Cape Fear River Channel Improvement Study

Introduction

1. The U.S. Army Engineer District, Wilmington (CESAW) has proposed channel improvements for the Cape Fear River, NC. The project location is shown in Figure 1. Ships require between 2 ½ and 3 hours to complete the approximately 26-mile transit. The tidal range for Cape Fear River and Wilmington Harbor is approximately 4 ft.

2. The Cape Fear River Project consists of numerous channel segments and is shown in Figure 2. Discussion of the Cape Fear River Project is divided into three reaches for this report. The reaches are defined as follows:

   a. Reach 1 extends from the Baldhead Shoal Channel in the Atlantic Ocean to the Cape Fear Memorial Bridge in downtown Wilmington.

   b. Reach 2 extends from the Cape Fear Memorial Bridge to 750 ft above the Hilton Railroad Bridge and includes the confluence of the Cape Fear and Northeast Cape Rivers.

   c. Reach 3 extends from 750 ft above the Hilton Railroad Bridge to the upstream limit of the Federal project on the Northeast Cape Fear River.

3. Proposed improvements. The improvements proposed by CESAW are presented for each of Reaches 1, 2, and 3.

4. Reach 1. Reach 1 is presently 400 ft wide and 38 ft deep MLLW for most of its nearly 21 miles. However, the Baldhead Shoal Channel is 500 ft wide and 40 ft deep. The additional 2 ft of depth in the Ocean Bar Channel is to allow for vertical motion due to waves. The pilots are currently requiring 4 ft of underkeel clearance in the harbor and 6 ft of underkeel clearance in the Baldhead Shoal Channel. Ships transit at a maximum draft by using tidal advantage. Inbound ships move with the tide, thus maintaining a 4 ft tidal advantage throughout. Therefore, the tidal advantage meets the underkeel requirements and the maximum draft for inbound ships is 38 ft. However, the maximum draft for outbound ships is 37 ft because they cannot complete the 3-hour voyage before the tide begins to fall. To remove tidal restrictions on container traffic, allow for a two-way traffic passing lane, and ease some of the turns between reaches, CESAW has proposed the following:

   a. Deepen the channels in Reach 1 by 4 ft.

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1 All depths in the report are mean lower low water (MLLW) unless noted otherwise.
b. Consider realigning the Baldhead Shoal Channel (Figure 3). Two different alignments (Plans 1 and 2) were proposed. However, Plan 2 was eliminated from consideration prior to the simulation program.

c. Accommodate two-way traffic by widening a 6.2 mile section from 400 to 600 ft (Figure 4). The 600 ft wide section will be used both for overtaking and meeting.

d. Widen five bends (Figure 4).

e. Improve the Anchorage Basin.

5. **Reach 2.** Reach 2 is approximately 2.4 miles long and is presently 32 ft deep and 400 ft wide from the Cape Fear Memorial Bridge to the Highway 133 Bridge. Reach 2 is presently 32 ft deep and 300 ft wide from the Highway 133 Bridge to the Hilton Railroad Bridge. The reach is 25 ft deep and 200 ft wide for the 750 ft extension past the Hilton Railroad Bridge. The Reach 2 turning basin is located just south of the Highway 133 Bridge. The proposed improvements will deepen all of Reach 2 to 38 ft. No widening has been proposed for Reach 2.

6. **Reach 3.** Reach 3 is approximately 1.9 miles long and begins at the upstream limit of Reach 2. Reach 3 terminates at a point opposite the docks of the Arcadian corporation. Reach 3 is 200 ft wide and 25 ft deep. A 700 ft wide turning basin is located at the upstream end of Reach 3. The proposed improvement plan for Reach 3 is to widen the channel to 250 ft and deepen to 32 ft. Widening the turning basin to 800 ft is also being considered.

**Navigation Study Components**

7. CESAW requested the assistance of the U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC) to conduct a navigation study to evaluate the proposed improvements. This navigation study consisted of a TABS-MD study to calculate currents in the existing and proposed channels and a real-time ship simulation study. ERDC conducted the TABS-MD study. ERDC operates the U.S. Army Corps of Engineers (COE) only ship-tow simulator. However, due to contracting requirements, the ship simulator study was contracted to a private facility. ERDC provided technical oversight for the simulation work and acted as liaison between the contractor and CESAW.

8. The contract for the ship simulation study was issued through Solicitation Number DACW-39-98-R-0024. The solicitation was issued on 20 May 1998 with proposals due on 8 July 1998. Several proposals were received from private simulators. These were evaluated and the contractors were requested to submit the “best and final” proposals. The “best and final” proposals were evaluated and the contract was awarded to the Simulation Training and Research Center (STAR) from Dania Florida on 26 August 1998. A “kick-off” meeting followed by a reconnaissance effort was held the first week in September 1998. The purpose of the reconnaissance effort was to ride ships with the pilots and observe navigation conditions in Cape Fear River firsthand. Photographs and video of the project
were taken during the transits. These were used to develop the simulator visual scenes.

Simulation Results

9. Simulation testing and validation occurred January – March 1999. Testing was done on STAR Center’s full mission bridge simulator (Figure 5 and 6).

10. Results. Results will be presented in the form of ship track plots and pilot ratings. Results will be presented from the Atlantic Ocean, heading inland.

11. Baldhead Shoal Channel, Existing Condition and Plan 1. The track plots for the existing and Plan 1 conditions for Baldhead Shoal Channel are presented in Enclosures 1 – 9.

12. Inbound, Flood. Five inbound runs of a 38 ft draft containership were simulated with flood tide in the existing channels at the mouth of the Cape Fear River. The track plot (Encl 1) shows consistent grouping with all runs staying within the authorized channels, except for the Battery Island Channel. All runs crossed the channel limits on the west side of Battery Island Channel while making the turn from Southport Channel to Lower Swash Channel Range. This is consistent with the pilot’s real-world practice. There is water of navigable depth in that area and none of the runs would have grounded.

13. Track plots of the 42 ft draft containership transiting the Plan 1 channels at the mouth of the Cape Fear River (Encl 2) are consistently grouped and similar to those from the existing channels. Four of the five runs crossed the channel limits when turning from the northern segment of Bald Head Shoal Channel onto Smith Island Range. Also, runs in the Plan 1 channel went further out of the western side of Battery Island Channel than did the existing condition simulations. One run left the channel by approximately 100 ft and may have grounded.

14. Inbound Ebb. Track plots of the 34 ft draft containership transiting the mouth of the Cape Fear River, inbound with ebb tide, are shown in Encl 3. These plots show more scatter than the existing condition flood tide. All five of the runs crossed the western channel limit while making the turn from the Bald Head Shoal Channel onto Smith Island Range. Two runs left the channel while transiting Smith Island Range. One run crossed the eastern limit and one run crossed the western limit. However, neither runs left the channel by a significant margin. Four of the runs used the naturally deep water on the western side of Battery Island Channel. However, one pilot turned early, crossed the eastern side of Battery Island Channel, and went over 400 ft east of the Lower Swash Channel range.

15. Track plots of the 38 ft draft containership transiting the mouth of the Cape Fear River, inbound with ebb tide (Encl 4), were consistent. All vessels left the eastern
edge of the channel while turning from Bald Head Shoal Channel onto Smith Island Range. All runs left the southern side of Southport Channel, while beginning the turn onto the Lower Swash Channel Range.

16. **Outbound Flood.** Five simulations of an outbound containership drafting 38 ft were conducted. The composite track plot of those runs is shown in Encl 5. All runs began on the west side of the Lower Swash Channel Range and cut the northeast corner of Battery Island Channel prior to turning into Southport Channel. Several of the runs left the channel on the south side where the water is naturally deep. One run left west side of Smith Island Range by about 100 ft and probably would have grounded. Another ship left the east side by a marginal amount. All vessels transited the Bald Head Shoal Channel without incident.

17. Five outbound containerships drafting 41 ft were simulated for the Plan 1 channel. The composite track plot of those runs (Encl 6) shows that, from the Lower Swash Channel Range through the Smith Island Range, the pilots followed path similar to the one used during the outbound flood runs in the existing channel. All of the ships left the west side of the northern leg of the Bald Head Shoal Channel. This is because they swung their ships wide to reduce the angle between the legs of the Bald Head Shoal Channel.

18. **Outbound Ebb.** The composite track plot of outbound containerships (34 ft draft) transiting the existing channels in the mouth of the Cape Fear River during ebb tide is shown in Encl 7. All five ships ran along the western edge of the channel from Lower Swash Channel Range through Baldhead Caswell. Spacing of the ship icons in the track plot show that the ships are traveling somewhat faster than they were during the flood tide runs. The extra speed is required to maintain steerage while sailing in fair tide (i.e., traveling in the same direction as the current). Four of the runs stayed along the west side of Bald Head Shoal Channel. However, one run traveled the entire length of Bald Head Shoal Channel along the eastern edge.

19. The composite track plot of 38 ft draft, outbound containerships transiting the Plan 1 channels in the mouth of the Cape Fear River (Encl 8) shows that the portion of the exercise from the Lower Swash Channel Range to the Smith Island Range changed little from the existing condition run. A total of seven exercises (two reruns are included) are shown in this composite track plot. Most of the pilots stayed on the western channel edge of the northern leg of Bald Head Shoal Channel. All of the pilots left the channel on the western side while turning onto the southern leg of Bald Head Shoal Channel. These two requested to re-run this scenario because it was their first time running the new alignment and they had a hard time judging the turn. One of the pilots lost control at the same point in the repeat run. The other pilot successfully completed his re-run. Enclosure 9 shows both repeat runs.
20. **Pilot Evaluations.** The pilot’s final evaluation forms are included as Appendix A. None of the pilots felt that the Plan 1 Entrance Channel provided safe navigation. The pilots’ suggestions for improving the proposed re-alignment ranged from straightening Bald Head Shoal and Smith Island Channel to increasing the channel width in the turns.

21. **Conclusions.** Based upon the results of the Plan 1 Channel simulation exercises, three new proposed channel alignments were developed (Figure 7). Plan 3 combined Bald Head Shoal Channel and Smith Island Range into one straight reach. Plans 4 and 5 were modifications of Plan 1. Plans 3, 4, and 5 were identical to Plan 1 from Baldhead Caswell Channel, inland. STAR conducted a test program for these three alternative channels in March 1999. Three pilots participated in the simulation exercises. The results from that testing program are presented in the following section.

22. **Baldhead Shoal Channel, Plans 3, 4, and 5.** The track plots for the Plan 3, 4, and 5 conditions for Baldhead Shoal Channel are presented in Enclosures 10 – 21.

23. **Inbound, Flood.** The track plots for inbound runs, ebb tide, for Plans 3, 4, and 5 are shown in Encls 10, 11, and 12, respectively. These track plots show that the pilots used similar techniques for maneuvering through all three alignments. All vessels remained in the center of the channel while in the Atlantic Ocean, moving to the starboard side of the channel to improve the approach into Southport Channel.

24. **Inbound, Ebb.** Encls 13, 14, and 15 contain the composite inbound, ebb tide track plots for Plans 3, 4, and 5, respectively. The pilots were able to keep their ships within the channel limits while transiting the Atlantic Ocean. As with flood tide, the pilots kept their ship to the eastern channel edge for the approach to Southport Channel. However, they typically waited until later before moving to the eastern side. One run in the Plan 4 channel (Encl 14) entered Smith Island Range on the port side.

25. **Outbound, Flood.** Composite track plots of ships transiting Plans 3, 4, and 5 outbound, with flood tide, are shown in Encls 16, 17, and 18, respectively. Pilots outbound in the Plan 3 channel (Encl 16) brought their ships to the eastern edge of the channel after the turn from Southport Channel. They remained in the channel for the remainder of the simulation exercise. Pilots had the most difficulty in the Plan 4 channel. They kept their vessel to the west side of Smith Island Range. Two pilots kept their ship along the west side of the channel while transiting Smith Island Range in Plan 5. The other pilot used the east side of Smith Island Range. The pilots had no problems staying in the channel for the Atlantic Ocean portion of Plan 5.

26. **Outbound, Ebb.** The composite track plots of ships transiting the mouth of the Cape Fear River for Plans 3, 4, and 5, are shown in Plates 19, 20, and 21,
respectively. The pilots brought their ships to the west side of the channel while turning from Baldhead Caswell in the Plan 3 channel (Encl 19). One of the pilots in the Plan 4 channel (Encl 20) used the east side of Smith Island Range, while the other two pilots stayed towards the center of the channel. The pilots cut the southwest corner of the channel while turning from Smith Island Range. Pilots stayed to the center of Smith Island Range in the Plan 5 channel (Encl 21) and cut the southwest corner of the channel, as did the Plan runs.

27. Pilot Evaluations. All three of the pilots preferred the straight entrance channel (Plan 3) because they felt it would be safer to navigate during poor visibility. The pilot's second choice was Plan 5.

28. Conclusions. The straightened alignment (Plan 3) was the easiest for the pilots to navigate, will be the easiest to mark, and eliminates any turns in limited visibility. However, actual construction of Plan 3 is dependant upon dredging costs and shoaling analysis. An entrance channel that requires excessive maintenance will not provide adequate service to the Port of Wilmington. Simulation results indicate that the Plan 5 Entrance Channel also provided acceptable navigation. We recommend that a widener be placed in the Plan 5 turn between Smith Island Range and Bald Head Shoal Channel. This widener is shown in Figure 8. We also recommend that the U.S. Coast Guard be contacted to determine means of marking the channel so that the channel limits can be discerned in limited visibility.

29. Passing Zones. Simulations were conducted for two different (northern and southern) meeting locations for the passing zone.

30. Southern Location, Flood Tide. Individual track plots for simulations of 38-ft draft containerships meeting in the southern portion of the channel are shown in Encls 22-27. The southbound ship left the authorized channel in all simulations conducted under these conditions. Two of the outbound ships (Encls 22 and 26) experienced strong enough bank forces on the west side of the channel, that they ran out of the channel on the east side.

31. Results from the simulations of a 41-ft draft containership meeting a 41-ft draft bulk carrier in the southern portion of the proposed passing zone are shown in Encls 28 – 41. These runs were simulated with the containership inbound meeting the outbound bulk carrier, and for the inbound bulk carrier meeting the outbound containership. The meeting situations in the 600-ft wide channel were, for the most part, very successful. The track plots for three runs (Encls 30, 37, and 41) show the inbound ship leaving the channel shortly after meeting the outbound ship. This was caused by the pilot's leaving the bridge once the meeting was completed. The simulation was not aborted; the ship ran aground without the pilot. Therefore, the fact that the three runs ran aground does not indicate a deficiency in channel width. Another exercise (Encl 35) was aborted due to a simulator malfunction. The run was re-started and is shown in Encl 36.
One of the tests conducted with the containership inbound and the bulk carrier outbound (Encl 33) resulted in the containership leaving the channel. This was due to meeting too soon after the turn between Upper and Lower Midnight Ranges. The remainder of the meetings with the inbound containership and the outbound bulk carrier were successful. All of the tests conducted with the inbound bulk carrier meeting the outbound containership (Encls 36 – 41) resulted in the containership being out of the channel while meeting the bulk carrier. The bulk carriers in all those runs had sufficient clearance to the east channel edge (161 ft minimum, Encl 39). The containerships would not have left the channel if the bulk carriers had moved east. It should be noted that the pilot’s final questionnaire includes comments that the bulk carrier was too hard to control.

32. **Southern Location, Ebb Tide.** Results from the simulations of 34-ft draft containerships meeting in the existing channel are shown in Encls 42 – 47. The outbound ship left the channel during the meeting scenario for all runs conducted under these conditions. Simulations of 38-ft draft containerships meeting in the 600-ft-wide passing zone (Encls 48 – 52) were completed without any adverse incidents.

33. **Northern Location, Flood Tide.** Individual track plots for two; 38-ft draft containerships meeting in the northern portion of the existing channel during flood tide are shown in Encls 53 – 58. Examination of the track plots reveals that one or both of the ships left the channel during the meeting scenarios. Track plots of the 41-ft draft containership and bulk carriers meeting in the proposed 600-ft wide passing zone are shown in Encls 59 – 70. Three of outbound containerships (Encls 60, 61, and 63) left the channel while meeting the inbound bulk carriers. The bulk carriers all maintained high clearances to the east side of the channel, thus forcing the containerships to stay along the west side. Track plots of the inbound 42-ft draft containership meeting the 41-ft draft outbound bulk carrier (Encls 65 – 70) show all simulations were successfully completed.

34. **Northern Location, Ebb Tide.** Individual track plots of 34-ft draft containerships meeting in the existing channel with ebb tide are shown in Encls 71- 76. The outbound ship in all runs left the channel during the meeting scenario. The individual track plots of the 38-ft containerships in the proposed 600-ft wide passing zone are shown in Encls 77 – 82. Two of the runs (Encls 77 and 81) show the outbound ship leaving the channel during, or just after, the meeting scenario. Observers notes, recorded during the simulations, noted that the ships were traveling at a speed over 14 knots. This increased bank effects and ship-to-ship interaction forces, thus causing the ships to leave the channel.

35. **Pilot Evaluations.** The pilot’s felt the 600-ft wide passing zone provided adequate channel width for meeting.

36. **Conclusions.** The 600-ft width is adequate for two-way traffic. The only problem with the channel design was meeting too soon after a ship makes a turn form one
channel segment to another. Bend wideners between the turns would make the entire length of the zone more usable. The passing zone may be moved north or south if necessary.

37. Northern End of Cape Fear River. Simulations were conducted for the existing and proposed portions of the northern end of Cape Fear River, just south off the Anchorage area. The composite track plots are shown in Enclosure 83 – 90. These track plots, along with the pilot evaluations, indicate that deepening the channel did not adversely affect navigation.

38. Anchorage Turning Basin. Track plots of containerships turning in the existing and proposed Anchorage Turning Basins are shown in Encls 91 – 94.

39. Inbound, Flood Tide. Results from the simulations of 950-ft long containerships turning in the Anchorage are shown in Encl 91 for the existing condition and Encl 92 for the proposed condition. All turns were completed without any ships leaving the authorized channel. None of the pilots operating in the proposed condition utilized the widener on the west side of the Anchorage area.

40. Inbound, Ebb Tide. Results from simulations of ships turning in the existing Anchorage area with ebb tide are shown in Encl 93. One ship left the authorized channel on the west side while turning. The composite plot of ships turning in the proposed Anchorage area in ebb tide is shown in Encl 94. One ship left the authorized channel on the east side while turning. None of the pilots used the widener on the west side of the channel.

41. Conclusions. The pilots were able to turn the ships within the Anchorage area and did not use the widener.

42. Wilmington Harbor Reach 2. Track plots for Reach 2 are shown in Encls 95 - 102.

43. Ship Track Plots. The composite track plot of pilots turning the 650-ft long product carrier in the existing channel, during ebb tide, are shown in Encl 95. All runs left the channel on the east side. Two of the three runs left the northern channel. Two of the pilots waited too late to begin their turn and the flood currents carried the ship out of the north end of the basin. Plots of pilots turning the 712-ft long product carrier in the proposed channel, during ebb tide, are shown in Encl 96. The turning basin is 825 ft wide at its southern limit and 750 ft wide across its northern limit. Only one run was completed without the ship leaving the northern end of the channel.

44. Plots of the ships turning in ebb tide are shown in Encls 97 and 98 for the existing and proposed conditions, respectively. One run in the existing channel left the northern end of the basin. One ship left the western side of the channel by approximately 10 ft. The remaining vessel was turned within the channel limits.
All the runs conducted in the proposed channel left the east side of the basin. One ship left the west side by approximately 20 ft.

45. Composite track plots of ships turning on the outbound portion of the transit are shown in Encls 99 and 100 (flood tide) and Encls 101 and 102 (ebb tide). These ships were turned at a draft of 26 ft. All the runs in both the existing and proposed channels either turned within the basin, or barely crossed the limits of the turning basin. Since the ships were light, none would have grounded.

46. Conclusions. The 750-ft wide northern portion of the basin is not wide enough to turn a loaded 712-ft long ship in flood tide. Unless an empty berth alongside the basin provides additional room, the northern end of the basin should be widened to 825 ft.

47. Wilmington Harbor Reach 3. Composite track plots for Reach 3 are shown in Encls 103 – 106. The composite of the existing condition, inbound with flood tide is presented in Encl 103. The pilots tended to take their ships deep into the turns. This caused them to cross the authorized channel lines. One ship ran aground about halfway through the scenario. The composite of the proposed condition, inbound with flood tide is presented in Encl 104. These results were very similar to the existing conditions with the plots bringing their ships deep into the turns.

48. The composite of the existing condition, outbound with ebb tide is presented in Encl 105. As with the flood tide runs, the pilots tended to take their ships deep into the turns. One ship ran aground about halfway through the scenario. Results of the proposed conditions were similar to the existing condition, outbound ebb tide.

49. Conclusions. Navigation conditions for the proposed conditions were very similar to those the pilots already experience.
Figure 1. Project Location
Figure 5. Containership outbound from Wilmington Harbor.

Figure 6. Bulk Carrier Inbound to Wilmington Harbor
Figure 7. Plans 3, 4 and 5 for Baldhead Shoal Channel
BALD HEAD SHOAL CHANNEL AND MOUTH OF THE CAPE FEAR RIVER
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
INBOUND, FLOOD TIDE
CONTAINERSHIP DRAFT - 38 FT

ENCLOSURE 1
Bald Head Shoal Channel and Mouth of the Cape Fear River Composite Ship Track Plots
Existing Conditions
Inbound, Ebb Tide
Containership Draft - 34 ft
Bald Head Shoal Channel and Mouth of the Cape Fear River Composite Ship Track Plots Existing Conditions Outbound, Flood Tide Containership Draft - 38 FT
Bald Head Shoal Channel and Mouth of the Cape Fear River Composite Ship Track Plots
Plan 1 Conditions
Outbound, Flood Tide Containership Draft - 38 ft
BALD HEAD SHOAL CHANNEL AND MOUTH OF THE CAPE FEAR RIVER
COMPOSITE SHIP TRACK PLOTS
PLAN 5 CONDITIONS
INBOUND, FLOOD TIDE
CONTAINERSHIP DRAFT - 42 FT
BALD HEAD SHOAL CHANNEL AND MOUTH OF THE CAPE FEAR RIVER
COMPOSITE SHIP TRACK PLOTS
PLAN 3 CONDITIONS
INBOUND, EBB TIDE
CONTAINERSHIP DRAFT - 38 FT
Bald Head Shoal Channel and Mouth of the Cape Fear River
Composite Ship Track Plots
Plan 5 Conditions
Inbound, Ebb Tide
Containership Draft - 38 FT

Enclosure 21
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 23
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 3 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 5 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 4 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE

INDIVIDUAL SHIP TRACK PLOTS

PROPOSED CONDITIONS, FLOOD TIDE

PILOT 1 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 41 FT DRAFT BULK CARRIER
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 41 FT DRAFT BULK CARRIER

950- X 106- X 41-FT CONTAINERSHIP, INBOUND
762- X 144- X 41-FT BULK CARRIER, OUTBOUND
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 41 FT DRAFT BULK CARRIER
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 41 FT DRAFT BULK CARRIER

950- x 106- x 41-FT CONTAINERSHIP, INBOUND
762- x 144- x 41-FT BULK CARRIER, OUTBOUND
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 4 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 41 FT DRAFT BULK CARRIER
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 5 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 4 OUTBOUND, 41 FT DRAFT BULK CARRIER

ENCLOSURE 34
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 2 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 2 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

ENCLOSURE 36
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 3 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

762- x 144- x 41-FT BULK CARRIER, INBOUND
950- x 106- x 41-FT CONTAINERSHIP, OUTBOUND

ENCLOSURE 37
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 1 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 3 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 1 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 4 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 5 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

ENCLOSURE 40
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 5 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 4 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 34 FT DRAFT CONTAINERSHIP

ENCLOSURE 42
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 34 FT DRAFT CONTAINERSHIP

ENCLOSURE 43
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 2 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 34 FT DRAFT CONTAINERSHIP

ENCLOSURE 44
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 3 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 34 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 4 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 34 FT DRAFT CONTAINERSHIP
Southern Vessel Passing Zone
Individual Ship Track Plots
Existing Conditions, Ebb Tide
Pilot 5 Inbound, 34 FT Draft Containership
Pilot 4 Outbound, 34 FT Draft Containership
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 48
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 2 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 3 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 51
SOUTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 4 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 52
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 3 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
PILOT 4 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 2 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 3 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

ENCLOSURE 60
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 1 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

ENVELOPE 61
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 3 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 1 OUTBOUND, 41 FT DRAFT CONTAINERSHIP

ENCLOSURE 62
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 4 INBOUND, 41 FT DRAFT BULK CARRIER
PILOT 5 OUTBOUND, 41 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 1 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 42 FT DRAFT BULK CARRIER

ENCLOSURE 66
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 2 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 42 FT DRAFT BULK CARRIER
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 3 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 42 FT DRAFT BULK CARRIER
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 4 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 42 FT DRAFT BULK CARRIER
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
PILOT 5 INBOUND, 41 FT DRAFT CONTAINERSHIP
PILOT 4 OUTBOUND, 42 FT DRAFT BULK CARRIER

ENCLOSURE 70
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 34 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 34 FT DRAFT CONTAINERSHIP

ENCLOSURE 72
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 3 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 34 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 5 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 4 OUTBOUND, 34 FT DRAFT CONTAINERSHIP

SCALE IN FEET
0  1000  2000  5000

SCALE IN METERS
0  1000  2000
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
EXISTING CONDITIONS, EBB TIDE
PILOT 2 INBOUND, 34 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 34 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 2 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 77
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 1 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 3 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 78
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 2 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 79
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 3 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 1 OUTBOUND, 38 FT DRAFT CONTAINERSHIP

ENCLOSURE 80
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 4 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 5 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
NORTHERN VESSEL PASSING ZONE
INDIVIDUAL SHIP TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
PILOT 5 INBOUND, 38 FT DRAFT CONTAINERSHIP
PILOT 4 OUTBOUND, 38 FT DRAFT CONTAINERSHIP
NORTHERN END OF CAPE FEAR RIVER
COMPOSITE TRACK PLOTS
EXISTING CONDITIONS, FLOOD TIDE
OUTBOUND
38 FT DRAFT CONTAINERSHIP
950'- X 106'- X 41-FT CONTAINERSHIP, OUTBOUND

SCALE IN FEET
0 5000

SCALE IN METERS
0 1000 2000

NORTHERN END OF CAPE FEAR RIVER
COMPOSITE TRACK PLOTS
PROPOSED CONDITIONS, FLOOD TIDE
OUTBOUND
41 FT DRAFT CONTAINERSHIP
NORTHERN END OF CAPE FEAR RIVER
COMPOSITE TRACK PLOTS
PROPOSED CONDITIONS, EBB TIDE
OUTBOUND
38 FT DRAFT CONTAINERSHIP
ANCHORAGE TURNING BASIN
COMPOSITE SHIP TRACK PLOTS
PROPOSED CONDITIONS
INBOUND, FLOOD TIDE
CONTAINERSHIP DRAFT - 42 FT

NORTH CAROLINA STATE PORTS
ANCHORAGE TURNING BASIN
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
INBOUND, EB3 TIDE
CONTAINERSHIP DRAFT - 34 FT
ANCHORAGE TURNING BASIN
COMPOSITE SHIP TRACK PLOTS
PROPOSED CONDITIONS
INBOUND, EBB TIDE
CONTAINERSHIP DRAFT - 38 FT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
INBOUND, FLOOD TIDE
PRODUCT CARRIER, 31 FT DRAFT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
PROPOSED CONDITIONS
INBOUND, FLOOD TIDE
PRODUCT CARRIER, 38 FT DRAFT

ENCLOSURE 96
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
INBOUND, EBB TIDE
PRODUCT CARRIER, 31 FT DRAFT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
PROPOSED CONDITIONS
INBOUND, EBB TIDE
PRODUCT CARRIER, 38 FT DRAFT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
OUTBOUND, FLOOD TIDE
PRODUCT CARRIER, 26 FT DRAFT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
PROPOSED CONDITIONS
OUTBOUND, FLOOD TIDE
PRODUCT CARRIER, 26 FT DRAFT
WILMINGTON HARBOR, REACH 2
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
OUTBOUND, EBB TIDE
PRODUCT CARRIER, 26 FT DRAFT
WILMINGTON HARBOR, REACH 3
COMPOSITE SHIP TRACK PLOTS
EXISTING CONDITIONS
INBOUND, EBB TIDE
CHEMICAL CARRIER, 25 FT DRAFT

ENCLOSURE 103