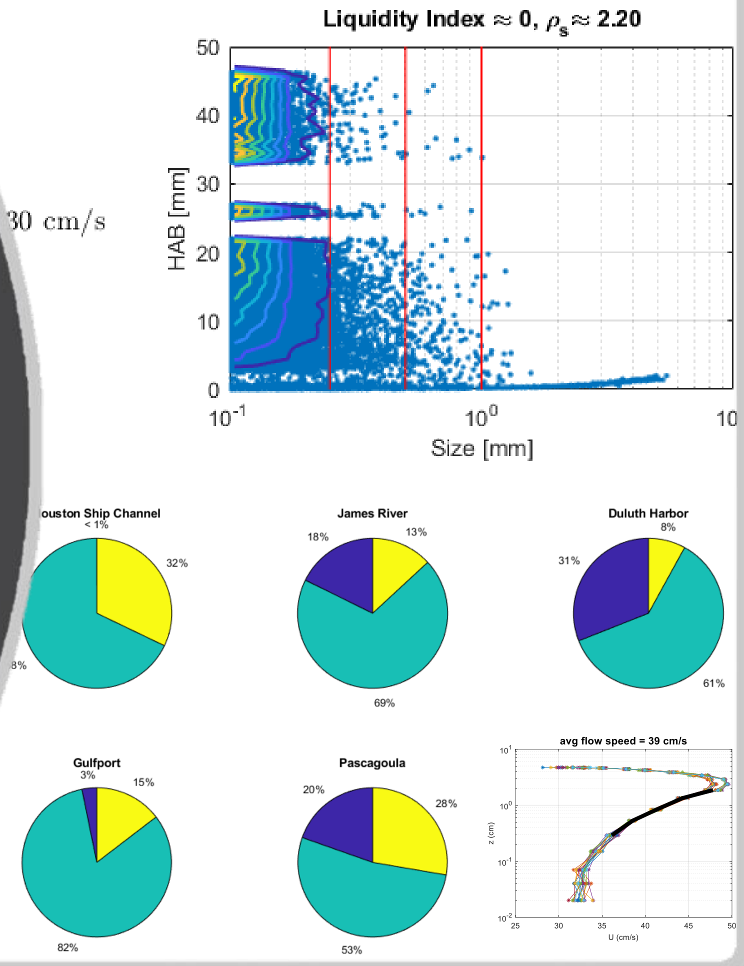
TRANSPORT MODE OF MARINE AGGREGATES



Coastal Inlets Research Program
Vicksburg, MS
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Aggregates in the Environment

Research & Development - Aggregate Transport

Aggregate Erosion

- What are the initial states of aggregation upon erosion? What sediment properties control aggregate size?

Aggregate Durability

- What rate do bed aggregates break-up? Is there a minimum size of breakup? What sediment properties relate to aggregate durability?
- What mechanism are aggregates transported (bedload, suspended load)?

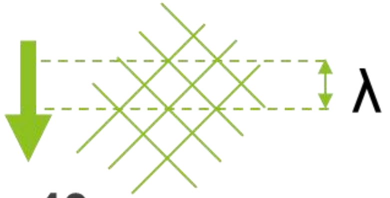
Modeling Framework

- Presently developing a flexible modeling framework and library to accommodate aggregate transport processes.

Aggregate Durability Flume

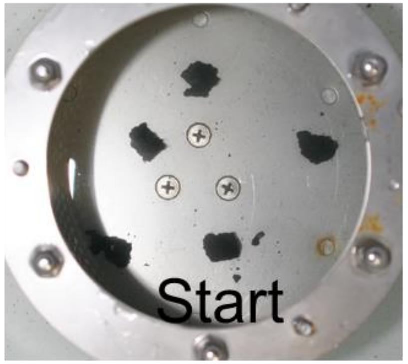
Flume

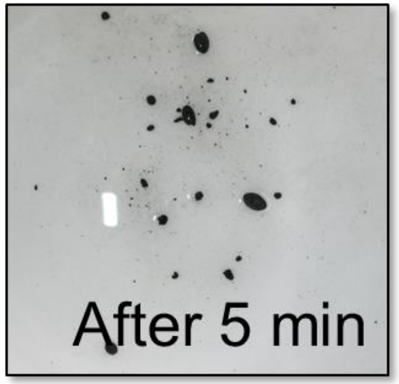
- Oscillating flume
- 5 x 10 cm rectangular test section
- Bottom roughness (0.5 mm crosshatch)
- Flow speeds (laser velocimetry) 30, 40 and 50 cm/s

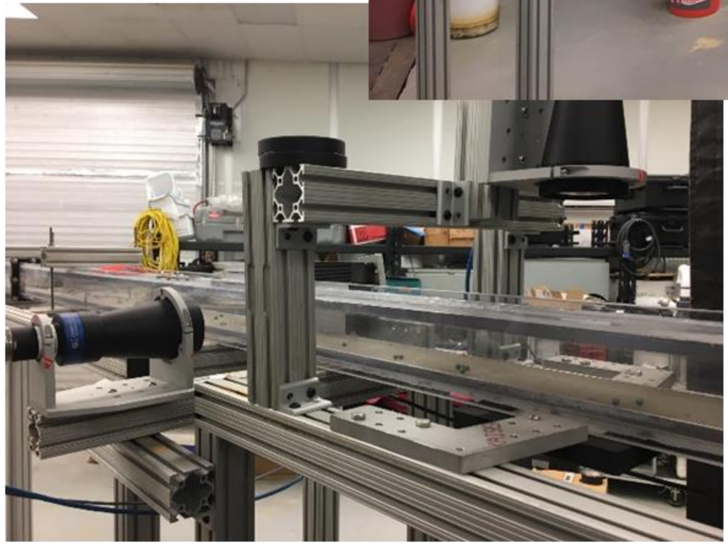


Transport Modes

- Bedload – side looking video camera
- Suspended Load – video profile (5 cm depth)





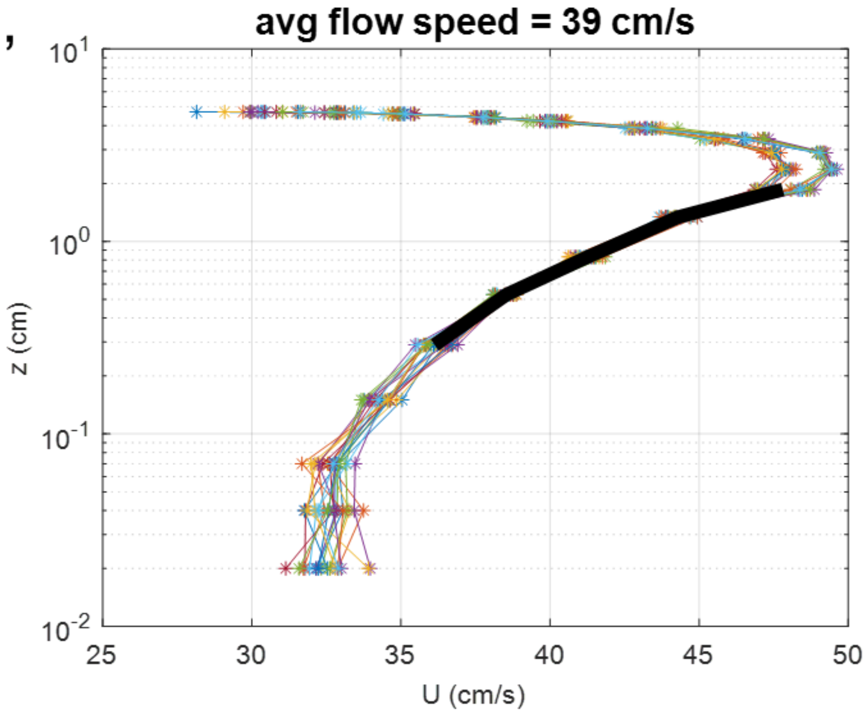


Size determined by flow visualization PICS

Bed Shear Stress Measurements

- Conducted uniform flow measurements
- Measured bottom stress using the 'law of the wall'
- Repeated in the oscillatory flume

$$\frac{u}{u_*} = \frac{1}{k}\ln\left(\frac{z}{z_o}\right)$$



Oscillatory flume

Re = 18,784
z_0 = 0.00123 cm
u_* = 1.84 cm/s

Re = 24,419
z_0 = 0.00127 cm
u_* = 2.55 cm/s

Re = 30,156
z_0 = 0.00189 cm
u_* = 3.17 cm/s

Steady flow measurements

u_* = 1.98 cm/s @ 30 cm/s
= 2.49 cm/s @ 40 cm/s
= 3.05 cm/s @ 50 cm/s

z_0 = 0.0018 cm @ 30 cm/s
= 0.0015 cm @ 40 cm/s
= 0.0016 cm @ 50 cm/s

$z_0 = k_b/30$
k_b = 0.05 cm
z_0 = 0.0016667 cm

Sediment Characteristics

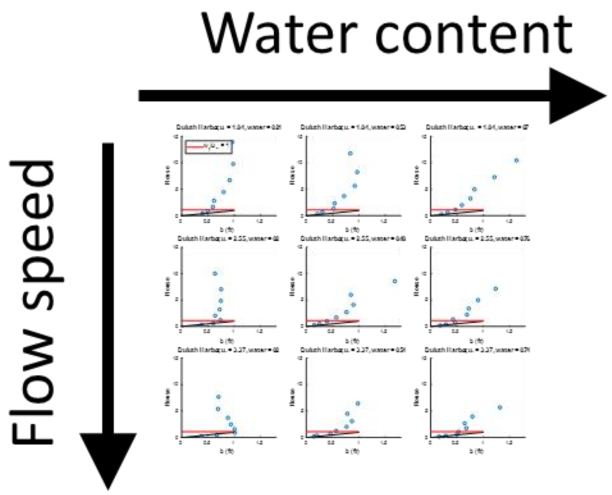
Sediment Source

- Aggregates obtained from 5 sources:
- Duluth Harbor, Houston Ship Channel, Gulfport, Pascagoula (Ship Island), & James River

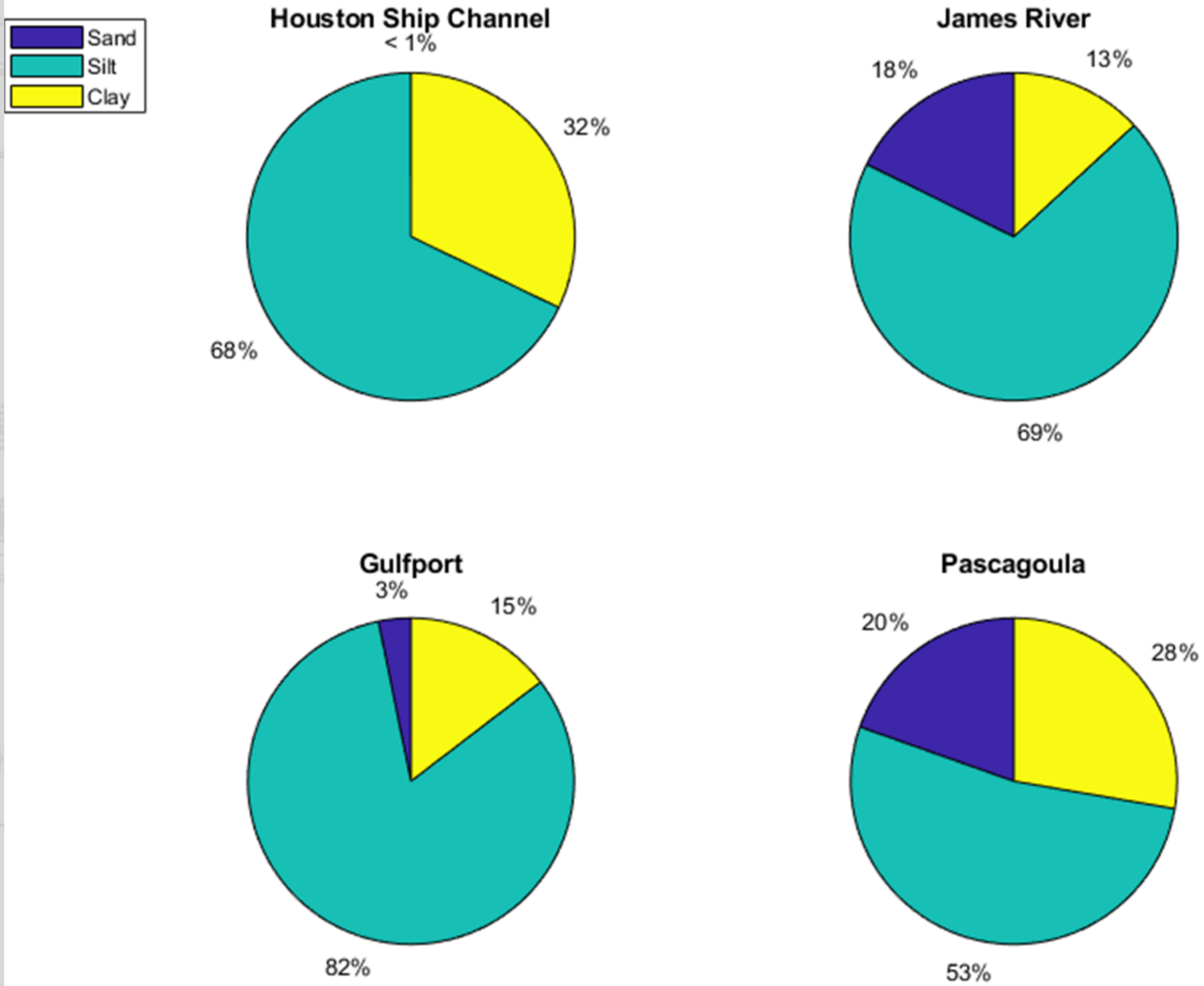
Sediment Preparation

- Prepared with three different densities (water content) plastic/liquid limit
- Cut into 5 mm cubes
- Three different bed stresses

9 x 9 testing matrix
3 flow velocities
3 densities

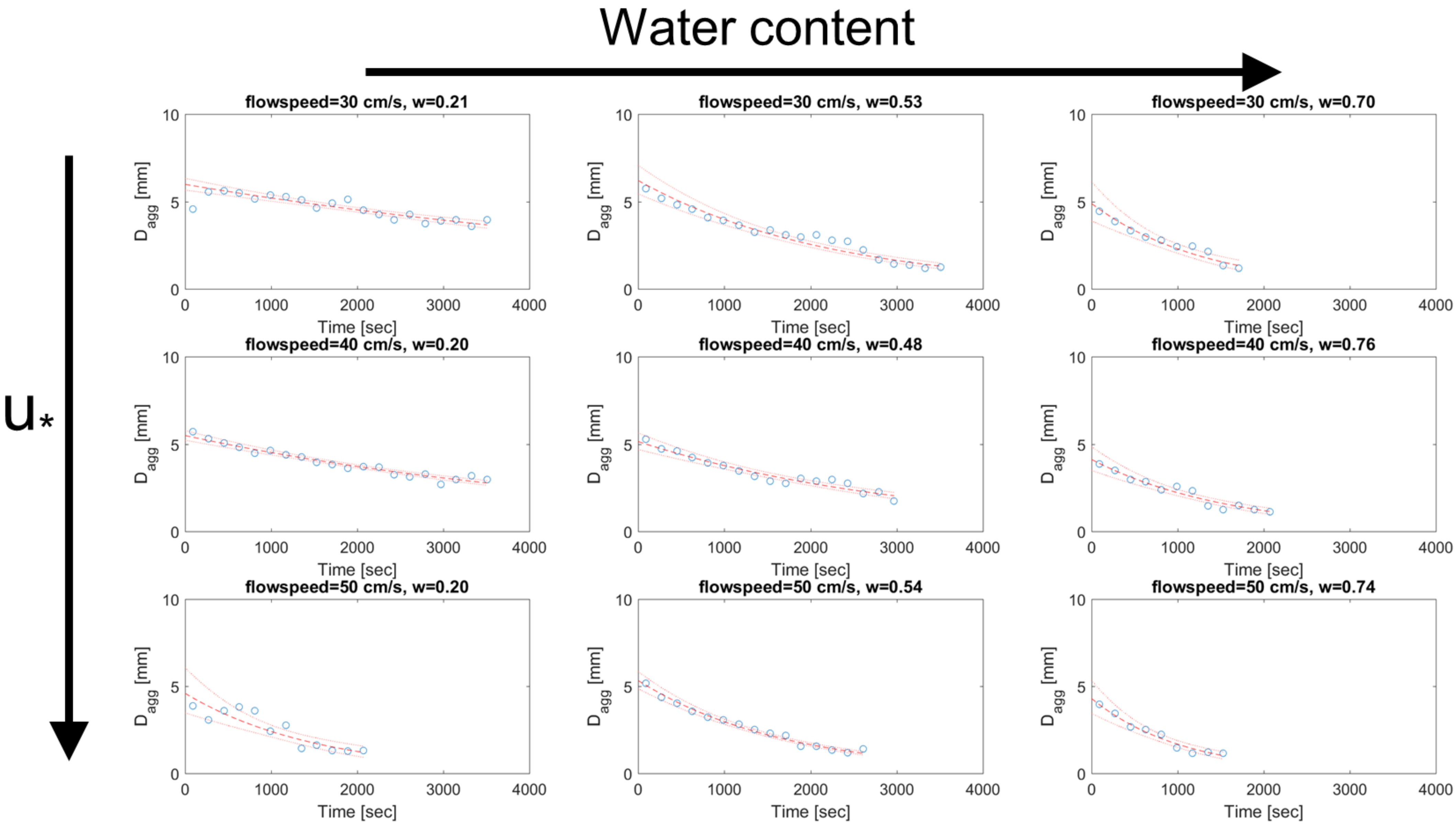


Sediment Distribution



Sample	Plastic Index	Activity	% Organic (LOI)
Houston Ship Channel	0.44	1.4	0.35
James River	0.6	4.6	4.47
Duluth Harbor	0.3	3.8	3.41
Gulfport	1.08	7.2	4.58
Pascagoula	0.5	1.8	1.09

Disaggregation of Sediments



Suspended Sediment Transport Theory

$K = \kappa u_* z$ Eddy viscosity

$K_D = \gamma K = K/\beta$ Eddy diffusivity for sediment mass

$\gamma = 0.35 - 1.0 \ (0.74)$

$\gamma = 1/\beta$

Rouse = $b = w_f/\beta\kappa u_*$

Rouse profile

$$\frac{C(z)}{C_0} = \left(\frac{h-z}{z} \frac{z_0}{h-z_0} \right)^{-b}$$

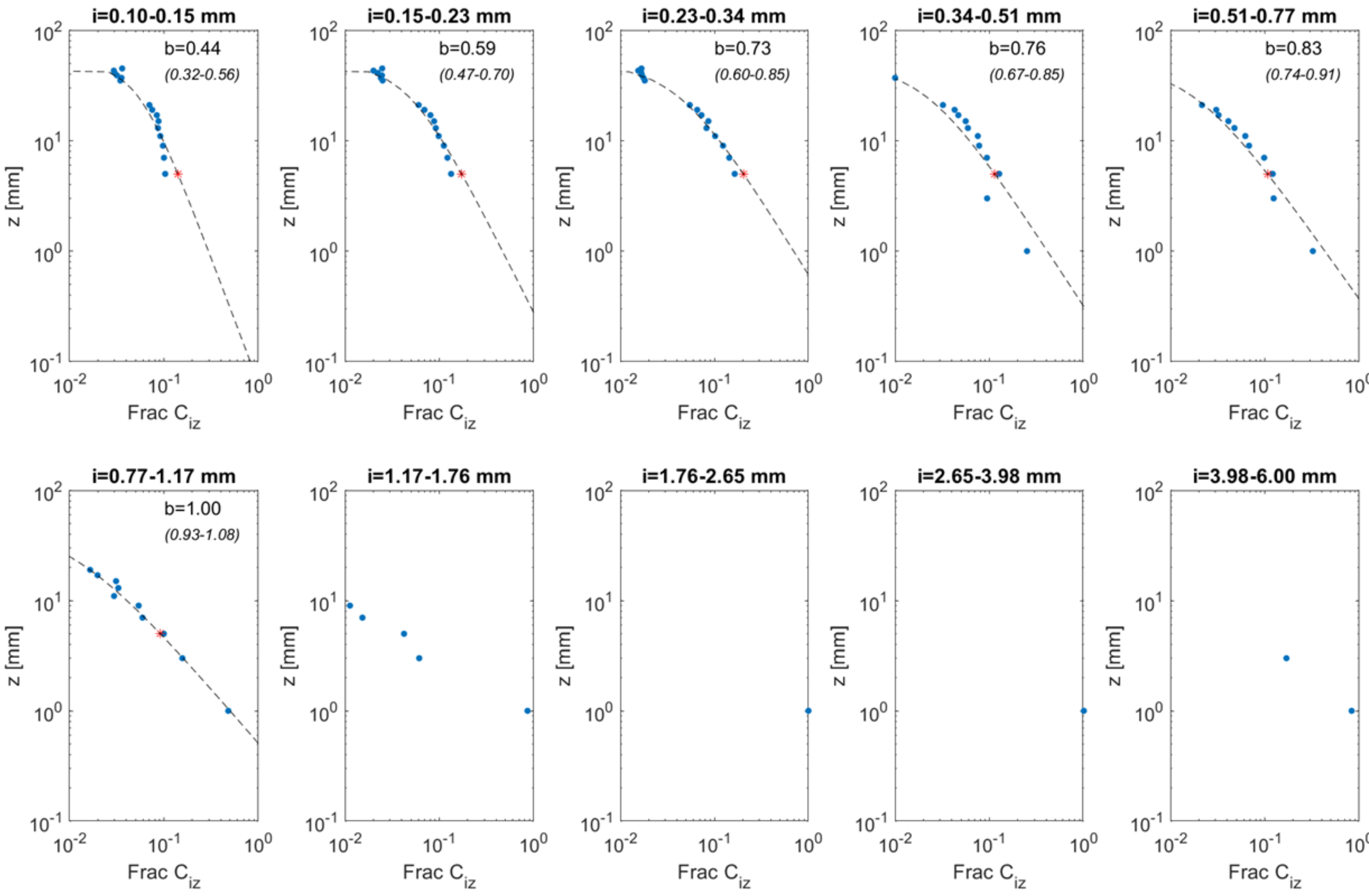
$w_f/u_* < 1$

$w_f/u_* > 1$

w_f – fall velocity
κ – von Karman constant (0.4)
h – water depth
z_0 – hydraulic roughness
u_* – shear velocity

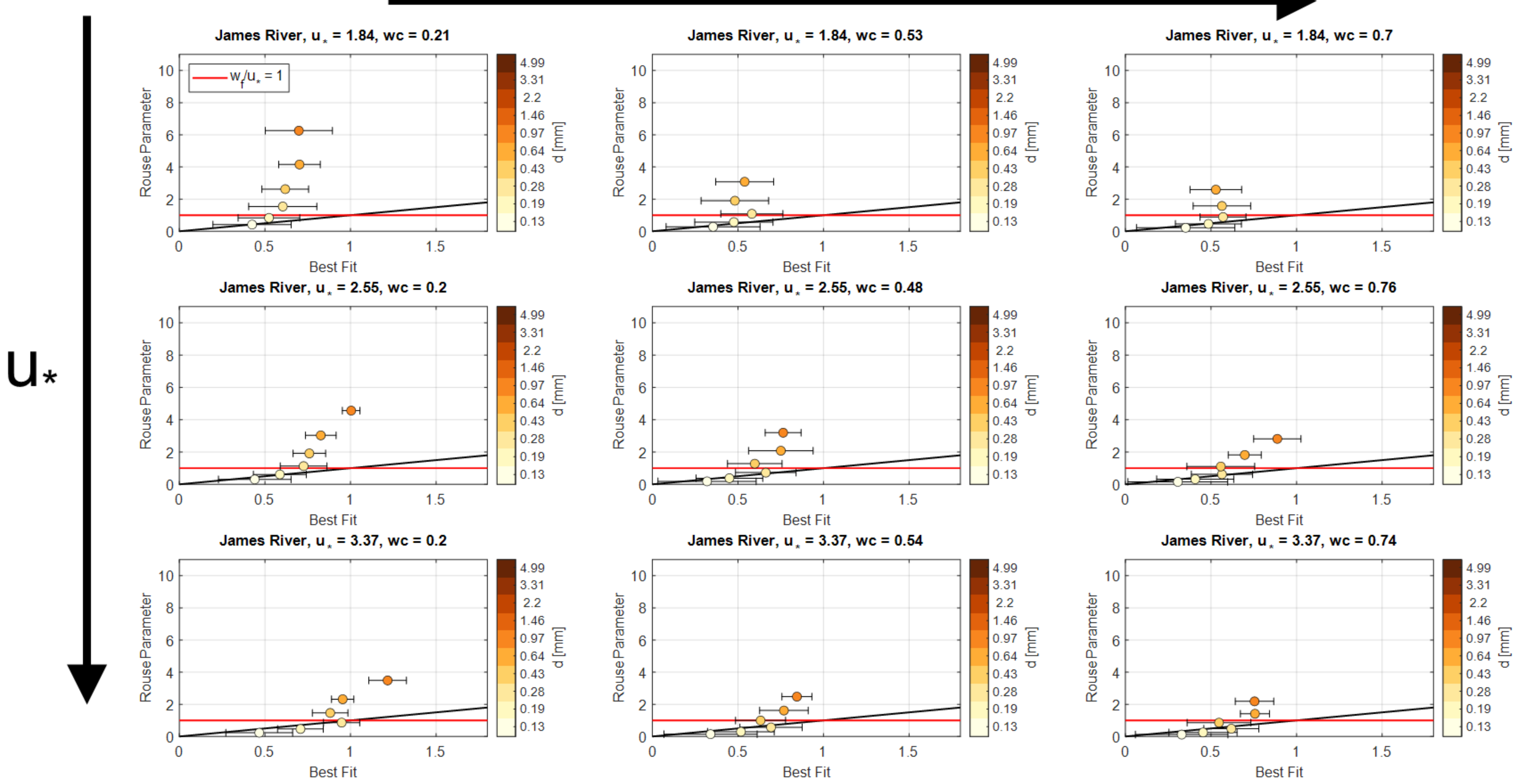
James River Concentration Profiles

Flow speed = 40 cm/s
Water content = 0.26

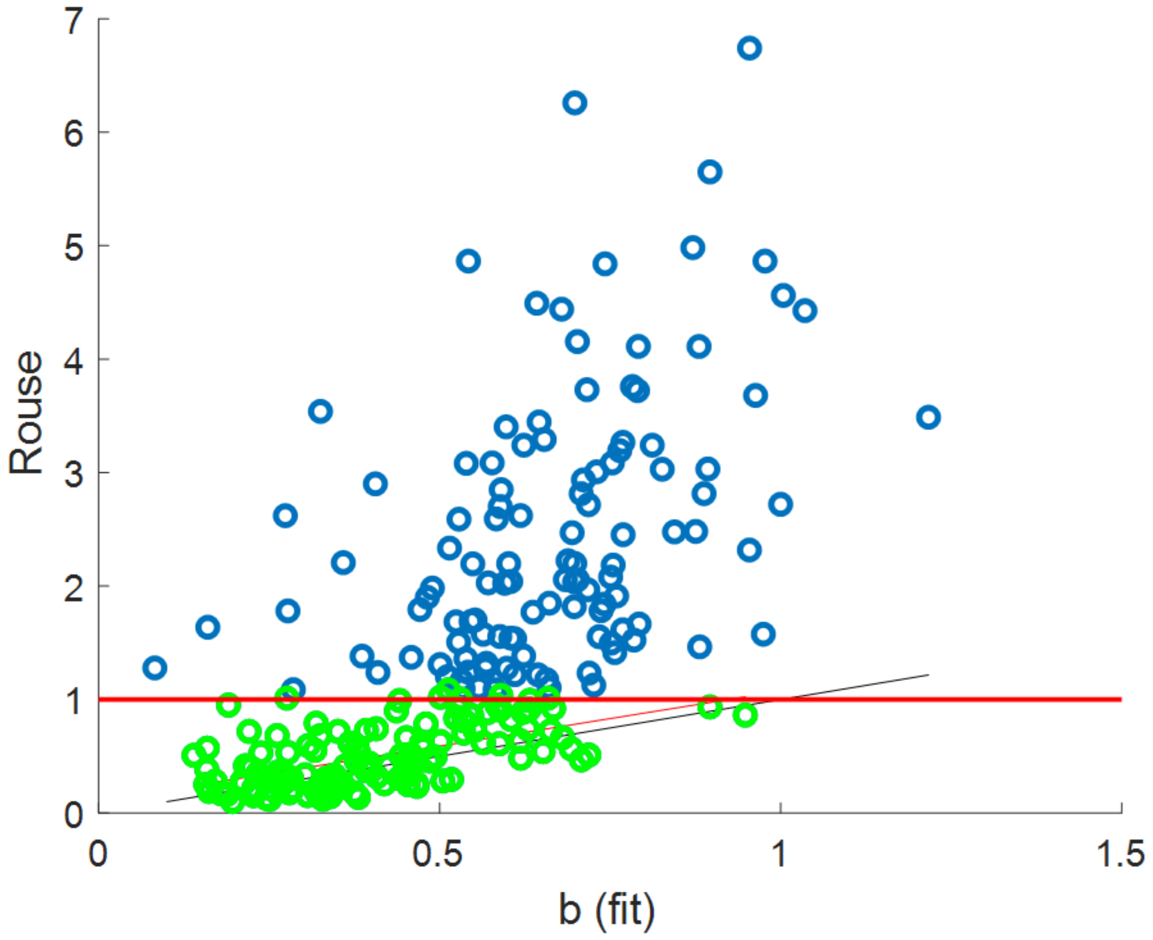


- data
-- best fit
- ref. con.

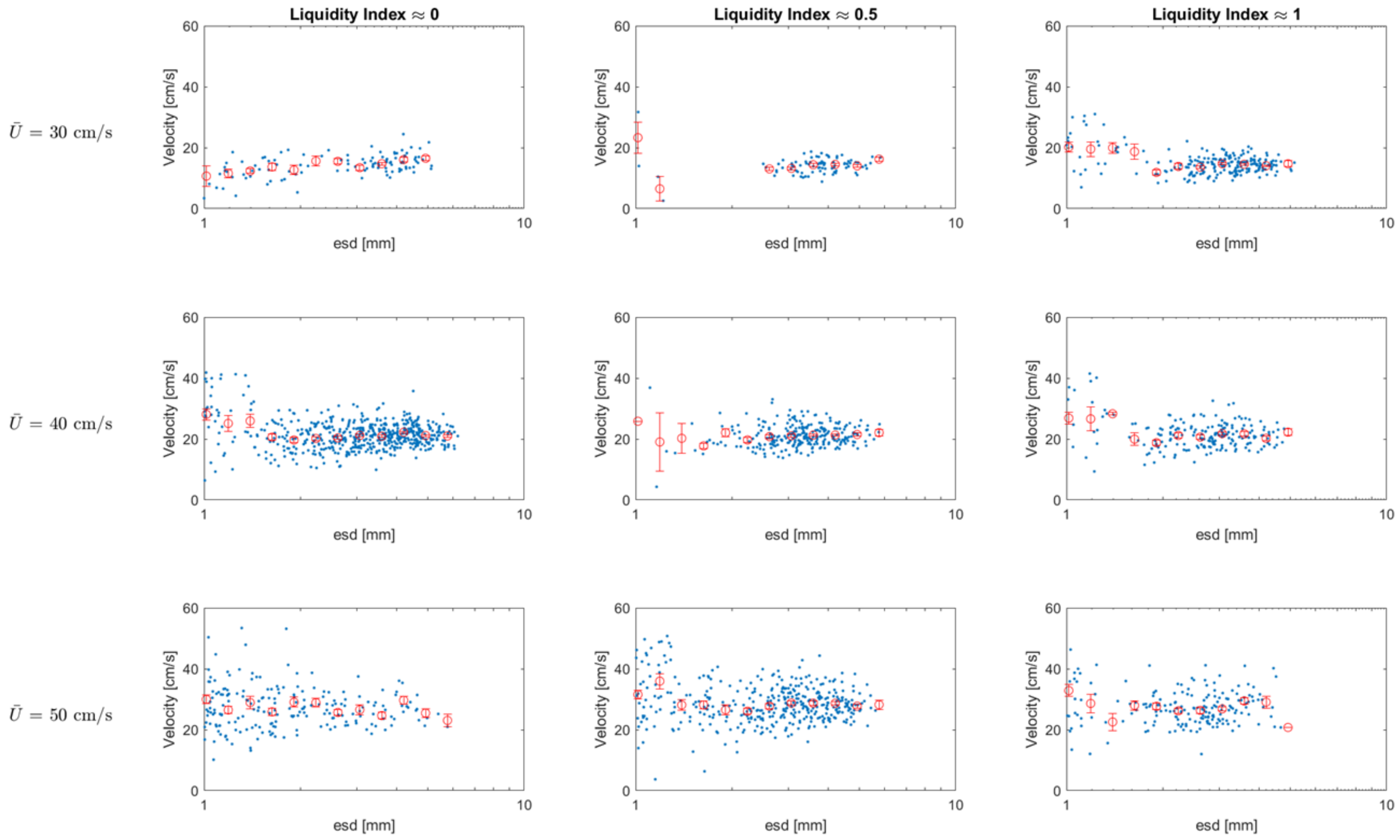
Water content



All Data Best Fit Trends



Bedload Transport



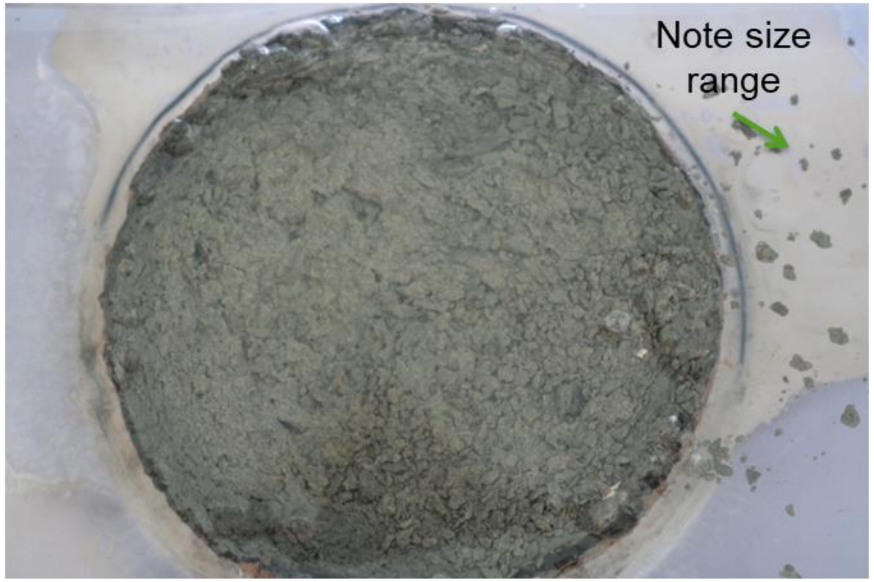
- Transport increases with flow speed
- Transport is approximately half the flow speed
- Transport is ~independent of aggregate water content
- Larger particles show less scatter

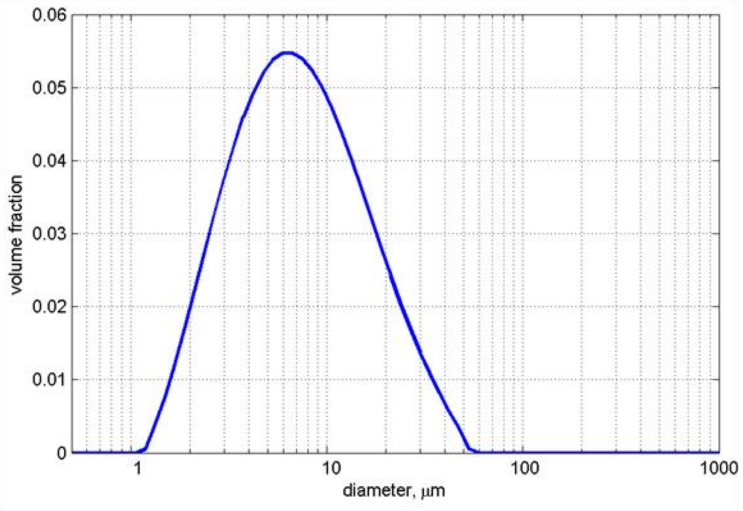
Next Steps

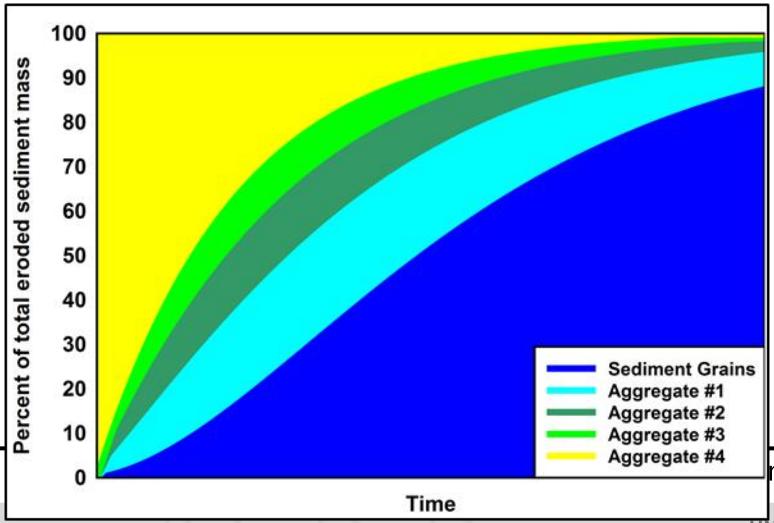
Suspended Sediment Transport
- ✓ Look for trends based on sediment source
- ✓ Transport dynamics – size versus density (composition)

Bedload Transport
- ✓ Identify thresholds based on sediment source/physical characteristics
- ✓ Bedload velocity versus size (log velocity profile)
- ✓ Convert to transport distance as a function of size/density

Modeling
- ✓ Use results to develop/test algorithms of aggregate transport







Thank You