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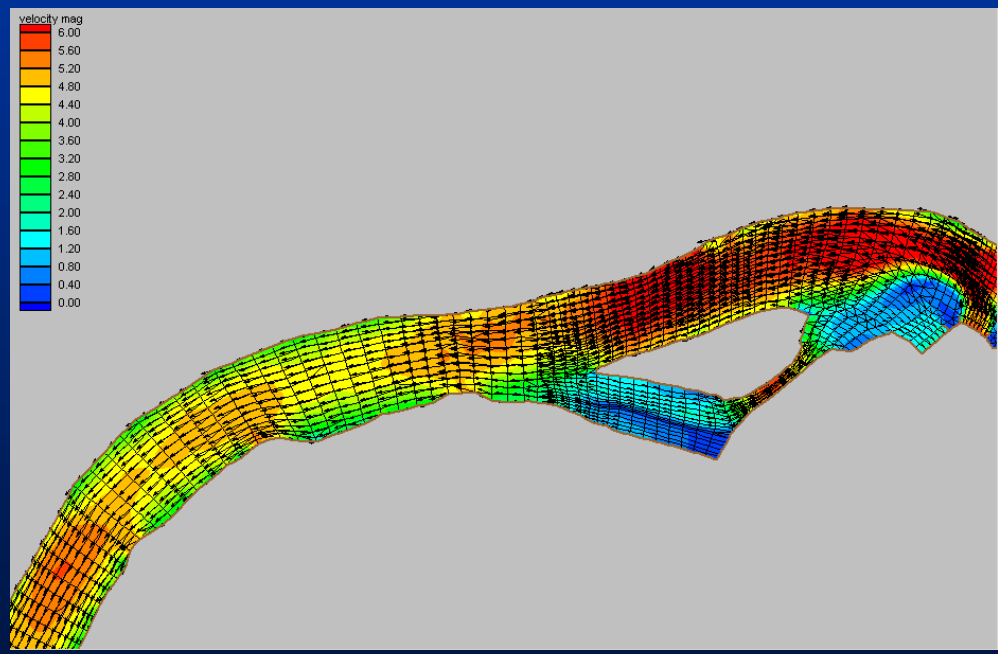
Tools for Flow and Sediment Modeling

USGS Hydrologic Workshop



U.S. Department of the Interior
U.S. Geological Survey

Outline

- Two-dimensional hydrodynamic model of Ohio River, Jefferson County, Kentucky – Ohio River Valley Water Sanitation Commission (ORSANCO)
- Olmsted Locks and Dam hydrodynamic and sediment transport model – Louisville Corps of Engineers
- Other USGS modeling applications

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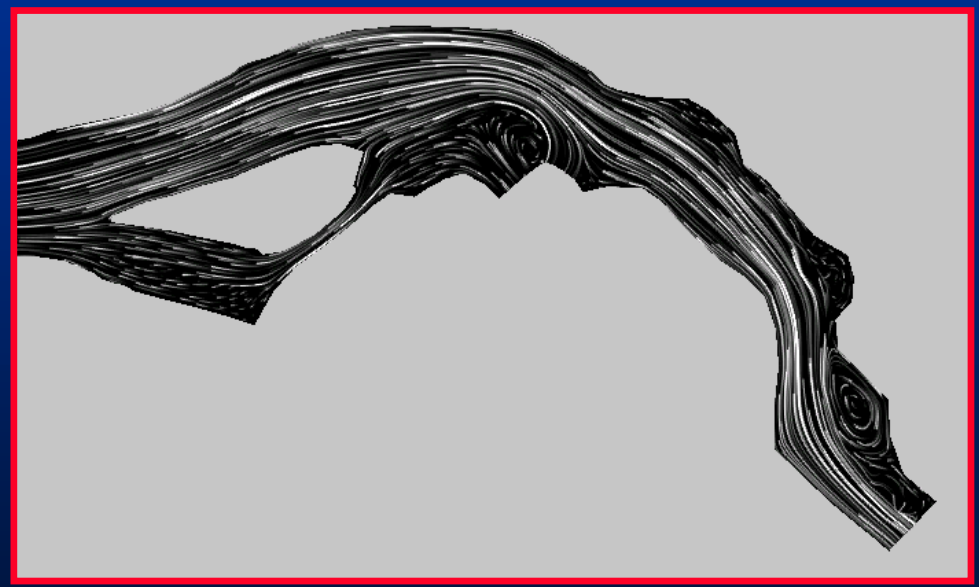
Two-Dimensional Hydrodynamic Model of the Ohio River, Jefferson County, KY

U.S. Geological Survey

ORSANCO



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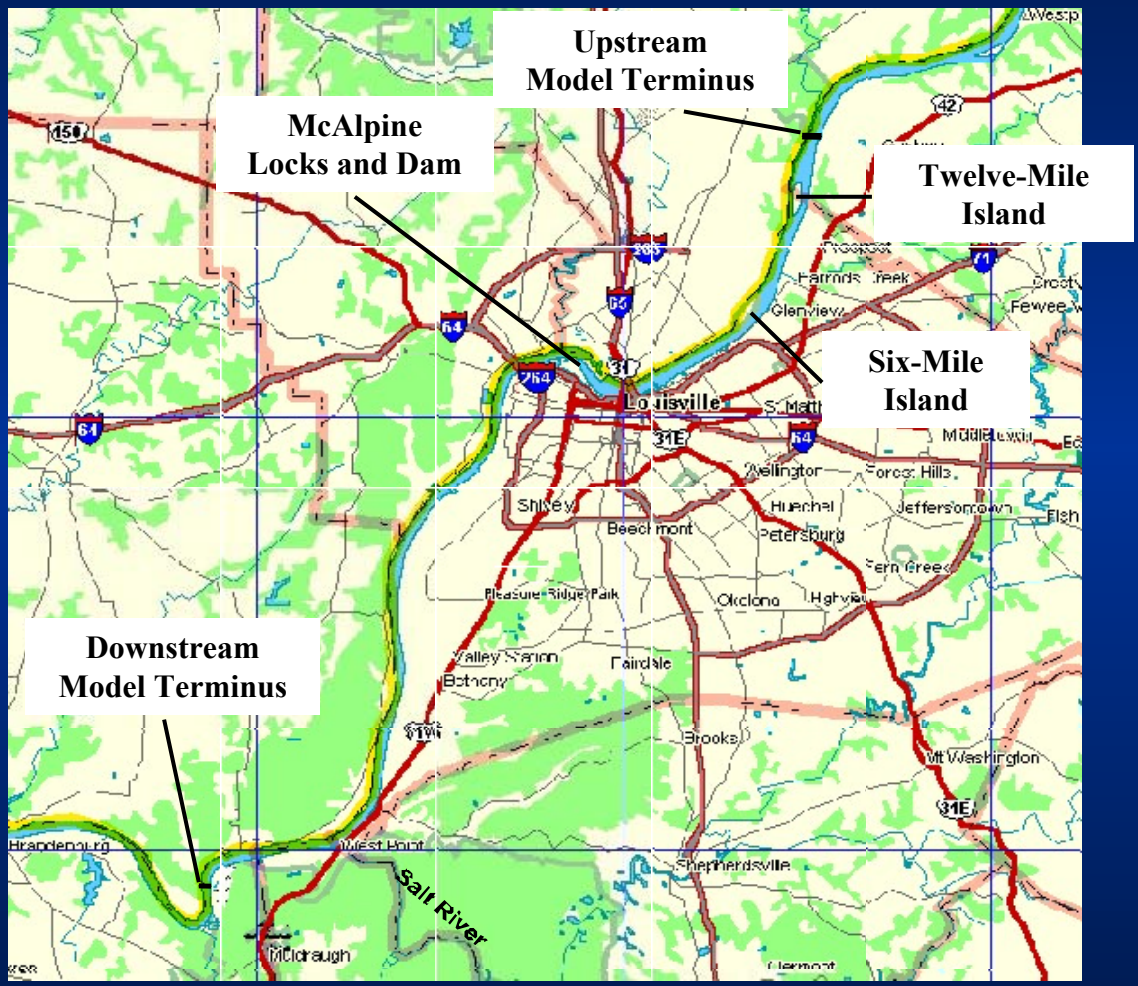
Site Map



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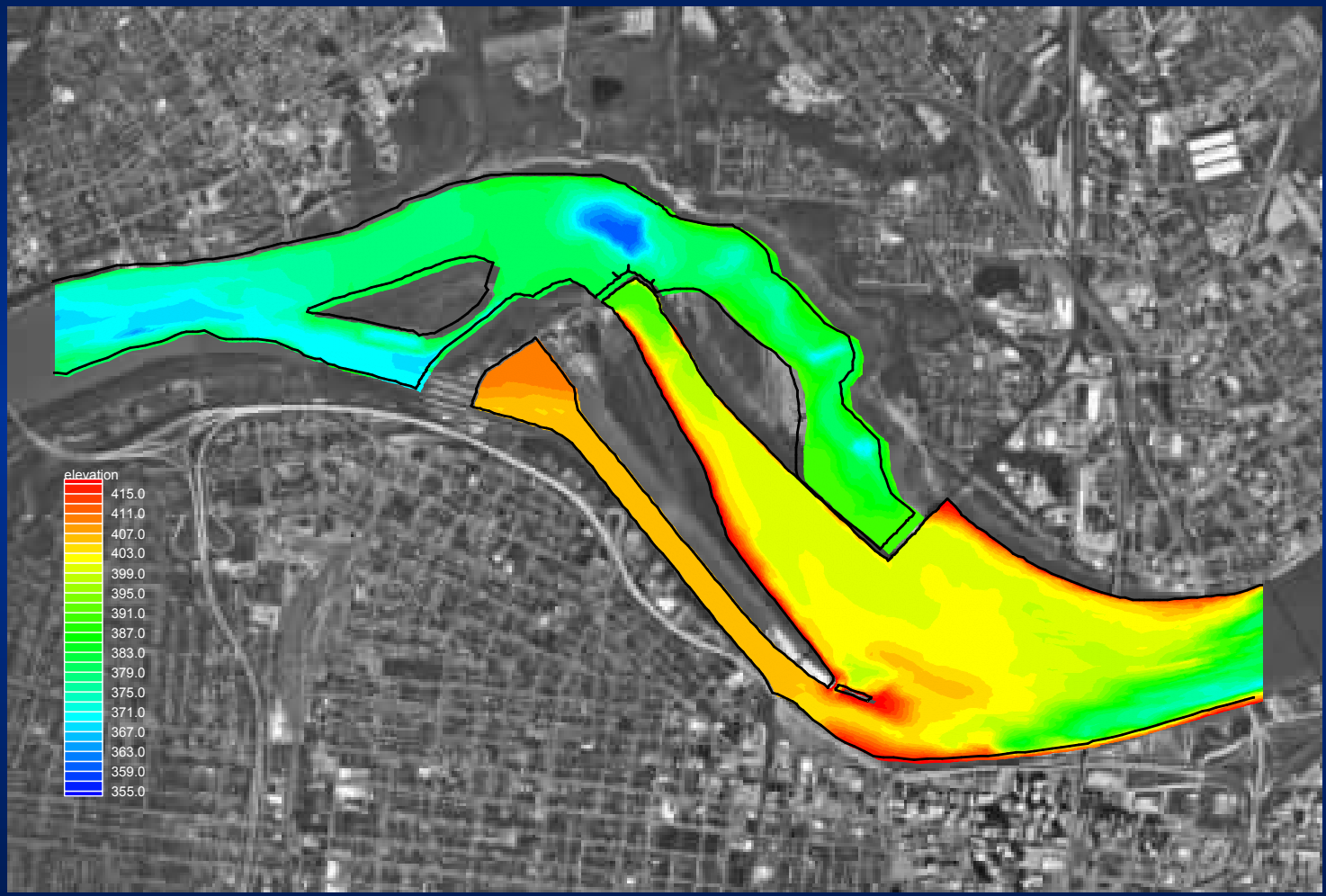
Model Bathymetry around McAlpine Locks and Dam



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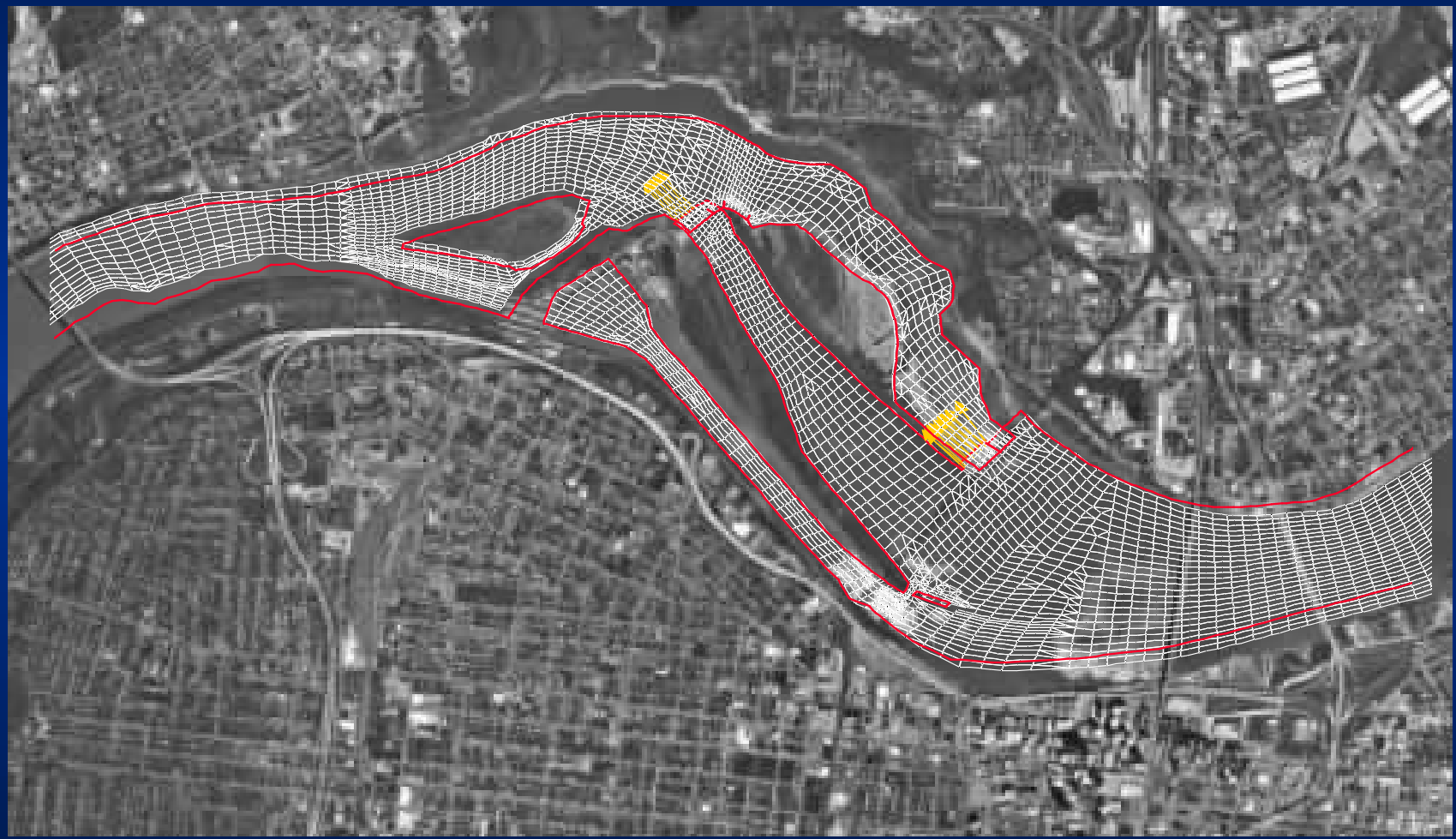
McAlpine Locks and Dam Mesh



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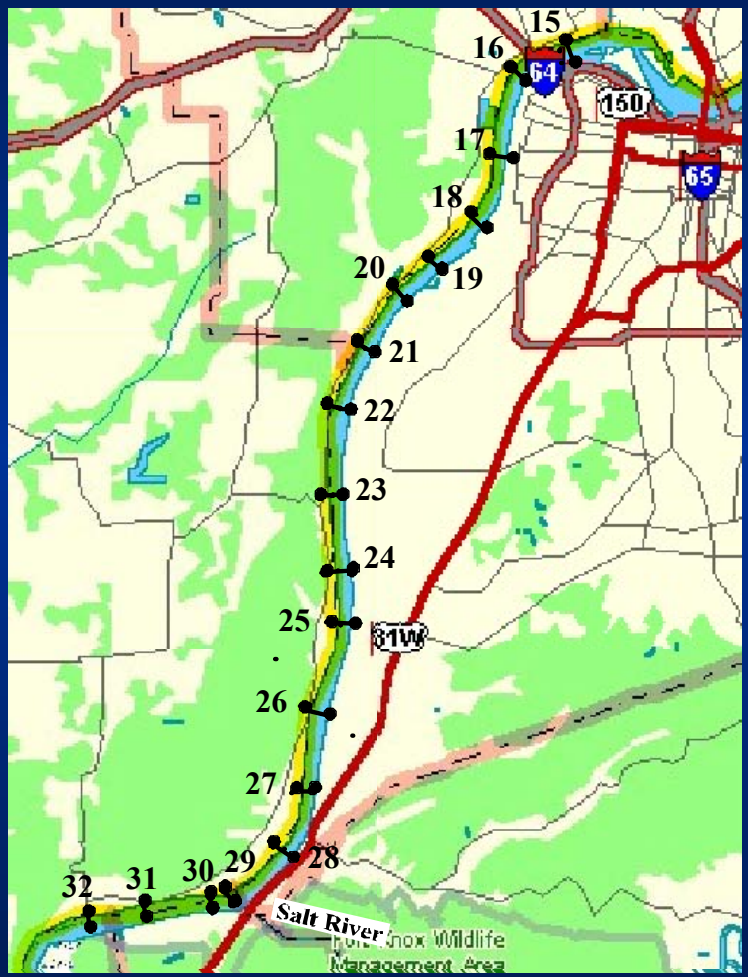
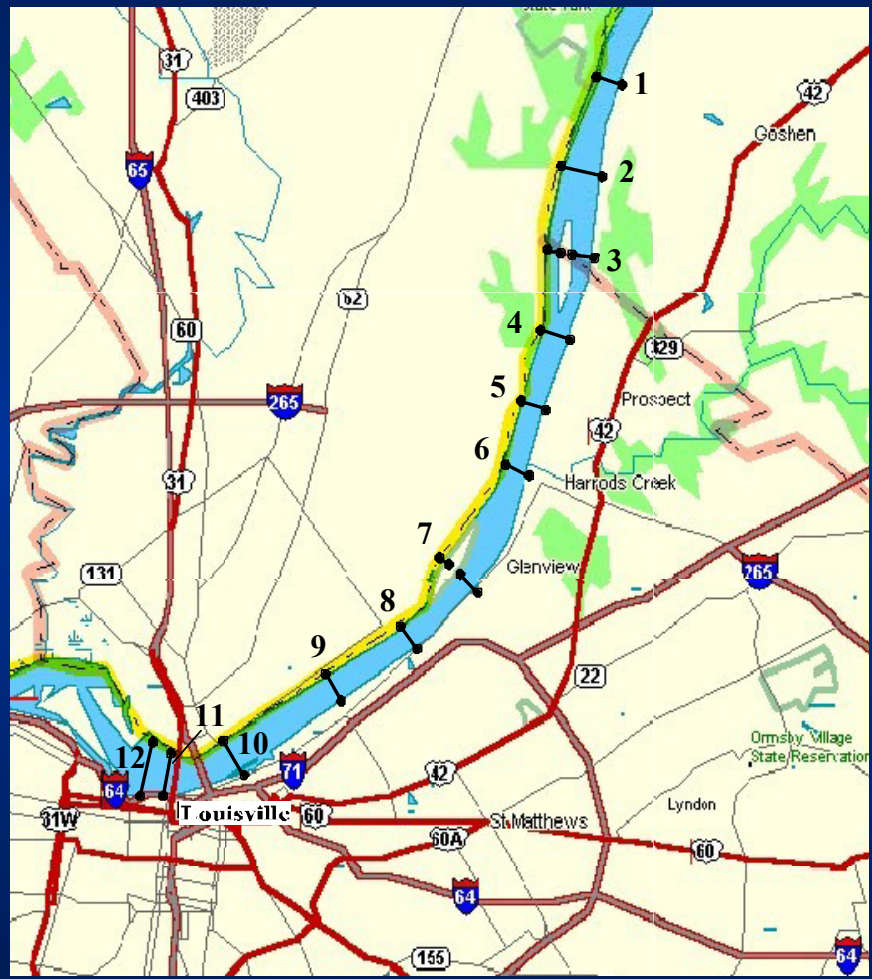
Hydrographic Survey Lines





Island Flows

High Flow Location	Field Flow Split	Model Flow Split
12-Mile Island - Right	51.60%	49.90%
12-Mile Island - Left	48.40%	49.50%
6-Mile Island - Right	11.20%	10.00%
6 - Mile Island - Left	88.80%	90.00%

Low Flow Location	Field Flow Split	Model Flow Split
12-Mile Island - Right	53.60%	51.70%
12-Mile Island - Left	46.40%	48.30%
6-Mile Island - Right	8.90%	7.80%
6 - Mile Island - Left	91.10%	92.00%

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Upstream Velocity Comparison

	Low Flow		High Flow	
	ADCP (WinRiver)	Model	ADCP (WinRiver)	Model
Xsection	Avg. Vel (ft/s)	Avg.Vel(ft/s)	Avg. Vel (ft/s)	Avg.Vel(ft/s)
1	0.483	0.522	4.71	4.76
2	0.577	0.529	4.29	4.38
3L	0.55	0.561	4.75	4.87
3R	0.407	0.492	3.84	4.28
4	--	--	4.37	4.48
5	0.492	0.482	4.67	4.69
6	0.53	0.461	4.37	4.37
7L	0.363	0.318	3.84	3.33
7R	0.546	0.478	4.37	4.53
8	0.486	0.46	4.37	4.44
9	--	--	3.88	4.15
10	0.43	0.426	4.05	4.35
11	0.673	0.541	5.08	5.32
12	0.561	0.541	4.17	4.83

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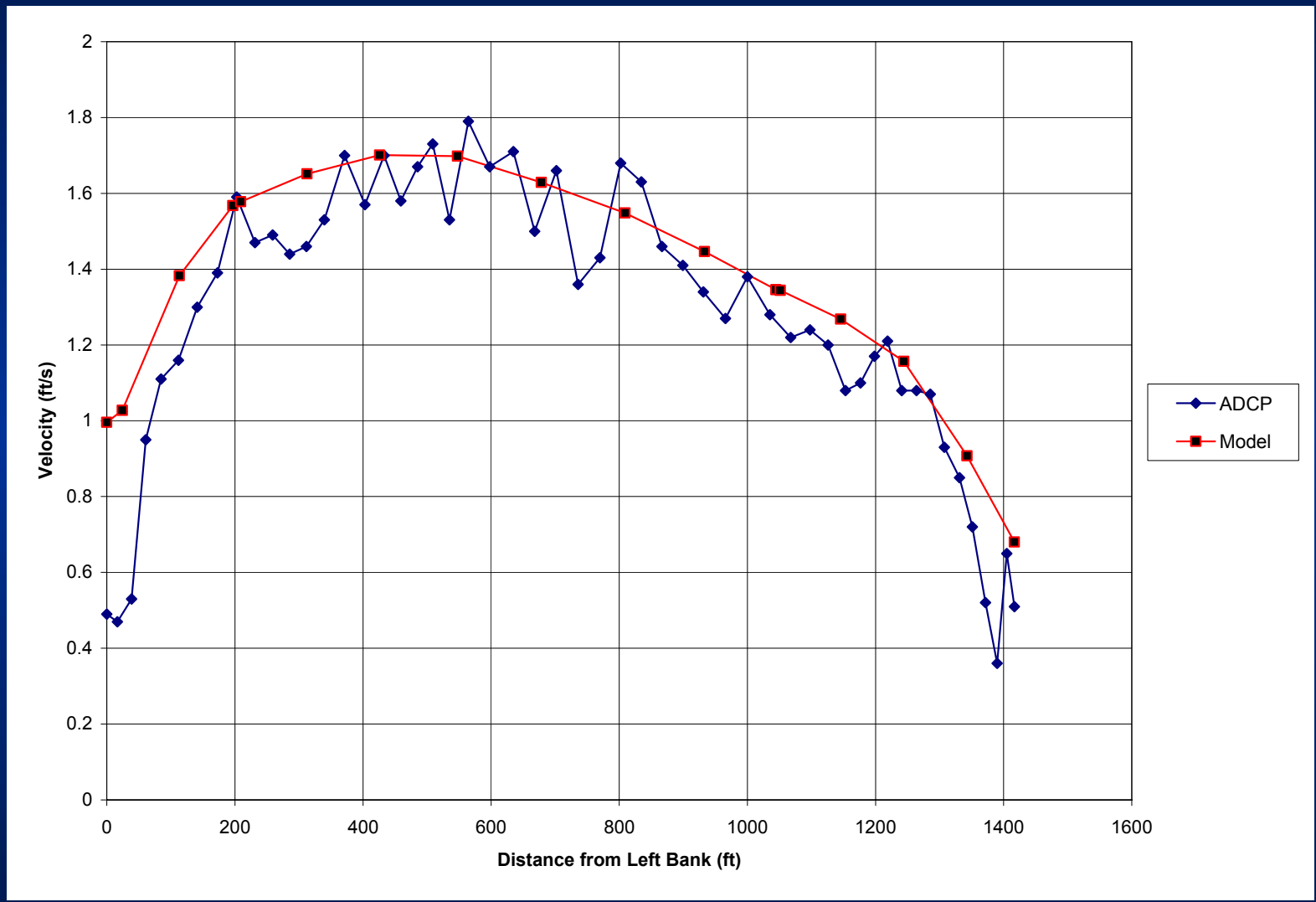
DS Section (Line 19) – Low-Flow Velocity Profile



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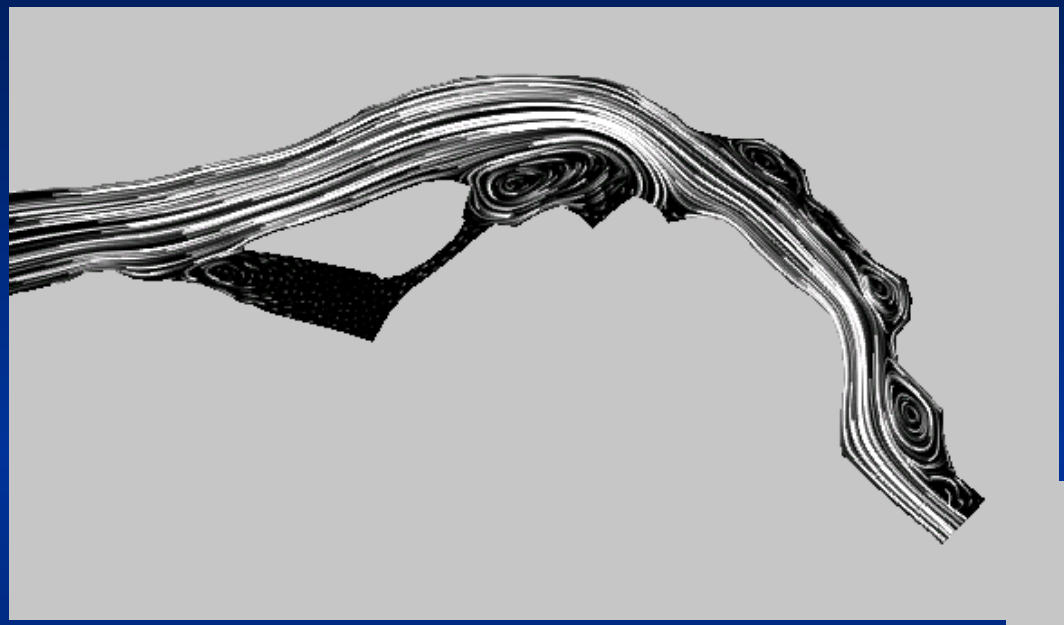
Flow Trace –McApline Locks & Dam (High Flow / 390,000 cfs)



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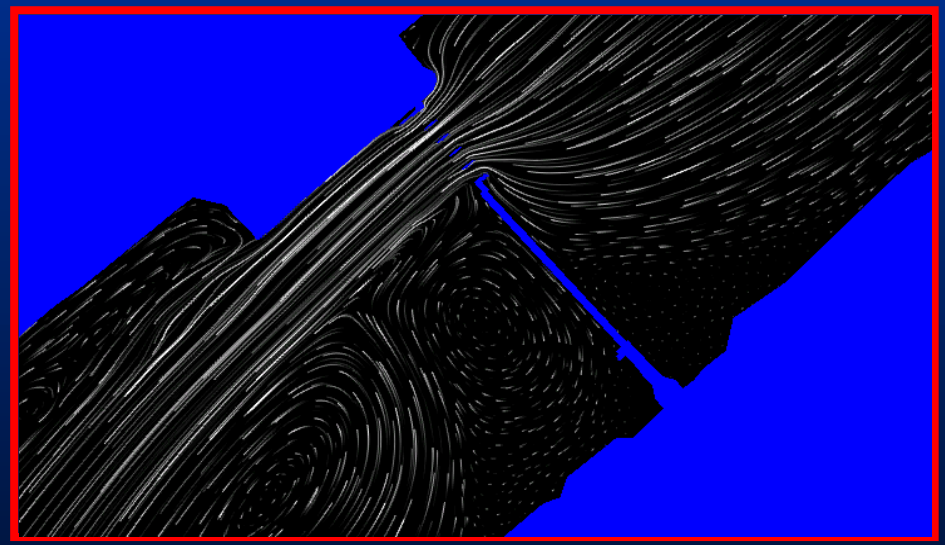
Olmsted Sediment Transport Modeling Project

U.S. Geological Survey
Army Corps of Engineers, Louisville District



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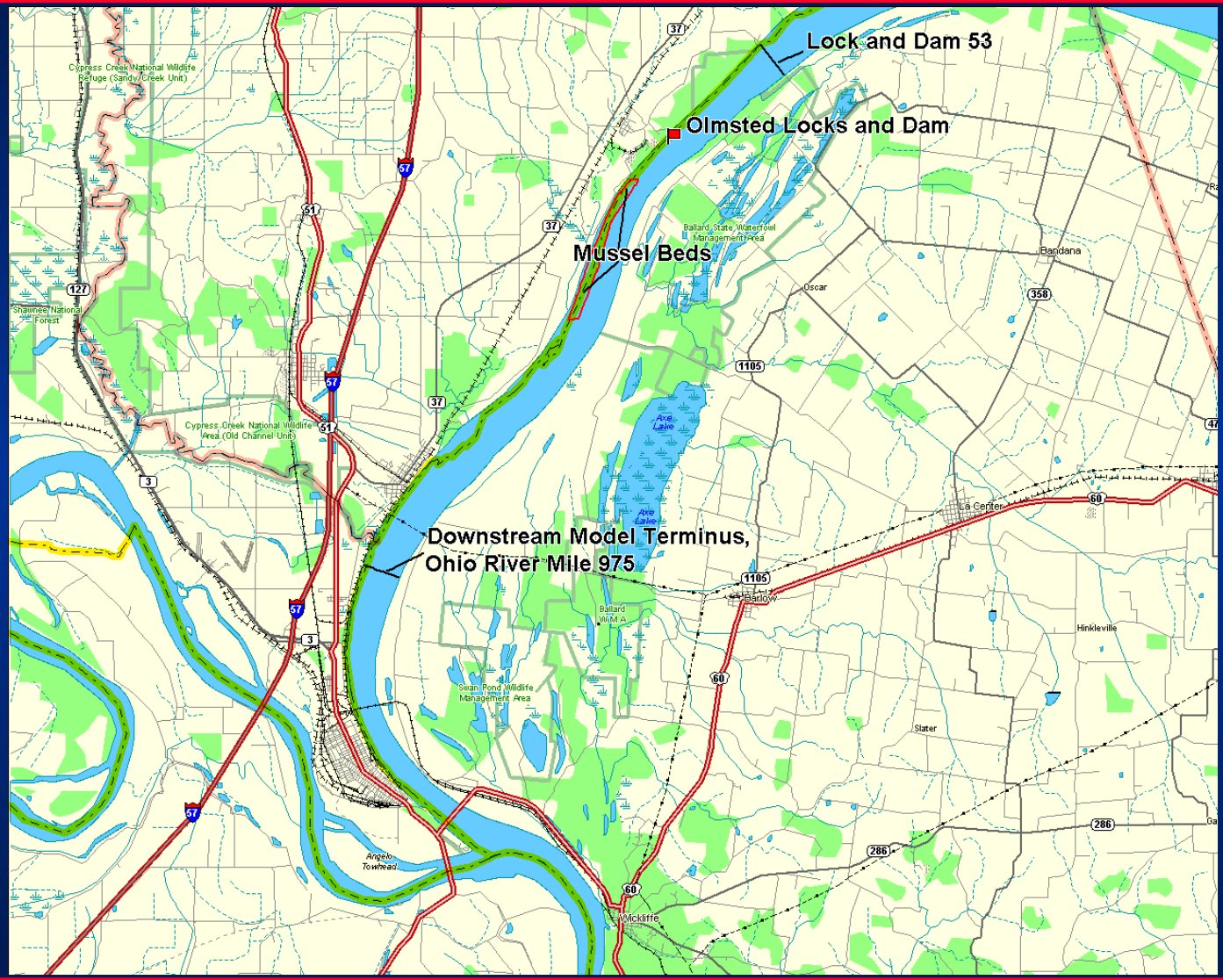
Site Map – Olmsted Locks and Dam



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Hydrodynamic Calibration and Validation

- Three hydrographic surveys conducted in study reach (75,000 - 350,000 - 750,000 cfs) with ADCP.
- ADCP, 3-D velocities processed to Depth Integrated 2-D using measured velocities w/ no compensation for unmeasured areas (~ 4% error)
- Bathymetry in study reach surveyed by St. Louis COE with a multi-beam echo sounder; floodplains digitized from USGS 7.5' Quadrangle maps.

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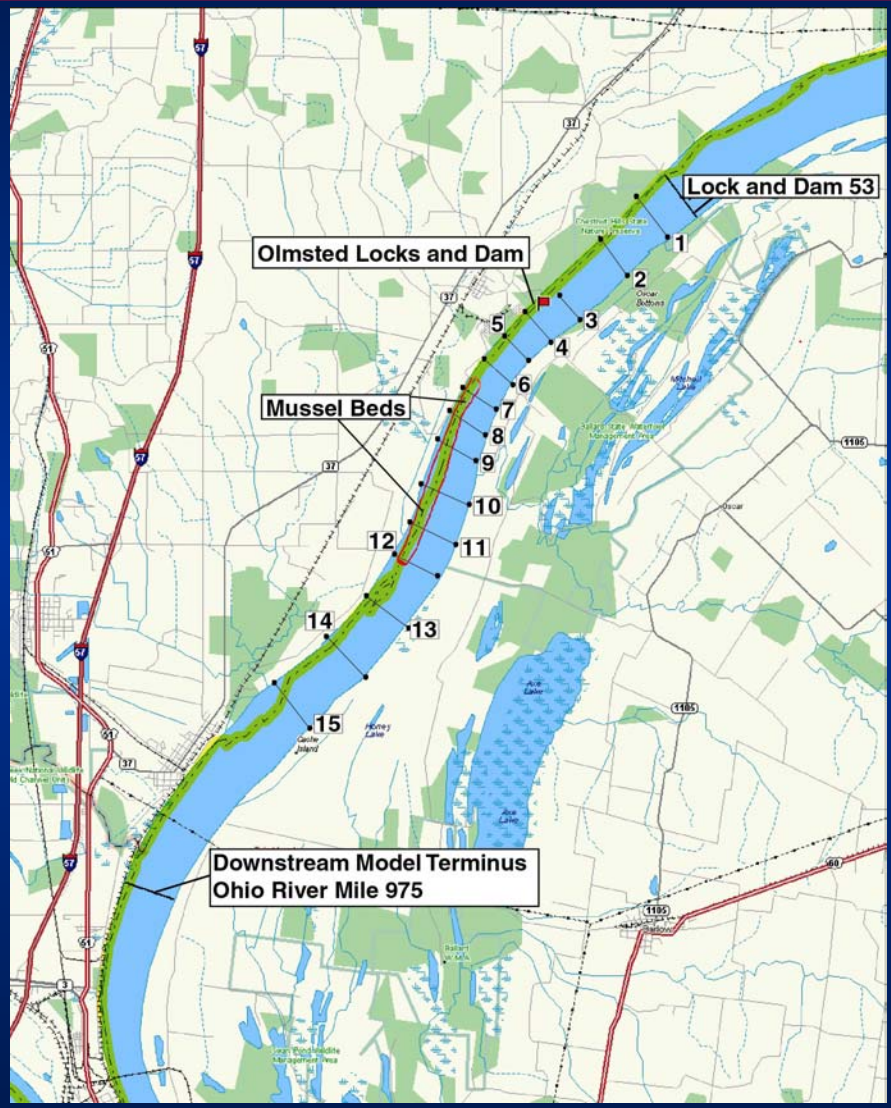
Hydrographic Survey Lines



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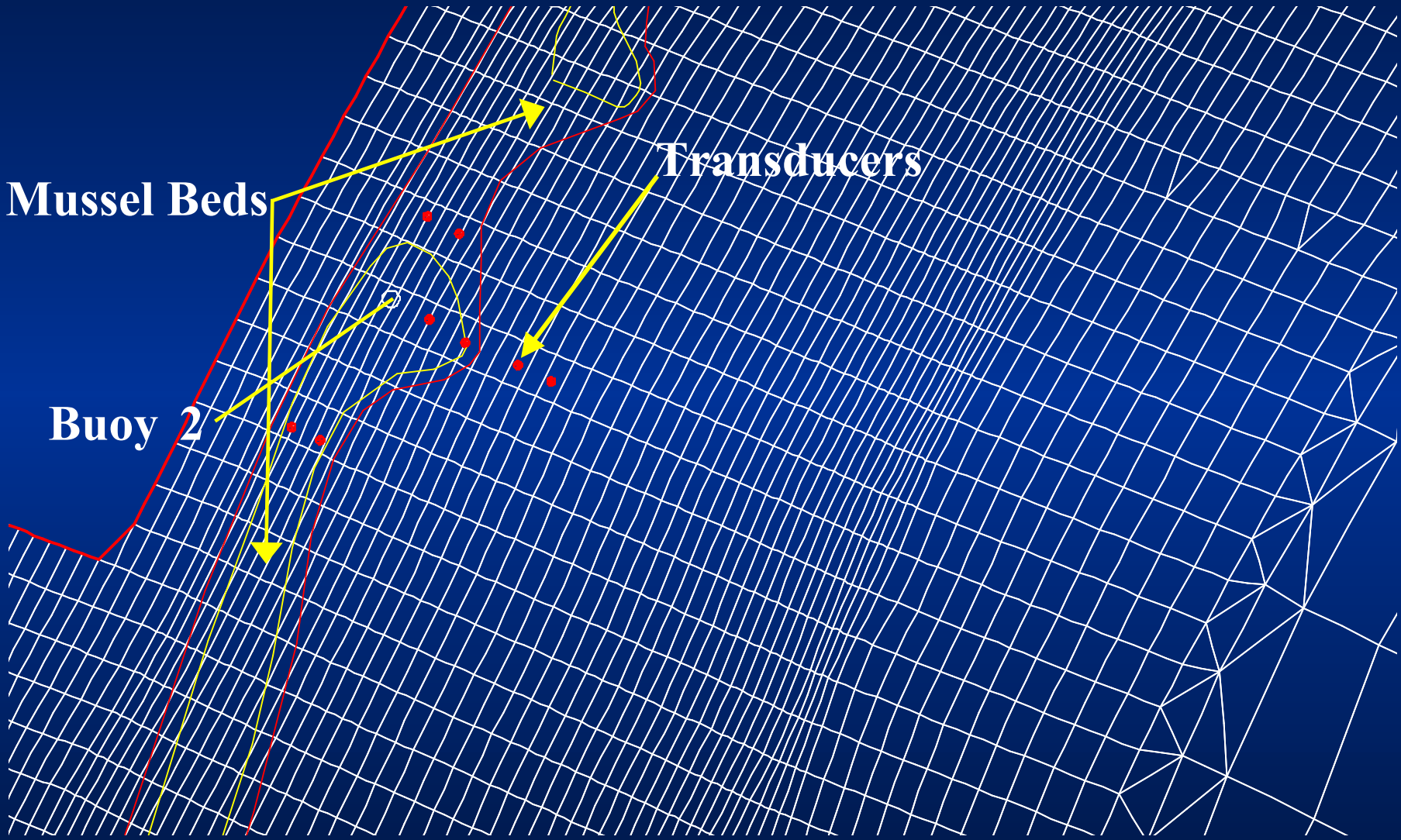
Section of Mesh Around Mussel Beds



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Water Surface Elevation Comparison

	Water Surface Elevation		
	Field	Model	
Discharge (cfs)	Olmsted (ft)	Olmsted (ft)	Difference (ft)
75,000	286.84	287.06	0.22
350,000	305.94	306.00	0.06
750,000	322.34	322.10	-0.24

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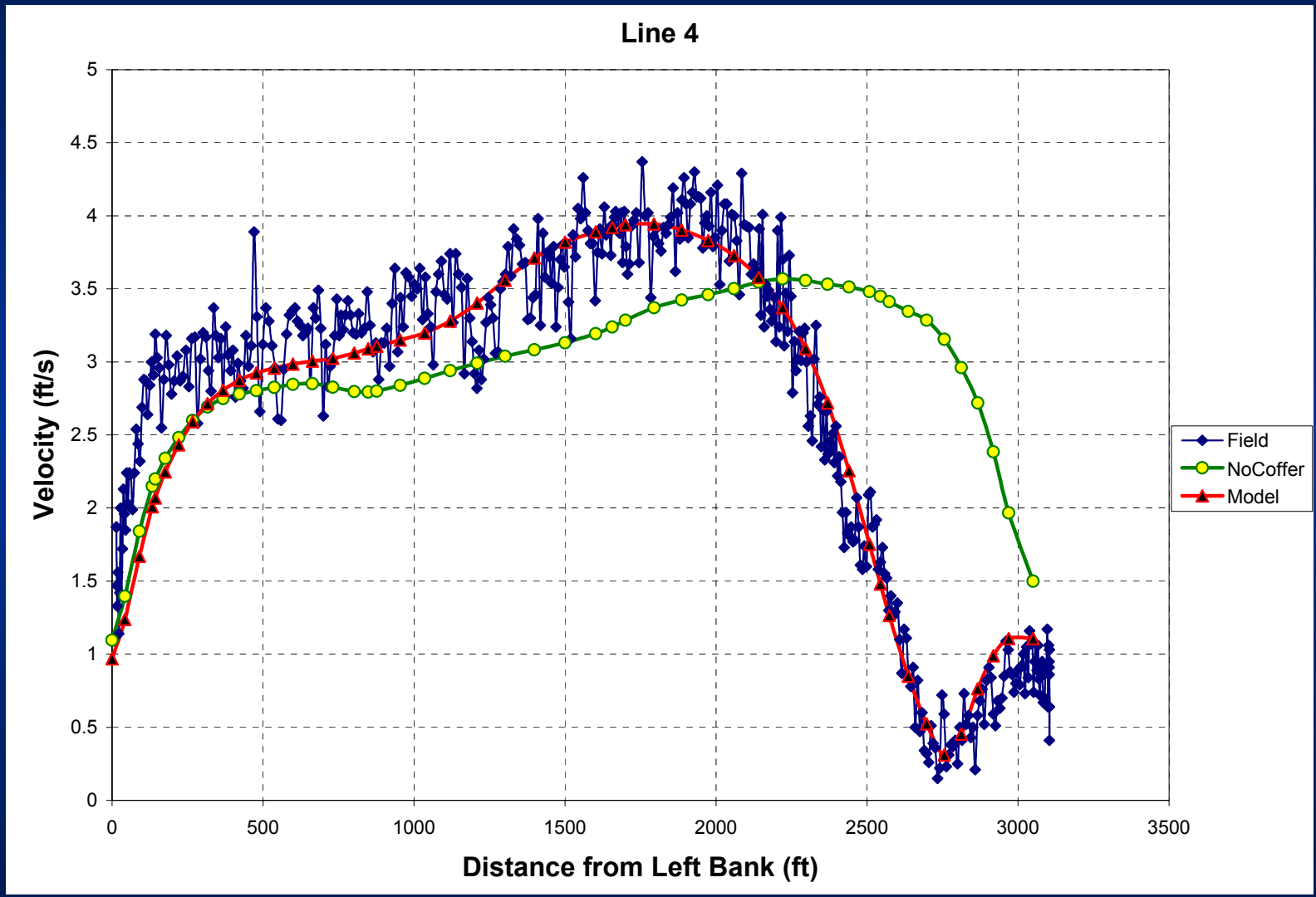
Line 4 – Velocity Profile (350,000 cfs)



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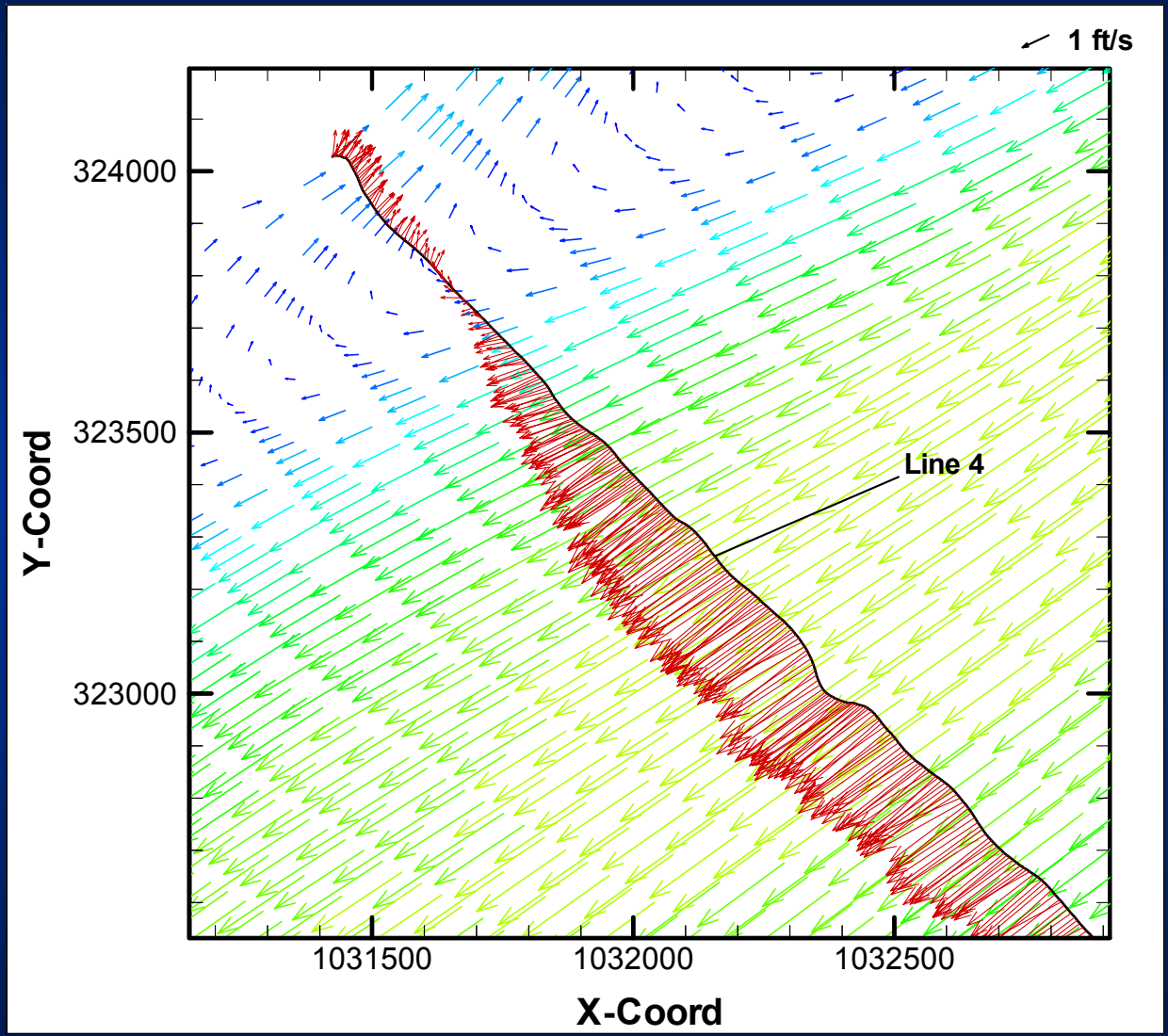
Line 4 – Velocity Direction Comparison (350,000 cfs)



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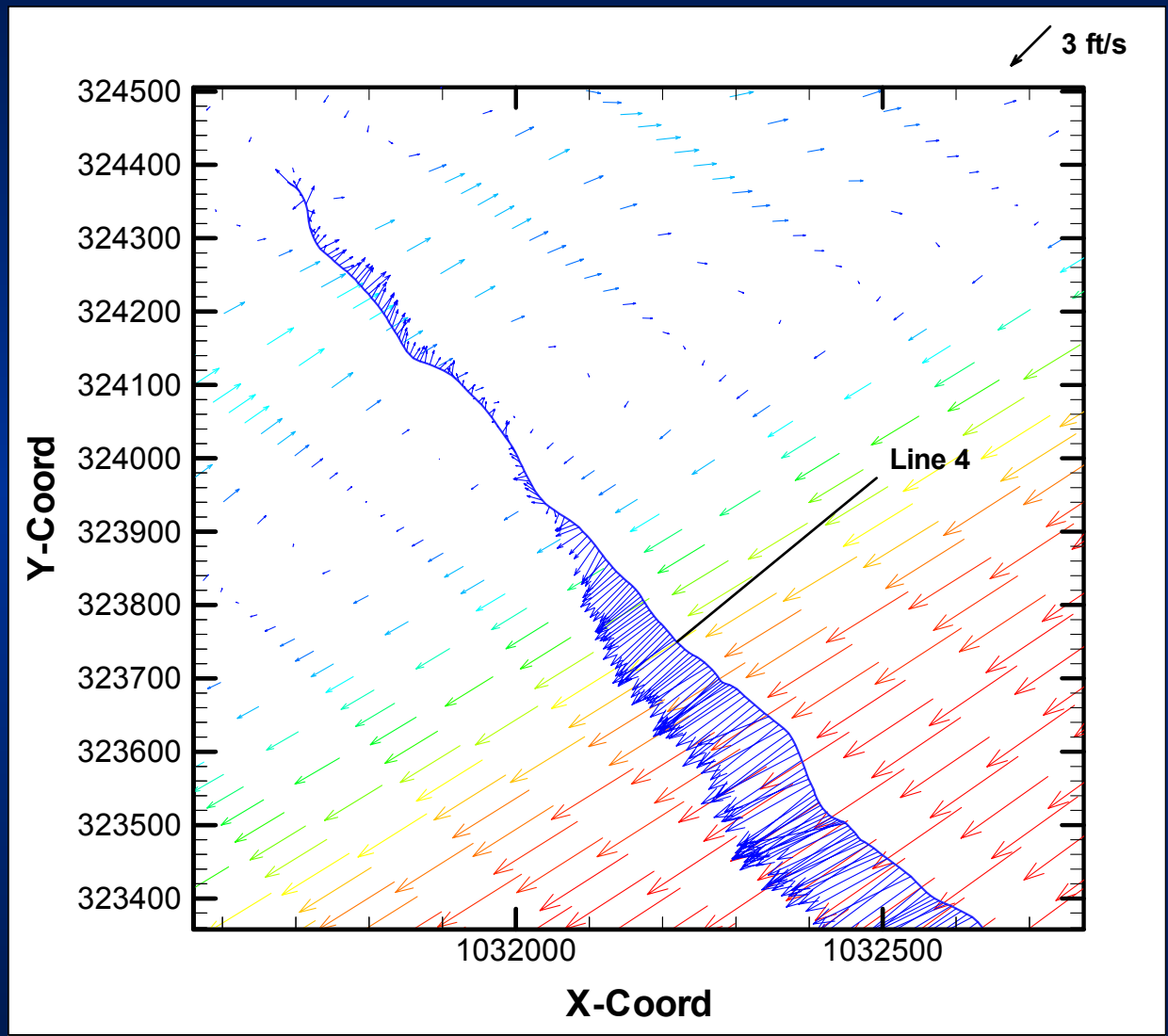
Line 4 – Velocity Direction Comparison (750,000 cfs)



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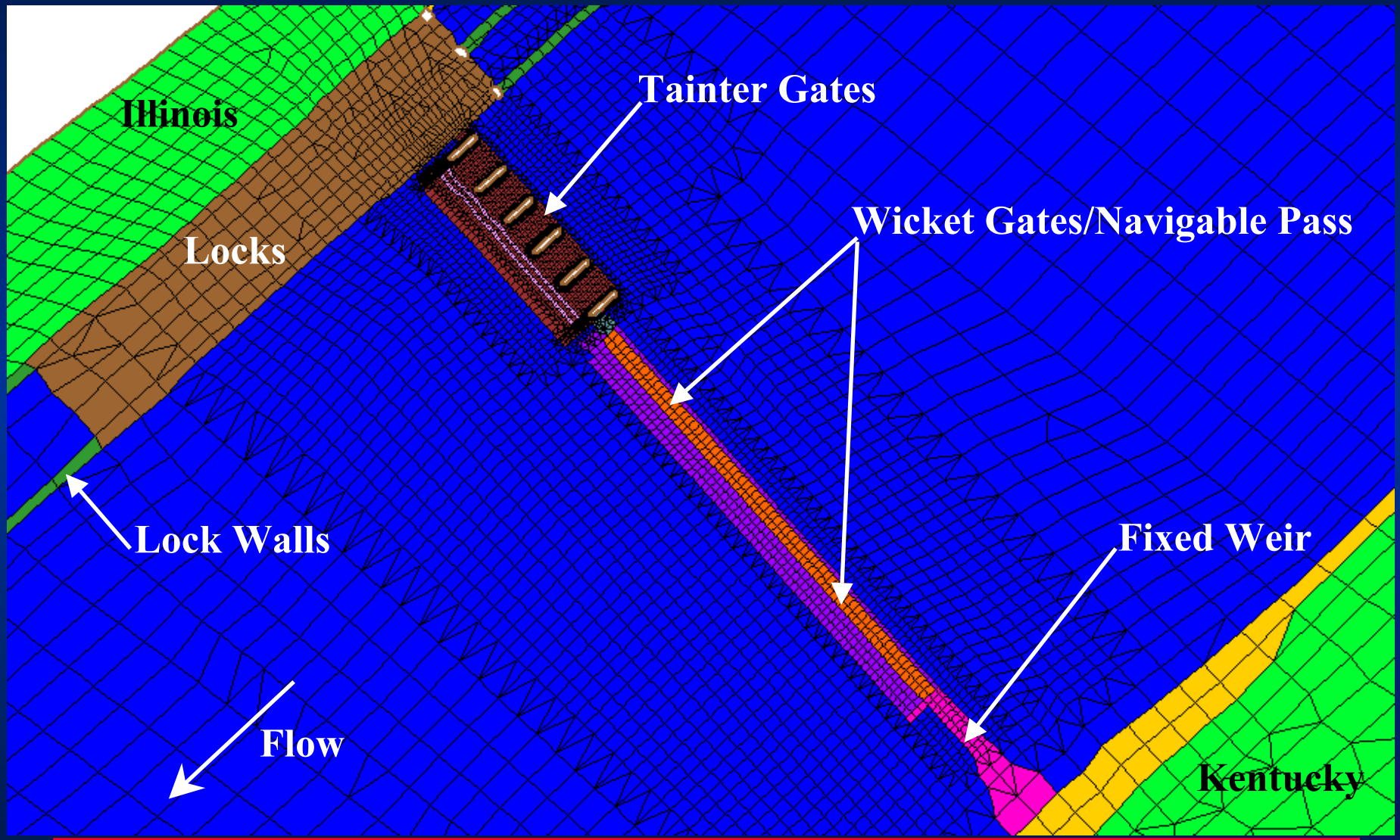
Sediment Transport Modeling

- Phased-in-the-wet construction process planned to take 6 years to complete.

- The construction process was simulated by utilization of the following three geometry scenarios/phases:
  1. Locks + 2 ½ Tainter Gates + Fixed Weir (interim elevation = 315ft)
  2. Locks + 5 Tainter Gates + Fixed Weir (interim elevation=315ft)
  3. Locks + 5 Tainter Gates + 1400 ft Navigable Pass + Fixed Weir (final elevation=303.5ft)

- Baseline scenario, which included only completed lock section, was run concurrently with the phased construction scenarios.

Phase 3 model configuration around the Olmsted Locks and Dam



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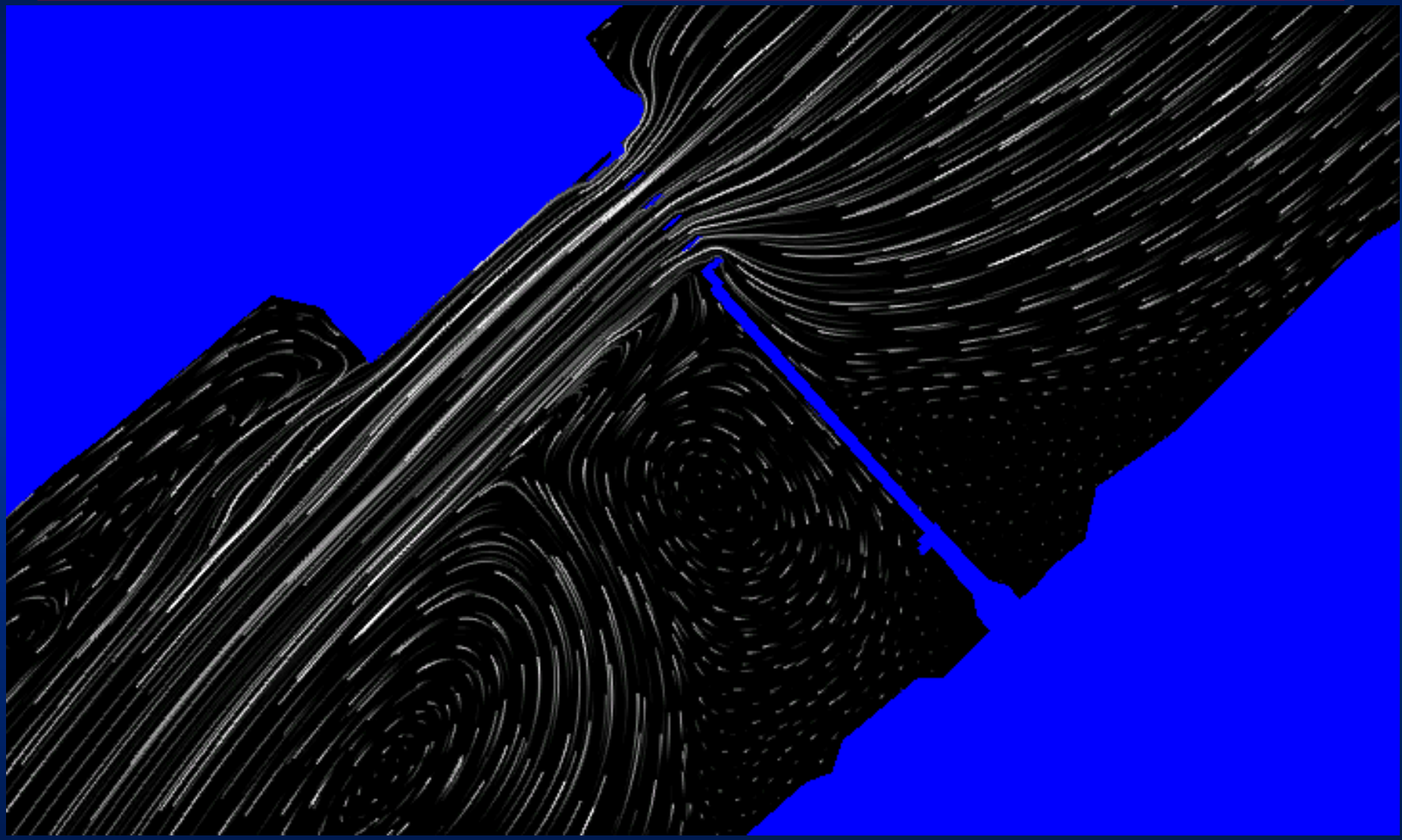
Flow trace of simulated flow field around locks and dam for 1997 low-flow condition



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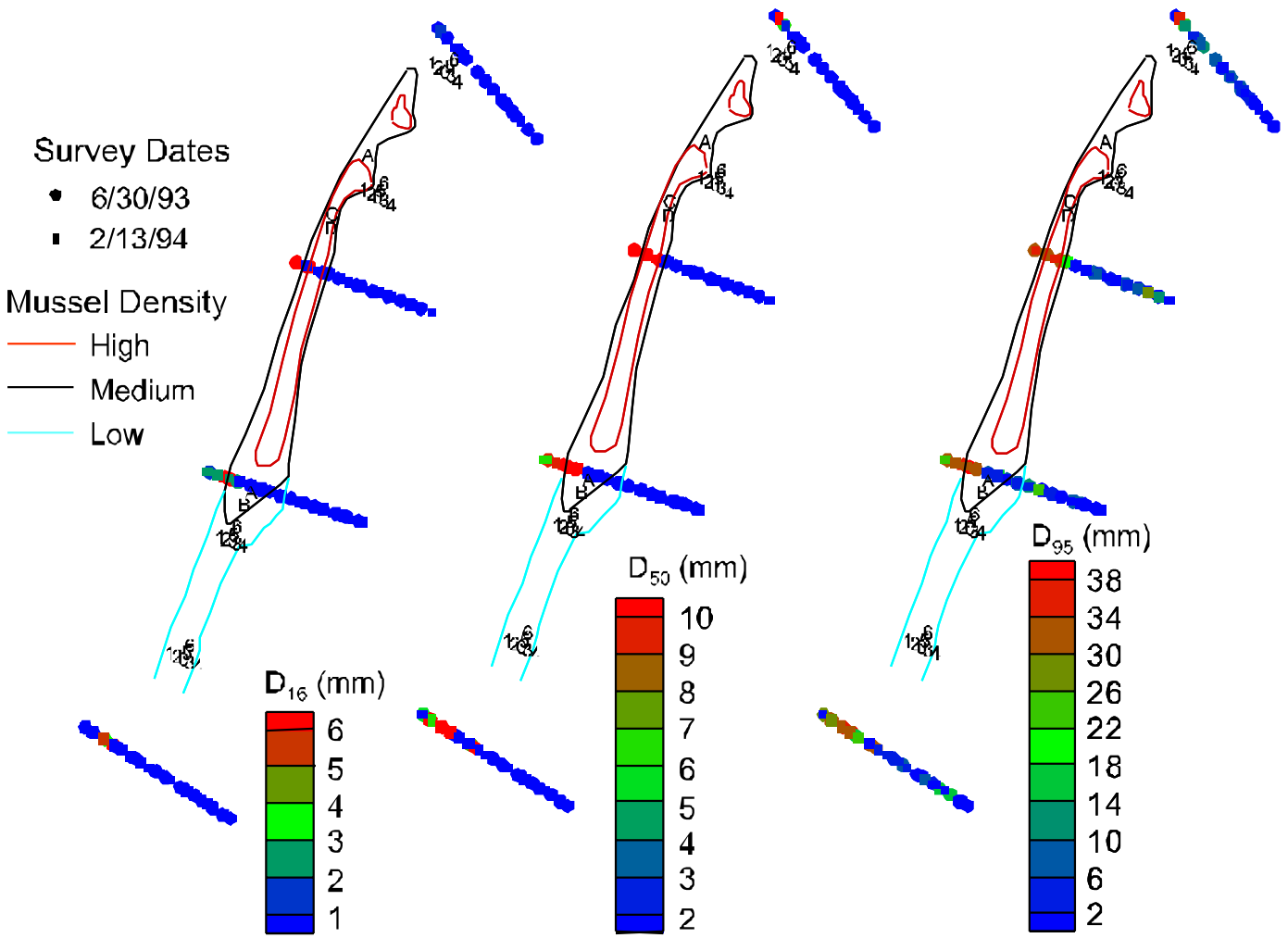
Selection of representative grain size (D_{50})



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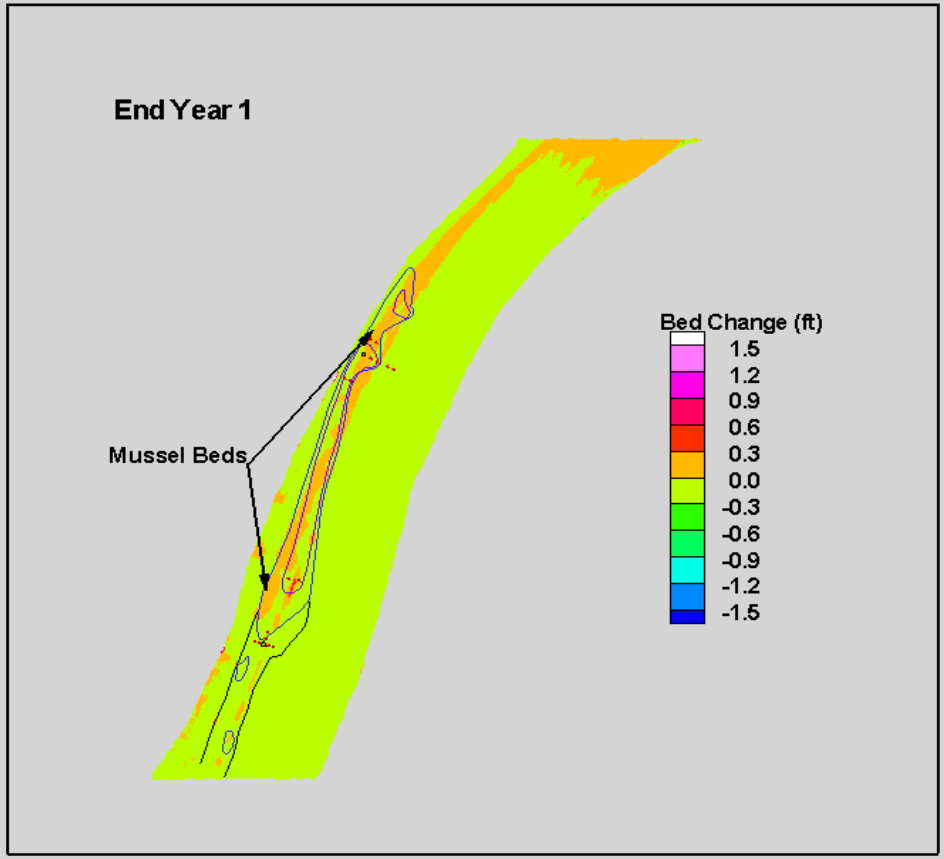
Bed change (ft) around mussel beds due to locks and dam construction during the 9-year simulation



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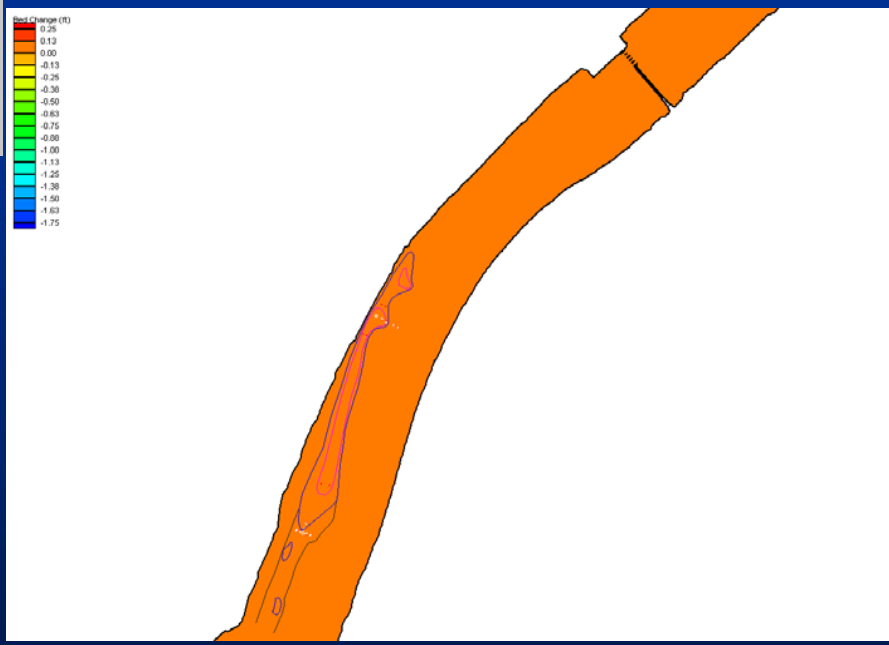
Bed change comparison between Baseline and Phase 3 Construction for low flow condition (1997)

Baseline

Phase 3



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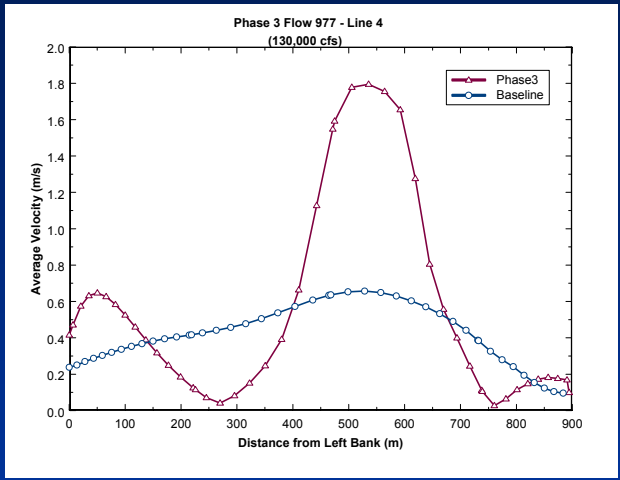
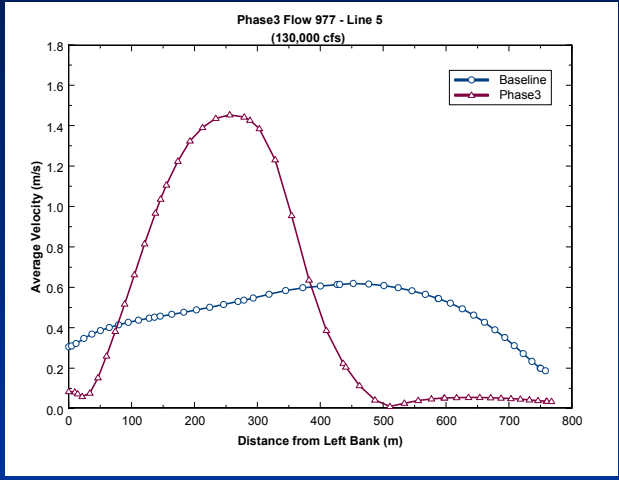
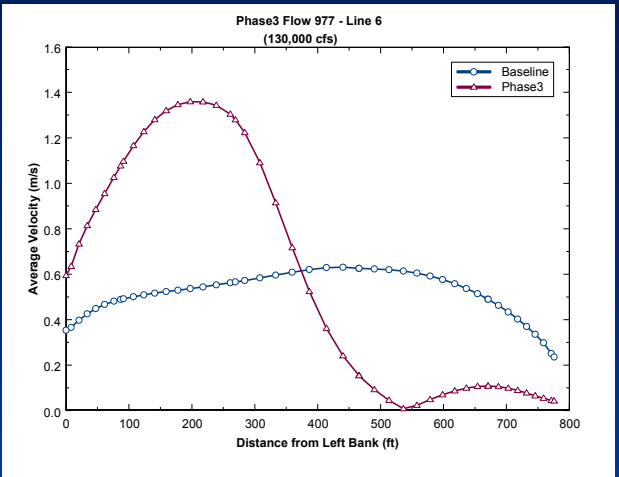
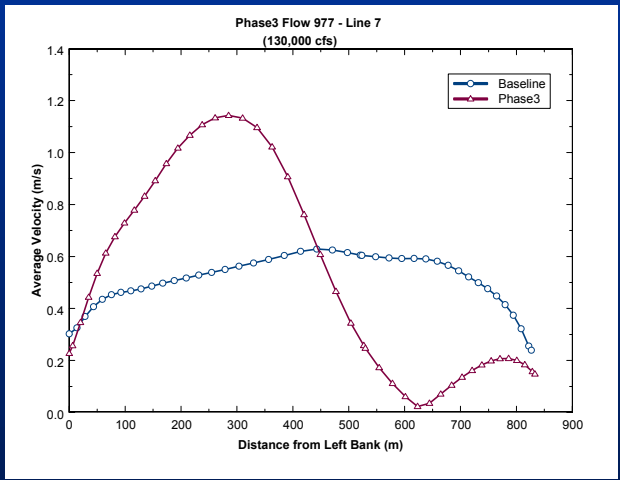
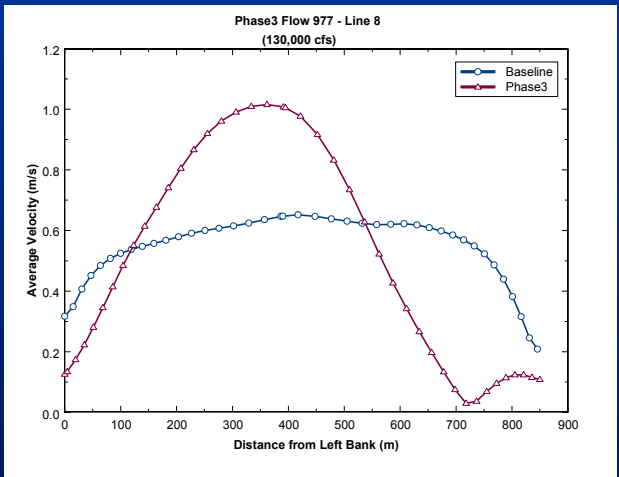
Low-flow (130,000 cfs) velocity profiles

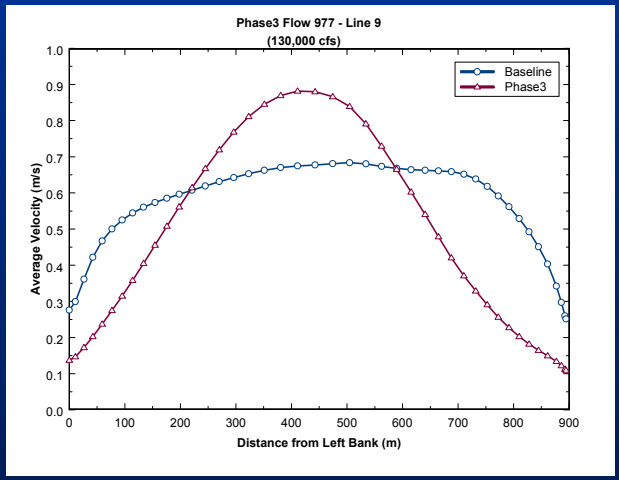












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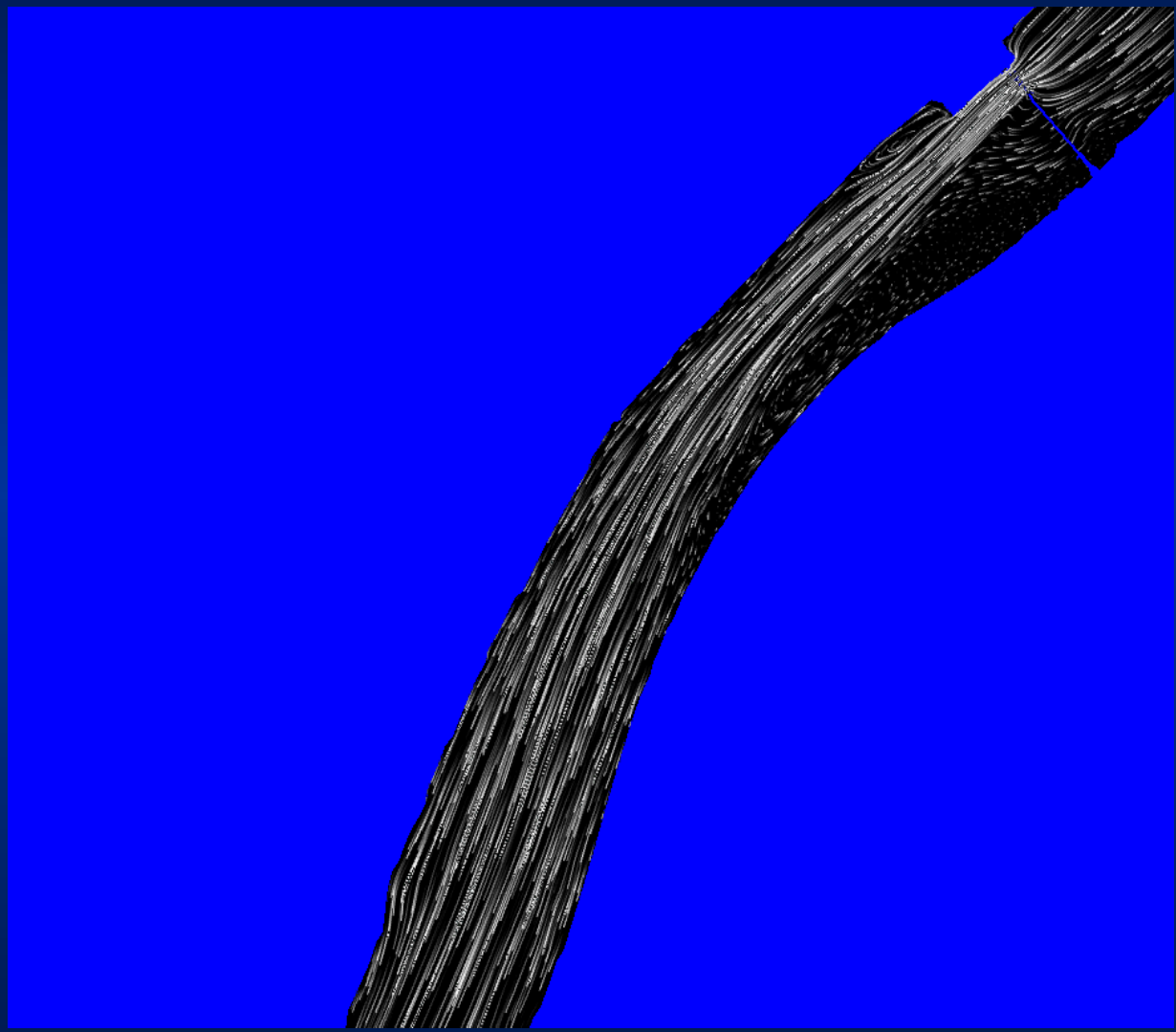
Flow trace of simulated flow field around locks and dam for low-flow condition



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Olmsted Sediment Modeling - Summary and Conclusions

- Most areas on the mussel beds received less than .5 ft of net bed change due to construction;
- Maximum localized deposition on mussel beds ~ 1.8 ft;
- Hydrodynamic and subsequent sediment transport changes are most prominent during low-flow period, in which entire river is passed through tainter gates.

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Other Modeling Applications

- 1-D and 2-D sediment transport models can be developed and calibrated to USGS sediment data and be used as planning tools to assess various management strategies for priority areas;

- Watershed models can be developing using historic and forecasted meteorological and climate data of a region to predict hydrologic conditions (drought/flood potential, water quality) of a watershed;

- Real-time flood inundation mapping using an interaction between 1-D hydraulic models and gaging station data.

Other Modeling Applications

- Bridge scour – simulated hydraulics through bridge openings during floods of various magnitude are used to assess scour potential and aid in bridge design;

- Discharge Ratings - 1-D, unsteady flow models are being used to develop discharge ratings for regulated rivers (i.e. Ky River) to refine the stage-discharge relationship under slope conditions (when locks and dams are inundated);

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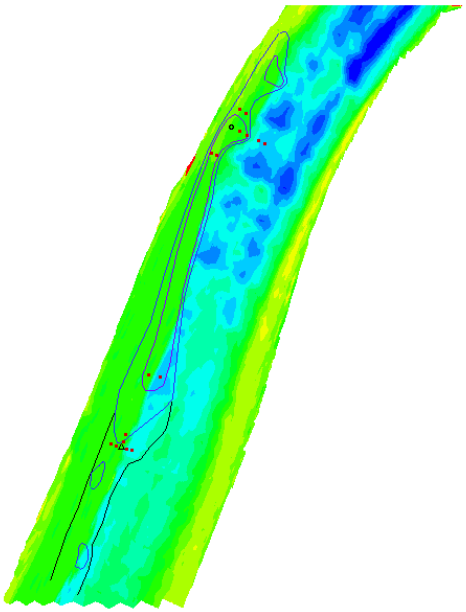
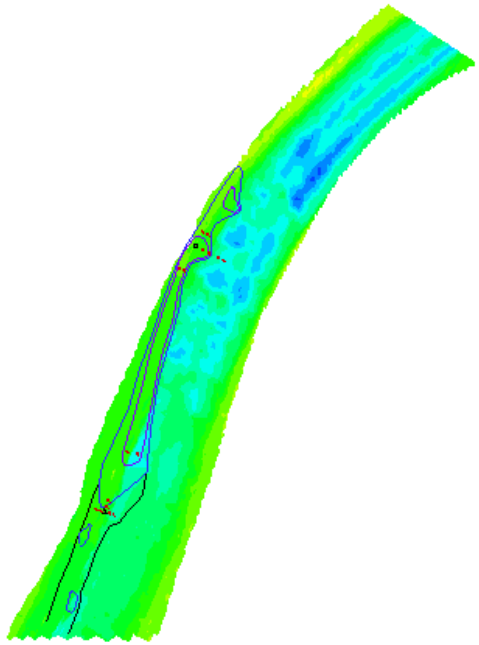
Questions?

Bed change around mussel bed during 1997 Flood



Bed Change during 1997 Flood Hydrograph

Cumulative Bed Change



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