APPENDIX A

ENGINEERING

FINAL
FEASIBILITY REPORT
AND ENVIRONMENTAL IMPACT STATEMENT
PORT EVERGLADES HARBOR NAVIGATION STUDY
BROWARD COUNTY, FLORIDA

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1 INTRODUCTION

1.1 LOCATION

1. Port Everglades is located on the southeast coastline of Florida, approximately 23 miles north of Miami and 48 miles south of West Palm Beach (Figure A- 1). The port falls within the three cities of Dania, Fort Lauderdale, and Hollywood, as well as unincorporated Broward County. The full extent of the port covers over 448 acres of submerged land and 1,742 acres of upland territory. It is one of Florida's deepest ports.

2. Port Everglades has close proximity to north-south and east-west ocean trade lanes, interstate and state highway systems, extensive railroad networks, and the Fort Lauderdale/Hollywood International Airport. On the north, the port is bordered by residential and commercial developments, including private docks and marinas accessible from the Intracoastal Waterway (ICWW). Federal Highway 1, the airport, and additional residential and commercial developments lie to the west. At the southern border is Westlake Park adjoined by several private marinas. A narrow barrier island lies to the east occupied by John U. Lloyd State Park, U.S. Coast Guard Station Fort Lauderdale, the U.S. Navy South Florida Testing Facility, and Nova Southeastern University Ocean Science Center.

1.2 STUDY PURPOSE

3. Economic forecasts predict growth in containerized cargo, cruise, liquid bulk, and general cargo traffic at Port Everglades. The purpose of this feasibility study is to investigate improvements to the Federal navigation project at Port Everglades to accommodate this growth. All major basins and channels within the port were investigated. This engineering appendix provides detail regarding engineering studies necessary for development and analysis of proposed structural plans.

2 HISTORIC AND EXISTING CONDITIONS

2.1 HISTORY

4. Initial construction of Port Everglades began in 1925 and continued through 1928. Construction was accomplished through the excavation of Lake Mabel, a shallow water body separated from the Atlantic Ocean by a low sand ridge. Originally called Bay Mabel Harbor and later Hollywood Harbor, the port was the result of a cooperative effort between the cities of Hollywood, Fort Lauderdale, and a private investor. The Federal government became involved with the port after the passage of the River and Harbor Act of 1930 which provided the locally constructed project with Federal maintenance. The early harbor design was simple, consisting of a 7,300 foot long entrance channel; a single 1,200 foot long, 300 foot wide slip (Slip 1); two bulkheads; two jetties; two submerged breakwaters; and a single turning basin. Initial project depth was 35 feet. Since 1931, 11 Federal maintenance dredging projects at Port Everglades have been completed.

Figure A- 1. Study Location

5. Initially serving as the post of a battalion of marines known as the Fleet Marine Service and a hub for minor commercial trade, Port Everglades began full scale commercial services with the arrival of regularly scheduled calls by the Bull Line in 1931. This was followed by passenger ships of the United Fruit Company, commercial vessels of Hamburg American and Cunard Anchor Lines, and tankers of the petroleum shipper Aeroland Oil Company. The increase of commercial activity through the 1930's lead to the first port enlargement project, the construction of a new berth known as Slip 2.

6. In the 1940's Port Everglades dedicated a significant portion of its resources to military operations. By the 1950's, however, commercial tonnage had risen, prompting the expansion and deepening of the existing turning basin to 37 feet and deepening of the entrance channel to 40 feet. Improvements to the port's infrastructure were also made including construction of new buildings, open storage areas, roads, railways connections, utilities, and the addition of Slip 3.

7. The 1960's marked significant steps in port land development. Early in the decade, Florida Power & Light Co. brought four operating units on-line at its Port Everglades Plant. At this time, petroleum was the port's predominant commodity leading to significant expansion of the storage tank farm. Such strong growth prompted the initiation of a Master Plan process in 1965 followed in 1967 by the acquisition of 300 additional acres of land that would decades later become the Southport cargo terminal.

8. In the early 1970's the Federal Harbor Deepening Project was initiated. This provided for widening and deepening the port's entrance channel to 450 feet and 45 feet respectively, deepening the main turning basin to 42 feet, making improvements to the Pier 7 channel, extending Slip 2, and adding cold storage space to existing facilities. The late 1970's saw the opening of the Foreign Trade Zone No. 25 and the first rail-mounted container gantry crane.

9. Continued increases in commercial activity into the 1980's lead to the purchase of the first port-owned gantry crane in 1981 and implementation of proposals from the Master Plan 1984-2000, including the construction of the Southport facilities. By the late 1980's a third gantry crane was in place, the eighth cruise terminal opened, and a total of 30 berths were operational.

10. Port development continued through the 1990's beginning with the completion of the Southport Turning Notch in August of that year. In 1991, the Greater Fort Lauderdale/Broward County Convention Center at Northport opened, two parking garages were completed, and further cruise and cargo facility enhancements were made. In 1993 three post-Panamax, low profile gantry cranes were added to Southport facilities followed in 1995 by completion of the initial phases of the Southport Container Terminal. In the late 1990's three additional post-Panamax gantry cranes were acquired as well as approximately 270 acres of land for additional development adjacent to the Southport Container Terminal.

11. Beyond the year 2000 commercial activity is expected to continue to grow and diversify. Plans for further port development to accommodate increased berthing and cargo demands as well as increased vessel size are currently underway.

2.2 SITE LAYOUT

12. The current layout of Port Everglades is shown in Figure A- 2. Access to the Port begins at the sea buoy marking the outer limit of the port's entrance channel. The entrance channel itself is a 500 foot wide, 45 foot deep stretch that runs 1.7 miles due west, passing between north and south jetties at either side of the inlet entrance, and into the main turning basin. The main basin measures 1,200 feet from east to west and 2,450 feet north to south. Mean lower low water depth in the basin is 42 feet. Beyond the main basin, Port Everglades is divided into three main regions, Northport, Midport, and Southport with a total of 33 active berths.

13. For purposes of investigation and design, Port Everglades can be further sub-divided into nine components (Figure A- 3):

(1) Outer Entrance Channel (OEC), extending from the outer sea buoy to the harbor jetties

(2) Inner Entrance Channel (IEC), extending from the harbor jetties to the interior of the harbor

(3) Main Turning Basin (MTB) , covering the main bulk of the northern interior where vessel turning occurs

(4) North Turning Basin (NTB), the northern extension to the MTB

(5) South Turning Basin (STB), the southern extension of the MTB

(6) Widener Shoal (Widener), area covering the shallow shoal located in the southeast corner of the MTB

(7) Southport Access Channel (SAC), the channel that extends south from the MTB

(8) Turning Notch (TN), the turning basin located midway down and to the west of the SAC

(9) Dania Cutoff Canal (DCC), the boat canal extending westward from the south end of the SAC

14. Project components are described in greater detail under Section 3.4 (**Description and Engineering Analysis of Project Components).**

2.3 METEOROLOGICAL AND OCEANOGRAPHIC CONDITIONS

2.3.1 <u>CLIMATE</u>

14. The climate at Port Everglades is categorized as tropical, with a mean annual temperature of 75°F and average humidity range of 60% to 87%. The average annual rainfall is 60 inches with about 65% occurring during the summer and early fall months (June to October).

Figure A- 2. Port Layout and Berthing

Figure A- 3. General Layout of Project Components

2.3.2 SEASONAL WINDS AND STORMS

15. During the summer months Port Everglades experiences predominantly east and southeast Trade Winds. This information is based on both offshore and upland wind data.

16. Measured offshore wind data is collected as part of the National Data Buoy Center (NDBC) Coastal-Marine Automated Network (C-MAN) program. The nearest C-MAN station to Port Everglades is located at Fowey Rocks, Florida, approximately 13 miles southeast of Miami (Figure A- 4). Meteorological observations at Fowey Rocks cover a period from January 1991 to December 2009.

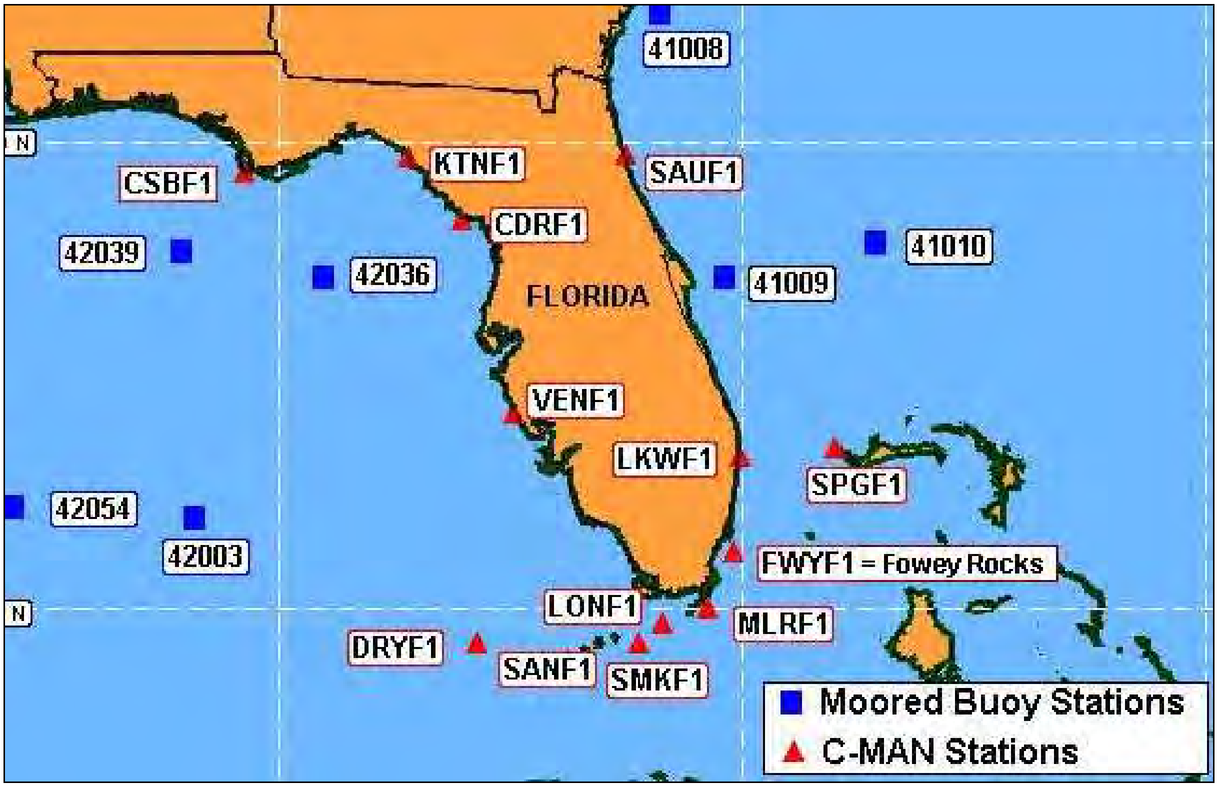

Figure A- 4. Fowey Rocks CMAN Station Location

17. In addition to measured offshore wind data, hindcast wind data are available from the U.S. Army Corps of Engineers (USACE), Wave Information Study (WIS) Program. WIS hindcast data are generated using the numerical hindcast model WISWAVE (Hubertz, 1993). WISWAVE is driven by wind fields overlaying a bathymetric grid. Model output includes significant wave height, peak and mean wave period, peak and mean wave direction, wind speed, and wind direction.

18. There are 523 WIS stations along the Atlantic Coast. WIS station 467 is considered to be the most representative of offshore deepwater wind and wave conditions for Port Everglades. Station 467 is located at Latitude 26.08N and Longitude 79.92W, approximately 11 miles due east of the Port Everglades Harbor jetties. The WIS hindcast is provided at 1 hour intervals and covers a period from 1980 to 1999.

19. Upland wind data is most often collected at airports. At the time of this report wind data from the Fort Lauderdale/Hollywood Airport, located just east of Port Everglades was not available for analysis. However, upland wind data collected as part of the University of Florida's Florida Automated Weather Network (FAWN) was available at a location approximately 7 miles west of the Port (Figure A- 5). The FAWN data set was obtained from weather station #420 and covers a time period from January 2001 through December 2010.

Figure A- 5. FAWN Weather Station Location

20. Table A- 1 provides a summary of average wind speeds and percentages of occurrence (based on direction) for both hindcast (WIS) and measured (C-MAN/FAWN) data. Review of both measured and hindcast offshore data reveal similar overall trends in direction and magnitude. Inland wind data displays similar trends in direction, but experiences a decrease in overall magnitude due to dissipation of energy as it travels over land.

21. Due to the variability of wind conditions in South Florida throughout the year, a further breakdown of data provides a summary of seasonal conditions (Table A- 2).

22. Between December and March, frontal weather patterns driven by cold Arctic air masses can extend as far as South Florida. These fronts typically generate winds that veer to the northwest before the frontal passage, and to the northeast behind the front. This post-frontal "Northeaster" behavior is responsible for the increased intensity of wind speed seen in the northeast sector winds during the winter months.

23. Daily breezes onshore and offshore result from differential heating of land and water masses. These diurnal winds typically blow perpendicular to the shoreline and have less magnitude than Trade winds and Northeasters. Daily breezes account for the general shift to east/southeast winds during the summer months when Northeasters no longer dominate.

Table A- 1. Average Wind Conditions

Wind Direction (from)	Fowey Rocks C-MAN Station (1991 – 2009)		WIS Station #467 (1980 – 1999)		FAWN Station #420 (2001 – 2010)	
	Percent. Occur. (%)	Average Wind Speed (mph)	Percent. Occur. (%)	Average Wind Speed (mph)	Percent. Occur. (%)	Average Wind Speed (mph)
North	6	14.1	8	14.0	12	3.5
Northeast	14	16.9	16	14.0	8	3.9
East	30	15.4	32	12.7	24	7.7
Southeast	20	14.0	29	11.1	21	6.3
South	11	13.9	9	10.6	10	5.5
Southwest	5	13.1	5	10.7	7	4.4
West	6	13.7	5	12.4	9	4.3
Northwest	8	15.1	6	14.4	10	4.3

Table A- 2. Seasonal Wind Conditions

Month	Fowey Rocks C-MAN Station (1991 – 2009)		WIS Station #467 (1980 – 1999)		FAWN Station #420 (2001 – 2010)	
	Average Wind Speed (mph)	Dominant Direction (from)	Average Wind Speed (mph)	Dominant Direction (from)	Average Wind Speed (mph)	Dominant Direction (from)
January	17.25	E-NE	14.35	E-NE	5.31	N
February	15.75	E	14.48	E	5.46	E-NE
March	16.85	E	14.36	E	6.50	E
April	16.03	E-SE	12.75	E-SE	6.61	E-SE
May	14.16	E-SE	11.39	E-SE	6.26	E-SE
June	12.27	E-SE	9.95	E-SE	4.93	E-SE
July	11.75	E-SE	9.91	E-SE	4.70	E-SE
August	11.73	E-SE	9.85	E-SE	4.74	E-SE
September	13.00	E	10.71	E	5.24	E
October	15.81	NE	13.23	NE	5.71	E
November	17.42	NE	15.05	NE	5.37	E-NE
December	16.59	E-NE	14.24	E-NE	5.40	E-NE

2.3.3 HURRICANES AND STORM SURGE

Hurricane season for the Atlantic runs from June 1 to November 30. During these months, hurricanes develop in the tropical and subtropical latitudes of the Atlantic Ocean north of the equator. Hurricanes are characterized by low barometric pressure, high winds in excess of 75 miles per hour, large waves, heavy rainfall, and surges. Such events have historically had significant impact to Port Everglades and the adjoining shorelines. Between 1889 and 2009, over 100 hurricanes have made landfall on the coastline of Florida. Figure A- 6 illustrates the locations of direct hits of hurricanes of ranking category 3 and above on the Saffir/Simpson scale

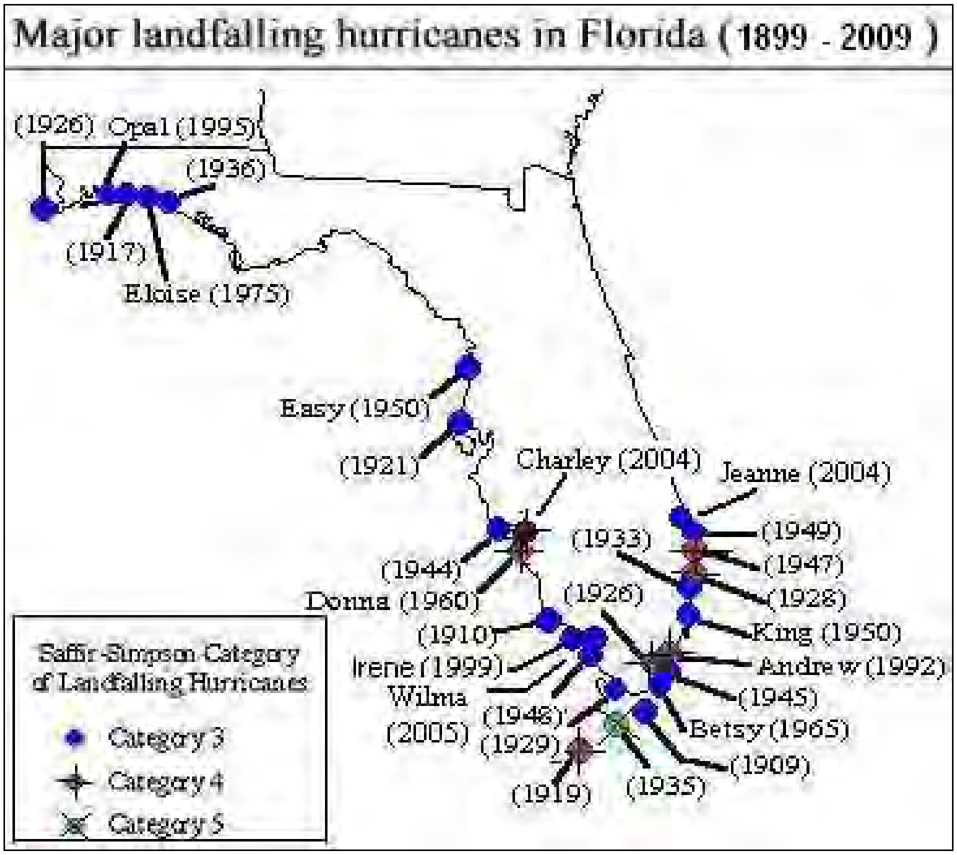

Figure A- 6. Hurricanes Achieving Landfall (1899 - 2009)

24. Storm surge is generally defined as an increase in water level that results from forcing by atmospheric weather systems, such as hurricanes. Storm surge elevations, based on storm event return period, for Broward County, Florida have been predicted by the University of Florida for the Florida Department of Transportation (FDOT) (Sheppard and Miller, 2003). These values are presented in Table A- 3.

Table A- 3. Storm Surge Frequencies and Elevations

Return Period (Years)	Surge Elevations (ft above MLLW)
	University of Florida
10	7.1
20	8.2
50	10.5
100	12.4
200	14.1
500	16.5

2.3.4 <u>SEA LEVEL RISE</u>

25. The geologic record of historical sea level variations indicates that both increases and decreases in global sea level have occurred. Both global cooling and warming contribute to sea level change. The National Ocean Service (NOS) has compiled long term records of measured water surface elevations along the Atlantic coast. This data is the basis for projecting future relative sea level rise at the Port Everglades Harbor.

26. Relative sea level (RSL) refers to local elevation of the sea with respect to land, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. It is anticipated that sea level will rise within the next 100 years. To incorporate the direct and indirect physical effects of projected future sea-level change on design, construction, operation, and maintenance of coastal projects, the U.S. Army Corps of Engineers (USACE) has provided guidance in the form an Engineering Regulation, ER 1110-2-8162 (USACE, 2013).

27. ER 1110-2-8162 provides both a methodology and a procedure for determining a range of sea level rise estimates based on the local historic sea level rise rate, the construction (base) year of the project, and the design life of the project. Three estimates are required by the guidance, a baseline estimate representing the minimum expected sea level change, an intermediate estimate, and a high estimate representing the maximum expected sea level change. Following procedures outlined in ER 1110-2-8162, Appendix B, baseline, intermediate, and high sea level rise values were estimated over the life of the project. Based on historical sea level measurements taken from NOS gage 8723170 at Miami Beach, Florida, the historic sea level rise rate was determined to be 2.39 mm/year (0.0078 ft/year) (http://www.corpsclimate.us/ccaceslcurves.cfm); the project base year was specified as 2017; and the project life was projected to be 50 years. Figure A- 7 shows the three levels of projected future sea level rise for the life of the project. From these curves, the baseline, intermediate, and high sea level rise values at the end of the 50 year life of the project were projected to be 0.39, 0.84 ft, and 2.25 ft, respectively.

28. The total regional sea level rise predicted by the three scenarios (baseline, intermediate, and high) will not have a significant impact to the performance of the Port Everglades project. Potential impacts of rising sea level include overtopping of waterside structures, increased shoreline erosion, and flooding of low lying areas.

29. <u>Overtopping</u>. Baseline and Intermediate sea level rise over the life of the project will have no impact to the proposed project structures. The proposed structures consist of a bulkhead system of sheetpile topped with a sloped riprap revetment that is designed to allow for tidal flushing of upland mangroves and other habitat (see Figure A- 78, Section 4.3.2). Presently the conceptual design of these structures includes a riprap revetment that extends from -5 feet MLLW to approximately +3 feet MLLW. While the baseline and intermediate sea level rise could result in some overtopping of the structure it would occur only during the highest of tides. Because the structure is already designed to accommodate a fair degree of overtopping (due to wave action and storm surge), the relatively small increase in overtopping due to the predicted increase in water depth will not adversely impact either the integrity of the structure or its intended purpose. The highest level of sea level rise could potentially result in nearly constant

overtopping of the structure as it is presently designed. However, such sea level rise is expected to occur at a given rate over a period of years, allowing for the application of adaptive management measures. Should the rate of sea level rise reflect the high scenario, the riprap design is adaptable and allows for additional and/or larger stone to be added as necessary.

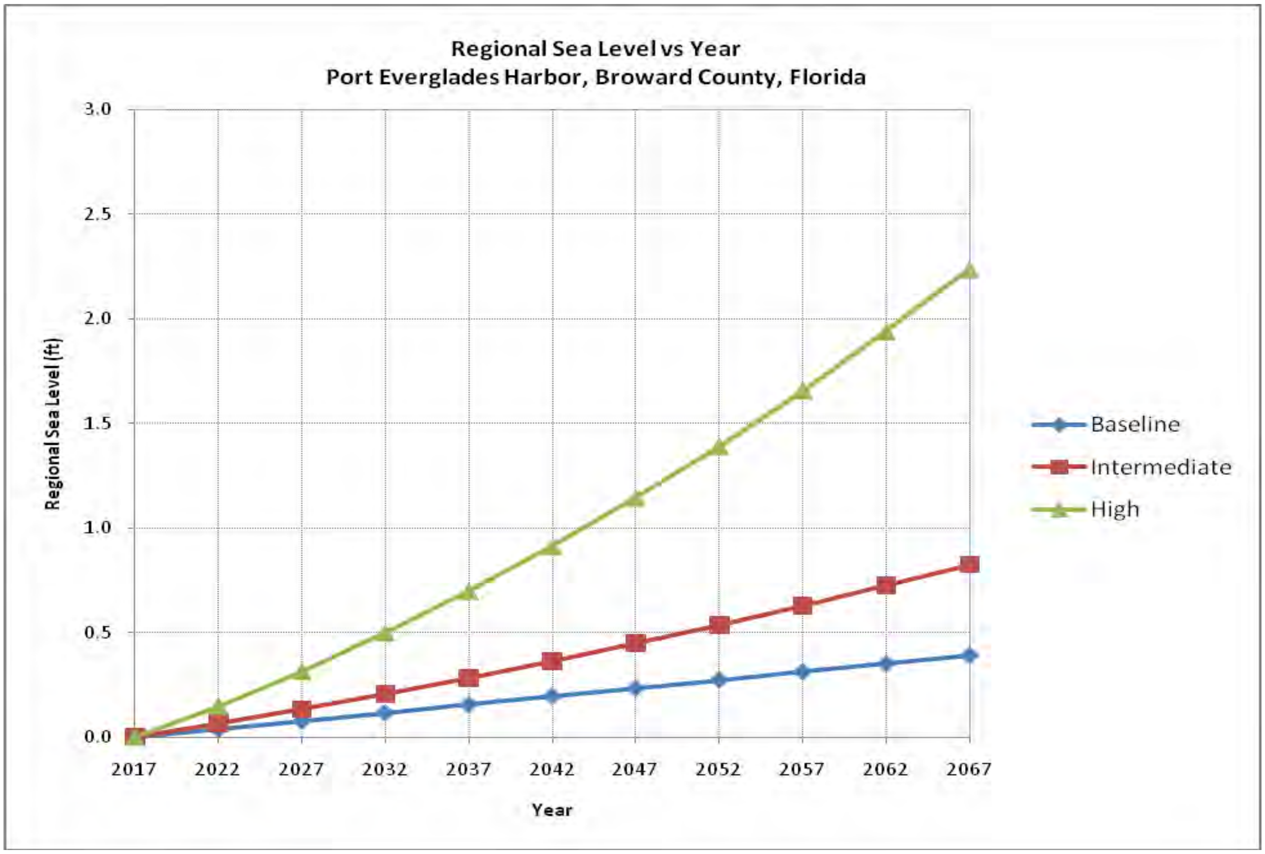

Figure A- 7. Projected Future Sea Level Rise at Port Everglades

30. Shoreline erosion and flooding. While there are regions of Port Everglades that may be susceptible to increased erosion and flooding, these regions are not within the scope of the present study.

31. In general, regional sea level rise (baseline, intermediate, and high) will not affect the functioning of the project alternatives or the overall safety of the vessel. While there is expected to be a small increase in tide range and storm surge penetration for all three scenarios, the structural aspects of the project will be either unaffected or can be easily adapted to accommodate the change.

2.3.5 TIDES

32. Three NOAA tide stations are located within Port Everglades (Figure A- 8). The first is in the Main Turning Basin near Slip 1 (Station 8722951), the second is located in the Southport Access Channel near berth 28 (Station 8722956), and the third is near the western port boundary along the Dania Cutoff Canal (Station 8722968). Tide datums at the Main Turning Basin station are based on a 3-year time series and a 19-year National Tidal Datum Epoch. Datums at the remaining two locations are based on a 1-month time series and a 19-year National Tidal Datum Epoch. Elevations of tidal datums for all three locations are provided in Table A- 4.

33. Tides at Port Everglades are semi-diurnal. Mean tide level is less than 2ft-MLLW throughout the Port, while storm tides can range from 3 to 10 ft above NAVD88 (~1 to 8 ft above MLLW) during severe hurricanes (South Florida Regional Planning Council, 2009).

2.3.6 CURRENTS

2.3.6.1 General

34. Two types of currents affect Port Everglades, offshore currents and currents within the harbor itself. Offshore currents affecting Port Everglades Harbor include littoral currents adjacent to the shoreline, inlet related tidal currents, and strong currents resulting from the proximity of the Florida Current, a component of the Atlantic Gulf Stream. Harbor currents arise from flood and ebb tides, river outflows, and power plant discharge.

2.3.6.2 Nearshore and Offshore Currents

35. Littoral currents may be classified as longshore or cross-shore currents. Longshore currents are caused by waves breaking at an angle relative to the shoreline. The most influential cross-shore currents are typically generated during storm events that may be characterized by short-term extreme wave and/or water level conditions.

36. Tidal currents are generated due to the natural ebb and flood of ocean waters caused by the gravitational attraction of the moon and sun on the earth. As water levels rise and fall, flood and ebb currents are formed. Currents are strongest at points of constriction such as the inlet entrance. Tidal currents are present both exterior and interior of the harbor jetties.

37. The Florida Current produces the strongest offshore current that affects Port Everglades. As it flows north along the eastern coastline, the Florida Current migrates randomly to the East and West, at times coming within close proximity to the coastline (Gyory, et al., 2009). The presence of the Florida Current creates a strong northerly current that acts perpendicular to vessels approaching and transiting the port's entrance channel.

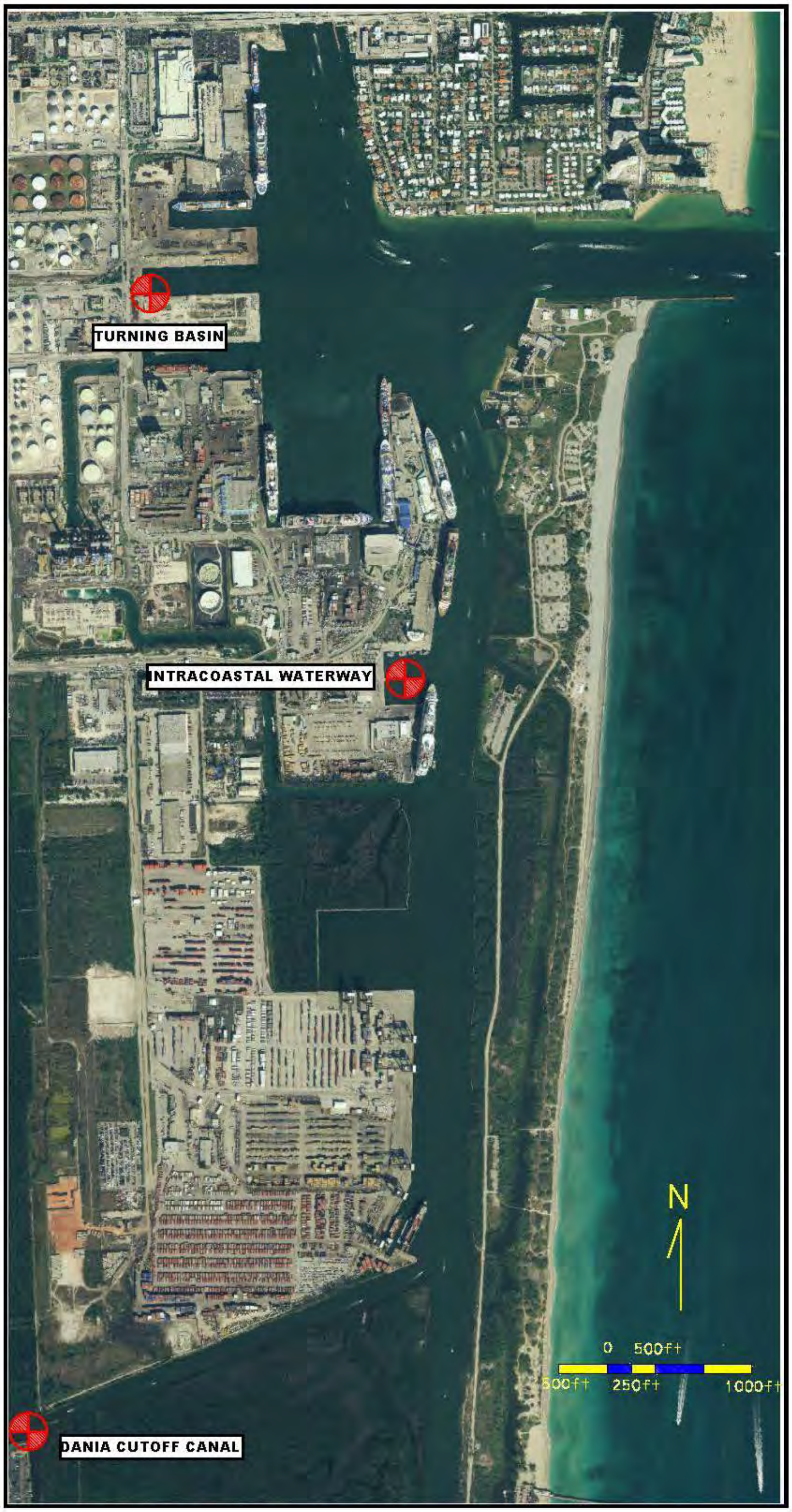

Figure A- 8. Port Everglades Tide Stations

Table A- 4. Tidal Statistics for Port Everglades

Tidal Statistics Relative to Mean Lower Low Water (MLLW)			
	N. Turning Basin	Southport Channel*	Dania Canal**
Highest Observed Water Level	4.42 ft	----	3.26 ft
Mean Higher High Water (MHHW)	2.81 ft	2.78 ft	2.56 ft
Mean High Water (MHW)	2.69 ft	2.66 ft	2.47 ft
North American Vertical Datum – 1988	2.24 ft	2.28 ft	----
Mean Sea Level (MSL)	1.43 ft	1.43 ft	----
Mean Tide Level (MTL)	1.42 ft	1.42 ft	1.32 ft
Mean Low Water (MLW)	0.16 ft	0.18 ft	0.17 ft
Mean Lower Low Water (MLLW)	0.00 ft	0.00 ft	0.00 ft
Lowest Observed Water Level	-1.27 ft	----	-0.19 ft

* Highest and lowest observed water levels were not recorded for this station.
** During the course of this study, this station has been deactivated. Available data is historical. No additional water levels (NAVD88 or MSL) are available at this location.

38. Secondary currents are frequently produced when back eddies form from the main flow of the Florida Current. A back eddy is defined as a circular current having the same magnitude as the originating flow, but moving in an opposite direction. Conditions are created in which a northerly current may be present in the farshore (i.e. near the outer sea buoy), while the back eddy creates a southerly current nearer to the harbor's entrance. It is also possible for a third current to form even closer to shore when a back eddy spawns a third eddy. In this case the new current is equal in magnitude to the original but returns to a northerly direction. When one or more back eddies is present, it is possible for a long vessel to experience both north and south flowing currents at the same time on different portions of the hull.

39. Currents shed from the Florida Current are highly variable in magnitude and unpredictable in occurrence. On the average, surface current velocities range from 2 to 4 knots (Bowditch, 1995). Research conducted in the Fort Lauderdale area indicates that the complex relationship between the Florida Current and the locally narrow continental shelf results in an inshore front that is dominated by horizontal wave-like meanders and submesoscale eddies with strong horizontal shear (Shay et al., 1998). During a National Research Laboratory experiment conducted in 2001, both surface current mapping, and bottom mounted current profilers captured significant current reversals and the presence of eddies in the vicinity of Port Everglades (Martinez-Pedraja et al., 2004). These and previously recorded events corroborate observations made by members of the Port Everglades Pilot Association regarding the magnitude and unpredictability of horizontal shear in the navigation channel.

2.3.6.3 Harbor Currents

40. Flood and ebb currents are present throughout the harbor. They occur on predictable time tables with average velocities of 0.5 to 2 knots (http://tidesandcurrents.noaa.gov/currents09). In the Main Basin, ebb currents create a particularly strong north to south flow along the face of the tanker slips on the east side of the basin. The currents in this vicinity can reach a maximum if a back eddy is also present. Along the south side of the basin in the vicinity of the finger pier at Berth 22, a steady west to east current exists at all stages of ebb and flood. In the Southport Access Channel, the presence of the flood and ebb currents has the most effect when vessels travel into the notch 90deg to the direction of the flow.

41. In addition to tides, spill out from New River and the Dania Cutoff Canal generates currents within Port Everglades. Spill out from these freshwater sources is controlled by inland flood gates. The outflow and therefore the resulting current magnitudes are highly variable. During heavy inland rain, the gates are opened and a strong flow is generated. Currents can be so strong that they can change the predicted magnitude and even direction of the tidal flow. During the rainy season (approximately June to September), the outflow increases and ebb currents become markedly stronger while flood currents are diminished or reversed. Outside of the rainy season, tidal currents are closer to predicted values.

42. Power plant discharge and intake are another example of localized currents. The discharge canal for the power plant lies just south of Berth 29. The rate of outflow is highly variable depending on plant production rates. Currents from the discharge canal are most strongly felt at Berth 29. The intake for the power plant is located at the east end of Slip 3. Vessels at Berths 13 and 14 often experience an acceleration due to the east to west flow created by suction when the plant is operational.

43. Swirling currents are an additional current type found within Port Everglades. Swirling currents are generated when the strong flow of tidal or other currents encounter solid bulkheads. Swirling currents are unpredictable and vary in magnitude. While they can be present throughout the harbor, they are most often encountered in the vicinity of the Knuckle (a “bend” in the channel at the juncture of berths 25 and 26), the Turning Notch, South Turning Basin, and Berth 33.

44. Wind and barometric pressure changes (set-up and set-down) also have an influence on observed currents. Strong winds can act to either increase or decrease current velocities depending on wind speed and direction while pressure changes effect water levels. The highly variable conditions at Port Everglades make it difficult to isolate the exact extent to which wind and barometric pressure effect local conditions. However, observed wind effects were included in ship simulation runs of Port Everglades. Predominant wind conditions for the simulations were 15 knot winds originating from east and northwest (see Sub-Appendix A). Barometric pressure changes were considered to be negligible.

45. The combination of generally predictable flood and ebb currents with various other sources of flow intrinsic to Port Everglades creates a highly unpredictable environment where localized currents can develop unexpected with extreme magnitude and variable direction.

2.3.7 WAVES

46. Deep water wave conditions representative of Port Everglades were obtained using hindcast data available from WIS station 467. Hindcast wave conditions cover the twenty year period between 1980 and 1999. Table A- 5 summarizes the percentage of occurrence and average wave height of waves by direction.

Table A- 5. Average Deep Water Waves (1980 to 1999)

Direction	Percent Occurrence (%)	Average Wave Height (feet)
North	17	3.9
Northeast	31	2.9
East	26	3.1
Southeast	16	2.3
South	6	2.8
Southwest	1	2.2
West	1	2.3
Northwest	2	2.6

47. Similar to wind conditions, wave conditions in South Florida experience seasonal variability (Figure A- 9). Winter months show a marked increase in wave height due to Northeaster activity. The intensity and direction of these winter wave conditions are reflected in the dominant southward sediment transport and seasonal erosional patterns. Summer months experience milder conditions with a more shore normal propagation of incident waves.

Table A- 6. Seasonal Wave Conditions

Month	Average Wave Height (ft)	Predominant Direction (from)
January	3.6	N
February	3.7	NE
March	3.6	NE
April	3.0	NE
May	2.6	E
June	2.0	E
July	1.8	E
August	1.9	E
September	2.6	NE
October	3.6	NE
November	4.1	NE
December	3.7	NE

48. Overall, wave conditions at Port Everglades are dominated by wind waves with limited exposure to open-ocean swell. Open-ocean swells originating from southeast through the northeast are blocked by two large shoals north and west of the Bahamas known as the Little Bahama Bank and the Great Bahama Bank, respectively (Figure A- 9). Water depths across the Bahama Banks average about 30 feet, so longer-period swells are reduced by bottom friction or the presence of land masses as they traverse the Bank. The minimum fetch between the western edge of the Banks and Port Everglades is about 50 miles, which allows ample distance for the generation of shorter-period wind waves in the deep waters of the Florida Straits. During severe storm events such as hurricanes and tropical storms, high wind velocities can generate large, damaging waves over the relatively short distance between the Bahamas and Florida.

Figure A- 9. Little and Great Bahama Banks

2.3.8 SALINITY

49. The Broward County Department of Planning and Environmental Protection (DPEP) maintains multiple monitoring stations throughout the waterways of Broward County. Three of these stations fall within Port Everglades Harbor (Figure A- 10). Station 38 is located at the ICWW 100ft north of the east fender of the 17th street Causeway Bridge and 100ft west of the east bank. Station 39 is located 50ft west of the east bank. Station 47 is located at the Dania Cutoff Canal 200ft west of the ICWW. Salinity values at each station, measured 2 to 4 times annually between 1997 and 2007 are given in Table A- 7. Changes in salinity levels may be attributed to fluctuations in local rainfall levels as well as variations in freshwater discharge levels from New River and the Dania Cutoff Canal.

Figure A- 10. Port Everglades Salinity Stations

Table A- 7. BCDPEP Salinity Data 1997-2007

Broward County Department of Planning and Environmental Protection Salinity Data									
DATE	STATION	TIME	SAL (PPT)	STATION	TIME	SAL (PPT)	STATION	TIME	SAL (PPT)
970128	38	1045	33.2	39	1115	32.9	47	1145	33.5
970430	38	950	30.2	39	1038	31.0	47	1054	29.9
970729	38	1030	24.3	39	1125	28.9	47	1140	27.0
971028	38	945	27.5	39	1020	32.3	47	1035	28.2
980127	38	1035	22.1	39	1110	32.6	47	1135	26.4
980429	38	1030	33.2	39	1110	32.4	47	1215	33.1
980729	38	955	31.2	39	1035	30.9	47	1045	29.3
981028	38	1045	32.5	39	1110	32.0	47	1220	33.2
990127	38	1005	26.5	39	1045	33.4	47	1110	30.0
990414	38	955	37.1	39	1030	37.1	47	1045	37.2
990721	38	945	21.3	39	1030	30.9	47	1037	27.4
991025	38	1055	23.6	39	1200	29.3	47	1215	26.5
000126	38	1025	34.2	39	1105	33.0	47	1115	33.7
000427	38	1217	29.0	39	1144	30.5	47	1133	27.0
000727	38	1413	30.1	39	1157	31.2	47	1211	28.2
001026	38	1300	29.8	39	1150	32.5	47	1203	32.2
010201	38	1515	34.5	39	1245	34.5	47	1430	34.8
010426	38	1450	33.6	39	1230	35.0	47	1245	34.8
010719	38	1125	33.6	39	1100	36.2	47	1048	34.4
011108	38	1245	29.7	39	1135	30.8	47	1200	27.7
020131	38	1205	37.2	39	1130	36.9	47	1115	37.0
020425	38	1032	36.8	39	1135	37.4	47	1145	37.1
020724	38	1125	28.7	39	1225	32.8	47	1255	27.6
021031	38	1350	35.4	39	1315	35.2	47	1255	35.1
030106	38	1245	34.1	39	1215	33.9	47	1205	35.0
030424	38	1550	34.7	39	1230	33.8	47	1200	33.6
030813	38	1500	21.8	39	1430	30.5	47	1400	24.2
031105	38	1330	24.5	39	1250	26.8	47	1240	22.6
040212	38	1105	27.8	39	1210	30.4	47	1225	31.5
040506	38	1415	32.9	39	1320	33.9	47	1300	34.0
040811	38	1440	26.8	39	1400	29.1	47	1350	23.0
041118	38	1330	31.7	39	1235	33.6	47	1255	31.4
050224	38	1300	33.6	39	1240	35.0	47	1220	35.0
050608	38	1300	23.4	39	---	---	47	---	---
050811	38	1315	27.3	39	1230	30.6	47	1200	35.0
051201	38	1255	22.8	39	1200	32.1	47	1145	26.4
060223	38	1320	32.2	39	1215	31.1	47	---	---
060601	38	1330	32.8	39	1245	32.9	47	---	---
060824	38	1205	30.5	39	1135	32.9	47	---	---
061130	38	850	31.8	39	---	---	47	---	---
070221	38	1215	33.7	39	1150	33.4	47	---	---
070516	38	1145	35.0	39	---	---	47	---	---
070822	38	1100	25.8	39	1025	32.7	47	---	---
071115	38	1200	32.1	39	1125	30.1	47	---	---

2.4 GEOLOGY

2.4.1 REGIONAL

50. Peninsular Florida occupies a portion of a much larger geologic unit called the Florida Plateau. The plateau is a partially submerged platform nearly 500 miles long and 450 miles wide that separates the deep water of the Gulf of Mexico from the deep water of the Atlantic Ocean. In the last 200 million years, the plateau has been alternately dry or covered by shallow seas. During that time up to 20,000 feet of carbonate and marine sediments were deposited. Additionally, there has been a tilting of the Florida Plateau about its longitudinal axis. This tilting has caused the West Coast of Florida to be partially submerged, as indicated by the wide estuaries and offshore channels. The East Coast is correspondingly elevated, showing the characteristics of an emergent coastline.

51. During the last million years, a series of four glacial periods, or ice ages, brought about significant changes in sea level. As a result of these sea level fluctuations, the Florida peninsula has been alternately covered and uncovered by shallow seas. Following the first glacial period, sea level rose 270 ft above its present level, restricting dry land on the peninsula to a few small islands in northeast Florida and along the central Florida ridge. During the last glacial period, approximately 100,000 years ago, sea level fell to 300 ft below its present level, causing the Florida Plateau to emerge as dry land.

52. Approximately 15,000 years ago, sea level began its most recent rise towards present sea level. The average rate of rise was 30 feet per 1,000 years. About 7,000 years ago, when sea level had risen within 30 feet of its present level, rate of rise slowed. It was during this most recent slowing of sea level rise that the modern barrier islands of southeast peninsular Florida formed and the present coral reefs in south Florida began to develop.

53. It is generally accepted that sea level has continued to rise and is a major contributor to erosion at the shoreline. The primary causes of sea level rise today are the melting of the polar ice caps and thermal expansion of ocean waters.

2.4.2 SOUTHEAST FLORIDA

54. The surficial geologic deposits of southeast Florida are the Fort Thompson, Key Largo, Anastasia, and Miami Formations. These limestone formations were deposited in shallow Pleistocene seas. The Fort Thompson Formation is the oldest formation and was deposited in warm shallow seas similar in environment to the broad barren marine plains covering the Bahamas Banks today. Later, coral reefs of the Key Largo Limestone formed. This in turn created sheltered waters behind which the bryozoan facies of the Miami Limestone formed. Deposition of broad shoals of oolitic sediments along the coast followed.

55. The Anastasia and the Miami Formations were formed as sand shoals and beach ridges 100,000 to 125,000 years ago. Tidal channels cut through the carbonate and oolitic shoals, connecting the Atlantic Ocean with the shallow sea covering the Everglades. These channels form the parallel cuts known today as the Transverse Glades in Dade County.

56. The topography of Palm Beach, Broward, and Dade counties are dominated by Lake Okeechobee, the Everglades, sandy flatlands, the Atlantic Coastal Ridge, coastal lagoons, and the modern barrier islands

57. The Atlantic Coastal Ridge extends along the Atlantic coast as an irregularly shaped highland composed of broad marine plains, beach ridges and bars north of Boca Raton. The Anastasia Formation forms the backbone of the Atlantic Coastal Ridge. South of Boca Raton, the Atlantic Coastal Ridge is formed by the Miami Oolite.

2.4.3 Broward County – Local Coastal

58. Broward County is geologically divided into the Everglades to the west, the heavily populated Atlantic Coastal Ridge on the east, the barrier islands, and nearshore deposits. The barrier islands and the nearshore deposits are underlain by the Miami Limestone. The nearshore shelf off Broward County is characterized by 3 step-like plateaus, each lower than its immediate shoreward neighbor and separated by irregular, rock reef ridges. The plateaus were created by sediments filling depressions located between the rock ridges. Each reef grew offshore during a different lower stand of sea level.

59. Approximately 40 to 80 percent of the coastal sediments deposited on the Florida peninsula are carbonates locally produced by calcite producing plants and animals. It is estimated that 20 to 60 percent of the carbonate material is reworked material from outcropping Pleistocene formations offshore. The quartz sand component is a combination of quartz sand that has migrated southward along the Atlantic coast and Pamlico Sand that was previously deposited over the entire region. The beach sand in Broward County consists predominantly of carbonate grains and shell fragments. A small amount of quartz grains are present. In general, the mean grain size ranges from 1.38 phi (0.38 mm) to 1.06 phi (0.48 mm). The phi standard deviation ranges from 1.12 to 1.36.

2.5 Shoaling and Maintenance

60. Littoral processes at Port Everglades are influenced heavily by the presence of man-made structures in the vicinity of the port's entrance channel. A spoil shoal to the north of the inlet, the inlet's jetties, and the navigation channel itself lead to the occurrence of accretion and erosion at the adjacent shorelines.

61. The spoil shoal originated in 1962 when a Port improvement project resulted in the deposition of approximately 2 million cubic yards of dredged material at a spoil area 2,000 feet offshore north of the entrance channel. Evaluation of hydrographic surveys performed between 1962 to 1994 show that the spoil shoal area has slowly migrated towards the shore, but is presently relatively stable. Along with the North jetty the shoal acts to impound sediment contributing to high accretion rates on the beach north of the inlet.

62. The navigation channel and south jetty act jointly as a sediment sink for sediment that reaches the inlet. Based on surveys of channel dredging, it is estimated that approximately 21,700 cubic yards of sand enters the inlet each year (Olsen Associates Inc., 2007). This material migrates westerly along the northern seawall and deposits on the side slopes of the channel, at the western end of the wall adjacent to the Main Turning Basin, and in the Main Turning Basin.

63. In June 2004, Olsen Associates Inc., under contract with Broward County, completed the Port Everglades Inlet Sand Management Phase I: Sand Bypassing Feasibility Study (Olsen Associates Inc., 2004). This study determined that the shoreline north of the jetty to be fully impounded and proposed several bypassing alternatives to prevent annual sand transport moving past the jetty and increasing shoaling within the federal navigation channel. Phase II: Sand Bypassing Feasibility –Addendum (Olsen Associates Inc., 2007) determined the most feasible and acceptable plan based upon logistical and environmental criteria. This project plan includes modification of the rubble spoil shoal, sand-tightening of the northern jetty, and creation of a sediment trap. The result is expected to be the alleviation of increased sand shoaling of the navigation channel between sand bypassing events.

64. As the plan recommended in Phase II has not yet been implemented, the present study will rely on shoaling rates determined in the absence of a sand bypassing system for the purposes of planning and cost estimating. See Section 4.5.2 (Maintenance of the NED Plan) for discussion of future shoaling rates.

65. Since Port Everglades was adopted as a Federal navigation project in 1930, there have been eleven federally sponsored maintenance dredging projects aimed at removing accumulated sediments within the entrance channels and Main Turning Basin. The last maintenance dredging occurred in 2005. The chronology of these episodes is given in Table A- 8.

2.6 SEDIMENT BUDGET

66. The combination of the inlet and jetty system at Port Everglades acts as a complete sediment barrier which interrupts the southerly littoral drift, creating a sediment surplus to the north of the inlet and a deficit at the beaches to the south.

67. A sediment budget for Port Everglades Inlet is illustrated in Figure A- 11 (Olsen Associates, 2007). This budget is based on the long-term volumetric changes (1979 to 2006) along adjacent beaches from Florida Department of Environmental Protection survey monuments R-77 and R-94, including the inlet channel. The net southerly longshore sediment transport rate 8,000 feet north of the inlet is 54,900 cubic yards per year, of which 37,700 cubic yards accumulate along the north beach and 17,200 cubic yards deposit in the inlet. The annual erosion rate of 48,500 cubic yards at John U. Lloyd includes an additional 4,500 cubic yards entering the inlet and 7,500 cubic yards being lost in the cross-shore. The resultant net southerly transport rate 8,000 feet south of the inlet is 36,500 cubic yards.

Table A- 8. Chronology of Maintenance Dredging at Port Everglades

Year	Location	Volume (cy)	Disposal
1934	Entrance Channel and Turning Basin	139,900	Ocean
1935	Entrance Channel and Turning Basin Turning Basin	97,400 73,100	Ocean Upland
1939	Entrance Channel and Turning Basin	48,300	Upland
1948	South side of Turning Basin Entrance Channel and N. side of Turning Basin	93,900 206,300	Upland Ocean
1950	Northern portion of Turning Basin	47,300	Upland
1953	Entrance Channel Turning Basin	97,300 179,800	Ocean Upland
1954	Turning Basin	101,200	Upland
1960	Entrance Channel Turning Basin	38,700 179,800	Ocean Upland
1961-1962	Entrance Channel Turning Basin Turning Basin	22,500 9,600 12,200	Beach/Ocean Upland Ocean
1978	Turning Basin	144,500	Ocean
2005	Turning Basin	46,700	Ocean

3 ENGINEERING ANALYSIS OF STRUCTURAL PLANS

3.1 GENERAL

68. This section describes engineering analyses of the structural improvement plans proposed at Port Everglades. The Main Report provides more information regarding plan formulation and screening. This section is organized as follows:

(1) Design Vessels
(2) Depth
(3) Project Components
(4) Design Plans
(5) Hydrology and Hydraulics
(6) Geotechnical Investigations
(7) Structural Design Considerations
(8) Civil Design of USCG Facility Reconfiguration
(9) National Economic Development Plan
(10) Selected Plan

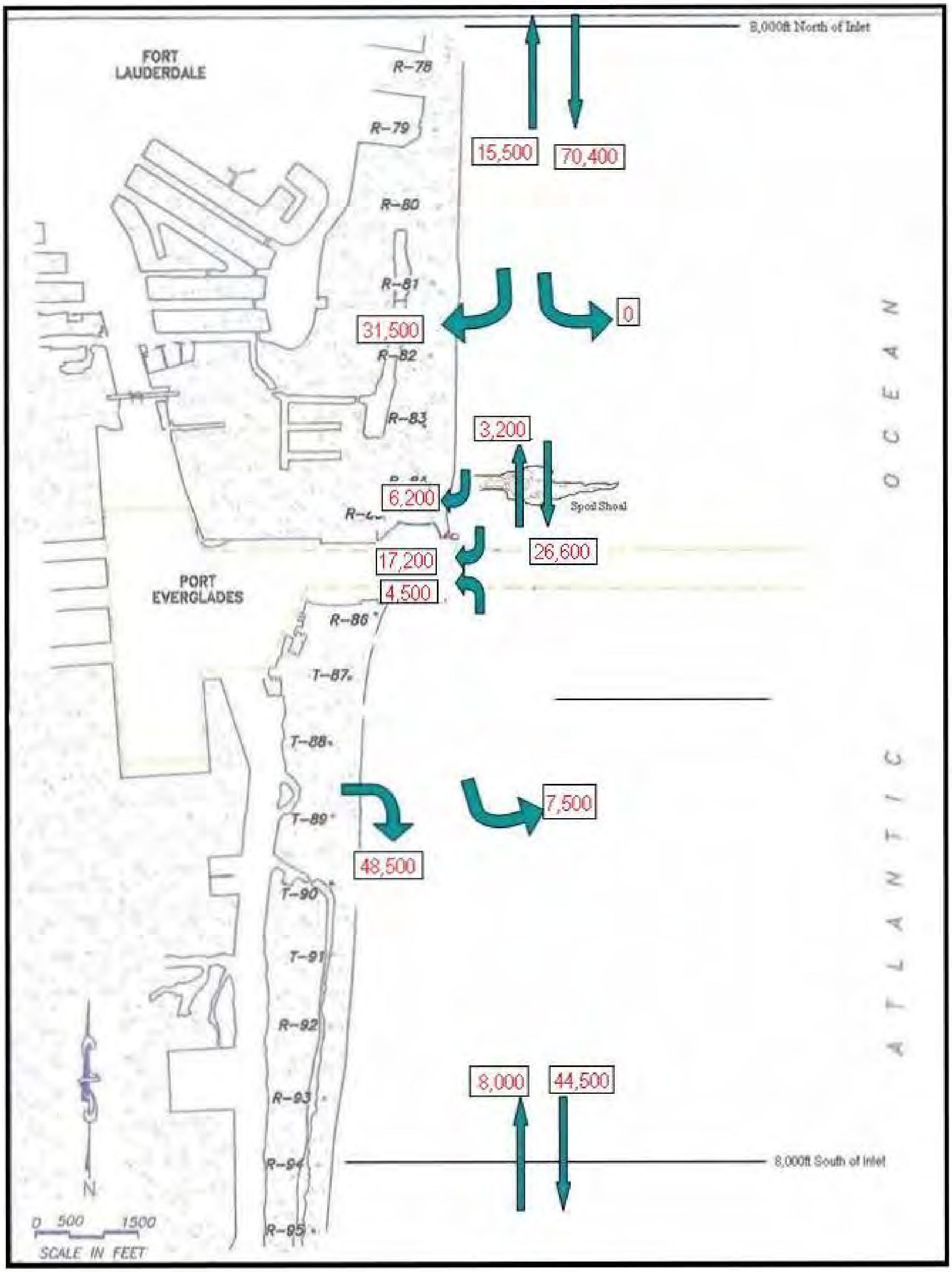

Figure A- 11. Sediment Budget, Port Everglades

3.2 DESIGN VESSELS

69. The following design vessels were used in the development and analysis of structural design plans for Port Everglades Harbor.

70. Post Panamax Design Vessel. The design vessel selected as representative of the Post Panamax Container Class was a 6,600 TEU containerized S-Class cargo vessel with a 141 foot beam, 48 foot draft, and a length of 1,139 feet.

71. Liquid Bulk Design Vessel. The vessel selected as representative of the liquid bulk carrier was a generic oil product tanker with a beam no greater than 142 feet, a draft no greater than 55 feet and a length not to exceed 900 feet.

72. Future Cruise Design Vessel. The vessel selected as representative of the future class of cruise ships was the Eagle Class cruise ship, Voyager of the Seas. “Voyager” has a beam of 156 feet, a draft of 28 feet, and a length of 1,020 feet.

73. Panamax Design Vessel. The design vessel selected as representative of the Panamax Container Class was the cargo vessel Bellatrix. The Bellatrix is a containerized cargo vessel with an 82 feet beam, 29 feet draft, and an overall length of 524 feet.

74. South Turning Basin Design Vessel. The design vessel selected for the development of plans to facilitate transit of a Panamax class vessel to the STB was a generic vessel with a beam of 106 feet, a draft of 43 feet, and a length of 926 feet. These dimensions are considered representative of Panamax class vessels which will berth in the STB.

75. Pleasure Craft. To represent pleasure craft traffic in the design process, a generic 20 foot beam vessel was selected.

76. Table A- 9 provides a summary of selected design vessels, their dimensions, and the project components to which they were applied during engineering design.

3.3 DEPTH

3.3.1 GENERAL

77. The total depth of a Federal navigation project is determined by several factors. The project depth (also known as the authorized depth upon project completion) is based on maximizing net transportation savings while considering safety, physical conditions, and vessel operating characteristics. Additional depth, known as advanced maintenance, addresses the reliability of the channel, based on the degree of expected shoaling and maintenance. Finally, the variability and limitations of construction techniques are accounted for with a depth increment known as allowable overdepth.

Table A- 9. Design Vessels

Design Vessel	Beam (ft)	Draft (ft)	Length (ft)	Project Component
Post Panamax"S-Class"	141	48	1,139	OEC, IEC, MTB, Widener, SAC, TN
Liquid Bulk	≤ 142	≤ 55	≤ 900	OEC, IEC, MTB
Future Cruise "Voyager"	156	28	1,020	OEC, IEC, MTB, Widener, SAC
Panamax "Bellatrix"	82	29	524	DCC
South Turning Basin	106	43	926	STB
Pleasure Craft[1]	20	N/A	N/A	All
[1] Pleasure Craft design vessels were used as "passing vessels" in the determination of channel and turning basin dimensions				

78. For new work projects that include areas of hard rock or heavily consolidated materials, USACE regulations require an additional depth increment known as required overdepth (USACE, 1996). Required overdepth ensures an additional margin of safety for vessels during transit and acts to minimize future maintenance dredging.

3.3.2 PROJECT DEPTH/AUTHORIZED DEPTH

79. The project depth[1] is determined from both economic analysis and engineering considerations. It is a depth that maximizes the net transportation savings while simultaneously optimizing the physical dimensions of channels and turning basins based on vessel safety (avoidance of collisions and groundings), physical conditions (winds, waves, tides, currents, etc…), and vessel dimensions and operating characteristics (turn radius capabilities, tug assist requirements, etc…). Maximum project depths evaluated for each project component are provided in Section 3.4 (Description and Engineering Analysis of Project Components), while NED project depths are provided in Section 3.10 (Economic Development Plan).

80. Included in the project depth of each project component is an allowance of safety known as underkeel clearance. Underkeel clearance provides a safety margin that accounts for wave action and vessel squat, especially in entrance channels where adverse conditions are most likely to occur. Underkeel clearance requirements for each of the Port Everglades project components are discussed in detail in Section 3.4.11 (Underkeel Clearance).

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[1] All channel and basin depths indicated in this report are project depths unless otherwise specified. Project depth is the authorized depth to which the federal government maintains channels and basins. For construction purposes, the Federal government may dredge channels and basins an additional amount below project depth. For this study, that additional amount consists of 1 foot of required overdepth (allowance for maintenance purposes) and 1 foot allowable overdepth (allowance for dredge tolerances). See Section 3.3 (Depth) for more details.

3.3.3 ADVANCED MAINTENANCE

81. Advance maintenance is dredging beyond the project (authorized) depth/width of a channel or basin in critical and fast-shoaling areas in order to avoid frequent redredging. This ensures reliability and least cost operation and maintenance of the project's authorized dimensions.

82. Port Everglades has been categorized as a slow-shoaling harbor with a present shoaling rate of approximately 21,700 cubic yards per year, including entrance channels (Section 4.5.2 - Maintenance of the NED Plan). Therefore, advanced maintenance is not required as part of the Port Everglades project depth.

3.3.4 ALLOWABLE OVERDEPTH

83. Allowable overdepth is additional depth increment included to compensate for inaccuracies in the dredging process due to physical conditions (tides, currents, waves, etc…), dredged material types, (silt, clay, sand, gravel, rock, etc…); and equipment type (mechanical, hydraulic, hopper, etc…). Allowable overdepth generally ranges from 1 to 2 feet. Based on a review of allowable overdepth values applied to an array of previously studied/constructed USACE deep draft navigation projects, an allowable overdepth of 1 foot is considered applicable at Port Everglades.

3.3.5 REQUIRED OVERDEPTH

84. Required overdepth is additional depth increment in areas where hard rock or heavily consolidated materials may be present that provides an additional margin of safety and acts to minimize future maintenance. Based on geotechnical analysis, regions of hard rock and/or consolidated materials are present throughout the project area. Therefore, required overdepth is mandated (USACE, 1996). Combined with the existing safety margins resulting from the underkeel clearance analyses (Section 3.4.11– Underkeel Clearance), a required overdepth of 1 foot is considered sufficient for the new work at Port Everglades.

3.3.6 CHARACTERIZATION DEPTH

85. Characterization and evaluation of dredged material is a vital component in the dredging process. This component is initiated by assessing existing core borings from the project area and/or taking new core borings. For a complete evaluation, the depth to which this data is obtained (characterization depth) must account for not only material up to the maximum allowable project depth (project depth + advance maintenance + allowable overdepth + required overdepth), but also material beyond that depth that can reasonably be expected to be removed due to such factors as unanticipated variation in substrate, submerged obstructions, or environmental conditions that reduce the operator's ability to maintain the proper dredging depth.

86. To aid in the determination of the characterization depth for a given project, the USACE,

Engineer Research and Development Center (ERDC) has provided general guidance based on project type (new work or maintenance), location (open water or sheltered/harbor), material type (hard, consolidated or soft), and dredge type (mechanical, cutterhead, or hopper) (Tavolaro, et. al., 2007). Using this guidance, the maximum characterization depth in open water portions of the project (exterior of the harbor jetties) is 10 feet. The maximum characterization depth in sheltered portions of the project (interior of the harbor jetties) is 7 feet.

3.4 DESCRIPTION AND ENGINEERING ANALYSIS OF PROJECT COMPONENTS

3.4.1 GENERAL

87. The following sections describe the existing conditions at each of the project components, initial design changes to meet project goals, and further refinements due to structural, environmental, and/or navigational considerations. Preliminary designs were drafted based on USACE guidance (USACE, 2006) and subsequently refined through ship simulation and coordination with USACE Engineer Research and Development Center (ERDC), Port Everglades Pilots Association, and the Port Everglades Port Authority.

3.4.2 OUTER ENTRANCE CHANNEL (OEC)

3.4.2.1 Existing Dimensions

88. The existing OEC extends approximately 5,000 feet from the outer sea buoy to the seaward end of the harbor jetties (Figure A- 12). The channel has a constant width of 500 feet and an authorized project depth of -45 ft-MLLW.

Figure A- 12. OEC Existing Layout

3.4.2.2 Preliminary Design

89. Under conditions of strong, variable currents, the 500 foot OEC presents a hazard to both the existing and future design fleet. Presently, Pilots are required to line up with the channel before the outer marker and bring vessels in at high speed to maintain a straight course. Rapid deceleration of the vessel is then required for safe negotiation of the entrance jetties. To alleviate the need for potentially dangerous maneuvering for the existing and future design fleet, the OEC requires lengthening as well as widening of the seaward end of the channel. By extending and expanding the outer end of the existing channel and then tapering evenly over a distance back to the original design width, a "flare" is created. The flared entrance allows the vessel room to maneuver in the presence of strong currents while still maintaining safe speeds when lining up to the entrance channel.

90. Improvement of the OEC is based on a combination of project design vessel dimensioning and local environmental conditions. In this case, the maximum width to be considered is the 156 foot beam of the “Voyager” cruise ship. The maximum length is the 1,139 foot LOA of the “S-Class” post-panamax vessel. These dimensions along with the local high velocity currents in the vicinity of the OEC and average and seasonal incident wind conditions resulted in the development of a 1,000 foot flare extending an additional 2,200 feet from the existing seaward end of the OEC (Figure A- 13). The depth of the OEC is highly site specific and based heavily upon local environmental conditions. Determination of the underkeel clearance in the OEC (and other project components) is discussed in detail in Section 3.4.11(Underkeel Clearance). In summary, the maximum OEC depth evaluated was -58 ft-MLLW.

91. While this channel layout provided for a high margin of safety under adverse weather and current conditions, it also created significant impacts to natural resources, specifically a relic reef (denoted the “third reef”) that runs shore parallel, approximately 1.3 miles east of the entrance jetties and still maintains some degree of live coral coverage. After consultation with the Port Everglades Pilots and further evaluation including a series of ship simulations (Sub-Appendix A) it was possible to reduce the maximum width of the flare from 1,000 feet to 800 feet, decreasing impacts to the third reef without significant impact to vessel safety.

3.4.2.3 Alternative OEC Alignments

92. To further minimize impacts to the third reef, several alignments for the OEC were considered. These alignments included two with “dogleg” turns at the seaward end and two alignments that would make use of natural gaps in the outermost reef. The latter would require vessels to transit between the second and third reefs until reaching the existing entrance channel location. The two “dogleg” alignments (1) Double Dog-Leg (Figure A- 14) and (2) Single Dog-Leg (Figure A- 15) would bring vessels through a portion of the third reef that early biological surveys indicted might sustain less live coverage than the original alignment. The natural gap alignments included orienting the channel through (1) a gap approximately ¾ mile to the north of the existing entrance channel (Northern Reef-Gap Alternative) and (2) a gap approximately 3 miles to the south of the existing entrance channel (Southern Reef-Gap Alternative). Each of the natural gap alternatives would avoid all impacts to the third reef with only minor additional impacts to the second reef line (approximately ½ mile east of the jetties).

Figure A- 13. OEC – Extension with 1,000 foot Flare

Figure A- 14. OEC – Double Dog-Leg Alignment (1)

Figure A- 15. OEC – Single Dog-Leg Alignment (2)

93. Due to navigational and environmental concerns as well as security issues raised by environmental groups, the U.S. Coast Guard, the U.S. Navy, and the Port Everglades Pilot Association, the four alternative alignments were removed from consideration. Concerns and security issues included increased impacts to offshore reefs during construction necessary for offshore turning basins, increased difficulty in vessel handling due to additional turning maneuvers in a high current region, a high level of unknown risk to vessels and potential for environmental damage to regions previously not impacted, and violation of U.S. Navy offshore exclusion zones. A detailed discussion of these concerns, including pertinent correspondence can be found in the Environment Impact Statement (EIS).

3.4.2.4 OEC Project Component – Final Design

94. Figure A- 16 shows the final dimensions and alignment of the OEC project component.

3.4.3 <u>INNER ENTRANCE CHANNEL (IEC)</u>

3.4.3.1 Existing Dimensions

95. The existing IEC extends approximately 2,340 feet from landward end of the OEC to the main basin of the harbor (Figure A- 17). The channel has a constant width of 450 feet and an authorized project depth of -42 ft-MLLW.

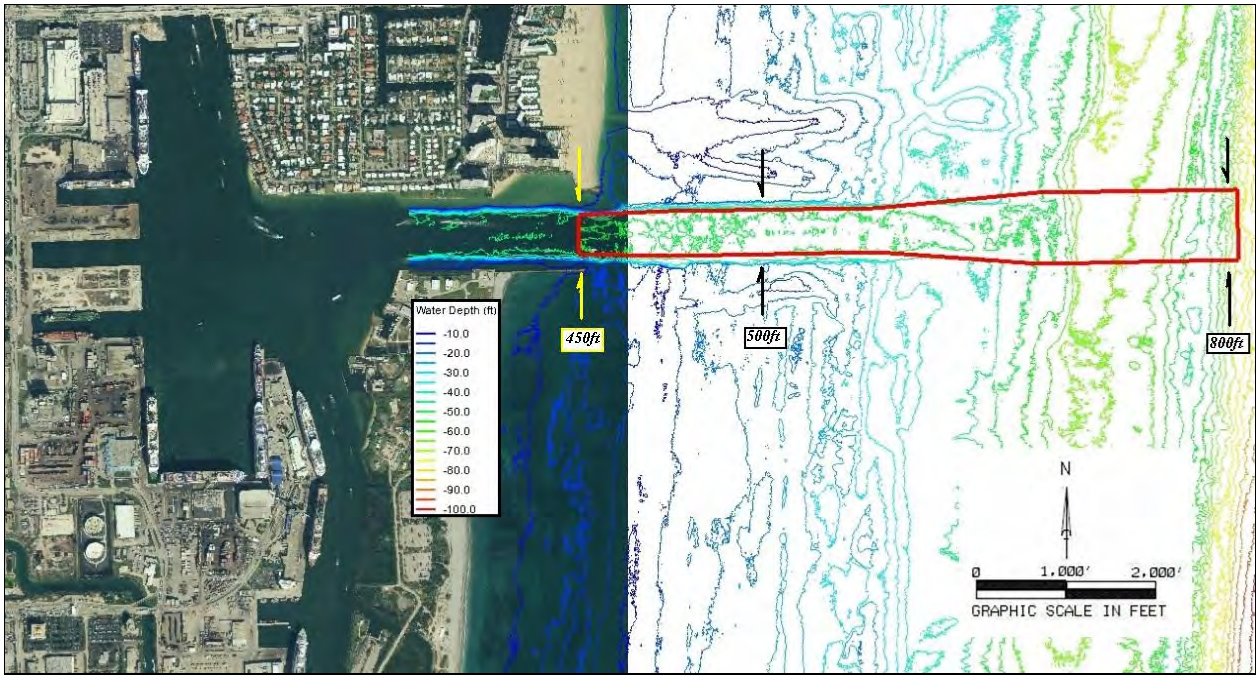


Figure A- 16. OEC Project Component – Final Design

3.4.3.2 Preliminary Design

96.   Due to landside development to the north and south of the channel, there is no option to further widen the IEC without considerable impact to surrounding property. Ship simulation (Sub-Appendix A) indicates that the existing channel width is suitable for the largest vessels of the design fleet. Optimization for the IEC component consists of deepening only.   The maximum project depth to be considered is -51 ft-MLLW.

3.4.3.3 IEC Project Component – Final Design

97.   Figure A- 17 shows the final (and existing) layout of the IEC project component.

3.4.4 <u>MAIN TURNING BASIN (MTB)</u>

3.4.4.1 Existing Dimensions

98.   The authorized limits of the main turning basin measure approximately 1,200 feet from east to west and 2,450 feet north to south (Figure A- 18). The MTB covers approximately 95 acres and has a current authorized project depth of -42 ft-MLLW.

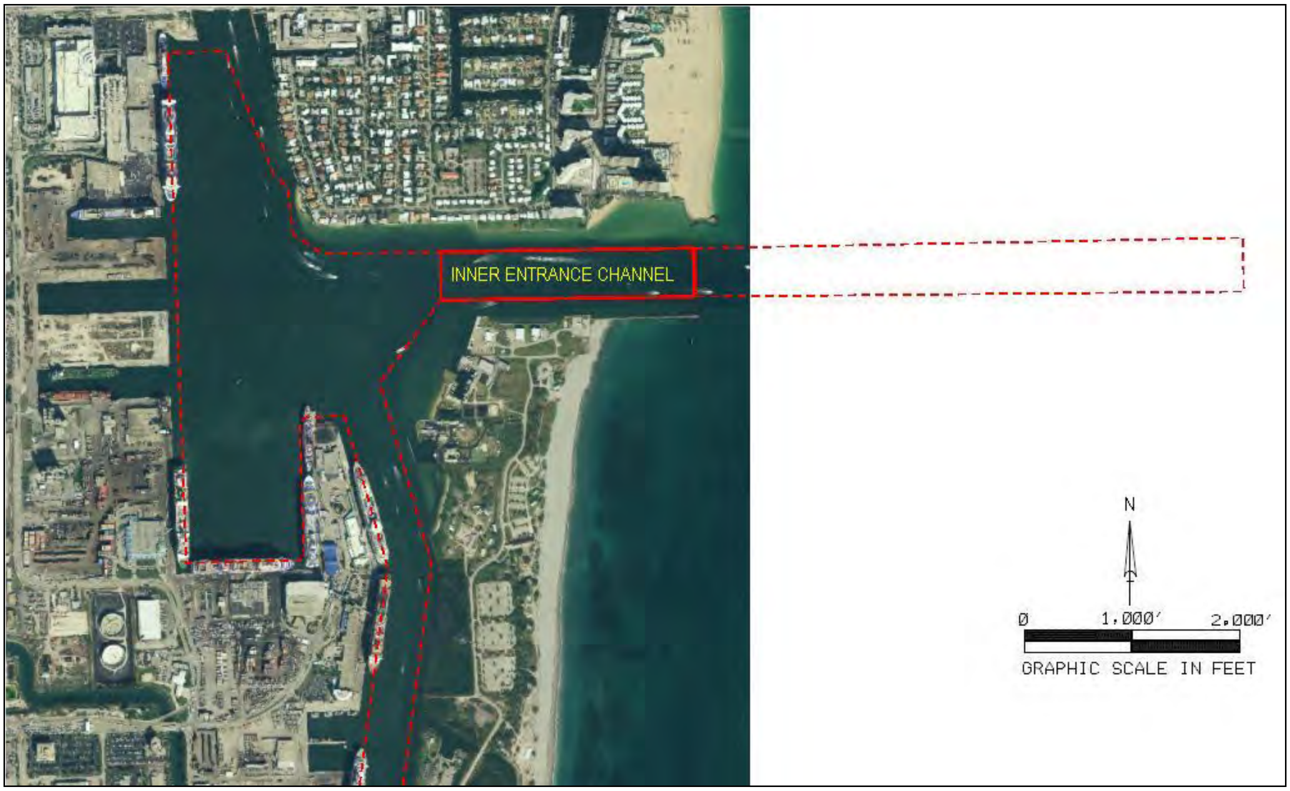


Figure A- 17. IEC Project Component – Final (and Existing) Design

Figure A- 18. MTB Project Component – Existing Layout

3.4.4.2 Preliminary Design

99. As with the IEC, the MTB is surrounded by development and does not lend itself to widening. In this case, widening of the MTB is unnecessary to accommodate the goals of the project. The original goal of deepening the MTB was to accommodate both the turning of S-Class design vessels and to provide additional depth for liquid bulk vessels transiting to berths 7 through 15. Based on results of the ship simulation a preliminary design was developed that deepened only a portion of the existing authorized footprint, based on the turning requirements of the “S Class” container vessel. Due to changes in the projected tanker fleet, only a single “slip” was added to allow deeper draft tanker vessels to reach berths 7 through 10. For this, and subsequent alternatives, both the reduced turning basin and tanker slip would be deepened, while the remainder of the authorized footprint would continue to be maintained at the authorized project depth of -42 feet. This alternative was denoted “MTB (Container and Tanker)” and is shown in Figure A- 19.

100. Upon consultation with the Port Everglades Pilots it was determined that while the reduced MTB footprint would technically allow for vessel turning it generated significant risks to vessel safety. Specifically the reduced footprint did not allow adequate room to slow or turn a vessel in the event of tug failure. This is a scenario that has occurred in the past at Port Everglades and would result in significant vessel damage and possible risk to human life if it occurred with a deep draft vessel in the confines of the proposed turning area. The sharp difference in depth between the deeper proposed turning area and the surrounding 42 foot existing depth also has the potential of creating hydraulic conditions that would make vessel maneuvering difficult and unpredictable. Based on these concerns two additional alternatives were proposed, an extension of the turning area to the western existing Federal limits with a small “flare” to the south (Figure A- 20) and an extension to the west with “flares” to both the south and the north (Figure A- 21).

101. While the expansion of the turning area and the addition of flares alleviated some safety concerns regarding emergency maneuvering, the potential for difficult and unpredictable vessel handling due to the depth differences in the confined turning area could not be eliminated. Of particular concern was the proximity of the depth transition (essentially a vertical rock shelf) to the oil tanker slips at the west end of the MTB. A small course deviation, resulting in impact with the shelf could result in serious environmental consequences. USACE personnel and the Port Everglades Pilots concurred that for maximum safety, deepening of the MTB should encompass the full extents of the existing MTB footprint. The maximum project depth to be considered for the MTB is -51 ft-MLLW.

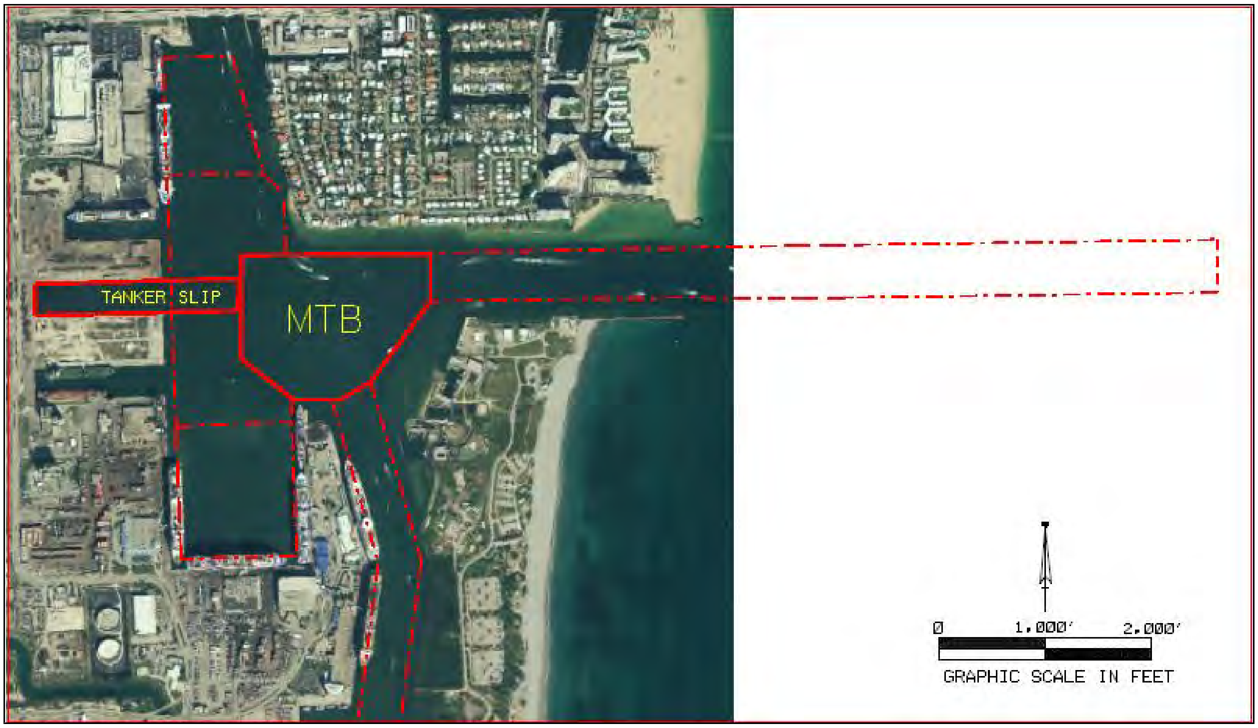


Figure A- 19. MTB (Container and Tanker) Project Component

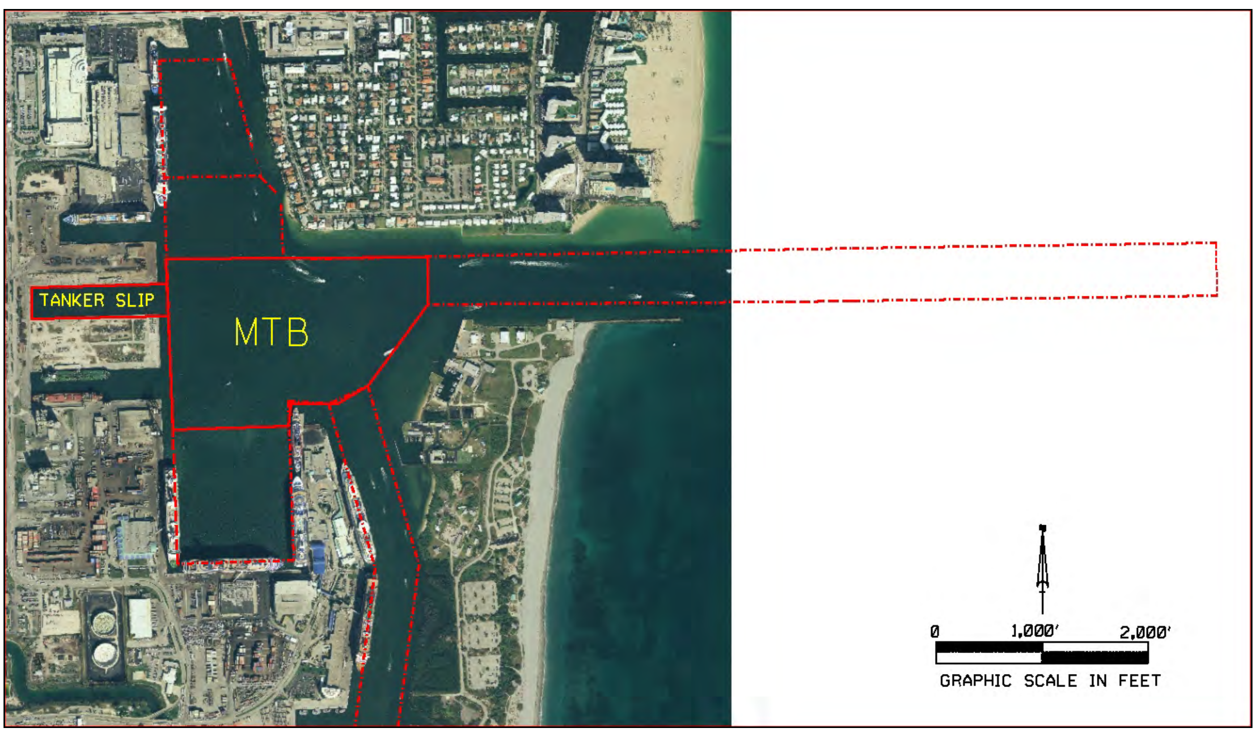


Figure A- 20. MTB (Extended with South Flare) Alternative

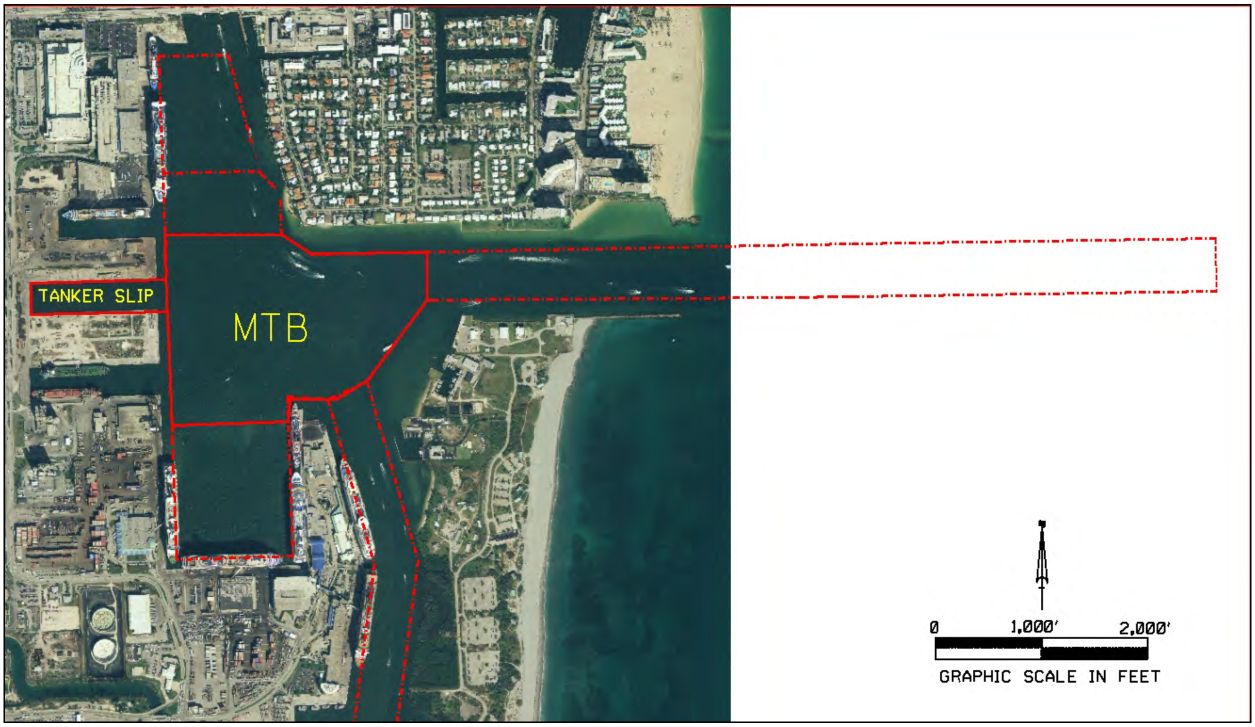


Figure A- 21. MTB (Extended with North and South Flares) Alternative

3.4.4.3 MTB Project Component – Final Design

102. Figure A- 22 shows the final layout of the MTB project component. This MTB alternative was denoted "MTB (Full)". Although it is no longer shown graphically (berthing is not considered to be part of the Federal project channel/basin layout) it is assumed that the tanker slip encompassing berths 7 through 10 will be deepened to match the project depth of the MTB.

3.4.5 <u>North Turning Basin (NTB)</u>

3.4.5.1 Existing Dimensions

103. The NTB covers 19 acres immediately to the north of the MTB (Figure A- 23). The current authorized project depth for the NTB is -31 ft-MLLW.

3.4.5.2 Preliminary Design

104. The present project depth of -31 ft-MLLW in the NTB is adequate to accommodate the full draft of the "Voyager" cruise ship (design vessel for the NTB) with an acceptable safety clearance of 3 feet.

Figure A- 22. MTB (Full) Project Component – Final Design

Figure A- 23. NTB Existing Layout

3.4.5.3 NTB Project Component – Final Design

105. Further modification of the NTB was not necessary. Therefore, the NTB project component was removed from the study.

3.4.6 SOUTH TURNING BASIN (STB)

3.4.6.1 Existing Dimensions

106. The STB covers 32 acres immediately to the south of the MTB (Figure A- 24). The current authorized project depth for the STB is -31 ft-MLLW.

3.4.6.2 Preliminary Design

107. Due to the 39 foot draft of the design vessel, it is necessary to deepen the STB from a present project depth of -31 ft-MLLW to a maximum depth of -42 ft-MLLW. This allows for the fully loaded draft of the vessel as well as a 3 foot safety clearance. Because the vessel will be berthed only at Berths 16 and 17, deepening is not required over the entire extent of the STB. Therefore, depth requirements can be met with a cut across the western side basin from north to south. This provided a uniformly deepened area, 260 feet wide from the south wall of the basin to the north where the STB and MTB merge.

3.4.6.3 Refinement of Design

108. The initial uniform north-south layout of the STB was found to have inadequate maneuvering room for vessels transiting to Berths 17 and 18. In order to increase access, the original north to south straight cut along the western side of the STB was replaced by a diagonal cut that provides a uniformly deepened area that is 260 feet wide to the south and 1,100 feet wide to the north where the STB and MTB merge.

3.4.6.4 STB Project Component – Final Design

109. Figure A- 25 shows the final layout of the STB project component. However, due to operational changes, the Port has asked that the STB component be withdrawn from this study. While the STB component remains feasible from an engineering standpoint, it will not be considered further.

3.4.7 WIDENER SHOAL (WIDENER)

3.4.7.1 Existing Dimensions

110. The Widener shoal is a shallow shoal located in the southeast corner of the MTB (Figure A- 26). This portion of the harbor is not presently part of a federal project and does not have an authorized project depth. Current average depth over the shoal is approximately -6 ft-MLLW.

Figure A- 24. STB Existing Layout

Figure A- 25. STB Project Component – Final Design

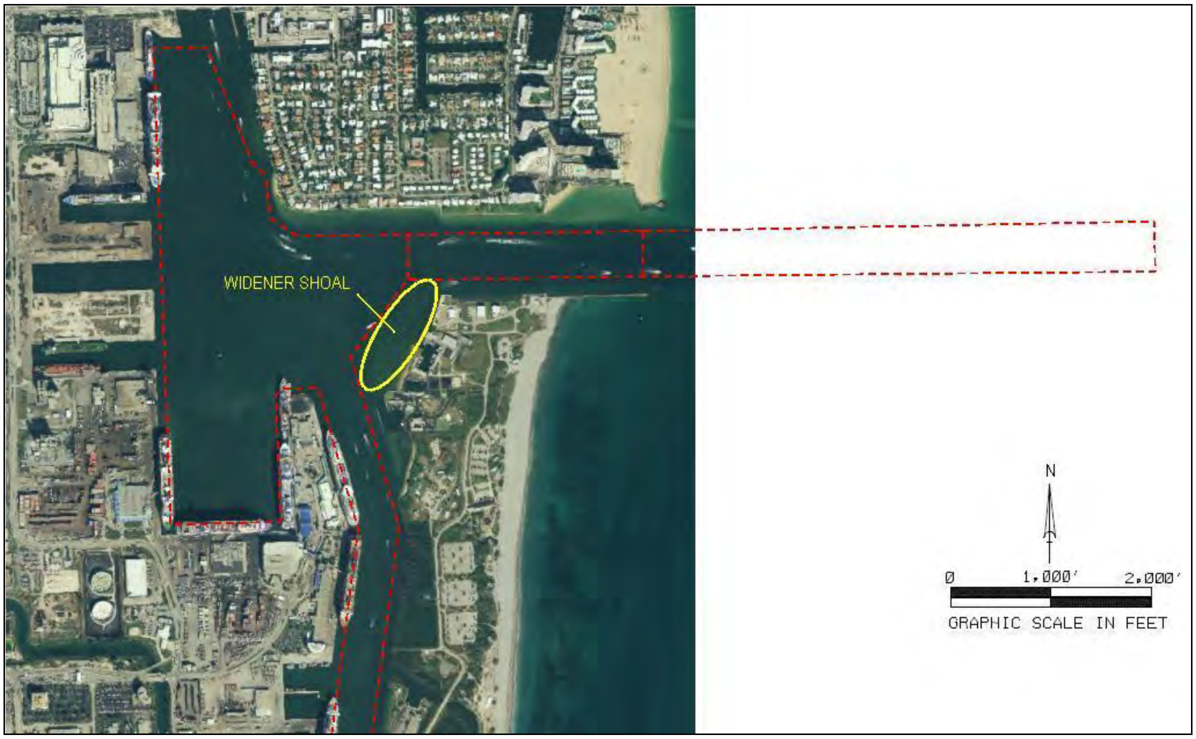


Figure A- 26. Widener Shoal Location

3.4.7.2 Preliminary Design

111. The presence of the shallow Widener currently restricts the amount of maneuvering room a vessel has when turning in the MTB in preparation for backing down the SAC (a common method of transit). The Widener also prohibits other traffic from transiting and exiting the SAC while another vessel is in the MTB. Removal of the Widener shoal is necessary to turn the "S-Class" (post-panamax container design vessel). Removal will also alleviate existing congestion by allowing for two-way traffic in the MTB. The dimensions of the widener footprint were determined by a combination of the size and shape of the shoal, adequate offset from existing structures to the southeast, and vessel maneuverability requirements (verified through ship simulation). To accommodate the full draft of the design vessel and safety clearance, a maximum project depth of -51 ft-MLLW was considered.

3.4.7.3 Widener Project Component – Final Design

112. Figure A- 27 shows the final dimensions of the Widener project component.

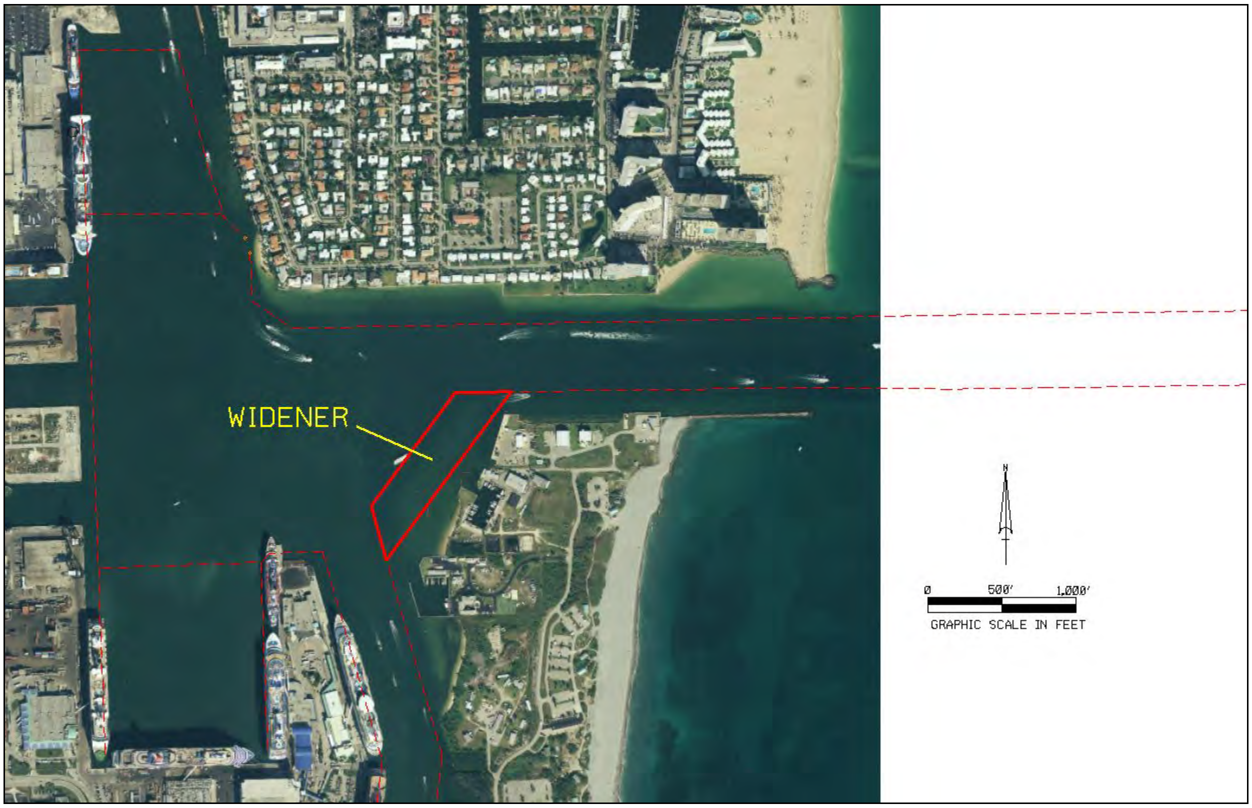


Figure A- 27. Widener Project Component – Final Design

3.4.8 <u>SOUTHPORT ACCESS CHANNEL (SAC)</u>

3.4.8.1 Existing Dimensions

113. The existing SAC is a 400 foot wide channel that extends south approximately 8,500 feet (1.6 miles) along the Intracoastal Waterway from the MTB to the southern end of berth 33 (Figure A- 28). The SAC layout includes a 150 deg bend at the north end known as "the knuckle", seven channel parallel berths, and has a uniform authorized project depth of -42 ft-MLLW.

3.4.8.2 Preliminary Design

114. In order for the design container vessel, "S-Class", to transit the SAC to one of its proposed berths (berth 30, 31, or 32) it must make the turn at the knuckle. Based on the projected fleet it is likely that this transit will occur when one or more "Voyager" cruise ships are at berth in the knuckle area (berths 24 – 27) or at berth 29. It is equally likely that passing of pleasure craft and/or other commercial vessels in the channel itself will occur. From these likelihoods, two design scenarios were developed (1) "S-Class" passing a pleasure craft with "Voyager" vessels at berth, and (2) 'S-Class" passing the "Bellatrix" design vessel with "Voyager" vessels at berth.

Figure A- 28. SAC Existing Dimensions

115. Another consideration in the design of the SAC project component is the presence of a USCG station at the north end of the SAC on the eastern edge of the channel. The USCG station includes a 58,000 square foot boat basin with a 240 foot bulkhead that extends within 115 feet of the existing channel. The presence of the USCG bulkhead complicates the turning maneuver required in the knuckle by limiting the available open space and creating the potential for collision.

116. Given present channel dimensions, wider berth requirements for "Voyager" vessels, the presence of the USCG bulkhead, and the likely distribution of vessels at berth, turning through the knuckle with a vessel the size of "S-Class" is not possible. To allow for passage of the "S-Class", the knuckle alignment must be altered to provide for a lesser degree of turning and allowing more maneuvering room.

3.4.8.3 Alternative SAC Designs

117. Incorporating the design considerations described above, six initial designs were developed to address transit of the "S-Class" vessel from the MTB to berths 30 – 32. The six alternative component designs are detailed as follows:

(1) SAC Alt. Comp. 1 (Figure A- 29): Eastern expansion of the SAC to accommodate "S-Class" passing a pleasure craft with "Voyager" vessels at berth. Eastern channel edge stabilized by bulkheads to minimize property and habitat impacts.

(2) SAC Alt. Comp. 2 (Figure A- 30): Eastern expansion of the SAC to accommodate "S-Class" passing a "Bellatrix" vessel with "Voyager" vessels at berth. Eastern channel edge stabilized by bulkheads to minimize property and habitat impacts.

(3) SAC Alt. Comp. 3 (Figure A- 29): Eastern expansion of the SAC to accommodate "S-Class" passing a pleasure craft with "Voyager" vessels at berth. Eastern channel edge allowed to stabilize with a natural sideslope projected to be 1V:2.5H.

(4) SAC Alt. Comp. 4 (Figure A- 30): Eastern expansion of the SAC to accommodate "S-Class" passing a "Bellatrix" vessel with "Voyager" vessels at berth. Eastern channel edge allowed to stabilize with a natural sideslope projected to be 1V:2.5H.

(5) SAC Alt. Comp. 5 (Figure A- 31): Western expansion of the SAC to accommodate "S-Class" passing a pleasure craft with "Voyager" vessels at berth. Eastern channel edge stabilized by Port bulkheads.

(6) SAC Alt. Comp. 6 (Figure A- 32): Western expansion of the SAC to accommodate "S-Class" passing a "Bellatrix" vessel with "Voyager" vessels at berth. Eastern channel edge stabilized by Port bulkheads.

Figure A- 29. SAC – Eastern Expansion (Alternatives 1 and 3), Pleasure Craft Passing

Figure A- 30. SAC – Eastern Expansion (Alternatives 2 and 4), "Bellatrix" Passing

Figure A- 31. SAC – Western Expansion (Alternative 5), Pleasure Craft Passing

Figure A- 32. SAC – Western Expansion (Alternative 6), "Bellatrix" Passing

118. Each of the above alternative component designs includes widening of the existing northern SAC berths (24 – 27, and 29) from 90 feet to 160 feet, widening of the southern SAC berths (31 and 32) from 90 feet to 145 feet, and channel widening along the length of the channel in accordance with USACE design guidance for vessel passing (USACE, 2006). The maximum project depth in each case is -51 ft-MLLW. Eastern expansion includes significant environmental impacts and reconfiguration of the USCG station. Western expansion includes significant impact to Port infrastructure and cargo storage capabilities.

119. Initial screening of the six alternative component designs resulted in elimination of all but one alternative. Eliminations were made due to severe environmental impacts to John U. Lloyd State Park (alternative designs 2 – 4) and excessive impacts to Port infrastructure and adjacent cargo/passenger facilities (alternative components 5 and 6). Table A- 10 provides a summary of the screening process.

Table A- 10. Summary of SAC Alternative Component Screening

Alternative Component	Screening Results
SAC Alt. Comp. 1	Retained
SAC Alt. Comp. 2	Eliminated due to excessive impacts to John U. Lloyd State Park
SAC Alt. Comp. 3	Eliminated due to excessive impacts to John U. Lloyd State Park
SAC Alt. Comp. 4	Eliminated due to excessive impacts to John U. Lloyd State Park
SAC Alt. Comp. 5	Eliminated due to excessive impacts to Port infrastructure
SAC Alt. Comp. 6	Eliminated due to excessive impacts to Port infrastructure

120. The remaining alternative component, SAC Alt. Comp. 1, allows the “S-Class” to pass “Voyager” at berth in the knuckle (Berths 24 to 27), while passing a pleasure craft in the channel. To accommodate the larger design vessels, the north end of the channel, the knuckle is expanded from a design width of 400 feet to a width of 786 feet. The width at the center of the knuckle (juncture of Berths 25 and 26) is widened from 400 feet to 480 feet. At the south end of the knuckle, adjacent to Berth 27, the width of the channel changes from 400feet to 575 feet. Channel width is then tapered in a southerly direction over a distance of 3,030 feet to a design width of 460 feet. A constant width of 460 feet is maintained over the remainder of the channel until reaching berths 31 and 32 where it decreases to a width of 315 feet.

3.4.8.4 Refinement of Design

3.4.8.4.1 Ship Simulation

121. After initial screening of all project components was accomplished, a series of ship simulations were initiated to evaluate and refine channel dimensions of the remaining alternative components. The ship simulation study was conducted at the RTM Simulation, Training, and Research (STAR) Center, located in Dania Beach, Florida. The simulation involved the

evaluation of the initial and final designs of the alternative components to determine if proposed dimensions were adequate to safely transit the design vessels. Based on results from the ship simulation study (Sub-Appendix A), the following observations were recorded for the initial design of the SAC component:

- The US Coast Guard boat basin presents a navigation hazard to Post-Panamax vessels transiting the SAC and must be relocated to the east to allow for safe vessel passage.

- Additional widening of the SAC from berths 24 to 29 is required to allow for safe transit of a Post-Panamax vessel past berthed cruise ships. Expansion of the SAC to the east by 60 feet north of Berth 26 and 50 feet south of Berth 26 will provide suitable clearance.

- Present SAC design width of 400 feet is sufficient south of Berth 29 to allow a Post-Panamax vessel to transit while passing a Panamax vessel at berth and a pleasure craft in the channel

3.4.8.4.2 USCG Reconfiguration and Basin Oscillation Study

122. Based on recommendations of the ship simulation study, several alternatives for modifying the USCG station were investigated. Two overall options were evaluated, reconfiguration of the outer protective bulkhead and total reconfiguration of the entire USCG basin.

123. Proposed modification and/or reconfiguration of the US Coast Guard ship basin presented a significant problem. Any degree of decreased protection to Coast Guard vessels within the basin from ship wake and wind generated waves could have major negative impacts on operations. In order to ensure that any proposed USCG basin would afford, at a minimum, the same protection from ship wake, wind waves, and swell, a harbor oscillation study was conducted to evaluate both the existing USCG basin and proposed reconfiguration alternatives (Sub-Appendix B).

124. During the course of the harbor oscillation study, multiple harbor designs were created and evaluated. Some focused on relocating the outer breakwater of the existing basin, others on relocating the basin eastward on existing USCG property. Subsequent ship simulation testing, numerical harbor wave response modeling, and coordination with USCG personnel showed that the majority of new configurations either conflicted with the port expansion project, caused increased wave amplification throughout the USCG basin, included structural aspects that would create undue navigational hazards to larger vessels, or did not meet the operational requirements of the station.

125. Initially, at the request of USCG personnel, some buildings were not eligible for reconfiguration in the creation of a new boat basin. This limited the orientation of the new basin resulting in a preliminary reconfiguration plan that extended significantly eastward and impacted a large portion of the USCG property. While this resulted in a reconfiguration plan with a suitable level of protection for moored vessels, it reduced the footprint of the USCG station to a degree that impacted negatively on operations at the station.

126. During further coordination efforts, the USCG lifted the restriction on relocating certain buildings. This allowed for a simple translation of the existing basin configuration 158 feet to the east, limiting the extent of USCG property impacted. Because the new basin has a slightly different entrance channel orientation, it was necessary to employ wave dissipating breakwaters in some locations to reduce the wave energy inside of the basin to acceptable levels. Figure A-33 illustrates the proposed configuration for the relocated USCG basin. A complete discussion of the USCG basin oscillation study and final USCG basin configuration is presented in Sub-Appendix B.

Figure A- 33. Proposed USCG Station Reconfiguration Plan

3.4.8.5 SAC Project Component – Final Design

Figure A- 34 shows the final layout of the SAC project component.

3.4.9 <u>Turning Notch (TN)</u>

3.4.9.1 Existing Dimensions

127. The TN measures approximately 1,000 feet from east to west and 750 feet north to south (Figure A- 35). The TN covers roughly 17 acres, including a single berth along the southern extent (berth 30). The current authorized project depth in the basin is -42 ft-MLLW.

Figure A- 34. SAC Project Component – Final Design

Figure A- 35. TN Existing Layout

3.4.9.2 Preliminary Design

128. Two scenarios were considered for the modification of the TN to accommodate the "S-Class" design vessel. The first was to modify the notch by extending the total east-west extent westward to 1,500 feet to allow for berthing the "S-Class" vessel at berth 30 as well as turning the same vessel in preparation for berthing in the SAC at berths 31 and 32. The second was to expand the TN by 150 feet to the north or south to allow for turning of the "S-Class" only. Due to a deficiency in available berthing, environmental factors (north expansion), and infrastructure impacts (south expansion), the north and south expansions were eliminated. The maximum project depth for the westward expansion TN component was -51 ft-MLLW.

3.4.9.3 Refinement of Design

3.4.9.3.1 <u>Ship Simulation</u>

129. Based on results from the ship simulation study (Sub-Appendix A), the following observations were recorded for the initial design of the TN component:

- To accommodate berthing of the design vessel at berth 30, the TN must be extended to west.

- To accommodate turning of the design vessel in the TN, the northern channel limits must be repositioned further to the north (without impact to the conservation easement located north of the existing TN) to allow adequate maneuvering room.

- To accommodate berthing and turning of the design vessel in the TN at berth 30, the western side of the SAC just north of the TN and the eastern side of the SAC across from the TN must be widened.

130. Ship simulation results indicate that due to flood and ebb tide currents in the SAC as well as the overall size of the design vessel, the existing design of the TN does not provide adequate maneuvering room to allow for either berthing or turning of the "S-Class" design vessel. To accommodate berthing, it was necessary to first increase the interior dimensions of the TN and to modify the SAC to the north and east of the TN. This involved relocating the western limit of the federal channel 320 feet to the west, expanding the limits of the TN to the north by 50 feet, gradually increasing the SAC channel width from 400 feet to 530 feet along the conservation easement beginning just south of berth 29 and ending at the TN, and adding a 1,340 foot long by 75 foot wide expansion to the eastern SAC channel limits east of the TN. To incorporate turning of the design vessel, an additional 500 foot by 75 foot expansion cut was added to the eastern SAC limits south of the previous 1,340 foot cut.

131. Additional modification for berthing the "S-Class" resulted from operational criteria provided by the sponsor. Port plans to add Post Panamax cranes along the southern edge of the TN required changes to east-west dimensions of the notch and berth. In order to allow the cranes to reach all cargo areas of the "S-Class" design vessel , the federal channel and berth

limits had to be moved an additional 290 feet to the west, resulting in a TN measuring 800 feet north to south (655 feet, Federal Channel + 145 feet, Berth 30 width) and 1,500 feet west to east.

132. In order to eliminate additional environmental impacts to either John U. Lloyd State Park to the east or the conservation easement to the north, bulkheads were added to the northern interior of the TN, along the west side of the SAC from berth 29 to the TN, and along the expansion cuts made at the east side of the SAC opposite the TN.

3.4.9.4 TN Project Component – Final Designs

133. Originally, expansion of the TN was investigated as two separate alternatives, a "Turning Only" alternative that included only those modifications necessary to turn the "S-Class" vessel and a "Turning and Berthing" alternative that included all of the proposed modifications. However, during the course of the study, the sponsor made the decision to proceed with components of the Port's Master Plan, including expansion of the existing TN to the full 1,500 foot dimension previously discussed. The Port's expansion of the TN (to the authorized depth of -42 ft-MLLW) is independent of the Federal project and will become the "existing condition". Expansion of the SAC to the north and east of the TN, to accommodate vessel turning, as well as deepening the expanded TN to the NED project depth will remain components of the Federal project. This revised project component will be denoted "S_TN". Figure A- 36 and Figure A-37 show the "existing" and the final design layouts for the TN. Note that these figures indicate the navigation channel only and do not show the expansion of the berthing area. Prior to this study, there was no federally recognized berthing area within the TN.

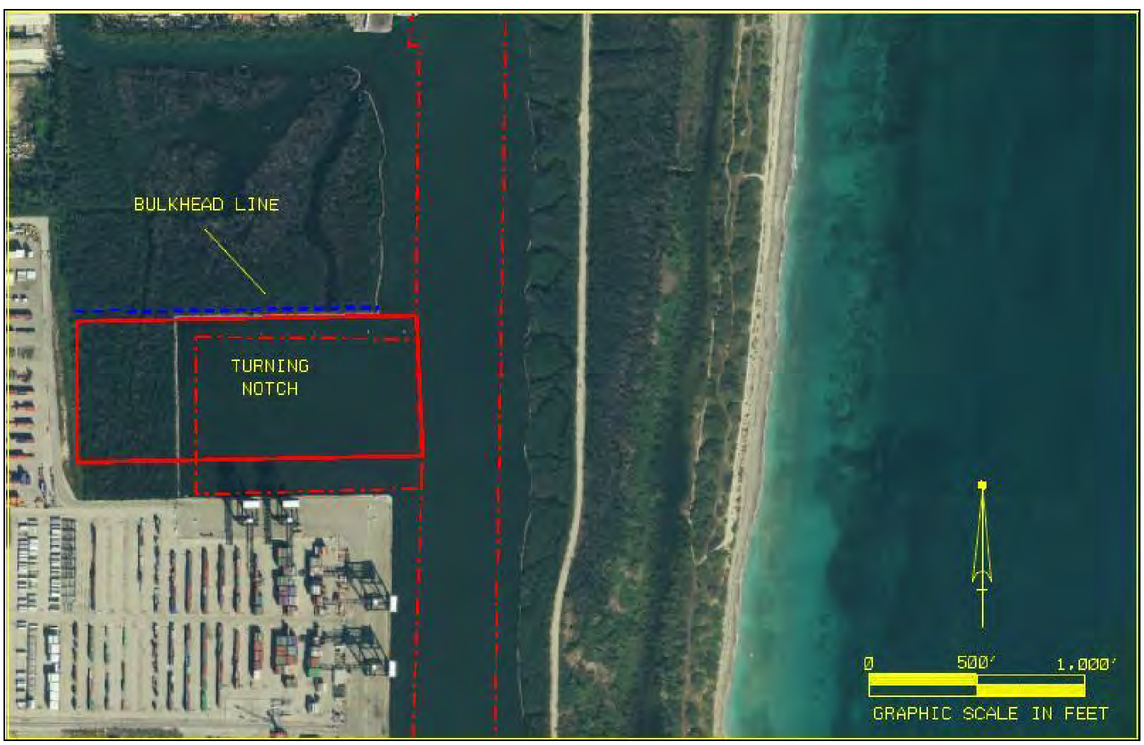


Figure A- 36. TN Projected "Existing" Layout

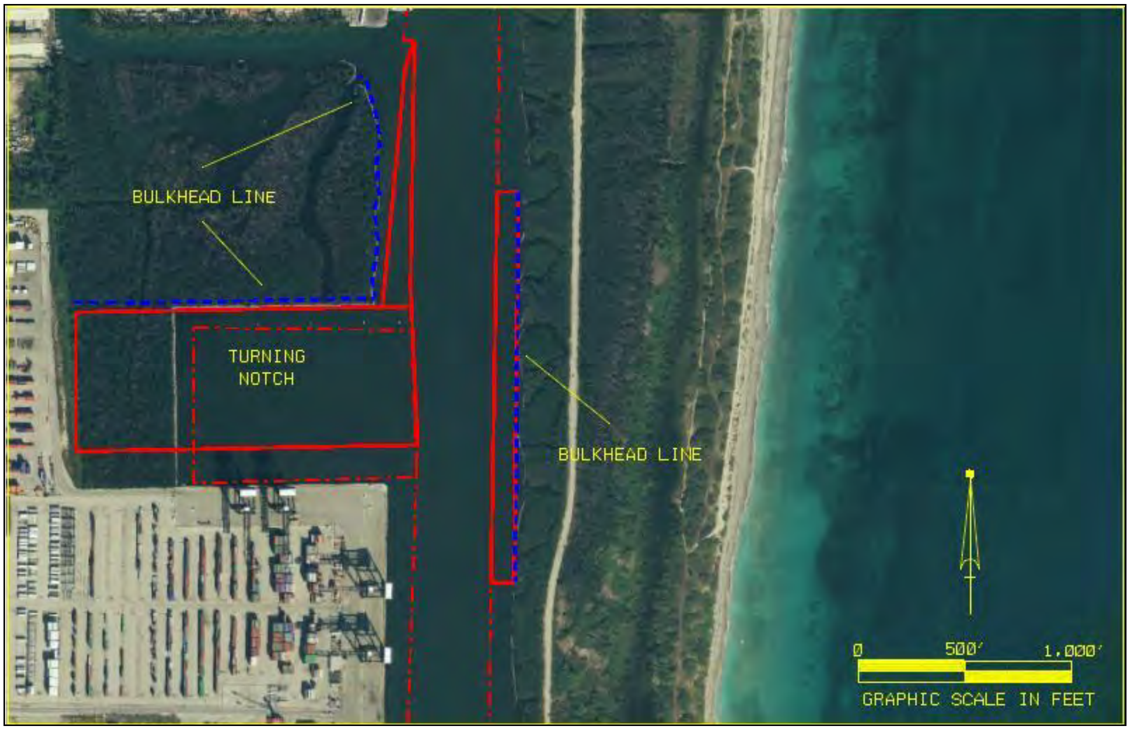


Figure A- 37. TN (S_TN) Project Component – Final Design

3.4.10 DANIA CUTOFF CANAL (DCC)

3.4.10.1 Existing Dimensions

134. The DCC is presently a small boat canal that intersects the Intracoastal Waterway and SAC at the southeast corner of the Port Everglades property (Figure A- 38). In the vicinity of the Port, it is approximately 200 feet wide with an average depth of -13 ft-MLLW.

3.4.10.2 Preliminary Design

135. In order to develop the southern extent of Port Everglades, it is necessary to accommodate commercial vessels in the DCC. Based on projections for the future fleet, the design vessel is the panamax class "Bellatrix".

136. The present width of the DCC combined with local boat traffic presents an obstacle to commercial vessels. The DCC is the location of several privately owned marinas. It is therefore unavoidable that pleasure craft will be present during the transit and berthing of cargo vessels. Also, the port intends to maintain multiple berths in the DCC, making it highly likely that the Bellatrix will pass other commercial vessels at berth as well as pleasure craft in the channel. For the purpose of design, the ship representing the berthed vessel shares the same dimensions as the Bellatrix. Pleasure craft are given a beam of 20 feet. The maximum project depth considered for

the DCC component is -34 ft-MLLW.

137. To accommodate the above requirements, the width of the DCC requires widening from 200 ft to 280 ft. In addition, a 90 foot wide, 2,125 foot long berthing area is created along the north side of the channel. This berthing area includes two roll on/roll off (ro/ro) vessel slips at the western edge. Initially four options were considered (1) widening to the north into Port property with a bulkhead stabilizing the southern channel edge, (2) widening to the north into Port property while allowing the southern edge of the channel to stabilize with a natural side slope, (3) widening to the south in Westlake Park with a bulkhead stabilizing the southern channel edge, and (4) widening to the south into Westlake Park while allowing the southern edge of the channel to stabilize with a natural side slope.

Figure A- 38. DCC Existing Layout

138. Options involving expansion to the south were eliminated during initial screening due to extensive environmental impacts to Westlake Park. Of the two remaining options, the northern expansion with a bulkhead along the southern edge was considered the most practical as it allows the channel to be pressed to the edge of Westlake Park (without impact), minimizing costly impacts to Port property. Natural side slopes to the south would require an additional excavation into Port property to avoid impacting parkland to the south. As this would increase impacts to existing container storage areas and effect operations, this alternative was eliminated.

3.4.10.3 Refinement of Design

3.4.10.3.1 <u>Ship Simulation</u>

139. Based on results from the ship simulation study (Sub-Appendix A), the following observations were recorded for the initial design of the DCC component:

- Design width of the DCC requires widening to 310 feet for safe transit of design vessel
- A turning basin is required at the intersection of the SAC and DCC to allow for safe transit of the Bellatrix to the DCC. The turning basin must include an eastward expansion of the SAC just north of the intersection and a southward expansion into the ICWW south of the intersection.

140. Due primarily to strong currents associated with the intersection of the DCC and SAC, initial channel limits of the DCC component were found to be unsuitable for transiting a Panamax vessel to berths located in the DCC. In order to remedy this, two primary modifications were made to the original channel layout. The first was to widen the proposed DCC channel from 280 feet to 310 feet allowing for increased vessel clearance and more maneuvering room when berthing. This was accomplished by expanding the channel 30 feet to the north. This increased the overall width of the channel to 310 feet while maintaining protection of Westlake Park to the south.

141. The second modification was inclusion of a turning basin at the intersection of the DCC and SAC. This was accomplished through the following: (1) addition of a 50 foot wide eastward expansion of the channel just north of the turning basin extending from the southern end of Berth 32 to the intersection of the DCC and SAC, (2) addition of a 300 foot by 375 foot extension of the turning basin extending to the south into the ICWW, and (3) widening of the northwest and southwest corners of the turning basin. Impacts to John U. Lloyd Park from the 50 foot expansion described in (1) are avoided through the use of a bulkhead.

142. Further modification of the DCC component was made at the request of the sponsor. The sponsor indicated a desire to omit proposed ro/ro ramps from the DCC design while at the same time extending the DCC channel 1,000 feet to the west and increasing the length of the northern berthing area from 2,250 feet to 3,600 feet.

3.4.10.4 DCC Project Component – Final Design

143. Figure A- 39 shows the final layout of the DCC project component. However, due to operational changes, the Port has asked that the DCC component be withdrawn from this study. While the DCC component remains feasible from an engineering standpoint, it will not be considered further.

Figure A- 39. DCC Project Component – Final Design

3.4.11 <u>Underkeel Clearance</u>

144. Underkeel clearance is the distance between the keel of the vessel and the channel bottom that is required for safe maneuvering of the vessel in the harbor. When determining underkeel clearance, care must be taken that the design channel depths developed from the economic analysis are equal to the loaded draft of the design ship, plus an allowance for the following factors: the effect of fresh water, vertical motion due to wave action, ship squat, safety clearance, and dredging tolerances. These components of underkeel clearance are shown graphically in Figure A- 40.

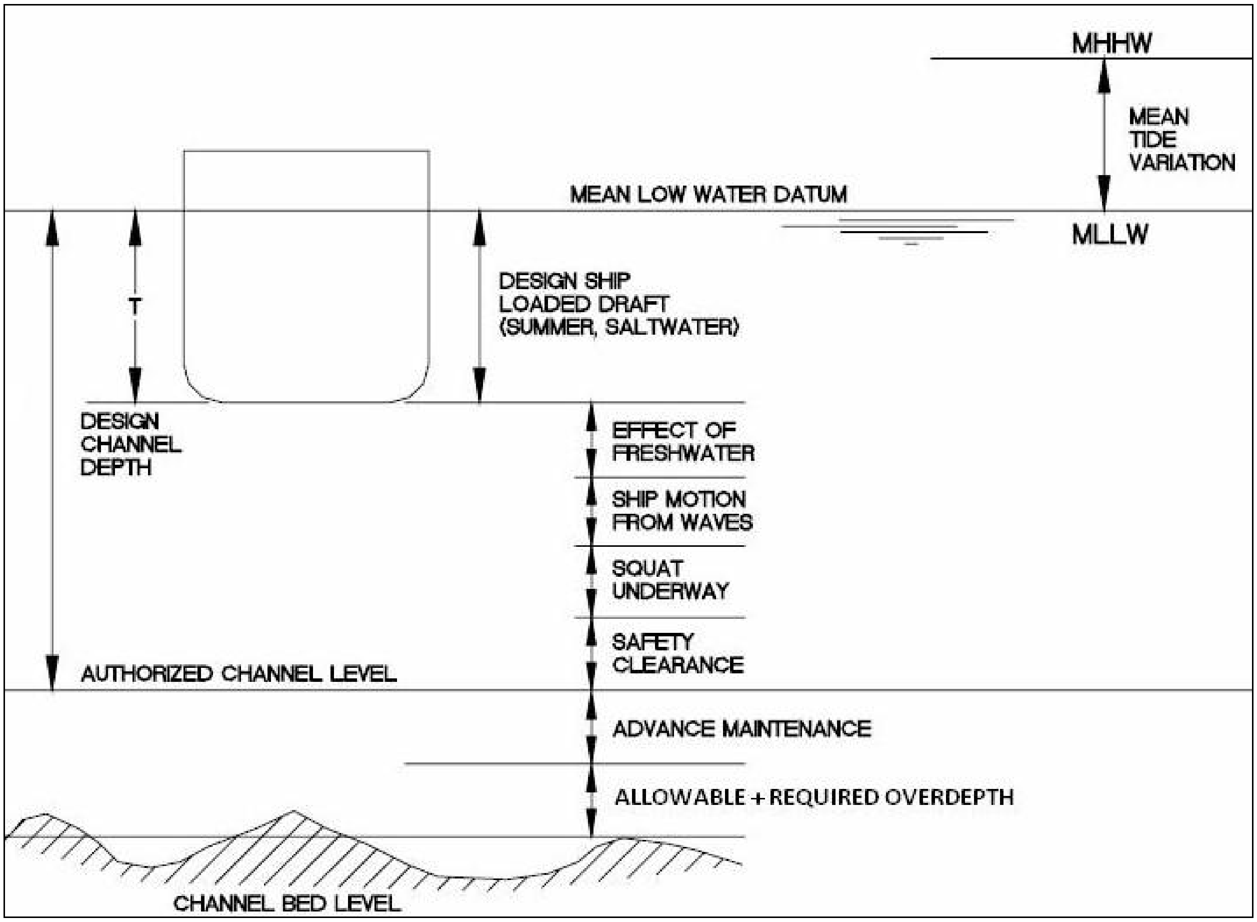


Figure A- 40. Underkeel Clearance Definition Sketch

3.4.11.1 Effects of Fresh Water

145. When ships enter fresh or brackish water, the ship draft will increase due to a decrease in the density of the water. At Port Everglades Harbor salinity levels within the port are consistent with those exterior or the harbor. Therefore, fresh water effects are not a design concern for this project.

3.4.11.2 Ship Motion from Waves

146. Ship response from waves is the movement of the ship bottom below the static water surface caused by waves. It is a vertical excursion that is composed primarily of motions in three response modes, heave, pitch, and roll (USACE, 2006). Because of the complex interrelationship between these three response modes, techniques for predicting maximum net vertical excursion due to waves tend to be highly variable and are often based upon approximations. In general, to account for wave influences, a gross underkeel clearance, of 10% to 20% of the maximum draft of the vessel is recommended. USACE Engineering Manual EM 1110-2-1613 (USACE, 2006) refers to recommendations made in 1981 by the International Association of Ports and Harbors (IAPH) Committee on Port Safety, Environment, and Construction in which the committee recommended gross underkeel clearance of 15% of the

maximum draft in regions exposed to strong and long swell. A gross underkeel wave clearance of 10% of the maximum draft was recommended for regions less exposed to swell. Due to sheltering effects of the Bahamas in the vicinity of the OEC, an underkeel clearance adjustment of 10% of the maximum allowable draft of the design vessel was considered to be sufficient.

147. Within the IEC and the remaining portions of the project located in the interior of the harbor, ship response from waves is less of a concern. Typically, wave effects are more pronounced and important in the design of the entrance channel or harbor fairway, which is open to ocean waves. Maximum ship response occurs with wavelengths equal to or nearly equal to the ship length. In these cases, the wave period resonates with the natural ship period. Conversely, typical commercial deep-draft design ships respond very weakly to wind waves with wave periods of less than 6 sec. In these cases, the wave period is considerably shorter than the natural ship period. In the exterior entrance channel, it is possible for swell to have wavelengths long enough to impact the vertical motion of the vessel. However, within the inner channels of the harbor, swell of significant wave lengths are not sustainable. Additionally, fetch limitations and sheltering limit the growth of the dominant wind waves. Wave lengths interior of the harbor jetties are significantly less than the length of the design vessel. Therefore, additional depth for wave motion was not applied to interior harbor channels.

3.4.11.3 Squat Underway

148. Squat underway is the vertical lowering of the vessel below the still water surface due to increased velocity past the ship causing the pressure on the ship hull to be decreased. This phenomenon occurs in deep, open-water situations and also in shallow waters. It is within shallow, restricted water such as canal- or trench-type open navigation channels (Figure A- 41) that the squat effect the most pronounced. The squat analysis conducted for Port Everglades is presented in Sub-Appendix C and summarized in the following paragraphs.

149. Methods for determining squat are generalized and varied. EM 1110-2-1613 discusses restricted channel squat under a variety of conditions and establishes a prediction method known as the Canal Theory (Blaauw and van der Knaap, 1983), in which squat and return velocity are obtained through an iterative analysis. Additional computational methods of determining squat are provided by the Permanent International Association of Navigation Congresses (PIANC, 1997). These include four methods applicable to restricted channels: Barrass (1979/1981), Eryuzlu et al. (1994), Huuska and Guliev (1976/1971), and Romisch (1989).

150. Based on evaluation of present Port Everglades transit procedures, a design speed of 10 knots was used for determining squat in the OEC. Though relatively high compared with OEC transit speeds at other harbors, this transit speed is at the lower end of the Port Everglades entrance speed range (10 to 12 knots) that is required to maintain vessel maneuverability under cross-current rotational forces prevalent in the vicinity of the OEC (see Section 2.3.6.2 – Offshore Currents), wind forces acting on the vessel's air draft, and natural hydraulic forces encountered in restricted waterways. The design vessel was the "S-Class" vessel, as its dimensions will result in the maximum squat condition for the design fleet.

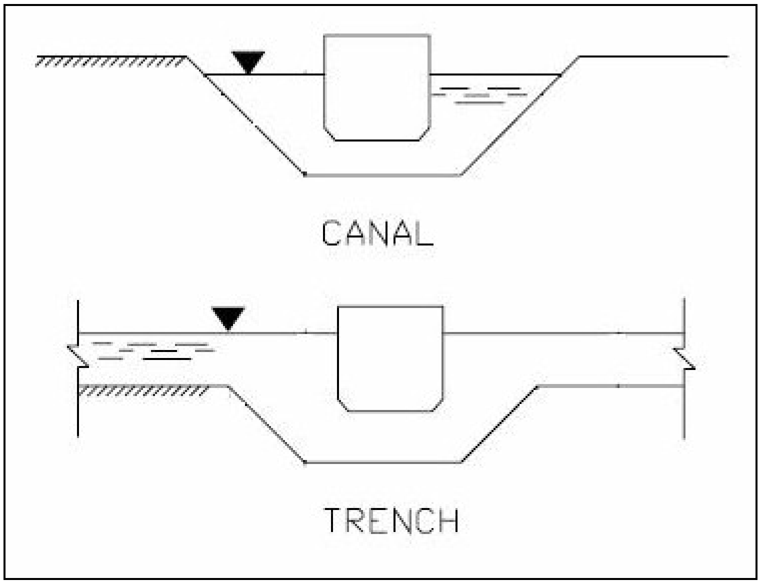


Figure A- 41. Restricted Channel Types

151. Of the five methods presented, the Canal Theory and Barrass methods result is the most conservative estimates of squat. The three remaining methods are less conservative, but show excellent agreement with one another for all vessel drafts considered. Because the Canal Theory is considered to be a first approximation for channel design and is open for refinement, it was not considered for the final determination of squat at Port Everglades. Of the remaining four methods, all are considered to be acceptable means of estimating squat. Therefore, it was decided that squat at Port Everglades would be determined as an average of the three methods that provided the most consistent results. Figure A- 42 shows squat as a function of vessel draft for each of the three determining methods (Eryuzlu et al., Huuska and Guliev, and Romisch). The Canal Theory and Barrass method are also shown (dashed lines) for comparison purposes. Final average squat for each incremental depth is provided in Table A- 11.

152. As vessels enter the IEC, forward speed is reduced drastically and the vessel is no longer subject to significant amounts of squat. Therefore, squat is not a factor in determining the project depths for the IEC or other interior channels.

153. The absence of additional depth for squat (and wave) effects in the interior channels will create a difference in design depths between the OEC and IEC. In order to minimize hydraulic effects that may result from an abrupt change in water depth, the bottom of the IEC channel will be sloped on 1V:3H gradient beginning just inside the harbor jetties at the point where the OEC becomes the IEC (Figure A- 43). This transition region will not only reduce hydraulic effects on transiting vessels, but will also provide an additional margin of safety for a project area where wave conditions, vessel speeds, and current conditions are also in transition.

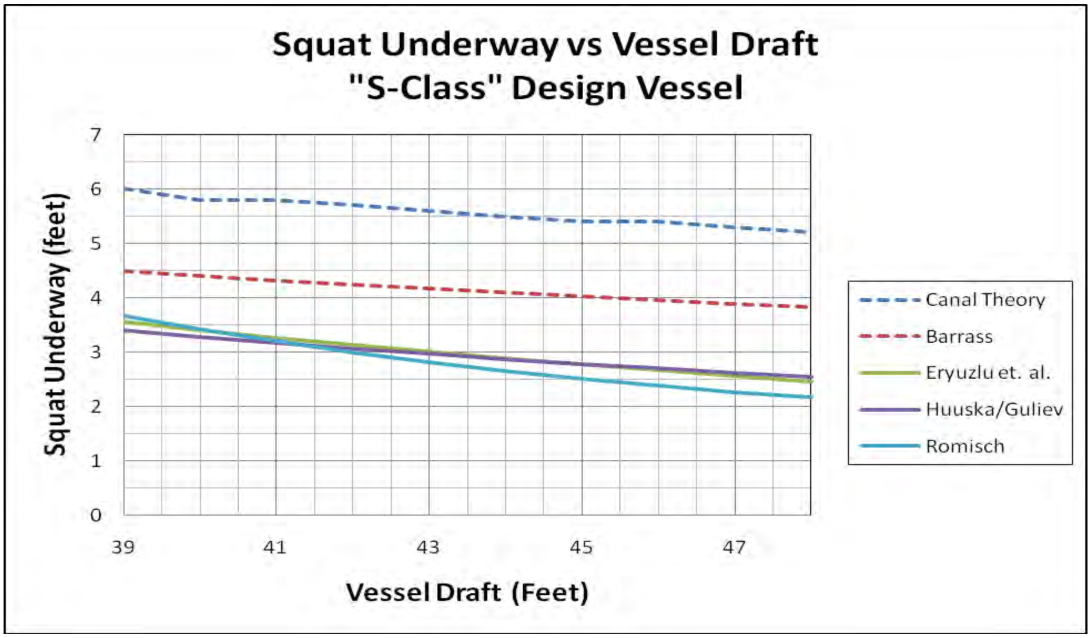


Figure A- 42. Squat Underway vs Vessel Draft: "S-Class" Design Vessel

3.4.11.4 Safety Clearance

154. In the interest of safety, a clearance is provided between the bottom of the ship and the floor of the design channel to avoid damage to ship hull, propellers, and rudders from bottom irregularities and debris. A clearance of 2 feet is recommended when the bottom of the channel is soft material, such as sand. When the bottom of the channel is hard, consisting of rock, consolidated sand, or clay, the clearance should be increased to at least 3 feet (USACE, 2006). Due to the presence of rock and consolidated clay at Port Everglades, a safety clearance of 3 feet is specified.

3.4.11.5 Advance Maintenance and Overdepth

155. Advance maintenance, allowable overdepth, and required overdepth are additional depth increments for channel design that are associated with the dredging process. These increments were discussed previously in greater detail in the Section 3.3 Depth, and have the following values: 0 feet of advance maintenance, 1 foot allowable overdepth, and 1 foot required overdepth.

3.4.11.6 Total Underkeel Clearance

156. Combining effects due to fresh water, net vertical excursion due to wave action, the expected amount of squat, the safety clearance, and dredge related overdepths, results in the total underkeel clearance. Table A- 11 provides resulting project depths (not including dredge related overdepths) for all project components including the OEC. Design drafts range from 8 feet to 31 feet for the "Bellatrix" (DCC), from 31 feet to 42 feet for the STB Panamax vessel (STB), and from 39 feet to 48 feet for the "S-Class" vessel (OEC, IEC, MTB, Widener, SAC, and TN).

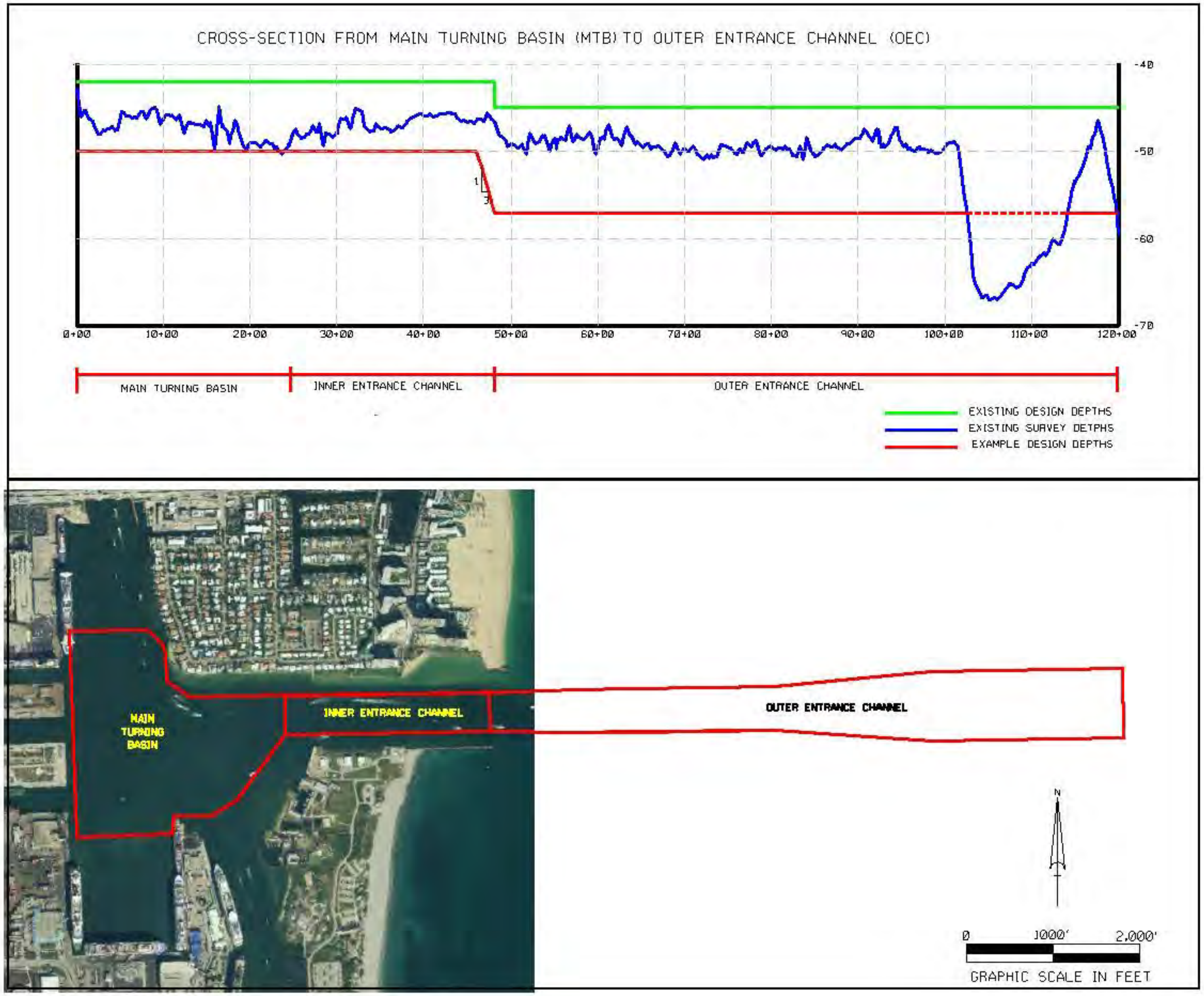


Figure A- 43. Example Transition From OEC Depth to IEC Dept

Table A- 11. Underkeel Clearance and Project Depths for Outer and Inner Channels

Design Parameters				Outer Entrance Channel (OEC)				Interior Channels/Basins	
Vessel			Draft (ft)	Wave Clearance (ft)	Ave. Squat (ft)	Safety Clearance (ft)	Project Depth* (ft)	Safety Clearance (ft)	Project Depth* (ft)
"Bellatrix" (DCC)			8					3	11
			9					3	12
			10					3	13
			11					3	14
			12					3	15
			13					3	16
			14					3	17
			15					3	18
			16					3	19
			17					3	20
			18					3	21
			19					3	22
			20					3	23
			21					3	24
			22					3	25
			23					3	26
			24					3	27
			25					3	28
			26					3	29
			27					3	30
			28					3	31
			29					3	32
			30					3	33
	"STB Panamax" (STB)		31					3	34
			32					3	35
			33					3	36
			34					3	37
			35					3	38
			36					3	39
			37					3	40
			38					3	41
		"S-Class" (OEC, IEC, MTB,Wide, SAC, TN)	39	3.9	3.5	3.0	49	3	42
			40	4.0	3.4	3.0	50	3	43
			41	4.1	3.2	3.0	51	3	44
			42	4.2	3.1	3.0	52	3	45
			43	4.3	2.9	3.0	53	3	46
			44	4.4	2.8	3.0	54	3	47
			45	4.5	2.7	3.0	55	3	48
			46	4.6	2.6	3.0	56	3	49
			47	4.7	2.5	3.0	57	3	50
			48	4.8	2.4	3.0	58	3	51

* Project Depths do not include dredge related overdepths. Actual channel depths will include an additional 1 foot of allowable overdepth plus 1 foot of required overdepth.

3.5 DETERMINATION OF DESIGN PLANS

157. In order to meet project goals and generate an economically viable plan, the nine project components were arranged into six economic alternative plans (Plans 1 – 6) which were further divided into sixteen economically and logistically feasible alternatives based on the grouping of individual project components. Table A- 12 presents each Plan, itemizing associated project components and providing a brief description. Note that some alternatives are repetitive. This is for purposes of economic grouping and has no effect on the engineering or cost analyses. An asterisk denotes Plans that were dropped during the course of the study due to elimination of project components: STB, DCC, TN (Turning and Berthing), and TN (Turning Only).

3.6 HYDROLOGY AND HYDRAULICS

3.6.1 GENERAL

158. Port Everglades is a complex system of interconnecting channels and basins that vary in shape and depth. Deepening and widening such features can lead to localized hydrologic and hydraulic impacts. Among potential impacts at Port Everglades are changes to the nearshore wave climate, which can change shoreline erosion and accretion patterns, and changes to existing salinity levels, which can impact local ecosystems. The following summarizes evaluation of these potential impacts.

3.6.2 HYDROGRAPHIC AND TOPOGRAPHIC SURVEYS – EXISTING CONDITIONS

159. Three hydrographic surveys were utilized for the Port Everglades Feasibility Study. The first was a SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) survey conducted by U.S. Army Engineer Airborne Lidar Bathymetry Technical Center of Expertise in December 1997. This comprehensive survey was conducted to determine the existing condition of the Port Everglades Harbor navigational project and to establish the horizontal positions of navigational aids and existing jetties. The second hydrographic survey was a project condition survey completed by the U.S. Army Corps of Engineers Jacksonville District in June 2000, specifically for the Port Everglades Feasibility Study. The third survey was conducted June 2005 as part of the 2006 maintenance event. The horizontal datum for each survey is Florida East State Plane, NAD83, Transverse Mercator Projection. The vertical datum is Mean Lower Low Water (MLLW).

160. Two topographic surveys were conducted of Port Everglades by the Port Authority. The first, conducted in 1999 is a land survey. The second, conducted in August 2000 is an aerial survey covering John U Lloyd State Park from the south jetty at the Port Everglades entrance channel to the Dania Cutoff Canal as well as portions of port property located north of the Dania. The horizontal datum for both surveys is Florida East State Plane, NAD83.

161. Contours depicting coverage of the hydrographic (truncated north and south of the OEC) and topographic surveys of Port Everglades are displayed in Figure A- 44.

Table A- 12. Project Alternative Plans

Alternative Plan	Components	Description
Plan 1A	OEC, IEC, MTB	Widen (where applicable) and deepen to an economically determined depth
Plan 1B*	OEC, IEC, MTB, STB	
Plan 2A	OEC, IEC, MTB	Widen (where applicable) and deepen to an economically determined depth
Plan 2B	OEC, IEC, MTB, Widener, SAC	
Plan 2C*	OEC, IEC, MTB, Widener, SAC, TN (Turning & Berthing)	
Plan 2D*	OEC, IEC, MTB, Widener, SAC, TN (Turning Only)	
Plan 2E	OEC, IEC, MTB, Widener, SAC, TN (S_TN)	
Plan 3A*	DCC	Widen (where applicable) and deepen to an economically determined depth
Plan 4A*	STB	Widen (where applicable) and deepen to an economically determined depth
Plan 5A	OEC, IEC, MTB	Widen (where applicable) and deepen to an economically determined depth
Plan 5B*	OEC, IEC, MTB, STB	
Plan 5C*	OEC, IEC, MTB, STB, Widener, SAC	
Plan 5D*	OEC, IEC, MTB, STB, Widener, SAC, TN (Turning & Berthing)	
Plan 5E*	OEC, IEC, MTB, STB, Widener, SAC, TN (Turning & Berthing), DCC	
Plan 5F*	OEC, IEC, MTB, STB, Widener, SAC, TN (Turning Only)	
Plan 5G*	OEC, IEC, MTB, STB, Widener, SAC, TN (Turning Only), DCC	
Plan 6A	Widener	Widen (where applicable) and deepen only (with the exception of the DCC) to a project depth 42'. Widen and deepen DCC to an economically determined depth.
Plan 6B	Widener, SAC	
Plan 6C*	Widener, SAC, TN (Turning & Berthing)	
Plan 6D*	Widener, SAC, TN (Turning & Berthing), DCC	
Plan 6E*	Widener, SAC, TN (Turning Only)	
Plan 6F*	Widener, SAC, TN (Turning Only), DCC	
* Plans dropped due to the elimination of individual project components		

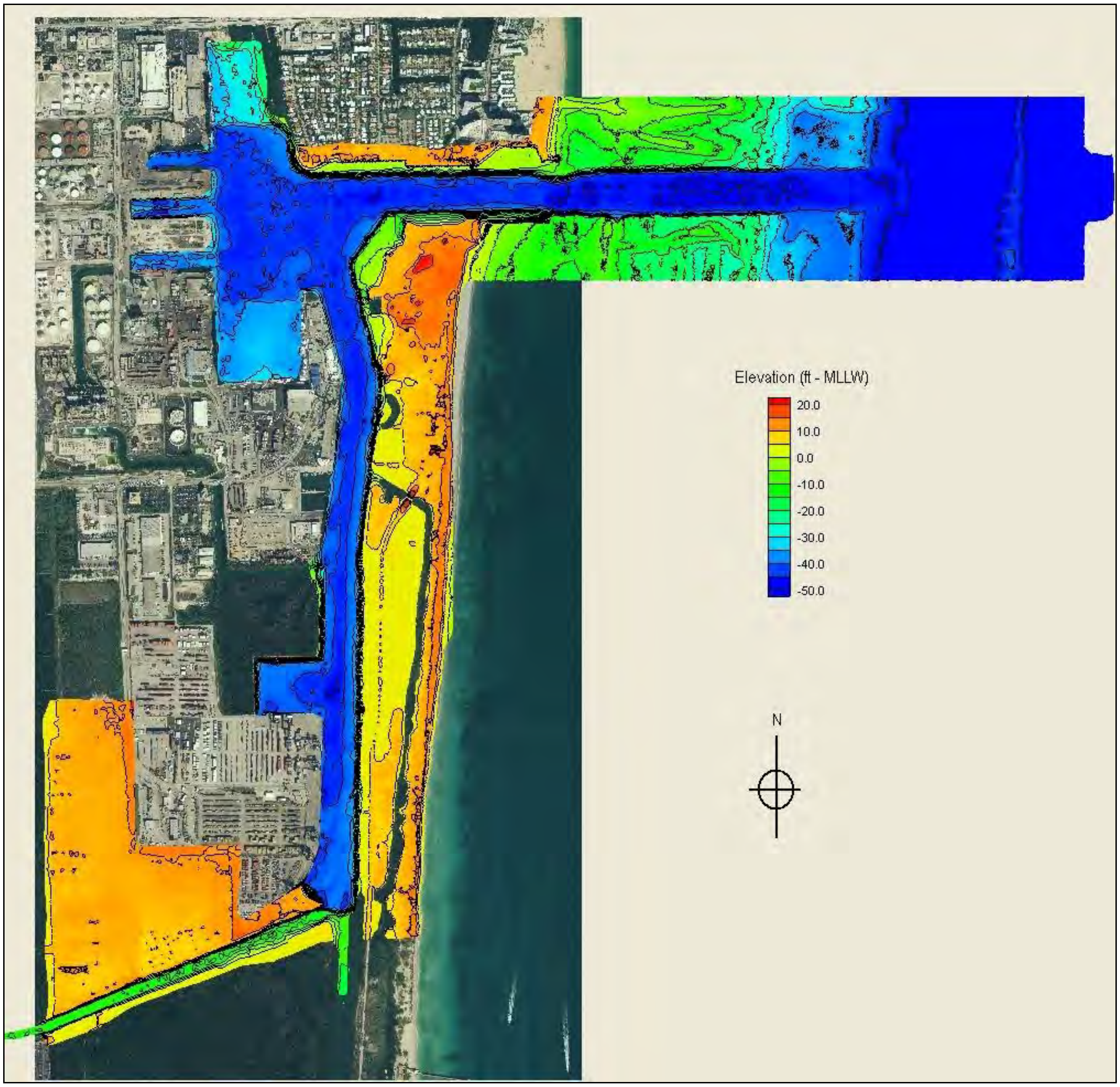


Figure A- 44. Coverage of Hydrographic and Topographic Surveys

162. It should be noted that the surveys detailed in previous paragraphs were the most currently available surveys at the time that the incremental benefit and cost analyses were initiated. Because Port Everglades is a slow shoaling harbor, maintenance surveys are not taken on a yearly basis, making timely updates during the analyses impossible. However, surveys conducted after completion of the Final Draft of this report will be incorporated into the PED phase of the study.

3.6.3 <u>REGION 2D HYDRODYNAMIC MODELING</u>

3.6.3.1 General

163. The proposed expansion of Port Everglades has the potential to alter the hydrodynamics in the vicinity of the Inlet and thus change sediment transport conditions in the nearshore areas to the north and south of the inlet.

164. As part of the Port Everglades Inlet Sand Management Phase I: Sand Bypassing Feasibility Study (Olsen Associates, Inc., 2004), the 2D nested hydrodynamic model MIKE 21 HD was setup to evaluate a series of bypassing alternatives. Within this study, the proposed expansion of the Port Everglades port facilities was also evaluated. The purpose of the addition of the port expansion to the bypass study was to "determine impact of port expansion on flow through Port Everglades Inlet, and to determine whether there will be any interaction between the proposed port expansion and the proposed bypassing scheme."

3.6.3.2 Impact on Inlet Discharge and Sediment Transport

165. Widening and deepening associated with the expansion project increases the water area in internal waterways and inlet channels. This has the potential to alter the discharge rates normally associated with the present harbor configuration and impact the sediment transport climate in the vicinity of the entrance channel. However Figure A- 45 (Olsen Associates, Inc., 2004), providing modeled discharge through the Port everglades inlet with and without port expansion elements, indicates that the net effect of the port expansion is an increase in the magnitude of discharge of only 1% to 3%. This small percentage of increase was determined to be negligible with respect to influencing the sediment transport conditions in the vicinity of the inlet.

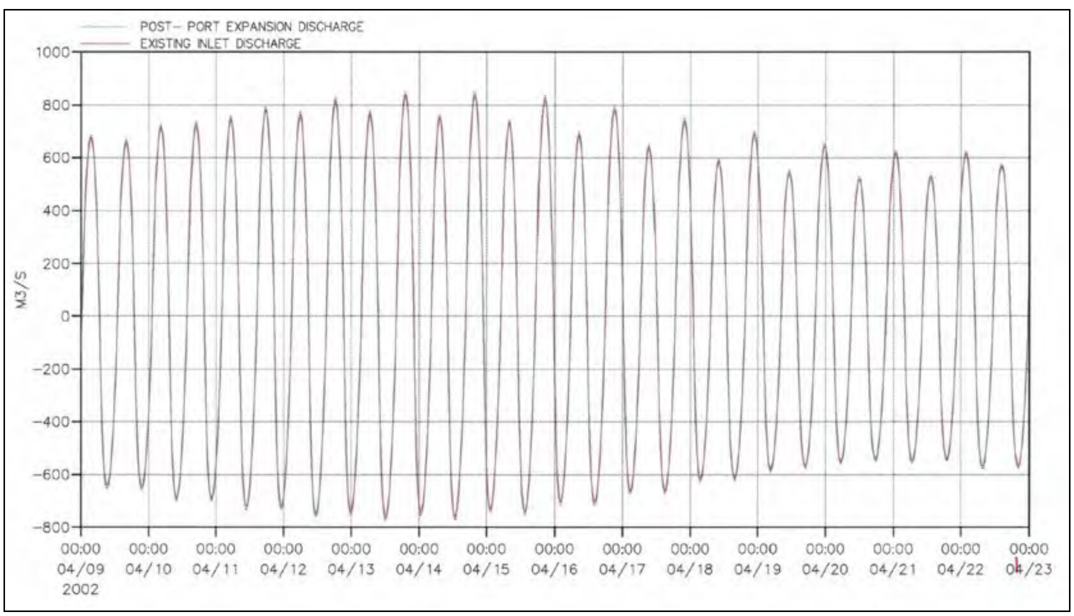


Figure A- 45. Inlet Discharge Rates, With and Without Port Expansion

166. Widening and deepening at Port Everglades , especially in the OEC, has the potential to impact the nearshore wave climate and therefore the longshore sediment transport patterns along the adjacent shorelines. However, further modeling proved that the effect of widening and deepening of the project elements on the longshore transport in the vicinity of Port Everglades was negligible. Figure A- 46 and Figure A- 47 (Olsen Associates, Inc., 2004) show examples of with and without expansion transport rates results.

Figure A- 46. Sediment Transport Rates With and Without Port Expansion, Wave "Case 2"

Figure A- 47. Sediment Transport Rates With and Without Port Expansion, Wave "Case 5"

3.6.3.3 Conclusions

167. The findings of Olsen indicate that widening and deepening associated with the expansion of Port Everglades will have negligible impact on sediment transport patterns along the shorelines to the north and south of the inlet.

3.6.4 RMA MODELING

168. In order to examine potential impacts to the salinity regime that could result from the proposed project, the numerical model RMA-2 was employed to analyze hydrodynamic changes in the study area. This modeling effort focused on plans that would most likely cause the largest impacts to the salinity regime (Plans 2 and 5). This RMA modeling effort is described in Sub-Appendix D.

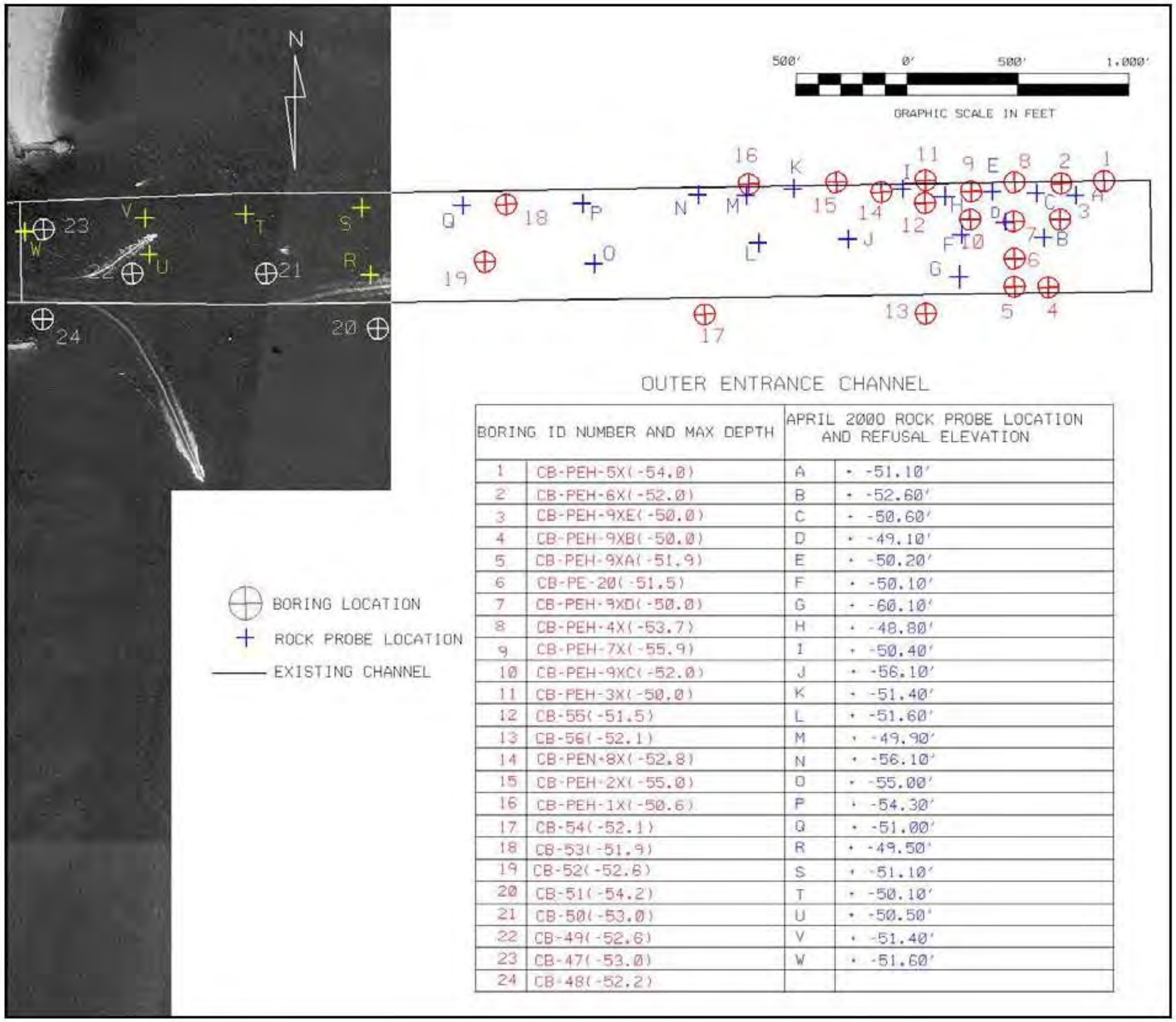
169. RMA-2 is a two-dimensional depth-averaged finite-element hydrodynamic model which computes water surface elevations and horizontal velocity components for subcritical, free-surface flow. RMA-2 provides a means for examining changes in tidal flushing which can be used as an indirect indicator of the magnitude of potential changes in the salinity regime of the study area.

170. A finite element mesh geometry was developed that allowed for the modeling of both the with- and without-project conditions. Transient head input data files were used to simulate forcing tides and steady-state volumetric inflows were included to simulate the fresh water discharge of rivers and canals. From resulting model output, computed average flows across selected channel locations were generated. Through comparison of with- and without-project flows, a relative percent change for each selected location was determined. Based on the 14 selected locations dispersed throughout the study area, differences in flow were found to be minimal, indicating that changes in tidal flushing and the existing salinity regime resulting from with-project channel configurations are not expected.

3.7 GEOTECHNICAL INVESTIGATIONS

3.7.1 CORE BORINGS

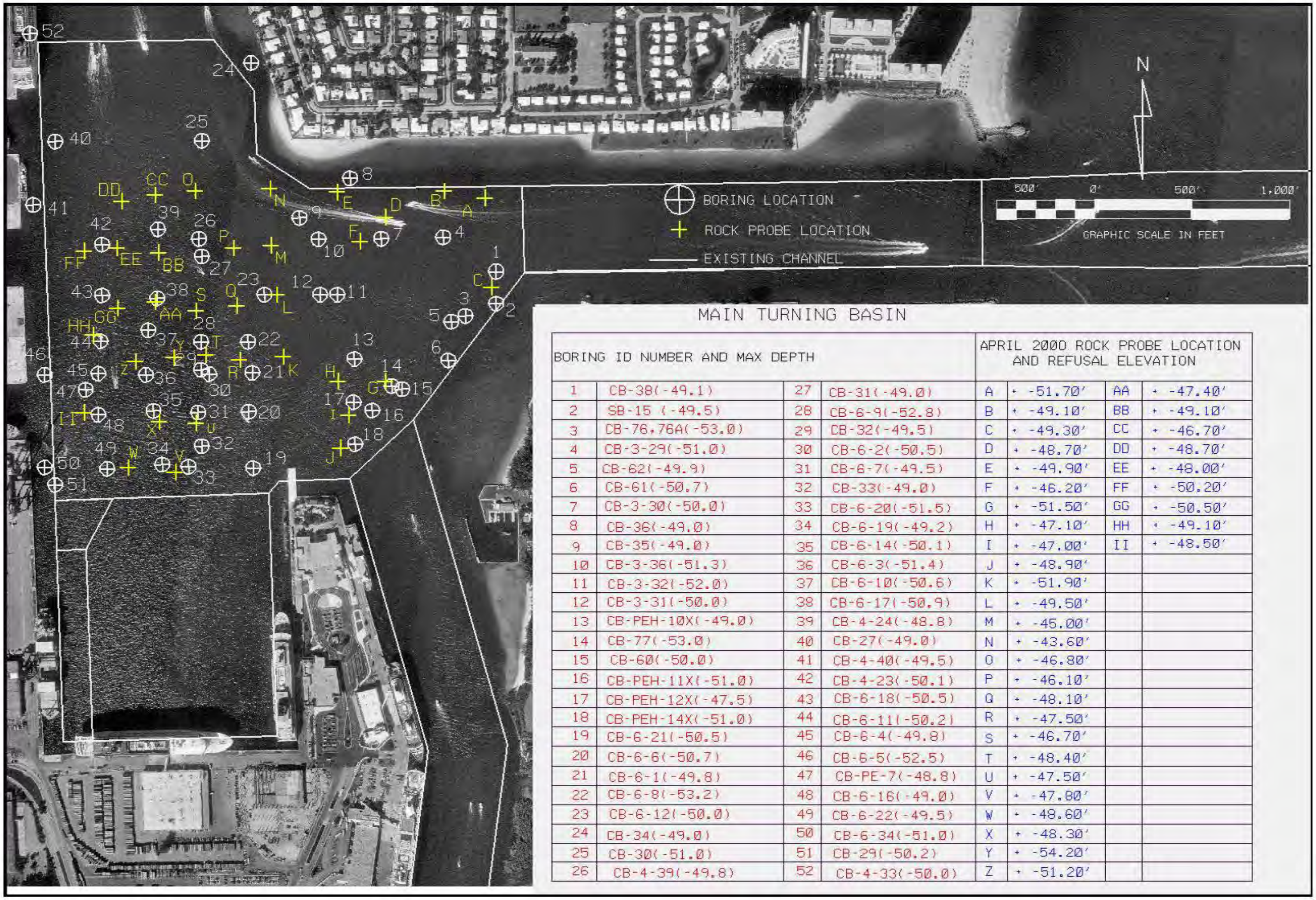
171. Hundreds of core borings have been drilled in and around Port Everglades Harbor. Figure A- 48 through Figure A- 56 illustrate core boring locations in the OEC, IEC, MTB, STB, Widener, SAC, TN, and DCC, respectively. Core borings were drilled by the Corps of Engineers, the Broward County Port Authority, and dredging contractors. The quality of the core borings is variable. The Corps of Engineers core borings can be relied upon to document the ground conditions. Other core borings vary in usefulness. Major problems observed on many of the core boring logs include poor recovery, uncertain locations, poor documentation of drilling data, and poor descriptions of materials.



BORING ID NUMBER AND MAX DEPTH		APRIL 2000 ROCK PROBE LOCATION AND REFUSAL ELEVATION	
1	CB-PEH-5X(-54.0)	A	-51.10'
2	CB-PEH-6X(-52.0)	B	-52.60'
3	CB-PEH-9XE(-50.0)	C	-50.60'
4	CB-PEH-9XB(-50.0)	D	-49.10'
5	CB-PEH-9XA(-51.9)	E	-50.20'
6	CB-PE-20(-51.5)	F	-50.10'
7	CB-PEH-9XD(-50.0)	G	-60.10'
8	CB-PEH-4X(-53.7)	H	-48.80'
9	CB-PEH-7X(-55.9)	I	-50.40'
10	CB-PEH-9XC(-52.0)	J	-56.10'
11	CB-PEH-3X(-50.0)	K	-51.40'
12	CB-55(-51.5)	L	-51.60'
13	CB-56(-52.1)	M	-49.90'
14	CB-PEN-8X(-52.8)	N	-56.10'
15	CB-PEH-2X(-55.0)	O	-55.00'
16	CB-PEH-1X(-50.6)	P	-54.30'
17	CB-54(-52.1)	Q	-51.00'
18	CB-53(-51.9)	R	-49.50'
19	CB-52(-52.6)	S	-51.10'
20	CB-51(-54.2)	T	-50.10'
21	CB-50(-53.0)	U	-50.50'
22	CB-49(-52.6)	V	-51.40'
23	CB-47(-53.0)	W	-51.60'
24	CB-48(-52.2)		

Figure A- 48. Core Borings - Outer Entrance Channel

Figure A- 49. Core Borings - Inner Entrance Channel



BORING ID NUMBER AND MAX DEPTH				APRIL 2000 ROCK PROBE LOCATION AND REFUSAL ELEVATION			
1	CB-38(-49.1)	27	CB-31(-49.0)	A	-51.70'	AA	-47.40'
2	SB-15 (-49.5)	28	CB-6-9(-52.8)	B	-49.10'	BB	-49.10'
3	CB-76,76A(-53.0)	29	CB-32(-49.5)	C	-49.30'	CC	-46.70'
4	CB-3-29(-51.0)	30	CB-6-2(-50.5)	D	-48.70'	DD	-48.70'
5	CB-62(-49.9)	31	CB-6-7(-49.5)	E	-49.90'	EE	-48.00'
6	CB-61(-50.7)	32	CB-33(-49.0)	F	-46.20'	FF	-50.20'
7	CB-3-30(-50.0)	33	CB-6-20(-51.5)	G	-51.50'	GG	-50.50'
8	CB-36(-49.0)	34	CB-6-19(-49.2)	H	-47.10'	HH	-49.10'
9	CB-35(-49.0)	35	CB-6-14(-50.1)	I	-47.00'	II	-48.50'
10	CB-3-36(-51.3)	36	CB-6-3(-51.4)	J	-48.90'		
11	CB-3-32(-52.0)	37	CB-6-10(-50.6)	K	-51.90'		
12	CB-3-31(-50.0)	38	CB-6-17(-50.9)	L	-49.50'		
13	CB-PEH-10X(-49.0)	39	CB-4-24(-48.8)	M	-45.00'		
14	CB-77(-53.0)	40	CB-27(-49.0)	N	-43.60'		
15	CB-60(-50.0)	41	CB-4-40(-49.5)	O	-46.80'		
16	CB-PEH-11X(-51.0)	42	CB-4-23(-50.1)	P	-46.10'		
17	CB-PEH-12X(-47.5)	43	CB-6-18(-50.5)	Q	-48.10'		
18	CB-PEH-14X(-51.0)	44	CB-6-11(-50.2)	R	-47.50'		
19	CB-6-21(-50.5)	45	CB-6-4(-49.8)	S	-46.70'		
20	CB-6-6(-50.7)	46	CB-6-5(-52.5)	T	-48.40'		
21	CB-6-1(-49.8)	47	CB-PE-7(-48.8)	U	-47.50'		
22	CB-6-8(-53.2)	48	CB-6-16(-49.0)	V	-47.80'		
23	CB-6-12(-50.0)	49	CB-6-22(-49.5)	W	-48.60'		
24	CB-34(-49.0)	50	CB-6-34(-51.0)	X	-48.30'		
25	CB-30(-51.0)	51	CB-29(-50.2)	Y	-54.20'		
26	CB-4-39(-49.8)	52	CB-4-33(-50.0)	Z	-51.20'		

Figure A- 50. Core Borings - Main Turning Basin

Figure A- 51. Core Borings - South Turning Basin

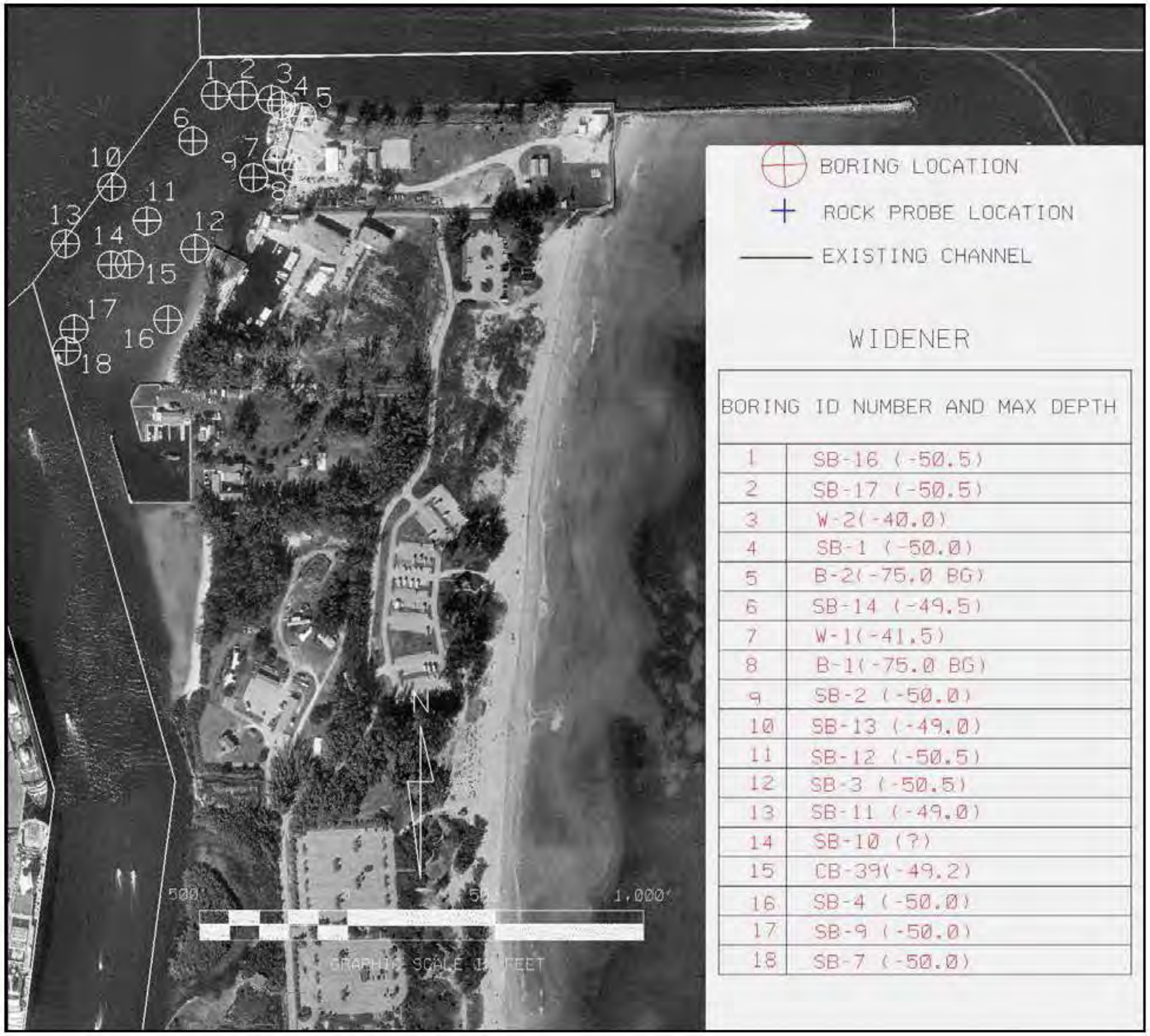
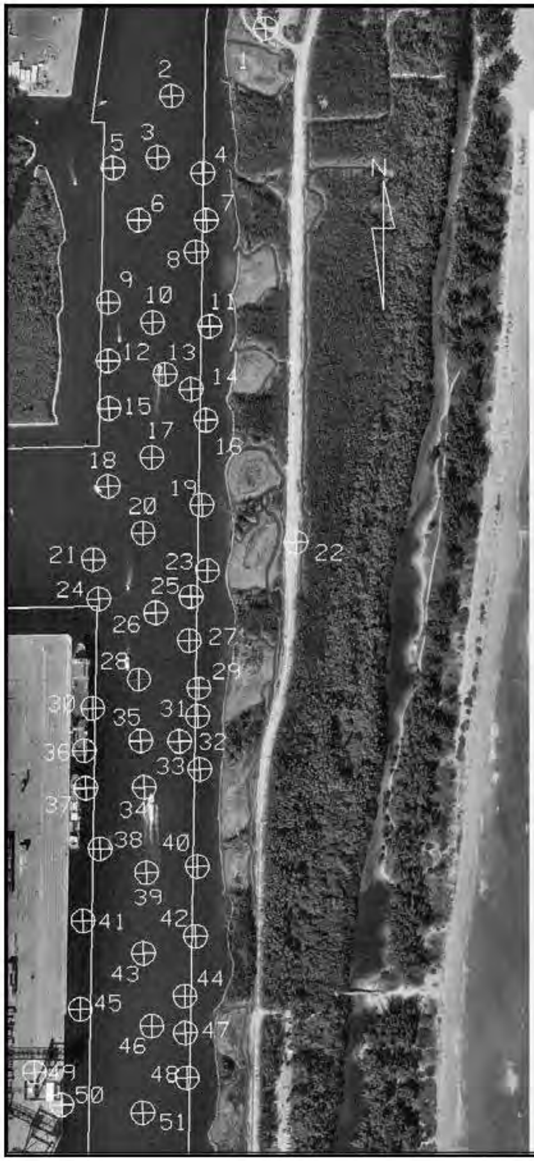


Figure A- 52. Core Borings - Widener

SOUTHPORT ACCESS CHANNEL
(NORTH OF BERTH 29)

BORING ID NUMBER AND MAX DEPTH					
1	CB-59(-50.0)	27	TH-15 (-50.0)	A	+ -49.90'
2	CB-58(-50.0)	28	CB-PEH2001-5	B	+ -49.80'
3	CB-37(-49.7)	29	TH-16 (-50.0)	3	+ -48.10'
4	SB-5 (-50.0)	30		4	+ -51.70'
5	CB-69(-50.4)	31		5	+ -48.70'
6	CB-42(-49.0)	32		6	+ -49.70'
7	SB-6 (-49.0)	33		7	+ -48.30'
8	SB-18 (-50.0)	34		8	+ -49.70'
9	SB-19 (-50.5)	35		9	+ -48.90'
10	SB-20 (-50.0)	36		10	+ -50.70'
11	SB-21 (-50.0)	37		11	+ -48.50'
12	CB-PEH2001-6	38		12	+ -51.20'
13	CB-75(-50.3)	39			
14	TH-2 (-50.0)	40			
15	TH-3 (-50.5)	41			
16	TH-4 (-50.5)	42			
17	TH-5 (-50.0)	43			
18	TH-6 (-50.0)	44			
19	TH-7 (-50.0)	45			
20	TH-8 (-50.0)	46			
21	TH-9 (-50.0)	47			
22	TH-10 (-51.0)	48			
23	TH-11 (-50.5)	49			
24	TH-12 (-50.0)	50			
25	TH-13 (-50.0)	51			
26	TH-14 (-50.0)	52			

Figure A- 53. Core Borings - Southport Access Channel (North of Berth 29)



SOUTHPORT ACCESS CHANNEL
(SOUTH OF BERTH 29)

BORING ID NUMBER AND MAX DEPTH			
1	CB-PEH2001-4	27	B-26(-52.0)
2	B-6	28	B-27(-51.0)
3	B-13	29	B-29(-50.0)
4	B-14	30	B-40(-53.0)
5	B-15	31	B-45(-51.0)
6	B-17(-51.0)	32	B-2(-50.0)
7	B-5	33	B-57(-53.0)
8	B-18(-51.0)	34	B-58(-52.0)
9	B-16(-52.7)	35	B-30(-52.0)
10	B-19(-50.0)	36	B-62
11	B-22	37	B-31(-52.0)
12	B-21(-52.0)	38	B-34(-52.5)
13	B-50(-51.0)	39	B-33(-51.0)
14	B-4	40	B-44(-52.0)
15	B-51(-52.0)	41	B-38(-52.5)
16	B-49(-51.7)	42	B-43(-51.0)
17	B-23	43	B-30(-52.0)
18	B-25(-50.0)	44	B-1(-51.8)
19	B-24(-51.0)	45	B-36
20	B-52(-53.0)	46	B-35
21	B-47	47	B-42(-51.0)
22	CB-PEH2001-3	48	B-41(-51.0)
23	B-48(-51.5)	49	B-11
24	B-28(-53.0)	50	B-5
25	B-3	51	B-37(-52.0)
26	B-46	52	

BORING LOCATION
ROCK PROBE LOCATION
EXISTING CHANNEL

500' 0' 500' 1,000'

Figure A- 54. Core Borings - Southport Access Channel (South of Berth 29)

Figure A- 55. Core Borings - Turning Notch

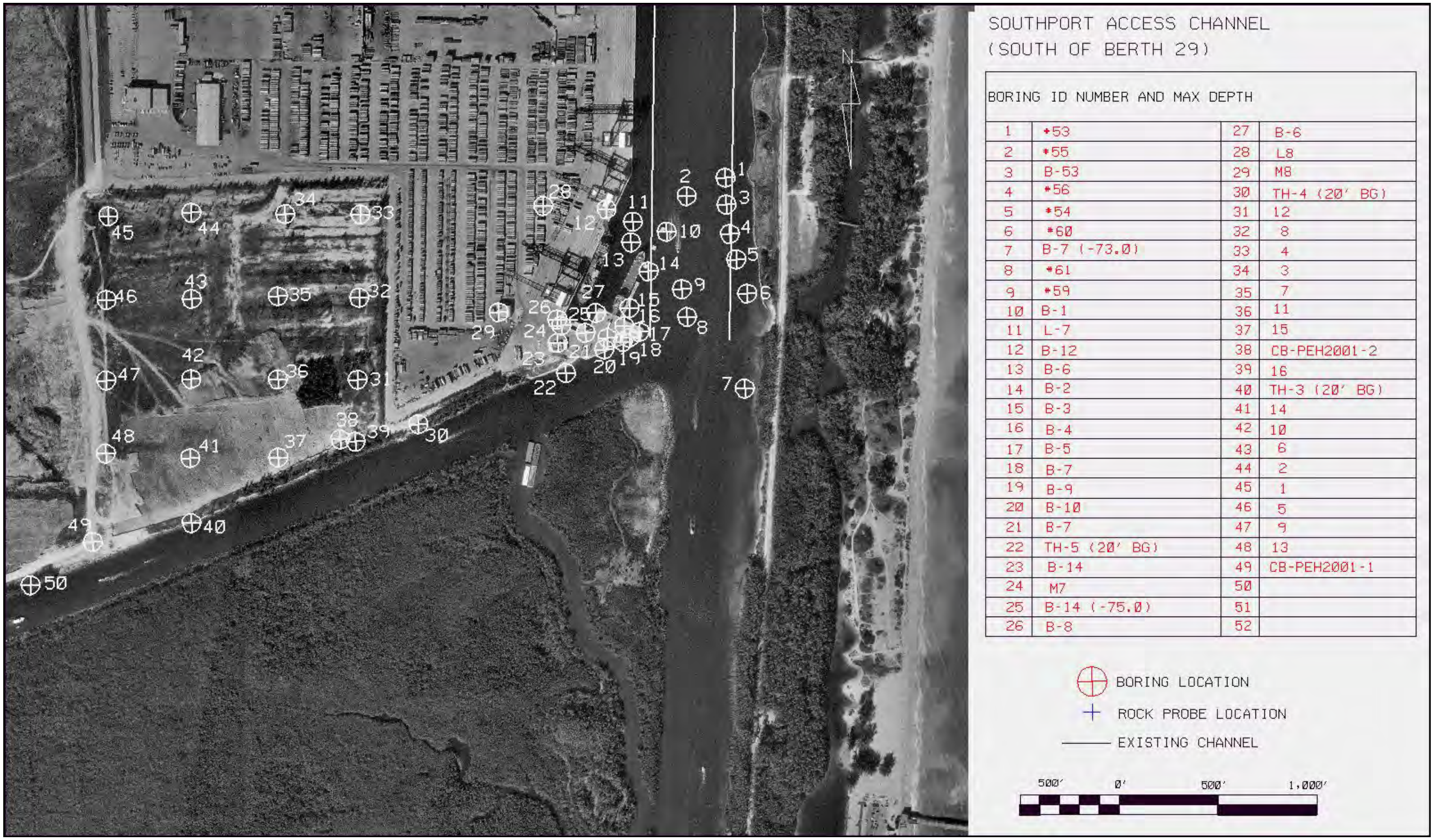


Figure A- 56. Core Borings - Dania Cutoff Canal

172. The sponsor (Broward County) has drilled two groups of core borings in support of the two widening portions of the project. The first group of 15 core borings (TH-2 through TH-16) was drilled in July-August 1997 by Ardaman & Associates Inc. These core borings were drilled to the east of the Intracoastal Waterway along an irregular alignment over a distance of 1,600 feet. The core borings were logged by a Professional Geologist. No gradations were run on the recovered samples.

173. The second group of 21 core borings (SB-1 through SB-21) was drilled in August 1998 by Geo Verse, Incorporated. These core borings were drilled just to the northeast of where the Intracoastal Waterway enters Port Everglades Harbor from the south. These core boring were drilled on a pattern to cover an area approximately 1,400 feet long by 400 feet wide. The core borings were logged by a Professional Engineer. Forty gradations were run on the recovered samples

174. Both groups of core borings were drilled using the standard split-spoon with 18-inch drives and continuous sampling. The borings were drilled to elevation -50 feet below "mean low water". They were drilled to a standard and quality that are acceptable to a Corps of Engineers project.

175. Materials generally encountered at Port Everglades are highly variable between core boring locations and elevations. Basic materials found in interbedded layers are peat, organic silts, sands, silty sands, gravelly sands, weakly cemented sands, moderately cemented sands, weakly cemented sandstones and limestones, occasional competent beds of sandstones and limestones and deposits of hard massive sandstone and limestone. The borings obtained during this study make up an extensive core boring library, too large for incorporation in this document. However, all core boring data are available upon request through USACE Jacksonville District.

3.7.2 MATERIAL TYPES

176. Geotechnical core borings and investigations determined that materials at Port Everglades were composed predominately of unconsolidated materials, “soft” rock (rock not requiring blasting for excavation), and “hard” rock (rock requiring blasting). Table A- 13 gives estimated percentages of materials based on project component. The delineation between hard rock, softer rock and unconsolidated material as presented in Table A-13 was derived from examination of the available individual core borings. Consideration was given to rock hardness, strength, fracturing, massiveness, vugs, solution cavities, RQD, N-values and area of influence. Often a rock is hard but it’s thickness (<3’), fracturing and homogeneity determines if it needs to be blasted or can be removed with a large rock cutter. A majority of the borings were drilled at or just below the future project depth, thus requiring extrapolation and best professional judgment, when determining the percentage, if the rock was hard at or near project depth, it was considered to require blasting as the thickness could not be determined. This gives us reasonable reliability of the material to be removed and whether blasting may be required. Note that unconsolidated materials found in the project will include, for the most part, sands with varying amounts of fines, and silts, with varying amounts of organic materials mostly found on the Southport Access Channel and Turning Notch. The hardness of cohesive materials (silts and clays) is defined by

their "consistency" (very soft, soft, firm, hard, and very hard). Granular-non-cohesive unconsolidated materials including sands and gravels are defined by their "relative density" (very loose, loose, medium, dense, and very dense). Consolidated materials include sandstones and limestones with varying degrees of hardness, fracturing, weathering. Softer rock formations are usually associated more weathered materials. Harder rock formations are usually associated with unweathered and massive materials containing less jointed rock mass that will significantly resist excavation and will require blasting for economical removal.

177. A geotechnical analysis for beach quality sand potential at the Widener area was performed by the SAJ Geotechnical Branch in August 1999. The purpose of the analysis was to evaluate all available information gathered to date to determine and quantify the suitability of the excavated material for beach quality materials. The information gathered included subsurface investigations consisting of borings completed from about 1966 to 1977 for the 1981 dredging project; and recent borings completed in two areas for the current widening of the southeast harbor section and adjacent waterway. The 3 phases of drilling involved continuous sampling with the standard 18-inch splitspoon with coring operations in harder zones. The following were identified during the review and evaluation of the information to assist in the determination of the suitability of the proposed material for beach quality material.

Table A- 13. Distribution of Materials by Percentage

Location	Percentage of Unconsolidated Matierials (%)	Percentage of Soft Rock (%)	Percentage of Hard Rock (%)
Outer Entrance Channel	70.0	20.0	10.0
Inner Entrance Channel	40.0	55.0	5.0
Main Turning Basin	40.0	20.0	40.0
North Turning Basin	40.0	10.0	50.0
South Turning Basin	40.0	10.0	50.0
Widener	50.0	50.0	0.0
Southport Access Channel	50.0	50.0	0.0
Turning Notch	50.0	50.0	0.0
Dania Cutoff Canal	50.0	40.0	10.0

a) The processed materials will be primarily coarse to fine grained sand (SP & SP-SM) with lesser amounts of fine grained gravel.

b) Based on the Atterberg Limits, the processed material can be expected to be nonplastic making handling, blending and washing easier.

c) Based on the analysis, the information shows:

- Without processing, the excavated material would produce marginal quality beach fill.

- 35-percent of the as-excavated material would require processing. This material contains 5-percent gravel larger than 1-inch in size, 15-percent gravel up to 1-inch in size, and 15-percent fines (#200-sieve).
- Localized peat deposits can be separated and wasted to a designated spoil area.

d) A comparison of the samples to the geologic interpretation in the logs shows that overall:

- About 2/3 of the material (weathered limestone) is expected to be tan to gray sand.
- About 1/3 of the material (sand, cemented sand and sandstone) is expected to be tan or light brown and gray sand.
- This would result in a tan to gray, fine to coarse-grained sand with gravel.

e) The materials can be processed to produce beach quality sands:

- The material will have to be screened to remove gravel larger than 1-inch in size.
- The materials cannot be selectively mined to produce beach material without processing.
- Excessive silts will have to be removed. The silt concentration is variable ranging from a few percent to over 50 percent. Silt is defined as materials that pass the no. 200 sieve, are smaller than 75 micrometers, and plot below the A-line in the USCS Plasticity Chart.
- There is not an excessive amount of silt; but it would be difficult to get the as excavated material permitted for beach fill because the silt content of the excavation as a whole is 15 percent.

178. The following are recommendations concerning beach placement as a result of the review and evaluation of the project geotechnical data. These recommendations apply only if beach placement is part of the selected plan.

a) By volume, up to approximately 50-percent of the material could be used as beach material, but would require extensive processing to remove non-beach quality elements (gravels, silts).

b) A detailed QA/QC Plan needs to be prepared to control the manufacturing of the material to produce beach quality material.

c) The burden of responsibility to produce beach quality material should be placed on the Contractor to meet the required specifications and approved as a contract submittal.

d) The work may be receptive to a RFP.

3.7.3 EXCAVATION

3.7.3.1 General

179. The terms "top of rock" and "quantity of rock" have little meaning over much of the area as the majority of the materials encountered fall into a gray area of materials between the classic sand definition and the classic rock definition. For excavation purposes, materials at Port Everglades can be classified in two broad categories, softer material and harder material.

180. Softer materials on average will excavate as partially cemented sand with occasional thin (inches to a few feet) layers of competent rock. After excavation, a majority of the materials will appear as gravelly sand with occasional pockets of silt. Some boulders may result in regions of blasting. Although approximately 50 percent of the excavated material would be classified as sands, the gravelly component (broken rock), silt pockets, and the peat deposits make the material unsuitable, without processing, for beach disposal.

181. Softer materials may be excavated using a rock cutterhead dredge or other methods of excavation. The use of mechanical dredging may require a method to break up the occasional bed of resistant sandstone/limestone to aid in the excavation.

182. Harder materials are concentrations of hard massive rock that will significantly resist excavation. It is anticipated that hard rock encountered during the current project will require blasting for its economical removal.

183. The majority of hard massive rock at Port Everglades is located in the MTB and STB. However, additional hard massive rock may be found in the OEC, IEC, DCC, and in limited isolated deposits throughout the remainder of the project area.

184. Unconfined Compressive strength tests have been run on approximately 306 rock samples from the Port Everglades OEC, IEC, and MTB. Most of the samples are from the MTB. Figure A- 57 displays a chart showing the test results. The rocks strengths documented in Figure A- 57 indicate that while much of the rock is can be excavated with a rock cutterhead dredge, some of the rock would not and may require blasting. While this chart contains a significant quantity of data on the rock strengths at Port Everglades Harbor, it is important to note that much of this data came about as a result of a rock claim on this project. Because of the claim and the way the rock samples were selected for testing, the data over-represents the harder rock and under-represents data from the softer rock. In addition to a sampling bias for testing harder rock, the softer rock is less likely to be tested because it is difficult to obtain samples suitable for testing and it is difficult to physically test the softer rock.

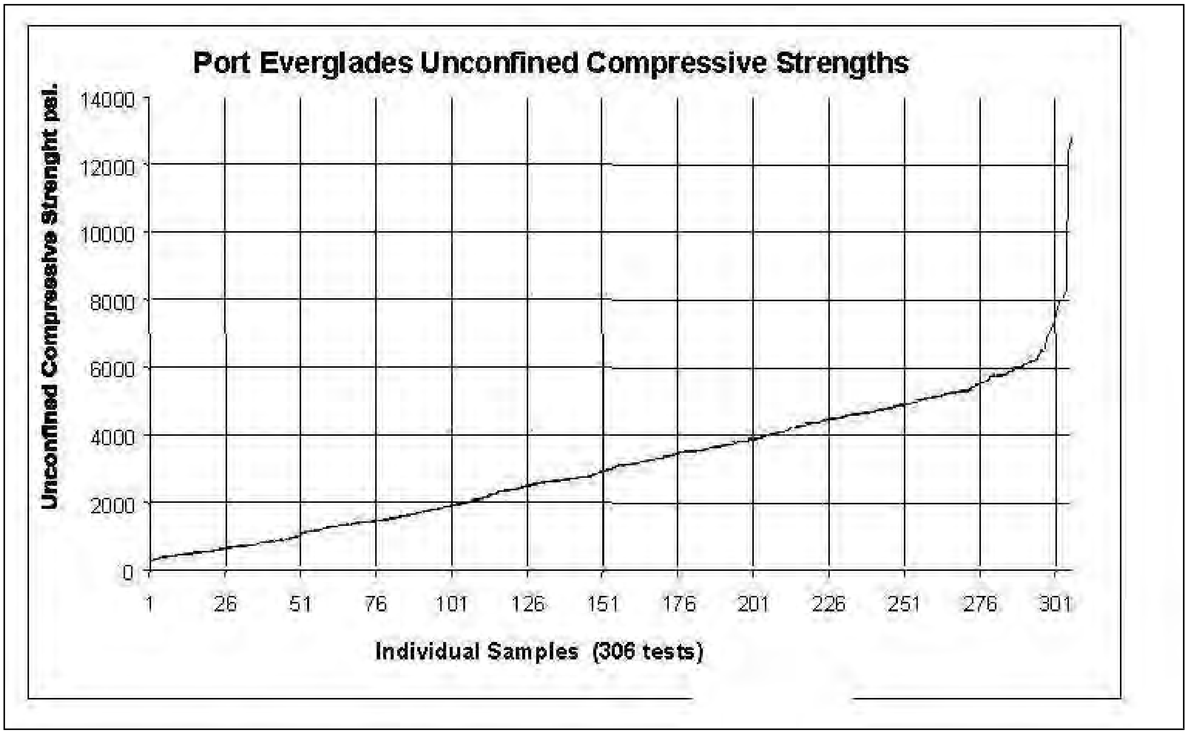


Figure A- 57. Unconfined Compressive Strengths

3.7.3.2 Previous Excavation

185. Deepening of Port Everglades Harbor in the early 1980's required rock excavation in the MTB and OEC. To aid in the rock excavation, a punch barge was employed. The procedure involved dropping a heavy steel beam/chisel to break hard rock formations into fragments that could then be excavated mechanically. The punch barge was used for 216 days in Port Everglades Harbor and proved to be prohibitively expensive and exorbitantly time consuming.

186. Records pinpoint locations where the punch barge was used. These records show areas of concentrated punch barge usage that indicate the locations of hard massive rock that proved difficult to excavate. Due to cost and environmental concerns the rock in these areas will likely have to be blasted in order to be excavated in the current deepening and widening plans.

187. During the same deepening event, sand and soft rock were excavated from the Widener and northern SAC. A combination of hydraulic, clam shell, and drag line dredges were employed with the hydraulic dredge providing the highest production rates (Table A- 14 and Table A- 15).

188. Based on Federal contract acquisition guidelines, the Corps of Engineers will, in general, not specify dredging methods, techniques, or specific types of dredging equipment. Rather the Corps of Engineers will specify performance results required by the dredging contract (i.e. a channel so many feet wide and so many feet deep). The contractor, being an expert in dredging technology, will determine the best and most cost effective type of dredging equipment required to do the job.

Table A- 14. Production Rates for Widener

Name of Dredge	Type of Dredge	Production cy/hr	Production cy
Cherokee	Hydraulic	307	30,000
Powel Brothers	Clam Shell	106	39,000
Michigan	Drag Line	127	193,000
Illinois	Drag Line	106	22,000
Moody Barge	Clam Shell	62	4,000
		Total Production cy	**288,000 est.**

Table A- 15. Production Rates for North SAC

Name of Dredge	Type of Dredge	Production cy/hr	Production cy
Clinton	Hydraulic	284	16,000
Cherokee	Hydraulic	228	90,000
Powel Brothers	Clam Shell	65	4,000
Michigan	Drag Line	153	110,000
Illinois	Drag Line	127	150,000
		Total Production cy	**370,000**

3.7.3.2.1 Port Everglades Side Slopes

189. When a channel or basin is deepened, its walls will attempt to stabilize by achieving a natural slope. The grade of the natural side slope depends on characteristics of the materials that comprise it and environmental factors such as wave and current conditions. Time also has an impact as all slopes will degrade to some degree over an extended lifetime.

190. There are three principal reasons side slopes must be identified. First, the side slope chosen must be flat enough to prevent excessive erosion or sloughing of the side slope that would cause shoaling to obstruct the navigation channel. Second, the effective side slope may undermine structures or affect land use. Third, sideslope determination is critical for defining the dredging prism; the fully defined dredging prism is a key element of the dredging quantity calculations.

191. It should be noted that a specified or design side slope does not always correspond to the natural or effective side slope. Often side slopes are specified for economic or environmental reasons. For the present study, however, design side slopes were specified based on the natural side slope as determined though investigation of the existing channels and basins. The exception occurs in areas with hard materials where a 0.5H:1V is specified as a "vertical" cut. Note that it is not practical to excavate a side slope to the specific dimensions of design template. Instead, the dredger performs a box cut into the side slopes to achieve the required grade along the edge of the channel. Typically, in order to achieve grade along the edge of a channel, the dredger must excavates outside the theoretical channel template allowing the material to slope downward.

192. The following are design side slopes for Port Everglades:

- **OEC, IEC, MTB, STB, and Widener:** These areas will maintain a 3 horizontal on 1 vertical side slope (3H:1V) except in reef and rock areas where a slope of 0.5H:1V is specified**.** The rock layer in the OEC and IEC is relatively uniform at an elevation of -48 ft-MLLW. Therefore slopes in the OEC and IEC are expected to transition from 0.5H:1V to 3H:1V at this interface.

- **SAC, TN:** 2H:1V side slopes are predicted based on previous excavations.

  Note: Theoretically the SAC can be designed based on 1.5H:1V side slopes if the dredger is prevented from excavating beyond the template. In practice, it would be virtually impossible to achieve grade along the edge of the channel without the excavation allowance.

- **DCC:** There is limited Geotechnical data available to determine a design slope along the DCC. It is anticipated that the geology along the DCC will be similar to the geology along the SAC. Therefore a design slope of 2H:1V can be considered. This slope is also considered appropriate as a transitional slope between the deeper depths within the project and the more shallow depths of the existing channel to the west of the project boundary. Variable flow within the DCC and potential head cutting up the canal was taken into account in reaching this conclusion.

3.7.3.3 Blasting

193. Areas requiring blasting can be identified as (1) areas documented by core borings to contain hard massive rock, (2) areas of high punch barge use during the 1980's deepening, and (3) areas of low production in the 1980's deepening.

194. Based on evaluations of the core boring logs, punch barge usage, and low production rates the following is an evaluation of the blasting requirements for the current project:

- **OEC and IEC:** The entrance channels can be excavated without blasting through the use of a rock cutting hydraulic dredge.

- **MTB, STB, and NTB:** A significant quantity of rock will require blasting in these main harbor areas. In general there is a wide ridge of hard massive rock that extends in a north-south direction from NTB, through the MTB, and through STB.

- **Widener, SAC, and TN:** Blasting was used to aid in the original excavation of the SAC. However, blasting was not needed due to the rock characteristics but, rather to allow the contractor to deepen the channel using available dredging equipment. Based on the historic core borings drilled along the SAC, it appears that the materials can be dredged in the future deepening of the channel by using a rock cutting hydraulic dredge. It is possible that harder more massive rock could be encountered at lower elevations that would require blasting for economical excavation.

- **DCC:** Although Geotechnical data is limited in the DCC, preliminary analysis indicates that materials can be dredged in the future deepening of the canal by using a rock cutting hydraulic dredge. It is possible that harder more massive rock could be encountered at lower elevations that would require blasting for economical excavation.

195. Several considerations must be taken into account during the blasting process. Core borings in areas where blasting may be anticipated will have to be carefully drilled and logged. The recovery, the RQD, and the drill time per foot must be documented. Maximizing the recovery in the rock mass is important. Voids, seams and/or layers of sediments or soft rock within the rock mass must be documented when possible. Borings within the rock mass must to be drilled at least 7 feet below the proposed grade. The reason for the above considerations is that blasting is extremely sensitive to weak or soft zones. The power of the blast can bleed off into the weak zones or sediment layers and prevent fragmentation of the rock mass. Although blasting techniques can be used to compensate for these conditions, their presence can significantly affect the cost of blasting.

196. Environmental considerations are also a factor that must be considered during the blasting process. Areas requiring blasting at Port Everglades have been designated as manatee refuge areas during the winter months from November 15 through March 31. Although few manatees are known to reside in Port Everglades during the summer months, a marine wildlife protection program is necessary to protect any manatees that might be in the area during underwater blasting. Further details are available in the Environmental Impact Statement (EIS).

197. The blasting program for the Port Everglades project shall include a Safety Blasting Plan and an Operational Blasting plan, to be reviewed by USACE.

198. In addition seasonal restrictions and business hours for blasting operations, the Blasting Program shall comply with all current county, local, state, and federal regulations. County regulations will govern and dictate maximum peak particle velocity and water borne overpressures.

199. The final limestone removal thickness will be determined based on data to be obtained from future geotechnical investigations, current hydrosurvey data, and current project depths for the channel. Project overdepth and allowable overdepth is 1-ft.

200. Rock blasting assessment for Port Everglades shall take into consideration core borings located within the proposed dredging area. Therefore, the proposed blasting operation shall be calibrated to actual geological conditions of the blasting areas defined based on the new geotechnical investigation and most current PED.

201. The Contractor shall obtain rights-of-entry to the pre-blast survey locations. The pre-blast survey shall become part of the operational blasting plan.

202. A test blast plan shall be a requirement in the specifications of the project and shall be incorporated into the Blasting Program. It shall be developed by the Contractor as part of the Blasting program and also include the planned test patterns and weights of explosives of each

test blast with anticipated peak particle velocities and pressures at structures most likely to receive damage from the test blast.

3.7.3.4 Disposal

203. Three disposal methods were initially considered for Port Everglades material: beach disposal, offshore disposal, and upland disposal.

204. Beach disposal consists of using excavated materials as beach fill. While approximately half of excavated materials at Port Everglades will be sand sized, these materials will contain gravel components, pockets of silt, and limited deposits of peat. In addition, excavation of hard massive rock areas will result in a mixture of sandy gravelly materials, cobbles, and boulders depending on the method of excavation employed. Individual material components cannot be selectively excavated and therefore require processing to be used as beach fill. Processing would consist of screening out any gravel (+1 inch) and removing all silts and peat deposits, resulting in slightly gravelly-fine to coarse-grained sand.

205. Offshore disposal consists of excavating materials, for instance using a clamshell dredge or cutter-suction dredge, placing it on barges, and towing the barges to a designated offshore dredged material disposal site (ODMDS). In 2004 an ODMDS site was designated 4 miles northeast of Port Everglades (Figure A- 58). Based on numerical modeling prior to designation, disposal capacity is limited to 500,000 cubic yards per event. As the volume of material for this project is expected to exceed this cap, efforts to expand the disposal site and redefine the capacity are underway and are expected to be complete before the final Feasibility Study is completed.

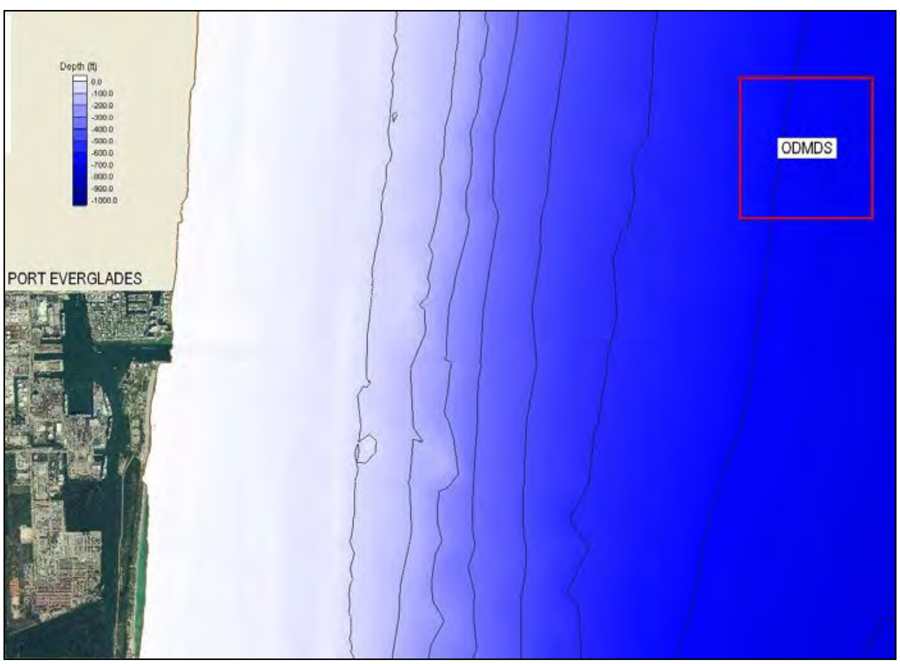


Figure A- 58. Port Everglades ODMDS Location

206. Upland disposal is a third option. This option consists of excavating material using a cutter suction dredge, clamshell dredge, or other type of dredge and transporting the material to a diked upland disposal site. Two upland sites were originally identified, just north of the Dania Cutoff Canal. Site 1 was a single use site located at the southwest corner of Port property. During the early stages of the study, Site 1 measured 62 acres offering approximately 1 million cubic yards of storage, but later evolved into 107 acres with a capacity of 3.2 million cubic yards (Figure A-59). Site 2 was a 64 acre site located on Airport property (Figure A- 60) expected to provide a capacity of approximately 1.6 million cubic yards. Although originally designated as a multiple use site, plans to expand the Airport's runway system made it necessary to designate Site 2 as a single use site.

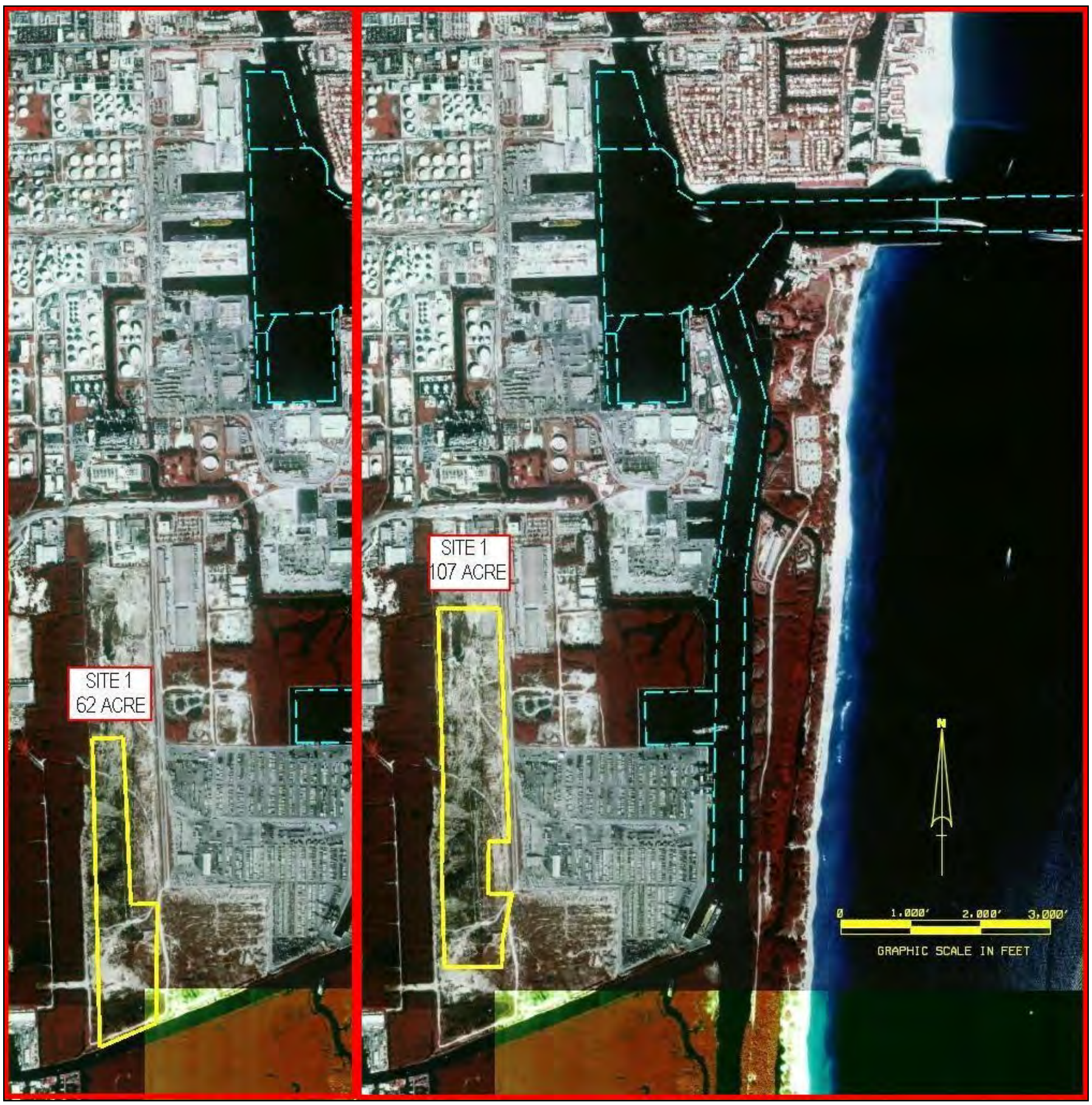


Figure A- 59. Disposal Site "Site 1" (2 Alternatives) Located at Port Everglades

Figure A- 60. Disposal Site "Site 2" Located at Fort Lauderdale Airport

207. Due to development within the Port and further evaluation of the Airport's runway expansion plans, both the Port and the Airport have withdrawn the use of their upland properties as disposal sites. Therefore, Site 1 and Site 2 disposal areas have been removed from further consideration. Because there were no other viable upland alternatives in the heavily developed study region, upland disposal was removed entirely as a disposal option.

3.8 STRUCTURAL DESIGN AND CONSTRUCTION

3.8.1 <u>GENERAL</u>

208. In general, the Corps does not specify types of equipment and construction methods within its specifications. In general, the Corps does specify the result of the construction work though detailed plans and specifications. It is during the Request for Proposal (RFP) process, conducted prior to award of the construction contract, that an in-depth evaluation of a potential contractor's proposal will occur. This includes complete technical review of construction equipment and proposed methodologies. Therefore, for purposes of this report, only generic information will be provided as to the nature of construction and the types of equipment that may be employed. Additional discussion on potential construction techniques can also be found in the Environmental Impact Statement (EIS).

3.8.2 <u>CHANNELS AND BASINS</u>

3.8.2.1 Dredging and Disposal

209. As previously discussed, a majority of the material to be dredged can be removed without blasting. The specifications should limit the extent of blasting as much as possible through appropriate language. For environmental reasons, it is preferred that blasting occur only when excavation cannot be accomplished with hydraulic or mechanical dredging equipment. Such equipment may include a hydraulic pipeline dredge with a rock cutterhead or certain types of clamshell dredges that can effectively excavate the layered material. Use of small or inappropriate dredges may be discouraged through the use of minimum monthly production standards or other language within the specifications. The contractor may employ the use of more than one dredge at a given time and this possibility should be left open in the project specifications.

210. The type of dredge(s) used will affect methods used to convey the material to the disposal sites. For offshore disposal, split hull or similar barges will most likely be used.

211. It is almost certain that some material will require blasting. The EIS provides detailed information regarding blasting process. Included are items that will be incorporated into the project specifications. Additional core borings during PED will help further quantify specific areas of massive hardened materials prior to final design and construction.

3.8.2.2 Sideslope and Land Excavation

212. Based on evaluation of historical channel slopes, sideslopes excavated along John Lloyd Park (SAC) are expected to hold a slope of 2:1. To avoid further impacts to the Park, waterborne construction methods such as the use of a dredge (to cut the slope in a tiered fashion) will be employed. Excavated material will be placed into barges, pumped to the disposal sites, or placed in trucks. Although not likely, the use of cofferdams or shoring may be employed.

213. Excavation into areas with less restrictive access will employ land based construction

methods. Land based methods may include the use of truck mounted or crawler cranes with a clamshell attached, use of a Grade-all, use of loaders or dozers, or similar equipment. Primary landside removal activities include excavation of a new USCG basin and excavation of Port property for modification of the TN.

3.8.3 BULKHEADS

3.8.3.1 Port Bulkheads

214. Broward County Port Authority will be responsible for structural designs for all port toewall and bulkhead systems. Based on the most recent structural report (Halcrow Inc., 2010), it is assumed that any Port bulkhead that has exceeded its design life of 40 years will be replaced prior to construction of the Federal project. An exception to this is made in cases where the Port's Master Plan indicates relocation or modification of the impacted bulkhead. For these cases towalls will be constructed to accommodate the deeper project depth. Any deepening required to accommodate the project depth will be an element of the Federal project. In regions where bulkheads have not exceeded the 40 year design life, toewalls will be constructed to accommodate the deeper project depth. Table A- 16 provides a summary of potential bulkhead impacts due to the Federal project. It should be noted that although berths 24 through 29 fall within the Federal project they are not included in Table A- 16. Because these berths can already accommodate the design cruise ship draft, they will not be deepened beyond their existing depths. The 160 foot distance between the bulkhead and the channel at these locations prevents the existing bulkheads from being impacted by the proposed deepening.

Table A- 16. Port Bulkhead Impacts

Project Component	Impacted Bulkhead (by Berth)	Bulkhead Age		Required Action
		< 40 yrs	> 40 yrs	
OEC	---			---
IEC	---			No existing bulkheads
MTB	7 - 8		X	Bulkhead modification in Master Plan; Construct toewall to stabilize
	9 - 10		X	Bulkhead relocation in Master Plan; No Federal action
STB*	16 - 19		X	Bulkhead to be replaced prior to Federal Project; No Federal action
Widener	---			No existing bulkheads impacted
SAC	31 - 32	X		Construct toewall to stabilize bulkhead
TN	30	X		Bulkhead modification in Master Plan; No Federal action
DCC*	New			Construct new bulkhead

* Note that the STB and DCC project components were removed from consideration during the course of the study. Bulkhead information for these components is included here for completeness of project component documentation.

3.8.3.2 Park Bulkheads

215. In order to minimize environmental impacts to sensitive species and habitats, an environmentally friendly sheet pile bulkhead (EFB) system (Figure A- 61) was developed. The proposed bulkhead system uses a toe wall bulkhead that eliminates the need for tie backs. This significantly reduces construction impacts to adjacent lands. The design also includes a sloped rubble cap to allow flushing into adjacent mangroves areas. This will aide in the establishment of a healthy habitat and enhance survival of newly planted growth and/or growth disturbed by channel improvements.

216. In order to construct the steel sheet pile bulkheads, pile driving equipment will be required. Bulkheads along the SAC and DCC will require piles to be driven from a barge in the channel. The steel sheet pile bulkheads will have to be driven into rock. In order to drive the steel sheet pile bulkheads to their proper tip elevations, it is anticipated that pre-splitting of the rock will be required. Pre-splitting of rock will be accomplished through blasting.

217. The bulkheads shall be in place prior to the channel excavation. Land side construction equipment will not be used because there is no access to the site at these locations for such equipment.

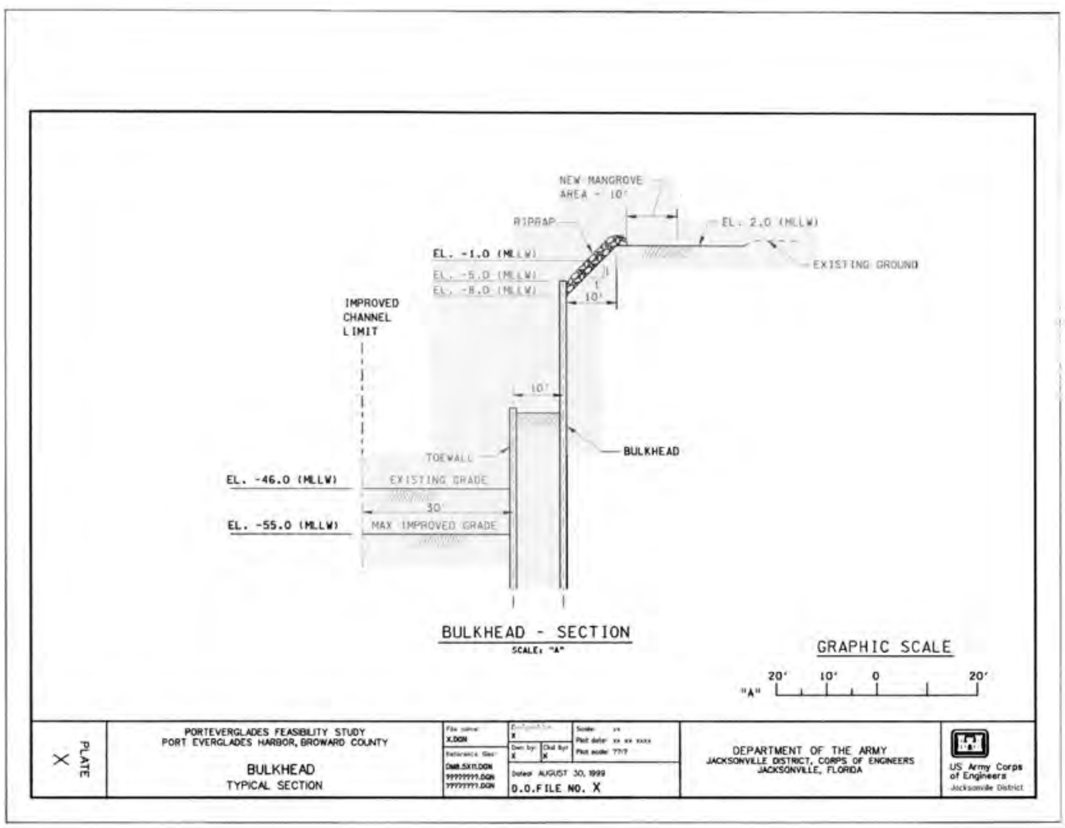


Figure A- 61. Initial Bulkhead Design

3.8.3.3 USCG Basin Bulkheads

218. The extent and type of bulkhead relocations required for the USCG basin were estimated based on the USCG reconfiguration plan presented in Sub-Appendix B. USCG Basin bulkheads can be constructed with equipment from inside the basin and from the land side. The bulkheads for the new USCG Basin shall be in place prior to the basin being excavated to its final depth. Once the bulkheads are in place, the concrete cap and facing can be completed at all the locations. Further details for the USCG basin bulkheads are provided in Section 3.9 (Civil Design of USCG Facility Reconfiguration).

3.8.3.4 Staging Areas

219. It is the Contractor's responsibility to arrange for staging area(s). The staging area(s) will have to be defined early in the plan and specification preparation phase for each contract. The Contractor will need to secure sufficient land to: install construction trailers, park vehicles, stage dredging and construction equipment. The staging area will have to have navigable water access to allow the contractor to use work boats to shuttle the crew to the dredge(s). One or more mooring areas will need to be provided for the dredge(s).

3.8.4 UTILITY RELOCATIONS

Preliminary investigations indicate that Florida Power and Light (FPL) maintains a single cable crossings within the project area (Figure A- 62). The crossing occurs at the SAC running between Berth 27 and John U. Lloyd Park. Cable at this crossing is currently laid on the existing channel bottom. However, in the fall of 2014, FPL will relocate this crossing to a depth beyond the maximum channel depth of the project area. No additional relocation of this crossing will be required.

220. Utility relocations will also be required in conjunction with reconfiguration of the USCG basin. Utilities to be relocated include electric cables and service boxes, water lines, sewer systems, telephone lines, and fuel pumps. All utility relocations will be in accordance with USACE permit guidelines.

3.8.5 NAVIGATION AIDS

221. The U.S. Coast Guard is responsible for providing and maintaining the proper number of navigational aids needed for day and night navigation of the Federal project. Preliminary discussions with the U.S. Coast Guard indicate that navigational aids may include, but are not limited to, 2 additional buoys in the OEC, 2 navigation lights in the Widener.

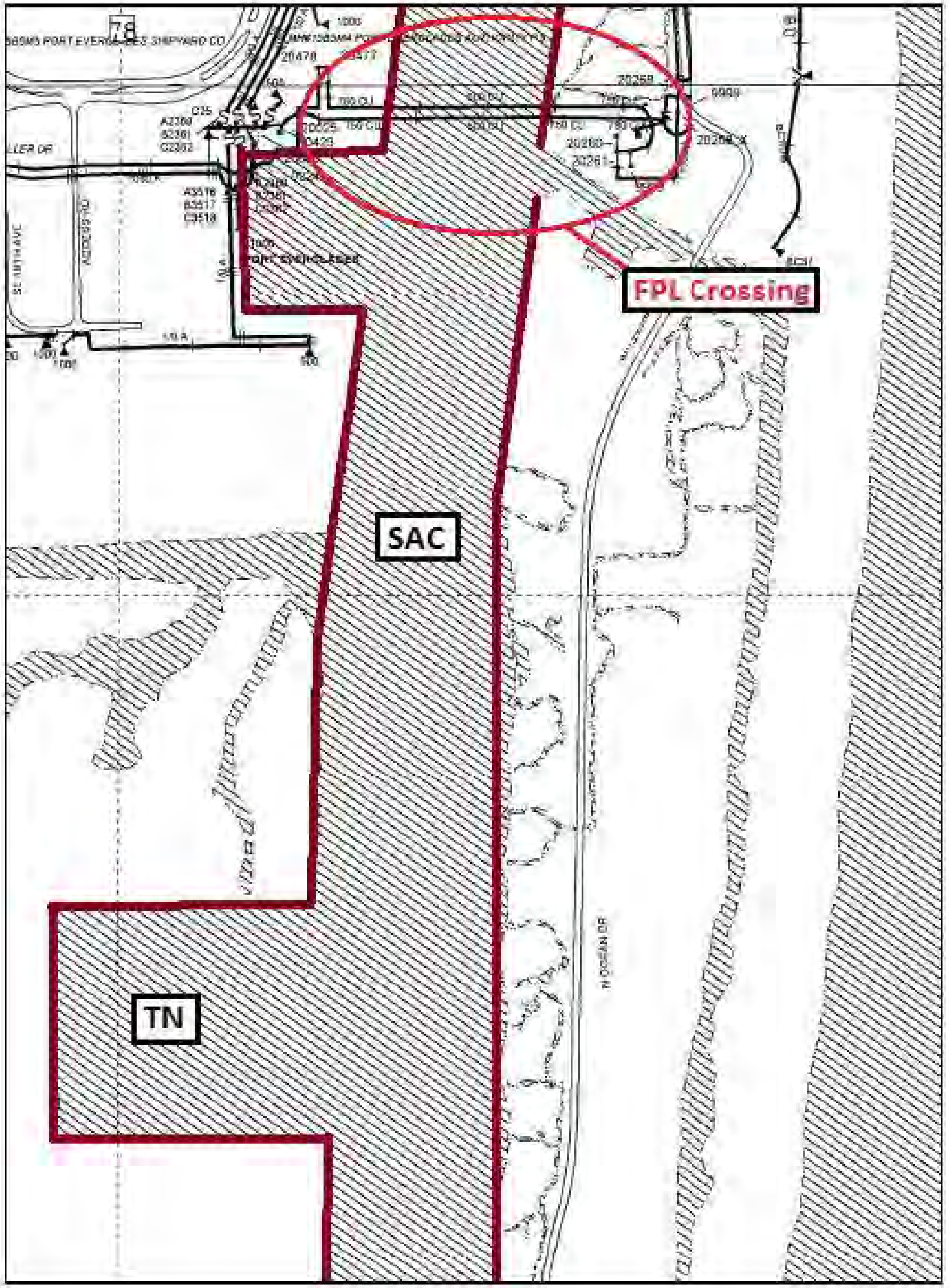


Figure A- 62. FPL Utilities

3.9 CIVIL DESIGN OF USCG FACILITY RECONFIGURATION

222. As previously discussed, the USCG boat basin at Port Everglades will require reconfiguration to the east on existing USCG property to allow for SAC improvements. The Preliminary design calls for the removal of existing USCG bulkheads and the excavation of approximately 1 acre of the existing USCG facility, presently occupied by boat maintenance sheds, the station's administration building, a multipurpose building which includes berthing, a heliopad, a fueling station, various parking areas, connecting roadways, and part of an open grassy field. All facilities are to be reconfigured to positions consistent with USCG operational requirements. All connecting roadways will be rerouted and new parking areas provided.

3.9.1 USCG BASIN

223. Based on existing bulkhead designs and proposed dimensioning, three bulkheads types were determined for the relocated USCG boat basin. The first (Figure A- 63) is a bulkhead/buttress combination developed for a maximum design water depth of –52 ft-MLLW. Surfacing on the bulkhead aides in the damping of wave energy, reducing reflection. This bulkhead, designated Typical Section 1, will be applied to the outer breakwater of relocated basin as well as the eastern interior wall the basin (adjusted for a project depth of -14 ft-MLLW). The second bulkhead (Figure A- 64) is a bulkhead/anchor wall combination capped with a slope of rubble wave absorber. This bulkhead, denoted Typical Section 2, was developed for a project depth of -14 ft-MLLW and will be placed at the northern/eastern interior of the entrance channel as well as the south side of the interior basin. The third bulkhead (Figure A- 65) is a solitary bulkhead developed for a project depth of –14 ft-MLLW. This bulkhead, designated Typical Section 3, will be placed along the north interior of the basin. Bulkhead locations along the proposed USCG basin are shown in Figure A- 66.

3.9.2 UNIT PRICE COST ESTIMATES

224. Incremental unit price cost estimates were preformed for all of the plans detailed previously in Table A- 12. Although it has previously been stated that some of these plans were eliminated, this occurred after the incremental cost analysis was completed. For completeness and consistency these plans will be included in the incremental cost analysis discussions.

225. Unit price cost estimates include the following: mobilization/demobilization, drilling and blasting, dredging and disposal, bank stabilization, lands and damages, environmental mitigation, aids to navigation, and associated general costs (bulkheads, revetments, utilities, and relocations). Planning, Engineering, and Design (PED), Supervision and Administration (of construction work) (S&A) costs, and contingencies were included. For the incremental cost analysis PED, S&A, and all contingencies were represented as percentages of the total project cost. Detailed itemized PED and S&A estimates are included in the final cost estimate for the Selected Plan.

226. Incremental costs are presented in the Cost Engineering Appendix.

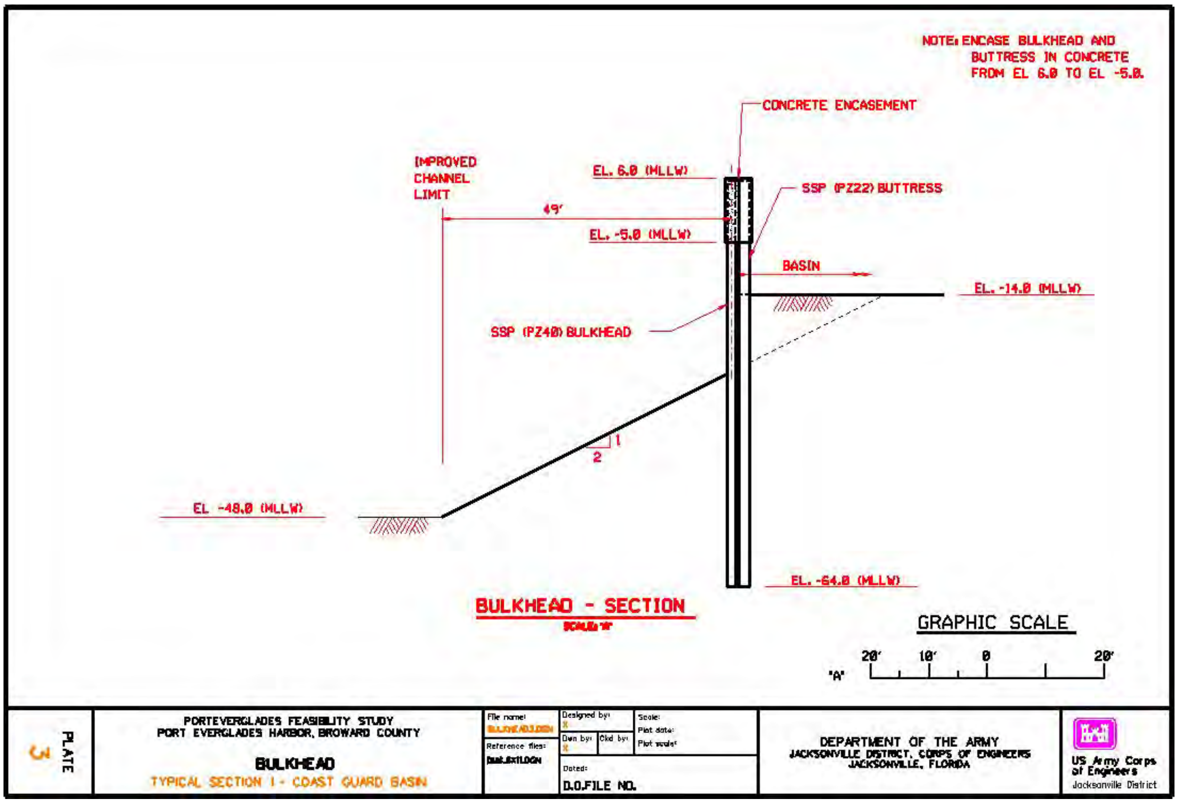


Figure A- 63. Preliminary USCG Wave Damping Bulkhead Design

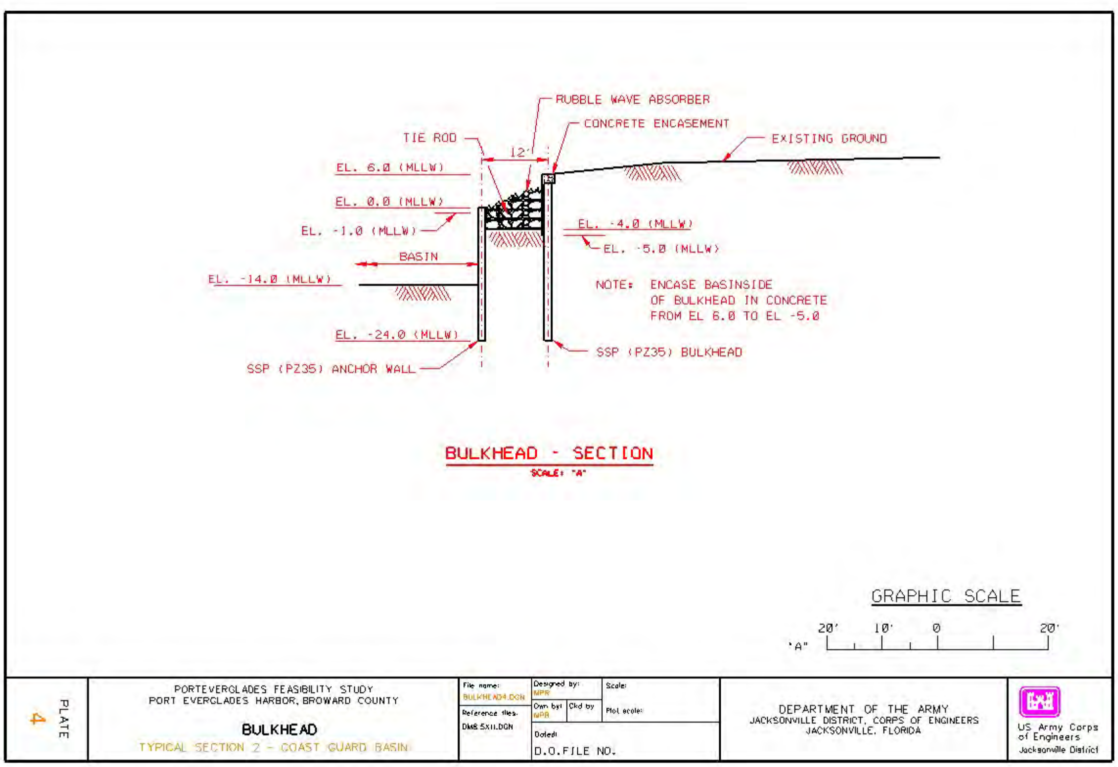


Figure A- 64. Preliminary USCG Wave Absorbing Bulkhead Design

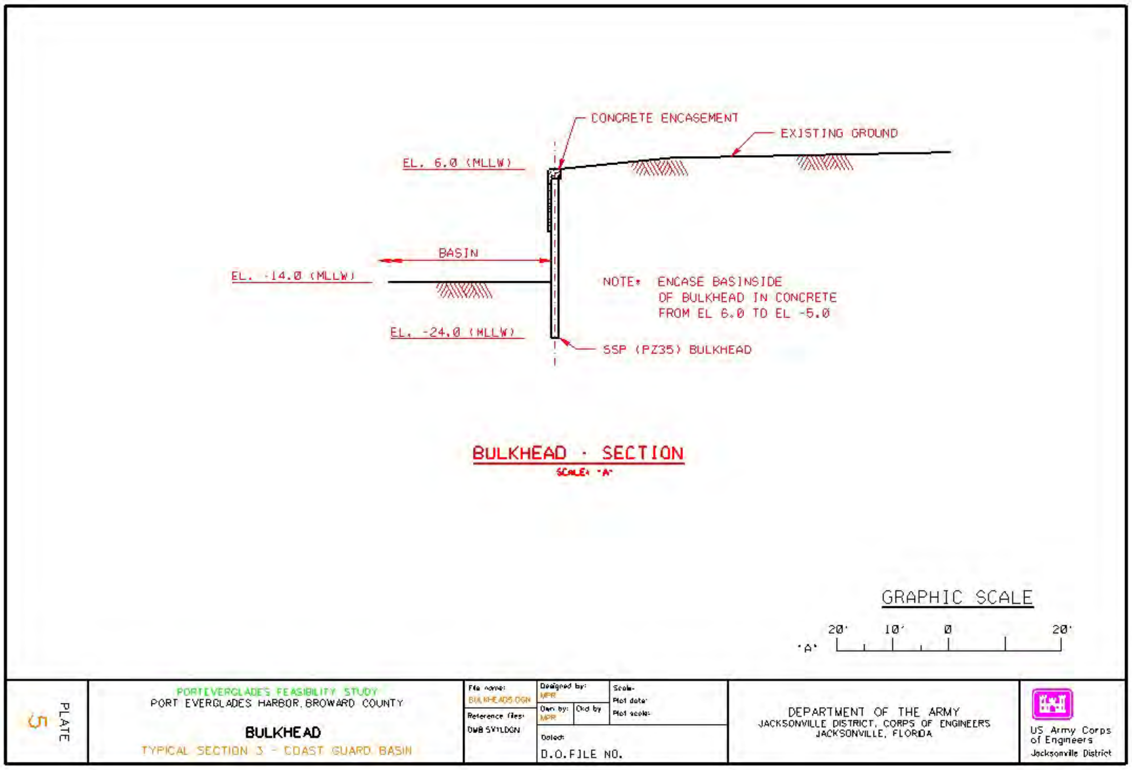


Figure A- 65. Preliminary USCG Interior Bulkhead Design

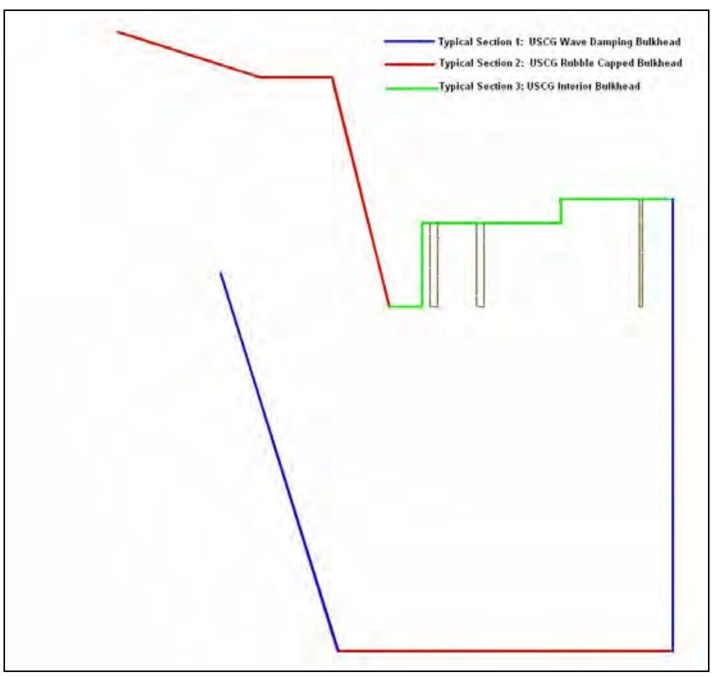


Figure A- 66. Locations of USCG Bulkhead Type

3.10 National Economic Development Plan

The National Economic Develop (NED) Plan maximizes net benefits while protecting the Nation's environment. Details of the NED Plan identification process can be found in Appendix B: Economics. Based on this analysis the NED Plan was identified as Plan 2E, which is described in Table A- 17.

Table A- 17. NED Plan - Summary

NED Plan Component	Description[1]
OEC	Extend OEC 2,200ft seaward, add an 800ft wide "flare", and deepen to -54 ft
IEC	Deepen IEC to -47 ft
MTB (Full)	Deepen MTB (existing Federal footprint) to -47 ft
Widener	Remove Widener shoal to –47 ft
SAC	Widen SAC in the vicinity of berths 23 to 26 and deepen to -47 ft
TN (S_TN)	Shave NE corner of the TN, widen SAC north and east of TN, and deepen to –47 ft
[1] All depths indicated are project depths. Add 1 foot for required overdepth and 1 foot for allowable overdepth.	

3.11 Selected Plan

227. The Port has indicated that they agree with all plan elements of the NED Plan with the exception of the design depth. The Port has indicated a locally preferred plan that increases the design depth throughout the project extents by an additional foot. Therefore, the Selected Plan that the Corps and Port will cost share in, seek permits for, and ultimately construct, reflects this additional depth (Table A- 18). The following section provides design details of the Selected Plan.

Table A- 18. Selected Plan - Summary

Selected Plan Component	Description[1]
OEC	Extend OEC 2,200ft seaward, add an 800ft wide "flare", and deepen to -55 ft
IEC	Deepen IEC to -48 ft
MTB (Full)	Deepen MTB (existing Federal footprint) to -48 ft
Widener	Remove Widener shoal to –48 ft
SAC	Widen SAC in the vicinity of berths 23 to 26 and deepen to -48 ft
TN (S_TN)	Shave NE corner of the TN, widen SAC north and east of TN, and deepen to –48 ft
[1] All depths indicated are project depths. Add 1 foot for required overdepth and 1 foot for allowable overdepth.	

4 BASIS FOR DESIGN OF SELECTED PLAN

4.1 TYPICAL CHANNEL CROSS-SECTIONS

228. The layout of the Selected plan is shown graphically in Figure A- 67and Figure A- 68. Figure A- 69 through Figure A- 71 shows typical channel cross-sections for the OEC, IEC, and SAC Project Components of the Selected Plan. Sections A-A and B-B depict deepening of the OEC, illustrating both the nearly vertical slopes that are predicted for reef and rock cuts and the natural side slopes expected to form in sand. Section C-C depicts a typical IEC cross-section. Section D-D depicts a typical cross section for expansion of the northern portion of the SAC, including the environmental bulkhead system along John U. Lloyd State Park. Section E-E depicts a typical cross-section for the southern portion of SAC, including natural side slopes to the east. All Port Bulkheads shown in these cross-sections are generic and are not to scale.

229. Figure A- 72 and Figure A- 73 provide the locations of typical cross-sections for the Widener Project Component. Section F-F (Figure A- 74) provides a sectional view of the proposed cut in the south portion of the Widener where landside slopes are unconfined by any existing bulkheads. Section G-G (Figure A- 75) provides a sectional view of the proposed cut in the north portion of the Widener where landside slopes are confined by existing bulkheads.

230. Figure A- 76 provides the location of a typical cross-section of the TN Project Componenet. Section H-H (Figure A- 77) provides a sectional view of the proposed cut in the TN from the EFB bulkhead to the north to the existing Port bulkhead to the south.

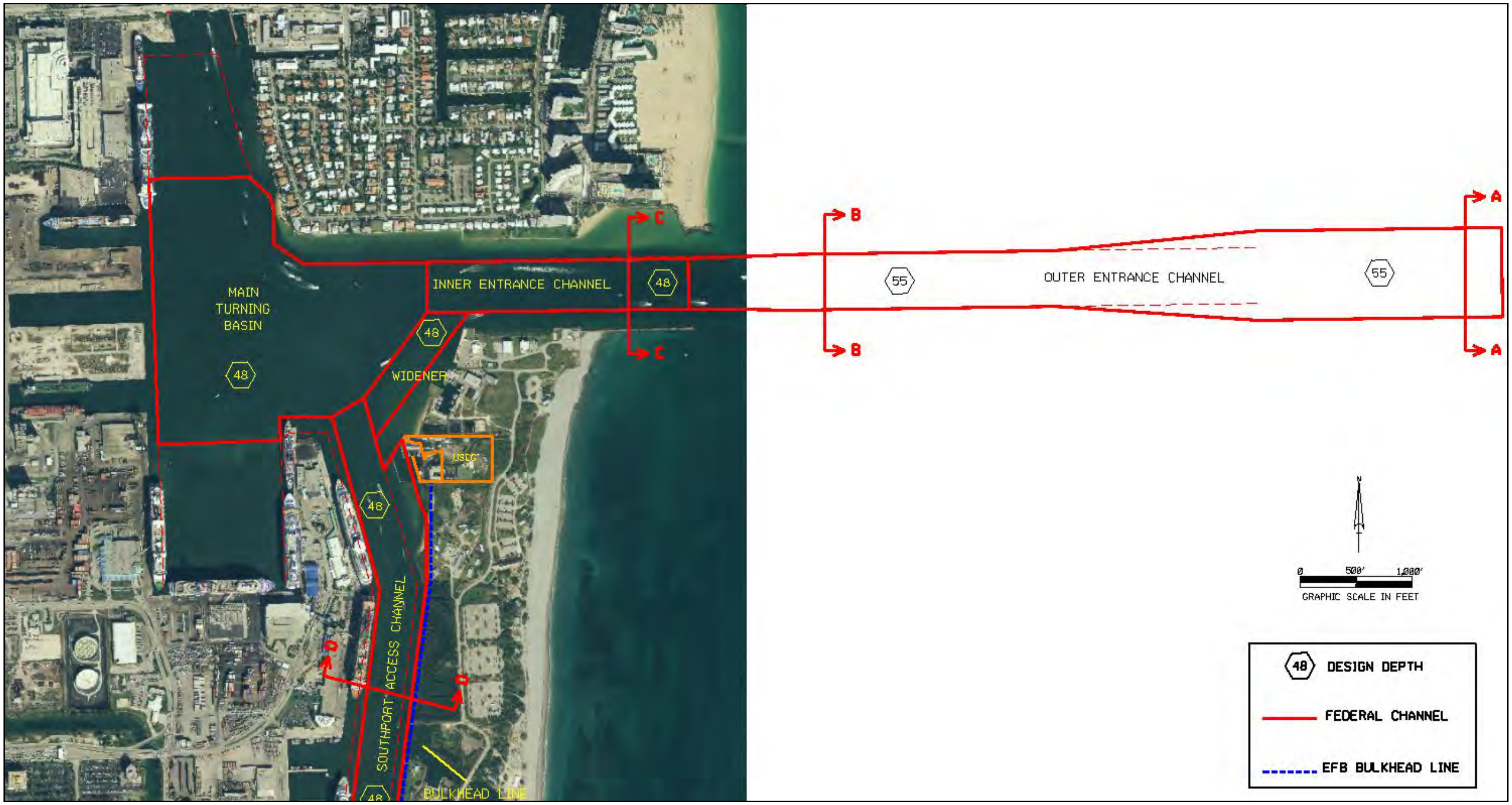


Figure A- 67. Port Everglades Selected Plan (North Portion)

Figure A- 68. Port Everglades Selected Plan (South Portion)

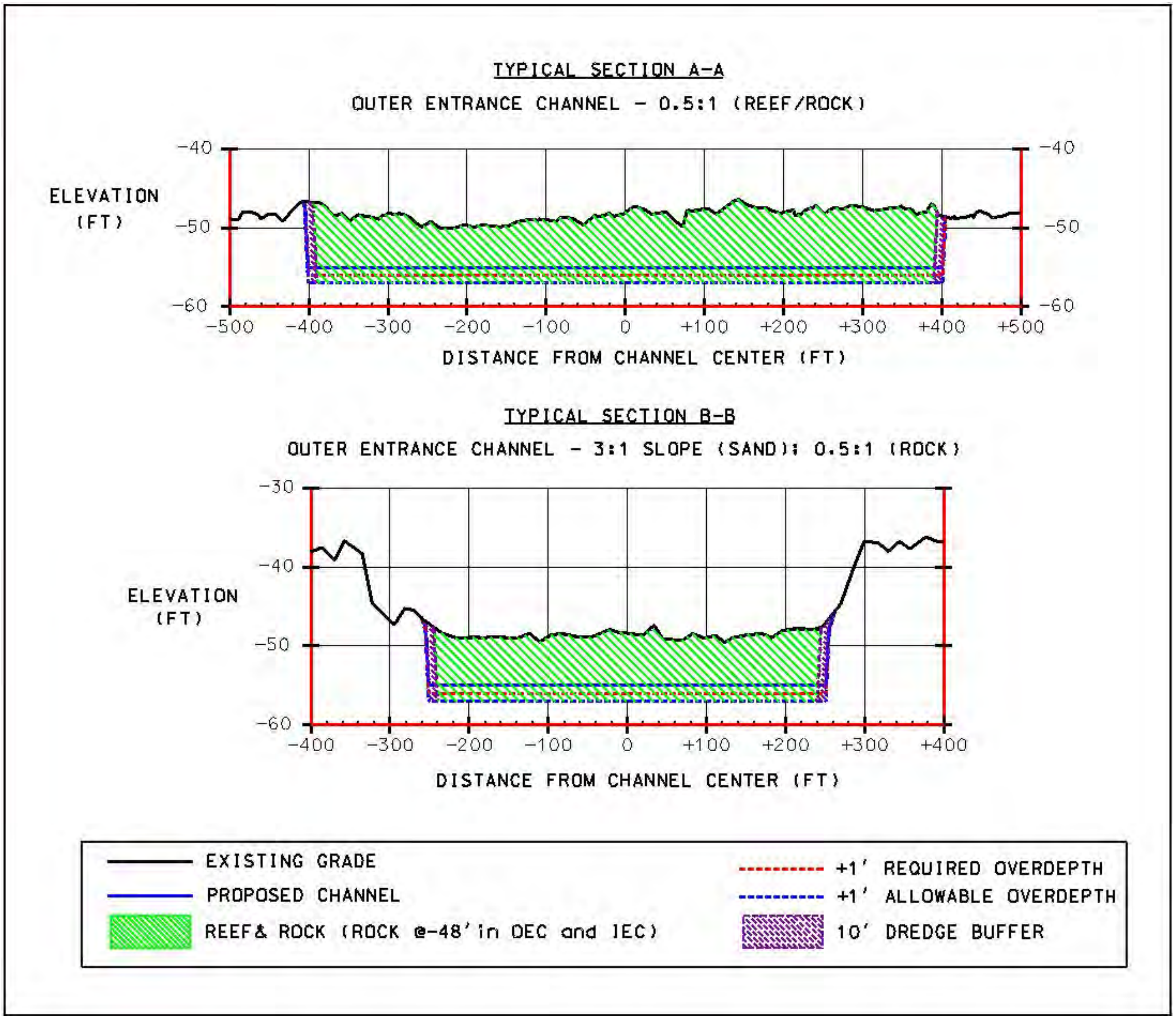


Figure A- 69. Typical Channel Cross-Sections: Outer Entrance Channels

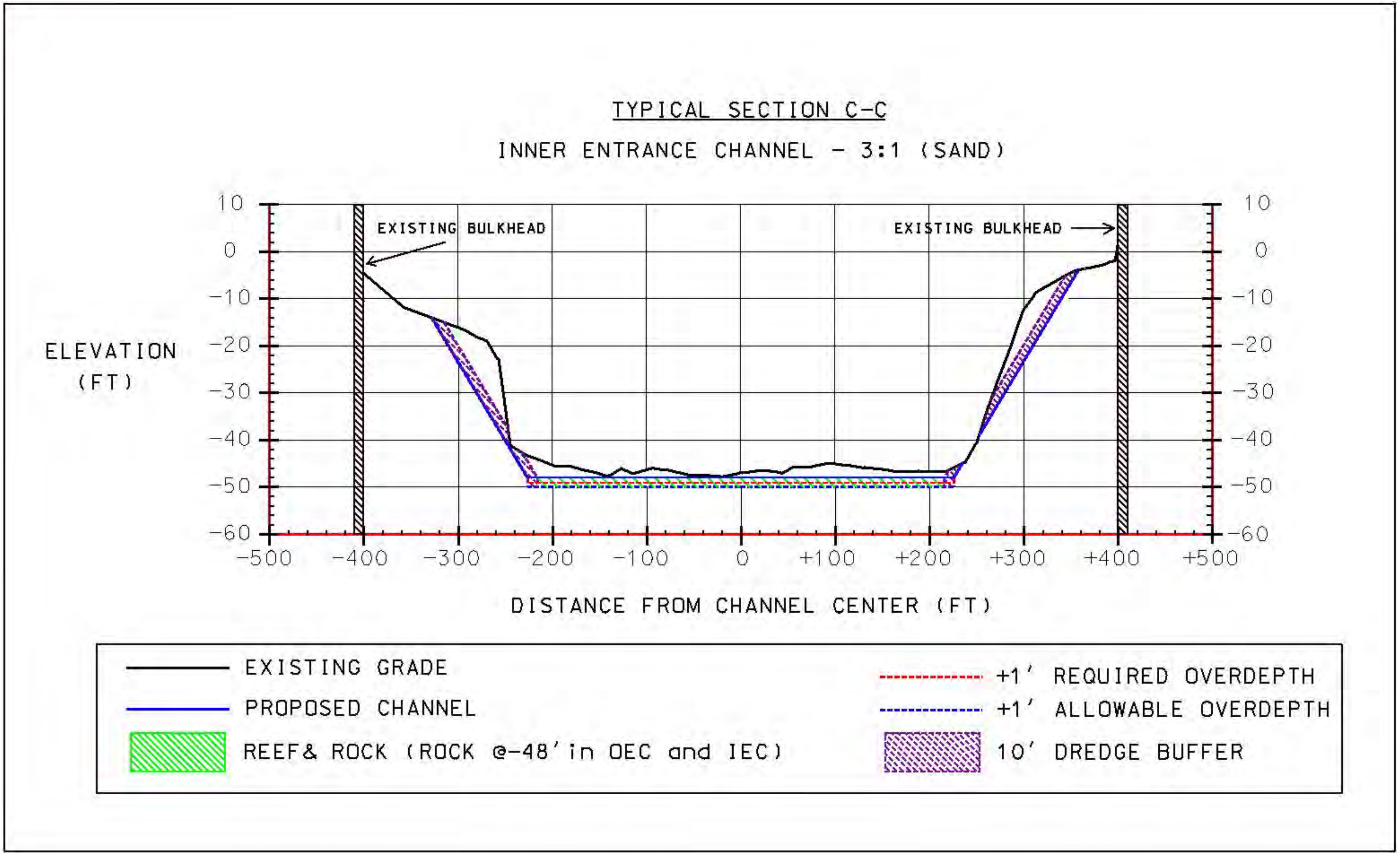


Figure A- 70. Typical Channel Cross-Sections: Inner Entrance Channel

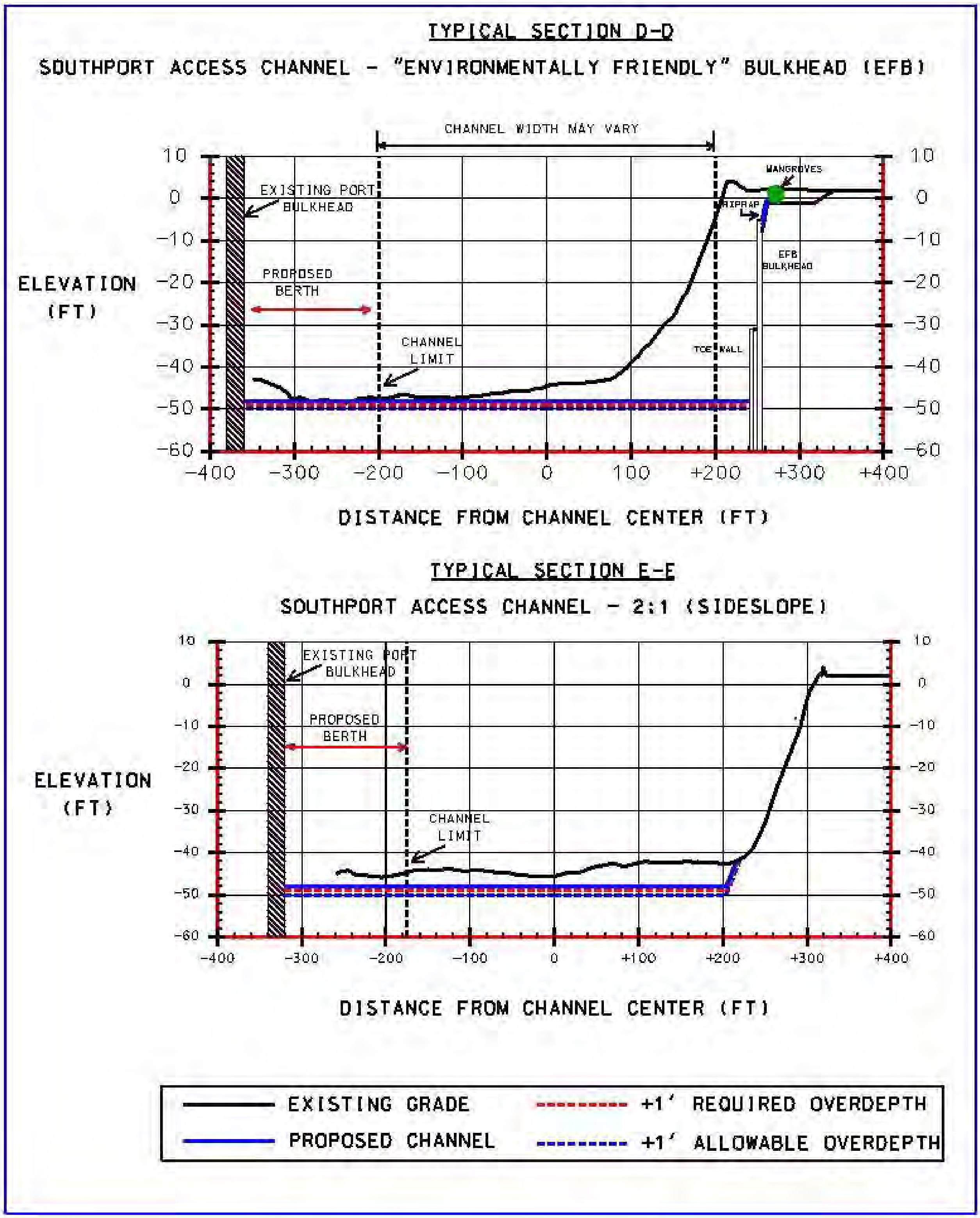


Figure A- 71. Typical Channel Cross-Sections: Southport Access Channel

Figure A- 72. Typical Cross-Section Location: Widener (Unconfined)

Figure A- 73. Typical Cross-Section Location: Widener (Confined)

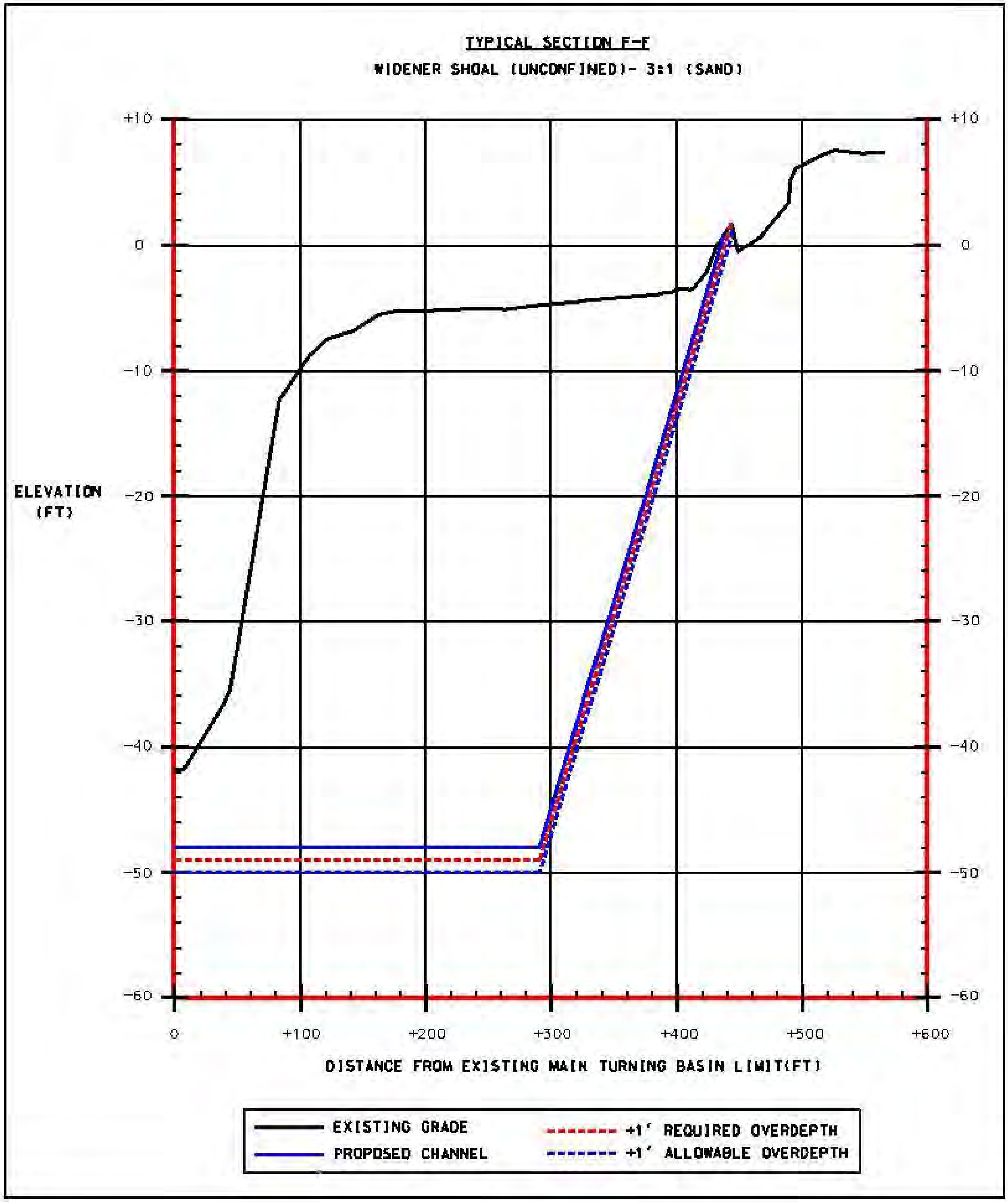


Figure A- 74. Typical Cross-Section: Widener (Unconfined)

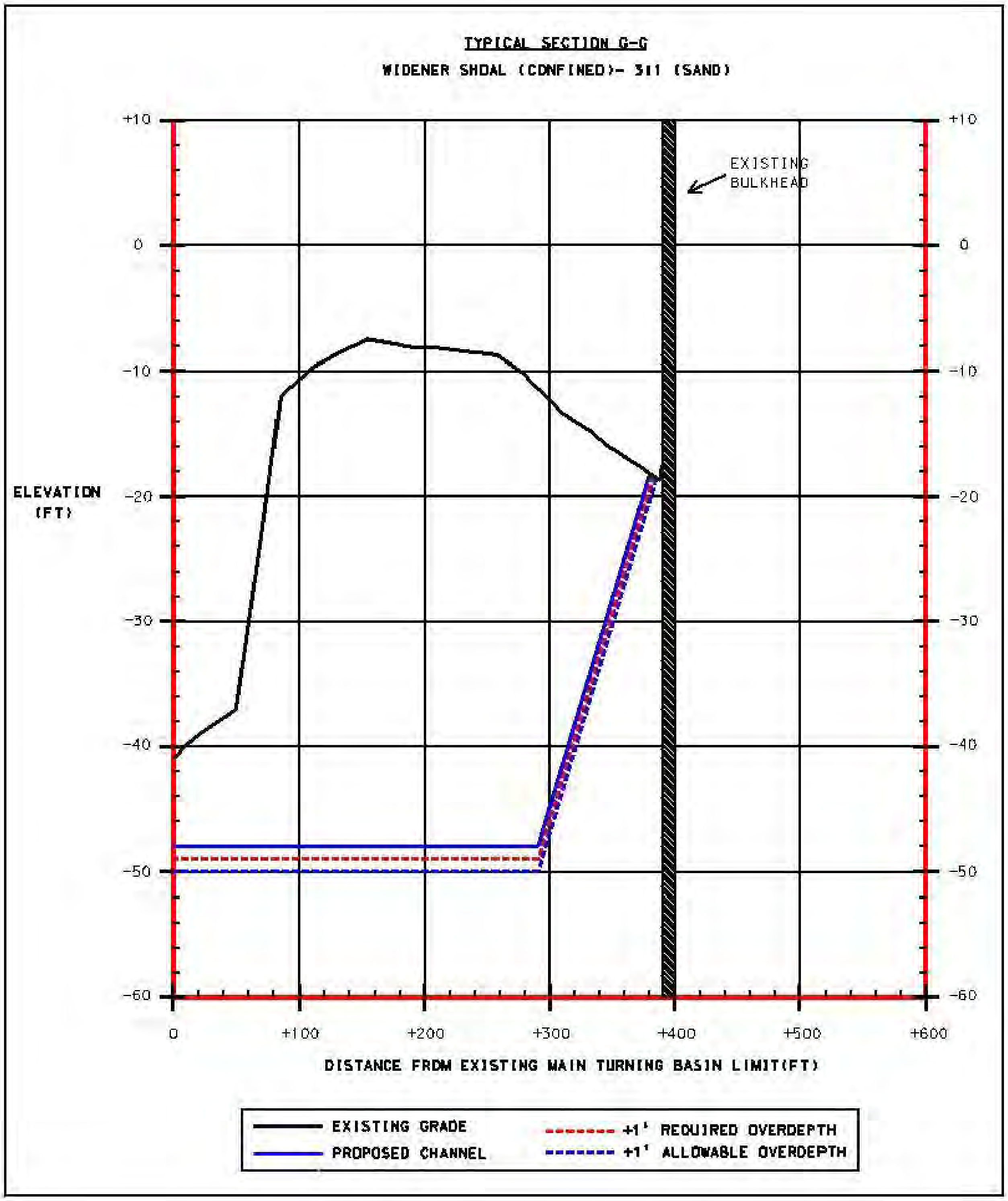


Figure A- 75. Typical Cross-Section: Widener (Confined)

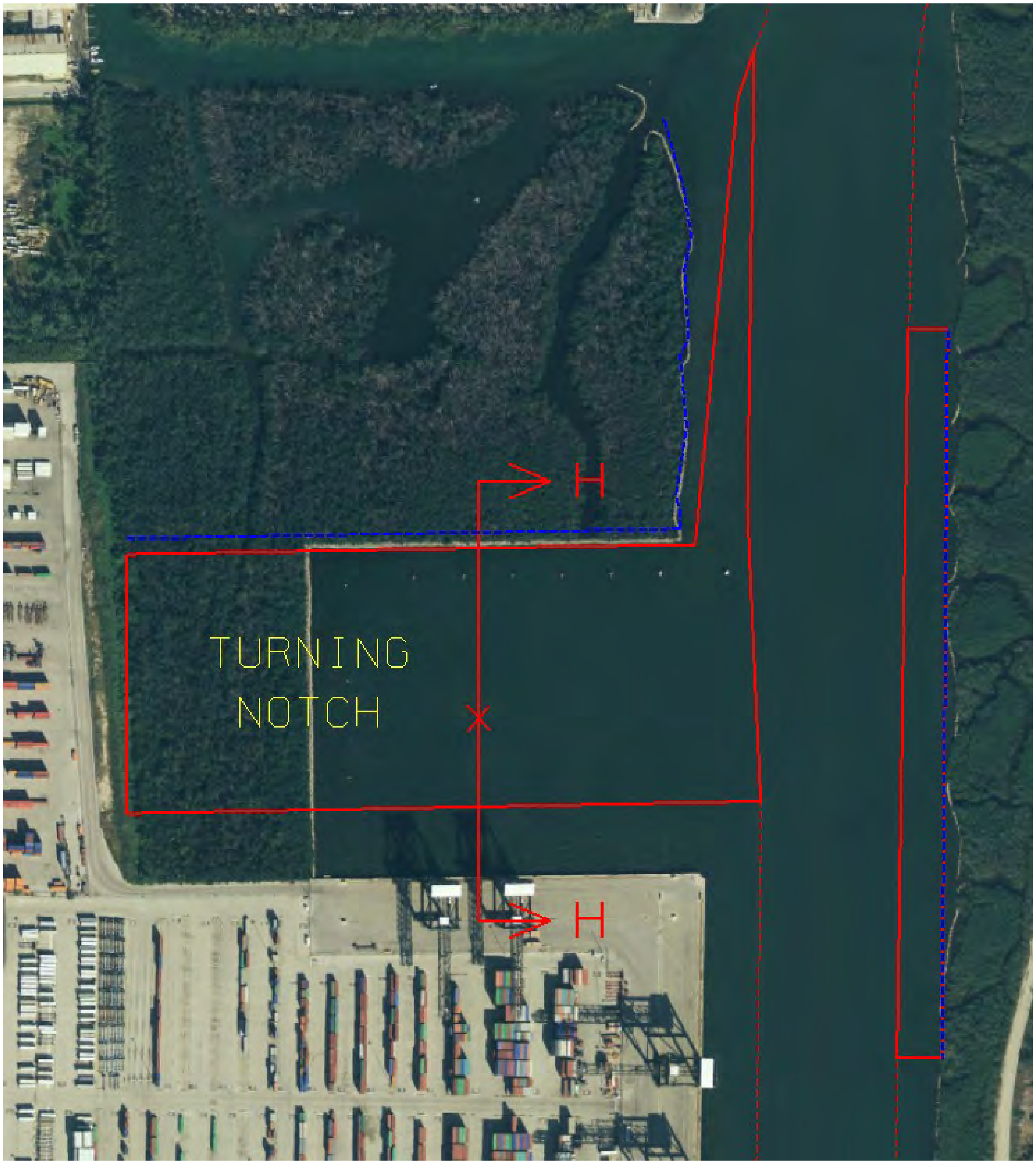


Figure A- 76. Typical Cross-Section Location: Turning Notch

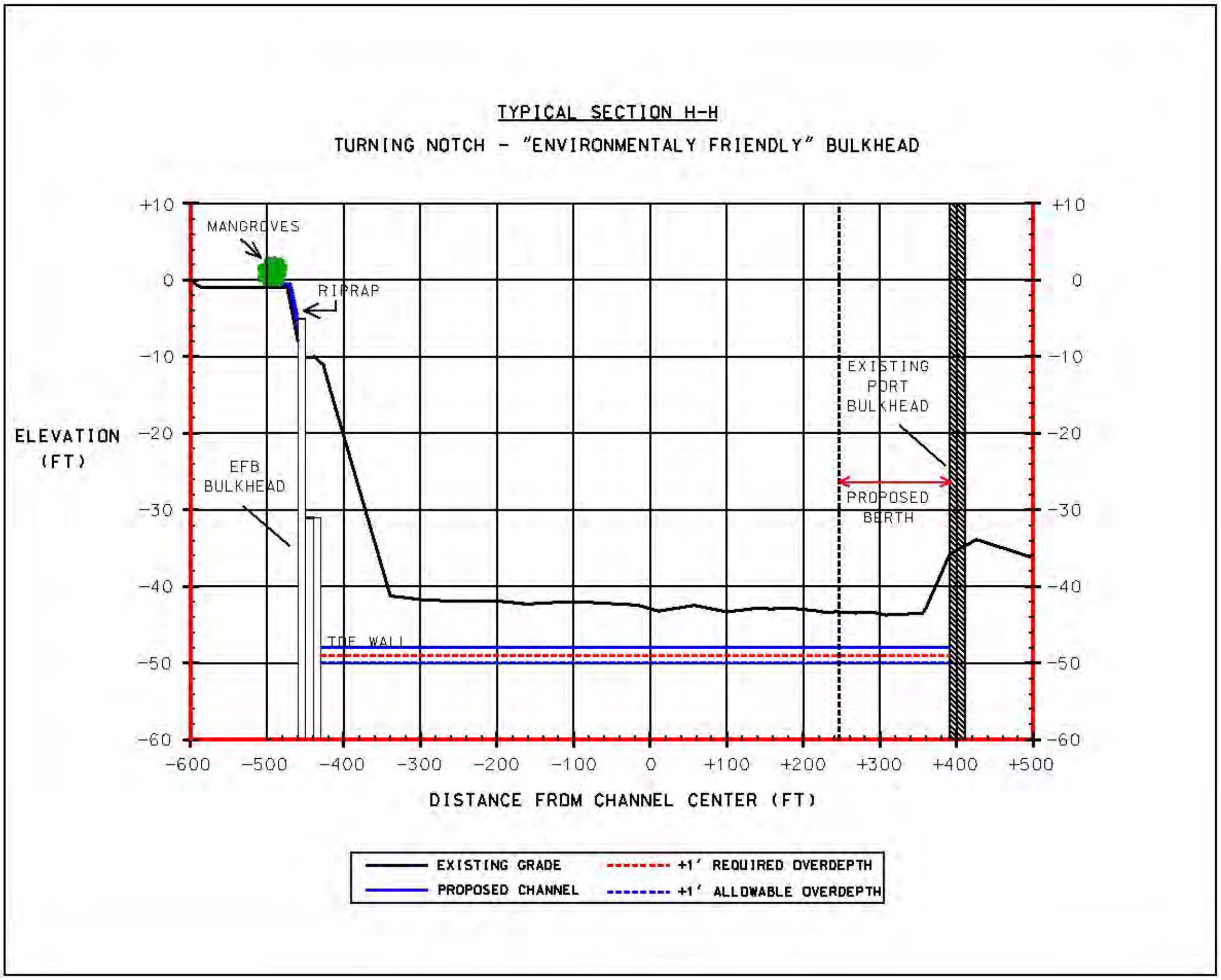


Figure A- 77. Typical Cross-Section: Turning Notch

4.2 STRUCTURAL DESIGN OF THE SELECTED PLAN

231. The Selected Plan requires the development of structural designs for the following bulkheads (by Project Component):

- MTB
  - (a) Toewalls along Berths 7 and 8
- SAC
  - (a) EFB bulkhead along eastern channel from USCG to John U. Lloyd Park, opposite of FP&L discharge canal (south end of Berth 29)
  - (b) USCG bulkheads (USCG reconfiguration plan)
  - (c) Toewalls along Berths 31 and 32

• TN

(a) EFB bulkhead along north portion of TN (south side of conservation easement), west portion of SAC (east side of conservation easement), and east portion of SAC (John U. Lloyd Park, east of TN)

232. The conceptual location of all toewalls and EFBs are shown in Figure A- 78 and Figure A- 79. USCG bulkhead locations were provided previous in Figure A- 66. It is assumed that all toewall and bulkhead systems will be in place prior to dredging of the project channels. It is further assumed that existing channel access points (canals, creeks, marinas, etc.) will be taken into account during final bulkhead design and will remain accessible. Construction methodologies, equipment, and precise construction timeline for all toewalls and bulkheads will be the responsibility of the contractor.

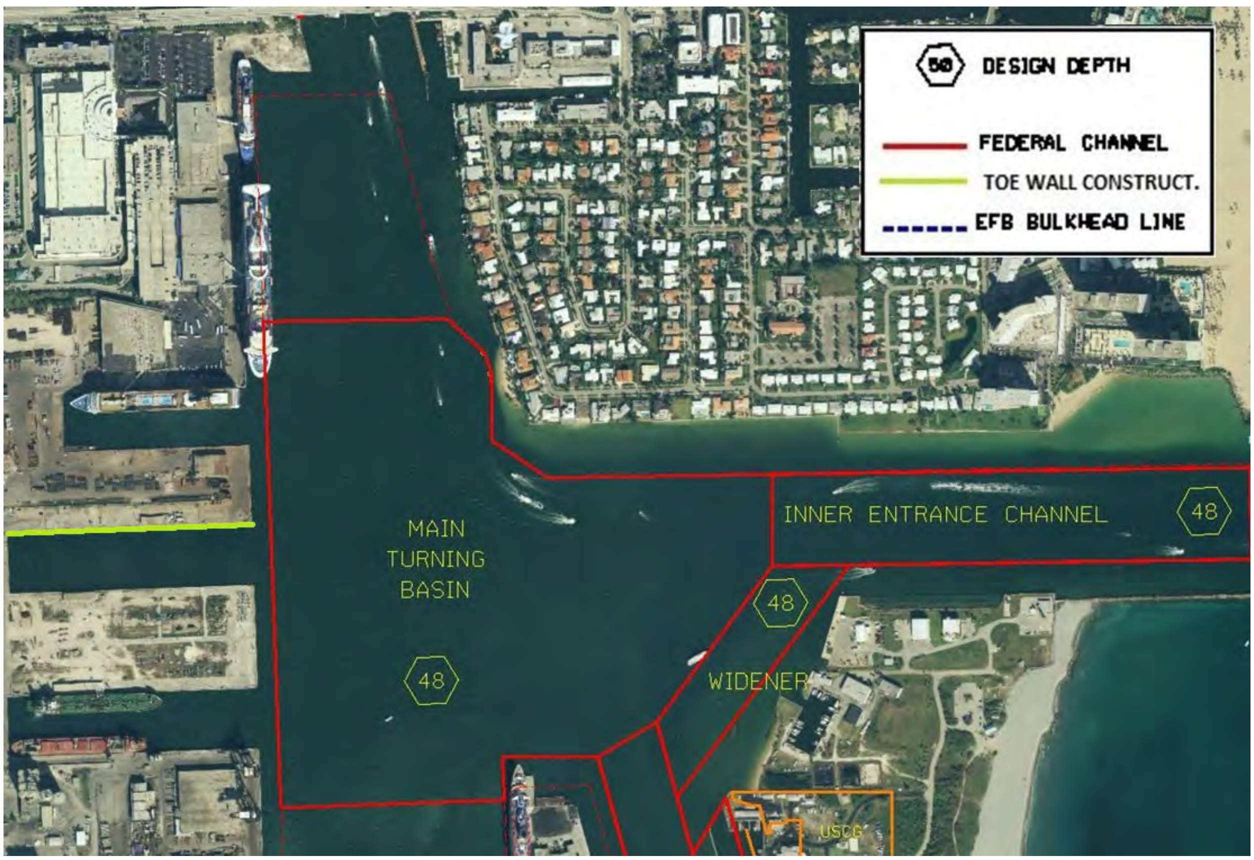


Figure A- 78. Toewall and EFB Locations (Conceptual) – North Selected Plan

Figure A- 79. Toewall and EFB Locations (Conceptual) – South Selected Plan

4.2.1 MAIN TURNING BASIN (MTB)

233. Broward County Port Authority will be responsible for structural designs for all port toewall and bulkhead systems.

4.2.2 SOUTHPORT ACCESS CHANNEL (SAC)

4.2.2.1 SAC - EFB Bulkheads

234. Expansion of the SAC in the vicinity of berths 24 through 29 requires a bulkhead along the eastern shore (John U. Lloyd Park) for slope stability. A single "environmentally friendly" bulkhead design (EFB) (Figure A- 80) was developed for this purpose. The following soil properties, provided by CESAJ-EN-GS, were used in the development of this design:

- Sand layer from top of ground to –60ft with a saturated unit weight of 125pcf and a friction angle (phi) of 30deg.
- Limestone from –60ft to –80ft with a saturated unit weight of 140pcf and a phi of 38deg
- Sand layer at –80ft and below with a saturated weight of 125pcf and phi of 34deg.

4.2.2.2 USCG – Bulkheads

235. Figure A- 63 through Figure A- 65 (previously shown in Section 3.9.1 USCG Basin) provide details of the three bulkhead designs to be incorporated into the USCG station reconfiguration. The following soil properties were used in the development of the USCG bulkhead designs:

- Sand layer from top of ground to –60ft with a saturated unit weight of 125pcf and a friction angle (phi) of 30deg.
- Limestone from –60ft to –80ft with a saturated unit weight of 140pcf and a phi of 38deg
- Sand layer at –80ft and below with a saturated weight of 125pcf and phi of 34deg.

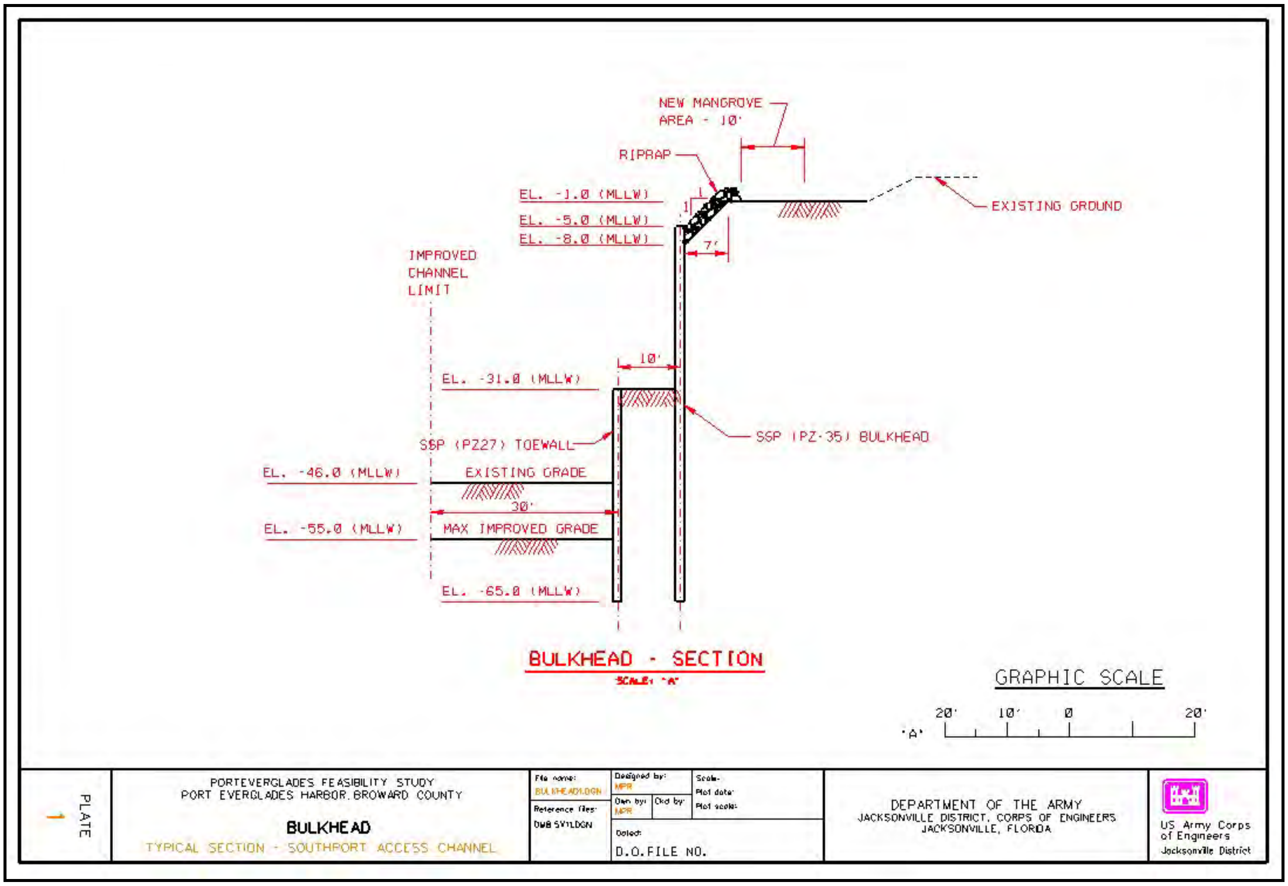


Figure A- 80. SAC – EFB Bulkhead Design

236. The following assumptions were also made during the development of the USCG basin bulkheads:

- No mooring directly at the bulkheads. Therefore, bulkheads were not designed for boat loadings.

- Soil profile on the channelside of exterior bulkhead was assumed to slope up from a depth of –48ft to a depth of –10ft on a 1 vertical on 2 horizontal (1V:2H) slope. The –10 ft basin represents the depth of the existing USCG basin which will not be raised with fill material after removal of present bulkheads.

- A 300psf construction surcharge loading was assumed for the installation of the USCG basin bulkheads along shore.

4.2.2.3 Port – Toewalls

237. Broward County Port Authority will be responsible for structural designs for all port toewall and bulkhead systems.

4.2.3 TURNING NOTCH (TN)

4.2.3.1 TN - EFB Bulkheads

238. Expansion of the TN and SAC (associated with the TN component) requires bulkheads along the north of the TN (south edge of the conservation easement), a western portion of the SAC (west edge of the conservation easement), and the western shore (John U. Lloyd Park) opposite the TN for slope stability. The "environmentally friendly" bulkhead design (EFB) (Figure A- 80) previously discussed for the SAC will be implemented as part of the TN component design as well. Design and construction of the segment of EFB along the northern portion of the TN is a future without project condition as is the responsibility of the Port Authority. The following soil properties, provided by CESAJ-EN-GS, were used in the development of bulkhead design:

- Sand layer from top of ground to –60ft with a saturated unit weight of 125pcf and a friction angle (phi) of 30deg.
- Limestone from –60ft to –80ft with a saturated unit weight of 140pcf and a phi of 38deg
- Sand layer at –80ft and below with a saturated weight of 125pcf and phi of 34deg.

4.2.3.2 Port – Toewalls

239. Broward County Port Authority will be responsible for structural designs for all port toewall and bulkhead systems.

4.3 CONSTRUCTION OF THE SELECTED PLAN

4.3.1 QUANTITY CALCULATIONS – SELECTED PLAN

240. A Triangulated Irregular Network (TIN) model was created for the study area using available hydrographic and topographic surveys (Section 3.6.2 Hydrographic and Topographic Surveys – Existing Conditions). TIN surfaces were created for the Selected Plan using INROADS software via wire frame and roadway modeler methods. INROADS was used via the triangle volume method to calculate dredge quantities. The quantity of material requiring blasting was estimated based on hard material mapping provided by CESAJ-EN-GG, which were converted to percentages (Section 3.7.2 Material Types).

4.3.2 PHASING OF CONSTRUCTION

241. The phasing, or number of contracts, required to complete this project will be contingent on the RFP process. Construction methodologies, equipment availability, and construction window compliance may result in multiple contracts being required. Additionally, due to the fact that total project cost exceeds $300,000,000, there is a strong possibility that construction will have to be phased into several contracts to meet Corps and Port funding constraints. Because

available data is insufficient at this time to determine the precise number of contracts that will be required, a single continuing contract is assumed. This will allow the contractor to group like items, to meet Port implementation schedules, and to reduce mobilization and demobilization costs. Bid items for setup/setdown can be placed as second year bid items within the continuing contracts. It should be noted that construction phasing and schedule may increase or decrease based on available resources and funding.

242. Table A- 19 provides information on the currently proposed construction order for the project components under a single contract. Note that this proposal assumes that dredging will be implemented consecutively, with excavation occurring in a single project component at a time. However, actual construction may include dredging of project components concurrently, reducing the overall construction timeline. Sequence of construction will be resolved during the RFP process. Additional details regarding project phasing will be presented in Section 4.5 (MCACES Estimates of the Selected Plan).

Table A- 19. Proposed Construction Phasing

Location	Depth	Channel Quantity[1] (cy)	Berth Quantity (cy)	Site	Start Year	Contract No.
ODMDS Designation	---	----	----	---	Year 1	1
Plans & Specifications	---	----	----	---	Year 2	1
Outer Entrance Channel	55	1,057,062	0	ODMDS	Year 3	1
Inner Entrance Channel	48	307,693	0	ODMDS	Year 4	1
Widener	48	996,245	0	ODMDS	Year 5	1
Main Turning Basin	48	700,734	146,286	ODMDS	Year 5	1
Southport Access Channel	48	1,571,500	40,004	ODMDS	Year 6	1
Turning Notch	48	608,528	42,497	ODMDS	Year 8	1
[1] Quantities include maintenance material and required and allowable overdepth						

4.4 MAINTENANCE

4.4.1 MAINTENANCE OF THE EXISTING PROJECT

243. The existing Federal navigation project at Port Everglades requires maintenance of existing channels and basins.

244. provides maintenance dredge quantities based upon the FY 2005 Corps hydrographic survey. The quantities were estimated assuming dredging to project depth +1 foot required overdepth and +1 foot allowable overdepth. The estimate is based on INROADS surface to surface calculations. This work could be accomplished in conjunction with the improvement dredging. A hydrographic survey and INROADS calculation will have to be performed prior to dredging in order to estimate the final maintenance quantities. This is necessary as maintenance dredging is funded with OM funds while the improvement work is funded with CG funds.

Table A- 20. Existing Project Federal Maintenance Quantities

Reach	Project Depth (ft)	Maintenance Quantity Avail. (cy)[1]
OEC	45/42	18,700
IEC	42	43,204
MTB	42	41,799
NTB	31	25,600
STB	31	0
SAC	42	362,100
TN	42	42,700
Total		534,100
[1] Quantities include +1ft required and +1ft allowable overdepth		

4.4.2 MAINTENANCE OF THE NED PLAN

245. Future maintenance of the channel and basin areas are expected in years 2027, 2037, 2047, and 2057. Table A- 21 provides the breakdown. Future maintenance material is expected to be placed in the Port Everglades ODMDS site

Table A- 21. Future Maintenance Quantities

Project Component	Estimated Future Shoaling Rate (cy/yr)	Estimated Future Maintenance Quantity (cy)			
		2027	2037	2047	2057
Federal Channels	27,440	274,400	274,400	274,400	274,400
Port Berthing Areas	2,000	20,000	20,000	20,000	20,000

246. Future Federal maintenance of Port Everglades Harbor was estimated using the history of Federal maintenance dredging previously discussed in this document. The history indicates a total volume of 1,538,500 cubic yards was dredged from the OEC, IEC, MTB, NTB, and STB between 1934 and 2005, yielding an average yearly shoaling rate of 21,700 cy/yr. This is approximately 0.003 cubic yards of shoaled material per square foot of channel. The widening/extension of the project will increase the channel by approximately 2,033,000 sq.ft., increasing the estimated annual shoaling rate for the increased project footprint by 5,740 cy/yr to total rate of 27,440 cy/yr.

247. The Port has reported that 30,000 cubic yards has been maintenance dredged from berthing areas in the last 15 years. This translates to a yearly berthing area maintenance dredge rate of 2,000 cy/yr. Maintaining berthing areas to project depths is the responsibility of the Broward County Port Authority.

4.5 MCACES ESTIMATES OF THE SELECTED PLAN

248. MCACES estimates were prepared for the Selected Plan. This estimate includes all project costs, contingency, PED, and S/A. MCACES estimates can be found in the Cost Engineering Appendix.

249. MCACES estimates for the Selected Plan were based on a single continuing construction contract and a phased project schedule. The project phasing schedule is presented graphically in Figure A- 81 and Figure A- 82. It should be noted that the timeline of the project phasing schedule presented here may change (increase or decrease) based on available resources and funding.

4.6 STUDIES/DATA REQUIRED DURING PED

4.6.1 SURVEYS REQUIRED DURING PED

250. While existing hydrographic and topographic surveys were sufficient for the feasibility phase of the Port Everglades study, additional data will be required before the project can progress to Plans and Specifications. The following information will need to be acquired:

- Controlled aerials with 1-foot contours including: the rock reef mitigation area, the entire port from the OEC through SAC and offshore from 4,000 feet offshore west to the limits of the Port property.

- A comprehensive hydrographic survey of the rock reef mitigation area and the port, including OEC, IEC, MTB, Widener, SAC, TN, all related berthing areas, and USCG station.

- Topographic surveys of all the USCG facility, impacted portions of John U. Lloyd Park, impacted portions of port property, and of mitigation areas.

4.6.2 GEOTECHNICAL INVESTIGATIONS REQUIRED DURING PED

251. The harbor has a history of dredging problems and claims involving rock excavations. A significant number of core borings were drilled in the past to document the materials present in the harbor Area. While the existing core boring program was adequate for planning purposes, many of the historic cores were not drilled deep enough to cover the elevations that currently need to be dredged. Additionally, most of the physical core samples of the sediments and rock have been discarded.

252. In order to fully document the rock conditions to be encountered in the current excavation plan, a significant number of core borings and rock probes (wash borings) will have to be drilled. Some gradation tests may also be needed for the TH-2 through TH-16 core borings.

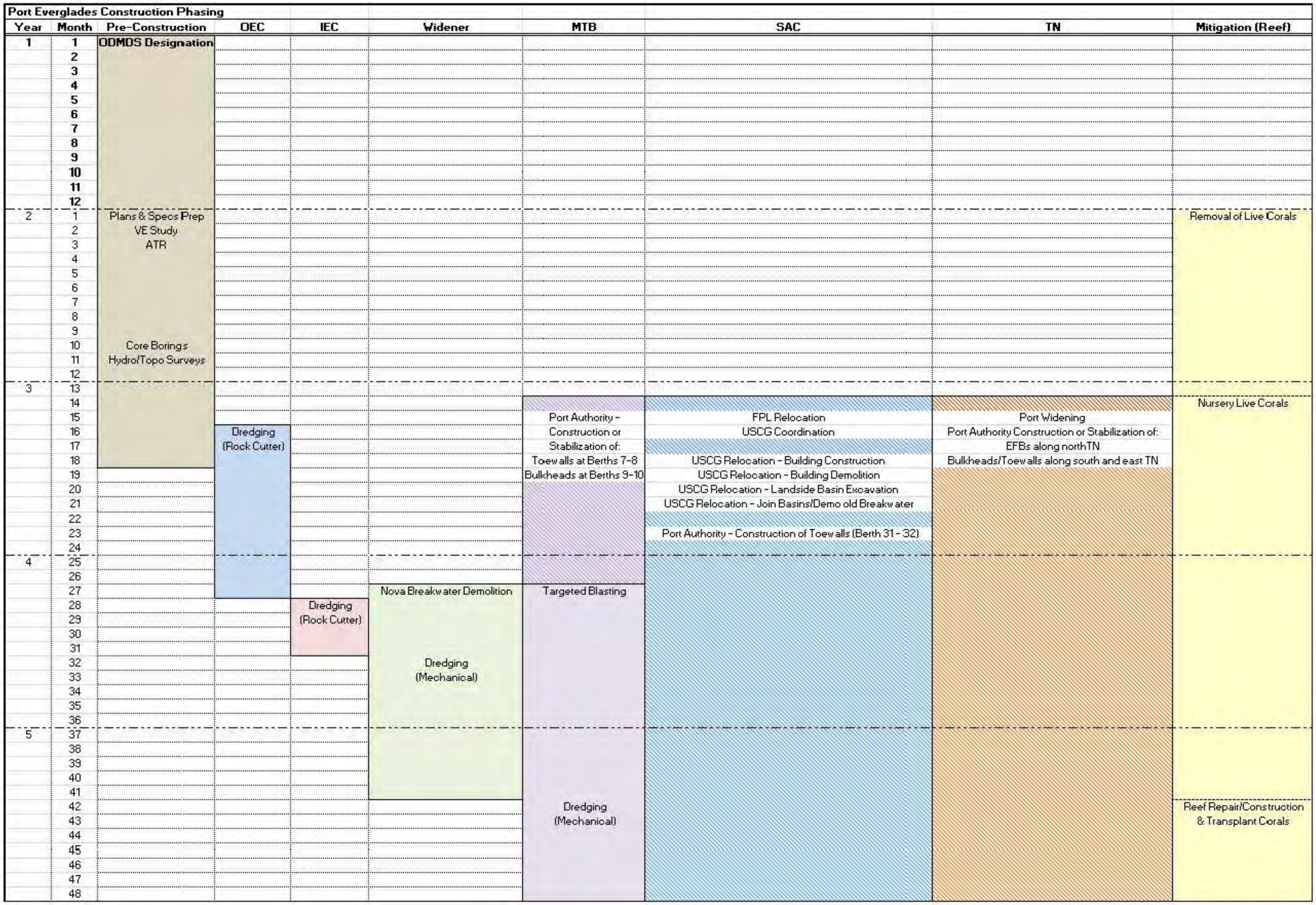


Figure A- 81. Port Everglades Project Phasing (Year 1 through Year 5)

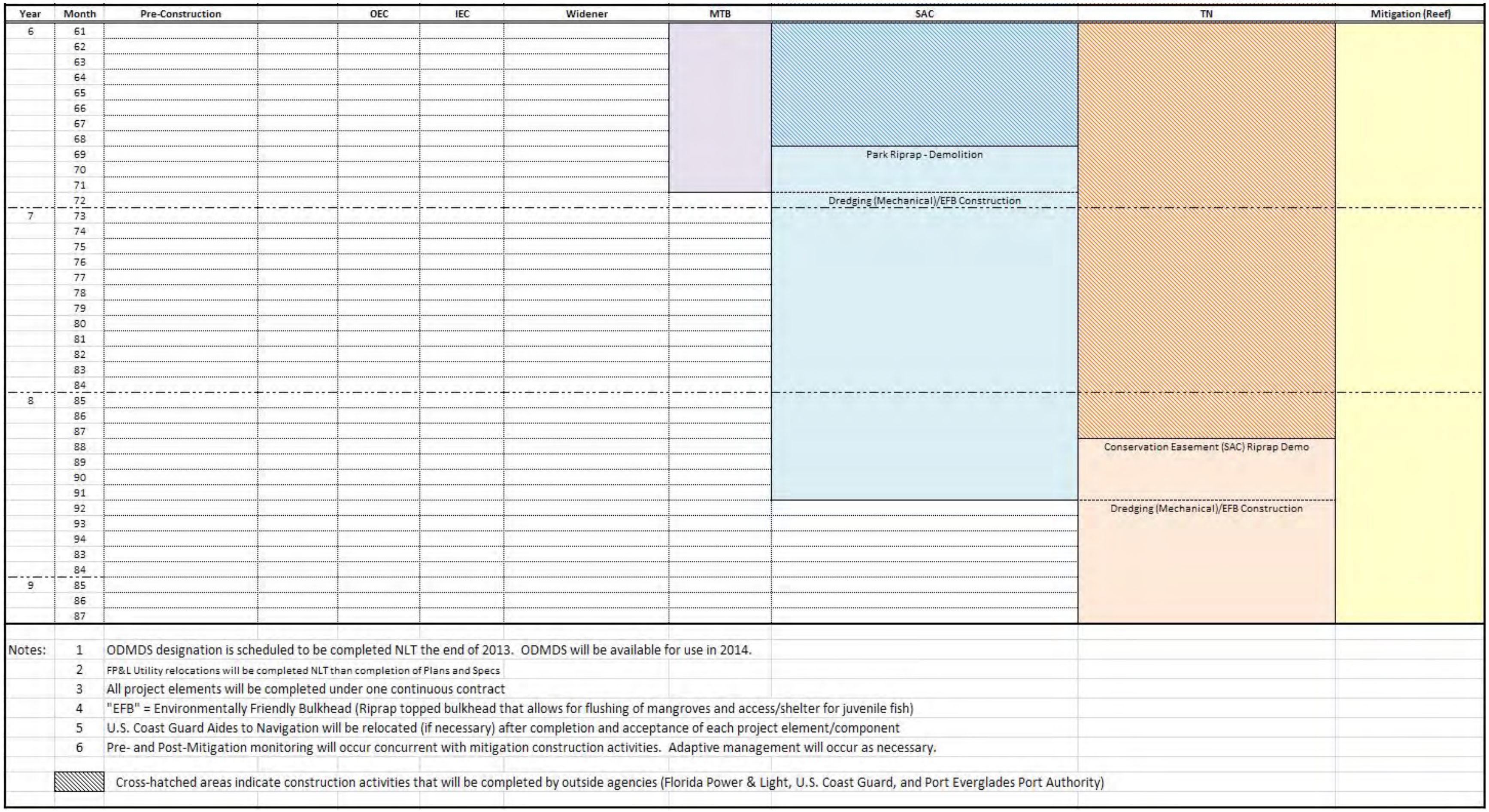


Figure A- 82. Port Everglades Project Phasing (Year 6 through Year 9)

253. Table A- 22 provides the PED drilling estimate and is established for plan/budget only. It is expected that the actual number of borings, the location of borings, and the depths of borings, may be revised as required during PED. Historic geotechnical data and borings obtained by the Port during feasibility should be used to aid in selecting actual drilling locations.

Table A- 22. Required Core Borings

Location	Number of Borings	Boring Location Type	Boring Depth (ft-MLLW)
OEC	13	Water	-69
IEC	5	Water	-62
MTB	5	Water	-62
Widener	2	Water	-62
USCG Facility	1	Land	-62
SAC - Channel	16	Water	-62
SAC – New Bulkheads	8	Water and Land	-62
TN	4	Water	-62

4.6.3 Utility Relocation Information Required

254. Detailed information regarding the location and specifications of all utilities to be relocated will need to be obtained early in the PED phase.

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PORT EVERGLADES HARBOR, FLORIDA

SUB-APPENDIX A

PORT EVERGLADES HARBOR, FLORIDA
SHIP SIMULATION STUDY

PORT EVERGLADES HARBOR
FORT LAUDERDALE, FLORIDA

SHIP SIMULATION STUDY

PREPARED FOR:

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Port Everglades Ship Simulation Study

Background

Port Everglades is located on the southeastern coastline of Florida, approximately 23 miles north of Miami and 48 miles south of West Palm Beach (figure 1). The port falls within the three cities of Dania, Fort Lauderdale, and Hollywood, as well as unincorporated Broward County. The full extent of the port covers over 448 acres of submerged land and 1,742 acres of upland territory. It is one of Florida's deepest ports

Access to Port Everglades begins at the sea buoy marking the outer limit of the port's entrance channel. The entrance channel itself is a 500 foot wide, 45 foot deep stretch that runs 1.7 miles due west, passing between north and south jetties at either side of the inlet entrance, and into the main turning basin. Mean lower low water depth in the basin is 42 feet. Beyond the main basin, Port Everglades is divided into three main regions, Northport, Midport, and Southport with a total of 33 active berths (figure 2).

As part of the US Army Corps of Engineer's (USACE) Port Everglades Harbor Feasibility Study, a series of harbor improvements have been proposed. In order to evaluate the navigation performance of the proposed modifications, US Army Engineer District Jacksonville (SAJ) and the Port Everglades Port Authority contracted with Raymond T. McKay Simulation, Training, Assessment & Research (RTM STAR) Center and the US Army Engineer Research & Development Center (ERDC) to perform a series of ship simulations. Study details, parameters and results are presented below.

Description of the Simulator

The RTM STAR Center, located in Dania Beach, Florida, is considered to be one of the most advanced facilities for maritime training and research in the world. A central component of this facility is a 360-degree-view training bridge. The bridge mockup includes realistic helm controls (figure 3) that allows pilots to command any vessel from the smallest tug to the largest super tanker under any conditions. The 360-degree-view screens display computer generated graphics that represent specific harbor and land features in sufficient detail to provide pilots with familiar visual cues. Figure 4 provides and example of the graphic display. As the simulation progresses in real-time, the visual scene is updated as the hydrodynamic portion of the simulator program computes a new ship's position and heading based on manual input from the pilot (rudder, engine throttle, bow and stern thrusters, and tug commands) and external forces (wind, waves, currents, banks, shallow water, ship/ship interaction, and tugboats). Operators in a separate control room control all of the simulated conditions, from the visual display to engine malfunctions and environmental hazards. Pilots are provided with simulated radar, water depth, relative ground and water speed of the vessel, magnitude of lateral vessel motions, relative windspeed and direction, and ship's heading.

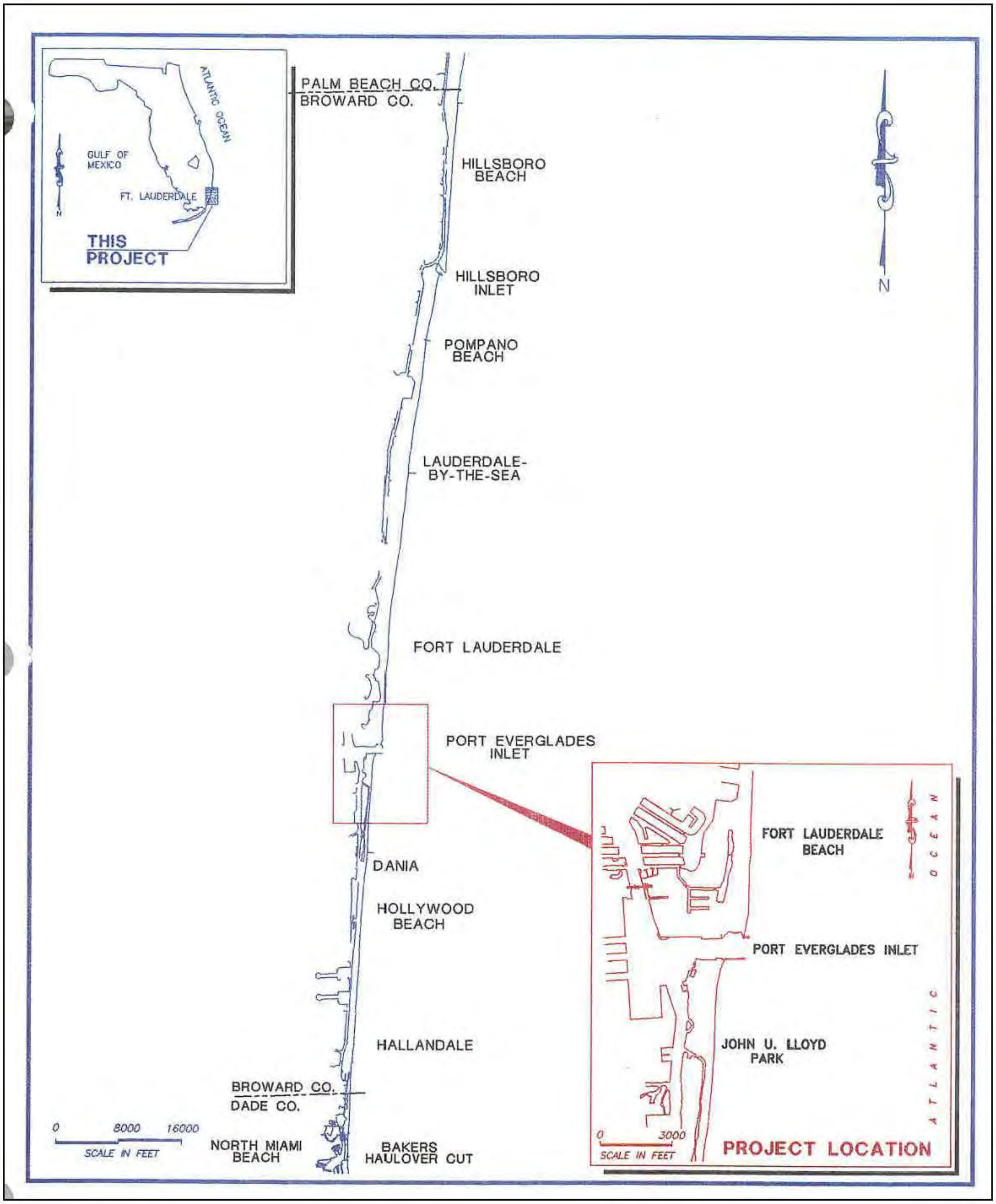


Figure 1. Location of Port Everglades Harbor

Figure 2. Layout of Port Everglades Harbor

Figure 3. RTM STAR Center Training Bridge Helm

Figure 4. Example View from RTM STAR Center Training Bridge

Required Data

Data required for a simulation study includes channel geometry, bottom topography, channel currents for proposed and existing conditons, numerical models of design vessels, and visual data of the physical scene in the study area. RTM STAR had previously developed a geographic model for Port Everglades which accurately depicted existing channels, piers, shoreline, aids to navigation, and other distictive features. Details and allignments for proposed improvements to existing channels were provided by SAJ. Design vessels were taken from RTM STAR's existing model library and are considered to be good representations of both the design vessels referenced in the feasibility study and ships that presently utilize or are expected to utilize the docking facilities of Port Everglades. Data on channel currents as well as verification of visual data and other environmental condtions was provided by USACE and the Port Everglades Pilots Association.

Existing Project Conditions

For study purposes, Port Everglades Harbor can be divided into nine sub-areas referred to as project elements. Existing conditions for each project element can be described as follows:

- *Outer Entrance Channel (OEC)* – The OEC covers approximately 5,100ft of the Port Everglades Entrance Channel, extending from the open sea to the inlet's north and south jetties.

- *Inner Entrance Channel (IEC)* – The IEC covers approximately 2,300ft of the Port Everglades Entrance Channel, extending from the inlet jetties to the main basin of the harbor.

- *Main Turning Basin (MTB)* – The MTB covers the main turning area of the harbor, extending a maximum of 2,450ft from east to west and a maximum of 2,400ft from north to south.

- *North Turning Basin (NTB)* – The NTB is a northern expansion of the MTB that covers an area of approximately 1,100ft x 900ft.

- *South Turning Basin (STB)* – The STB is a southern expansion of the MTB that covers an area of approximately 1,200ft x 1,100ft.

- *Widener* – The Widener is a shoal area, measuring approximately 1,300ft x 400ft, located to the east of the MTB, just south of the intersection between the IEC and MTB.

- *Southport Access Channel (SAC)* – The SAC is the 400ft wide primary channel of the harbor. It extends 8,500ft north to south along the Intracoastal Waterway (ICWW) from the MTB to the intersection of the ICWW and the Dania Canal.

- *Turning Notch (TN)* – The TN is turning area south of the MTB. It measures approximately 1,000ft by 750ft and is located to the west of SAC approximately midway between the MTB and Dania Canal.

- *Dania Cutoff Canal (DCC)* – The DCC project element covers approximately 4,200ft of the Dania Canal, extending from the intersection of the Dania Canal and the ICWW.

Problem Identification

In order to accommodate projected growth in containerized cargo, cruise, liquid bulk, and general cargo traffic at Port Everglades Harbor, it was determined that regions of the harbor require deepening and expanding. In June 2000, representatives from the Broward County Port Authority, the Port Pilots Association, and the US Army Corps of Engineers identified several navigation problems within the harbor that resulted in the following design objectives:

- Create safer navigational conditions in the OEC and IEC.

- Accommodate deeper drafting bulk carriers to Berths 9-13 (adjacent to MTB).

- Accommodate transit of Post Panamax containerized cargo vessels to SAC Berths 30-33.

- Accommodate transit and berthing of mid size commercial vessels to the DCC.

- Accommodate new generation cruise ships into the NTB.

- Accommodate Panamax class container vessels into the STB.

- Accommodate berthing and turning of Panamax and Post Panamax class container vessels into the TN.

Design Vessels

The following vessels were the primary design vessels used in the evaluation of structural design plans for Port Everglades Harbor.

Susan Maersk. A Post Panamax Class Container vessel with a 141ft beam, 48ft draft, and a length of 1,139ft.

Voyager of the Seas. A future class of cruise ship with a beam of 156ft, a draft of 28ft, and a length of 1,020ft.

Bellatrix. A Panamax Container Class vessel with an 82ft beam, 29ft draft, and an overall length of 524ft.

Atlantic Class Container Ship. A generic cargo vessel, representative of a "larger" panamax containerized cargo vessel, with a 106ft beam, 38ft draft, and an overall length of 965ft.

Ambassador. A Ro/Ro vessel representative of a "short" Ro/Ro vessel to be berthed at Berth 33C. The Ambassador has a beam of 71ft, a draft of 29ft, and a length of 554ft.

Ro/Ro. A generic Ro/Ro vessel representative of a "long" vessel to be berthed at Berth 33C. This generic Ro/Ro has a beam of 90ft, a draft of 32ft, and a length of 755ft.

Jutlandia. A Panamax container vessel with a beam of 106ft, a draft of 42ft, and a length of 965ft.

SL Anchorage. A container ship with a beam of 78ft, a draft of 28ft, and a length of 710ft.

Pleasure Craft. To represent pleasure craft traffic in the design process, a generic 20ft beam vessel was selected.

Tugs. Tugs were available during each simulation exercise. The Fort Lauderdale Twin Screw is a 4200 HP tug with a beam of 32ft and a length of 90ft. The Everglades Single Screw is a 2145 HP tug with a beam of 25ft and a length of 88ft. During the runs the tugs on the plots were 118 feet long with 28ft beam. Thus, the tugs shown during the simulation were approximately 30ft longer than either real-world tug. It should be noted that this caused some runs to result in false groundings.

Series I Simulation

General

Series I ship simulation runs were conducted at the RTM STAR Center in October 2000. Six Port Everglades Pilots conducted the runs using three design vessels in both inbound and outbound scenarios. Wind conditions were represented by either a 15 knot wind from the East or a 15knot wind from the Northwest, depending on the scenario. The wind conditions were considered to be representative of the "worst case" situations. Except where specifically indicated to be otherwise, it was left up to the individual pilot's discretion to determine if a run would be made bow or stern first. During each simulation run, the pilot had full control over the vessel's rudder and engines. The pilot conned the vessel and operated steering and engine controls while operators provided tug assistance as requested.

Simulator output for each test run was processed and a ship track was generated. In addition, each pilot was asked to respond to items on a questionaire (detailed in the section entitled **Series I Pilot Evaluation Form** below) immediately following each completed simulation exercise. The questionnaire attempts to qualify the authenticity of each simulation and record additional comments that the pilot may have regarding the effectiveness of simulated alternatives.

Proposed Improvements to Existing Conditions

In order to address navigation concerns and to allow larger, deeper draft vessels to call at Port Everglades, SAJ proposed a combination of modifications. Modifications to the existing channel and basin dimensions are detailed below. It should be noted that channel and/or basin deeping, although a major part of the harbor improvement plan, is not a component of the ship simulation study.

Outer Entrance Channel (OEC)

Under conditions of strong, variable currents, the 500ft OEC presents a hazard to the existing and future design fleet. Presently, Pilots are required to line up with the channel early and bring vessels in at high speed to maintain a straight course. Rapid deceleration of the vessel is then required for safe negotiation of the entrance jetties. To alleviate the need for potentially dangerous maneuvering for the existing and future design fleet, the OEC was first flared to a maximum width of 800ft at its present outer most limit and then extended 2,200ft offshore past the third outer reef (figure 5). Channel depth must also be increased to accommodate design vessels.

Inner Entrance Channel (IEC), Main Turning Basin (MTB), and Widener

Presently the depths in the IEC and MTB restrict the size of bulk carriers able to transit to berth in the main harbor. The widener shoal restricts the amount of maneuvering room a vessel has when turning in the MTB in preparation for backing down the SAC (a common method of transit). The shoal also prohibits other traffic from transiting and exiting the SAC while another vessel is in the MTB. The IEC and OEC was deepened and the Widener shoal removaled to (1) allow transit of larger vessels, (2) turn the Post Panamax Container Vessels preparing to enter the SAC, and (3) allow for two-way traffic in the MTB.

North Turning Basin (NTB)

The present design depth of 31ft in the NTB is adequate to accommodate the full draft of an S Class cruise ship with aan accepted safety clearance of 3ft. However, recent surveys indicate an accumulation of sediment has reduced depths in some areas of the basin. To transit a cruise ship to Berths 1 and 2 on the west side of the basin, a cut was made made along the western side of the basin providing a uniformly deepened area that is 250ft wide from the northern wall to the south where the NTB and MTB merge (figure 6).

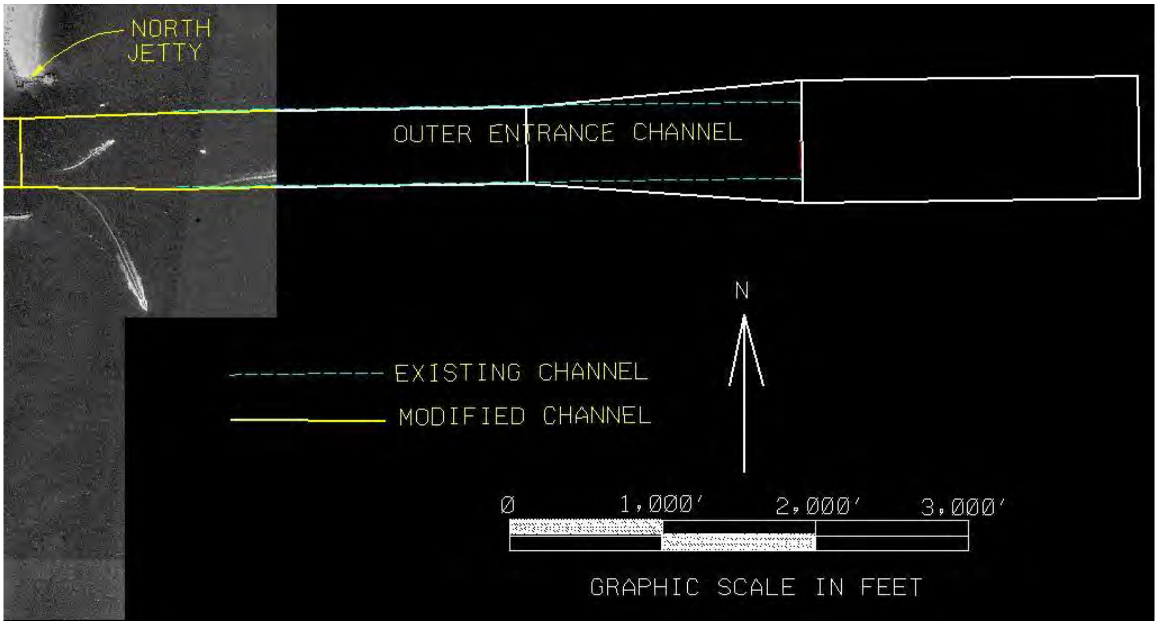


Figure 5. Modifications to Existing Outer Entrance Channel

Figure 6. Modifications to Existing North and South Turning Basins

South Turning Basin (STB)

Due to the 39ft draft of the design vessel, it is necessary to deepen the STB from a present design depth of 31 ft to a depth of 42ft. Because the vessel will be berthed only at Berths 16 and 17, deepening is not required over the entire extent of the STB. Depth requirements are met with a cut across the western side basin from north to south. This provides a uniformly deepened area that is 260ft wide from the south wall of the basin to the north where the STB and MTB merge (figure 6).

Southport Access Channel

The width and configuration of the SAC, and the proximity of a US Coast Guard Station to the northeast portion of the channel present obstacles in transiting a Post Panamax Container Vessel past cruise ships at berth in the Knuckle (a “bend” in the SAC between Berths 24 and 27) to Berths 31 and 32. At the north end of the channel, the Knuckle area was expanded from a design width of 400ft to a width of 786ft. The width at the center of the Knuckle (juncture of Berths 25 and 26) was widened from 400 ft to 480ft. At the south end of the Knuckle, adjacent to Berth 27, the width of the channel was changed from 400ft to 575ft. Channel width was then tapered in a southerly direction over a distance of 3,030ft to a design width of 460ft. A constant width of 460ft was then maintained over the remainder of the channel until reaching berths 31 and 32 where it was decreased to a width of 315ft. SAC modifications are shown in figure 7.

Turning Notch

There are two primary obstacles to bringing a Post Panamax vessel such as the Susan Maersk into the TN, the present depth in the notch and its present dimensions. To alleviate these problems, the depth of the TN was first deepened to a uniform 51ft. The dimensions of the TN are currently 1,000ft from east to west and 750ft from north to south. Under these conditions, the east to west length of the notch is not adequate to allow berthing of the 1,139ft vessel even if depth limitations could be overcome with light-loading. The design plan expanded the TN to the west, extending the total width of the Notch from 1,000ft to 1,500ft (figure 8). This plan is intended to allow for both berthing and turning of the Susan Maersk.

Dania Cutoff Canal

Presently, depths in the IEC, OEC, MTB, SAC, and the TN are sufficient to accommodate commercial vessels comparable in size to the design vessel Bellatrix. The relatively shallow depth of the DCC, however, prohibits transit to that area. In order to bring the Bellatrix into the DCC, the present design depth must be increased to a depth that accommodates both vessel draft and safety clearance. The present width of the DCC also presents an obstacle to commercial vessels. To accommodate the design vessel passing another vessel at berth and a pleasure craft in the channel, the DCC requires widening from 200 ft to 280 ft. It was also necessary to add a 356,000-sq. ft. turning area at the intersection of SAC and the DCC to allow access to and from the SAC. In

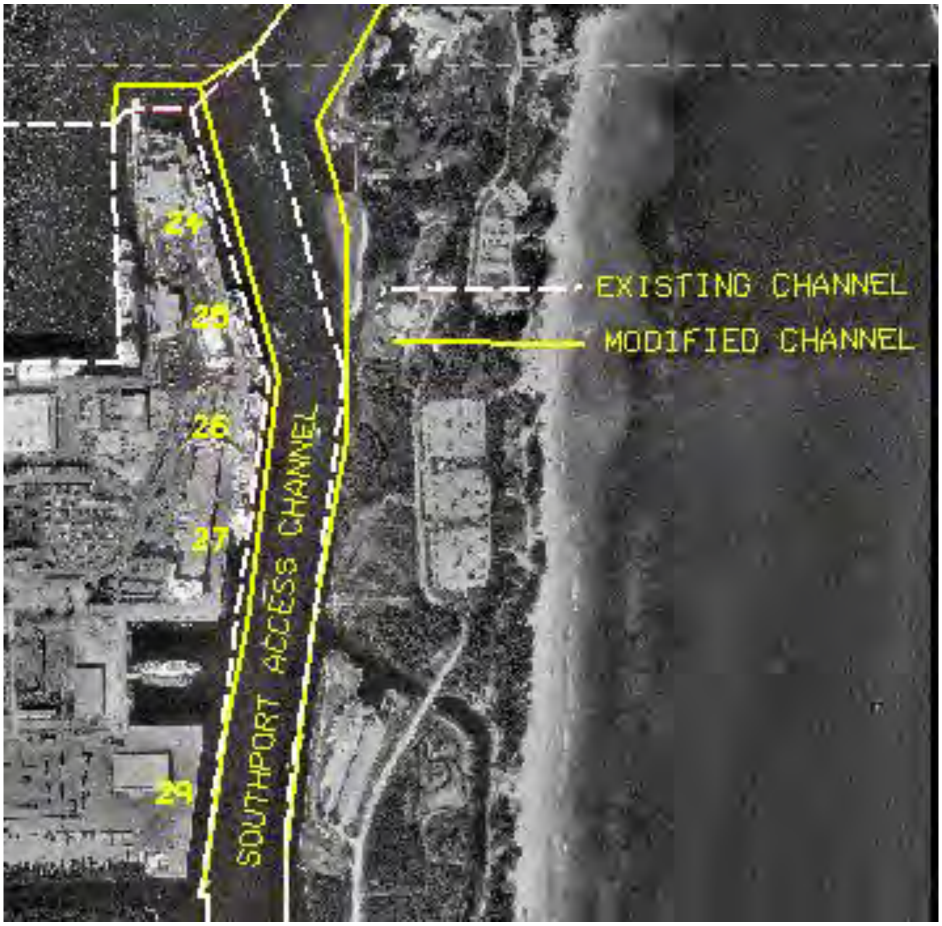


Figure 7. Modifications to Existing Southport Access Channel

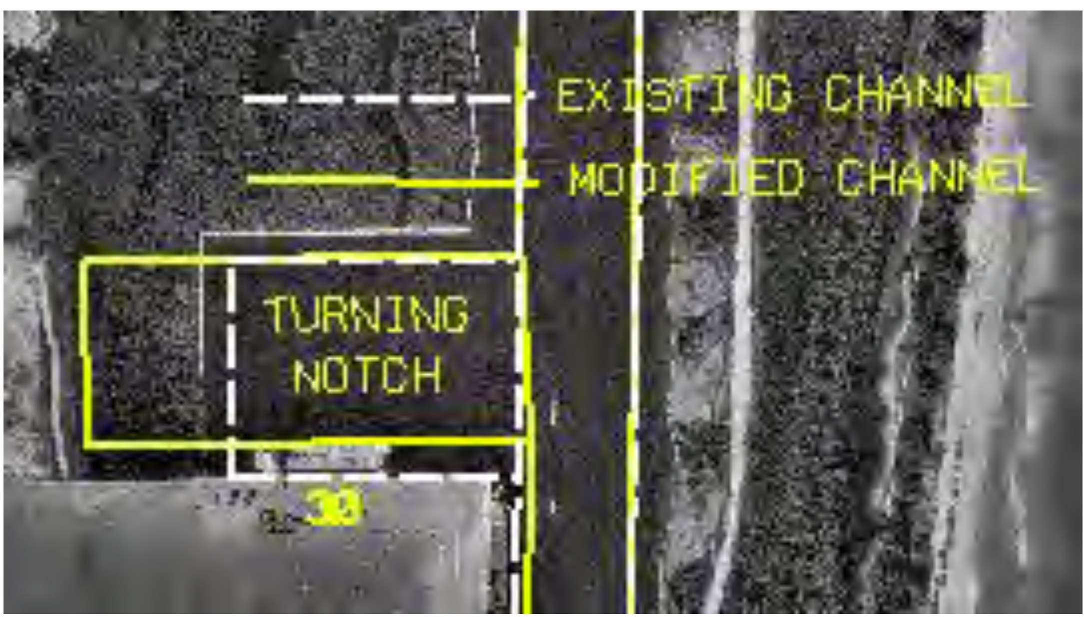


Figure 8. Modifications to Existing Turning Notch

addition, a 90ft wide berthing area and two ro/ro (roll on/roll off) ramps were created along the north side of the channel. Figure 9 illustrates modifications to the DCC.

Series I Testing Matrix

The testing matrix for the Series I Ship Simulation is provided in Table 1. Simulation runs consisted of both inbound and outbound scenarios under both flood and ebb tide conditions. Vessel orientation was specified only for DCC runs in order to better evaluate the difficult turning conditions at the intersection of the SAC and DCC. Winds were 15knots and originated from two directions, East and Northeast. Vessels at berth during transit are also specified. All scenarios, with the exception of E15 and E08 were run multiple times using different pilots. E15 and E08 were run only once.

Table 1. Series I Ship Simulation Testing Matrix

Run ID	Project Element(s)	Design Vessel	Direction	Bow/Stern[1]	Tide	Wind	Vessels At Berth Berth	 Vessel
E01a	OEC, IEC, MTB, Widener, SAC (with breakwater)	Susan Maesk	Inbound		Flood	15knot - East	25 26	Cruise Cruise
E01	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Inbound		Flood	15knot - East	25 26	Cruise Cruise
E02	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Inbound		Ebb	15knot - East	25 26	Cruise Cruise
E09	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Outbound		Flood	15knot - East	25 26	Cruise Cruise
E10	OEC, IEC, MTB, Widener, SAC (with breakwater)	Susan Maersk	Outbound		Ebb	15knot - East	25 26	Cruise Cruise
E10	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Outbound		Ebb	15knot - East	25 26	Cruise Cruise
E03	DCC	Bellatrix	Inbound	Bow	Flood	15knot - Northwest		
E04	DCC	Bellatrix	Inbound	Bow	Ebb	15knot - Northwest		
E05	DCC	Bellatrix	Inbound	Stern	Flood	15knot - Northwest		
E06	DCC	Bellatrix	Inbound	Stern	Ebb	15knot - Northwest		
E11	DCC	Bellatrix	Outbound	Bow	Flood	15knot - Northwest		
E12	DCC	Bellatrix	Outbound	Bow	Ebb	15knot - Northwest		
E13	DCC	Bellatrix	Outbound	Stern	Flood	15knot - Northwest		
E14	DCC	Bellatrix	Outbound	Stern	Ebb	15knot - Northwest		
E15	NTB	Voyager	Outbound		Flood			
E08	STB	Voyager	Inbound		Ebb			

[1] Orientation was left to pilot discretion except for DCC simulation runs

Series I Pilot Evaluation Forms

Upon completion of each test run, pilot's were asked to fill out a pilot evaluation form. These forms provide a means by which to help qualify the authenticity of each simulation and provide the opportunity for pilot's to record additional comments that they may have regarding the effectiveness of the design plan. The evaluation form for Series I contained 12 questions, each requiring that the answer be given as a numerical rating. Three questions rated the vessel trackline, six rated vessel controllability, one rated overall safety of the maneuver, one rated task difficulty, and one rated the stress level of the maneuver. Questions and their associated rating systems for the Series I Simulation are provided in Table 2.

Table 2. Series I Simulation Evaluation Questions and Rating System

Port Everglades, Florida – Run Evaluation Form					
	Extremely -------------------- Not at all Satisfactory Satisfactory				
Vessel Trackline					
(1) Vessel position with regard to centerline	5	4	3	2	1
(2) CPA to channel boundaries and/or buoy at the entrance	5	4	3	2	1
(3) Vessel position with regard to ships at berth	5	4	3	2	1
Vessel Controllability					
(4) Engine reserve	5	4	3	2	1
(5) Rudder reserve	5	4	3	2	1
(6) Course control	5	4	3	2	1
(7) Speed control	5	4	3	2	1
(8) Use of tugs	5	4	3	2	1
(9) Thruster reserve	5	4	3	2	1
	Absolutely ----------------------- Not at All Safe Safe				
(10) **Overall Safety**	5	4	3	2	1
	Extremely ------------------------- Not at All Difficult Difficult				
(11) **Task Difficulty**	5	4	3	2	1
	Extremely ------------------------- Not at All High				
(12) **Stress Level**	5	4	3	2	1

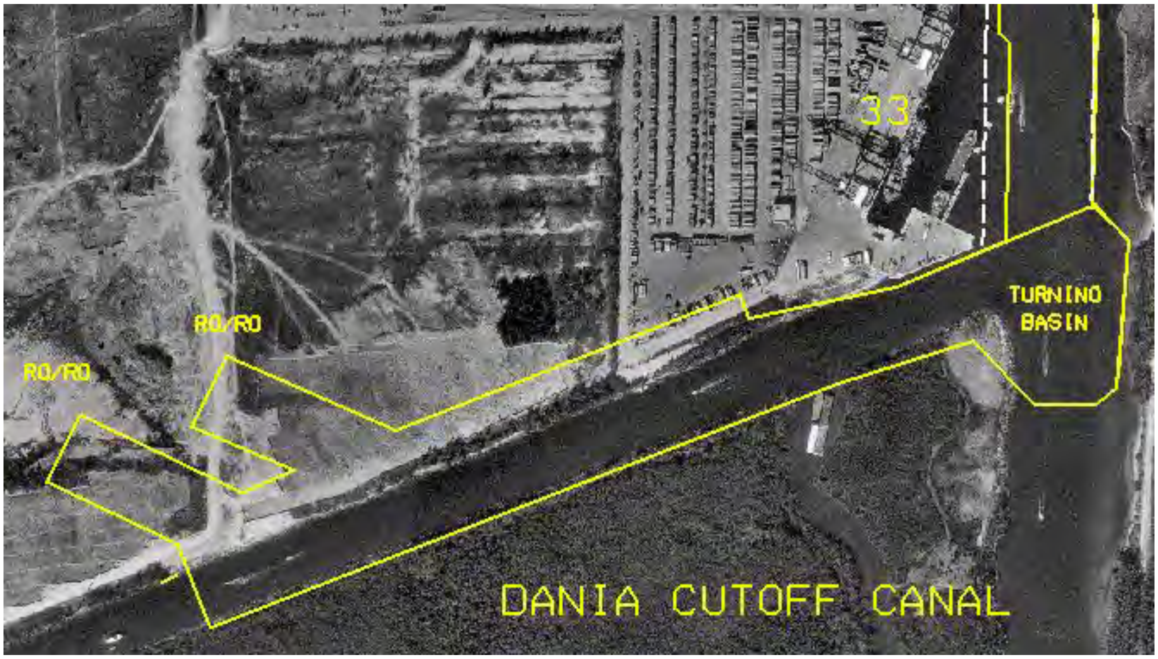


Figure 9. Modifications to Existing Dania Cutoff Canal

Series I Results

Plots showing average Pilot evaluation ratings for each run completed during the Series I simulation are shown in Attachment I. Actual composite tracks plots and pilot questionnaires will remain at USACE SAJ as these original documents are considered to be proprietary information belonging to the Port Everglades Pilots Association.

Susan Maersk, Inbound (OEC to Berth 31-32)

<u>Flood Tide</u>

Inbound, flood tide Susan Maersk runs consisted of one run with the USCG Station in its present location and four runs in which the USCG station breakwater was removed. None of the inbound vessels encountered significant problems in the OEC, IEC, or MTB. Upon entering the SAC, a single pilot lost control of his vessel, creating a collision with a cruise ship at Berth 25. This scenario was considered to be an abnormality and restarted. The pilots second attemp was completed without incident. None of the vessels came within 100ft of the proposed channel edge where it was widened on the east side of the channel. However, it was noted that no vessel was presently berthed at Berth 29. The inclusion of a cruise ship at this berth would cause transiting vessels to move further to the east. While pilots felt relocation of the USCG breakwater improved channel conditions, overall comments indicated that the constriction of the knuckle area still presents a significant problem. The average pilot rating for Overall Safety was 3 with the USCG breakwater in place and 3.5 with the breakwater removed.

<u>Ebb Tide</u>

All inbound, ebb tide Susan Maersk runs were made with the USCG Station breakwater removed from the channel. Pilots rated the ebb tide runs as easier than those conducted under flood tide. When vessels transit against the tidal currents, this increases the flow past the rudder, thus improving steerage. However, pilots continued to note that the knuckle area remained tight even without the USCG breakwater. The average pilot rating for Overall Safety was 4.3.

Susan Maersk, Outbound (Berth 31-32 to OEC)

<u>Flood Tide</u>

Outbound, flood tide runs with the Susan Maersk were all completed with the USCG breakwater removed from the channel. Four pilots participated in the runs. During outbound, flood tide runs, none of the vessels made use of the southern portion of the additional space created by widening the channel east of the knuckle. However, all of the vessels used the additional space near the USCG Station. Three of the runs left the channel near the USCG Station and one ship hit the station. Despite these incidents, Pilot comments indicate that moving the USCG breakwater was an improvement and the track plots showed that they used the extra room to avoid the docked ships. The average pilot rating for Overall Safety was 2.8.

<u>Ebb Tide</u>

Outbound, ebb tide Susan Maersk runs consisted off two runs made with the existing USCG Station configuration and three runs in which the USCG Station bulkhead was removed. Three pilots participated in these runs. While transiting outbound under an ebb tide, one ship ran aground due to excess speed. Upon rerunning the scenario, however, the run was completed successfully. The remainder of the runs, including those in which the USCG breakwater remained in its original location, were completed successfully. In runs were the breakwater was relocated, all of the pilots used the additional space provided. In all runs, none of the vessels left the existing channel limits while south of the knuckle. The average pilot rating for Overall Safety was 2 with the USCG breakwater in place and 3.3 with the breakwater removed.

Bellatrix, Inbound (Berth 31 to DCC Berth)

<u>Flood Tide</u>

Inbound, flood tide Bellatrix runs consisted of three bow first and five stern first transits. Three pilots participated in the bow first runs and each clipped the eastern edge of the channel as they approached the turning basin at the intersection of the SAC and DCC. One of the ships left the channel by approximately 40ft as it entered the turning basin. Two other vessels did not have adequate room for the tugs (ship's port side) as they made the turn into the DCC. Pilot comments reflect that the entrance was tight at Berth 33C. The average pilot rating for Overall Safety was 3.5.

Four pilots participated in stern first inbound scenarios. One pilot began his run as if he had turned his ship prior to leaving the SAC. The other three pilots turned their vessels in the turning basin provided at the intersection of the SAC and DCC. In all three runs, the vessel left the turning basin at the southern limit. None of the four runs had enough room for tug assistance as they entered the DCC. Pilots again commented on the tightness of the channel near Berth 33C. The average pilot rating for Overall Safety was 2.7.

Ebb Tide

Inbound, ebb tide Bellatrix runs consisted of three bow first and four stem first transits. A single pilot conducted the ebb tide runs. Evaluations indicated that this was a fairly easy scenario to complete. However, the assist tug of one vessel ran aground in the DCC and it was noted in pilot comments that the channel and turning basin were tight around Berth 33C. The average pilot rating for Overall Safety was 3.7.

Four pilots participated the stem first scenarios. Three of the four runs in the widened channel were able to stay within the provided turning basin. The additional run left the turning basin at the southern limit. The improved success (compared with flood tide runs) was due to the fact that the ebb tide keeps the ship further north. However, two of the runs had instances of the port side assist tug running aground on the south side of the DCC. All pilots commented that the turning basin was tight for this maneuver. The average pilot rating for Overall Safety was 2.8.

Bellatrix, Outbound (DCC Berth to Berth 31)

Flood Tide

Outbound, flood tide Bellatrix runs consisted of three bow first and four stern first transits. Three pilots participated in the bow first cases. Two of the pilots were unable to make the turn to the north without leaving the channel on the east. The other was able to remain in the channel. In all of the runs, the assist tug (starboard side) for all runs ran aground. Two ran aground in the DCC and the other ran aground in turning area. The tightness of the turning basin was again expressed in the pilot's comments. The average pilot rating for Overall Safety was 3.0.

Three pilots participated in the stern first runs. All of the runs went too far south into the turning basin and left the authorized channel. In addition, all runs had instances of the assist tug running aground. Comments again focused on the tightness of the turning basin. The average pilot rating for Overall Safety was 2.7.

Ebb Tide

Outbound, ebb tide Bellatrix runs consisted of three bow first and four stern first transits. Three pilots participated in the bow first cases. In all cases, the vessel remained within the channel limits. The ebb tide helped the ships make the turn from the DCC. This is opposite the flood tide runs, in which the current pushed against the turning ship. However, during the three runs the assist tug ran aground. It was commented that the northbound turn under ebb tide conditions increased the difficulty of the maneuver. The average pilot rating for Overall Safety was 2.5.

Four pilots participated in the stern first runs. Three of the runs left the southern end of the turning area. The forth run stayed within the southern limits, but had inadequate room for tugs to maneuver. Comments again focused on the tightness of the turning basin, particularly under less than ideal ebb tide conditions. The average pilot rating for Overall Safety was 2.3.

Eagle, Inbound (OEC to Berth 17-18)

A single inbound run with the Eagle was conducted. Prior to the simulation run, the pilots, based on experience, recommended modification of the STB dimensions. As a result of visual inspection it was determined that the proposed STB cut would allow inadequate maneuvering room for vessels transiting to Berths 17 and 18. In order to provide more room, the original north to south straight cut along the western side of the STB was replaced by a diagonal cut that provides a uniformly deepened area measuring 260ft wide at the south and 1,100ft wide to the north where the STB and MTB merge. Using the new STB configuration, the pilot easily completed the exercise and no addition runs were required. The average pilot rating for Overall Safety was 5.

Eagle, Outbound (Berth 1-2 to OEC)

A single outbound run with the Eagle was conducted. As with the STB, it was recommended prior to simulation that the NTB dimensions be modified to allow more maneuvering room. It was also determined during this time frame that the NTB element was being removed from the project. A similar diagonal cut was added to the NTB and the simulation was run as planned. The pilot easily completed the exercise. No further NTB runs were made. The average pilot rating for Overall Safety was 5.

Series I Conclusions and Recommendations

Examination of ships tracks and pilot evaluations for inbound and outbound Susan Maersk runs leads to three primary conclusions in regard to transiting Post-Panamax vessels to Berths 31 and 32, (1) the Widener shoal must be removed from the southeast portion of the main harbor to successfully turn a Post-Panamax vessel in the MTB, (2) the USCG Station is a significant limiting factor for navigation for vessels traveling in and out of the SAC even with the USCG breakwater relocated, and (3) proposed SAC dimensions south of Berth 29 are adequate to accommodate the design vessel. It is therefore recommended that at the very least, the Widener shoal be removed and the USCG breakwater be relocated to the east. However, total relocation of the entire USCG basin should also be considered. If removal of the shoal and total relocation of the basin occurs it will also be possible to reduce the eastward expansion of the SAC (and therefore environmental impacts) south of the basin by 50ft to 100ft (figure 10).

During the Susan Maersk transits into the SAC, it became evident that the dimensions of the proposed TN modifications were not sufficient to allow for either turning or berthing of a Post-Panamax vessel. In light of this, no simulation runs were conducted that involved use of the TN. It is therefore recommended that the TN dimensions be revisited to allow for berthing and turning of a vessel the size of the Susan Maersk. TN runs should be added to the next series of simulations to ensure that adequate maneuvering room has been provided.

After evaluating ships tracks and pilot questionnaires for the Bellatrix runs, it was determined that several modifications to the proposed DCC design plan were required. Numerous simulations included vessels which left the southern end of the proposed turning area. Additionally, two of the vessels left the turning basin on the northeast. A majority, however, did not come close to the eastern side. In order to alleviate maneuvering difficulties in the DCC turning area, it is recommended that the southern limits of the area be extended an additional 50ft to the south. At the same time, it is possible to move the eastern edge to the west by 25ft. The final result is a slightly elongated turning basin (figure 11). Given the additional room to the south, vessels should no longer encroach on the northwest limits of the turning area. It is also recommended that the main channel of the DCC be widened from 280ft to 310ft to provide more room for vessels entering and leaving berths under high current conditions. These recommended changes are significantly different from the original plan. Therefore, it is advisable that the new turning basin and channel configuration be simulated to ensure that it provides adequate clearance for ships entering and leaving the DCC.

Series II Simulation

General

Series II ship simulation runs were conducted at the RTM STAR Center between July 2002 and August 2002. Five Port Everglades Pilots conducted simulator runs that employed three design vessels. Simulations included, inbound, outbound, and turning scenarios under both flood tide and ebb tide conditions. Simulations took place using channel dimensions which were modified based upon Series I recommendations and changes made by the project sponsor.

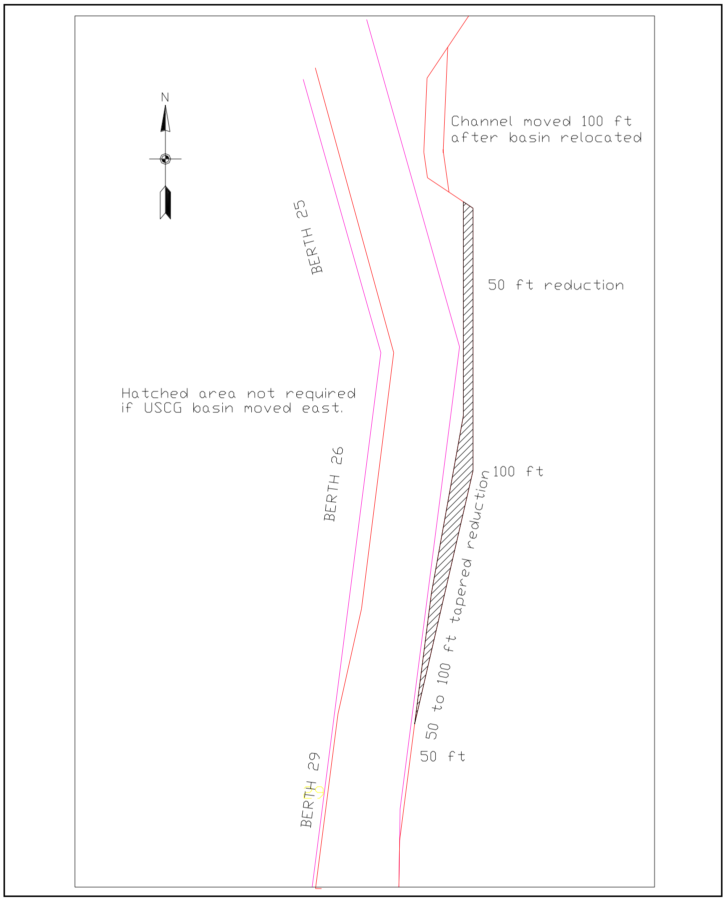


Figure 10. Recommended Reduction of SAC Design Channel Limits

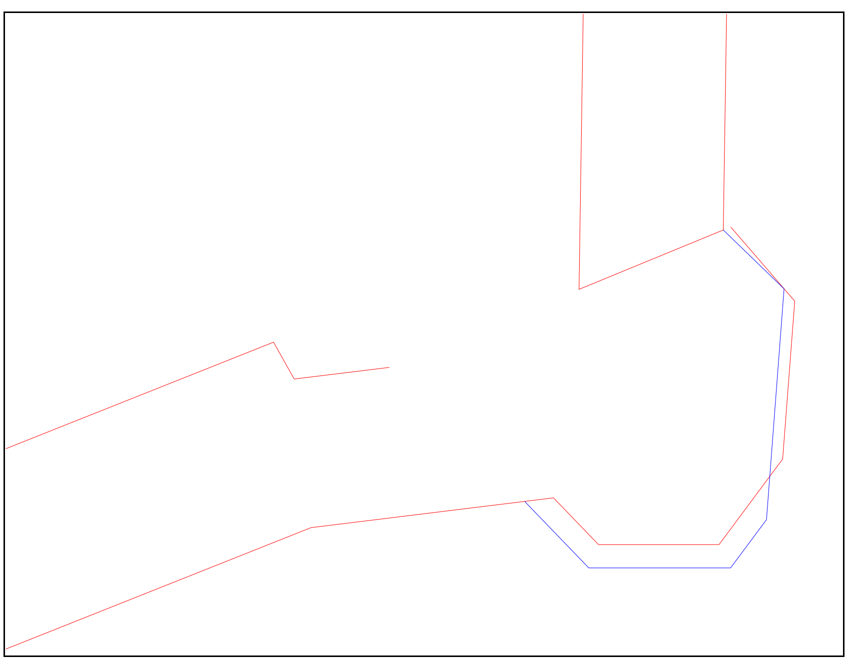


Figure 11. Recommended Modifications (blue) to DCC Design Turning Basin (red)

Series II simulations, like Series I simulations, were run with 15knot winds from the east and northwest. However, entrance channel crosscurrents varied in both magnitude and direction along the channel. The current magnitude decreased from west to east as the ships approached the harbor. Several current configurations were modeled. Pilots were not told current conditions prior to the simulations. This simulated real-life conditions where pilots occasionally don't know the predominant crosscurrent direction until the ship is affected by those currents.

Modifications Based on Series I Simulations

Series I ship simulation runs indicated that modifications were required if design plans were to meet the goals for which they were developed. In addition, the sponsor also indicated modifications that would help to further the Port's goals. Details of plan modifications for Series II simulation are provided below.

Outer Entrance Channel, Inner Entrance Channel, and Main Turning Basin

Series I simulations indicated that no additional modifactions were required to these project elements.

Widener and South Turning Basin

Series I simulation results confirmed that modification to the Widener shoal (i.e. removal of the shoal) were necessary for safe transit of Post-Panamax vessels into the SAC. Likewise, simulation results confirmed that proposed modifications to the STB were necessary and that dimensions provided for Series I simulations were adequate to allow safe transit of the design vessel to Berth 18. No further simulation was deemed necessary for either project element.

North Turning Basin

During the course of project development, the NTB project element was dropped from the study. No further testing of this element was conducted.

Southport Access Channel

Following the recommendations made based on Series I simulation results several modifications were made to the SAC design plan. In order to alleviate constriction at the entrance of the SAC, the USCG Station facilities and boat basin were relocated to a position 100ft east of the proposed channel limits (figure 12). Previously proposed widening south of the basin was then reduced approximately 50ft between Berths 25 and 26 and 50ft to 100ft between Berths 26 and 29 (see figure 10).

Figure 12. USCG Basin Relocation Plan

Turning Notch

Two modifications were made to the TN design plan. The first modification resulted from recommendations of the Series I simulation. Due to a lack of room to turn or berth the Post-Panamax design vessel, the TN was expanded 50ft to the north to allow for additional clearance. The second modification resulted from changes made by the project sponsor. Port plans to add a dock area along the western edge of the TN required the federal channel limits to be moved 180ft to the east. In addition, berths at the south of the TN were widened from 110ft to 145ft. Figure 13 shows TN modifications.

Dania Cutoff Canal

Based on recommendations made following the analysis of Series I results, the DCC dimensions were modified to allow for better vessel access. In order to alleviate maneuvering difficulties in the DCC turning area, the southern limits were extended an addition 50ft to the south and the eastern edge was moved 25ft to the west. To accommodate vessels in the main portion of the channel, the width of the channel was expanded from 280ft to 310ft. Two additional modifications were made at the request of the project sponsor: (1) Extension of the main DCC channel from 3,200ft to 4,200ft and (2) Removal of ro/ro ramps at the western end of the DCC, replaced by an extension of the northern berthing. Figure 14 shows DCC modifications.

Series II Testing Matrix

The testing matrix for the Series II Ship Simulation is provided in Table 3. Simulation runs consisted of both inbound and outbound scenarios under both flood and ebb tide conditions. Vessel orientation was specified only for DCC and TN runs in order to better evaluate the difficult turning conditions at both locations. Winds were 15knots and

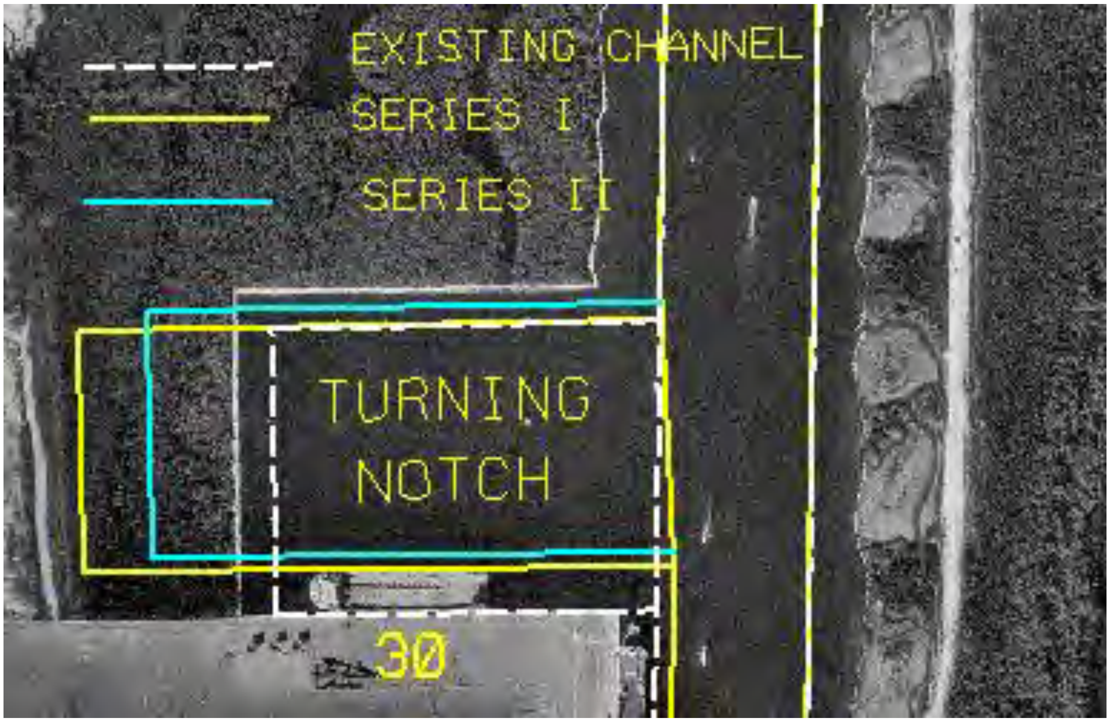


Figure 13. Turning Notch Modifications for Series II Simulation

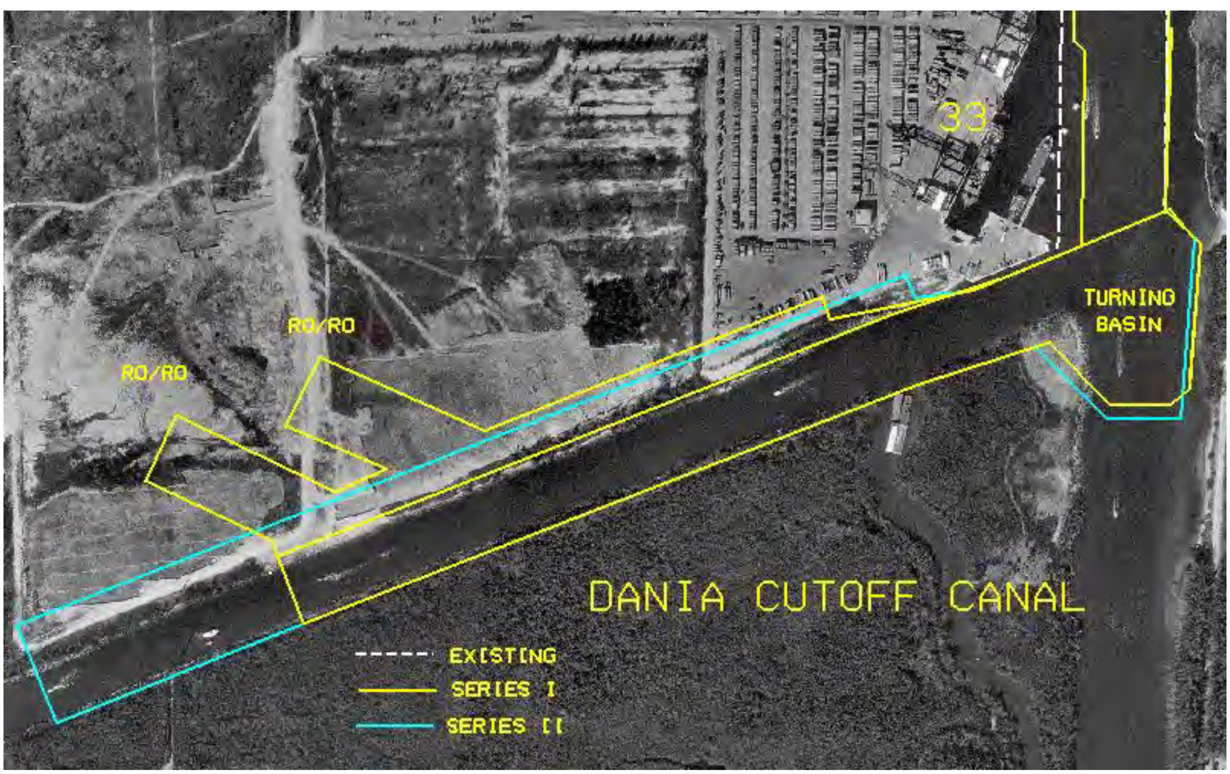


Figure 14. Dania Cutoff Canal Modifications for Series II Simulation

originated from two directions, East and Northeast. Vessels at berth during transit are also specified. All scenarios, with the exception of E13 through E16 were run multiple times using different pilots. E13 through E16 were each run once under flood tide and once under ebb tide conditions. All four of these runs were completed by the same pilot.

Series II Pilot Evaluation Forms

Upon completion of each test run, pilot's were asked to fill out a pilot evaluation form. These forms, including questions and rating systems were identical to the evaluation forms used during the Series I Simulation (Table 2).

Table 3. Series II Ship Simulation Testing Matrix

Run ID	Project Element(s)	Design Vessel	Direction	Orientation[1]	Tide	Wind	Vessels At Berth Berth	Vessel
E01	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Inbound		Flood	15knot - East	25 26 29	Cruise Cruise Cruise
E02	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Inbound		Ebb	15knot - East	25 26 29	Cruise Cruise Cruise
E07	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Outbound		Flood	15knot - East	25 26 29	Cruise Cruise Cruise
E08	OEC, IEC, MTB, Widener, SAC	Susan Maersk	Outbound		Ebb	15knot - East	25 26 29	Cruise Cruise Cruise
E13	TN	Susan Maersk	Turning	Bow	Flood	15knot-East		
E14	TN	Susan Maersk	Turning	Bow	Ebb	15knot-East		
E15	TN	Atlantic Class	Turning	Bow	Flood	15knot-East		
E16	TN	Atlantic Class	Turning	Bow	Ebb	15knot-East		
E03	DCC	Bellatrix	Inbound	Bow	Flood	15knot - Northwest	33C	Ro/Ro
E04	DCC	Bellatrix	Inbound	Bow	Ebb	15knot - Northwest	33C	Ro/Ro
E05	DCC	Bellatrix	Inbound	Stern	Flood	15knot - Northwest	33C	Ro/Ro
E06	DCC	Bellatrix	Inbound	Stern	Ebb	15knot - Northwest	33C	Ro/Ro
E09	DCC	Bellatrix	Outbound	Bow	Flood	15knot - Northwest	33C	Ro/Ro
E10	DCC	Bellatrix	Outbound	Bow	Ebb	15knot - Northwest	33C	Ro/Ro
E11	DCC	Bellatrix	Outbound	Stern	Flood	15knot - Northwest	33C	Ro/Ro
E12	DCC	Bellatrix	Outbound	Stern	Ebb	15knot - Northwest	33C	Ro/Ro

[1] Orientation was left to pilot discretion except for DCC and TN simulation runs

Series II Results

Plots showing average Pilot evaluation ratings for each run completed during the Series II simulation are shown in Attachment II. Actual composite tracks plots and pilot questionnaires will remain at USACE as these original documents are considered to be proprietary information belonging to the Port Everglades Pilots Association.

Susan Maersk, Inbound (OEC to Berth 31-32)

<u>*Flood Tide*</u>

Inbound, flood tide Susan Maersk runs were conducted by four pilots. Although most runs were without major incident, one pilot left the entrance channel by over 150ft on the north side of the channel. It should be noted, however, that the pilot felt that simulated currents were too strong compared to real-life. Vessels in all four of the runs stayed to the northern side of the entrance channel due to the presence of cross-currents, confirming the significant effect that these currents have at Port Everglades. Upon entering the SAC, two vessels left the west side of the channel approximately 25ft across from the former position of the USCG station. The two pilots that left the channel did not go as far west into the MTB before beginning to back down the SAC. It is likely that the flood tide, which pushed the stern of the ships south near the completion of the turning maneuver, was a factor in these two runs leaving the channel. The other pilots went over 600ft further west into the MTB before backing and were able to keep their vessels centered in the SAC. The SAC has a six-degree course change near Berth 29. One vessel came extremely close to the channel edge while making the turn. All of the vessels remained close to the west side of the SAC during the exercise due to the 15knot wind blowing from the east. Pilot comments indicated that the constriction at the knuckle, most like due to channel narrowing south of the USCG, remained a significant problem. The average pilot rating for Overall Safety was 3 for this scenario.

<u>*Ebb Tide*</u>

Four pilots participated in the inbound, ebb tide scenario. As in the flood tide scenario, the cross-currents in the entrance channel pushed the vessels to the northern side of the channel. One vessel left the channel by nearly 90ft. The other vessels were able to stay within the channel limits. All of the vessels in the ebb tide case successfully entered the northern end of the SAC after turning in the MTB. The ebb tide appears to help the pilots control the turning maneuver and keep their vessels further east. One pilot turned his vessel further north and left the north side of the channel before backing in the SAC. Another brought his vessel close to the curise ships docked at Berth 25 and 26. The same vessel left the channel south of Berth 29. All of the vessels remained close to the west side of the SAC during the exercise due to the 15knot wind blowing from the east. Again, pilot comments indicated that the knuckle area remains constricted, particulary south of the former USCG position and across from Berth 29. The average pilot rating for Overall Safety for this scenario was 2.9.

Susan Maersk, Outbound (Berth 31-32 to OEC)

Flood Tide

Outbound, flood tide Susan Maersk runs were conducted by four pilots. In each case, at the initial portion of the run (i.e. between Berth 31 and the southern end of Berth 25) the opposing flood tide appeared to assist the pilots in keeping the vessel in the center of the SAC. One pilot kept his vessel further east while heading north in the SAC and brought his vessel to the channel edge across from Berths 25 and 26 near the relocated USCG Station. None of the other vessels came within 100ft of the eastern channel limit. However, one vessel did cross the northwest channel corner across from the USCG due to beginning the turn too soon. Because outbound vessels are accelerating and are not as affected by the presence of cross-currents, the outbound runs ended once the vessel completed the turn into the entrance channel. Again pilots commented on the tightness of the knuckle area. The average pilot rating for Overal Safety was 3.4 for this scenario.

Ebb Tide

Four pilots participated in the outbound, ebb tide scenario. In all cases, the vessels transited in the same direction as the tidal currents and had more difficulty staying in the center of the channel between Berths 31 and 25. The wind appeared to keep these vessels along the west side of the channel. Although several runs came close to the channel's edge, only one run left the channel at any time during the simulations. One vessel crossed the northwest corner of the SAC by the USCG station by about 20ft. Another went further north than the other vessels before turning into the entrance channel, but the ship made the turn without any problem. According to pilots the constriction at the knuckle remained a problem. The average pilot rating for Overall Safety was 3 for this scenario.

Bellatrix, Inbound (Berth 31 to DCC Berth)

Flood Tide

Flood tide, inbound Bellatrix runs consisted of four bow first and four stern first transits. Four pilots participated in each of these scenarios. During the bow first runs, two of the pilots left the SAC north of the turning basin. Both of the vessels left the eastern side of the channel, one by about 30ft and the other by about 5ft. Another vessel cut the northwest corner of the intersection of the SAC and the canal. Although the flood tide helped the vessel make the turn, swinging the vessel's stern to the south while it was turning, comments indicated turning basin dimensions continued to provide inadequate manuevering room. The presence of a vessel at Berth 33C (absent during Series I cases also increased the difficulty of the maneuver. The average pilot rating for Overall Safety for this scenario was 3.1.

During the stern first runs, one vessel left the SAC twice by about 40ft each time. Both incidents occurred on the eastern side of the SAC across from Berth 33C, just north of the DCC turning area. One vessel also left the eastern side of the turning area by about 30ft and another cut the northwest corner of the intersection of the SAC and DCC. Again, the overall size and dimensions of the turning basin, particulary in the vicinity of Berth 33C, were a problem in conducting the manuever. The average pilot rating for Overall Safety was 1.8 for this scenario.

<u>*Ebb Tide*</u>

Inbound, ebb tide Bellatrix runs consisted of four bow first and four stern first transits. Four pilots participated in these scenarios. During the ebb tide, bow first runs, one pilot turned in the turning basin and backed his vessel in rather than pulling in bow first. The remainder of the runs were completed successfully using the proper vessel orientation. The only incident was a vessel cutting the northwest corner of the intersection of the SAC and the DCC. Pilot comments again mentioned the tightness in the vicinity of Berth 33C. The average pilot rating for Overall Safety was 2.8 for this scenario.

During the stern first runs, one pilot crossed into the SAC just north of the turning area. In general, however, the pilots were better able to stay in the SAC north of the DCC turning basin. Due to a miscommunication, one pilot conducted a bow first maneuver. The most significant incident occurred within the turning basin when one vesssel left the eastern edge by about 60ft. The presence of ebb currents tended to press vessels to the east. Again Berth 33C was considered a difficult area. The average pilot rating for Overall Safety was 3 for this scenario.

Bellatrix, Outbound (DCC Berth to Berth 31)

<u>*Flood Tide*</u>

Outbound, flood tide Bellatrix runs consisted of four bow first and four stern first transits. Four pilots participated in these scenarios. During the flood tide, bow first runs, one pilot left the southwest corner of the turning basin because he began his port turn too soon. Another vessel clipped the northwest corner of the intersection of the SAC and the canal. As the vessels left the DCC and entered the SAC, the flood tide pushed the vessel's bow to port, opposite the direction the pilots was trying to turn. Pilot comments again noted the tightness at Berth 33C, particulary in the presence of the tidal currents. The average pilot rating for Overall Safety was 2.6 for this scenario.

During stem first runs, several of the pilots cut across the northwest corner of the intersection of the SAC and the DCC in the vicinity of Berth 33C. The only significant incident occurred when one pilot failed to stop his vessel from swinging as he completed the turning maneuver and left the channel on the east side, just north of the turning basin. Again overall turning basin dimensions were considered to be tight. The average pilot rating for Overall Safety was 2.6 for this scenario.

Ebb Tide

Outbound, ebb tide Bellatrix runs consisted of four bow first and four stern first transits. Four pilots paticipated in these scenarios. During the ebb tide, bow first runs, two pilots crossed the channel limits as they turned north into the SAC, one on the east side of the channel and one on the west side. Overall, the ebb current helped the vessels make the turn from the DCC into the SAC. Tightness in the vicinity of Berth 33C was again mentioned in the pilot comments. The average pilot rating for Overall Safety for this scenario was 2.9.

During the stern first runs, one of the vessels clipped the northern edge of the channel in the northwest corner of the turning basin. All remaining runs were completed successfully and without incident. It was noted that the maneuver could use more space, particulary in the vicinity of Berth 33C. The average pilot rating for Overall Safety was 3 for this scenario.

Susan Maersk, Turning Notch

In order to evaluate the TN, two runs were made in which pilots attempted to turn the Susan Maersk design vessel in the TN. One run was under flood tide conditions and the other was under ebb tide conditions. Although the flood tide appeared to assist the ship during the maneuver by turning the vessel's stern to the south as the vessel backed out of the notch, the pilot was unable to complete the maneuver successfully. During the ebb tide run, the current had the opposite affect and the vessel was unable to counter the forces turning its stern north as the pilot tried to back out of the notch. The pilot was unable to complete either maneuver successfully. The average pilot rating for Overall Safety was 1 for both scenarios.

Atlantic Class Vessel, Turning Notch

In addition too the two runs made using the larger Susan Maersk design vessel, two runs were made using the Atlantic Class design vessel. One run was made under flood tide conditions and the other under ebb tide conditions. During the flood tide run, the pilot was able to turn, but left the western channel limit as it entered the TN. During the ebb tide run, the currents affected the Atlantic Class vessel in the much the same manner as they did the Susan Maersk. Neither run was completely successful. The average pilot rating for Overall Safety was 1 for both scenarios.

Series II Conclusions and Recommendations

Overall, the results of the Series II simulation were better than the results from the Series I simulation. However, several observations and recommendations can be made.

Inbound ships are subjected to a variety of cross-currents in the Port Everglades entrance channel. The ships are slowing down as they approach the jetties and are very much influenced by these currents. This has also been observed in real-life. The simulation exercises show the pilots using the additional width in the OEC, particulary on the north side. Although several vessels left the north side of the channel, it appears that they may have been able to keep the vessels further south had the simulations started further east and the pilots given more time to set up for the entrance channel. It should also be noted that several of the pilots stated that they currents seemed too strong compared to real-life experience at the port. It is recommened that the OEC extension be widened by 150ft on both the north and south side of the channel as it was tested during Series II.

Moving the USCG Station and boat basin to the east, away from the navigation channel, is vital for the development of the port. It is recommended that the USCG basin be relocated as it was during the Series II simulation.

The width and alignment of the proposed SAC south of Berth 29 is adequate for the Susan Maersk design vessel. However, the region north of Berth 29 through the knuckle area remains tight despite relocation of the USCG basin. It is recommended that SAC be widened approximately 50ft to 60ft between the USCG basin and Berth 29.

Results of the DCC, particulary at the DCC turning basin do not show a significant improvement over those for the configuration tested in Series I. This is most likely due to the addition of a vessel at Berth 33C during the Series II cases. Also, it was general felt by the pilots that the design vessel in these cases was an extremely bad handling vessel. Based on overall results and comments, it can be seen that several areas consistently caused problems. It is recommended that the alignment of the turning basin be modified by extending southern and eastern limits of the basin and adding a 50ft eastern expansion in the vicinity of Berth 33C, just north of the intesection with the DCC.

Series III Simulation

General

Series III ship simulation runs were conducted at the RTM STAR Center between June 2003 and July 2003. Six Port Everglades Pilots conducted simulator runs that employed five design vessels. Runs included, inbound, outbound, and turning scenarios under both flood tide and ebb tide conditions. Winds coming at 15 knots from East and Northwest directions were considered to represent the “worst case” wind conditions. Simulations took place using channel dimensions that were modified based upon Series II recommendations.

Modifications Based on Series II Simulation

Southport Access Channel

The results of the Series II ship simulation study showed that the USCG station is a navigational hazard to Post-Panamax vessels and must be relocated. Series II results also indicated the need to increase the width of the SAC between berths 24 and 29. This was accomplished by expanding the SAC channel to the east a maximum of 60ft (north of Berth 26) and a maximum of 50ft (south of Berth 26) (figure 15). No additional modifications were required for the OEC, IEC, MTB or Widener designs. It should be noted that the pilots remain concerned about the depth in the OEC channel. This issue will be addressed in the USACE feasibility report.

Turning Notch

Due to flood and tide current patterns in the SAC as well as the overall size of the design vessel, the TN design proved to provide inadequate maneuvering room to allow for either the berthing or turning of a post-panamax vessel. To accommodate berthing, it was necessary to first increase the interior dimensions of the TN and to modify the SAC to the north and east of the TN. This involved (1) expanding the limits of the TN to the north by 40ft, (2) gradually increasing the SAC channel width from 400ft to 530ft along the conservation easement beginning just south of berth 29 and ending at the TN, and (3) adding a 1,340ft long by 75ft wide expansion to the eastern SAC channel limits east of the TN. To incorporate turning of the design vessel, an additional 500ft by 75ft expansion cut was added to the eastern SAC limits south of the previous 1,340ft cut. Figure 16 illustrates TN modifications.

Dania Cutoff Canal

Due primarily to strong currents associated with the intersection of the DCC and SAC, channel limits of the DCC turning basin were found to be unsuitable for transiting a Panamax vessel to berths located in the DCC. In order to remedy this, an expansion of the DCC turning basin was developed. This was accomplished through the following: (1) addition of a 50ft wide eastward expansion of the channel just north of the turning basin extending from the southern end of Berth 32 to the intersection of the DCC and SAC, (2) addition of a 300ft by 375ft extension of the turning basin extending to the south into the ICWW, and (3) widening of the northwest and southwest corners of the turning basin. Remaining DCC dimensions were found to adequately meet safety standards. Figure 17 illustrates DCC modifications.

Series III Testing Matrix

The testing matrix for the Series III Ship Simulation is provided in Table 4. It should be noted that Susan Maersk and Voyager runs involving the SAC (E01 through E16) used both Series II and Series III layouts. Modifications to the SAC are considered vital to the development of the port and it was deemed important that the same pilots complete both plan layouts. Bellatrix to the DCC runs also used two design plans, one with only the southern expansion of the turning basin and the other with the southern, eastern, and northeastern expansions. TN runs were conducted with four vessels. Three vessels used a design plan which included all north and east expansions of the TN, while the forth used a design plan which did not include the eastern expansion. All simulation runs consisted of both inbound and outbound scenarios under both flood and ebb tide conditions. Vessel orientation was specified only for DCC and TN runs in order to better

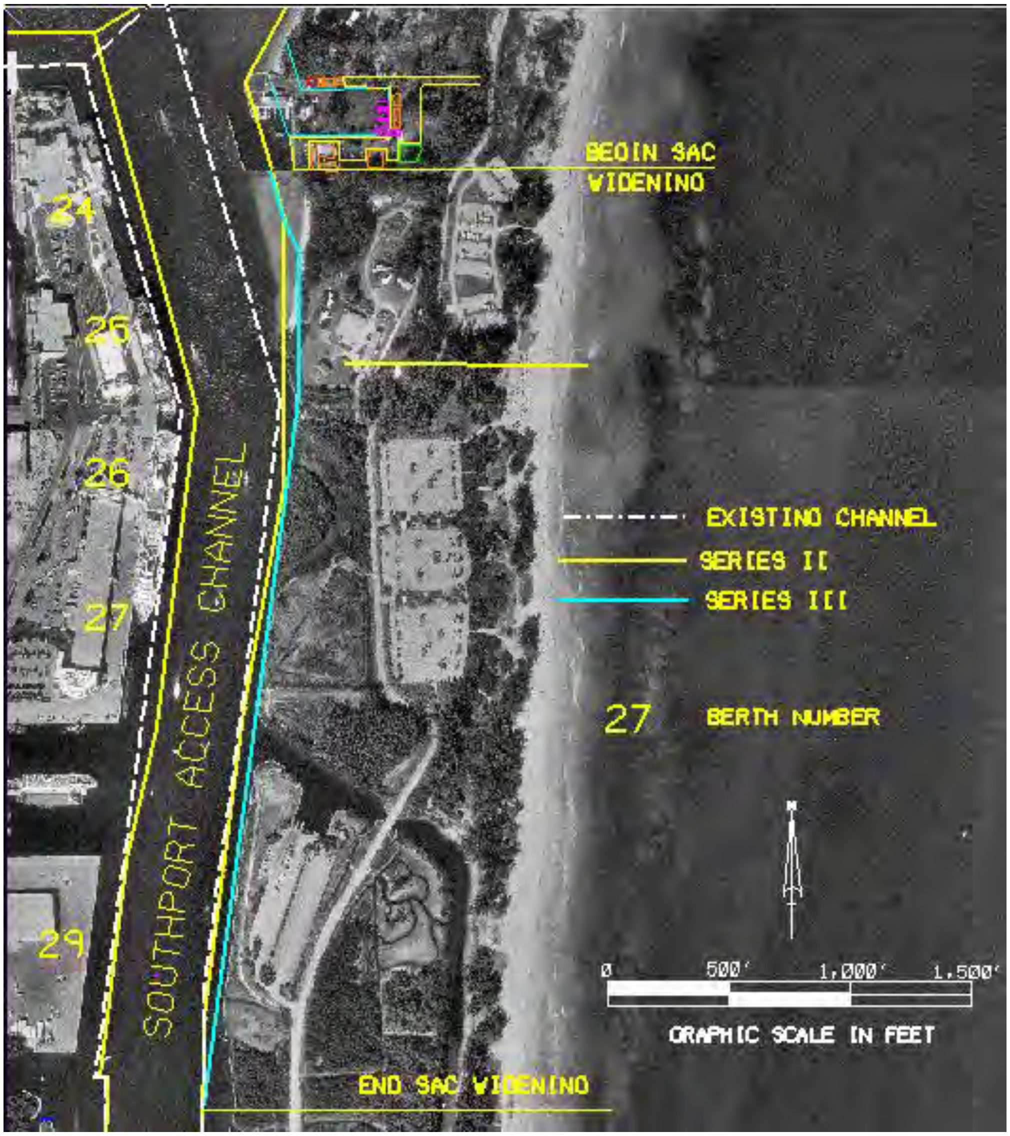


Figure 15. Modifications to Southport Access Channel for Series III Simulation

evaluate the difficult turning conditions at both locations. Winds were 15knots and originated from two directions, East and Northeast. Vessels at berth during transit are also specified.

Series III Pilot Evaluation Forms

Upon completion of each test run, pilot's were asked to fill out a pilot evaluation form. These forms, including questions and rating systems were identical to the evaluation forms used for the Series I Simulation (Table 2) with one exception. Under the topic of "Vessel Tracking" an forth question was added: "Maneuvering room at turning basin". The same rating scale was applied with "5" being given for an "extremely satisfactory" run and "1" being given for a run that was "not at all satisfactory". The remainder of the questions were unchanged.

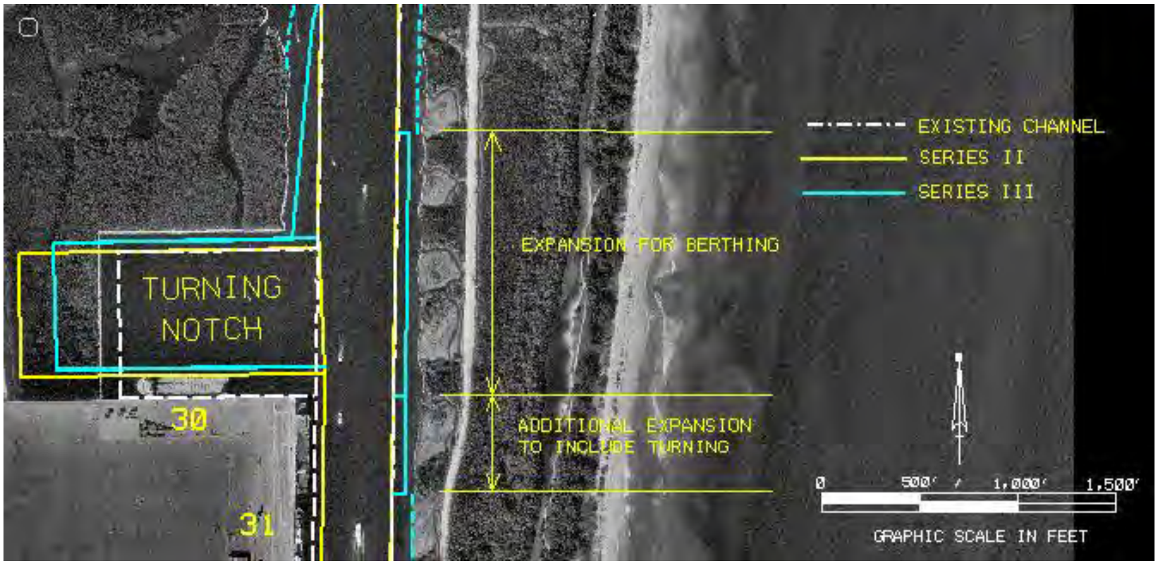


Figure 16. Modification of Turning Notch for Series III Simulation

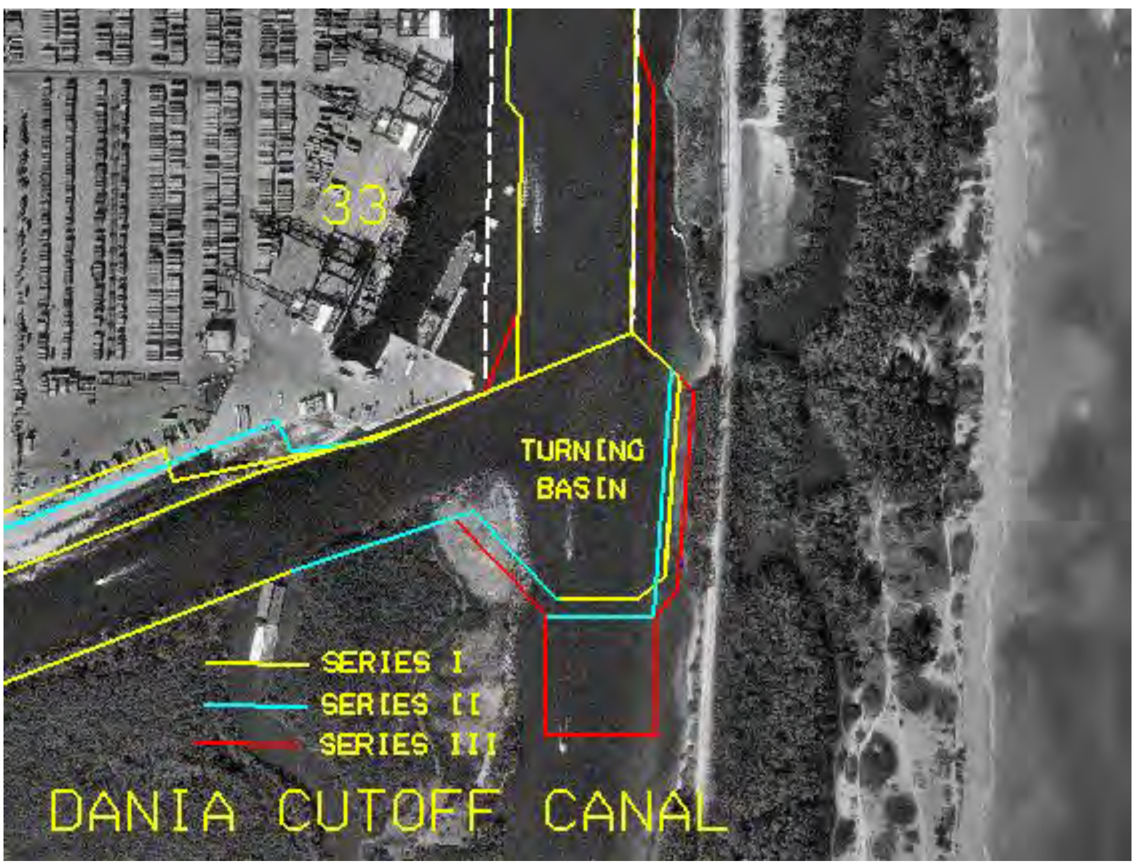


Figure 17. Modification of Dania Cutoff Canal for Series III Simulation

Table 4. Series III Testing Matrix

Run ID	Project Element(s)	Design Vessel	Direction	Bow/ Stern [1]	Tide	Wind	Vessels At Berth Berth	 Vessel
E01	MTB, Widener, SAC (Series II layout)	Susan Maersk	Inbound		Flood	15knot - East	25,26,29	Cruise
E02	MTB, Widener, SAC (Series II layout)	Susan Maersk	Inbound		Ebb	15knot - East	25,26,29	Cruise
E03	MTB, Widener, SAC (Series II layout)	Susan Maersk	Outbound		Flood	15knot - East	25,26,29	Cruise
E04	MTB, Widener, SAC (Series II layout)	Susan Maersk	Outbound		Ebb	15knot - East	25,26,29	Cruise
E05	MTB, Widener, SAC (Series III layout)	Susan Maersk	Inbound		Flood	15knot - East	25,26,29	Cruise
E06	MTB, Widener, SAC (Series III layout)	Susan Maersk	Inbound		Ebb	15knot - East	25,26,29	Cruise
E07	MTB, Widener, SAC (Series III layout)	Susan Maersk	Outbound		Flood	15knot - East	25,26,29	Cruise
E08	MTB, Widener, SAC (Series III layout)	Susan Maersk	Outbound		Ebb	15knot - East	25,26,29	Cruise
E09	MTB, Widener, SAC (Series II layout)	Voyager	Inbound		Flood	15knot - East	25,26	Cruise
E10	MTB, Widener, SAC (Series II layout)	Voyager	Inbound		Ebb	15knot - East	25,26	Cruise
E11	MTB, Widener, SAC (Series II layout)	Voyager	Outbound		Flood	15knot - East	25,26	Cruise
E12	MTB, Widener, SAC (Series II layout)	Voyager	Outbound		Ebb	15knot - East	25,26	Cruise
E13	MTB, Widener, SAC (Series III layout)	Voyager	Inbound		Flood	15knot - East	25,26	Cruise
E14	MTB, Widener, SAC (Series III layout)	Voyager	Inbound		Ebb	15knot - East	25,26	Cruise
E15	MTB, Widener, SAC (Series III layout)	Voyager	Outbound		Flood	15knot - East	25,26	Cruise
E16	MTB, Widener, SAC (Series III layout)	Voyager	Outbound		Ebb	15knot - East	25,26	Cruise
E17	DCC – South Expansion Only	Bellatrix	Inbound	Bow	Flood	15knot - Northwest	33C	Ambassador
E18	DCC – South Expansion Only	Bellatrix	Inbound	Bow	Ebb	15knot - Northwest	33C	Ambassador
E19	DCC – South Expansion Only	Bellatrix	Inbound	Stern	Flood	15knot - Northwest	33C	Ambassador
E20	DCC – South Expansion Only	Bellatrix	Inbound	Stern	Ebb	15knot - Northwest	33C	Ambassador
E21	DCC – South Expansion Only	Bellatrix	Outbound	Bow	Flood	15knot - Northwest	33C	Ambassador
E22	DCC – South Expansion Only	Bellatrix	Outbound	Bow	Ebb	15knot - Northwest	33C	Ambassador
E23	DCC – South Expansion Only	Bellatrix	Outbound	Stern	Flood	15knot - Northwest	33C	Ambassador
E24	DCC – South Expansion Only	Bellatrix	Outbound	Stern	Ebb	15knot - Northwest	33C	Ambassador
E37	DCC – All Expansions	Bellatrix	Inbound	Bow	Flood	15knot - Northwest	33C	Ro/Ro
E38	DCC – All Expansions	Bellatrix	Inbound	Bow	Ebb	15knot - Northwest	33C	Ro/Ro
E39	DCC – All Expansions	Bellatrix	Inbound	Stern	Flood	15knot - Northwest	33C	Ro/Ro
E40	DCC – All Expansions	Bellatrix	Inbound	Stern	Ebb	15knot - Northwest	33C	Ro/Ro
E41	DCC – All Expansions	Bellatrix	Outbound	Bow	Flood	15knot - Northwest	33C	Ro/Ro
E42	DCC – All Expansions	Bellatrix	Outbound	Bow	Ebb	15knot - Northwest	33C	Ro/Ro
E43	DCC – All Expansions	Bellatrix	Outbound	Stern	Flood	15knot - Northwest	33C	Ro/Ro
E44	DCC – All Expansions	Bellatrix	Outbound	Stern	Ebb	15knot - Northwest	33C	Ro/Ro
E25	TN – All Expansions	SL Anchorage	Inbound	Bow	Flood	15knot - East	30, ro/ro	Susan Maersk, Ambassador
E26	TN – All Expansions	SL Anchorage	Inbound	Bow	Ebb	15knot - East	30, ro/ro	Susan Maersk, Ambassador
E27	TN – All Expansions	SL Anchorage	Outbound	Stern	Flood	15knot - East	30, ro/ro	Susan Maersk, Ambassador
E28	TN – All Expansions	SL Anchorage	Outbound	Stern	Ebb	15knot - East	30, ro/ro	Susan Maersk, Ambassador
E29	TN – All Expansions	Atlantic Class	Inbound	Bow	Flood	15knot - East	Ro/ro	Ambassador
E30	TN – All Expansions	Atlantic Class	Inbound	Bow	Ebb	15knot - East	Ro/ro	Ambassador
E31	TN – All Expansions	Atlantic Class	Outbound	Stern	Flood	15knot - East	Ro/ro	Ambassador
E32	TN – All Expansions	Atlantic Class	Outbound	Stern	Ebb	15knot - East	Ro/ro	Ambassador
E33	TN – All Expansions	Susan Maersk	Inbound	Bow	Flood	15knot - East	Ro/ro	Ambassador
E34	TN – All Expansions	Susan Maersk	Inbound	Bow	Ebb	15knot - East	Ro/ro	Ambassador
E35	TN – All Expansions	Susan Maersk	Outbound	Stern	Flood	15knot - East	Ro/ro	Ambassador
E36	TN – All Expansions	Susan Maersk	Outbound	Stern	Ebb	15knot - East	Ro/ro	Ambassador
E45	TN – No East Expansion	Jutlandia	Inbound	Bow	Flood	15knot - East	Ro/ro	Ambassador
E46	TN – No East Expansion	Jutlandia	Inbound	Bow	Ebb	15knot - East	Ro/ro	Ambassador
E47	TN – No East Expansion	Jutlandia	Outbound	Stern	Flood	15knot - East	Ro/ro	Ambassador
E48	TN – No East Expansion	Jutlandia	Outbound	Stern	Ebb	15knot - East	Ro/ro	Ambassador

[1] Orientation (bow or stern first) was left to pilot discretion except for DCC and TN simulation runs

Series III Results

Plots showing average Pilot evaluation ratings for each run completed during the Series III simulation are shown in Attachment III. Actual composite tracks plots and pilot questionnaires will remain at USACE SAJ as these original documents are considered to be proprietary information belonging to the Port Everglades Pilots Association.

Susan Maersk, Inbound (OEC to Berth 31-32)

Flood Tide

Inbound, flood tide Susan Maersk runs were conducted by four pilots. Two vessels crossed into the northern portion of Berth 24 during the turning maneuver in the MTB. The area is in deep water, however, and the pilots did not regard this to be a problem. Once they had completed the turn in the MTB and begin backing down the SAC, none of the vessels strayed from the channel. The pilots rated the modified SAC transit as significantly safer than the Series II configuration. Series II received an average pilot rating for Overall Safety of 1.7 while the Series III plan received a rating of 3.5. The higher numbers indicate increased safety. The pilots commented that the extra room to the east improved the maneuver significantly.

Ebb Tide

Inbound, ebb tide Susan Maersk runs were conducted by three pilots. Although none of the pilots strayed beyond the SAC channel limits, all of the vessels came very close to the western channel edge several times. It should be noted that one pilot stated that he did not know how much additional room was available in the widener, which affected his positioning going into the SAC. Although the pilots still noted a tightness to the knuckle area, comments were generally favorable about the added width. The average pilot rating for Overall Safety for this scenario is was 2.7 for both the Series II and Series III plans.

Susan Maersk, Outbound (Berth 31-32 to OEC)

Flood Tide

Outbound, flood tide Susan Maersk runs were conducted by four pilots. None of the pilots strayed beyond the channel limits of the SAC and gave generally favorable comments to the overall. In all cases the pilot noted the channel was tight, but also indicated sufficient room to complete the maneuver. The average pilot rating for Overall Safety increased from 2.8 for the Series II plan to 3.8 for the Series III plan.

Ebb Tide

Outbound, ebb tide Susan Maersk runs were conducted by four pilots. Two of the pilots left the channel south of the cruise ship docked at berth 29 while attempting to align with the southern portion of the channel. Both pilots were able to recover and complete the remainder of the run without incident. Despite these minor incidents, the average pilot rating for Overall Safety increased from 2.8 for the Series II plan to 3.5 for the Series III plan.

Voyager, Inbound (OEC to Berth 29)

Flood Tide

Inbound, flood tide Voyager runs were conducted by three pilots. Two of the pilots swung too far west while making the turn in the MTB. This was partially due to lack of tug assist and experimentation with the thruster system. Once in the channel, all of the pilots were able to stay far enough to the east to avoid the cruise ships docked at berths 25 and 26. Comments reflected that the eastern expansion at the knuckle was required for safe completion of the maneuver. The average pilot rating for Overall Safety increased from 3.2 for the Series II plan to 3.8 for the Series III plan.

Ebb Tide

Inbound, ebb tide Voyager runs were made by three pilots. All of the runs were completed successfully, with the pilots being able to keep their vessels within all channel limits and away from the docked cruise ships. Comments were favorable and comments reflected the importance of the eastward expansion at the knuckle. The average pilot rating for Overall Safety increased from 3 for the Series II plan to 3.5 for the Series III plan.

Voyager, Outbound (Berth 29 to OEC)

Flood Tide

Outbound, flood tide Voyager runs were conducted by three pilots. Again, all of the runs were completed successfully with the pilots being able to maintain their positions within the channel limits and away from the cruise ship. Comments indicated that the maneuvers were “comfortable” with the additional width in the knuckle area. The average pilot rating for Overall Safety was 4 for both the Series II and Series III plans.

Ebb Tide

Outbound, ebb tide Voyager runs were conducted by three pilots. Although, the pilots commented that this was a somewhat difficult maneuver given the size of the vessel, all runs were completed successfully with the vessels remaining within the channel limits and away from the docked cruise ships. The average pilot rating for Overall Safety was 4 for both the Series II and Series III plans.

Susan Maersk, Inbound, Turning Bow First in the Turning Notch

Flood Tide

Inbound, Susan Maersk turning runs were conducted bow first under both flood tide conditions. Four pilots participated in this scenario. One pilot strayed 40ft out of the north channel limit during the turn. Two other vessels strayed less than 10ft out of the eastward expansion. All of the vessels required the additional widening to the north and east as well as the empty berth space at Berths 30 and 31. Pilots regarded this maneuver as having no room for error. In real-life it would be conducted only under ideal conditions. The average pilot rating for Overall Safety was 2.0 for this scenario.

Ebb Tide

Four pilots participated in the inbound, ebb tide cases. The ebb tide runs were conducted stern first. All of the pilots successfully completed the maneuver, again using all available space in the vicinity of the TN including berths 30 and 31. Comments reflected the difficulty of the maneuver and noted again that there was little to no margin of error. The average pilot rating for Overall Safety was 2.3 for this scenario.

Susan Maersk, Outbound, Turning Stern First in the Turning Notch

Flood Tide

Outbound, Susan Maersk turning runs were conducted bow first under flood tide conditions. For pilots participated in the scenario. All four runs were completed successfully, but were again considered to very difficult maneuvers. In each case, the pilot was able to penetrate further west into the TN and did not require the use of the additional widening to the east. The average pilot rating for Overall Safety was 2.5 for this scenario.

Ebb Tide

Four pilots participated in the outbound, ebb tide cases. During the ebb tide runs, one of the vessels left the northeast corner of the notch by approximately 10ft when swing the bow of the vessel in the SAC. Another vessel went to the channel's edge near the north end of the eastern expansion. All runs were completed successfully, but left no margin for error. The average pilot rating for Overall Safety was 3.5 for this scenario.

Atlantic Class, Inbound, Turning Bow First in the Turning Notch

Inbound, Atlantic Class turning runs were conducted bow first under both flood and ebb tide conditions. Four pilots participated in these runs. The Atlantic Class is a smaller vessel than the Susan Maersk and pilots had little difficulty in completing the maneuver successfully under either of the tide conditions. It should be noted that the Atlantic Class vessel did require the additional room offered by the eastern expansion in order to complete the maneuver. The average pilot rating for the Overall Safety was 3.7 for flood tide runs and 4 for ebb tide runs.

Atlantic Class, Outbound, Turning Stern First in the Turning Notch

Outbound, Atlantic Class turning runs were conducted stern first under both flood and ebb tide conditions. Four pilots participated in these runs. Again, the Atlantic Class is a smaller vessel than the Susan Maersk and pilots had little difficulty in completing the maneuver. The average pilot rating for the Overall Safety was 3.7 for both flood tide runs and ebb tide runs.

SL Anchorage, Inbound, Turning Bow First in the Turning Notch

Inbound, SL Anchorage runs were made under both flood and ebb tide conditions. Four pilots participated in these exercises. It was left to the pilot to determine if the run would be made bow or stern first. All of the runs were completed successfully with little difficulty. During most runs, the eastern expansion was left unused, but vessels did stay very close to crossing into it. Comments were favorable and the average pilot rating for Overall Safety was 4 for the flood tide runs and 3.8 for ebb tide runs.

SL Anchorage, Outbound, Turning Stern First in the Turning Notch

Outbound, SL Anchorage runs were made under both flood and ebb tide conditions. Four pilots participated in these exercises. Again, it was left to the pilot to determine if the run would be made bow or stern first. All of the runs were completed successfully with little difficulty. Comments indicated that there was adequate room to maneuever. The average pilot rating for Overall Safety was 4 for both flood tide and ebb tide runs.

Jutlandia, Inbound, Turning Bow First in the Turning Notch

Inbound, Jutlandia runs were made under both flood and ebb tide conditions. Four pilots participated in these exercises. The Jutlandia was the smallest of the vessels to be turned in the TN. Once it became obvious that the east expansion would be unnecessary for this vessel, the expansion was removed. The northern expansions were left in place. Not surprisingly, all of the runs were completed successfully with little difficulty although the maneuver was tighter without the expansion. Comments were generally favorable and the average pilot rating for Overall Safety was 3 for both flood tide and ebb tide.

Jutlandia, Outbound, Turning Stern First in the Turning Notch

Outbound, Jutlandia runs were made under both flood and ebb tide conditions. Four pilots participated in these exercises. All of the runs were completed successfully with little difficulty with comments indicating a tight but doable maneuver. The average pilot rating for Overall Safety was 3.3 for the flood tide runs and 3.5 for the ebb tide runs.

Bellatrix, Inbound (Berth 31 to DCC Berth)

Flood Tide

Inbound, flood tide Bellatrix runs consisted of four bow first and four stern first scenarios. In addition, the same vessel orientations were run for two different design plans. The first plan involved adding only the southern expansion to the DCC turning basin. The second plan involved the complete expansion of the turning basin. It should be noted that a larger vessel was placed at Berth 33C during runs that included all of the proposed expansions.

All bow first runs with the south expansion were successful, although three of the pilots brought the stern of the vessel very close to the eastern edge across from Berth 33C as they made the turn into the DCC. Pilots noted that the vessel at Berth 33C was smaller than vessels that normally berth there and indicated that a larger vessel would significantly complicate the manuever. It should be noted that none of the pilots in these runs made use of the southern expansion. The average pilot rating for Overall Safety was 3.5 for this scenario.

During runs made with the full turning basin expansion, one pilot swung his stern into the eastward expansion, while the other three stayed very close to the eastern edge. All of the runs were completed successfully and received generally favorable comments. Pilots indicated that the expansion across from Berth 33C increases the safety of the manuever. The average pilot rating for Overall Safety was 3.7 for this scenario.

Bellatrix, stern first inbound runs under flood conditions were completed by four pilots. During runs made with the southern expansion alone, pilots were able to successfully able to bring the vessel to berth, but had to keep their vessels close to the corner of Berth 33C and the vessel docked there in order to keep the stern clear of the eastern channel limit. Pilots used the southern expansion to make the turn into the DCC and agreed that the additional space was necessary. However, pilots indicated they were uncomfortable with the proximity to the berthed vessel and felt the area around Berth 33C remained too tight. The average pilot rating for Overall Safety was 2 for this scenario.

During stern first runs made with the full turning basin expansion, pilots were able to stay within the channel limits by using the southern expansion and the extra room provided in the vicinity of Berth 33C. Comments indicated that all of the expansions used in this scenario were necessary to improve the safety of the manuever. The average pilot rating for Overall Safety was 3 for this scenario.

Ebb Tide

As with the flood tide runs, inbound ebb tide runs consisted of four bow first and four stern first scenarios for two different design plans. Again a larger vessel was placed at Berth 33C when the full expansion plan was evaluated.

During bow first, ebb tide runs made with the southern expansion, all of the runs were completed successfully. Although none of the pilots brought their vessels beyond the eastward channel limits across from Berth 33C, vessel remained close to it. Despite comments reflecting that the turning basin remained tight, the average pilot rating for Overall Safety was 4 for this scenario.

Bow first, ebb tide runs for the complete turning basin expansion were very similar to those with only the southern expansion. All of the runs were completed successfully. Although none of the pilots brought their vessels into the eastward expansion across from Berth 33C, one vessel did come close to the north-west edge of it. Comments were favorable about the additional space. The average pilot rating for Overall Safety was 3.3 for this scenario.

During stern first, ebb tide runs made with the southern expansion were all completed successfully. Pilots stayed within channel limits but tended to stray close to the corner of Berth 33C and the vessel docked there. Again it was noted that the vessel at Berth 33C was smaller than those normally at berth and that a larger vessel would impact the ability to complete the maneuver safely. The average pilot rating for Overall Safety was 3.5 for this scenario.

During stern first, ebb tide runs for the complete turning basin three pilots completed the maneuver successfully. The fourth pilot collided with the north side of the DCC just after turning in the basin. Pilot indicated that the error was a result of a communication problem. All of the runs made use of the additional room to the south, but none of the vessels made use of the eastern expansion. While the average pilot rating for Overall Safety was a relatively low 2.5, it should be noted that three of the pilots gave this scenario a 3 for safety while the remaining pilot rated it a 1, or “not safe at all”. The pilot who rated the scenario lowest commented that the visibility in the simulator was not adequate.

Bellatrix, Outbound (DCC Berth to Berth 31)

<u>*Flood Tide*</u>

As with the inbound runs, outbound flood tide runs consisted of four bow first and four stern first scenarios for two different design plans. Again a larger vessel was placed at Berth 33C when the full expansion plan was evaluated.

During the bow first outbound runs for the southern expansion, pilots had to come close to the southern corner of Berth 33C in order to swing the stern of the vessel into the turning basin. While all runs were completed successfully, without use of the southern extension of the turning basin, the pilots commented that it required a great deal of power and assistance to keep the vessel from going aground on the east bank. The average pilot rating for Overall Safety was 3 for this scenario.

During the bow first outbound runs for the full turning basin expansion, pilots completed all of the runs successfully despite the larger vessel at Berth 33C. While none of the pilots brought their vessel into the east expansion across from the Berth, overall comments indicate that having the additional space provided increased confidence when bringing the bow into the flood current during the turn. The average pilot rating for Overall Safety was 3.5 for this scenario.

Bellatrix, stern first outbound runs using only the southern expansion were all completed successfully. It should be noted, however, that as the pilots emerged from the turning basin and began moving to the north, the flood current pressed the vessels to the west toward Berth 33C. Had the vessel at berth been larger, the runs may not have been as successful. The average pilot rating for Overall Safety was 3.3 for this scenario.

During the stern first outbound runs using the full expansion of the turning basin, one pilot was unable to back out of the DCC due to an inability to judge distances in the simulator. The run was unsucessful and resulted in an individual safety rating of 1. The remaining three runs were completed successfully although one pilot cut the southeast corner of the DCC while backing into the south expansion. The average pilot rating for Overall Safety was 3.0. However, pilots who completed the scenario gave it a safety rating of 4.

Ebb Tide

During the outbound, bow first runs using the southern expansion only, three of the runs were completed successfully. Of the three, two clipped the northwest corner of the turning basin and the third left the south channel limit just prior to entering the turning basin. The forth pilot left the channel to the east across from Berth 33C and caused the vessel to go aground. Pilot comments indicated that there was inadequate room in the basin for the run under ebb conditions and that if a longer vessel were at Berth 33C the maneuver would be unsafe. The average pilot rating for Overall Safety was 3.3 for this scenario.

During the bow first runs using the full turning basin expansion, pilots were able to keep their vessels within the channel limits despite the large vessel at Berth 33C. The ebb current forced the vessels to the east, requiring the additional space provided by the eastward expansion opposite the berth. Pilots commented that the added space was neccesary to complete the maneuver safely. The average pilot rating for Overall Safety was 3.3 for this scenario.

During the outbound, stern first runs using the southern expansion only, all of the pilots completed the maneuver successfully. None of the vessels left the channel limits, but vessels tended to press toward Berth 33C after completing the turn. Pilots indicated that the additional space to the south increased the safety of the maneuver and that additional room to the east would also be useful. The average pilot rating for Overall Safety was 4 for this scenario.

During the stern first runs using the complete turning basin expansion, two of the three participating pilots completed the scenario successfully. The third pilot was unable to turn his ship and went aground on the southeast corner of the turning area. Again the problem appeared to be a lack of visibility in the simulator. Of the two pilots who completed their runs, ratings were mixed. One pilot rated the run a 1 (“not at all safe”) while the other rated it a 4. The average pilot rating for Overall Safety was 2.3 for this scenario.

Series III Conclusions and Recommendations

Maneuvering extremely large vessels such as the Susan Maersk and Voyager of the Seas past docked cruise ships and through the course changes necessitated by the knuckle is a difficult undertaking. The consequences of an incident involving a cruise ship (either at the dock or transiting the waterway) could be severe. The pilots have stated repeatedly that they fear not being able to bring ships to the new facilities unless the SAC is widened to the east across from the knuckle. Based on results from the final series of simulations it is recommended that the final configuration for the SAC as tested during the Series III simulations be adopted.

Turning the Susan Maersk or Voyager of the Seas in the turning notch is an extremely tight maneuver. Simulation results indicate that it can be done successfully if the final configuration, including the full eastern expansion is implemented. Pilots indicate that the conditions will have to be ideal for this maneuver to take place.

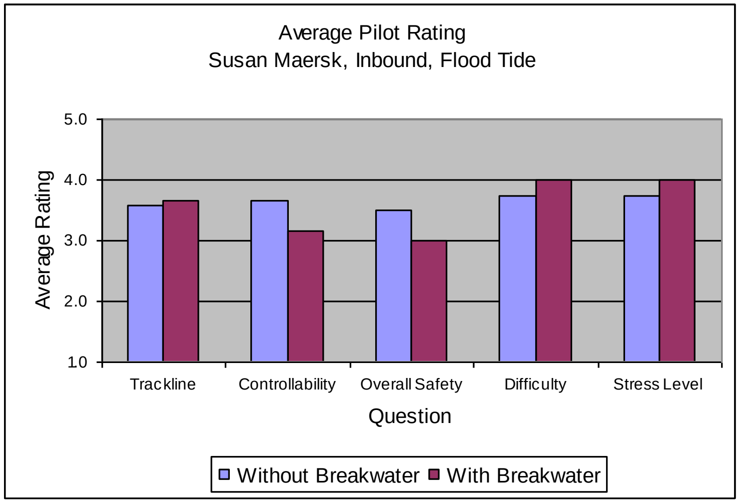
The eastern expansion across from the Turning Notch was also used by the Jutlandia, but was not required. Pilots indicated that they will turn panamax vessels on a regular basis if the expansion is constructed. They also indicated that they would turn panamax vessels without the expansion, but only under ideal circumstances. Smaller vessels, such as the SL Anchorage, will use the TN with our without the eastern expansion. Based on simulation results for the TN, it is recommended that the final configuration involving all north and expansions of the TN as tested during the Series III simulations be adopted.

In order to bring the Bellatrix into the DCC, modifications are required for the DCC turning basin. Pilots indicated that the both the eastward expansion north of the turning basin (across from Berth 33C), the eastward expansion within the turning basin, and the southern expansion of the turning basin are necessary for safe transit. Although not all vessels in the simulations used the expansion to the north, all agreed that it provided a margin of safety that increased their confidence in performing the maneuver. In addition, the eastern expansion to the north reduces bank effects making the maneuver easier. Pilots also indicated that the maneuver would not be possible during ebb tide if a larger vessel is docked at Berth 33C. Given the active nature of berth 33C and in light of simulation results and pilot’s comments, it is recommended that the final configuration of the DCC including all eastern and southern expansions as tested during Series III simulations be adopted.

Attachment I

Average Pilot Evaluation Ratings

Series I Simulation


Average Pilot Rating
Susan Maersk, Inbound, Flood Tide
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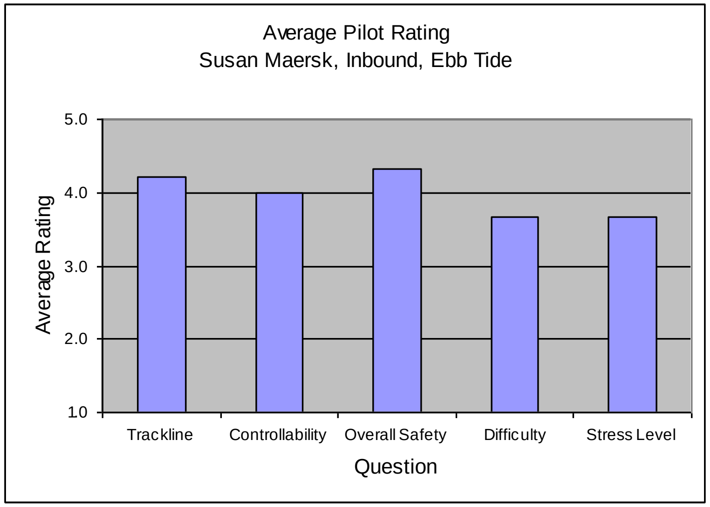
Controllability
Overall Safety
Difficulty
Stress Level
Question
Without Breakwater
With Breakwater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Difficulty
Stress Level
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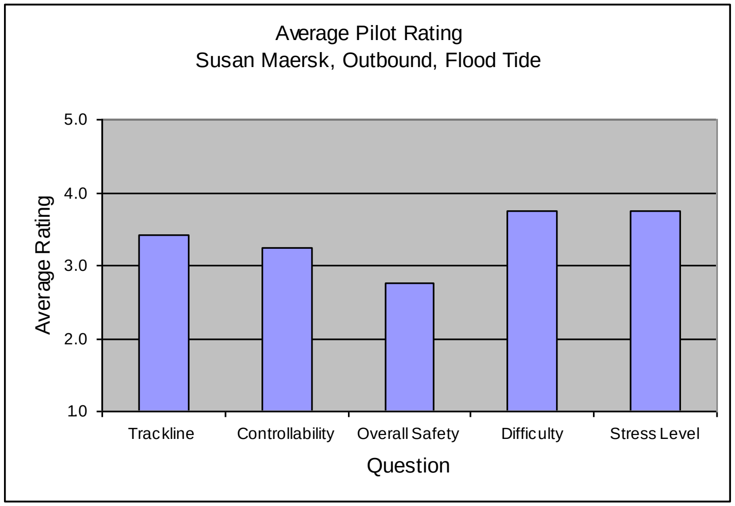
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Stress Level
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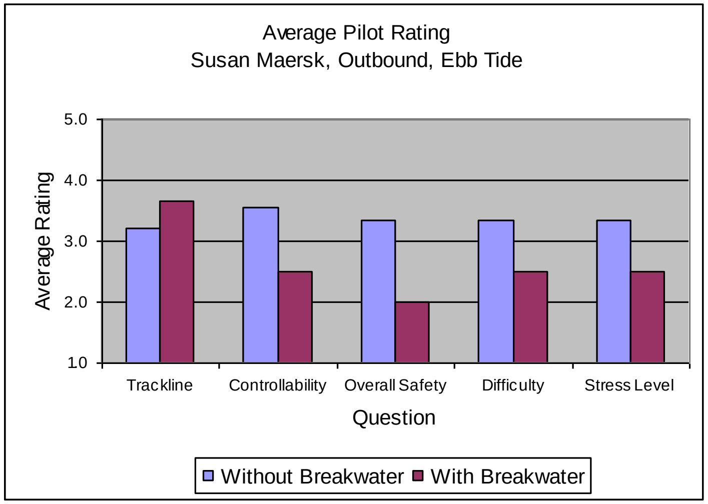
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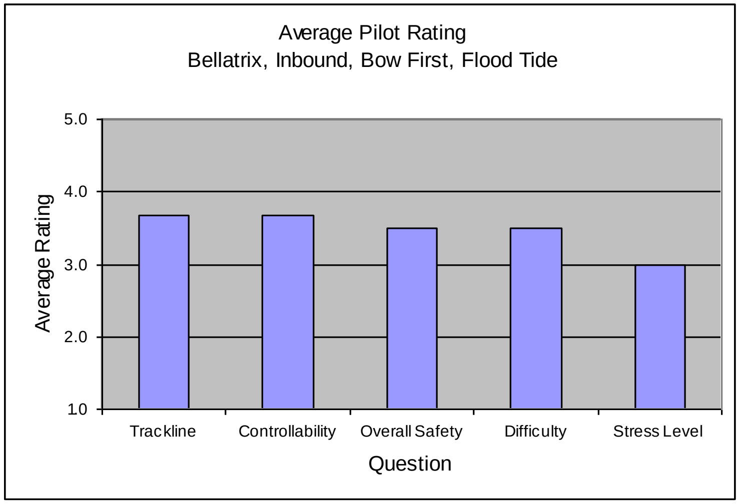
Difficulty
Stress Level
Question
Without Breakwater
With Breakwater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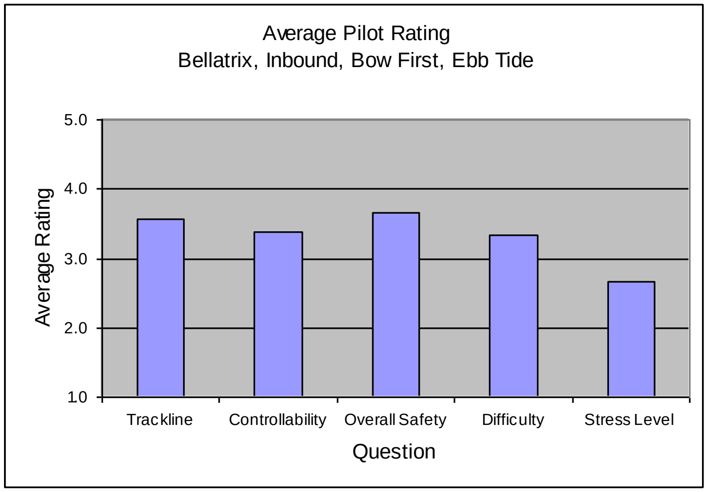
Difficulty
Stress Level
Question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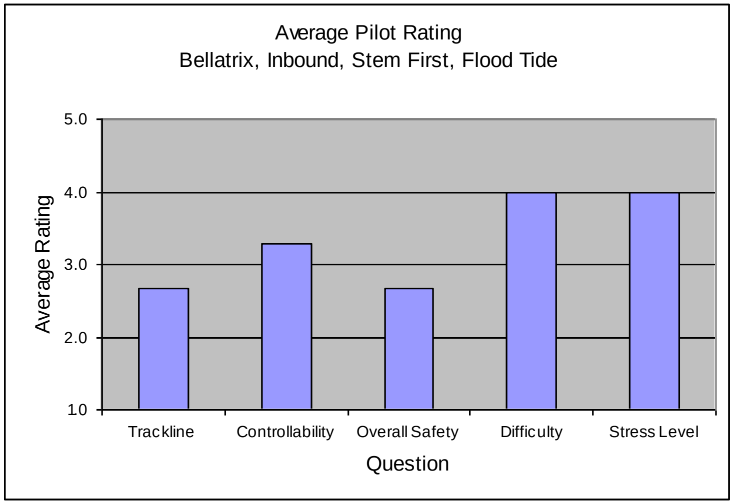
Difficulty
Stress Level
Question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Bellatrix, Inbound, Stem First, Flood Tide
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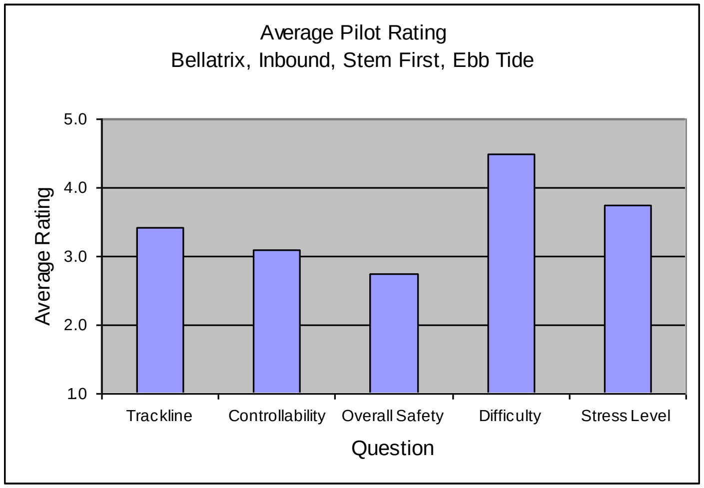
Overall Safety
Difficulty
Stress Level
Question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Difficulty
Stress Level
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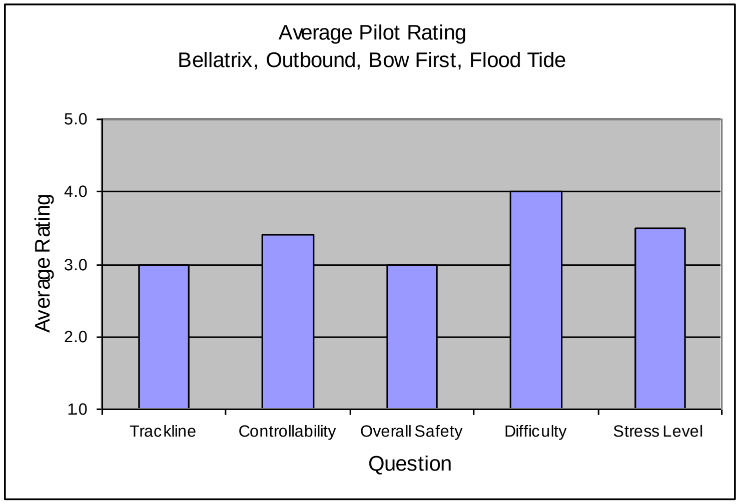
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Average Rating
Trackline
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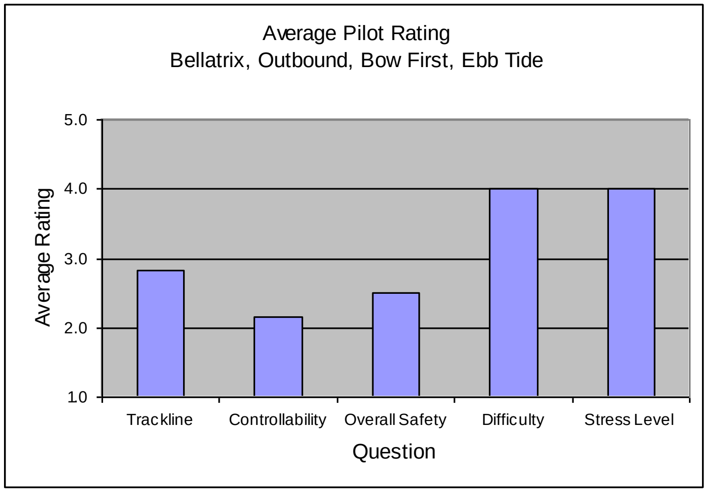
Overall Safety
Difficulty
Stress Level
Question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Bellatrix, Outbound, Bow First, Ebb Tide
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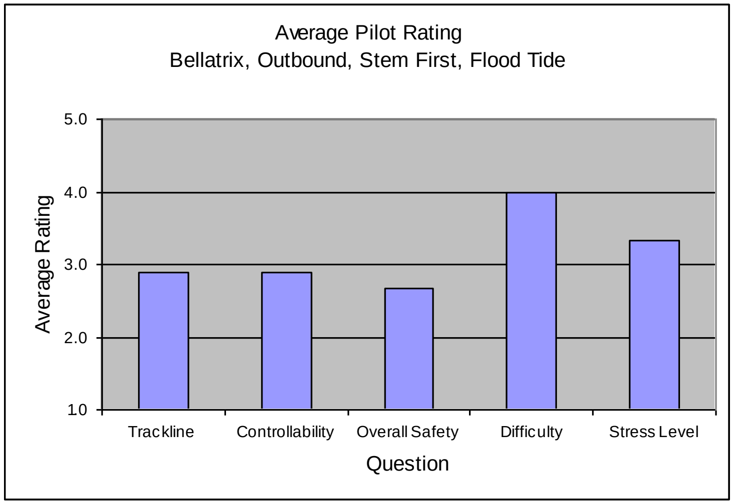
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Outbound, Stem First, Flood Tide
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3.0
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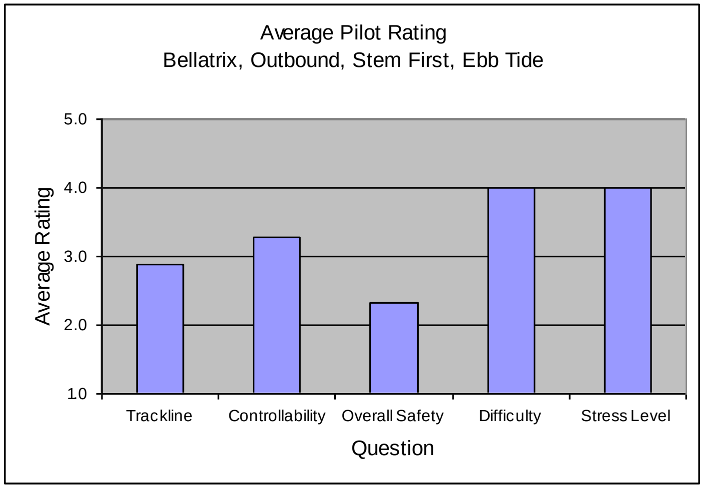
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Outbound, Stem First, Ebb Tide
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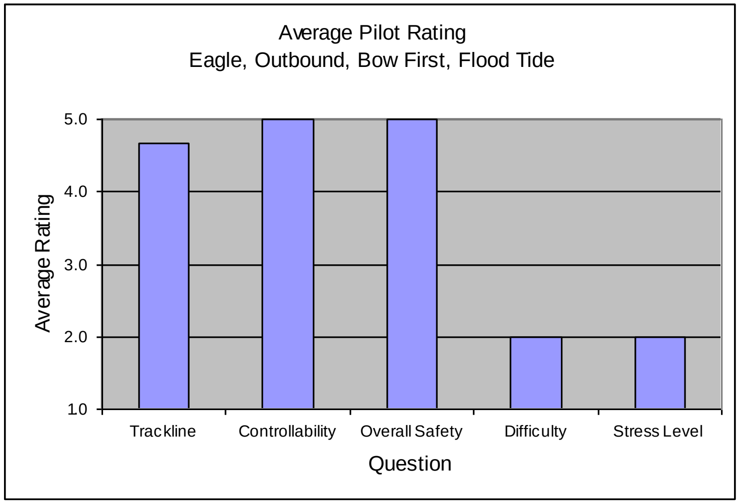
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question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Eagle, Outbound, Bow First, Flood Tide
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3.0
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Average Rating
Trackline
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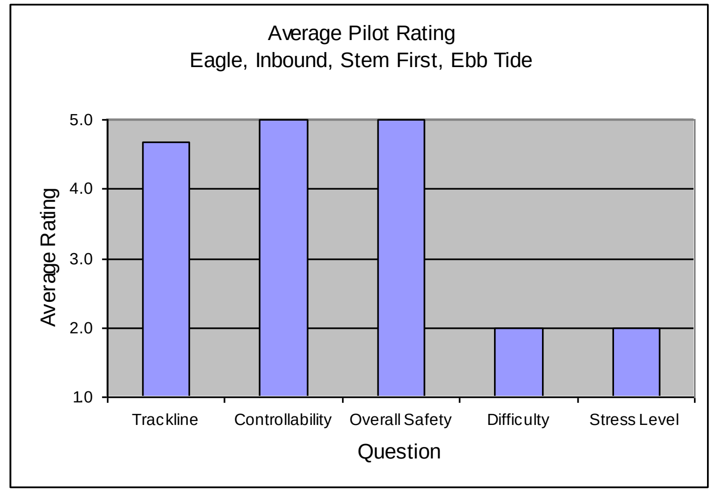
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Eagle, Inbound, Stem First, Ebb Tide
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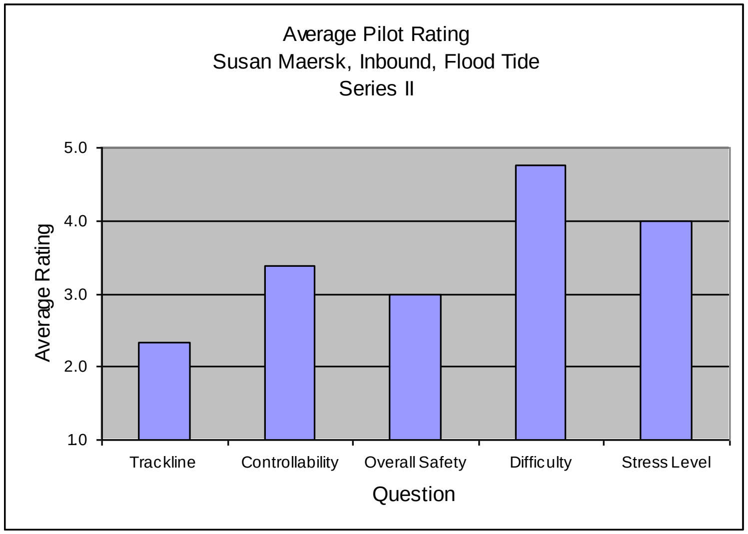
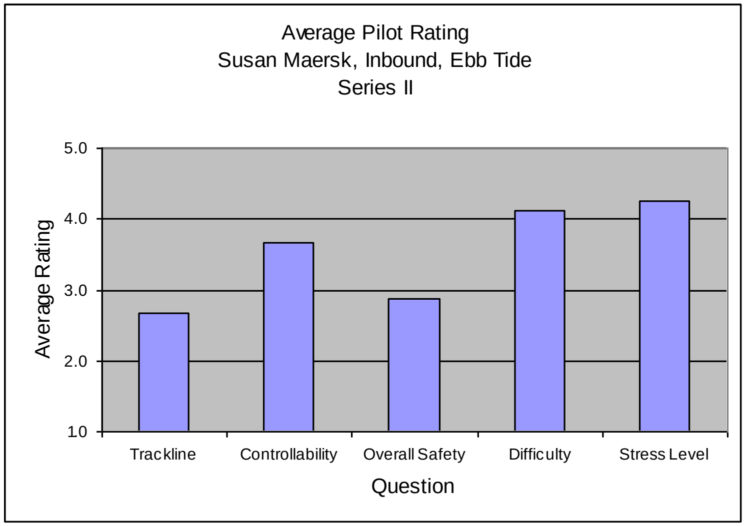
3.0
2.0
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question

Attachment II

Average Pilot Evaluation Ratings

Series II Simulation


Average Pilot Rating
Susan Maersk, Inbound, Flood Tide
Series II
Average Rating
5.0
4.0
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Inbound, Ebb Tide
Series II
Average Rating
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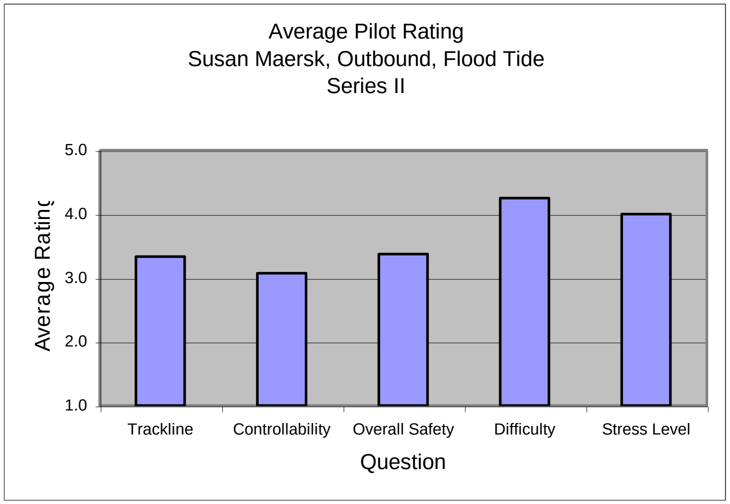
4.0
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Outbound, Flood Tide
Series II
Average Rating
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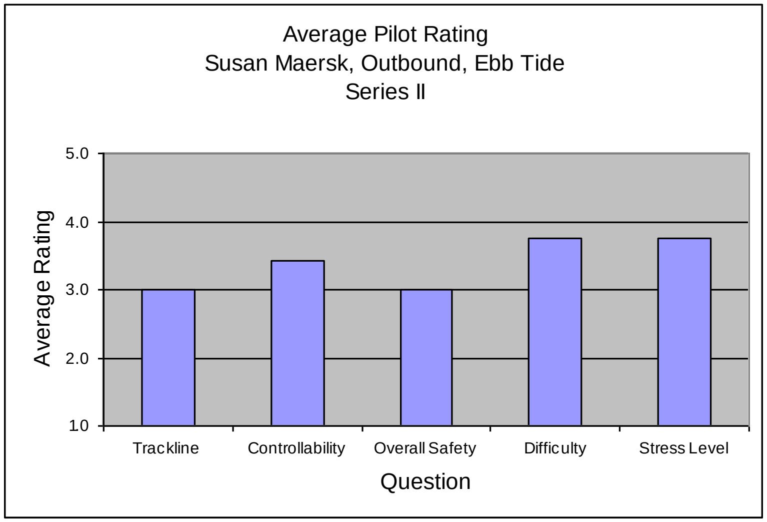
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Outbound, Ebb Tide
Series II
Average Rating
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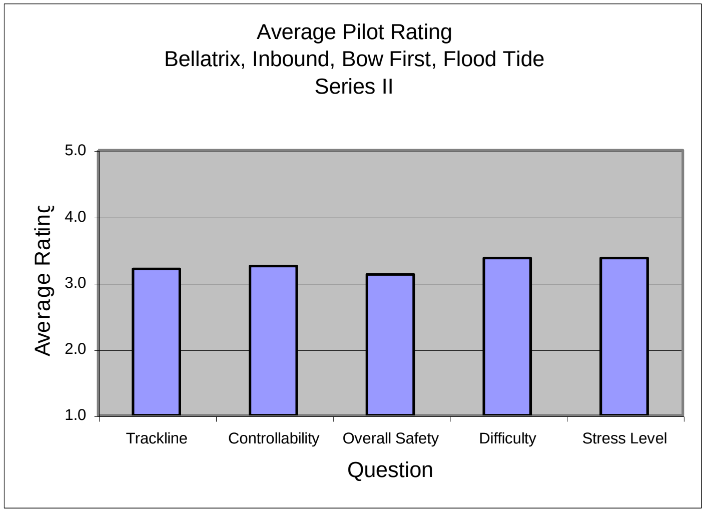
4.0
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Inbound, Bow First, Flood Tide
Series II
Average Rating
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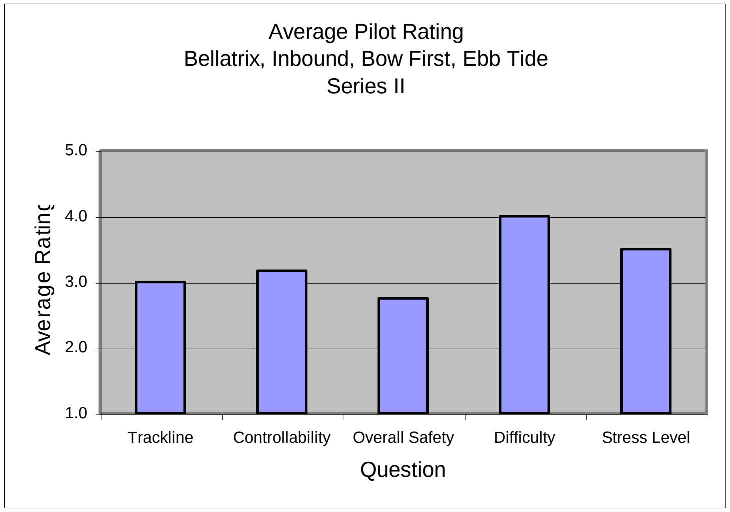
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Inbound, Bow First, Ebb Tide
Series II
Average Rating
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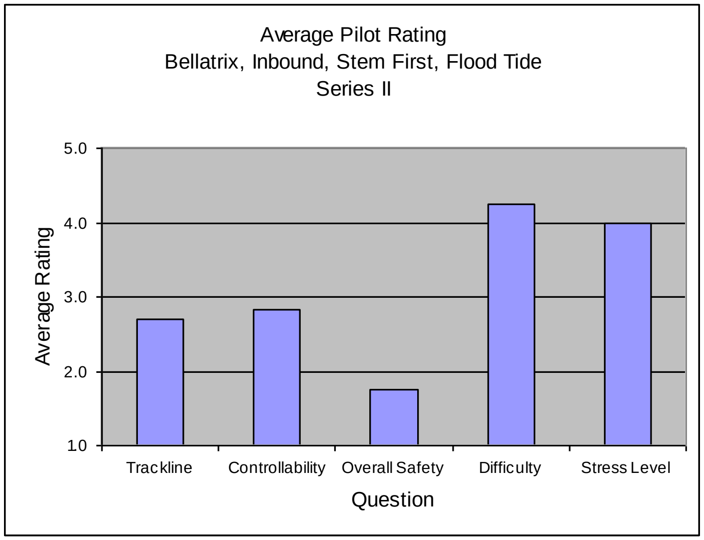
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Inbound, Stem First, Flood Tide
Series II
Average Rating
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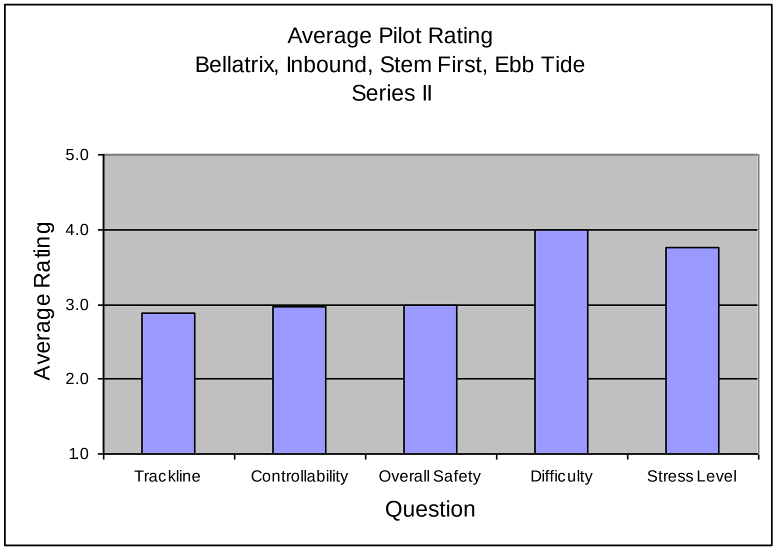
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Inbound, Stem First, Ebb Tide
Series II
Average Rating
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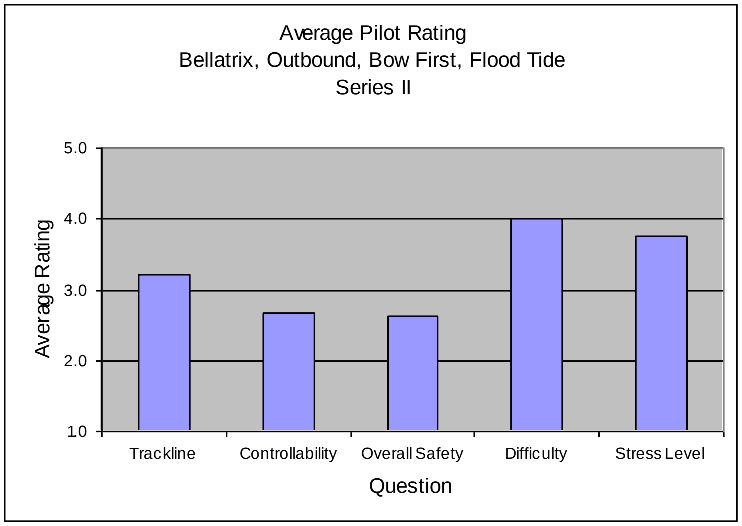
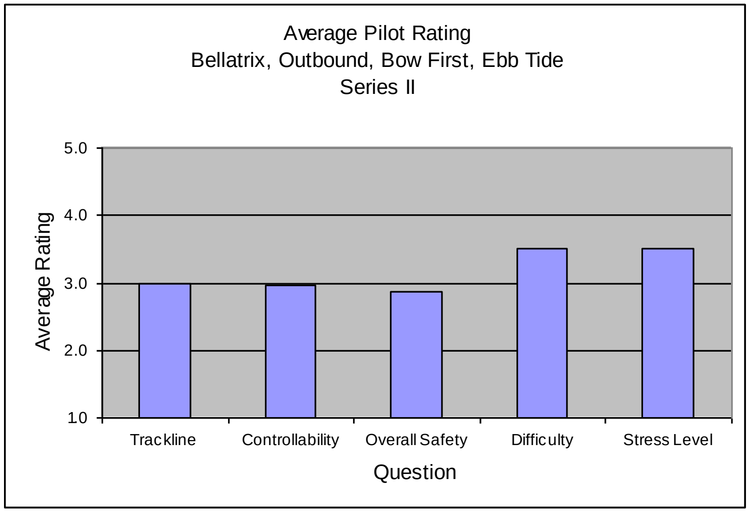
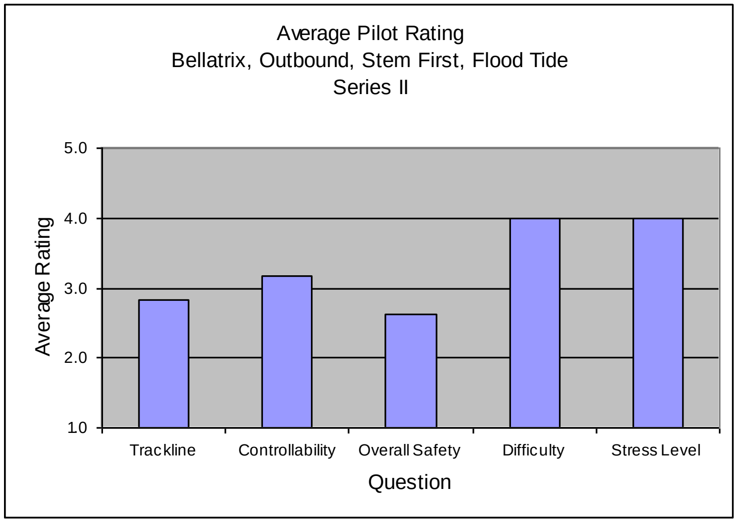
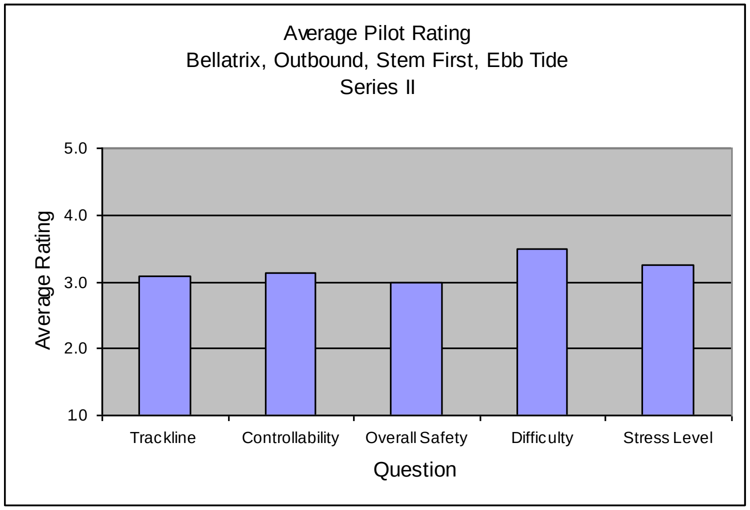
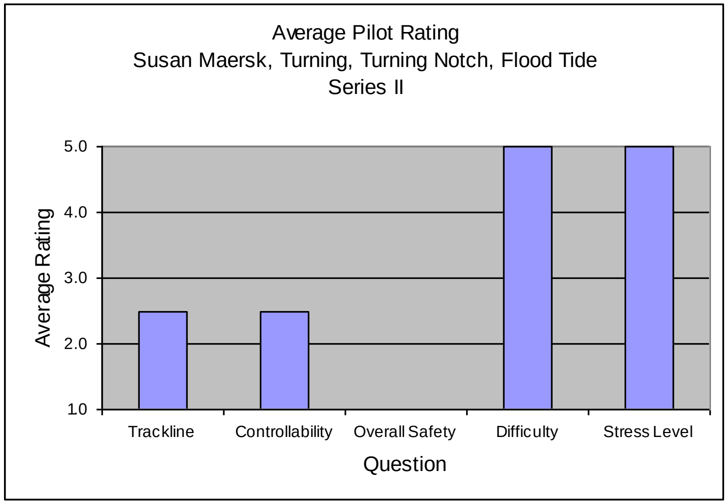
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question

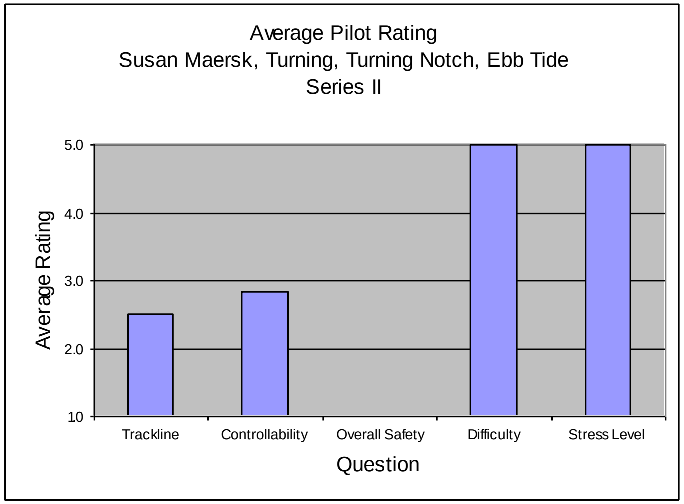

Average Pilot Rating
Bellatrix, Outbound, Bow First, Flood Tide
Series II
5.0
4.0
3.0
2.0
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Outbound, Bow First, Ebb Tide
Series II
5.0
4.0
3.0
2.0
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Outbound, Stem First, Flood Tide
Series II
5.0
4.0
3.0
2.0
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Bellatrix, Outbound, Stem First, Ebb Tide
Series II
5.0
4.0
3.0
2.0
1.0
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Turning Notch, Flood Tide
Series II
Average Rating
5.0
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Turning Notch, Ebb Tide
Series II
Average Rating
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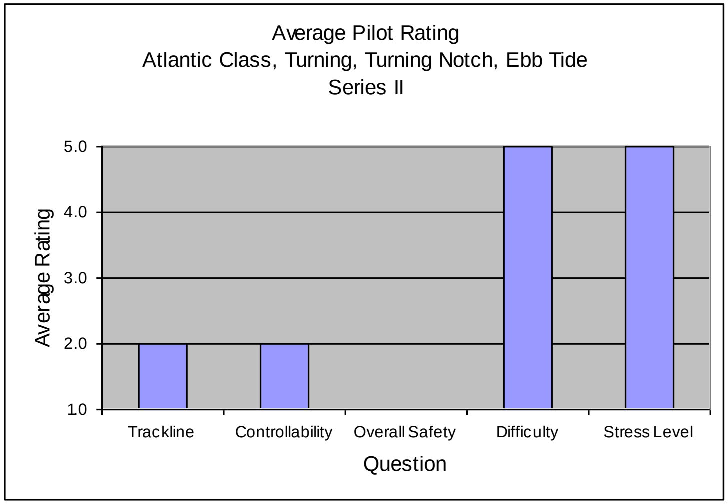
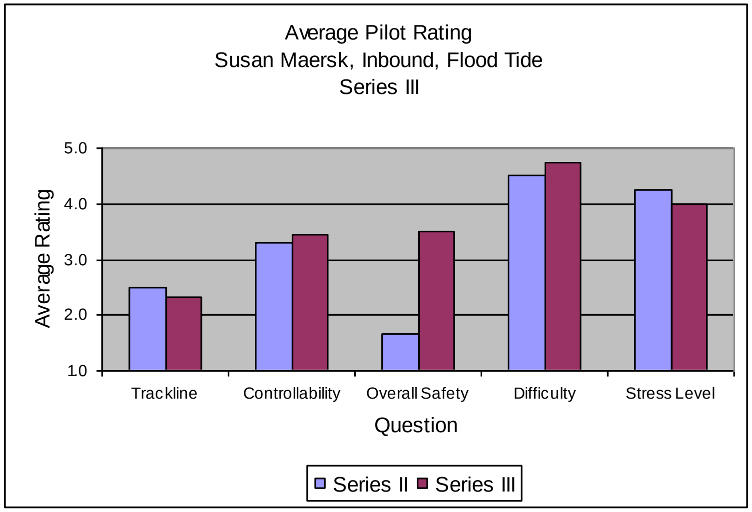
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Atlantic Class, Turning, Turning Notch, Ebb Tide
Series II
Average Rating
5.0
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question

Attachment III

Average Pilot Evaluation Ratings

Series III Simulation


Average Pilot Rating
Susan Maersk, Inbound, Flood Tide
Series III
Average Rating
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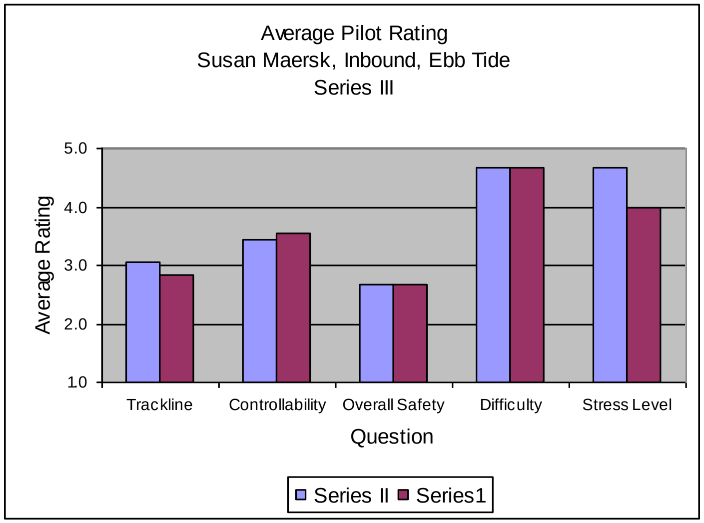
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Susan Maersk, Inbound, Ebb Tide
Series III
Average Rating
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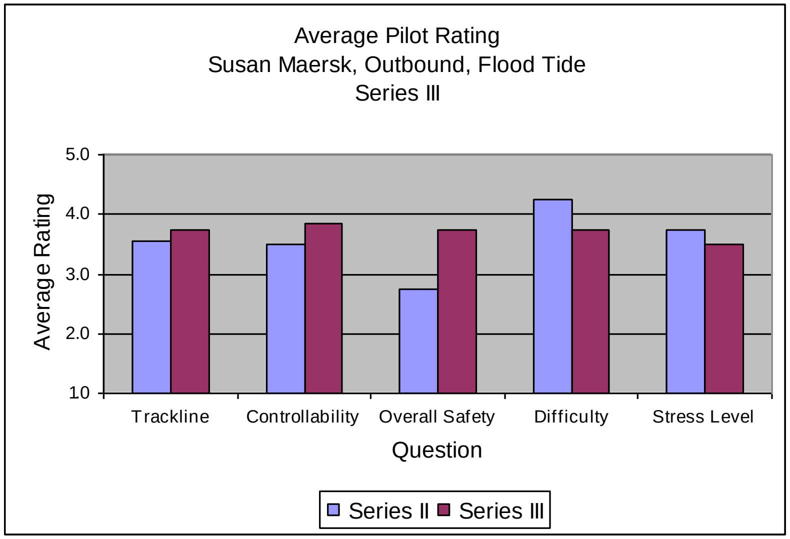
4.0
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series1


Average Pilot Rating
Susan Maersk, Outbound, Flood Tide
Series III
Average Rating
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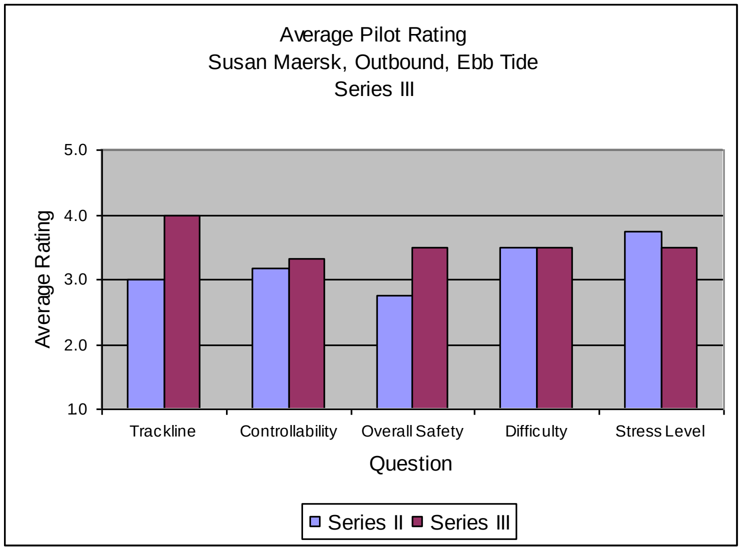
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Susan Maersk, Outbound, Ebb Tide
Series III
Average Rating
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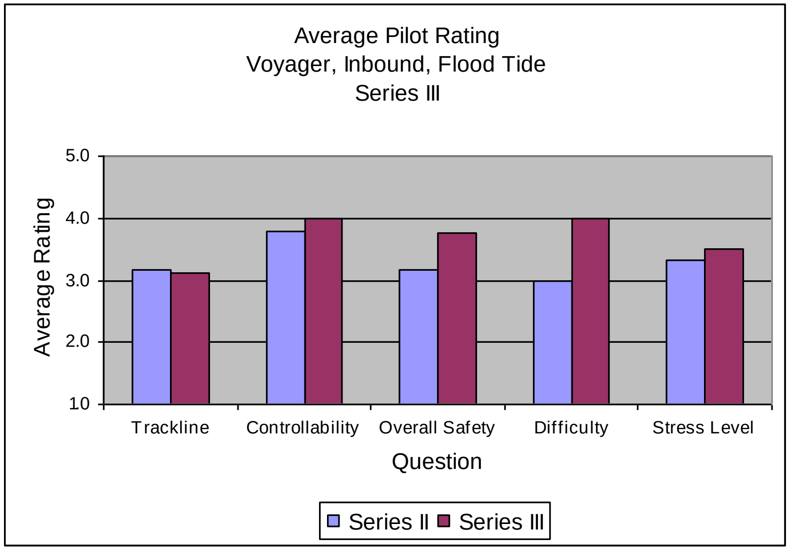
3.0
2.0
1.0
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Voyager, Inbound, Flood Tide
Series III
Average Rating
5.0
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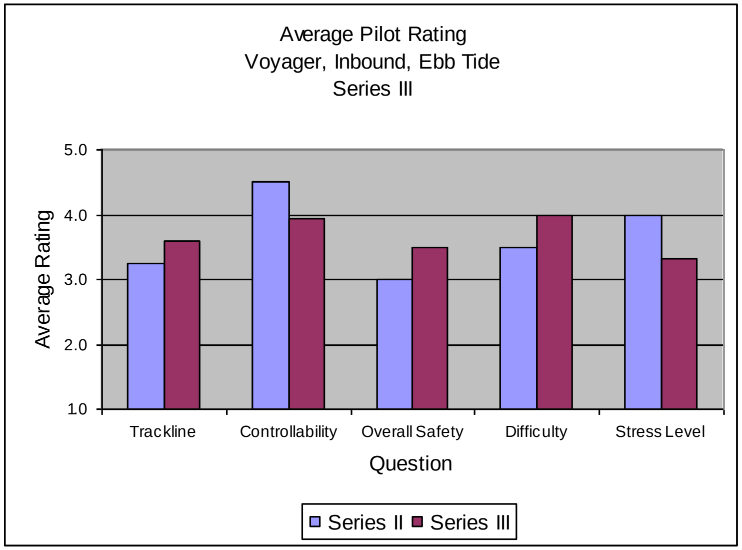
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Voyager, Inbound, Ebb Tide
Series III
Average Rating
5.0
4.0
3.0
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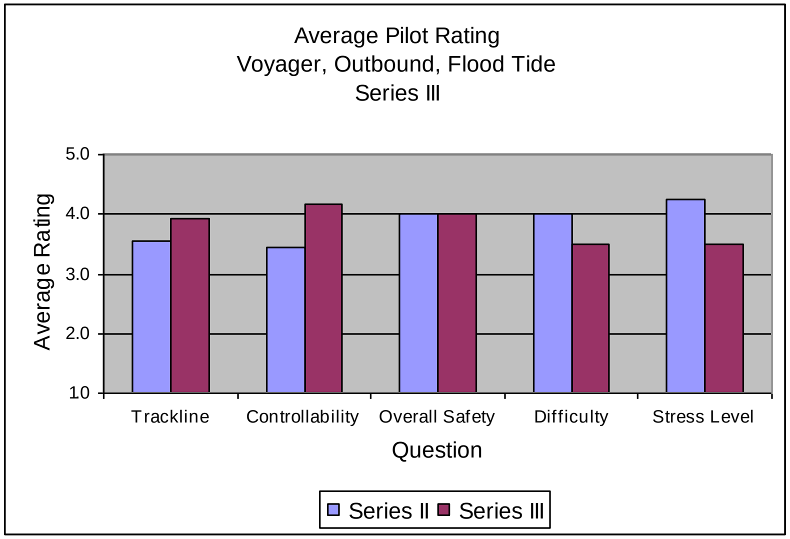
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Voyager, Outbound, Flood Tide
Series III
Average Rating
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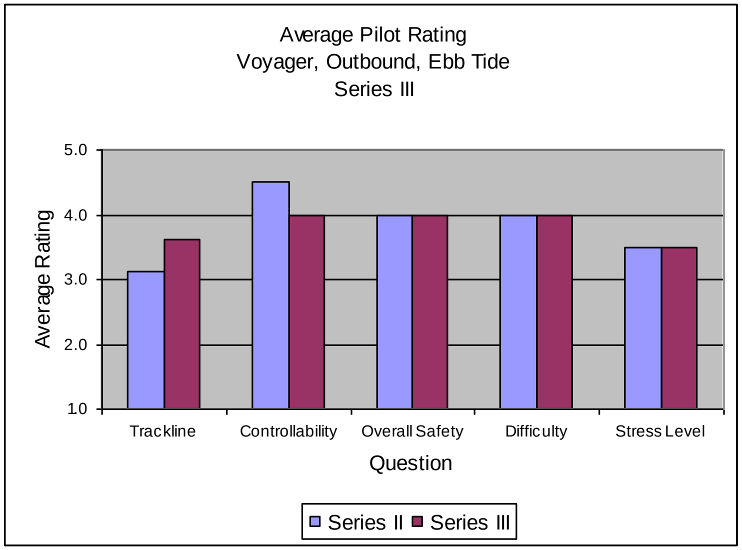
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Voyager, Outbound, Ebb Tide
Series III
Average Rating
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3.0
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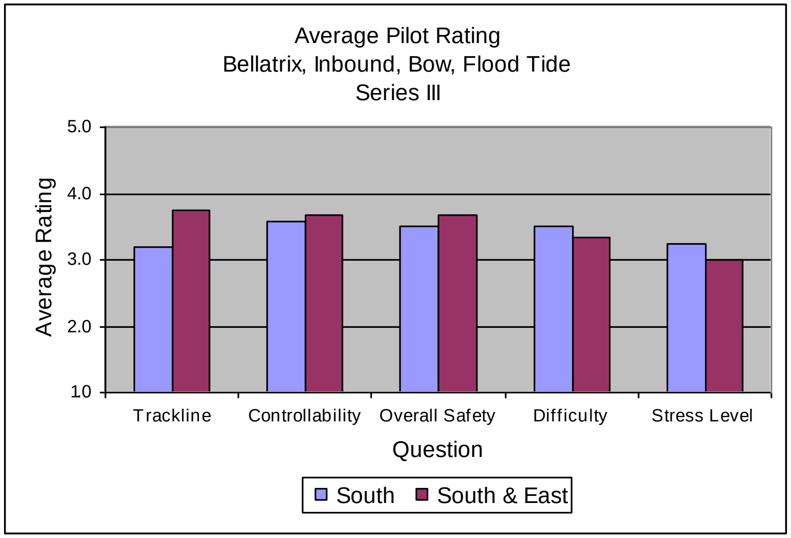
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
Series II
Series III


Average Pilot Rating
Bellatrix, Inbound, Bow, Flood Tide
Series III
Average Rating
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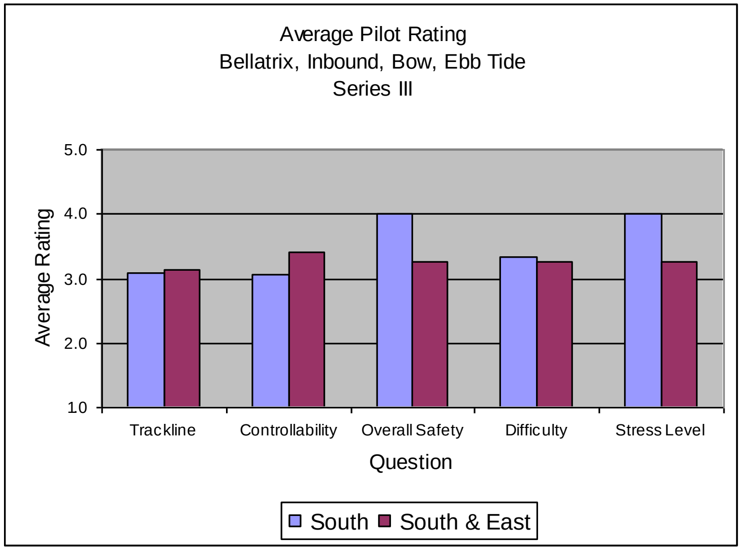
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East


Average Pilot Rating
Bellatrix, Inbound, Bow, Ebb Tide
Series III
Average Rating
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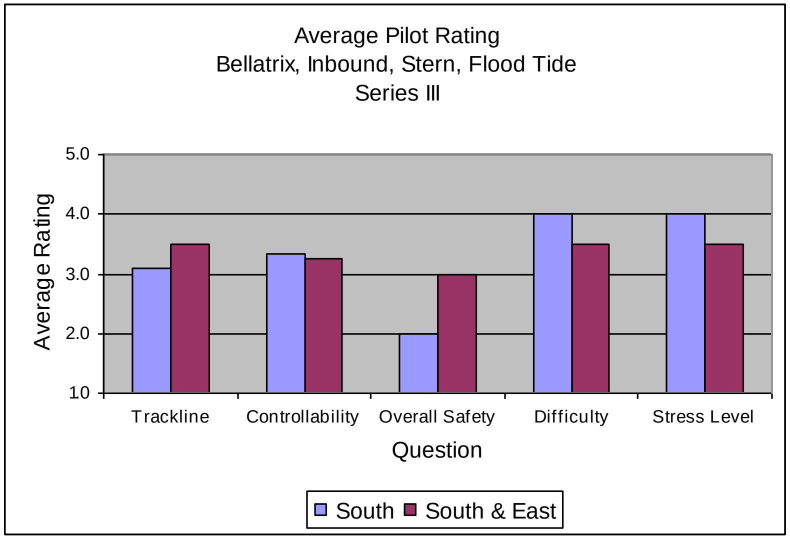
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East


Average Pilot Rating
Bellatrix, Inbound, Stern, Flood Tide
Series III
Average Rating
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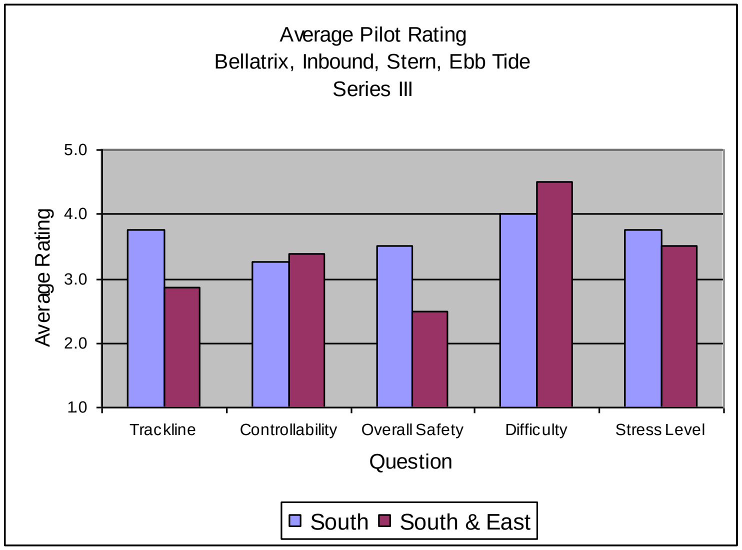
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East


Average Pilot Rating
Bellatrix, Inbound, Stern, Ebb Tide
Series III
Average Rating
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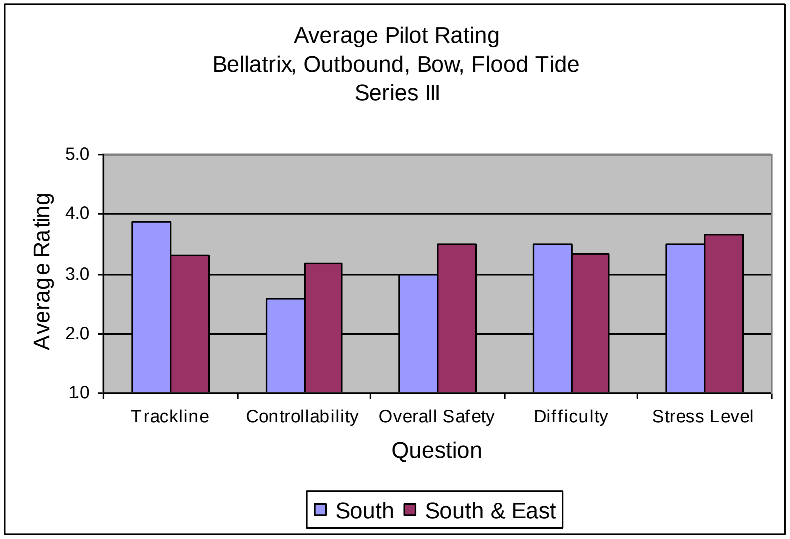
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East



Average Pilot Rating
Bellatrix, Outbound, Bow, Flood Tide
Series III
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4.0
3.0
2.0
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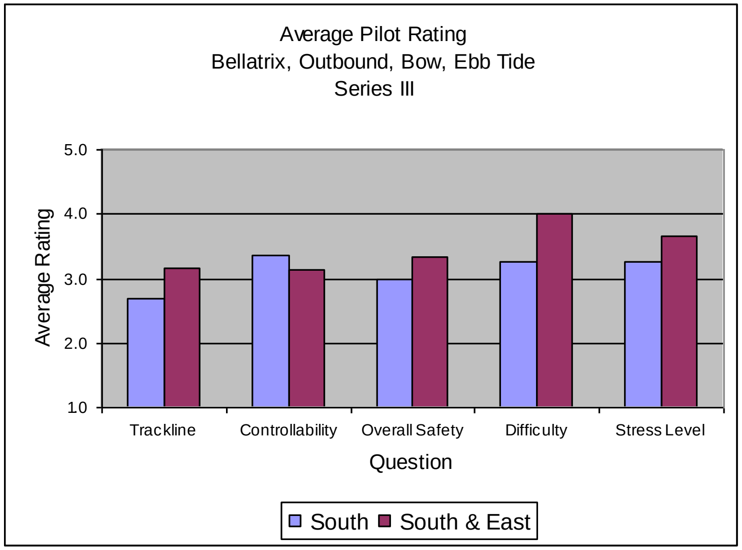
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East



Average Pilot Rating
Bellatrix, Outbound, Bow, Ebb Tide
Series III
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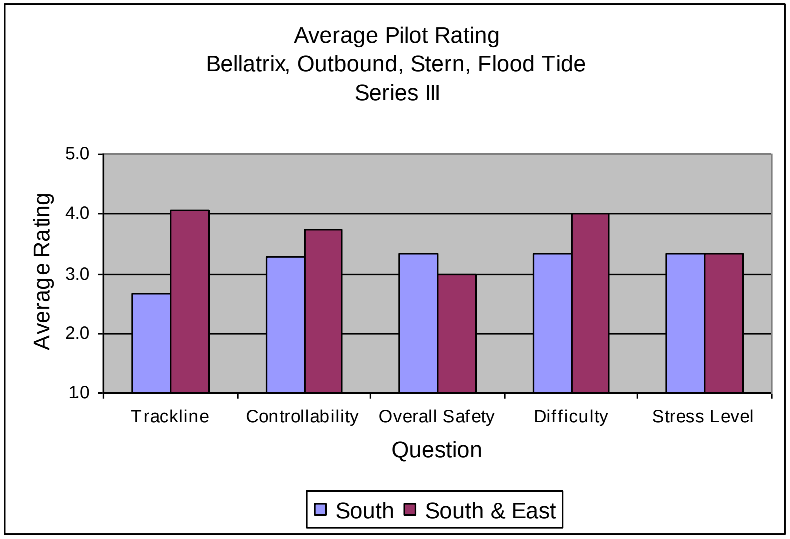
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East



Average Pilot Rating
Bellatrix, Outbound, Stern, Flood Tide
Series III
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2.0
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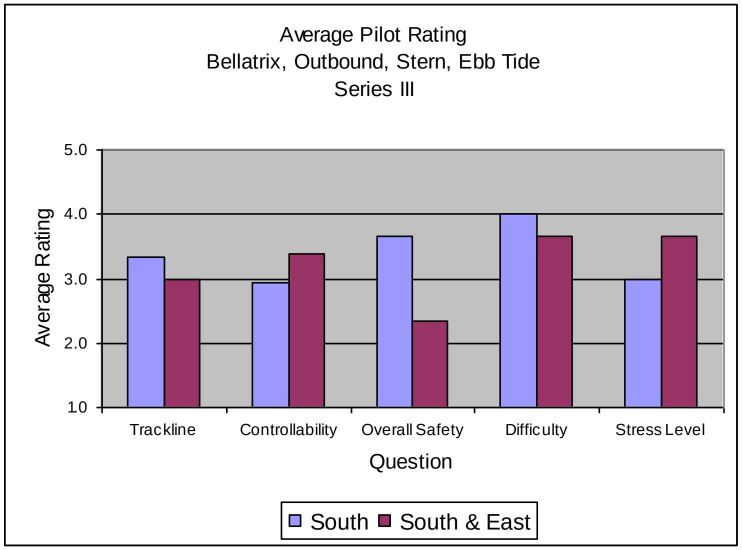
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East



Average Pilot Rating
Bellatrix, Outbound, Stern, Ebb Tide
Series III
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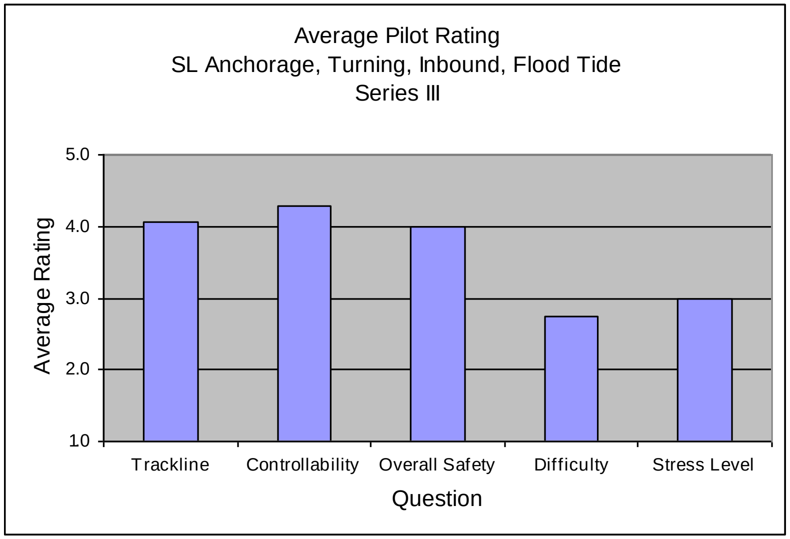
3.0
2.0
10
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question
South
South & East


Average Pilot Rating
SL Anchorage, Turning, Inbound, Flood Tide
Series III
Average Rating
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2.0
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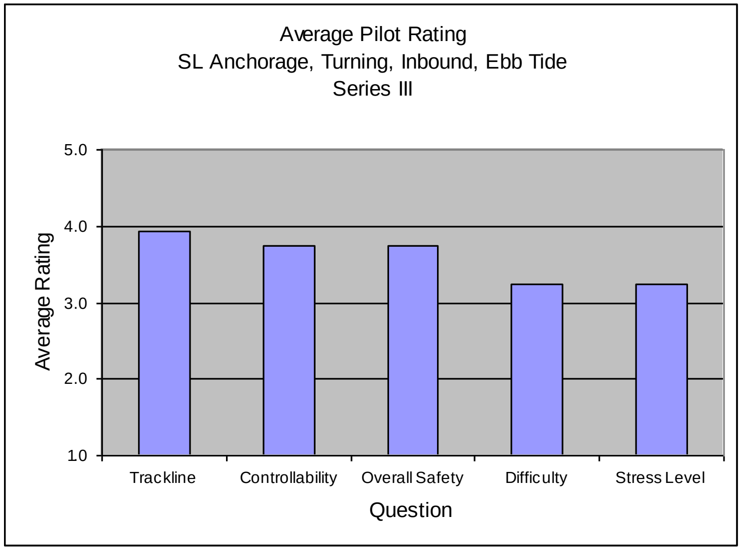
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
SL Anchorage, Turning, Inbound, Ebb Tide
Series III
Average Rating
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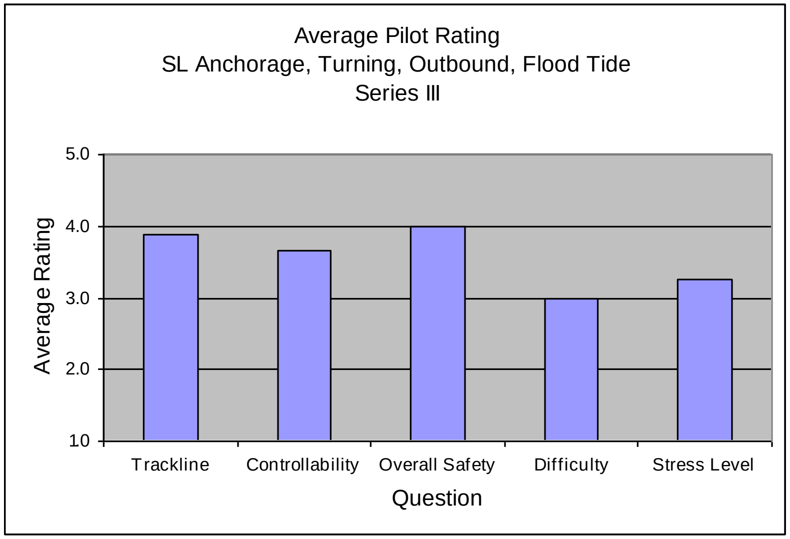
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
SL Anchorage, Turning, Outbound, Flood Tide
Series III
Average Rating
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3.0
2.0
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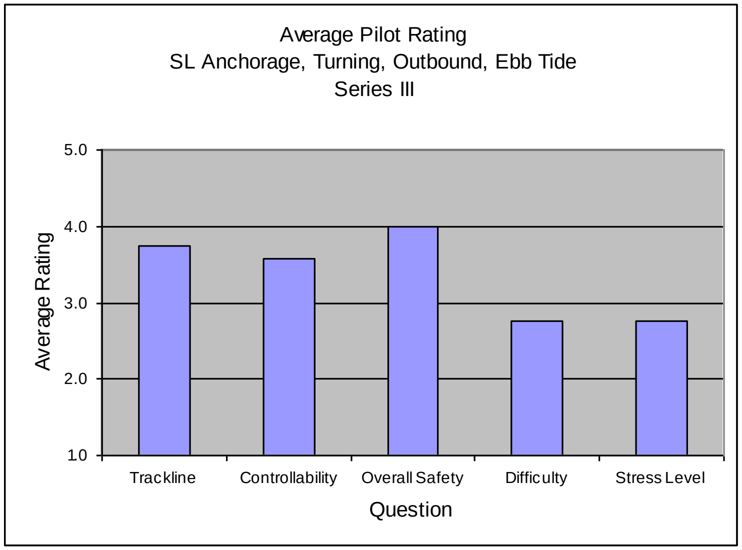
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
SL Anchorage, Turning, Outbound, Ebb Tide
Series III
Average Rating
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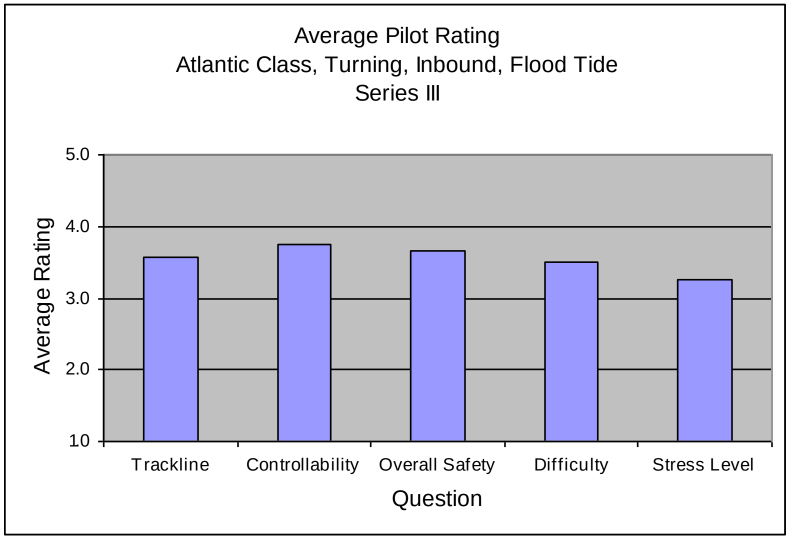
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Atlantic Class, Turning, Inbound, Flood Tide
Series III
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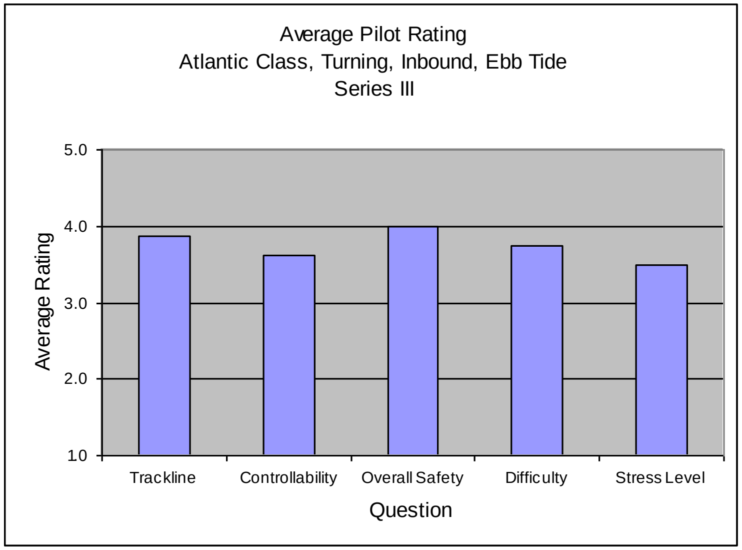
4.0
3.0
2.0
10
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Atlantic Class, Turning, Inbound, Ebb Tide
Series III
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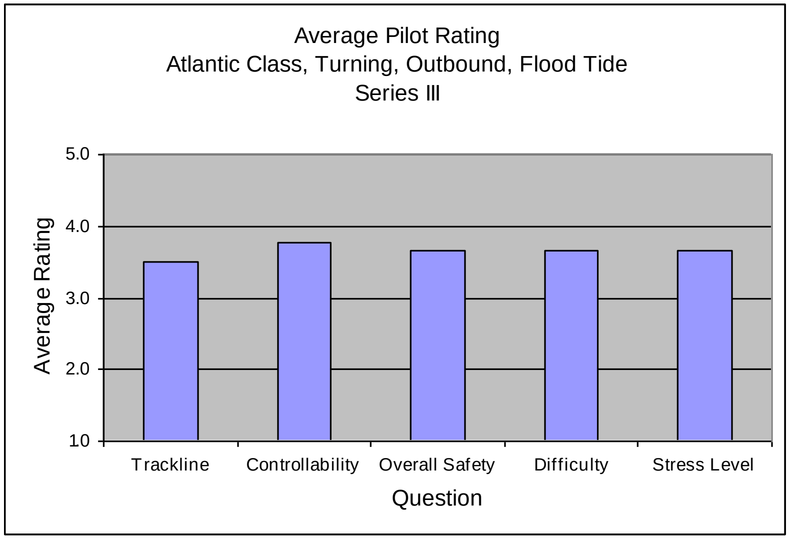
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Atlantic Class, Turning, Outbound, Flood Tide
Series III
5.0
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2.0
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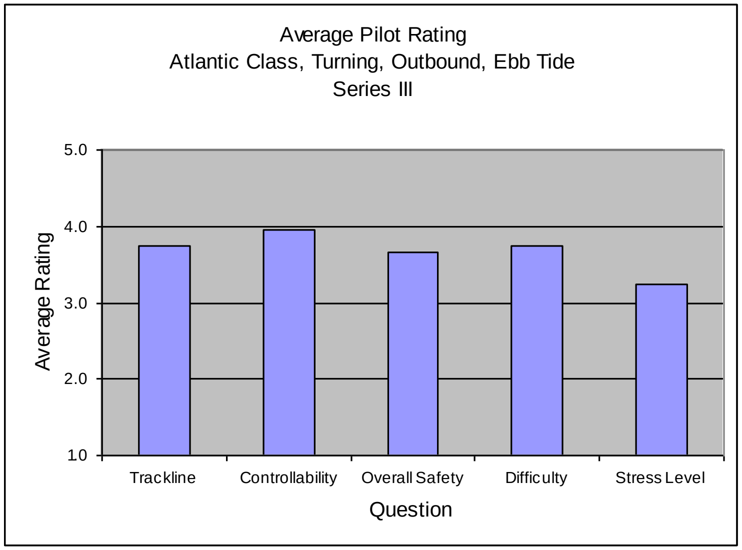
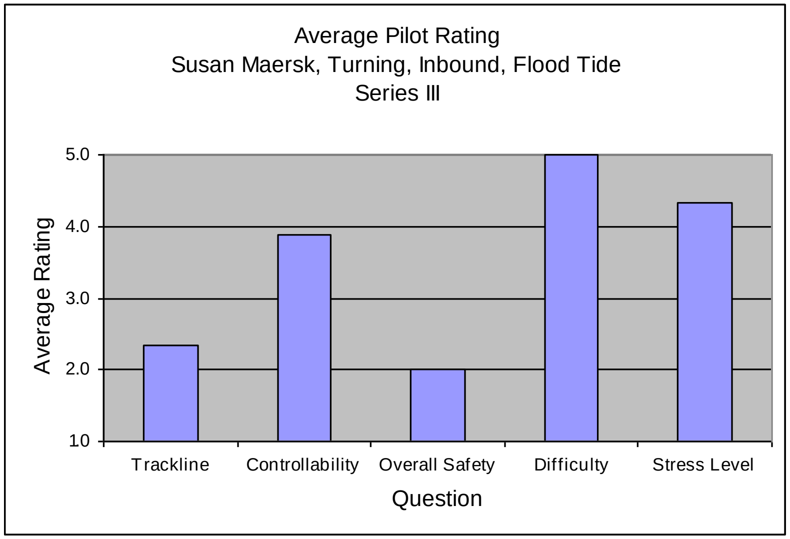
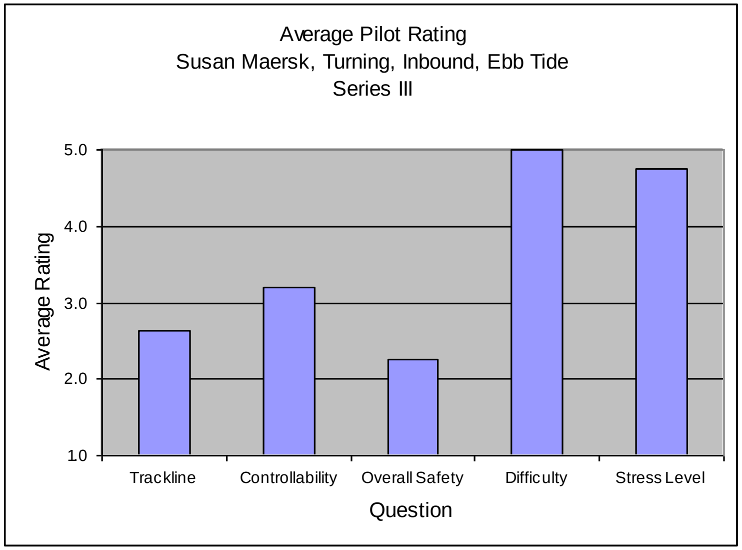
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Atlantic Class, Turning, Outbound, Ebb Tide
Series III
5.0
4.0
3.0
2.0
10
Average Rating
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Inbound, Flood Tide
Series III
Average Rating
5.0
4.0
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Inbound, Ebb Tide
Series III
Average Rating
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Trackline
Controllability
Overall Safety
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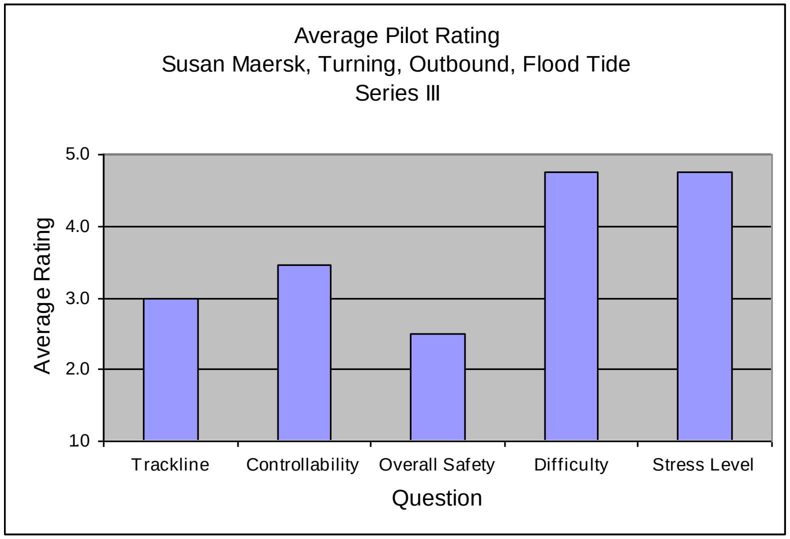
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Outbound, Flood Tide
Series III
Average Rating
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4.0
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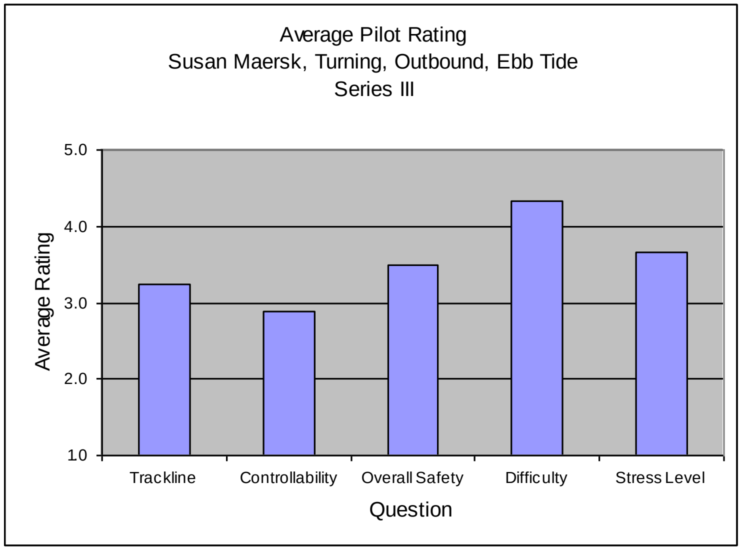
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Susan Maersk, Turning, Outbound, Ebb Tide
Series III
Average Rating
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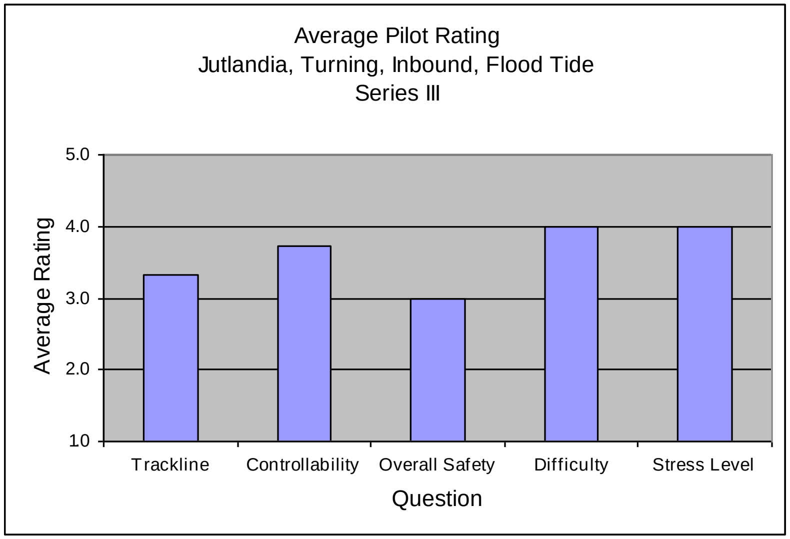
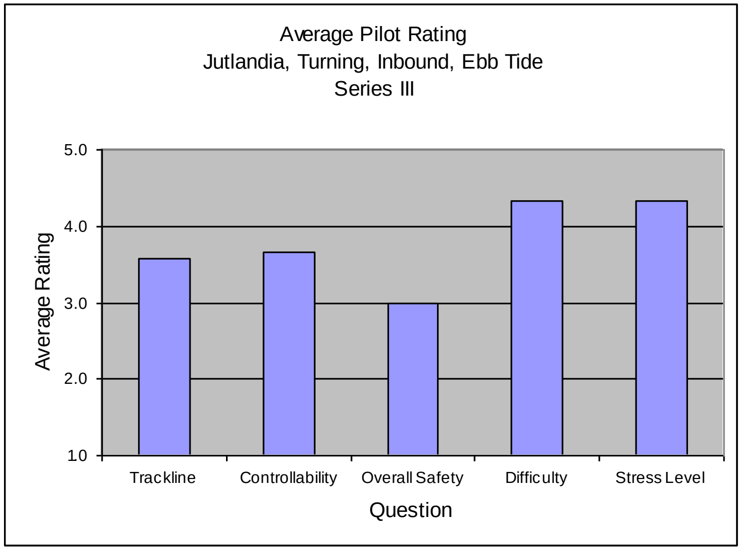
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question


Average Pilot Rating
Jutlandia, Turning, Inbound, Flood Tide
Series III
Average Rating
5.0
4.0
3.0
2.0
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question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Jutlandia, Turning, Inbound, Ebb Tide
Series III
Average Rating
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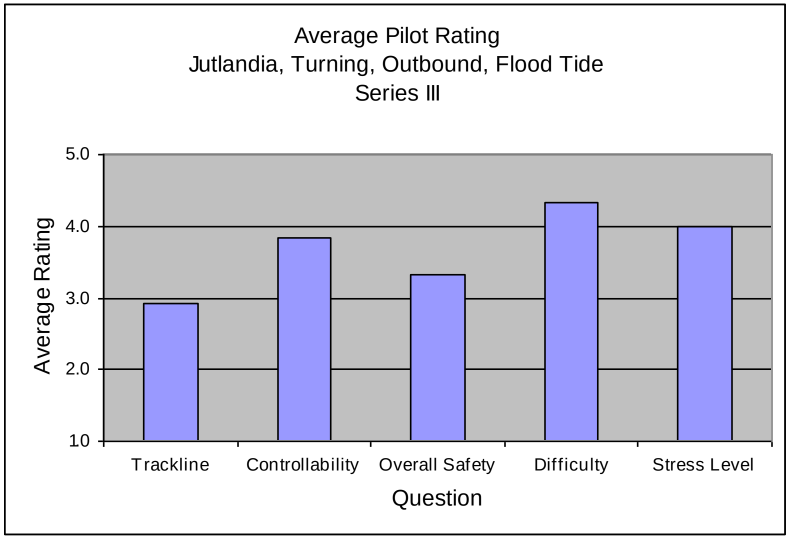
10
Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question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Overall Safety
Difficulty
Stress Level
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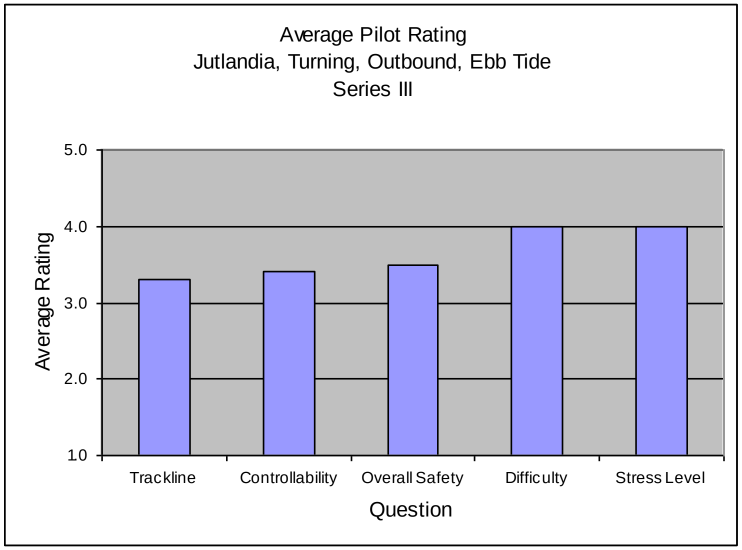
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Trackline
Controllability
Overall Safety
Difficulty
Stress Level
Question

PORT EVERGLADES HARBOR, FLORIDA

SUB-APPENDIX B

WAVE RESPONSE MODELING OF THE U.S. COAST GUARD STATION, PORT EVERLGADES, FORT LAUDERDALE, FLORIDA

Wave Response Modeling of the U.S. Coast Guard Station, Port Everglades, Fort Lauderdale, Florida

EN-WC
USACE Jacksonville District

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Background

The U.S. Army Corps of Engineer's (USACE) Port Everglades feasibility study currently being prepared by the Jacksonville District office proposes widening the Southport Access Channel (SAC) in the area of the port referred to as "the knuckle" (berths 24 through 27). The U.S. Coast Guard (USCG) station at Fort Lauderdale is located across from berth 24 on the eastern side of the SAC (Figure 1). If approved, the expansion of the knuckle area will broaden the existing SAC channel such that the limits of the channel fall within the area currently occupied by Fort Lauderdale's U.S. Coast Guard (USCG) boat basin (Figure 2). While portions of the present USCG facility will remain unaffected, accommodation of the expanded SAC will require modification of the outer breakwater, boat basin, and some adjacent infrastructure.

Purpose

The purpose of this study is to determine to what extent the present USCG facility at Fort Lauderdale will need to be modified in order to maintain current levels of operation. The existing basin layout, including the positioning of the outer breakwater, was established to protect the interior of the USCG boat basin from ship wake and wind waves generated outside of the boat basin. In order to maintain the USCG basin at its present position, with an adequate level of protection for USCG vessels, a series of alternative harbor configurations were developed and the wave response of each was analyzed using the numerical harbor response model CGWAVE (Coastal Gravity WAVE). This report provides of summary of the methodology of the wave response analysis and presents model results for evaluation.

Wave Response Modeling

CGWAVE Model

CGWAVE is a finite element model for the calculation of wave response in harbors of arbitrary size, shape, and depth (Demirbilek and Panchang, 1998). CGWAVE includes both wave diffraction and refraction and is a standard tool for numerical harbor response studies.

The CGWAVE model covers in detail a domain that includes all harbor features. This domain is bounded by a 180-deg semicircle in the water region seaward of the harbor (boat basin) entrance. The area outside of the semicircle is treated as a semi-infinite region which extends seaward to infinity. This region is assumed to have a constant water depth and no bottom friction. For the present application the following assumptions were also made:

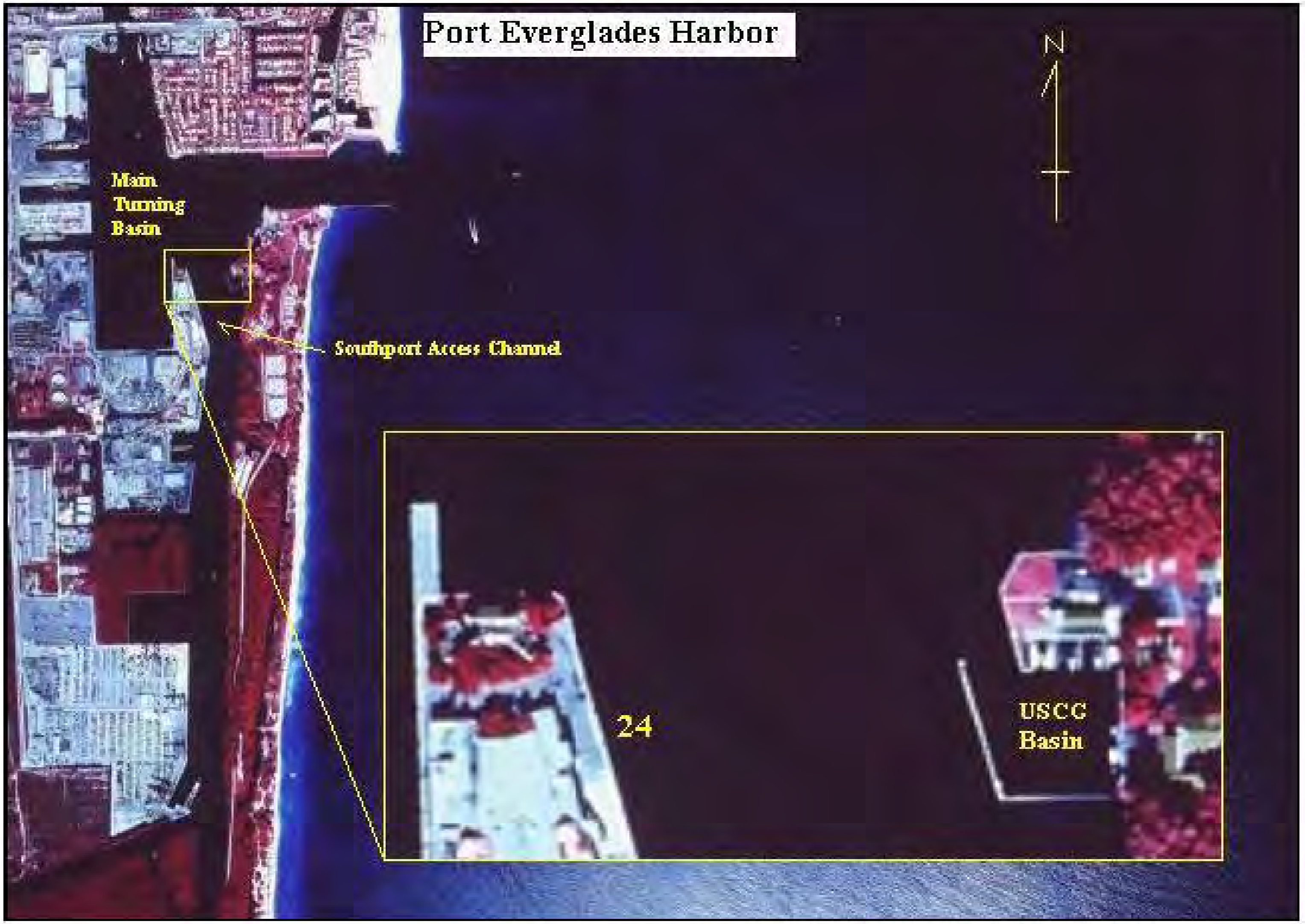

Figure 1. Location of U.S. Coast Guard Station at Fort Lauderdale

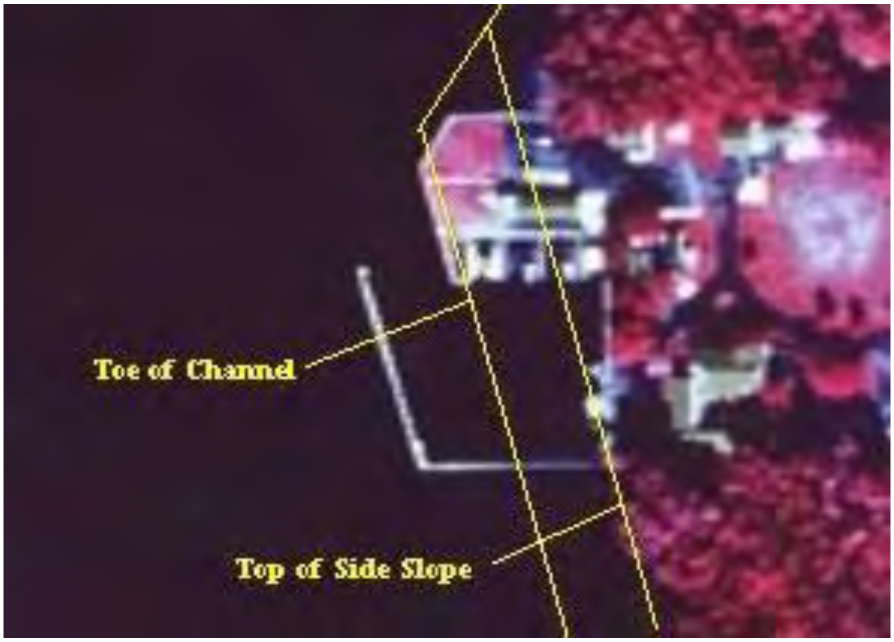

Figure 2. Location of Proposed Channel Limits at Existing USCG Station

a) No wave transmission or overtopping of structures.
b) No optimization of structure crest elevations.
c) No wave-current interactions.
d) No wave-bottom interactions.
e) No wave breaking effects.
f) No nonlinear effects.

Despite limitations imposed by the above assumptions, the CGWAVE tests can be expected to give a reasonable evaluation of the relative differences in protection between the existing and proposed harbor configurations.

Model Input

CGWAVE is run on a conventional finite element grid that is developed and solved over the harbor domain. In addition to the finite element grid, CGWAVE requires the specification of a number of parameters. Parameters include wave period, wave direction, wave height, and reflection coefficients specified for all solid boundaries within the model domain. Reflection coefficients are set according to boundary type (coastal or structural), but can differ depending on structure characteristics. For example, a permeable rubble mound breakwater will exhibit lower wave reflection than an impermeable breakwater. A compilation of accepted ranges of values for common structures is shown in Table 1.

Table 1. Reflection Coefficients by Structure Type

Structure Type	Description	Reflection Coefficient
Vertical Wall	Crown above water	0.7 – 1.0
	Submerged crown	0.5 – 0.7
	Crown above water, thick rubble toe protection	0.4 – 0.6
	Vertical energy dissipater	0.3 – 0.8
Smooth Impermeable Slope	Crown above water, 1:1.5 to 1:2.5 slope	0.5 – 0.9
	Submerged crown, 1:1.5 slope	0.3 – 0.5
Rough Slope	Rubble, 1:1.5 to 1:3 slope	0.3 – 0.6
	Rubble, less than 1:3 slope	0.1 – 0.3
	Energy dissipating concrete blocks	0.3 – 0.5
Rough, Permeable Breakwater	Rubble, 1:1.5 slope	0.2 – 0.6
	Rubble, 1:2.5 slope	0.1 – 0.5
	Dolos, 1:1.5 to 1:3 slope	0.1 – 0.4
Natural Beach		0.05 – 0.2

Since no wave measurements are available within the SAC, a range of incident wave conditions (wave height, wave period, and wave direction) were evaluated.

Due to the nature of the study, specific wave height and occurrence parameters were not necessary. As the objective was to assess the relative difference in harbor wave response between the existing and proposed harbor configurations, rather than to estimate specific wave conditions within the harbor, quantification of the local wave climate was not essential and an input wave height of 1ft was used. CGWAVE is used in a linear mode, therefore the results for each incident wave period and direction can be taken as representative for any non-breaking wave height.

The USCG boat basin is located within the relatively sheltered environment of Port Everglades Harbor. Therefore, wave periods were limited to short waves likely to be produced by passing vessels (2 and 4 seconds), wind waves developed over the fetch of the Main Turning Basin (MTB) and SAC (6 and 8 seconds), and two cases representative of storm conditions (10 and 15 seconds). Wave periods greater than 15 seconds are extremely unlikely within Port Everglades and were not considered.

Given the location of the harbor and the established routes of vessels transiting through Port Everglades' MTB and SAC, it was determined that the incident waves could approach from a wide range of directions, depending upon the orientation of the boat basin entrance channel. The complete range of incident wave directions (covering all the existing and proposed entrance channel orientations), is illustrated in Figure 3. Wave directions were evaluated in 15^{o} increments.

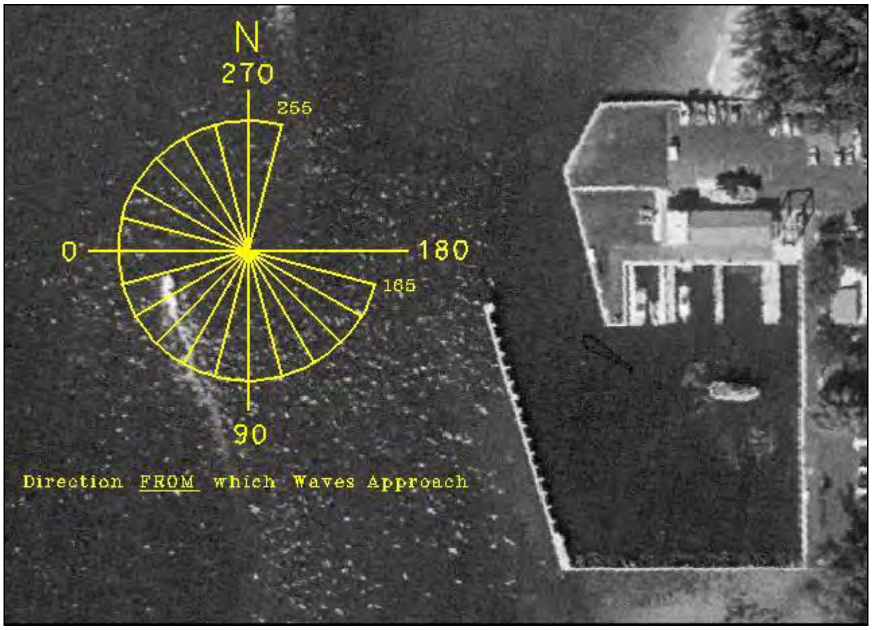

Figure 3. Study Wave Directions

Model Output

CGWAVE's principal output consists of an amplification factor (i.e. the ratio of the computed wave height to the incident input wave height) and phase at each node of the input finite element grid. Amplification factors are easily interpreted (i.e. if it is assumed that a 3ft wave is incident to the harbor entrance, an amplification factor of 0.1 at a given location will result in a wave height of 0.3ft at that location). Phases are more complex, but provide a useful means in long wave studies of interpreting harbor oscillation patterns. This study is a short wave application (incident waves have periods of less than 30 seconds), therefore phases are not considered.

CGWAVE Model Runs (Existing Layout vs Preliminary Alternative Layouts)

Existing USCG Layout

The existing USCG basin is equipped with 3 pile-supported piers, 2 aluminum floating docks, and a travel lift slip bordered by a permeable interior wall. Pile supported piers are essentially invisible to the CGWAVE model and are therefore removed as solid boundaries. The remaining piers and permeable interior wall were retained and are evident along the northern boundary of the finite element grid representing the existing harbor configuration (Figure 4). The finite element grid for the existing boat basin was generated using the USACE flow-model grid generator FASTTABS/SMS (Brigham Young, 1997). Model boundaries were defined by the existing basin dimensions and bathymetry was based on an evaluation of existing survey data and a proposed operating depth of 11ft.

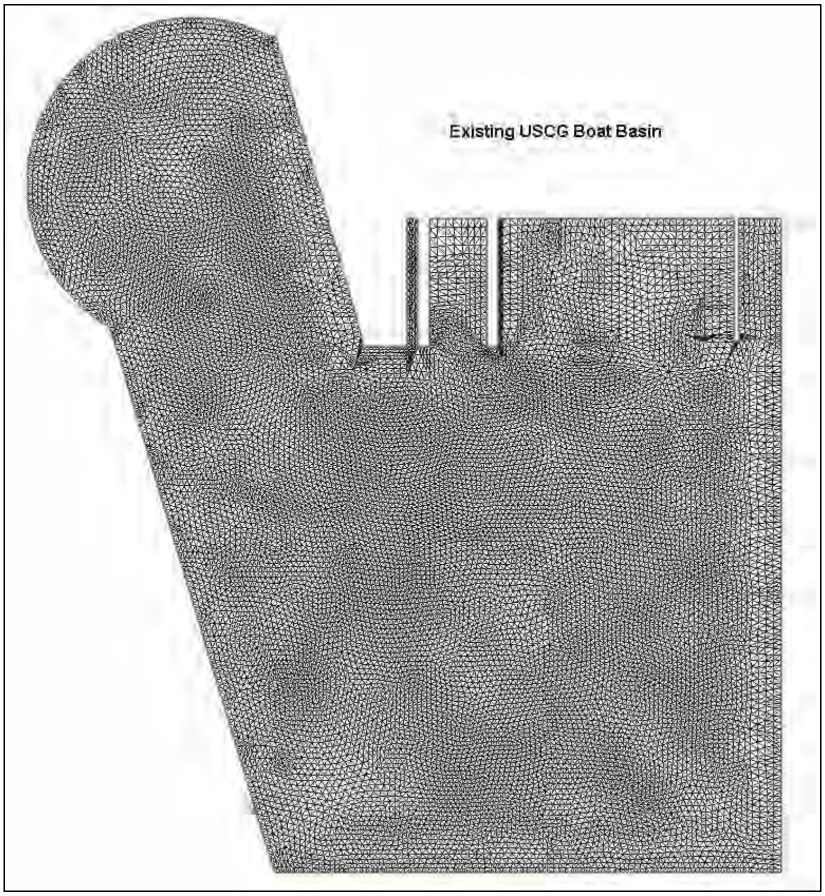

Figure 4. CGWAVE Numerical Grid – Existing USCG Boat Basin

Reflection coefficients for solid boundaries were based on visual inspection of the existing basin and the accepted ranges (based on structure type) provided previously in Table 1. The basin configuration was divided into zones based on structure type with a representative reflection coefficient assigned to each. For the existing layout, there were five structure types, standard vertical concrete bulkheads (Figure 5), wave damping bulkheads (Figures 6 and 7), rubble wave absorbers (Figure 8), floating aluminum docks, and, a permeable interior wall. Structural types and their corresponding reflection coefficients are summarized in Table 2. Reflection coefficients assigned to the existing harbor configuration are shown in Figure 9.

Table 2. Reflection Coefficients for Given Structural Zones

Structure Type	Reflection Coefficient
Standard Bulkhead	1.0
Wave Damping Bulkhead	0.8
Rubble Wave Absorber	0.5
Floating Aluminum Pier	0.2
Permeable Interior Wall	0.2

Figure 5. Example of Standard Vertical Concrete Bulkhead at USCG Fort Lauderdale

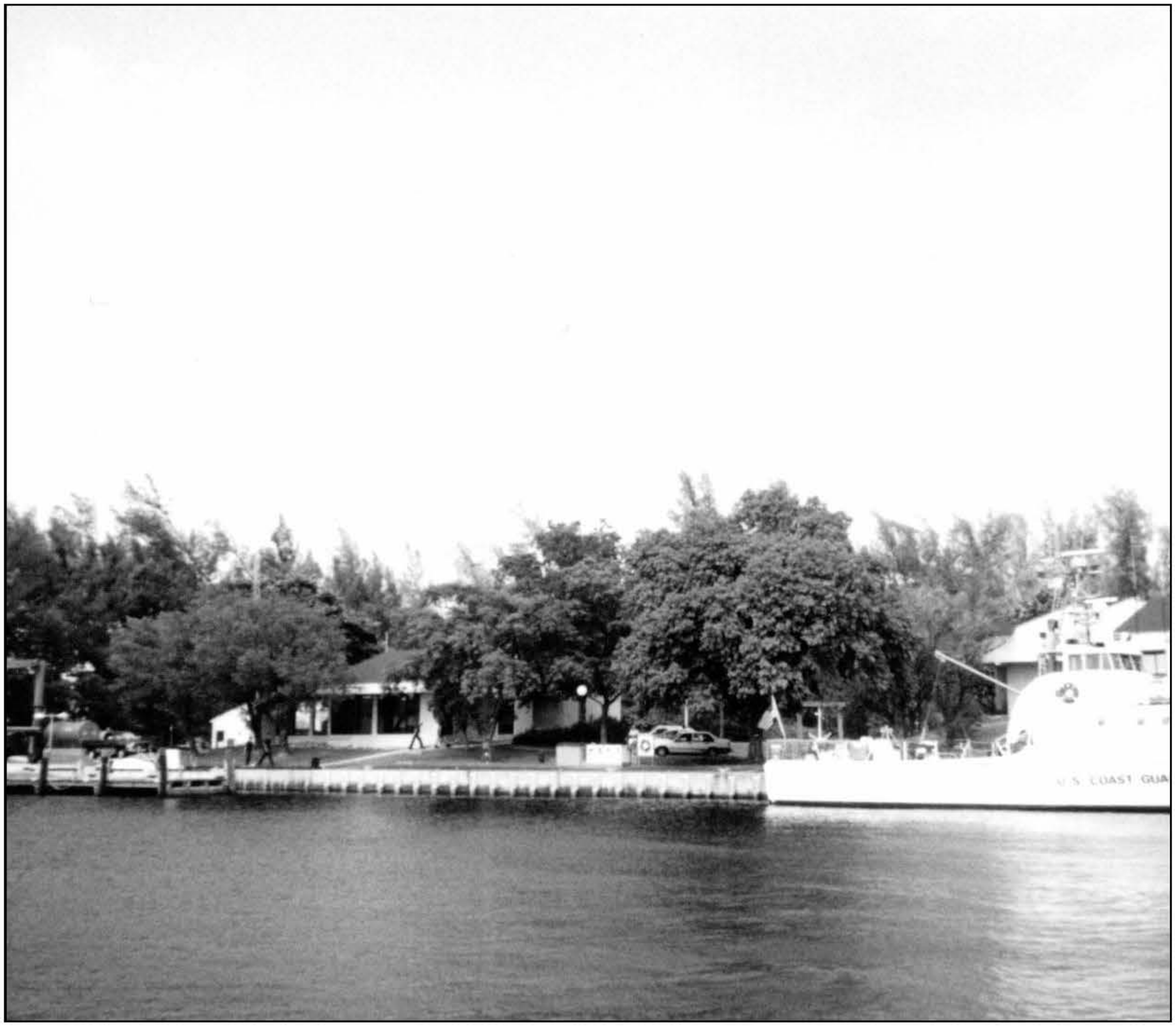

Figure 6. Example of Wave Damping Bulkhead at USCG Fort Lauderdale (East Bulkhead)

Figure 7. Example of Wave Damping Bulkhead at USCG Fort Lauderdale (Entrance Channel Bulkhead)

Figure 8. Example of Rubble Wave Absorber at USCG Fort Lauderdale (South Bulkhead)

While CGWAVE provides amplification information at every grid element, in order to closely evaluate areas where Coast Guard vessels are most affected by wave conditions, 11 output locations (OLs) were selected. A single OL is comprised of a small cluster of grid elements over which the CGWAVE response is averaged. The eleven output locations were placed in berthing areas along the harbor's boundaries. OLs 1-6 are located along the northern bulkhead berths and OLs 7-11 are located along the eastern berthing areas (Figure 10).

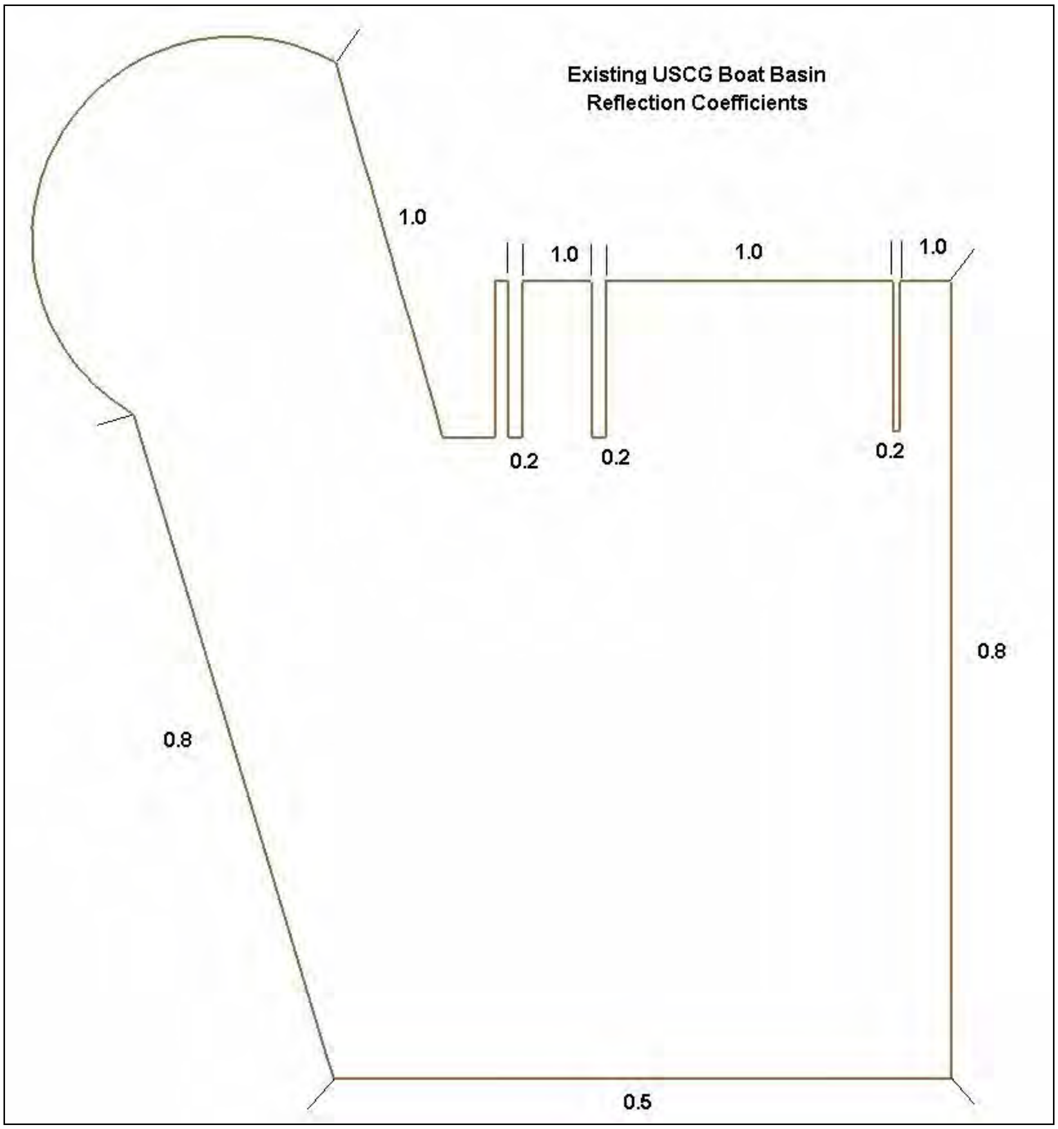

Figure 9. Reflection Coefficients Representing Existing Boundary Conditions

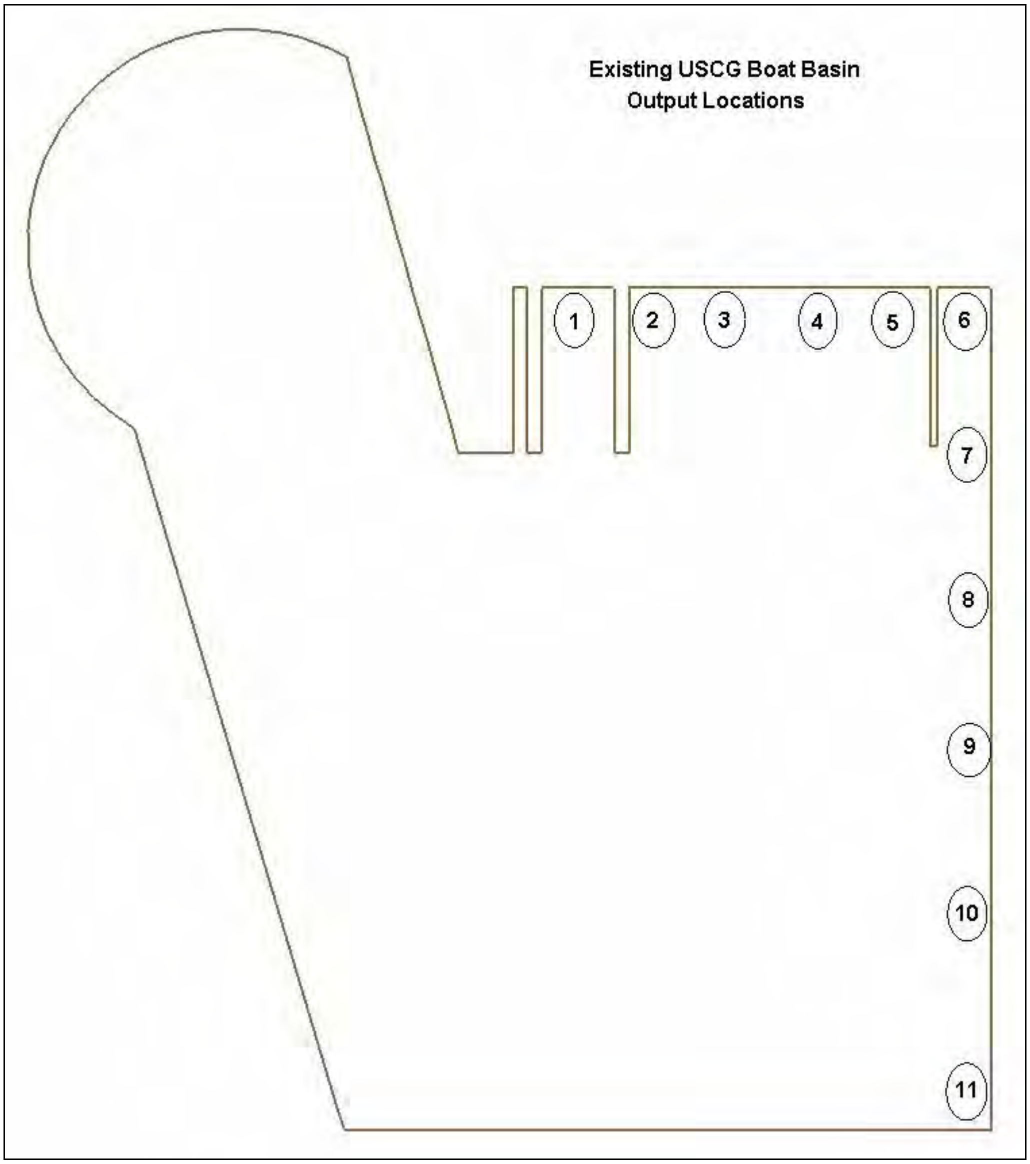

Figure 10. Output Locations for Existing USCG Boat Basin Grid

Initial Relocation Plans

Initially, a series of eight alternative plans were developed and analyzed using the CGWAVE model (Figure 11). Each alternative plan was designed to keep the existing boat basin intact, with the exception of the outer entrance channel and breakwater. Finite element grids for each alternative were generated using the USACE flow-model grid generator FASTTABS/SMS. Model boundaries were defined by existing and proposed basin dimensions. Bathymetry was based on an evaluation of existing survey data and a proposed operating depth of 11ft.

Each of the eleven output locations previously defined (OLs 1-6 located along the northern bulkhead and OLs 7-11 located along the eastern berthing areas) was repeated in each of the alternative basin configurations, allowing for a one-to-one comparison of conditions between existing and alternative plans. Additionally, reflection coefficients between the existing and alternative basin configurations were the same.

The CGWAVE numerical model was run for the existing plan and alternative plans Alt 1 through Alt 8. The incident wave height for each model run was 1ft, while incident wind directions varied based on the orientation of the basin entrance. Eleven input wind directions were evaluated for each alternative plan. Two wave periods, 2 seconds and 4 seconds, were specified for the initial runs. These are considered to be representative of a majority of incident waves and provide a sound basis for initial evaluation of relative changes in basin amplification.

Results(Existing vs Initial Plans)

Maximum amplification factors, regardless of incident wave direction, were determined for each basin configuration for each wave period. The percent increase/decrease of amplification at each basin (relative to the existing basin) is provided in Tables 3 and 4.

As shown in Tables 3 and 4, alternatives Alt 1 through Alt 7, show marked increases in the amplification of wave energy within the USCG boat basin, particularly in the northwest and northeast regions. Maximum increases for these alternatives exceed 200% and reach a maximum (Alt 6) of 486%. Such increases are not acceptable in meeting the goal of maintaining the existing level of protection to USCG vessels. Therefore, alternatives Alt 1 through Alt 7 were discarded from further consideration.

Both Tables 3 and 4 indicate that Alt 8 does not show significant increases in wave amplification. This alternative has only a 2% increase at OL 11 (southeast corner) for a 4-second wave and displays reductions in amplification at all other berthing locations for both 2- and 4-second waves. However, while numerical results show an adequate level of protection from incident waves, consultation with USCG personnel indicated that the overall basin configuration would create undue navigational hazards to larger USCG vessels. The configuration of the basin entrance would also unacceptably increase response times for smaller USCG vessels during emergency operations. Alternative 8 was therefore also eliminated from further consideration.

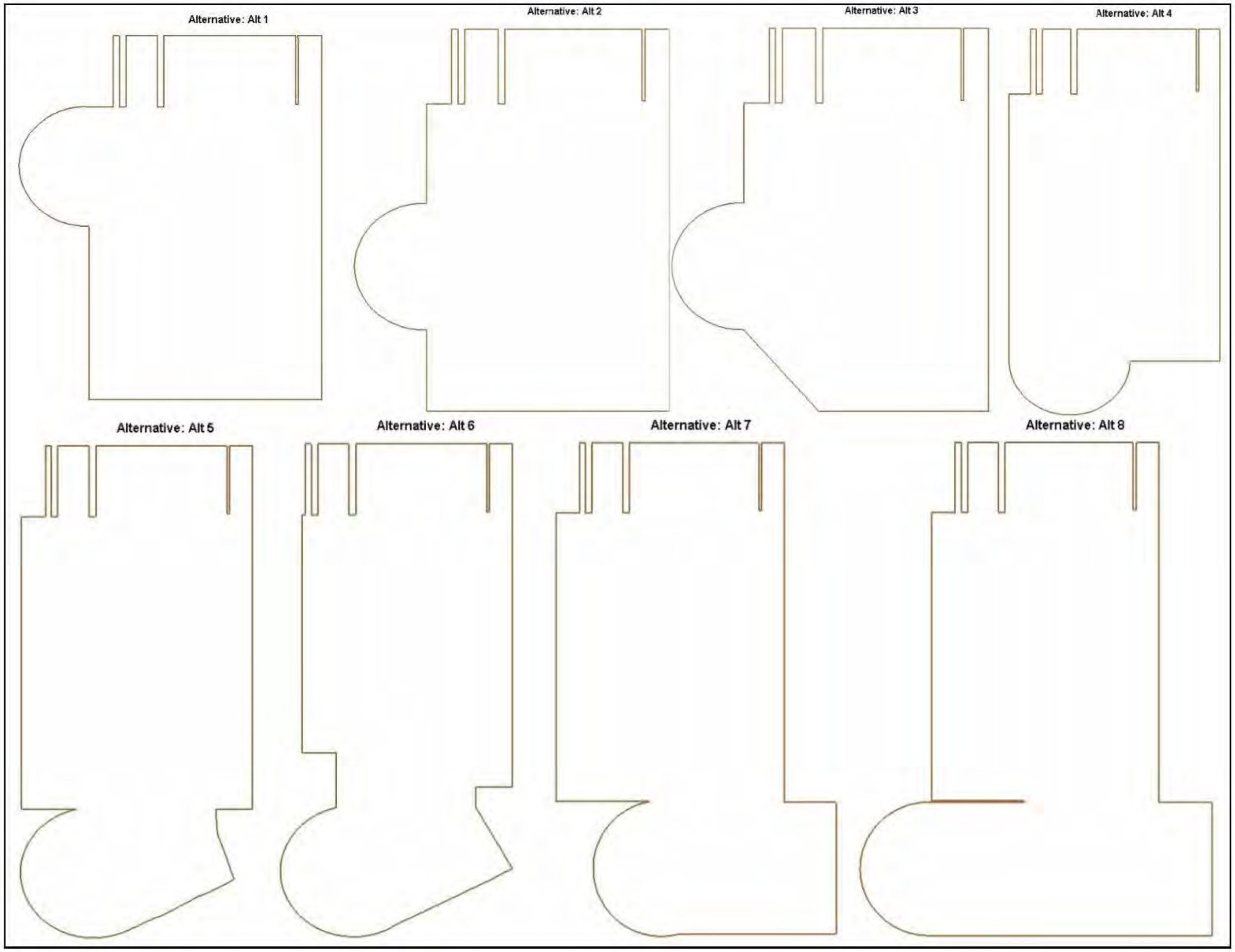

Figure 11. Alternate USCG Plans: Alt 1 through Alt 8

Table 3. Percent Increase/Decrease of Amplification (2-Second Wave Period)

Percent Increase/Decrease of Amplification Relative to Existing Boat Basin (2sec Wave)								
OL	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
1	54	37	31	438	134	-3	-17	-74
2	227	184	48	119	51	151	-5	-43
3	120	82	8	73	-26	98	37	-66
4	149	107	109	88	27	48	24	-44
5	192	290	153	233	75	486	67	-12
6	290	473	165	215	248	324	208	-2
7	284	311	236	155	245	275	129	-14
8	77	31	41	9	-12	-16	-23	-72
9	155	120	102	29	3	68	24	-52
10	151	189	121	45	20	83	71	-10
11	65	26	15	-28	-15	10	16	-6

Table 4. Percent Increase/Decrease of Amplification (4-Second Wave Period)

Percent Increase/Decrease of Amplification Relative to Existing Boat Basin (4sec Wave)								
OL	Alt 1	Alt 2	Alt 3	Alt 4	Alt 5	Alt 6	Alt 7	Alt 8
1	269	177	75	554	182	73	4	-67
2	147	109	5	189	95	292	41	-18
3	22	18	13	54	-33	19	-40	-48
4	106	113	60	163	21	24	2	-57
5	117	202	108	115	-22	37	19	-51
6	256	180	88	218	52	172	24	-72
7	39	13	51	157	97	113	21	-70
8	93	139	97	127	26	153	5	-43
9	78	29	-14	-18	-38	12	-50	-82
10	19	43	63	6	-14	8	-9	-23
11	99	124	31	-37	-44	18	29	2

Modified USCG Design Plans

After the elimination of the original eight design plans, USACE and USCG personnel coordinated to develop a second set of plans that would better accommodate vessel maneuverability and operational functions. The resulting alternatives were denoted USCG Designs 1, 2, and 3 and can be seen graphically in Figure 12.

The CGWAVE numerical model was run for the three USCG Design configurations for 2- and 4-second wave periods using variable boundary reflection coefficients to minimize reflections.

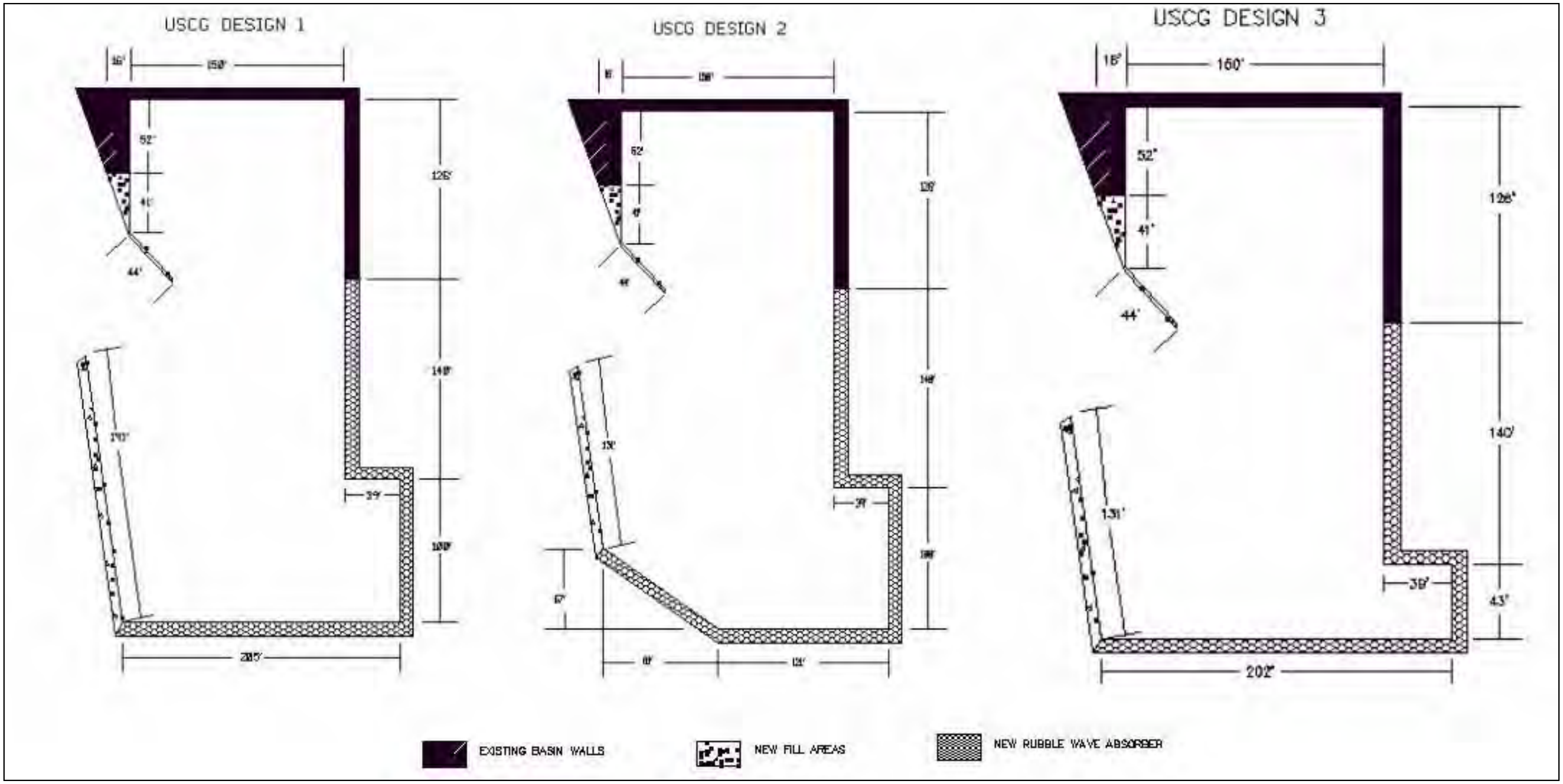

Figure 12. USCG Boat Basin Alternatives: Design 1, Design 2, and Design 3

Results(Existing vs Modified Plans)

While initial model runs showed promising amplification results, further refinement of the SAC (based on ship simulation results) resulted in additional changes to channel dimensions that directly conflicted with the outer breakwater of Designs 1 – 3. Removal of the breakwater would result in unacceptably high wave conditions within the basin. Therefore, Designs 1 – 3 were removed from further consideration.

CGWAVE Model Runs (Existing Layout vs Final Layout)

Final Relocated USCG Basin Layout

The final relocated USCG layout addressed in this report was developed in coordination with USCG personnel. Previous coordinated efforts to develop alternative basin layouts were unsuccessful due to either unacceptable wave amplification detected by CGWAVE or operational constraints that would interfere with the function of the station. In August of 2009, as part of the coordination effort, the USCG Civil Engineering Unit Miami provided a facility and infrastructure requirements report for Station Fort Lauderdale (Attachment A). Included in this report was a proposed relocated basin layout, made possible by removal of restrictions on relocating specific structures, that would meet operation requirements of the facility. Figure 13 shows a slightly modified version of this layout, with the entire basin footprint shifted approximately 80ft to the west in order to minimize property impacts. Based upon this modified layout, a numerical grid and corresponding set of CGWAVE model runs were developed.

Figure 13. Proposed Relocated USCG Boat Basin

The relocated boat basin has approximately the same shape and dimensions as the existing boat basin. The primary difference between the two layouts is their location within the boundary of the USCG property. The relocated basin is approximately 170ft east of the existing basin, allowing for the expansion of the SAC. Due to the similar layout and dimensions, 11 OLs were specified (Figure 14). Each OL corresponds to a similarly placed OL in the existing basin layout. This allows for a one-to-one comparison of conditions between existing and relocated design.

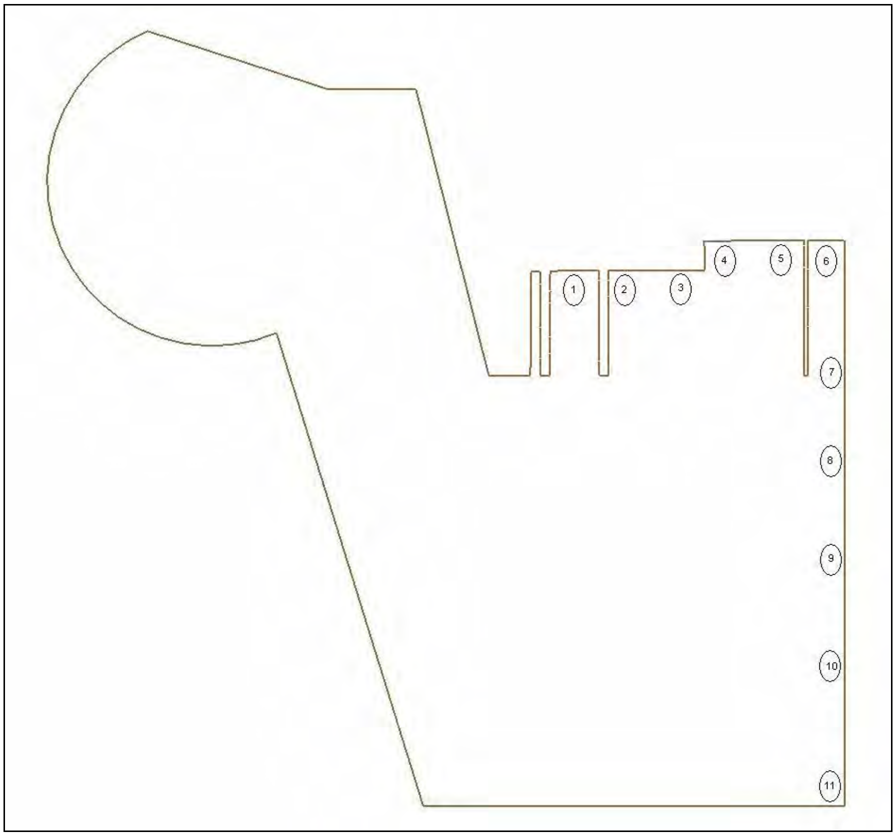

Figure 14. Output Locations for Relocated USCG Boat Basin Grid

Specification of reflection coefficients within the relocated basin were initially based on those of the existing basin (Figure 15). Because the type and location of docks can influence the amplification characteristics of the basin, docks identical to the existing docks were placed in similar locations within the relocated basin and assigned the same reflection coefficients. The basin boundaries, including wave damping bulkheads and rubble wave absorbers, remained unchanged.

Input wave conditions for the relocated basin were identical in amplitude (1ft) and period as those evaluated for the existing basin layout. Due to a slightly more western facing entrance, however, the range of wave directions differed. Table 5 provides the input wave period and directions associated with CGWAVE runs of the relocated basin layout (compared to those of the existing basin runs).

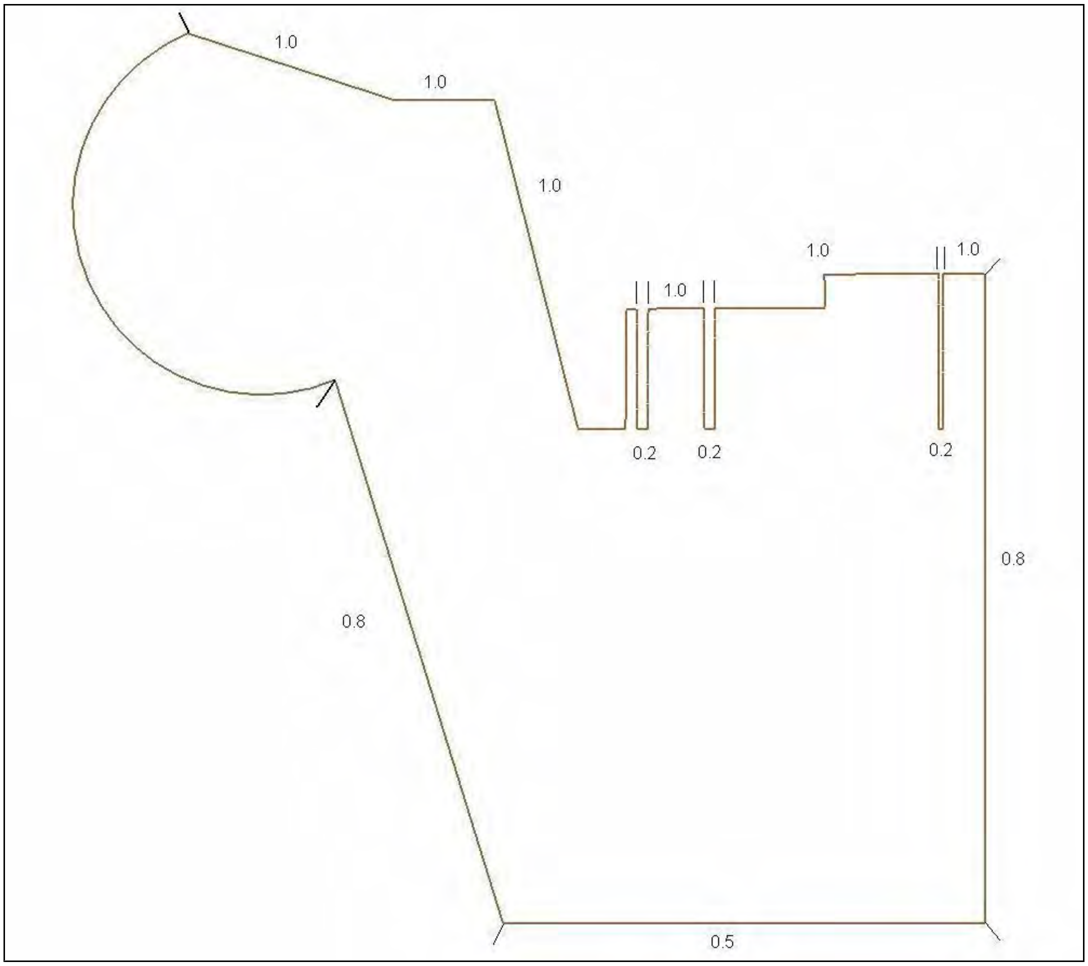

Figure 15. Reflection Coefficients Representing Relocated Basin Boundary Conditions

Table 5. CGWAVE Input Conditions – Relocated Basin

Wave Period (Sec)	Wave Direction (Deg-from)	
	Existing Basin	Relocated Basin
2	255	300
4	270	315
6	285	330
8	300	345
10	315	0
15	330	15
	345	30
	0	45
	15	60
	30	75
	45	90
	255	105

Results (Existing vs Relocated)

Maximum amplification factors, regardless of incident wave direction, were determined for both basin configurations. Maximum amplification factors for each basin layout (at each OL) are shown in Figures 16-21 for each wave period. The percent increase/decrease of amplification, indicating the increase or decrease in wave height (wave energy) at each OL relative to the existing basin, is provided in Figure 22.

Figure 22 indicates that at each OL, at least one wave condition (wave period) induces an increase in wave height (increase in wave amplification factor). The percent increase ranges from 4% at OL 9 (eastern dock) to 135% at OL 2 (northern dock). Given the magnitudes of the larger percent increases and the fact that all areas of interest show some degree of increased wave energy, it is apparent that the present relocation plan does not provide the same degree of protection to moored vessels as the existing layout.

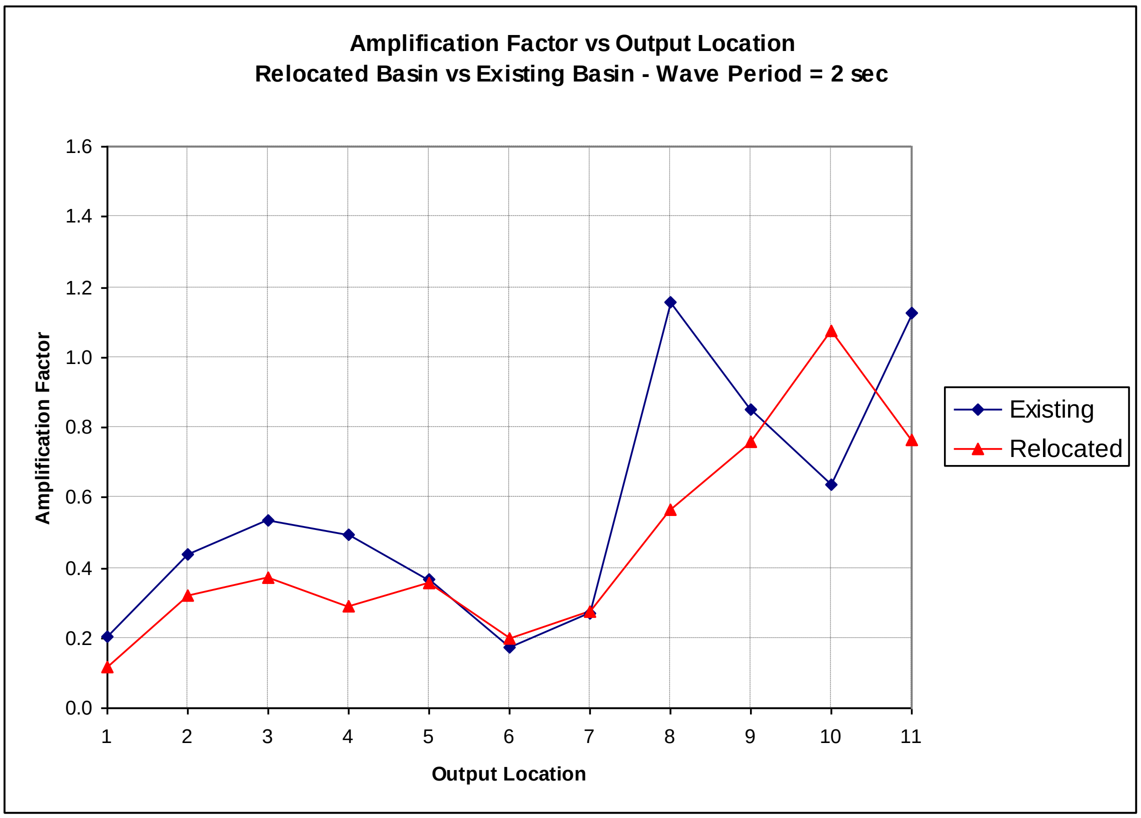

Figure 16. Maximum Amplification Factor – Relocated vs Existing (Period = 2sec)

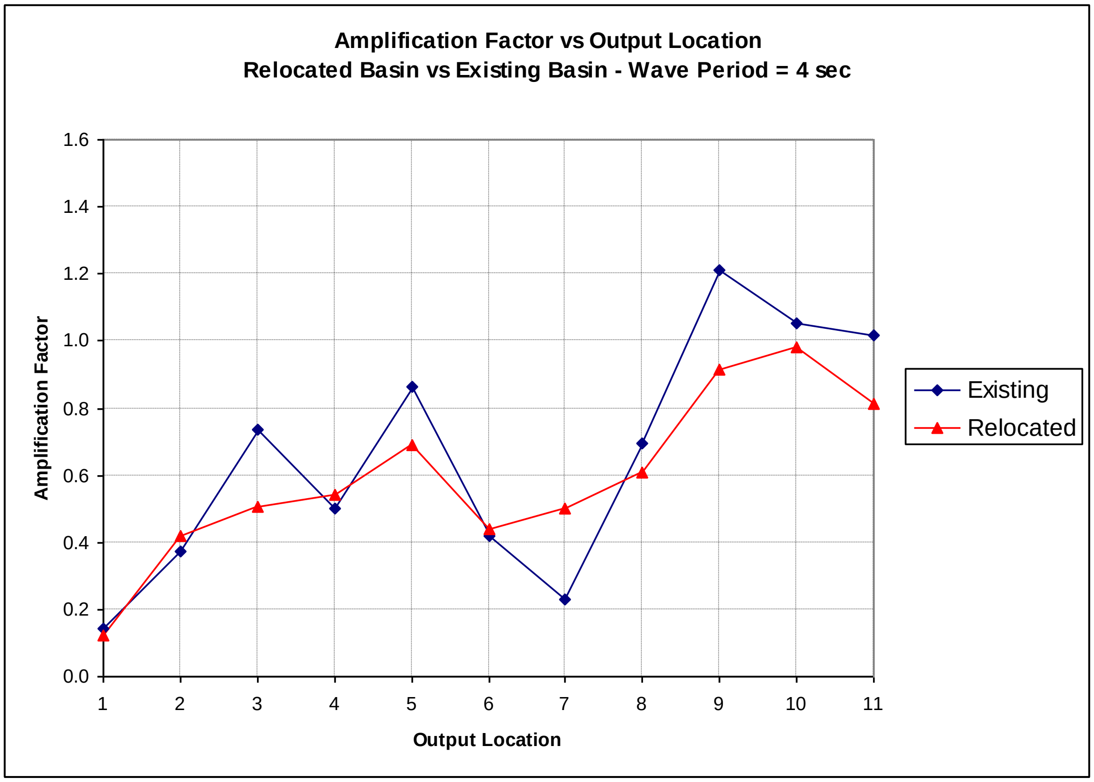

Figure 17. Maximum Amplification Factor – Relocated vs Existing (Period = 4sec)

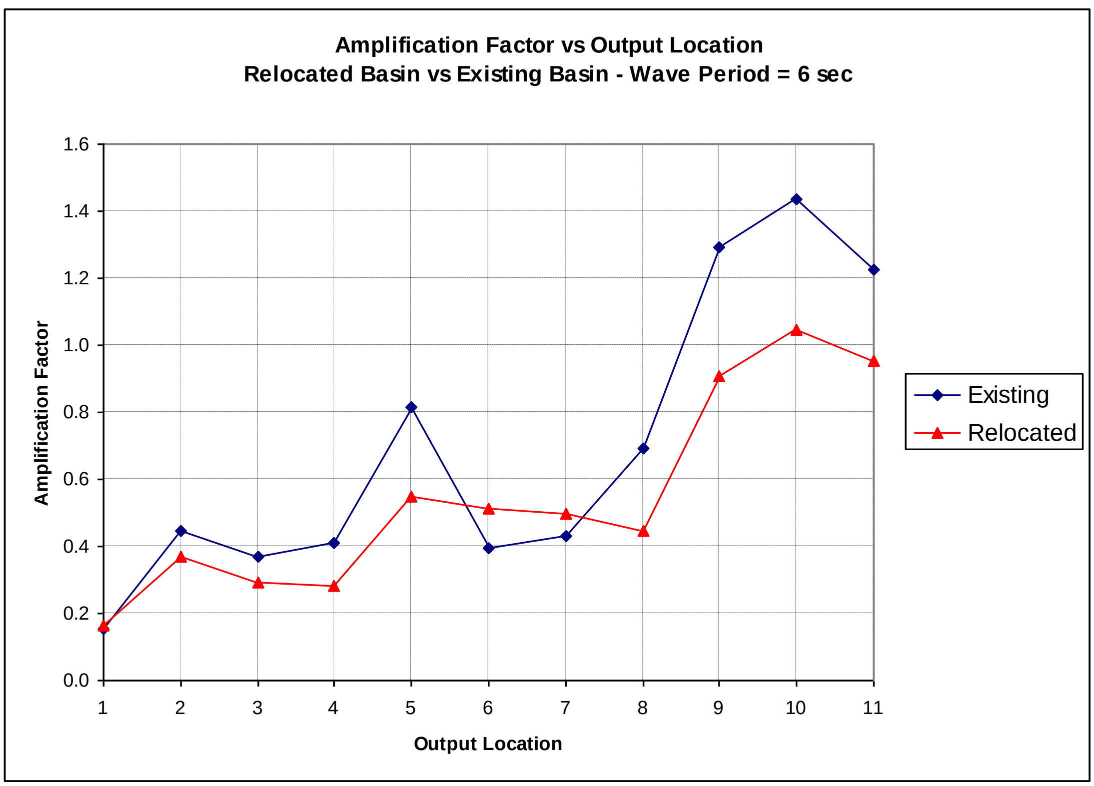

Figure 18. Maximum Amplification Factor – Relocated vs Existing (Period = 6sec)

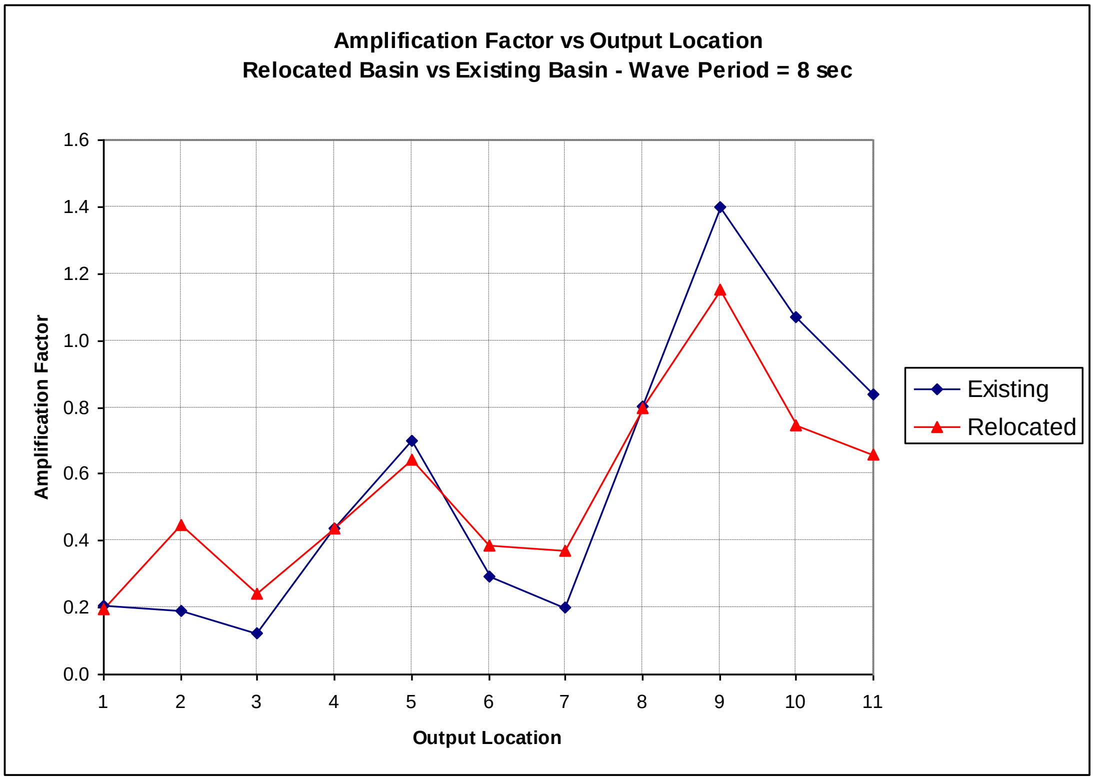

Figure 19. Maximum Amplification Factor – Relocated vs Existing (Period = 8sec)

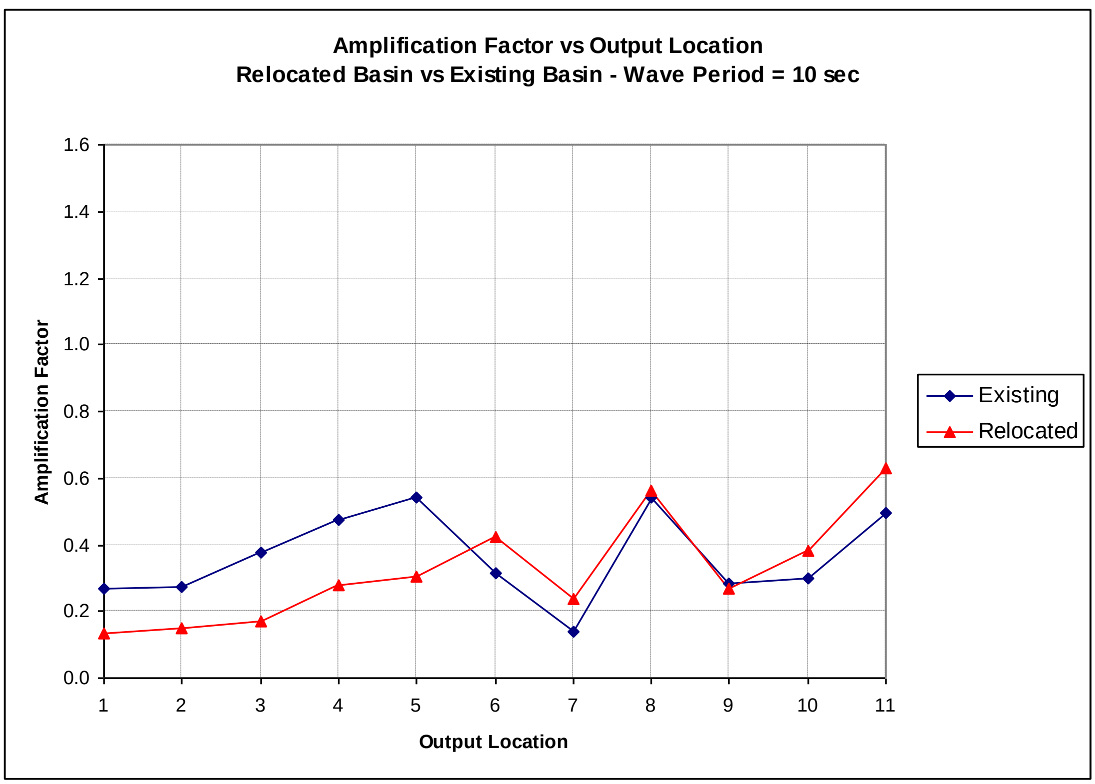

Figure 20. Maximum Amplification Factor – Relocated vs Existing (Period = 10sec)

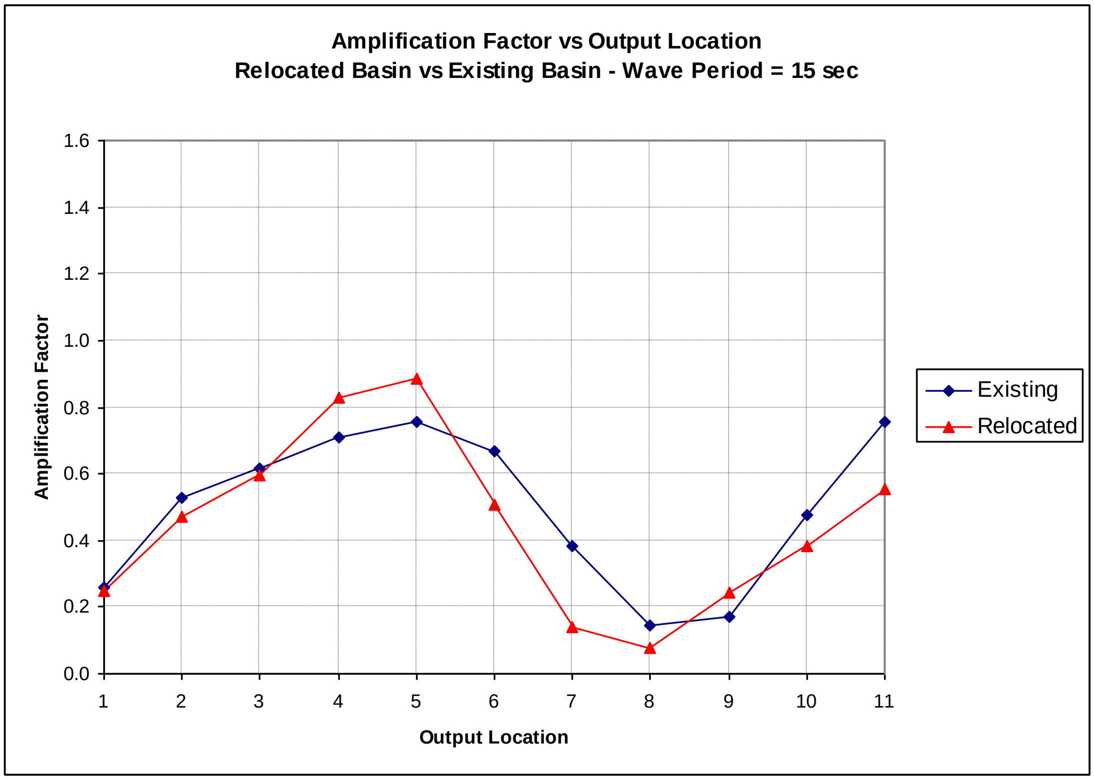

Figure 21. Maximum Amplification Factor – Relocated vs Existing (Period = 15sec)

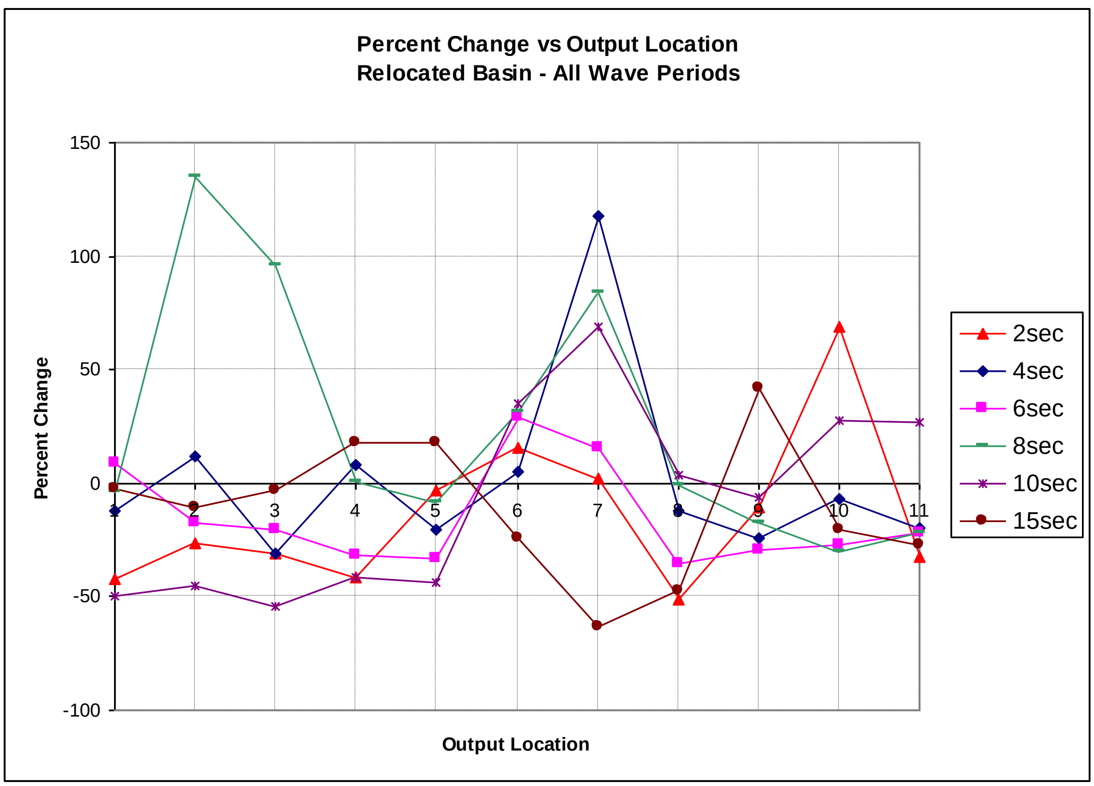

Figure 22. Percent Change in Amplification Factor – Relocated (All Wave Periods)

Relocated Basin Optimization

Optimization Alternatives

The results of the preliminary comparison between the existing basin layout and the relocated basin layout show that the new basin layout does not provide the same level of protection against incident wave energy. Because the physical layout of the proposed basin is the most suitable to date for operations, it is preferable to optimize the wave response by modifying bulkhead types rather than reconfiguring basin dimensions. The bulkheads selected for optimization were the three segments nearest the opening of the basin entrance channel (Figure 23). Modification involved altering the original bulkhead type from a standard vertical bulkhead to either a wave damping bulkhead, or rubble wave absorber. Table 6 provides 8 alternative bulkhead configurations (including the original relocation design) with corresponding reflection coefficients. Other than the three bulkhead portions indicated, all reflection coefficients remained the same.

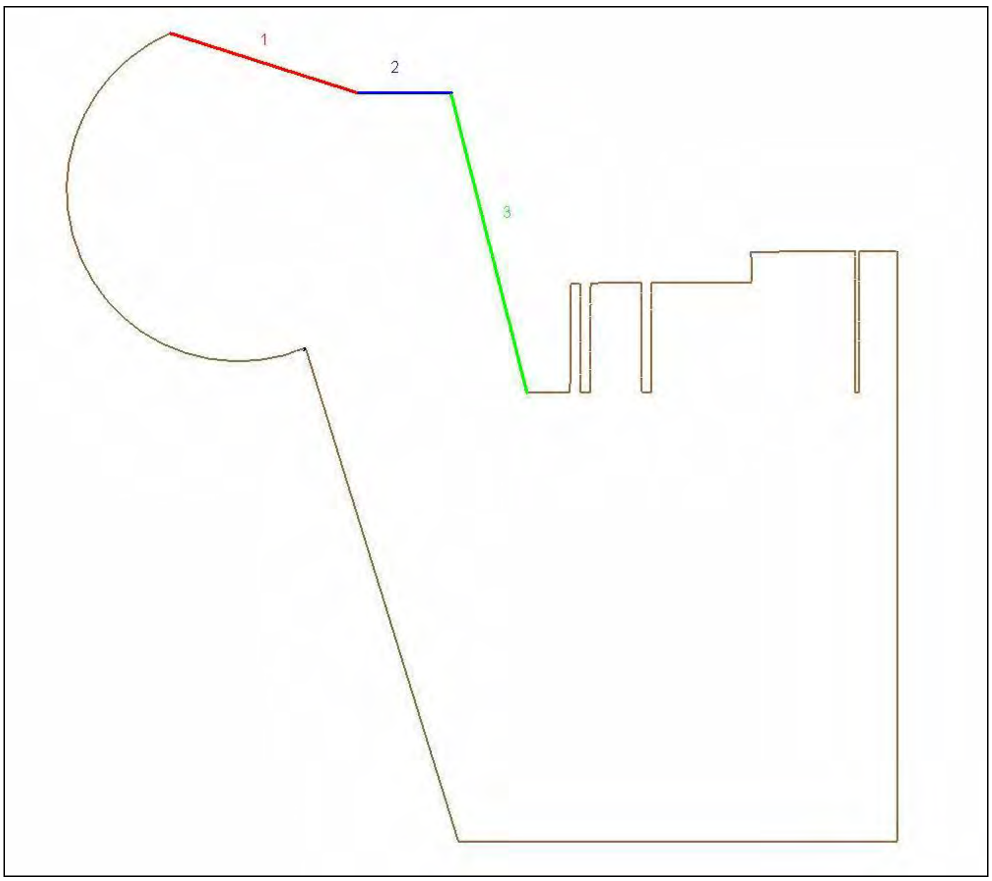

Figure 23. Bulkhead Segments Optimized for Wave Damping

Table 6. Entrance Channel Bulkhead Type (Reflection Coefficient) by Alternative

Alternative Configuration	Bulkhead Type (Reflection Coefficient) by Bulkhead Segment		
	1	2	3
A (Original "Relocated")	Standard (1.0)	Standard (1.0)	Standard (1.0)
B	Wave Damping (0.8)	Standard (1.0)	Standard (1.0)
C	Rubble (0.5)	Standard (1.0)	Standard (1.0)
D	Wave Damping (0.8)	Wave Damping (0.8)	Wave Damping (0.8)
E	Rubble (0.5)	Wave Damping (0.8)	Wave Damping (0.8)
F	Rubble (0.5)	Rubble (0.5)	Wave Damping (0.8)
G	Rubble (0.5)	Rubble (0.5)	Rubble (0.5)

Optimization Results

Maximum amplification factors, regardless of incident wave direction, were determined for all basin configurations for each wave period. Maximum amplification factors for the six additional configurations (B – G) can be found in Attachment B. The percent increase/decrease of amplification at each OL for each alternative plan (relative to the existing basin) is provided in Figures 24 to 29.

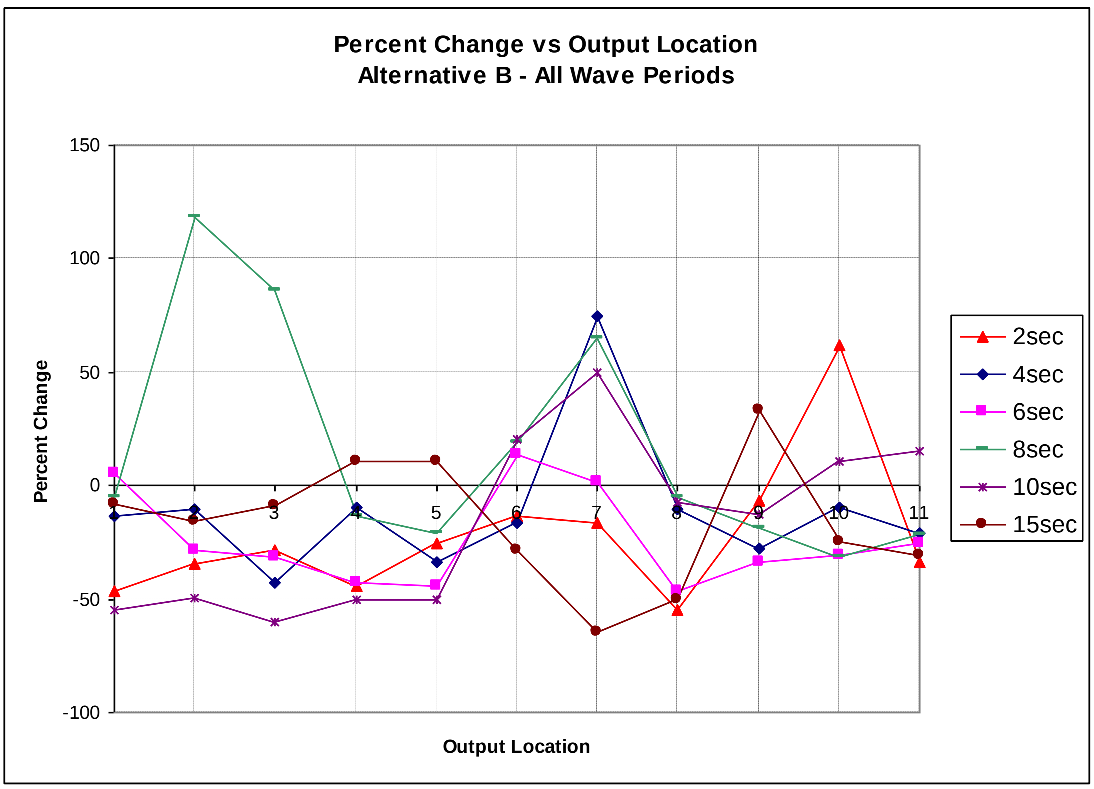

Figure 24. Percent Change in Amplification Factor – Alt. B (All Wave Periods)

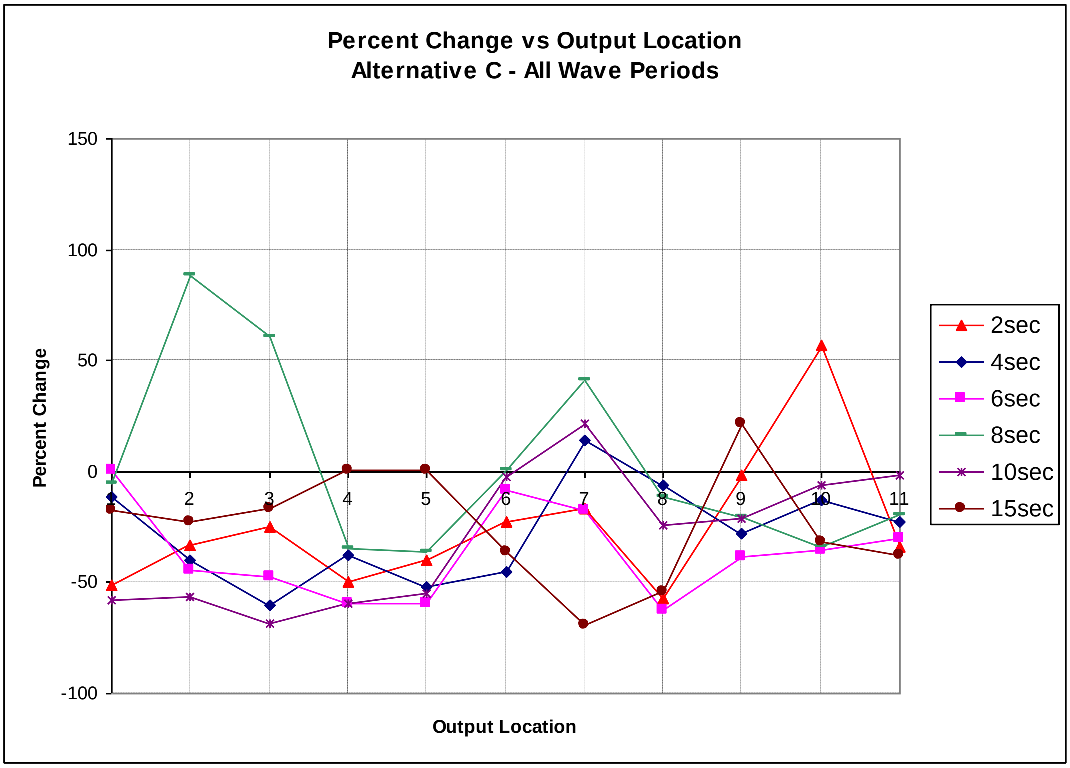

Figure 25. Percent Change in Amplification Factor – Alt. C (All Wave Periods)

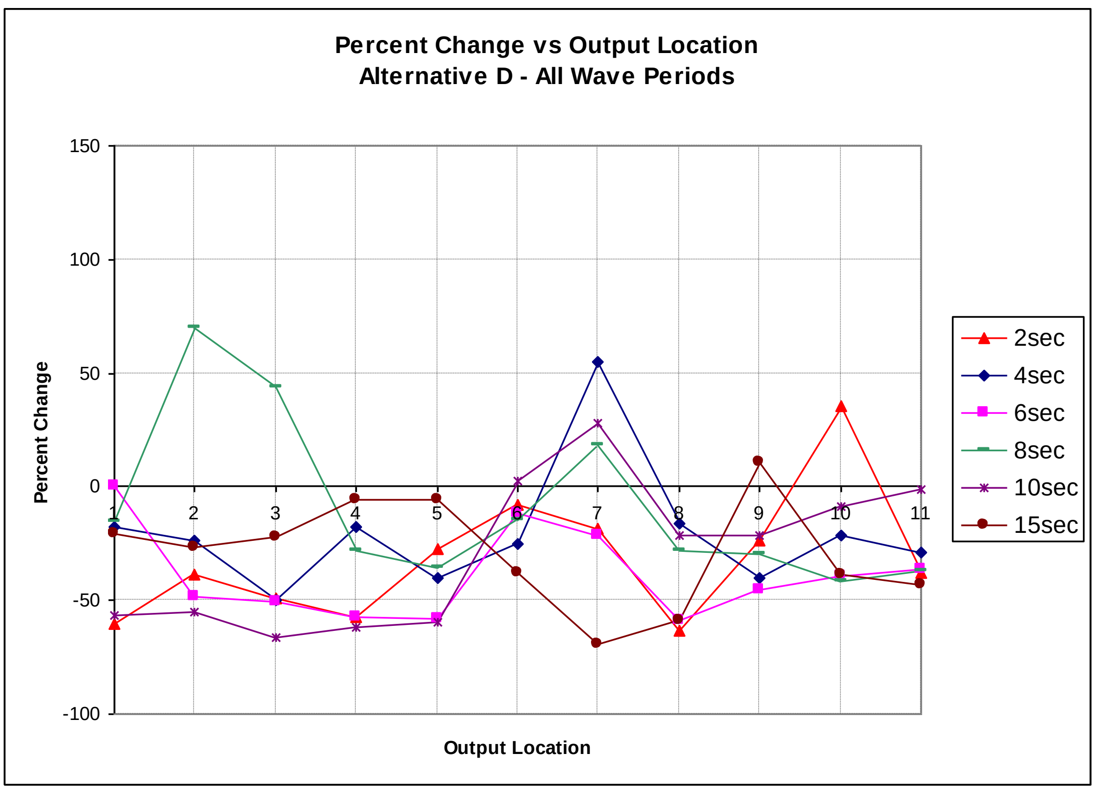

Figure 26. Percent Change in Amplification Factor – Alt. D (All Wave Periods)

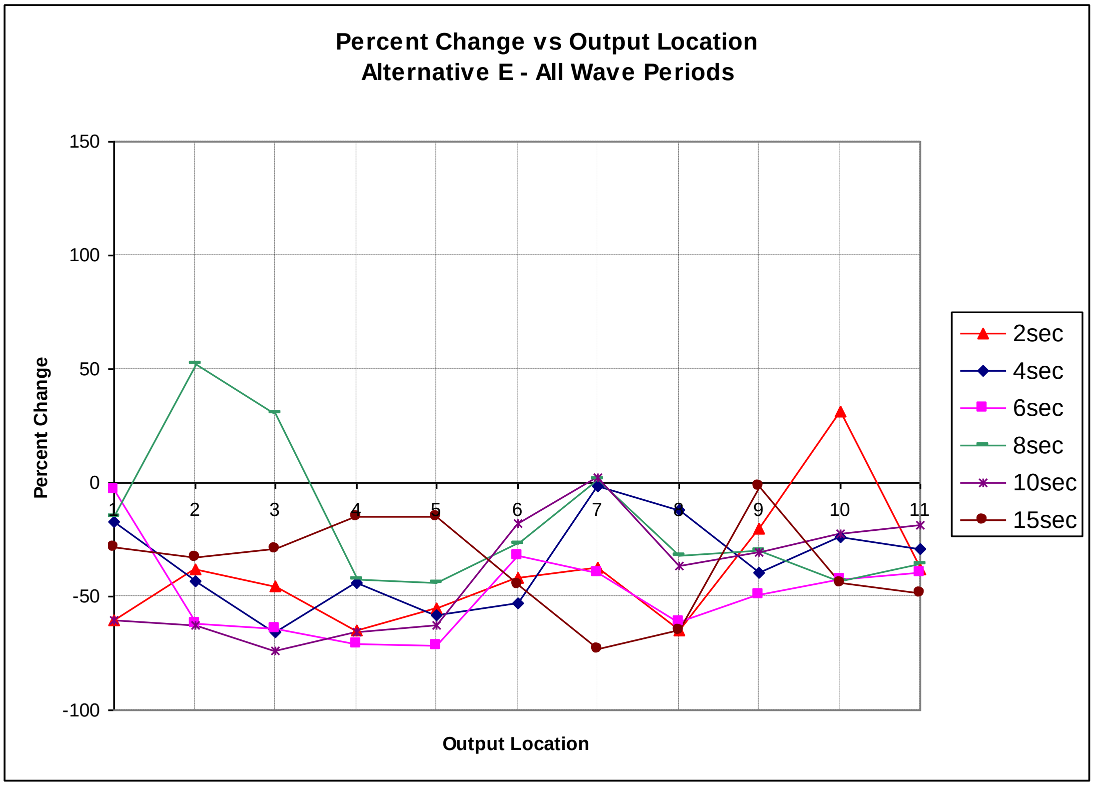

Figure 27. Percent Change in Amplification Factor – Alt. E (All Wave Periods)

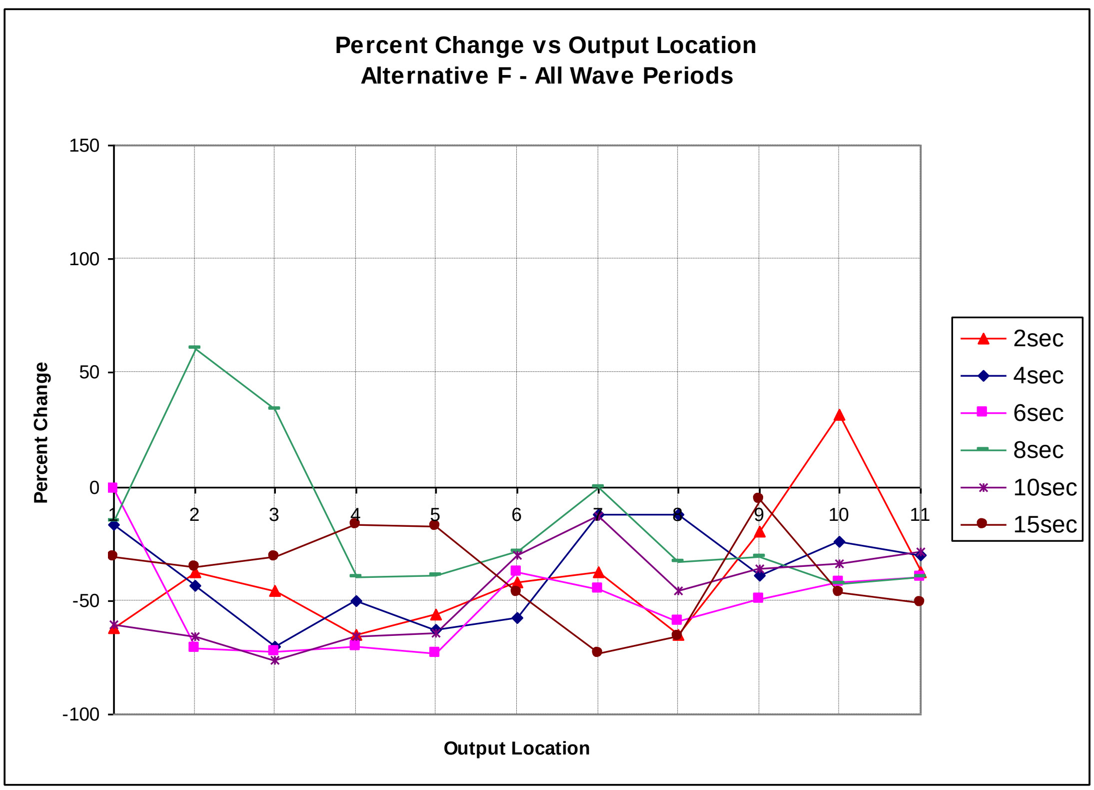

Figure 28. Percent Change in Amplification Factor – Alt. F (All Wave Periods)

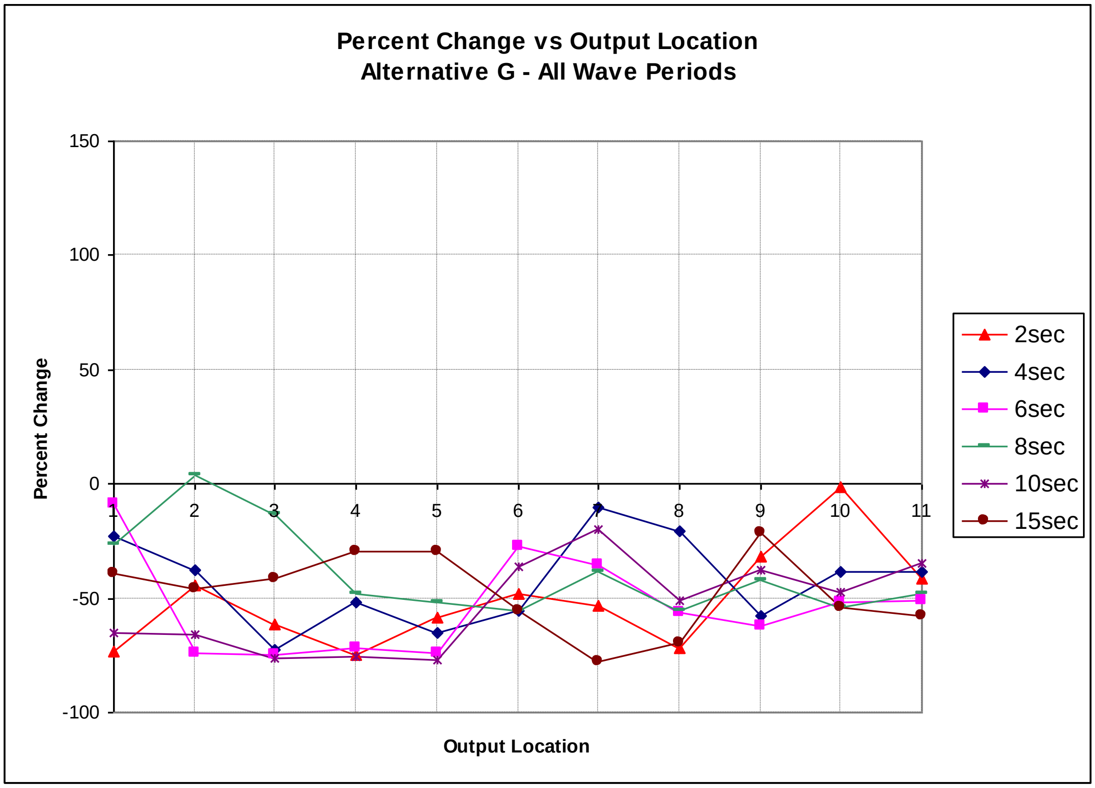

Figure 29. Percent Change in Amplification Factor – Alt. G (All Wave Periods)

Results provided in Figures 24 through 29 show instances of both significantly increased wave amplification and significantly decreased wave amplification. Alternatives with standard vertical concrete bulkheads in the vicinity of the entrance channel (B and C) have the largest increases in wave amplification over the existing basin. Percent changes range from -5% to 118% (B) and -6% to 88% (C). Replacing standard bulkheads with wave damping bulkheads (D, E, and F) reduces the magnitude, but does not eliminate increases of wave amplification. Percent changes in amplification for these alternatives range from -16% to 70% (D), -18% to 52% (E), and -29% to 61% (F).

Replacing all three standard bulkheads with riprap proved to be the most effective way to virtually eliminate increases in wave amplification in the mooring areas of the relocated plan. Alternative G produces percent changes ranging from -35% to 4%. Of the 11 OLs, all but OL 2 experience a reduction in wave amplification, which reduces predicted wave heights (wave energy) in a majority of the mooring locations. OL 2 does experience an increase in wave amplification. However the increase is small (4%) and occurs for only a single case (8 second wave period). The remaining wave periods resulted in decreases in wave amplification at OL 2 ranging from -38% to -74%. Based on an examination of all cases, it was determined that the minor increase in wave amplification was not significant enough to pose a danger to USCG vessels or negatively impact operations.

Conclusions

Figure 29 indicates that the relocated USCG boat basin (as presented in Figure 13), with bulkheads constructed according to reflection coefficients optimized in Alternative G, provides a level of wave protection that is, in most cases, greater than that of the existing basin. A 4% increase for a single wave condition was shown, but is not considered to be detrimental to station vessels or operations. Based on these results and pending verification that the layout of the basin and orientation of the entrance channel continue to meet USCG operational requirements, the Alternative G relocated basin design will be adopted as the draft USCG boat basin design for inclusion in the draft Port Everglades Harbor Feasibility Report.

It should be noted that although this report provides a draft USCG basin relocation plan, it does not draw conclusions other than to indicate that the draft plan meets safety and operational requirements in regard to the local wave climate. USCG personnel have the final authority on the design and construction of USCG facilities and may chose to conduct further evaluations or make further modifications as necessary to meet USCG goals. This report provides both a viable alternative appropriate for the feasibility phase of the Port Everglades Harbor Study and a set of data that can be used in conjunction with first hand knowledge of operational and safety requirements, local wind and current climates, and existing navigational conditions to determine a final design plan for relocation of the USCG facility at Fort Lauderdale.

References

Demirbilek, Z. and Panchang, V. (1998). CGWAVE: A Coastal Surface Water Wave Model of the Mild Slope Equation, *Technical Report CHL-98-26*, U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory, Vicksburg, Ms.

Brigham Young University Engineering Computer Graphics Laboratory (1997), "Surface-Water Modeling System Reference Manual," Brigham Young University, Provo, UT.

Attachment A

Facility & Infrastructure Requirements for

Station Fort Lauderdale Multi-Mission Facility

Fort Lauderdale, Florida

FACILITY & INFRASTRUCTURE REQUIREMENTS FOR

STATION FORT LAUDERDALE MULTI MISSION FACILITY

FORT LAUDERDALE, FLORIDA

U.S. Coast Guard
Civil Engineering Unit Miami

15608 S.W. 117th Avenue
Miami, FL 33177

August 2009

EXECUTIVE SUMMARY

The purpose of this document is to identify the current Coast Guard Station Ft Lauderdale facility requirements, and to provide the necessary background information should it become necessary to relocate or rebuild the Station as a result of the Southport access channel widening project.

In 1997 when the Port Everglades Harbor Feasibility Study was initiated, it was identified that widening of the "knuckle" (Southport access channel) is necessary for port expansion. The proposed Southport access channel impacts the USCG boat basin's exterior breakwater and requires the property to setback approximately 300 feet parallel to the channel. The original plan proposed by the Army Corps of Engineers (ACOE) was to cut a new basin into the Station property and rebuild the structures previously in the footprint of the new basin. However, this plan did not provide mitigation for the property loss and greatly reduced the Station's spatial functionality, operational readiness, and capacity for surge, expansion, recreation, and community outreach, and is therefore considered nonviable to the Coast Guard.

The ACOE has requested a cost estimate for the anticipated construction at Station Ft Lauderdale associated with this project. However, since the proposed plan was determined nonviable, the Coast Guard has identified and presented additional options in order to capture a more realistic summary of the implications and costs associated with necessary mitigation strategies. This document describes the shortfalls of the proposed plan, recommends potentially acceptable alternatives, and provides an estimated cost of constructing new facilities.

The most viable alternative is to rebuild a new, single, multi-mission facility east of the current basin, demolish all existing buildings, and rebuild a new basin that will maintain the same proportion and dimensions of the current basin. This new building is envisioned to meet the requirements of the Station, Aids to Navigation Team (ANT), and USCGC GANNET. This will minimize the amount of property lost for the construction of the basin and ensure that the Coast Guard missions are not adversely affected. The new facility should be constructed to support Station Ft Lauderdale's operational mission and personnel allocation at the time of construction, which is subject to minor changes between now and then.

The new facility should be designed to withstand a Category III hurricane, as per the load requirements of ASCE 7-05 for gravity loads, flood, wave action and wind. The lowest finished floor elevation should be 1 foot above the 100 year flood plain.

The optimal facility is approximately 34,000 Gross Square Feet at a cost of $19 million, based on historical cost of construction of similar facilities. *Note: The costs represented in this document are only those associated with the building and associated site work but do not include the costs of the new basin, waterfront, or new land acquisition, remediation, and/or preparation.*

LIST OF ACRONYMS AND GLOSSARY

AC	Acre
ANT	Aids to Navigation Team
AOR	Area of Responsibility
AtoN	Aids to Navigation
BFR	Basic Facility Requirement
CG	Coast Guard
CGC	Coast Guard Cutter
CATEX	Categorical Exclusion (NEPA)
COMDTINST	Commandant Instruction
GSF	Gross Square Feet
NSEU	Nova South Eastern University
NSF	Net Square Feet
NEPA	National Environmental Policy Act
NM	Nautical Mile
OIC	Officer in Charge
PAL	Personnel Allocation List
SFCAM	Shore Facilities Capital Asset Management
SF	Square feet/ Square Foot
UFC	Unified Facilities Criteria
US ACOE	United States Army Corp of Engineers
USCG	United States Coast Guard
USCGC	United States Coast Guard Cutter

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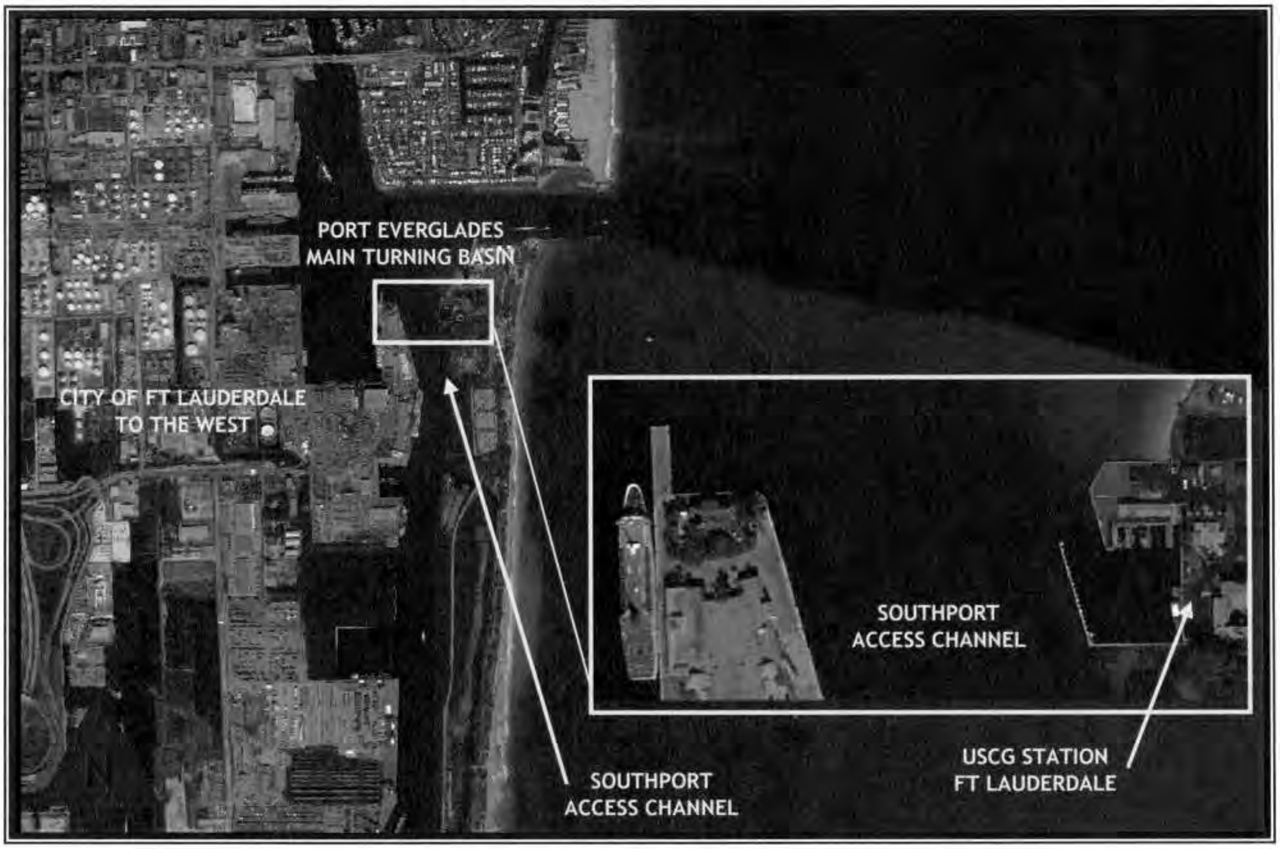
Appendices

1.0 INTRODUCTION

1.1 Purpose

The purpose of this document is to present alternatives that will accommodate the proposed port expansion and associated widening of the Southport access channel, while maintaining at a minimum, the present level of protection afforded to USCG vessels within the boat basin, and the level of operations and readiness required at the Station's current site.

Exhibit 1.1. Vicinity Map



1.2 Methodology

This document includes recommendations, alternative analysis, preliminary cost estimates, supporting photos and other graphical documentation. The alternatives were developed using COMDTINST M11012.9, Shore Facility Standards Manual (SFSM) outlined requirements, GIS mapping, and on-site interviews with Station personnel. This report ensures a right-sized facility that meets the minimum operational requirements and potential future growth.

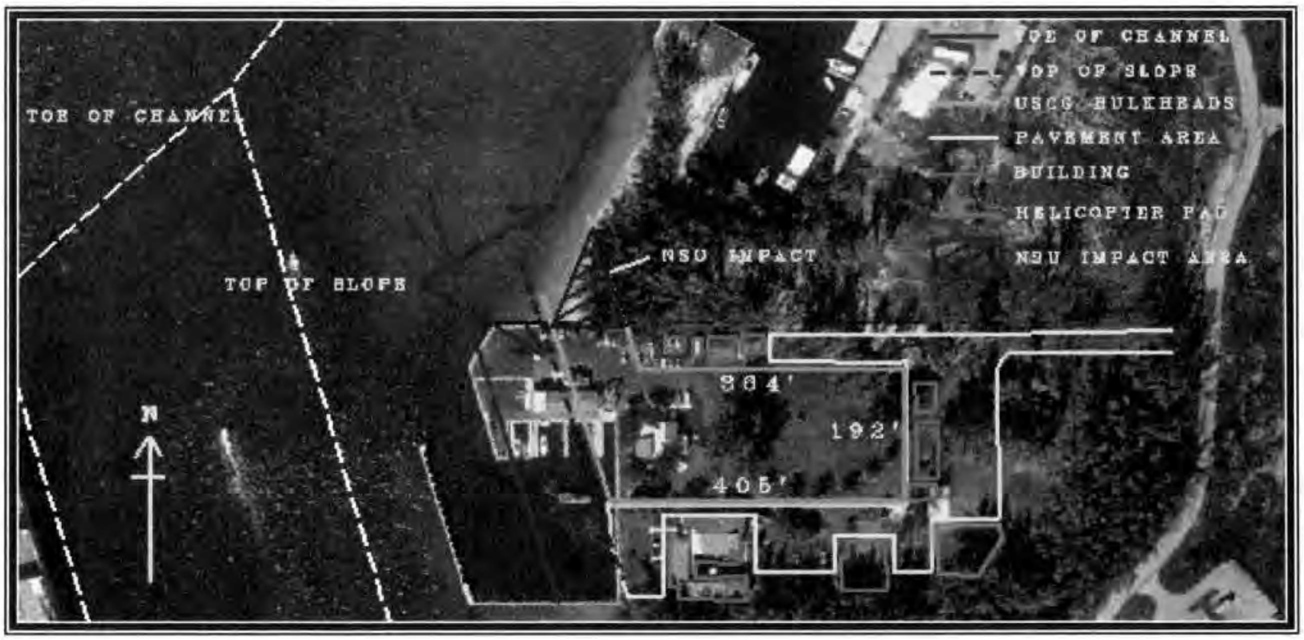
2.0 PROBLEM STATEMENT

2.1 Problem Description

In 1997, the Port Everglades Harbor Feasibility Study was initiated. In 2002, initial ship simulations indicated widening of the "knuckle" (Southport access channel) was necessary for the port expansion, and impacted the USCG boat basin's exterior breakwater. Also, wave response modeling of the USCG boat basin layouts with relocated exterior breakwater/ channel entrance locations were developed. In 2003, additional ship simulation indicated further widening of the "knuckle" was necessary, proposing relocation of the USCG boat basin to the east of its current location.

However, the proposed site plan resulting from this additional widening requirement was determined nonviable by the Coast Guard due to the amount of real estate lost and the functional inefficiency of the site layout.

Exhibit 1.2. Latest US ACOE Proposed Relocated USCG Station Ft Lauderdale Design



2.2 Problem Definition

The proposed design supplied by the US ACOE (Exhibit 1.2), incorporated relocating the boat basin to the east of its current location. This layout demolishes the two maintenance buildings and one administrative building to open space for the new basin but avoids moving the two-story multi-purpose building. This results in the multi-purpose building being separated from the new maintenance and support buildings by the new basin. The current property area is approximately 7.8 AC including the boat basin. Approximately 1.8 AC will be deducted from the available property after the channel widening is accomplished, leaving the total size of the property to be 6 AC including the boat basin. The proposed layout is unacceptable for Coast Guard mission accomplishment and operational requirements due to the following reasons:

- Locating the basin in the center of the property, leaves two narrow strips of land to access the facilities on the south and north side of the property. This jeopardizes the ability to maneuver equipment, boat trailers and personnel in such narrow areas.

- With the two narrow areas of land located on the south and north of the property, there is very limited available land for future growth.

- Unlike the existing basing, which is 262' wide, the proposed basin regardless of being 0.76 AC larger presents greater challenges for the Station's operational requirements. The proposed basin is only 192' wide, making maneuvering large Coast Guard vessels more difficult, and possibly restricting the size of vessels that could be moored at the station.

- The proposed basin is only approximately 20' north of the multipurpose building, greatly impacting access to the main entrance. The majority of traffic would need to enter through the back of the facility where all the services are located.

- Typically, when multi-function stations are designed, only two sides of the basin are used for facilities. By using the three sides of the basin, access from the administrative and maintenance buildings will be very limited and unpractical. This can jeopardize response time and the unit effectiveness.

- The proposed layout provides insufficient parking area for all of the Station's personnel and equipment. The proposed parking area, at a minimum, shall be equal to the existing area.

- The total acreage of the property will be reduced by 24%, greatly affecting the already limited available developable land and green areas.

- The proposed plan greatly reduces the Station's capacity for surge, expansion, recreation, and community outreach.

The Coast Guard's operational capabilities cannot be sacrificed in order to make the project more feasible.

2.3 Mission Functions of Benefiting Units

Multi-mission Station Ft Lauderdale is located in a 7.8 AC site on John U. Lloyd state park, Dania, Fl. Normal Area of Responsibility (AOR) covers over 950 square miles from Boca Raton to Bakers Haulover and 30 Nautical Miles (NM) offshore. The mission of Coast Guard Station Ft Lauderdale is to operate boats safely and effectively in support of all Coast Guard missions. It defines those missions as Search and Rescue (SAR), Enforcement of Laws and Treaties (ELT), Recreational Boating Safety (RBS), Marine Safety and Security (MSS), Defense Operations (DO), Short Range Aids to Navigation (SRA), Ports and Waterways Safety, Marine Environmental Protection (MEP), Marine Protected Species, and Natural Disaster and Civil Preparedness. The Station mission plays a crucial role, due to its location and high traffic of commercial, pleasure and cargo vessels in the area.

Station Ft Lauderdale is a Coast Guard shore facility with an OPFAC, command cadre, permanently assigned duty standers, unit boat allowance, and equipment, which reports to Sector Miami and/or District 7 Commander. The station also has a weapons allowance, designations for allowable covered moorings, and associated waterfront and shore-side facilities. To accommodate the allowances, the Station will require facilities in the following space codes: 100 Operations and Training, 200 Maintenance and Production, 400 Warehouse, 600 Administrative, 700 Housing and Community, and 800 Utilities and Ground Improvements.

The total active duty compliment ashore at Station Ft Lauderdale is 83 personnel (60 Station Ft Lauderdale, 9 ANT Ft Lauderdale and 14 from the CGC GANNET). Station and ANT Ft Lauderdale staffing is presented in the following tables, and also documented in Appendix A.

Table 2.1. Station Ft Lauderdale Personnel Allowance List

CG STATION FT LAUDERDALE (000011) PERSONNEL ALLOWANCE LIST			
	Current Allowance	Position	Rank
Officer	1	STATION CO	LT
Officer	1	STATION XO	LTJG
Enlisted	1	OPS	BMC
Enlisted	3	TACTICAL & PURSUIT COXSWAIN	BM1
Enlisted	9	TACTICAL & PURSUIT COXSWAIN	BM2
Enlisted	10	COXSWAIN/TACTICAL & PURSUIT BCM	BM3
Enlisted	4	BCM	SN
Enlisted	6	BCM	SA
Enlisted	1	WEAPONS PETTY OFFICER & SAI	GM1
Enlisted	1	EPO/ENG	MKC
Enlisted	1	ENG/TACTICAL & PURSUIT BCM	MK1
Enlisted	6	ENG/TACTICAL & PURSUIT BCM	MK2
Enlisted	5	ENG/TACTICAL & PURSUIT BCM	MK3
Enlisted	1	HOUSING/MAINTENANCE	DC2
Enlisted	1	ENG/TACTICAL & PURSUIT BCM	EM1
Enlisted	2	BCM	FA
Enlisted	3	BCM	FN
Enlisted	1	SUPPORT PETTY OFFICER	SK2
Enlisted	1	FOOD SERVICES OFFICER	FS1
Enlisted	2	GALLEY WATCH STANDER	FS2
TOTAL	**60**		

Source: Coast Guard Central

Table 2.2. ANT Ft Lauderdale Personnel Allowance List

CG ANT FT LAUDERDALE (000266) PERSONNEL ALLOWANCE LIST			
	Current Allowance	Position	Rank
Enlisted	1	OIC/ATON COXSWAIN	BMC
Enlisted	1	XPO/ATON COXSWAIN	BM1
Enlisted	1	ATON COXSWAIN	BM2
Enlisted	1	COXSWAIN/ATON BCM	BM3
Enlisted	1	EPO/ENG	MK1
Enlisted	2	ENG/ATON BCM	MK3
Enlisted	2	ATON BCM	FN
TOTAL	**9**		

Source: Coast Guard Central

Table 2.3. CGC GANNET Personnel Allowance List

CGC GANNET (WBP-87334) (006267) PERSONNEL ALLOWANCE LIST			
	Current Allowance	Position	Rank
Enlisted	1	OIC	BMCM
Enlisted	1	XPO	BMC
Enlisted	1	DUTY	BM1
Enlisted	3	DUTY	BM2
Enlisted	3	DUTY	FN,SN,SA
Enlisted	1	ENGINEER PETTY OFFICER	MKC
Enlisted	1	ENGINEER DUTY	MK2
Enlisted	1	STRIKER TRAINING BILLET	FNMK
Enlisted	2	DUTY	FN, FS2
TOTAL	**14**		

The total active ashore equipment at Station Ft Lauderdale is 10 vessels (7 Station Ft Lauderdale, 2 ANT Ft Lauderdale and 1 from the CGC GANNET). Station and ANT Ft Lauderdale and CGC GANNET equipment lists are presented in the following tables.

Table 2.4.Station Ft Lauderdale Equipment Assignment List

CG STA FT LAUDERDALE (000011) EQUIPMENT ASSIGNMENT LIST		
Resource	Class	Unit
Boat	RBS (25515)	CG STA FT LAUDERDALE
Boat	RBS (25611)	CG STA FT LAUDERDALE
Boat	RBS (25775)	CG STA FT LAUDERDALE
Boat	(33125)	CG STA FT LAUDERDALE
Boat	(33135)	CG STA FT LAUDERDALE
Boat	UTB (41341)*	CG STA FT LAUDERDALE
Boat	UTB (41424)*	CG STA FT LAUDERDALE
TOTAL	**7**	

* The UTBs may be replaced by 45' RB-M's, which will bring larger utility and covered moorings requirements

Table 2.5.ANT Ft Lauderdale Equipment Assignment List

CG ANT FT LAUDERDALE (000266)) EQUIPMENT ASSIGNMENT LIST		
Resource	Class	Unit
Boat	(231218)	CG ANT FT LAUDERDALE
Boat	TANB (26157)	CG ANT FT LAUDERDALE
TOTAL	**2**	

Table 2.6.CGC Gannet Equipment Assignment List

CGC GANNET (WBP-87334) (006267) EQUIPMENT ASSIGNMENT LIST		
Resource	Class	Unit
Boat	CBM (171190)	CGC GANNET (WBP 87334)
TOTAL	**1**	

This section summarizes the facility space requirements that were calculated using Commandant Instruction (COMDTINST) M11012.9 Shore Facilities Standards Manual (SFSM). Appendix C provides the detailed space requirements for Station Ft Lauderdale, FL with the current PAL. The total net area required for a new Station facility equals 26,821 Net Square Feet (NSF), which translates to a total gross area requirement of 33,794 gross square feet (GSF). We will assume an area of 34,000 GSF for planning purposes. More specific functional areas and their respective net space requirements are as follows:

Table 2.7.SpaceCategory Area Breakdown

SPACE CATEGORY AREA BREAKDOWN	
• SPACE	AREA (SF)
• PERSONNEL SUPPORT	850
• OPERATIONS AND TRAINING	3,735
• MAINTENANCE AND PRODUCTION	5,615
• ADMINISTRATIVE	7,181
• HOUSING AND COMMUNITY	8,095
• FACILITY SUPPORT	1,345
• **TOTAL NET AREA (NSF)**	**26,821 NSF**
• ADJUSTMENT FACTORS	6,973
• **TOTAL (GSF)**	**33,794 GSF**
• **ASSUME**	**34,000 GSF**

For Detail Space Breakdown see Appendix B

2.4 Planning Factors and Assumptions

1. If real estate is reduced due to the widening of the channel, an equal amount of property needs to be acquired adjacent to the current property line to compensate for the area lost and the several new facilities spread around the site.
2. A single multi-function, multi-story facility may be built to incorporate all of the station, ANT, and cutter functions in a smaller footprint, in order to compensate for the real property lost.
3. During construction, the station operations should not be negatively affected. The project needs to incorporate consideration for temporary facilities, project sequencing and pier space to ensure no disruption of operational capabilities.
4. Right-sized facilities shall be provided, incorporating requirements from COMDTINST M11012.9 Shore Facilities Standards Manual (SFSM). Appendix C.
5. The new basin will expand to the east of the property maintaining the same size and proportion of the existing basin in order to maximize use of the current available real estate.
6. Any new construction will be designed to withstand a Category III hurricane, as per the load requirements of ASCE 7-05 for gravity loads, flood, wave action and wind. Specific design parameters shall be based on the location of the building with respect to the coastline, type of terrain, building category occupancy and importance factor. These requirements are included in chapters 1 through 6 of ASCE 7-05.
7. The majority of the building is to be of reinforced concrete construction.

3.0 ALTERNATIVE DEVELOPMENT

3.1 Status Quo

The Station is currently slightly undersized due to its mission expansion since it was originally established; the unit has a projected usable life of at least another 15 years before the Coast Guard will be forced to replace or repair the facilities. The Station continues to be very effective in the accomplishment of its mission, however, the expansion project has the potential to jeopardize this level of effectiveness.

3.2 Non Viable Alternative

Army Corps of Engineers' proposal, as presented, has been identified as a nonviable alternative for numerous reasons. See section 2.2 for the specific discussion.

3.3 Viable Alternatives

There are three different alternatives that have been identified by the Coast Guard as more feasible than the current proposal. These alternatives will allow execution of the channel widening project with minimal operational impact to the Station mission:

Alternative 1:

Development of the current recommended layout by the ACOE. The only way this option can become feasible is by acquiring more land either south or north of the current property in order to minimize or eliminate the issues described in section 2.2 of this document.

Advantages:

- Lower construction and infrastructure cost since existing facilities will be re-used, minimizing the amount of new construction.

Disadvantages:

- Adjacent land will need to be acquired, which will likely require significant environmental remediation.
- This option may require temporary relocation of the Station while construction is being executed.

Alternative 2:

Construction of the Station at an alternate waterfront site within a two mile radius of the current Station's location. The selected property features, at a minimum, must be equivalent to the current property owned by the Coast Guard and have the same area of developable land.

Advantages:

- The Station Mission will suffer no impacts, since it will continue to operate from its current location while construction is being done in the alternate site, and once construction is finished the Station will permanently move to the new location.

Disadvantages:

- Waterfront land will need to be acquired, which is currently believed to be scarce.
- Site will most likely require full development and new construction, greatly exceeding the other two options cost.
- This alternative will require a relocation cost.

Alternative 3:

Construction of a single multi-function, multi-story Station building and supporting infrastructure at current location. Site planning will need to account for the ANT's buoy yard, as well as other equipment currently stored on site to ensure the impacts of the loss of land is mitigated.

Advantages:

- No additional land will be required. A smaller footprint for a single facility allows for more efficient use of the available real estate, eliminating the need of more land to compensate for the footprint of several buildings spread around the site.
- The Station mission impact will be minimized; it will be easier to phase the project and ensure operations can continue while construction of the new facility is executed.
- Although the initial construction cost will be higher than Alternative 1, it will be more economical than trying to acquire new land.

Disadvantages:

- Initial construction cost higher than Alternative 1.
- Will likely require some temporary boat mooring and crew berthing arrangements.

3.4 Preferred Alternative

The preferred alternative is Alternative 3, to rebuild Station Ft Lauderdale as a single, multi-function, multi-story facility, capable of withstanding a Category III hurricane. The facility at a minimum will be designed to meet the following parameters:

1. The new multi-mission building will be a three-story, approximately 34,000 GSF facility accommodating the Station, ANT, and USCGC GANNET needs. The first deck will be maintenance & shops; the second deck will be administrative, operations, and training; and the third deck will be housing and personnel support spaces. It will include all associated site work, utilities, roadways and parking areas in accordance with Coast Guard guidelines, standards and requirements.
2. The old maintenance, administrative and housing buildings will be demolished to open space for the new basin. Construction must be executed in a manner that will allow construction of the multi-mission facility on site while the old facilities continue to be used.

Appendix A
STATION FT LAUDERDALE, ANT FT LAUDERDALE AND COAST GUARD CUTTER GANNET PAL

Position Details

Position information for: CG STA FORT LAUDERDALE (000011) (PAL)

	Unit Type	Position	Rank	Number	BCN	Source
Officer	Boat Stations	XO	LTJG	00033892	0795491	MIL
Officer	Boat Stations	CO	LT	00035662	0702361	MIL
Enlisted	Boat Stations	OPS	BMC	00035396	0785703	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM1	00072799	P072799	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM1	00072799	P072799	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00069994	P069994	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00028853	0844003	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00037388	0718773	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00033769	0718663	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM1	00033768	0718653	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00033767	0718643	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00068712	P068712	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00035686	0718693	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00033766	0718633	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00033766	0718633	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00033763	0718593	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00035686	0718693	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00033765	0718623	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00033787	0718983	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00033764	0718613	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00035688	0718783	MIL
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Enlisted	Boat Stations	BCM	SN	00033776	0718803	MIL
Enlisted	Boat Stations	BCM	SN	00033777	0718823	MIL
Enlisted	Boat Stations	BCM	SN	00033778	0718833	MIL
Enlisted	Boat Stations	BCM	SA	00035692	0718973	MIL
Enlisted	Boat Stations	BCM	SA	00035687	0718723	MIL
Enlisted	Boat Stations	BCM	SA	00033773	0718733	MIL
Enlisted	Boat Stations	BCM	SA	00033771	0718703	MIL
Enlisted	Boat Stations	BCM	SN	00033781	0718883	MIL
Enlisted	Boat Stations	WEAPONS PETTY OFFICER & SAI	GM1	00091561		MIL
Enlisted	Boat Stations	EPO/ENG	MKC	00035691	0718933	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00035690	0718903	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK1	00033784	0718923	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00022661	0113543	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00035689	0718813	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00033782	0718893	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00072798	P072798	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK3	00033762	0718583	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK3	00033779	0718843	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK3	00022972	0721323	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK3	00022973	0721343	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK3	00033780	0718863	MIL

Enlisted	Boat Stations	HOUSING/MAINTENANCE	DC2	00033783	0718913	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	EM1	00033785	0718953	MIL
Enlisted	Boat Stations	BCM	FA	00033786	0718963	MIL
Enlisted	Boat Stations	BCM	FN	00000420	0717573	MIL
Enlisted	Boat Stations	BCM	FN	00000421	0717593	MIL
Enlisted	Boat Stations	BCM	FN	00000420	0717573	MIL
Enlisted	Boat Stations	BCM	FA	00000438	0718123	MIL
Enlisted	Boat Stations	ENG/TACTICAL & PURSUIT BCM	MK2	00022993	0721833	MIL
Enlisted	Boat Stations	SUPPORT PETTY OFFICER	SK2	00033788	0719003	MIL
Enlisted	Boat Stations	BCM	SA	00000439	0718133	MIL
Enlisted	Boat Stations	FOOD SERVICES OFFICER	FS1	00033790	0719033	MIL
Enlisted	Boat Stations	GALLEY WATCH STANDER	FS2	00035693	0719023	MIL
Enlisted	Boat Stations	GALLEY WATCH STANDER	FS2	00033789	0719013	MIL
Enlisted	Boat Stations	BCM	SA	00033772	0718713	MIL
Enlisted	Boat Stations	COXSWAIN/TACTICAL&PURSUIT BCM	BM3	00035684	0718573	MIL
Enlisted	Boat Stations	TACTICAL & PURSUIT COXSWAIN	BM2	00037387	0718743	MIL

TOTAL OFFICERS	2
TOTAL ENLISTED	58
TOTAL ACTIVE PAL	60

Position Details						
Position information for: CG STA FORT LAUDERDALE (000011) (RPAL)						
	Unit Type	**Position**	**Rank**	**Number**	**BCN**	**Source**
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BMCS	00051188	B009781	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BMC	00051549	B009807	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM1	00051608	B009809	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM1	00051199	B009808	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM1	00069805	P069805	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM3	00051189	B009782	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM2	00051200	B009810	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM2	00051201	B009811	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM2	00069806	P069806	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM2	00048934	B009604	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM2	00051187	B009780	RSV
Enlisted	Boat Stations	CONTINGENCY COXSWAIN	BM3	00051708	B009779	RSV
Enlisted	Boat Stations	CONTINGENCY BCM	SN	00051709	B009783	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK1	00051465	B013847	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK1	00051190	B009784	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK2	00051192	B009786	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK3	00051768	B009791	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK1	00069807	P069807	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK3	00051194	B009788	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK2	00051191	B009785	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK2	00069808	P069808	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK3	00051195	B009789	RSV
Enlisted	Boat Stations	CONTINGENCY BCM	FN	00051710	B009794	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK3	00051768	B009791	RSV
Enlisted	Boat Stations	CONTINGENCY ENG	MK3	00051757	B009790	RSV
Enlisted	Boat Stations	GALLEY WATCH STANDER	FS2	00051186	B009762	RSV
TOTAL RESERVE PAL		**26**				

Position Details

Position information for: CG ANT FORT LAUDERDALE (000266) (PAL)

	Unit Type	Position	Rank	Number	BCN	Source
Enlisted	AtoN	OIC/ATON COXSWAIN	BMC	00038182	0726753	MIL
Enlisted	AtoN	XPO/ATON COXSWAIN	BM1	00039652	0786803	MIL
Enlisted	AtoN	ATON COXSWAIN	BM2	00040078	0726743	MIL
Enlisted	AtoN	COXSWAIN/ATON BCM	BM3	00041545	0726763	MIL
Enlisted	AtoN	EPO/ENG	MK1	00038183	0726803	MIL
Enlisted	AtoN	ENG/ATON BCM	MK3	00039651	0786793	MIL
Enlisted	AtoN	ENG/ATON BCM	MK3	00040079	0726783	MIL
Enlisted	AtoN	ATON BCM	FN	00038184	0726813	MIL
Enlisted	AtoN	ATON BCM	FN	00038184	0726813	MIL
ALL ACTIVE PAL		9				

Position Details

PAL Information for: **CGC GANNET (WPB-87334) (006267)**

	Unit Type	Position	Rank	Number	BCN	Source
Enlisted	Patrol Boats	OFFICER IN CHARGE	BMCM	00000381	0704813	MIL
Enlisted	Patrol Boats	EXECUTIVE PETTY OFFICER	BM1	00000382	0704823	MIL
Enlisted	Patrol Boats	EXECUTIVE PETTY OFFICER	BM1	00000382	0704823	MIL
Enlisted	Patrol Boats	DUTY	BM2	00000383	0704833	MIL
Enlisted	Patrol Boats	DUTY	BM2	00000383	0704833	MIL
Enlisted	Patrol Boats	DUTY	BM2	00000383	0704833	MIL
Enlisted	Patrol Boats	DUTY	FN	00002472	0704893	MIL
Enlisted	Patrol Boats	DUTY	SN	00002470	0704843	MIL
Enlisted	Patrol Boats	DUTY	SA	00000384	0704853	MIL
Enlisted	Patrol Boats	ENGINEER PETTY OFFICER	MKC	00000385	0704863	MIL
Enlisted	Patrol Boats	DUTY	MK2	00002471	0704873	MIL
Enlisted	Patrol Boats	STRIKER TRAINING BILLET	FNMK	00000386	0704883	MIL
Enlisted	Patrol Boats	DUTY	FN	00002472	0704893	MIL
Enlisted	Patrol Boats	DUTY	FS2	00000387	0704903	MIL
TOTAL ACTIVE PAL		**14**				

Appendix B
STATION FT LAUDERDALE, ANT FT LAUDERDALE AND COAST GUARD CUTTER GANNET BASIC FACILITY REQUIREMENTS

SUMMARY

BASIC FACILITY REQUIREMENTS FOR STATION FT LAUDERDALE, ANT FT LAUDERDALE AND CGC GANNET

Space Name	Space Code SFSM-1	Personnel/ Equipment Allot	Qty	Space Allocations CMDT	TOTAL
PERSONNEL SUPPORT					
Lobby	900.002	150	3	450	
Elevator Lobby	900.005	50	3	150	
Shop Lunch Room	900.053	250	1	250	
		Personnel Support PNA			850
PARTIAL NET AREA CALCULATIONS					
Operations & Training PNA					3,735
Station				3,735	
Maintenance & Prod. PNA					5,615
Station				2,710	
ANT				2,190	
CGC GANNET				715	
Administrative PNA					7,181
Station				5,475	
ANT				1,456	
CGC GANNET				250	
Housing and Community					8,095
Station				8,095	
		Partial Net Area			24,626
FACILITY SUPPORT					
Mechanical Equipment	800.006	285	3	855	
Electrical Equipment	800.012	10	3	30	
Telecomm Equipment	800.040	15	3	45	
Telephone Equipment	800.044	15	3	45	
Emergency Generator	800.020	270	1	270	
General Building Storage	800.400	100	1	100	
		Total Facilities Support			**1,345**
GROSS AREA CALCULATION					
Partial Net Area				24,626	
Facilities Support				1,345	
		Total Net Area (TNA)			**26,821**
ADJUSTMENT FACTORS					6,973
Net/ Gross		0.25	TNA	5,364	
Thicker Exterior Walls		0.02	TNA	536	
Vertical Circulation (.04/ flr)		800	min.	1,073	
		Gross Floor Area			**33,794**
		SAY			**34,000**

BASIC FACILITY REQUIREMENT (BFR)

ASSET CLASS: STATION FORT LAUDERDALE

TOTAL NET AREA REQUIREMENT (SQFT)	**20,015**

Functional Statement:

l To accommodate the allowances, Stations will require facilities in the following space codes: 100 Operations and Training, 200 Maintenance and Production, 400 Warehouse, 600 Administrative, 700 Housing and Community, and 800 Utilities and Ground Improvements.

Space Codes:

l 100- Operations and Training. Stations are assigned one or more standard boats; sizes are typically a 47' Motor Life Boat (MLB), 41' Utility Boat (UTB), a Response Boat Medium (RB-M), and Response Boat Small (RB-S). Actual Station requirements are determined from each Individual Station's boat allowance. Stations may also have legacy non-standard boats such as skiffs for extreme shallow water missions. A Station requires a secure communications/operations room to maintain command and control, provide SAR communications, and maintain contact with its boats underway (radio guard) and Command. Station personnel carry weapons for patrols and boardings which must be stored in a secure area. Wet rooms are required to provide a dedicated drying area for Station SAR and boarding gear. Station Operations are described in U.S. Coast Guard Boat Operations and Training (Boat) Manual, Volume 1 COMDTINST M16114.32 (series). A critical part to station operations are the associated training requirements which are described in U.S. Coast Guard Boat Operations and Training (Boat) Manual, Volume II COMDTINST M16114.33 (series).

l 200- Maintenance and Production. The Stations are responsible for accomplishment of all organizational level maintenance (inspecting, servicing, lubricating, and adjusting) on all installed equipment. Shop facilities are required to perform the maintenance and repair of the assigned boats and will typically include a boatswain shop, a machine and engine shop for engine repairs and maintenance, and an associated flammable storage.

l 400- Warehouse. Storage facilities are required to store spare parts and tools for maintenance and repair of boats.

l 600- Administrative. Administrative facilities are required for the CO / Officer-in-Charge, the Executive Petty Officer, and the Engineering Petty Officer. Other Station personnel will require periodic shared access to a workstation at a ratio of 1 per 7 personnel.

l 700- Housing and Community. Station operations are 24/7, requiring duty standers. Ready crew berthing must be provided for these duty standers in close proximity to meet B0 readiness. Associated laundry, linen and storage areas are also required. In some locations, depending upon other living arrangements, stations will require a small UPH for its unaccompanied members, but this is a site-specific decision and is addressed in the Coast Guard Housing Manual COMDTINST M11101.13 (series). Stations will also require a physical fitness area if not collocated with a physical fitness center.

l 800- Utilities and Ground Improvements. A Station's boats require shore ties and other utility connections as outlined in the Operational Logistics Support Plan (OLSP) for the various boats. Additionally, the grounds of the Station are typically maintained by unit personnel.

Space Code	Space Name	Maximum Allowance	Unit of Measure	Notes See Below)	Required	Total
FACILITY REQUIREMENTS						
100	**OPERATIONS AND TRAINING**					
140.016	Weapons Storage	80	NSF		1	80
140.023	Communications/Operations Room	300	NSF		1	300
140.401	Maintenance Equipment Storage	200	NSF		1	200
140.142	Wet Rooms (Unit PAL of 11 or more)	300	NSF		1	300
140.904	Male and Female Locker area	300	NSF		1	300
140.905	Male and Female toilets	200	NSF		1	200
140.906	Laundry Area	120	NSF		1	120
140.144	Wet Rooms					
140.910	Male and Female Locker area	15	NSF	1,2	15	225
140.912	Male and Female toilets/showers	350	NSF		1	350
	Drying Area	40	NSF	3	1	40
140.913	Laundry Area	120	NSF		1	120
171.001	Training Space			4		
171.003	12 or less	300	NSF			
171.004	13 to 24	600	NSF			
171.005	25 to 36	900	NSF			0
	above 36	25	NSF	5	60	1,500
	TOTAL OPERATIONS AND TRAINING					**3,735**

Notes	
1	Locker space is sized for duty crew, not entire PAL and is based on 15 NSF per double locker. Double lockers are for those members who do not otherwise have assigned locker space for their duty gear (pilots, MSO inspectors, boat crews, etc). Provides a 3' wide double locker, 2 feet deep, with 2.5 feet of space to edge of a bench for seating that is 1 foot wide. This is for storage of equipment, but not a drying area.
2	The space allocated should be 120% of the duty crew PAL, with a 90% male, 30% female ratio. Local justification is required to alter this ratio. No more than 120% of the duty crew PAL should be counted towards this requirement.
3	This is a dedicated ventilated area with a drain.
4	Training facilities should be provided only if the unit is isolated, otherwise training facilities will be shared with other units. Training facilities can also function as an all-hands facility but should not be sized specifically to accomplish this function. The 300-900 SF training requirement can be met through the use of a conference room, or other available spaces. It should be sized based on type of training conducted, rather than the total PAL.
5	Provided for each additional student.

200	**MAINTENANCE AND PRODUCTION**					
	Covered Mooring	Individual	sized individually	6	2	
213.002	Boatswain Shop					
213.003	Workstation	150	NSF		2	300
213.401	Parts/Tool Storage	300	NSF		1	300
213.011	Machine and Engine Shop					
213.010	Work Bay (for up to 21 ft. boats)	600	NSF	7		0
213.011	Work Bay (for up to 41 ft. boats)	1350	NSF	7	1	1,350*
213.012	Outboard Engine Test	200	NSF	8	1	200
213.406	Flammable Storage	40	NSF		1	40
	Industrial Laundry	120	NSF	9	1	120
	Shop Lunch Area	15	NSF	10		0
	TOTAL MAINTENANCE AND PRODUCTION				**2**	**2,310**

Notes	
6	Covered mooring facilities provided per COMDTNOTE 11010 on an individual basis.
7	Up to 21 or 41 ft. boats, where severe weather conditions require indoor maintenance and ability exists to move equipment. *Will increase when Station shifts to 45' boats.
8	Provide (2) 100 NSF test areas.
9	Industrial Laundry space includes 2 washers and 2 dryers. This space is for shop laundry and is separate from domestic laundry.
10	Size per person. Minimum size 250 NSF, this includes a seating area (150 NSF) and a kitchenette (100 NSF). To be provided for shop personnel only.

400	**WAREHOUSE**					
140.404	Small Boat Storage	400	NSF	11	1	400
	TOTAL WAREHOUSE					**400**

Notes	
11	Space justified based on severe weather conditions. Required to store spare parts and tools for maintenance and repair of boats.

600	**ADMINISTRATIVE**					
	PRIVATE OFFICE SPACE					
	Command Cadre					
	Officer-In-Charge	150	NSF		1	150
	Executive Petty Officer	150	NSF		1	150
	OPEN OFFICE SPACE					
	Supervisory O-1 and O-2	80	NSF	12		
	Supervisory E-6 through E-8	80	NSF	12,13	9	720
	Non-Supervisory O-1 through O-4	60	NSF			
	Non-Supervisory E-7 through E-9	60	NSF			0
	Title 10 Reservist	60	NSF	14		
	E-1 through E-6	48	NSF		48	2,304
	Hoteling Cubicles	48	NSF	15	4	192
	Workstation Circulation @ 25% of Open Office Space			16		804

	<u>SHARED USE OFFICE SPACE</u>					
610.100	*File Areas*					
610.103	Lateral file cabinet/bookcase (ea.)	8	NSF		1	8
610.111	Conference/Training Space (if Station small)	150	NSF	17,18		
610.111	Conference/Training Space (if Station large)	300	NSF	17,18	1	300
	Resource/Technical Library Room	See Note	LF	19		
610.120	Coffee Mess (ea.)	60	NSF	20	2	120
610.130	Administrative Storage	65	NSF	21	1	65
610.150	Office Equipment Space	150	NSF	22	1	150
	Mail Distribution Area	40	NSF	23	1	40
	Locker (ea.)	8	NSF	24	59	472
	TOTAL ADMINISTRATIVE					**5,475**

Notes	
**	Administrative facilities shall not exceed 230 gross square feet per person (based on GSA standards). To calculate the SF per person, total the sum of all office space and divide by the number of billets authorized on the PAL for office space.
**	Reservists - Include space for Reservists listed as billets on the RPAL. One space should be provided per every 7 reservists (7 reservists = 1 FTE).
12	Supervisory means that the position has signature authority on a performance evaluation, either military or civilian.
13	Also includes Supervisory WG/WL/WS equivalent if applicable.
14	Title 10 Reservists - Calculate open office space based on the average annual total Title 10 hours over the past 3 years and divide by 2,080. Round up to the nearest full FTE. Individual justification is required for this space.
15	Office carrels are recommended for those spending less than 25% of total time in the office at a rate of 1:7 personnel assigned.
16	A circulation factor of 25% should be added to the sum of the Open Office Space spaces and is to be used in addition to the Net to Gross Multiplier. The circulation factor provides interior circulation between workstations in an open office plan.
17	Conference room size is based on the number of typical users and function, not on the PAL. Allocate 150 NSF for 1 - 7 persons and 300 NSF for 8 - 15 persons. Conference rooms may need to be located adjacent to each other to benefit from configurable partitions.
18	Conference rooms and mess deck should be collocated to allow for use as all hands training space.
19	Provides space for technical manuals, reference materials. This space is to be accommodated within the conference room requirement. The space is calculated by linear footage of bookcases. 100% retention on site is not required.
20	Coffee mess includes refrigerator, coffee maker, microwave, and sink. Provide at a rate of 1 per 35 people. Provide one per floor if Unit is located on multiple floors. This space is not provided if the unit is located on a single floor and a non-established mess is already provided.
21	Includes general office supplies (e.g. paper, files, pens, staples, etc.). Provide one per Unit, or Department/Division if Unit is not collocated. Provide one per floor if Unit is located on multiple floors.
22	To include fax, printer, copier, scanner. Additional equipment requires individual justification. Provide one per Unit, or Department/Division if Unit is not collocated. Provide one per floor if Unit is located on multiple floors.
23	Provide only one per Unit, even if the Unit resides on multiple floors.
24	Provides a private locker (full height - 1' wide, 1.5' deep, 2.5' area in front to access) for all military personnel, civilians, and contractors.

700	HOUSING AND COMMUNITY					
	READY CREW BERTHING			25		
721.014	Officer-of-the-Day night room	240	NSF		1	240
721.014	Enlisted Watch stander E-1 thru E-9	240	NSF	26	16+	3,840
721.014	Enlisted Watchstander Male/Female Sep	150	NSF			
721.972	Domestic Laundry Room	80	NSF	27	1	80
721.470	Linen Storage	50	NSF		1	50
	TV Room / Recreation Room (Station Small)	150	NSF			0
	TV Room / Recreation Room (Station Large)	300	NSF		1	300
	Physical Fitness Area	8	NSF	28	70	560
	ESTABLISHED MESS (Food Service Specialist (FS) Personnel Assigned			31		
722.150	Dinning for 41-80 people MESS DECK	540	NSF		1	540
722.935	Foyer	80	NSF		1	80
722.936	Public Toilets	180	NSF		1	180
722-153	GALLEY		NSF	31		
722.154	Can Wash	30	NSF		1	30
722.155	Dish Washing	175	NSF		1	175
722.433	Dry Storage	95	NSF		1	95
722.157	Inventory Work Station	75	NSF		1	75
722.832	Janitor's Closet	30	NSF		1	30
722.158	Pot Washing	90	NSF		1	90
722.159	Preparation/cooking/Baking	345	NSF		1	345
722.160	Receiving /Issue	135	NSF		1	135
722.161	Refrigerator/Freezer	345	NSF		1	345
722.169	Serving Area	810	NSF		1	810
722.937	Staff Toliets/Lookers	95	NSF		1	95
	SENTRY BOOTH		NSF			
730.252	Guard Booth	50	NSF	32		0
	TOTAL HOUSING AND COMMUNITY					**8,095**

Notes	
25	This is for ready crew berthing only. UPH for permanent party is a based upon site specific condition. The maximum is two watch standers per room. A head is included in the 240 NSF.
26	Single module - 150 NSF minimum, 240 NSF preferred.
27	Provides one washer and one dryer for every 15 persons.
28	Minimum size 200, maximum size 1,200. Provide only if there is no fitness center located on site.
29	This space utilized by watch standers only for food preparation. It will be provided even if the Unit is collocated with a galley. This space includes a kitchenette, pantry and mess deck.
30	Equipment should include refrigerator, stove, microwave, and sink.
31	An Established Mess will be provided if the Unit is not collocated with an ISC or district that provides a galley. Requirements for this space can be found in the 700 series Space Allocation List.
32	Provide only if not collocated at a site that provides security.

SITE REQUIREMENTS						
100	**OPERATIONS AND TRAINING**					
	BOAT SUPPORT			33		
	47' MLB					
	Depth Requirement (minimum (preferred))	5 (7)	Feet			
	Mooring Length (alongside a single pier)	58	Feet			
	Mooring Length (finger pier on one side)	53	Feet			
	Mooring Length (finger piers on both sides)	40	Feet			
	Mooring Height (Mast Lowered)	18	Feet			
	Mooring Height (Mast Raised)	28.33	Feet			
	Mooring Width (nominal wind or currents)	24	Feet			
	Mooring Width (no wind or currents)	21	Feet			
	Trailer	N/A	N/A			
	RB-M					
	Depth Requirement (minimum (preferred))	4.5 (6)	Feet			
	Mooring Length (alongside a single pier)	55	Feet			
	Mooring Length (finger pier on one side)	50	Feet			
	Mooring Length (finger piers on both sides)	37	Feet			
	Mooring Height (Mast Lowered)	13.2	Feet			
	Mooring Height (Mast Raised)	26.7	Feet			
	Mooring Width (nominal wind or currents)	24	Feet			
	Mooring Width (no wind or currents)	21	Feet			
	Trailer	N/A	N/A			
	41' UTB				2	
	Depth Requirement (minimum (preferred))	4.5 (6)	Feet			
	Mooring Length (alongside a single pier)	52	Feet			
	Mooring Length (finger pier on one side)	47	Feet			
	Mooring Length (finger piers on both sides)	34	Feet			
	Mooring Height (Mast Lowered)	13.2	Feet			
	Mooring Height (Mast Raised)	26.7	Feet			
	Mooring Width (nominal wind or currents)	24	Feet			
	Mooring Width (no wind or currents)	21	Feet			
	Trailer	N/A	N/A			
	RB-S				3	
	Depth Requirement	3.25	Feet			
	Mooring Length	36	Feet			
	Mooring Height	15	Feet			
	Mooring Width	12	Feet			
	Trailer	TBD	Feet			
	33' Utility Boat Light (UTL)				2	
	Depth Requirement	2.5	Feet			
	Mooring Length	43	Feet			
	Mooring Width	15	Feet			
	Trailer	TBD	Feet			
	TOTAL OPERATIONS AND TRAINING					
Notes						
33	Standards provided for standard boats only. Non-standard boat support requirements are subject to CCB approval.					

800	UTILITIES AND GROUND IMPROVEMENTS					
	Boat Ramp					
	47' MLB					
	Sewage	N/A	N/A	34		
	Fuel					
	Connection	1	Schedule 40 Pipe	35		
	Grey Water	N/A	N/A			
	Bilge Water	N/A	N/A			
	Connection					
	Electrical					
	VAC	120	VAC			
	Amps	100	AMPS			
	Water		Gallons	36		
	45' RB-M					
	Fuel					
	Connection	1	TBD			
	Electrical					
	VAC	120	VAC			
	Amp	100	AMPS			
	Water	5	Gallons	36		
	41' UTB				2	
	Fuel					
	Connection	1	TBD	37		
	Electrical					
	VAC	120	VAC			
	Amps	100	AMPS			
	Water	20	Gallons	36		
	25' RB-S				3	
	Fuel					
	Connection	1	TBD			
	Electrical					
	VAC	120	VAC			
	Amp	100	AMPS			
	Potable Water		Gallons	36		
	PARKING					
	GOVs	See note		38	3	
	Personnel Parking	See note		39	56	
	TOTAL UTILITIES AND GROUND IMPROVEMENTS					

Notes	
34	Manually emptied.
35	2" connection, capacity 412 gallons
36	Potable water is stored aboard the vessel in containers, a supply line is not necessary at mooring.
37	capacity 486.8 gallons
38	Size parking spaces per assigned vehicles.
39	Parking to be provided for 70% of assigned personnel. This a generalized criterion, and local site conditions (e.g. availability of mass transit), along with implemented strategies to reduce parking demand, should determine the final ratio. The turning radius needs to accommodate the largest vehicle and trailer accessing that area.
**	Consult the associated Process Guide for guidance on restroom and facility support space determination.

BASIC FACILITY REQUIRMENT (BFR)	
ASSET CLASS: AIDS TO NAVIGATION TEAM (ANT) FORT LAUDERDALE	
TOTAL NET AREA REQUIREMENT	3,646

Functional Statement:

The mission of a Coast Guard ANT is to provide maintenance of all assigned aids to navigation, including buoys, lighthouses, lighthouse structures, and daybeacons. ANT is also responsible for positioning and repositioning buoys that shift. The Coast Guard also uses cutters to place, position, and maintain aids to navigation. Each Inland (65' and 100'), Coastal (175'), or Seagoing (225') buoy tender is a separate OPFAC that has its own requirements.

l An ANT is a Coast Guard shore unit with an OPFAC, command cadre, unit boat allowance, and equipment, which reports to a Sector. An ANT also has associated waterfront and shore-side facilities.

l To accommodate the allowances, ANTs will require facilities in the following space codes: 100 Operations and Training, 200 Maintenance and Production, 400 Warehouse, 600 Administrative, 700 Housing and Community, and 800 Utilities and Ground Improvements.

Space Codes:

l **100- Operations and Training.** ANT boats can include Trailerable Aids to Navigation Boat (TANB) varying from 17' to 23', 49' BUSL, 55' ATON, and 64' ANB. Actual ANT requirements are determined from each Individual ANT's boat allowance.

l **200- Maintenance and Production.** ANTs are responsible for accomplishment of all organizational level maintenance (inspecting, servicing, lubricating, and adjusting) on all installed equipment. Shop facilities are required to perform the maintenance and repair of the assigned boats and will typically include a boatswain shop, a machine and engine shop for engine repairs and maintenance, and an associated flammable storage. In addition to maintaining the equipment the ANT uses to access aids, it repairs and maintains aids in shop spaces.

l **400- Warehouse.** Storage facilities are required to store spare parts and tools for maintenance and repair of boats and ATON. Outdoor storage is also required for buoys, sinkers, and chains. Indoor storage is required for dayboards and lanterns.

l **600- Administrative.** Administrative facilities are required for the Officer-in-Charge, Executive Petty Officer, and Engineering Petty Officer. Other ANT personnel will require periodic shared access to a workstation at a ratio of 1 per 7 personnel.

l **700- Housing and Community.** In some remote locations, the CG may elect to have duty watchstanders. If so, watchstanders will require watchstander berthing and a small mess deck for food preparation. Fitness facilities may also be required in those cases.

l **800- Utilities and Ground Improvements.** ANT's boats require shore ties and other utility connections as outlined in the Operational Logistics Support Plan (OLSP) for the various boats. Parking is required for GOV vehicles and boat trailers (for trailerable boats). These spaces are not included in this SAL as they are not considered typical.

Space Code	Space Name	Maximum Allowance	Unit of Measure	Notes (See Below)	Required	Total
FACILITY REQUIREMENTS						
200	**MAINTENANCE AND PRODUCTION**					
	AIDS TO NAVIGATION TEAM SHOP					
218.011	Shop (Size Per 2 Team Members)	100	NSF	1	2	200
218.411	ANT Shop Storage (Size Per 2 Team Members)	100	NSF	1	2	200
218.012	Small Boat Bay (Size Per TANB)	400	NSF	2	1	400
218.412	Battery Charging/Storage	40	NSF		1	40
218.413	Flammable Storage	150	NSF	3	1	150
	DAYBOARD PRODUCTION SHOP					
218.041	Shop	400	NSF		1	400
218.440	Storage	150	NSF		1	150
	ELECTRICAL (EM) SHOP					
218.051	Shop (size per required workstation)	150	NSF		1	150
218.450	Storage (size per workstation)	100	NSF		1	100
	ELECTRONICS (ET) SHOP					
218.061	Shop (size per required workstation or mock-up)	100	NSF		0	0
218.460	Storage (size per workstation)	100	NSF		0	0
	TOTAL MAINTENANCE AND PRODUCTION					1,790

Notes

1. If separate ET and/or EM shops required, do not count EM/ET(s) toward team members. Separate EM/ET shops are required if both EM and ET billets are assigned.
2. Space must be justified based on severe weather conditions that hamper operations.
3. Not required if collocated with a Sector or ISC.
4. Spaces not required if collocated with depot level boat maintenance facility.
5. Spaces are in addition to the Carpentry Shop.
6. If collocated with a depot level boat maintenance facility, add 1/2 of this NSF to the boat maintenance shop space at the depot facility.
7. Space includes 2 welding stations sized at 165 sf each.
8. Industrial Laundry space includes 2 washers and 2 dryers. This space is for shop laundry and is separate from domestic laundry.

Space Code	Space Name	Maximum Allowance	Unit of Measure	Notes (See Below)	Required	Total
400	**WAREHOUSE**					
	Tractor/Forklift Storage					
218.403	Storage (for buoys up to 2744 mm x 10,668 mm (9' x 35'))	400	NSF		1	400
218.404	Storage (for river buoys only)	200	NSF			0
	TOTAL WAREHOUSE					400

Notes

600	ADMINISTRATIVE					
	PRIVATE OFFICE SPACE					
	Command Cadre					
	Officer-In-Charge	150	NSF		1	150
	Executive Petty Officer	150	NSF		1	150
	Engineering Petty Office	150	NSF		1	150
	OPEN OFFICE SPACE					
	Supervisory E-6 through E-8	80	NSF	9	0	0
	Non-Supervisory E-7 through E-9	60	NSF		0	0
	Title 10 Reservist	60	NSF	10	0	0
	E-1 through E-6	48	NSF		6	288
	Hoteling Cubicles	48	NSF	11	0	0
	Workstation Circulation @ 25% of Open Office Space			12		185
	SHARED USE OFFICE SPACE					
610.100	*File Areas*					
610.103	Lateral file cabinet/bookcase (ea.)	8	NSF	13	4	32
610.111	Conference/Training Space	150	NSF	14	1	150
610.120	Coffee Mess (ea.)	60	NSF	15	1	60
610.130	Administrative Storage (ea.)	65	NSF	16	1	65
610.150	Office Equipment Space	150	NSF	17	1	150
	Mail Distribution Area	40	NSF	18	1	40
	Locker (ea.)	4	NSF	19	9	36
	Shop Lunch Area	15	NSF	20		
	TOTAL ADMINISTRATIVE					**1,456**

Notes

9 Supervisory means that the position has signature authority on a performance evaluation, either military or civilian, and not assigned a private office.

10 Title 10 Reservists - Calculate open office space based on the average annual total Title 10 hours over the past 3 years and divide by 2,080. Round up to the nearest full FTE. Individual justification is required for this space.

11 Office carrels are recommended for those spending less than 25% of total time in the office.

12 A circulation factor of 25% should be added to the sum of the Open Office Space spaces and is to be used in addition to the Net to Gross Multiplier. The circulation factor provides interior circulation between workstations in an open office plan.

13 Individual justification required.

14 Conference/training space size is based on the number of typical users and function, not on the PAL. Allocate 150 NSF for 1 - 7 persons and 300 NSF for 8 - 15 persons. Conference/training spaces may need to be located adjacent to each other to benefit from configurable partitions.

15 Coffee mess includes refrigerator, coffee maker, microwave, and sink. Provide at a rate of 1 per 35 people. This space is not provided if the unit is located on a single floor and a non-established mess is already provided.

16 Includes general office supplies (e.g. paper, files, pens, staples, etc.). Provide one per Unit, or Department/Division if Unit is not collocated. Provide one per floor if Unit is located on multiple floors.

17 To include fax, printer, copier, scanner. Additional equipment requires individual justification. Provide one per Unit, or Department/Division if Unit is not collocated. Provide one per floor if Unit is located on multiple floors.

18 Provides space for mail sorting. Provide only one per Unit, even if the Unit resides on multiple floors.

19 Provides a private locker (full height - 1' wide, 1.5' deep, 2.5' area in front to access) for all military personnel, civilians, and contractors. This applies to those members who do not otherwise have assigned locker space for their duty gear (pilots, MSO inspectors, boat crews, etc.)

20 Size per person. Minimum size 250 NSF, this includes a seating area (150 NSF) and a kitchenette (100 NSF). To be provided for shop personnel only.

700	**HOUSING AND COMMUNITY**					
	Physical Fitness Area	8	NSF	21,22		
	NON-ESTABLISHED MESS (No Food Service Specialist (FS))			23		
722.003	Mess Deck - Dining Area (8 seats)	120	NSF	24		0
722.006	Janitor's Closet	30	NSF			0
	ESTABLISHED MESS (Food Service Specialist (FS) Assigned)	See Note		25		
	SENTRY BOOTH					
730.252	Guard Booth	50	NSF	26		
	TOTAL HOUSING AND COMMUNITY					**0**

Notes

21 Minimum size 200, maximum size 1,200. Provide only if there is no fitness center located on site.

22 Shower and locker rooms with toilets are warranted if the site is isolated.

23 This space will be provided if the unit is isolated and there is not a Food Service Specialist billeted.

24 Includes a kitchenette, pantry and mess deck.

25 An Established Mess will be provided if the Unit is not collocated with an ISC or district that provides a galley. Requirements for this space can be found in the 700 series Space Allocation List.

26 Provide only if not collocated at a site that provides security.

SITE REQUIREMENTS

100	**OPERATIONS AND TRAINING**					
	BOAT SUPPORT					
	<u>17-26' TANB</u>				**2**	
	Depth Requirement	3.25	Feet			
	Mooring Length	36	Feet			
	Mooring Height	15	Feet			
	Mooring Width	12	Feet			
	Trailer	TBD	Feet			
	Boat Ramp	See Note		27		
	TOTAL OPERATIONS AND TRAINING					

Notes

27 A boat ramp is required to launch trailerable boats into the water. This requirement can be met off-site through the use of a public boat launch.

400	**WAREHOUSE**					
	Buoy Storage Yard	See Note		28		
	TOTAL WAREHOUSE					

Notes						
28	To be determined by the size and number of buoys required to be stored outside.					
800	**UTILITIES AND GROUND IMPROVEMENTS**					
	17-26' TANB				2	
	Electrical					
	VAC	TBD				
	Amp	TBD				
	Water	TBD	Gallons	29		
	PARKING					
	Boat Trailer Parking	See Note		30	2	
	GOVs	See Note		31	1	
	Personnel Parking	See Note		32	7	
	TOTAL UTILITIES AND GROUND IMPROVEMENTS					
Notes						
29	Potable water is stored aboard the vessel in containers, a supply line is not necessary at mooring.					
30	Requirements based on boat trailer size.					
31	Size parking spaces per assigned vehicle.					
32	Parking to be provided for 70% of assigned personnel. This a generalized criterion, and local site conditions (e.g. availability of mass transit), along with implemented strategies to reduce parking demand, should determine the final ratio. The turning radius needs to accommodate the largest vehicle and trailer accessing that area.					
**	Consult the associated Process Guide for guidance on restroom and facility support space determination.					

BASIC FACILITY REQUIREMENT (BFR)

ASSET CLASS: WPB 87' MARINE PROTECTOR CLASS CUTTER GANNET, FT LAUDERDALE

TOTAL NET AREA REQUIREMENT **965**

Functional Statement:

The Mission of an 87' Marine Protector Class Patrol Boat is to provide law enforcement, defense operations, marine environmental protection, and SAR operations under the Command of a District.

l The 87' WPB contains a stern launching and recovery system using Rigid Hull Inflatable Boats (RHIBs) to conduct boardings, and has the capability to operate in heavy seas, up to Sea State 5. The crew size is 10 personnel (1 officer and 9 enlisted). The ship can accommodate 12 with any mix of males and females.

l To accommodate the mission support requirements, each WPB 87' will require facilities in the following space codes: 100 Operational and Training, 400 Supply, 600 Administrative, 700 Housing and Community, and 800 Utilities and Ground Improvements.

Space Codes:

l **100- Operational and Training.** An 87 WPB will require periodic access to training facilities, but these do not need to be dedicated. These can be provided at a gym facility, galley, club, or at local hotel or school. The 87' will require mooring facilities.

l **400- Supply.** Storage space is required for spares and tools. In addition, the 87' will require long-term storage and a staging area for receiving storage items.

l **600- Administrative.** One office is required on the shore side for each 87' Patrol Boat.

l **700- Housing and Community.** Housing and Community facilities required include a physical fitness area if the site is not collocated with an existing fitness center.

l **800- Utilities and Ground Improvements.** An 87' WPB requires shore ties and other utility connections as outlined in its Operational Logistics Support Plan (OLSP).

Space Code	Space Name	Maximum Allowance	Unit of Measure	Notes (See Below)	Required	Total
FACILITY REQUIREMENTS						
100	**OPERATIONAL AND TRAINING**					
171.001	Training Space			1		
171.003	12 students or less	300	NSF			0
171.004	13 to 24 students	600	NSF			0
171.005	25 to 36 students	900	NSF			0
	TOTAL OPERATIONAL AND TRAINING					

Notes

1 Personnel will require periodic access to training facilities, but these do not need to be dedicated and can be provided using various scenarios. Training Facilities are not sized for all-hands training. Spaces already accounted under the Station FT Lauderdale BFR.

400	**SUPPLY**			2		
213.481	Cutter Storage	250	NSF		1	250
213.483	Cutter Parts/Tool Storage	400	NSF		1	400
	Flammable Storage	40	NSF		1	40
	HAZMAT storage	25	NSF		1	25
	TOTAL SUPPLY					**715**
Notes						
2	87' OLSP COMDTINST M4081.9 Chapter 6 Paragraph D					
600	**ADMINISTRATIVE**					
	<u>OPEN OFFICE SPACE</u>					
	Cutter Office	250	NSF	3	1	250
	TOTAL ADMINISTRATIVE					**250**
Notes						
3	Office space per cutter.					
700	**HOUSING AND COMMUNITY**					
	Physical Fitness Area	8	NSF	4		0
	TOTAL HOUSING AND COMMUNITY					
Notes						
4	Sized per user. Minimum size 200, maximum size 1,200. Provide only if there is no fitness center located on site. Space Accounted for under Station Ft Lauderdale BFR.					
SITE REQUIREMENTS						
100	**OPERATIONAL AND TRAINING**					
	BOAT SUPPORT					
	87' WPB					
	Depth Requirement (minimum (preferred))	11	Feet	5		
	Operational Draft	5.43	Feet			
	Mooring Length (alongside a single pier)	109	Feet	6		
	Mooring Length (finger pier on one side)	TBD	Feet			
	Mooring Width (nominal wind or currents)	TBD	Feet			
	Mooring Width (no wind or currents)	TBD	Feet			
	TOTAL OPERATIONAL AND TRAINING					
Notes						
5	Minimum, at lowest predicted tide.					
6	Minimum. Add 25-feet between cutters and 25-feet at ends of mooring.					

800	UTILITIES AND GROUND IMPROVEMENTS					
	87' WPB					
	Sewage	363	Gallons	7		
	Fuel					
	Connection	TBD	Gallons	8		
	Telephone	4	Telephone line pairs	9		
	Grey Water	1	TBD			
	Bilge Water					
	Connection	92	GPD	7		
	Electrical					
	VAC	450	VAC	10		
	Amps	100	AMPS			
	Potable Water	400.9	GPD	11		
	Lighting		5-foot candles	12		
	Cable TV			13		
	Local Area Network (LAN)		TBD	14		
	PARKING					
	GOVs	See note		15	2	
	Long-Term Cutter Parking	See note		16	12	
	Personnel Parking	See note		17		
	TOTAL UTILITIES AND GROUND IMPROVEMENTS					

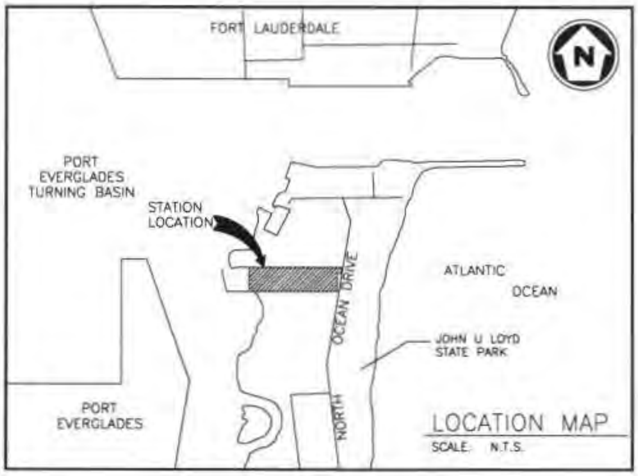
Notes

7	2.5" bronze valve to 4" flange
8	2.5" pipe, and 1.5" O pipe
9	Connection point is 0.5 meters forward of frame 16, 1.75 meters inboard port side.
10	3-phase. If transformer serves only shore tie, should be tapped-down as close as possible to 450 volts. If is also serves shoreside loads, 480 volts is acceptable. Should be identical to 110' WPB to permit accommodation of visiting PBs.
11	1 1/2 inch connection size.
12	For open working areas on a slip and in storage buildings while working.
13	1 commercial service, connection point is .5 meters forward of frame 16, 1.75 meters inboard port side.
14	Currently under development at TISCOM. CPB has two pair fiber optic cables, terminated in ST connectors plus two pair copper lines for data transmission.
15	Size parking spaces per assigned vehicle.
16	Provides long-term parking for assigned cutters while they are deployed. This can be provided off-site.
17	Parking to be provided for 70% of assigned personnel. This a generalized criterion, and local site conditions (e.g. availability of mass transit), along with implemented strategies to reduce parking demand, should determine the final ratio. The turning radius needs to accommodate the largest vehicle and trailer accessing that area.
**	Consult the associated Process Guide for guidance on restroom and facility support space determination.

Appendix C
EXISTING & RECOMMENDED SITE LAYOUT

1 2

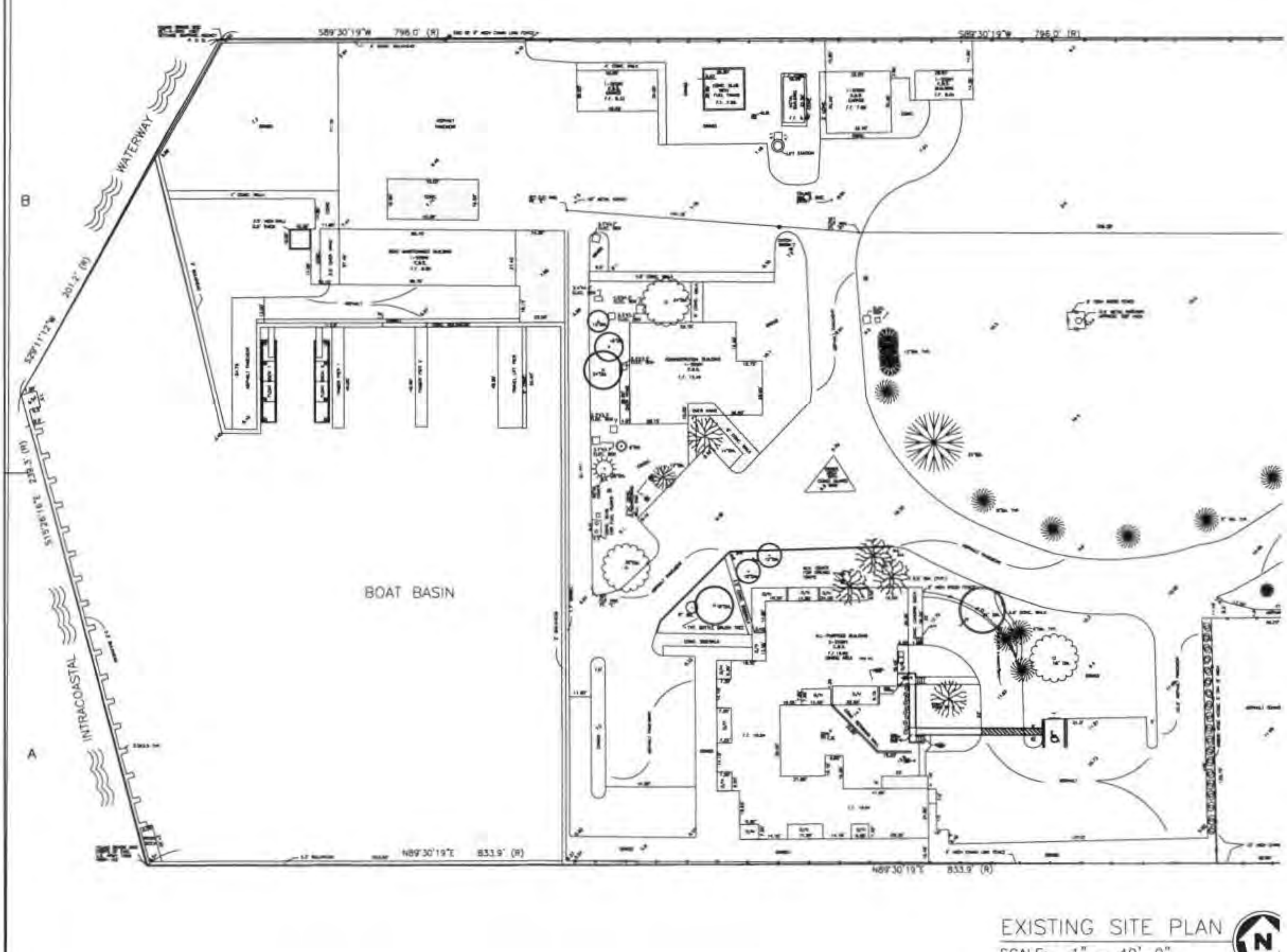
C



LOCATION MAP
SCALE: N.T.S.

B

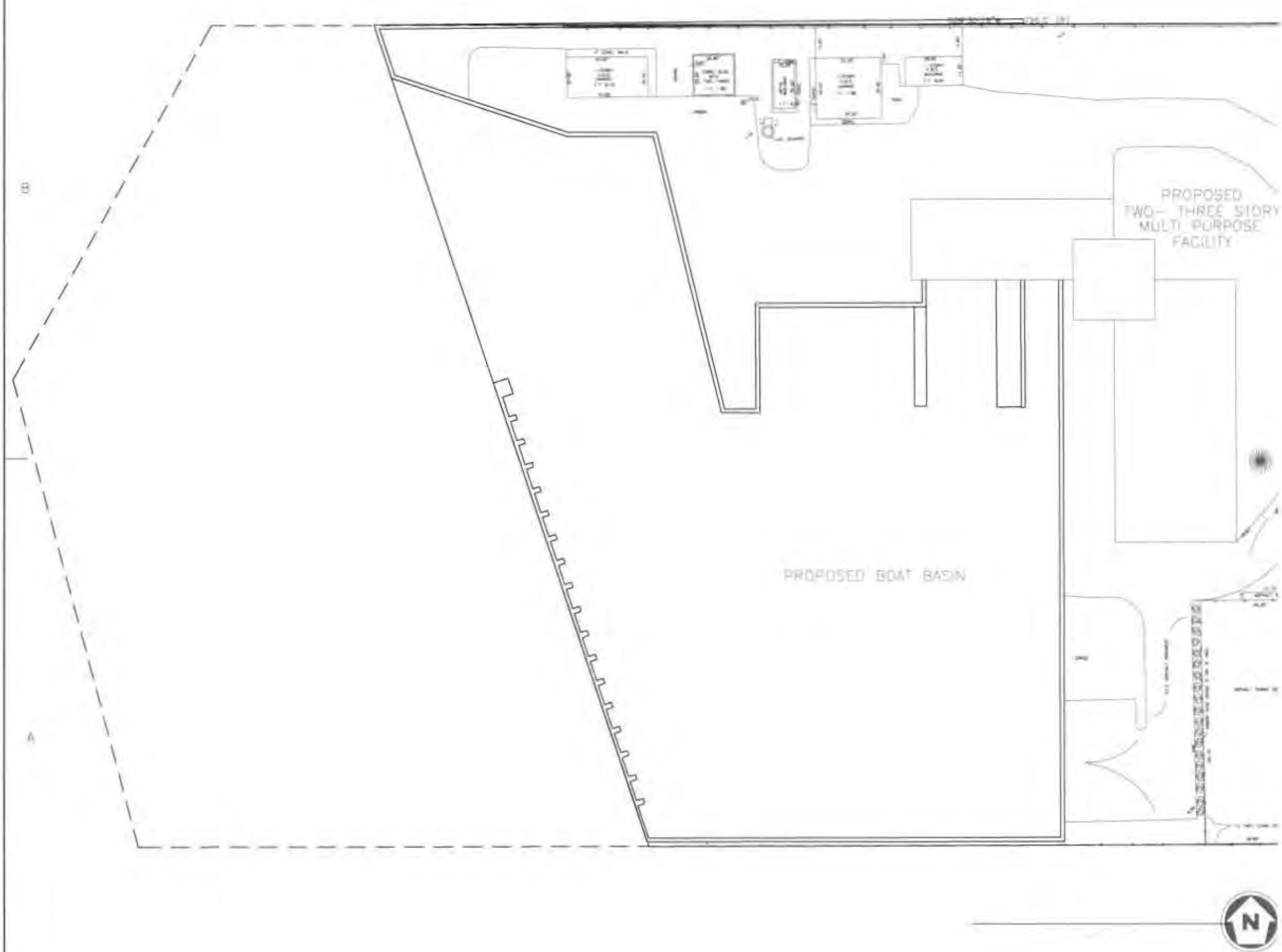
A



EXISTING SITE PLAN
SCALE: 1" = 40'-0"

1 2

NOTE:
THE ATTACHED LAYOUT IS FOR ILLUSTRATION PURPOSES ONLY AND DOES NOT REPRESENT A FINAL FACILITY DESIGN OR APPROVAL.



Appendix D
COST ESTIMATE

COST ESTIMATE			DATE PREPARED		5/29/2009
PROJECT COST ESTIMATE -					

ACTIVITY AND LOCATION	DESIGN/ENGINEERING CONTRACT NO.	PROJECT NUMBER
United States Coast Guard	N/A	N/A
PROJECT TITLE **SECTOR MIAMI-STATION FT LAUDERDALE**	**ESTIMATED BY** **Alejandro Holguin**	

PROJECT TITLE

Construct New Split STA buildings @ Current Site, Cost does not include Water front infrastructure and support.

Item No.	Item Description	Quantity Unit	Quantity Number	Cost/Unit	Total Cost ($)	% Cost
1.0	**DEMOLITION**					
	Demo Sta Building RPFN 101	CF	219276	$0.40	$87,710	
	Bldg Foundation Demolition	SF	16897.0	$6	$100,537	
	Mob/Demob/Environmental	Ea	1.0	$50,000	$50,000	
				Subtotal	**$238,248**	1.28%
2.0	**SITE WORK**					
	Flag Pole	Ea	2.0	$6,000.00	$12,000	
	Pile Foundation	Ea	42.0	$15,000.00	$630,000	
	Soil Remediation	Ea	1.0	$25,000.00	$25,000	
	Concrete Sidewalks	SF	12000	$5.40	$64,800	
	Flexible Pavement	SF	36000	$2.50	$90,000	
	Landscaping	LS		$35,000.00	$35,000	
				Subtotal	**$856,800**	4.60%
3.0	**EXTERIOR UTILITIES**					
	Electrical Power	LS	1.0	$35,000	$35,000	
	Exterior Lighting	EA	36.0	$5,000	$180,000	
	Telephone	LS	1.0	$20,000	$20,000	
	Water	LS	1.0	$25,000	$25,000	
	Sanitary Sewer	LS	1.0	$15,000	$15,000	
				Subtotal	**$275,000**	1.48%
4.0	**BUILDING CONSTRUCTION**					
	Construct admin/OPS/Berthing	SF	18,000	$297	$5,534,000	
	Construct Industrial Shop facility	SF	12,000	$225	$2,700,000	
	Miscellaneous	LS	1.0	$55,000	$55,000	
				Subtotal	**$9,289.000**	49.90%
5.0	**FURNISHINGS/EQUIPMENT**					
	Building Outfitting	SF	17015.0	$7	$111,448	
				Subtotal	**$111,448**	0.60%
6.0	**ELECTRONICS OUTFITTING**					
	Telephone Equipment	LS	1.0	$120,000	$120,000	
	SW3 setup/cabling	LS	1.0	$190,000	$190,000	
				Subtotal	**$310,000**	1.67%
7.0	**OTHER**					
	Temporary Offices	Ea	1.0	$60,000	$60,000	
				Subtotal	**$60,000**	0.32%
				Subtotal	**$11,140,496**	59.85%
8.0	**COST AMPLIFIERS**					
	Escalation Factor to 2011(7% Per Year)				$2,333,504	12.57%
				Subtotal	**$13,480,000**	
	Location Factor			0.98	$13,210,400	
	Design Contingency			15%	$1,981,560	10.65%
	Construction Contingency			10%	$1,321,040	7.10%
	A/E and Survey Fees			10%	$1,321,040	7.10%
	Construction Surveillance (12K/Month)			6%	$118,894	0.64%
	LEED			5%	$660,520	3.55%
Project Total =>					**$18,613,453**	**100%**

Attachment B

Maximum Wave Amplification for Relocated Basin Alternatives:

Alternatives B through G

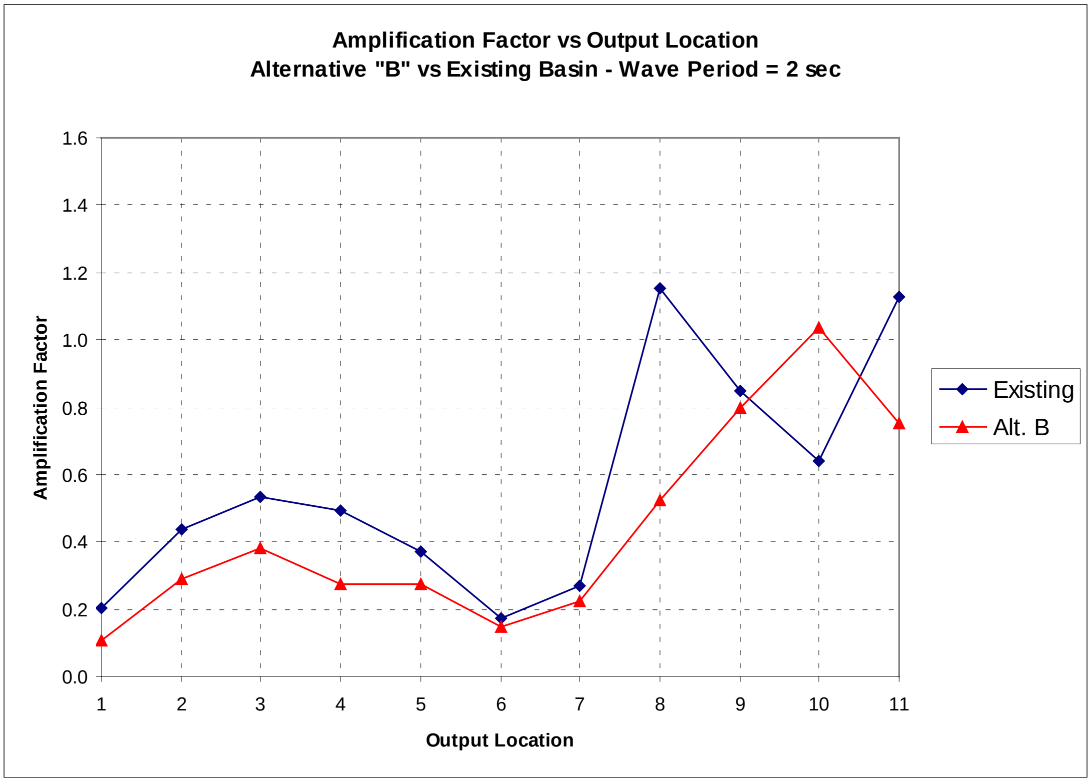


Figure B- 1. Maximum Amplification Factor – Alternative “B” vs Existing (Period = 2sec)

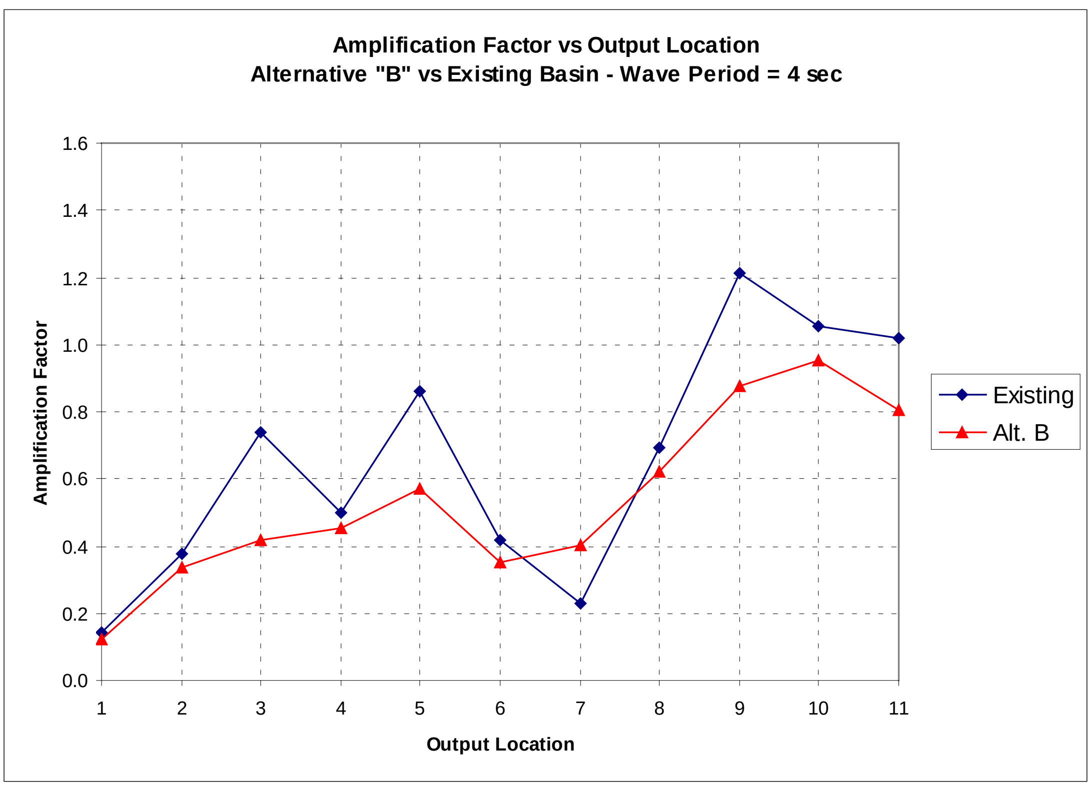


Figure B- 2. Maximum Amplification Factor – Alternative “B” vs Existing (Period = 4sec)

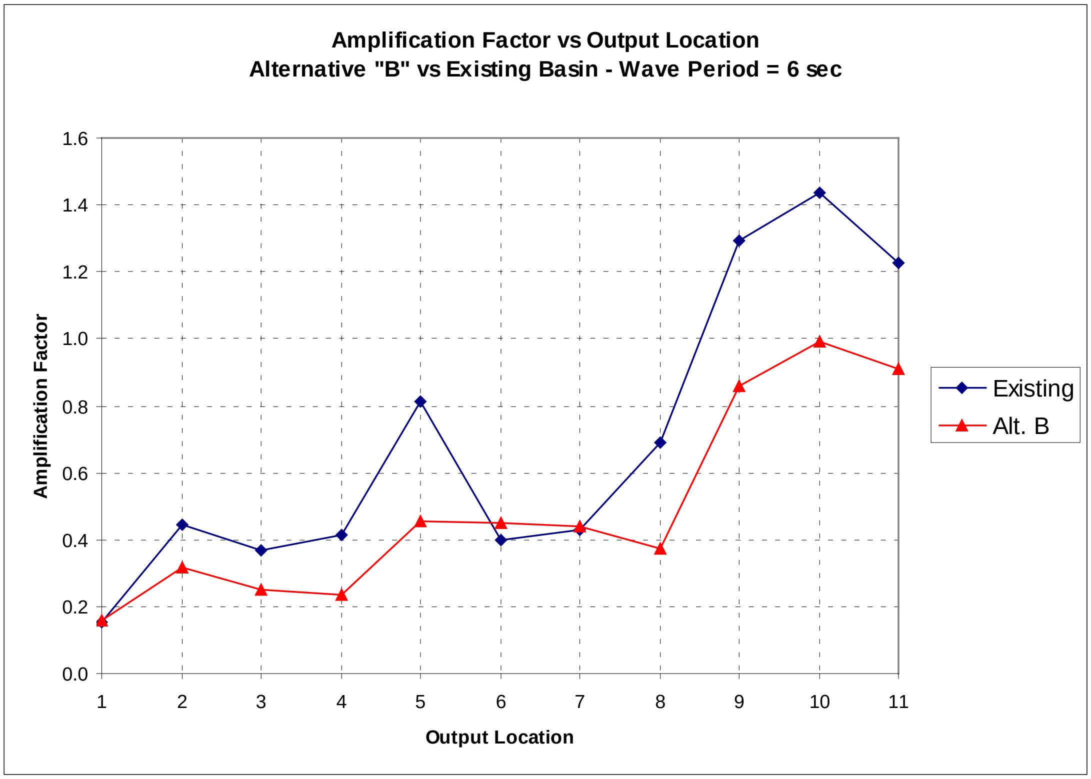


Figure B- 3. Maximum Amplification Factor – Alternative "B" vs Existing (Period = 6sec)

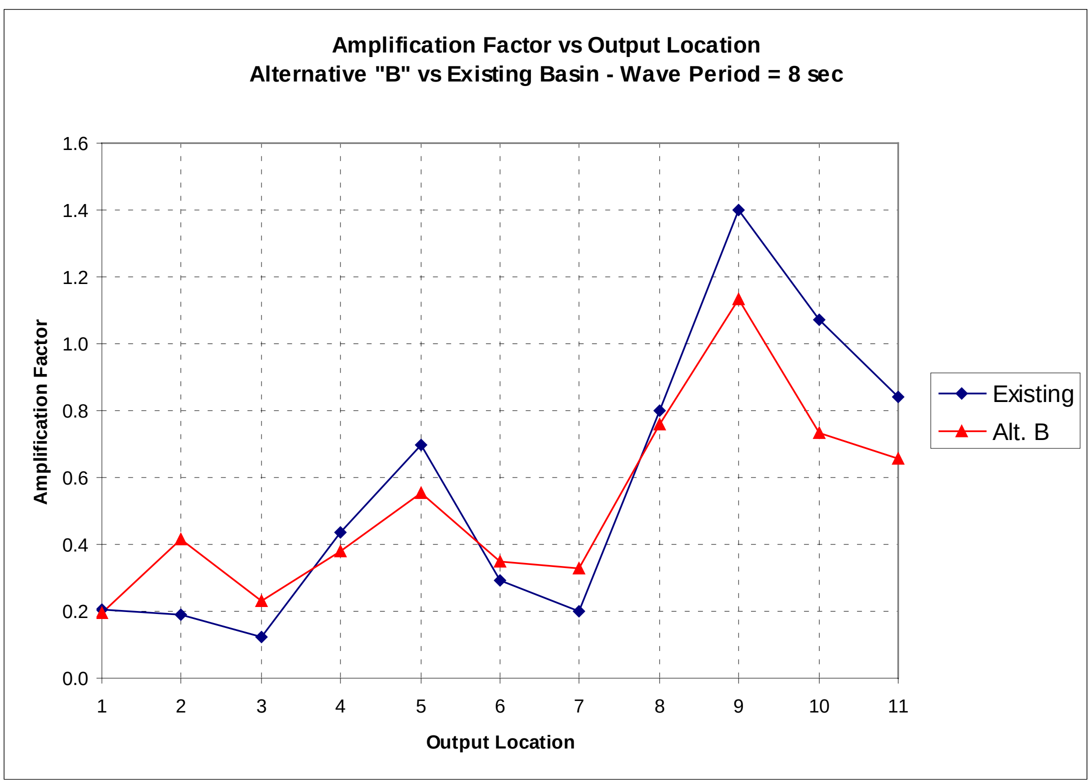


Figure B- 4. Maximum Amplification Factor – Alternative "B" vs Existing (Period = 8sec)

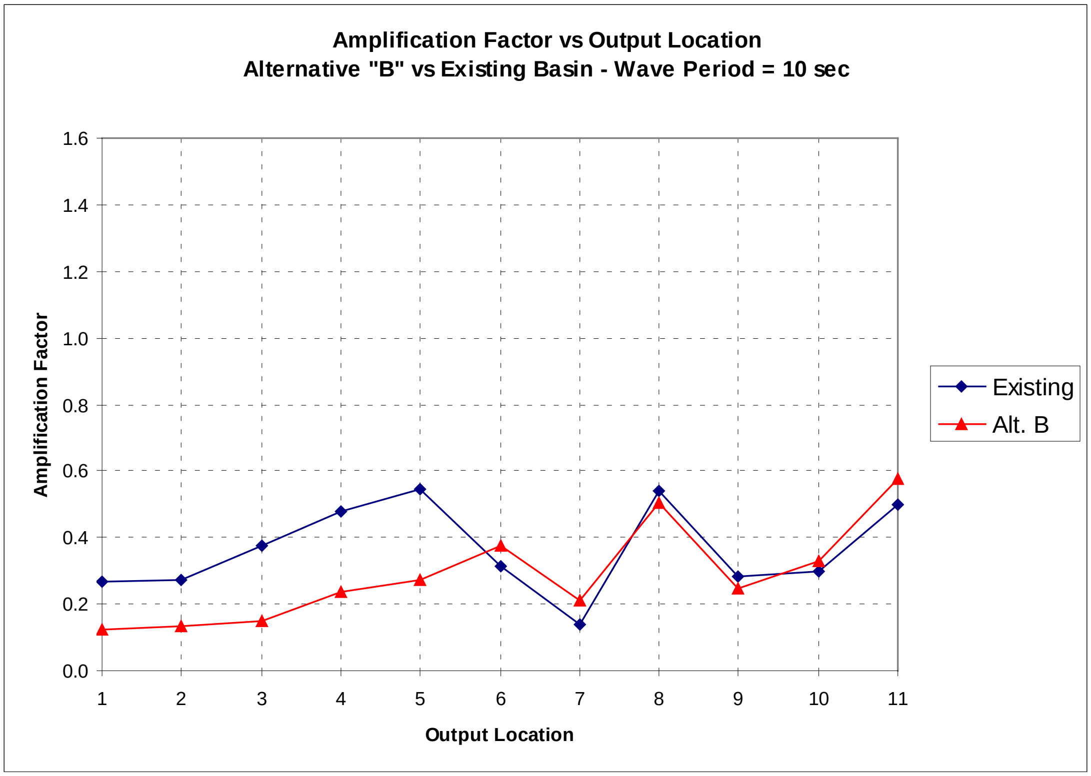


Figure B- 5. Maximum Amplification Factor – Alternative "B" vs Existing (Period = 10sec)

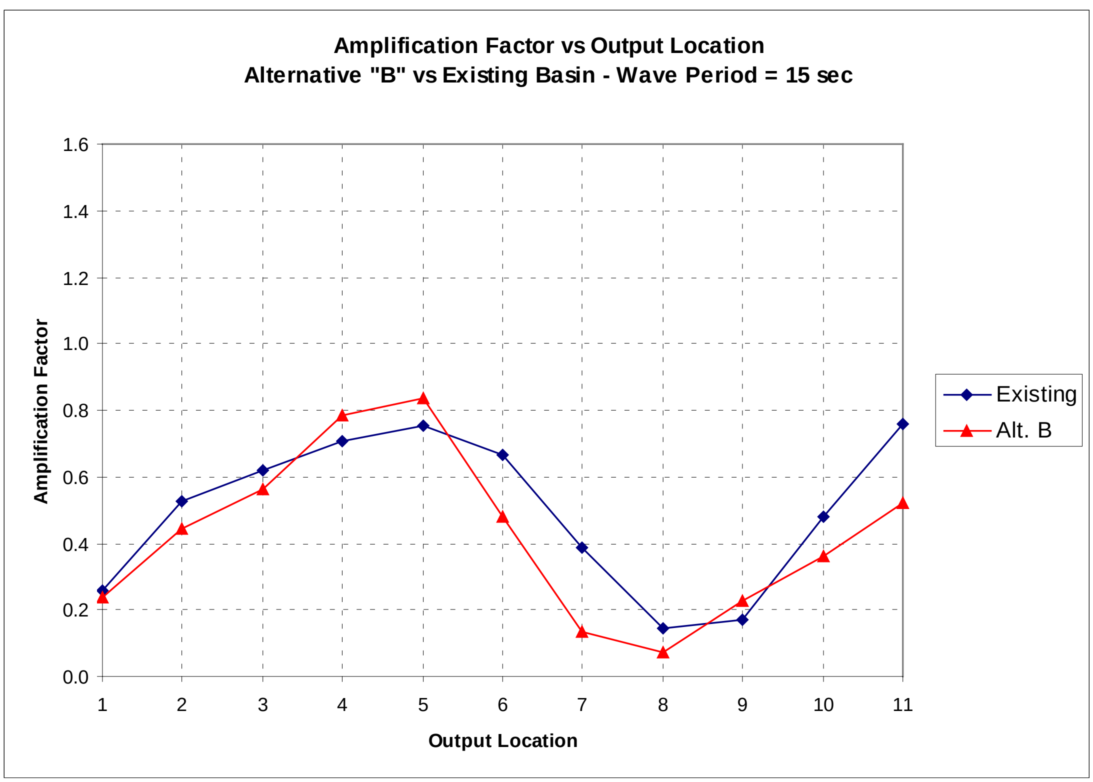


Figure B- 6. Maximum Amplification Factor – Alternative "B" vs Existing (Period = 15sec)

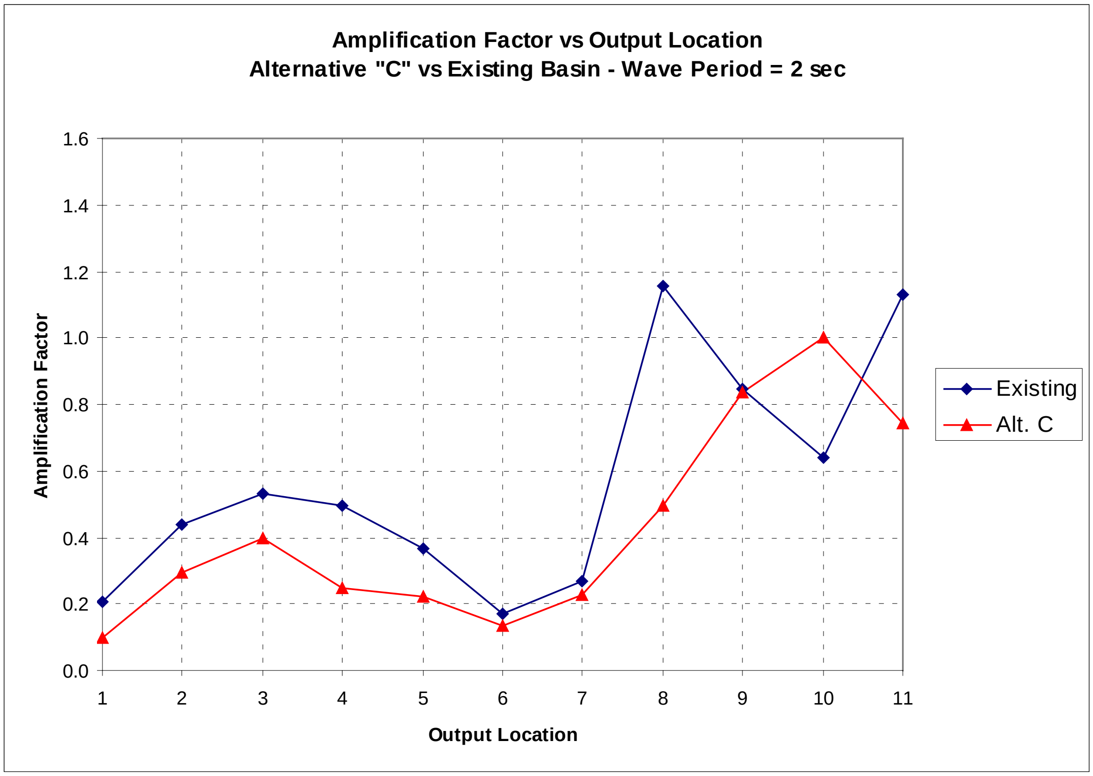


Figure B- 7. Maximum Amplification Factor – Alternative "C" vs Existing (Period = 2sec)

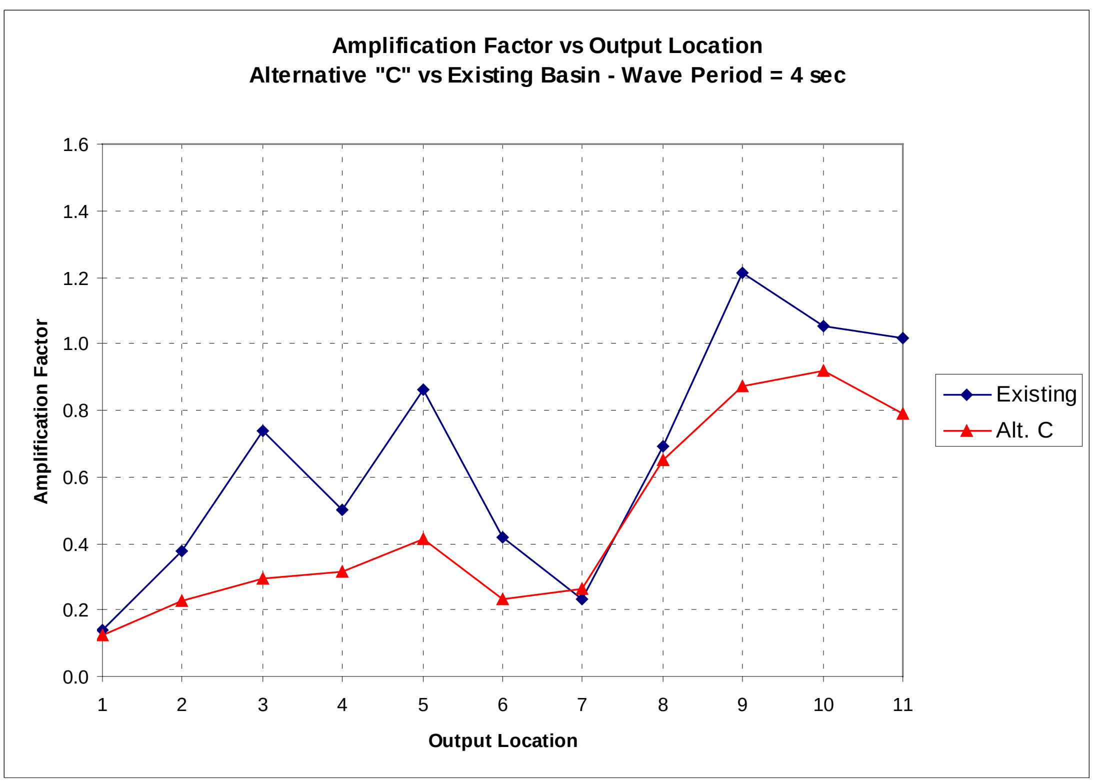


Figure B- 8. Maximum Amplification Factor – Alternative "C" vs Existing (Period = 4sec)

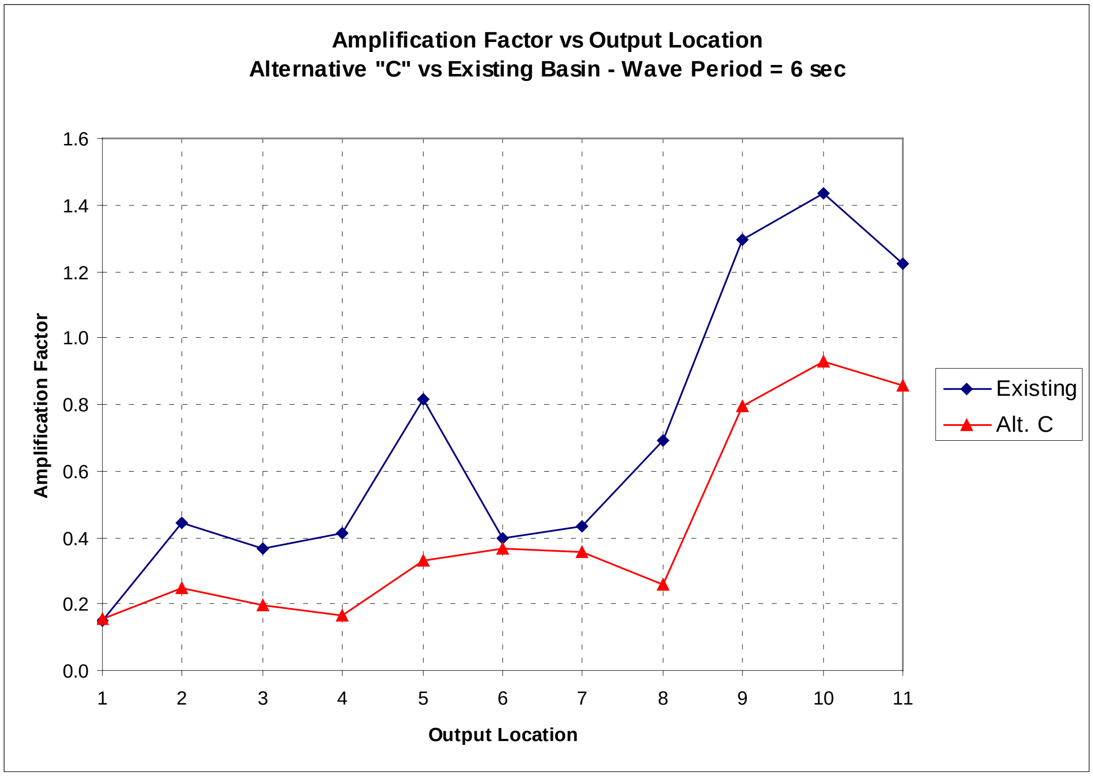


Figure B- 9. Maximum Amplification Factor – Alternative “C” vs Existing (Period = 6sec)

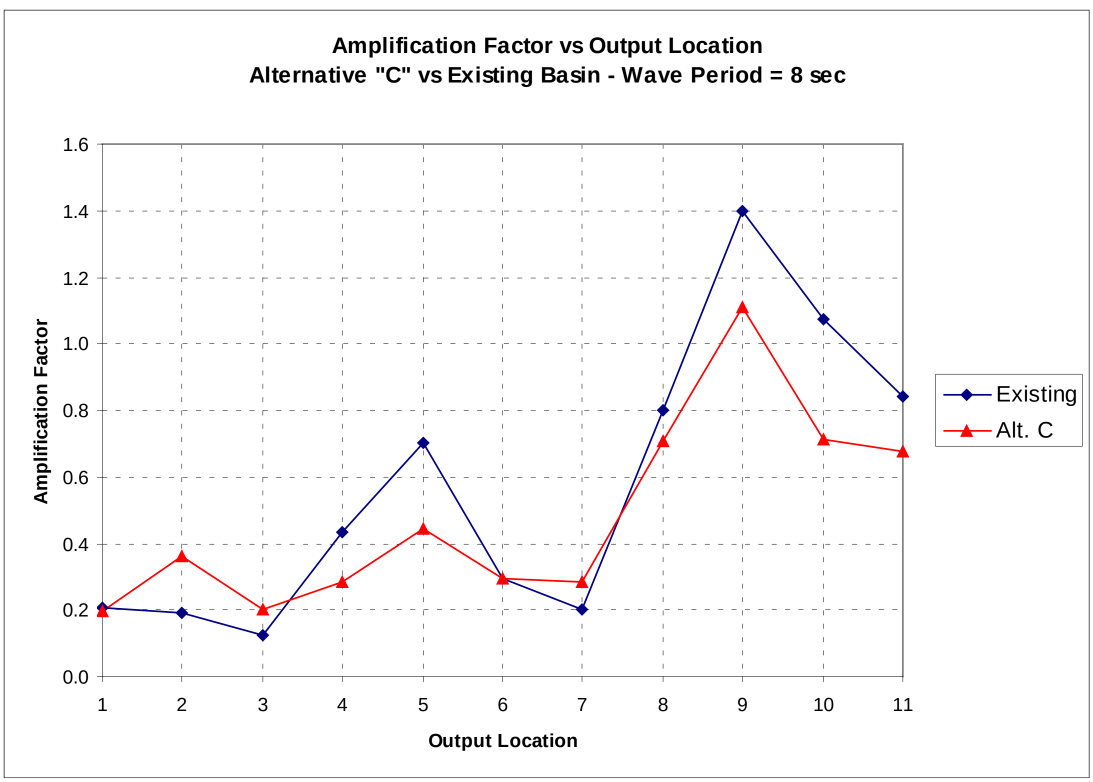


Figure B- 10. Maximum Amplification Factor – Alternative “C” vs Existing (Period = 8sec)

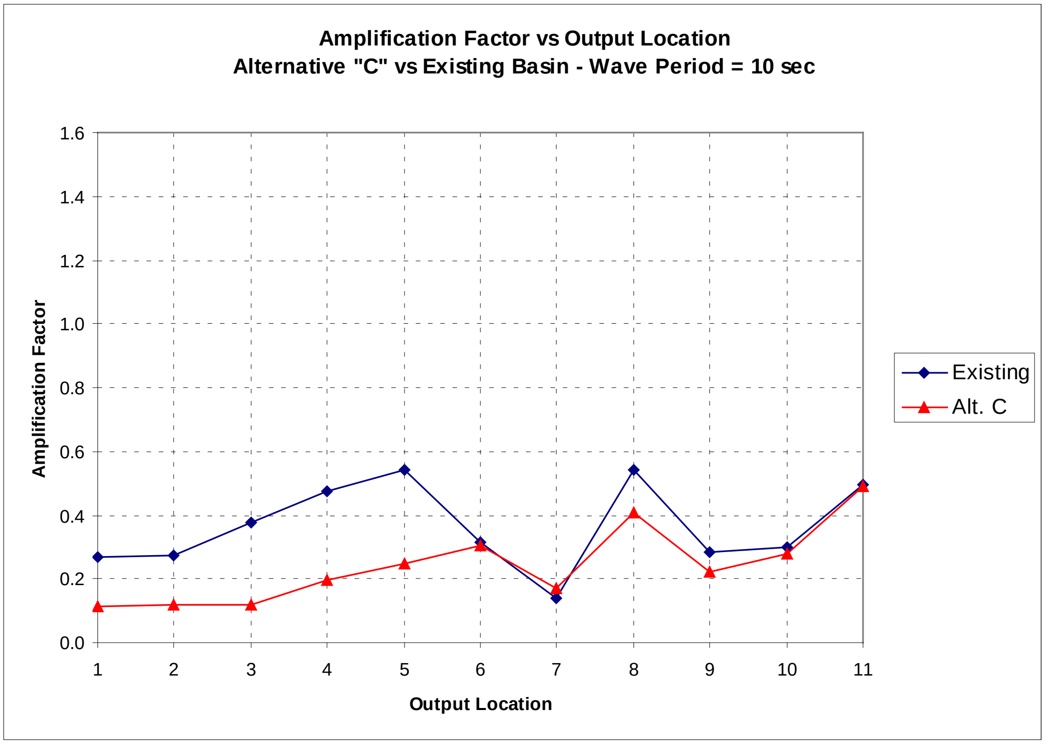


Figure B- 11. Maximum Amplification Factor – Alternative "C" vs Existing (Period = 10sec)

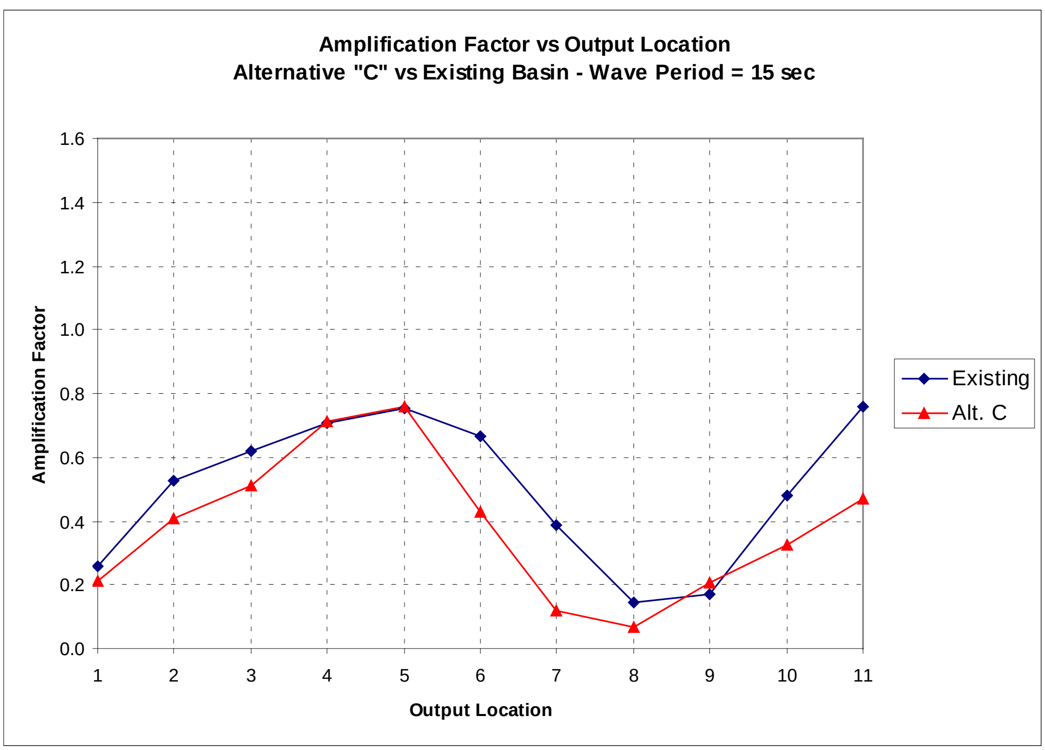


Figure B- 12. Maximum Amplification Factor – Alternative "C" vs Existing (Period = 15sec)

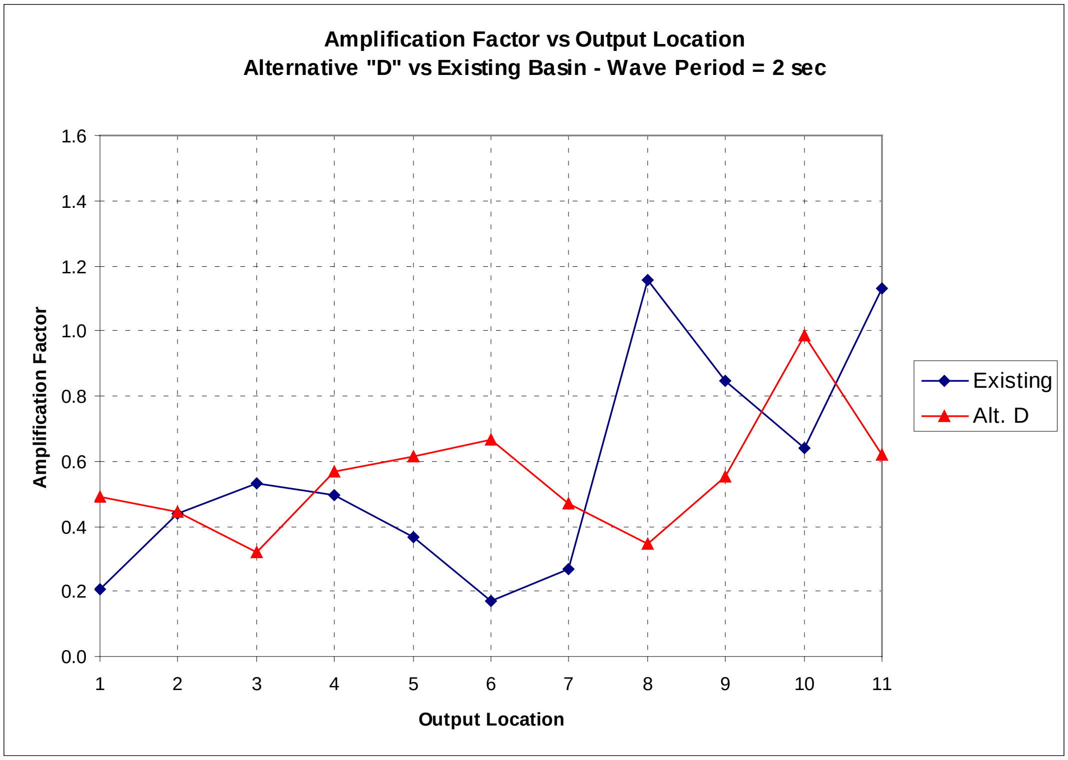


Figure B- 13. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 2sec)

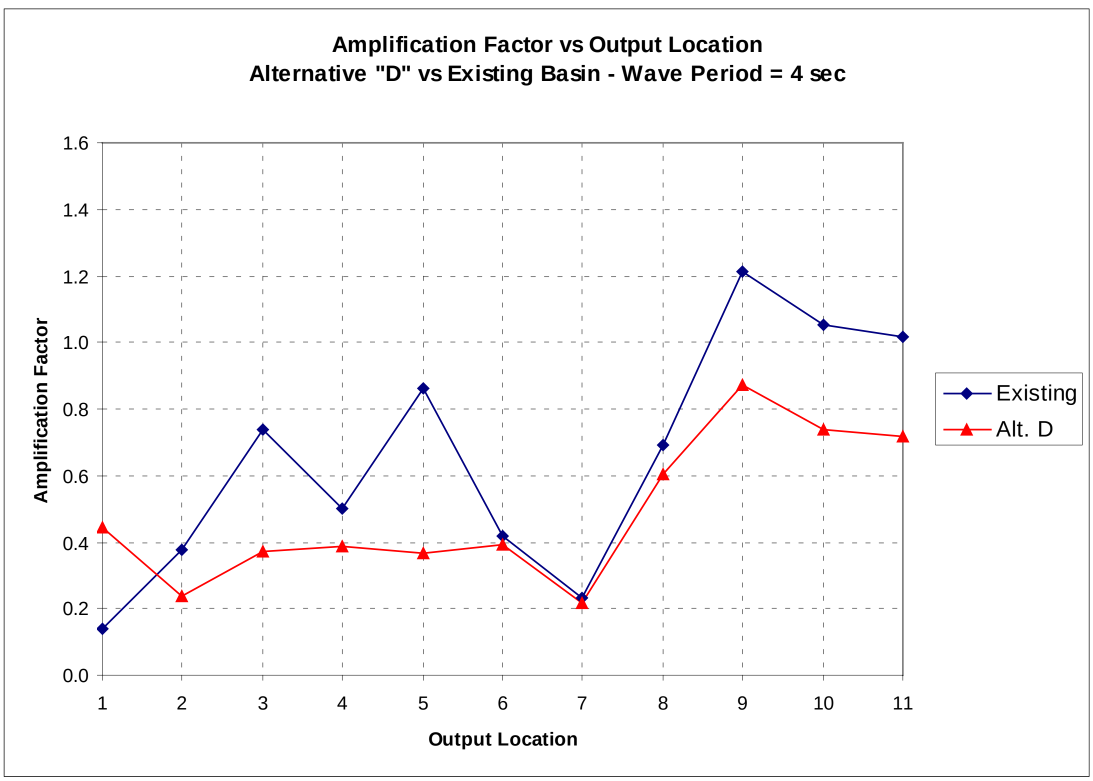


Figure B- 14. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 4sec)

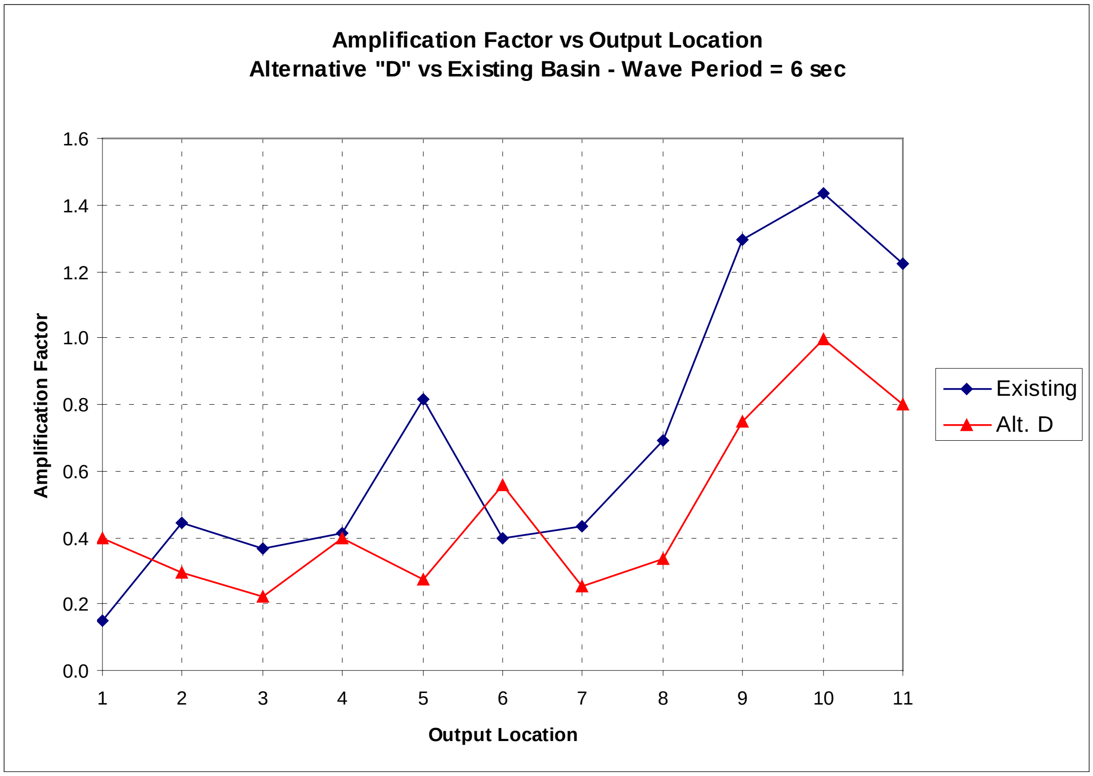


Figure B- 15. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 6sec)

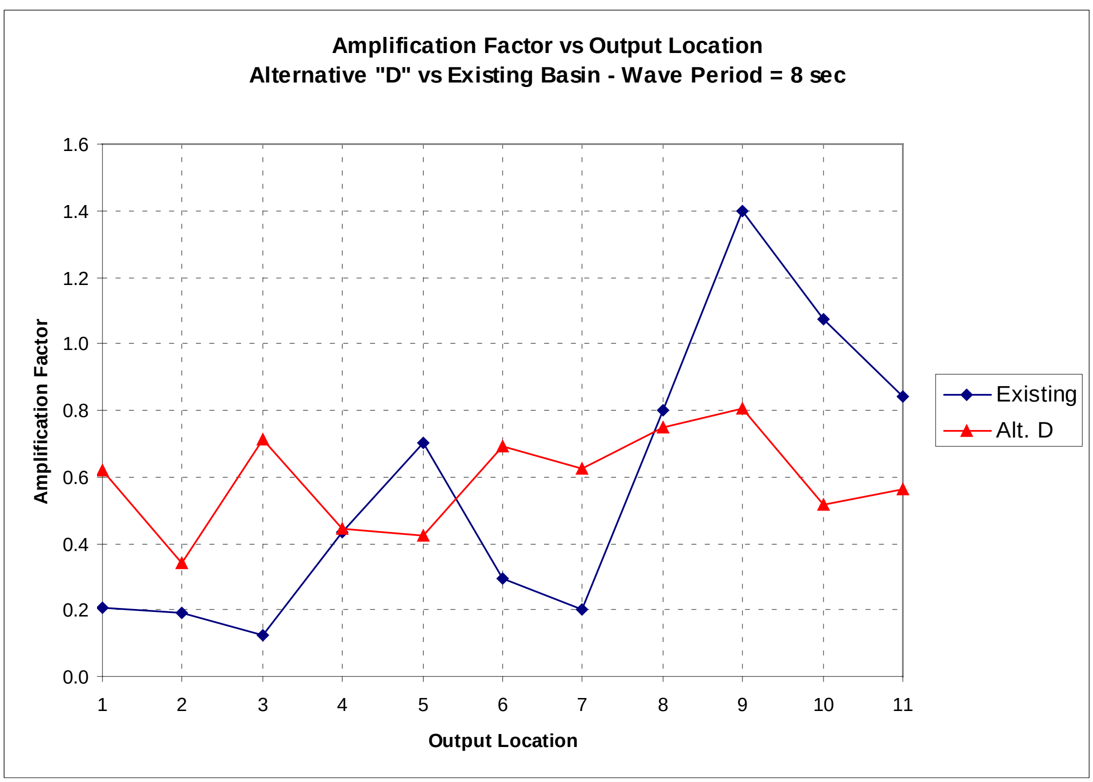


Figure B- 16. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 8sec)

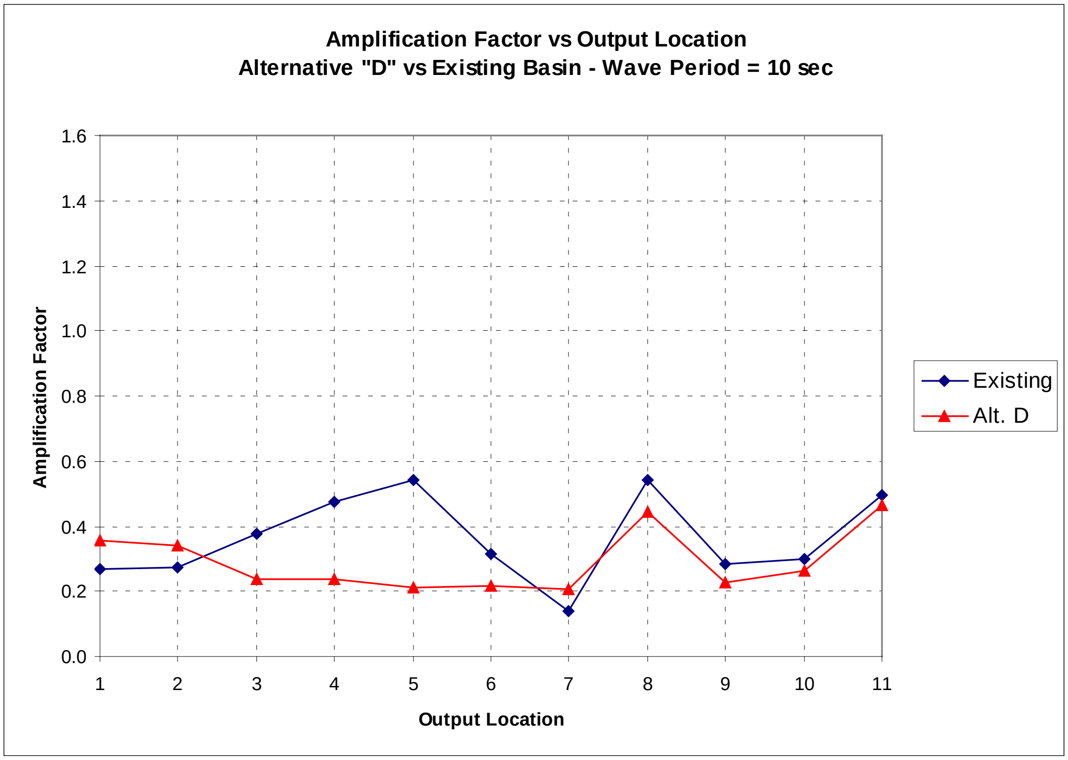


Figure B- 17. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 10sec)

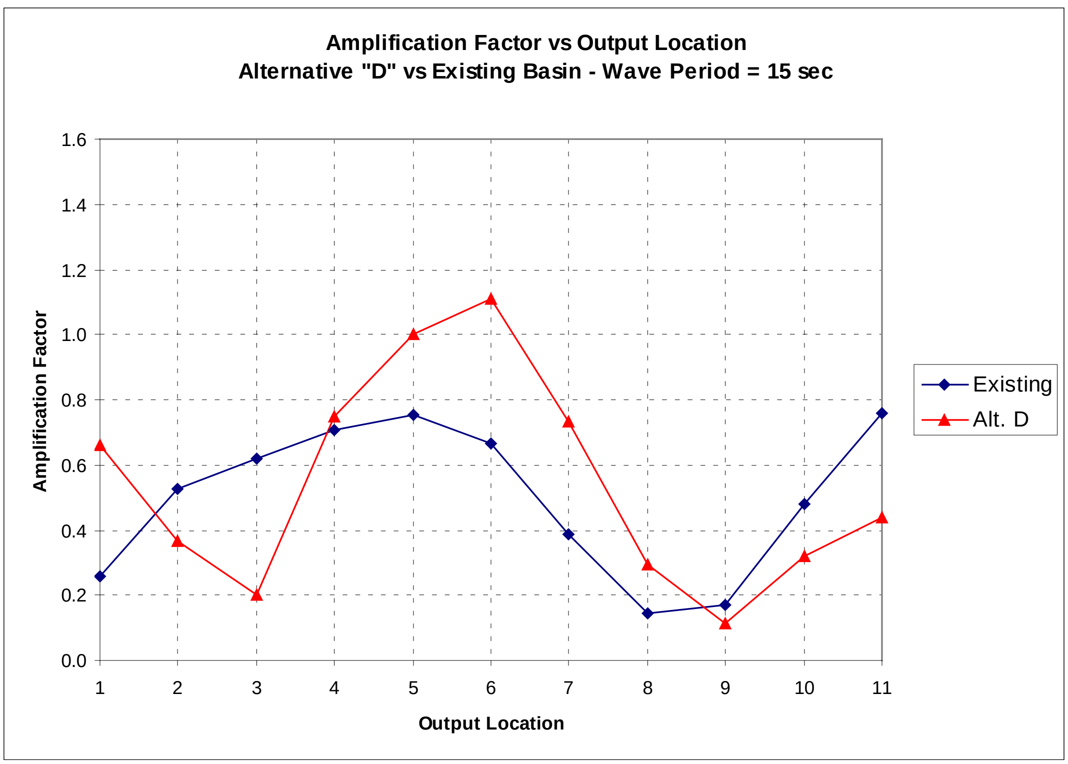


Figure B- 18. Maximum Amplification Factor – Alternative "D" vs Existing (Period = 15sec)

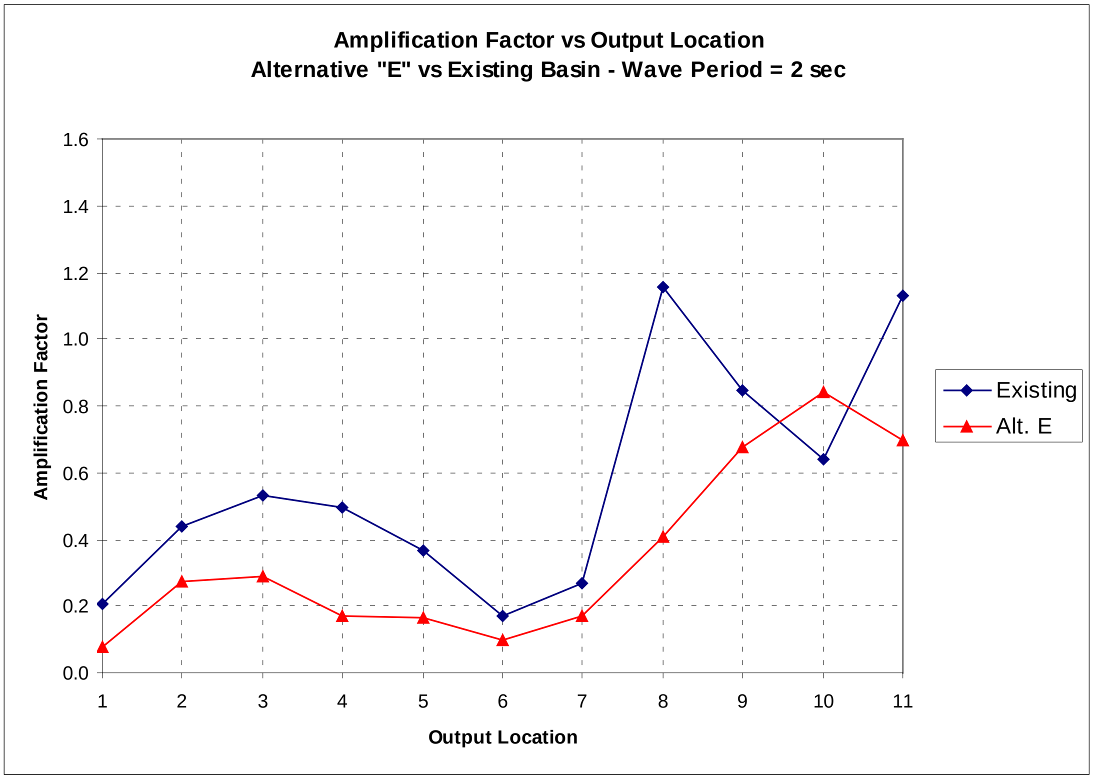


Figure B- 19. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 2sec)

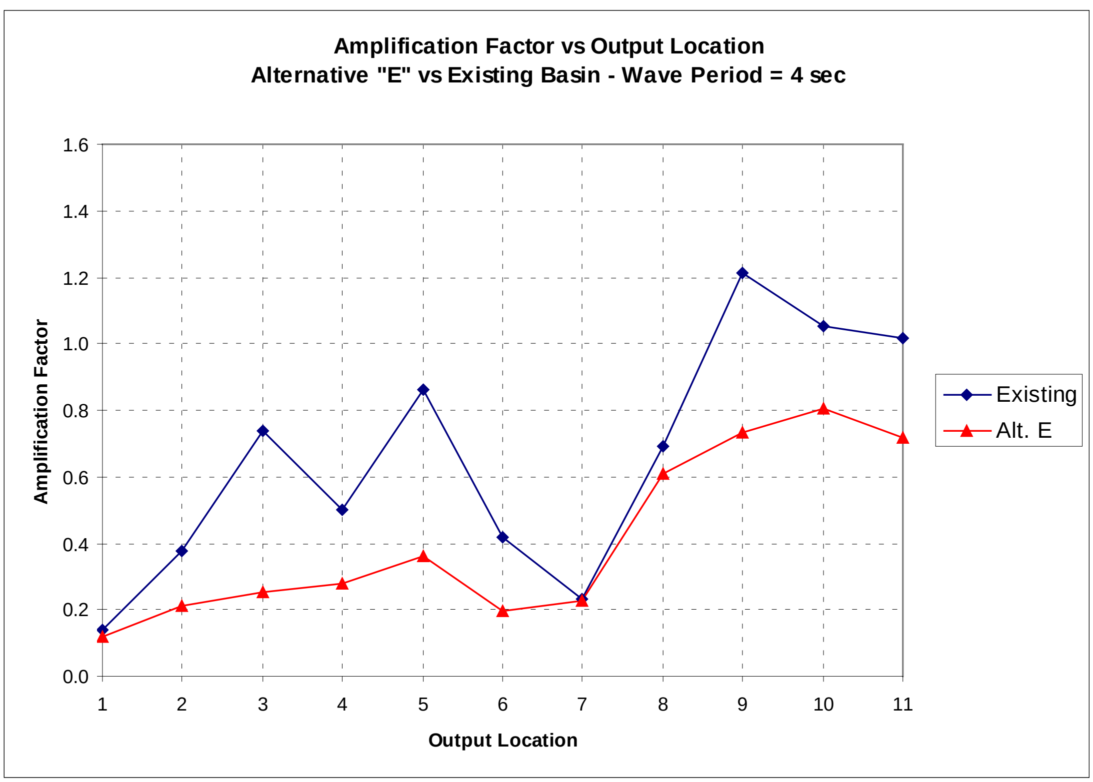


Figure B- 20. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 4sec)

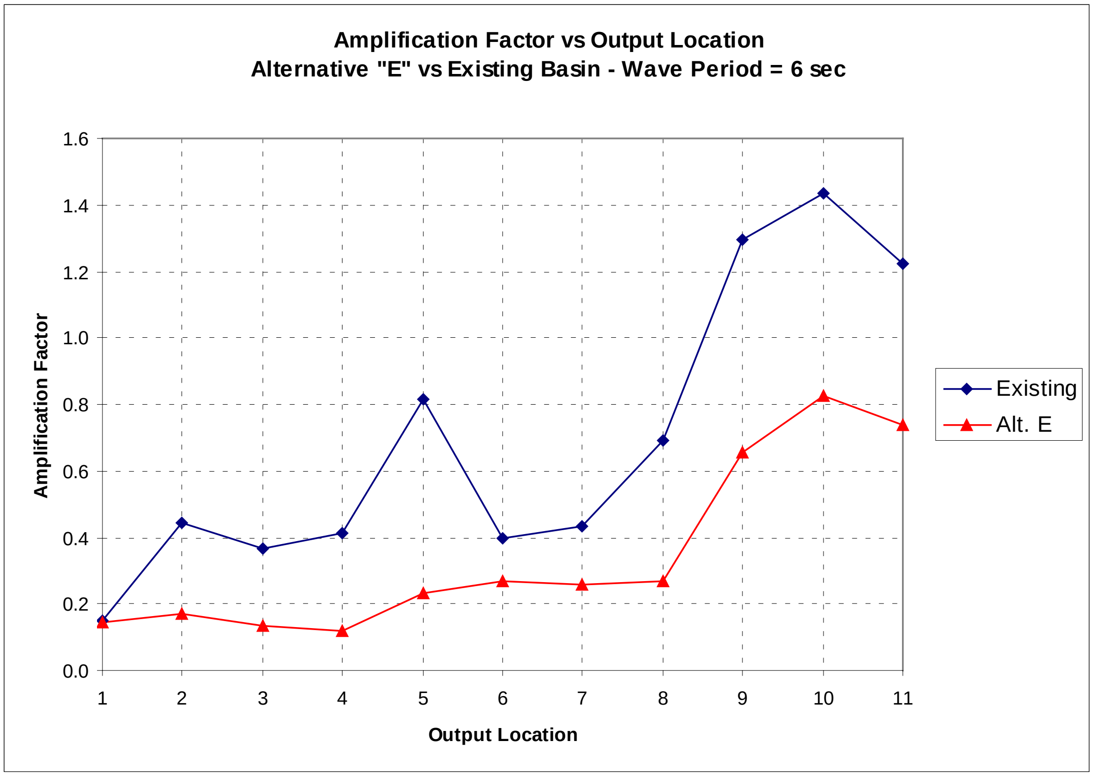


Figure B- 21. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 6sec)

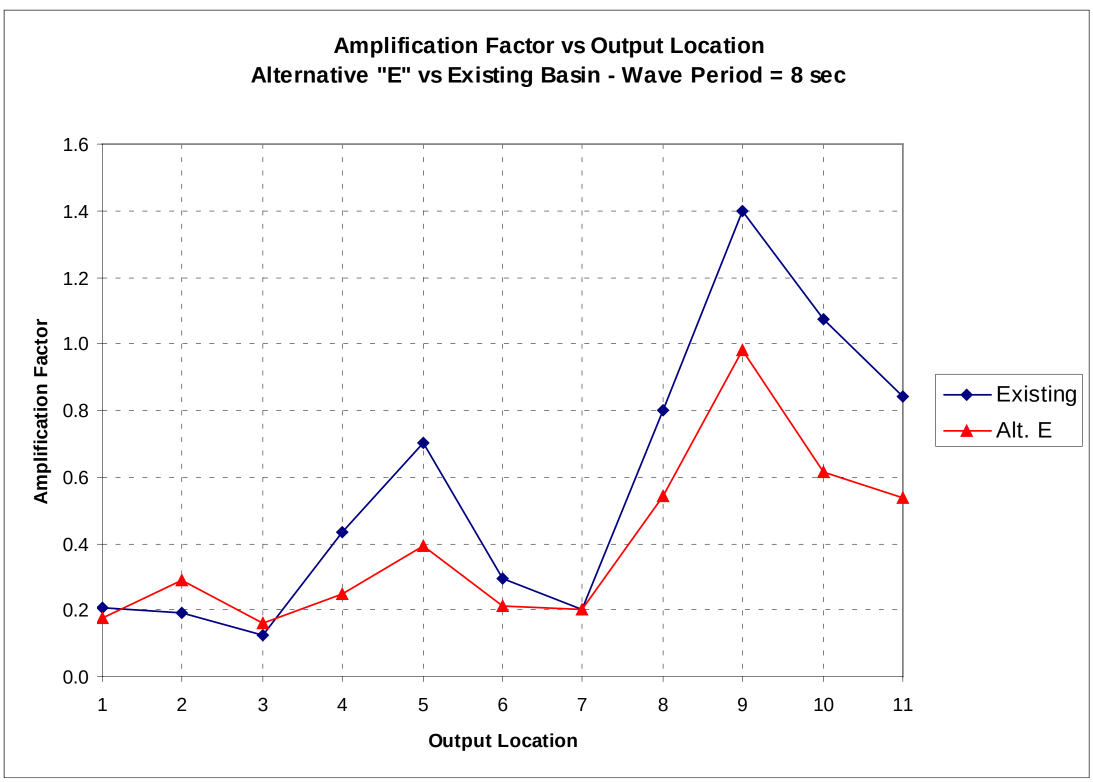


Figure B- 22. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 8sec)

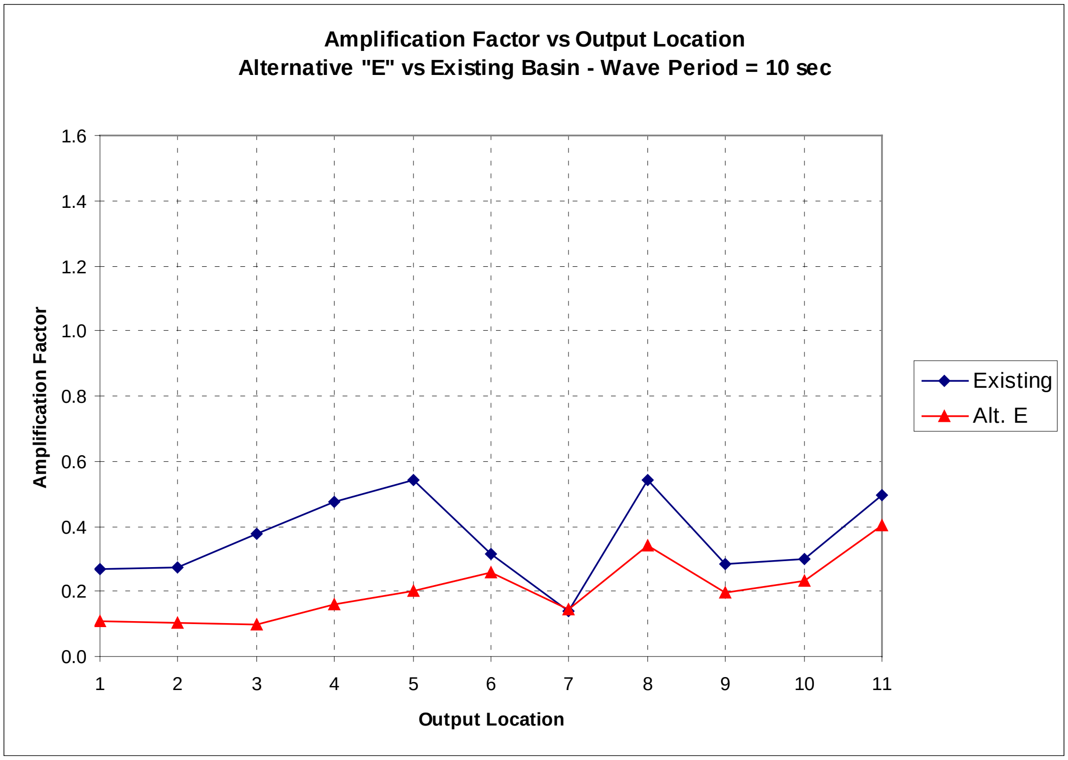


Figure B- 23. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 10sec)

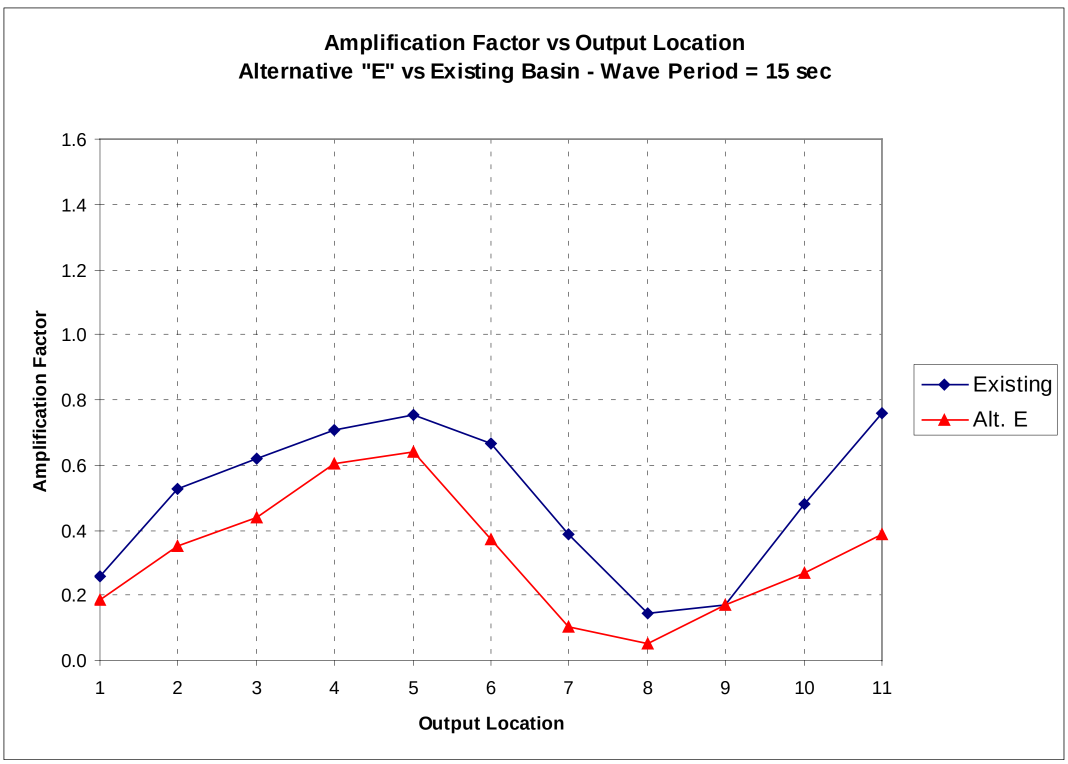


Figure B- 24. Maximum Amplification Factor – Alternative "E" vs Existing (Period = 15sec)

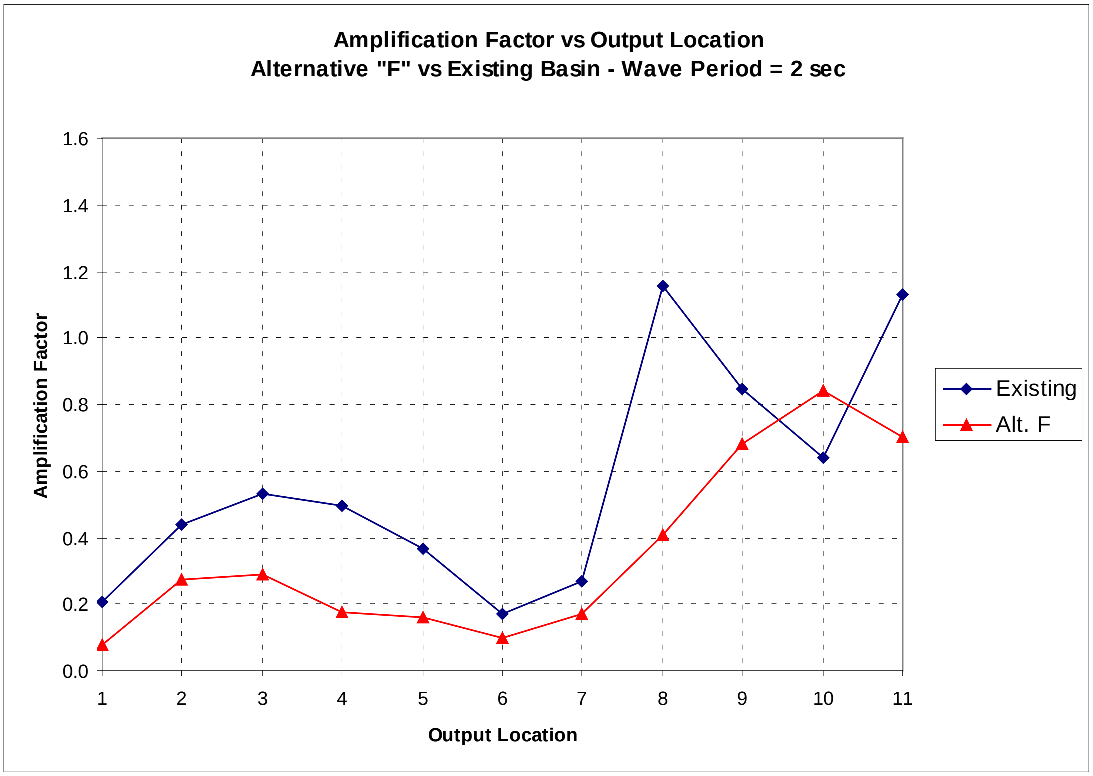


Figure B- 25. Maximum Amplification Factor – Alternative "F" vs Existing (Period = 2sec)

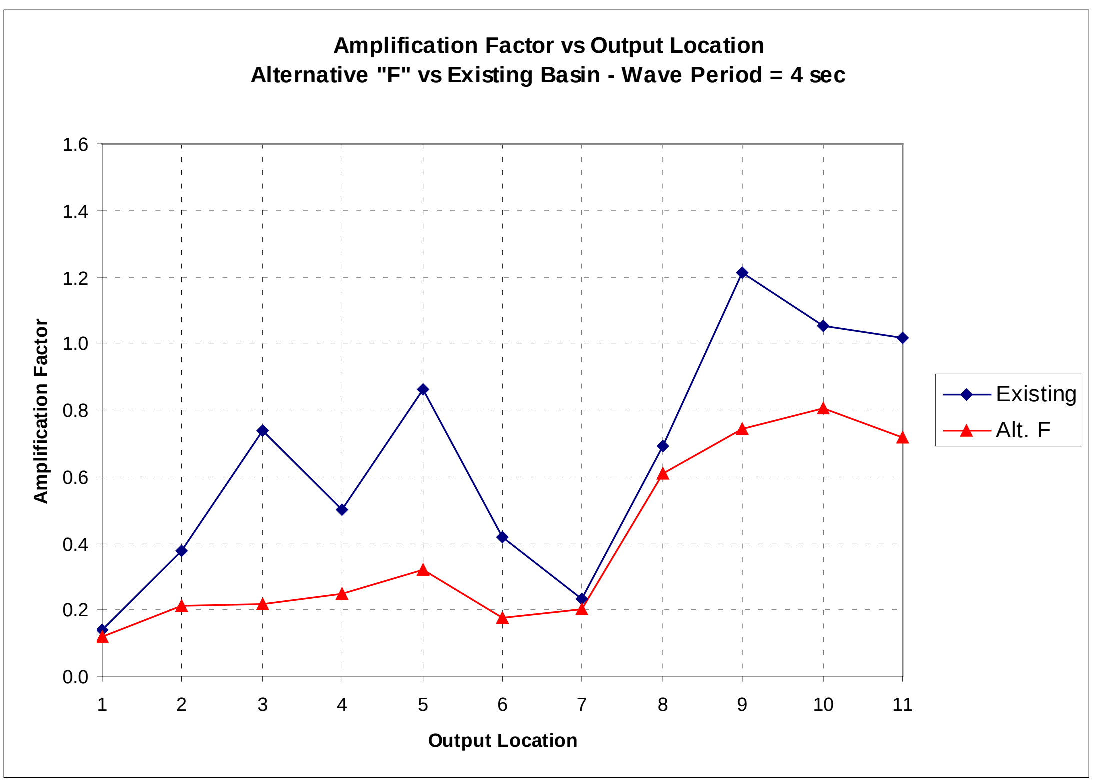


Figure B- 26. Maximum Amplification Factor – Alternative "F" vs Existing (Period = 4sec)

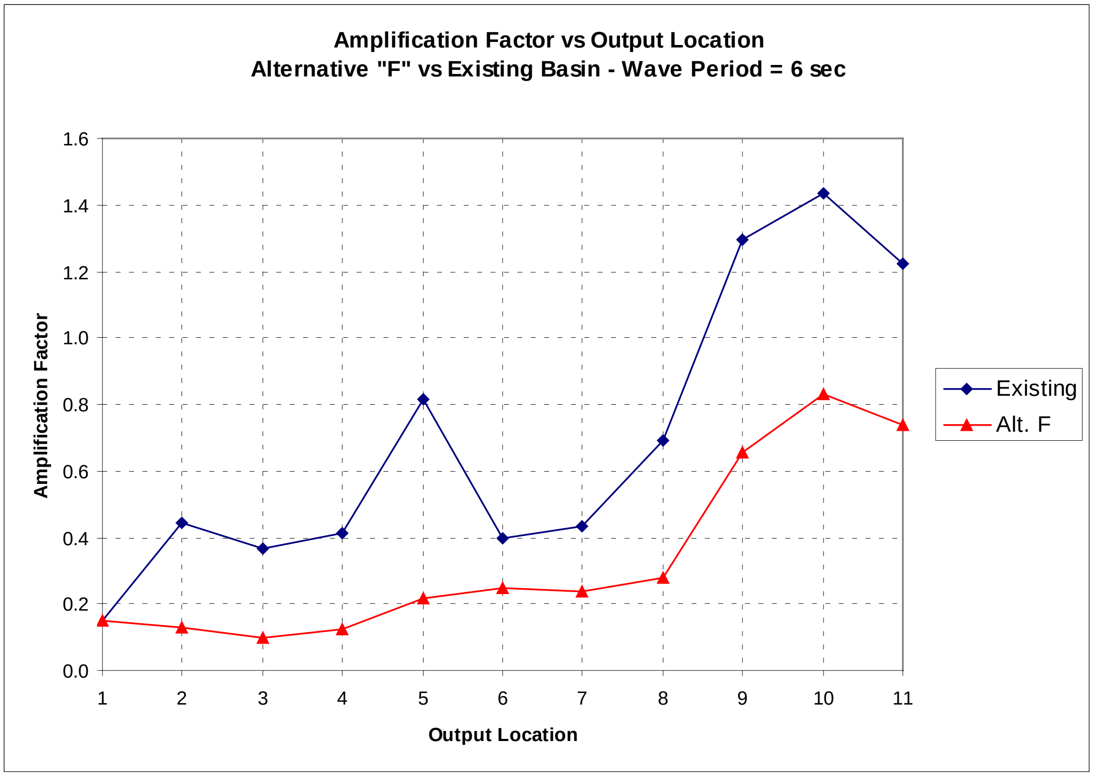


Figure B- 27. Maximum Amplification Factor – Alternative “F” vs Existing (Period = 6sec)

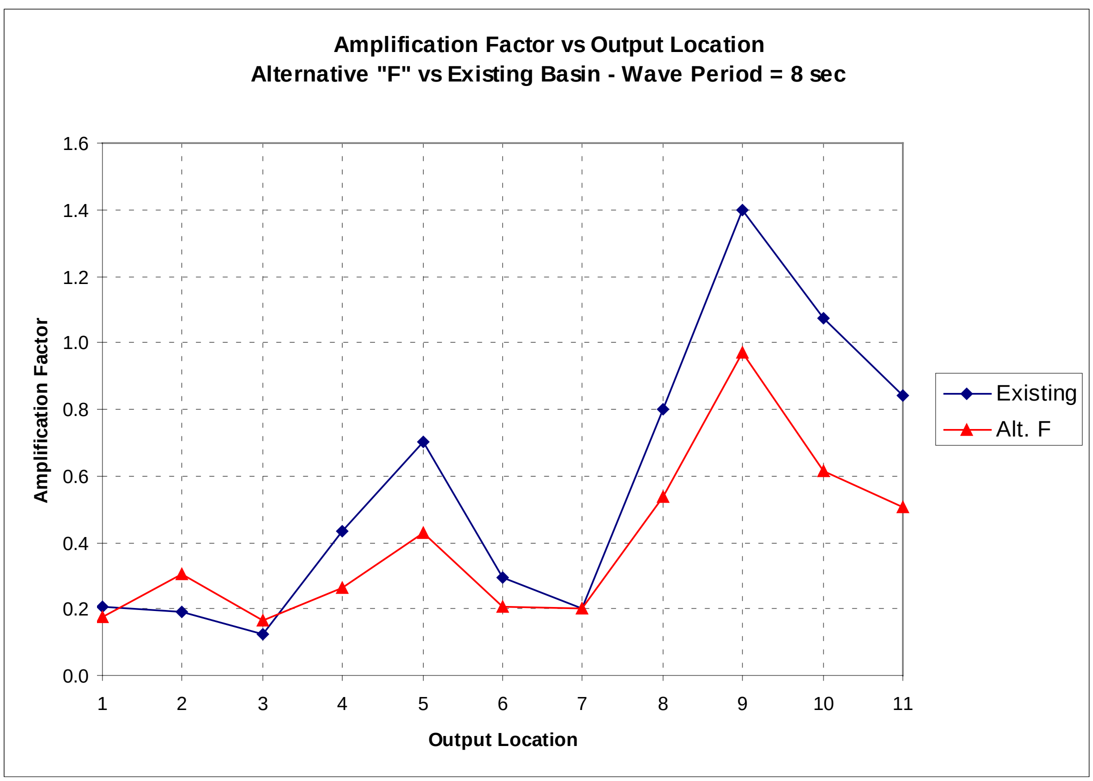


Figure B- 28. Maximum Amplification Factor – Alternative “F” vs Existing (Period = 8sec)

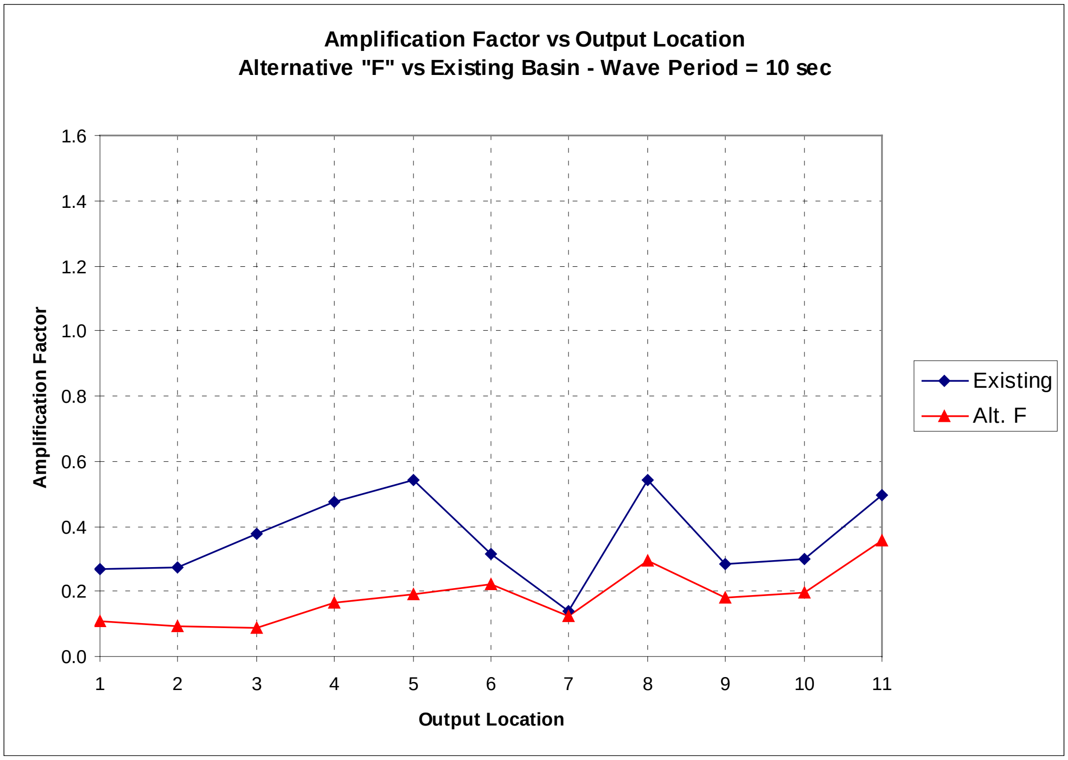
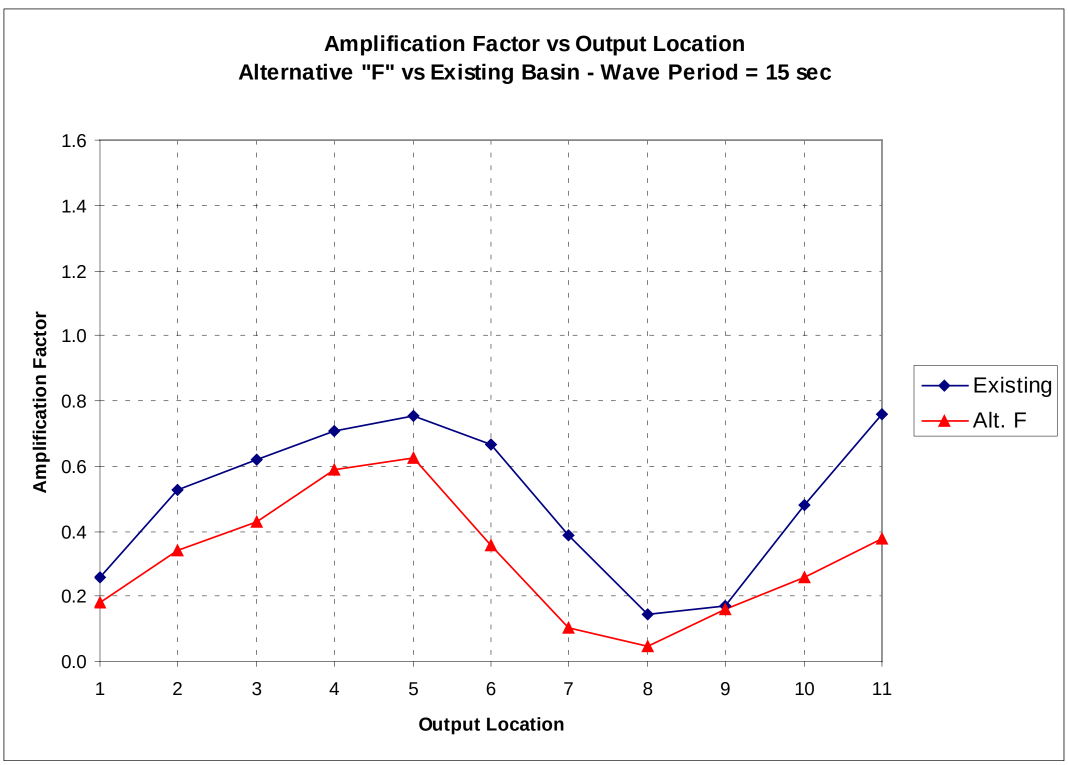


Figure B- 29. Maximum Amplification Factor – Alternative "F" vs Existing (Period = 10sec)



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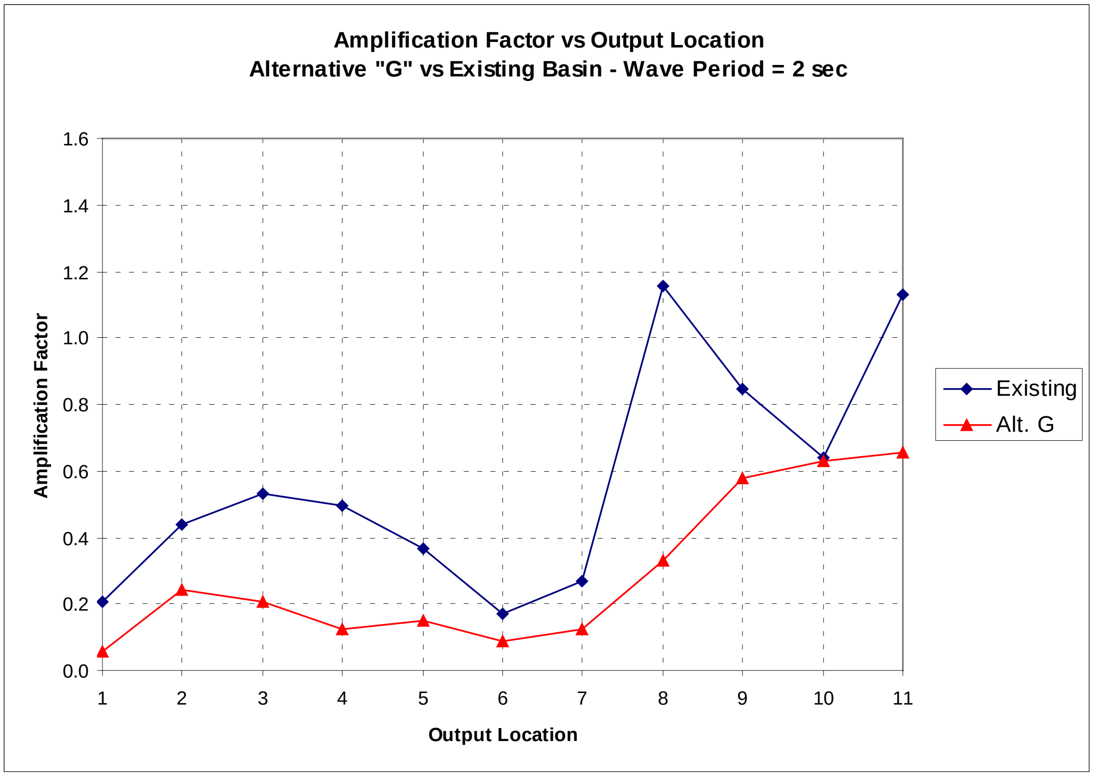

Figure B- 31. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 2sec)

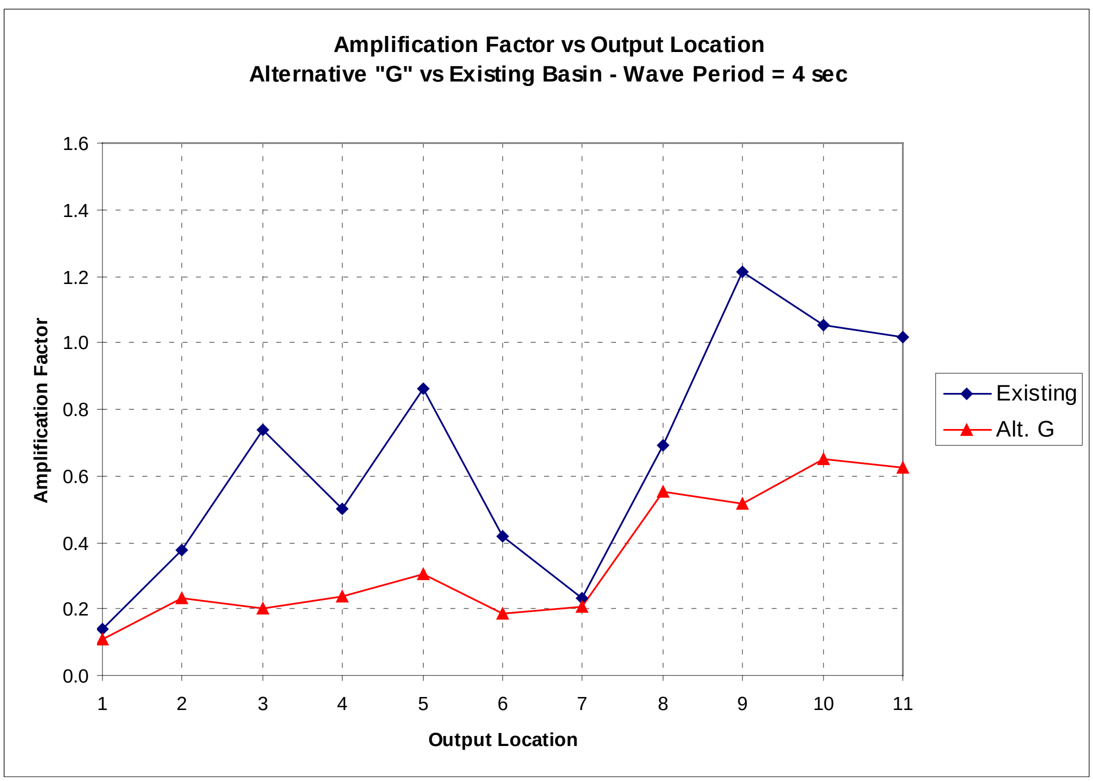

Figure B- 32. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 4sec)

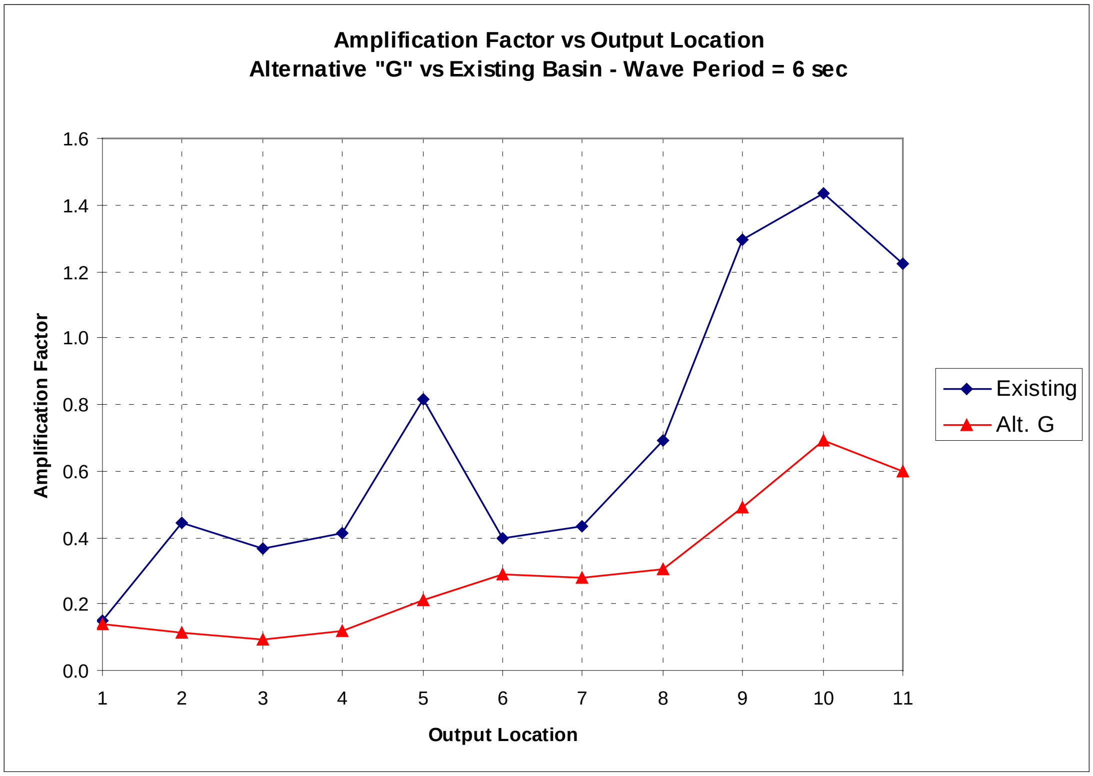

Figure B- 33. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 6sec)

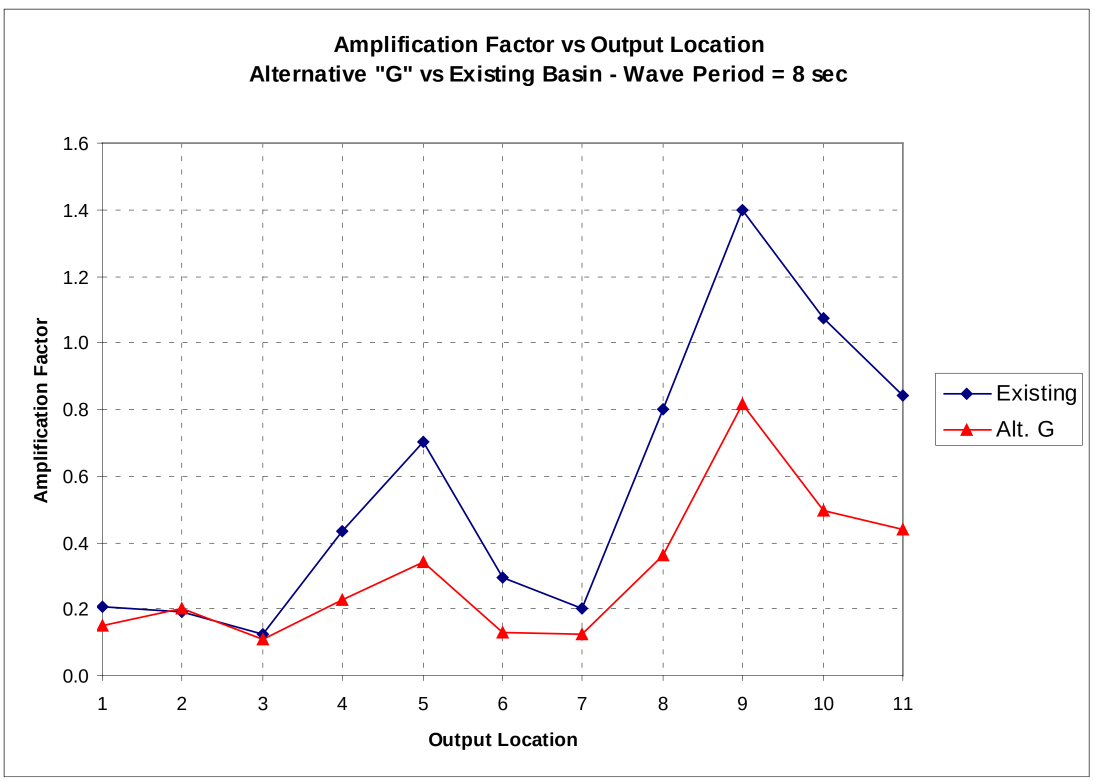

Figure B- 34. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 8sec)

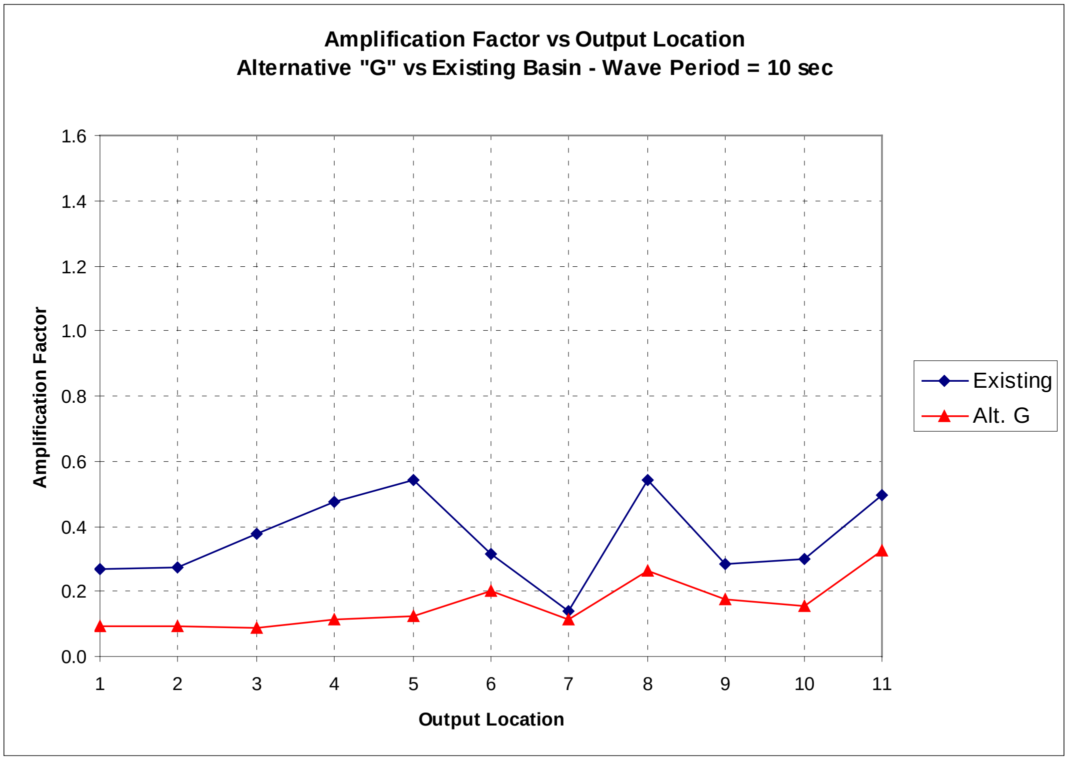

Figure B- 35. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 10sec)

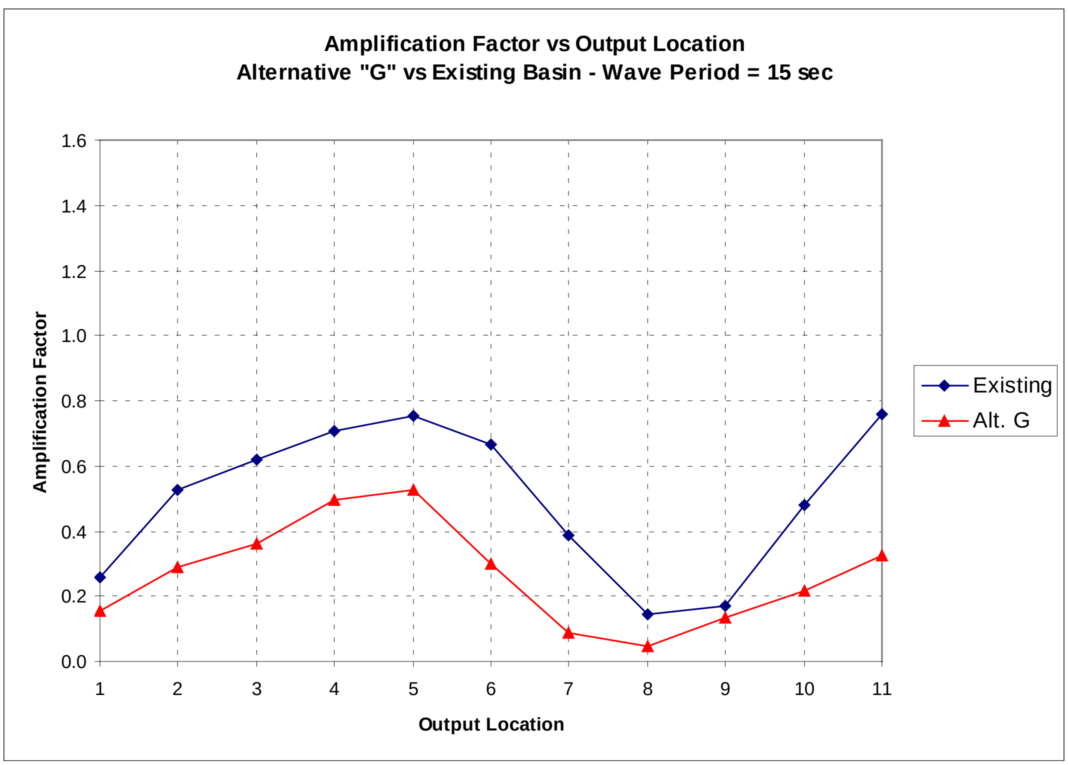

Figure B- 36. Maximum Amplification Factor – Alternative "G" vs Existing (Period = 15sec)

PORT EVERGLADES HARBOR, FLORIDA

SUB-APPENDIX C

PORT EVERGLADES HARBOR, FLORIDA
VESSEL SQUAT EVALUATION

Port Everglades Harbor Entrance Channel

Vessel Squat Evaluation

USACE – Jacksonville District
Last Revision: June 2011

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General

A large part of port and harbor design today includes making modifications to accommodate the growth of vessel traffic and an increase in vessel size. While modification may include channel widening and basin expansion to accommodate wider beams and longer lengths, it will almost certainly include channel deepening to accommodate deeper drafts. Determining how much underkeel clearance (distance between the keel and the channel bottom) a design vessel requires for safe passage depends on many factors including the dimensions of the vessel, the anticipated speed of the vessel, and the physical conditions that the vessel will likely encounter. One major component of the total underkeel clearance for a given design vessel is the ship squat while underway.

Ship squat is the "sinkage" that a vessel experiences while underway. As the ship moves forward, water passes around the hull producing a hydrodynamic pressure change that results in a water level depression into which the ship sinks. While it translates into a vertical displacement, squat is actually the combined effect of sinkage (heave), trim (pitch), and heel (roll) caused by the forward motion of the vessel. Factors that influence squat include the geometry of the vessel, the geometry of the channel, the position of the vessel relative to the channel, and the forward velocity of the vessel. Due to its dependence on vessel speed, squat is generally only determined in a harbor's entrance channels. Within the port, vessel speeds drop to such a degree that squat is no longer a significant component of underkeel clearance requirements.

Design Parameters

Vessel Geometry

The design vessel for the Port Everglades Harbor study is an S-Class Post-Panamax containership. An example of this vessel is the Susan Maersk, an 8,680 TEU capacity vessel with a length over all (LOA) of 1,138 feet. Dimensions and response parameters for the Susan Maersk were obtained from the Vertical Ship Motion Study for Savannah, GA (USACE, 2010) and are presented in Table 1.

Table 1. S-Class Dimensions and Response Parameters

Description	Symbol	Dimension
Length Between Perpendiculars	L_{pp}	1,088.1 feet
Beam	B	140.4 feet
Draft (Full)	T	48 feet
Block Coefficient	C_B	0.65
Longitudinal Center of Gravity	LCG	544.0 feet
Vertical Center of Gravity	KG	60 feet
Metacentric Height	GM	2.57 feet
Roll Damping Factor, fraction percent	R	0.036

Channel Geometry

Channel geometry plays a large role in how much squat a vessel will experience. In general there are three types of channels: canal, trench, and fairway (Figure 1). Of these three, canal and trench channels are considered to be restricted. Fairways are unrestricted. The Port Everglades Harbor entrance channel is a restricted, trench style channel. Key dimensions of a trench style channel are presented in Figure 2.

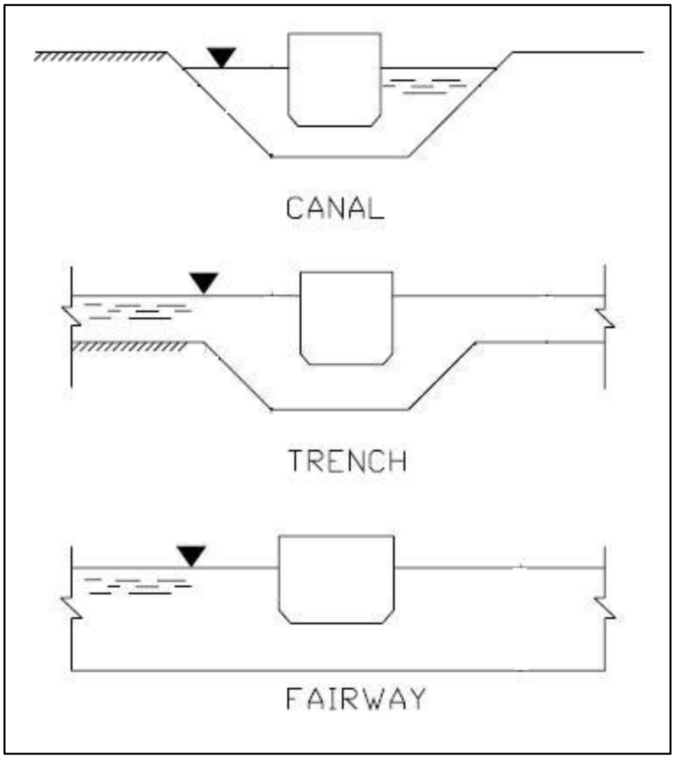

Figure 1. Navigation Channel Types

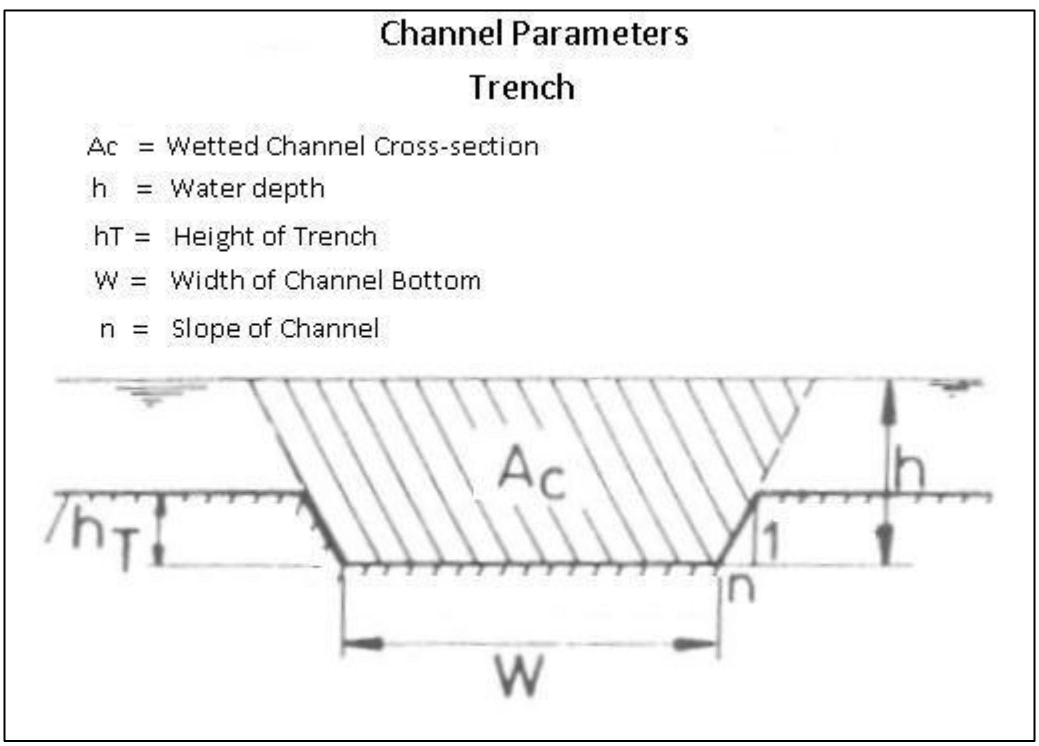

Figure 2. Channel Geometry Parameters

Velocity

The velocity of the vessel is another important factor in how much squat it will experience. At Port Everglades, the proximity of the Gulf Stream creates a unique water current environment immediately outside the entrance, along the vessel approach. The Gulf Stream moves to the north, across the path of approaching vessels. Immediately shoreward of the Gulf Stream, there is an opposing current, flowing southward, that changes its position within an east to west envelope, and varies in strength. This opposing current environment requires ships' pilots to move forward at 12 to 8 knots of speed (decreasing from the outer marker to the eastern tip of the jetties), to maintain directional control of the vessel during the critical last stages of the entrance transit. This speed, and consequent enormous momentum, must then be immediately damped and removed as the vessel enters the jetties. The necessary shedding of momentum requires three tugs that meet the vessel just as it approaches the eastern end of the jetties. Based on the velocity requirements for these conditions, an average velocity of 10 knots was used for determining squat.

Empirical Squat Formulas

A number of empirical formulas are available for estimating squat. Formulations have been developed for both deep and shallow water and can further be broken down into those that apply to restricted or unrestricted channels. Port Everglades Harbor can be defined as shallow water (relative to open ocean depths) with a restricted, trench type entrance channel.

Two primary sources of guidance were consulted for determining squat in the Port Everglades entrance channel, EM 1110-2-1613: Hydraulic Design of Deep-Draft Navigation Projects (USACE, 2006) and Permanent International Association of Navigation Congresses: Approach Channels, A Guide for Design (PIANC, 1997). Supplemental information was obtained from USACE Coastal Engineering Technical Notes CHETN I-63 (Demirbilek and Sargent, 1999), CHETN IX-14 (Briggs et al., 2004), and CHETN I-72 (Briggs, 2006). From these sources five empirical methods were found that applied to the shallow water, trench type Port Everglades entrance channel:

- Canal Method (USACE, 2006)
- Barrass (1981)
- Eryuzlu et al. (1994)
- Huuska/Guliev (1979/1971)
- Romisch (1989)

Computational Parameters

Many empirical squat formulas, including those discussed here, share common computational parameters. Attachment 1 provides a summary table of computational parameters that were used in this study.

Canal Method

The simple canal method presented in EM 1110-2-1613 depends on certain idealized assumptions including a rectangular channel cross-section, rectangular ship cross-section, and uniform return flow throughout the channel. It is considered to provide a good first approximation for channel design.

The governing equation is based on the Bernoulli Effect and can be expressed as:

$$F_h = \sqrt{\frac{2\frac{z}{h}\left(1 - \frac{A_S}{A_C} - \frac{z}{h}\right)^2}{1 - \left(1 - \frac{A_S}{A_C} - \frac{z}{h}\right)^2}}$$

Where

F_h	= Depth froude number
z	= Squat
h	= Water depth
A_s	= Wetted ship cross-section (= 0.98BT; Briggs, 2006)
A_c	= Wetted channel cross-section

The depth Froude number can also be defined as:

$$F_h = \frac{V}{\sqrt{gh}}$$

Where

V	= Ship speed
g	= Acceleration due to gravity

Squat is determined by setting the two equations equal to each other, assuming an initial amount of squat, and solving iteratively until a final squat value is converged upon. For Port Everglades, squat was determined for vessel drafts ranging from 39 feet to 48 feet. Attachment 2 provides computational results for squat at Port Everglades using the Canal method.

Barrass Method

The Barrass method, based on validation with full-scale measurements, is expressed as:

$$z = \frac{C_B S_2^{2/3} V_k^{2.08}}{30}$$

Where

z	= Squat
S_2	= Blockage Ration; $A_s/(A_c-A_s)$
C_B	= Block Coefficient
V_k	= Ship speed in knots

Attachment 3 provides Barrass method computational results for vessel drafts ranging from 39 feet to 48 feet.

Eryuzlu et al. Method

The Eryuzlu et al. method, based on a series of physical model tests and field measurements is expressed as:

$$z = 0.298\frac{h^2}{T}\left(\frac{V}{\sqrt{gT}}\right)^{2.289}\left(\frac{h}{T}\right)^{-2.972} K_b$$

Where

z	= Squat
h	= Water depth
T	= Ship Draft
V	= Ship speed
g	= Acceleration due to gravity
K_b	= Correction factor for channel width, given by:

$$K_b = \begin{cases} \frac{3.1}{\sqrt{W/B}} & \frac{W}{B} < 9.61 \\ 1 & \frac{W}{B} \geq 9.61 \end{cases}$$

Where

W	= Channel width at bottom
B	= Ship Beam

Attachment 4 provides Eryuzlu et al. computational results for vessel drafts ranging from 39 feet to 48.

Huuska/Guliev Method

The Huuska/Guliev method is an extension of a previously developed unrestricted channel computation (Hooft, 1974), which was modified by adding a correction factor for channel width. This method is expressed as:

$$z = 2.4\frac{\nabla}{L_{pp}^2}\frac{F_h^2}{\sqrt{1 - F_h^2}}K_s$$

Where

z	= Squat
∇	= Ship volume displacement (= $C_B L_{PP} BT$)
L_{pp}	= Ship length between perpendiculars
F_h	= Depth Froude number
K_s	= Correction factor for channel width, given by:

$$K_s = \begin{cases} 7.45 s_1 + 0.76 & s_1 > 0.03 \\ 1 & s_1 \leq 0.03 \end{cases}$$

Where

$$s_1 = \frac{A_s / A_c}{K_1}$$

K_1 = Correction Factor; Figure 3

Attachment 5 provides Huuska/Guliev computational results for vessel drafts ranging from 39 feet to 48 feet.

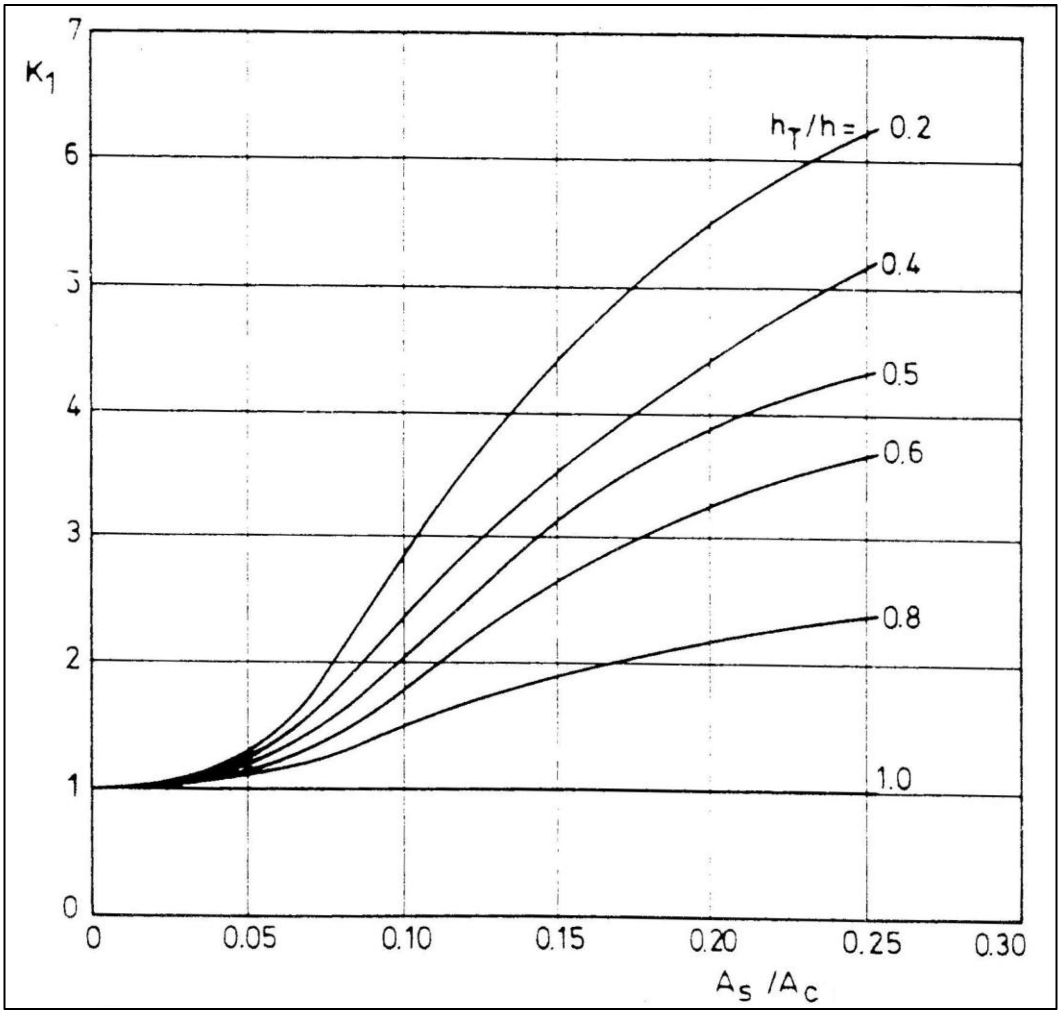

Figure 3. Correction Factor, K_1 (Huuska, 1976)

Romisch Method

The Romisch method, based on physical model experiments, is expressed as:

$$z = C_V C_F K_{\Delta T} T$$

Where

z	= Squat
C_V	= Correction factor for ship speed
C_F	= Correction factor for ship shape
$K_{\Delta T}$	= Correction factor for squat at ship critical speed
T	= Ship draft

The values of the correction factors are defined as:

$$C_V = 8\left(\frac{V}{V_{cr}}\right)^2 \left[\left(\frac{V}{V_{cr}} - 0.5\right)^4 + 0.0625\right]$$

$$C_F = \left(\frac{10C_B}{L_{pp}/B}\right)^2$$

$$K_{\Delta T} = 0.155\sqrt{\frac{h}{T}}$$

Where

V	= Ship speed
V_{CR}	= Ship critical speed
C_B	= Block Coefficient
L_{PP}	= Ship length between perpendiculars
B	= Ship beam
h	= Water depth

A ship's critical velocity, V_{CR}, is based on the channel configuration. For restricted, trench style channels, the critical velocity is given by:

$$V_{CR} = C_{mT}\left[K_{ch}\left(1 - \frac{h_T}{h}\right) + K_c\left(\frac{h_T}{h}\right)\right]$$

Where

C_{mT} = wave celerity based on the relevant water depth
h_T = height of the trench (see Figure 2)
K_{ch} = correction factor on critical speed (restricted/unrestricted)
K_c = correction factor on critical speed (canal)

Above parameters are defined as:

$$C_{mT} = \sqrt{g h_{mT}}$$

$$h_{mT} = h - \frac{h_T}{h}(h - h_m)$$

$$h_m = \frac{A_C}{W_{top}} \quad and \quad W_{top} = W + 2nh; n = channel\ side\ slope$$

$$K_c = \left[2sin\left(\frac{Arcsin(1-S)}{3}\right)\right]^{1.5} (USACE, 2010);\ \ S = \frac{A_S}{A_C}$$

$$K_{ch} = 0.58\left[\left(\frac{h}{T}\right)\left(\frac{L_{PP}}{B}\right)\right]^{0.125}$$

Where

h_{mT} = relevant water depth
h_m = mean water depth

Attachment 6 provides Romisch computational results for vessel drafts ranging from 39 feet to 48 feet.

Results

Of the five methods presented, the Canal Theory and Barrass methods result in the most conservative estimates of squat. The three remaining methods are less conservative, but show excellent agreement with one another for all vessel drafts considered. Because the Canal Theory is considered to be a first approximation for channel design and is open for refinement, it was not considered for the final determination of squat at Port Everglades. Of the remaining four methods, all are considered to be acceptable means of estimating squat. Therefore, it was decided that squat at Port Everglades would be determined as an average of the three methods that provided the most consistent results. A summary of all squat results for vessel drafts ranging from 39 feet to 48 feet is provided in Table 2, including the average squat value to be applied to the project design. Results for each of the five methods are also show graphically in Figure 4.

Table 2. Vessel Squat, All Cases

Draft (feet)	Squat (feet)					
	Canal Method	Barrass Method	Eryuzlu et al. Method	Huuska/Guliev Method	Romisch Method	Average* Squat
39	5.91	3.82	2.53	2.59	2.79	2.64
40	5.77	3.82	2.53	2.59	2.71	2.61
41	5.68	3.83	2.53	2.59	2.63	2.58
42	5.61	3.83	2.53	2.54	2.55	2.54
43	5.51	3.84	2.52	2.54	2.49	2.52
44	5.45	3.84	2.52	2.54	2.42	2.49
45	5.38	3.85	2.52	2.53	2.36	2.47
46	5.31	3.86	2.52	2.53	2.30	2.45
47	5.25	3.86	2.51	2.48	2.24	2.41
48	5.18	3.86	2.51	2.48	2.19	2.39

* Represents the average of three methods (Eryuzlu et al., Huuska/Gulieve, and Romisch)

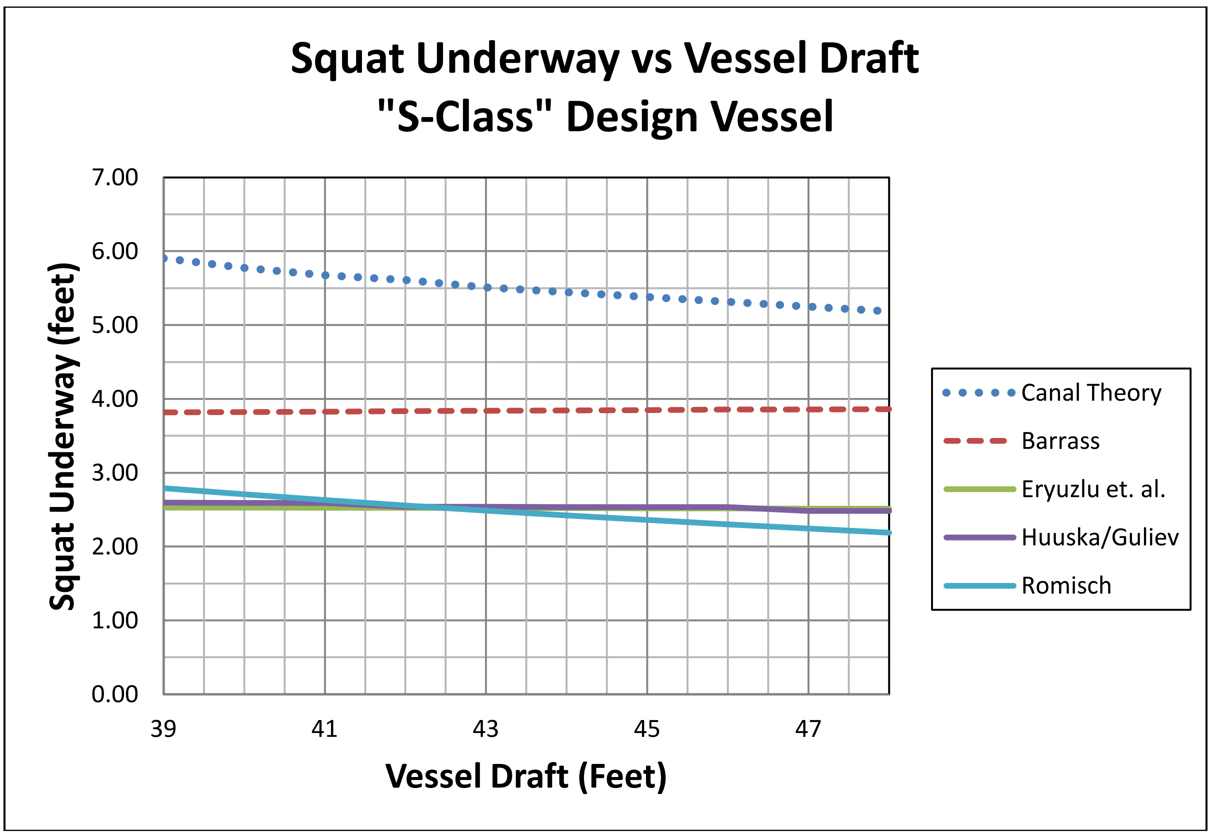

Figure 4. Vessel Squat, All Cases

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Attachment 1

Computational Parameters

Parameter	Symbol	Value (English Units)	Value (Metric Units)
Vessel Geometry:			
Length Between Perpendiculars	L_{PP}	1,088.1 ft	331.7 m
Beam	B	140.4 ft	42.8 m
Draft*	T	48 ft	18 m
Block Coefficient	C_B	0.65	0.65
Longitudinal Center of Gravity	LCG	544.0 ft	165.8 m
Vertical Center of Gravity	KG	60.0 ft	18.3 m
Metacentric Height	GM	2.6 ft	0.8 m
Roll Damping Factor, fraction percent	R	0.036	0.036
Channel Geometry:			
Channel Bottom Width	W	500 ft	152.4 m
Channel Top Width (Assumes Vertical Rock Slope)	W_{top}	500 ft	152.4 m
Ave. Depth of Water Exterior of Trench	$(h - h_T)$	10 ft	3.048 m
Slope of Trench Wall	n	1	1
Vessel Speed:			
Velocity	V	16.9 ft/s	5.14 m/s
Velocity (knots)	V_k	10 knots	10 knots
* The vessel draft value shown is the maximum for this S-Class vessel. As the vessel may not be operating at maximum draft at Port Everglades, squat must be calculated for a range of vessel drafts. This parameter becomes variable.			

Attachment 2

Iterative Squat Computations

Canal Method

Canal Theory

Iterative Computations

Assumed Squat, z (meters)	Vessel Draft, T (meters)	Vessel Draft, T (feet)	Wave Allowance* (meters)	Resultant Depth, h (meters)	Resultant Depth, h (feet)	z/h	As/Ac	Froude # (w/squat) F_h	Froude # (w/Velocity) F_h	Difference	Iterated Squat, z (meters)	Iterated Squat, z (feet)
1.82	11.89	39	1.19	14.90	48.87	0.12	0.22	0.43	0.43	-0.002	1.82	5.97
1.81	11.89	39	1.19	14.89	48.84	0.12	0.22	0.43	0.43	-0.001	1.81	5.94
1.80	11.89	39	1.19	14.88	48.81	0.12	0.22	0.43	0.43	0.000	1.80	5.91
1.79	11.89	39	1.19	14.87	48.77	0.12	0.22	0.43	0.43	0.001	1.79	5.87
1.78	11.89	39	1.19	14.86	48.74	0.12	0.22	0.42	0.43	0.001	1.78	5.84
1.78	12.19	40	1.22	15.19	49.84	0.12	0.23	0.42	0.42	-0.001	1.78	5.84
1.77	12.19	40	1.22	15.18	49.81	0.12	0.23	0.42	0.42	0.000	1.77	5.81
1.76	12.19	40	1.22	15.17	49.77	0.12	0.23	0.42	0.42	0.000	1.76	5.77
1.75	12.19	40	1.22	15.16	49.74	0.12	0.23	0.42	0.42	0.001	1.75	5.74
1.74	12.19	40	1.22	15.15	49.71	0.11	0.23	0.42	0.42	0.002	1.74	5.71
1.75	12.50	41	1.25	15.50	50.84	0.11	0.23	0.42	0.42	-0.001	1.75	5.74
1.74	12.50	41	1.25	15.49	50.81	0.11	0.23	0.42	0.42	0.000	1.74	5.71
1.73	12.50	41	1.25	15.48	50.78	0.11	0.23	0.42	0.42	0.000	1.73	5.68
1.72	12.50	41	1.25	15.47	50.74	0.11	0.23	0.42	0.42	0.001	1.72	5.64
1.71	12.50	41	1.25	15.46	50.71	0.11	0.23	0.42	0.42	0.002	1.71	5.61
1.73	12.80	42	1.28	15.81	51.88	0.11	0.23	0.41	0.41	-0.002	1.73	5.68
1.72	12.80	42	1.28	15.80	51.84	0.11	0.23	0.41	0.41	-0.001	1.72	5.64
1.71	12.80	42	1.28	15.79	51.81	0.11	0.23	0.41	0.41	0.000	1.71	5.61
1.70	12.80	42	1.28	15.78	51.78	0.11	0.23	0.41	0.41	0.001	1.70	5.58
1.69	12.80	42	1.28	15.77	51.74	0.11	0.23	0.41	0.41	0.001	1.69	5.54
1.70	13.11	43	1.31	16.12	52.88	0.11	0.23	0.41	0.41	-0.001	1.70	5.58
1.69	13.11	43	1.31	16.11	52.84	0.10	0.23	0.41	0.41	0.000	1.69	5.54
1.68	13.11	43	1.31	16.10	52.81	0.10	0.23	0.41	0.41	0.000	1.68	5.51
1.67	13.11	43	1.31	16.09	52.78	0.10	0.23	0.41	0.41	0.001	1.67	5.48
1.66	13.11	43	1.31	16.08	52.75	0.10	0.23	0.41	0.41	0.002	1.66	5.45
1.68	13.41	44	1.34	16.43	53.91	0.10	0.23	0.41	0.41	-0.001	1.68	5.51
1.67	13.41	44	1.34	16.42	53.88	0.10	0.23	0.41	0.41	-0.001	1.67	5.48
1.66	13.41	44	1.34	16.41	53.85	0.10	0.23	0.41	0.41	0.000	1.66	5.45
1.65	13.41	44	1.34	16.40	53.81	0.10	0.23	0.40	0.41	0.001	1.65	5.41
1.64	13.41	44	1.34	16.39	53.78	0.10	0.23	0.40	0.41	0.002	1.64	5.38
1.66	13.72	45	1.37	16.75	54.95	0.10	0.23	0.40	0.40	-0.002	1.66	5.45
1.65	13.72	45	1.37	16.74	54.91	0.10	0.23	0.40	0.40	-0.001	1.65	5.41
1.64	13.72	45	1.37	16.73	54.88	0.10	0.23	0.40	0.40	0.000	1.64	5.38
1.63	13.72	45	1.37	16.72	54.85	0.10	0.23	0.40	0.40	0.001	1.63	5.35
1.62	13.72	45	1.37	16.71	54.81	0.10	0.23	0.40	0.40	0.002	1.62	5.31
1.64	14.02	46	1.40	17.06	55.98	0.10	0.23	0.40	0.40	-0.002	1.64	5.38
1.63	14.02	46	1.40	17.05	55.95	0.10	0.23	0.40	0.40	-0.001	1.63	5.35
1.62	14.02	46	1.40	17.04	55.91	0.10	0.23	0.40	0.40	0.000	1.62	5.31
1.61	14.02	46	1.40	17.03	55.88	0.09	0.23	0.40	0.40	0.001	1.61	5.28
1.60	14.02	46	1.40	17.02	55.85	0.09	0.23	0.40	0.40	0.002	1.60	5.25
1.62	14.33	47	1.43	17.38	57.01	0.09	0.23	0.40	0.39	-0.001	1.62	5.31
1.61	14.33	47	1.43	17.37	56.98	0.09	0.23	0.39	0.39	-0.001	1.61	5.28
1.60	14.33	47	1.43	17.36	56.95	0.09	0.23	0.39	0.39	0.000	1.60	5.25
1.59	14.33	47	1.43	17.35	56.92	0.09	0.23	0.39	0.39	0.001	1.59	5.22
1.19	14.63	48	1.46	17.28	56.70	0.07	0.24	0.36	0.40	0.038	1.19	3.90
1.60	14.63	48	1.46	17.69	58.05	0.09	0.23	0.39	0.39	-0.001	1.60	5.25
1.59	14.63	48	1.46	17.68	58.02	0.09	0.23	0.39	0.39	0.000	1.59	5.22
1.58	14.63	48	1.46	17.67	57.98	0.09	0.23	0.39	0.39	0.000	1.58	5.18
1.57	14.63	48	1.46	17.66	57.95	0.09	0.23	0.39	0.39	0.001	1.57	5.15
1.56	14.63	48	1.46	17.65	57.92	0.09	0.23	0.39	0.39	0.002	1.56	5.12

* Based on USACE and PIANC guidance, a wave allowance of 10% of the vessel draft is assumed.

Attachment 3

Iterative Squat Computations

Barrass Method

Barrass Method

Iterative Computations

Assumed Squat, z (meters)	Vessel Draft, T (meters)	Vessel Draft, T (feet)	Wave Allowance* (meters)	Resultant Depth, h (meters)	Resultant Depth, h (feet)	$A_c - A_s$	S_2	Calculated Squat, z (meters)	Calculated Squat, z (feet)
1.18	11.89	39	1.19	14.26	46.77	1674.08	0.30	1.16	3.81
1.17	11.89	39	1.19	14.25	46.74	1672.55	0.30	1.16	3.81
1.16	11.89	39	1.19	14.24	46.71	1671.03	0.30	1.16	3.82
1.15	11.89	39	1.19	14.23	46.67	1669.50	0.30	1.16	3.82
1.14	11.89	39	1.19	14.22	46.64	1667.98	0.30	1.16	3.82
1.18	12.19	40	1.22	14.59	47.87	1712.39	0.30	1.16	3.82
1.17	12.19	40	1.22	14.58	47.84	1710.87	0.30	1.16	3.82
1.16	12.19	40	1.22	14.57	47.81	1709.34	0.30	1.17	3.82
1.15	12.19	40	1.22	14.56	47.77	1707.82	0.30	1.17	3.82
1.14	12.19	40	1.22	14.55	47.74	1706.29	0.30	1.17	3.83
1.19	12.50	41	1.25	14.94	49.00	1752.23	0.30	1.17	3.82
1.18	12.50	41	1.25	14.93	48.97	1750.70	0.30	1.17	3.82
1.17	12.50	41	1.25	14.92	48.94	1749.18	0.30	1.17	3.83
1.16	12.50	41	1.25	14.91	48.91	1747.66	0.30	1.17	3.83
1.15	12.50	41	1.25	14.90	48.87	1746.13	0.30	1.17	3.83
1.19	12.80	42	1.28	15.27	50.10	1790.54	0.30	1.17	3.83
1.18	12.80	42	1.28	15.26	50.07	1789.02	0.30	1.17	3.83
1.17	12.80	42	1.28	15.25	50.04	1787.49	0.30	1.17	3.83
1.16	12.80	42	1.28	15.24	50.01	1785.97	0.30	1.17	3.84
1.15	12.80	42	1.28	15.23	49.97	1784.45	0.30	1.17	3.84
1.19	13.11	43	1.31	15.61	51.20	1828.86	0.30	1.17	3.83
1.18	13.11	43	1.31	15.60	51.17	1827.33	0.30	1.17	3.84
1.17	13.11	43	1.31	15.59	51.14	1825.81	0.30	1.17	3.84
1.16	13.11	43	1.31	15.58	51.11	1824.28	0.30	1.17	3.84
1.15	13.11	43	1.31	15.57	51.07	1822.76	0.30	1.17	3.84
1.19	13.41	44	1.34	15.94	52.30	1867.17	0.30	1.17	3.84
1.18	13.41	44	1.34	15.93	52.27	1865.65	0.30	1.17	3.84
1.17	13.41	44	1.34	15.92	52.24	1864.12	0.30	1.17	3.84
1.16	13.41	44	1.34	15.91	52.21	1862.60	0.30	1.17	3.85
1.15	13.41	44	1.34	15.90	52.17	1861.07	0.30	1.17	3.85
1.19	13.72	45	1.37	16.28	53.40	1905.48	0.30	1.17	3.85
1.18	13.72	45	1.37	16.27	53.37	1903.96	0.30	1.17	3.85
1.17	13.72	45	1.37	16.26	53.34	1902.44	0.30	1.17	3.85
1.16	13.72	45	1.37	16.25	53.31	1900.91	0.30	1.17	3.85
1.15	13.72	45	1.37	16.24	53.27	1899.39	0.30	1.17	3.85
1.19	14.02	46	1.40	16.61	54.50	1943.80	0.30	1.17	3.85
1.18	14.02	46	1.40	16.60	54.47	1942.27	0.30	1.17	3.85
1.17	14.02	46	1.40	16.59	54.44	1940.75	0.30	1.18	3.86
1.16	14.02	46	1.40	16.58	54.41	1939.23	0.30	1.18	3.86
1.15	14.02	46	1.40	16.57	54.37	1937.70	0.30	1.18	3.86
1.20	14.33	47	1.43	16.96	55.64	1983.64	0.30	1.17	3.85
1.19	14.33	47	1.43	16.95	55.60	1982.11	0.30	1.18	3.86
1.18	14.33	47	1.43	16.94	55.57	1980.59	0.30	1.18	3.86
1.17	14.33	47	1.43	16.93	55.54	1979.06	0.30	1.18	3.86
1.19	14.63	48	1.46	17.28	56.70	2020.43	0.30	1.18	3.86
1.20	14.63	48	1.46	17.29	56.74	2021.95	0.30	1.18	3.86
1.19	14.63	48	1.46	17.28	56.70	2020.43	0.30	1.18	3.86
1.18	14.63	48	1.46	17.27	56.67	2018.90	0.30	1.18	3.86
1.17	14.63	48	1.46	17.26	56.64	2017.38	0.30	1.18	3.87
1.16	14.63	48	1.46	17.25	56.61	2015.85	0.30	1.18	3.87

* Based on USACE and PIANC guidance, a wave allowance of 10% of the vessel draft is assumed.

Attachment 4

Iterative Squat Computations

Eryuzlu et al. Method

Eryuzlu et. al.
Iterative Computations

Assumed Squat, z (meters)	Vessel Draft, T (meters)	Vessel Draft, T (feet)	Wave Allowance* (meters)	Resultant Depth, h (meters)	Resultant Depth, h (feet)	Froude # F_h	W/B	K_s	Calculated Squat, z (meters)	Calculated Squat, z (feet)
0.79	11.89	39	1.19	13.87	45.49	0.4411	3.56	1.64	0.77	2.52
0.78	11.89	39	1.19	13.86	45.46	0.4412	3.56	1.64	0.77	2.53
0.77	11.89	39	1.19	13.85	45.43	0.4414	3.56	1.64	0.77	2.53
0.76	11.89	39	1.19	13.84	45.39	0.4415	3.56	1.64	0.77	2.54
0.75	11.89	39	1.19	13.83	45.36	0.4417	3.56	1.64	0.77	2.54
0.79	12.19	40	1.22	14.20	46.59	0.4358	3.56	1.64	0.77	2.52
0.78	12.19	40	1.22	14.19	46.56	0.4360	3.56	1.64	0.77	2.53
0.77	12.19	40	1.22	14.18	46.53	0.4361	3.56	1.64	0.77	2.53
0.76	12.19	40	1.22	14.17	46.49	0.4363	3.56	1.64	0.77	2.53
0.75	12.19	40	1.22	14.16	46.46	0.4364	3.56	1.64	0.77	2.54
0.79	12.50	41	1.25	14.54	47.69	0.4308	3.56	1.64	0.77	2.52
0.78	12.50	41	1.25	14.53	47.66	0.4309	3.56	1.64	0.77	2.52
0.77	12.50	41	1.25	14.52	47.63	0.4311	3.56	1.64	0.77	2.53
0.76	12.50	41	1.25	14.51	47.59	0.4312	3.56	1.64	0.77	2.53
0.75	12.50	41	1.25	14.50	47.56	0.4314	3.56	1.64	0.77	2.54
0.79	12.80	42	1.28	14.87	48.79	0.4259	3.56	1.64	0.77	2.52
0.78	12.80	42	1.28	14.86	48.76	0.4260	3.56	1.64	0.77	2.52
0.77	12.80	42	1.28	14.85	48.73	0.4262	3.56	1.64	0.77	2.53
0.76	12.80	42	1.28	14.84	48.69	0.4263	3.56	1.64	0.77	2.53
0.75	12.80	42	1.28	14.83	48.66	0.4265	3.56	1.64	0.77	2.53
0.79	13.11	43	1.31	15.21	49.89	0.4212	3.56	1.64	0.77	2.52
0.78	13.11	43	1.31	15.20	49.86	0.4213	3.56	1.64	0.77	2.52
0.77	13.11	43	1.31	15.19	49.83	0.4214	3.56	1.64	0.77	2.52
0.76	13.11	43	1.31	15.18	49.79	0.4216	3.56	1.64	0.77	2.53
0.75	13.11	43	1.31	15.17	49.76	0.4217	3.56	1.64	0.77	2.53
0.79	13.41	44	1.34	15.54	50.99	0.4166	3.56	1.64	0.77	2.51
0.78	13.41	44	1.34	15.53	50.96	0.4167	3.56	1.64	0.77	2.52
0.77	13.41	44	1.34	15.52	50.93	0.4169	3.56	1.64	0.77	2.52
0.76	13.41	44	1.34	15.51	50.89	0.4170	3.56	1.64	0.77	2.53
0.75	13.41	44	1.34	15.50	50.86	0.4171	3.56	1.64	0.77	2.53
0.79	13.72	45	1.37	15.88	52.09	0.4122	3.56	1.64	0.77	2.51
0.78	13.72	45	1.37	15.87	52.06	0.4123	3.56	1.64	0.77	2.52
0.77	13.72	45	1.37	15.86	52.03	0.4124	3.56	1.64	0.77	2.52
0.76	13.72	45	1.37	15.85	51.99	0.4126	3.56	1.64	0.77	2.52
0.75	13.72	45	1.37	15.84	51.96	0.4127	3.56	1.64	0.77	2.53
0.79	14.02	46	1.40	16.21	53.19	0.4079	3.56	1.64	0.77	2.51
0.78	14.02	46	1.40	16.20	53.16	0.4080	3.56	1.64	0.77	2.51
0.77	14.02	46	1.40	16.19	53.13	0.4081	3.56	1.64	0.77	2.52
0.76	14.02	46	1.40	16.18	53.09	0.4083	3.56	1.64	0.77	2.52
0.75	14.02	46	1.40	16.17	53.06	0.4084	3.56	1.64	0.77	2.52
0.79	14.33	47	1.43	16.55	54.29	0.4037	3.56	1.64	0.76	2.51
0.78	14.33	47	1.43	16.54	54.26	0.4039	3.56	1.64	0.77	2.51
0.77	14.33	47	1.43	16.53	54.23	0.4040	3.56	1.64	0.77	2.51
0.76	14.33	47	1.43	16.52	54.19	0.4041	3.56	1.64	0.77	2.52
1.19	14.63	48	1.46	17.28	56.70	0.3950	3.56	1.64	0.73	2.38
0.79	14.63	48	1.46	16.88	55.39	0.3997	3.56	1.64	0.76	2.51
0.78	14.63	48	1.46	16.87	55.36	0.3998	3.56	1.64	0.76	2.51
0.77	14.63	48	1.46	16.86	55.33	0.3999	3.56	1.64	0.77	2.51
0.76	14.63	48	1.46	16.85	55.29	0.4001	3.56	1.64	0.77	2.52
0.75	14.63	48	1.46	16.84	55.26	0.4002	3.56	1.64	0.77	2.52

* Based on USACE and PIANC guidance, a wave allowance of 10% of the vessel craft is assumed.

Attachment 5

Iterative Squat Computations

Huuska/Guliev Method

Huuska/Guliev													
Iterative Computations													
Assumed Squat, z (meters)	Vessel Draft, T (meters)	Vessel Draft, T (feet)	Wave Allowance* (meters)	Resultant Depth, h (meters)	Resultant Depth, h (feet)	h_T/h	A_s/A_{ch}	K_1	s_1	K_s	Froude # F_n	Calculated Squat, z (meters)	Calculated Squat, z (feet)
0.81	11.89	39	1.19	13.89	45.56	0.78	0.24	2.30	0.10	1.52	0.4407	0.79	2.59
0.80	11.89	39	1.19	13.88	45.52	0.78	0.24	2.30	0.10	1.52	0.4409	0.79	2.59
0.79	11.89	39	1.19	13.87	45.49	0.78	0.24	2.30	0.10	1.52	0.4411	0.79	2.59
0.78	11.89	39	1.19	13.86	45.46	0.78	0.24	2.30	0.10	1.52	0.4412	0.79	2.60
0.77	11.89	39	1.19	13.85	45.43	0.78	0.24	2.30	0.10	1.53	0.4414	0.79	2.60
0.81	12.19	40	1.22	14.22	46.66	0.79	0.24	2.30	0.10	1.52	0.4355	0.79	2.59
0.80	12.19	40	1.22	14.21	46.62	0.79	0.24	2.30	0.10	1.52	0.4357	0.79	2.59
0.79	12.19	40	1.22	14.20	46.59	0.79	0.24	2.30	0.10	1.53	0.4358	0.79	2.59
0.78	12.19	40	1.22	14.19	46.56	0.79	0.24	2.30	0.10	1.53	0.4360	0.79	2.59
0.77	12.19	40	1.22	14.18	46.53	0.79	0.24	2.30	0.10	1.53	0.4361	0.79	2.60
0.81	12.50	41	1.25	14.56	47.76	0.79	0.24	2.30	0.10	1.53	0.4305	0.79	2.58
0.80	12.50	41	1.25	14.55	47.72	0.79	0.24	2.30	0.10	1.53	0.4306	0.79	2.59
0.79	12.50	41	1.25	14.54	47.69	0.79	0.24	2.30	0.10	1.53	0.4308	0.79	2.59
0.78	12.50	41	1.25	14.53	47.66	0.79	0.24	2.30	0.10	1.53	0.4309	0.79	2.59
0.77	12.50	41	1.25	14.52	47.63	0.79	0.24	2.30	0.10	1.53	0.4311	0.79	2.60
0.79	12.80	42	1.28	14.87	48.79	0.80	0.24	2.40	0.10	1.50	0.4259	0.77	2.53
0.78	12.80	42	1.28	14.86	48.76	0.79	0.24	2.40	0.10	1.50	0.4260	0.77	2.54
0.77	12.80	42	1.28	14.85	48.73	0.79	0.24	2.40	0.10	1.50	0.4262	0.77	2.54
0.76	12.80	42	1.28	14.84	48.69	0.79	0.24	2.40	0.10	1.50	0.4263	0.77	2.54
0.75	12.80	42	1.28	14.83	48.66	0.79	0.24	2.40	0.10	1.50	0.4265	0.78	2.55
0.79	13.11	43	1.31	15.21	49.89	0.80	0.24	2.40	0.10	1.50	0.4212	0.77	2.53
0.78	13.11	43	1.31	15.20	49.86	0.80	0.24	2.40	0.10	1.50	0.4213	0.77	2.54
0.77	13.11	43	1.31	15.19	49.83	0.80	0.24	2.40	0.10	1.50	0.4214	0.77	2.54
0.76	13.11	43	1.31	15.18	49.79	0.80	0.24	2.40	0.10	1.50	0.4216	0.77	2.54
0.75	13.11	43	1.31	15.17	49.76	0.80	0.24	2.40	0.10	1.50	0.4217	0.78	2.54
0.79	13.41	44	1.34	15.54	50.99	0.80	0.24	2.40	0.10	1.50	0.4166	0.77	2.53
0.78	13.41	44	1.34	15.53	50.96	0.80	0.24	2.40	0.10	1.50	0.4167	0.77	2.53
0.77	13.41	44	1.34	15.52	50.93	0.80	0.24	2.40	0.10	1.50	0.4169	0.77	2.54
0.76	13.41	44	1.34	15.51	50.89	0.80	0.24	2.40	0.10	1.50	0.4170	0.77	2.54
0.75	13.41	44	1.34	15.50	50.86	0.80	0.24	2.40	0.10	1.50	0.4171	0.77	2.54
0.79	13.72	45	1.37	15.88	52.09	0.81	0.24	2.40	0.10	1.50	0.4122	0.77	2.53
0.78	13.72	45	1.37	15.87	52.06	0.81	0.24	2.40	0.10	1.50	0.4123	0.77	2.53
0.77	13.72	45	1.37	15.86	52.03	0.81	0.24	2.40	0.10	1.50	0.4124	0.77	2.53
0.76	13.72	45	1.37	15.85	51.99	0.81	0.24	2.40	0.10	1.50	0.4126	0.77	2.54
0.75	13.72	45	1.37	15.84	51.96	0.81	0.24	2.40	0.10	1.50	0.4127	0.77	2.54
0.79	14.02	46	1.40	16.21	53.19	0.81	0.24	2.40	0.10	1.50	0.4079	0.77	2.53
0.78	14.02	46	1.40	16.20	53.16	0.81	0.24	2.40	0.10	1.50	0.4080	0.77	2.53
0.77	14.02	46	1.40	16.19	53.13	0.81	0.24	2.40	0.10	1.50	0.4081	0.77	2.53
0.76	14.02	46	1.40	16.18	53.09	0.81	0.24	2.40	0.10	1.50	0.4083	0.77	2.54
0.75	14.02	46	1.40	16.17	53.06	0.81	0.24	2.40	0.10	1.50	0.4084	0.77	2.54
0.78	14.33	47	1.43	16.54	54.26	0.82	0.24	2.50	0.10	1.47	0.4039	0.76	2.48
0.77	14.33	47	1.43	16.53	54.23	0.82	0.24	2.50	0.10	1.47	0.4040	0.76	2.48
0.76	14.33	47	1.43	16.52	54.19	0.82	0.24	2.50	0.10	1.47	0.4041	0.76	2.48
0.75	14.33	47	1.43	16.51	54.16	0.82	0.24	2.50	0.10	1.47	0.4042	0.76	2.49
1.19	14.63	48	1.46	17.28	56.70	0.82	0.23	2.50	0.09	1.45	0.3950	0.73	2.39
0.79	14.63	48	1.46	16.88	55.39	0.82	0.24	2.50	0.10	1.47	0.3997	0.75	2.48
0.78	14.63	48	1.46	16.87	55.36	0.82	0.24	2.50	0.10	1.47	0.3998	0.76	2.48
0.77	14.63	48	1.46	16.86	55.33	0.82	0.24	2.50	0.10	1.47	0.3999	0.76	2.48
0.76	14.63	48	1.46	16.85	55.29	0.82	0.24	2.50	0.10	1.47	0.4001	0.76	2.48
0.75	14.63	48	1.46	16.84	55.26	0.82	0.24	2.50	0.10	1.47	0.4002	0.76	2.49

* Based on USACE and PIANC guidance, a wave allowance of 10% of the vessel draft is assumed.

Attachment 6

Iterative Squat Computations

Romisch Method

Romisch

Iterative Computations

Assumed Squat, z (meters)	Vessel Draft, T (meters)	Vessel Draft, T (feet)	Wave Allowance* (meters)	Resultant Depth, h (meters)	Resultant Depth, h (feet)	h_m A_c/W_{top}	K_{ch}	K_c	h_T/h	A_s/A_c	H_{mT}	C	C_{mT}	V_{cr}	$K_{\Delta t}$	C_F	C_v	Calculated Squat, z (meters)	Calculated Squat, z (feet)
0.82	11.89	39	1.19	13.90	45.59	13.90	0.76	0.43	0.78	0.24	13.90	11.68	11.68	5.90	0.17	0.70	0.50	0.85	2.78
0.81	11.89	39	1.19	13.89	45.56	13.89	0.76	0.43	0.78	0.24	13.89	11.67	11.67	5.90	0.17	0.70	0.50	0.85	2.78
0.80	11.89	39	1.19	13.88	45.52	13.88	0.76	0.43	0.78	0.24	13.88	11.67	11.67	5.89	0.17	0.70	0.50	0.85	2.79
0.79	11.89	39	1.19	13.87	45.49	13.87	0.76	0.43	0.78	0.24	13.87	11.66	11.66	5.89	0.17	0.70	0.50	0.85	2.79
0.78	11.89	39	1.19	13.86	45.46	13.86	0.76	0.43	0.78	0.24	13.86	11.66	11.66	5.89	0.17	0.70	0.50	0.85	2.80
0.80	12.19	40	1.22	14.21	46.62	14.21	0.76	0.43	0.79	0.24	14.21	11.81	11.81	5.94	0.17	0.70	0.48	0.82	2.70
0.79	12.19	40	1.22	14.20	46.59	14.20	0.76	0.43	0.79	0.24	14.20	11.80	11.80	5.94	0.17	0.70	0.48	0.82	2.70
0.78	12.19	40	1.22	14.19	46.56	14.19	0.76	0.43	0.79	0.24	14.19	11.80	11.80	5.93	0.17	0.70	0.48	0.83	2.71
0.77	12.19	40	1.22	14.18	46.53	14.18	0.76	0.43	0.79	0.24	14.18	11.79	11.79	5.93	0.17	0.70	0.49	0.83	2.71
0.76	12.19	40	1.22	14.17	46.49	14.17	0.76	0.43	0.78	0.24	14.17	11.79	11.79	5.93	0.17	0.70	0.49	0.83	2.72
0.78	12.50	41	1.25	14.53	47.66	14.53	0.76	0.43	0.79	0.24	14.53	11.94	11.94	5.98	0.17	0.70	0.47	0.80	2.62
0.77	12.50	41	1.25	14.52	47.63	14.52	0.76	0.43	0.79	0.24	14.52	11.93	11.93	5.98	0.17	0.70	0.47	0.80	2.63
0.76	12.50	41	1.25	14.51	47.59	14.51	0.76	0.43	0.79	0.24	14.51	11.93	11.93	5.97	0.17	0.70	0.47	0.80	2.63
0.75	12.50	41	1.25	14.50	47.56	14.50	0.76	0.43	0.79	0.24	14.50	11.93	11.93	5.97	0.17	0.70	0.47	0.80	2.64
0.74	12.50	41	1.25	14.49	47.53	14.49	0.76	0.43	0.79	0.24	14.49	11.92	11.92	5.97	0.17	0.70	0.47	0.81	2.64
0.77	12.80	42	1.28	14.85	48.73	14.85	0.76	0.43	0.79	0.24	14.85	12.07	12.07	6.02	0.17	0.70	0.46	0.78	2.55
0.76	12.80	42	1.28	14.84	48.69	14.84	0.76	0.43	0.79	0.24	14.84	12.07	12.07	6.02	0.17	0.70	0.46	0.78	2.55
0.75	12.80	42	1.28	14.83	48.66	14.83	0.76	0.43	0.79	0.24	14.83	12.06	12.06	6.02	0.17	0.70	0.46	0.78	2.55
0.74	12.80	42	1.28	14.82	48.63	14.82	0.76	0.43	0.79	0.24	14.82	12.06	12.06	6.01	0.17	0.70	0.46	0.78	2.56
0.73	12.80	42	1.28	14.81	48.60	14.81	0.76	0.43	0.79	0.24	14.81	12.05	12.05	6.01	0.17	0.70	0.46	0.78	2.56
0.75	13.11	43	1.31	15.17	49.76	15.17	0.76	0.43	0.80	0.24	15.17	12.20	12.20	6.06	0.17	0.70	0.44	0.76	2.48
0.74	13.11	43	1.31	15.16	49.73	15.16	0.76	0.43	0.80	0.24	15.16	12.19	12.19	6.06	0.17	0.70	0.45	0.76	2.48
0.73	13.11	43	1.31	15.15	49.70	15.15	0.76	0.43	0.80	0.24	15.15	12.19	12.19	6.06	0.17	0.70	0.45	0.76	2.49
0.72	13.11	43	1.31	15.14	49.66	15.14	0.76	0.43	0.80	0.24	15.14	12.19	12.19	6.05	0.17	0.70	0.45	0.76	2.49
0.71	13.11	43	1.31	15.13	49.63	15.13	0.76	0.43	0.80	0.24	15.13	12.18	12.18	6.05	0.17	0.70	0.45	0.76	2.50
0.74	13.41	44	1.34	15.49	50.83	15.49	0.76	0.43	0.80	0.24	15.49	12.33	12.33	6.10	0.17	0.70	0.43	0.74	2.41
0.73	13.41	44	1.34	15.48	50.80	15.48	0.76	0.43	0.80	0.24	15.48	12.32	12.32	6.10	0.17	0.70	0.43	0.74	2.42
0.72	13.41	44	1.34	15.47	50.76	15.47	0.76	0.43	0.80	0.24	15.47	12.32	12.32	6.10	0.17	0.70	0.44	0.74	2.42
0.71	13.41	44	1.34	15.46	50.73	15.46	0.76	0.43	0.80	0.24	15.46	12.32	12.32	6.09	0.17	0.70	0.44	0.74	2.42
0.70	13.41	44	1.34	15.45	50.70	15.45	0.76	0.43	0.80	0.24	15.45	12.31	12.31	6.09	0.17	0.70	0.44	0.74	2.43
0.72	13.72	45	1.37	15.81	51.86	15.81	0.76	0.43	0.81	0.24	15.81	12.45	12.45	6.14	0.17	0.70	0.42	0.72	2.35
0.71	13.72	45	1.37	15.80	51.83	15.80	0.76	0.43	0.81	0.24	15.80	12.45	12.45	6.14	0.17	0.70	0.42	0.72	2.36
0.70	13.72	45	1.37	15.79	51.80	15.79	0.76	0.43	0.81	0.24	15.79	12.44	12.44	6.14	0.17	0.70	0.42	0.72	2.36
0.69	13.72	45	1.37	15.78	51.76	15.78	0.76	0.43	0.81	0.24	15.78	12.44	12.44	6.13	0.17	0.70	0.43	0.72	2.36
0.68	13.72	45	1.37	15.77	51.73	15.77	0.76	0.43	0.81	0.24	15.77	12.44	12.44	6.13	0.17	0.70	0.43	0.72	2.37
0.71	14.02	46	1.40	16.13	52.93	16.13	0.76	0.43	0.81	0.24	16.13	12.58	12.58	6.19	0.17	0.70	0.41	0.70	2.29
0.70	14.02	46	1.40	16.12	52.90	16.12	0.76	0.43	0.81	0.24	16.12	12.58	12.58	6.18	0.17	0.70	0.41	0.70	2.30
0.69	14.02	46	1.40	16.11	52.86	16.11	0.76	0.43	0.81	0.24	16.11	12.57	12.57	6.18	0.17	0.70	0.41	0.70	2.30
0.68	14.02	46	1.40	16.10	52.83	16.10	0.76	0.43	0.81	0.24	16.10	12.57	12.57	6.18	0.17	0.70	0.42	0.70	2.30
0.67	14.02	46	1.40	16.09	52.80	16.09	0.76	0.43	0.81	0.24	16.09	12.56	12.56	6.17	0.17	0.70	0.42	0.70	2.31
0.70	14.33	47	1.43	16.46	54.00	16.46	0.76	0.43	0.81	0.24	16.46	12.71	12.71	6.23	0.17	0.70	0.40	0.68	2.24
0.69	14.33	47	1.43	16.45	53.96	16.45	0.76	0.43	0.81	0.24	16.45	12.70	12.70	6.22	0.17	0.70	0.40	0.68	2.24
0.68	14.33	47	1.43	16.44	53.93	16.44	0.76	0.43	0.81	0.24	16.44	12.70	12.70	6.22	0.17	0.70	0.40	0.68	2.24
0.67	14.33	47	1.43	16.43	53.90	16.43	0.76	0.43	0.81	0.24	16.43	12.69	12.69	6.22	0.17	0.70	0.41	0.68	2.25
1.19	14.63	48	1.46	17.28	56.70	17.28	0.76	0.44	0.82	0.23	17.28	13.02	13.02	6.43	0.17	0.70	0.36	0.62	2.04
0.69	14.63	48	1.46	16.78	55.06	16.78	0.76	0.43	0.82	0.24	16.78	12.83	12.83	6.27	0.17	0.70	0.39	0.67	2.18
0.68	14.63	48	1.46	16.77	55.03	16.77	0.76	0.43	0.82	0.24	16.77	12.83	12.83	6.27	0.17	0.70	0.39	0.67	2.19
0.67	14.63	48	1.46	16.76	55.00	16.76	0.76	0.43	0.82	0.24	16.76	12.82	12.82	6.26	0.17	0.70	0.40	0.67	2.19
0.66	14.63	48	1.46	16.75	54.97	16.75	0.76	0.43	0.82	0.24	16.75	12.82	12.82	6.26	0.17	0.70	0.40	0.67	2.19
0.65	14.63	48	1.46	16.74	54.93	16.74	0.76	0.43	0.82	0.24	16.74	12.82	12.82	6.26	0.17	0.70	0.40	0.67	2.20

* Based on USACE and PIANC guidance, a wave allowance of 10% of the vessel draft is assumed.

PORT EVERGLADES HARBOR, FLORIDA

SUB-APPENDIX D

RMA MODELING OF PORT EVERGLADES HARBOR

RMA-2 HYDRODYNAMIC MODELING OF PORT EVERGLADES HARBOR

Hydrodynamic Modeling Approach – The objective of the Port Everglades Feasibility Study hydrodynamic modeling effort was to gain insight into the magnitude of potential changes to tidal flushing in the harbor and estuary. Direct modeling of salinity would require use of a three-dimensional model, such as RMA-10, that is capable of simulating complex flows where vertical variations of variables are important and where the effect of fluid density is included. Since the cost and time requirements to develop a fully three-dimensional stratified hydrodynamic model were not practicable in light of the study plan, a less intensive two-dimensional modeling effort was chosen as an alternative approach. Predicted changes in tidal flushing can provide an indirect indicator of the magnitude of potential changes in salinity. Comparison of changes in the tidally driven hydrodynamics under a constant freshwater inflow regime is considered sufficient in this case to meet the limited modeling objective.

Model Description - Hydrodynamic modeling of Port Everglades was done using RMA-2 version 4.52, which is a two-dimensional depth-averaged finite-element hydrodynamic numerical model. RMA-2 computes water surface elevations and horizontal velocity components for subcritical, free-surface flow in two-dimensional flow fields. The Surface Water Modeling System (SMS) version 7.0 was employed in pre- and post-processing of the RMA-2 model and results.

Calibration and Verification – Due to limited funding and study time frames, the Port Everglades RMA-2 model was not calibrated to field measured parameters such as velocities, flows, or heads. Nevertheless, the relative difference in the computed solutions for the respective model configurations is useful as an indicator of the magnitude of potential changes in flows.

Model Geometry - The finite element mesh geometry for the Port Everglades RMA-2 model was developed using SMS. A finite element mesh is composed of computational nodal points where each point has a Cartesian coordinate (x, y) and a depth (z). The nodes are connected to form the triangular and quadrilateral elements of the mesh. The plan layout of the model mesh was developed from several sources of georeferenced aerial photography in combination with USGS quadrangle maps and NOAA navigational charts. The mesh elements are configured in such a way that both the Existing-Condition and With-Plan channel alignments and depths can be represented. The mesh contains

56,528 computational nodes and 19,476 elements. The full computational mesh is shown in Figure 1. Recent bathymetric survey data of the existing Federal channels were imported into the mesh through an automatic interpolation process. This process assigns nodal z-values for the Existing-Condition mesh configuration. Bathymetry for areas without survey coverage was hand sculpted using information from the navigational charts and best professional judgment. For the With-Plan mesh geometry, the existing condition mesh was modified to include the proposed new channel alignments and depths. Figures 2 & 3 show the Existing-Condition and With-Plan bathymetry, respectively, for the inshore portion of the mesh. Figures 4 and 5 show the Existing-Condition and With-Plan bathymetry, respectively, for the northern area of the port including the entrance channel. Figures 6 and 7 show the Existing-Condition and With-Plan bathymetry, respectively, for the southern area of the port including the Dania Cut-off Canal.

RMA-2 Boundary Conditions – Boundary conditions for the Port Everglades model include transient head boundaries on the ocean side and on the Intracoastal Waterway (IWW) to simulate tidal forces. Steady-state volumetric flows at locations corresponding to major canals were included to simulate freshwater inflows. The Florida Power and Light power plant cooling canal was also included to simulate an average condition pumped flow within the model domain. The model control file runs the model for 750 time-steps with each time-step representing a 30-minute increment of the tidal cycle. The first 15 time steps are used for model spin-up and the remaining 735 time-steps represent approximately 15 days of simulation time, or about 30 tidal cycles. The transient head input data files used to simulate the forcing tides were developed with the tide prediction software “XTide”. Tide elevations corresponding to the run-control time series were extracted from the XTide data. The XTide data was generated from input parameters corresponding to a spring tide that occurred in September 2000, thereby simulating high flow conditions. The four XTide stations are shown in the Table 1.

Tidal Boundary Location in Mesh	XTide Station Name
Ocean Side North	Lauderdale by the Sea
Ocean Side South	North Miami Beach
IWW North	Bahia Mar Yacht Club
IWW South	Hollywood Beach

Table 1

The transient head time series for these boundaries are shown in Figures 8-11. Constant inflows of 500 and 200 cubic feet per second were applied as flow boundaries at the Dania Cut-off Canal and New River, respectively.

RMA-2 Model Results and Analysis – Computed average flows across selected channel locations were compared between the Existing-Condition and With-Plan model results. The average flow, or flux, is computed by multiplying the average RMA-2 nodal velocities (feet per second) by the corresponding channel cross-sectional area (square feet) to give the average flow across the flux line in cubic feet per second. Figure 12 shows the locations of 14 flux lines within the model domain. At these flux lines, results from the two RMA-2 simulations can be examined. Differences between the two solution sets were computed by subtracting the With-plan solution from the Existing-Condition solution. Table 2 shows the percent change in computed flow across these flux lines. The percent change is relative to the computed flow under the Existing Condition run. Positive values indicate an increase in With-Plan flow compared to the Existing-Condition flow, and negative values represent a reduction in flow, respectively.

Line #	Line Location in model.	% Change
Line 1	IWW east of New River	0.1
Line 2	IWW south of New River	0.0
Line 3	IWW A1A bridge north of port	0.3
Line 4	Port Everglades Entrance Channel	-0.4
Line 5	IWW north of small notch	-0.4
Line 6	IWW north of FPL outflow	-0.2
Line 7	Turning Notch mangroves tidal creek	-1.7
Line 8	Lloyd Park tidal creek north	-0.7
Line 9	IWW south of Dania Cutoff Canal (DCC)	3.2
Line 10	DCC mangroves tidal creek	-5.5
Line 11	Lloyd Park tidal creek south	-0.8
Line 12	DCC west of new birth	0.0
Line 13	IWW north of West Lake	0.4
Line 14	West Lake	0.3

Table 2

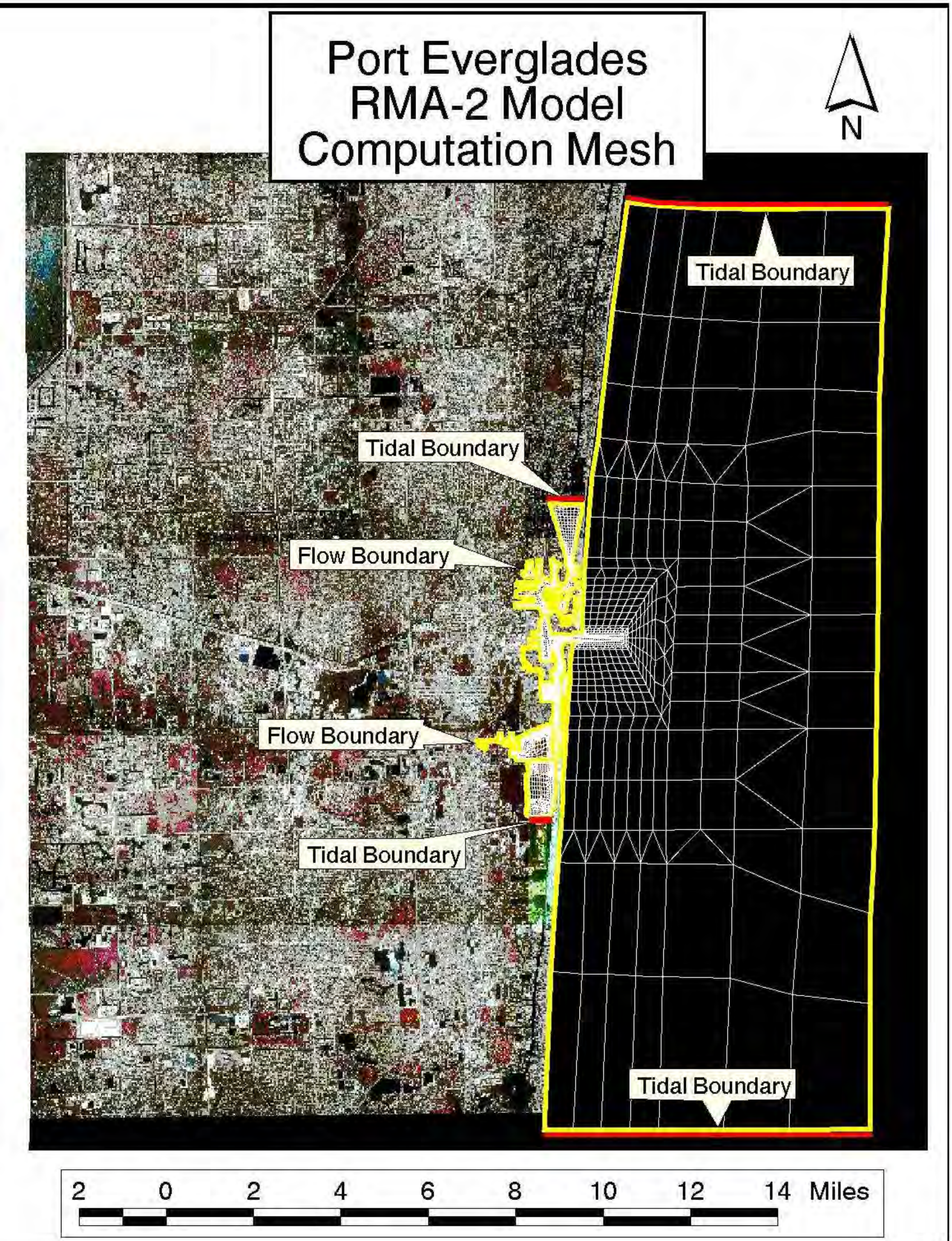
The following inferences can be drawn from the computed changes in flow:

Changes of less than 1 percent are within the computational error of the model and represent virtually no change.

The increase of approximately 3 percent in Line 9 would be expected due to the increase in cross-sectional area of the channel to be dredged in the With-Plan configuration. The small reductions in flow in the tidal creeks (Lines 7 and 10) result from the slight reductions in velocity in the nearby areas where the channel cross-sections are being increased. These changes are not considered to be significant. Computed flows through the Port Everglades entrance channel are virtually unaffected by the changes in mesh geometry in the port areas.

In addition to the flux lines, time-series plots of water-surface elevation and depth-averaged velocity were prepared for a point midway along each line (See Figures 13-40). Each plot shows the computed velocity under the Existing Condition and With-Plan mesh configurations as well as the difference between the two. Differences between the two solution sets were computed by subtracting the With-plan solution from the Existing-Condition solution. Changes in these individual parameters are consistent with the changes in the flux lines shown in Table 2. Note that for Observation Points 7 & 10 (figures 26 & 36), the velocity doesn’t slow to near zero as would be expected during slack tide. This is due to the location of the observation points near flow boundaries that provide a constant base velocity.

Conclusion - The Port Everglades Feasibility Study hydrodynamic modeling was undertaken as a cost-effective screening tool to gain insight into the magnitude of potential changes to tidal flushing in the project area. This screening exercise indicates that changes in the tidally driven hydrodynamics of the project area are predicted to be minimal.



Port Everglades
RMA-2 Model
Computation Mesh
N
Tidal Boundary
Tidal Boundary
Flow Boundary
Flow Boundary
Tidal Boundary
Tidal Boundary
2 0 2 4 6 8 10 12 14 Miles

Figure 1

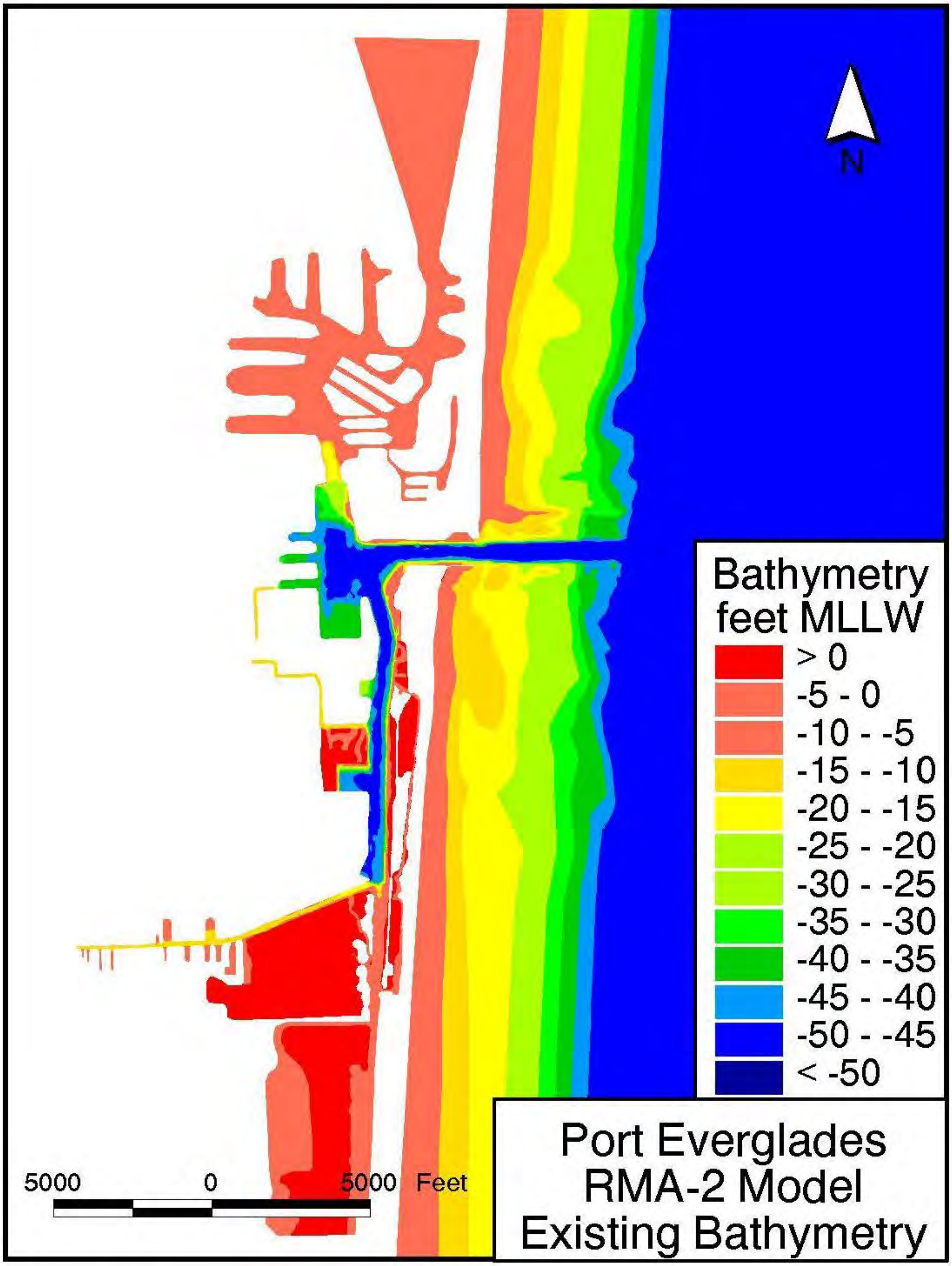

N
Bathymetry
feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
5000
0
5000 Feet
Port Everglades
RMA-2 Model
Existing Bathymetry

Figure 2

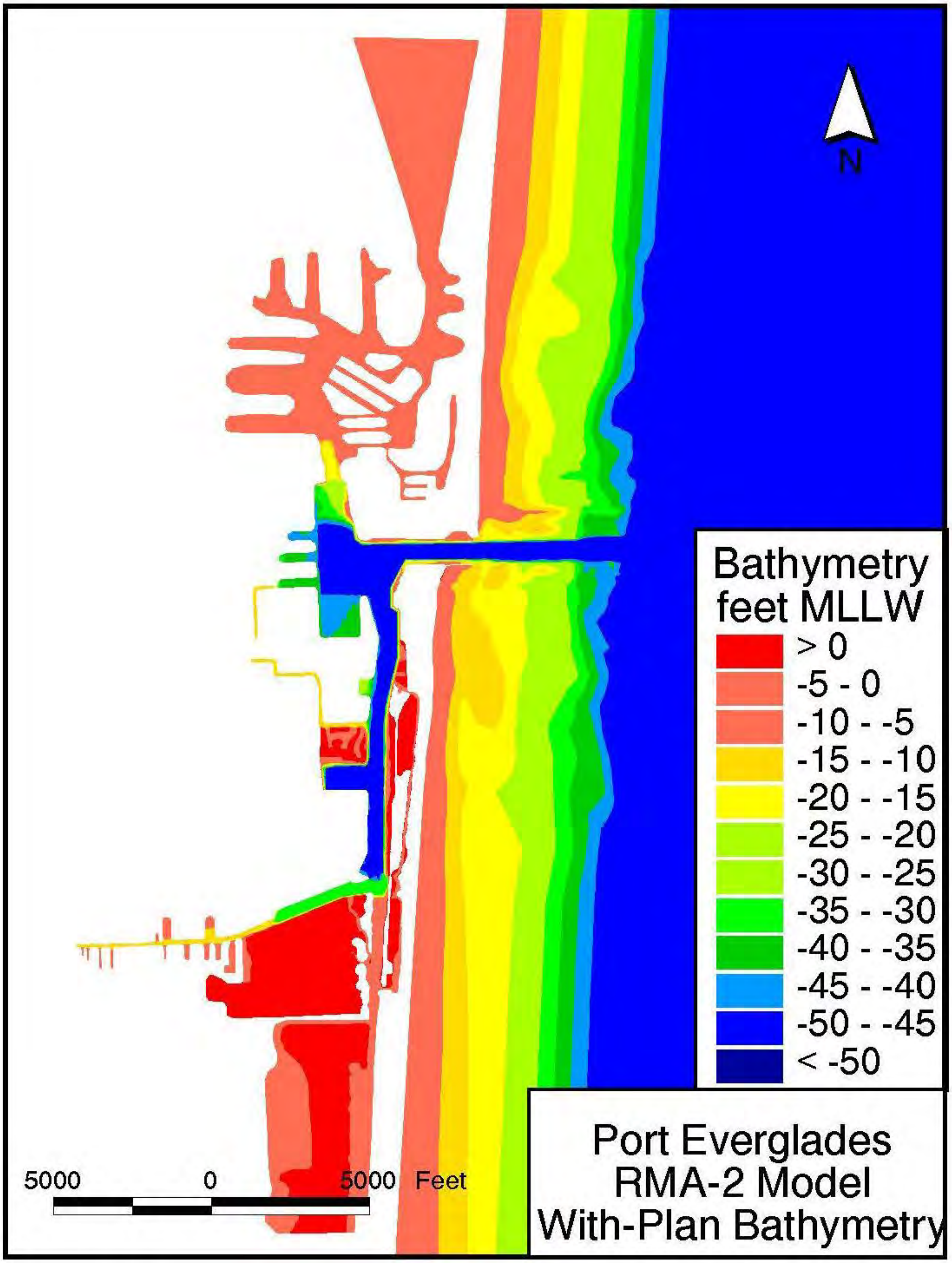
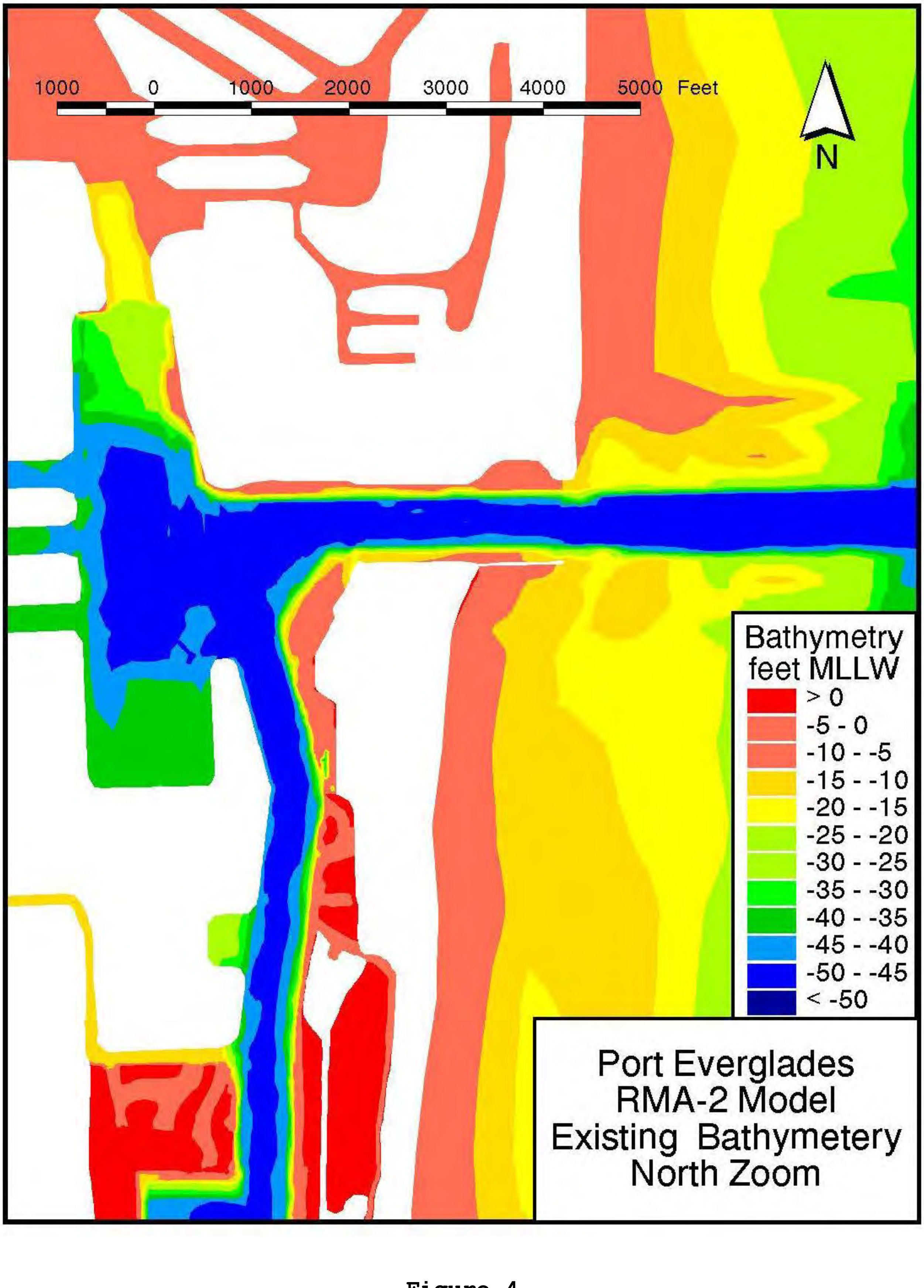

N
Bathymetry
feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
5000 0 5000 Feet
Port Everglades
RMA-2 Model
With-Plan Bathymetry

Figure 3



1000
0
1000
2000
3000
4000
5000
Feet
N
Bathymetry
feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
Port Everglades
RMA-2 Model
Existing Bathymetery
North Zoom

Figure 4

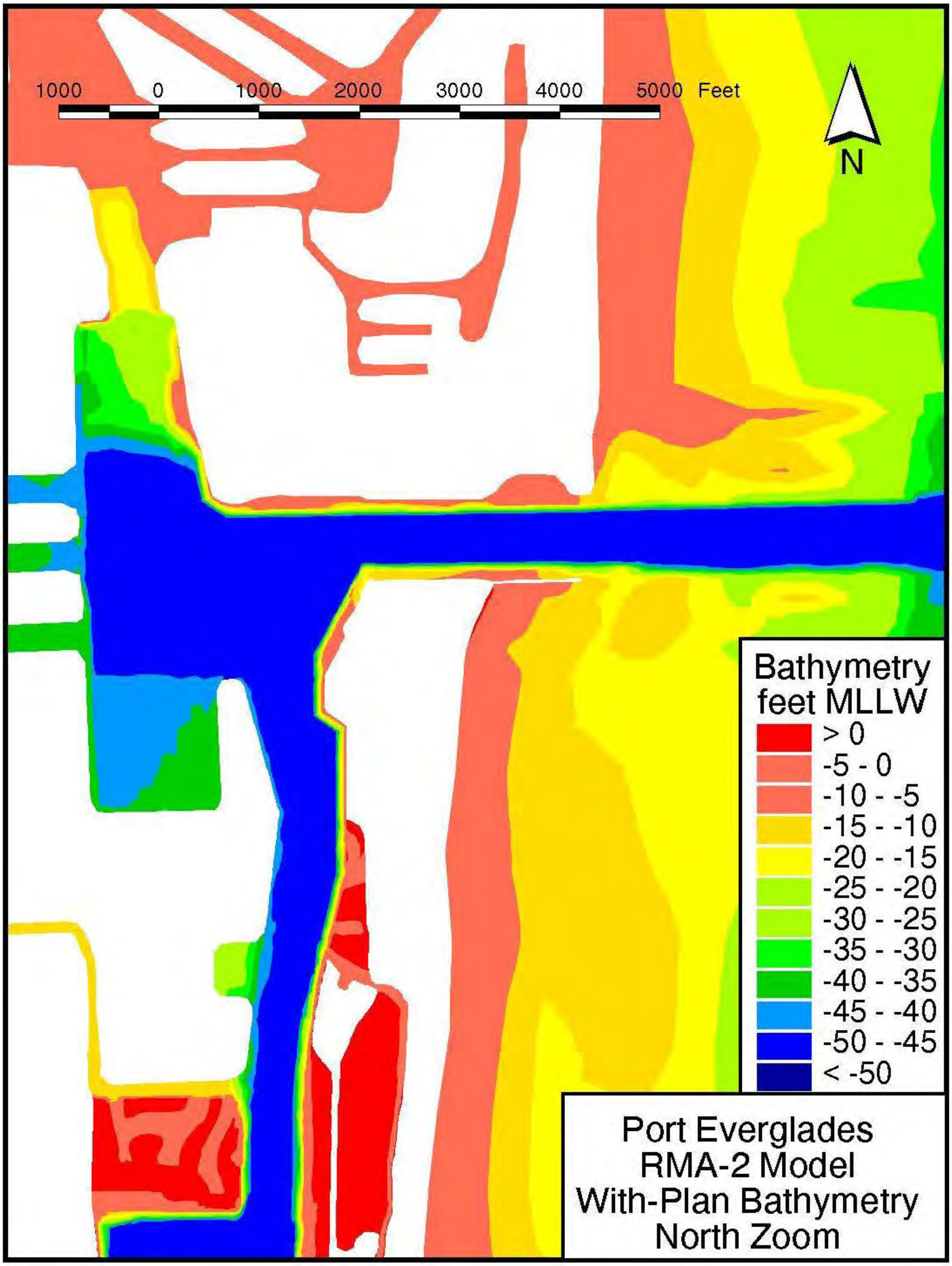

1000 0 1000 2000 3000 4000 5000 Feet
N
Bathymetry feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
Port Everglades
RMA-2 Model
With-Plan Bathymetry
North Zoom

Figure 5

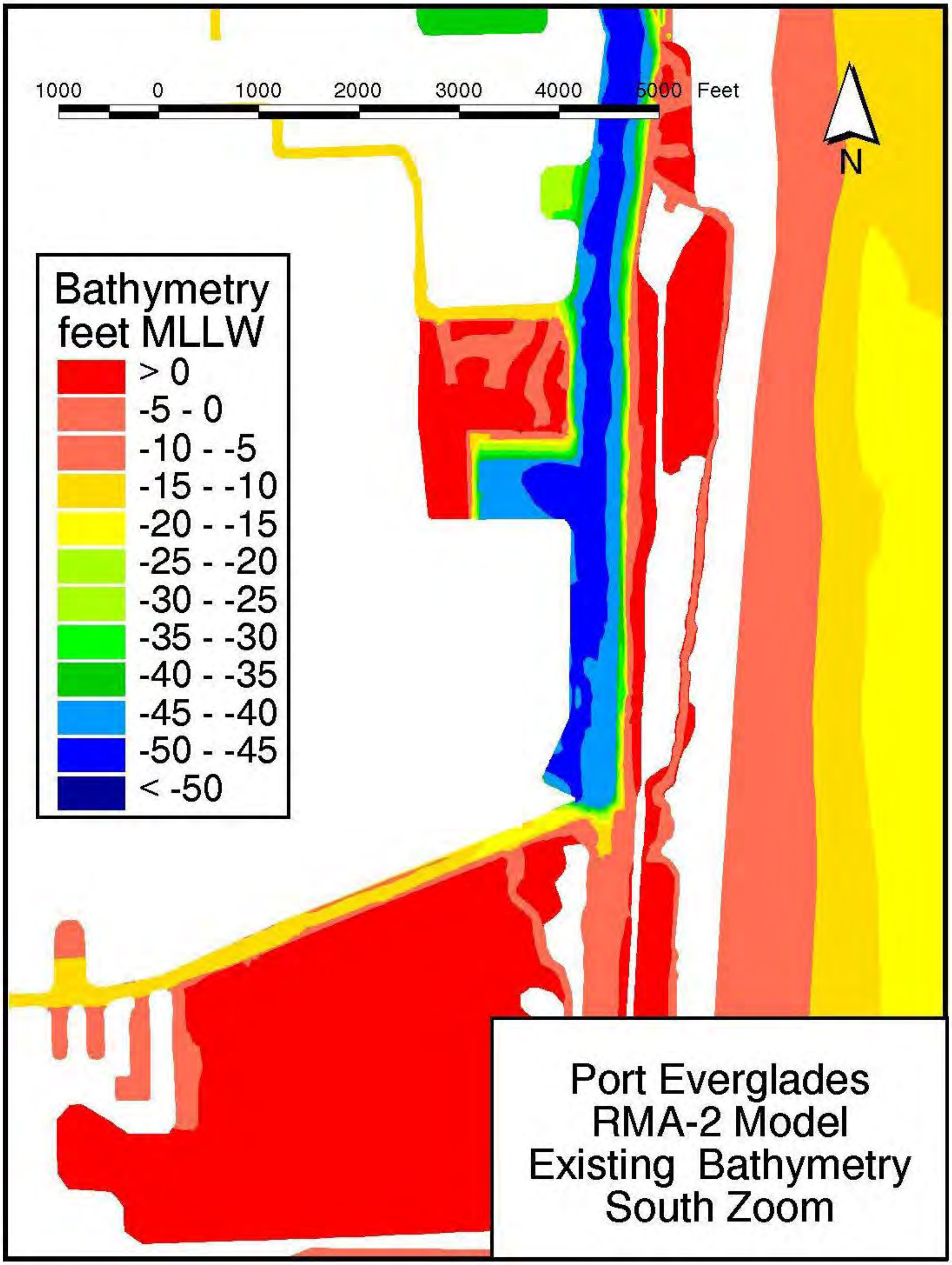

1000 0 1000 2000 3000 4000 5000 Feet
N
Bathymetry
feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
Port Everglades
RMA-2 Model
Existing Bathymetry
South Zoom

Figure 6

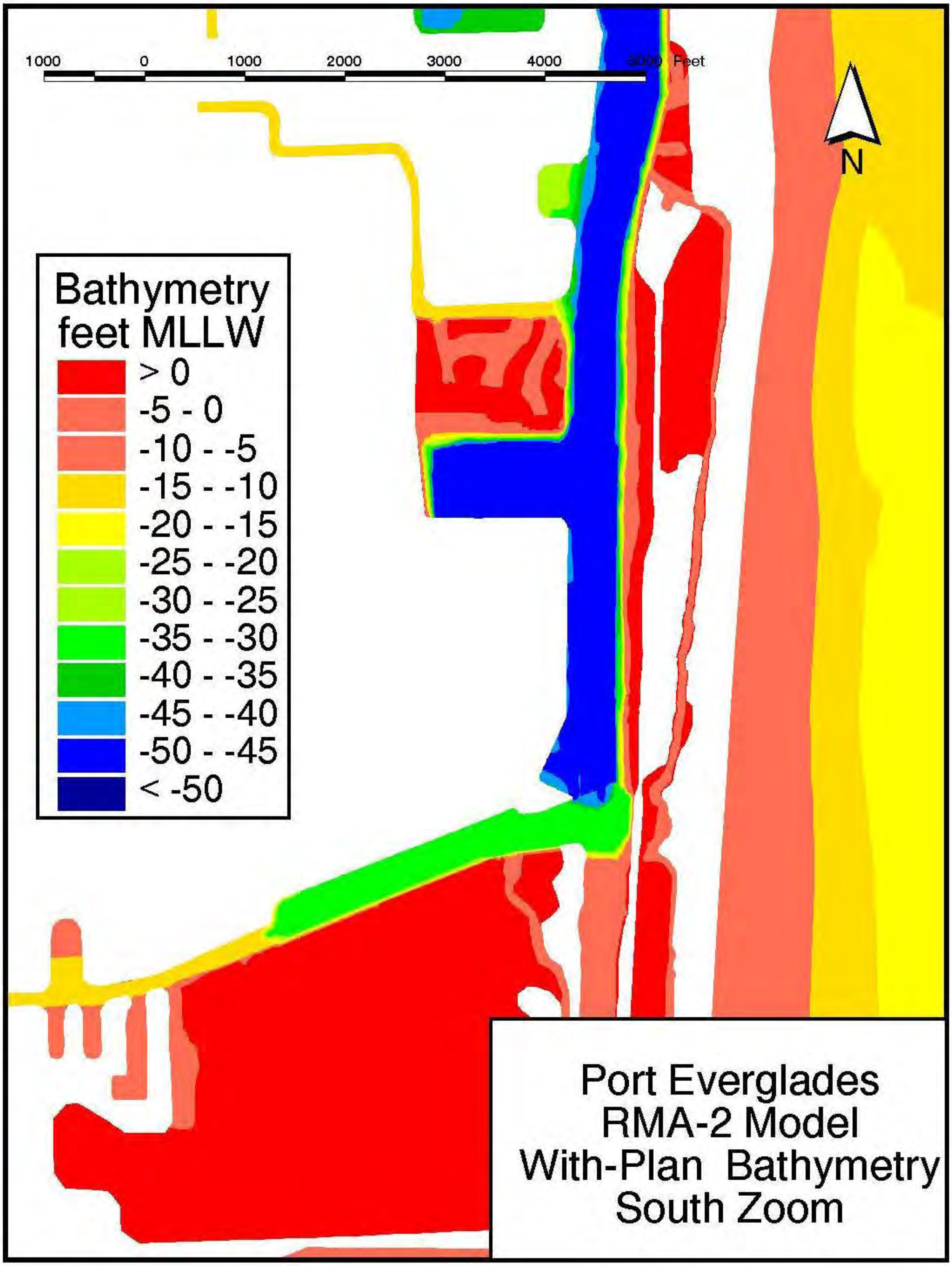

1000
0
1000
2000
3000
4000
5000
Feet
N
Bathymetry
feet MLLW
> 0
-5 - 0
-10 - -5
-15 - -10
-20 - -15
-25 - -20
-30 - -25
-35 - -30
-40 - -35
-45 - -40
-50 - -45
< -50
Port Everglades
RMA-2 Model
With-Plan Bathymetry
South Zoom

Figure 7

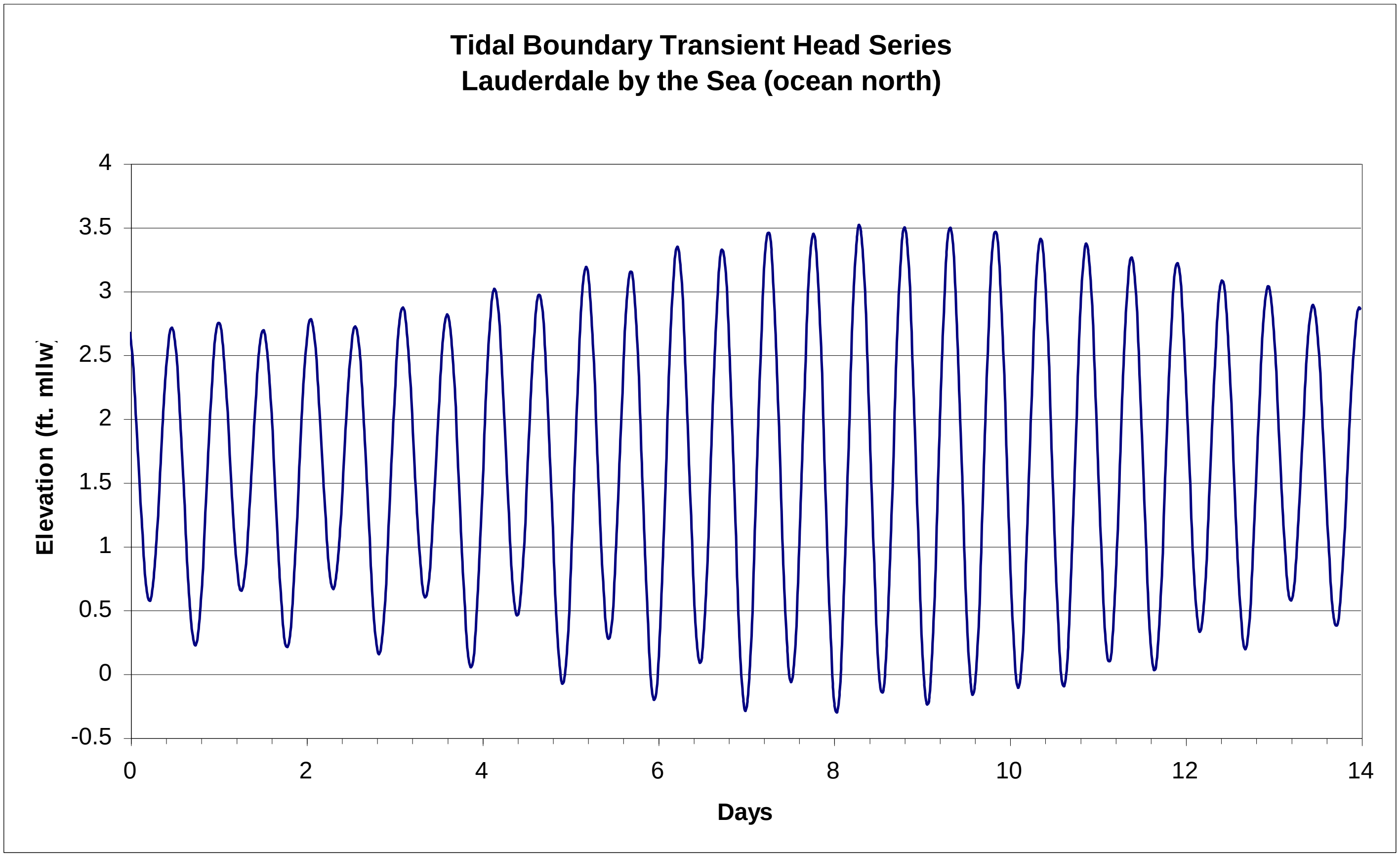


Figure 8

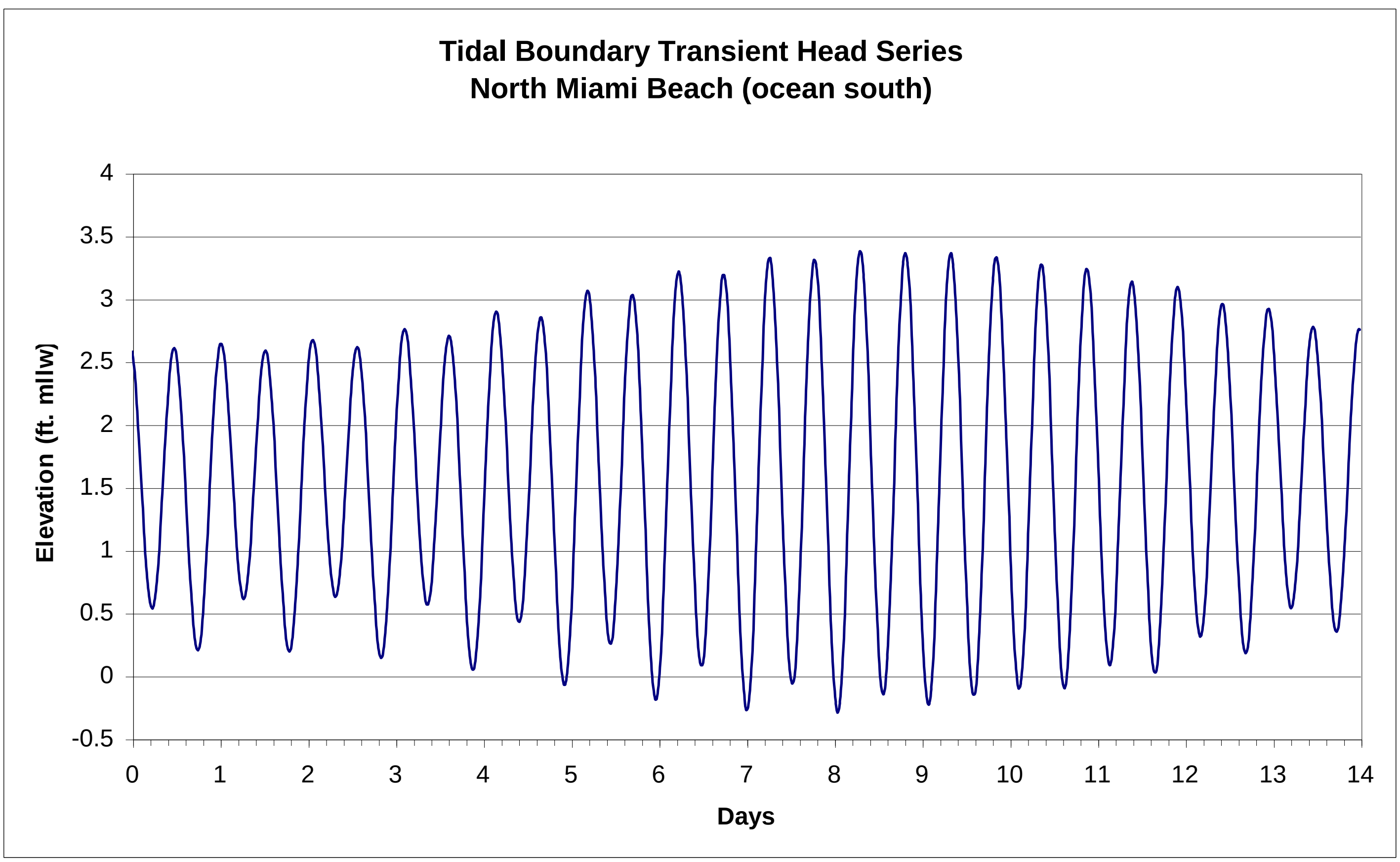


Figure 9

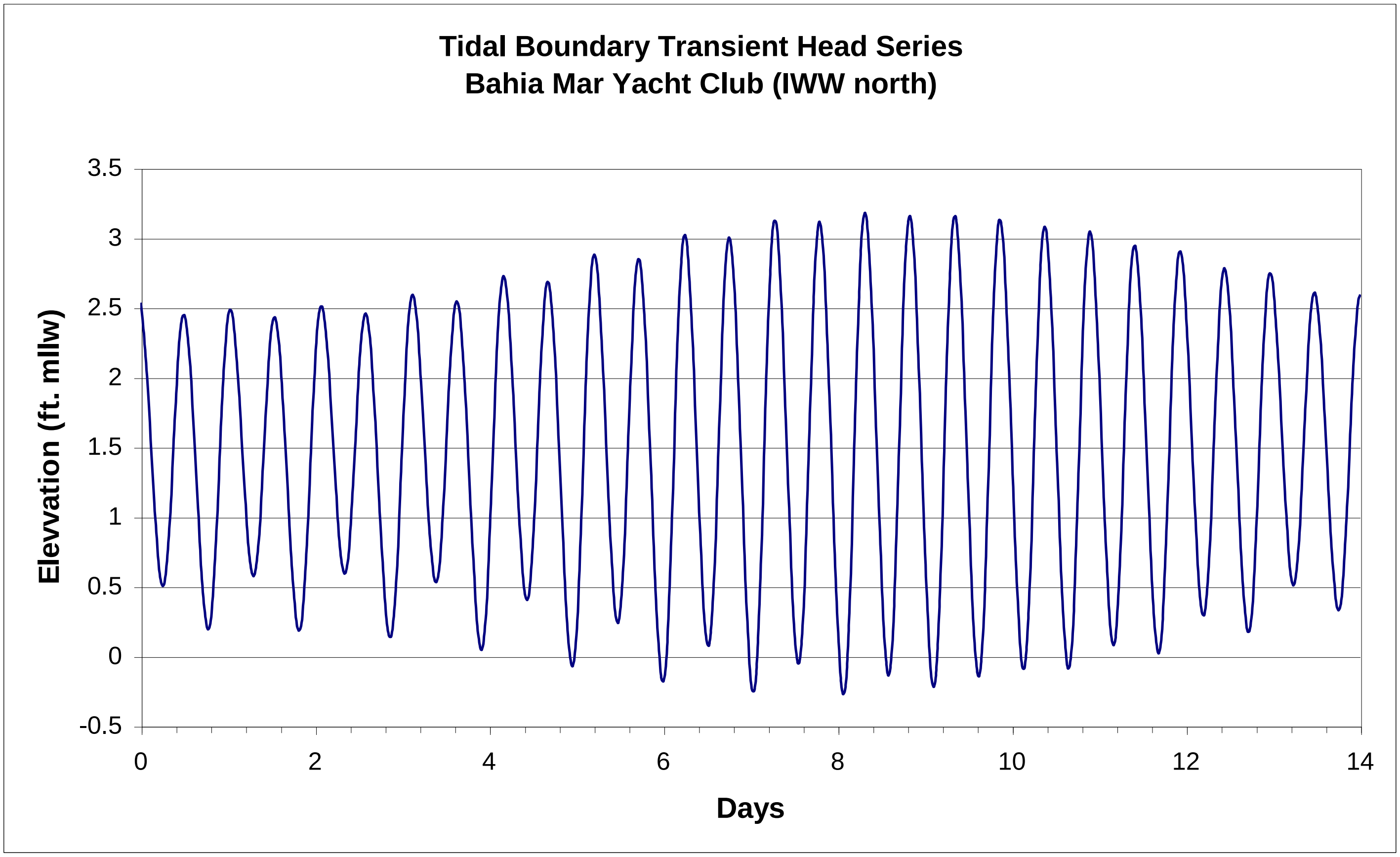


Figure 10

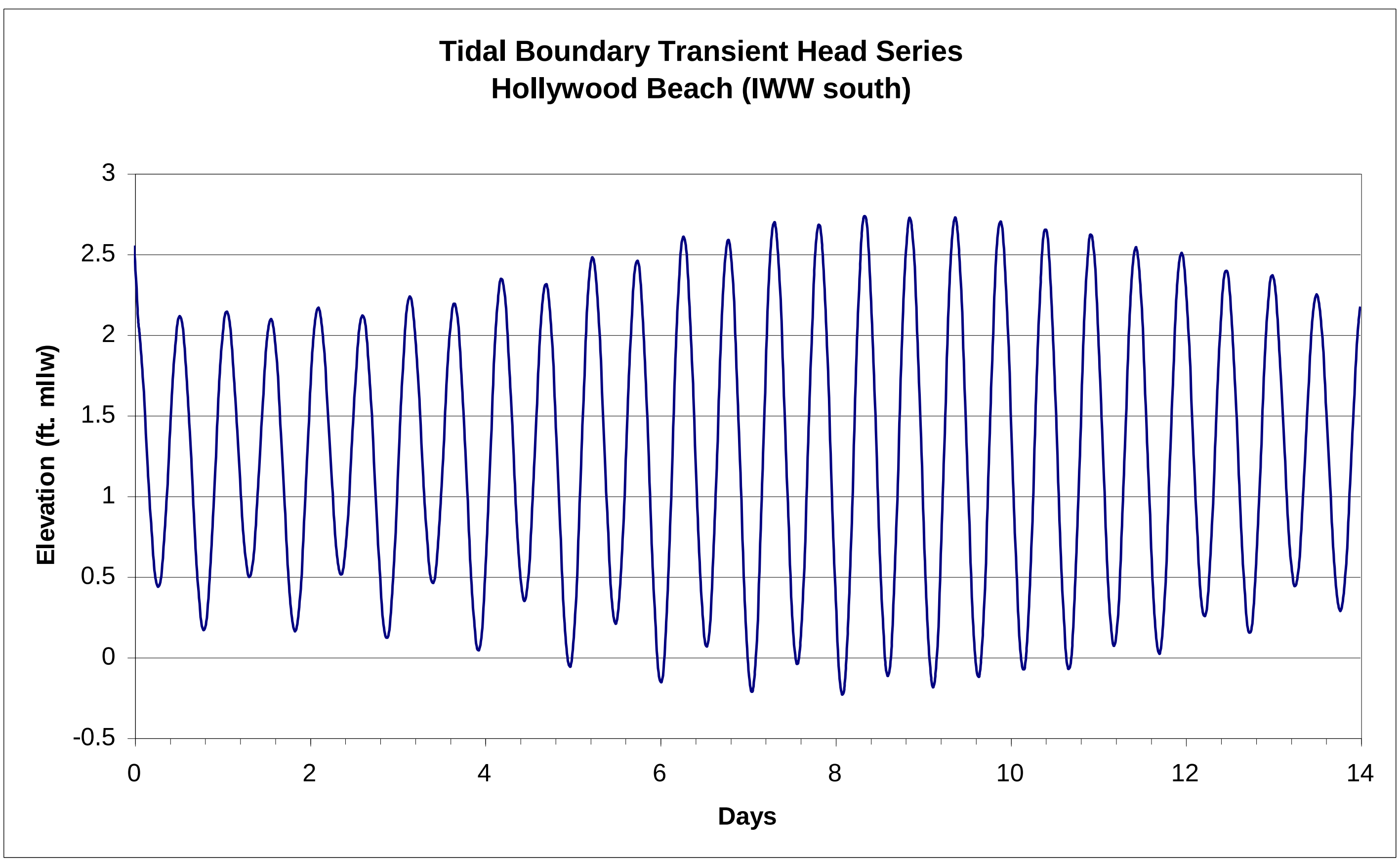


Figure 11

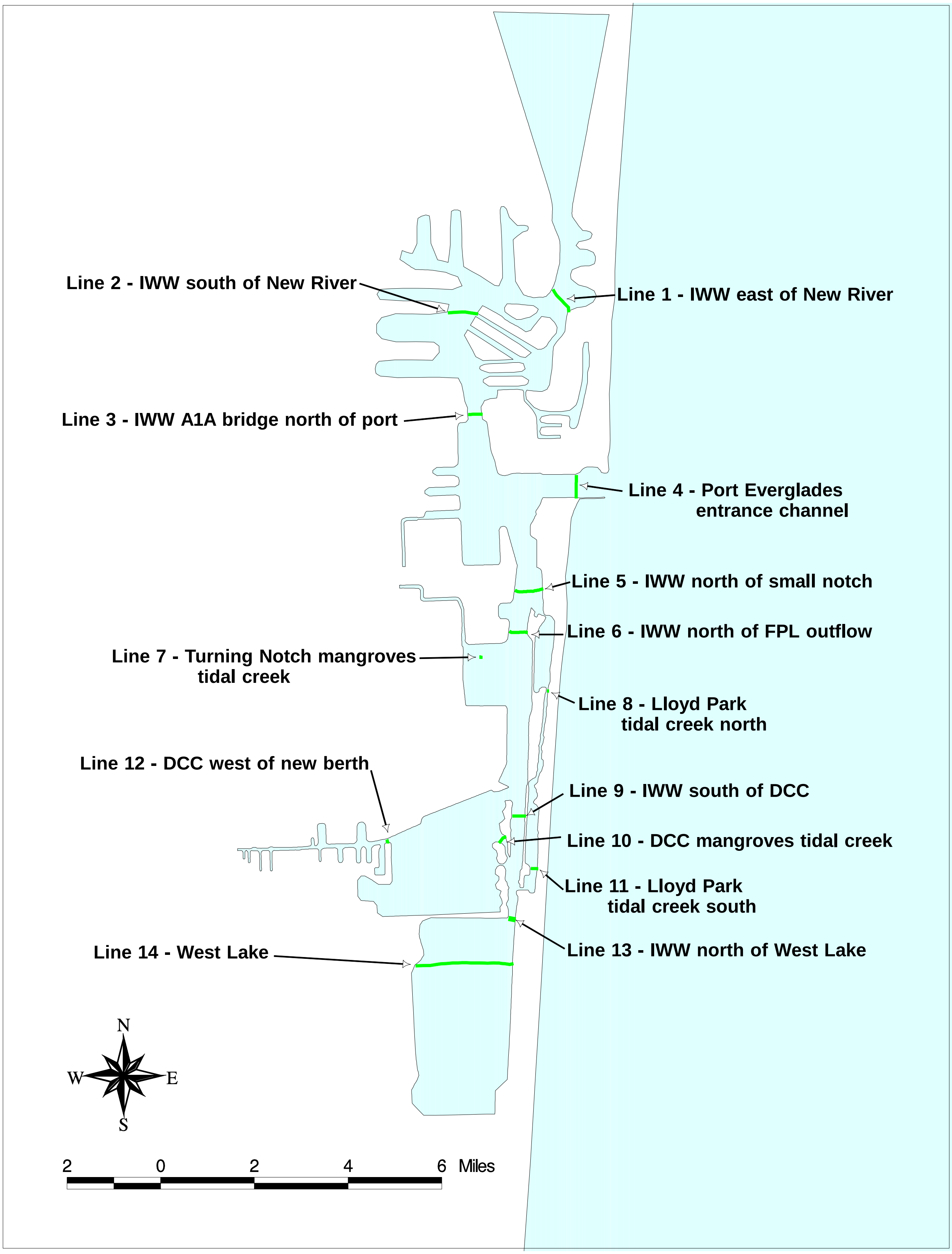

Line 1 - IWW east of New River
Line 2 - IWW south of New River
Line 3 - IWW A1A bridge north of port
Line 4 - Port Everglades entrance channel
Line 5 - IWW north of small notch
Line 6 - IWW north of FPL outflow
Line 7 - Turning Notch mangroves tidal creek
Line 8 - Lloyd Park tidal creek north
Line 9 - IWW south of DCC
Line 10 - DCC mangroves tidal creek
Line 11 - Lloyd Park tidal creek south
Line 12 - DCC west of new berth
Line 13 - IWW north of West Lake
Line 14 - West Lake
N
W
E
S
2
0
2
4
6
Miles

Figure 12

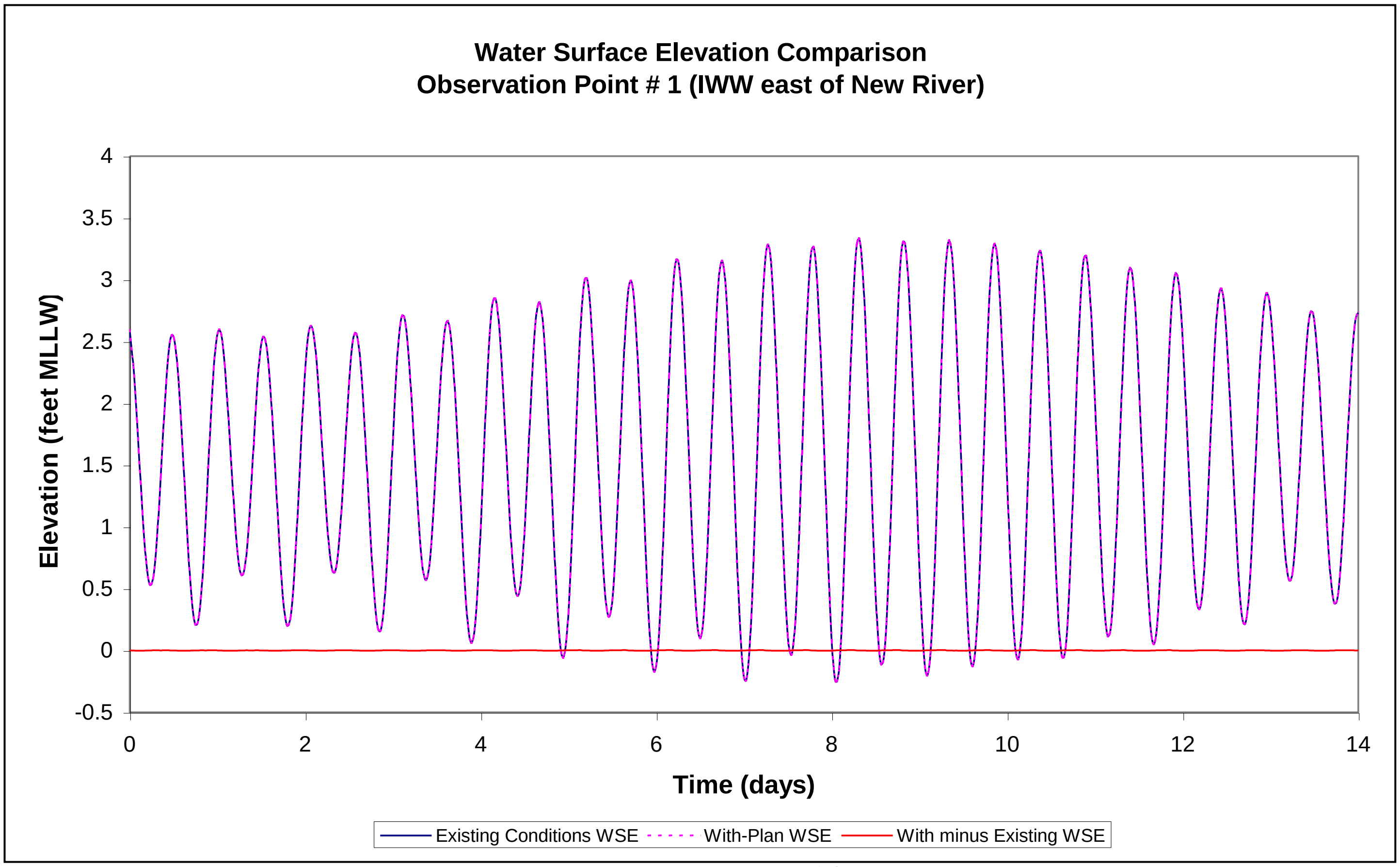


Figure 13

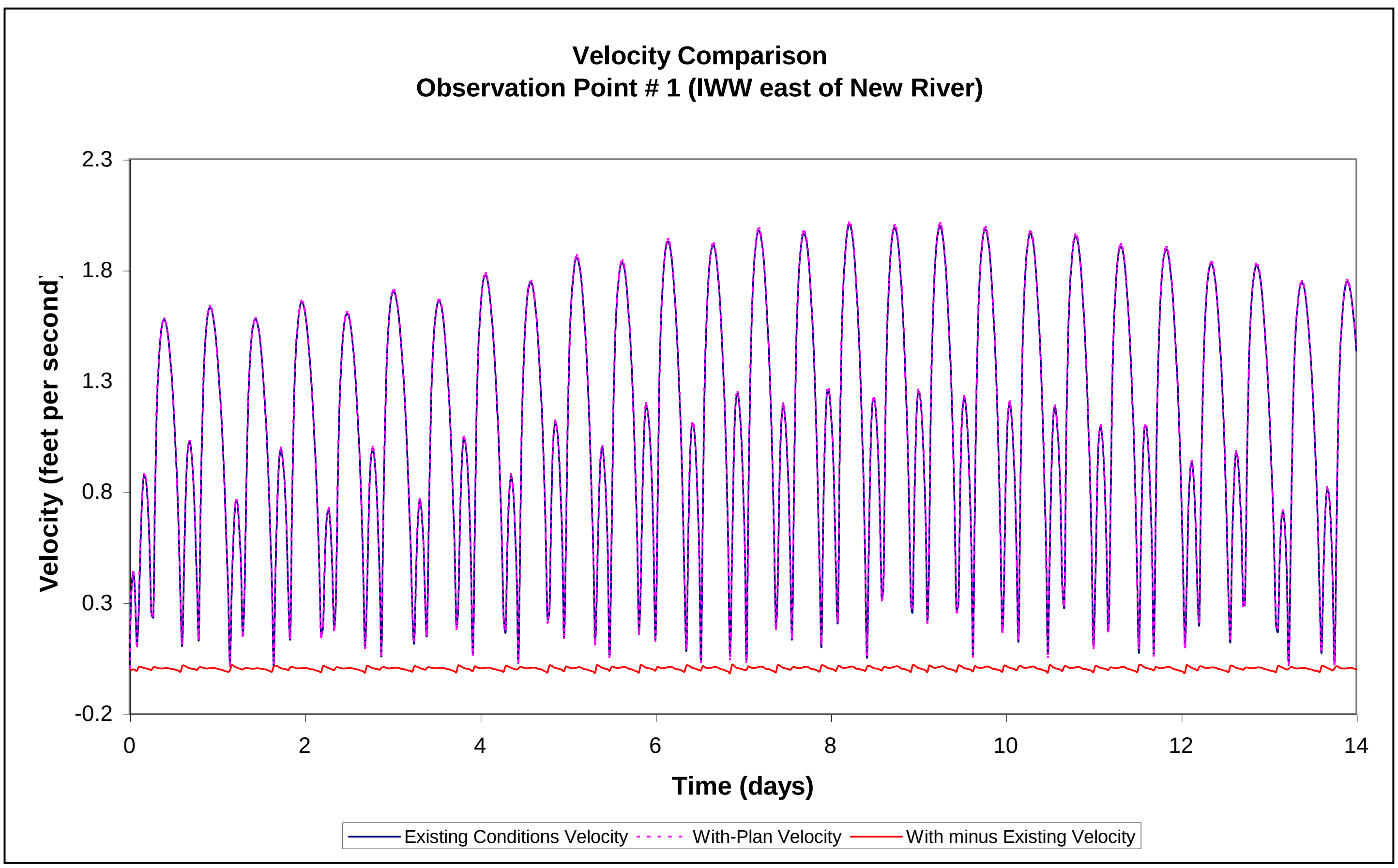


Figure 14

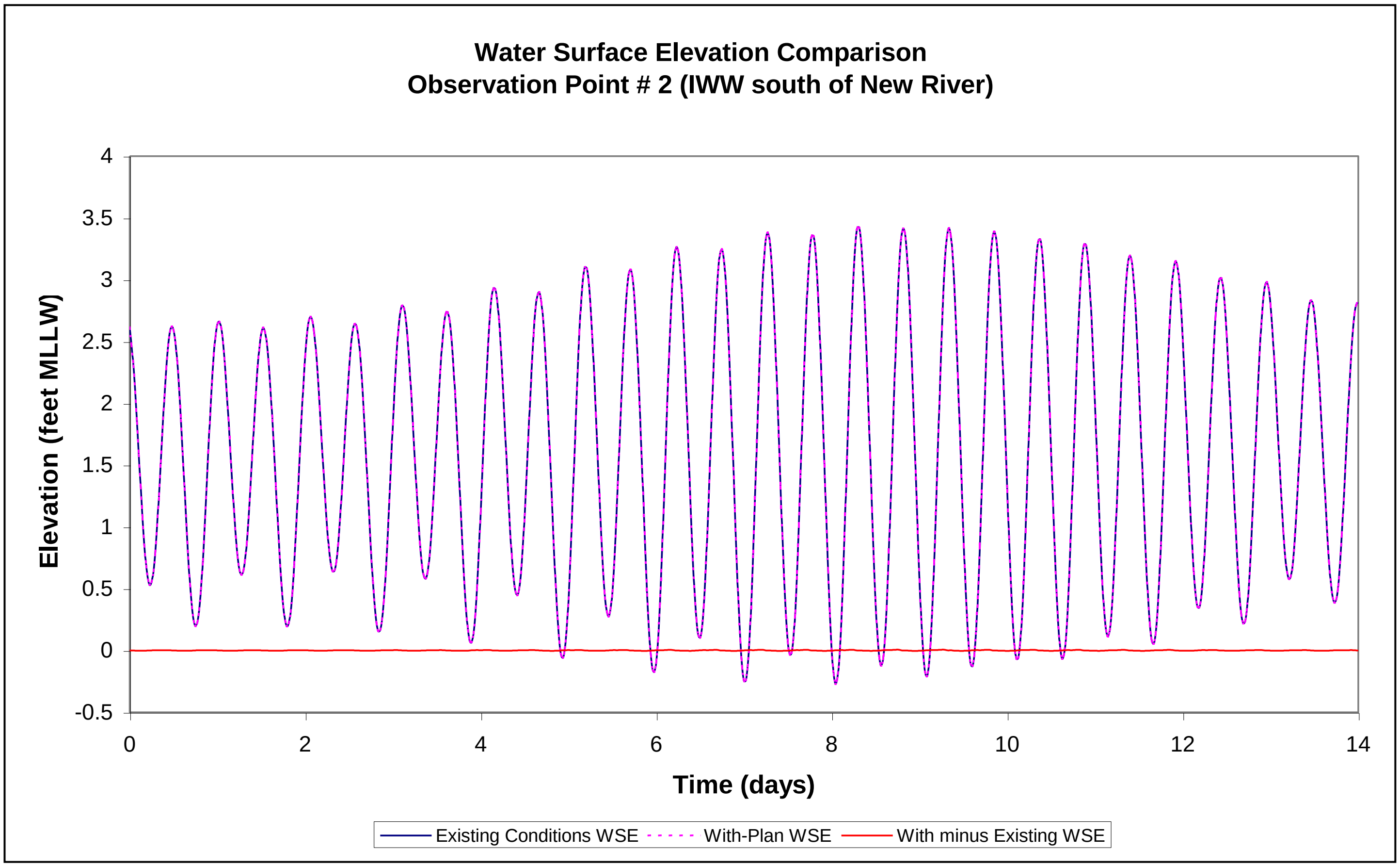


Figure 15

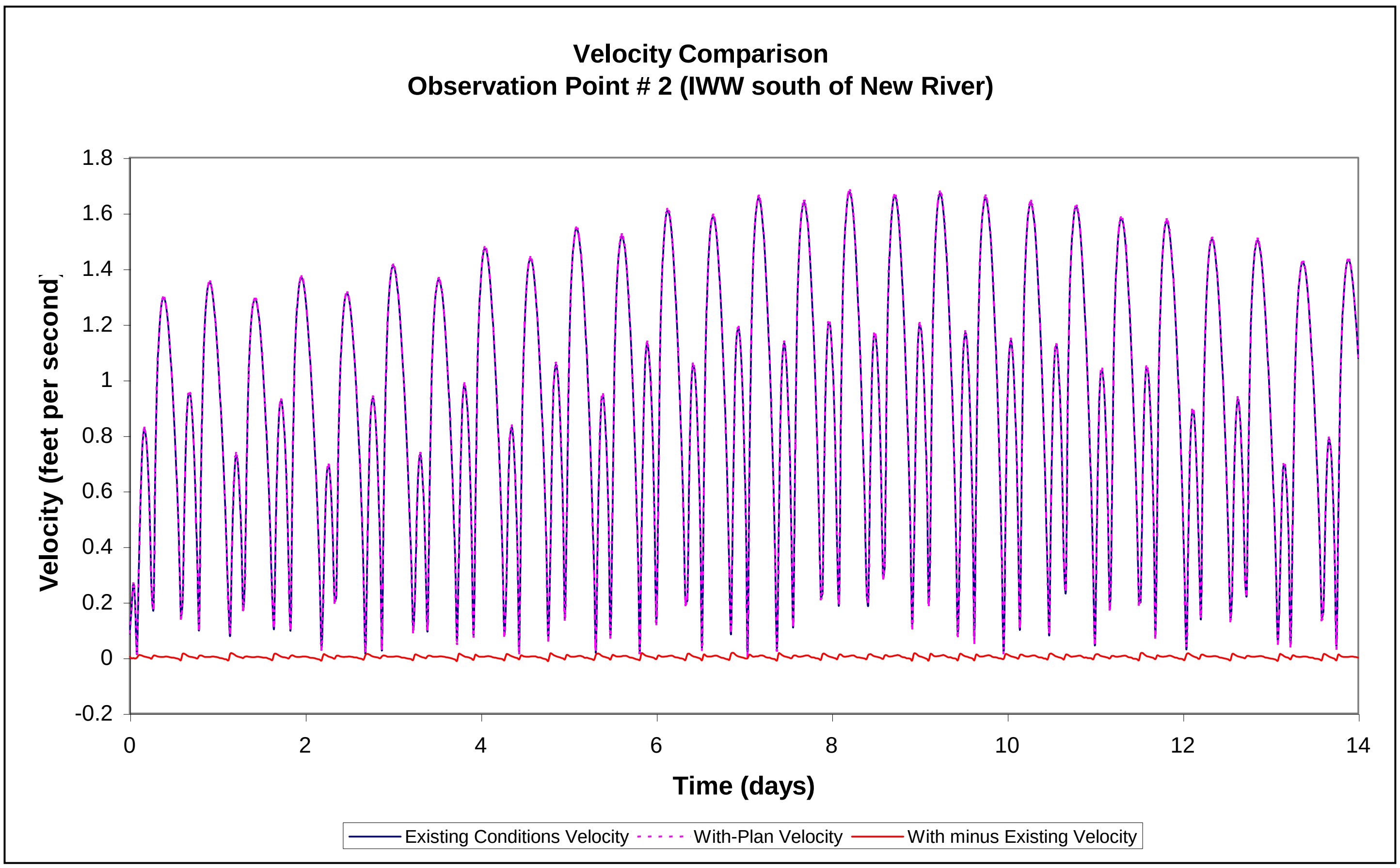


Figure 16

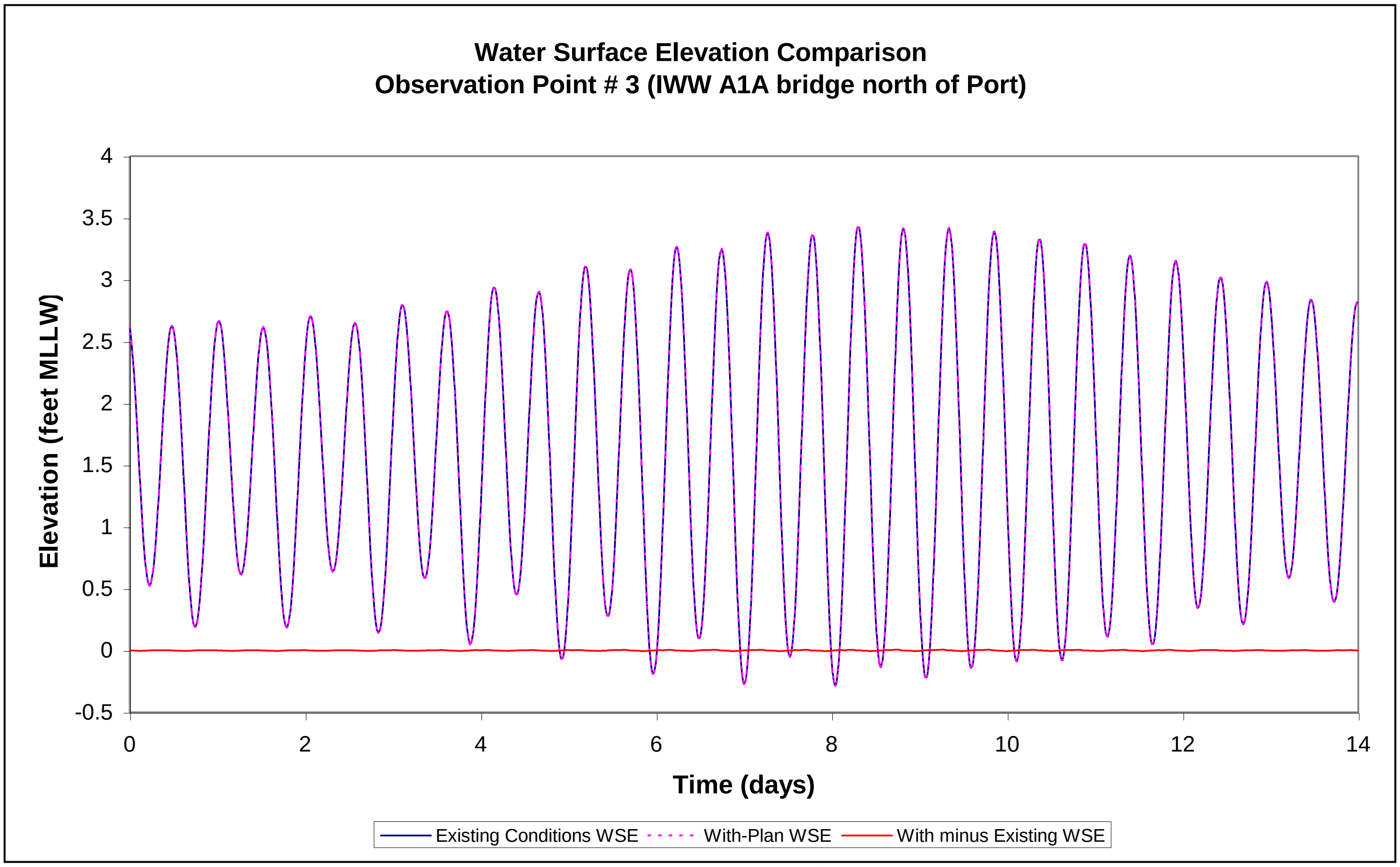


Figure 17

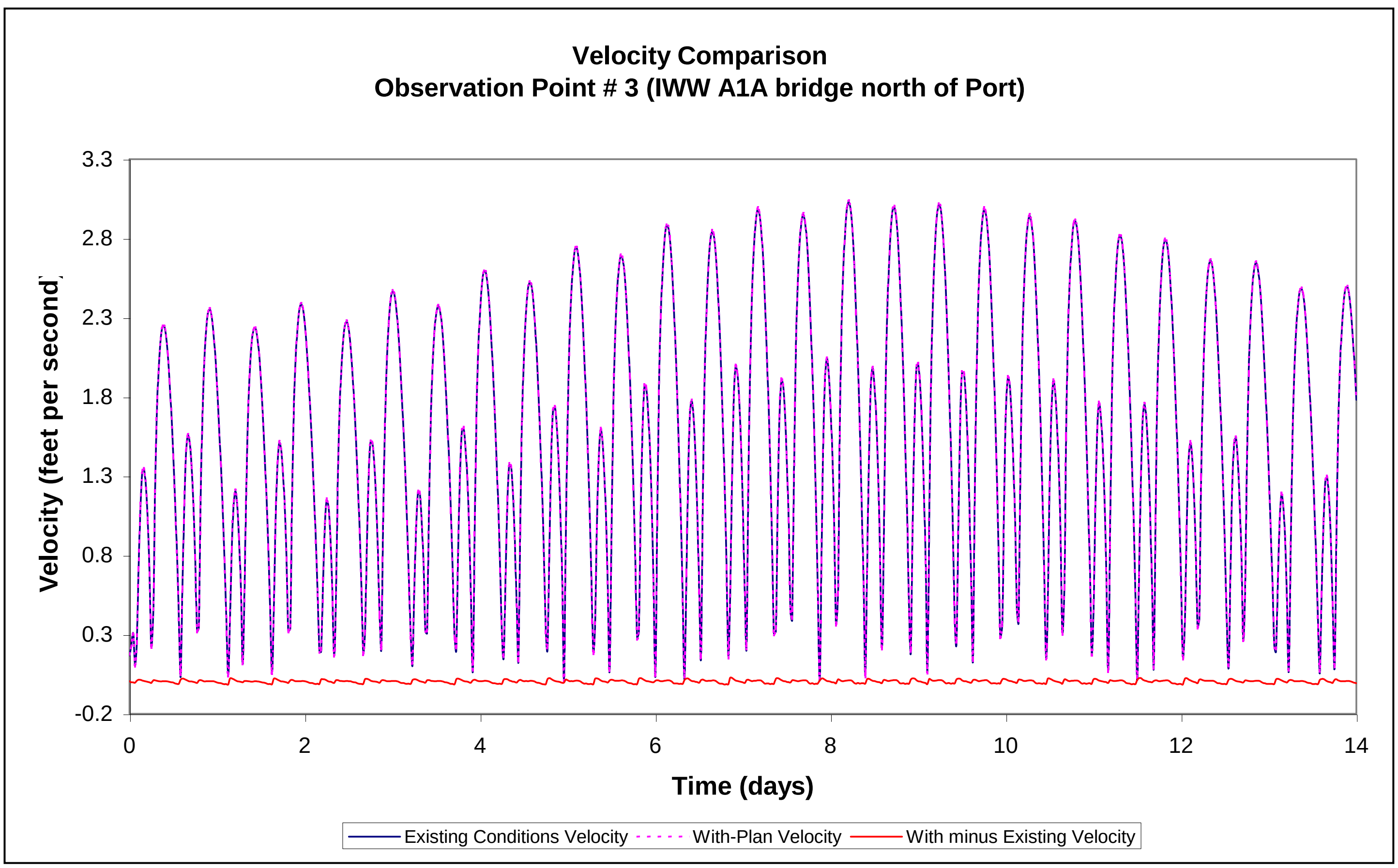


Figure 18

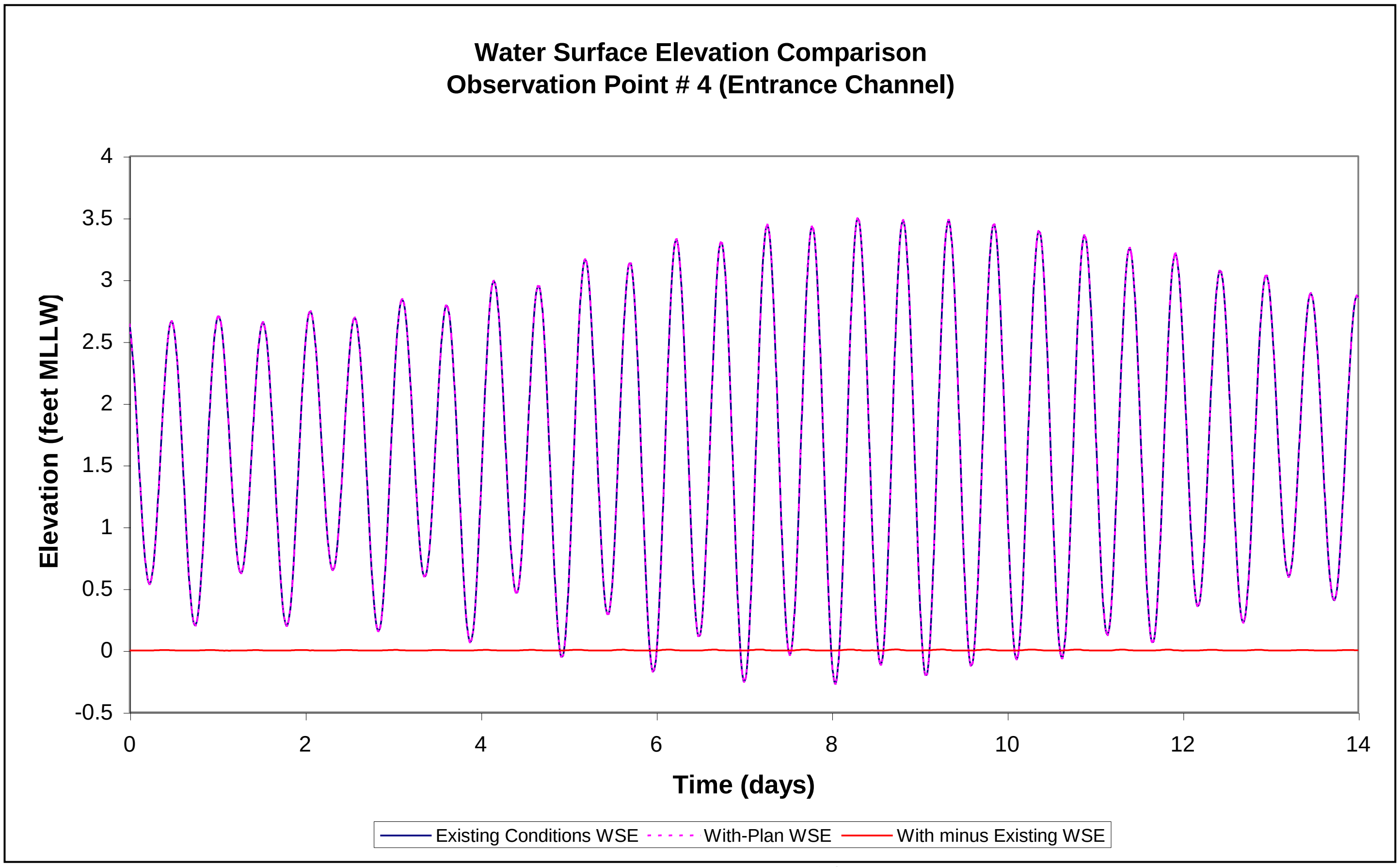


Figure 19

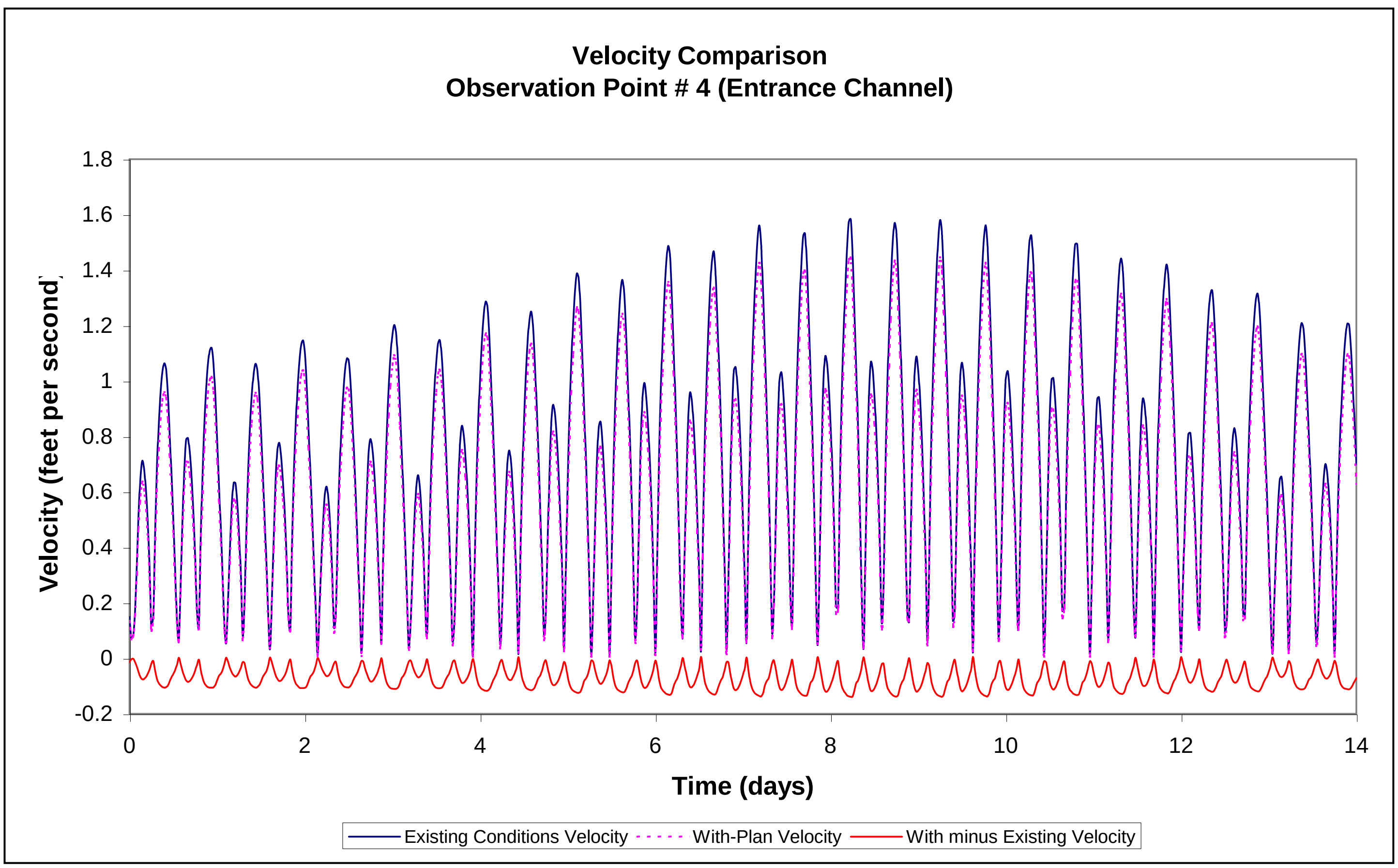


Figure 20

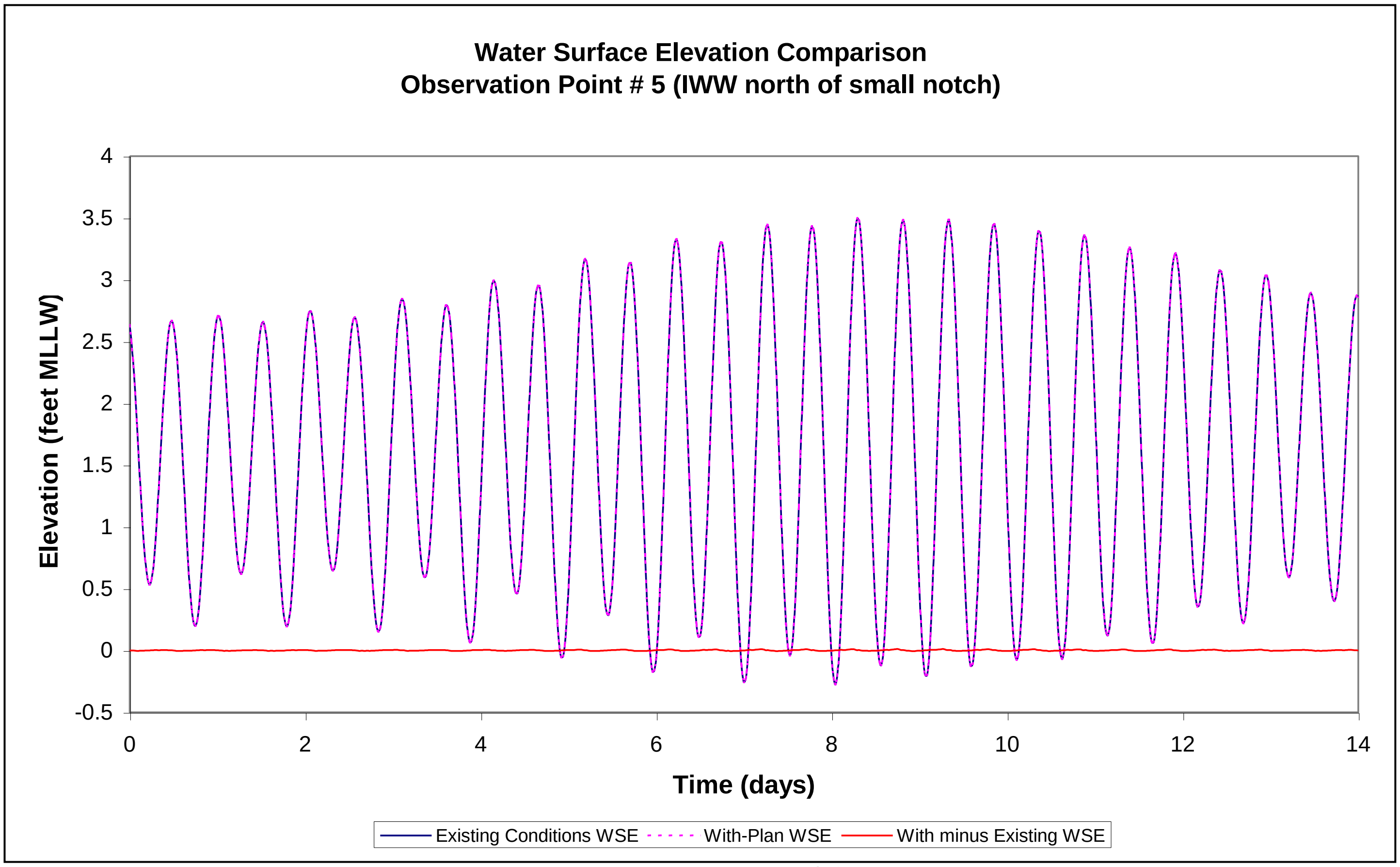


Figure 21

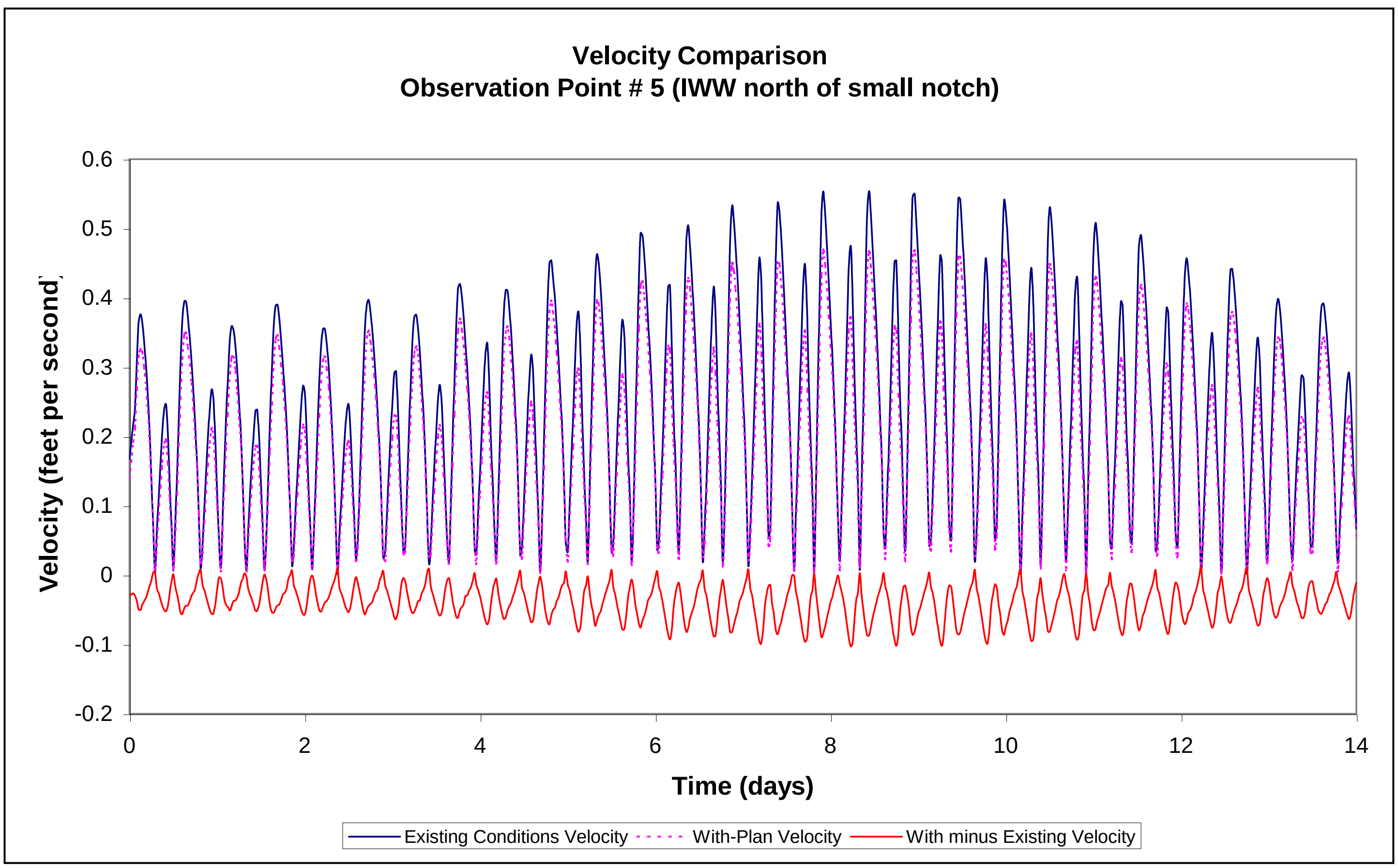


Figure 22

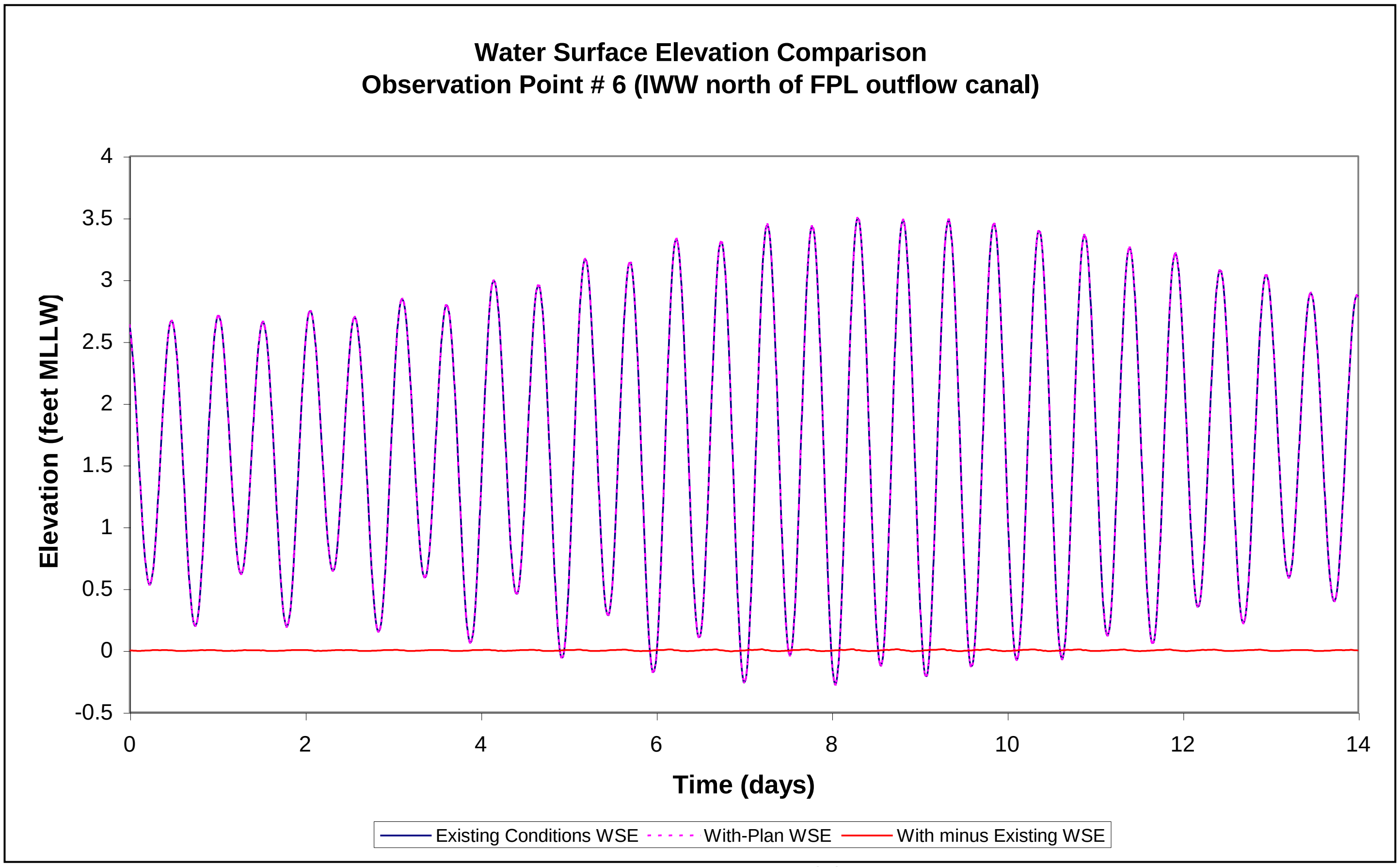


Figure 23

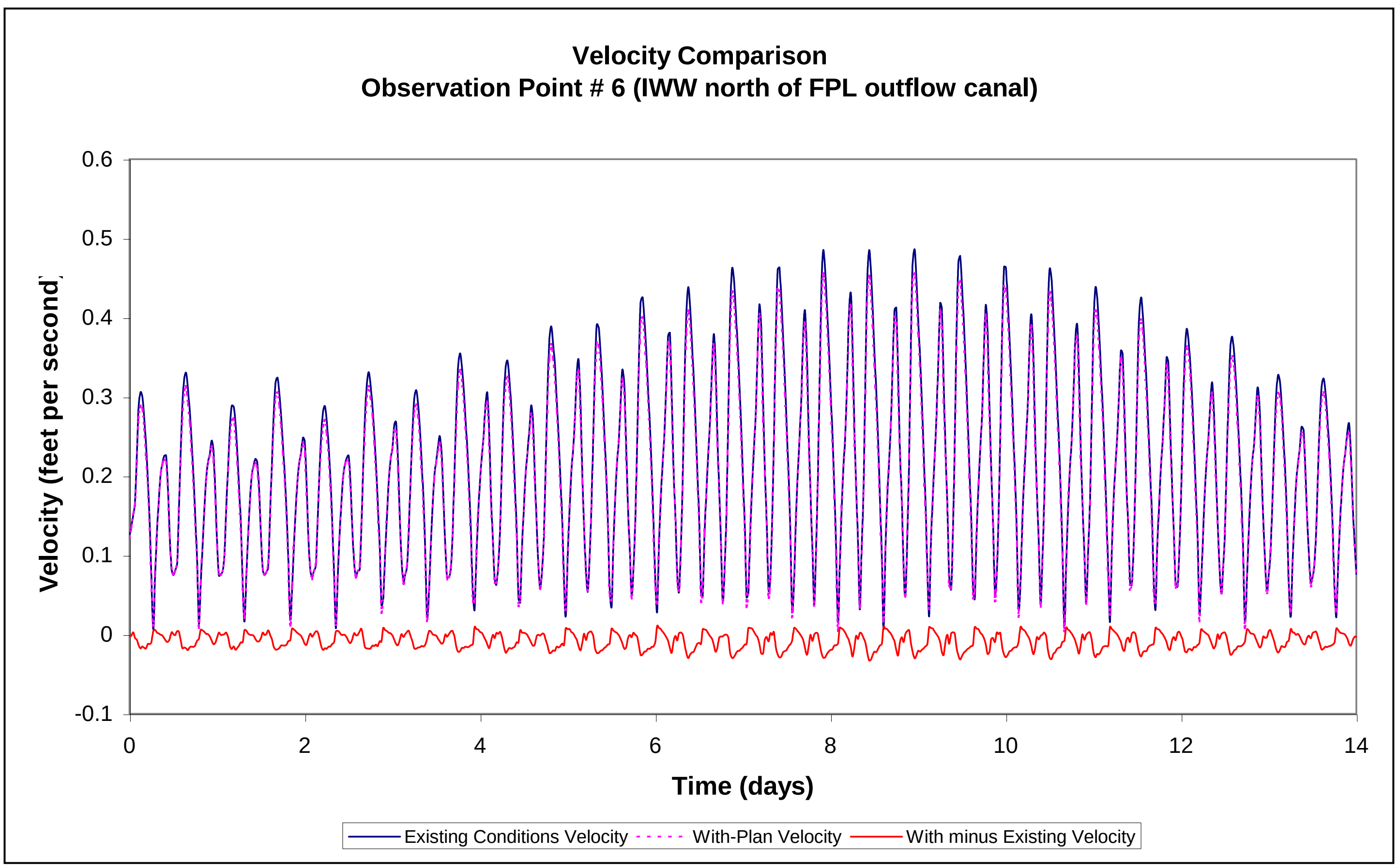


Figure 24

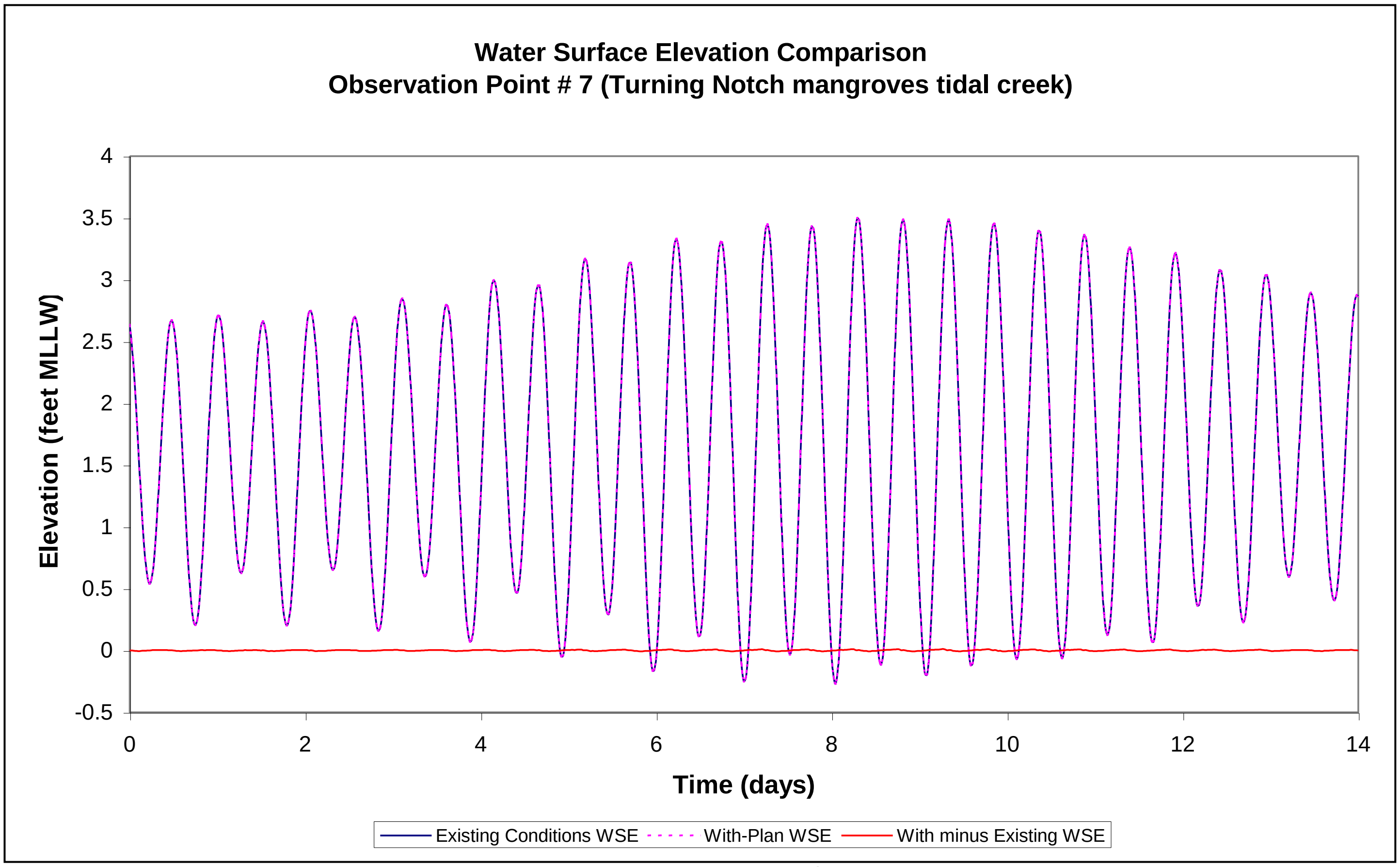


Figure 25

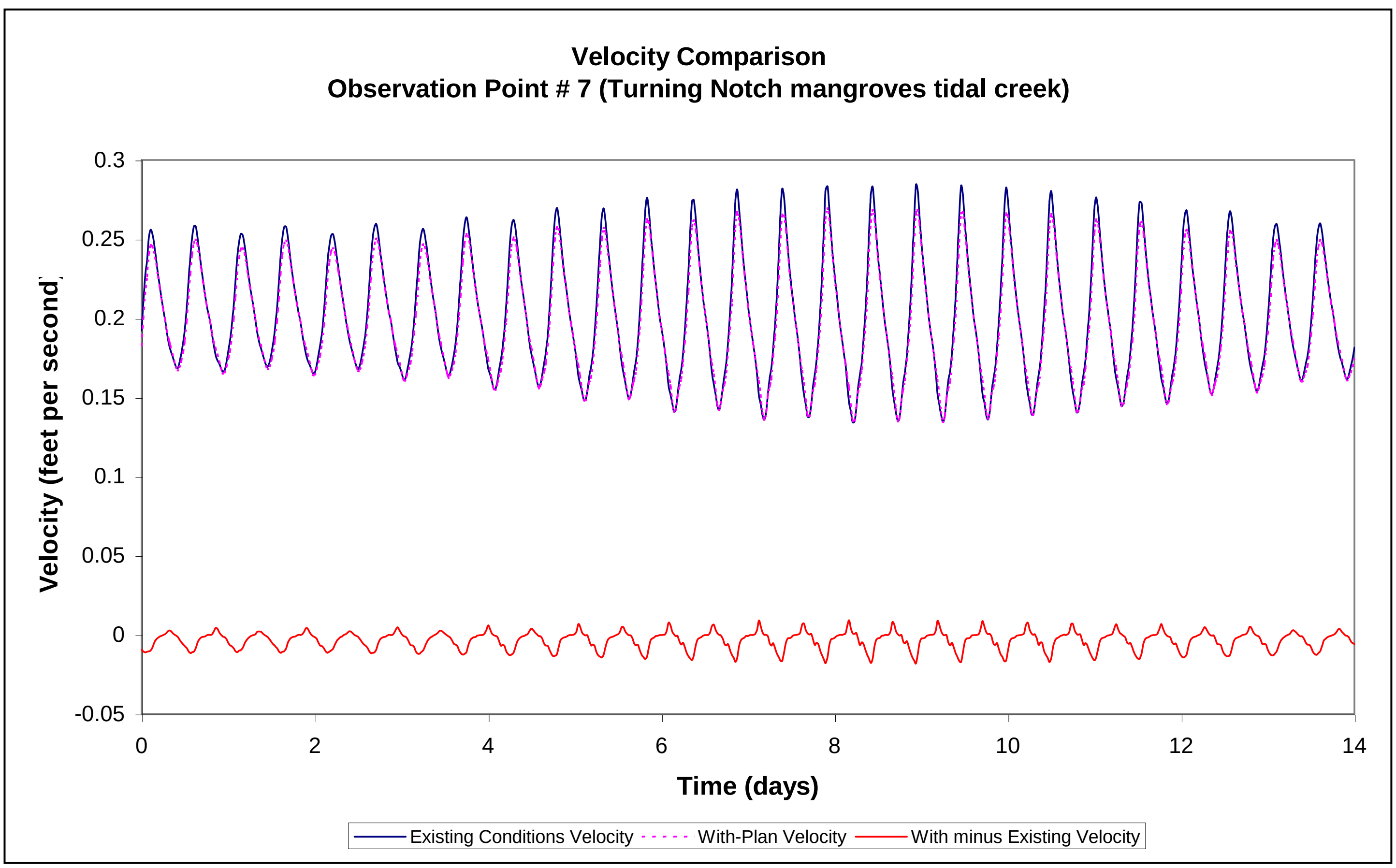


Figure 26

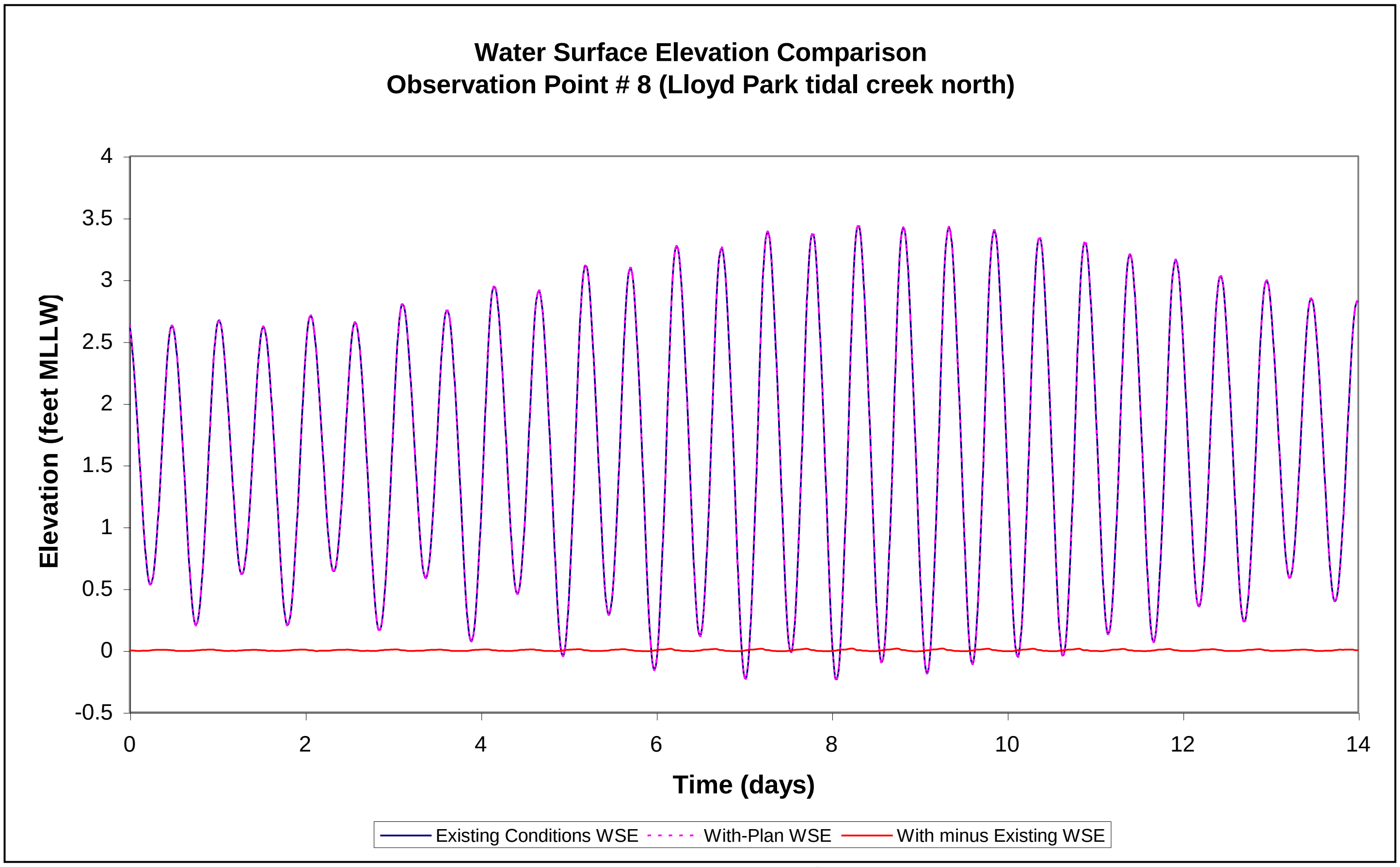


Figure 27

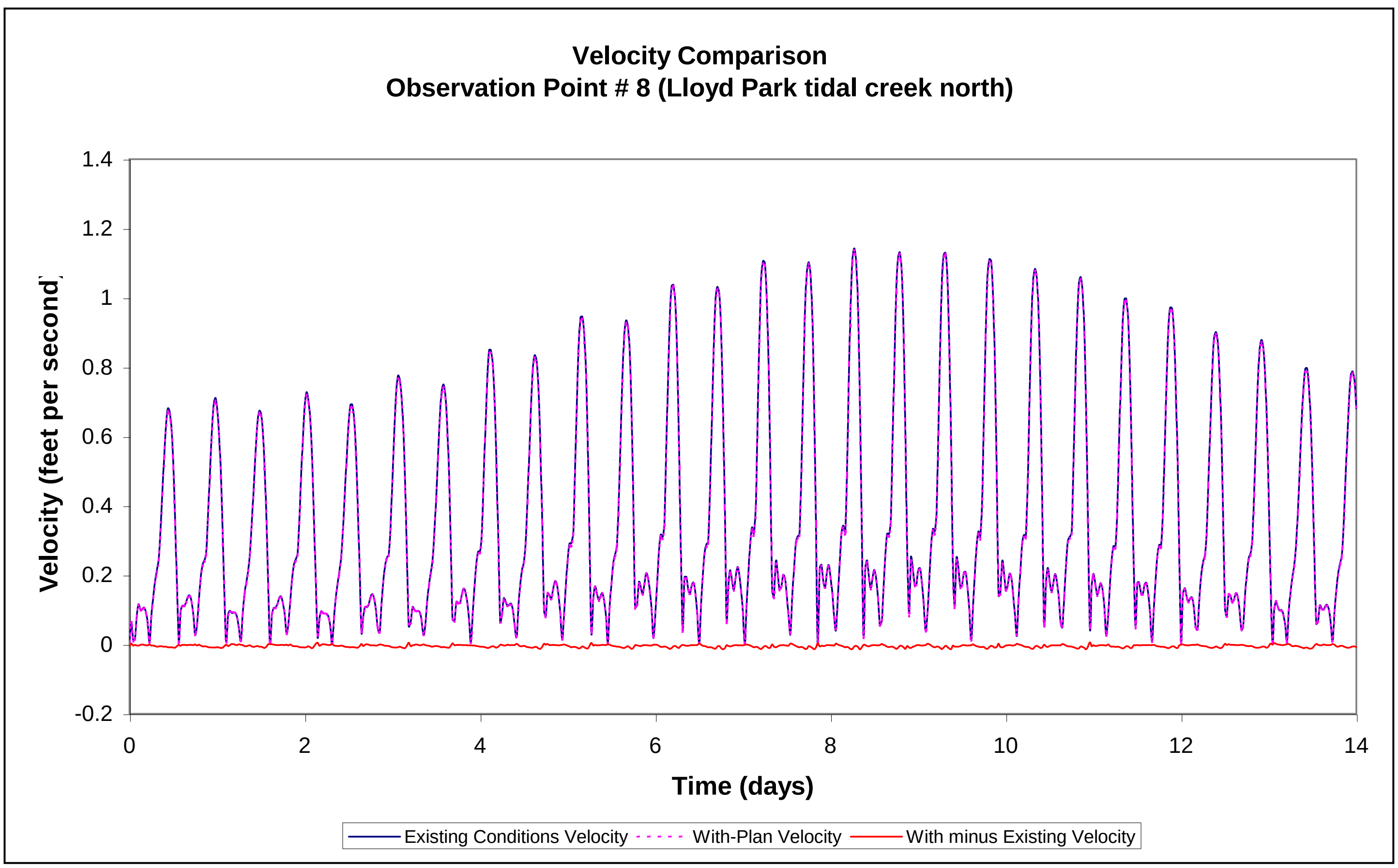


Figure 28

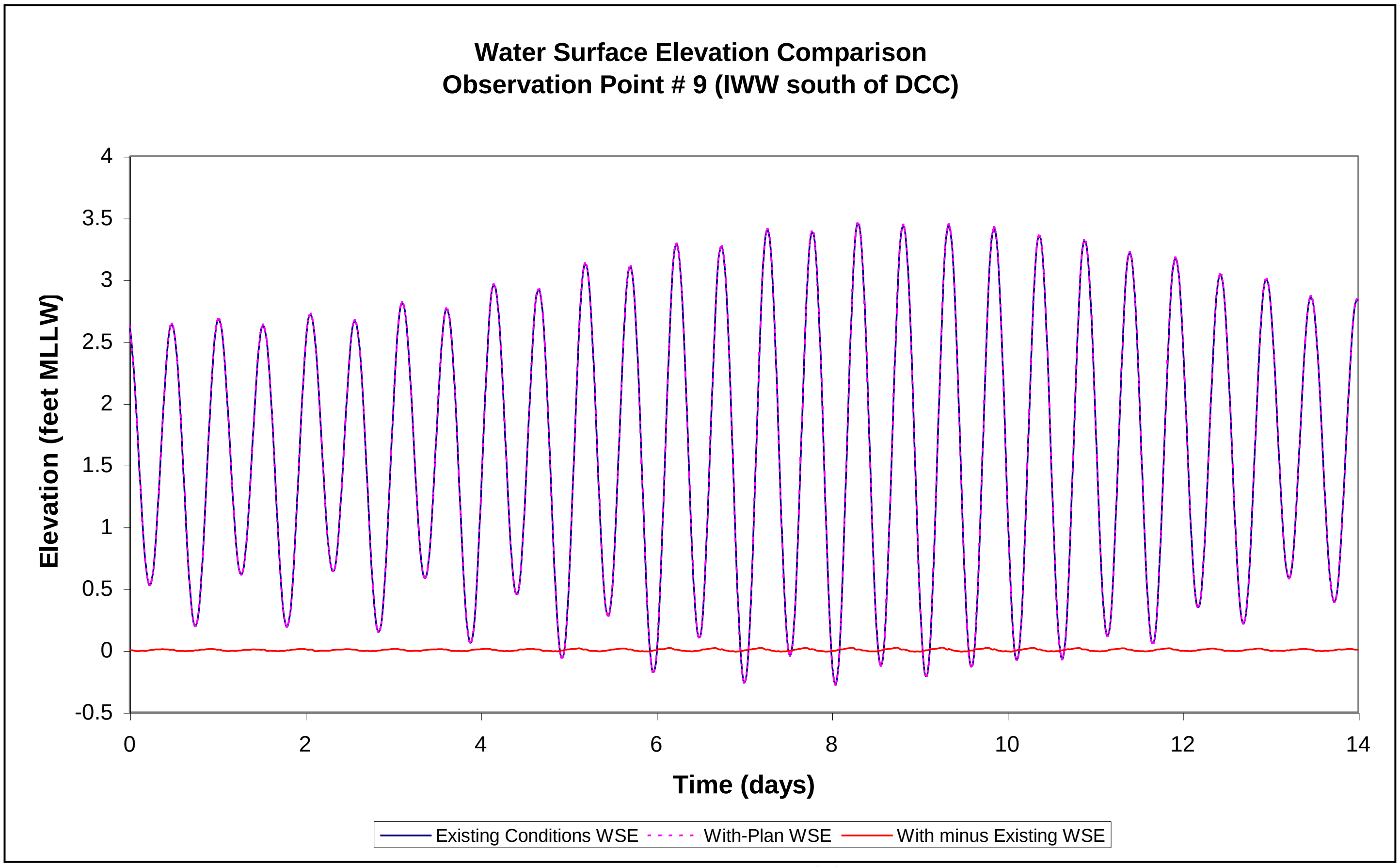


Figure 29

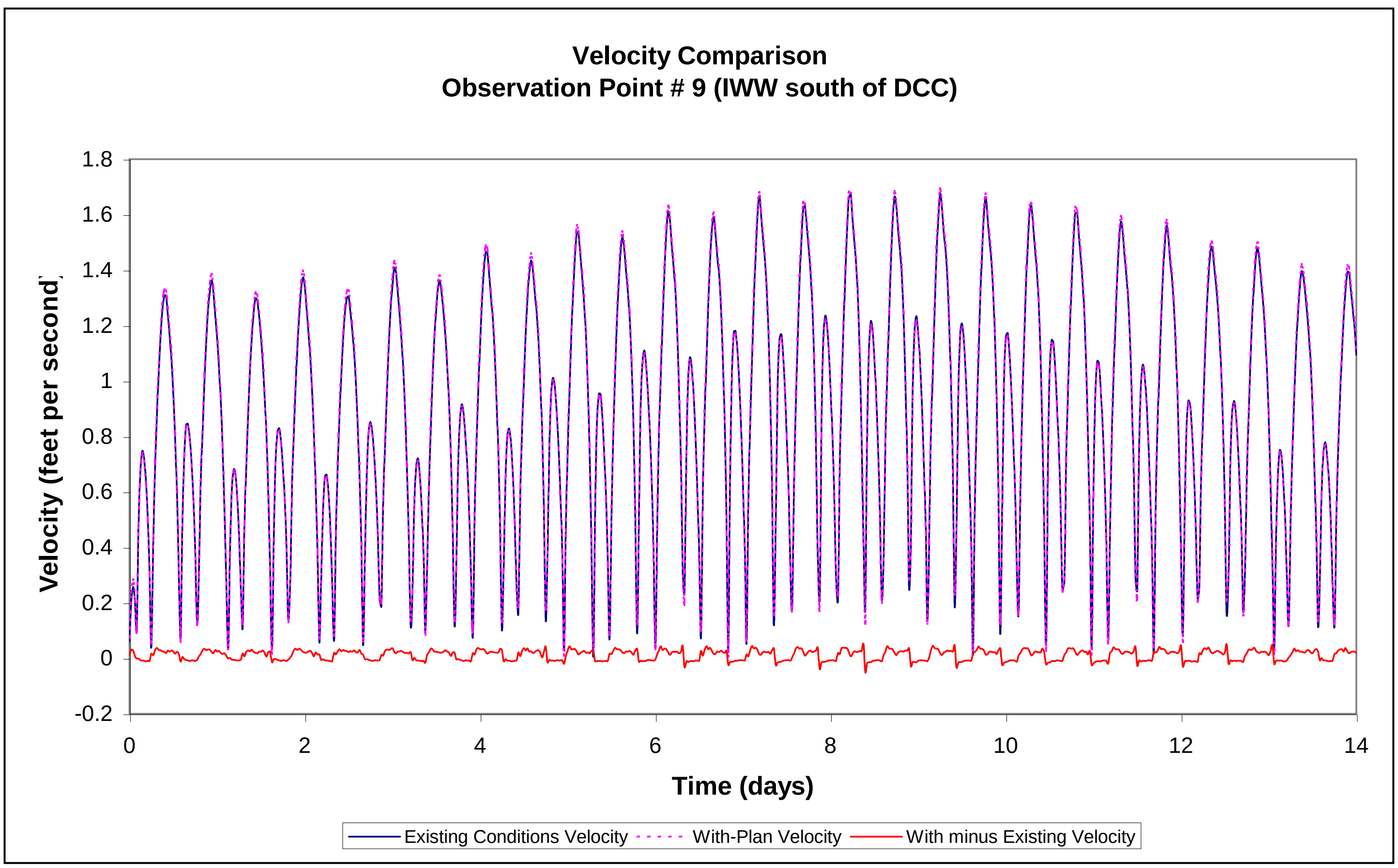


Figure 30

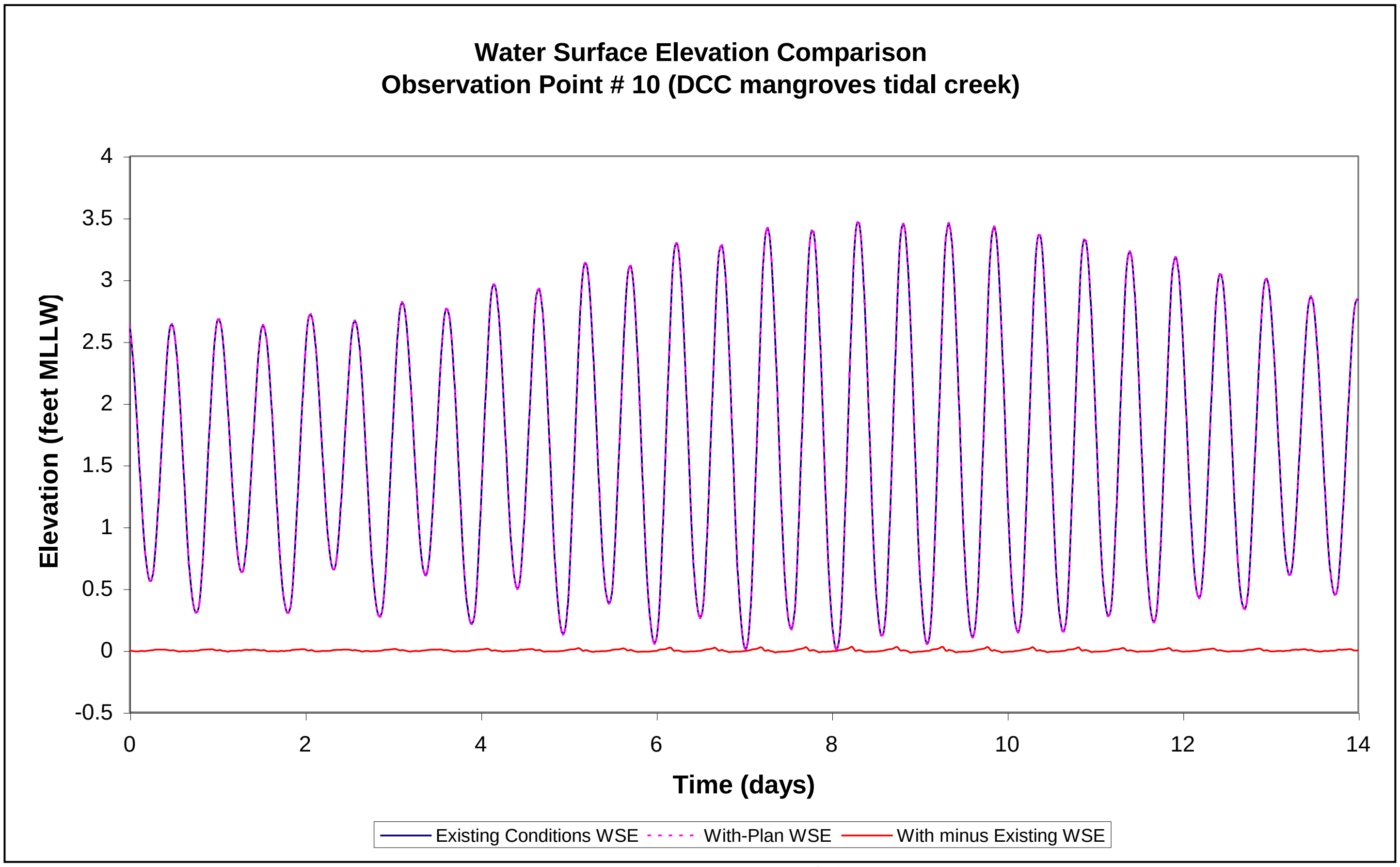


Figure 31

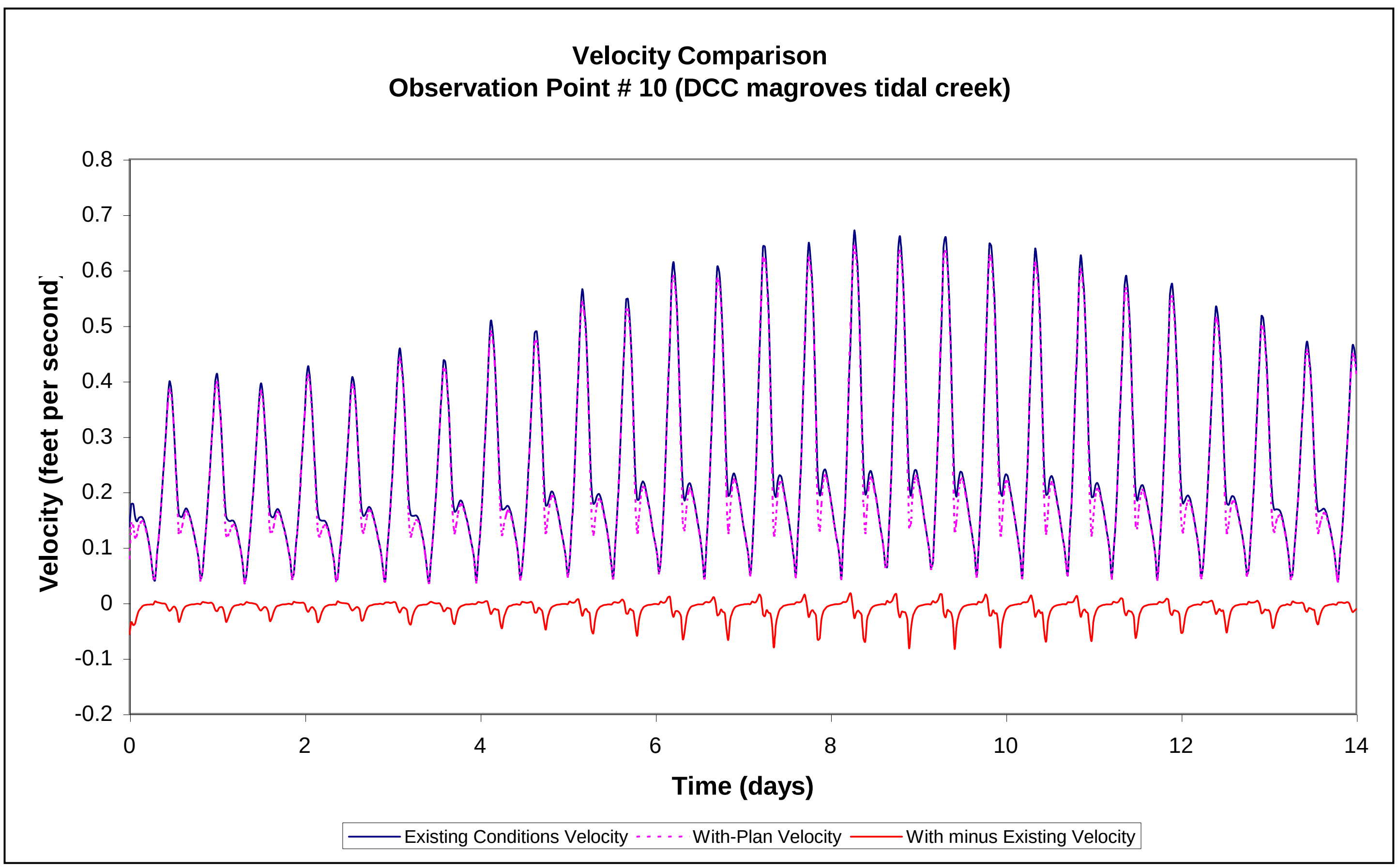


Figure 32

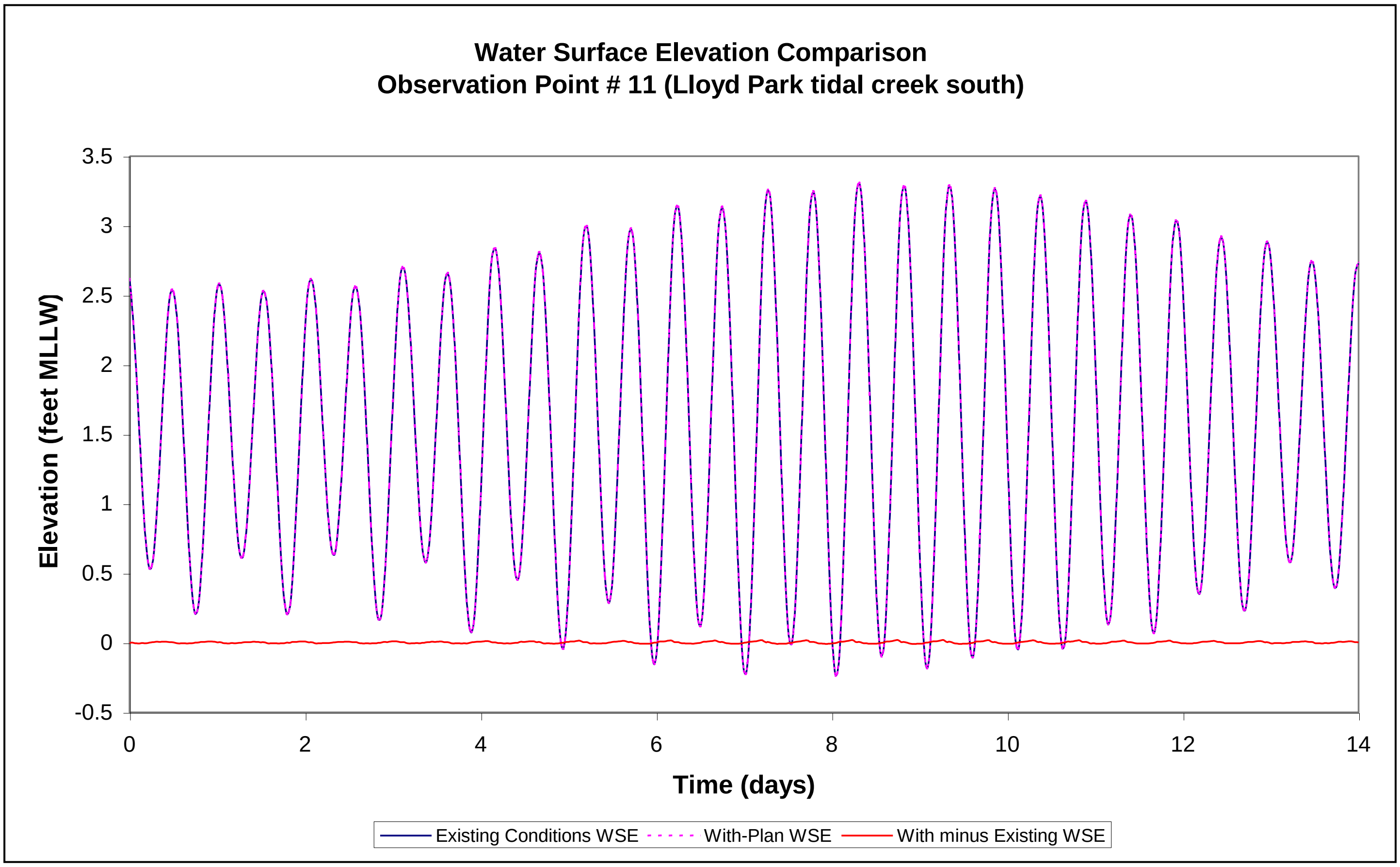


Figure 33

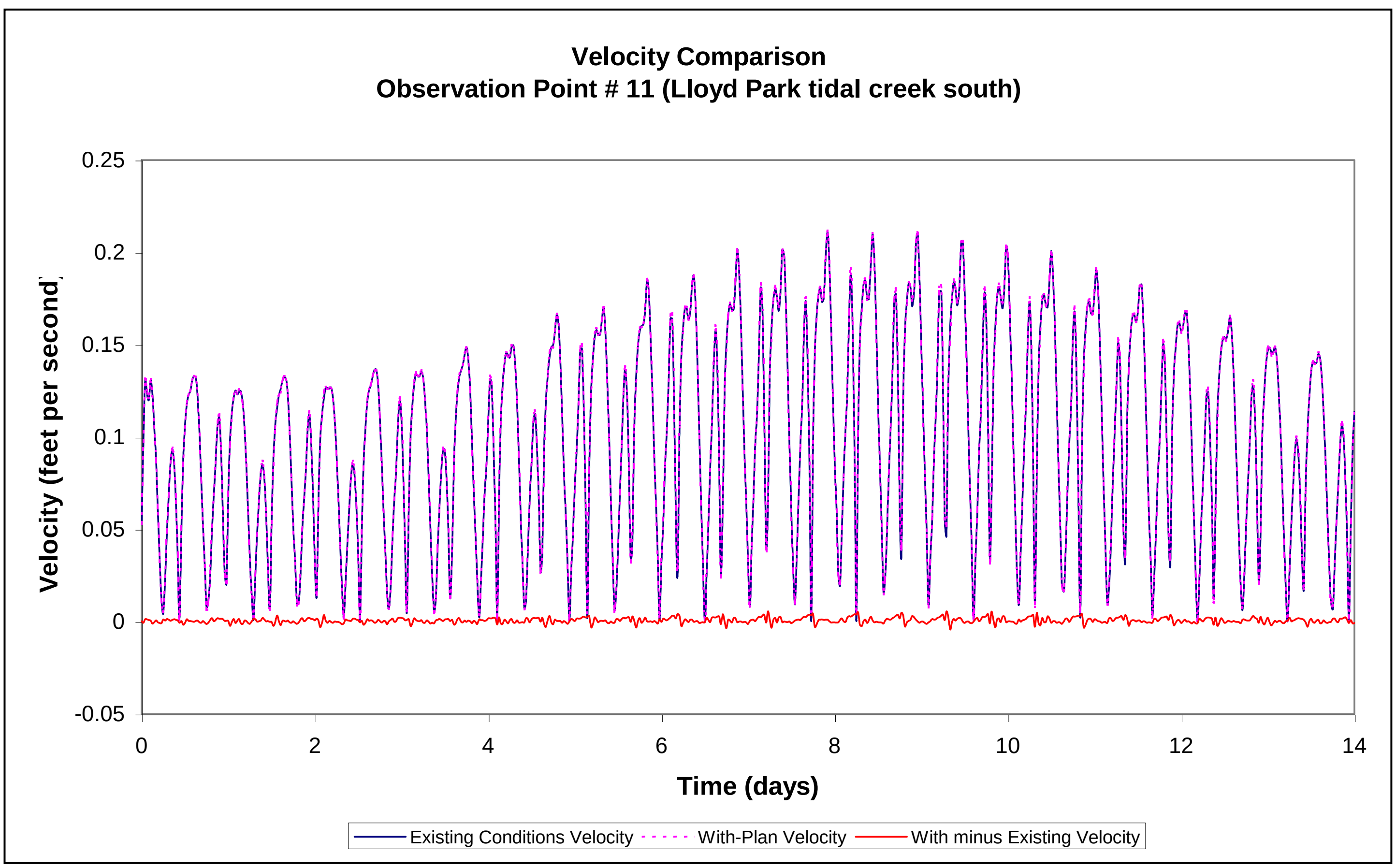


Figure 34

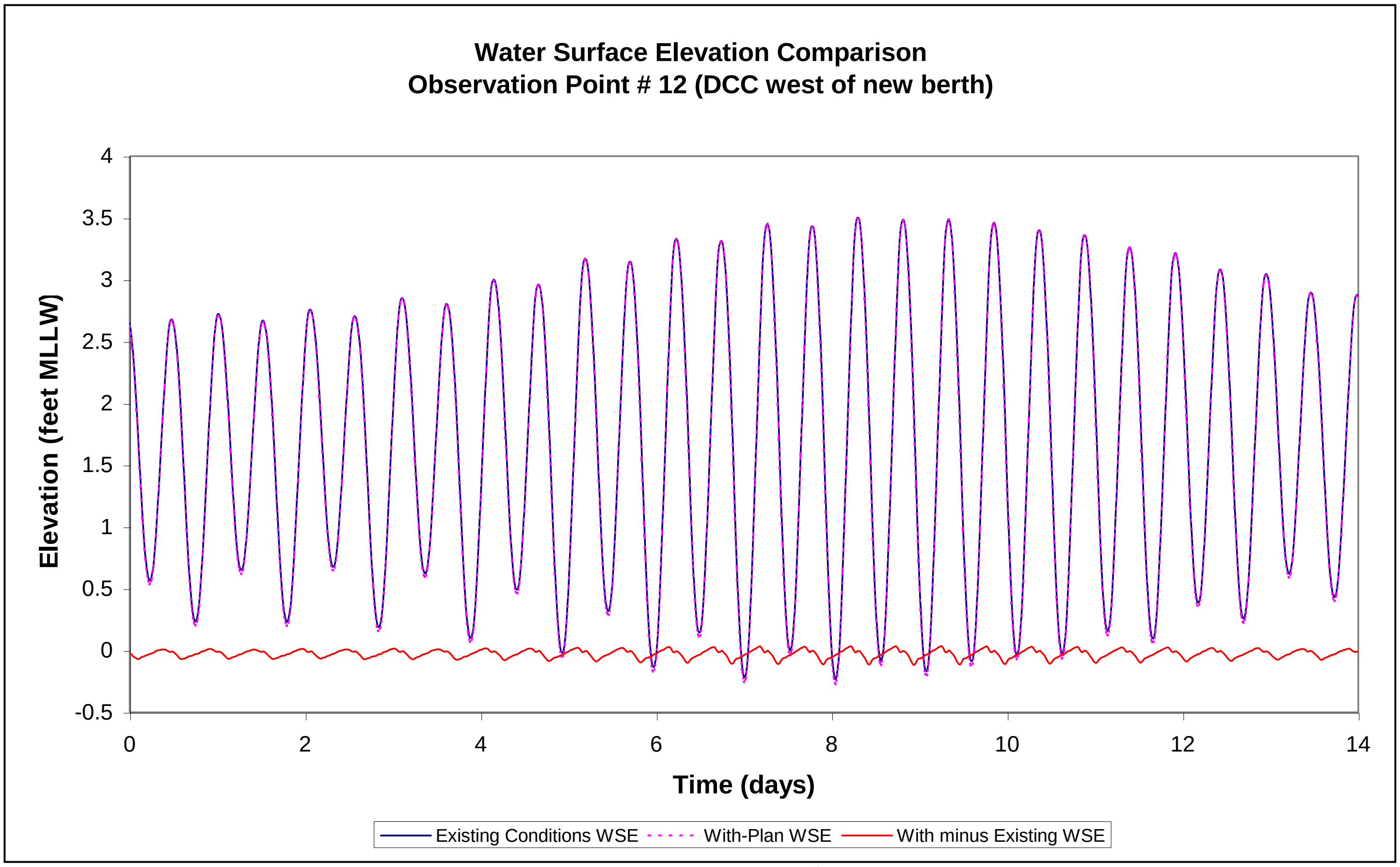


Figure 35

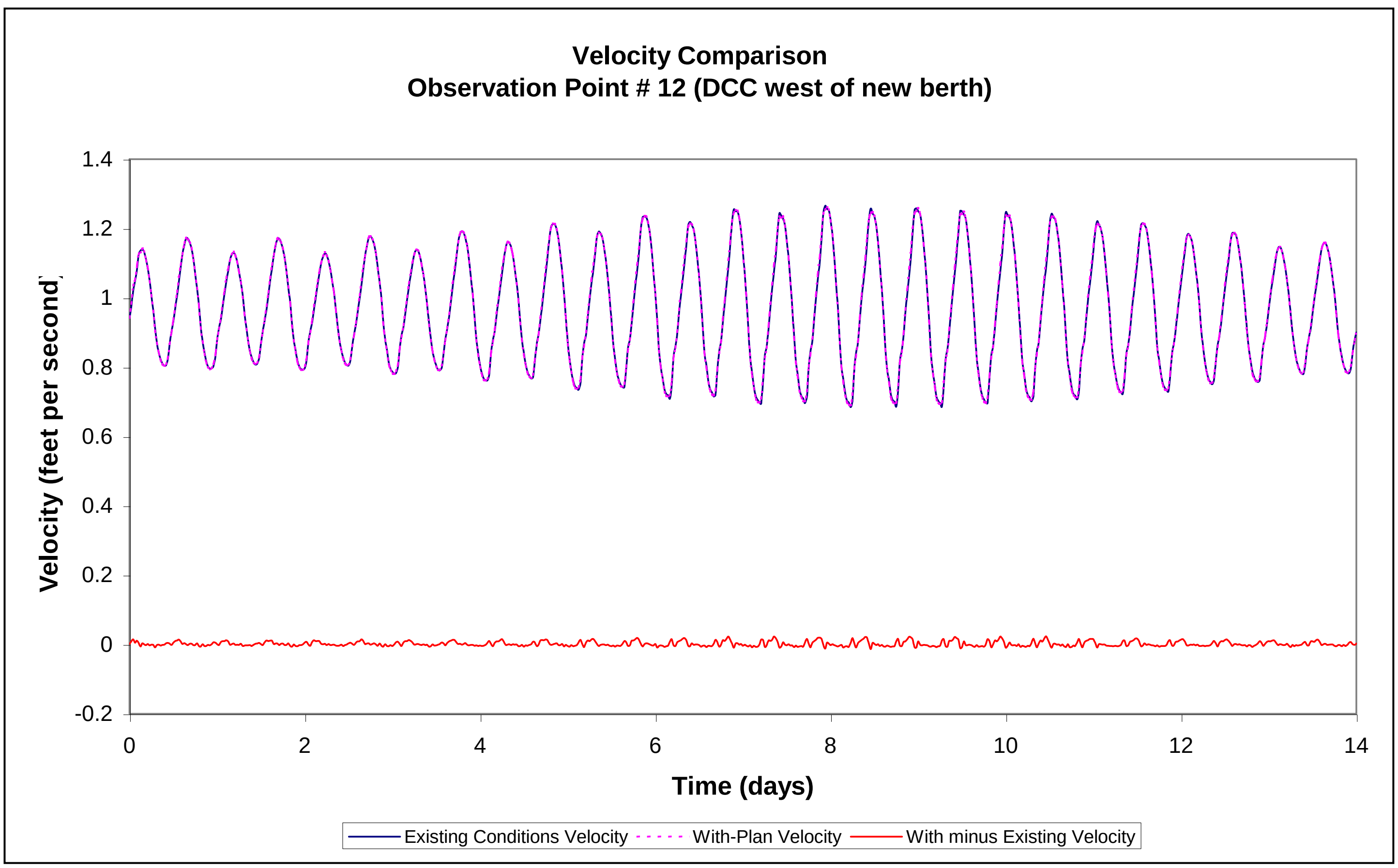


Figure 36

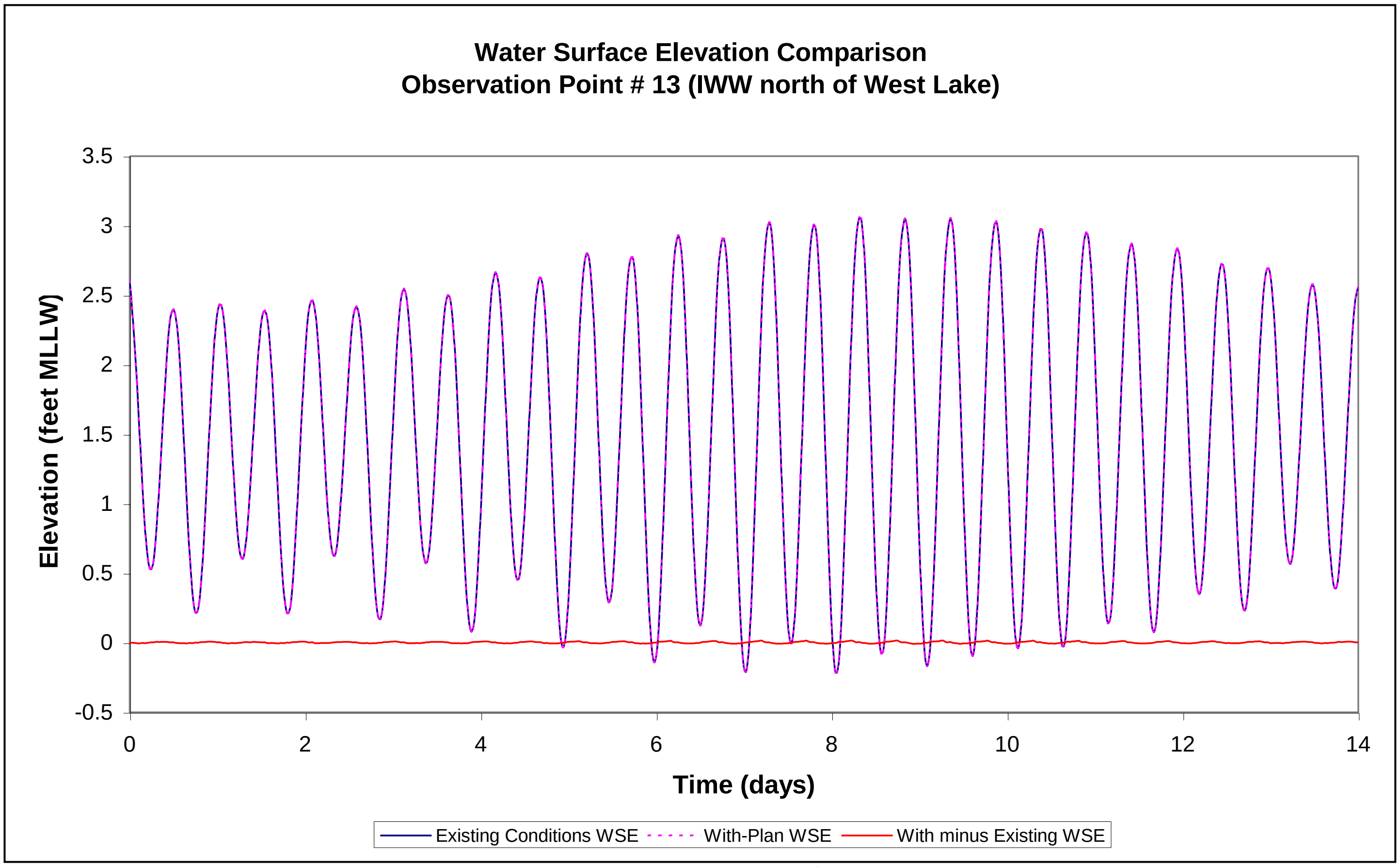


Figure 37

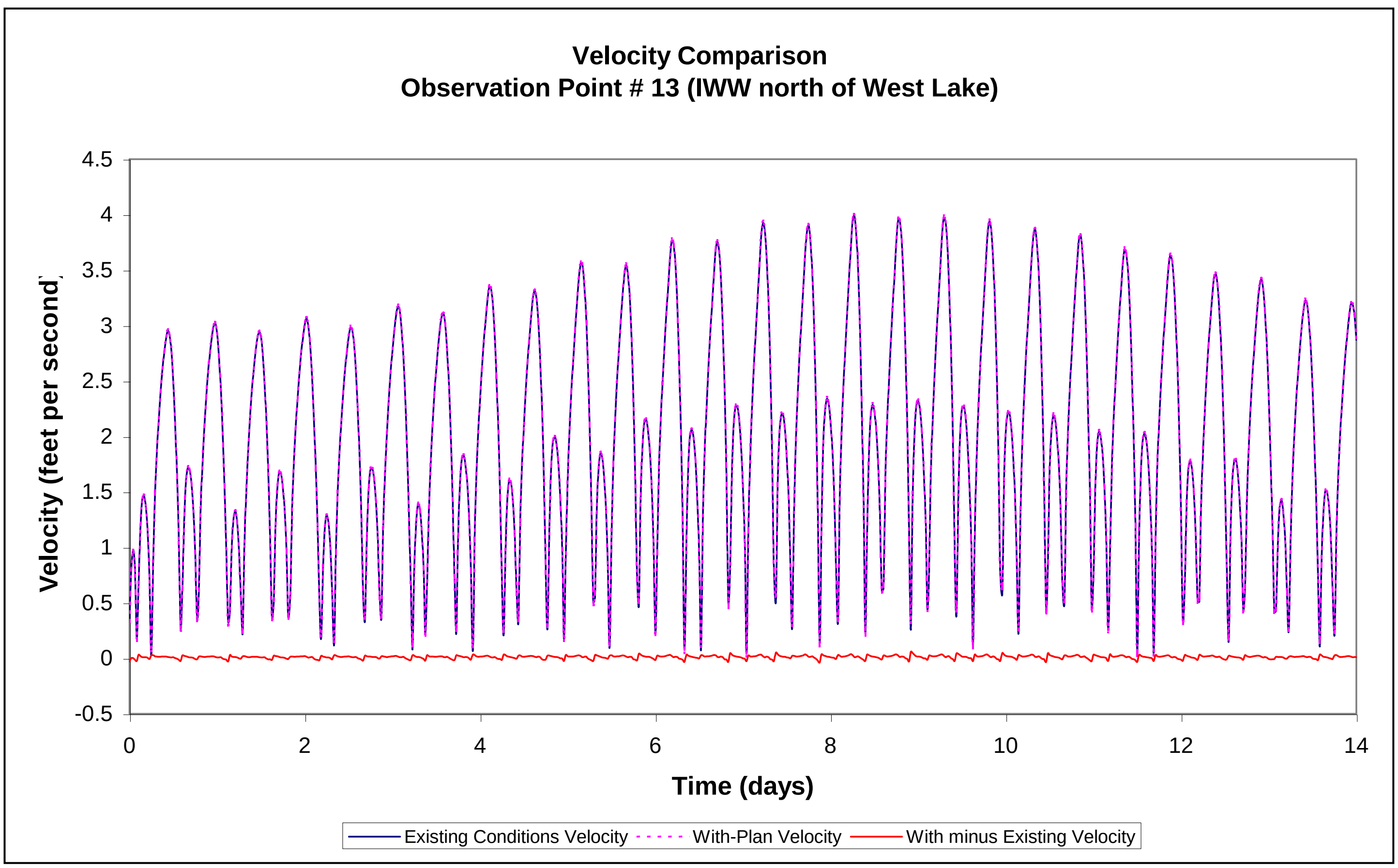


Figure 38

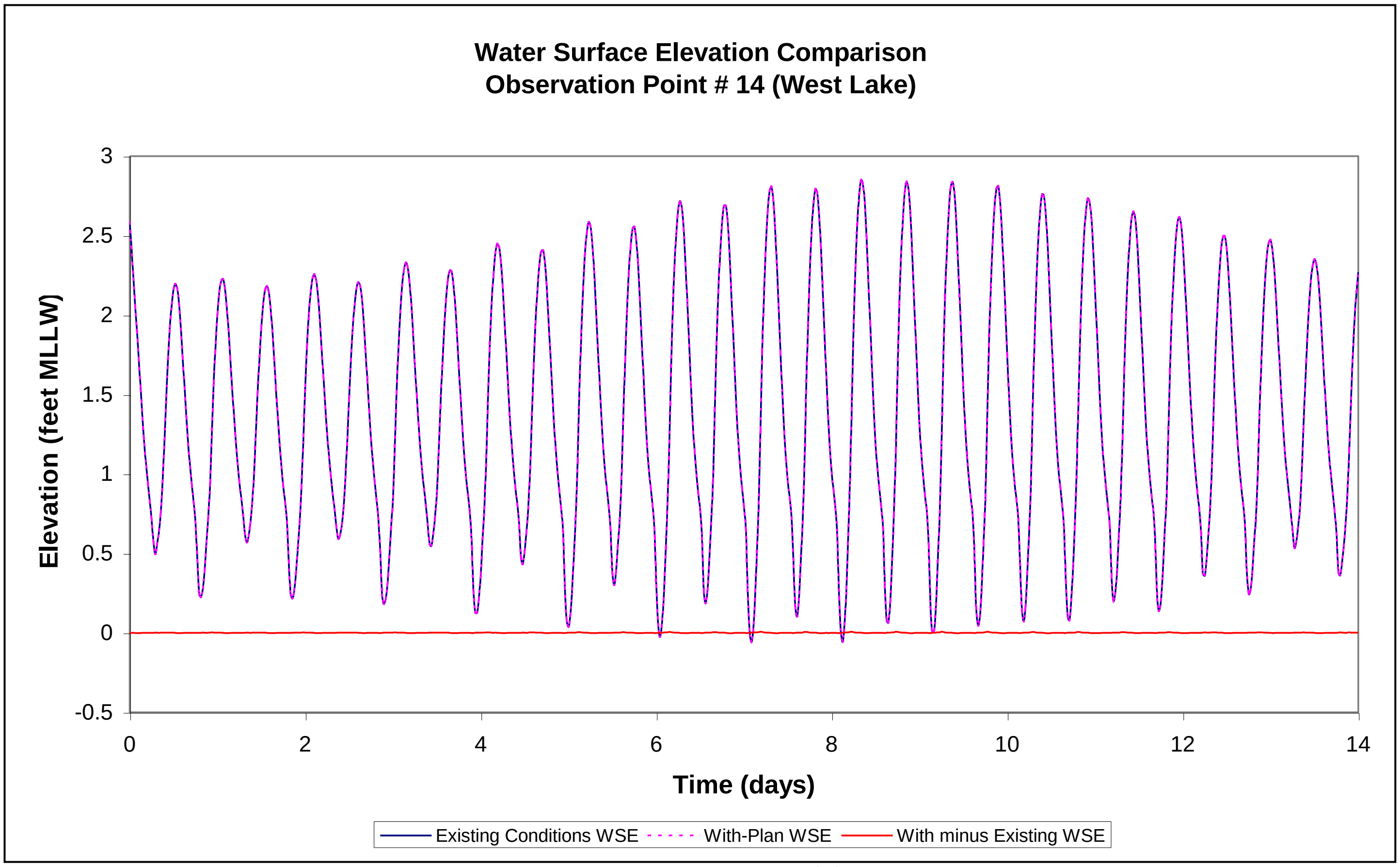


Figure 39

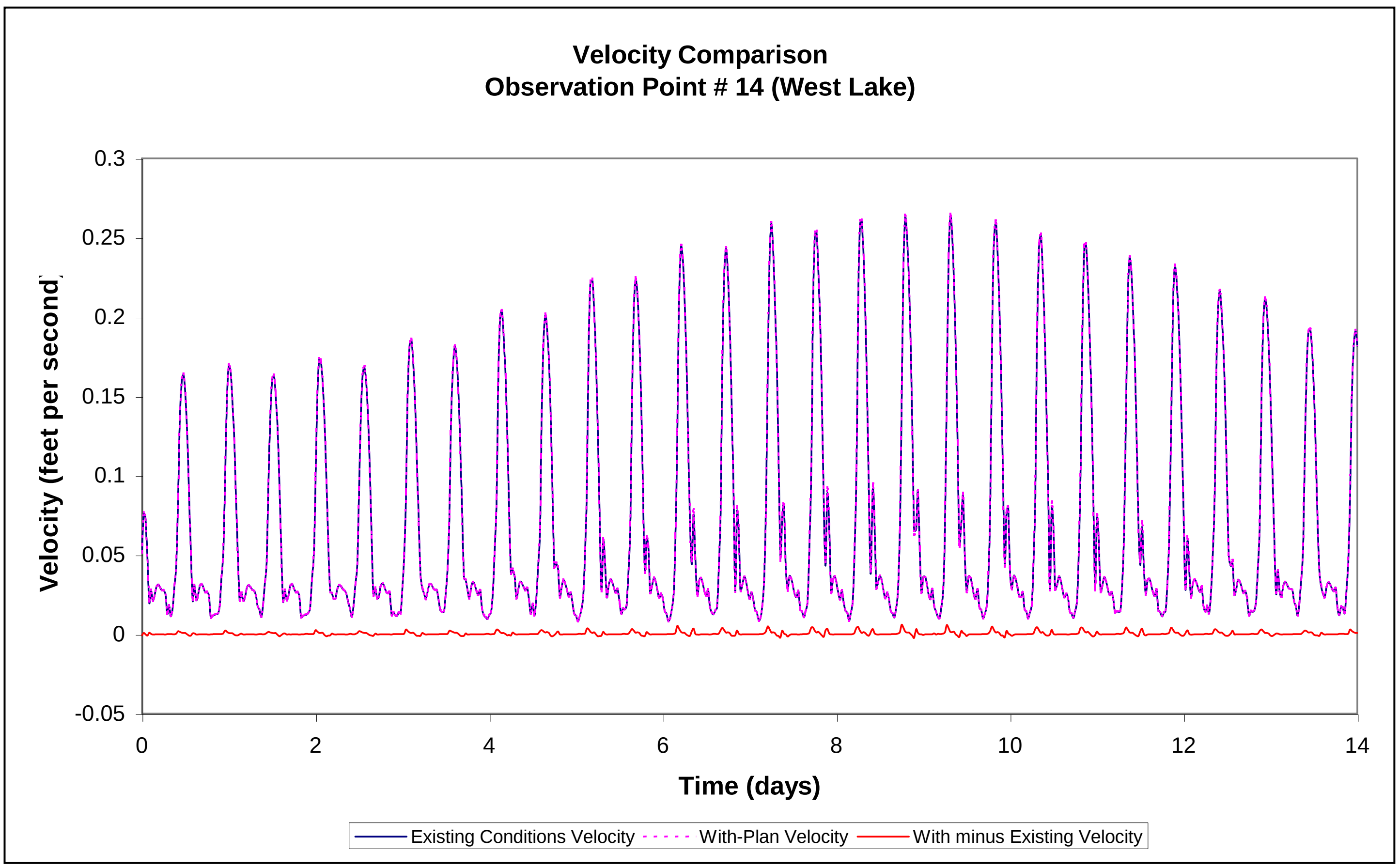


Figure 40