

HEC-RAS Geometry for Dam Breach Analysis

Cameron Ackerman, P.E., BC.WRE

USACE, Institute for Water Resources, Hydrologic Engineering Center



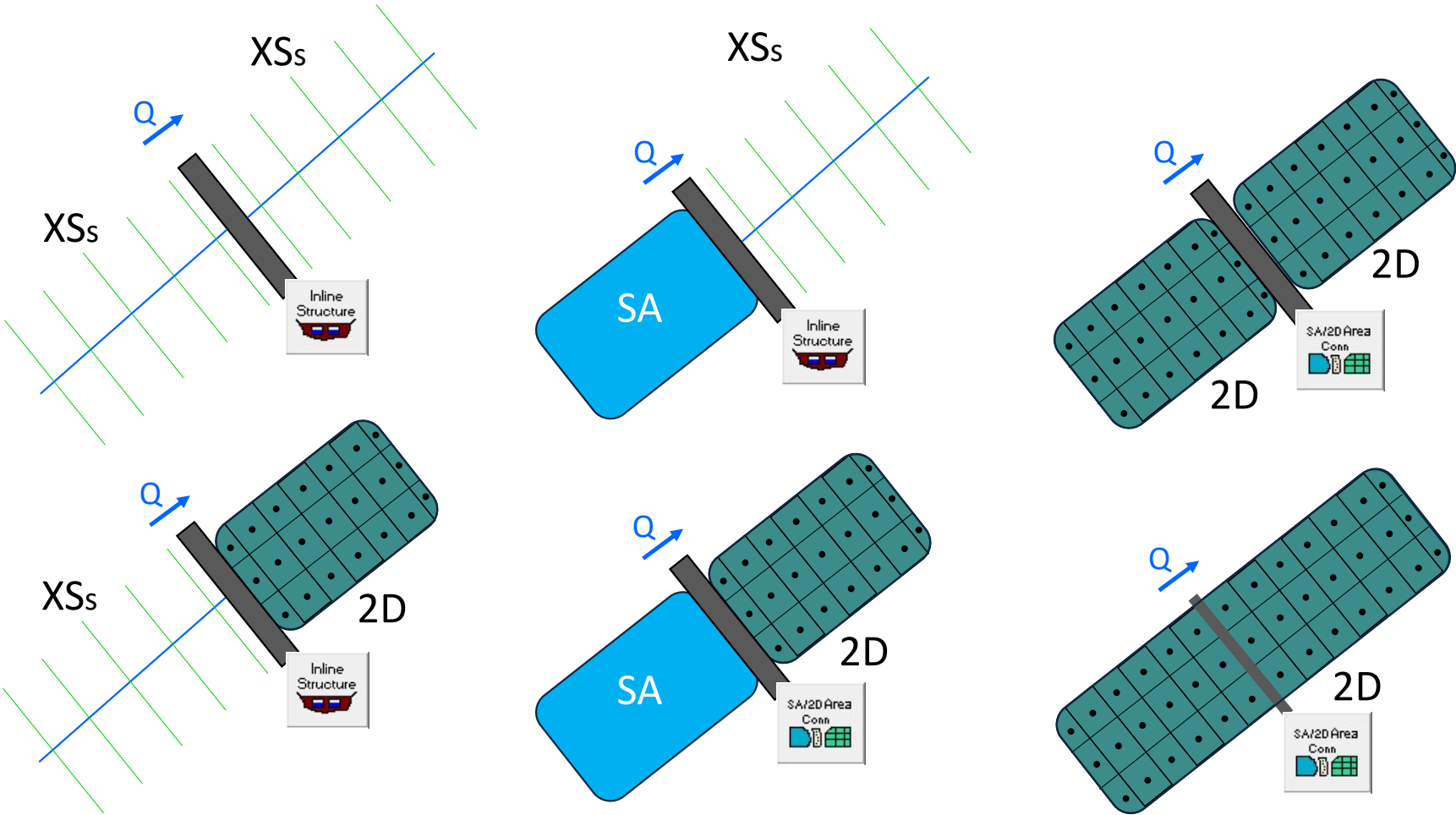


Objectives

- HEC-RAS Introduction and Model Configuration
- Creating a RAS Terrain
- Editing Layers
- 1D and 2D Modeling Layers
- 2D Subgrid Technology

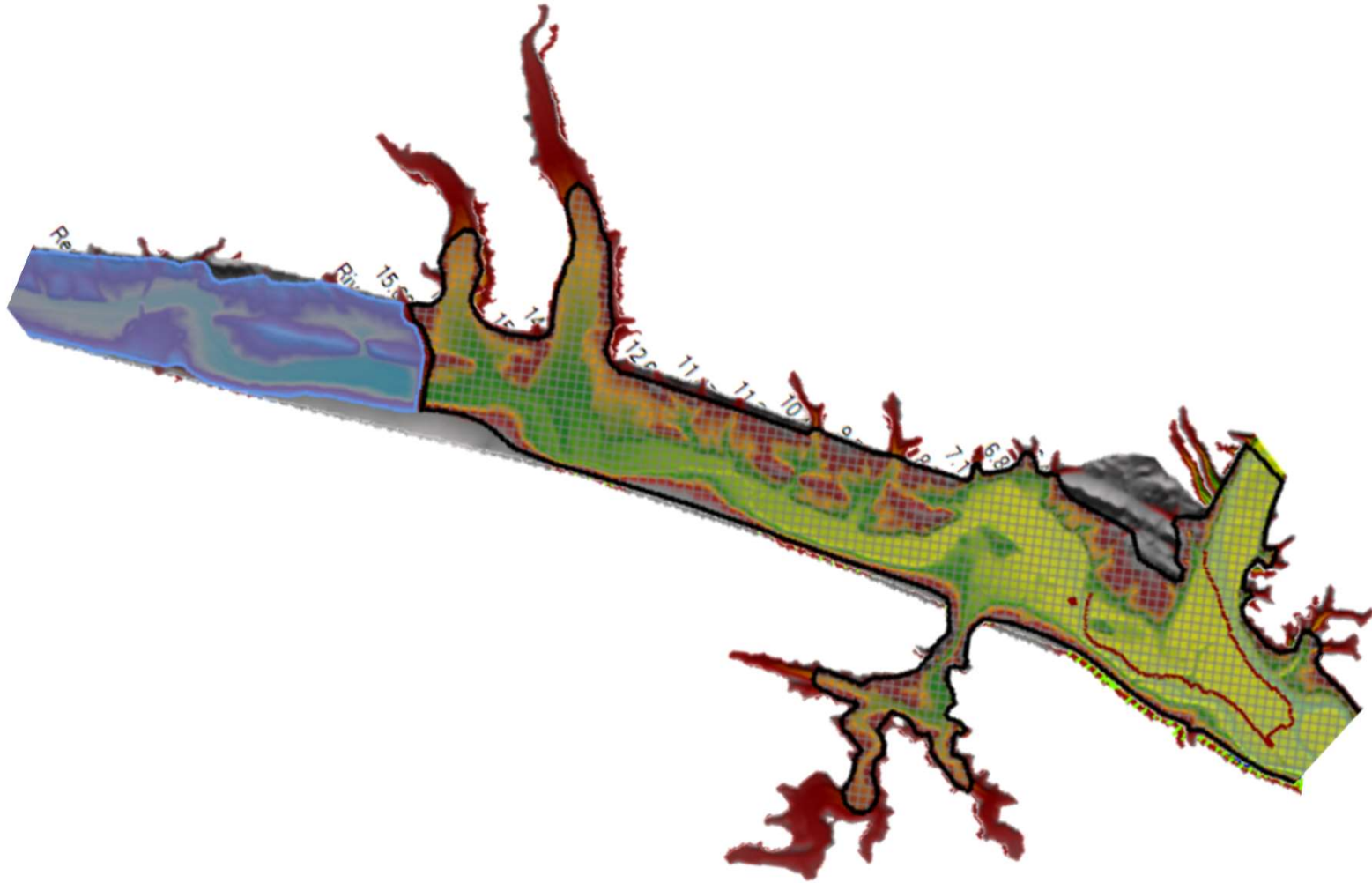


Breach Model Configurations





RAS Model Creation – RAS Mapper





HEC-RAS

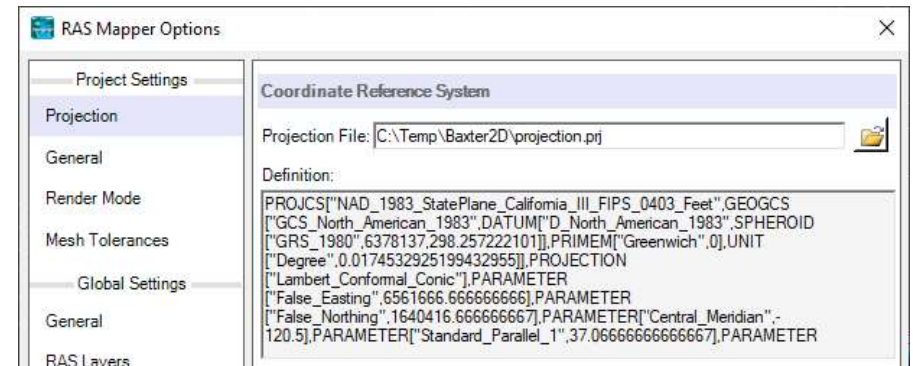
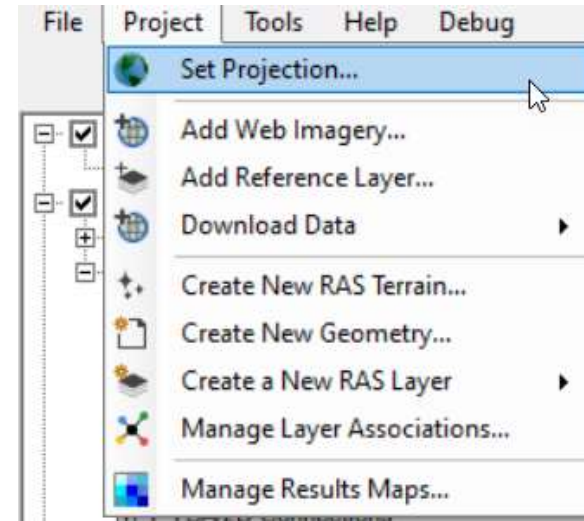


The screenshot displays the HEC-RAS 6.5 software interface. The main window, titled "HEC-RAS 6.5", features a menu bar with "File", "Edit", "Run", "View", "Options", "GIS Tools", and "Help". Below the menu is a toolbar with various icons, including a red arrow pointing to the "RAS Mapper" icon. On the left side of the main window, there are input fields for "Project:", "Plan:", "Geometry:", "Steady Flow:", "Unsteady Flow:", and "Description:". The "RAS Mapper" window is open in the foreground, showing a "Features" panel on the left with a tree view containing "Features", "Geometries", "Plans", "Event Conditions", "Results", "Map Layers", and "Terrains". The main map area is currently blank. At the bottom of the RAS Mapper window, there are tabs for "Messages", "Views", "Profile Lines", and "Acti", and a status bar displaying coordinates and a scale of 5 miles.



Projection

- Data used in RAS Mapper must be a common coordinate system.
- Projection will be used to re-project Terrain data that is imported into RAS Mapper.
 - Defined using esri PRJ file.
- Web Imagery will be projected on-the-fly to RAS Mapper coordinate system.

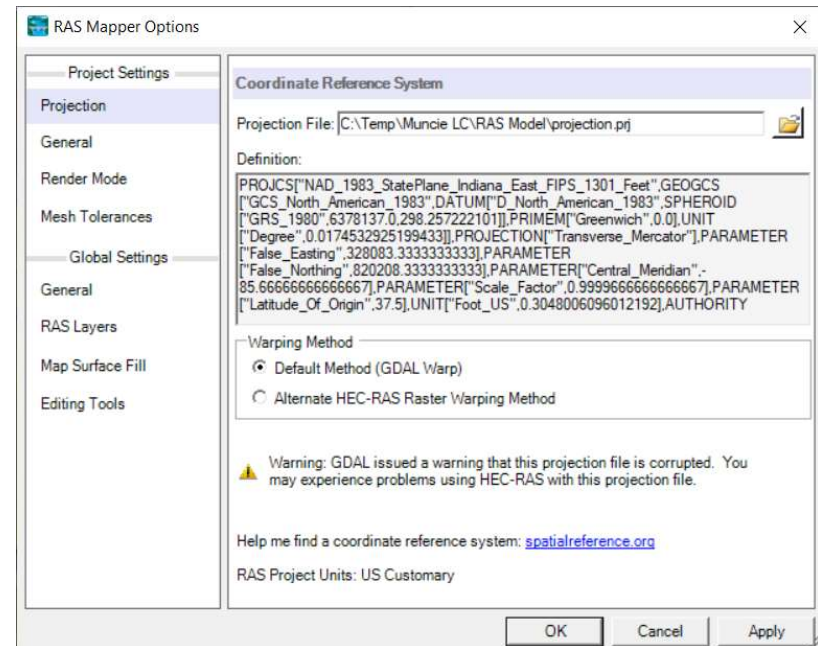
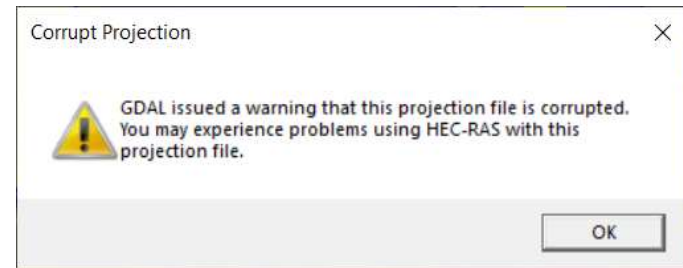




Projection Files

- Not all PRJ files are the same

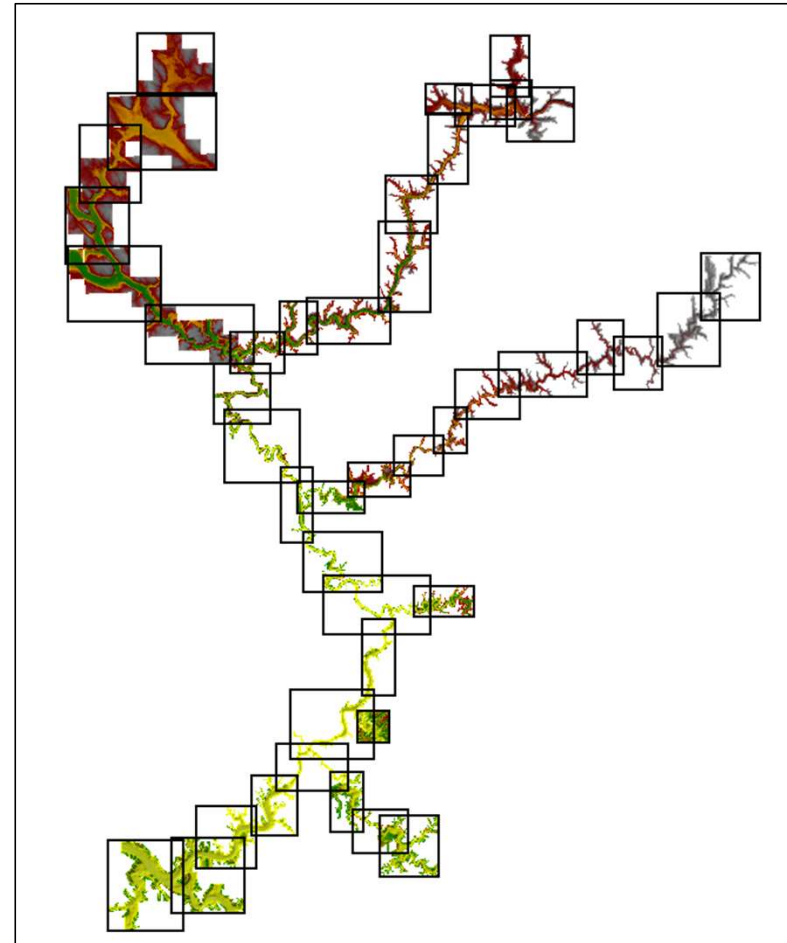
```
PROJCS["NAD_1983_StatePlane_Pennsylvania_South_FIPS_3702_Feet",  
GEOGCS["GCS_North_American_1983",  
DATUM["D_North_American_1983",  
SPHEROID["GRS_1980",6378137.0,298.257222101]],  
PRIMEM["Greenwich",0.0],  
UNIT["Degree",0.0174532925199433]],  
PROJECTION["Lambert_Conformal_Conic"],  
PARAMETER["False_Easting",1968500.0],  
PARAMETER["False_Northing",0.0],  
PARAMETER["Central_Meridian",-77.75],  
PARAMETER["Standard_Parallel_1",39.93333333333333],  
PARAMETER["Standard_Parallel_2",40.96666666666667],  
PARAMETER["Latitude_of_Origin",39.33333333333334],  
UNIT["Foot_US",0.3048006096012192]].
```





Terrain in RAS Mapper

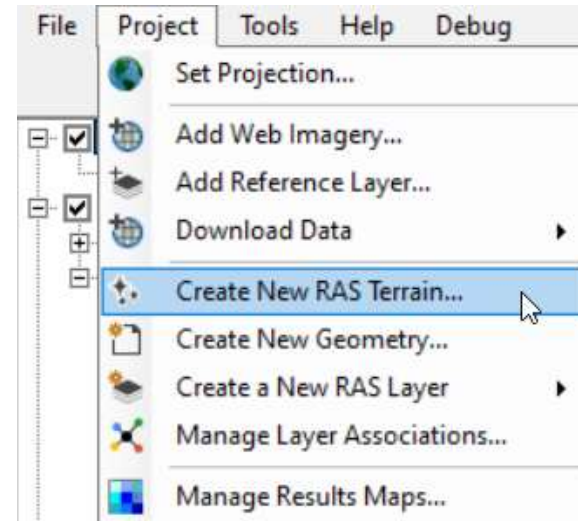
- Uses GeoTIFF format
 - Tiled data for more efficient storage
 - Compressed data for efficient storage
 - Pyramided data for fast visualization
 - Allows for on-the-fly inundation mapping
- One Layer for Multiple Terrain Models
- No file size limitations – BigTIFF supported



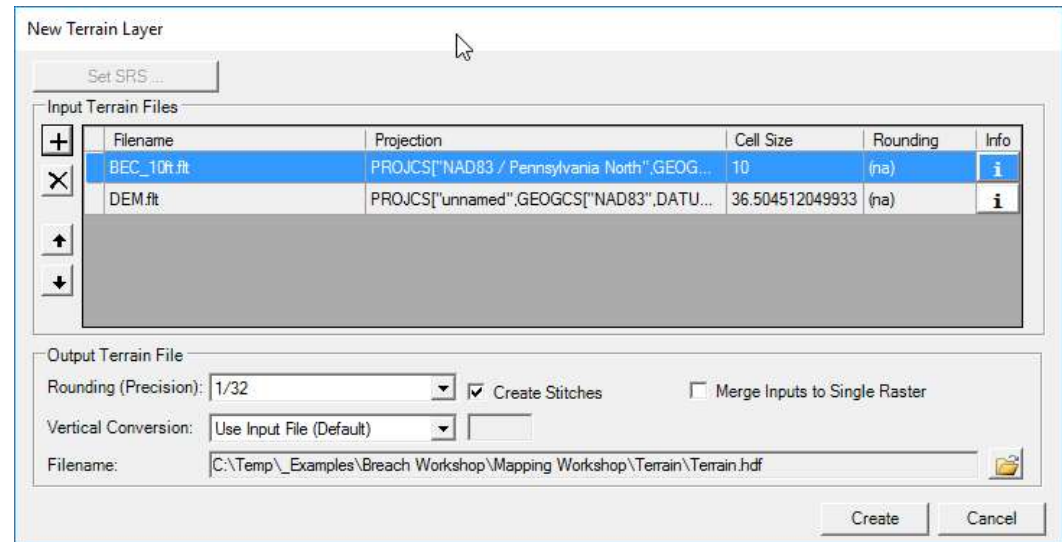


Terrain Importer

- Click **Project | Create New RAS Terrain**
- **Add** raster files for import



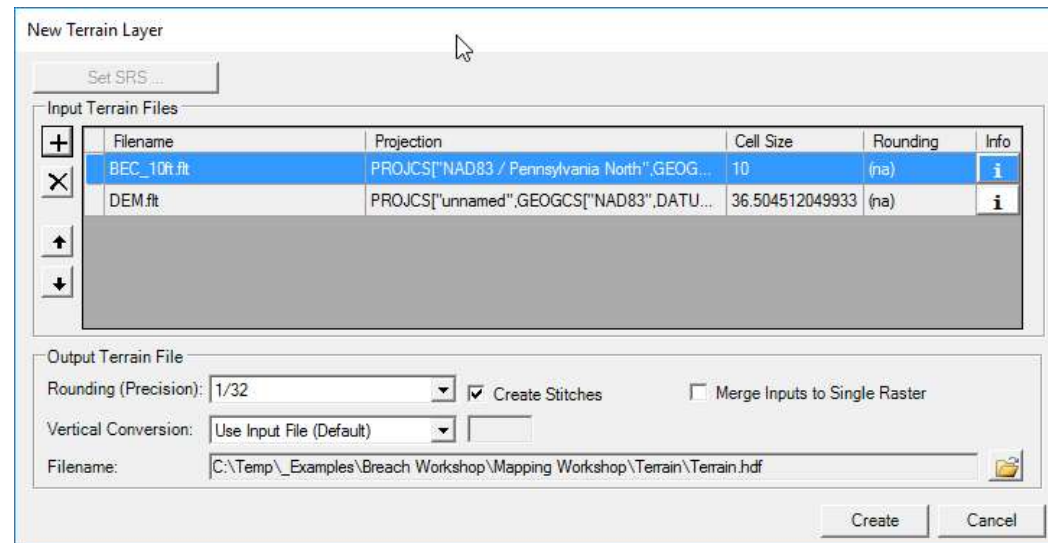
- Click **Create**





Terrain Importer

- Add files – allows user to select rasters for import
- Order raster files based on **Priority** on what cell value should be used if there is overlap by the terrain models.
 - Highest Priority to the top





Terrain Importer

- Data is translated (to .tif), projected, and rounded for all data
- Data is pyramided (overlays created) and compressed
- TIN stitches are created for overlapping regions
- **Terrain.hdf** is the single layer loaded to RAS Mapper

```
Compute Window - Creating Terrain 'Terrain'
```

```
Importing 1 of 2: BEC_20ft.flt
Step 1 of 4: Translating to GeoTiff with SRS...           |           1
Step 2 of 4: Rounding and/or Generating Statistics...   |           7
Step 3 of 4: Generating Histogram...                   |           2
Step 4 of 4: Adding Overlays...                       |           2
BEC_20ft.flt Import Complete.                          |          14
-----
Importing 2 of 2: BEC_DEM.flt
Step 1 of 4: Translating to GeoTiff and reprojecting... |          26
Step 2 of 4: Rounding and/or Generating Statistics...   |         1:05
Step 3 of 4: Generating Histogram...                   |          11
Step 4 of 4: Adding Overlays...                       |          13
BEC_DEM.flt Import Complete.                          |         1:56
-----
Final Processing: Terrain.hdf
Step 1 of 3: Creating Terrain.vrt...                   |           0
Step 2 of 3: Creating Terrain.hdf...                   |         1:17
Step 3 of 3: Creating Stitch-TIN for merging rasters... |           6
Terrain Complete                                     |         3:34
```

Close



Terrain in RAS Mapper



RAS Mapper

File Project Tools Help

Max Min

Terrains

- Features
- Geometries
- Event Conditions
- Results
- Map Layers
- Terrains
 - Terrain

Messages Views Profile Lines Active Features Layer Values

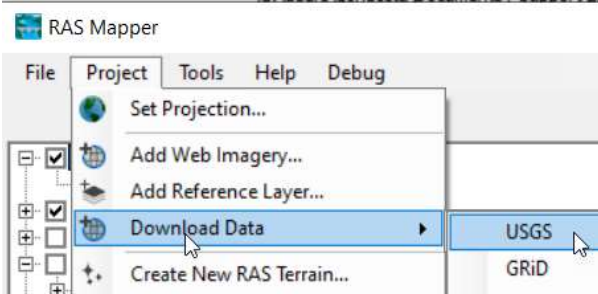
(2058227.99, 311155.13 1 pixel = 182.86 ft)

5 mi

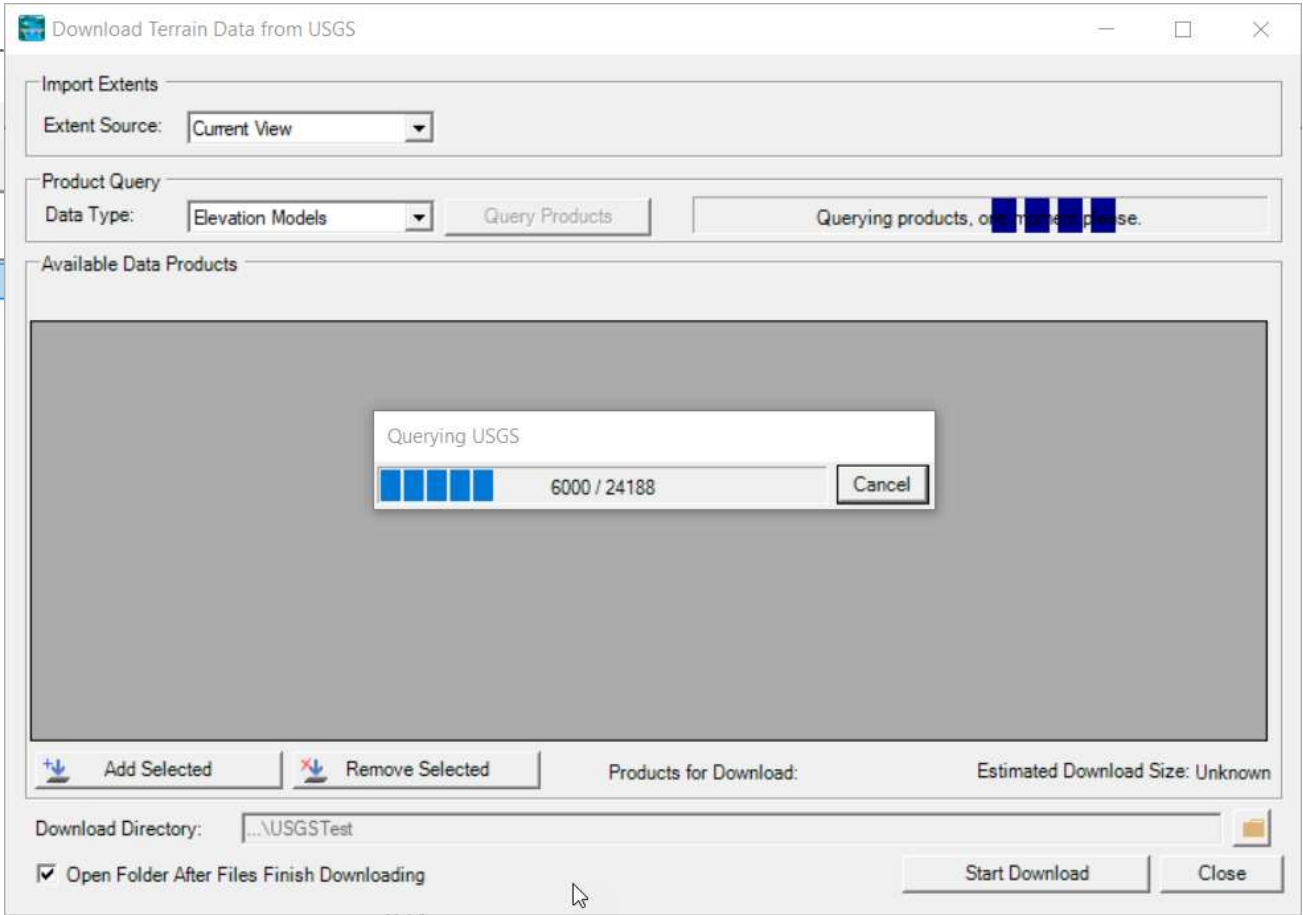
The screenshot displays the RAS Mapper software interface. The main window shows a 3D terrain map of a river system, with the terrain color-coded by elevation. A legend on the left side of the interface lists various map layers, with 'Terrains' and its sub-layer 'Terrain' checked. A color scale legend is positioned to the right of the 'Terrain' layer. The bottom of the interface includes a status bar with coordinates and a scale bar indicating 5 miles. The title bar of the window reads 'RAS Mapper' and the menu bar includes 'File', 'Project', 'Tools', and 'Help'.



Terrain Data Download



- USGS Terrain
- GRiD (CRREL)





Terrain Data Download

RAS Mapper

File Project Tools Help Debug

Selected Layer: USGS Products Available

- Features
 - Profile Lines
- Geometries
- Event Conditions
- Results
 - Tujunga
 - Tujunga Steady
 - Event Conditions
 - Geometry
 - Depth (PF 1)
 - Velocity (PF 1)
 - WSE (PF 1)
 - 1DOnly
 - Event Conditions
 - Geometry
 - Depth (Max)
 - Velocity (Max)
 - WSE (Max)
- Map Layers
 - USGS Products Available
 - USGS Products To Download

Messages Views Profile Lines Active Features Layer Values

(-6169279.69, 4841941.97 1 pixel = 588.15 ft)

Download Terrain Data from USGS

Import Extents
Extent Source: Current View

Product Query
Data Type: Elevation Models Query Products

Available Data Products (Filtered: 359 of 24188)

1m 10m 30m Original Filter: Apply Only Show

	CellSize	Description	Date	FileSize	Web
1	1m	USGS one meter x48y378 CA SoCal Wildfires B1 2018	2020-03-30	429 MB	Link
2	1m	USGS one meter x43y384 CA SoCal Wildfires B2 2018	2020-03-30	5 MB	Link
3	1m	USGS one meter x43y378 CA LosAngeles 2016	2020-03-30	Unknown	Link
4	1m	USGS one meter x45y377 CA SoCal Wildfires B1 2018	2020-03-30	423 MB	Link
5	1m	USGS one meter x40y375 CA SoCal Wildfires B1 2018	2020-03-30	311 MB	Link
6	1m	USGS one meter x47y378 CA SoCAL Wildfires TL 2018	2020-03-30	18 MB	Link
7	1m	USGS one meter x48y379 CA SoCal Wildfires B1 2018	2020-03-30	387 MB	Link
8	1m	USGS one meter x46y380 CA SoCal Wildfires B1 2018	2020-03-30	145 MB	Link
9	1m	USGS one meter x49y378 CA SoCal Wildfires B1 2018	2020-03-30	474 MB	Link
10	1m	USGS one meter x40y378 CA SE Fault Zone 2017	2020-03-30	12 MB	Link

Add Selected (1) Remove Selected Products for Download: 0 of 24188 Estimated Download Size: 0 B

Download Directory: ..\USGSTest

Open Folder After Files Finish Downloading

Start Download Close

10 mi



Terrain Data Download



RAS Mapper

File Project Tools Help Debug

Selected Layer: USGS Products Available

Selected: 'USGS Pro'

Messages Views Profile Lines Active Features Layer Values

(-6551574.33, 4941338.58 1 pixel = 588.15 ft)

Download Terrain Data from USGS

Import Extents
Extent Source: Current View

Product Query
Data Type: Elevation Models Query Products

Available Data Products (Filtered: 359 of 24188)

CellSize	Description	Date	FileSize	Web
1m	USGS one meter x4y378 CA SoCal Wildfires B1 2018	2020-03-30	429 MB	Link
1m	USGS one meter x4y384 CA SoCal Wildfires B2 2018	2020-03-30	5 MB	Link
1m	USGS one meter x4y378 CA LosAngeles 2016	2020-03-30	Unknown	Link
1m	USGS one meter x4y377 CA SoCal Wildfires B1 2018	2020-03-30	423 MB	Link
1m	USGS one meter x4y375 CA SoCal Wildfires B1 2018	2020-03-30	311 MB	Link
1m	USGS one meter x4y378 CA SoCal Wildfires TL 2018	2020-03-30	18 MB	Link
1m	USGS one meter x4y379 CA SoCal Wildfires B1 2018	2020-03-30	387 MB	Link
1m	USGS one meter x4y380 CA SoCal Wildfires B1 2018	2020-03-30	145 MB	Link
1m	USGS one meter x4y378 CA SoCal Wildfires B1 2018	2020-03-30	474 MB	Link
1m	USGS one meter x4y378 CA SE Fault Zone 2017	2020-03-30	12 MB	Link

Products for Download: 32 of 24188 Estimated Download Size: 1.33 GB

Download Directory: \USGSTest

Open Folder After Files Finish Downloading

Start Download Close



Terrain Build



New Terrain Layer

Set SRS ...

Input Terrain Files (13 files)

+	×	↑	↓	Filename	Projection	Cell Size	Rounding	Info
				tile (1).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (2).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (3).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (4).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (5).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (6).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (7).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (8).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (9).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i
				tile (10).tif	PROJCS["NAD83(2011) / UTM zone 11N",GEO...	0.5	None	i

Output Terrain File

Rounding (Precision): 1/32 Create Stitches Merge Inputs to Single Raster

Vertical Conversion: Use Input File (Default)

Filename: C:\Temp_NewModels\Merced\Terrain\Terrain.hdf

Create Cancel



Create a New Geometry







- Create a New Geometry
- Provide a Name
- Select the Geometry
- Edit the New Geometry

The screenshot shows the RAS Mapper software interface. The 'Tools' menu is open, and the 'Create New Geometry...' option is highlighted. Below the menu, the 'New Geometry Data' dialog box is open, with the text 'Enter a unique Name for the new Geometry:' and a text input field containing the word 'Geometry'. Below the dialog box, the 'RAS Mapper' window is visible, showing a tree view of layers. The 'Geometries' folder is expanded, and the 'Geometry' layer is selected and highlighted in pink. A red arrow points to a yellow pencil icon in the top right corner of the 'RAS Mapper' window, indicating the edit function.



Editing Tools



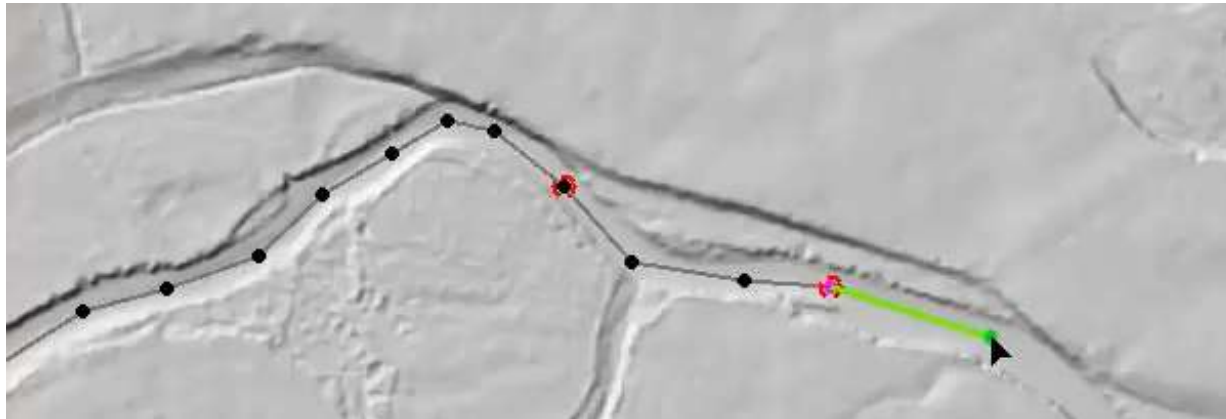
- Add New Feature 
- Select/Edit Feature 
- Undo/Redo 
- Plot Profile 
- Tools 
- Help 



Add New Feature



- Left-click to start adding a new point, line, or polygon
- Double-click to end a line or polygon
- Pan by switching to Pan tool, Shift key, Middle Mouse, or right-click to re-center.

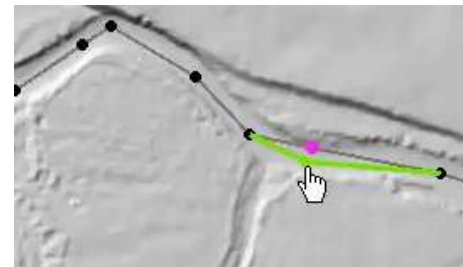
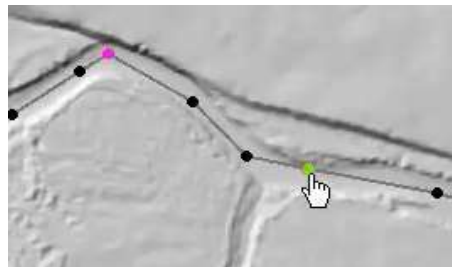
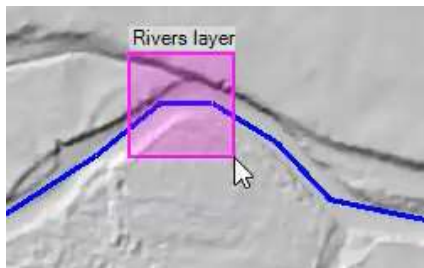




Select / Edit



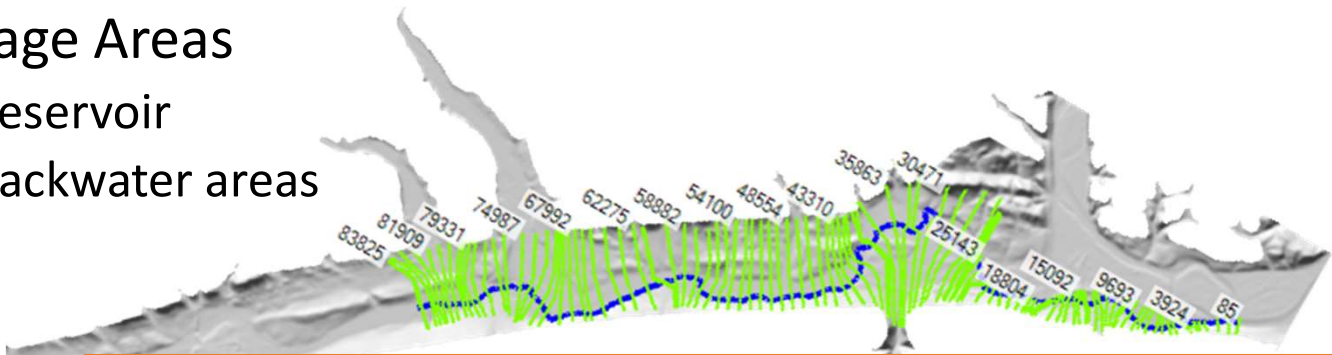
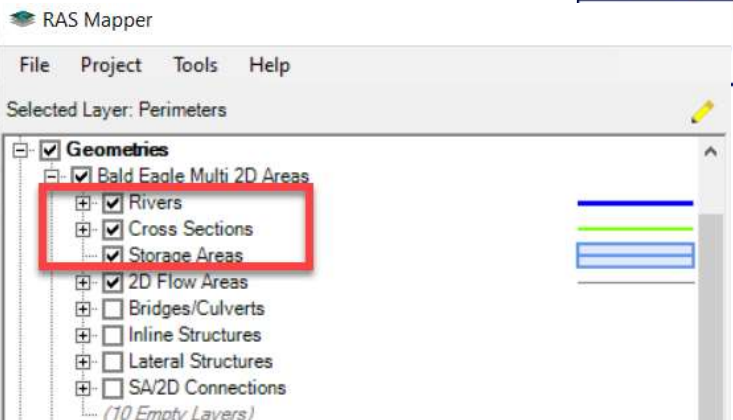
- Select / Edit tool is used to select feature(s) and then begin editing (move, add points, delete, etc).
 - Double-click to Start Editing (Open feature)
 - Double-click to End Editing (Close feature)
- Mouse hover indicates action
 - **Green** point indicates: Move, Insert, Delete point





1D Model Areas

- Rivers
- Cross Sections
 - Oriented from the left to right bank (looking d/s)
 - Perpendicular to flow for correct XS area
 - Elevations are extracted from the DTM
- Storage Areas
 - Reservoir
 - Backwater areas



River	Reach	River Station	Length LOB	Length Channel	Length ROB	Left Bank	Right Bank
Bald Eagle Creek	Below Sayers Dam	82671	332.924347	332.924347	332.924347	5393.39844	5593.358
Bald Eagle Creek	Below Sayers Dam	82338	429.508026	429.508026	429.508026	5113.08154	5319.7915
Bald Eagle Creek	Below Sayers Dam	81909	494.6595	494.6595	494.6595	4921.44873	5068.88867
Bald Eagle Creek	Below Sayers Dam	81414	527.047241	527.047241	527.047241	5033.24268	5154.98242
Bald Eagle Creek	Below Sayers Dam	80887	688.114441	688.114441	688.114441	5083.96826	5224.024



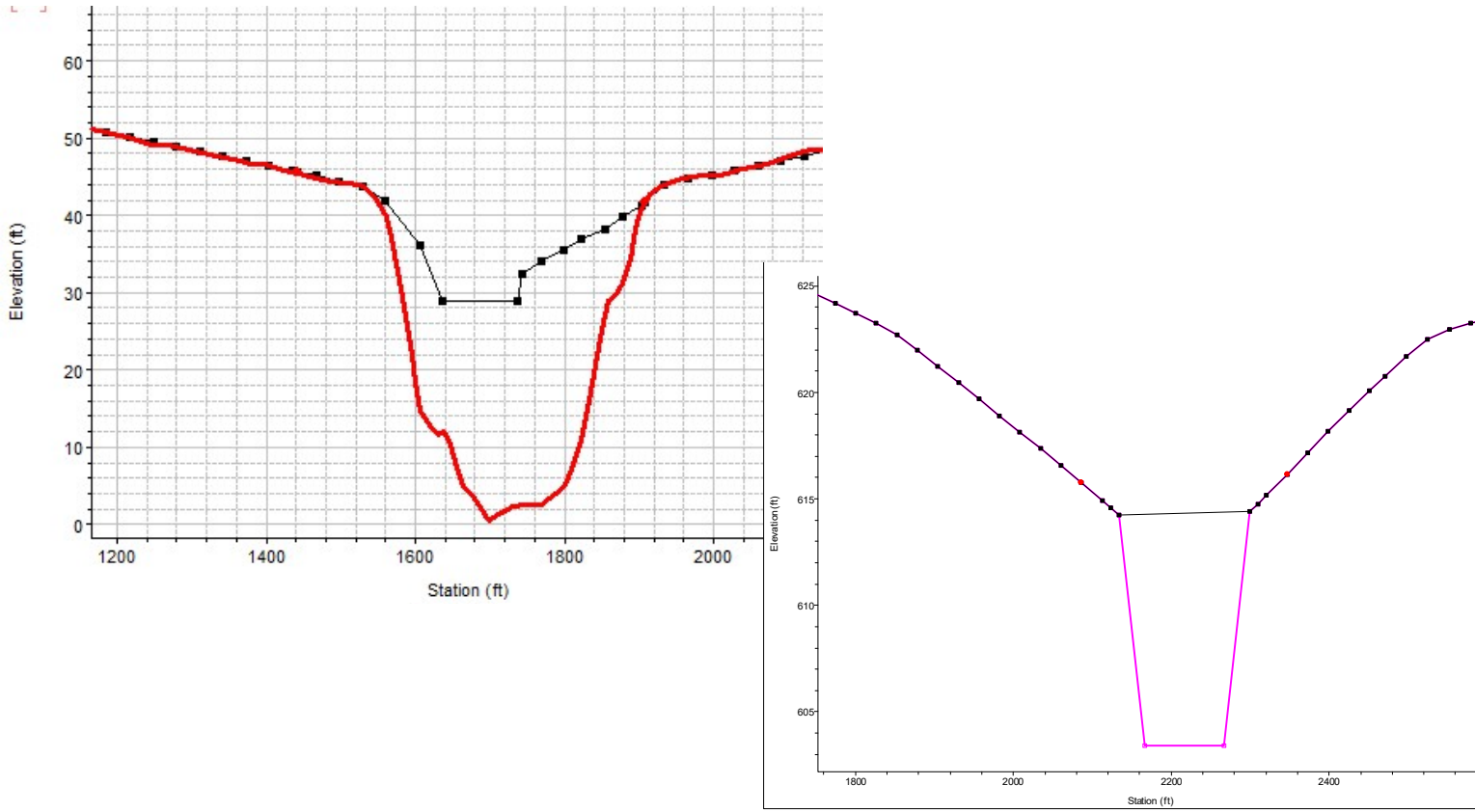
Main Channel

- Terrain often doesn't clearly indicate location of main channel.
- Use imagery to establish bank station locations.



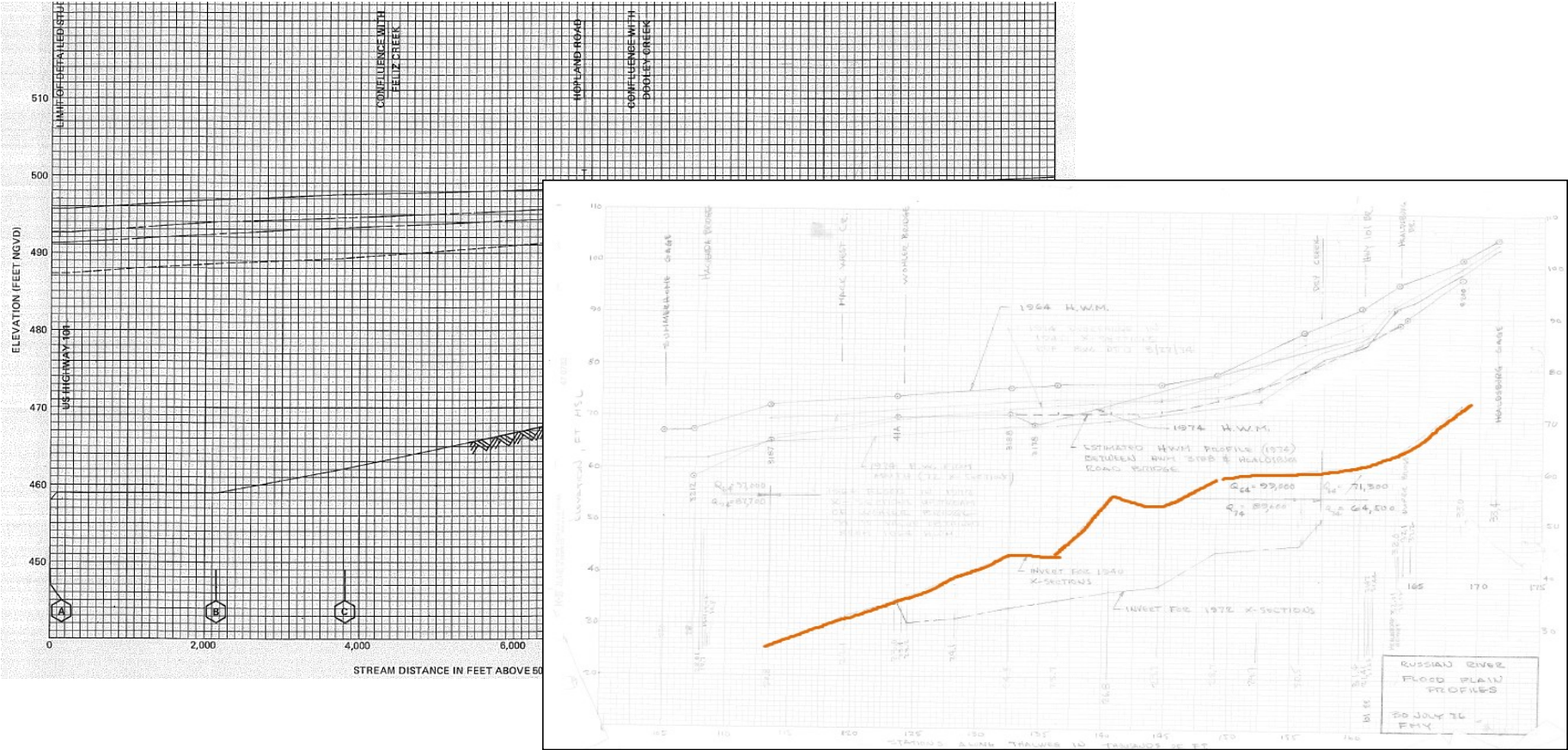


Main Channel





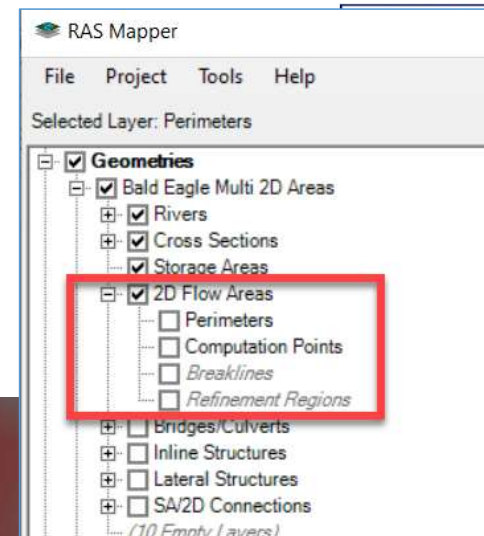
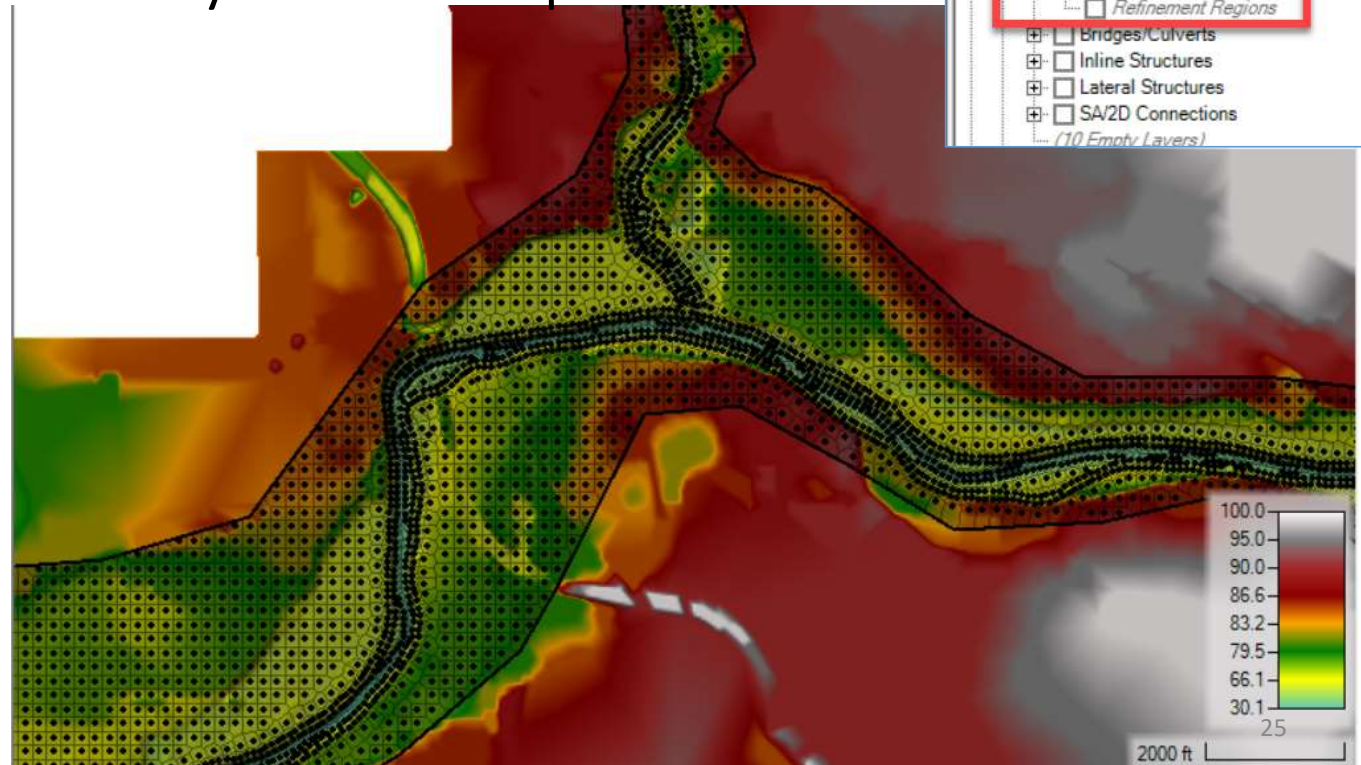
Published Elevation Data






2D Model Areas

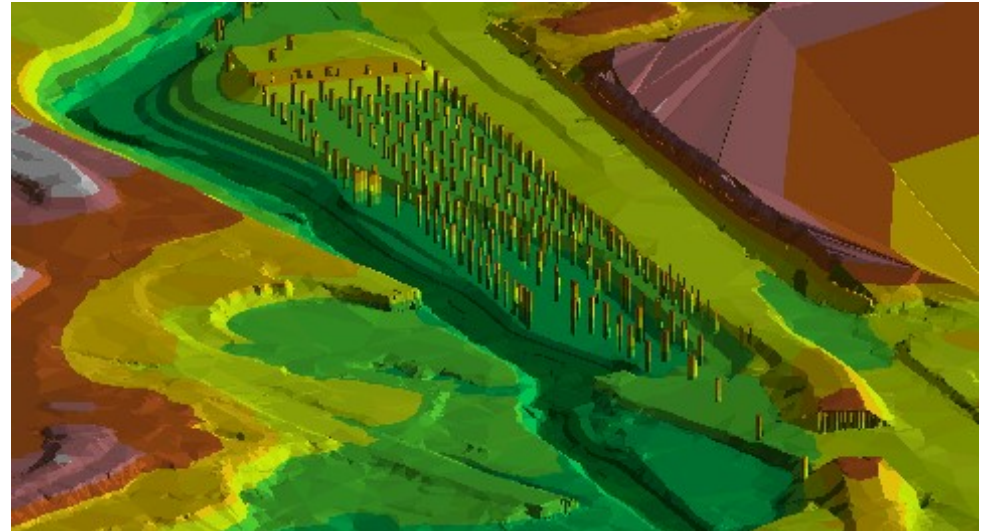
- 2D Flow Areas are used where flow direction is highly variable/unknown.
- Can use for the entire study area or for specific areas.
 - Reservoir
 - River Floodplain
 - Protected Area
 - Tributaries




A red square icon containing a white silhouette of a castle with three towers.

2D Modeling Subgrid Technology

- Problem
 - Water levels usually vary much more smoothly than the terrain
 - Unfeasible to resolve every detail of the terrain with the computational mesh
- Approach
 - Utilize a grid resolution sufficient to resolve the hydraulics
 - Capture the details of the subgrid terrain through hydraulic properties tables



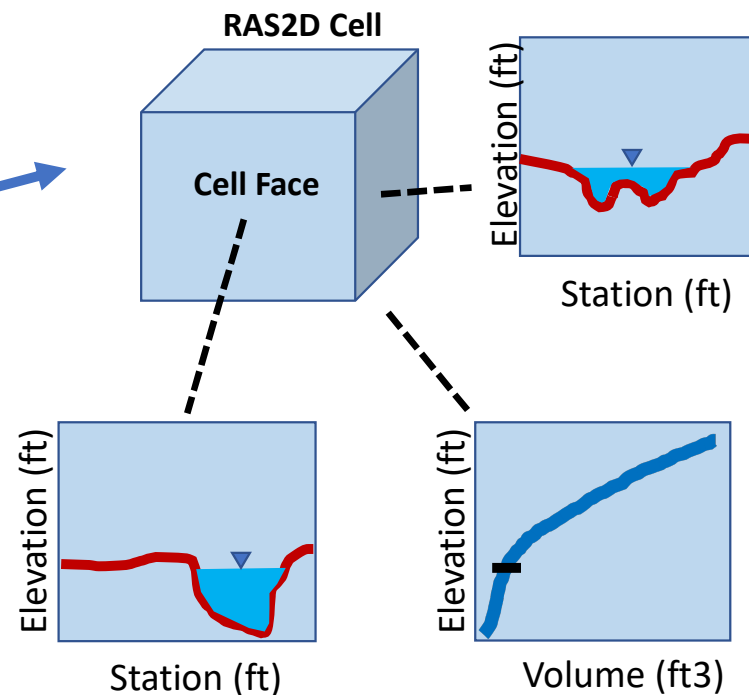
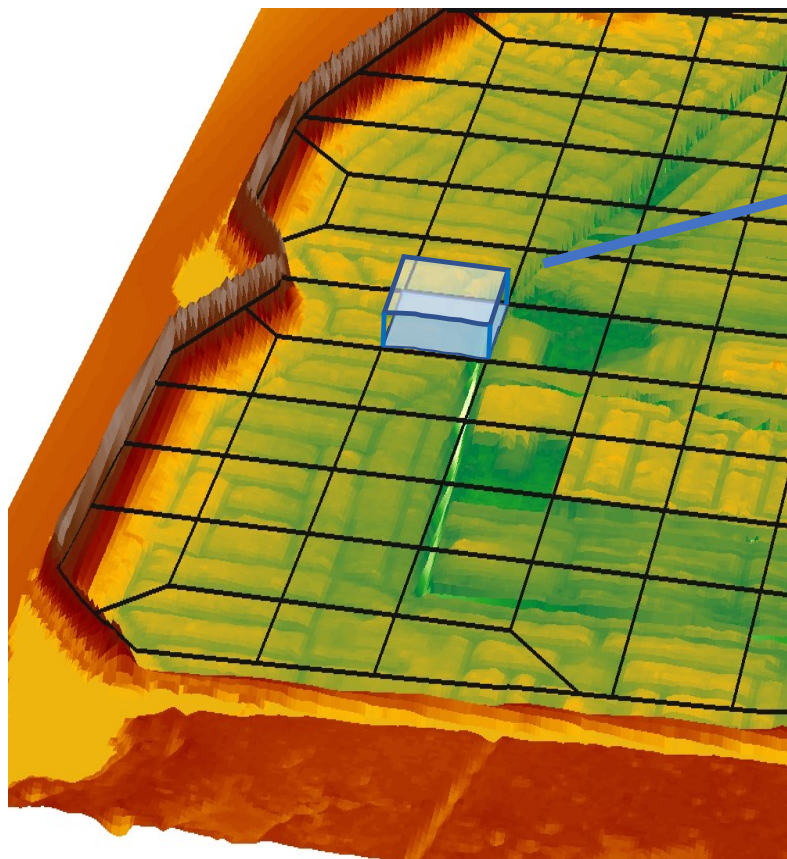
A red square icon containing a white silhouette of a castle with three towers.

2D Modeling Subgrid Technology

- Detailed elevation-volume relationship for each 2D Cell.
- Hydraulic properties for each Cell Face (pre-computed).
- Cells can be partially wet.
- Allows for larger computational cells, without losing details of the underlying terrain.
- Larger cells = less computations = faster run times!
- HEC-RAS produces more detailed results for a given cell size than models using a single elevation for each cell and face.



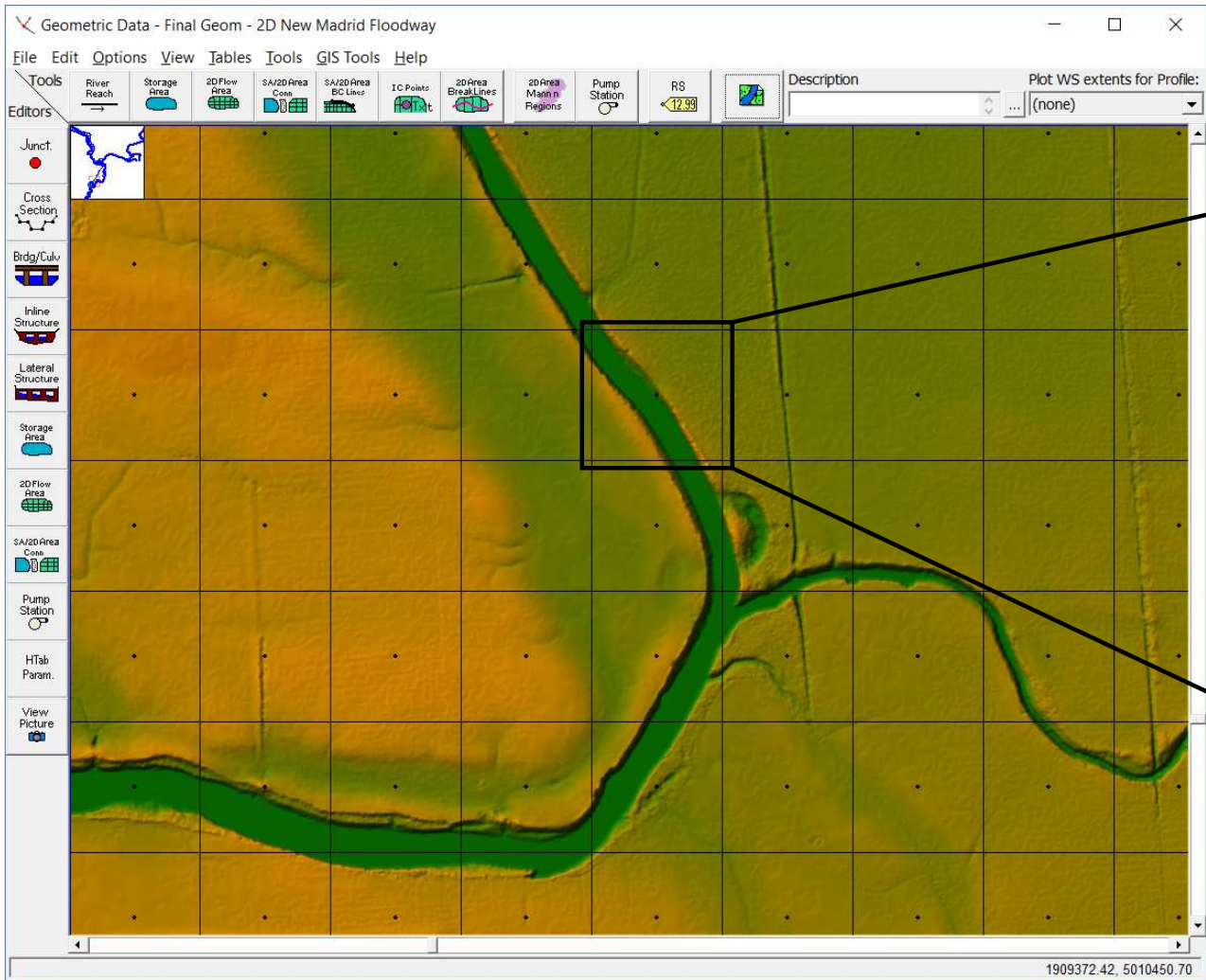
2D Computational Mesh Subgrid Terrain



Each cell face profile and stage-volume curve is based on **hundreds to thousands topo-bathymetric data-points**, depending of resolution of underlying terrain raster. Cell approach very efficiently discretizes space including complex terrain & surface roughness.

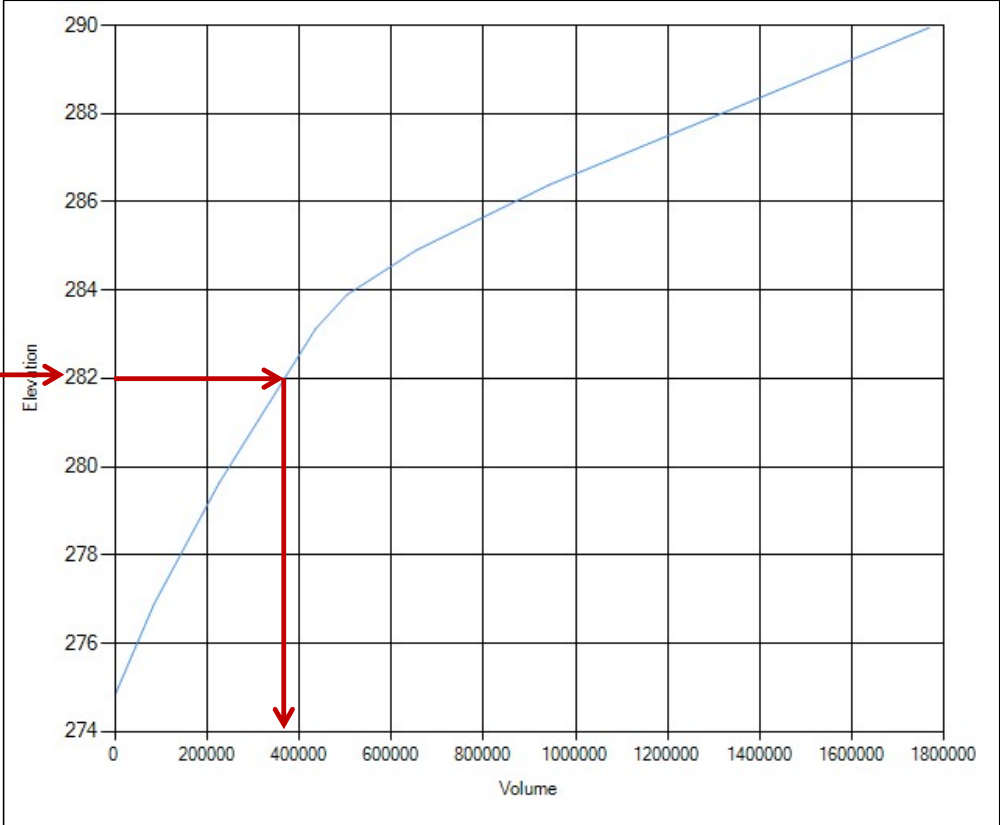
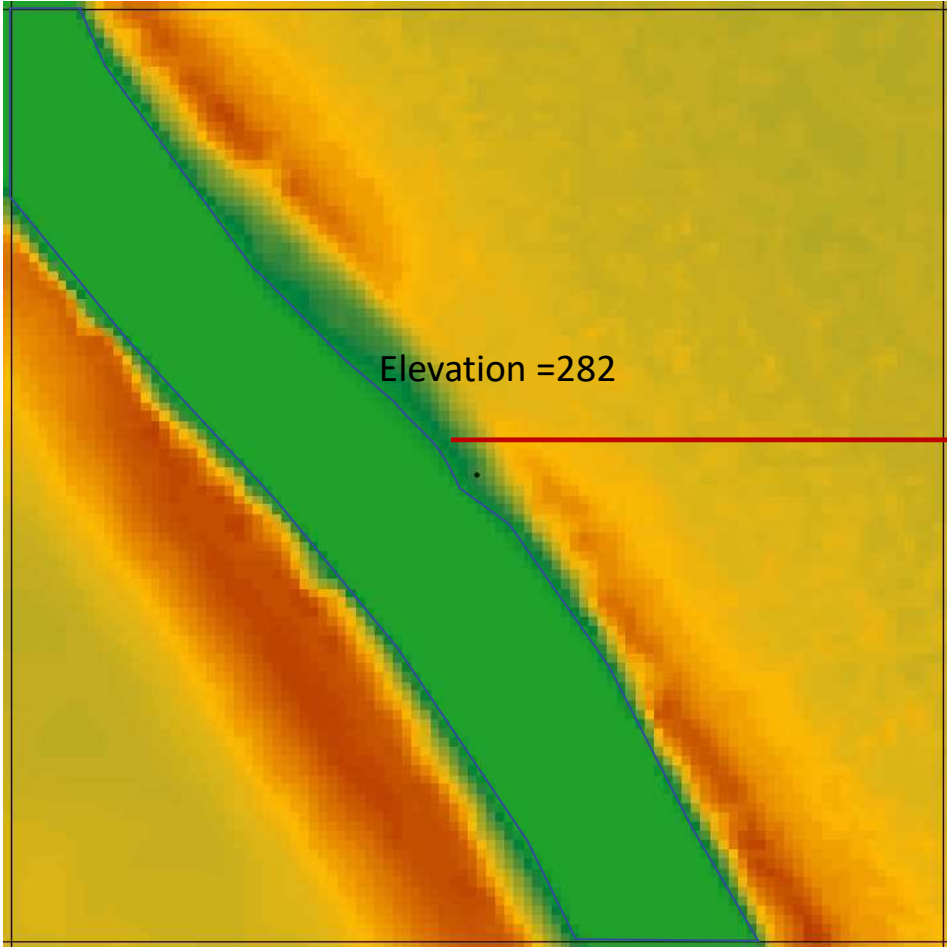


Computational Mesh Sub-grid Terrain



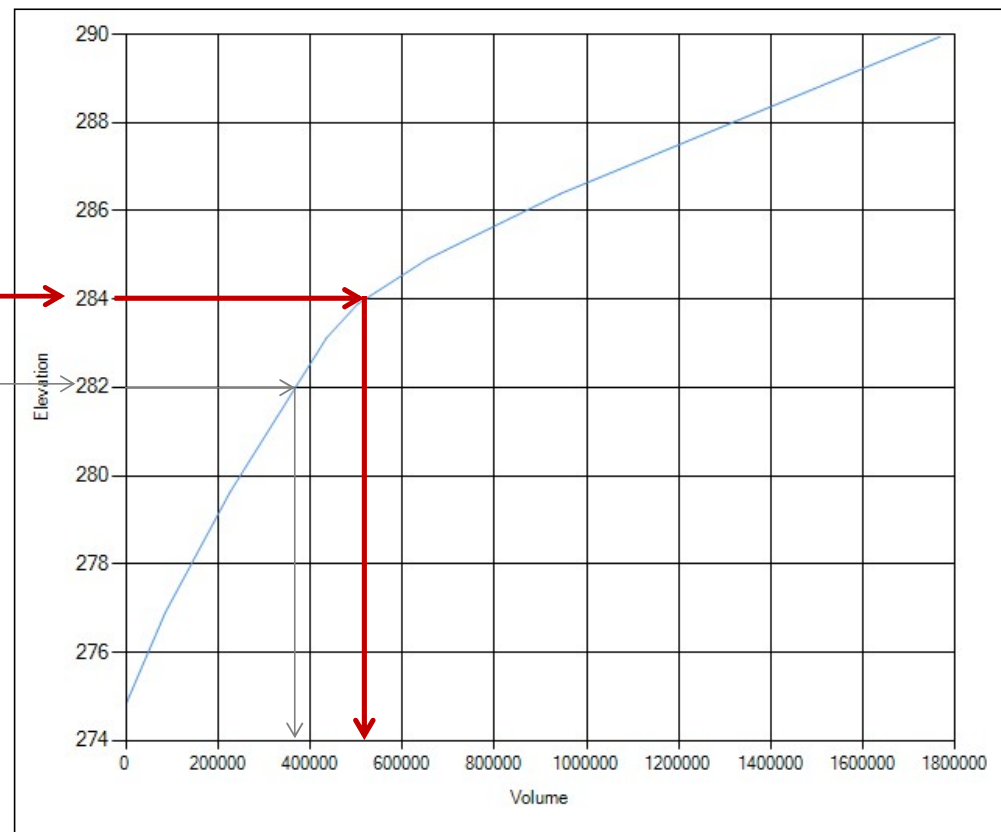
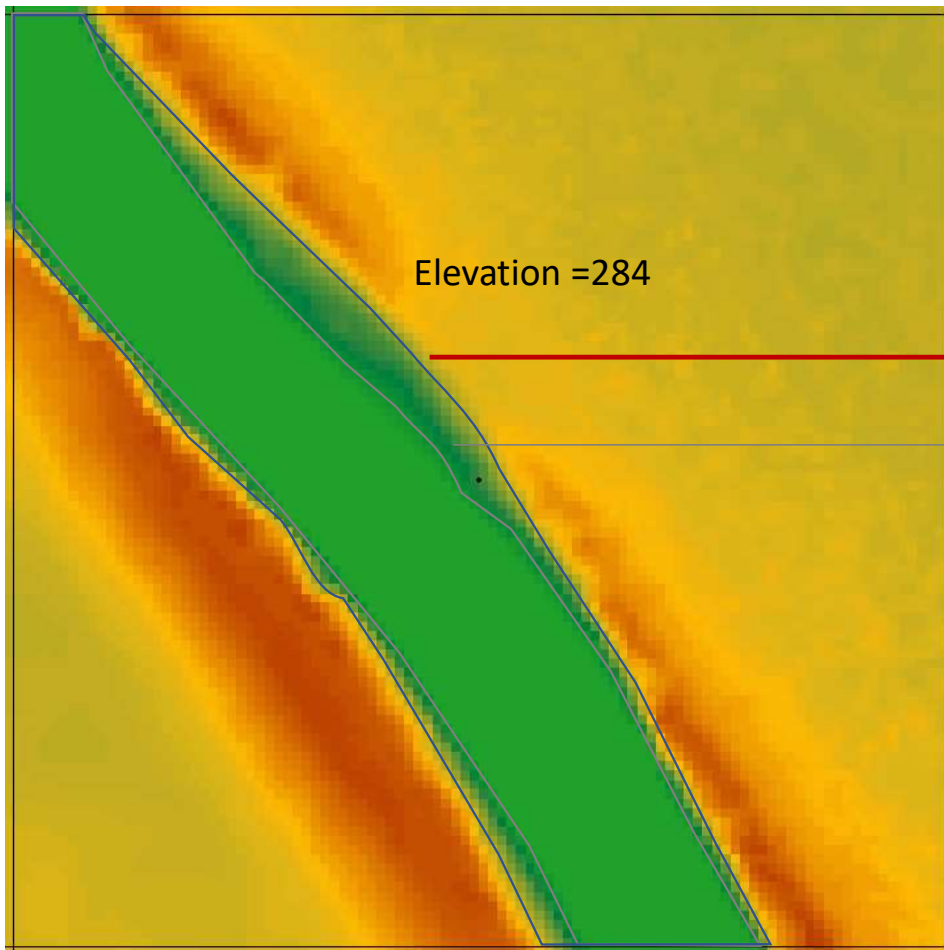


Computational Cells - Elevation vs. Volume





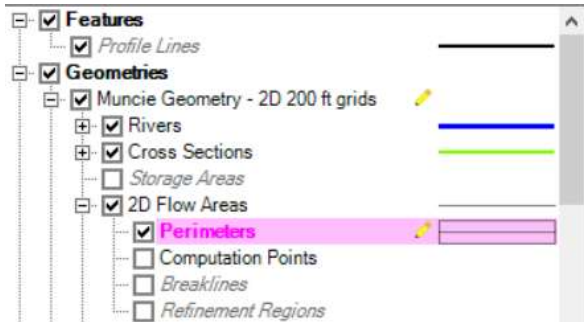
Computational Cells - Elevation vs. Volume



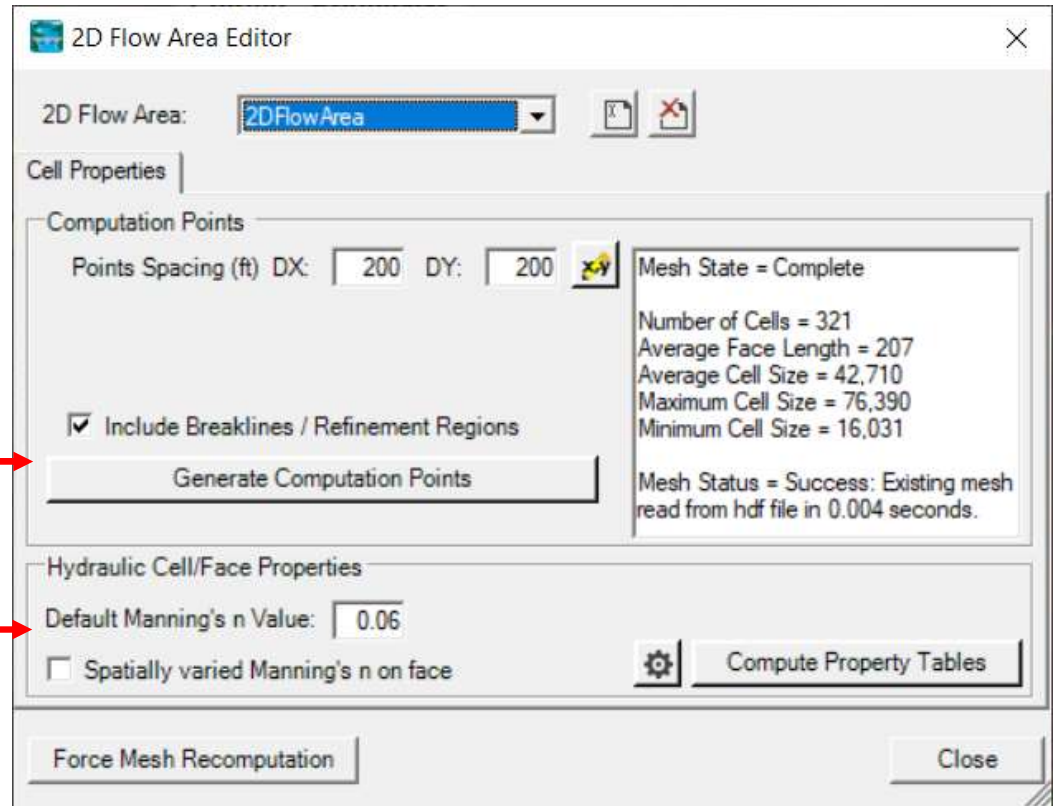
Subgrid = Higher fidelity cell volume tracking ³¹



2D Flow Areas



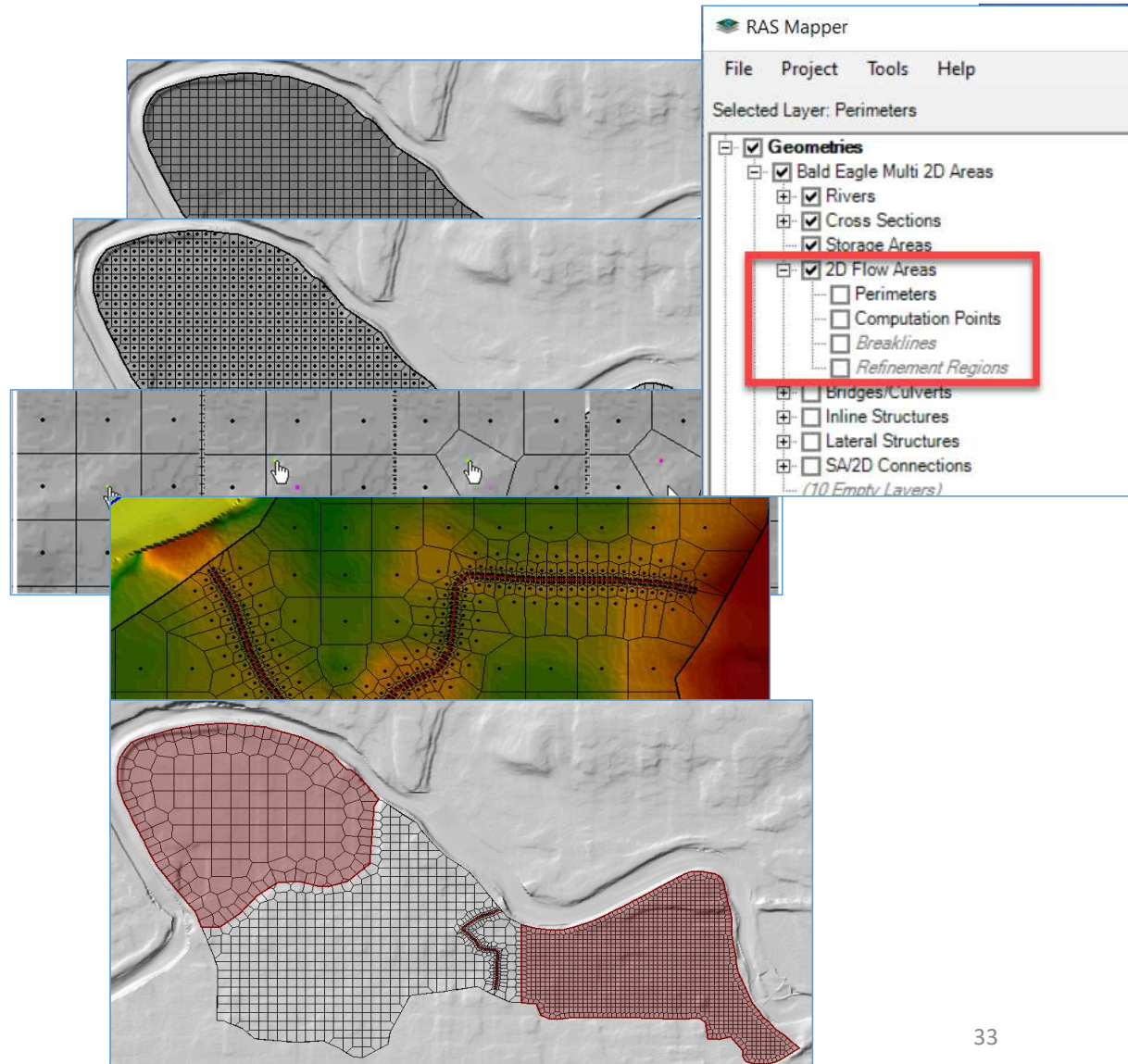
- Tools to autogenerate computation points
- Manning's n values
 - Single - or -
 - Spatially Varied





2D Flow Areas

- Perimeter
- Computation Points
- Breaklines
- Refinement Regions



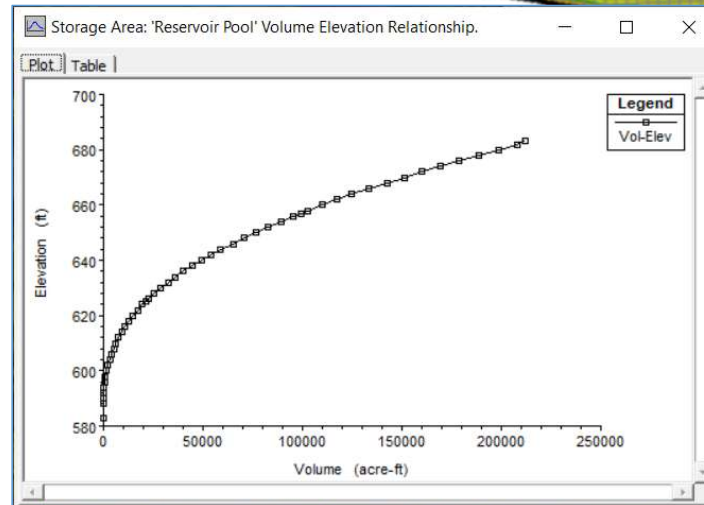
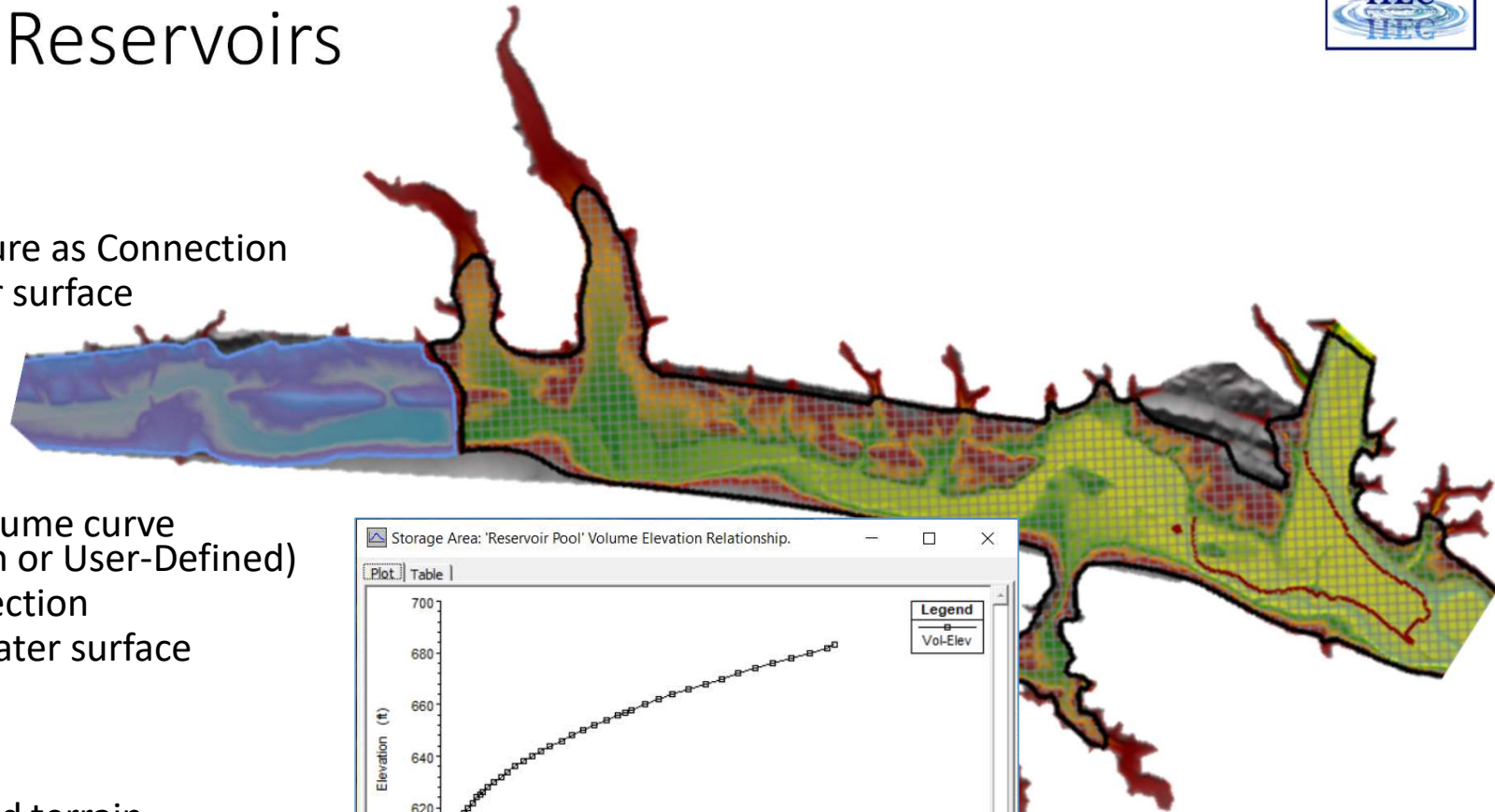


Modeling Reservoirs

- Cross Sections
 - Use Terrain
 - Inline Structure as Connection
 - Sloped water surface

- Storage Area
 - Elevation Volume curve (From Terrain or User-Defined)
 - SA/2D Connection
 - Horizontal water surface

- 2D Flow Area
 - Requires good terrain
 - 2D Connection
 - Sloped water surface



Questions?

