Finding and Fixing Model Stability Problems

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Objectives

- The Objectives of this lecture are to teach students how to detect, find, and fix model stability problems, using the available tools in HEC-RAS

Overview

- Detecting Stability Problems
- Utilizing the Profile Plot
- Computational Level Output for Debugging
- Utilizing the Cross Section Plot
- Profile Summary Tables
- Detailed Output Tables
- Turning on Detailed Log Output File for Debugging

Detecting Stability Problems

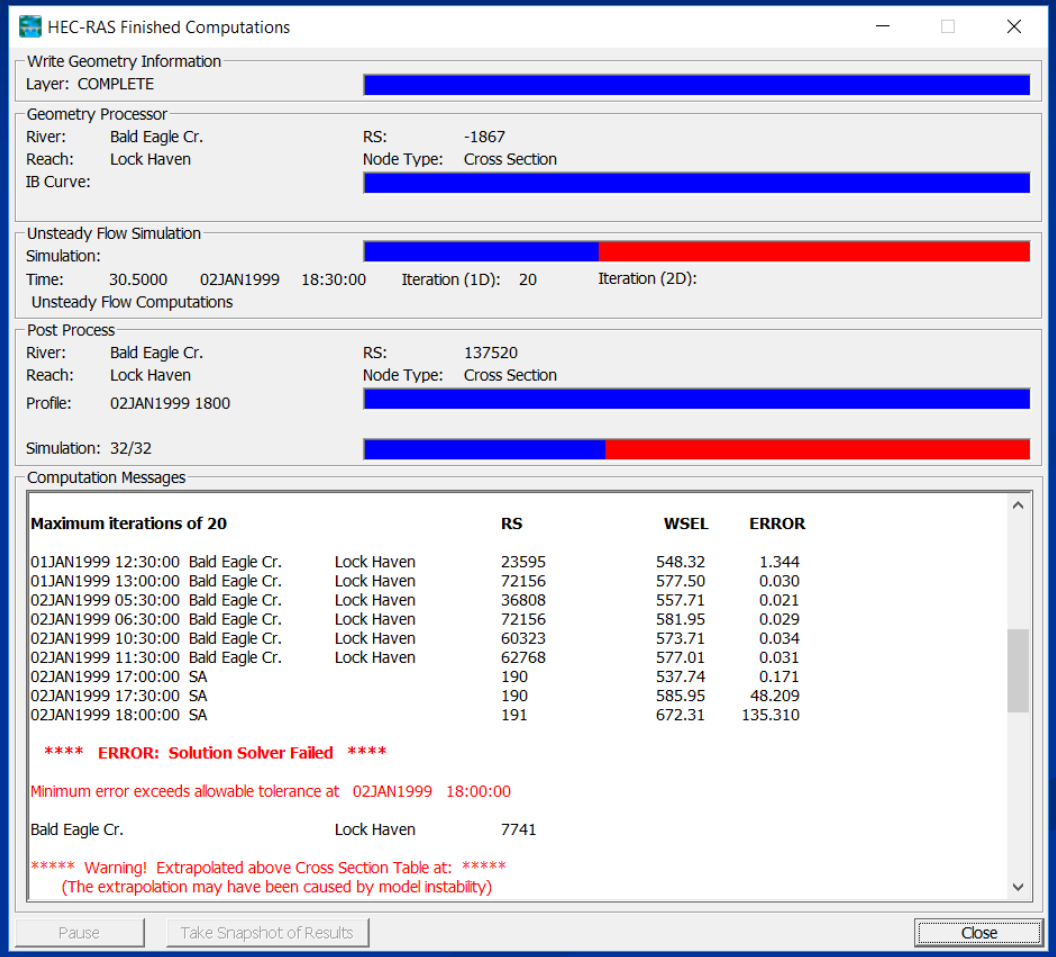
- How do you know you have a model stability problem?
  - Program completely blows up during run.
  - Program says matrix solution went completely unstable during the calculations.
  - Computed error in water surface calc is very large
  - Program goes to maximum number of iterations for several time steps in a row, with large errors.
  - Program has oscillations in the computed stage and flow hydrographs.

Detecting Stability Problems - Continued

- What do you do when this happens?
  - Note the simulation time and location from the computation window when the program either blew up or first started to go to the maximum number of iterations with large water surface errors.
  - Use the HEC-RAS Profile and Cross Section Plots as well as the Tabular Output to find the problem location and issue.
  - If you can not find the problem using the normal HEC-RAS output - Turn on the "Detailed Output for Debugging" option and re-run the program.
  - View the text file that contains the detailed log output of the computations. Locate the simulation output at the simulation time when the solution first started to go bad.
  - Find the river station locations that did not meet the solution tolerances. Then check the data in this general area.

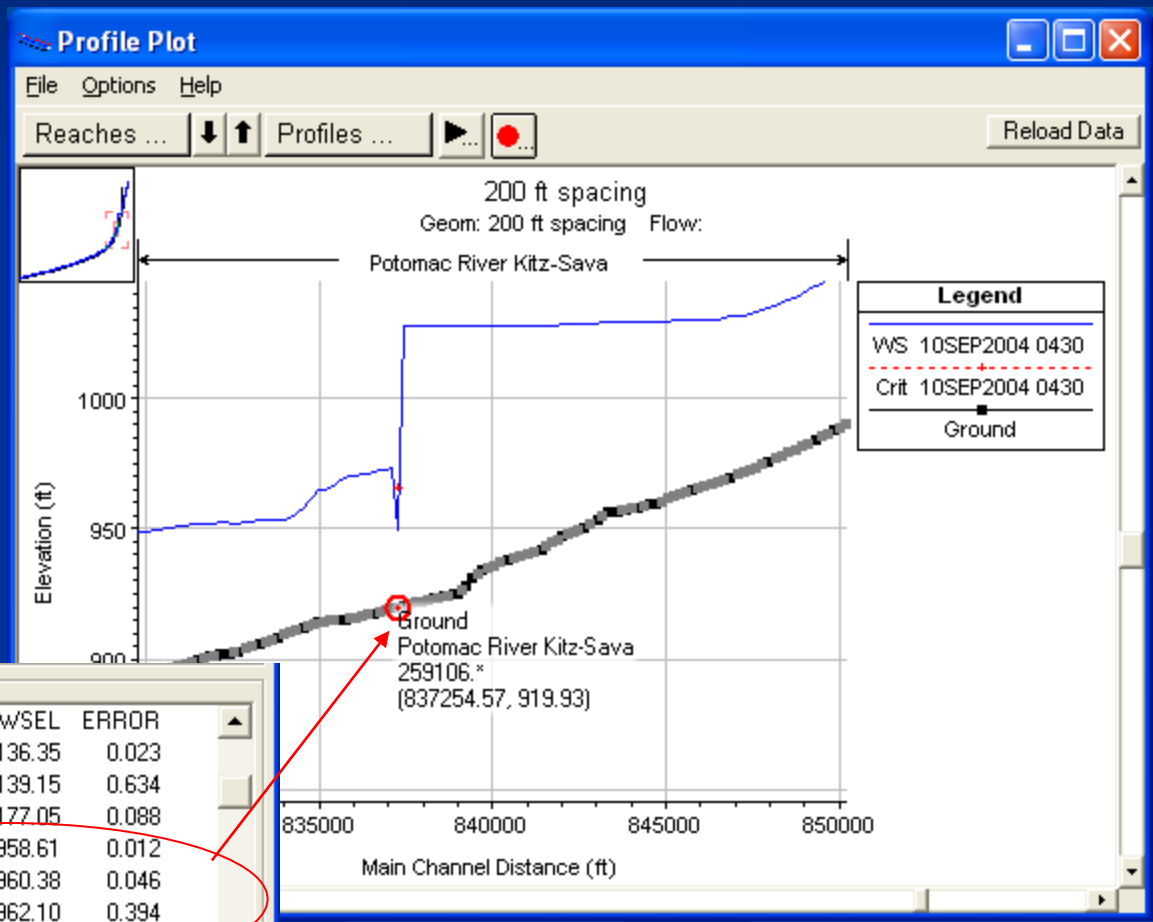
Computation Window

- First place to look for problems
- When the maximum number of iterations is reach, and solution error is greater than the predefined tolerance, the time step, river, reach, river station, water surface elevation and the amount of error is reported.
- When the error increases too much, the solution will stop and say "Matrix Solution Failed".
- Often the first RS to show up on the window can give clues to the source of instabilities



Computation Window

- Small errors are generally not problematic
- Focus on larger compounding errors.
- Try to find time and location when errors first begin to occur.



Computation Messages

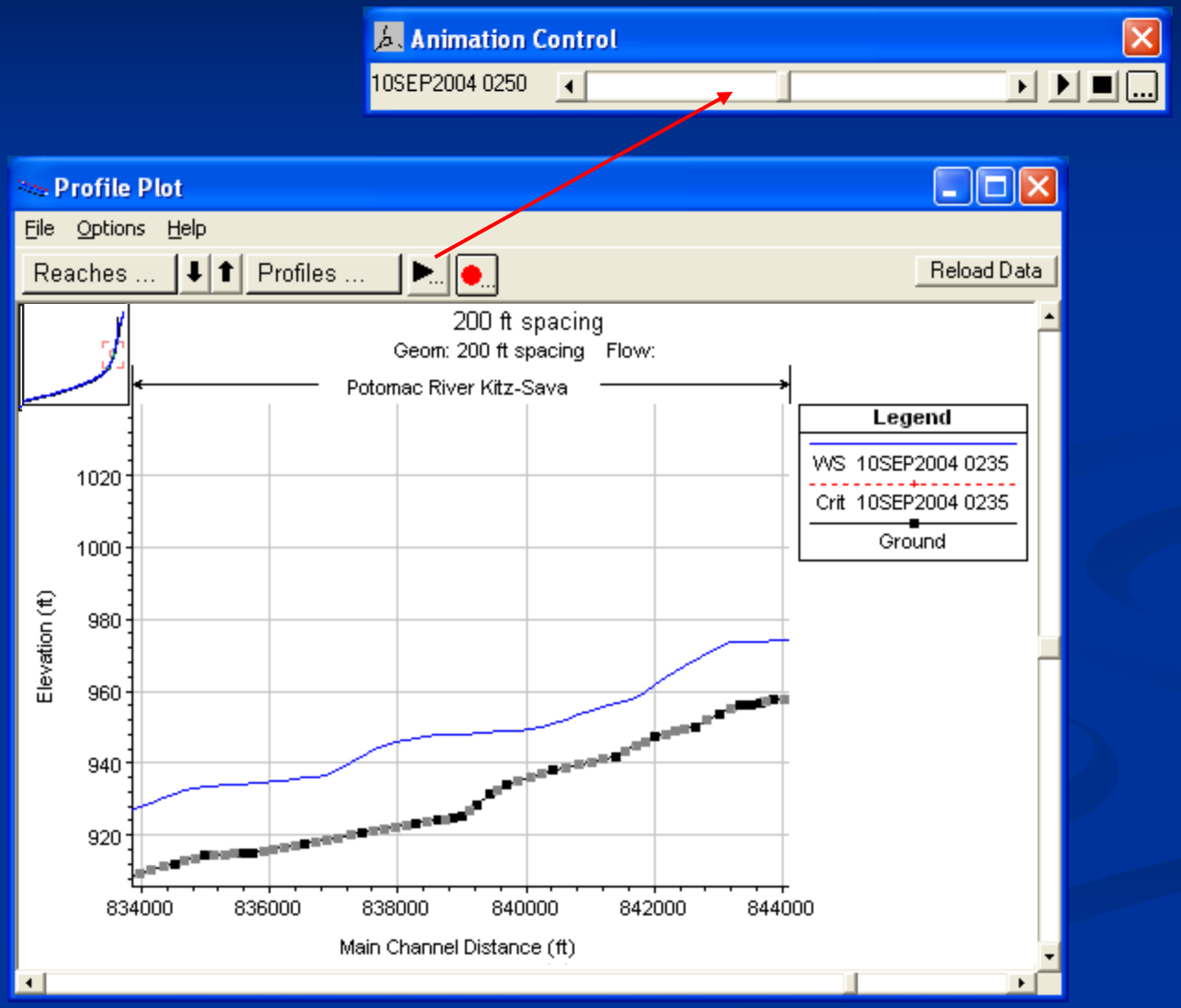
Maximum iterations of 20 at:		RS	WSEL	ERROR
10SEP2004 03:28:45	Potomac River Kitz-Sava	267788.9	1136.35	0.023
10SEP2004 03:29:00	Potomac River Kitz-Sava	267788.9	1139.15	0.634
10SEP2004 03:29:15	Potomac River Kitz-Sava	267788.9	1177.05	0.088
10SEP2004 04:48:30	Potomac River Kitz-Sava	259106.*	958.61	0.012
10SEP2004 04:48:45	Potomac River Kitz-Sava	259106.*	960.38	0.046
10SEP2004 04:49:00	Potomac River Kitz-Sava	259106.*	962.10	0.394
10SEP2004 04:49:15	Potomac River Kitz-Sava	259106.*	983.33	0.290
10SEP2004 05:10:30	Potomac River Kitz-Sava	242421.*	772.63	0.014

Close

Utilizing the Profile Plot

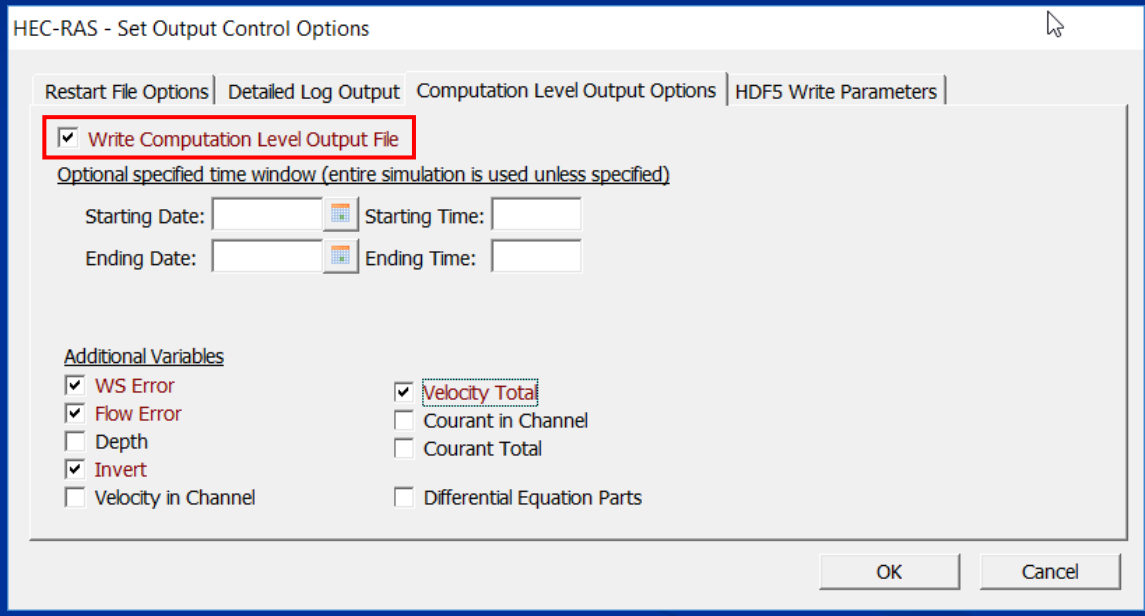
- Great visual tool for finding problem areas.
- Use the "Animation" option to look for obvious instabilities. Zoom in to get a closer look.
- You will need to refine the Detailed Output Interval to see where and when the instability occurs.
- When the first hints of an instability is revealed, click on that "node" and investigate further.

Profile Plot Animation

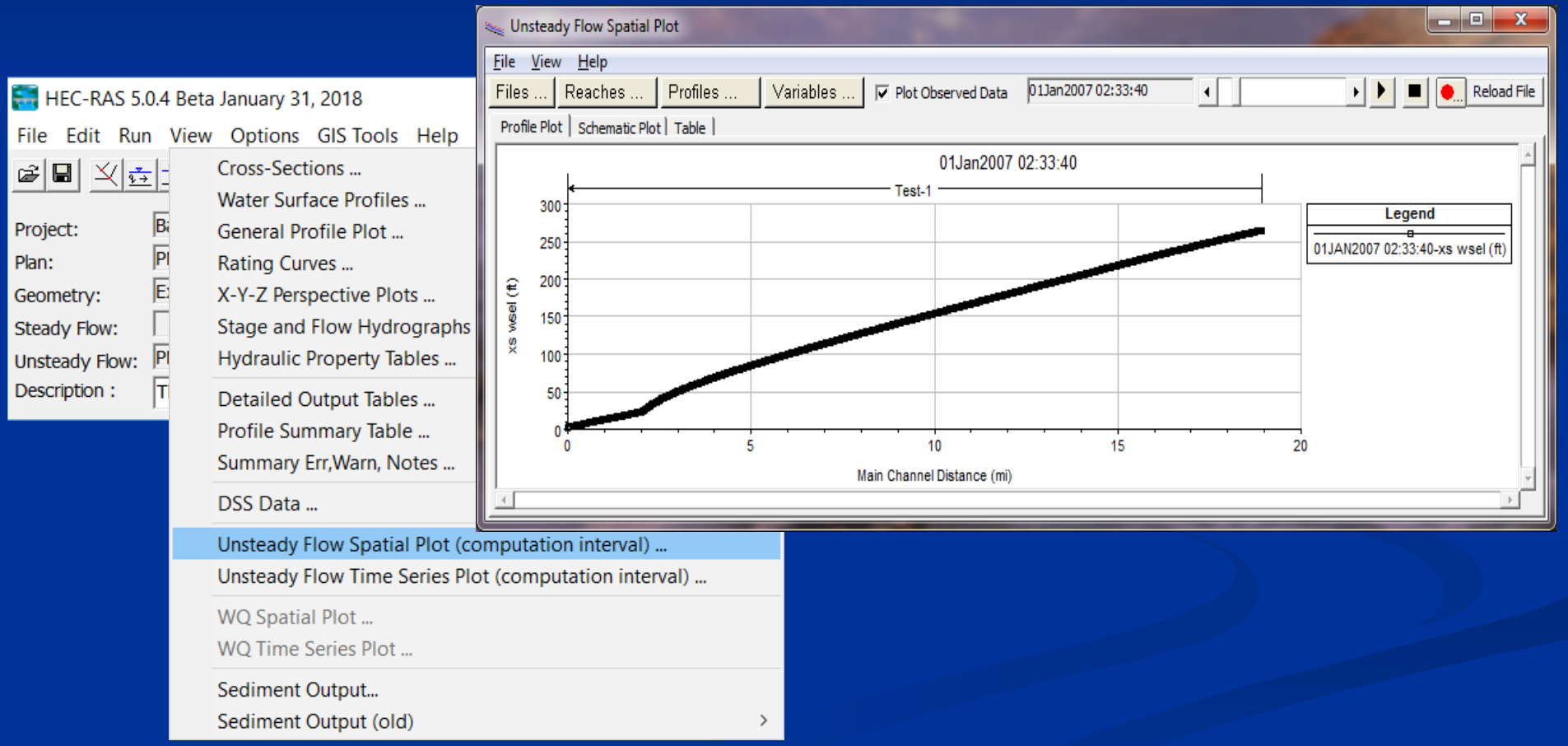


Computation Level Output for Debugging

- Writes flow and stage at all locations to a separate file.
- Tools available from the View menu:
  - Spatial Plots
    - profile
    - schematic
  - Time Series plots
    - water surface, depth, flow
    - WS and flow errors
- Warning: Can create large output files when used with large data sets for long times

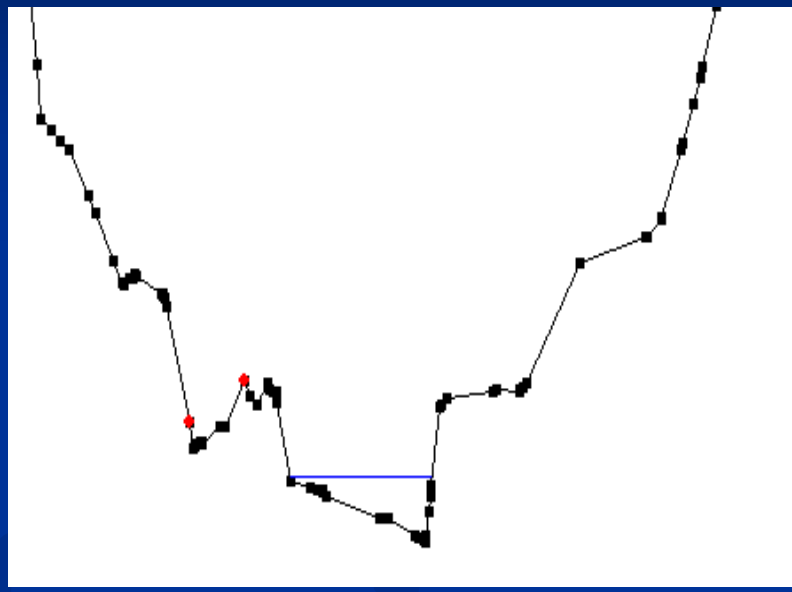


Computation Level Output Visualization Tools



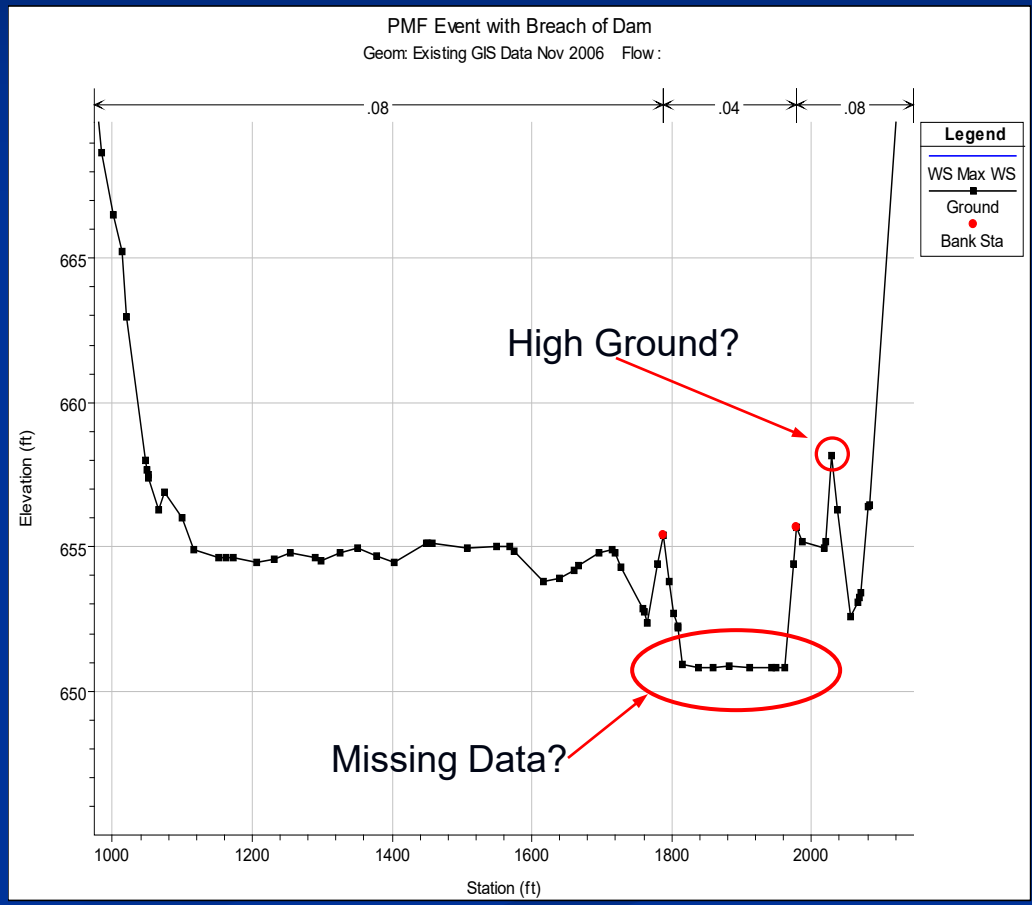
Utilizing the Cross Section Plot

- Can help spot isolated problems such as:
  - Incorrect Bank Station locations
  - Bad Manning's n Values
  - Bad Station-elevation points
- Can help spot transition problems
  - Contraction/Expansion Areas
  - Ineffective Flow Areas
  - Levees



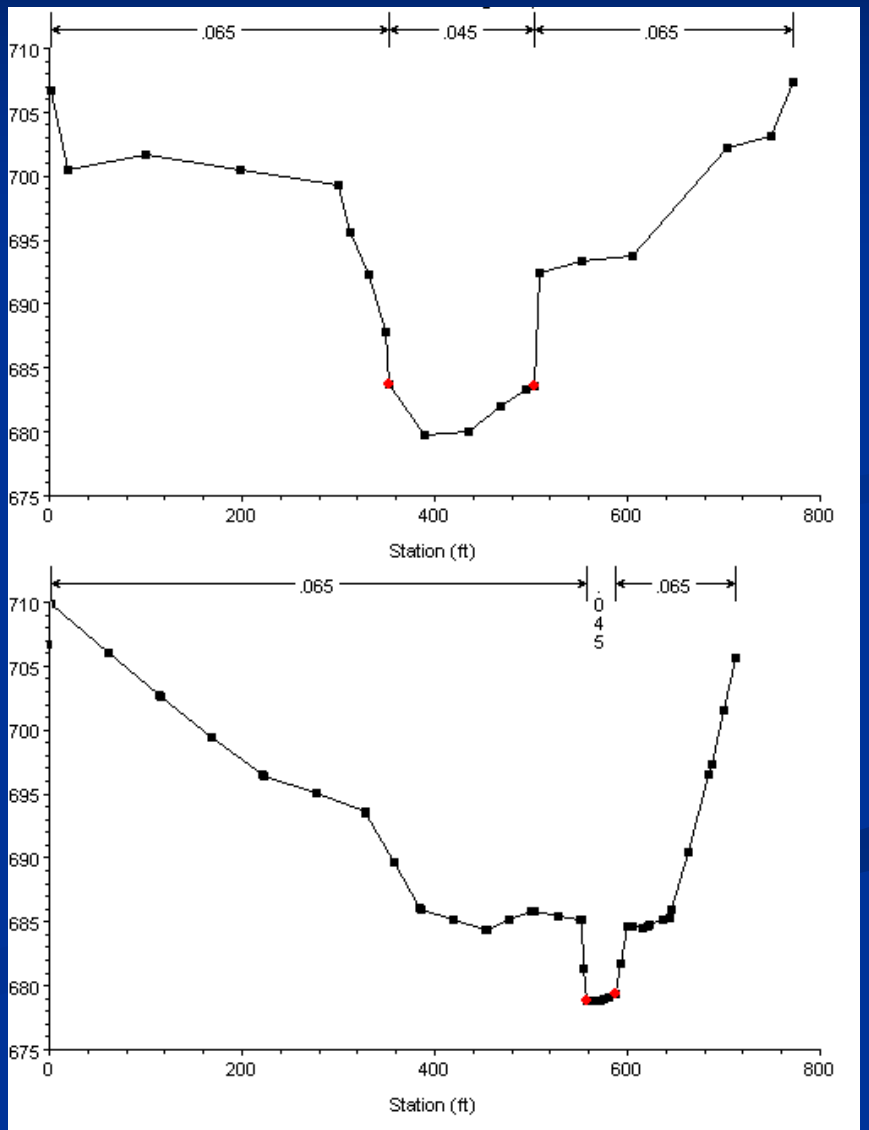
Cross Section Plot

- Wide, Horizontal Beds
  - Estimated XS?
  - LIDAR, no bathymetry?
  - Prone to instabilities – High Area:Depth ratio
- High Ground
  - Levee Option
  - Ineffective Flows?
- Solutions?



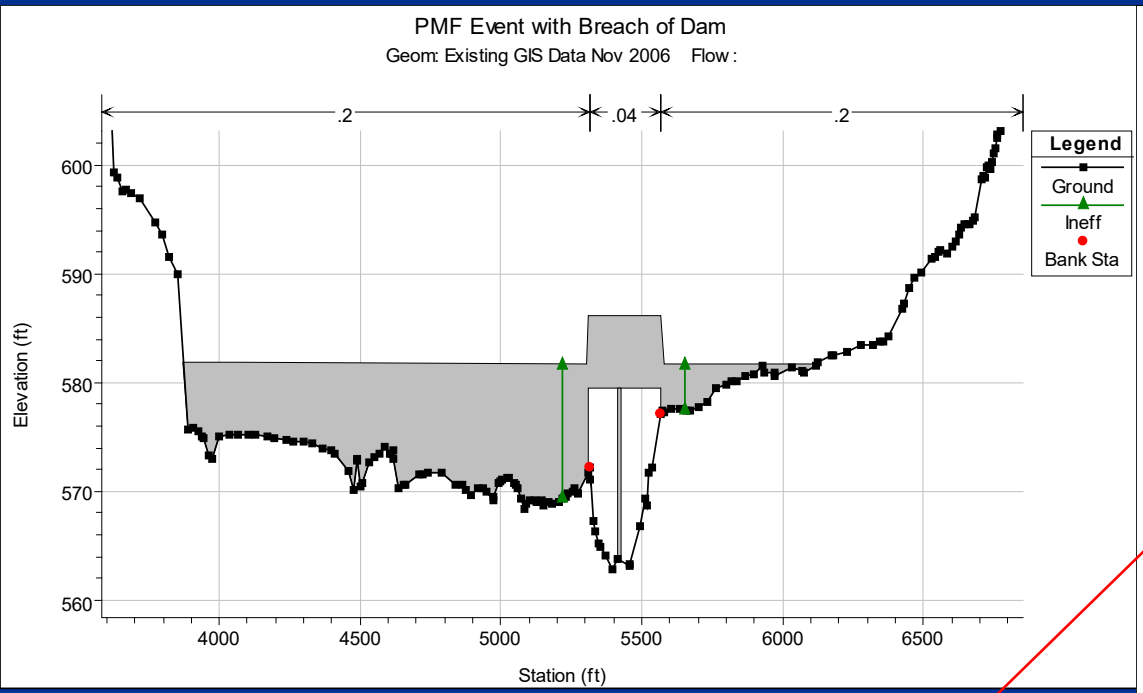
Cross Section Plot

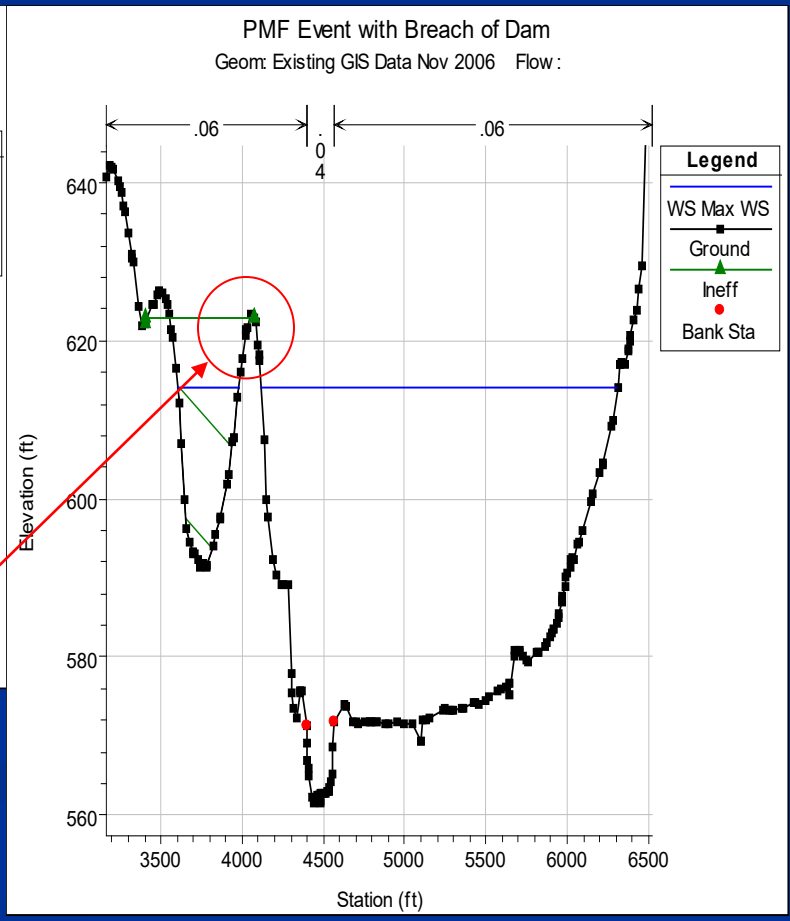
- Transitions
  - If sudden contraction or expansion occurs over a short distance, how can this be handled?
  - Ineffective Flow Areas
  - More Cross Sections
    - Interpolation



Cross Section Plot

- Ineffective Flow Areas

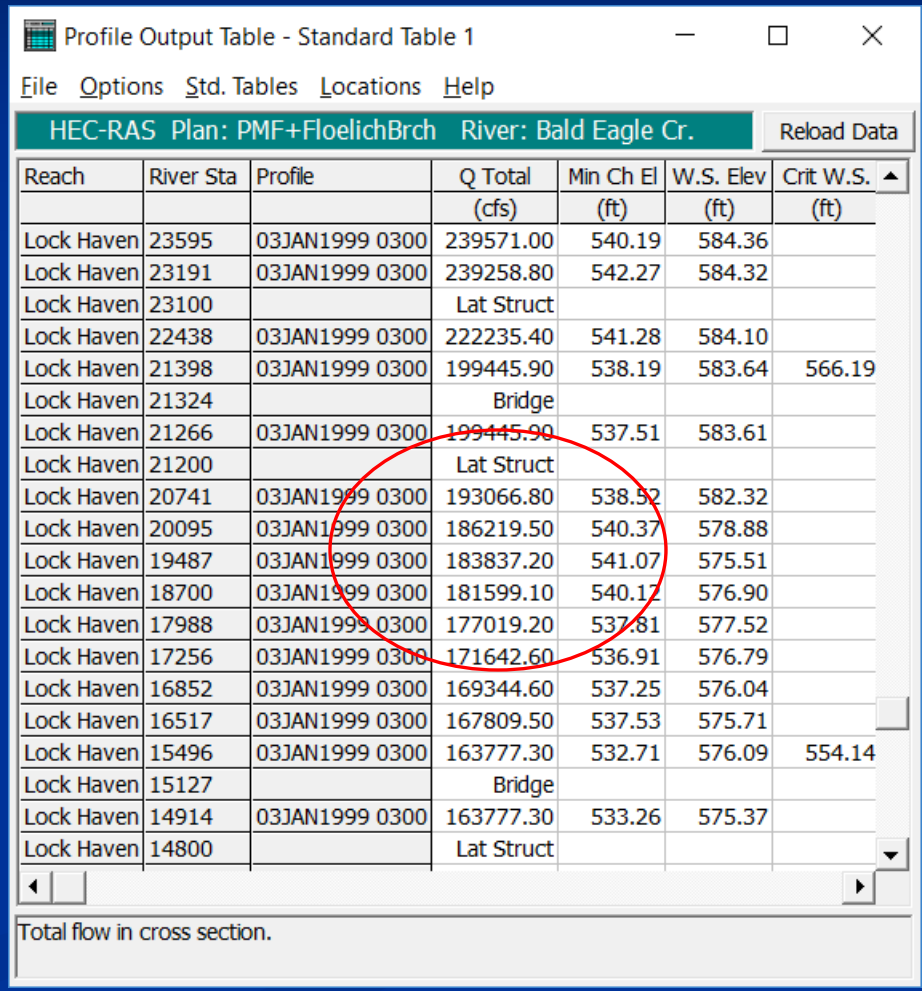




- Levee or Ineffective Flow? Or Neither?

Profile Summary Tables

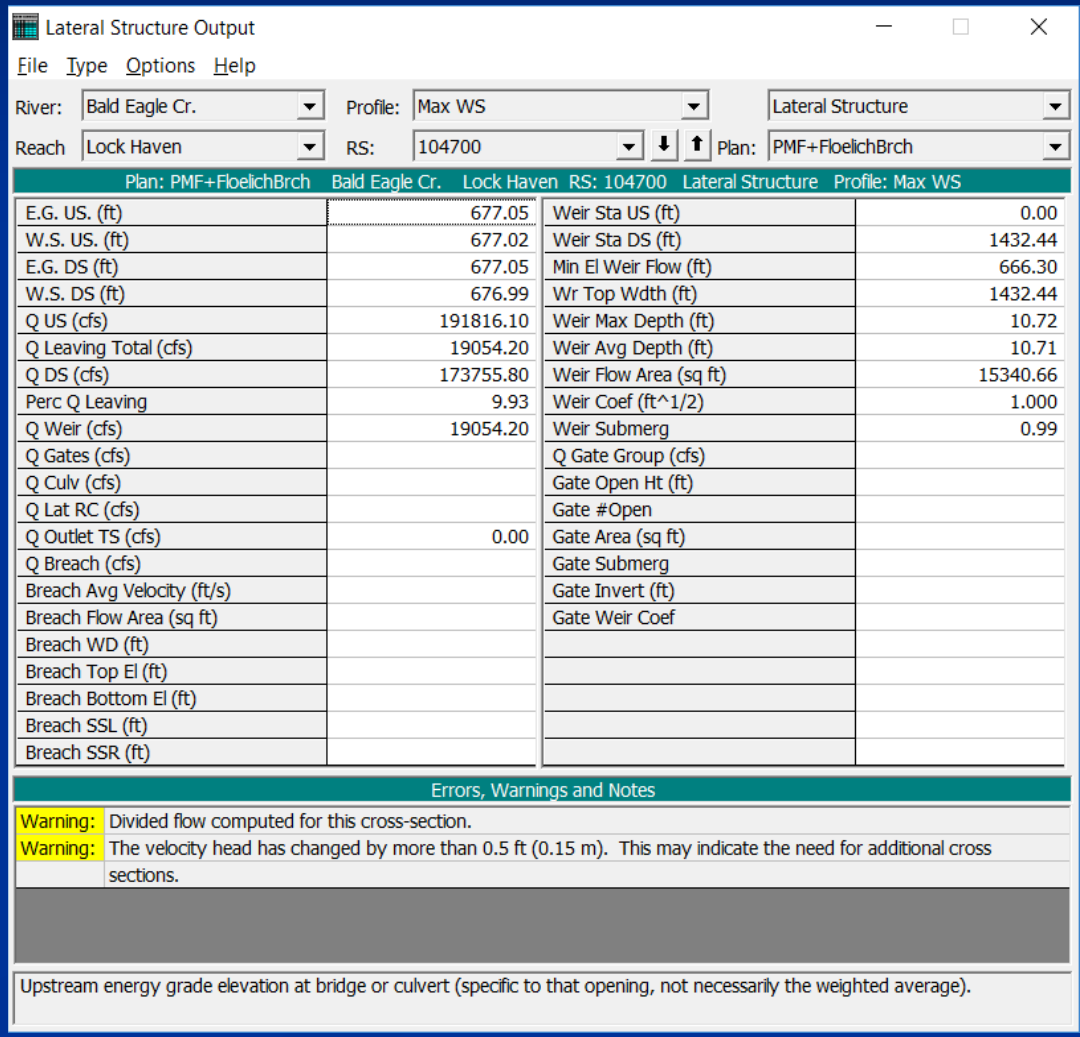
- Sometimes visual clues are not available. Tabular output help.
  - lateral inflow/outflow
    - Tributaries
    - Interaction with storage areas
  - Lateral structure flow
  - Inline structure flow
  - Flow inconsistency
    - Main channel to overbanks
  - Other internal boundaries
    - Groundwater



Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.
			(cfs)	(ft)	(ft)	(ft)
Lock Haven	23595	03JAN1999 0300	239571.00	540.19	584.36	
Lock Haven	23191	03JAN1999 0300	239258.80	542.27	584.32	
Lock Haven	23100		Lat Struct			
Lock Haven	22438	03JAN1999 0300	222235.40	541.28	584.10	
Lock Haven	21398	03JAN1999 0300	199445.90	538.19	583.64	566.19
Lock Haven	21324		Bridge			
Lock Haven	21266	03JAN1999 0300	199445.90	537.51	583.61	
Lock Haven	21200		Lat Struct			
Lock Haven	20741	03JAN1999 0300	193066.80	538.52	582.32	
Lock Haven	20095	03JAN1999 0300	186219.50	540.37	578.88	
Lock Haven	19487	03JAN1999 0300	183837.20	541.07	575.51	
Lock Haven	18700	03JAN1999 0300	181599.10	540.12	576.90	
Lock Haven	17988	03JAN1999 0300	177019.20	537.81	577.52	
Lock Haven	17256	03JAN1999 0300	171642.60	536.91	576.79	
Lock Haven	16852	03JAN1999 0300	169344.60	537.25	576.04	
Lock Haven	16517	03JAN1999 0300	167809.50	537.53	575.71	
Lock Haven	15496	03JAN1999 0300	163777.30	532.71	576.09	554.14
Lock Haven	15127		Bridge			
Lock Haven	14914	03JAN1999 0300	163777.30	533.26	575.37	
Lock Haven	14800		Lat Struct			

Detailed Output Tables

- Very good for looking at details of :
  - Inline Structures
  - Lateral Structures
  - Bridges/Culverts
  - Storage Areas
  - Pump Stations
  - Cross Sections



Lateral Structure Output

File Type Options Help

River: Bald Eagle Cr. Profile: Max WS Lateral Structure

Reach Lock Haven RS: 104700 Plan: PMF+FloelichBrch

Plan: PMF+FloelichBrch Bald Eagle Cr. Lock Haven RS: 104700 Lateral Structure Profile: Max WS

E.G. US. (ft)	677.05	Weir Sta US (ft)	0.00
W.S. US. (ft)	677.02	Weir Sta DS (ft)	1432.44
E.G. DS (ft)	677.05	Min El Weir Flow (ft)	666.30
W.S. DS (ft)	676.99	Wr Top Wdth (ft)	1432.44
Q US (cfs)	191816.10	Weir Max Depth (ft)	10.72
Q Leaving Total (cfs)	19054.20	Weir Avg Depth (ft)	10.71
Q DS (cfs)	173755.80	Weir Flow Area (sq ft)	15340.66
Perc Q Leaving	9.93	Weir Coef (ft^1/2)	1.000
Q Weir (cfs)	19054.20	Weir Submerg	0.99
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)		Gate Submerg	
Breach Avg Velocity (ft/s)		Gate Invert (ft)	
Breach Flow Area (sq ft)		Gate Weir Coef	
Breach WD (ft)			
Breach Top El (ft)			
Breach Bottom El (ft)			
Breach SSL (ft)			
Breach SSR (ft)			

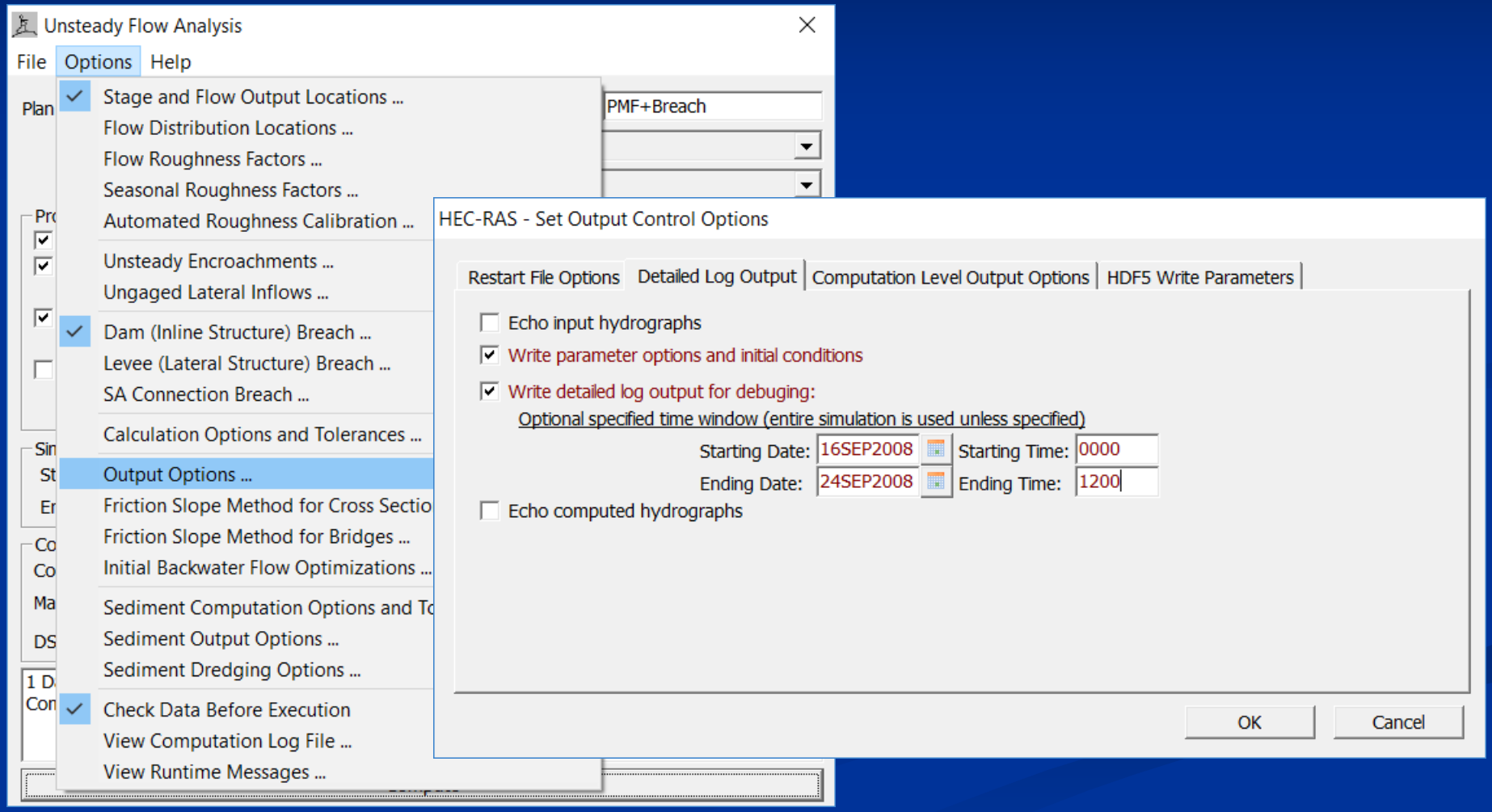
Errors, Warnings and Notes

Warning: Divided flow computed for this cross-section.

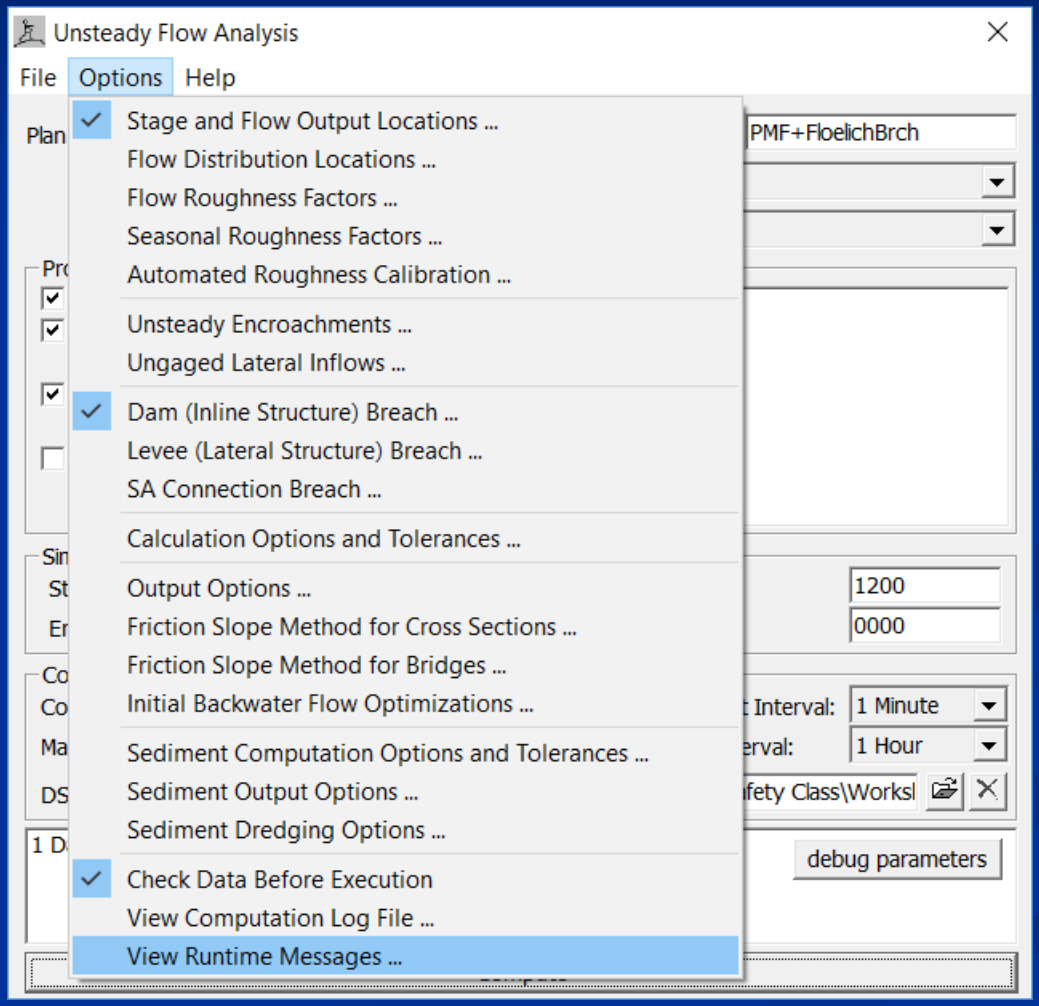
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

Upstream energy grade elevation at bridge or culvert (specific to that opening, not necessarily the weighted average).

Turning on Detailed Log Output for Debugging



Viewing Detailed Log Output



What is found in the detailed Output

- DSS Data – shows all the data that was read from DSS.
- Unsteady Flow Computations Output – Detailed unsteady flow calculations:
  - Job control parameters
  - Initial conditions calculations
  - Detailed output for each time step
- TABLE Output – final hydrographs that are written to DSS

Initial Conditions Output

Diamond.bco - Notepad

File Edit Format Help

Initial Conditions from Backwater

	Diamond		North					
Riv. Sta.	Flow	WSEL	Crit Depth	EG Slope	Area	Topwidth	Velocity	Error	Converged
6.0	100.0	11.21		0.0000036	320.88	43.21	0.312	0.00000	T
5.8	100.0	11.20		0.0000027	355.63	44.00	0.281	0.00000	T
5.6	100.0	11.20		0.0000020	391.05	44.80	0.256	0.00000	T
5.4	100.0	11.20		0.0000015	443.55	100.40	0.225	0.00000	T
5.2	100.0	11.20		0.0000011	553.25	174.29	0.181	0.00000	T
5.0	100.0	11.20		0.0000008	720.29	230.22	0.139	0.00000	T
4.8	100.0	11.20		0.0000008	720.08	230.22	0.139	0.00000	T
4.6	100.0	11.20		0.0000008	719.88	230.22	0.139	0.00000	T
4.4	100.0	11.19		0.0000008	719.68	230.22	0.139	0.00000	T
4.2	100.0	11.19		0.0000008	719.47	230.21	0.139	0.00000	T
4.0	100.0	11.19		0.0000008	719.27	230.21	0.139		

	Diamond		Northwest					
Riv. Sta.	Flow	WSEL	Crit Depth	EG Slope	Area	Topwidth	Velocity	Error	Converged
4.0	70.0	11.19		0.0000004	719.32	230.21	0.097	0.00000	T
3.8	70.0	11.19		0.0000004	719.24	230.21	0.097	0.00000	T
3.6	70.0	11.19		0.0000004	719.16	230.21	0.097	0.00000	T
3.4	70.0	11.19	-0.51	0.0000004	498.62	45.00	0.140	0.00000	T
3.395 Culvert									
3.39	70.0	11.00	-0.51	0.0000005	489.99	45.00	0.143	0.00000	T
3.35	70.0	11.00		0.0000005	489.99	45.00	0.143		

	Diamond		Northeast					
Riv. Sta.	Flow	WSEL	Crit Depth	EG Slope	Area	Topwidth	Velocity	Error	Converged
3.9999	30.0	11.00		0.0000001	675.21	230.00	0.044	0.00000	T
3.77768	30.0	11.00		0.0000001	675.19	230.00	0.044	0.00000	T
3.55547	30.0	11.00		0.0000001	675.17	230.00	0.044	0.00000	T
3.33326	30.0	11.00		0.0000001	675.14	230.00	0.044	0.00000	T
3.11105	30.0	11.00		0.0000001	675.12	230.00	0.044	0.00000	T
2.88884	30.0	11.00		0.0000001	675.10	230.00	0.044	0.00000	T
2.66663	30.0	11.00		0.0000001	675.08	230.00	0.044	0.00000	T
2.44442	30.0	11.00		0.0000001	675.06	230.00	0.044	0.00000	T
2.22221	30.0	11.00		0.0000001	675.03	230.00	0.044	0.00000	T

Example Detailed Time Step Output for cross sections

Beaver_spec_store.bco - Notepad

File Edit Format Help

Solving for T = -3.250

Iter	River	Station	Elev	DZ	Storage	Zsa	DZsa	River	Station	Q
0	Beaver Creek	5.0	210.53	0.51156	Bayou	206.13	0.01598	Beaver Creek	5.0	5358
1	Beaver Creek	5.0	210.22	-0.43984	Bayou	206.13	0.00000	Beaver Creek	5.0	5538
2	Beaver Creek	5.0	209.94	-0.39653	Bayou	206.13	0.00000	Beaver Creek	5.0	5700
3	Beaver Creek	5.0	209.68	-0.37383	Bayou	206.13	0.00000	Beaver Creek	5.0	5805
4	Beaver Creek	5.0	209.43	-0.35521	Bayou	206.13	0.00000	Beaver Creek	5.0	5883
5	Beaver Creek	5.0	209.22	-0.30138	Bayou	206.13	0.00002	Beaver Creek	5.0	6041
6	Beaver Creek	5.065*	211.02	0.62017	Bayou	206.13	0.00005	Beaver Creek	5.0	5909
7	Beaver Creek	5.065*	214.64	5.17663	Bayou	206.13	0.00076	Beaver Creek	5.0	2843

WARNING! EXTRAPOLATED ABOVE THE TOP OF THE PROPERTY TABLE AT XSEC(S):
Beaver Creek 5.065* 214.642090

8	Beaver Creek	5.0	207.13	-1.03604	Bayou	206.13	-0.00055	Beaver Creek	5.065*	3234
9	Beaver Creek	5.0	206.04	-1.55023	Bayou	206.13	0.00057	Beaver Creek	5.0	2142
10	Beaver Creek	5.0	204.72	-1.89683	Bayou	206.13	0.00053	Beaver Creek	5.0	930
11	Beaver Creek	5.0	203.50	-1.73679	Bayou	206.13	-0.00003	Beaver Creek	5.065*	1564
12	Beaver Creek	5.0	202.14	-1.94503	Bayou	206.13	0.00028	Beaver Creek	5.0	457
13	Beaver Creek	5.0	200.64	-2.13693	Bayou	206.13	0.00038	Beaver Creek	5.0	-175
14	Beaver Creek	5.0	199.25	-1.98779	Bayou	206.13	-0.00013	Beaver Creek	5.065*	802
15	Beaver Creek	5.0	197.84	-2.01339	Bayou	206.13	0.00001	Beaver Creek	5.0	-1
16	Beaver Creek	5.0	196.46	-1.97657	Bayou	206.13	-0.00006	Beaver Creek	5.0	88
17	Beaver Creek	5.0	195.08	-1.97219	Bayou	206.13	-0.00002	Beaver Creek	5.0	126
18	Beaver Creek	5.0	193.70	-1.96514	Bayou	206.13	-0.00002	Beaver Creek	5.0	155
19	Beaver Creek	5.0	192.33	-1.95701	Bayou	206.13	-0.00002	Beaver Creek	5.0	184
20	Beaver Creek	5.0	190.97	-1.94689	Bayou	206.13	-0.00002	Beaver Creek	5.0	218

!WARNING, USED COMPUTED CHANGES IN FLOW AND STAGE AT MINIMUM ERROR. MINIMUM ERROR OCCURED DURING ITERATION 5.

Example Detailed Time Step Output for cross sections - Continued

beaver.bco - Notepad

File Edit Format Help

COMPUTED STAGES AND DISCHARGES AT T = 0.1167 HOURS - 2/10/1999 AT 0007 HOURS

Beaver Creek Kentwood

Riv. Station	Z	Q	V	Riv. Station	Z	Q	V	Riv. Station	Z	Q	V
5.99	213.03	599.	1.09	5.97	212.94	588.	1.22	5.951	212.83	579.	1.37
5.93	212.71	571.	1.56	5.913	212.56	564.	1.79	5.894	212.38	558.	2.04
5.875	212.19	552.	2.34	5.855	211.98	547.	2.65	5.836	211.74	543.	2.91
5.81	211.52	540.	2.96	5.798	211.36	536.	2.45	5.779	211.24	532.	1.76
5.76	211.17	528.	1.18	5.741	211.07	523.	1.64	5.72	210.91	521.	2.15
5.703	210.75	519.	2.31	5.685	210.61	517.	2.30	5.666	210.48	516.	2.19
5.647	210.37	515.	1.92	5.628	210.27	514.	1.62	5.61	210.21	513.	1.31
5.593	210.13	512.	1.52	5.576	210.03	511.	1.80	5.559	209.93	511.	2.06
5.542	209.85	510.	2.23	5.525	209.78	510.	2.24	5.508	209.72	510.	2.14
5.491	209.67	510.	1.94	5.474	209.64	510.	1.76	5.457	209.61	510.	1.60
5.44	209.58	510.	1.47	5.425	209.58	509.	1.11	5.41	209.57	509.	0.88
5.39	209.54	509.	0.88	5.37	209.52	509.	1.11	5.35	209.48	509.	1.46
5.33	209.40	510.	1.67	5.31	209.28	510.	1.67	5.29	209.15	510.	1.47
5.274	208.95	510.	1.66	5.258	208.68	511.	1.95	5.242	208.29	511.	2.55
5.226	207.85	511.	3.05	5.21	207.46	512.	3.29	5.194	207.15	512.	3.13
5.178	206.95	513.	2.68	5.162	206.83	513.	2.16	5.146	206.75	514.	1.75
5.13	206.71	514.	1.45	5.113	206.65	515.	1.50	5.097	206.59	515.	1.56
5.081	206.53	516.	1.60	5.065	206.46	517.	1.63	5.048	206.39	517.	1.65
5.032	206.31	518.	1.66	5.016	206.23	519.	1.66	5.0	206.13	519.	1.64

Solving for T = 0.133

Iter	River	Station	Elev	DZ	River	Station	Q	DQ
0	Beaver Creek	5.99	213.07	0.03530	Beaver Creek	5.99	613	14
1	Beaver Creek	5.0	206.13	-0.00050	Beaver Creek	5.93	584	1