

COMBINING FIELD AND LABORATORY EXPERIMENTS WITH NUMERICAL SIMULATIONS TO INFORM STREAM RESTORATION DESIGN

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Minneapolis, Minnesota, USA

Mississippi River

St. Anthony Falls

Outdoor StreamLab

Public park

St. Anthony Falls
Laboratory



OSL as an educational tool

General Public

University classes (Ecology,
Stream Restoration
Certificate)

Undergraduate interns



Summer Institute for Earth Surface
Dynamics

Research Assistants (undergraduate
and graduate students



» Features » Scientist on the Spot

She's Learning from Life at the Bottom

"The Outdoor StreamLab is teeming with life. I study its macroinvertebrates, but many plants, algae, and sometimes even ducks also make the OSL their home."



Swimming and crawling through the pebbles and sand, a host of creatures lives at the bottoms of our streams and rivers. They graze on rotting leaves, suck meals of algae and bacteria from the flowing water, and hunt each other in the mud. They're called benthic

macroinvertebrates, and the lives of these bugs can tell us a lot about the quality of our water, and the health of the streams they live in.

Jessica Cormier, a biology student at St. Catherine University, is studying benthic macroinvertebrates at the Outdoor StreamLab at the National Center for Earth-surface Dynamics. By finding out which bugs (and how many) live under which conditions, she can help tell when a body of water is healthy, and when it might need help.

Have a question for the benthic biologist?

post your question



read the answers

Do you have questions about what it's like to be a benthic biologist? Ask Jessica Cormier, and keep your eyes on Science Buzz for the answer!



Water Outlet

Sediment Feed

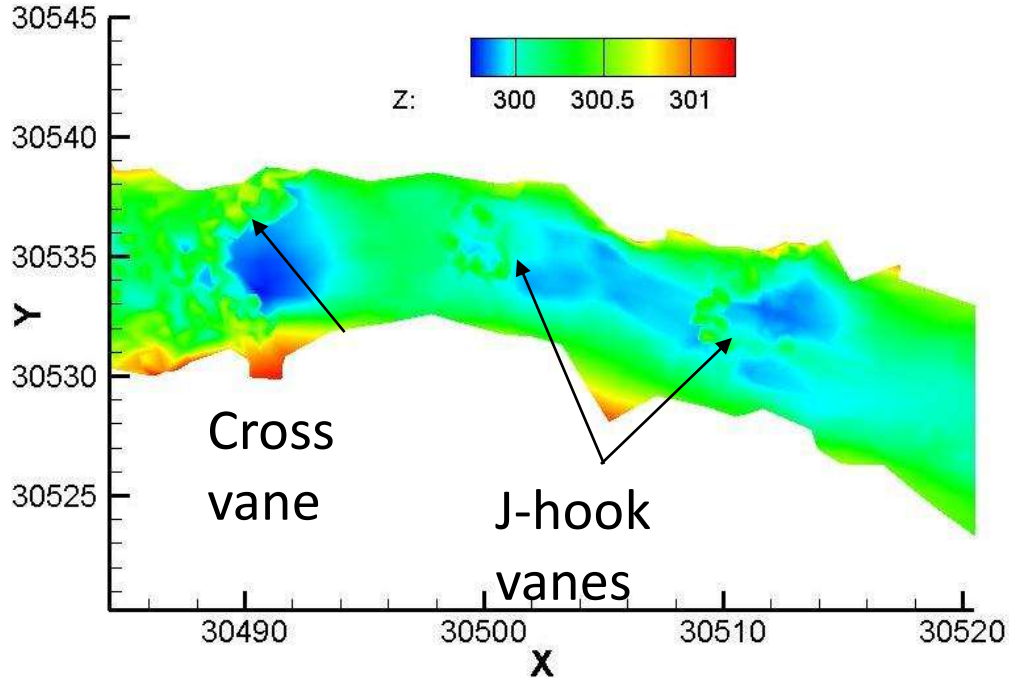
**Groundwater
Barrier**

**Sediment Collection
and Recirculation**

To Mississippi R.

In-stream structures are often installed with goals to:

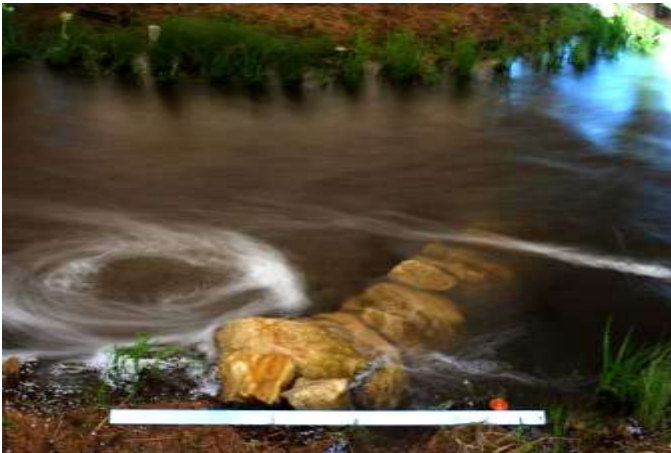
- prevent lateral migration
- protect property
- reduce bank erosion
- provide grade control
- improve instream habitat



In-stream structures in the OSL

How do complex three-dimensional flow patterns around in-stream structures interact with the stream bed?

How do these complex flow and sediment transport environments affect nutrient dynamics, dissolved oxygen, and temperature?



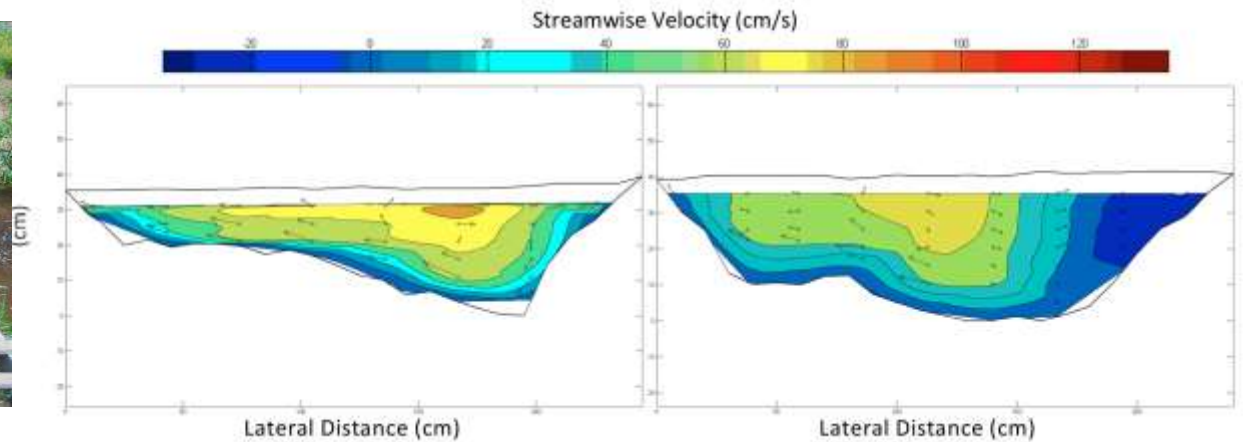
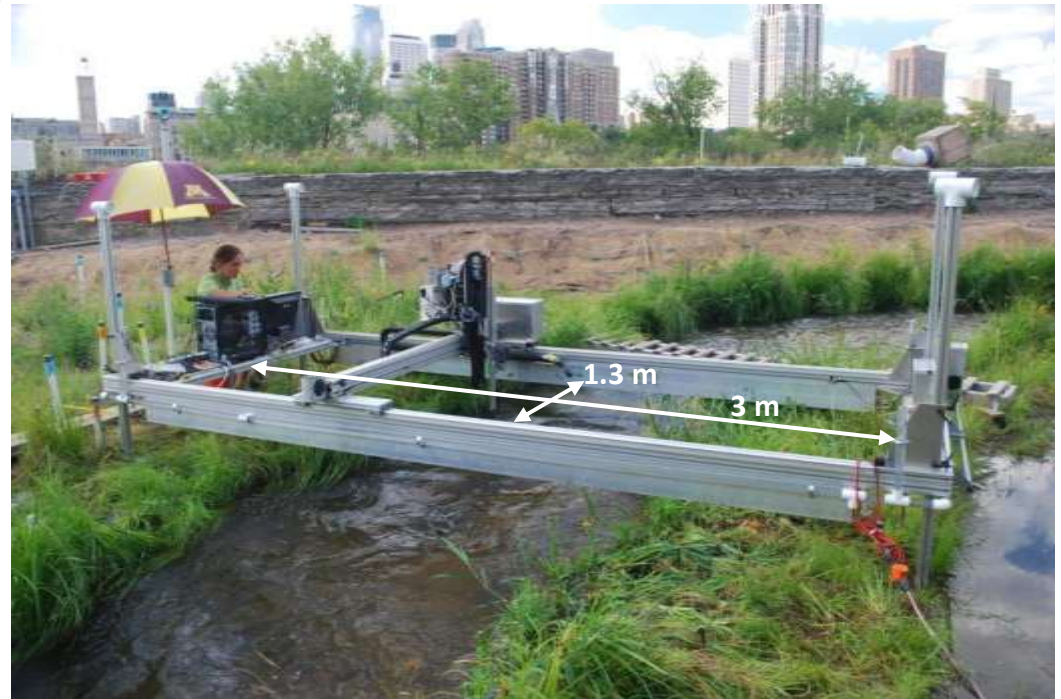
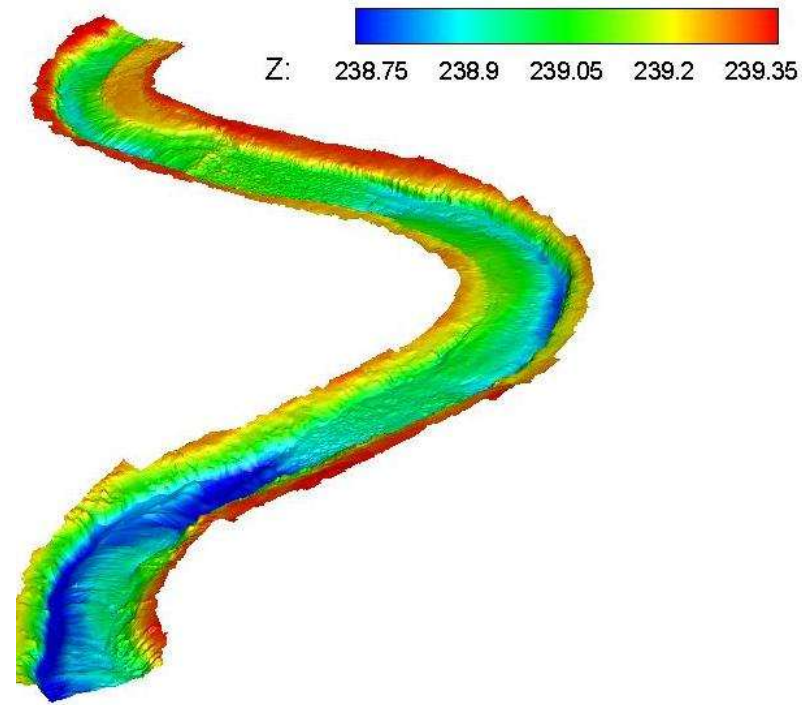
In-stream structures in the OSL

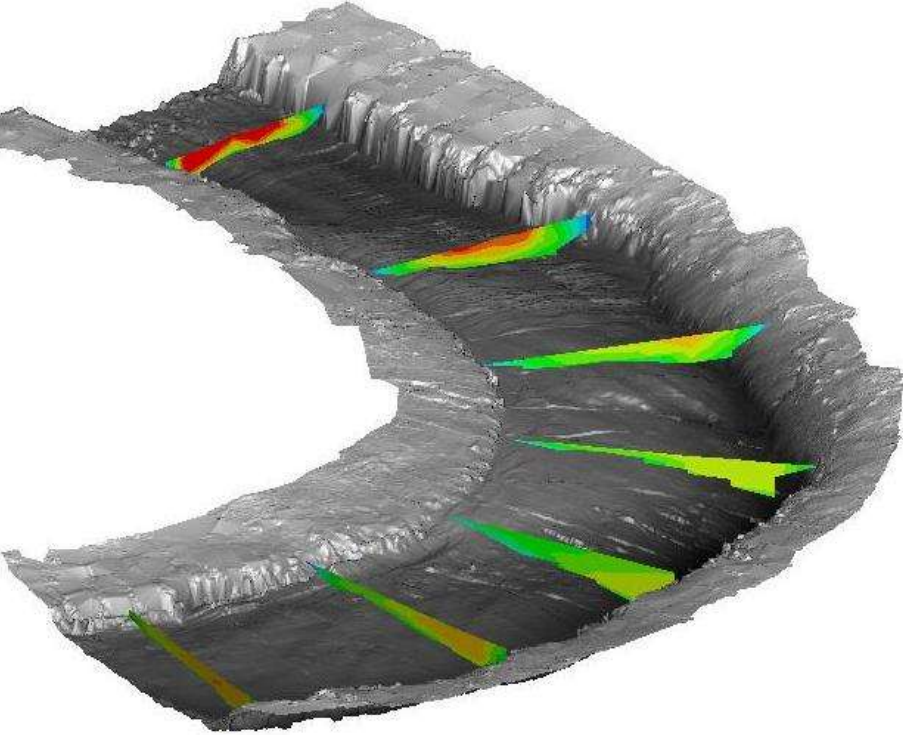
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High-resolution measurement capabilities





Velocity Magnitude

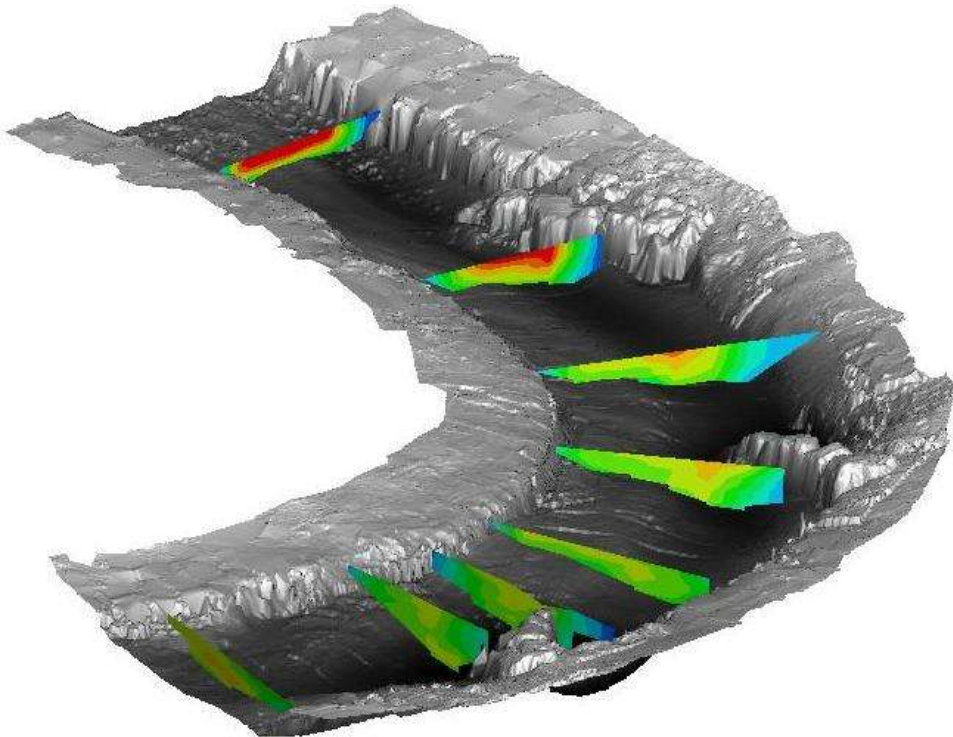


0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1

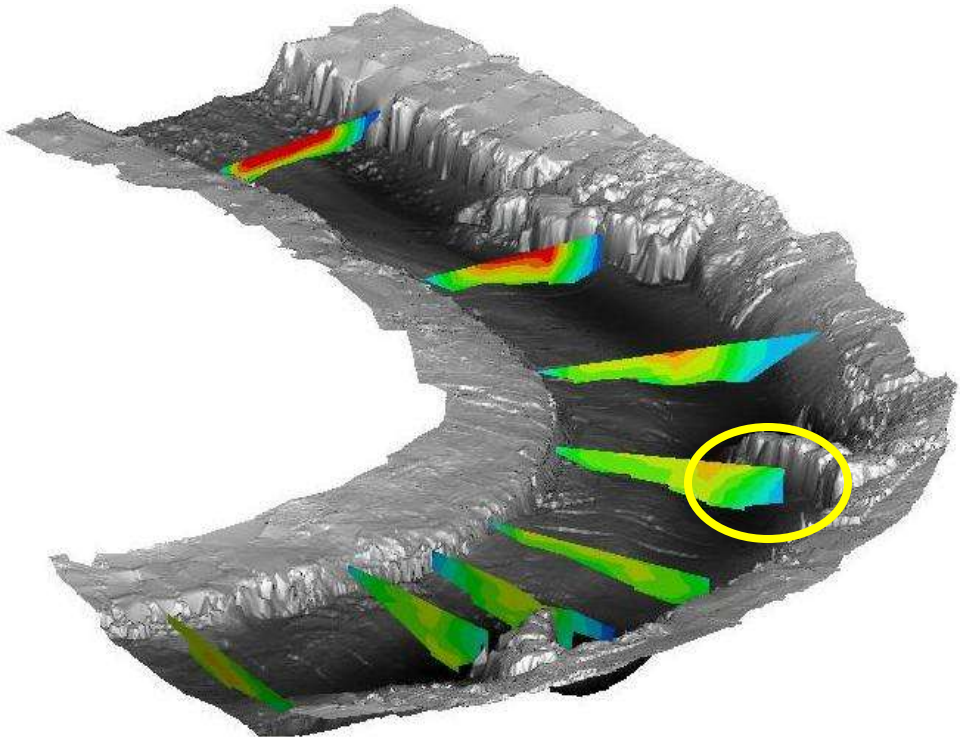
m/s

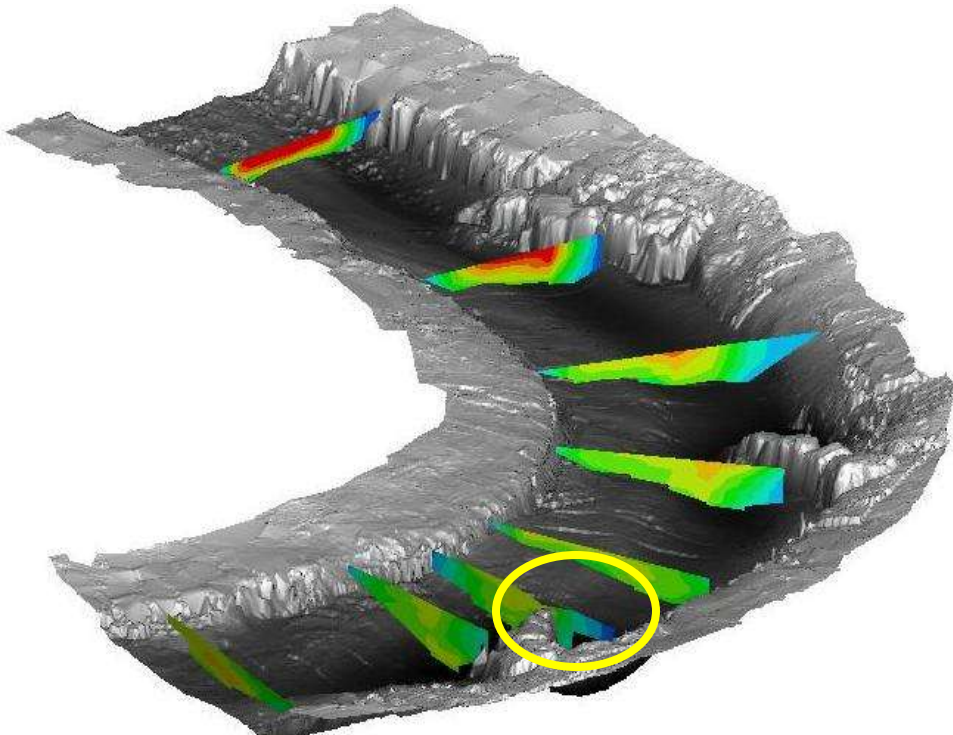
Visualizations provide
insight into flow
patterns

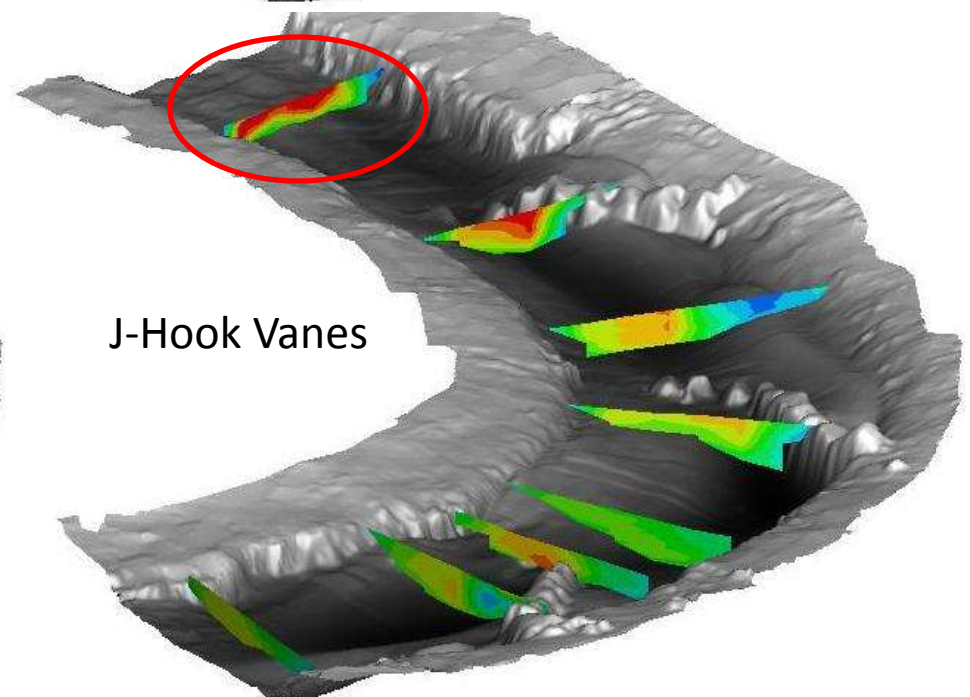
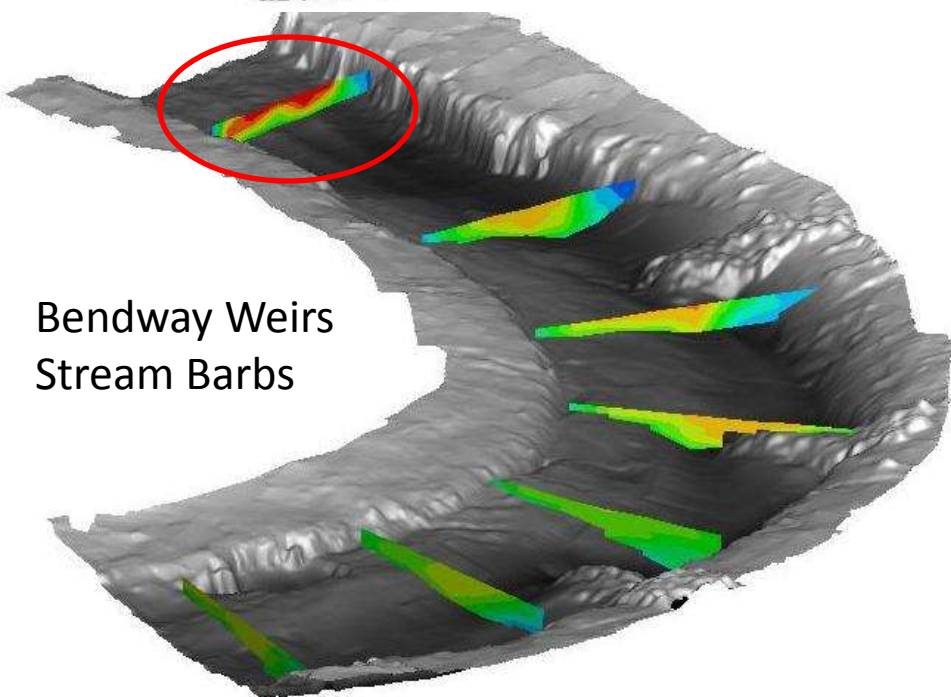
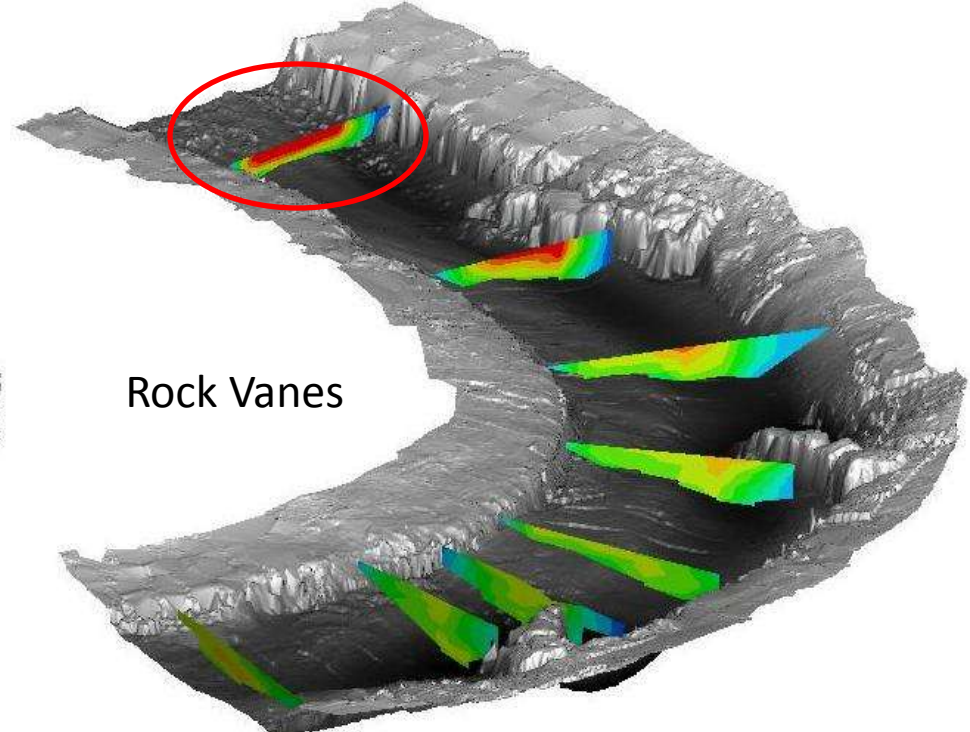
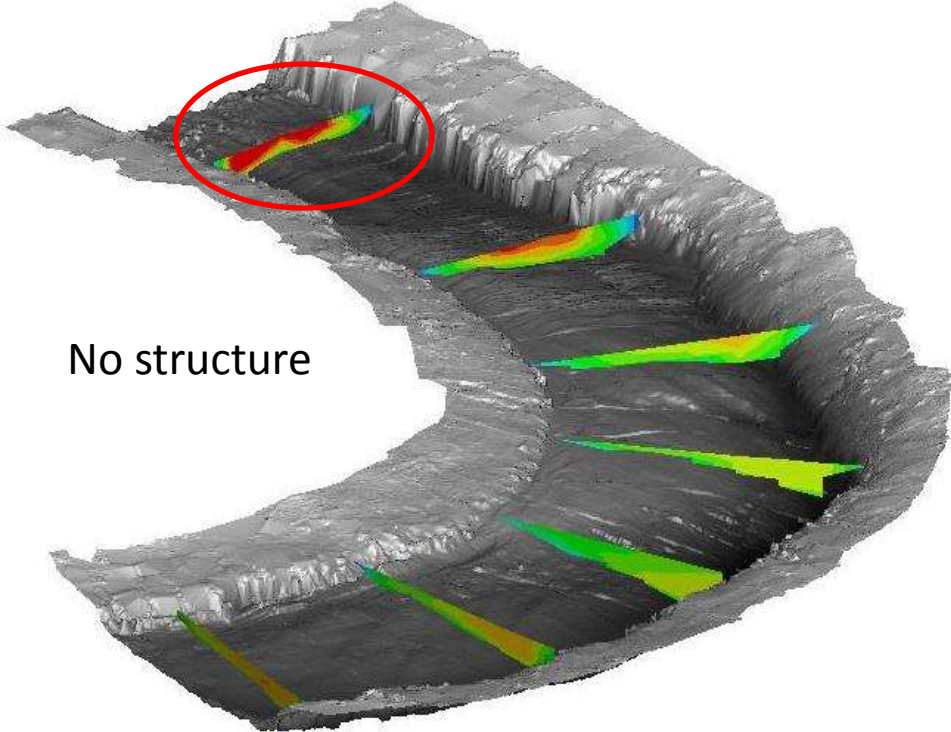


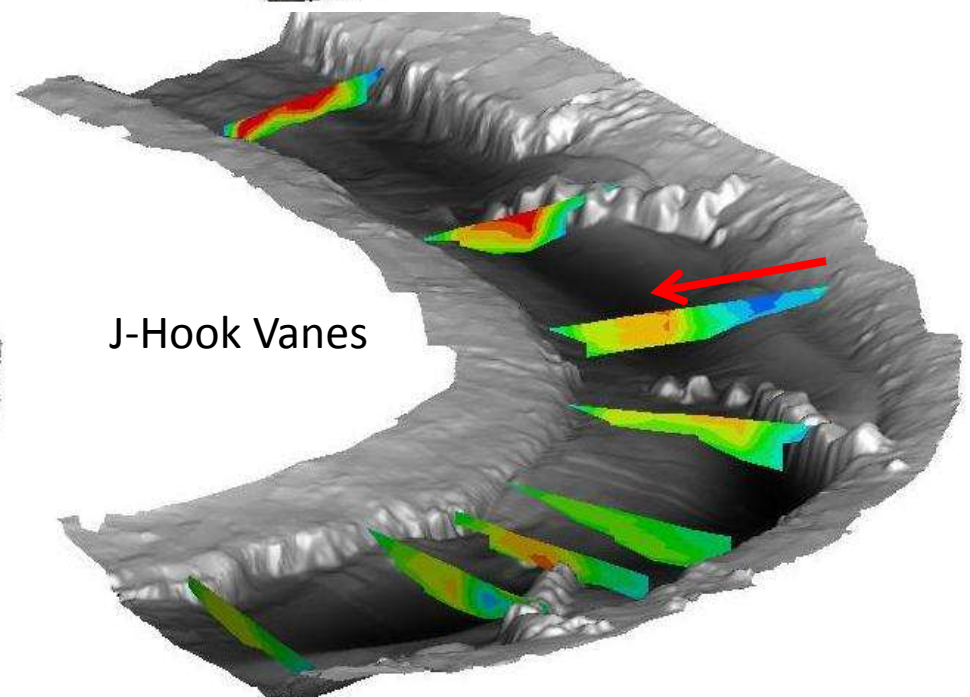
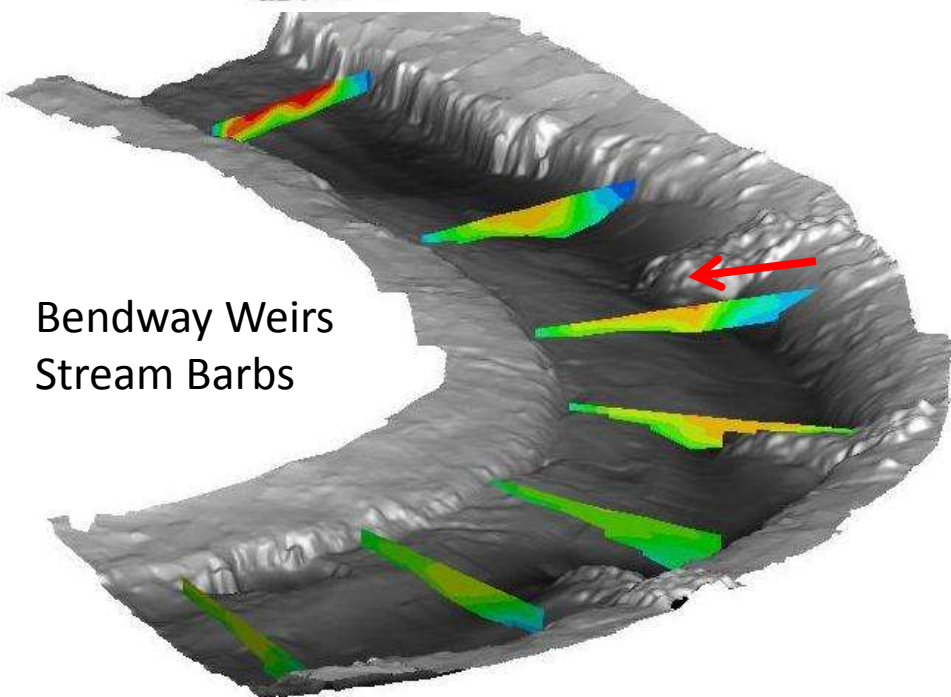
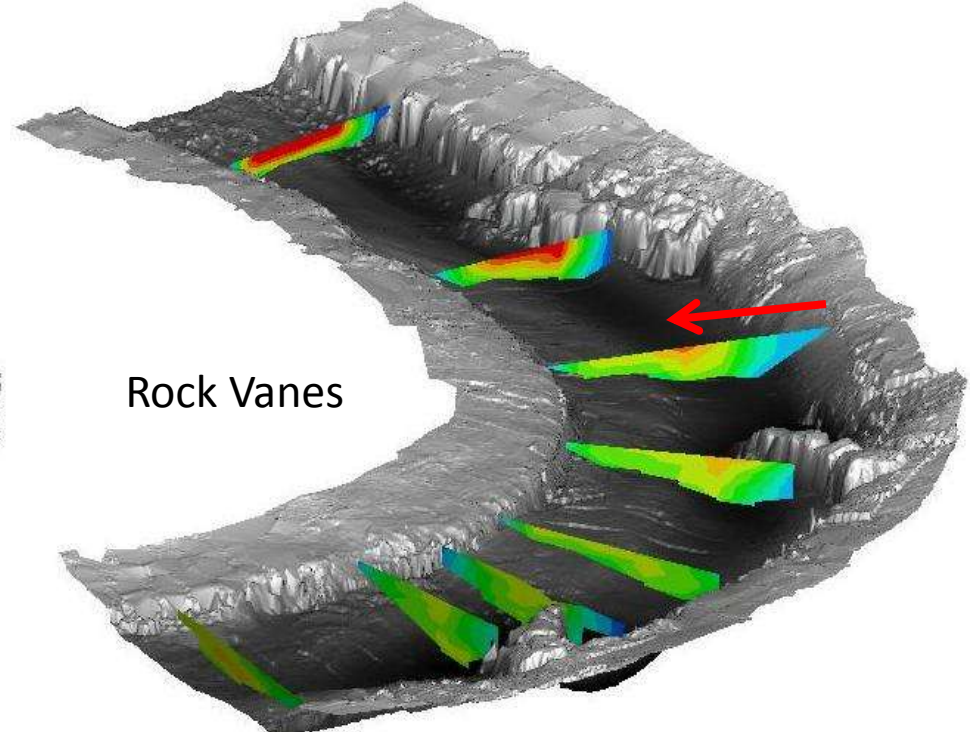
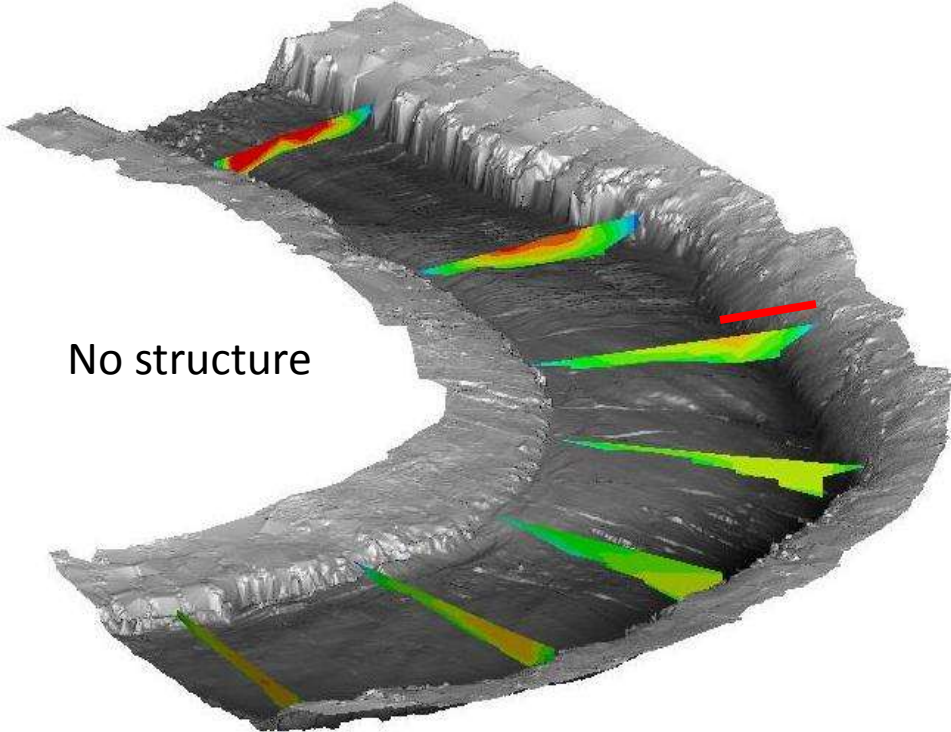


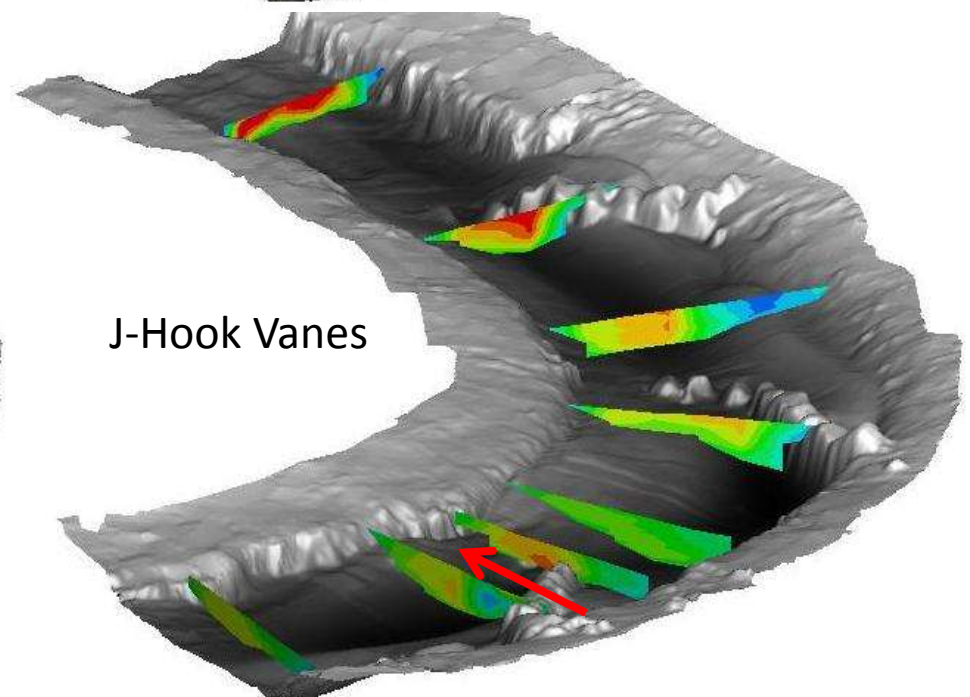
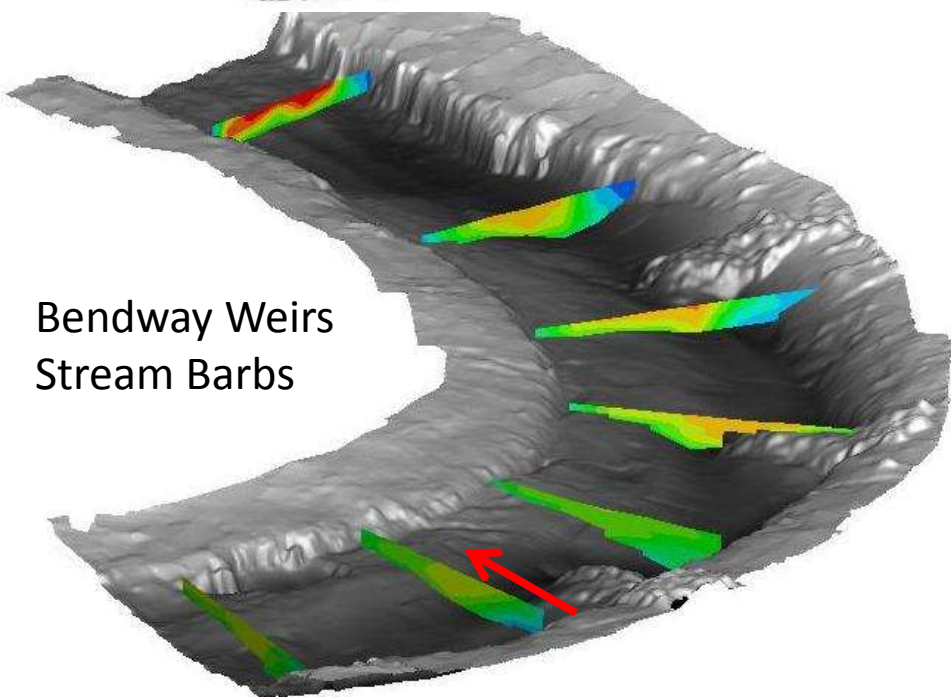
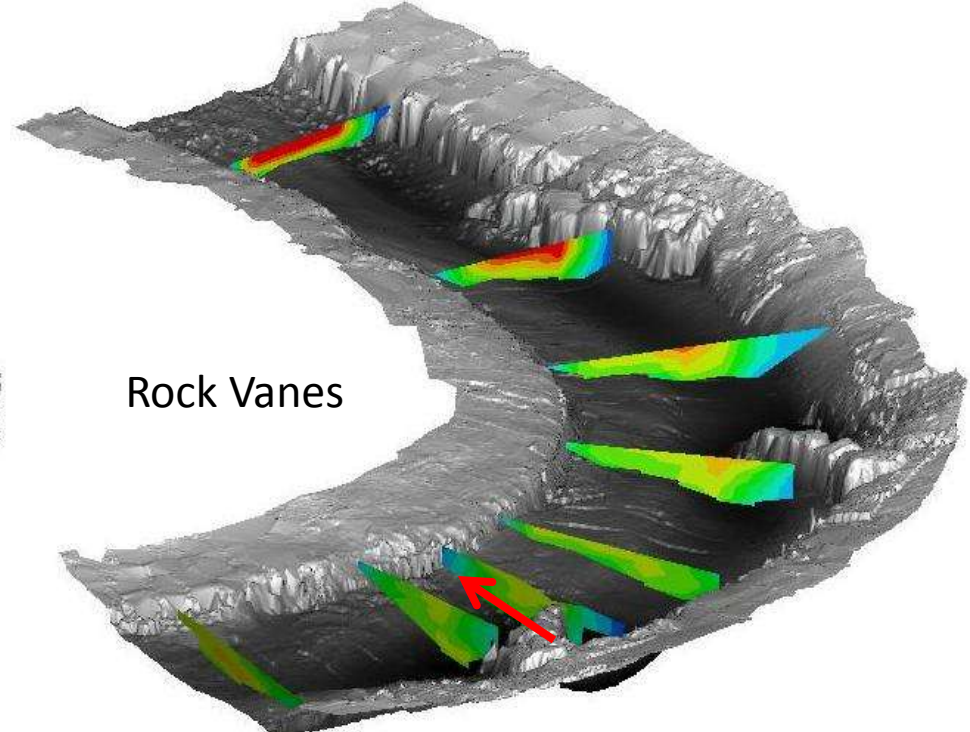
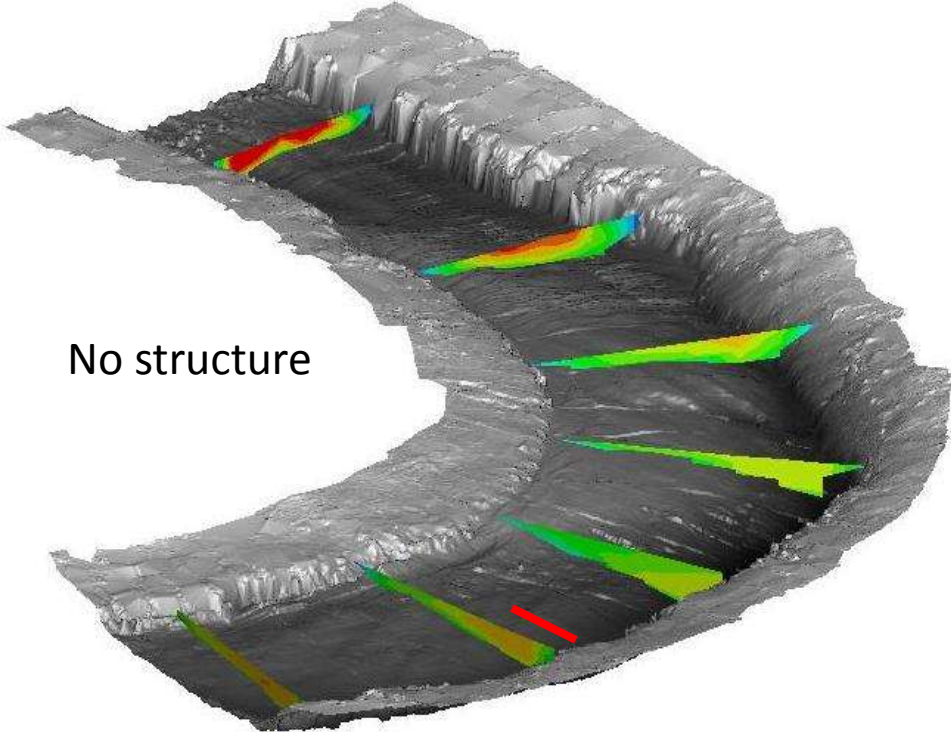
Flow Patterns around a
Rock Vane Array

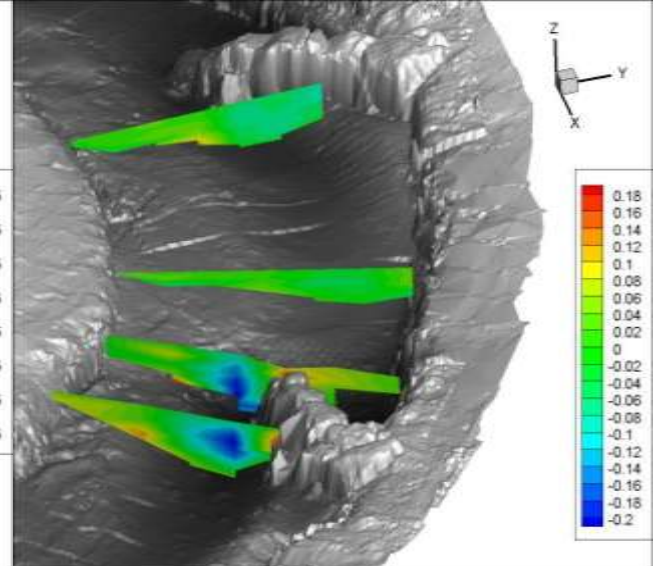
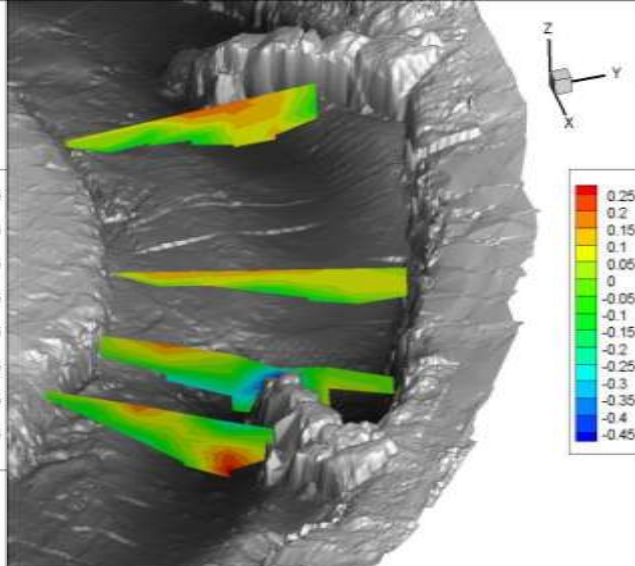
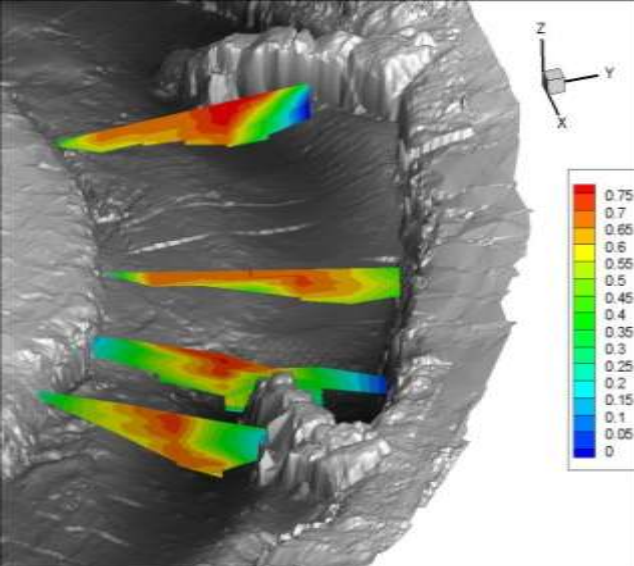








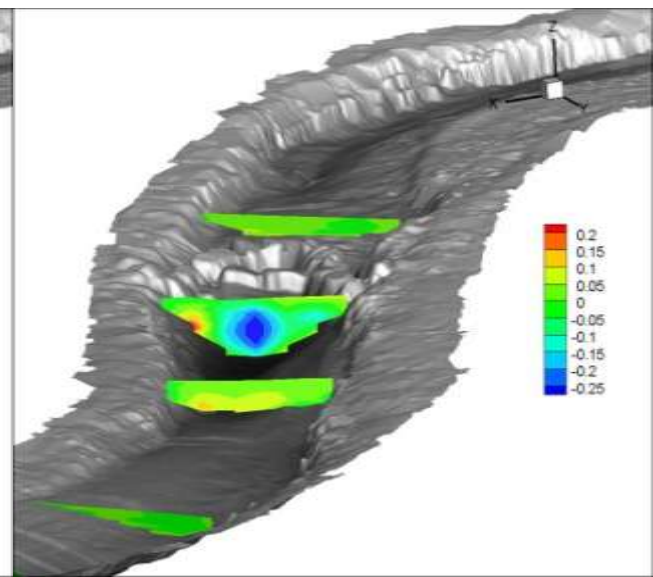
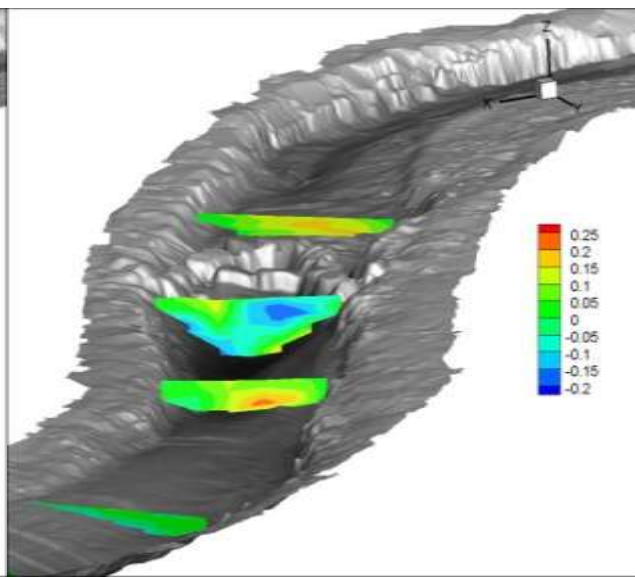
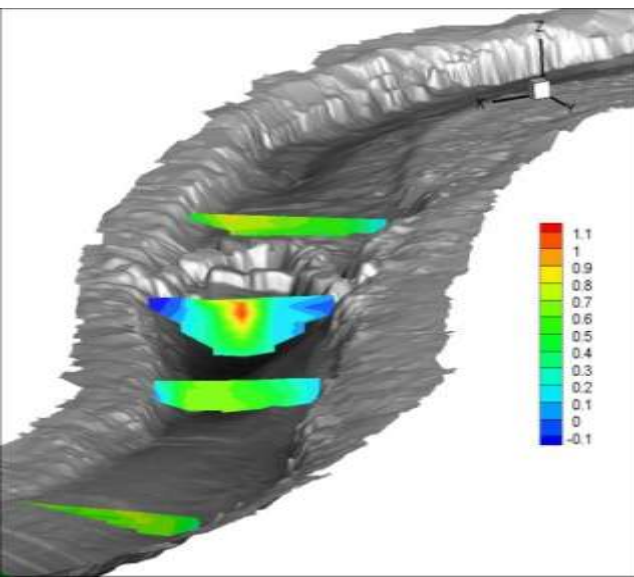




U (m/s)

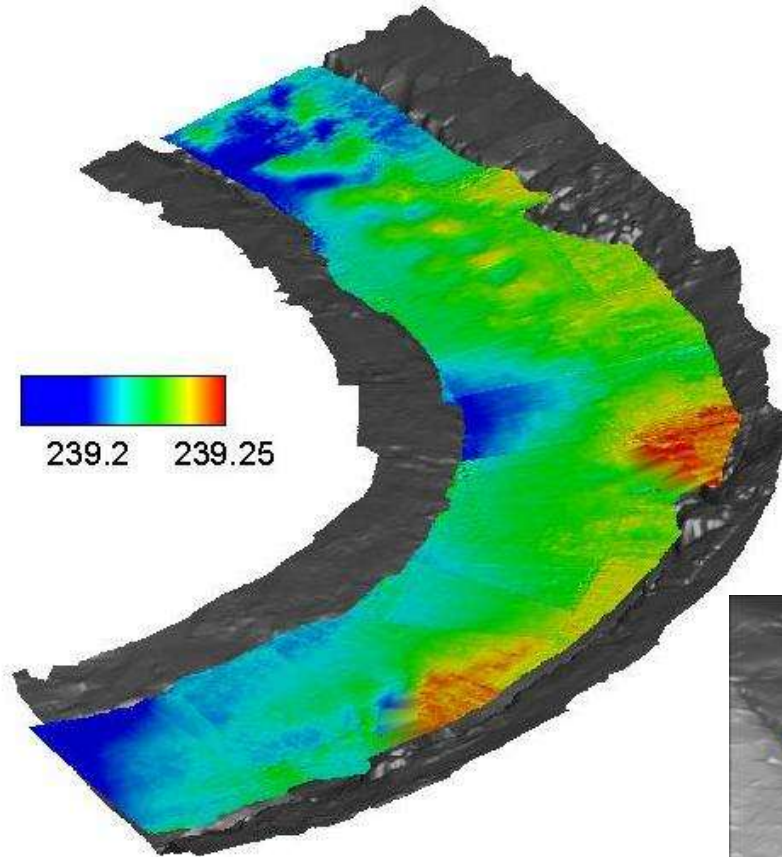
+ \rightarrow V (m/s)
 - \leftarrow

+ \uparrow W (m/s)
 - \downarrow

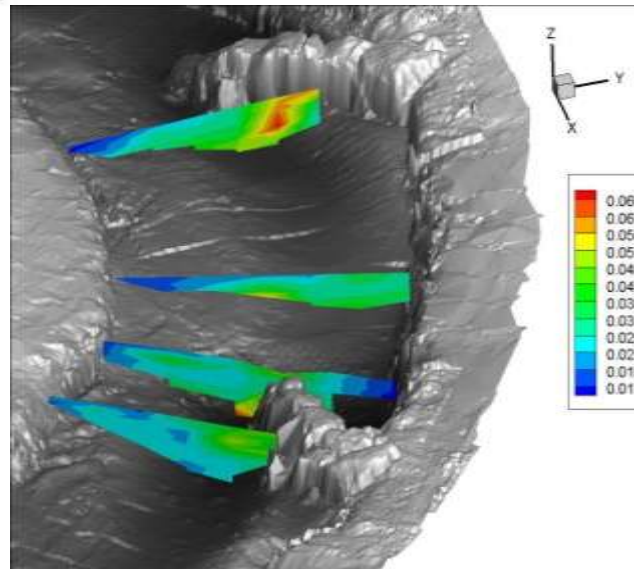
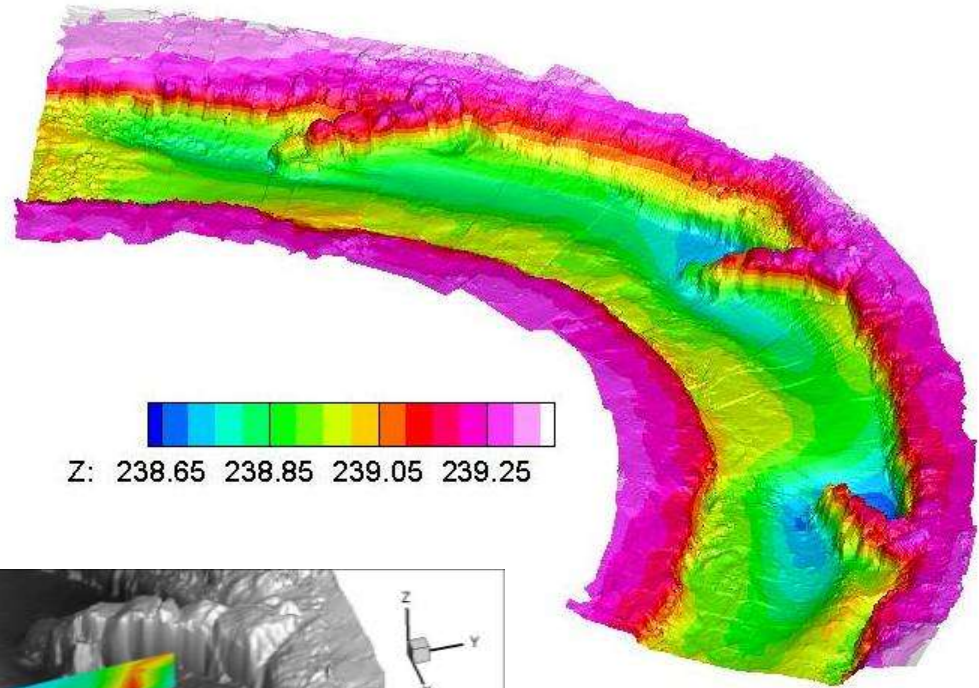


A closer look at rock vanes...

Water surface elevation

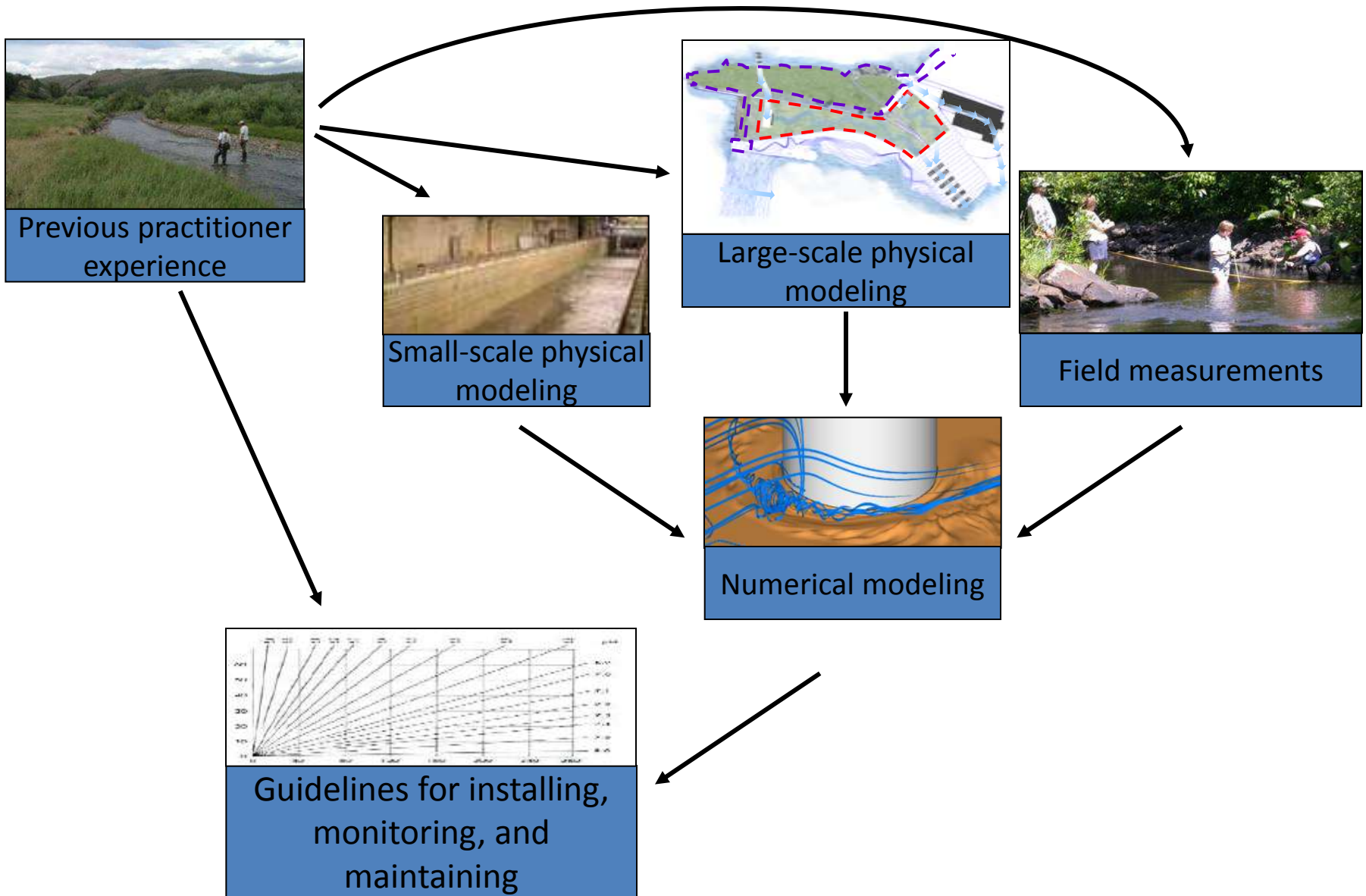


Bed elevation



TKE (m^2/s^2)

Towards Quantitative Guidelines



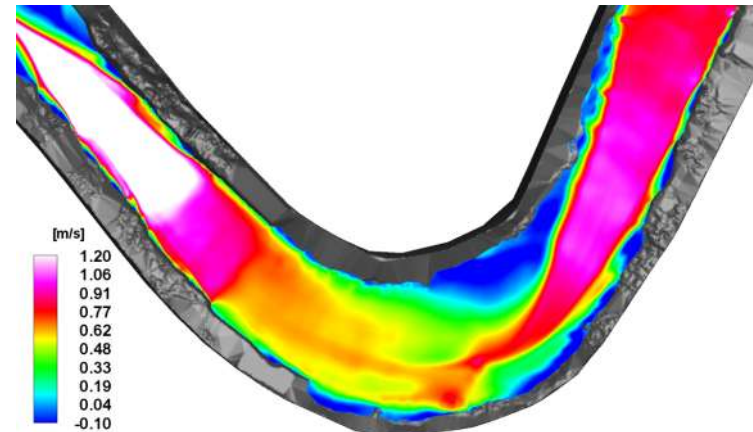
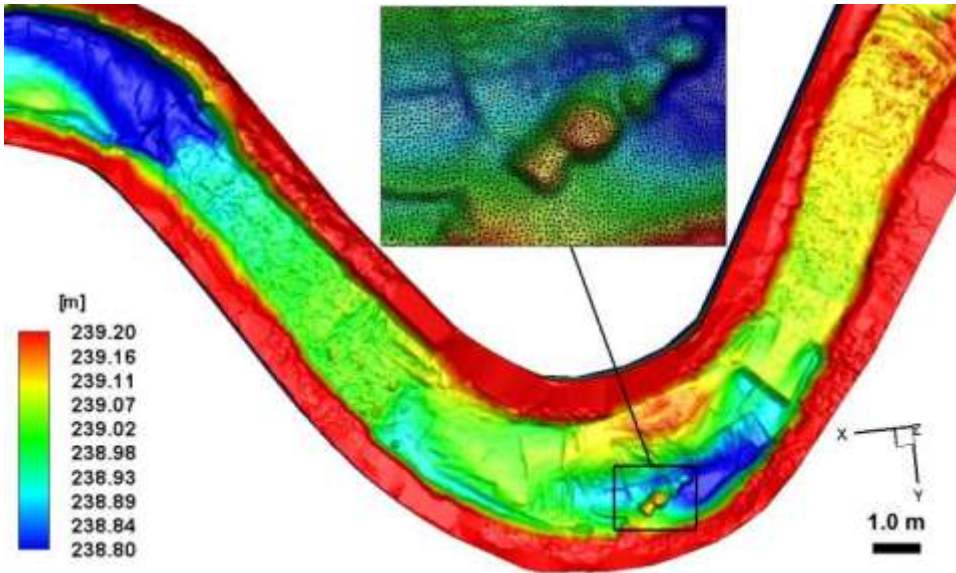
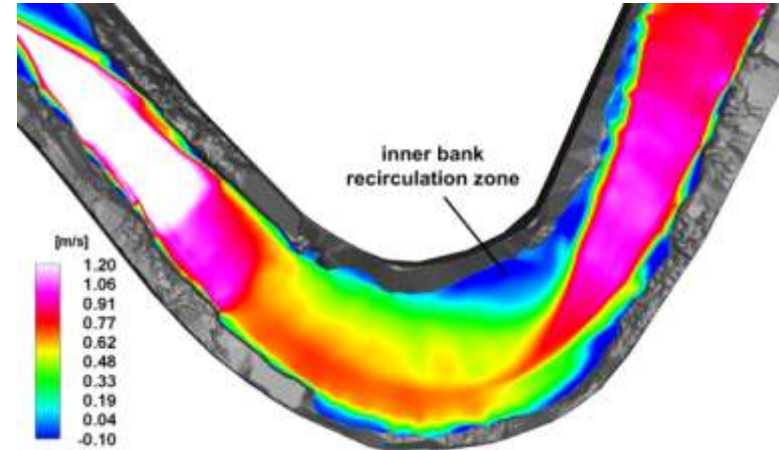
Towards Quantitative Guidelines

Objectives:

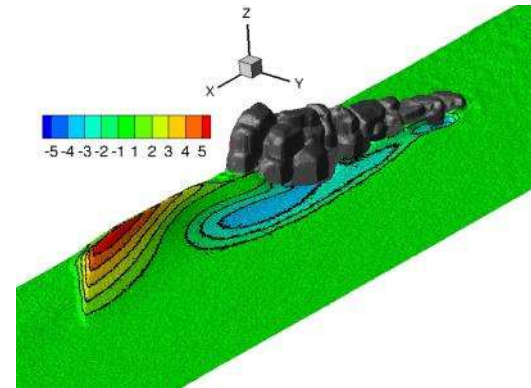
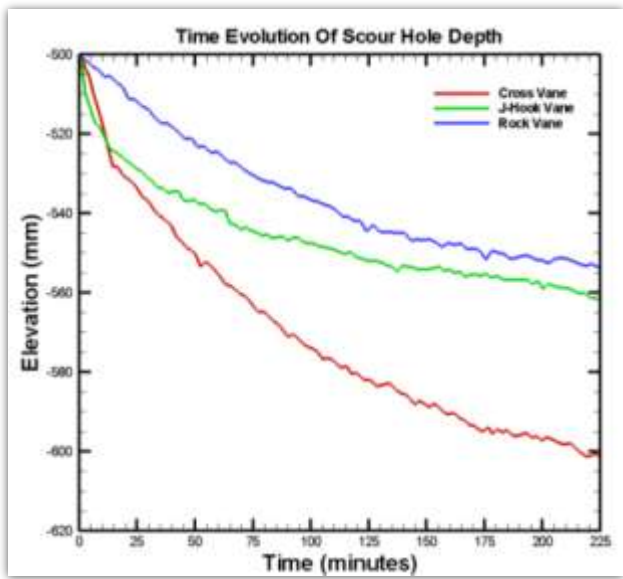
- Validate hydrodynamic & deformable bed model components using indoor laboratory flume, OSL, and field measurements
- Use the VSL to extend the detailed laboratory and field measurements to a wider range of channel configurations and flow rates
- Determine for site-specific stream properties (e.g., radius of curvature, slope, bed and bank material, etc.) what structures and installation practices are most appropriate
- Develop and test new structure types

monitoring, and
maintaining

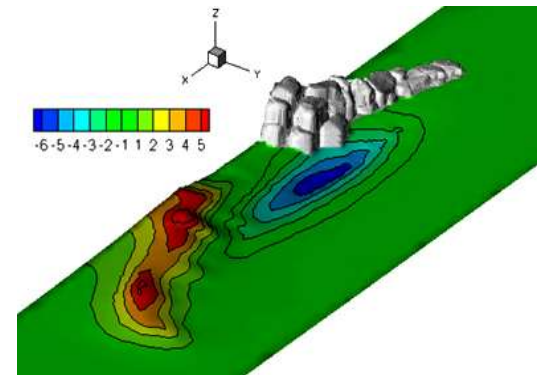
Virtual StreamLab Hydrodynamics



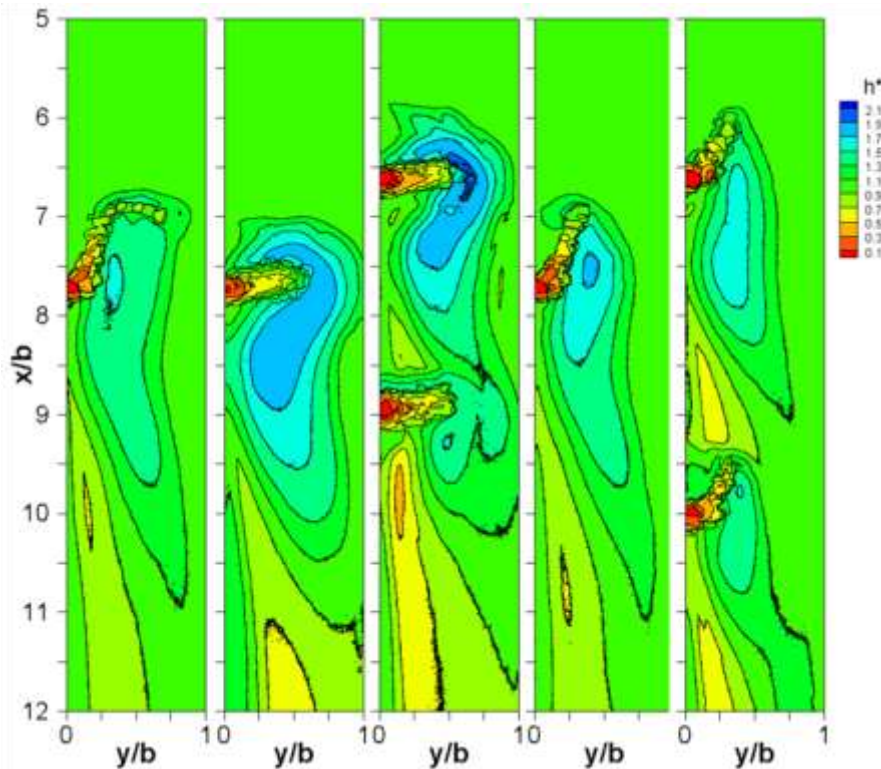
Combining hydrodynamic module with bed morphodynamics



Measured

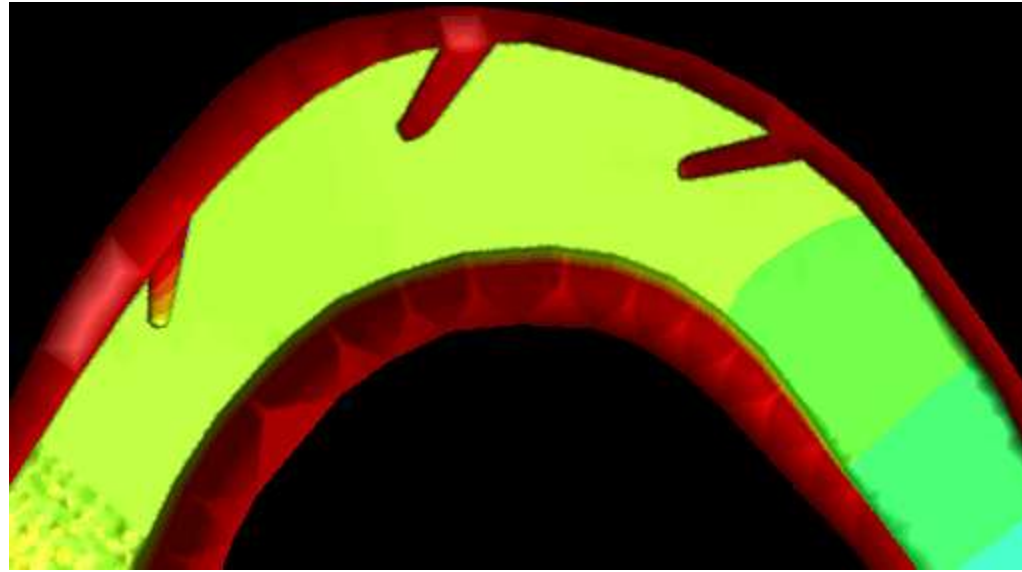


Modeled

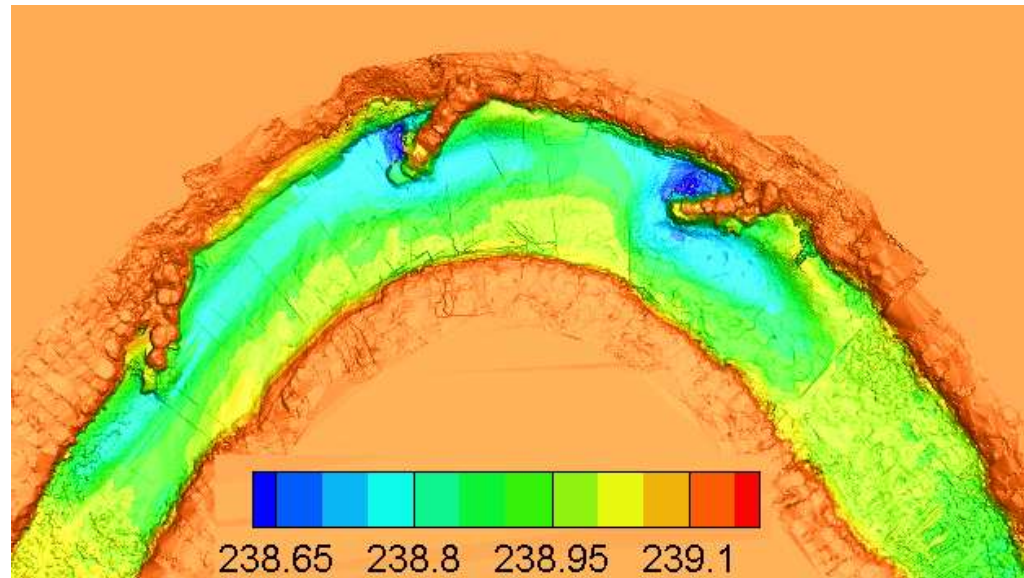


Bed morphodynamics – meandering channel

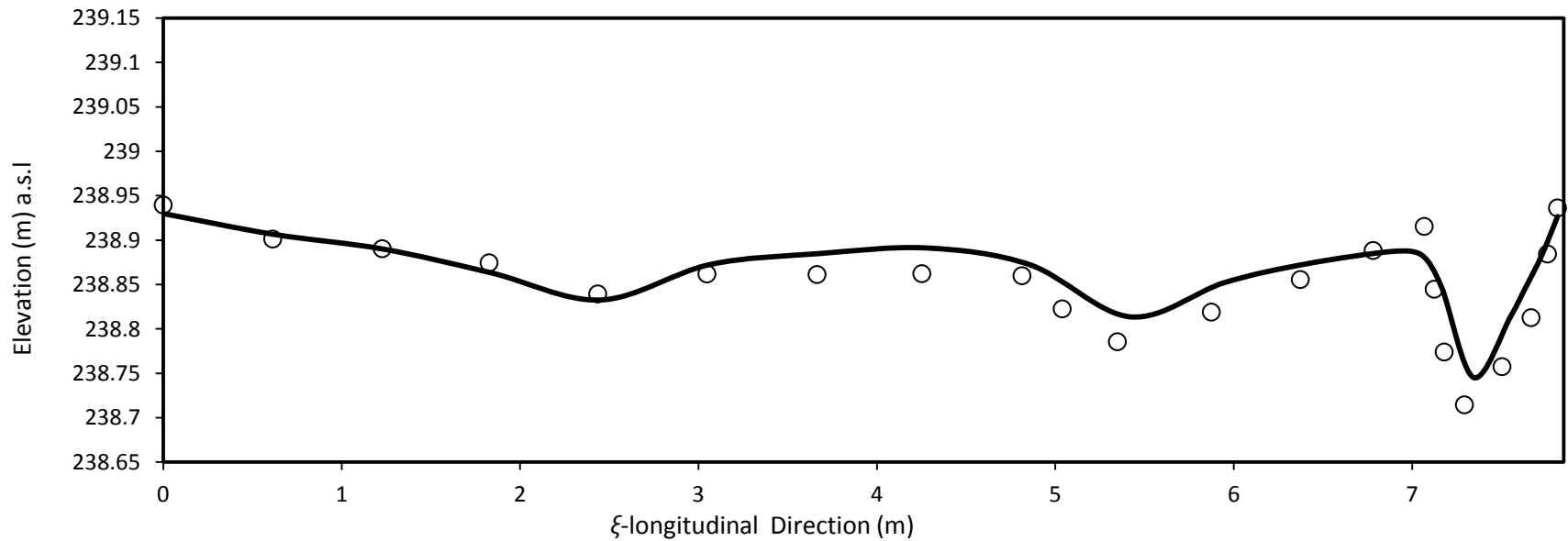
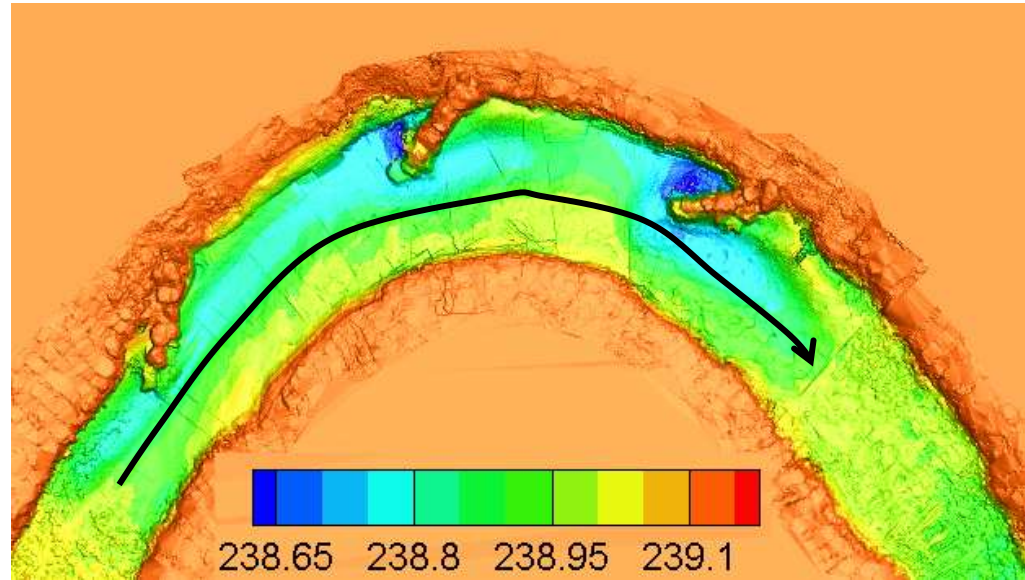
Computed
(LES):



Measured:

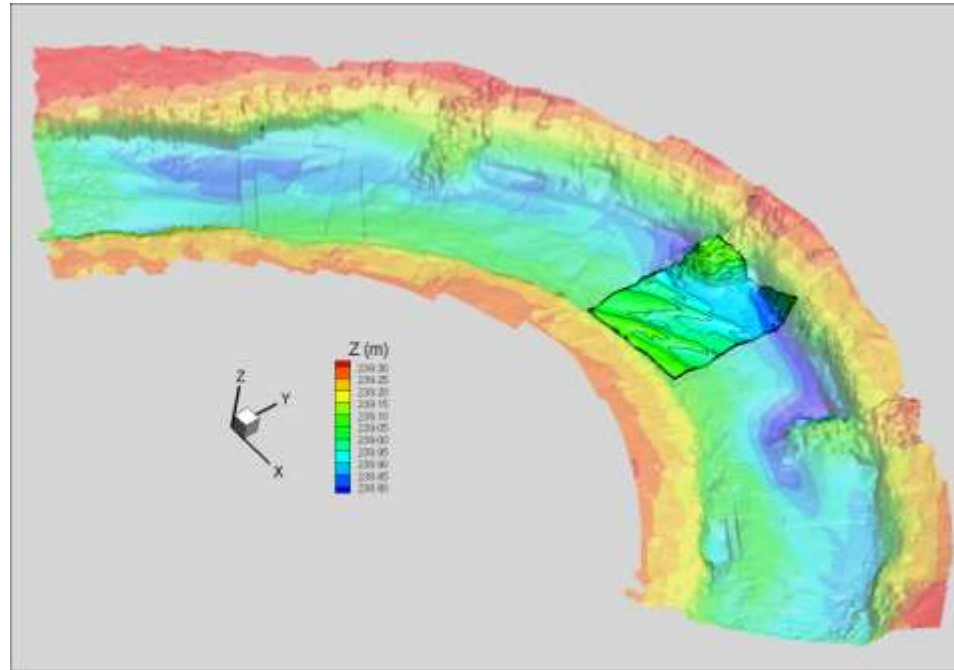


Bed morphodynamics – meandering channel



Bedforms

Scour
development:



Quasi-
equilibrium:

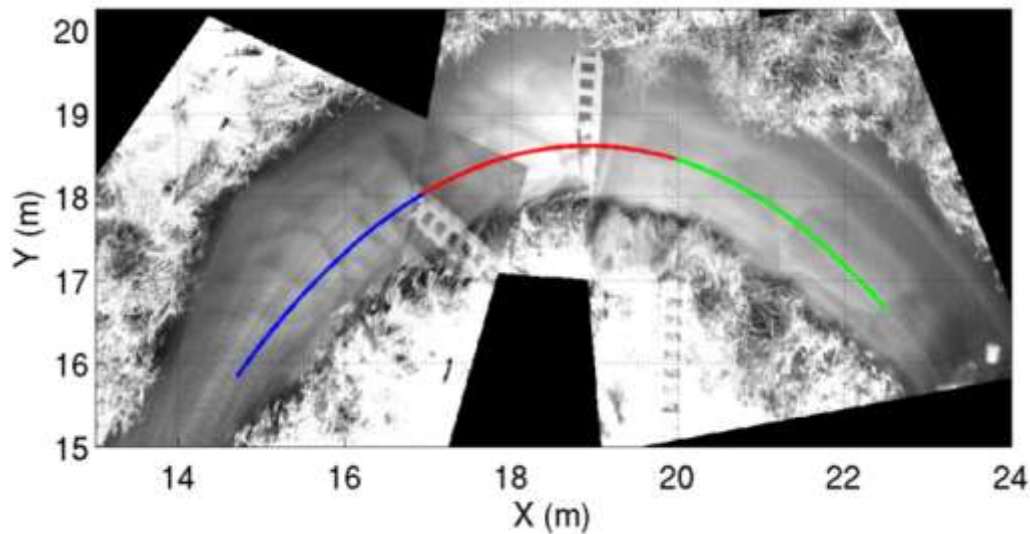
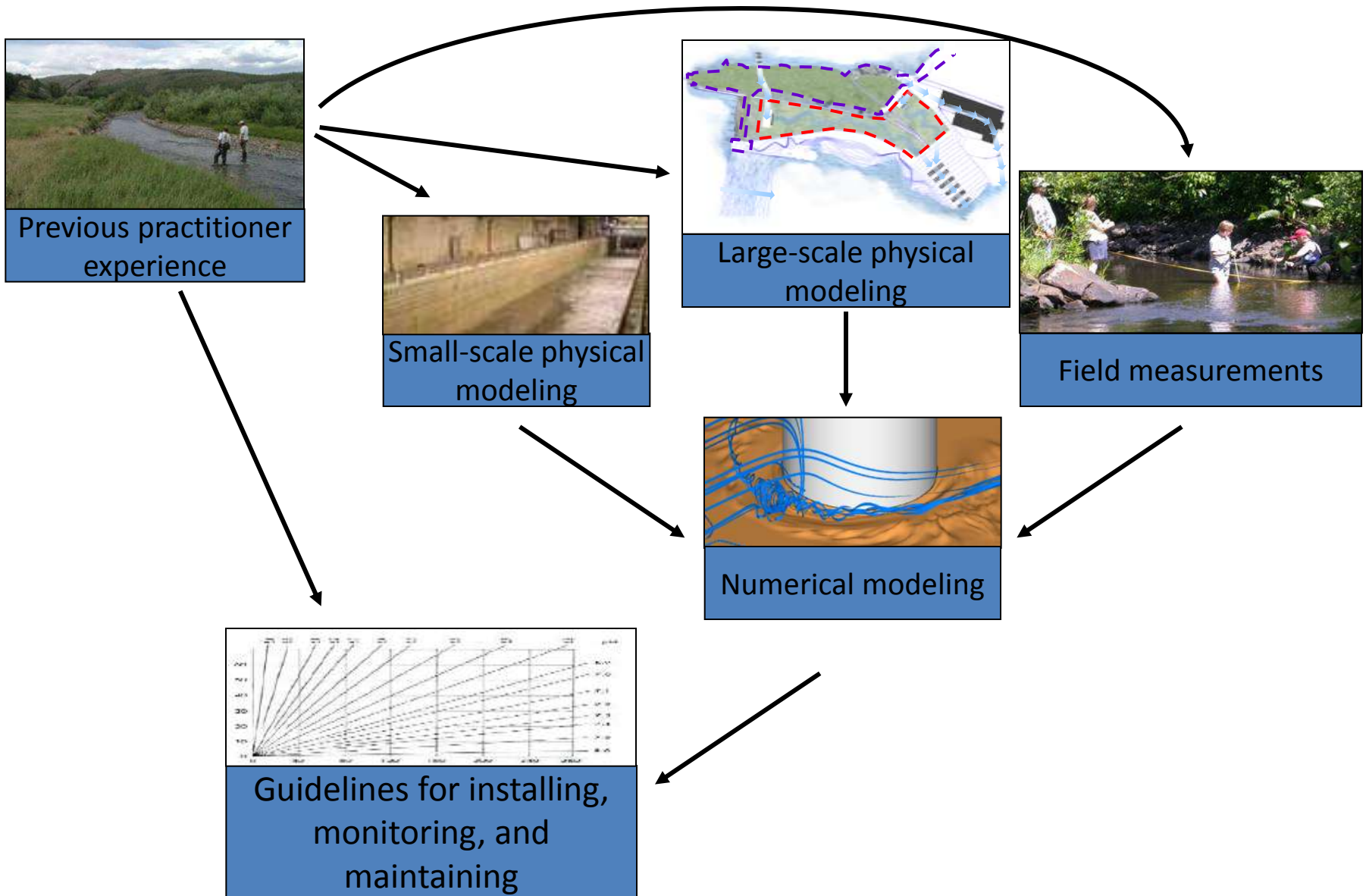


Figure from
M. Palmsten, NRL

Towards Quantitative Guidelines



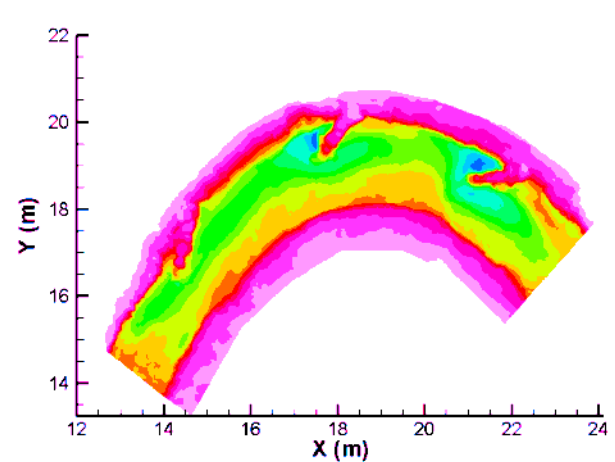
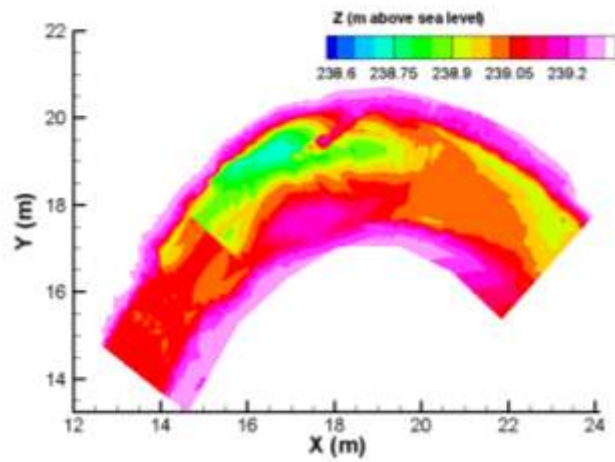
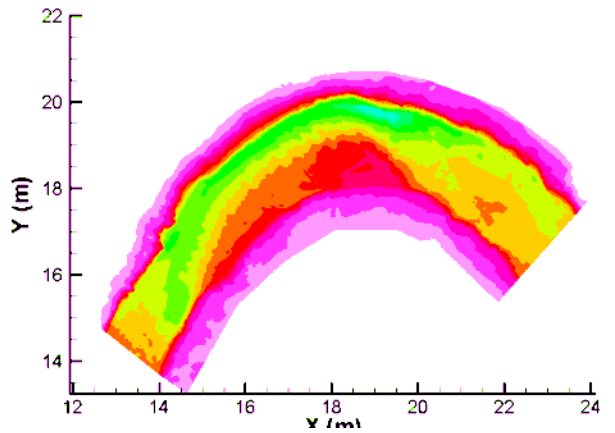
Towards Quantitative Guidelines

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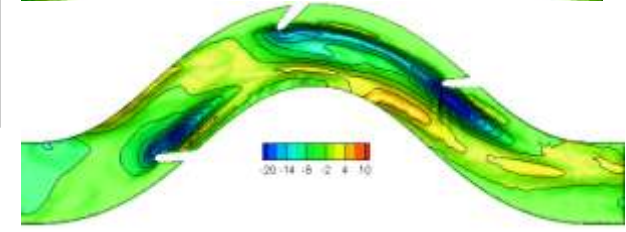
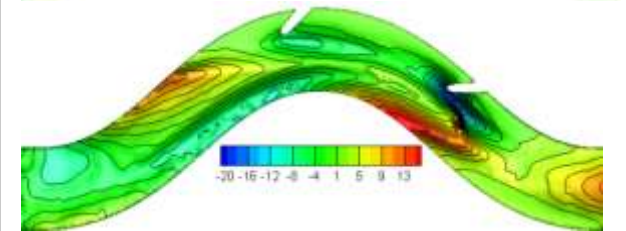
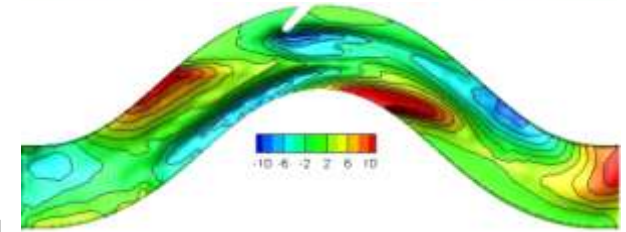
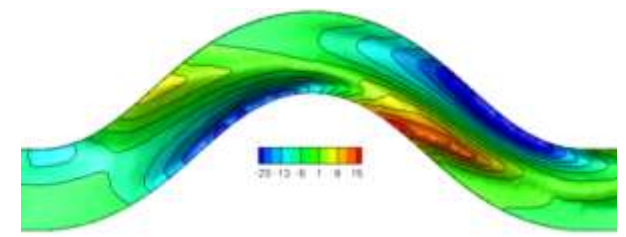
monitoring, and
maintaining

OSL Experiments and VSL testing



OSL
Sinuosity 1.3
Single Rock Vane
Triple Rock Vane

VSL
Sinuosity 1.15
Single Rock Vane
Double Rock Vane
Triple Rock Vane
> 100 runs



In-stream structures in the OSL

How do complex three-dimensional flow patterns around in-stream structures interact with the stream bed?

How do these complex flow and sediment transport environments affect nutrient dynamics, dissolved oxygen, and temperature?



In-stream structures in the OSL

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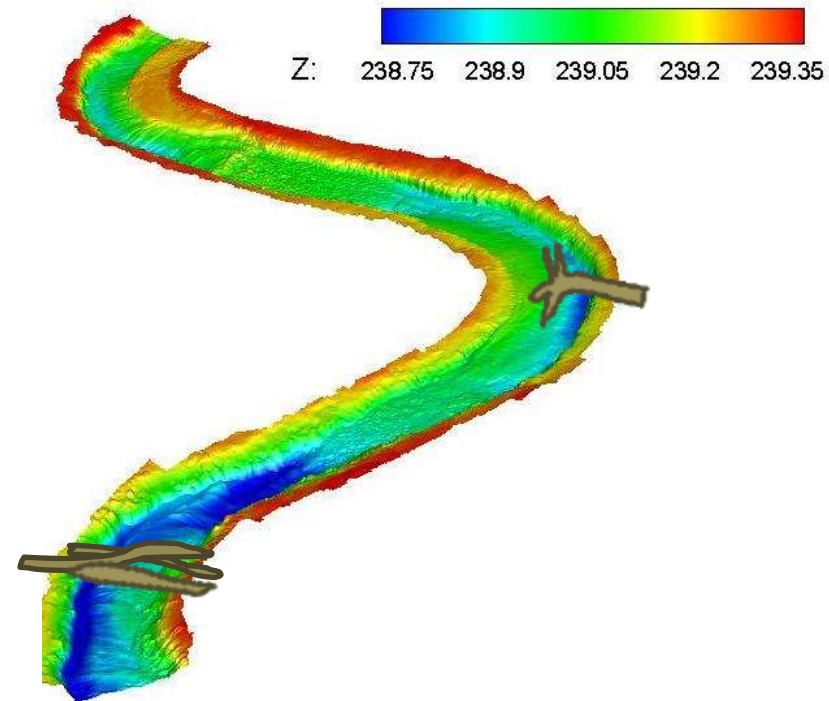
How do these complex flow patterns affect sediment transport, nutrients, dissolved oxygen, and temperature?

See Kris Guentzel's Poster



Full-scale outdoor experiments, combined with indoor flumes and numerical modeling: What can we learn about restoration?

- High-resolution measurements of velocity, sediment transport and water quality in complex flows
- Feedbacks between sediment transport and vegetation
- Biological, chemical, and physical interactions between a channel and its floodplain
- Flow/biota interactions



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and REU students

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Yonsei University





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