Hydraulic Analysis and Successful Design for Geomorphology and Risk

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Paradigm Shift: Treating water as a resource, not an enemy..
Designing for a Spectrum of Events

- **High Flows**
  - Flooding and Damage, Avulsion and Erosion Hazards, Infrastructure, Stripping of Vegetation, Rare

- **Low Flows**
  - Ecology and Stream Health, Long term Stability, Vegetation and Overbanks, Frequent
Combining Visual Assessment with Hydraulic Analysis

- Visually
  - Transects (Sections)
  - ID Stability / CEM
  - Assuming past results

- Hydraulically
  - Sections (Uniform Flow)
  - Models (1D or 2D)
  - Replicating Past
  - Estimating Future Results
Visual Stream Assessment
Streams Move

- Suddenly with one or two large events.
- Over time with base flows and average high flows.
Visual: Mobil Bed / Active Avulsion/Erosion
Visual: Debris Height, Secondary Channels, Armoring Size
Visual: Erosion / Avulsion
Hydraulic Analysis
Hydraulic Analysis: 1D vs. 2D

Information Required:
1. Topography
2. Roughness
3. Flow

Information Gathered:
1. Depths
2. Velocities
3. Stream Power
4. Shear
5. Banks and Channel
Hydraulic: Hydraulic Models

1D - Velocity

2D - Velocity
Froude No, Velocity, Power

1D Cross Sections

Velocity Profile

- Stream Distance (feet)
- Channel Centerline
- Right Bank
- Left Bank

Froude Number Profile

- Stream Distance (feet)
Hydraulic Analysis

Stability

Transport Capacity

Sediment Supply

Erosion

Varying Channel Widths

High Flow Widths (What do we design to?)
Hydraulics Analysis – Sediment Balance

\[ Q_s \cdot D_{50} \propto Q_w \cdot S \]
Stable Hydraulics = Stable Transport Rate

GSSHA Total Volume Results

Sediment Transport Rate
\[ Q = 100 \text{ cfs} \]

Total Volume of Sediment Transported over a 10 year Period (cubic feet)

- Existing
- Future

\( q_s \) (Meyer, Peter, Muller)
\( q_s \) (Simons and Li)
In Summary

• Both are Necessary
  1. Visual
  2. Hydraulic

• Visual
  • Channel Movement
  • Pre and Post Assessment
  • Historic

• Hydraulics
  • 2D –
    • Requires Same Information as 1D
    • More information for analysis
  • 1D -
    • Meets Regulatory Requirements (FEMA)
    • Less Distributed Results

= Successful Design / Restoration
Designing for Sediment, Erosion, and Hydraulics—New(ish) Tools

- Public 2D Sediment and Hydraulic Models
  - Gridded Surface and Sub-Surface Analysis (GSSHA)
    - (US Army Corps)
  - Sediment and River Hydraulic 2D (SRH-2D)
    - US Bureau of Reclamation
  - HEC-RAS 2D
    - (US Army Corps) (Beta)

- Visual Assessment
  - GIS

- Erosion and Hazard Analysis
  - Vermont Geomorphic Assessment Protocols:
    - http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm
  - Watershed Assessment of River Stability and Sediment Supply:
  - Framework for delineating channel migration zones: Washington State:
Thank you!

Rare Geomorphic “Stacking”