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Using GenCade to Create a Sediment Budget in SBAS

by Ashley E. Frey

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) presents a new connection between GenCade, a shoreline change and sand transport model (Frey et al. 2012a), and the Sediment Budget Analysis System (SBAS) (Dopsovic et al. 2003). Two of the main GenCade outputs are shoreline change and longshore transport rates, which can be analyzed to develop a sediment budget. A new, automated connection utilizes the results of a GenCade simulation as input for a sediment budget in SBAS. The step-by-step process is described in this CHETN. This CHETN is intended for those who have experience with GenCade and have at least a conceptual knowledge of how to construct a sediment budget.

INTRODUCTION: Developed by the Coastal Inlets Research Program (CIRP), GenCade is a one-line model that combines the project-scale, engineering design-level calculations of GENESIS (Hanson and Kraus 1989) and the regional-scale, planning-level calculations of Cascade (Larson et al. 2003; Connell and Kraus 2006). GenCade represents coastal structures including seawalls, groins, and breakwaters; beach fills; bypassing; inlets and inlet shoals; and dredging events. GenCade Version 1 was released in April 2012 and can be set up and run in two interfaces in the Surface-Water Modeling System (SMS) 11.1 with georeferencing capabilities. The features related to the SBAS connection are available in SMS 12.0 and subsequent versions; however, it is also possible to use advanced cards in the GenCade input files for earlier versions of the SMS. A GenCade technical report (Frey et al. 2012a) includes model theory, a user's guide, idealized cases, and applications. A second GenCade report (Frey et al. 2014) provides additional details that were not described in the first report including model requirements and setup recommendations. Finally, a quick-start guide (Munger and Frey 2015) provides new users enough information to determine if the model is suitable for a specific project and details steps to set up and run a simple model simulation.

SBAS is used to develop sediment budgets by calculating sediment gains and losses within specified control volumes for inlets and adjacent beaches (Dopsovic et al. 2003). In the past, SBAS was available as a PC-based application. SBAS was upgraded several years ago and was made available as a toolbar in ArcGIS 10 through the Regional Sediment Management (RSM) Program. However, users found several improvements were needed. The latest version is a Python toolbox which is accessed through ArcCatalog within ArcGIS 10.1 or later. The newest version of SBAS can be downloaded through a link on the RSM website (*http://rsm.usace.army.mil/*). It does not require administrator privileges, which makes installation more user friendly. A user's guide is included as part of the installation. In SBAS, a user can create littoral cells and sediment transport fluxes (transport into or out of a cell), enter sediment volumes for the cells, enter magnitudes for the fluxes, and define sediment gains and losses for each cell. The sediment budget equation in SBAS is expressed as

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14. ABSTRACT
This Coastal and Hydraulics Engineering Technical Note (CHETN) presents a new connection between GenCade, a shoreline change and sand transport model (Frey et al. 2012a), and the Sediment Budget Analysis System (SBAS) (Dopsovic et al. 2003). Two of the main GenCade outputs are shoreline change and longshore transport rates, which can be analyzed to develop a sediment budget. A new, automated connection utilizes the results of a GenCade simulation as input for a sediment budget in SBAS. The step-by-step process is described in this CHETN. This CHETN is intended for those who have experience with GenCade and have at least a conceptual knowledge of how to construct a sediment budget.

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$$\sum Q_{source} - \sum Q_{sink} - \Delta V + P - R = Residual$$

where Q_{source} and Q_{sink} represent the sources and sinks to the control volume (cell), ΔV is the volume change within a cell, P is the volume of material placed within the cell, R is the volume of material removed from the cell, and *Residual* is the degree to which a cell is balanced (Dopsovic et al. 2003). If the *Residual* is 0, the cell is balanced.

GenCade calculates shoreline change and sand transport in the vicinity of inlets and adjacent barrier islands. It has also been used to aid in sediment budget analyses. Because GenCade calculates many of the required inputs for sediment budgets, the connection of GenCade and SBAS in a more automated manner provides an efficient methodology for sediment budget studies. The transport rate or flux into or out of a cell calculated by GenCade represents Q_{source} or Q_{sink}, respectively. Shoreline change calculated by GenCade can be converted to volume change, which represents ΔV in SBAS. Dredging events and sink terms specified in GenCade are classified as removal (R) in SBAS while beach fills and source terms in GenCade are placements (P) in SBAS. Previously, to use GenCade for a sediment budget, it was necessary to manually calculate volume over each SBAS control cell based on shoreline change per GenCade cell, retrieve the output record for fluxes (transport) between cells, calculate volume change for each inlet shoal, and record beach fill and dredging volumes. Each calculated value was manually added to SBAS after cells and fluxes were manually drawn in ArcGIS. Now, the user directs GenCade to the proper cells for volumes and fluxes and imports the output results to SBAS. Note that volumes and flux rates in SBAS can be defined in m^3/yr, yd^3/yr, m^3, or yd^3. In GenCade, volumes and transport rates are averaged over the years within the simulation, so the units to be defined in SBAS must be m^3/yr or yd^3/yr.

GENCADE TO SBAS PROCESS: A number of steps must be followed to use GenCade output as input into an SBAS sediment budget. These steps are outlined here, and more detail is provided in the subsequent sections. Steps 1–5 are in GenCade modules in the SMS, step 6 is in the SMS, and steps 7–9 are completed in SBAS.

- Step 1: Set up GenCade grid and calibrate.
- Step 2: Set up sediment budget cells and fluxes in the GenCade conceptual model and convert to the GenCade model.
- Step 3: Review GenCade input representing sediment budget cells and fluxes in the GenCade model or within the *.gen file.
- Step 4: Run GenCade.
- Step 5: Review output in *.prt file.
- Step 6: Draw shapefiles in the SMS representing SBAS cells and fluxes.
- Step 7: In SBAS, set up the SBAS environment, create the SBAS alternative, and load the SBAS alternative.
- Step 8: Import *.gen, *.prt, and the shapefile (created in step 6) into SBAS.
- Step 9: View results in SBAS and make modifications to cells and fluxes as necessary.

SAMPLE CASE: In order to illustrate the process of using GenCade to create a sediment budget, a previous GenCade study at Onslow Bay, NC, is used as an example. Further details about the setup and simulations are included in Frey et al. (2012b). The original study required three grids to simulate shoreline change and sand transport across all of Onslow Bay, but only the Secondary–West grid is used here for simplicity. The Secondary–West grid extends 36.1 miles from 1 mile south of New Topsail Inlet to 2 miles north of Cape Fear (Figure 1). It includes four, shallow-draft, Federally maintained inlets (Rich, Mason, Masonboro, and Carolina Beach), multiple Federal Shore Protection projects or beach fills, many navigation channel dredging events, and a sink term (removal of volume from the model; needed to account for a submerged headland). All of the inlets, with the exception of Mason Inlet, require maintenance dredging, and Masonboro Inlet is the only inlet with structures (north and south jetties), so a wide variety of inlet conditions are included in this sample case. The multiple inlets and beach fills make it an ideal region to investigate the application of GenCade to develop a sediment budget.

Figure 1. GenCade grid in southern Onslow Bay, NC.

The GenCade model must be calibrated before defining SBAS cells and producing sediment budget outputs. Details about the site-specific calibration are in Frey et al. (2012b) while general setup and calibration procedures are described in Frey et al. (2012a, 2014). One difference between the sample case and the previously calibrated model is the time of the simulation. The original case was run from January 1997 to August 2004. Although the results for the 7.66 yr simulation could be used to produce a sediment budget in SBAS, the model was run for 6 yr from 1 January 1998 to 1 January 2004 to simplify the sediment budget results for this sample case.

SET UP SBAS CELLS AND FLUXES IN GENCADE: Once the GenCade model has been calibrated, the sediment budget cells and fluxes for SBAS can be set up in GenCade. There are two approaches available to define the sediment budget cells and fluxes: through the SMS interface version 12.0 or later (the recommended approach) or through advanced cards for earlier versions of SMS. By drawing arcs representing the cells and fluxes in the SMS, a user eliminates the need to open the control file (*.gen file). This is the recommended approach; however, enough details will be provided to allow a user to manually define advance cards, if necessary.

The GenCade conceptual model in the SMS is used to define the sediment budget cells and fluxes for SBAS. Instead of drawing a polygon to represent each sediment budget cell, an arc is drawn that provides the starting and ending GenCade cell numbers to the model. Before drawing the arcs, the user must decide which GenCade cells should represent a sediment budget cell. Generally, sediment budget cell boundaries are determined by geologic controls, structures, and knowledge of the site. Depending on the desired resolution, there could be between one and hundreds of GenCade cells representing a sediment budget cell. A sediment budget cell may not be smaller than a GenCade cell.

For this example, nine sediment budget cells were created: four cells representing each of the four inlets and five cells representing each of the adjacent beaches. Fluxes were created between each of the cells and at the left and right boundaries of the grid. At a minimum, each barrier island or inlet should represent a single sediment budget cell. If there is a known nodal point or a structure impacting transport and shoreline position, multiple sediment budget cells should be defined along a single barrier island to capture those significant details.

To draw an arc representing a sediment budget cell, select the *Create Feature Arc* tool. Click once within the SMS Workspace to start drawing the arc and double-click to end the arc. The arc must be drawn from the lower-numbered GenCade cell to the higher GenCade cell. If the arc is oriented incorrectly, GenCade will write the higher-numbered GenCade cell as the beginning cell and the lower-numbered GenCade cell as the end cell. If this happens, GenCade will misinterpret the GenCade cells representing a sediment budget cell and will not calculate the volume change within the sediment budget cell. Therefore, it is very important that the arc is drawn with the same orientation as the grid *x*-axis.

Once the arc is drawn, click the *Select Feature Arc* button and double-click on the arc. The *GenCade Arc Attributes* window will open, and the user should select *SBAS Polygon* (Figure 2). No additional attributes need to be defined for *SBAS Polygon*. After clicking *OK*, the arc will turn bright blue (white lines have been drawn on Figure 2 pointing to the arcs). The same procedure should be followed to draw the fluxes, but *SBAS Flux* should be selected under *GenCade Arc Attributes* (Figure 2). The arc will turn pink. Note that GenCade cell numbers refer to the center of a GenCade cell while transport rates are calculated at GenCade cell boundaries. Therefore, if a sediment budget cell is represented by GenCade cells 1–10, the adjacent fluxes should be at the left boundary (before cell 1; at cell-wall 1) and after cell 10 (at cell-wall 11).

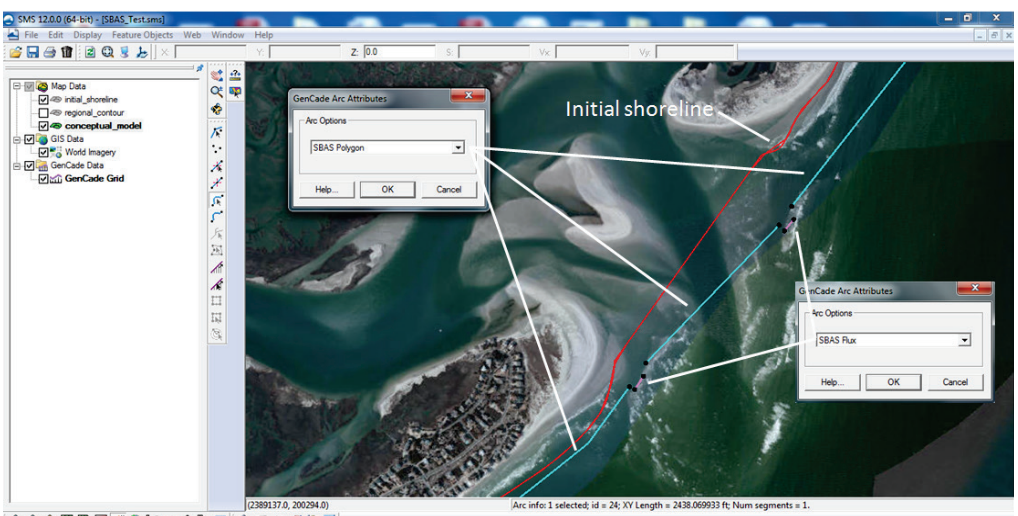
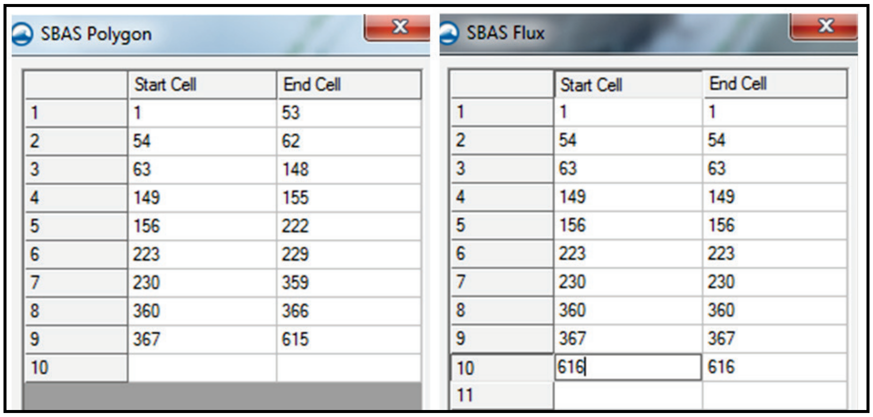


Figure 2. GenCade Arc Attributes for SBAS Polygons (in blue) and SBAS Fluxes (in pink).

After all of the arcs have been drawn and defined, convert from the conceptual model to the GenCade model (*Map->1D Grid*). If any of the arcs are not representing the correct GenCade cells, go to *GenCade->Edit SBAS Polygon* or *GenCade->Edit SBAS Flux* and delete the existing start and end cells before adjusting the arc. Since the adjusted arc will represent different GenCade cells, it will not overwrite the previous start and end cells, and there could be overlapping SBAS cells. Figure 3 shows the starting and ending GenCade cells for the SBAS Polygons and SBAS Fluxes in the example. After all of the arcs represent the proper SBAS cells and fluxes, save the project.


SBAS Polygon

	Start Cell	End Cell
1	1	53
2	54	62
3	63	148
4	149	155
5	156	222
6	223	229
7	230	359
8	360	366
9	367	615
10		

SBAS Flux

	Start Cell	End Cell
1	1	1
2	54	54
3	63	63
4	149	149
5	156	156
6	223	223
7	230	230
8	360	360
9	367	367
10	616	616
11		

Figure 3. Edit SBAS Polygon and Edit SBAS Flux windows in the GenCade model in the SMS for the example.

Figure 4 shows the SBAS cells and fluxes in the *.gen file for the Secondary – West grid of the Onslow Bay case. The first line of the SBAS section is the header which says *****SBAS*****. When the SBAS-related advanced cards are added manually, they should be added at the very end of the *.gen file. *ISBASV1* and *ISBASV2* are the starting cell index and ending cell index, respectively, for the range of cells that represent the volume control cell or the representative polygon in SBAS. *ISBASQ1* and *ISBASQ2* define the starting cell-wall index and ending cell-wall index, respectively, for the range of cells that are spanned by the SBAS flux arrow. In this example, cell-wall 54 (*ISBASQ1:* 54; *ISBASQ2*: 54) represents a single wall between adjacent cells for the transport flux calculations. This flux spans from the first sediment budget cell (GenCade cells 1–53; Lea-Hutaff Island) to the second sediment budget cell (GenCade cells 54–62; Rich Inlet). While a flux could span several cell-walls, it would not make much sense to make this specification, with reasons as follows. First, the volume change and any beach fills along the GenCade cells between the starting cell-wall index and ending cell-wall index will not be included in the sediment budget. Second, the transport rate at the first cell-wall will represent *ISBASQ1* while the rate at the second cell-wall will represent *ISBASQ2*. Although all of the cells will be balanced, *ISBASQ1* and *ISBASQ2* could be a short distance from each other and cause confusion when viewing the sediment budget. For these reasons, *ISBASQ1* and *ISBASQ2* should be identical for each SBAS flux. The last SBAS cell is represented by GenCade cells 367 to 615. Since the first cell-wall is located before the cell, there is one additional cell-wall (616) at the right boundary of the grid. If the cards are added manually, the *.gen file must be saved before running the simulation in the SMS.

```
***** SBAS *****
ISBASQ1: 1      ISBASV2: 222
ISBASQ2: 1      ISBASQ1: 223
ISBASV1: 1      ISBASQ2: 223
ISBASV2: 53     ISBASV1: 223
ISBASQ1: 54     ISBASV2: 229
ISBASQ2: 54     ISBASQ1: 230
ISBASV1: 54     ISBASQ2: 230
ISBASV2: 62     ISBASV1: 230
ISBASQ1: 63     ISBASV2: 359
ISBASQ2: 63     ISBASQ1: 360
ISBASV1: 63     ISBASQ2: 360
ISBASV2: 148    ISBASV1: 360
ISBASQ1: 149    ISBASV2: 366
ISBASQ2: 149    ISBASQ1: 367
ISBASV1: 149    ISBASQ2: 367
ISBASV2: 155    ISBASV1: 367
ISBASQ1: 156    ISBASV2: 615
ISBASQ2: 156    ISBASQ1: 616
ISBASV1: 156    ISBABQ2: 616
```

Figure 4. Example SBAS input for GenCade simulation. Input must be in a single column; two columns are shown to conserve space.

GENCADE RESULTS FOR SBAS: Once the files have been saved and the *.gen file has been reviewed, the user should follow these steps to run the GenCade simulation. First, ensure GenCade_v1r6.exe or a subsequent executable is being used. To check the executable, go to *Edit->Preferences* and click on the tab labeled *File Locations.* Scroll down to *GenCade* under *Model Executables* and confirm that GenCade_v1r6.exe is the executable in use[1]. Finally, click on *GenCade->Run GenCade* to run the simulation.

All of the results will be identical to the calibration, but there will be additional output related to SBAS in the *.prt file. The GenCade output for SBAS input is located at the end of the *.prt file under *SBAS OUTPUT*. Figures 5 and 6 provide partial outputs for cells and fluxes for the sample case, respectively. In Figure 5, SBAS cell 1 represents a barrier island, so only volume change and volumetric change rate are included. If a beach fill or bypassing was specified in the GenCade cells representing SBAS cell 1, there would be additional information written to the SBAS Output. SBAS cell 2 is an inlet, so it also includes dredged removal volume/volumetric rate (Figure 5). The *AVG. VOLUME CHANGE RATE* for an inlet is 0, since this value is calculated from shoreline change which is 0 at an inlet. The *AVG. INLET VOL. CHANGE RATE* is calculated from the *.irv file and represents the volume change of the inlet per year. In Figure 6, the first flux is not adjacent to an inlet, so only transport at the grid cell-wall is shown. These rates can be found in the *.mql and *.mqr files. Each SBAS flux in this example represents a single GenCade cell, so the two *TRANSPORT AT GRID CELL-WALL* rates are duplicates. If a user defines a sediment budget flux

[1] To obtain GenCade_v1r6.exe or later, see the CIRP website under Products-GenCade: *http://cirp.usace.army.mil/products/gencade.php*.

over multiple GenCade cells, there will be two separate transports at the grid cell-wall. While it might be informative for a user, it is not suitable for SBAS and should be avoided. For a sediment budget flux adjacent to an inlet, the SBAS output includes both the transport at the grid cell-wall and the flux arrow adjacent to the inlet. The transport at the grid cell-wall is 0 since there is no shoreline change in an inlet. The SBAS flux arrow information represents the volume rate moving into or out of the inlet and is used for the SBAS sediment budget.

```
****************************************************************
*                          SBAS OUTPUT                         *
****************************************************************

 SBAS CELL           1
    GENCADE GRID CELL RANGE:
        STARTING GRID CELL:                    1
        ENDING   GRID CELL:                    53
    VOLUME CHANGE (CY):                       -497787.277508768
    AVG. VOLUME CHANGE RATE (CY/YR):          -82964.5440954911

    WARNING: SBAS CELL            1
    IS ADJACENT TO BOUNDARY OF INLET: Rich
    INLET VOLUME CONTRIBUTION NOT INCLUDED IN CALCULATION

 SBAS CELL           2
    GENCADE GRID CELL RANGE:
        STARTING GRID CELL:                    54
        ENDING   GRID CELL:                    62
    VOLUME CHANGE (CY):                       0.000000000000000E+000
    AVG. VOLUME CHANGE RATE (CY/YR):          0.000000000000000E+000

    SBAS CELL INCLUDES INLET:               Rich
    VOLUME TRANSPORTED INTO INLET (CY):        7996275.
    VOLUME TRANSPORTED FROM INLET (CY):        7723018.
    DREDGED VOLUME PLACEMENT (CY):            0.0000000E+00
    DREDGED VOLUME REMOVAL (CY):              -540005.2
    INLET VOLUME CHANGE (CY):                 -266748.2
    AVG. DREDGED PLACEMENT RATE (CY/YR):      0.0000000E+00
    AVG. DREDGED REMOVAL RATE (CY/YR):        -90000.88
    AVG. INLET VOL. CHANGE RATE (CY/YR):      -44458.04
```

Figure 5. Output for SBAS cells 1 and 2 (from *.prt file).

```
SBAS FLUX ARROW           1
   GENCADE GRID CELL RANGE:
       STARTING GRID CELL-WALL:                 1
       ENDING   GRID CELL-WALL:                 1

   TRANSPORT AT GRID CELL-WALL:                 1
       VOLUME TO RIGHT (CY):                  3868526.
       VOLUME TO LEFT  (CY):                 -3827406.
       AVG. RATE TO RIGHT (CY/YR):            644901.5
       AVG. RATE TO LEFT  (CY/YR):           -638046.6

   TRANSPORT AT GRID CELL-WALL:                 1
       VOLUME TO RIGHT (CY):                  3868526.
       VOLUME TO LEFT (CY):                  -3827406.
       AVG. RATE TO RIGHT (CY/YR):            644901.5
       AVG. RATE TO LEFT  (CY/YR):           -638046.6

SBAS FLUX ARROW           2
   GENCADE GRID CELL RANGE:
       STARTING GRID CELL-WALL:                54
       ENDING   GRID CELL-WALL:                54

   TRANSPORT AT GRID CELL-WALL:                54
       VOLUME TO RIGHT (CY):                 0.0000000E+00
       VOLUME TO LEFT  (CY):                 0.0000000E+00
       AVG. RATE TO RIGHT (CY/YR):           0.0000000E+00
       AVG. RATE TO LEFT  (CY/YR):           0.0000000E+00

   TRANSPORT AT GRID CELL-WALL:                54
       VOLUME TO RIGHT (CY):                 0.0000000E+00
       VOLUME TO LEFT (CY):                  0.0000000E+00
       AVG. RATE TO RIGHT (CY/YR):           0.0000000E+00
       AVG. RATE TO LEFT  (CY/YR):           0.0000000E+00

   SBAS FLUX ARROW ADJACENT TO INLET:   Rich
   TRANSPORT INTO OR OUT OF INLET AT CELL-WALL:              54
       VOL. INTO INLET LEFT TO RIGHT (CY):   4211960.
       VOL. FROM INLET RIGHT TO LEFT (CY):  -3668748.
       AVG. RATE INTO INLET L TO R(CY/YR):   701672.8
       AVG. RATE FROM INLET R TO L(CY/YR):  -611178.9

   SBAS FLUX ARROW ADJACENT TO INLET:   Rich
   TRANSPORT INTO OR OUT OF INLET AT CELL-WALL:              54
       VOL. INTO INLET LEFT TO RIGHT (CY):   4211960.
       VOL. FROM INLET RIGHT TO LEFT (CY):  -3668748.
       AVG. RATE INTO INLET L TO R(CY/YR):   701672.8
       AVG. RATE FROM INLET R TO L(CY/YR):  -611178.9
```

Figure 6. Output for SBAS fluxes 1 and 2 (from *.prt file).

SHAPEFILES FOR SBAS: Before the output from the *.prt file can be imported to SBAS, it is necessary to create shapefiles for each of the cells and fluxes. Shapefiles are necessary because the *.prt and *.gen files do not provide geographical information for the cells and fluxes. While arcs representing the sediment budget cells and fluxes are created in GenCade, these are not in the proper shape for SBAS to create the sediment budget.

To develop the shapefiles in SMS, right-click on *Map Data* and create a *New Coverage*. The default coverage type is *Area Property*, which is the coverage needed to develop the shapefiles. After the new coverage is created, click on the *Create Feature Arc* and draw each cell and flux. Cells should be drawn as polygons that begin on land and extend into the water. Close the polygon by double-clicking. Start drawing cells from the beginning of the GenCade grid (near GenCade cell 1) and continue along the GenCade *x*-axis until all of the polygons representing sediment budget cells are drawn. GenCade calculates left-directed and right-directed transport, so two fluxes need to be drawn between each sediment budget cell. After all of the polygons and fluxes have been created, click on *Area Property* and save the file type as *.shp. Select *Feature Arcs* -> *Arc Shapefile.* Now a shapefile representing the cells and fluxes calculated by GenCade has been created and is ready for input into SBAS.

SEDIMENT BUDGET IN SBAS: SBAS is accessed through the Arc Catalog of ArcMap 10.1 or a later version. SBAS does not require administrator privileges and can be installed in any location on the computer. Figure 7 shows the options under SBAS. Before the GenCade data may be incorporated into SBAS, it is necessary to set up the environment and create an alternative.

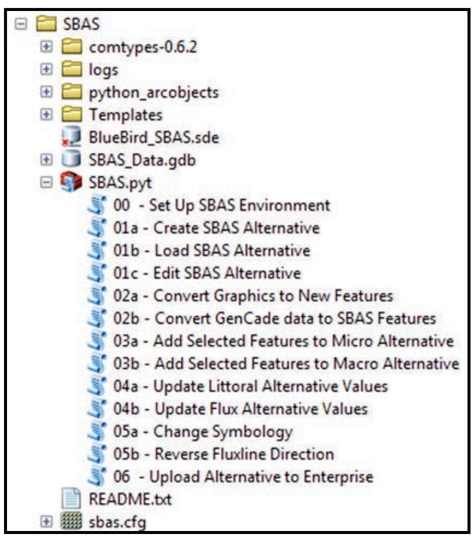


Figure 7. SBAS menu in ArcCatalog.

The first step, 00 – Set Up SBAS Environment, allows the user to choose a basemap for the alternative and enter metadata. After the environment has been set up, 01a – Create SBAS Alternative is used to name and describe the alternative and enter starting and ending dates for the sediment budget. Finally, the user may define the units and load the alternative under 01b – Load SBAS Alternative. To enter the data from GenCade, the user should select 02b – Convert GenCade data to SBAS Features. If the first three steps are not completed, no alternatives will be listed under *Add Features to Micro Alternative*.

Next, the shapefile, *.gen, and *.prt are brought into SBAS by clicking on the folder next to each option and selecting the proper file (Figure 8). After the data have been loaded into SBAS, the sediment budget will be created automatically. The user should check to make sure each flux is in the proper direction. If a flux is in the wrong direction, go to 05b – Reverse Fluxline Direction to change the flux direction. Initially, the sediment budget cells will be color coded by residual volume. In order to see color coding by volume change, click on 05a – Change Symbology and change from residual to volume change. The sediment budget can be used to visually show the locations alongshore that are eroding and accreting, where placements are located, inlet volume change and dredging, and transport alongshore (Figure 9). While GenCade provides all of this information, this process automates the procedure to use the results of a GenCade simulation within SBAS. The sediment budget in SBAS can be further modified, if needed, by using 02a – Convert Graphics to New Features and the editor in ArcMap.

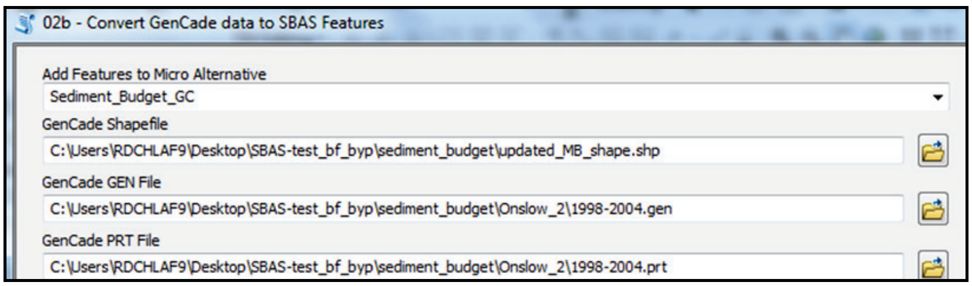


Figure 8. GenCade data to SBAS features.

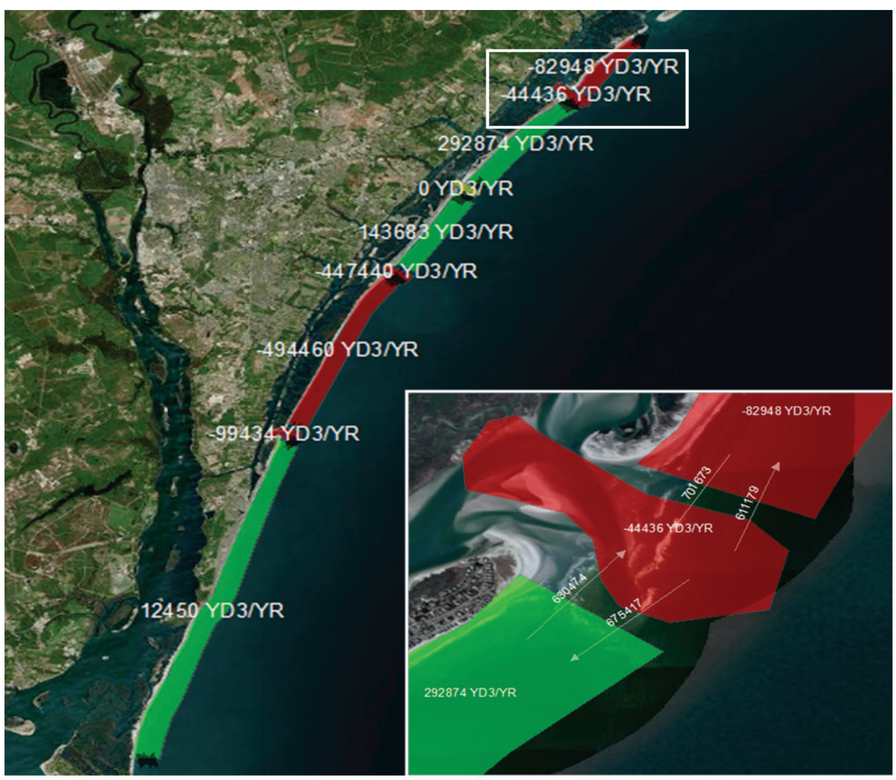


Figure 9. Sediment budget (in SBAS) for lower Onslow Bay. Rich Inlet (within white rectangle) is shown in more detail in the inset. Green is volume increase; red is volume decrease.

CONCLUSIONS AND SUMMARY: This CHETN presents the automated procedure of developing a sediment budget in SBAS using results of a GenCade simulation. A previous study in southern Onslow Bay, NC, was used as an example. Step-by-step details were given, beginning with the additional information needed in GenCade to produce the proper input and output files and ending with converting the GenCade data to SBAS features. User's guides and other documentation for GenCade and SBAS are listed in the references.

POINT OF CONTACT: This CHETN was prepared as part of the Coastal Inlets Research Program (CIRP) and was written by Ashley E. Frey (*Ashley.E.Frey@usace.army.mil*, voice: 601-634-2006), of the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL). Dr. David King and Linda Lillycrop provided peer review of this publication. This technical note should be referenced as follows:

> Frey, A. E. 2015. *Using GenCade to create a sediment budget in SBAS*. ERDC/CHL CHETN-IV-105. Vicksburg, MS: U.S. Army Engineer Research and Development Center. An electronic copy of this CHETN is available from *http://cirp.usace.army.mil/wiki/Publications*.

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