

Combined 1D River and 2D Floodplain/Levee Areas

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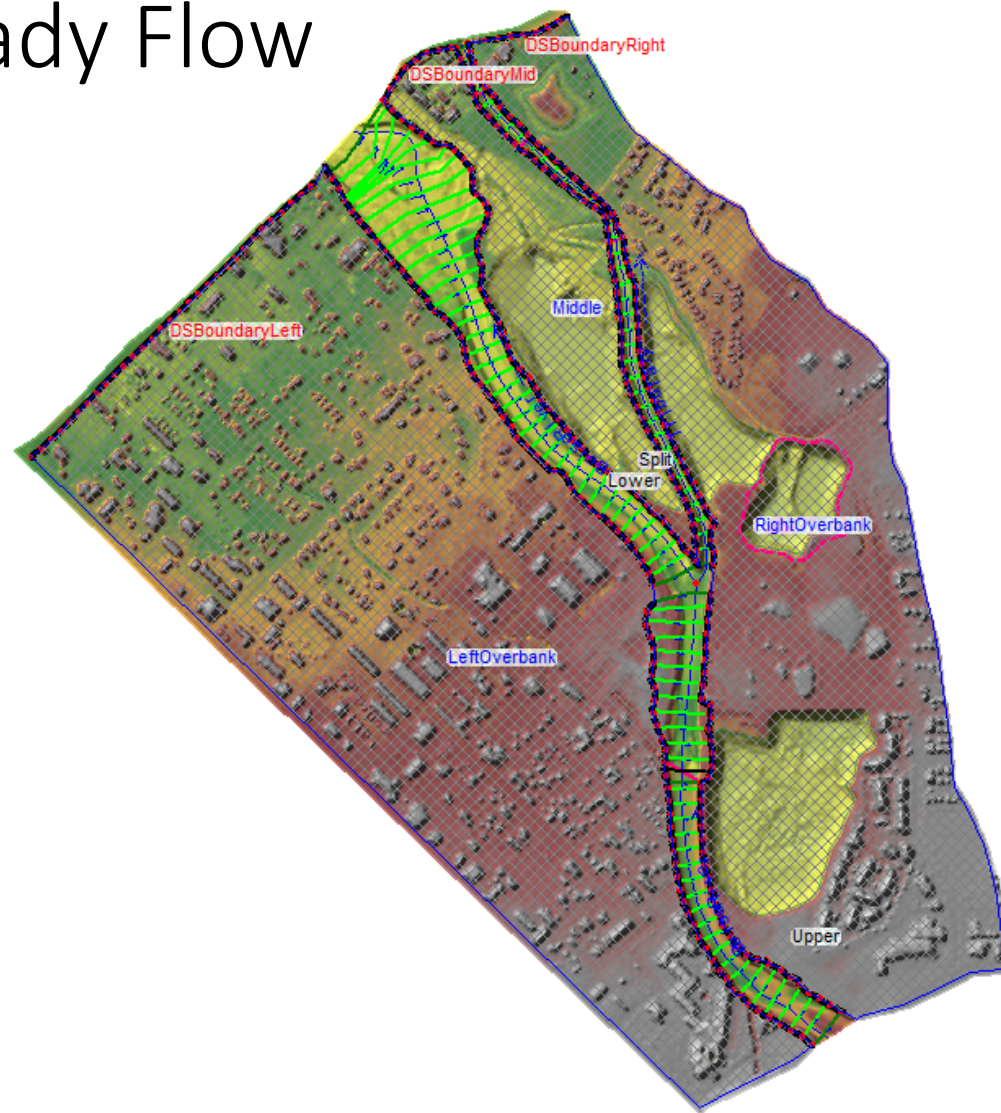


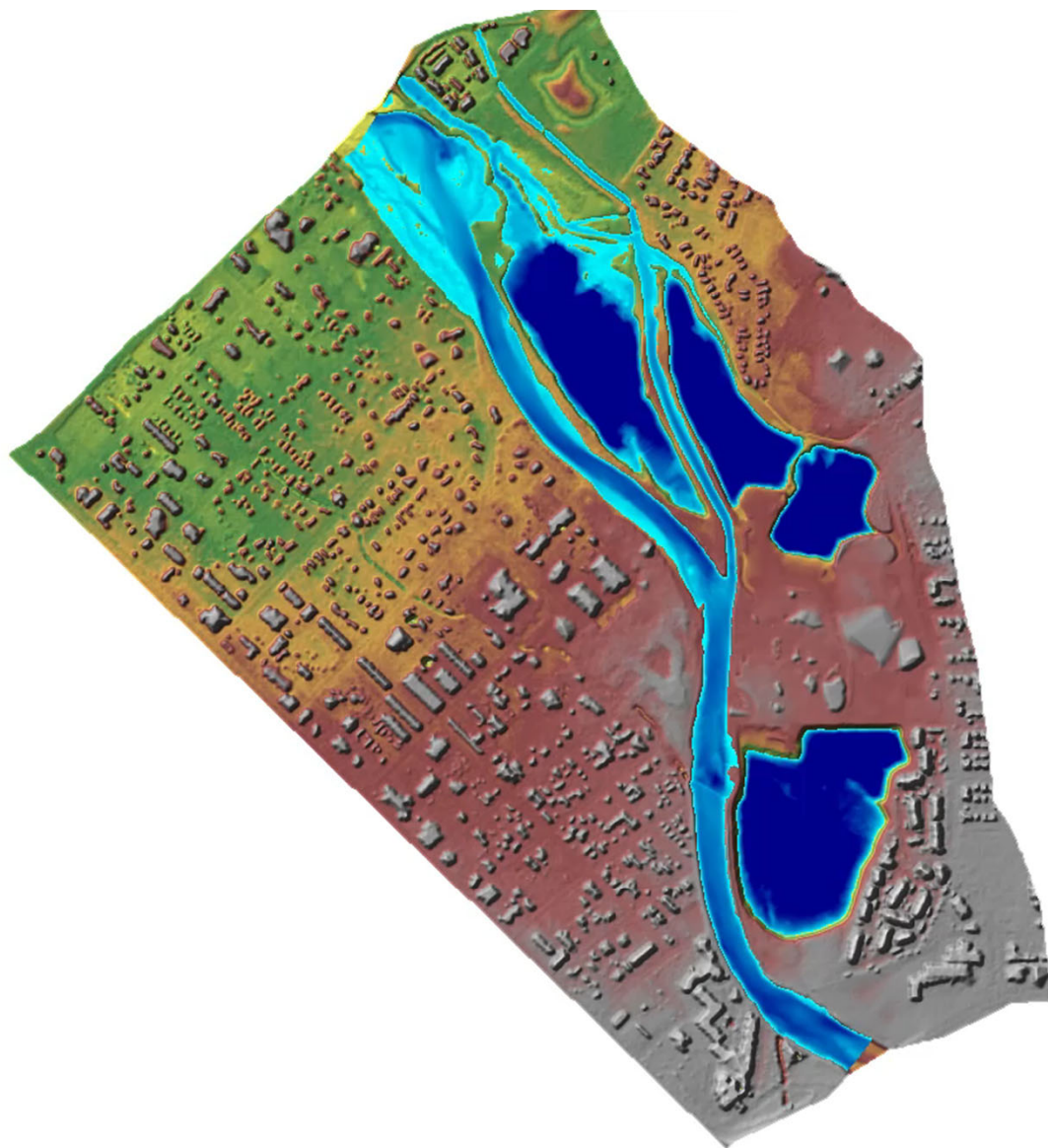
Combined 1D / 2D Modeling

- Use both 1D and 2D hydraulics in the same domain
- Leverage advantages of 1D or 2D where needed
- Common applications:
 - 2D in overbanks
 - 2D in protected areas
 - Channel transitions from 1D to 2D



1D/ 2D Unsteady Flow





4

1000 ft

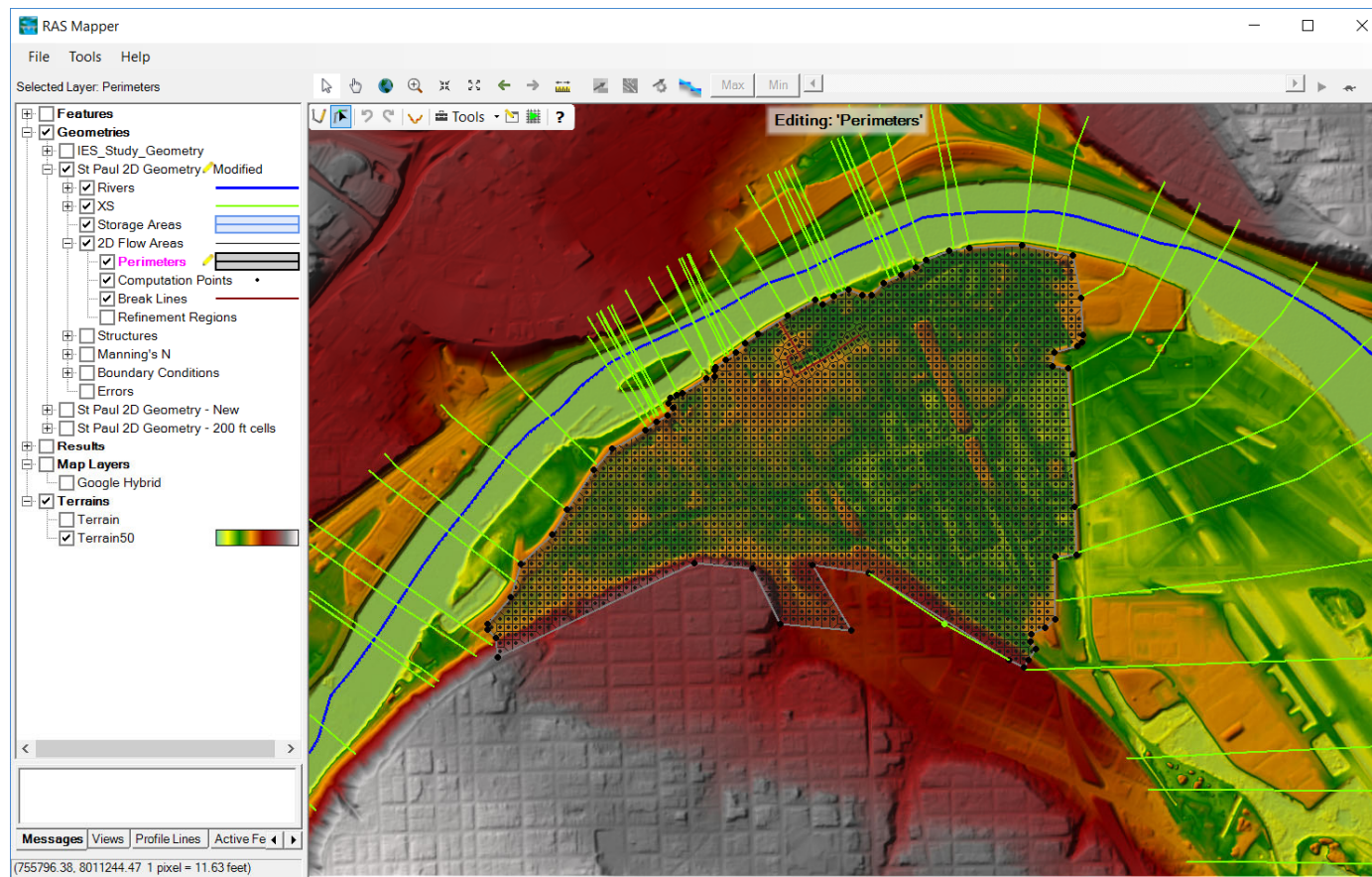


Overview

- Connecting 2D overbanks to 1D channels with lateral structures
- Selecting appropriate parameters
- Selecting appropriate computation options

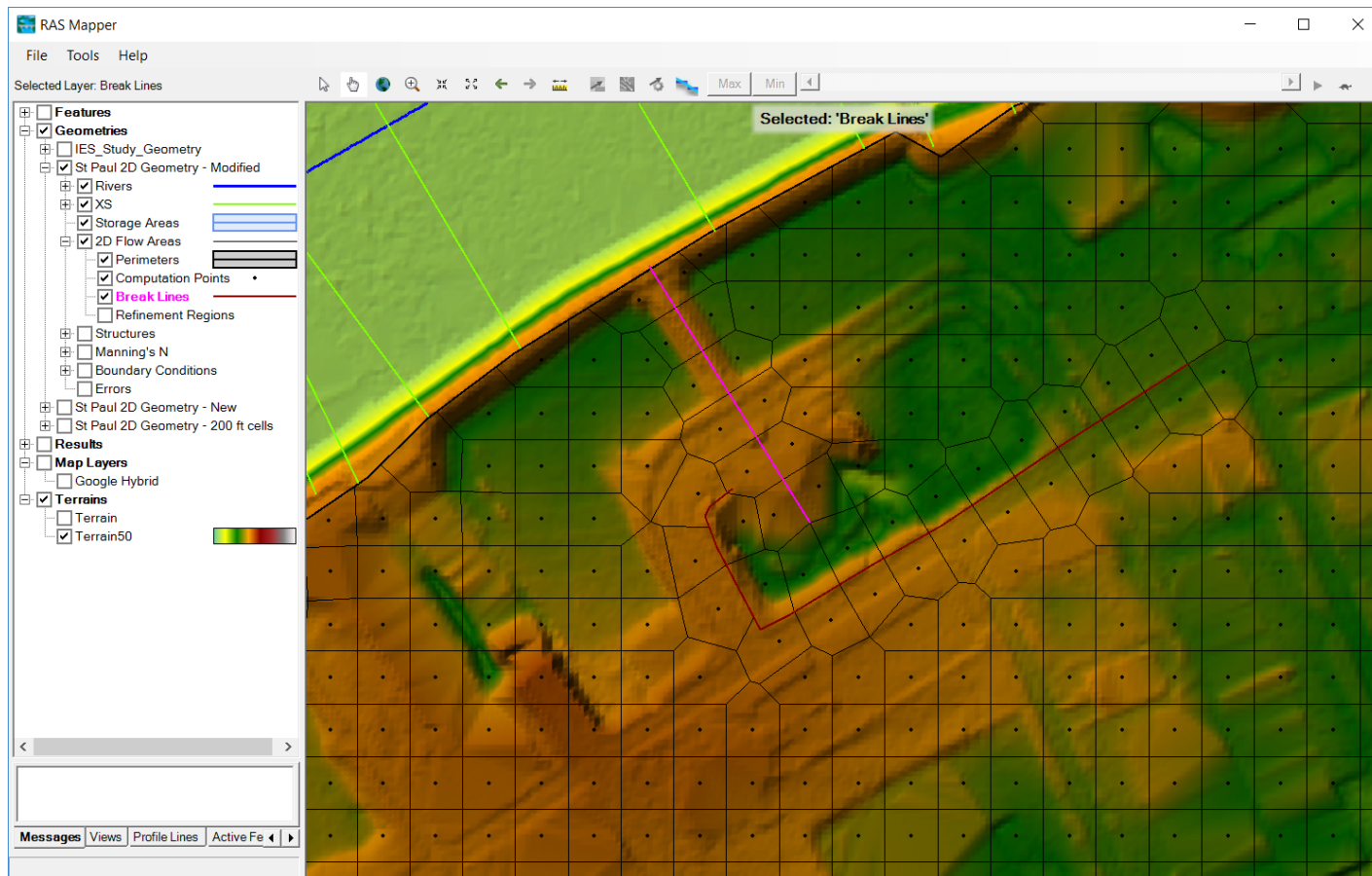


Modeling a Leveed Area in 2D

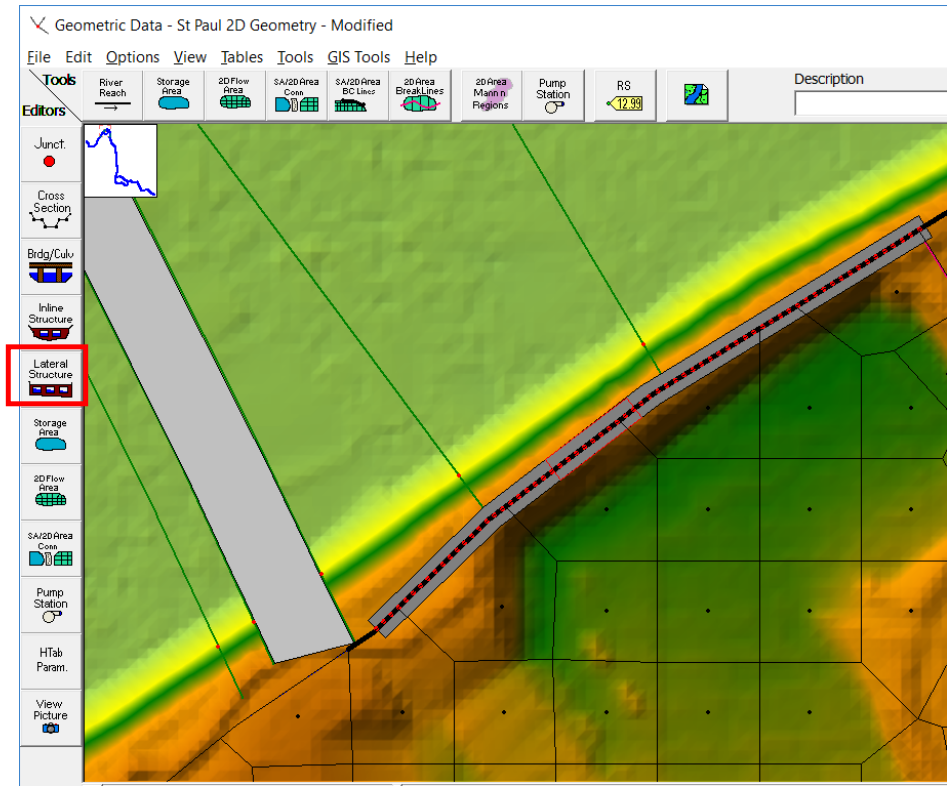
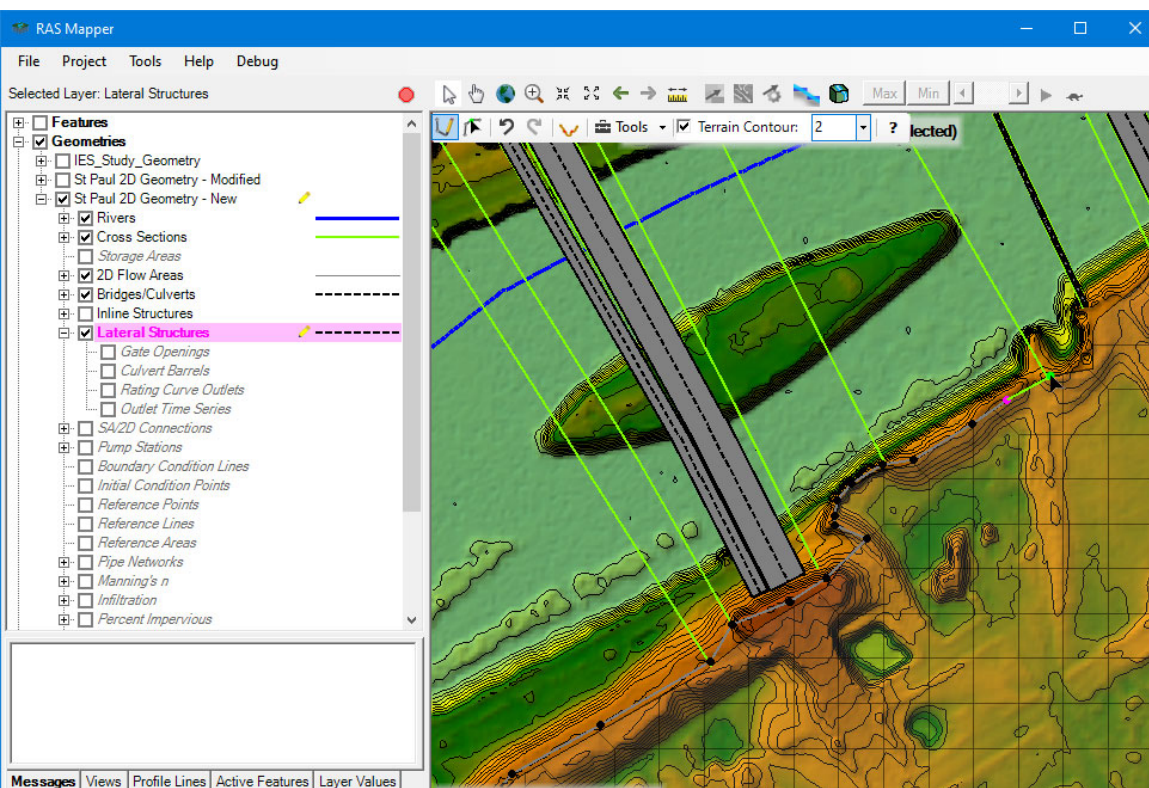




Modify The Mesh as Needed

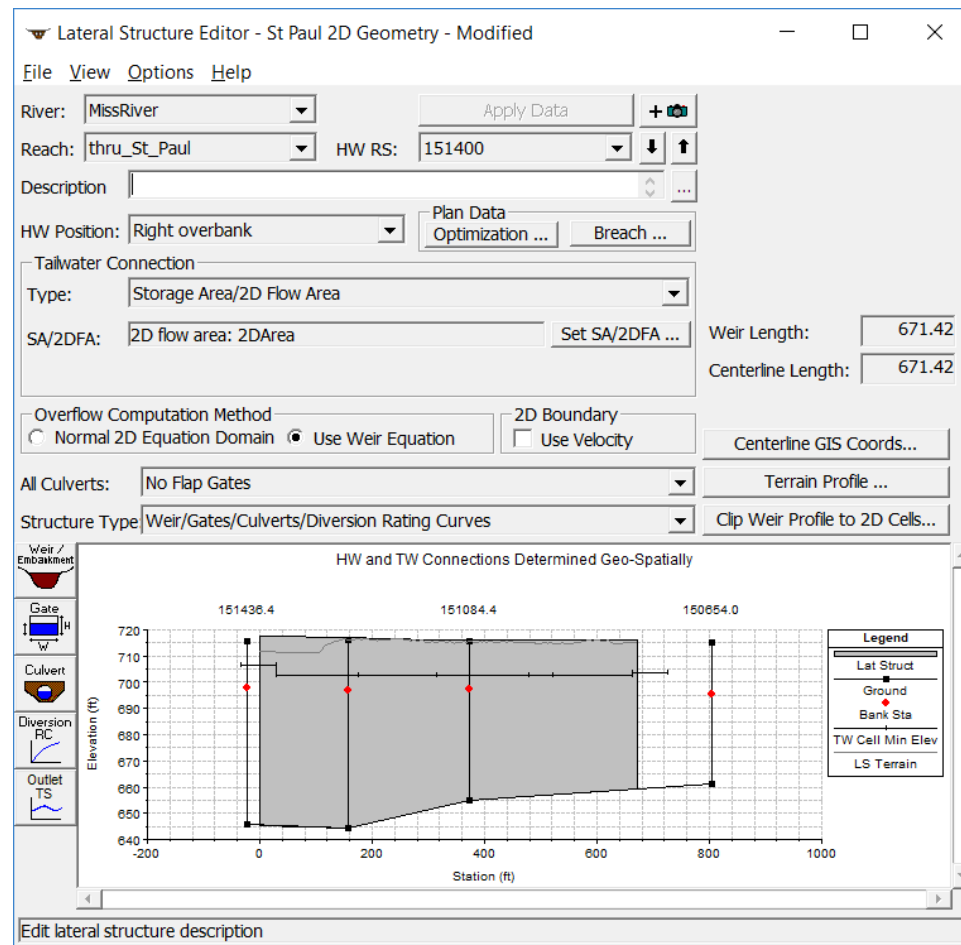


Connecting a 2D Flow Area to a 1D River Reach with Lateral Structures





Lateral Structure Editor





Weir/Embankment

Lateral Weir Embankment

Weir Data

Weir Width: 25.

Weir Computations: Standard Weir Eqn

Standard Weir Equation Parameters

Weir flow reference: Water Surface

Weir Coefficient (Cd): 2.

Weir Crest Shape: Broad Crested

Weir Stationing Reference

HW - Distance to Upstream XS: 23.

HW Connections ... TW Connections ...

Embankment Station/Elevation Table

	Station	Elevation
1	0	717.52
2	160.9	717.328
3	217.23	716.861
4	239.07	716.825
5	297.36	716.253
6	477.08	716.183
7	556.99	716.042
8	671.42	716.046
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		

OK Cancel

Lateral Structure Editor - St Paul 2D Geometry - Modified

File View Options Help

River: MissRiver Apply Data +

Reach: thru_St_Paul HW RS: 151400

Description

HW Position: Right overbank Plan Data Optimization ... Breach ...

Tailwater Connection

Type: Storage Area/2D Flow Area

SA/2DFA: 2D flow area: 2DArea Set SA/2DFA ...

Weir Length: 671.42

Centerline Length: 671.42

Overflow Computation Method

☐ Normal 2D Equation Domain ☒ Use Weir Equation ☐ 2D Boundary ☐ Use Velocity

Centerline GIS Coords...

All Culverts: No Flap Gates Terrain Profile ...

Structure Type: Weir/Gates/Culverts/Diversion Rating Curves Clip Weir Profile to 2D Cells...

Weir / Embankment

Gate

Culvert

Diversion RC

Outlet TS

HW and TW Connections Determined Geo-Spatially

Station (ft)

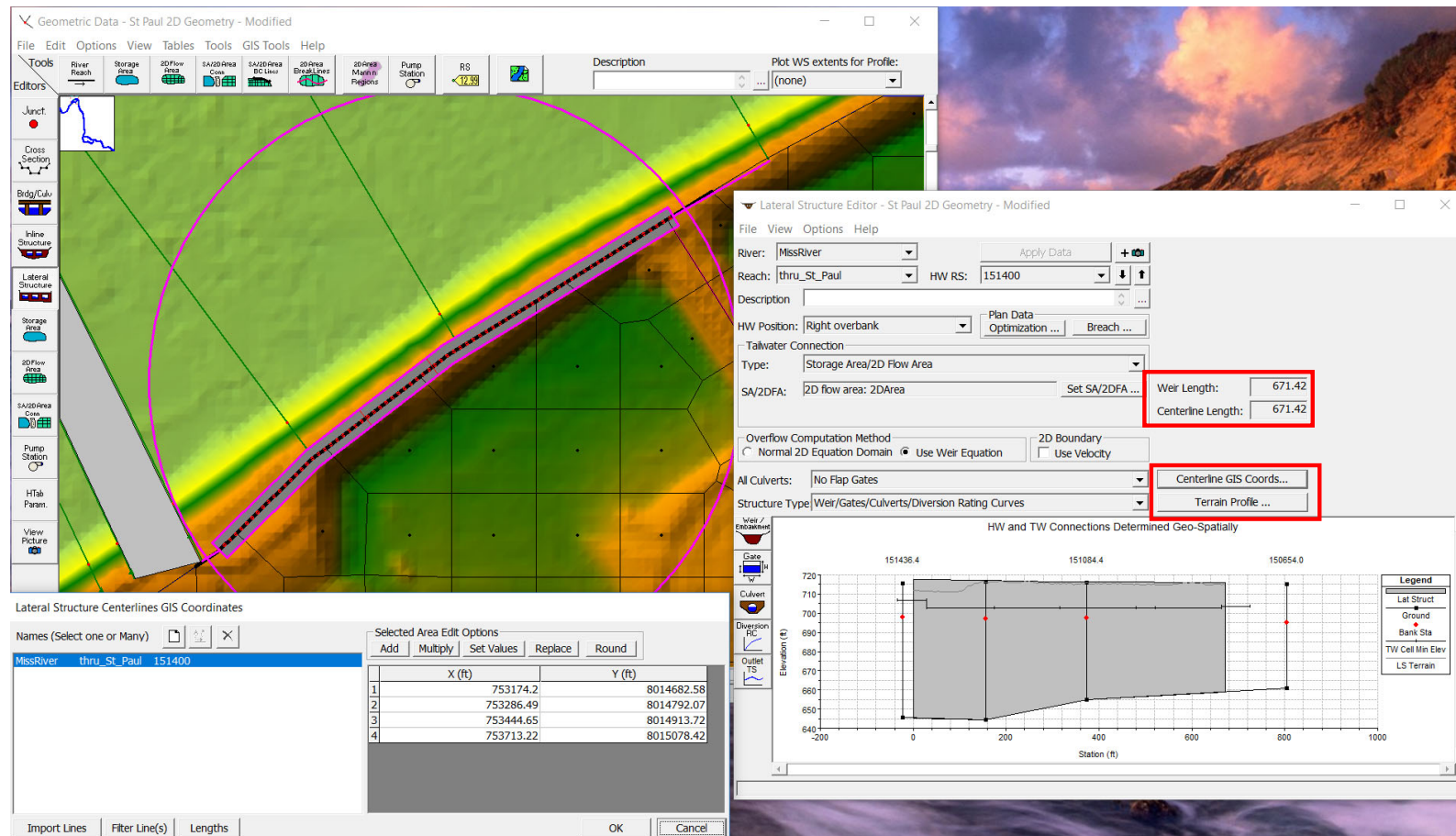
Legend

- Lat Struct
- Ground
- Bank Sta
- TW Cell Min Elev
- LS Terrain

structure description



Weir Length vs GIS Length





Lateral Weir Headwater Connections (HW)

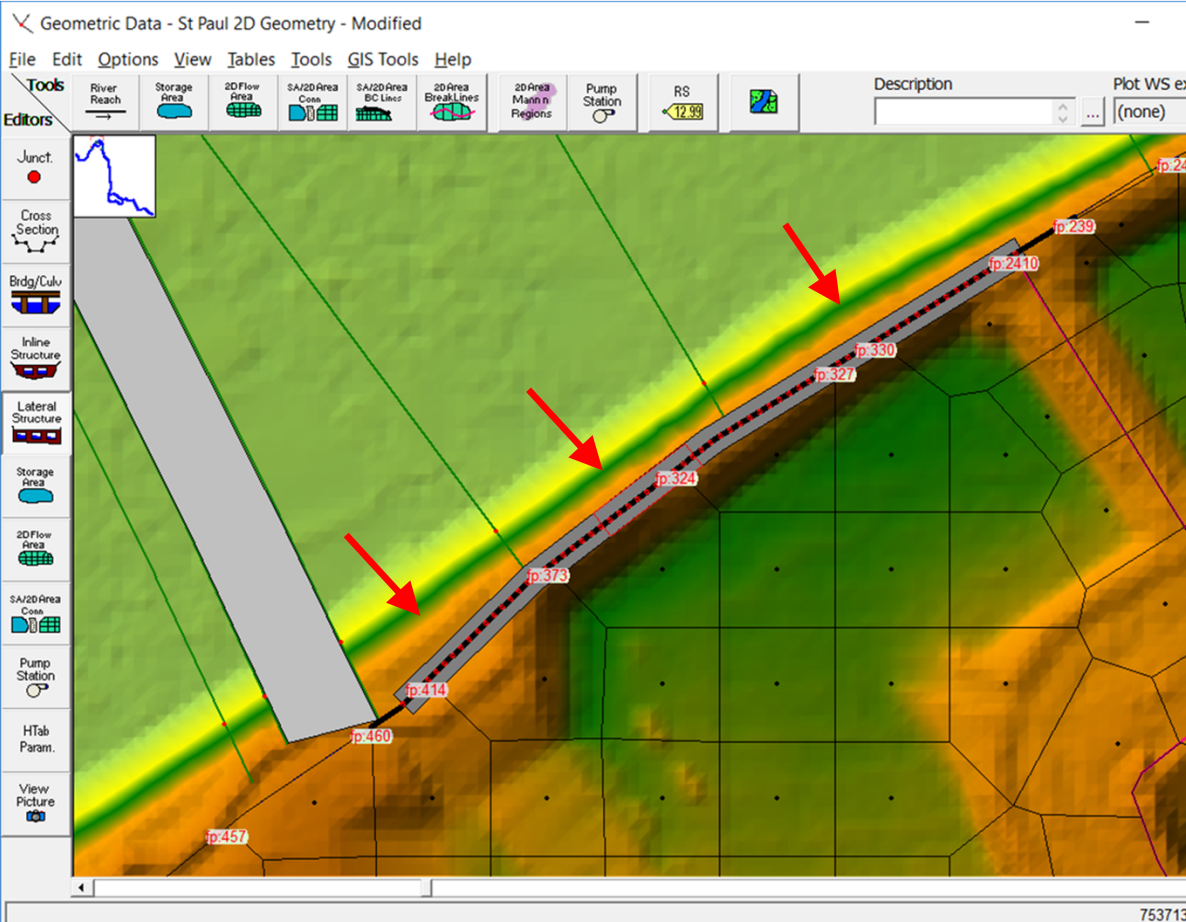
HW Lateral Structure Connections

☒ Computed Default Weir Stationing ☐ User Defined Weir Stationing

Default Computed Weir Stationing		
	XS RSs	Weir Station
1	151436.4	-22.92
2	151354.9	156.84
3	151084.4	373.92
4	150654.0	803.62
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

User Defined Weir Stationing		
	XS RSs	Weir Station
1	151354.9	5692
2	151084.4	5909
3	150654.0	6435
4		
5		
6		
7		
8		
9		
10		
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18		
19		

OK Cancel





Lateral Weir Tailwater Connections (TW)

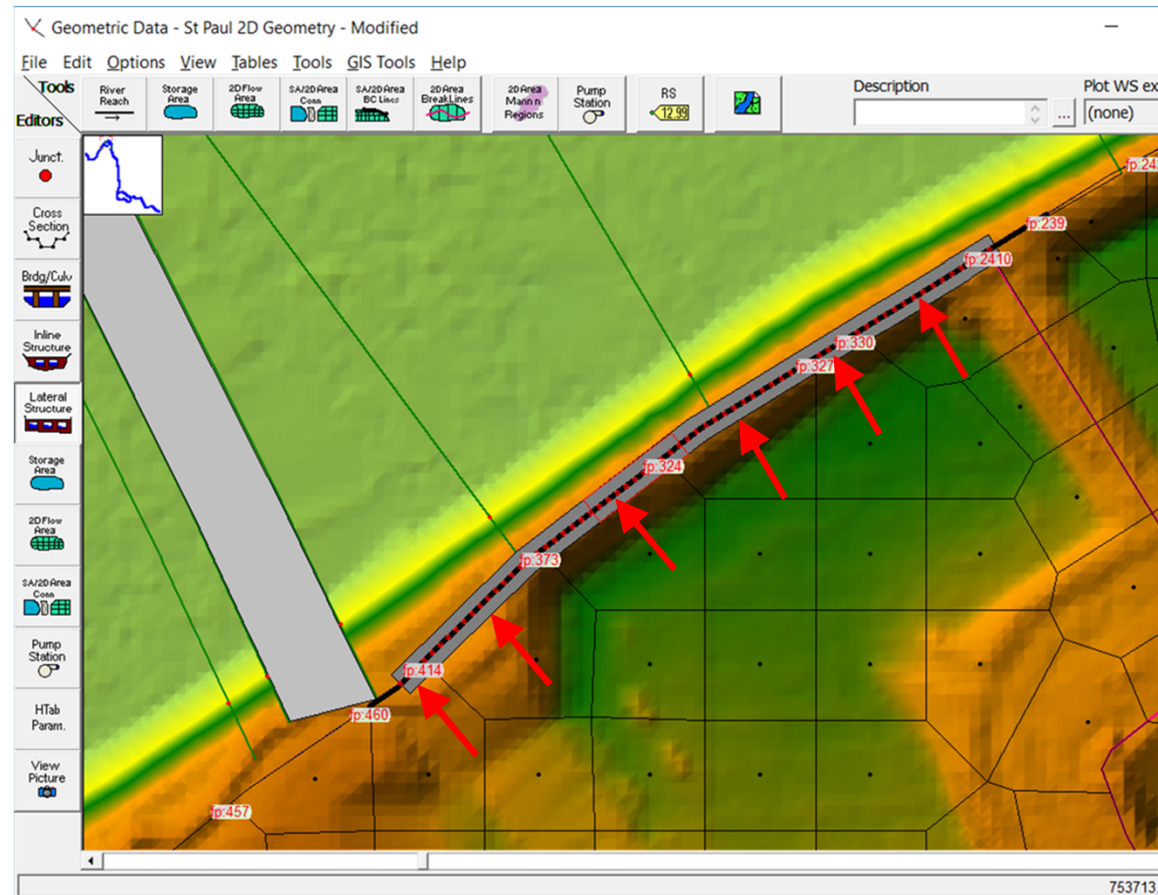
TW Lateral Structure Connections

☒ Computed Default Weir Stationing ☐ User Defined Weir Stationing

Default Computed Weir Stationing		
	2D Face Points	Weir Station
1	456	-34.3083
2	412	28.59606
3	368	174.9681
4	319	314.8326
5	322	479.7218
6	325	521.3957
7	2408	663.5559
8	239	725.6677
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		

User Defined Weir Stationing		
	2D Face Points	Weir Station
1	454	5470.98
2	411	5537.3
3	368	5703.08
4	319	5861.57
5	322	6048.15
6	325	6095.38
7	User Specified Connections	
8	Option will not be used	
9	because the lateral structure	
10	has a geo-referenced	
11	centerline.	
12		
13		
14		
15		
16		
17		
18		
19		

OK Cancel





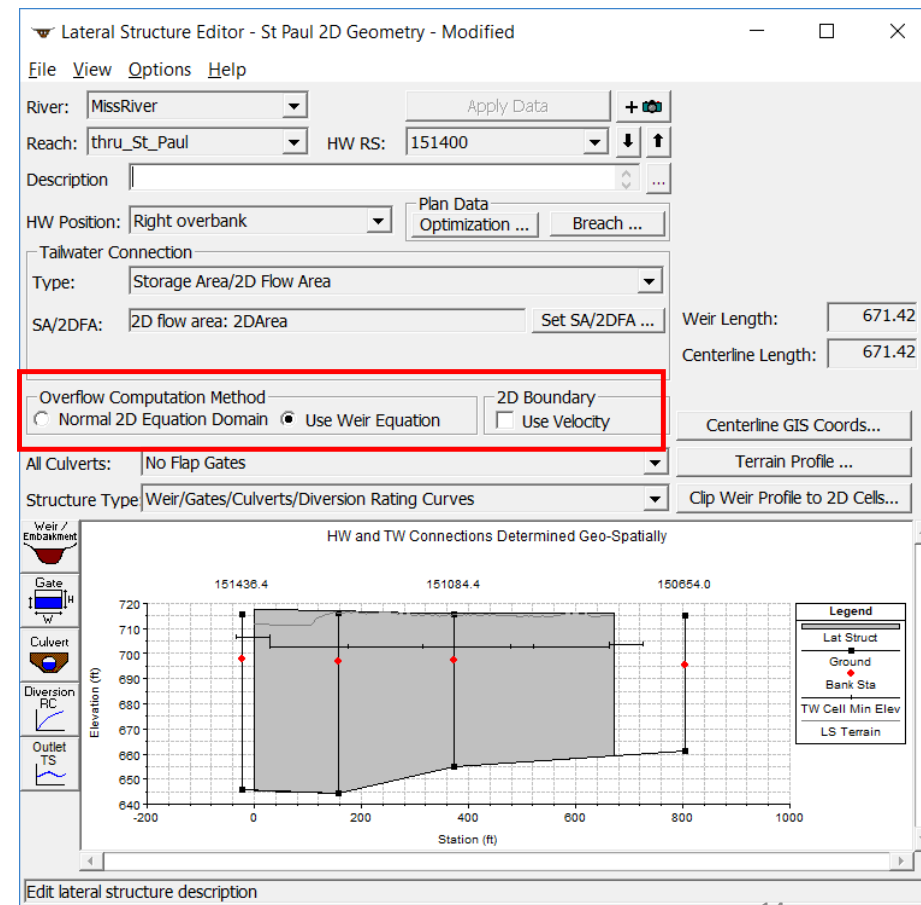
Overflow Computations

- Weir Equation

- $Q = CLH^{3/2}$
- Good for free fall conditions
- Not great for submerged weir

- 2D Equation

- Simply modifies cell face properties
- Good for highly submerged conditions





Weir Coefficients for Lateral Structures

What is being modeled with the Lateral Structure	Description	Range of Weir Coefficients
Levee/Roadway – 3ft or higher above natural ground	Broad crested weir shape, flow over Levee/road acts like weir flow	1.5 to 2.6 (2.0 default) SI Units: 0.83 to 1.43
Levee/Roadway – 1 to 3 ft elevated above ground	Broad Crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.	1.0 to 2.0 SI Units: 0.55 to 1.1
Natural high ground barrier – 1 to 3 ft high	Does not really act like a weir, but water must flow over high ground to get into 2D area.	0.5 to 1.0 SI Units: 0.28 to 0.55
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	0.2 to 0.5 SI Units: 0.11 to 0.28

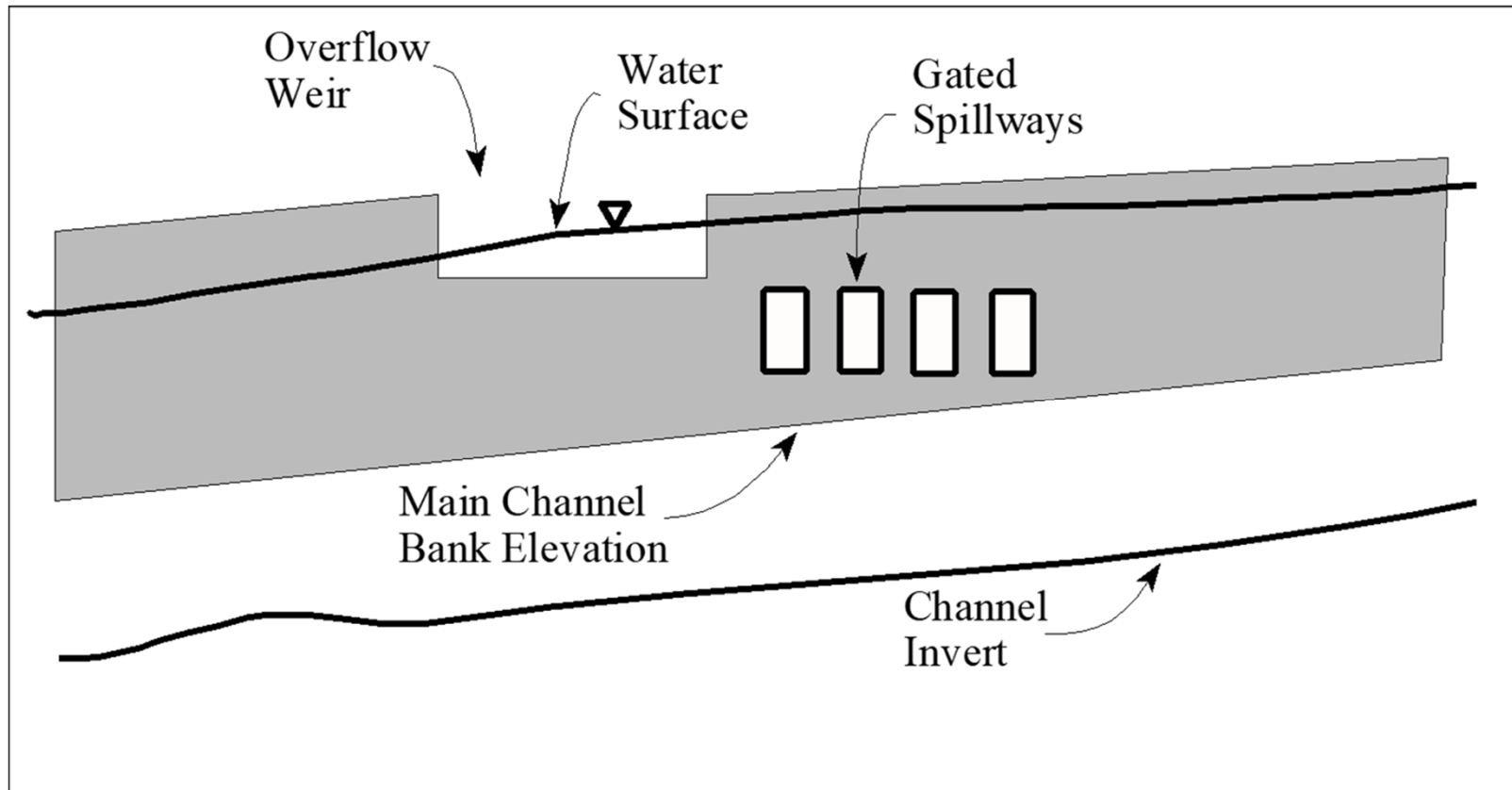


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Weir Computation





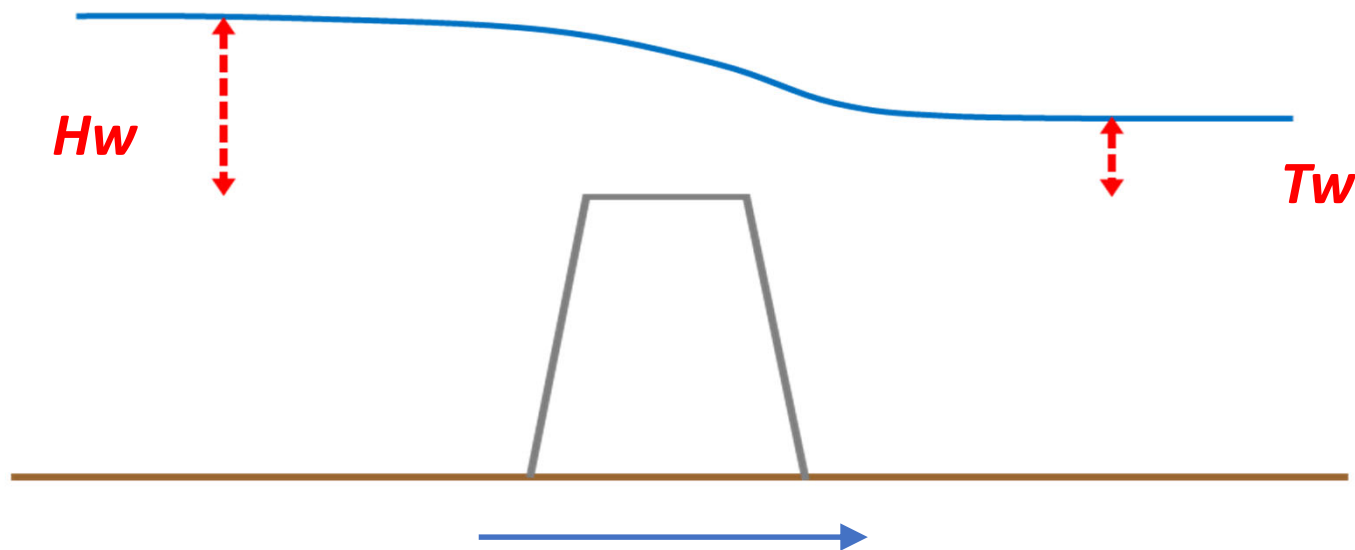
Computation Considerations

- Flow is assumed constant over the timestep
 - Long timesteps can transfer too much volume and oscillate
- Order of computations
 - 1D computes first then 2D
 - Weir flow is computed with current HW (1D) and previous TW (2D)
- Tailwater elevations
 - TW elevations of each connected cell is used
- Weir submergence



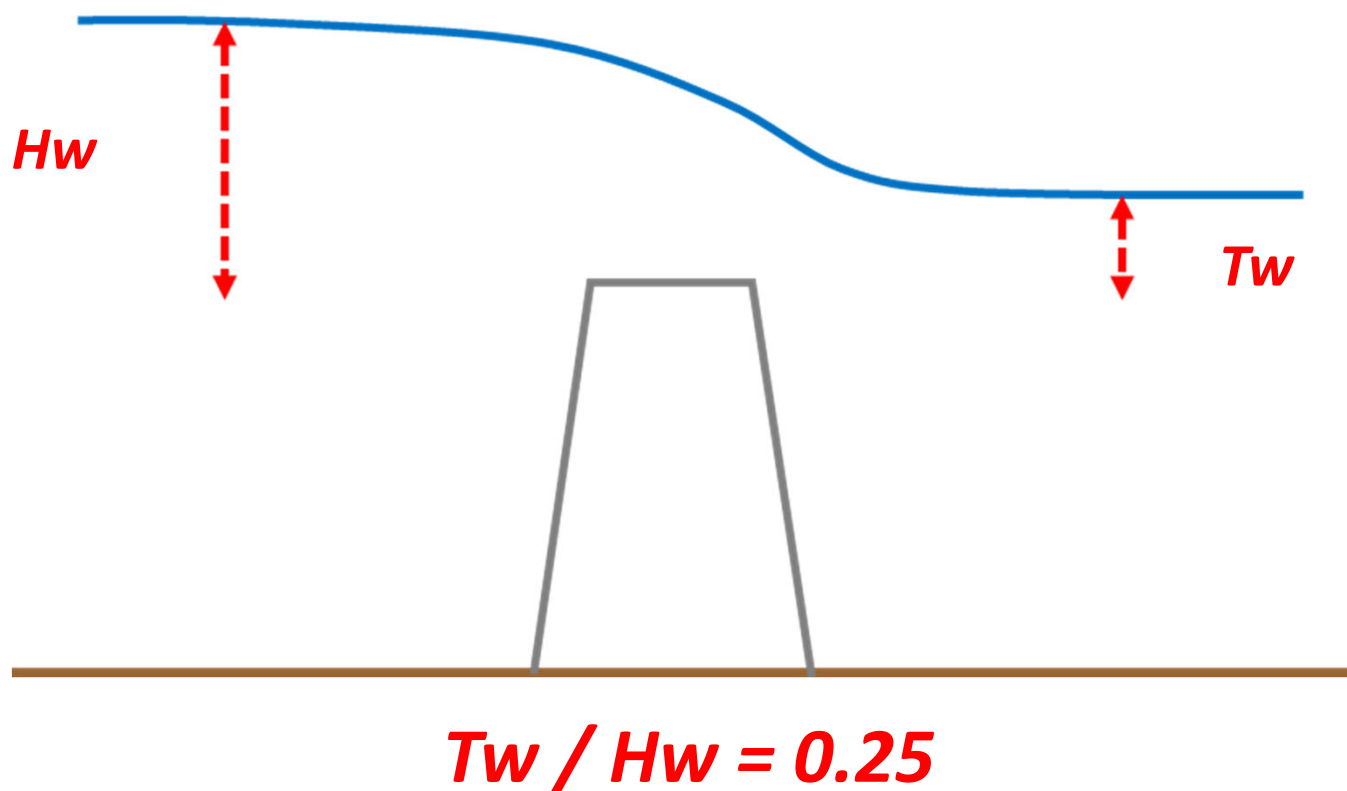
Weir Submergence

- Tailwater begins to impact weir flow
- A weir submergence curve is used to compute the reduction in flow
- This can be a dramatic reduction



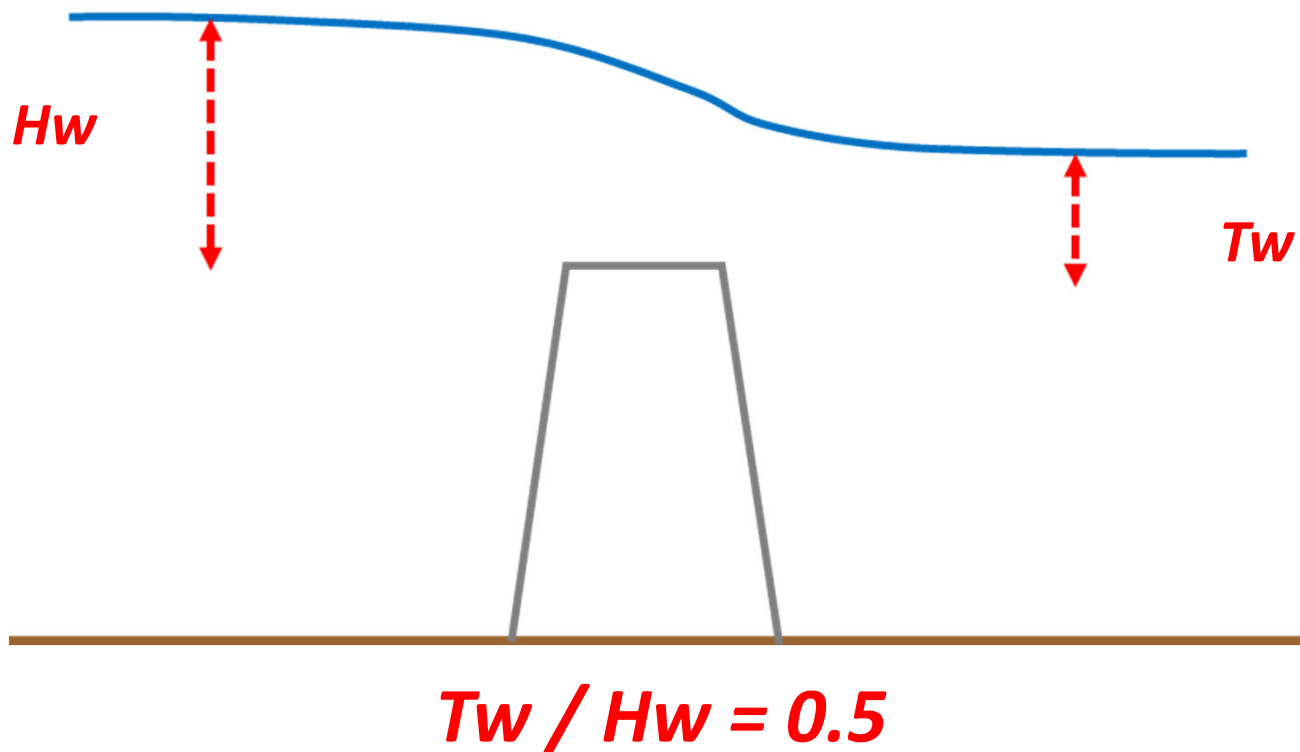


Will Weir Submerge?



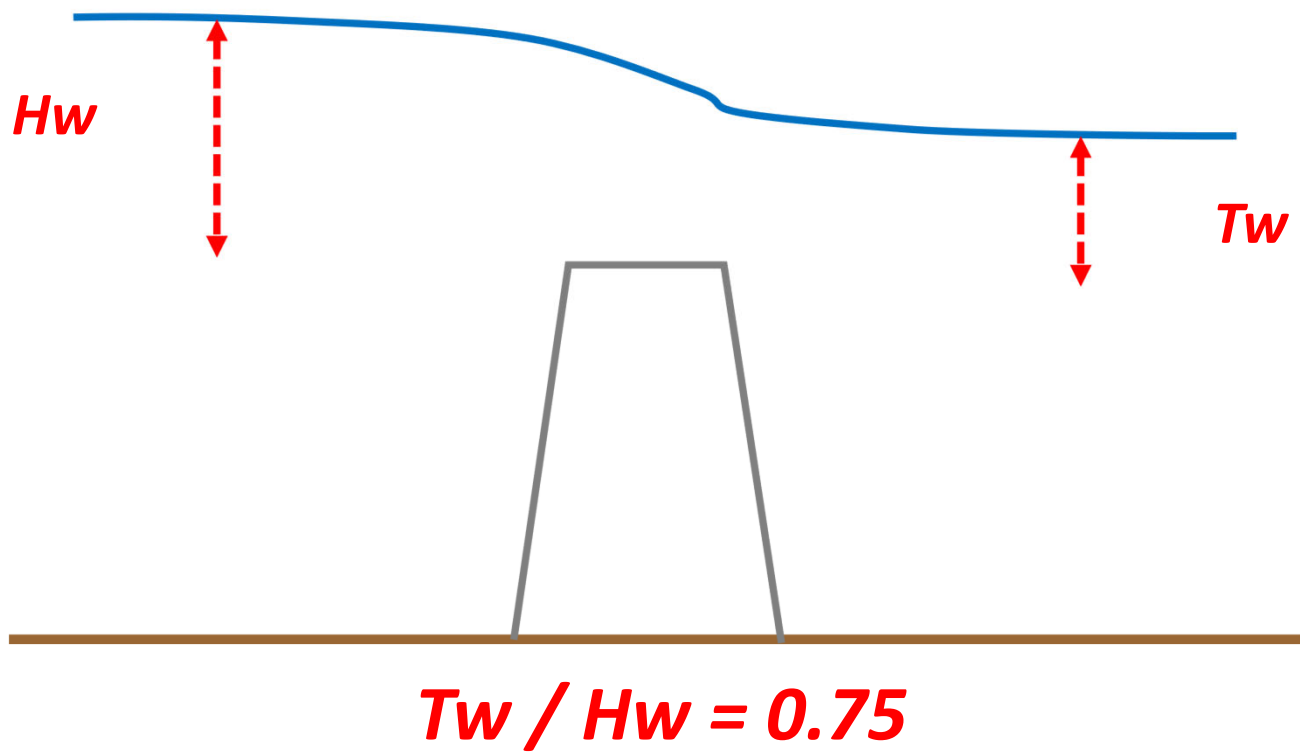


Will Weir Submerge?



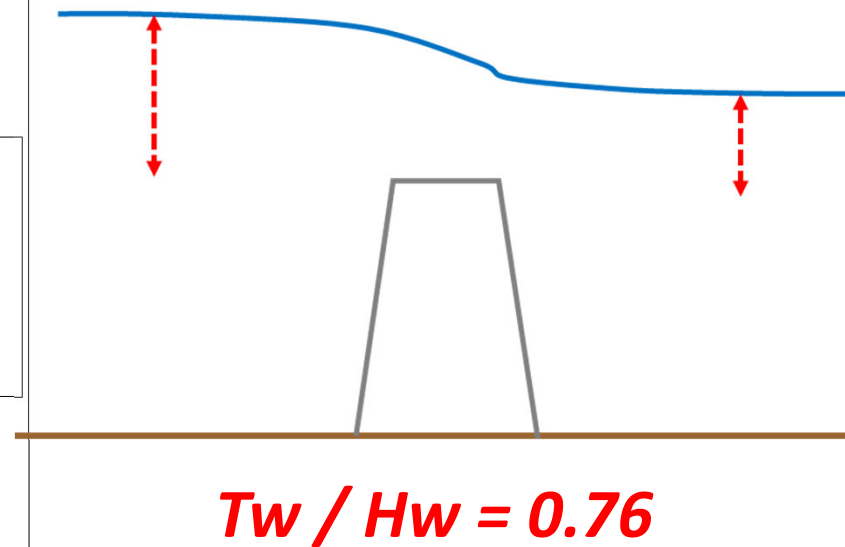
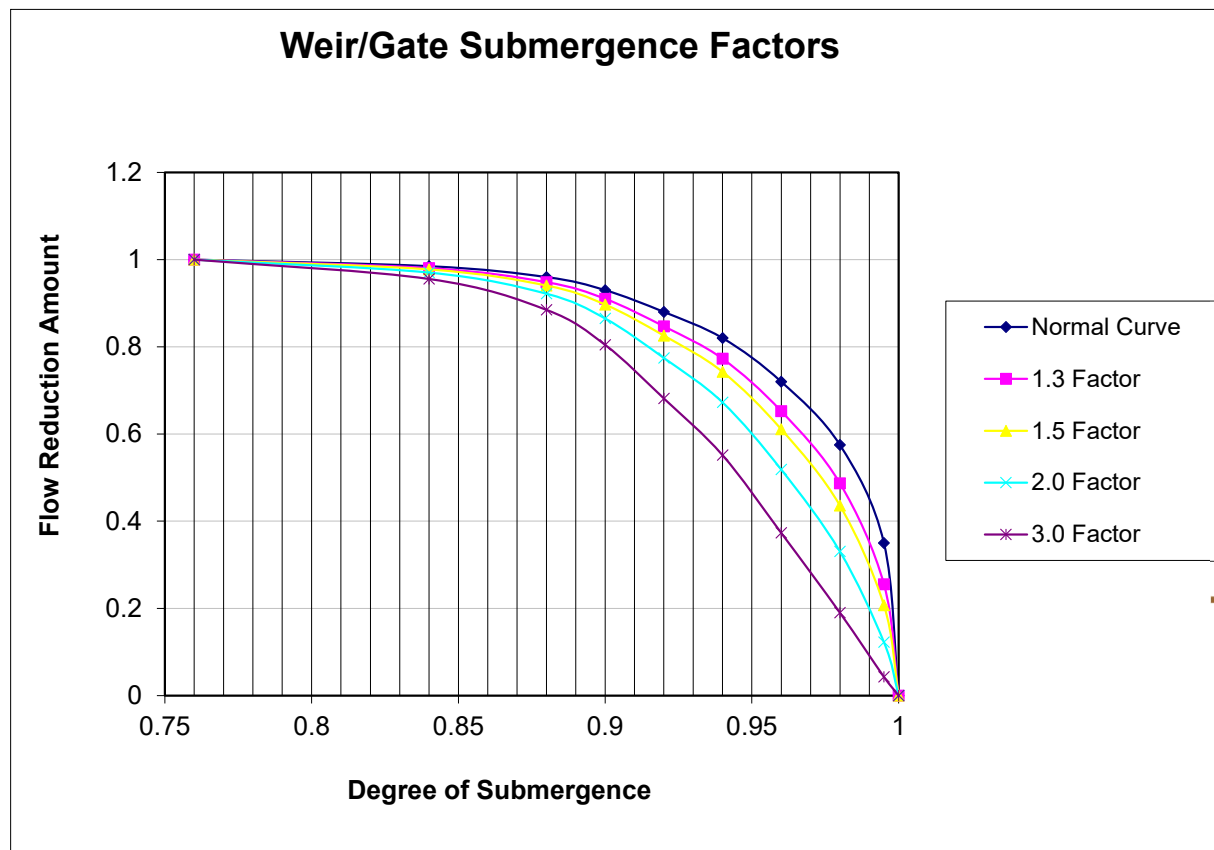


Will Weir Submerge?





Weir Submergence Curves





Lateral Structure Computational Options

HEC-RAS Unsteady Computation Options and Tolerances

General | 2D Flow Options | 1D/2D Options | Advanced Time Step Control | 1D Mixed Flow Options

1D Unsteady Flow Options

Theta [implicit weighting factor] (0.6-1.0):	1.
Theta for warm up [implicit weighting factor] (0.6-1.0):	1.
Water surface calculation tolerance [max=0.2](ft):	0.02
Storage Area elevation tolerance [max=0.2](ft):	0.05
Flow calculation tolerance [optional] (cfs):	
Max error in water surface solution (Abort Tolerance)(ft):	100.
Maximum number of iterations (0-40):	20
Maximum iterations without improvement (0-40):	

1D/2D Unsteady Flow Options

Number of warm up time steps (0 - 100,000):	0
Time step during warm up period (hrs):	0.05
Minimum time step for time slicing (hrs):	0
Maximum number of time slices:	20
Lateral Structure flow stability factor (1.0-3.0):	3.
Inline Structure flow stability factor (1.0-3.0):	1.
Weir flow submergence decay exponent (1.0-3.0):	3.
Gate flow submergence decay exponent (1.0-3.0):	1.
DSS Messaging Level (1 to 10, Default = 4)	4

Geometry Preprocessor Options

Family of Rating Curves for Internal Boundaries

- ☒ Use existing internal boundary tables when possible.
- ☐ Recompute at all internal boundaries

1D Numerical Solution

☒ Finite Difference (classic HEC-RAS methodology)

Finite Difference Matrix Solver

- ☒ Skyline/Gaussian (Default: faster for dendritic systems)
- ☐ Pardiso (Optional: may be faster for large interconnected systems)

☐ Finite Volume (new approach)

Number of cores to use with Pardiso solver: All Available

OK Cancel Defaults ...



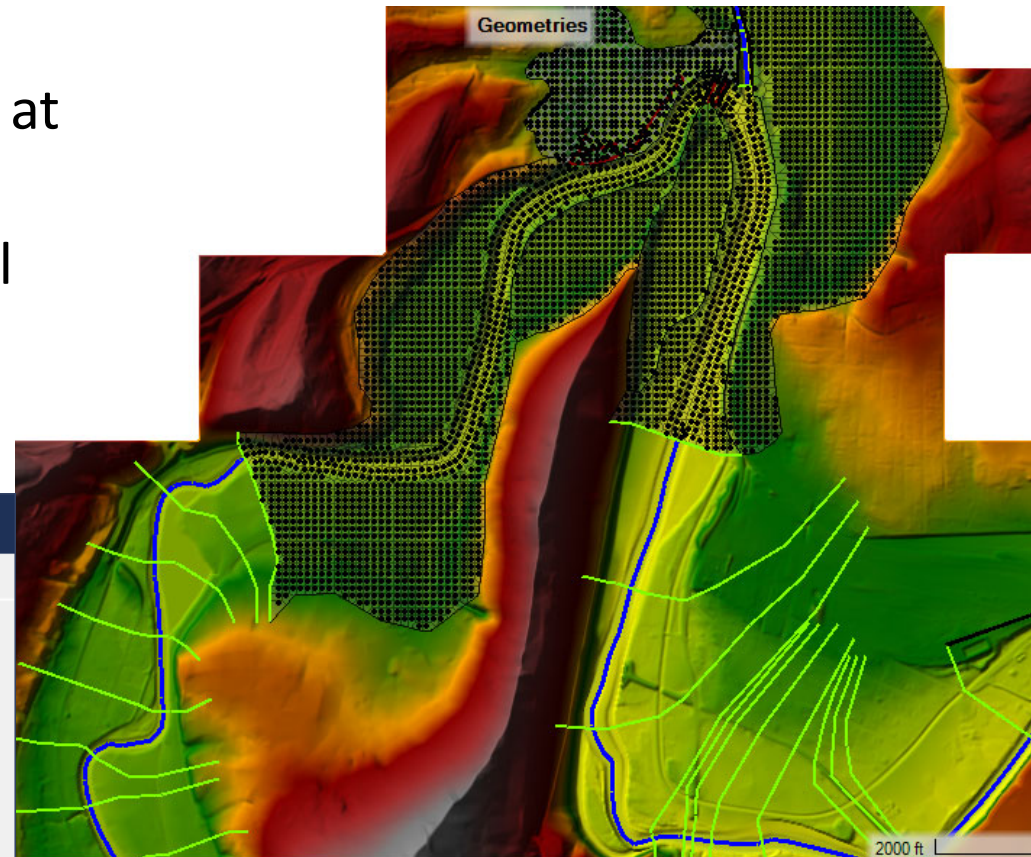
1D/2D Iterations Option

- Monitors WSEL and Flow Tolerance at boundaries
- Iterates the 1D and 2D domain until tolerances are met
- Off by default (0 iterations)

HEC-RAS Unsteady Computation Options and Tolerances

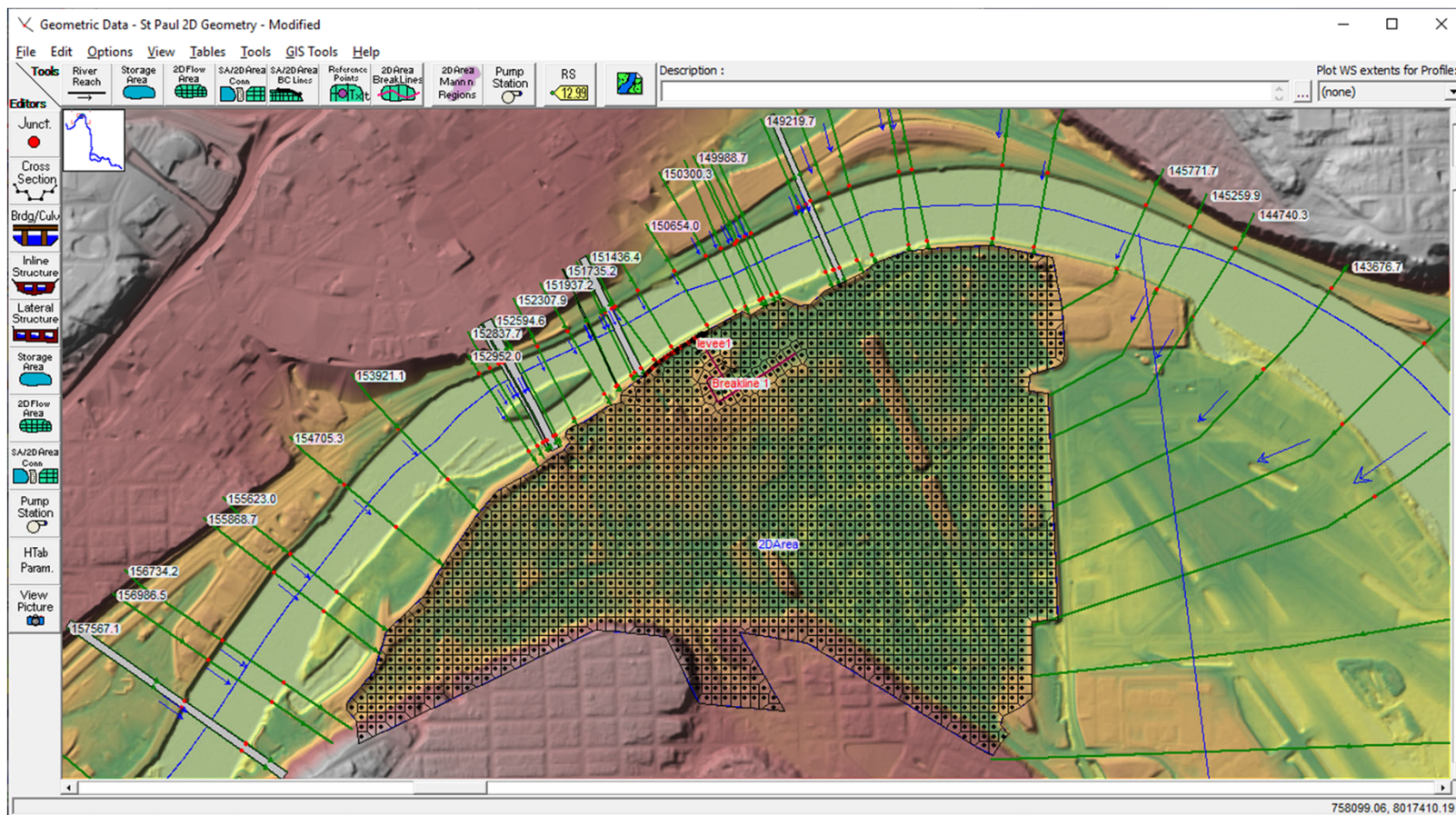
General | 2D Flow Options | **1D/2D Options** | Advanced Time Step Control | 1D Mixed Flow Options

Maximum iterations between 1D and 2D (0=off, 1 to 20):	<input type="text" value="0"/>
Water surface tolerance (ft):	<input type="text" value="0.01"/>
Flow Tolerance (%)	<input type="text" value="0.1"/>
Minimum flow tolerance (cfs):	<input type="text" value="1."/>





1D/2D Modeling Computational Time Step





2D Time Slicing

- Use fraction of computation interval

HEC-RAS Unsteady Computation Options and Tolerances

General 2D Flow Options 1D/2D Options Advanced Time Step Control 1D Mixed Flow Options

☐ Use Coriolis Effects (not used with Diffusion Wave equation)

Parameter	(Default)	BaldEagleCr
1 Theta (0.6-1.0)	1	1
2 Theta Warmup (0.6-1.0)	1	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)		4
8 Initial Conditions Ramp Up Fraction (0-1)	0.5	0.5
9 Number of Time Slices (Integer Value)	1	1
10 Turbulence Model	non-Conservative (original)	non-Conservative (original)
11 Longitudinal Mixing Coefficient		
12 Transverse Mixing Coefficient		
13 Smagorinsky Coefficient	0	0
19 Minimum Iterations		
20 Maximum Iterations		
21 Restart Iteration	10	10
22 Relaxation Factor	1.5	1.5
23 SOR Preconditioner Iterations	10	10

Computation Settings

Computation Interval: 30 Second ... Hydrograph Output Interval: 30 Minute

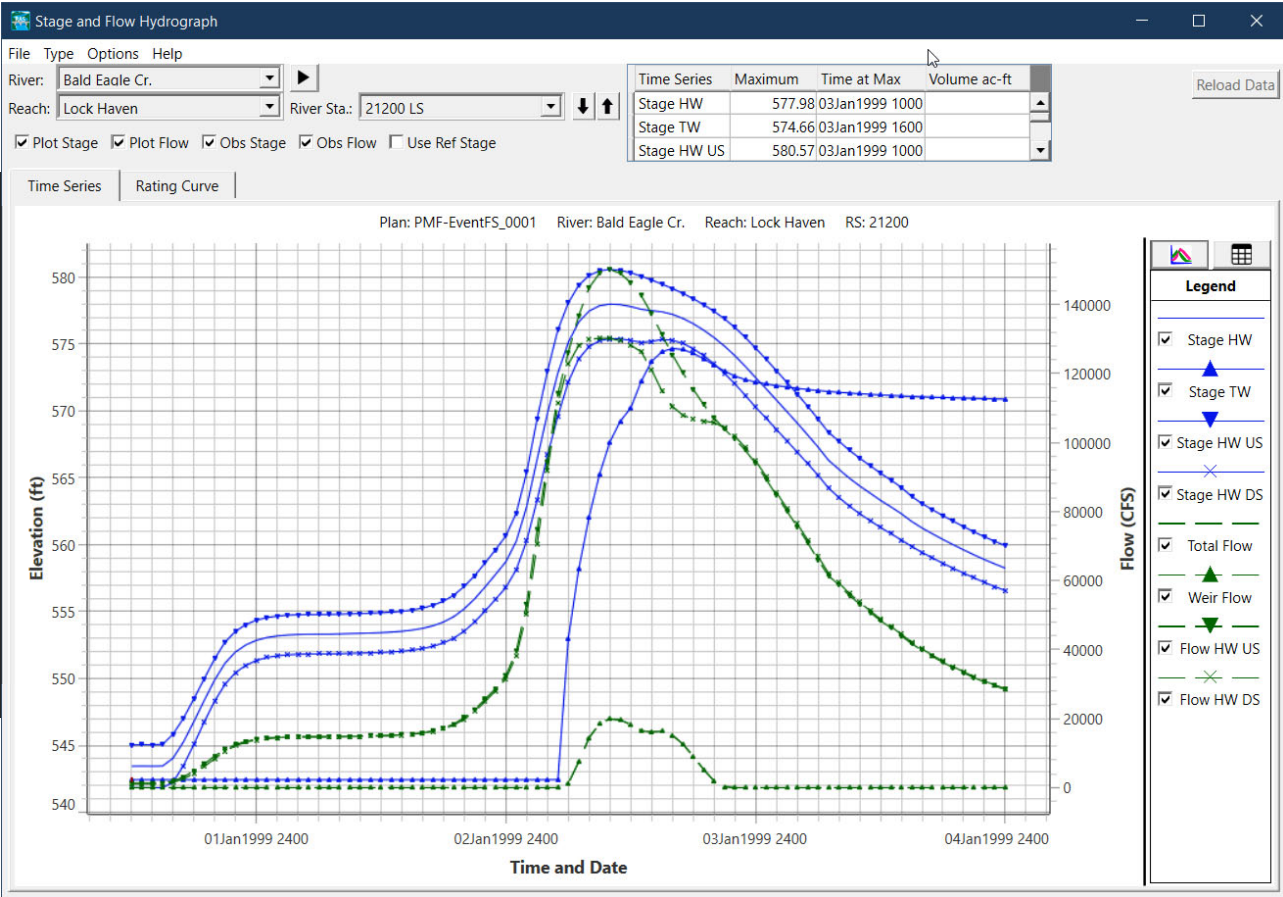
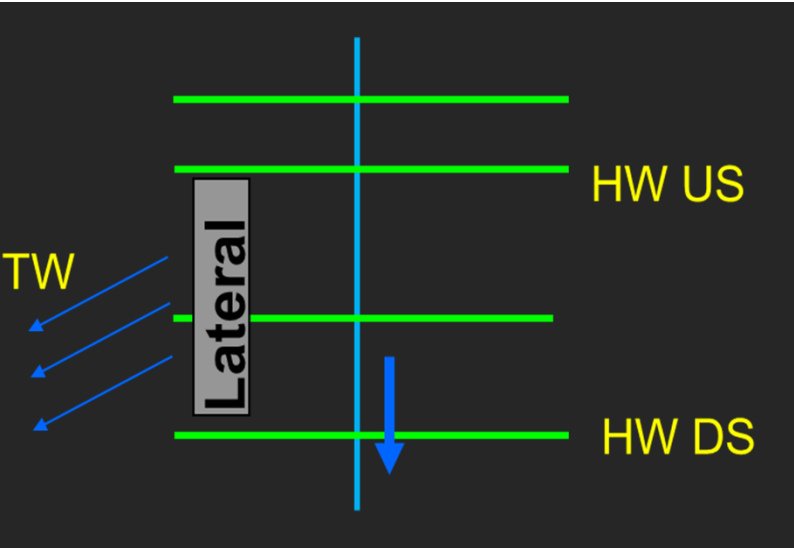
Mapping Output Interval: 30 Minute Detailed Output Interval: 1 Hour

Project DSS Filename: C:\Computational Investigations\Testing\Upper Chickasawh...

OK Cancel Defaults ...

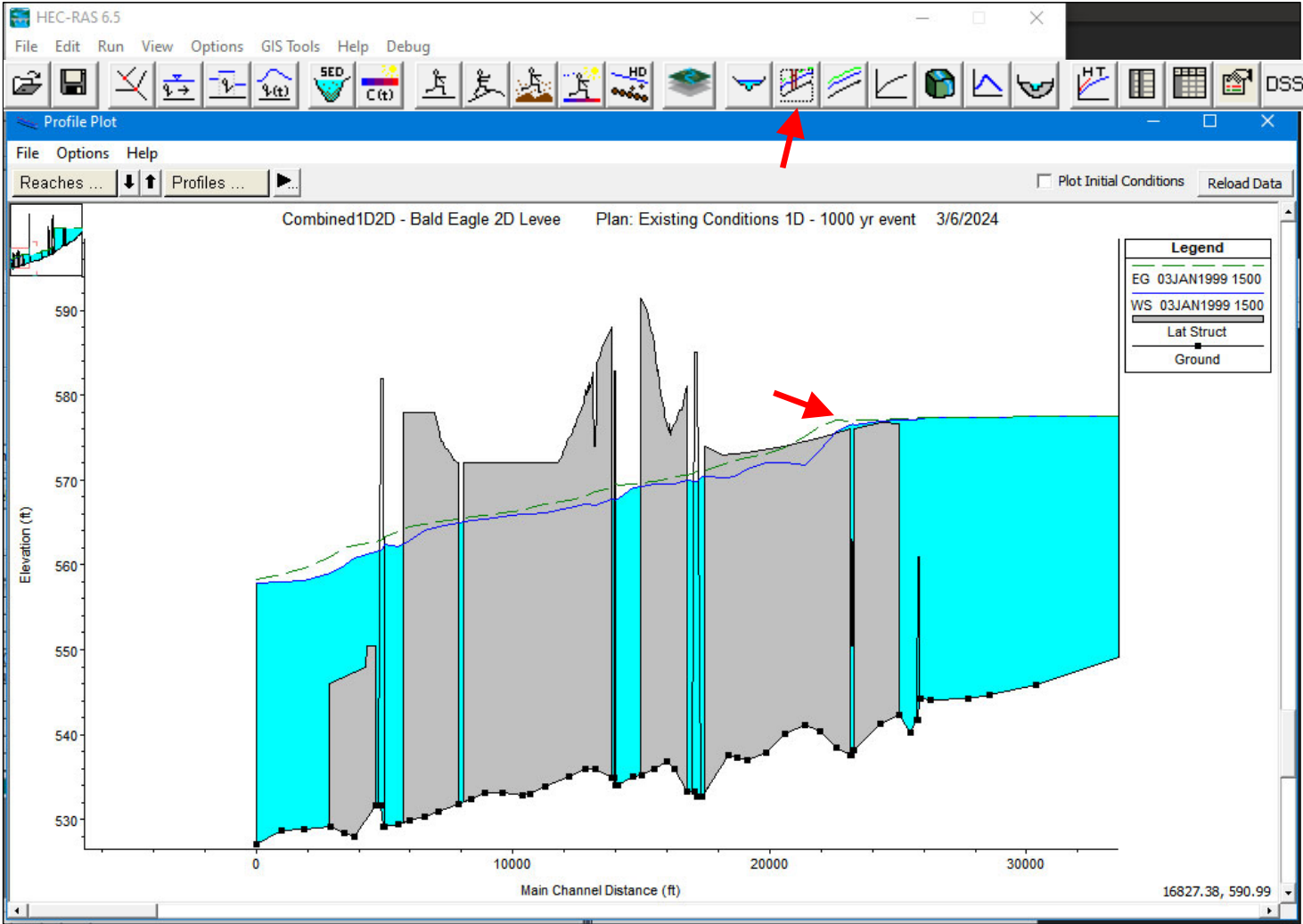


Hydrograph – Lateral Structure





Profile Plot





Lateral Structure Detailed Output

Lateral Structure Output			
File Type Options Help			
River:	MissRiver	Profile:	13FEB2099 0600
Reach:	thru_St_Paul	RS:	151400
Plan: 2D Run Modified MissRiver thru_St_Paul RS: 151400 Lateral Structure Profile: 13FEB2099 0600			
E.G. US. (ft)	716.10	Weir Sta US (ft)	5750.00
W.S. US. (ft)	715.28	Weir Sta DS (ft)	5850.00
E.G. DS (ft)	716.08	Min El Weir Flow (ft)	704.00
W.S. DS (ft)	714.80	Wr Top Wdth (ft)	100.00
Q US (cfs)	281458.70	Weir Max Depth (ft)	11.22
Q Leaving Total (cfs)	4332.12	Weir Avg Depth (ft)	11.14
Q DS (cfs)	277159.10	Weir Flow Area (sq ft)	1113.82
Perc Q Leaving	1.54	Weir Coef (ft ^{1/2})	2.600
Q Weir (cfs)	4332.12	Weir Submerg	0.95
Q Gates (cfs)		Q Gate Group (cfs)	
Q Culv (cfs)		Gate Open Ht (ft)	
Q Lat RC (cfs)		Gate #Open	
Q Outlet TS (cfs)	0.00	Gate Area (sq ft)	
Q Breach (cfs)	4332.12	Gate Submerg	
Breach Avg Velocity (ft/s)	3.89	Gate Invert (ft)	
Breach Flow Area (sq ft)	1113.82	Gate Weir Coef	
Breach WD (ft)	100.00		
Breach Top El (ft)			
Breach Bottom El (ft)	704.00		
Breach SSL (ft)	0.00		
Breach SSR (ft)	0.00		
Errors, Warnings and Notes			
Average flow velocity through a breach.			



Levee Breaching

Levee (Lateral Structure) Breach Data

Lateral:

☒ **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:

Start Date:

Start Time:

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

StPaulIES Plan: Fail Middle - 2D Run Modified FEQ Jan17 7/17/2018

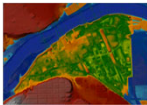
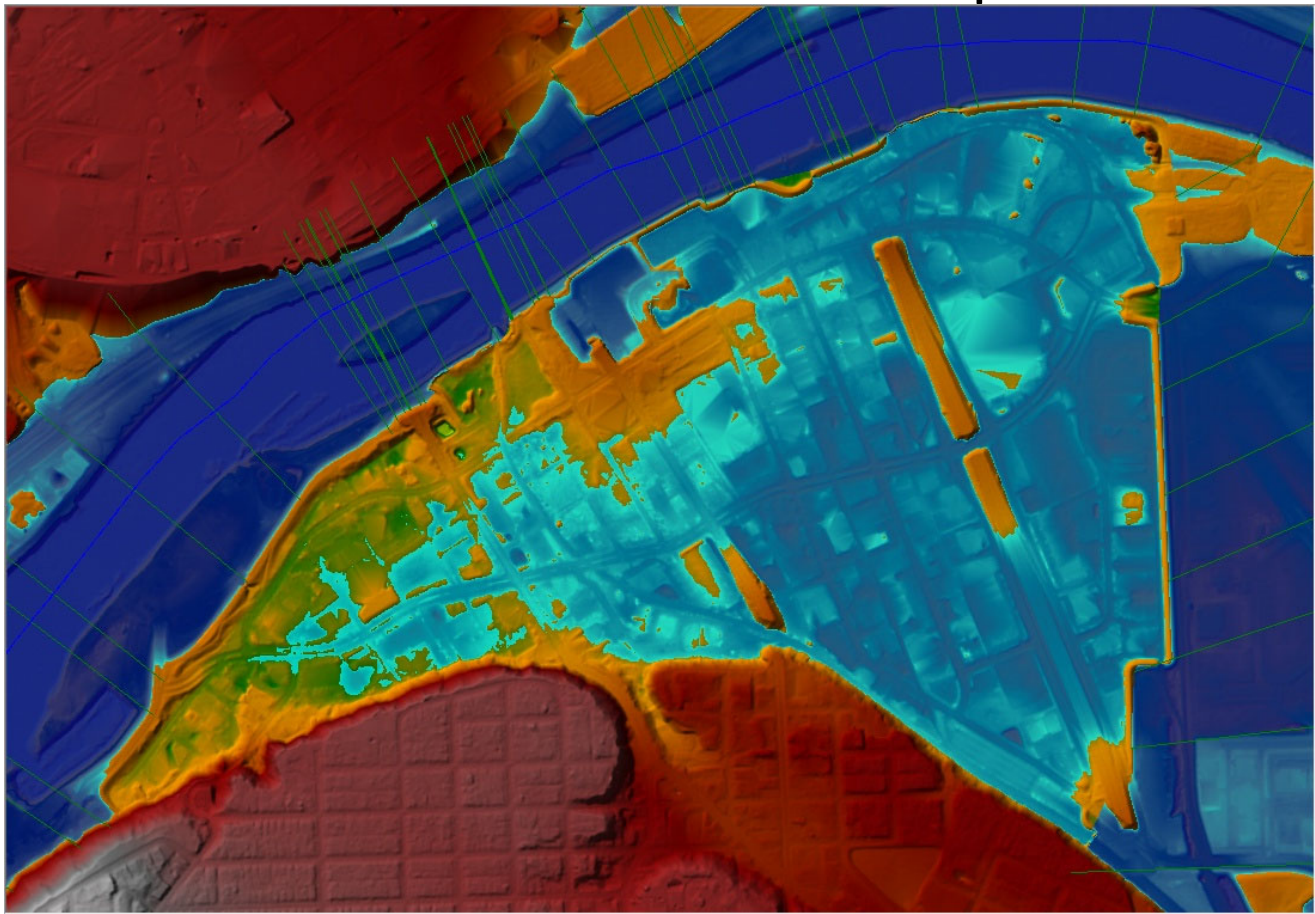
Legend

- Lat Struct
- Centerline Terrain
- Final Breach

OK Cancel



Saint Paul Levee Breach Example



Questions?

