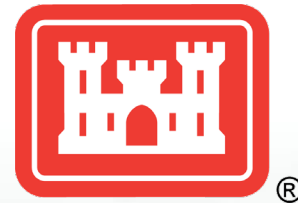


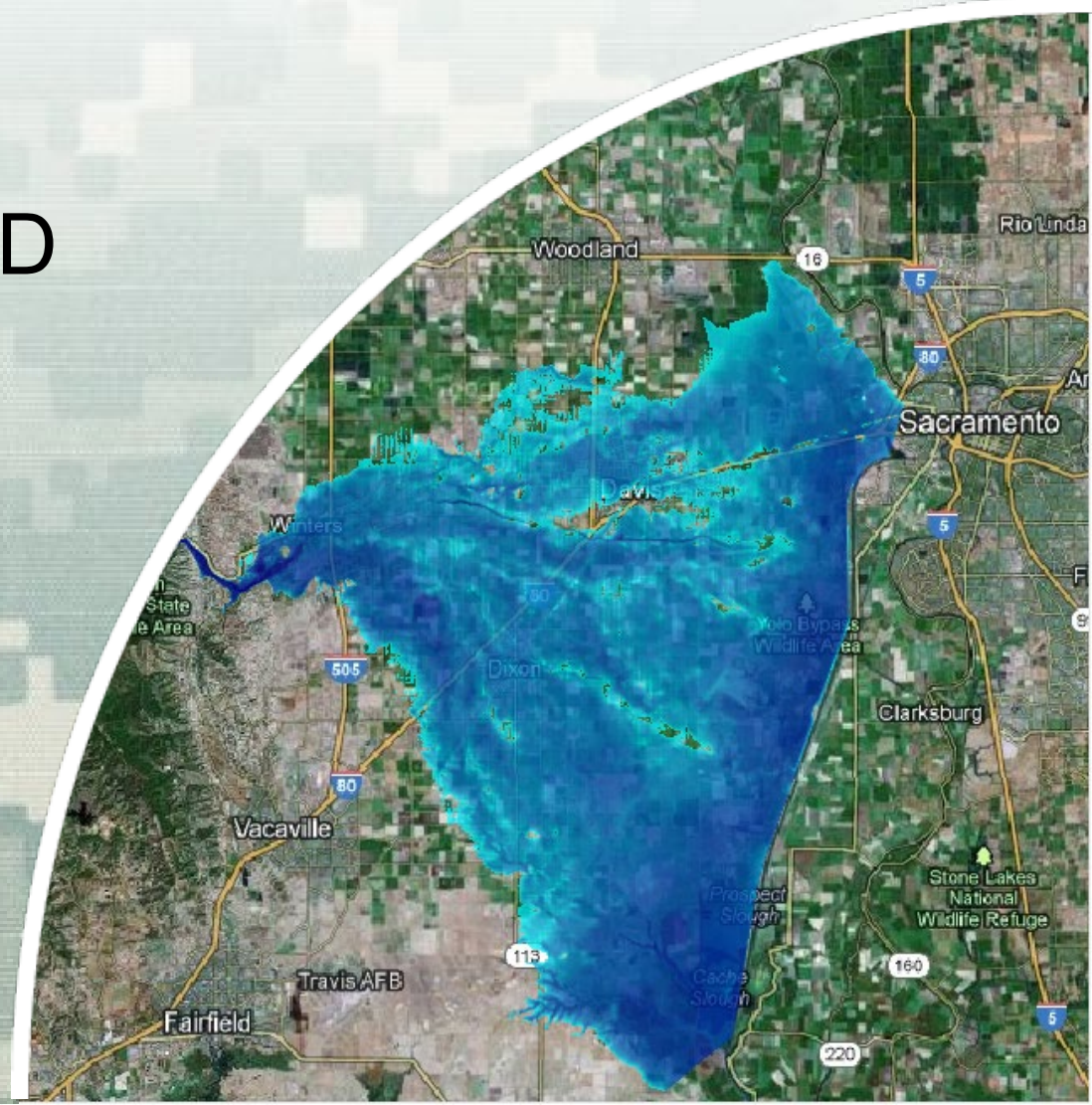
# Dam Breaching Analysis with Combined 1D and 2D Elements



Stanford Gibson, PhD

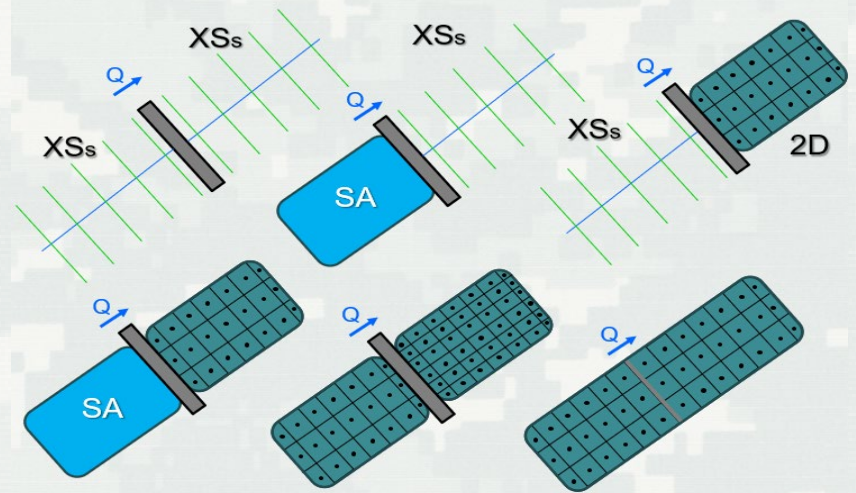
Slides by

Gary Brunner, P.E.

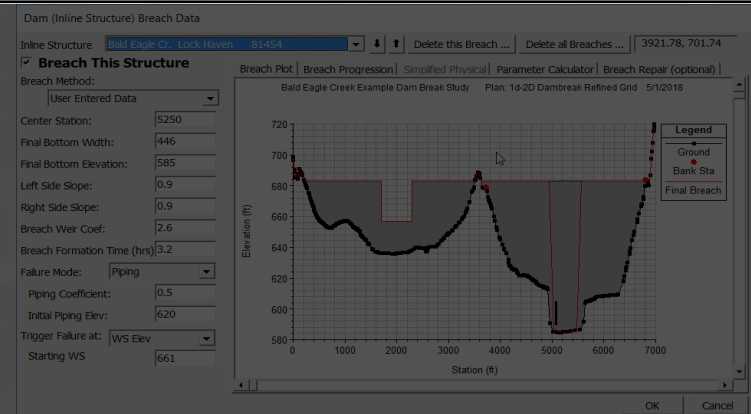


US Army Corps of Engineers  
**BUILDING STRONG**®

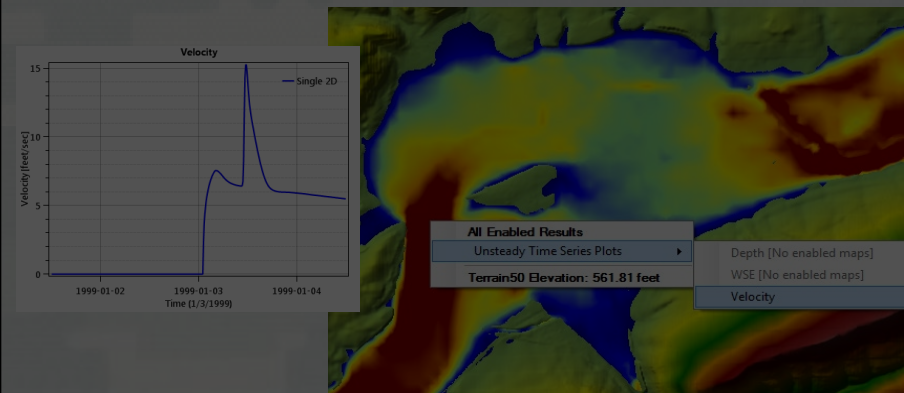
# 1. Six Dam Breach Model Configurations



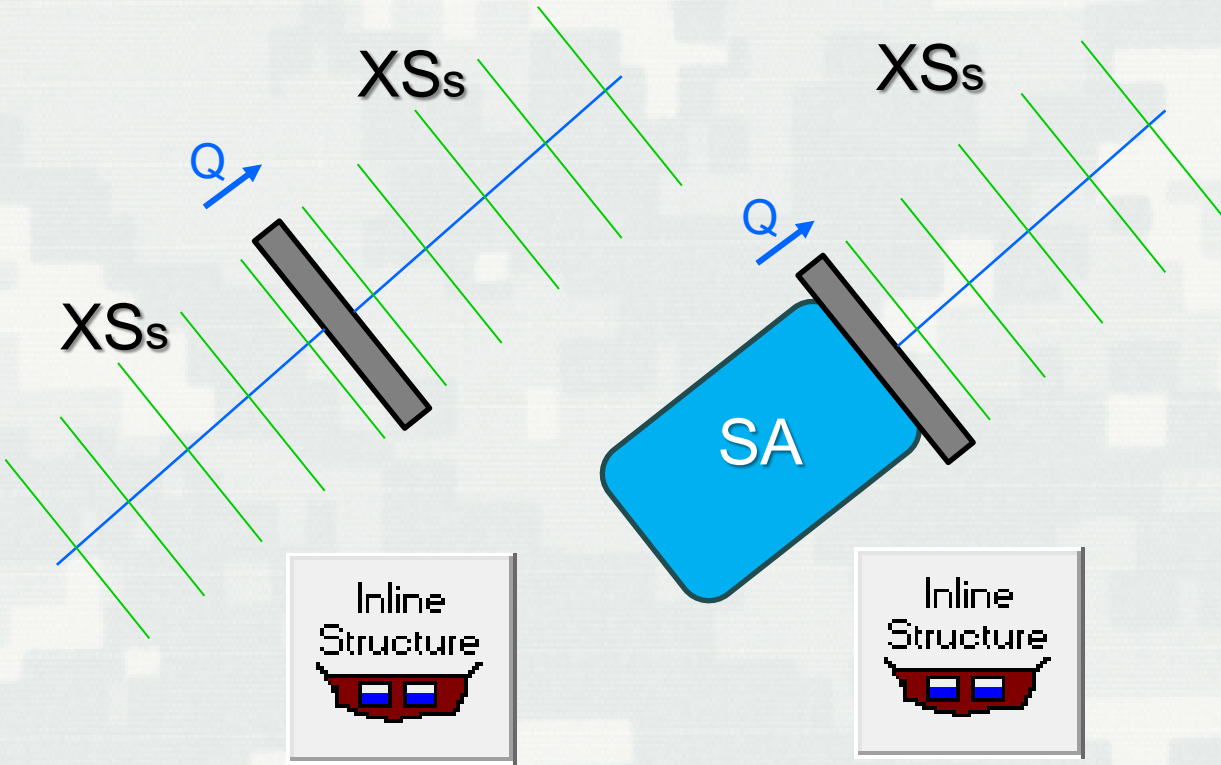
# 2. Breaching Options and Parameters



# 3. Breach Results and Visualization



# Breach Model Configuration Options



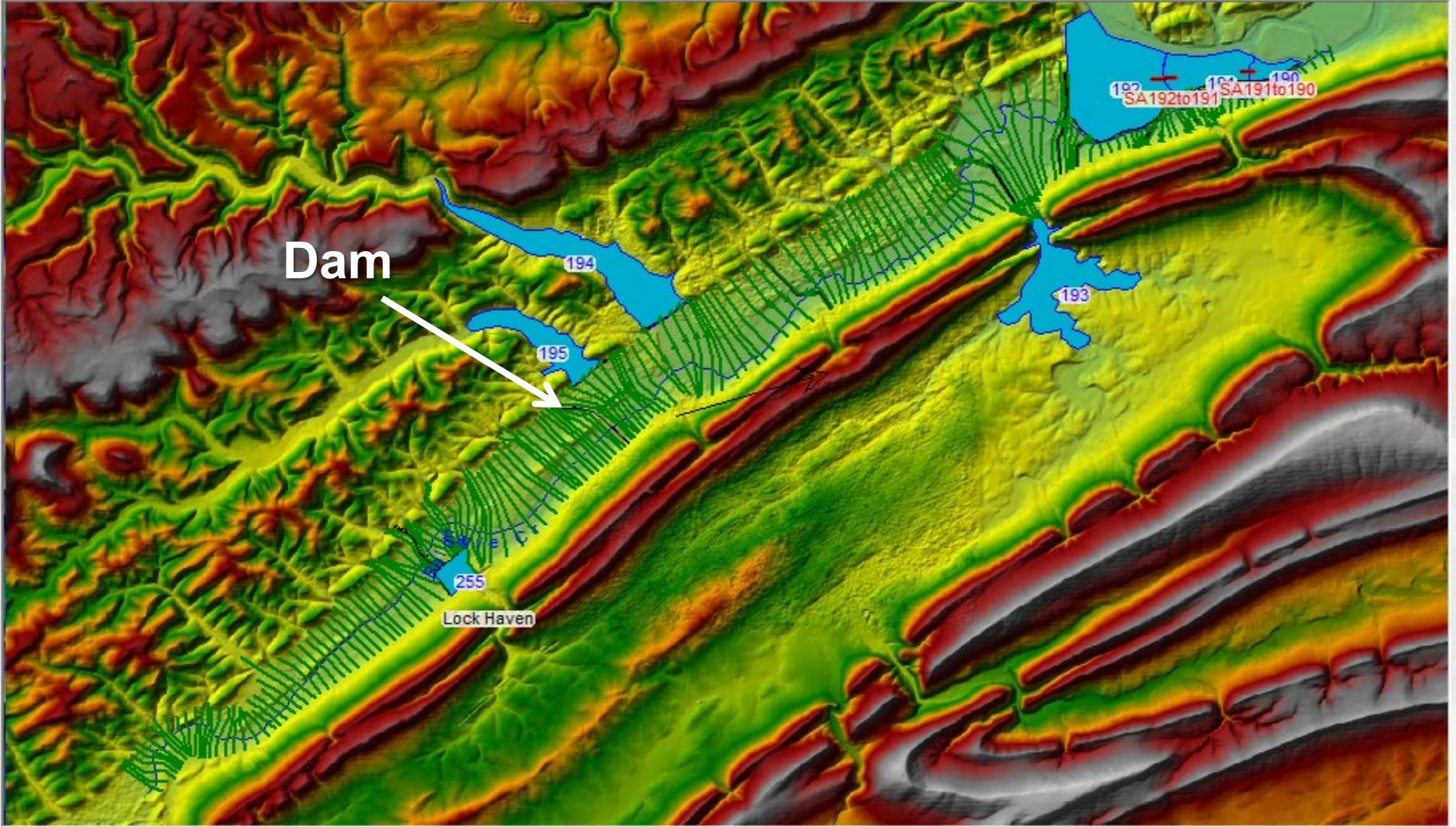
Pre-2D  
Options



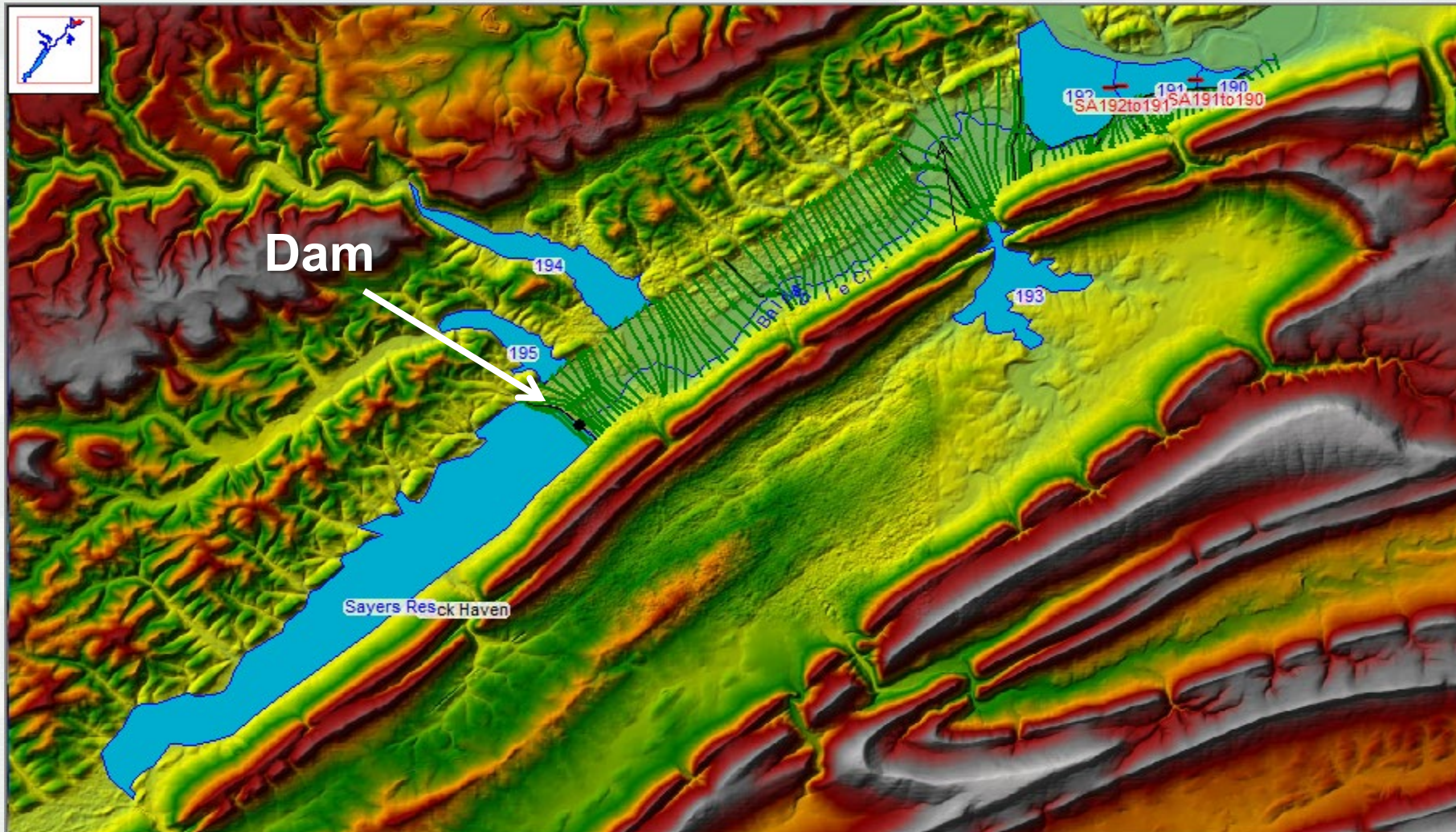


# 1D Dam Breaching Analysis

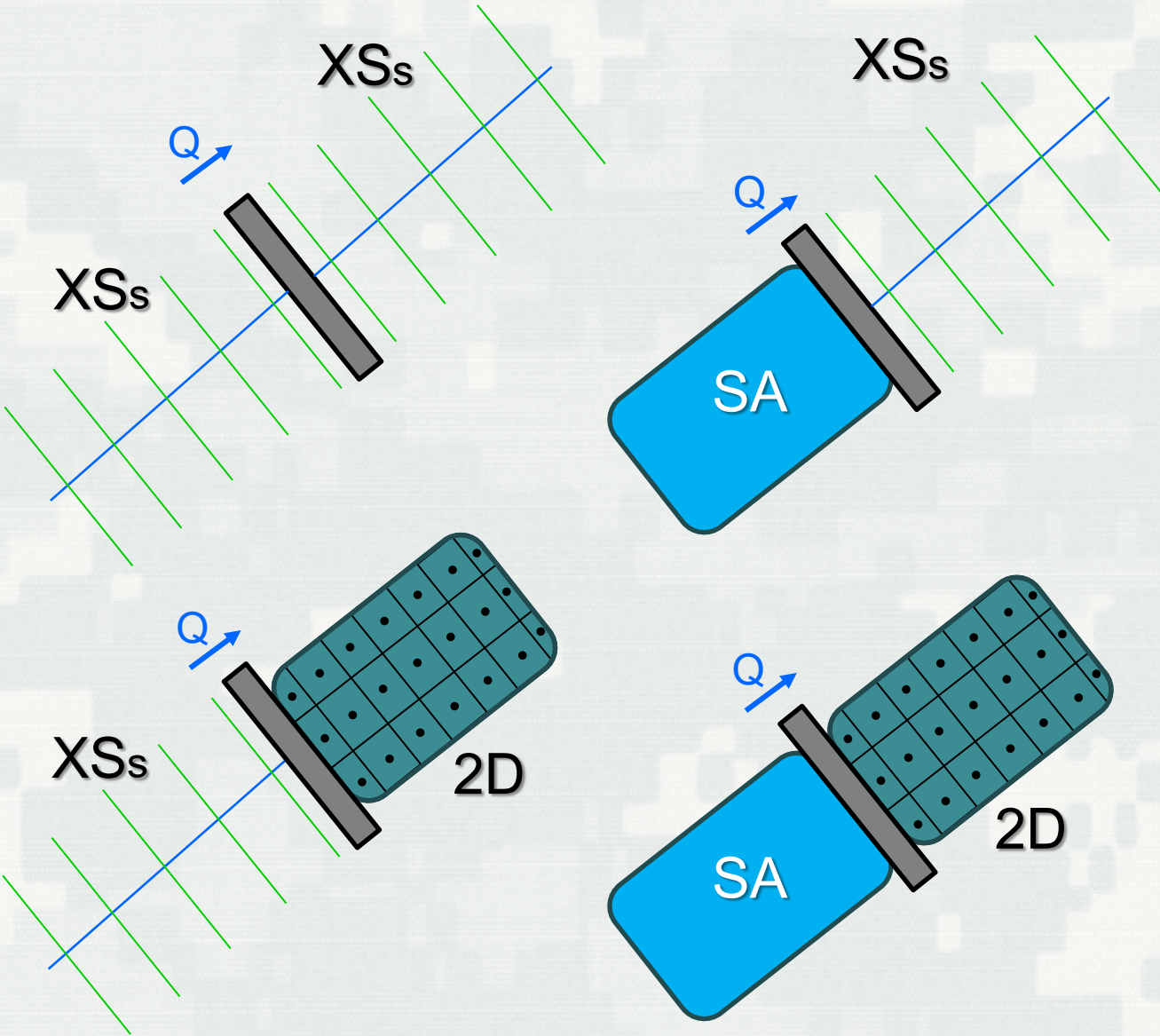
## Cross Section for Pool and Downstream



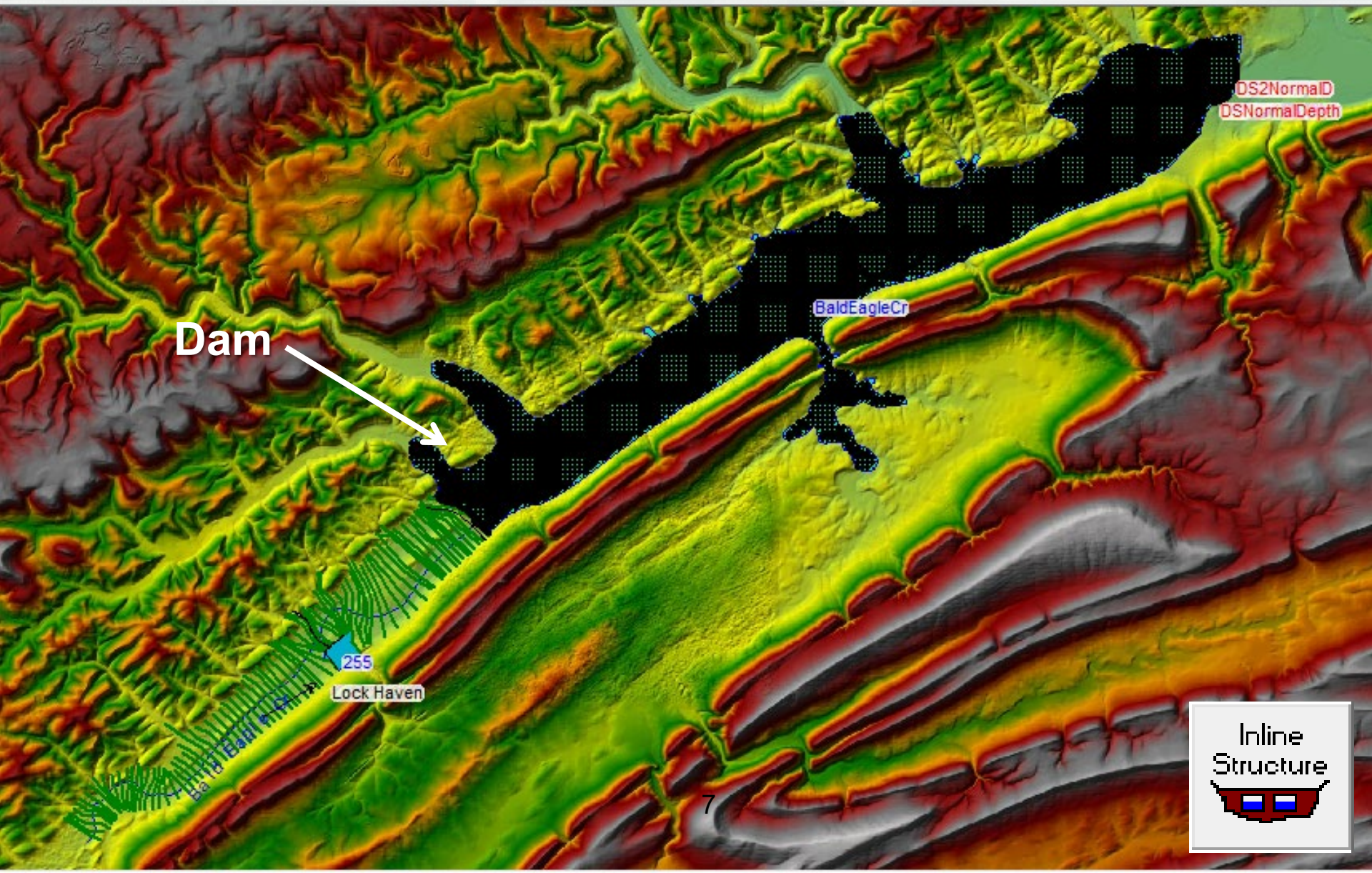
# 1D Dam Breaching Analysis Storage Area Pool and XS Downstream



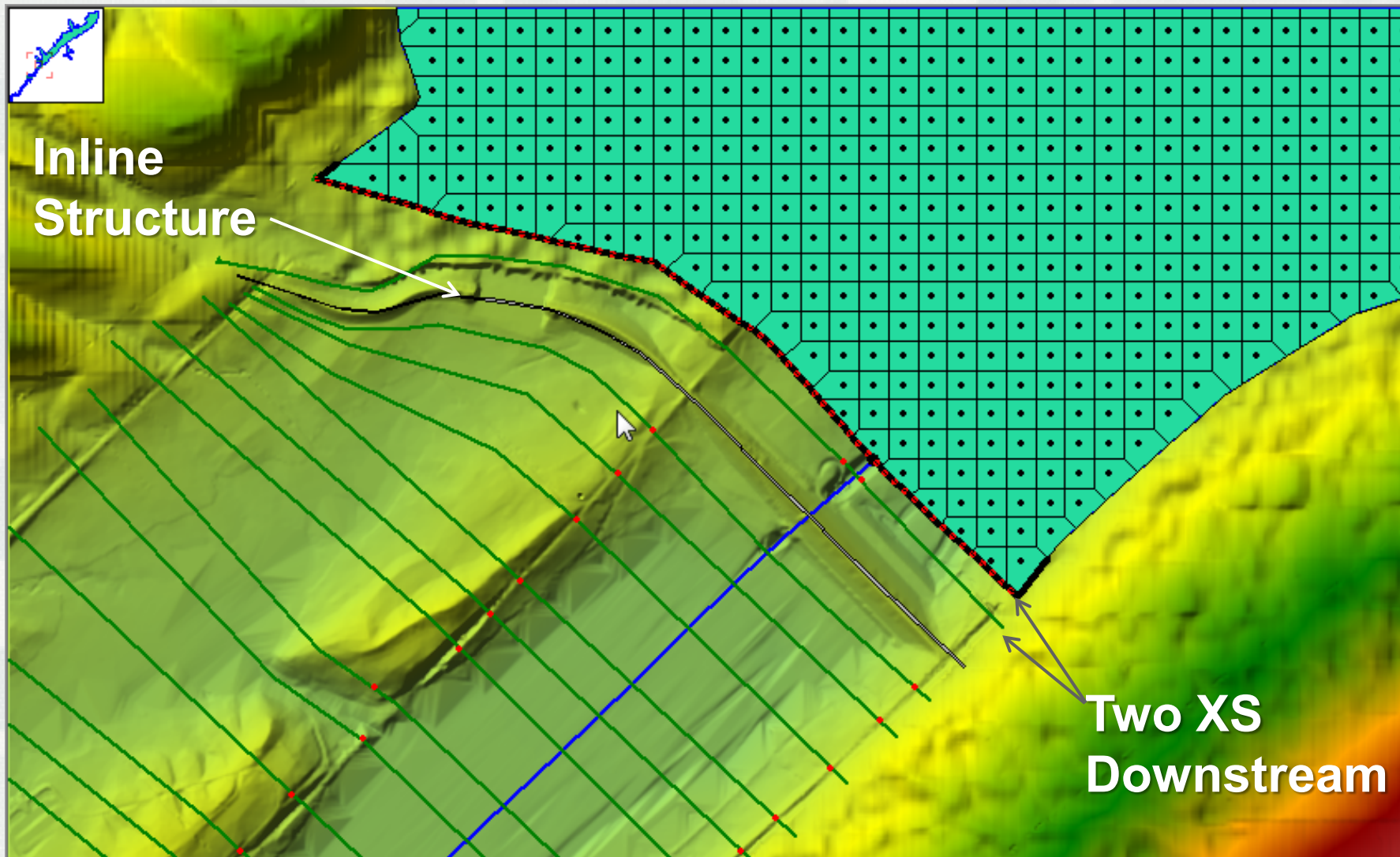
# Breach Model Configuration Options



# 1D River Reach Pool and 2D Downstream

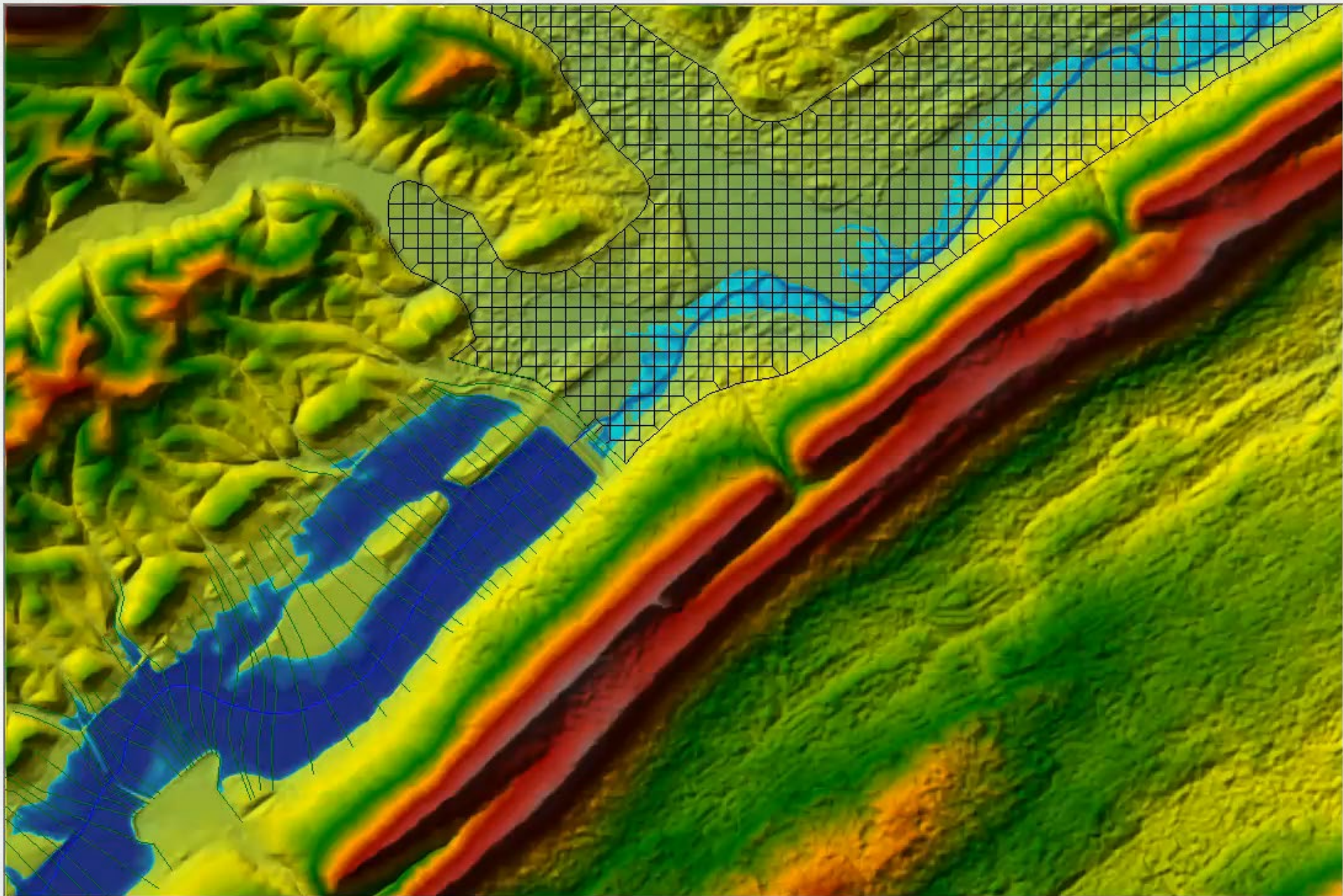


# 1D River Reach Pool and 2D Downstream

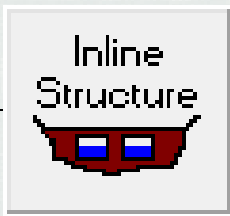
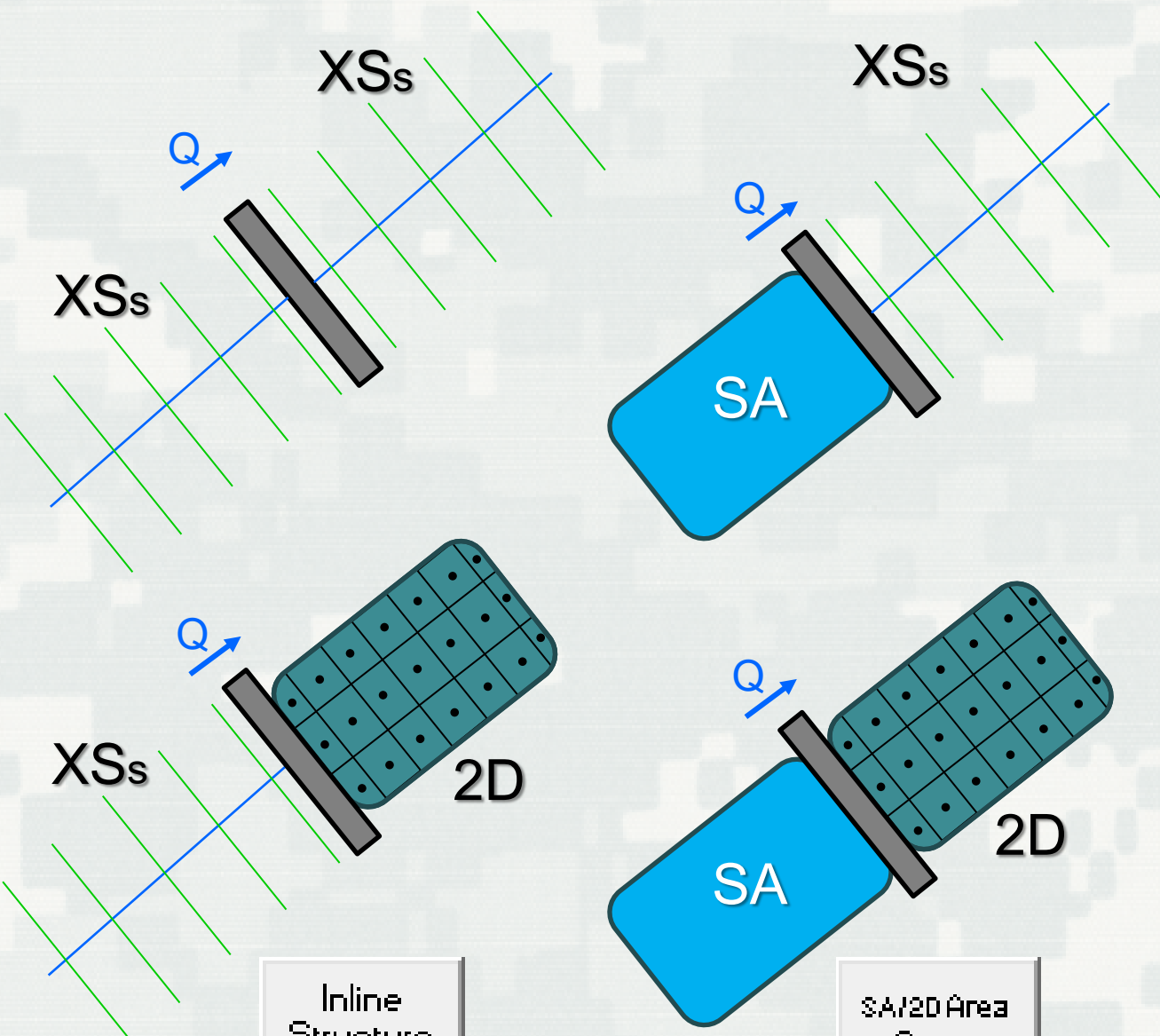




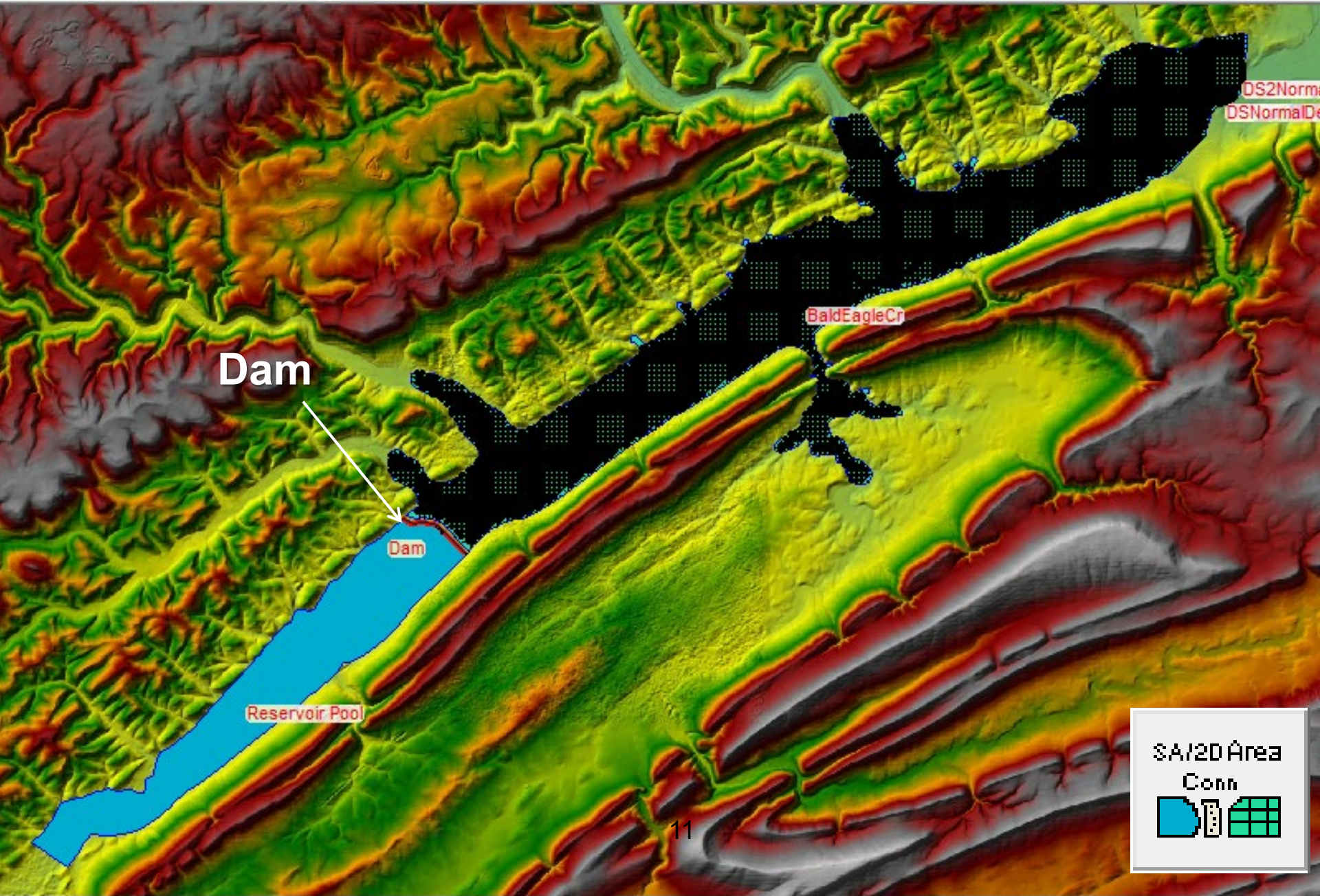
# Animation 1D River Reach Pool and 2D Downstream



# Breach Model Configuration Options



# 1D Storage Area Pool and 2D Downstream



Dam

Dam

Reservoir Pool

BaldEagleCr

DS2Norm  
DSNormalD

SA/2D Area  
Conn

The legend consists of two items: a blue square representing the 1D storage area and a black square with a white grid representing the 2D downstream area.

# 1D Storage Area Pool and 2D Downstream

Geometric Data - SA to 2D Flow Area - Detailed

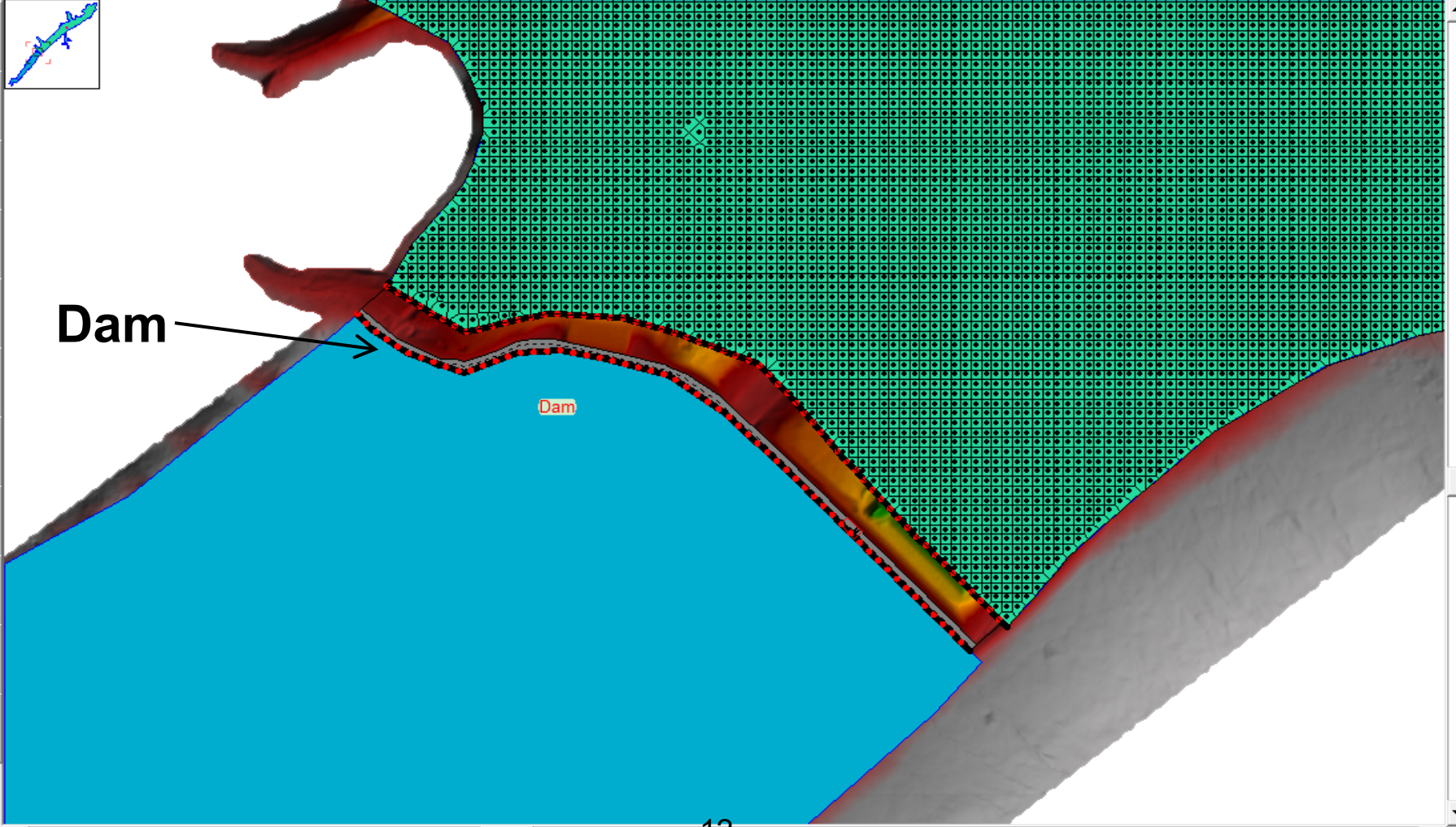
File Edit Options View Tables Tools GIS Tools Help

Tools  
Editors

River Reach Storage Area 2D Flow Area **SA/2D Area Conn** SA/2D Area BC Lines IC Points 2D Area Break Lines 2D Area Mann n Regions Pump Station RS 12.99

Description Plot WS extents for Profile: (none)

- Junct.
- Cross Section
- Brdg/Culv
- Inline Structure
- Lateral Structure
- Storage Area
- 2D Flow Area
- SA/2D Area Conn
- Pump Station
- HTab Param.
- View Picture



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# Steps to Connect a SA to a 2D Flow Area with a SA/2D Area Hydraulic Connection

- Draw the Storage Area and enter its data
- Draw the 2D Flow Area and create Mesh
- Using the **SA/2D Area Conn** drawing tool
  - ▶ draw the line that represents the hydraulic Structure from left to right looking downstream
- Select the **SA/2d Area Conn** data editor
  - ▶ Enter the “From” and “To” connections
  - ▶ Enter the top of dam and spillway profile
  - ▶ Enter any gate data, etc...



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

Connection Data Editor - SA to 2D Flow Area - Detailed

File View Help

Connection: **Dam** [Apply Data]

Description [Breach (plan data) ...]

Connections

From: Storage area: Reservoir Pool [Set SA/2D ...] Weir Length: 7423.00

To: 2D flow area: BaldEagleCr [Set SA/2D ...] Centerline Length: 7423.02

[Centerline GIS Coords...]

Structure Type: Weir, Gates, Culverts, Outlet RC and Outlet TS [Terrain Profile ...]

Flap Gates: No Flap Gates

**Dam**

Elevation (ft)

Station (ft)

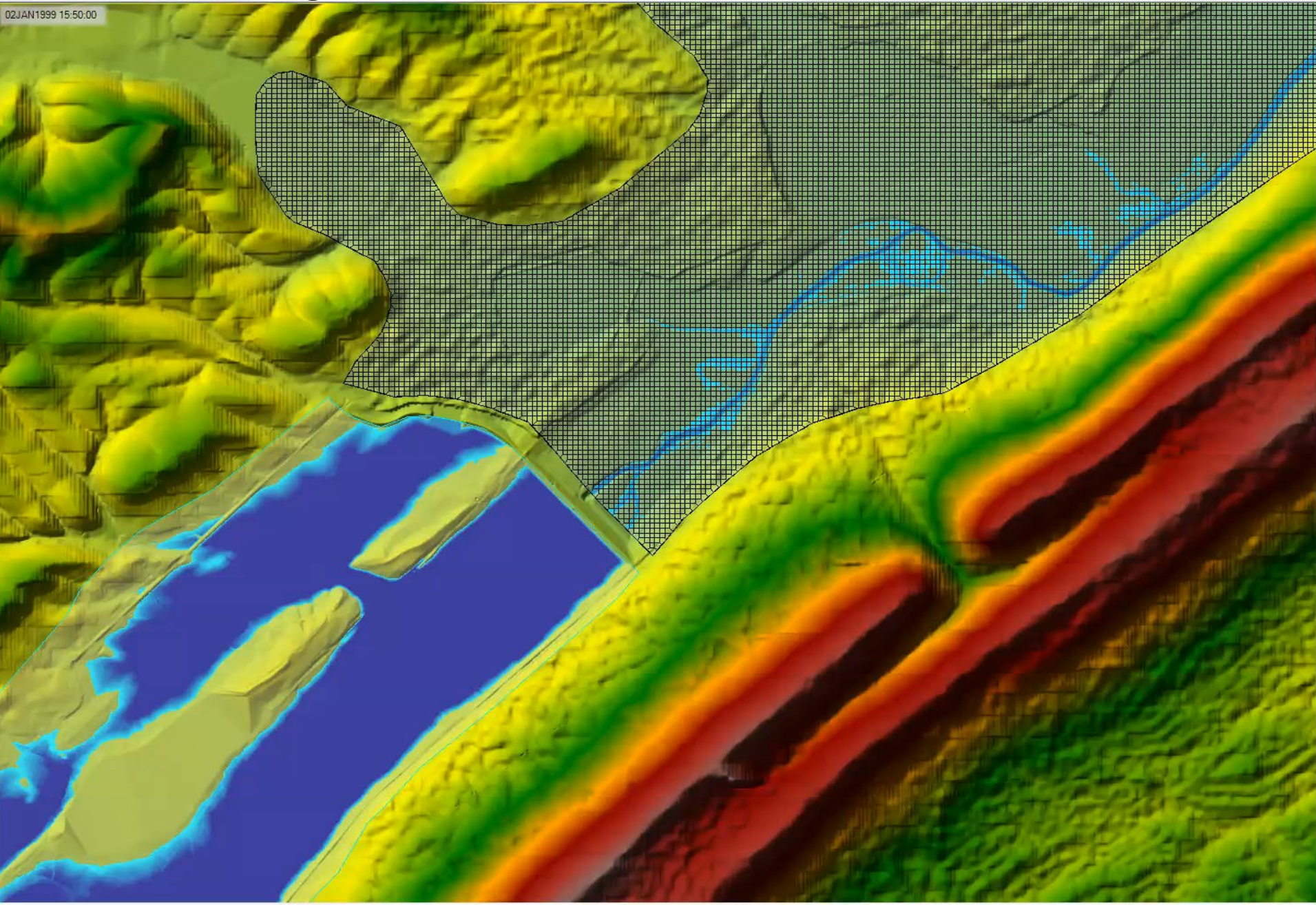
Legend

- Spillway
- TW Cell Min Elev
- Centerline Terrain

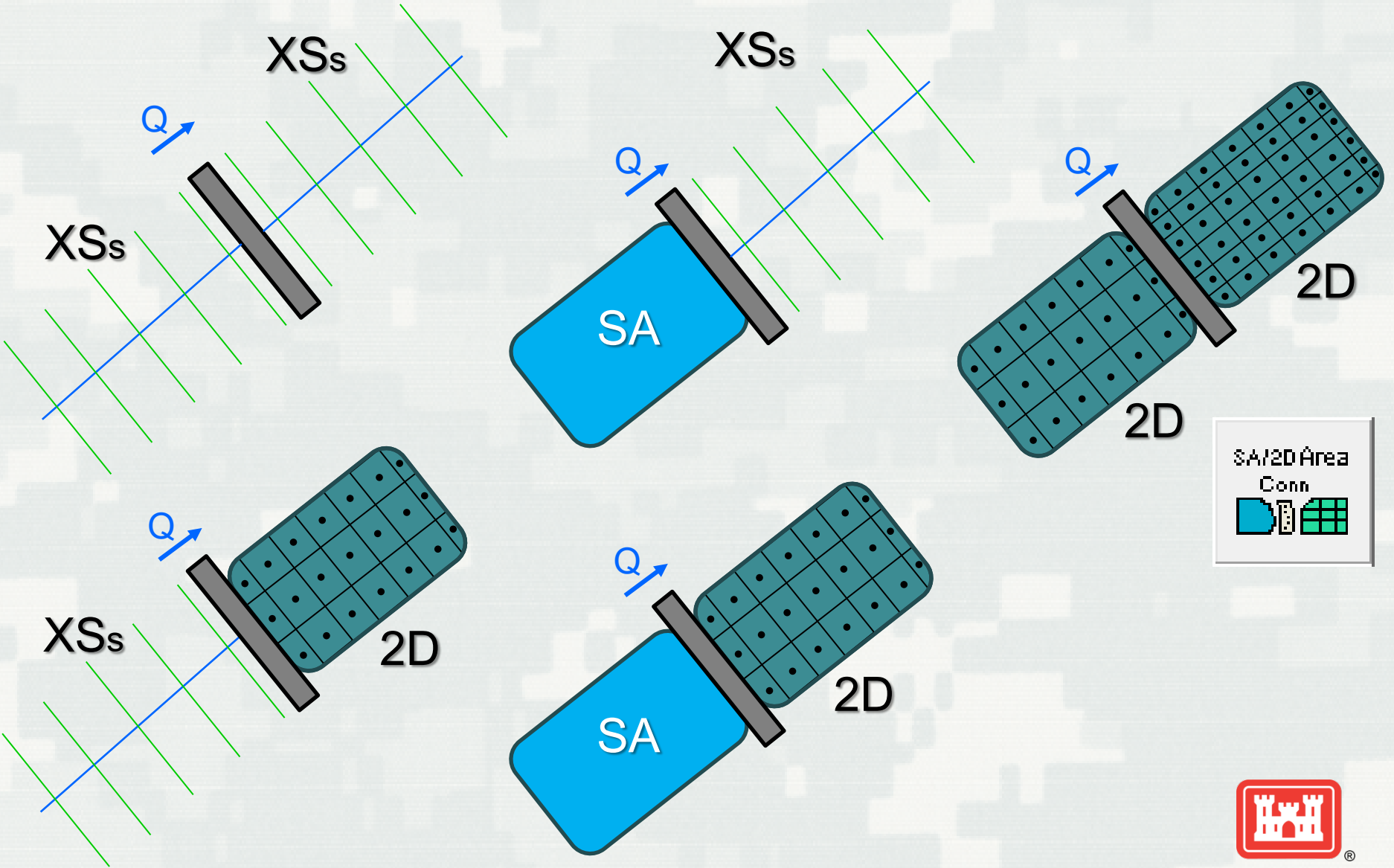
Select connection to Edit



# 1D Storage Area Pool → 2D Area Downstream



# Breach Model Configuration Options



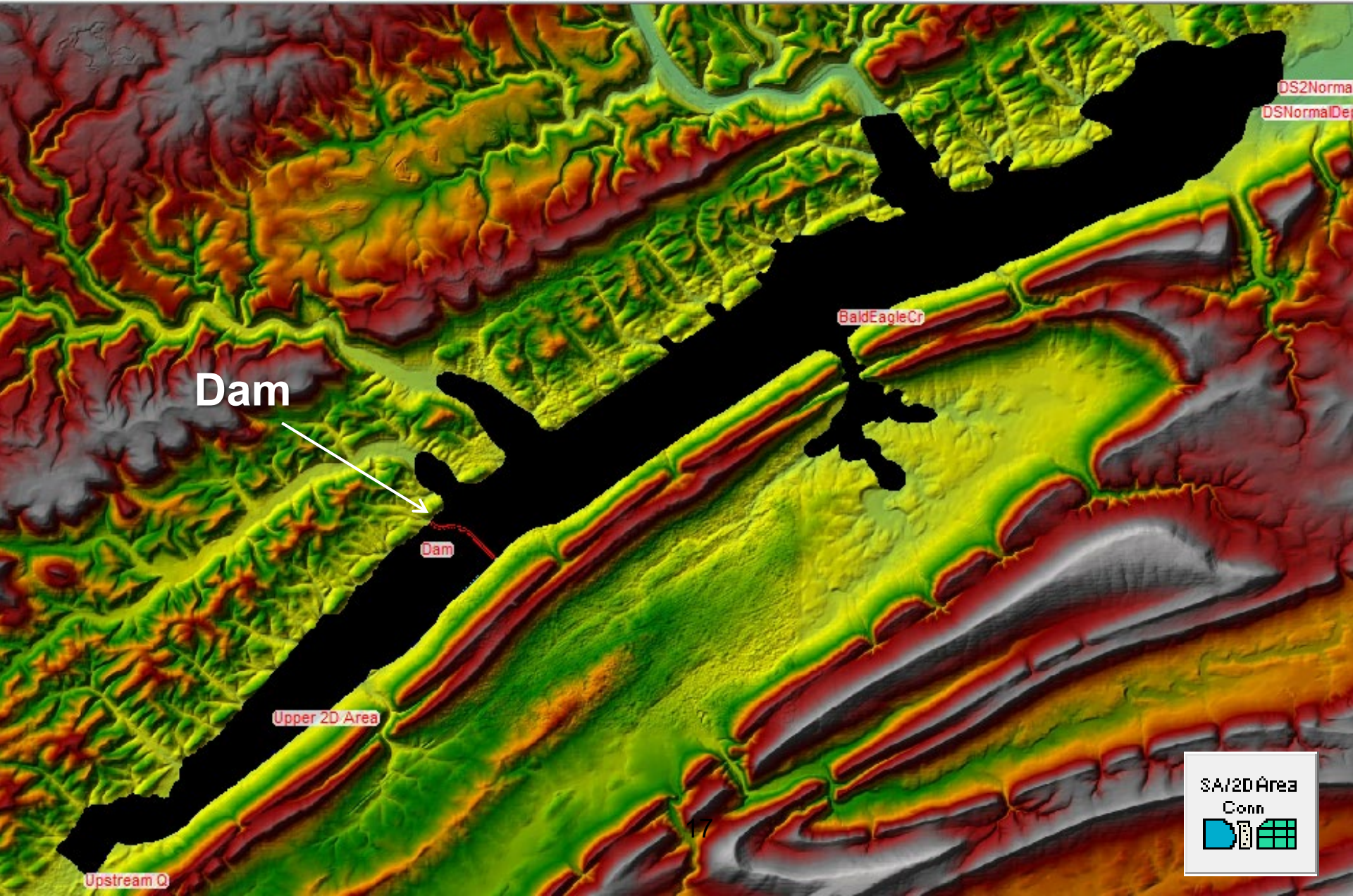
SA/2D Area  
Conn

The legend shows three components: a blue rounded rectangle, a grey barrier, and a teal rounded rectangle with a grid of dots.

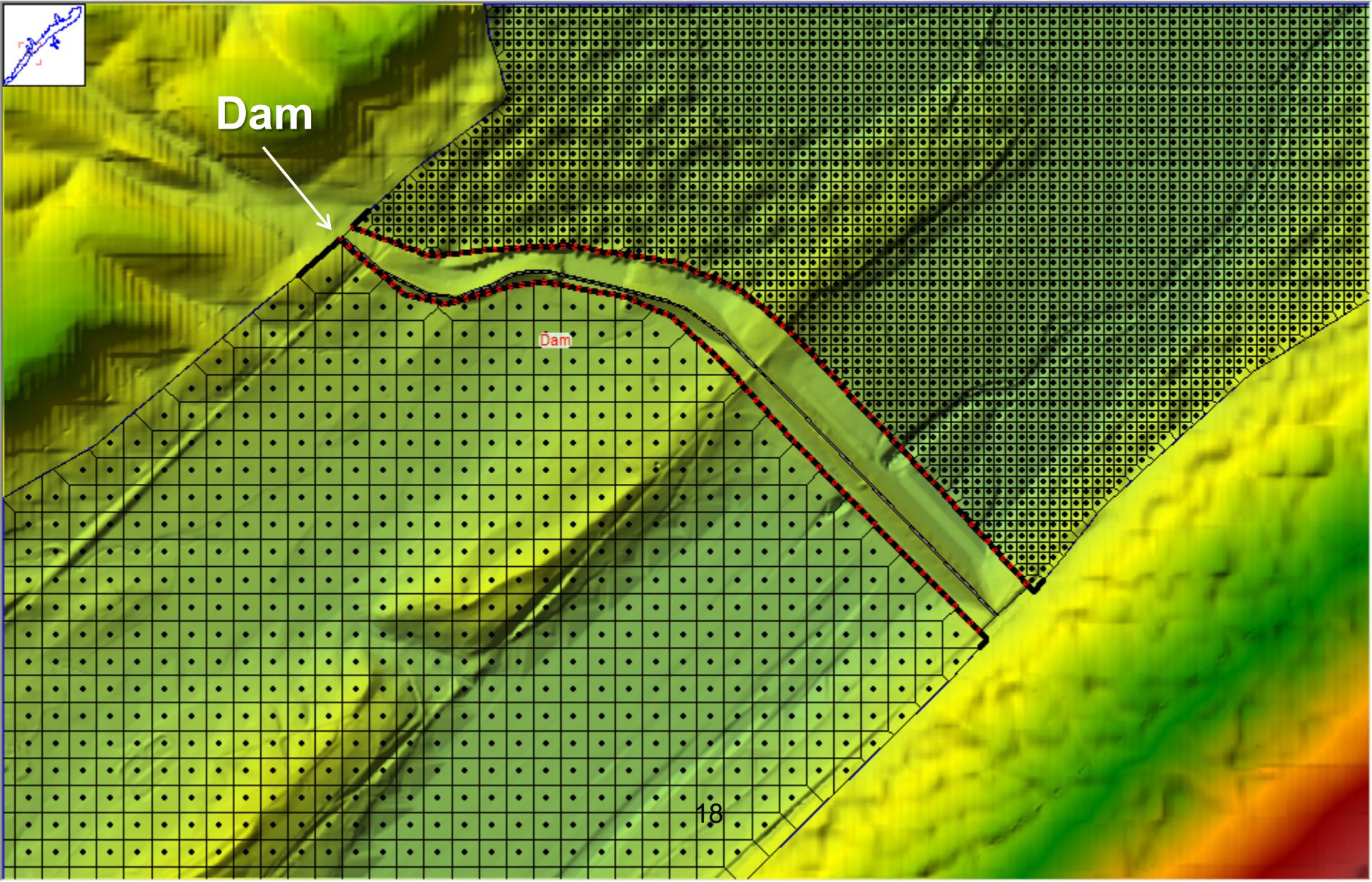




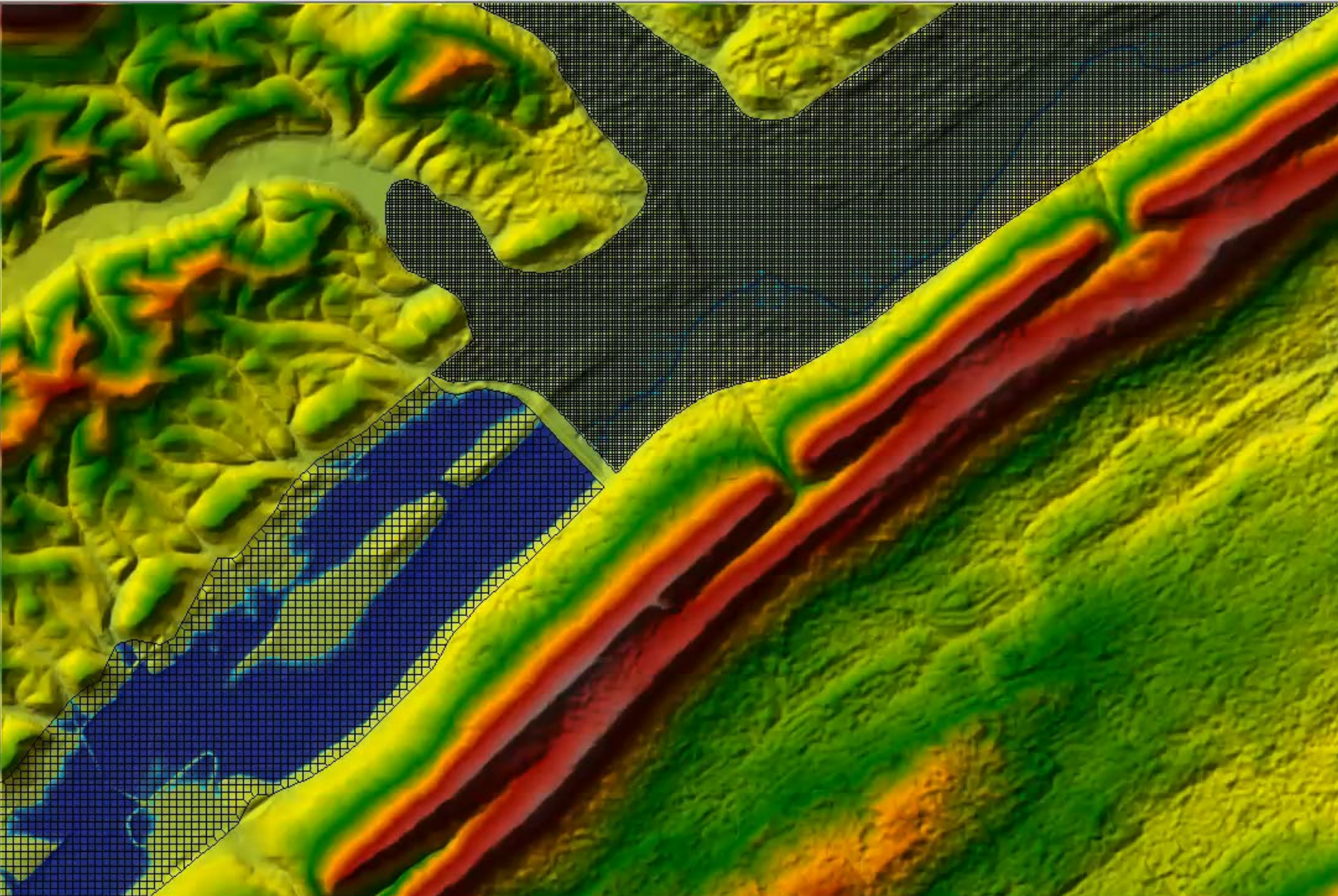
# 2D Reservoir Pool and 2D Downstream



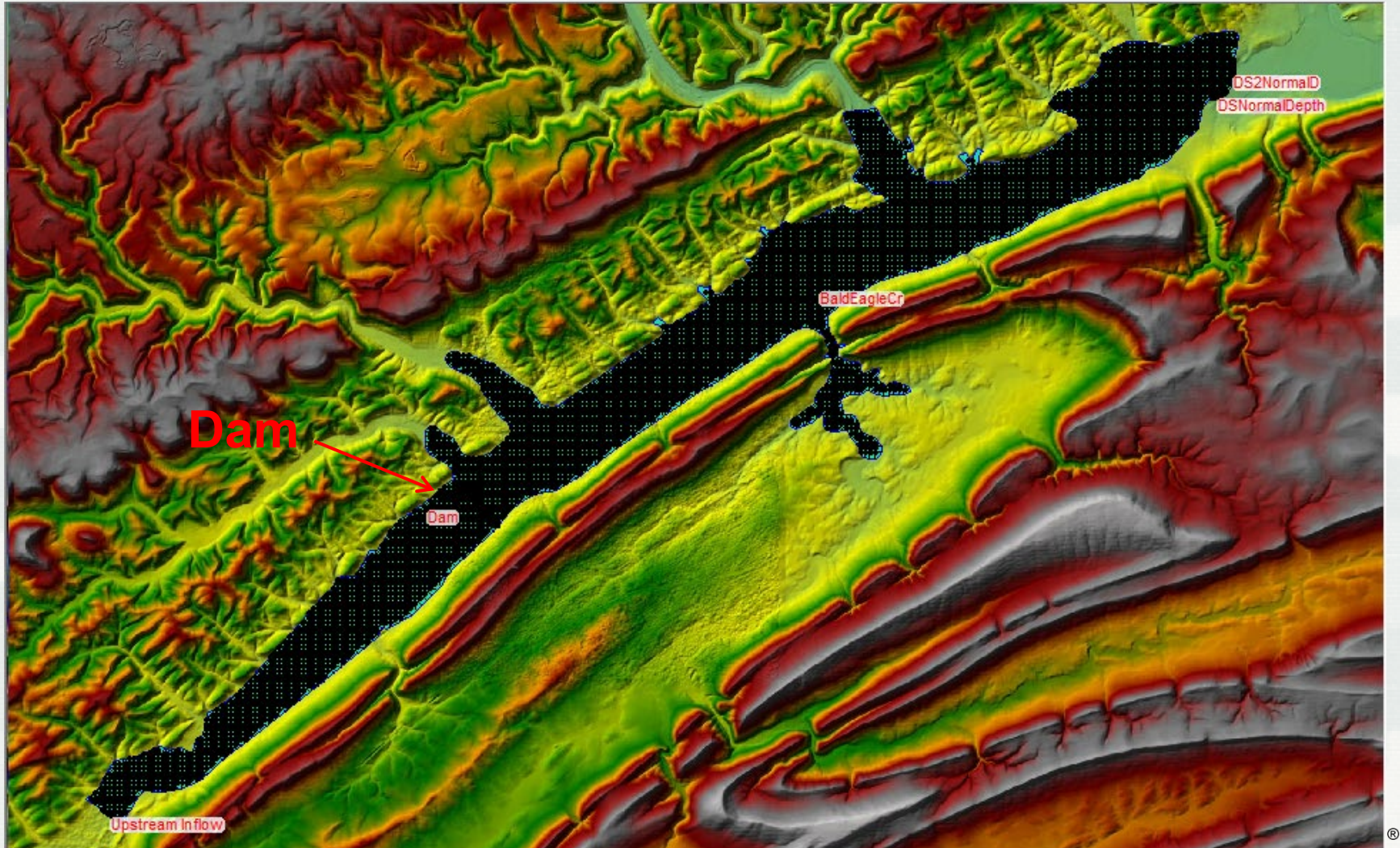
# 2D Reservoir Pool and 2D Downstream



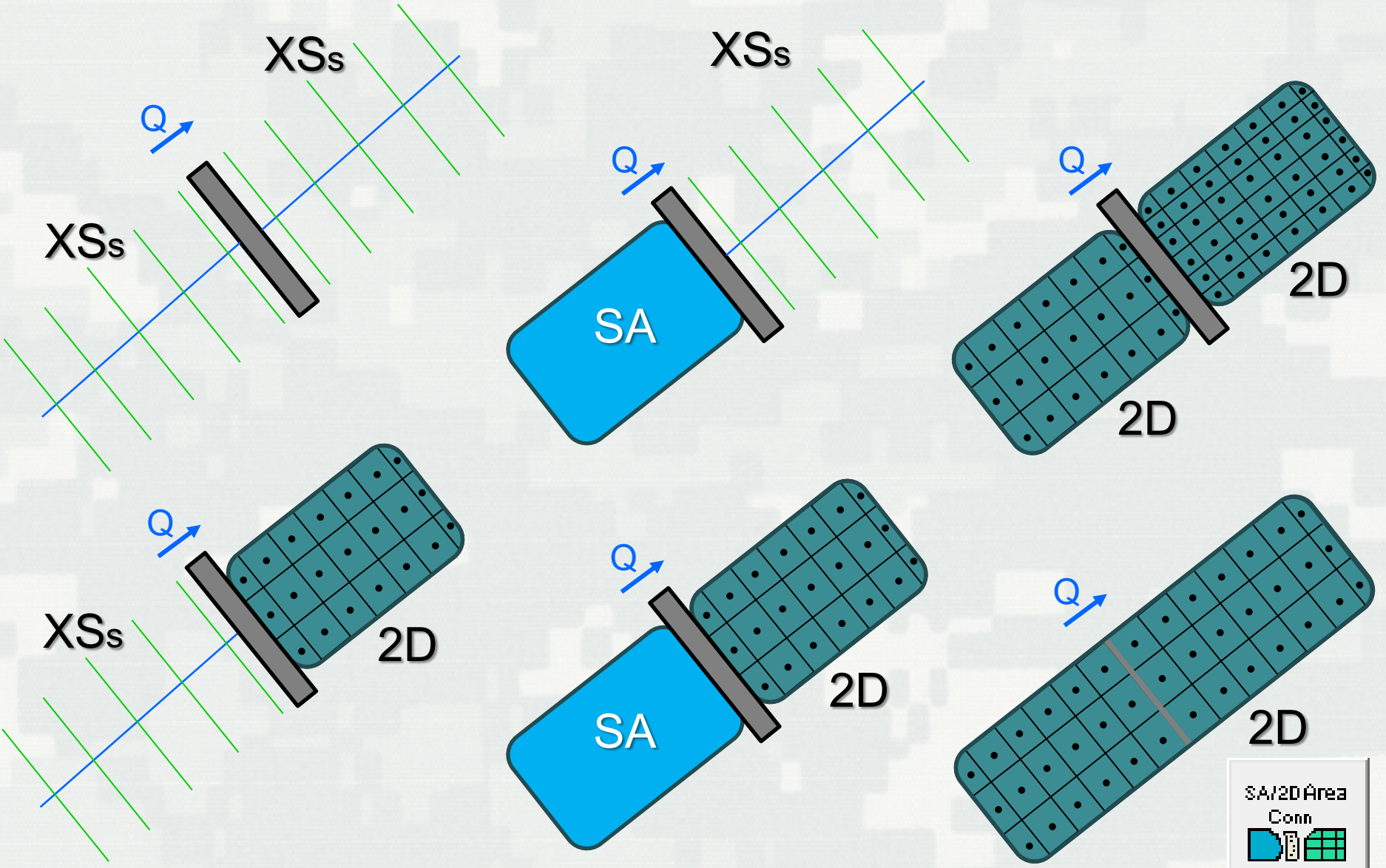
# Animation of 2D Reservoir Pool and 2D Downstream



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



# Breach Model Configuration Options



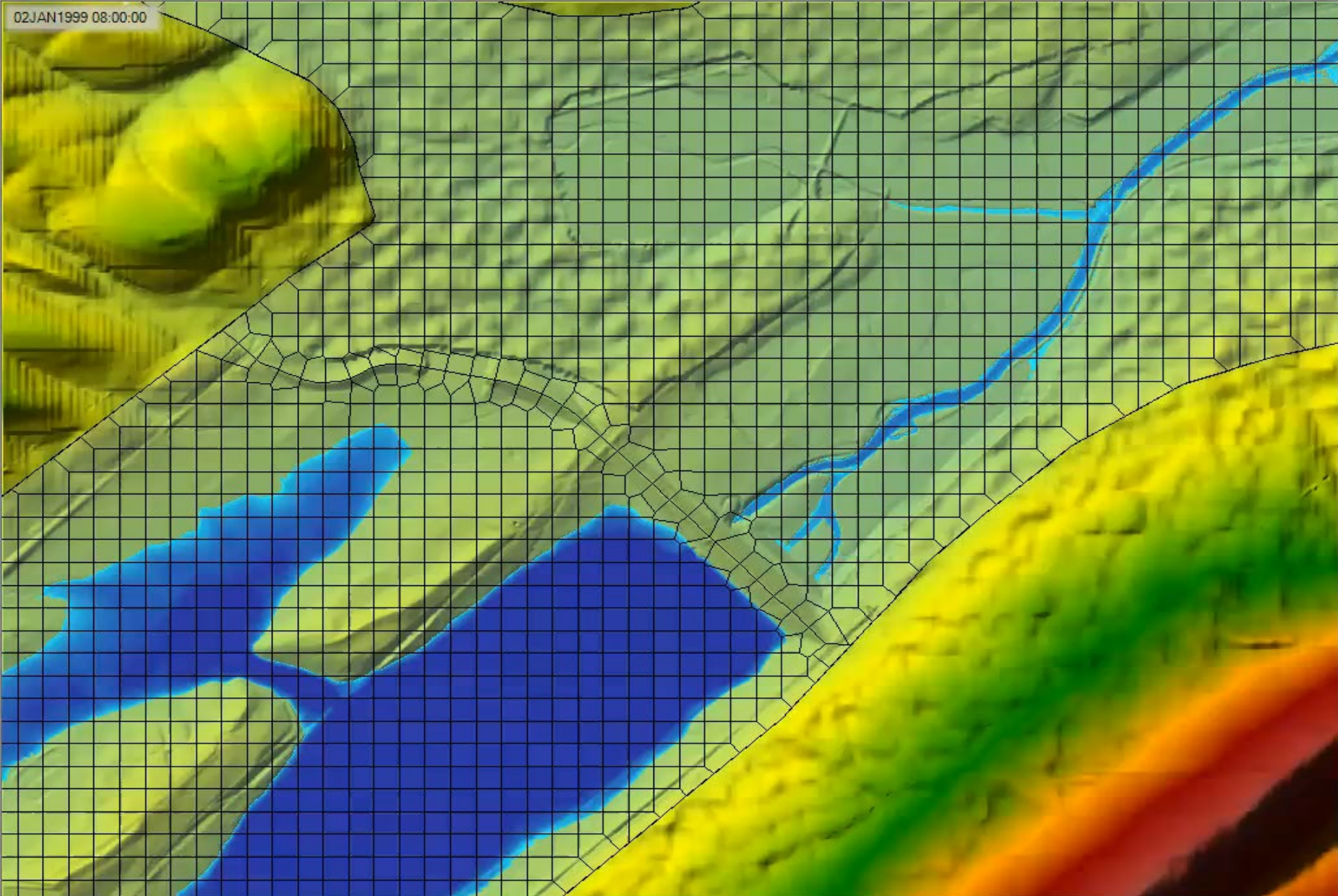
SA/2D Area  
Conn

The legend shows a blue square representing the SA area and a green grid representing the 2D area.

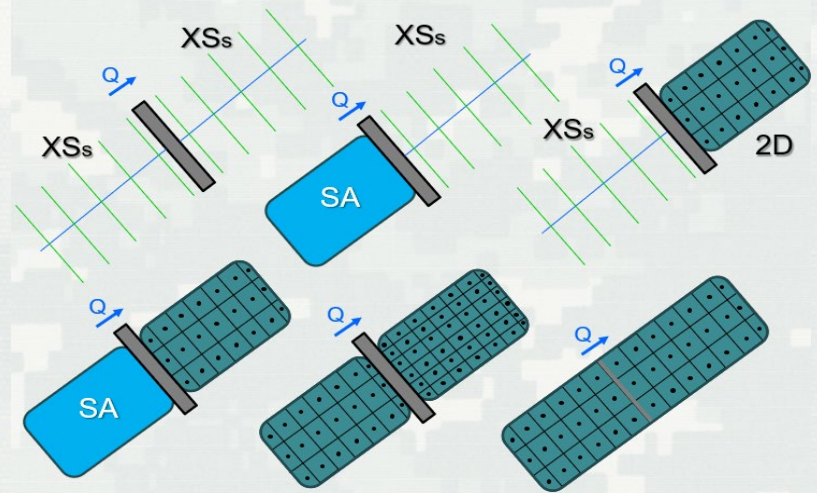
# Single 2D Flow Area with Internal Hydraulic Structure for the Dam



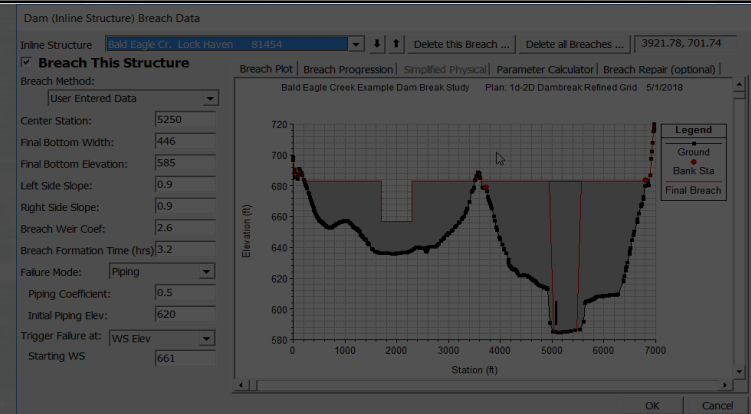
# Animation of Single 2D Flow Area with Internal Hydraulic Structure for the Dam



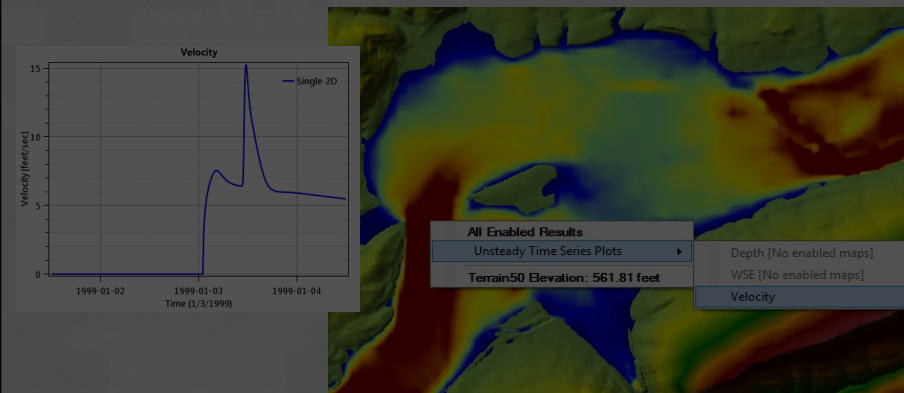
# 1. Six Dam Breach Model Configurations



# 2. Breaching Options and Parameters

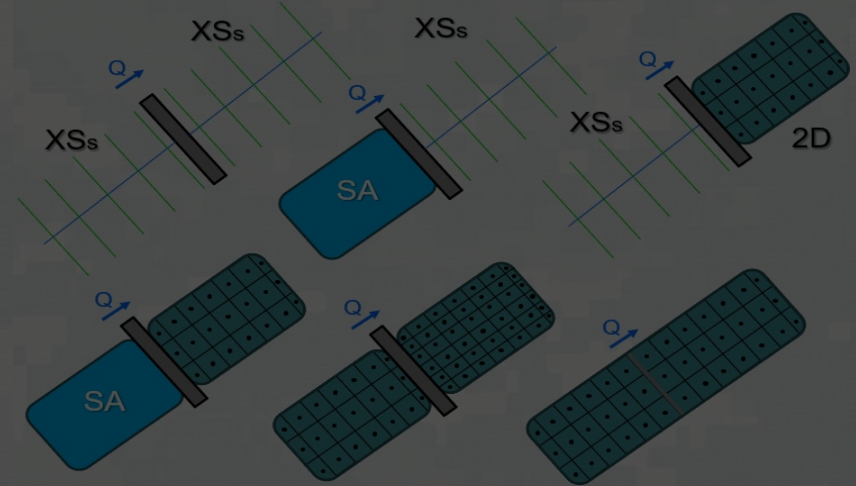


# 3. Breach Results and Visualization

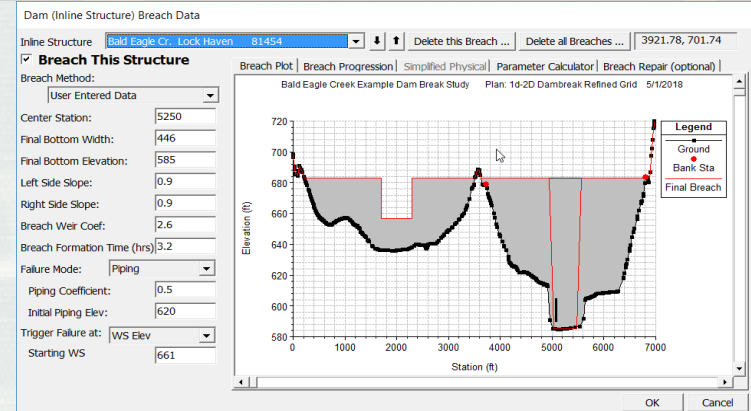




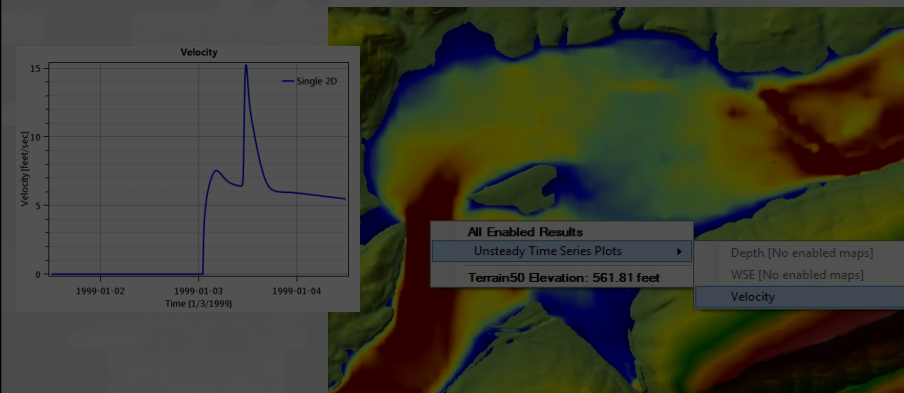
# 1. Six Dam Breach Model Configurations



# 2. Breaching Options and Parameters



# 3. Breach Results and Visualization



# Dam Break 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

Connection Data Editor - SA to 2D Flow Area - Detailed

File View Help

Connection: **Dam** [Apply Data]

Description: [Breach (plan data) ...]

Connections

From: Storage area: Reservoir Pool [Set SA/2D ...]

To: 2D flow area: BaldEagleCr [Set SA/2D ...]

Weir Length: 7423.00

Centerline Length: 7423.02

[Centerline GIS Coords...]

Structure Type: Weir, Gates, Culverts, Outlet RC and Outlet TS [Terrain Profile ...]

Flap Gates: No Flap Gates

**Dam**

Elevation (ft)

Station (ft)

Legend

- Spillway
- TW Cell Min Elev
- Centerline Terrain

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Select connection to Edit



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# Inline Structure Dam Break Control

Inline Structure Data - 1D-2D Dam Break Model Refin...

File View Options Help

River: **Bald Eagle Cr.** Apply Data

Reach: Lock Haven River Sta.: 81454 Joseph Sayers Da

Upstream XS: 81914 Upstream channel length: 998.163 (ft)

Description: Foster Joseph Sayers Dam and Reservoir

Pilot Flow: 0 **Breach (plan data) ...** Rules (unsteady data) ...

All Culverts: No Flap Gates

Legend

- Ground
- Bank Sta

Select the river for inline structure editing

Unsteady Flow Analysis

File Options Help

- Stage and Flow Output Locations ...
- Flow Distribution Locations ...
- Flow Roughness Factors ...
- Seasonal Roughness Factors ...
- Automated Roughness Calibration ...
- Unsteady Encroachments ...
- Ungaged Lateral Inflows ...
- Dam (Inline Structure) Breach ...**
- Levee (Lateral Structure) Breach ...
- SA Connection Breach ...
- Calculation Options and Tolerances ...
- Output Options ...
- Friction Slope Method for Cross Sections ...
- Friction Slope Method for Bridges ...
- Initial Backwater Flow Optimizations ...
- Sediment Computation Options and Tolerances ...
- Sediment Output Options ...
- Sediment Dredging Options ...
- Check Data Before Execution
- View Computation Log File ...
- View Runtime Messages ...

1D-2D Refined Grid

1200

1200

Interval: 5 Minute

Interval: 1 Hour

sets\2D Unsteady



# Dam Breach Data

Dam (Inline Structure) Breach Data

Inline Structure **Bald Eagle Cr. Lock Haven 81454**   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

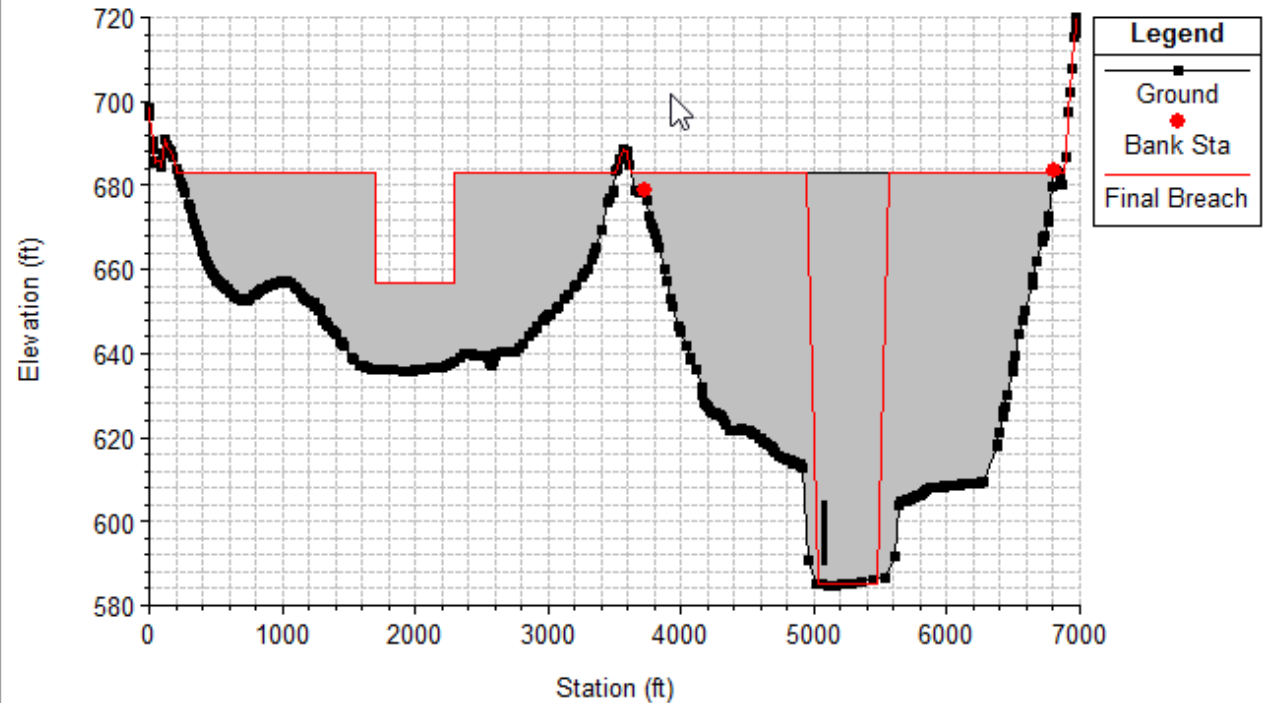
Initial Piping Elev: 620

Trigger Failure at: WS Elev

Starting WS 661

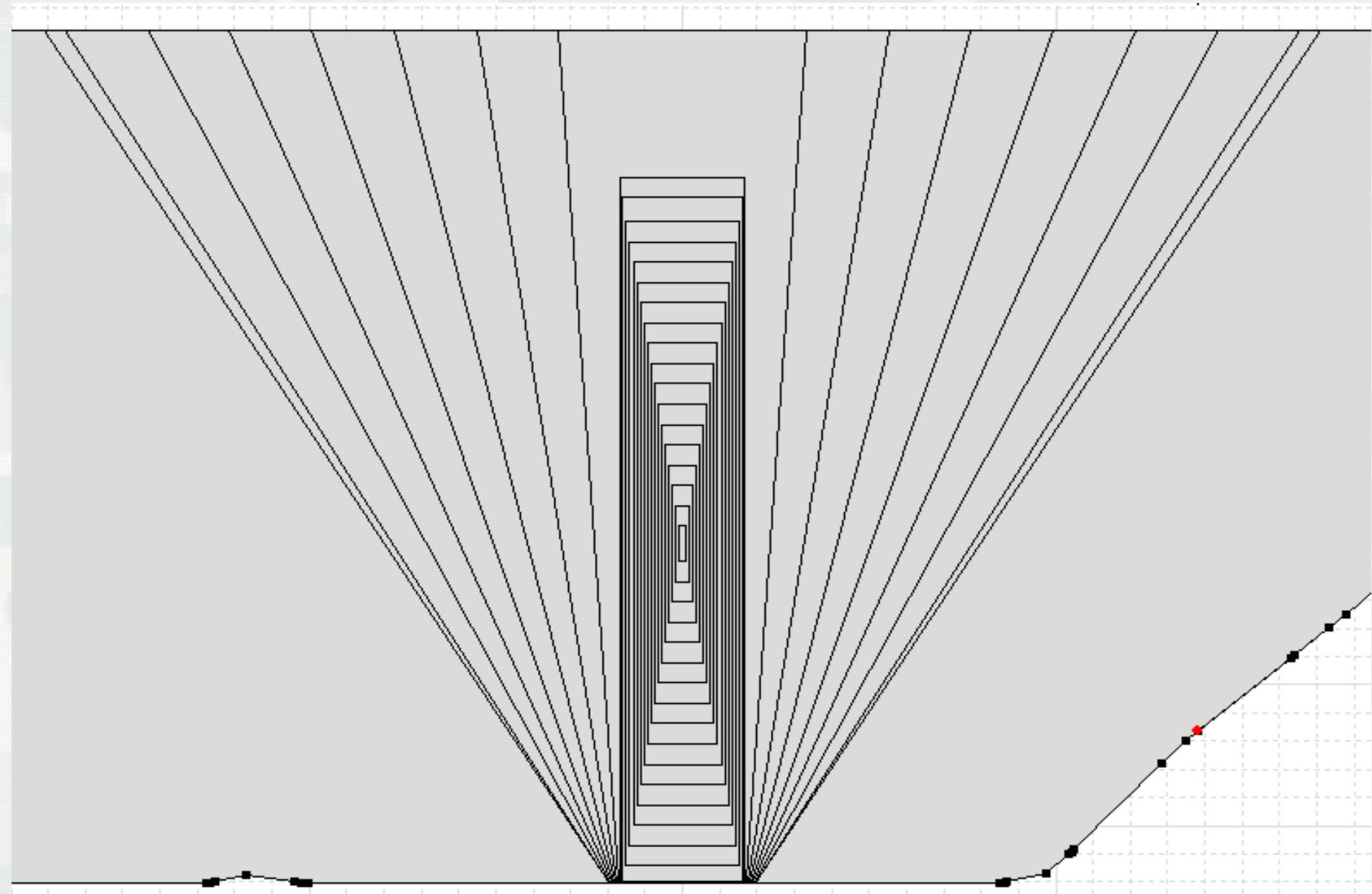
Breach Plot | Breach Progression | Simplified Physical | Parameter Calculator | Breach Repair (optional)

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



OK Cancel

# Piping Failure Breach Growth Geometry



# Breach Repair Option

Dam (Inline Structure) Breach Data

Inline Structure

**Breach This Structure**

Breach Method:

▼

Center Station:

Final Bottom Width:

Final Bottom Elevation:

Left Side Slope:

Right Side Slope:

Breach Weir Coef:

Breach Formation Time (hrs)

Failure Mode:  ▼

Piping Coefficient:

Initial Piping Elev:

Trigger Failure at:  ▼

Starting WS

Number of hours after full breach to start repair:

Total repair time (hours):

Final filled in elevation:



OK

Cancel

# Breach Regression Equation Calculator

## Dam (Inline Structure) Breach Data

Inline Structure

**Breach This Structure**

Breach Method:

Center Station:

Final Bottom Width:

Final Bottom Elevation:

Left Side Slope:

Right Side Slope:

Breach Weir Coef:

Breach Formation Time (hrs)

Failure Mode:

Piping Coefficient:

Initial Piping Elev:

Trigger Failure at:

Starting WS

Input Data

Top of Dam Elevation (ft):  Breach Bottom Elevation (ft):

Pool Elevation at Failure (ft):  Pool Volume at Failure (acre-ft):

Failure mode:

MacDonald

Dam Crest Width (ft):  Slope of US Dam Face Z1 (H:V):

Earth Fill Type:  Slope of DS Dam Face Z2 (H:V):

Xu Zhang (and Von Thun)

Dam Type:  Dam Erodibility:

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



# 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

# Performing the Computations

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

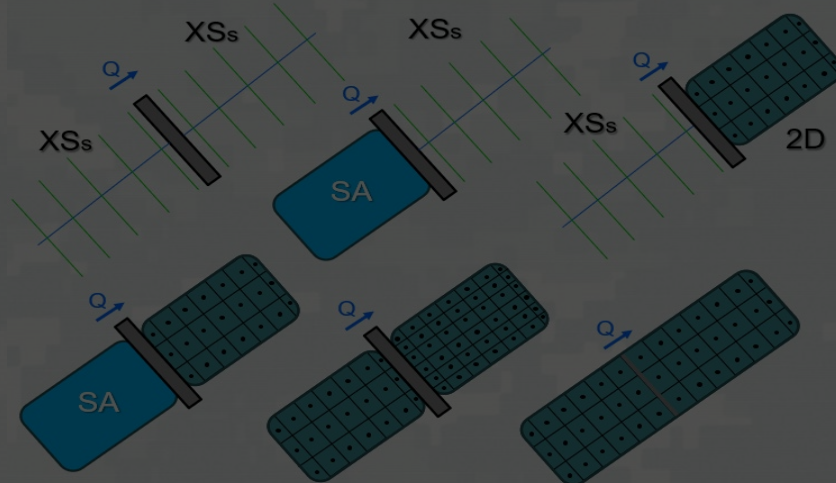
1 Storage Area Connection with breach data. 1 set to breach.

Compute

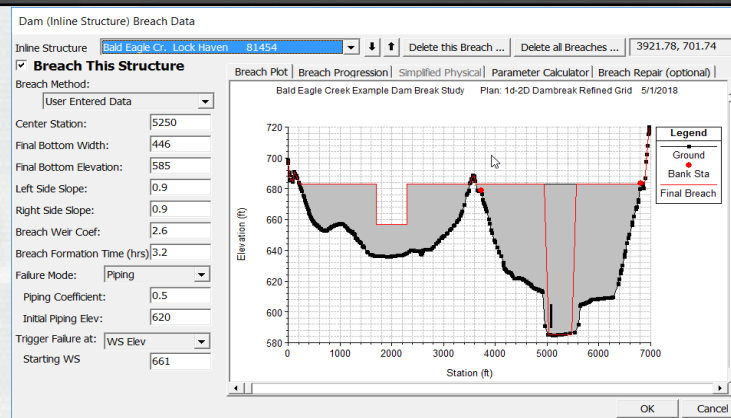
Important  
Computational  
Settings



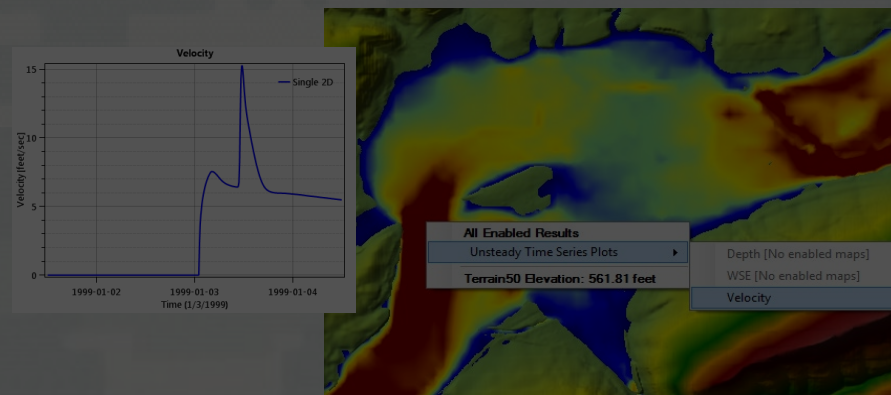
# 1. Six Dam Breach Model Configurations



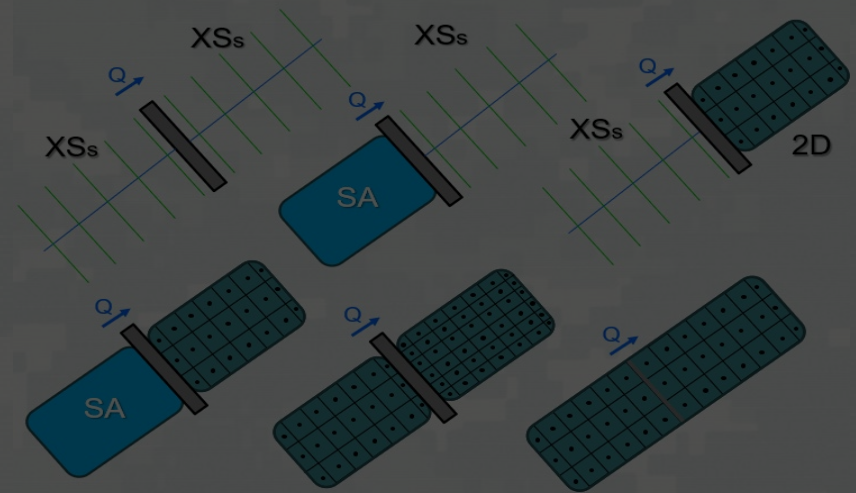
# 2. Breaching Options and Parameters



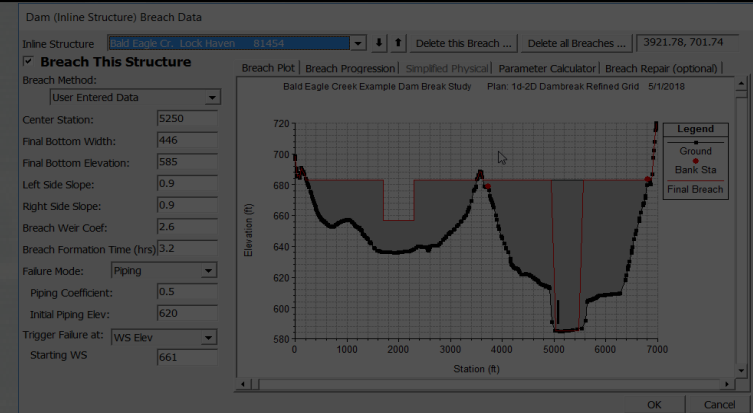
# 3. Breach Results and Visualization



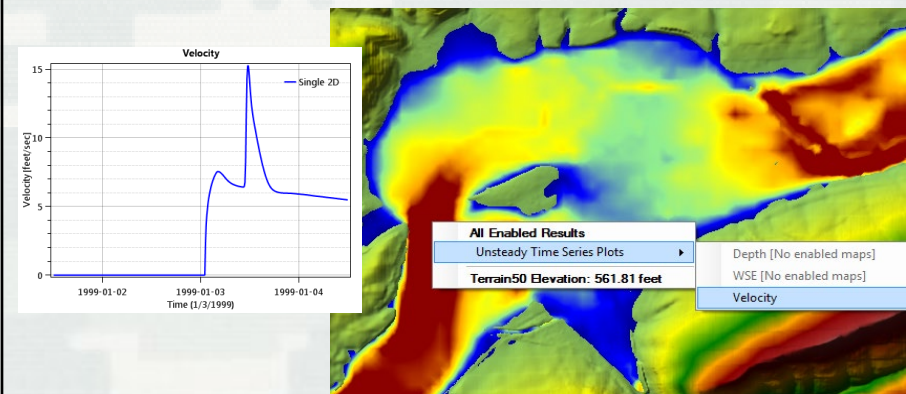
# 1. Six Dam Breach Model Configurations



# 2. Breaching Options and Parameters



# 3. Breach Results and Visualization

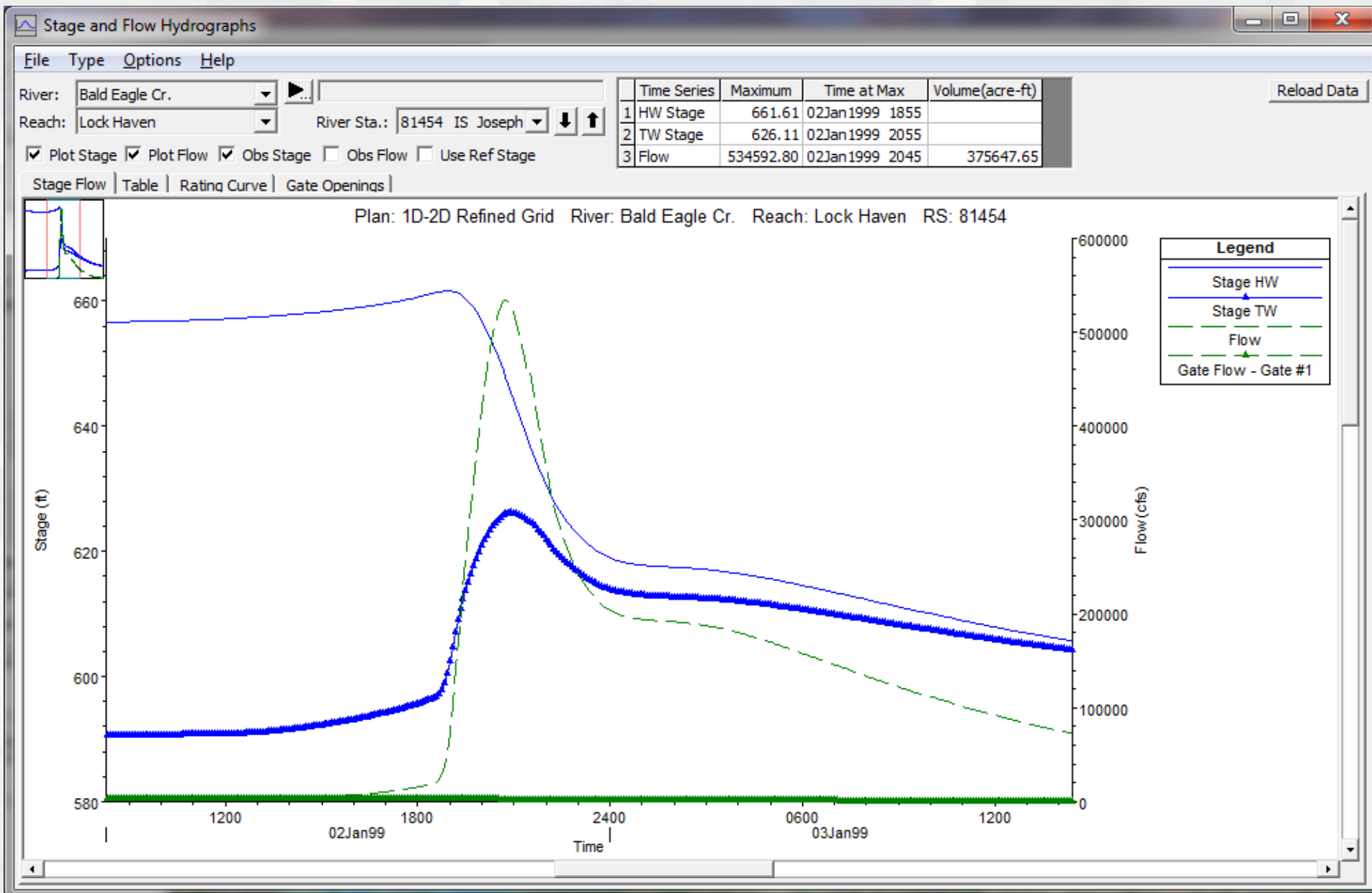


# Breach Results and Visualization

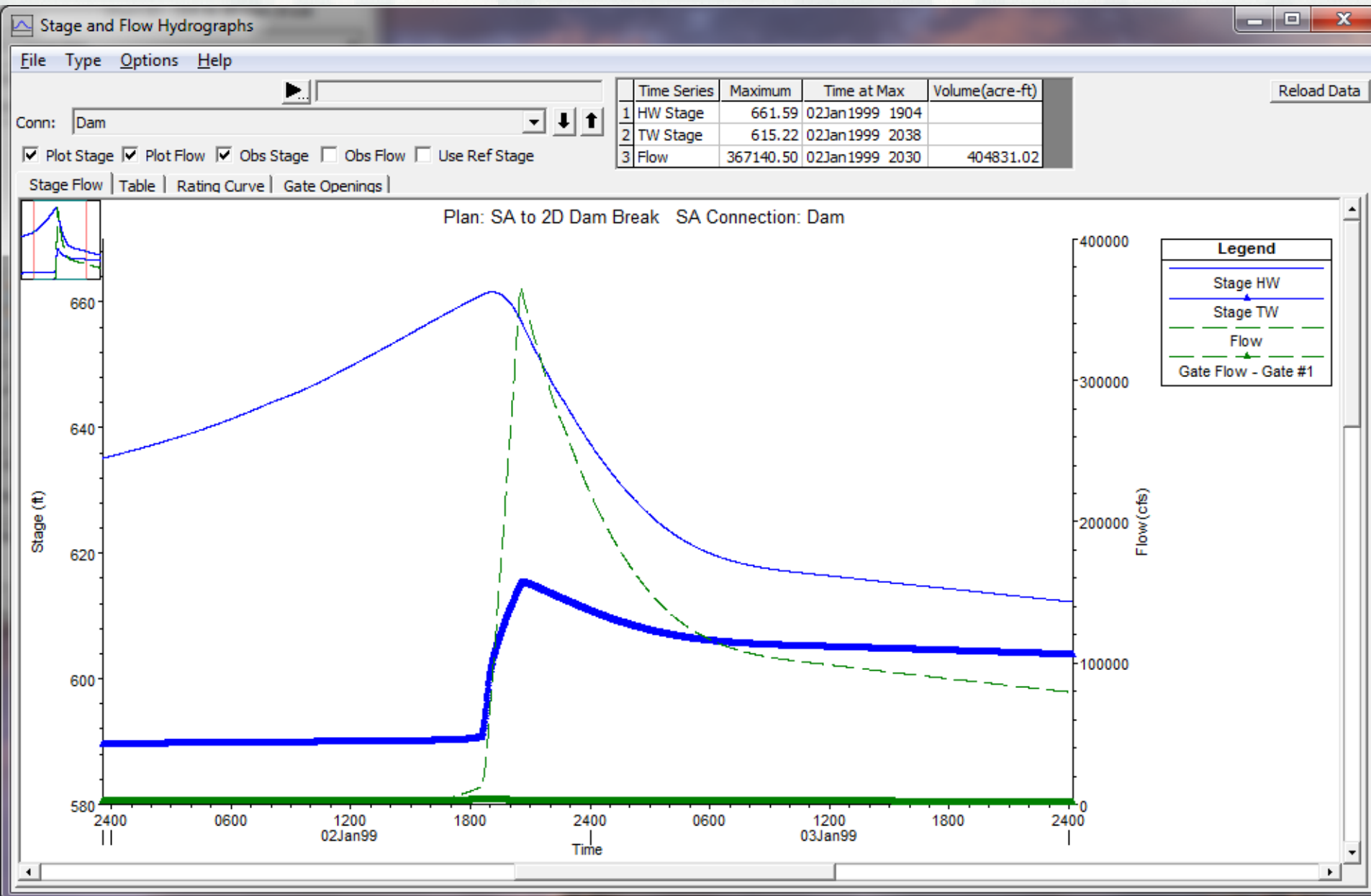
- Hydrographs at Inline Structures, SA/2D Hydraulic Connections, and Storage Areas
- Profile Plots for 1D Reaches
- Flow Hydrographs at 2D Area Boundaries
- Inundation Maps/Animations in RAS-Mapper
- Stage Hydrograph Plots in RAS-Mapper
- Velocity Time Series in RAS-Mapper



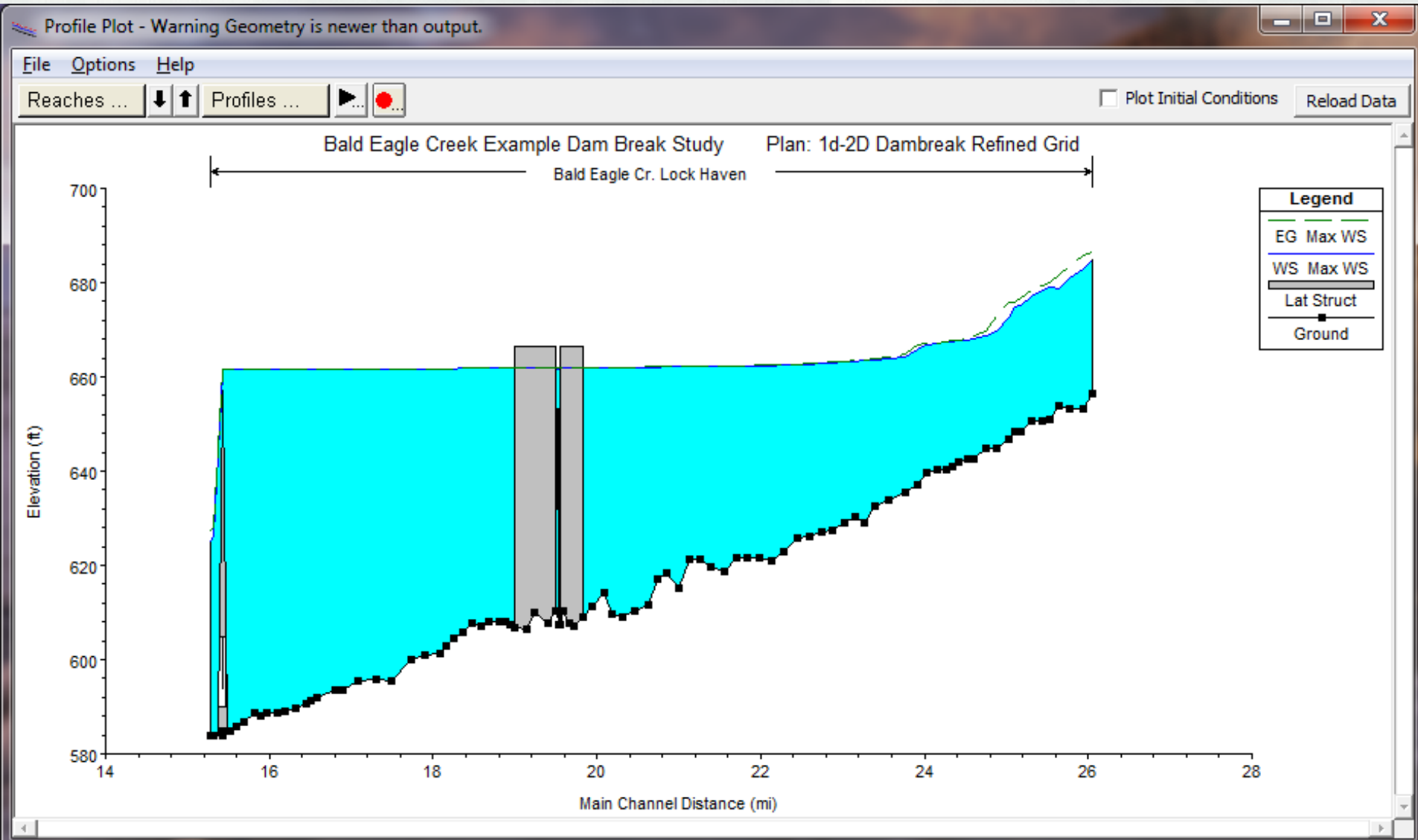
# Inline Structure Hydrograph



# SA/2D Conn Hydrograph



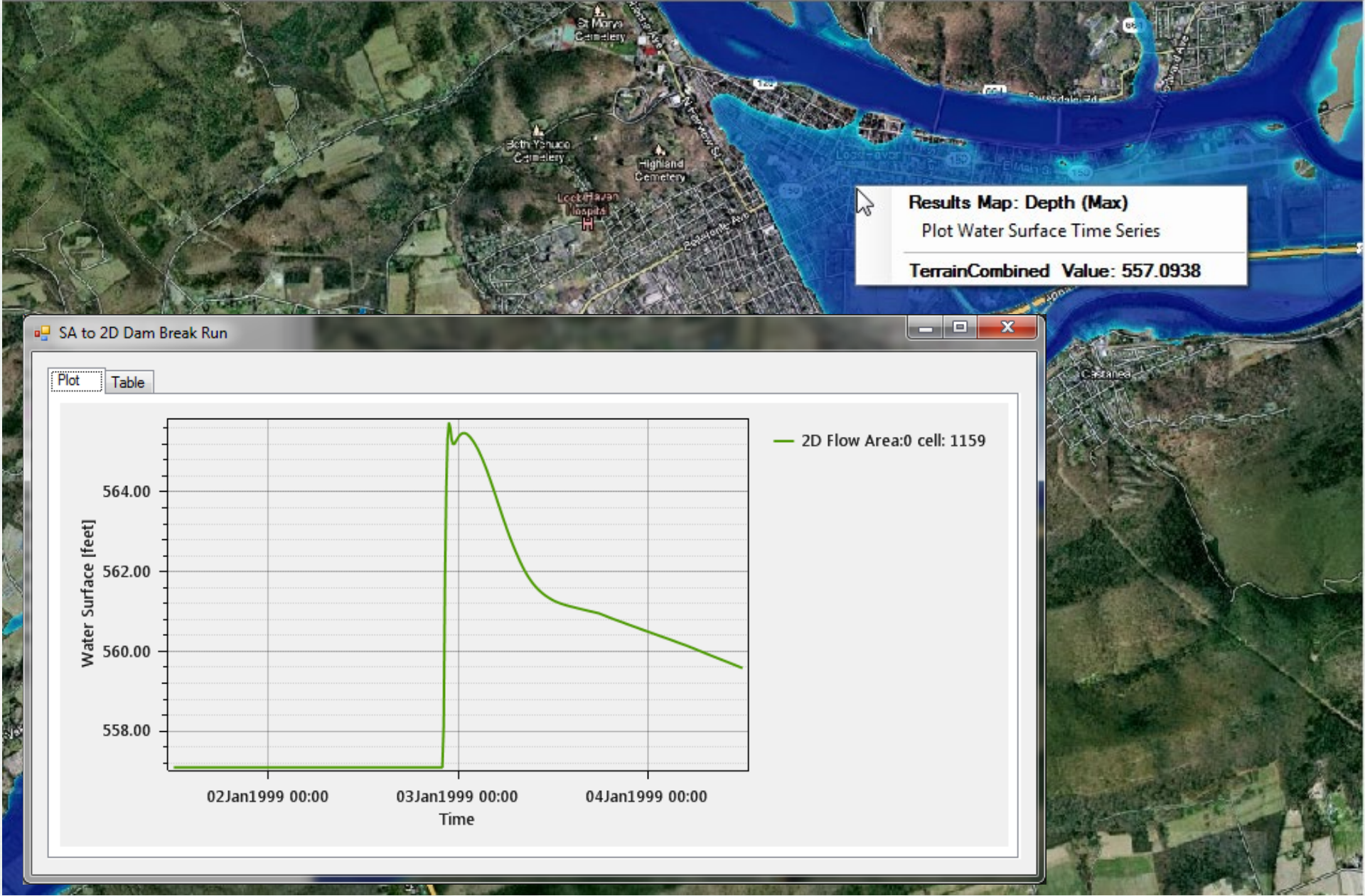
# 1D River Reach W.S Profile Plots



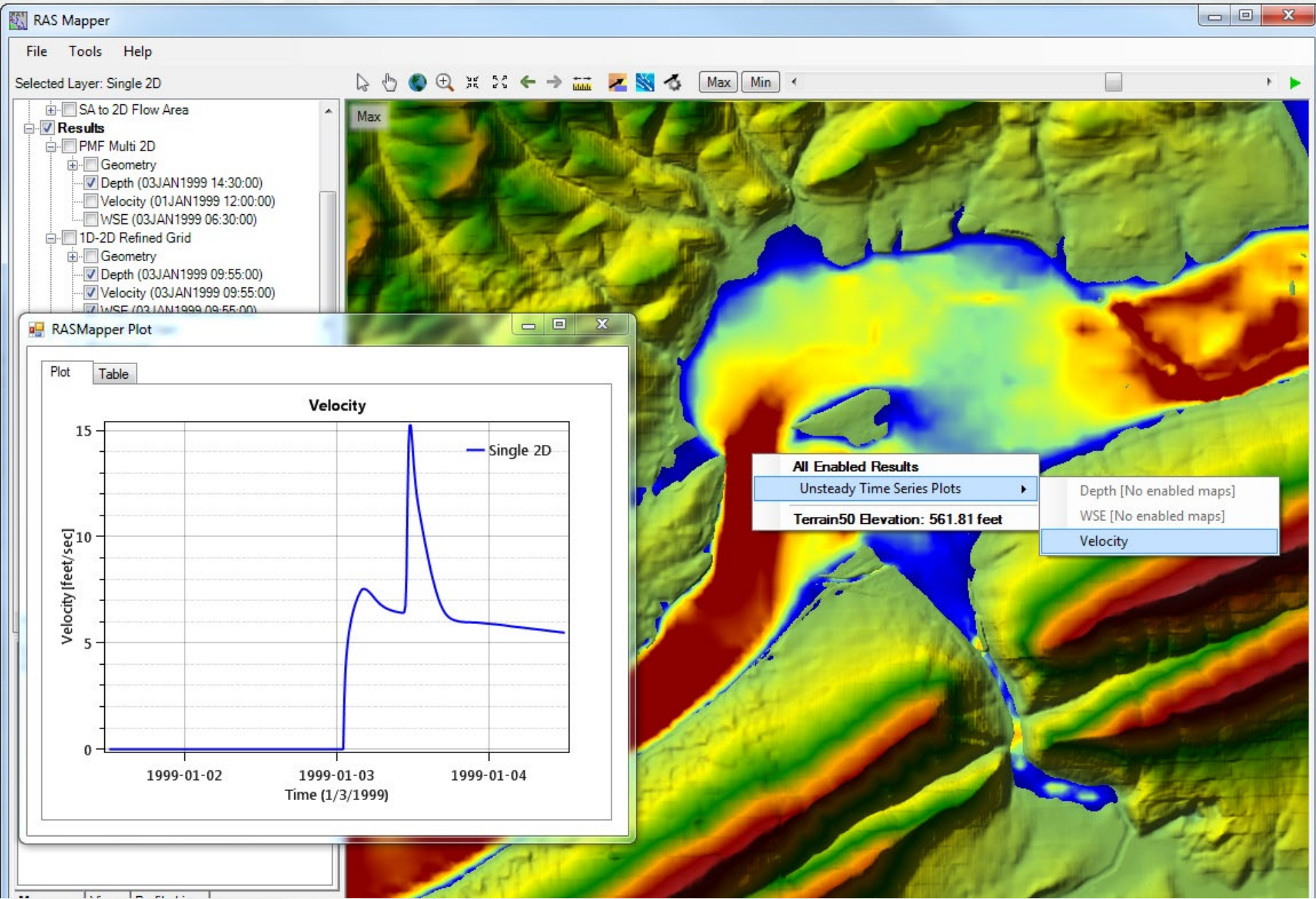




# Stage Hydrographs – RAS-Mapper



# Velocity Time Series – RAS-Mapper



# Profile Lines – RAS-Mapper

