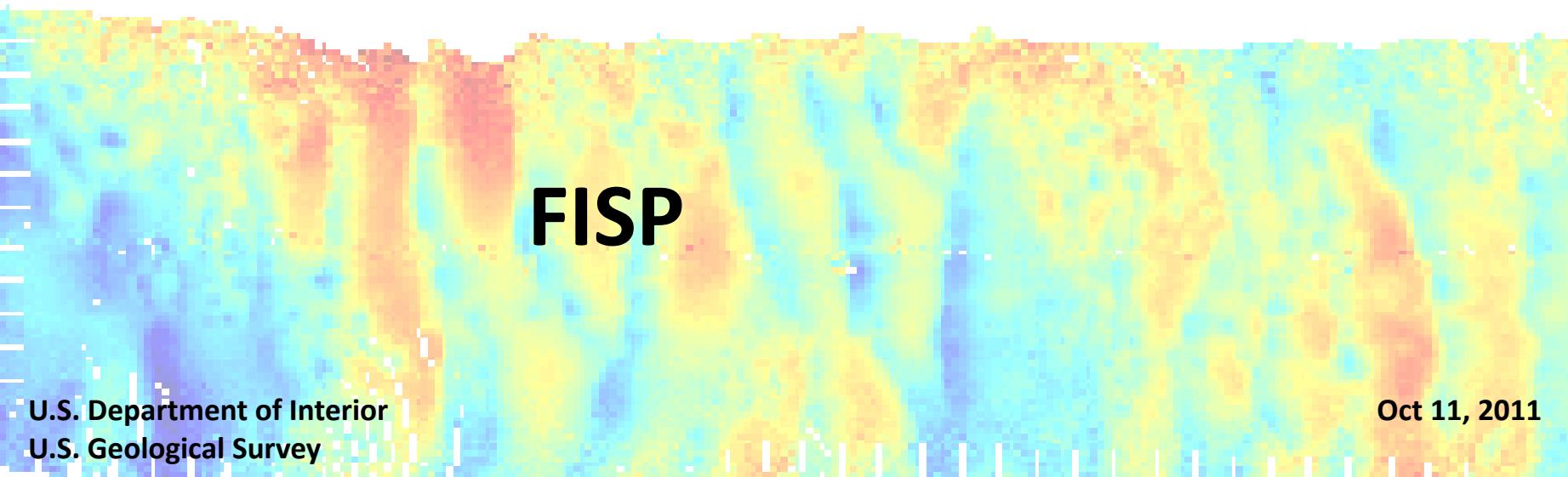


DISTINGUISHING BED-LOAD AND BED-MATERIAL-LOAD FLUXES WITH REPEAT BATHYMETRIC DATA



Brandon McElroy
USGS

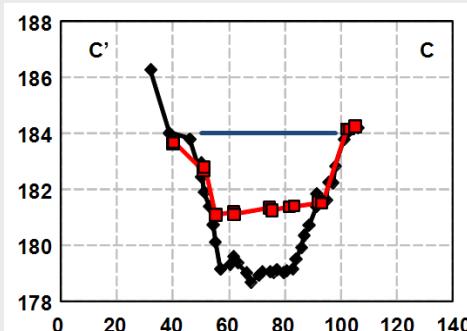
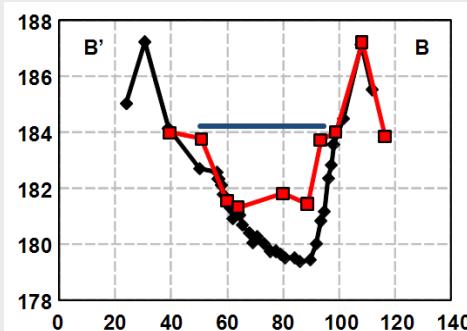
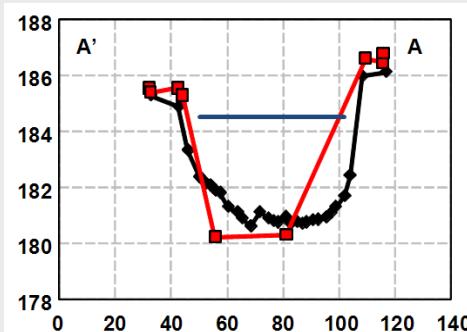
David Abraham
USACE



FISP

Why (Sand) Bed-Material-Load?

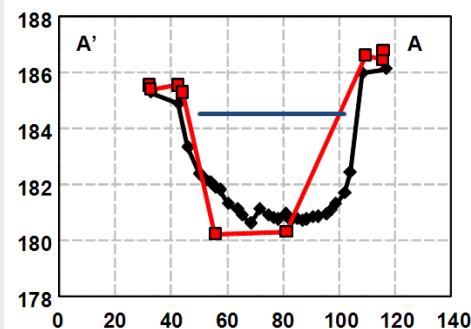
Geomorphic Change



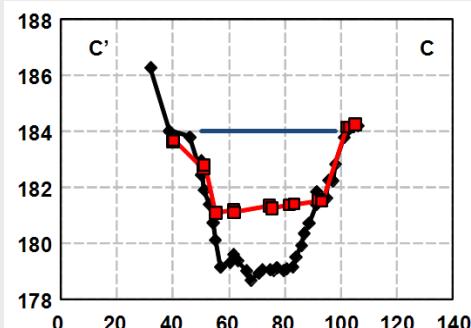
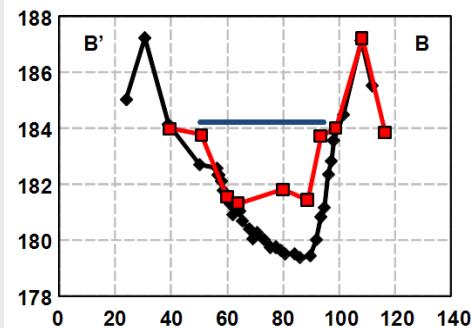
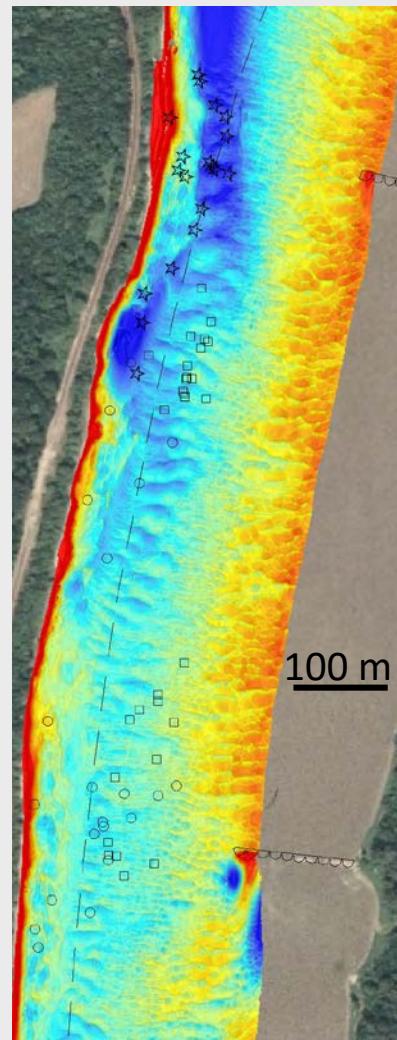
— 2007 USACE Survey
— 2009 USGS Survey
— 2009 Water Surface
All distances in meters

Why (Sand) Bed-Material-Load?

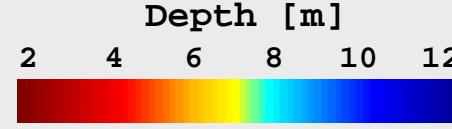
Geomorphic Change



Physical Habitat

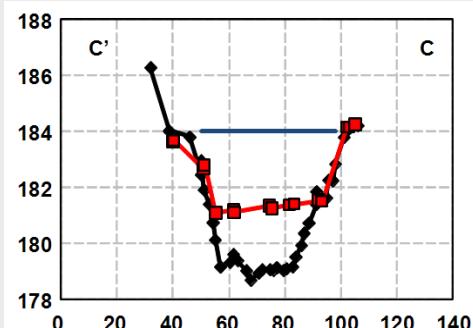
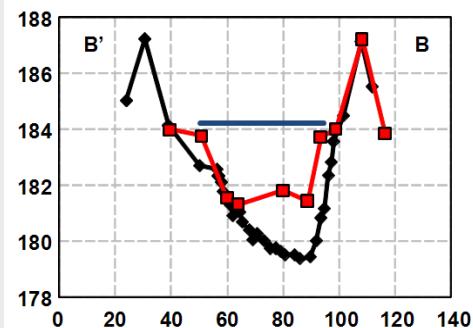
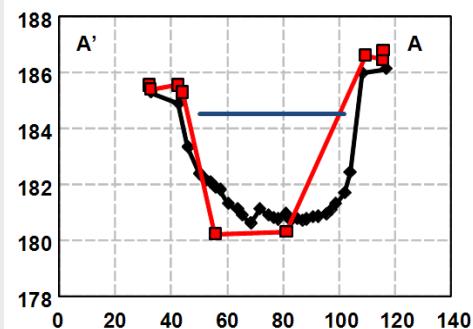


2007 USACE Survey
 2009 USGS Survey
 2009 Water Surface
All distances in meters



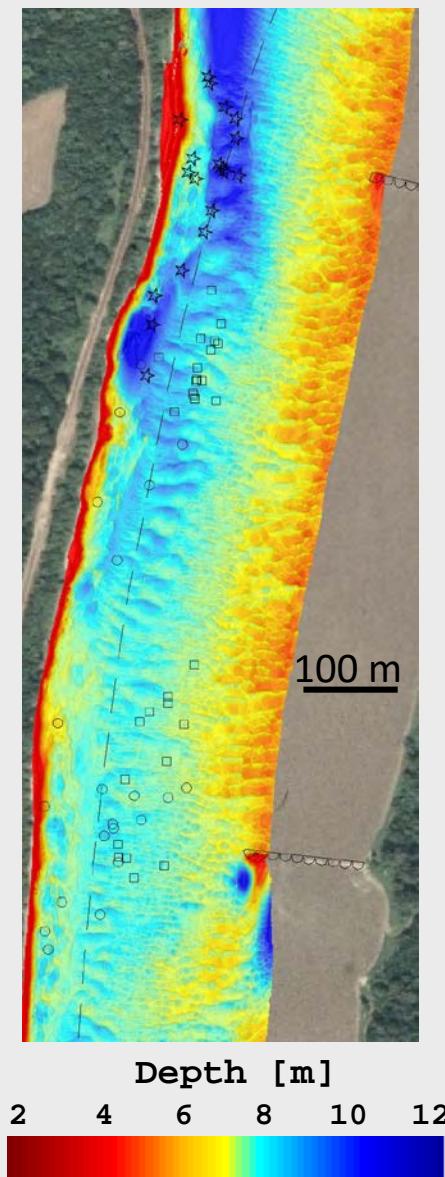
Why (Sand) Bed-Material-Load?

Geomorphic Change

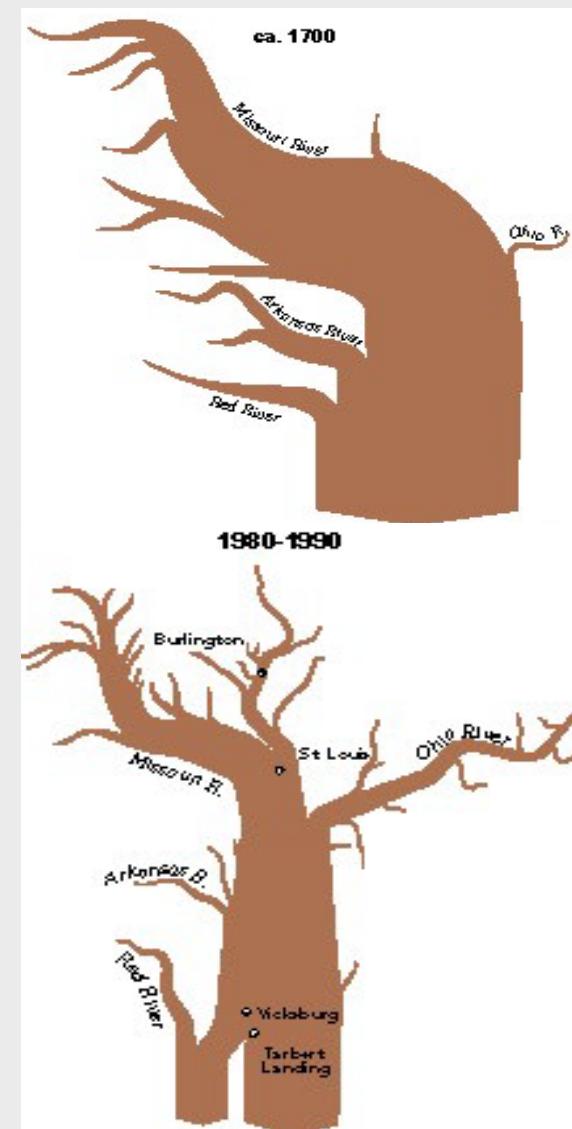


— 2007 USACE Survey
— 2009 USGS Survey
— 2009 Water Surface
All distances in meters

Physical Habitat

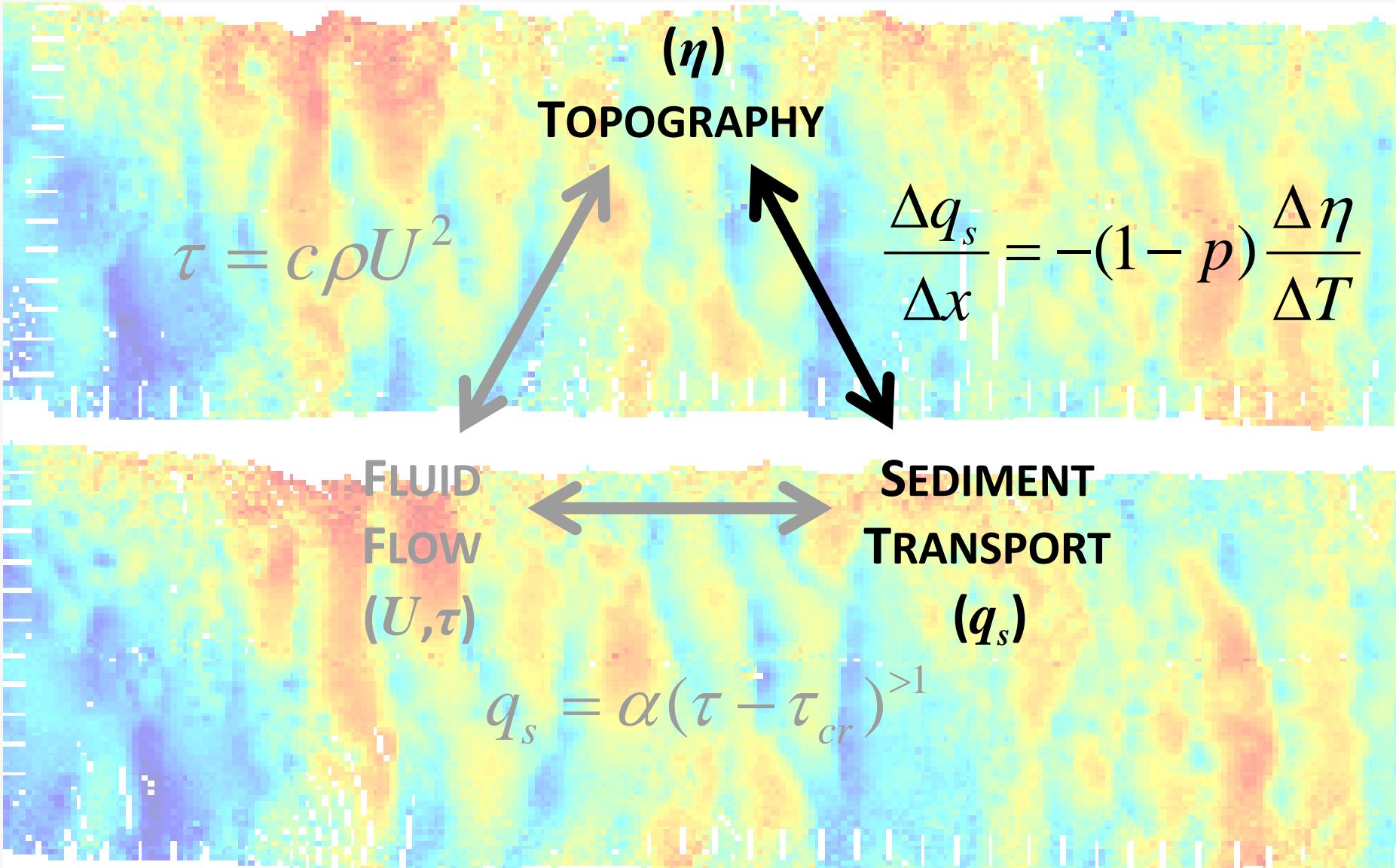


Sediment Budgets

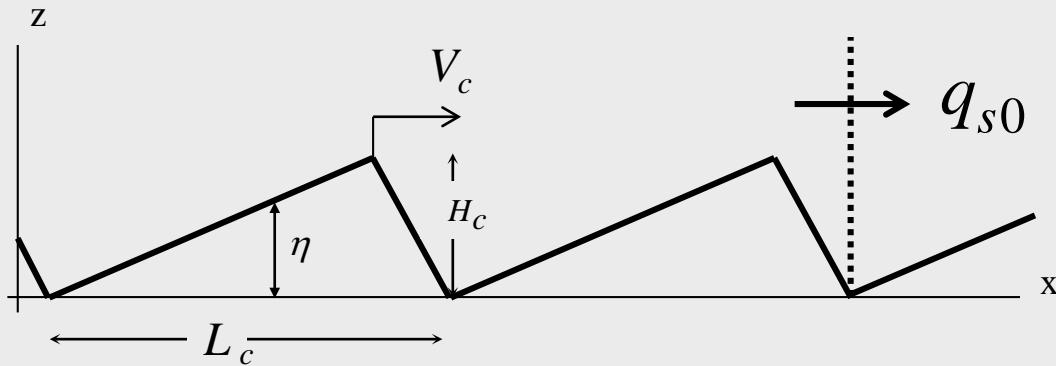


[Meade, 1995]

Why Repeat Bathymetric Data?



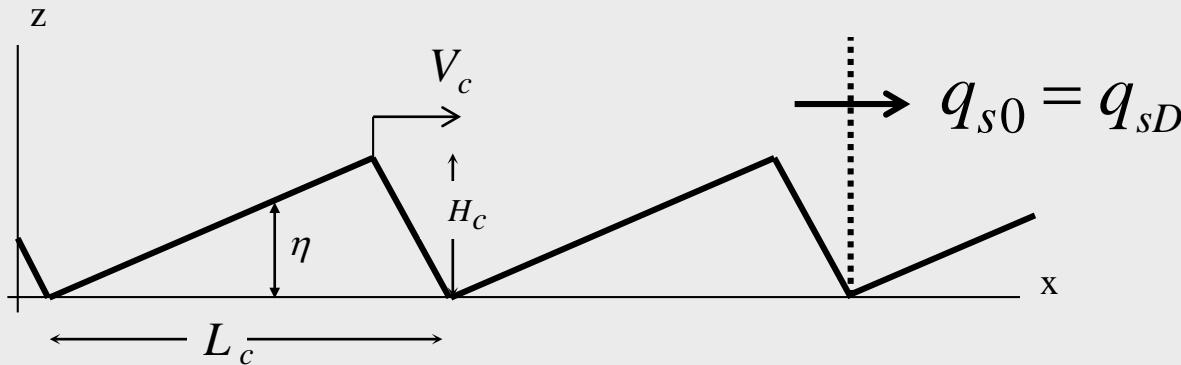
Quantitative Framework for Fluxes from Bed Evolution



$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T}$$

$$\langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

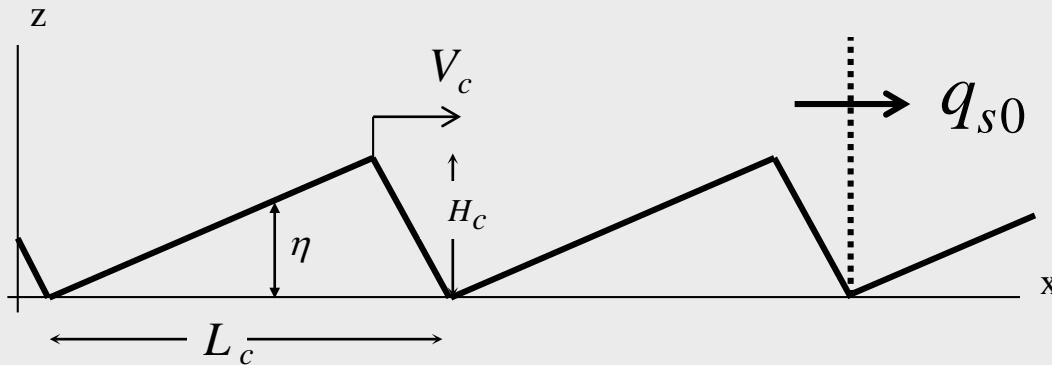
Quantitative Framework for Fluxes from Bed Evolution



$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T} \quad \langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

$$q_s = q_{sT} + q_{sD} = \text{TRANSLATIVE FLUX} + \text{DEFORMATIVE FLUX}$$

Quantitative Framework for Fluxes from Bed Evolution



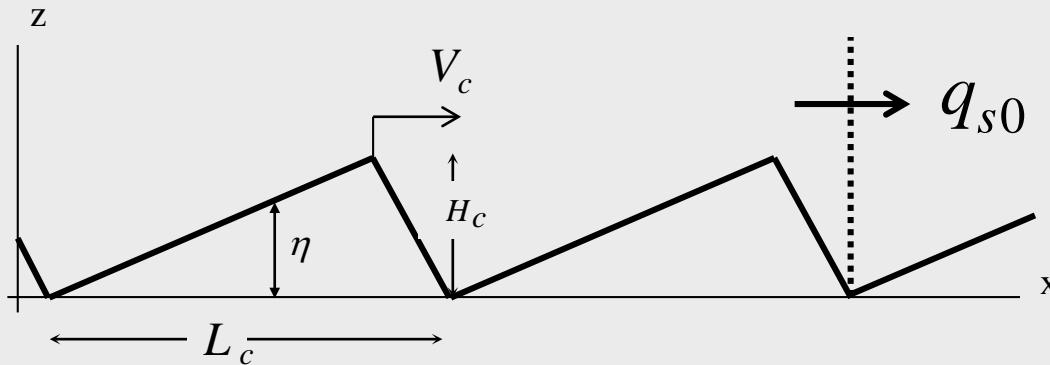
$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T}$$

$$\langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

$$\frac{\Delta \eta}{\Delta T} + V_c \frac{\Delta \eta}{\Delta x} = 0$$

Translationally invariant bed topography

Quantitative Framework for Fluxes from Bed Evolution



$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T}$$

$$\langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

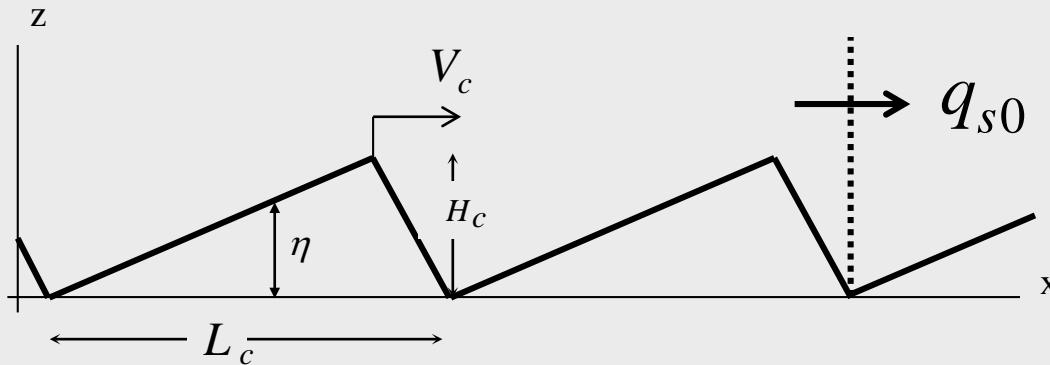
~~$\frac{\Delta \eta}{\Delta T} + V_c \frac{\Delta \eta}{\Delta x} = 0$~~

Translationaly invariant bed topography

$$\frac{\Delta \eta}{\Delta T} + V_c \frac{\Delta \eta}{\Delta x} = -\Pi$$

Translation with deformation

Quantitative Framework for Fluxes from Bed Evolution



$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T}$$

$$\langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

$$\frac{\Delta \eta}{\Delta T} + V_c \frac{\Delta \eta}{\Delta x} = 0$$

Translationaly invariant bed topography

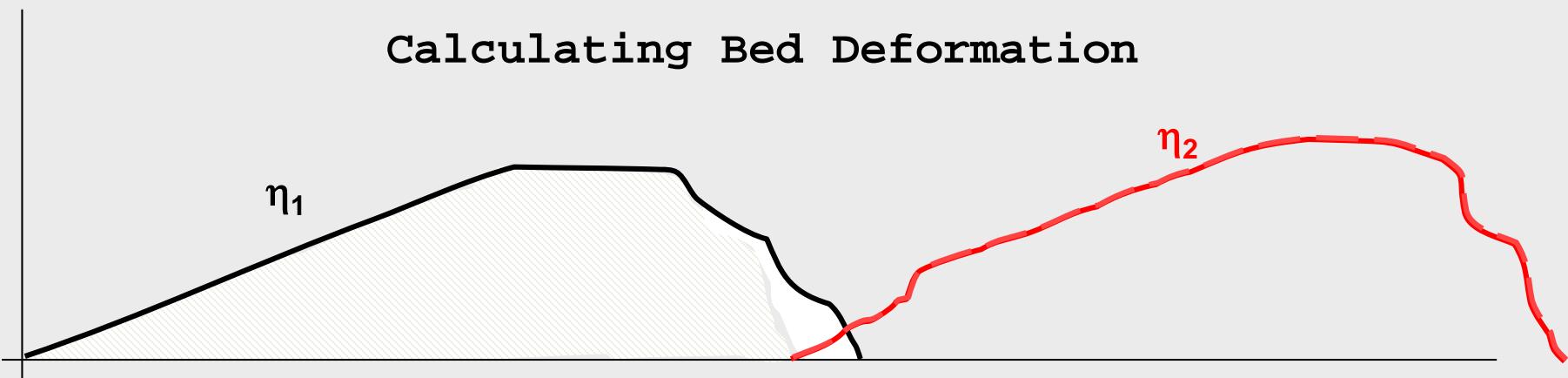
$$\frac{\Delta \eta}{\Delta T} + V_c \frac{\Delta \eta}{\Delta x} = -\Pi$$

Translation with deformation

$$\langle \Pi \rangle_{\Delta t} = 0 = \frac{1}{\Delta t} \int_{\Delta t} \Pi$$

Dynamic Equilibrium Condition

Calculating Bed Deformation



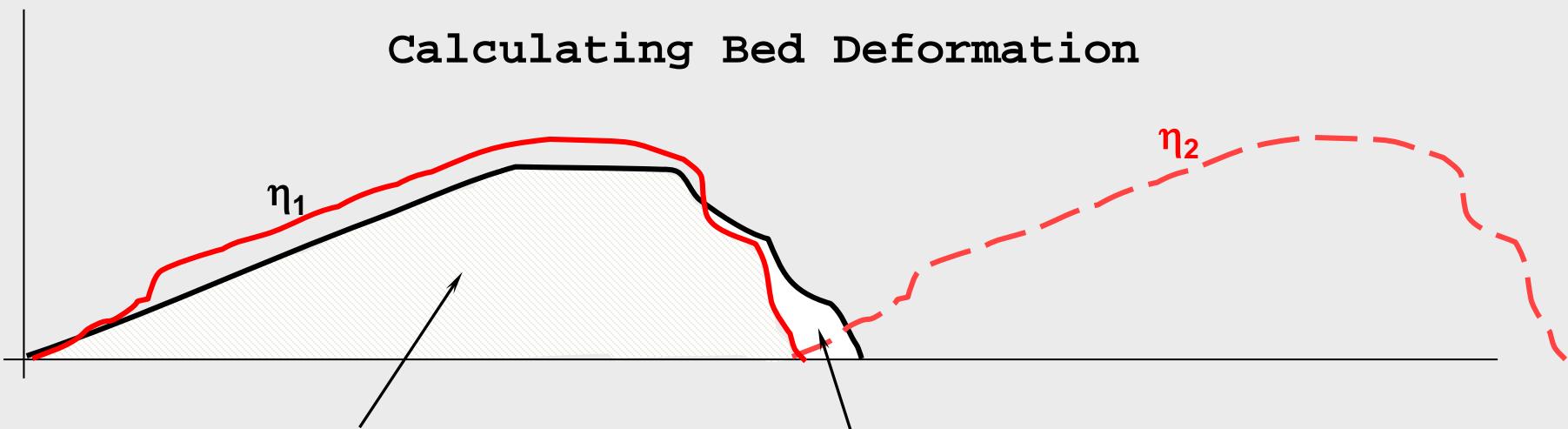
Calculating Bed Deformation



Translated Area = $\eta_1 \cap \eta_2$

Deformed Area = $(\eta_1 \cap \eta_2^c)$; $\eta_1 > \eta_2$

Calculating Bed Deformation



Translated Area = $\eta_1 \cap \eta_2$

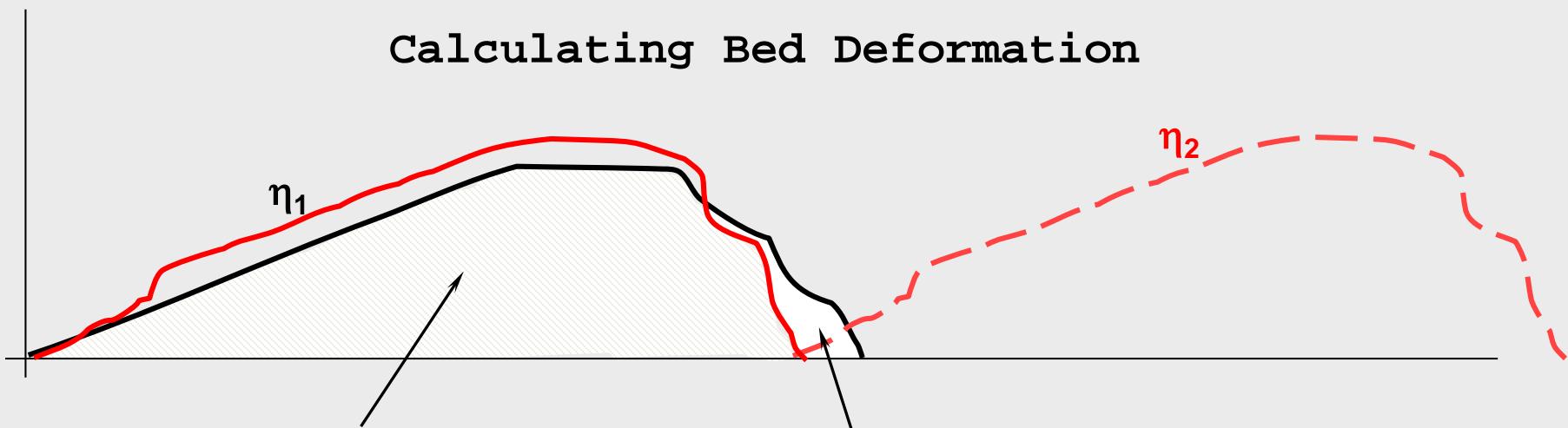
Deformed Area = $(\eta_1 \cap \eta_2^c)$; $\eta_1 > \eta_2$

$$D = \frac{\Delta x}{2N} \sum_x |\Pi| \quad \Pi = \frac{|\eta(x + V_c \Delta t, t_2) - \eta(x, t_1)|}{\Delta t}$$

D = Deformation rate

- Mean absolute elevation change summed over the bed domain
- Measurement spacing (along profile)
- Number of measurements (in profile)
- Time of bed evolution

Calculating Bed Deformation



Translated Area = $\eta_1 \cap \eta_2$

Deformed Area = $(\eta_1 \cap \eta_2^c)$; $\eta_1 > \eta_2$

D = Deformation rate

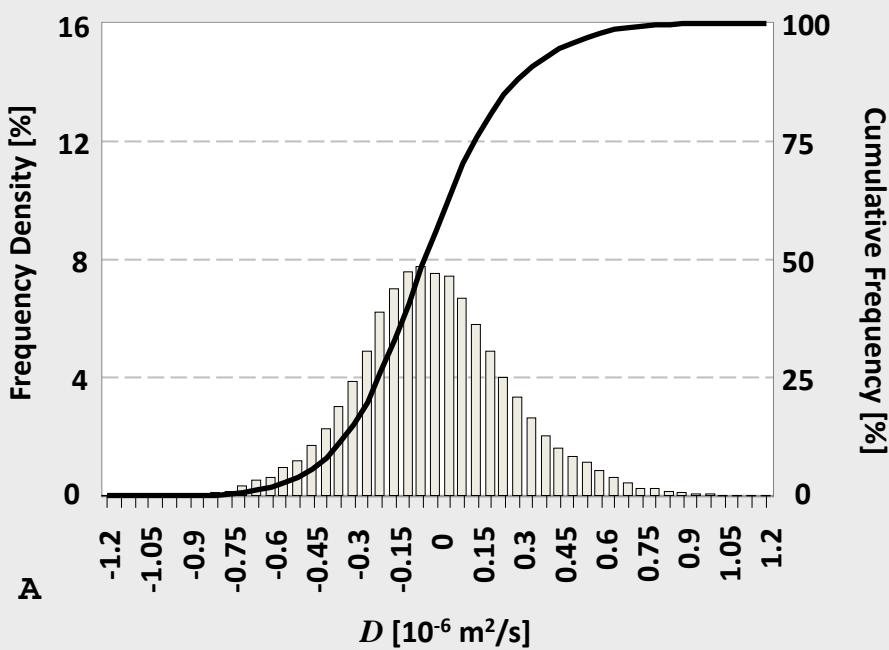
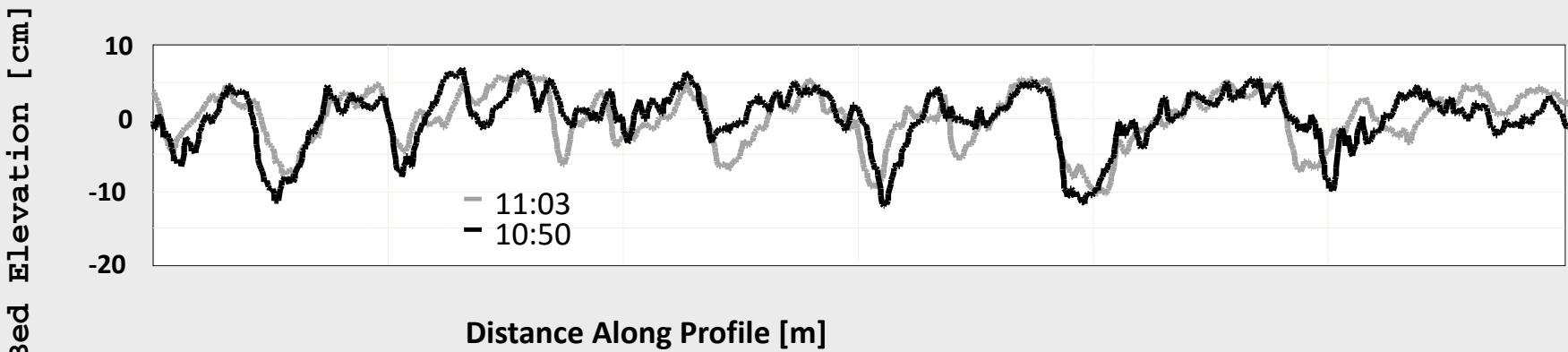
~ vertical changes exclusive of net
translation summed over reach

$$D = \frac{\Delta x}{2N} \sum_x |\Pi|$$

$$q_{sD} = (1 - p)D \frac{V_s}{w_s}$$

Deformation Flux

Calculating Deformation Flux



$$q_{sD} = (1-p)D \frac{V_s}{w_s}$$

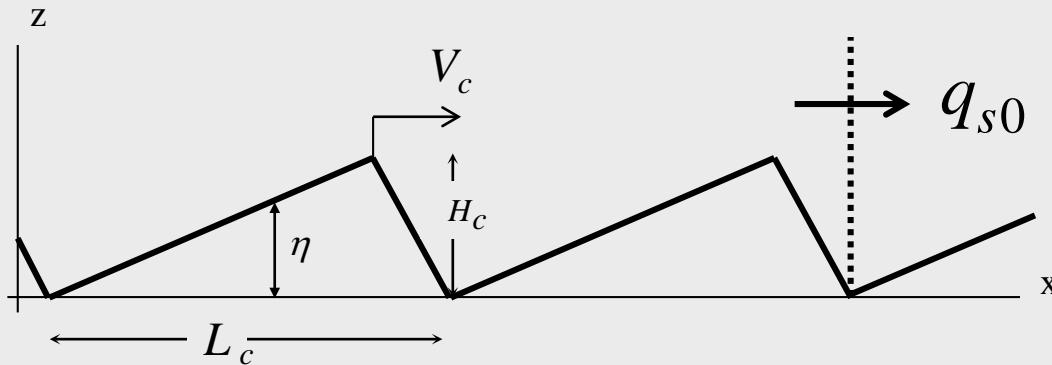
Flux estimates

$$q_{sD} = 1.4 \times 10^{-5} \text{ m}^2/\text{s}$$

$$q_{sT} = 2.2 \times 10^{-5} \text{ m}^2/\text{s}$$

q_{sD} ~39% of total

Quantitative Framework for Fluxes from Bed Evolution

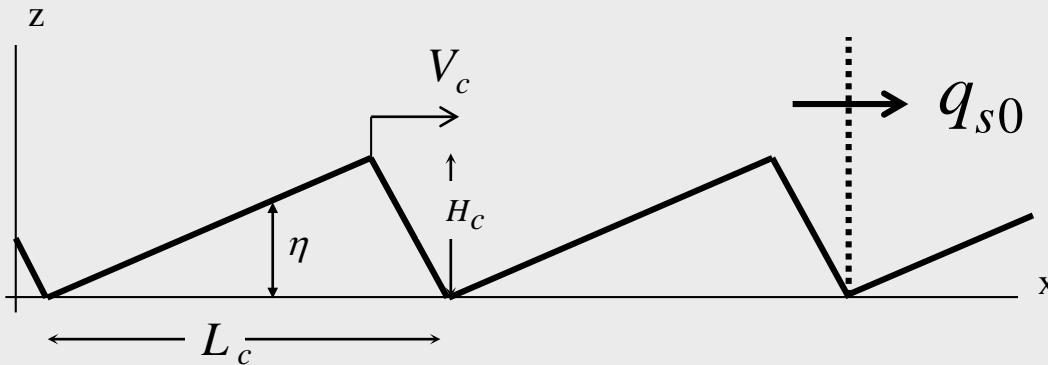


$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T} \quad \langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

$$q_s = q_{sT} + q_{sD} = \text{TRANSLATIVE FLUX} + \text{DEFORMATIVE FLUX}$$

With the condition of statistical steady-state

Quantitative Framework for Fluxes from Bed Evolution



$$\frac{\Delta q_s}{\Delta x} = -(1-p) \frac{\Delta \eta}{\Delta T} \quad \langle q_s \rangle = \frac{1}{L_c} (1-p) V_c \left(\frac{H_c L_c}{2} \right) + q_{s0}$$

$q_s = q_{sT} + q_{sD} = \text{TRANSLATIVE FLUX} + \text{DEFORMATIVE FLUX}$

With the condition of statistical steady-state

$q_s = q_{sT} + q_{sD} = \text{bed load} + \text{suspended bed material load}$

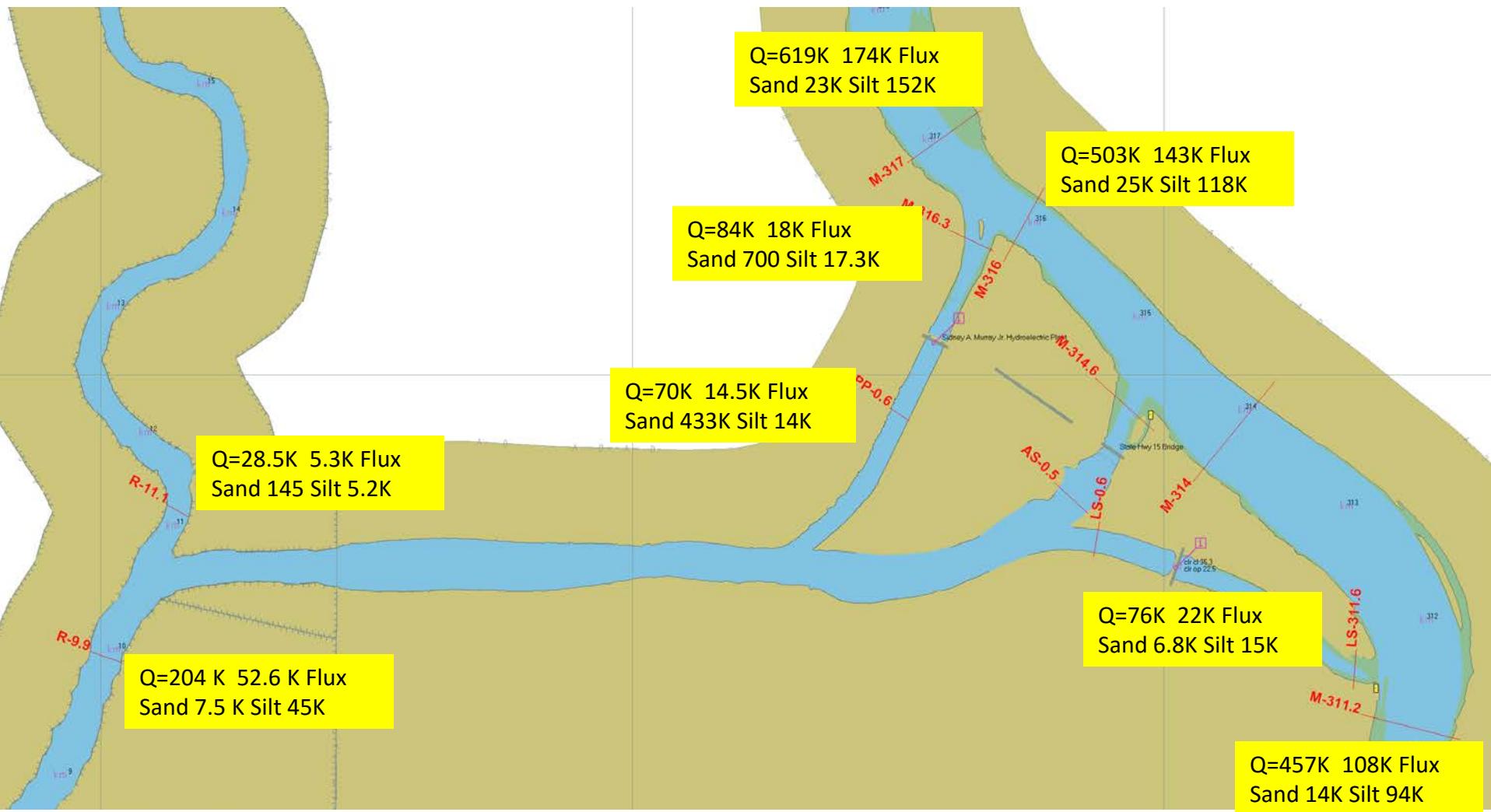
DISTINGUISHING BED-LOAD AND BED-MATERIAL-LOAD FLUXES WITH REPEAT BATHYMETRIC DATA

David Abraham & Brandon McElroy

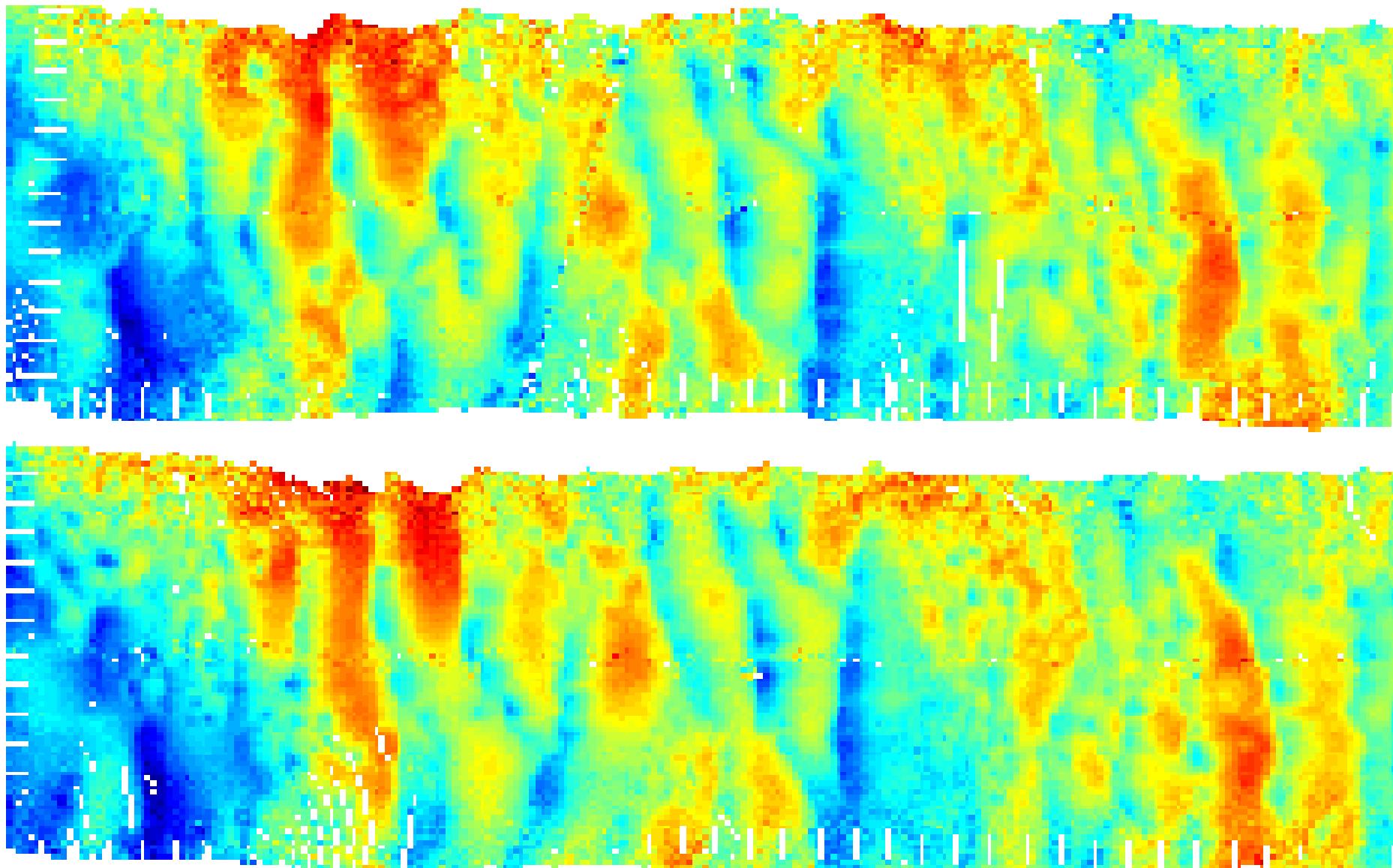
$$\frac{\text{Bed Material Load} - \text{Bed Load}}{\text{Suspended Bed Material Load}}$$

Federal Interagency Sedimentation Project

April 29-30 Survey



Repeat Bathymetric Data



+ Suspended Sediment Data

