

# Dam Breach Modeling with HEC-RAS

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Stanford Gibson, Ph.D

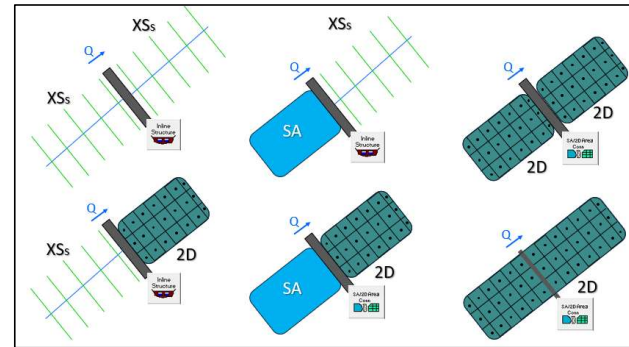
USACE, Institute for Water Resources, Hydrologic Engineering Center





# Breach Modeling

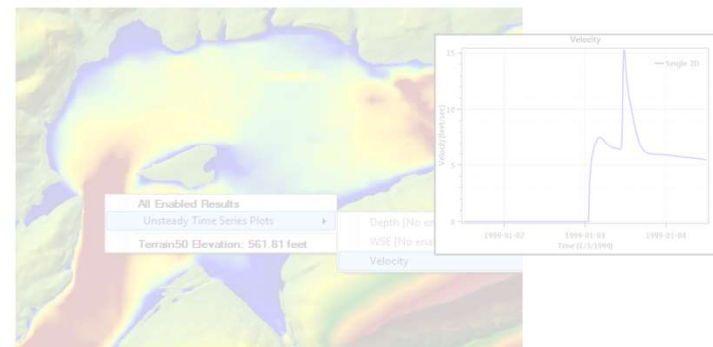
- 6 Breach Model Configurations



- Breach Options and Parameters

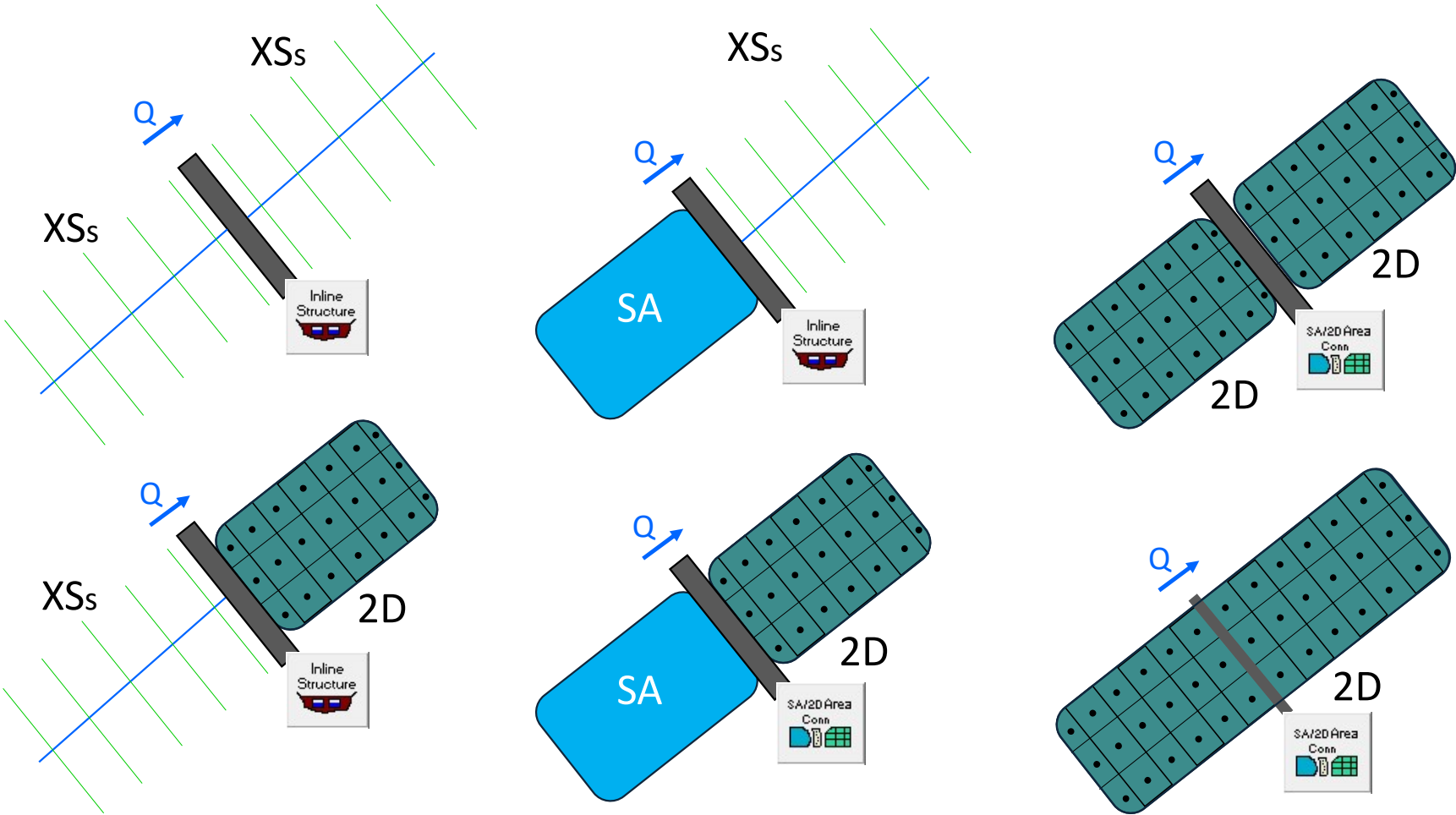


- Breach Results and Visualization



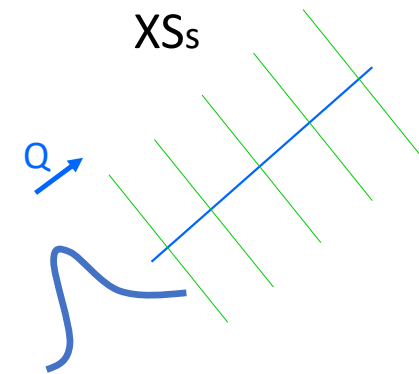
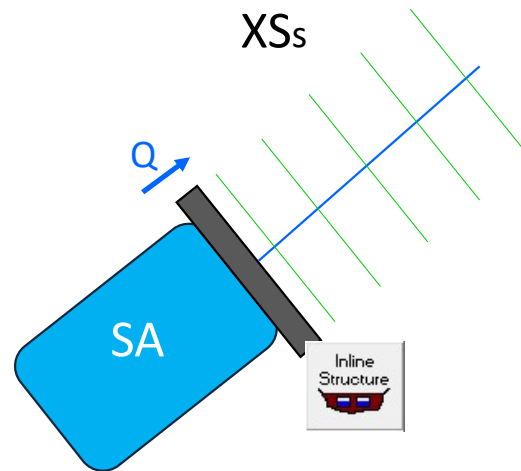
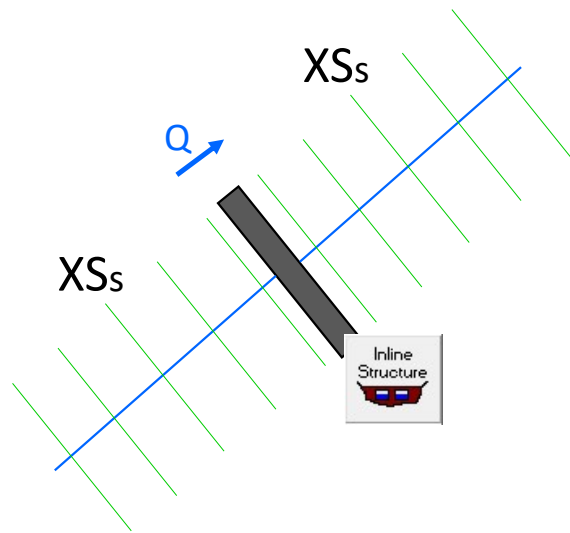


# Breach Model Configurations



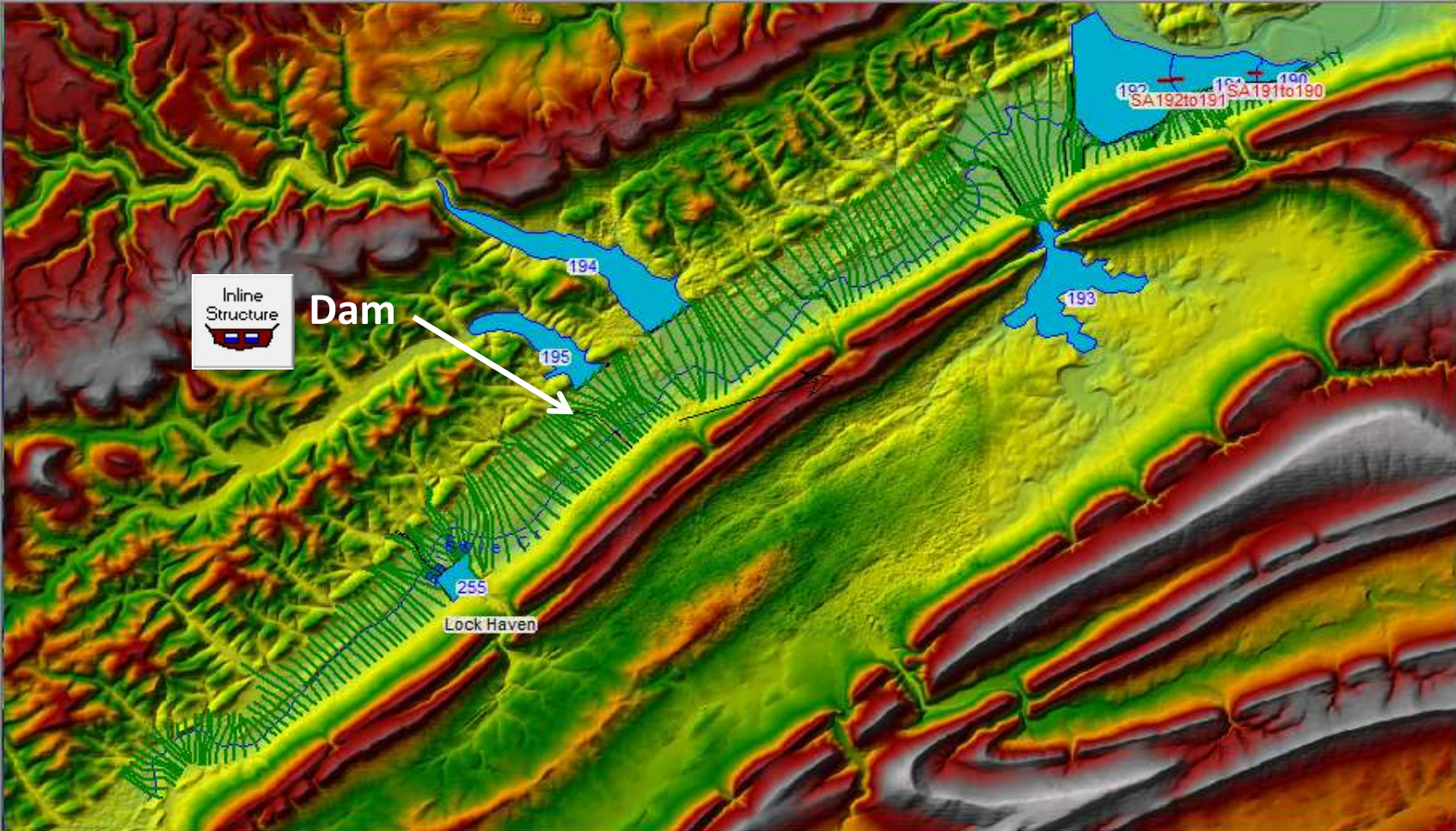


# 1D Breach Model Configurations





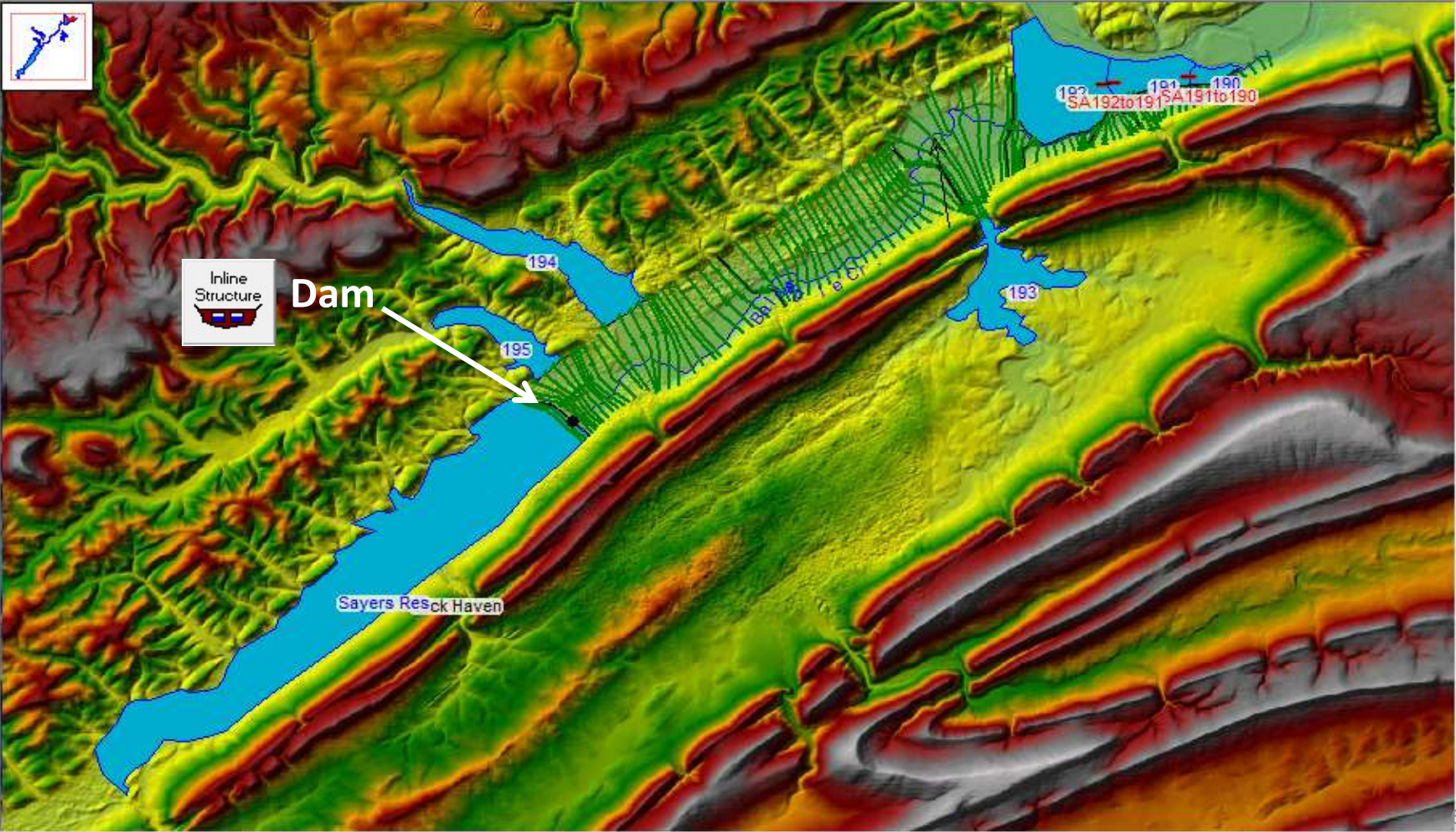
# 1D Cross Sections for Pool and Downstream





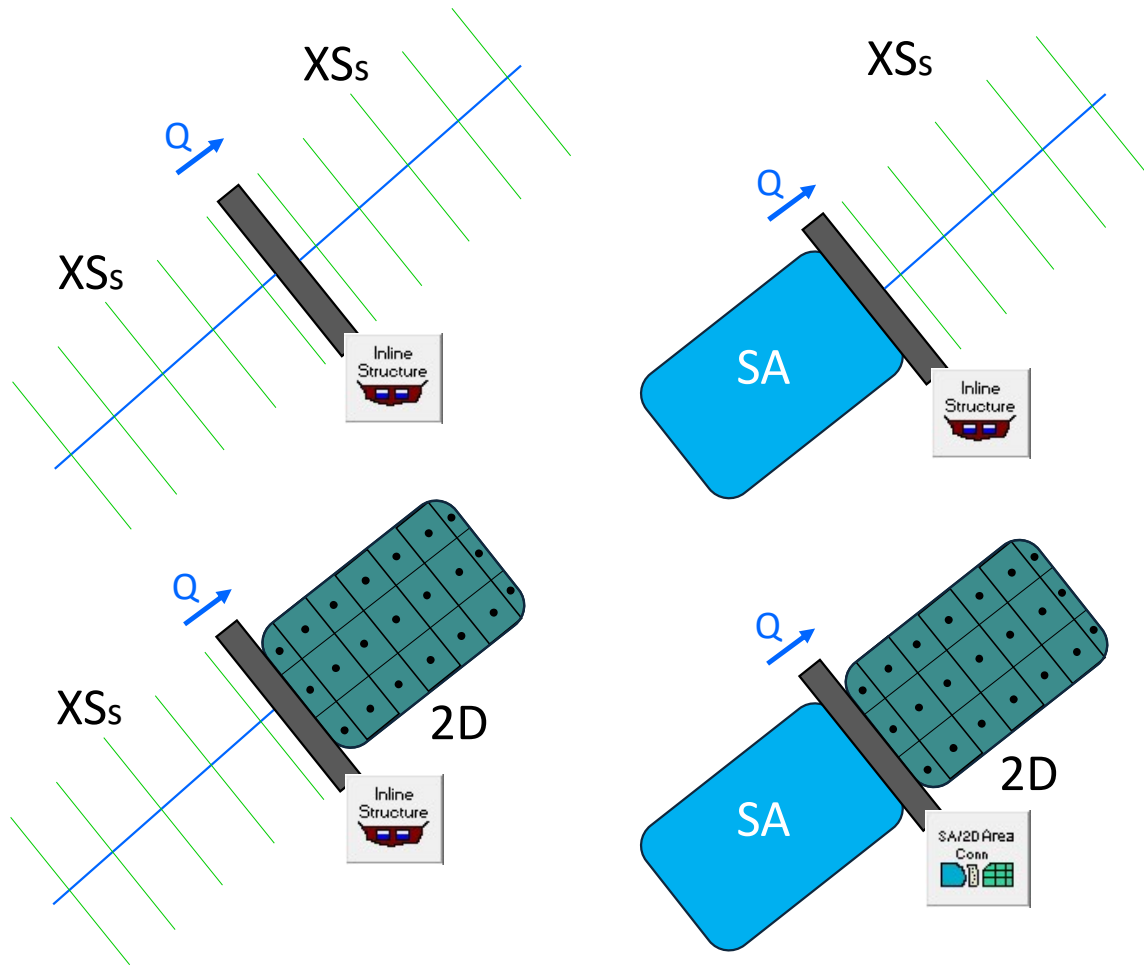


# 1D Storage Area Pool and XS Downstream





# Breach Model Configurations



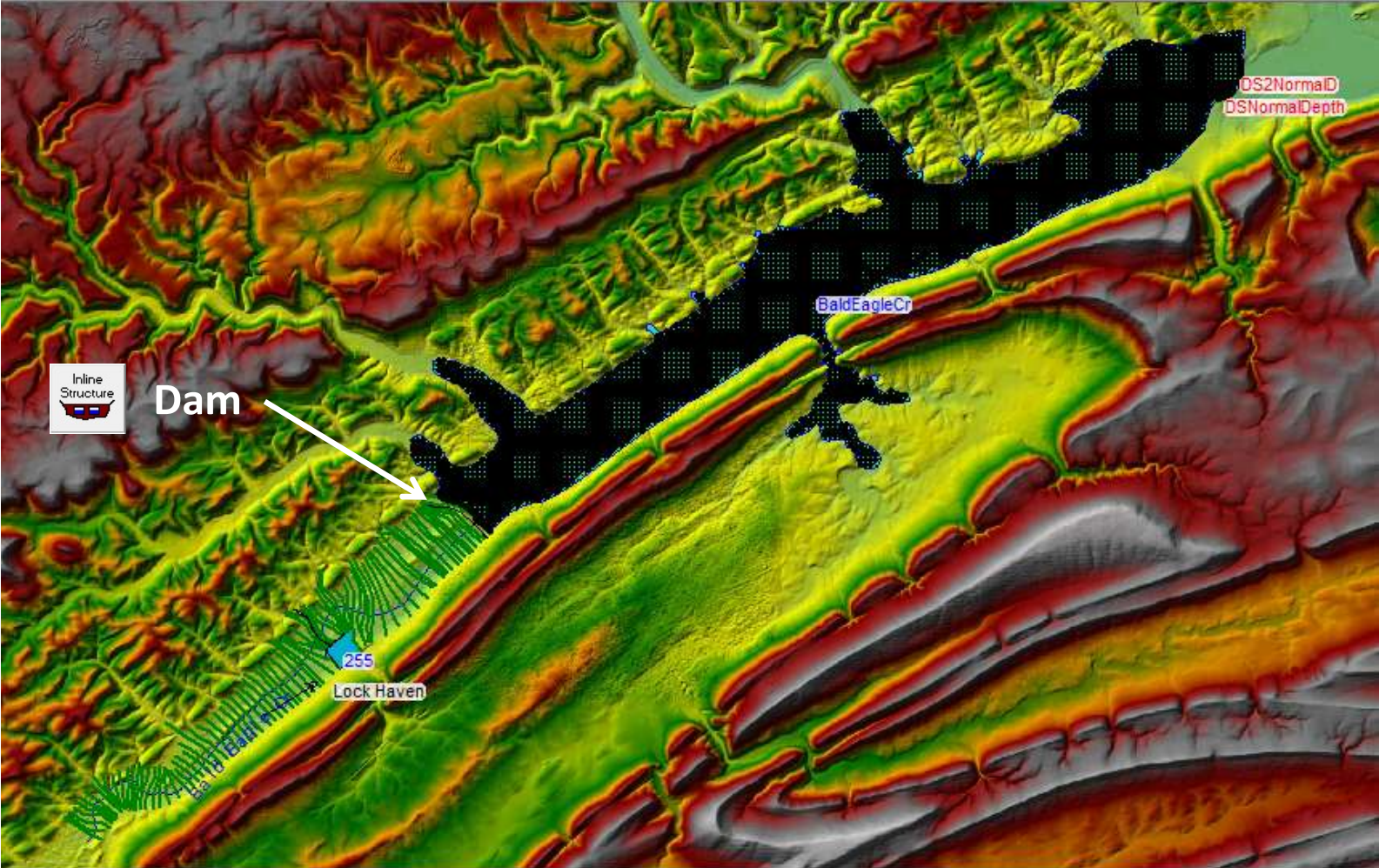
- 1D Breach Model Configurations

- Combined 1D/2D Breach Model Configurations





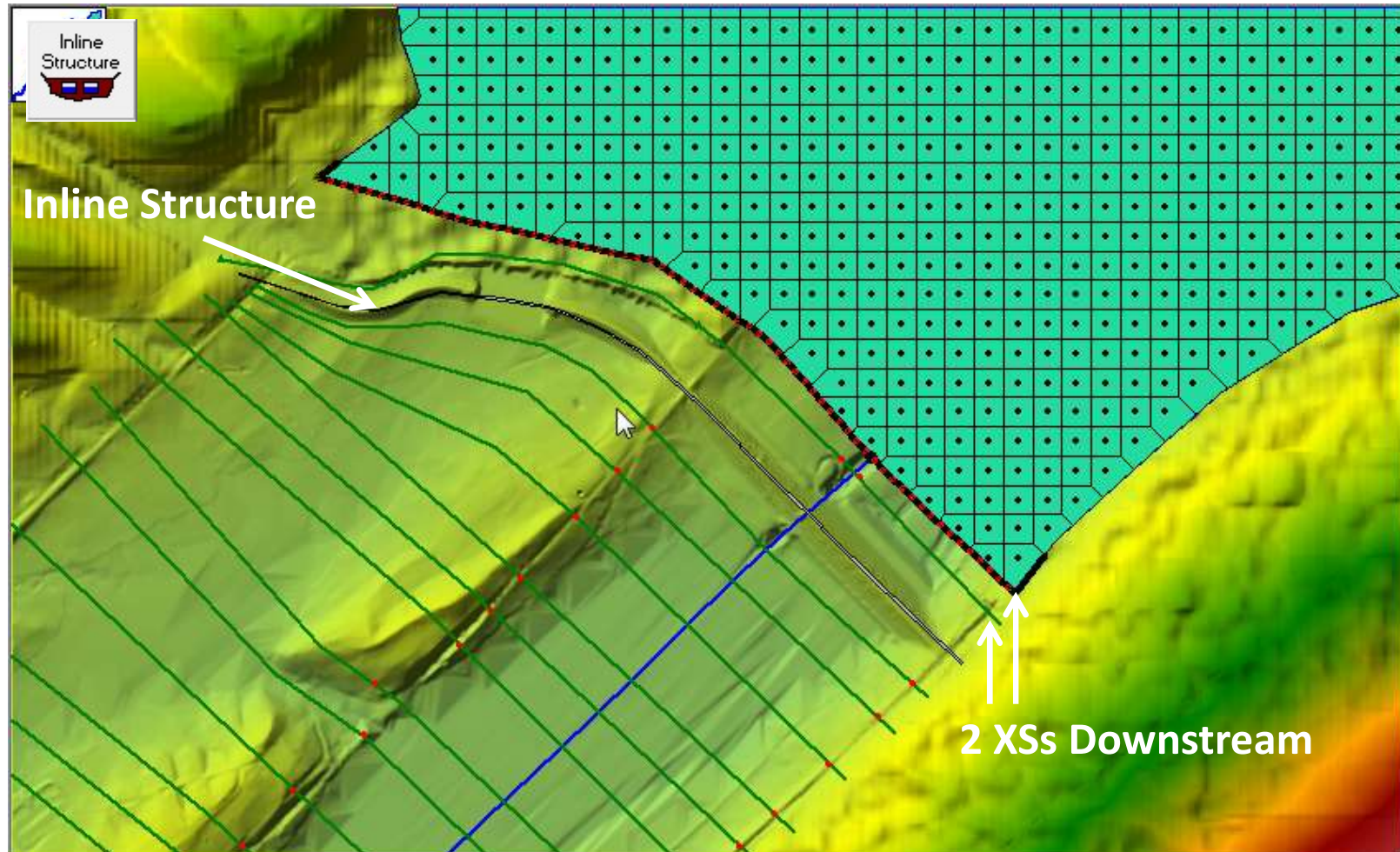
# 1D River Reach Pool and 2D Downstream







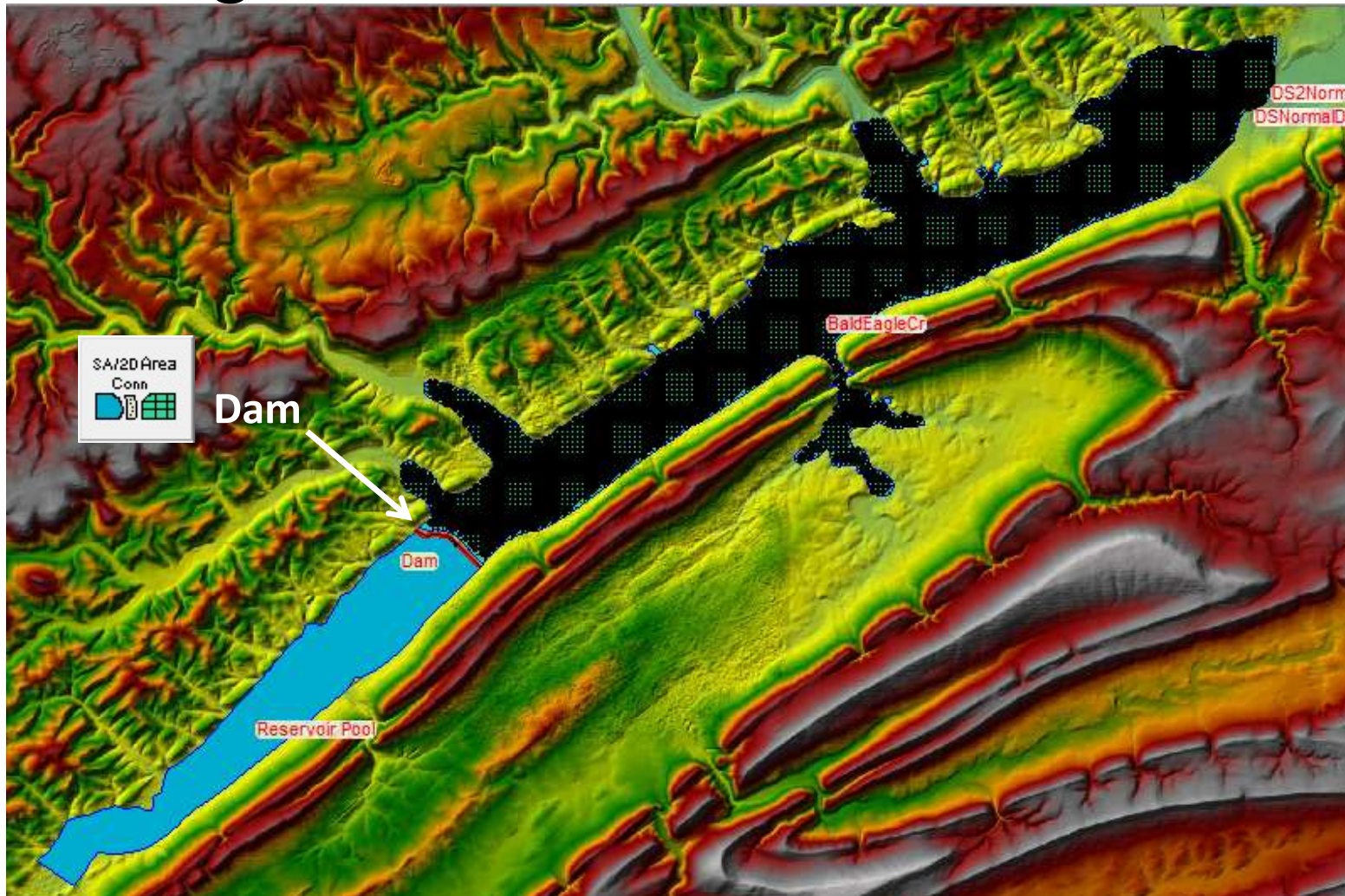
# 1D XSs and 2D Downstream - Caveat







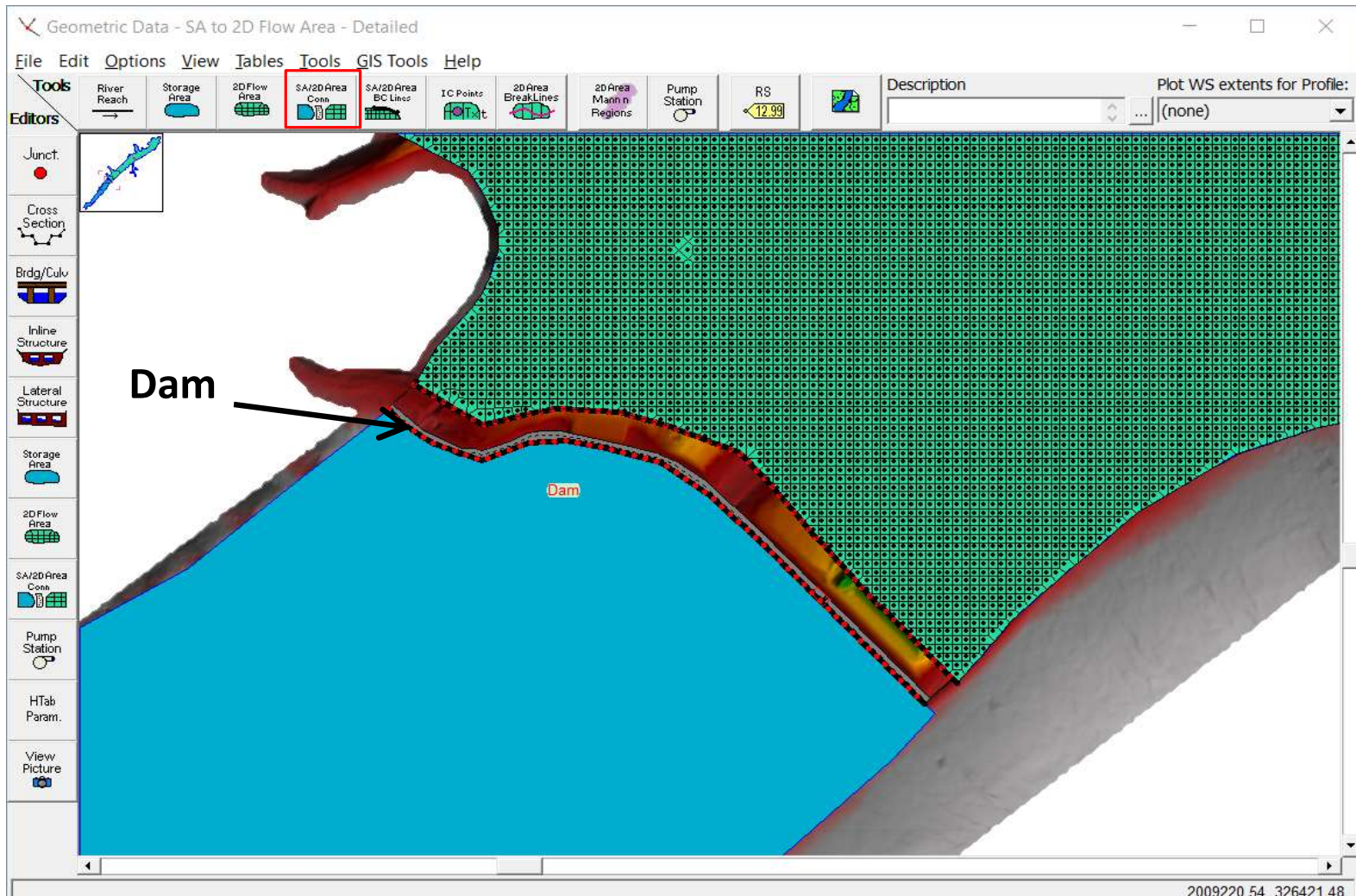
# 1D Storage Area Pool and 2D Downstream







# 1D Storage Area Pool and 2D Downstream

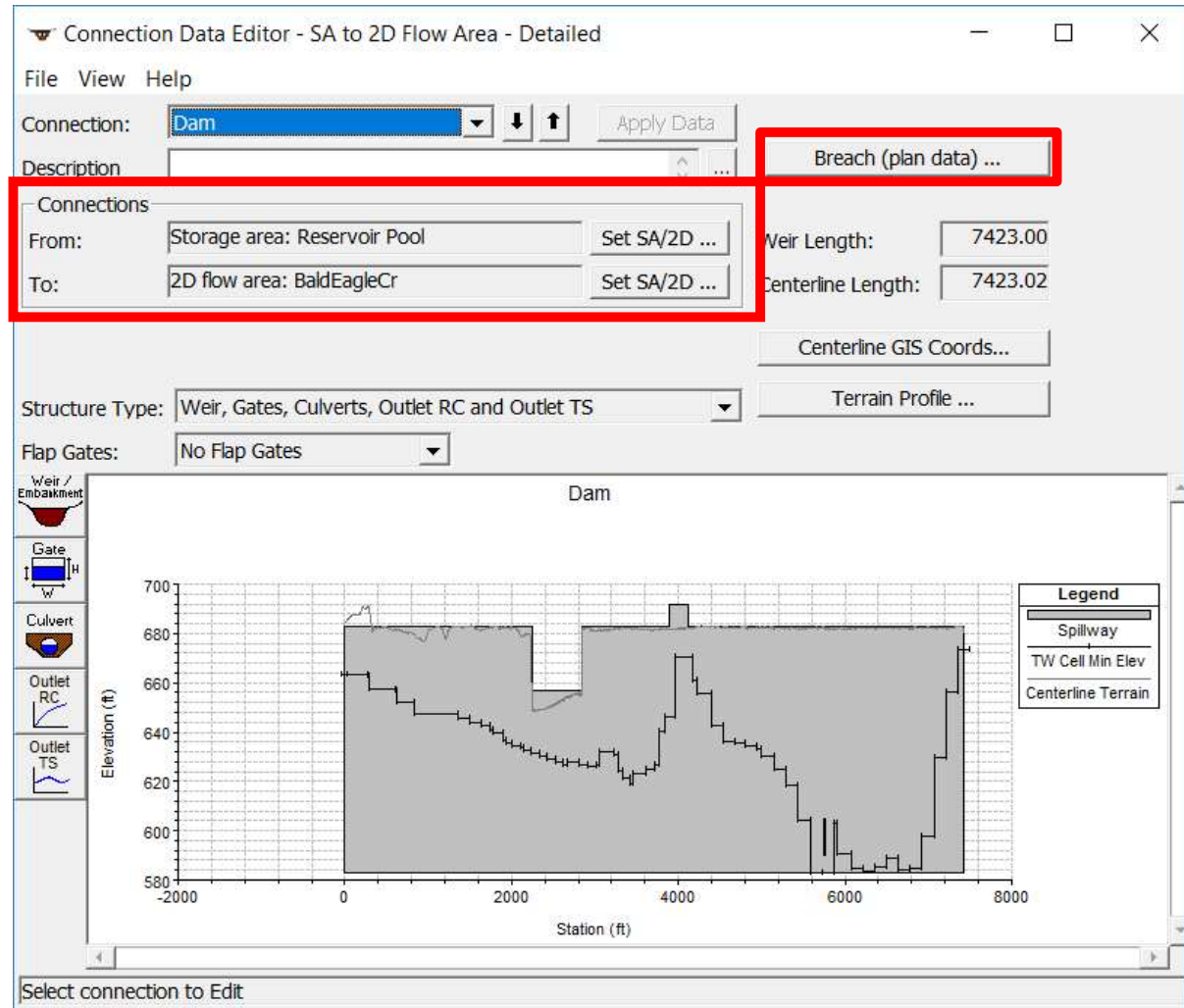






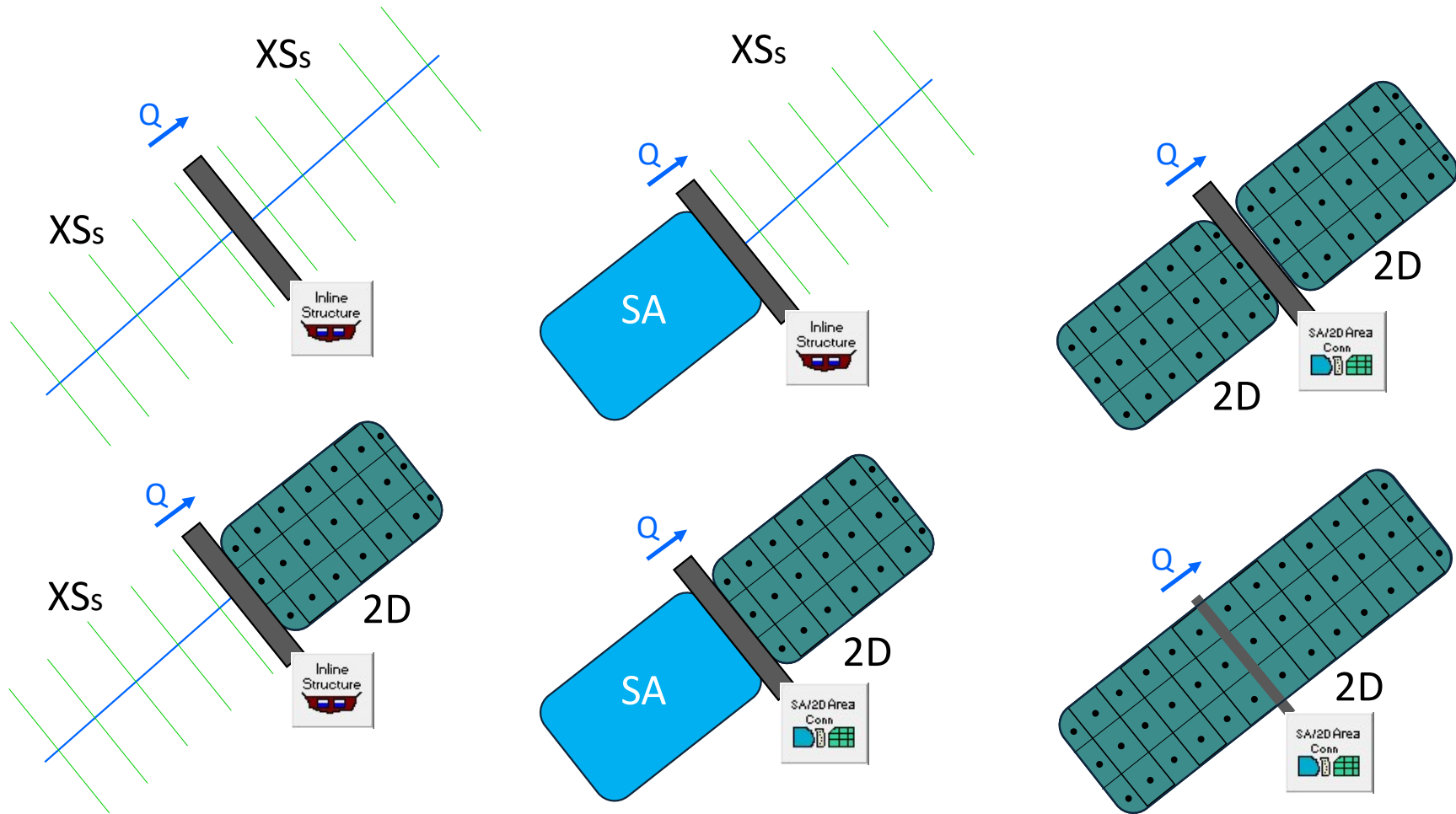
# Modeling the Dam with a SA/2D Area Hydraulic Connection

- From Node
- To Node
- Breach Info



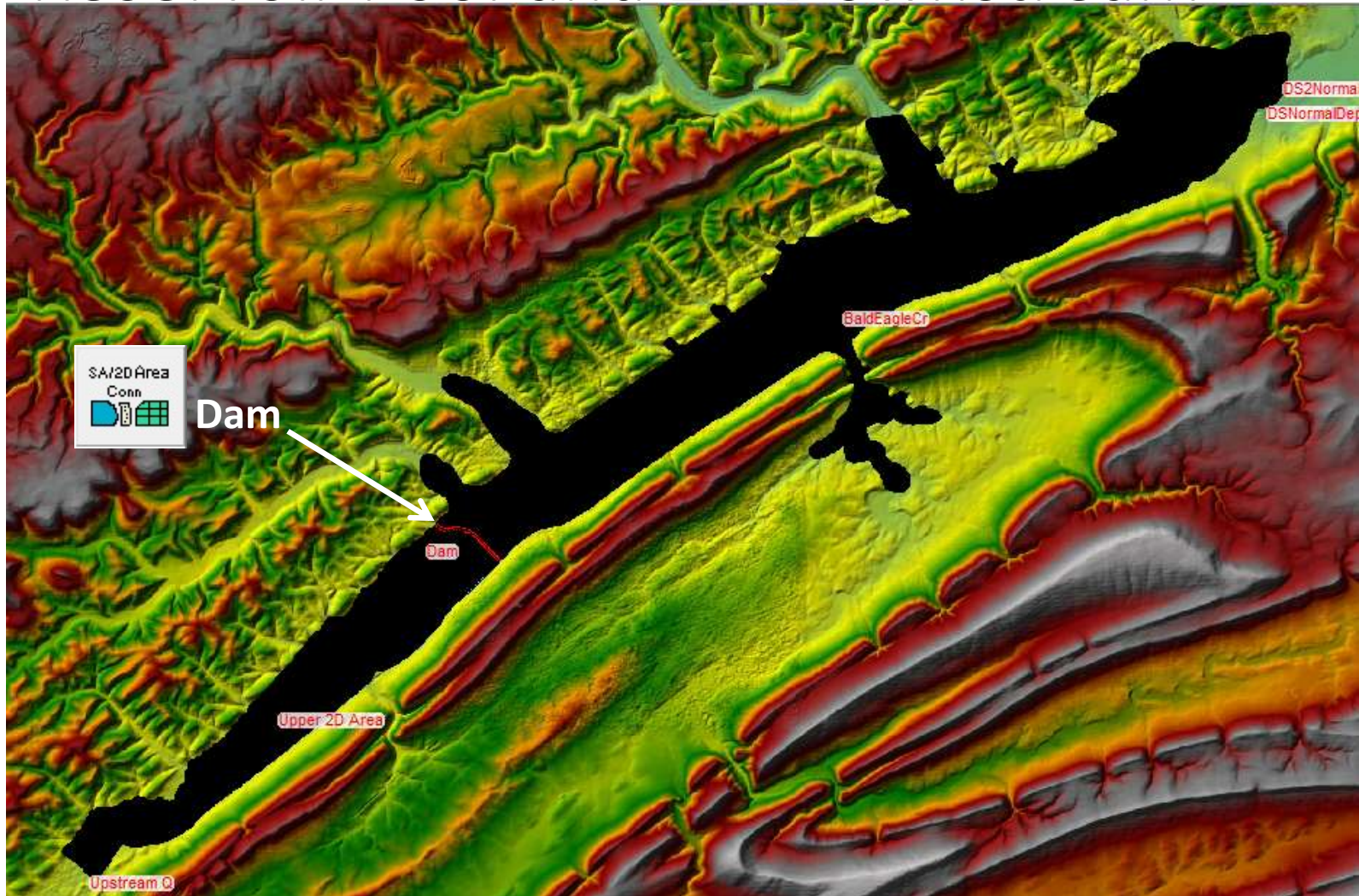


# Breach Model Configurations





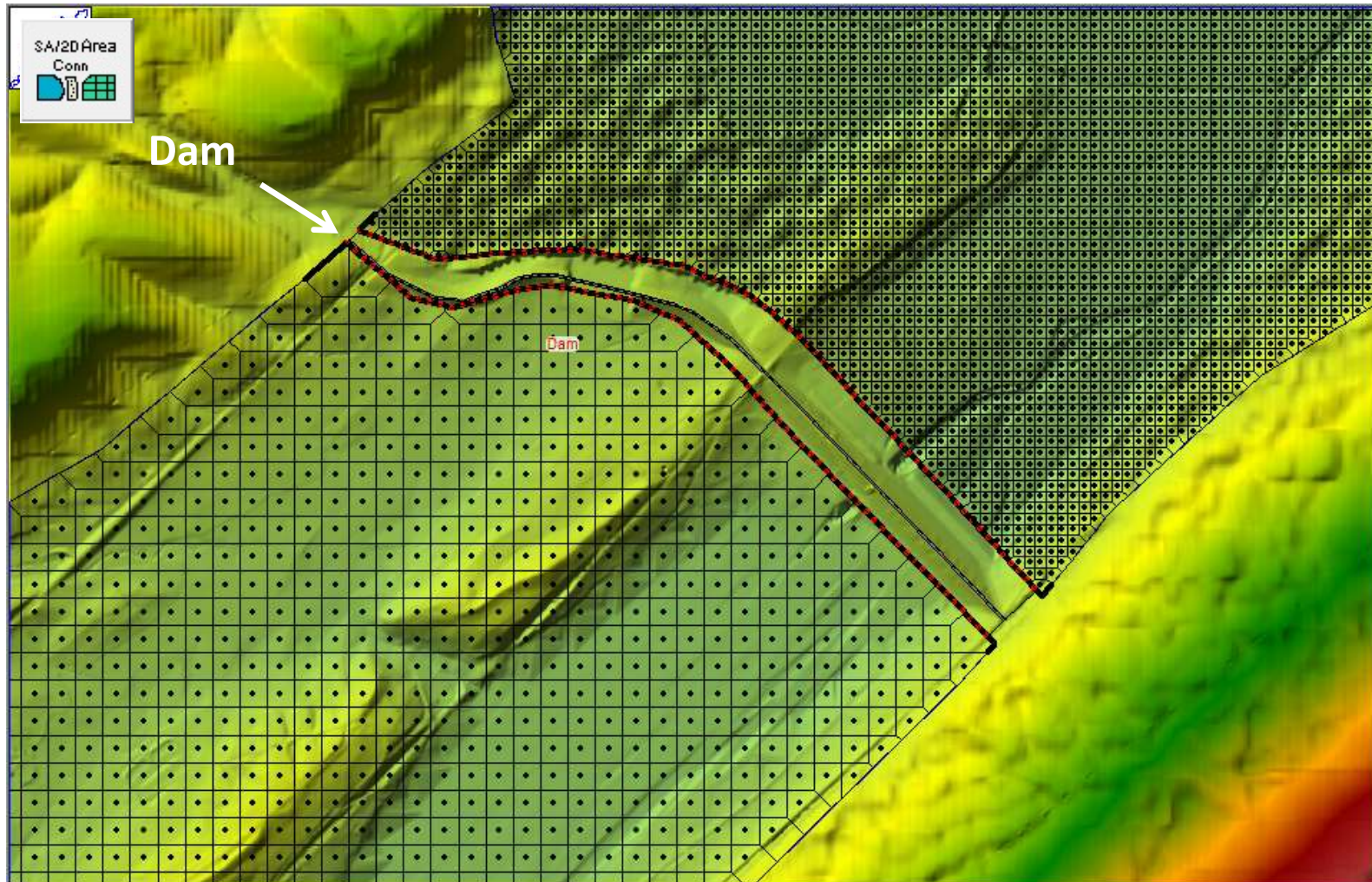
# 2D Reservoir Pool and 2D Downstream







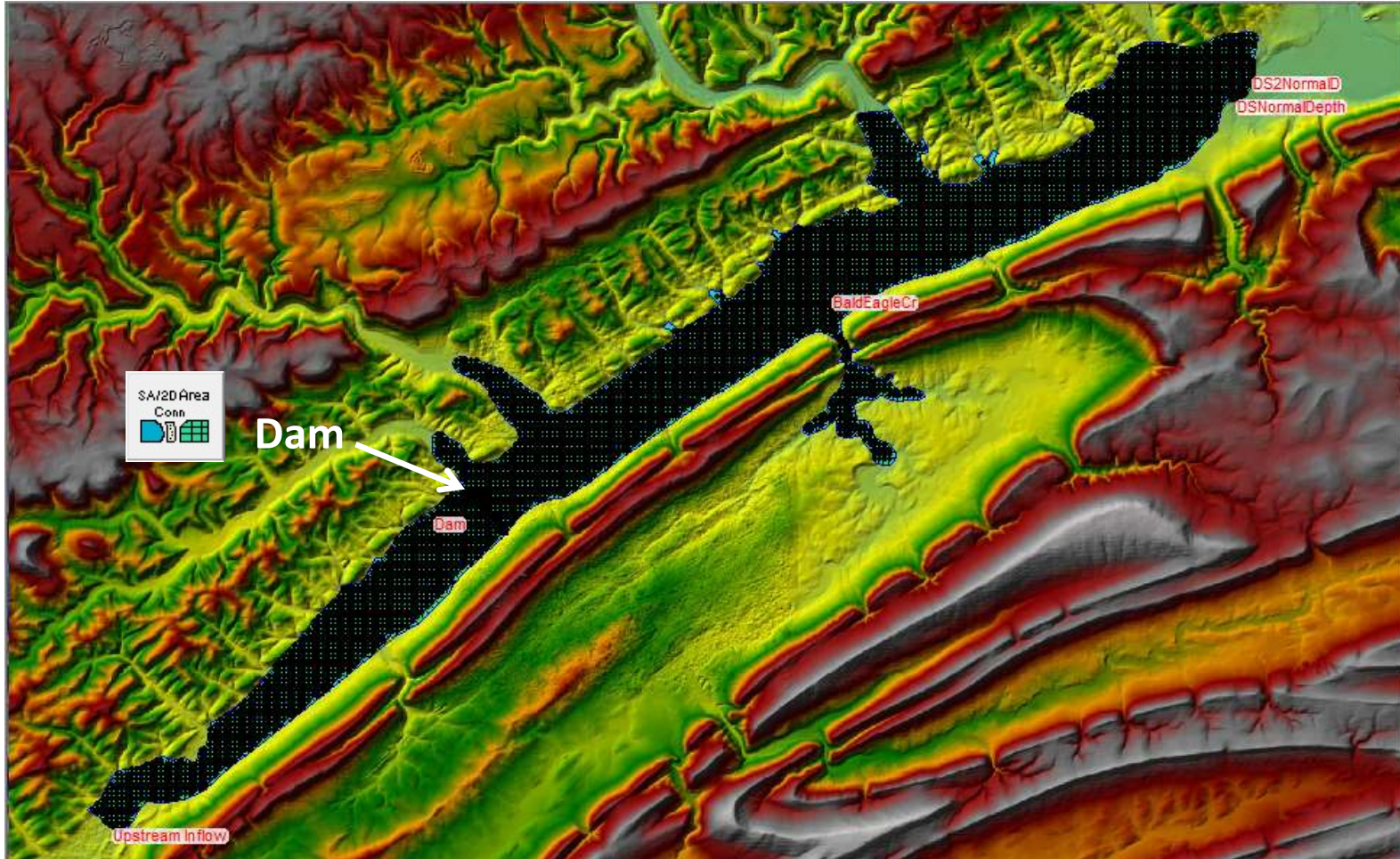
# 2D Reservoir Pool and 2D Downstream







# Single 2D Flow Area with Internal Hydraulic Structure for the Dam







# Single 2D Flow Area with Internal Hydraulic Structure for the Dam

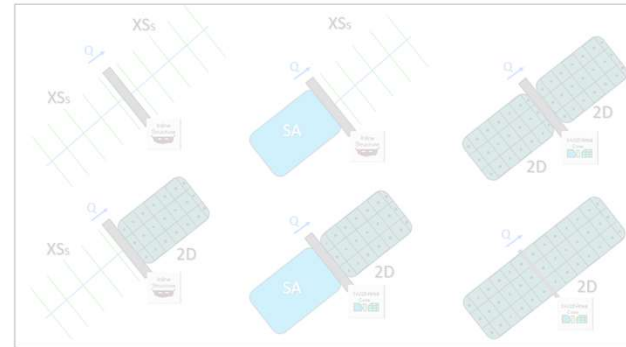




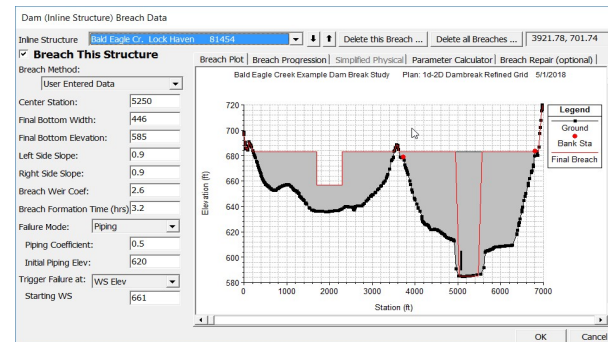


# Breach Modeling

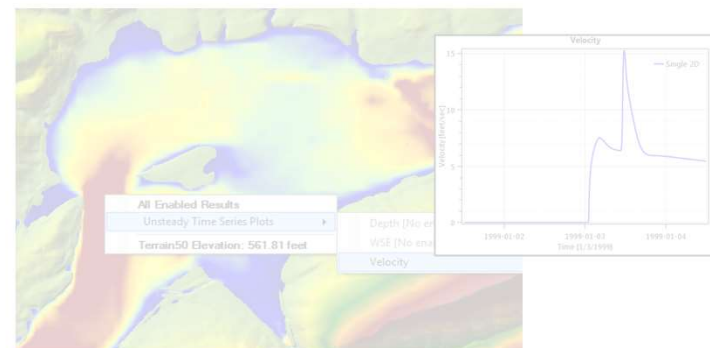
- 6 Breach Model Configurations



- Breach Options and Parameters



- Breach Results and Visualization



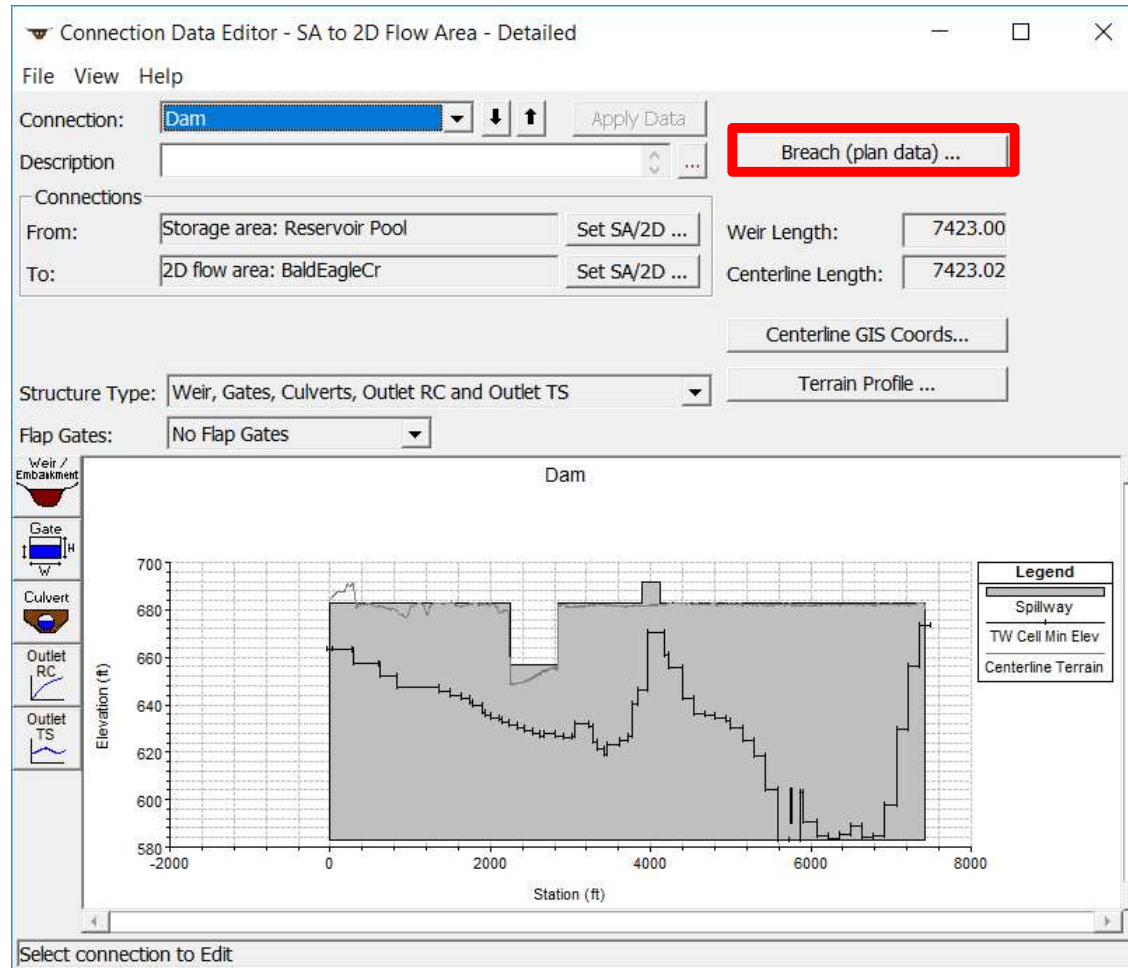
A red square icon containing a white silhouette of a dam with water behind it.

# Dam Breach Analysis in HEC-RAS

- Failure Modes
  - Overtopping and Piping
- Failure Initiation based on:
  - stage
  - simulation time
  - stage + duration, and immediate initiation stage.
- Breach progression
  - linear or nonlinear (user specified)
  - Simplified Physical Breaching Option
  - DL Breach



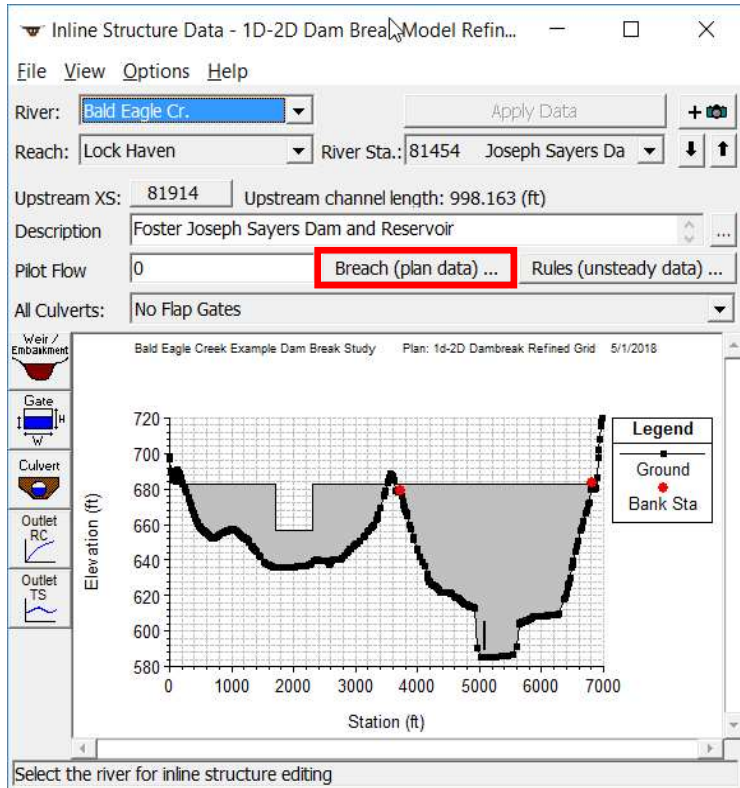
# Modeling the Dam with a SA/2D Area Hydraulic Connection







# Inline Structure Dam Break Control



Unsteady Flow Analysis

File Options Help

Plan:  Stage and Flow Output Locations ... 1D-2D Refined Grid

Flow Distribution Locations ...

Flow Roughness Factors ...

Seasonal Roughness Factors ...

Automated Roughness Calibration ...

Pro:  Unsteady Encroachments ...

Ungaged Lateral Inflows ...

**Dam (Inline Structure) Breach ...**

Levee (Lateral Structure) Breach ...

SA Connection Breach ...

Calculation Options and Tolerances ...

Sim: Output Options ... 1200

St: Friction Slope Method for Cross Sections ... 1200

Er: Friction Slope Method for Bridges ...

Co: Initial Backwater Flow Optimizations ...

Co: Interval: 5 Minute

Ma: Sediment Computation Options and Tolerances ... Interval: 1 Hour

DS: Sediment Output Options ... sets\2D Unsteady

Sediment Dredging Options ...

1D:  Check Data Before Execution

View Computation Log File ...

View Runtime Messages ...



# Dam Breach Data



Dam (Inline Structure) Breach Data

Inline Structure: **Bald Eagle Cr. Lock Haven 81454** [Delete this Breach ...] [Delete all Breaches ...] 3921.78, 701.74

**Breach This Structure**

Breach Method: **User Entered Data**

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3.2

Failure Mode: **Piping**

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: **WS Elev**

Starting WS: 661

Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

Bald Eagle Creek Example Dam Break Study Plan: 1d-2D Dambreak Refined Grid 5/1/2018

Elevation (ft)

Station (ft)

Legend

- Ground
- Bank Sta
- Final Breach

OK Cancel



# Non-Linear Breach Growth



Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle Cr. Lock Haven 81454

**Breach This Structure**

Breach Method: User Entered Data

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3.2

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS: 661

Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

Use equal vertical and horizontal growth rate

User specified vertical/horizontal growth ratio: 1

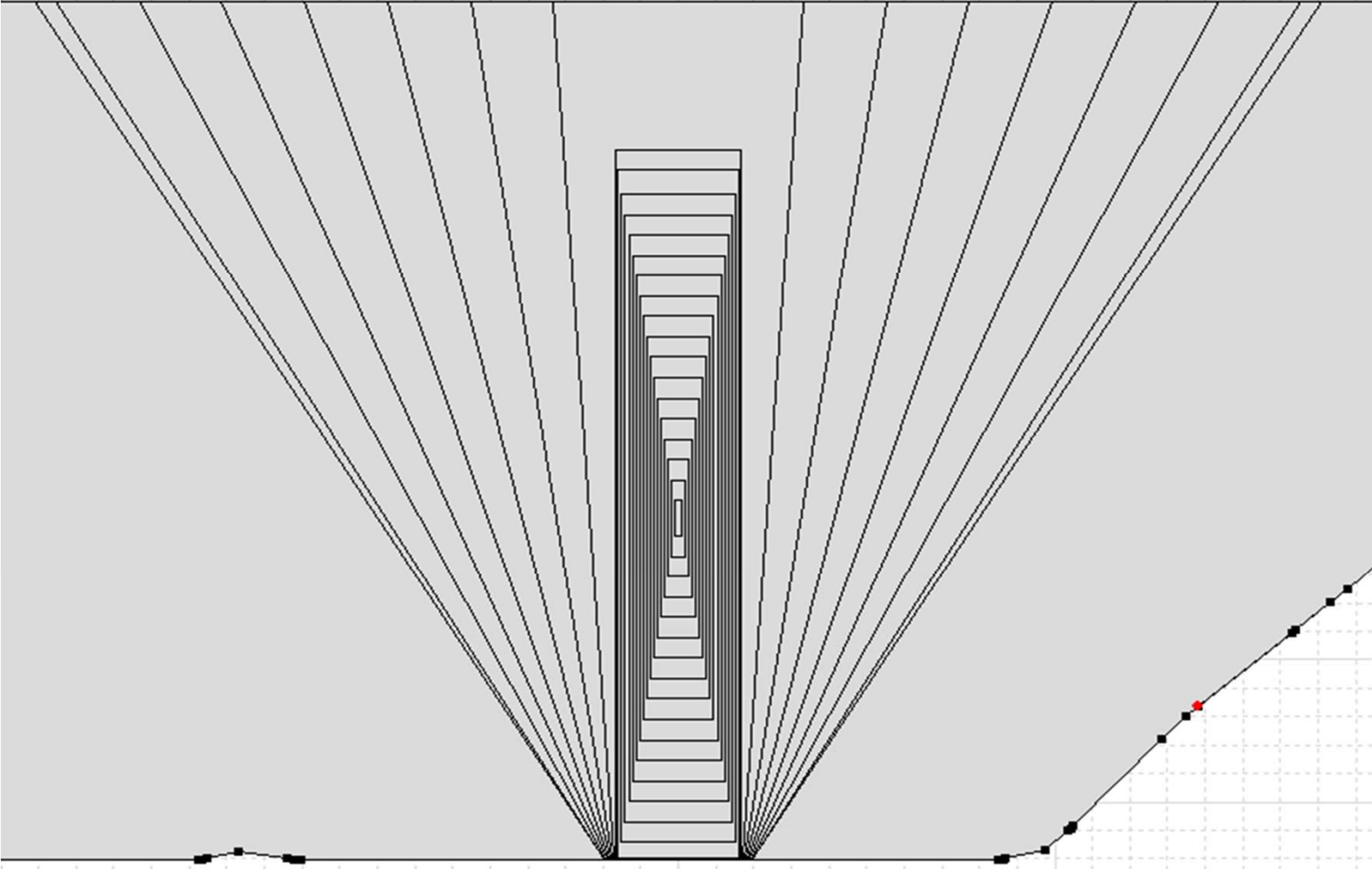
	Time Fraction	Breach Fraction
1	0	0
2	0.05	0.006
3	0.1	0.024
4	0.15	0.054
5	0.2	0.095
6	0.25	0.146
7	0.3	0.206
8	0.35	0.273
9	0.4	0.345
10	0.45	0.422
11	0.5	0.5
12	0.55	0.578
13	0.6	0.655
14	0.65	0.727
15	0.7	0.794
16	0.75	0.854
17	0.8	0.905

**Breach Progression Plot**

OK Cancel



# Piping Failure Breach Growth Geometry







# Breach Repair Option



Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle Cr. Lock Haven 81454 [Dropdown] [Down Arrow] [Up Arrow] [Delete this Breach ...] [Delete all Breaches ...]

**Breach This Structure**

Breach Method: User Entered Data [Dropdown]

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3.2

Failure Mode: Piping [Dropdown]

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: WS Elev [Dropdown]

Starting WS: 661

Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

Number of hours after full breach to start repair: [Text Box]

Total repair time (hours): [Text Box]

Final filled in elevation: [Text Box]

OK Cancel



# Breach Regression Equation Calculator



Dam (Inline Structure) Breach Data

Inline Structure: Bald Eagle Cr. Lock Haven 81454

**Breach This Structure**

Breach Method: User Entered Data

Center Station: 5250

Final Bottom Width: 446

Final Bottom Elevation: 585

Left Side Slope: 0.9

Right Side Slope: 0.9

Breach Weir Coef: 2.6

Breach Formation Time (hrs): 3.2

Failure Mode: Piping

Piping Coefficient: 0.5

Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS: 661

Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

Input Data

Top of Dam Elevation (ft): 683

Pool Elevation at Failure (ft): 676.8

Breach Bottom Elevation (ft): 585

Pool Volume at Failure (acre-ft): 187000

Failure mode: Piping

MacDonald

Dam Crest Width (ft): 25

Earth Fill Type: Non-homogeneous or Rockfill

Slope of US Dam Face Z1 (H:V): 3.5

Slope of DS Dam Face Z2 (H:V): 3.5

Xu Zhang (and Von Thun)

Dam Type: Dam with corewall

Dam Erodibility: Medium

Method	Breach Bottom Width (ft)	Side Slopes (H:V)	Breach Development Time (hrs)	
MacDonald et al	743	0.5	2.51	Select
Froehlich (1995)	447	0.9	3.23	Select
Froehlich (2008)	413	0.7	2.85	Select
Von Thun & Gillete	361	0.5	0.81	Select
Xu & Zhang	297	0.62	4.88 *	Select

OK Cancel



# Simplified Physical Breaching



Levee (Lateral Structure) Breach Data

Lateral: Bald Eagle Cr. Lock Haven 23100

**Breach This Structure**

Breach Method: **Simplified Physical**

Center Station: 1000

Max Possible Bottom Width: 1000

Min Possible Bottom Elev: 566

Left Side Slope: 0.1

Right Side Slope: 0.1

Breach Weir Coef: 2.6

Breach Formation Time (hrs):

Failure Mode: Overtopping

Piping Coefficient: 0.5

Initial Piping Elev:

Mass Wasting Feature:

Trigger Failure at: WS Elev+Duration

Threshold WS: 577.6

Duration Above Threshold: 1

Immediate Initiation WS: 580.6

Accumulate Duration

Breach Plot | Breach Progression | **Simplified Physical** | Parameter Calculator | Breach Repair (optional)

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	0	3	2	0
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		
13			13		
14			14		
15			15		
16			16		
17			17		
18			18		
19			19		
20			20		
21			21		
22			22		
23			23		

OK Cancel



# Compute

Important  
Computational  
Settings



Unsteady Flow Analysis

File Options Help

Plan : Single 2D Area - Internal Dam Structure Short ID: Single 2D

Geometry File : Single 2D Area - Internal Dam Structure

Unsteady Flow File : Single 2D Area

Programs to Run

- Geometry Preprocessor
- Unsteady Flow Simulation
  - Sediment
- Post Processor
- Floodplain Mapping

Plan Description

In this example a single 2D flow area is used to model the entire system, including the Dam. The computational mesh was modified in the area of the dam to align the cell faces along the top of the dam. A SA/2D Connection was added inside of the 2D flow area to represent the Dam, including the top of dam, overflow spillway, and low flow gates. This internal hydraulic structure will control flow from the cells upstream to the cells downstream.

Simulation Time Window

Starting Date: 01JAN1999 Starting Time: 1200

Ending Date: 04JAN1999 Ending Time: 1200

Computation Settings

Computation Interval: 30 Second Hydrograph Output Interval: 1 Minute

Mapping Output Interval: 10 Minute Detailed Output Interval: 1 Hour

DSS Output Filename: d:\HEC Data\HEC-RAS\Automated Test Datasets\2D Unsteady

1 Storage Area Connection with breach data. 1 set to breach.

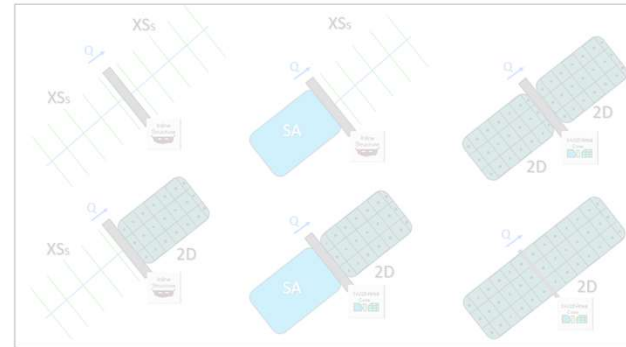
Compute



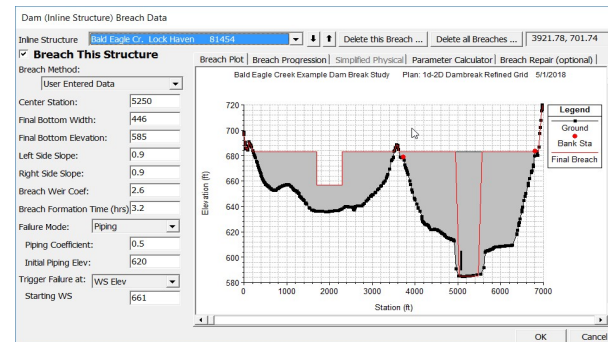


# Breach Modeling

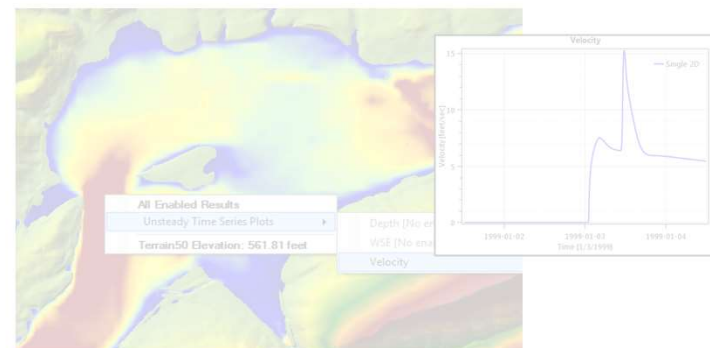
- 6 Breach Model Configurations



- Breach Options and Parameters



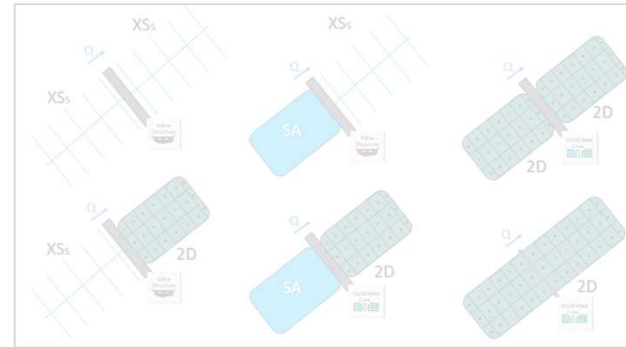
- Breach Results and Visualization





# Breach Modeling

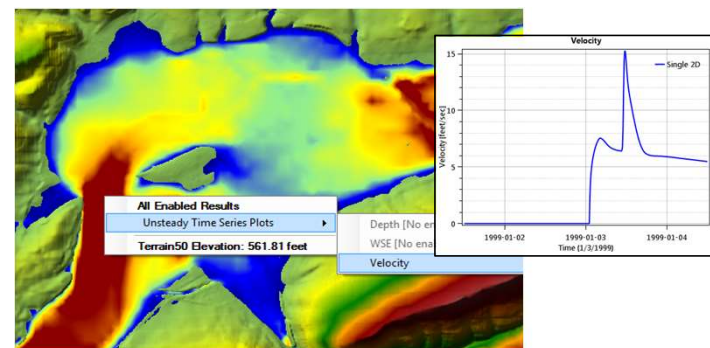
- 6 Breach Model Configurations



- Breach Options and Parameters

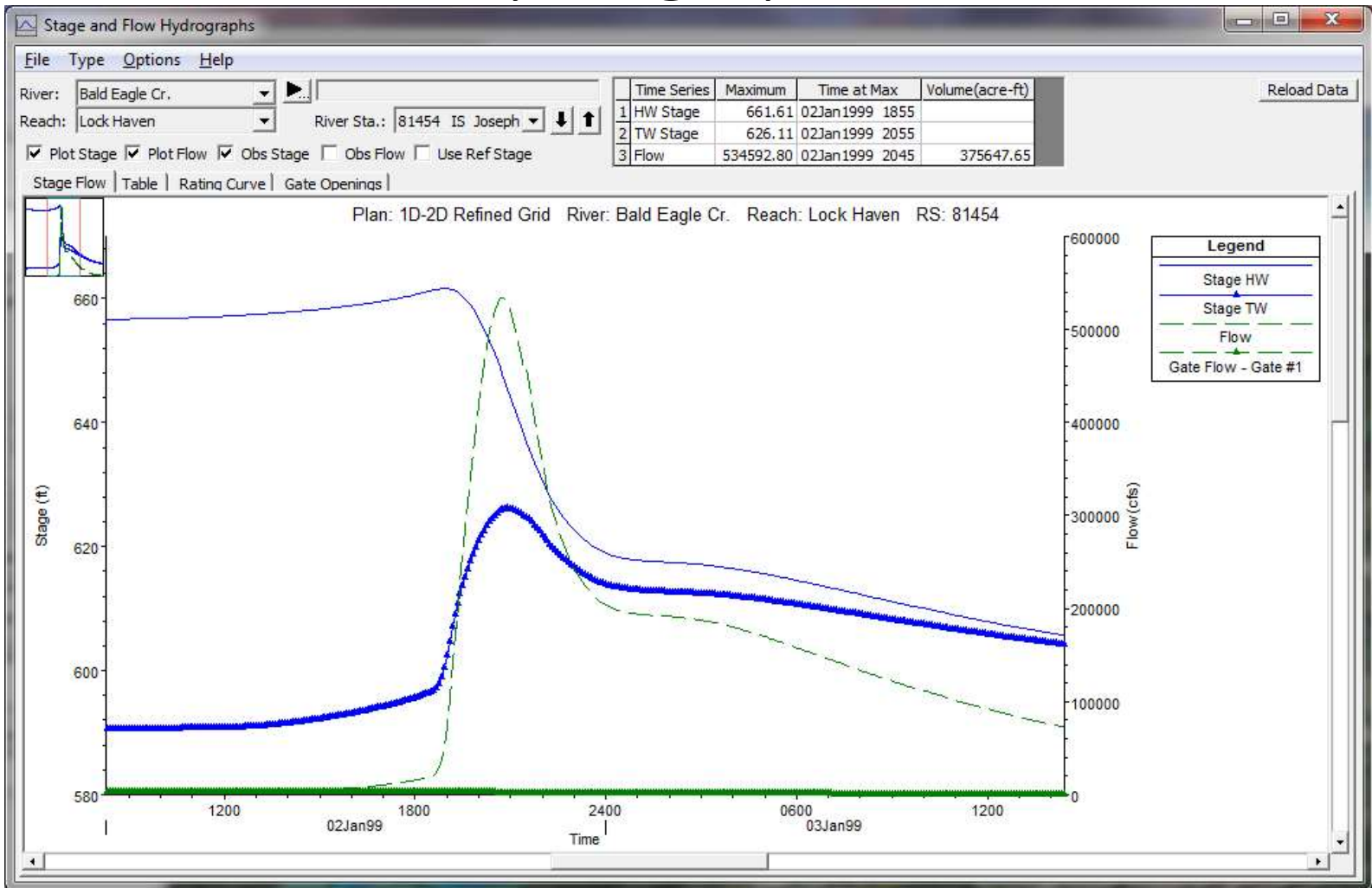


- Breach Results and Visualization





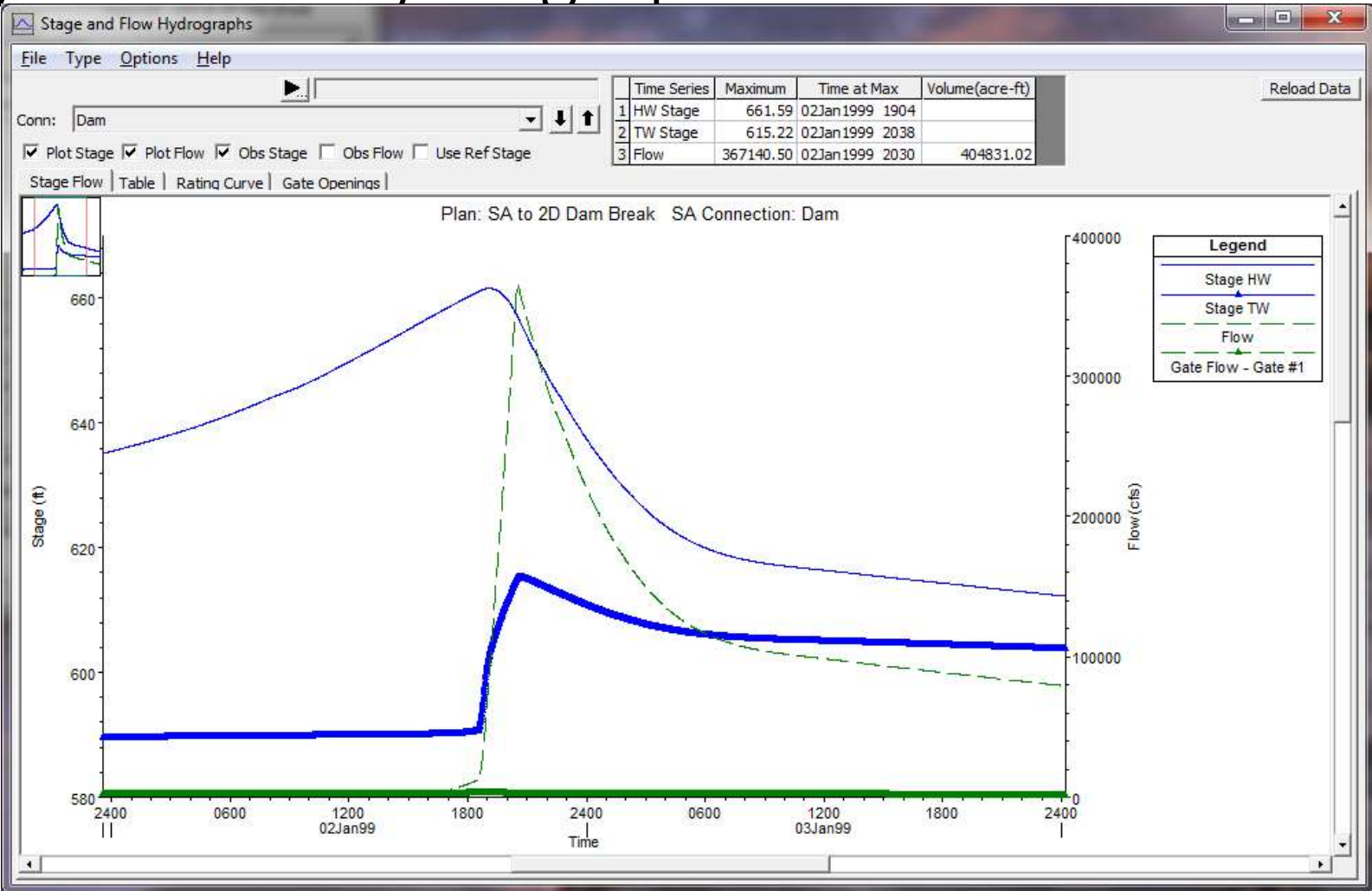
# Inline Structure Hydrograph







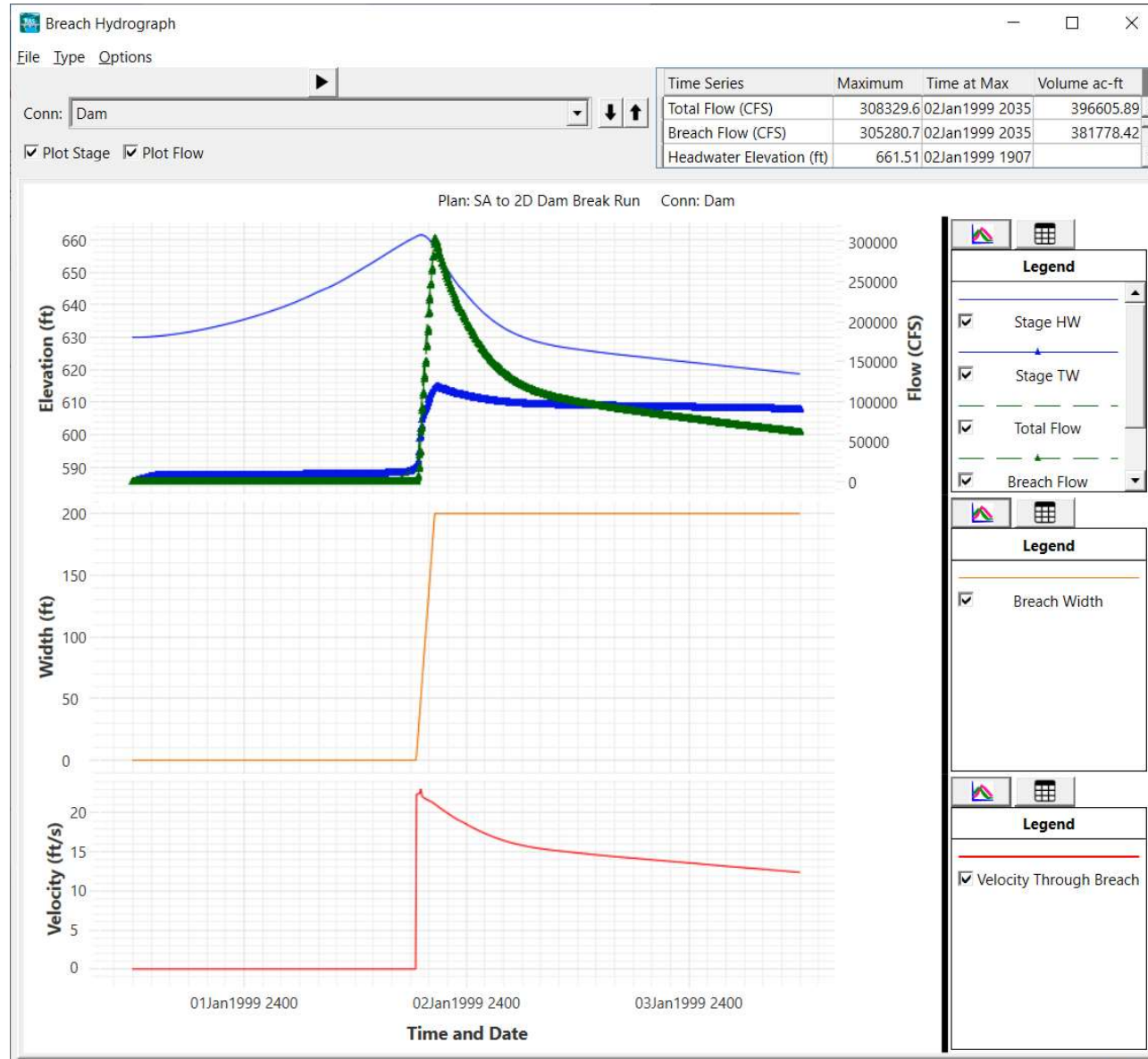
# SA/2D Conn Hydrograph





# Breach Hydrograph

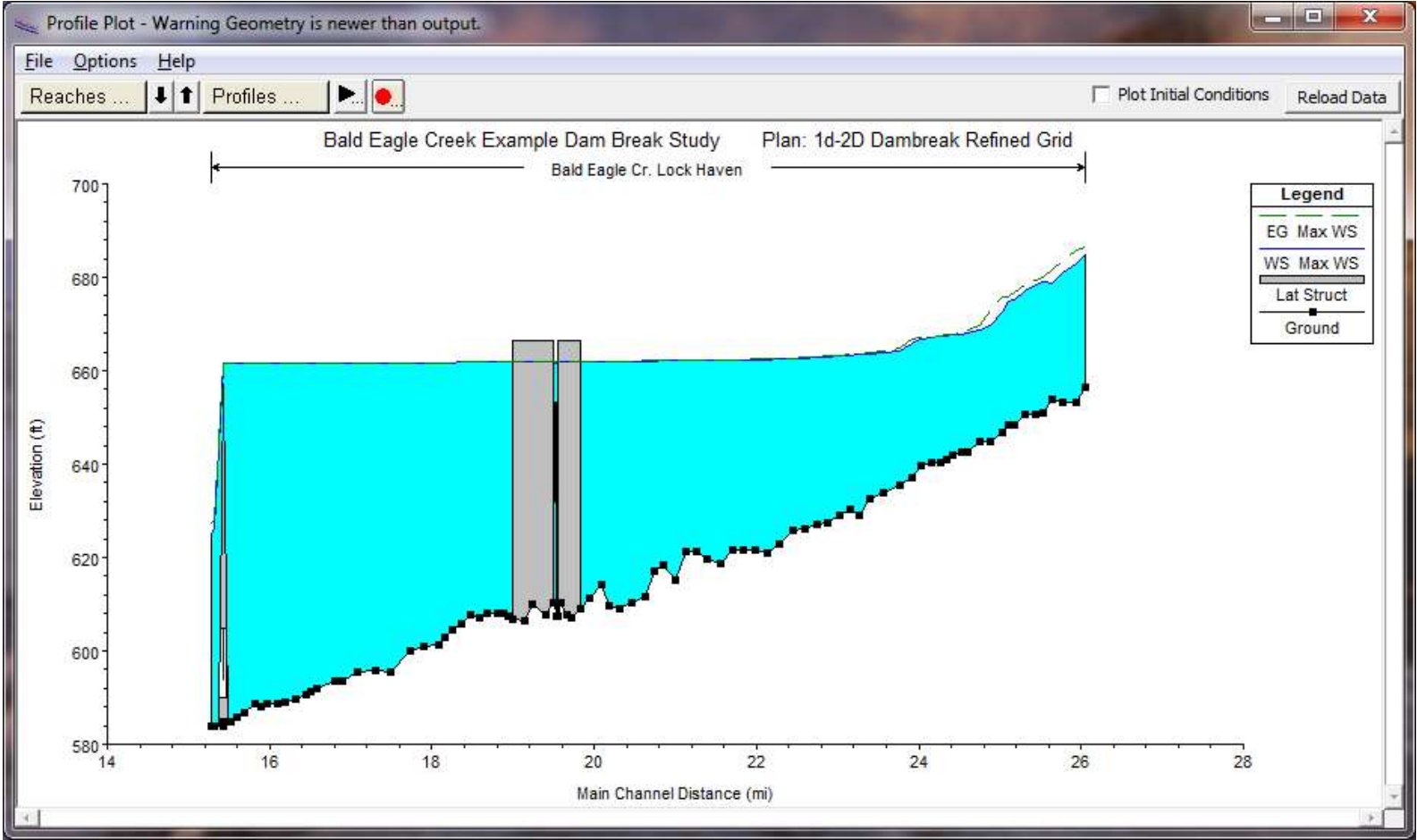
- Flow
- Stage
- Breach Progression
- Velocity





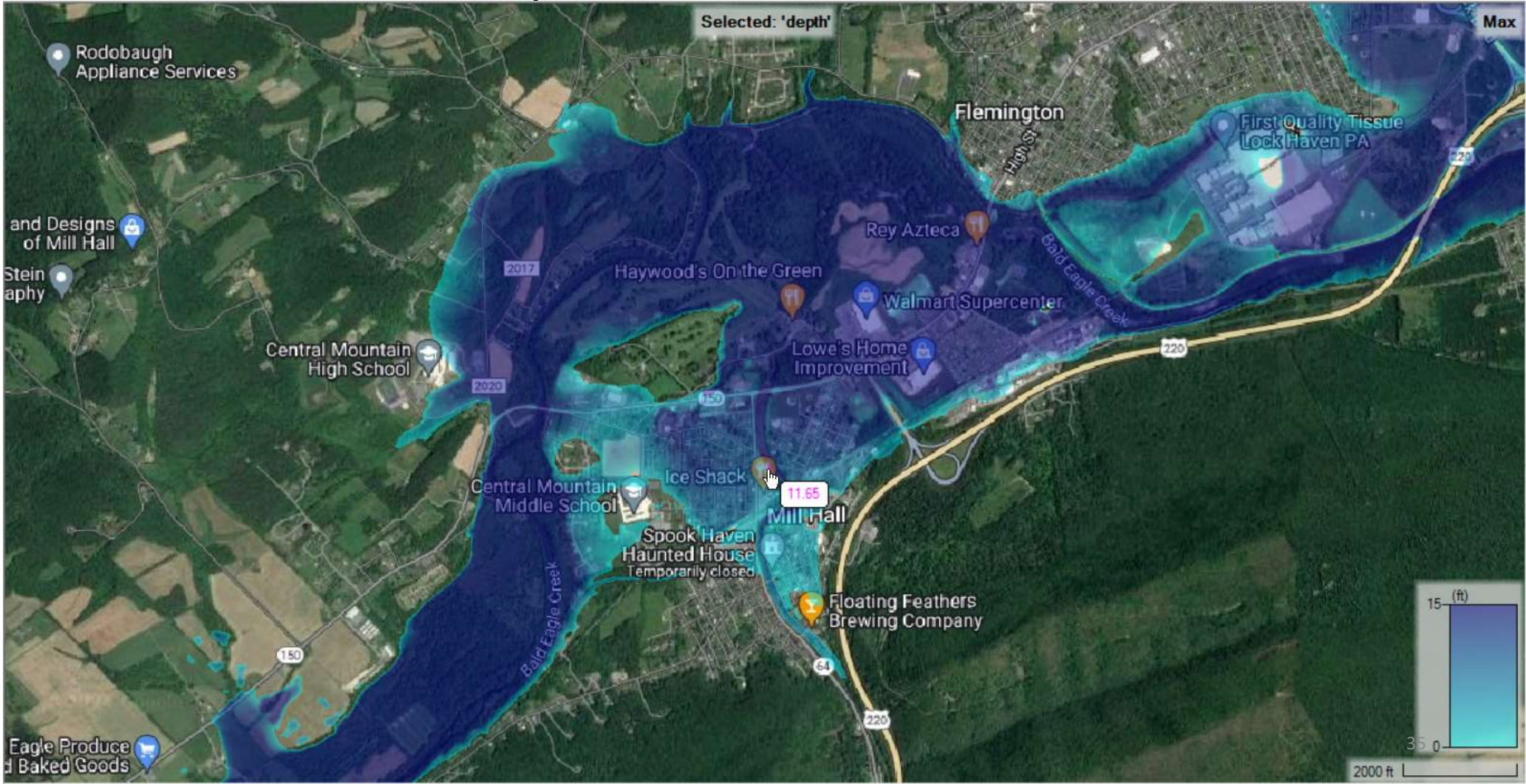


# 1D River Reach WS Profile Plots





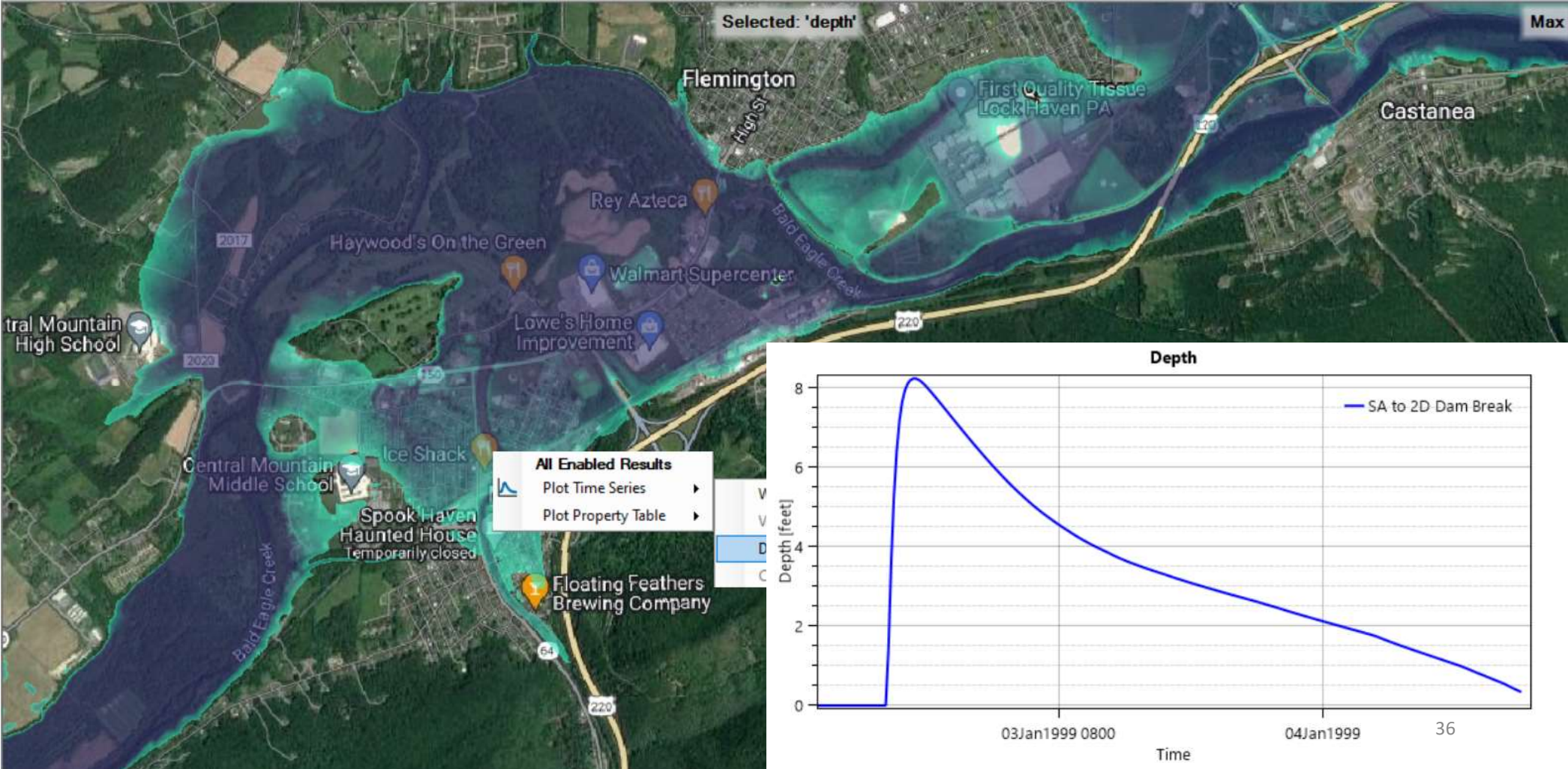
# Inundation Maps







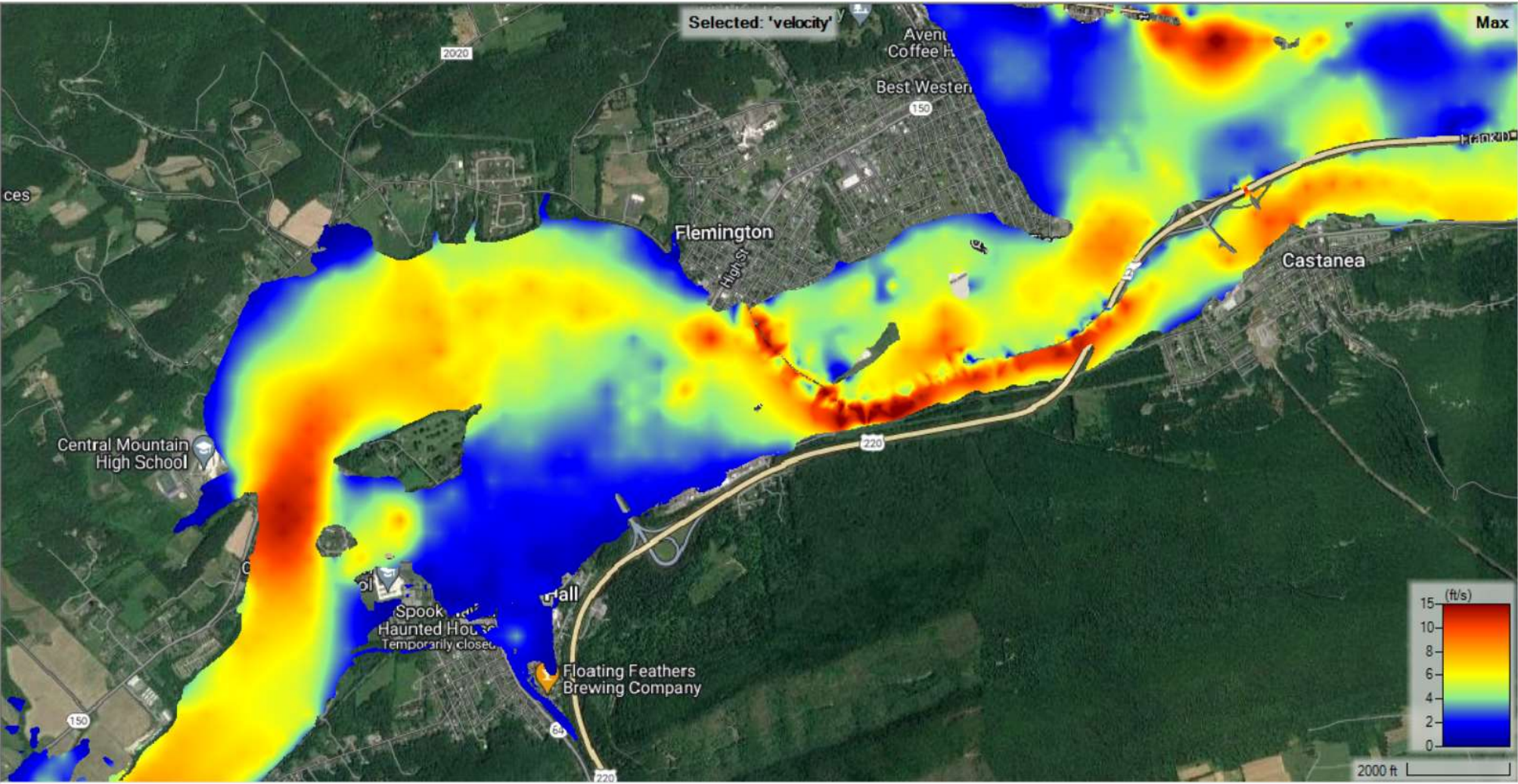
# Hydrographs – RAS Mapper







# Velocities







# Arrival Time



Results Map Parameters

**Map Type**

- Depth \* Velocity
- Depth \* Velocity^2
- Energy (Depth)
- Energy (Elevation)
- Pressure
- Arrival Time**
- Arrival Time (Max)
- Recession
- Duration
- Percent Time Inundated
- Stream Power
- Wet Cells
- Final N Values
- Pipe Water Surface Elevation
- Pipe Depth
- Pipe Percent Full
- Mesh Cell Size
- Additional 2D Variables

**Parameters**

Start Time at: 02JAN1999 18:34:00

Start of simulation

Offset from start of simulation

Fixed date/time (08JUL1995 17:00:00)

02Jan1999 18:34

Use Depth Threshold as Delta from Start

**Unsteady Profile**

Hours

Days

**Parameters**

Threshold Depth: 2

**Map Output Mode**

Generated for Current View (in memory)

Raster (with Associated Terrain)

Point Feature Layer:

**Stored (saved to disk)**

Raster based on Terrain: Terrain50

Point Feature Layer:

Polygon Boundary at Value: Min: 0 Max: Max

Map Type	Layer Name
Arrival Time	Arrival Time

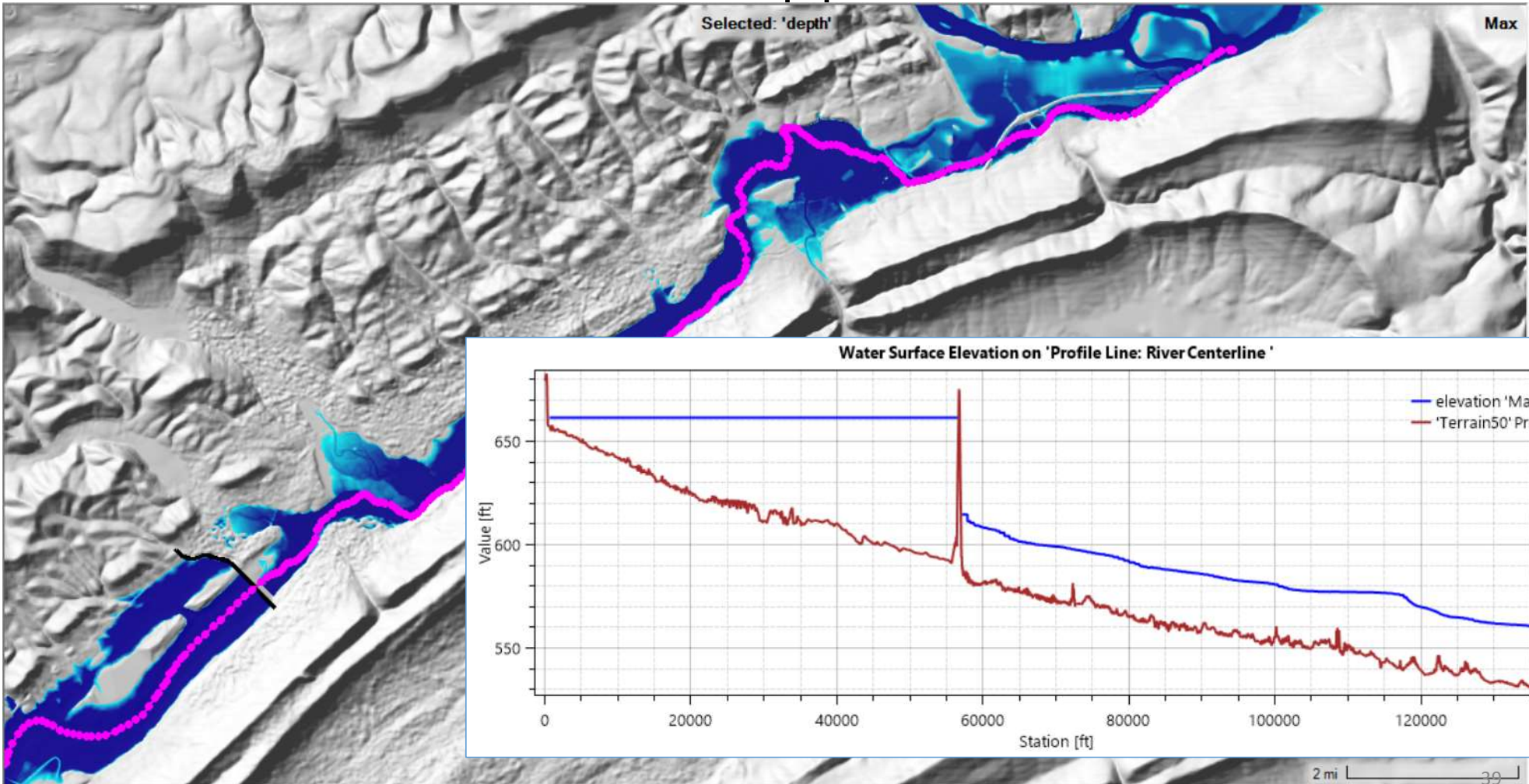
Map Type: A Map layer will be created for The time (from a specified Start Time) for water to reach a specified flood depth.  
 Map Mode: Map results are computed using the specified Terrain and stored to disk.

Add Map Close





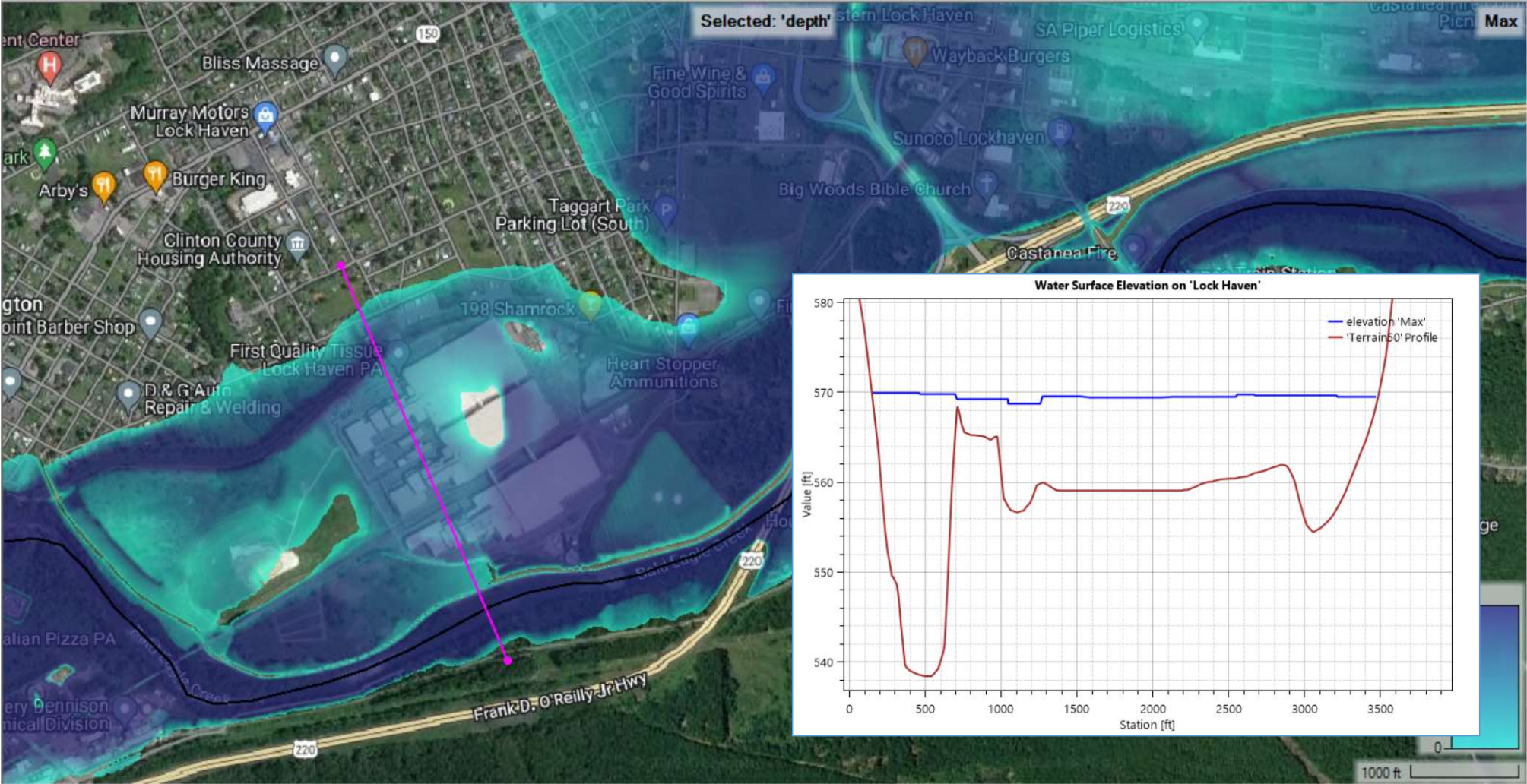
# Profile Lines – RAS Mapper







# Profile Lines - Location



# Questions?

