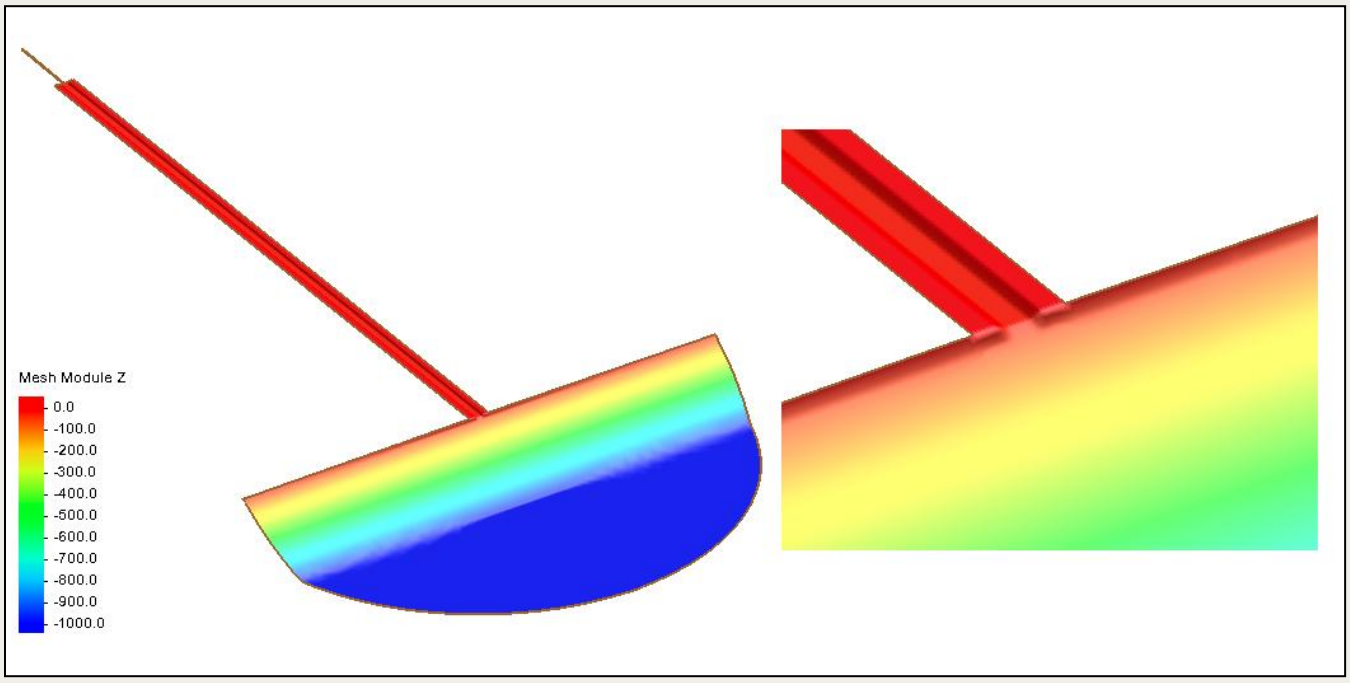
SMS 14.0 Tutorial

Idealized Estuary Mesh Generation

Creating a mesh for an idealized estuary.



Objectives

This tutorial demonstrates how to create the geometry for an idealized estuary for SCHISM inside of SMS.

Prerequisite Tutorials

- Overview
- Map Module

Required Components

- SMS Core

Time

- 10–15 minutes

AQUAVEO™

1 Introduction

This tutorial demonstrates creating the mesh for an idealized estuary. Some refer to this as a "toy case". This geometry could be used with any engine that utilizes an unstructured mesh of triangles and quadrilaterals such as SCHISM or SRH-2D. The quadrilaterals could be split for engines that require all triangles (i.e. ADCIRC or AdH).

This tutorial illustrates common **Map Module** functions.

2 Getting Started

Start by opening SMS and setting up the projection. To do this:

1. If necessary, launch SMS.
2. If SMS is already open, close any existing data by selecting *File* | **New**.
3. If a dialog appears asking to save changes, click **Don't Save** to clear all data.
4. Click *Display* **| Display Projection…** to open the *Display Projection* dialog.
5. Under *Horizontal* and *Vertical,* change *Units* to "Meters".
6. Click **OK** to close the *Display Projection* dialog.

SMS can be used to layout and create a mesh of unstructured grid. This involves the following steps:

- Define the domain polygon
- Specify mesh attributes
- Define elevation data
- Generate the mesh

3 Creating the Ocean Domain

A mesh starts with a domain polygon. In this case the domain consists of a semi-circular "ocean", an attached rectangular "estuary", with a "river" flowing into the estuary. To define the 150 km radius ocean part of the domain:

1. Right-click on "Map Data" in the Project Explorer and select **New Coverage** to open the *New Coverage* dialog.
2. For *Coverage Type,* under *Generic,* select *Mesh Generator***.**

3. For *Coverage Name,* enter “Estuary”.
4. Click **OK** to close the *New Coverage* dialog.
5. Using the **Create Feature Arc** tool, create a horizontal arc from right to left, double-clicking to end the arc.
6. Using the **Select Feature Point** tool, click on the left node of the arc.
7. For the *X:* edit field, enter “-150000”.
8. For the *Y:* edit field, enter “0”.
9. Repeat steps 6–8 for the right node of the arc, entering (150000, 0) as the XY coordinates.
10. Click the **Frame** macro to center the display.
11. Using the **Select Feature Arc** tool, select the arc.
12. Right-click and select **Define Domain** to open the *Domain Options* dialog.
13. Click **OK** to select the default of a semi-circular domain and close the *Domain Options* dialog.
14. Click the **Frame** macro to center the display.

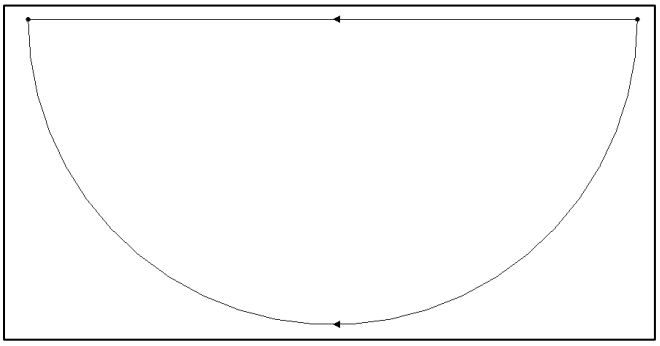


Figure 1 150 km radius ocean domain

4 Subdividing the Ocean Domain

A significant advantage of unstructured meshes over structured grids is the ability to vary the resolution. This can be done inside a polygon (shown later), or for even more control, the domain can be subdivided. For this case, we will create a smaller semi-circle around the entrance of the estuary to give that area higher resolution.

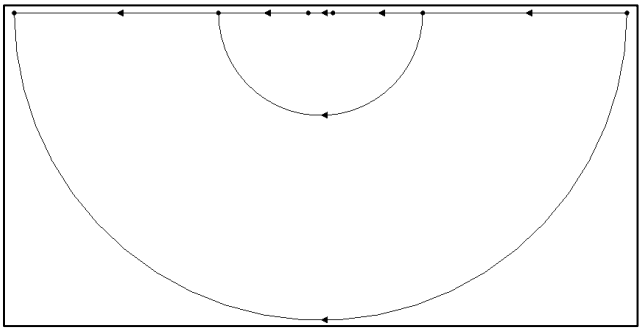


Figure 2 Subdivided ocean domain

To do this:

1. Select the **Create Feature Point** tool.
2. Click on the horizontal shoreline arc twice to create two nodes.
3. Select the **Select Feature Point** tool.
4. Click on the left node created in step 2.
5. For the *X:* edit field, enter “-50000”.
6. Click the right node from step 2.
7. For the *X:* edit field, enter “50000”.
8. Click on the **Select Feature Arc** tool.
9. Drag a box around both new nodes.
10. Right-click on the highlighted arc, and select **Define Domain** to open the *Domain Options* dialog**.**
11. Click **OK** to select the default of a semi-circular domain and close the *Domain Options* dialog.
12. Click on the **Frame** macro to center the display again.

5 Creating the Estuary Domain

For this case the “estuary” is a 12 km wide, 400 km long rectangle.

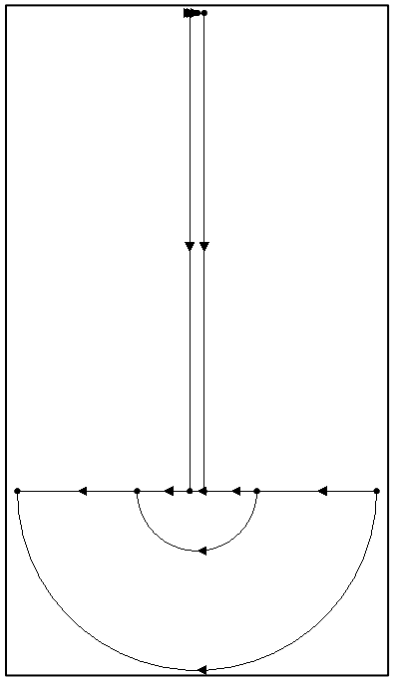


Figure 3 Ocean with estuary

To define this portion of the domain:

1. Select the **Create Feature Arc** tool.
2. Click in the empty area above the semi-circle and create a vertical arc, from top to bottom, double-clicking to end the arc.

3. Use the **Select Feature Point** tool to select the top node of the new arc.
4. For the XY coordinates, enter (-6000, 400000).
5. Select the bottom node of the arc and enter (-6000, 0) as the XY coordinates.
6. Click on the **Frame** macro to center the display.

This creates the first arc. To create the second arc, do the following:

7. Using the **Select Feature Arc** tool, select the arc.
8. Right-click and select **Offset Arc(s)…** to open the *Offset Arcs Tool* dialog.
9. For *Side to offset*, select “Left” from the drop-down menu (because it is created from top to bottom).
10. Under *Total offset distance*, for both *Begin* and *End,* enter “12000”.
11. Click **OK** to create an offset arc and close the *Offset Arcs Tool* dialog.
12. Select the **Create Feature Arc** tool.
13. Click on the two end points in either order, to close the top of the estuary.

Note: a red box should appear when you approach the end points. This indicates that SMS will snap the new arc to the existing location.

14. Click on the **Clean** macro to open the *Clean Options* dialog.
15. Click **OK** to accept defaults and close the *Clean Options* dialog.

This connects the estuary arcs to the shoreline arc.

6 Creating the River Domain

For this case the “river” is a 1 km wide, 40 km long rectangle.

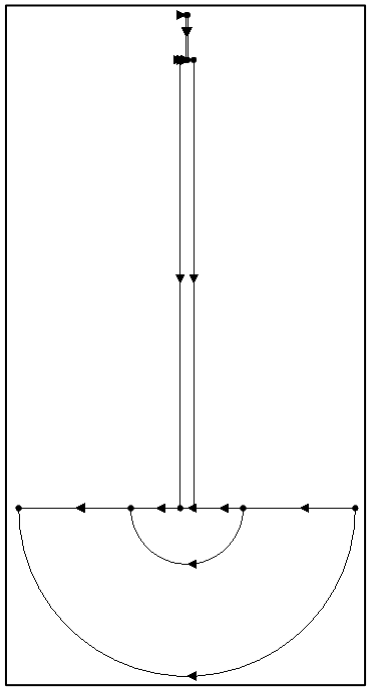


Figure 4 Entire domain

To define this river portion of the domain:

1. Select the **Create Feature Arc** tool.
2. Create a vertical arc from top to bottom, above the top of the estuary, clicking twice to end the arc.
3. Use the **Select Feature Point** tool to select the top node of the new arc.
4. For the XY coordinates, enter (-500, 440000).
5. Repeat steps 3–4 for the bottom node of the arc, entering (-500, 400000) as the XY coordinates.

This creates the first arc. To create the second arc, do the following:

6. Using the **Select Feature Arc** tool, select the arc.
7. Right-click and select **Offset Arc(s)…** to open the *Offset Arcs Tool* dialog.
8. For *Side to offset*, select “Left” from the drop-down menu.
9. Under *Total offset distance,* for both *Begin* and *End, enter* “1000”.
10. Click **OK** to create an offset arc and close the *Offset Arcs Tool* dialog.
11. **Zoom** into the top of the river.
12. Select the **Create Feature Arc** tool.
13. Click on the two end points in either order, to close the top of the river.
14. Click on the **Clean** macro to open the *Clean Options* dialog.
15. Click **OK** to accept the defaults and close the *Clean Options* dialog.

This will connect the river to the estuary.

16. Click the **Frame** macro to center the display.

7 Loading the Bathymetry Points

SMS includes a dataset calculator that could be used to assign bathymetry to this domain based on the X,Y location of the points. However, this approach is not very useful for most simulations because the coordinates are not that convenient.

Instead, a scatter set that defines the elevations will be used. This scatter set consists of 30 points located at transition points in the depth. To load the scatter set:

1. Select *File* | **Open…** to bring up the *Open* dialog.
2. Browse to the *data files* folder for this tutorial and select “TopoBathy.h5”.
3. Click **Open** to import the data points and exit the *Open* dialog.

Review the points by selecting them in turn. Notice:

- The river starts at an elevation of -1.0 (1 meter below sea level) at the top of its 40 km length and slopes down to -20.0 (20 meters below sea level) at its junction with the estuary.
- The estuary consists of a 6 km wide trapezoidal channel with a bottom width of 3 km. The bottom is 20 meters below sea level and the top is 1 meter above sea level.
- On either side of the trapezoidal channel the domain includes a 3 km wide tidal flat.

- From the shoreline, the depth increases from 20 meters to 1000 meters (-20 to -1000) over 45 km. Beyond 45 km from the shoreline the depth is constant at 1000 meters.

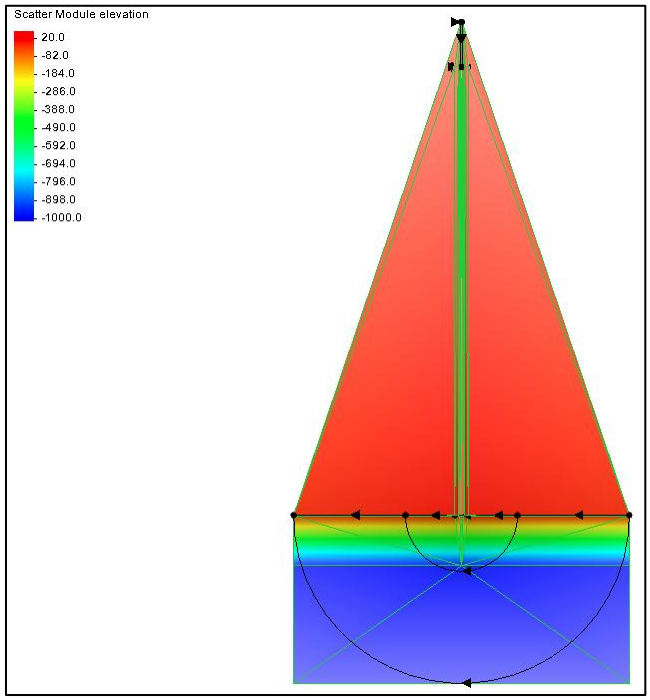


Figure 5 Scattered bathy/topo data over domain

8 Redistributing Vertices on the arcs

This domain consists of four areas (defined above) that must be closed into polygons for meshing. To build the polygons and assign attributes:

1. In the Project Explorer, turn off "Idealized Estuary".
2. Click on the **Display Options** macro to open the *Display Options* dialog.
3. Select "Map" from the list on the left.
4. Turn on *Vertex*.
5. Click **OK** to exit the *Display Options* dialog.

Now to redistribute vertices along the river (smallest polygon) (See Figure 6).

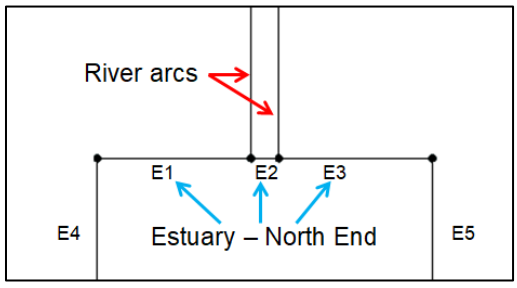


Figure 6 Arc details – river and north end of estuary

6. Make sure the **Map Module** is active.

7. **Zoom** into the area of the river.
8. Select the **Select Feature Arc** tool.
9. Hold down the *CTRL* key and drag a line through the two river arcs.
10. Right-click on one of the arcs and select **Redistribute Vertices…** to open the *Redistribute Vertices* dialog.
11. For *Specify,* select "Specified spacing" from the drop-down menu.
12. For *Average spacing,* enter "2000".
13. Click **OK** to close the *Redistribute Vertices* dialog.

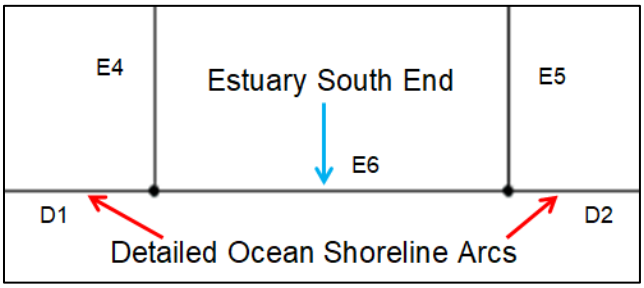


Figure 7 Arc details – estuary and shoreline arcs of detailed ocean area

To redistribute vertices at the north and south ends of the estuary (See Figure 6 and 7):

14. **Zoom** into the area where the river enters the estuary.
15. Select the **Select Feature Arc** tool, hold down the *Shift* key and click on the arcs E1, E2, E3, and E6 (refer to figures), zooming or scrolling between the north and south of the estuary.
16. Repeat steps 10–13, entering "500" for *Average spacing.*

To redistribute vertices along the sides of the estuary:

17. Repeat steps 7–13 for the estuary, selecting the arcs E4 and E5, and, for *Average spacing,* entering "1000".

To redistribute vertices around the detailed area of the ocean (See Figures 7 and 8):

18. **Zoom** into the center semi-circle of the ocean.
19. Using the **Select Feature Arc** tool, click on arc D3.
20. Hold down the *Shift* key and click on arcs D1 and D2.
21. Repeat steps 10–13, selecting one of the shoreline arcs, and entering "1000" for *Average spacing.*

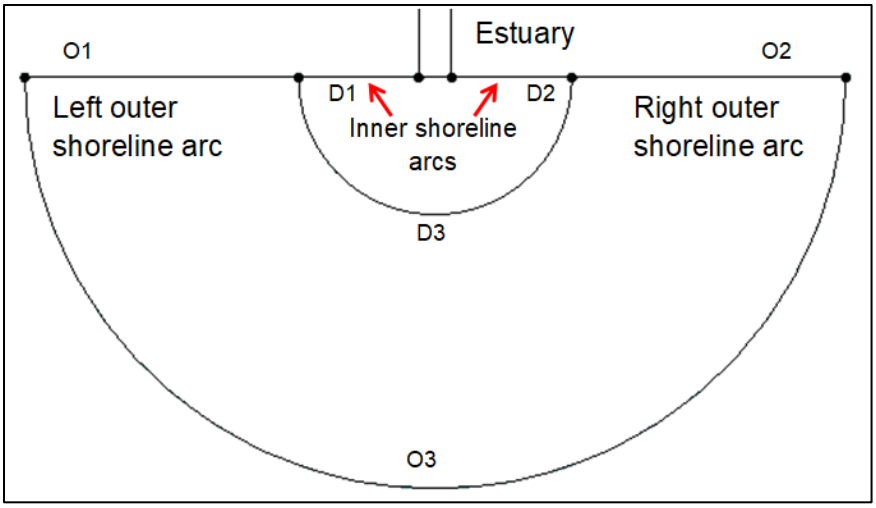


Figure 8 Arc details – estuary and ocean

To redistribute vertices on the left side of the shoreline (arc O1) (See Figure 8):

22. Using the **Select Feature Arc** tool, click on arc O1.
23. Right-click on arc O1 and select **Redistribute Vertices…** to open the *Redistribute Vertices* dialog.
24. Change the *Specify* option to "Min/max spacing".

This option will be later be renamed. It actually allows the specification of the beginning and ending spacing. Since this arc was created right to left, the right side is the start of the arc. This can be viewed by turning on the arc direction arrows in display options. This option was turned on for some of the figures in this tutorial.

25. For *Min length,* enter "1000" (beginning spacing).
26. For *Max length,* enter "2000" (ending spacing).
27. Click **OK** to close the *Redistribute Vertices* dialog.

To redistribute vertices on the right side of the shoreline (arc O2):

28. Repeat steps 22–27 for arc O2, entering "2000" for *Min length,* and "1000" for *Max length.*

Note: another option would have been to reverse the arc direction and then use the same options as the left side of the shoreline.

To redistribute vertices on the ocean boundary (arc O3):

29. Using the **Select Feature Arc** tool, click on arc O3.
30. Right-click on arc O3 and select **Redistribute Vertices…** to open the *Redistribute Vertices* dialog.
31. Change the *Specify* option to "Specified spacing".
32. For *Average spacing,* enter "6500".

Spacing should vary from 2 km near the shore to a maximum of 15 km at the point farthest from shore. This is a ratio of 7.5.

33. For *Bias (0.01-100),* enter "7.5".
34. Turn on the *2nd bias (0.01-100),* and enter "7.5".

This will cause the spacing to increase from both ends to the middle.

35. Click **OK** to close the *Redistribute Vertices* dialog.

The method used to find the bias was by trial and error, starting with a value about 20% lower than the average of the desired min/max values. In this case, this works out to "(2.0 + 15.0)/2 * 0.8 = 6.7" km. The values can be applied in the *Redistribute Vertices* dialog. The dialog displays the current range of segment lengths for the selected arc(s). If the lengths are too large, reduce the average. If they are too small, increase the average. If they are acceptable, close the dialog.

This section illustrates multiple arc redistribution options. It can serve as a good reference document for these options.

9 Defining General Polygon Attributes

Each polygon in the domain can have its own attributes, which control how the region is filled with elements (or cells). To assign these mesh generation attributes:

1. Click the **Build Polygons** macro to close the arcs into polygons.
2. Using the **Select Feature Polygon** tool, right-click in the empty space in the Graphics Window and choose **Select all…** to select all the polygons.
3. Right-click in the empty space of the Graphics Window and select **Polygon Attributes…** to bring up the *2D Mesh Multiple Polygon Properties* dialog.
4. Turn on *Mesh type* and select the "Patch (quadrilaterals)" from the drop-down menu.

This will allow us to specify all of the regions that work as patches, to be assigned as patches. If there are not four clearly defined corners, SMS will leave the polygon as "Pave (triangles)" and issue a warning.

5. Turn on *Elevation (bathy/topo) type* and select "Scatter set" from the drop-down menu.
6. Click **OK** to assign the specified attributes to close the *2D Mesh Multiple Polygon Properties* dialog.
7. Click **OK** to acknowledge an error in the ocean polygon and close the dialog.

10 Defining Ocean Polygon Attributes

The ocean polygon was assigned to be a patch in the previous section. This worked because the shape is topologically a rectangle. However, we want to use triangles in this region. To assign this:

1. Using the **Select Feature Polygon** tool, double click in the outer ocean polygon to bring up the *2D Mesh Polygon Properties* dialog.

Note that the polygon is set to be a patch.

2. Click the **Preview Mesh** button to see how the region would be filled with elements.

With some adjustment, a patch may be suitable, but for this tutorial another option will be selected.

3. Set the *Mesh type* to the "Constant Paving (triangles)" option.
4. For *Bias (0.0-1.0),* enter "0.2"

5. For *Size,* enter “15000”.
6. Click the **Preview Mesh** button.
7. To get higher resolution in the ocean, change the *Bias* to “0.1”, then click **Preview Mesh** again.
8. Click **OK** to accept properties and close the *2D Mesh Polygon Properties* dialog.

11 Saving the Project

It is a good idea to save the project periodically, to do this:

1. Select *File* | **Save New Project…** to bring up the *Save As* dialog.
2. Enter the name “IdealEstuary” and click the **Save** button.

12 Generating the Mesh

The example is now ready to generate a computational mesh.

To generate the mesh:

1. Click the **Toolbox** macro to open the *Toolbox* dialog.
2. Expand the *2D Mesh* folder.
3. Select the *2D Mesh from Coverage* tool.
4. Click **Run Tool…** to open the *2D Mesh from Coverage* tool dialog.
5. For the *Coverage*, select “Map Data/Estuary” from the drop-down.
6. Set the *Name of the output mesh* to “Ideal Estuary”.
7. Click **OK** to run the tool.
8. Click **OK** again to close the *2D Mesh from Coverage* dialog.

The generated mesh should appear similar to 9.

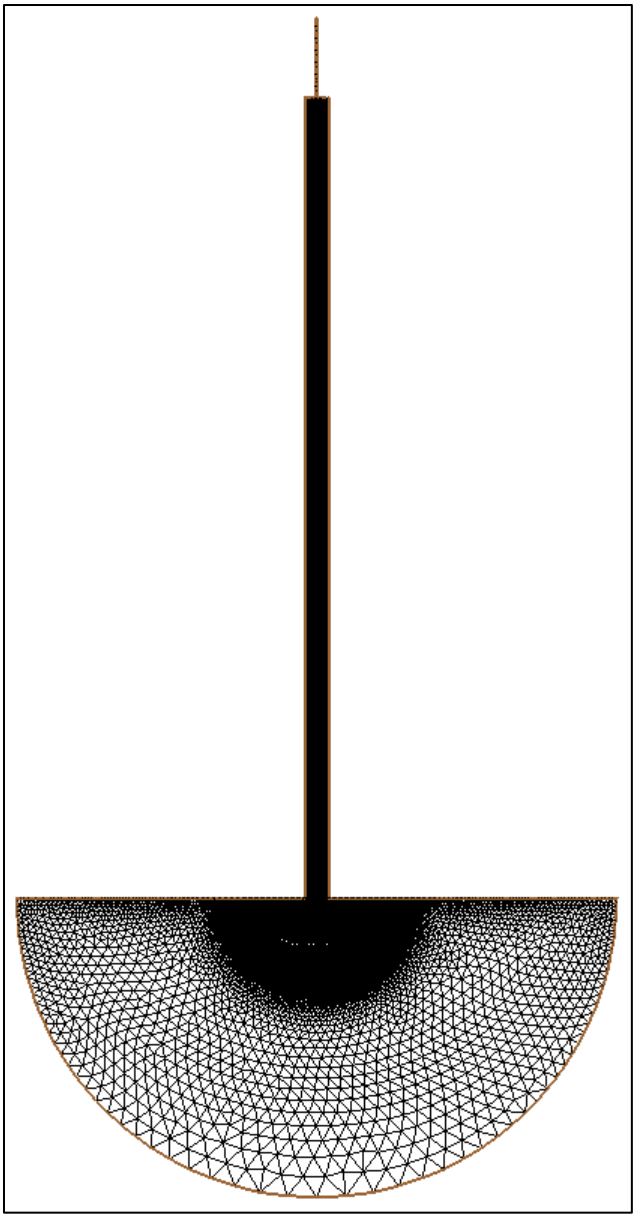


Figure 9 Generated mesh

13 Conclusion

This concludes the “Ideal Estuary Mesh Generation” tutorial. Multiple vertex redistribution options and meshing attributes have been demonstrated.

You may want to experiment with these options more to understand how they work and their impact on the mesh. This is a significant skill to develop due to the iterative nature of mesh generation and modeling.