Steady Flow Modeling with HEC-RAS

Workshop

1 Objective

In this workshop, you will learn how to create a 1D model with HEC-RAS of the main channel and floodplain area. This workshop will require you to acquire terrain datasets, create a terrain model, lay out cross sections, provide steady flow information, downstream boundary conditions, add land cover data and associate Manning's n values, refine the model, and perform model runs. You will also attempt to calibrate the model using observed high water mark information using the capabilities in HEC-RAS to adjust Manning's n values.

2 Background

You will be working on the Merced River in the Yosemite Valley. Steady flow data will be used for the inflow and a Normal Depth Boundary Condition will be used for the downstream boundary.



3 Create a New RAS Project and Set the Projection

This part of the workshop will quide you through the process of importing terrain data. The terrain data will be used as the basis for the mesh used for 2D hydraulic computations.

- 1. Start HEC-RAS.
- 2. Start a NEW project using File | New Project... Go to the workshop directory for this workshop ("Merced River") and then providing a Title and File Name. Press OK to save it.
- 3. Launch **RAS Mapper**
- 4. Select **Project | Set Projection.** Select the Folder button at the top left and navigate to the "River.prj" provided in the "GIS_Data" folder. Select and Open this file. This sets the coordinate system for all the data you will view in RAS. The press the **OK** button to close the window. RAS Mapper Options X

Project Settings	Coordinate Reference System
Projection	Projection Files (C) Terroly 2022, Standy Class Workshap (GIS, Data) amindian pri
General	
Render Mode	PROJCS["NAD_1983_StatePlane_California_III_FIPS_0403_Feet",GEOGCS
Mesh Tolerances	['GRS_1980'',6378137,298.257222101]].PRIMEM['Greenwich'',0].UNIT [''GRS_1980'',6378137,298.257222101]].PRIMEM[''Greenwich'',0].UNIT [''Degree'' 0.0174522251994329551].PROJECTION''Lambert Conformal Conic'''.PARAMETER
Global Settings	["False_Easting",6561666.666666666666666666666666667],PARAMETER["False_Northing",1640416.6666666667],PARAMETER ["Central_Meridian",-120.5],PARAMETER["Standard_Parallel_1",37.0666666666666667],PARAMETER
General	["Standard_Parallel_2",38.43333333333333].PARAMETER["Latitude_Of_Origin",36.5].UNIT ["Foot_US",0.304800609601219241]]
RAS Lavers	

- 5. Add the "**River**" shapefile to RAS Mapper from the "GIS_Data" folder.
- 6. Right-click on the **River** layer and **Zoom to Layer**

4 Download Terrain Data

*** If you don't have internet access, skip this step and use the terrain data provided in the "Terrain\USGS_Data" folder. ***

7. Select the Project | Download Data | USGS Terrain menu item.

File	Pro	ject	Tools Help		_			
Selecte	٢	Set	Projection					1
	1	Add	Web Imagery					
	*	Add	Reference Layer					
	1	Dow	vnload Data	•		USGS Terrain		
	÷.	Crea	ate New RAS Terrain.			GRiD Terrain	~~	
	6 3	~			_			
Choos	se C	Curre	e nt View for tl	ne data's	ext	ent.		
Exten	t Sou	rce:	Current View	-	r:			

-

8.

9. Press the Query Products button interrogate the USGS web service. -Product Query

	Data Typ	e:	Elevation Models	•	Query Products	
10.	Utilize tl	ne dat	a filter to Filt	er to the	" Original " data.	
	[1m	☐ 10n	30r 🗸 Ori	iginal Filte	r. [Apply

- ☐ 1m ☐ 10m ☐ 30r. V Original Filter:
- 11. Select the terrain tiles that cover the valley floodplain using the graphical selection tools in RAS Mapper.



12. Click the **Add Selected** button from the Download Terrain dialog. The check boxes will be filled in for the selected datasets and the terrain tiles will turn green (indicating they are selected for download).



13. Press the **Start Download** button.

A dialog will inform you when the download is complete.

Download Complete	,
Download Complete	~
Files were downloaded to:	
C:\Temp\Workshop\Terrain\USGS	

14. **Close** the Terrain Downloader.

5 Terrain Model Preparation

- 15. Import terrain data for use in RAS by selecting the **Project | Create New RAS Terrain** menu item.
- 16. Click the **Add Files** + button and navigate to the **"Terrain\USGS**" folder.
- 17. Select **ALL** of the files (Ctrl+A) and then press the **Open** button at the bottom.

) S	et SRS Terrain Files (1	5 files)					
+1[Filename		Projection	Cell Size	Rounding	Info	•
	USGS_OPR_	CA_YosemiteNP_201	PROJCS["NAD83(2011) / UTM zone 11N",GEO	0.5	None	i	
2	USGS_OPR_	CA_YosemiteNP_201	PROJCS["NAD83(2011) / UTM zone 11N",GEO	0.5	None	i	
•1	USGS_OPR_	CA_YosemiteNP_201	PROJCS["NAD83(2011) / UTM zone 11N",GEO	0.5	None	i	1
-1	USGS_OPR_	CA_YosemiteNP_201	PROJCS["NAD83(2011) / UTM zone 11N",GEO	0.5	None	i	1
┛║	USGS_OPR_	CA_YosemiteNP_201	PROJCS["NAD83(2011) / UTM zone 11N",GEO	0.5	None	i	1
L	USGS OPP	CA VecemiteNIP 201	PRO (CSPINAD92/2011) / UTM 2000 11NII GEO	0.5	Nono	-	Ŀ
Outpu Round Vertic	ut Terrain File — ding (Precision) al Conversion:	1/32 Use Input File (Default)	Create Stitches	erge Inputs to	Single Raster		
ilena	ame:	C:\Temp_2D_Class\T	errain/Terrain.hdf				P

- 18. Click the Merge Inputs to Single Raster checkbox.
- 19. Press the **Create** Button.

As the Terrain is created, a computation window will inform you of progress.



20. When the terrain process is finished, select **Close** on the processing window, this will close both windows. Turn on the Terrain Layer.

- 21. **Right-click** on the Terrain Layer and choose **Zoom to Layer** (if necessary to see the terrain).
- 22. **Double-click** on the **Terrain** Layer to access its Properties.

Below is what the terrain should look like. Also shown are all the boundary condition locations for this workshop.



6 Initial Model Creation

In this part of the workshop, you will create the initial model. This rough model will provide and understanding of the floodplain from which you can improve the hydraulics model. The rough model will allow you to answer simple questions such as listed below.

- Where does water go and what is the extent of the floodplain?
- What velocities does the river experience?
- Where is flow rapidly varied?
- What is controlling where flow goes and are there major obstructions to flow?

6.1 Create the 1D Geometry

- 23. Choose the **Project | Create New Geometry** menu item. Enter **"Base**" for the name. Press **OK** to create the geometry layer.
- 24. **Select** new Geometry Layer and press the **Edit** button.

25. Create the River Centerline

a. **Copy** and **Paste** the river centerline from the "River" shapefile (previously loaded) to the **River** Layer. – or – you could import the river using the shapefile importer. – or – you could create it by hand

- b. Using the **Edit** tool and right-click on the River line and select **Rename River Reach**.
- c. Rename the River Reach to "Merced River", "Yosemite Valley".

Provide River ar	nd Reach Name	×				
River Name:	River Name: Merced River					
Reach Name:	Yosemite Valley	ł				
Rename entire	e River (All other	Reaches)				
	ОК	Cancel				

26. Create Cross Sections

- a. Select the Cross Sections layer and lay out cross sections to properly capture the floodplain.
- 27. Stop Editing and Close RAS Mapper.
- 28. Open the Geometric Schematic and **Open** the new **Geometry** ("Base"). Open Geometry File

Selected File Title	Filename
Base	C:\Temp_2022_Steady Class\Workshop\MercedRiver.g01
Base	C:\Temp_2022_Steady_Class\Workshop\MercedRiver.g01

- 29. Stop Editing to Save the Geometry!
- 30. Enter Manning's n value data
 - a. Select the **Tables | Manning's n or k values** menu item

 Tables
 Tools
 GIS Tools
 Help

 Manning's n or k values (Horizontally varied) ...
 Reach Lengths ...
 - b. Set all of the n values to **0.04**.
- 31. Open the **Reach Lengths** data table notice the Left, Channel, and Right lengths are all the same. Why is that do you think?
- 32. **Close** the Geometric Editor.

6.2 Enter the Flow Data

- 33. Open the Steady Flow Data Editior.
- 34. Enter **6** for the number of profiles.
- 35. Enter flows of **100**, **500**, **1000**, **2000**, **5000**, and **10000** cfs.

36. Select the **Options | Edit Profile Names** menu item and provide names for each flow.

	Edit Profile Names. (16 Characters Max)							
	Profile #	Profile Name						
1	1	100cfs						
2	2	500cfs						
3	3	1k						
4	4	2k						
5	5	5k						
6	6	10k						

37. Enter a **Normal Depth** boundary condition.

What slope should you use? Does it matter?

38. Save the Steady Flow data when complete (call it "Steady Flows").

6.3 Plan and Simulation

39. Save a Steady Flow plan ("**Base**") to use the geometry and flows.

<u></u>	eady Flow Analysis			20 <u>—</u> 21	\times
File	Options Help				
Plan:	Base		Short ID: B	ase	
	Geometry File:	Base			 •
	Steady Flow File:	Steady Flows			•

40. Run the simulation (press the **Compute** button).

6.4 Set the Bank Stations

You can use a base run to set the bank stations for all the cross sections.

- 41. After you have run the model, look at the inundation results in **RAS Mapper**.
- 42. Plot individual cross sections using the XS Plot in either the main interface or RAS Mapper.
- 43. **Determine** which WS Profile looks to be at the channel banks.
- 44. Open the Geometric Data Editor.
- 45. Select the Tools | Channel Bank Station Locations menu item.

46. Chose the Profile you decided was at the channel banks.



47. Choose how to insert the Bank Stations.

HEC-RAS
Select location for bank stations
 At existing station/elevation just above water surface Insert station/elevation at the water surface
$\ensuremath{\mathbb{C}}$ At existing station/elevation just below water surface
Cancel

6.5 Establish Flow Path Lines

If you have time, set up the Flowpaths Layer. If not, skip this step.

- 48. In RAS Mapper, Edit the Base geometry.
- 49. Select the **Flowpaths** Layer and create a flow path line in the left and right overbank.
- 50. **Stop Editing**, when finished.

6.6 Re-run the Model

- 51. **Compute** the **Base** plan.
- 52. Evaluate the results.

7 Model Refinement

Once you have a working model, you can use it to inform you on how to improve/refine the model to better represent real-world conditions. This is where you'd refine the cross section layout, move bank stations, realign flow paths, etc.

7.1 Create a Copy of the Geometry

You will want to keep a copy of the old mesh and work on a new one (you never know when you might want to go back, but you will certainly want to compare to see progress).

53. Open RAS Mapper

54. Right-click on the base Geometry and choose **Save Geometry As**.

55. Provide a new name ("**Refined**").

7.2 Land Cover Data

Utilize the 2019 NLCD dataset provide for you to compute hydraulics using spatially varied Manning's n Values.

- 56. Choose the Project | Create New RAS Layer | Land Cover Layer
- 57. Select the **NLCD_2019.tif** file from the "**GIS_Data**" folder.

Filename	Projection Ir	nfo	Naming Std. Nam	me Field	
NLCD_2019.tif	(Same as Project) C	ell Size: 10 US s	J NLCD 2016 N/A	1	_
1					
1					
J					
ue Classification Na	ames for Selected File		utout File		
ame Field	Classification		PAS Classification	ID	
	Classification		TAS classification		
	NoData		NoData	0	
	NoData Shrub-Scrub	-	NoData Shrub-Scrub	0 52	-
	NoData Shrub-Scrub Evergreen Forest		NoData Shrub-Scrub Evergreen Forest	0 52 42	-
	NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous		NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous	0 52 42 71	-
	NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intens		NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intensity	0 52 42 71 23	
	NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intens Developed, Low Intensity		NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intensity Developed, Low Intensity	0 52 42 71 23 22	
	NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intens Developed, Low Intensity Developed, High Intensity		NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intensity Developed, Low Intensity Developed, High Intensity	0 52 42 71 23 22 24	
	NoData Shrub-Scrub Evergreen Forest Grassland-Herbaceous Developed, Medium Intens Developed, Judy Intensity Developed, High Intensity Woody Wetlands		NoData Shub-Sorub Evergreen Forest Grassland-Herbaceous Developed, Medium Intensity Developed, Low Intensity Developed, High Intensity Woody Wetlands	0 52 42 71 23 22 24 90	
	NoUsta Shrub-Scnub Evergreen Forest Grassland-Herbaceous Developed, Medium Intens Developed, Low Intensity Developed, High Intensity Woody Wetlands		NoData Shrub-Scrub Evergreen Forest Tassland-Herbaceous Developed, Medium Intensity Developed, High Intensity Woody Wetlands Woody Wetlands: INLCD	0 52 42 71 23 22 24 90	

- 58. Press the **Create** button
- 59. **Close** the compute window when finished.
- 60. Associate the LandCover layer with your geometry, in the dialog that appears. Manage Layer Associations

	Туре	RAS Geometry Layers	Terrain		Manning's n	
	Geometry	Base	Terrain	-	(None)	•
	Geometry	Refined XS	Terrain	-	LandCover	-

7.3 Manning's n values

61. Right-click on the LandCover layer and select **Edit Land Cover Data Table** to associate Manning's n value data with the classification scheme.







- 63. Update the Cross Sections with Manning's n values for the cross sections.
 - a. Start Editing the new Geometry
 - b. Select the Cross Section Layer and choose the **Update Cross** Sections | Manning's n Values menu item.

Cross Section	laver Dropertier		J	
	Open Attribute Table			
⊡ Bridges □ Inline S ●	Stop Editing			
	Update Cross Sections (104 of 104)	•	3	All XS Attributes (Except Terrain)
D Pump S	River Stations Table		5.9	River Stations
Bounda	Generate Layers	٠	~	Bank Stations
	Remove Duplicate Cross Sections		¥	Reach Lengths
Referen	Zoom to Layer		4.8	Ineffective Flow Areas
	Remove Laver		V.	Blocked Obstructions
🕀 🔲 Infiltrati	Move Layer		₩	Manning's n Values

- c. You can see if it worked by turning on the Cross Section Layer Plot Option | Manning's n Values.
- d. Stop Editing and Save Edits.

7.4 Plan and Simulation

- 64. Open the Steady Flow Analysis window and create a new Plan using the refined geometry using the **File | Save Plan As** menu option.
- 65. Provide a new Title and Name ("**Refined**").

66.	Make	e sure to select t eady Flow Analysis	he Refined geometr	ry.	_	×
	File	Options Help				
	Plan:	RefinedXS	Sho	ort ID:	RefinedXS	
		Geometry File:	Refined XS			 •
		Steady Flow File:	Steady Flows			•

67. Run the simulation (press the **Compute** button).

7.5 Evaluate/Compare Results

Plot the Water Surface Profile Results comparing the two plans.

68. Plot them using the **Profile Plot**

- a. Compare plans by selecting the **Options | Plans** menu item.
- b. Turn on the both plans

Select Plans (current plan = RefinedXS)	
Base (Short ID = Base	Geom = Base)
RefinedXS (Short ID = RefinedXS	Geom = Refined XS)

69. Plot them in **RAS Mapper**

- a. Select the River centerline layer you added at the start of the project. Right-click on the line and choose **Save as Profile Line**. Provide a name.
- b. Turn on the **WSE** layer for both results
- c. Highlight the **Results** group layer, press the **Max** button on the Animation control.
- d. Click on the **Profile Lines** tab (lower left corner).
- e. Right-click on the **River** line and select the **Plot Profile | WSE** menu item

How do the results compare?

7.6 Observed Data

At this point we don't really know how are model is doing. We can use observed data to help inform us and how to refine the model. Add an Observed High Water Mark (at the Bridge, at the Yosemite Falls Vantage Point, near River Station 2.88 based on the provided river centerline).

70. Open the **Steady Flow Data editor**.

71. Select the **Options | Observed WS** menu item.

72. Select the river station 2.88 (yours may vary) and **Add the Observed WS** Location.

Observed Water Surfaces for Comparison	
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River:	Merced River	-			Add Multiple	Delete Row
Reach:	Yosemite Valley	▼ Rive	er Sta.:	2.88	Add an Obs. \	WS Location 🚽

- 73. Enter a WSE of **3966ft** for the 10,000cfs profile.
- 74. Save, and Close the Unsteady Flow Editor
- 75. **Re-run** the simulation

How do the results compare with the observed data? How can you improve the results?

7.7 Improve Manning's Data

76. Select the LandCover | Classification Polygons layer

77. Start Editing

- 78. Right-click on the **Classification Polygons** and choose the **Import Features from Shapefile** menu option
- 79. Select the "Channel_Polygon" shapefile in "GIS_Data" folder.
- 80. Switch to the Edit Tool and then right-click on the new channel shape and choose **Edit Classification Value**.

 Polygon: Channel	
🛅 Edit Classification Value 📡	

81. Enter a value of **0.04** for the **Manning's n** value.

Classifi	ication Name: Char	nnel	•
	ManningsN	Percent Impervious	
Ĩ	0.04		

- 82. Stop Editing and Save edits.
- 83. Update the Cross Sections with Manning's n values for the cross sections.
 - a. Start Editing the new Geometry
 - b. Select the Cross Section Layer and choose the Update Cross Sections | Manning's n Values menu item.

c. **Stop Editing** and Save Edits.

84. Re-run and Compare results.

How do the results compare with the Observed High Water Mark data?

What else can you do to improve the model?

8 Sensitivity Analysis – Bonus Material

As time allows perform sensitivity analysis.

- 85. How sensitive is the model to the downstream boundary?
- 86. What do the model results show if you increase or decrease the Manning's n values?