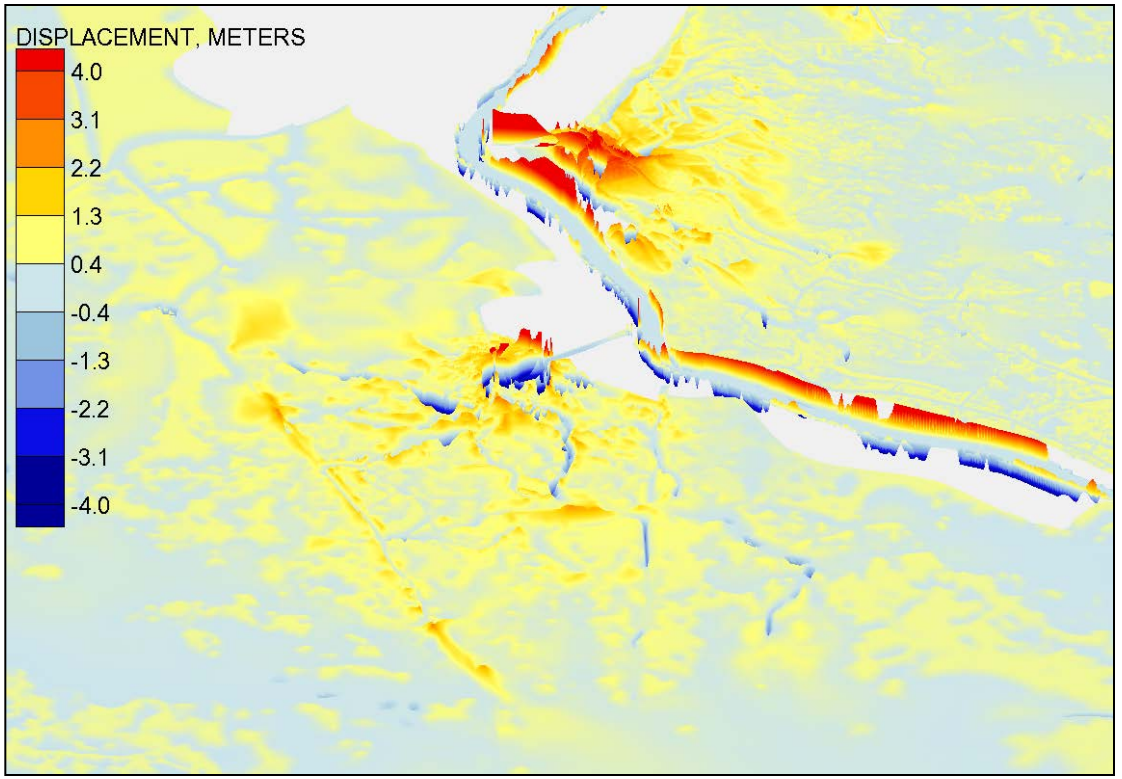
Linking GSSHA to SEDLIB

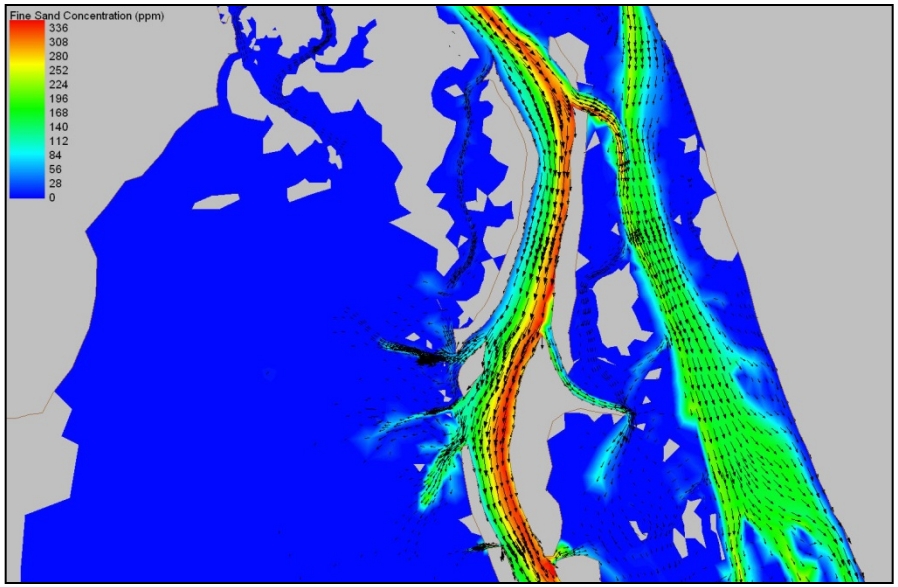
- GSSHA is being linked to SEDLIB, a generalized sediment transport library
- Initial linkage is for in-channel transport.



AdH/SEDLIB morphologic modeling of proposed sediment diversions in Coastal Louisiana

Sediment Transport Library (SEDLIB)

- SEDLIB was developed at CHL in 2008 (Brown, 2012a, 2012b)
- Implemented in AdH (Adaptive Hydraulics)
- Used broadly throughout the Corps for a wide range of sediment problems
  - Channel shoaling
  - Analysis of training structures
  - Analysis of riparian ecosystem restoration
  - fly ash transport and fate
  - analysis of morphologic response in gravel bed streams
  - Overtopping and headcutting of landslide deposition
  - Marsh creation and evolution



AdH/SEDLIB Velocity vectors and color contours of suspended concentration of fine sand: Pool 5 of the Mississippi River

Brown, Gary L, 2012a, "A Quasi-3D Suspended Sediment Model Using a Set of Correction Factors Applied to a Depth Averaged Advection Diffusion Equation", proceedings, IIHR 3rd International Shallow Flows Symposium, University of Iowa, 2012.
Brown, Gary L, 2012b, "Modification of the bed sediment equations of Spasojevic and Holly (1993) to account for variable porosity, variable grain specific gravity, and nonerodable boundaries" proceedings, IIHR 3rd International Shallow Flows Symposium, University of Iowa, 2012.

WHY SEDLIB?

- Existing GSSHA in-channel sediment
  - Sand is modeled as bedload
  - Sand is modeled with total load equation of Yang (1973)
  - Fines are routed through the channel (no interaction with the in-channel sediment bed).
  - Depth of erosion is constrained by user input
  - Bed characteristics are relatively simple

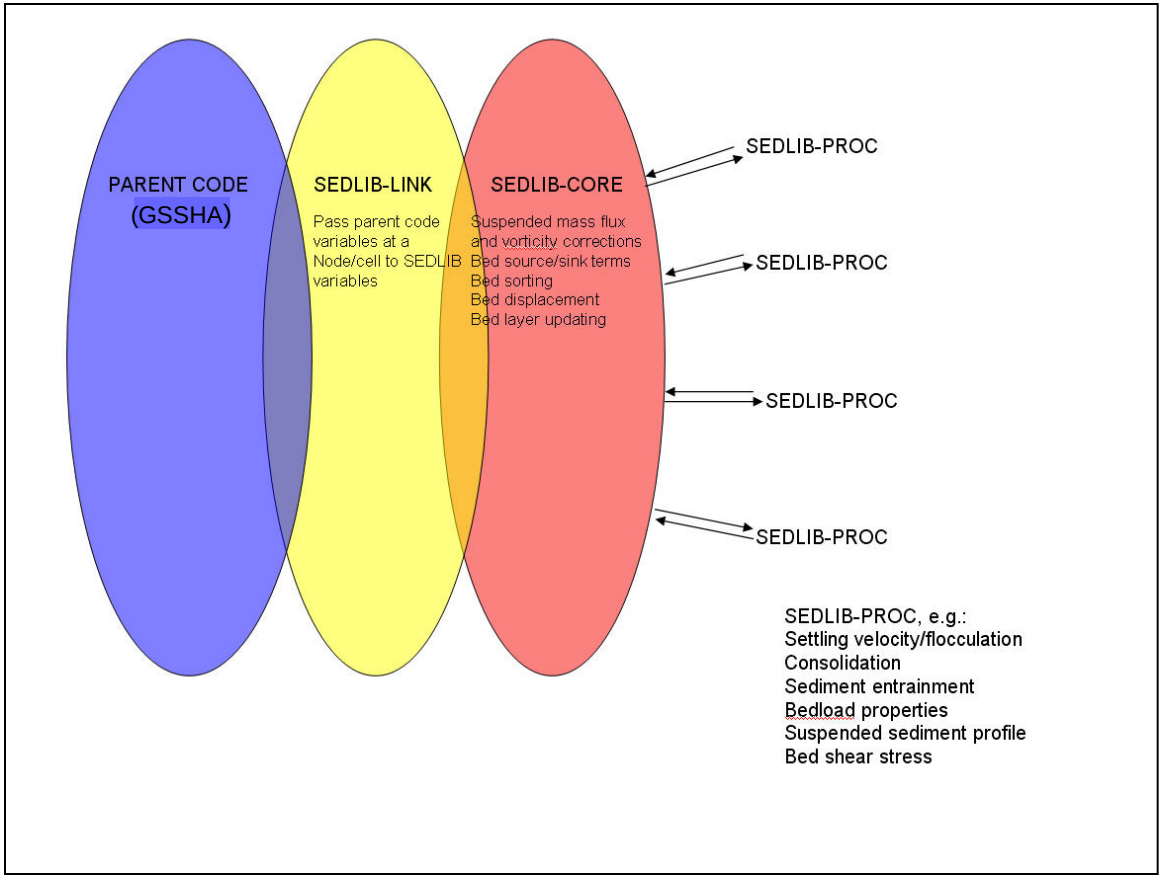
- Downer, C. W., N. R. Pradhan, F. L. Ogden, and A. R. Byrd, 2014. Testing the effects of detachment limits and transport capacity formulation on sediment runoff predictions using the US Army Corps of Engineers GSSHA model. JHE, 04014082 1-11, doi: 10.1061/(ASCE)HE.1943-5584.0001104.

WHY SEDLIB?

- SEDLIB in-channel sediment
  - Sand can be modeled as suspended load, bedload, or total load
  - Sand can be modeled with Yang (1973), but can also be modeled with several other methods
  - Fines are modeled as suspended load
  - Sand and fines are stored together in the in-channel sediment bed
  - Sand and fines can be eroded from the in-channel bed
  - Multiple bed layers can be defined
  - Depth of erosion is automatically determined by the total bed thickness, or the erodability of individual layers/grains.
  - Robust bed armoring and sorting processes are included
  - Percolation and/or bridging of fines in gravel beds is included (Gibson, et al 2010)
  - Future updates to SEDLIB can be utilized by GSSHA.

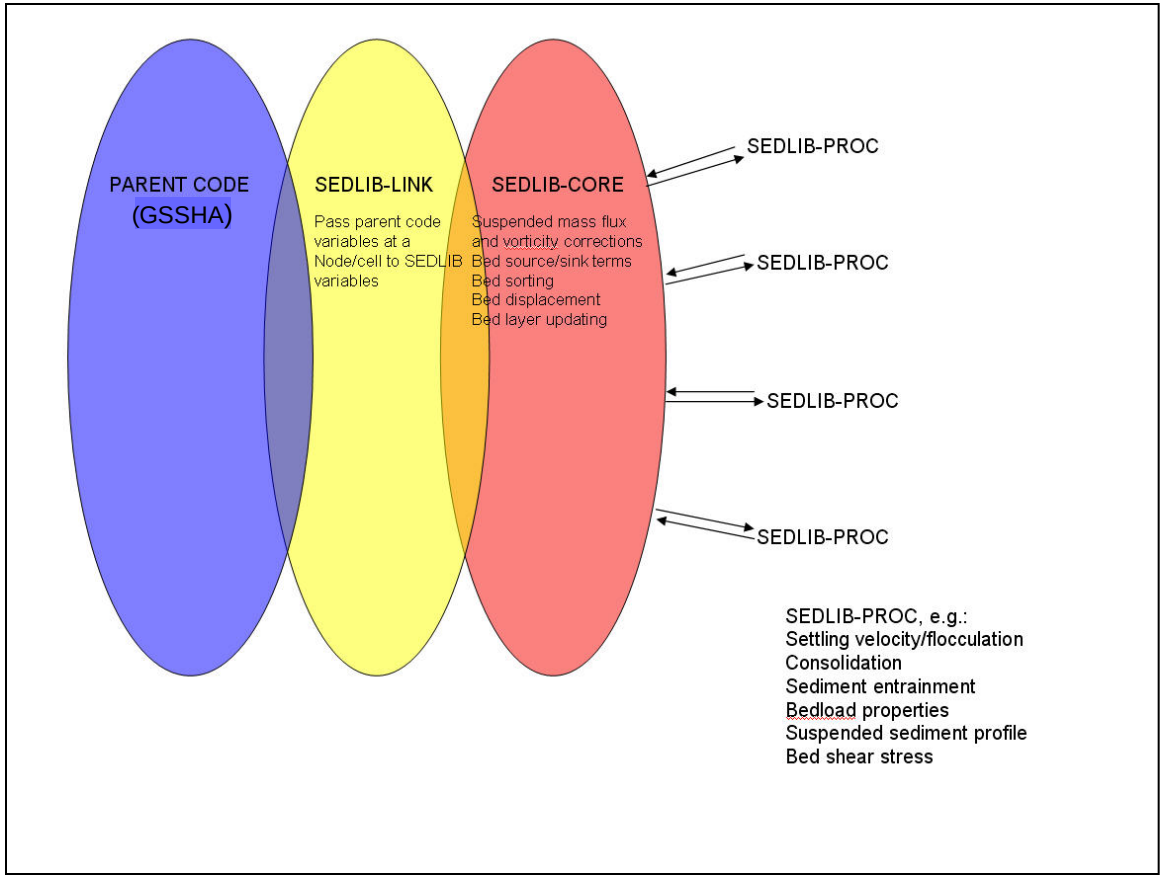
Sediment Transport Library (SEDLIB)

- The SEDLIB library system is designed to link to any appropriate hydrodynamic code.
- The hydrodynamic code must be capable of performing advection diffusion calculations for a constituent.



Sediment Transport Library (SEDLIB)

- SEDLIB interacts with the parent code by providing sources and sinks to the advection diffusion solver in the parent code.
- The solver is then used to calculate both bedload and suspended load transport, for each grain class.
- The sources and sinks are passed to the parent code via a source/sink bed sediment flux, for both suspended load and bedload.



Sediment Transport Library (SEDLIB)

Fundamental Bed Sediment Equations in SEDLIB

Mass Conservation for Each Grain Fraction

$$\frac{\partial\left(\left(1-p_{AL}\right)\beta_i\varepsilon_m\right)}{\partial t}+\frac{\beta_i E_{SL.i}+\beta_i E_{BL.i}-D_{SL.i}C_{SL.i}-D_{BL.i}C_{BL.i}}{\rho_w s_i}$$

$$+\left(1-p_{AS}\right)\beta_{AS.i}\frac{\partial\left(\eta-\varepsilon_m\right)}{\partial t}=0$$

Mass Conservation for Sum of All Grain Fractions = 1

$$\left(1-p_{AS}\right)\frac{\partial\left(\eta-\varepsilon_m\right)}{\partial t}+\frac{\partial\left(\left(1-p_{AL}\right)\varepsilon_m\right)}{\partial t}$$

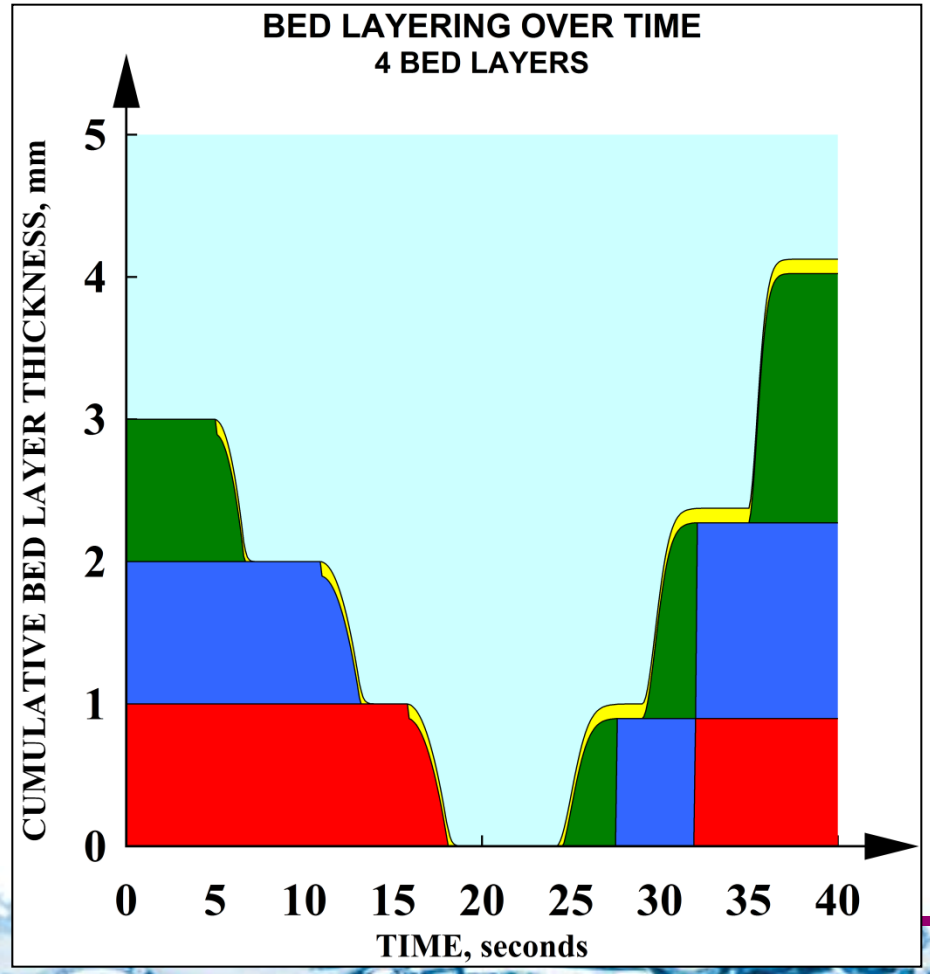
$$+\sum_{i=1}^{i=ngc}\frac{\left(\beta_i E_{SL.i}+\beta_i E_{BL.i}-D_{SL.i}C_{SL.i}-D_{BL.i}C_{BL.i}\right)}{\rho_w s_i}=0$$

where:

ρ_w	=	density of water (kg m^{-3})
$\beta_{AS.i}$	=	active stratum fraction for grain size class i
s_i	=	specific gravity for grain size class i
p_{AS}	=	porosity of the active stratum
η	=	bed elevation (m)
β_i	=	grain size distribution of the active layer
p_{AL}	=	porosity of the active layer
ε_m	=	active layer thickness (m)
$E_{SL.i}$	=	the suspended erosion flux potential (kg m^{-2} s^{-1})
$D_{SL.i}$	=	the suspended deposition flux potential (kg m^{-2} s^{-1})
$E_{BL.i}$	=	the bedload erosion flux potential (kg m^{-2} s^{-1})
$D_{BL.i}$	=	the bedload deposition flux potential (kg m^{-2} s^{-1})
$C_{SL.i}$	=	suspended concentration for grain class i (kg kg^{-1})
$C_{BL.i}$	=	bedload concentration for grain class i (kg kg^{-1})

Sediment Transport Library (SEDLIB)

Some Features and Capabilities of SEDLIB



Suspended and Bedload Nonequilibrium Transport

Implicit Bed Sediment Sorting Calculations

Multiple bed layer erosion (within a single time step, if necessary)

Optimized bed bookkeeping algorithm

Mixed sediment modeling capability

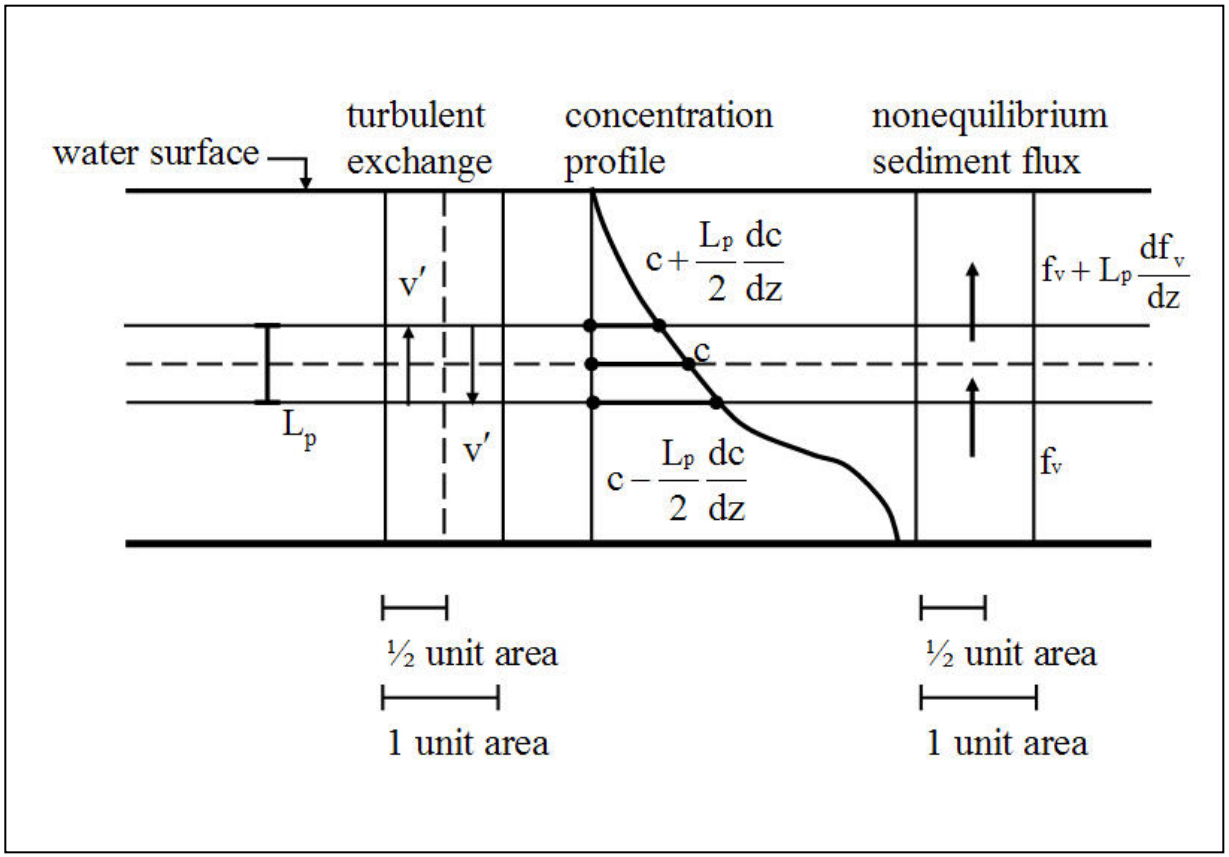
Multiple bed layer bulk density and sediment specific gravity capability

Bed consolidation

Gravel transport, and simulation of bridging/percolation of fines

Nonequilibrium Transport

The Nonequilibrium Suspended Sediment profile is used by SEDLIB to adjust the rate of deposiiton and/or erosion for nonequilibrium conditions



Brown, G.L. (2008) "An Approximate Profile for Nonequilibrium Suspended Sediment" J. Hydr. Engrg. Volume 134, Issue 7 pp 1010-1014.

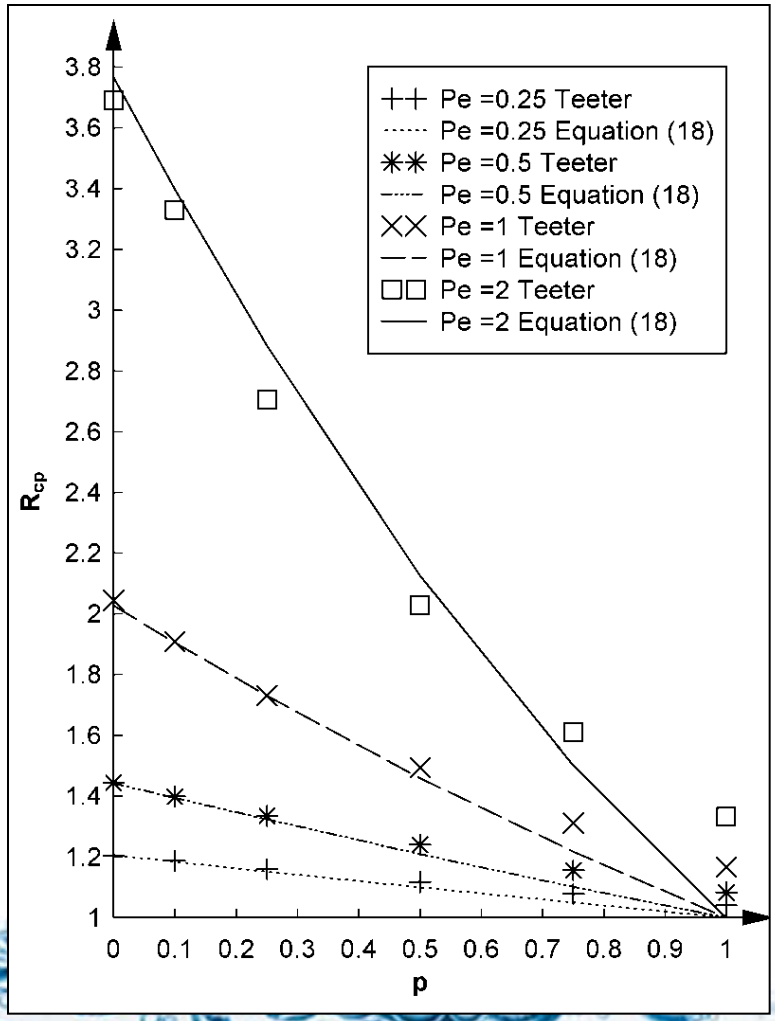
Nonequilibrium Transport

Brown, G.L. (2008) “An Approximate Profile for Nonequilibrium Suspended Sediment” J. Hydr. Engrg. Volume 134, Issue 7 pp 1010-1014.

$$\frac{c}{c_a} = \left(\frac{Z}{A} \frac{(1-A)}{(1-Z)} \right)^{-K}$$

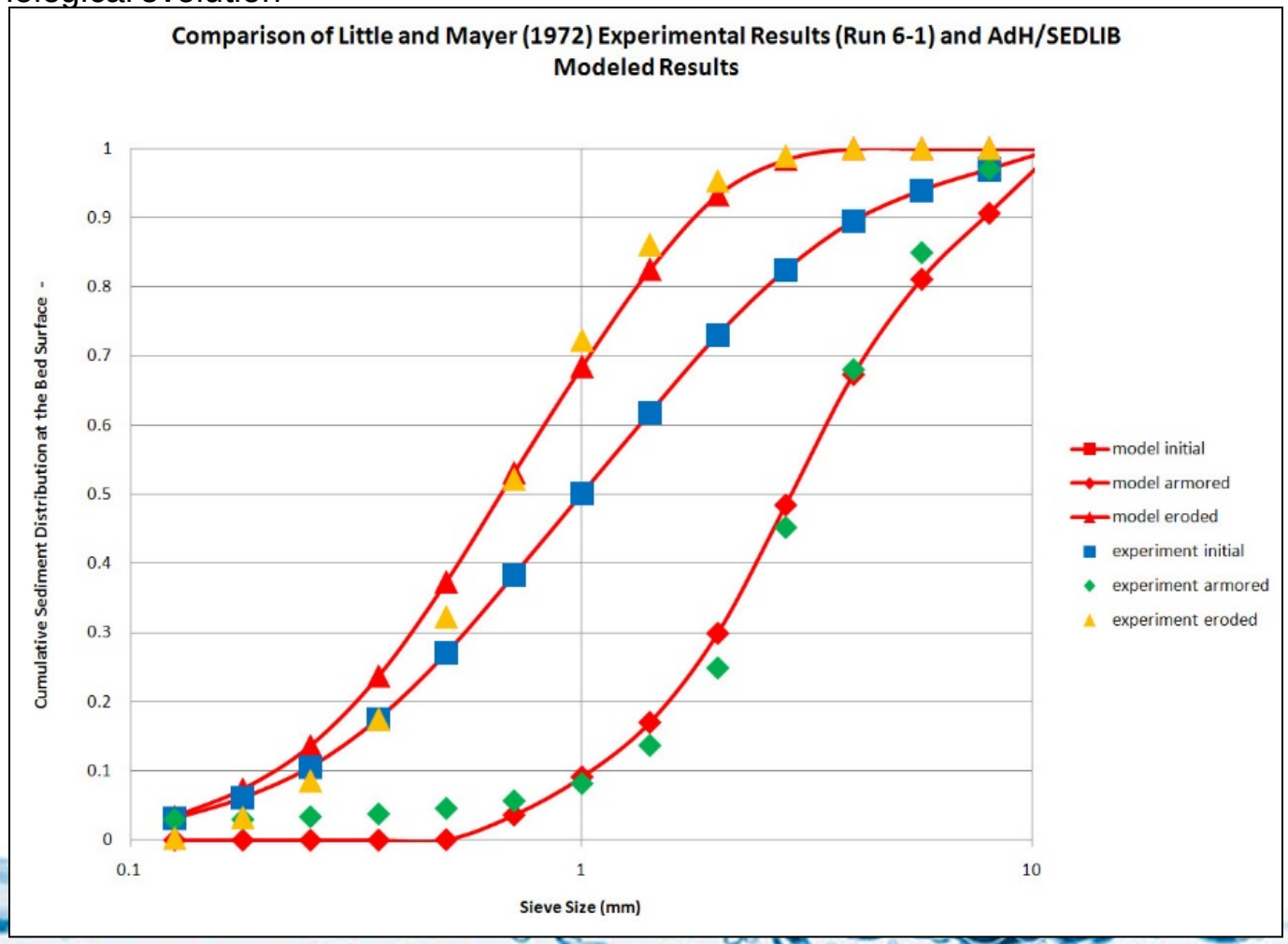
$$K = \frac{1}{\beta_{ss} \kappa} \frac{(1+F_{v.a})}{\left(\frac{u_*}{v_s} + F_{v.a} \right)}$$

$$F_{v.a} = \frac{f_{v.a}}{v_a c_a}$$



Laboratory Test Cases

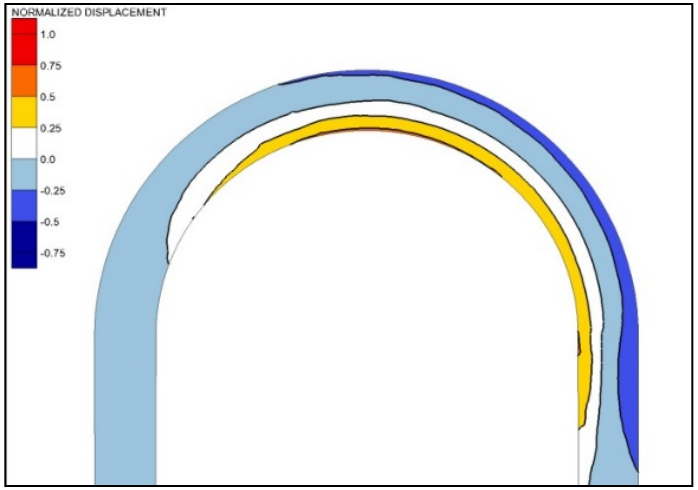
These comparisons to laboratory experiments show good agreement with laboratory data, demonstrating the ability to model bed sorting and bendway morphological evolution

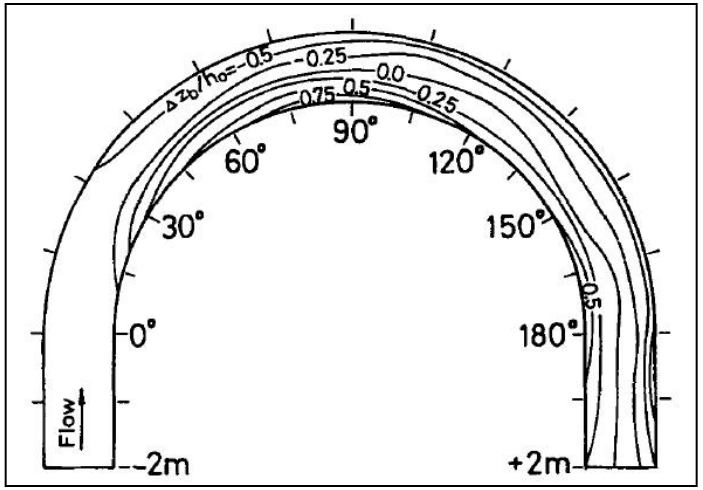


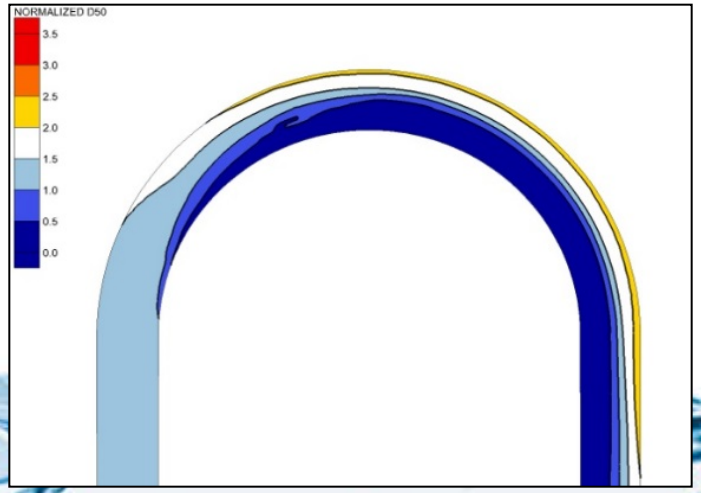
Little and Meyer (1972) armoring experiment

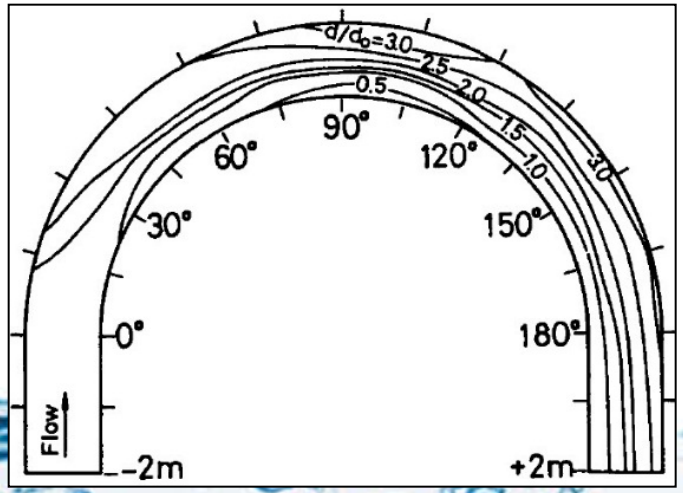
Laboratory Test Cases

These comparisons to laboratory experiments show good agreement with laboratory data, demonstrating the ability to model bed sorting and bendway morphological evolution









Yen and Lee (1995) bendway experiment

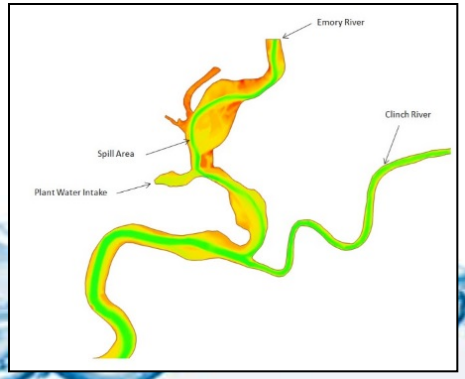
EXAMPLE SEDLIB APPLICATIONS

Some Sample Riverine Applications

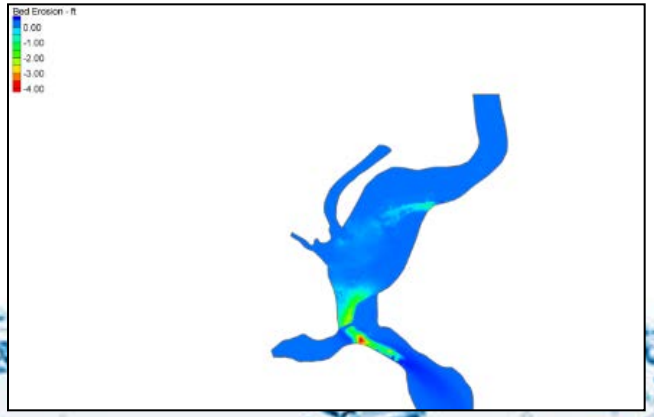
Missouri River Deer Island (Aaron Buesing, MVP, Chris Svendsen, NWO) Little Sioux, IA - Channel widening project to create shallow water habitat. ADH/SEDLIB run with sediment to determine optimum geometry for a sustainable project, doesn't impact the navigation channel and the habitat is sustainable. Numerous stakeholders.

Yellowstone River at Intake, MT (Dan Pridal, NWO) Project to install a new irrigation diversion headworks and rock ramp to allow fish passage on the Yellowstone River. ADH/SEDLIB to evaluate fish passage and sediment transport on the ramp and past the headworks. Numerous stakeholders.

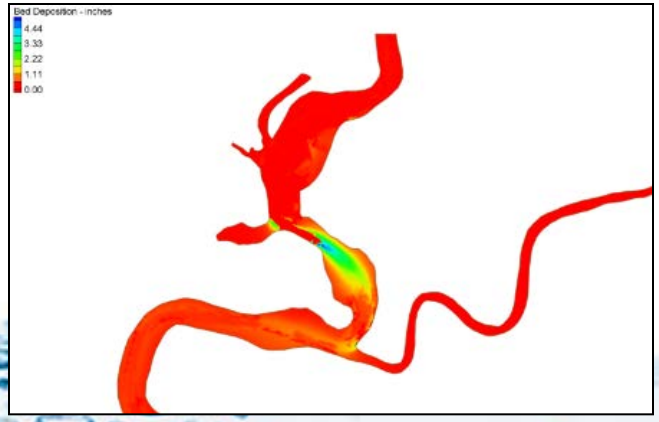
TVA Kingston Flyash Study (CHL) *Model the transport and fate of a flyash spill*



Flyash Erosion



Flyash Deposition



EXAMPLE SEDLIB APPLICATIONS

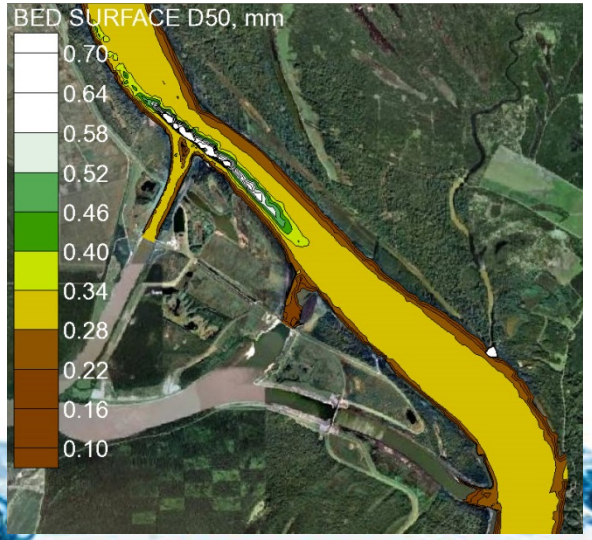
Some Sample Riverine Applications

Kate Aubrey Reach, Mississippi River (Jeremy Sharp, CHL) 5 year hydro and sediment simulation for long term comparisons to field

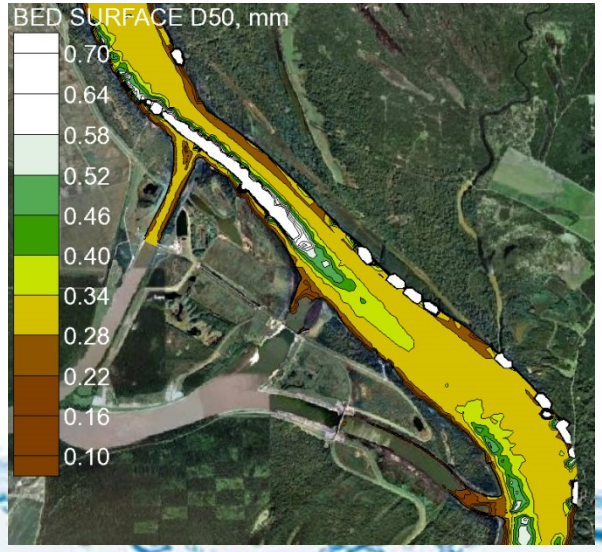
West Bay Diversion (CHL) Evaluate impacts of West Bay diversion on downstream shoaling in Pilottown Anchorage Area

Old River Control Structure (CHL) Evaluate sediment diversion efficiencies of diversion structures at Old River Control Complex, by sediment grain class

Bed Surface D50: Rising Limb of Hydrograph



Bed Surface D50: Falling Limb of Hydrograph



SEDLIB EXAMPLE: BADAKHSHAN MUDSLIDE

- The AdH/SEDLIB model was used to predict the evolution of uncontrolled channel incision into the mudslide
- The model was simulated with constant tributary inflows, that roughly approximate high discharges during a storm event
- The model simulation gives an indication of how the channel might eventually evolve (in the absence of an engineered solution), and locations where the potential exists for bank failure and further slides.

AdH/SEDLIB MODEL RESULTS

Note: erosion exceeds [illegible] in some places; the 10 m contour limit is [illegible] visualization purpo[illegible]

AdH/SEDLIB MODEL RESULTS

Note: erosion exceeds 10 m in some places; the 10 m contour limit is for visualization purpo

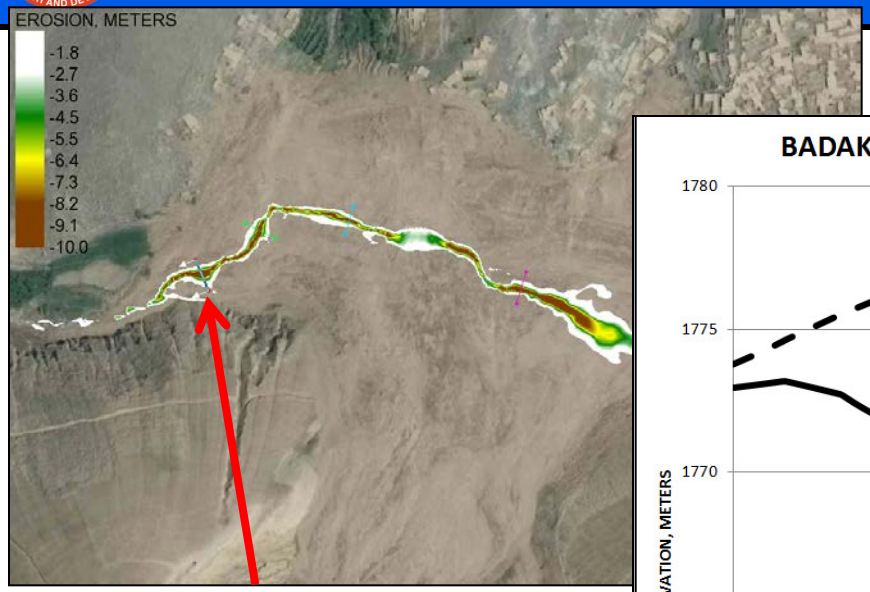
AdH/SEDLIB MODEL RESULTS

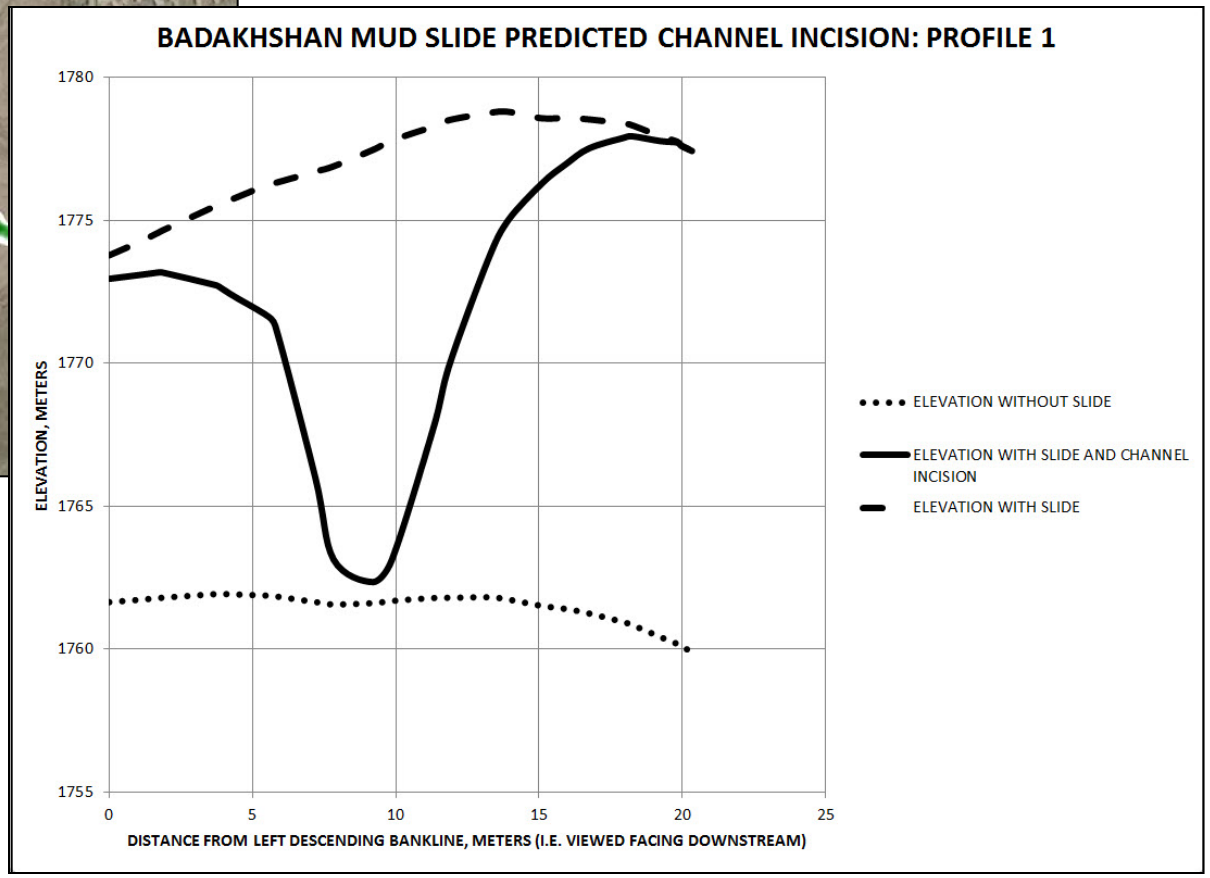
Note: erosion ex… …pieces. The 10… …contour limit… …alization pur…

AdH/SEDLIB MODEL RESULTS

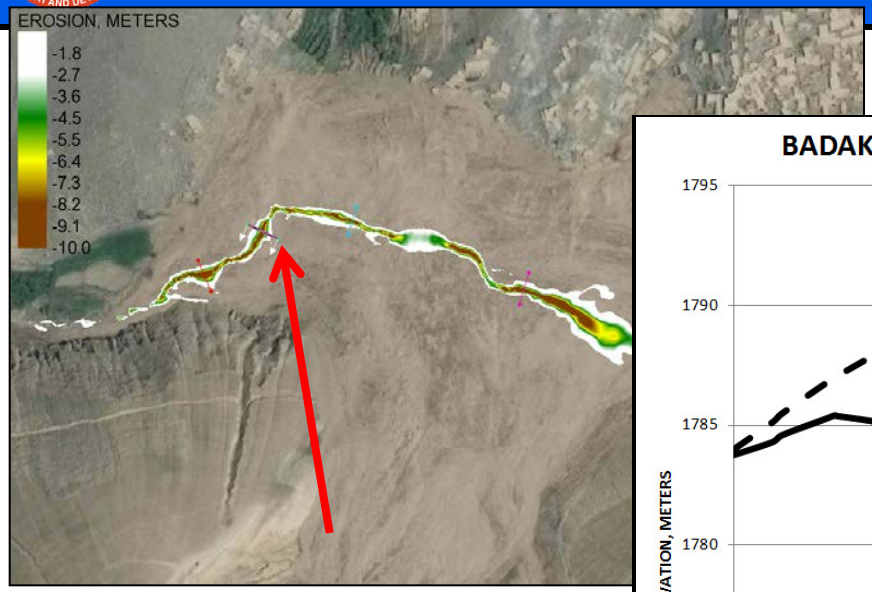
Note: erosion exceeds 2.0 m in some places; the 10 m contour limit is for visualization purp

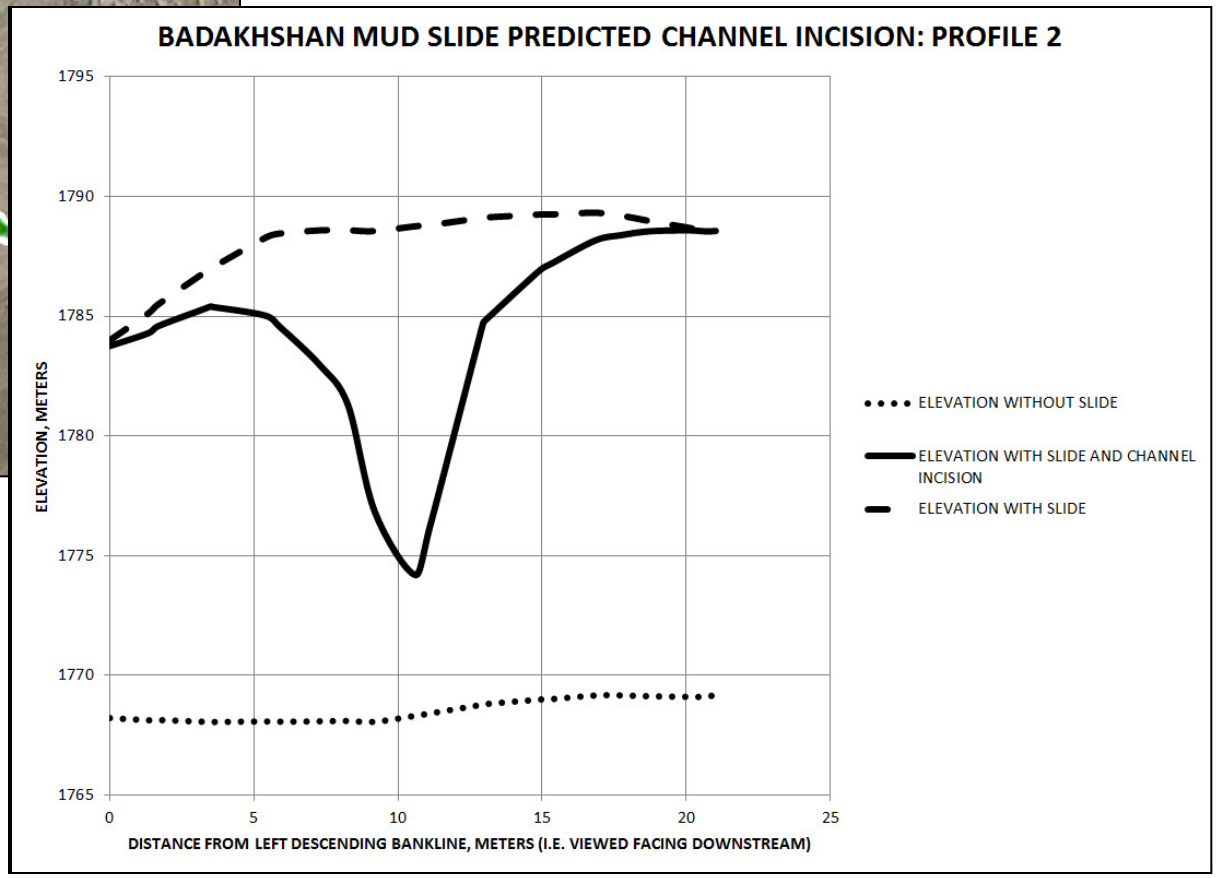
AdH/SEDLIB MODEL RESULTS



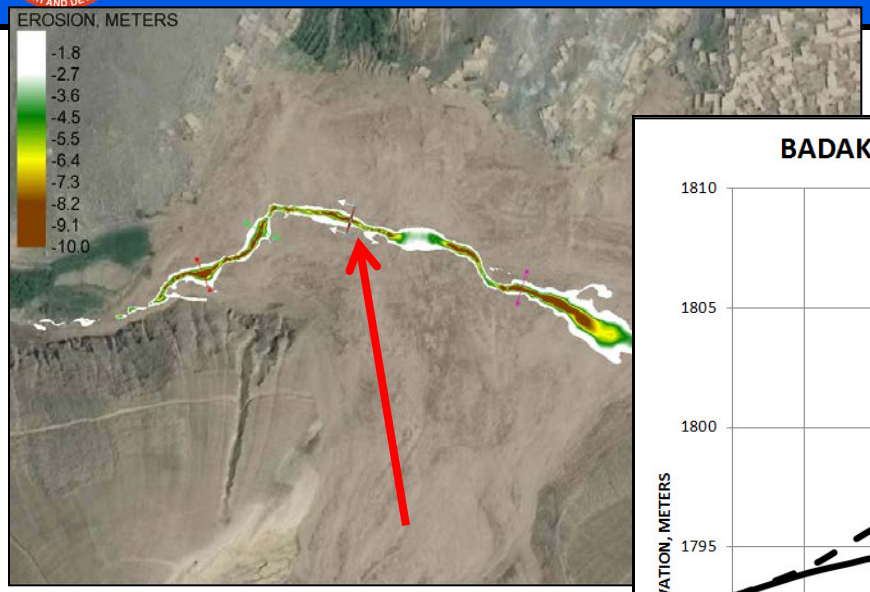


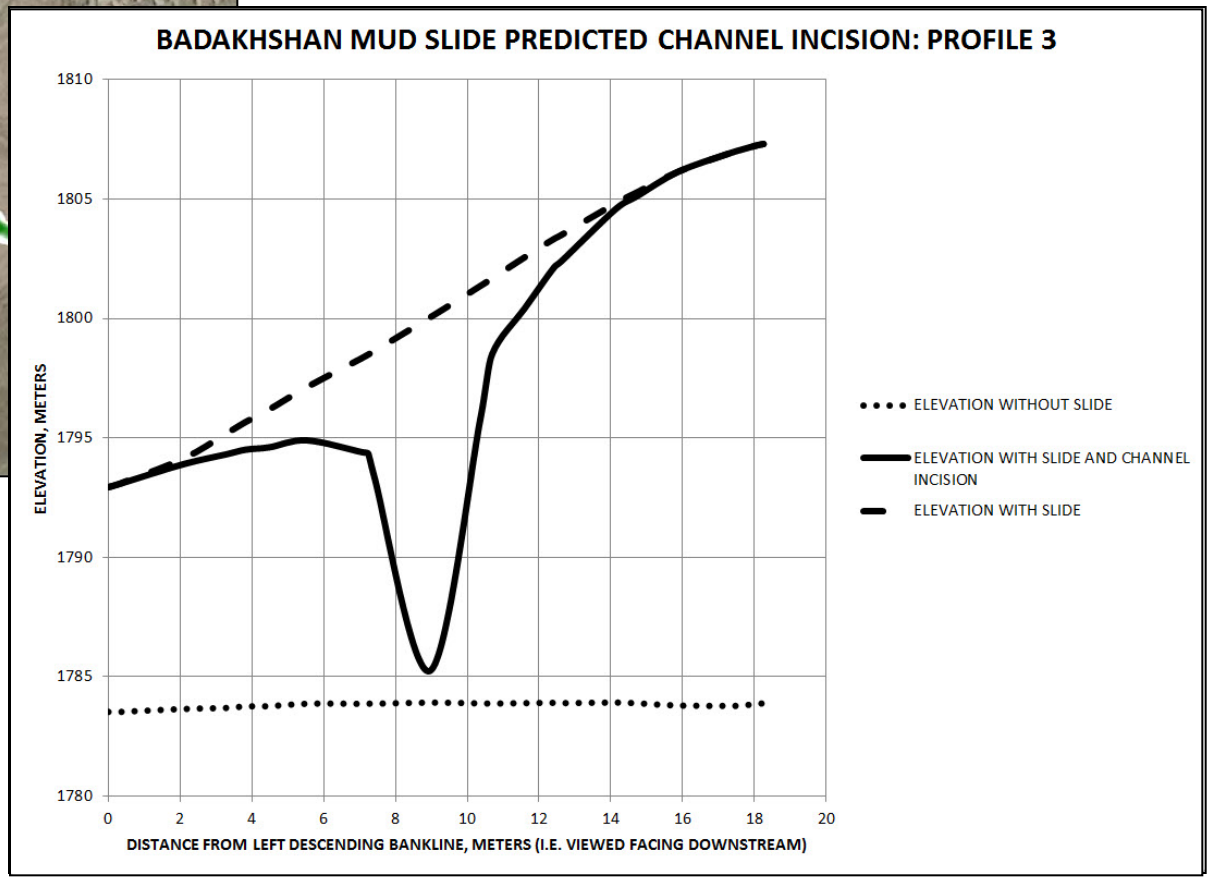
AdH/SEDLIB MODEL RESULTS



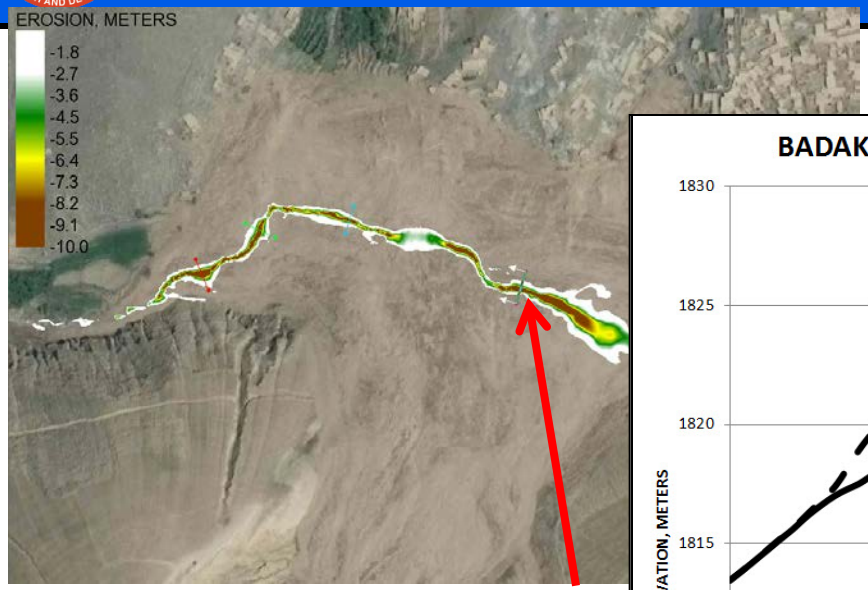


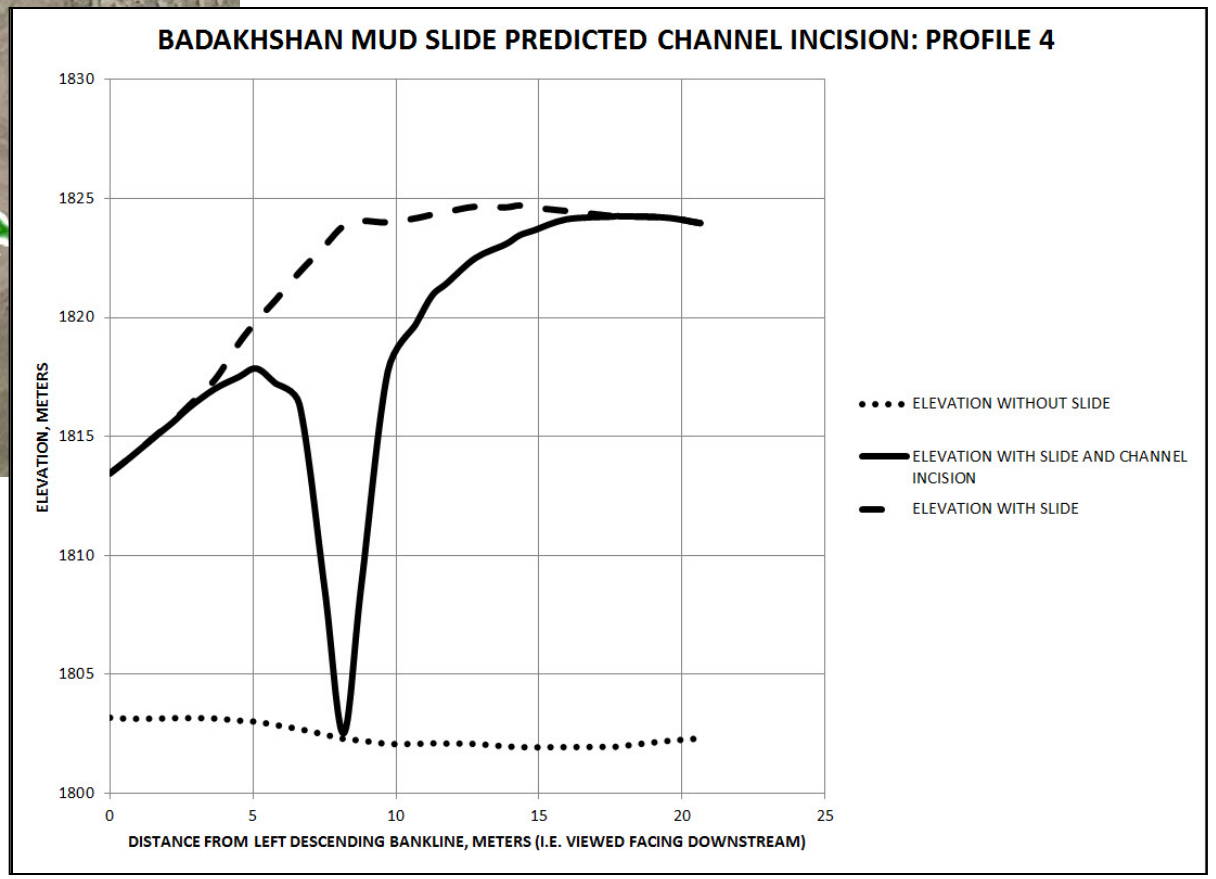
AdH/SEDLIB MODEL RESULTS





AdH/SEDLIB MODEL RESULTS





SEDLIB Example: Lower White River

AdH/SEDLIB model investigation of the sedimentation response to a proposed levee setback

The model showed that the river will have a tendency to rebuild the levee, as its location coincides with the location of the natural levee.