CESAW-TS-EG

ENVIRONMENTAL AND GEOTECHNICAL SECTION

US Army Corps of Engineers®
Wilmington District

SAVANNAH HARBOR EXPANSION BANK EROSION STUDY

FORT PULASKI & NORTH TYBEE ISLAND GEORGIA

02 November 2006
Amended per comments dated 29 July 2010

Savannah Harbor Expansion General Bank Erosion Study

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SUMMARY
SAVANNAH RIVER BANK EROSION STUDY
SAVANNAH HARBOR EXPANSION PROJECT

1. Introduction

The Wilmington District Geotechnical Section (CESAW-TS-EG) has completed bank erosion studies for the shoreline at Fort Pulaski and North Tybee Island. Studies are based on available soils information, bathymetry, topographic surveys, aerial photographs, historical information, observation/review of channel side slopes resulting from previous harbor widening and deepening projects, and information from previous dredging works regarding channel side slope performance. Also included is information and data from the 'Ship Forces on the Shoreline of the Savannah Harbor Project' report recently completed by the US Army Engineer Research and Development Center (ERDC) and certain assumptions with regard to energies, erosion, and causal relationships. The ERDC Ship Forces Report originally included as Appendix A herein has been removed is now included as a separate document.

2. General

a. Channel side slopes historically average approximately 1 vertical on 3 horizontal (1V on 3H) for the Savannah River Inner Harbor and are generally considered the norm within the inner harbor. Channel side slopes for the Bar Channel are typically taken at 1V on 5H for dredging purposes; however, they will vary from 1V on 5H to flatter slopes. The shoreline for both the Fort Pulaski and North Tybee sites are well removed from the shipping channel and exist with much flatter side slopes that range from 1V on 12H to 1V on 14H. The distance from the Fort Pulaski shoreline to the southernmost edge of the shipping channel varies from about 470 feet to 1,060 feet. The distance from the North Tybee Island shoreline to the shipping channel varies from just under to over one mile. The shoreline is separated from the shipping channel by the Cockspur Island Training Wall. A General Location Map is included as Appendix B.

Each is discussed separately in the following paragraphs. Areas that are not specifically addressed herein were also reviewed in detail using the proposed channel geometries and the most recent survey/sounding information, the results of which are addressed in other studies.

b. **A**ddressed are the effects (or assumed effects) of time, tide, river currents, wind, rainfall, ship wakes, storms, channel configuration, aerial photography, structural enhancements, and other shoreline changes made from about 1957 to the present. Where actual measurements were obtained, they were considered in preparation of this report. Other information is based on known performance, bank materials, flow, area use, proximity of traffic, and other general assumptions made for each site.

c. Inspections were performed as a part of obtaining riverbank and structural information within the areas of concern. Field data obtained is described and discussed in ERDC's report Ship Forces on the Shoreline of the Savannah Harbor Project. A copy of the report is included as a separate document.

3. Subsurface Investigation

The U.S. Army Corps of Engineers (USACE) has performed a number of surface investigations and measurements within the Fort Pulaski and North Tybee Island areas. Soil borings were also made in the vicinity of the shipping channel. While these borings are not in the immediate vicinity of the shoreline, they describe typical soil types encountered nearby. The majority of these borings were drilled along the north side of the channel for the Savannah Harbor Widening and the Savannah Harbor Deepening projects. The investigations used a variety of methods to obtain subsurface data, including Vibracore, splitspooning, coring, cone penetration tests, and other methods. Standard penetration sampling using a split-barrel sampler was the method most often used. Using this method, a 1-3/8 inch inner diameter standard split barrel sampler was driven through the material using a 140-pound hammer with a 30-inch fall. The sampler was retrieved, and the material was described in accordance with the Unified Soil Classification System. Soil samples were obtained from borings and selected samples were tested for moisture content, plasticity, soil grain-size distribution, and strength characteristics.

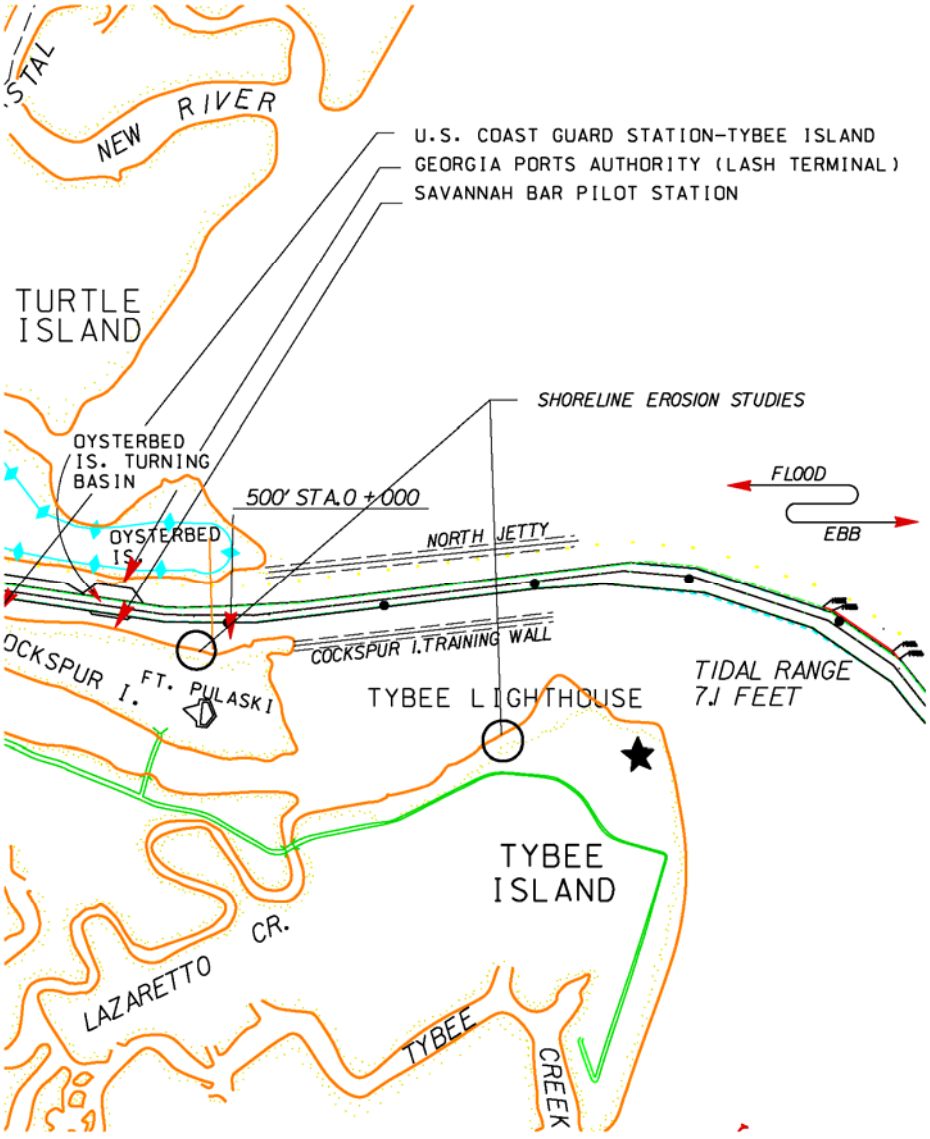
4. Analyses Overview

The analyses are intended to estimate the additional loss of shoreline due to ship wakes as a direct result of deepening the Savannah River shipping channel near the Fort Pulaski property and the northern beach of Tybee Island. The result was determined by taking the difference between the ship wakes of today versus the ship wakes of the future, after deepening. The total estimated shoreline erosion (due to all causes) is based on aerial photography from 1964 through 2003. While additional data is available, it doesn't appear to change the outcome with regard to shoreline recession. Other shoreline changes are discussed which include placement of dredged materials, armoring of adjacent shoreline, drainage features, and proximity of shoreline to the shipping channel.

5.. Fort Pulaski and North Tybee Descriptions

5.1 Fort Pulaski

The Fort Pulaski site is defined herein as the property along the shoreline from Georgia East NAD83 coordinates E 1049657.94, N 741683.76 (upstream) to E1052062.12, N 741085.54 (downstream); a distance of about 2,480 feet. The property is located at the entrance to the Savannah River from the Atlantic Ocean, directly adjacent to and on the outside bank of a 149 degree bend in (the river) real estate configuration. The general location is shown on the following Study Location Plan.



STUDY LOCATION PLAN

This shoreline is unprotected and lies immediately downstream from the protected shoreline utilized by the Savannah Pilots Association (SPA) and immediately upstream from the protected shoreline at the lower end of Cockspur Island. A circular erosion pattern exists immediately downstream from the SPA slope protection. The erosion for this area is apparently caused by eddy currents from tidal flows each day, the extent of which far exceeds other noted erosion anomalies. In addition, three prominent drainage features exist from upland areas to the shoreline spaced about 300 to 400 feet apart and located in the upstream half of the site.

The distance from the shoreline to shipping channel varies in a non-linear manner from about 790 feet to about 1,260 feet (Fort Pulaski), as determined from the shoreline visible on aerial photographs and measured to the shipping channel centerline, plotted and shown by coordinates (GA NAD 83).

Cross sections were plotted at 100-foot intervals along a baseline near the shore to cover the site and include the protected shoreline beyond the site at either end for a short distance. The plan view of the area indicating cross section locations is contained in Appendix C. Plans include the apparent shoreline taken from aerial photos for the years 1957 to 2003. Selected sections showing the range of variation are presented in Appendix D.

The proposed plan for deepening of the shipping channel calls for maintaining the existing shipping channel side slopes and allows for deepening by narrowing the channel bottom. Note that the shipping channel side slopes are separate and well removed from the shoreline or bank side slopes for both Fort Pulaski and North Tybee areas.

Review of the available information for Fort Pulaski and North Tybee indicates the proposed expansion with regard to the change or difference in ship wakes from 2005 through the year 2030 will not have a remarkable effect on either shoreline.

5.2 North Tybee

The North Tybee site is defined herein as the property along the shoreline from Georgia East NAD83 coordinates E 1060300.0, N 737576.0 (upstream) to E1062490.0, N 739000.0 (downstream); a distance of about 2,670 feet. The property is located near the entrance to the Savannah Front River from the Atlantic Ocean and behind a jetty located between the Front River and the Savannah River shipping channel. The general location is shown on the Study Location Plan.

The distance from the shoreline to shipping channel varies from less than one mile to almost one mile for North Tybee, as determined from the shoreline visible on aerial photographs and measured to the shipping channel centerline, plotted and shown by coordinates (GA NAD 83).

Immediately behind the Tybee shore and beach exists residential dwellings and various beach access structures.

6. Surface Investigations

The (unprotected) area of Fort Pulaski, North Tybee beach, City Front, and the north bight area has been investigated by several entities and methods. The City Front shows no adverse impacts due to deepening and will not be discussed herein. The bight area is being addressed as a separate issue and is currently programmed for repair and protection in the near future.

The unprotected river bank at Fort Pulaski has been the subject of several investigations.

(1) The Corps of Engineers, Savannah District has conducted an investigation of erosion using known soil properties composition, tide and flow patterns, aerial photographs from 1957 through 2006 showing the river's bank, and ship traffic through the shipping channel, now and predicted.

(2) The Engineer Research Development Center, Vicksburg, MS (formerly WES) was commissioned to conduct a study and has completed a 'Ship Forces on the Shoreline of the Savannah Harbor Project' Report which addresses the effect of ship wake(s) on the shoreline.

(3) The Skidaway Institute of Oceanography (SKIO) in Skidaway Island, GA has also conducted studies in and around the Fort Pulaski area under the direction of Dr. Alexander.

It appears that all of the studies, performed separately, have arrived at roughly the same conclusion with regard to 'the amount of shoreline recession' and 'where' erosion is taking place. There may some future discussion on exactly 'why' the (observed) erosion is taking place at any given point. Dr. Alexander has implied that the erosion at Fort Pulaski was due largely to ship traffic which is not supported by USACE studies.

Studies of the North Tybee area indicate some degree of erosion from various causes. However, correlations to ship traffic and the proposed deepening work do not appear to be supported. All indications suggest that the deepening of the shipping channel will reduce energies from ship wakes by approximately 2.3 to 5.9 percent. It is not believed that the deepening project will have any measurable effect on the North Tybee shore.

7. Fort Pulaski

The Fort Pulaski site identified in this study is the unprotected area previously described, it has three major drainage features, and one ongoing scour depression on the upstream side immediately adjacent to the end of the rock slope protection. Aerial photographs from 1955 through 2006 were used to estimate the average yearly bank erosion along about 4,100 feet of shoreline. Photos indicate that about 1.8 feet minimum each year is lost toward the approach and discharge ends. The maximum erosion occurs in the bend area of this site (about 148 degrees), and measurements indicate about 3 feet of shoreline per year are lost to erosion. Maps of the area are shown in Appendix C.

The early study was correlated with Dr. Alexander of the Skidaway Institute. His separate study indicated about 1 meter or a little over 1 meter for the same area; thus, with a good match on how much erosion is taking place for the area, additional refinements were not attempted.

The next step involved plotting of cross sections to determine channel configuration with respect to the shoreline; calculating the flow area; estimating the average velocity of flows, depths, radius, and other factors in an attempt to find the amount of scour and erosion that would take place on the bank (without ships), for the existing channel depth of 46 feet and the maximum proposed channel depth of 52 feet. Using the Zeller Bend Scour method from a paper and computation spreadsheet developed by David T. Williams, Ph.D. PE, and Leo R.

Kreymborg, PE, with input from Steve Maynord, ERDC and others, the erosion predicted for the Fort Pulaski bend site ranges from 1.6 feet to 3.2 feet. The model isn't perfect; it assumes that side slopes are uniform (not), bottom is uniform (not), crest contains smooth lines (not), and so forth.

Additional checks were performed using the CEDAS –ACES program. ACES is an interactive computer-based design and analysis system in the field of coastal engineering containing six functional areas: wave prediction, wave theory, wave transformation, structural design, wave runup, and littoral processes. This program looks at tides, velocities, shape and size of the entrance and discharge openings, and bend angle, among other parameters. The predicted erosion from this model ranged from 3.0 to 3.3 feet. Both models do not include ship traffic and/or ship wakes.

Consideration is given to the occasional storms, Northeastern'rs and long fetch waves on the Fort Pulaski site. However, this effort was limited to results from a single one hour event with a maximum wind of 45 mph. One such event yielded a 4.2 –foot wave height and a 4.2 - second wave period. A storm duration of the scope defined above is estimated to account for about 0.1 foot of shoreline loss each year/event.

Omitted are the eddy effects of the armor stone placed immediately upstream of this area, the three drainage features (ditches or severe roughness factors), and other shape factors that serve only to complicate erosion patterns beyond that actually measured on the ground.

Included are the results from ERDC's Ship Wake Study that notes: "Wave power, found by Kamphuis (1987) to correlate with shoreline recession, was calculated with equation 4. Bow and stern wave periods from the field study were 3-3.5 sec. The composite short period wave height increases of 1.5 to 4.4% result in wave power increases of 2.3 to 19%." The report is included as a separate document.

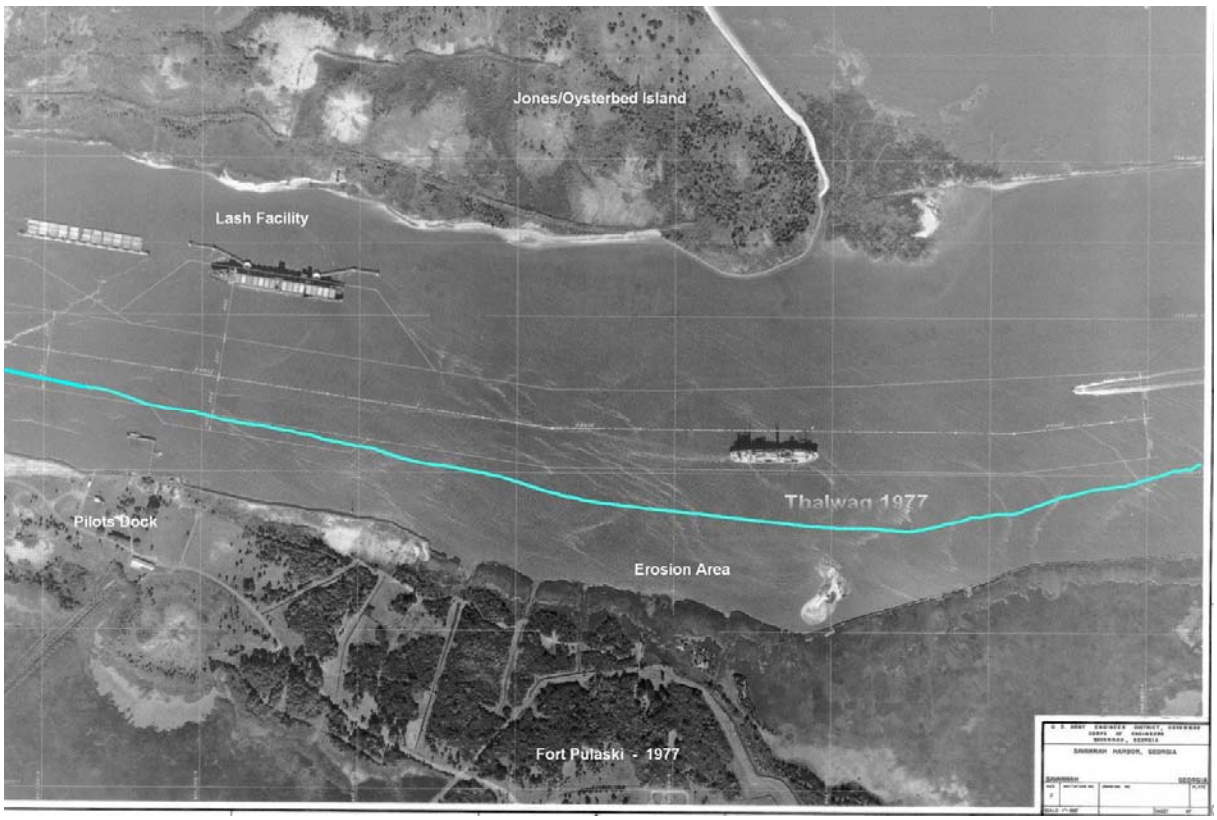
Also considered is the effect of the channel shape and appurtenances constructed which influence flow, thalwag configuration and direction, and the amount of time that a ship will spend contributing energy to the shore which could in turn contribute to erosion. The photo of the Fort Pulaski area (shown below) from 1977 is a good example of the ebb tide flow regime. It also shows the apparent magnitude of ship wake compared to normal ebb currents and waves.

The present ship traffic has been estimated from the ERDC study as shown in Table 4 of the early draft report (below):

Table **4**. 2003 Containership Traffic for Savannah Harbor

Vessel Type	Length, ft	Beam, ft	Design Draft, ft	# Calls	% of calls(*)
Post-Panamax	1044	140	45.3	7	0.6(4.9)
Panamax	951	106	40.7	872	70.0(48.0)
Sub-Panamax	716.3	99.8	37.7	255	20.5(15.7)
Handysize	579.1	85.1	31.8	105	8.4(17.6)
Feedermax	427.5	67.7	25.2	5	0.4(8.8)
Feeder	344.7	56.1	20.0	1	0.1(4.9)

*%of ship transits in 2005 field study- based on 102 ship transits



FORT PULASKI - 1977

Based on the estimated number of ships in the ERDC study, approximately 1,245 calls were made to Savannah Harbor for the year 2003 (as estimated from the 2005 study). Georgia Ports, as of 2006, adjusted the 2003 port calls to 1,258. Ship traffic is quantified by number of calls with each call being equal to one inbound and one outbound transit. Ship speeds were measured from 9 to 14 knots (1 Foot per Second (fps) = 0.593124324324324 Knot) relative to the shore. Roughly translated, ship speeds varied between 15.2 and 23.6 feet per second, the average of which is about 19.4. At Fort Pulaski, ship speeds increased slightly, measured at 11.5 to 11.8 knots (19.4 to 19.9 fps) for an average of 19.6 fps. The average length of 98.9 percent of all ships calling was determined from the ERDC report to be 574 feet. The average

time that any ship spent passing any given spot along the shore at Fort Pulaski was 574 / 19.6 or about 29 seconds. The duration of ship generated standing wave plus trailing waves incident upon the shore was approximately equal to the ship's speed. The effective time of ship generated wave activity incident upon the shore is estimated as 19.6 mph average. This is also a good match with field observations of incident waves on the shore from passing ships.

Summarizing, there is about (worst case) one meter or about 3.1 feet of shoreline lost to erosion each year due to all causes. Of the 3.1 feet, the flows, tides and normal wave activity accounts for between 3.0 +0.1 and 3.3 feet roughly determined from software model programs. For the purpose of this study, we have assumed that the values obtained with the erosion model do not exceed the observed erosion values.

For the year 2003: 1,258 calls * 2 (in and out) equals 2,516 passing events (at Fort Pulaski) of a duration approximately 19.6 seconds each which corresponds to about 49,314 seconds of impact at any given point during the year. Thus, the percent of time for ships is about 0.156 percent of the year 2003 at any given point.

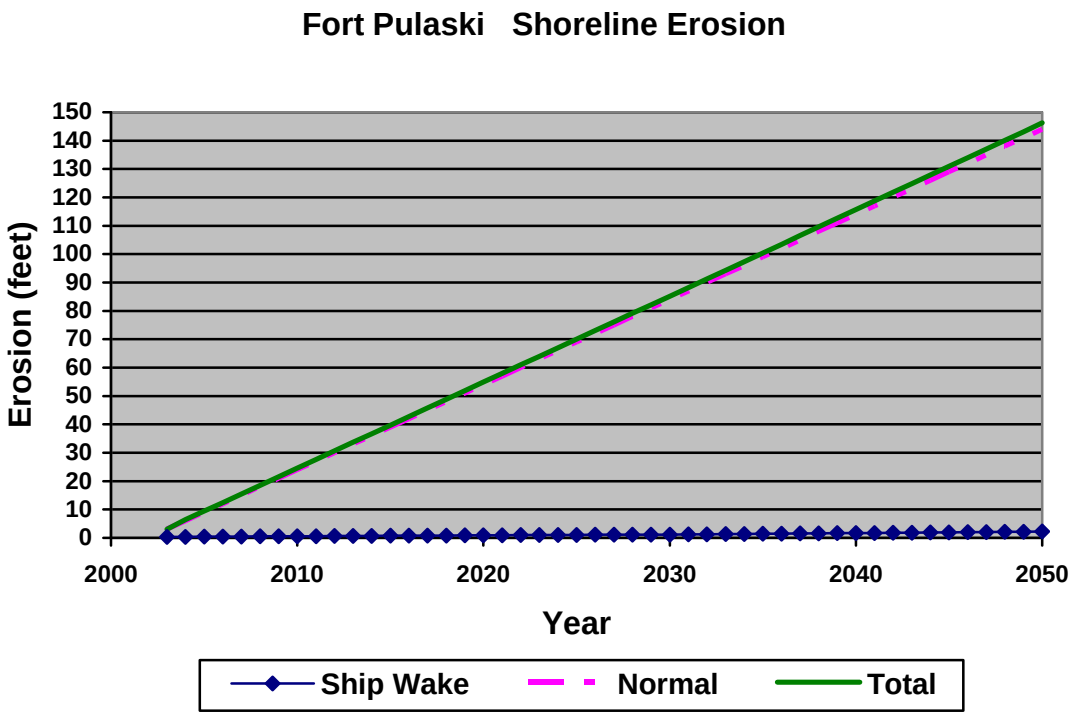
For the year 2030: 4,030 calls *2 (in and out) is 8,060 passing events (at Fort Pulaski), same duration, corresponds to about 157,976 seconds of impact at any given point during the year. Thus, the percent of time for ships is about 0.500 percent of the year 2030 at any given point.

For the year 2050: 7,801 calls *2 (in and out) is 15,602 passing events (at Fort Pulaski), same duration, corresponds to about 305,799 seconds of impact at any given point during the year. Thus, the percent of time for ships is about 0.970 percent of the year 2050 at any given point.

What is left (as a worst case) is the 3.1 feet (total) minus the 3.0 feet (predicted without traffic or other events) or 0.1 foot of erosion due to ship traffic and other causes. While 'other causes' were considered, detailed measurements were not made and could only be estimated. No doubt, the magnitude of each could be debated (until measurements are actually taken). Such events would include rain events, drainage events through the three drainage features, foot traffic, pleasure boat wakes, wind, the amount sedimentation contained or suspended in water flows, the GA Ports Lash Facility which serves to move the thalwag toward Fort Pulaski, etc., all of which will contribute to shoreline erosion of the unprotected slope. For the purpose of this study, the amount of erosion caused by 'other' events is estimated to operate more than 70 percent of the time each year with the ship traffic being responsible for the remaining possible 30 percent. Together, each is assumed to be responsible for the remaining 0.1 foot (1.2 inches) of erosion. Thus, it is estimated that 0.36 inch (about 3/8 inch maximum) of erosion could be attributed to all ship wakes during the year 2003. The existing range for erosion due to ship wakes then becomes an estimated negligible to 0.36 inch maximum.

Working with the maximum estimated erosion, predicting erosion for the years 2030 and 2050 becomes a function of ship numbers and size. Ships (of various size) have been predicted to call in about the same proportion as years earlier; thus, sizes were normalized and averaged. Therefore, if 1,258 ship calls were responsible for 0.36 inch of erosion at Fort Pulaski; then:

in the year 2030, 4,030 ship calls could be responsible for 3.2 * 0.36 or 1.15 inches, and in the year 2050, ship calls could be responsible for 6.2 * 0.36 or 2.23 inches of erosion, assuming the shoreline remains unprotected. The following chart graphically shows the predicted erosion due to ship wake(s), normal erosion, and the sum of the two (Total Erosion) over time.



The chart plots the erosion predicted from ship wakes (4.69) feet from 2003 through 2050. The chart also shows the expected normal erosion, without ship traffic or deepening, which is predicted to be 144 feet. It becomes obvious that if 148.69 feet (total) actually occurs over the next 47 years at this location, that amount of erosion would create a multitude of other problems. It is far more likely other events would prevent the full scope of the predicted erosion, i.e. slope protection might be installed.

8. North Tybee

As per the ERDC Ship Forces on the Shoreline of the Savannah Harbor Project Report, the Savannah Harbor Deepening will have no significant effect on North Tybee. The report concludes:

“At Tybee Island, the only significant ship effect reaching the shoreline is the long period drawdown or pressure wave. It is uncertain if the south jetty blocks ship effects at high tides

because ship effects generated outside the jetties reach the TI shoreline. As shown in Tables 16-19, the composite drawdown in the channel between the jetties per ship is 2.3 to 5.9% less in the with project (deepened) channel. The actual drawdown at the TI shoreline will be about 1/3 of the drawdown in the channel between the jetties."

9. City Front

The average drawdown for all ship traffic measured was 0.355 foot. (See Table 21 of the ERDC Report.) Due to the reduced speed in the City Front area, drawdown and ship wake are predicted to remain unchanged. Deepening of the channel is predicted to reduce the effect of ship wake by approximately 4 percent.

10. Confined Disposal Facility

This area of the bight has been predicted to experience approximately the same effect as the Fort Pulaski Site. However, a separate project is currently in progress to armor the shoreline to protect the GA State owned property at the expense of the State of Georgia.

11. Bank Stability Review

A review of the Savannah Harbor Expansion Bank Stability Report dated May 2005 has been completed with respect to the ERDC Ship Wake Study. The May 2005 report addressed the shipping channel with special attention given to areas where the deepened and/or revised channel alignment would or could impact existing shore, involve real estate taking, or directly affect real property in any way. Nothing contained in the ERDC Ship Wake study directly impacts the previous study in a way that would require redesign or additional takings. Previously noted, the global or overall factor of safety (FS) against slope failure is 2.2 for the riverbank and dike. However, for the softer soils located generally within the tidal zone, the calculated factor of safety is approximately 1.1. While the lower FS does not necessarily indicate a local failure problem, the fact that soft soil material occurs in the tidal zone could indicate an ongoing erosion problem due mainly to tidal and wave action. The analyses also indicate that the calculated slope exposed to the river should remain stable on an approximate 1 vertical on 3.2 horizontal slope (1V on 3H). Erosion due to time and tide is not generally considered a concern in need of Federal intervention with regard to private property.

12. Summary

The effects of deepening the Savannah River channel will not impact either the City Front or the North Tybee Site to any measurable degree.

The Confined Disposal Facility Site while impacted is in the process of being protected with armor stone against future erosion from tides, flows, and ship traffic.

Unprotected portions of Fort Pulaski are subject to shoreline erosion measurable from 1.6 to 3.1 feet per year, depending on specific location. The majority of erosion is due to tide,

flows, river mechanics, shape and other causes unrelated to ship traffic through channel. Ship traffic is estimated to have a minimal but measurable impact of about 0.36 inch (year 2003), 1.15 inch (year 2030), and 2.23 inch (year 2050) based on the predicted fleet mix and volume.

The total cumulative 47-year shoreline loss due to river environment without ships is estimated to be between 144 feet (maximum) and 75 feet (minimum).

The total cumulative 47-year shoreline loss due to ship traffic and predicted fleet mix is estimated to be between 4.69 feet (maximum) and 2.3 feet (minimum).

The total cumulative (predictable maximum) shoreline loss due to all causes, except for unforeseen and/or catastrophic events, is 144 + 4.69 or about 149 feet.

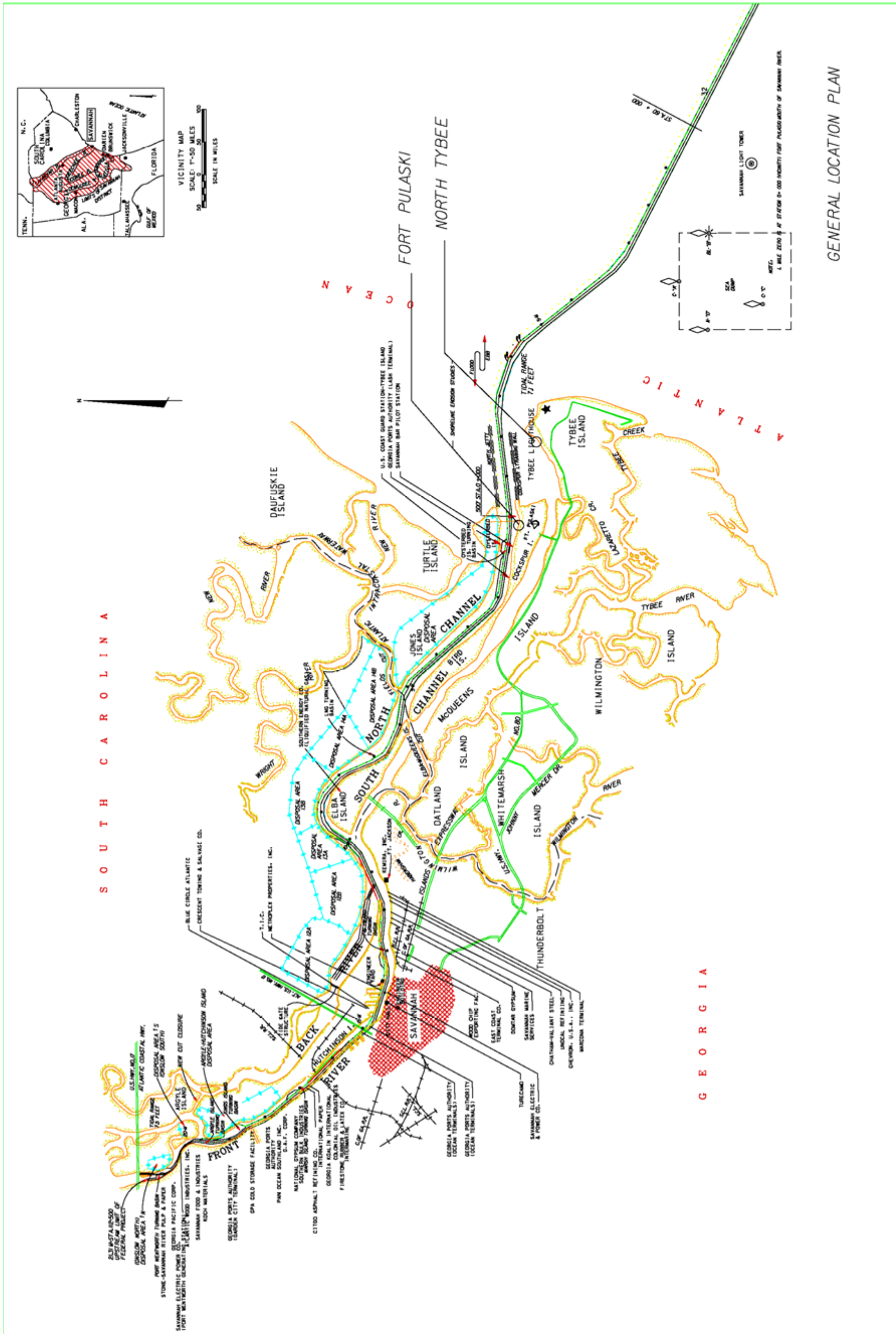
APPENDIX A

SHIP FORCES

Removed from this report and included as a separate document.

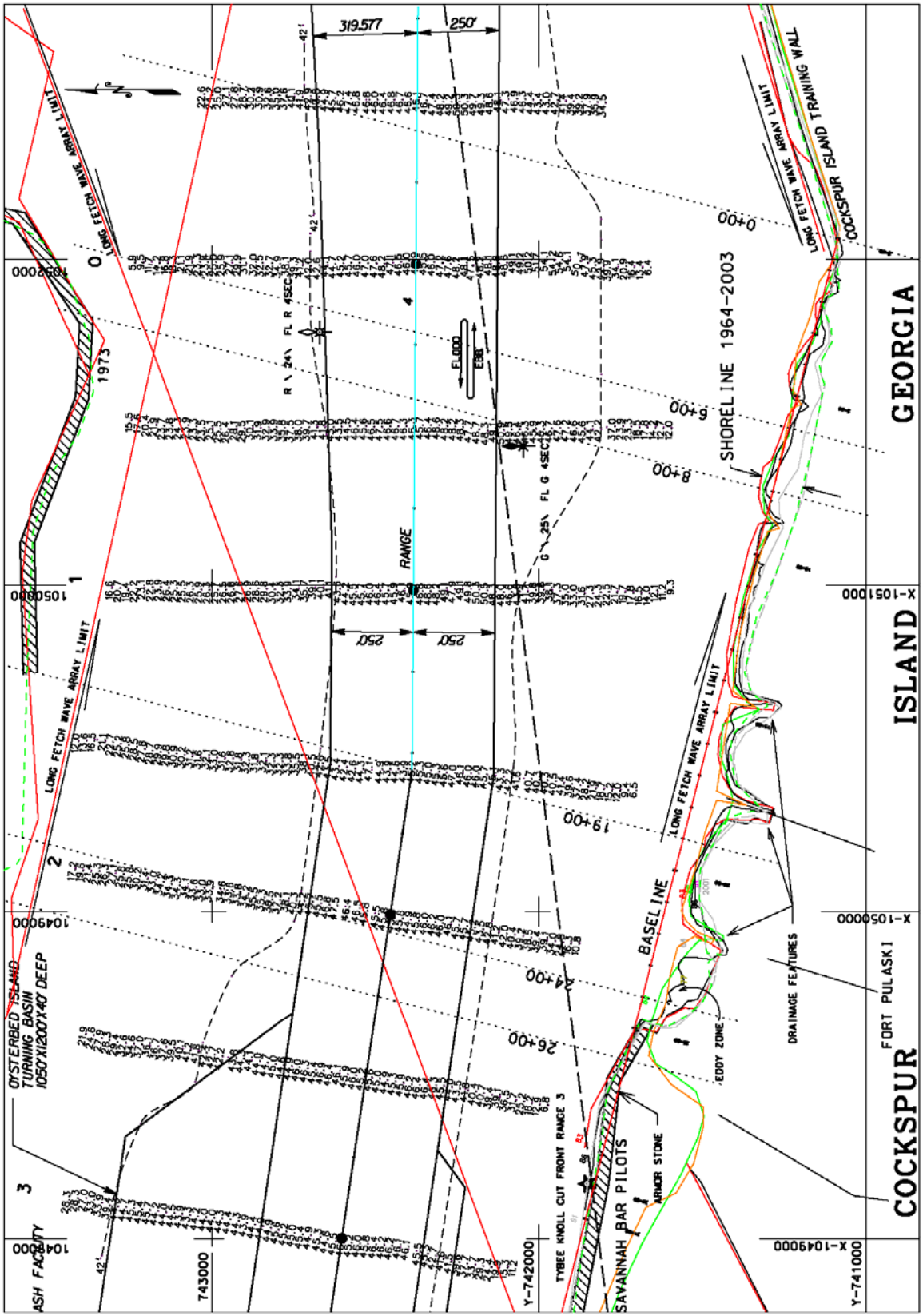
APPENDIX B

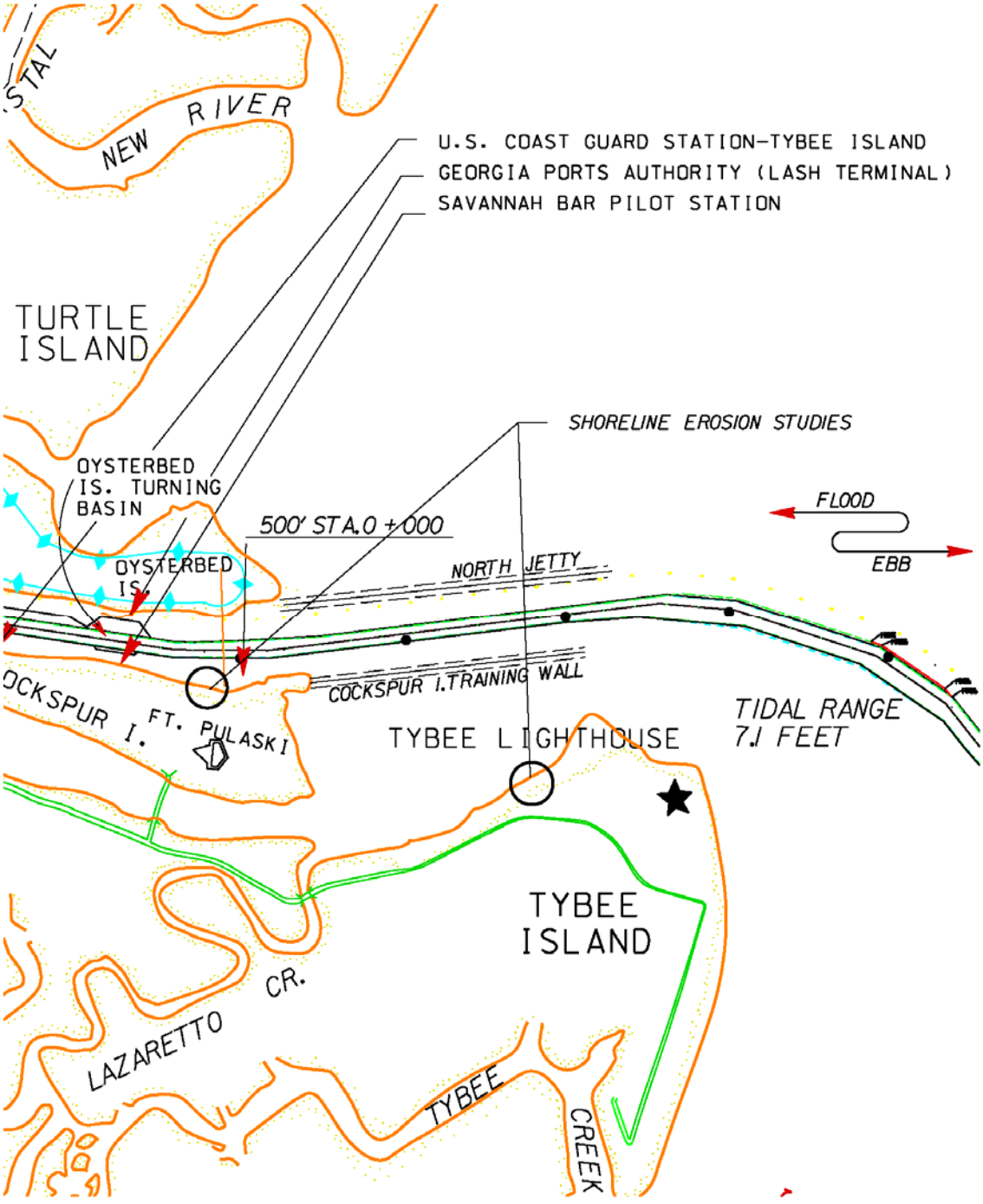
GENERAL LOCATION MAP

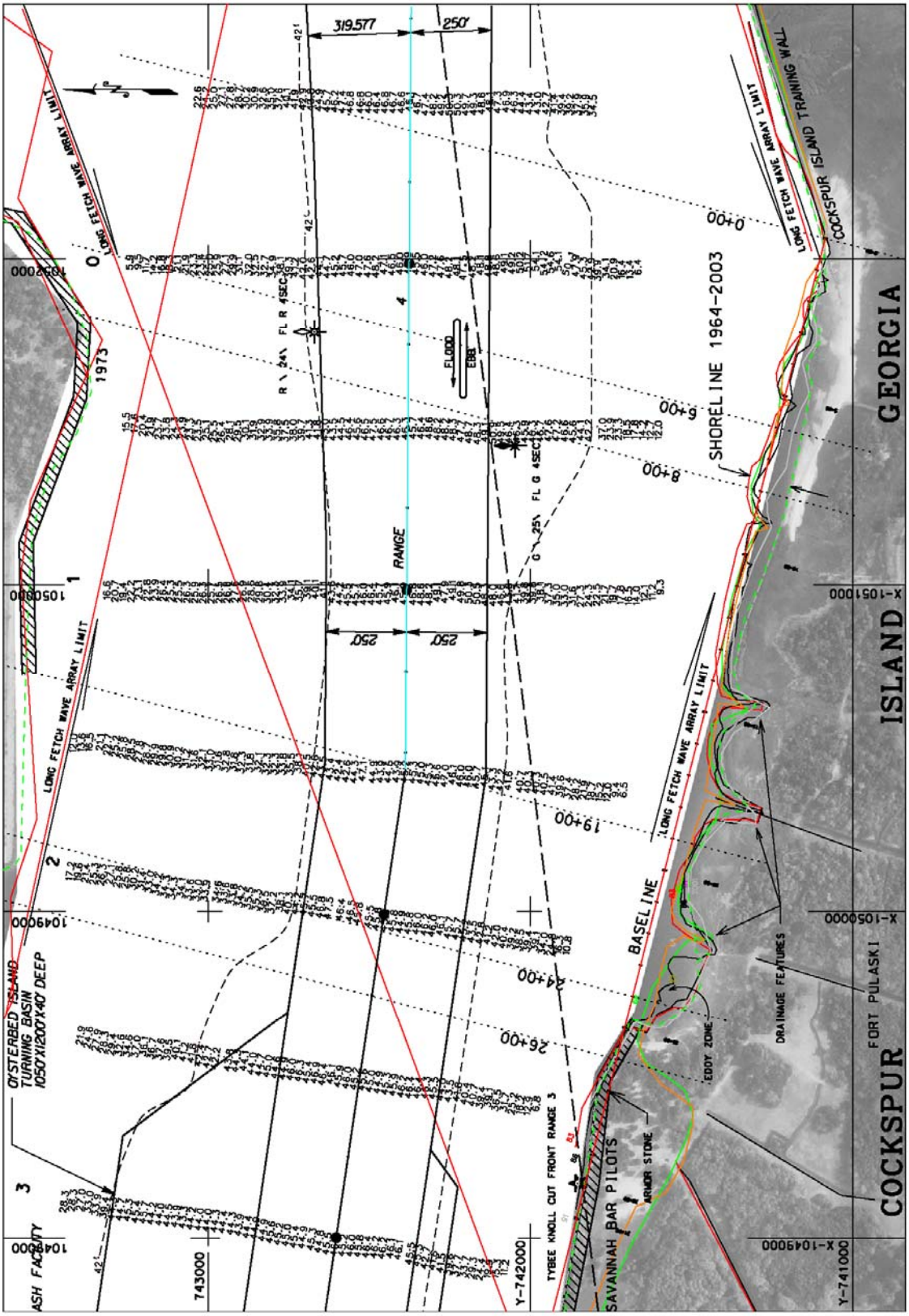

GENERAL LOCATION PLAN
VICINITY MAP
SCALE: 1"=50 MILES
SCALE IN MILES
FORT PULASKI
NORTH TYBEE
ATLANTIC OCEAN
SOUTH CAROLINA
GEORGIA
SAVANNAH
DAUFUSKIE ISLAND
TURTLE ISLAND
TYBEE ISLAND
TYBEE LIGHTHOUSE
TIDAL RANGE 7.1 FEET
SAVANNAH LIGHT TOWER
JONES ISLAND DISPOSAL AREA
ELBA ISLAND
McQUEENS ISLAND
WILMINGTON ISLAND
WHITEMARSH ISLAND
OATLAND ISLAND
COCKSPUR ISLAND
THUNDERBOLT
NORTH CHANNEL
SOUTH CHANNEL
BACK RIVER
FRONT RIVER
HUTCHINSON I.
ARGYLE ISLAND
TYBEE RIVER
WRIGHT RIVER
NEW RIVER
LAZARETTO CR.
TYBEE CREEK

APPENDIX C

MAPS GENERAL


319.577
250'
LONG FETCH WAVE ARRAY LIMIT
1973
SHORELINE 1964-2003
COCKSPUR ISLAND TRAINING WALL
GEORGIA
ISLAND
COCKSPUR
FORT PULASKI
RANGE
BASELINE
OYSTERBED ISLAND
TURNING BASIN
1050'X1200'X40' DEEP
TYBEE KNOLL CUT FRONT RANGE 3
SAVANNAH BAR PILOTS
ARMOR STONE
EDDY ZONE
DRAINAGE FEATURES
0+00
6+00
8+00
19+00
24+00
26+00
X-1051000
X-1050000
X-1049000
Y-742000
Y-741000
743000

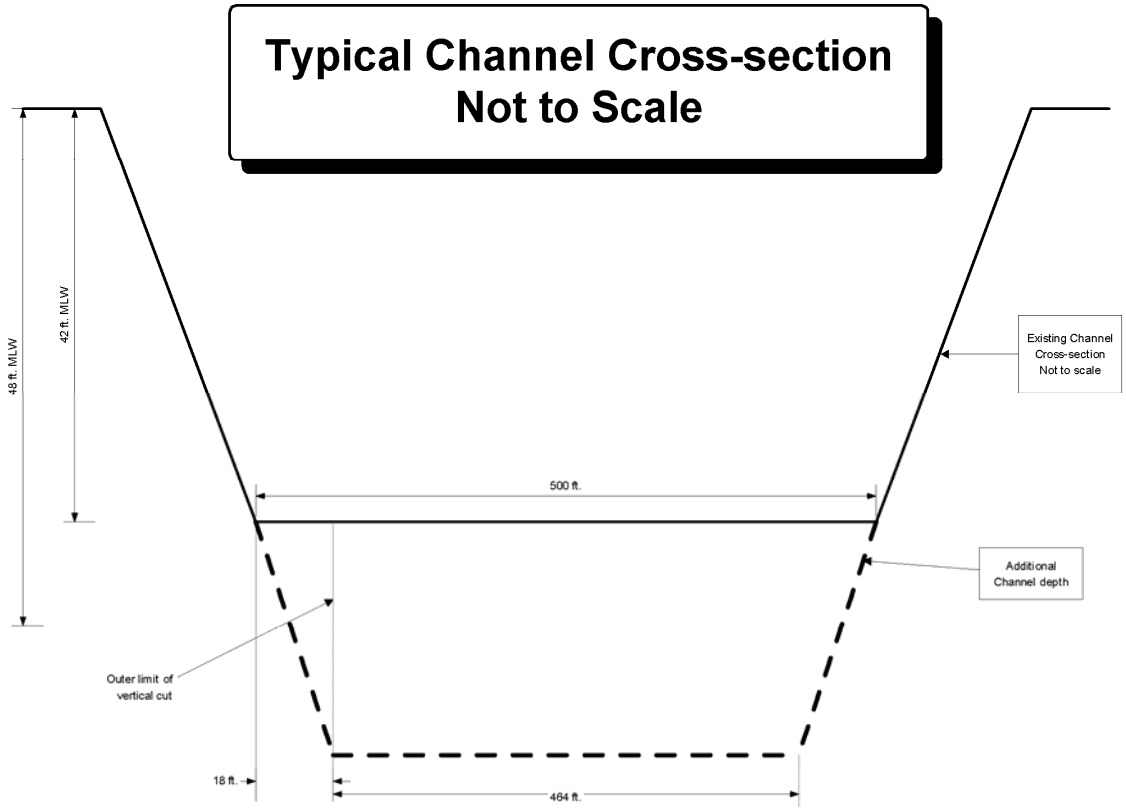

NEW RIVER
U.S. COAST GUARD STATION-TYBEE ISLAND
GEORGIA PORTS AUTHORITY (LASH TERMINAL)
SAVANNAH BAR PILOT STATION
TURTLE ISLAND
SHORELINE EROSION STUDIES
OYSTERBED IS. TURNING BASIN
OYSTERBED IS.
500' STA.0+000
FLOOD
EBB
NORTH JETTY
COCKSPUR I.TRAINING WALL
COCKSPUR I.
FT. PULASKI
TYBEE LIGHTHOUSE
TIDAL RANGE 7.1 FEET
TYBEE ISLAND
LAZARETTO CR.
TYBEE CREEK

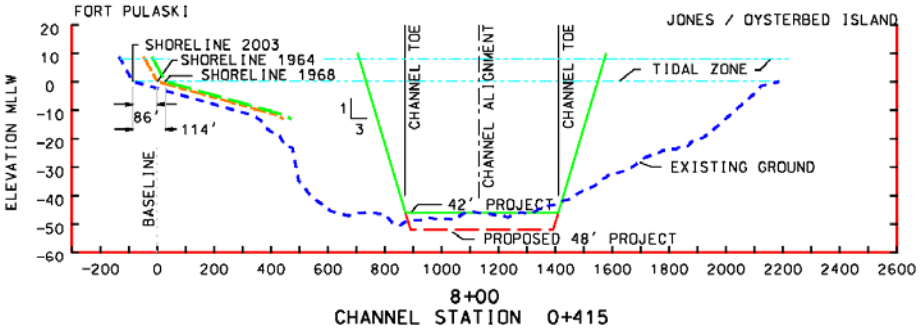

319.577'
250'
LONG FETCH WAVE ARRAY LIMIT
COCKSPUR ISLAND TRAINING WALL
SHORELINE 1964-2003
1973
FL R 4SEC
R \ 24\
FLOOD
EBB
FL G 4SEC
G \ 25\
RANGE
250'
250'
BASELINE
EDDY ZONE
DRAINAGE FEATURES
ARMOR STONE
SAVANNAH BAR PILOTS
TYBEE KNOLL CUT FRONT RANGE 3
OYSTERBED ISLAND
TURNING BASIN
1050X1200X40' DEEP
FORT PULASKI
COCKSPUR ISLAND
GEORGIA
0+00
6+00
8+00
19+00
24+00
26+00
X-1051000
X-1050000
X-1049000
Y-741000
Y-742000
743000

Savannah River Entrance 2006

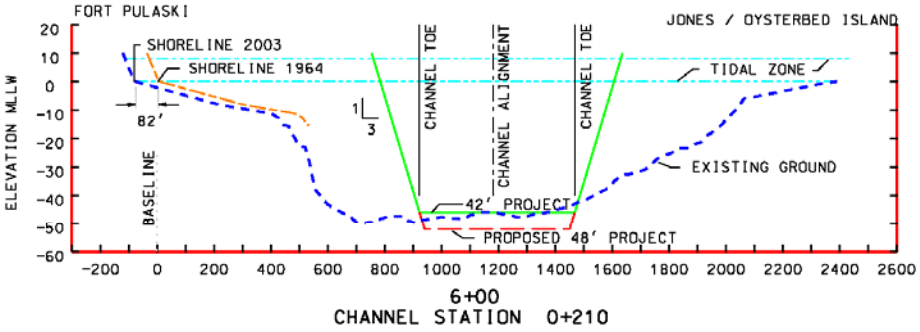
APPENDIX D

CROSS SECTION DRAWINGS

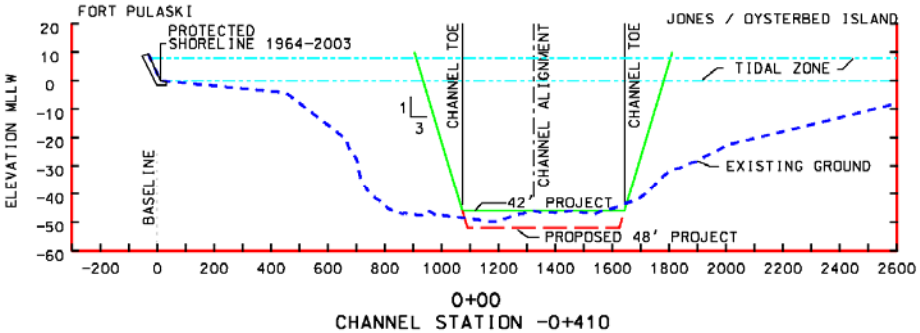

Typical Channel Cross-section
Not to Scale
48 ft. MLW
42 ft. MLW
Existing Channel
Cross-section
Not to scale
500 ft.
Additional
Channel depth
Outer limit of
vertical cut
18 ft.
464 ft.



8+00
CHANNEL STATION 0+415

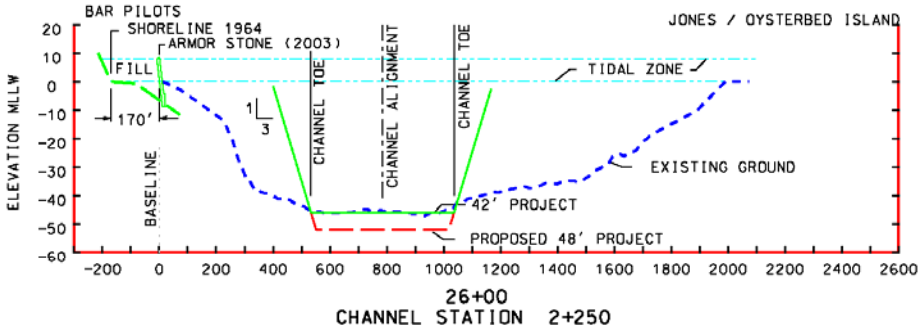


6+00
CHANNEL STATION 0+210

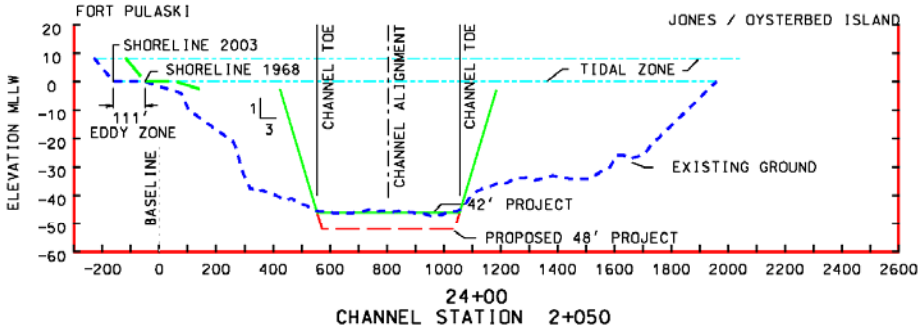


0+00
CHANNEL STATION -0+410

FORT PULASKI
SAVANNAH HARBOR



26+00
CHANNEL STATION 2+250



24+00
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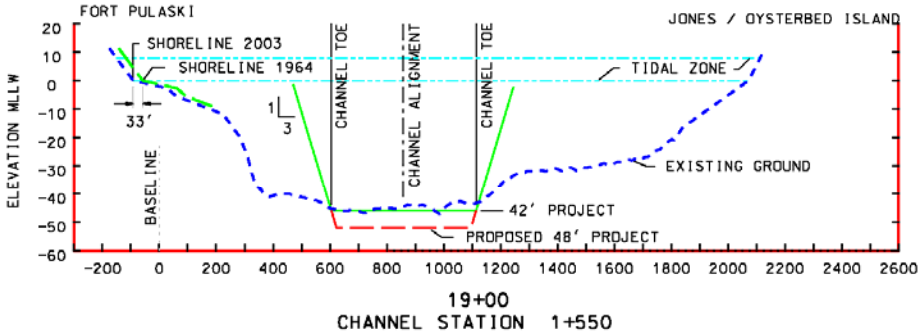


19+00
CHANNEL STATION 1+550

FORT PULASKI
SAVANNAH HARBOR

APPENDIX E

AERIAL PHOTOS

Savannah Harbor Entrance 1961

Note: Absence of Lash Facility and apparent even flow regime

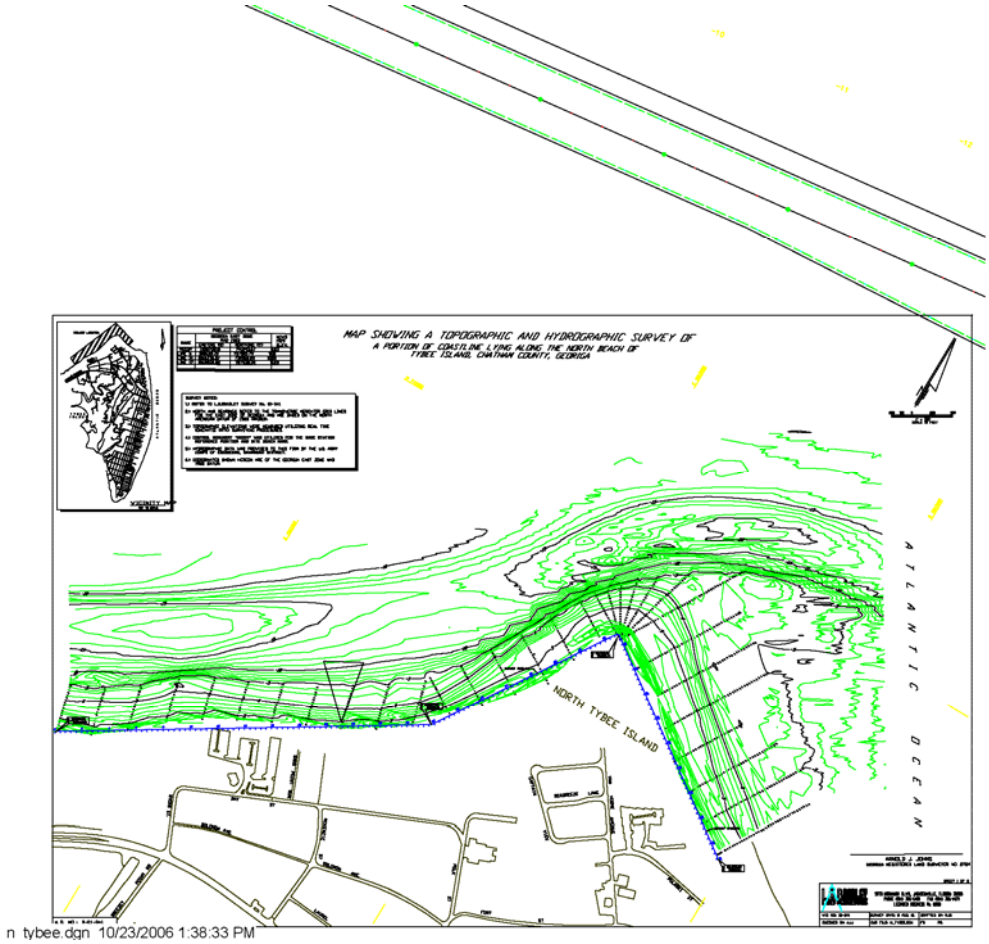
Savannah Harbor Entrance 1968

Note: Thalwag generally away from Fort Pulaski side of river.

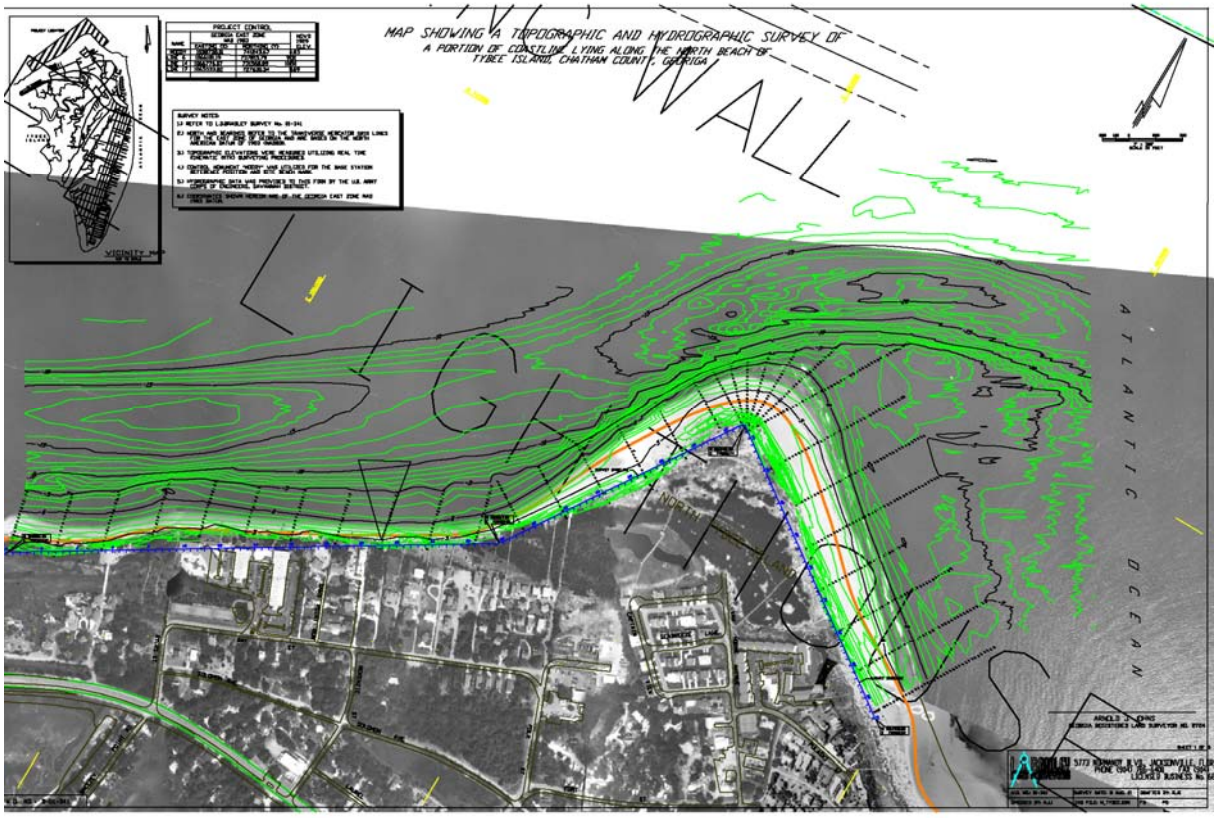
Savannah River Entrance 1983

Savannah River Entrance 1991

Savannah River Entrance / North Tybee 2006



North Tybee w/respect to Savannah River Entrance Channel


MAP SHOWING A TOPOGRAPHIC AND HYDROGRAPHIC SURVEY OF
A PORTION OF COASTLINE LYING ALONG THE NORTH BEACH OF
TYBEE ISLAND, CHATHAM COUNTY, GEORGIA
WALL
ATLANTIC OCEAN
North Jetty
VICINITY MAP

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Sample Input Sheet for Scour Spreadsheet

PBS&J Scour Spreadsheet Version 1.1 August 30, 2006

Instructions: Change values in colored cells only

Parameter	**Value**
Design Discharge, Q	320000
Design Top Width, T (top width at design Q)	2200
Average / Hydraulic / Mean Depth	46
Hydraulic Radius	2990
Maximum Depth	48
Average Velocity	4
Bankfull Depth at Channel-Forming Discharge	46
Bankfull or Channel-Forming Discharge	320000
Bankfull Width at Channel-Forming Discharge	2200
Energy Slope	0.0044
Manning n-value	0.043
Inputs for Bend Scour only:	
Design Top Width, T	1810
Average / Hydraulic / Mean Depth	8
Maximum Depth	12
Bankfull Width	1800
Average Velocity	2.3
Energy Slope	0.02
Water Temperature	72
Bed form regime	dune
Dune scour fraction	0.167
Use Laceys Regime Equation For Mean Water Depth?	no
D_{50}	2.4
D_{90}	30
Neill Incised exponent	0.7
Bend Radius R in feet, at design Q	200
Degree of bend	severe
Additional scour components	
Low-flow incisement / thalweg scour	0.5
Calculated:	
R/T	0.0909091