Inline and Lateral Structures

Eric Tichansky, PE, CFM

Goals

1. Use Cases for Hydraulic Structures in HEC-RAS

2. Computations for Hydraulic Structures

3. Controlling Hydraulic Structure in HEC-RAS

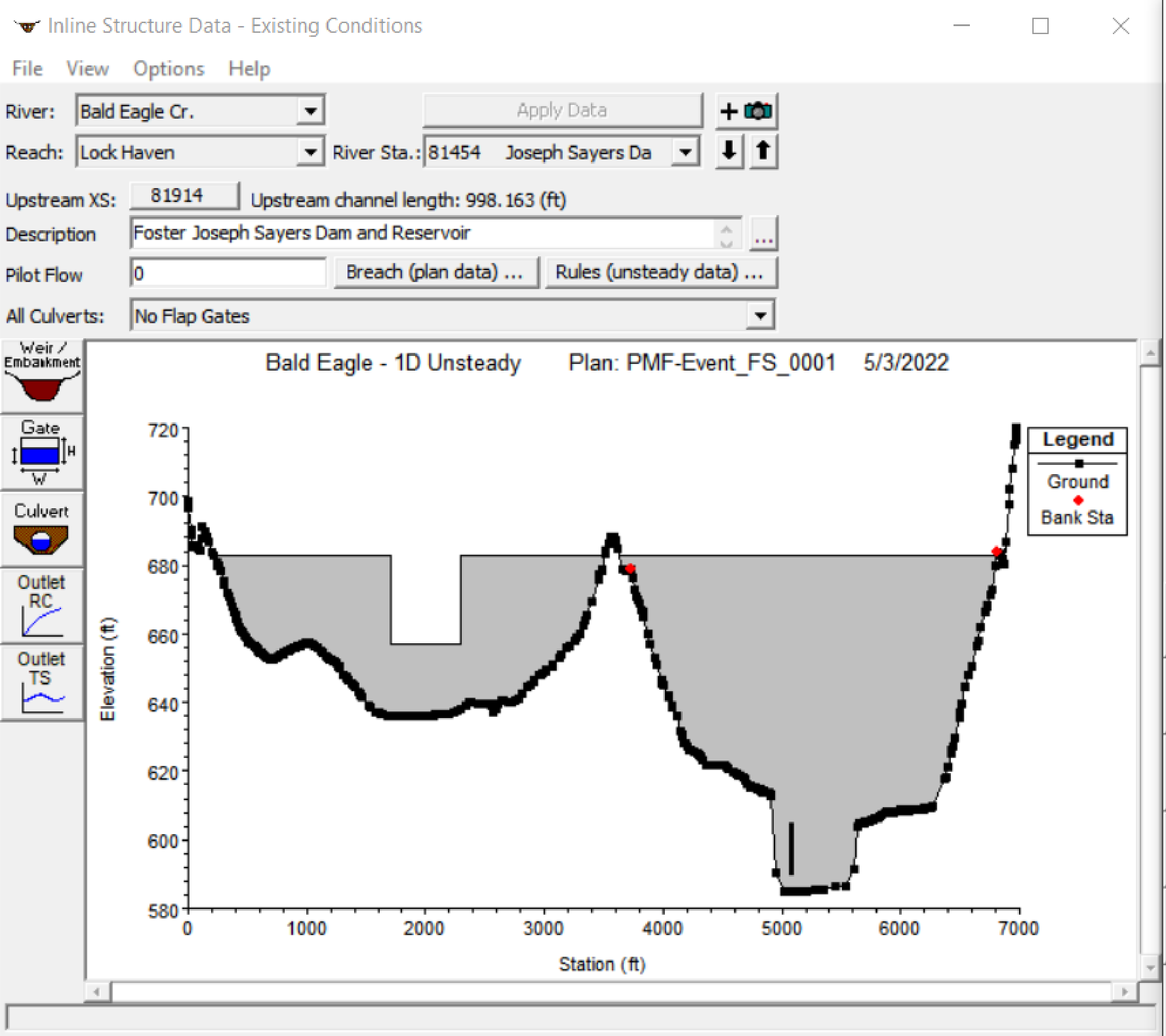
Overview

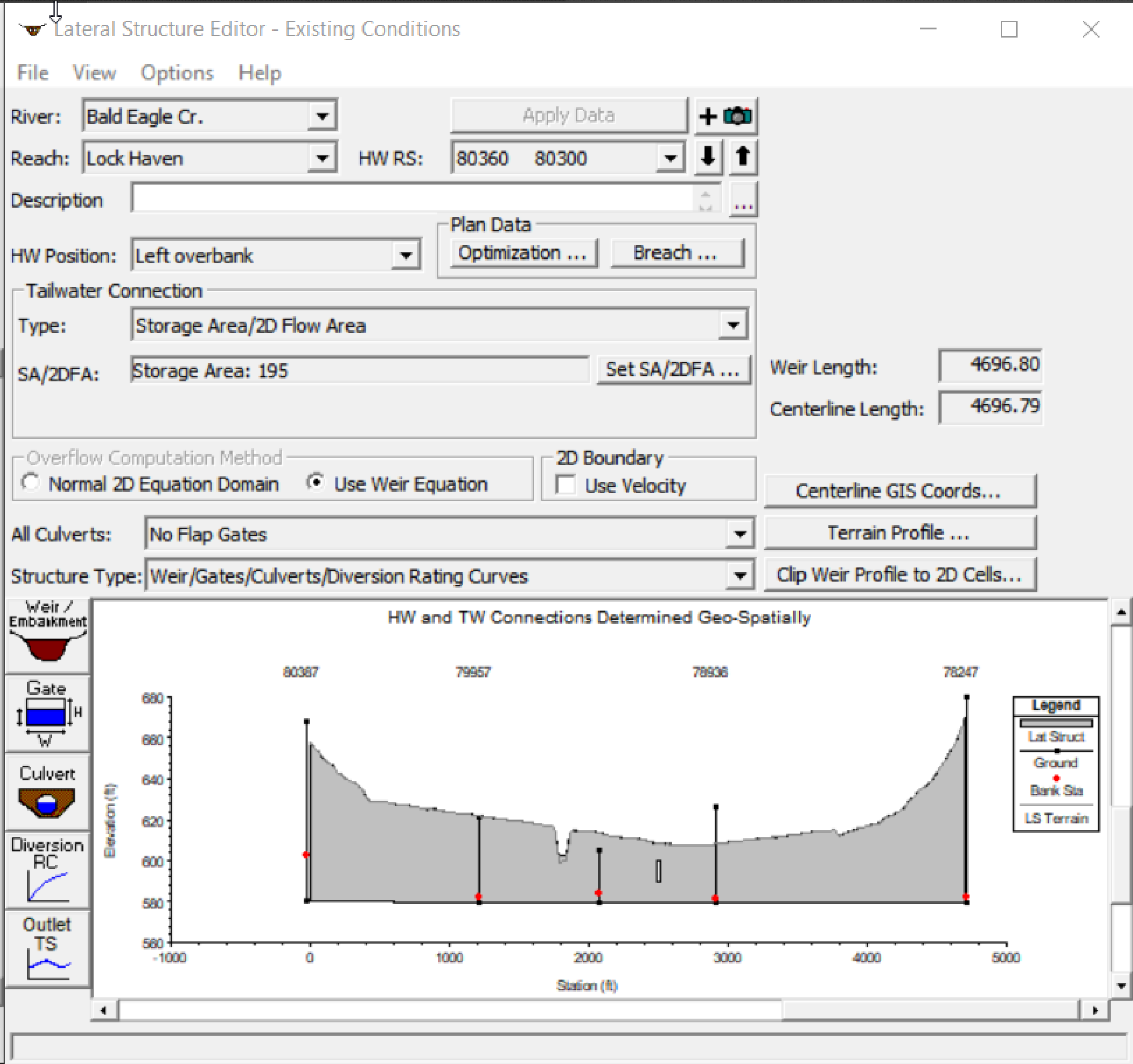
- Introduction to Hydraulic Structures
- Inline Structures
  - Uses
  - Weirs
  - Gates
  - Ratings
- Lateral Structures
  - Uses
  - Differences from Inline Structures

Inline & Lateral Structures

- Hydraulic structures are used to model:
  - Dams of all shapes and sizes
  - Drop structures and natural drops
  - Culverts
  - Levees
  - Diversions
  - Detention ponds
  - Natural overbank flow

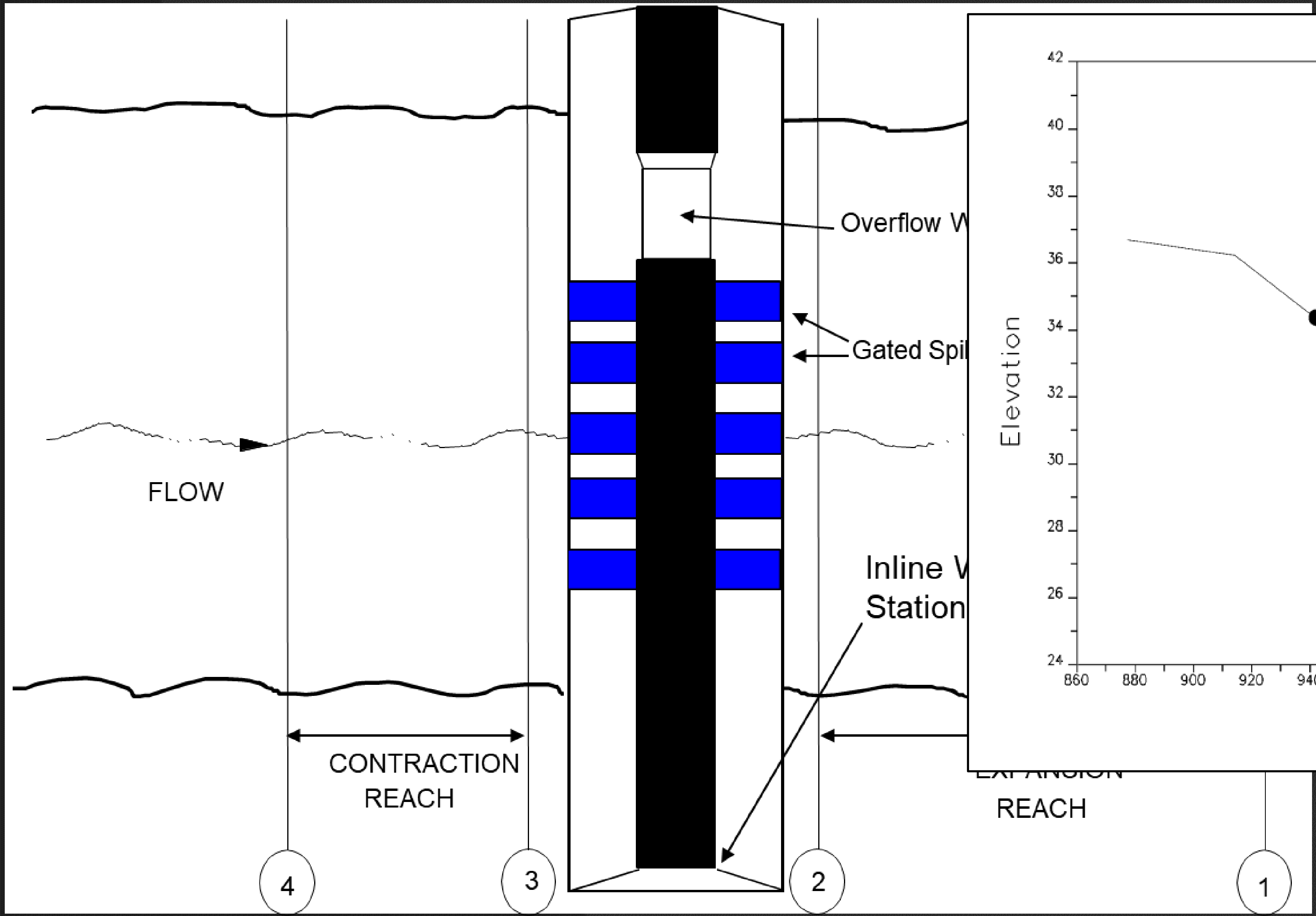
Hydraulic Structure Features

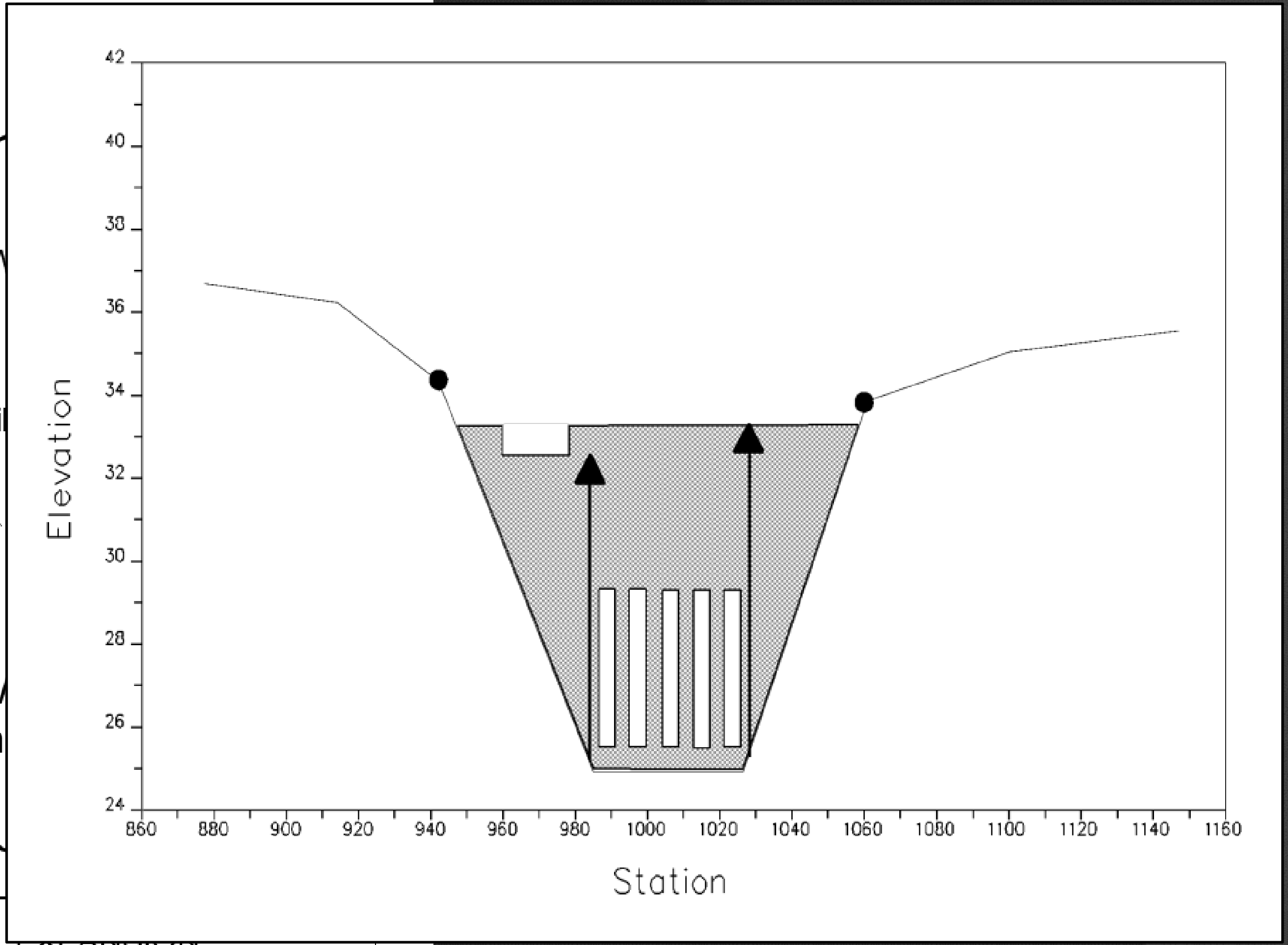


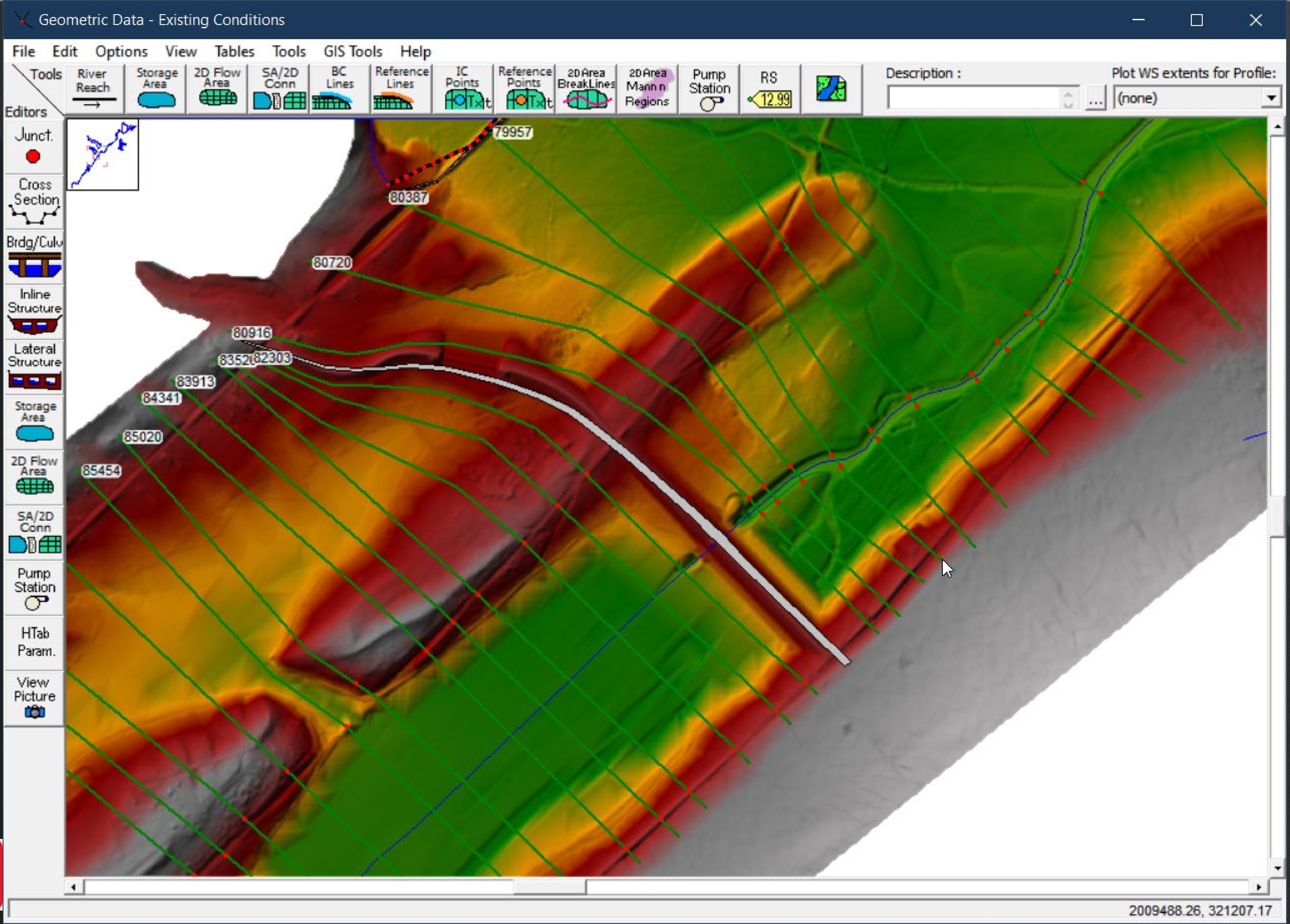


Inline Structures

Cross Section Layout






Geometric Data - Existing Conditions
File
Edit
Options
View
Tables
Tools
GIS Tools
Help
Tools
Editors
River Reach
Storage Area
2D Flow Area
SA/2D Conn
BC Lines
Reference Lines
IC Points
Reference Points
2D Area BreakLines
2D Area Mann n Regions
Pump Station
RS
12.99
Description :
Plot WS extents for Profile:
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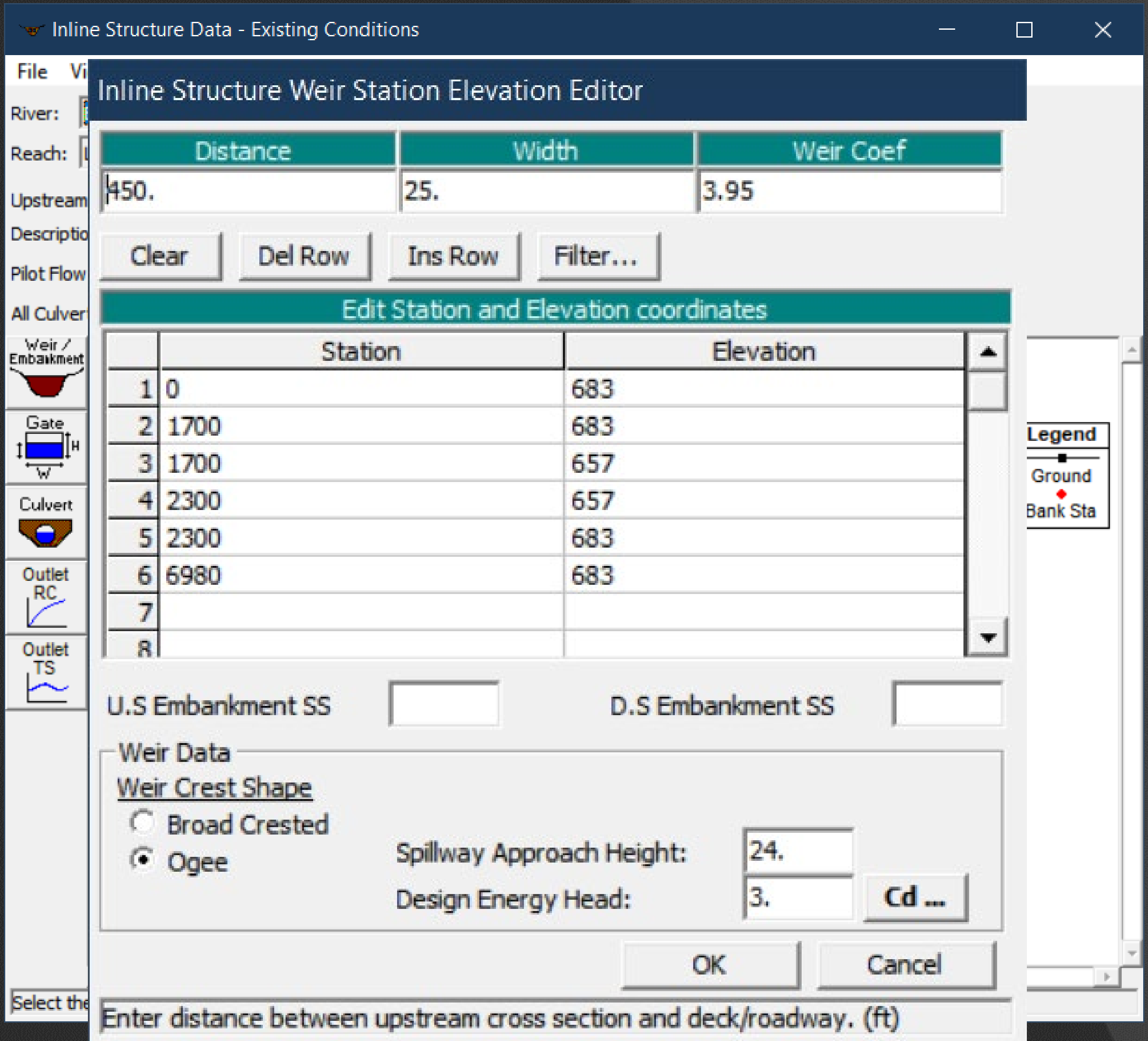
Cross Section
Brdg/Culv
Inline Structure
Lateral Structure
Storage Area
2D Flow Area
SA/2D Conn
Pump Station
HTab Param.
View Picture
79957
80387
80720
80916
8352
82303
83913
84341
85020
85454
2009488.26, 321207.17

Weir Options for Inline Structures

- Uses standard weir flow equation

$$Q = CLH^{3/2}$$

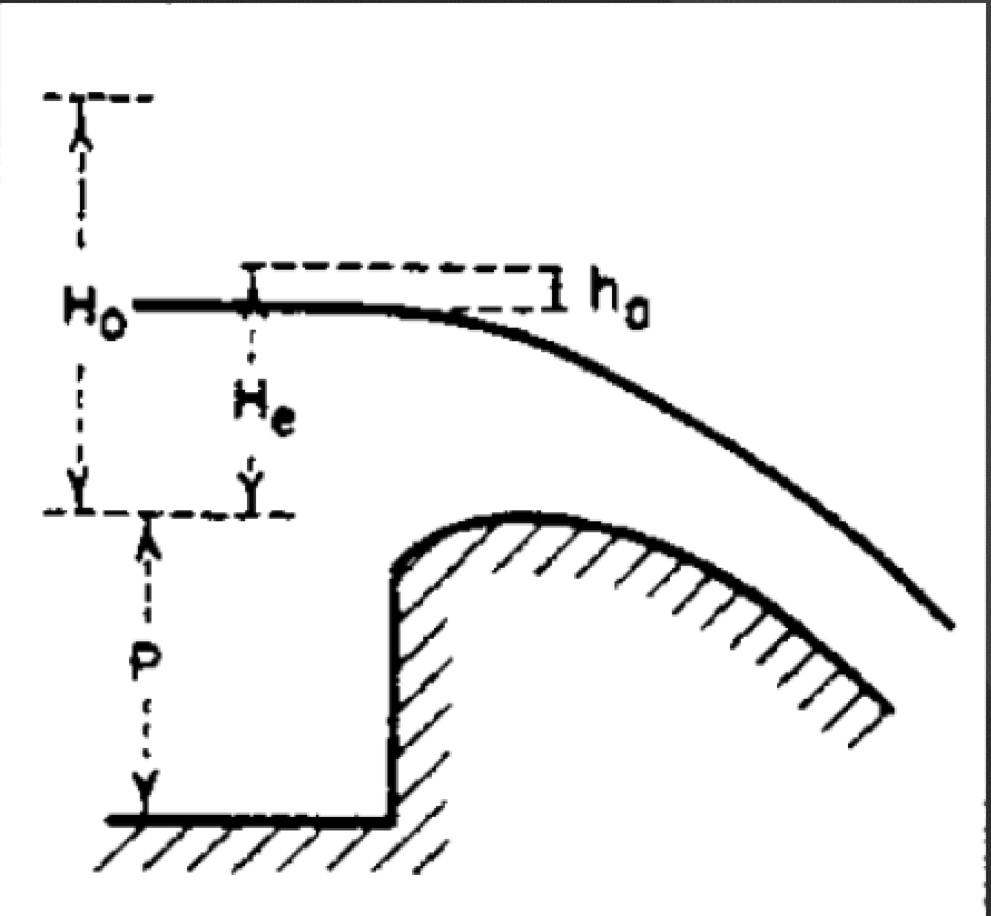
- HEC-RAS accounts for weir submergence to reduce flow
- Weir shape
  - Broad Crested
  - Ogee



Ogee Weir vs Broad Crested

$$Q = CLH^{3/2}$$

- Broad Crested
  - Single weir coefficient
- Ogee
  - Spillway Approach Height (*P*)
  - Design Energy Head (*He*)
  - Weir coefficient (C)
- Ogee (C) Adjustment
  - Ratio of *He* / *Ho*

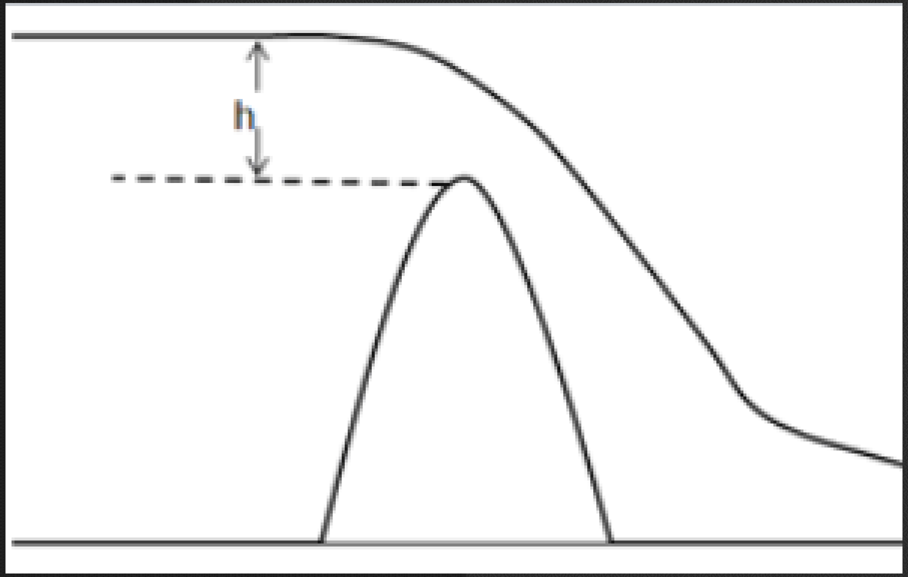


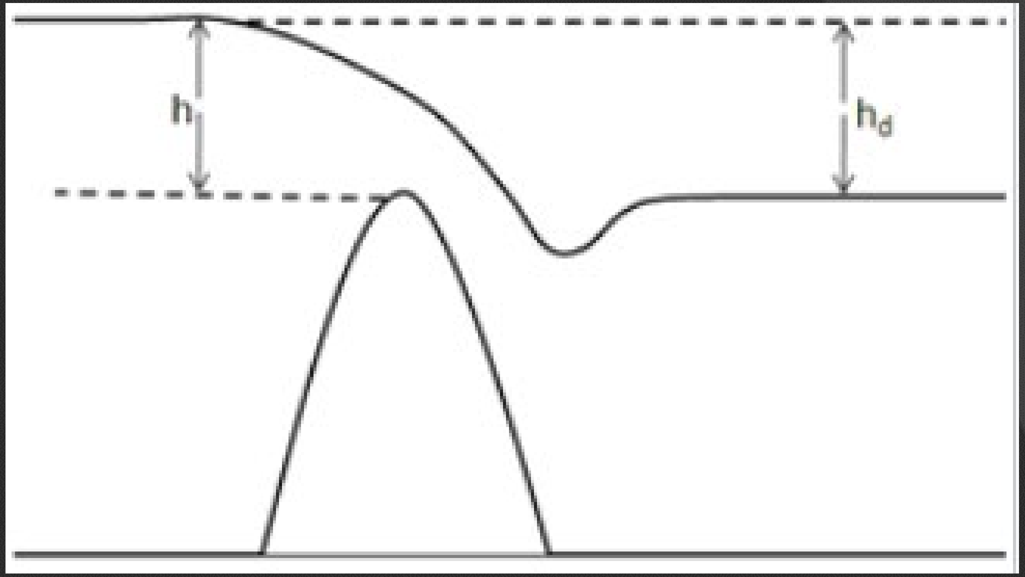
Typical Weir Coefficients

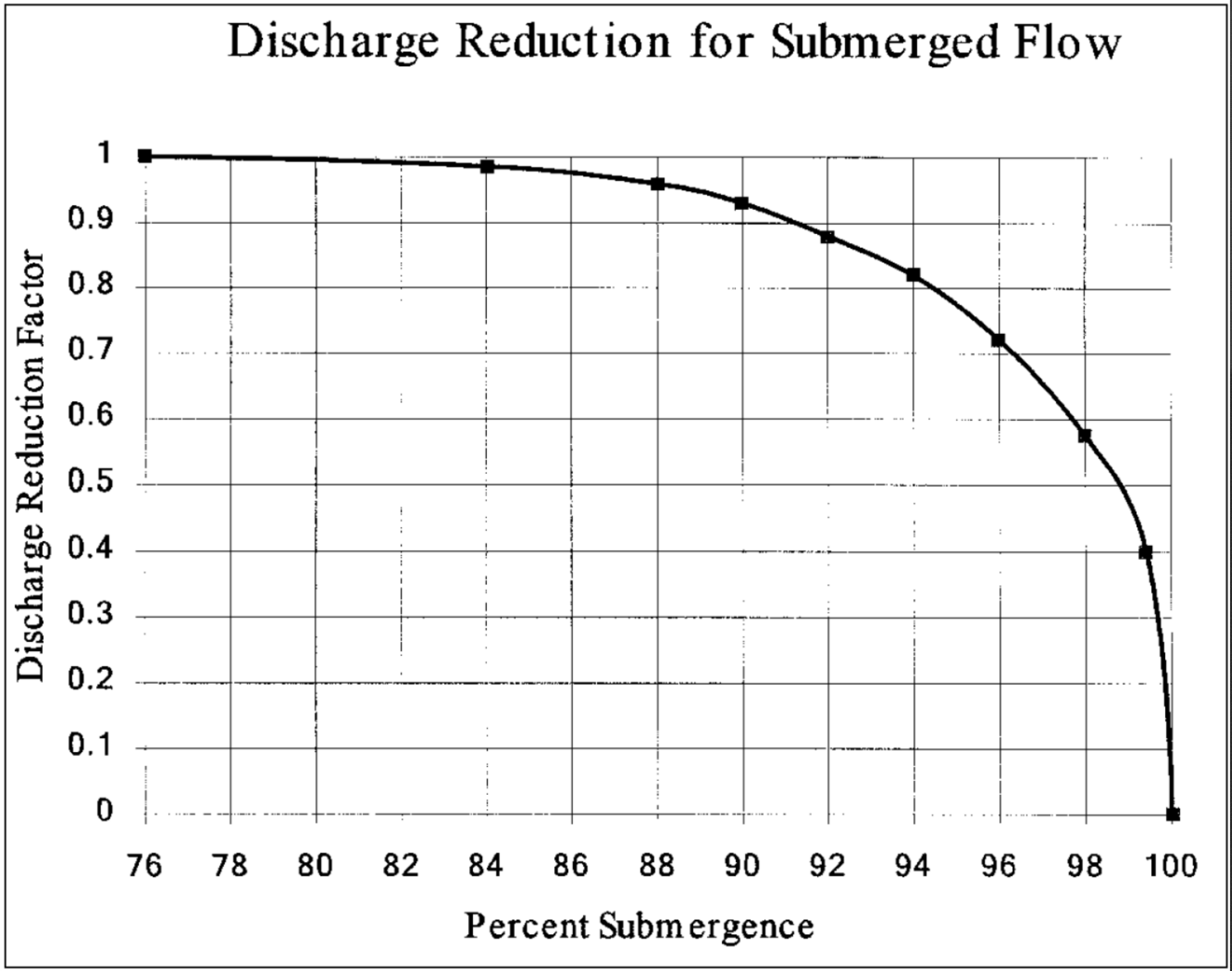
Weir Crest Shape	*Typical Coefficient Range*
Broad Crested	2.6 - 3.1
Ogee Crested	3.2 – 4.1
Sharp Crested	3.1 – 3.3

Weir Submergence

- Tailwater begins to impact flow
- RAS reduces weir flow coefficient automagically
- Different methods for Ogee and Broad Crested

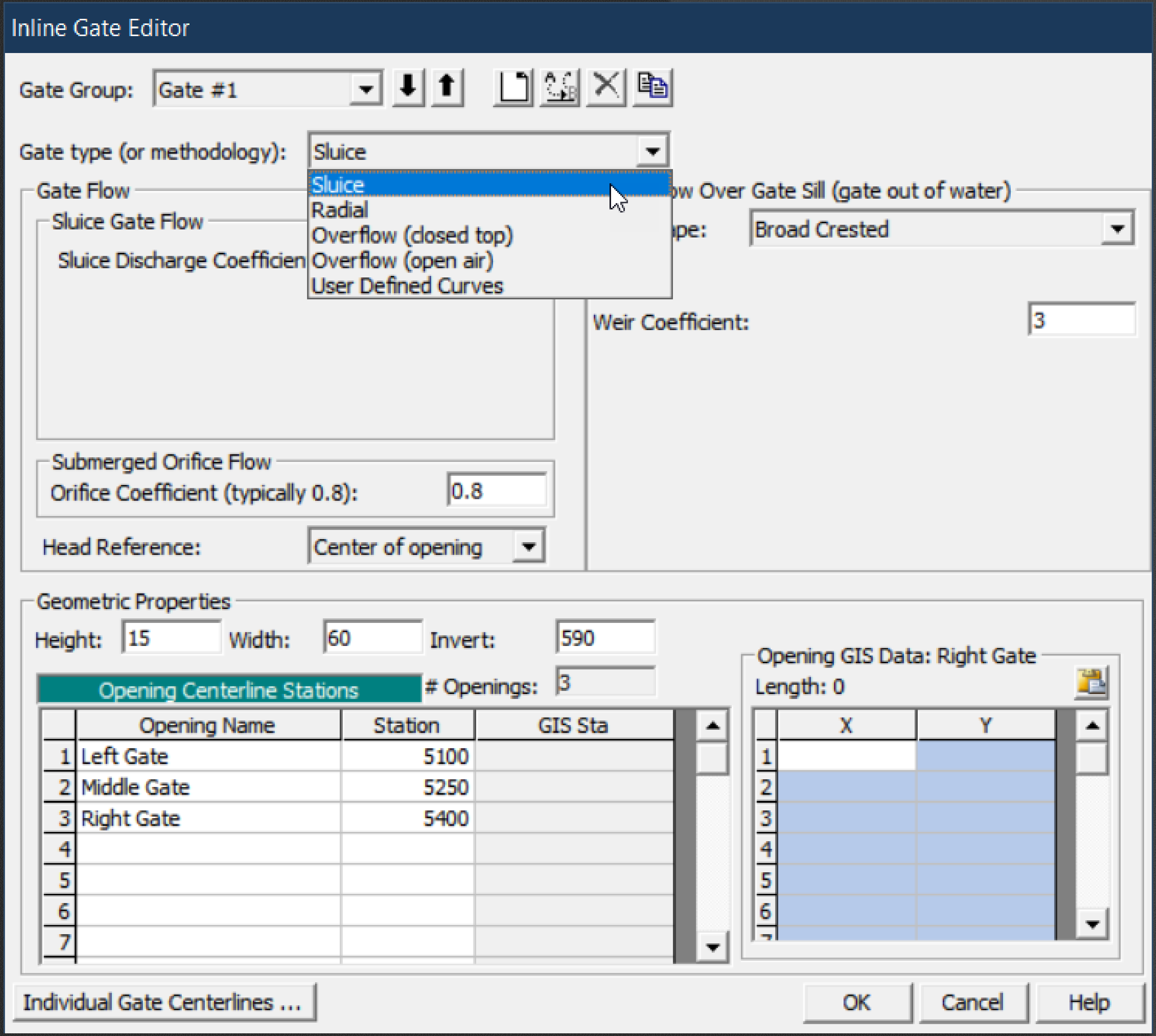




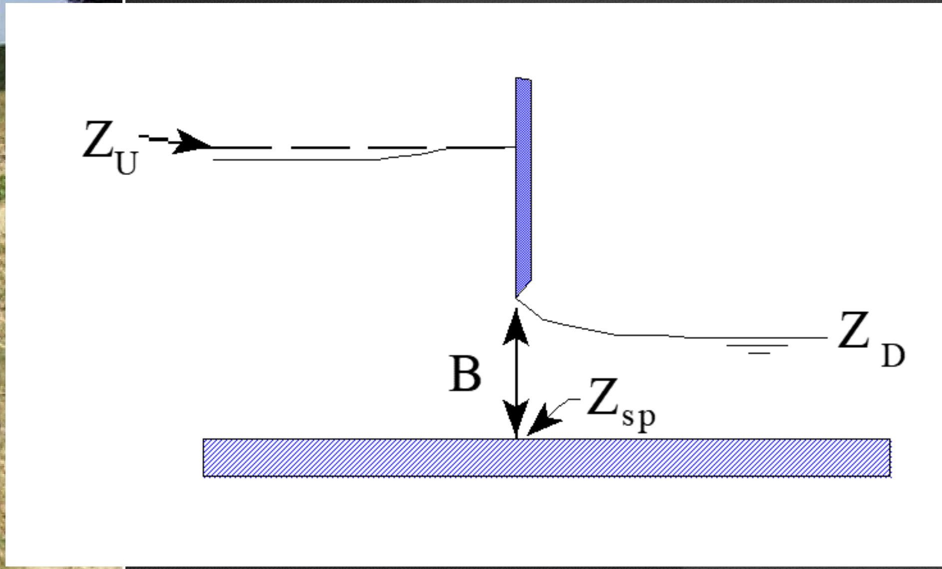

Discharge Reduction for Submerged Flow
Discharge Reduction Factor
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
76
78
80
82
84
86
88
90
92
94
96
98
100
Percent Submergence

Gates

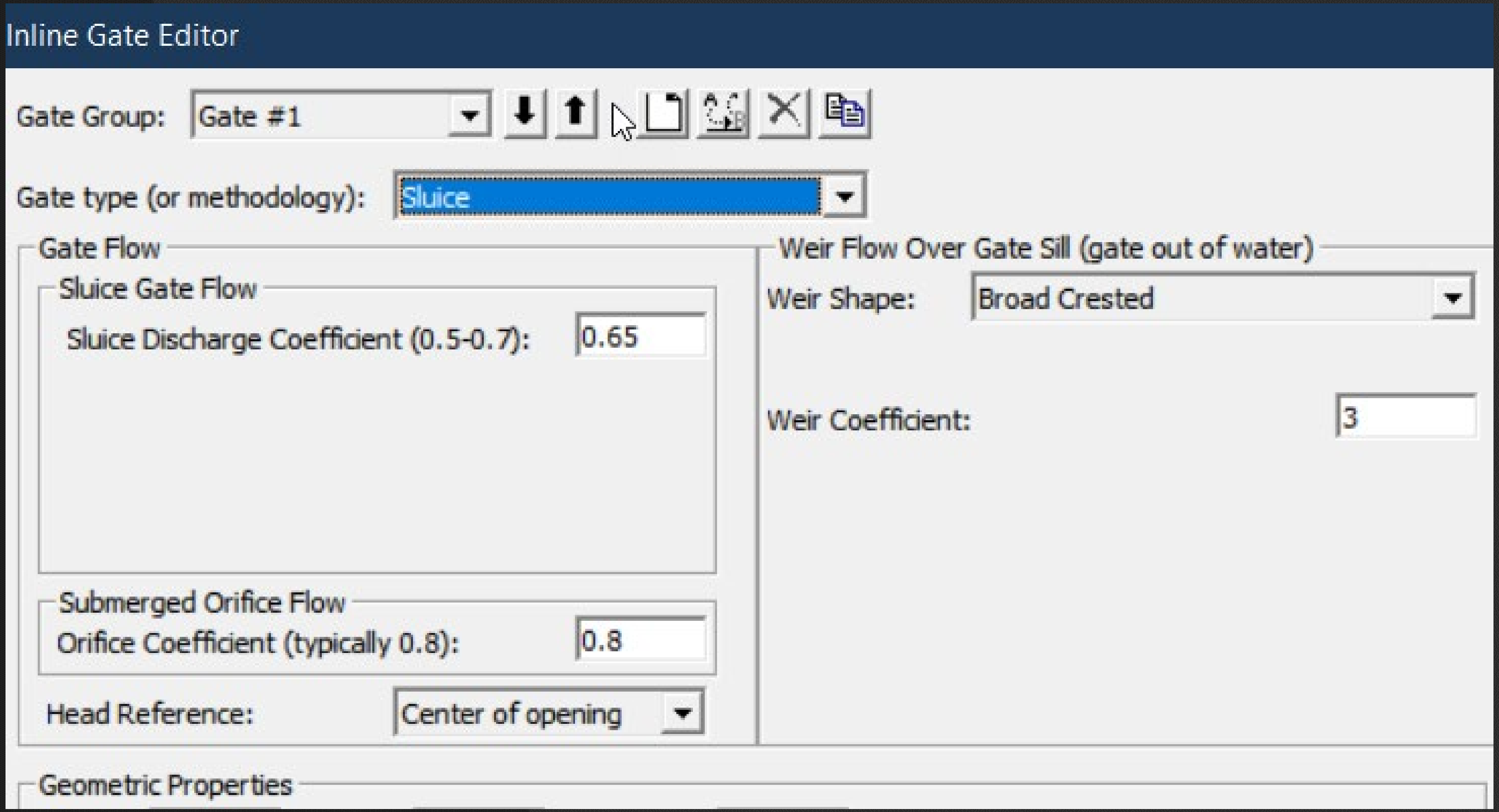
- Gate methods
  - Sluice
  - Radial
  - Overflow Gates
  - Rating rurve



Sluice Gates

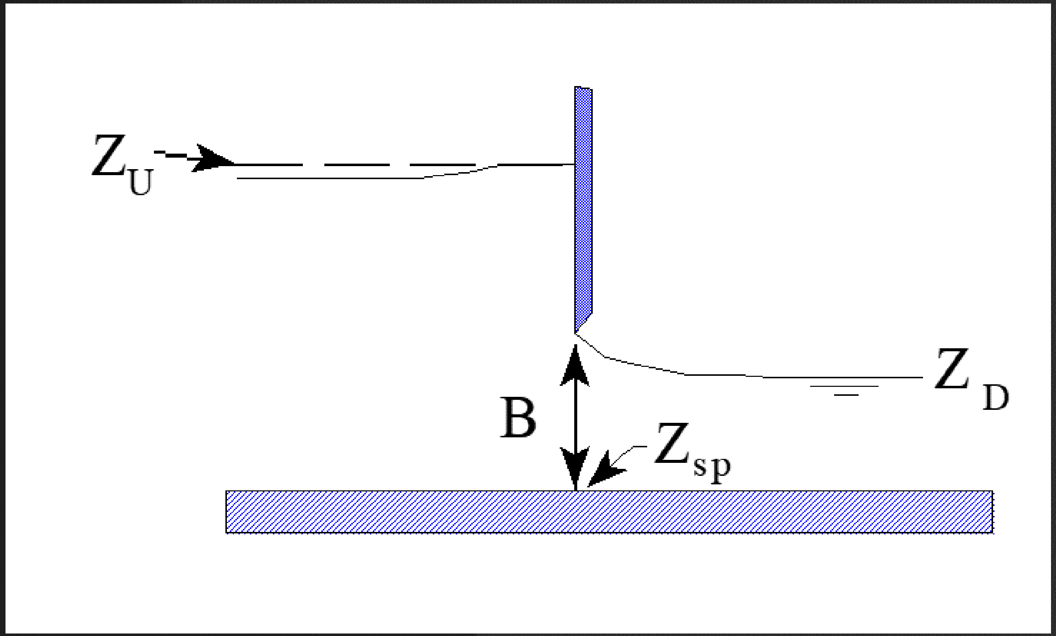


Gate Flow Types



- Gate Flow
- Submerged Orifice
- Weir Flow

Sluice Gate Flow



$$Q = CWB\sqrt{2gH}$$

Where:

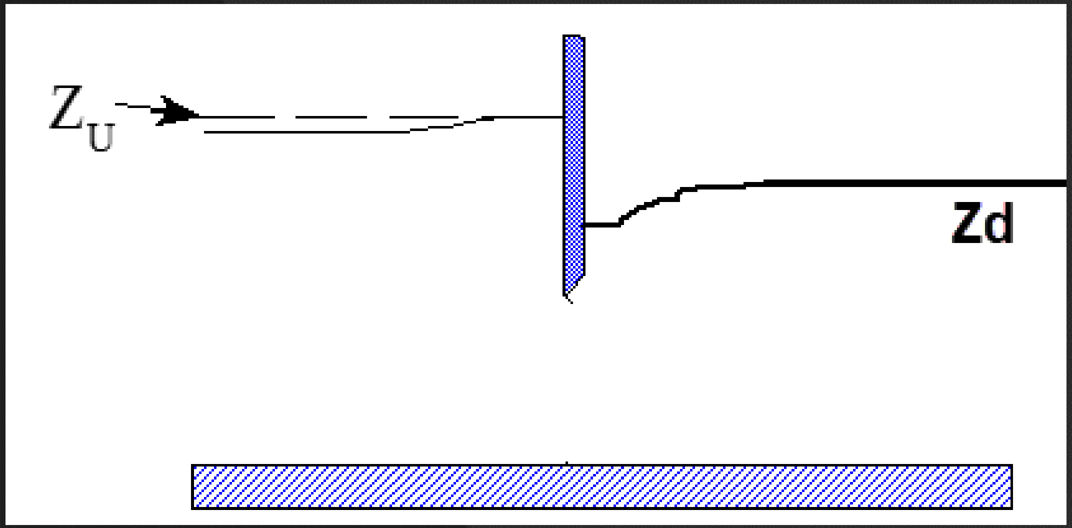
H = Upstream energy head ($Z_U - Z_{sp}$)

C = Discharge Coefficient , 0.5 to 0.7

W = Width

B = Opening

Orifice Flow / Submerged Flow

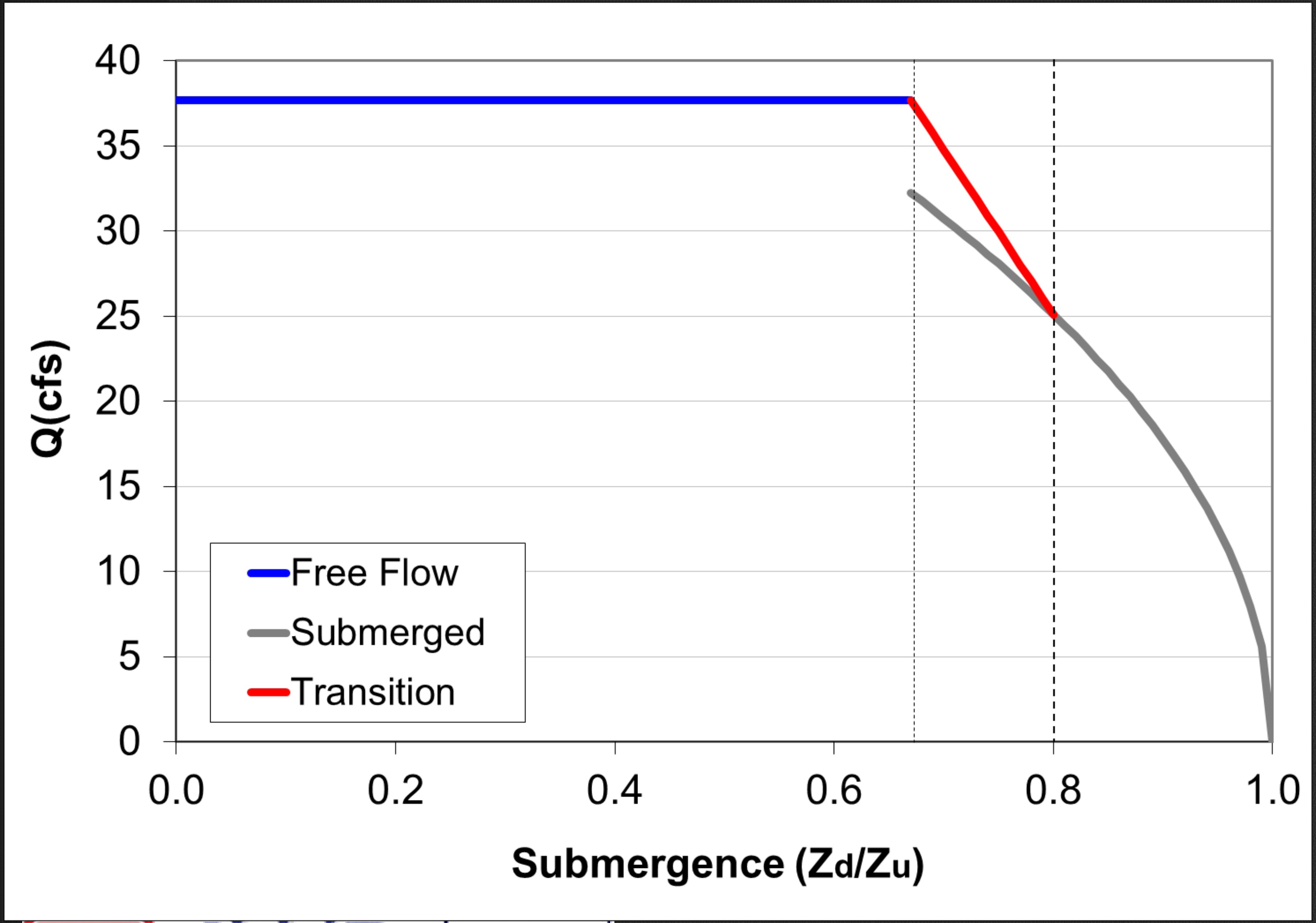


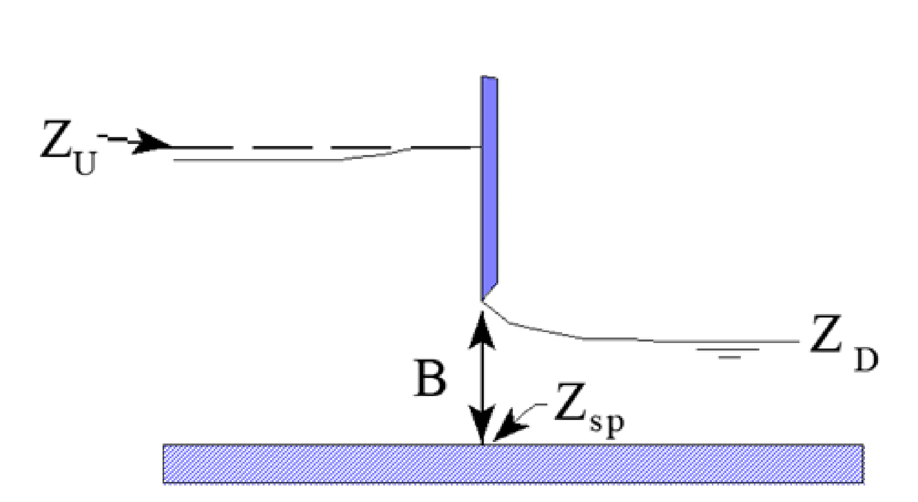
$$Q = CWB\sqrt{2gH}$$

Where: $H = Z_U - Z_D$

C = Discharge Coefficient, typically 0.8

Submergence Transition

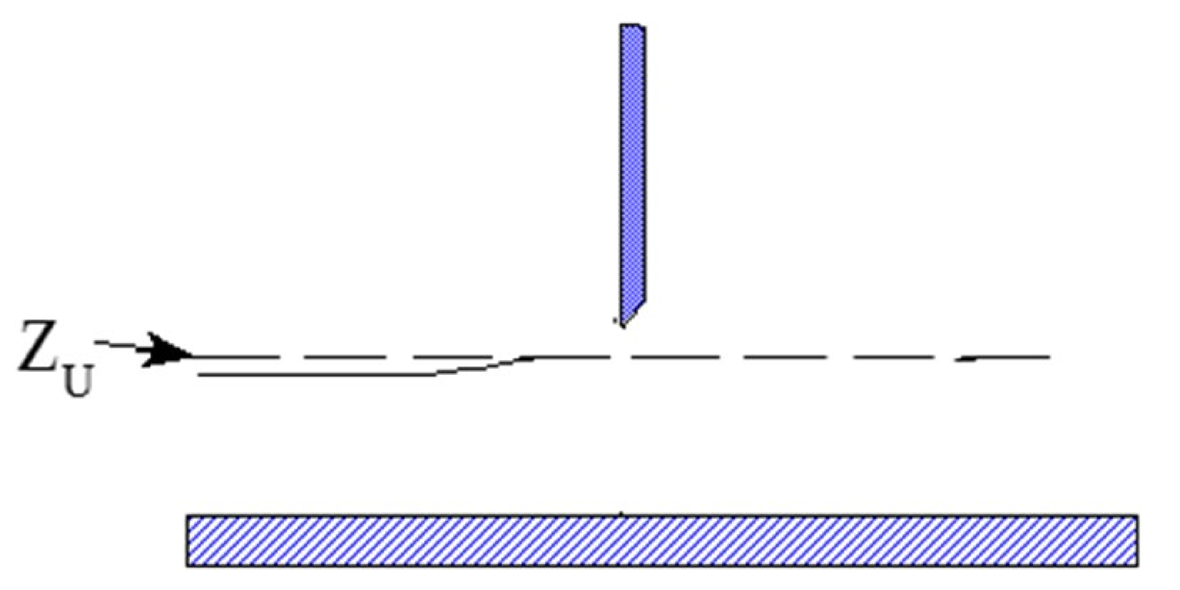




$$Q = CWB\sqrt{2g3H}$$

Where: $H = Z_U - Z_D$

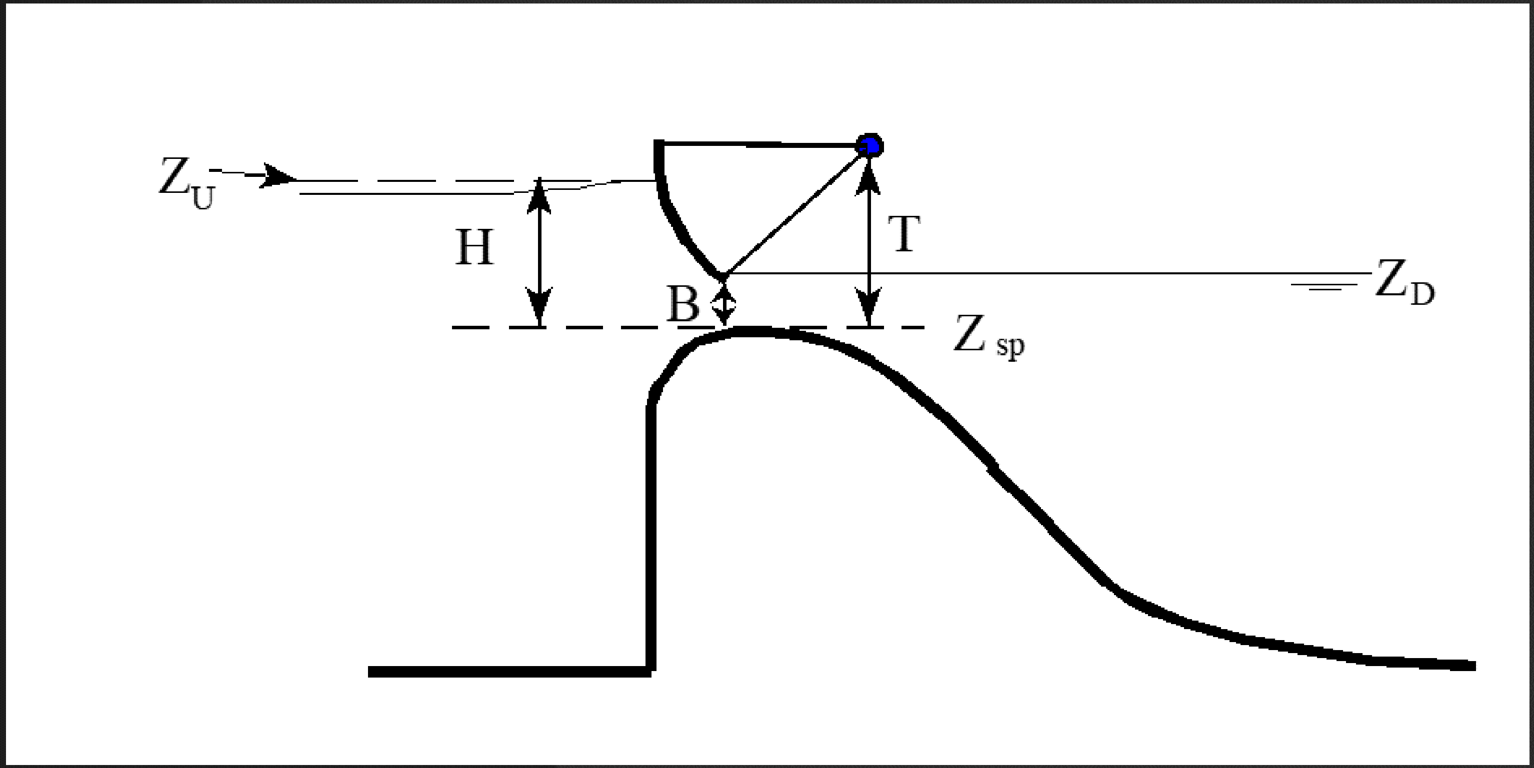
Low Flow / Weir Flow

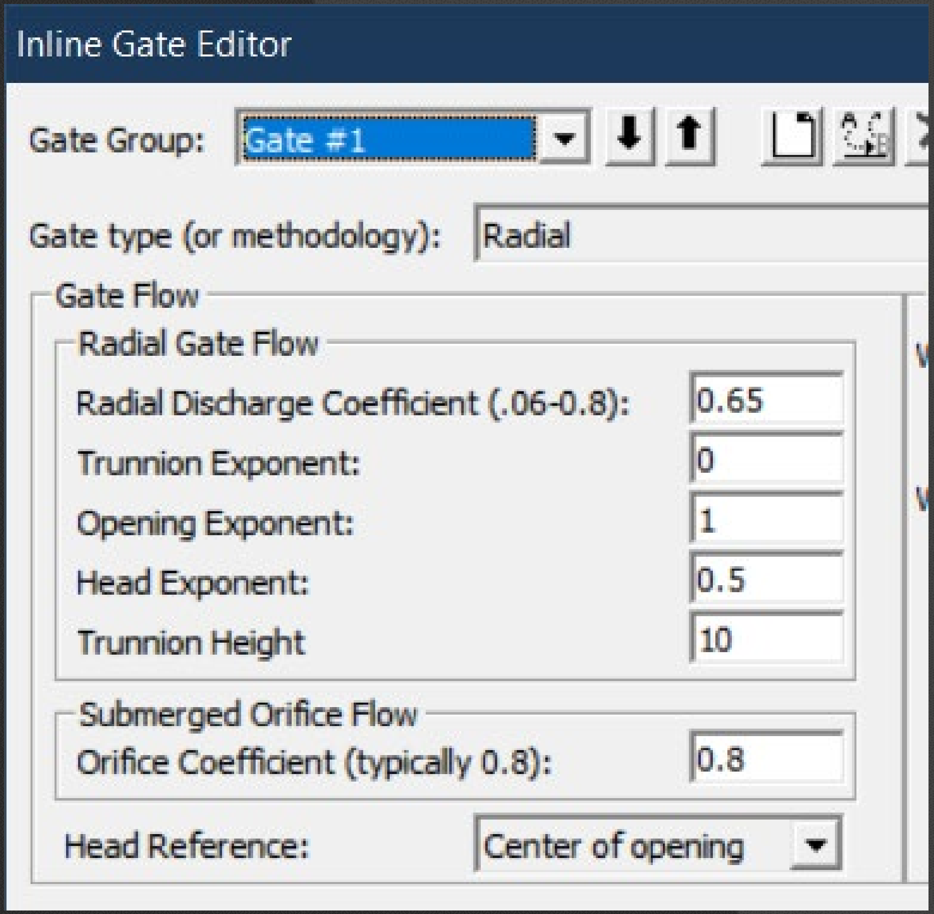


$$Q = CLH^{3/2}$$

Radial Gates

Radial Gate Flow





$$Q = C\sqrt{2g}WT^{TE}B^{BE}H^{HE}$$

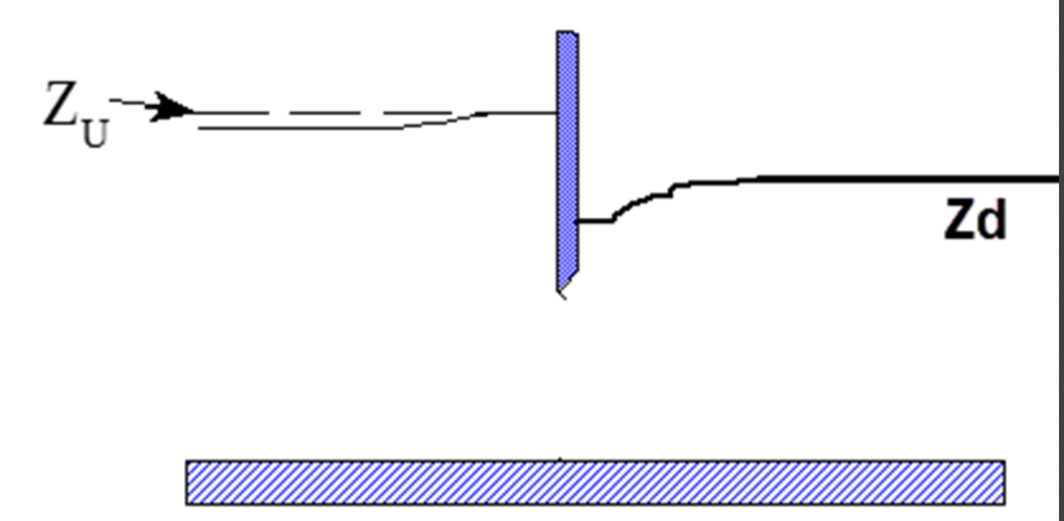
Radial Gate Submergence

- Tailwater increases and **begins** to impact flow

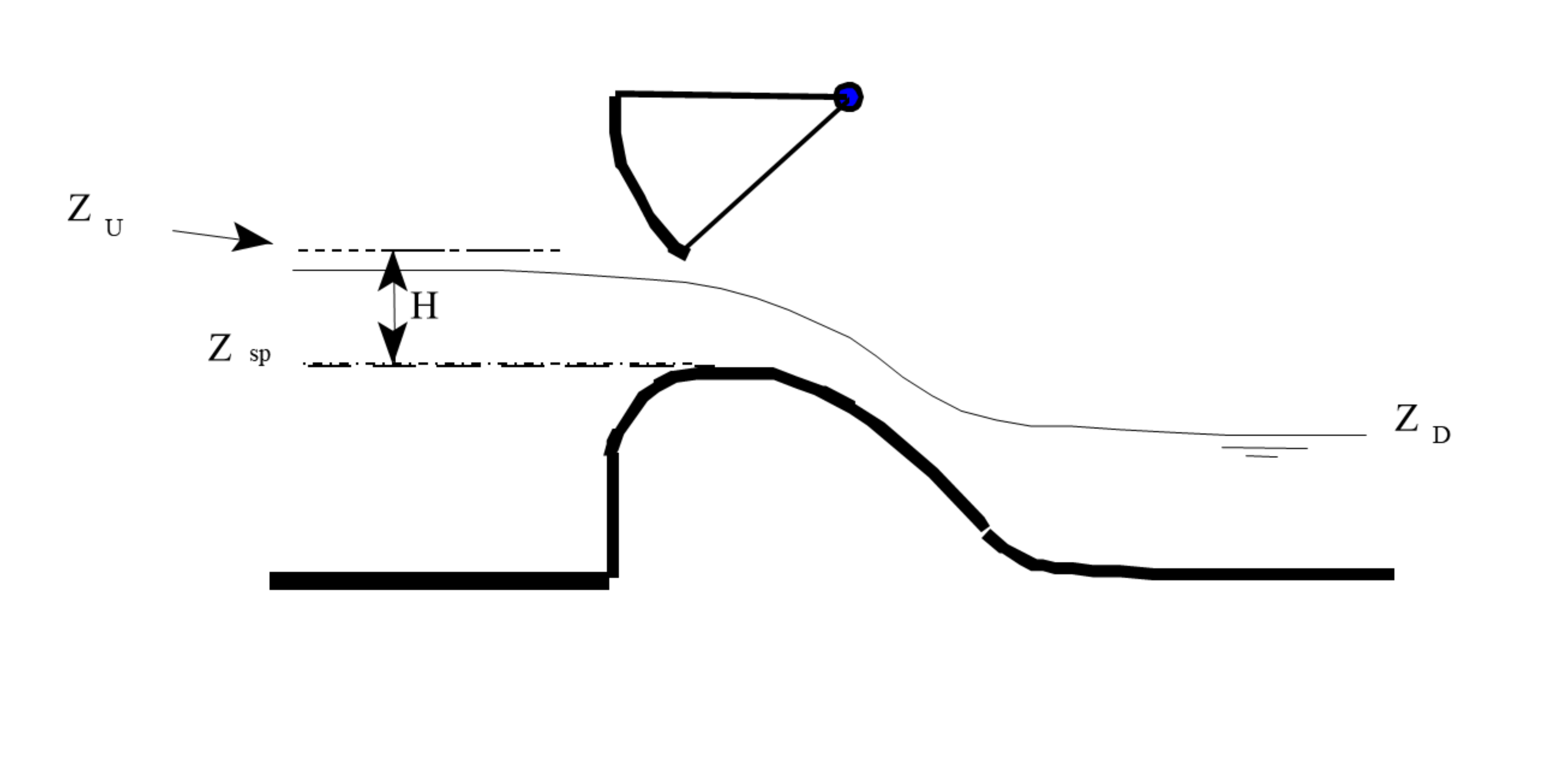
$$Q = C\sqrt{2g}WT^{TE}B^{BE}(3H)^{HE}$$

- Transitions to fully **submerged orifice** flow

$$Q = CWB\sqrt{2gH}$$



Low Flow / Weir Flow



$$Q = CLH^{3/2}$$

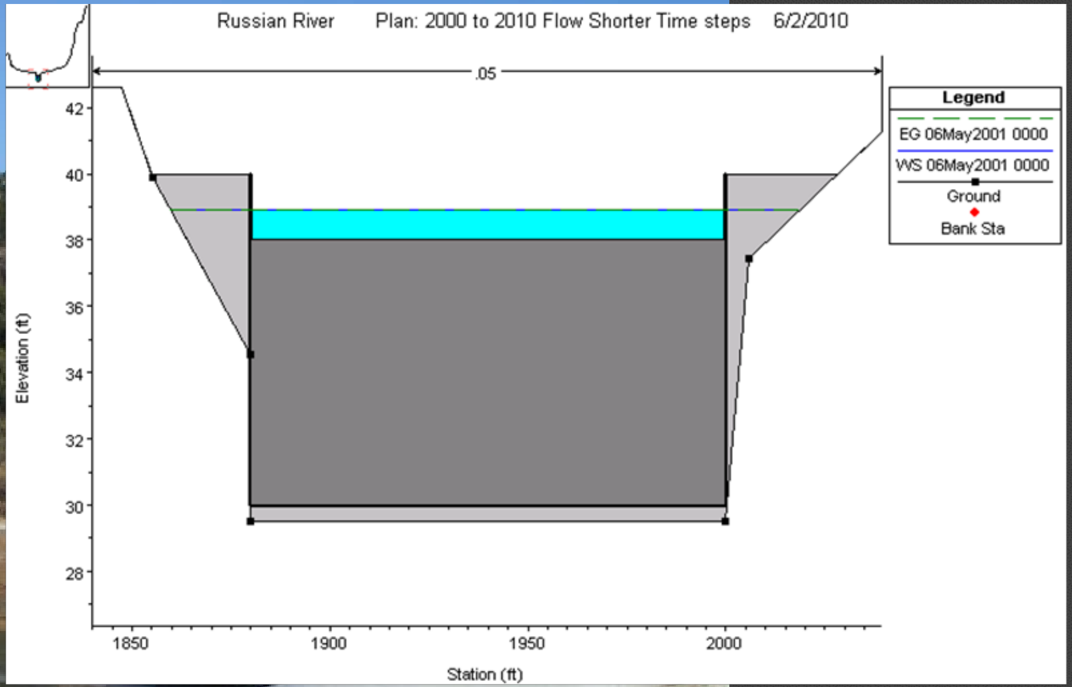
Overflow Gates

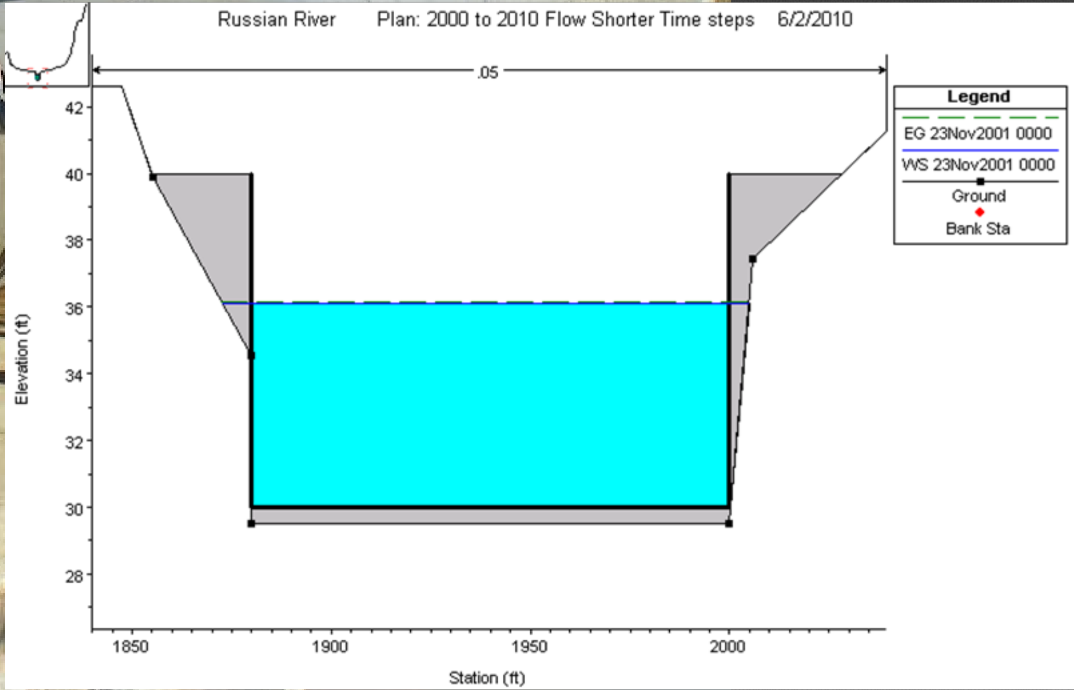
$$Q = CLH^{3/2}$$

Where:

H = Upstream energy head ($Z_U - Z_{sp}$)

C = Weir coefficient, 3.1 – 3.3


Russian River Plan: 2000 to 2010 Flow Shorter Time steps 6/2/2010
.05
Legend
EG 06May2001 0000
WS 06May2001 0000
Ground
Bank Sta
Elevation (ft)
42
40
38
36
34
32
30
28
1850
1900
1950
2000
Station (ft)


Russian River Plan: 2000 to 2010 Flow Shorter Time steps 6/2/2010
.05
Legend
EG 23Nov2001 0000
WS 23Nov2001 0000
Ground
Bank Sta
Elevation (ft)
42
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38
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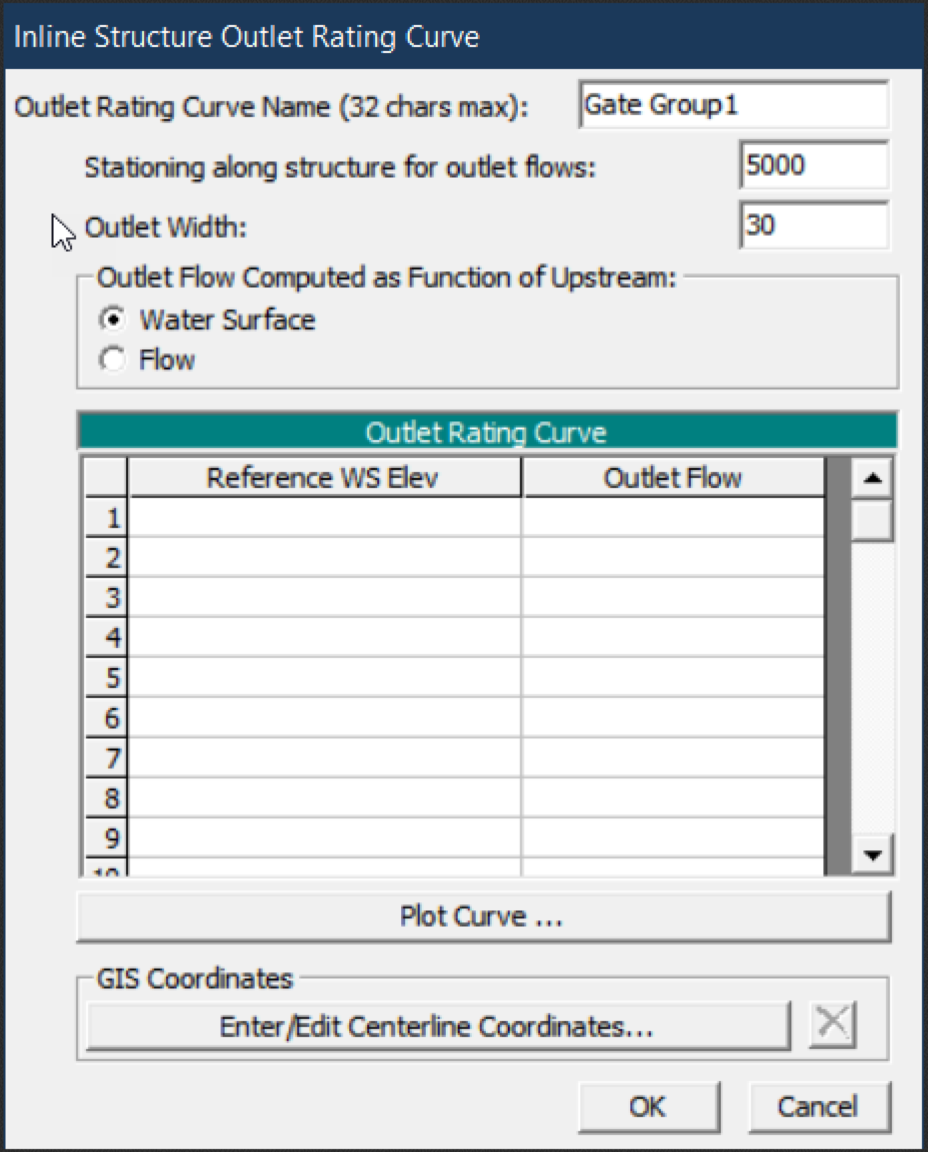
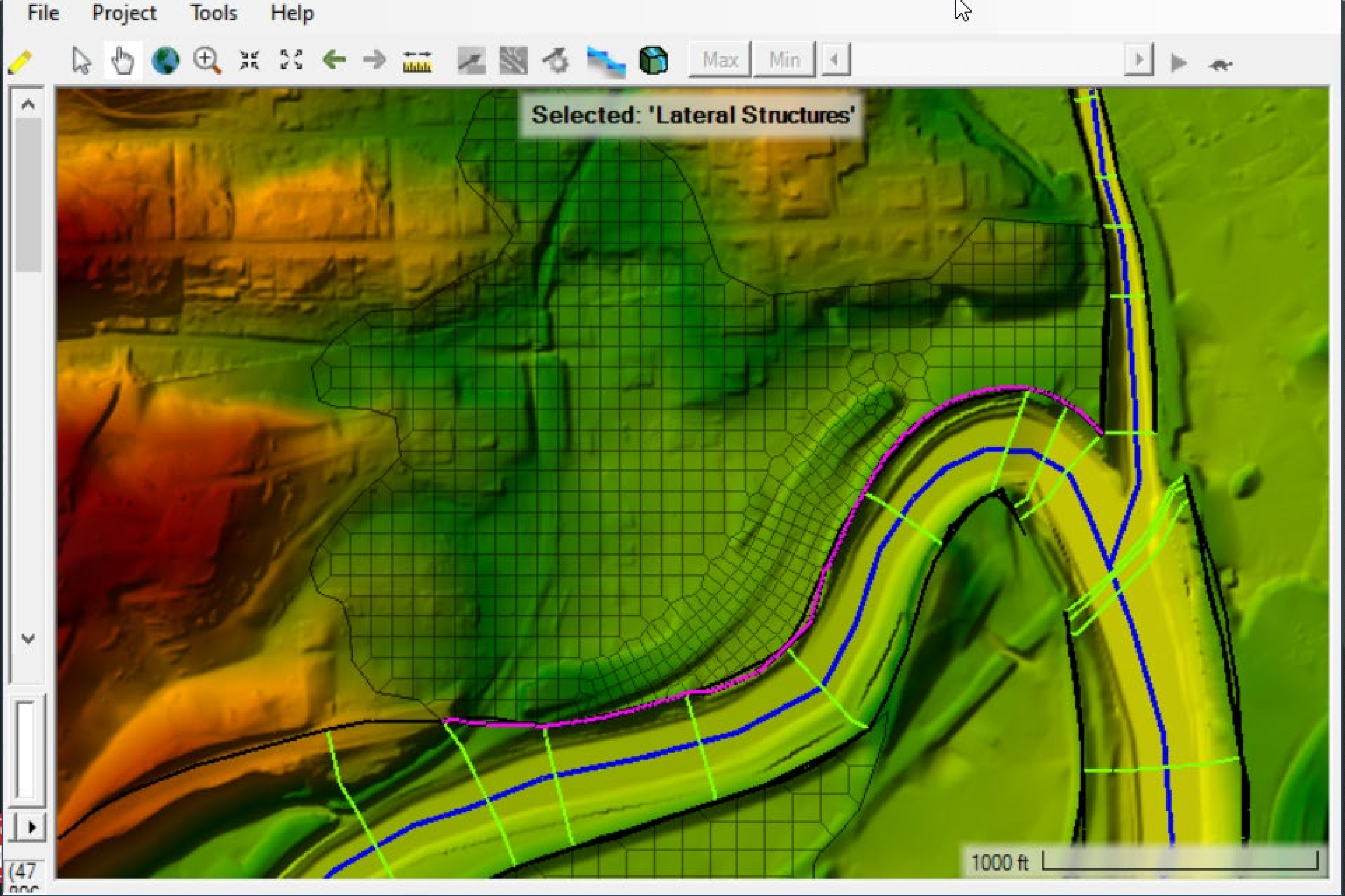
34
32
30
28
1850
1900
1950
2000
Station (ft)

Outlet Rating Curve



Lateral Structures

Lateral Weir – Sacramento River


File
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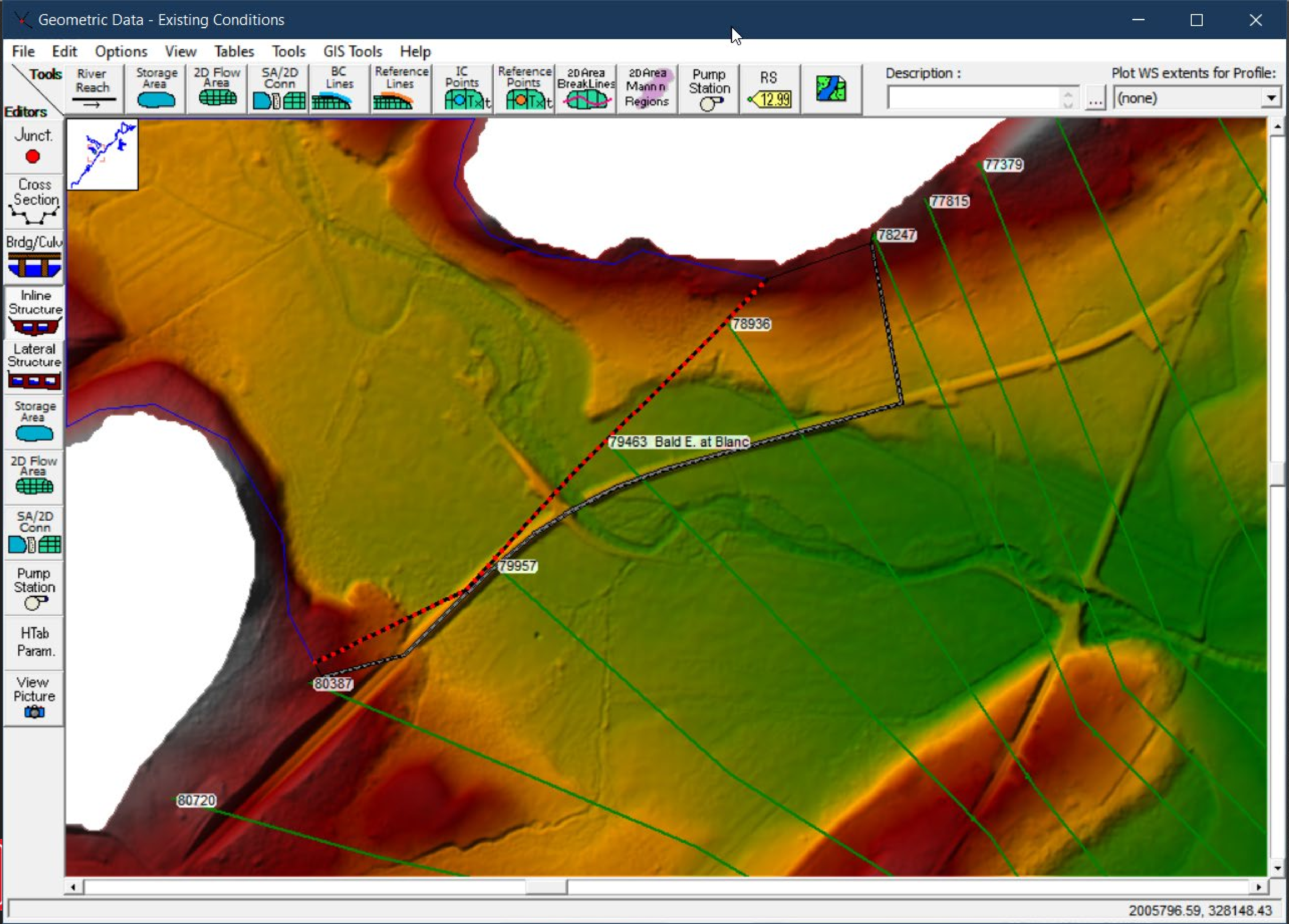
Max
Min
Selected: 'Lateral Structures'
1000 ft
(47


Geometric Data - Existing Conditions
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GIS Tools
Help
Tools
Editors
River Reach
Storage Area
2D Flow Area
SA/2D Conn
BC Lines
Reference Lines
IC Points
Reference Points
2D Area BreakLines
2D Area Mann n Regions
Pump Station
RS
12.99
Description :
Plot WS extents for Profile:
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Cross Section
Brdg/Culv
Inline Structure
Lateral Structure
Storage Area
2D Flow Area
SA/2D Conn
Pump Station
HTab Param.
View Picture
77379
77815
78247
78936
79463 Bald E. at Blanc
79957
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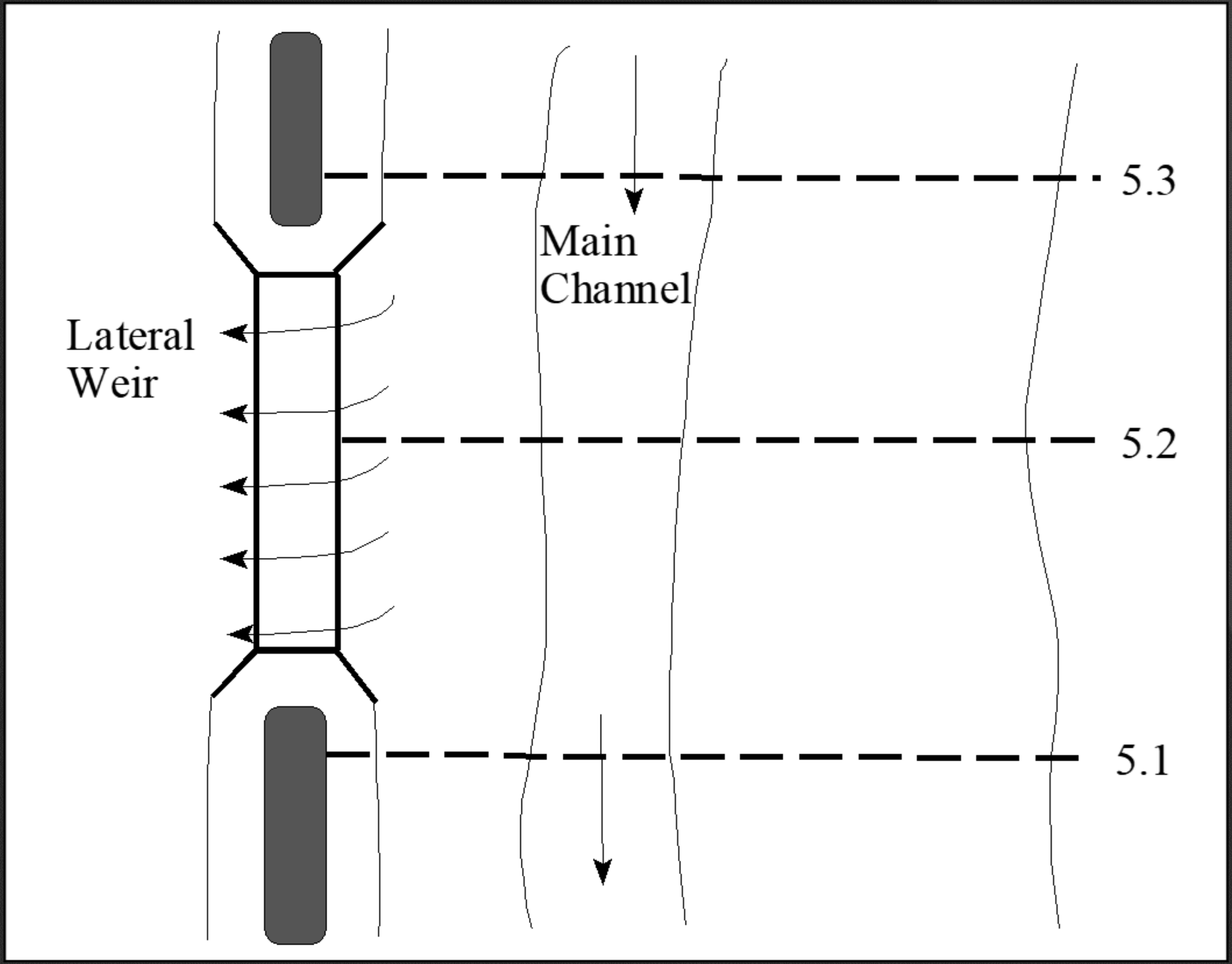
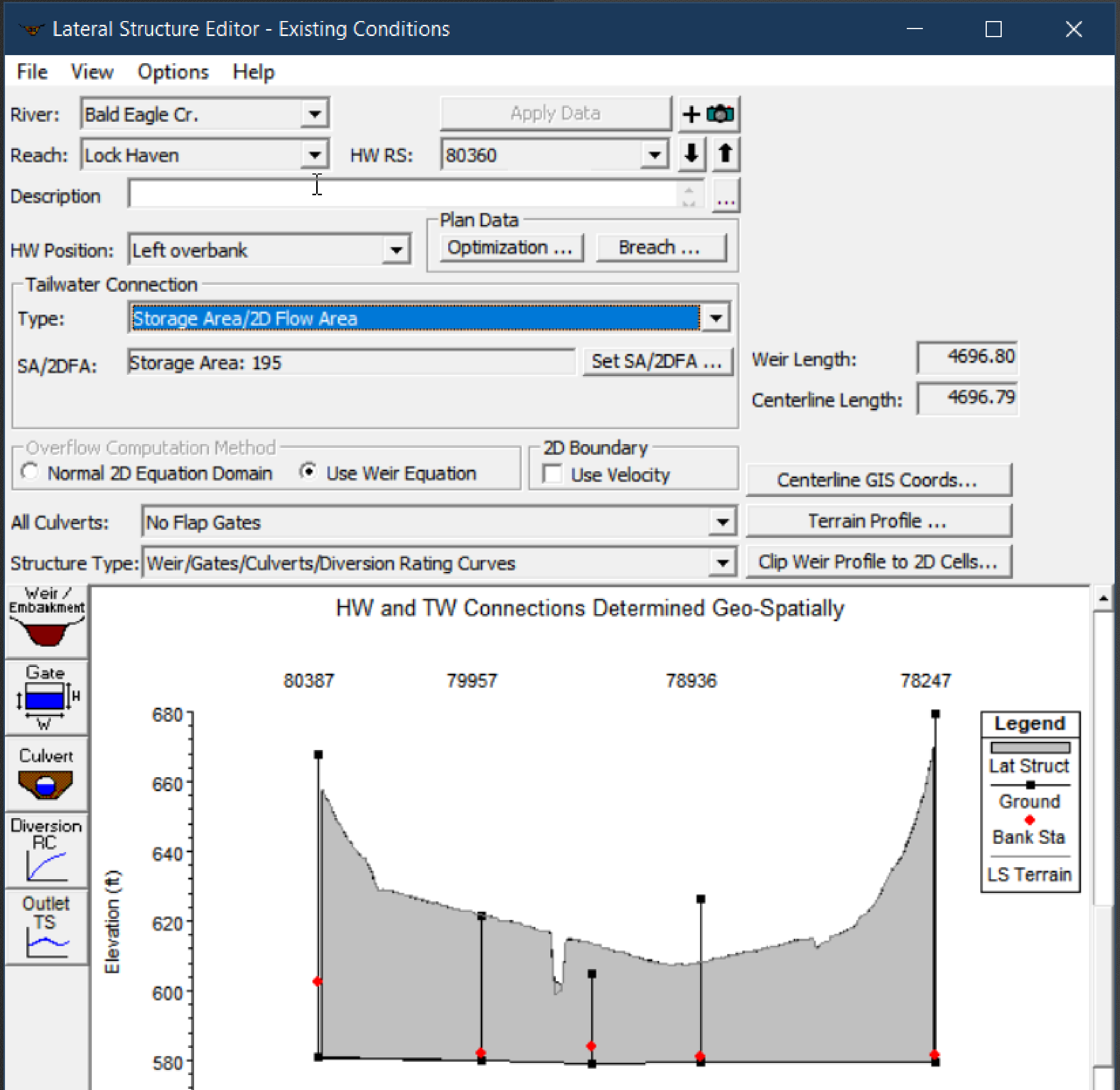
80720
2005796.59, 328148.43

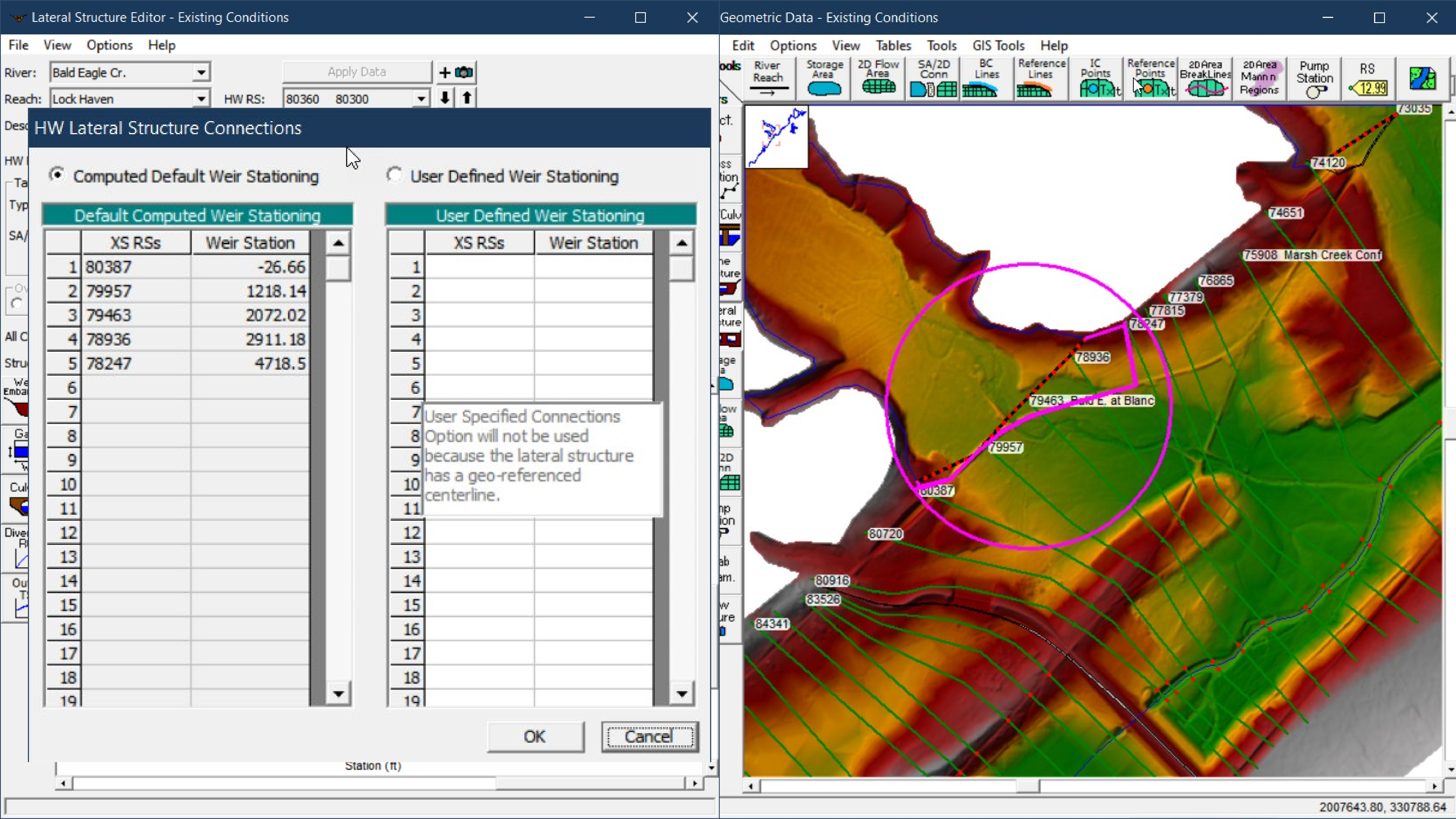
Cross Section Layout



Lateral Connections

- Headwater connected to cross sections:
  - Left or right
- Tailwater connected to
  - Other cross-sections
  - Storage Areas
  - 2D Areas
  - Out of system




Lateral Structure Editor - Existing Conditions
File View Options Help
River: Bald Eagle Cr.
Reach: Lock Haven
Apply Data
HW RS: 80360 80300
HW Lateral Structure Connections
Computed Default Weir Stationing
User Defined Weir Stationing
Default Computed Weir Stationing
XS RSs | Weir Station
1 80387 -26.66
2 79957 1218.14
3 79463 2072.02
4 78936 2911.18
5 78247 4718.5
User Defined Weir Stationing
XS RSs | Weir Station
User Specified Connections Option will not be used because the lateral structure has a geo-referenced centerline.
OK
Cancel
Station (ft)
Geometric Data - Existing Conditions
Edit Options View Tables Tools GIS Tools Help
River Reach
Storage Area
2D Flow Area
SA/2D Conn
BC Lines
Reference Lines
IC Points
Reference Points
2D Area BreakLines
2D Area Mann n Regions
Pump Station
RS
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75908 Marsh Creek Conf
76865
77379
77815
78247
78936
79463 Bald E. at Blanc
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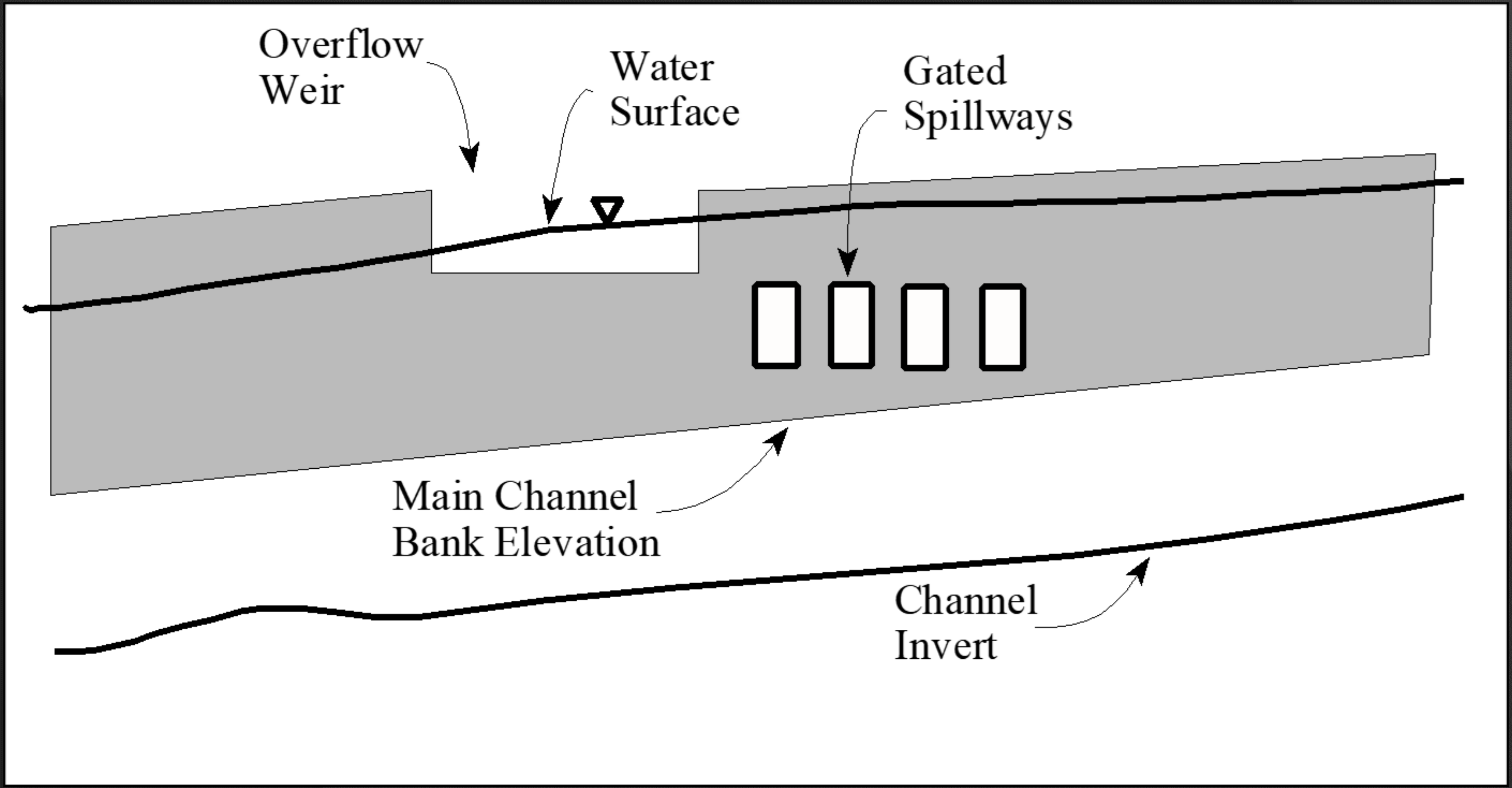
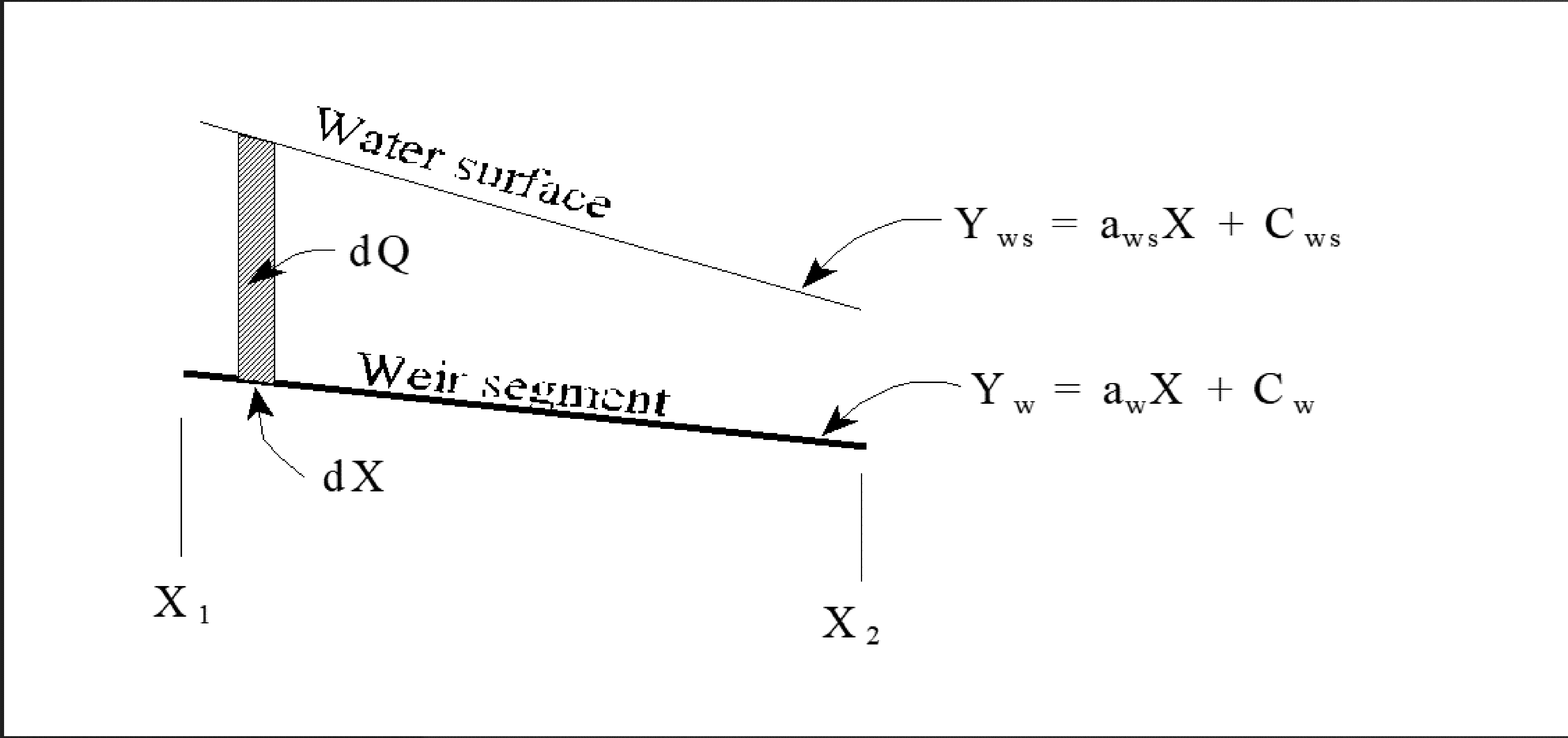
Lateral Structure Computations



Lateral Structure Computations

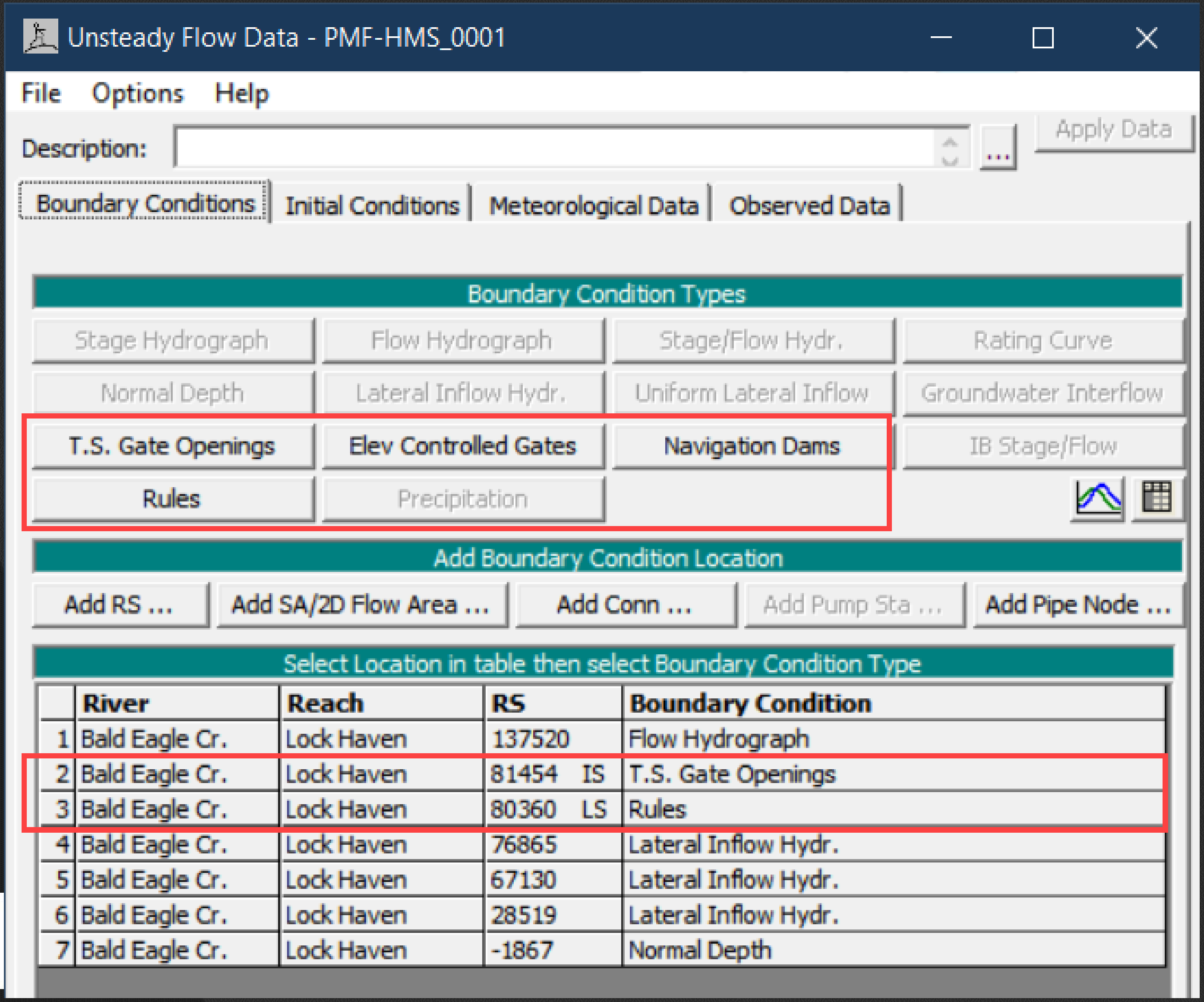


Lateral Weir Coefficients (Guidelines)

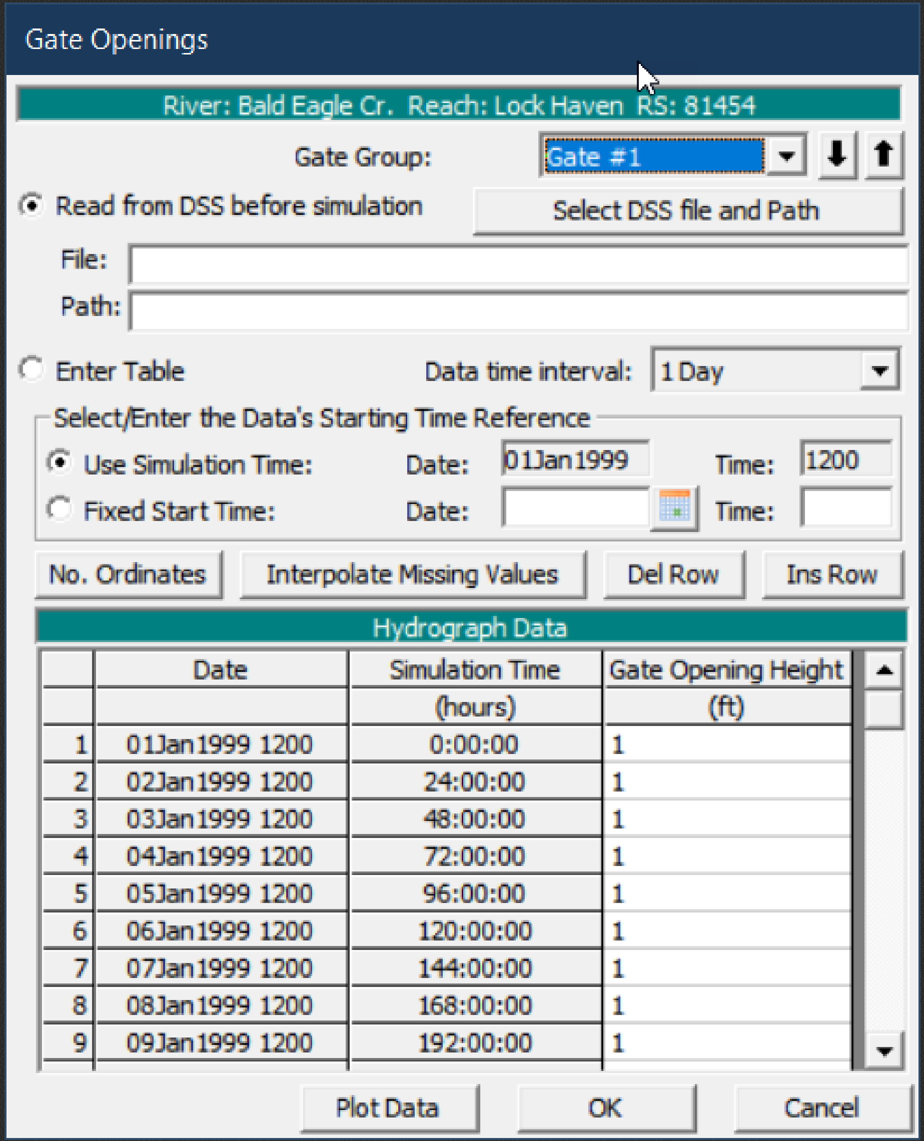
Terrain Feature	Flow description	Range of Weir Coefficients
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	**0.2** to **0.5** SI Units: 0.11 to 0.28
Natural high ground barrier – 1 to 3 ft high	Not quite a weir. Water must flow over high ground. Flow does not pass through critical depth	**0.5** to **1.0** SI Units: 0.28 to 0.55
Levee/Roadway – 1 to 3 ft elevated above ground	Flow over levee/road acts like weir flow, but becomes submerged easily.	**1.0** to **2.0** SI Units: 0.55 to 1.1
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

Controlling Structures

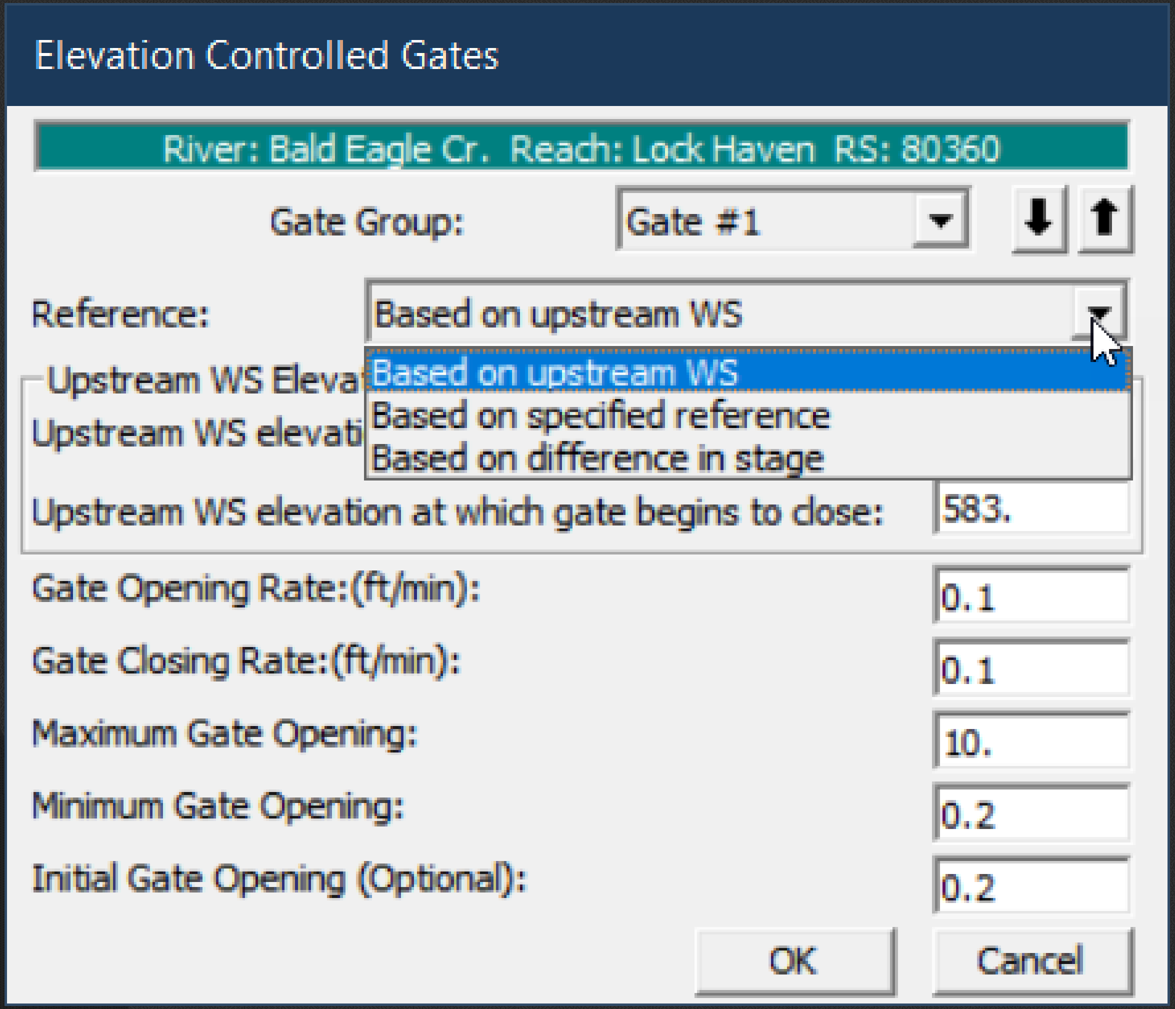
Structure Boundary Conditions



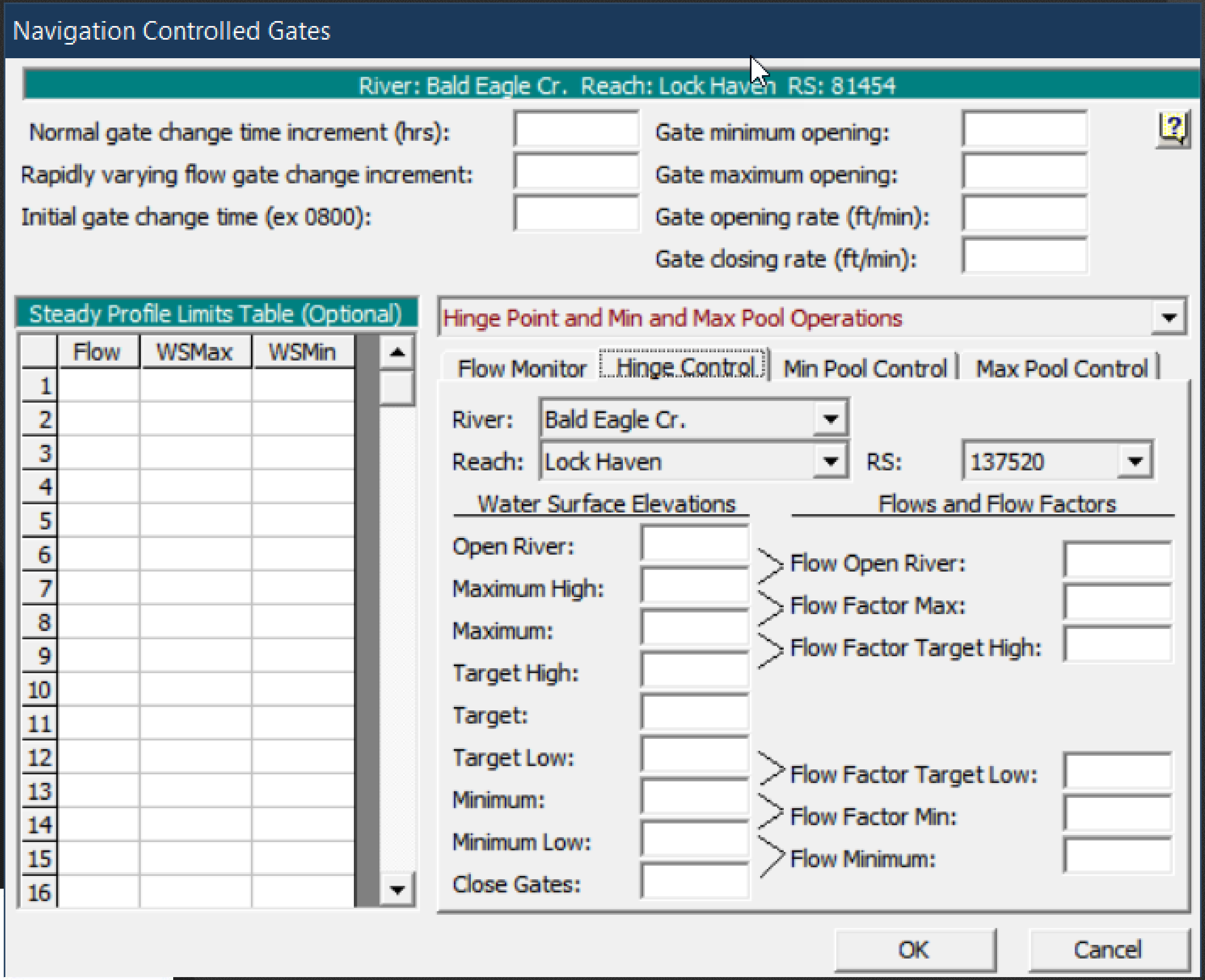
Time Series Gate Openings



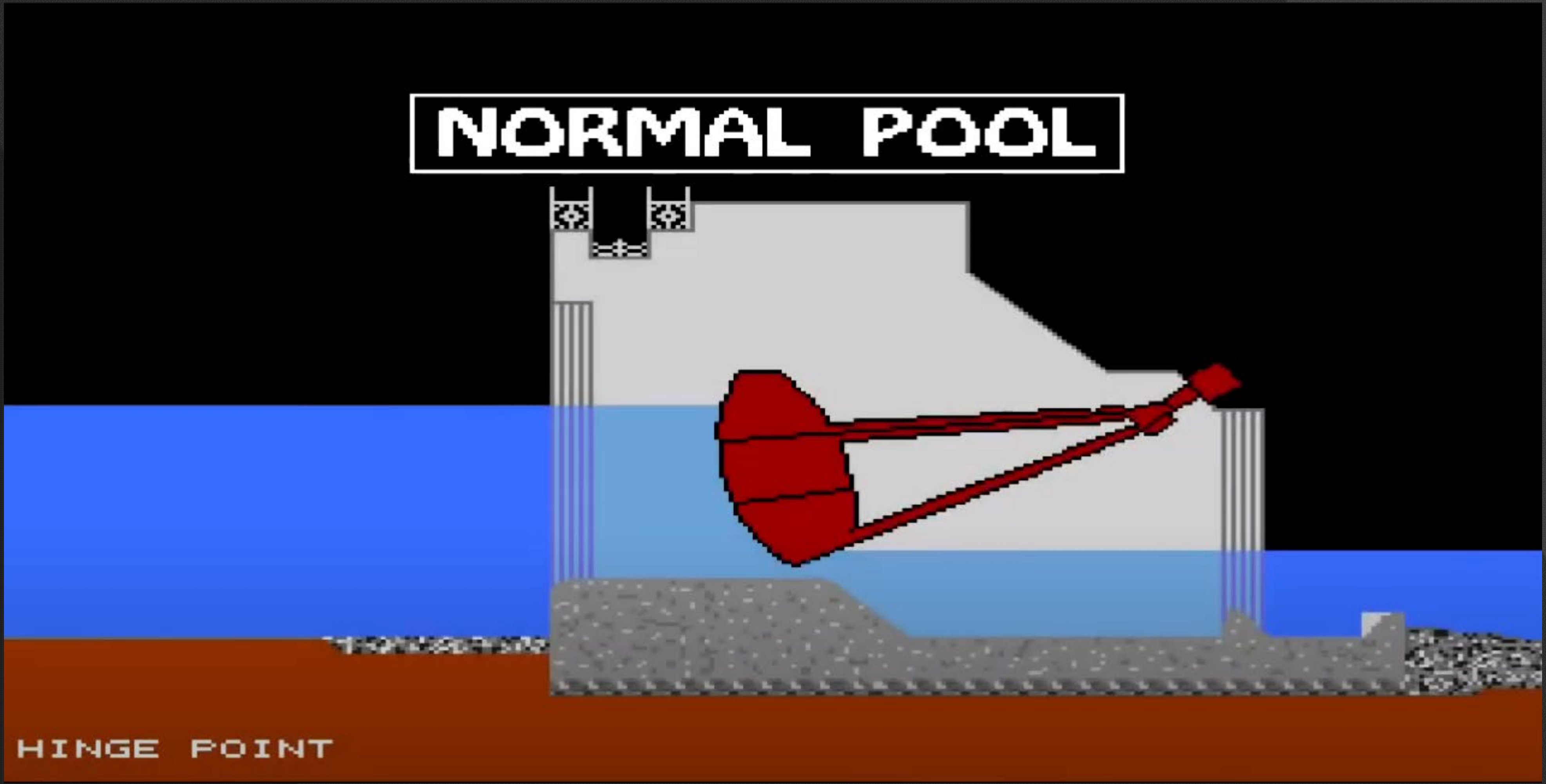
Elevation Controlled Gates



Navigation Dam



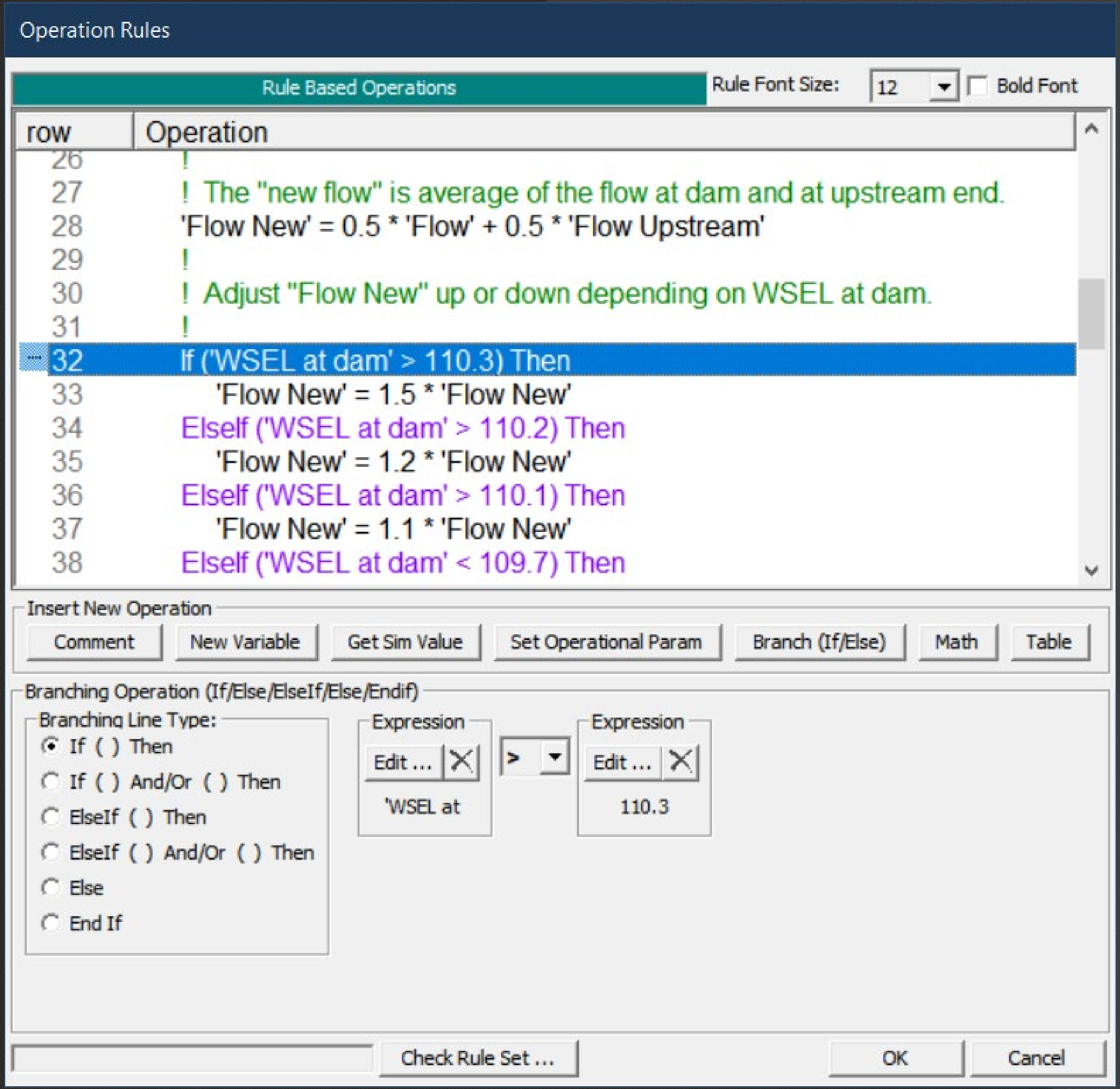
Navigation Dam



https://www.youtube.com/watch?v=IbXld0FH-OE

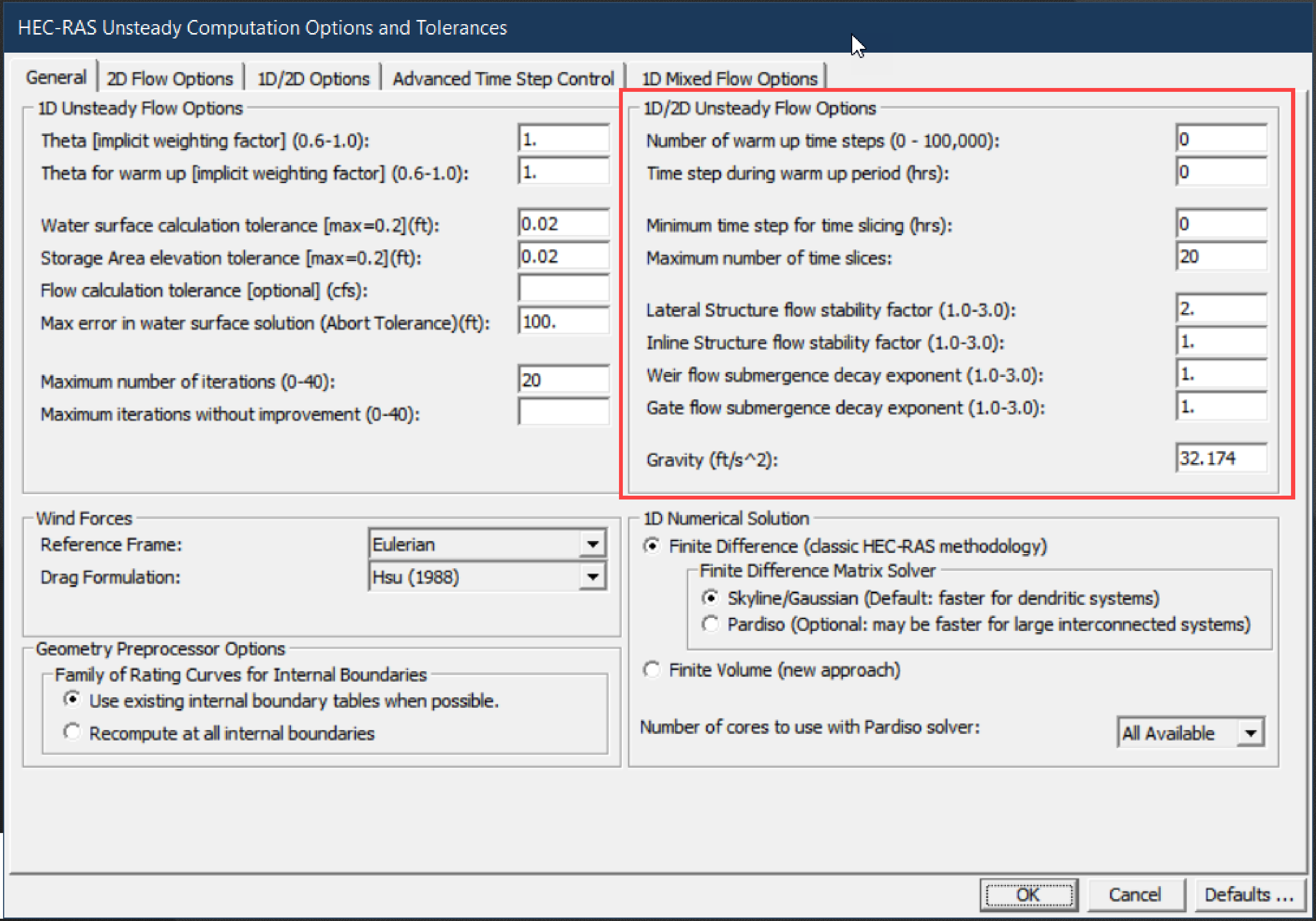
Rules

- A script for how to operate structures
- Can apply to:
  - Inlines
  - Laterals
  - Storage Area Connections
  - Pumps
- Flexible and powerful

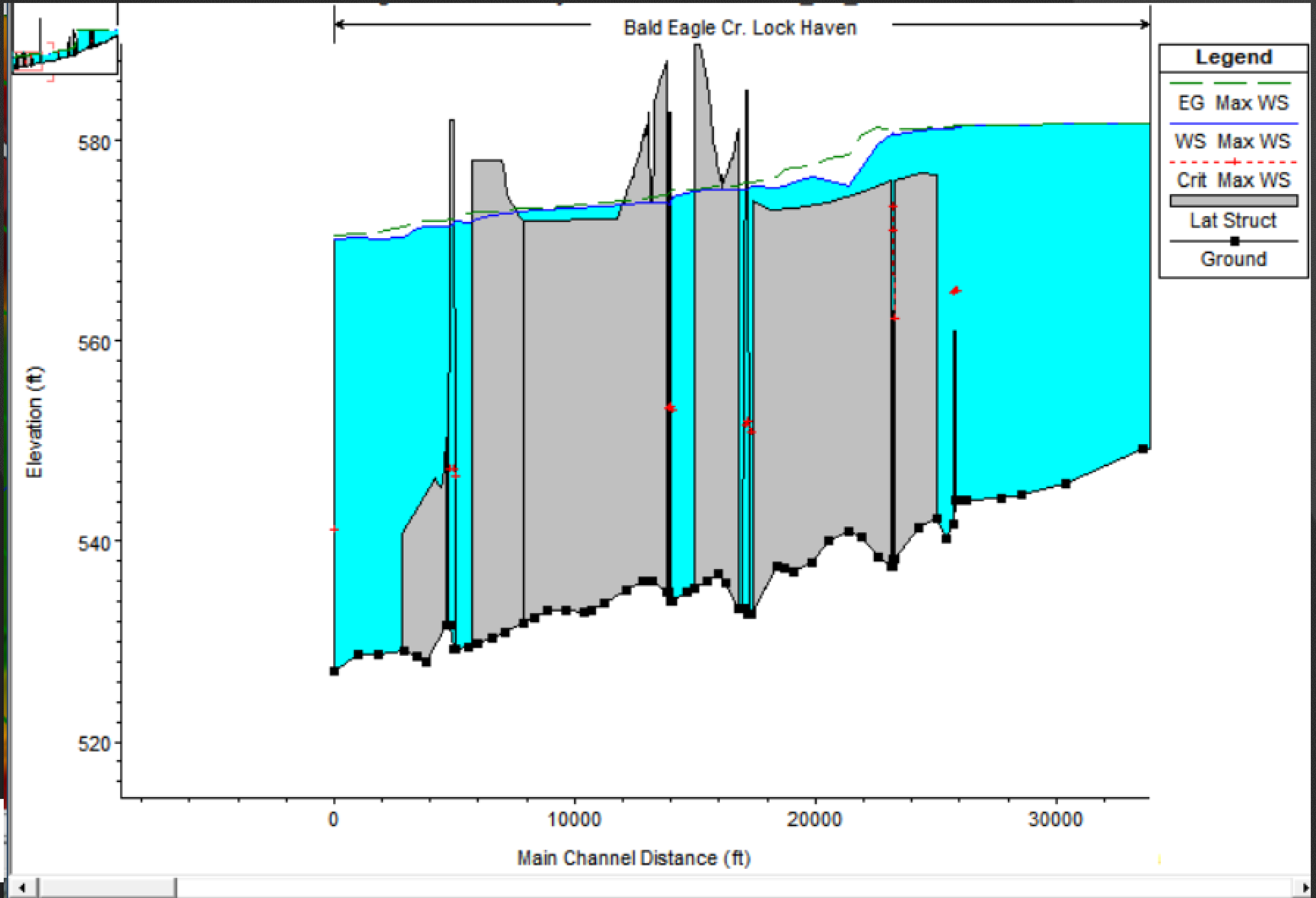


Stability Considerations

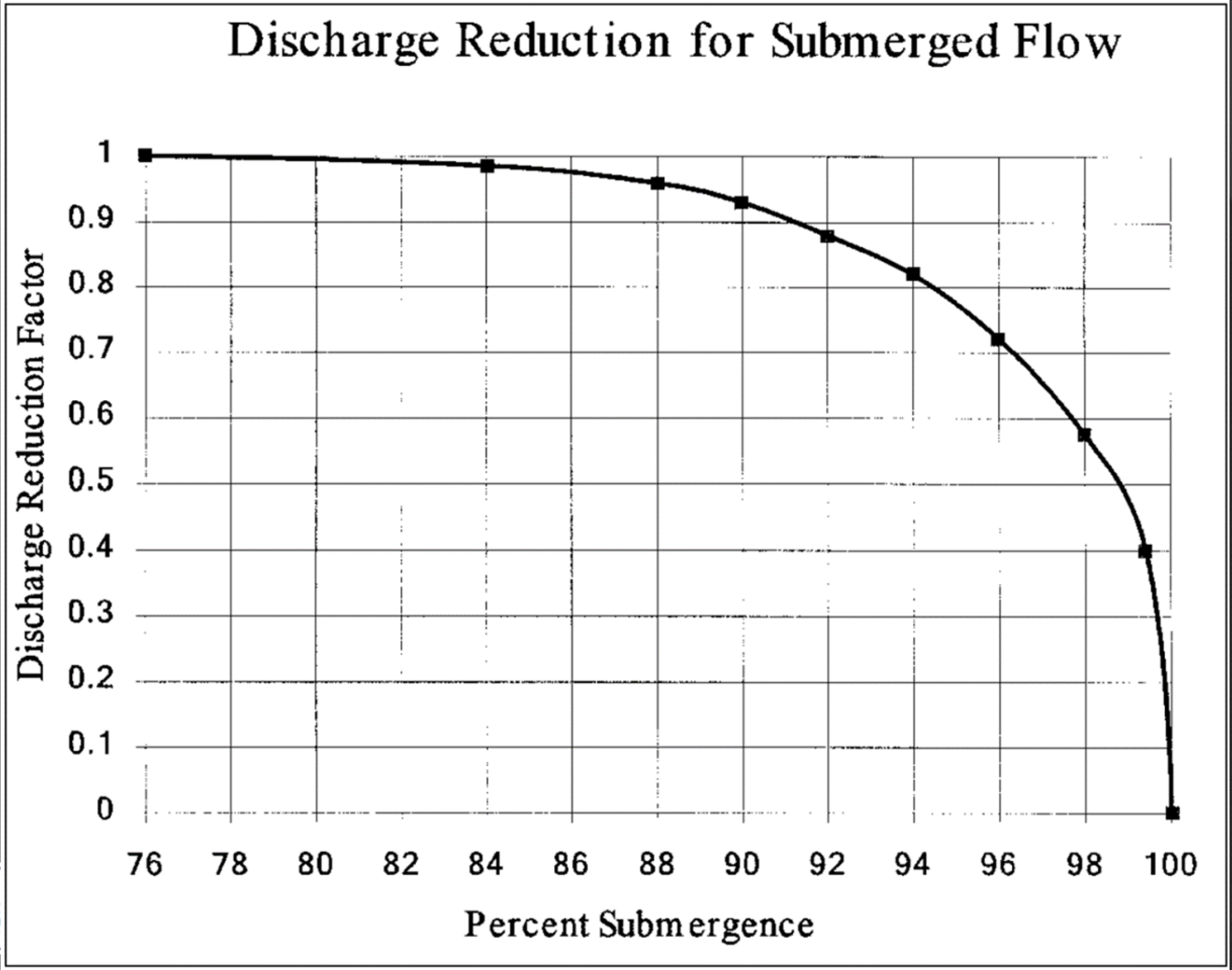
Lateral and Inline Stability



Initial Overflow



Submergence Stability



Questions?