was completed due to the somewhat uncertain nature of dredging accuracy. The jetty outline, with the additional 15’ horizontal bench, became the jetty template that was used throughout the analysis. The jetty template was then added to cross sections. Figure 1 shows the jetty templates, the existing surface, and the design surface.

Per guidelines in the USACE manual Geotechnical Engineering in the Coastal Zone dated 1987, coastal embankments (structures) shall have safety factors of or greater than 1.5.

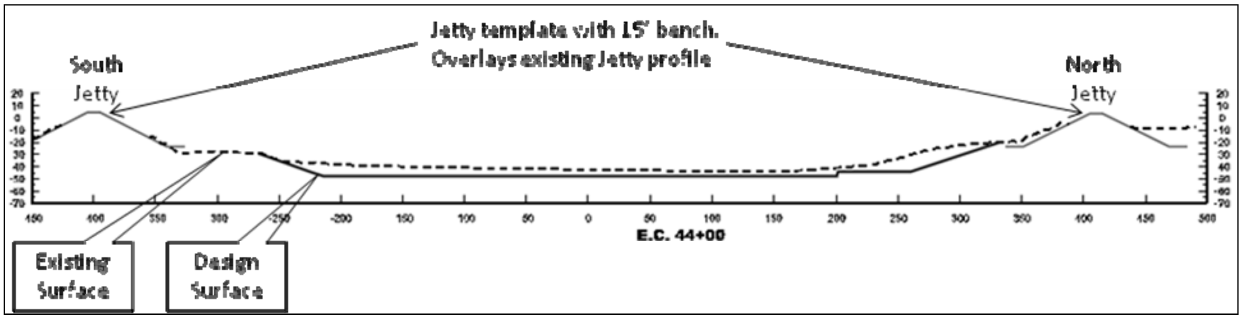


Figure 1. The jetty templates, the existing surface, and the design surface.

<u>Model Parameters</u>
Model parameters were based on estimates from existing core boring and vibracores obtained adjacent to the jetties. Detailed information regarding the data collected can be found above under Section 2 titled "Investigations". Soil parameter estimates were based on SPT blow counts, geologist's description of material, and past experience modeling similar materials. Values used in analysis are listed below.

	Unit Weight	Cohesion	Phi
Jetty (Rock)	150	0	40
Unconsolidated Sediments (Sand)	120	0	32
Interfingering Unconsolidated Sediments (Rock)	135	0	40

South Jetty

For the existing conditions, as mentioned above, model results showed an inadequate factor of safety from the jetty toe (STA 42+50) to approximately STA 45+50. This is due to existing steep side slopes from elevations approximately -23.5 to -30. The design channel did not impact jetty stability since the dredged template meets the existing surface approximately 50' north of the steepened areas. Figure 2 shows the factor of safety within this stationing and demonstrates that the dredged channel will not impact the existing southern jetty.

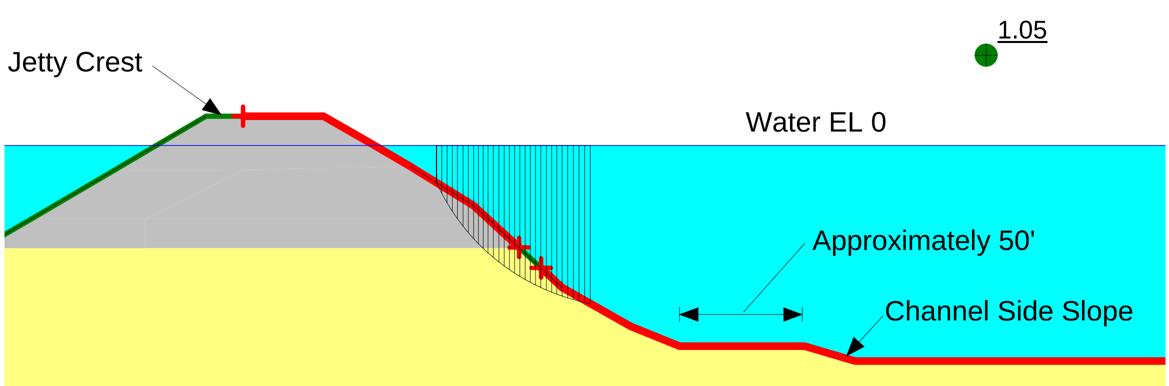


Figure 2. Unsatisfactory FS of existing Southern Jetty

North Jetty

Model results showed an adequate factor of safety greater than 1.5 for existing conditions (Figure 3). Once existing conditions showed satisfactory, the proposed design template was evaluated so that it didn't infringe on the jetty template. The settling basins that borders the jetty tip to the north, east, and south were also evaluated to determine their effect on jetty stability.

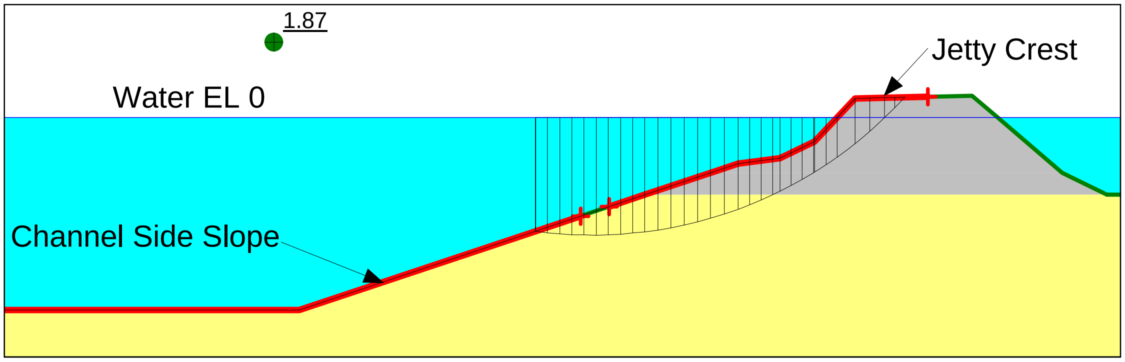


Figure 3. Adequate FS of existing Northern Jetty

Where the channel overlapped the jetty template (STA 39+00 to 44+00), the channel was either adjusted or jetty stabilization measures were implemented. Where channel adjustments were made, advanced maintenance was eliminated.

An abbreviated area, from approximately STA 38+75 to 40+75, required advance maintenance due to the vast amount of sand that shoals around the jetty tip. For this area a jetty stabilization feature will be implemented approximately 330 feet from the centerline of the channel. The jetty stabilization feature consists of a sheet pile wall placed near the jetty toe. This feature will prevent the jetty foundation from sliding into the dredged channel. Due to a lack of geotechnical data, the stabilization feature was preliminarily evaluated using CWALSHT, a sheetpile analysis and design program, with all the input parameters being estimated based on the best available data. Based on this analysis, a PZC-26 sheet extending to elevation -60.0 is recommended to stabilize the existing jetty. This preliminary evaluation was performed in order to provide sufficient detail to have the feature priced. Design details such as the exact location, width, depth, and sheet pile type will need to be refined at the PED phase using actual design values from the geotechnical exploration. Figure 4 depicts the profile of the jetty stabilization measure. Values used in analysis are listed below.

	Unit Weight	Cohesion	Phi
Jetty (Rock)	140	0	40
Unconsolidated Sediments (Sand)	125	0	32

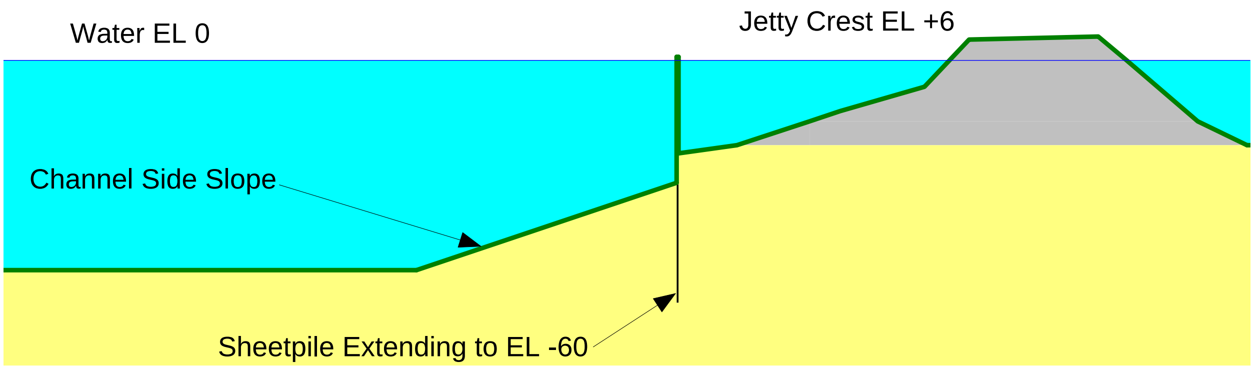


Figure 4. Depiction of the north jetty with stabilization feature.

Dredging Limits for Settling Basin

The configuration for the settling basin was optimized to capture the maximum amount of sand before it enters the entrance channel. Details of the analysis can be found in the Hydrodynamic and Sediment Transport Modeling within the Engineering Appendix. The sediment transport analysis determined that it would be highly beneficial if the basin could be moved as close as possible to the northern jetty. The north, east, and southern areas of the northern jetty were evaluated in SLOPE/W to ensure this dredging would not negatively impact the jetty. The northern and eastern borders of the jetty and settling basin intersect were acceptable as can be seen in Figure 5. This was due in large part by the shallow depths required within the settling basin. The southern border of the jetty required the stabilization feature (sheet pile) due to the deeper settling basin dredged depth and its closer proximity.

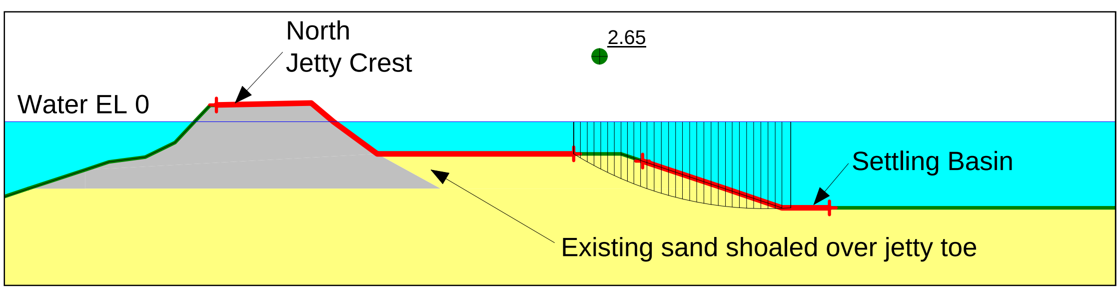


Figure 5. Adequate FS of north and eastern borders of existing Northern Jetty bordering the Settling Basin

Table 1

Lake Worth Inlet: List of Borings and Washprobes

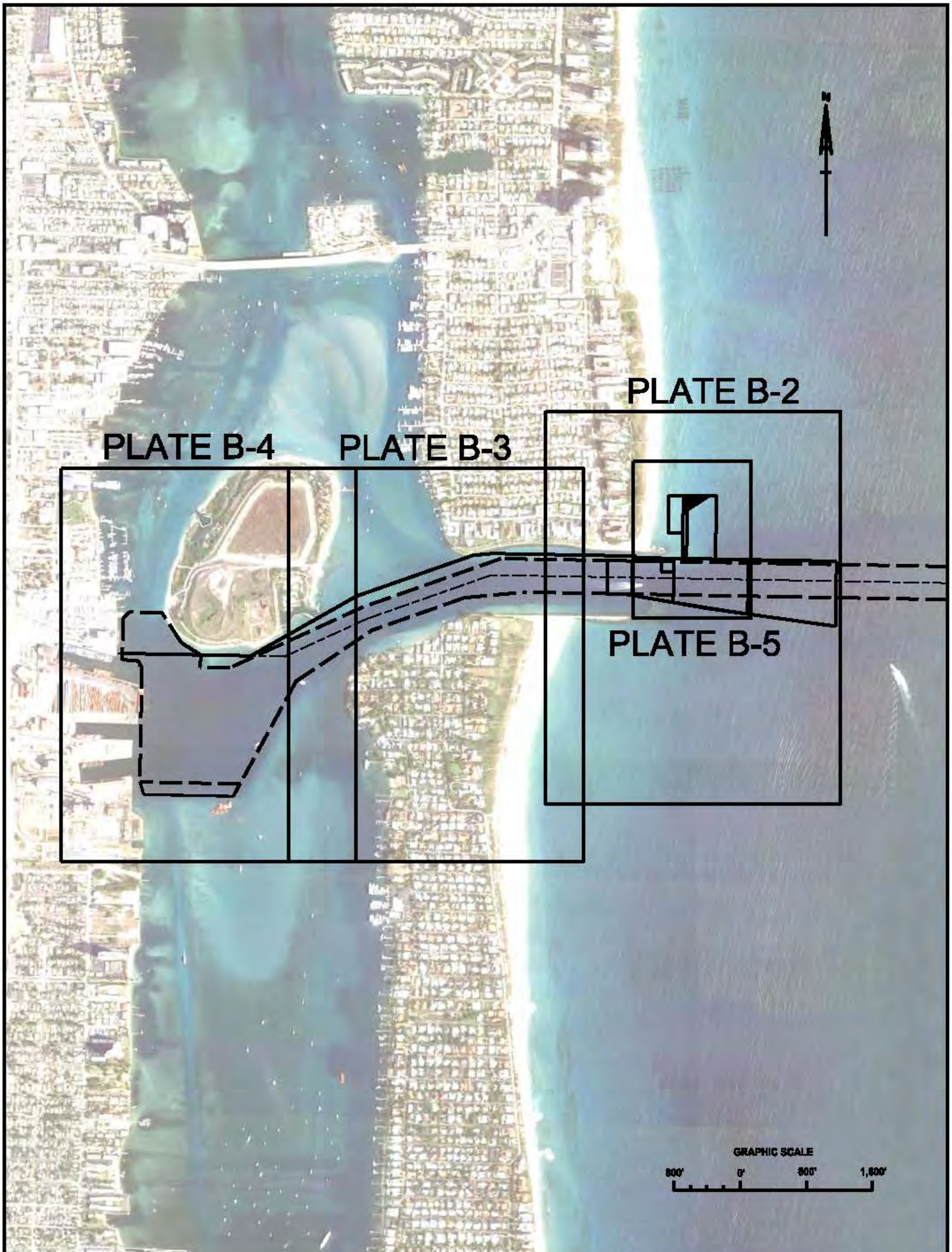
BORING	Type	NAD27		NAD83		Bottom of Boring	Area
		X	Y	X	Y		
CB-1	CB	815,920	887,550	972157	887713	42	Entrance Channel
CB-2	CB	815,120	887,590	971357	887753	43.3	Entrance Channel
CB-3	CB	815,125	887,285	971362	887448	41.7	Entrance Channel
CB-4	CB	814,410	887,700	970647	887863	42	Entrance Channel
CB-5	CB	814,270	887,405	970507	887568	42	Entrance Channel
CB-14	CB	814,440	887,590	970677	887753	42.5	Entrance Channel
CB-22	CB	814,915	887,575	971152	887738	42.4	Entrance Channel
CB-23	CB	814,370	887,360	970607	887523	43.4	Entrance Channel
CB-38	CB	815,380	887,560	971617	887723	42.8	Entrance Channel
CB-39	CB	815,730	887,485	971967	887648	43.2	Entrance Channel
CB-40	CB	815,880	887,620	972117	887783	43.1	Entrance Channel
CB-41	CB	816,780	887,600	973017	887763	42.8	Entrance Channel
CB-42	CB	817,320	887,600	973557	887763	42.5	Entrance Channel
CB-43	CB	814,700	887,690	970937	887853	42.5	Entrance Channel
CB-44	CB	814,680	887,320	970917	887483	41.6	Entrance Channel
CB-PBH95-1	CB	814,427	887,420	973840	887446	42.3	Entrance Channel
CB-PBH95-2	CB	817,221	887,325	973458	887488	41	Entrance Channel
CB-PBH95-3	CB	816,935	887,502	973172	887665	42.2	Entrance Channel
CB-PBH95-6	CB	815,526	887,492	971763	887655	40.1	Entrance Channel
CB-PBH95-7	CB	814,926	887,504	971163	887667	41.3	Entrance Channel
CB-PBH95-8	CB	814,524	887,582	970761	887745	40.3	Entrance Channel
VC-5[1]	VB	817,491	887,356	973728	887518	55	Entrance Channel
WB-PBH95-1	WP	814,427	887,420	970664	887583	42.3	Entrance channel
WB-PBH95-2	WP	814,520	887,577	970757	887740	40.5	Entrance channel
WB-PBH95-3	WP	814,722	887,585	970959	887748	41.7	Entrance channel
WB-PBH95-4	WP	814,927	887,313	971164	887476	42.2	Entrance channel
WB-PBH95-5	WP	815,032	887,665	971269	887828	41	Entrance channel
WB-PBH95-6	WP	815,220	887,385	971457	887548	47.5	Entrance channel
WB-PBH95-7	WP	815,422	887,549	971659	887712	41.4	Entrance channel
WB-PBH95-8	WP	815,675	887,370	971912	887533	41	Entrance channel
WB-PBH95-9	WP	815,813	887,596	972050	887759	52	Entrance channel
WB-PBH95-10	WP	816,118	887,317	972355	887480	52.4	Entrance channel
WB-PBH95-12	WP	816,328	887,597	972565	887760	45.9	Entrance channel
WB-PBH95-13	WP	816,422	887,322	972659	887485	49	Entrance channel
WB-PBH95-15	WP	816,624	887,432	972861	887595	47.1	Entrance channel
WB-PBH95-17	WP	816,721	887,590	972958	887753	45.7	Entrance channel
WB-PBH95-18	WP	816,925	887,375	973162	887538	45.5	Entrance channel
WB-PBH95-19	WP	817,127	887,554	973364	887717	47.3	Entrance channel
WB-PBH95-20	WP	817,331	887,372	973568	887535	46.6	Entrance channel
WB-PBH95-21	WP	817,514	887,450	973751	887613	47.1	Entrance channel
WB-PBH95-22	WP	817,603	887,300	973840	887463	46.7	Entrance channel
VB-LWI2012-03	VB			971933.5	887366.3	48.7	Entrance Channel
VB-LWI2012-04	VB			973544.6	887689.9	59.5	Entrance Channel
VB-LWI2012-05	VB			972557	887705.6	62.3	Entrance Channel
VB-LWI2012-06	VB			972192.8	887927.5	35.6	Entrance Channel
VB-LWI2012-07	VB			970831.9	887854.8	25.7	Entrance Channel
VB-LWI2012-08	VB			970279	887494.2	46	Entrance Channel
VB-LWI2012-20E	VB			972342	887956.8	29.6	Entrance Channel
VB-LWI2012-01	VB			973876.6	887227.6	51.6	Area A-1
VB-LWI2012-02	VB			973295.1	887326	53	Area A-1
CB-LWI-SJ01-3	CB	816,104	887,141	972341	887304	61.9	Area A-1
CB-LWI-SJ01-6	CB	816,469	887,125	972706	887288	52.2	Area A-1
B-2[1]	CB			970637	887201	97.01	South Jetty
B-1[1]	CB			972139	888070	92.71	North Jetty and Area B-2
DM-3[1]	CB			971495	888014	71.75	North Jetty and Area B-2
DM-4[1]	CB			971498	887973	43.8	North Jetty and Area B-2
DM-5[1]	CB			971623	887974	44.8	North Jetty and Area B-2
DM-6[1]	CB			971550	888013	28	North Jetty and Area B-2
CB-PBH95-4	CB	816,621	887,739	972858	887902	36.6	Settling Basins
CB-PBH95-5	CB	816,636	887,707	972873	887870	41	Settling Basins
CB-LWI-PSB01-1	CB	816,502	888,542	972739	888705	35	Settling Basins
CB-LWI-PSB01-2	CB	816,690	888,531	972927	888694	34.8	Settling Basins
CB-LWI-PSB01-3	CB	816,901	888,531	973138	888694	34.7	Settling Basins

Table 1

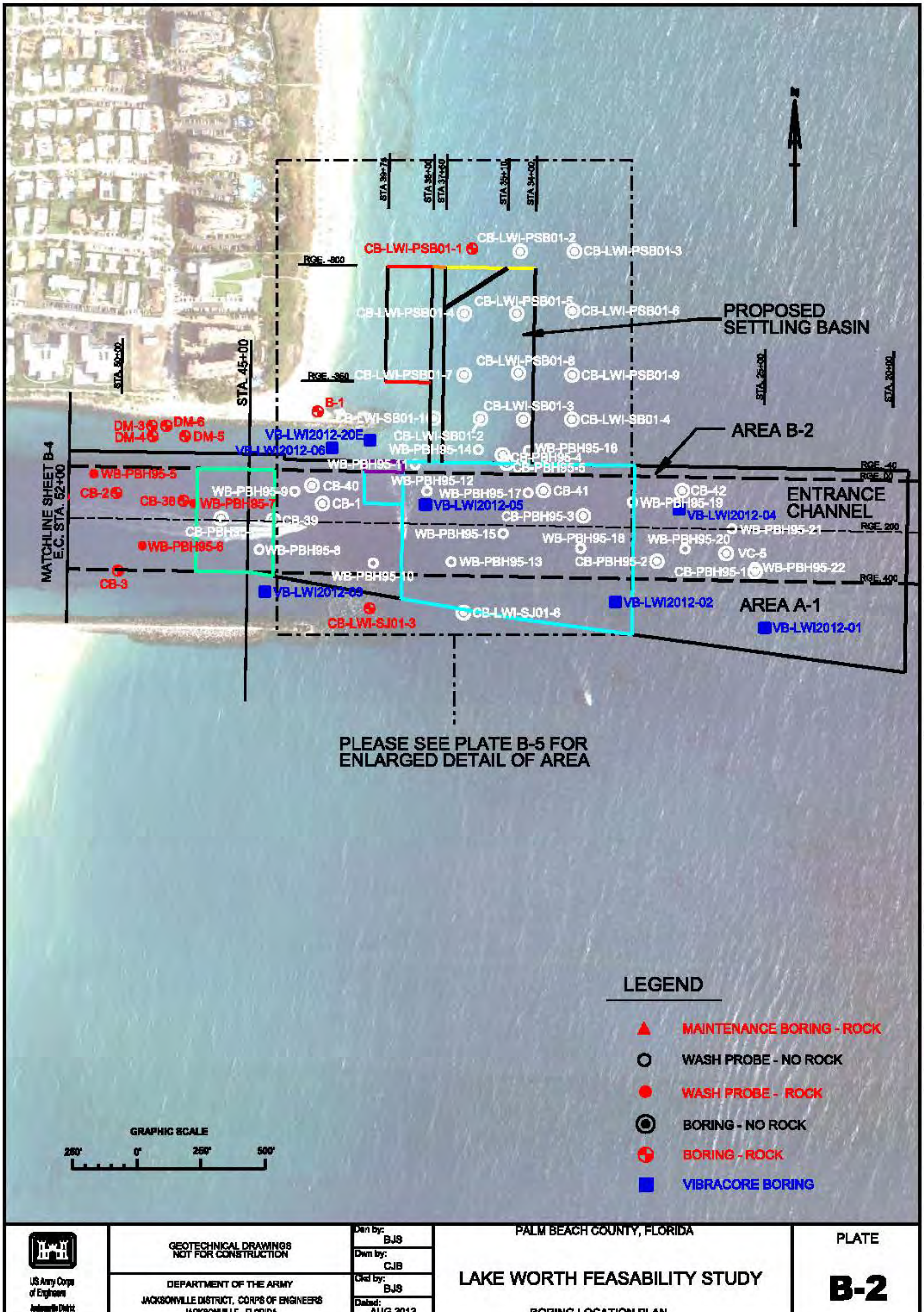
Lake Worth Inlet: List of Borings and Washprobes

BORING	Type	NAD27		NAD83		Bottom of	Area
		X	Y	X	Y	Boring	
CB-LWI-PSB01-4	CB	816,473	888,289	972710	888452	35.2	Settling Basins
CB-LWI-PSB01-5	CB	816,676	888,289	972913	888452	35.3	Settling Basins
CB-LWI-PSB01-6	CB	816,893	888,299	973130	888462	35.3	Settling Basins
CB-LWI-PSB01-7	CB	816,471	888,050	972708	888213	35	Settling Basins
CB-LWI-PSB01-8	CB	816,683	888,058	972920	888221	35	Settling Basins
CB-LWI-PSB01-9	CB	816,892	888,050	973129	888213	35	Settling Basins
CB-LWI-SB01-1	CB	816,353	887,881	972590	888044	35.7	Settling Basins
CB-LWI-SB01-2	CB	816,535	887,880	972772	888043	35.9	Settling Basins
CB-LWI-SB01-3	CB	816,703	887,879	972940	888042	34.9	Settling Basins
CB-LWI-SB01-4	CB	816,891	887,877	973128	888040	35.2	Settling Basins
WB-PBH95-11	WP	816,282	887,701	972519	887864	42	Settling Basins
WB-PBH95-14	WP	816,527	887,758	972764	887921	43.9	Settling Basins
WB-PBH95-16	WP	816,723	887,755	972960	887918	44.4	Settling Basins
CB-6	CB	813,880	887,530	970117	887693	41.7	Cut-1
CB-7	CB	813,765	887,500	970002	887663	42.6	Cut-1
CB-8	CB	813,300	887,310	969537	887473	42	Cut-1
CB-9	CB	813,340	887,190	969577	887353	42	Cut-1
CB-10	CB	812,850	887,150	969087	887313	42.8	Cut-1
CB-15	CB	813,915	887,220	970152	887383	43	Cut-1
CB-16	CB	813,665	887,330	969902	887493	43.2	Cut-1
CB-17	CB	813,190	887,140	969427	887303	41.3	Cut-1
CB-18	CB	812,400	886,775	968637	886938	42.9	Cut-2
CB-19	CB	812,185	886,800	968422	886963	40.8	Cut-2
CB-20	CB	811,750	886,595	967987	886758	40.8	Cut-2
CB-21	CB	812,000	886,520	968237	886683	41.4	Cut-2
VB-LWI2012-11	VB			968516.7	886930.2	48.6	Cut-2
VB-LWI2012-09	VB			969656.9	887693	38.2	Area C
VB-LWI2012-10	VB			968825	887409.7	32.5	Area C
VB-LWI2012-12	VB			967955.8	886964.8	60.7	Area C
CB-WP97-2	CB	811,209	886,545	967446	886708	38	Turning Basin
CB-24	CB	810,135	885,480	966372	885643	41.1	Turning Basin
CB-26	CB	809,730	886,585	965967	886748	41	Turning Basin
CB-27	CB	809,860	885,880	966097	886043	41.2	Turning Basin
CB-28	CB	810,200	886,540	966437	886703	41.1	Turning Basin
CB-29	CB	810,180	886,050	966417	886213	41	Turning Basin
CB-30	CB	810,180	885,210	966417	885373	41.4	Turning Basin
CB-31	CB	810,700	886,280	966937	886443	41.2	Turning Basin
CB-32	CB	810,700	885,840	966937	886003	40.8	Turning Basin
CB-33	CB	810,700	885,285	966937	885448	46.1	Turning Basin
CB-34	CB	811,235	886,480	967472	886643	41.6	Turning Basin
CB-35	CB	811,180	886,130	967417	886293	41	Turning Basin
CB-36	CB	811,175	885,560	967412	885723	41.6	Turning Basin
CB-37	CB	811,180	885,180	967417	885343	41.5	Turning Basin
CB-PBH95-9	CB	810,665	886,735	966220	887195	27.6	Turning Basin
CB-PBH95-11	CB	809,924	886,867	966161	887030	28.3	Turning Basin
CB-PBH95-12	CB	810,046	886,932	966283	887094	36.7	Turning Basin
VB-LWI2012-13	VB			967726.9	886421.4	51.5	Turning Basin
VB-LWI2012-15	VB			967296.5	886039.7	56.8	Turning Basin
VB-LWI2012-16	VB			966405.2	886335.4	54.3	Turning Basin
VB-LWI2012-17	VB			966629.6	885712	53	Turning Basin
VB-LWI2012-14	VB			966952.6	886601.6	50.6	Area D
VB-LWI2012-18	VB			966973.3	885073.5	40.7	Area G
VB-LWI2012-19	VB			966230	885125.2	41.7	Area G
CB-LWI99-1	CB	814,524	886,552	970765	886715	21	Beach
CB-LWI99-3	CB	814,086	884,230	970323	884393	24.4	Beach
CB-LWI99-2	CB	814,266	885,750	970503	885913	7.5	Beach

CB= Core Boring
VB= Vibracore Boring
WP= Washprobe
[1] Sponser Supplied Borings



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS NOT FOR CONSTRUCTION	Dsn by: BJS Dwn by: CJB	PALM BEACH COUNTY, FLORIDA	PLATE
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: BJS Dated: AUG 2012	LAKE WORTH FEASABILITY STUDY OVERVIEW MAP	B-1


PROPOSED
SETTLING BASIN
AREA B-2
ENTRANCE
CHANNEL
AREA A-1
MATCHLINE SHEET B-4
E.C. STA. 52+00
STA. 45+00
PLEASE SEE PLATE B-5 FOR
ENLARGED DETAIL OF AREA
CB-LWI-PSB01-1
CB-LWI-PSB01-2
CB-LWI-PSB01-3
CB-LWI-PSB01-4
CB-LWI-PSB01-5
CB-LWI-PSB01-6
CB-LWI-PSB01-7
CB-LWI-PSB01-8
CB-LWI-PSB01-9
CB-LWI-SB01-1
CB-LWI-SB01-2
CB-LWI-SB01-3
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B-1
DM-3
DM-4
DM-5
DM-6
VB-LWI2012-20E
VB-LWI2012-06
VB-LWI2012-05
VB-LWI2012-04
VB-LWI2012-03
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WB-PBH95-12
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CB-3
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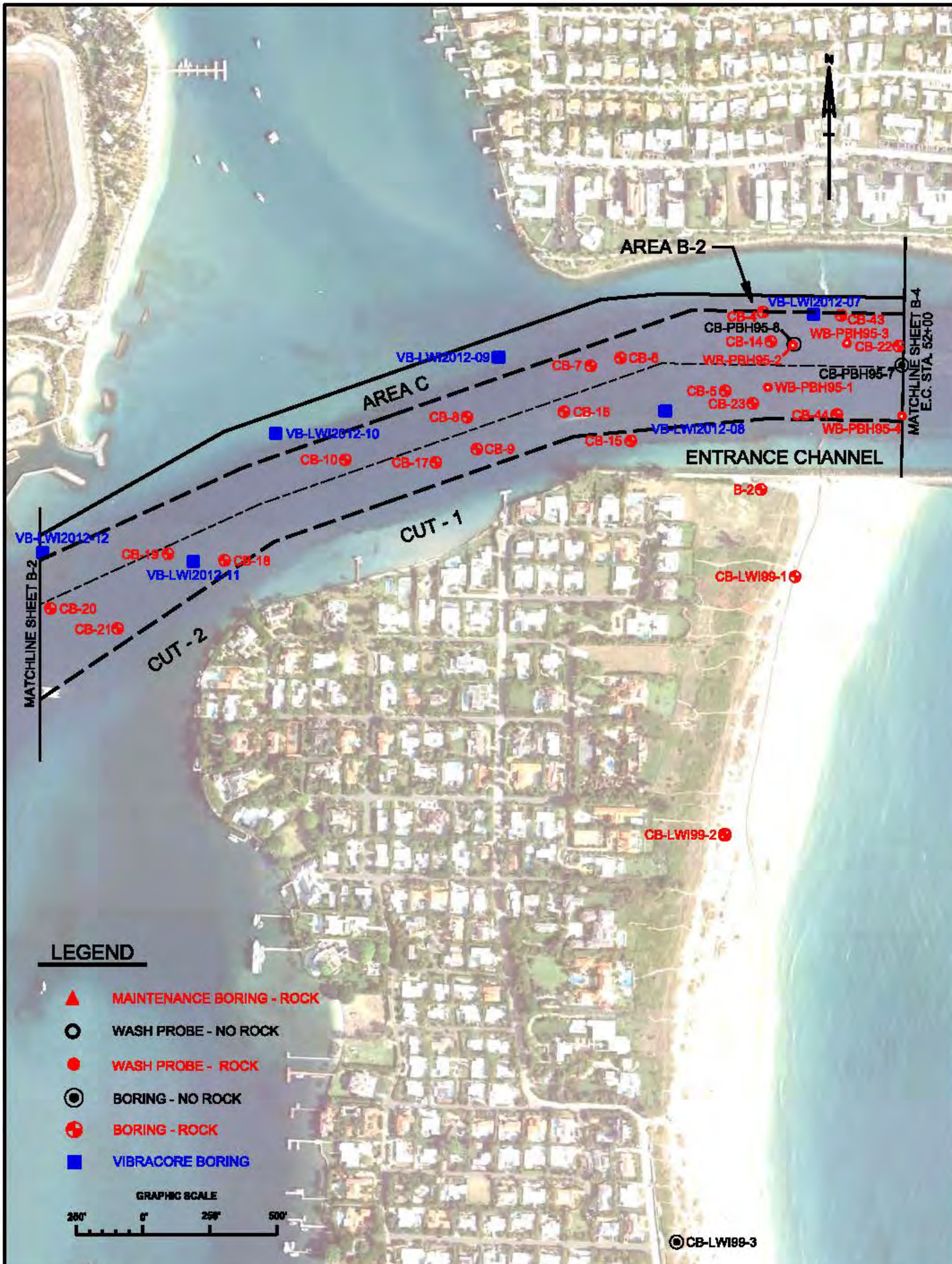
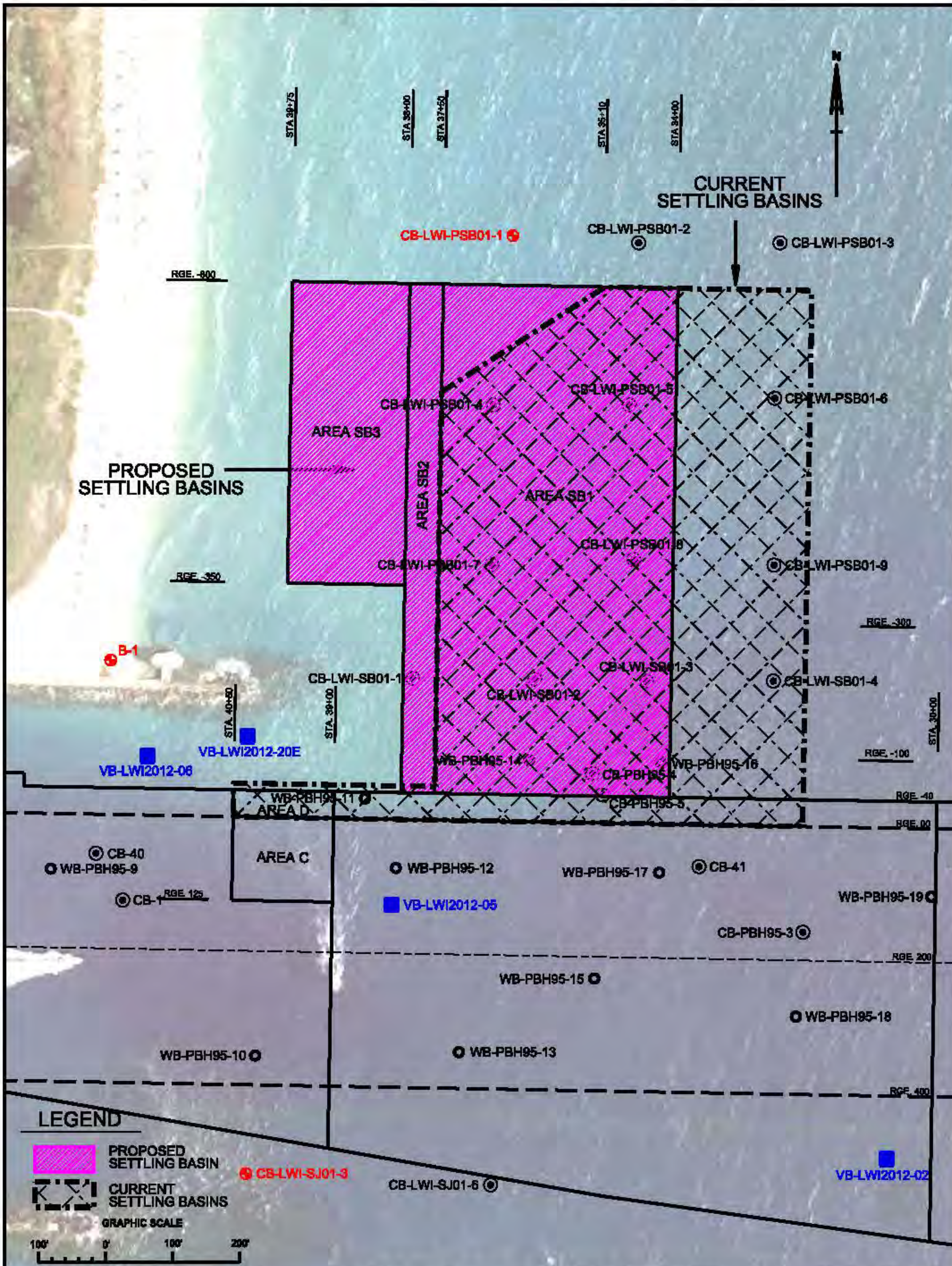
CB-39
CB-40
CB-41
CB-42
CB-1
CB-PBH95-1
CB-PBH95-2
CB-PBH95-3
CB-PBH95-5
VC-5
CB-LWI-SJ01-6
CB-LWI-SJ01-3
RGE. -800
RGE. -360
RGE. -40
RGE. 200
RGE. 400
STA. 25+00
STA. 20+00
LEGEND
MAINTENANCE BORING - ROCK
WASH PROBE - NO ROCK
WASH PROBE - ROCK
BORING - NO ROCK
BORING - ROCK
VIBRACORE BORING
GRAPHIC SCALE
250' 0' 250' 500'
US Army Corps of Engineers
Jacksonville District
GEOTECHNICAL DRAWINGS
NOT FOR CONSTRUCTION
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
Dsn by: BJS
Dwn by: CJB
Ckd by: BJS
Dated: AUG 2012
PALM BEACH COUNTY, FLORIDA
LAKE WORTH FEASABILITY STUDY
BORING LOCATION PLAN
PLATE
B-2



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS NOT FOR CONSTRUCTION	Dsn by: BJS Dwn by: CJB	PALM BEACH COUNTY, FLORIDA LAKE WORTH FEASABILITY STUDY BORING LOCATION PLAN	PLATE B-3
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: BJS Dated: AUG 2012		

US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS NOT FOR CONSTRUCTION	Dsn by: BJS	PALM BEACH COUNTY, FLORIDA	PLATE
		Dwn by: CJB	LAKE WORTH FEASABILITY STUDY	B-4
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: BJS		
		Dated: AUG 2012	BORING LOCATION PLAN	



US Army Corps of Engineers Jacksonville District	GEOTECHNICAL DRAWINGS NOT FOR CONSTRUCTION	Dsn by: BJS	PALM BEACH COUNTY, FLORIDA	PLATE
		Dwn by: CJB	LAKE WORTH FEASABILITY STUDY	B-5
	DEPARTMENT OF THE ARMY JACKSONVILLE DISTRICT, CORPS OF ENGINEERS JACKSONVILLE, FLORIDA	Ckd by: BJS		
		Dated: AUG 2012	SETTLING BASIN DETAIL	

US Army Corps of Engineers Jacksonville District

GEOTECHNICAL DRAWINGS NOT FOR CONSTRUCTION

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

Dsn by: BJS
Dwn by: CJB
Ckd by: BJS
Dated: AUG 2012

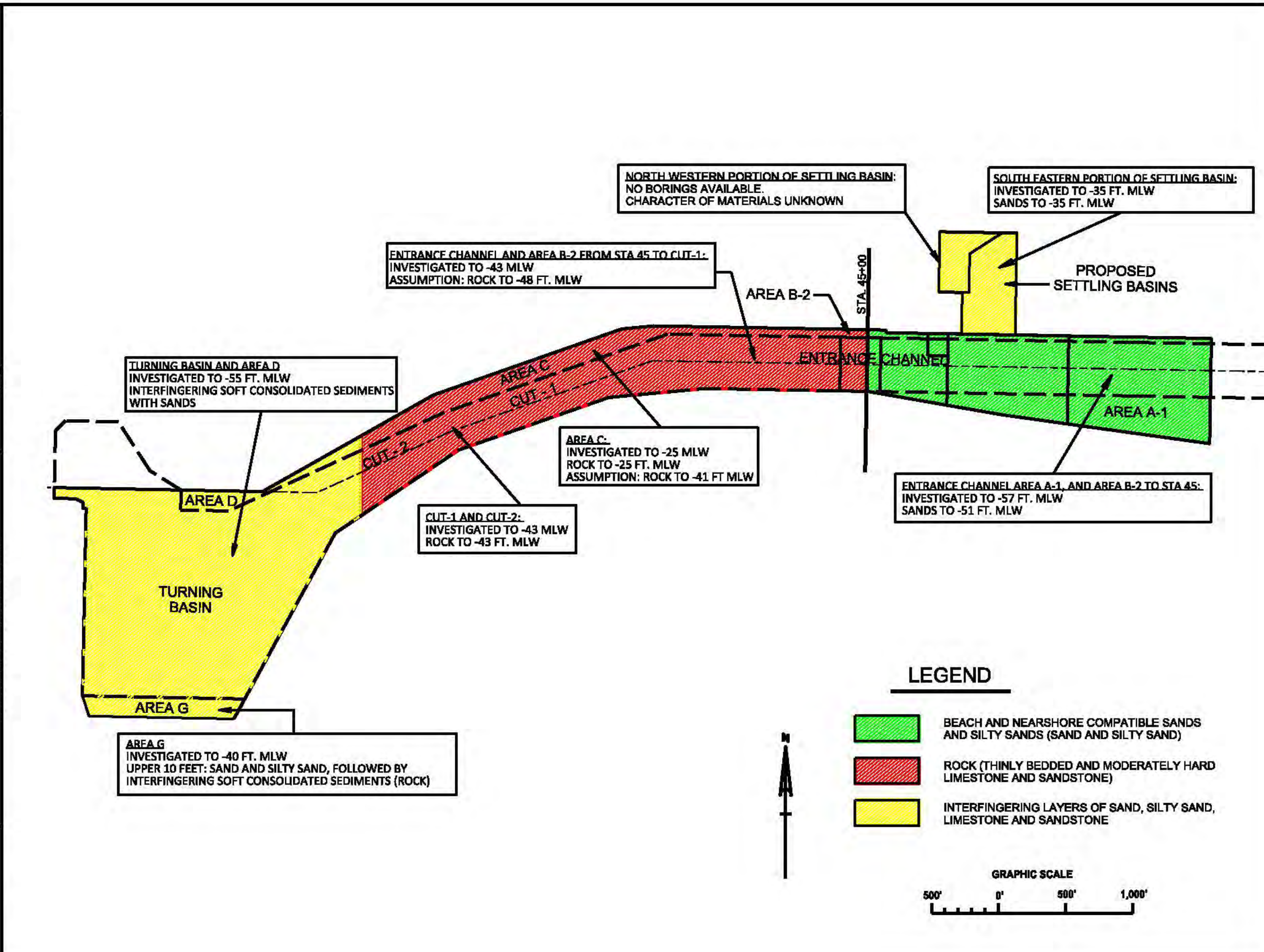
PALM BEACH COUNTY, FLORIDA

LAKE WORTH FEASABILITY STUDY

SUMARIZED GEOTECHNICAL INFORMATION

PLATE

B-6



Appendix A: Engineering

Attachment D: Value Engineering Report

LAKE WORTH INLET
Palm Beach Harbor

U.S. ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT

LAKE WORTH INLET NAVIGATION PROJECT
PILOT FEASIBILITY STUDY

Engineering Appendix - Attachment D
VALUE ENGINEERING REPORT

25 JULY 2012

DOD SERVICE: USACE **VALUE ENGINEERING OFFICER:** Jimmy Matthews, PE, CVS
CONTROL NO: CESAJ-VE-2012-003C

REPORT INFORMATION

VALUE ENGINEERING FIRM: U. S. Army Corps of Engineers
Jacksonville District
701 San Marco Blvd
Jacksonville, FL 32232-0019
(904) 232-1903

VALUE ENGINEERING WORKSHOP CONDUCTED: 18-25 June 2012

VALUE ENGINEERING STUDY TEAM LEADERS: Frank Vicidomina, CVS and Jimmy Matthews, PE, CVS

VALUE ENGINEERING STUDY TEAM MEMBERS: Team member names and contact information are listed in Appendix A.

POINTS OF CONTACT: Frank Vicidomina, PE, CVS, CEMVN-PM, (504) 862-1251

Stacey Roth, PE, Planning Technical Lead, CESAJ-PD-PN, (904) 232-1055

Jimmy Matthews, PE, CVS, Value Engineering Officer, CESAJ-EN-Q,
(904) 232-2087

STUDY RESULTS:

Number of Proposals: 4
Number of Accepted Proposals: 4

Number of Quantitative Proposals: 4
Number of Qualitative Proposals: 0

Maximum Cost Avoidance (Gross): $34,000,000
Accepted Cost Avoidance (Gross): $19,500,000

Study Cost to Government: $80,000

Return on Investment: *TBD*

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EXECUTIVE SUMMARY

This report contains the results of the Value Engineering (VE) Workshop that was performed June 18 – 22, 2012 using the USACE six step Value Engineering Job Plan. The objective of this workshop was to incorporate VE analysis into the development and validation of the proposed Tentatively Selected Plan (TSP). This was achieved by refinement of the current proposed TSP with focus on high-cost items and high risk issues including, but not limited to the following aspects of this navigation project:

- Mitigation options
- Disposal options
- Advanced channel maintenance issues
- Jetty stabilization issues

The results indicated 4 Potential Cost Avoidance opportunities as listed below and 25 comments that should be considered during subsequent project refinements. It is recommended that below proposals 1 and 2 be budgeted and scheduled for further investigation during the Pre-construction, Engineering and Design (PED) Phase. The reason is that authorization is not expected for two to three years and the PED phase start for two to four years. Expending current funding may not add value at the present time as these disposal sites may not be available in out years. Refer to Appendix H and Appendix G for supporting documentation.

PROPOSAL NUMBER	DESCRIPTION	POTENTIAL AVOIDANCESS	RECOMMENDED ACTION
1	Consider potential alternate and/or beneficial use disposal sites for non-beach suitable dredged material	$16,500,000	Adopt
2	Utilize FIND DMMA on Peanut Island for a portion of dredged material generated from the Inner Channel and Turning Basin	$14,500,000	Adopt **
3	Increase beach template (south of the inlet)	$6,500,000	Adopt
4	Eliminate reinforcement and deepening of Marginal Wharves bulkheads	$13,000,000	Adopt
	Estimated Total First Cost Savings	$19,500,000 to $34,000,000	
	Estimated Total Life Cycle Cost Savings	Same	

****** The Florida Inland Navigation District has near term plans for the DMMA that may make it unavailable.

INTRODUCTION

As stated above, this report documents the VE workshop conducted 18-22 June 2012. This workshop was conducted using the six-phase Value Engineering Job Plan as sanctioned by USACE and the Society of American Value Engineers International (SAVE). This process, as explained below, was executed as part of daily activities as described in the Workshop Agenda exhibited in Appendix A. The VE Team was comprised of project team members, representatives from the non-Federal sponsor and the Florida Department of Environmental Protection (FDEP). A roster of workshop participants can be found at Appendix B. As part of the workshop, the Team identified important project issues and developed project performance attributes. These are tabulated in Appendix C. A Function Analysis System Technique (FAST) diagram was developed to map the project function analysis. It is displayed in Appendix D. Next, creative project improvement ideas were compiled and screened. Appendix E lists all ideas (Speculation List) with their disposition. The VE Workshop culminated in the development phase where ideas were captured as either Quantitative Potential Cost Avoidances or Comments. Appendices G and H provide the related documentation.

Value Engineering Job Plan:

<u>Information Phase</u>

At the beginning of the study, the project team presents current planning and design status of the project. This includes a general overview and various project requirements. Project details are presented as appropriate. Discussion with the VE Team enhances the Team's knowledge and understanding of the project. A field trip to the project site may also be included as part of information gathering.

<u>Function Analysis Phase</u>

Key to the VE process is the Function Analysis Process. Analyzing the functional requirements of a project is essential to assuring an owner that the project has been designed to meet the stated criteria and its need and purpose. The analysis of these functions is a primary element in a value study, and is used to develop alternatives. This procedure is beneficial to the team, as it forces the participants to think in terms of functions and their relative value in meeting the project's need and purpose. This facilitates a deeper understanding of the project.

<u>Creativity Phase</u>

The Creativity Phase involves identifying and listing creative ideas. During this phase, the team participates in a brainstorming session to identify as many means as possible to provide the necessary project functions. Judgment of the ideas is not permitted in order to generate a broad range of ideas.

<u>Evaluation Phase</u>

The purpose of the Evaluation Phase was to systematically assess the potential impacts of ideas generated during the Creativity Phase relative to their potential for value improvement. Each idea is evaluated in terms of its potential impact to cost and overall project performance. Once each idea is fully evaluated, it is given a rating to identify whether it would be carried forward and developed as an alternative, presented as a design suggestion, dismissed from further consideration or is already being done.

Development Phase

During the Development Phase, ideas passing evaluation are expanded and developed into value alternatives. The development process considers such things as the impact to performance, cost, constructability, and schedule of the alternative concepts relative to the baseline concept. This analysis is prepared as appropriate for each alternative, and the information may include an initial cost and life-cycle cost comparisons. Each alternative describes the baseline concept and proposed changes and includes a technical discussion.

Presentation Phase

The VE Workshop concludes with a preliminary presentation of the value team's assessment of the project and value alternatives. The presentation provides an opportunity for the owner, project team, and stakeholders to preview the alternatives and develop an understanding of the rationale behind them.

PROJECT DESCRIPTION

Lake Worth Inlet is in Palm Beach County, Florida**.** The Port of Palm Beach is located 1.1 miles west of the entrance to Lake Worth Inlet. The north side of the harbor is Riviera Beach and the south side of the harbor is West Palm Beach. Palm Beach Harbor is 259 miles south of Jacksonville and 68 miles north of Miami.

The inlet and harbor provide access to deep draft vessel traffic using terminal facilities located at the Port of Palm Beach. As exhibited below, the existing authorized channel is comprised of: an entrance channel 35 feet deep, 400 feet wide, and 0.8 miles long;, an inner channel 33 feet deep, 300 feet wide and 0.3 miles long; a turning basin, 1,400 feet north-south along the north of the project turning basin to 24 feet; and jetties and shore revetments at the inlet. The entire length of the project is approximately 1.6 miles. Maintenance of the northern turning basin including the area of slip 1 is authorized to 24 feet; however much of this area is constructed to 33 feet by the non-Federal sponsor.

Lake Worth Inlet

The Port of Palm Beach is the fourth busiest container port in Florida and the eighteenth busiest in the continental United States. The port has evolved into an export port and is a major nodal point for the shipment of bulk sugar, molasses, cement, utility fuels, water, produce, and break bulk items. In addition, the Bahamas Celebration cruise ship is based at the port. Located in the heart of south Florida's tourism enclave, the port also serves significant recreational boat traffic.

Based on modern vessel sizes, the port is operating with insufficient channel width and depth. These deficiencies cause the local harbor pilots and the U.S Coast Guard to place restrictions on vessel transit to ensure safety. In turn, these restrictions lead to time delays and light loading – resulting in economic inefficiencies that translate into costs to the national economy. Lake Worth Inlet, serving as the entrance channel to the port, is inadequate both in width and depth, negatively impacting future port potential and creating economic inefficiencies with the current fleet of vessels. Project problems, objectives and constraints are further defined and illustrated in Appendix F.

The current feasibility study is being executed under the USACE Accelerated Feasibility Study Pilot Program. This program tests streamlined applications of planning principles while completing a feasibility study on an accelerated schedule. A number of alternative options that will address problems and needs have been identified and evaluated. Optimization of benefits, costs and risks has resulted in the current determination of a proposed Tentatively Selected Plan as presented below.

PROPOSED TENTATIVELY SELECTED PLAN

At the time of this workshop, the PDT has performed a preliminary evaluation of channel enlargement alternatives ranging from maintaining a 33-foot depth and just widening the channel, to establishing a 43-foot channel depth with widening. Benefits and costs for alternatives at one-foot depth increments in between these min and max limits were developed and resulted in alternative 'net benefits' (equivalent annual benefits minus equivalent annual costs) as illustrated in the below graph. Having the highest net benefits, channel deepening to 38-feet with widening was identified as the preliminary TSP.

The preliminary TSP is further defined as follows (reference below map):

- Widening and deepening of the entrance channel, ocean-side settling basin, interior channel and turning basin.

- Total dredged material quantity of approximately 1.2 million cubic yards (CY) of which 200,000 CY is designated for hydraulic beach fill re-nourishment and 1 million CY to be sent via scow barge transport to the designated offshore disposal site (ODMDS).

- Dredging of the entrance channel and settling basin assumed to be accomplished by cutter head plant with hydraulic pipeline discharge (pipeline dredging)

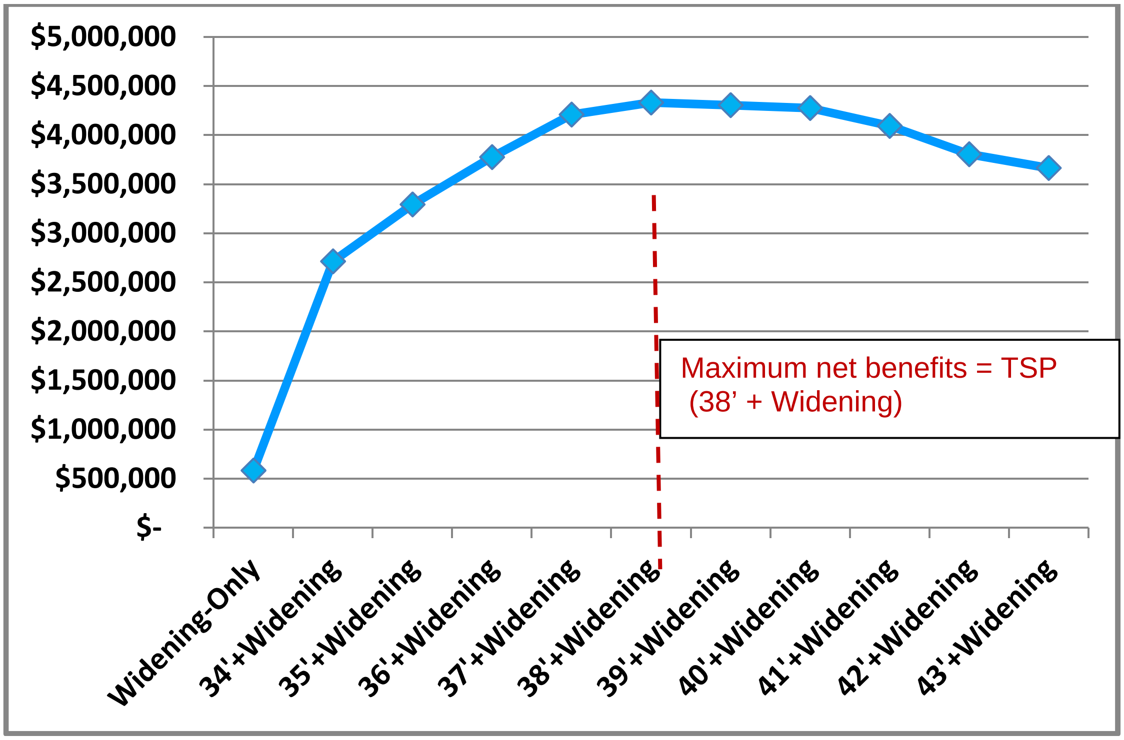
- Interior channel and turning basing dredging assumed to be performed via mechanical excavation (mechanical dredging)

- Bulkhead stabilization and/or berth deepening to three existing wharfs

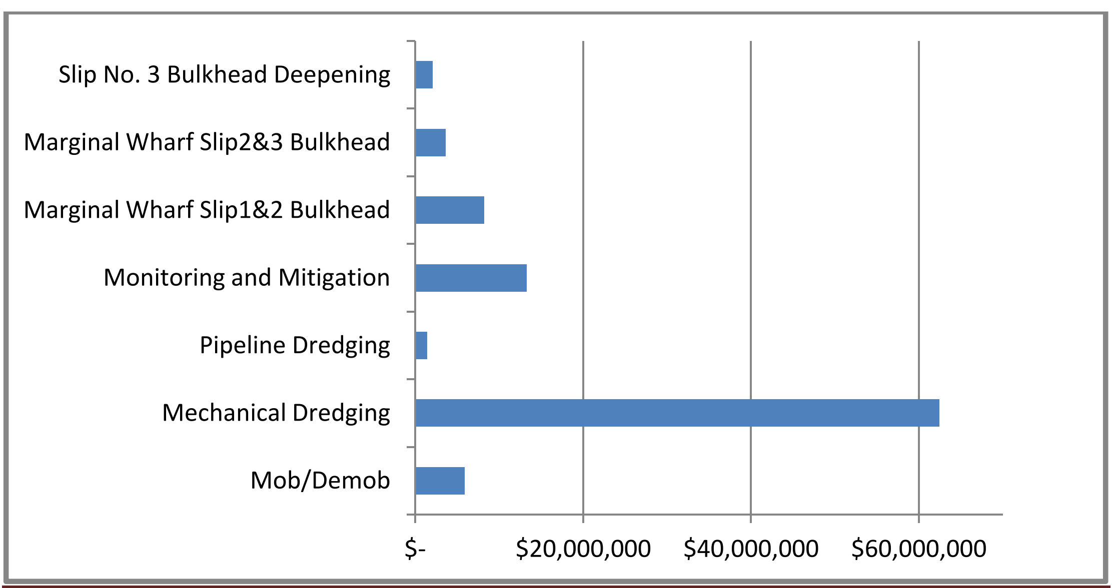
- Associated environmental mitigation of anticipated disturbance to seagrass, hard bottom and reef areas; a specific project environmental impact mitigation plan is to be developed.

Preliminay Average Annual Equivalent (AAEQ) Net Benefits and preliminary estimated costs were developed and are illustrated below.

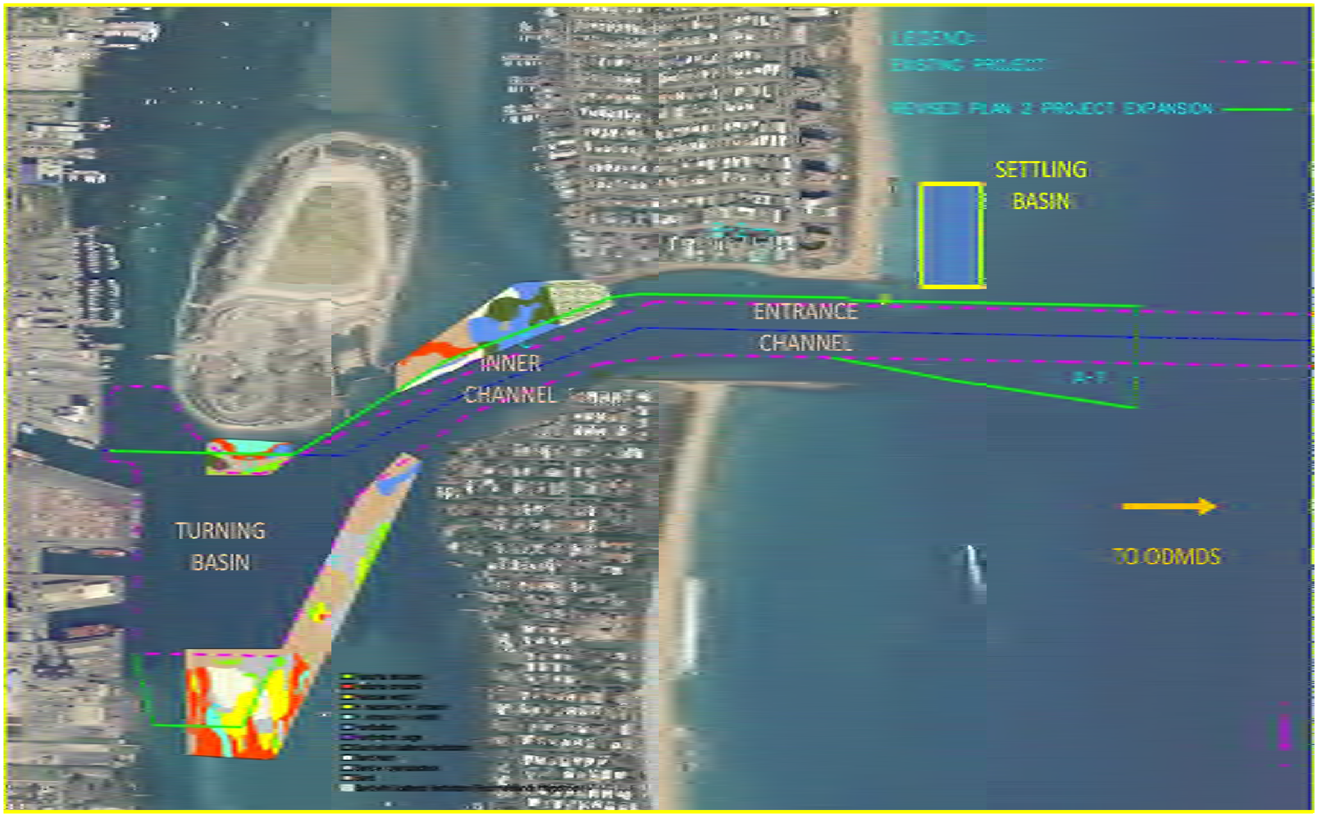
AAEQ Net Benefits



Preliminary Cost Model for 38-Foot Alternative



Current Plan with Environmental Resources



STUDY RESULTS

Study results are summarized below in findings where overall concepts have been summarized, in proposals where quantitative cost avoidance opportunities can be realized and in comments where ideas are captured that could add value during subsequent stages of development. Four VE 'Proposals' are illustrated in a structured format and indicate potential cost-savings relative to the current preliminary plan. The remaining items are presented as non-structured comments that further discuss each potential refinement. Refer to Appendices G and H for supporting documentation.

It should be noted that these proposals and comments were developed in a very short period of time and are intended to present conceptual measures for consideration. Further evaluation and design is required to substantiate each recommendation and provide rationale for its implementation or rejection.

Also, a number of recommendations may 'conflict' with others. That is to say that one idea cannot be implemented with the other. No decision as to preference was made by the VE Team and all options are presented for further consideration by the PDT.

FINDINGS

Use pipeline dredging instead of mechanical dredging for the inner channel and turning basin. Preliminary soils testing data presented at the workshop indicates that there may be no significant hard rock content of the channel bottom. If further testing validates such conditions throughout the area, it will be possible to utilize cutter head and pipeline dredge plant. As discussed below there are apparent locations within pumping distance of the project that may accept the majority or all of the required dredged material removal. This will result in significant cost-avoidance versus the current plan of mechanical excavation with scow barge transport to the designated off-shore disposal site (ODMDS).

Develop additional alternatives that would reduce and could totally eliminate disposal at ODMDS. A number of locations appear to be available to receive beach suitable sand from the entrance channel and settling basin or mixed material from the inner channel and turning basin with resulting reduction or total elimination of the need to deliver material to the ODMDS. Possible options include:

- Expand beach template – Nearby beaches designated for dredged sand placement can be enlarged and accept additional material.
- Mid-town beach placement – Additional dredged material pumping distance is possible and delivery to beaches further south (Mid-town) of the currently planned sand placement area can be considered.
- Use of FIND DMMA on Peanut Island for dredged material placement – The previously utilized dredged material placement area on Peanut Island may apparently accept significantly more material. Its close proximity to the inner channel and turning basin would make its use a most cost-effective option.
- Possible placement locations in the lagoon- Several lagoon locations are within reasonable distance from the project and are in apparent need of beneficial (submerged) fill (Little Lake Worth, Turtle Cove and Ibis Isle). Significant fill capacity is available in one or more of these sites

and if used in combination with the above mentioned Peanut Island area, it appears possible to place all project dredged material from the inner channel and turning basin (mixed material) to these sites.

Explore other mitigation considerations. Comments that could possibly improve and/or expedite mitigation are:

- Mitigation work may be performed by non-fed sponsor or other agencies – Several non-federal entities have experience and on-going mitigation activities and/or needs that may efficiently accommodate project mitigation requirements.
- Possibility of having non-federal sponsor do work in advance with credit towards project – The non-federal sponsor may perform (either directly or via other appropriate /approved entities) mitigation work in advance of project construction. Cost-sharing credit may be obtained by the sponsor for approved cost.
- Consideration of presenting multiple mitigation locations in approved report – It may be advantageous to draft and present several mitigation plan options in lieu of a single plan. This will provide flexibility and pre-arranged adaptation if future conditions change prior to implementation of mitigation measures.

PROPOSALS

PROPOSAL NUMBER	DESCRIPTION	POTENTIAL AVOIDANCES	RECOMMENDED ACTION
1	Consider potential alternate and/or beneficial use disposal sites for non-beach suitable dredged material	$16,500,000	Adopt
2	Utilize FIND DMMA on Peanut Island for a portion of dredged material generated from the Inner Channel and Turning Basin	$14,500,000	Adopt**
3	Increase beach template (south of the inlet)	$6,500,000	Adopt
4	Eliminate reinforcement and deepening of Marginal Wharves bulkheads	$13,000,000	Adopt
	Estimated Total First Cost Savings	$19,500,000 to $34,000,000	
	Estimated Total Life Cycle Cost Savings	Same	

****** The Florida Inland Navigation District has near term plans for the DMMA that may make it unavailable.

COMMENTS

5. Obtain permit variances to allow greater flexibility with turbidity

6. Consider capping non-select dredged material with sand to meet fill area requirements

7. Develop the Port's DMMA on Peanut Island; raise dikes on FIND DMMA and improve dikes on Port DMMA and empty the port side of Peanut Island and use it for beneficial use

8. Segregate rock and/or other select material for various specific utilizations

9. Use peanut island DA for processing

10. Investigate Upland Disposal Options

11. Use controlled placement scheme to place rock at interim ODMDS to create habitat

12. Use sand shooter (rainbow) to create seagrass in substrate limited areas

13. Optimize “expanded” settling basin design and advanced maintenance footprints

14. Optimize channel advanced maintenance/ vertical settling basin

15. Optimize Sand Transfer Plant

16. Consider construction of a groin north of “expanded” settling basin

17. Consider Canaveral-type sand bypass to beach

18. Optimize the reef at Peanut Island

19. Dredge the Peanut Island shoal and use the area to create seagrass mitigation –

20. Use of dredged rock for placement into existing county approved reef sites

21. Buy privately owned submerged lands, then put them under conservation easement and donate them to state park

22. Partner with the resource agencies to identify mitigation and beneficial use sites

23. Allow non-federal interests to complete project and/or work-in-kind mitigation and beneficial use features

24. Install mitigation features early to avoid temporal loss of habitat

25. Create mangrove islands

26. Have a suite of mitigation options, rather than one option, for authorized report (and have NEPA cover all options)

27. Develop recreation alternatives for inclusion into recommended plan evaluations and explore the use of dredged materials in the same

28. Combine entrance channel area deepening with regular dredging maintenance cycle

29. Execute multiple dredging contracts

VALUE ENGINEERING RECOMMENDATIONS

The VE Team identified **29** items that are believed to either improve project performance and/or cost-effectiveness. The results indicated Potential Cost Avoidance opportunities and 25 comments that should be considered during subsequent project refinements. It is recommended that proposals 1 and 2 be budgeted and scheduled for further investigation during the Pre-construction, Engineering and Design (PED) Phase. The reason is that authorization is not expected for two to three years and the PED phase start for two to four years. Expending current funding may not add value at the present time as these disposal site opportunities may not be available in out years. Refer to Appendix H and Appendix G for supporting documentation.

APPENDIX A: VALUE ENGINEERING WORKSHOP AGENDA

LAKE WORTH INLET – VALUE ENGINEERING WORKSHOP AGENDA

(ALL MEETINGS HELD AT USACE OFFICE – PRUDENTIAL OFFICE BUILDING, 12TH FLOOR CONFERENCE ROOM)

MONDAY
18Jun12:

Scope: To refine the Tentatively Selected Plan (TSP) in terms of high cost and high risk issues: 1) mitigation options, 2) disposal options, 3) advanced maintenance issues, and 4) jetty stability issues. Goal is for the VE to act as a catalyst to launch the team into detailed design and refined costs of TSP.

12:30-1:00	Introductions and Workshop Purpose - Tim Murphy VE Process, How it will be used, and Agenda - Jimmy Matthews
1:00-5:00	*Information Phase:* Presentation of Project Status and Summary of Tentatively Selected Plan (TSP) – Project Delivery Team Project background presentation – Stacey Roth PDT Site Visit Presentation with Google Earth – Stacey Roth and PDT Plan Formulation – Stacey Roth Design – Steve Conger Project depths and associated added depths – PDT Economics (Restrictions) – Max Millstein Shoaling Analysis (advanced maintenance and settling basin) – Steve Bratos Geotechnical and Geology – Felicia Copeland and Barbara Nist ▪ Jetty stabilization issue ▪ Types of dredged materials Environmental – Pat Griffin and Angie Dunn ▪ Seagrass, Hardbottoms, Manatees Cost Overview and Cost Model – Jennifer Tyler Final Array and Net benefits – TSP Net Benefits Stakeholders Presentation Summary of Project Issues, Risks, and Constraints – VE Team (Mitigation, Material Disposal and Beneficial Use, Advanced Maintenance and Settling Basin Configuration, Jetty Stability Risk Avoidance) VE Study Performance Attributes - Frank Vicidomina Summarize TSP and Re-cap for the day – Stacey Roth and Tim Murphy
Hourly	Break

TUESDAY
<u>19Jun12:</u>

8:30 – 9:30 *<u>Day One Re-cap and Function Analysis Phase:</u>* - Frank Vicidomina

9:45-11:30 *<u>Creativity Phase</u>:* (Brainstorming – Ideas by PDT/VE Team) - Frank Vicidomina

Hourly Break

11:30-12:30 Lunch

12:30-1:00 *<u>Complete Creativity Phase</u>:* (Brainstorming – Ideas by PDT/VE Team) - Frank Vicidomina

1:00 – 4:00 *<u>Evaluation Phase:</u>* (Critical assessment of Brainstorming - Includes determination of priority ideas and assignments for PDT/VE members) – Frank Vicidomina

4:00-5:00 *<u>Proposal and Comment Development Assignments</u>*: - Frank Vicidomina

Hourly Break

WEDNESDAY
<u>20Jun12:</u>

8:30 – 10:30 *<u>Explain and Start Development Phase:</u>* (Start PDT development of priority ideas recommended to be incorporated into BCR Comparison and TSP Selection/Refinement) - Frank Vicidomina

Hourly Break

11:30-12:30 Lunch

10:30 – 5:00 *<u>Continue Development Phase:</u>* (Start PDT development of priority ideas recommended to be incorporated into BCR Comparison and TSP Selection/Refinement)

THURSDAY
<u>21Jun12:</u>

8:30-2:00 *<u>Complete Development Phase:</u>* Team Touch base on Development Phase progress

2:00-4:00 *<u>Summarize Proposals for IPR and Start Presentation Prep:</u>* - PM, PDT, & Jimmy Matthews

Work Shop Completion Activities and IPR Preparation:

MONDAY
25Jun12: **To be determined**
10:00 AM PDT/VE Meeting - Discuss final proposals and submit proposals

Presentation Phase: Presentation of Workshop Results – Jimmy Matthews and Frank Vicidomina

Where do we go from here?

11:00-5:00 Continue to build IPR4 Presentation
*Goal is to have PowerPoint presentation which includes:

TUESDAY
26Jun12:
2:30 – 5:00 PM **IPR4 –** VE/PDT Briefs Vertical team of TSP and early VE findings, receives feedback and input for incorporation and development of VE Study – Jimmy Matthews and Frank Vicidomina

6Jul12: Draft Value Engineering Study Report submittal to PDT – Jimmy & Frank

13Jul12: PDT Comments on Draft Value Engineering Study Report - PDT

20Jul12: Final Comment Resolution by PDT/VE Team Leader – Jimmy & Frank

24Jul12: Submit Final VE Report to PDT (VE Complete) – Jimmy & Frank

APPENDIX B: WORKSHOP PARTICIPANT ROSTER

LAKE WORK INLET VALUE ENGINEERING WORKSHOP
18-21 June 2012 ATTENDANCE

DATE:
PROJECT:
LOCATION:

NAME	AGENCY	PHONE	E-MAIL
Frank Vicidomina	CEMVN-PM	504-862-1251	Frank.Vicidomina@us.army.mil
Jimmy Matthews	CESAJ-EN-Q	904-232-2087	Jimmy.D.Matthews@usace.army.mil
Stacey Roth	CESAJ-PD-PN	904-232-1055	Stacey.L.Roth@usace.army.mil
Jennifer Tyler	CESAJ-EN-TC	904-232-2213	Jennifer.L.Tyler@usace.army.mil
Angie Dunn	CESAJ-PD-ES	904-232-2108	Angela.E.Dunn@usace.army.mil
Pat Griffin	CESAJ-PD-EC	904-232-2286	Patrick.M.Griffin@usace.army.mil
Felica Copeland	CESAJ-EN-GS	904-232-1685	Felicia.M.Copeland@usace.army.mil
Tim Murphy	CESAJ-PM-WN	904-232-1671	Jerry.T.Murphy@usace.army.mil
Candida Bronson	CESAJ-PD-PN	904-232-1697	Candida.M.Bronson@usace.army.mil
Patrice Morey	CESAJ-PD	904-232-1078	Patrice.M.Morey@usace.army.mil
Andrew Loschiavo	CESAJ-PD-ES	904-232-2077	Andrew.J.Loschiavo@usace.army.mil
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Jenny Cheng	FDEP	850-413-7845	Jenny.Cheng@dep.state.fl.us
Roxane Dow	FDEP-BBCS	850-922-8752	Roxane.Dow@dep.state.fl.us
Mike Carothers	FDEP-BBCS	850-413-7765	Michael.Carothers@dep.state.fl.us
Steve Bratos	CESAJ-EN-WC	904-232-1824	Steve.M.bratos@usace.army.mil
Steve Conger	CESAJ-EN-DW	904-232-1601	Stephen.R.Conger@usace.army.mil
Barbara Nist	CESAJ-EN-GG	904-232-1890	Barabra.U.Nist@usace.army.mil
Max Millstein	CESAJ-PD-D	904-232-2481	Max.J.Millstein@usace.army.mil
Samantha Borer	CESAJ-PD-PN	904-232-1066	Samantha.J.Borer@usace.army.mil

APPENDIX C: PROJECT ISSUES, PERFORMANCE ATTRIBUTES AND GENERAL NOTES

(Project Issues)

1. Potential hydraulic condition changes due to reconf of channel and settling basin and impacts.
2. Potential change in mitigation impact conditions if there is a lag between project authorization and construction.
3. Expensive mechanical dredging.
4. Possibility of windows for dredging (manatees and sea turtles).
5. North jetty stability – deeper depths, more likely jetty impact.
6. Potential mitigation sites may get used and might be available when project is constructed.
7. Limited beach disposal capacity.
8. Limited capacity in ODMDS (per SMMP, 2004)
9. Potential impact to long term coastal sediment budget.
10. How the final array is clustered. Note the undocumented 5% rule.
11. The unknown material is a big cost. No blasting currently in cost estimate.
12. 24 hr vs 12 hr work for mechanical (excavator)
13. Mitigation and monitoring cost %.
14. Effectiveness of settling basin.
15. Cost limitations for non-fed sponsor. Could eventually have a locally preferred plan.
16. Construction duration of project ranges. Mechanical dredging drives the duration.
17. How much material is available for beneficial use? Is the sand/rock mix appropriate for beneficial use?
18. Try to keep lagoon sediments (even rock/sand) in the lagoon.
19. Dredged holes are still available to accept material for seagrass mitigation.
20. Hydraulic placement has been prohibited on past PBC filling projects.

(Performance Attributes)

The following 'performance attributes' list and describe critical factors that impact project performance and/or cost. Their purpose is to provide some order of measure as to whether or not a specifically proposed project change is justified or not.

While not quantifiably 'weighted' relative to one another, the relative order of importance of each attribute is reflected in the numbering as indicated:

1) ***Enhance Navigation*** - This is the project's highest order function; recommendations that further improve channel navigation over and beyond present conceptual design should be fully considered. Specific objectives include, but are not limited to, reducing vessel light loading, tidal delays and improving ship traffic safety.

2) ***Reduce Project Cost Risk*** - Cost variance for several critical aspects of this project can have a significant effect on overall project cost and may affect plan selection. Such uncertainty risk must be covered in project funding. Alternatives that reduce such uncertainty ultimately reduce total project cost.

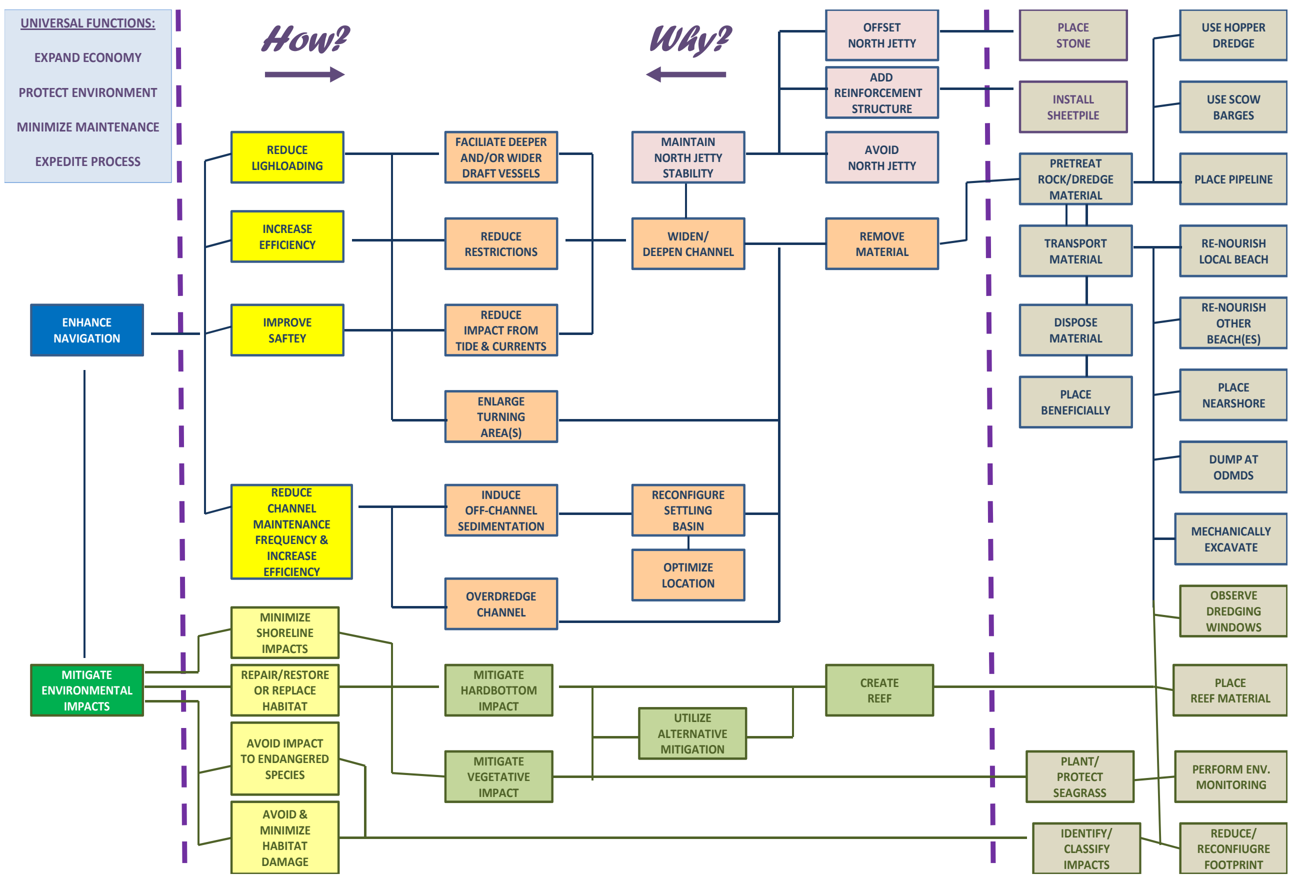
3) ***Expedite Process*** – Measures that facilitate both completion of the Pilot Feasibility study, project authorization and execution bring forward significant project benefits.

4) ***Optimize Disposal*** - Dredged material disposal options vary considerably and have a direct and significant effect on project cost. Disposal alternatives do, however have varying benefits depending on utilization. Options that balance and further optimize disposal should be considered.

5) ***Optimize Channel Maintenance*** - The benefits of over dredging to lengthen the interval until maintenance is required must be weighed against cost. Additionally, any adverse impacts to harbor maintenance through increased shoaling should be avoided. Recommendations that improve overall channel maintenance should be considered.

APPENDIX D: FUNCTION ANALYSIS SYSTEM TECHNIQUE (F.A.S.T.) DIAGRAM

F.A.S.T. DIAGRAM FOR LAKE WORTH INLET



APPENDIX E: SPECULATION LIST

		LAKE WORTH INLET VALUE ENGINEERING STUDY IDEA SPECULATION LIST	PAGE 1 of 4
P,C,ABC,X	NO.	IDEA	Notes
x	1	relocate the Warm Water Discharge from FP&L (location currently in vicinity of G)	would be helpful to project and possible savings - could dredge in winter
c	2	screen dregding material from turning basin and put it on beach/nearshore or break into little pieces, no ODMDS	best would be to screen if upland; but bigger screens can work on scows; or "grizzly"
c	3	Look at putting more of the material from inner channel onto beach	will be done once material is known
x	4	extend north jetty	good idea but possibly not cost effective; would be better to define toe of north jetty
x	5	install teleportation system at port	
x	6	put in breakwaters at singer island	interupt sand transport
x	7	tighten the north jetty so no sand transports through it	
x	8	move south part of peanut island so no tight left turn in channel	cost prohibitive
c	9	optimize the reef at peanut island	potential cost savings for hard ground mitigation
x	10	shut down the port	
c	11	dredge the peanut island shoal and use the area to create seagrass mitigation	same as 9, except use for seagrass mitigation
c	12	use the material on the port side of peanut for mitigation	estimated 300,000 cy capacity (per Julie Bishop)
x	13	identify HSRD benefits and recreation benefits for beach nourishment	would be good only if marginal on BCR. Locals have never had to renourish since feds put O&M material there. Beach fx time consuming and costly
c	14	let the resource agencies choose the out of kind mitigation	potential cost savings. Ref Lake worth Inlet Mgmt Plan. (per Julie Bishop)
c	15	Allow credit to be given or pay into a mitigation bank for non-fed agency (via port) to perform mitigation	reduce BCRs and will ensure mitigation sites not used by time of construction; risk to non-fed
c	16	install mitigation features early to avoid temporal loss of habitat	tradeoff - build early, spend money sooner, lower BCR vs. incurring interest
x	17	prebase year ecosystem restoration benefits	don't think we can claim extra ecosystem benefits for additional mit
c	18	optimize settling basin and adv main footprints	
x	19	deepen intracoastal and include mega yacht benefits	being done by others
P	20	increase beach template (south of inlet)	similar to #3; compare to taking to mid-town

P = Proposal
C = Comment
ABC = Already Being Considered
X = Idea Eliminated

P,C,ABC,X	NO.	IDEA	Notes
x	21	coordinate section 107 for NED benefits	
P	22	identify and auth beneficial use disposal sites (specific locations)	proposal will ID a menu of specific potential sites and quantify ROM costs; can use for dredge disposal and/or for mitigation
P/22	23	use interim ODMDS for rock placement	explore using it or for placement of harder substrate (rock) to create hardbottom mitigation; would need to coordinate with EPA. Premise is it would be less cost than placement at more recent ODMDS.
c/18	24	optimize sand transfer plant (expand capacity) and intake reach	
c/15	25	work with non-federal interests to do out of kind mitigation opportunities	
x	26	sink a ship as an art reef for mitigation	not as favorable in terms of artificial reef; more recreational. Cost prohibitive.
x	27	buy out homeowners that border the jetty and move jetty	
x	28	expand peanut island for project mitigation opportunities	possible con: fed agencies don't often allow open water fill
c	29	create mangrove islands	would be out of kind for mitigation, but could be use for dredge material and incidental ben use
c	30	coordinate with FDOT to beneficially recycle bridges for hardbottom mitigation	currently being used in big pieces and placed outisde of the lagoon. Could be cut into smaller pieces though and placed inside lagoon.
x	31	use submerged geotubes to extend the jetties	too deep
ABC	32	arrange local agreement with town of PB to place at mid-town	cost share agreement already in place
c/18	33	consider vertical settling basins	4 ft adv main in entrance channel is authorized; identify smaller reach for deeper depths
ABC	34	maximize project depth based on entrance channel configuration	
x	35	have port take over peanut island to expand port operations	
c	36	consider topping non-sand disposal with sand disposal	filling of holes with non-sand, and top with sand to then be used for seagrass mit. (Ref: Material used for peanut was similar to what will be found during this project - and was good for seagrass. Per Julie Bishop)
c	37	groins on the north side	would have to be longer than jetty to be effective, might not be cost effective. Present depths are 10-15 feet deep. Possibly use local stone (vs. georgia stone) since not life safety issue. Could install it farther south than the barge shown in photo and would still be effective. (per Bratos)
x	38	put a wide underground sand tunnel from settling basin under the channel to the south side of channel	
ABC	39	designate 37 ft channel as TSP	address at IPR4
c/37	40	install terminal groin north of jetty (backpass north of terminal jetty)	

P,C,ABC,X	NO.	IDEA	Notes
c/2	41	reuse any rock to stabilize shoreline to the south	
c	42	do two construction contracts (one for interior/ext)	
c$	43	do the entrance channel construction concurrent with O&M (timing)	potential $ savings with mob/demob
P	44	fill FIND's DMMA on peanut instead of ODMDS	
P/44	45	develop the Port's disposal area on peanut; make it adequate for use	
c/44	46	use peanut island DA for processing	
x	47	use seismic testing (resistivity analysis) to detemine rock content	
c	48	use permit variances to allow for greater flex with turbidity	temp turbidity will be assoc, with hyd dredging
c/2	49	use project rock to build breakwaters for seagrasses (inshore)	
c/2	50	sell rock from turning basin for inland riprap construction	
c	51	use control placement scheme for rock at interim ODMDS to create habitat	to be done durin PED
c	52	hyd pump to lagoon area	current project would use mech with low turbidity. To do it hyd., corps would need to get special permit for turbidity variance to allow contractor to do it.
c/3	53	consider pipeline delivery for nearshore and offshore placement areas	
x	54	use confined placement scheme in interim ODMDS for pump out area	too far out in the ocean for the pipeline
ABC	55	for sediment basin - look at seasonal or partial backpass of sediments/sand	
x	56	use rock to create land and put sand on it to create new land and sell it	
c	57	use sand shooter (rainbow) to create seagrass in substrate limited areas	
P/22	58	use hyd placement to build dredged holes (little lake worth and turtle cove - could take about 600K cy)	
x	59	expand northern peanut island	
c	60	investigate upland disposal	check to see if real estate search was ever done
x	61	small area in port facilities or nearby - find real estate	
c/2	62	mining operation - segregate it - then give it away for free	
c	63	create temp barge area at peanut island to give away material	
x	64	transform port and vessels	
x	65	offshore loading area for vessels and port	
c	66	buy privately owned submerged lands and put them under conservation easement and donate it to state park	Info from Julie Bishop
c/44	67	empty the port side of peanut island and use it for ben use	
c	68	build a recreation area	
x	69	put a bridge on peanut island	
x	70	buy out the maritime museum	

P,C,ABC,X	NO.	IDEA	Notes
x	1	rainbow the material from the settling basin to the south of inlet	
ABC	2	model design vessel with a naval arch to quantify the amount of heave and pitch tolerance (entrance channel underkeel clearance)	done
x	3	wave attenuation device or reef to alter currents	
x	4	line channel with "soft bumper"	
ABC	5	get larger tugs at port (port-owned) to big in bigger ships with lower cost to shippers	non-structural
ABC	6	don't enlarge turning basins, use tugs, increase risk	
x	7	remove/reconsider area D or capture cruise ship benefits	coordinate with Tim M and Sponsor
x	8	cut the southwest corner of peanut and make a slip for cruise ships for passenger recreation during delays	
x	9	big suction pipe next to sand transfer plant	
c/24	10	portable pump that you can put in with a crane next to sand transfer plant	
x	11	permanent pump and sump insitu	
ABC	12	size the settling basin to avoid adv main	
c/24	13	look at canaveral style sand bypass to beach	
x	14	dredge turning basin down to only 25 ft where cruise vessels transit	
x	15	dredge side slopes to recreate hard bottom habitat faster	habitat will already re-establish fairly fast
x	16	johnson sea grass - have fed delist	
x	17	install sheetpile in strategic places to serve mitigation and stability (ref. hard bottoms growing on port sheetpile)	
c/52	18	allow hydraulic dredging in interior	
P/44	19	raise dikes on FIND and improve dikes on south of peanut island; or combine both	
P/44	20	segregate/process dredge material for future DA unloading	
c/52	21	containment dike around hyd pumping in lagoon (turbidity control)	
ABC	22	equivalent to an industry day with resource agencies to go over current dredging methods and controls	
c	23	coordinate with EPA on 500K ODMDS capacity	
ABC	24	re-assess marginal wharfs for slips 1&2 (non-fed)- no benefits associated and high cost	
x	25	water chiller in front of FPL discharge	
x	26	wave attenuation device (WAD) in settling basin to catch sand and mitigate hardbottoms	
c	97	use dredged rock for hardbottom mitigation in existing sites provided by county approved sites	
c	98	have a suite of mitigation options, rather than one option, for authorized report (and have NEPA cover all options).	coordinate permit and shorter time lag.

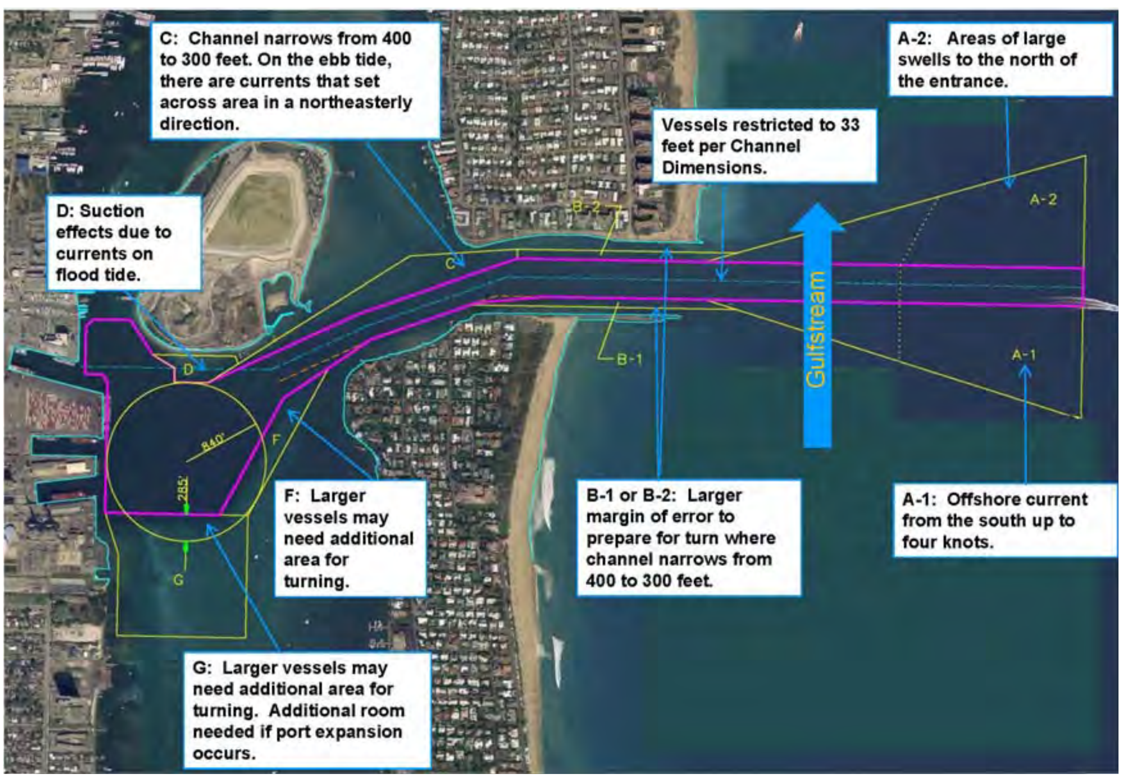
APPENDIX F: PROJECT PROBLEMS, OBJECTIVES AND CONSTRAINTS (Information obtained from Pilot Re-scoping Plan – Oct 2011)

Problems

The existing conditions in Palm Beach Harbor cause vessels to be restricted by light loading, tidal delays, and maneuvering difficulties due to three navigation concerns (see below map):

- Insufficient Depth: Depths are limited to 33 feet in the inner entrance channel and turning basin.
- Insufficient Width: The channel width decreases from 400 feet to 300 feet at a turn in the inner entrance channel, limiting the safe transit of vessels. The turning basin dimensions also limit the vessel size that can safely turn.
- Currents: The proximity of the Gulf Stream current to the entrance channel and perpendicular direction to the channel make entering the entrance channel and slowing to safe speeds problematic. Additional currents occur in the area C on ebb tide that effect the turning of vessels to stay in the channel.

Problems in Palm Beach Harbor



Opportunities

The opportunity at Palm Beach Harbor is more efficient navigation, resulting from a reduction in light loading, tidal delays, easier maneuvering, and shoaling. See map below.

Opportunities in Palm Beach Harbor

Objectives

The following project objectives have been established:

- Reduce transportation costs via a reduction in vessel light loading, tidal delays, or other transportation cost savings for commercial navigation from the entrance channel to the inner channel and to the main turning basin that serves Slips 1, 2 and 3, which include Berths 7 through 17.

- Reduce transportation costs via a reduction in vessel light loading, tidal delays, or other transportation cost savings for commercial navigation for the northern turning basin and, northern marginal wharf.

- Reduce navigation concerns and improve ship traffic safety by widening the harbor in areas A-1, A-2, B, C, D, F, and G.

- Determine if beneficial uses of dredged material such as manufactured soils, recycling of dredge material for construction fill, development of artificial reefs, or use of beach quality material for placement along adjacent beaches would provide appropriate alternatives for disposal of dredged material. This was requested at the NEPA Scoping meeting on 9-January-2008 by two town residents, a Surf rider member and the Town Manager for the Town of Palm Beach. In a letter dated 22 January 2008 from Palm Beach County, there is another request for placement of beach quality material to be placed on the beach.

Constraints

The following project constraints have been identified:

- Avoid adverse impacts to harbor maintenance through increases in shoaling.

- Avoid adverse impacts of shoreline erosion along Lake Worth Inlet.

- Avoid or minimize potential impacts to manatees and grass beds along the reefs as requested by the Coalition for Wilderness Islands in their 12 January 2008 letter (see map below). Two area residents also requested the no-action alternative at the NEPA scoping meeting on 9 January 2008; Manatees congregate, by the hundreds, at the Florida Power & Light (FP&L) warm water discharge that is located in Area G. While manatees use this area year-round, they congregate at the warm water outfall when water temperatures drop (especially Jan and Feb and pretty much limited to mid-Dec to mid-March). All of Lake Worth inlet is designated Critical Habitat for Manatees (50 CFR 17.95). All of the inner Harbor area is a "Manatee Protection Zone" (speed of water craft is regulated). The area is not considered a Manatee "refuge" or "sanctuary". Most of the harbor is considered an Important Manatee Area (IMA). See http://www.fws.gov/northflorida/Manatee/federal-manatee-protection-areas.htm

- Avoid or minimize impacts to environmental resources including seagrass, hardbottom and soft bottom resources found in the study areas A1, A2, B, C, D, F, and G.

- Placement of material on the beaches shall occur outside the sea turtle nesting season (April through November) to the maximum extent practicable.

Seagrass Distribution and Potential Project Impact Zone

APPENDIX G: PROPOSAL DOCUMENTATION

(1) – (Proposal) Consider potential alternate and/or beneficial use disposal sites for non-beach suitable dredged material

ORIGINAL DESIGN: Current plan indicates mechanical (excavator) dredging of material in the inner channel and turning basin area with scow barge transported offshore disposal (ODMDS). Current data indicates that most of this material is a sand/soft-rock mixture not suitable for beach re-nourishment. See below map.

PROPOSED DESIGN: Consider local alternate disposal sites including potential beneficial use at nearby proposed area restoration projects in Lake Worth Lagoon. **Potential sites and their potential material utilization quantities and benefits are listed /illustrated below**. Dredged material placement to closer locations could facilitate use of cost-effective means of hydraulic pipeline delivery of dredged material versus scow barge transport. Some sites may also be considered for project mitigation.

Sites 1) and 2), Little Lake Worth and Turtle Cove are about 5-miles away from the project and appear to have needed fill capacity (over 1.5 MCY) to accommodate project dredged material removal requirements (inner channel and turning basin). This distance is at the maximum limits of a single pump pipeline discharge but is within the means of this type of operation. Ibis Isle 8.5 miles south of the project also has significant receiving capacity (600,000 CY) and may also be considered. A second 'booster pump' would likely have to be employed for this conveyance but is also within the means of such dredging operation.

If material in the inner channel and turning basin cannot be hydraulically dredged and/or transported, placement to the proposed nearby potential beneficial use sites should still be considered, via mechanical excavation and scow barge transport. Cost difference between this and transport/disposal to the ODMDS would likely be negligible.

ADVANTAGES:

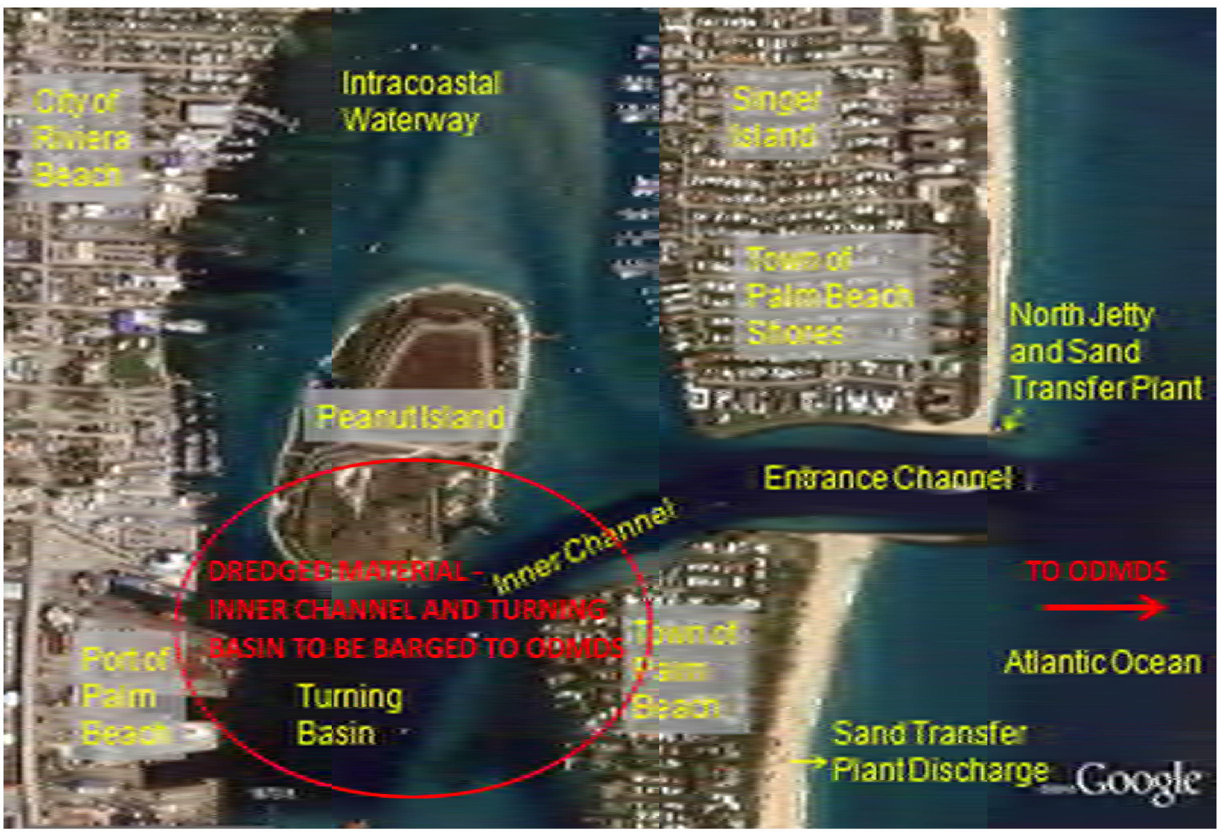
1. Dredged material could be utilized with some benefit as opposed to non-use offshore disposal.
2. Potential for local hydraulic placement would significantly reduce cost.

DISADVANTAGES:

1. If hydraulic material placement is used, turbidity control and permits would be required.
2. Hydraulic delivery and placement several miles or more away from the channel would require a long pipeline that would need special care and attention in relatively high vessel use area.

JUSTIFICATION: There is the potential for nearby placement and beneficial use of dredged material that will be obtained from the inner channel and turning basin. If in-situ material is soft enough to allow cutter head removal then hydraulic transport and delivery of dredged material to such locations is possible. Hydraulic pipeline delivery to the currently designated offshore disposal site is not possible via pipeline and scow barge delivery will still be necessary regardless of material removal means. Temporary turbidity control/permitting and care in pipeline placement through a high vessel traffic area would have to be addressed. Potential cost-avoidance would be significant if hydraulic pipeline material delivery can be utilized.

If material in the inner channel and turning basin cannot be hydraulically dredged and/or transported, placement to the proposed nearby potential beneficial use sites should still be considered, via mechanical excavation and scow barge transport. Cost difference between this and transport/disposal to the ODMDS would likely be negligible.



Current Plan

Project #	Project Name	Project Type	Site Conditions	Habitat Created
1	Little Lake Worth	Dredged Hole Capping/Filling	30 ac (-30'NGVD) ; contains muck sediments 900,000 cy3 capacity to -12' NGVD	Limited potential for seagrass Art reef <10 ac
2	Turtle Cove	Dredged Hole Capping/Filling	+42 ac (-18'NGVD); contains muck sediments. 660,000 cy3 capacity to -4.5' NGVD	<10 ac seagrass 6-10 ac art reef
3	Singer Island Seagrasses	Acquisition Conservation	147 ac of privately held submerged lands w/ healthiest seagrass bed in LWL	Purchase & Preservation by adjoining to J.D. MacArthur Beach State Park
4	Kelsey Park Reef	Artificial Reef	6 ac permitted site contains 2 ac art reef 4 ac remain for new reef creation	4 ac art reef
5	Sugar Sands Reef	Artificial Reef	10 ac permitted site contains 7ac art reef 3 ac remain for new reef creation	3 ac art reef
6	Singer Island Reef Pods	Artificial Reef	Permitted nearshore site 4ac art reef built & under 5yr monitoring plan. 2 ac remain for new reef creation	2 ac art reef
7	Peanut Island shoal	-Dredging -Artificial Reef	30 ac shoal >100,000 cy3 sand to be dredged	10 ac seagrass (temporary-may accrete) 1 ac art reef
8	Peanut Island Breakwaters	Artificial Reef	SE Peanut has existing breakwaters 3 ac remain for new reef creation	3 ac area for additional breakwaters
9	Rybovich Reef	Artificial Reef	5 ac permitted site contains 3 ac art reef 2 ac remain for new reef creation	2 ac art reef
10	Ibis Isle	-Filling/Capping	41 ac dredged hole, muck sediments Located 8.5 mi south of LW inlet >600,000 cy3 capacity	<20 ac seagrass
Note	All sites		Require verification of resources & conditions	

Lake Worth Lagoon Proposed Restoration Projects - North

ASSUMTIONS AND ESTIMATES:

(For cost comparison purposes, dredged material placement at the Turtle Cove site is considered)

If **mechanical excavation dredging** is required for the inner channel and turning basin, the cost difference of transportation and placement to Turtle Cove, about 5 miles, would likely be negligible versus the current plan of transport and disposal to the ODMDS – about 7 miles **(negligible cost difference)**.

If **hydraulic (pipeline) dredging** can be performed significant cost-avoidance may be realized is calculated below with the following assumptions and estimates:

Current unit cost estimate for mechanical excavation and scow barge transport and disposal from the inner channel and turning basin to the ODMDS is approximately $45/cy with 24 hr operation.

Pipeline dredging from inner channel and/or turning basin to Turtle Cove site estimated between $15 and $20/cy; Assume **$17.50/cy.**

Assume about 90% of available capacity of 650,000 cy or **600,000 cy** dredged material quantity.

Potential cost avoidance calculated in the following table.

COST ESTIMATE WORKSHEET				
DELETIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Mechanical excavation	CY	600,000	$45	$27,000,000
with scow barge transport				$0
and disposal at ODMDS				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Deletions		**$27,000,000**
ADDITIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Pipeline dredging and	CY	600,000	$17.50	$10,500,000
placement on Peanut Isl.				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Additions		**$10,500,000**
	Net Cost Decrease			**$16,500,000**
	Mark-ups	**0.00%**		**$0**
	Total Cost Decrease			**$16,500,000**

(2) – (Proposal) Utilize FIND DMMA on Peanut Island for a portion of dredged material generated from the Inner Channel and Turning Basin

ORIGINAL DESIGN: The original design disposes all dredge materials in the Offshore Dredged Material Dispose Site (ODMDS). The overall reason was that channel materials could not be hydraulically dredged (pipeline dredging) and upland disposal areas were not available for the LWI New Work Navigation Project.

PROPOSED DESIGN: The proposed design will use a hydraulic cutter head suction dredge to dispose new work dredged materials in the Florida Inland Navigation District (FIND) Dredged Material Management Area (DMMA) on Peanut Island. The site can also be used for any material separation that is needed for project purposes. The FIND site has a capacity of about **500,000 cy** and according to the non-Federal sponsor, is available of use. In addition, the current analysis indicates that the substrate rock is softer than initially envisioned and can be dredged with a hydraulic cutter head dredge.

Peanut Island is exhibited in the below map. The FIND site is the DMMA immediately under the Peanut Island Label. The FIND DMMA was recently unloaded as part of another project. The Site also has roads and barge unloading areas that are available for other new work project purposes such as material separation, processing and re-handling. Existing containment dikes appear to be adequate, as is, to accept an additional 500,000 cy hydraulically dredged material. Even if some dike restoration and/or raising is necessary, it is believed that this work can be accomplished with earth graders and dozers on the site and not be cost-prohibitive.

ADVANTAGES:

1. Lowered cost to dredge and dispose new work materials.
2. Increased material availability for other project and non-project purposes such as habitat creation.
3. Material separation location and re-handling. Examples could be rock separation for re-use as wetland slope protection and/or low height breakwaters for seagrass establishment areas.

DISADVANTAGES:

1. Utilization of FINDS not considered as ‘high’ beneficial use of material; other ‘higher’ beneficial use sites, albeit more expensive, may be available to receive this material (see **Item 1**).
2. A Consent-to-Use agreement will need to be executed with FIND. A successful outcome is uncertain at this time. The idea still has merit for investigation during PED.

JUSTIFICATION:

There are potentially significant quantifiable project savings that will support the additional field investigations and design costs associated with material classification and DMMA design and incidental site modification costs. If material can be hydraulically dredged, this appears to be the 'least cost' disposal alternative.
Other higher beneficial use sites would not receive this material under this plan. This may also include beach placement if beach-suitable sands are identified in the inner channel and turning basin.

PALM BEACH HARBOR

ASSUMTIONS AND ESTIMATES:

Current unit cost estimate for mechanical excavation and scow barge transport and disposal from the inner channel and turning basin to the ODMDS is approximately $45/cy with 24 hr operation.

Pipeline dredging from inner channel and/or turning basin to Peanut Island site estimated between $10 and $15/cy; Assume **$12.50/cy.**

Assume 90% of available capacity of 500,000 cy or **450,000 cy** dredged material quantity and site is available. Subsequent to the VE Workshop, it was discovered that FIND had a permit to use the DMMA. The site will only be evaluated during the PED Phase, if available.

Potential cost avoidance calculated in the following table.

COST ESTIMATE WORKSHEET				
DELETIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Mechanical excavation	CY	450,000	$45	$20,250,000
with scow barge transport				$0
and disposal at ODMDS				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Deletions		**$20,250,000**
ADDITIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Pipeline dredging and	CY	450,000	$12.50	$5,625,000
placement on Peanut Isl.				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Additions		**$5,625,000**
	Net Cost Decrease			**$14,625,000**
	Mark-ups	**0.00%**		**$0**
	Total Cost Decrease			**$14,625,000**
			Rounded:	**$14,500,000**

(3) – (Proposal) Increase beach template (south of the inlet)

ORIGINAL DESIGN: For past O&M events in the Lake Worth Inlet, beach quality sand has been obtained. This material has been placed south of the inlet, as the least cost disposal plan. The capacity of the beach can vary anywhere from 0 cy to 400,000 cy per nourishment event, depending on when the last O&M event occurred. An O&M event will occur in Fall 2012 which will fill the current remaining capacity of 150,000 cy. The template is from R-76 to R-79, making it roughly 4,000 ft long. The berm is at elevation 8.68 ft MLW with a 1:20 slope.

PROPOSED DESIGN: Areas C and G (inner channel and turning basin) have not had sufficient core borings to date, and therefore the material that will be dredged in those areas is largely unknown. Roughly 996,000 cy of material, largely from those areas of C and G, is of unknown composition. It is relatively certain that approximately 209,000 cy of sand will be dredged throughout the rest of the channel. If areas C and G have more than 200,000 cy of sand in them, then increasing the existing beach template would provide a cost savings to the project as it is the least cost disposal option.

ADVANTAGES:

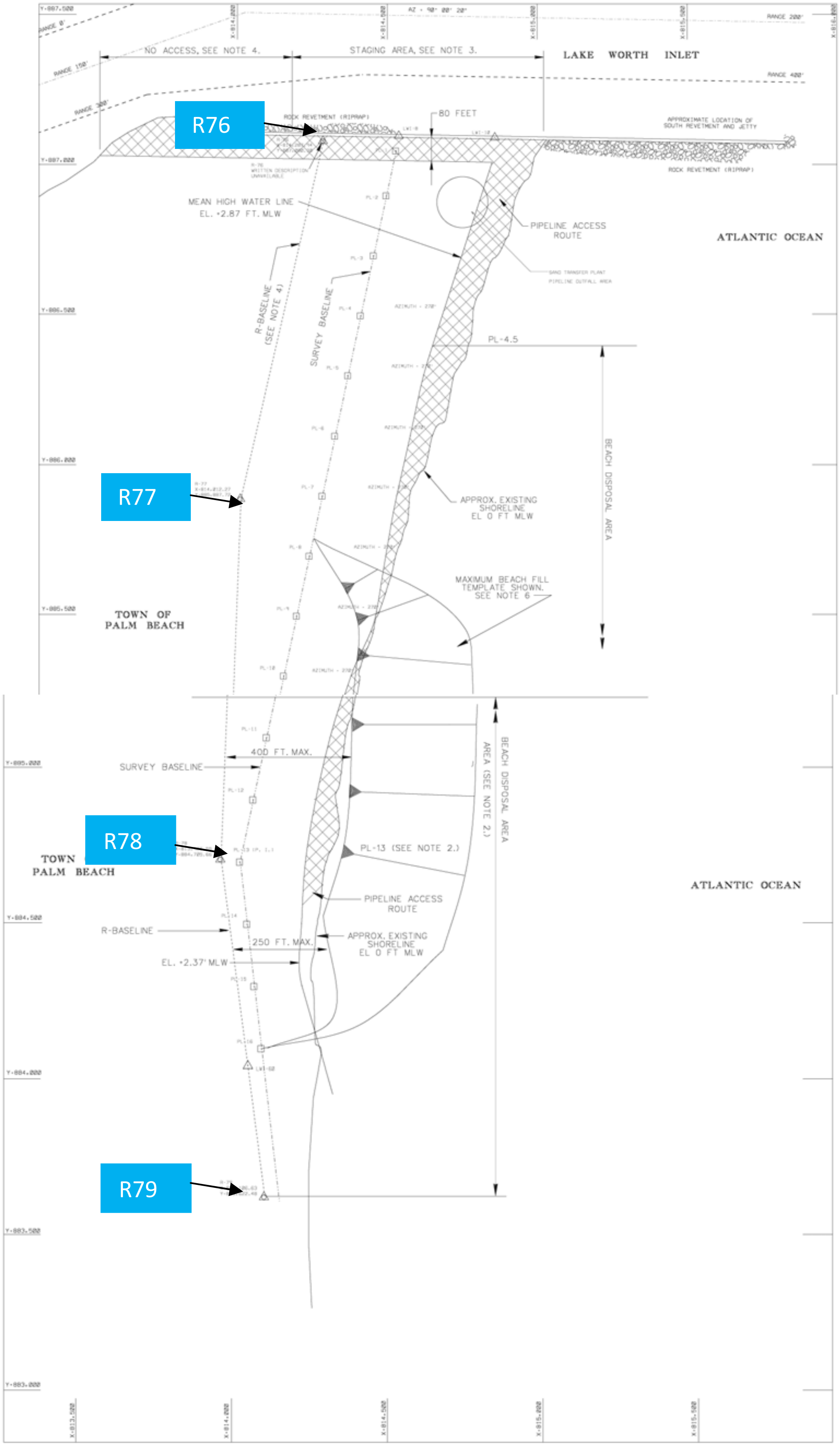
1. Close proximity of beach to the project would provide cost savings to project (least cost disposal).
2. Incidental benefits of the sand on the beach:
    a. Hurricane and storm damage protection
    b. Sea turtle nesting habitat
    c. Recreation

DISADVANTAGES:

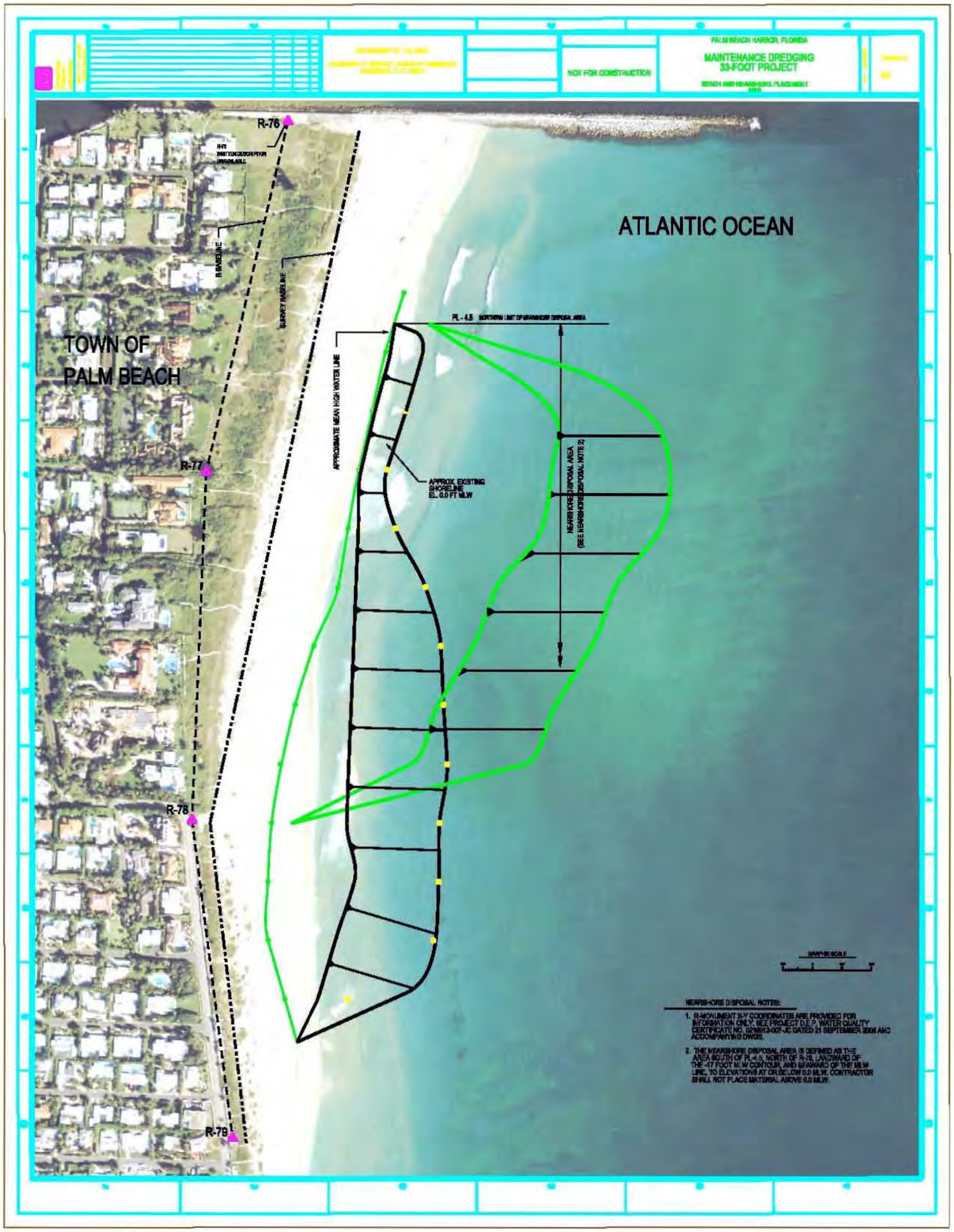
1. There could be hard bottom impacts if the beach template is increased, as hardbottoms are known to exist to the south, and the original permitted template was created to avoid those impacts.
2. Additional coordination will be required to affirm adequacy of existing NEPA documentation and FEDP permit which includes the Water Quality Certificate.

JUSTIFICATION: If suitable material exists in Areas C and G, then pipeline dredging with nearshore placement along the beachfront south of the inlet will be both cost effective and beneficial. Potential local impacts would have to be assessed.

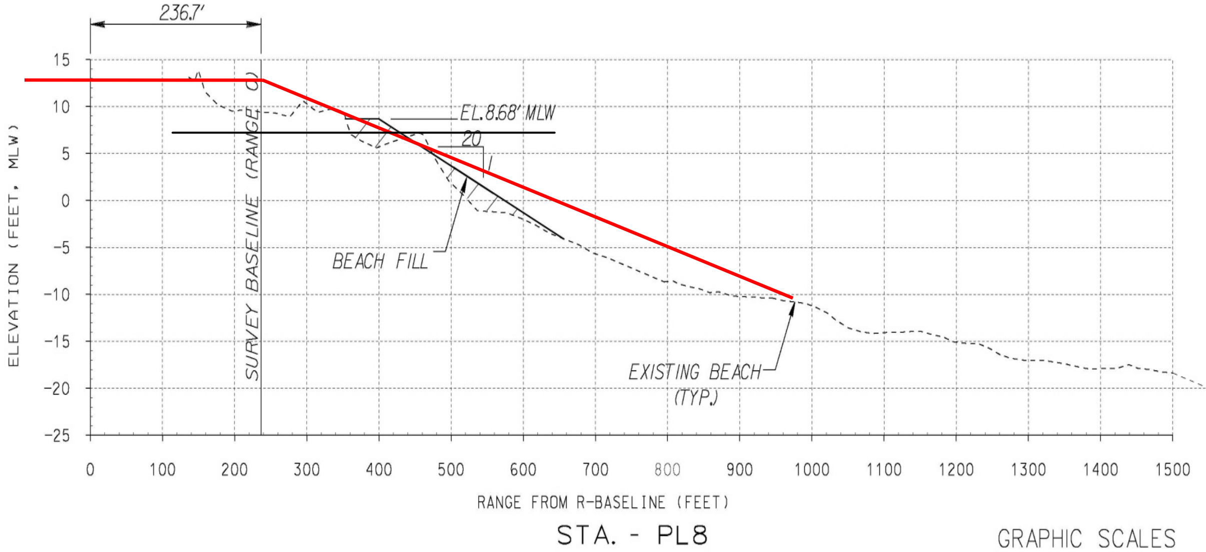
(EXISTING PLAN)



(PROPOSED CHANGE)



Option 1 – Build higher berm and stack beach higher

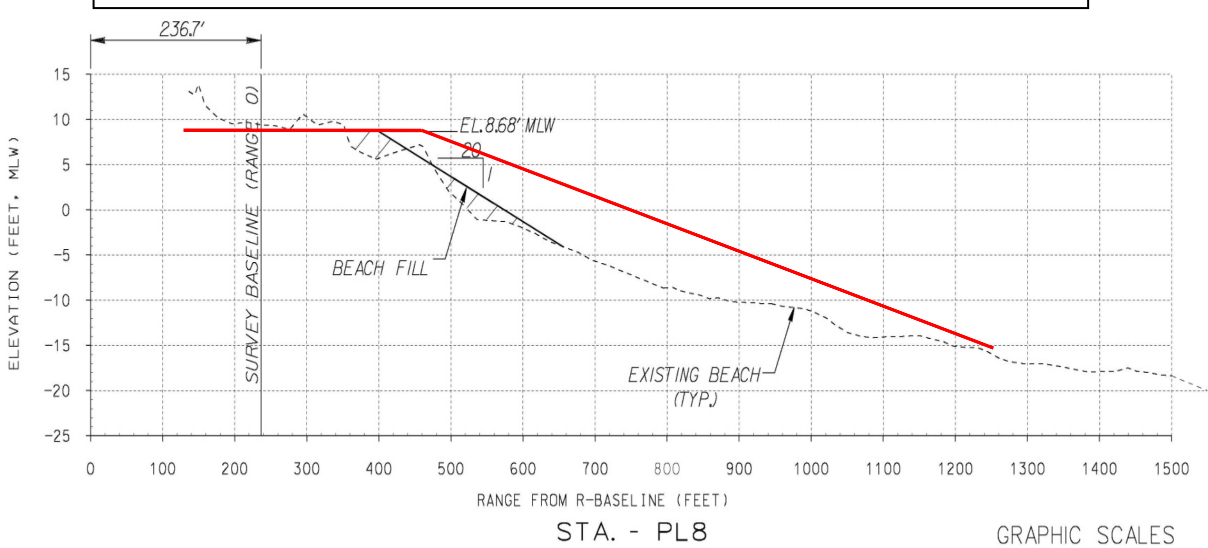


NOTES:

1. SEE DWG. C 103 FOR BEACH DISPOSAL AREA SURVEY NOTES.

2. PERMITTED BEACH FILL TEMPLATE IS FULL AT THIS STATION. CONTRACTOR SHALL PERFORM PRE-FILL SURVEY OF BEACH DISPOSAL AREA FOR USE BY CONTRACTING OFFICER TO ADJUST DISPOSAL WHERE NEEDED.

Option 2 – Keep same berm elevation and extend toe farther out



NOTES:

1. SEE DWG. C 103 FOR BEACH DISPOSAL AREA SURVEY NOTES.

2. PERMITTED BEACH FILL TEMPLATE IS FULL AT THIS STATION. CONTRACTOR SHALL PERFORM PRE-FILL SURVEY OF BEACH DISPOSAL AREA FOR USE BY CONTRACTING OFFICER TO ADJUST DISPOSAL WHERE NEEDED.

ASSUMTIONS AND ESTIMATES:

Current Area C and G unit cost estimate for mechanical excavation and scow barge transport and disposal to the ODMDS is approximately $60/cy with 12 hr operation restriction. If operation time restriction is removed, price will lower to perhaps **$45/cy**; Assume lower cost for this comparison.

Pipeline dredging from Area C and G to beach nearshore estimated between $10 and $15/cy; Assume **$12.50/cy.**

Quantity can vary, assume **200,000 cy** for comparison.

Potential cost avoidance calculated in the following table.

COST ESTIMATE WORKSHEET				
DELETIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Mechanical excavation	CY	200,000	$45	$9,000,000
with scow barge transport				$0
and disposal at ODMDS				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Deletions		**$9,000,000**
ADDITIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
Pipeline dredging and	CY	200,000	$12.50	$2,500,000
placement at beach				$0
nearshore				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
=================	==========	===========	============	============
		Total Additions		**$2,500,000**
	Net Cost Decrease			**$6,500,000**
	Mark-ups	**0.00%**		**$0**
	Total Cost Decrease			**$6,500,000**


SETTLING
BASIN
ENTRANCE
CHANNEL
INNER
CHANNEL
TURNING
BASIN
TO ODMDS

(4) – (Proposal) Eliminate reinforcement and deepening of slip bulkheads

ORIGINAL DESIGN: Current plan calls for bulkhead reinforcement and/or deepening for Slips 1,2 and 3 (see map below).

PROPOSED DESIGN: Updated project footprint indicates that there may be no significant stability degradation of existing bulkheads negating need for this work.

ADVANTAGES:

Keeps project strictly within scope.

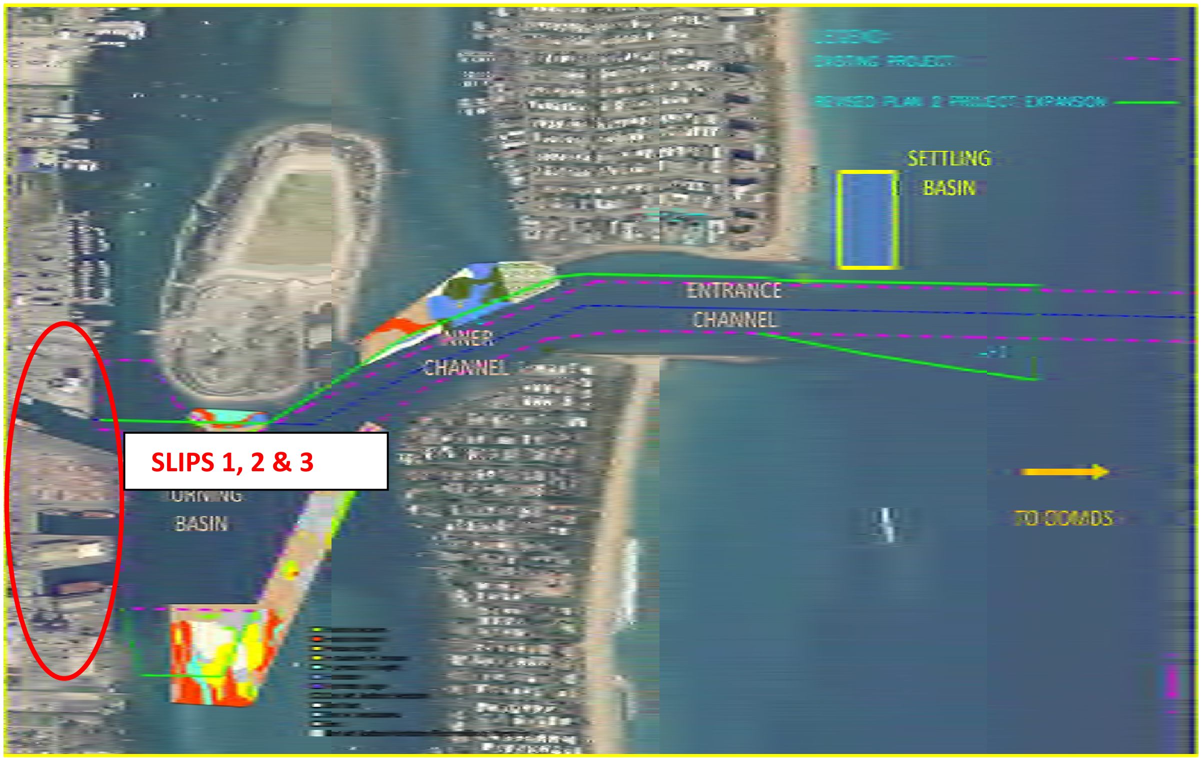
DISADVANTAGES:

Possible anticipation of slip Port regarding bulkhead improvements.

JUSTIFICATION: Deeper drafting vessels berth on the north-south docks and not in these slips. The slips themselves do not need to be deepened as part of this project. Updated channel alignment indicates that proposed channel deepening excavation will not impact the stability of the existing slip bulkheads. Cost avoidance and the potential for unanticipated structural need once if the bulkheads are improved are significant.

Estimated cost avoidance is shown on the following table.

Current Plan



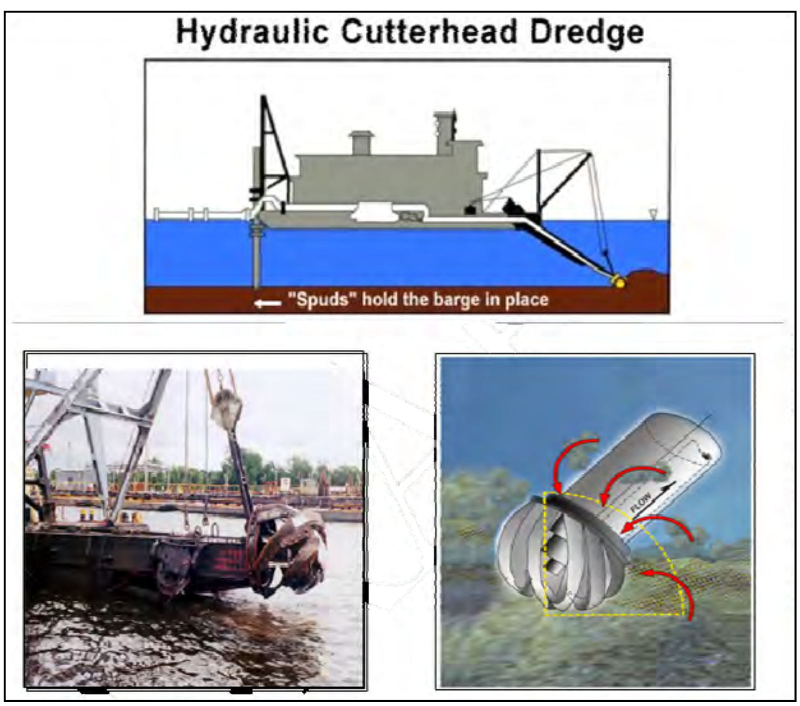
COST ESTIMATE WORKSHEET				
DELETIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
(From Current Plan		0	$0	$0
Cost Model)				$0
Marginal Wharf Slip 1 & 2	LS	1	$8,000,000	$8,000,000
Bulkheads				$0
				$0
Marginal Wharf Slip 3	LS	1	$3,000,000	$3,000,000
Bulkheads				$0
				$0
Slip 3 Bulkhead Deepening	LS	1	$2,000,000	$2,000,000
				$0
				$0
				$0
================	==========	===========	============	============
		Total Deletions		**$13,000,000**
ADDITIONS				
ITEM	**UNITS**	**QUANTITY**	**UNIT COST**	**TOTAL**
				$0
(none)		0	$0.00	$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
				$0
================	==========	===========	============	============
		Total Additions		**$0**
	Net Cost Decrease			**$13,000,000**
	Mark-ups	**0.00%**		**$0**
	Total Cost Decrease			**$13,000,000**

<u>(5) Obtain permit variances to allow greater flexibility with turbidity</u> – Dredging equipment uses either pipeline or mechanical means to transport material from the substrate to the surface. Pipeline dredges use water to pump the dredged material as slurry to the surface and mechanical dredges use a bucket-type device to excavate and raise the material from the *channel* bottom. The most common pipeline dredges include cutter head-suction, and hopper dredges; the most common mechanical dredges include clamshells, backhoes, and marine excavator dredges.

Pipeline dredging (as opposed to mechanical) could be a great cost savings to the project. However, if used, it may contribute to temporary increased turbidity at the discharge area, as the slurry mix is pumped out. Permit variances of this nature are not uncommon, and could be obtained, as long as the project demonstrates that no adverse impacts to the environmental resources due to short term increase in turbidity would occur.

Pipeline delivery to water bottoms may also cause temporary turbidity that may exceed normal allowable limits. Measures to minimize such should be implemented but a temporary variance may be necessary.

First, it should be confirmed that a pipeline dredge could operate within the permitted turbidity allowable threshold (permitted amount such as 29NTUs). The permit variance should only be pursued if increased turbidity will be foreseeable. Second, in order to show that higher turbidity cannot be avoided, it may be helpful to check past O&M information which should show where higher NTUs have occurred in the past in the project area.



(6) Consider capping non-select dredged material with sand to meet fill area requirements While no specific location(s) has been indentified to date, a situation may arise where an upland and/or submerged area may need a significant dept of fill but should be surfaced with select sand. It is possible to utilize interior dredged material (believed to be a mixture of sand and soft rock) to fill the base of the receiving void and cap it with sand from exterior area (or identified suitable sand interior area). While this would not be appropriate for a beach section, possible application to such an area such as a deep submerged hole to be raised, capped with the intent for seagrass growth, or, perhaps an upland fill area (no exposed to regular wave action) where a mixed sub-base and sand surface would be suitable.

(7) Develop the Port's DMMA on Peanut Island; raise dikes on FIND DMMA and improve dikes on Port DMMA and empty the port side of Peanut Island and use it for beneficial use

The Port of Palm Beach has an existing DMMA on Peanut Island that is approximately half full. Should the port agree and capacity can be obtained within the Port's DMMP, it is suggested that this area also be considered for new or O&M dredged material measures. Dike raising and other activities could make these attractive dredged material management measures. It has also been stated that contained dredged sediments can be used for habitat creation opportunities. In a like manner, the FIND DMMA dikes could be raised to gain additional capacities.

(8) Segregate rock and/or other select material for various specific utilizations - It is recommended that beneficial use options for rock and other select be considered. While processing dredged material is costly and will require a processing site, potentially high-cost offshore disposal can be avoided. Options include, but may not be limited to the following:

Placing rock inshore to build breakwaters for sea grasses. The project may get credits for required mitigation. For this purpose the rock would not need to be further processed, i.e. crushed or segregated and it would be easily feasible for both the rock from the Turning Basin and from the Entrance Channel, cut-1 and cut-2.

Mining and processing non-beach compatible dredged material composed of rock fragments and unconsolidated sediments from the Turning Basin for industrial upland use (i.e. rip-rap, cement production, roadway construction). Additional sampling and testing would be required to see if the dredged material would be of the required quality. However, it could be an option with potentially significant cost savings and should be considered, especially if fuel prices raise and ODMDS disposal would get too expensive.

Processing the rock from Entrance Channel, cut-1 and cut-2 into sand-sized fractions so that it can be placed on beach. This may be feasible only for dredged material composed of sandstone. The rock present in the entrance channel, cut-1 and cut-2 is composed of sand and shell and is often described as coquina rock and could be processed like described in attached article. If approximately 300,000 cy dredged rock would be processed potential revenue of $24 million could be produced, which could offset the costs for processing or even leave a profit. However permitting could be an issue.

(Rough cost estimate notes):

- Processing to prepare rock for beach placement:

$500,000 Assume three crushers are needed to convert big rock to medium size, medium

size to small, and small to sand; ref. information located at:
http://www.alibaba.com/product-gs/443820285/Stone_crusher_machine_price.html?s=p

- Rock from scow to land:

Processed sand (retrieved from sandstone) is sold $110/ton – 1 cy sand is 2700lb = 1.35 ton = $80/cy sand
Estimated 300,000 cy dredged rock could potentially create $24 million in revenue, which could offset the costs for processing or even leave a profit; ref. information located at:
http://fuelfix.com/blog/2011/09/15/sand-mines-boom-along-with-fracking/

(9) Use peanut island DA for processing - This comment suggests that Peanut Island be considered as a material processing area if needed. The island has an existing unloading area with roads and sufficient lay down areas. The island FIND DMMA was recently unloaded and recreation facilities installed.

(10) Investigate Upland Disposal Options – There are currently no known opportunities for upland disposal in the Lake Worth Inlet Area, other than Peanut Island, which was specified in the Palm Beach Harbor Preliminary Assessment (PA) (see **Item 2**). The PA was completed in 1996 to assess 20 years of capacity for maintenance dredged material. The PA concluded that there are 5 major options for placement of material. First, any beach suitable material should be placed on the beach south of the inlet. Any material not suitable for direct beach placement can go into four areas: 1) nearshore (the state allows material with higher percentages of fines not suitable for beach placement to be placed), 2) upland area on Peanut Island (in the sponsor owner disposal area on the southern portion of the island), 3) in the borrow pit near interstate 95 (was currently available at the time for beneficial use), and in the 4) interim ODMDS. (PA, pg. 16). The new ODMDS was since established to replace the interim site. The new site is 4.8 nmi offshore, has a depth range of 525 to 625 feet, and an area of 1 nmi. (Palm Beach Harbor 2004 SMMP,pg. 2).

Placement of dredged material in upland locations should be processed/segregated such that re-use and utilization may be optimized.

(11) Use controlled placement scheme to place rock at interim ODMDS to create habitat
The comment suggests that a controlled disposal scheme can be used at the interim ODMDS to create additional habitat. As exhibited below, mounds can create subsurface ridges that can develop habitat. Turbidity and other concerns can be addressed by using a specified release scheme to place material at specific locations within the interim ODMDS. Releases can be made at specific coordinates within prescribed boundaries such that subsequent releases are contained to limit material migration and turbidity.

<u>(12) Use sand shooter (rainbow) to create seagrass in substrate limited areas</u> – This type of operation should be mentioned in project documentation so it can be allowed for consideration during later stages of project development. Rainbow material placement is known to be a favorable means that accommodates seagrass.

<u>(13) Optimize "expanded" settling basin design and advanced maintenance footprints</u>

Longshore sediment transport from the north to south creates a chronic shoal in the entrance channel which requires annual and emergency maintenance. An existing settling basin north of the entrance channel has not prevented the chronic shoaling and maintenance requirements. An "expanded" settling basin has recently been authorized separate from the navigation feasibility study. The design of the "expanded" settling basin was based on the existing sediment transport capabilities available at the time. Advances in sediment transport modeling capability allow a reanalysis and improvement of the "expanded" settling basin design which has the potential to increase performance and decrease cost. The settling basin performance has a significant impact on entrance channel design, including advanced maintenance within the channel. Modification of the original "expanded" settling basin size, shape, and location will result in more efficient trapping of littoral sediment and reducing the volume of the shoal in the entrance channel. However, preliminary analysis indicates that the settling basin, due to limitations related to north jetty stability impacts, may not trap enough sediment to eliminate the shoal in the channel. Solutions which would work in combination with an optimized "expanded" settling basin to reduce the entrance channel shoal, so that maintenance events can be limited to every other year, include modifying existing channel advanced maintenance, optimizing the sand transfer plant, and construction of a groin north of the settling basin.

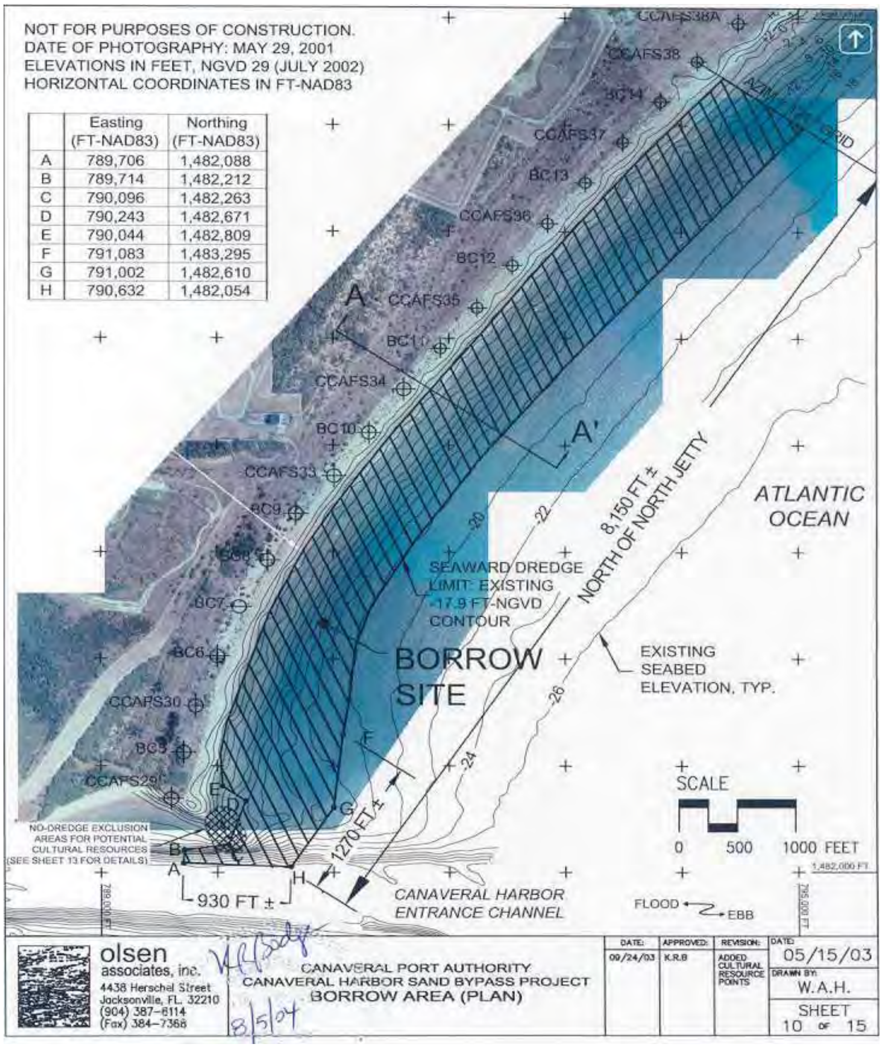
(14) Optimize channel advanced maintenance/ vertical settling basin – Advanced Maintenance of 4 feet is authorized uniformly across the entrance channel and along a portion of its length. Since the chronic shoal occurs in a relatively small area just south of the north jetty, it would be advantageous to provide additional advanced maintenance depth in this area and reduce advanced maintenance in other parts of the entrance channel where it is not required. This design is potentially limited by the TSP project depth and its impact on jetty stability.

(15) Optimize Sand Transfer Plant – The existing sand transfer plant (STP) is a moveable hydraulic suction dredge with a suction head suspended from a rotating boom which pumps 250,000 cy/yr. However, the plant does not operate during the summer because of lack of sediment within the reach of the existing boom during these months. Increasing the area which the STP can reach could reduce the amount of sediment that is transported between the north jetty and settling basin and into the channel. The STP reach could be extended by extending the boom length or changing the design of the plant. Several options include suspension of the suction head and or a pump from a crane which would allow a longer boom, adding a track along the north jetty on which the crane/ suction head/ pump could travel and more extensive modifications which include submerged pump(s) and fluidizers.

(16) Consider construction of a groin north of "expanded" settling basin – Construction of a groin north of the settling basin would work in combination with an optimized "expanded" settling basin to reduce the entrance channel shoal by diverting sediment from the nearshore into the "expanded" settling basin. The length of the groin would need to be similar to the north jetty to be effective. Depending on stone required this option may not be cost effective. Use of local stone, if allowed, could make this option more cost effective. Additionally, the sediment captured by the groin would be available to back-pass to the beach north of jetty if needed. There will likely be significant public opposition, however, to any new beach structure in the reach.

(17) Consider Canaveral-type sand bypass to beach – Canaveral bypasses about 1 MCY every 6 years from the north jetty fillet to the beaches south of the inlet. This is generally similar to the present operation at Lake Worth Inlet but dredging extends to Mean High Water north of the jetty. The dredge (borrow) area is between the existing mean high water line and the -17.9 ft NGVD'29 contour, between the inlet's north jetty and 8350 ft north thereof (see figure below). If the Lake Worth Inlet optimized settling basin extended to the MHW line, then entrance channel shoaling may be reduced significantly with no other measure required. However, this would impact sediment available to the Sand Transfer Plant. Reference information may be found at:

http://bcs.dep.state.fl.us/env-prmt/brevard/issued/0220629_(Canaveral%20Harbor%20Bypassing)/001_JC/Final%20Order/APPROVED%20Phys_Mon_Plan%20(Rev%202009).pdf http://bcs.dep.state.fl.us/env-prmt/brevard/issued/0220629_(Canaveral%20Harbor%20Bypassing)/001_JC/Final%20Order/Canaveral%20Harbor%20Bypass%20Plans%20(08-25-04).pdf



(18) Optimize the reef at Peanut Island – ***This and related comments below regarding the beneficial use of dredged material also recommend that project disposal measures address Section 204 and Section 207 implications and opportunities.*** The County of Palm Beach has identified several non-Federal restorations areas that could be used for the Beneficial Placement of Dredged Materials or mitigation areas (see list and map in **Item 1**). There are two sites at Peanut Island. One is a reef and the other is a shoal area. New work dredged materials will be a mixture of sand and rock varying in sizes. This comment suggests that the existing reef site should be included as a likely candidate for beneficial placement. New work rock could be sorted and used for reef materials. Transport and sorting of dredged materials can be done efficiently because there is an existing barge unloading area and interior roads that were recently used to unload the DMMA. The site can readily receive and distribute materials as needed. The existing transportation facilities also make Peanut Island a cost effective material handling and re-handling site.

(19) Dredge the Peanut Island shoal and use the area to create seagrass mitigation –
The Peanut Island shoal contains good quality sands that could be used in capping work that may be needed to beneficially dispose project new work materials at other locations (see map in **Item 1)**. The shoal area has been offered by non-Federal interests as a likely candidate for a sea grass creation area. This comment suggests that this site be dredged to a depth needed to establish sea grasses, the excavated sand be re-used at another location and new work rock be used to install small breakwater mounds for energy dissipation to facilitate establishment.

(20) Use of dredged rock for placement into existing county approved reef sites –
This comment suggests that the use of county approved reef sites be included as beneficial use opportunities and sites in project documentation (see map, **Item 1**). Coordination with PBC for size and available locations for adding to already approved sites could be done during later stages of project development.

(21) Buy privately owned submerged lands, then put them under conservation easement and donate them to state park – It may be possible to obtain privately owned water bottoms and place dredged material (beneficial use) to create land for purposes to include public recreation, education, and outreach. Such locations are not identified at this time and further investigation is needed.

(22) Partner with the resource agencies to identify mitigation and beneficial use sites -Several options have been identified in the project area that could be implemented for needed mitigation and/or beneficial use. This comment suggests that USACE and the non-Federal sponsor coordinate with the resource agencies to determine the most effective sites for mitigation and the beneficial use of dredged materials. Actual implementation of mitigation by local entities may also be considered (see next item).

(23) Allow non-federal interests to complete project and/or work-in-kind mitigation and beneficial use features – This comment suggests that the mitigation and beneficial use of dredged material opportunities be screened to form a set of likely work that could be more efficiently performed by the non-Federal sponsor or their selected sub-entities. The County of Palm Beach has an extensive history and staff expertise in successfully installing these type public works. Increased efficiency and better quality could be realized by having county lead these efforts. The proposed mechanism would have the Implementation Section of the Decision Document identify having the non-Federal sponsor perform this work as part of the project and/or work-in-kind.

(24) Install mitigation features early to avoid temporal loss of habitat – This comment piggybacks the above comment by suggesting that the non-Federal sponsor be permitted to install mitigation features pre-base year in an effort to avoid temporal habitat loss. Temporal lag is used to calculate mitigation acreage needed but in this case, anticipated loss of habitat from temporal lag may be small and may not result in significant mitigation cost saving. However, this beneficial use of dredged material for mitigation could lower disposal costs.

(25) Create mangrove islands – Creation of mangrove islands should be considered as one of the beneficial use opportunities for later project development and documented in the decision document. These are likely opportunities available in Lake Worth Lagoon System.

(26) Have a suite of mitigation options, rather than one option, for authorized report (and have NEPA cover all options) This comment suggests that a suite of mitigation options and sites be included in project documentation to reduce cost risks and to afford flexibility for prospective contractors to adjust to the most suitable equipment mix at the time of offering. This comment will also reduce long term risks associated with the time gap between project feasibility studies and mitigation features installation (sometimes 3 or more years). Providing a suite of options would further support the USACE required Adaptive Management plan. Finally, working with Palm Beach County will allow for multiple options since the County has a proven success record with similar project planning and implementation activities.

(27) Develop recreation alternatives for inclusion into recommended plan evaluations and explore the use of dredged materials in the same. (Spec Item 68) Recreation opportunities exist in the project area. This comment suggests that recreation measures be developed and evaluated as recreation alternatives for inclusion in recommended plan evaluations. In addition, project dredged material should be considered to enhance related lands and resources.

(28) Combine entrance channel area deepening with regular dredging maintenance cycle - Current entrance channel maintenance dredging occurs on a fairly regular annual frequency unless there is a storm event. Implementing construction concurrent with this annual cycle would eliminate an extra contract execution, contractor mobilization, etc. and avoid an extra cost currently estimated at $5 - $6 million.

(29) Execute multiple dredging contracts – It would appear that multiple dredging contracts would be a more efficient means of implementing this project versus a single procurement. First, overall contract value currently estimated in the $50 - $100 million range, while not unprecedented, would be a very large individual contract. Additionally, the current plan indicates two different required dredging and disposal means for the entrance channel/settling basin (exterior) area versus that for the interior channel and turning basin. The former calls for probable cutterhead dredging with hydraulic pipeline material transport to nearby beaches with

possible scow barge transport of excess material to the designated offshore disposal site (ODMDS). The latter, currently indicates mechanical excavation with scow barge transport to the ODMDS. Interior channel/turning basin dredging will also be constrained with manatee protection requirements that will likely restrict operations. Planning and design may, however further develop and identify that cutterhead dredging with hydraulic pipeline material transport can be employed in the interior area as well as the exterior (see **Item 1**). Total project cost may also be significantly reduced for a number of factors including this possible change. As such, execution of a single or multiple contract projects should be further evaluated with consideration given to these possible changes.