

Dam Breach Analysis with 1D and 2D Areas

Workshop

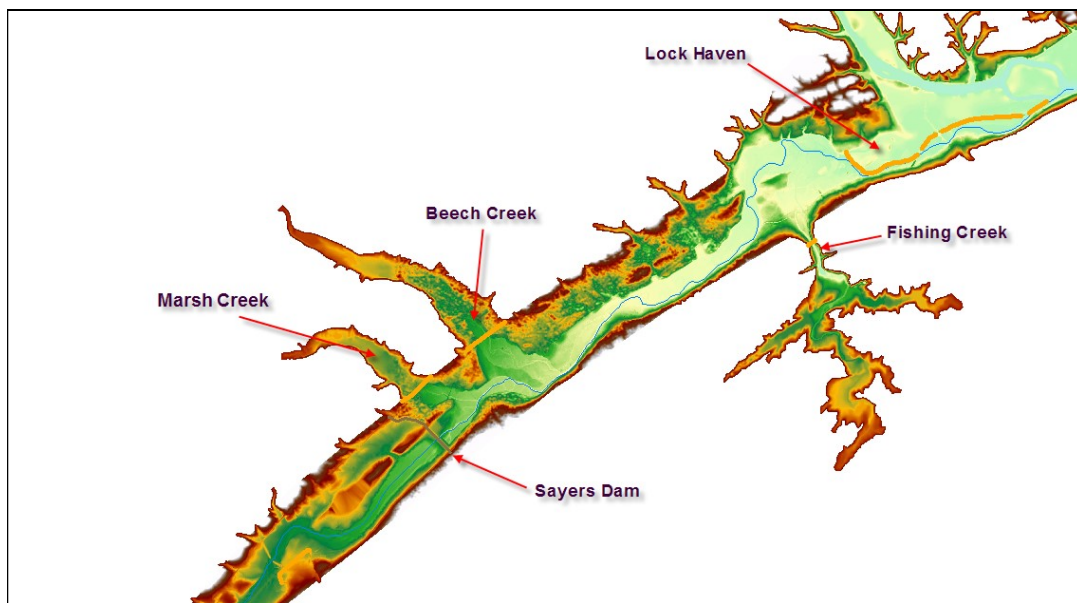
1 Objective

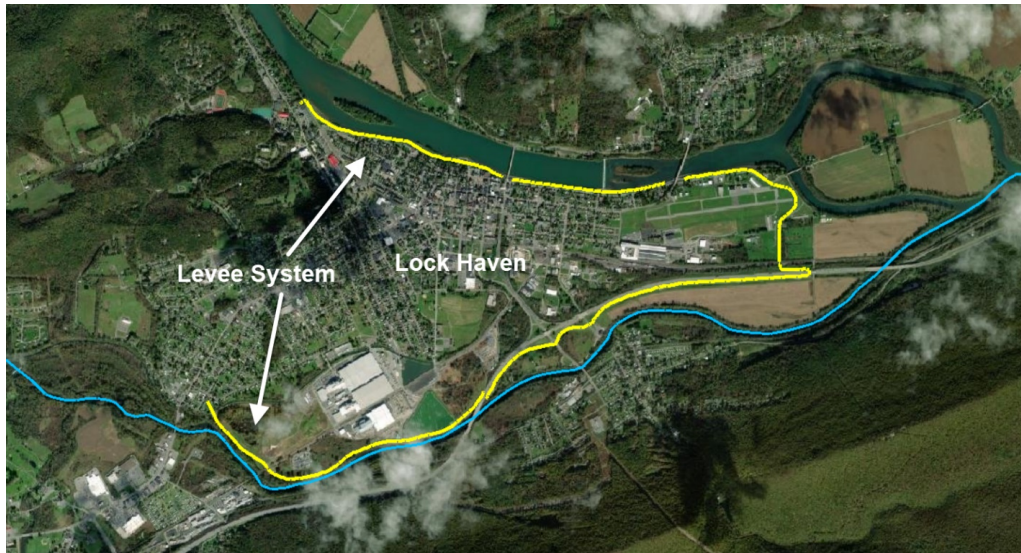
This workshop will guide students on using HEC-RAS to:

- Create a new dam breach model using 1D and 2D elements
- Connect 1D and 2D elements using SA/2D Connections
- Set a SA/2D Connection to breach
- Interpret the results of a dam breach simulation

2 Background

The town of Lock Haven is situated on the north bank of Bald Eagle Creek in central Pennsylvania. Lock Haven sits behind a levee system that was designed to provide protection for a 500-year (0.2% Chance) event. Sayers Dam, a flood control project on Bald Eagle Creek, is approximately 15 miles upstream of Lock Haven. See the figures below to become acquainted with the domain.





In this workshop we will be performing a dam breach analysis to determine the consequences of a failure of Sayers Dam by inputting design inflows for the reservoir and setting the Sayers Dam to breach.

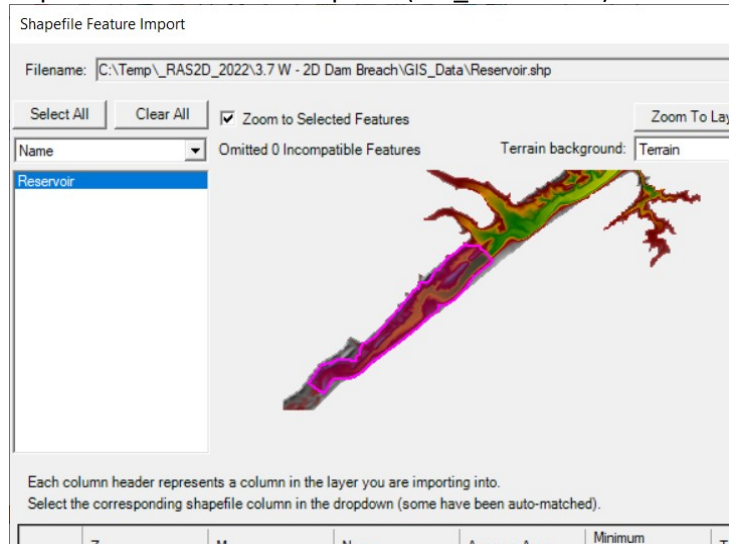
3 Create the HEC-RAS Project

1. **Create** a new HEC-RAS project in the “2D Dam Breach” directory. Name it “BaldEagleCreekDamBreach”
2. **Open RAS Mapper**
3. **Set the projection** from a projection in the “GIS_Data” directory
4. **Add the Existing RAS Terrain** (“Terrain.hdf”)

4 Create the Geometry in RAS Mapper

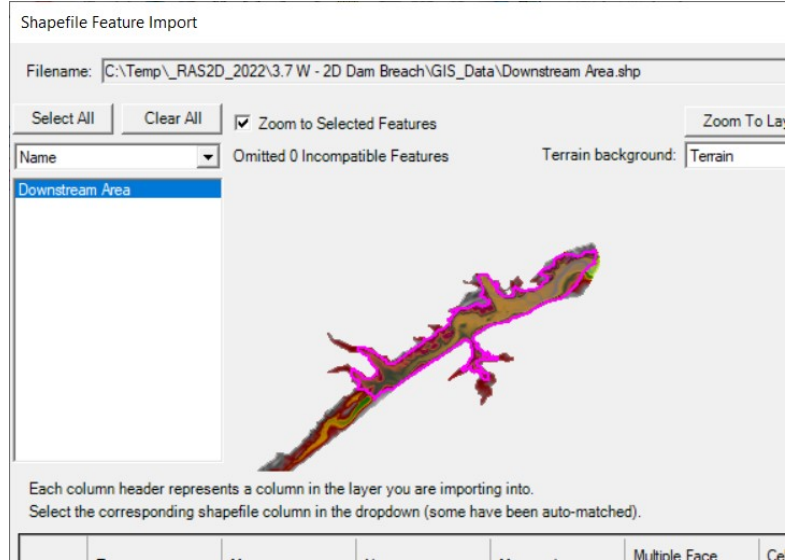
5. **Add a New Geometry**
6. **Start Editing** the Geometry
7. **Create the Reservoir** behind Sayers Dam
 - a. Select the **Storage Areas** layer

b. Import the “Reservoir” shapefile (GIS_Data folder)



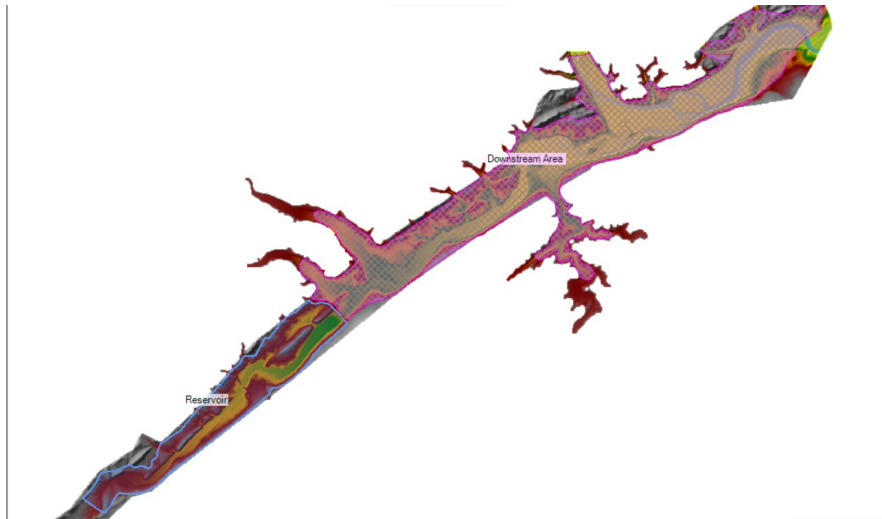
8. Create the 2D Flow Area

- a. Expand the **2D Flow Areas** layer
- b. Select the **Perimeters** layer
- c. Import the “**Downstream Area**” shapefile (GIS_Data folder)



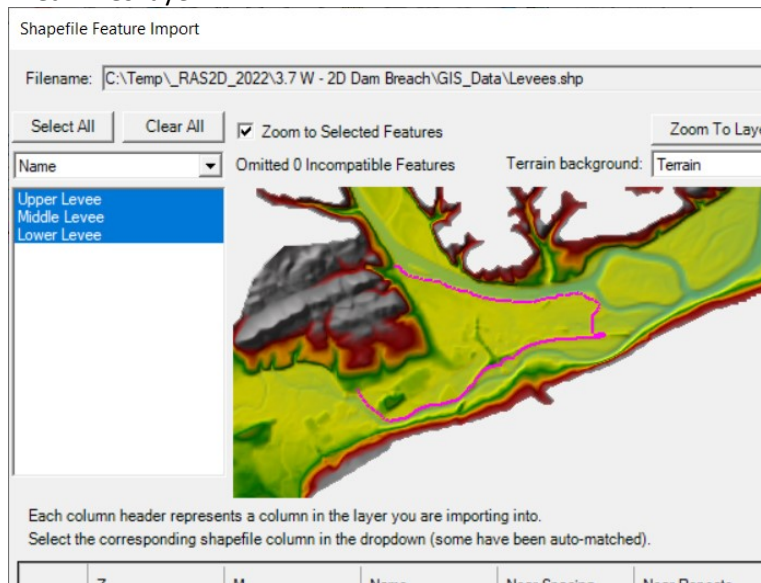
- d. Right-click on the perimeter and choose **Edit 2D Area Properties**.
- e. Set the **cell size to 500ft**
- f. Set the **Manning’s n value to 0.04**.
- g. **Generate computation points** for the 2D Flow Area
- h. **Inspect the mesh for bad cells**

At this point you should have a Storage Area and a Mesh, as shown below.



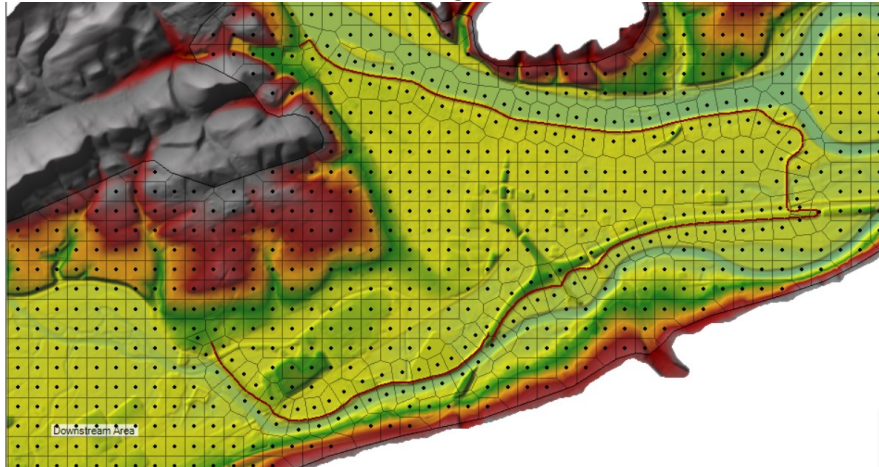
9. **Create Breaklines** along the levees

- a. Import the **Levee** shapefile for the upper, middle, and lower levee to the **Breaklines** layer.



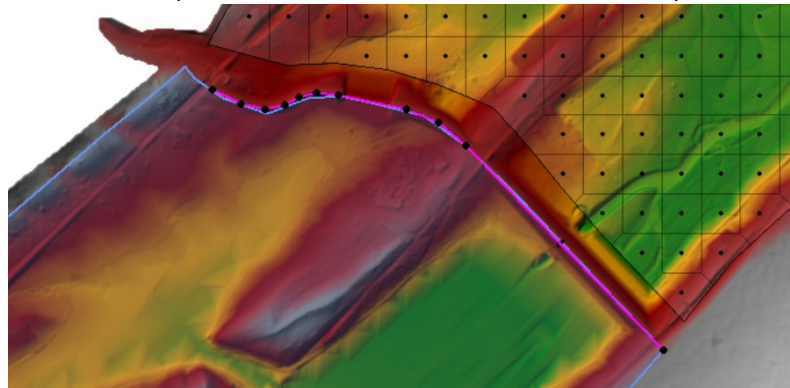
- b. Right-click on the **Breaklines** layer and choose **Enforce All Breaklines** to modify the mesh.

The mesh should look similar to the figure below.



10. Create the Dam

- a. Zoom to the Dam location
- b. Select the **SA/2D Connections** layer
- c. **Draw the structure** along the top of the dam, left to right when looking downstream. (We will override the weir elevations later)

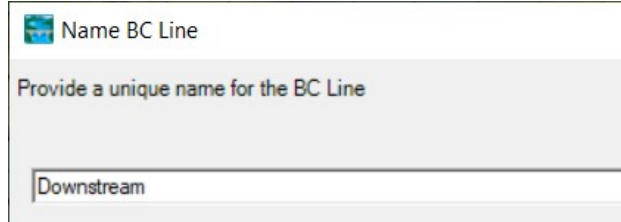


d. Provide a Name

New Connection Structure	
From:	2D Flow Area: Downstream Area
To:	Storage Area: Reservoir
(From and To can be changed from connection editor)	
Name:	Sayers Dam
Width (ft):	100
Structure Type:	Weir, Gates, Culverts, Outlet RC and Outlet
Description:	

11. **Create the Downstream Boundary**

- a. **Zoom** to the lower end of the model
- b. **Select** the Boundary Condition Lines Layer.
- c. **Draw the Downstream Boundary** line and provide a **Name**



12. **Stop Editing**, saving the edits.

13. **Close RAS Mapper**

5 Complete the Reservoir

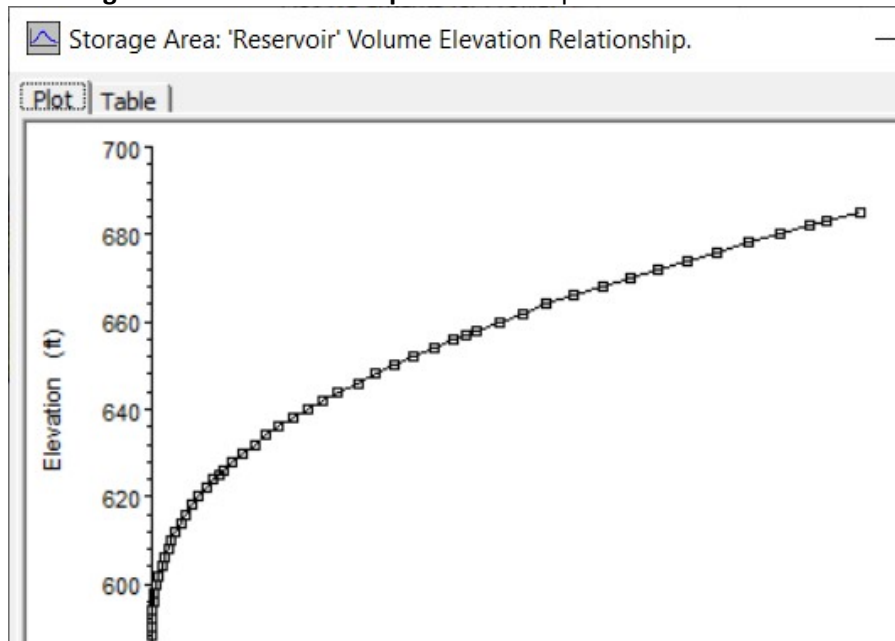
14. **Open the Geometric Data Editor**

15. **Open the Geometry**

16. **Edit the Storage Area**

Note that there are already data provided. These E-V data were extracted from the terrain model, but we need to replace with more accurate data.

17. **Enter the Elevation-Volume Relationship** – this data is in the “BaldEagleDamBreachWorkshopData” Excel spreadsheet.



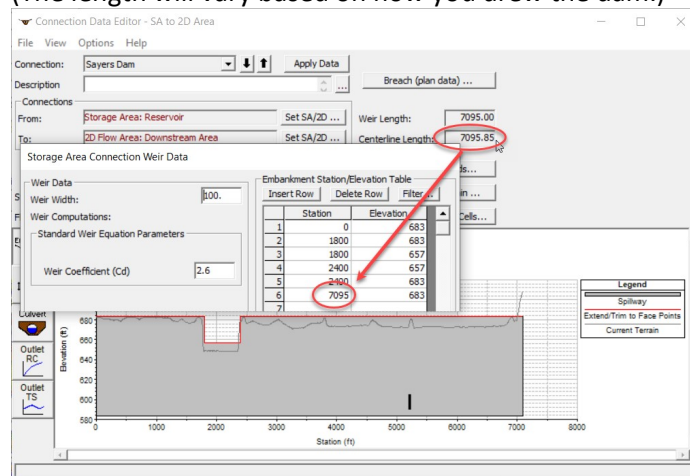
6 Complete the Dam Data (Weir Profile and Gates)

18. Edit the SA/2D Area Connection

19. Verify the From and To connection

20. Replace the Weir/Embankment profile from the terrain (see below)

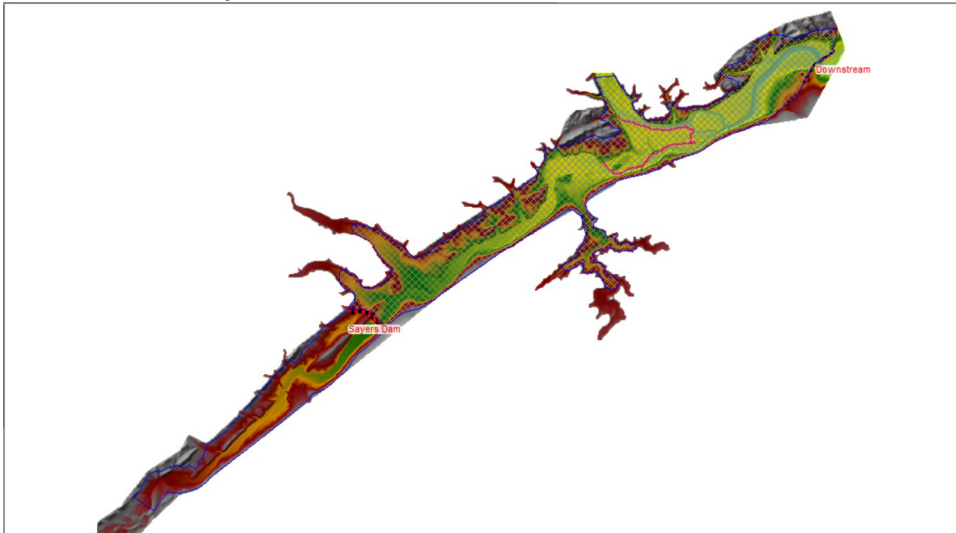
- The top of dam is **683ft**, top of spillway is **657ft** and the auxiliary spillway is **600ft** wide. You will need to match the weir width with the centerline length. The final dimensions are shown below.
(The length will vary based on how you drew the dam.)



21. Add Gates using the information specified below.

- Gate information is provided below. Two gates (that line up with the river) that are **15ft** high and **7ft** wide with an invert at **590ft**.

22. Save the Geometry



7 Enter Flow Data and Boundary Conditions

23. Open the **Unsteady Flow Data** editor

24. Use **Normal Depth** for the **Downstream Boundary** with $S=0.0003$.

25. Use a **Flow Hydrograph** for inflow into the **Reservoir**.

- Click **Add SA/2D Flow Area** button
- Select the **Reservoir**
- Add a Lateral Inflow Hydrograph** to the Reservoir
- Increase the number of points** in the table to **200** using the
- Copy and paste** the flow hydrograph from the Excel sheet

26. Set the Gate Openings

- For **Sayers Dam**, set the boundary type to **Time Series of Gate Opening**.

- Change the **Time Interval** to **1 hour**
- Change the number of ordinates to **200**
- Set the opening to **2ft**.

27. Set the Initial Conditions for the Reservoir Pool

- Click on the **Initial Conditions** tab

- b. Set the Reservoir to 630 ft.

	Storage Area/2D Flow Area	Initial Elevation
1	2D: Downstream Area	
2	SA: Reservoir	630

- c. Leave the 2D Flow Area blank. It will start dry.

28. **Save** the Flow Data

8 Create a Plan with Breach and Simulate

29. Set up the plan with a **5-day** simulation window

30. Set the plan with a reasonable **time step**

31. Set the Initial Conditions Time for the 2D area to **2 hrs**

	Parameter	(Default)	Downstream Area
1	Theta (0.5-1.0)		1
2	Theta Warmup (0.5-1.0)		1
3	Water Surface Tolerance (max=0.2)(ft)	0.01	0.01
4	Volume Tolerance (ft)	0.01	0.01
5	Maximum Iterations	20	20
6	Equation Set	Diffusion Wave	Diffusion Wave
7	Initial Conditions Time (hrs)		2
8	Initial Conditions Ramp Up Fraction (0-1)	0.1	0.1

32. Set up Breach Parameters as shown in the figure below

Storage Area Connection Breach Data

SA Connection: Sayers Dam

Breach This Structure

Breach Method: User Entered Data

Center Station: 5200

Final Bottom Width: 200

Final Bottom Elevation: 590

Left Side Slope: 0.5

Right Side Slope: 0.5

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 2

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 630

Trigger Failure at: WS Elev

Starting WS: 676

Breach Plot: Bald Eagle Creek Example Dam BreachStudy Plan:

Elevation (ft): 580 to 720

Station (ft): 0 to 8000

Legend: Spillway, Centerline Terrain, Final Breach

OK Cancel

33. Turn on **Breach This Structure**

34. **Save** the Plan Data.

35. **Compute** the results.

9 Review Results

After running the model, review the output and answer some questions.

Question: What is the Peak Outflow coming out of the Dam from the PMF event and the breach?

Question: What is the peak flow coming out of the 2D Flow Area for the downstream Normal Depth boundary condition outlet? Does this flow make sense given the upstream inflow from the Dam breach, the terrain data, and the computational mesh used?

Question: Is the Computational Time Step appropriate for the selected 2D Flow Area cell size and the floodwave being routed through it?

Question: Is the Computational cell size in the 2D Flow Area adequate for modeling the terrain, levees, and roads in this area? If not, briefly describe why not?

10 Change 2D Cell Size and Rerun

36. **Save** the base **Plan** to a new plan (“Breach 250”)
37. In **RAS Mapper**, **Save Geometry As** and provide a new name (“Mesh 250”)
38. **Start Editing** the mesh,
39. Change the cell size to **250ft**, and **Generate Computation Points with All Breaklines**.
40. **Stop Editing**
41. **Select** the **new Geometry** for the Plan
42. **Select** an appropriate **time step**
43. **Compute**
44. Review the following questions

Question: Is the peak outflow from the dam any different than the previous run done with 500ft mesh?

Question: Has the Peak outflow coming out of the 2D Flow Area changed? If so, why?

Question: Are there any differences in the inundation mapping between the two runs? Look at the Max Depth inundation, as well as different time steps during the event in order to answer this question. It will also be helpful to change the color of one of the plans to something other than Blue. I changed my 250 ft Plan to Red/green, and moved it to be the top layer, which made it easier to see differences between the two plans.

Question: Does the smaller cell size better represent the downstream terrain and the levee system protecting Lock Haven? Is it detailed enough with this cell size? If not, what are the options you could use to model the Lock Haven levee system more accurately than it is currently represented in this model?

Question: Do you think it is appropriate to use the Diffusion Wave equations or the Full Shallow Water equations for this Dam Breach analysis in the Bald Eagle system? Why or why not?