The Benefits of Using an Acoustic Doppler Current Profiler for Hydraulic Modeling

National Hydraulic Engineering Conference 2014

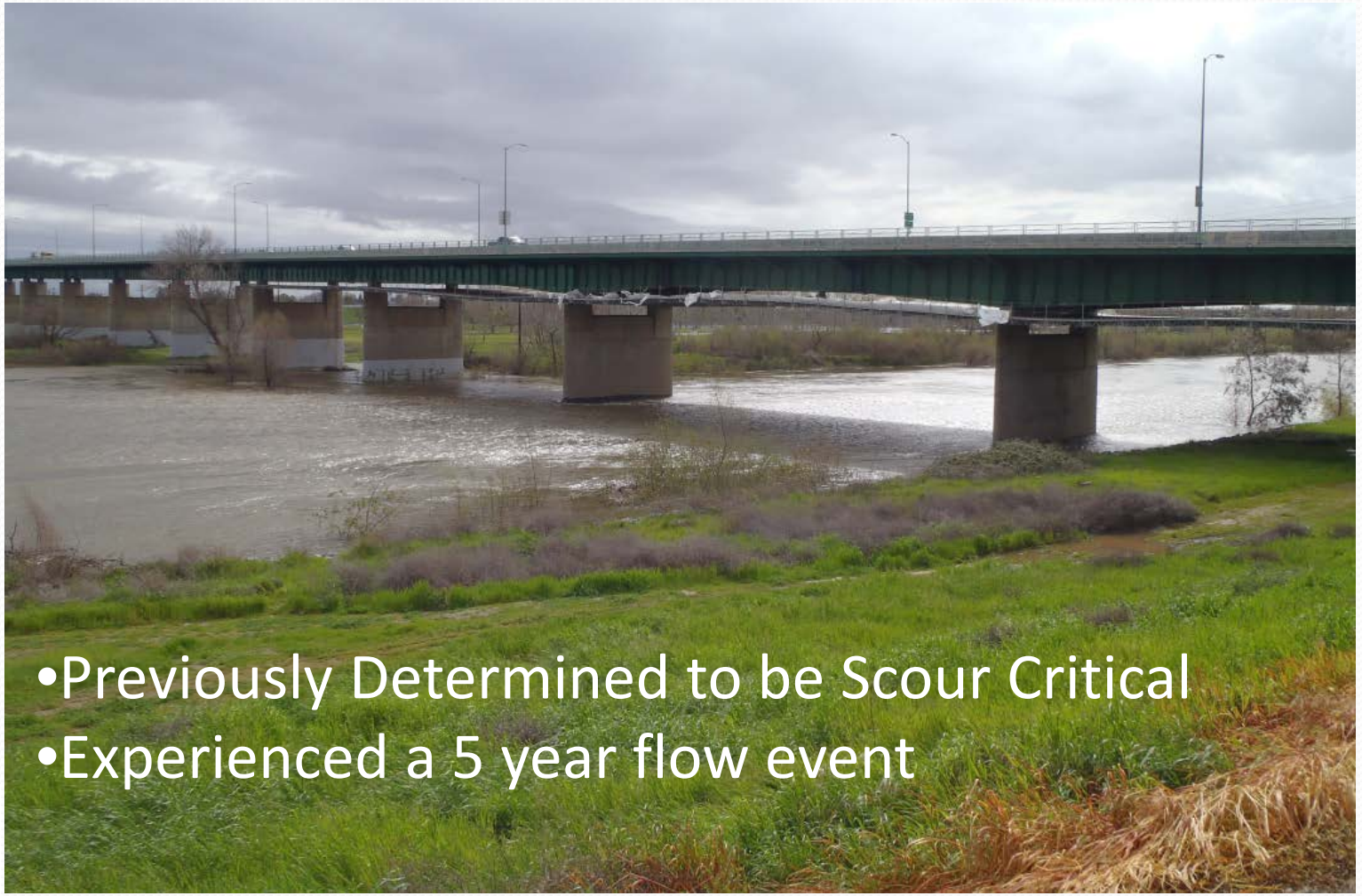
Iowa City, Iowa

Kevin Flora. P.E.
Caltrans

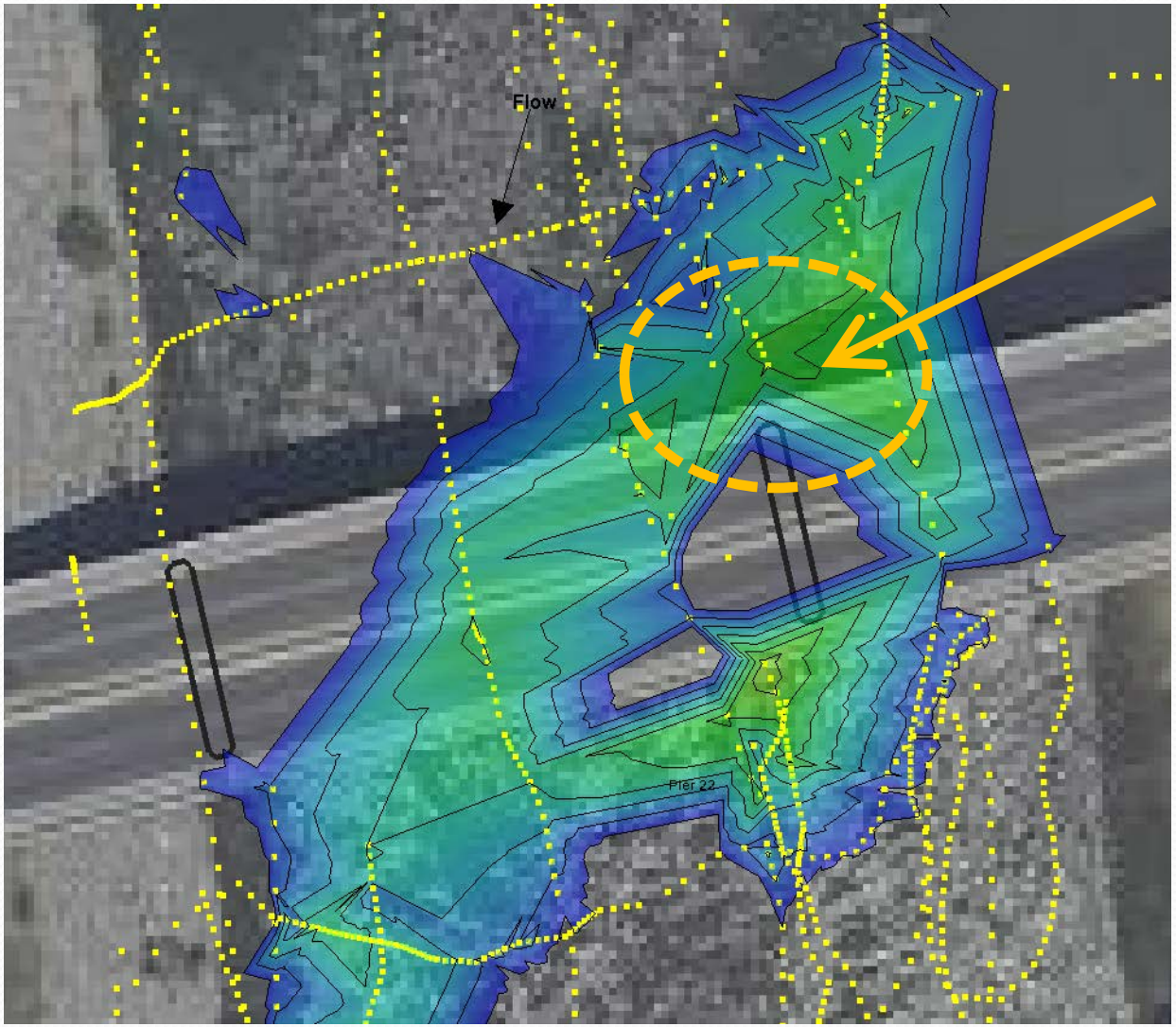
Key Questions ?

- What's up with the Feather River?
- What other tools are out there that can help me do my work better?

Feather River Br. No. 18-0009
March 22, 2011

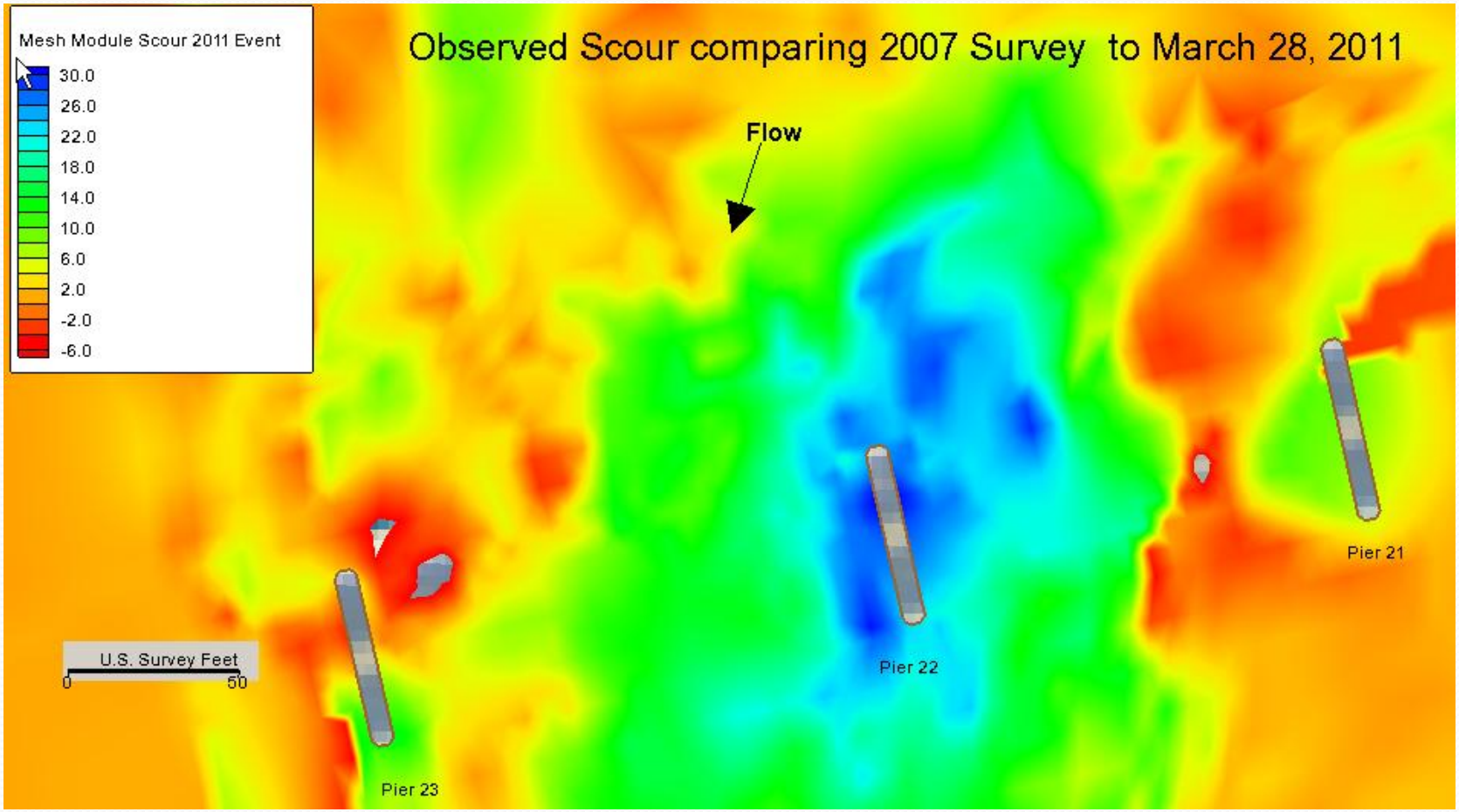


Emergency or Not?

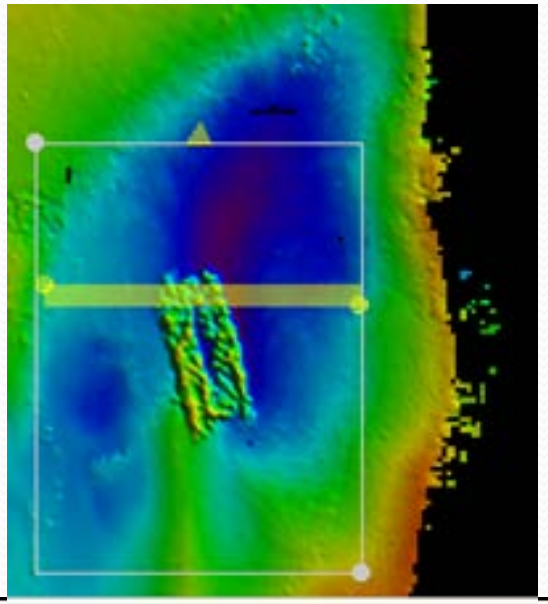


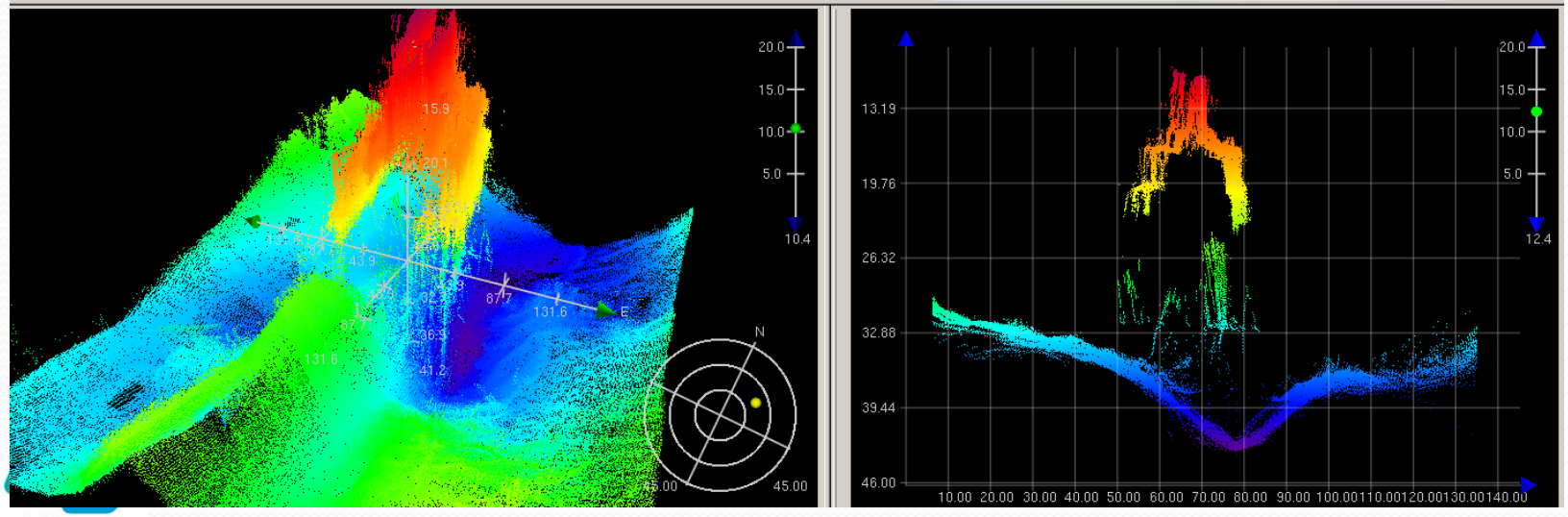
Limited Data showed a 30-foot Scour hole at the Pier

Confirmation from Follow-up Surveys



Multi-beam Bathymetry by Contract





Lessons Learned

- Capturing Scour Data during or immediately after an event is critical
- Acquisition of Baseline Bathymetric Data is invaluable
- **Clear need for improved methods for collecting data under a bridge**
- **Need for better estimates of Key Hydraulic Parameters**
  - **Hydraulic Skew**
  - **Upstream Flow Distribution**
  - **Roughness**

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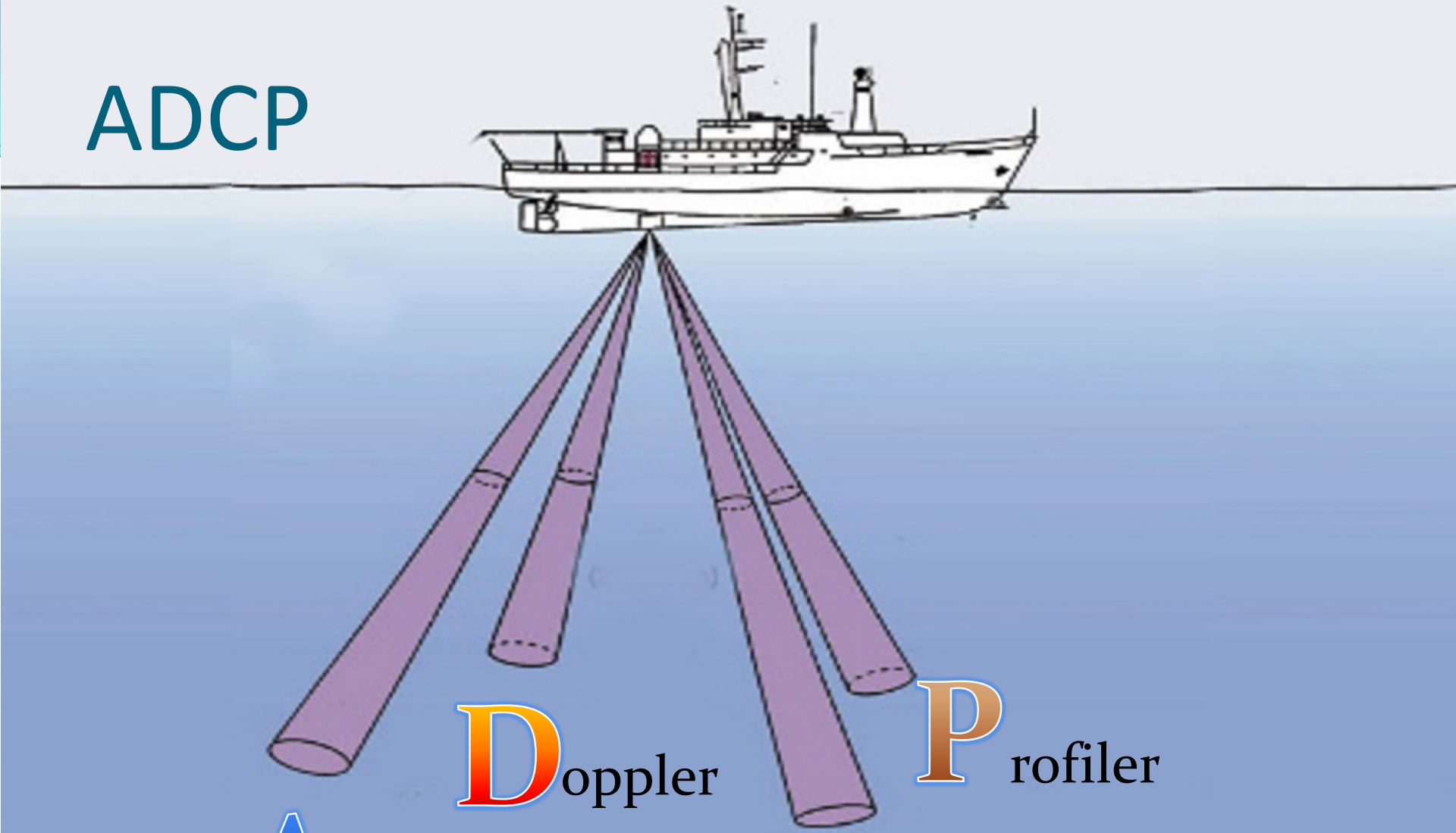
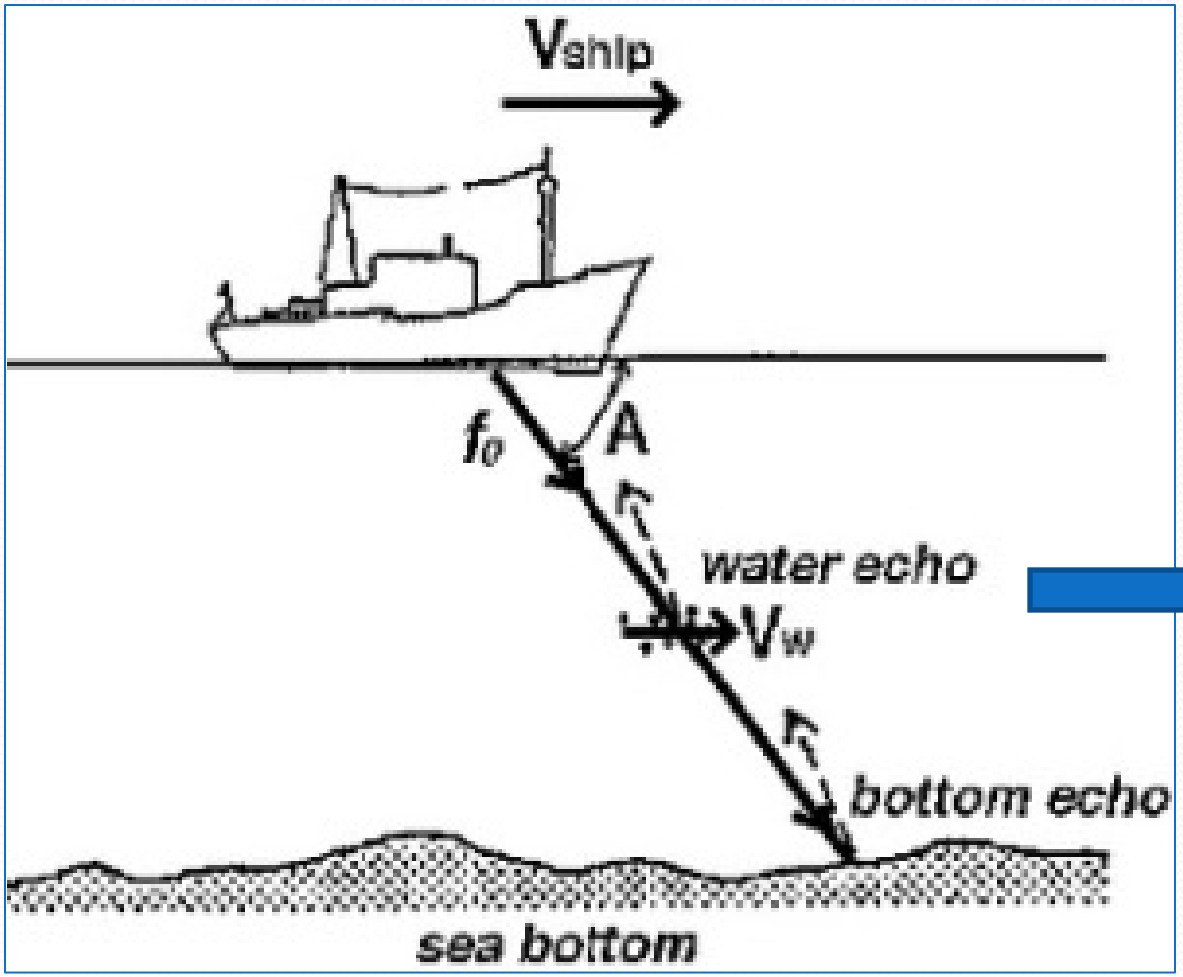
ADCP



Acoustic **D**oppler **C**urrent **P**rofiler

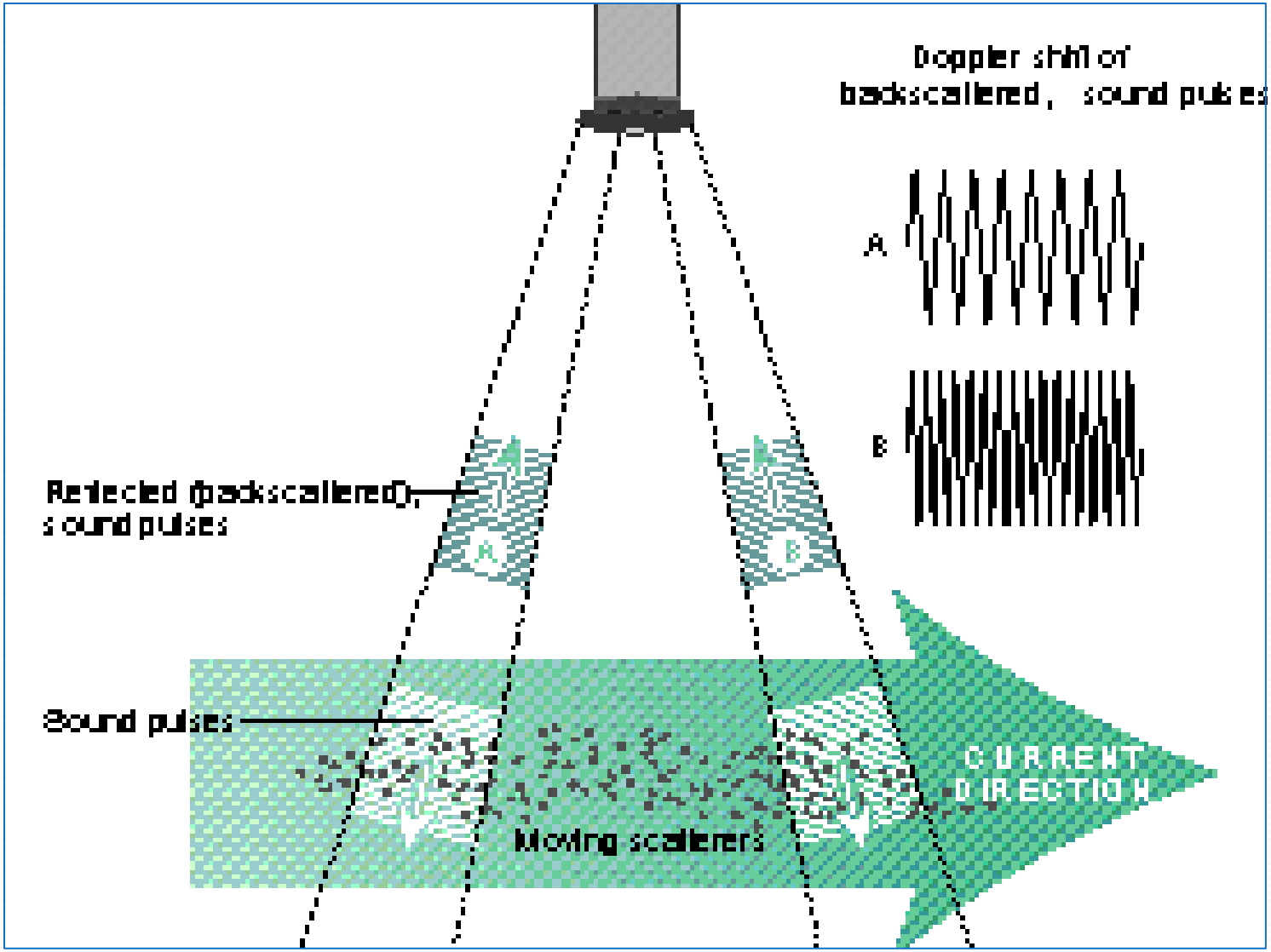
ADCP Operation



Velocity of Flow

Location

ADCP Operation

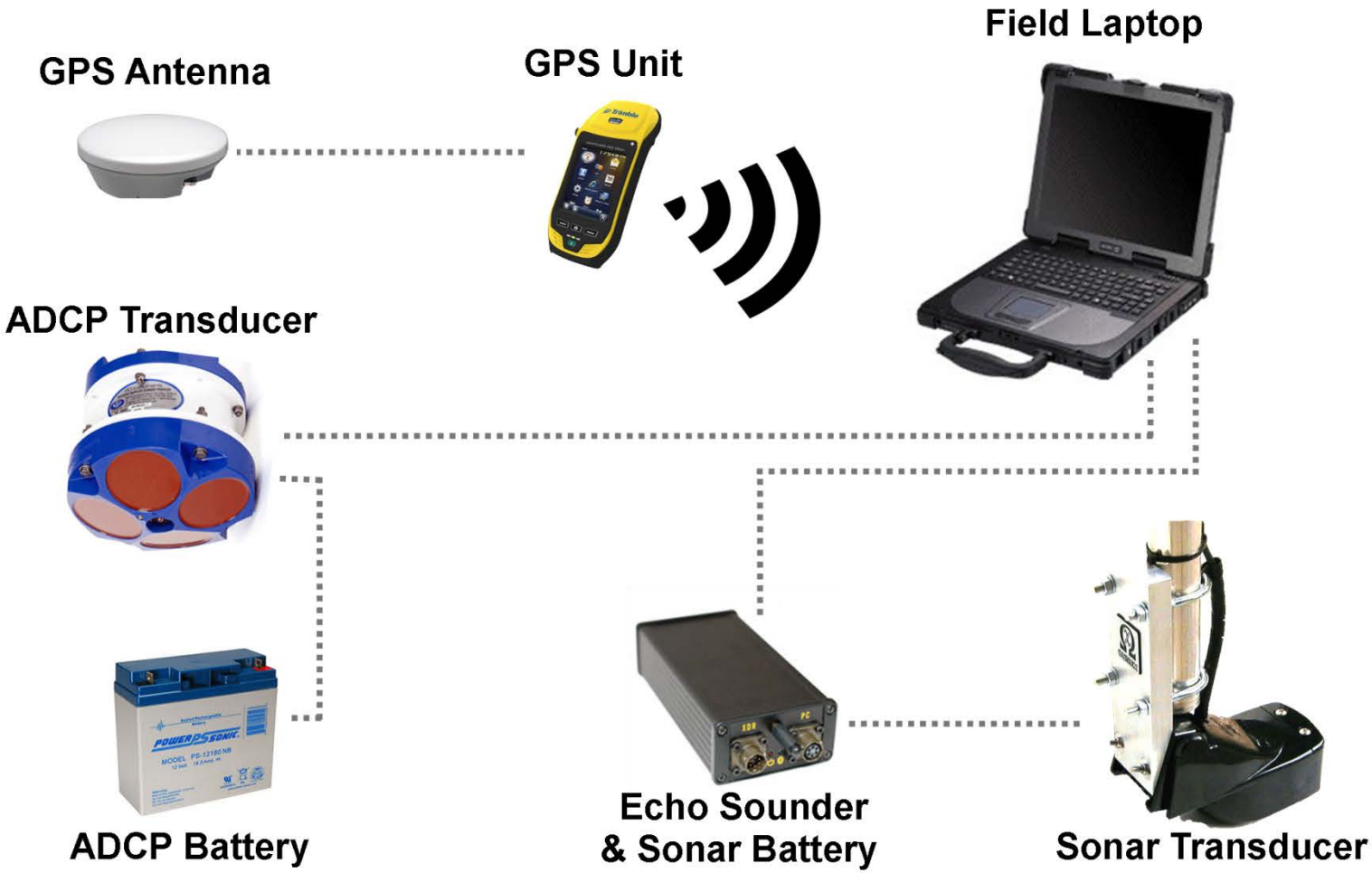


ADCP Acquired in Spring 2012

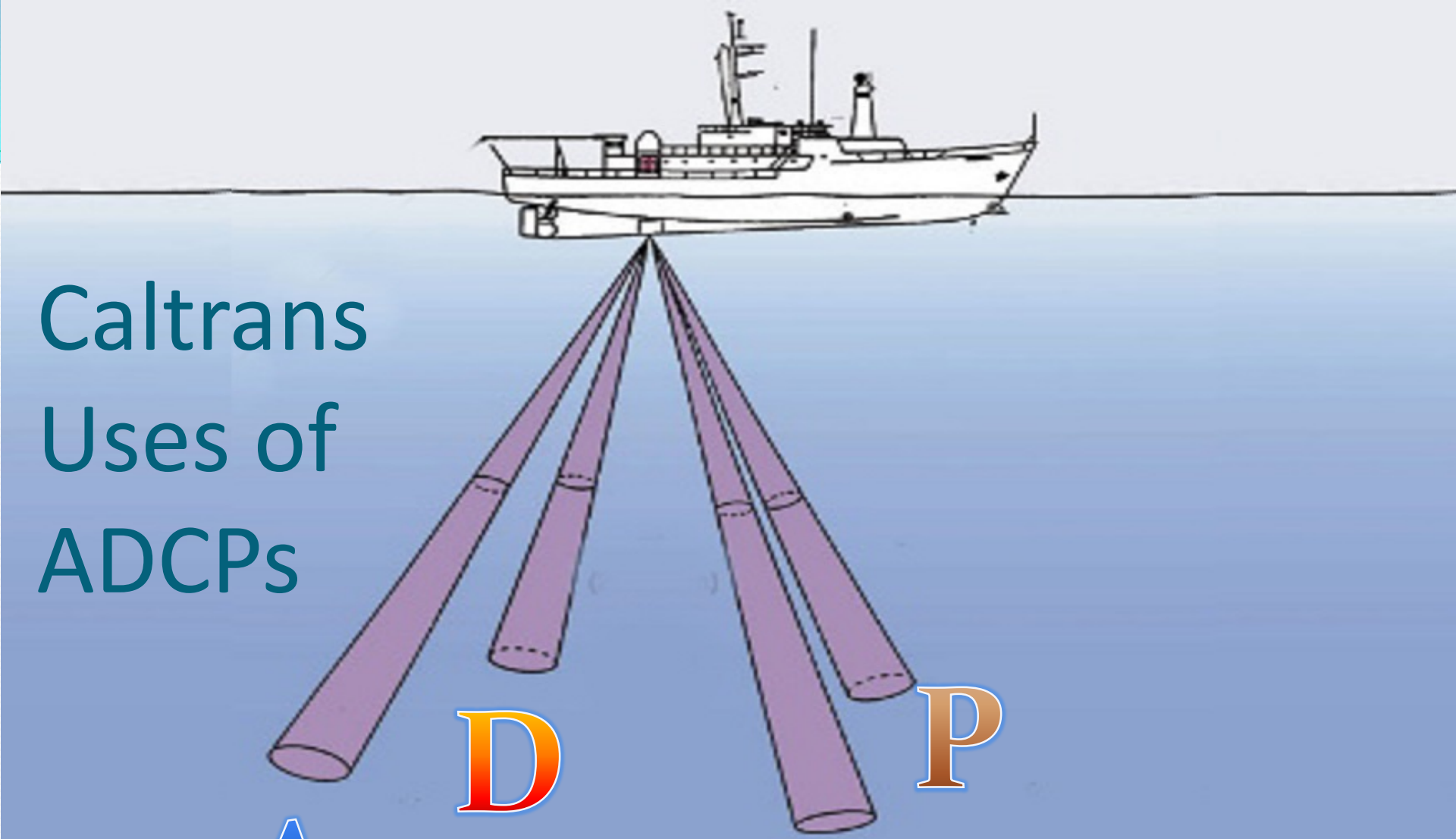
- RDI Rio Grande Workhorse ADCP
  - 1200 kHz
  - High Speed Sampling (Mode 12)
  - Shallow water bottom tracking
- USGS Kentucky Mounted on 12-foot Achilles Inflatable Boat
- RDI's WinRiver II Software

SM&I Dive Boat

Equipment Set up



Caltrans Uses of ADCPs



A quisition of Bathymetric Data

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Combine ADCP/Sonar/GPS Data

- In house Program written in VBA for Microsoft Excel
- Provides a means to improve bathymetric surveys by intelligently combining GPS, Sonar and ADCP depth data
- Outputs in a CSV format for easy input into 2D models

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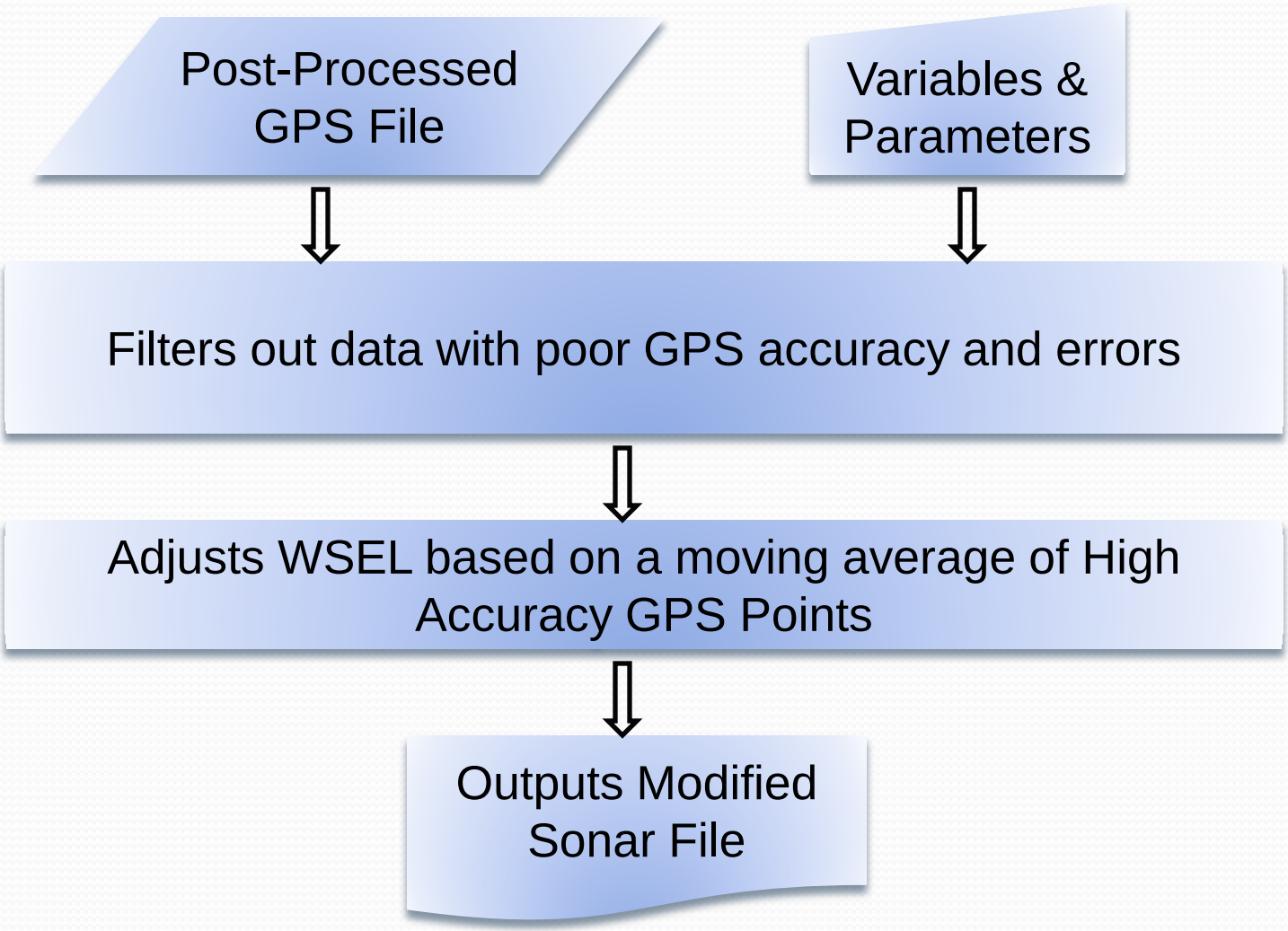
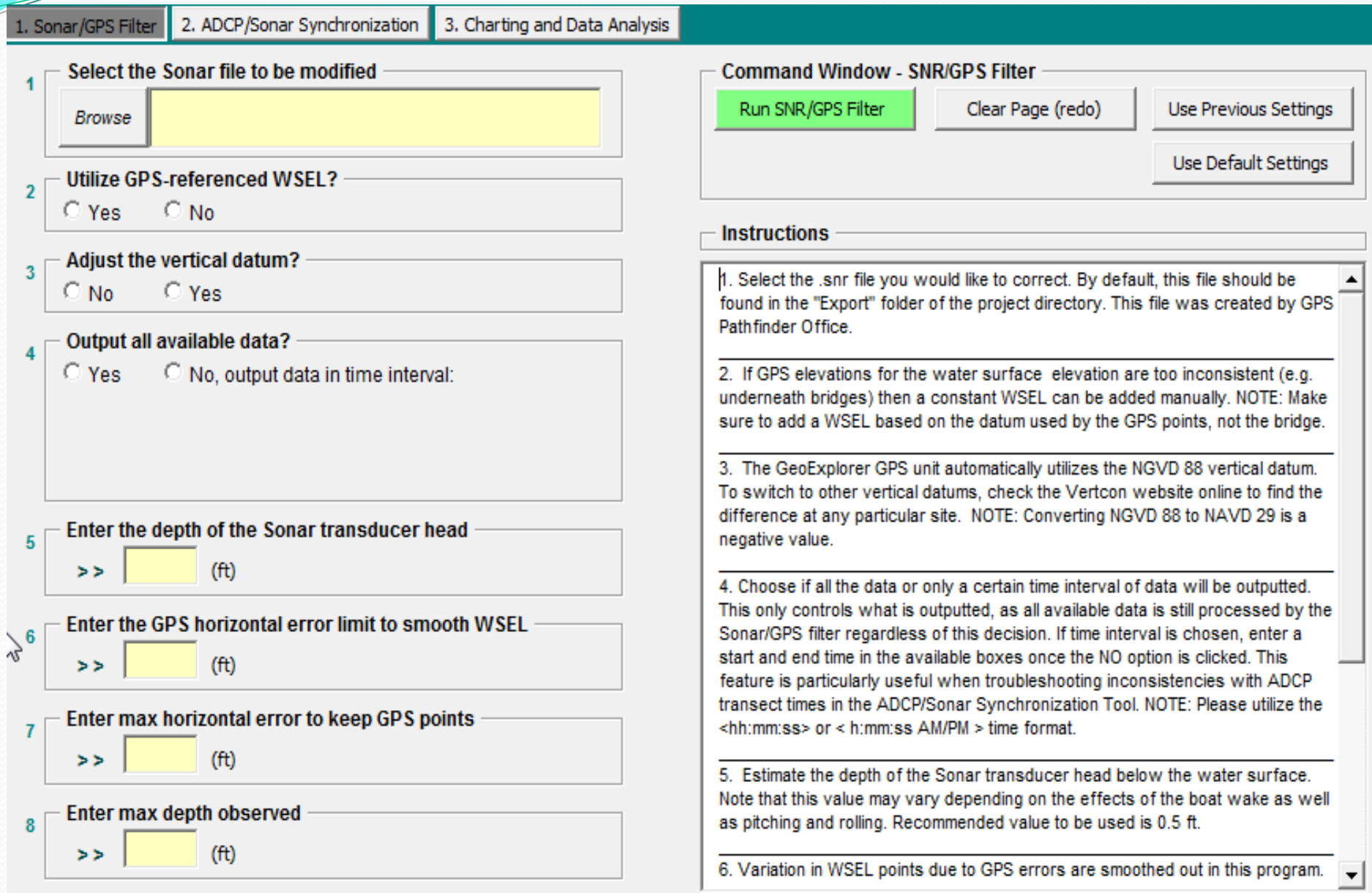
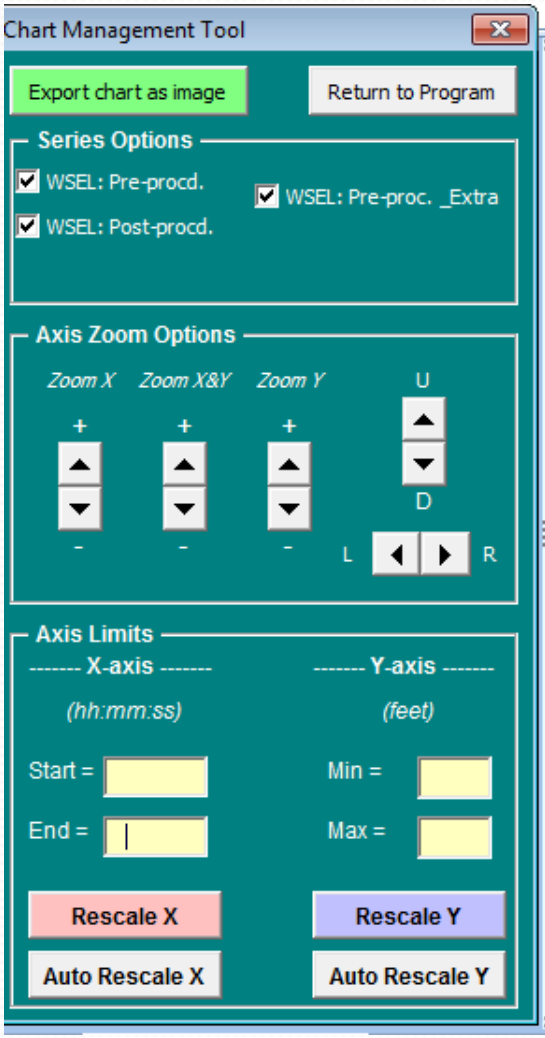
PART 1 - Sonar/GPS Filter Flowchart

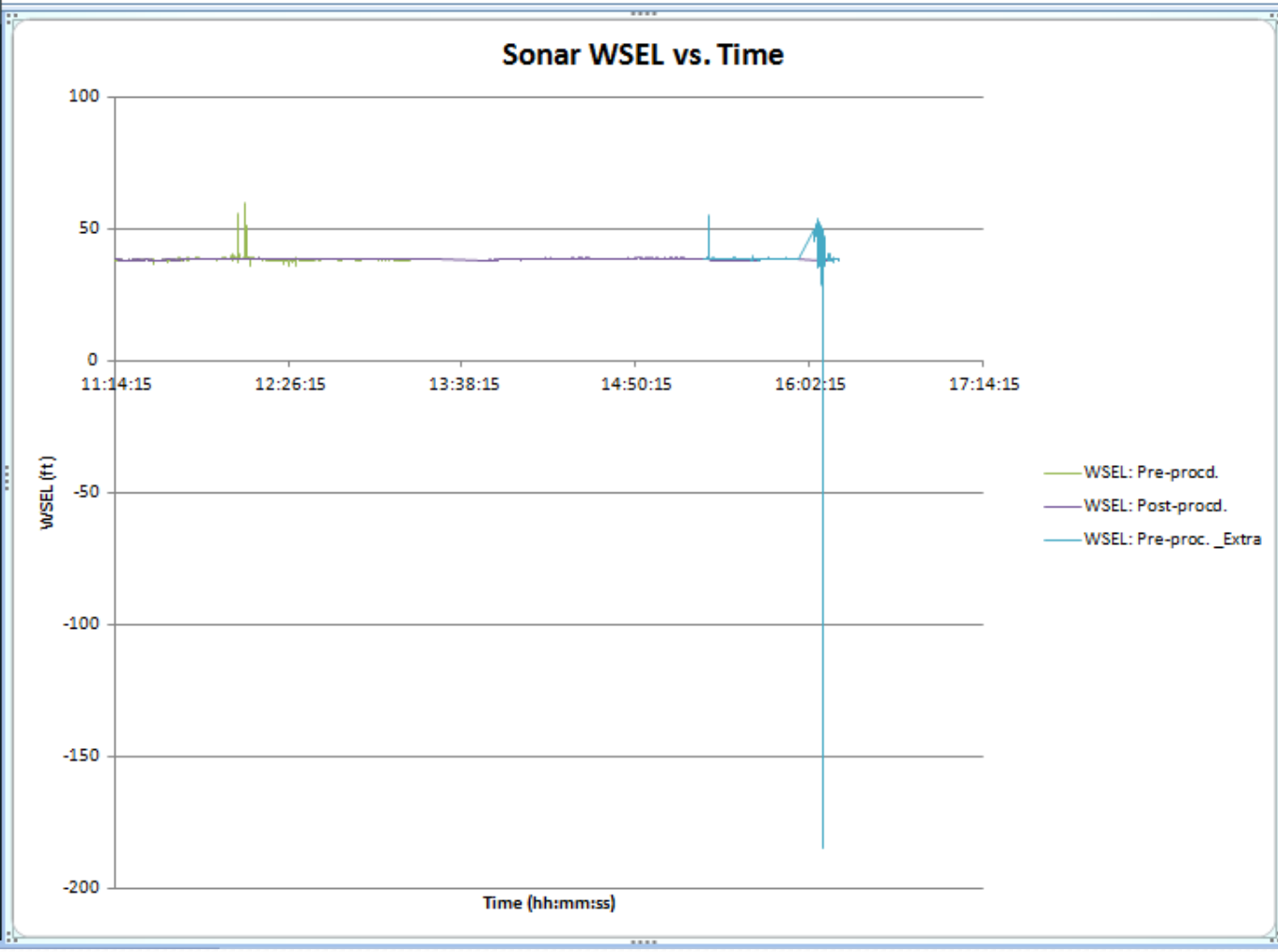


Sonar/GPS Filter Macro

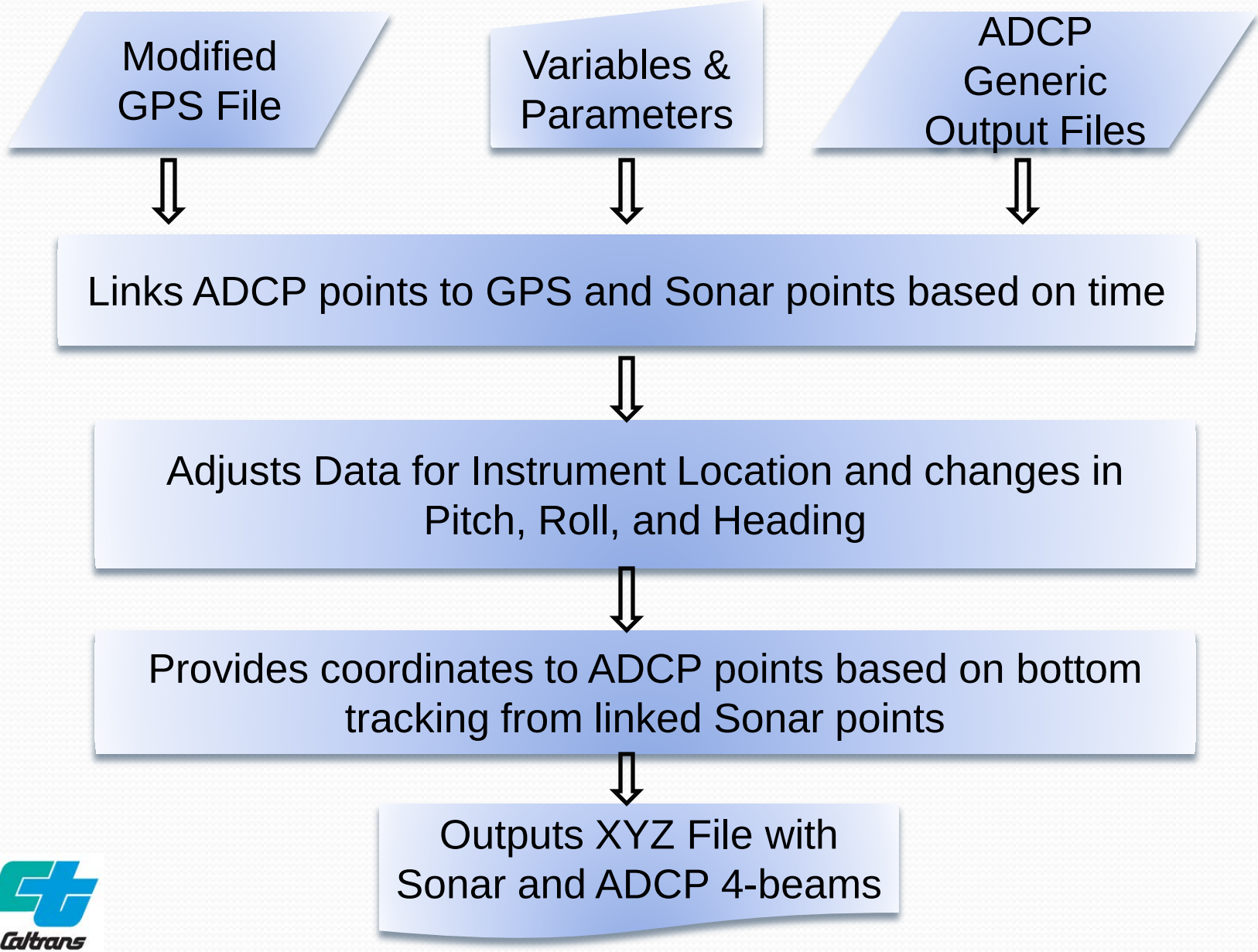


Sonar/GPS Filter Macro





PART 2 - ADCP/Sonar Synchronization Flowchart



Sonar/GPS Filter Macro

1. Sonar/GPS Filter | 2. ADCP/Sonar Synchronization | 3. Charting and Data Analysis

1 **Select the first ADCP text file**

Browse

2 **Select the last ADCP text file**

Browse

☐ Click Here If Only Processing A Single Transect

3 **Select the modified Sonar file**

Browse

4 **Select all, all-minus-one, or one output data point**

☐ Beam 0 (Sonar) ☐ Beam 1 ☐ Beam 3 ☐ Beam 2 ☐ Beam 4

5 **Would you like to offset the time?**

○ No ○ Yes

6 **Enter the depth of the ADCP transducer head**

>> (ft)

7 **Enter the depth of the Sonar transducer head**

>> (ft)

8 **Enter the X and Y distances from the ADCP to Sonar unit**

Distance X (lengthwise) = (ft)

Distance Y (widthwise) = (ft)

Command Window - ADCP/SNR Synchronization

Run ADCP/SNR Sync | Clear Page (redo) | Use Previous Settings | Use Default Settings

Instructions

1. Choose the first or single ADCP transect text file that was created by WinRiverII in the measurements folder. By default the lowest sequential filename will be "4beamcorrection_000_ASC.txt". NOTE: Each text files refers to an individual ADCP transect. A transect encompasses the time when the ADCP begins and stops pinging.

2. Choose the ASCII file with the highest sequential file name (e.g. "4beamcorrection_014_ASC.txt") in the same folder as Step 1. If only a single transect will be processed, please click on the option available under the prompt.

3. Choose the .SNR(mod) file newly created by the Sonar/GPS Filter in the main project "Export" folder.

4. To assist in delineating between Sonar depths and ADCP corrected depths, please select the the type of data points to output. Either ALL beams, ONE beam, or FOUR beams can be chosen.

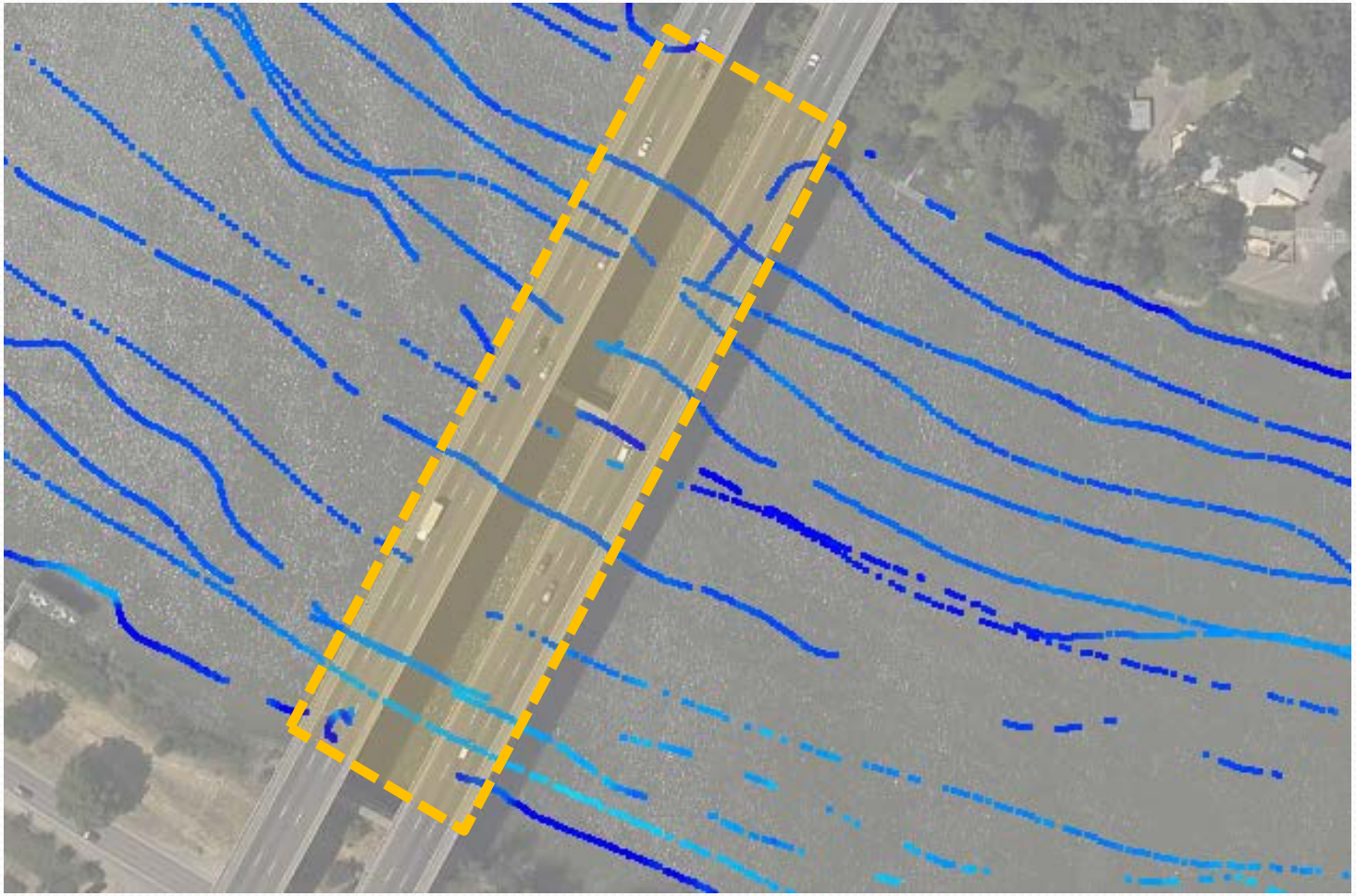
5. If the Sonar clock and ADCP clock are not synced prior to data collection, there will be a constant time difference between two instantaneous data points measured by the devices. Analyze the .snr and ADCP text files to identify this constant time difference. Then enter the time difference in seconds (e.g., 1 hour = 3600 seconds). If the ADCP is lagged 1 hour after the Sonar, then input a positive (+) number, if Sonar lags, then enter a negative (-) number. NOTE: Sometimes transects have time errors in which the time offset will be different amongst the transects. If this is the case, only subsets of transects with the same time "base" can be processed. Outliers can then be processed individually.

6. Estimate the depth of the ADCP transducer head below the water surface. Note that this value may vary depending on the effects of the boat wake as well

Without ADCP Beams

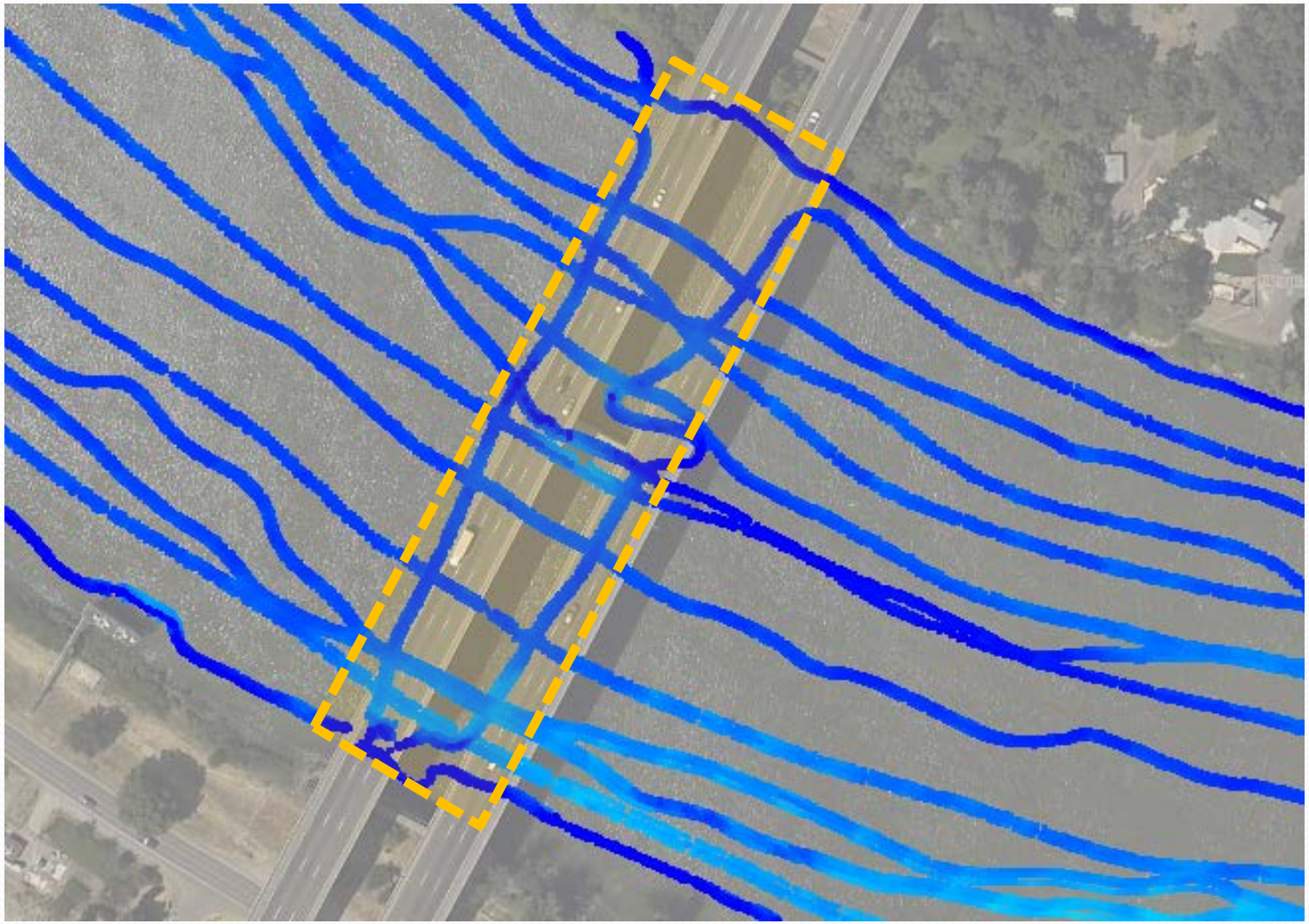
Sonar Data Using Only GPS Under Bridge

➔ *1121 points*

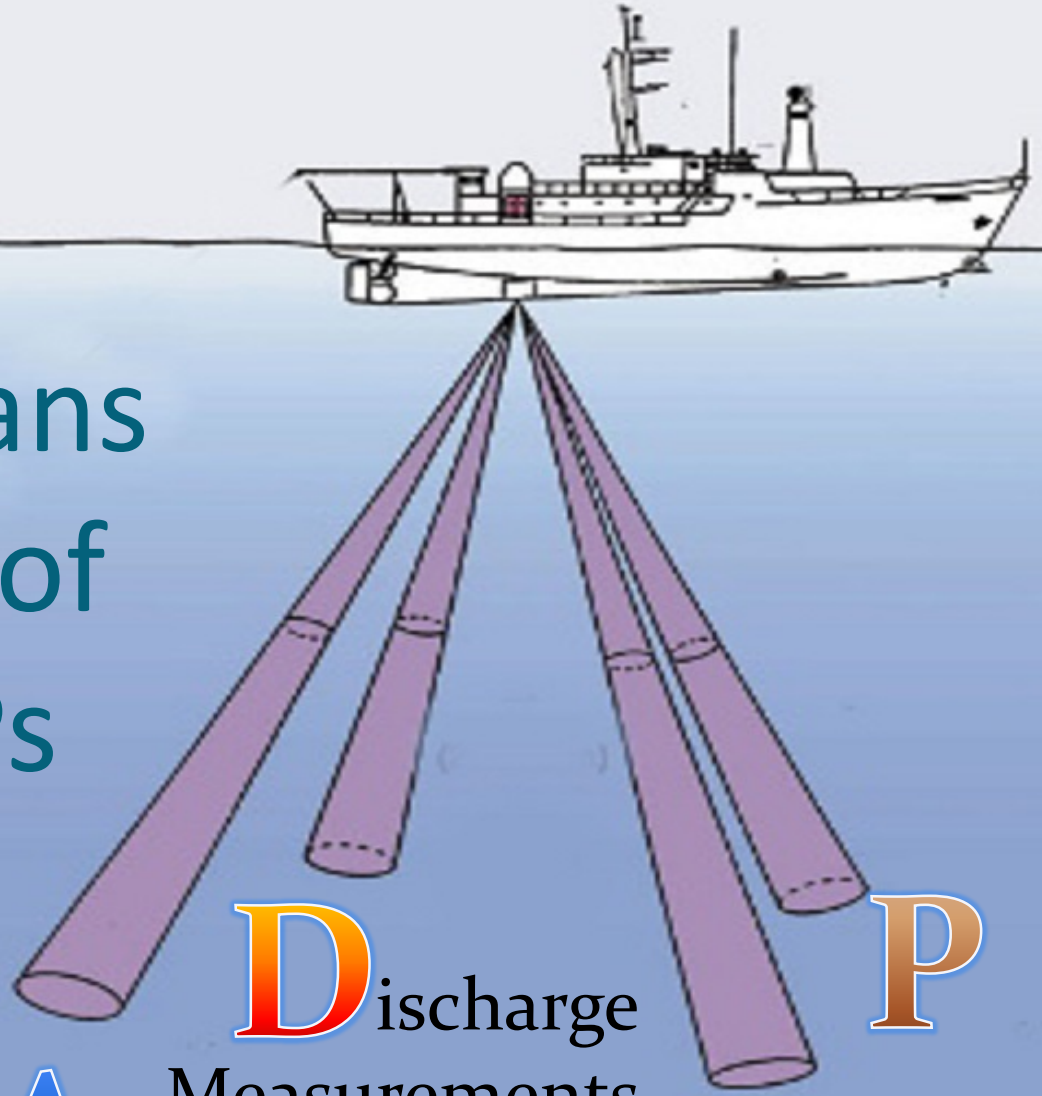


With ADCP Beams and Bottom Tracking

Combined Sonar & ADCP Data Under Bridge ➔ 10,221 points



Caltrans Uses of ADCPs



Discharge Measurements

Aquisition of Bathymetric Data

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Discharge Measurements

- Obtained Simply by Traversing the Channel
- Velocity Data and Depth is Measured Simultaneously
- Estimates at the Edges and Top and Bottom of the Water Profile are automatically made
- Data is accumulated to obtain the Flow Rate

- Discharge Data will be useful for Model Calibration and during Flood Events

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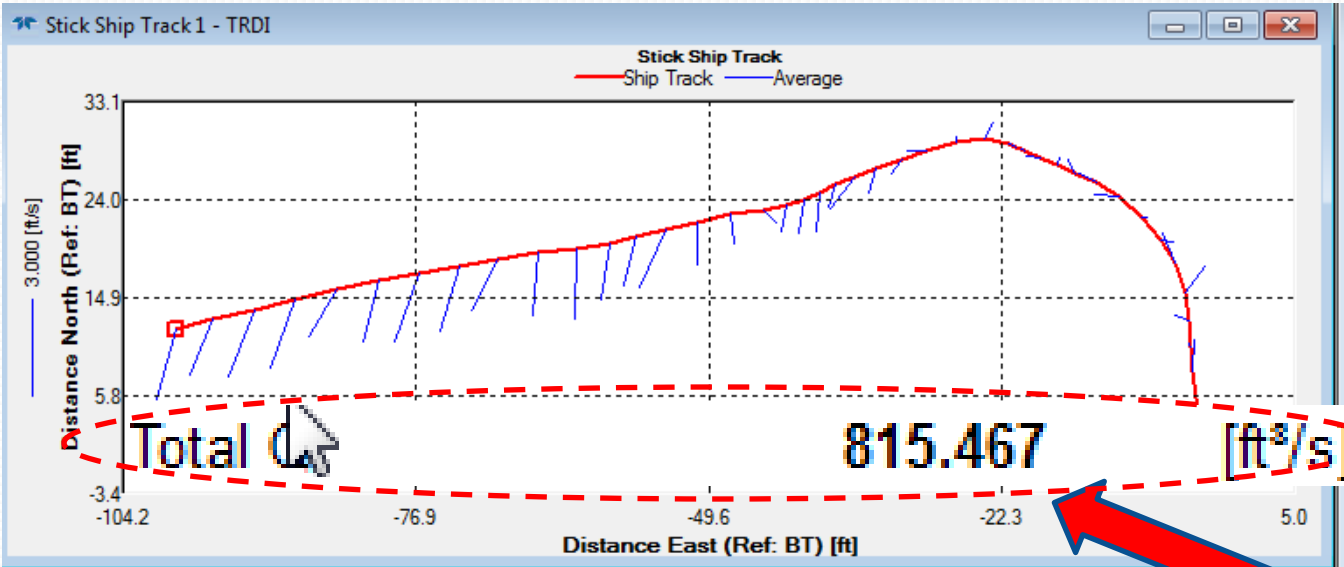
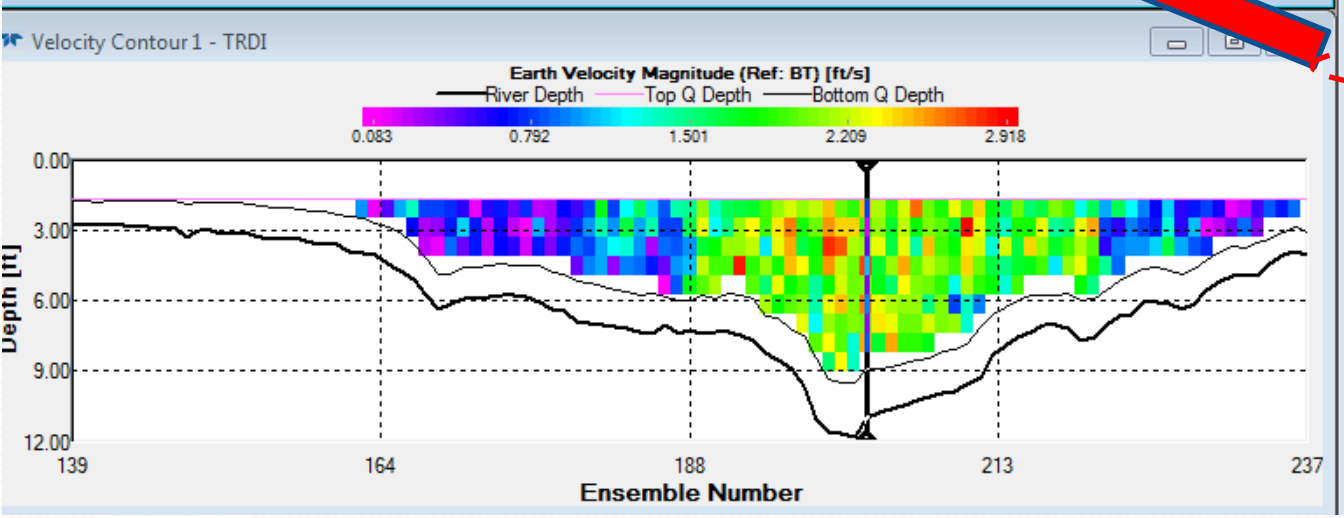
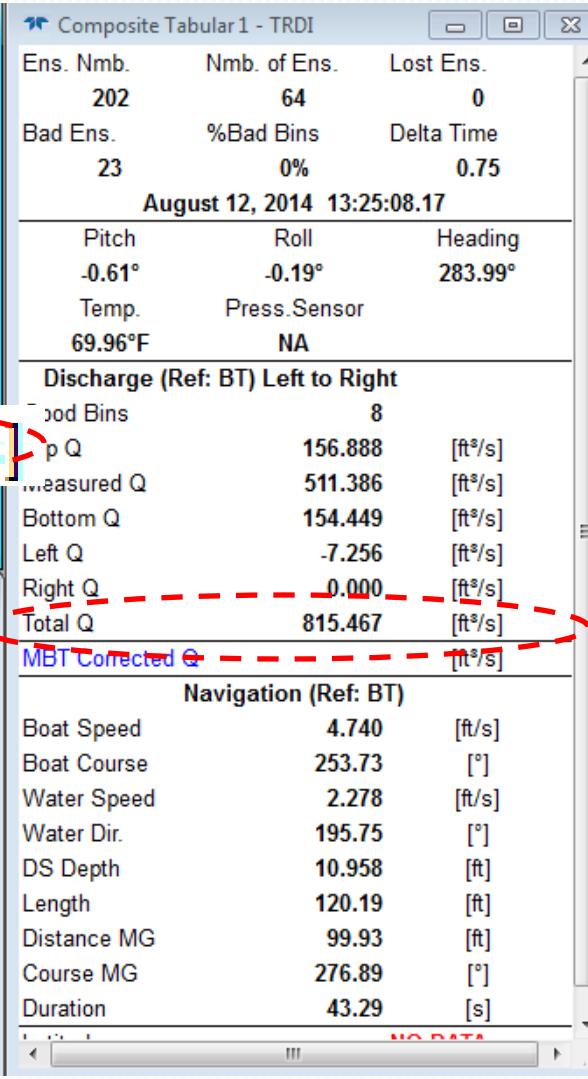
Discharge Measurements







Measured Flow Rates

(Q=26,400 cfs with Standard Deviation < 2%)

Transect	Start Bank	# Ens.	Start Time	Total Q ft^3/s	Delta Q %
Butte12-4-12-01000	Left	145	10:10:10	26890.865	1.74
Butte12-4-12-01001	Right	153	10:15:57	26194.577	-0.89
Butte12-4-12-01002	Left	132	10:21:07	25860.402	-2.15
Butte12-4-12-01003	Right	128	10:26:19	26447.183	0.07
Butte12-4-12-01004	Left	133	10:30:54	25788.939	-2.42
Butte12-4-12-01005	Right	123	10:35:47	26131.926	-1.13
Butte12-4-12-01006	Left	238	10:40:24	27041.511	2.31
Butte12-4-12-01009	Left	172	11:02:18	27082.249	2.47
Average		153		26429.707	-0.00
Std Dev.		38		519.854	1.97
Std./| Avg.|		0.25		0.02	0.00

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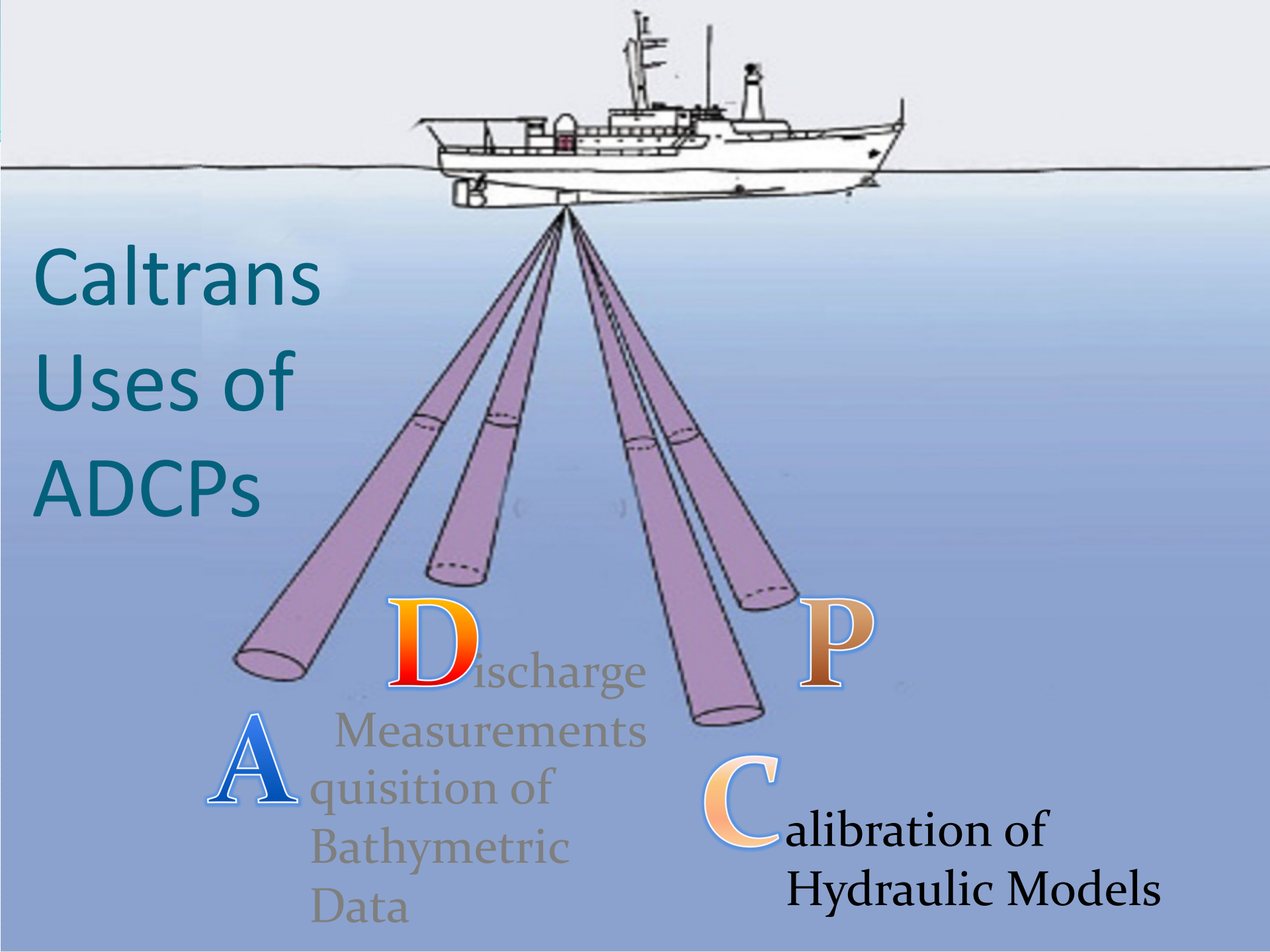
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Uses of
ADCPs
Discharge
Measurements
Acquisition of
Bathymetric
Data
Calibration of
Hydraulic Models

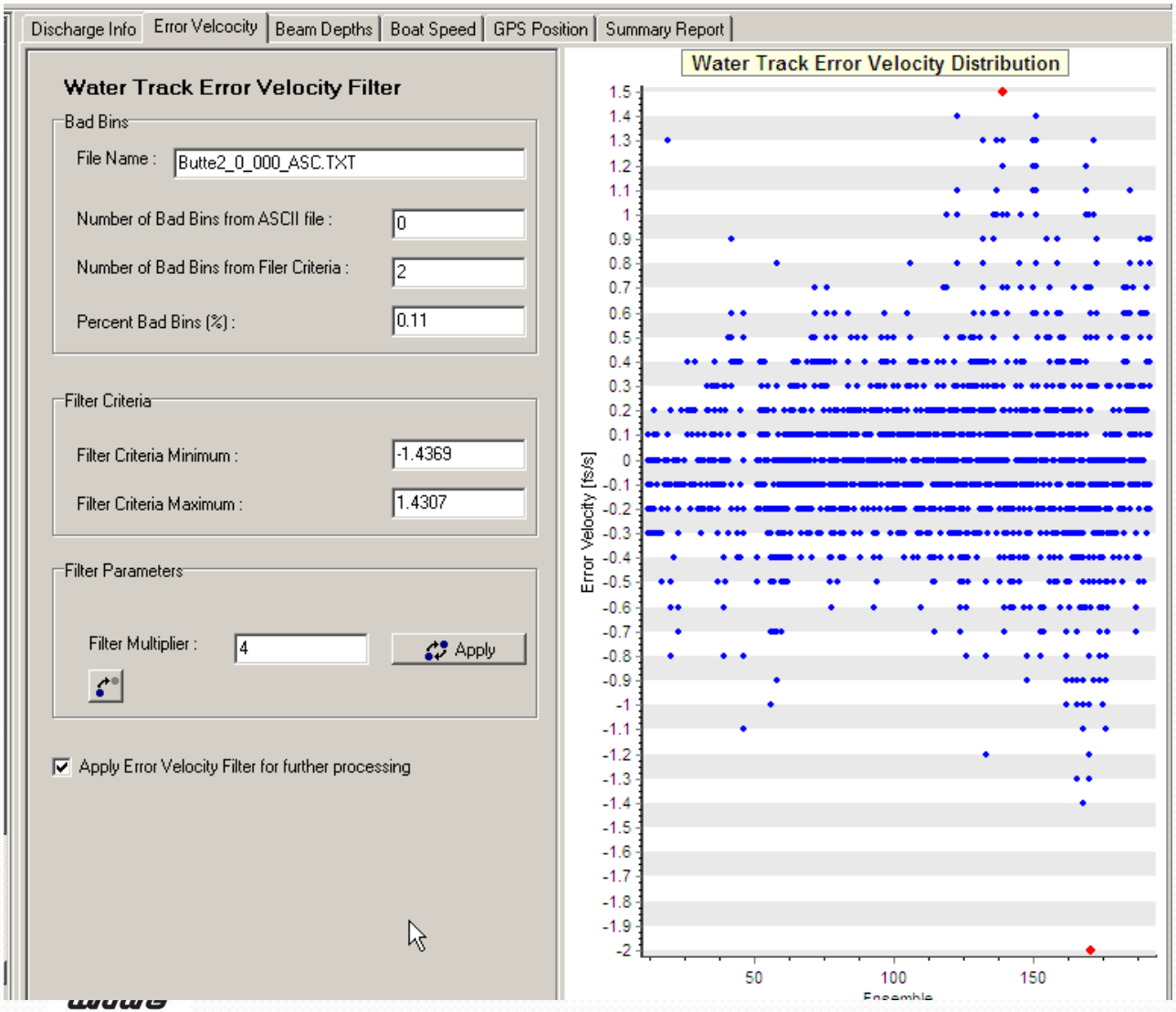
ADCP Calibration Post-processing for Hydraulic Models

VMS - *ADCP Velocity Mapping Software*

(IIHR, USGS and USACE)

- Data Filtering of outliers
- Spatial Averaging of Velocity

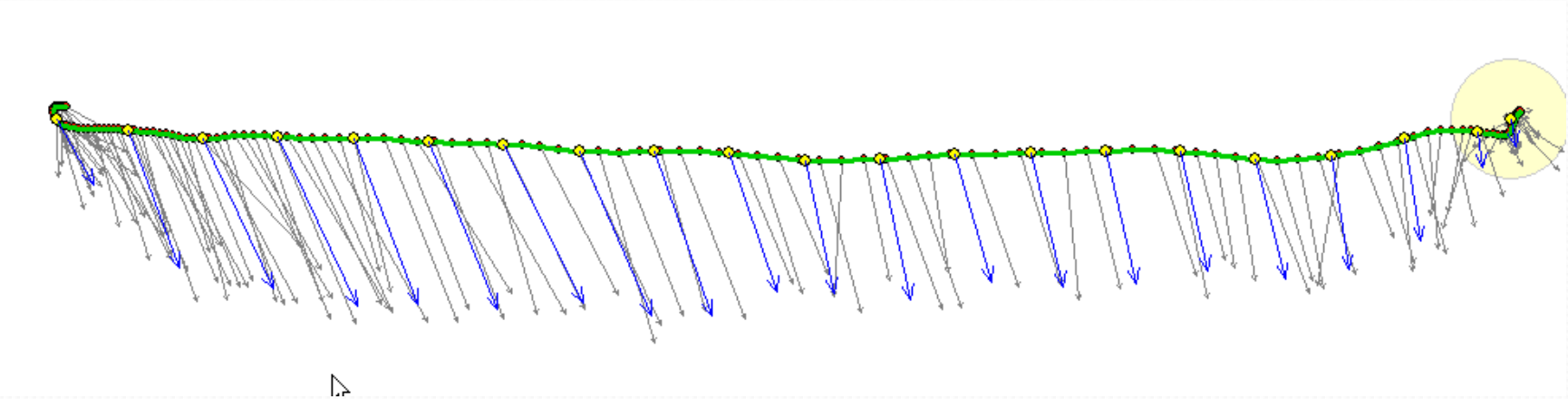
Post-processing with VMS Software



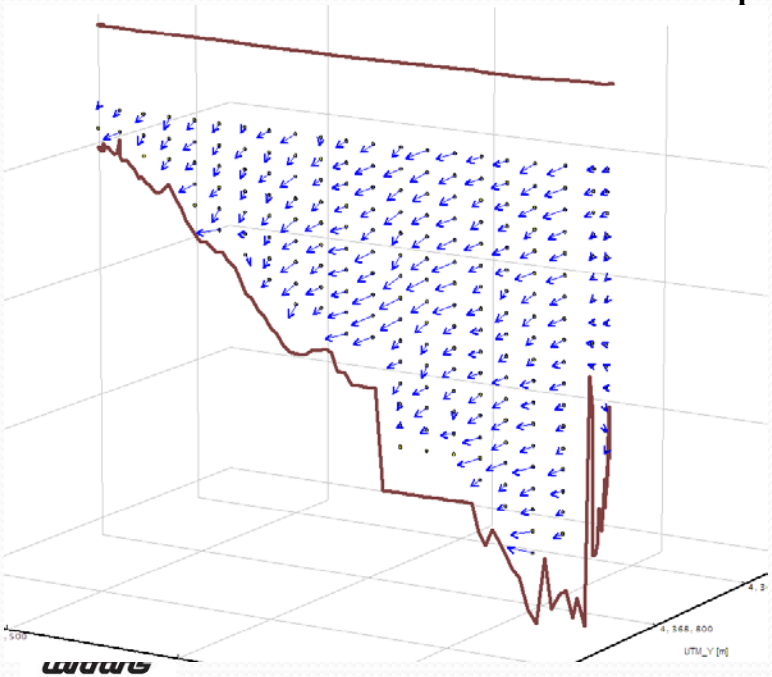
Data Filtering

- Discharge
- Error Velocity
- Beam Depths
- Boat Speed

Post-processing with VMS Software

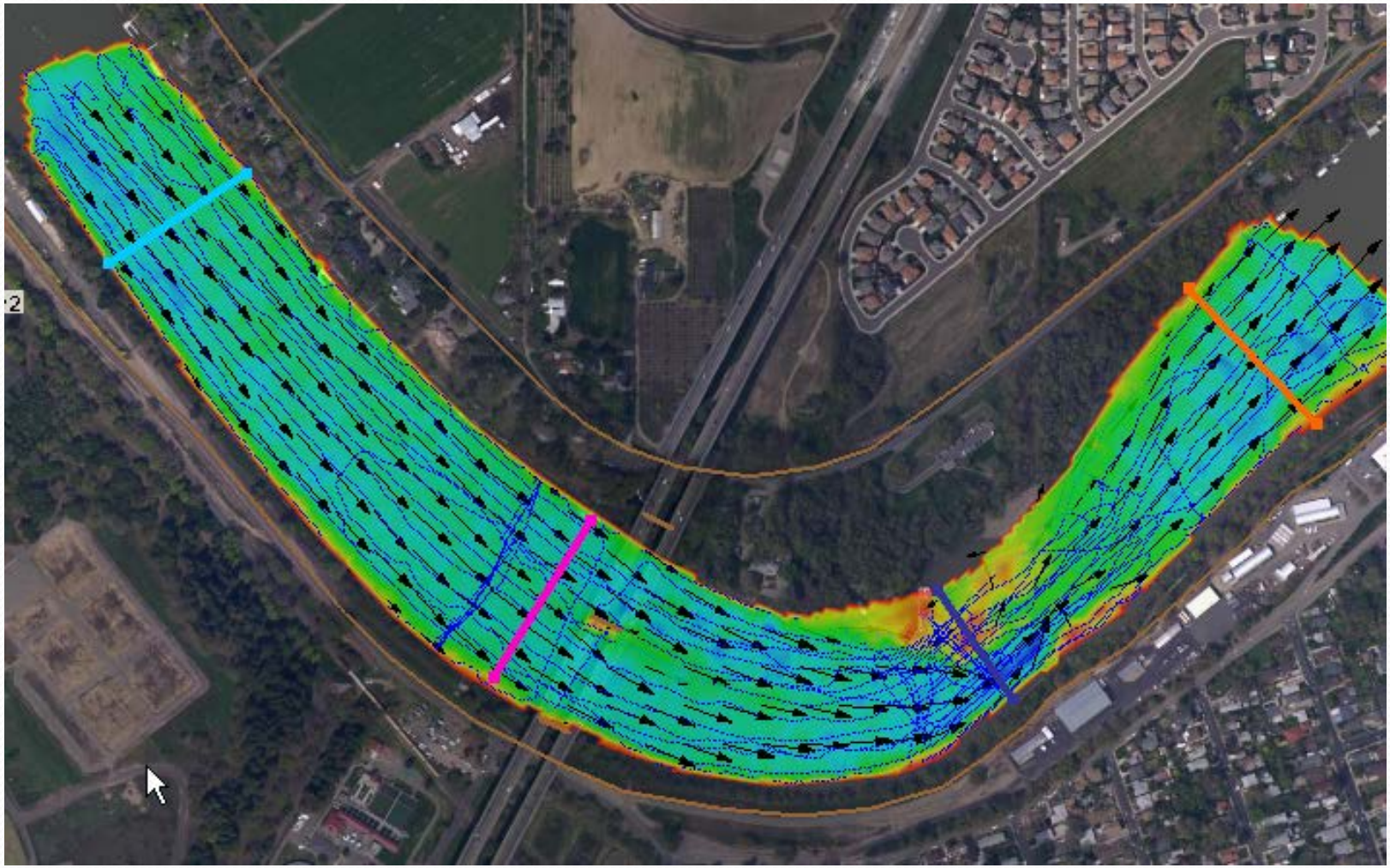


Spatial Averaging of Data

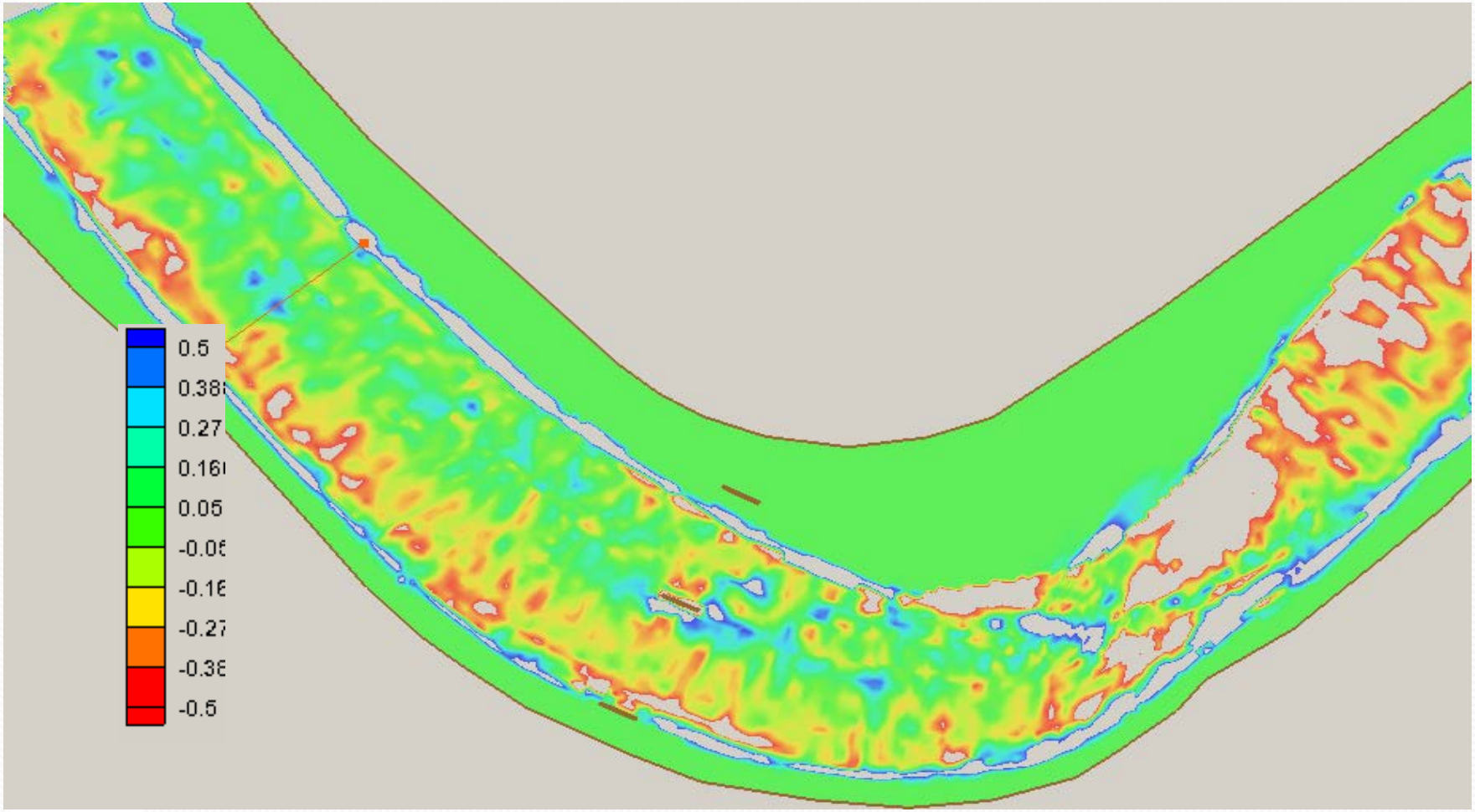


Spatially Averaged ADCP Velocities

(9170 pts)

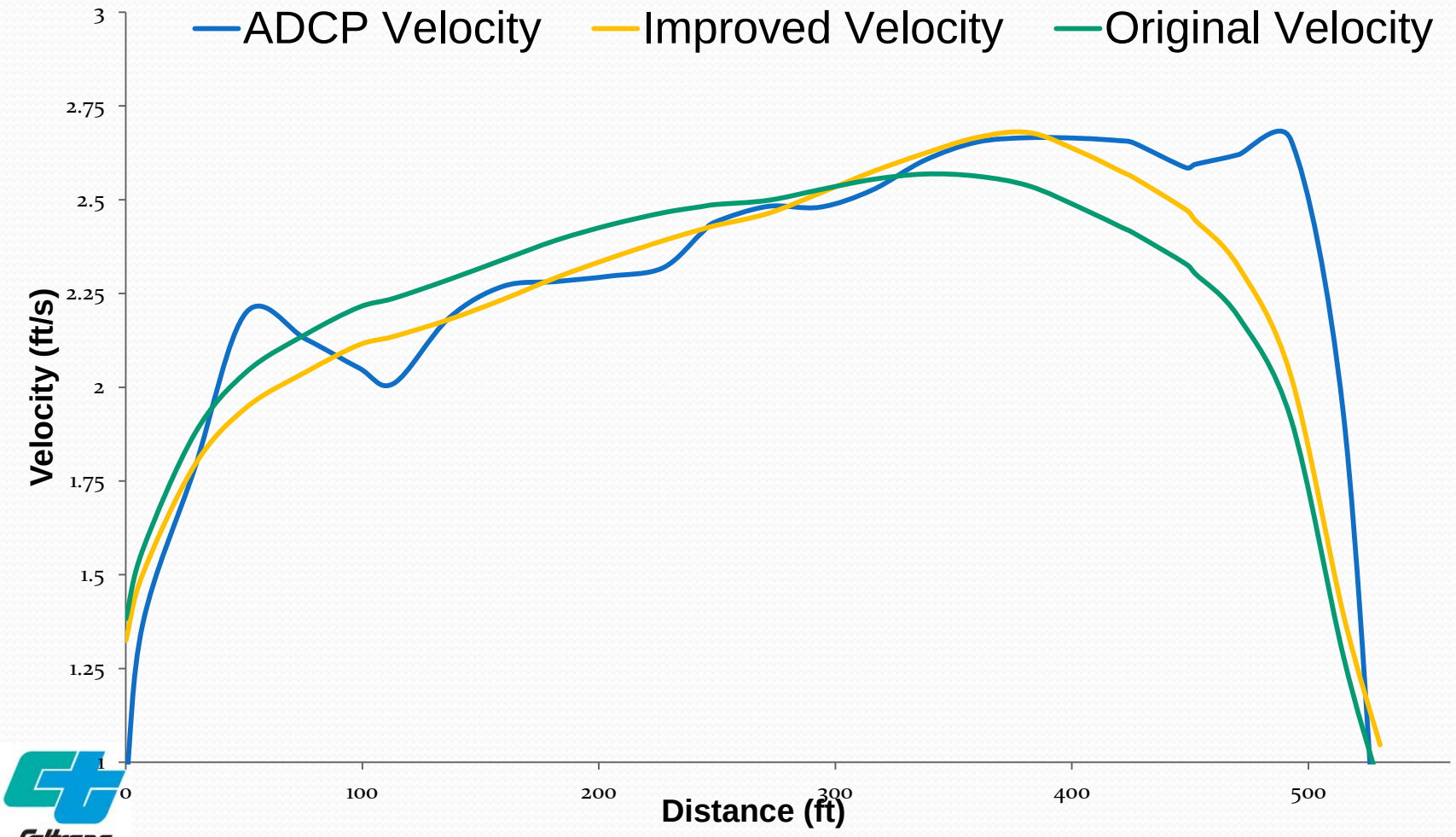


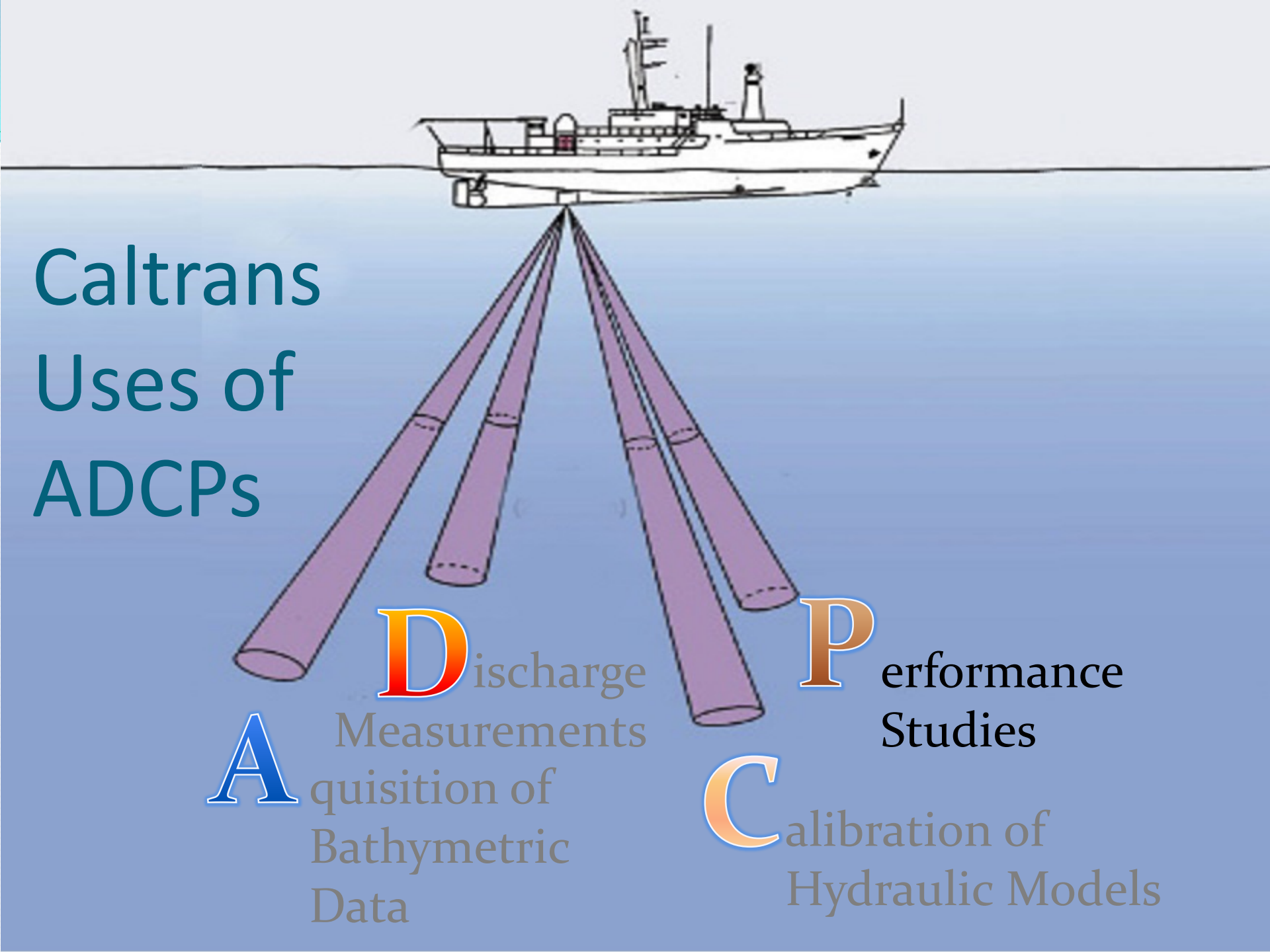
Difference between Measured and Modeled Velocity Magnitude (ft/s)



SMS with Revised Mannings Values

Velocity Comparison after Calibration

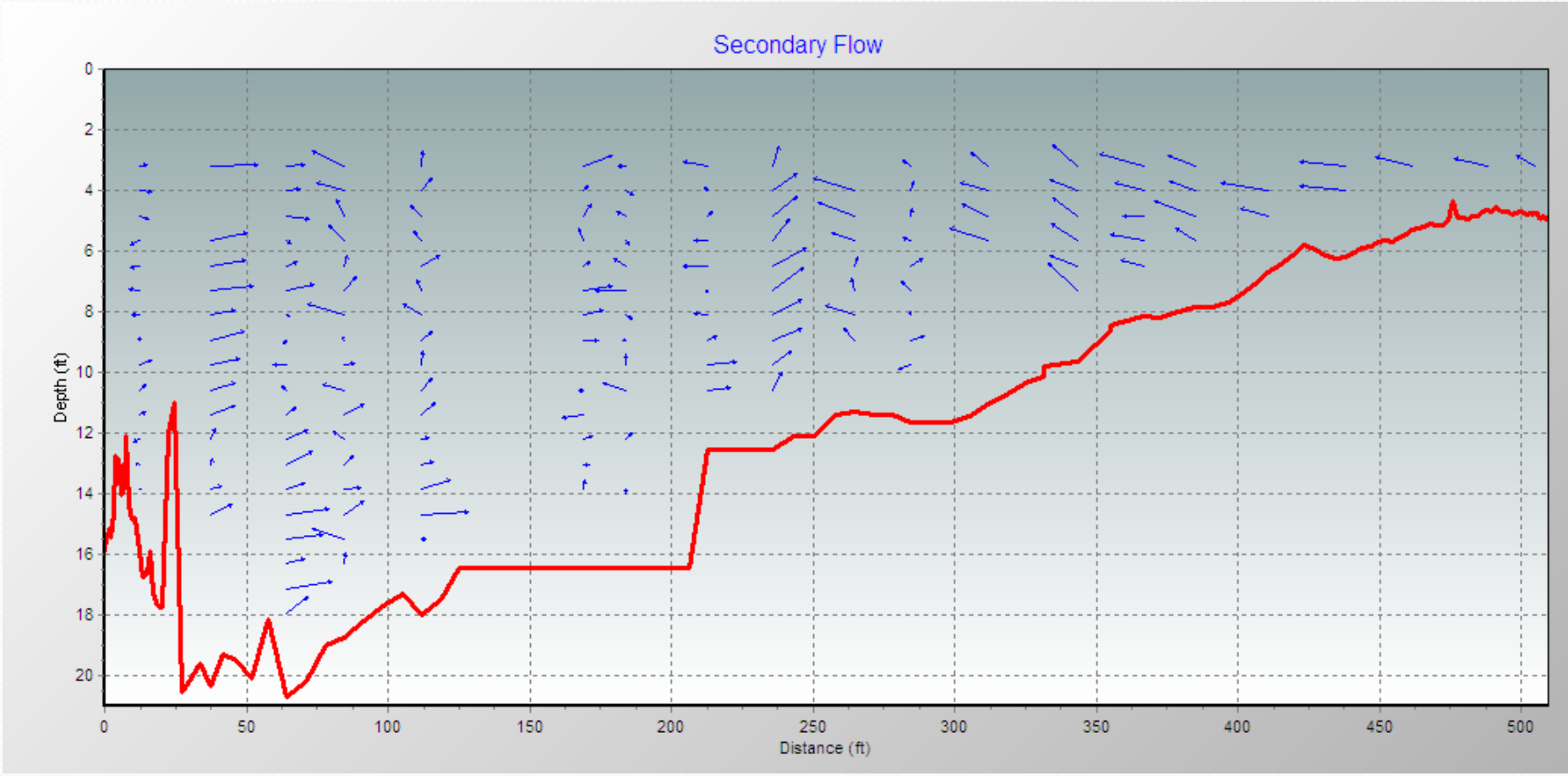



Caltrans Uses of ADCPs
Discharge Measurements
Performance Studies
Acquisition of Bathymetric Data
Calibration of Hydraulic Models

Additional ADCP Post-processing

- ADCPxp - *University of Iowa's IIHR*
  - Transect Analysis
  - Velocity Profile Analysis
  - Turbulence Quantities

Post-processing with ADCPxp Software



Visualization of Secondary Currents

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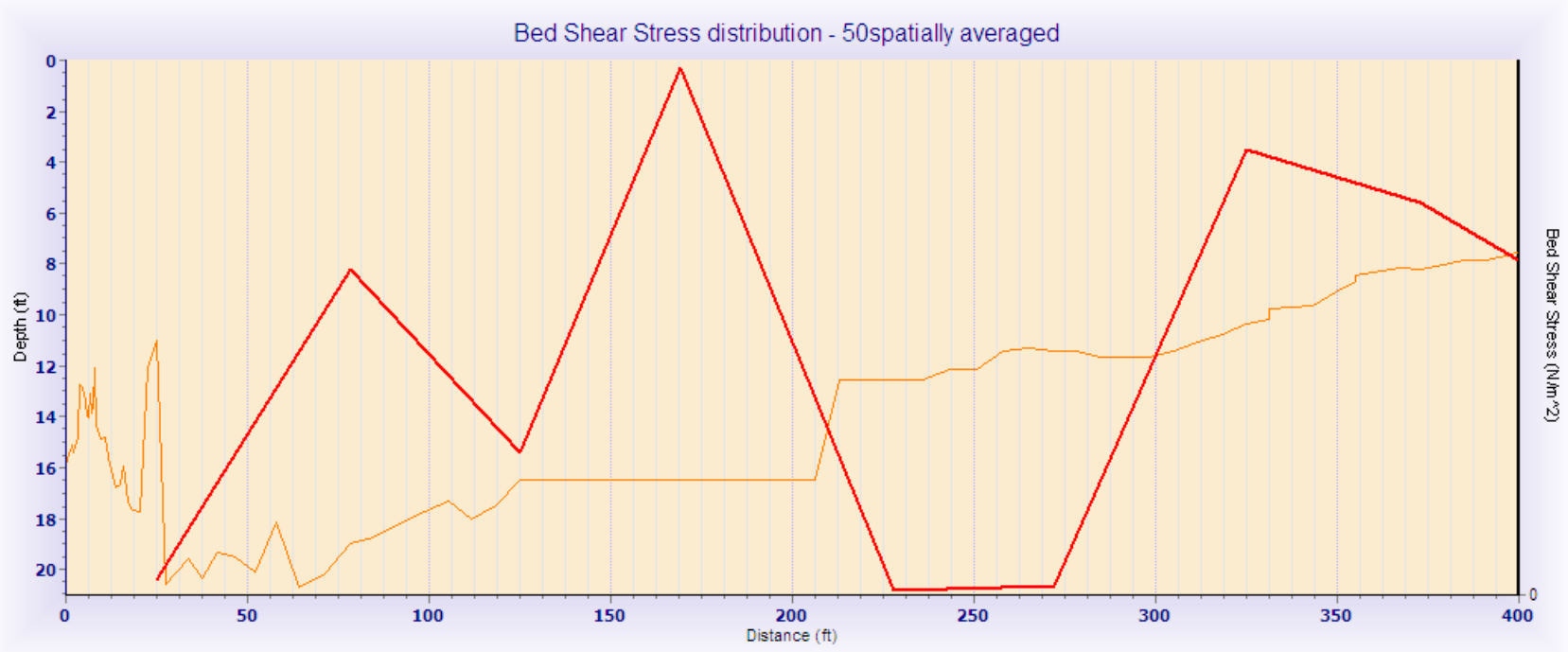
Post-processing with ADCPxp Software



Bed Shear Stress and Shear Velocity Estimates

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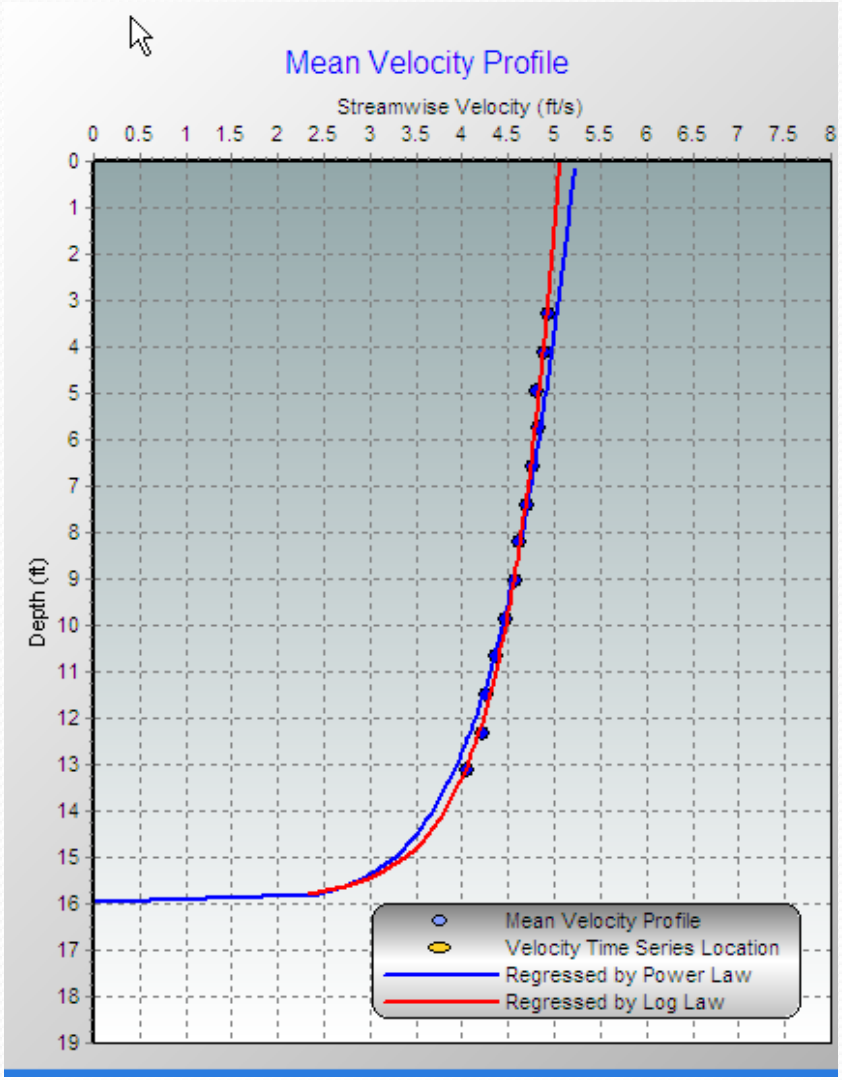
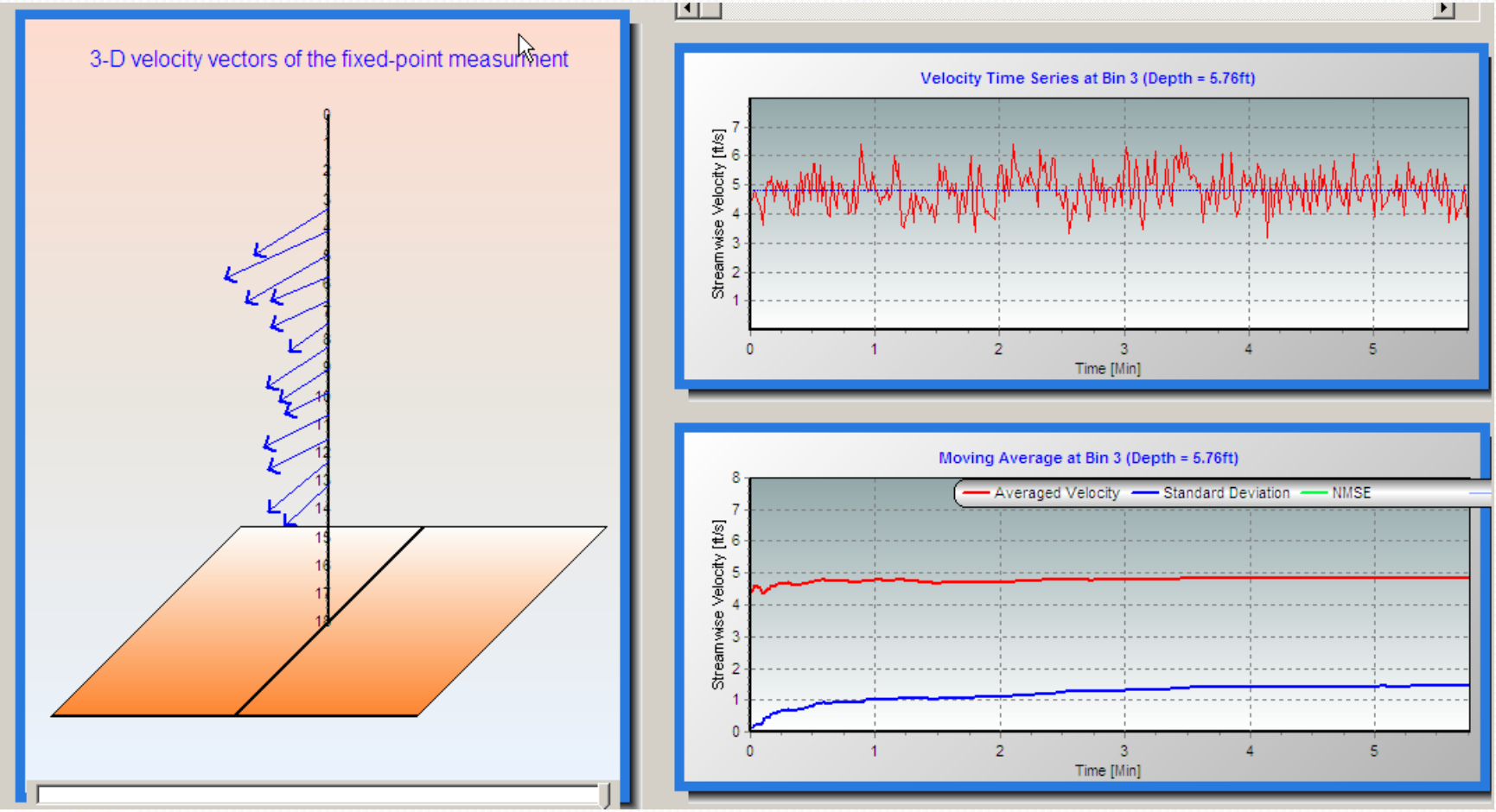
Post-processing with ADCPxp Software



Velocity Profiles

Post-processing with ADCPxp Software



Velocity Fluctuations and Turbulence Quantities

Future Improvements for the Use of the ADCP

- Best Practice for using ADCP Data for estimating roughness for calibrating 2D Models

- Learn how to process and utilize turbulence information in 3-dimensional CFD models

Future Deployment – R/C Boat

- **Smaller**
- **Safer**
- **Quickly Deployable Anywhere**

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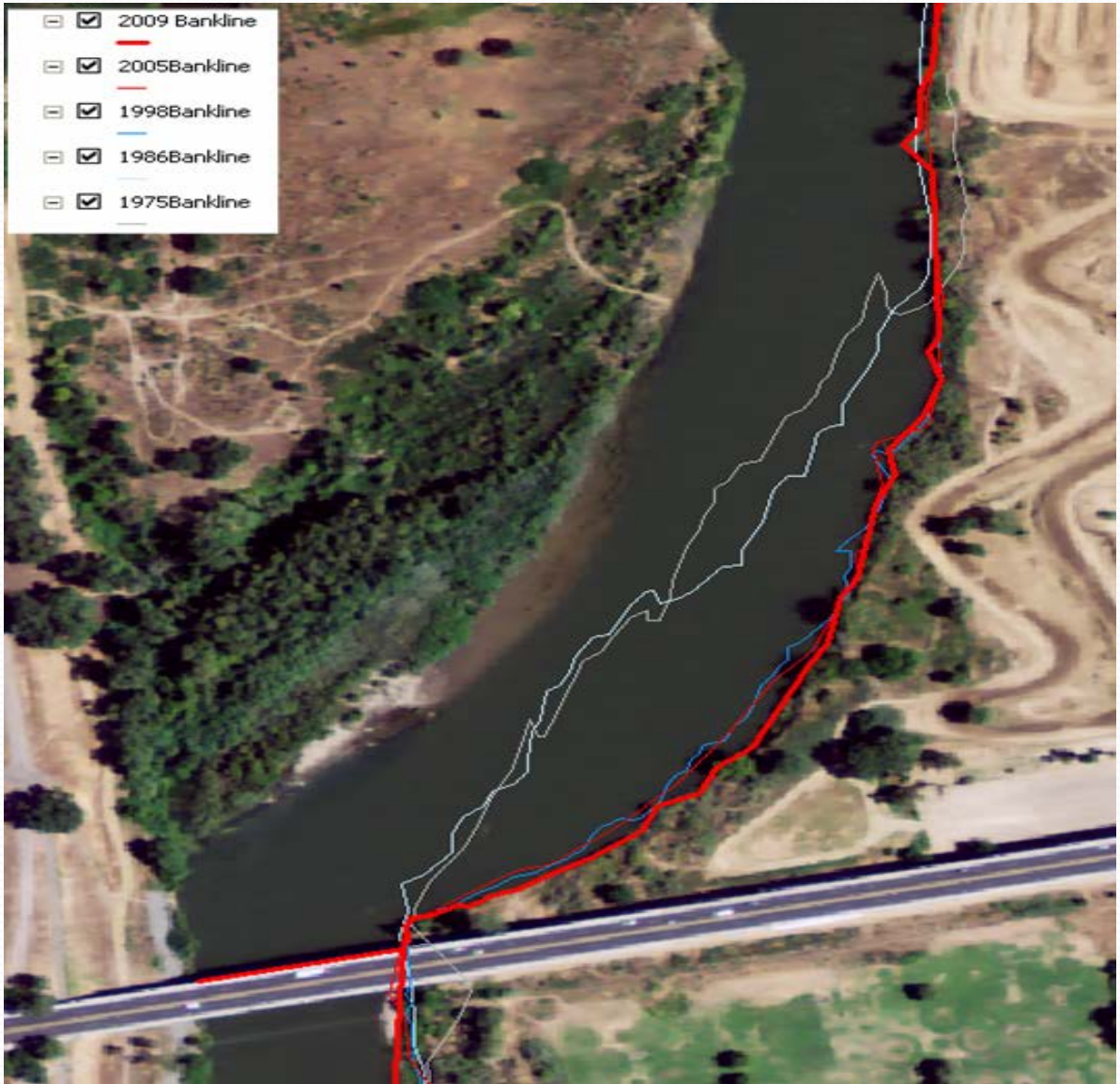
Future Improvements for the Feather River

Feather River - Erosion of the east bank from 1975 to 2009



Feather River - Spur Design Issues

Design Questions

1. How many spurs?
2. How far into the water?
3. Orientation of spurs?
4. Spacing between spurs?

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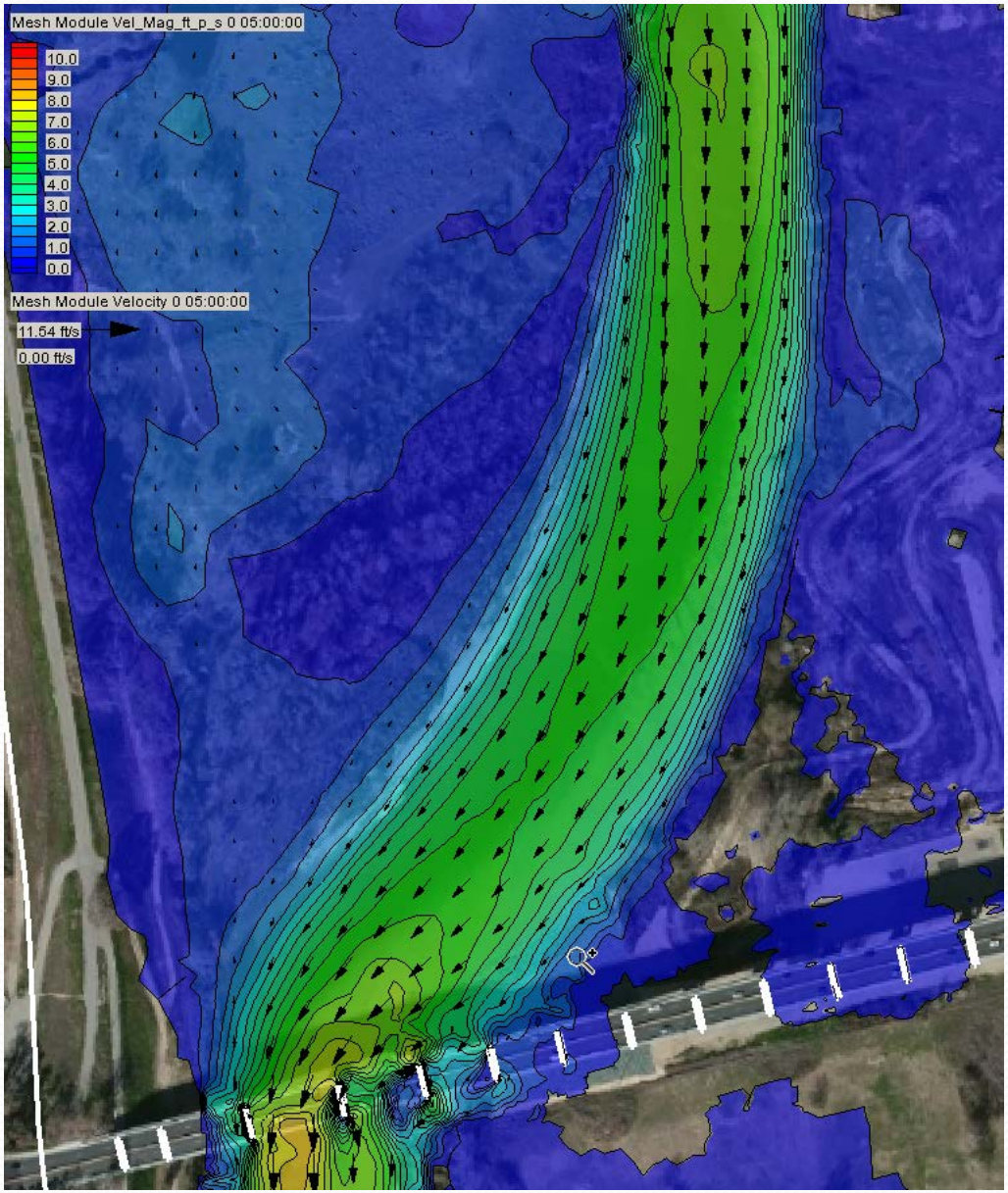
Preliminary 2D Hydraulic Modeling – SRH2D

Existing Condition

Q = 44,500 cfs
(March 2011)



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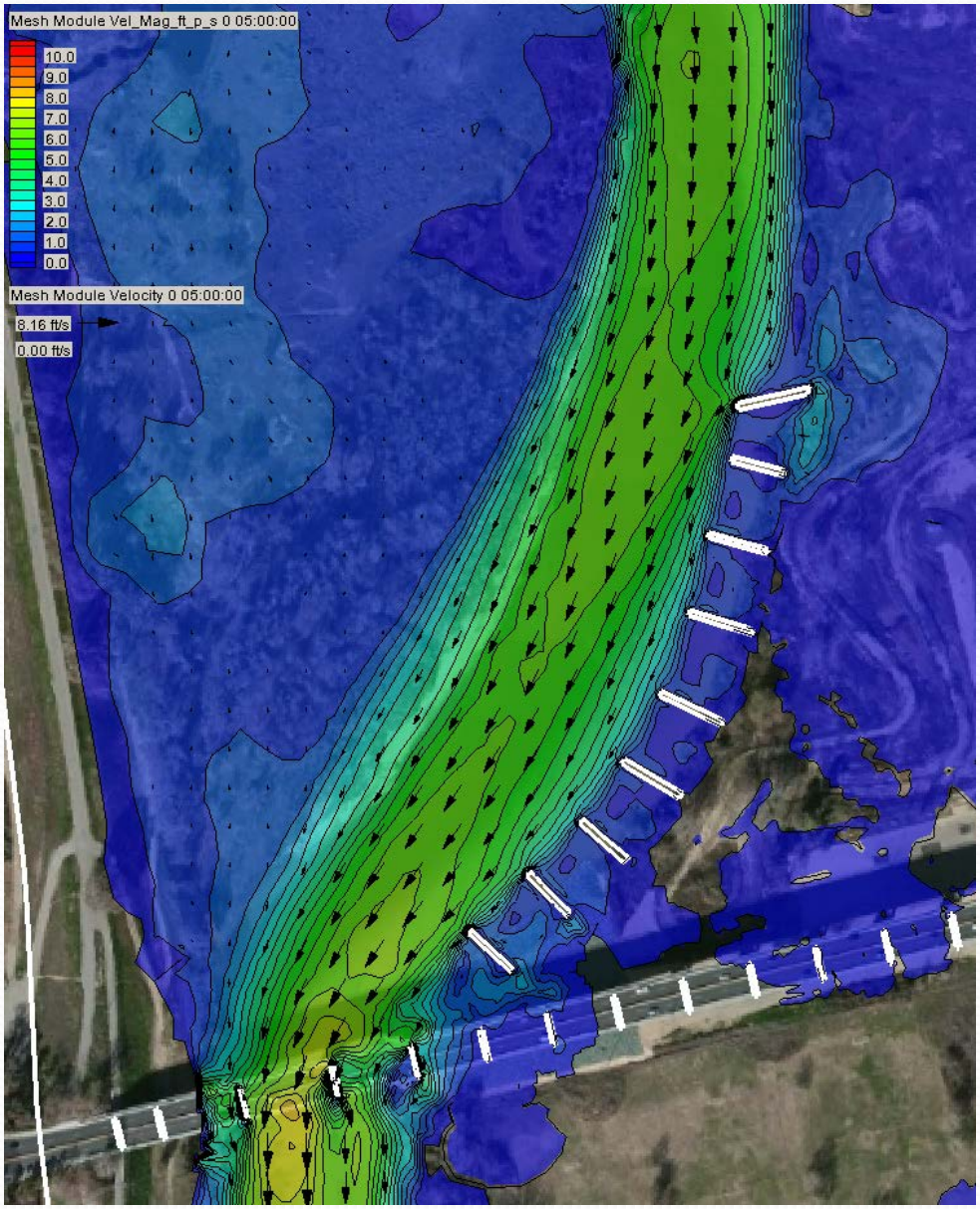
Preliminary 2D Hydraulic Modeling – SRH2D

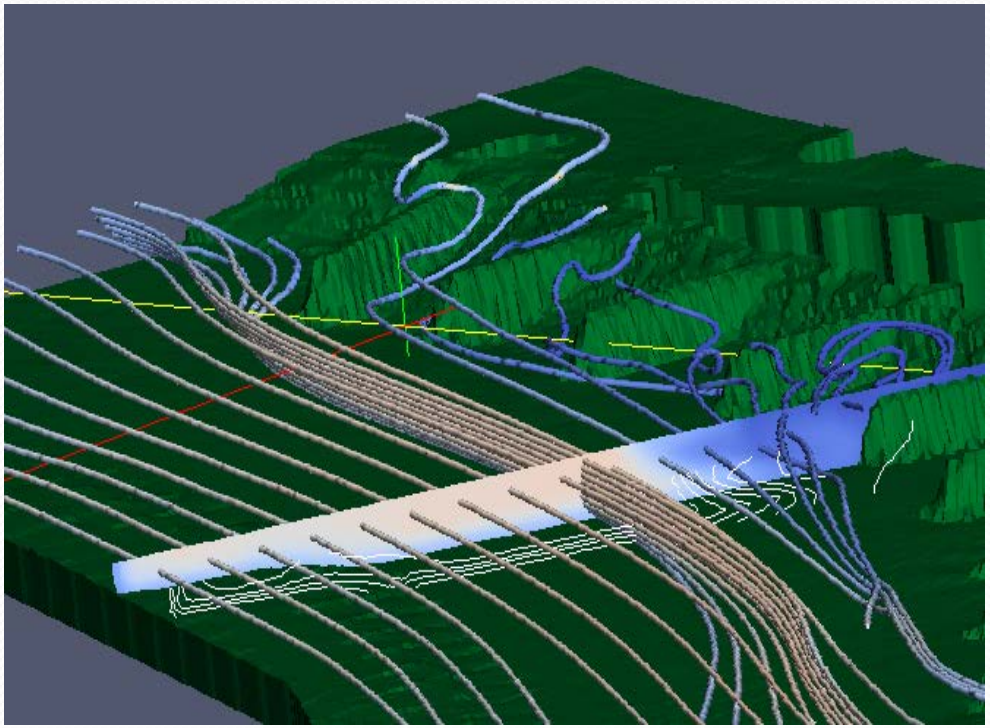
Case with Spurs

Q = 44,500 cfs
(March 2011)



Future Modeling using CFD

- SSIIM – Sediment Simulation In Intakes with Multiblock
- The Norwegian University of Science and Technology, Norway, Trondheim
- Dr. Nils Reidar Olsen



- CFD for Rivers
- Unstructured Mesh
- 1990's GUI

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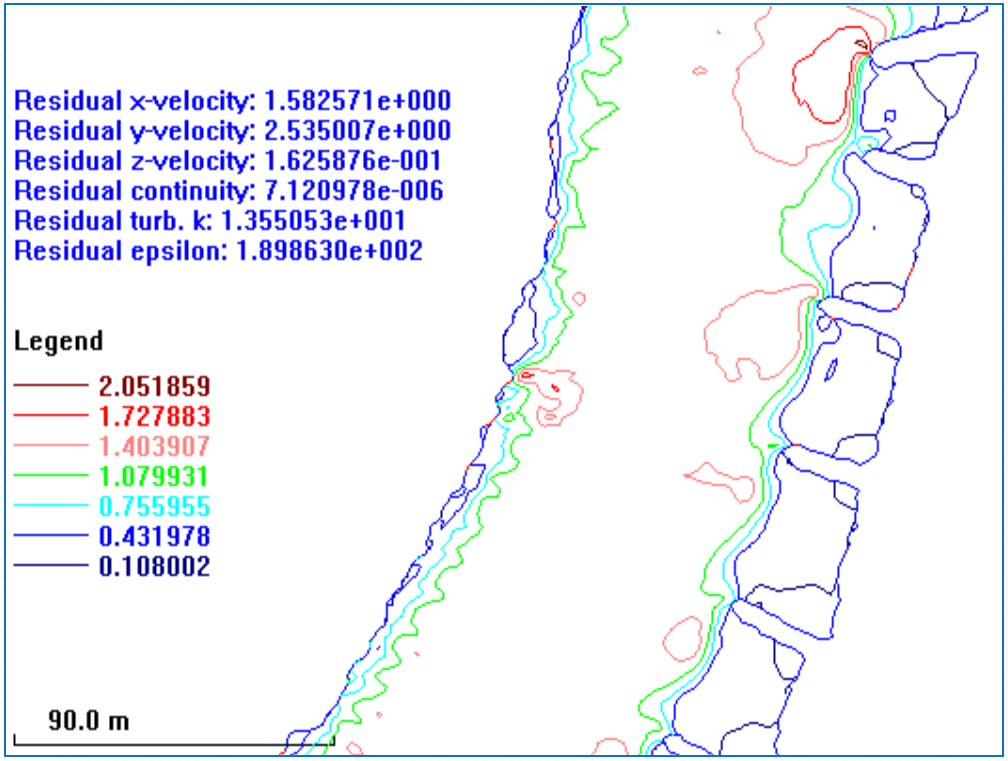
Strengths of SSIIM

- Free
- Documentation
- Efficient Computational Resources
- Real-time Graphical Monitoring



- Exports to ParaView Parallel Visualization Application for Postprocessing
- Designed for Riverine Applications

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Riverine Capabilities of SSIIM

- Wetting and Drying
- Steady and Unsteady Flow
- Sediment Transport
- Vegetation
- Mixed Grain Sizes
- Scour and Deposition

Limitations of SSIIM

- Academic Code
- Free, but not Open Source

- Limited Support / User Community
- Unable to Mesh Complex Geometries (e.g., complex pier shapes)
- User Interface is dependent on ascii text files

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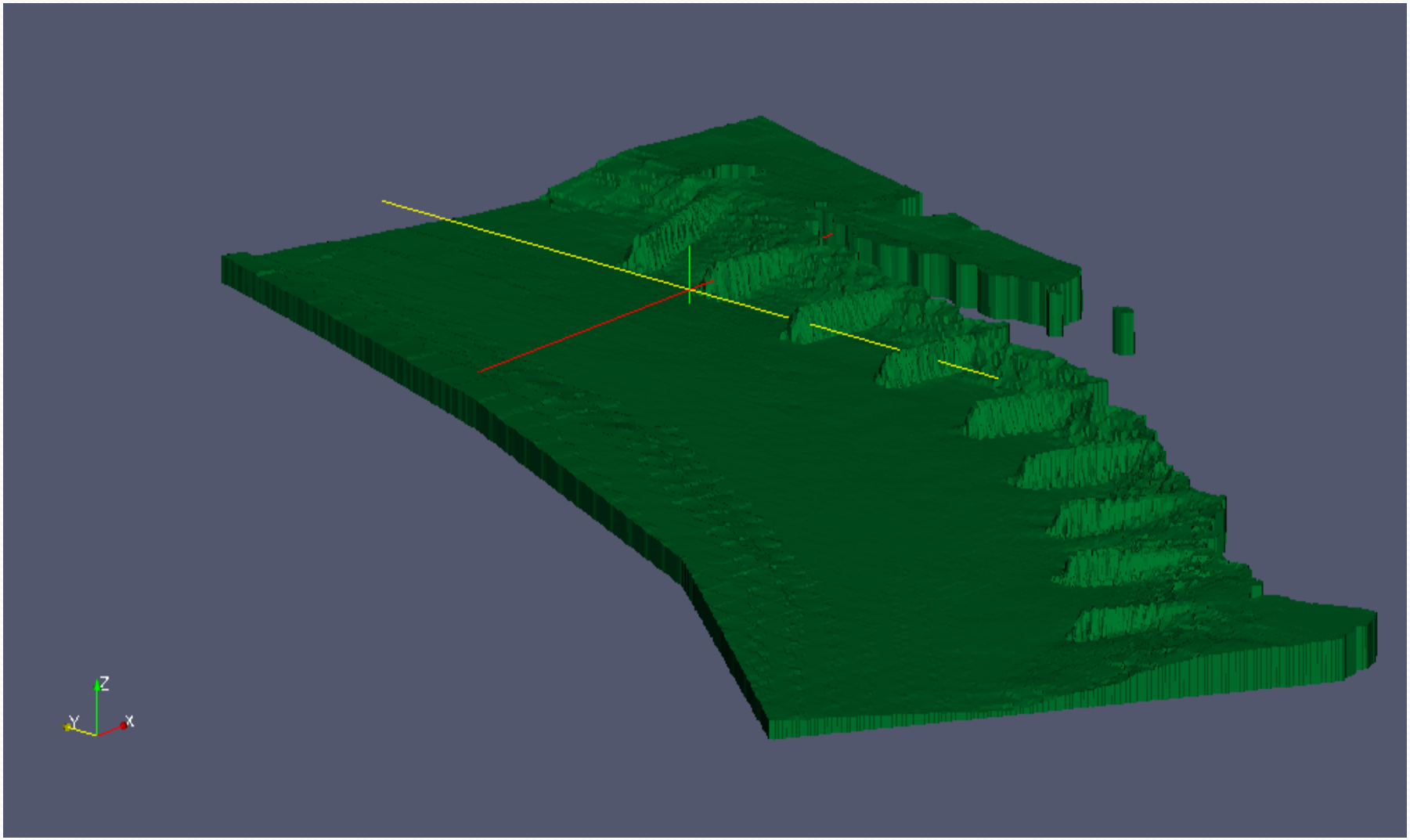
SSIIM Example Results



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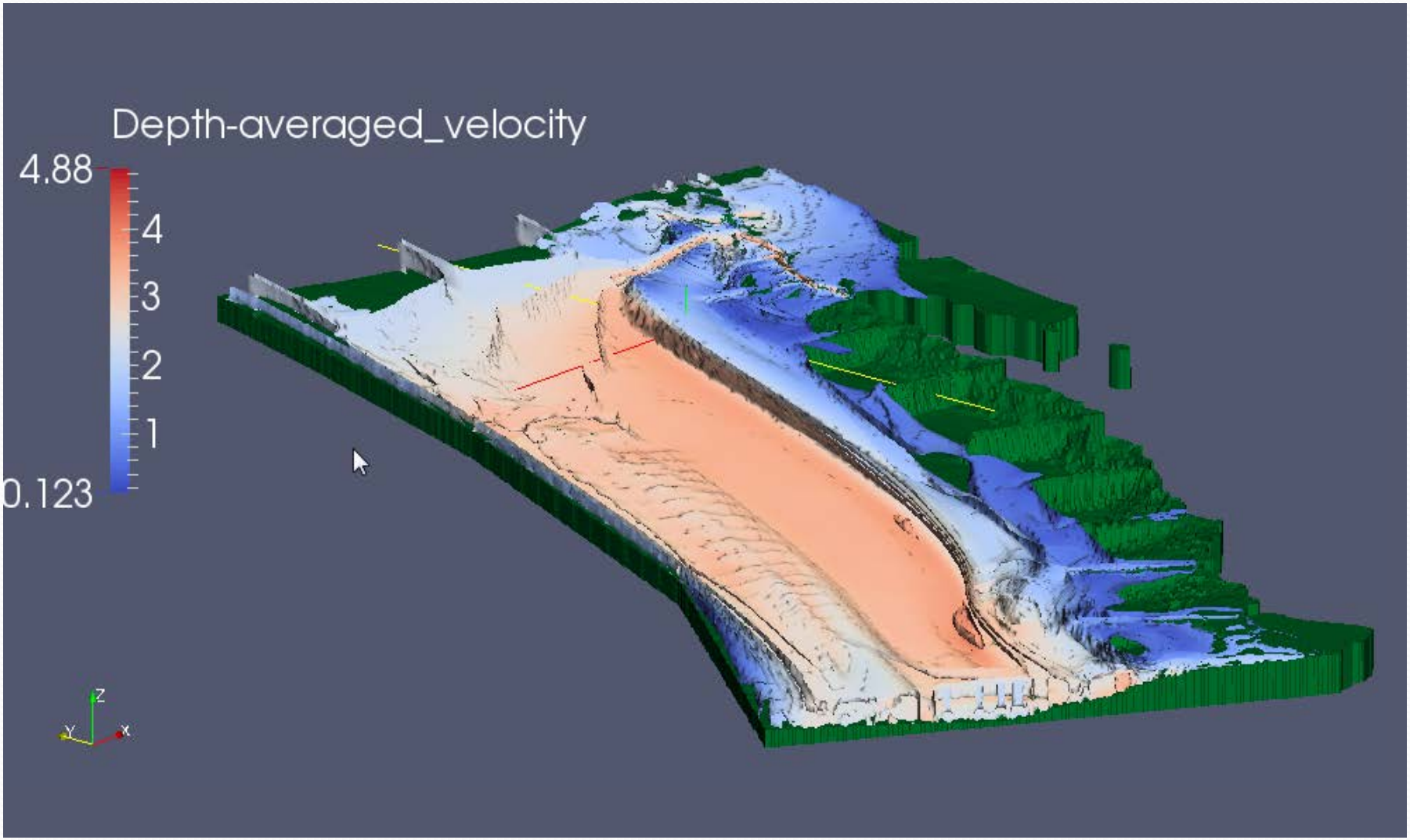
SSIIM Velocity Data



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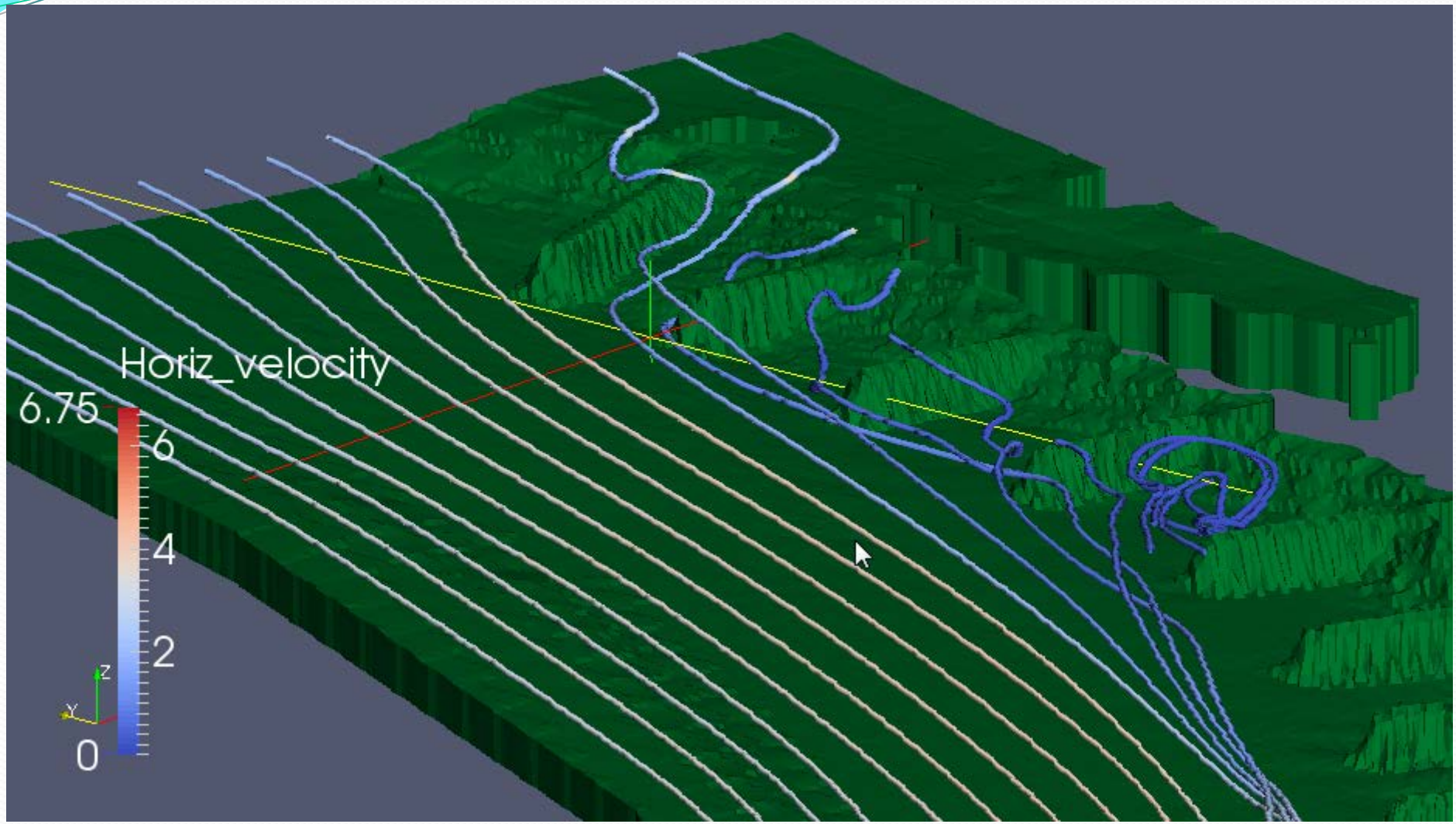
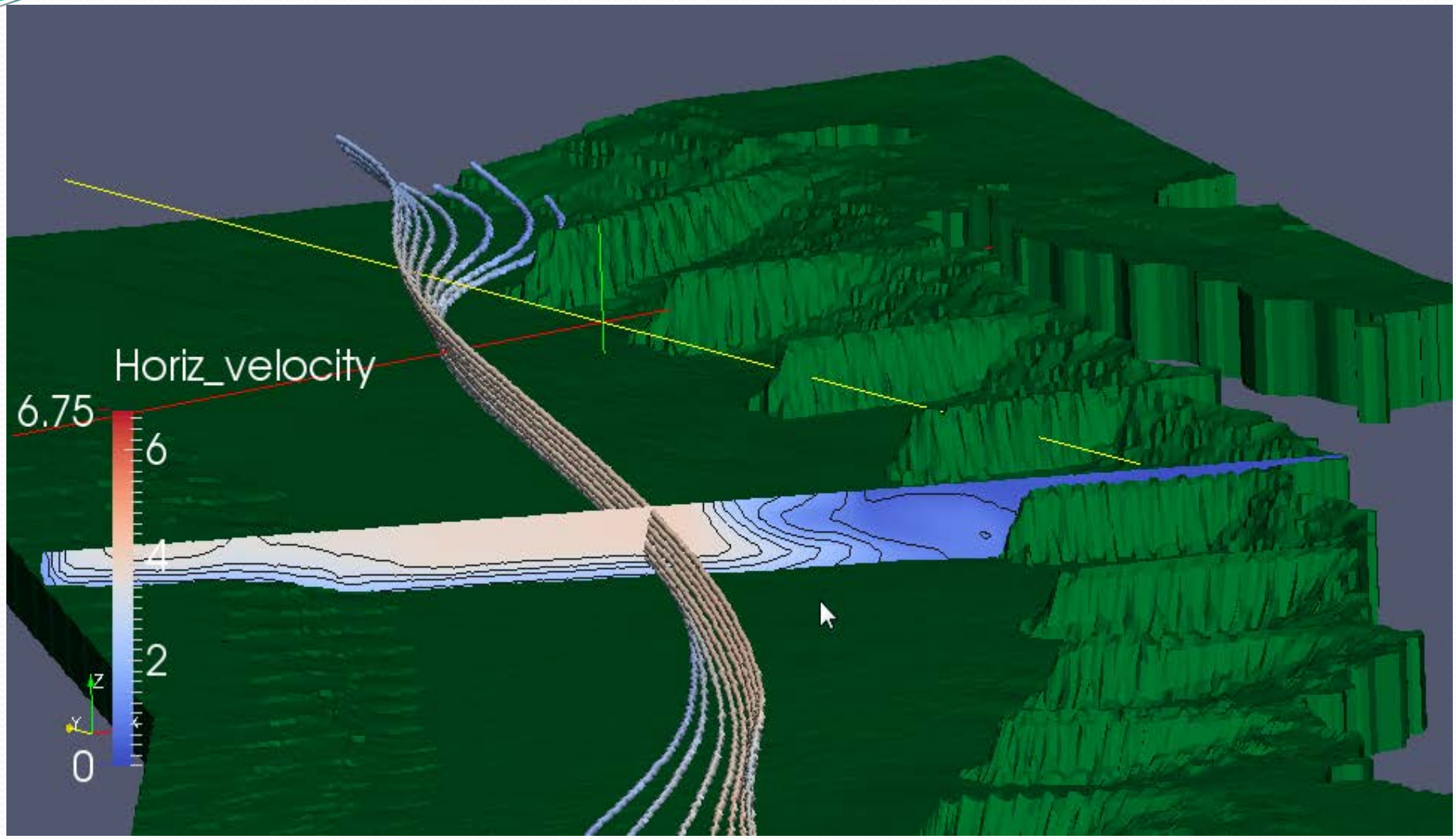
SSIIM 3-Dimensional Flow Paths



Vertical and Transverse Velocities



Key Answers?

- What's up with the Feather River?

  A lot – if your not convinced yet, listen to the next set of presentations!

- What other tools are out there that can help me do my work better?
  - ADCP
    - VMS
    - ADCPxp
  - SSIIM – CFD for Rivers

Your Questions?

Kevin Flora

kevin_flora@dot.ca.gov

916-227-8036