Dam and Levee Breach
Workshop Solution

1 Objective

In this workshop, you will learn how to:

- Enter and edit dam and levee breach data
- Perform unsteady breach simulations
- Perform sensitivity analyses on timestep and breach parameters
- Review and interpret pertinent dam and levee breach output

2 Background

3 Enter Dam Breach Parameters

4 Compute and Review Results

Question: What time does the breach begin? How did you determine that?

Sayers Dam begins to breach at 03 Jan 1999 02:14:00

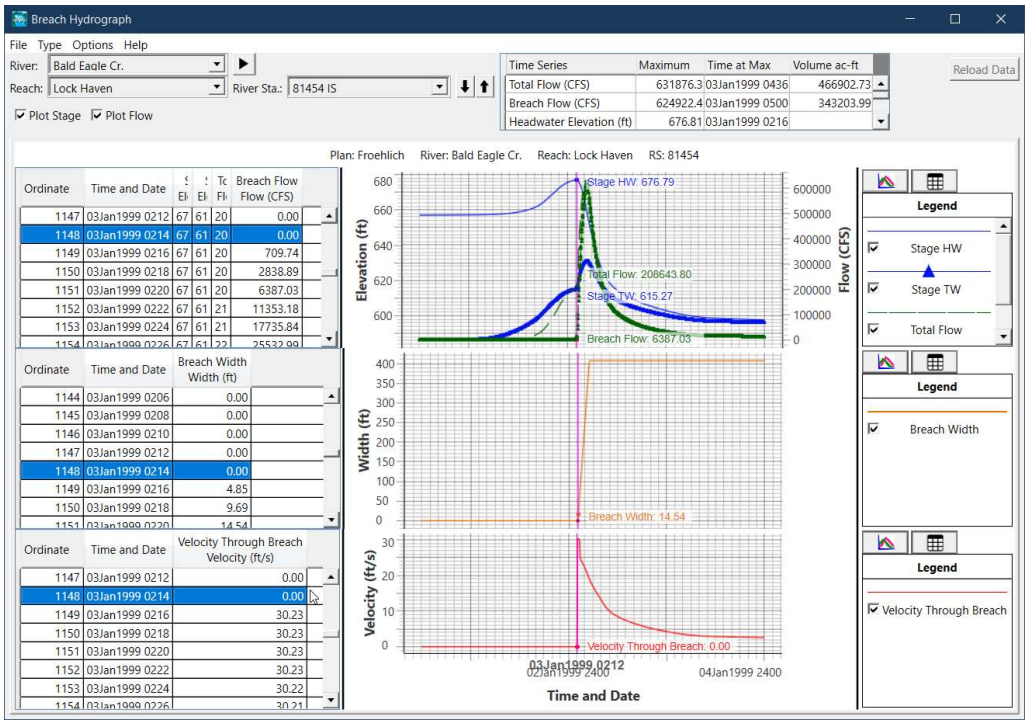
One way to determine when the dam breach occurs is watching the computation messages. A message will display will be written any time a structure in the model breaches.

Performing Unsteady Flow Simulation HEC-RAS 6.2 March 2022

Unsteady Input Summary:
1D Unsteady Finite Difference Numerical Solution

Maximum iteration location			RS	WSEL	ERROR	ITERATIONS
02JAN1999 15:34:00	193			544.34	0.148	20
02JAN1999 17:02:00	193			551.69	0.276	20
02JAN1999 17:04:00	Bald Eagle Cr.	Lock Haven	58756	581.00	0.369	20
02JAN1999 17:06:00	Bald Eagle Cr.	Lock Haven	58756	581.09	1.375	20
02JAN1999 18:12:00	193			558.92	0.035	20
02JAN1999 19:24:00	255			637.43	0.691	20
02JAN1999 19:56:00	255			651.87	0.288	20
02JAN1999 20:12:00	255			658.59	0.031	20
02JAN1999 23:08:00	192			543.43	0.025	20
02JAN1999 23:10:00	192			544.44	0.361	20
03JAN1999 00:22:00	191			542.74	0.209	20
03JAN1999 00:24:00	191			542.87	0.079	20
03JAN1999 00:38:00	191			545.19	0.066	20
03JAN1999 01:28:00	191			553.07	0.033	20
Breach at Bald Eagle Cr. Lock Haven 81454 at 03JAN1999 02:14:00						
03JAN1999 05:28:00	193			595.41	0.023	20
03JAN1999 22:22:00	Bald Eagle Cr.	Lock Haven	102904	621.12	0.020	20

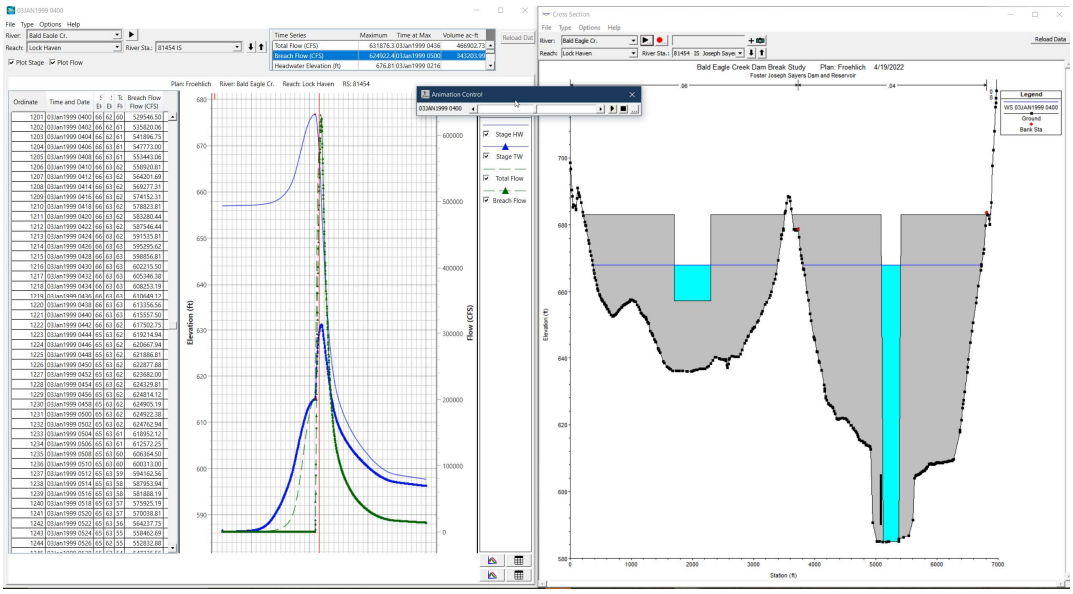
Additionally, you could display the Breach Hydrograph plot from the RAS main window to see when the breach begins to flow or starts to widen.



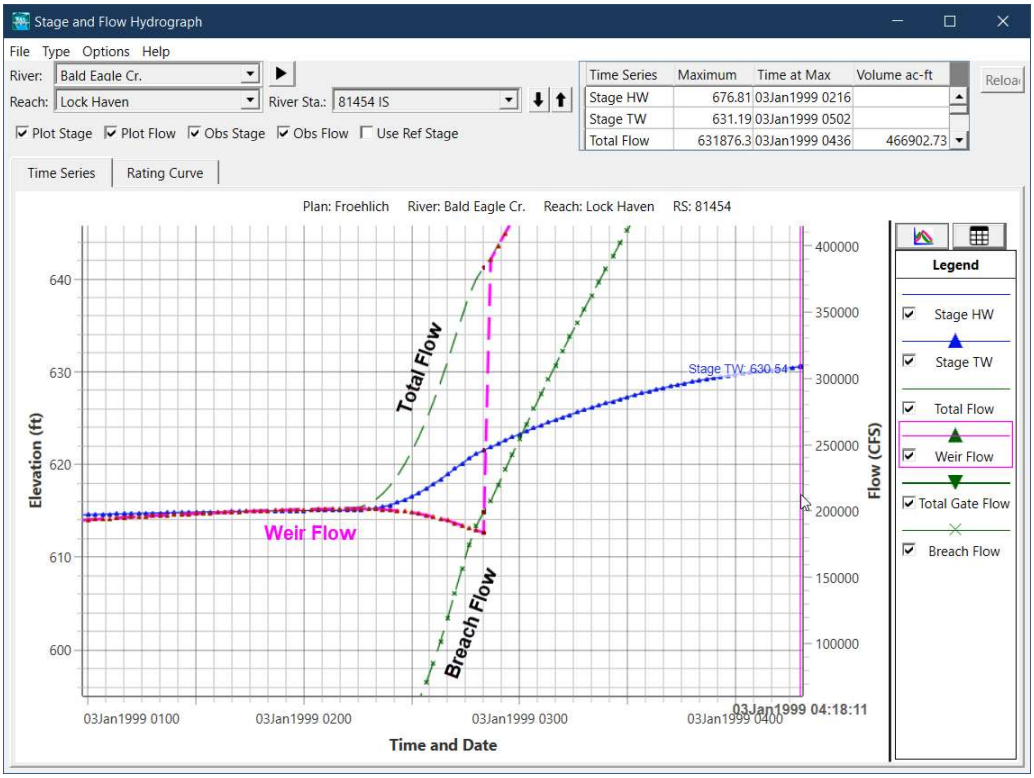
Question: What is the peak flow leaving the dam due to the breach, and what is the total peak flow leaving the dam. Why are they different?

From the summary table at the top of the Breach Hydrograph plot, we can see that the maximum total flow is 631,876.3 cfs. The maximum breach flow is 624,922.4 cfs.

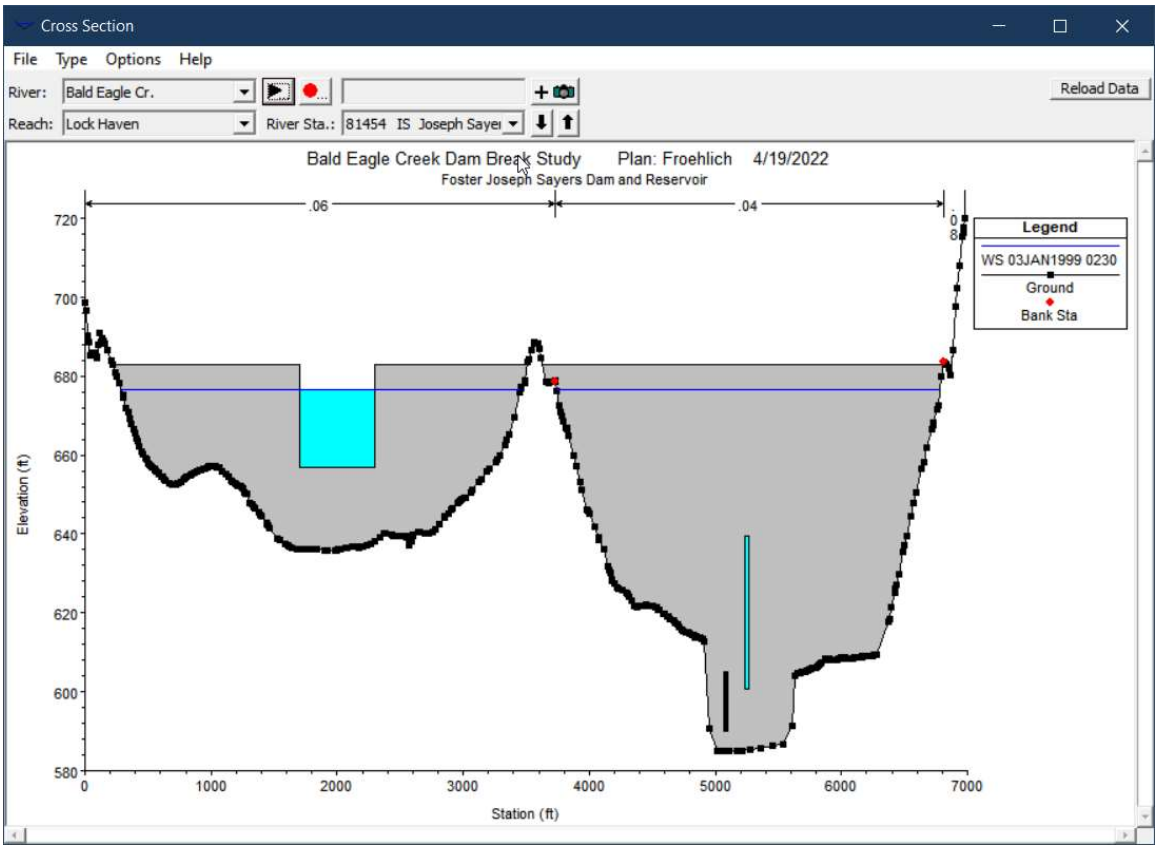
The difference in these flows is because the total flow includes, breach flow, weir flow over the spillway, a small amount of gate flow. We visualize this with the cross-section plot that shows the breach progression while the spillway is still flowing.



We can see more detail on the breakdown of total flow in the Stage and Flow Hydrograph plot for the structure. As shown below we can see that be watching the weir flow hydrograph, immediately after the breach the breach flow is entirely piping and not weir flow. Then, at 03Jan1999 0250 the breach flow becomes weir flow as the piping breach opens to a free surface.



Note: for the class workshop, the Detailed Output Interval was set to 1 hour and the piping breach turned into an overtopping breach in between the hourly output. To better see the growth in the piping breach, a smaller interval, such as 10 Minutes, should be selected. The figure below demonstrates the piping breach forming.



Question: What is the maximum velocity through the breach?

From the Breach hydrograph Plot, the maximum velocity through the breach is 30.23 feet per second.

5 Timestep Sensitivity

Question: What differences in stage and flows did you find between the two plans? Which timestep do you think is more appropriate for this dam breach problem?

The ten second time step is slightly higher peak flows and stages. The peak flow at the dam is about 4,000 cfs higher out of a total of 631,000 cfs. Differences in stages were > 0.1 ft.

The 2-minute time step had a maximum water surface errors and the volume accounting errors significantly higher than the 10-second timestep. That said, a 2-minute time step is generally too long for a dam break problem.

The 2-minute time step only had a single time step with a large error. For a large dam break, a few iterations with an error of a foot or more is not necessarily a problem. On the other hand, a maximum error of 0.09 is a lot better. For this problem, the difference in flow and water surface between the two results is actually quite small.

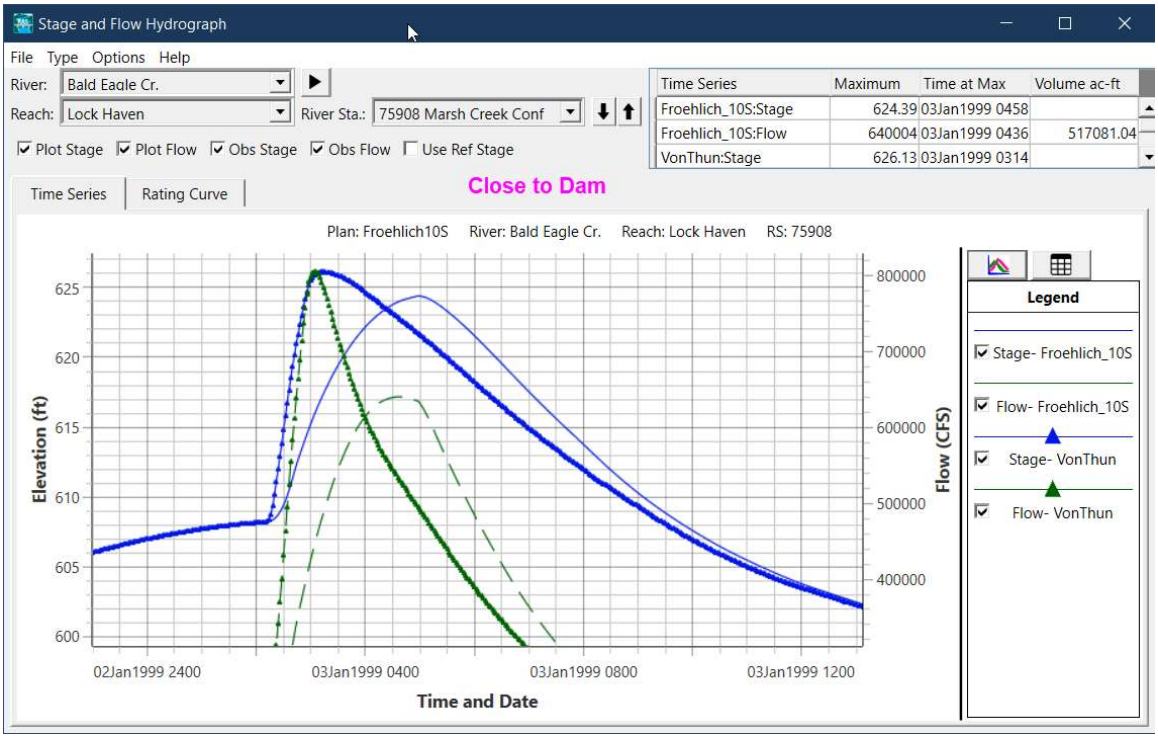
In general, a smaller time step is more accurate, and it is also extremely important for model stability.

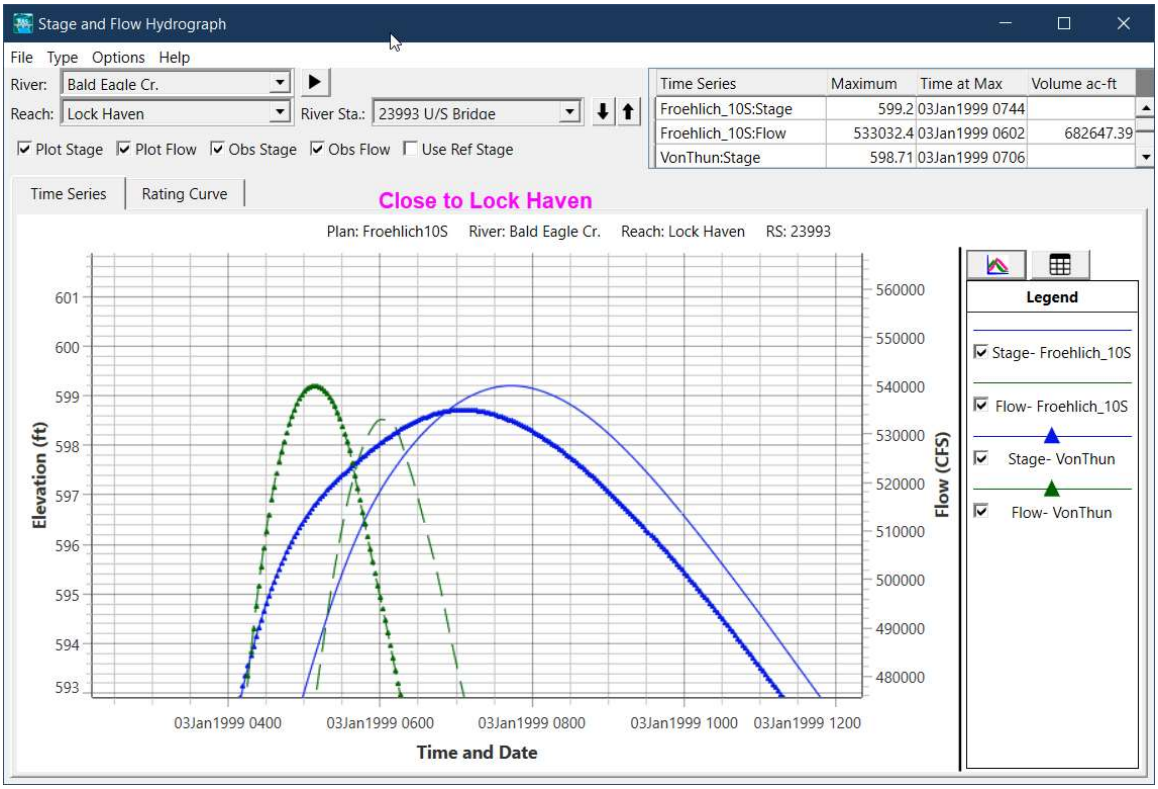
A good way to identify what time step should be used is to satisfy the Courant condition for the impending flood wave. The quick way to estimate a timestep starts with estimating the flood wave will travel velocity (20-30 fps). Then identify the average reach length between cross sections – in our case it is about 300 ft. If we use 30 fps and 300 ft, then our time step should be around 10-seconds.

6 Breach Parameter Sensitivity

Question: What differences do you see in the results when comparing the Von Thun and Froehlich plans? Where do you see the most differences?

The Von Thun has a noticeably shorter breach formation time. Not surprisingly, this leads to a greater peak flow and stage, and a faster peak than the Froehlich method. The biggest differences can be found closest to the dam. Further downstream around Lock Haven the breach, the peak flows and peak stages are more similar due to attenuation of the hydrograph. However, the peak stage near Lock Haven is actually less than in the Von Thun method and arrives approximately 90 minutes earlier for the Von Thun method.


Stage and Flow Hydrograph
File Type Options Help
River: Bald Eagle Cr.
Reach: Lock Haven
River Sta.: 75908 Marsh Creek Conf
Plot Stage Plot Flow Obs Stage Obs Flow Use Ref Stage
Time Series | Maximum | Time at Max | Volume ac-ft
Froehlich_10S:Stage | 624.39 | 03Jan1999 0458
Froehlich_10S:Flow | 640004 | 03Jan1999 0436 | 517081.04
VonThun:Stage | 626.13 | 03Jan1999 0314
Close to Dam
Time Series
Rating Curve
Plan: Froehlich10S River: Bald Eagle Cr. Reach: Lock Haven RS: 75908
Elevation (ft)
625
620
615
610
605
600
800000
700000
600000
500000
400000
Flow (CFS)
02Jan1999 2400
03Jan1999 0400
03Jan1999 0800
03Jan1999 1200
Time and Date
Legend
Stage- Froehlich_10S
Flow- Froehlich_10S
Stage- VonThun
Flow- VonThun

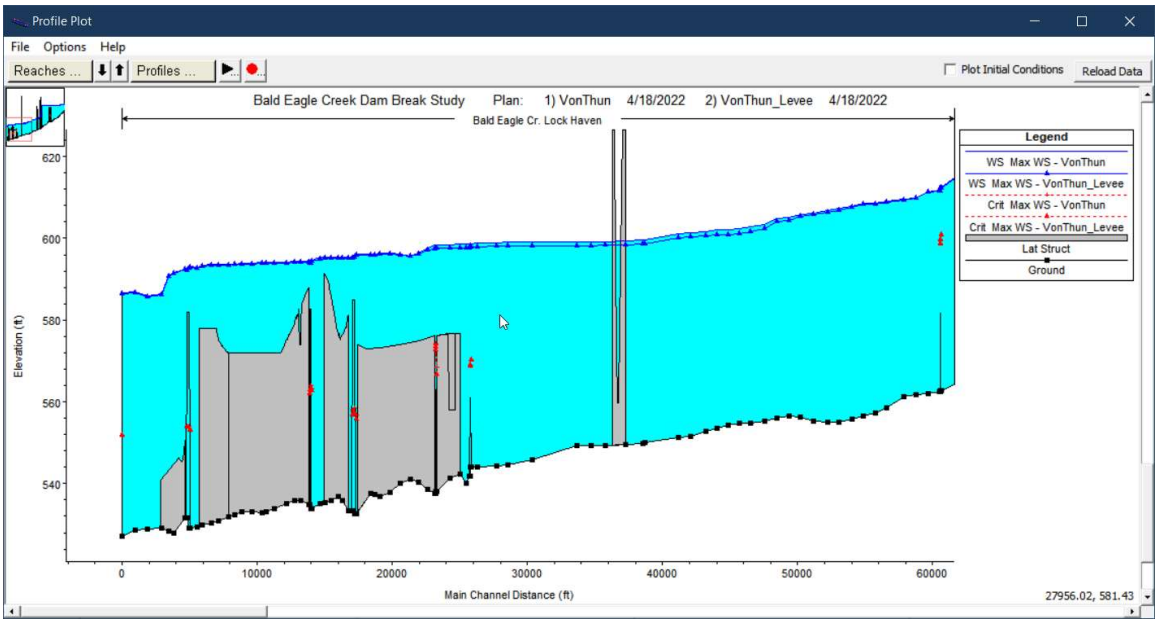

Stage and Flow Hydrograph
File Type Options Help
River: Bald Eagle Cr.
Reach: Lock Haven
River Sta.: 23993 U/S Bridge
Plot Stage Plot Flow Obs Stage Obs Flow Use Ref Stage
Time Series | Maximum | Time at Max | Volume ac-ft
Froehlich_10S:Stage | 599.2 | 03Jan1999 0744
Froehlich_10S:Flow | 533032.4 | 03Jan1999 0602 | 682647.39
VonThun:Stage | 598.71 | 03Jan1999 0706
Close to Lock Haven
Time Series
Rating Curve
Plan: Froehlich10S River: Bald Eagle Cr. Reach: Lock Haven RS: 23993
Elevation (ft)
601
600
599
598
597
596
595
594
593
560000
550000
540000
530000
520000
510000
500000
490000
480000
Flow (CFS)
03Jan1999 0400
03Jan1999 0600
03Jan1999 0800
03Jan1999 1000
03Jan1999 1200
Time and Date
Legend
Stage- Froehlich_10S
Flow- Froehlich_10S
Stage- VonThun
Flow- VonThun

7 Add Levee Breach at Lock Haven

Question: How much did the lateral weir breach change the maximum water surface elevation at storage area 192? How did the breach impact water surface elevations in Bald Eagle Creek?

There was little difference in maximum water surface elevations in the storage areas at Lock Haven. This is because the lateral structure is already being grossly overtopped at the time of the breach. The levee breach plan does fill storage area faster than the plan without a breach.

The maximum water surface elevations in the channel are impacted by the levee breach with differences in the two plans at about 1ft just upstream of Lock Haven.



Question: For the levee breach plan, what time does water first arrive at the "Main & Mill" location. What time is the water surface elevation at a maximum at "Main & Mill"?

The arrival time for the Main & Mill location is approximately 03 Jan 04:00. The maximum water surface elevation occurs at 03 Jan 07:15.

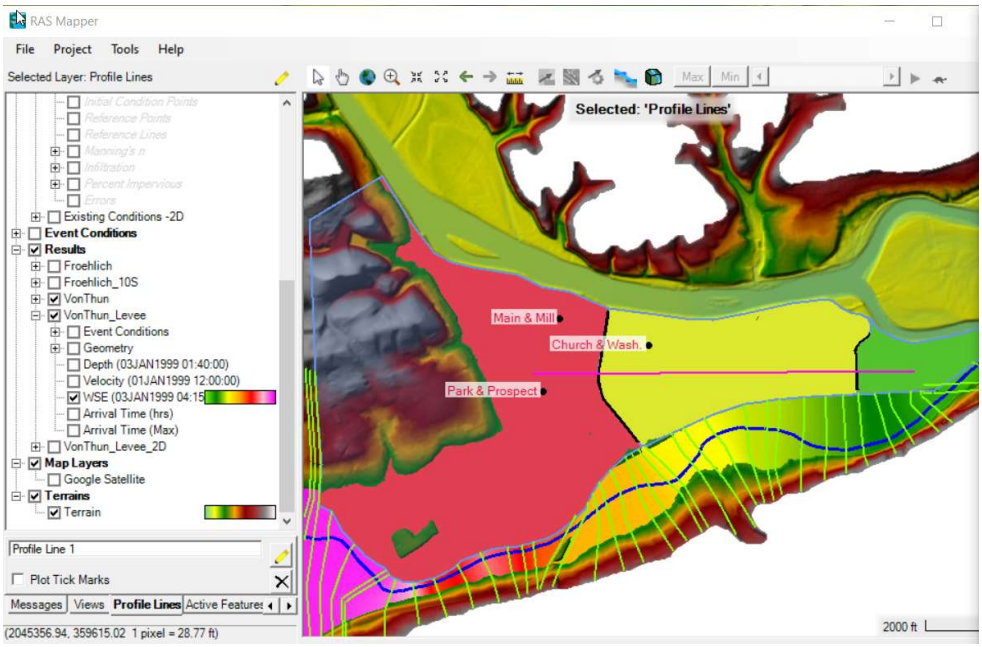
Question: For the levee breach plan, what time does water first arrive at the "Church & Washington" location. What time is the water surface elevation at a maximum at "Church & Washington"?

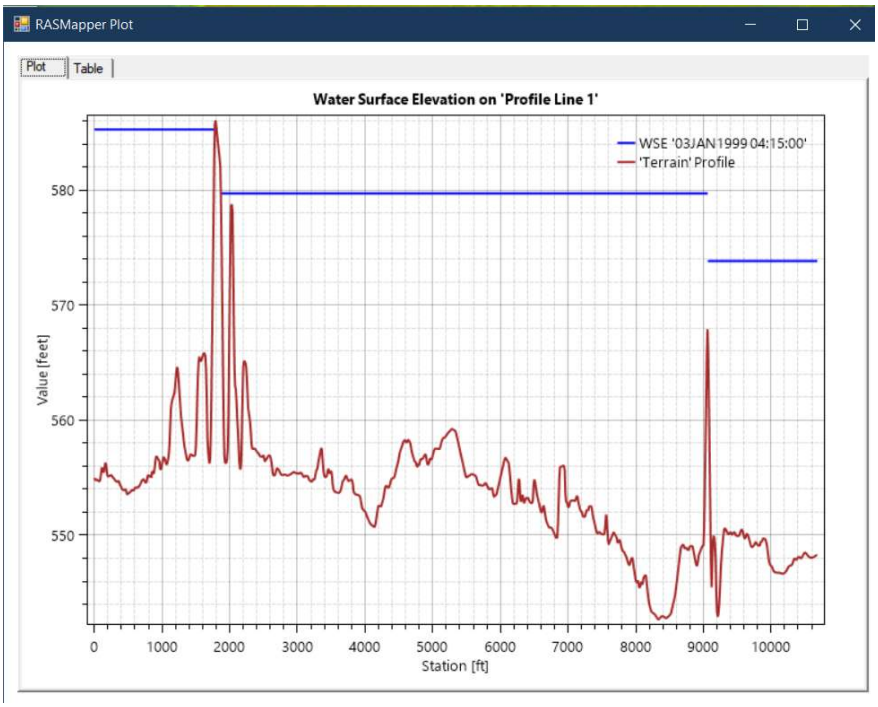
The arrival time for the Church & Washington location is approximately 03 Jan 01:40. The maximum water surface elevation for Church & Washington occurs at 03 Jan 07:30.

Question: Are the three storage areas (190, 191, and 192) an adequate approach to model the area behind the levee? Does model output make "hydraulic sense?" (Hint: display the water surface elevations layer in RAS Mapper). What could be done to improve the results?

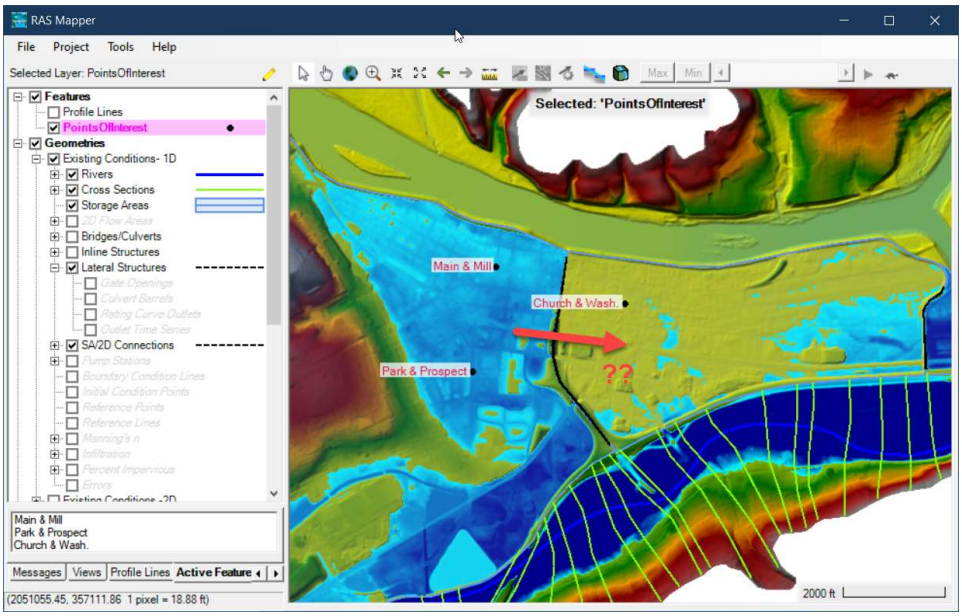
While viewing results in in RAS Mapper, you can see that the three storage areas have big differences in water surface elevations, making a stair step pattern. This does not make much sense when comparing to sloping water surface elevations of the adjacent channel. Turning on the WSE layer and drawing a Profile Line through them makes that clear.

With these differences in water surface elevations between the channel and storage area, flow is recirculating into a storage area upstream and back out again downstream.





Because of the single water surface elevation in each storage area, the inundation during filling of the storage areas does not make much sense either since water will appear only based on the elevation (filling lowest elevation to highest).

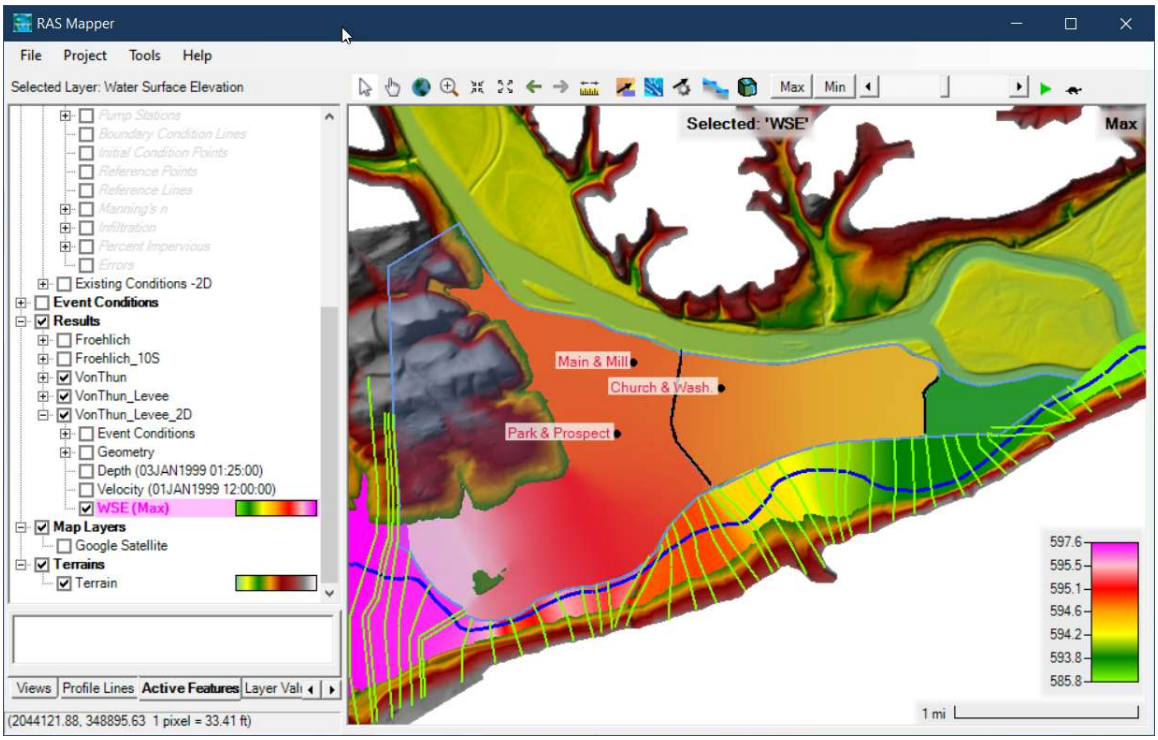


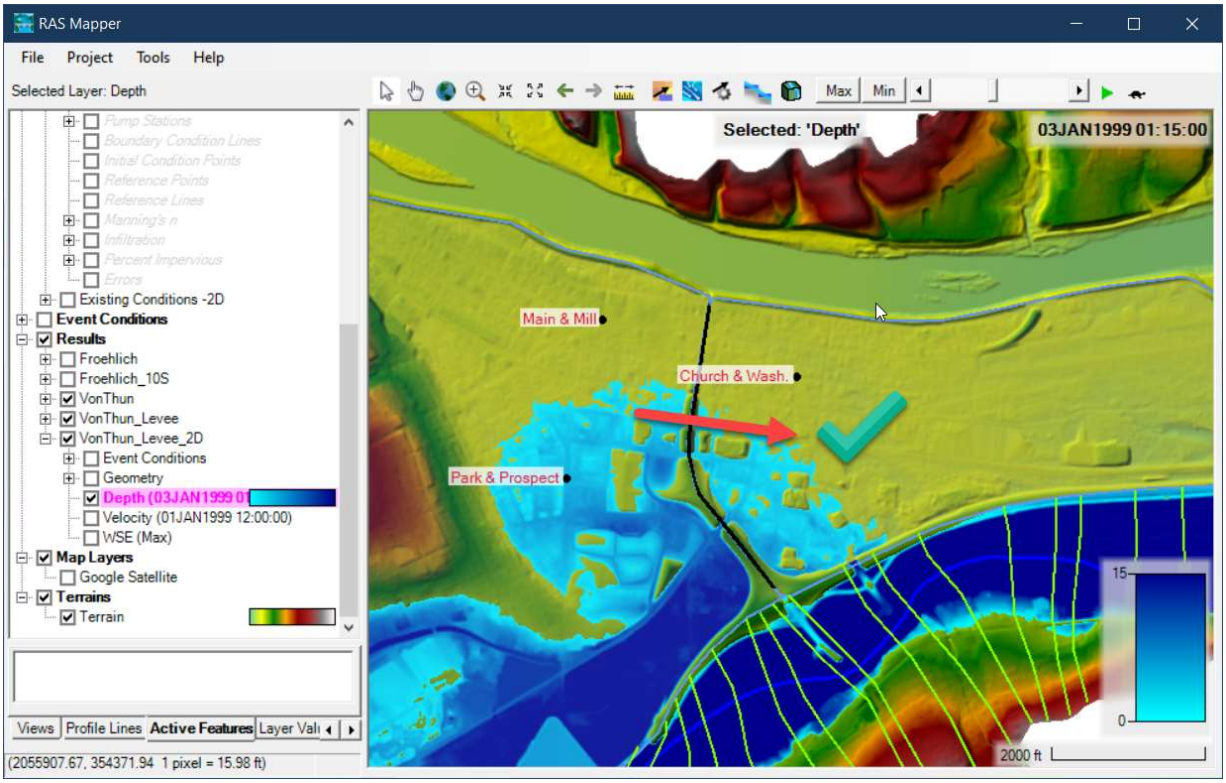
Modeling the area behind the levee with more storage areas would or replacing them with a 2D area could improve results for Lock Haven.

8 2D Area Sensitivity

Question: What differences do you see between the 2D and 1D inundations behind the levees?

The 2D area makes for a more realistic sloping water surface behind the levee and make more sense next to the adjacent channel. Additionally, arrival times to the locations of interest in Lock Haven are different since water must route to them instead of simply filling the lowest water surface elevations.




RAS Mapper
File
Project
Tools
Help
Selected Layer: Depth
Max
Min
Pump Stations
Boundary Condition Lines
Initial Condition Points
Reference Points
Reference Lines
Manning's n
Infiltration
Percent Impervious
Errors
Existing Conditions -2D
Event Conditions
Results
Froehlich
Froehlich_10S
VonThun
VonThun_Levee
VonThun_Levee_2D
Event Conditions
Geometry
Depth (03JAN1999 01
Velocity (01JAN1999 12:00:00)
WSE (Max)
Map Layers
Google Satellite
Terrains
Terrain
Views
Profile Lines
Active Features
Layer Vali
(2055907.67, 354371.94 1 pixel = 15.98 ft)
Selected: 'Depth'
03JAN1999 01:15:00
Main & Mill
Church & Wash.
Park & Prospect
15
0
2000 ft