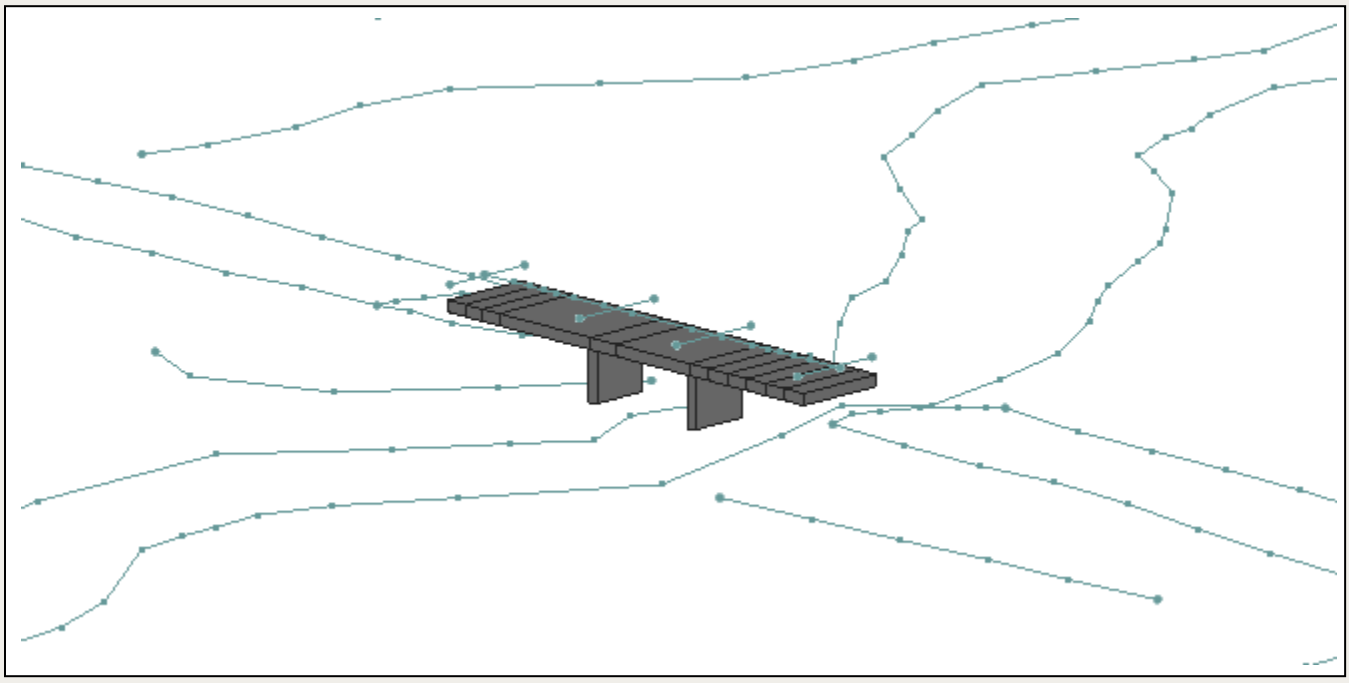
SMS 14.0 Tutorial

3D Structures (1 of 3) – Advanced Mesh Generation

Creating 3D structures in SMS



Objectives

This tutorial gives an introduction to creating 3D structures in SMS.

Prerequisite Tutorials

- Overview
- Map Module

Required Components

- SMS Core

Time

- 15–30 minutes

AQUAVEO™

1 Introduction

This tutorial illustrates the workflow for generating a mesh that includes a 3D bridge and a 3D culvert. This includes inserting a bridge into a mesh generator coverage. The bridge and culvert meshes will be associated with polygons in the mesh generator coverage.

2 Getting Started

To open the project, do the following:

1. Launch the SMS application.
2. Select *File* | **Open...** to bring up the *Open* dialog.
3. Browse to the *data files* folder for this tutorial and select “start.sms”.
4. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

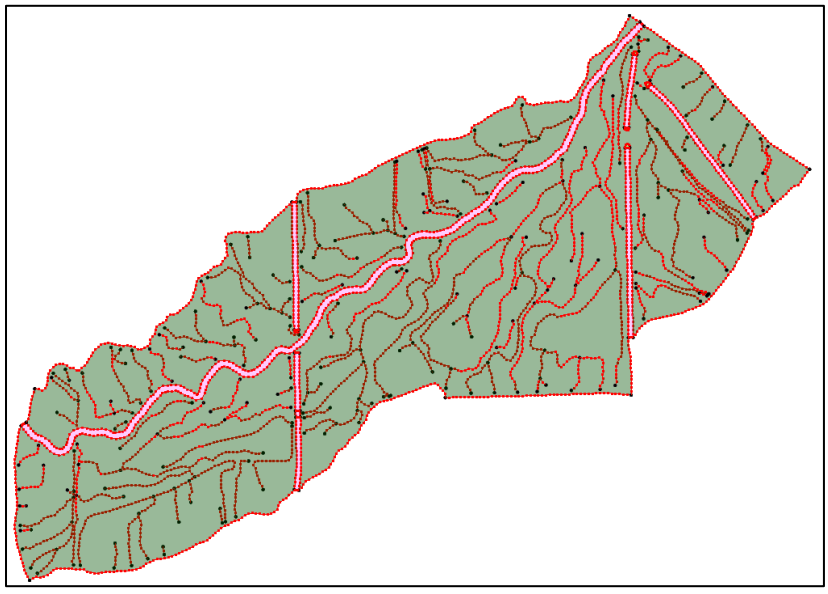


Figure 1 Initial project appearance

3 Defining 3D Structure Coverage – Bridge

The layout for a 3D bridge has already been defined in the "Hwy 641" coverage. The longest arc in the coverage defines the bridge centerline. Other arcs, which cross this centerline, represent abutments and piers. Note that the Bridge centerline has vertices to roughly represent the number of elements that are desired through the bridge section. Also note that the pier and abutment arcs are single segments and do not include vertices.

To define the properties of the 3D Structure complete the following:

1. In the Project Explorer, turn on and select the "Hwy 641" coverage.
2. Right-click on "Hwy 641" and select *Type* | *Models* | *3D Structure* | **3D Structure**.
3. Right-click on "Hwy 641" and select **Zoom to Coverage**.

The Graphics Window should appear similar to Figure 2.

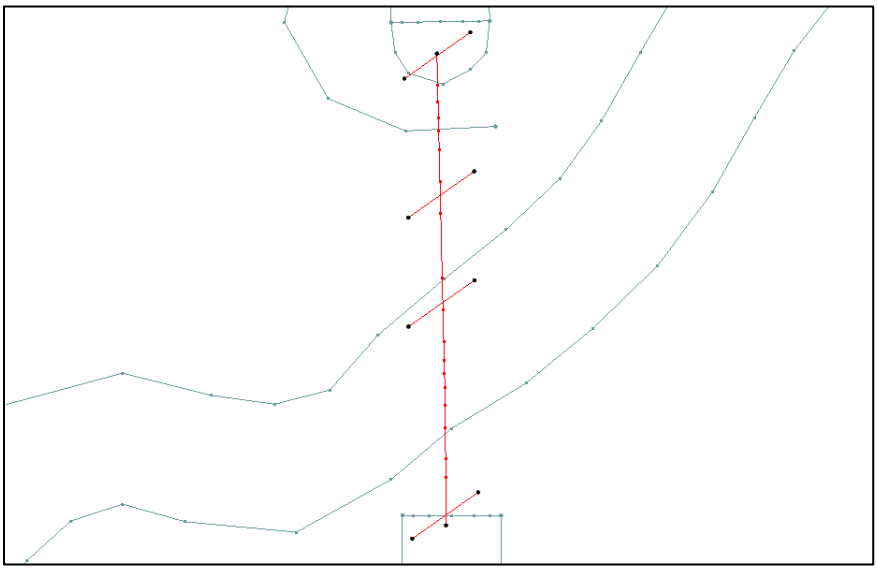


Figure 2 Location of the bridge structure

4. Right-click on "Hwy 641" and select **Edit Structure** to open the *Structure Properties* dialog.

This dialog is used to defined 3D Structures (3D Bridges and 3D Culverts). For 3D Bridges, the first tab in the dialog is used to define the *Crest profile* for the bridge and the *Low chord upstream profile*. If the *Low chord downstream profile* is different from the upstream then it can be specified as well. The Low chord profiles are used to define the pressure ceiling file that is an input to SRH-2D.

3.1 3D Bridge Profiles

Start with defining the 3D bridge profiles on the *Profiles* tab.

1. In the *Crest profile* section, for *Constant bridge crest elevation* enter "488.0".
2. In the *Low chord upstream profile* section, for *Constant bridge low chord upstream elevation* enter "485.0".

3.2 Bridge and Arc Properties

Next, define the bridge and pier properties on the *Bridge Properties* tab and preview the bridge 2d mesh. This portion of the dialog is where the width of the bridge is specified as well as the ceiling roughness coefficient. The Low chord profiles and the roughness coefficient are used to define the pressure ceiling file that is an input to SRH-2D.

Refer to the xmswiki.com for a description of all the parameters described below.

1. Switch to the *Bridge Properties* tab.
2. Turn on the *Assign properties to individual arcs* option.
3. Click the **Preview coverage arcs** button to open the *Preview Bridge Mesh* dialog to see the layout of the arcs labeled with their IDs.
4. In the table, change each of the *Arc ID*s to have the following type:
    a. *Arc ID 1* set *Type* to “Bridge”
    b. *Arc ID 2* set *Type* to “Abutment”
    c. *Arc ID 3* set *Type* to “Wall Pier”
    d. *Arc ID 4* set Type to “Wall Pier”
    e. *Arc ID 5* set Type to “Abutment”
5. Click the **Preview coverage arcs** button to open the *Preview Bridge Mesh* dialog to see an updated view of the arcs.
6. For both *Arc ID 3* and *4*, set the Wall pier attributes to be the following:
    a. For *Element width around piers*, enter “2.0”
    b. For *WP width*, enter “3.0”
    c. For *WP length*, enter “30.0”
    d. For *WP end type* set as “Square”
7. For the *Bridge width (upstream to downstream)*, enter “40.0”.
8. For the *Bridge wrapping width*, enter “8.0”.
9. For the *Number of elements through bridge width* enter 6.
10. Click the **Select elevation raster** button to open the *Select Elevation Raster* dialog to choose an elevation source for the bridge mesh.
11. Select the checkbox next to the “Middle Fork Clark Z.tif”.
12. Click **OK** to close the *Select Elevation Raster* dialog.
13. Click the **Preview bridge mesh** button to open the *Preview Bridge Mesh* dialog.

The *Preview Bridge Mesh* dialog allows zooming in and out on the previewed mesh. Clicking and dragging on the dialog allows panning across the mesh.

14. Close the *Preview Bridge Mesh* dialog.
15. Turn on the *Add 3D Bridge UGrid* option.
16. For the *Pier base elevations,* enter “465”.

Note that the piers can be generated as part of the 3D Bridge UGrid only if a 2d mesh can be generated from the properties entered in this dialog. Otherwise the piers will not be included in the 3D Bridge UGrid.

If desired, the parameters can be changed and the *Preview Bridge Mesh* dialog used to see how the changes affect the mesh.

17. Turn on the *Add "structure mesh" coverage* option.
18. Turn on the *Add "structure mesh" 2D mesh* option.
19. Click **OK** to close the *Structure Properties* dialog.

This command results in multiple additions to the *Project Explorer*. This includes:

- A 3D UGrid representing the bridge for visualization.
- A 2D mesh representing the layout of the bridge footprint. This mesh has been assigned elevations from the selected raster.
- A map coverage containing the boundary of the bridge footprint.

20. Turn off the "Hwy 641_footprint_grid" 2D mesh in the Project Explorer.

Note: folders can be created under the "Mesh Data" item in the Project Explorer to help with organization. If desired, create a new folder named "Structures" and drag "Hwy 641_footprint_grid" into the folder.

4 Adding a Bridge to a Mesh

The bridge mesh can be added to the larger project area mesh.

1. In the Project Explorer, right-click on the "Middle Fork" coverage and select the **Duplicate** command.
2. Select the "Hwy641_struct_cov" coverage to make it active.
3. Using the **Select Feature Arc** tool, right-click in the Graphics Window and use the **Select All** command.
4. Right-click in the Graphics Window and select the **Copy to Coverage** command to bring up the *Select Coverage* dialog.
5. Select the "Middle Fork (2)" coverage and click **OK** to close the *Select Coverage* dialog.
6. Select the "Middle Fork (2)" coverage to make it active.
7. Right-click on the "Hwy641_struct_cov" coverage and select **Zoom to Coverage**.
8. **Zoom** in until the display is similar to Figure 3.

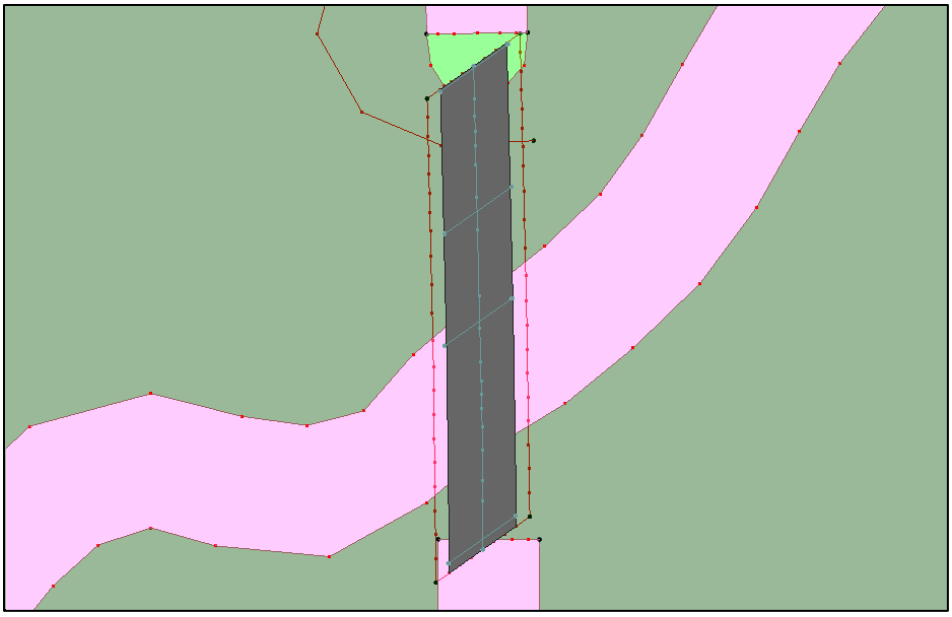


Figure 3 The unedited mesh generator coverage with bridge

This coverage could now be used to generate a mesh that includes the bridge. However, the coverage must be edited to transition between the bridge footprint and the surrounding features in the coverage.

This tutorial is not intended to teach how to edit the coverage. An edited coverage has already been provided.

1. In the Project Explorer, select the "Middle Fork with Bridge" coverage to make it active.
2. Turn on the "Middle Fork with Bridge" coverage and turn off the "Middle Fork (2)", "Middle Fork", and "Hwy 641" coverages.

The display should be similar to Figure 4.

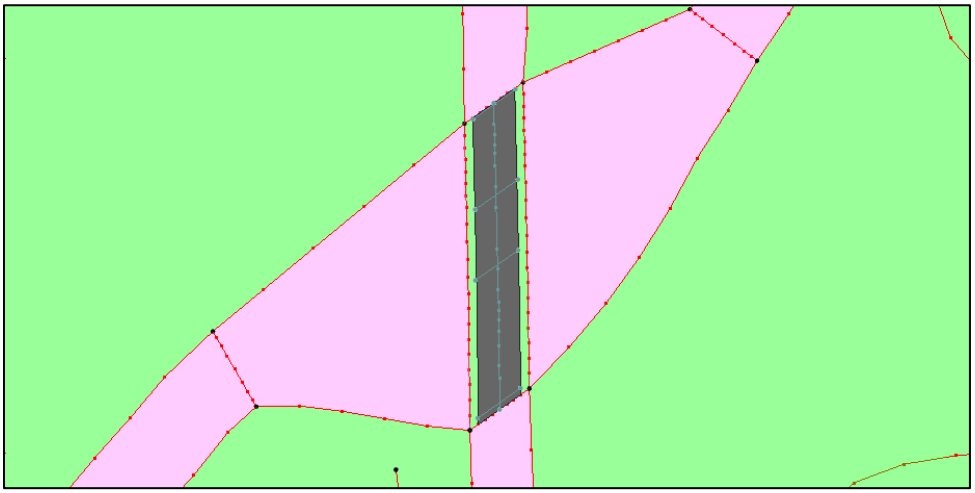


Figure 4 The edited mesh generator coverage with bridge

5 Specifying the Mesh Generation Properties

Before generating a mesh from the coverage, the mesh type needs to be adjusted for the polygons around the bridge area.

1. Using the **Select Feature Polygon** tool, double-click on the polygon for the bridge footprint to bring up the *2D Mesh Polygon Properties* dialog.
2. Change the *Mesh Type* drop-down to "2D Mesh/UGrid".

This type setting instructs SMS to incorporate an existing mesh or UGrid into this polygon when a mesh/UGrid is generated from the coverage.

3. Click the **Select** button to bring up the *Select 2D Mesh/UGrid* dialog.
4. Select "Hwy 641_footprint_grid".
5. Click **OK** to close the *Select 2D Mesh/UGrid* dialog.
6. Click **OK** to close the *2D Mesh Polygon Properties* dialog.

6 Defining 3D Structure Coverage – Culvert

The layout for a 3D culvert has already been defined in the "Hwy 641-Culvert" coverage. The longest arc in the coverage defines the structure centerline. Other arcs, which cross this centerline, represent abutments and the culvert centerline.

1. In the Project Explorer, turn on and select the "Hwy 641-Culvert" coverage.
2. Right-click on "Hwy 641-Culvert" and select *Type* | *Models* | *3D Structure* | **3D Structure**.
3. Right-click on "Hwy 641-Culvert" and select **Zoom to Coverage**.
4. Right-click on "Hwy 641-Culvert" and select **Edit Structure** to open the *Structure Properties* dialog.
5. At the top of the dialog, change the *Structure type* to "Culvert".

6.1 3D Culvert Top Profile

Now, define the 3D culvert top profile on the *Profiles* tab. A "Culvert" only requires the Crest profile to be defined. The Low chord profiles will come from the culvert properties.

1. In the *Crest profile* section, uncheck *Use constant crest elevation (overwrites existing profile)* if already checked.
2. Click the **Edit** button to open the *XY Series Editor* dialog.
3. Change the *Number of rows* to "2".
4. Enter the following values for the *Distance* and *Elevation*:

	Distance	Elevation
1	0.0	483.5
2	1.0	484.0

5. Click **OK** to close the *XY Series Editor* dialog.

6.2 Culvert Properties

Next, define the culvert properties on the *Culvert Properties* tab and preview the mesh. Refer to the xmswiki.com for a description of all the parameters described below.

1. Switch to the *Culvert Properties* tab.
2. Turn on the *Assign properties to individual arcs* option.
3. Click the **Preview coverage arcs…** button. This shows a map view of the arcs with their IDs and assigned types.
4. Change the types assigned to the arcs under the *Arc Properties* section of the dialog using the table below.

Arc ID	Type
1	Embankment
2	Abutment
3	Abutment
4	Culvert

5. Click the **Preview coverage arcs…** button again to see the updated arc with assigned types.
6. For the *Culvert length*, enter “40.0”.
7. For the *Circular culvert diameter*, enter “9.0”.
8. For the *Upstream invert elevation*, enter “473.3”.
9. For the *Downstream invert elevation*, enter “473.2”.
10. For the *Culvert embedment depth*, enter “1.0”.
11. For the *Number of culvert barrels*, enter “2”.
12. For the *Wall width between culvert barrels*, enter “1.5”.

Under the *Culvert 2D mesh generation* section, enter the following:

13. For the *Culvert wrapping width*, enter “10.0”.
14. For *Culvert number of side elements*, enter “4”.
15. For *Culvert number of elements across barrel*, enter “5”.
16. Click the **Select elevation raster** button to open the *Select Elevation Raster* dialog to choose an elevation source for the bridge mesh.
17. Select the checkbox next to “Middle Fork Clark Z.tif”.
18. Click **OK** to exit the *Select Elevation Raster* dialog.
19. Click the **Preview culvert mesh** button to open the *Preview Bridge Mesh* dialog.

The *Preview Bridge Mesh* dialog allows zooming in and out on the previewed mesh. Clicking and dragging on the dialog allows panning across the mesh.

20. Close the *Preview Bridge Mesh* dialog.
21. Turn on the *Add “culvert mesh” 2D mesh to SMS on OK* option.

In this case the culvert coverage will not be added to SMS because the mesh generator coverage was previously edited to include the boundary of the culvert mesh.

22. Click **OK** to close the *Structure Properties* dialog.

7 Updating the Mesh Generation Properties

Before generating a mesh, the culvert mesh must be referenced in the mesh generator coverage. The "Middle Fork with Bridge" coverage has already been edited to include the boundary of the culvert mesh. The polygon for the culvert mesh must be updated to refer to the newly created 2D mesh of the culvert.

1. In the Project Explorer, select the "Middle Fork with Bridge" coverage to make it active.
2. Right-click on the "Hwy 641-Culvert" coverage and select the **Zoom to coverage** command.
3. Turn off the "Hwy 641-Culvert_footprint_grid" 2D mesh in the Project Explorer.
4. Using the **Select Feature Polygon** tool, double-click on the polygon for the culvert footprint to bring up the *2D Mesh Polygon Properties* dialog.
5. Change the *Mesh Type* drop-down to "2D Mesh/UGrid".
6. Click the **Select** button to bring up the *Select 2D Mesh/UGrid* dialog.
7. Select the "Hwy 641-Culvert_footprint_grid".
8. Click **OK** to close the *Select 2D Mesh/UGrid* dialog.
9. Click **OK** to close *2D Mesh Polygon Properties* dialog.

8 Generating the Mesh

The mesh, including the bridge and culvert, can now be generated.

1. Click the **Toolbox** macro to open the *Toolbox* dialog.
2. Expand the "2D Mesh" folder to locate and select the *2D Mesh from Coverage* tool.
3. Click the **Run Tool** button to open the *2D Mesh from Coverage* dialog.
4. For the *Coverage*, select "Map Data/MeshGen/Middle Fork with Bridge".
5. Turn on the *Merge triangles* option.
6. For the *Name of the output mesh*, enter "Hwy 641 with Structures"
7. Click **OK** to run the tool.
8. When the tool finishes, click **OK** to close the *2D Mesh from coverage* dialog.
9. In the Project Explorer, select the "Hwy 641 with Structures".
10. **Zoom** in on the location of the bridge.

Now, examine the 2D Mesh to see how the bridge footprint was incorporated.

1. In the Project Explorer, turn off "Map Data".

2. Use the **Pan**, **Zoom**, and **Rotate** tools to view the "Hwy 641 with Structures" from different angles.

Figure 5 shows an example of one angle of the resulting 2D Mesh.

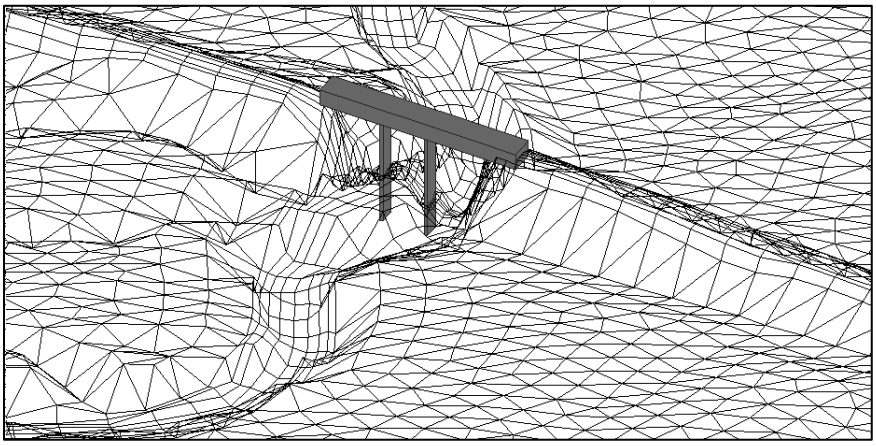


Figure 5 2D Mesh with incorporated bridge footprint

9 Conclusion

This concludes the initial "3D Structures" tutorial. Feel free to further explore the 3D structure tools or exit the program.