Basic Unsteady Flow Modeling

Workshop

1 Objective

In this workshop, you will exercise your knowledge on the basics on unsteady flow modeling to setup and compute a simulation for Bald Eagle Creek, PA. The workshop consists of the following major tasks:

- Creating an Unsteady Flow file and adding boundary conditions
- Linking boundary conditions to DSS data
- Setting initial conditions
- Performing a sensitivity analysis on boundary conditions
- Revieing results using various methods

2 Background

You will be working with a dataset for Sayers Dam on Bald Eagle Creek in central Pennsylvania. Sayers Dam is approximately 15 miles upstream of the town of Lock Haven, which is protected by a levee system. See the figure below to become acquainted with the dataset.



3 Setup Unsteady Flow Boundary Conditions

- 1. Start HEC-RAS and Open the "Bald Eagle Unsteady" project
- 2. **Open** the **Geometric Data** editor to become familiar with the data. Identify areas of interest such as Lock Haven, Sayers Dam and the tributaries using the figure above.



3. Open the Unsteady Flow Data editor

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a. Notice that at a minimum, the this geometry requires an upstream, downstream, and inline structure boundary condition.

Unsteady Flow	Data			- 0
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Boundary Conditio	ns Initial Condition	Meteorolog	jical Data Observed Data	
		Boundary Co	ndition Types	
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Normal Dept	h Lateral Ir	flow Hydr.	Uniform Lateral Inflow	Groundwater Interflow
T.S. Gate Open	ings Elev Cont	rolled Gates	Navigation Dams	IB Stage/Flow
Rules	Preci	pitation		 [1]
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Add RS	Add SA/2D Flow Area	Add	Conn Add Pump S	ta Add Pipe Node
	Select Location i	n table then s	elect Boundary Condition Ty	/pe
River	Reach	RS	Boundary Condition	
1 Bald Eagle Cr.	Lock Haven	137520		
2 Baid Eagle Cr.	Lock Haven	81454 IS		
	lock Haven	-1867		

- 4. Select File, Save Unsteady Flow Data. Name flow file "PMF-HMS".
- 5. Set the upstream boundary condition at **River Station "137520**" to a **Flow Hydrograph**. This boundary condition will represent the reservoir inflows.

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undary Condition	ns Initial Condition	s Meteorologi	cal Data Observed Data	d .	
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an und	- L - 5	Boundary Cor	aluon Types	1	
Stage Hydrogra	IPN Flow Hy	/orograph	Stage/How Hydr.	Rating Curve	
Normal Depth	Lateral In	nflow Hork	Uniform Lateral Inflow	Groundwater Interflow	
T.S. Gate Openi	ngs Elev Cont	rolled Ga s	Navigation Dams	IB Stage/Flow	
Rules	Preci	pitation			
	A	dd Boundary (ndition Location		
Add RS	Add SA/2D Flow Area	a Add (Add Pump S	ta Add Pipe Node	
	Select Location	in table then se	lect Coundary Condition Ty	/pe	
River	Reach	RS	Boundary Condition		
Bald Eagle Cr.	Lock Haven	137520			
Bald Eagle Cr.	Lock Haven	81454 IS		- 63	
Bald Carls Co	Lock Haven	-1967			

6. When the Flow Hydrograph editor opens, select Read from DSS before Simulation Option.

Flow Hydrograph						
River: Bald Eagle Cr. Reach: Lock Haven RS: 137520						
C Read from DSS before simulation	Select DSS file and Path					
File: Path:						

7. Click Select DSS File and Path button.

Flow Hydrograph							
River: Bald Eagle Cr. Reach: Lock Haven RS: 137520							
C Read from DSS before simulation	Select DSS file and Path						
File:							
Path:							

 Click the Add File button and select the DSS file in the "Flow_Data" directory as shown below.

River: Bald Eagle Cr. Reach: Lock Hav	ven RS: 137520: Flow		- C	x c		
File Options Help						
 File Count: 0 Time Window: In 	valid Time Window					
Add a DSS file		Time Window		•		
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✓ Show Plot	JATA (D:)	, v <				>
Selected Path:	Fi	le name: HMS_Flows-BaldEagle.dss	~	DSS files (*	.dss)	~
				Open	Cance	1

- a. This DSS file contains results from an HEC-HMS hydrologic model. You will add those results as boundary conditions to this model.
- 9. Select the pathname with the "SAYERS INFLOW" B-Part and select OK.

🚟 River:	Bald Eagle Cr. Reach: L	ock Haven RS: 1375	20: Flow	Į							×
File Opt	ions Help										
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2	HMS_Flows-BaldEagle	RegularTimeSeries		FISHING CREEK	FLOW	01DEC1998-01JAN1999	15MIN	PMF-EVENT	INST-VAL	CFS	
3	HMS_Flows-BaldEagle	RegularTimeSeries		LOCAL DOWNSTREAM OF DAM	FLOW	01DEC1998-01JAN1999	15MIN	RUN:PMF-EVENT	INST-VAL	CFS	
4	HMS_Flows-BaldEagle	RegularTimeSeries		MARSH CREEK	FLOW	01DEC1998-01JAN1999	15MIN	PMF-EVENT	INST-VAL	CFS	
5	HMS_Flows-BaldEagle	RegularTimeSeries		RESERVOIR LOCAL	FLOW	01DEC1998-01JAN1999	15MIN	RUN:PMF-EVENT	INST-VAL	CFS	
6	HMS_Flows-BaldEagle	RegularTimeSeries		SAYERS INFLOW	FLOW	01DEC1998-01JAN1999	15MIN	PMF-EVENT	INST-VAL	CFS	
 Show 	Plot										
Selected I	Path: //SAYERS INFLOW/	FLOW/01DEC1998-0		999/15MIN/PMF-EVENT/						ок с	ancel

- 10. Select OK in the Flow Hydrograph editor to accept the changes.
- 11. Set the downstream boundary condition at **River Station** "-**1867**" to **Normal Depth**. Use a **Friction Slope** of **0.0005**.
- 12. Set the Inline Structure boundary condition at River Station "81454 IS" to T.S. Gate Opennings.
 - a. Change the **Data time interval** to **1 day**. Enter **1 ft** in the table through 06 Jan as shown below. **Click OK**.

	River: Baid Eagle	Cr. Reach	: Lock Ha	ven R5: 014	PH R
	Gate	Group:	Gat	e #1	- 1
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File:					
Pat	n:				
Ente	r Table	Data	time inter	val: 1Day	
Sele	ct/Enter the Data's St	arting Time I	Reference		
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				Carried Street	
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- 13. In the Unsteady Flow Data Editor select File | Save Unsteady Flow Data
 - a. At this point, the **Unsteady Flow Data** editor should look like the figure below.

Unstead	ly Flow D	ata - PMF-HMS			₽			×	
le Optio escription:	ns Help						0	Ap	
Boundary C	onditions	Initial Conditions	Meteorologi	cal Data	Observed Data	1			
		В	oundary Cor	dition Typ	es				
Stage Hydrograph		Flow Hydro	ograph	Stage	/Flow Hydr.	Rating Curve			
Norm	al Depth	Lateral Inflo	Lateral Inflow Hydr.		Uniform Lateral Inflow		Groundwater Interflo		
T.S. Gat	e Opening	s Elev Controll	ed Gates	Navigation Dams		IB Stage/Flow		W.	
R	ules	Precipita	ation				Ø		
		Add	Boundary Co	ndition Lo	cation				
Add RS .	Ad	d SA/2D Flow Area	. Add (Conn	Add Pump St	a	Add Pipe N	ode	
		Select Location in t	able then se	ect Bound	ary Condition Ty	pe	21		
River		Reach	RS	Bounda	ry Condition				
1 Bald Ea	gle Cr.	Lock Haven	137520	Flow Hydrograph					
2 Bald Ea	gle Cr.	Lock Haven	81454 IS	T.S. Gate	T.S. Gate Openings				
3 Bald Ea	gle Cr.	Lock Haven	-1867 Normal Depth						

- 14. Next you'll create additional boundary conditions for the tributary inflows.
 - a. In the **Unsteady Flow Data** editor **Select** the **Add RS...** button.
 - b. Select the 3 rivers stations where tributary flow will enter the model. **River Stations: 76865, 67130, and 28519**

accription:	пер			~ 1
Boundary Cond	itions In	nitial Conditions Meteo	rological Data Observed Da	ta
		Boundar	y Condition Types	
Stage Hydrograph Flow Hydr		Flow Hydrograph	Stage/Flow Hydr.	Rating Curve
Normal Depth		Lateral Inflow Hydr	. Uniform Lateral Inflow	Groundwater Interfi
T.S. Gate Openings		Elev Controlled Gate	es Navigation Dams	IB Stage/Flow
Rules		Precipitation		
		Add Bounda	ry Condition Location	
Add RS	Add SA	A/2D Flow Area	Add Conn Add Pump	Sta Add Pipe Node
)			n 27. d 19. r	
Selected Loca	tions	Locations		
Deneeved Eved		Select	ed Locations	(3 selected)
A second s	S	Baid E	agle Cr. Lock Haven 7686	5
Node Type		Bald E		
River: Bald	Eagle Cr.	■ Bald E Bald E	agle Cr. Lock Haven 2851	9
River: Bald Reach: Lock	Eagle Cr. Haven	Bald E	agle Cr. Lock Haven 2851	9

c. Set each of the new locations to a **Lateral Inflow Hydrograp** boundary condition and **select the appropriate DSS File and path** for each location as indicated below:

River Station	DSS B-Part
76865	MARSH CREEK
67130	BEECH CREEK
28591	FISHING CREK

4 Set Initial Conditions

15. In the **Unsteady Flow Data** editor, switch to the **Initial Conditions** tab.

上 Unsteady Flow Data - PMF-HMS	-		×
File Options Help			
Description:	÷	Apply	Data
Boundary Conditions Initial Conditions Meteorological Data Observed Data			
Initial Flow Distribution Method			
C Restart Filename:		È	
C Prior WS Filename:		Ē	
Profile:		Ŧ	

16. Set the initial flow at the cross-section just downstream of the dam

上Unsteady Flow Data - PMF-HMS	- 0	×
File Options Help Description:	C Apply	Data
Boundary Conditions Initial Condition	s Meteorological Data Observed Data	1
Initial Flow Distribution Method	Initial Condition Flow Locations	11
Prior WS Filename: Enter Initial flow distribution (Option Add RS Use River Reach I Bald Eagle Cr. Lock Haven	Node Types Selected Locations River: Bald Eagle Cr. Reach: Lock Haven RS: 81914 80916 80916 809216 80387 79957 79463 79957 79463 78247 77815 77379 75865 759908 Marsh Creek 7451 74120 70315 72156 69539 66146 65730 66041 66041 Beech Cr. Cc	(1 selected)
	Glear Selected List OK	Cancel

a. Select Add RS... and ad, River Station 80916.

b. Then set the **Initial Flow** to **900 CFS**. This will represent the initial outflow from the dam.

LUnsteady Flow	Data - PMF-HMS					×
File Options He	lp					
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Initial Flow Distribution	on M thod					
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			Profile:			Ŧ
Enter Initi	distribution (Optional	- leave blank	to use boundary condition	s)		
Add RS						
	User s	pecified fixed	flows (Optional)			2
River	Reach	RS	Initial Flow			
1 Bald Eagle Cr	. Lock Haven	100-				
2 Bald Eagle Cr	. Lock Haven	80916	900			

17. Next, add an **Initial Stage** to represent the starting pool elevation.

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File	Options	Help				
Desc Bou	Dele DSS Bou	te Initial Flow(s) From Table Pathname Summary Table Indary Condition Names	ed Data	<u>.</u>	Apply	/ Data
C i	Inte Flov Obs	rnal RS Initial Stages v Minimum and Flow Ratio Table erved (Measured) Data	· ·		L L	

a. In the Options menu select Internal RS Initial Stages...

b. Find **RS 81914** in the "**River Sta.:**" dropdown and select **Add an Initial Stage Location.**

Unstea	dy Flow Data	- Initial Stages				
River:	Bald Eagle Cr	. 💌			Delete row(s)	Add Multiple
Reach:	Lock Haven	▼ R	iver Sta.:	31914 💌	Add an Initial S	Stage Location
			ocations and	d Initial Stages		
	River	Reach	RS	_	Elev	
1						Ĵ
					N	
					~	
					OK	Cancel

c. Set the starting elevation to **657 ft**, the spillway crest elevation, and press OK.

Unstea	dy Flow Data -	Initial Stages				
River:	Bald Eagle Cr.	•		1	Delete row(s)	Add Multiple
Reach:	Lock Haven	▼ Riv	er Sta.: 819	914 💌	Add an Initial St	age Location
		Lo	ocations and I	nitial Stages		
	River	Reach	RS	-	Elev	
1 Bal	d Eagle Cr.	Lock Haven	81914			657
					ОК	Cancel

18. Save and close the Unsteady Flow Data editor.

5 Create a Plan and Compute

19. Open the **Unsteady Flow Analysis** editor.



20. Enter the **Programs to Run, Simulation Time Window, and Computation Settings** as shown below:

lan: PMF-Event				Short ID:	PMF-Event	
Geome	try File:	Existing (Condition	IS		
Unstea	dy Flow File:	PMF-HMS	l.			
Programs to Run	-	Plan Des	cription	2		
Unsteady Flow Sediment Post Processor Floodplain Mar	r Simulation					
Simulation Time W	indow	12				1000
Starting Da Ending Date	te: 10 e: 0	5Jan 1999		Sta Enc	ding Time:	0000
Computation Setti	nas					
Computation Inter	val: 1	Minute	•	Hydrograph Ou	utput Interval:	6 Hour
Mapping Output Ir	nterval: 6	Hour	•	Detailed Outpu	t Interval:	6 Hour
Project DSS Filen	ame: 🔻 🔿	:\Unsteady	1D\2018	Class Materials	Working Unstea	ady Flor
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Note: The 6 hour output intervals will be changed again later in the workshop.

- 21. Save the Plan and call it "PMF-Event".
- 22. Compute

6 Reviewing Results

23. **Open** the **Cross-Section Plot** and the **Profile Plot.** Arrange them side-by-side on your screen.

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File Edit Run View Options GIS Tools Help			
			I ri

- 24. In the Cross Section Viewer, display River Station "81454 IS Joseph Sayers Dam"
- 25. Launch the **Animation Control** and advance through the profiles and answer the questions

Question: Which profile (date and time) had the highest water surface elevation at the dam and what was it?

Question: What is the water surface elevation at the dam for the "Max WS" profile? What is the difference in from the answer above?

26. Open the Stage & Flow Hydrograph Viewer

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File Edit Run View Options GIS Tools Help		
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27. From the **Type** menu select **Inline Structures** to view the hydrographs for the dam.

Question: What is the maximum water surface elevation and maximum total flow for the dam? Comment on the shape of the hydrographs.

28. In the **Unsteady Flow Analysis** editor, go to **File | Save Plan As ...** and call the plan **PMF-Event-New**. Change the output intervals to **30 min**.

29. Recompute

Question: Now that we've decreased the output interval, how do the stage and flow hydrographs compare to the previous run?

Question: Similarly, how does Profile Plot compare to the previous run?

7 Revieing Results in RAS Mapper

30. Open RAS Mapper



31. From the **Project Menu** select **Set Projection** and navigate to the projection in the **GIS_Data** directory.

Project Settings	Co	ordinate Reference	System				
Projection	Bu	instan Eiler					
ieneral	De	finition:					
ender Mode		in tron.					
	Drouteo	for the coordinate	roforonco austom f	ile for this project			
esh Tolerances	Browse	for the coordinate	reference system f	ile for this project			
esh Tolerances	Browse	for the coordinate	reference system f king > Unsteady	ile for this project Flow > GIS_Data		~ 0	
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fesh Tolerances Global Settings ieneral AS Layers	Browse → → Organize	for the coordinate ✓ ↑	reference system f	ile for this project Flow > GIS_Data Date modified	Туре	× ⊘ Size	

- 32. Right-click on "Terrains" in the tree and select Add Existing RAS Terrain.
 - a. Navigate to the "**Terrain.hdf**" file in the "**Terrain**" directory.
- 33. Expand the "Results" node in the tree and turn on the "Depth" layer. Use the Animation Toolbar to visualize the flood wave move downstream.



34. In Mapper, **animate** the **Depth** layer again to see the impact of the output interval change.

35. **Turn on** the **Velocity** Layer and **Select** the **Max** button in the animation toolbar.

Question: Locate 3 areas where velocities are the highest. What are the velocities in these areas? What do you think is causing the high velocities?

8 Downstream Boundary Sensitivity

- 36. Open the Unsteady Flow Data Editor, and select File | Save Unsteady Flow Data As.... Name the Unsteady Flow Data as "PMF-HMS_0001".
- 37. Reduce to Friction Slope on the downstream boundary condition to 0.0001.
- 38. Save the new Unsteady Flow File.
- 39. Create a new Plan using the File | Save Plan As.... in the Unsteady Flow Analysis editor.
 - a. Name the new plan "PMF-Event_FS_0001"
 - b. Ensure the plan is using the new Unsteady Flow Analysis file

Unsteady Flow Analysis				×
File Options Help	43			
lan; PMF-Event_FS_0001		Short ID:	PMF-Event_FS_0001	
Geometry File:	Existing Conditions	8		
Unsteady Flow File:	PMF-HMS_0001			
Programs to Run	Plan Description			
 ✓ Geometry Preprocessor ✓ Unsteady Flow Simulation ✓ Sediment 				^
Post Processor				
Floodplain Mapping				\sim

- 40. Save and Compute
- 41. Open the **Profile Plot** and select **Plans...** from the **Options Menu.**
- 42. **Check** on both plans to display them simultaneously.

Plan Selection	
Plan Geometry and Results Comparison Compare Geometry as well as distput (can only select current Note: Geometry comparison only works for cross section and p	t plan + one more) profile plots
Select Plans (current plan = PMF-Event_f	FS_0001)
PMF-Event (Short ID = PMF-Event	Geom = Existing Conditio
PMF-Event_FS_0001 (Short ID = PMF-Event_FS_0001	Geom = E

Question: What is the largest difference in maximum water surface elevations between the two plans? Where does this occur?

Question: Do you think this is a good location for a downstream boundary condition? Why or why not?