HEC-RAS 2D
Mesh Generation and Refinement

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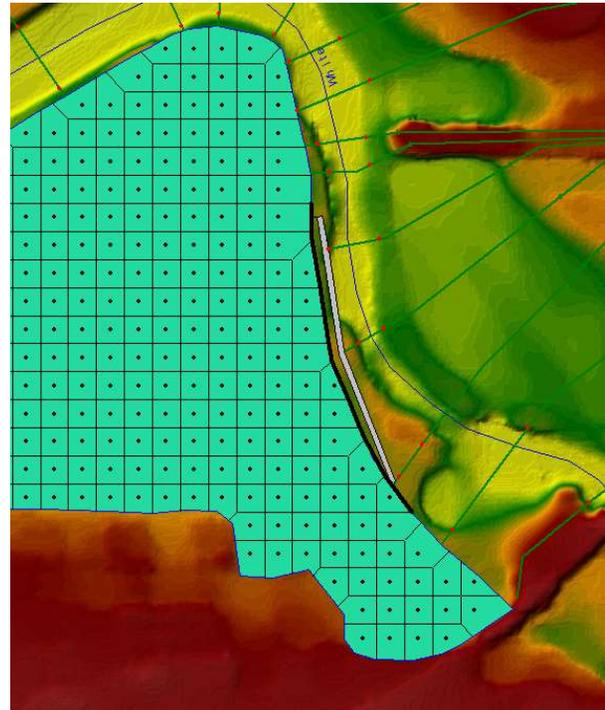
USACE, Institute for Water Resources, Hydrologic Engineering Center

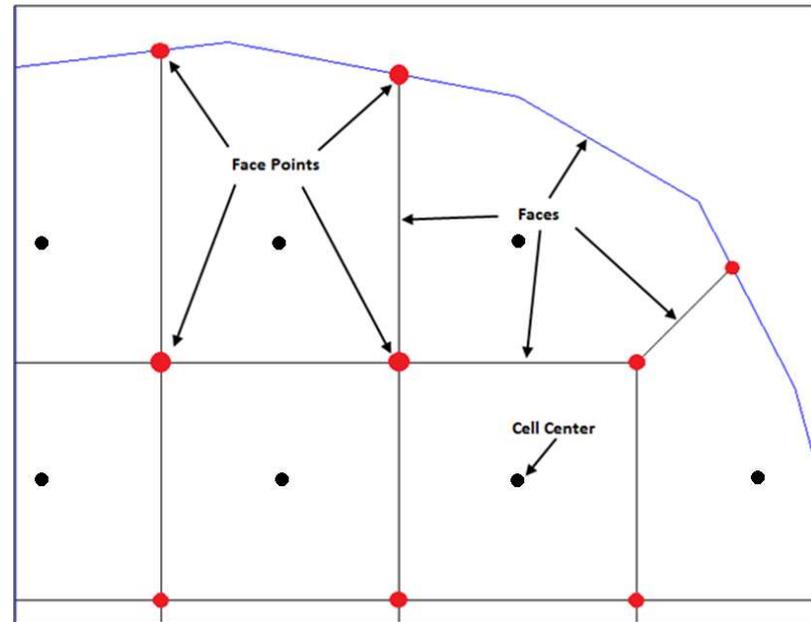**US Army Corps of Engineers ®**

Overview

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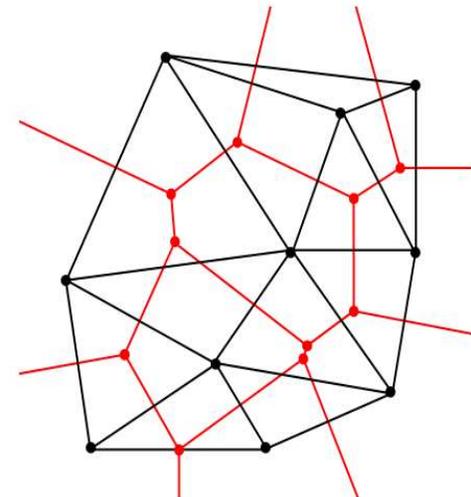- Hydraulic Property Tables

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)
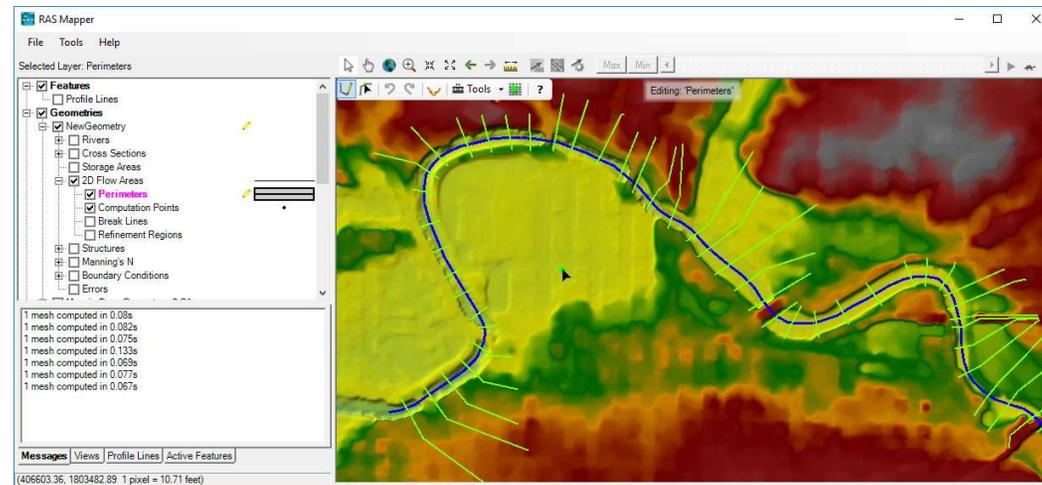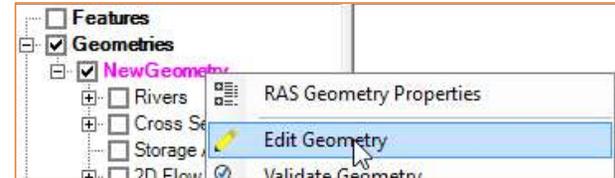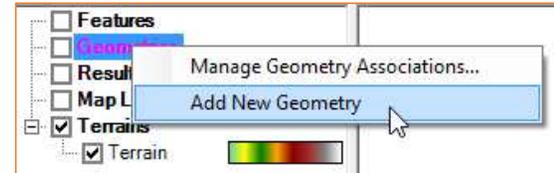 - Refinement Regions (Optional)

- Creating a good mesh is an iterative process!

Editor Access

- Create a New Geometry

- Edit Geometry

- Edit Toolbar
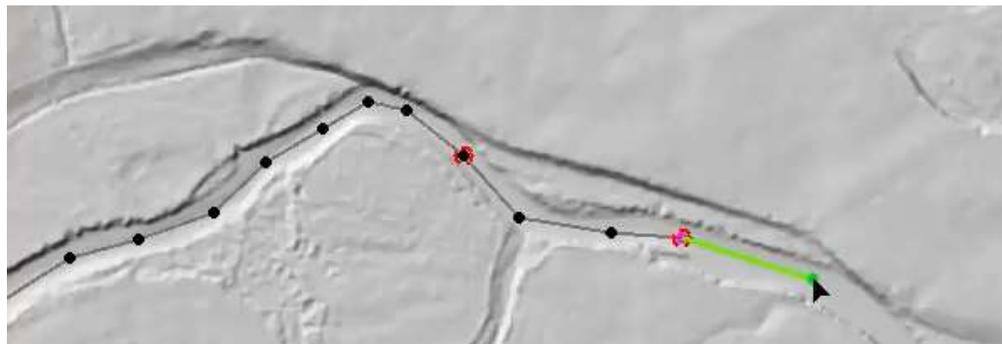- Select Layer

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.
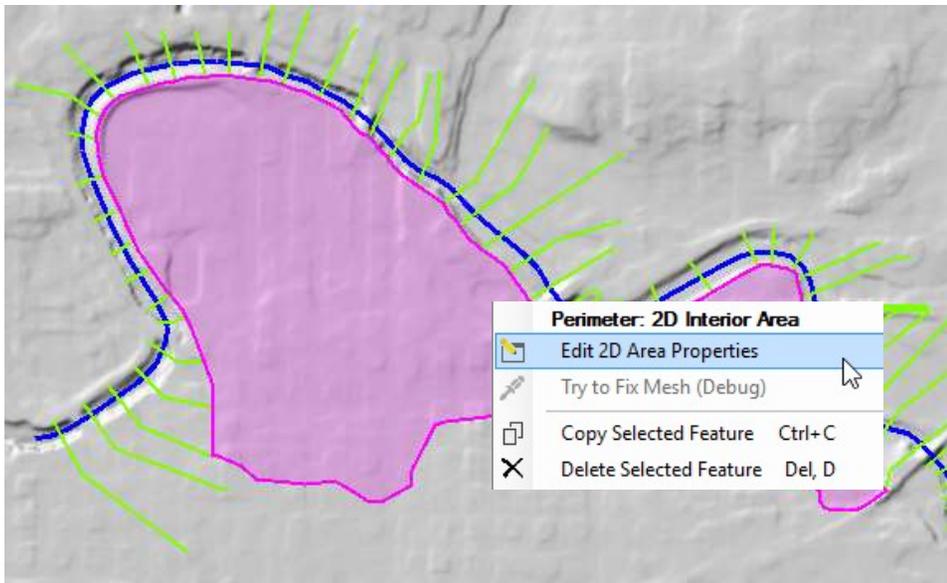
Select / Edit

- 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
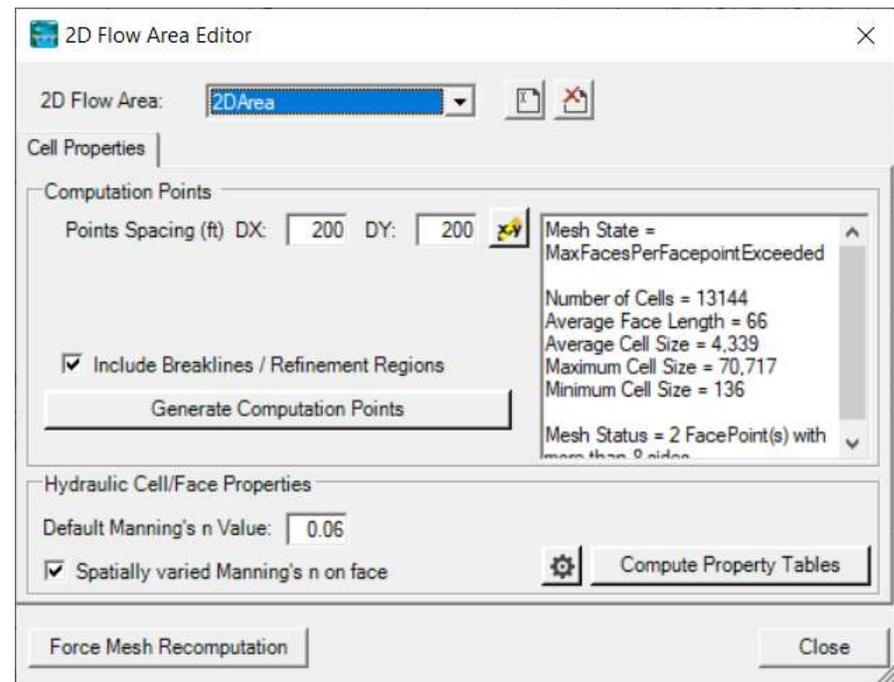 - Green point indicates: Move, Insert, Delete point
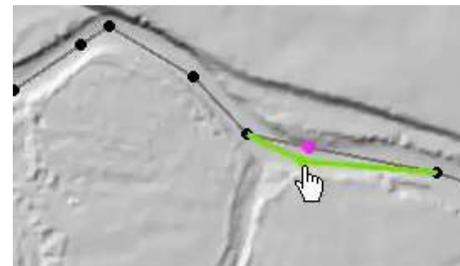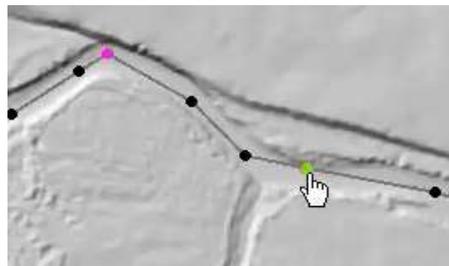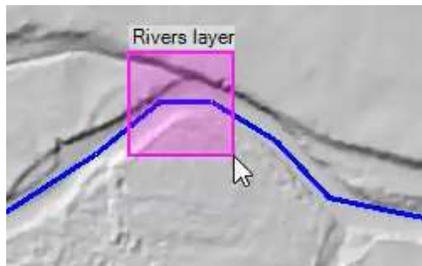
2D Flow Area

- Draw Perimeter
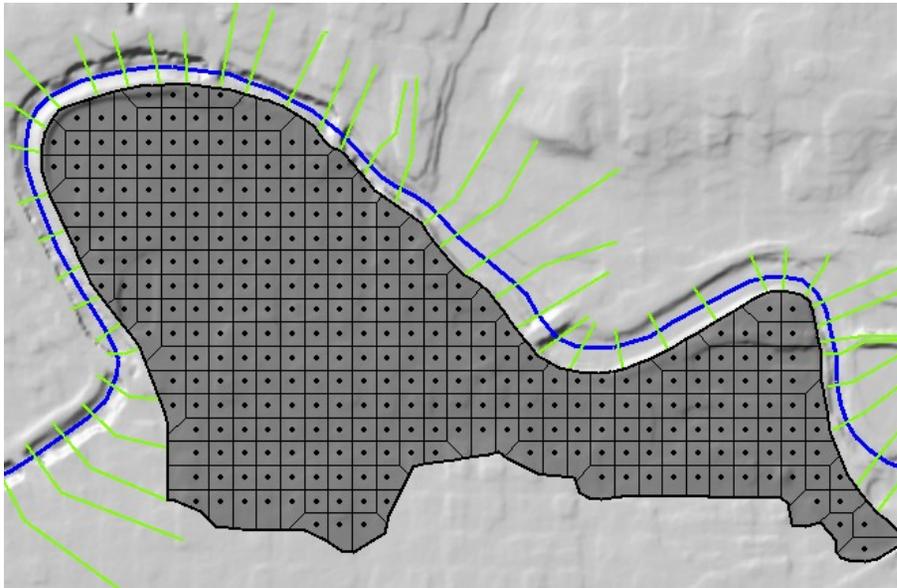

- 2D Flow Area Editor

Computation Points

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

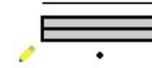- Hydraulic Table Property Tolerances

Computation Points

- Mesh is generated from resultant set of computation points.

Create 2D Flow Area Mesh
from an existing Storage Area

- Converting Existing Storage Area
  - Click convert button
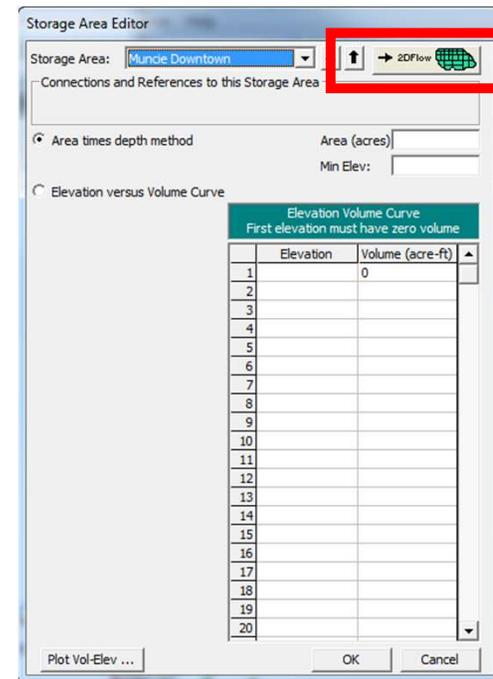
Hydraulic Property Tables
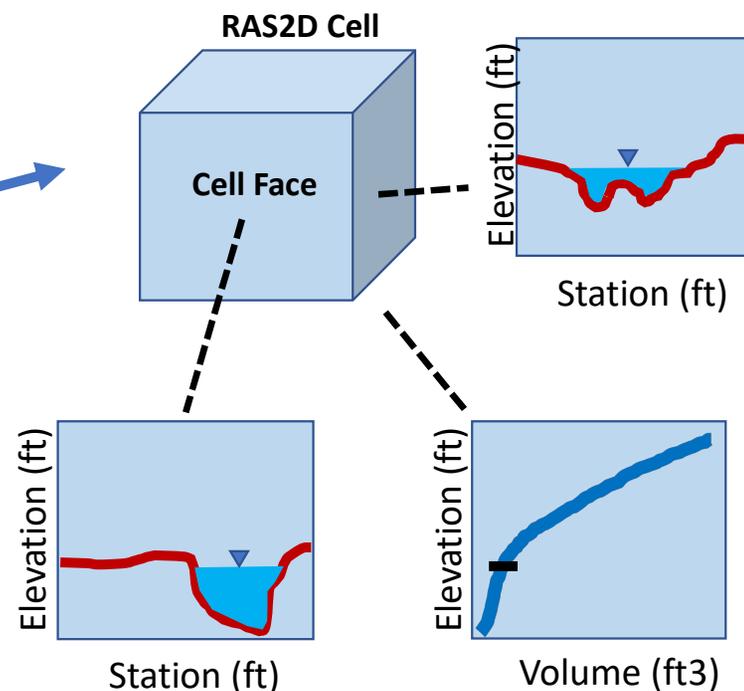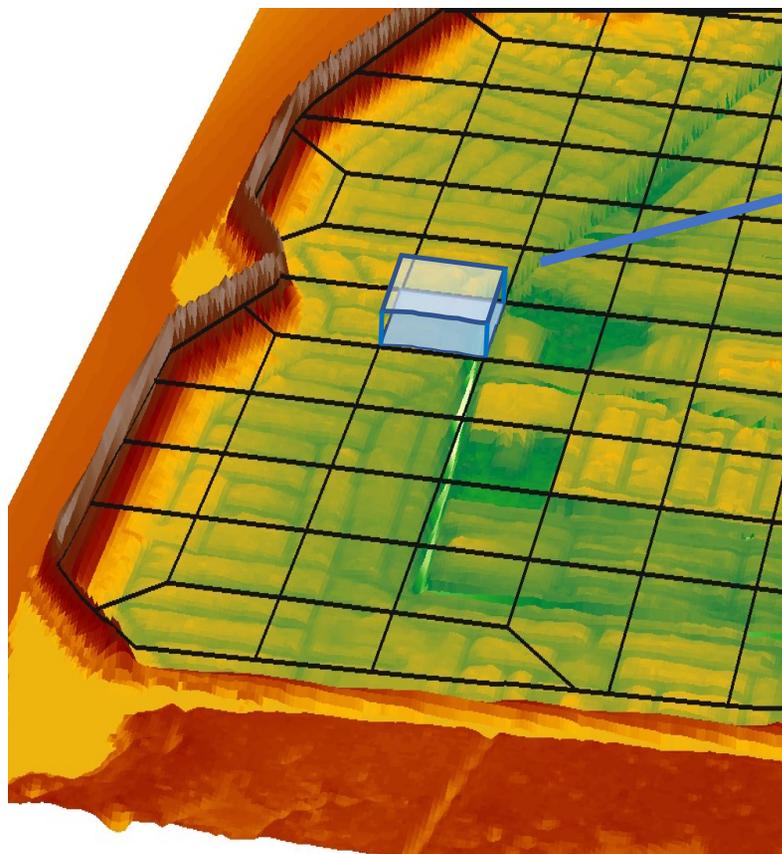
- Computation engine uses hydraulic property tables to represent the geometry of the system
- Cells
  - Elevation/Volume
- Faces
  - Elevation/Area
  - Elevation/Wetter Perimeter
  - Elevation/Manning's n
 - (all from station elevation profile)

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.
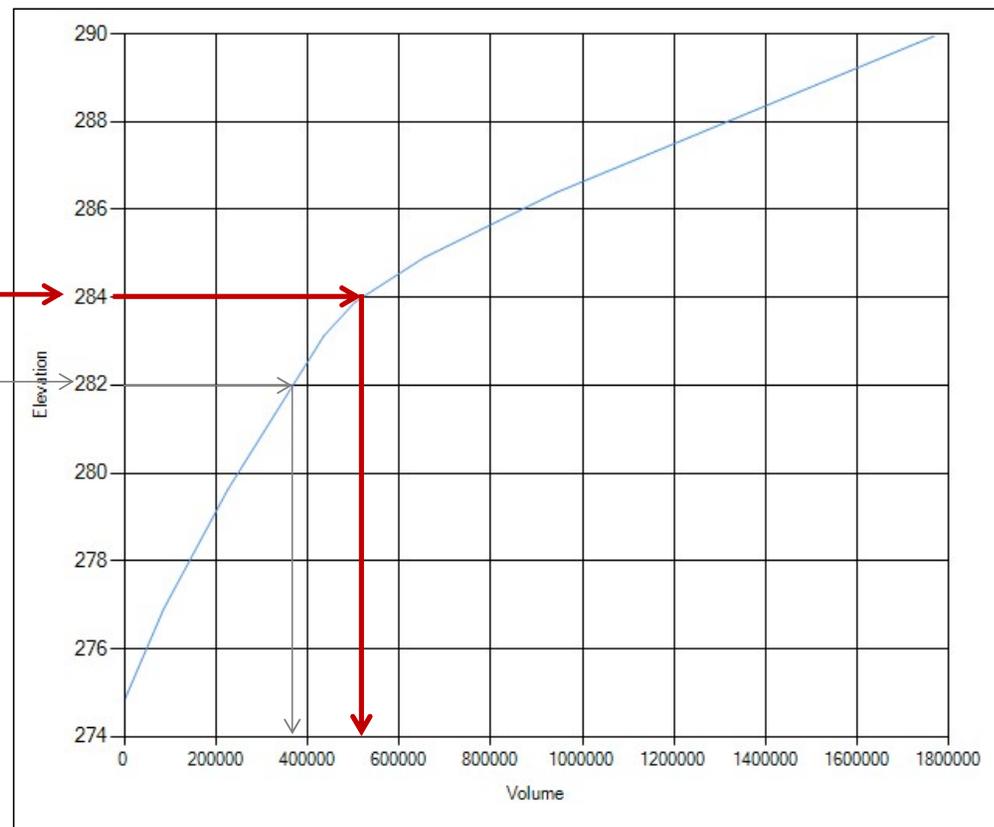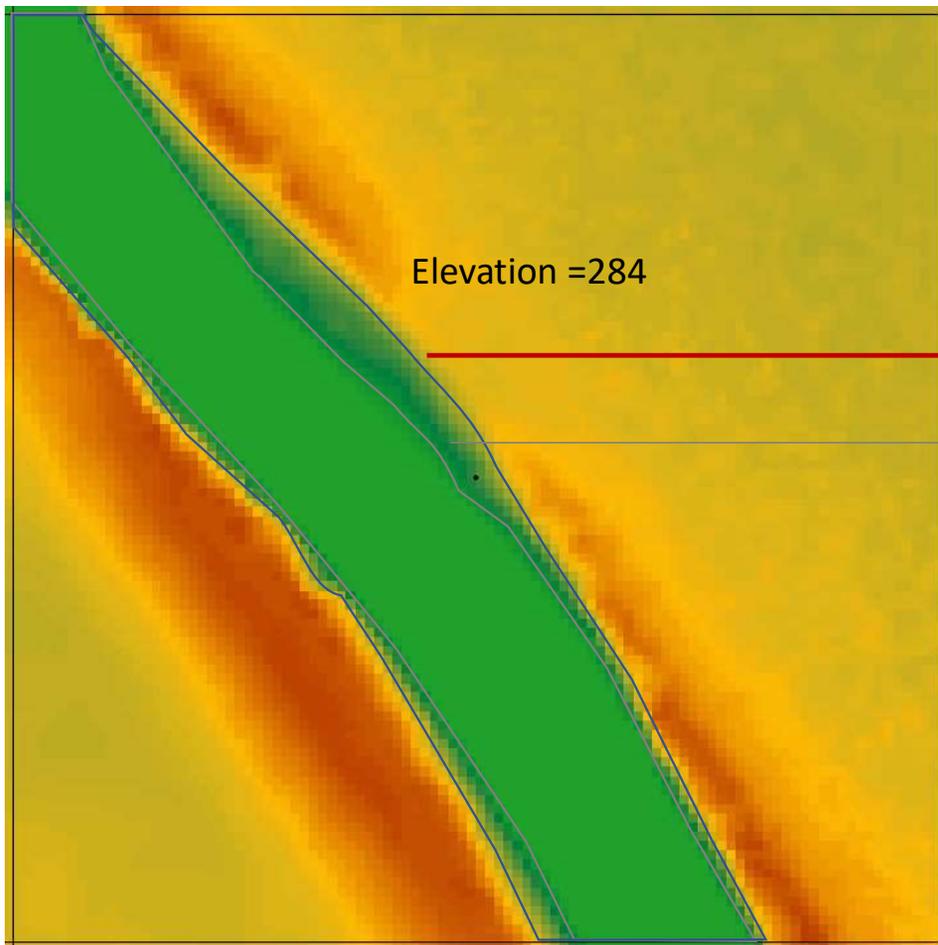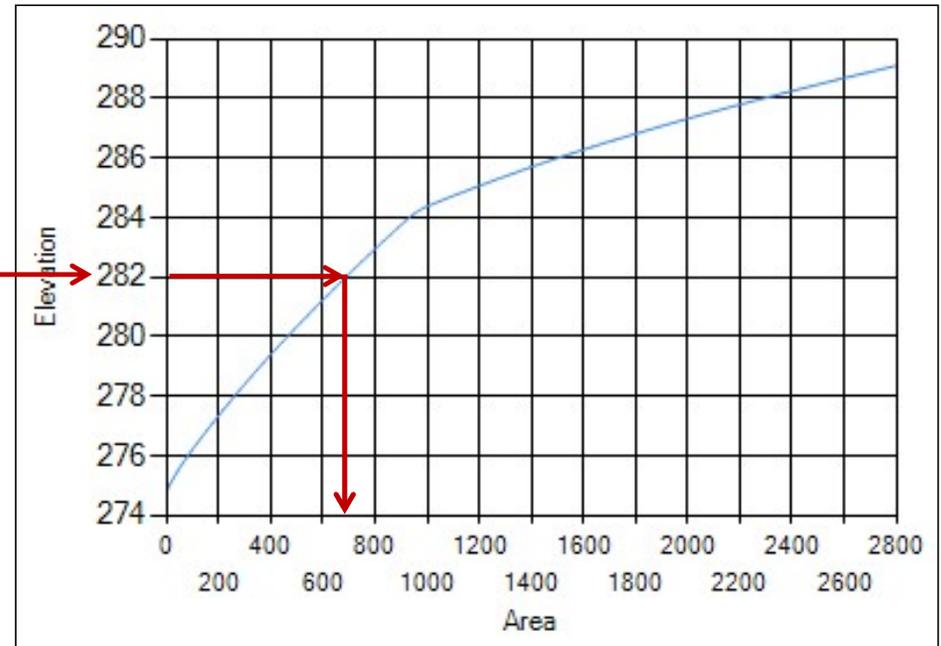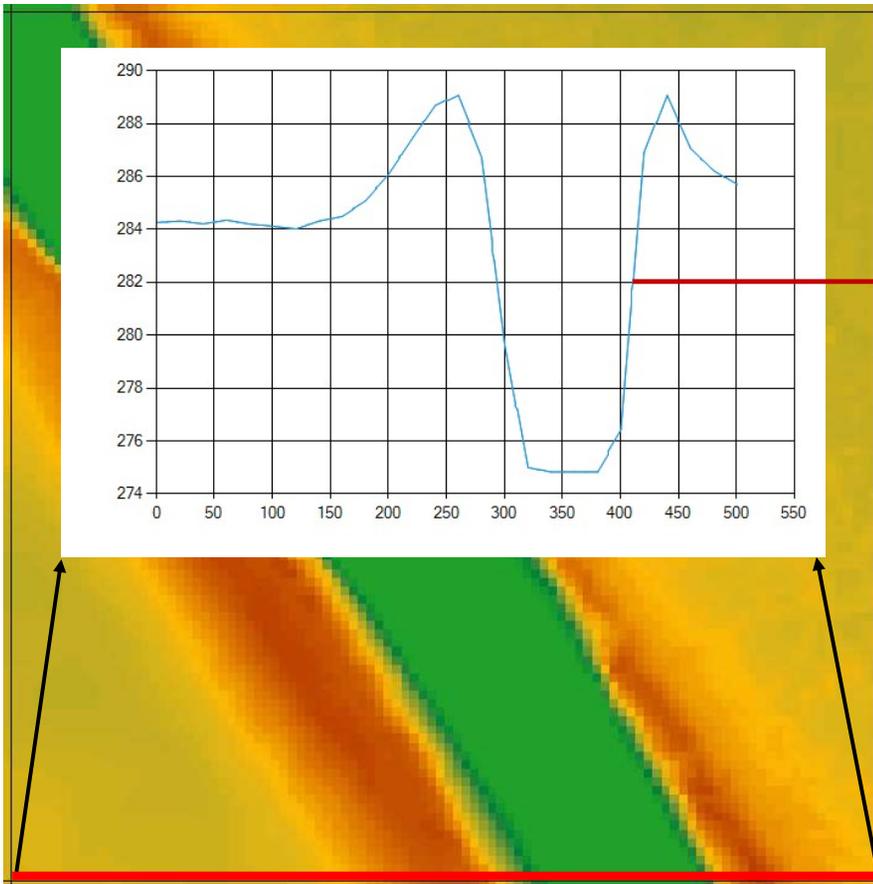
Computational Cells - Elevation vs. Volume

Elevation =282
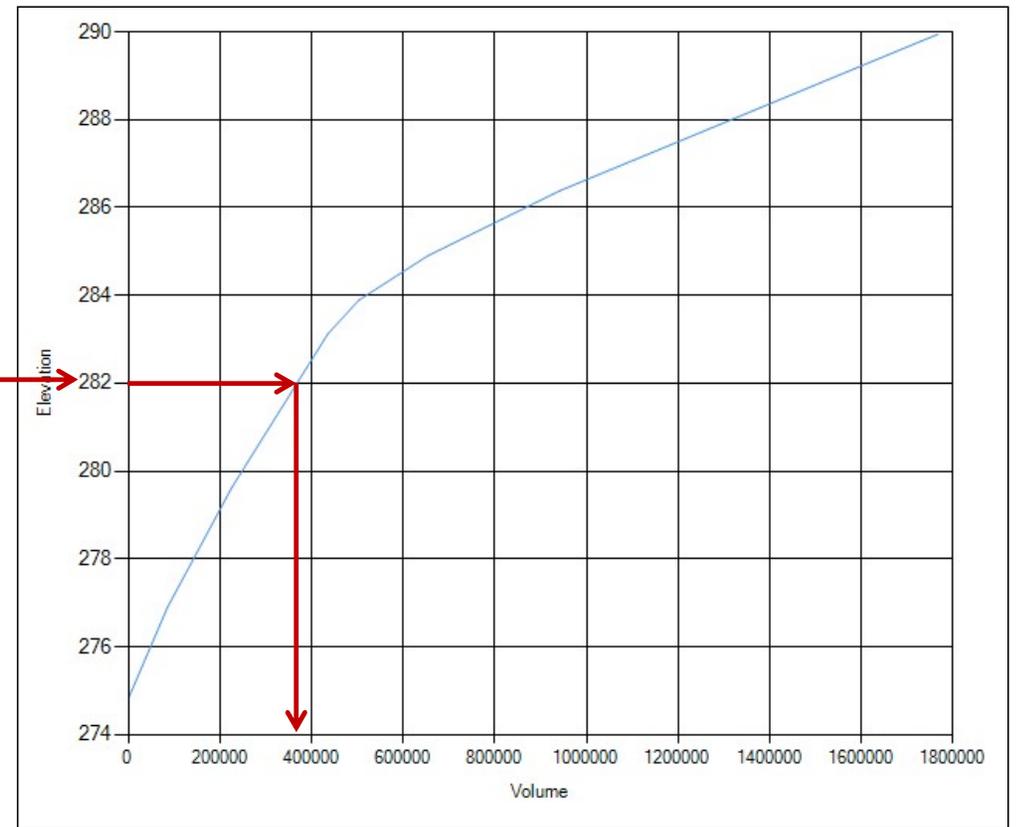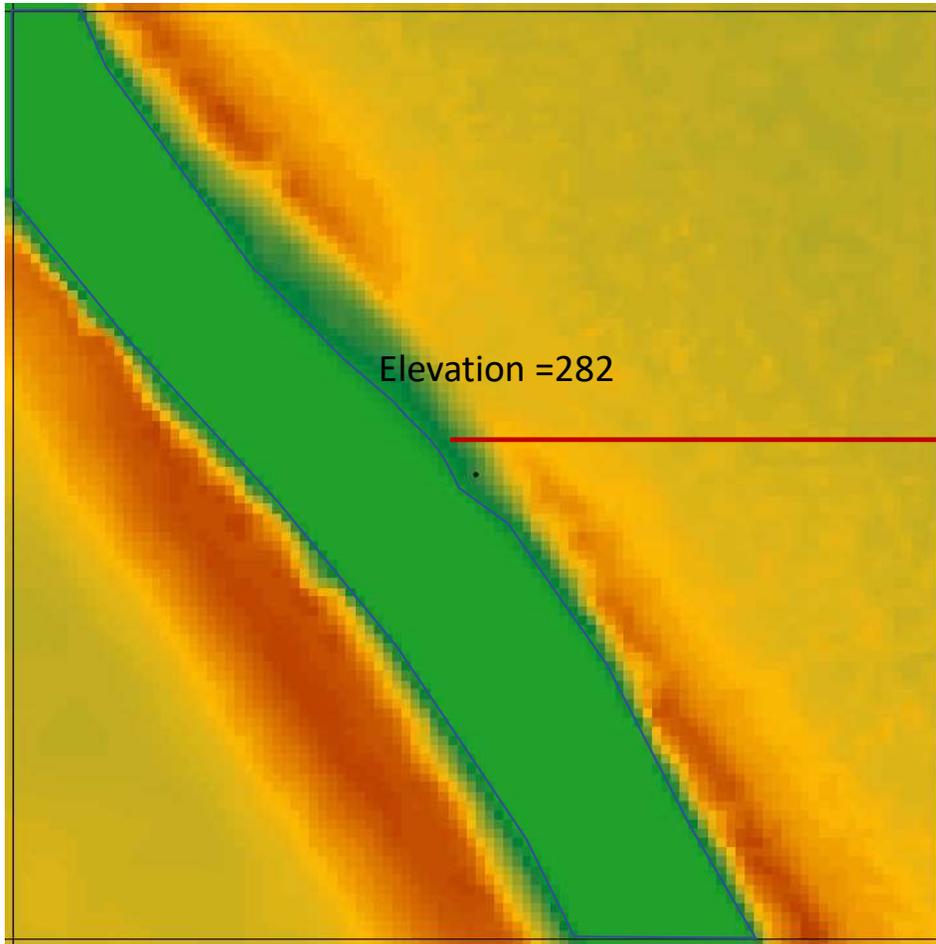
Computational Cells - Elevation vs. Volume

Elevation =284

Subgrid = Higher fidelity cell volume tracking
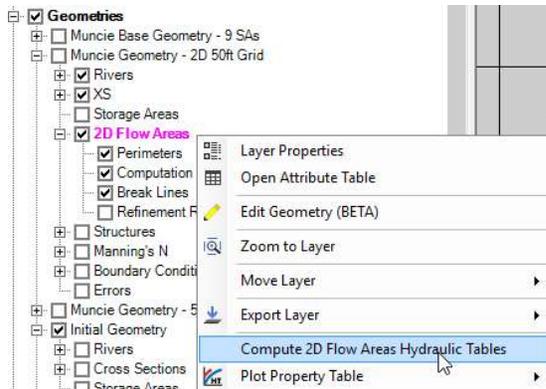
Faces = Control flow into and out of cell
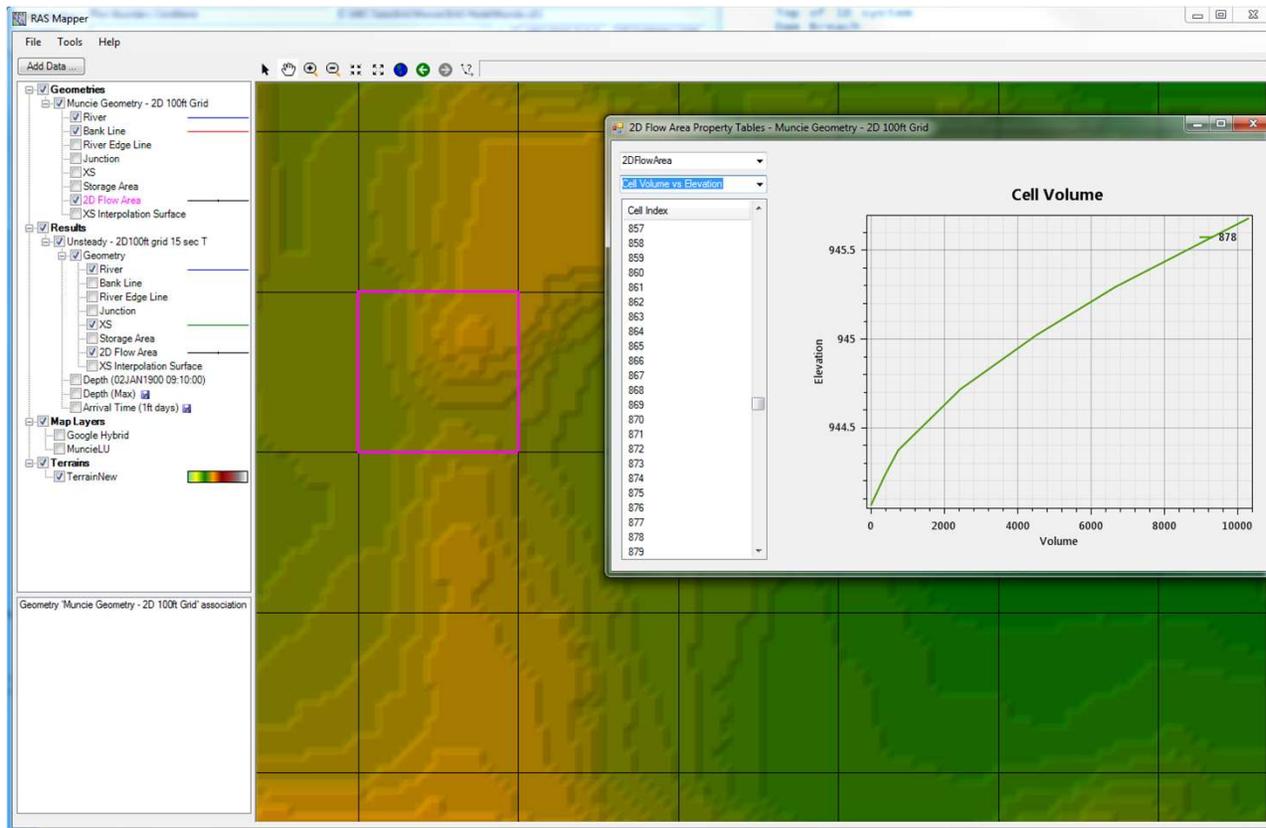**Can model small channels in with large cells**

Hydraulic Property Tables

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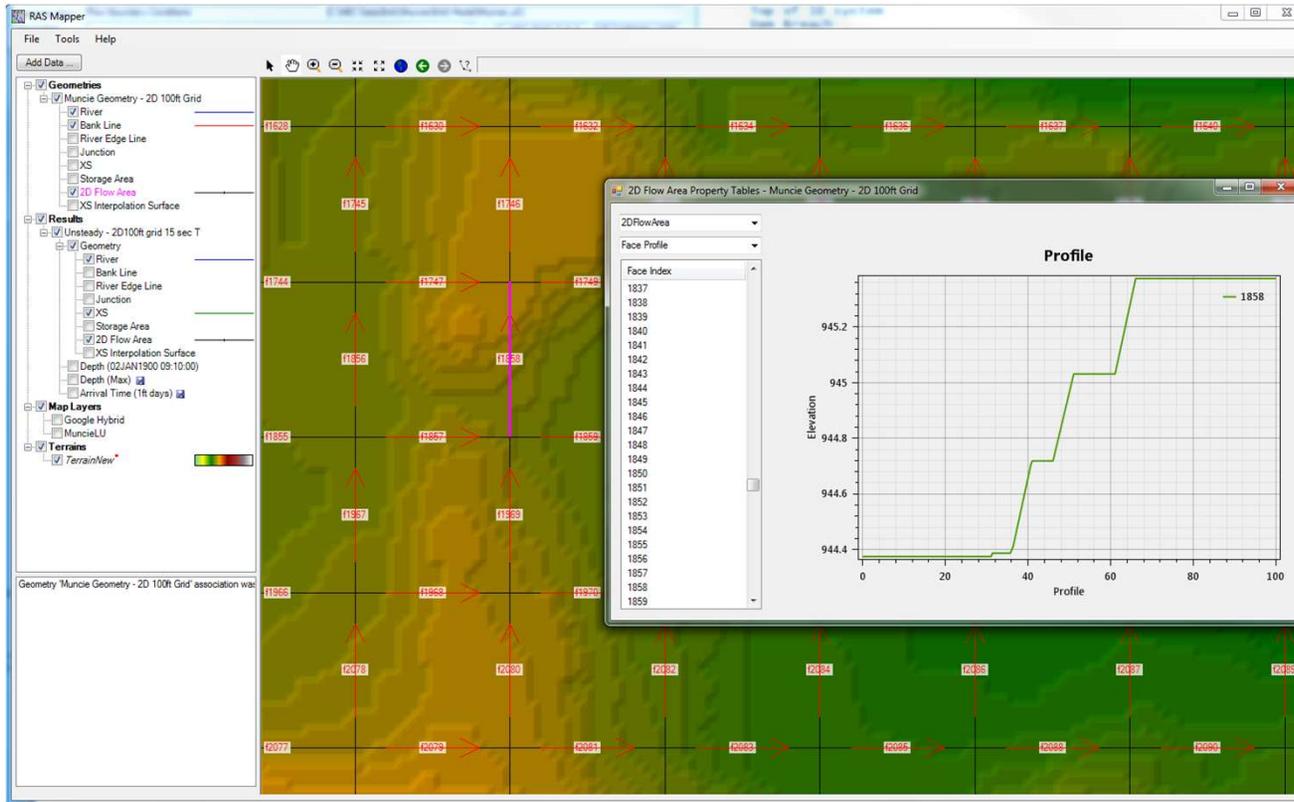 - Before unsteady-flow simulation
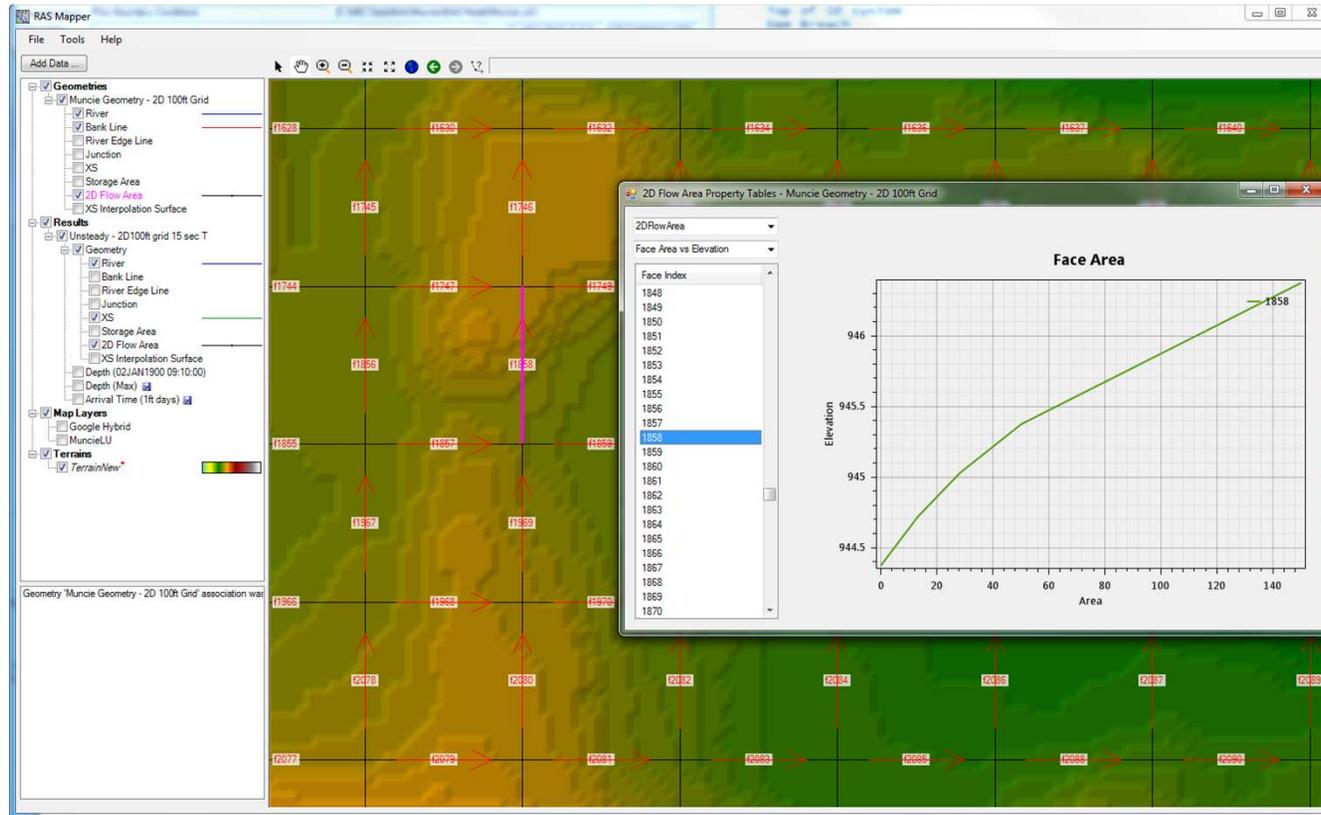
Cells

Faces

Face Profile

Face Elevation vs Area

Hydraulic Property Tables

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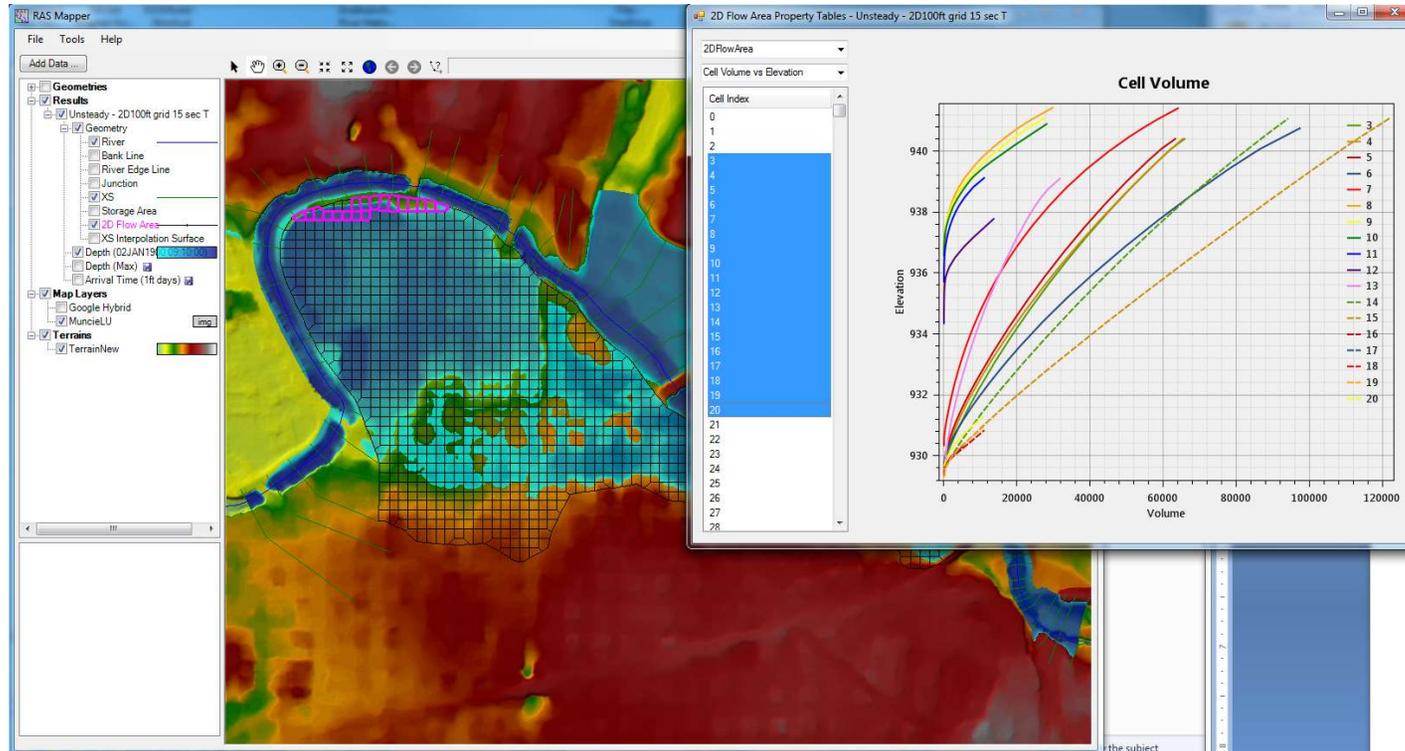
Mesh Limitations

- 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

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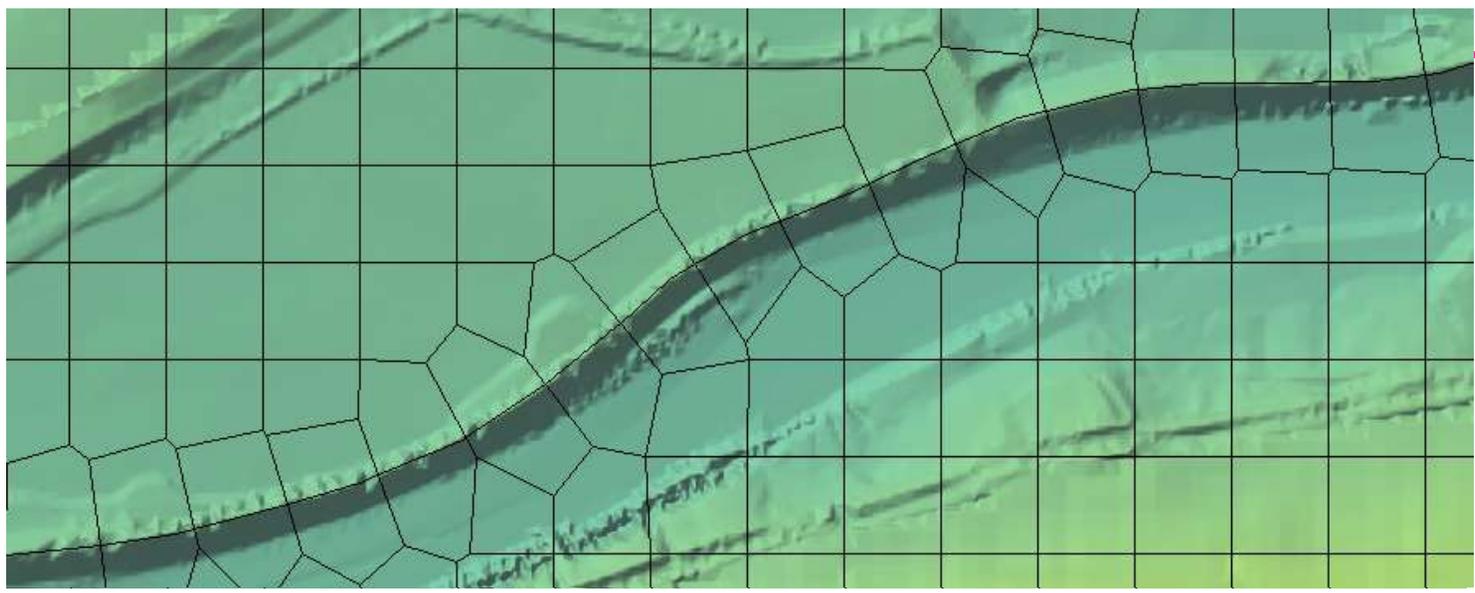
Breaklines

- "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.

Breakline Editor

		Name	Near Spacing	Near Repeats	Far Spacing	Enforce 1 Cell Protection Radius
1		Breakline 1	50	0	100	☑
2		Breakline 2	50	0	100	☑
3		Breakline 3	50	0	100	☑
4		testA	25	1	50	☑
5		TestB	50	1	100	☑

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	☑
		2	Breakline 2	50	0	100	☑
		3	Breakline 3	50	0	100	☑
		4	testA	25	1	50	☑
		5	TestB	50	1	100	☑

Enforce Selected Breaklines   OK   Cancel

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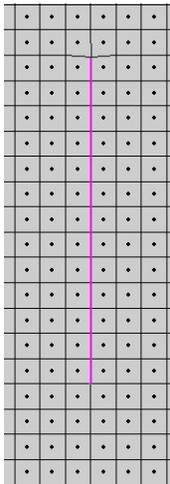
Breakline Examples

- Grid spacing = 100
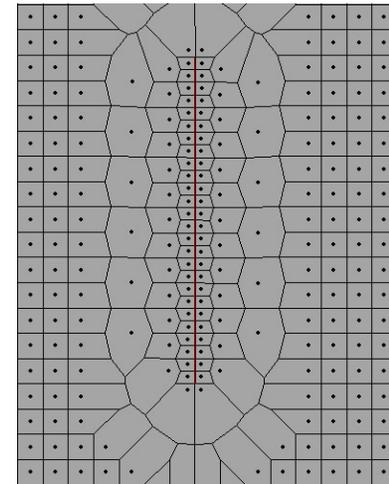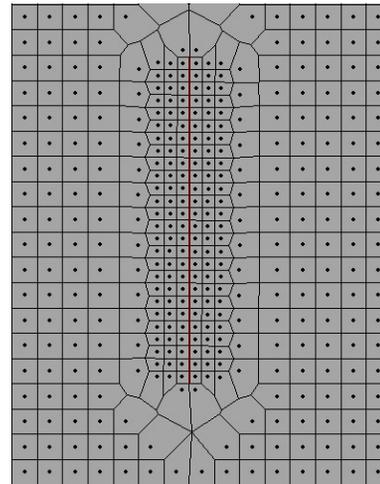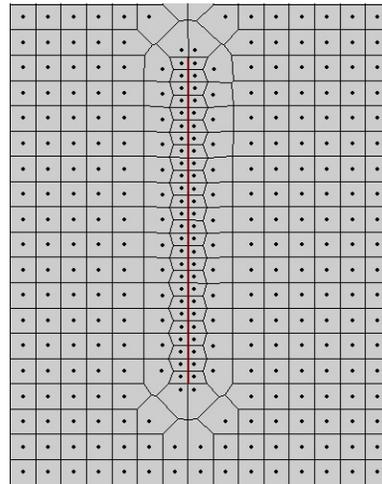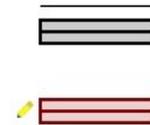
Refinement Regions

- 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
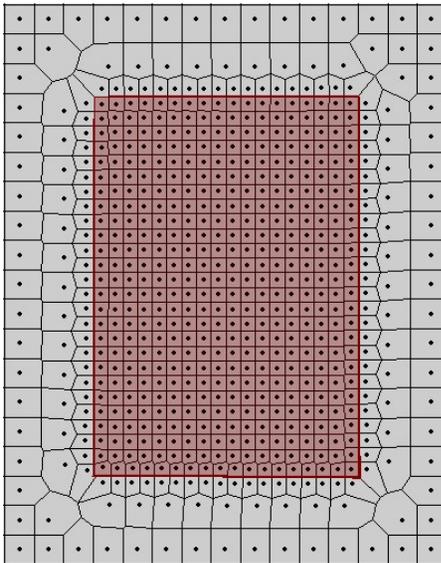- Internal cell size used for perimeter spacing, if not defined

Refinement Examples

- Grid spacing = 100
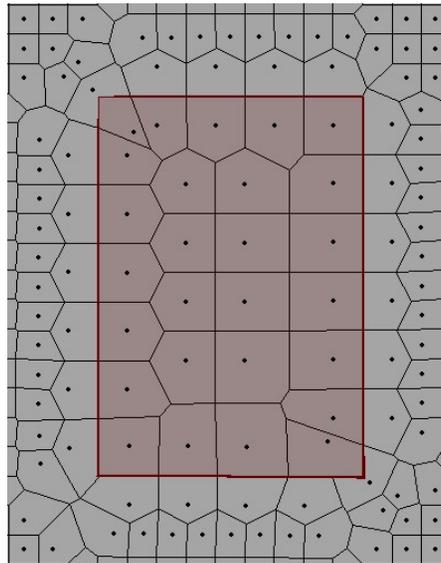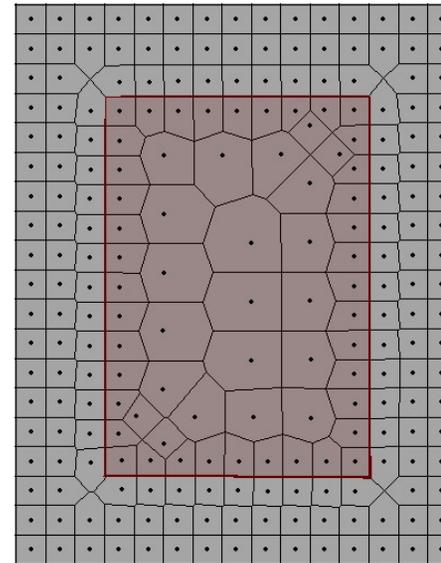
Refinement Regions and Break Lines to Align Channel Cells


Selected: 'Break Lines'
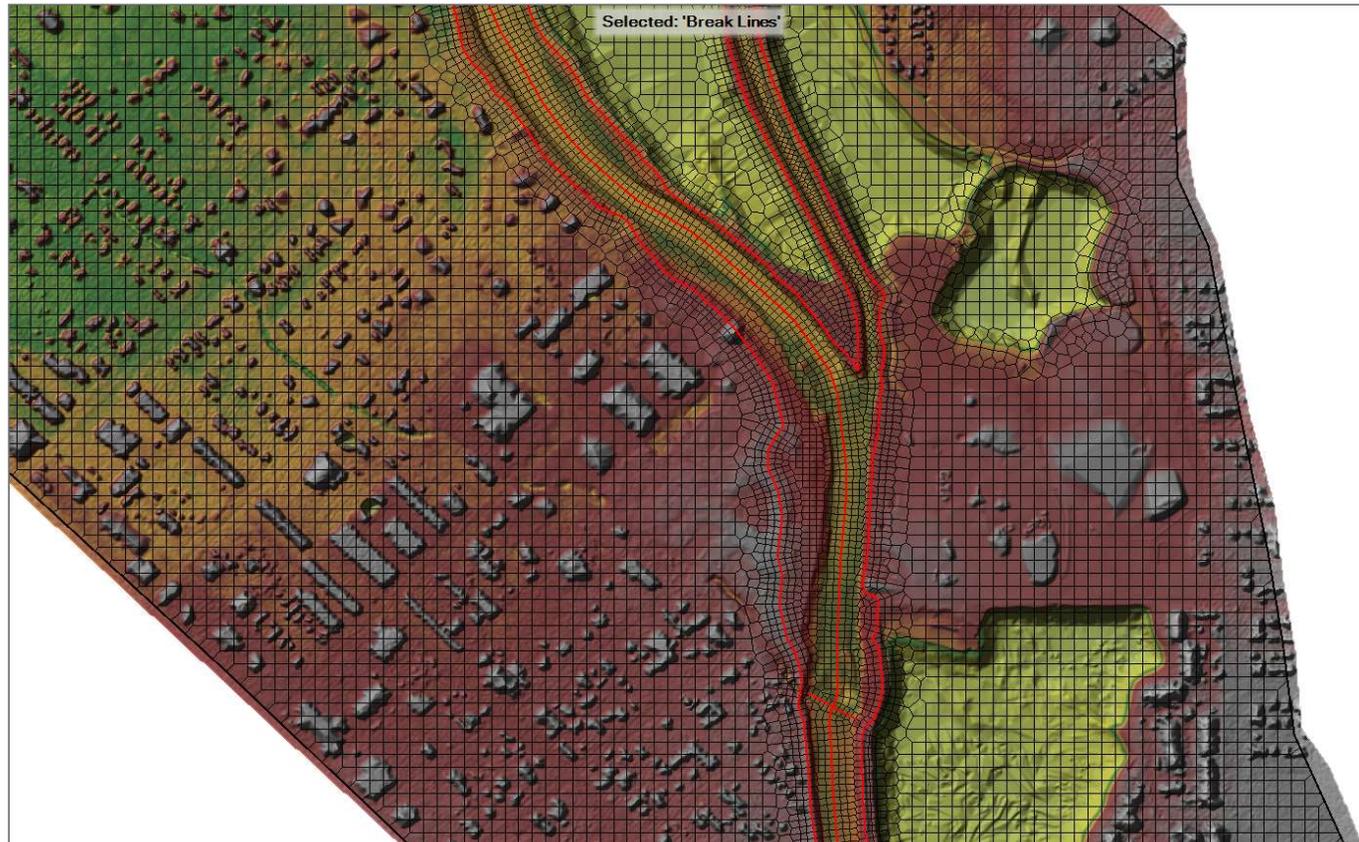
2D Flow Area Editor
Geometry Editor

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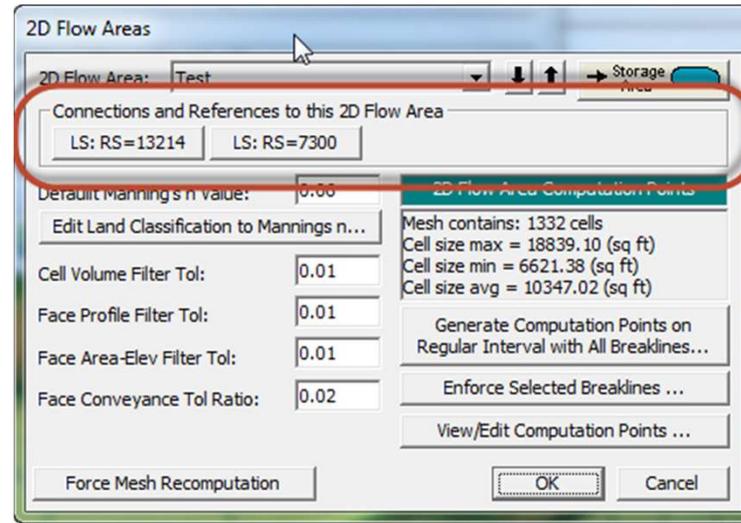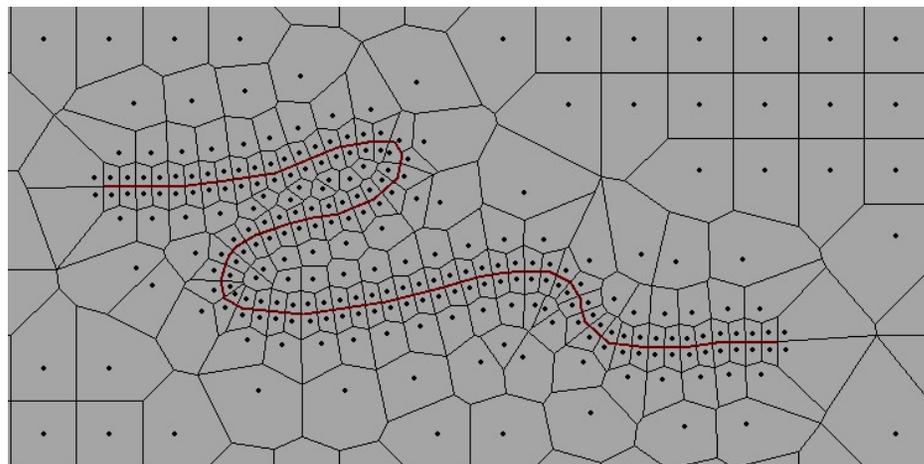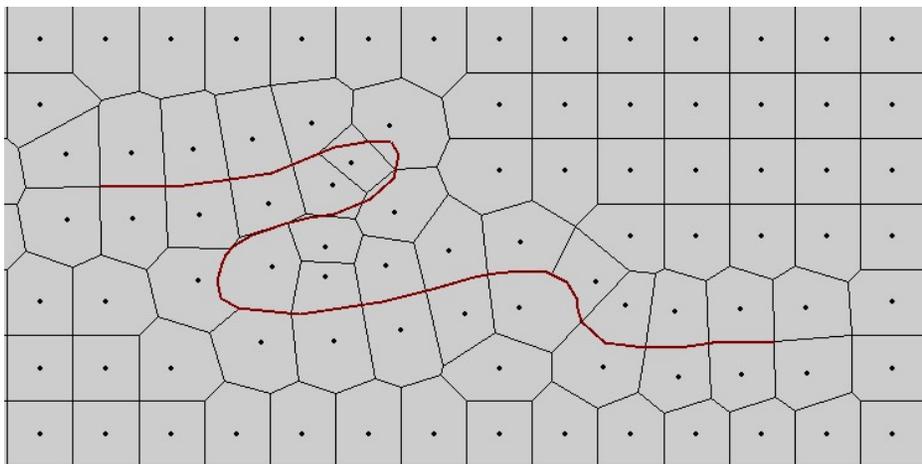
Computation Points

- 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).
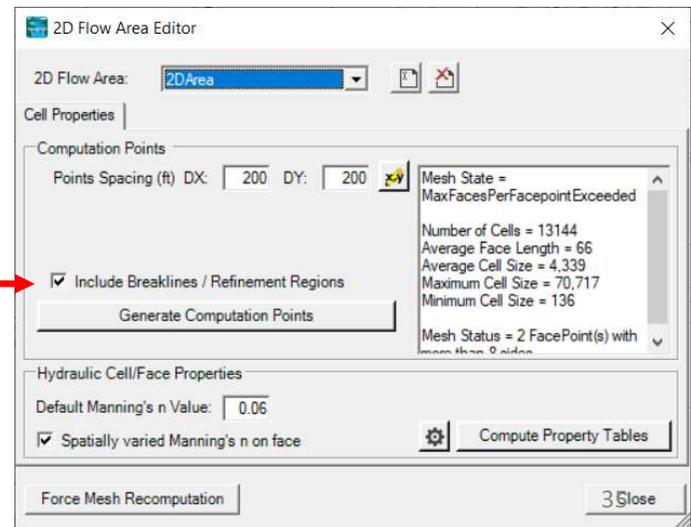
Fixing Problems

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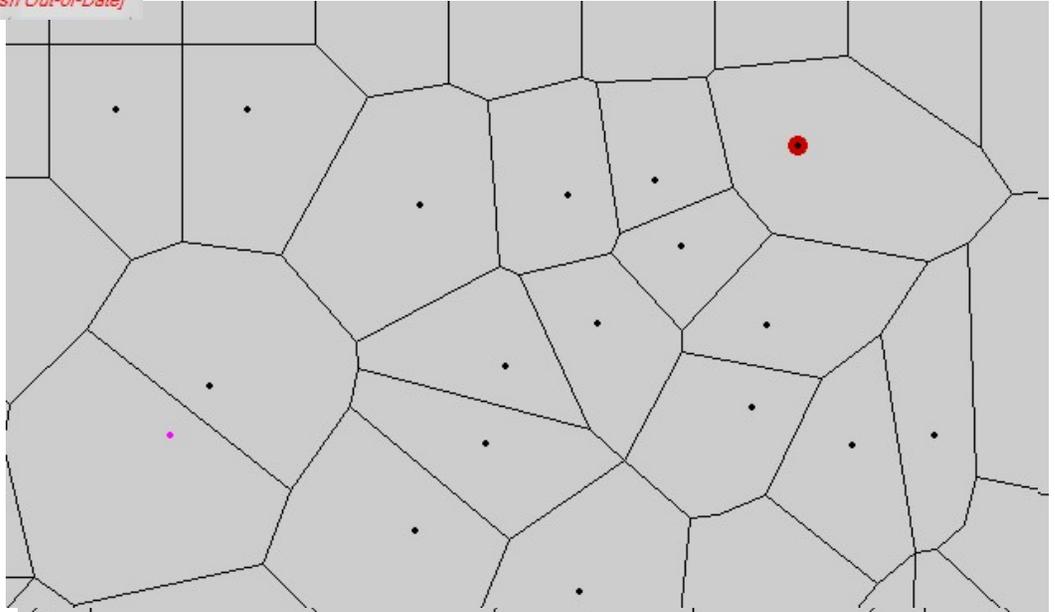
Fixing Problems

- More than 8 sides on a cell.

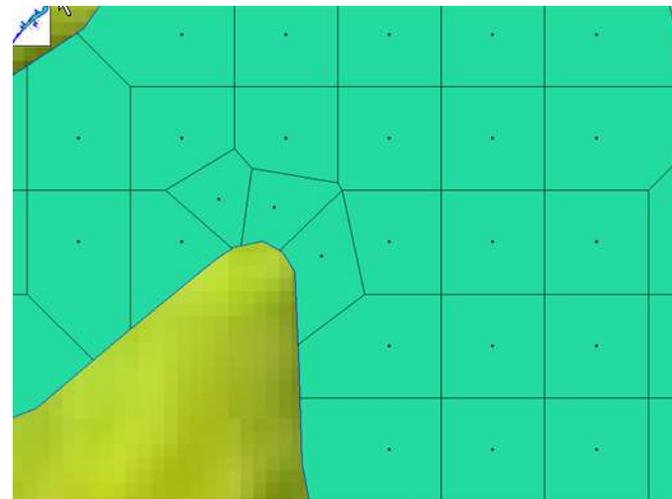2D_Area: 2 Error(s) - Maximum 8 Faces per Cell   [Displaying Local Mesh]   [Full Mesh Out-of-Date]
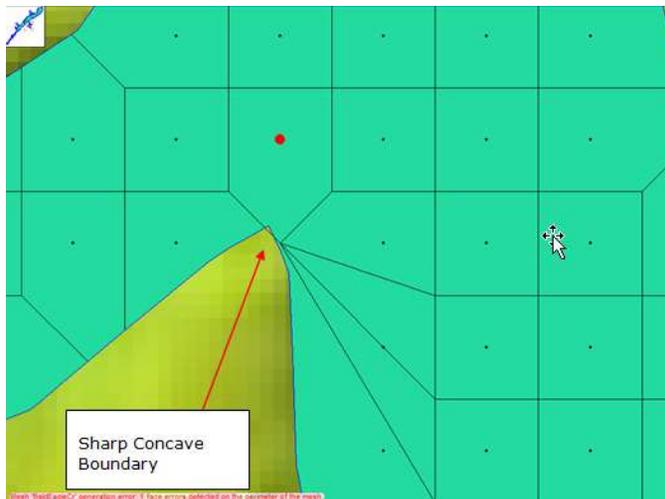
- Fix by Hand

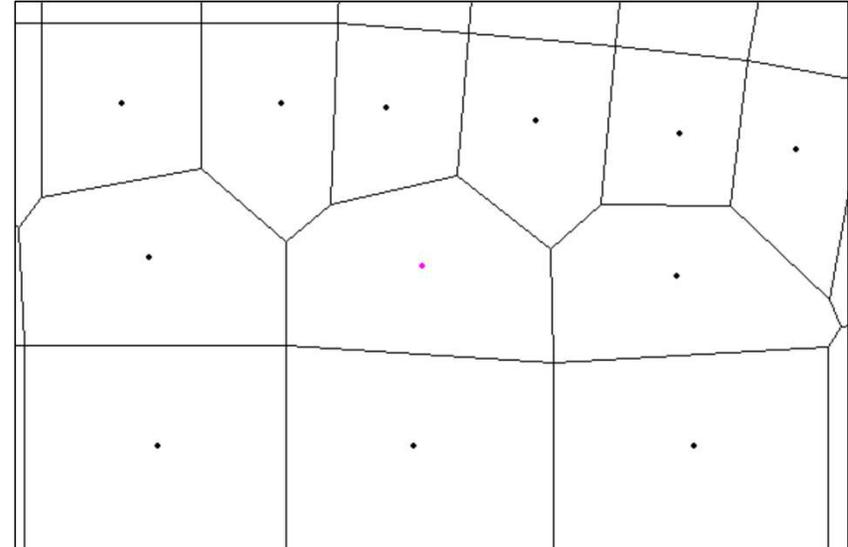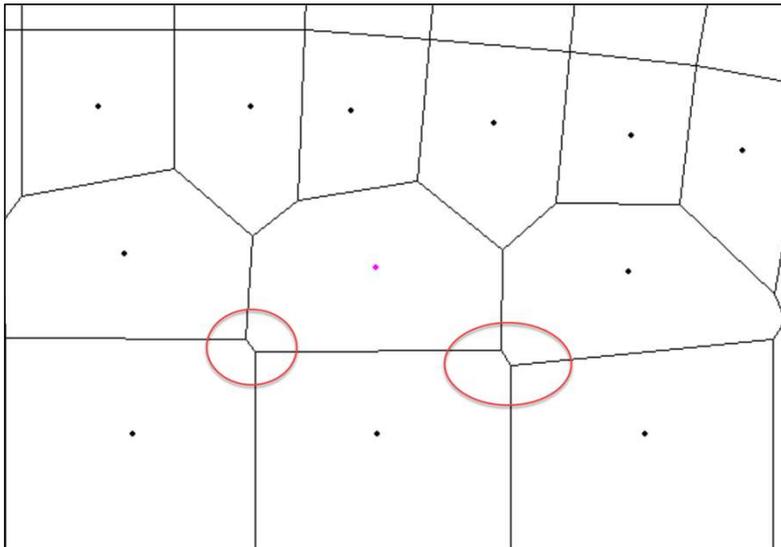- Auto "Try Fix" menu option

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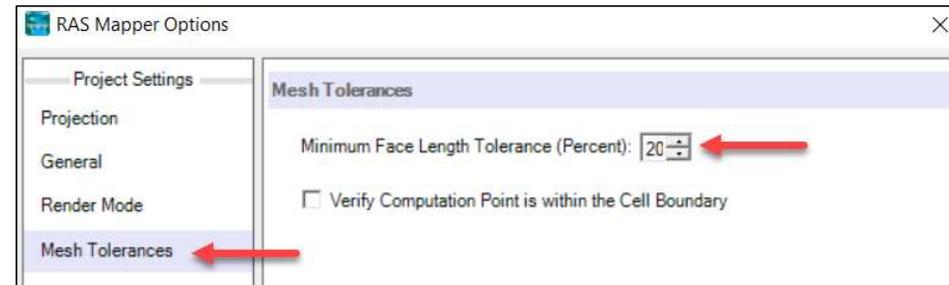
- Cells need to have exactly one Computation Point (Black Dot)
- Fix graphically by adding more points and/or moving points near perimeter

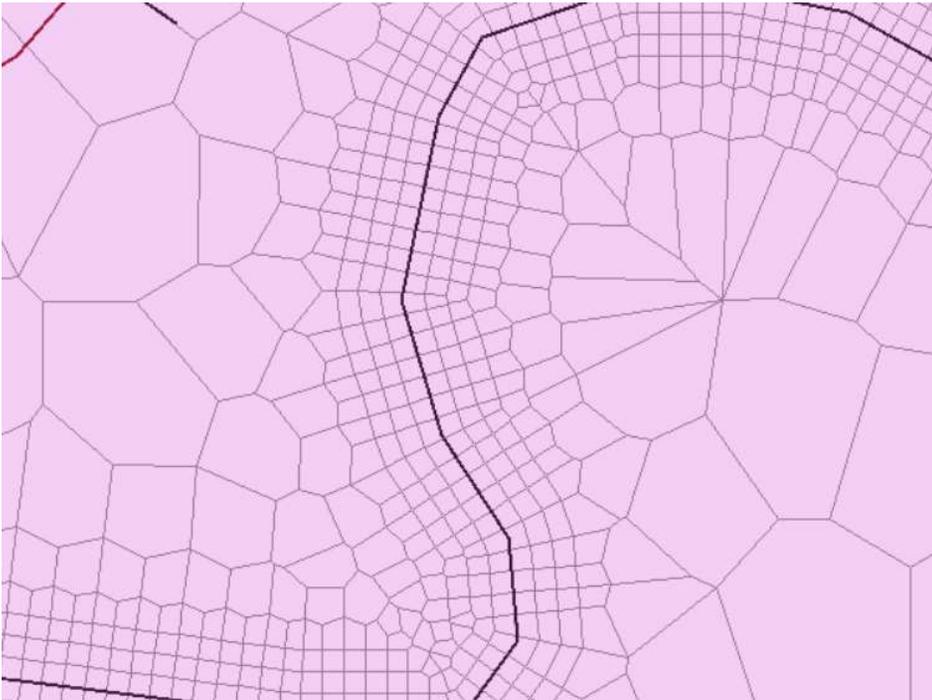Sharp Concave Boundary

Mesh Tolerances

- Minimum Face Length (%)
  - 5% is Default, Recommend increasing

Face Tolerance

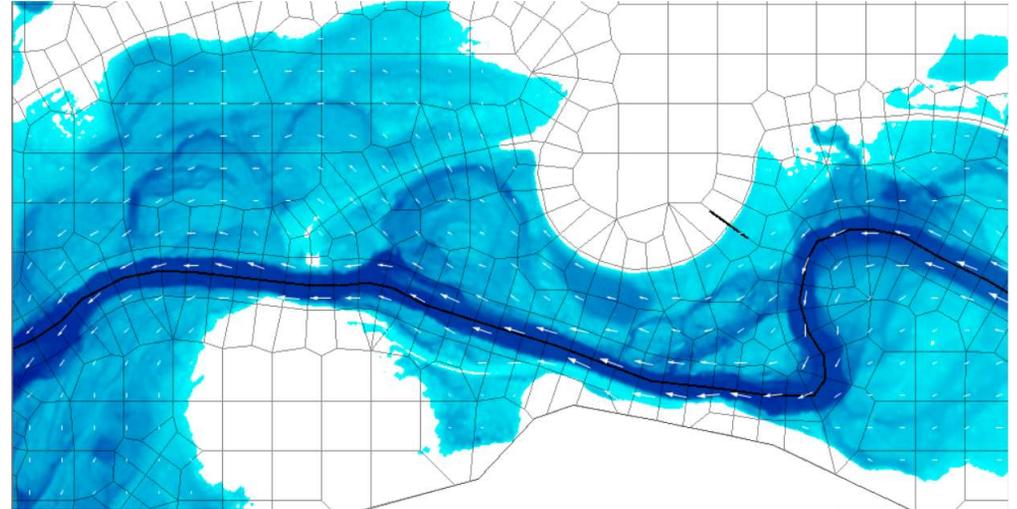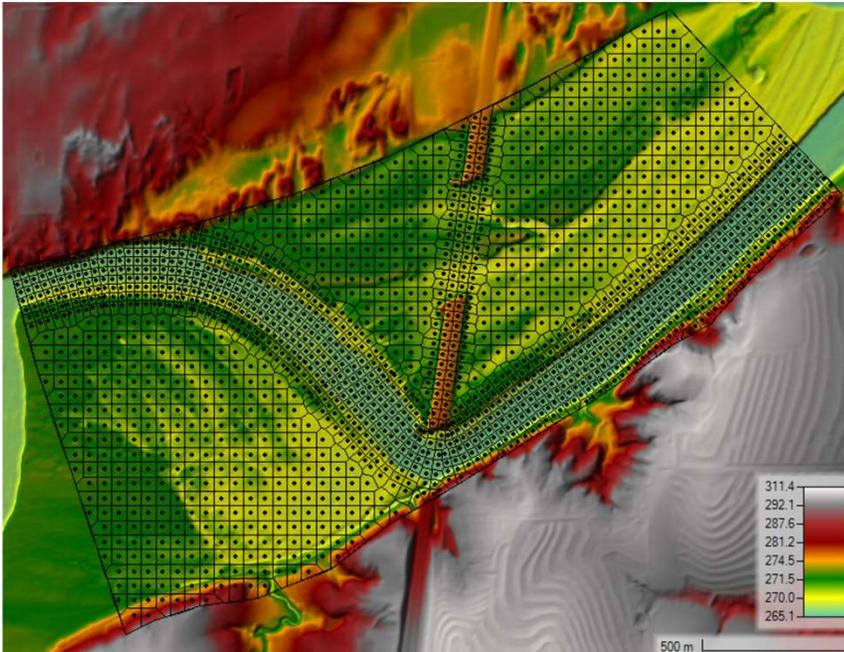- Small Face Tolerance
- Larger Face Tolerance

- 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

Questions?