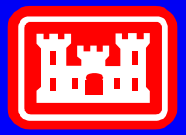
Sediment Model of Rivers

Charlie Berger
601-634-2570
Charlie.R.Berger@erdc.usace.army.mil



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CHL and HQ constraints "consolidate capabilities"

- TABS, HIVEL2D → Unstructured Mesh
- HIVEL2D → Super- and sub-critical flow
- HIVEL2D → Tow and ship effects
- CH3D → Multi-grain size sands
- TABS, CH3D-co-sed → Clays (cohesive)

Approach

- Create library of routines for sediment that are reusable in most hydrodynamic codes – Sediment Library
- Create modular hydrodynamic type code that includes many physical environments – Multiphysics

Sediment Library Development and application in ADH

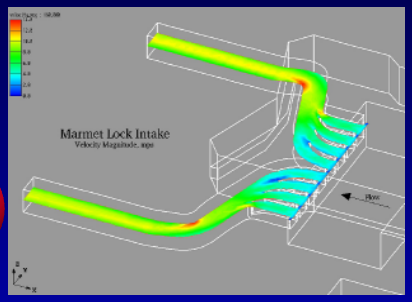
- Multiple grain size
- Cohesive and Noncohesive
- Suspended and Bed Load

ADH Features

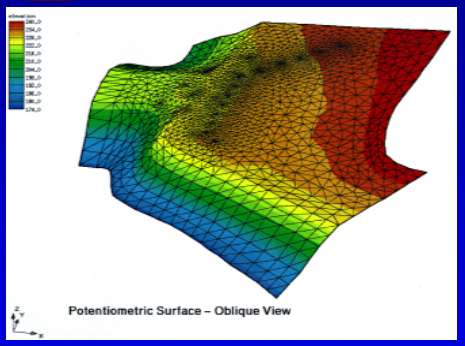
- Multi-Physics
- Adaptive Mesh
- Single to Multiprocessor - Portable

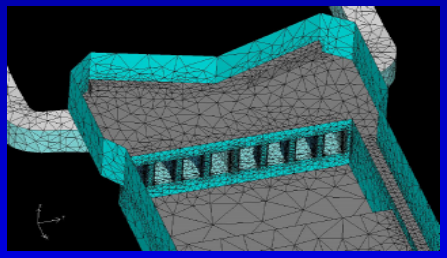
ADH Philosophy

Navier-Stokes Equations

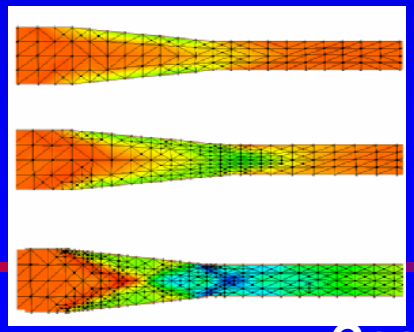


Unsaturated Groundwater Equations

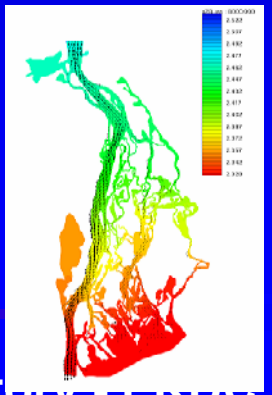




Computational Engine
(FE utilities, preconditioners, solvers, I/O to xMS GUIs)



Shallow Water Equations



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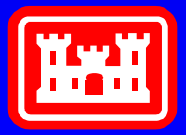
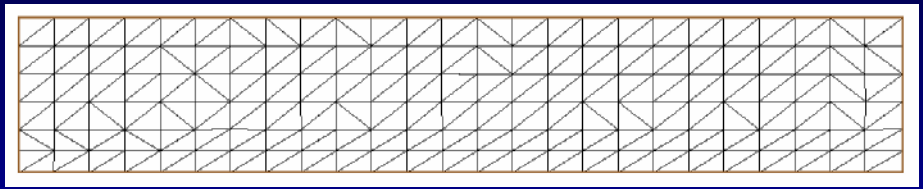
Adaption



Why should we care about adaption?

- Hydrodynamic models, with sufficient resolution, converge to the equations of motion. With coarse resolution they will converge to a different problem.
- Modelers have a feel for the resolution needed to capture the geometry, but not necessarily the hydro, sediment, . . .

How important is grid resolution?

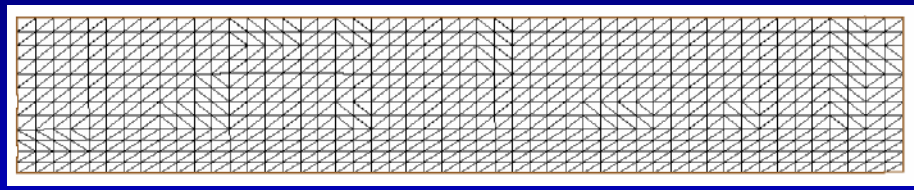


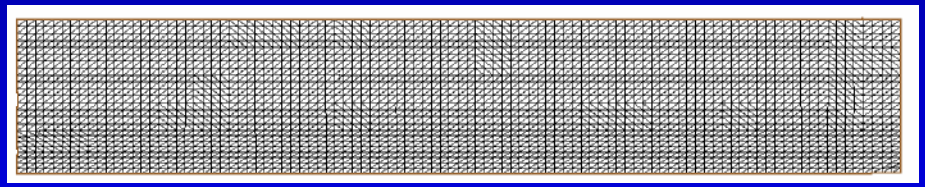
Coarse Mesh

182 nodes/300 elements

Refined Mesh #1

663 nodes/1200 elements



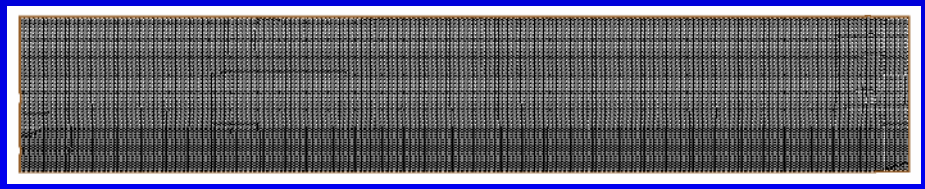


Refined Mesh #2

2525 nodes/4800 elements

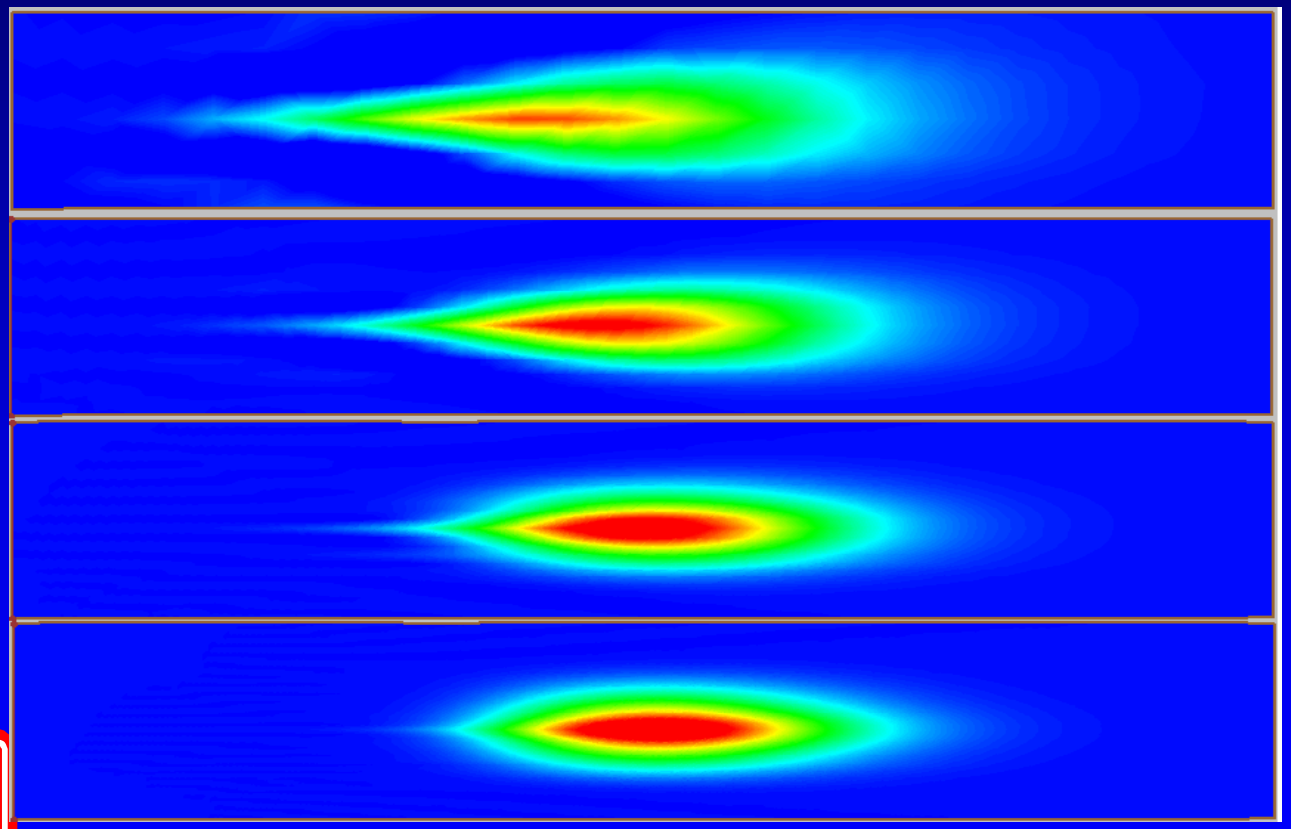
Refined Mesh #3

9849 nodes/19200 elements



Initial Concentration Cloud

Grid Resolution Results…



Coarse

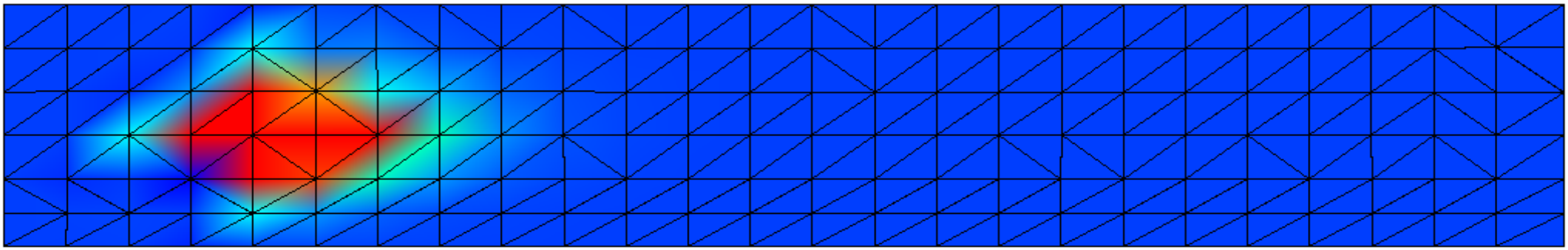
Refined #1

Refined #2

Refined #3

at timestep = 380 seconds

Adaptive Mesh with Concentration Plume



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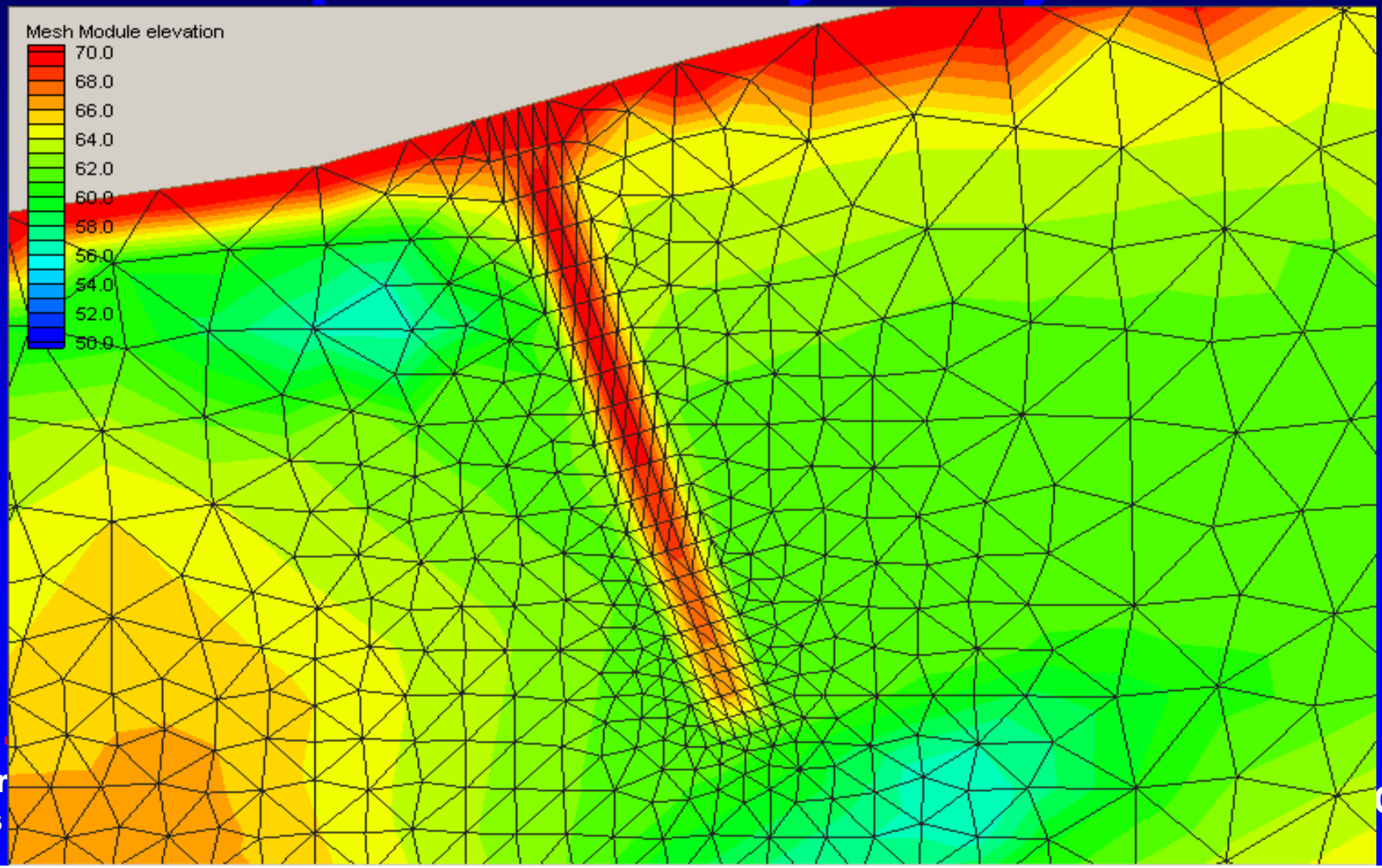
Benefit to users

- Create a mesh to capture the depths and geometry, let model refine mesh to capture hydraulic and sediment gradients.

Original Mesh Captures Bathymetry



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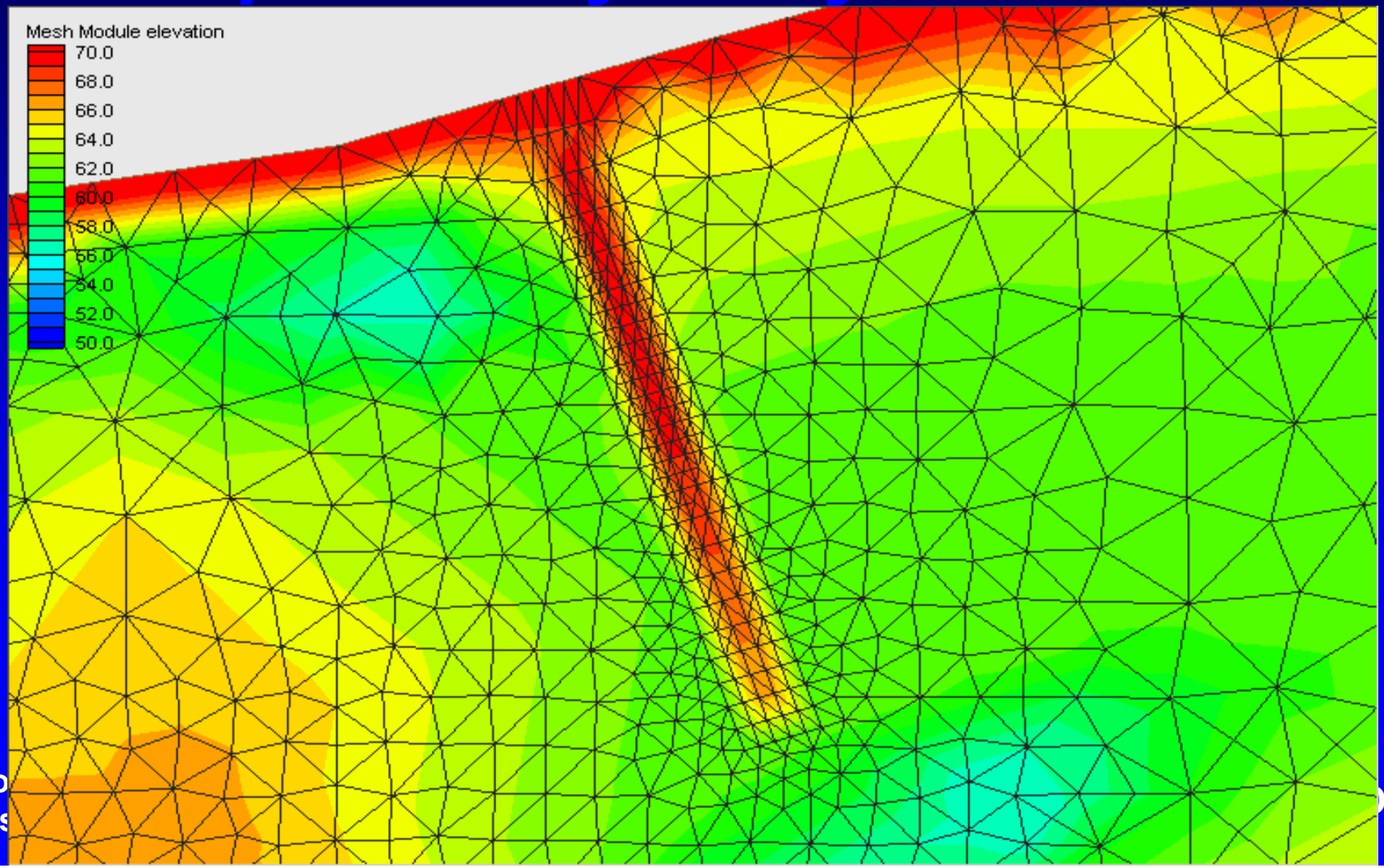
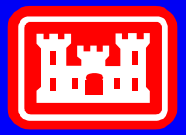
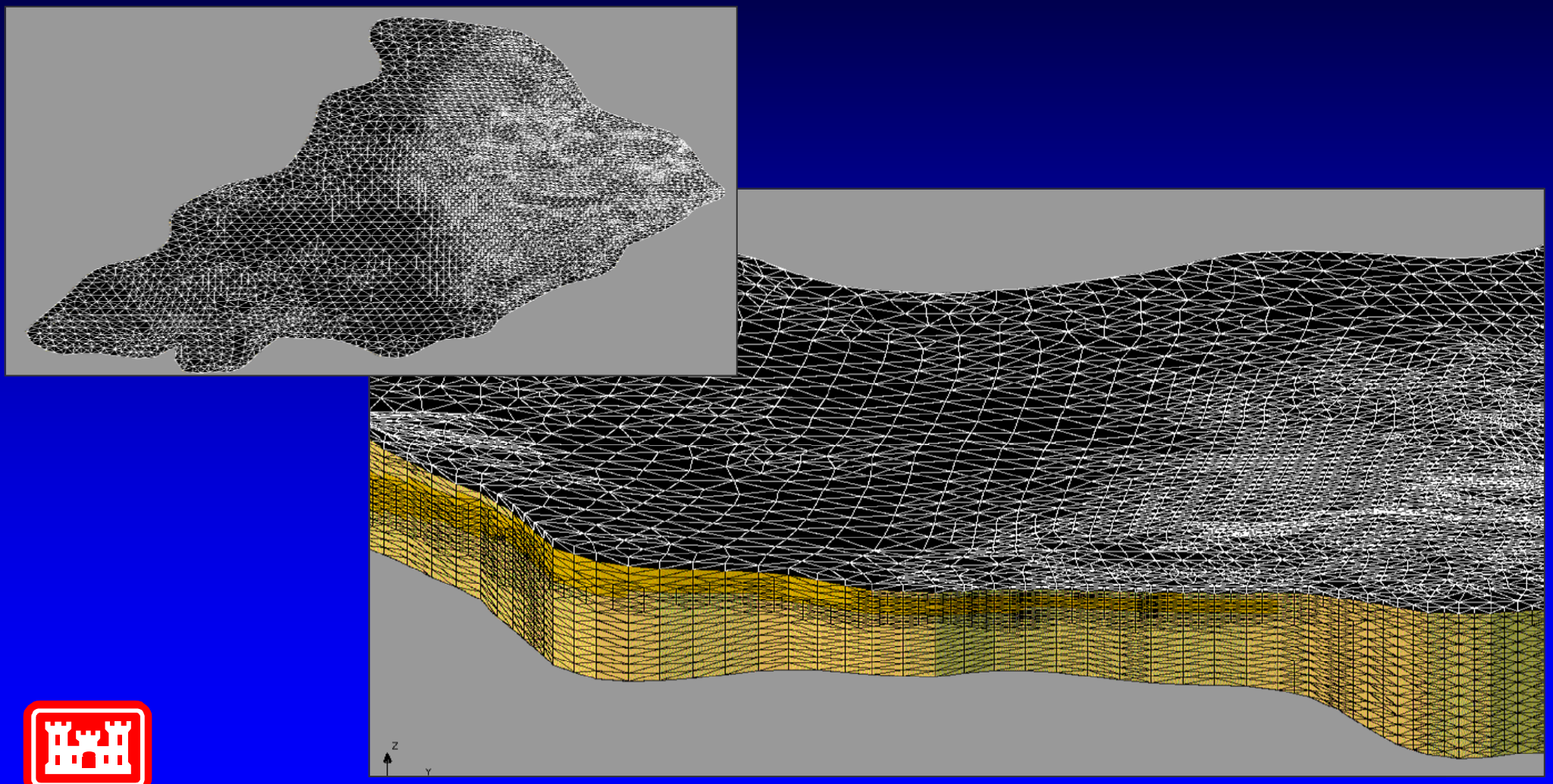
Adapted Mesh Captures Hydrodynamics



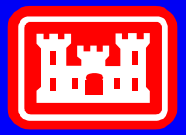
Adaption in 3D Example



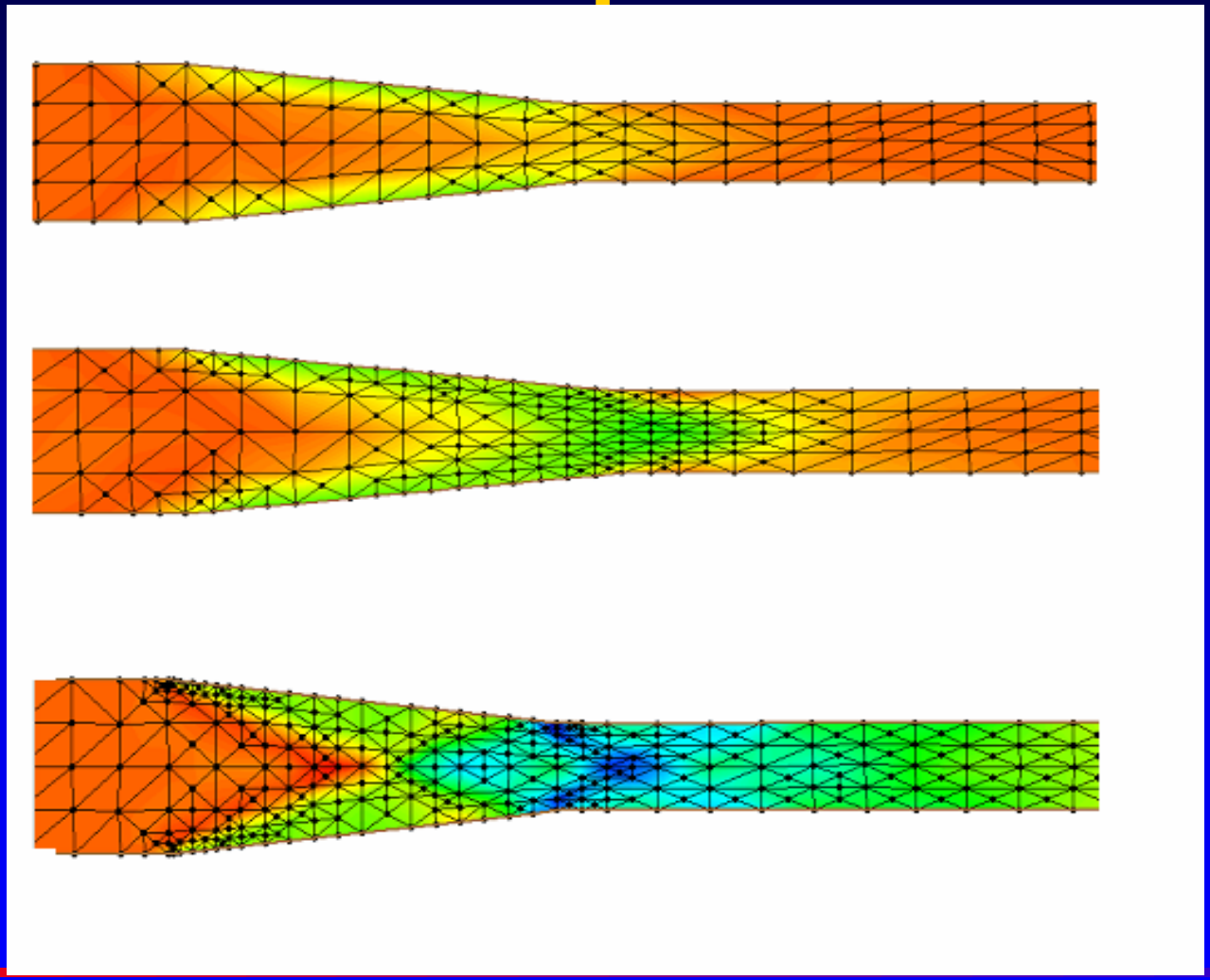
Mesh Adaption in the Subsurface



Adaption in 2D Examples



Supercritical Transition; Water Depth

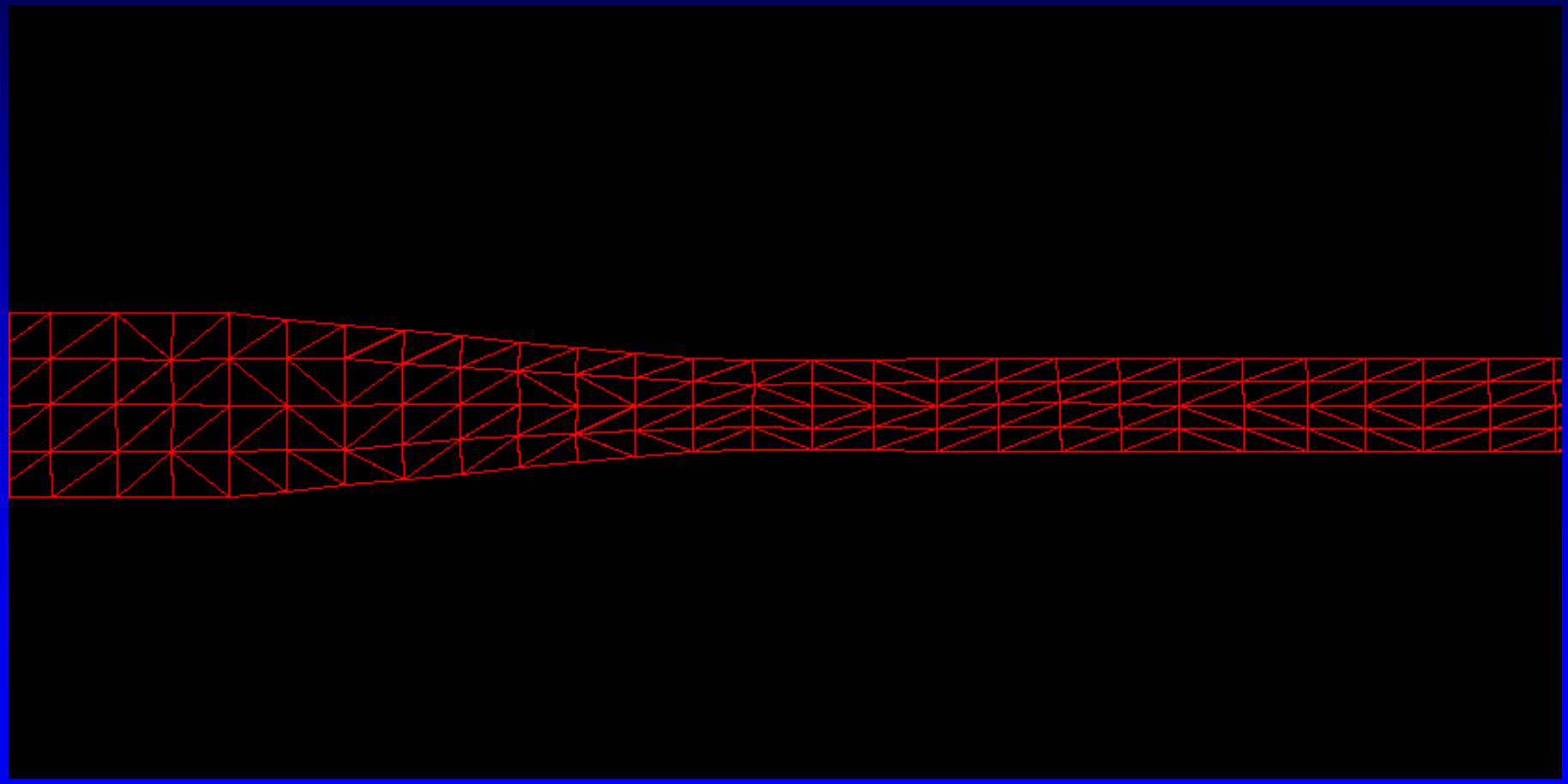


Early

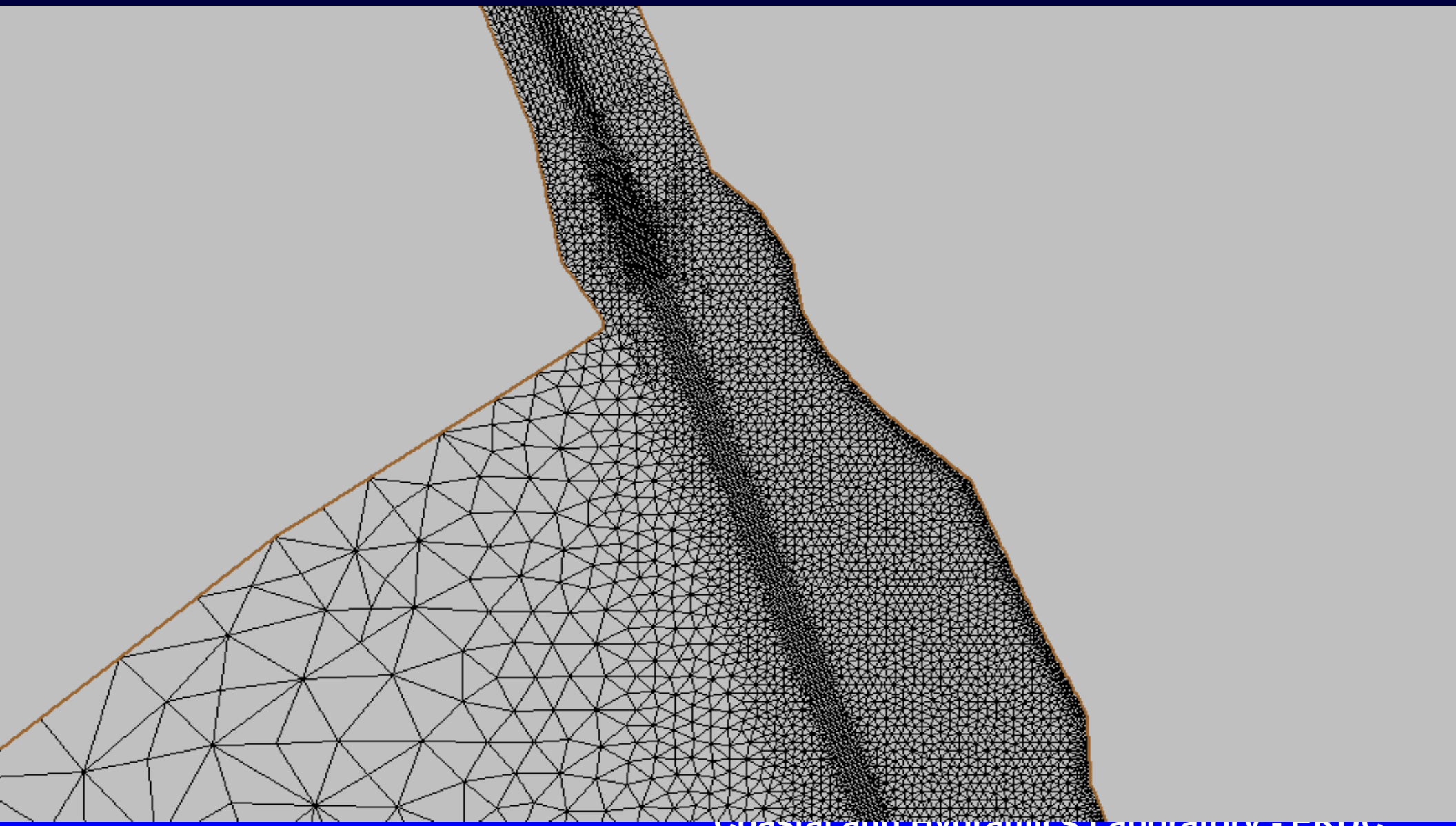
Intermediate

Final

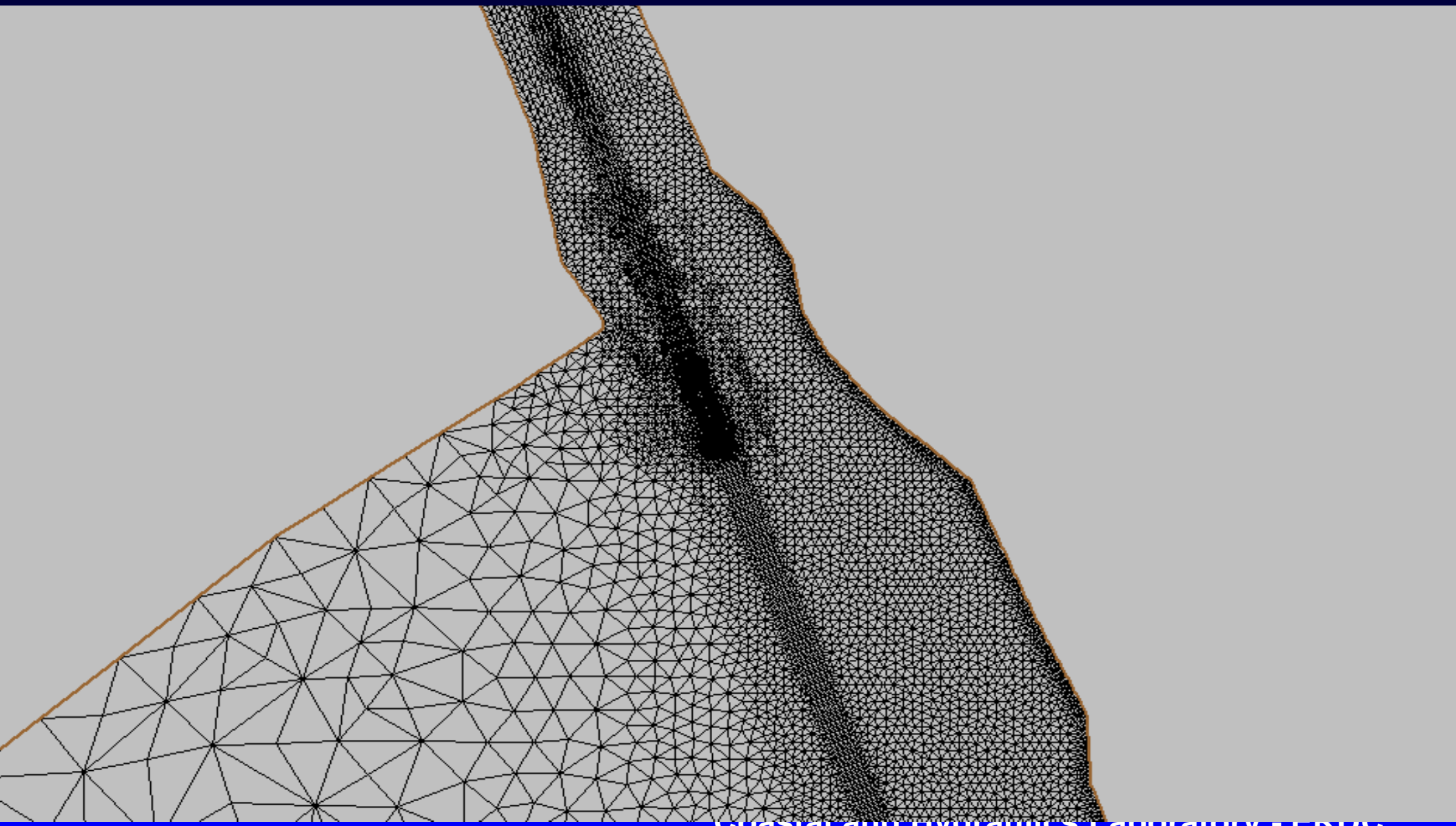
Supercritical Contraction



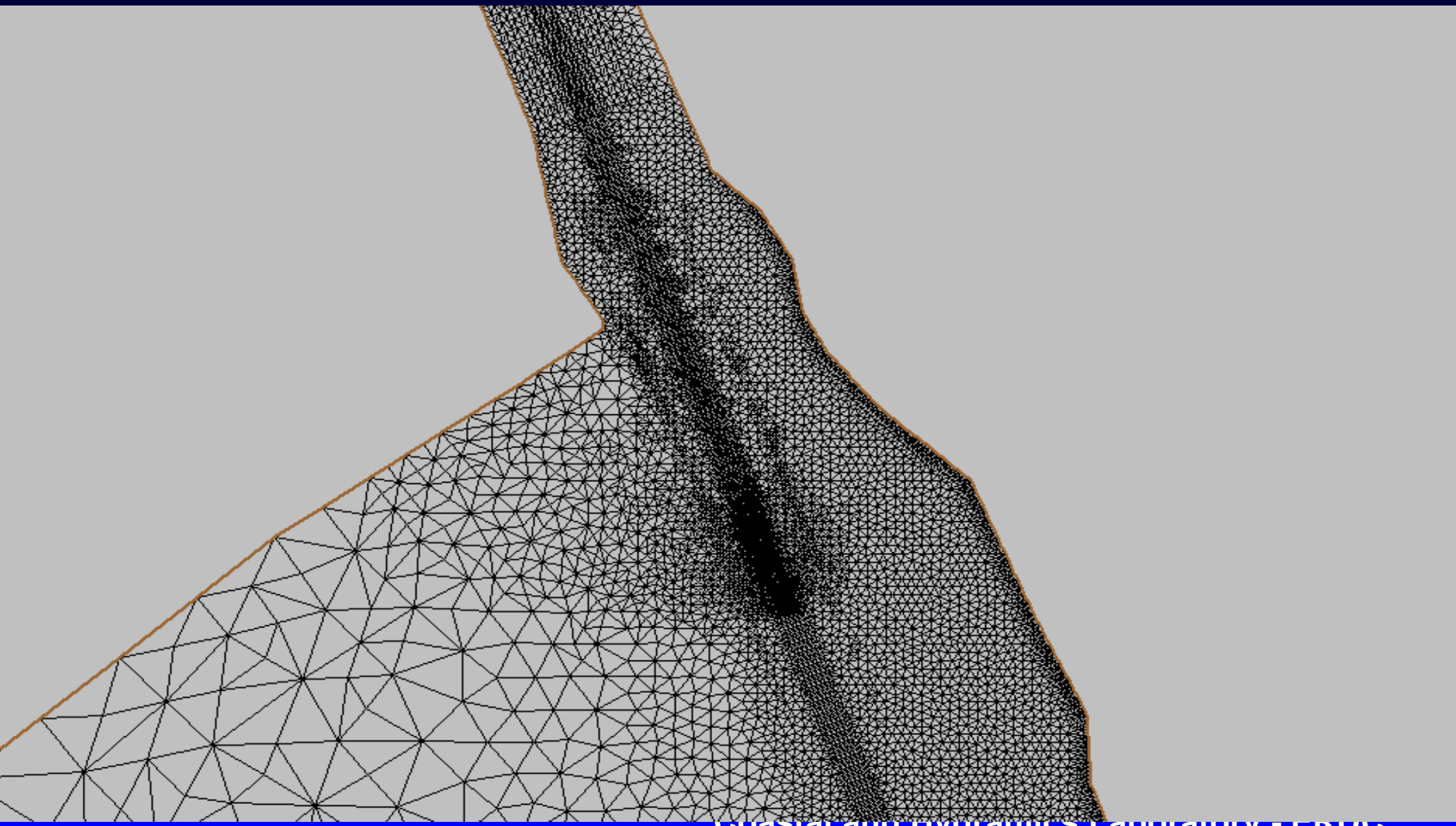
Adaption 1



Adaption 2

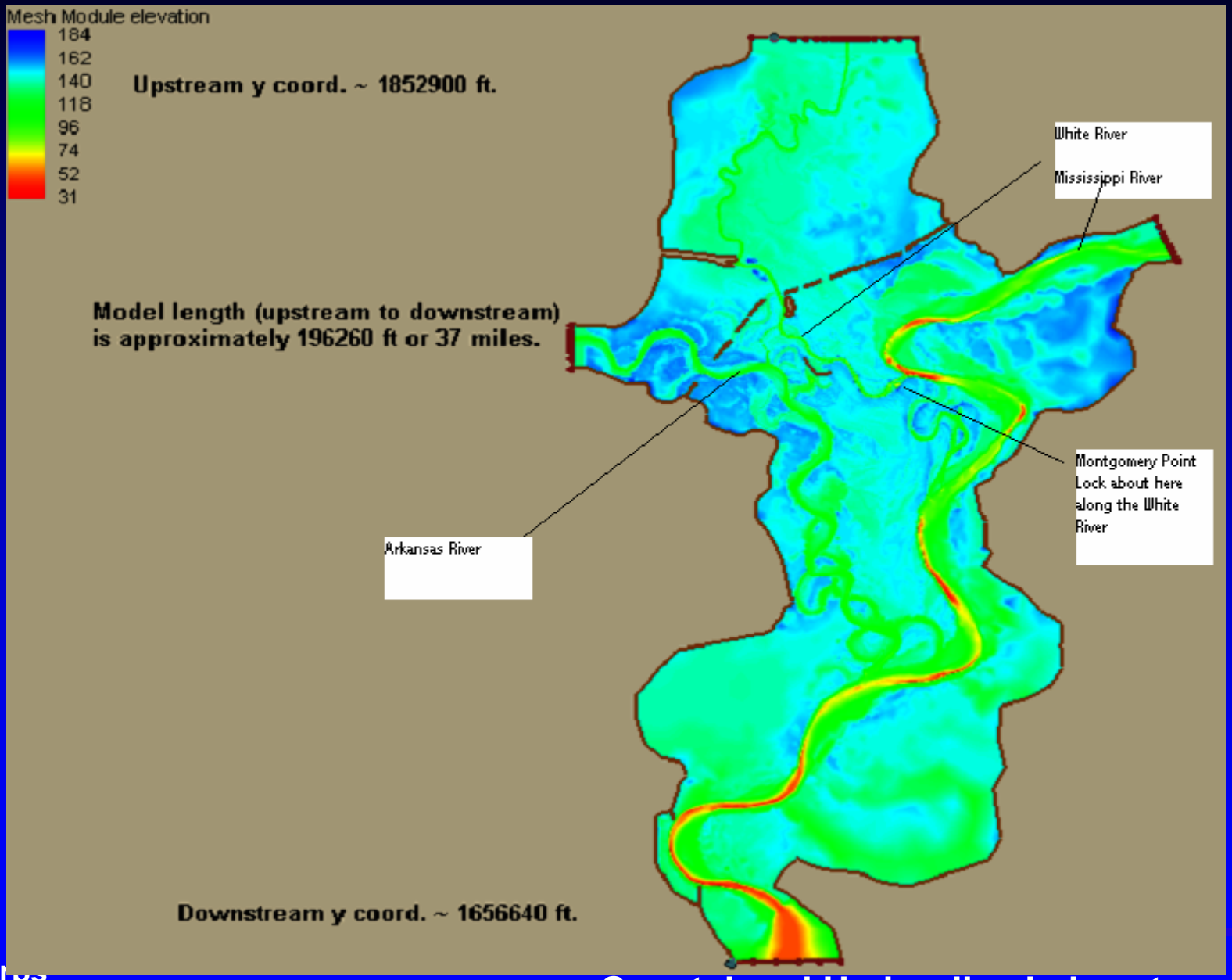


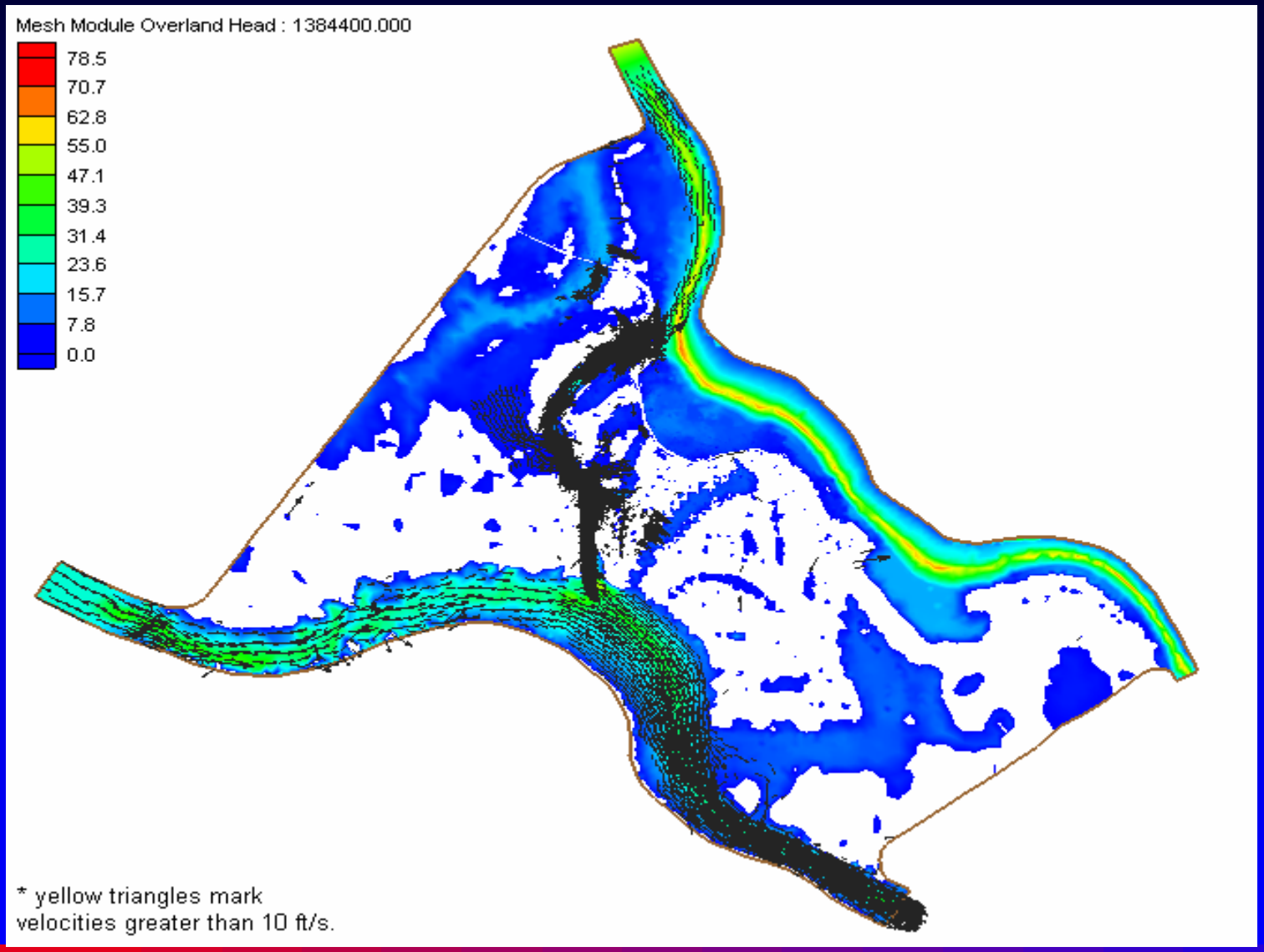
Adaption 3



Flooding Example – 2D

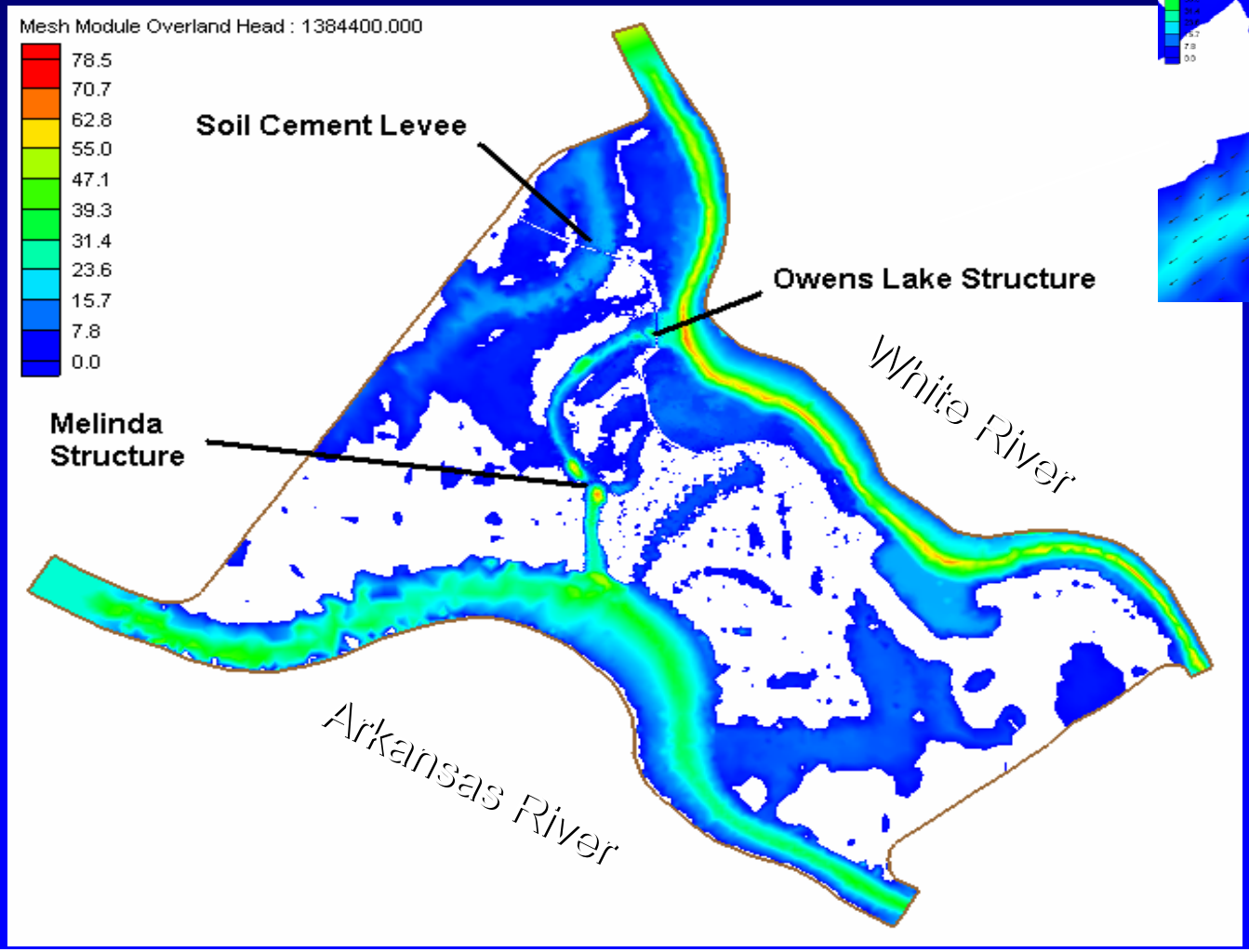

White River
Arkansas River
Mississippi River
Rosedale, MS


Mesh Module elevation
184
162
140
118
96
74
52
31
Upstream y coord. ~ 1852900 ft.
Model length (upstream to downstream) is approximately 196260 ft or 37 miles.
Downstream y coord. ~ 1656640 ft.
White River
Mississippi River
Montgomery Point Lock about here along the White River
Arkansas River

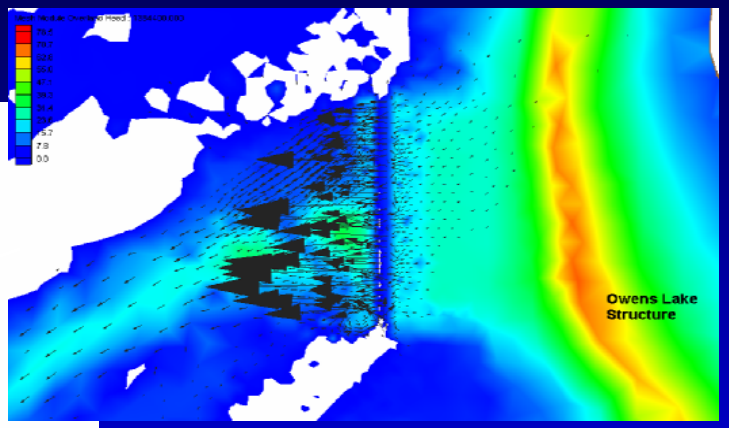

Mesh Module Overland Head : 1384400.000
78.5
70.7
62.8
55.0
47.1
39.3
31.4
23.6
15.7
7.8
0.0
* yellow triangles mark
velocities greater than 10 ft/s.

Arkansas and White Rivers Example

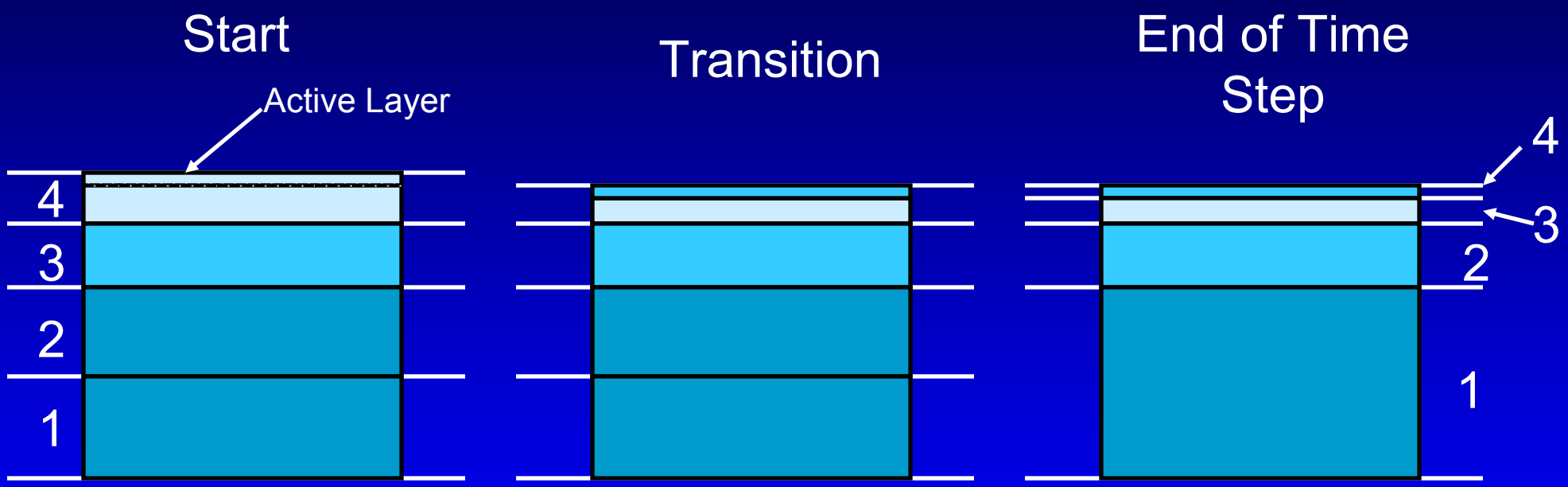
Inundation – water depths



Flow over levee - Velocity



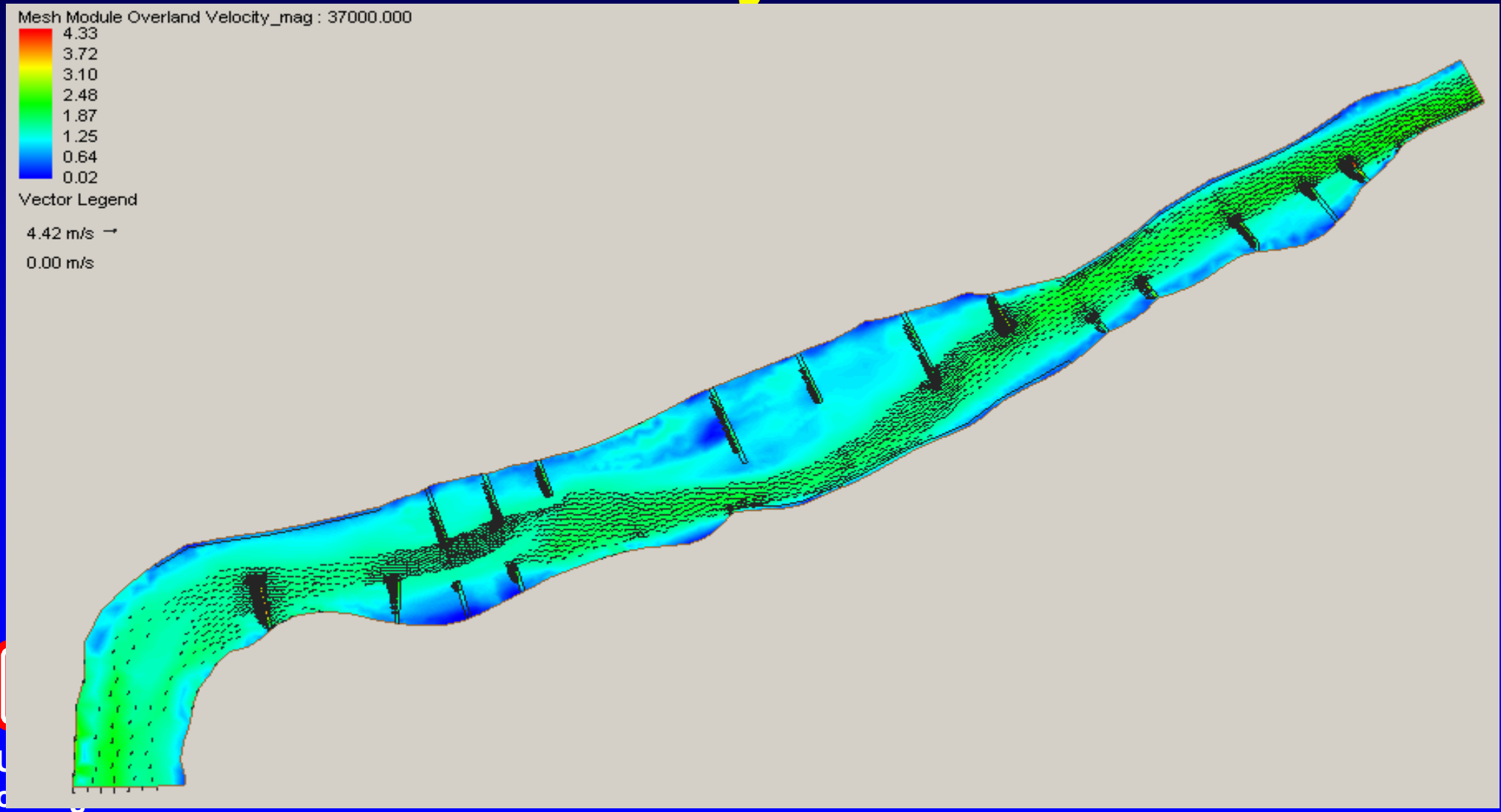
Bed Algorithm



Erosion with armoring

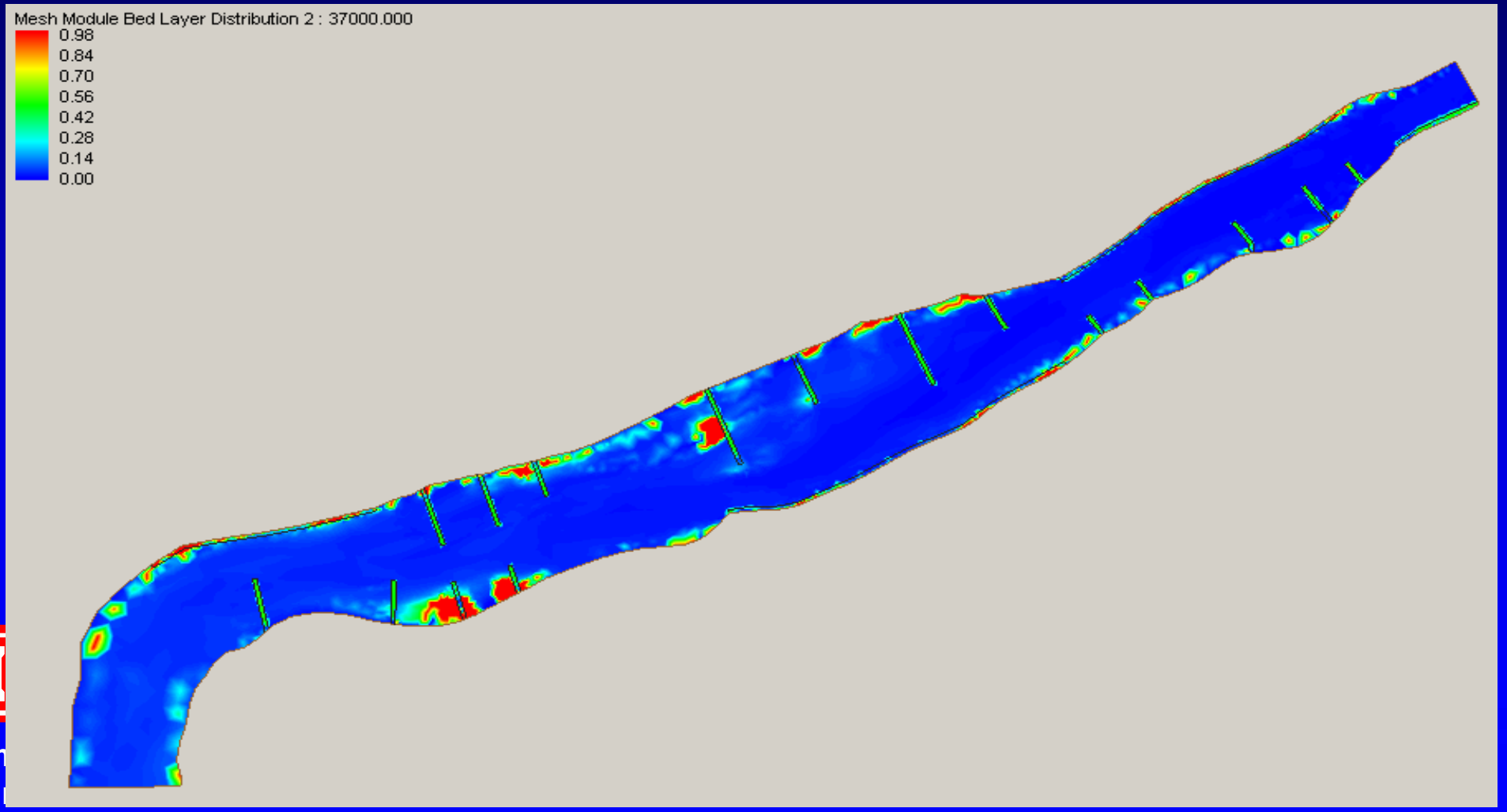
Combine most similar strata

Kate Aubrey - Currents



1975 Kate Aubrey – Miss. River

Sediment Bed
Very Fine Sand Deposits



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1999 Kate Aubrey – Miss. River

2D Module Features

- Bendway Correction
- Integration from 3D
- Coupled bed/flow calculations
- Wetting/drying

Development Path

- Long term simulation
- Water Quality Library connection
- 2D/3D meshes

Conclusions

- Modular Design
  Multiphysics
  Library – Sediment
- Adaption
- Bed Load, Suspended Load, Bendway Correction (flow and sediment)