Review of:

Draft Savannah Harbor Beach Erosion Study

prepared by Applied Technology and Management, Inc.
for the Georgia Ports Authority

Reviewed by:
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The purpose of the Draft Savannah Harbor Beach Erosion Study is to assess the potential incremental impact on Tybee Island erosion of deepening the Bar channel from the present 44 foot project depth to as much as 50 feet. The tools used in this study to achieve these goals are historical data analysis, field data collection, modeling of current, waves and sediment transport, and the development of sediment budgets. The following review addresses general comments for each section, highlights areas of weakness in the report and suggests ways to enhance the report's completeness and utility.

From the evidence presented and within the limits of the modeling work performed, the conclusion of the report (i.e., that the incremental deepening of the bar channel will not cause major changes in erosion on Tybee Island) appears to be sound. However, given the complete lack of uncertainty estimates for the model-derived values, it is not possible to evaluate how important some of the changes in certain parameters will be or if the modeled changes are statistically significant at all (see later discussions).

As in all model studies, the proof of the utility of the models is in how well the model results can reproduce real-world data. This study has mixed results in that arena. The sediment transport modeling is weakest in this regard (see discussion section #8 below). The only other serious problem with the report as it stands is the conceptual framework of the sediment budget. If it is to reflect reality, the budget must be altered to include the Jones-Oysterbed Island portion of the shipping channel and the large volume of high-quality sand that is annually removed from this reach by dredging.

Following are specific comments and suggestions for each section of the report. As a general comment pertaining to the whole report, you should use consistent units throughout. Switching between metric and english units when citing several data sources, even if that is how the data are originally presented, does not facilitate comparison of your data to that of others. An alternative would be to give any measured data in both metric and english units.

1. Introduction – no comments

2. Jetty and Bar Channel History

a) p. 2-1. As a general point, you need to label on your maps any location you reference in the text. There are references to sites that are not locatable on the maps without prior knowledge of the area (e.g., Tybee Knoll).

b) p. 2-5. I do not believe that the sand/mud proportions quoted in this section (paragraph 2) are representative or accurate of the channel bed material found in the bar channel, particularly in maintenance material. As such, citing only these data as background in the report is misleading in later discussions. Contractor observations of dredge material composition is based solely on visual estimates, which are typically grossly inaccurate when compared to laboratory analyses. From my experience collecting samples within the bar channel and in collecting sidescan data of that area, sediments are dominated by sand. Even your figures 3-2 and 3-4 show that most samples collected in the bar channel have greater than 80% sand content.
c) p. 2-8. Note that the data in Table 2-2 do not agree with the laboratory-derived sand fraction measurements shown in Figs 3-2 and 3-4. How representative of the typical sediments taken from the bar channel are the USACE 1999 sediment component data?
d) Fig 2-3. You may want to note in the text or on the figure that the data plotted is only the "good" data from the time periods described in paragraph 2, p. 2-4.

3. Project Environment

a) p. 3-1. What is your reference for the Savannah River's discharge during the early 20th century? Are there *good* estimates of this?
b) p. 3-6, paragraph 3. The coarser-grained material present on the mid and outer shelf was not laid down solely under lowstand conditions. The coarser-grained sediments (~250 um in mean size) are the repeatedly reworked remains of all the sediments that have been laid down on the continental shelf during the Pleistocene. As sea level has fallen and subsequently risen (at least 7 times in the past 2 million years), the retreating shoreline has reworked these shelf deposits as the shoreface has migrated repeatedly landward. All finer-grained particles are removed by this process, leaving the coarser material behind.
c) p. 3-6, paragraph 3. Define mesotidal in the text. Also, we do NOT have mixed tides here. Mixed tides means that there should be a very large difference between the heights of the two highs each day. See northern California tides for an example. Our tides are semidiurnal, but not mixed.
d) p. 3-6, paragraph 4. As I understand it, there is only one Bermuda High established each year, and once it becomes established, it stays until it breaks down at the end of the summer.
e) p. 3-8, paragraph 3. The mention of nor'easters here is important and should be highlighted somehow. The influence of these storms is underappreciated in comparison to hurricanes, which is a bone of contention that I'll get back to in a later section.
f) p. 3-10. I would not make too much of the grab sample composition. These samples typically are taken at slack tides to be able to get the sampling device to the channel bottom. It is at these times that there is a thick layer of temporarily deposited mud that settles out and would be collected in the sampler and later composited as part of the bottom sediments, although it is only there for a short period each tidal cycle.
g) p. 3-11. You use a distance to the calculated closure depth that is not representative of the distance to the 23' depth contours you show in your maps. Your distance

should be more like 6,000' to 9,000', not 3,000'. To what extent will this effect the modeling and the results of the study?

4. Shoreline and Bathymetry Morphology

a) p. 4-7. The 18' contour cannot be seen in Figure 4-11. Also, I believe you should be more tentative in your conclusions about where the bypassed sand would go in the end of the first paragraph. The sand could just as well go directly and dominantly to the north end of the island south of the inlet as is the case with most of the unaltered inlets along our coast.
b) In regards to looking at the HHI to Tybee area as one large ebb-tidal delta, you should point out that with the introduction of the submerged jetty north of the river, the southward migration of sand bodies by channel elongation and abandonment is no longer possible. Much of the sand that would have migrated into the shipping channel is now effectively transported seaward by the large, permanent channel bounded on the south by the submerged breakwater. Thus, very little material bypasses in water depths shallow enough to be relevant to natural beach renourishment. In my opinion, the bulk of the sand that gets to the channel is in water depths too deep for transport back up to the beach on Tybee. Note that the long-term trend has been one of increasing seabed elevation on the north side of the channel and deflation on the south side near the toe of the delta. This is sand beyond the "closure depth" you calculated and is not readily mobilized again. It would help us see this if you would put some contours on figures 4-16 to 4-19.
c) For clarity's sake, I suggest you reverse your color scheme on Figs. 4-16 to 4-20 so that areas of deepening are shown as blues and shoaling as reds. This is consistent with Figs. 4-6 to 4-9 in this section in which deeper depths are in blues and shoals are in "hot" colors.

5. Current Data Collection

a) p. 5-1. How were the salinity profiles and depths recorded at the transects and how often was this done? These parameters need to have been measured at the transect being collected, given the large tidal excursion near the estuary which changes the salinity distribution radically over a tidal cycle.
b) Table 5-1. What do the asterisks by several of the location designations signify?
c) The contours on the figures in this section do not show up. Darken them or delete them. What is the blue dot near HH15 in fig. 5-1?

6. Hydrodynamic Modeling

a) I seem to recall that this same model was reviewed by Jack Blanton and Harvey Seim of the Skidaway Institute. Did they have any comments pertinent to this Erosion study?
b) I assume that there may be some fundamental problems with using this 2-D conservation of mass and momentum model (developed for the estuarine and

fluvial environments) in a less-well-constrained 3-D environment. How does this extension of the model to open-ocean 3-D space affect your results?

c) Indicate whether positive values in flow are directed onshore or offshore in Figs. 6-6 to 6-8.
d) p. 6-8. In your 1854 scenarios, you should not be seeing any influence of the jetties, as they did not exist prior to the 1890's (end of first full paragraph). Also, did you increase the discharge of the savannah river in the 1854 scenario when compared to the present project scenario to account for the effect of the dam at the crosstides which increased the Savannah's tidal prism in the 1860's?
e) Table 6-2. This is an example of why you need some sort of uncertainty estimate in your work. As you begin to report percent changes in parameters, we have no way to evaluate whether the changes are even statistically significant. As an example, are tidal prism percent changes - 1.25% on ebb and 1.53% on flood - significant differences in a statistical sense? Both values are positive and reflect increased volume with a deeper channel. But, is the additional ~0.25% tidal prism on flood an indication of storage of saltwater upriver in presently fresh water areas? This percentage represents about 5 million cubic feet of water!
f) Why aren't all the data for the Wright River shown in fig. 6-7? Data exist in your table from ~0830, but is only plotted from ~1030.

7. Wave Modeling

a) As I understand it, the model doesn't really model wave reflection but instead can strongly refract waves so that it looks like reflection. The text should be altered to omit the term reflection and a more appropriate term used.
b) You spend much time talking about the average 60% of the wave record and exclude northeasters as only storm events (the most frequent of which have 10-y reoccurrence intervals). The northeasters are annual events, not 10-y return period storms and probably put more energy into the system than all those other waves combined each year. Somehow I feel that the modeling lost sight of the potential importance of energetic annual but short-lived events in the wave climate. How are the effects of the annual northeasters in spring and fall included?
c) p. 7-6, 4th paragraph. Do fair-weather waves even feel the bottom on the shoals or over the channel prior to coming ashore? If not, then refraction is not a significant process over the channel at all.
d) p. 7-7. I find the projected conclusions about what waves will affect Tybee to not be very useful and would get rid of them. Most of the bullets invoke reflection of waves (which the model cannot do) to protect Tybee.

8. Sediment Transport and Budget

Sediment Transport

a) This model calculates transport rate simply from waves and neglects the effects of currents. As observed in the current modeling section, the tidal currents can be quite swift and neglecting their effect may be a serious flaw in the sediment transport modeling effort. This model also neglects any effects from inlet/current interactions. Thus, the results from this model may be useful as a starting point, but do not incorporate all important environmental conditions by any means. Note the almost complete lack of agreement between model results and field data (p. 8-4, 8-5). I have some *in-situ* sediment transport measurements from the corners of the offshore box (section 5) that I will forward to you for comparison to your model results.

b) p. 8-1. The energy flux factor (which you correlate to the longshore sediment transport rate) is very sensitive to the angle of breaking waves to the shoreline. Yet in an earlier section, you show that the REF/DIF model is weak at predicting the wave propagation direction when the propagation vectors overlap. How important of an issue is this for the energy flux calculations? This is an area where a sensitivity analysis of the model would be appropriate.

c) p. 8-5, 2nd paragraph. I do not understand how a 3% increase in erosion and a 21% decrease in accretion can correspond to a 3% reduction of erosion south of the nodal point. Decreasing accretion (less material is accumulating) is the same as increasing erosion, therefore it is not clear how this can be anything other than a 24% increase in erosion.

d) Table 8-1 and 8-2. You need either positive or negative signs in front of your % change values. Here again you need some kind of statistical significance test. Is a 3%-9% change within the error of the technique?

e) Table 8-4. I understand that the wave length of storm waves changes as the storms get larger (i.e., 10, 50 and 100 y storms increase in magnitude). However, I would expect a trend in wave-induced erosion from any one direction as the storms got bigger. Why is there no apparent trend?

f) p. 8-10. I do not feel that it is reasonable to use an average grain size for the whole study area that is not representative of the major area of interest (i.e., seaward of Tybee Island). There are a plethora of samples from that area and you should at least use the known median grain sizes (which are much finer than 0.26 mm and dominantly fall within the 0.16-0.22 size classes) in the area of interest and use the average in the far-field regions.

g) p. 8-11, paragraph 4. There is a problem here when comparing the model results to field observations. You state that your model results demonstrate that waves must be present for sediment transport to occur. However, we know from your ADCP measurements that tidal currents are present during most of the tidal cycle that are capable of moving sediment (when currents are >20 cm/s) and this suggests that your model may be grossly underestimating transport and erosion. This is troubling and needs to be addressed if the models results are to be believed. How would greater transport over the tidal cycle be reflected in your transport changes pre- and post project?

h) p. 8-11,12. Isn’t the 5% envelope in transport rate change a minimum transport rate variation? As the length of the transport vector (and magnitude of transport) shrinks, the percentage change in transport becomes larger i.e., denominator (vector length) decreases as numerator (change in transport) remains constant, so the relative percent change increases. The problem discussed in (f) above suggests that the changes may be much greater if solely current-driven transport is included.

i) Figs. 8-17, 8-18 need reference vectors. These are current vectors (from the text), not transport vectors, which is a little confusing after the previous figures.

Sediment Budget

a) p. 8-12. What is closure depth here? Is it computed differently than on p. 3-10, 3-11? If so, why? Is it a reasonable distance as determined from charts of the area or unreasonable as was the 3000' you used in section 3?
b) p. 8-13, 8-14. This section would benefit from consistent units to facilitate data comparisons between different studies.
c) The biggest flaw in this budget is that it does not go far enough up river. There is documented accretion of high-quality sand in the Jones-Oysterbed Reach, representing material from littoral drift that is intercepted by the channel and transported landward by flooding tides at a rate of ~100,000 cubic yards/year. This region must be included in the budget to represent the major components in the system.
d) As discussed previously, the dredging records of sediment composition are unreliable. Scaling and reducing the amount of littoral material transported based on these values is not reasonable. Thus, the calculated impact on littoral transport of sediment and on annual dredging requirements in the Jones-Oysterbed Reach and the bar channel are probably underestimates of the true values. My experience sampling the sediments in the river and bar channel and subsequent laboratory analyses of sand content demonstrate that sediments are dominantly sand (>80%) in these areas. You have a great amount of data on sand percentage in your database – use them to calculate your own averages for percentages of sand and mud in channel sediments.
e) Table 8-6. The data from the 1999-2000 survey are the best evaluation of sedimentation volumes. The data from the dredging records is less accurate and does not contribute to the analysis by being averaged into the good data. I would use the survey data only, as it represents the only direct measurement of sediment volumes.
f) Fig. 8-13, 8-14. Where are the black arrows?

9. Conclusions

a) This section should be beefed up to include the modeled effects of not only the wave and current climates, but to discuss some of the results given in Table 8-3. Here again an error analysis is required. Because it is your final conclusion, it would be nice to know if an 8% increase of erosion is statistically significant.