Lateral Weir Applications

June 18, 2008
Henderson County DD#3
US of L&D 18 on Mississippi River (near Gladstone, IL)

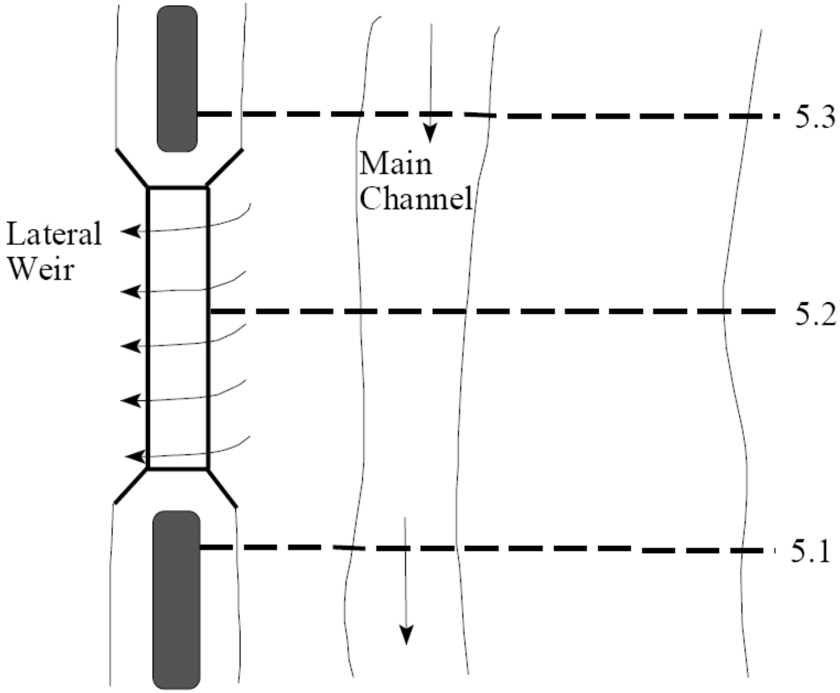
Wes Cattoor
IDNR – OWR
IAFSM Conference
March 9, 2010

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

Overview

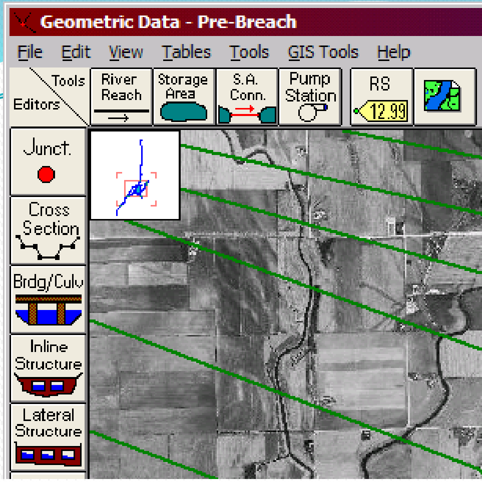
- General Data Entry
- Out of System
- Into a Reservoir
- Into a Channel
- Structure Impacts
- Confluences
- Meanders
- Breach Data Entry

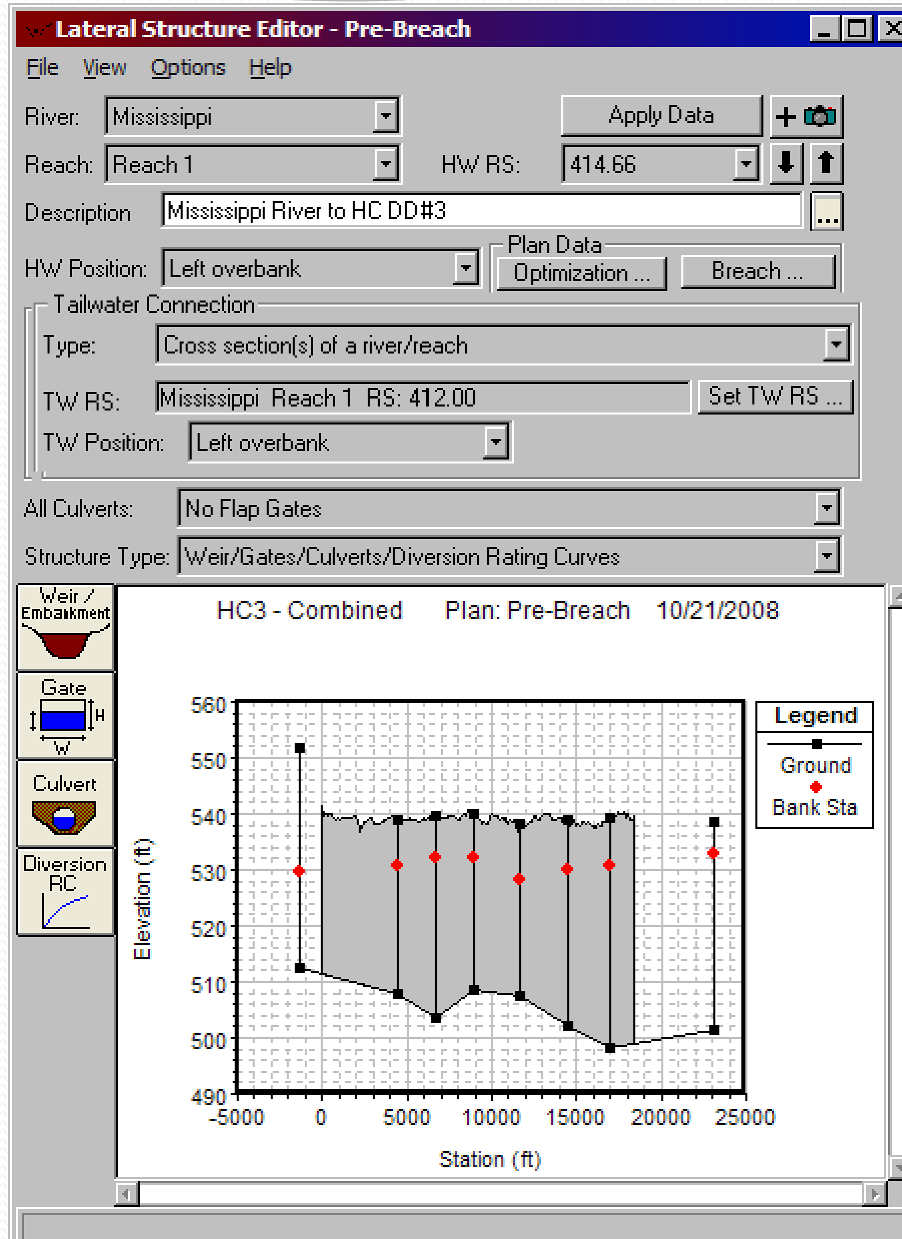
What Does a Lateral Weir Look Like?

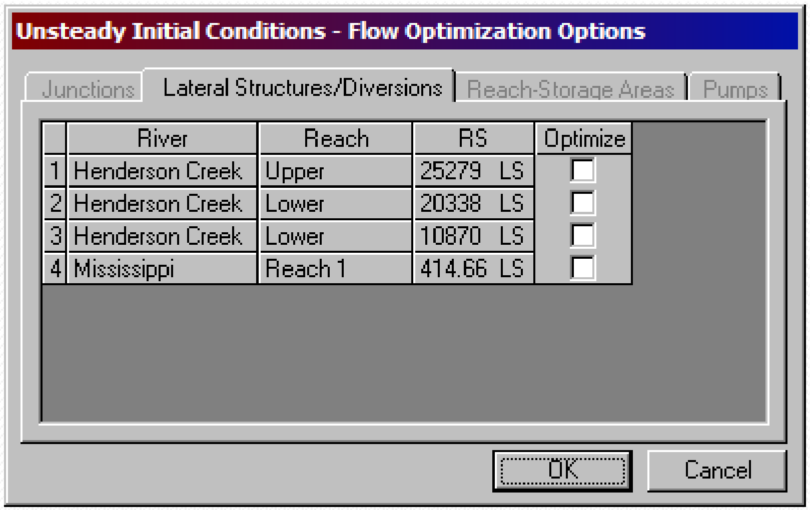


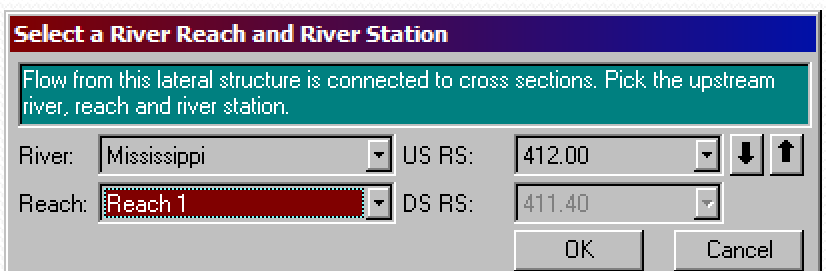
Source: HEC-RAS 4.0 Reference Manual (Fig 8-8)

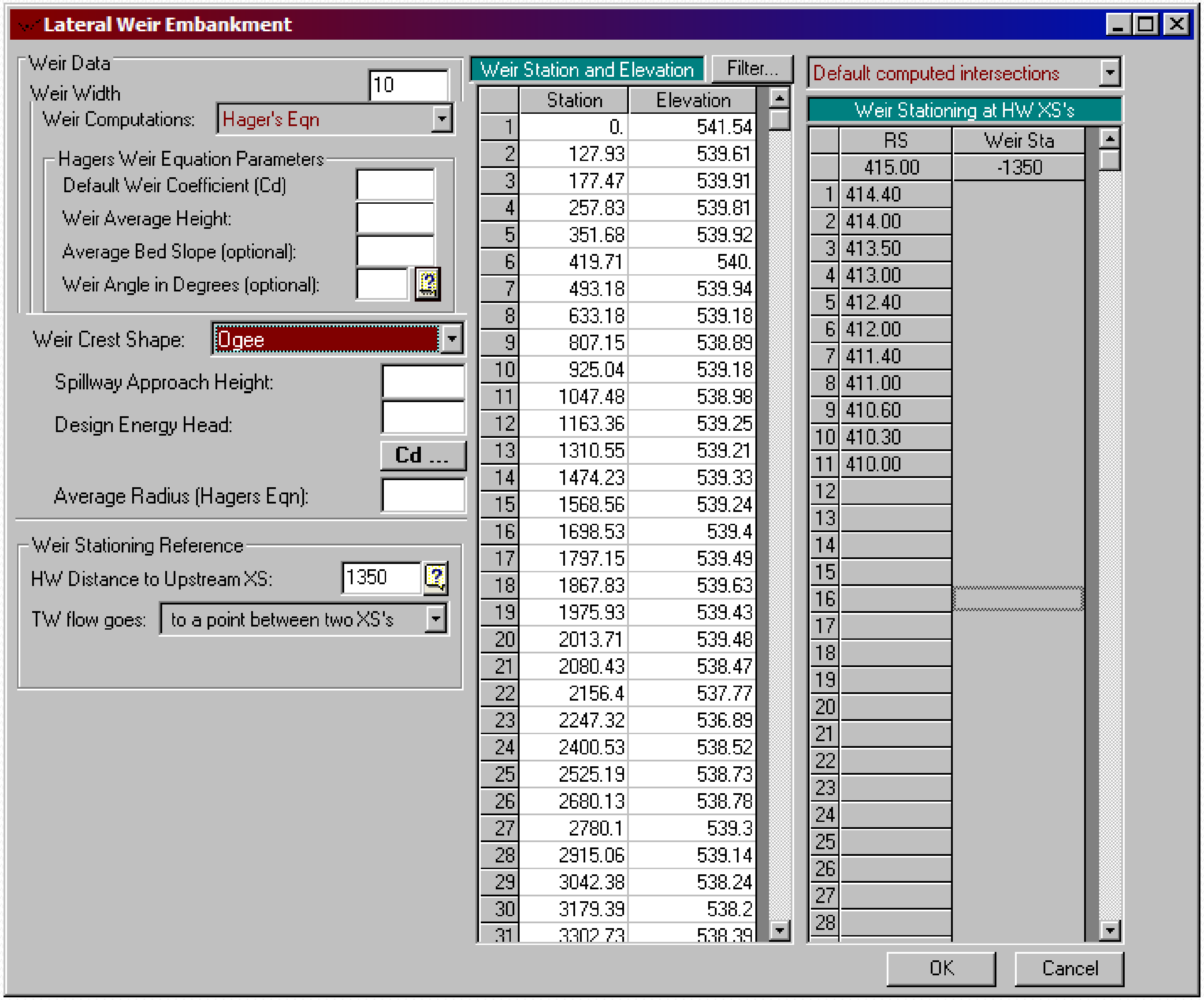
Location: Henderson County Drainage District #3


Geometric Data - Pre-Breach
File Edit View Tables Tools GIS Tools Help
Tools
Editors
River Reach
Storage Area
S.A. Conn.
Pump Station
RS
12.99
Junct.
Cross Section
Brdg/Culv
Inline Structure
Lateral Structure


Lateral Structure Editor - Pre-Breach
File View Options Help
River: Mississippi
Apply Data
Reach: Reach 1
HW RS: 414.66
Description Mississippi River to HC DD#3
Plan Data
HW Position: Left overbank
Optimization ...
Breach ...
Tailwater Connection
Type: Cross section(s) of a river/reach
TW RS: Mississippi Reach 1 RS: 412.00
Set TW RS ...
TW Position: Left overbank
All Culverts: No Flap Gates
Structure Type: Weir/Gates/Culverts/Diversion Rating Curves
Weir / Embankment
Gate
Culvert
Diversion RC
HC3 - Combined Plan: Pre-Breach 10/21/2008
Legend
Ground
Bank Sta
Elevation (ft)
Station (ft)
560
550
540
530
520
510
500
490
-5000
0
5000
10000
15000
20000
25000


Unsteady Initial Conditions - Flow Optimization Options
Junctions
Lateral Structures/Diversions
Reach-Storage Areas
Pumps
River
Reach
RS
Optimize
1 Henderson Creek Upper 25279 LS
2 Henderson Creek Lower 20338 LS
3 Henderson Creek Lower 10870 LS
4 Mississippi Reach 1 414.66 LS
OK
Cancel


Select a River Reach and River Station
Flow from this lateral structure is connected to cross sections. Pick the upstream river, reach and river station.
River: Mississippi
US RS: 412.00
Reach: Reach 1
DS RS: 411.40
OK
Cancel



	Station	Elevation
1	0.	541.54
2	127.93	539.61
3	177.47	539.91
4	257.83	539.81
5	351.68	539.92
6	419.71	540.
7	493.18	539.94
8	633.18	539.18
9	807.15	538.89
10	925.04	539.18
11	1047.48	538.98
12	1163.36	539.25
13	1310.55	539.21
14	1474.23	539.33
15	1568.56	539.24
16	1698.53	539.4
17	1797.15	539.49
18	1867.83	539.63
19	1975.93	539.43
20	2013.71	539.48
21	2080.43	538.47
22	2156.4	537.77
23	2247.32	536.89
24	2400.53	538.52
25	2525.19	538.73
26	2680.13	538.78
27	2780.1	539.3
28	2915.06	539.14
29	3042.38	538.24
30	3179.39	538.2
31	3302.73	538.39

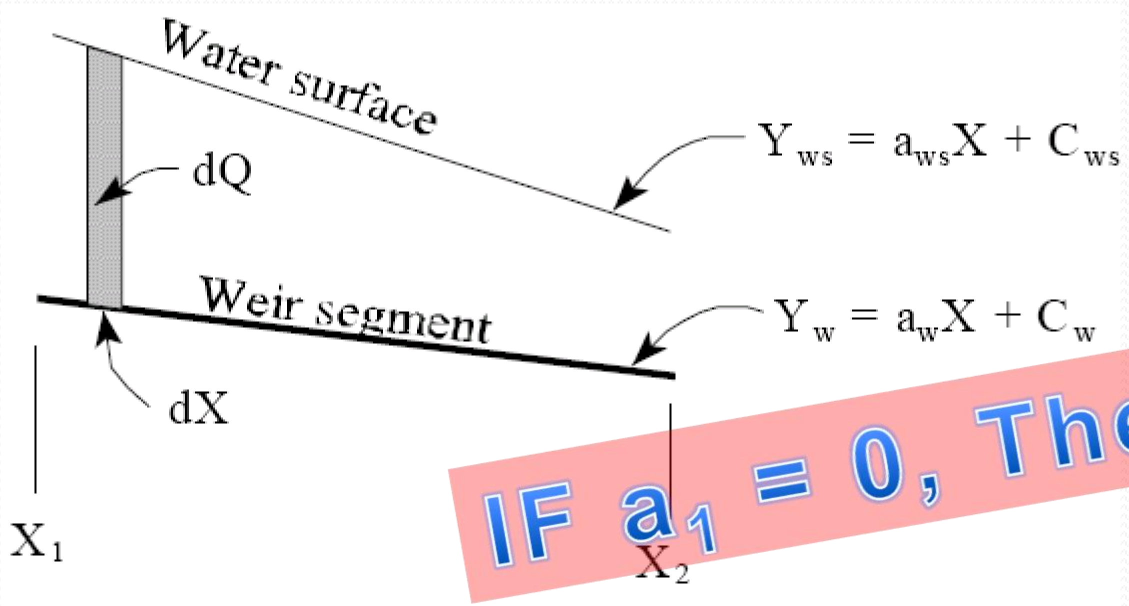
	RS	Weir Sta
	415.00	-1350
1	414.40	
2	414.00	
3	413.50	
4	413.00	
5	412.40	
6	412.00	
7	411.40	
8	411.00	
9	410.60	
10	410.30	
11	410.00	
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

Engineers Need Equations!

Standard Equation:

$$Q_{x_1-x_2} = \frac{2C}{5a_1}((a_1 x_2 + C_1)^{5/2} - (a_1 x_1 + C_1)^{5/2})$$

Assuming: $a_1 = a_{ws} - a_w$ and $C_1 = C_{ws} - C_w$



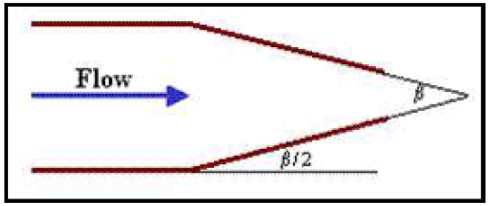
IF $a_1 = 0$, Then $Q=CLH^{1.5}$

Source: HEC-RAS 4.0 Reference Manual (Fig 8-10 & Eq. 8-12)

More Equations!

Hager's Equation:

$$C = \frac{3}{5} C_0 \sqrt{g} \left[\frac{1-W}{3-2y-W} \right]^{0.5} \left\{ 1 - (\beta + S_0) \left[\frac{3(1-y)}{y-W} \right]^{0.5} \right\} \qquad (8\text{-}13)$$



Where:

$$W = \frac{h_w}{H_t + h_w} \qquad y = \frac{H + h_w}{H_t + h_w} \qquad C_0 = Function(weir\ shape)$$

H	=	Height of the water surface above the weir
h_w	=	Height of the weir above the ground
H_t	=	Height of the energy gradeline above the weir
S_0	=	Average main channel bed slope
β	=	main channel contraction angle in radians (zero if the weir is parallel to the main channel).
C_0	=	Base Discharge coefficient. C_0 = 1.0 for a sharp crested weir. C_0 = 8/7 for a zero height weir.

For a broad crested weir (b = weir width):

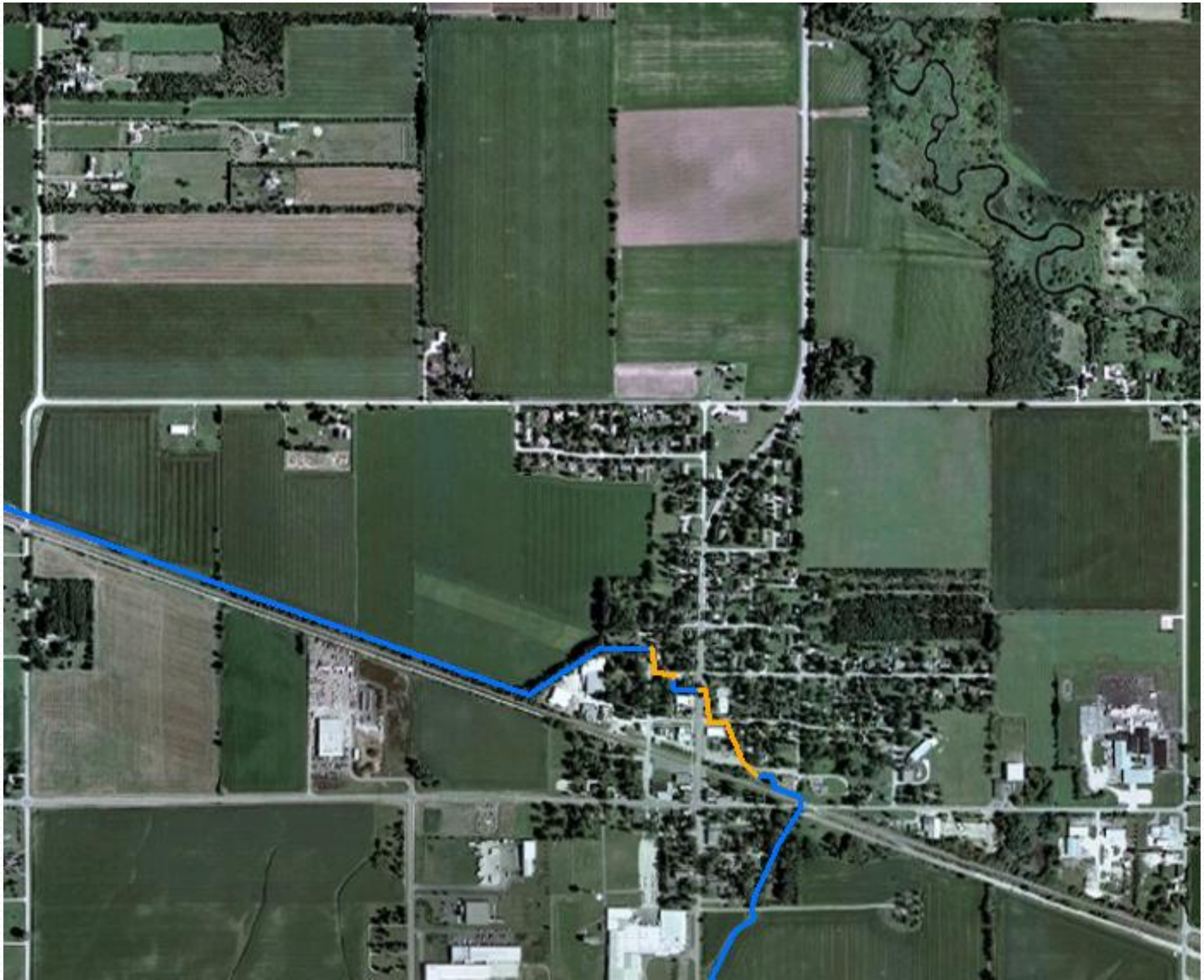
$$C_0 = 1 - \frac{2}{9\left[1 + \left(\frac{H_t}{b}\right)^4\right]}$$

For round or ogee crested weirs (r= weir radious):

$$C_0 = \frac{\sqrt{3}}{2}\left[1 + \frac{\frac{22}{81}\left(\frac{H_t}{r}\right)^2}{1 + \frac{1}{2}\left(\frac{H_t}{r}\right)^2}\right]$$

Source: HEC-RAS 4.0 Reference Manual (P. 8-17)

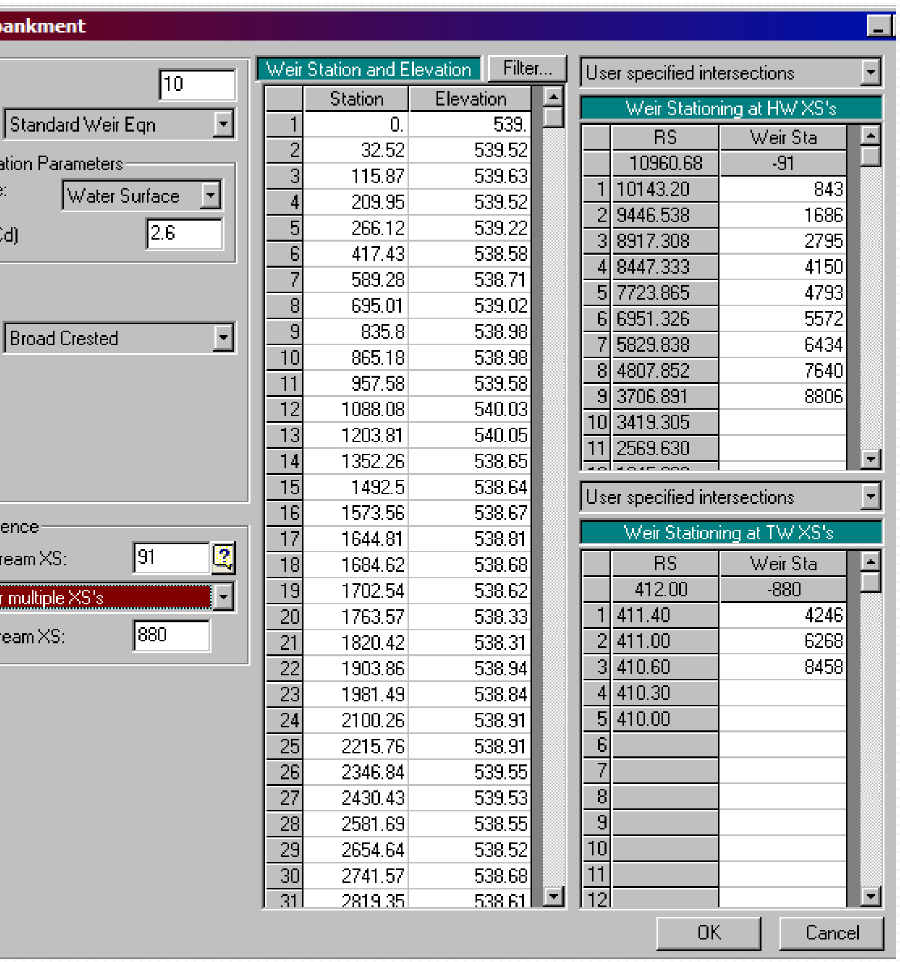
Out of System



Into a Reservoir

Location: Henderson County Drainage District #3

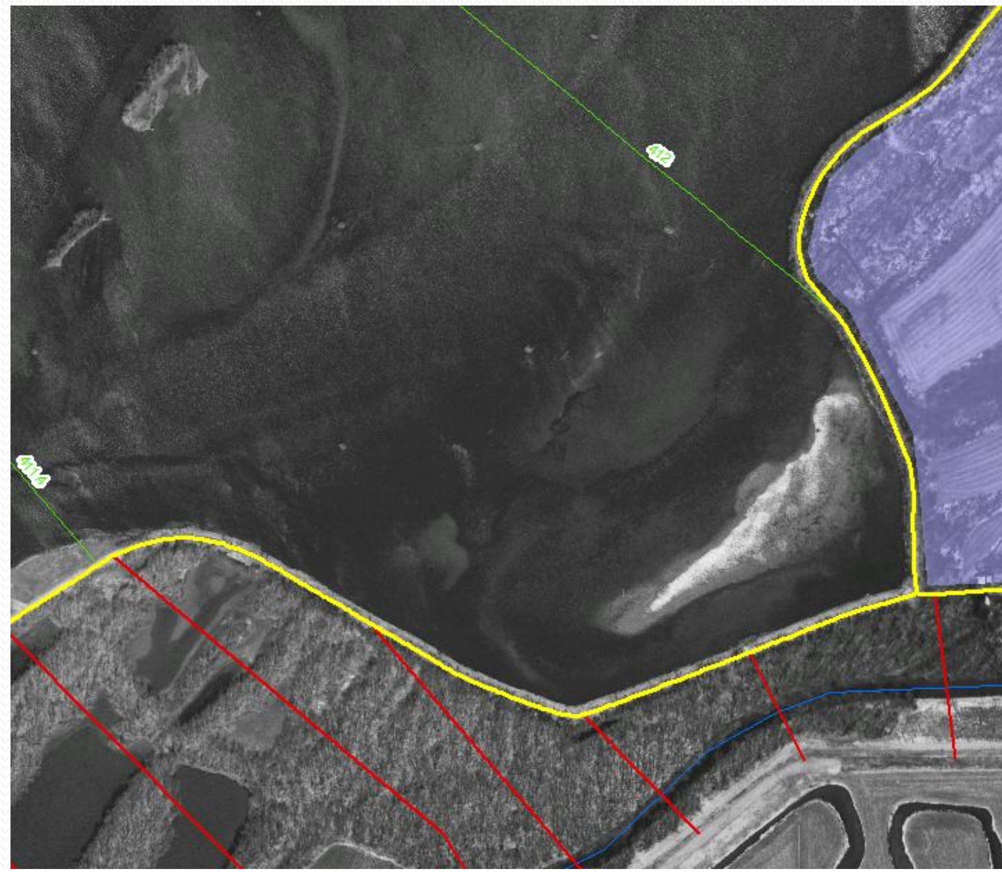
Into a Channel



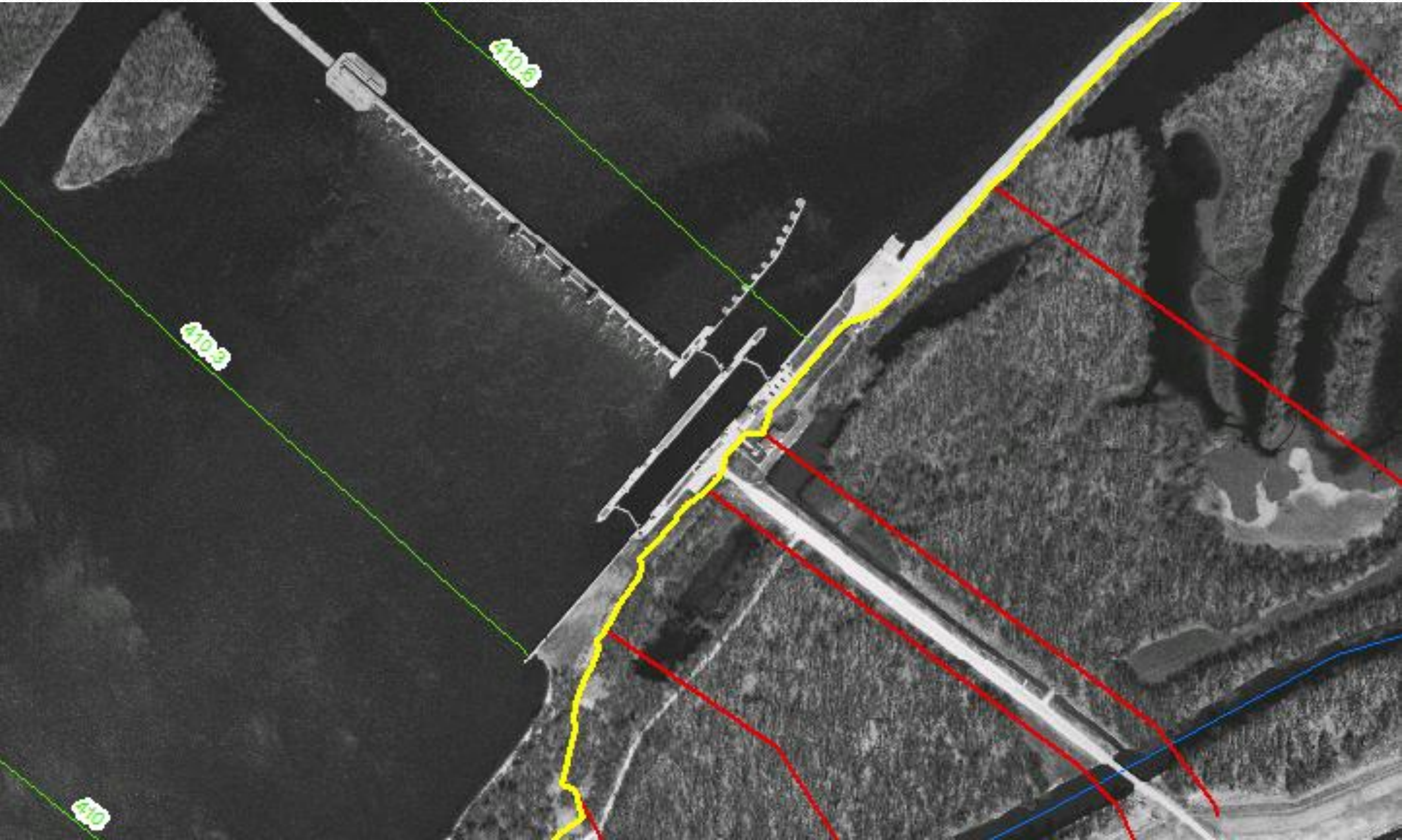
	Station	Elevation
1	0.	539.
2	32.52	539.52
3	115.87	539.63
4	209.95	539.52
5	266.12	539.22
6	417.43	538.58
7	589.28	538.71
8	695.01	539.02
9	835.8	538.98
10	865.18	538.98
11	957.58	539.58
12	1088.08	540.03
13	1203.81	540.05
14	1352.26	538.65
15	1492.5	538.64
16	1573.56	538.67
17	1644.81	538.81
18	1684.62	538.68
19	1702.54	538.62
20	1763.57	538.33
21	1820.42	538.31
22	1903.86	538.94
23	1981.49	538.84
24	2100.26	538.91
25	2215.76	538.91
26	2346.84	539.55
27	2430.43	539.53
28	2581.69	538.55
29	2654.64	538.52
30	2741.57	538.68
31	2819.35	538.61

	RS	Weir Sta
	10960.68	-91
1	10143.20	843
2	9446.538	1686
3	8917.308	2795
4	8447.333	4150
5	7723.865	4793
6	6951.326	5572
7	5829.838	6434
8	4807.852	7640
9	3706.891	8806
10	3419.305	
11	2569.630	

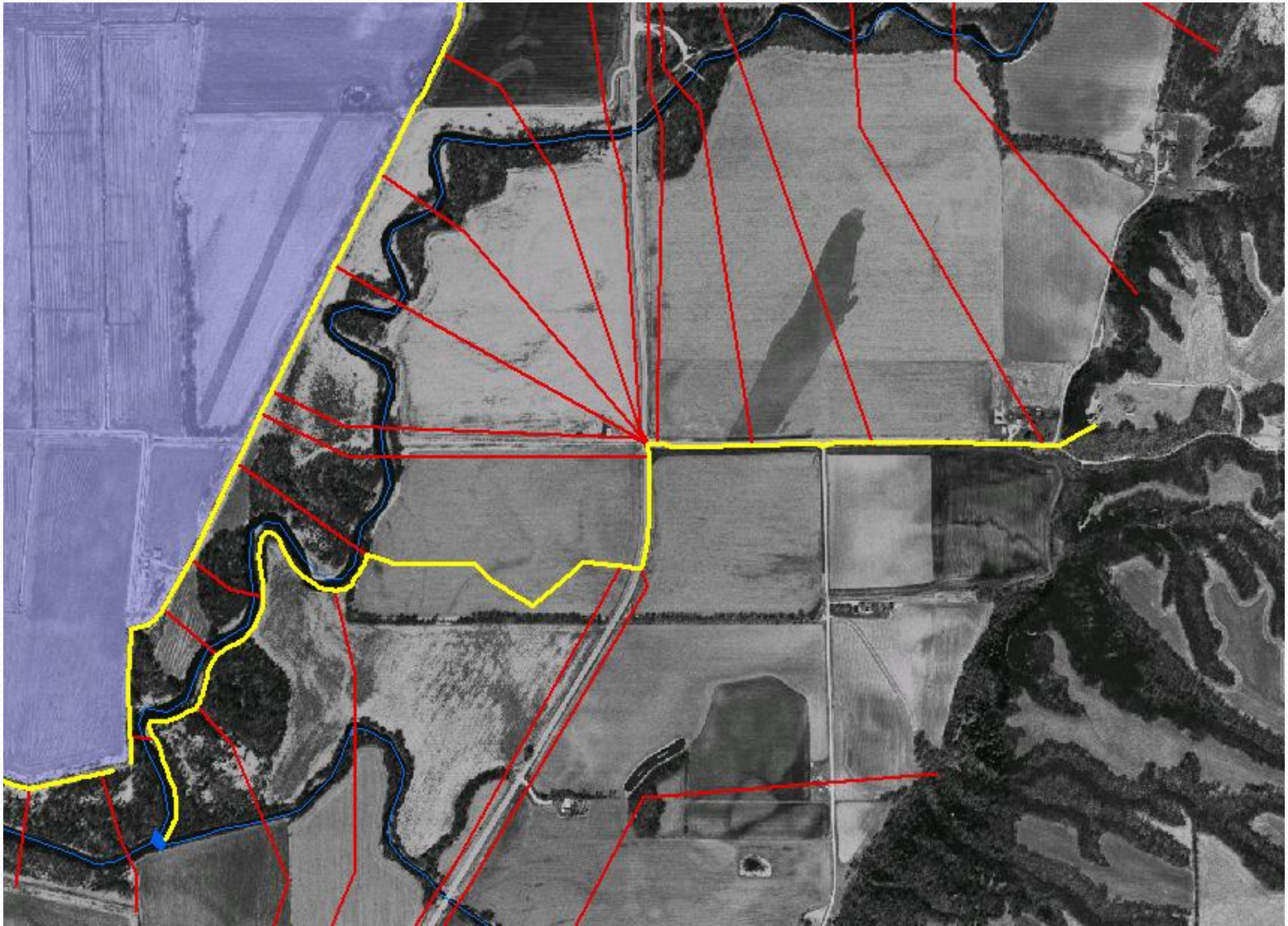
	RS	Weir Sta
	412.00	-880
1	411.40	4246
2	411.00	6268
3	410.60	8458
4	410.30	
5	410.00	
6		
7		
8		
9		
10		
11		
12		



Structures Impacts



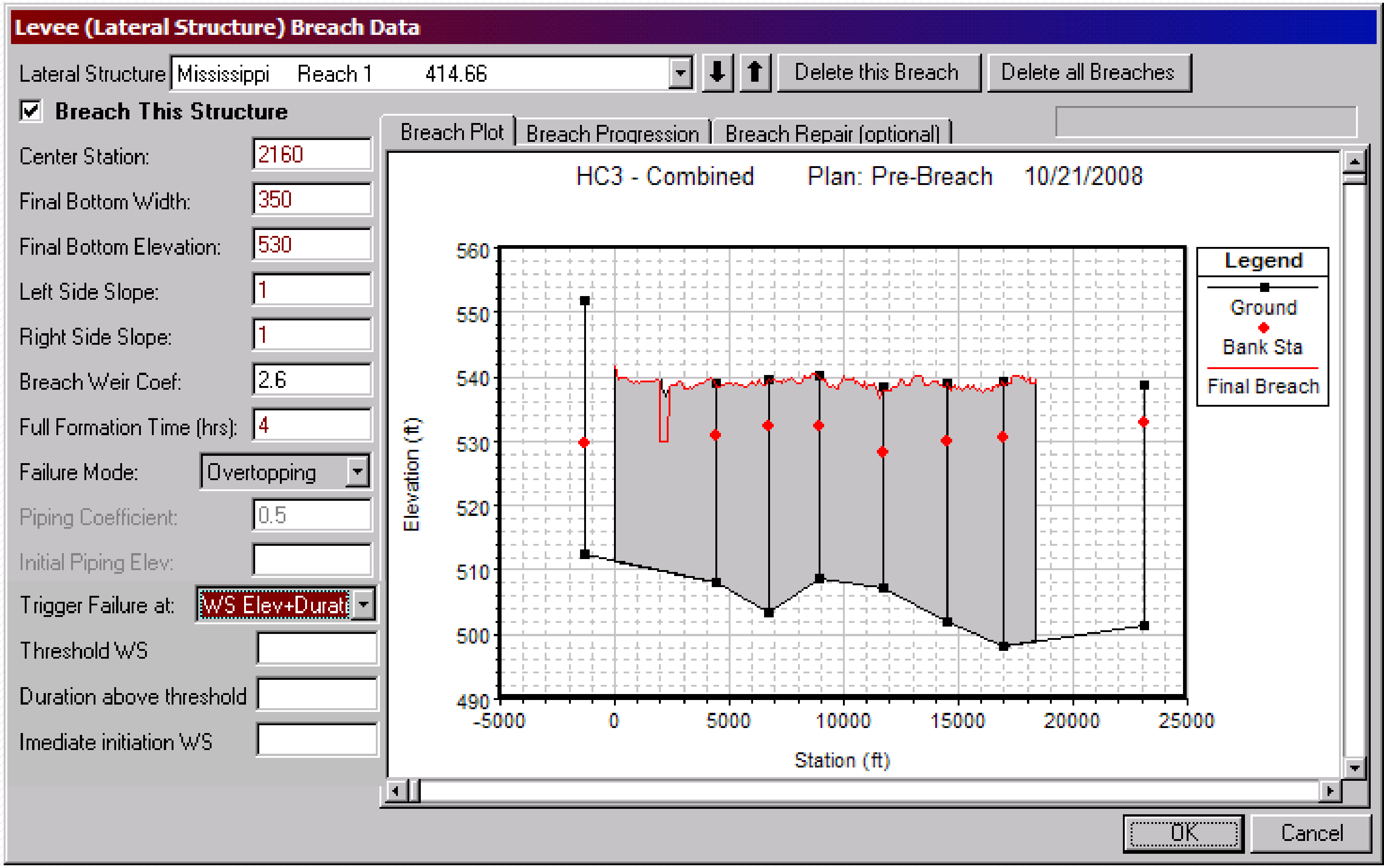
Confluences



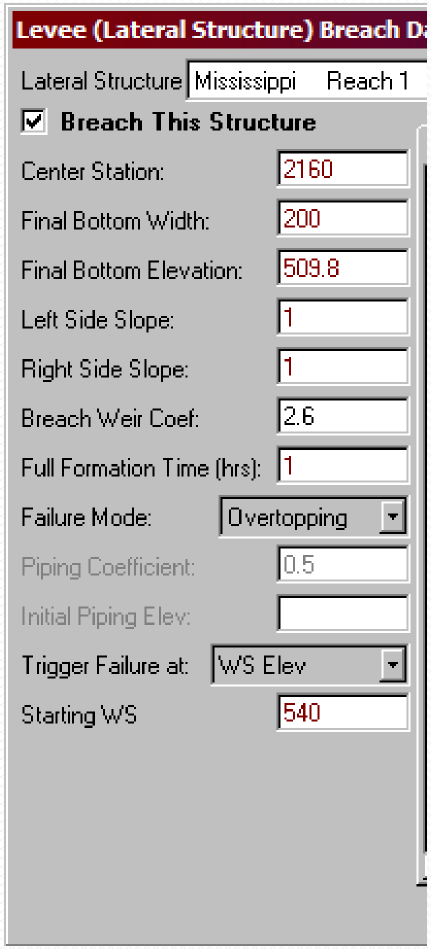
Meanders

Danville, IL
North Fork & Vermilion Confluence

Breach


Levee (Lateral Structure) Breach Data
Lateral Structure
Mississippi Reach 1 414.66
Delete this Breach
Delete all Breaches
Breach This Structure
Center Station: 2160
Final Bottom Width: 350
Final Bottom Elevation: 530
Left Side Slope: 1
Right Side Slope: 1
Breach Weir Coef: 2.6
Full Formation Time (hrs): 4
Failure Mode: Overtopping
Piping Coefficient: 0.5
Initial Piping Elev:
Trigger Failure at: WS Elev+Durati
Threshold WS
Duration above threshold
Imediate initiation WS
Breach Plot
Breach Progression
Breach Repair (optional)
HC3 - Combined Plan: Pre-Breach 10/21/2008
Elevation (ft)
Station (ft)
Legend
Ground
Bank Sta
Final Breach
OK
Cancel

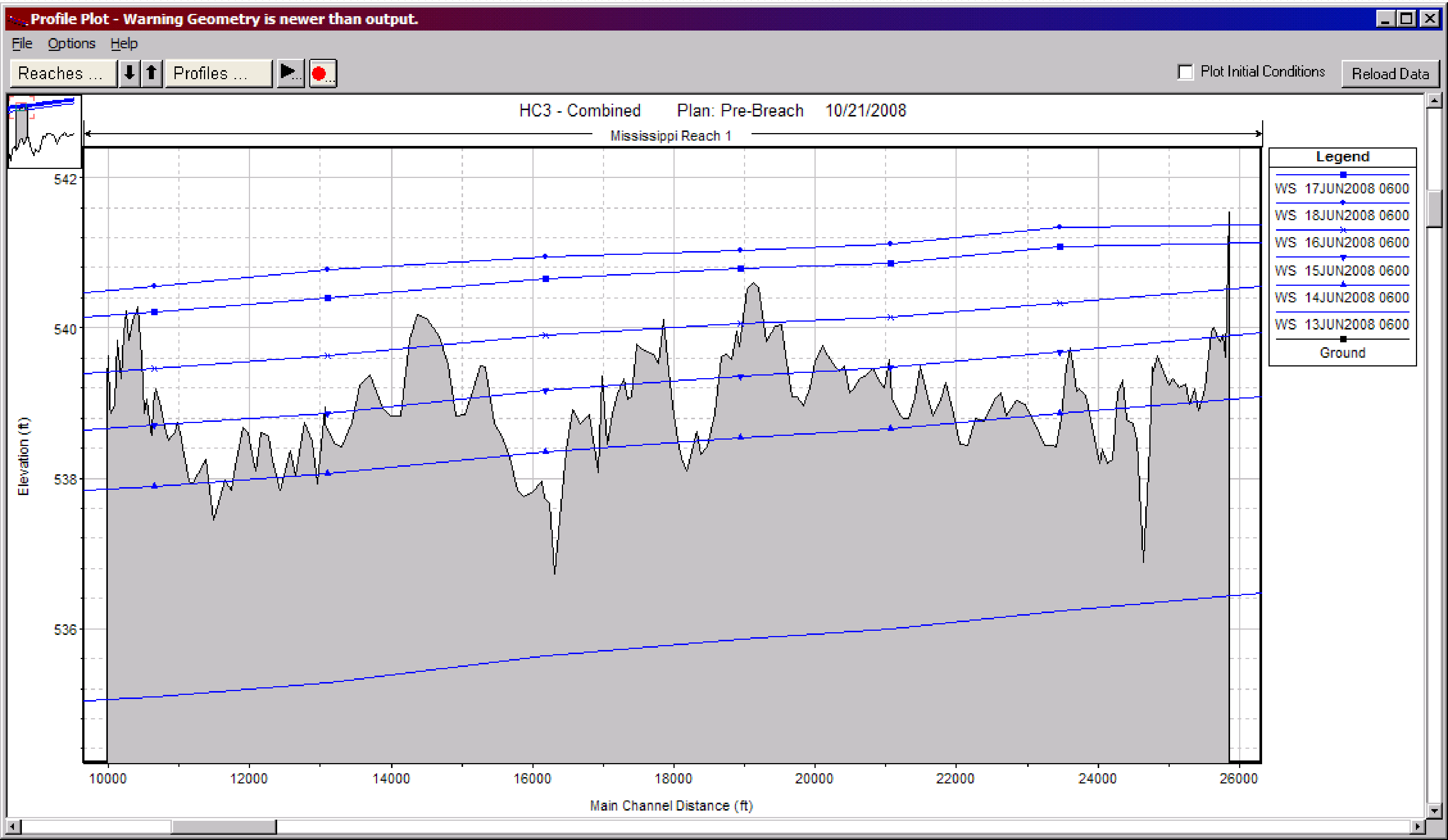
Breach – Inputs



- Station = Lowest embankment elevation vs. WS profile
- Bottom Width = 3 x Water Height above Final Bottom Elev.
- Final Bottom Elevation = Min Elevation DS of Breach
- Side Slopes = 0 to 1
- Time (hrs) = 0.2 x Bottom Width (Earthen Levee)

Sources: Bureau of Reclamation (1988) Downstream Hazard Classification Guidelines

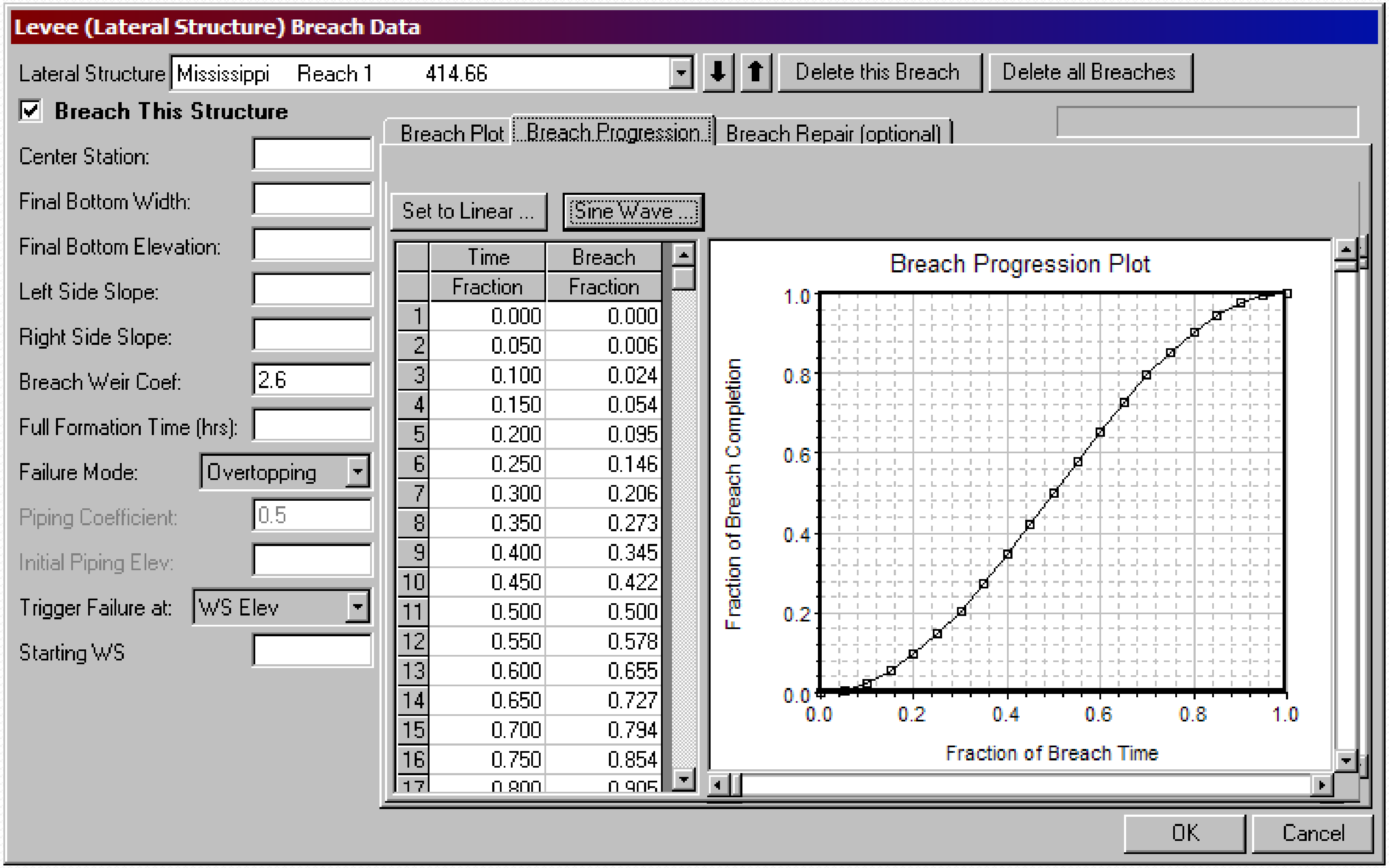
Breach – Station



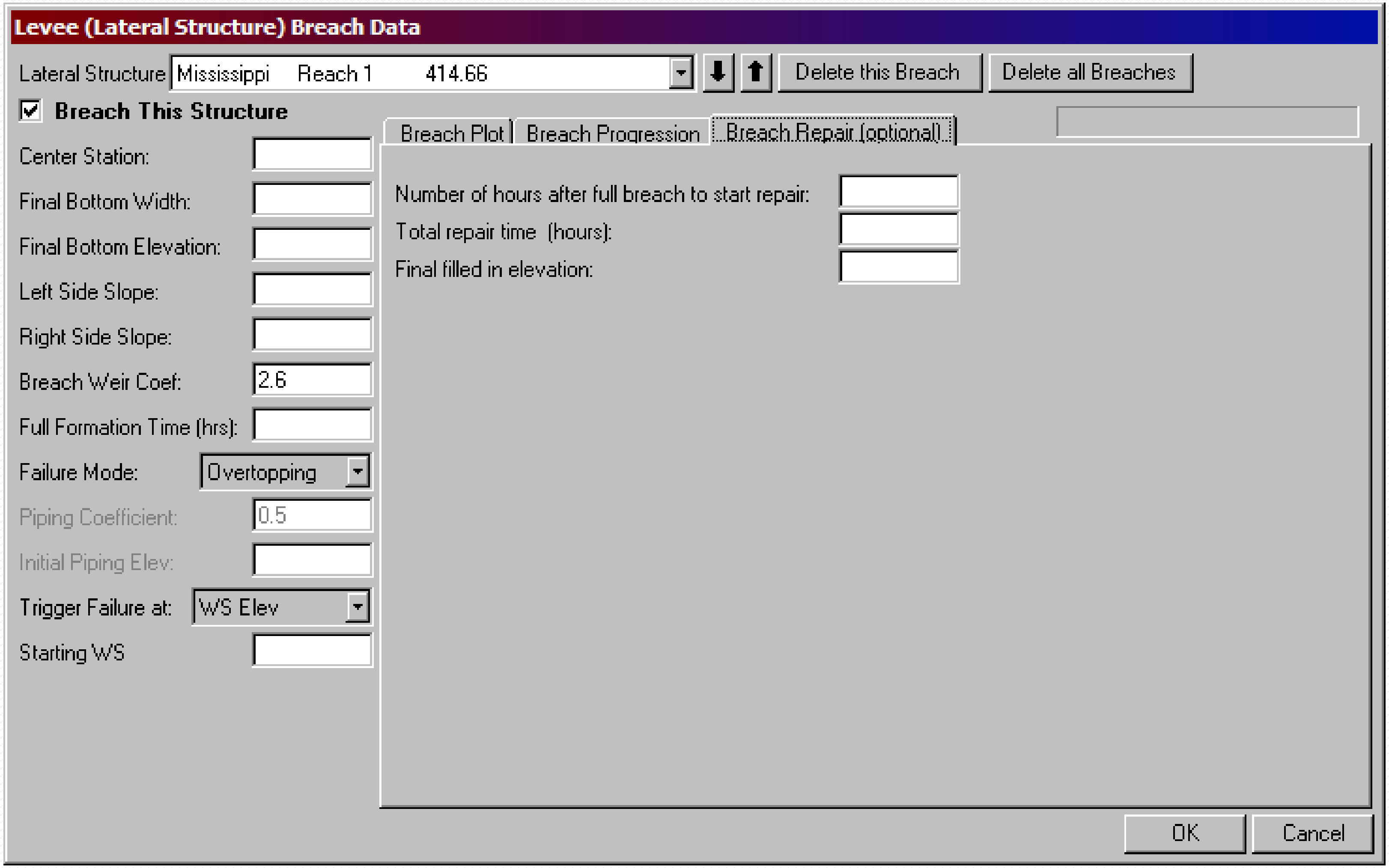
Breach – Parameter Studies

- USBR (1988) Downstream Hazard Classification Guidelines
- BOSS DAMBRK Manual
- Wahl, Tony (2004) Uncertainty of Predictions of Embankment Dam Breach Parameters
- USBR (1988) Prediction of Embankment Dam Breach Parameters

Breach - Progression



Breach – Repair



Further Recommendations

- Check Sensitivity in all cases
- Take a class
  - Unsteady RAS
  - Breach Analysis
- Test Conditions
- Plenty of available information

THANK YOU!