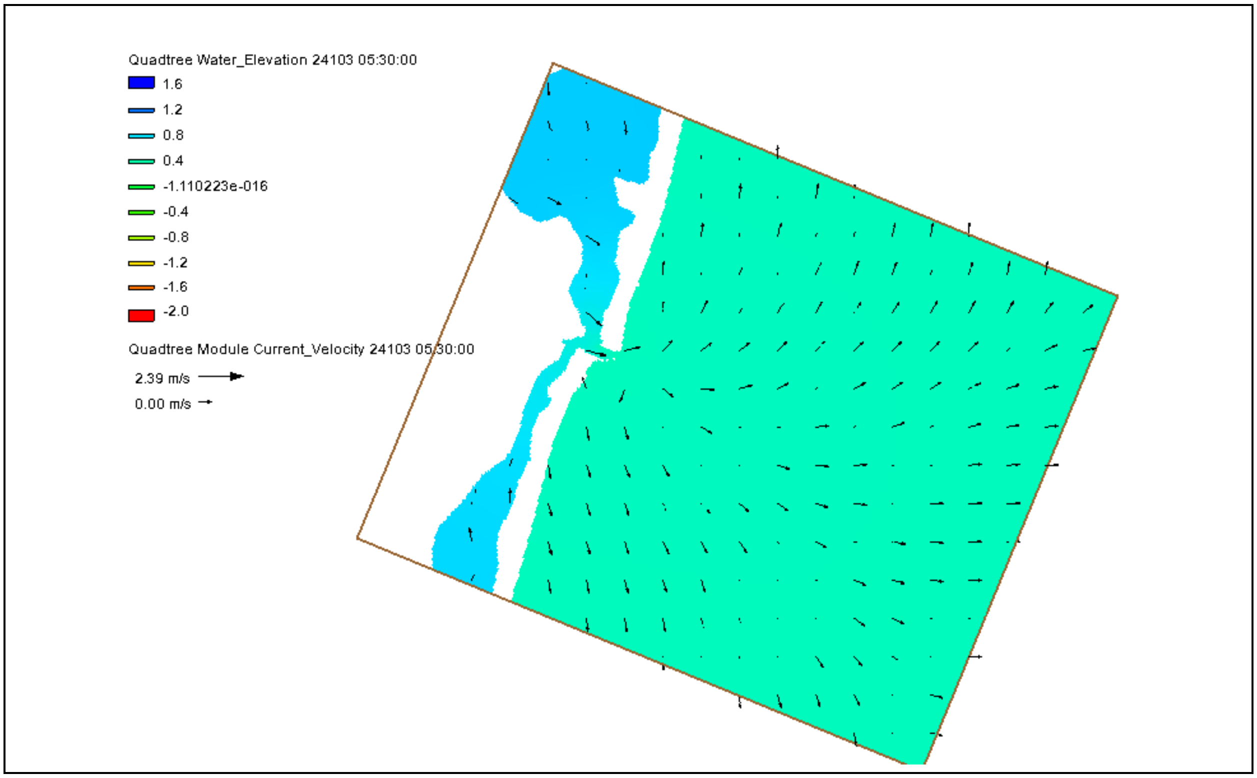
v. 12.2

SMS 12.2 Tutorial

CMS-Flow



Objectives

This lesson demonstrates how to prepare a grid and run a solution using CMS-Flow.

Prerequisites

- SMS Overview

Requirements

- Map Module
- Cartesian Grid Module
- Scatter Module
- CMS-Flow

Time

- 60–75 minutes

1 Getting Started

Launch the SMS application. This tutorial starts with importing a project file containing the data for this CMS-Flow simulation.

1. Select *File* | **Open** to bring up the *Open* dialog.
2. Select "Project Files (*.sms)" from the *Files of type* drop-down.
3. Browse to the *SMS_CMS-Flow\data files* folder and select "ocean_city.sms".
4. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1. The data used for this tutorial is from the Ocean City inlet and the surrounding coastline in the state of Maryland in the United States. An elevation dataset and an area property coverage have been included for use in the tutorial. The projection for the project has already been set.

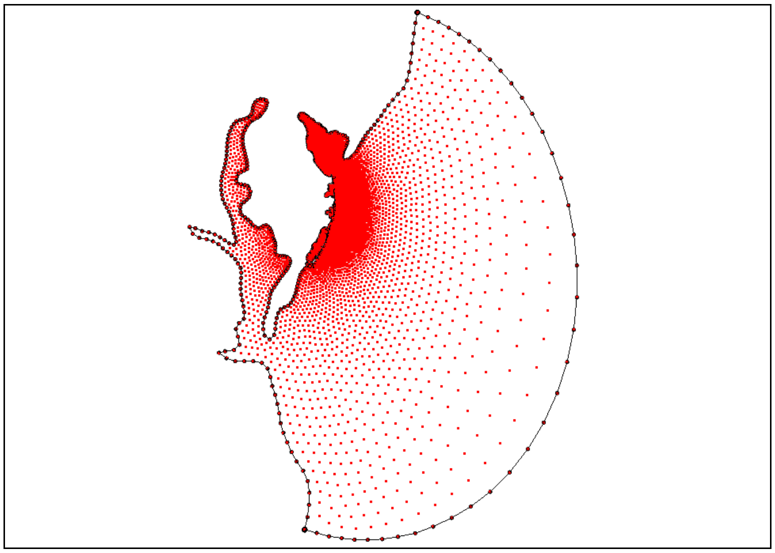


Figure 1 Ocean City inlet

The following sections of the tutorial will go over the components for the CMS-Flow model. Components for CMS-Flow include a Quadtree grid, a CMS-Flow Boundary Conditions coverage, an activity coverage, and a CMS-Flow Save Points coverage.

2 Creating a Quadtree Grid

Bathymetry data and an arc defining the shoreline are provided to start this tutorial. The bathymetry data is represented as a scatter point dataset—also called a triangulated irregular network (TIN). The shoreline is represented as an arc in the "CMS-Flow" coverage.

To create the grid that will be used for numerical computations:

1. Select " CMS-Flow" in the Project Explorer to make it active.
2. Using the **Zoom** tool, drag a box over the area show in Figure 2.

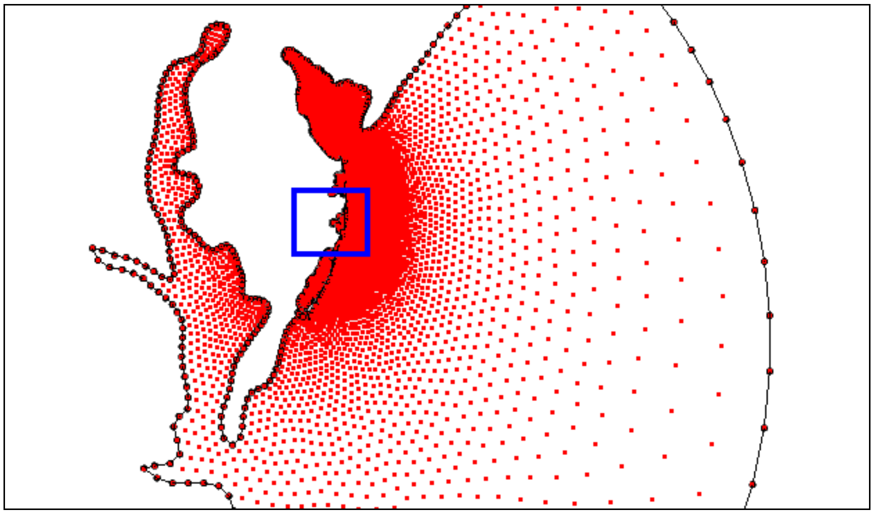


Figure 2 Zoom area indicated by the box

3. Right-click " Map Data" and select **New Coverage** to bring up the *New Coverage* dialog.
4. In the Coverage Type section, select "Quadtree Generator" under "Generic".
5. Enter "Inlet" as the *Coverage Name*.
6. Click **OK** to close the *New Coverage* dialog and create the new " Inlet" coverage in the Project Explorer.
7. Select " Inlet" to make it active.
8. Using the **Create 2-D Grid Frame** tool, define the extents of the computational domain. This is done with three clicks (see Figure 3).
   - The first click defines a corner of the CMS-Flow domain. Click in the region near the lower left corner of the domain shown in Figure 3.
   - The second click defines an edge of the domain and the extent of the domain along that edge. Click near the lower right of the domain shown in Figure 3.
   - The third click defines the extent of the domain perpendicular to the first edge. Click at the upper right corner of the domain to define this distance. The purple line in Figure 3 illustrates the desired grid frame. It is okay if the final grid frame does not appear exactly like the example. The exact dimensions will be set in a later step.

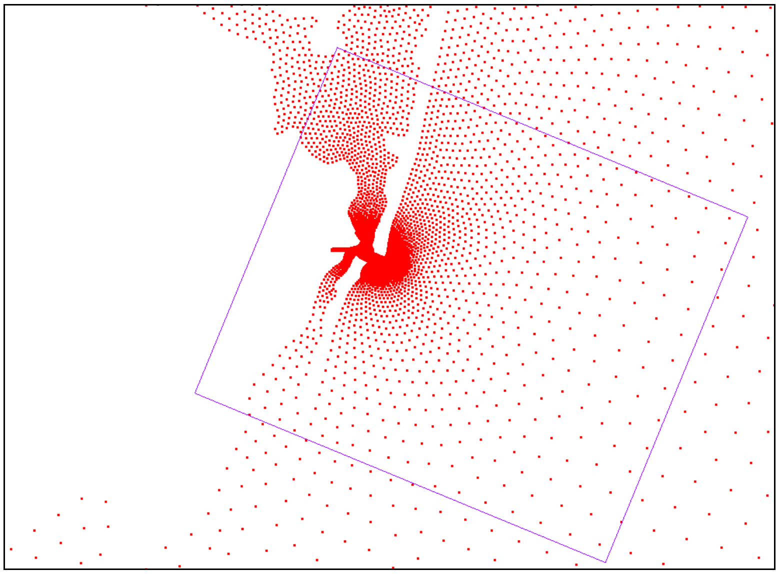


Figure 3 Grid dimensions

9. Right-click "Inlet" and select *Convert* | **Map → Quadtree Grid** to bring up the *Map → Quadtree Grid* dialog.

This dialog allows explicit modification of the extents of the grid frame and setting of the desired grid attributes. The exact values for the position and size of a grid do not generally matter in a real world simulation.

10. For consistency in this tutorial, however, enter the following in the *Origin, Orientation and Dimensions* section:
    - "560770.5" for *Origin X*
    - "70055.4" for *Origin Y*
    - "337.6" for *Angle*
    - "15450.0" for *I size*
    - "13000.0" for *J size*
11. In the *I Cell Options* section, select the *Cell size* radio button and enter "50.0" (this is the column cell size).
12. In the *J Cell Options* section, select the *Cell size* radio button and enter "50.0" (this is row cell size).

Notice that the number of cells is computed and reports that there will be 309 columns and 260 rows.

13. In the *Depth Options* section, select "Scatter Set" from the *Source* drop-down.
14. Click **Select…** to bring up the *Interpolation* dialog.
15. In the *Scatter Set To Interpolate From* section, select "depth". This defines the source for depth data for the model.

CMS-Flow uses depths (measured from the surface downward, so a positive number gives the distance below the surface). If a survey is done relative to a sea level datum and the data is measured as elevation (distance above sea level), the datum would need to be switched or a depth dataset computed using the data calculator.

16. Click **OK** to close the *Interpolation* dialog.
17. Click **OK** to close the *Map → Quadtree Grid* dialog.

SMS creates a quadtree grid within the defined grid frame and adds it to the Project Explorer as " Inlet Grid" under the " Quadtree Data" folder. SMS has defined the cells, assigned depth values to each cell and created cell strings around the boundaries.

To better see the depths on the grid, change the grid display.

1. Select " Inlet Grid" to make it active.
2. Click **Display Options** to bring up the *Display Options* dialog.
3. Select "Quadtree" from the list on the left.
4. On the *Quadtree* tab, turn off all options except for *Contours* and *Boundary*.
5. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
6. Click **OK** to close the *Display Options* dialog.
7. Turn off " Depth Values for Grid" in the Project Explorer.
8. Select " CMS-Flow" to make it active.

The project should appear similar to Figure 4.

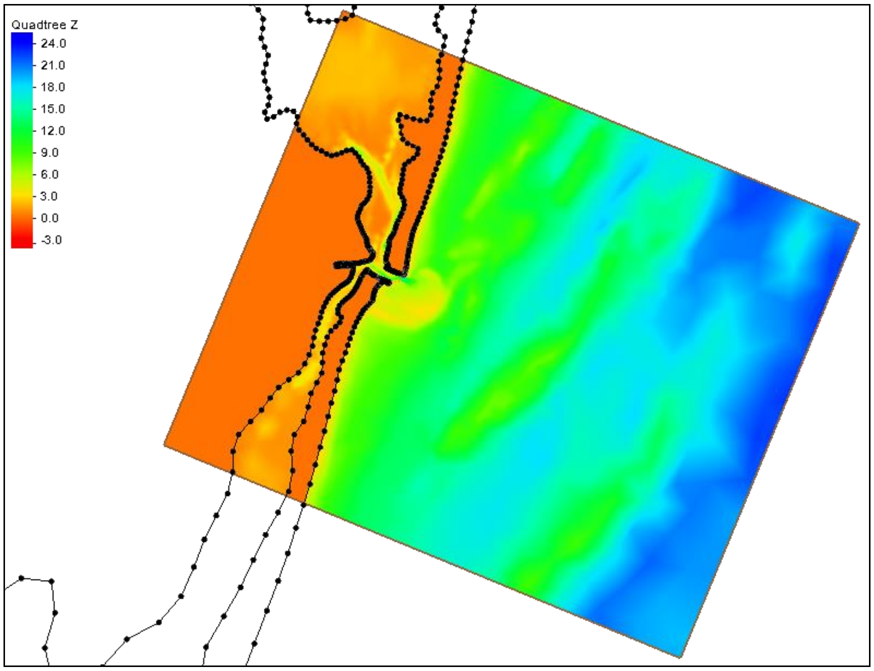


Figure 4 Quadtree contours with color fill

3 Defining Boundary Conditions

Boundary conditions for a CMS-Flow run are defined using feature arcs in a CMS-Flow boundary conditions coverage.

The following steps define how to create the boundary condition.

1. Right-click " CMS-Flow" and select **Duplicate** to create a new " CMS-Flow (2)" coverage.
2. Right-click on " CMS-Flow (2)" and select **Rename**.
3. Enter "BC" and press *Enter* to set the new coverage name.
4. Right-click on " BC" and select *Type* | *Models* | *CMS-Flow* | **Boundary Conditions**.

Next, an additional arc is needed that defines the boundaries of the quadtree grid.

5. Select " BC" to make it active.
6. Using the **Create Feature Arc** tool, create a boundary arc covering the ocean by starting at the top where the grid frame meets the shoreline arc, then following the grid frame border around to where it meets the shoreline arc again. The arc will automatically end by snapping to the shoreline arc.

The ocean boundary arc does not need to be precise as SMS will snap the boundary condition to the grid. Both the shoreline arc and the ocean boundary condition arc are unassigned by default (Figure 5). The arc around the grid boundary needs to be assigned additional data for this project.

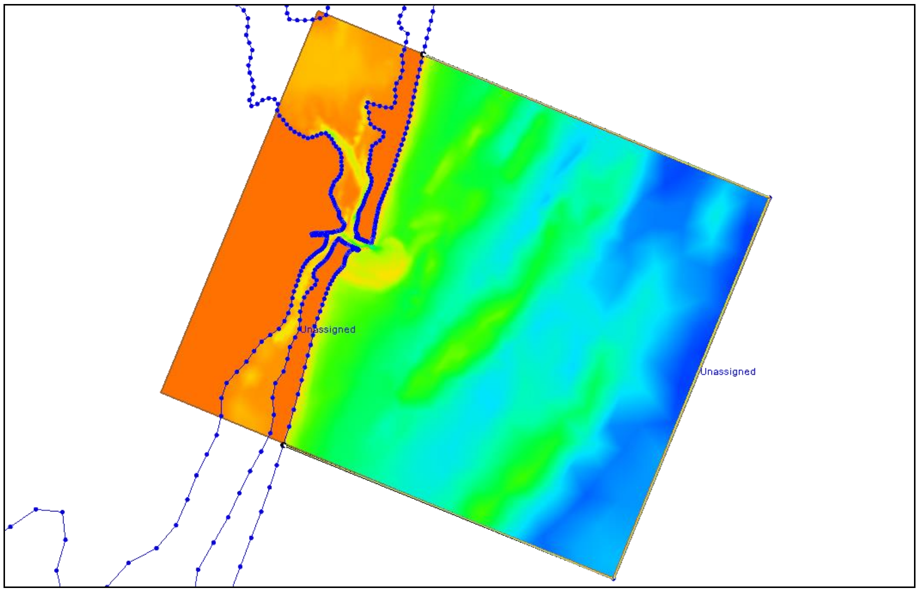


Figure 5 Ocean boundary condition arc

7. Using the **Select Feature Arc** tool, select the ocean boundary condition arc.
8. Right-click on the selected arc and select **Assign Boundary Conditions…** to bring up the *Arc Boundary Condition* dialog.

9. In the *Options* section, enter "Ocean" as the *Name* and select "WSE-forcing" from the *Type* drop-down.
10. Select "Tidal Constituent" from the *WSE Source* drop-down.
11. Enter "0" as the *Inflow direction*.
12. Below the *Constituents* table, click **Insert Above** twice to add two constituent rows to the table.
13. Use the table below to enter the data defining a tidal signal with a maximum of 1.8 meters amplitude:

Constituent	Amplitude (m)	Phase (deg)
M2	1.3	0
O1	0.5	0

14. Enter "0" as the *WSE offset*.
15. Click **OK** to close the *Arc Boundary Condition* dialog.

CMS-Flow supports several other types of boundary conditions that will not be illustrated in this tutorial.

4 Defining Save Points

Save points can be used to specify data to gather during the model run. Create save points by doing the following:

1. Right-click on " Map Data" and select **New Coverage** to bring up the *New Coverage* dialog.
2. In the *Coverage Type* section, select "Save Points" under the "CMS-Flow" model.
3. Click **OK** to close the *New Coverage* dialog and create the new " Save Points" coverage in the Project Explorer.
4. Right-click on " Save Points" and select **Save Points Properties…** to bring up the *Save Points Properties* dialog.
5. Select "minutes" from the *Hydro* drop-down and enter "10" as the value.
6. Click **OK** to close the *Save Points Properties* dialog.
7. Using the **Create Feature Point** tool, create a feature point within the grid area as in Figure 6.

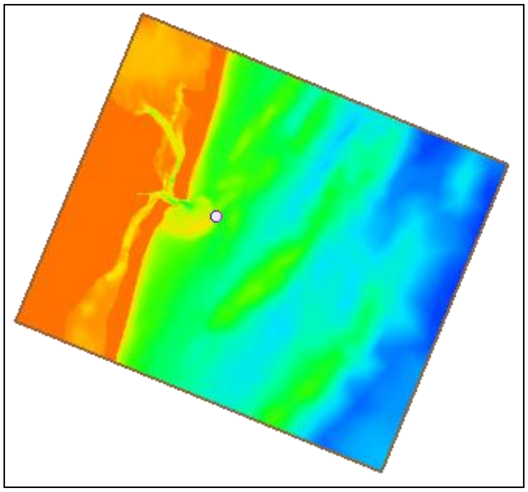


Figure 6 Save point

8. Using the **Select Feature Point** tool, select the newly-created point, then right-click on it and select **Assign Save Points…** to bring up the *Assign Save Points* dialog.
9. Enter “Ebb Shoal” as the *Name*.
10. Turn on *Hydro* and click **OK** to close the *Assign Save Points* dialog.

A save point has now been set and it is ready to be added to the simulation.

5 Defining Activity

A CMS-Flow simulation can be made more efficient by assigning areas that will never get wet to be inactive. An activity coverage defines active and inactive regions. In the case of Ocean City, the land regions do not have any elevation data, so the grid creation process assigned an elevation of 0.0 as specified for the extrapolation value. Since the tide range is greater than 1.0 meter (an amplitude of 1.3 was specified for M2 alone), the resulting CMS-Flow simulation would inappropriately inundate the land. To flag the land areas as inactive:

1. Right-click on “ CMS-Flow” and select **Duplicate** to create a new “ CMS-Flow (2)” coverage.
2. Right-click on “ CMS-Flow (2)” and select *Type* | *Generic* | **Activity Classification**
3. Right-click on “ CMS-Flow (2)” and select **Rename**.
4. Enter “Activity” and press *Enter* to set the new name.
5. Select “ Activity” to make it active.
6. **Frame** the project.

Now create a polygon in the activity coverage to enclose the land:

7. Using the **Create Feature Arc** tool, create an arc enclosing the land side of the project (Figure 7).

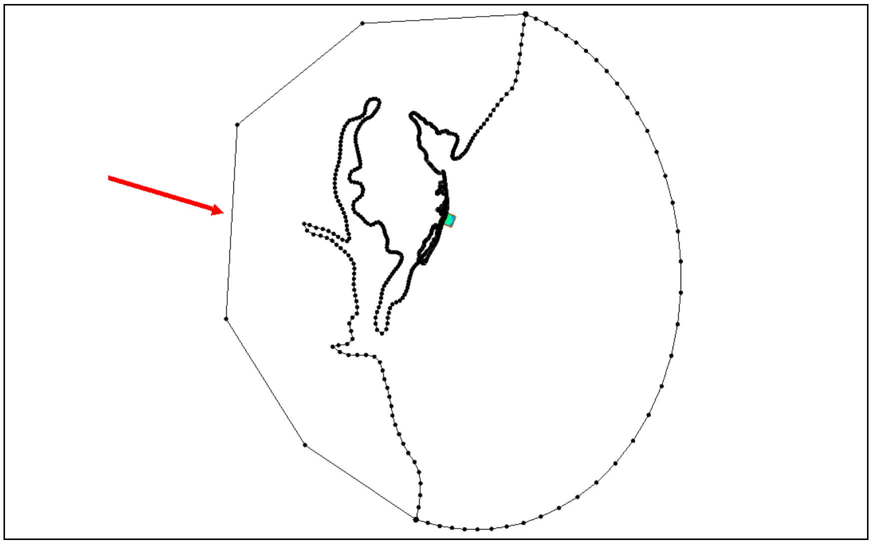
8. 

Figure 7 Arc enclosing the land

9. Select *Feature Objects* | **Build Polygons**.

By default, all polygons are classified as inactive regions. This must be changed for the region of the ocean.

10. Using the **Select Feature Polygon** tool, double-click on ocean side polygon to bring up the *Activity Classification Coverage* dialog.
11. In the Classification Type section, select *Active* and click **OK** to close the *Activity Classification Coverage* dialog.

The active and inactive definitions are now ready.

6 Setting Up the Simulation

CMS-Flow makes use of simulations, and multiple simulations can be included in a project. Set up the CMS-Flow simulation by doing the following:

1. Right-click in a blank area in the Project Explorer and select *New Simulation* | **CMS-Flow**.

This creates in the Project Explorer a new " Sim" under a " CMS-Flow Simulations" folder under " Simulation Data".

2. Right-click on " Sim" and select **Rename**.
3. Enter "Ocean City" and press *Enter* to set the new name.
4. Right-click " Inlet Grid" and select *Link to* | **CMS-Flow Simulations → Ocean City**.
5. Repeat step 4 for " BC", " Activity", and " Save Points".
6. **Frame** the project.

The Project Explorer should now appear similar to Figure 8.

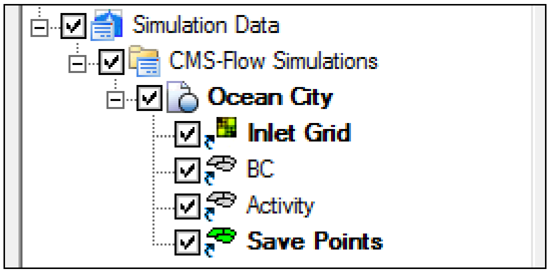


Figure 8 Components linked to the simulation in the Project Explorer

6.1 Defining the Model Control

Set the parameters for running CMS-Flow in the *Model Control* dialog by doing the following:

1. Right-click on " Ocean City" and select **Model Control…** to bring up the CMS-Flow *Model Control* dialog.
2. On the *General* tab, enter "6/1/2014 1:00:00 pm" as the *Start date/time*.
3. Enter "96" as the *Simulation duration* and select "hours" from the drop-down.

This simulates 96 hours (or four days).

4. Enter "2" as the *Ramp duration* and select "days" from the drop-down.

Full tidal runs often require a full lunar cycle of 28 days or at least 14 days. This run is shorter to allow for shorter run times.

5. Make sure *Second order skewness correction* is turned on.
6. In the *Hot start* section, make sure *Initial conditions file* is turned off.

This option instructs CMS-Flow to start from cold start conditions.

7. Set the *Time to write out:* to "48" hours to tell CMS-Flow to start writing hot start files after 2 days of simulation time.
8. Enter "6.0" as the *Interval* to tell CMS-Flow to update the hot start file after each 6 hours of simulation time.
9. In the *Solution scheme* section, select "Implicit" from the first drop-down.
10. Select "GMRES" from the *Matrix solver* drop-down.
11. In the *Threads* section, enter "4" for the *Number of threads*.
12. On the *Flow* tab in the *Parameters* section, enter "600" as the *Hydrodynamic time step* and select "seconds" from the drop-down.

This defines the maximum time step to be 600 seconds (10 minutes). CMS-Flow will reduce this if needed to maintain stability.

13. Scroll down to the *Bottom roughness dataset* sub-section of the *Bottom and wall friction* section and select "Mannings N" from the drop-down.
14. Click **Select** to bring up the *Dataset* dialog.
15. Click **Create** to bring up the *Dataset Toolbox* dialog.
16. In the *Calculator* sub-section of the *Data Calculator* section, enter "0.025".

17. Enter "n" as the *Output dataset name* and click **Compute**.
18. Click **Done** to close the *Dataset Toolbox* dialog.
19. Click **OK** to close the *Dataset* dialog.

For this simulation, no sediment transport, salinity, wave, or wind options will be included. These functions are off (or set to "none"), so no changes will be made on the Sediment Transport, Salinity, Wave, and Wind tabs.

20. On the *Output* tab in the *Output time lists* section under *List 1*:
    - Enter "48" in the *Start time (hrs)* column.
    - Enter "1" in the *Increments (hrs)* column.
    - Enter "96" in the *End time (hrs)* column.
21. Scroll down to the *Output options* section and enter "Ocean City" as the *Simulation label*.
22. Click **OK** to close the *Model Control* dialog.

7 Saving the Simulation

It is recommended to save the project prior to running CMS-Flow.

1. Select *File* | **Save As…** to bring up the *Save As* dialog.
2. Select "Project Files (*.sms)" from the *Save as type* drop-down.
3. Enter "OceanCity.sms" as the *File name.*
4. Click **Save** to save the project under the new name and close the *Save As* dialog.

8 Using CMS-Flow

CMS-Flow can be launched from inside SMS by doing the following:

1. Select " Ocean City" in the Project Explorer to make it active.
2. Right-click on " Ocean City" and select **Save, Export, and Launch CMS-Flow...** to save everything, export the files, and launch the analysis.
3. Click **OK** when advised the "Activity" coverage will be renumbered.

The *CMS-Flow: Ocean City* dialog will appear. If any problems are found in the model quality check, the problems will appear in the text field at the bottom of the dialog. The steps needed to correct the problems will also be displayed.

4. Click the CMS-Flow button to review the data and analysis being generated as CMS-Flow works through the simulation.

SMS saves the location of the CMS-Flow executable as a preference. If this preference is defined, the model will launch. If the preference is undefined, SMS shows a message that the executable is not found and the location of the executable must be specified. If this happens, click the **File Browser** button to browse and find the CMS-Flow executable, then click the **OK** button to run the model.

The CMS-Flow simulation may take one or two hours to complete, depending on the speed of the computer being used.

5. When CMS-Flow finishes, turn on *Load Solution* and click **Exit** to close the *CMS-Flow: Ocean City* dialog.

8.1 Viewing the Solutions

Once the simulation is completed, SMS adds the new solution datasets to the Project Explorer under " Inlet Grid". To view the solutions:

1. Click **Display Options** to bring up the *Display Options* dialog.
2. Select *Quadtree* from the list on the left.
3. On the *Quadtree* tab, turn on *Contours* and *Vectors*.
4. On the *Contours* tab in the *Contour method* section, select "Color Fill" from the drop-down.
5. Click **OK** to close the *Display Options* dialog.
6. Review all of the time steps to observe the changes over time.

9 Conclusion

This concludes the "CMS-Flow" tutorial. Continue to experiment with the SMS interface or quit the program.

