Regional Sediment Management

Northeast Florida Regional Sediment Budget

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for

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An important part of Regional Sediment Management (RSM) is the development of a regional sediment budget. As part of the Northeast Florida RSM program, the U.S. Army Corps of Engineers (USACE) and the Florida Department of Environmental Protection (FDEP), the two program participants, requested Taylor Engineering of Jacksonville, Florida to develop a sediment budget that covers the northeast Florida region. The software tool SBAS2001, developed by the USACE Engineering Research and Development Center, provided the means to develop the sediment budget for northeast Florida. This document serves as a reference for the accompanying SBAS sediment budget document. This sediment budget reflects volume changes and littoral drift volumes located within the literature. It does not reflect any new work involving volume calculations. Taylor Engineering accomplished this work under the Diagnostic Modeling System work unit administered by the USACE Engineering Research and Development Center.

A sediment budget represents an accounting of all sediment movement, both natural and mechanical, within a defined area over a specified time. The delineation of specific transport pathways establishes sources or sinks for an area and the magnitudes trapped or lost sediment volumes. Near tidal inlets, complex interacting mechanisms drive sediment transport. Typically, wave action, inlet tidal currents, sediment characteristics, mechanical bypassing, salinity and thermal stratification patterns, aeolian processes, and vegetation-associated sediment trapping govern sediment behavior and pathways. Data availability and model limitations restrict this degree of detail. However, the USACE's SBAS model can account for sediment gain or loss, such as trapping, transport, nourishment, and dredging within a system. This document describes application of SBAS to develop the northeast Florida regional sediment budget.

The first step in applying the SBAS model involves dividing the area of interest into regions of similar, littoral characteristics. Unique erosion or accretion occurrences, data coverages, dredging activities, or geographic areas define these regions or cells. Flux arrows connect these cells to indicate specific pathways of sediment transport. The sand fluxes into and out of any cell balance with the net accretion or erosion within the cell. The coupled balancing of sediment fluxes and accretion/erosion magnitudes for each cell determines the magnitudes and pathways of sediment transport within the entire region of interest. This process defines the sediment budget. The sediment budget also identifies and quantifies the sand deficit volumes for the regions adversely impacted by the inlets of study.

This sediment budget, generated from multiple literature sources, dredging records, and nourishment placements, covers the 1970 to 2000 time period. The selection of this period reflects the most common overlap of the available data. The 13-cell model, Figure 1, extends from approximately 6,000 ft north of St. Marys Entrance to approximately 5 miles south of the St. Johns River Entrance or the Atlantic Beach/Neptune Beach city line (approximately to FDEP monument R-52, Duval County). Each cell represents a separate component of sand storage. Arrows across any cell represent a sediment flux either into the cell (sediment gain) or out of the cell (sediment loss). The sum of the fluxes affecting each cell determines the net storage (accretion) or removal (erosion) of sediment within the cell.

Given the north to south net littoral drift that characterizes this environment, presentation and explanation of the sediment budget proceeds from the northernmost cell to the southernmost cell. The sediment budget begins at the first cell located immediately north of the St. Marys Entrance. Sediment transports south along the Georgia coast. Upon encountering the north jetty of the St. Marys Entrance, some of the sediment becomes trapped, and the remainder drifts into the inlet. From a 1960 USACE, Savannah District study of Amelia Island, an accretion rate of 128,800 cy/yr occurred north of the north jetty of St. Marys Entrance. Of the remaining sediment that passes the jetty, the Nassau Sound Inlet Management Plan by Olsen Associates (1993) reports that St. Marys Entrance traps an estimated 234,000 cy/yr. This number, combined with an assumed 40,000 cy/yr bypassing the inlet, implies that a flux of 274,000 cy/yr leaves the first cell. To balance the budget, 402,800 cy/yr must enter the first cell from the north. This estimated net littoral transport remains consistent with other estimates of net transport located in the literature.

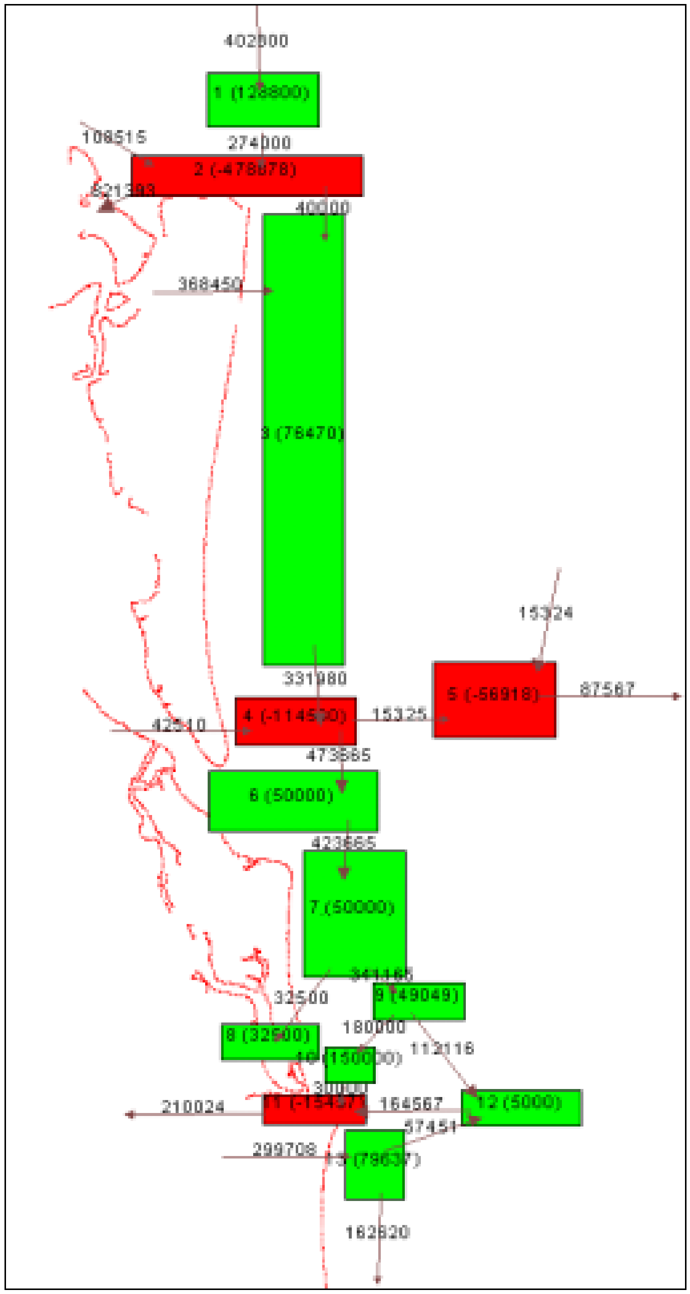

Figure 1. SBAS schematic of Sediment Budget from North of St. Marys Entrance to Atlantic Beach/Neptune Beach City Line

The second cell represents St. Marys Entrance. Fluxes through this cell include sediment transported along the coast from the north, sediment entering the inlet upstream from the St. Marys River, dredging activity, and sediment bypassing the inlet. This cell also experiences a significant volume change. From 1970 through 2000, USACE dredging reports (Raichle, 1993) indicate a total removal of 24,641,800 cy (821,393 cy/yr) of sediment. A significant portion of this activity, 14,366,300 cy (478,878 cy/yr), resulted directly from new work — deepening of the maintained channel. Dredging reports (Raichle, 1993) also indicate a significant amount offshore placement of dredged material — approximately 66-83% from 1987–1992. This suggests this material was not of beach quality and therefore, not littorally introduced. Given 234,000 cy/yr introduced by littoral transport and an assumed bypass volume of 40,000 cy/yr, balancing the cell requires an estimated 108,515 cy/yr of sediment received from an upstream source. Given the reasonable assumption that the material dredged due to new work did not arrive at the inlet through littoral drift, the new work material and the sediment from upstream equates to 71% of the total dredged amount. This estimate agrees with dredging records indicating that 66% to 83% of the sediment was not beach quality.

Cell 3 represents the majority of Amelia Island save for the southernmost 1.1 miles of the island. This area historically remains stable and exhibits areas of accretion. The area, designated by FDEP monuments R-10 to R-74 in Nassau County, experienced a net volume gain of approximately 1,300,000 cy from 1974 to 1991. This value, obtained from Raichle (1993), resulted from an application of the Brunn Rule to the area's survey data. This translates to a net annual accretion of 76,470 cy/yr. With only 40,000 cy/yr transported into the cell, the accretion results from 368,450 cy/yr of placement of dredged material from 1978 to 1999. St. Marys Entrance and an offshore borrow site provided the placed material. To balance the cell, 331,980 cy/yr of sediment must transport south to cell 4.

Cell 4 represents the southern 1.1 miles of Amelia Island from R74 to R80. This cell comprises of two sediment sources — the transport from cell 3 mentioned above and beach nourishment. The southern portion of Amelia Island received only 42,510 cy/yr of nourishment material between 1978 and 1999 as reported in the *South Amelia Island Shoreline Stabilization Study, Amelia Island, Florida* (Olsen, 2000). Even with nourishment, this area experiences significant erosion, on the order of 115,000 cy/yr (Olsen, 2000) from 1974 to 1999. Over a shorter, more recent, period, 1994 to 2000, this value increased dramatically to approximately 236,000 cy/yr. The majority of the sediment is transported into Nassau Sound during flood flow. Cell 5 represents an additional sediment sink — the borrow site constructed offshore of the southern portion of Amelia Island as part of the 1994 nourishment project. This project extended from R-60 to R-78 and spans both cells 3 and 4. The nourishment project removed 2,627,000 cy from the borrow site in 1994. Over the 30-year time frame, this mining results in an annual removal rate of 87,567 cy/yr. A comparison of a 1994 post construction survey and a 2001 survey of the borrow site estimated that approximately 35% of the borrow site filled from 1994 to 2001.

Annualized over the 30 yr time frame, this results in an annual accretion rate within the borrow site of approximately 30,648 cy/yr. Under the assumption that 50% of the material came from the surrounding bathymetry and 50% from the southern portion of Amelia Island, cell 4 lost 15,325 cy/yr to the borrow site. Balancing theses sources and sinks results in the transportation of 473,665 cy/yr of sediment from the southern 1.1 miles of Amelia Island, cell 4, into Nassau Sound, cell 6.

Nassau Sound, an “unimproved” inlet, exhibits significant change in overall morphology, but relatively little change in volume. Because no agency maintains the inlet for navigation purposes, few surveys or data exist from which to calculate shoaling rates. The *Nassau Sound Inlet Management Plan* (Raichle, 1993) reported a 71,000 cy/yr estimated accretion rate in Nassau Sound. Reducing this value proved appropriate given the difficulty in accurately calculating volume change with the constantly changing shoals and flow paths of Nassau Sound. Further, dredging records indicate only 5,000 cy/yr of sediment shoal in the Intracoastal Waterway, which crosses the Sound. Therefore, the budget includes the assumption of a slightly smaller accretion rate of 50,000 cy/yr. With this accretion rate estimate, maintaining a balanced sediment budget requires 423,665 cy/yr of sediment to bypass to Little Talbot Island, cell 7.

Little Talbot Island exhibited a net accreting trend of approximately 50,000 cy/yr from 1974 – 1990. This value measures substantially lower than the 1980 – 1990 accretion rate of 250,000 cy/yr (Raichle, 1993) due to a highly erosive period from 1974 – 1980. Although the southern end of the island exhibited significant erosion due to the northern migration of Ft. George Inlet, the northern portion of the island accreted due to a spit formation in Nassau Sound. The sediment leaving the southern end of Little Talbot Island is either swept into the Ft. George Inlet flood shoal during flood flow or transported to the ebb shoal for potential bypassing. Ft. George Inlet flood shoal, cell 8, traps all sediment entering the inlet. An estimated flux of 32,500 cy/yr, based on the flood shoal volume calculated from a 1998 survey, leaves Little Talbot Island and deposits in the flood shoal of Ft. George Inlet, such that the flood shoal experiences an estimated annual volume increase of 32,500 cy/yr. The ebb shoal, cell 9, receives 341,165 cy/yr from Little Talbot Island as the littorally transported material bypasses the inlet. This value balances the cell.

The sediment entering Ft. George ebb shoal follows two possible paths: to Wards Bank or to the St. Johns River ebb shoal. An estimated 49,049 cy/yr accumulates in the Ft. George ebb shoal (derived from a 1998 and 2001 survey comparison). This leaves a possible 292,116 cy/yr of sediment to transport to either Wards Bank, cell 10, or bypass to the St. Johns River ebb shoal, cell 12. As determined by the Wards Bank shoaling rate described in the following paragraph, 180,000 cy/yr enters Wards Bank and 112,116 cy/yr bypasses to the St. Johns River ebb shoal.

Wards Bank has accreted since the tightening of the St. Johns River north jetty in 1934. From volume calculations based on shoreline change from 1979/1980 to 1998 and a 1979 study by Kojima and Mehta, Wards Bank accreted at a rate of approximately 150,000 cy/yr. Sediment enters the area as it bypasses the inlet by means of the Ft. George Inlet ebb shoal. Formation of a shoal just south of the north jetty within the St. Johns River provides evidence of transport from Wards Bank into the river. An estimated 30,000 cy/yr transported into the St. Johns River either through aeolian transport or by wave action pushing sediment through the jetties.

Cell 11 represents the St. Johns River Entrance. This cell receives sediment from the ebb shoal and Ward's Bank and loses sediment due to maintenance dredging activities. USACE dredging records from 1994/1995 to 2000 report an annualized dredged amount of 210,024 cy/yr from the end of the project at the Atlantic Ocean to the Intracoastal Waterway. Shoaling rates estimated from 1994 to 2000 surveys indicate a shoaling rate of 194,567 cy/yr (assuming overdredge activity) for the same area. The change in volume for this cell equaled the difference in the dredged amount and the shoaling rate. Therefore, cell 11 experiences a volume loss of 15,457 cy/yr. The dredged value and transported value from Wards Bank, 30,000 cy/yr, require a sediment supply from the ebb shoal of 164,567 cy/yr.

Cell 12, the St. Johns River ebb shoal, receives sand from the Ft. George ebb shoal and beaches south of the jetties and supplies sand to the St. Johns River. Unfortunately, the data search for this study could not identify comprehensive historical survey data over the shoal for this time frame. Since the ebb shoal appears relatively stable with portions of shoal dredged, the volume change for this cell equals an assumed value of 5,000 cy/yr of accretion. The surrounding cells predetermine the flux values for this cell from Ft. George ebb shoal and into the St. Johns River Entrance. Therefore, the forced balance for transport from the beaches south of the jetties equals 57,451 cy/yr.

Cell 13 represents the beaches along Mayport through Atlantic Beach. An STWAVE model combined with calculations from the CERC equation predicts a southerly transport of approximately 162,620 cy/yr. Nourishment activity from 1970 to 1990 resulted in approximately 299,708 cy/yr of sediment placed on the beach (USACE, 1990). Calculated volumetric changes from surveys as reported in *Duval County Beaches, Florida, General Design Memorandum Addendum 1* (USACE, 1984) resulted in an annual accretion rate from 1974 to 1982 of 79,637 cy/yr. The remaining sediment transported north to the St. Johns River ebb shoal through entrainment by ebb and flood tides. A value of 57,451cy/yr backpassed to the shoal from the southern beaches balances the cell. Given the enormous tidal prism that conveys through the entrance, this value appears reasonable.

Many possibilities for error exist in this budget. Specifically, not all reported values cover the same period. Although every effort was made to provide data over the same period, this was not always possible. Errors in surveying could potentially create large volume differences, as this error propagates to the next survey line, often 1000 ft away. This budget, however, does capture the general trends in the areas described and provides approximate magnitudes of sediment flux and volume change. Table 1, below, provides a summary of the cells within the sediment budget with the associated volume changes.

Table 1. Summary Table of Volumetric Change for Each Cell.

Cell Number	Location	Volume Change (cy/yr)
1	North of St. Marys Entrance	128,800
2	St. Marys Entrance	-478,878
3	North Amelia Island	76,470
4	South Amelia Island (R-74 to R-80)	-114,500
5	Borrow Site	-56,918
6	Nassau Sound	50,000
7	Little Talbot Island	50,000
8	Ft. George Inlet Flood Shoal	32,500
9	Ft. George Inlet Ebb Shoal	49,049
10	Wards Bank	150,000
11	St. Johns River Entrance	-15,457
12	St. Johns River Ebb Shoal	5,000
13	Mayport - Atlantic Beach	79,637

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