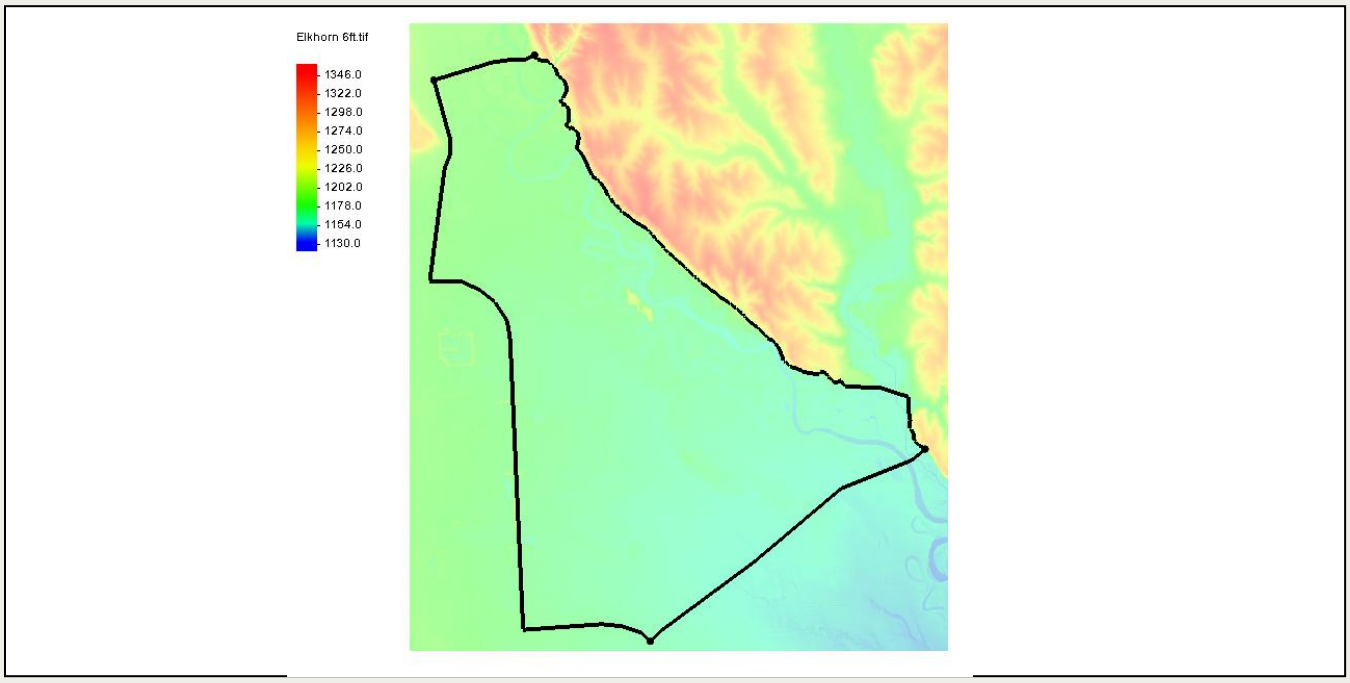
SMS 14.0 Tutorial

Define Domain

Methods of defining a model domain



Objectives

This tutorial demonstrates a few methods for creating the domain for a 2D hydraulic simulation.

Prerequisite Tutorials

- Overview
- Map Module
- Raster

Required Components

- SMS Core

Time

- 15–20 minutes

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1 Introduction

This tutorial demonstrates a couple approaches to facilitate the creation of a simulation domain. Specifically, the tutorial demonstrates:

- Creating a feature arc at a specified elevation of topography.
- Digitizing to follow features on an aerial photo.
- Creating domain boundaries representing where flow enters and leaves the domain (open boundaries).

This tutorial uses a digital elevation map (DEM) for a section of the Elkhorn River in Nebraska. It also depends on the availability of an internet connection because it makes use of an online image.

2 Getting Started

Start by importing a project file containing an existing mesh:

1. Launch the SMS application.
2. Select *File* | **Open…** to bring up the *Open* dialog.
3. Select “Project Files (*.sms)” from the *Files of type* drop-down.
4. Browse to the *data files* folder for this tutorial and select “Elkhorn.sms”.
5. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1. The project contains an elevation raster (DEM) and an online image.

A polygon defining the extents of a region to be modeled is the basis for creating a mesh or grid for a numerical simulation. This polygon can be arbitrary, but it must include any region that conveys significant flow. Flow within the simulation can’t go where the mesh or grid don’t exist.

In most cases, it is straightforward to digitize (click out) a polygon enclosing the region to be simulated. However, it is recommended, when feasible, to use guidelines to define a polygon that is more likely to create an efficient and useful domain.

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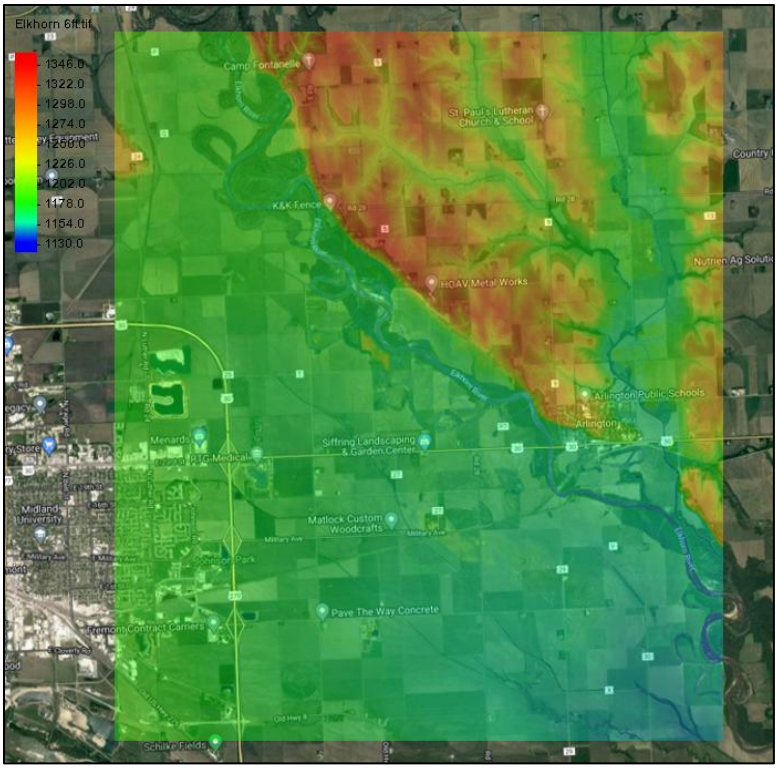

Figure 1 Initial project

3 Determining Floodplain Limit from Elevation Data

By reviewing the colors in the plot of the DEM, the warm colors in the upper right (north east) portion indicate hills or highlands that are out of the floodplain. The east side of the floodplain displays significant relief. If this is the case, a contour of elevation can be used as a boundary for the domain. This boundary should be high enough to stay out of the floodplain.

3.1 Determining the Elevation of the Floodplain Edge

1. In the Project Explorer, select the "Elkhorn 6ft.tif" DEM to make it active.
2. Move the cursor over the warm colors in the Graphics Window.

SMS displays the elevation of the location under the cursor at the bottom of the screen. Watching the elevation reveals that the floodplain has elevations roughly between 1150–1180 feet above sea level. Another way to examine the elevation is to do the following:

3. In the Project Explorer, right-click on the "Elkhorn 6ft.tif" DEM and select **Properties** to open the *Properties* dialog for the DEM.

Review the elevation range (1,136.4 – 1,342.3 ft).

4. When done, click **OK** to close the *Properties* dialog.

Through closer examination and trial and error, an elevation just outside of the floodplain can be determined. For this case, the elevation of 1,200 ft was randomly selected and proved to be applicable.

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3.2 Extracting an Arc at a DEM Elevation

Start defining the domain by creating an arc at a selected elevation from the DEM. To create an arc at the selected elevation:

1. In the Project Explorer, right-click on the "Elkhorn 6ft.tif" DEM and select *Convert To* | **Feature Contours at Elevation** to open the *Contours from Single Raster Value* dialog.
2. In the *Base contour height* field, enter "1200".
3. Click **OK** to close the *Contours from Single Raster Value* dialog and launch the tool.
4. After the tool finishes running, click **OK** to close the dialog.

SMS create a new coverage named " Elkhorn 6ft.tif _contours" which includes all contours matching the 1200 ft elevation value.

5. Right-click on the " Elkhorn 6ft.tif _contours" coverage and select **Rename**.
6. Enter "Domain" for the new name.
7. Right-click on the " Domain" coverage and select *Type* | *Generic* | **Mesh Generator** to specify the intended purpose of this coverage.

3.3 Removing Extra Contour Arcs

For this application we only want the arcs that define the east edge of the Elkhorn River floodplain. The west side is more gradual and will be defined in the next section.

To delete extraneous arcs:

1. Using the **Select Feature Arc** tool, click on the arc at the east edge of the floodplain in the upper section (see Figure 2).
2. Hold down the *Shift* key and select the bottom arc on the right side of the image.

There should be two arcs selected as shown in Figure 2.

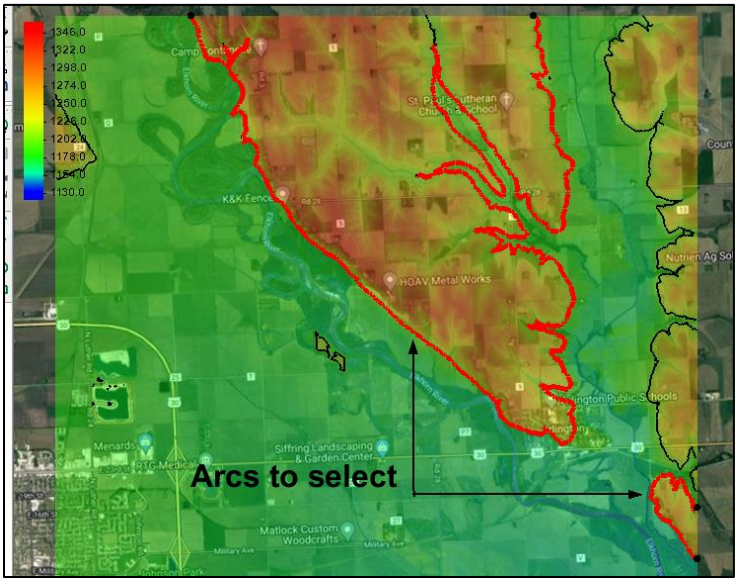

Figure 2 Arcs on the east side of floodplain selected

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3. Right-click in the Graphics Window and select **Invert Selection**.

This deselects the two arcs and selects all other arcs in the coverage.

4. Right-click in the Graphics Window again and select **Delete**.
5. Click **Yes** if asked to confirm the deletion.

This leaves just the two arcs on the coverage.

3.4 Removing Excess Detail

Contours extracted from a DEM can include excessive details in the form of small gullies or tributaries that may not be of interest for the simulation. This example should simplify the arc to remove features that are smaller than 300 ft across. To do this, use the *Prune Arcs* tool as follows:

1. Right-click in the Graphics Window and select **Select All**.
2. Right-click in the Graphics Window again and select **Prune Arc(s)** to open the *Prune Arcs* dialog.
3. Make certain the feature width type is set to “Constant” and enter a *Width* value of “300”.
4. Click **OK** to close the *Prune Arcs* dialog.

This removes branches less than 300 ft across on the left side of the arcs.

5. Right-click in the Graphics Window again and select **Prune Arc(s)** to open the *Prune Arcs* dialog.
6. Change the *Side to be pruned* to be “Right”.
7. Enter a *Width* value of “300”.
8. Click **OK** to close the *Prune Arcs* dialog.

This removes branches less than 300 ft across on the right side of the arcs. This pruning approach can be thought of as selective smoothing of the arcs.

3.5 Trimming to just the Main Floodplain

In addition to the east side of the floodplain of the Elkhorn River, the extracted contour defined the west side of the floodplain for the tributary. This application only calls for a simulation of the Elkhorn, to the tributary will be trimmed away. To do this:

1. **Zoom** into the region between the two arcs (lower right side) as shown in Figure 3.

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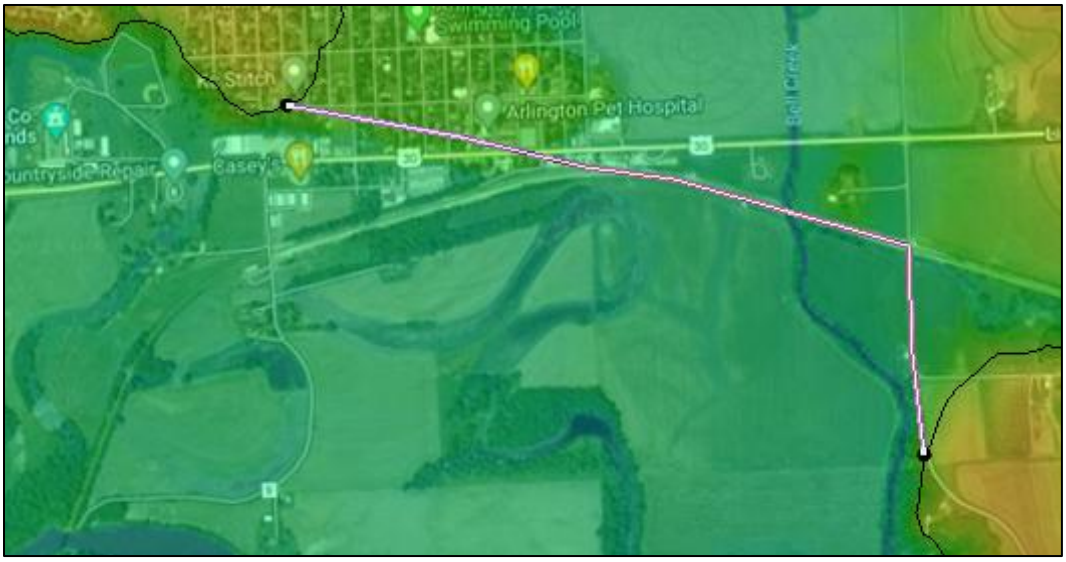

Figure 3 Cutting off the tributary

2. Using the **Create Feature Arc** tool, create an arc connecting the two existing arcs (Figure 3).

In this illustration the arc generally follows the roads, but this is not essential.

3. Using the **Select Feature Arc** tool, hold the *Shift* key and click on the two arcs bounding the tributary as shown Figure 4.

Figure 4 Selecting tributary arcs for deletion

4. Press the *Delete* key to remove the arcs.
5. Click **Yes** if asked to confirm the deletion.
6. Using the **Select Feature Point** tool, right-click and select **Select All**.
7. Right-click again and select **Nodes** ↔ **Vertices** to merge the arcs.

There is now a single arc that represents the east side of the floodplain.

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4 Digitize Floodplain Limit from Image

The left (west) side of the floodplain is not clearly defined by a single contour elevation. An approach similar to the previous section using multiple elevations could be used, but normally this is tedious and complicated. In this case, manual specification of a limit based on physical features in the aerial photo can provide guidance. To digitize this boundary:

1. **Zoom** in to the upper left corner of the DEM.
2. Using the **Create Feature Arc** tool, digitize an arc following the railroad embankment until the railroad crosses route 24 on the aerial map (Figure 5). Use the mouse wheel to pan and zoom as needed while drawing the arc.
3. Continue to digitize following route 24 to the intersection with Interstate 30.
4. Continue to digitize following I-30 down to Old Hwy 8. It is probably not necessary to follow the on-ramps and off-ramps instead of just following I-30.
5. Digitize following Old Hwy 8 until the arc reaches the bottom of the DEM.
6. Double-click or click *Enter* to finish digitizing.

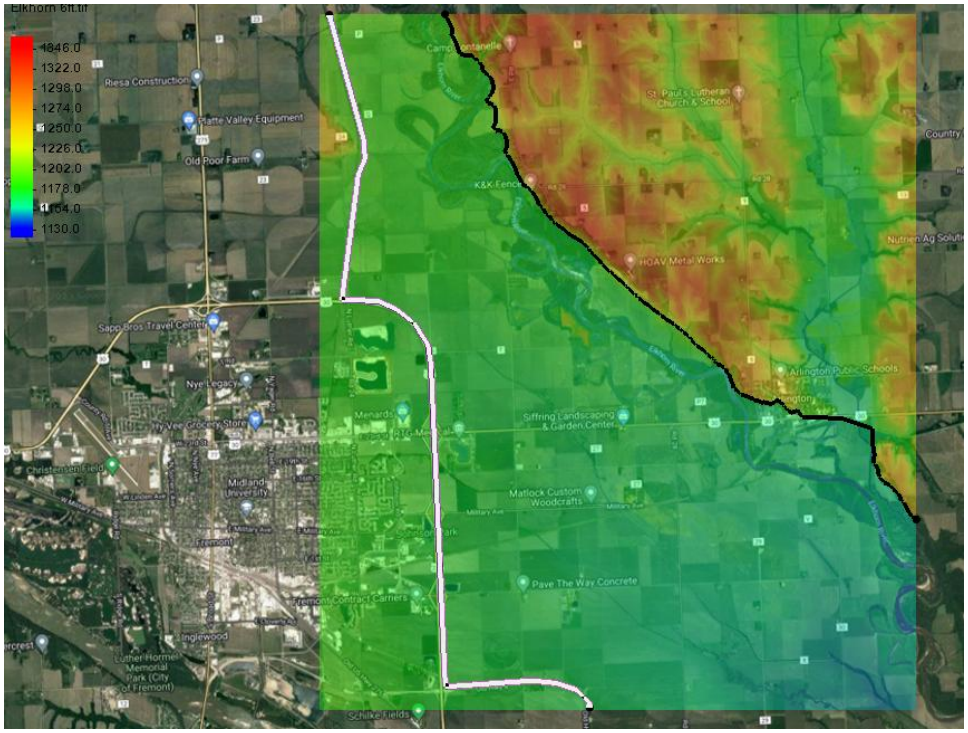

Figure 5 East floodplain limit digitized

Note: This is the edge of the simulation, so expect this edge to be dry. The digitization does not need to be precise. Digitizing just to the river side of the features will prevent getting extra terrain detail associated with the railroad/roads that are not of interest for the domain.

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5 Digitizing the Upstream Boundary

Open boundaries, where flow enters the domain define not only the flow rate, but also the flow direction as the water enters the simulation. For this reason, best practices dictates that the boundary be as short as possible (in a constriction) where the flow direction is well defined. For a wide floodplain, this can be difficult, as it is in this case.

When defining an upstream edge of a polygon, attempt to visualize the direction of flow, which is generally in a down floodplain or down channel direction. To digitize the upstream location:

1. **Zoom** into the upstream end of the domain and identify a location where the channel is generally in line with the floodplain. In this case the area near the "Camp Fontanelle" label seems appropriate.
2. Using the **Create Feature Arc** tool, digitize an arc that starts perpendicular to one of the edges of the flood plain and curves to stay perpendicular to a visualized flow direction until connecting to the opposite edge (see Figure 6).

Figure 6 Upstream domain edge

6 Digitizing the Downstream Boundary

The downstream edge of the domain does not control flow direction, so the orientation is not really significant. However, you may follow a consistent approach. To define the downstream boundary:

1. **Zoom** into the downstream end of the domain.
2. Using the **Create Feature Arc** tool, digitize the arc shown in Figure 7.

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Figure 7. Downstream domain edge

7 Trimming the Arcs

It is not required, but if desired select and delete the ends of the side arcs upstream and downstream of the domain. To do this:

1. Using the **Select Feature Arc** tool, click on a “dangling” arc.
2. Click the *Delete* key and click **Yes** if asked to confirm the deletion.

8 Conclusion

This concludes the “Define Domain” tutorial. It has demonstrated:

- Extracting arcs following a specified elevation from a raster (arcs can be extracted in a similar fashion from scatter sets and meshes).
- Pruning arcs
- Digitizing following features on an aerial image.
- Digitizing across a floodplain.

In this example, the terrain data was trimmed down to the domain size for more efficient distribution. In practice, the DEM will generally be larger than domain polygon by a greater factor than illustrated here.

If desired, experiment with the following:

- Extracting elevations at different elevations. Some elevations will result in loops and more complicated sets of arcs.
- Connecting arcs from multiple elevations into a continuous arc.
- Cleaning out noise.

The domain generated in this tutorial are used in the “Extract Features for Mesh Generation” and in the “Mesh Generation from Extracted Features” tutorials.

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