

HEC-RAS 2D

Mesh Generation and Refinement

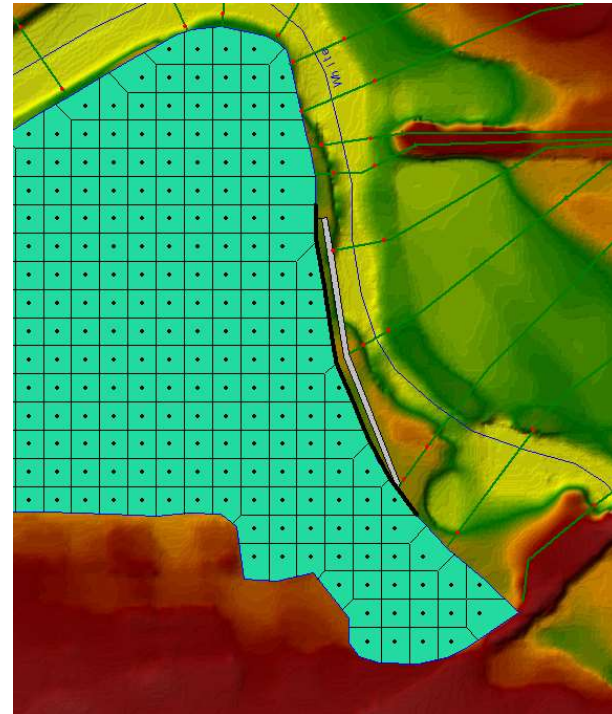
Cameron Ackerman, P.E., BC.WRE

USACE, Institute for Water Resources, Hydrologic Engineering Center



Overview

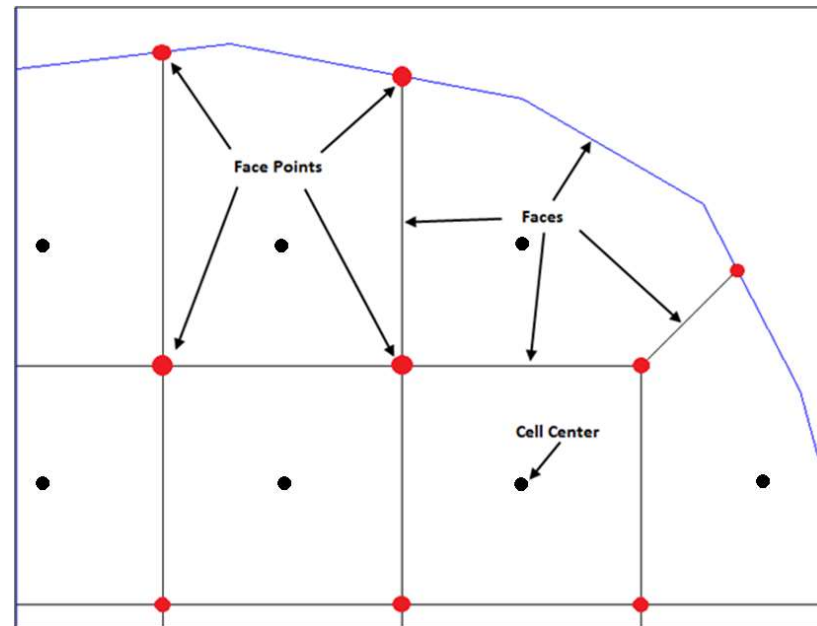
- Common Terms
- How to Create a Mesh
- Limitations
- Fixing Mesh Problems
- Hydraulic Property Tables





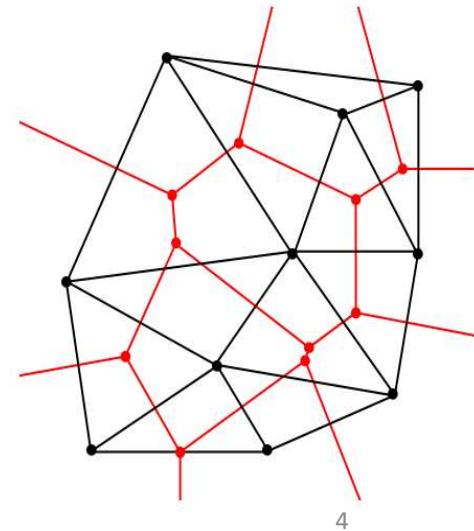
Finite Volume Mesh

- Naming Convention
 - Cells
 - Face Points
 - Faces
 - Computation Points (center)



Mesh Generation

- Define mesh boundary and triangulate Computation Points (black dots)
- Face Points (red dots) are triangle circumcircle centers
- Faces (red lines) connect face points
- Faces are also “Enforced” with internal breaklines





Create 2D Flow Area Mesh in RAS Mapper

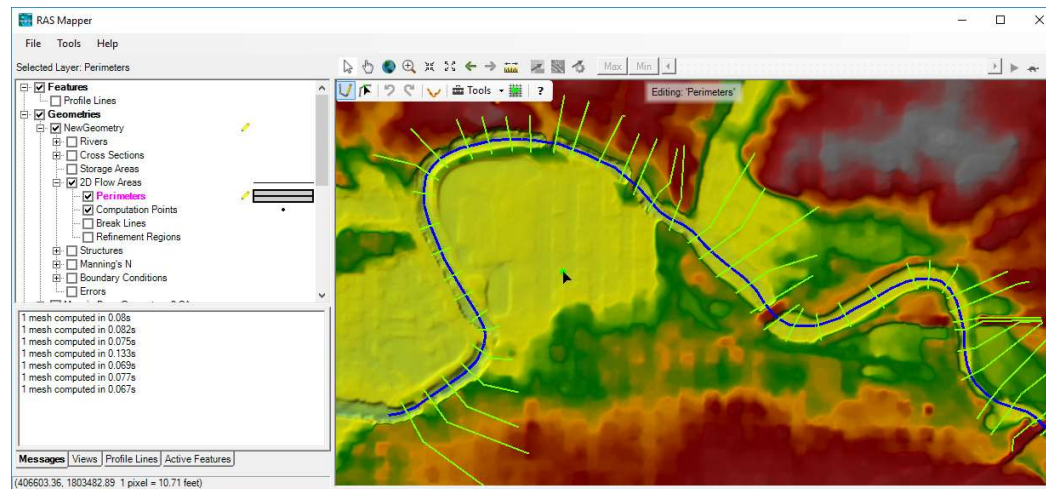
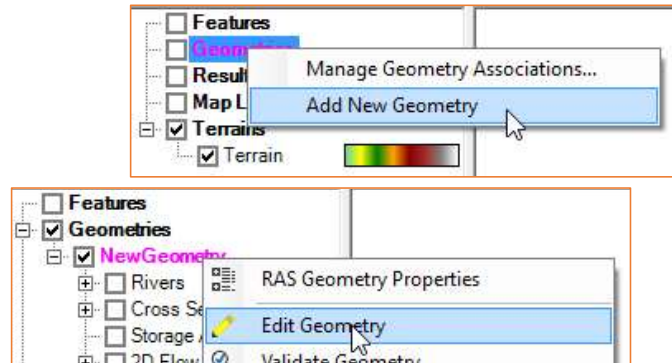
- Meshes are generated from a set of computation points with consideration to polygons and breaklines.
- Steps/Features used to create a mesh:
 - Perimeter Polygon
 - Computation Points
 - Breaklines (Optional)
 - Refinement Regions (Optional)
- Creating a good mesh is an iterative process!





Editor Access

- Create a New Geometry
- Edit Geometry
- Edit Toolbar
- Select Layer





Editing



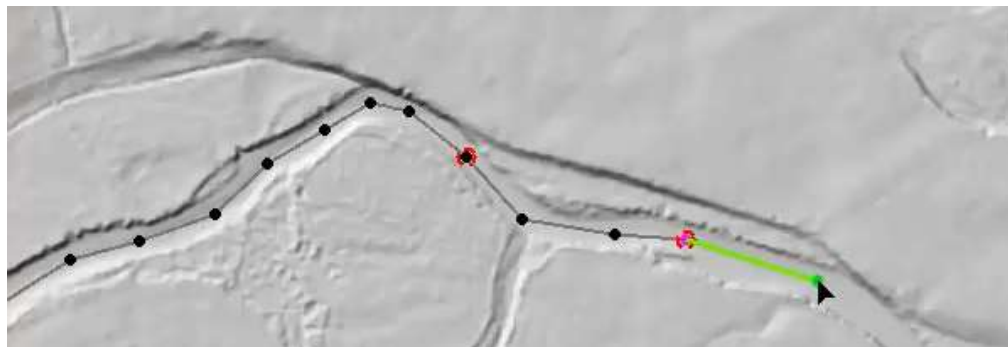
- Add New Feature
- Select/Edit Feature
- Undo/Redo
- Plot Profile
- Tools
- Help

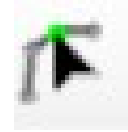




Add New Feature

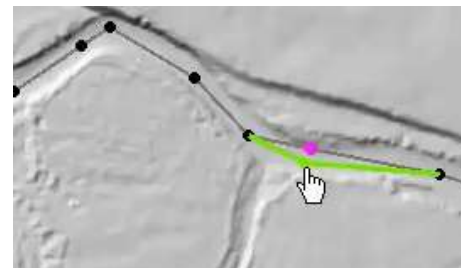
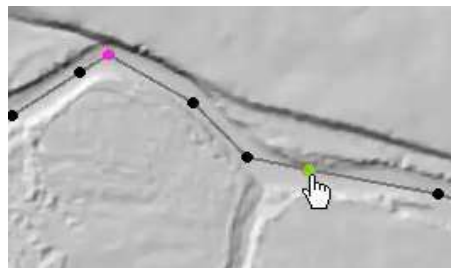
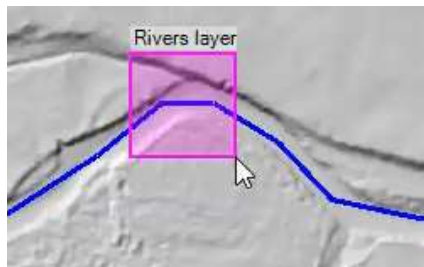
- Left-click to start adding a new point, line, or polygon
- Double-click to end a line or polygon
- Pan by switching to Pan tool, Shift key, Middle Mouse, or right-click to re-center.





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





2D Flow Area

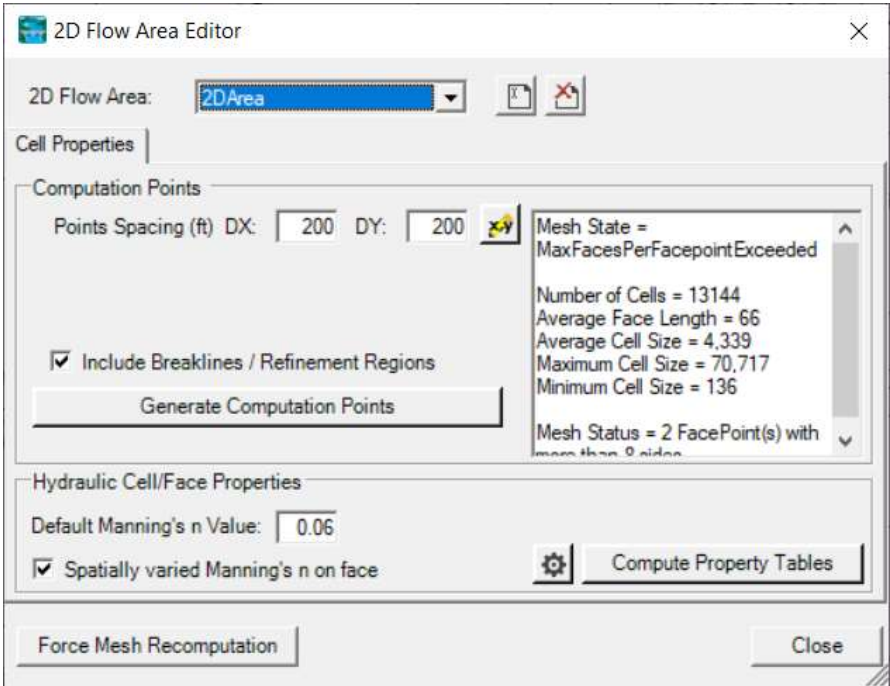
- Draw Perimeter



- ☒ 2D Flow Areas
 - ☒ Perimeters
 - ☐ Computation Points
 - ☐ Break Lines
 - ☐ Refinement Regions



- 2D Flow Area Editor





Computation Points

- Generate Computation Points at an even interval
 - Breaklines and Refinement Regions area enforced
- N Value (Default or Spatially Varied)
- Hydraulic Table Property Tolerances

- ☒ 2D Flow Areas
- ☒ Perimeters
- ☒ Computation Points
- ☐ Break Lines
- ☐ Refinement Regions



2D Flow Area Editor

2D Flow Area: 2DArea

Cell Properties

Computation Points

Points Spacing (ft) DX: 200 DY: 200

☒ Include Breaklines / Refinement Regions

Generate Computation Points

Mesh State = MaxFacesPerFacepointExceeded

Number of Cells = 13144
Average Face Length = 66
Average Cell Size = 4,339
Maximum Cell Size = 70,717
Minimum Cell Size = 136

Mesh Status = 2 FacePoint(s) with more than 8 sides

Hydraulic Cell/Face Properties

Default Manning's n Value: 0.06

☒ Spatially varied Manning's n on face

Compute Property Tables

Close

Hydraulic Property Table Tolerances

2D_Area

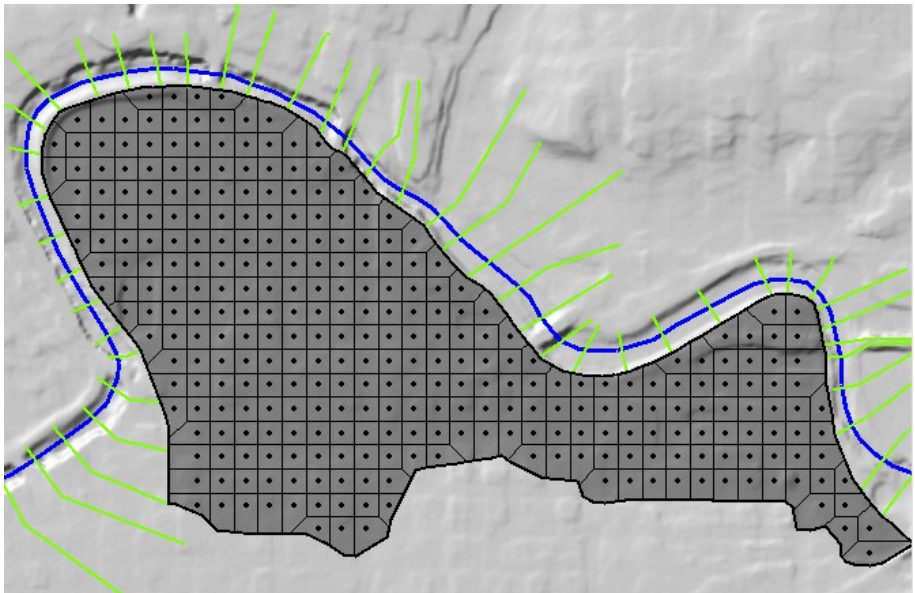
Set the 2D Flow Area's Cell and Face Filter Tolerances for the Hydraulic Table Computations.

Cell Elev-Vol Filter Tol (ft):	0.01
Cell Minimum Area Fraction:	0.01
Face Profile Filter Tol (ft):	0.01
Face Elev-Area Filter Tol (ft):	0.01
Face Conveyance Tol Ratio:	0.02
Face Laminar Depth (ft):	0.2

Defaults OK Cancel



Computation Points



- Mesh is generated from resultant set of computation points.

- ☒ 2D Flow Areas
- ☒ Perimeters
- ☒ **Computation Points**
- ☐ Break Lines
- ☐ Refinement Regions



Edit Points

Selected Area Edits

Table Tools

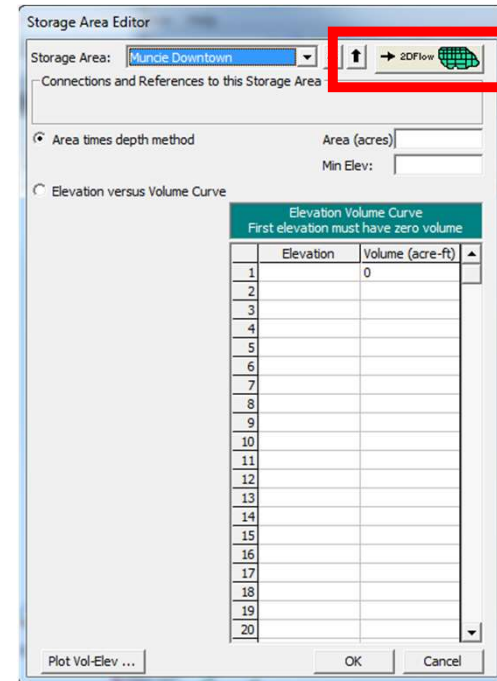
	X	Y
1	405880.1458	1804922.839
2	406080.1458	1804922.839
3	406280.1458	1804922.839
4	406480.1458	1804922.839
5	405280.1458	1804722.839
6	405480.1458	1804722.839
7	405680.1458	1804722.839
8	405880.1458	1804722.839
9	406080.1458	1804722.839
10	406280.1458	1804722.839
11	406480.1458	1804722.839
12	405080.1458	1804522.839
13	405280.1458	1804522.839
14	405480.1458	1804522.839
15	405680.1458	1804522.839
16	405880.1458	1804522.839
17	406080.1458	1804522.839
18	406280.1458	1804522.839

OK Cancel



Create 2D Flow Area Mesh from an existing Storage Area

- Converting Existing Storage Area
 - Click convert button



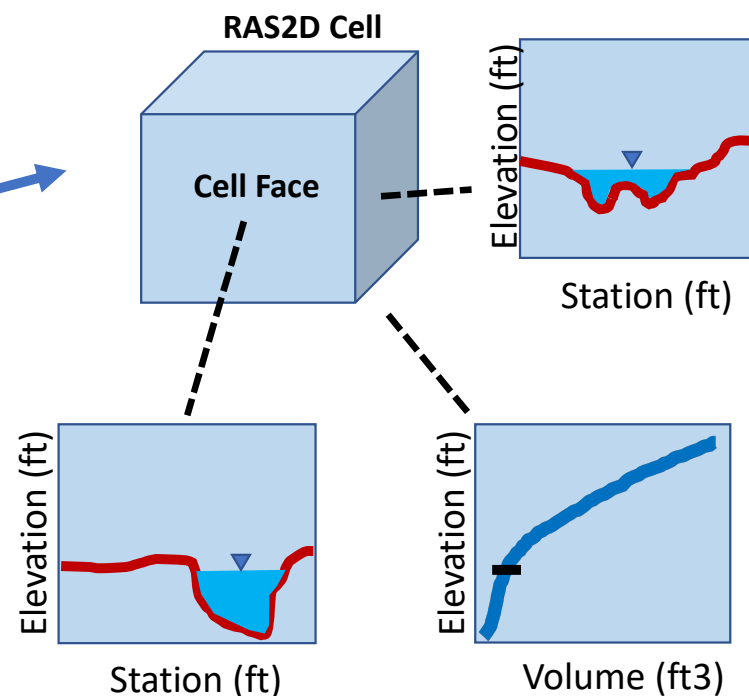
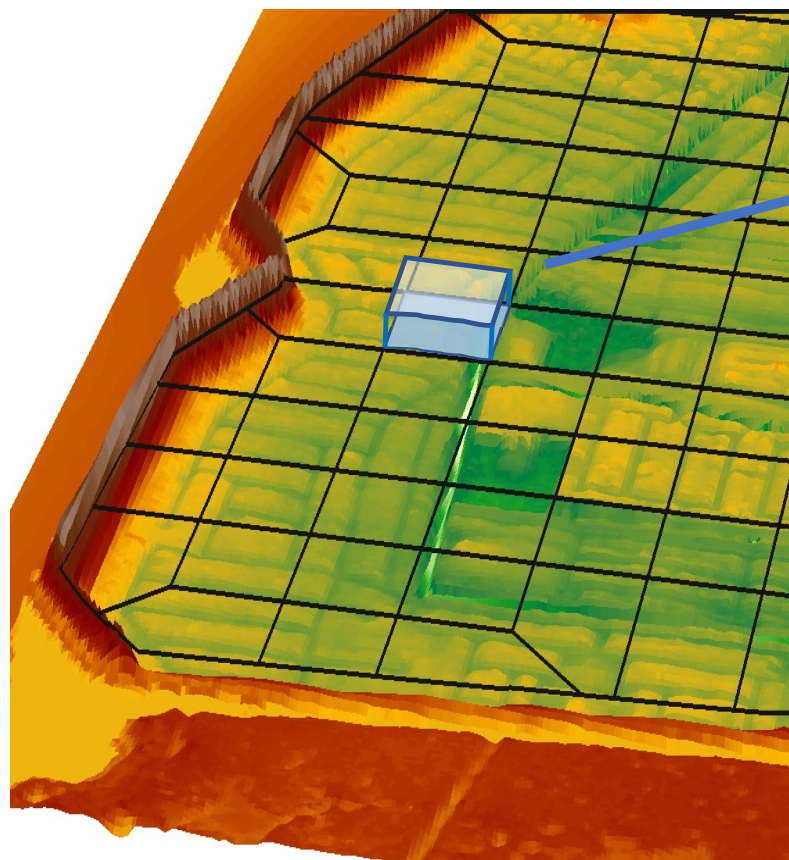


Hydraulic Property Tables

- Computation engine uses hydraulic property tables to represent the geometry of the system
- Cells
 - Elevation/Volume
- Faces
 - Elevation/Area
 - Elevation/Wetter Perimeter
 - Elevation/Manning's n
 - (all from station elevation profile)



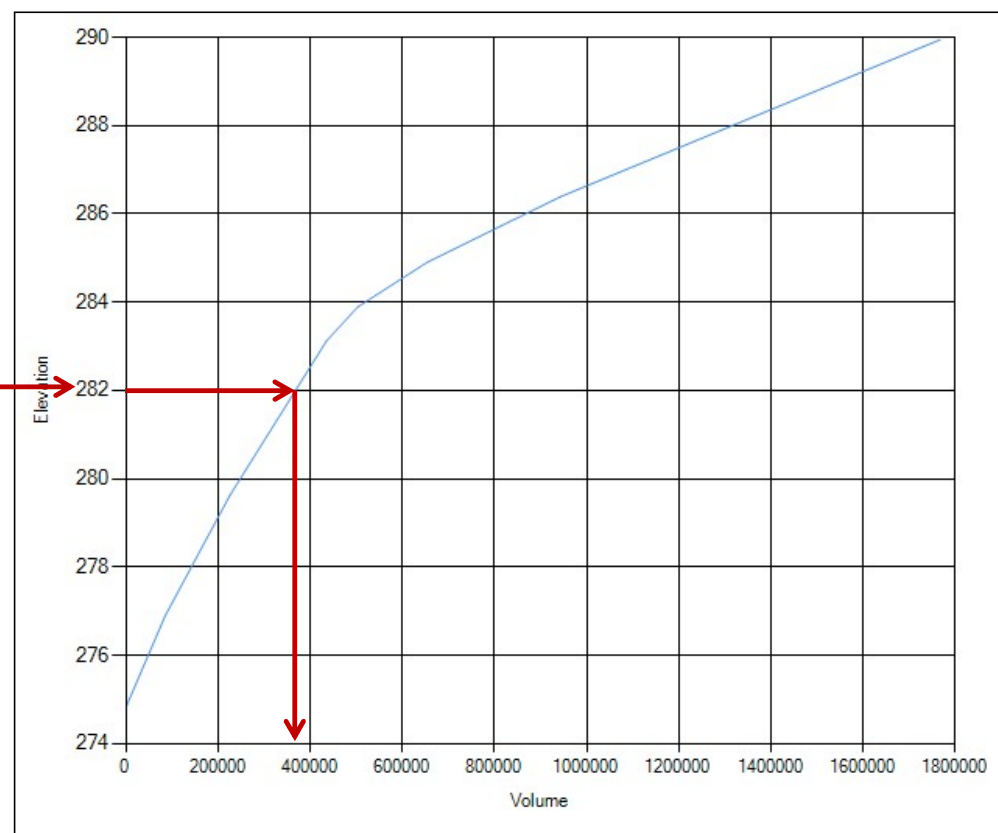
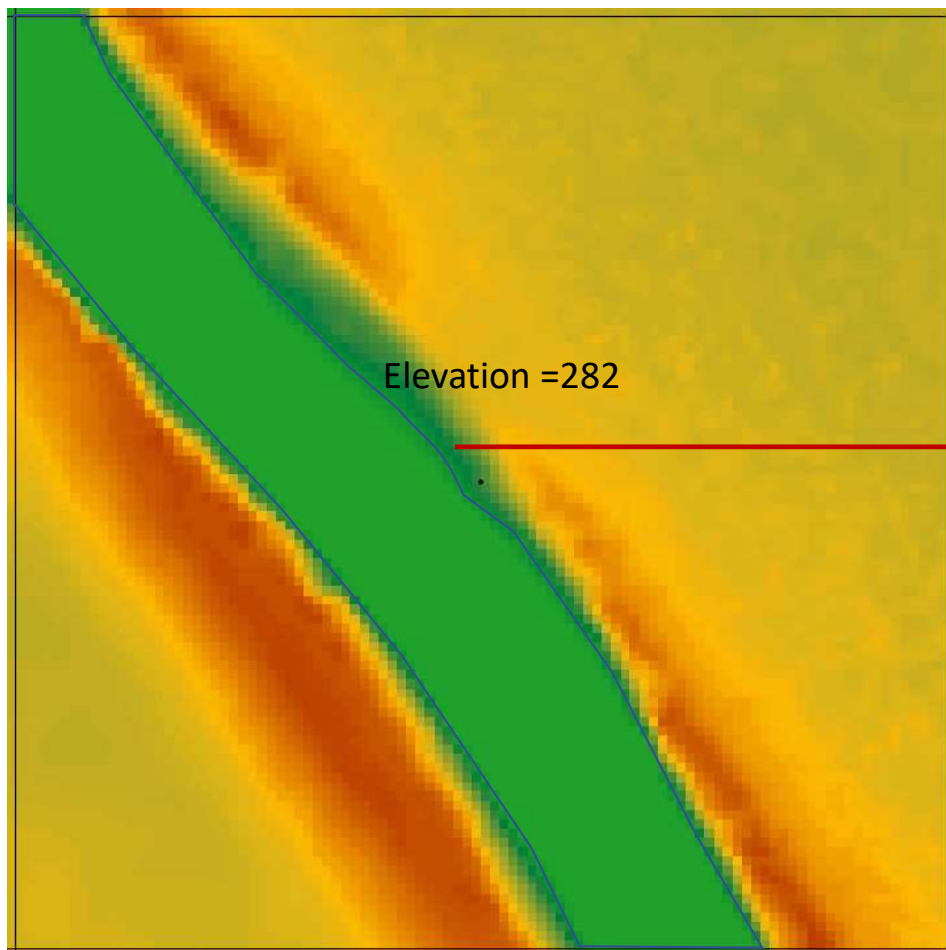
2D Computational Mesh Sub-grid Terrain



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.

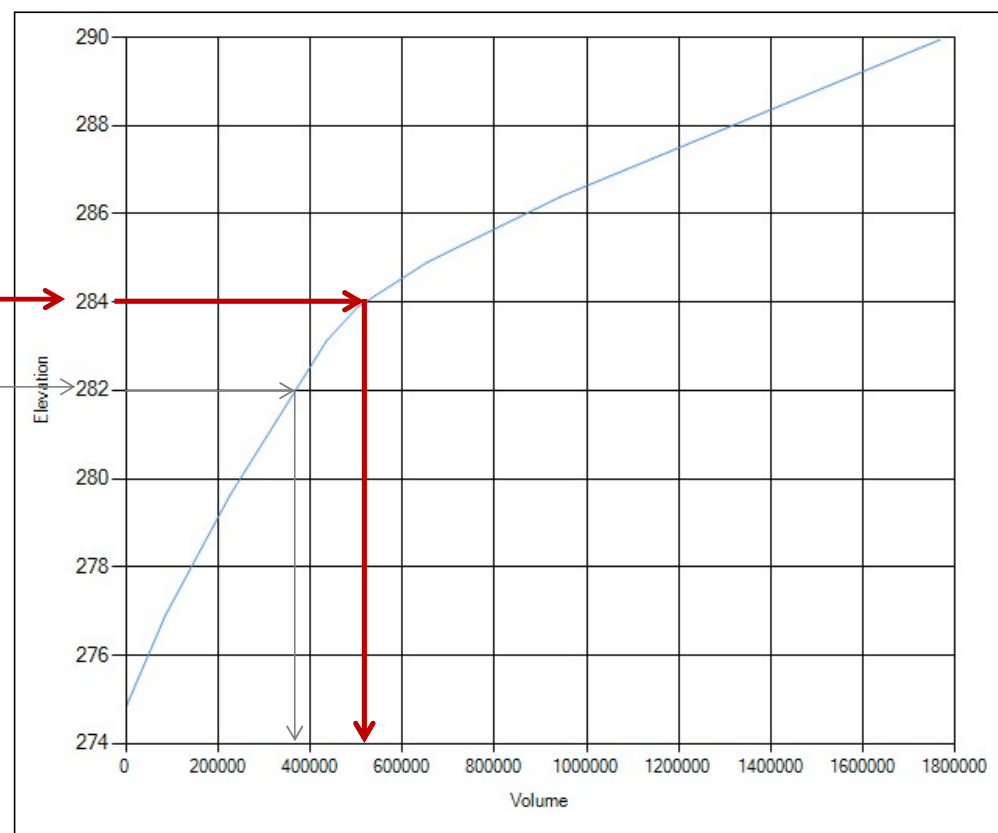
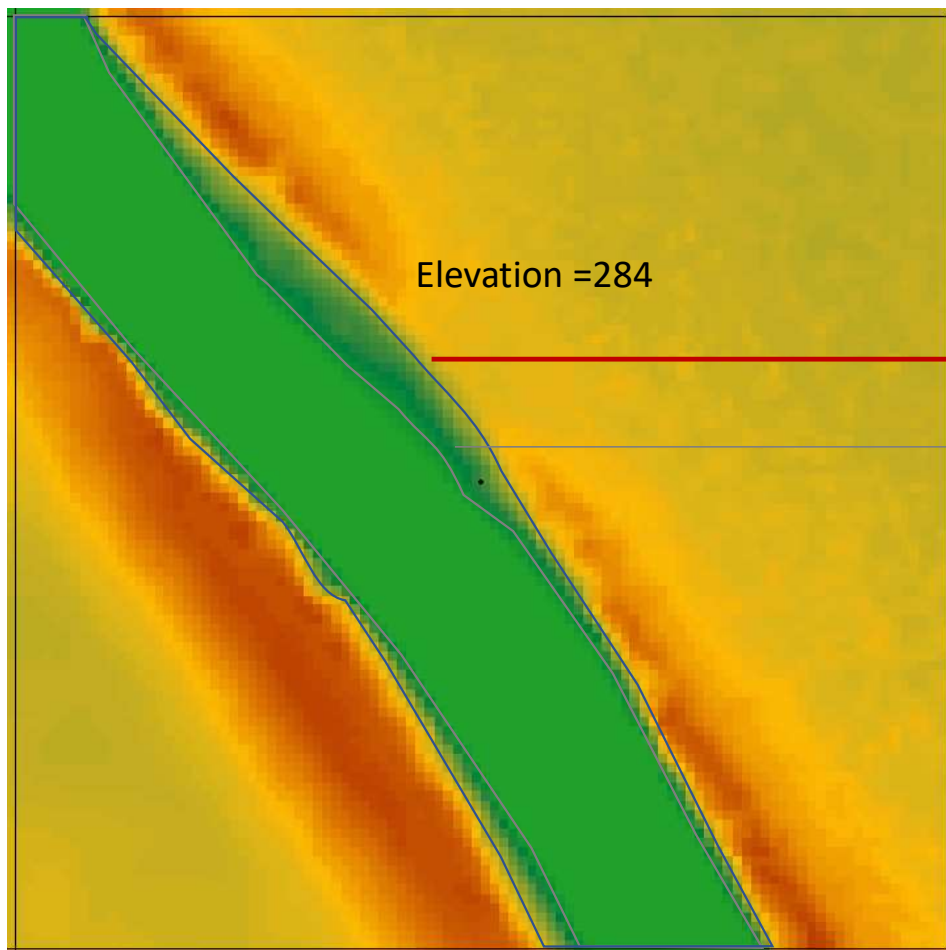


Computational Cells - Elevation vs. Volume





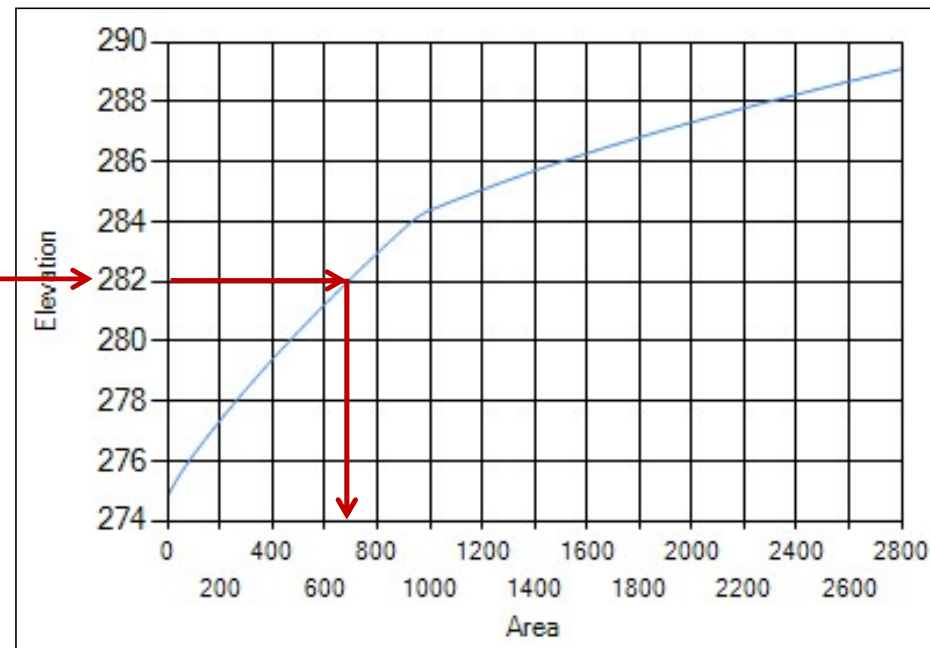
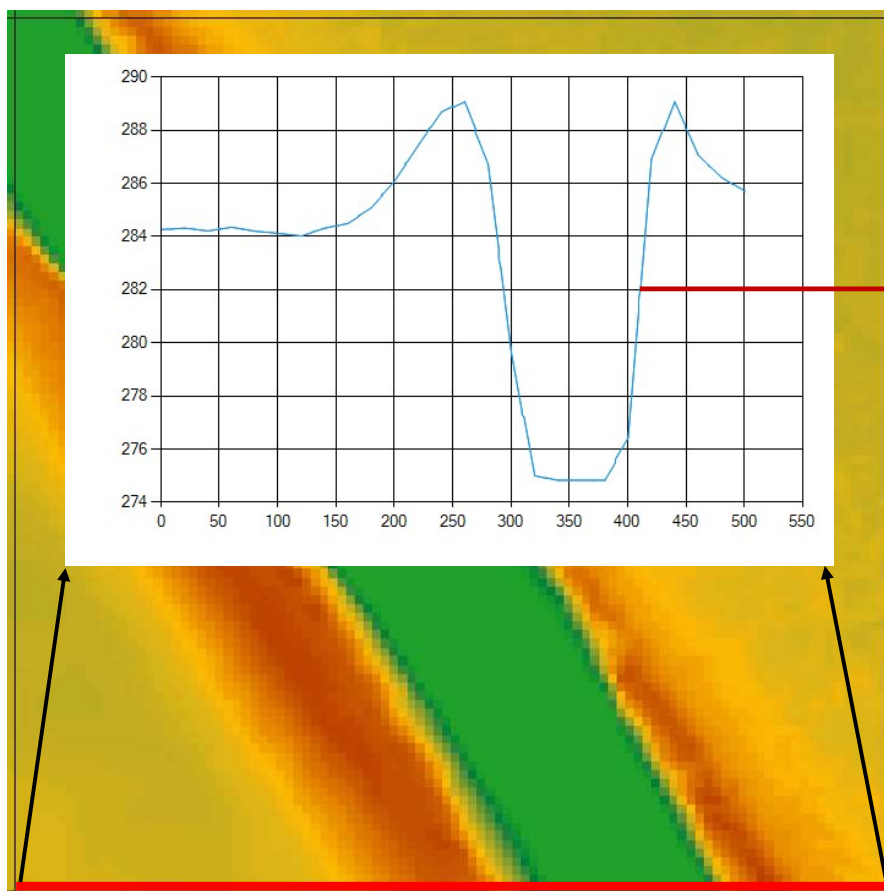
Computational Cells - Elevation vs. Volume



Subgrid = Higher fidelity cell volume tracking ¹⁷



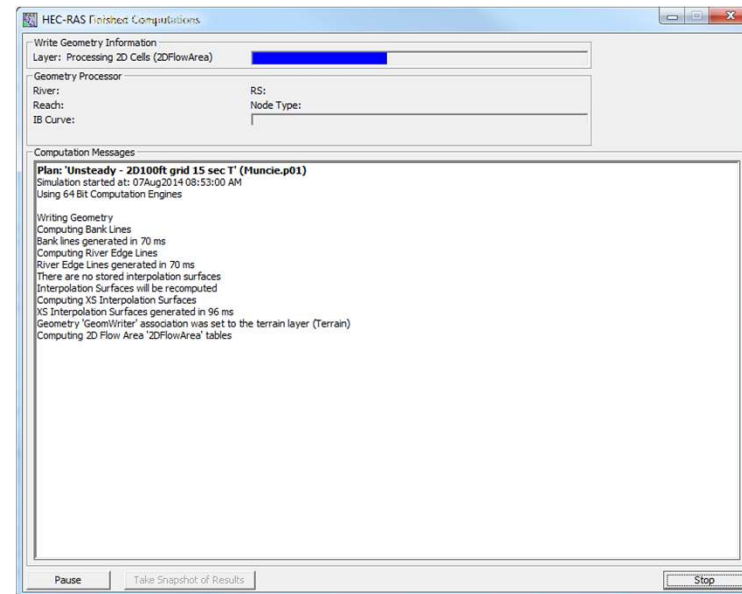
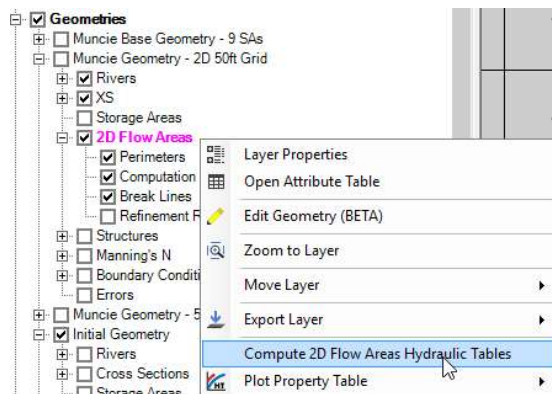
Computational Faces - Elevation vs. Area



Faces = Control flow into and out of cell
Can model small channels in with large cells

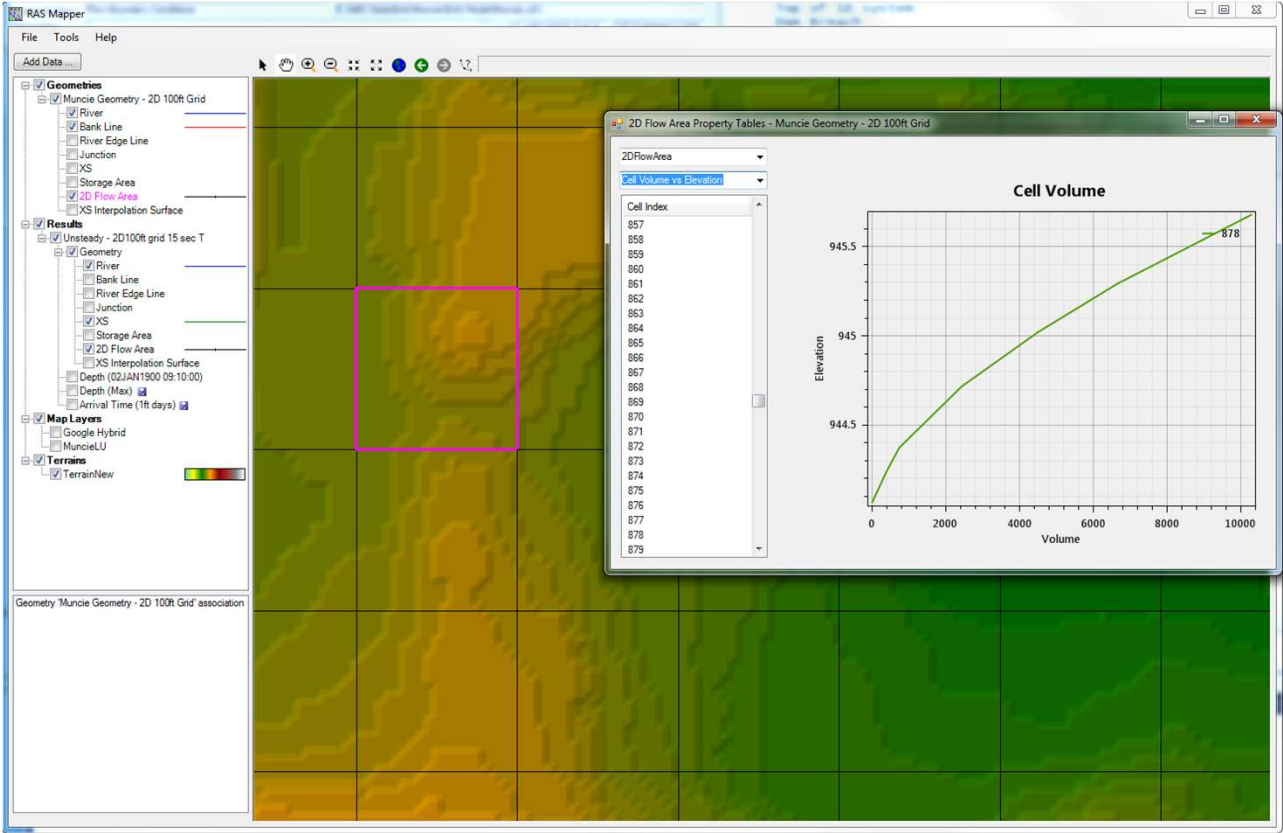
Hydraulic Property Tables

- Computed (once and stored in geometry *.hdf)
 - From RAS Mapper
 - Before unsteady-flow simulation





Cells

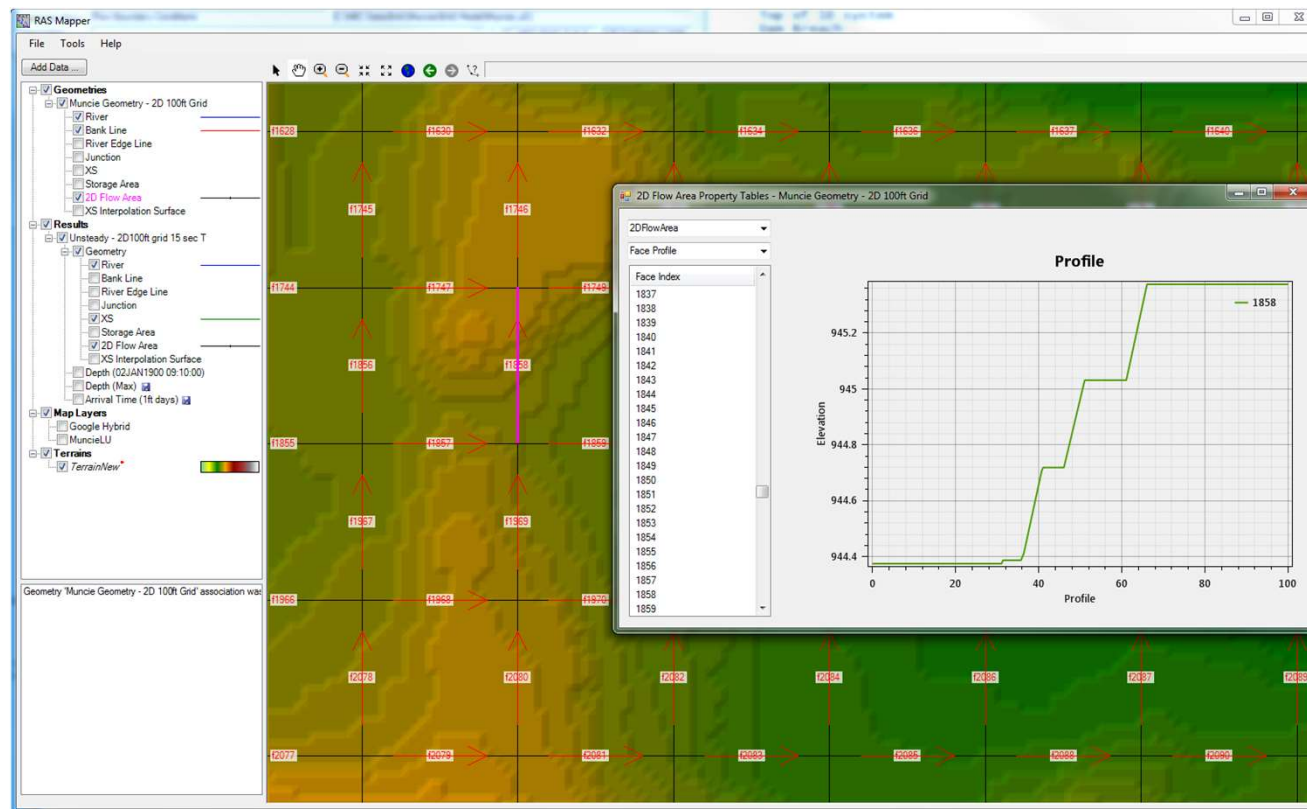




The screenshot displays the RAS Mapper application window. On the left, the 'Layers' panel shows a tree view with categories: Geometries, Results, Map Layers, and Terrain. Under 'Geometries', 'Muncie Geometry - 2D 100ft Grid' is expanded, showing sub-layers like River, Bank Line, River Edge Line, Junction, XS, Storage Area, 2D Flow Area (checked), and XS Interpolation Surface. The main map area shows a topographic background with a grid of red arrows indicating flow direction. A color scale bar is visible on the right side of the map. Overlaid on the map is the '2D Flow Area - Layer Properties' dialog box. This dialog has two tabs: 'Visualization and Information' and 'Features'. The 'Visualization and Information' tab is active, showing settings for Point Symbol, Line Style, Fill Style, Surface Color Style (Color Ramp), and Label Features. The 'Additional Options' section on the right lists various visualization options, with 'Mesh Cell Numbers' and 'Mesh Face Point Numbers' checked. The 'Source File' path is listed at the bottom: 'C:\IHEC Data\RAS\Muncie\RAS Model\Muncie.g01.hdf'.

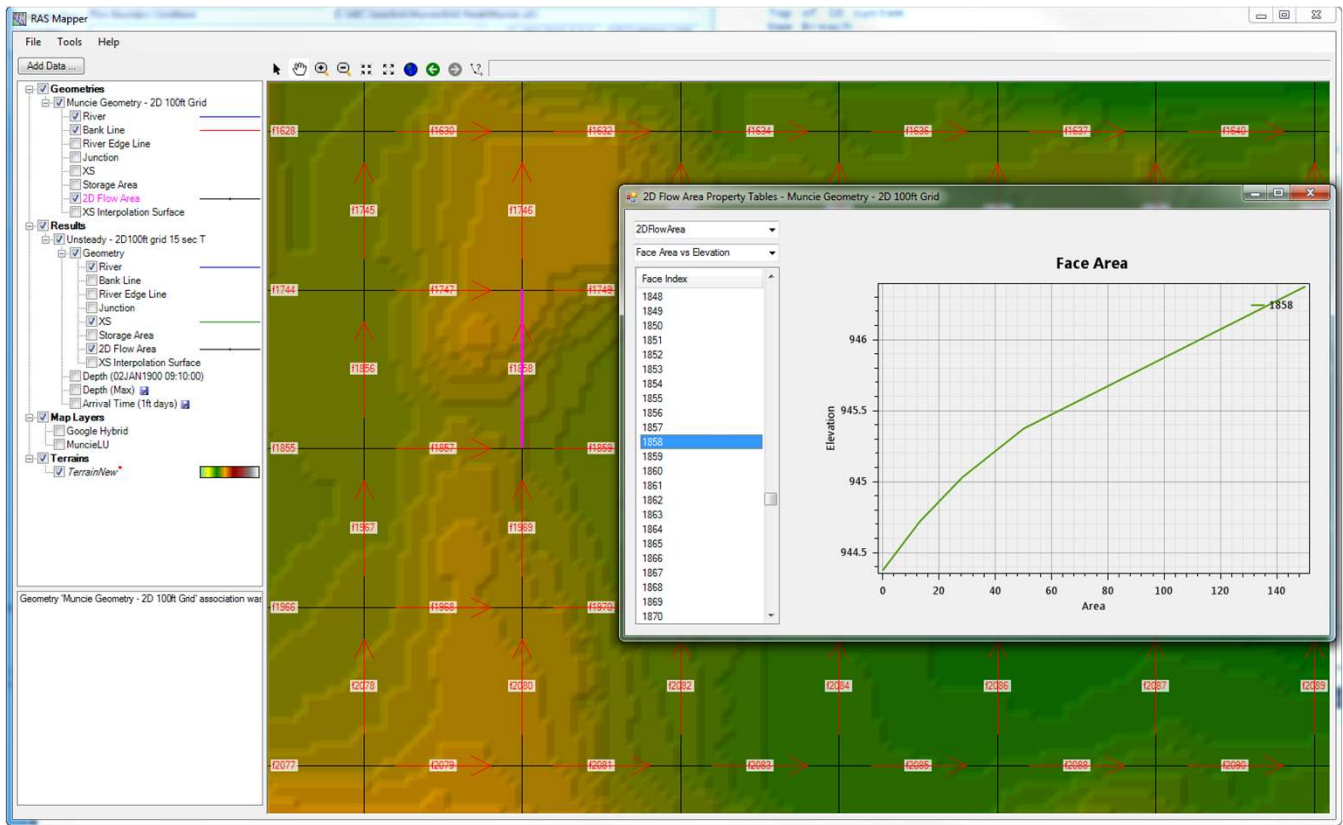


Face Profile





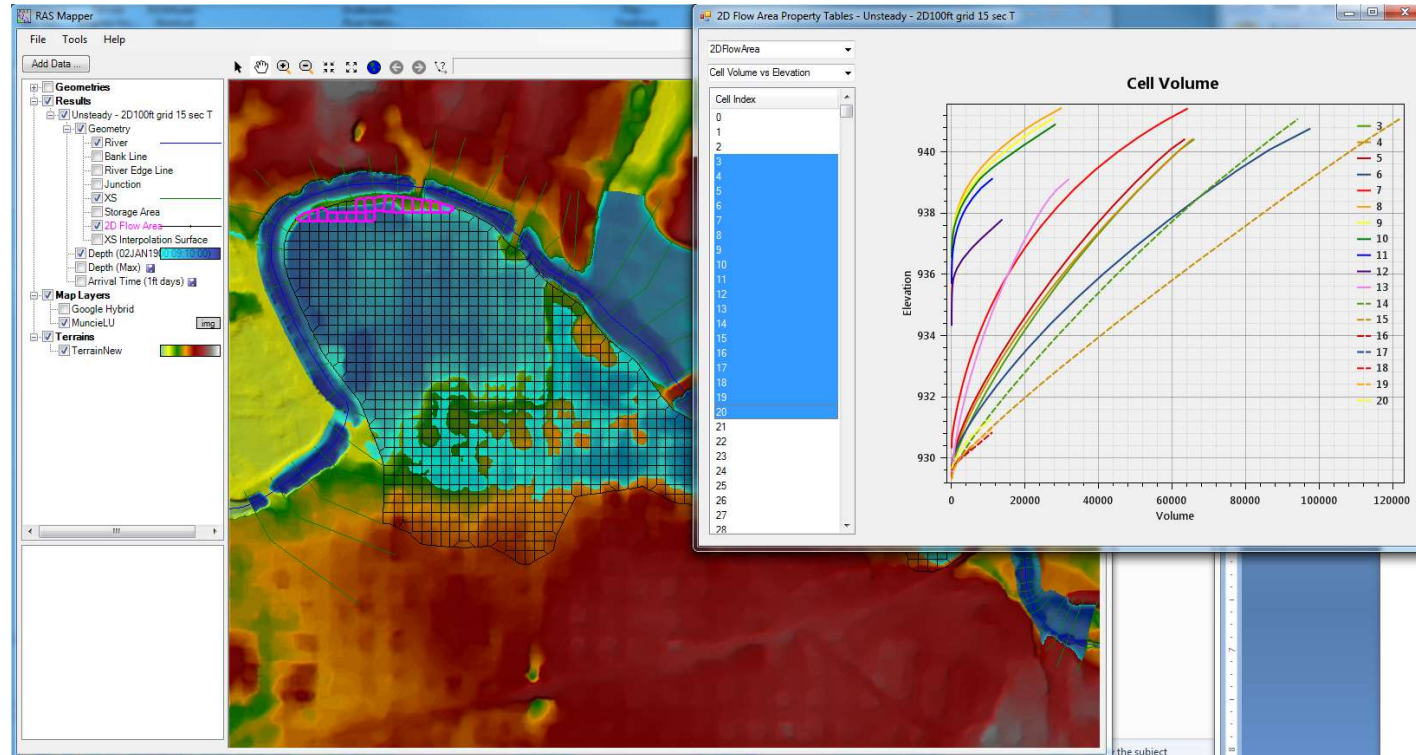
Face Elevation vs Area





Hydraulic Property Tables

- View from RAS Mapper - '2DFlow Area' in 'Geometry' or 'Results'





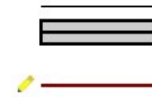
Mesh Limitations

- One face between cells – even on perimeter
- Only one boundary condition per Face
- Except for Lateral structures
 - Lateral structures can stop and start on the same 2D external Face, when connecting 1D reach to a 2D area.

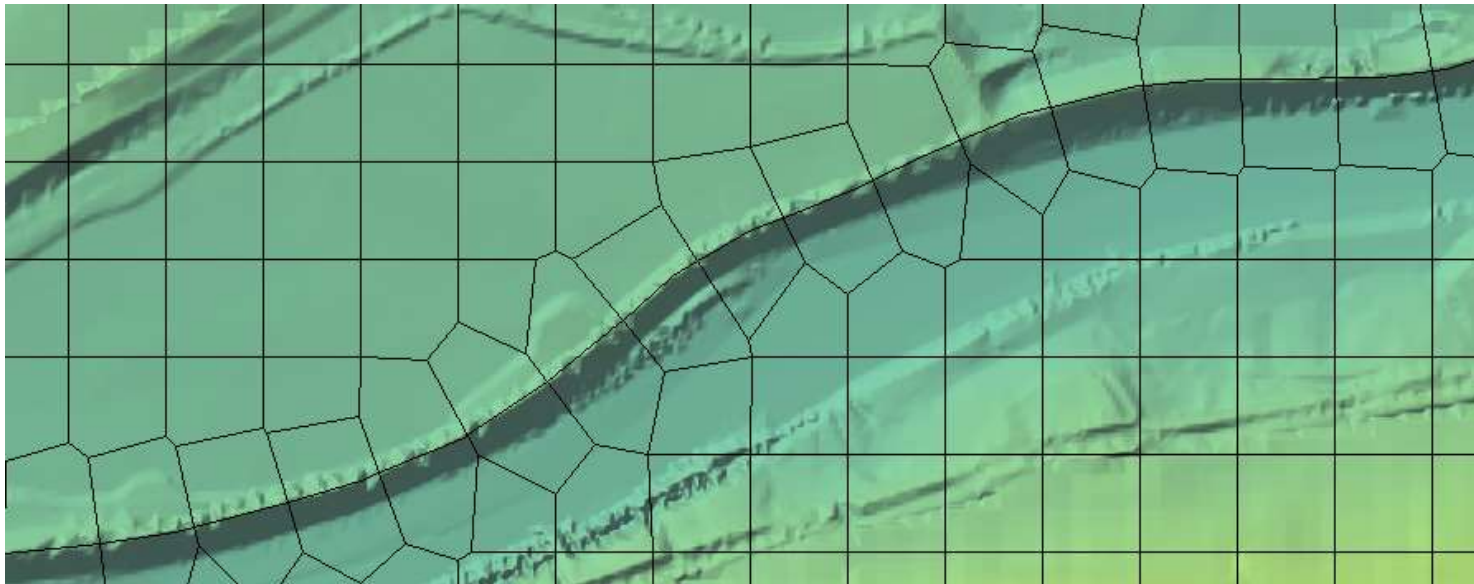


Breaklines

- ☒ 2D Flow Areas
- ☒ Perimeters
- ☐ Computation Points
- ☒ Break Lines
- ☐ Refinement Regions



- Breaklines enforce Cell Faces inside of the Mesh.
- Place along linear features that control water movement





Breaklines

- “Snapping” is part of mesh generation
 - Faces snap to breaklines if they are close enough
- “Enforcing” changes the cell points around a breakline
 - Improves the snapping of the 2D faces to the breaklines
 - Not perfect, might require tighter cell spacing and/or hand graphical editing



Breakline Properties

- Near Spacing – Initial cell size (approx.) along the breakline.
 - Default value is 2D Area point spacing
- Near Repeats – Repeats cell insertion using Near Spacing a multiple away from the breakline.
- Far Spacing – Max cell size (approx.) of newly added cells.
 - Default value is 2D Area point spacing
- Enforce 1 Cell Protection Radius – Once enforced cells near to the breakline will not be removed through the enforcement of additional breaklines.
 - Include cells added/edited by hand.

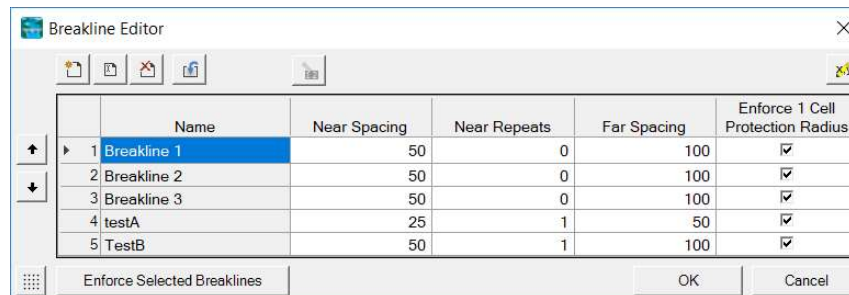
	Name	Near Spacing	Near Repeats	Far Spacing	Enforce 1 Cell Protection Radius
1	Breakline 1	50	0	100	<input checked="" type="checkbox"/>
2	Breakline 2	50	0	100	<input checked="" type="checkbox"/>
3	Breakline 3	50	0	100	<input checked="" type="checkbox"/>
4	testA	25	1	50	<input checked="" type="checkbox"/>
5	TestB	50	1	100	<input checked="" type="checkbox"/>

Enforce Selected Breaklines OK Cancel



Breakline Process

- All points within a computed buffer are removed.
- Cells are added uniformly along the side of breakline.
- Buffer for point removal is computed as:
Near Spacing * Near Repeats
+ Double Near Spacing size n times until reach Far Spacing size
(However, take 75% of last cell size so as to not delete too far)



	Name	Near Spacing	Near Repeats	Far Spacing	Enforce 1 Cell Protection Radius
1	Breakline 1	50	0	100	<input checked="" type="checkbox"/>
2	Breakline 2	50	0	100	<input checked="" type="checkbox"/>
3	Breakline 3	50	0	100	<input checked="" type="checkbox"/>
4	testA	25	1	50	<input checked="" type="checkbox"/>
5	TestB	50	1	100	<input checked="" type="checkbox"/>

Enforce Selected Breaklines OK Cancel

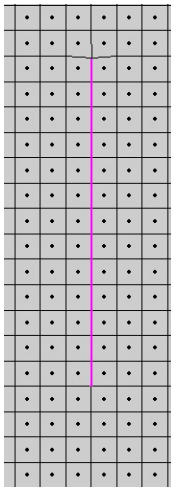
- A breaklines' area of influence is stopped by a neighboring breakline (will not proceed to opposite side).



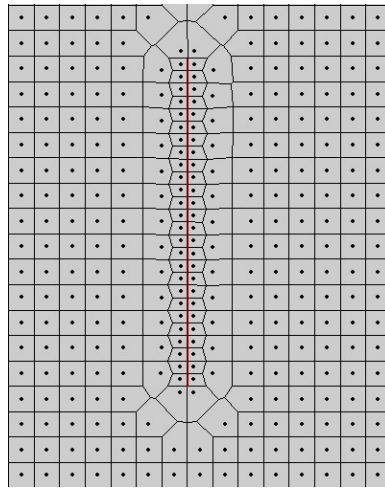
Breakline Examples

- Grid spacing = 100

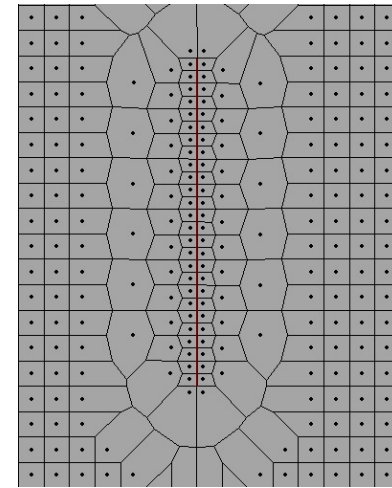
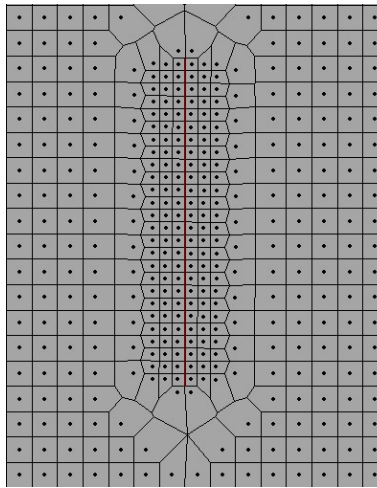
Near Spacing	Near Repeats	Far Spacing
50		



Near Spacing	Near Repeats	Far Spacing
50	2	

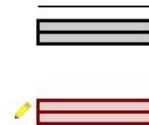


Near Spacing	Near Repeats	Far Spacing
50		200





- ☒ 2D Flow Areas
 - ☒ Perimeters
 - ☐ Computation Points
 - ☐ Break Lines
 - ☒ Refinement Regions



Refinement Regions

- Cell Size X,Y – Internal cell size dimension
- Perimeter is treated like a breakline
 - Perimeter Spacing, Near Repeats, Far Spacing, Cell Protection same as for breaklines
- Internal cell size used for perimeter spacing, if not defined

Refinement Region Editor

	Name	Cell Size X	Cell Size Y	Perimeter Spacing	Near Repeats	Far Spacing	Enforce 1 Cell Protection Radius
1	Region 1	50	50	100			<input checked="" type="checkbox"/>

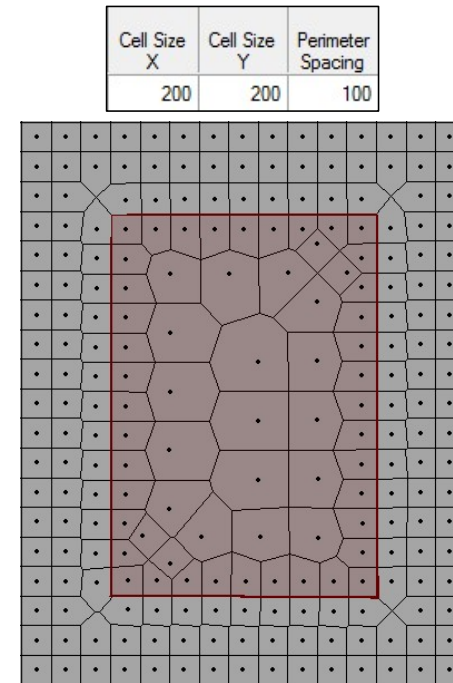
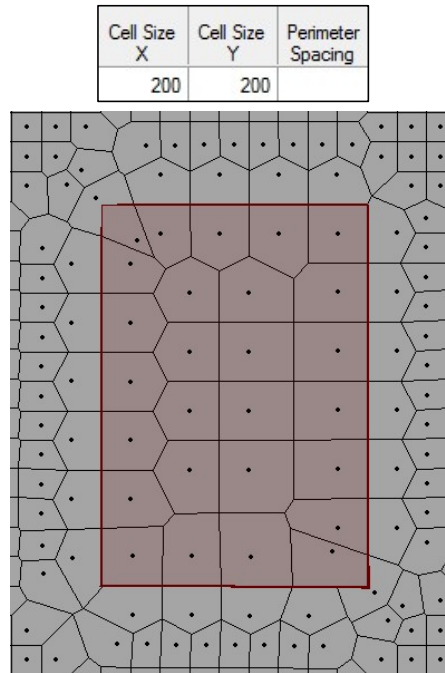
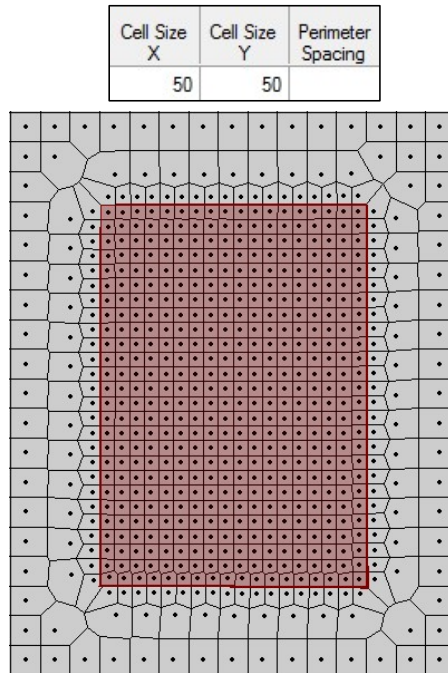
Enforce Selected Regions

OK Cancel



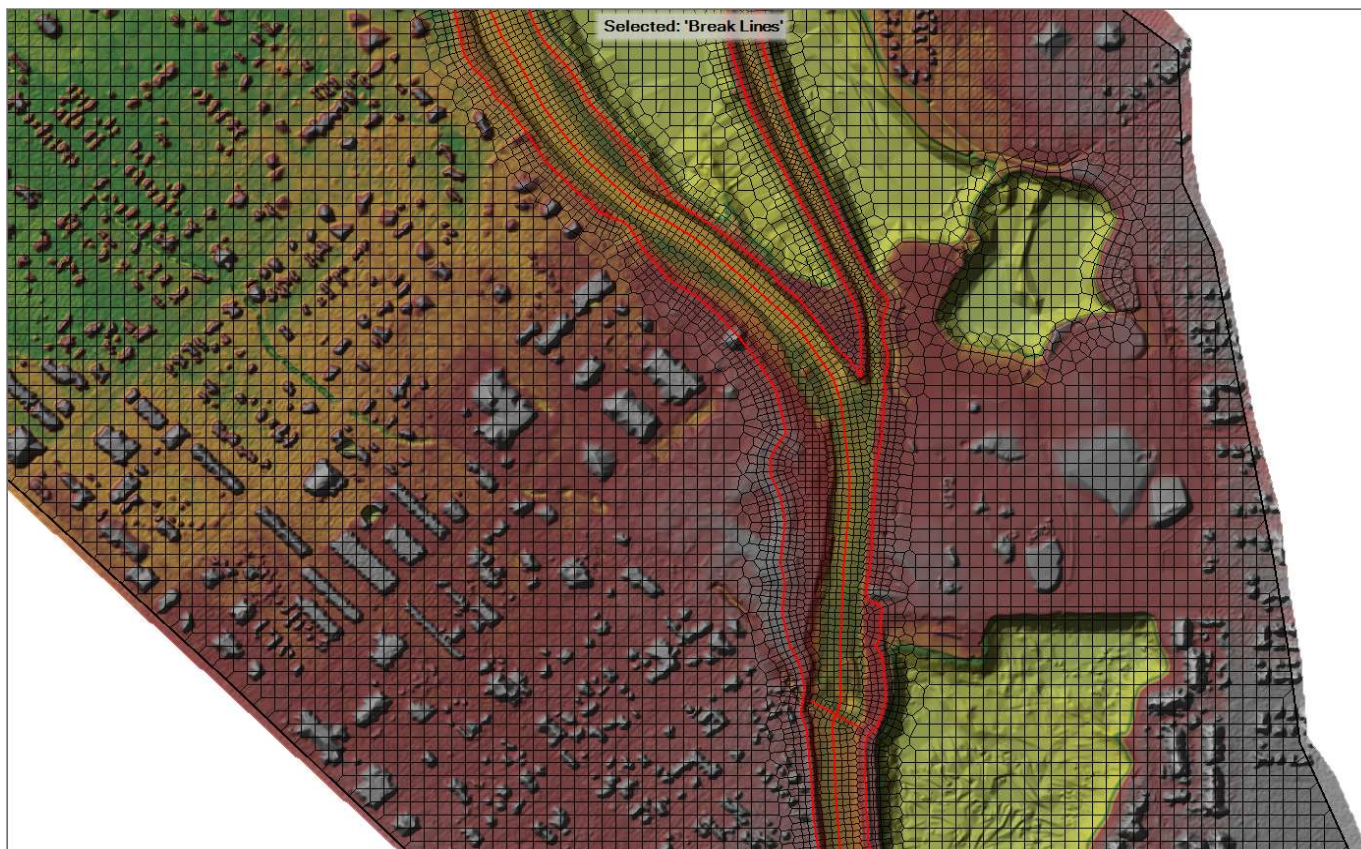
Refinement Examples

- Grid spacing = 100





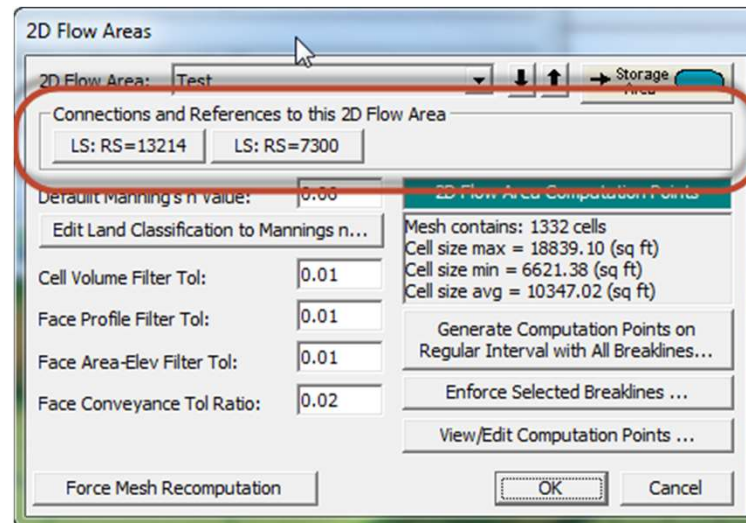
Refinement Regions and Break Lines to Align Channel Cells





2D Flow Area Editor Geometry Editor

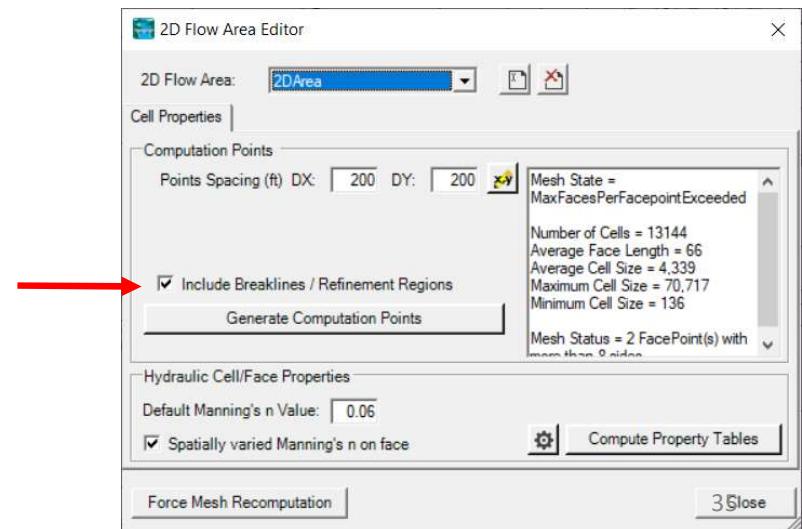
- Connections
 - Similar to Storage Area
 - Quick Link to Connections





Computation Points

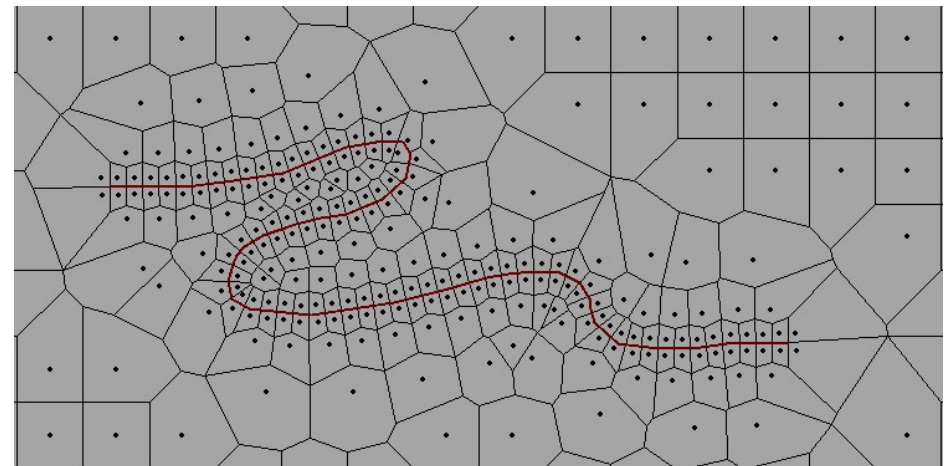
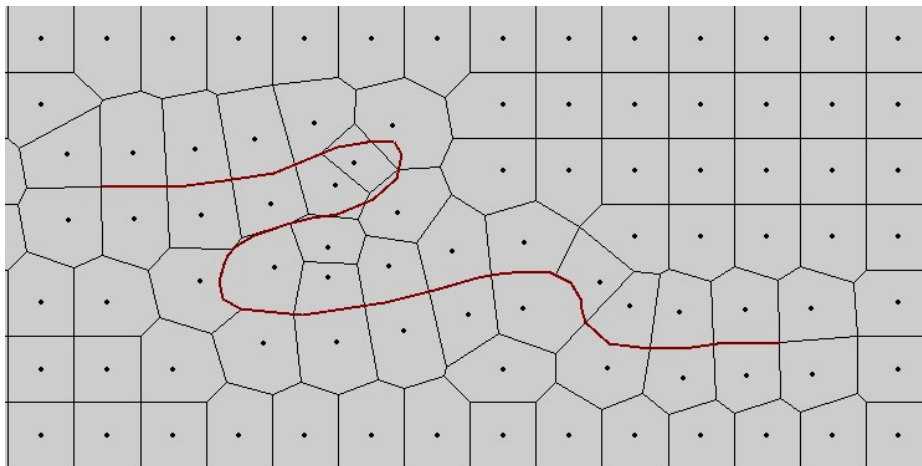
- Final mesh is based on final computation point set.
- Enforcement of Breaklines and Refinement Regions modifies existing computation points.
- Can enforce a breakline once, change parameters and enforce again.
 - Each iteration modifies the previous points.
- Point Regeneration will automatically use Breaklines and Refinement Regions (if included).





Fixing Problems

- If cell spacing is too large, cell faces may not be enforced



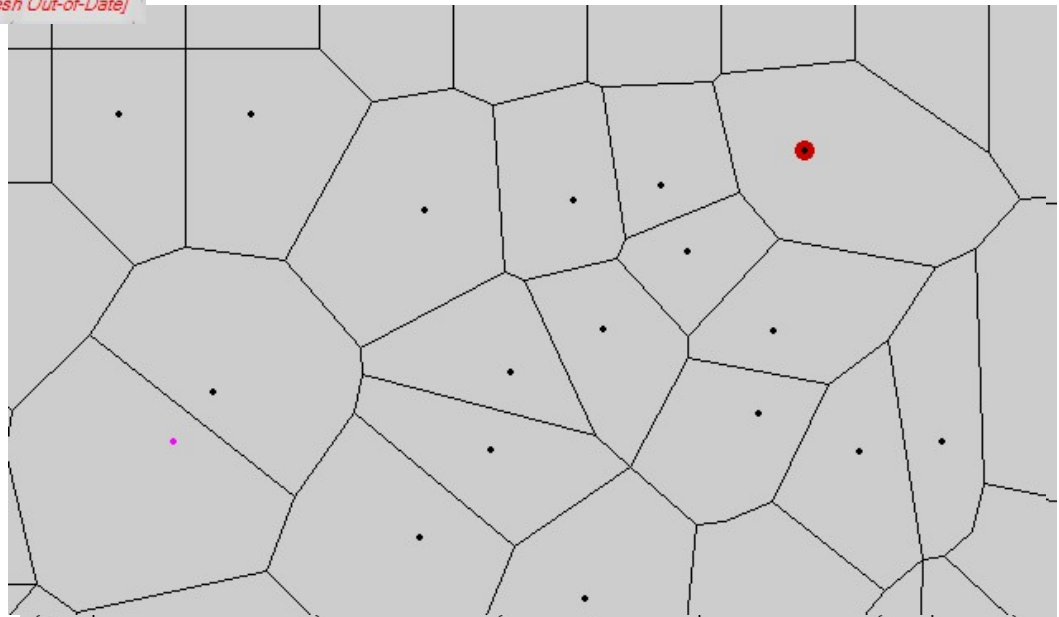


Fixing Problems

- More than 8 sides on a cell.

2D_Area: 2 Error(s) - Maximum 8 Faces per Cell [Displaying Local Mesh] [Full Mesh Out-of-Date]

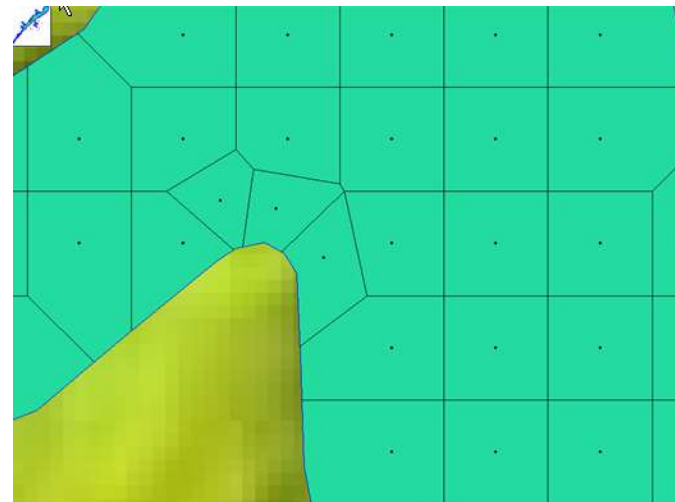
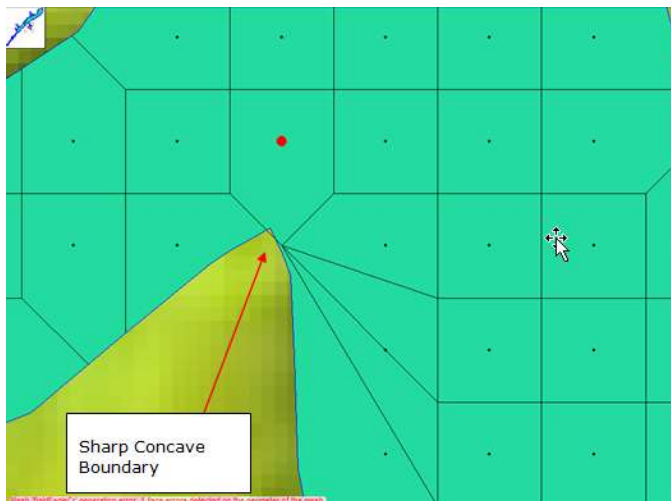
- Fix by Hand
- Auto “Try Fix” menu option





Fixing Problems

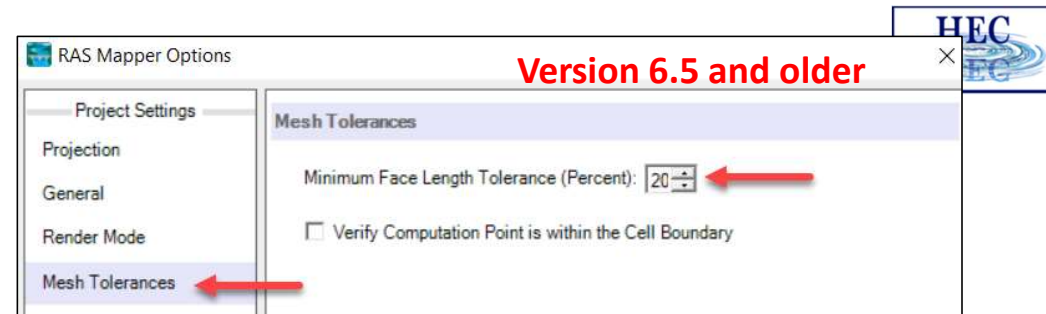
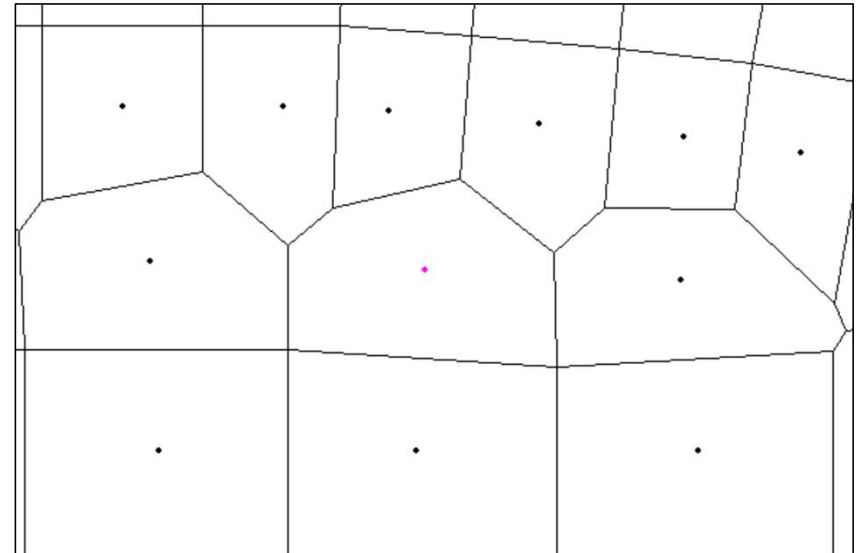
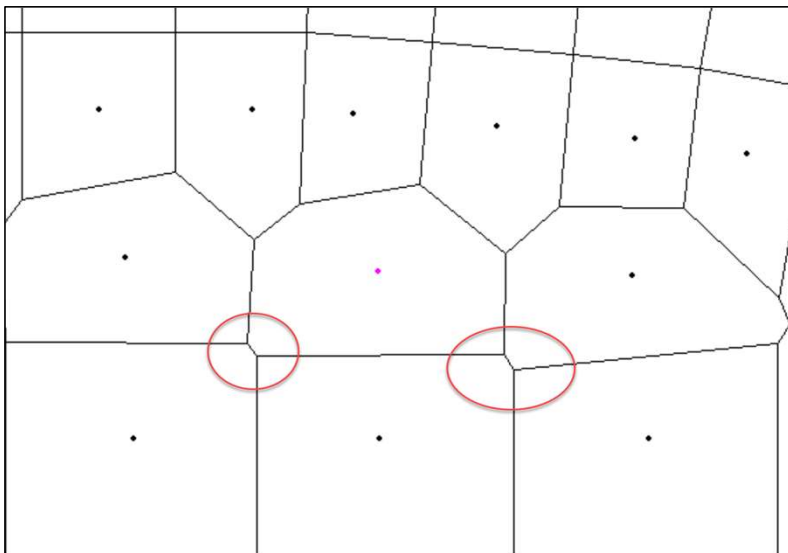
- Cells need to have exactly one Computation Point (Black Dot)
- Fix graphically by adding more points and/or moving points near perimeter





Mesh Tolerances

- Minimum Face Length (%)
 - 5% is Default, Recommend increasing - – done on the attribute table (6.6)

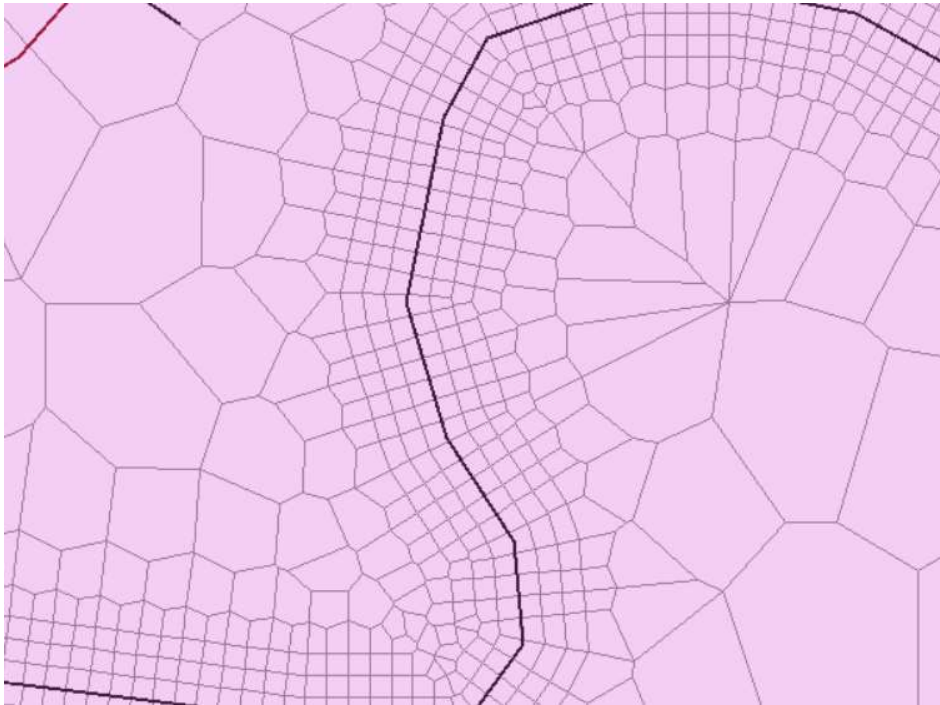




Face Tolerance



- Small Face Tolerance



- Larger Face Tolerance

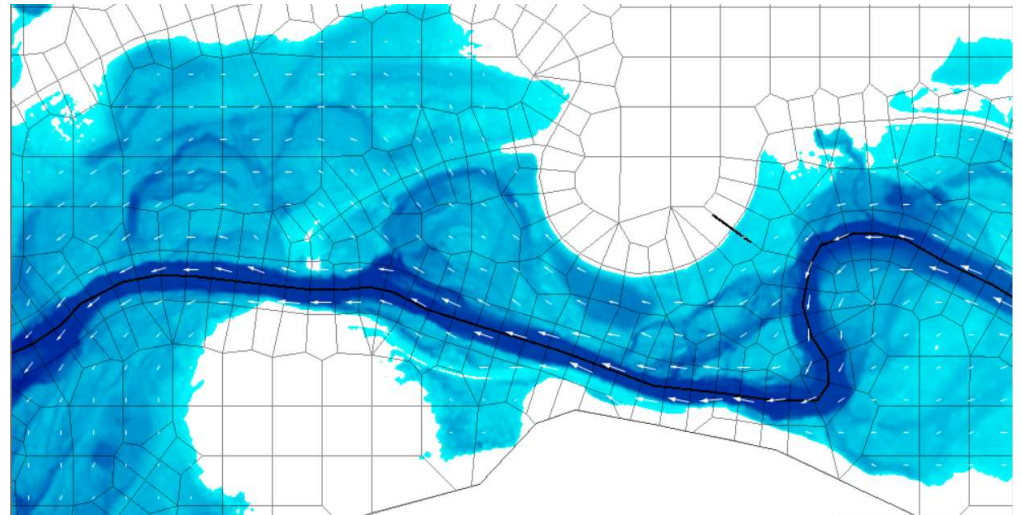
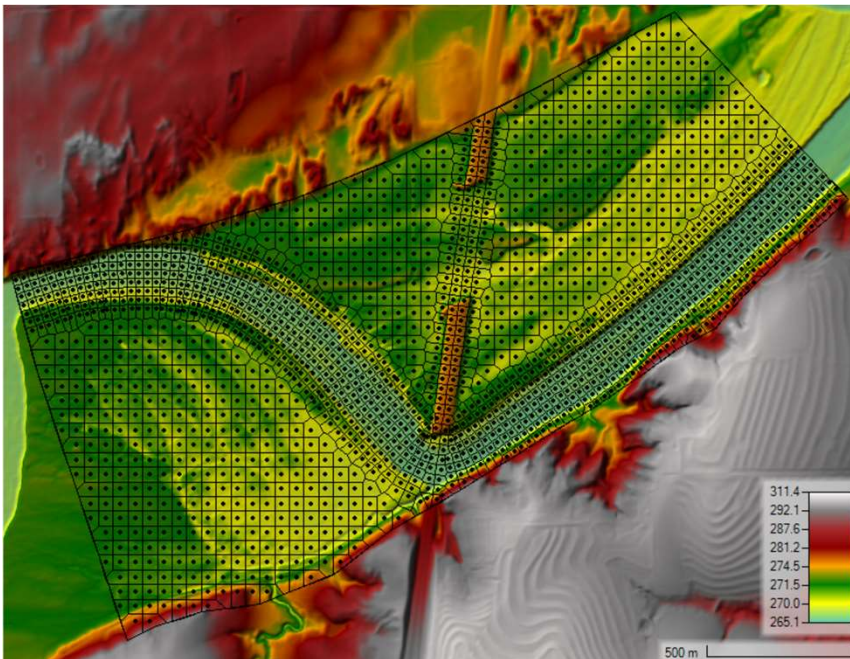


- Fewer faces faster models (less cell face computations).



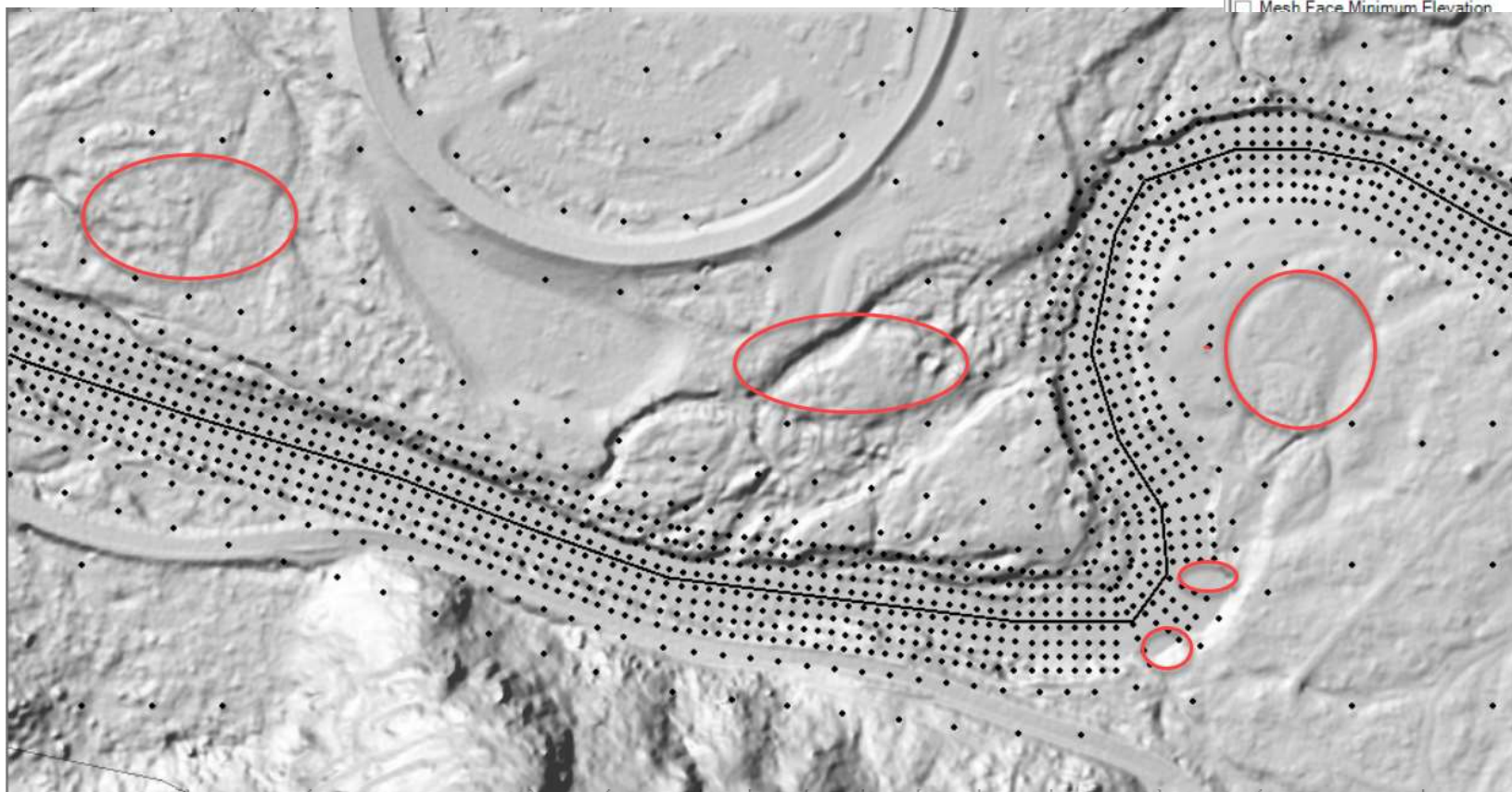
Face Alignment

- Normal velocities are computed at every face. Tangential velocities are interpolated; therefore, aligning faces with flow more accurate.





Mesh Evaluation



Additional Options

- ☒ Disable Mesh Edges
- ☐ Mesh Cell Numbers
- ☐ Mesh Face Numbers
- ☐ Mesh Face Minimum Elevation

Questions?

