1D/2D Direct Connections: Transitioning between 1D and 2D Channels

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US Army Corps of Engineers BUILDING STRONG_®

1D-2D Connection

→ Q



1D-2D Connection

2D-1D Connection

→ Q

→ O



1D to 2D to 1D Connection

✓ Geometric Data - Combined 1D/2D



Three Critical Take-Aways: Managing Instabilities at 1D-2D Transitions

- Cross section and mesh boundary must be <u>identical</u> at the connection.
- 2. 1D First→2D Second.
 1D uses lagged 2D result, which can cause instability.
- 3. Output choices can mask instabilities at the boundaries.



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1. Choose a 1D Flow Location

2. Carefully align 1D XS with 2D area boundary

3. 1D XS Station/Elevation must be exactly the same as 2D area terrain.

4. Same Manning's n at the 1D-2D boundary.



- 1. Choose a 1D Flow Location
- 2. Carefully align 1D XS with 2D area boundary
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1. Choose a 1D Flow Location



1D/2D Locations

1D to bay estuary or alluvial fan

1D river with regions of 2D river
 Complicated bridge/multiple opening
 Complex junction
 Detailed WSEs (e.g. sharp bend)
 Detailed Velocities



1. Choose a 1D Flow Location...

... or move connection away from the area of interest.

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Checking 1D/2D Boundary



1. Choose a 1D Flow Location

2. Carefully align 1D XS with 2D area boundary Why is this so important?

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1D Sta/Elev vs Terrain



Update1D Sta/Elev



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1D/2D Solution Overview



For each time step:

- ID is computed first, then 2D
- 2D has latest boundary conditions from 1D
- 1D gets "lagged" boundary conditions from 2D
- Upstream region uses the downstream WSE
- Downstream region uses upstream flow



1D/2D Solution Overview



Large differences between current 1D stage and previous 2D stage, at the shared transition transect, can cause instabilities at the boundaries.



Discontinuity between 1D and 2D results at the transition can cause instabilities:

Boundary instabilities can cause oscillate



That's fascinating...

... How do you fix it?



1D/2D Iterations

Smaller Time Step



1D/2D Iterations

X と Unsteady Flow Analysis Options Help File HEC-RAS Unsteady Computation Options and Tolerances Stage and Flow Output Locations ... \checkmark Plan un Flow Distribution Locations ... General (1D Options) 2D Flow Options 1D/2D Options Flow Roughness Factors ... Seasonal Roughness Factors ... Automated Roughness Calibration ... Pro Maximum iterations between 1D and 2D (0=off, 1 to 20): $\overline{\mathbf{v}}$ Unsteady Encroachments ... ☑ Water surface tolerance (ft): Ungaged Lateral Inflows ... Flow Tolerance (%) $\mathbf{\nabla}$ Dam (Inline Structure) Breach ... \checkmark Minimum flow tolerance (cfs): Levee (Lateral Structure) Breach ... Sim Sta SA Connection Breach ... En Mixed Flow Options ... Cor Time Slicing ... Con 1 Minute Ŧ Map 1 Hour Ŧ Calculation Options and Tolerances ... 2 Output Options ... is and Cl 😂 🗙 DSS Friction Slope Method for Cross Sections ... parameters Friction Slope Method for Bridges ...

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4

0.01

0.1

1

26

1D/2D Iterations

- For each time step: 1D is computed, then 2D
- Every 1D/2D boundary is checked for convergence
 - ► 1D to 2D WSE is checked
 - ► 2D to 1D Flow is checked
 - ► Lat Struct or SA Conn, Flow checked
 - Flow is based on "assumed" WSE
 - Flow is re-computed from "computed" WSE

2D to 1D Instability



1 Minute time step
 15 Second time step
 4 Iterations Max
 15 Second time step
 0 Iterations^{BUILDING STRONG}

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Causes

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Diagnostic



2D to 1D Instability

🔼 S	tage a	and Flow Hydrographs						
File Type Options Help								
River	: Bal	ld Eagle Cr.						
Read	h: Loc	dk Haven ▼ River Sta.: 50335 ▼ ↓ ↑ ↑ 13 tage 576.96 022an 1999 1140						
F	lot Sta	age 🗹 Plot Flow 🔽 Obs Stage 🗌 Obs Flow 🗍 Use Ref Stage						
Sta	ge Flov							
		Plan: 2D to 1D No Dam River: Bald Eagle Cr. Reach: Lock Haven RS: 50335						
M								
			200000					
	576		0					
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		1						
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	572	2-	-400000					
e e			v(cfs					
ta l			-600000호					
	570							
	568		-800000					
			-1000000					
	500							
	300		-1200000					

2D to 1D Instability



Output Options

Unsteady Flow Analysis				X
File Options Help				
Plan : 2D to 1D No Dam		Short ID	2D to 1D No Dam	
Geometry File :	U.S 2D - D.S 1D	No Dam		•
Unsteady Flow File :	Upstream 2D			-
	Plan Description	:		
Programs to Run Geometry Preprocessor Unsteady Flow Simulation Sediment Post Processor Floodplain Mapping				
Simulation Time Window Starting Date: 011 Ending Date: 033	AN 1999	Starting Time: Ending Time:	1200 1200	
Computation Settings Computation Interval: 30 Mapping Output Interval: 30 Computation Level Output DSS Output Filename: C:\User	Second H Second D S \q0hecssp\Docum	ydrograph Output : etailed Output Inte nents\1RAS Data\0	Interval: 1 Minute rval: 1 Minute	
Mixed Flow Regime (see mer	u: "Options/Mixed	Flow Options")	debug parameters	
1 Levee (Lateral Structure) with	oreach data. 1 sei	: to breach.		
	Compu	te		

- 30 Sec Time Step
- Hydrograph [DSS] limited to 1 Minute
- Mapping Output Interval [HDF5] can be same as computation
- Use Computation Level Output



Computation Level Output

- - X HEC-RAS 5.0.0 Beta June 2014 File Edit Run View Options GIS Tools Help Debug 🔲 🎬 😭 DSS 2 🖬 Cross-Sections ... ¥ 2 Water Surface Profiles ... Ba NP-ldE-alaCe Multi 2D/P-ldE-alaD-mPelee Project: Series Unsteady Flow Time Series 20 General Profile Plot ... Plan: Rating Curves ... Options Help File Geometry: X-Y-Z Perspective Plots ... Steady Flow: E 2D to 1D No Dam Variables ... Bald Eagle Cr. - Lock Haven Up Unsteady Flow: Stage and Flow Hydrographs ... Plot Table 50335 Г Description : Hydraulic Property Plots ... spiDocumental IRAS Data/Other/Docs and Cass/Unsteed//O2D/SaidEagleCr Muti 2D 49318 48337 Detailed Output Tables ... 47526 Profile Summary Table ... 46602 Ξ 45678 Summary Err, Warn, Notes ... 44653 12000 DSS Data ... 43806 42971 Unsteady Flow Spatial Plot (computation inter-42154 10000 41358 Unsteady Flow Time Series Plot (computation 40251 8000 39335 WQ Spatial Plot ... xs flow(cfs) 36808 U/S Bridge 36694 D/S Bridge 6000 35393 33911 Annal 32863 4000 31780 28519 26692 Fishing Creek Co 2000 25853 24405 23993 U/S Bridge 23863 U/S Bridge 23595 1645170017151730174518001815183018451900 23191 1/1/1999

2D to 1D Instability



2D to 1D Instability



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