

EVALUATING BEACH AND NEARSHORE SEDIMENT TRANSPORT IMPACTS FROM THE PROPOSED DEEPENING OF THE SAVANNAH HARBOR

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Abstract. The Savannah River system is both an important natural and economic resource. A recent proposal to deepen the Federal Navigation Channel must therefore consider all possible project-related impacts. In particular, this study focused on the changes the deepening of the Bar Channel will cause to the current, wave and sediment transport environment, which may result in impacts to the regional shorelines. This study evaluates these impacts using a combination of historical data analysis, field data collection, current, wave and sediment transport modeling, and sediment budget analysis. This study includes the Savannah River, Tybee Island (GA) and Turtle, Daufuskie, and Hilton Head Islands (SC). By evaluating post-project effects through state of the art computer modeling and analysis, potential problems can be identified prior to project implementation. This is an invaluable tool for resource managers.

In considering the large changes to the coastal environment caused by the navigation project (as shown by the comparison of 1854 simulations to existing condition simulations), the changes induced by the proposed 6-foot deepening of the 44-foot channel are small. The navigation channel is already a littoral sink and totally interrupts the natural sediment bypassing system. This study indicates that the project will result in small changes to the wave field, and thereby causing small changes to the sediment transport environment. The end result is that the deepening project will cause a small change to a system in which the navigation channel is already exerting its maximum potential as a littoral barrier.

INTRODUCTION

Applied Technology and Management, Inc. (ATM) was retained by the Georgia Ports Authority (GPA) to evaluate the coastal shoreline impacts of the proposed Savannah Harbor Expansion Project. The project is proposed to deepen the Federal Navigation Channel as

shown in Figure 1. The deepening of the portion of the channel that extends from Fort Pulaski to the offshore limit (known as the Bar Channel) is of particular concern with regard to coastal processes. The authorized depth for the existing navigation channel is -44 feet mean low water (MLW) for the Bar Channel, which would be deepened by up to 6 feet with the project. The deepening of the Bar Channel will cause changes to the current, wave and sediment transport environment, which may result in changes to erosion/accretion patterns to the regional shorelines. Tybee Island, GA is particularly susceptible to erosion due to Savannah Harbor modifications, and is the focus of this study. Economic impacts from this project include increased commerce. However beach erosion can have detrimental effects to tourism, turtle/bird nesting as well as costs associated with beach renourishment. Other resource management issues concerning the Savannah River Estuary are addressed in another ATM study.

In order to determine the potential impacts of the deepening project, the study first establishes an accurate description of the existing coastal processes in the study area. An analysis of the historic changes in the system provides necessary information for establishing the existing conditions. Previous engineering modifications to the inlet system, which must be assessed, include a number of deepening projects, construction of entrance jetties, and construction of a submerged breakwater. These modifications are assessed together as a group to allow identification of the cumulative impacts of previous inlet modifications. After the existing (without project) conditions have been established, the study assesses the potential impacts of the deepening project. The study goals can be summarized as follows: (1) Develop computer models to describe the waves, currents and sediment transport in the study area. (2) Qualitatively and quantitatively define the historical bathymetry and shoreline changes that have occurred in the study area.

Include the development of the federal navigation project and the construction of the jetties at the mouth of the Savannah River. Qualitatively assess changes in mechanisms that control shoreline accretion/erosion: incident wave energy, currents, sediment supply, and shoreline hardening (e.g., seawalls, groin fields, etc.). (3) Use the computer models to describe the existing conditions that influence sediment transport in the area, including incident wave energy and currents. Use the modeling results and historic change analysis to develop a sediment budget for the study area. (4) Use the computer models to determine effects to the local wave and current conditions caused by the proposed channel deepening. Utilize the projected effects to the wave and current conditions, and quantify the potential impact of the proposed channel deepening. Any effects of the proposed deepening on the nearshore and inlet sediment budget will also be identified.

RESULTS

The study area is composed of a complex barrier island, sea island, and near shore deltaic and ebb shoal featured system. Anthropogenic impacts to the Savannah River entrance date back to the early 1700's. Maintenance dredging of the Bar Channel, construction of the jetties, and construction of the submerged breakwater are three elements of the navigation project

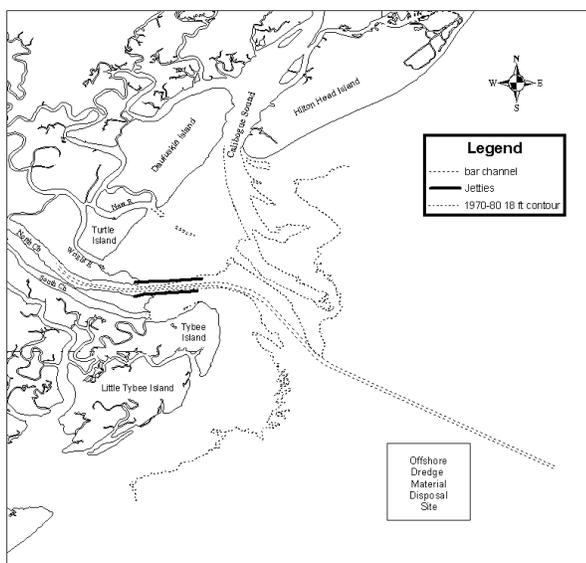


Figure 1. Project Location Map Showing Existing and Proposed Navigation Projects.

that significantly altered the coastal processes in the area. An analysis of the maintenance dredging in the bar channel shows that the maintenance dredging rate increased from approximately 500,000 CY/yr to 700,000 CY/yr with the channel deepening from a 26 foot depth to a 36 foot depth. Subsequent deepenings to 40 and 44-foot depths did not significantly increase maintenance dredging rates (the maintenance dredging rate has been approximately 710,000 CY/yr for the present 44 foot depth). Because deepening subsequent to the 26-foot depth has not increased sedimentation rates in the channel, this study concludes that the bar channel has been a total littoral sink since the 26-foot depth.

Study area shoreline and bathymetric morphology from 1854 to the present were analyzed (1854 bathymetry is from U.S. Coast and Geodetic Survey). Shoreline changes resulted from many factors, including: sea level rise, changes in sediment sources (i.e., upland erosion prior to sediment conservation practices, dam construction on the Savannah River, and dredging of the Savannah River), wave and storm environment. The construction of the entrance jetties corresponded to immediate changes along the Tybee Island shoreline.

Bathymetric analysis shows the evolution of the nearshore morphology between 1854 and 1970/80. The analysis shows: (1) the growth of the shoal at the north end of Tybee Island, (2) the deflation of the subaqueous platform seaward of Tybee Island, (3) the relative stability of the Daufuskie Island and Turtle Island subaqueous platforms, (4) the establishment of a deep channel on the north side of the submerged breakwater, and (5) the interception of the toe of Barrett Shoals at the seaward bend of the bar channel. Analysis of the 1999 after maintenance dredge and 2000 before maintenance dredge bar channel surveys shows the major sedimentation areas of bar channel are: (1) the north side of the seaward bend of the channel where it intercepts sediments from Barrett Shoals, and (2) near the north end of Tybee Island.

The Hydrodynamic model calibration shows good agreement with measured flows at Calibogue Sound, New River, Wright River, North Channel and South Channel, as well as measured current velocities at offshore locations. The model was used to simulate pre- and post-channel deepening currents, as well as 1854 currents. The simulations show that the deepening project will not significantly alter the current velocities in the study area (i.e., pre- to post-project changes are less than 2 cm/s). The 1854 scenario is modeled to evaluate the study area environment prior to

major dredging operations and construction of the jetties and submerged breakwater. The changes between the present conditions and the 1854 conditions provide a comparison to assess the relative magnitude of the pre- to post-project induced changes.

Wave model simulations were run with the pre- and post-channel deepening bathymetries as well as the 1854 bathymetry to determine the potential relative change resulting from the proposed deepening project. The wave model results indicate that the present navigational channel has a significant effect on wave transformation processes (refraction, diffraction, reflection and shoaling). The channel redistributes wave energy resulting in an apparent “sheltering effect” in the lee of the channel. This commonly causes the sheltering of the north end of Tybee Island from waves incident from the east. The wave model results show that significant changes have occurred to the wave field between 1854 and the present. In particular, the changes in bathymetry have caused a dramatic change in the wave environment incident to the Tybee Island shoreline. The comparison of model results for the pre- and post-deepening conditions show that the deepening will result in changes to the wave transformation properties of the channel. These changes cause increases and decreases in average wave height along the island that are generally less than 10 percent. In comparison to the historic changes in wave energy along the island, these changes are small.

The results of the wave model simulations are used to determine the longshore sediment transport potential along the Tybee Island shoreline. The wave and current simulations are used to determine sediment transport over the region between Hilton Head Island and Tybee Island as a method to evaluate the potential relative change in sediment transport rates (not predict actual transport rates). Lastly, a sediment budget is developed and the expected change to the sediment budget from the proposed deepening is determined.

The longshore sediment transport potential analysis indicates that the proposed deepening will result in a small increase (i.e., 12,000 CY/yr) in sediment transport to the north on Tybee Island. The change in transport to the south on Tybee Island is negligible.

The offshore sediment transport calculations indicate that the change in sediment transport rates between 1854 and the present are large (up to 100 percent change in transport magnitude). By comparison, the predicted change in sediment transport rates resulting from the channel deepening is small (i.e., typically less than 5 percent).

A sediment budget was developed for the study area based on measured shoreline and bathymetry changes and a number of simplifying assumptions. The budget includes 625,000 CY/yr of littoral material (i.e., sand) removed from the navigation channel. The only cell in the budget showing significant losses is the cell representing Tybee Island and the subaqueous platform. This cell is losing an estimated 320,000 CY/yr through transport to the north Tybee shoal, transport directly into the navigation channel and transport to the south.

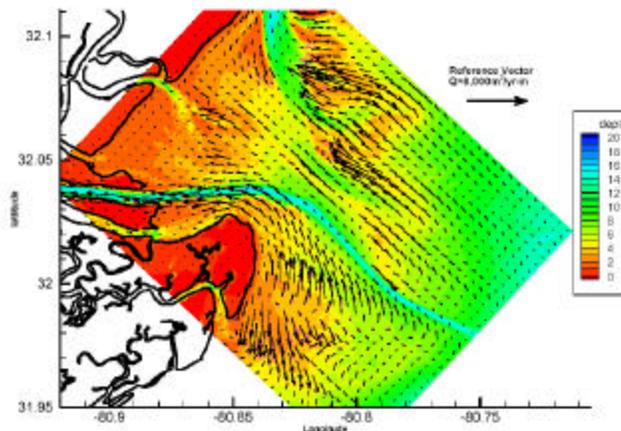


Figure 2. Tidally averaged (over 12.42 hours at 15 minute intervals) sediment transport vectors for pre- and post-project conditions (pre=black, post=gray).

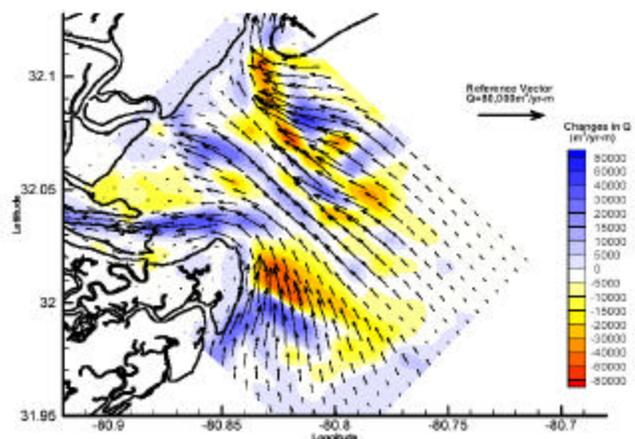


Figure 3. Contour changes in sediment transport rate between pre-project and 1854 bathymetry conditions during a typical peak flood tide (pre minus 1854) and sediment transport vectors are for pre-project conditions.

The predicted increase in northerly transport at the north end of Tybee Island of 12,000 CY/yr (based on the longshore sediment transport potential calculations) is less than 4% of this total loss rate, and is within the uncertainty of the sediment budget analysis.

SUMMARY

In considering the large changes to the coastal environment caused by the navigation project (as shown by the comparison of 1854 simulations to existing condition simulations), the changes induced by the proposed 6-foot deepening of the 44-foot channel are small. The navigation channel is already a littoral sink and totally interrupts the natural sediment bypassing system. This study indicates that the project will result in small changes to the wave field, and thereby causing small changes to the sediment transport environment. The end result is that the deepening project will cause a small change to a system in which the navigation channel is already exerting its maximum potential as a littoral barrier.

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