



**US Army Corps
of Engineers**
Waterways Experiment
Station

Ship Navigation Simulation Study, Brunswick Harbor, Georgia

by *Carl J. Huval, Gary C. Lynch*

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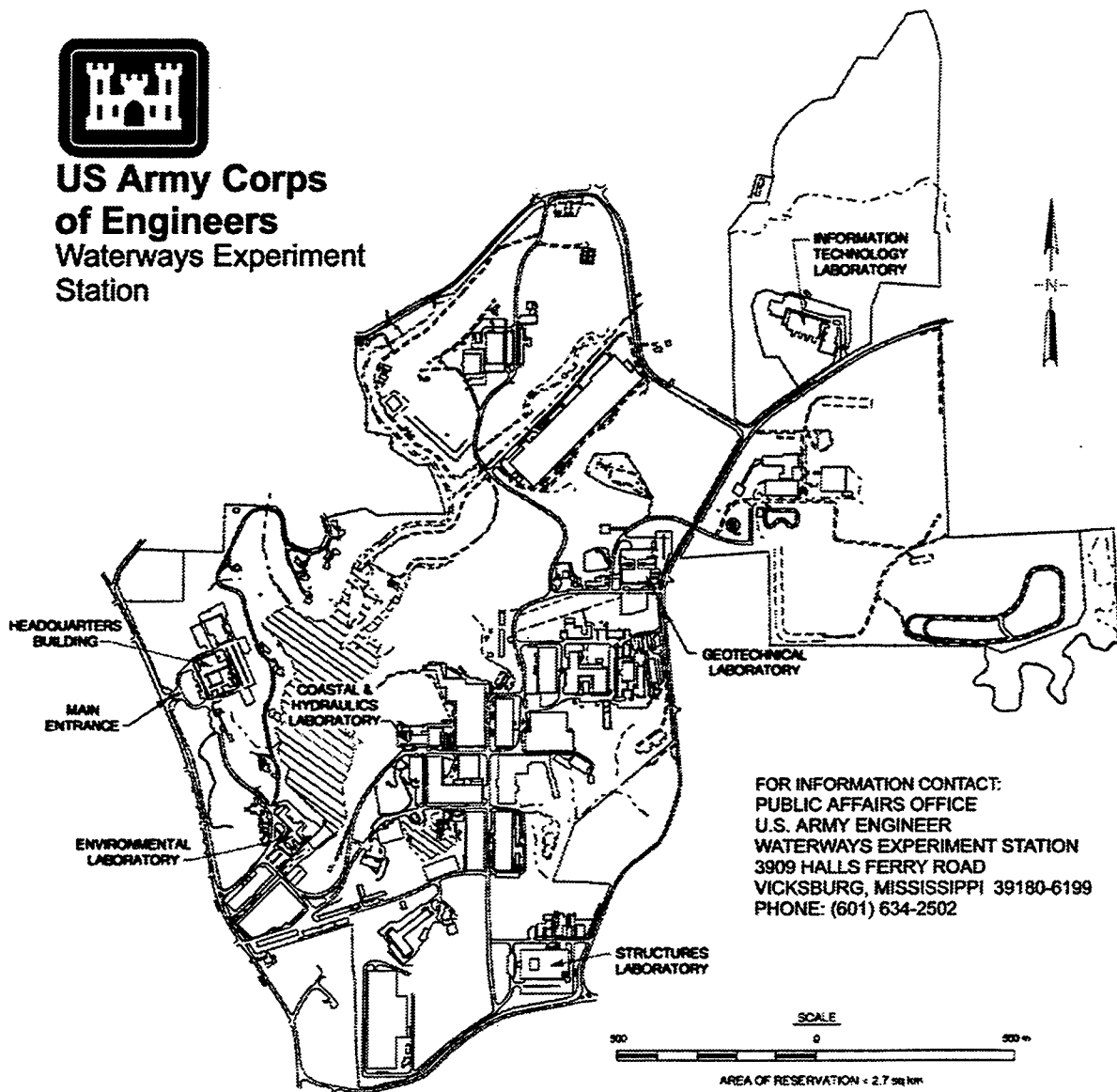
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Final report

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of Engineers
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Station**



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Preface

This investigation was performed by the Hydraulics Laboratory of the U.S. Army Engineer Waterways Experiment Station (WES) for the U.S. Army Engineer District, Savannah. This study was conducted with the WES research ship simulator and completed during October 1996.

This investigation was conducted by Mr. Carl J. Huval of the Simulation and Modeling Group, Navigation Division, Hydraulics Laboratory, under the general supervision of Mr. Richard A. Sager, Acting Director of the Hydraulics Laboratory, Mr. Bob Athow, Acting Assistant Director of the Hydraulics Laboratory, and Dr. Larry L. Daggett, Chief of the Navigation Division. Ms. Margaret Edris, Navigation Division, was the technical writer. This report was prepared by Messrs. Huval and Gary C. Lynch, Simulation and Modeling Group.

This report is being published by the WES Coastal and Hydraulics Laboratory (CHL). The CHL was formed in October 1996 with the merger of the WES Coastal Engineering Research Center and Hydraulics Laboratory. Dr. James R. Houston is the Director of the CHL, and Mr. Charles C. Calhoun, Jr., is Assistant Director.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

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Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
feet	0.3048	meters
miles (U.S. statute)	1.609347	kilometers

1 Introduction

Background

The Port of Brunswick, GA, is located on the Atlantic Ocean, 82 nautical miles north of Jacksonville, FL, and 104 nautical miles south of Savannah, GA on the east coast of the United States. A vicinity map of the study area is shown on Plate 1. The deep-draft port channels in Brunswick Harbor are used by ocean-going ships involving trade and associated manufacturing and processing firms which represent major economic activities in the Brunswick area.

Most of the port's waterfront facilities, docks, and terminals are located on the east bank of the East River opposite Andrews island in the City of Brunswick. Additional docks and terminal facilities have been developed along the south bank of the South Brunswick River at Colonels Island. The principal waterborne commodities handled at the seaport are seafood, wood pulp, salt, gypsum rock, petroleum products, and chemicals. In recent years, vehicle handling capabilities for automobiles and trucks have been developed at Colonels Island; a grain terminal is also under construction.

The harbor's navigable area includes a dredged entrance channel across the ocean bar to St. Simons Sound, which is a natural channel through the entrance between St. Simons Island on the north and Jekyll Island on the south. The channel continues through St. Simons Sound, Brunswick River, East River, Turtle River and South Brunswick River.

Tides and Currents

The tides in Brunswick Harbor (listed under St. Simons Sound in the NOAA tables) are typical of the East Coast of the United States; semi-diurnal with tidal cycles of 12.42 hours. The mean tidal range at St. Simons Light (according to the NOAA tables) is 6.6 ft and spring tide range is 7.8 ft. The mean tidal range increases at the upper end of the harbor and at Brunswick in East River it is 7.3 ft. Mean tidal level is 3.6 ft above mean lower low water (mlw) at St. Simons Light.

Maximum flood current in the entrance channel is 2.2 knots and maximum ebb is 1.6 knots.

Existing Conditions

The existing project provides for the following deep-draft channels (see map of channels on Plate 1):

- a.* 32 ft deep and 500 ft wide from the 32-ft contour in the Atlantic Ocean across the bar, joining naturally deep water in St. Simons Sound.
- b.* 30 ft deep and 400 ft wide through St. Simons Sound, Brunswick River, and East River to the Georgia State Docks in East River.
- c.* 27 ft deep and 350 ft wide in East River above the Georgia State Docks to the upper end of East River.
- d.* 30 ft deep and 300 ft wide in Turtle River from the vicinity of the Sidney Lanier highway bridge to near the Highway 303 bridge, which is the head of navigation for deep-draft vessels.
- e.* Local interests (Georgia Port Authority) have developed the Colonels Island dock and terminal area in the South Brunswick River with dredging at 30 ft depth and 300 ft width.

Table 1 presents the navigation channel project dimensions and the individual channel segment names and ranges. All depths refer to the plane of mean lower low water.

Navigation Problems

The areas of primary concern on the existing channel are in the East River Turning Basin, the Sidney Lanier Bridge highway lift bridge area, and the first channel turn seaward of the bridge. This area is shown to a larger scale on the map on Plate 2. The large tidal range (5-7 ft) is primarily responsible for the high currents which cause cross currents and affect maneuverability in channel turns and at side channel intersections. Skillful ship maneuvering by the local pilots is required to bring the ships stern-to on approaching the Colonels Island docks due to strong flood and ebb currents.

Table 1 Brunswick Harbor Navigation Project Dimensions				
Channel Segment	Authorized or Existing		PI Beginning Station	Inbound Course(deg)
	Width(ft)	Depth(ft)		
Bar Channel (St. Simons Range)	500	32	-50+000.000	303
Plantation Creek Range	400	30	-6+645.750	284-3/4
Jekyll Island Range	400	30	4+272.370	216-3/4
Cedar Hammock Range	400	30	14+464.540	255
Brunswick Point Cut Range	400	30	21+835.315	292-1/2
Lower Turtle River Range	300	30	35+500+/-	292-1/2
Colonels Island Range	400	30	45+068.550	278-1/2
South Brunswick River	400	30	2+753+/-	
East River (Brunswick Harbor) Range-Lower Reach	400	30	0+000.000	343-1/2
East River Range-Upper Rech	350	27	6+250+/-	343-1/2

East River is the main Brunswick Harbor channel and has a turning basin practically at the entrance and in close proximity to strong crosscurrents while turning into East River from Brunswick River. Plate 3 shows a detailed view of the existing highway bridge with 200 ft clearance and the turn angle of approximately 51 deg into the East River. Crosscurrent effects on a vessel just before moving into the shadow of Andrews Island during the approach to the basin require pilots to maintain speed. Therefore, slow maneuvering in the turning basin is difficult. In addition, a shoal area on the channel's east side at the entrance to the harbor develops rapidly further restricting maneuverability. Another navigation concern involves the transit of car-carriers through the entire channel during windy conditions. However, the other channel bends nearer the ocean and the entrance channel are not particular navigation problems.

Project Needs

In November 1985 the U.S. Congress authorized a feasibility study of navigation improvements at the Federal Brunswick Harbor Navigation Project. The Savannah District held a conference on December 13, 1990. As a result of that conference and of the comments from the Project Guidance Memorandum, it appeared only a limited two-foot deepening could be justified. So, the Georgia Ports Authority (GPA), the local sponsor, requested suspension of the study to allow development of more favorable economic conditions in the area and most recently to allow for resolution of the Sidney Lanier Bridge replacement. Due to

improved economic conditions in the area and funding commitments to replace the bridge, GPA has requested completion of the Feasibility Phase with a view of developing a four-foot project.

Proposed Conditions

The proposed project deepening will allow greater draft ships to call at Brunswick Harbor. Economic feasibility studies have been conducted for Brunswick Harbor which indicates three alternative depths of 32, 34, and 36 ft for evaluation. No general widening of the channel will be proposed.

The State of Georgia's project to replace the Sidney Lanier Bridge (now under construction, 1996) will have a horizontal clearance between piers of 1,100 ft. Plate 4 shows the conditions of the new high-level bridge after completion. The full channel width of 400 ft under the new bridge will reduce the maneuverability problems in making the turn into and from the East River. However, the design and placement of the turning basin relative to the bend will remain critical due to the crosscurrents at the turn. Therefore, the proposed project includes a considerable increase in the size of the East River turning basin and relocating it further north. This allows a greater distance for stopping the ship prior to turning and docking the ship port-side-to the East River docks.

The turning area downstream of Colonels Island Terminals at the junction of the Turtle and South Brunswick Rivers is naturally deep to 30 ft below mlw at the present time. Plate 5 presents the details of the existing area being used to turn the ships destined for the Colonels Island Terminals. In order to provide for the project depth of 34 ft below mlw, the turning area design will be developed as a part of the study.

Purpose and Scope of Work

Savannah District requested that the U.S. Army Engineers Waterways Experiment Station (WES) conduct a navigation study of Brunswick Harbor involving primarily real-time computer simulation experiments on the WES Ship/Tow Simulator and the necessary studies in support of the simulation experiments. These additional studies include the following: a field data study, a hydrodynamic current model, and training support for a sedimentation study.

The navigation simulation study was a) to determine channel and bend widening requirements throughout the channel based on simulator experiments with the design ships, and b) to determine the best design and placement of the East River turning basin.

Investigation of the navigation conditions (existing and proposed) was conducted using real-time piloted ship simulation experiments. A field data collection was undertaken to verify and adjust a numerical hydrodynamic model of the tidal currents and in the tidal sound and river system. A hydrodynamic model of the existing and plan conditions was developed and adjusted based on field data. Spring ebb and flood conditions were calculated for use in the ship simulator. Professional pilots from Brunswick participated in the simulation experiments. The project included the development of two hydrodynamic models of design ships for experimenting due to the different navigation concerns associated with each ship type. The exact dimensions were determined through an economic study by the District. The two ships were (1) a car-carrier for analyzing the South Brunswick Channel leading to the existing Colonels Island car facility, and (2) a bulk carrier for analyzing the East River channel and turning basin. Simulations included experiments of the design ships in the remainder of the channels and the existing and proposed channel alternative. Details of the experiment condition combinations are presented on Table 2. The study scope **did not** include channel deepening in Turtle River above the Brunswick and South Brunswick Rivers junction; therefore, no simulations were conducted in the upper end of the project channels.

Table 2 Definitive Pilot Testing Plan Test Condition Matrix, June-July 1996								
No	Test	Tide	Transit	Scenario	Depth	Ship	Draft	Turn?
1	Base	Flood	Inbound	East River	30+3	Bulk Carrier	30	Yes
2	Base	Flood	Inbound	Colonels Is.	30+3	Car Carrier	30	Yes
3	Prop.	Flood	Inbound	East River	34+3	Bulk Carrier	34	Yes
4	Prop.	Flood	Inbound	Colonels Is.	34+3	Car Carrier	30	Yes
5	Base	Ebb	Inbound	East River	30+3	Bulk Carrier	30	Yes
6	Base	Ebb	Inbound	Colonels Is.	30+3	Car Carrier	30	Yes
7	Prop.	Ebb	Inbound	East River	34+3	Bulk Carrier	34	Yes
8	Prop.	Ebb	Inbound	Colonels Is.	34+3	Car Carrier	30	Yes
9	Base	Flood	Outbound	East River	30+3	Bulk Carrier	30	No
10	Base	Flood	Outbound	Colonels Is.	30+3	Car Carrier	30	No
11	Prop.	Flood	Outbound	East River	34+3	Bulk Carrier	34	No
12	Prop.	Flood	Outbound	Colonels Is.	34+3	Car Carrier	30	No
13	Base	Ebb	Outbound	East River	30+3	Bulk Carrier	30	No
14	Base	Ebb	Outbound	Colonels Is.	30+3	Car Carrier	30	No
15	Prop.	Ebb	Outbound	East River	34+3	Bulk Carrier	34	No
16	Prop.	Ebb	Outbound	Colonels Is.	34+3	Car Carrier	30	No

2 Simulator Data Development

Two ship simulator experiment scenarios were developed which extended from near the channel entrance at the sea buoy to either (1) the upper end of the East River, or (2) the Colonels Island Terminal on the South Brunswick River. Since the entrance channel was not considered particularly difficult, limited training type experiments were performed in that region. The main focus of the study concentrated on the region starting about halfway up the Jekyll Island Range. Both inbound and outbound transit experiments were conducted, but most outbound transits were terminated once the ships were beyond the Sidney Lanier Bridge.

Tidal Current Modeling

A substantial portion of the total Brunswick Harbor navigation study consisted of a field data collection effort and a numerical hydrodynamic model of St. Simons Sound, the connecting river systems, and the adjacent Atlantic Ocean shelf area. The tide elevation and current field data results were used to verify and adjust the hydrodynamic model. The model was driven on the ocean boundary with a representative 30+ day tide to give an average lunar month in the study area. The model used the FasTABS modeling interface and the TABS-MD two-dimensional open channel, unsteady flow equations to calculate the tides and currents on a finite element grid that represented the water surface. After model verification and adjustment, the model was used to produce channel depths and currents for installation in the ship simulator for both the existing and proposed channels (deepened to 34 ft depths).

The tidal currents, as implemented on the ship simulator, are presented on Plate 6 for flood tide in the existing channel conditions and on Plate 7 for the ebb tide in the existing channel conditions. There was negligible difference in current conditions in the study areas between the existing and proposed conditions.

Channel Data

Channel depths and cross sections were developed from field hydrographic surveys conducted in June, July, and August 1994 (Annual Survey Sheets--1995). These surveys were conducted along the channel at intervals of about 500 ft. State plane coordinates were used to define all databases developed.

Visual Scene

The databases to drive the computer-generated visual scene were created partially under contract with Computer Explorations, Inc, Huntsville, AL, as well as in-house by the ship simulator team. The state plane coordinate system was also used to locate the visual 'world' in the simulator. Still photographs obtained during a site-visit and two on-board ship transits were used extensively in developing the visual scene. All aids-to-navigation including buoys, channel markers, range markers, and other objects were located in the visual scene as they existed in 1996. Other visible objects, such as docks, towers, and tanks used by the pilots were also located in the visual scene.

Radar

A radar database was also developed to drive the simulator radar for use by the pilots. These consist of land/water boundaries, all aids-to-navigation that usually have strong radar echoes, and other man-made objects which are visible from a typical ship-board radar. It is very important that the radar and visual scene be consistent in order to avoid conflicting visual cues which would confuse the pilots. A large, 1/4 mile range radar view is also used by the pilots in conjunction with the tug control touch screen in providing pilot feedback on tug force magnitude and direction.

Design Ships

The Savannah District has conducted a review of ships using the existing Brunswick Harbor project and coordinated with the local pilot group and other proposed project users to determine the existing and proposed project design ship characteristics. Based on this study, two ship models were devised and the hydrodynamic coefficients developed for use in the ship simulator. The following table presents the ship characteristics as used in the ship simulation experiments.

Project Conditions	Ship Type	Length (ft)	Beam (ft)	Draft (ft)
Existing	Bulk Carrier	660.0	105.6	30.0
Existing	Car Carrier	653.2	105.6	30.0
Proposed	Bulk Carrier	660.0	105.6	34.0
Proposed	Car Carrier	653.2	105.6	30.0

Because of channel depth limitations of 30 ft, ships calling at Brunswick Harbor presently are limited in draft. Pilots presently operate by waiting for high tide levels if necessary to allow maximum ship loading to ship drafts up to about 30 ft and still maintain 3 ft of underkeel clearance. The present operational practice of waiting for high tide (tidal advantage) to bring in maximum loaded ships was assumed to continue with the deepened channel to 34 ft.

3 Navigation Study

Four professional pilots from Brunswick Harbor participated in the simulation study. Table 2 (see page 6) shows the combination of conditions used to analyze the navigation channels. The following parameters were varied:

- a.* Base (existing) channel or proposed, deepened channel--from 30 ft +/- or 34 ft, respectively.
- b.* Flood or ebb tide--maximum tide currents during a typical spring tide.
- c.* Ship transit sailing direction--either inbound or outbound (inbound transits included ship turning operation).
- d.* Experiment scenario--either East River docks or Colonels Island terminal area.
- e.* Channel depth--existing channel 30 ft depths with 3 ft tidal advantage or proposed channel 34 ft depth with 3 ft tidal advantage.
- f.* Ship type--bulk carrier into or from East River or car carrier to or from Colonels Island terminal.
- g.* Ship draft--the bulk carrier was loaded either to 30 ft or 34 ft, depending on the channel depth but the car carrier draft remained at 30 ft.

4 Study Results

Ship Track Plots

The study results consisted of ship track plots of the simulator runs, because these demonstrate in a straightforward way the results of the experiments. For purposes of discussion and ease of comparison, the total length of the channels is divided into the Outer Harbor Area, the East River Area, and the Colonels Island Area. Simulator results are discussed and compared between the existing project and the proposed project conditions, including the new Sidney Lanier high-level highway bridge. The Entrance Channel region was not examined in detail, because the District has no plans to change the channel configuration in that area (except to deepen by 2, 4, or 6 ft), and after limited experiments the pilots and trackplots indicated no further runs were needed.

Outer Harbor Turns

There are two turns located at channel markers R "22" and R "24" which had been identified by the local pilots as difficult to maneuver around due to strong crosscurrents, Plate 2. The District had already improved the turn at R "22" by dredging an additional cut of 330 ft on the inside of the turn. Part of the study purpose was to investigate the need for another cut at turn R "24". Those ship track plot results are presented in Plates 8-11 and are divided into four combinations of ship transit directions (inbound or outbound) and tidal current direction (flood or ebb tide). All the ship track flood tide results on Plate 8 (except for one inbound) were within the channel limits of the 400 ft wide channel. The inbound transits appear to be more difficult than the outbound runs, showing greater variability towards the landward end of both turns. All ship tracks on Plate 12 show that the ship tracks near R "24" are within the channel limits.

East River Results

Ship track experiment results on Plate 13 (existing) and Plate 14 (proposed) are shown for inbound transits, flood tide. The main differences in the two channels are the turning basins' location and size and the new, high-level highway bridge's horizontal clearance is increased from 200 ft to the full channel width of 400 ft. Plate 13 shows that the pilots had no trouble maneuvering through the bridge. The only problem with the proposed bridge, Plate 14, is the encroachment on the northeast corner of the junction, after successfully navigating the bridge. This can be remedied by the placement of another navigation aid in this area.

The inbound transits for ebb tide ship track plots for existing and proposed channel/highway bridge conditions are shown on Plates 15 and 16, respectively. The turn ship track plots show that the ebb tide current for the existing condition tends to cause the ship to drift into the northeast corner of the turn. The results for the proposed channel indicate somewhat better control in making the turn.

The outbound runs for flood tide in the existing channel and highway bridge (Plate 17) are considered difficult since the ship needs to turn into the strong crosscurrent. Plate 18 also shows significant drift to the southern channel edge. Some of this can be attributed to the need to develop a plan of approach for the new channel.

At the present time, outbound ship transits on the ebb tide require the very complicated procedure of bringing the ship upstream into the Brunswick and Turtle rivers junction area, which allows a longer, straighter approach into the 200-ft clearance at the existing bridge. Local pilots do not conduct this maneuver, preferring to wait for more favorable tidal current conditions. For comparison, a direct outbound turn maneuver was conducted on the simulator to compare with the 400-ft channel clearance with the new bridge configuration. The ship track plots for these two conditions (Plates 19 and 20) show that this outbound, ebb tide maneuver can probably be safely done with the new bridge and proposed channel conditions. The ship tracks for the proposed condition show greater variability than for the existing channel/bridge with one track straying into the northeast corner at the East River turn.

Turning Basins

The ship tracks of all turning maneuver experiment runs in the existing and proposed turning basins are summarized on Plates 21 and 22, respectively. The existing 1,000-ft-long by 750-ft-wide turning basin provides 90 ft of clearance for the 660-ft-long design ships being turned and is inadequate. Because the present turning basin is located opposite a frequently used dock, the situation with a docked ship presents major difficulties. By contrast, the new turning basin is 1,100 ft long by 1,100 ft wide and provides much greater maneuvering room to

turn the 660 ft design ship, as can be seen by the composite experiment results on Plate 22. The tracks suggest that the pilots tended to start their turning operations too early; i.e., south of the beginning of the turning basin cut. The ship tracks show this can be easily rectified by more careful operations, because there is ample room on the turning basin's north end.

Colonels Island Turning Area

Ship track plots of the car carrier turning maneuver on approach to the Colonels Island terminal area for the existing channel condition are shown on Plate 23. The Brunswick, South Brunswick, and Turtle Rivers junction area is naturally deep and is presently used to turn the car carriers so they can be backed into the terminals in a starboard side-to position to accommodate the ship ramps. The turning operation is conducted with the ship bow thrusters and one tug to help control the ship. The strategy is governed by the tidal current direction (whether flood or ebb) and the fact that there is a strong tidal current component towards and from the Turtle River in flood and ebb, respectively. Thus, the pilot strives to keep the ship on the south bank on flood to counter the tendency to pull the ship towards Turtle River and also start the turning maneuver well east of the junction due to the flood current drift. This is evident from the ship track plot results shown on Plate 23. Comparison with the proposed channel conditions is shown on Plate 24, indicating very similar strategy and resulting ship tracks.

Plate 25 shows ship track experiment results with the existing channel under ebb tide conditions. The strategy on ebb is to start the turn close to the junction and keep the ship away from the south bank. Both turns are made in a clockwise rotation. The ship simulator tidal currents are for flood and ebb strength and, thus, are judged to be a real challenge to the pilot's control and judgement. Ship track plot results for the proposed channel under ebb tide current conditions are shown on Plate 26. The same car carrier ship with the same 30 ft draft was used in the existing and proposed channel conditions with only the channel area deepened by 4 ft. The results of both experiments are mainly controlled by the current direction and, therefore, can be combined as was done on Plates 27 and 28 for flood and ebb, respectively.

The simulation ship track plots indicate some difficulty in judging proper ship location with respect to channel edges. The proposed channel condition plot shows similar ship turning strategy with the car carrier sterns extending well beyond the channel limits on the southern edge. The difference in the ebb tide ship track results (Plate 28) is apparent where the ship is held on the northern edge of the turning area and the turn started closer to the eastern edge of the available turning area. The total composite ship tracks for turning covers an area about 1,000 ft wide across the channel and extends a distance of approximately 3,500 ft along the channel. The degree of difficulty is due to the strong currents and the drift experienced by the turning ships while the pilot turns the ship.

Outbound Runs

Several outbound simulation runs were made of the car carrier outbound from the Colonels Island terminal area and through the existing or new highway bridge. Plate 29 shows these results and that this transit is fairly straightforward, posing no particular difficulty. No changes in channel design are needed.

Recommended Design for the Colonels Island Turning Area

As shown on Plate 5, the natural channel depth in the Colonels Island turning area is generally at least 30 ft with some areas up to 35 ft. Using the channel depth contours and the composite ship track envelopes as guides, it is possible to devise a turning area which can be used as a proposed turning basin, Plate 30. The recommended turning area would be deepened to the proposed channel depth of 34 ft to accommodate the car carriers for any tide phase, thus reducing tidal delays. In addition, access would be provided for the possible development of bulk terminals in the Colonels Island area, such as grain terminals. Plate 31 shows the composite car carrier turning ship tracks with the superimposed recommended turning area limits. This shows that some of the turning operations resulted in ship tracks drifting beyond the recommended turning area, but probably can eventually provide adequate operational capability. Marking the recommended turning area with buoys or channel markers should be considered in consultation with the local pilots and the Coast Guard.

Pilot Evaluations

All four pilots were very helpful and positive about the study and contributed invaluable input into the simulations. Based on questionnaires filled out at the end of each pilot's experiment sequences, the three pilots rated the WES Simulator at 8.5, 9.5, and between 8 to 10, on a scale of 1 to 10, with 10 representing the highest realism. The ship model, simulator display, and the environmental conditions (wind, current, channel banks) were all given high marks. Verbatim quotes from the questionnaire questions relative to the Brunswick Harbor study are given below:

Please provide your evaluation of the proposed Brunswick Harbor Navigation Project, based on your simulator runs.

1. Do you feel that the proposed 400 ft wide, 34 ft deepened channel is adequate?

We can certainly handle a lot deeper ships than we are now serving. We are still way behind neighboring ports who offer 38 to 42 ft depths and are

planning now to go deeper, but we can use and appreciate any improvements.

Yes, under simulated conditions. Adverse conditions or passing conditions, 400 ft might be questionable.

Yes, it is adequate. Hopefully, COE specs for rock will be applied in order to provide overdredge in certain areas.

2. Do you feel that the proposed, relocated 1100 ft wide, 1100 ft long turning basin in East River is adequate?

Yes, it is a vast improvement over the existing turning basin. Safety is greatly enhanced by location and size.

Yes, for the proposed size vessels of 660 ft or less or a little larger.

Yes, this proposed basin is very nice. It will enhance safety in the East River area more than any other proposed improvements.

3. Can the proposed 1,100-ft-wide by 1,100-ft-long turning basin be safely reduced? Please explain with a sketch, if necessary.

We would recommend nothing less than Corps standard design criteria applied to the largest vessel projected to use this port area.

(Unless reduction is needed to make the project feasible.) No, the size will be needed for future vessel growth.

No, when the future class of ships likely to call at Brunswick (650 ft--750 ft) are considered along with the project completion date. In other words, the fleet for Brunswick will likely grow long before project dimensions for the East River and the proposed basin will carry us many years into the next century!

4. What should be done with the existing East River turning basin? Should the two green corner markers be moved? How should the new turning basin be marked?

We would not expect it to be maintained, other than the channel width passing through it; but there will be times smaller ships can use it more safely and quicker to turn around from the Marine Port Terminal area.

The two green markers should stay as long as the basin is useable. Hopefully, the Corps could maintain this basin to some degree is not

100%. [The new basin should be marked] at least similar to the old one; with markers in the corners.

The existing basin should be kept if possible--maybe even at reduced depths. The new basin could be marked in a similar manner as the old.

5. Do you see any problems in the proposed deepened channel into Colonels Island terminal? Should the channels be modified? Explain with a sketch, if possible.

The existing 10 deg right turn in the South Brunswick River needs to be straightened out all the way to the Turtle River turning basin. A widener at the mouth would improve safe entry.

The turning basin should be modified in shape and in such a manner to accommodate dredging and maintenance as well as ship handling. The 400 ft wide channel into Colonels Island might be considered for another 100 ft of widening.

Not at this time.

6. What is your opinion of the proposed deepened channel seaward of the new high-span highway bridge?

I believe some study needs to be given to the possibility of need for wider turn area, particularly at buoy # 24.

My opinion [-----] is they will be adequate as long as they are maintained to allow the deeper traffic to successfully utilize deeper water. In other words, if the Georgia Ports Authority continues to remove funds from Brunswick Harbor budget or they are allowed to continue this practice the new channels may not be used to capacity, or at least not very often.

They seem to be adequate.

7. Any additional comments on the navigation project?

All pilots and many ship captains that call regularly to Brunswick are very excited about this project. Many people on shore connected with the shipping companies feel the same way. Brunswick has not had a deepening project since 1958; it is sorely needed to support the current ships using the port now.

Is this project planned with future deepenings in mind or long range planning for the harbor from an engineering standpoint? Is there a long term plan for Brunswick? ([This question] could be directed at GPA.)

I am hopeful the project can begin as soon [as the] design/study is completed. Also, if the Georgia Port Authority can find available funds for additional deepening.

8. Do you expect to change your strategy in approaching the new high-lift highway bridge? Will the outbound left turn from East River through the bridge be easier? Will the bridge approach widener still be necessary with the new highway bridge? Please explain, with a sketch if necessary.

#1. Yes, we will be able [to] make a more reasonable controlled type turn in and out from the East River.

#2. Yes, by many multipliers.

#3. I am not prepared to say at this time that the widener is no longer needed. I would suspect so, but I don't want to see it discontinued at this time.

Yes, my strategy will change. It will be a learning process. The outbound turn will be much safer and easier. The widener for outbound moves probably would not be necessary except maybe reshaping of Brandy Point to accomodate vessels moving from East River to Colonels Island.

I will change my inbound approach and start turning below the bridge. The outbound turn from East River is not even legally possible at this time! Considering the currents at the junction of East and Turtle Rivers, the widener may prove necessary.

5 Conclusions and Recommendations

Conclusions

As a result of the navigation simulation study results presented and discussed in this report, the following conclusions are derived:

- a.* No apparent navigation problems were found in the two large channel turns seaward of the highway bridge.
- b.* Tidal currents cause major difficulty in turning ships into the East River from Brunswick River, compounded by the close proximity of the present turning basin.
- c.* The present (existing) turning basin in East River is inadequate for turning the 660 ft long break bulk project design ships presently calling at Brunswick Harbor.
- d.* The proposed, enlarged turning basin located further north in East River will allow greater ship speed and provide better control in the turn into East River. The turning basin will provide ample room to maneuver the 660 ft long design ship as well as any economically plausible future ships calling at Brunswick Harbor.
- e.* The removal and replacement of the present lift-span Sidney Lanier highway bridge with a high level span and full channel width clearance under the new bridge in the immediate proximity to the turn into East River is a major improvement to safe and efficient navigation in Brunswick Harbor.
- f.* The simulation experiment results showed that the pilots apparently have some difficulty in negotiating the right turn from the new high-

level highway bridge into the East River, because the ship track plots showed a tendency to cut across the northeast corner of the turn area.

- g.* The present turning area serving the Colonels Island terminal area is adequate for the car carriers and other ships with drafts up to 30 ft; to accommodate deeper draft ships up to 34 ft will require turning basin improvements.
- h.* The full size of the turning area into East River is needed, because ship piloting strategy is so different for flood or ebb tide and depends on ship transit direction.

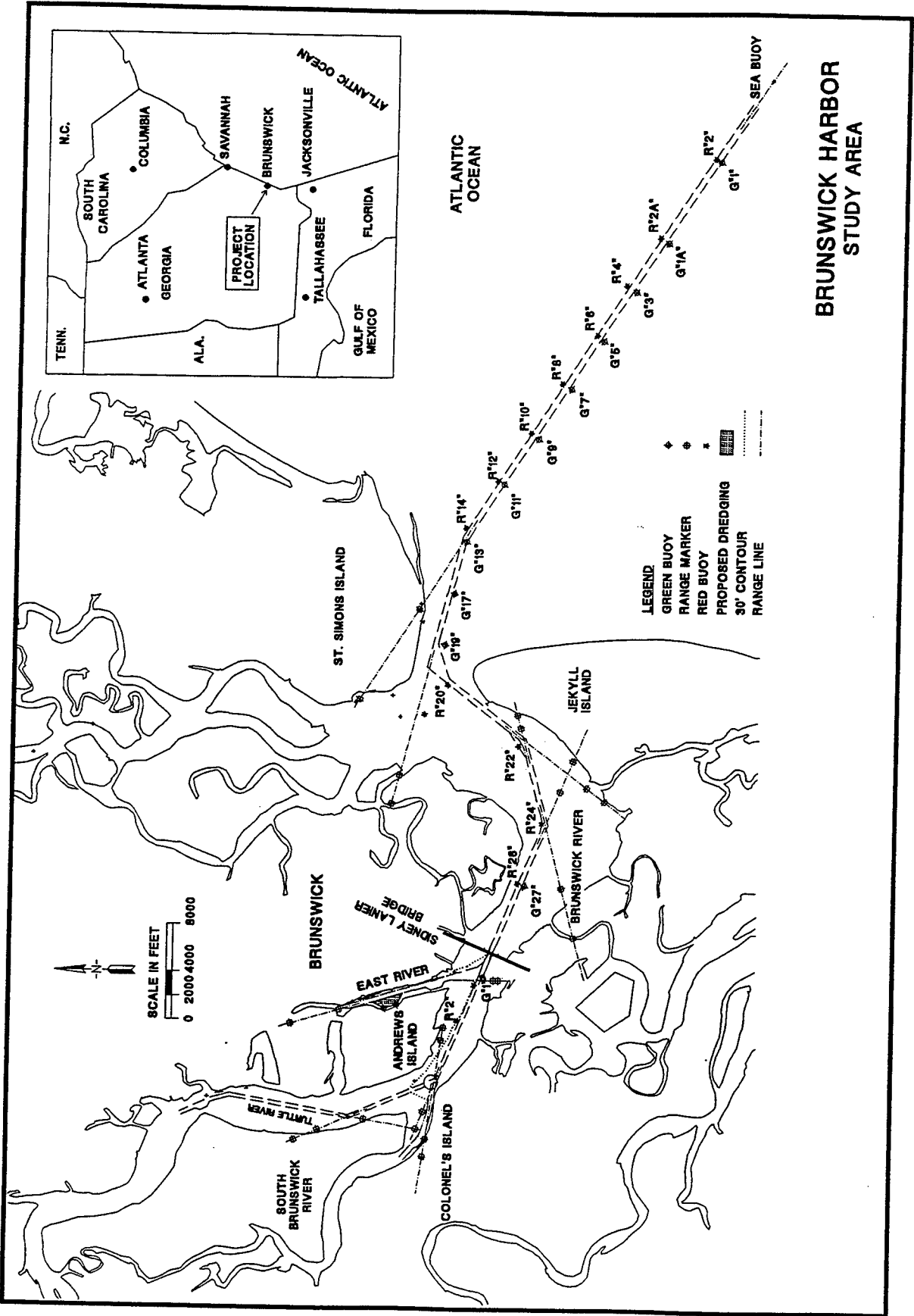
Recommendations

The following recommendations are presented as a result of the navigation simulation study and experiment results presented:

- a.* The proposed project deepening to 32, 34, or 36 ft in Brunswick Harbor will provide safe and efficient navigation.
- b.* No width changes are recommended in the channel turns seaward of the highway bridge other than that required from the proposed depth increase.
- c.* The proposed East River turning basin is strongly recommended; reducing the size from the proposed 1,100 ft to 900 ft may be considered, if project economics requires, especially if increased basin size is predicated for later construction on increased trade and ship sizes.
- d.* The existing turning area at the junction of the Brunswick and Turtle Rivers serving the Colonels Island terminal area is apparently naturally deep to 30 ft. With the proposed channel deepening to 32, 34, or 36 ft, a new recommended plan shown on Plate 30 is presented which is based on the simulated car carrier turning experiment results. This will be especially important when car carriers are loaded deeper than 30 ft and the tide height is low. If bulk carriers requiring drafts up to 34 to 35 ft start operations into Colonels Island, the recommended turning area should provide adequate room for turning those ship also. Additional channel markers may improve the usability of the recommended turning area to service Colonels Island terminal.
- e.* One additional channel marker is recommended on the northeast corner of the turn from Brunswick River into East River with the proposed channel and new highway bridge. Consultations with the pilots and the

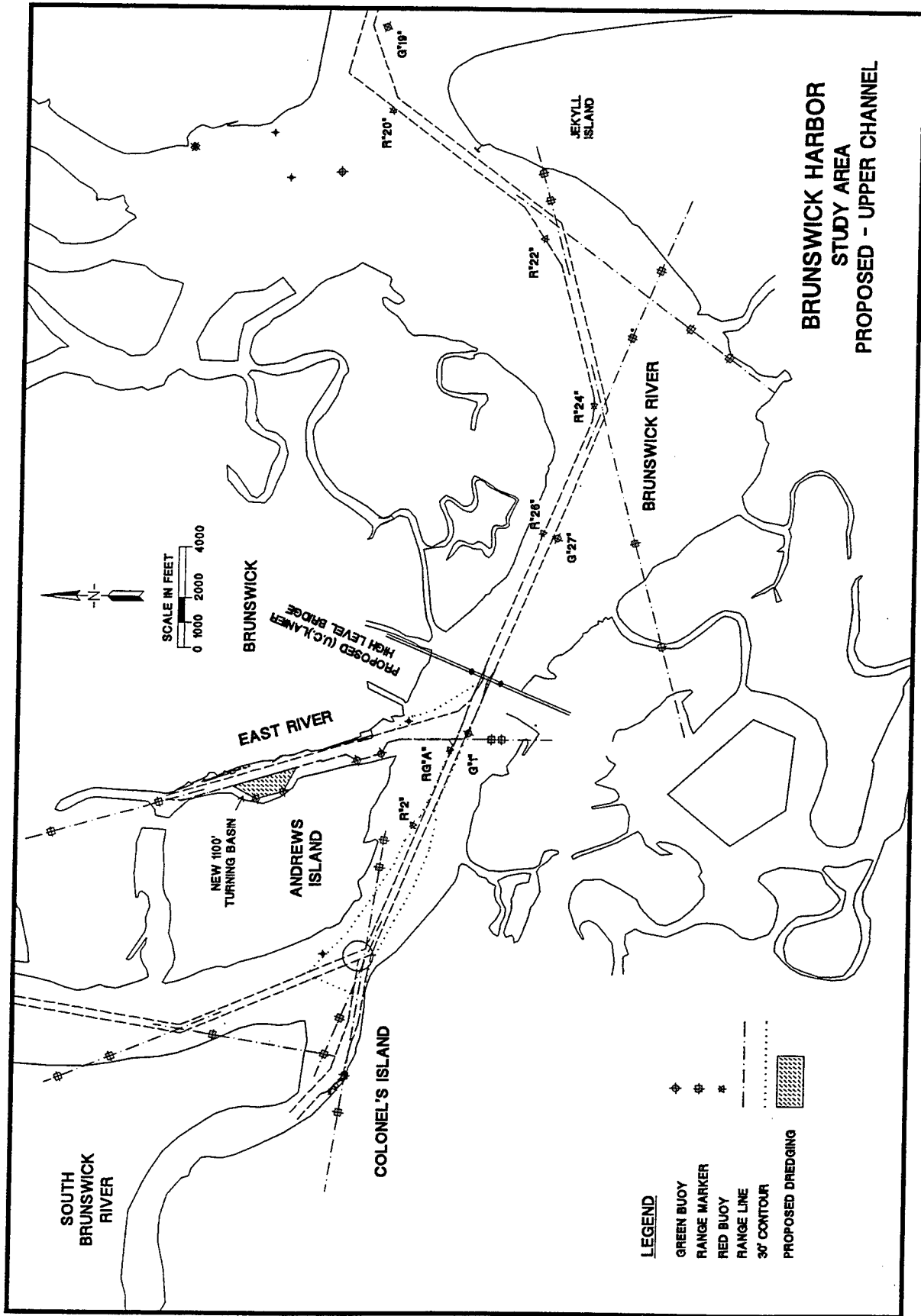
local Coast Guard office are recommended to position the marker; our recommended location based on the ship track simulation results is presented on Plate 32.

- f.* Channel edge markers on the new high-level highway bridge are also recommended for consideration, Plate 32. This may require coordination with the Georgia Highway Department and the Coast Guard, but would provide an important aid to the pilots in the transition from the existing 200 ft span bridge to the wide-open 1,000 ft span for the new high-level bridge.
- g.* The recommendations for the turning area to serve the Colonels Island terminal area and the additional channel markers at the East River turn and on the new high-level bridge were based on the simulations presented in this report. Further experiments with these proposed new modifications on the simulator would provide more definitive results and could be used to refine the recommendations.



**BRUNSWICK HARBOR
STUDY AREA**

- LEGEND**
- ◆ GREEN BUOY
 - ◇ RANGE MARKER
 - RED BUOY
 - PROPOSED DREDGING
 - 30' CONTOUR
 - RANGE LINE



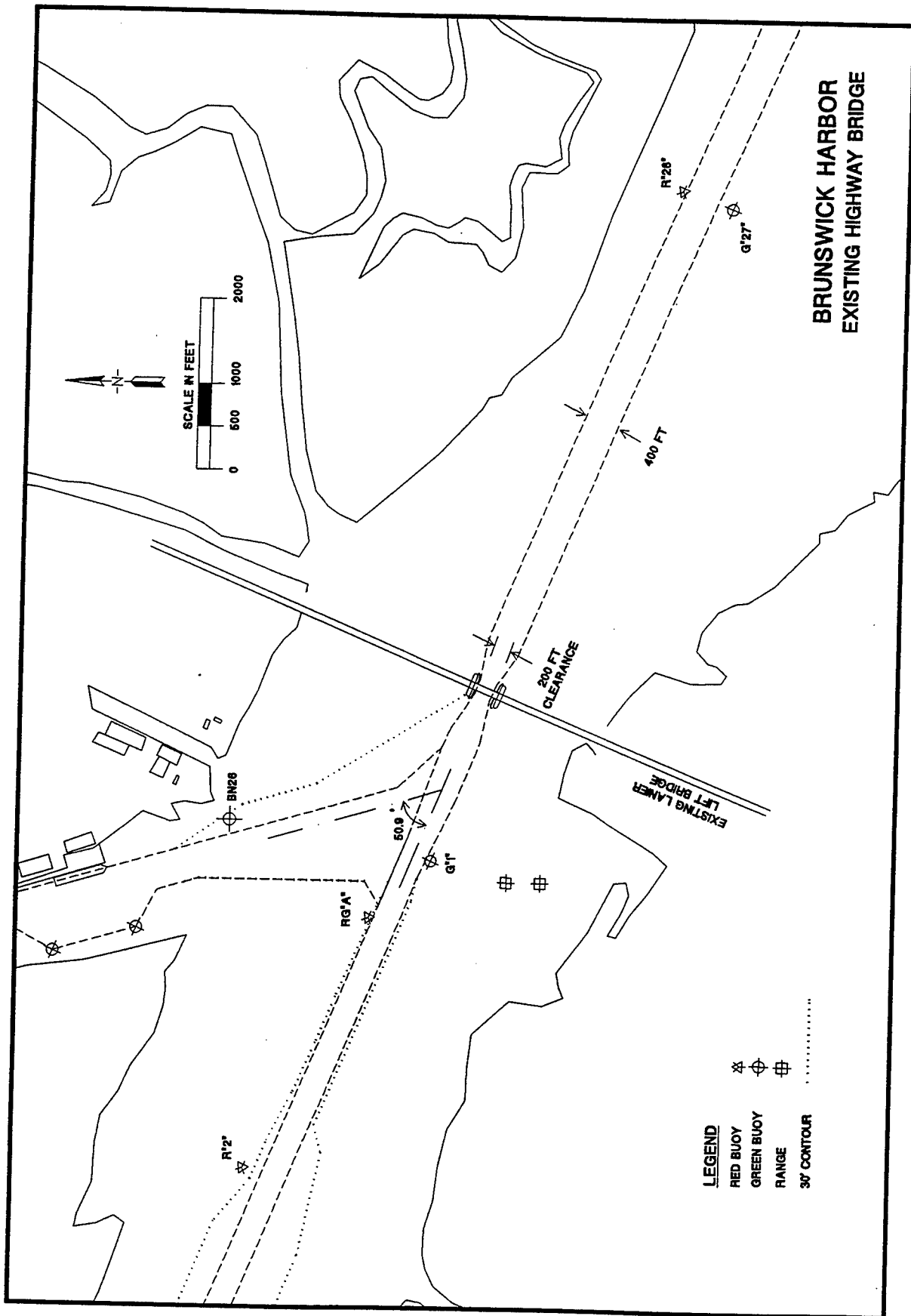
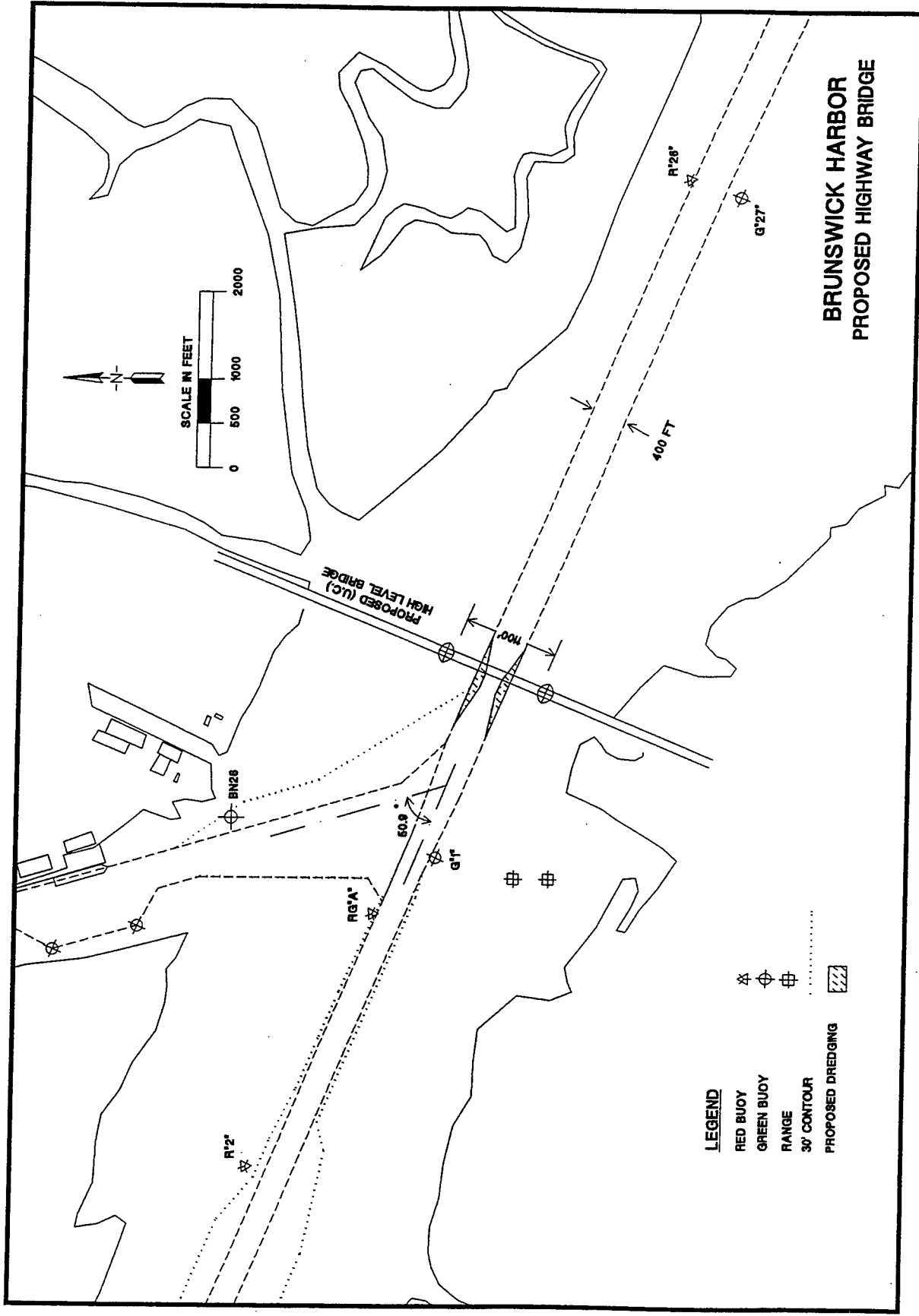


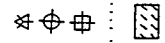
PLATE 3

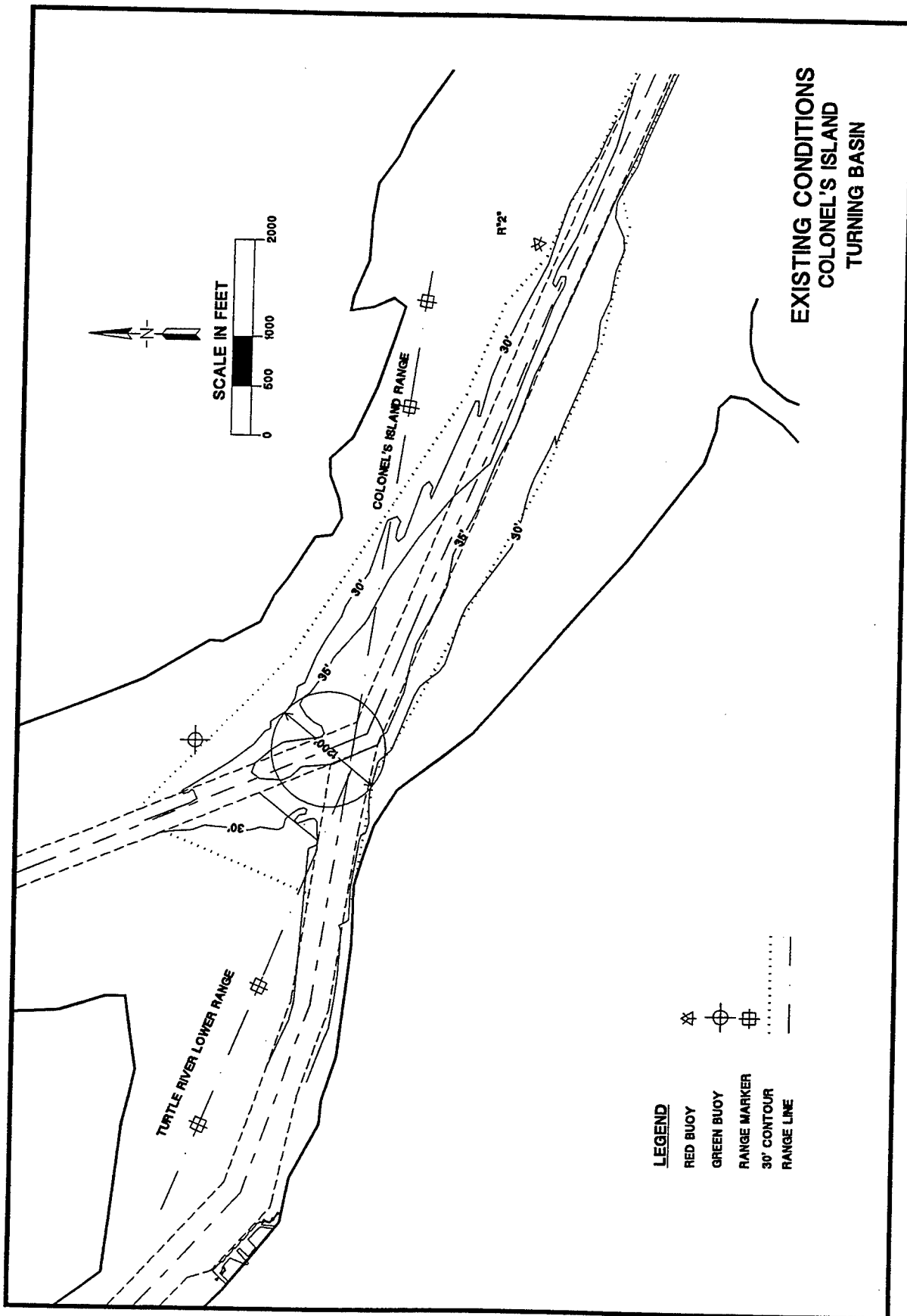


**BRUNSWICK HARBOR
PROPOSED HIGHWAY BRIDGE**

LEGEND

- RED BUOY
- GREEN BUOY
- RANGE
- 30' CONTOUR
- PROPOSED DREDGING





**EXISTING CONDITIONS
COLONEL'S ISLAND
TURNING BASIN**

LEGEND

- RED BUOY
- GREEN BUOY
- RANGE MARKER
- 30' CONTOUR
- RANGE LINE

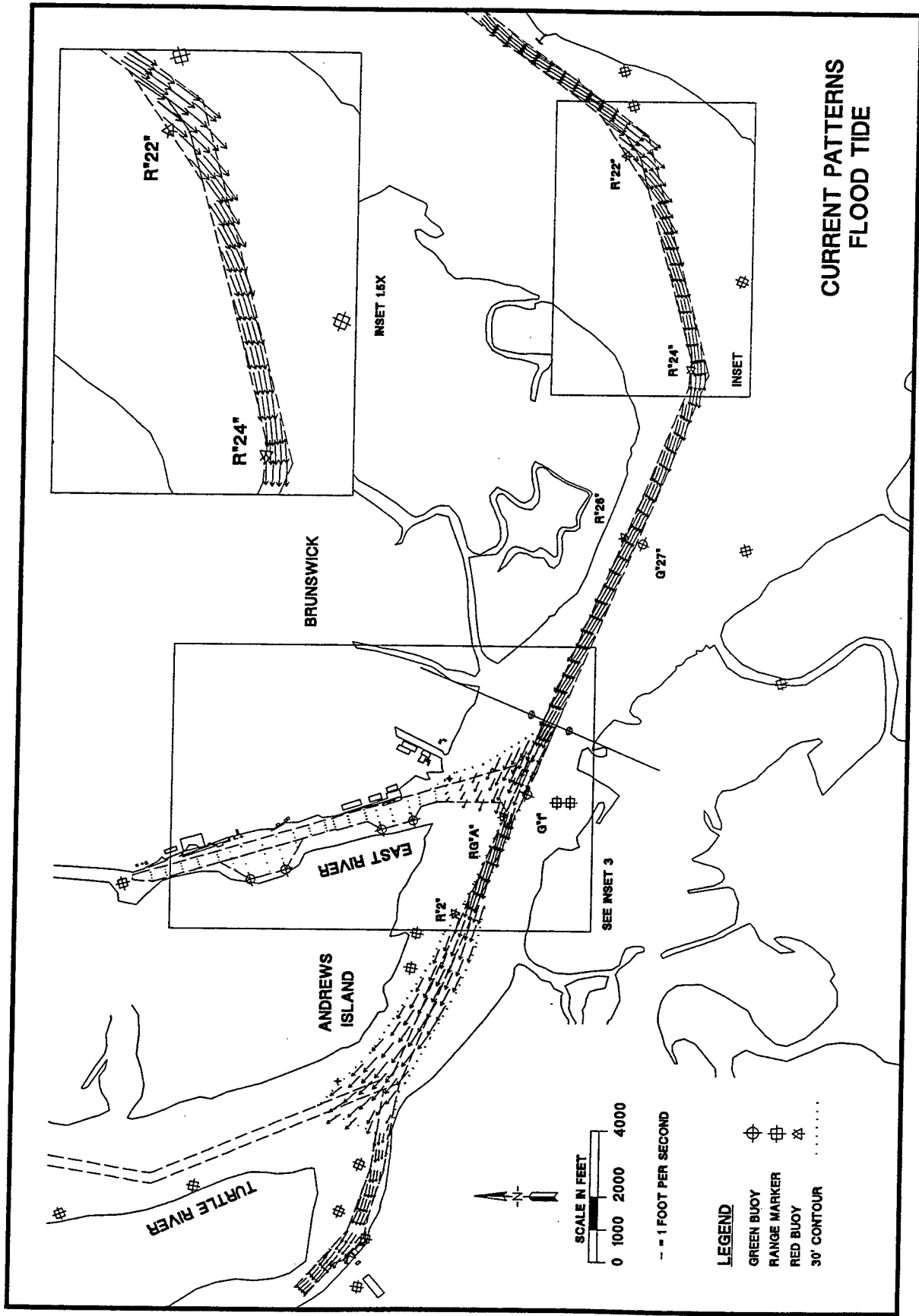
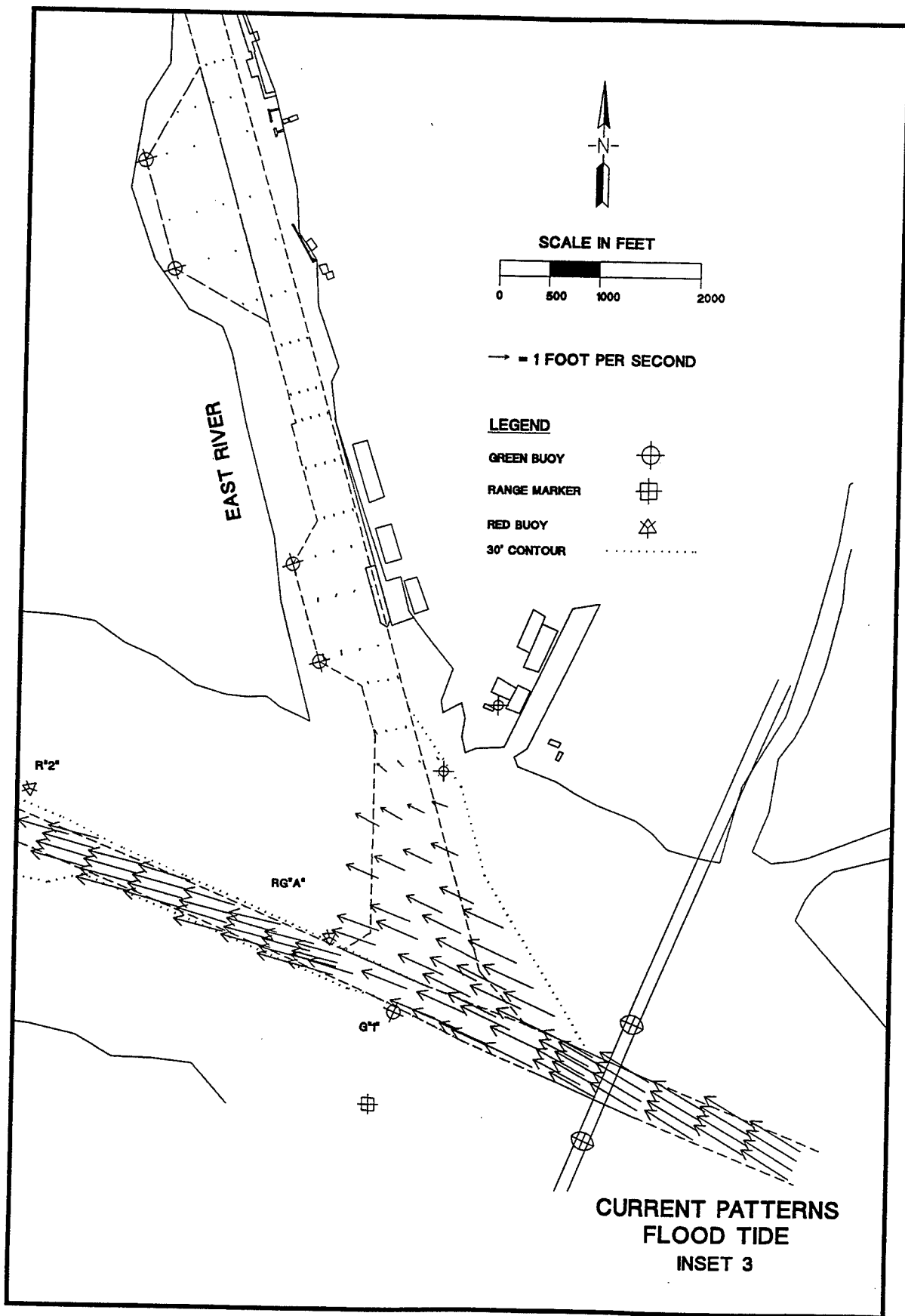


PLATE 6



**CURRENT PATTERNS
EBB TIDE**

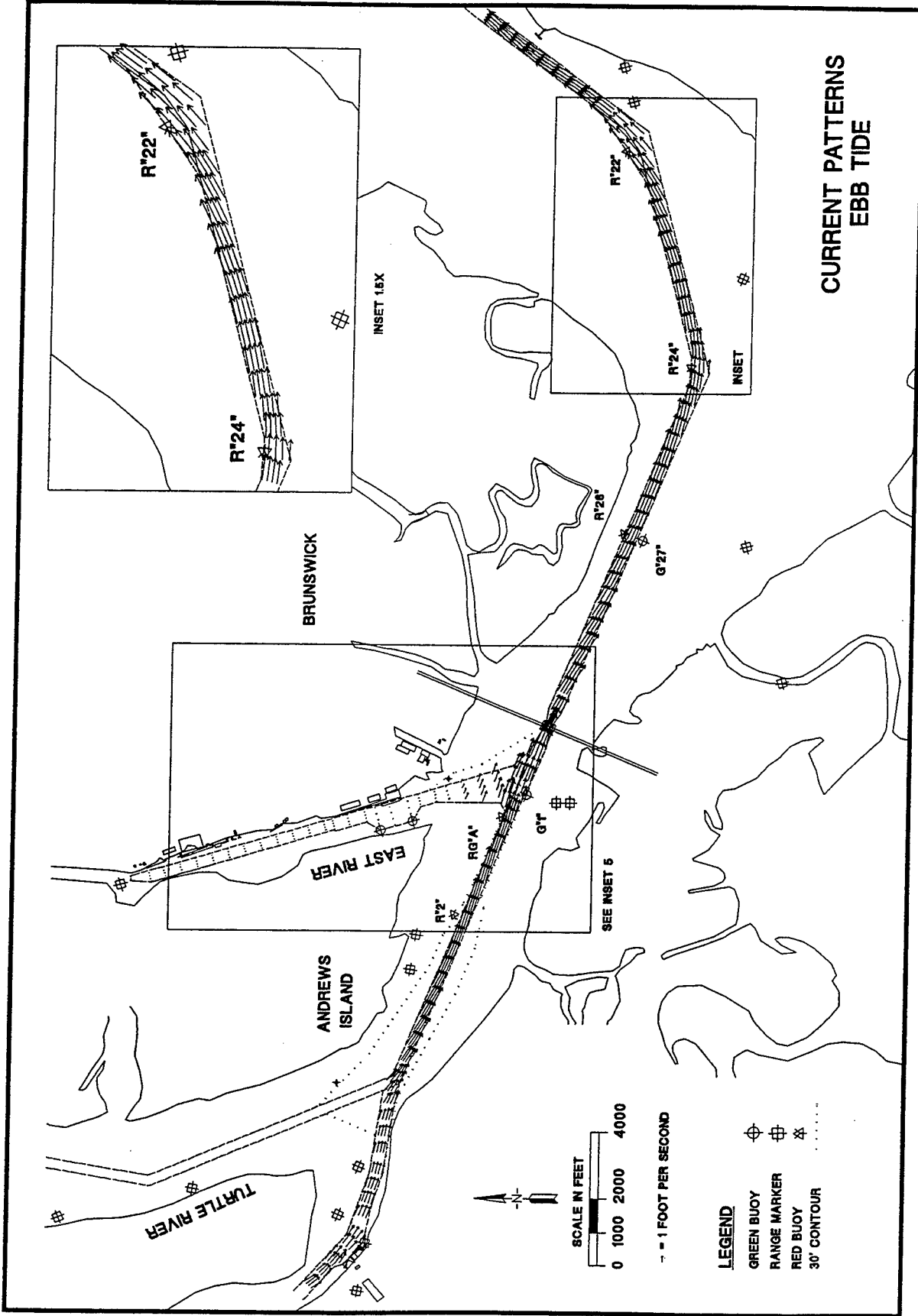
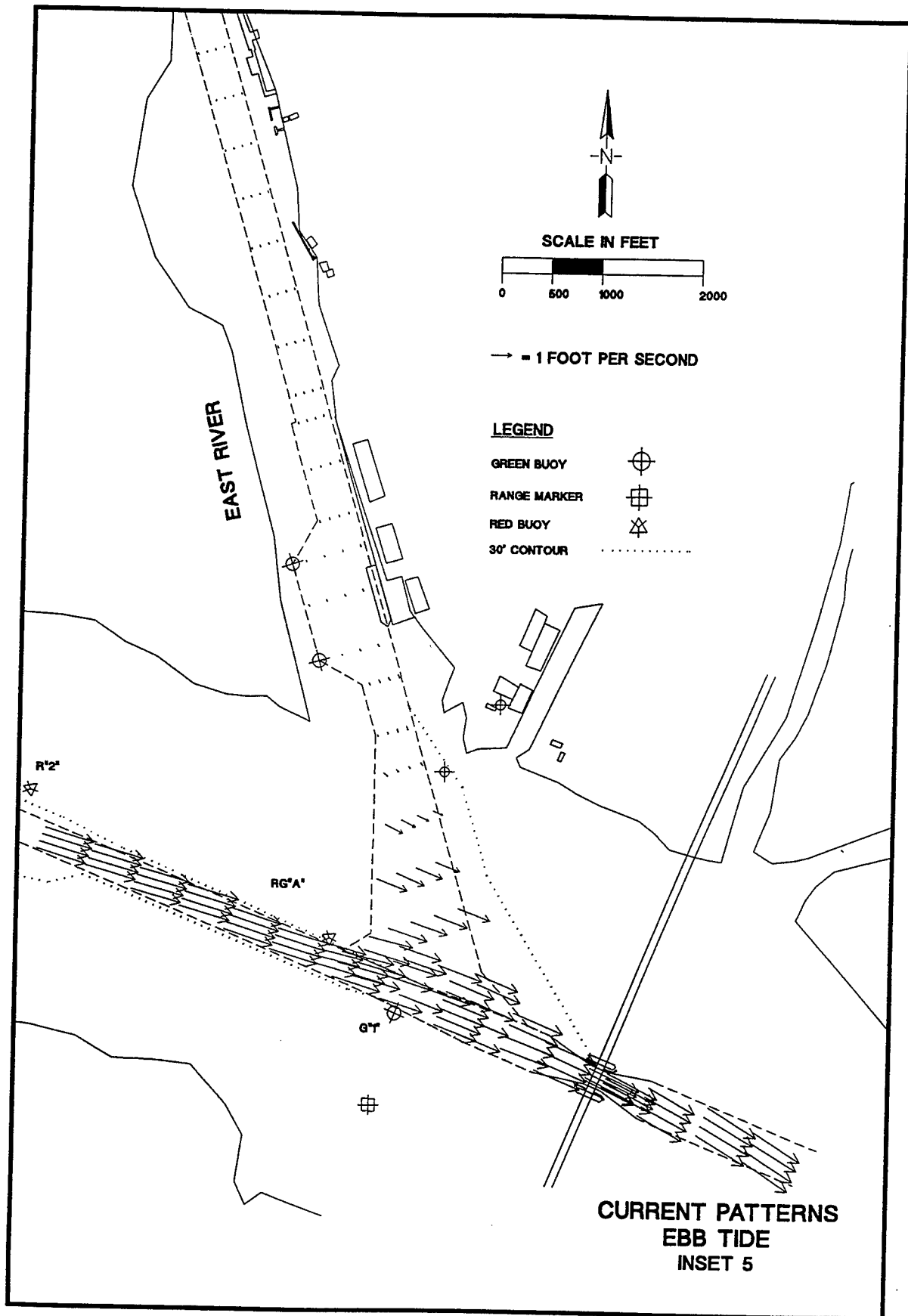
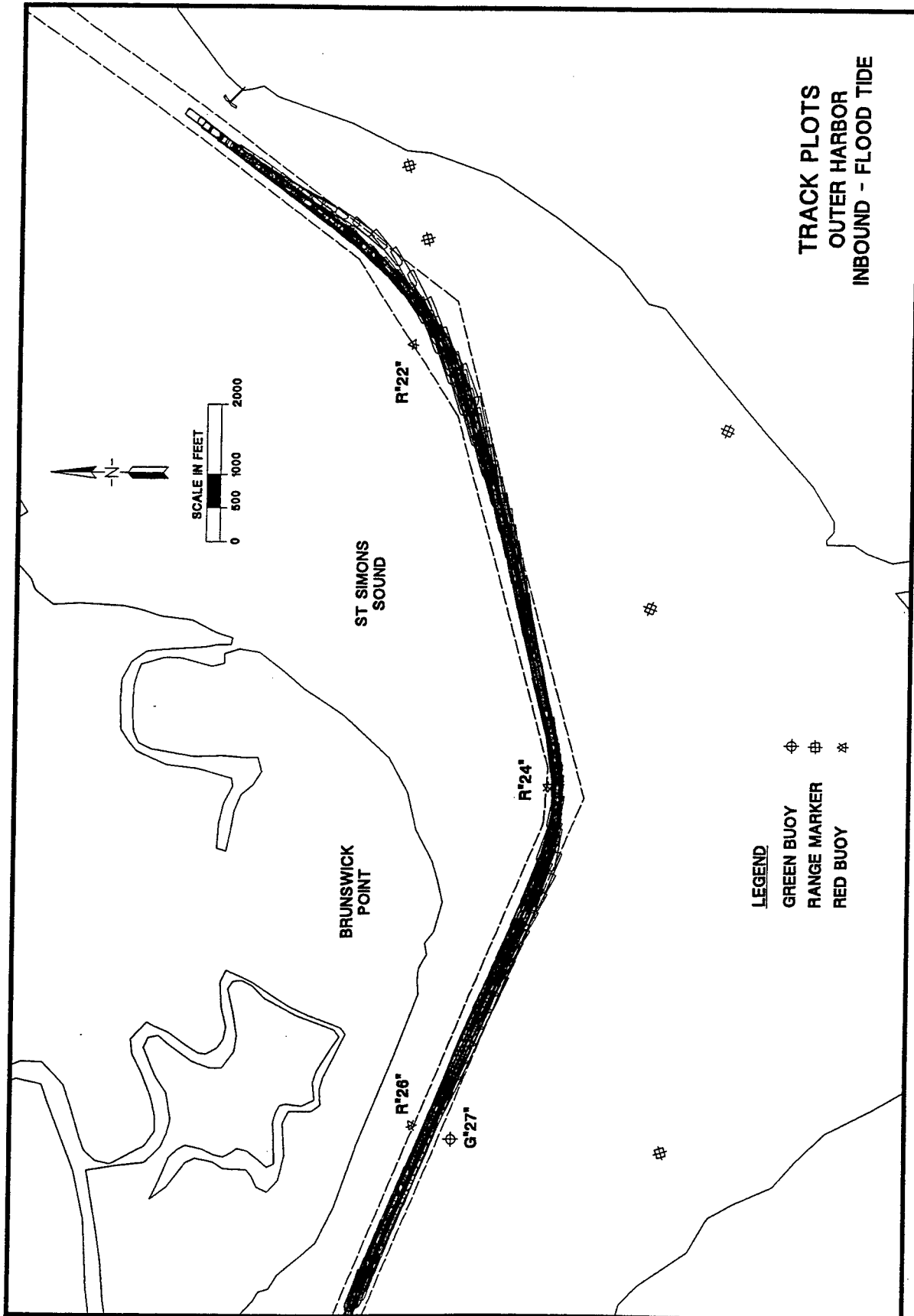
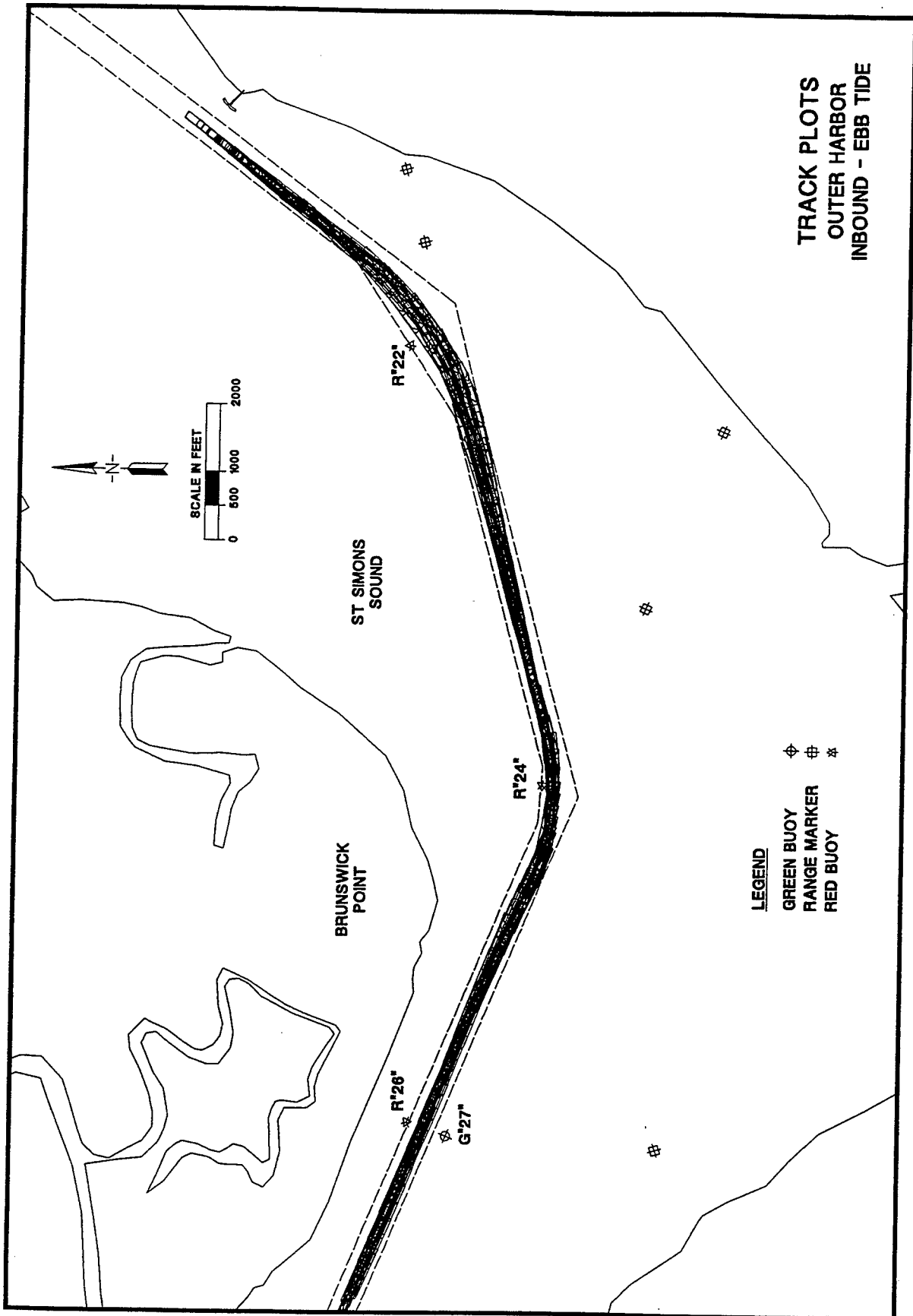
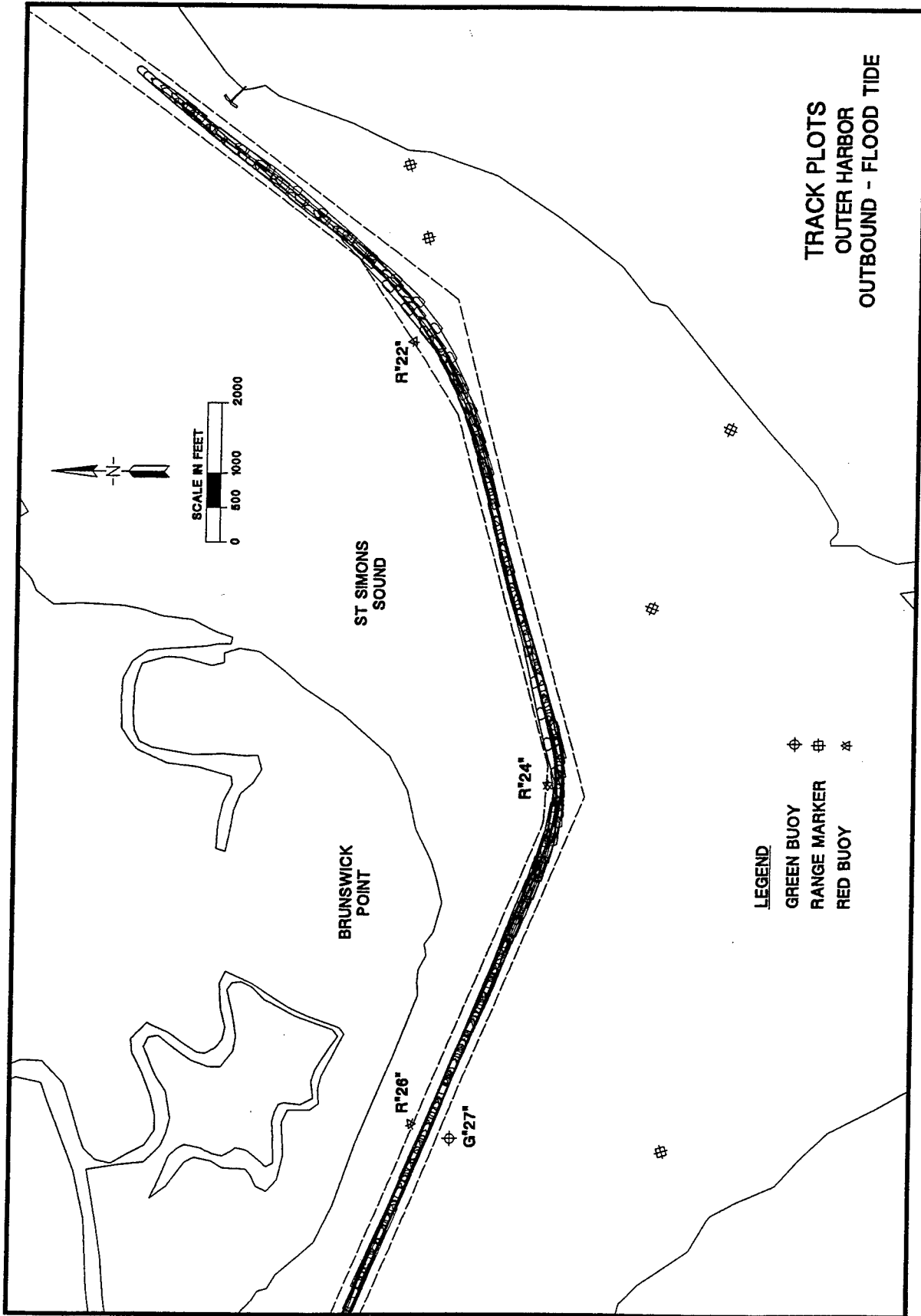


PLATE 7









TRACK PLOTS
 OUTER HARBOR
 OUTBOUND - FLOOD TIDE

LEGEND
 GREEN BUOY
 RANGE MARKER
 RED BUOY

SCALE IN FEET
 0 500 1000 2000

ST SIMONS
 SOUND

BRUNSWICK
 POINT

R'26"

G'27"

R'27"

R'24"

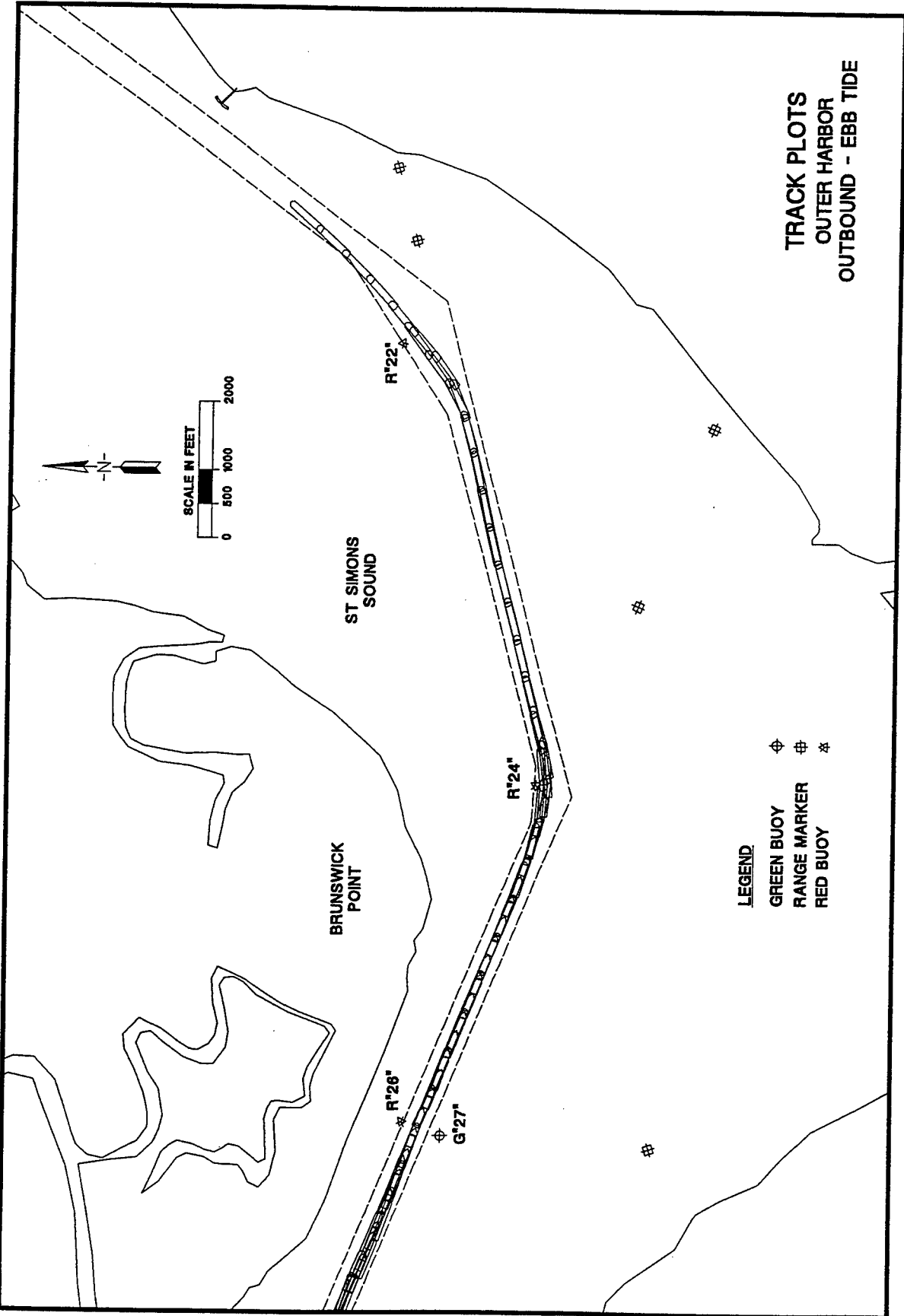
R'22"

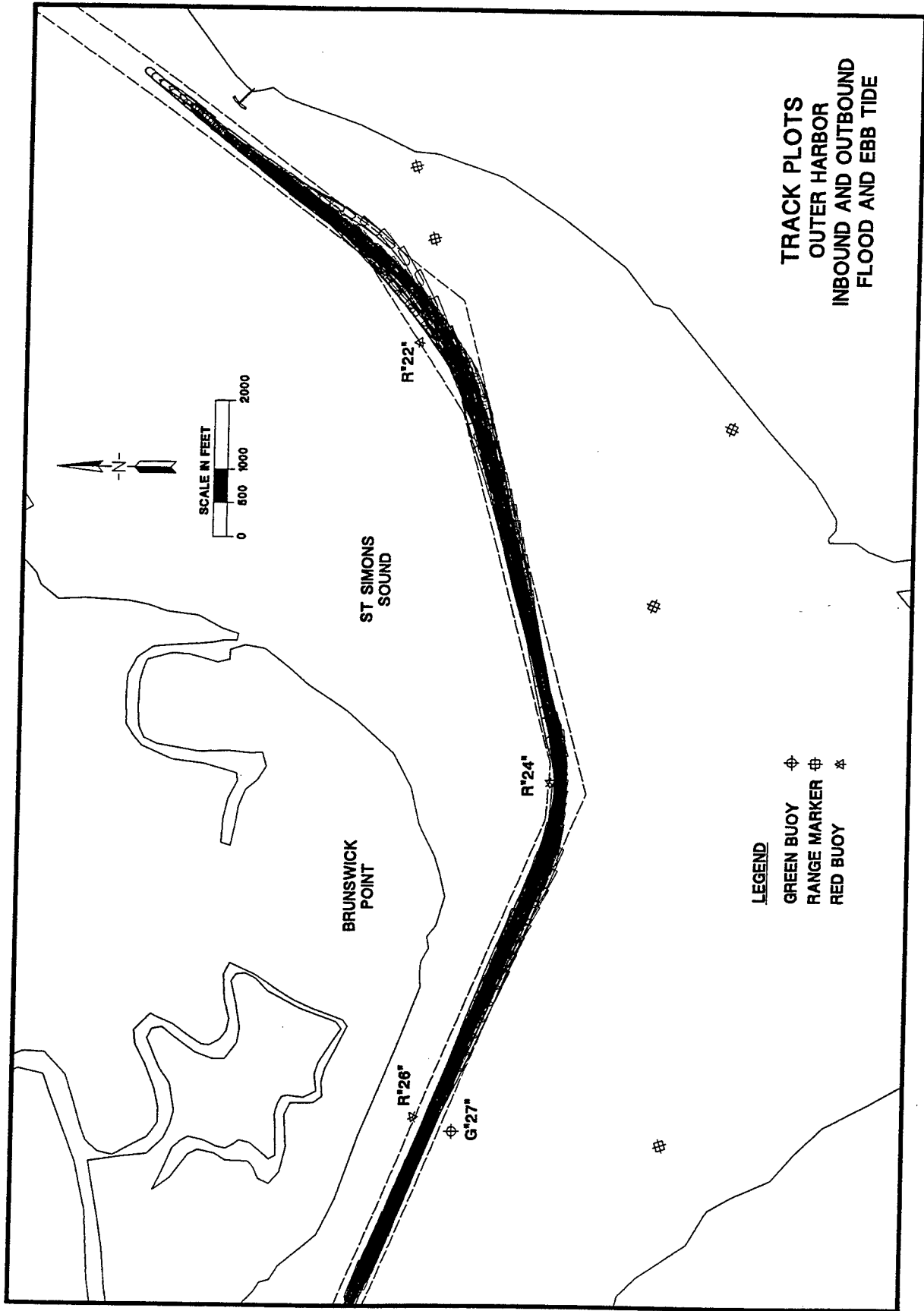
LEGEND

GREEN BUOY



RANGE MARKER

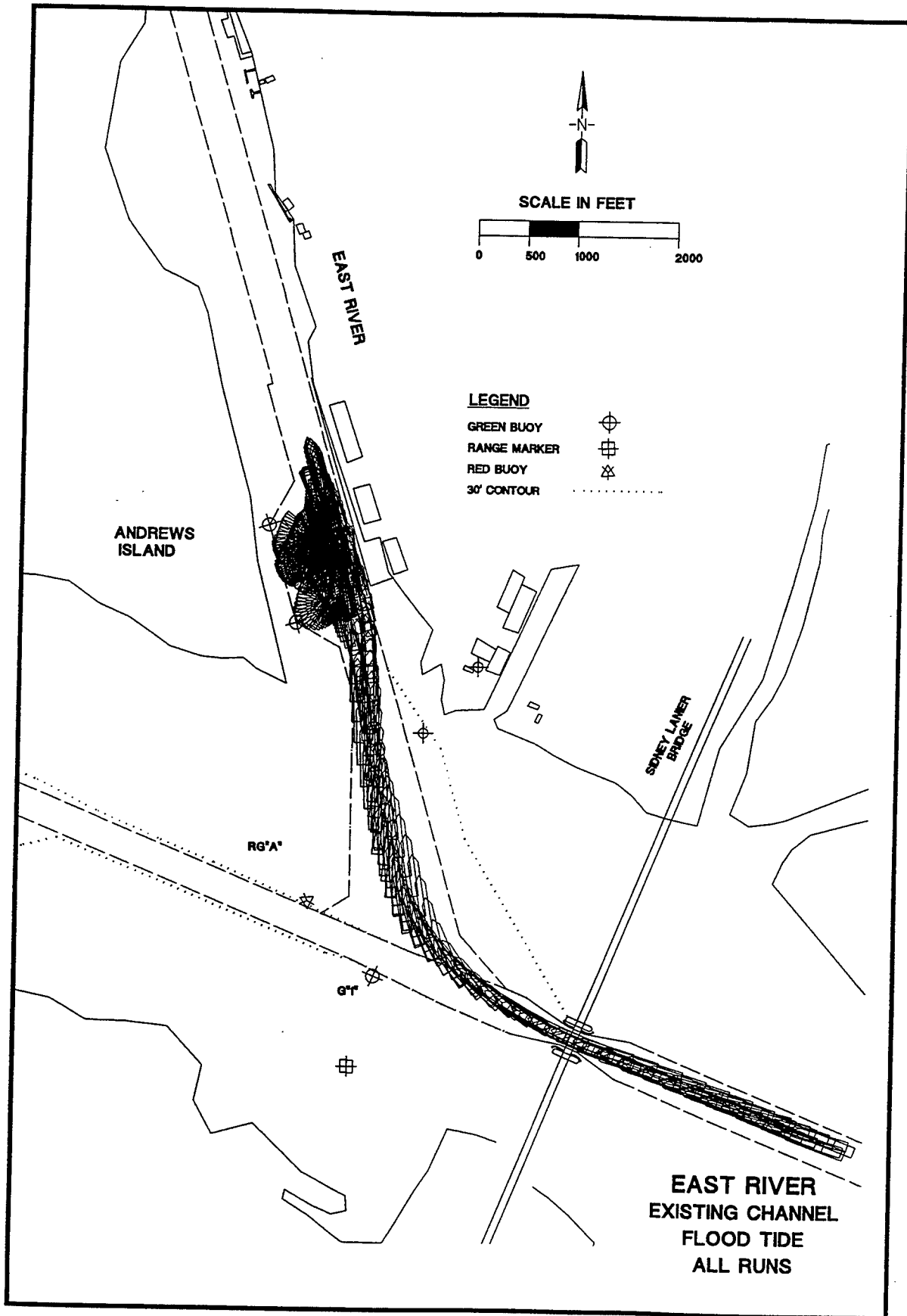
RED BUOY





TRACK PLOTS
 OUTER HARBOR
 INBOUND AND OUTBOUND
 FLOOD AND EBB TIDE

LEGEND
 GREEN BUOY 
 RANGE MARKER 
 RED BUOY 



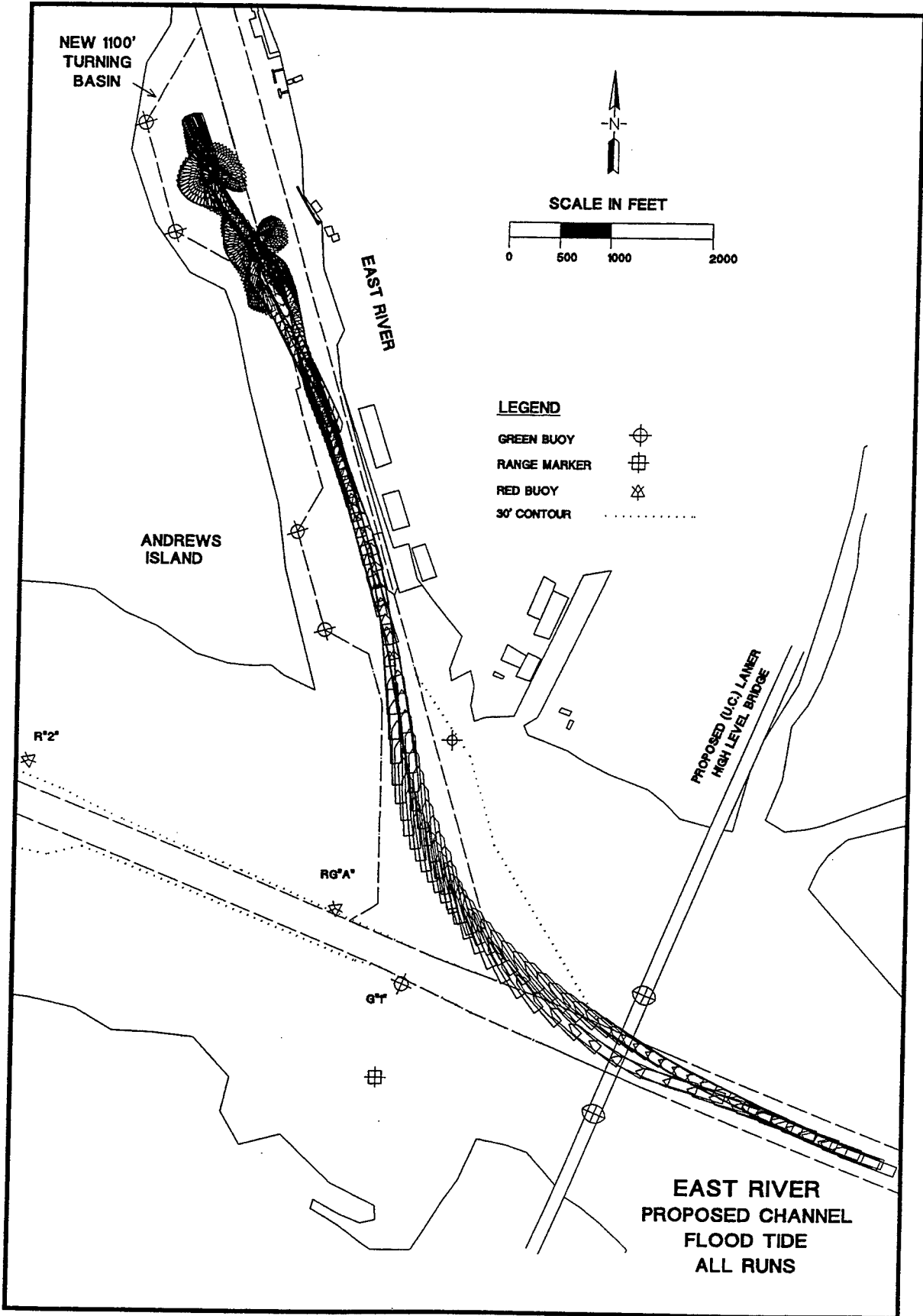
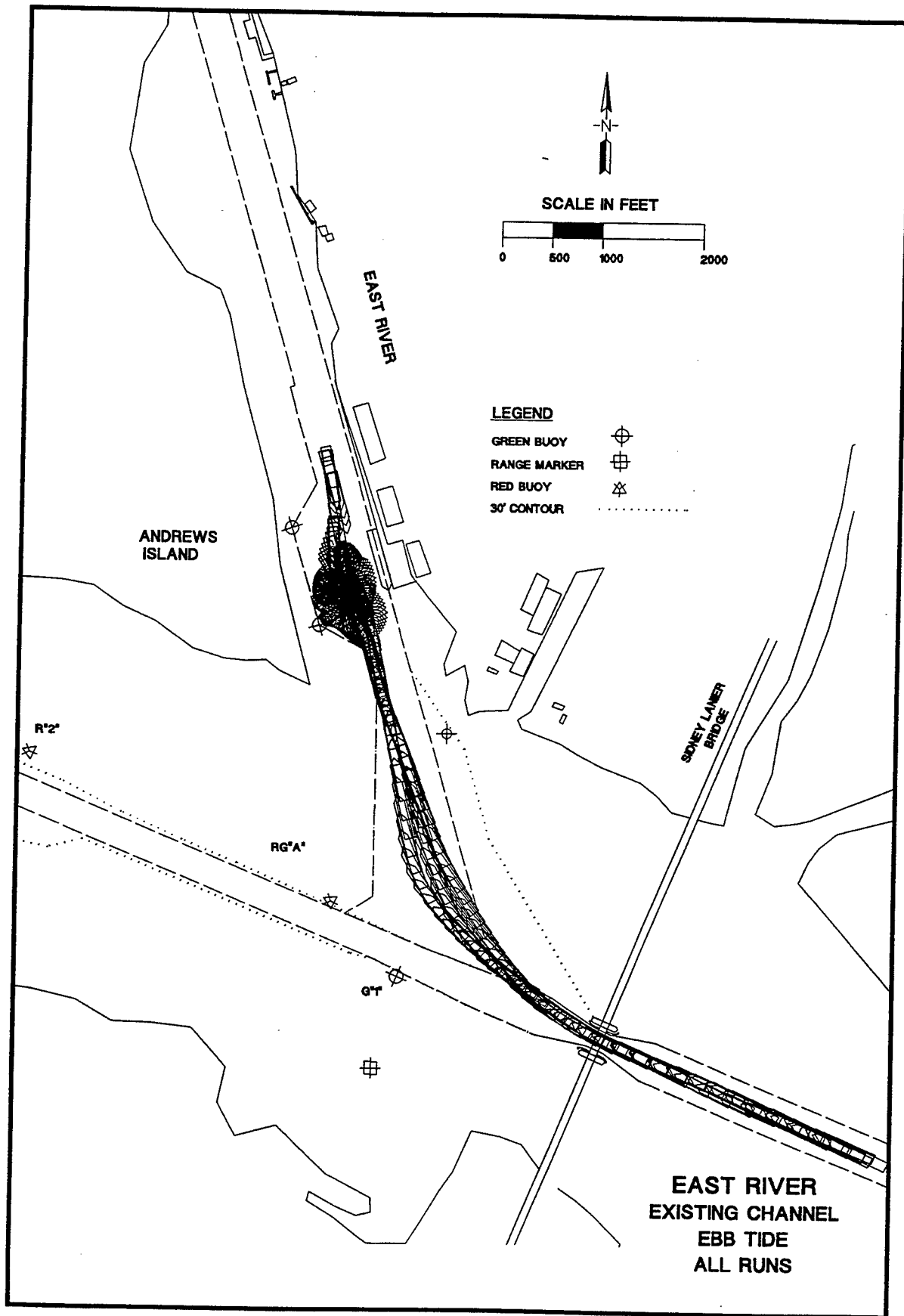
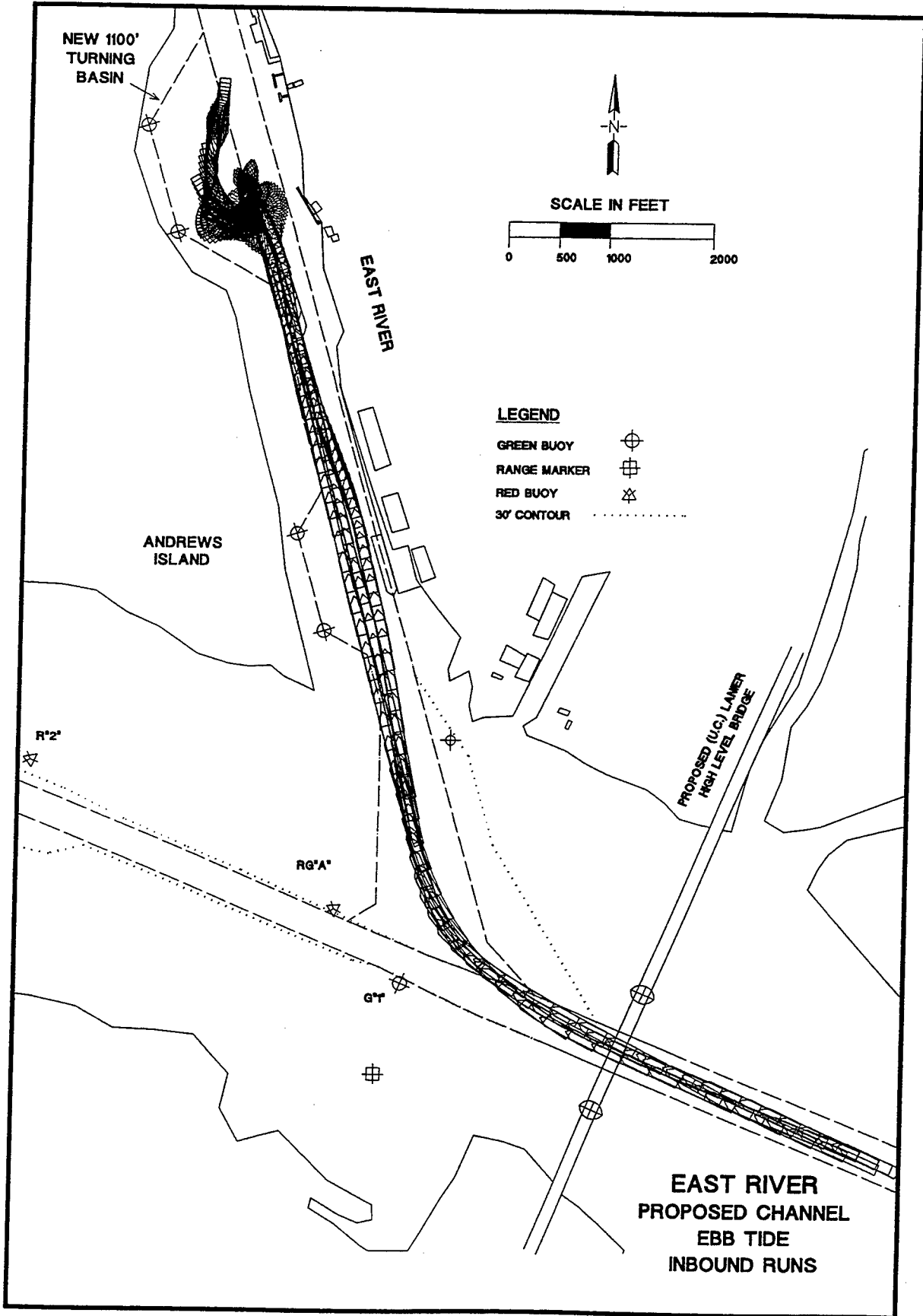
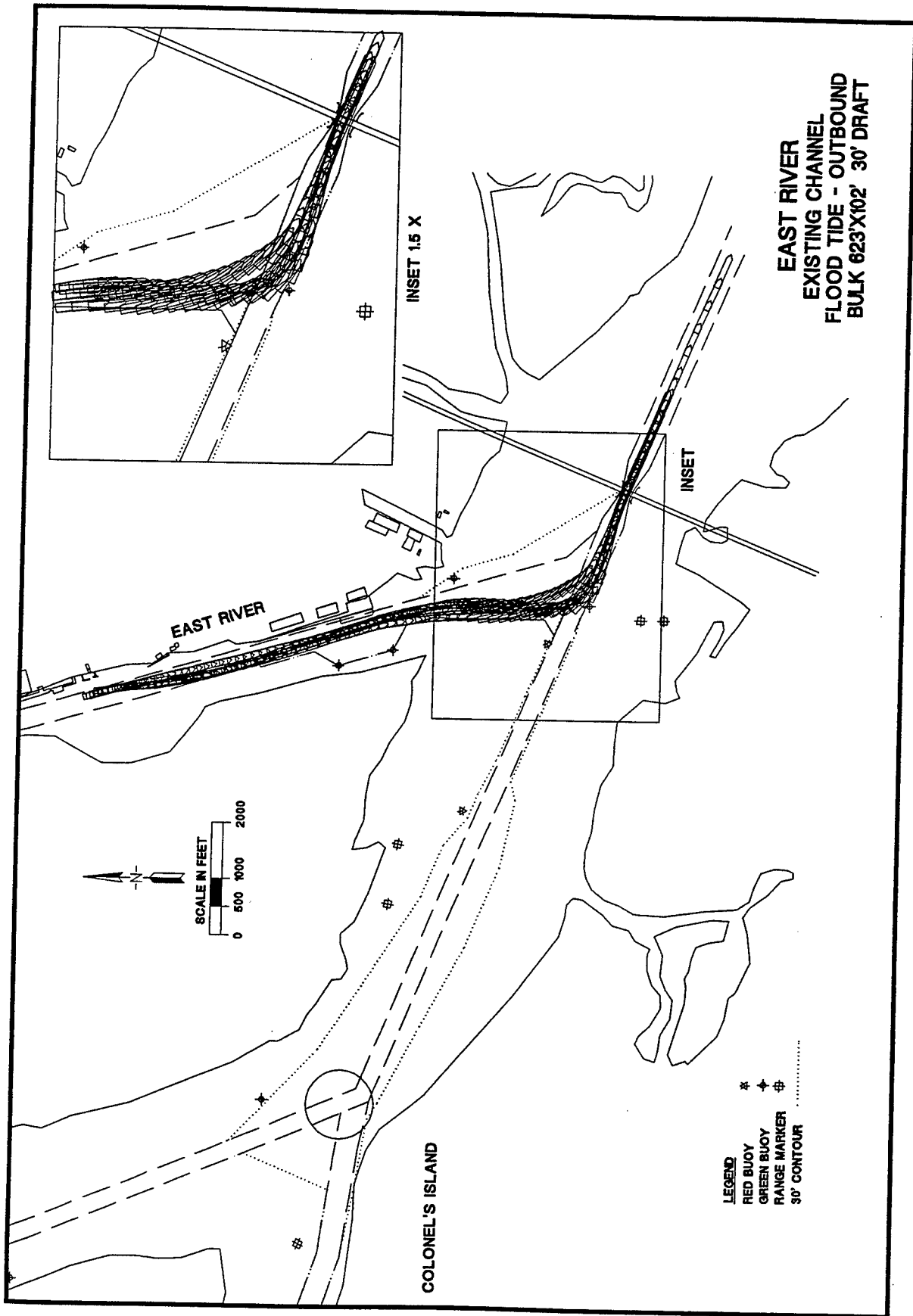
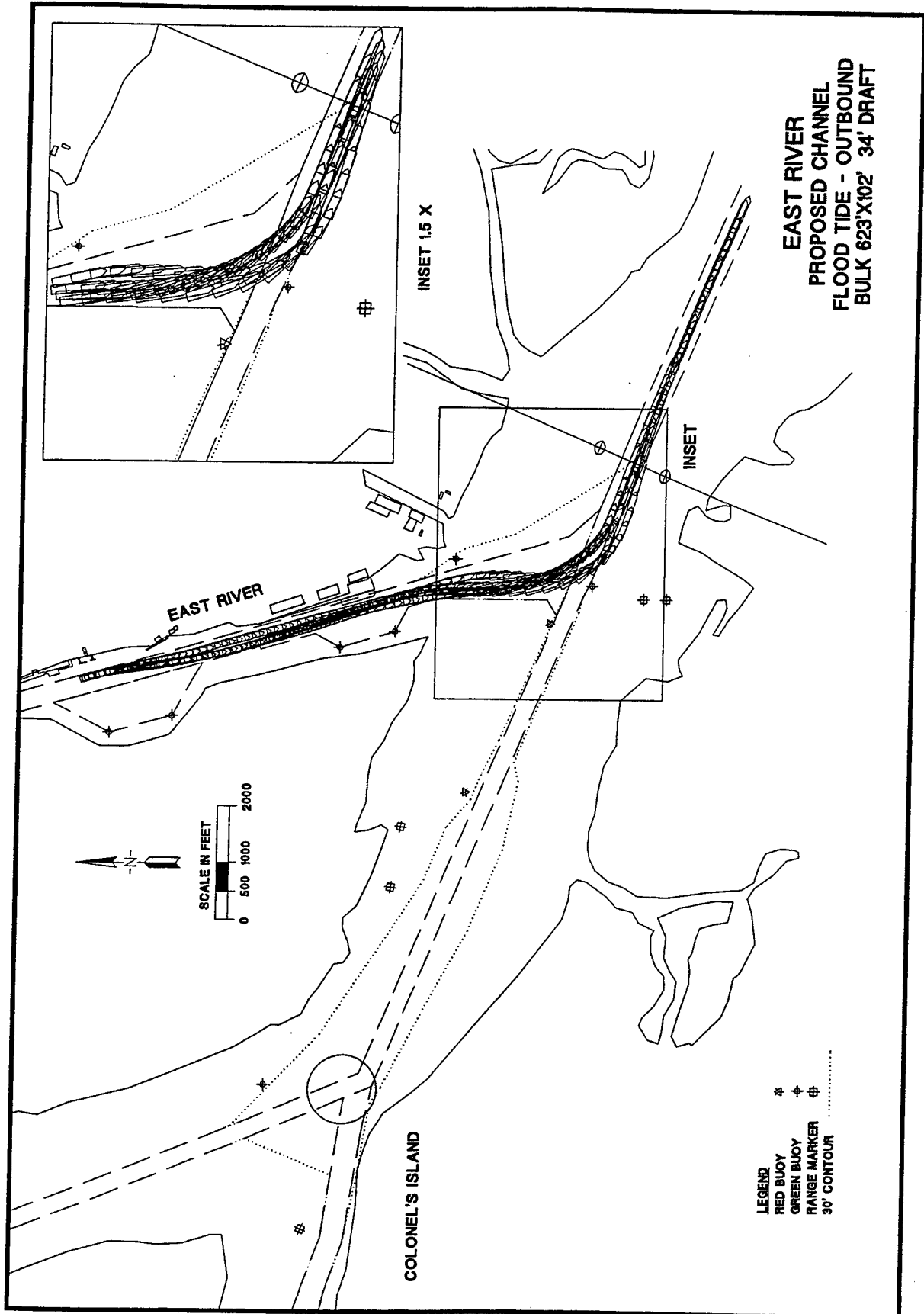


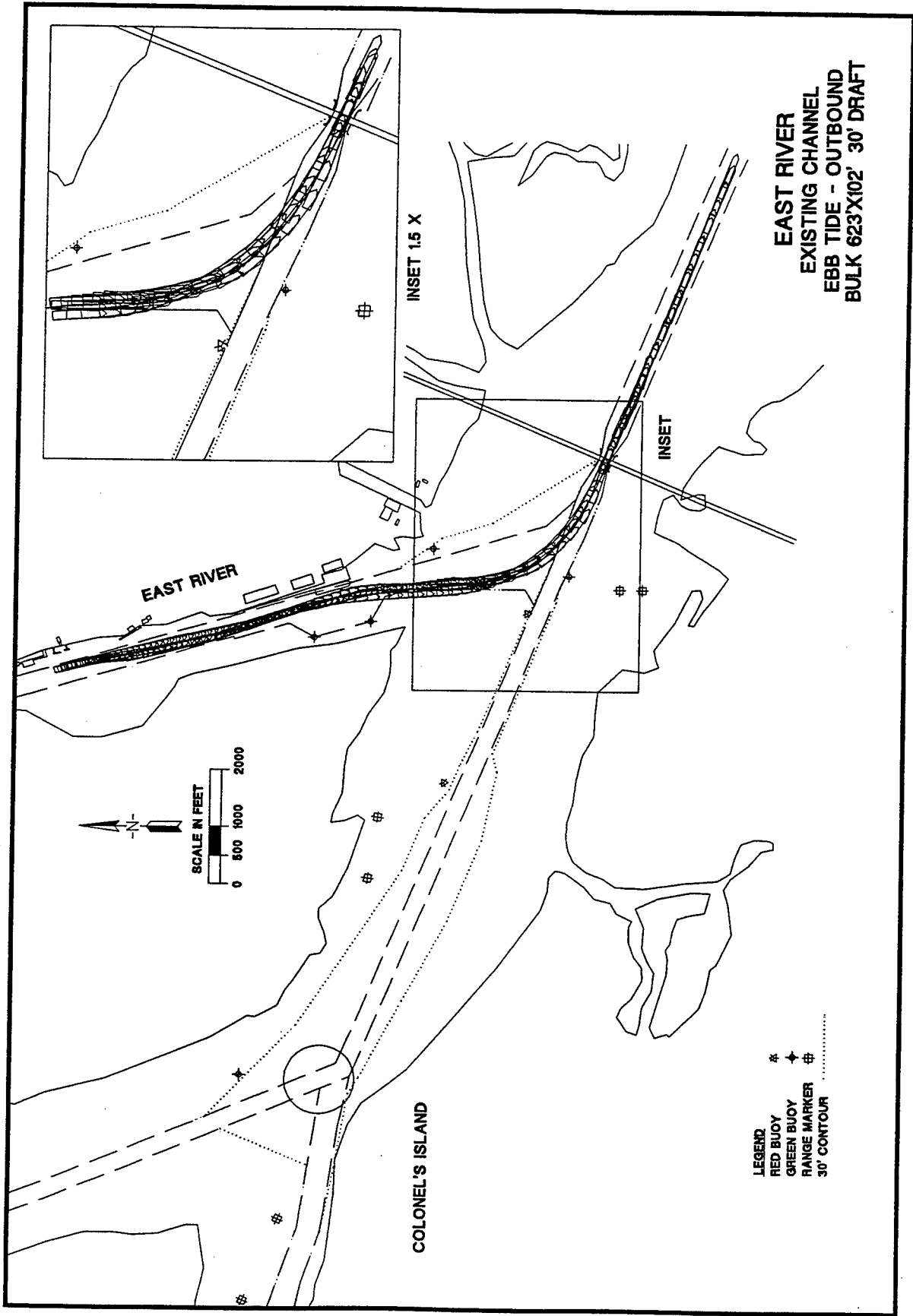
PLATE 14

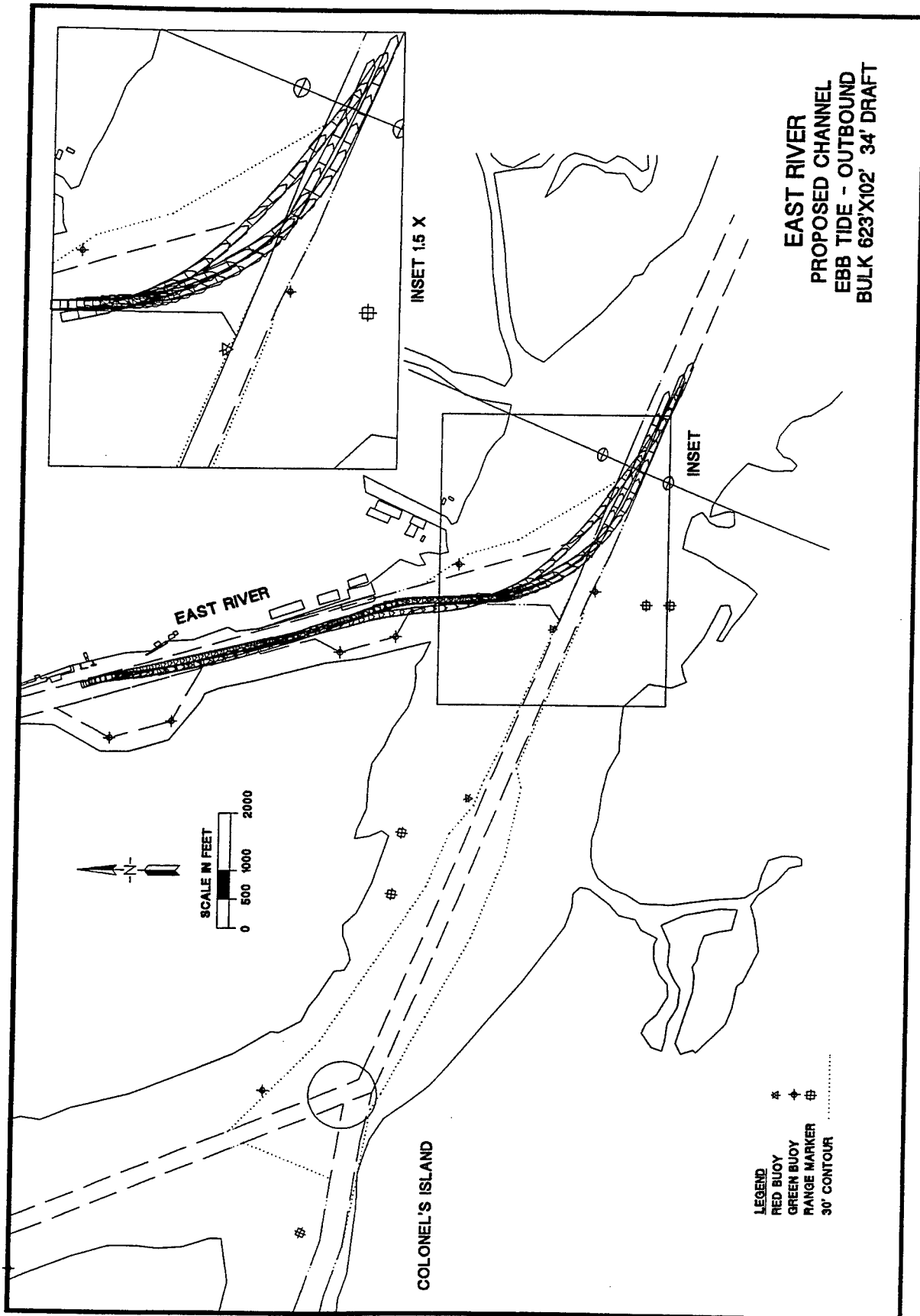


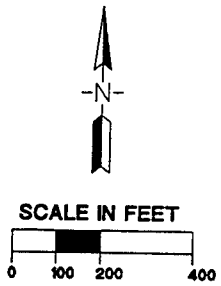
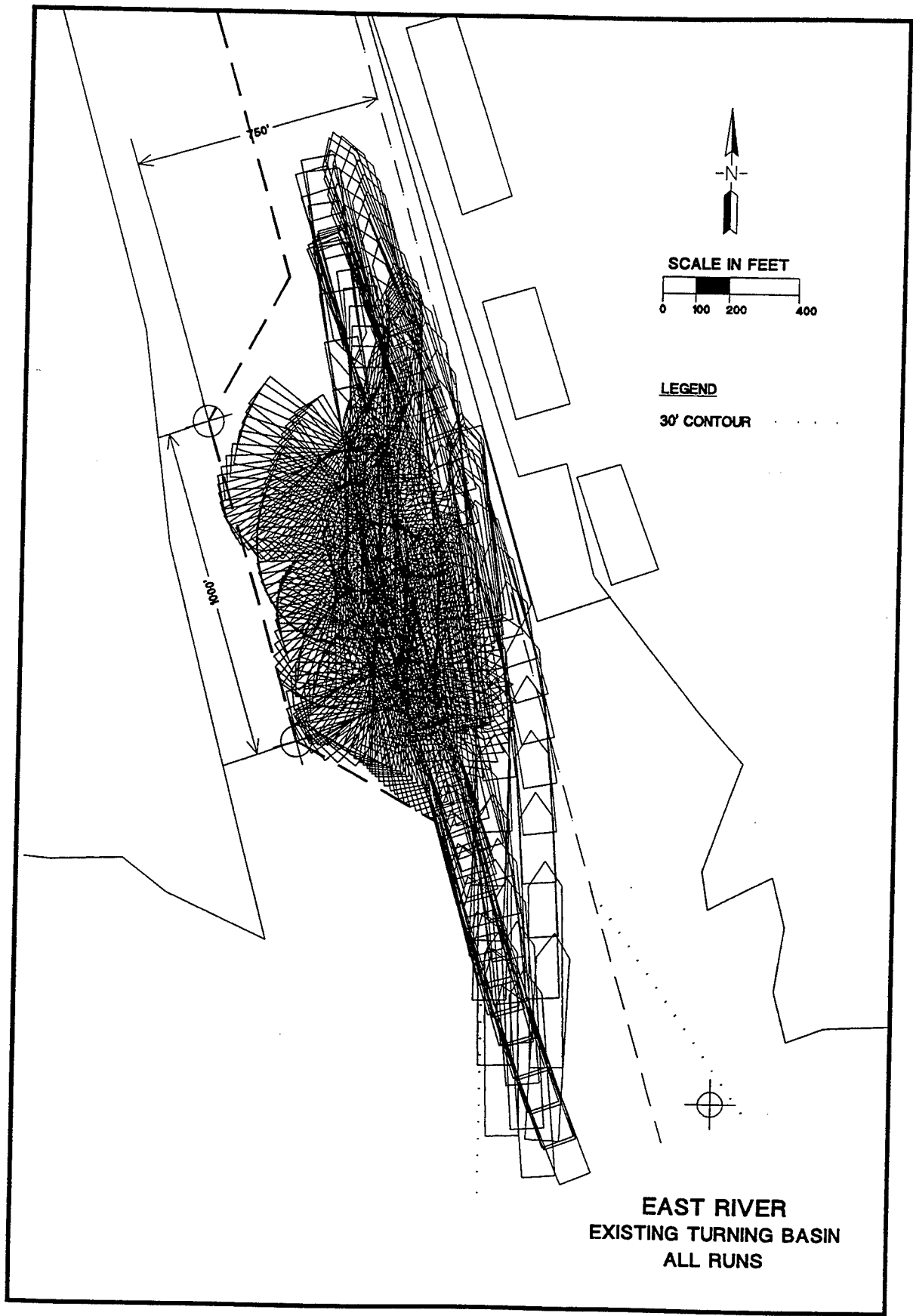






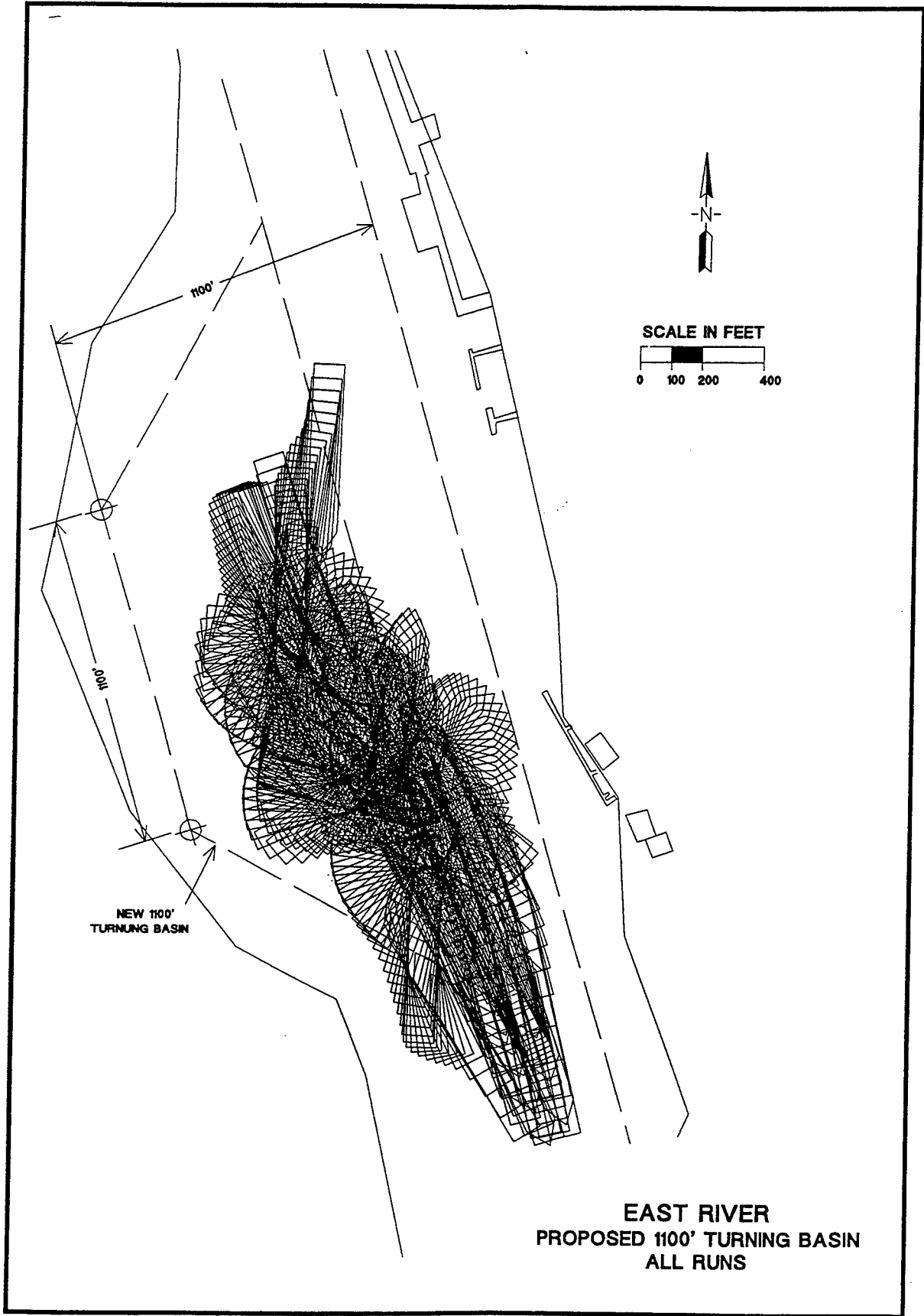


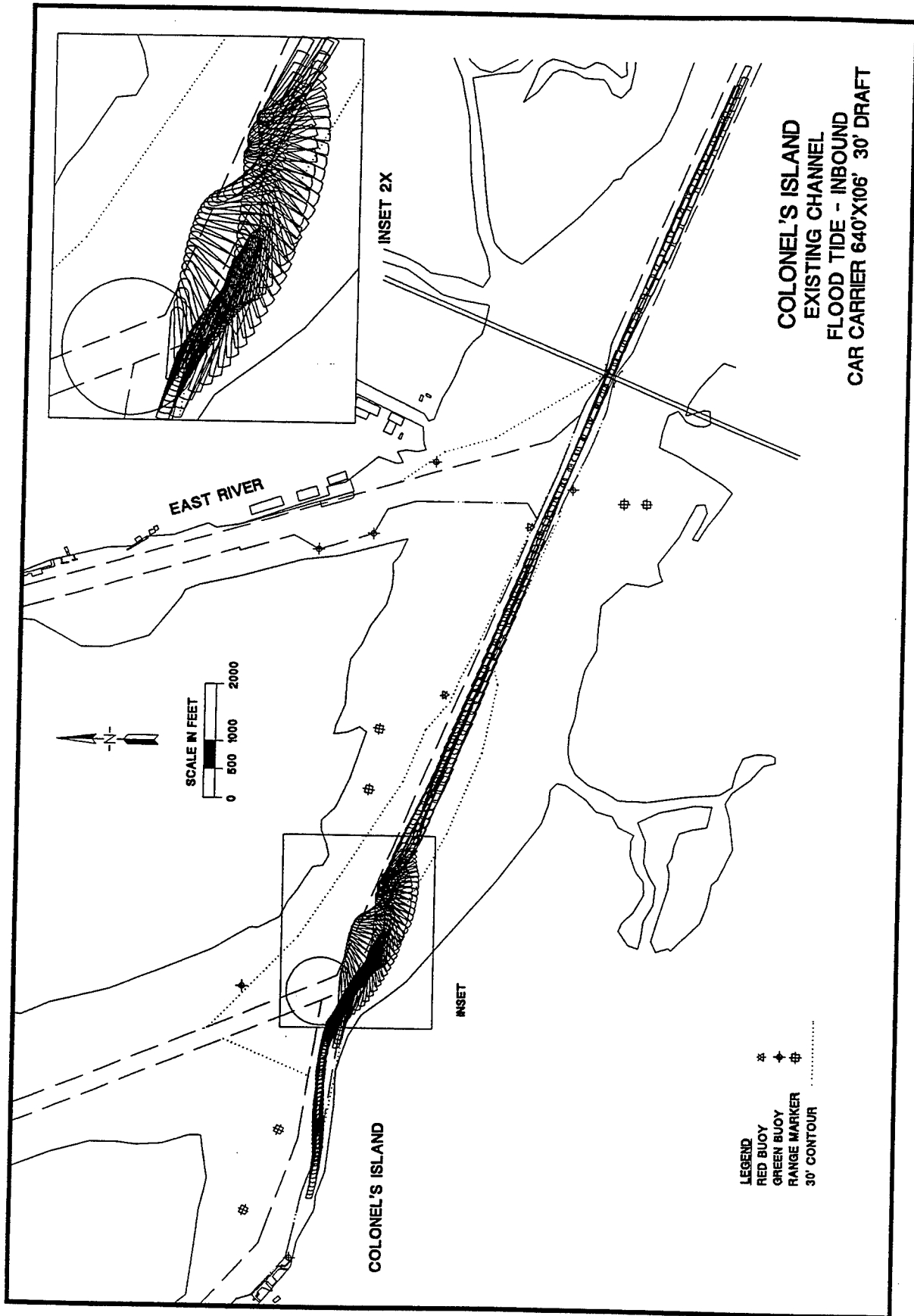


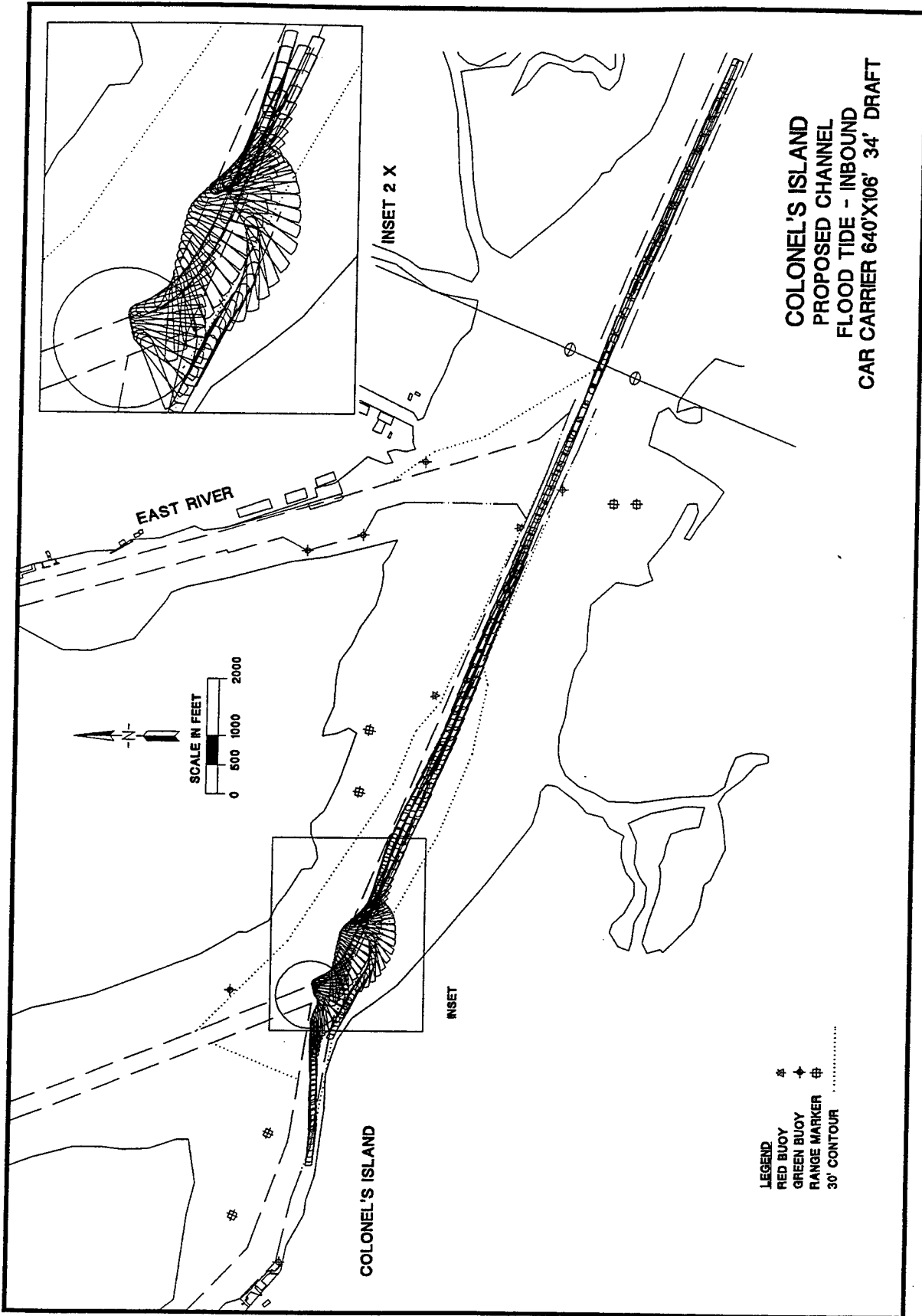


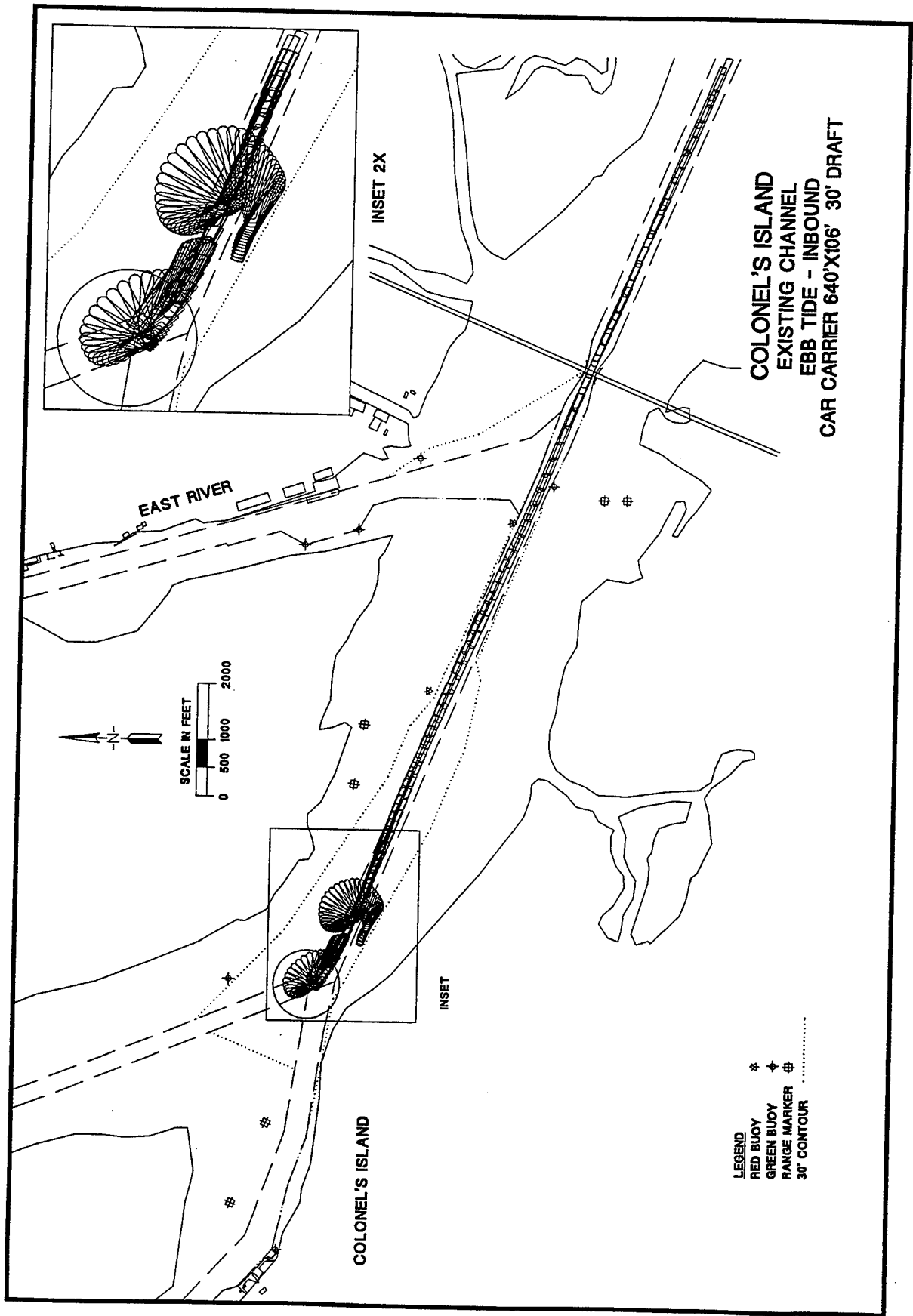
LEGEND
30' CONTOUR

**EAST RIVER
EXISTING TURNING BASIN
ALL RUNS**









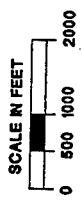
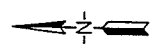
COLONEL'S ISLAND
 EXISTING CHANNEL
 EBB TIDE - INBOUND
 CAR CARRIER 640'X106' 30' DRAFT

EAST RIVER

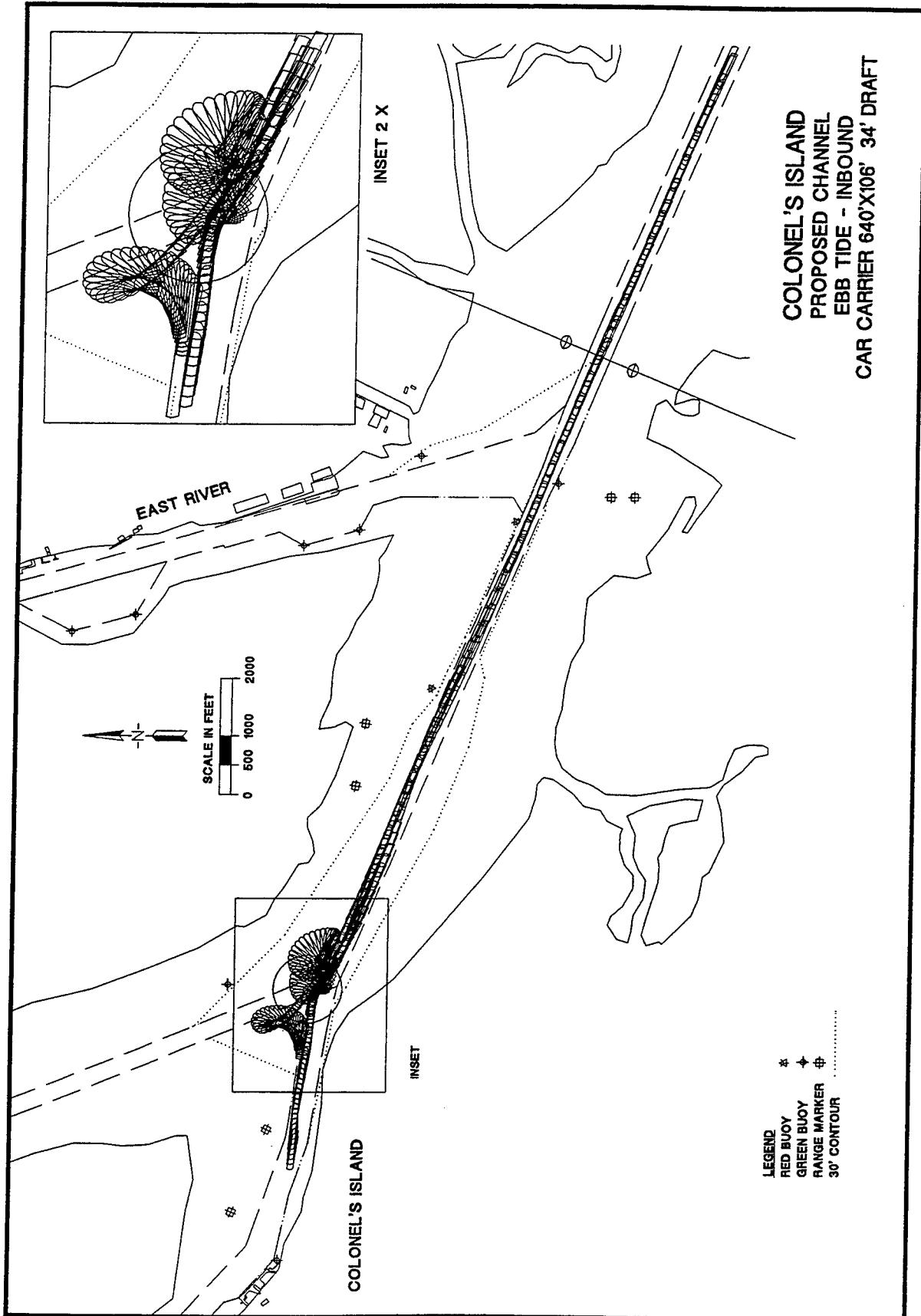
INSET 2X

INSET

COLONEL'S ISLAND



- LEGEND
- * RED BUOY
 - ◆ GREEN BUOY
 - ⊕ RANGE MARKER
 - 30' CONTOUR



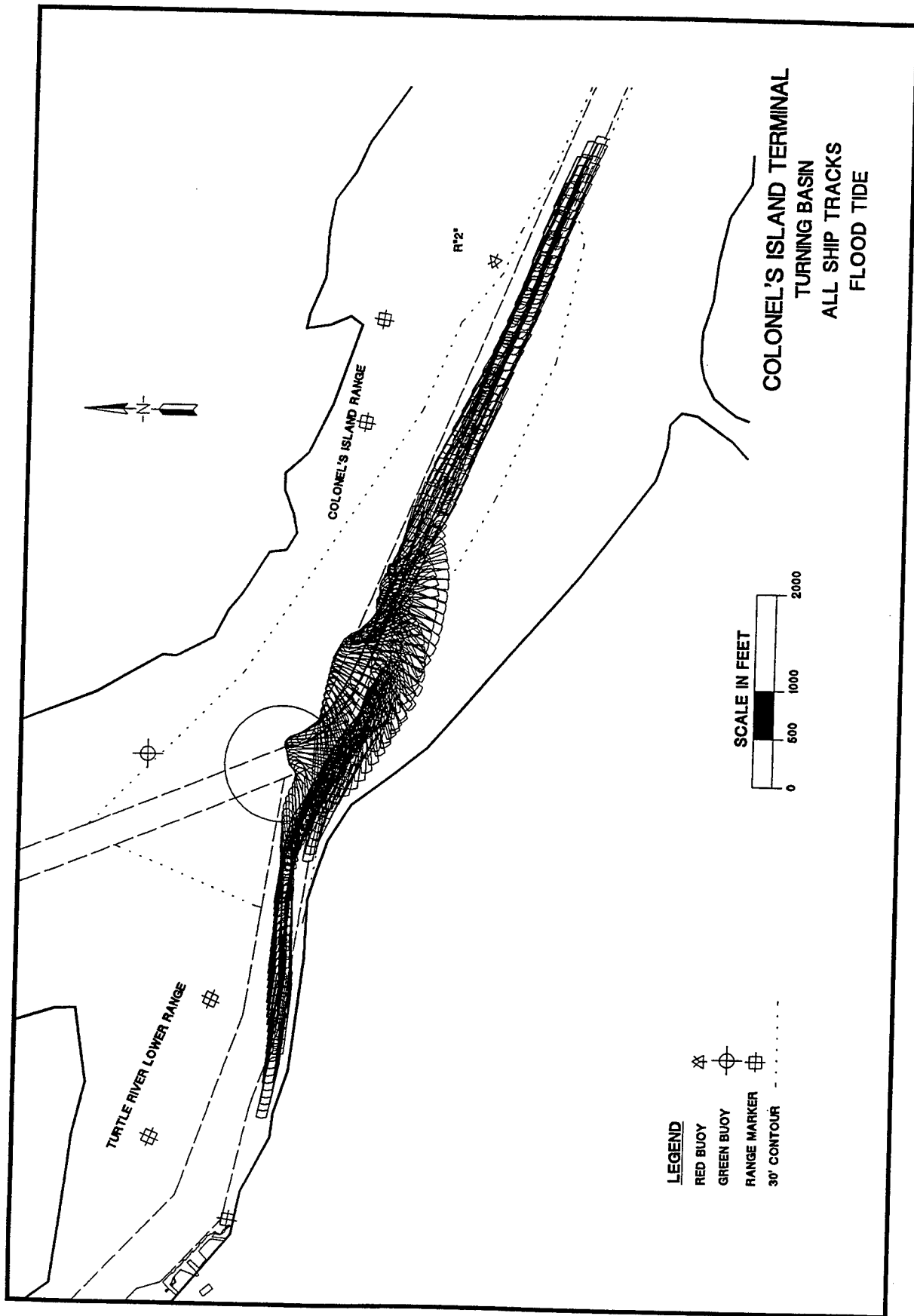


PLATE 27

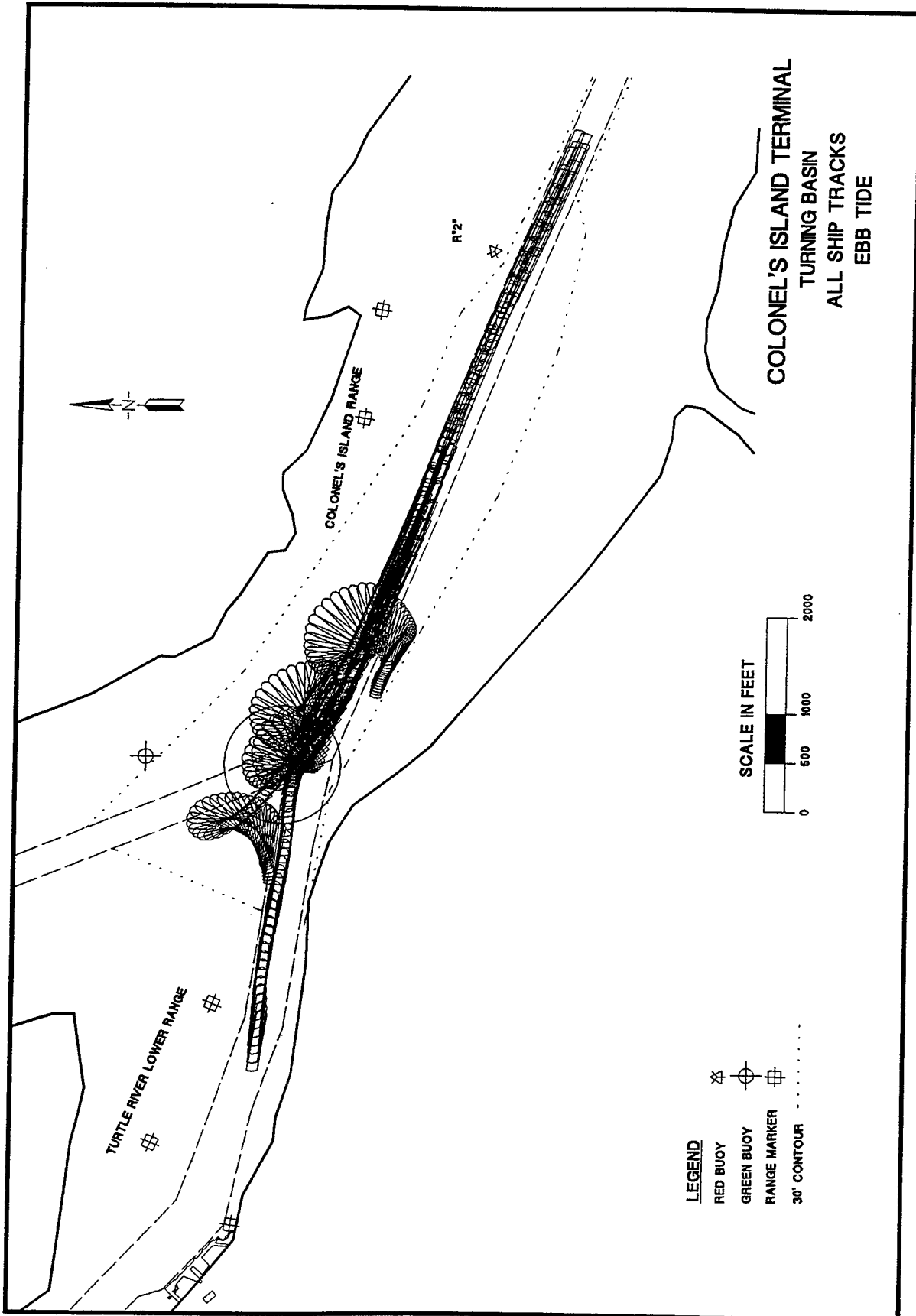
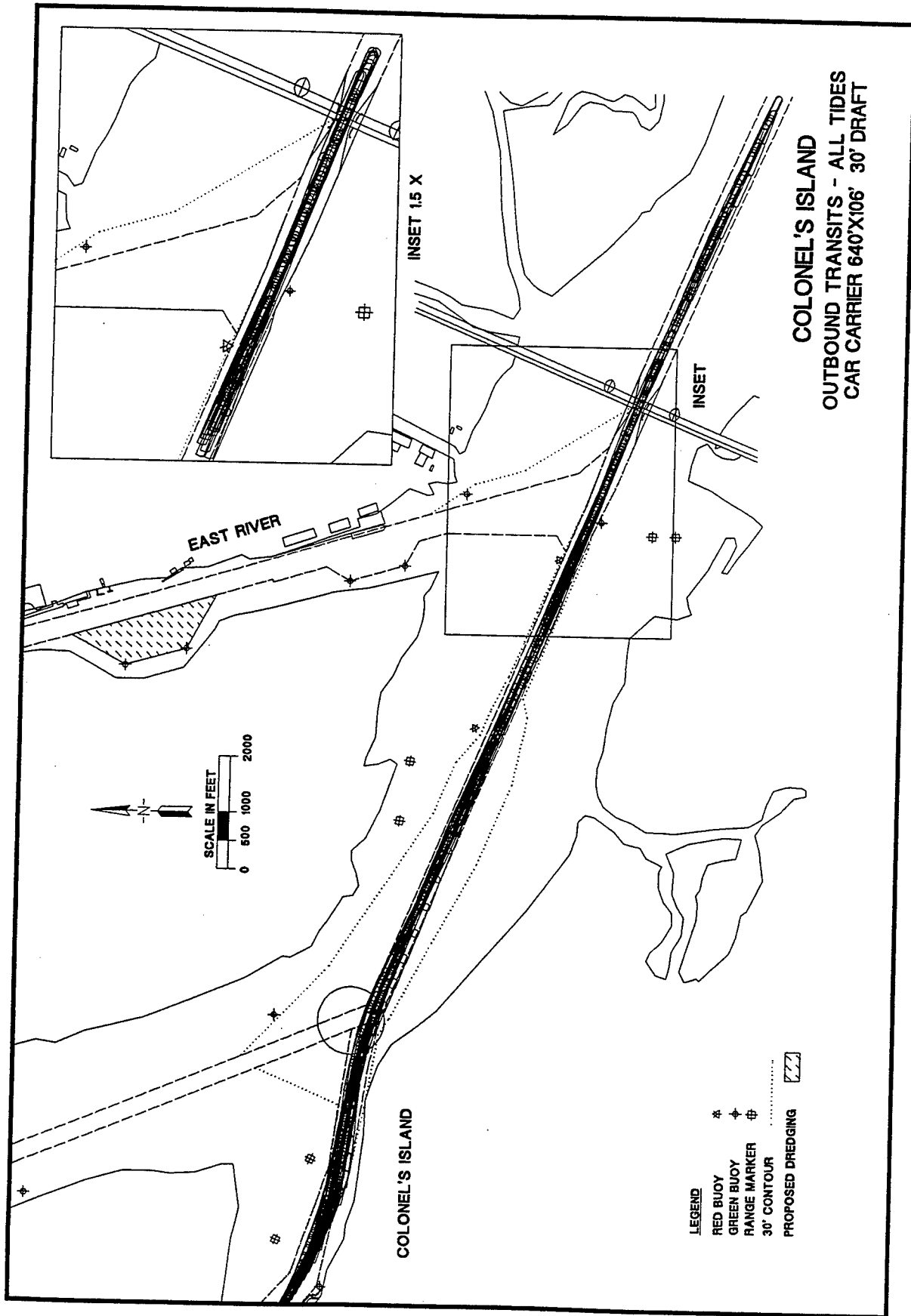


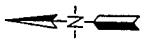
PLATE 28



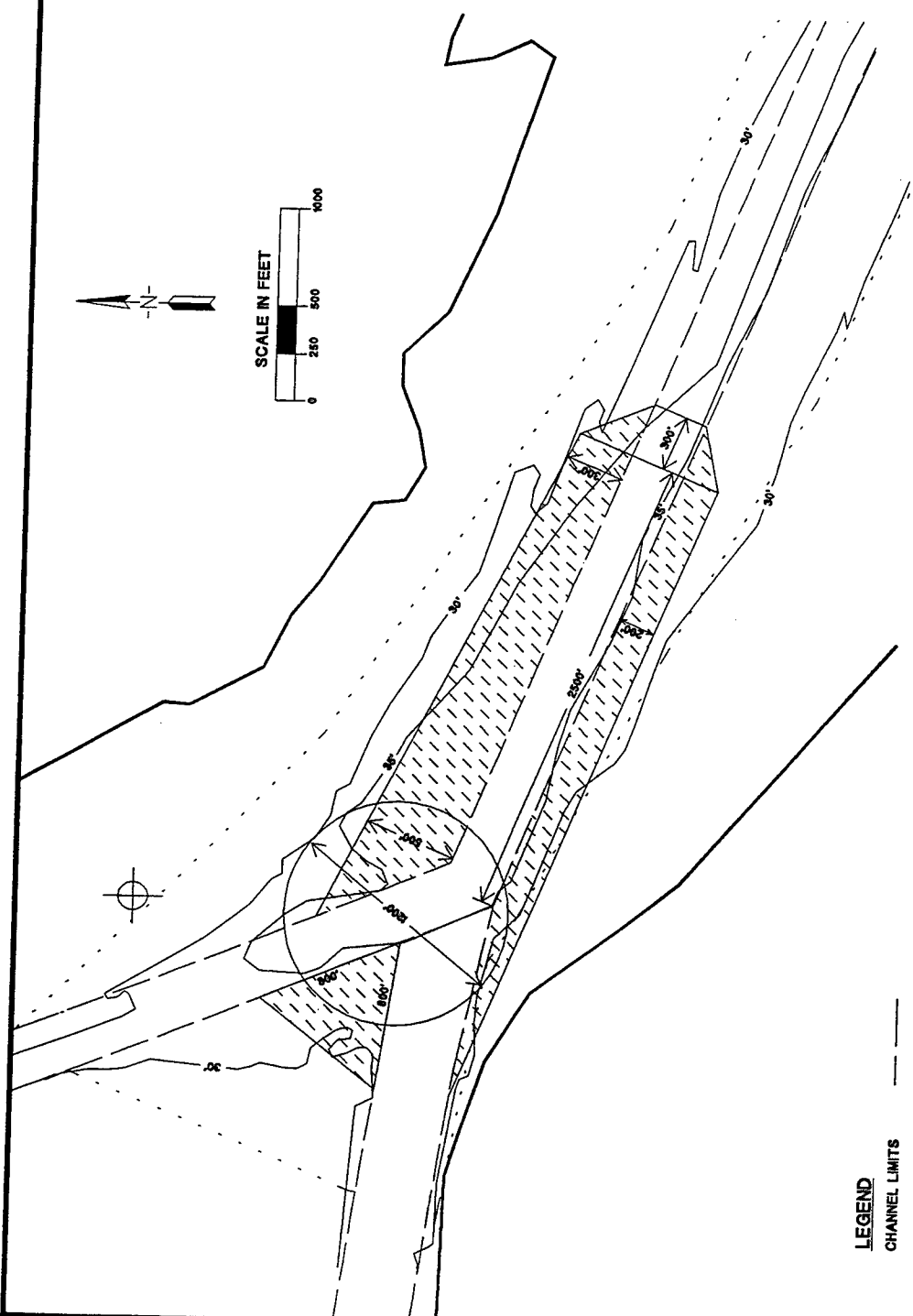
COLONEL'S ISLAND
OUTBOUND TRANSITS - ALL TIDES
CAR CARRIER 640'X106' 30' DRAFT

- LEGEND**
- * RED BUOY
 - ◆ GREEN BUOY
 - ⊕ RANGE MARKER
 - 30' CONTOUR
 - ▨ PROPOSED DREDGING

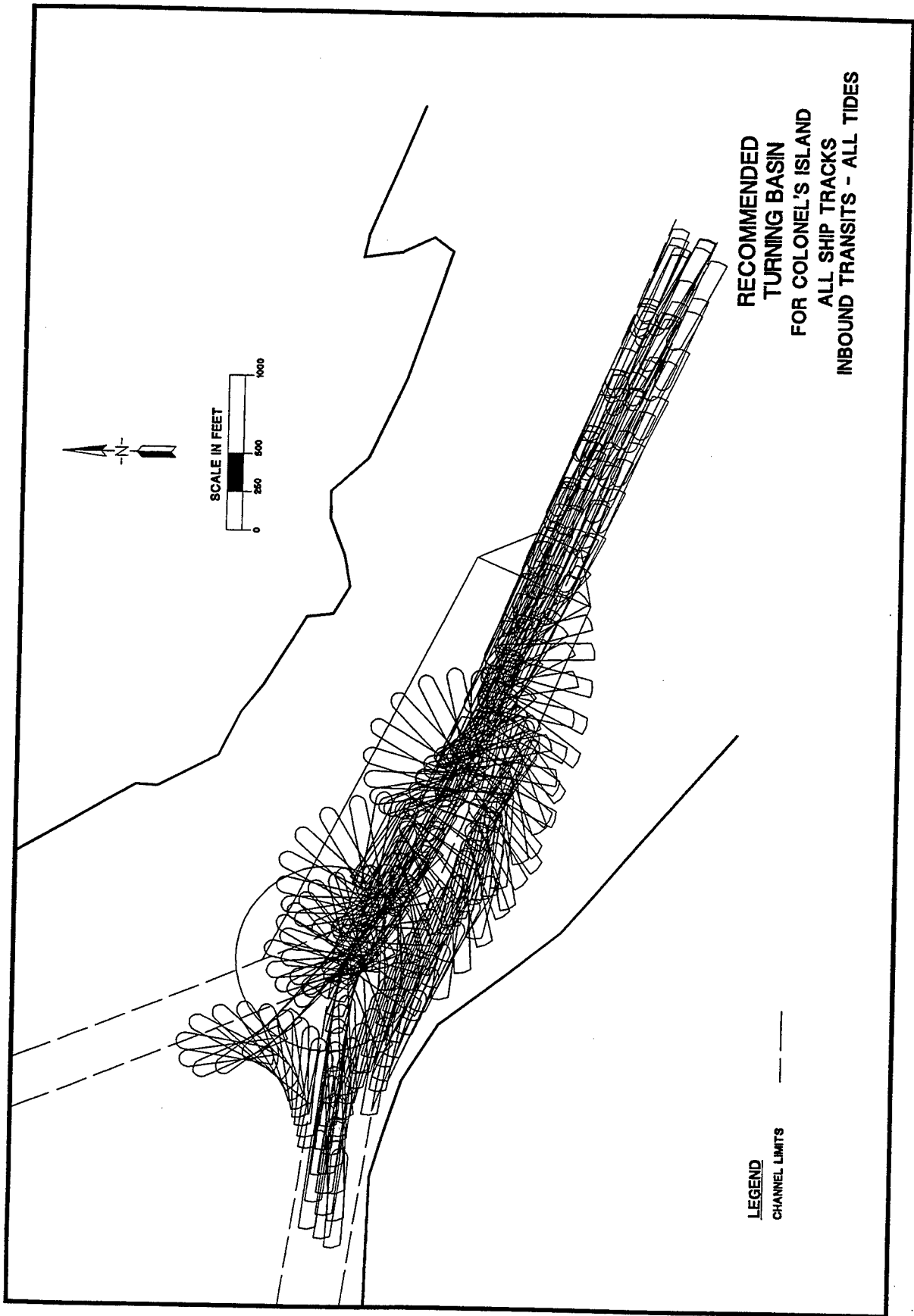
SCALE IN FEET
 0 500 1000 2000



RECOMMENDED
TURNING BASIN
FOR COLONEL'S ISLAND
TERMINAL



LEGEND
CHANNEL LIMITS ———
RECOMMENDED DREDGING [hatched box]



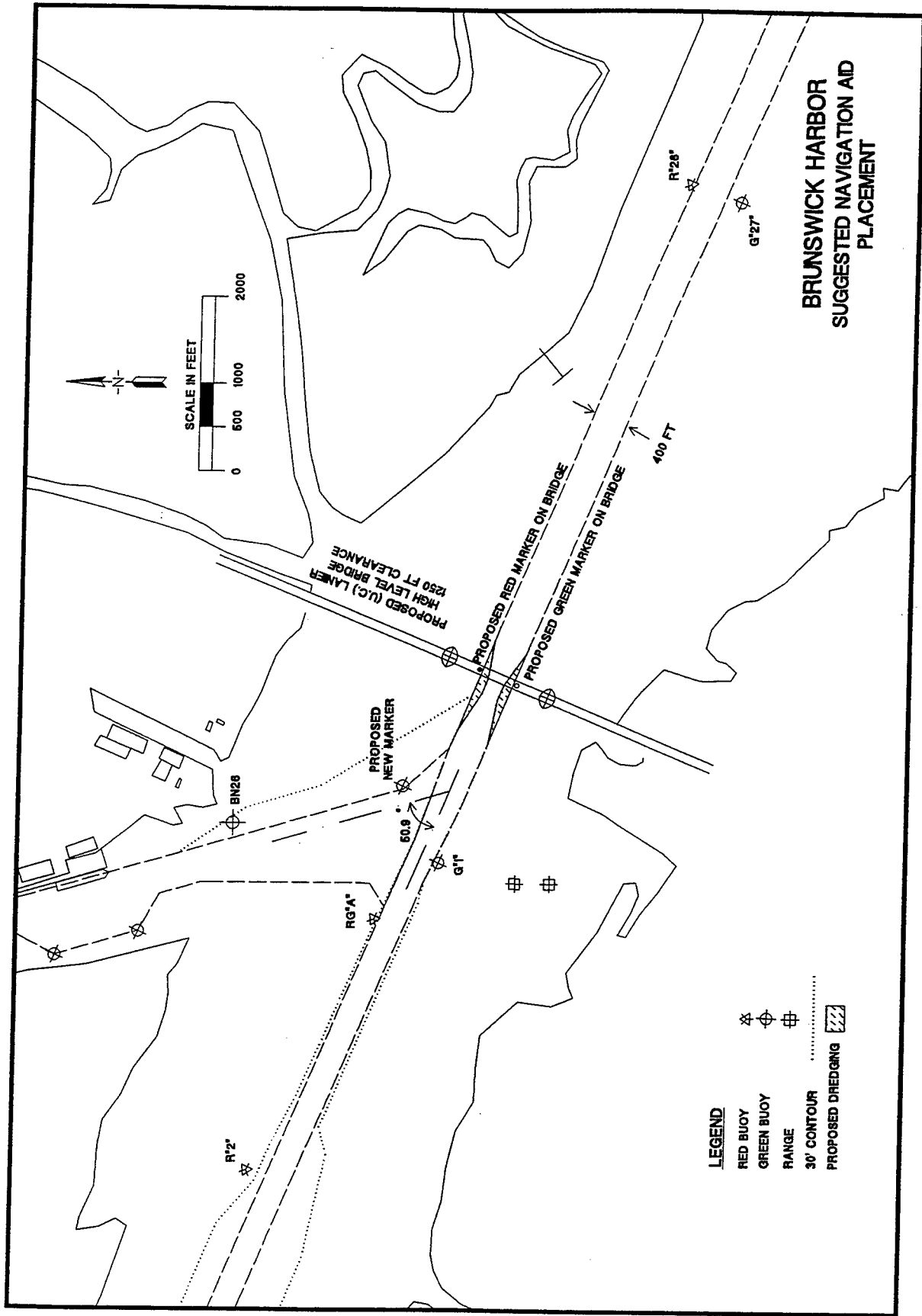


PLATE 32

REPORT DOCUMENTATION PAGE

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OMB No. 0704-0188

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Engineer Waterways Experiment Station 3909 Halls Ferry Road Vicksburg, MS 39180-6199			8. PERFORMING ORGANIZATION REPORT NUMBER Technical Report CHL-98-18	
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13. ABSTRACT (Maximum 200 words) <p>Savannah District requested a navigation simulation study of Brunswick Harbor to determine both channel and bend widening requirements throughout the channel based on, primarily, real-time simulator experiments with the design ships, and the best design and placement of the East River turning basin. Navigation conditions (existing and proposed) were conducted using real-time piloted ship simulation experiments. A field data collection verified and adjusted a numerical hydrodynamic model of the tidal currents and the tidal sound and river system; and a hydrodynamic model of the existing and plan conditions was developed and adjusted based on field data. Also, two hydrodynamic models of design ships (a car-carrier for analyzing the South Brunswick Channel leading to the existing Colonels Island car facility, and a bulk carrier for analyzing the East River channel and turning basin) for experimenting due to the different navigation concerns associated with each ship type were developed. Channel deepening in Turtle River above the Brunswick and South Brunswick Rivers junction was not included in the study.</p>				
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