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Little Sand Island Turning Basin and Channel Widening, Mobile Bay, AL, Deep Draft Navigation Improvement Project

Gary C. Lynch and Dennis W. Webb

July 2007

Coastal and Hydraulics Laboratory

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Little Sand Island Turning Basin and Channel Widening, Mobile Bay, AL, Deep Draft Navigation Improvement Project

Gary C. Lynch and Dennis W. Webb

Coastal and Hydraulics Laboratory
U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

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Final report

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Prepared for U.S. Army Engineer District, Mobile
Mobile, AL 36628-0001

Abstract: Mobile Bay is located on the southern shore of the state of Alabama. Little Sand Island is located on the north end of Mobile Bay, near the beginning of the Mobile Waterfront area. Little Sand Island is approximately 36 miles from the beginning of the Federal Channel. The Alabama State Port Authority proposes to construct a new container terminal on the northern end of McDuffie Island. The new container terminal will require a new turning basin on the east side of the Upper Reach, just north of Little Sand Island. Additionally, the northern end of the Upper Reach will have to be widened on the eastern side to ease the approach for ships entering the turning basin. To assist the U.S. Army Engineer District, Mobile (SAM), in evaluating various alternatives for the proposed turning basin and channel widening, the U.S. Army Engineer Research and Development Center (ERDC) conducted a navigation study utilizing real-time ship simulation modeling. Model development and online testing occurred at the ERDC Waterways Experiment Station (WES) in Vicksburg, MS, during the period from June to November 2006.

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Contents

Figures and Plates iv

Preface vi

Unit Conversion Factors vii

1 Proposed Improvements 1

2 Reconnaissance Trip 8

3 Database Development 9

4 Validation 12

5 Testing 13

6 Results 14

Alternative 1 14
Alternative 2 14
Alternative 3 15
Alternative 4 15
Modified Design 15

7 Conclusions and Recommendations 18

Report Documentation Page

Figures and Plates

Figures

Figure 1. Project Location Map 2
Figure 2. Existing channel. 3
Figure 3. Alternative 1 conditions. 4
Figure 4. Alternative 2 conditions. 5
Figure 5. Alternative 3 conditions. 6
Figure 6. Alternative 4 conditions. 7
Figure 7. Mobile visual scene as shown on ERDC Ship/Tow Simulator. 10
Figure 8. ECDIS showing the existing chart with an alternative overlay. 11
Figure 9. Modified design conditions. 17

Plates

Alternative 1 Conditions.
Plate 1. 3 Tugs – Inbound – Maximum Ebb Tide – 10 Knot Southeast Wind. 19
Plate 2. 3 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 20
Plate 3. 3 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 21
Plate 4. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind. 22
Plate 5. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 23
Plate 6. 4 Tugs – Outbound – Maximum Ebb Tide – 10 Knot North Wind. 24
Plate 7. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 25
Alternative 2 Conditions.
Plate 8. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind. 26
Plate 9. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 27
Plate 10. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 28
Plate 11. 4 Tugs – Outbound – Maximum Flood tide – 10 Knot Southeast Wind. 29
Plate 12. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 30
Plate 13. 4 tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 31
Alternative 3 Conditions.
Plate 14. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind. 32
Plate 15. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 33
Plate 16. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 34
Plate 17. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 35
Plate 18. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 36
Plate 19. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 37

Alternative 4 Conditions.
Plate 20. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind. 38
Plate 21. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 39
Plate 22. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 40
Plate 23. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 41
Plate 24. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 42
Plate 25. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 43
Modified Design Conditions.
Plate 26. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind. 44
Plate 27. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind. 45
Plate 28. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 46
Plate 29. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind. 47
Modified Design Conditions – Night.
Plate 30. 4 Tugs – Inbound – Maximum Ebb tide – 15 Knot North Wind 48
Plate 31. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind 49
Plate 32. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind. 50
Plate 33. 4 Tugs – Outbound – Maximum Flood tide – 10 Knot Southeast Wind. 51

Preface

This navigation study was performed at the U.S. Army Engineer Research and Development Center (ERDC), Ship/Tow Simulator Facility, located in the Coastal and Hydraulics Laboratory at the request of the U.S. Army Engineer District, Mobile.

It was conducted by Dennis W. Webb and Gary C. Lynch of the Deep Draft Navigation Group, Navigation Branch, CHL. Assistance with pilot testing was given by Donna Derrick, Danny Marshall, and Peggy Van Norman. Testing was completed in November 2006, under the supervision of Thomas W. Richardson, Director, CHL, and Dr. William D. Martin, Deputy Director, CHL.

Acknowledgment is made to Sidney Bufkin and Bob Harris of the Mobile District for cooperation and assistance. Special thanks are extended to the Mobile Bar Pilot and Harbor Pilot groups for their participation and expertise.

COL Richard B. Jenkins was Commander and Executive Director of ERDC. Dr. James R. Houston was Director.

Unit Conversion Factors

Multiply	By	To Obtain
acres	4,046.873	square meters
acre-feet	1,233.5	cubic meters
angstroms	0.1	nanometers
atmosphere (standard)	101.325	kilopascals
bars	100	kilopascals
British thermal units (International Table)	1,055.056	joules
centipoises	0.001	pascal seconds
centistokes	1.0 E-06	square meters per second
cubic feet	0.02831685	cubic meters
cubic inches	1.6387064 E-05	cubic meters
cubic yards	0.7645549	cubic meters
degrees (angle)	0.01745329	radians
degrees Fahrenheit	(F-32)/1.8	degrees Celsius
fathoms	1.8288	meters
feet	0.3048	meters
foot-pounds force	1.355818	joules
gallons (U.S. liquid)	3.785412 E-03	cubic meters
hectares	1.0 E+04	square meters
horsepower (550 foot-pounds force per second)	745.6999	watts
inches	0.0254	meters
inch-pounds (force)	0.1129848	newton meters
kilotons (nuclear equivalent of TNT)	4.184	terajoules
knots	0.5144444	meters per second
microinches	0.0254	micrometers
microns	1.0 E-06	meters
miles (nautical)	1,852	meters
miles (U.S. statute)	1,609.347	meters
miles per hour	0.44704	meters per second
mils	0.0254	millimeters
ounces (mass)	0.02834952	kilograms
ounces (U.S. fluid)	2.957353 E-05	cubic meters

Multiply	By	To Obtain
pints (U.S. liquid)	4.73176 E-04	cubic meters
pints (U.S. liquid)	0.473176	liters
pounds (force)	4.448222	newtons
pounds (force) per foot	14.59390	newtons per meter
pounds (force) per inch	175.1268	newtons per meter
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per cubic inch	2.757990 E+04	kilograms per cubic meter
pounds (mass) per square foot	4.882428	kilograms per square meter
pounds (mass) per square yard	0.542492	kilograms per square meter
quarts (U.S. liquid)	9.463529 E-04	cubic meters
slugs	14.59390	kilograms
square feet	0.09290304	square meters
square inches	6.4516 E-04	square meters
square miles	2.589998 E+06	square meters
square yards	0.8361274	square meters
tons (force)	8,896.443	newtons
tons (force) per square foot	95.76052	kilopascals
tons (long) per cubic yard	1,328.939	kilograms per cubic meter
tons (nuclear equivalent of TNT)	4.184 E+09	joules
tons (2,000 pounds, mass)	907.1847	kilograms
tons (2,000 pounds, mass) per square foot	9,764.856	kilograms per square meter
yards	0.9144	meters

1 Proposed Improvements

Mobile Bay is located on the southern shore of the state of Alabama, Figure 1. Little Sand Island is located at the north end of Mobile Bay, near the Mobile Waterfront area. Little Sand Island is approximately 36 miles from the beginning of the Federal Channel. It is near the northern end of the Upper Reach. The authorized dimensions of the Upper Reach are 650 feet wide and 45 feet deep, Figure 2.

The U.S. Army Engineer District, Mobile (SAM) and the Alabama State Port Authority are evaluating four alternatives for the turning basin located in the vicinity of Little Sand Island and the McDuffie Island coal handling facility. The configurations are shown in Figures 3 thru 6. The extended lower portion of the basin is necessary to facilitate entry to the Turning Basin and will coincidentally allow passing ships additional clearance from the docked ships at the McDuffie Island coal terminal.

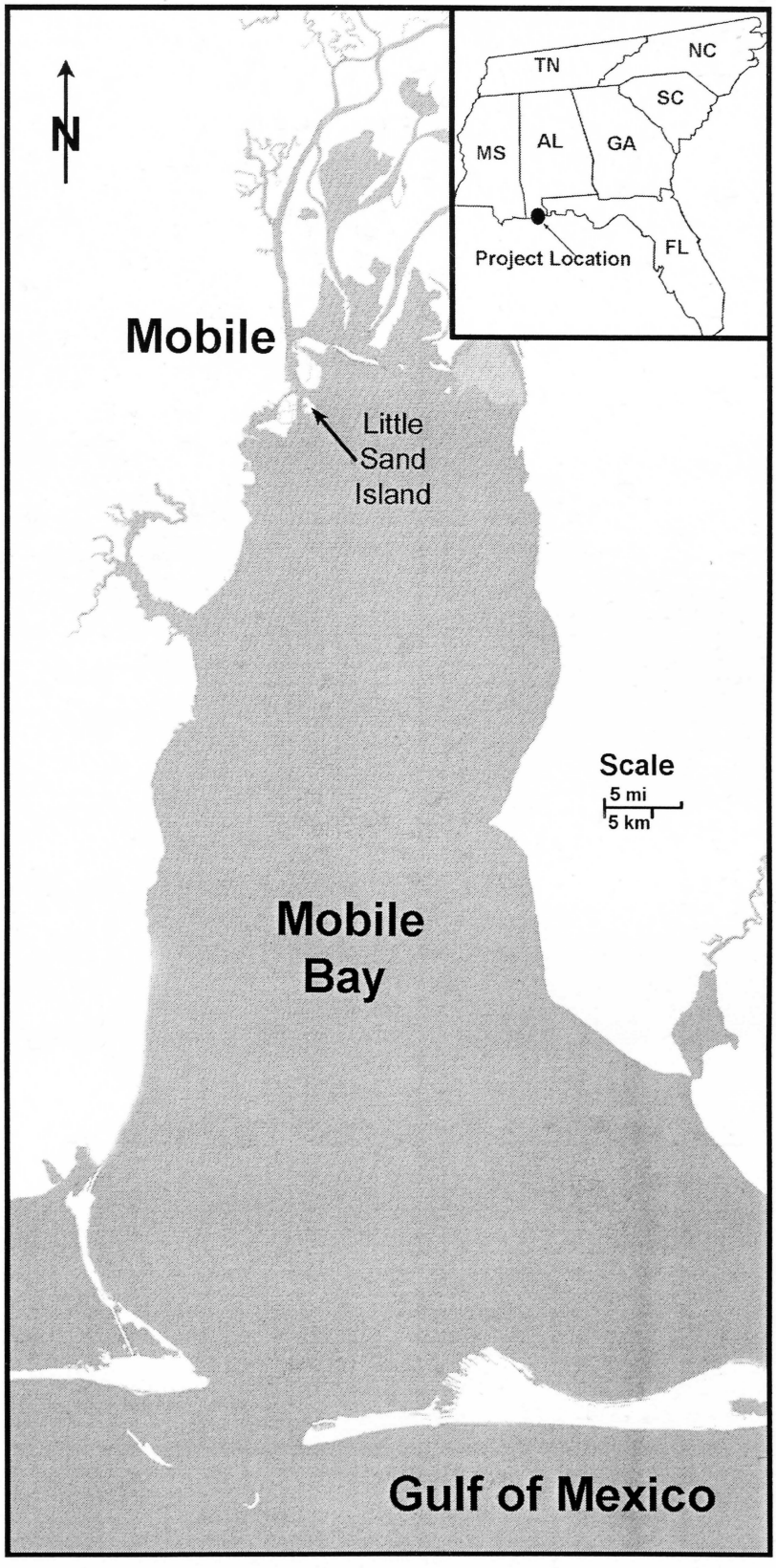

Figure 1. Project Location Map

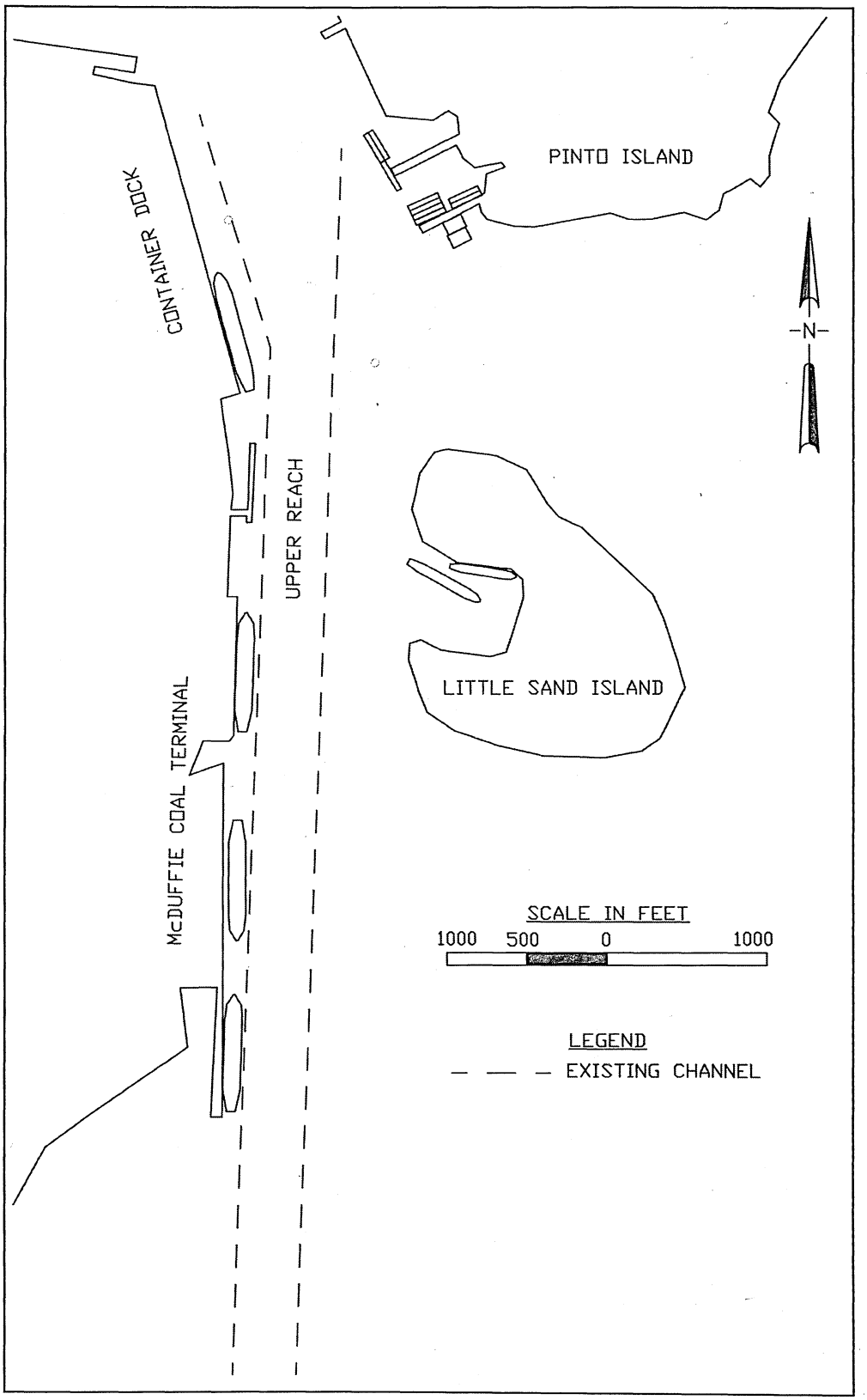

Figure 2. Existing channel.

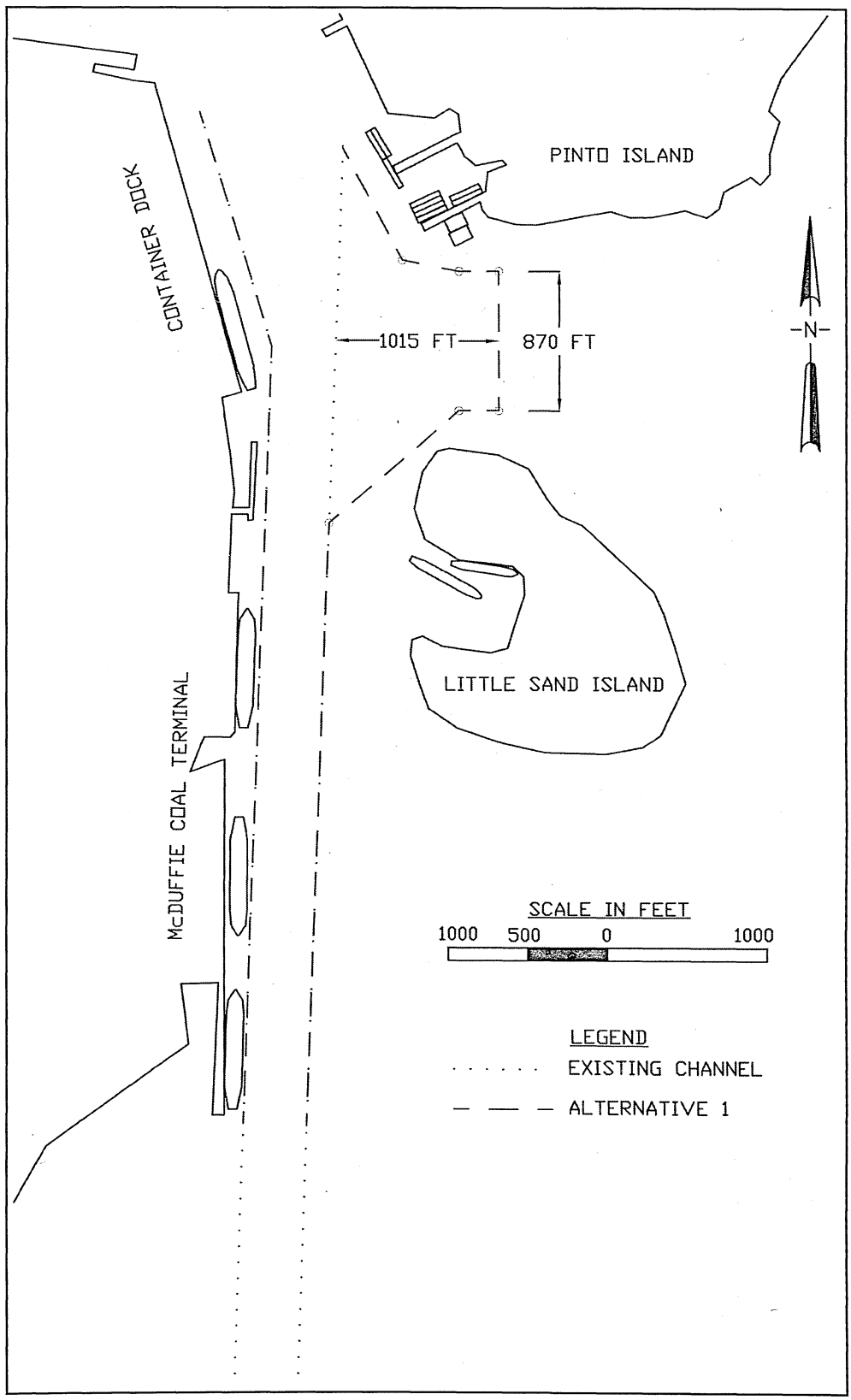

Figure 3. Alternative 1 conditions.

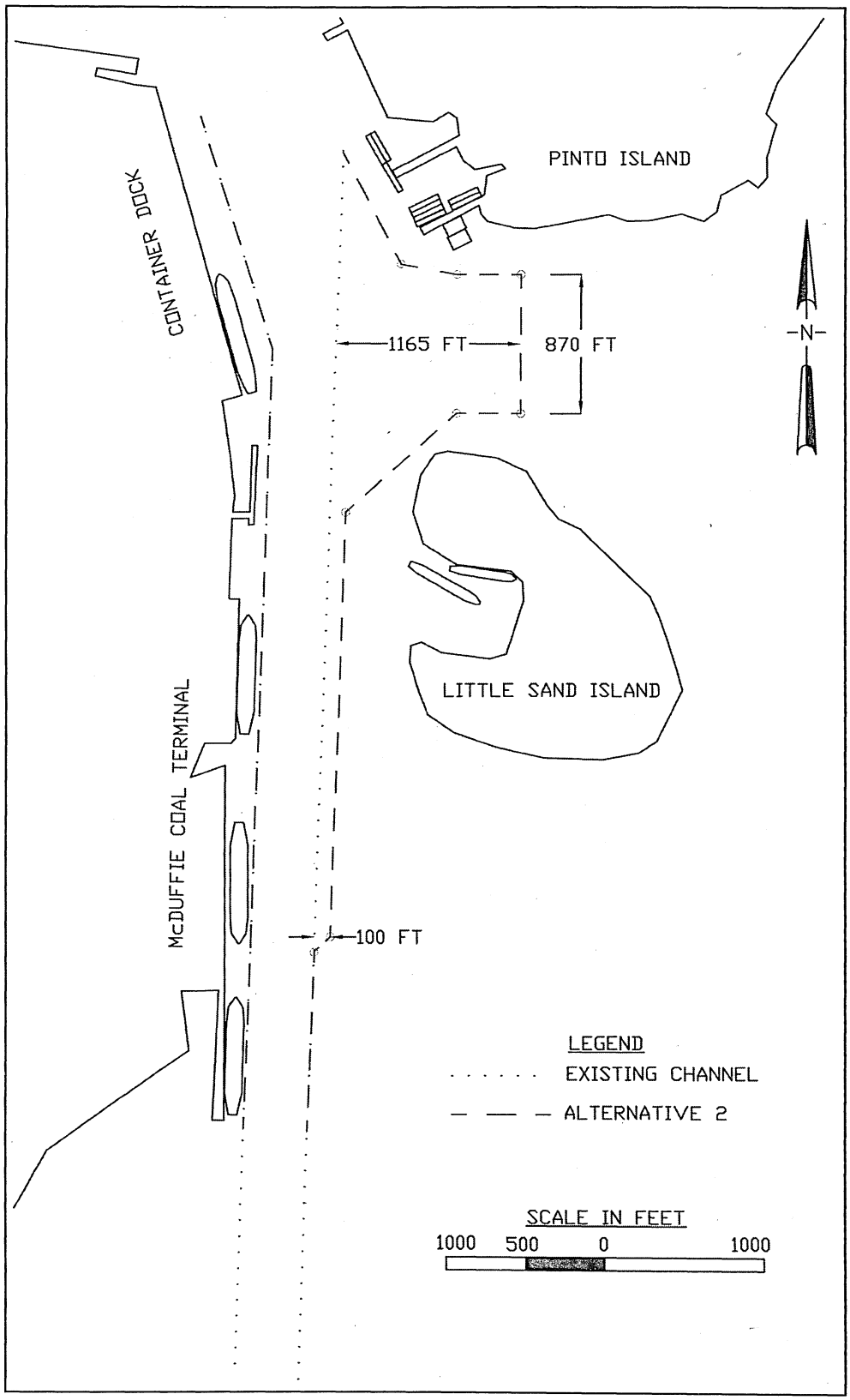

Figure 4. Alternative 2 conditions.

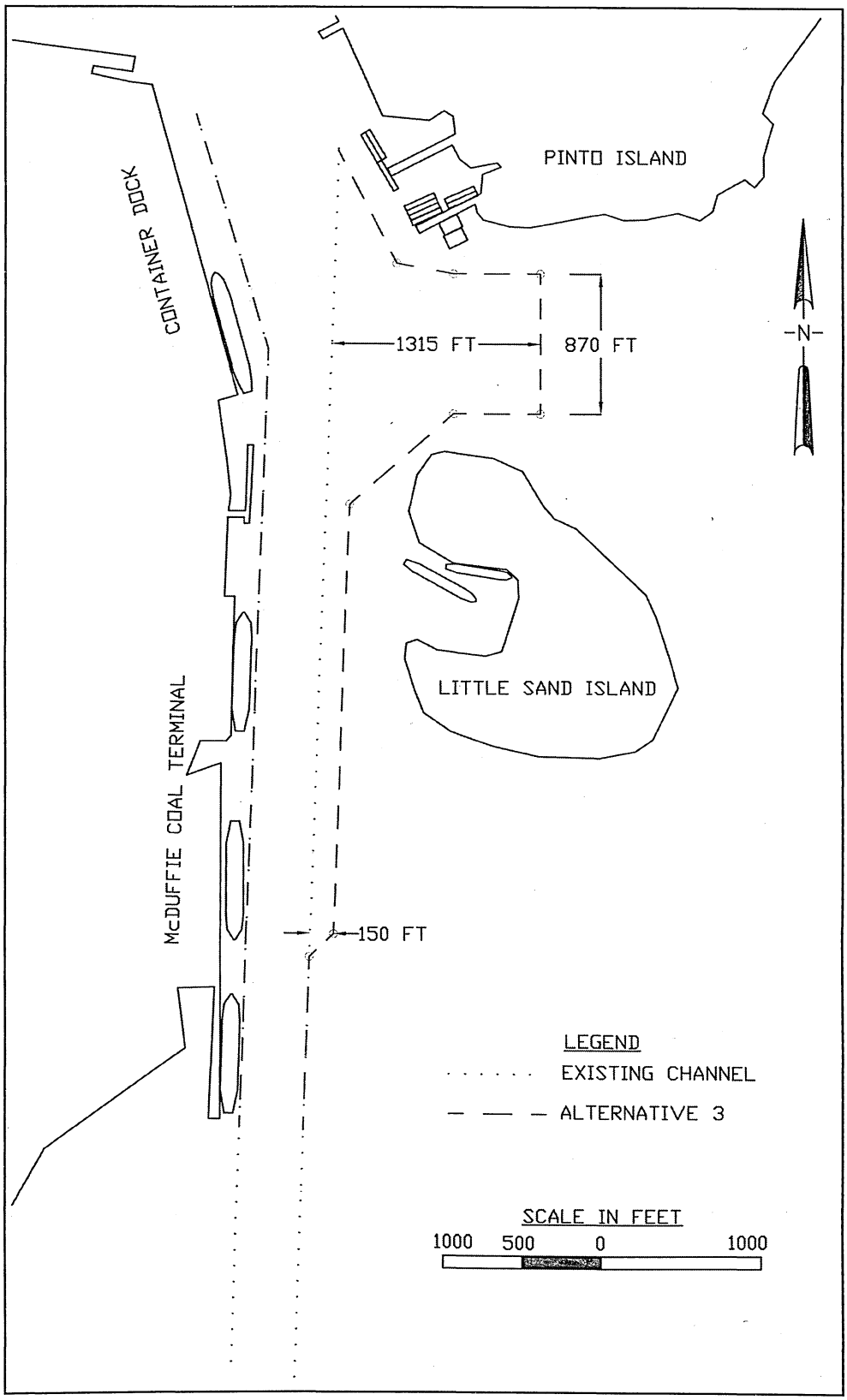

Figure 5. Alternative 3 conditions.

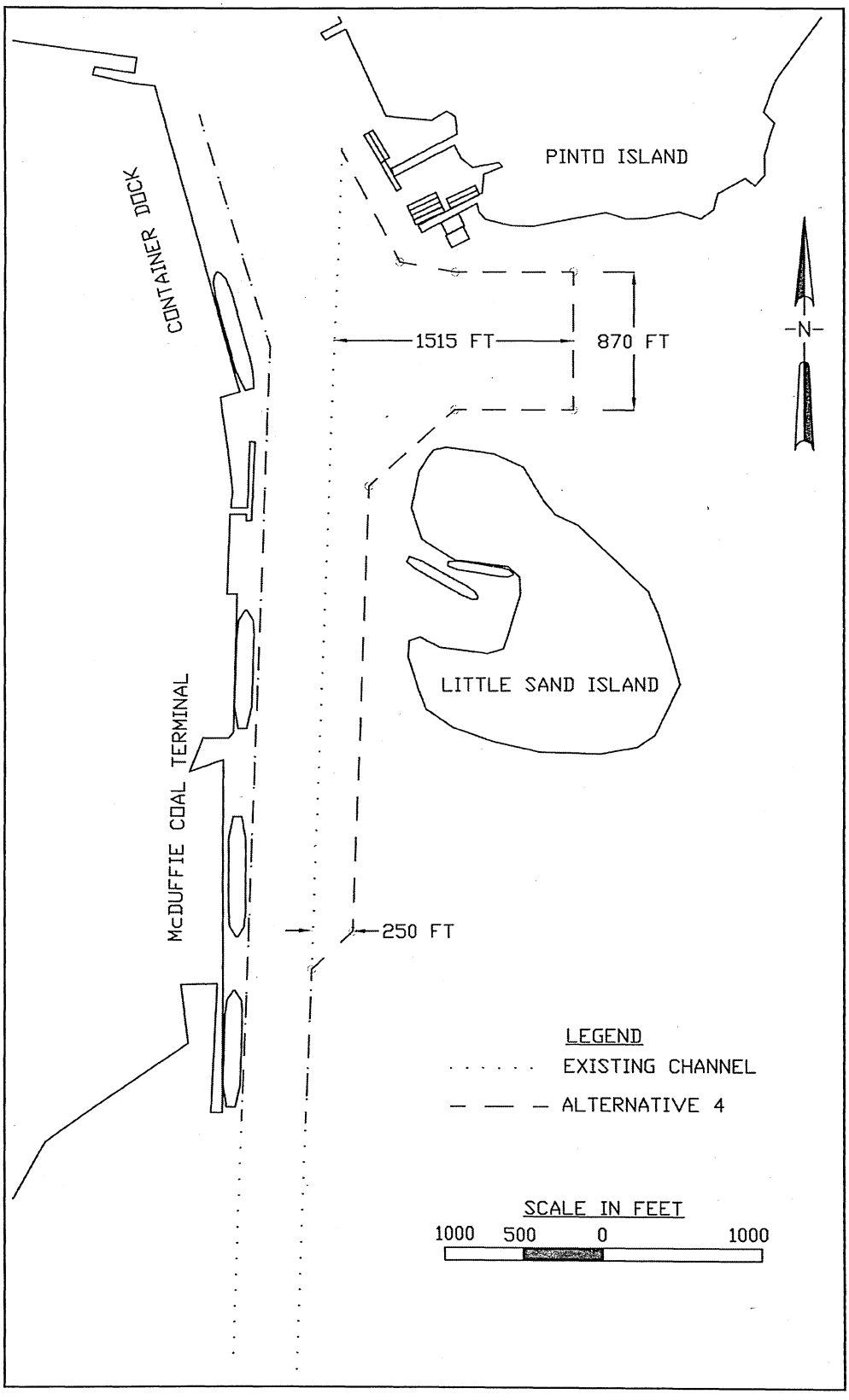

Figure 6. Alternative 4 conditions.

2 Reconnaissance Trip

The Reconnaissance trip for the Little Sand Island Turning Basin study was conducted June 19 and 20, 2006. The purpose of the trip was to meet with representatives of SAM and the Mobile Bar Pilots Association. Representatives of the U.S. Army Engineer Research and Development Center (ERDC) and SAM were able to board a ship transiting the study area for observation of navigation practices.

Dennis Webb (ERDC), Sid Bufkin (SAM), and Wade Ross (SAM) boarded the *Golden Elizabeth* at approximately 0700 on June 20. Capt. G. Wildon Mareno of the Mobile Bar Pilots Association was the ship's pilot. The ship's master was Capt. Kim Ygong-Sik. The ship was a carrier bringing paraffin to an asphalt company located north of the proposed turning basin location. The *Golden Elizabeth* has a length-over-all (LOA) of 555 feet, a beam of 72 feet, and a depth of 38 feet. The forward draft was 16 feet and the stern draft was 23 feet.

Many digital photographs were taken during the transit, which were later used for simulation model development. In addition, a GPS unit was placed behind the bridge near the ship centerline to record the vessel track. During the transit, the reconnaissance team had the opportunity to observe navigation conditions in Mobile Bay and to discuss the Little Sand Island Turning Basin with Capt. Mareno.

During these conversations, Capt. Mareno stressed the necessity of widening the east side of the channel in the Little Sand Island area. In his opinion, widening in this area would facilitate entry into the turning basin and relieve mooring line stress for ships docked on the west side of the channel caused by passing traffic. Capt. Mareno also stated that, unless the pilots were very confident of deep water in the turning basin, they would turn ships by bringing their bow into the basin to avoid possible damage to the ship's rudder and propeller caused by insufficient water depth. An additional alternative was discussed to modify the southwest corner of the proposed turning basin to allow inbound vessels sufficient clearance for initial turning maneuvers.

3 Database Development

Currents for both the existing and proposed conditions were calculated using the ADCIRC model in a separate ERDC effort.[1] Current data for the maximum strength of both the ebb and flood tides were extracted and converted into the format required by the ERDC Ship/Tow Simulator.

The design ship for the Little Sand Island Turning Basin study was the Susan Maersk, a post-panamax containership. The Susan Maersk is 1140 ft long (LOA), with a beam of 144 ft. The ship was loaded to a draft of 41 ft. This vessel is expected to be the largest that will use the new turning basin. This ship already existed in ERDC's ship database.

The visual scene was developed based on photos taken during the reconnaissance trip. Figure 7 shows the simulator with the visual scene for Mobile displayed. At the request of SAM, ERDC developed a night visual simulation for the Modified Design. Simulation runs were conducted for both daytime and nighttime runs. The containership was docked at the southern end of the proposed container terminal for all Modified Design simulations.

[1] McAlpin, T. O., G. L. Brown, and D. J. Mark. In preparation. Hydrodynamic and sedimentation studies of a proposed turning basin in Mobile Harbor, Alabama, near McDuffie and Little Sand Islands.

Figure 7. Mobile visual scene as shown on ERDC Ship/Tow Simulator.

The Electronic Chart Display and Information System (ECDIS) was modified to reflect proposed changes to the channel footprints. Figure 8 shows an ECDIS chart modified to reflect one of the turning basin alternatives.

Figure 8. ECDIS showing the existing chart with an alternative overlay.

4 Validation

Typically, a validation exercise is done for simulation models prior to testing proposed channels. Validation is the process of having bar and/or port pilots operate the simulation models for existing conditions to ensure realism. However, because the turning basin is "new work" there is no existing condition to validate.

5 Testing

Alternatives 1 through 4 were evaluated during two testing sessions. These sessions were conducted October 17–20 and 24–27, 2006. Two pilots from the Mobile Bar Pilots Association attended each session. For orientation of design alternatives and model simulations, the basin length was considered to be east-west, and basin width was considered north-south. Although a widened channel section was included in the simulation, ERDC assumed the turning basin would be evaluated independently. Therefore, the recommended alternative would consist of the down stream portion of one alternative, coupled with the upstream portion of another alternative. Modification of alternatives was done to increase the efficiency of the simulator and allow testing of more design alternatives.

Tests were conducted for scenarios of inbound ships turning and then docking bow-out and for an outbound ship (docked bow-in) turning on departure. Model simulations also included ships docked at the McDuffie Coal Terminal to provide "worst case" scenarios. Limited visibility (i.e. nighttime) simulations were also conducted as an additional "worst case" scenario.

The simulation testing for Modified Design was conducted from November 14 through November 17, 2006. Two pilots from the Mobile Bar Pilots Association and one from the port authority participated in testing the Modified Design.

6 Results

Results are presented in the form of composite track plots beginning with Alternative 1, followed by the remaining alternatives in order.

Alternative 1

Results for the Susan Maersk operating in the Alternative 1 configuration are shown in Plates 1 through 7. Plates 1 through 3 show the vessel using three assist tugs. After completing initial runs, the pilots expressed concern that three tugs were not sufficient for adequate maneuvering and four tugs were used for the remaining simulations. Plates 4 through 7 show the results of the four tug simulations. The pilots stated that a successful turn was dependant upon positioning the vessel as far east as possible into the basin and communicated their preference for a longer basin. They also stated that they would prefer the approach channel to be wider. Three runs were conducted for this alternative; two outbound runs, and one inbound run departing from the eastern side of the northern end of the Upper Reach Channel.

Alternative 2

Results for the Susan Maersk operating in the Alternative 2 channel and turning basin are shown in Plates 8 through 13. The initial runs for Alternative 2 are shown on Plate 8. The pilots communicated the usefulness of the additional 100-foot channel width of the basin approach. This provided additional clearance from the ships docked at the McDuffie Coal Terminal, and also provided additional maneuverability to enter the basin. It is noted that one inbound ship came extremely close to a docked ship. Furthermore, although a few of the tacks indicate ships left the authorized basin, the maneuvers by far were considered successful. The pilots commented that the additional basin length in Alternative 2 was beneficial. Upon completion of these runs, the pilots expressed concern that a ship docked at the southern end of the proposed container facility should be added to the model. This scenario would be a situation they might encounter in normal port operations and recommended inclusion of the ship in the model simulation. A ship was added to the database and outbound runs were conducted accordingly. These outbound runs are shown in Plates 12 and 13. Maneuvering around the docked ship limited

the amount of available turning basin when compared to the runs shown in Plates 10 and 11.

Alternative 3

Results for the Susan Maersk operating in the Alternative 3 configuration are shown in Plates 14 through 19. Initial runs for Alternative 3 are shown in Plate 14 through 17. The pilots expressed appreciation for the 150-foot channel widening of the northern end of the Upper Reach. While they liked the longer basin, none of them brought their ships to within 200 feet of the eastern end of the basin. Most of the runs were successful, but the pilots stated the basin wasn't long enough. Three of the vessel tracks indicate ship positions outside the basin on either the north or south sides. Results of the simulations conducted with the containership at the dock are shown in Plates 18 and 19. Even though the northern end of the Upper Reach was widened 150 feet, one ship track is outside the channel on the east side.

Alternative 4

Results for the Susan Maersk operating in the Alternative 4 configuration are shown on Plates 20 through 25. The initial runs for Alternative 4 are shown in Plate 20 through 23. The pilots expressed considerable appreciation of the 250-foot widening of the northern end of the Upper Reach. However, they did not use the eastern side of the widened channel. The pilots were also receptive of the longer basin, but did not take advantage of the length in the maneuvers. None of the ships came much nearer than 400 feet to the eastern end of the basin. Results of the simulations conducted with the containership at the dock are shown in Plates 24 and 25. The runs were successful, though one ship track (Plate 25) is positioned outside the northern side of the turning basin.

Modified Design

Upon completion of the first two testing sessions, a new alternative was designed based on previous simulation results. This alternative was identified as the "Modified Design." The Modified Design was developed based on Alternative 2; Figure 9 compares the Modified Design to Alternative 2. The southern end of the Alternative 2 100-foot widener was extended past the southern end of the McDuffie Coal Terminal. This was done to address pilot concern that previously tested channel widths did

not start far enough south during initial approach. The Modified Design widener will allow ships to maneuver safely away from any ship docked at the McDuffie Coal Terminal. The turning basin depth for Alternative 2 remained the same for the Modified Design. However, the turning basin was widened on the south side to ease the approach into the basin. This widening will require that a portion of the northern end of Little Sand Island be removed. The northern side of the Alternative 2 turning basin was slightly widened for the Modified Design.

Results for the Susan Maersk operating in the Modified Design channel and turning basin are shown on Plates 26 through 33. The daytime runs for the Modified Design are shown on Plates 26 through 29. Plate 26 shows one vessel track within 30 feet of the northernmost ship docked at the McDuffie Coal Terminal. However, the pilot stated he had temporarily lost track of his vessel position. In the same run, (Plate 26) the ship track indicates the vessel position outside the turning basin on the eastern side by approximately 80 feet. However, ship tracks for the additional two runs show positions no closer than 170 feet from the end of the basin. The remainder of the runs were considered successful, with pilot recommendations to widen the basin and extend the width of the northern end of the Upper Reach.

The nighttime runs for the Modified Design are shown in Plates 30 through 33. One ship track indicates a ship position approximately 30 feet outside the basin at the southeast corner of the turning basin. The pilot attributed this to severe climatic conditions and limited visibility.

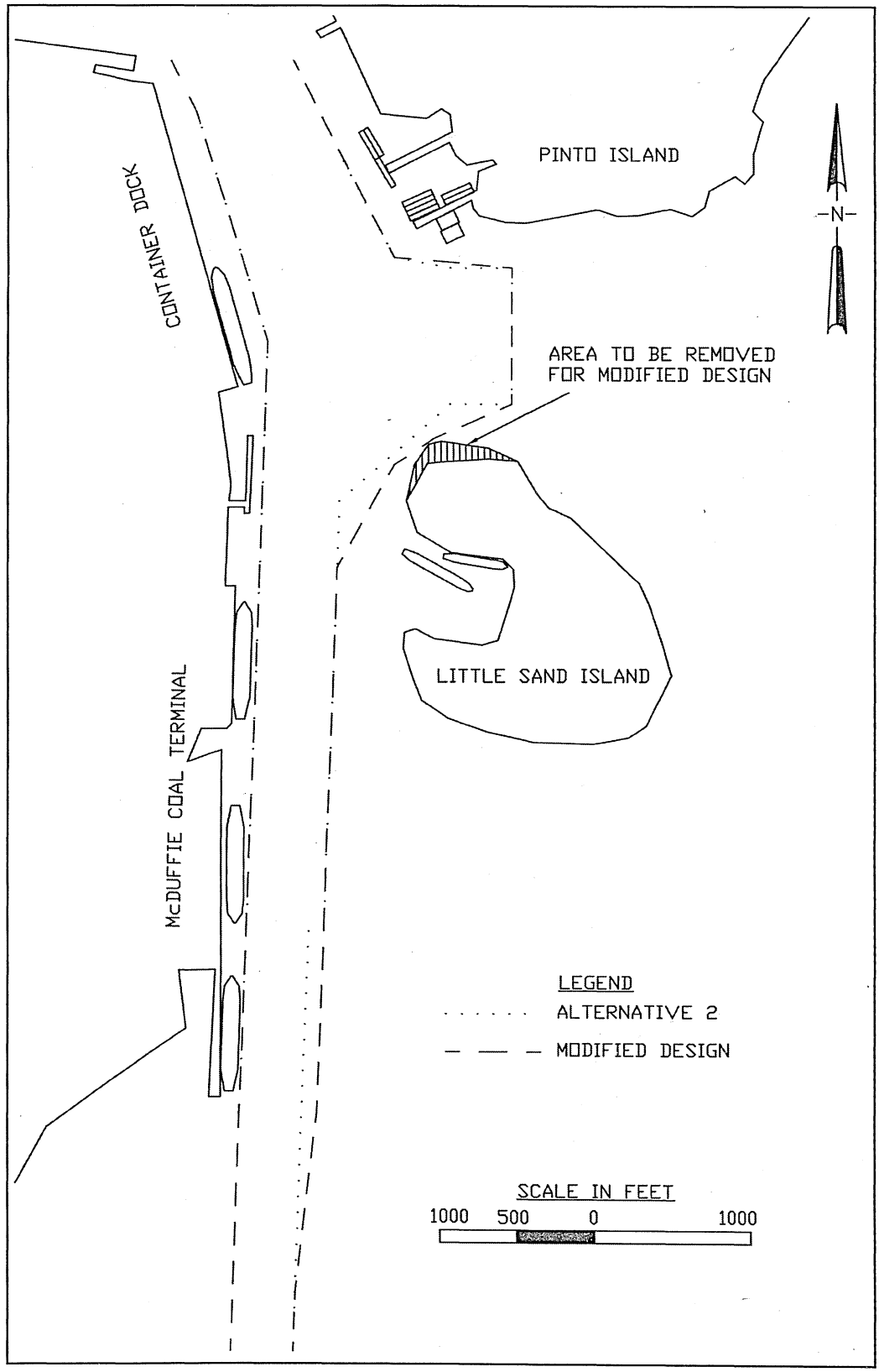

Figure 9. Modified design conditions.

7 Conclusions and Recommendations

Based upon the simulator results, the following conclusions are noted.

In addition to allowing more room to turn, the widening of the turning basin at its southwest corner allowed improved access into and out of the basin, The widening of the Upper Reach extending south past the McDuffie Coal Terminal.

1. Recorded ship tracks indicate test runs were more successful during simulations with channel widening from the McDuffie Coal Terminal to the Upper Reach.
2. The Modified Design alternative provided two major improvements over the first four alternatives; these were easing the approach into the basin and allowing ships to pass further from docked ships.
3. Aids to Navigation and marking of the basin are critical to successful ship maneuvering. The pilots mentioned adequate buoy locations numerous times during testing.
4. Night time simulations were completed for the modified design condition, and show no maneuvering problems.

The following recommendations are made for the Mobile Harbor Turning Basin.

1. The Modified Design alternative should be adopted as the final configuration of the basin.
2. The U.S. Coast Guard is responsible for marking the turning basin and should be provided with a copy of this report.
3. Additional ship simulations should be conducted for any changes in the authorized post constructed basin.

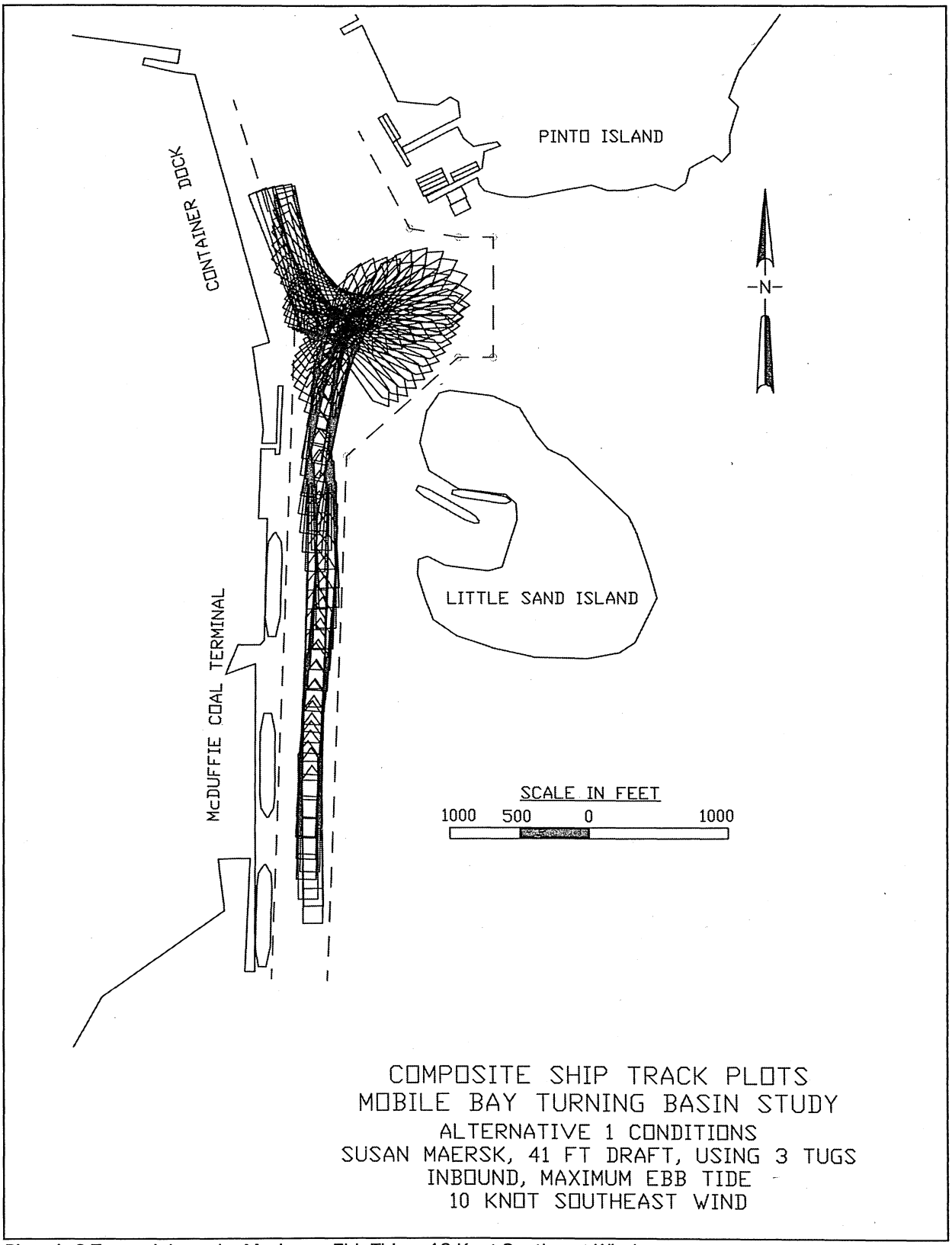

Plate 1. 3 Tugs – Inbound – Maximum Ebb Tide – 10 Knot Southeast Wind.

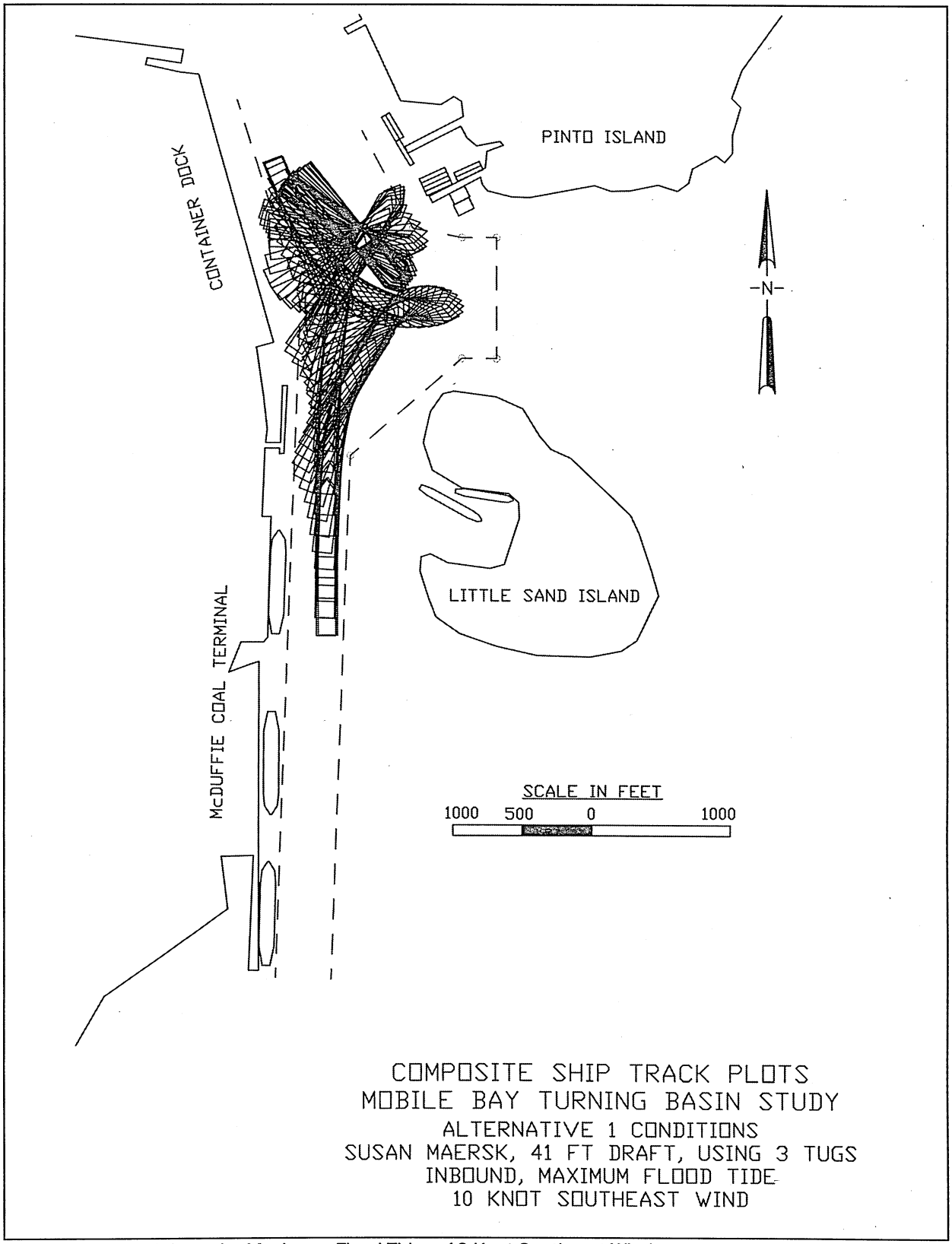

Plate 2. 3 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

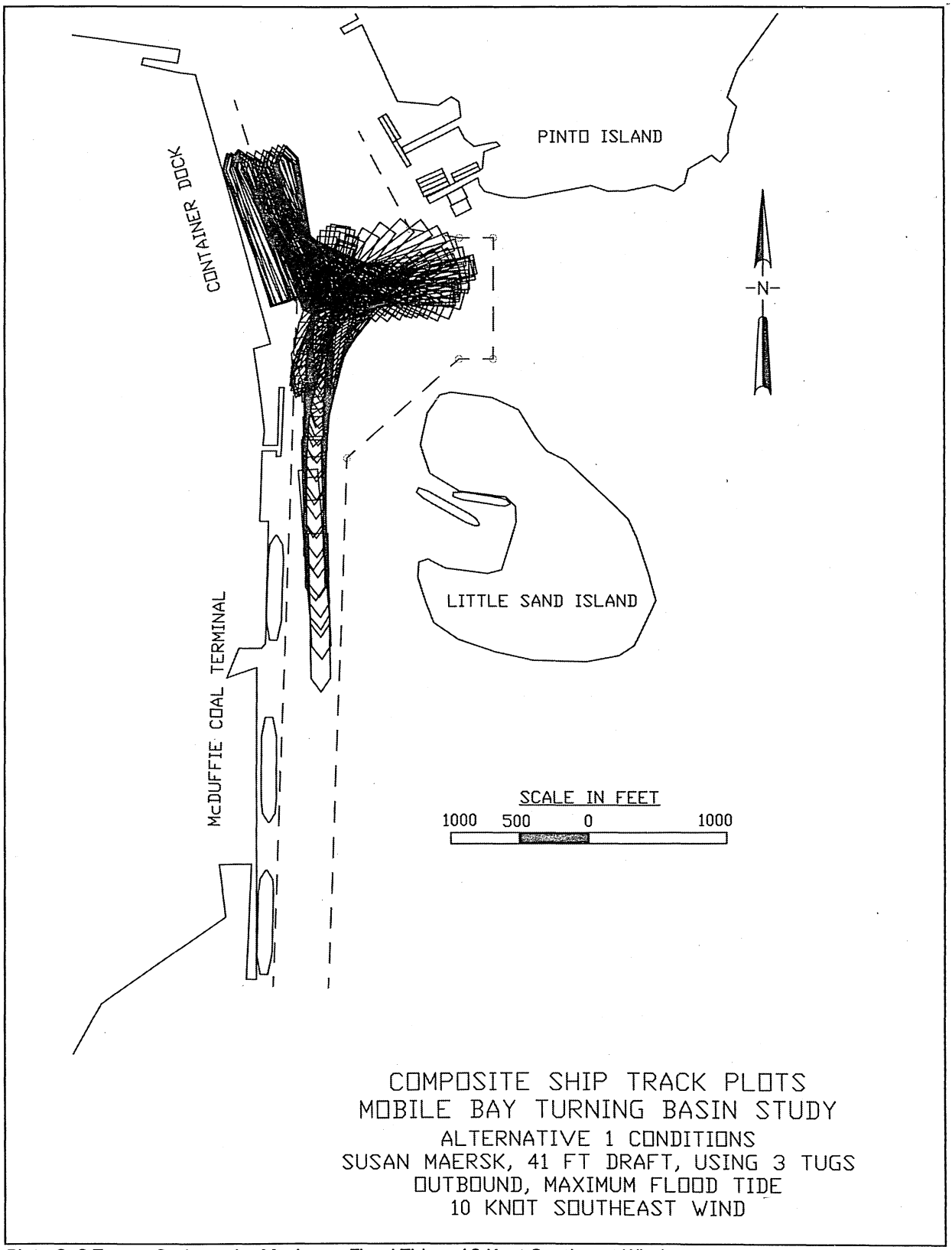

Plate 3. 3 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

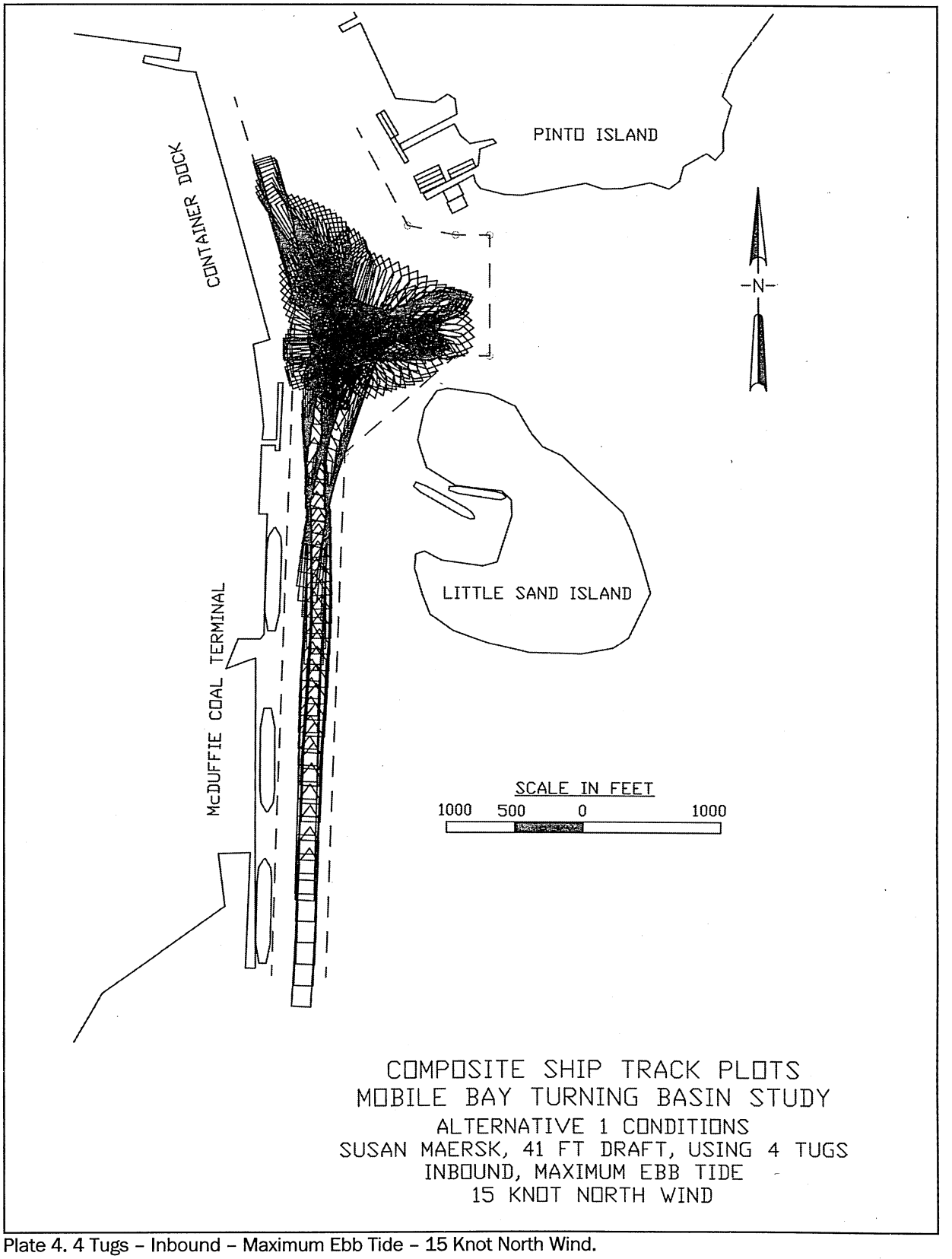

Plate 4. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind.

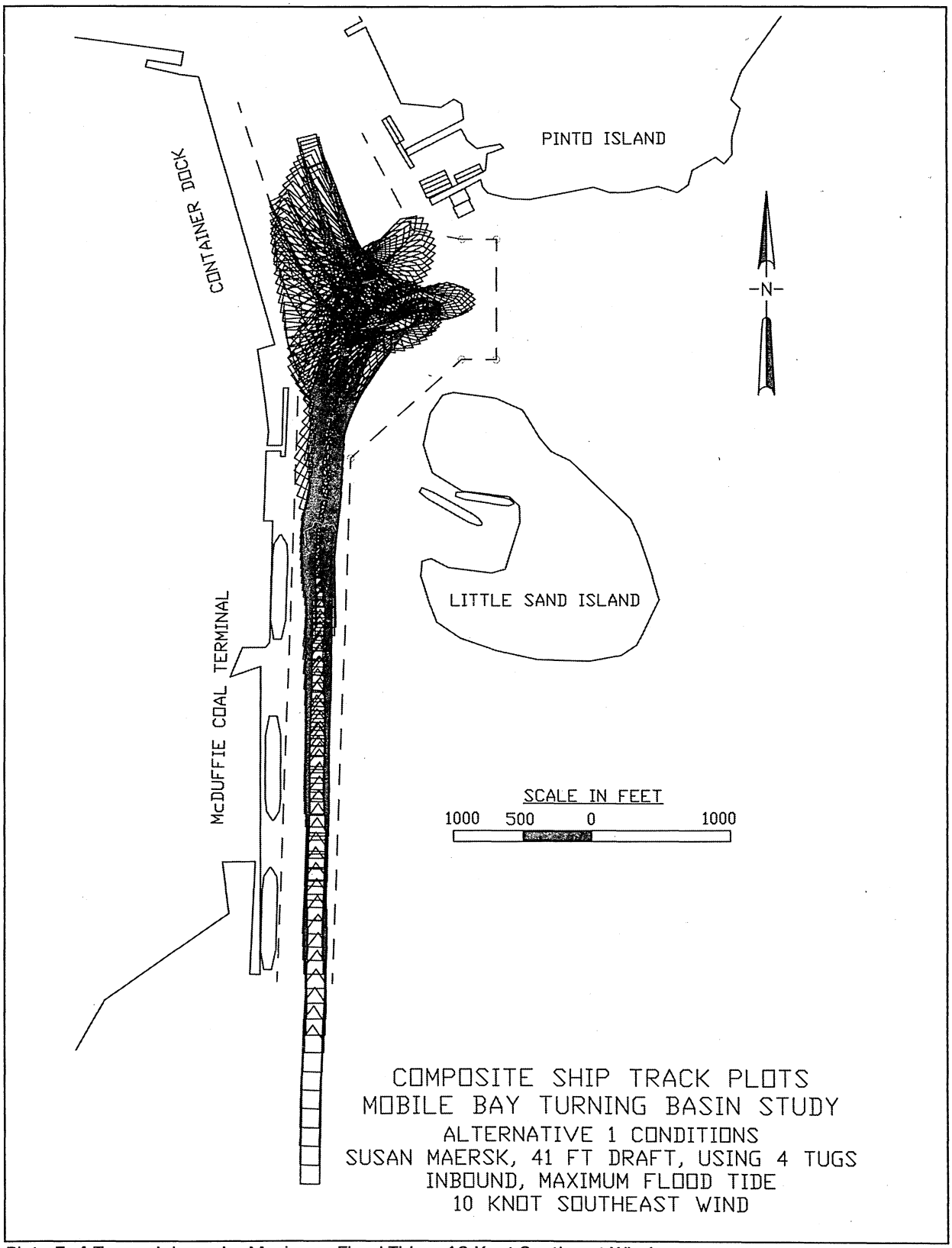

Plate 5. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

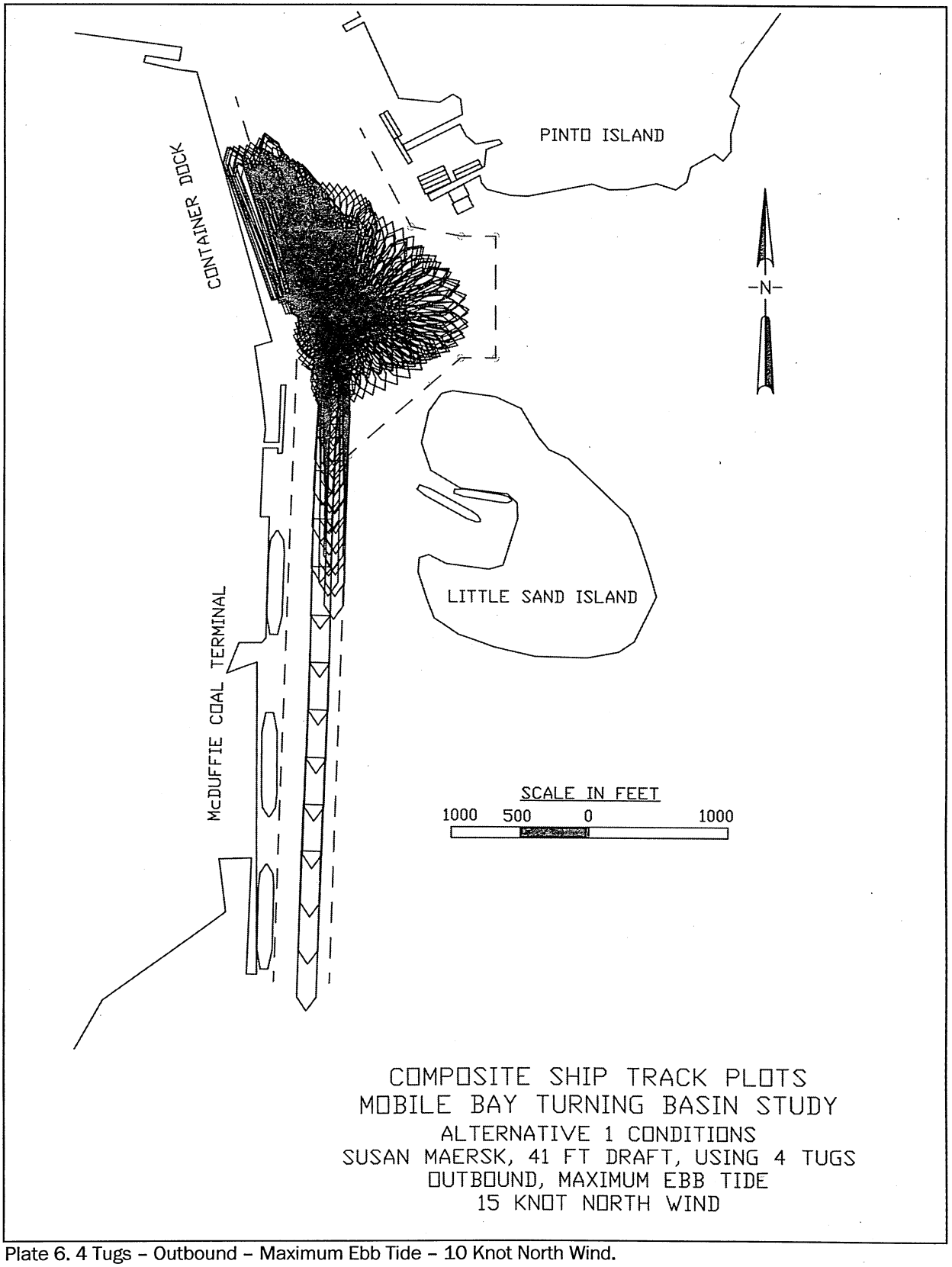

Plate 6. 4 Tugs – Outbound – Maximum Ebb Tide – 10 Knot North Wind.

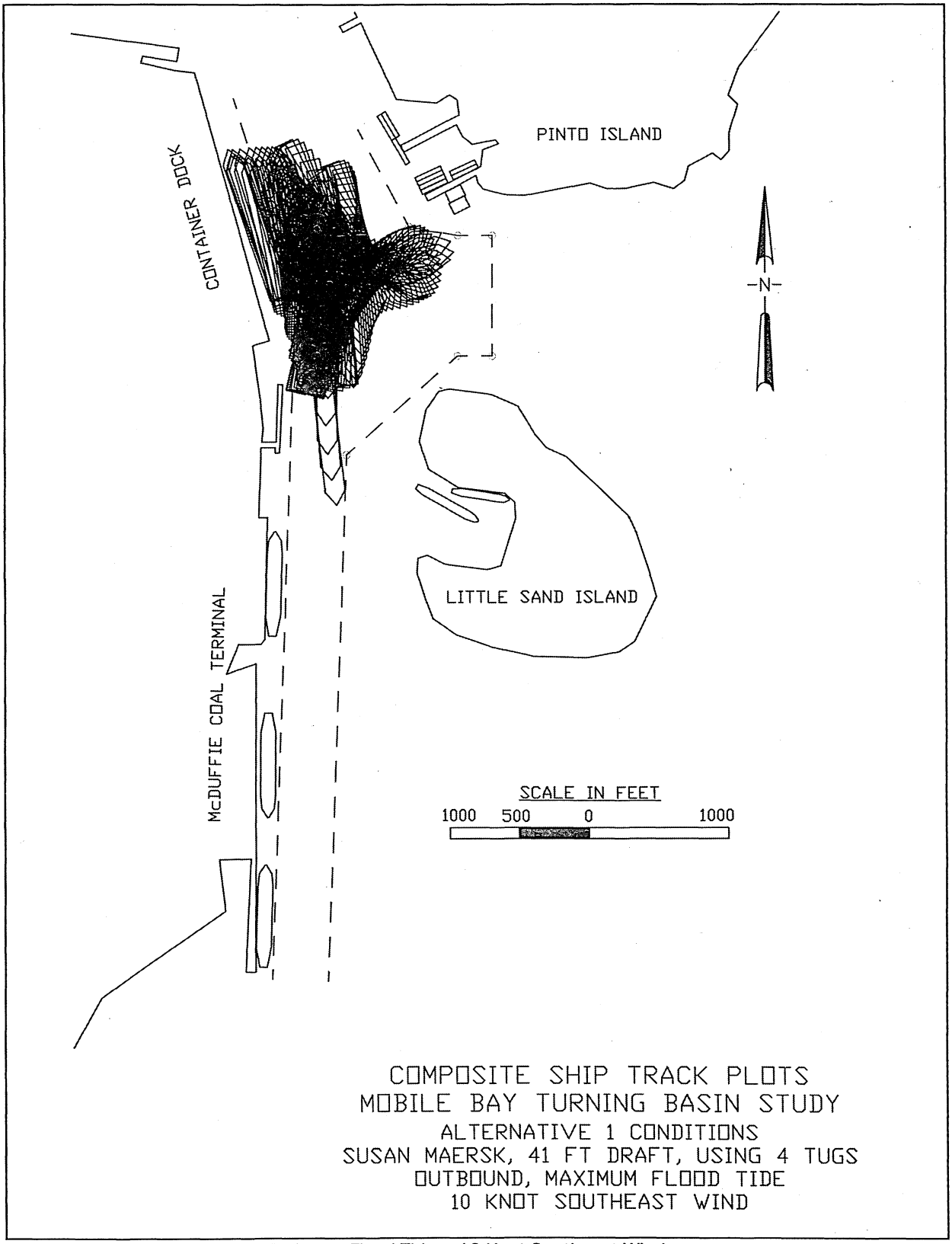

Plate 7. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

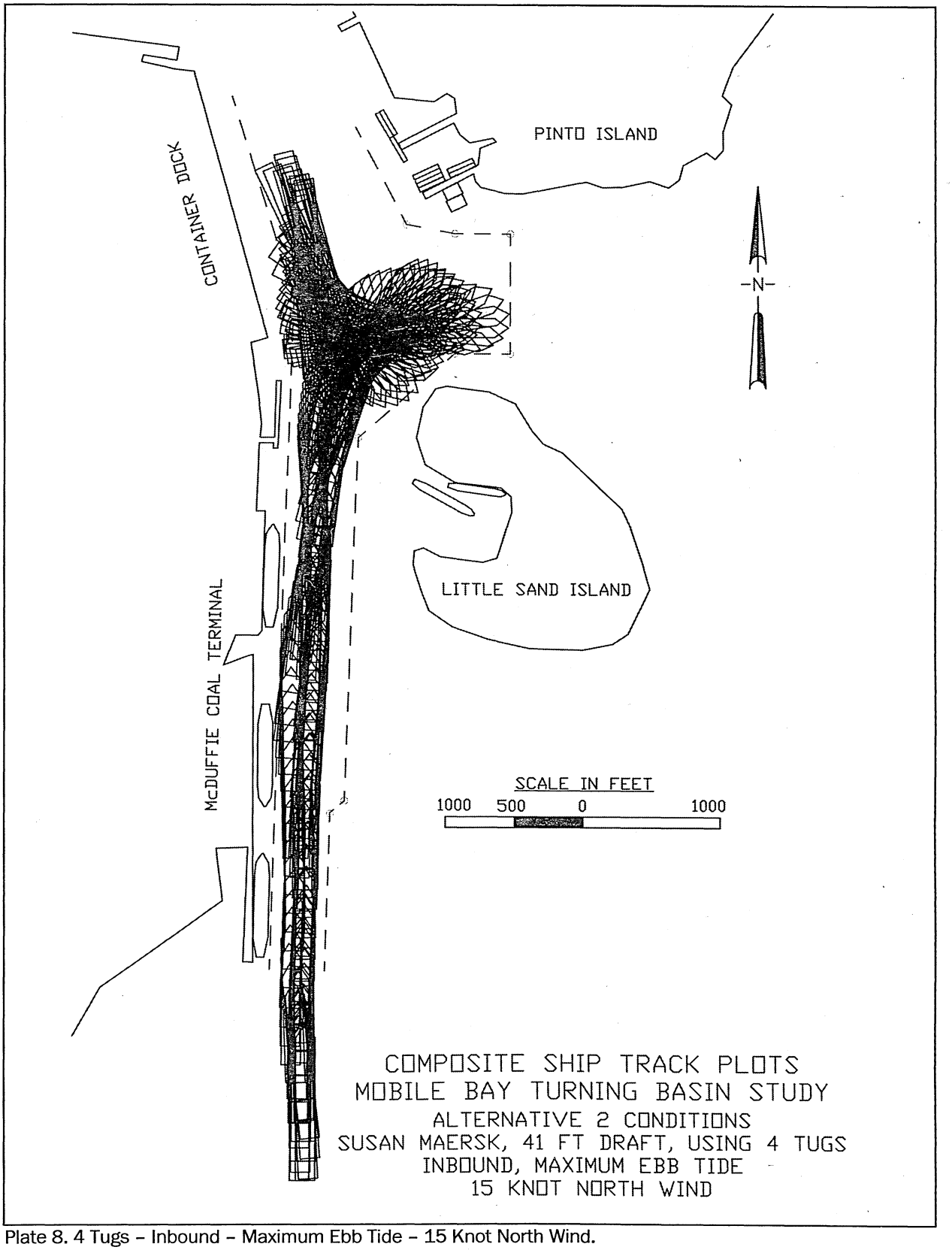

Plate 8. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind.

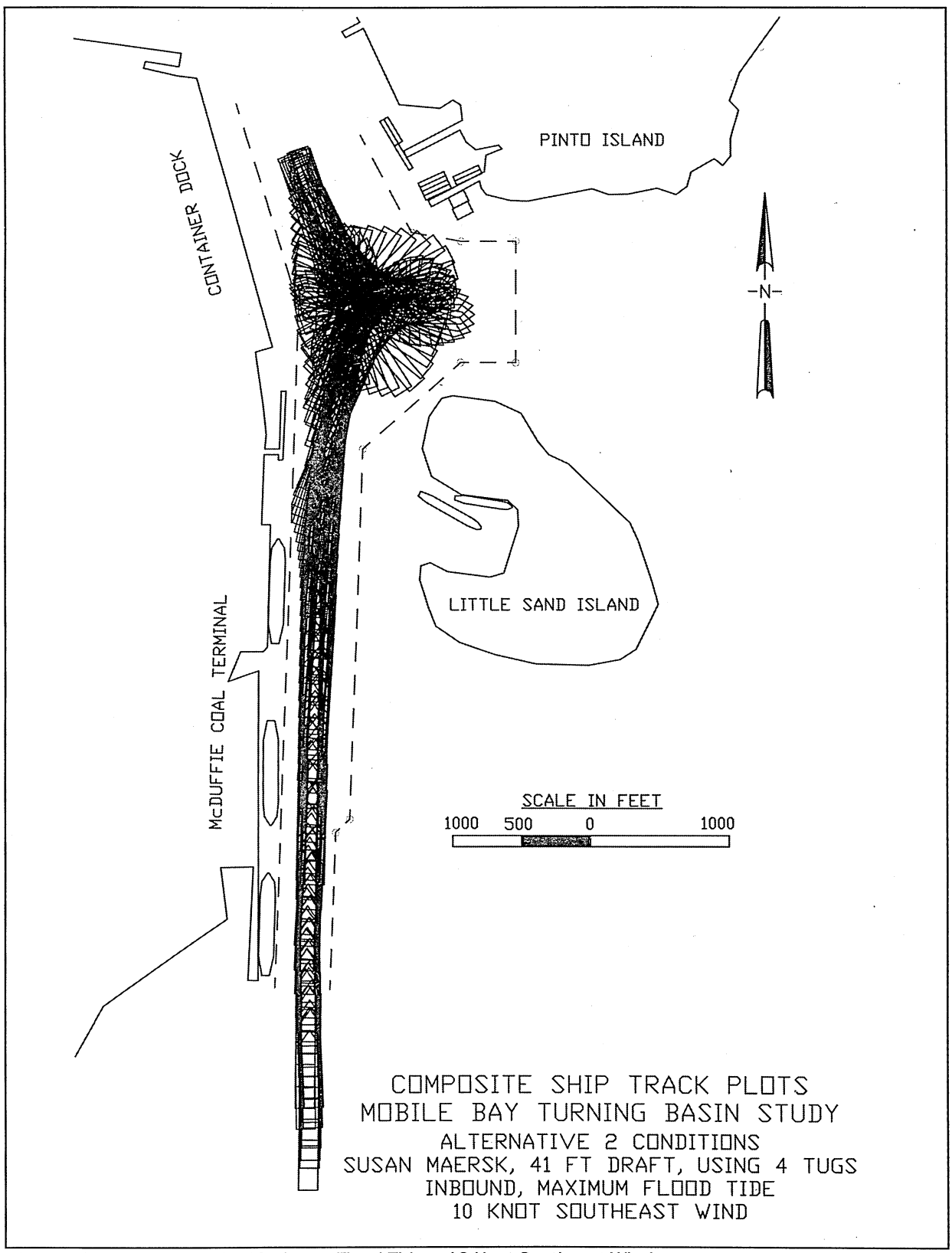

Plate 9. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

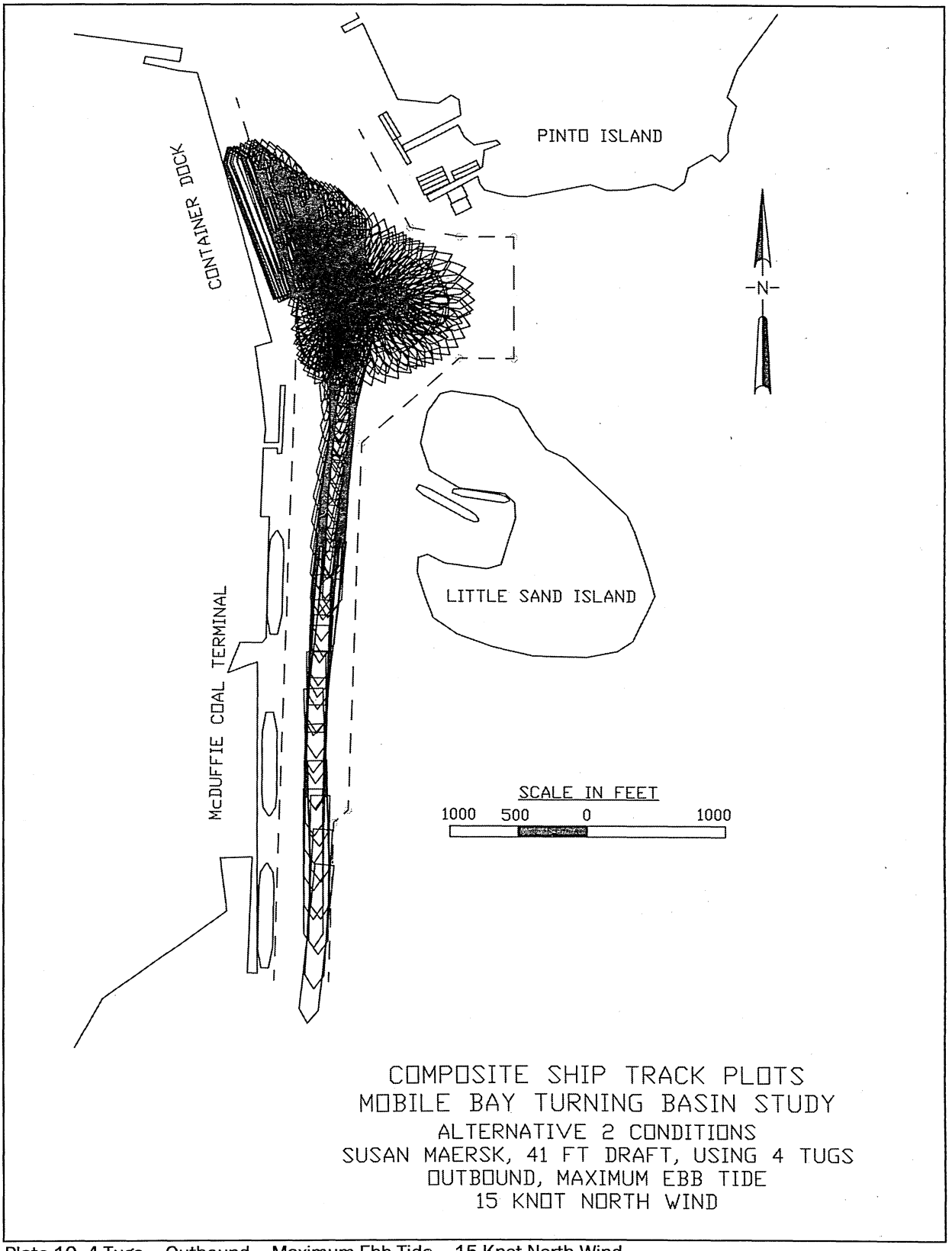

Plate 10. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

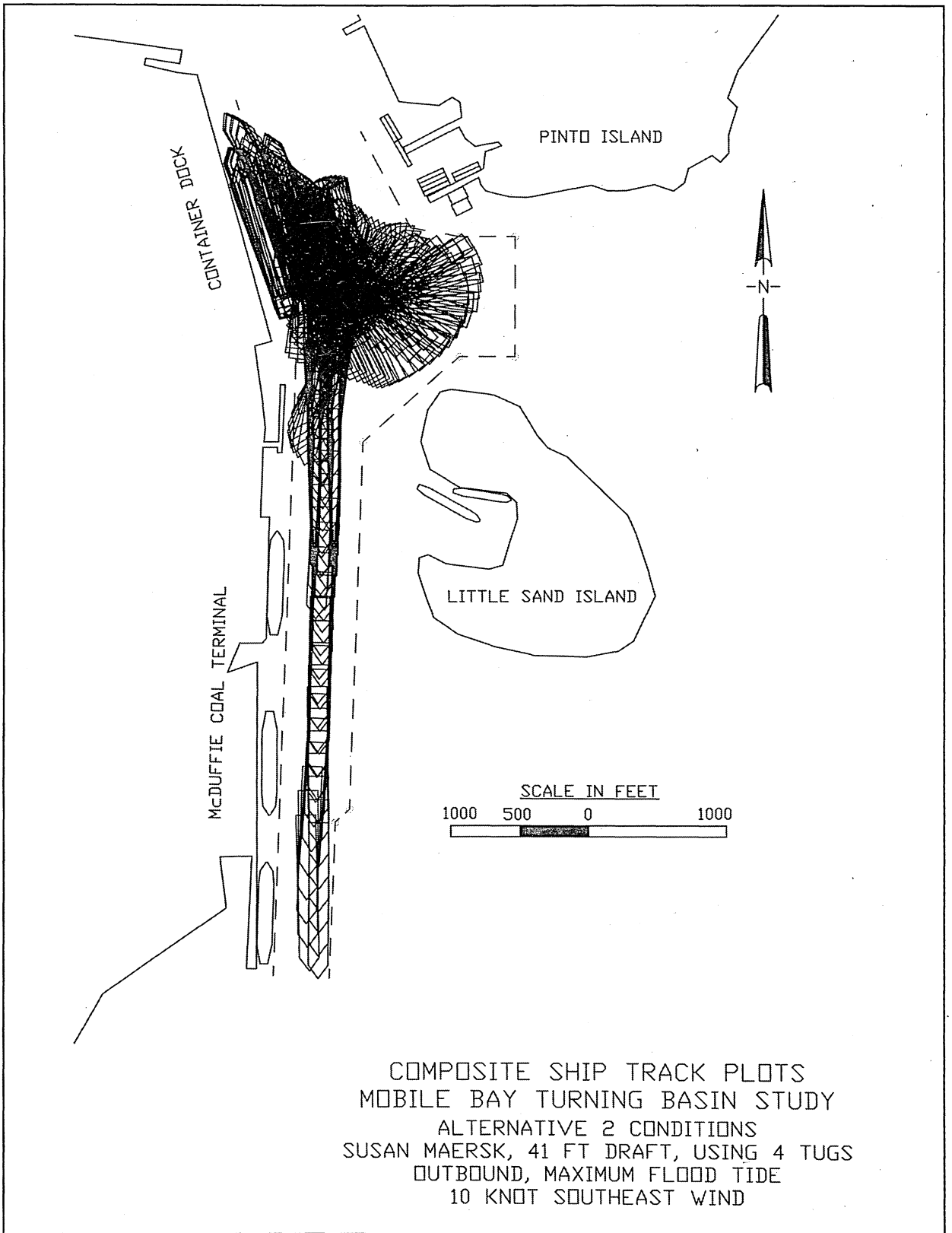

Plate 11. 4 Tugs – Outbound – Maximum Flood tide – 10 Knot Southeast Wind.

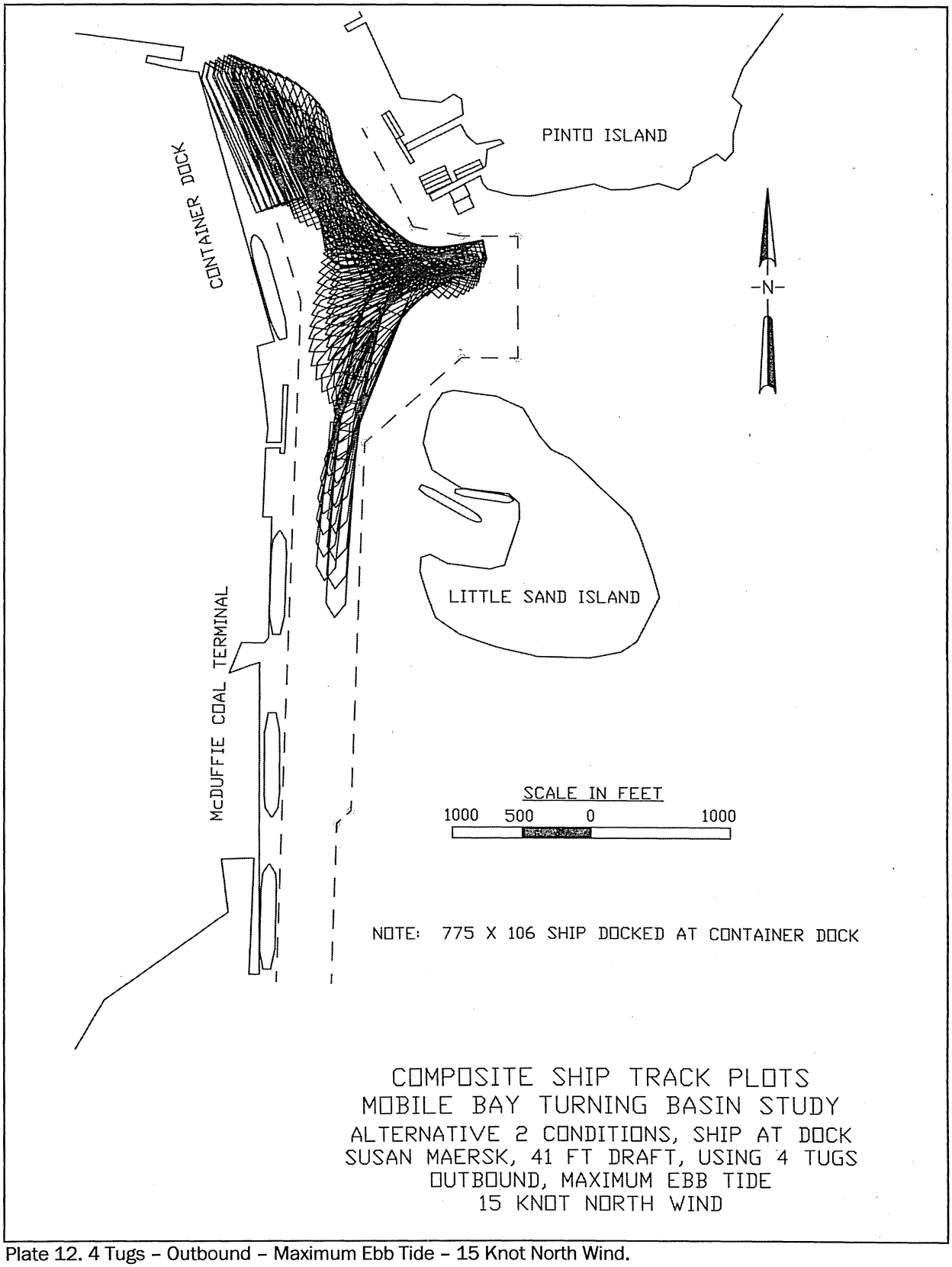

Plate 12. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

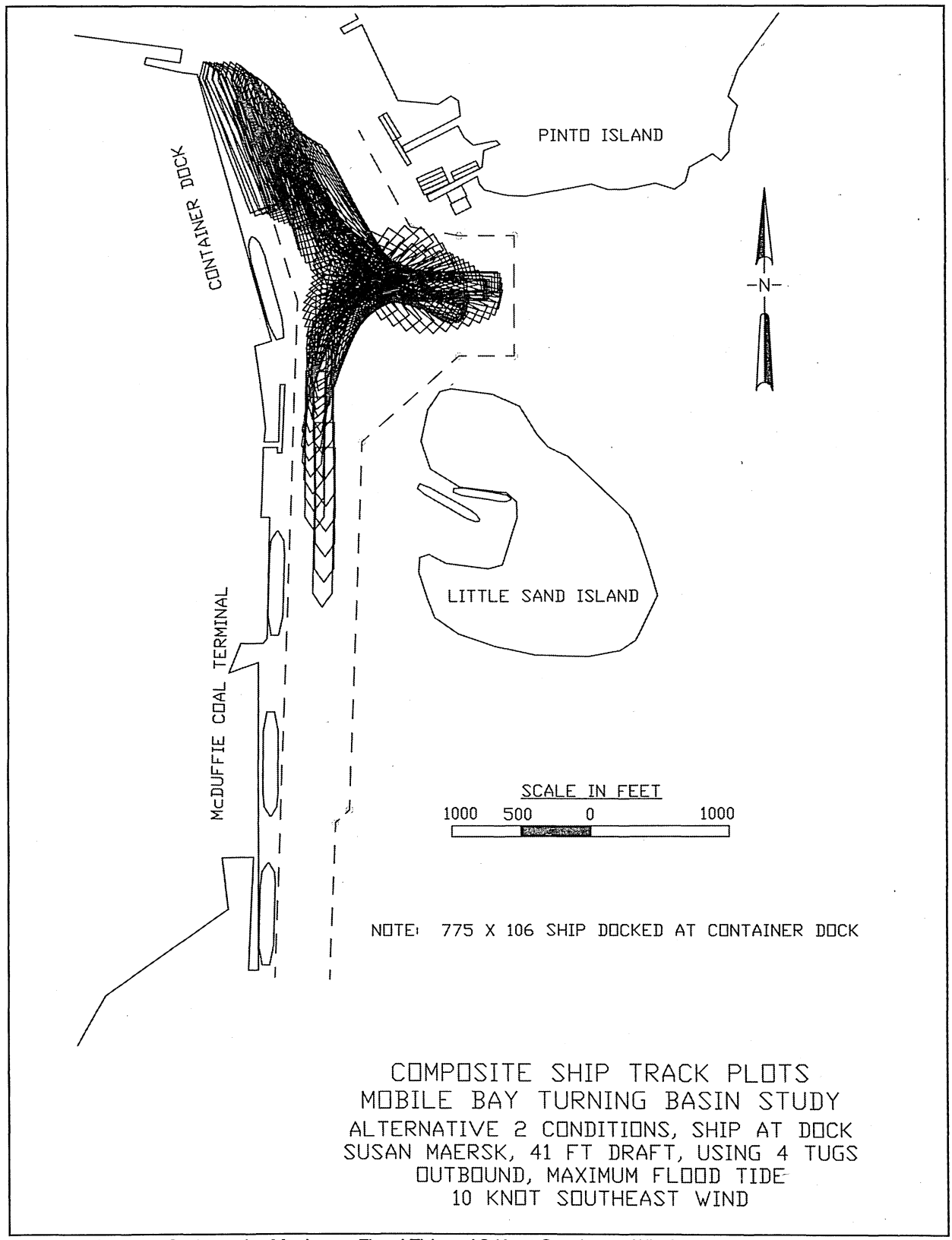

Plate 13. 4 tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

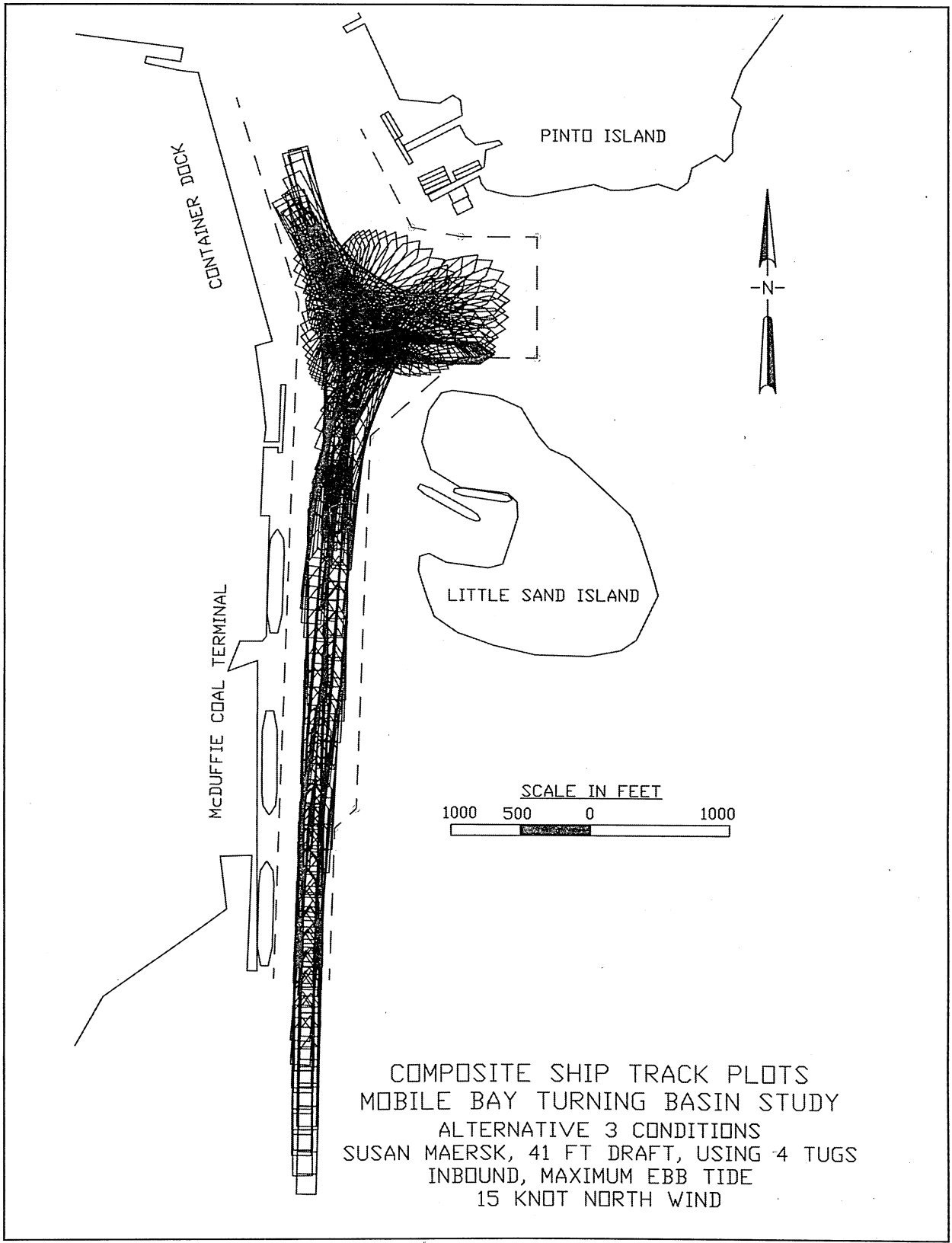

Plate 14. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind.

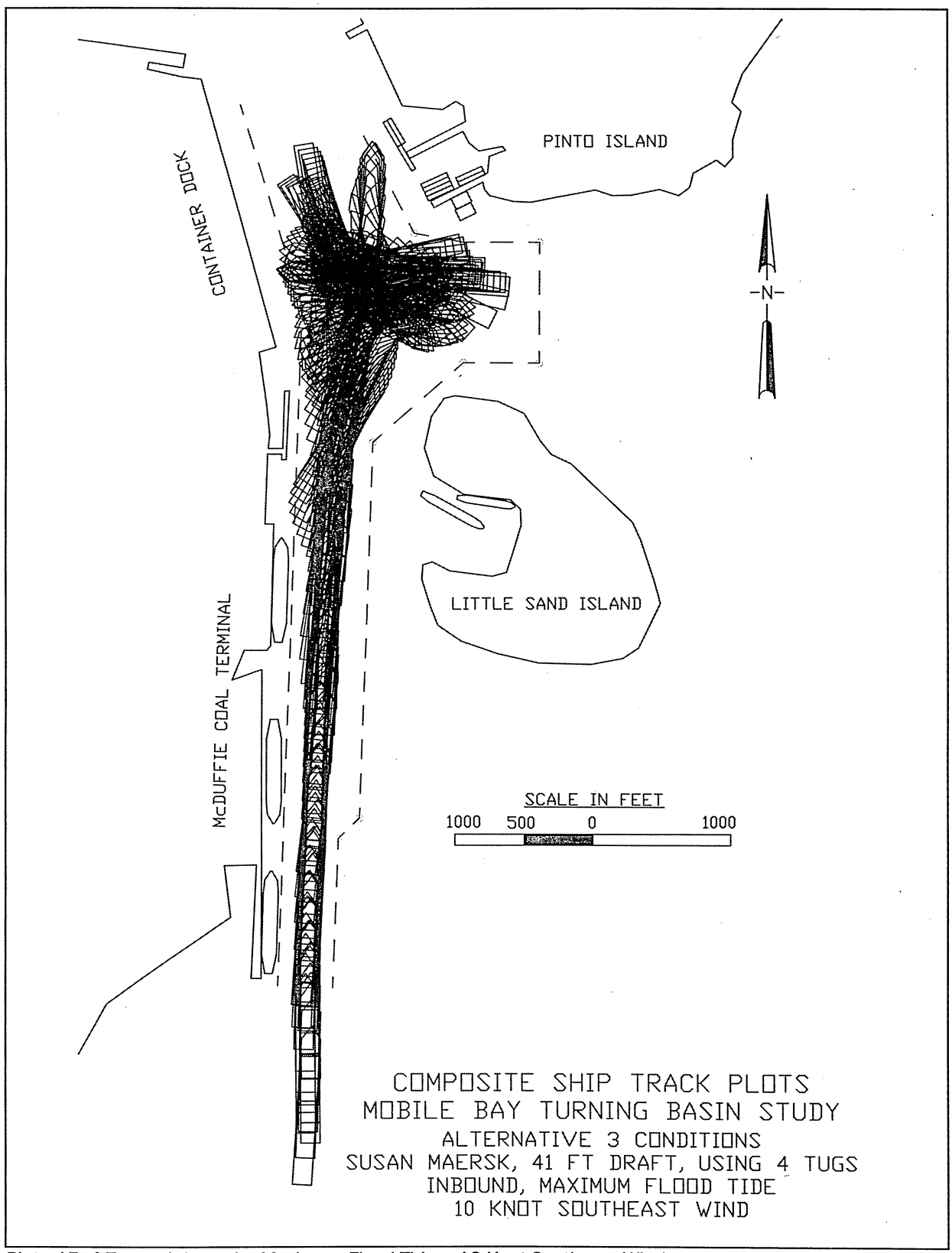

Plate 15. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

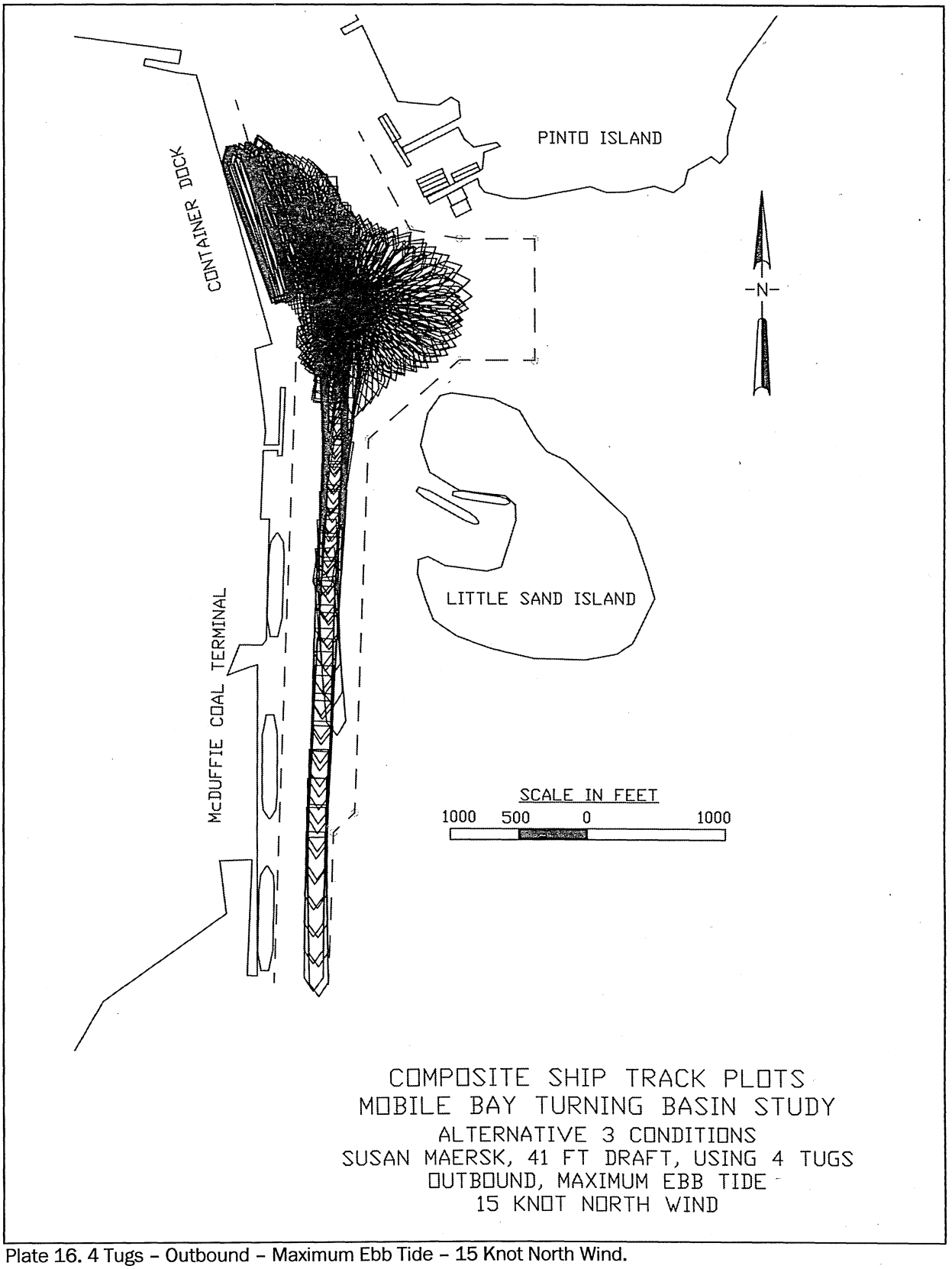

Plate 16. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

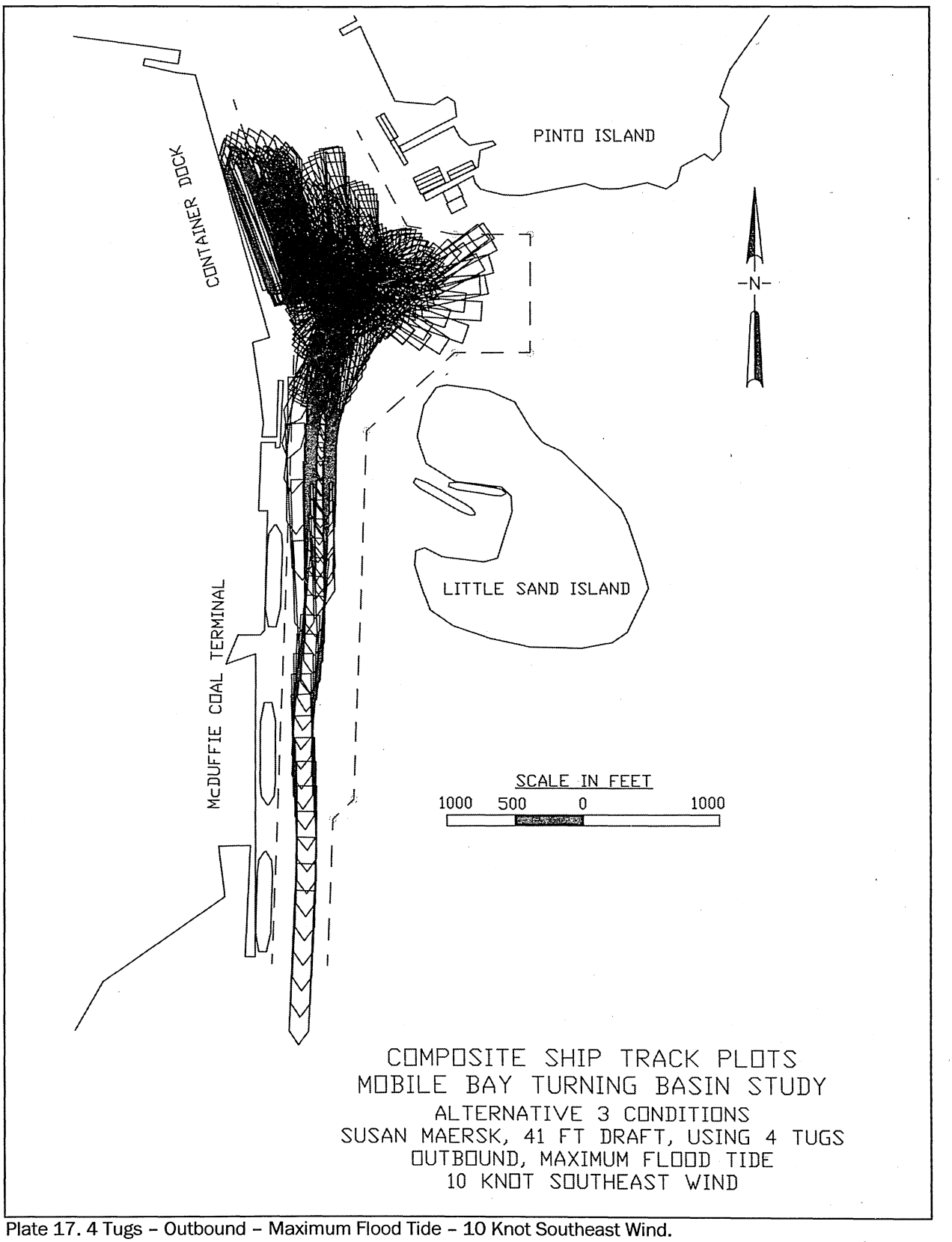

Plate 17. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

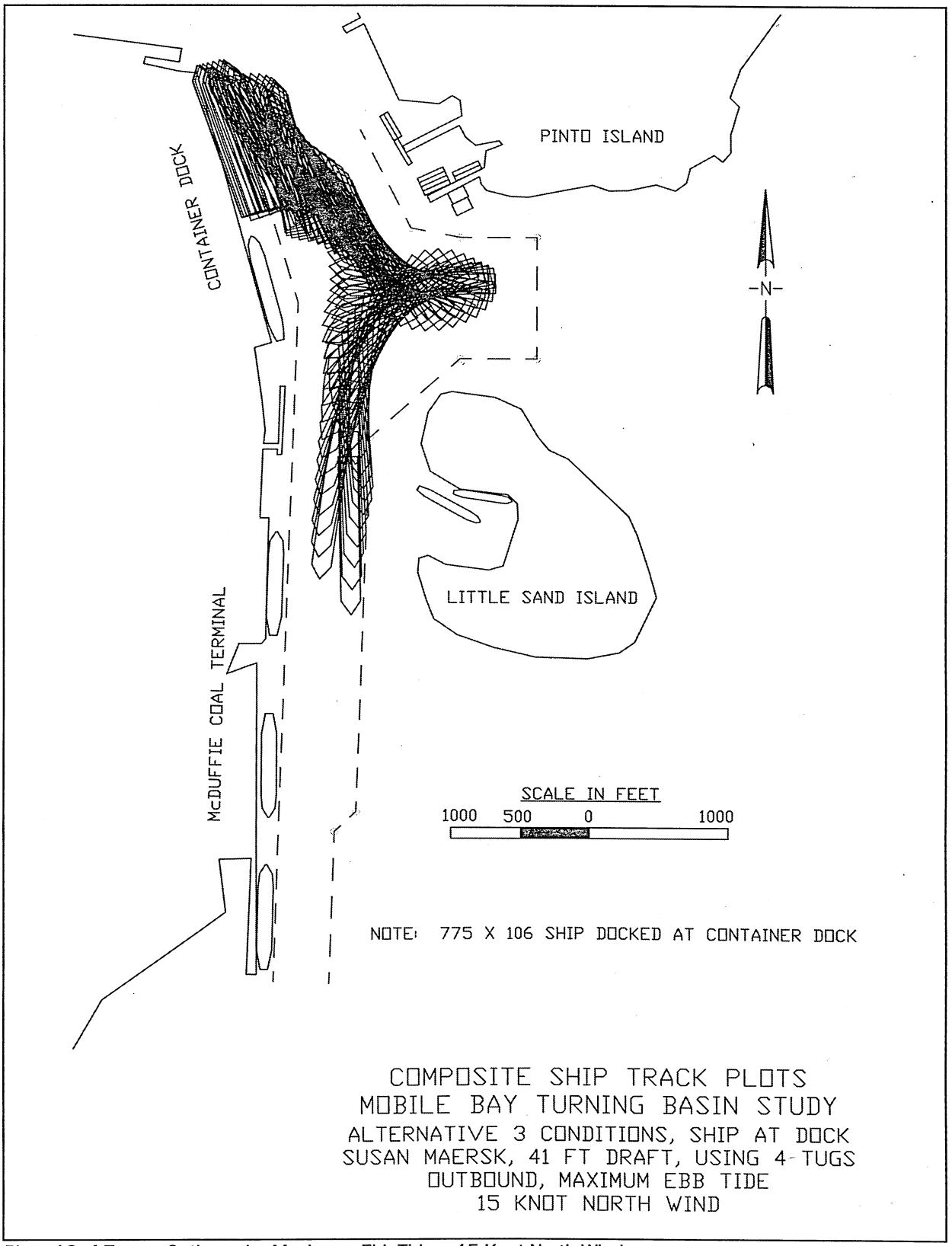

Plate 18. 4 Tugs – Outbound – Maximum Ebb Tide -- 15 Knot North Wind.

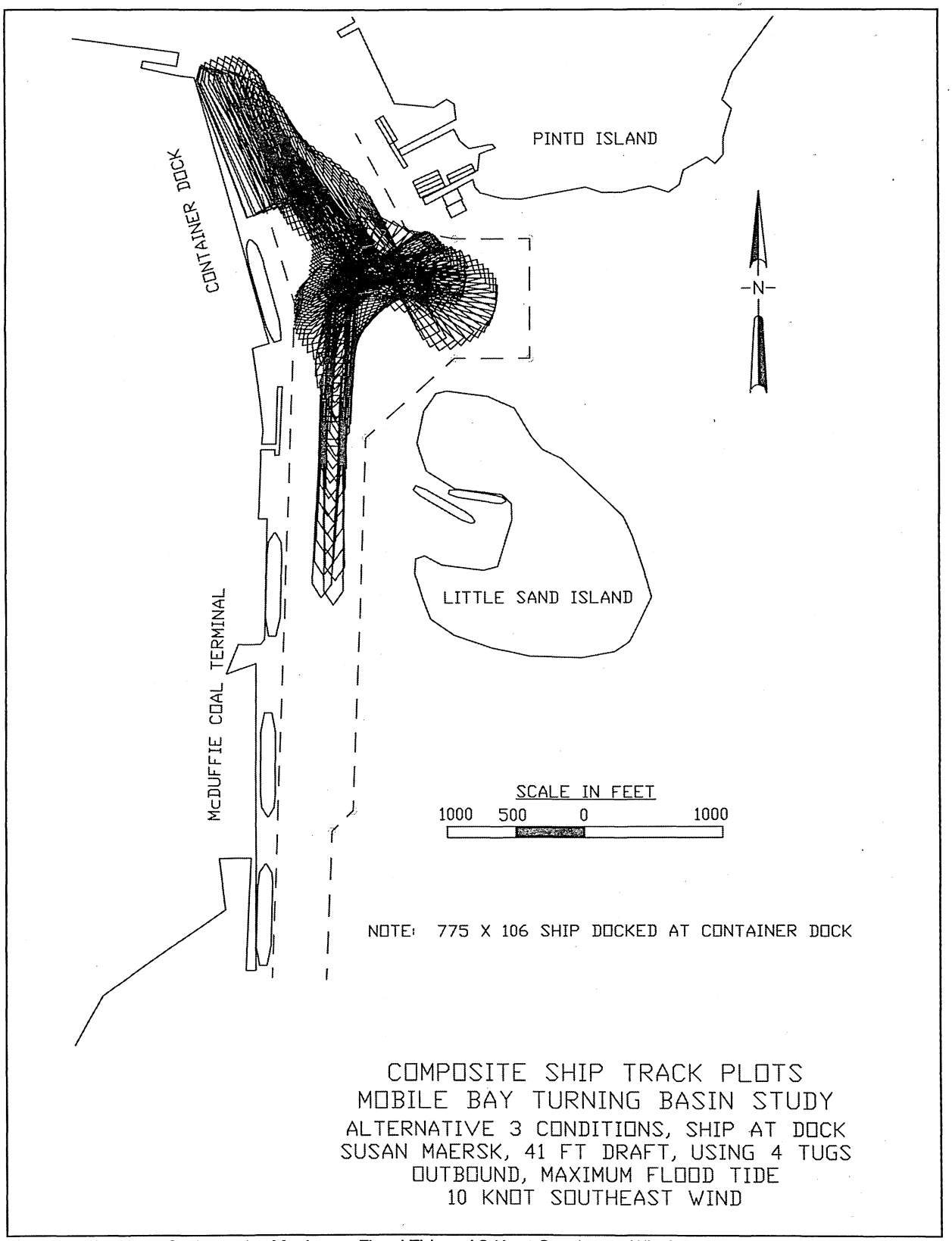

Plate 19. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

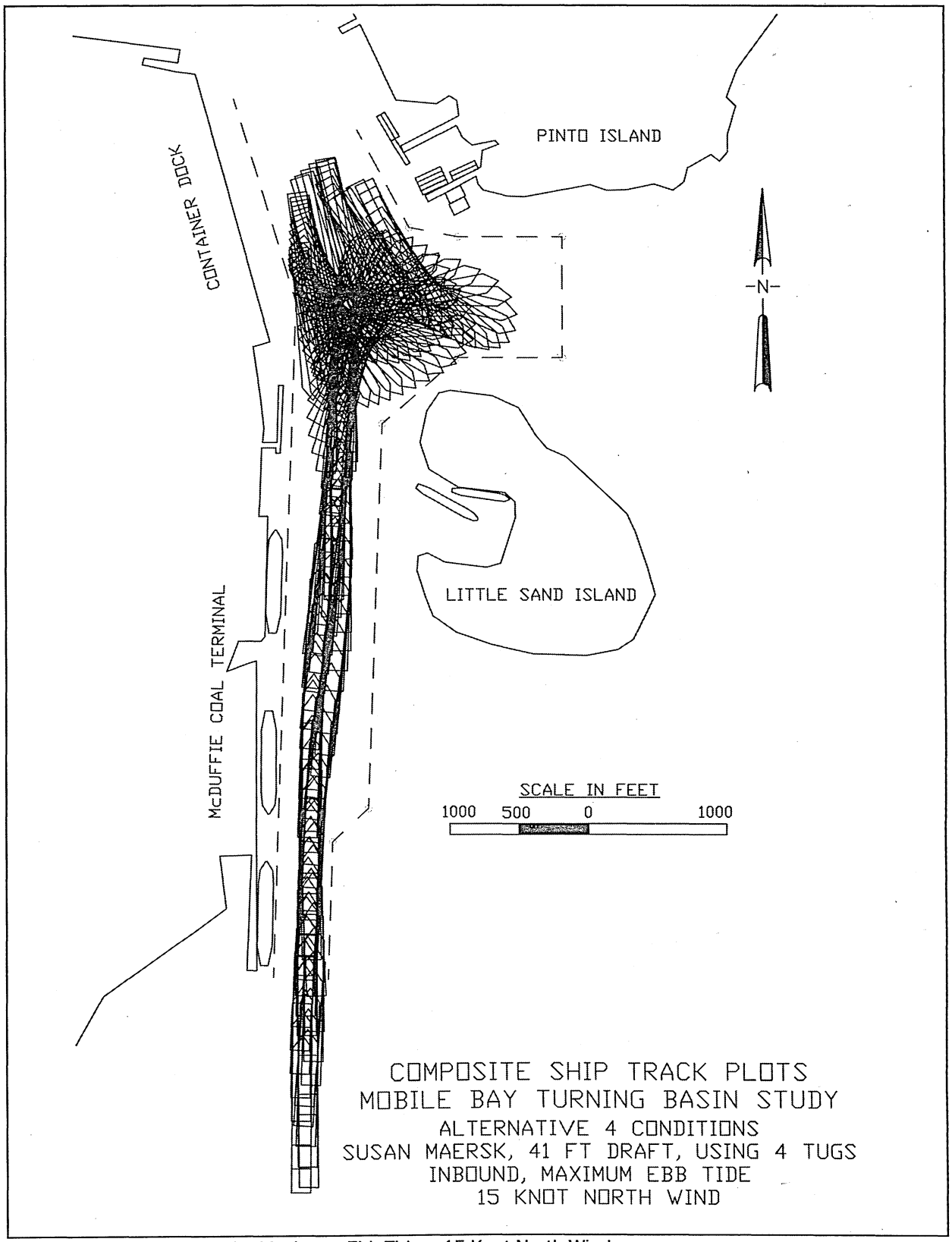

Plate 20. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind.

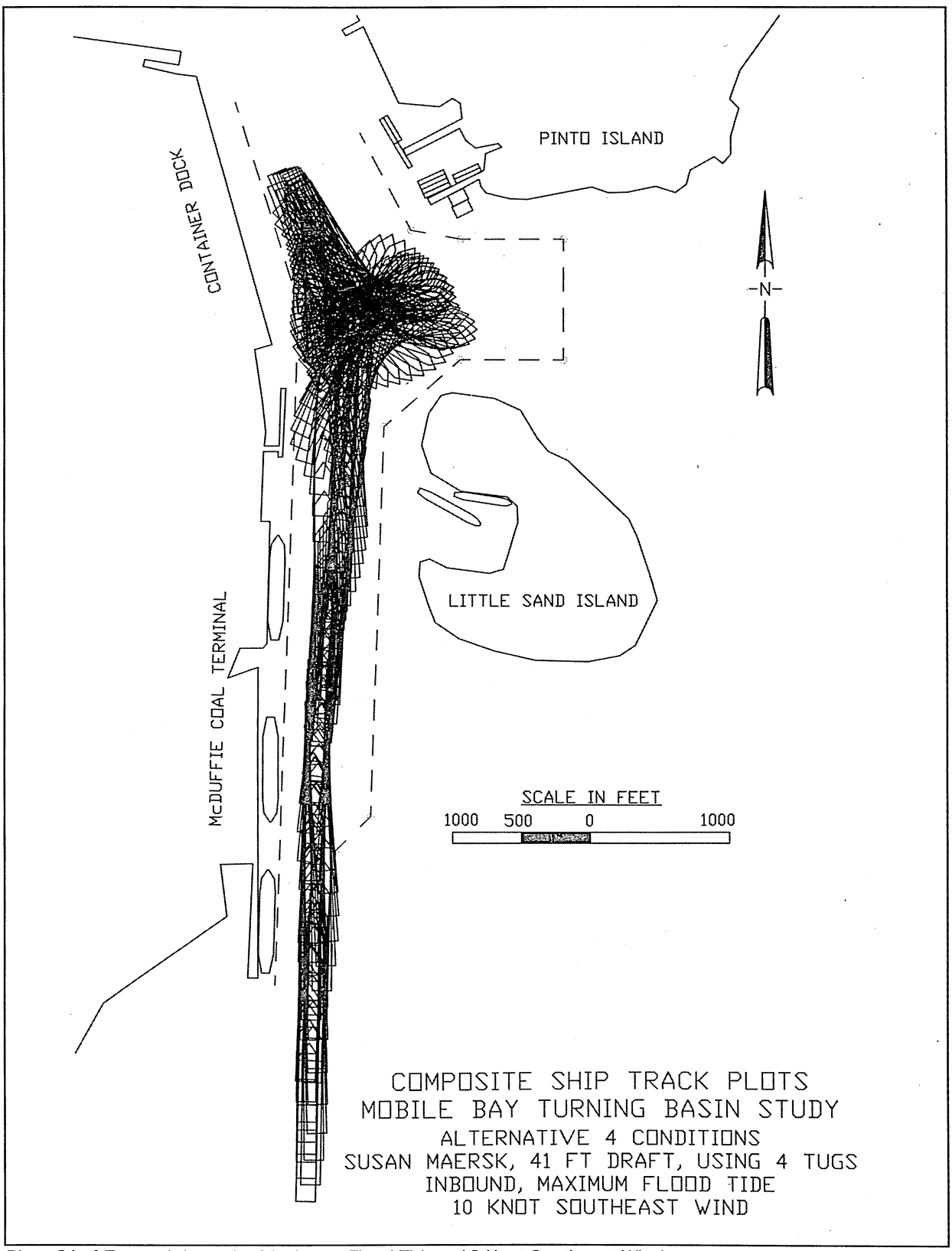

Plate 21. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

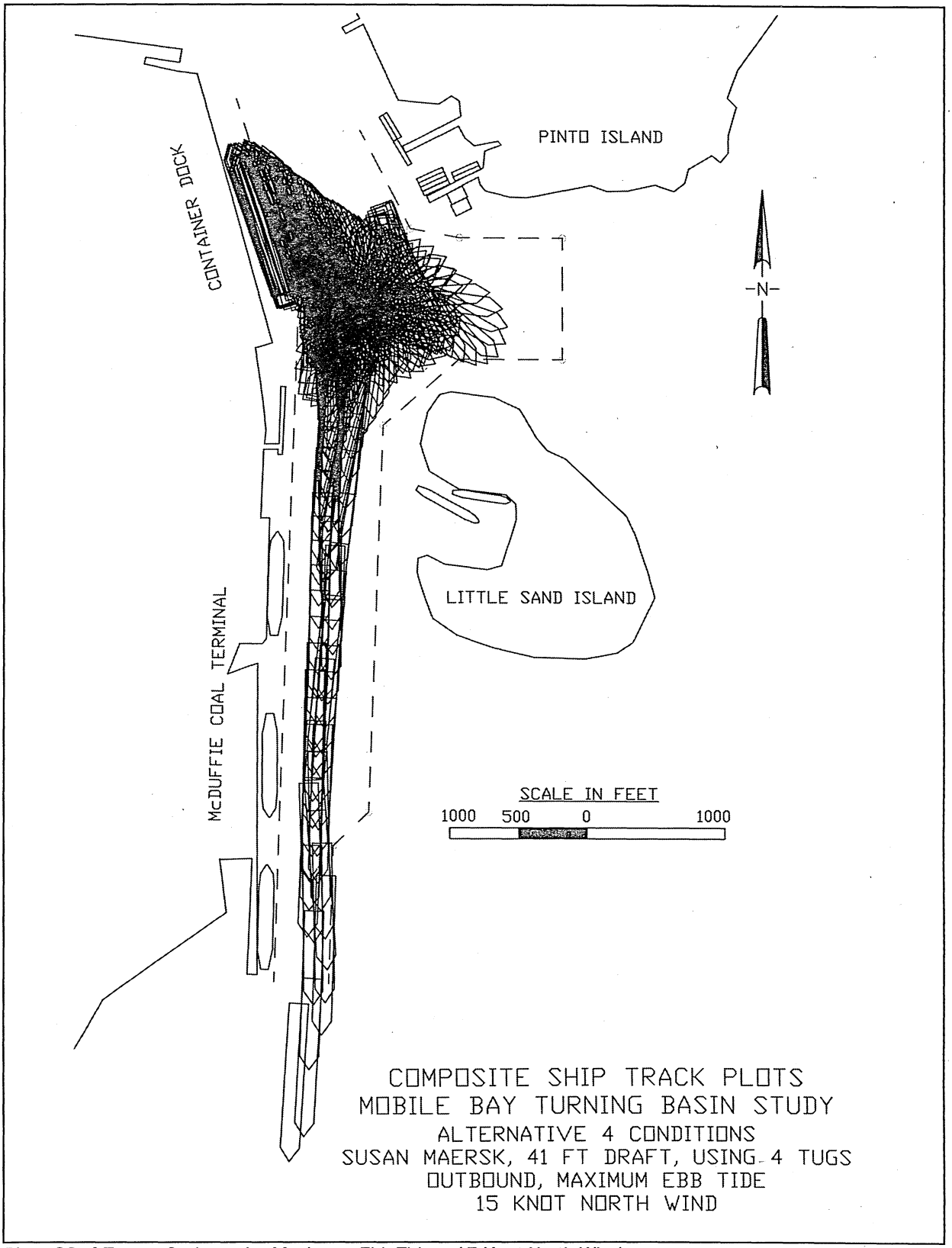

Plate 22. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

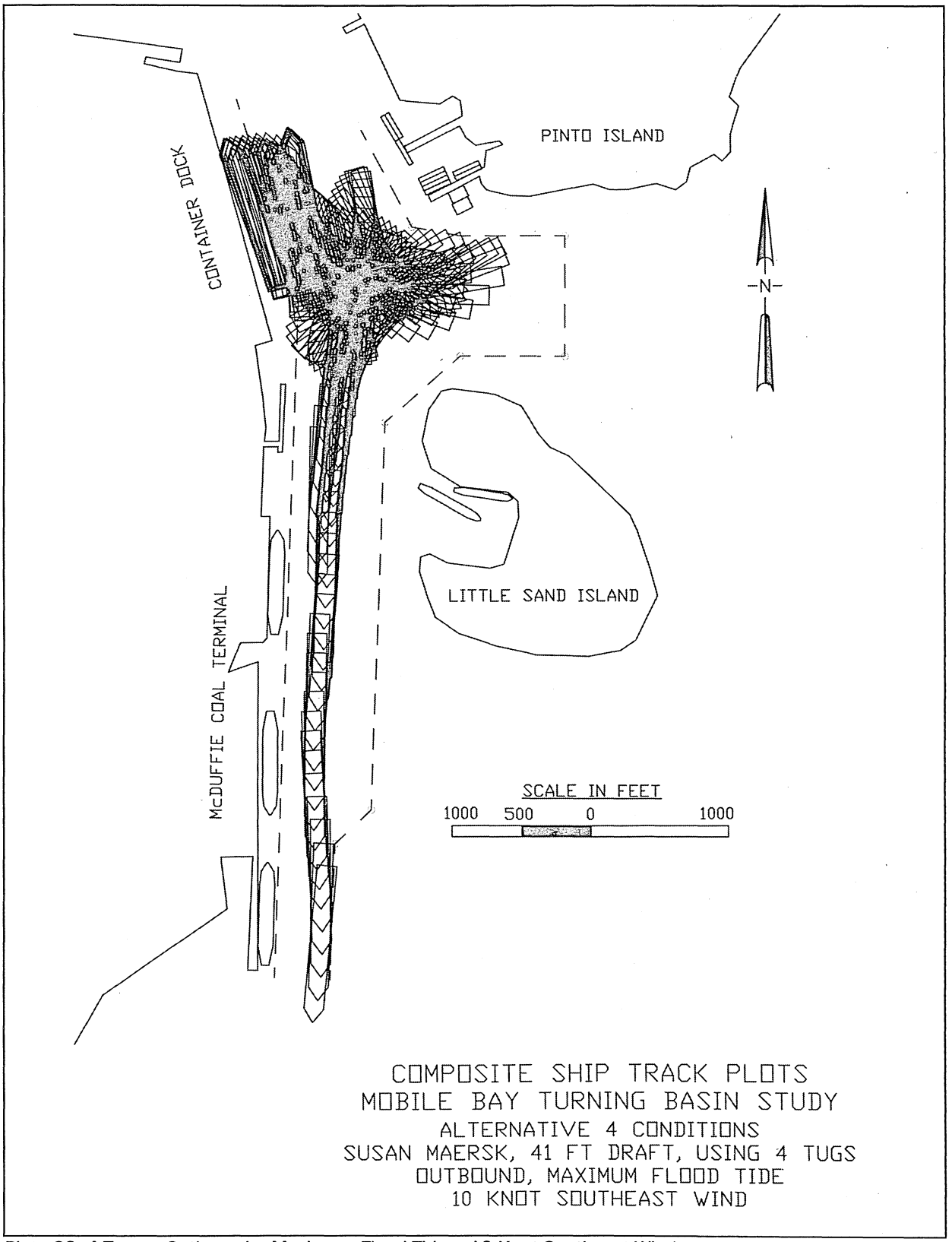

Plate 23. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

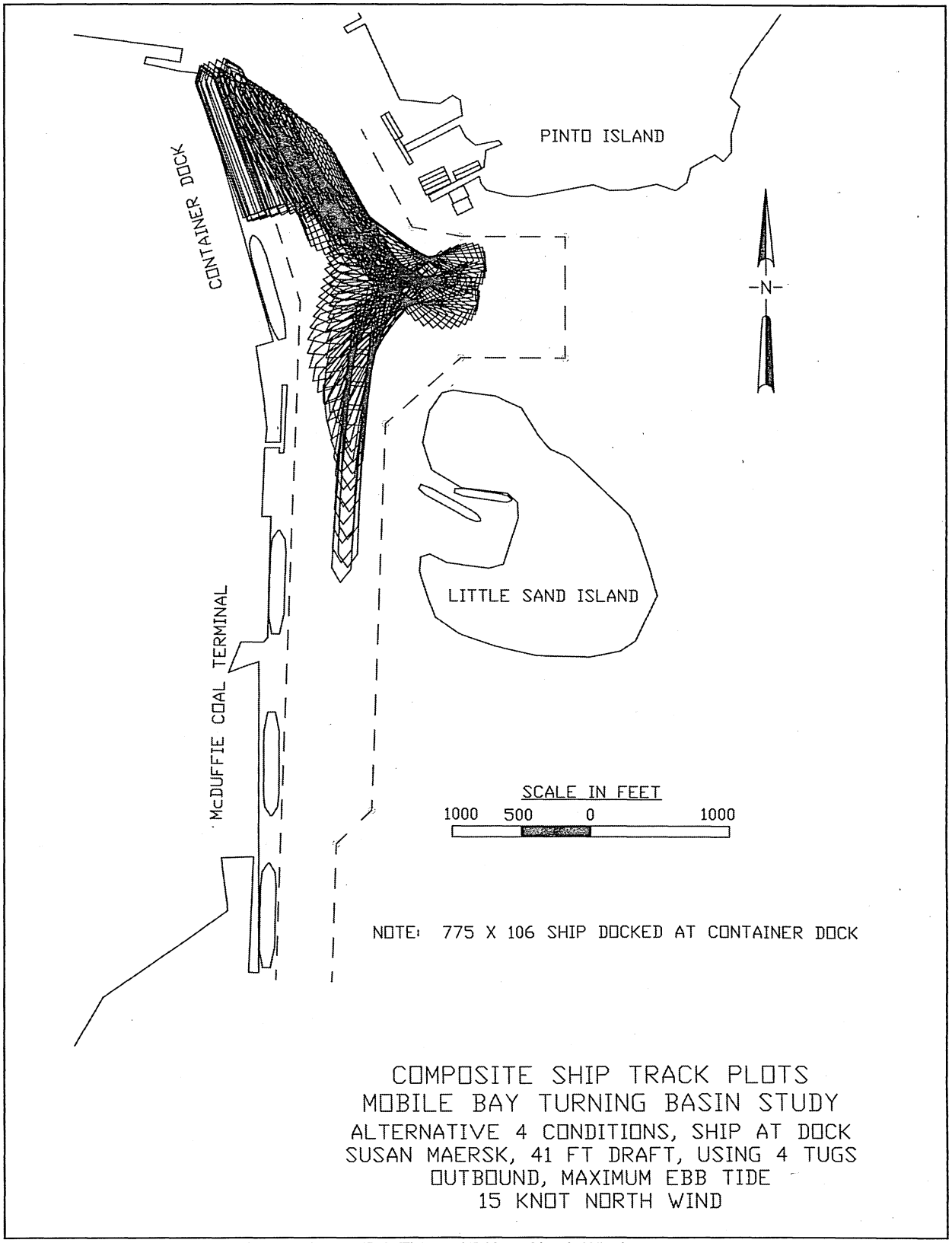

Plate 24. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

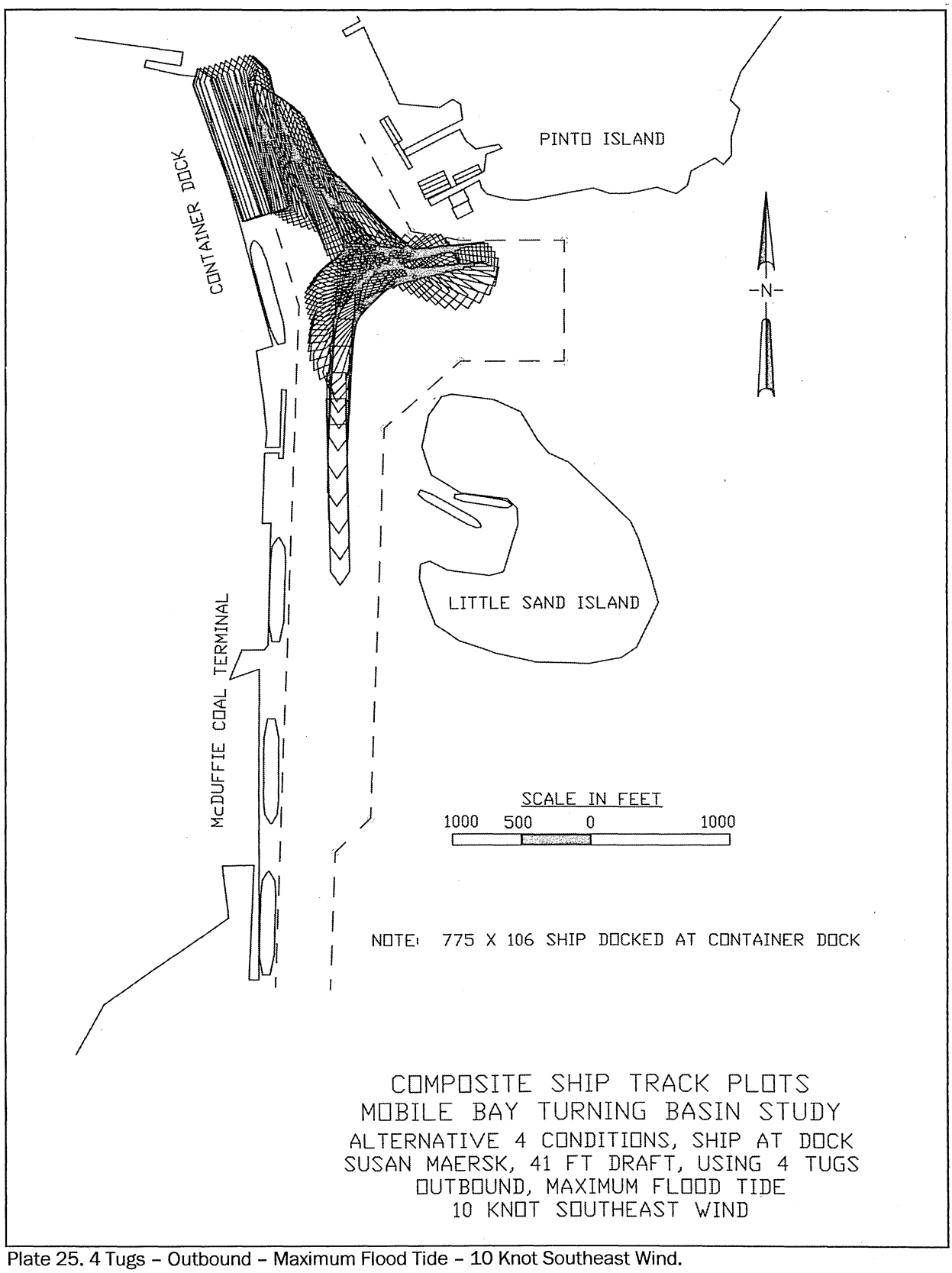

Plate 25. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

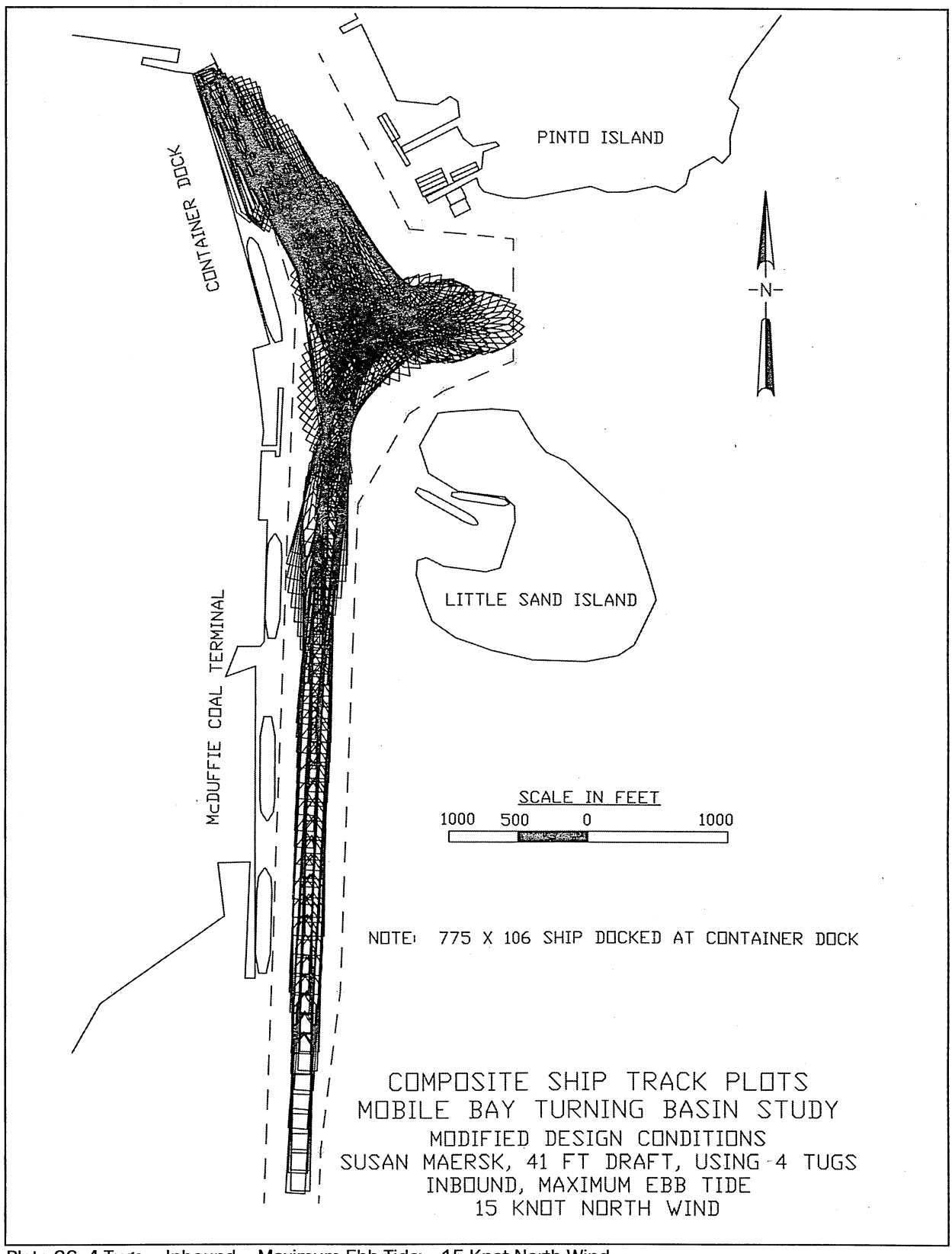

Plate 26. 4 Tugs – Inbound – Maximum Ebb Tide – 15 Knot North Wind.

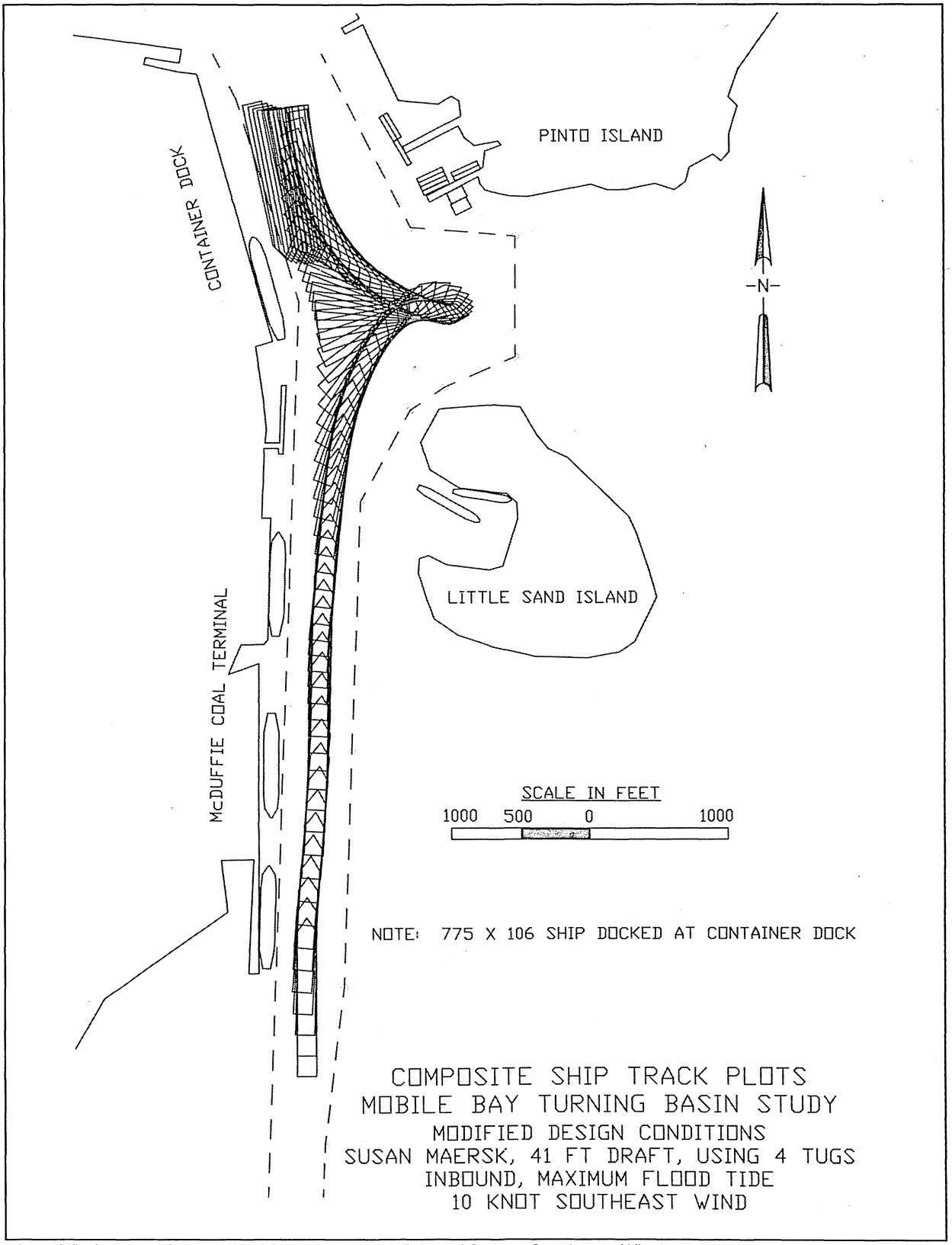

Plate 27. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

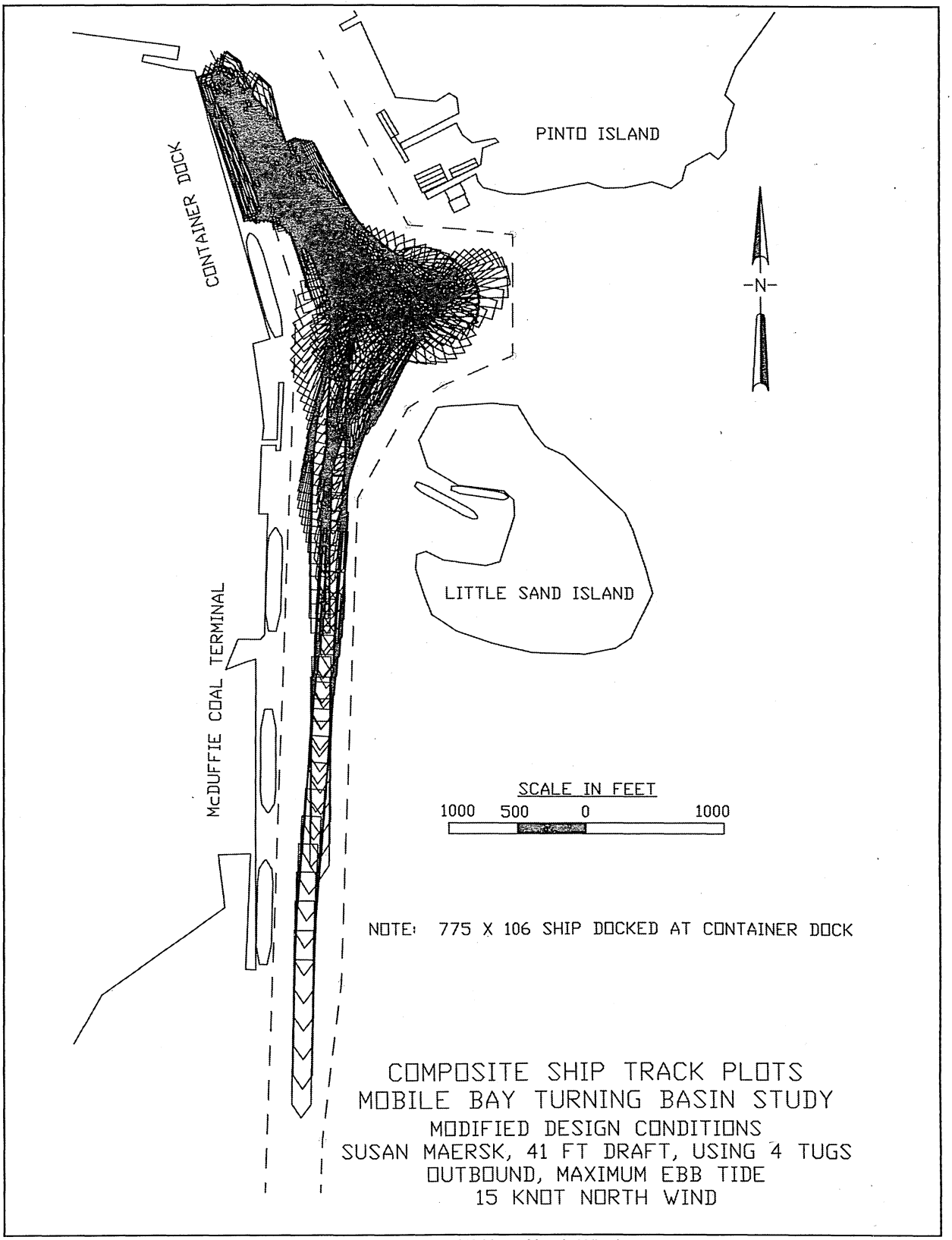

Plate 28. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

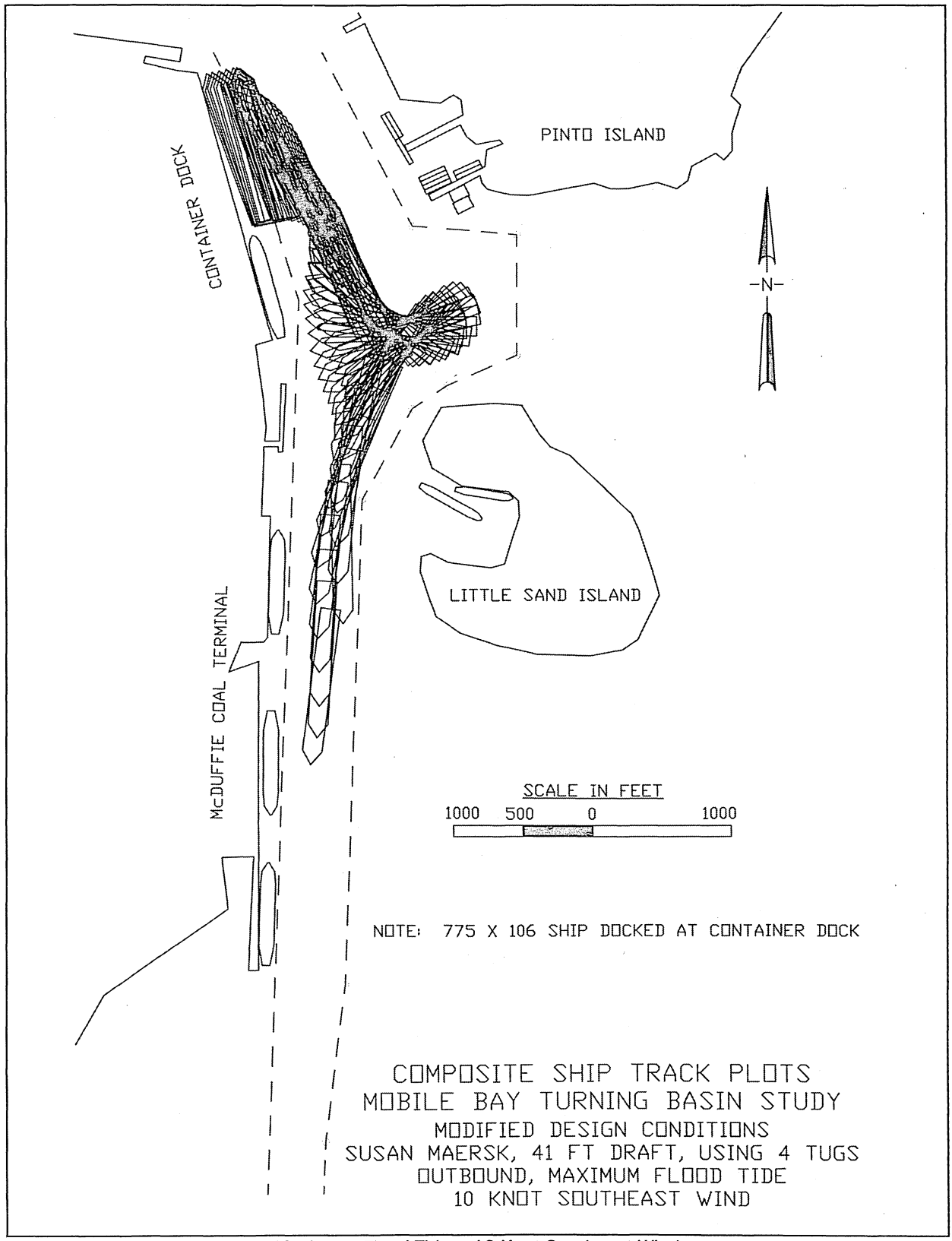

Plate 29. 4 Tugs – Outbound – Maximum Flood Tide – 10 Knot Southeast Wind.

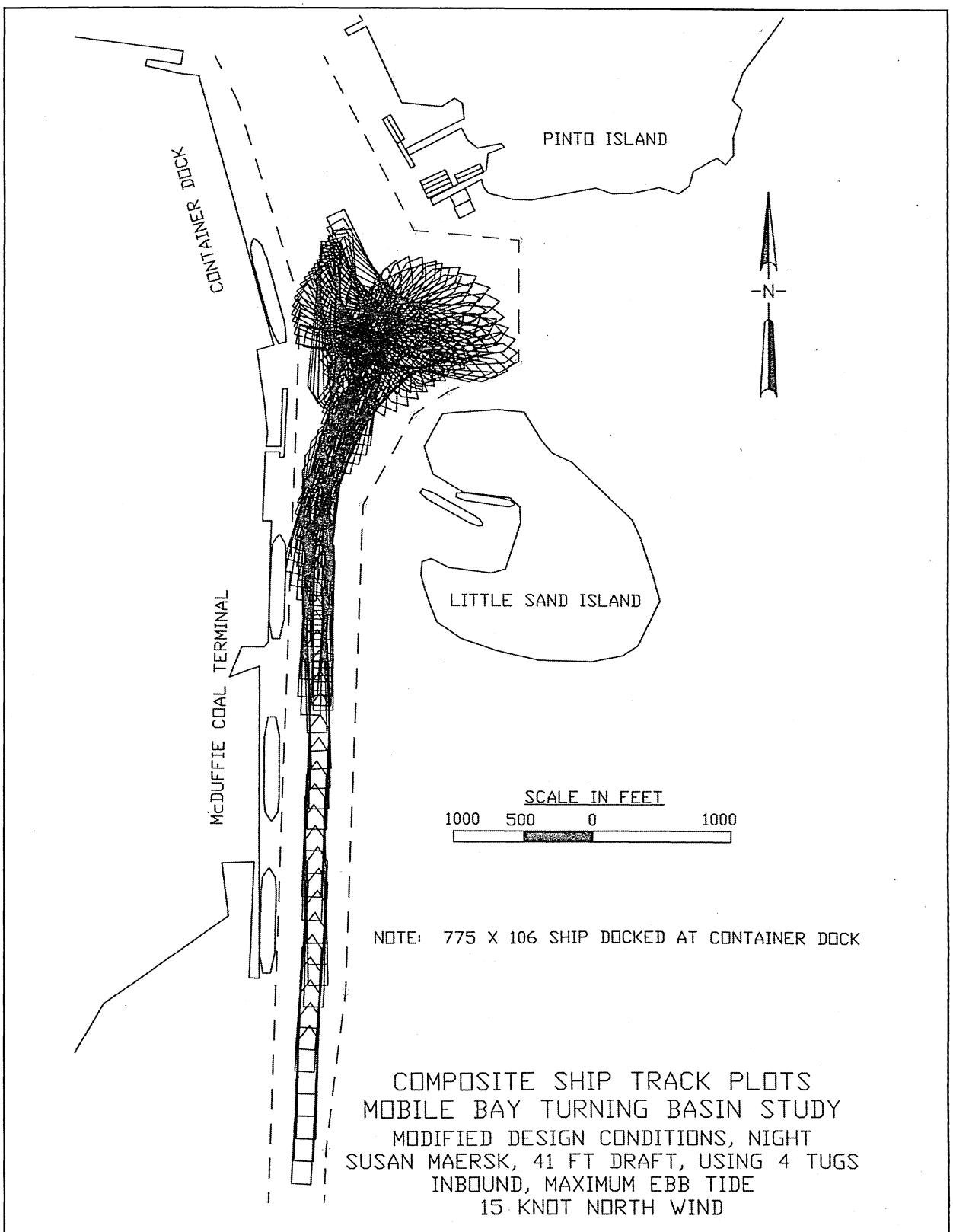

Plate 30. 4 Tugs – Inbound – Maximum Ebb tide – 15 Knot North Wind.

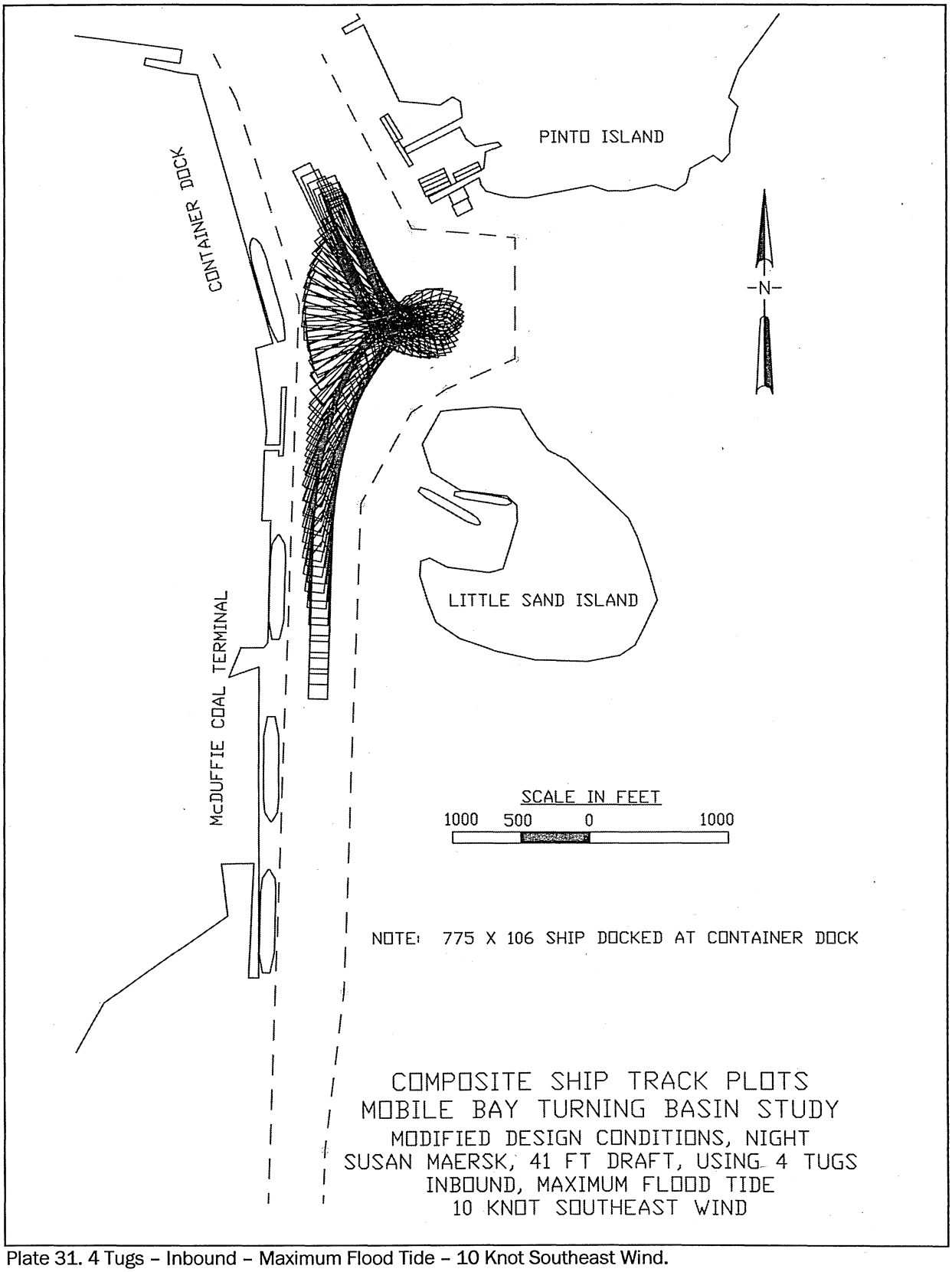

Plate 31. 4 Tugs – Inbound – Maximum Flood Tide – 10 Knot Southeast Wind.

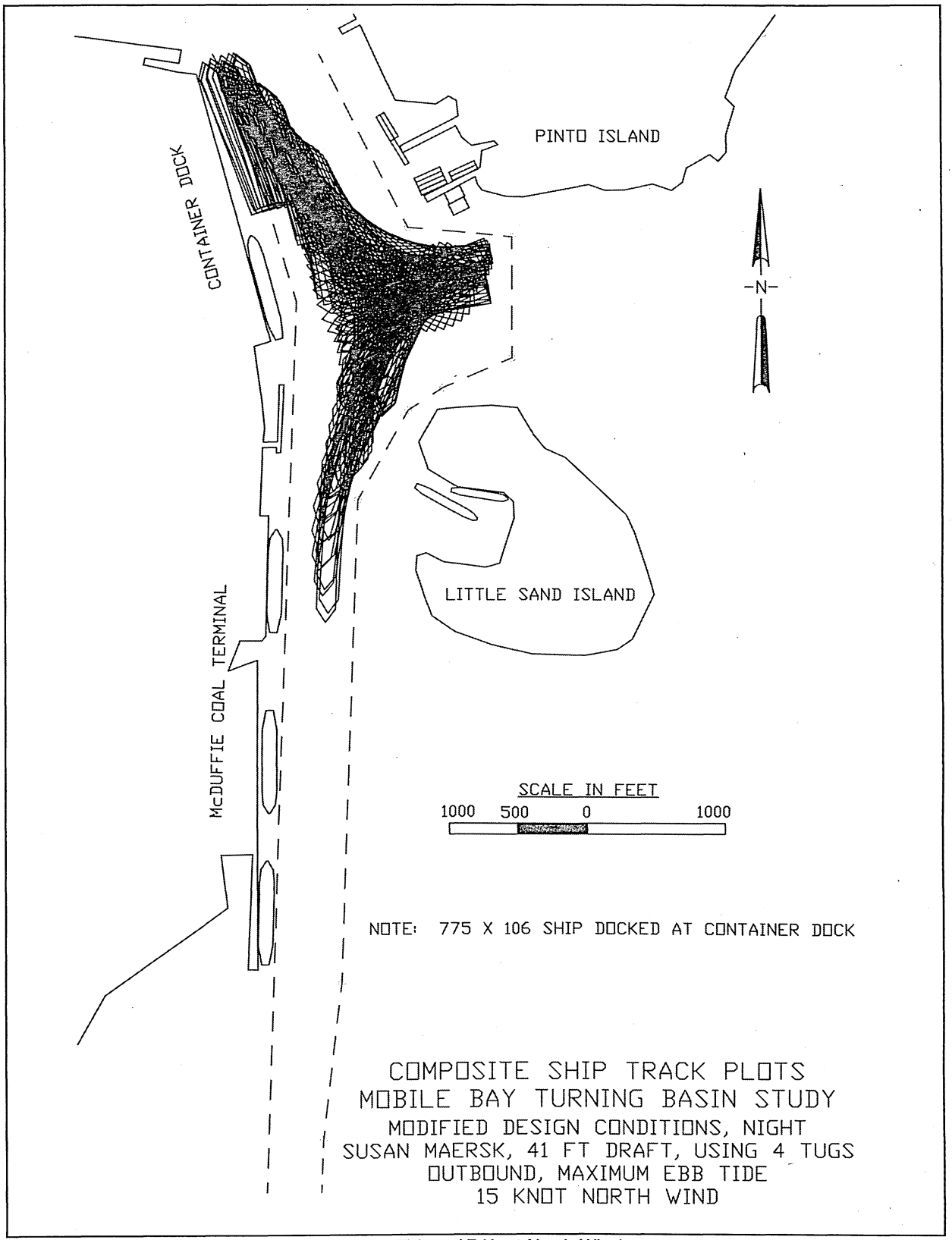

Plate 32. 4 Tugs – Outbound – Maximum Ebb Tide – 15 Knot North Wind.

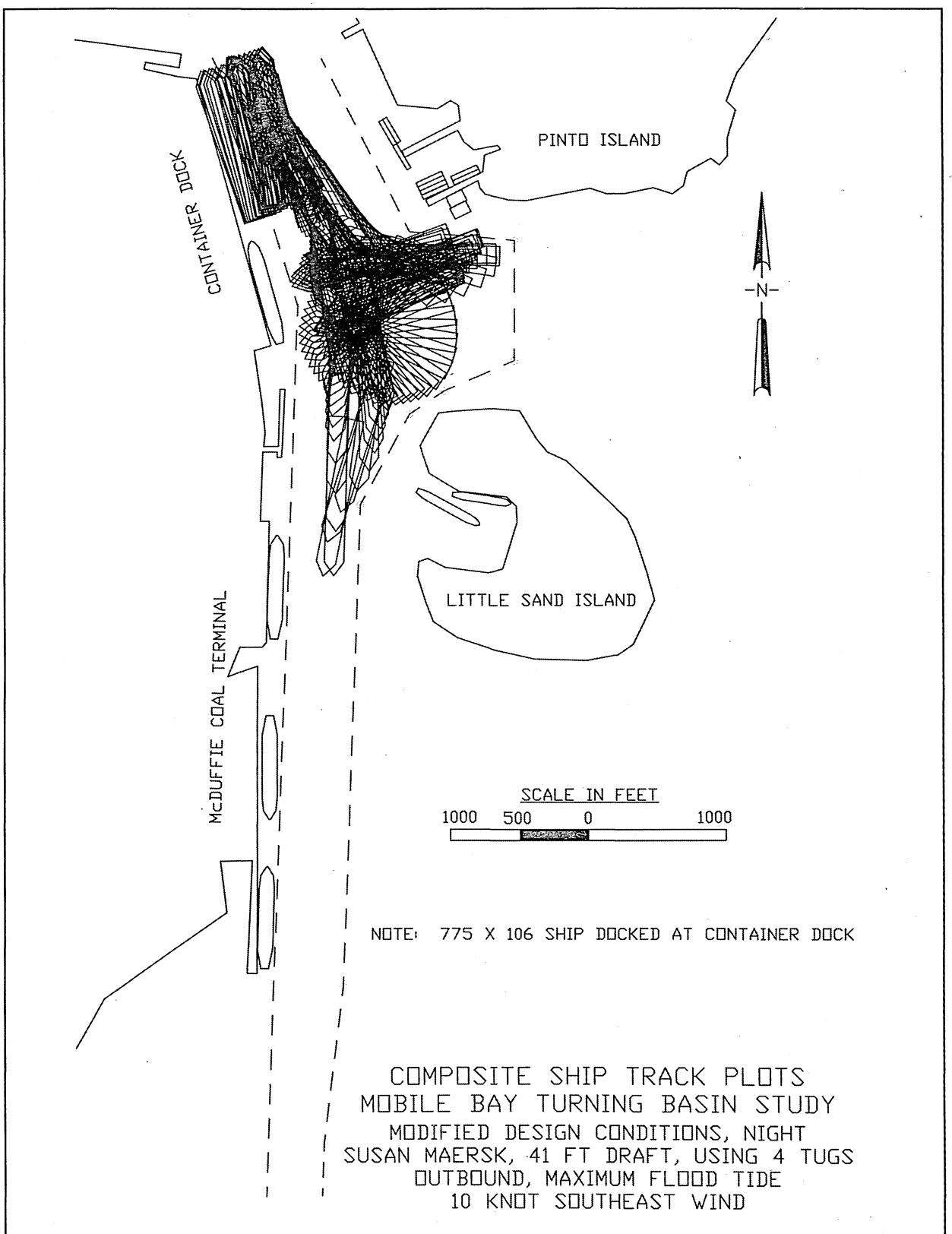

Plate 33. 4 Tugs – Outbound – Maximum Flood tide – 10 Knot Southeast Wind.

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4. TITLE AND SUBTITLE

Little Sand Island Turning Basin and Channel Widening, Mobile Bay, AL, Deep Draft Navigation Improvement Project

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5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Gary C. Lynch and Dennis W. Webb

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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U.S. Army Engineer Research and Development Center
3909 Halls Ferry Road
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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Mobile Bay is located on the southern shore of the state of Alabama. Little Sand Island is located on the north end of Mobile Bay, near the beginning of the Mobile Waterfront area. Little Sand Island is approximately 36 miles from the beginning of the Federal Channel. The Alabama State Port Authority proposes to construct a new container terminal on the northern end of McDuffie Island. The new container terminal will require a new turning basin on the east side of the Upper Reach, just north of Little Sand Island. Additionally, the northern end of the Upper Reach will have to be widened on the eastern side to ease the approach for ships entering the turning basin. To assist the U.S. Army Engineer District, Mobile (SAM), in evaluating various alternatives for the proposed turning basin and channel widening, the U.S. Army Engineer Research and Development Center (ERDC) conducted a navigation study utilizing real-time ship simulation modeling. Model development and online testing occurred at the ERDC Waterways Experiment Station (WES) in Vicksburg, MS, during the period from June to November 2006.

15. SUBJECT TERMS

Container terminal	McDuffie Island	Turning basin
Little Sand Island	Mobile Bay	

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
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