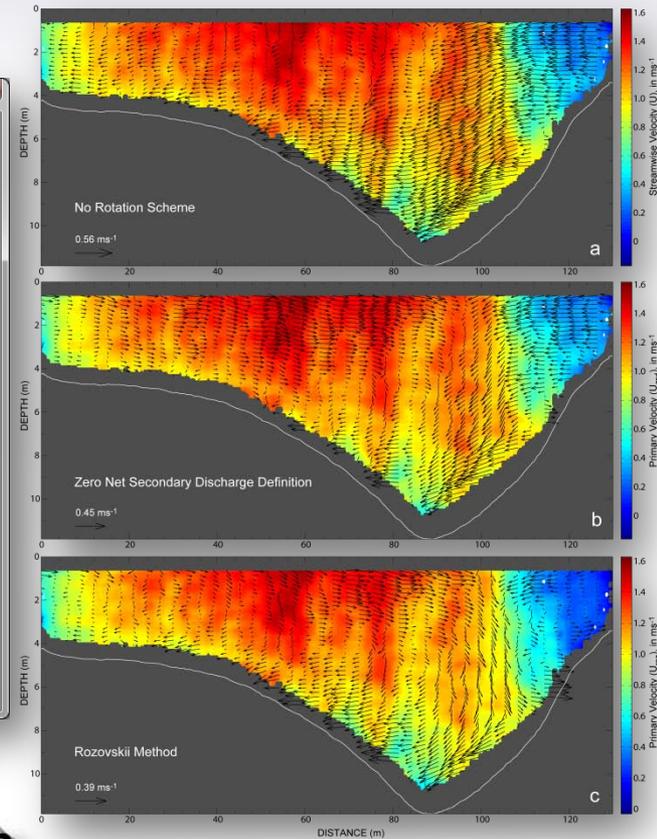
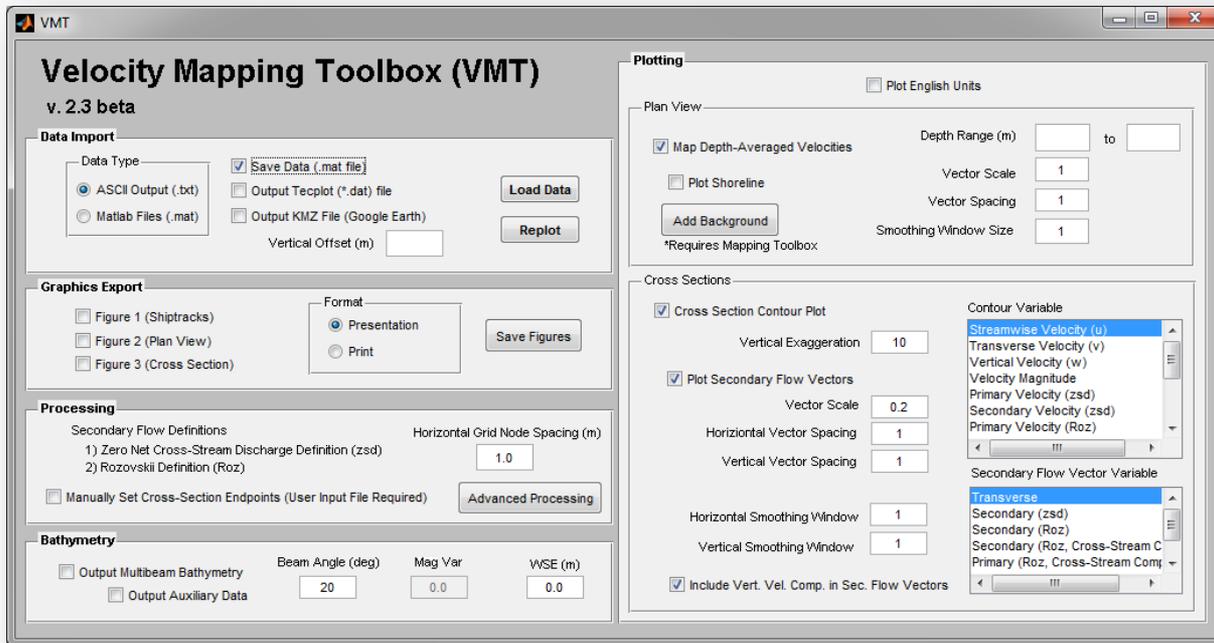


# Velocity Mapping Toolbox (VMT)

## An Overview/Update for the HAWG



# About VMT

## Matlab-based code for post-processing and visualization of ADCP data

- For moving-boat measurements with GPS
- Averages multiple transects at a single cross section to obtain a single representative velocity distribution for the cross section
- Reads TRDI ASCII output files
- Computes Primary and secondary velocity components using a variety of accepted methods
- Visualizes data in cross-sectional views as well as in planform
- Allows depth and layer-averaging over user-specified intervals
- Allows reachwise visualization of velocity data in planform
- Includes utilities for bathymetry export and data export to Google Earth, Tecplot, GIS, and iRIC.

# Graphical User Interface (GUI)

**Velocity Mapping Toolbox (VMT)**  
v. 2.3 beta

**Data Import**

Data Type:  ASCII Output (.txt)  Matlab Files (.mat)

Save Data (.mat file)  Output Tecplot (\*.dat) file  Output KMZ File (Google Earth)

Vertical Offset (m)

**Load Data** **Replot**

**Graphics Export**

Figure 1 (Shiptracks)  Figure 2 (Plan View)  Figure 3 (Cross Section)

Format:  Presentation  Print

**Save Figures**

**Processing**

Secondary Flow Definitions: 1) Zero Net Cross-Stream Discharge Definition (zsd) 2) Rozovskii Definition (Roz)

Horizontal Grid Node Spacing (m)

Manually Set Cross-Section Endpoints (User Input File Required) **Advanced Processing**

**Bathymetry**

Output Multibeam Bathymetry  Output Auxiliary Data

Beam Angle (deg)  Mag Var  WSE (m)

**Plotting**

Plot English Units

**Plan View**

Map Depth-Averaged Velocities Depth Range (m)  to

Plot Shoreline Vector Scale  Vector Spacing  Smoothing Window Size

**Add Background** \*Requires Mapping Toolbox

**Cross Sections**

Cross Section Contour Plot Vertical Exaggeration

Plot Secondary Flow Vectors Vector Scale  Horizontal Vector Spacing  Vertical Vector Spacing

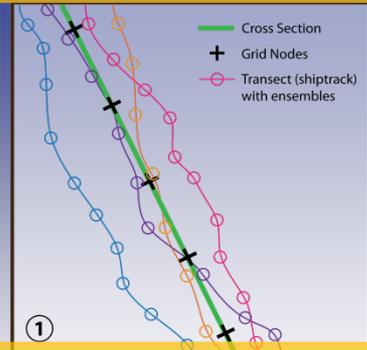
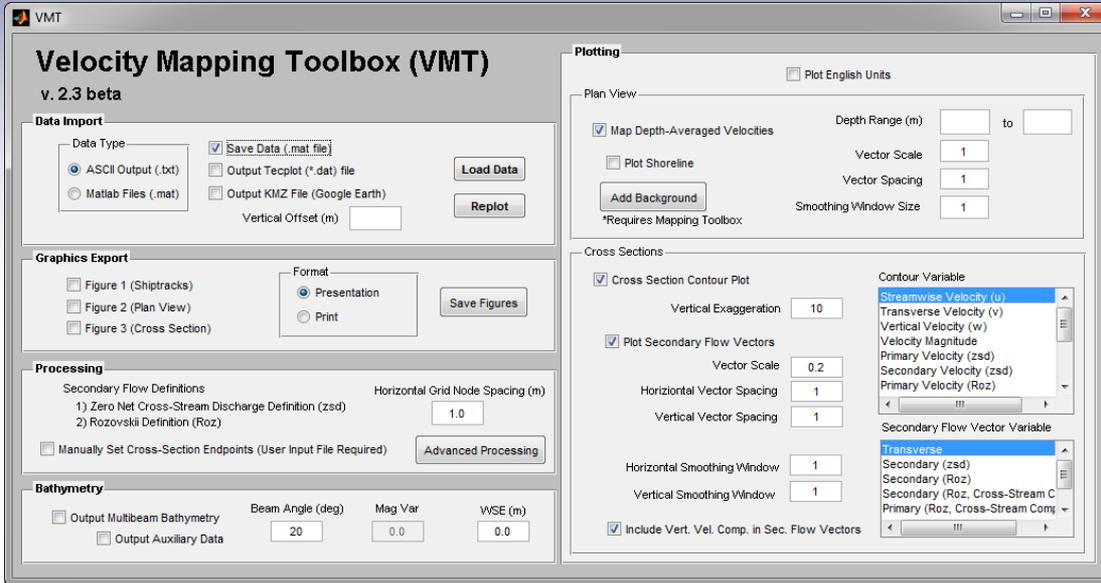
Horizontal Smoothing Window  Vertical Smoothing Window

Include Vert. Vel. Comp. in Sec. Flow Vectors

Contour Variable: Streamwise Velocity (u), Transverse Velocity (v), Vertical Velocity (w), Velocity Magnitude, Primary Velocity (zsd), Secondary Velocity (zsd), Primary Velocity (Roz)

Secondary Flow Vector Variable: Transverse, Secondary (zsd), Secondary (Roz), Secondary (Roz, Cross-Stream C), Primary (Roz, Cross-Stream Com)

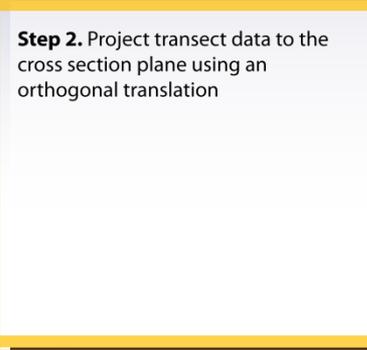
# Basic Data Processing



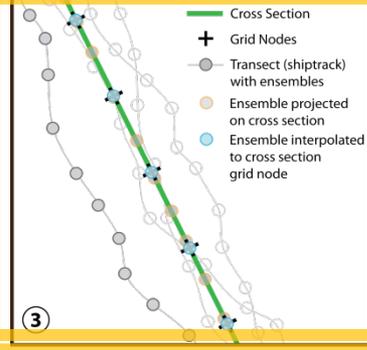
**Step 1.** Define the average cross section orientation and grid

Options:

1. Least-squares fit of data cloud
2. User-defined end points

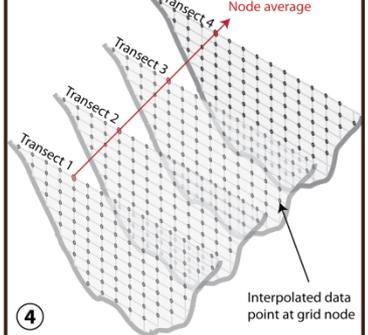


**Step 2.** Project transect data to the cross section plane using an orthogonal translation



**Step 3.** Interpolate projected data to the cross section grid for each transect (no interpolation in vertical is required when using a vertical grid defined by the bin size)

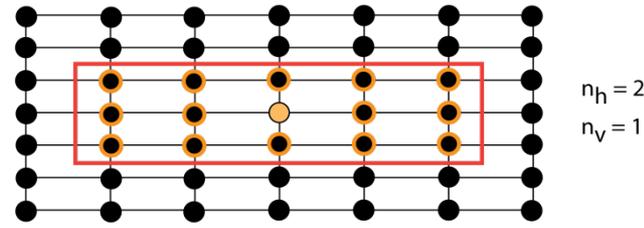
**Step 4.** Compute arithmetic average of all transects at each grid node for basic variables (e.g. velocity components)



One-Dimensional Moving Average (planform)



Two-Dimensional Moving Average (cross section)

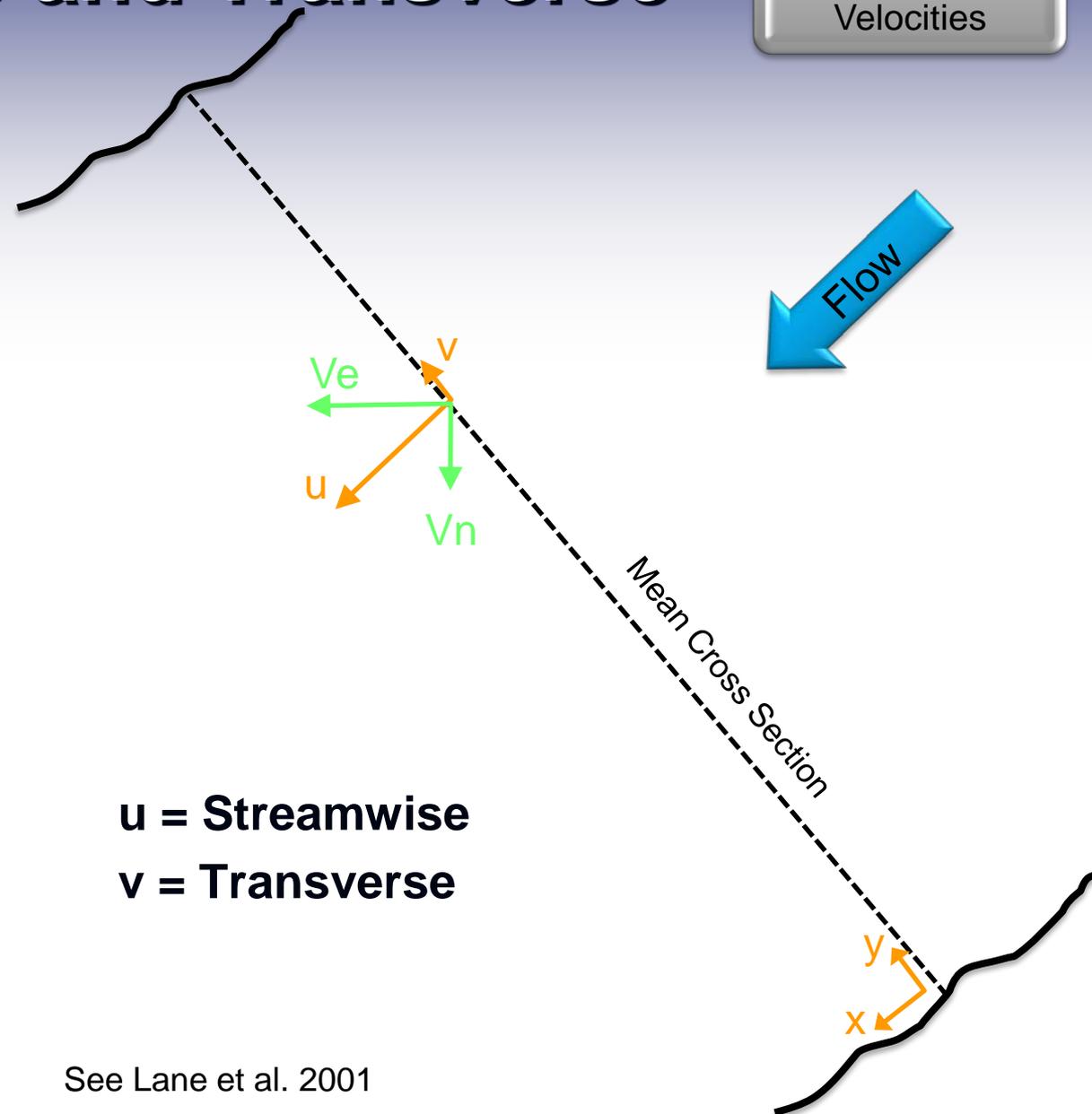


- Grid Node
- Grid node used in average
- Grid node replaced by average

Compute Streamwise and Transverse Velocities

# Streamwise and Transverse

- Streamwise defined perpendicular to mean cross section
- Transverse is parallel to mean cross section

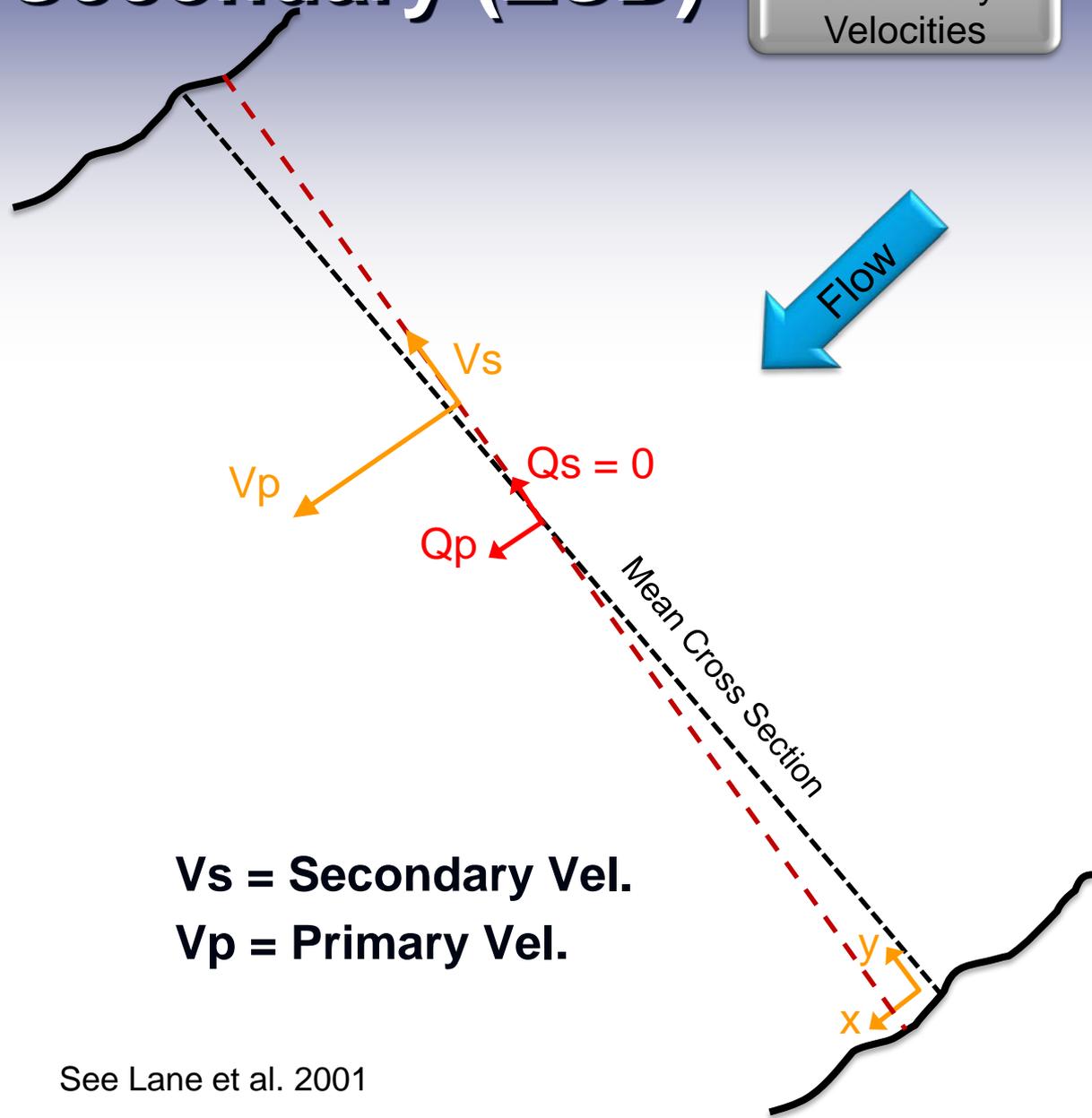


$u$  = Streamwise  
 $v$  = Transverse

# Primary and Secondary (ZSD)

Compute  
Primary and  
Secondary  
Velocities

- Zero Net Cross Stream Discharge Definition (ZSD)
- No net secondary discharge for entire cross section
- Finds components of velocity perpendicular ( $V_p$ ) and parallel ( $V_s$ ) to rotated cross section
- Better for bends (in general)

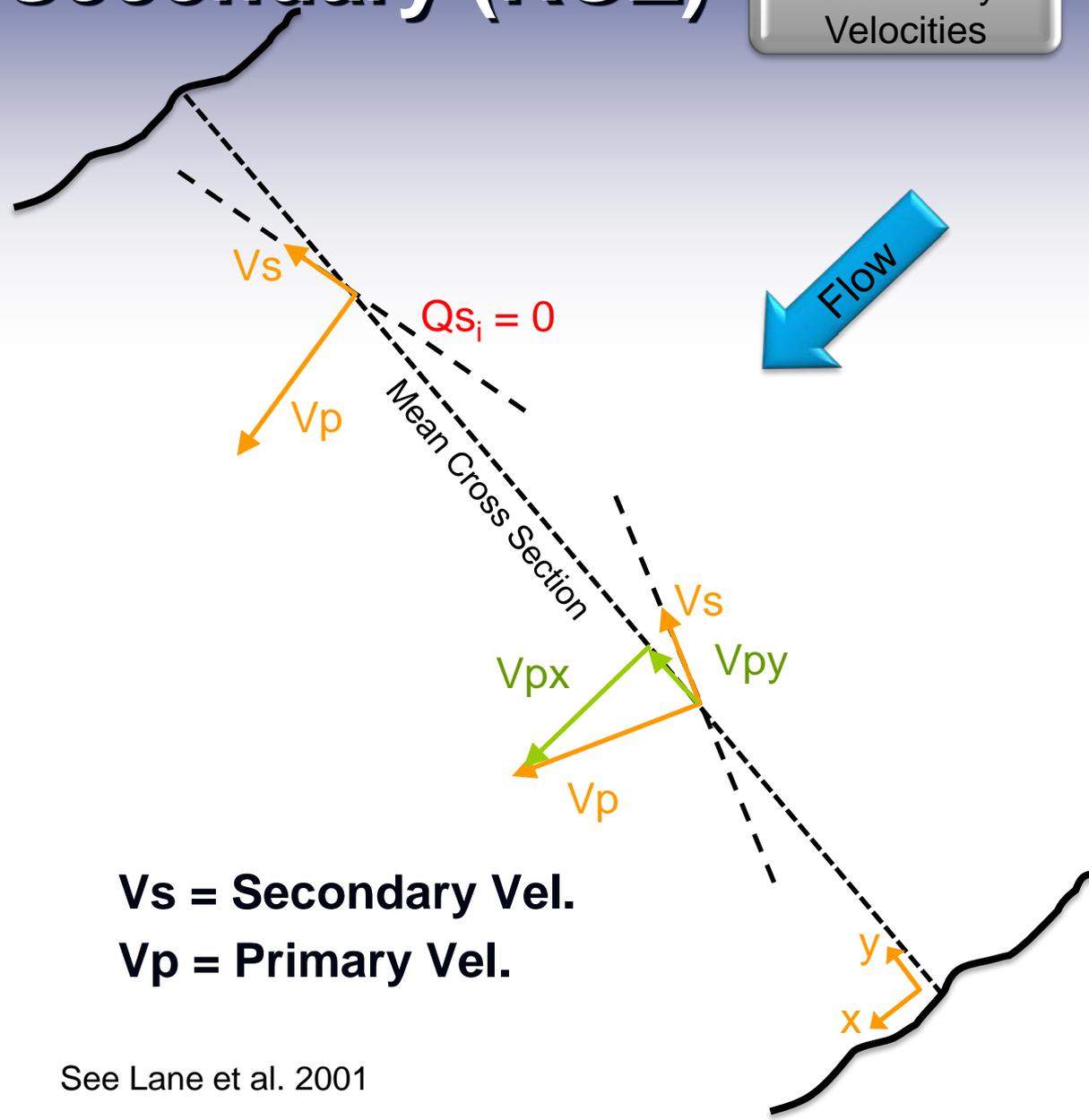


$V_s$  = Secondary Vel.  
 $V_p$  = Primary Vel.

# Primary and Secondary (ROZ)

Compute  
Primary and  
Secondary  
Velocities

- Rozovskii Definition (ROZ)
- No net secondary discharge for each profile (ensemble)
- $V_s$  and  $V_p$  differ for each ensemble
- Recompute X and Y components of  $V_p$  and  $V_s$
- Better for confluences and bifurcations

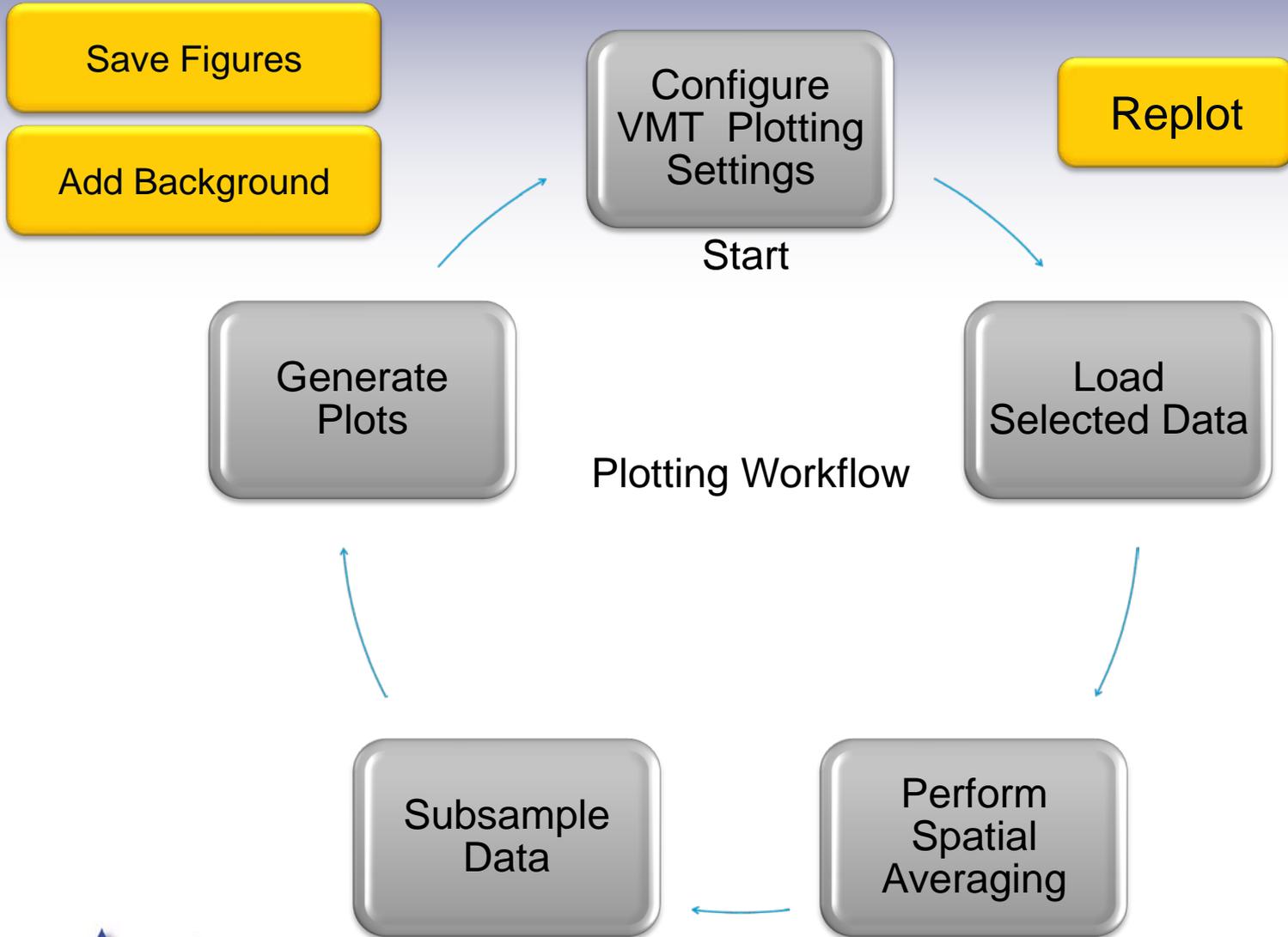


$V_s$  = Secondary Vel.  
 $V_p$  = Primary Vel.

See Lane et al. 2001

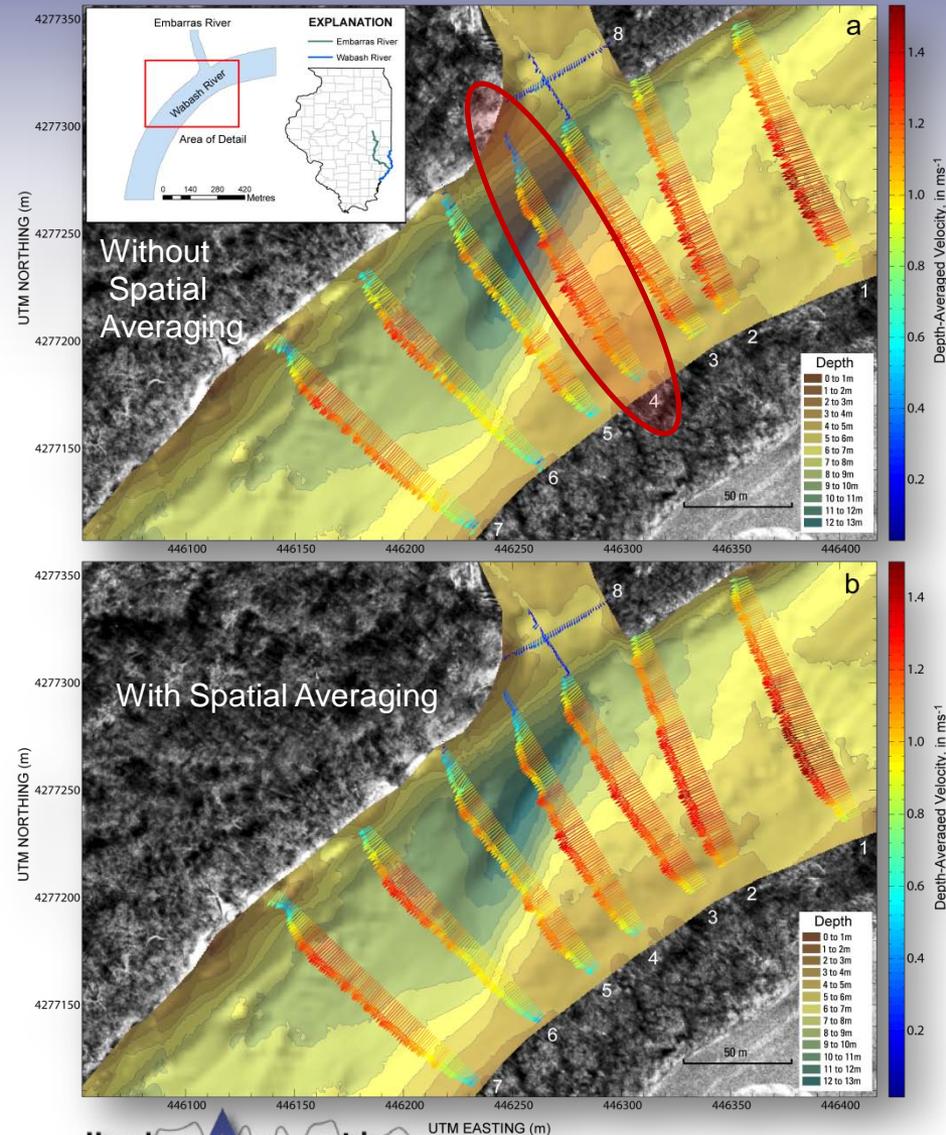
# Data Visualization

Visualize Data

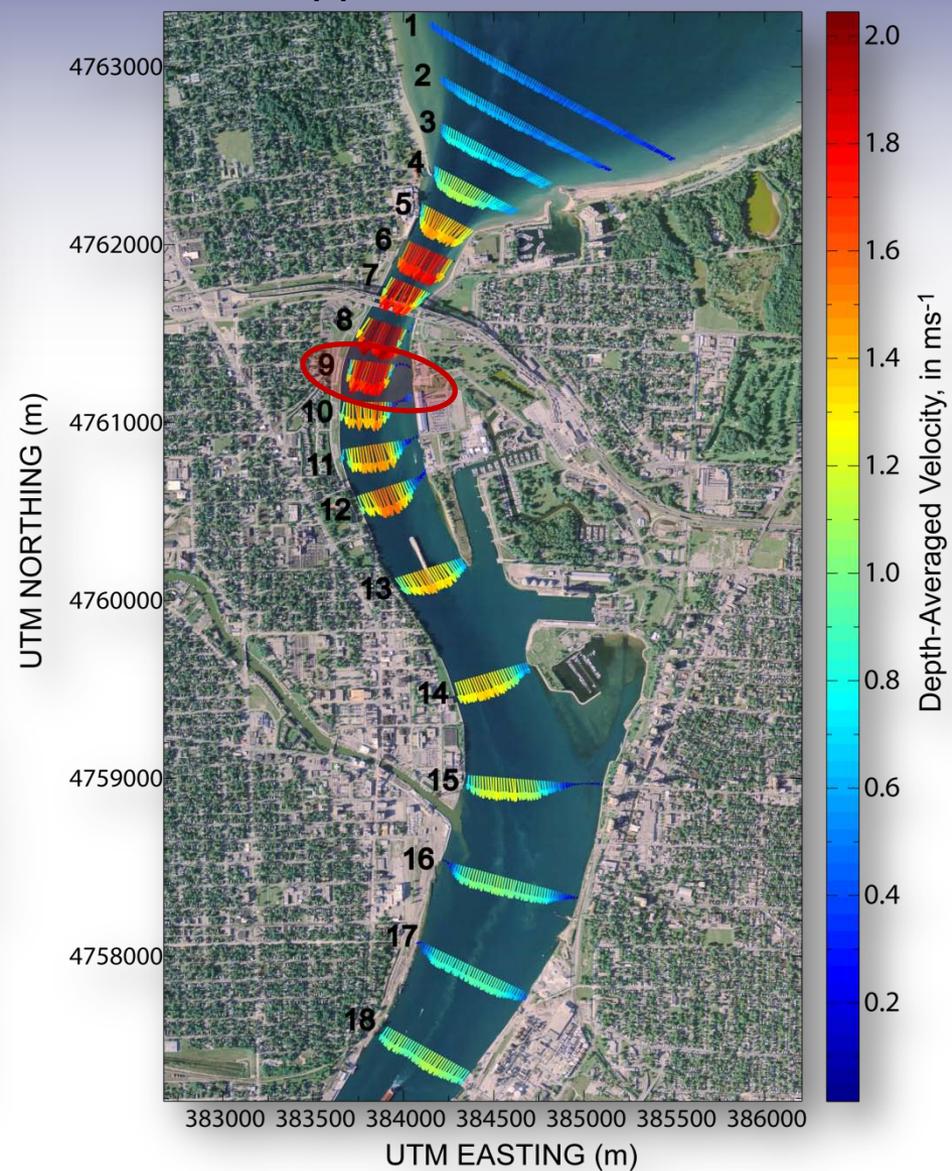


# Example Output – Planform

## Wabash-Embarras Confluence



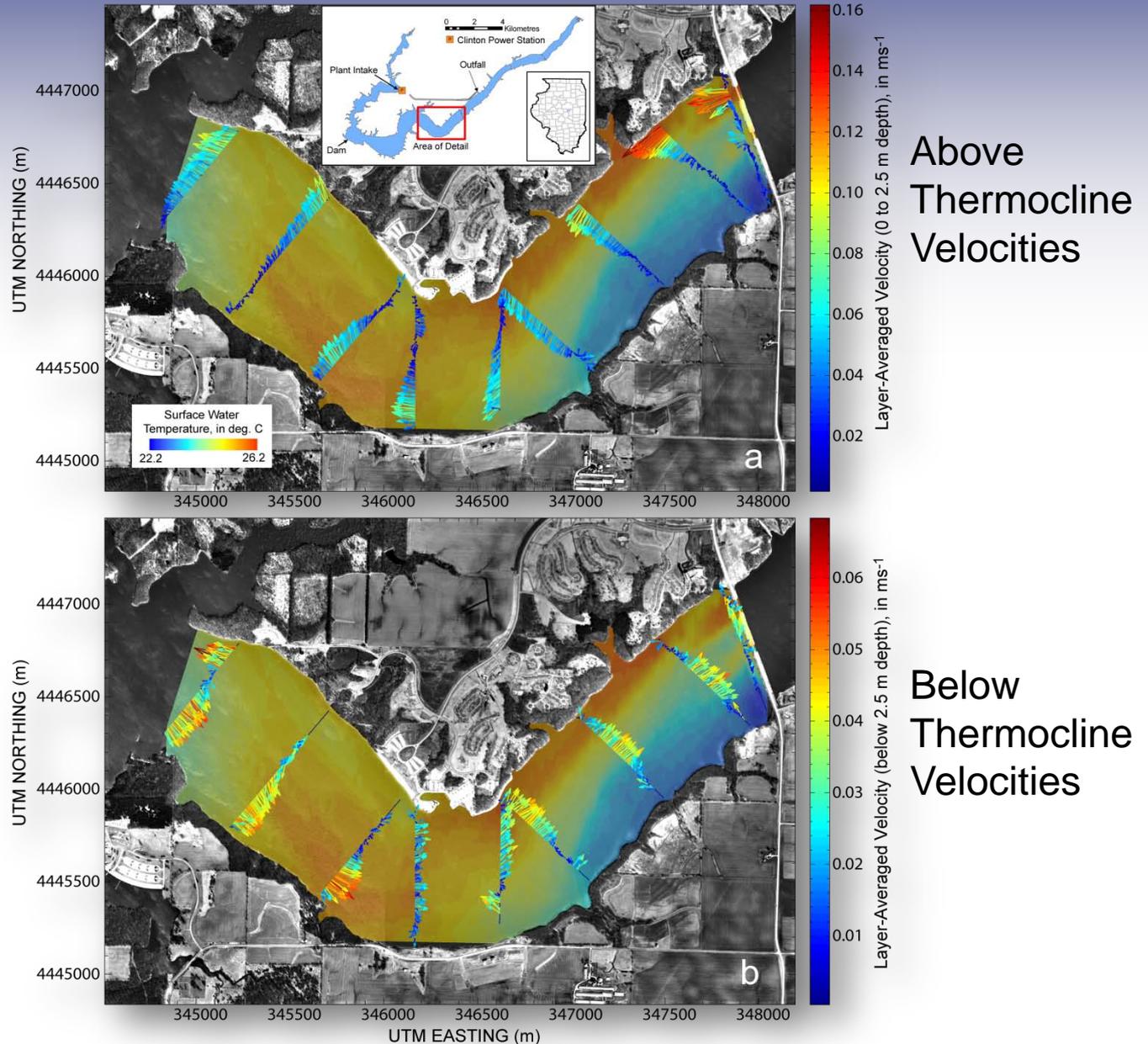
## Upper St. Clair River



# Example Output – Planform

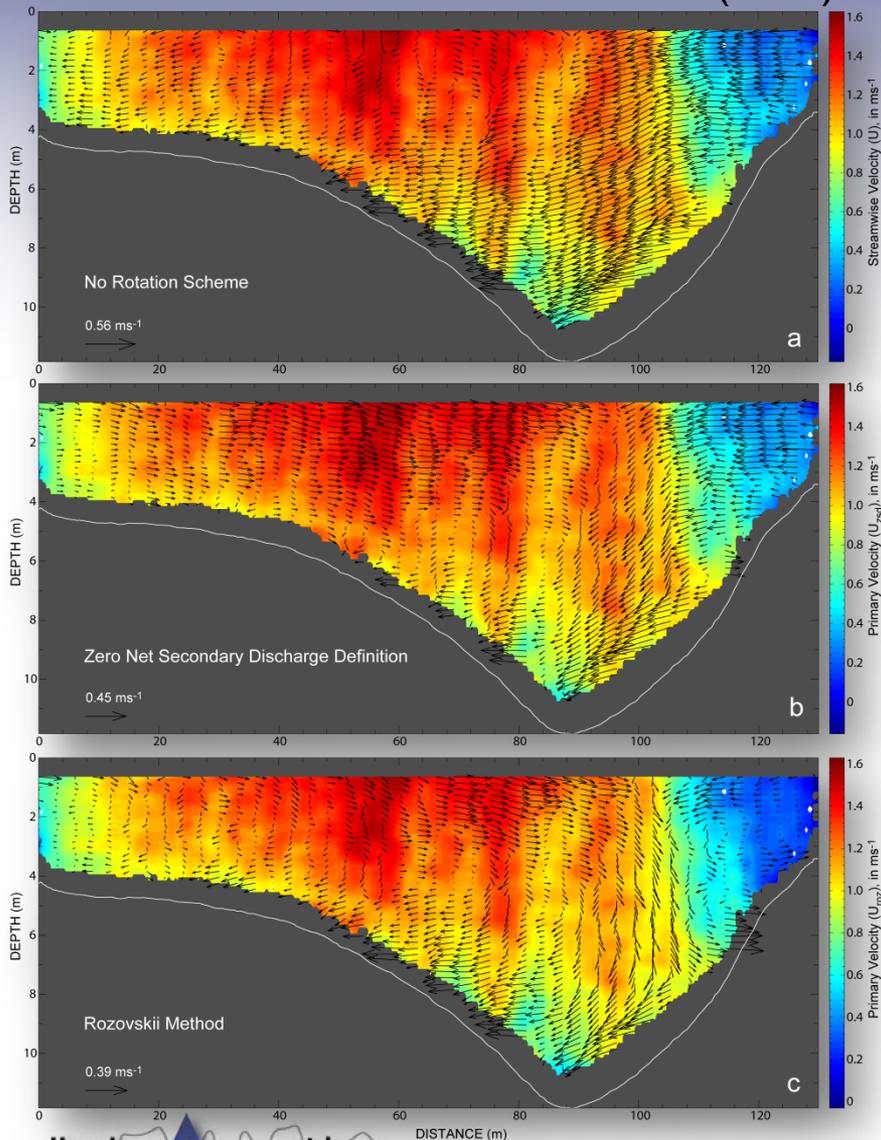
## Clinton Lake (IL)

With temperature data extracted from the ADCP

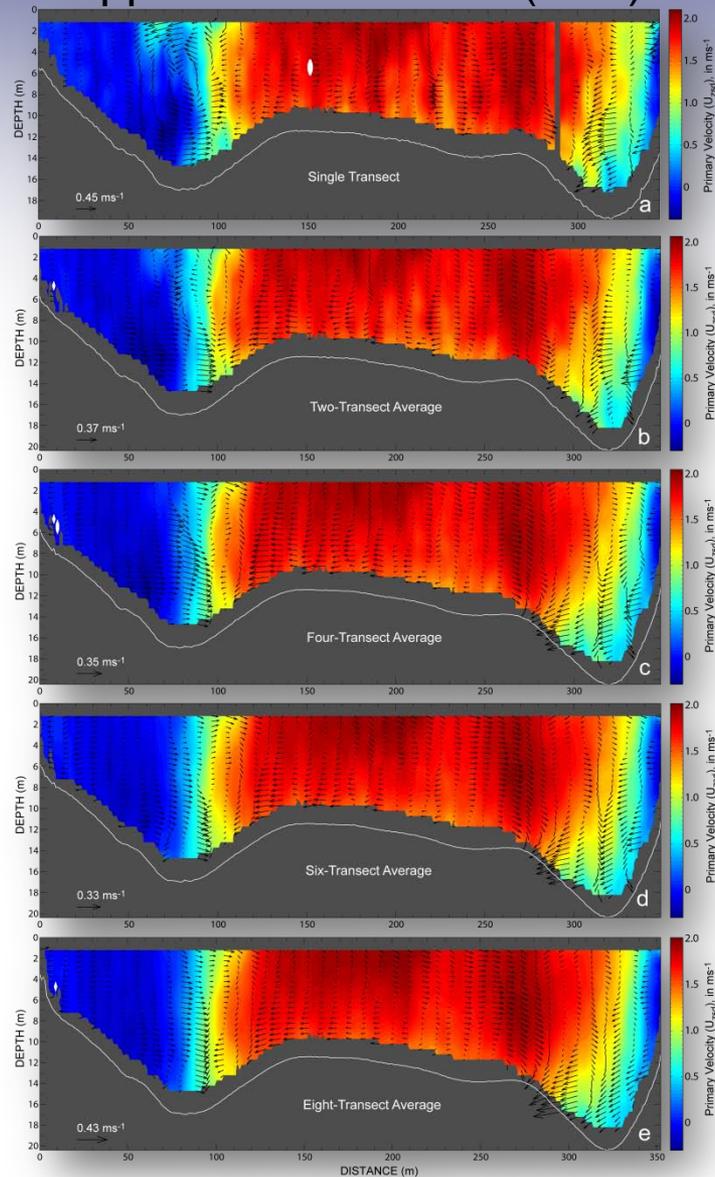


# Example Output – Cross Sections

## Wabash-Embarras Confluence (XS4)



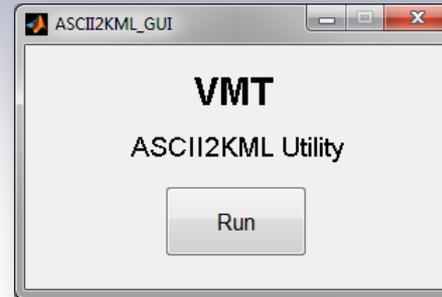
## Upper St. Clair River (XS9)



# VMT Standalone Utilities

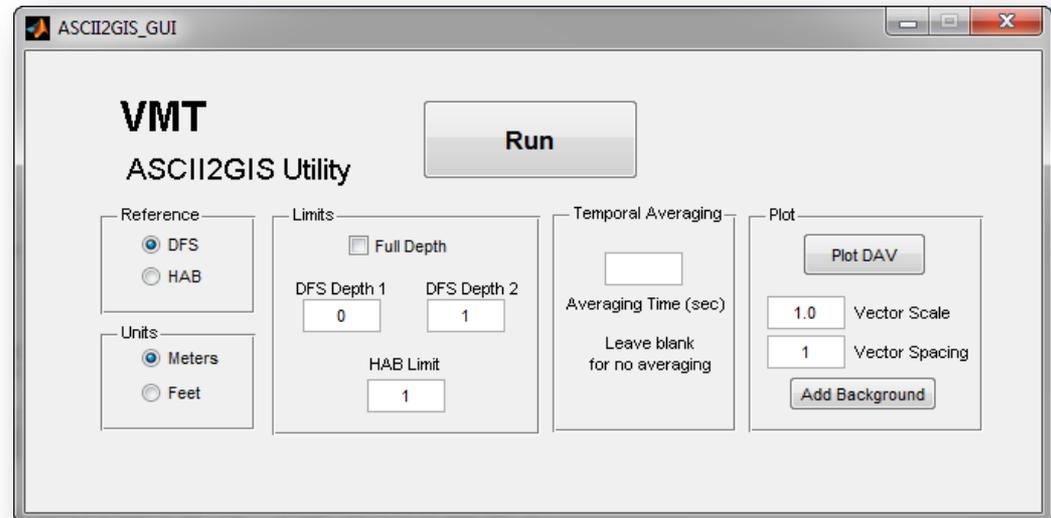
## ASCII2KML

- Shiptrack to Google Earth KML file
- Note: Mean XS from VMT can also be output to GE



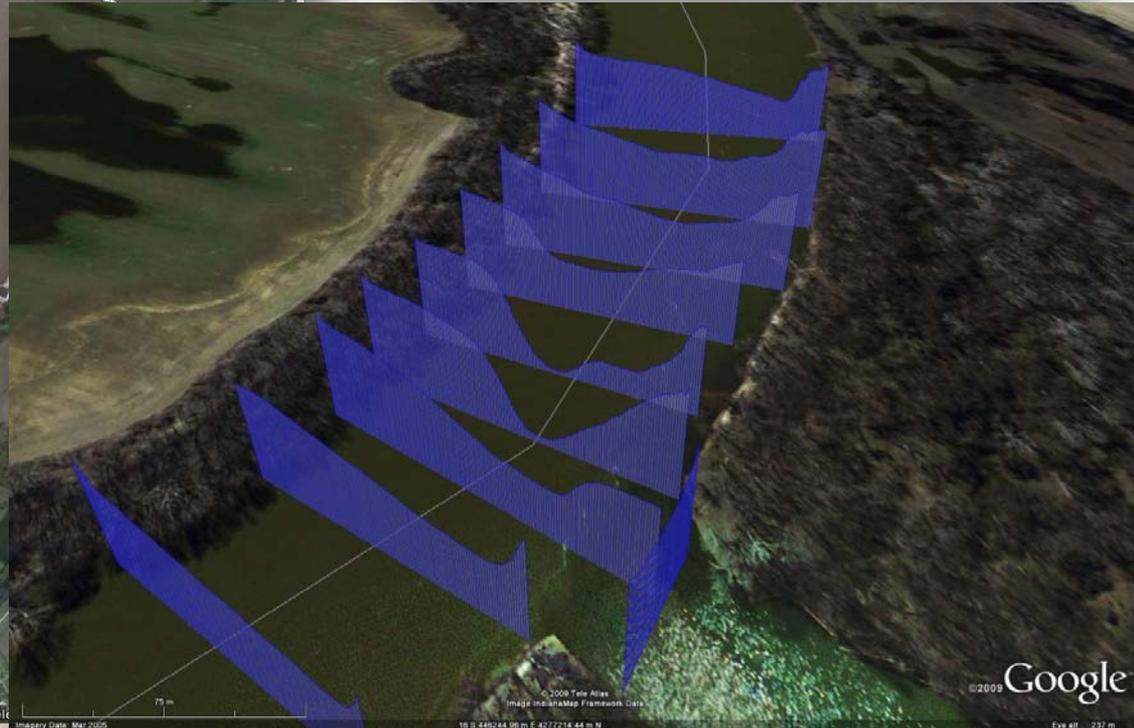
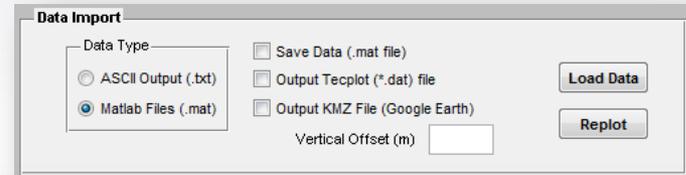
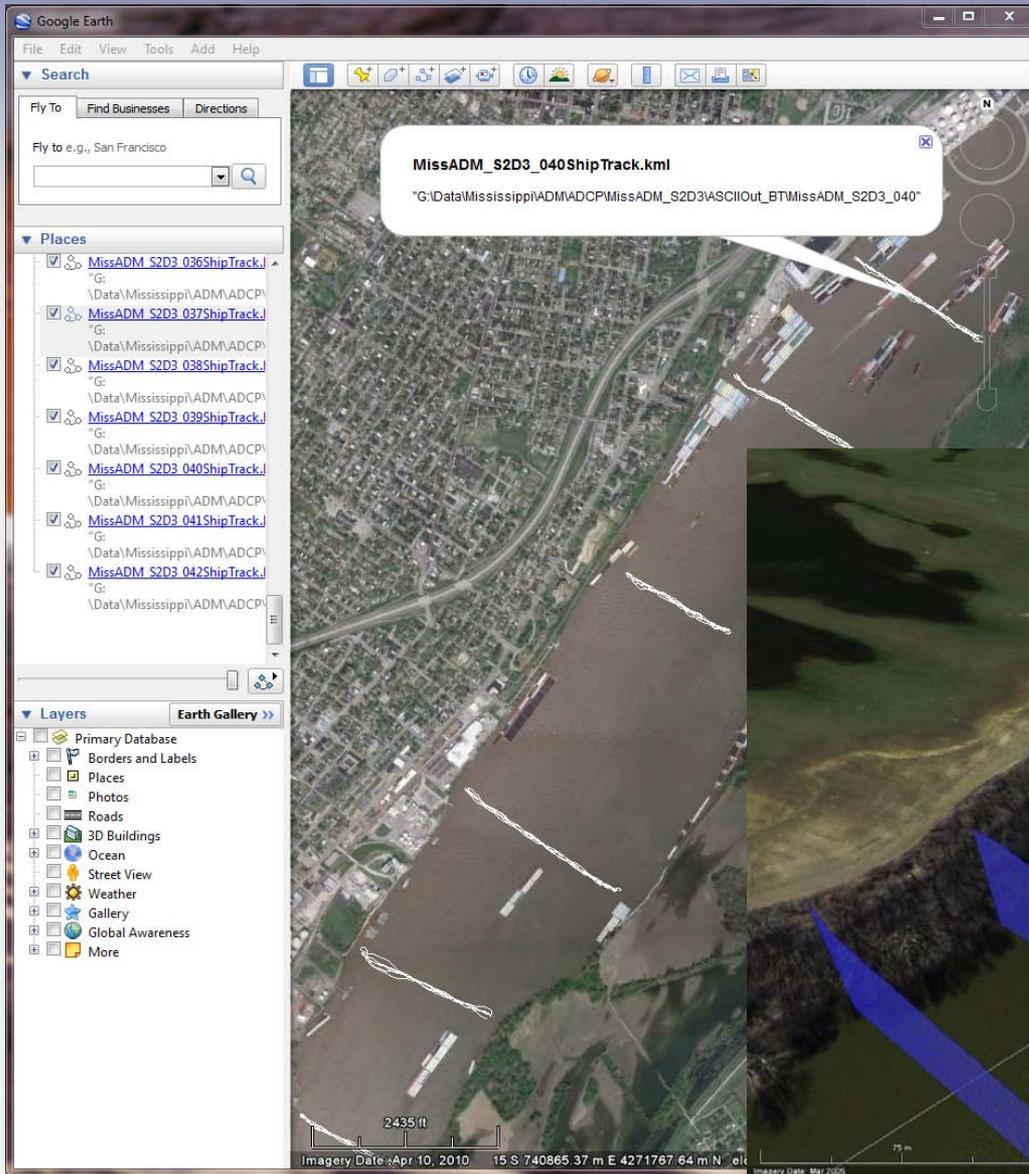
## ASCII2GIS

- ADCP data to text file formatted for GIS import
- Layer-Averaged (DFS or HAB)
- Temporal Averaging
- Plotting



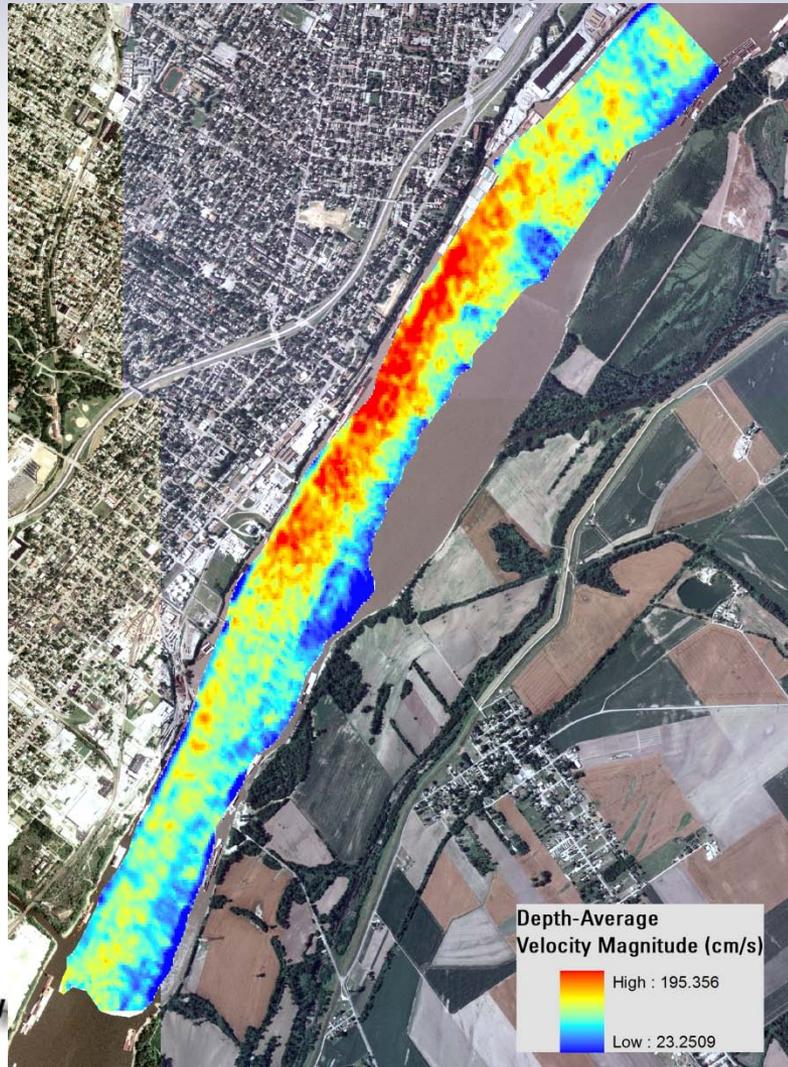
# ASCII2KML

## VMT Google Earth Export Option



# ASCII2GIS Example

## Depth-Average Velocity



## MBES bathymetry



# Status of VMT

- Taught VMT training class in Tampa (2011)
- Limited distribution to < 20 beta testers (inside and outside of USGS, but no industry) in late July 2011
- OSW website and forum established July 2011 (user guide, training material, video tutorials)
  - <http://hydroacoustics.usgs.gov/movingboat/VMT/VMT.shtml>
  - Username: VMTuser, Password: VMTrules
- Journal article submitted to ESPL in July 2011
- Paper reviews received and revisions made (resubmit any day now)
- Package nearly complete for Bureau approval
- Some feedback received from beta testers (but not as much as expected)
- VMT training class scheduled for HMEM 2012 (August, Snowbird, UT)

# Feedback on VMT

- Can be slow for large data sets
- Considerable interest in extending code to accept SonTek and RiverRay data
- Additional manual control of plots needed
  - Manual setting of color scales and reference vectors
- Output shows excellent agreement with similar plots produced outside VMT
- Add more QA/QC and clean-up minor bugs
- Four minor bug reports (fixed)

# Prioritized List of VMT Improvements

| Number | Task  |
|--------|---|
| 1      | Add generic input capabilities  |
| 2      | Add dynamic cell/bin size data handling   |
| 3      | Add temporal averaging to ASCII2GIS utility   |
| 4      | Update multibeam bathy comp to include M9, S5, and RiverRay data  |
| 5      | Look into issue with TecPlot primary velocity (sign convention)   |
| 6      | Improve 2-D interpolation of data on mean cross section (normalize, triangulate and then interpolate to regular 2-D grid)   |
| 7      | Determine how to handle multiple frequencies and backscatter  |
| 8      | Improve efficiency  |
| 9      | Improve memory usage  |
| 10     | Determine how to better integrate extensions  |
| 11     | Add iRIC bathy export compatibility   |
| 12     | Add iRIC ANV file export for plan view data   |
| 13     | Improve error handling to provide feedback for EXE users  |
| 14     | Improve GPS filter  |
| 15     | Start using version control software  |
| 16     | Develop better autoscaling routines to give better visualizations on first run (users and tune-in best results from there)  |
| 17     | Improve the figure export capabilities (add EPS option, format for USGS pubs, Remove titlebar, add axis to colorbar, etc.)  |
| 18     | Allow variable WSE file for bathy   |
| 19     | Investigate vertical velocity negative bias   |
| 20     | Update GPS script to pull nav file rather than rely on ASCII positions  |
| 21     | Build -in threshold/filter for data to remove data far away from the mean cross section   |
| 22     | Add QA/QC routines  |
| 23     | Add vorticity computation   |
| 24     | Improve batch processing capabilities (allow input of a processing file that has all transect groupings and settings)   |
| 25     | Allow fixed color scales and vector scales  |
| 26     | Integrate stationary extension  |
| 27     | Improve routines for estimating shear velocity and bed shear stress from moving boat data (and stationary data)   |
| 28     | Add option to interpolate missing data  |
| 29     | Improve handling of edge data (missing data at edges and top and bottom can cause loss of additional data during averaging)   |
| 30     | Add capabilities to develop/input calibrations for suspended sediment   |
| 31     | Add corrections for backscatter (sediment and water adsorption, etc.)   |
| 32     | Improve reachwise plotting capabilities including 3-D display of multiple cross sections  |
| 33     | Improve GIS export capabilities (output shapefiles of bathy points, velocity vectors)   |
| 34     | Improve Google Earth Export (export velocity vectors--both plan view and cross section-- to GE)   |
| 35     | Add data editor tool to allow removal of outliers   |
| 36     | Add bed velocity computation following Rennie   |
| 37     | Add uncertainty computation for bathy data (for obliques)   |
| 38     | Improve routines for estimating longitudinal dispersion coefficient   |
| 39     | Add TIN and contour generation for bathymetry and allow use as a background for velocity data (currently requires users to TIN and contour outside of VMT and import as background) |
| 40     | Develop handling of longitudinal data   |
| 41     | Add water quality import capability (YSI or other import with GeoRef from ADCP GPS using timestamp)   |
| 42     | Allow multiple plots to be generated simultaneously (by selecting more than one parameter and using subplot)  |
| 43     | Add capability to process data without GPS  |