Testing the Compatibility of the Sediment Budget Analysis System 2020 with Various Data Sources

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PURPOSE: This Regional Sediment Management technical note (RSM TN) provides the workflow for implementing results of various toolsets into the Sediment Budget Analysis System (SBAS). SBAS is a commonly used toolset developed by the US Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL) for creating and visualizing sediment budgets. Recent upgrades to SBAS have warranted an investigation into its ability to accurately accept various data sources. Three case studies are presented showcasing the variety of acceptable tools, both ERDC-CHL published and custom-user created.

BACKGROUND: Sediment budgets are a crucial first step for coastal engineering or research projects. Sediment budgets consist of cells and fluxes and depict areas of sediment sources (gain) and sinks (loss). Sediment budgets visualize and quantify sediment transport in a system and are categorized based on the quantity and quality of data used for its creation. Budgets can vary spatially, providing information on local (hundreds of meters) to regional (tens to hundreds of kilometers) scales. Additionally, the quality and quantity of data used for budget creation allow for different sediment budget levels. Conceptual budgets provide an initial, coarse scale description of a region based on existing data and literature reviews. Additional data sources, such as dredging records, shoreline change, and numerical model results, can convert a conceptual budget into a working, interim sediment budget. An operational budget is the highest detailed budget, incorporating multiple data sources that often contain overlap and redundancy to have the highest certainty possible. Regardless of sediment budget type, all budgets use the sediment budget equation:

$$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = Residual, \quad (1)$$

where

Q_{source}	=	input of sediment into cell,
Q_{sink}	=	loss of sediment from cell,
V	=	volume change within cell,
P	=	placement into cell (e.g., beach fill or dredged material),
R	=	removal from cell (e.g., dredging or mining), and
$Residual$	=	0 for a balanced cell.

The SBAS is an open-source toolset initially developed in the 1990s (Rosati and Kraus 1999) for sediment budget creation and has evolved since its inception. The latest iteration, SBAS 2020 (McGill et al. 2022), is an Esri ArcGIS Pro toolbox that includes new improvements such as incorporating results from GenCade, a numerical model that can calculate shoreline change (Frey et al. 2012), and publishing budgets online. While the compatibility of GenCade data has been proven, additional data products needed to be tested.

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This RSM-TN presents three case studies used to validate the improvements to SBAS. The case studies include (1) modification of an existing budget along the New Jersey coast, (2) creation of a budget in Lake Michigan using results from a custom toolset, and (3) validation of toolset used with a previous SBAS version to create a budget in Miami, FL highlighting hurricane impacts.

CASE STUDIES

1. New Jersey. Impacts to sediment transport due to a proposed storm surge barrier system (SSBS) at multiple inlets along the New Jersey coast is currently under investigation by the US Army Corps of Engineers (USACE), Philadelphia District, and ERDC-CHL. To designate a baseline for the study, a conceptual, regional sediment budget created in 2006 was used (USACE-NAP 2006). This initial report used shoreline position, dredging records, beach fills, and wave data from 1986 to 2003 to create the budget from Cape May Point to Manasquan Inlet. Modifications were first made to the budget's littoral cells for Hurricane Sandy with the inclusion of back bay littoral cells (Rosati et al. 2015). For this project, the most recently modified sediment budget was used.

Proper importation of fluxes and cells of sediment budgets created with older versions of SBAS is critical for continued acceptance of SBAS by USACE districts. Shapefiles and fluxes from the Rosati et al. (2015) budget were imported into SBAS and compared with the 2006 report (USACE-NAP 2006) for accuracy. After confirming accuracy of importation, the budget was modified again for the proposed SSBS plans, specifically in relation to back bay littoral cells (Figure 1). In situations where multiple inlets connected to a littoral back bay cell, that cell was split so each inlet with a proposed SSBS had its own cell. While appropriate for this study, these modifications magnified missing data highlighted in the initial 2006 report (USACE-NAP 2006), such as incomplete transport data between back bays and inlets, as well as between different back bay areas. With acknowledgements made towards the missing data, the cells were balanced, and the Adaptive Hydraulics model system was used to model the impacts of the storm surge barriers on the sediment transport between the open ocean and back bay areas.

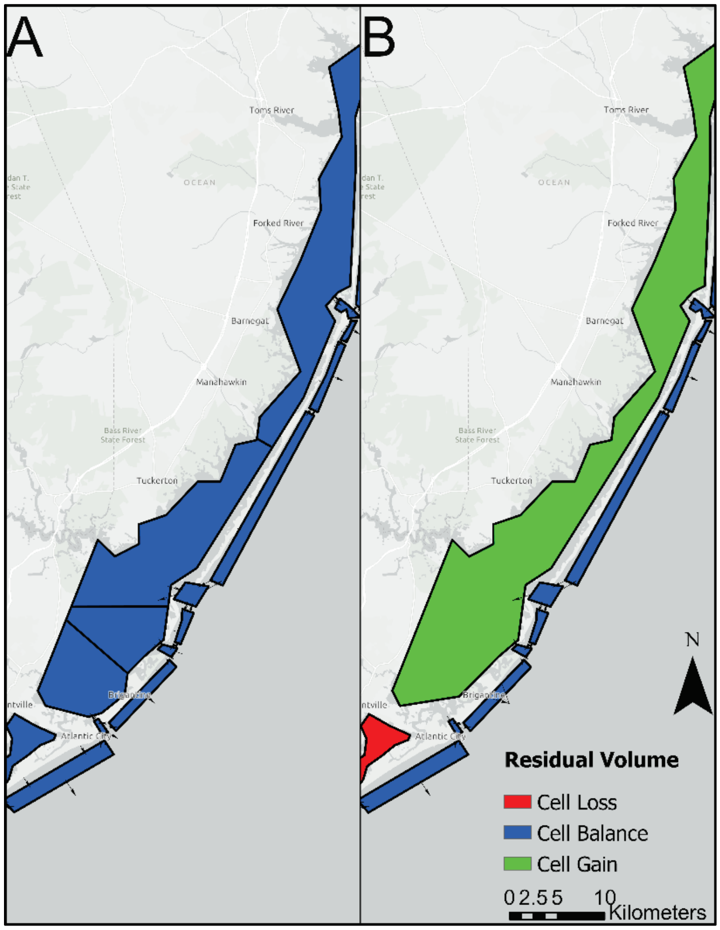

Figure 1. Comparison of the 2022 Baseline Budget (*A*) with the 2012 Rosati Budget (*B*). The green bay littoral cell in the 2012 Rosati Budget was split into four cells and balanced for the 2022 Baseline Budget.

2. Berrien and Van Buren, Michigan. The sediment budgets for Michigan counties Berrien and Van Buren were conceptual micro budgets focused mainly on bluff erosion and sediment lost within the nearshore environment. Budget creation was part of the Great Lakes Restoration Initiative (GLRI), a multiagency collaborative effort to protect and restore the Great Lakes. Sediment sources for the budget included bluff erosion rates and river deposition. Bluff erosion rates were calculated by identifying the historical 1980 bluff line and the contemporary 2012 bluff line. The erosion distance was calculated every 100 m[1] and summed into 1 km long littoral cells. More detail on these methods is presented in Sylvester et al. (2023), and data used for the budget are available at The Great Lakes Sediment Budget website (Great Lakes Restoration, n.d.).

The ability to load complementary data within SBAS was used to acquire sediment flows from inlets throughout this site. The lack of a known, dominant sediment transport direction for this region required fluxes to be added between each cell in both directions (north and south). Given

[1] For a full list of the spelled-out forms of the units of measure and unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office 2016), 248–52 and 345–7, respectively. https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

that this budget was a broad conceptual budget that included sediment in the nearshore environment, the cells were balanced aside from those which were adjacent to jetties or other hard structures through which sediment cannot flow (Figure 2). Dredging and placement records from this area could not be obtained, so they were omitted from this site.

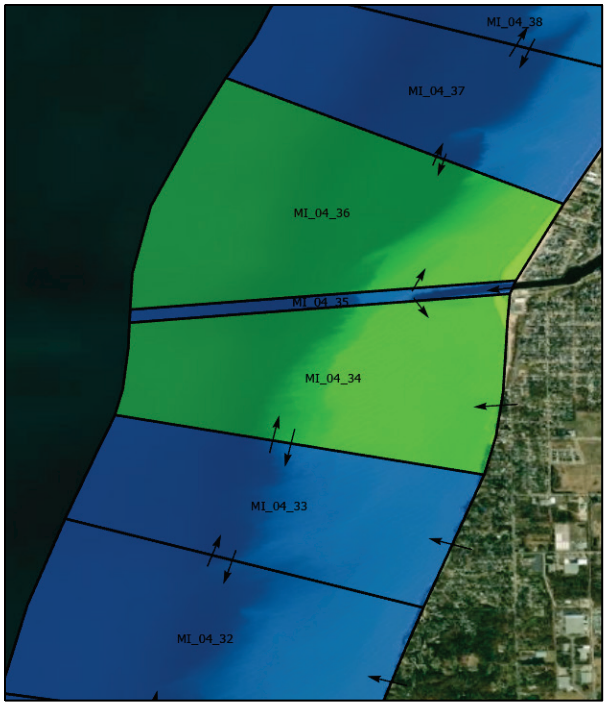

Figure 2. Close-up of the Lake Michigan budgets near an inlet and jetties. *Blue cells* represent a balanced residual where *green* equals a surplus.

The resulting budget is one for which all cells not against a hardened structure are balanced. This decision was made as this is a conceptual budget incorporating a select set of data, with the highest uncertainty related to unknown longshore transport values. This unknown was magnified when obstructed by hard engineered structures such as jetties and groins, highlighting an area of improvement for a higher accuracy regional budget. The importing of existing littoral cells through SBAS functioned without issue and carried through the naming convention from existing GLRI projects. The ability to pull in existing littoral cells that aligned with previously completed studies was a key feature for this site. These existing features were created using an older version of the SBAS toolbox and imported into this version without issue. Transferring the bluff recession rates as input fluxes was made possible after adding a linking attribute.

3. Miami. A sediment budget along the Florida coast was created using data originally collected to study the impacts of Hurricane Matthew in November 2016. The area for this study extended along the southeast coast of Florida from Palm Beach to Sunny Isles Beach. This budget validated the ability of SBAS to import and edit existing data created using the JALBTCX Volume Change Analysis Toolbox (Dunkin et al. 2020), an ability that was highlighted in a previous version of the system. The poststorm volume change analysis was obtained from the JALBTCX Volume Change web app viewer (USACE, n.d.). The volume change bins were much smaller than the littoral cells used for this site and were summed into 1 km bins similar to the Michigan study sites and imported in the SBAS. Historical longshore sediment transport rates and nodes were found from a compilation of literature and iterated for each cell-to-cell relationship (Van Gaalen 2016).

No inlet sediment transport values could be found for this location, so they were not included within the fluxes. Given the focused time scale for the sediment budget surrounding a storm event, dredging and placement values were not used, contributing to the presence of unbalanced cells. While viewing residuals was important for the other budgets in this RSM-TN to highlight areas of missing data, the Miami budget focused on the total volume change in each cell to highlight areas of erosion and accretion from Hurricane Matthew (Figure 3). This site demonstrates the continued capabilities of the SBAS Toolbox to import existing values from JALBTCX volume change studies.

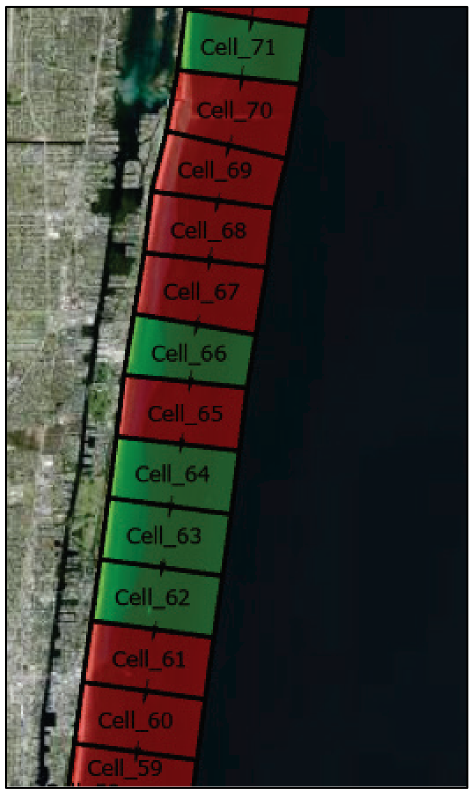

Figure 3. Miami sediment budget. *Green cells* represent areas of accretion, and *red cells* represent areas of erosion.

SUMMARY: Additional validation and verification of SBAS 2020 Version 1.0 proved to be successful while highlighting the tool's flexibility and user considerations for fundamental sediment budget creation. SBAS 2020 successfully imports cells and fluxes created from previous SBAS versions, accepts results from other toolsets similar to previous versions, and allows experienced users to incorporate results from custom toolsets when appropriate. Additionally, note that continuous modifications to sediment budgets without the inclusion of new, refined data can cause missing data or data with high uncertainty to become more apparent and have a larger impact on the budget. All budgets created with SBAS, including the ones in this RSM-TN, are available for download from the RSM SBAS Hub: *https://sbas-usace.hub.arcgis.com/*.

ADDITIONAL INFORMATION: This RSM-TN was prepared as part of the USACE RSM Program and Hydrology, Hydraulics, and Coastal Community of Practice by Mr. Sean McGill and Ms. Ashley Elkins, ERDC-CHL, Vicksburg, MS. Questions pertaining to this RSM-TN may be directed to Mr. McGill (*Sean.P.McGill@usace.army.mil*); Ms. Elkins (*Ashley.J.Elkins@usace.army.mil*), or to the USACE RSM program manager, Dr. David Perkey (*David.Perkey@usace.army.mil*). Additional information regarding RSM may be obtained from the RSM web site *http://rsm.usace.army.mil/*.

This ERDC/TN RSM-23-1 should be cited as follows:

> McGill, S. P., and A. J. Elkins. 2023. *Testing the Compatibility of the Sediment Budget Analysis System 2020 with Various Data Sources.* ERDC/TN RSM-23-1. Vicksburg, MS: US Army Engineer Research and Development Center. *http://dx.doi.org/10.21079/11681/47130*.

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