

Combined 1D/2D Modeling in HEC-RAS

Workshop

Objective

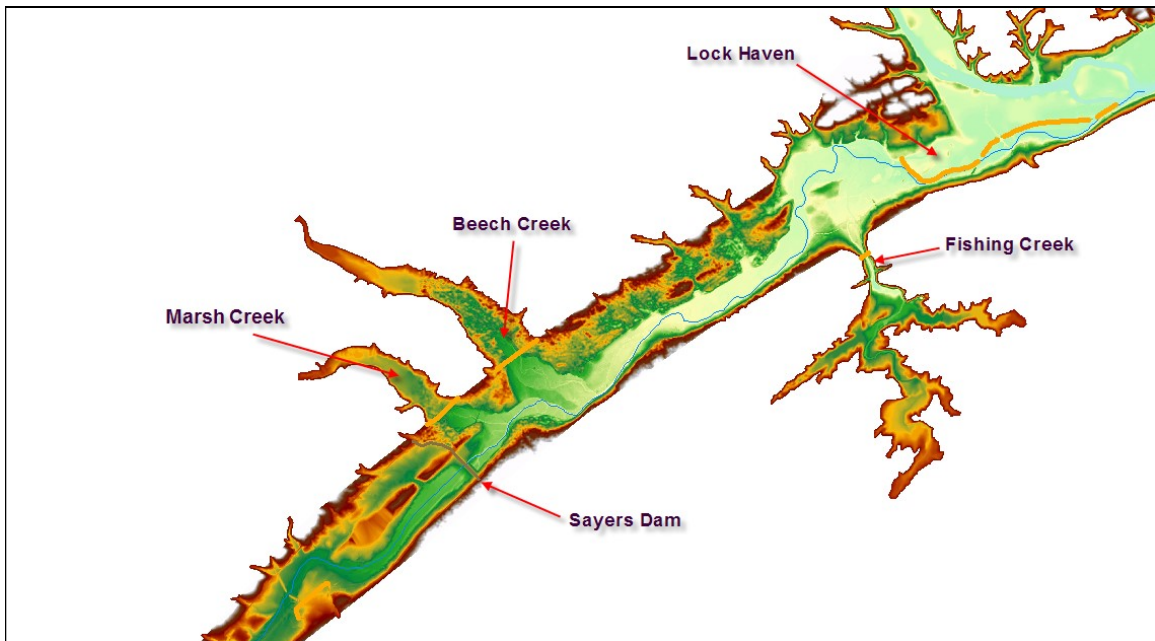
In this workshop, students will use HEC-RAS to:

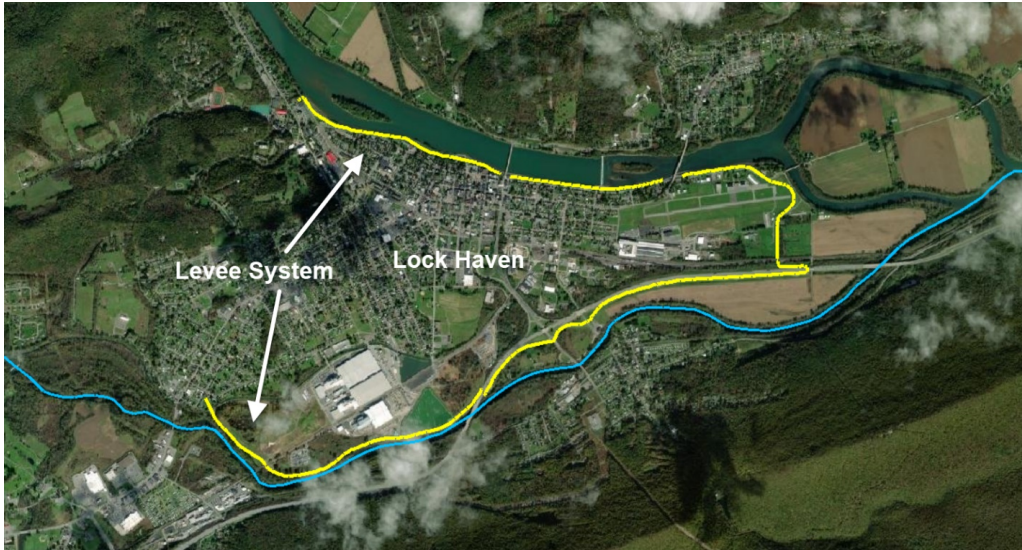
- Model areas behind levees with 2D Flow Areas
- Attach 2D Flow Areas to 1D Cross Sections using a Lateral Structure
- Compare and understand differences between 1D and 2D approaches

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 analyze how the levees perform for a 1000-year event and compare difference in results between 1D and 2D approaches for modeling the protected area.



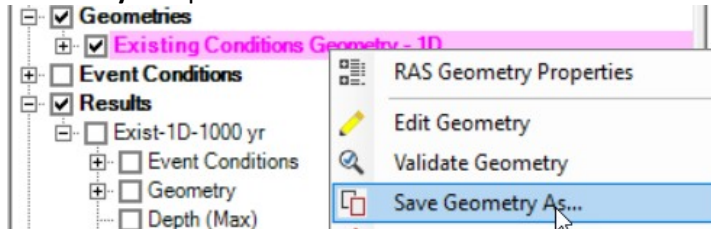


Review 1D Results

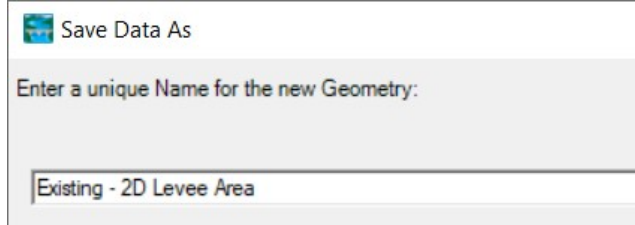
1. **Open** the Project and **Run** the 1D Plan called “**Existing Conditions 1D – 1000 yr Event**”.
2. Review the model results. Specifically, look at the water surface profiles and hydrographs to see what is happening around the town of Lock Haven.

Replace 1D Elements with 2D Flow Area

3. Go to **RAS Mapper** and make a copy of the current Geometry data using the **Save Geometry As** option.

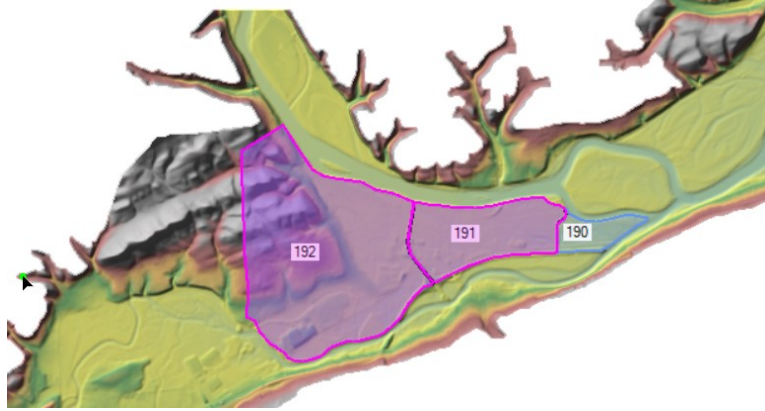


4. Name the new geometry something like: “**Existing – 2D Levee Area**”

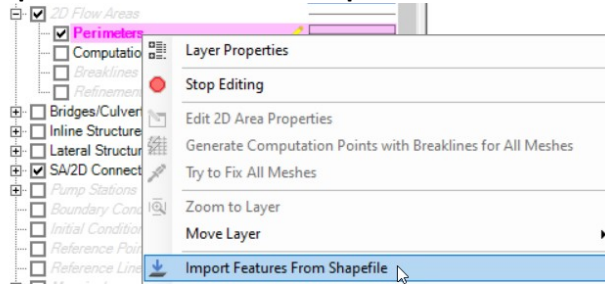


5. **Start Editing** the geometry

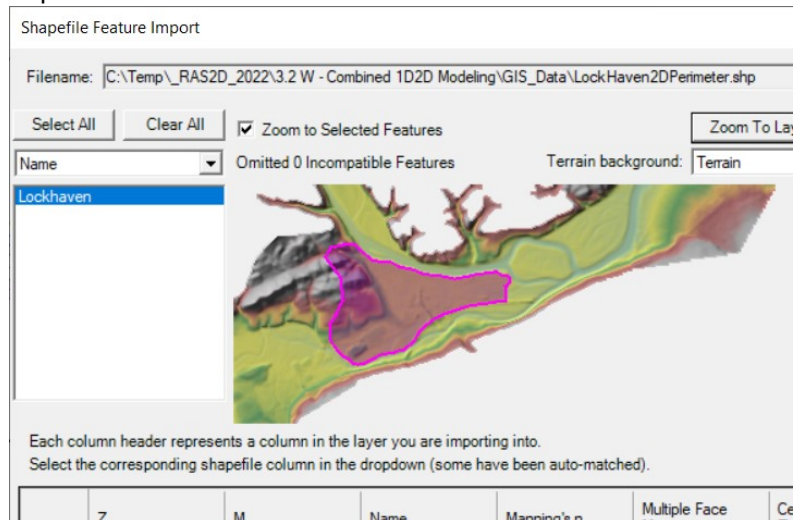
- Storage Areas layer - Delete the Storage Areas labeled 191 and 192 (the two upstream).



- SA/2D Connections layer - Delete the hydraulic connection that was between storage areas 191 and 192
- Import the new 2D Flow Area perimeter



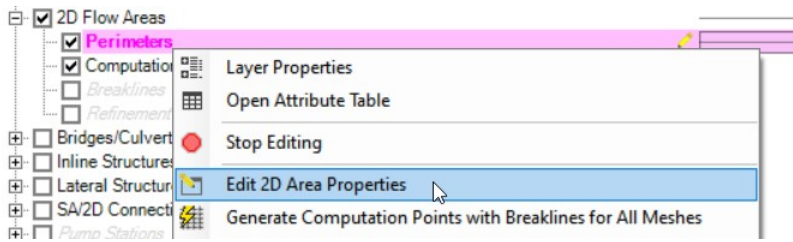
- Click the browse icon, navigate into the "GIS_Data" folder and select "LockHaven2DPerimeter.shp". You should see your perimeter now in the Importer.



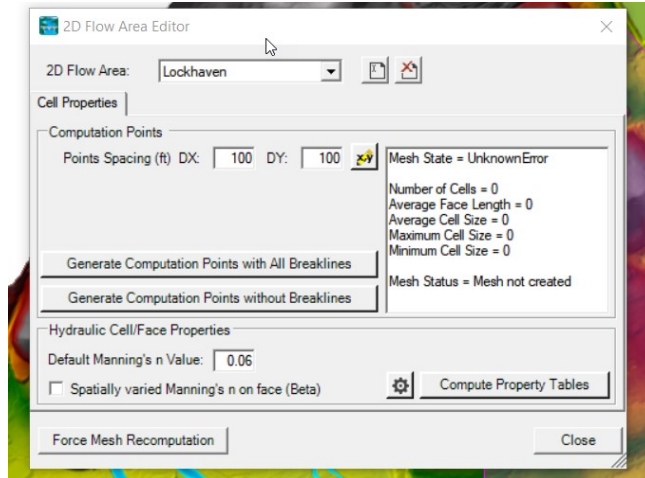
- Click **Import**, and your 2D perimeter will load into the geometry.

- Create a mesh for the new 2D Flow Area

- a. Right-click on the “Perimeters” layer in the map window and select **Edit 2D Area Properties**

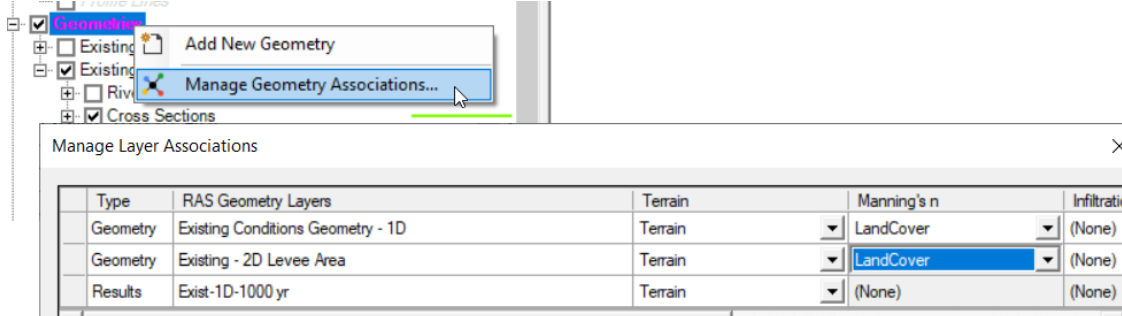


- b. Create the 2D Mesh with **100ft** cell spacing and Manning’s n value of **0.06**.

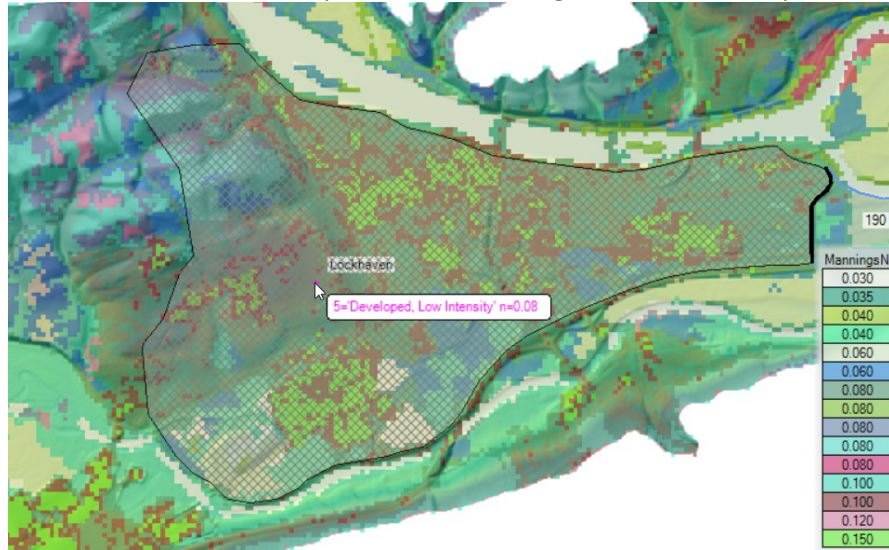


- c. Select **Generate Computation Points with Breaklines**
- d. Check to make sure the cells around the outside of the mesh are all formed correctly and there are no mesh generation mistakes
- e. **Stop Editing** and select **Yes** when asked to save the edits

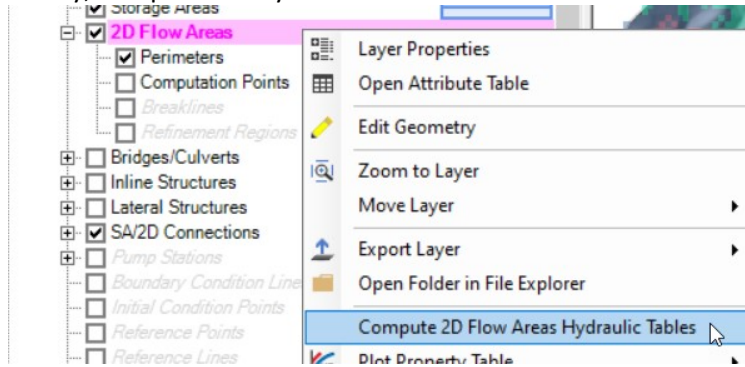
10. In RAS Mapper, **associate the Terrain and Manning’s n layers with the geometry.**



11. Turn on the **Land Cover** Layer to see what range of n values to expect.

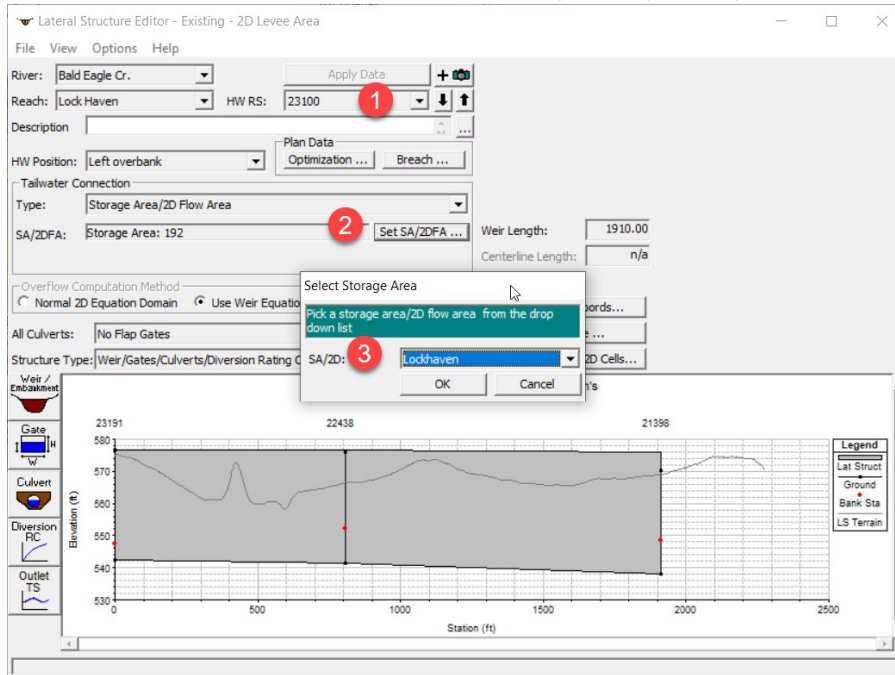


12. Finally, compute the hydraulic tables for the mesh.

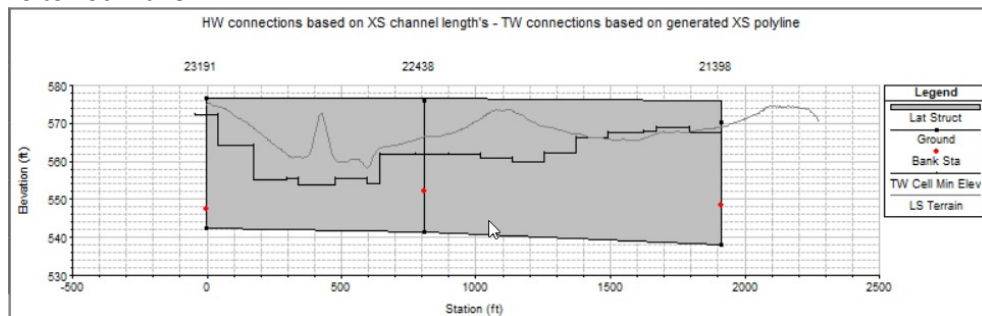


Connect 2D Flow Area to Cross Section with Existing Lateral Structures

13. Close RAS Mapper and open the **Geometry Editor**
14. **Open** the new Geometry - “Existing – 2D Levee Area”
15. Using the **Lateral Structure Editor**, connect all the Lateral Structures to the new **LockHaven 2D Flow Area**. This includes **23100, 21200, 14800, and 11950**.



- a. Notice that the plot displays the cell faces and the minimum cell elevation that the weir is connected to (you may have to switch the plot after hooking up the LS to LockHaven)



16. **Rename** the SA/2D Area Conn labeled “SA191to190” to “LockhavenTo190” using the “Edit|Change Name” option in the Geometric Data Editor



17. Using the **SA/2D Area Conn.** editor, connect the renamed connection to the the 2D Flow Area

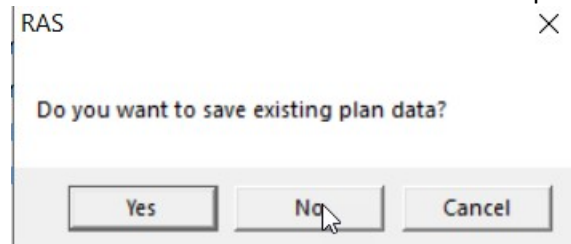
Connection:	LockHavenTo190	↓	↑	Apply Data	
Description					Breach (plan data) ...
Connections					
From:	2D Flow Area: Lockhaven			Set SA/2D ...	Weir Length: 2303.25
To:	Storage Area: 190			Set SA/2D ...	Centerline Length: 2303.25

18. **SAVE the Geometry Data.** Then close the geometry editor.

Make a New Plan for the 2D Flow Area Geometry

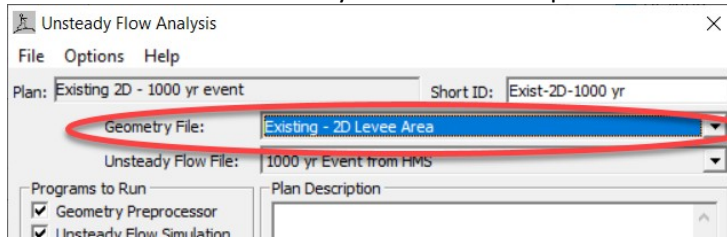
19. **Open the Unsteady Flow Analysis window and open the existing 1D Plan "Existing Conditions 1D -1000 yr event"**

- a. Choose **NO** when asked to save the current plan.



20. Make a new Plan file using the **Save Plan As** option from the **File** menu and call it **"Existing 2D Levee – 1000yr.** Give the Plan a relevant short ID, **"Exist-2D-1000yr**

21. Select the new 2D Geometry File for the new plan.



Perform Computations and Review Model Output

22. Run the new 2D Plan. When the model has finished running, compare the 1D model to the 2D Model with the Profile Plot, Hydrograph plots, and RAS Mapper

Question: What are the differences you see in the model output when comparing the 1D and 2D model runs? Why do you think they are different?

Question: There is a Point Shape file loaded under the Features Layer called PointsOfInterest that has three locations of interest. Turn on the layer and describe the differences in terms of time at which the streets got wet, peak stage, and time to peak using the table below What is the maximum velocity on the toe of the Lock Haven side of the levee?

Table 1. Intersection of Main St, Mill St

Model Type	Arrival Time	Peak Stage	Time of Peak
1D Storage Areas			
2D Flow Area			

Table 2. Intersection of Church St. and Washington St.

Model Type	Arrival Time	Peak Stage	Time of Peak
1D Storage Areas			
2D Flow Area			

Table 3. Intersection of Park St. and Prospect St.

Model Type	Arrival Time	Peak Stage	Time of Peak
1D Storage Areas			
2D Flow Area			

Question: Are these differences significant? Which answer do you think is more correct?

Question: Do you think that the cell size of 100 X 100 ft is adequate for this problem? If not why?

Question: What computational time Step did you use for the 2D Model run? Is this time step appropriate?

Question: Is the Terrain data adequate for this area? If not why?

Question: By Default the Diffusion Wave equation set was used in the model. Do you think this is adequate for this model, or should the Full Shallow Water Equations be used? How can you test this out?

Bonus - Levee Breaching

As time allows...

23. Save the Plan File as a new Plan, using the **SAVE AS** option.
24. **Add a levee** breach into the Lateral Structure at River Station **23100**.
25. Add in the breach with the following information, using the “**Levee (Lateral Structure) Breach**” option under the Unsteady Flow Analysis **Options** menu

Levee (Lateral Structure) Breach Data

Lateral Structure: Bald Eagle Cr. Lock Haven 23100

Breach This Structure

Breach Method: Simplified Physical

Center Station: 750

Max Possible Bottom Width: 1000

Min Possible Bottom Elev: 566

Left Side Slope: 0.1

Right Side Slope: 0.1

Breach Weir Coef: 2

Breach Formation Time (hrs):

Failure Mode: Overtopping

Piping Coefficient: 0.5

Initial Piping Elev:

Starting Notch Width:

Mass Wasting Feature:

Trigger Failure at: WS Elev+Duration

Threshold WS: 577.6

Duration Above Threshold(hrs): 1

Overtopping Downcutting			Widening Relationship		
	Velocity (ft/s)	Downcutting Rate (ft/hr)		Velocity (ft/s)	Widening Rate (ft/hr)
1	0	0	1	0	0
2	1	0	2	1	0
3	2	1	3	2	1
4	3	5	4	3	10
5	5	10	5	5	50
6	10	25	6	10	100
7	20	100	7	20	200
8			8		
9			9		
10			10		
11			11		
12			12		
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14			14		
15			15		
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19			19		
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21			21		
22			22		

26. **Run** the plan

Question: How much more water went into the Lock Haven area due to the levee breach vs. the just overtopping Plan? Compare the hydrographs for that Levee?

Question: What difference did it make to the inundated area and the resulting water surface elevations in downtown Lock Haven?

Question: What were the final Breach dimensions through the levee?

second run compare to the 20 second run?