2D Hydrodynamic Modeling in Riparian Community Research

Jarvis Caldwell[1], Andy McCoy, PhD, PE[2]

[1] HDR Inc., Aquatic Sciences. Gateway Oaks Drive, Sacramento, C.A. 95833. Jarvis.Caldwell@hdrinc.com

[2] HDR Inc., Water Resources Engineering, 300 Locust Street Ste. 210 Des Moines, Iowa 50309. Andrew.McCoy@hdrinc.com

BACKGROUND

Specific to riparian community function, we reviewed and evaluated the current application of 2D hydraulic models when used for this research.

We identified the practical considerations and limitations when using these models in an attempt to set realistic expectations for 2D model use in the riparian zone.

Gila River, New Mexico. HDR. June 2014

New River, West Virginia. HDR 2014

Gila River, New Mexico. HDR January 2014

METHODS

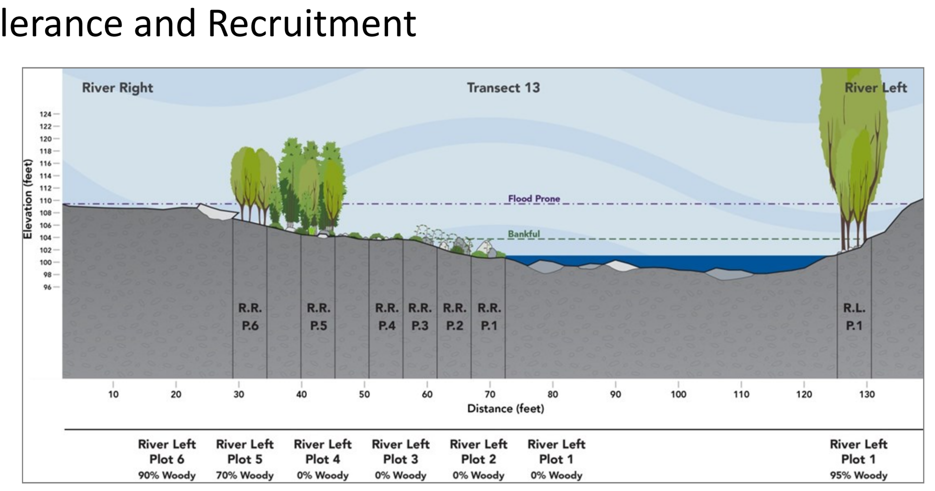
The regulated hydrograph and interaction with riparian zone has been studied in detail. Often, riparian zone research is built on the back of fish habitat models, geomorphology models, or floodplain inundation models.

Using data from recent studies, we evaluated the most common questions related to riparian zone function and addressed those that could be studied with a 2D hydraulic model.

We reviewed the application of the Bureau of Reclamation's Sedimentation and River Hydraulics (SRH-2D V2) model (Lai, Y.G., 2008) and the River2D (Steffler and Blackburn, 2002) and River2D Morphology (R2DM V7) models (Kwan et al, 2011).

PHYSICAL RIPARIAN ZONE PROCESSES

- Inundation: Magnitude, Frequency, Duration
- Community Structure: Spatial Distribution, Age, Species Diversity and Abundance
- Groundwater Interaction: Depth, Temporal Variability, Connectivity
- Root Zone Depth Requirements
- Species and Community Substrate Requirements
- Seedling Tolerance and Recruitment



Riparian Inundation Analysis, Middle Yuba River, CA. HDR, 2012.

2D MODEL APPLICATION

2D hydraulic models provide a detailed velocity description in the channel as well as in the floodplain, with certain limitations. They can resolve areas with high velocity gradients and interactions between the main channel and the floodplain.

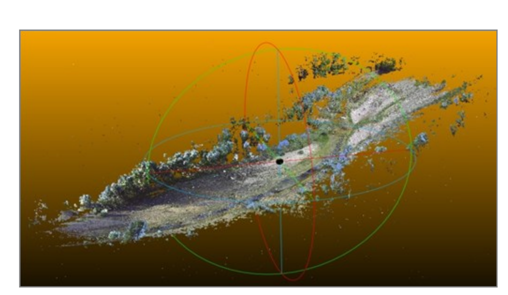
The models provide bed shear stress based on depth averaged uniform flow. SRH2D v2 does not incorporate sediment transport or vegetation functionality at this time. R2DMv7, is intended to model general bed changes, but not local scour.

Transient event analysis incorporates hydrologic data, historic, baseline, operational scenarios, and climate change predictions to determine the effect on inundation, and associated metrics.

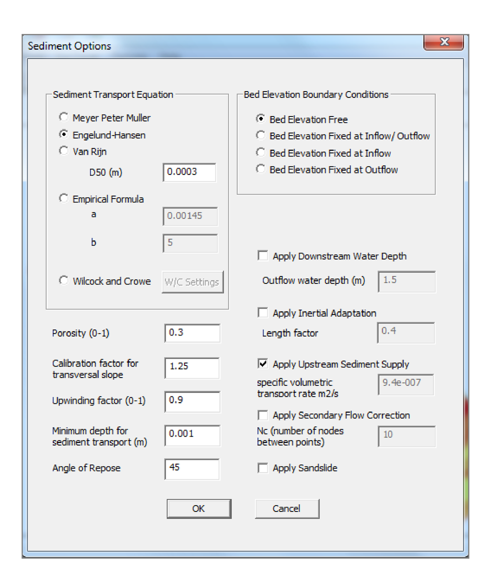
60,000 cfs flood event, New River, West Virginia. HDR 2014

DATA REQUIREMENTS

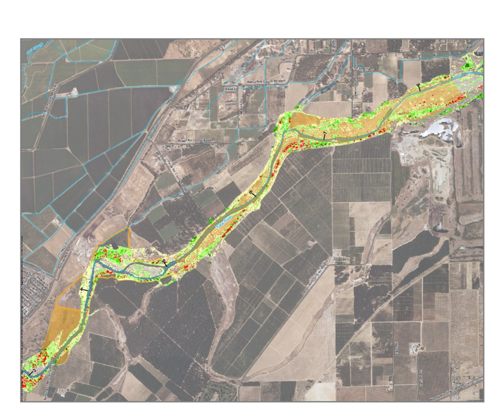
RTK survey and Faro laser scanning, New Mexico. HDR 2014



Faro laser scanning data output, New Mexico. HDR 2014



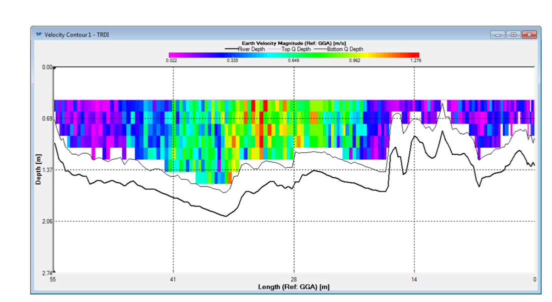
R2DMv7 sediment options dialogue box, Kwan 2011.



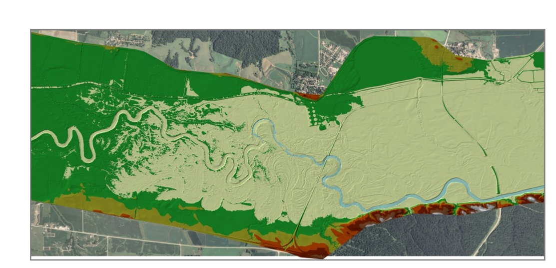
Vegetation mapping, Yuba River, CA, Watershed Sciences & HDR, 2013.

- Topography
  - LiDAR (Air & Ground)
  - Bathymetry
- Water Surface Elevations
  - RTK, Total Station
  - Transducers
- Velocity and Depths
  - ADCP, Manual
- Boundary Conditions
  - Rating Curve Development
- Aerial Imagery
  - Current
  - Seasonal
  - Historical
- Riparian Community
  - Vegetation Density
  - Species Mapping
  - Age Structure
  - Root zone requirements
- Groundwater
  - Water Table Monitoring
  - Modeling (MODFLOW)
- Sediment Transport
  - Particle Size Mapping
  - Sediment Depth, Porosity
  - Non-erodible Zones
  - Sediment Supply (inflow)
- Mesh Development
  - Scales of Importance
- Hydrology
  - Time Scale
  - Daily vs. Hourly

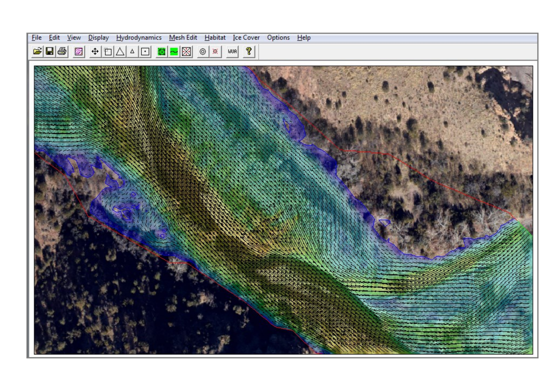
Reson MB1 multibeam & RDI ADCP research vessel, HDR 2014



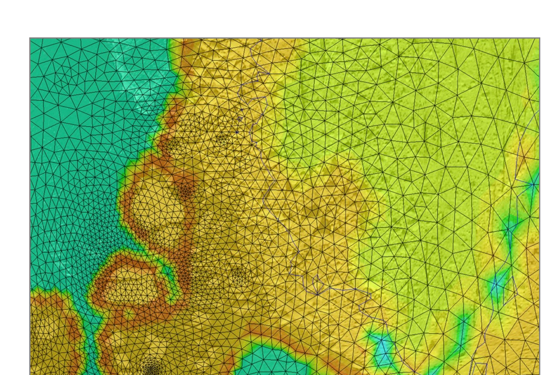
ADCP velocity magnitude profile for velocity calibration, HDR 2014



LiDAR and multibeam survey, HDR 2014

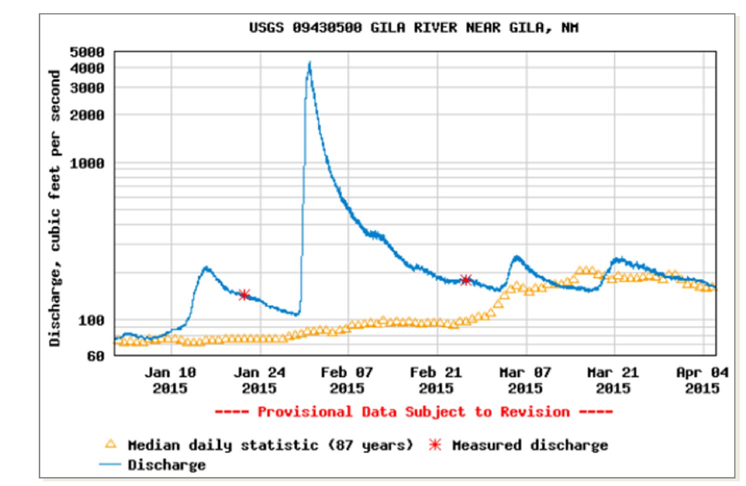


River2D velocity magnitude and vector plot. New Mexico, 2014. HDR.

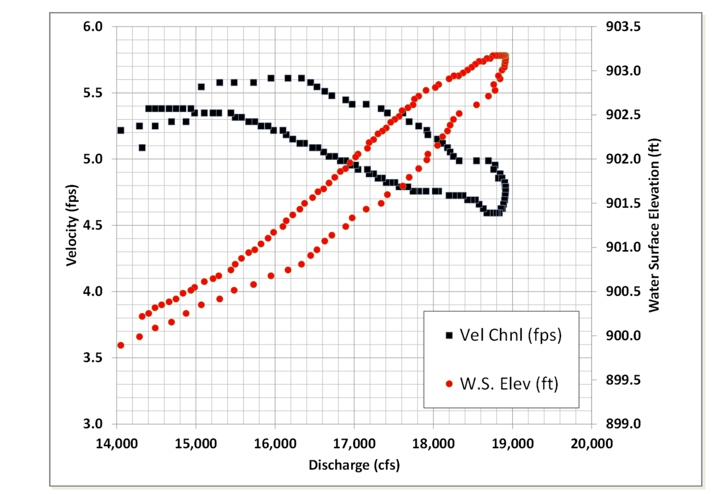


River2D variable sized mesh element, focus site. West Virginia, 2014. HDR.

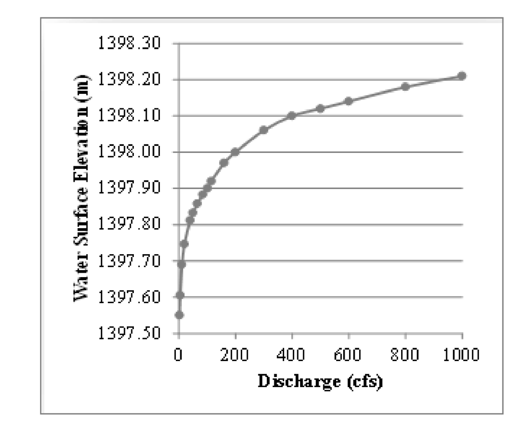
PRACTICAL CONSIDERATIONS



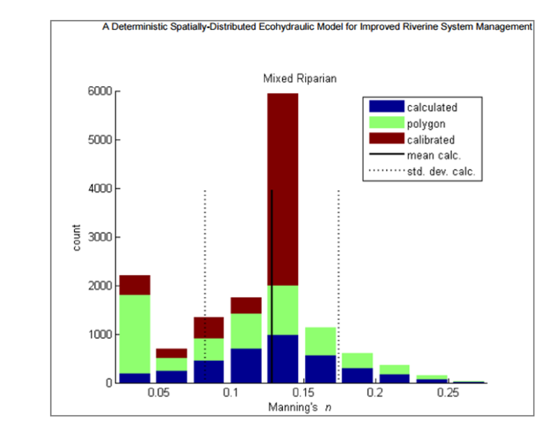
Hydrology Development - Time scale important to riparian zone processes. Daily vs. hourly time step.



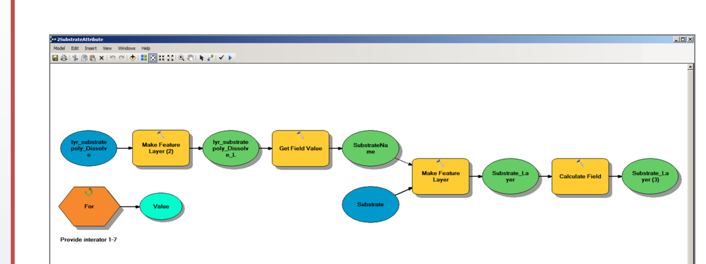
Steady vs. Unsteady - Related to hydrologic time step, careful consideration of the importance of hysteresis on bed shear and sediment mobility.

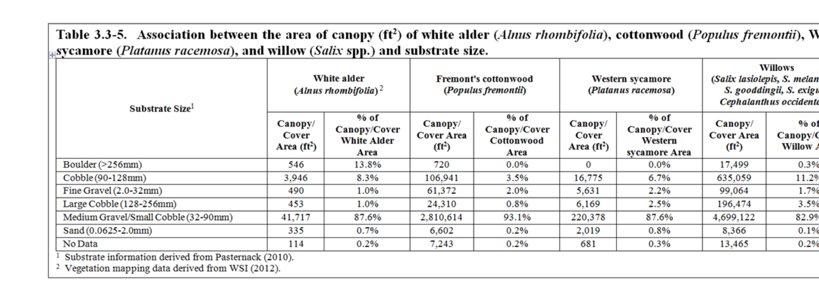


Boundary Conditions - Site specific rating curve development critical to accurate WSE and inundation predictions.



Riparian Vegetation and Hydraulics - Modeling 'vertical roughness.' Effects on the flow field. SRH2Dv - not yet public.





Spatial Predictive Model Development - Relational species models developed using output from 2D hydraulic models, substrate mapping, vegetation mapping, LiDAR data and field verification. Data intensive, multi –year.

CONCLUSIONS

- Improved Hydrologic and Hydraulic Relationships, Consideration of Time Step Important
- Transient Event Based Models Required to Better Predict Key Bed Shear and Sedimentation Processes
- Data Requirements Growing With Modeling Expectations, Data Collection Very Time Consuming and Expensive
- Consideration of Vegetation Roughness Shows Promise, Not Yet Available in the Public Domain
- No One Complete Modeling Solution, Multi-model Crosswalk Evaluations Required