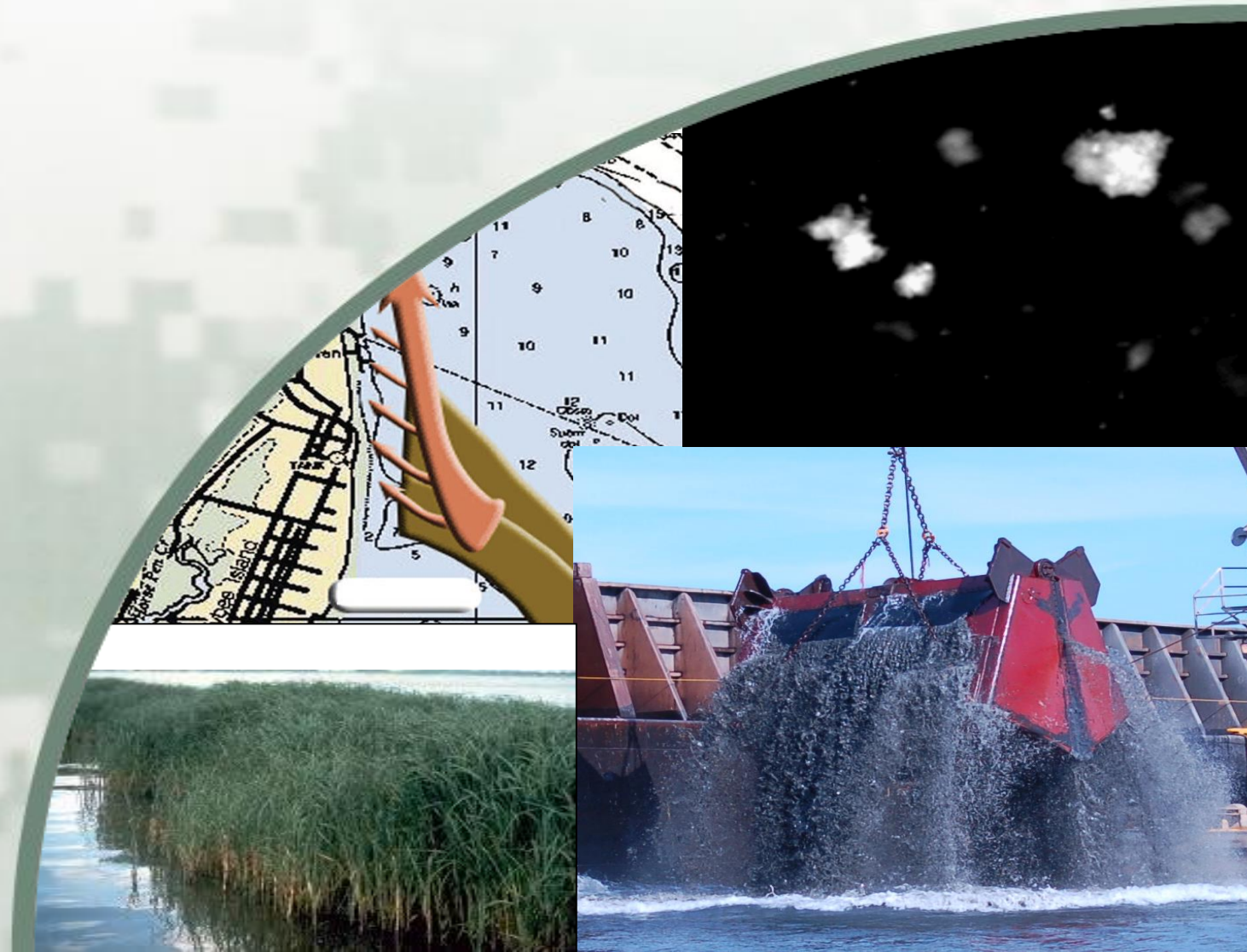
ERDC
Engineer Research and Development Center

Mud Aggregate Transport and Durability

Jarrell Smith, Richard Styles

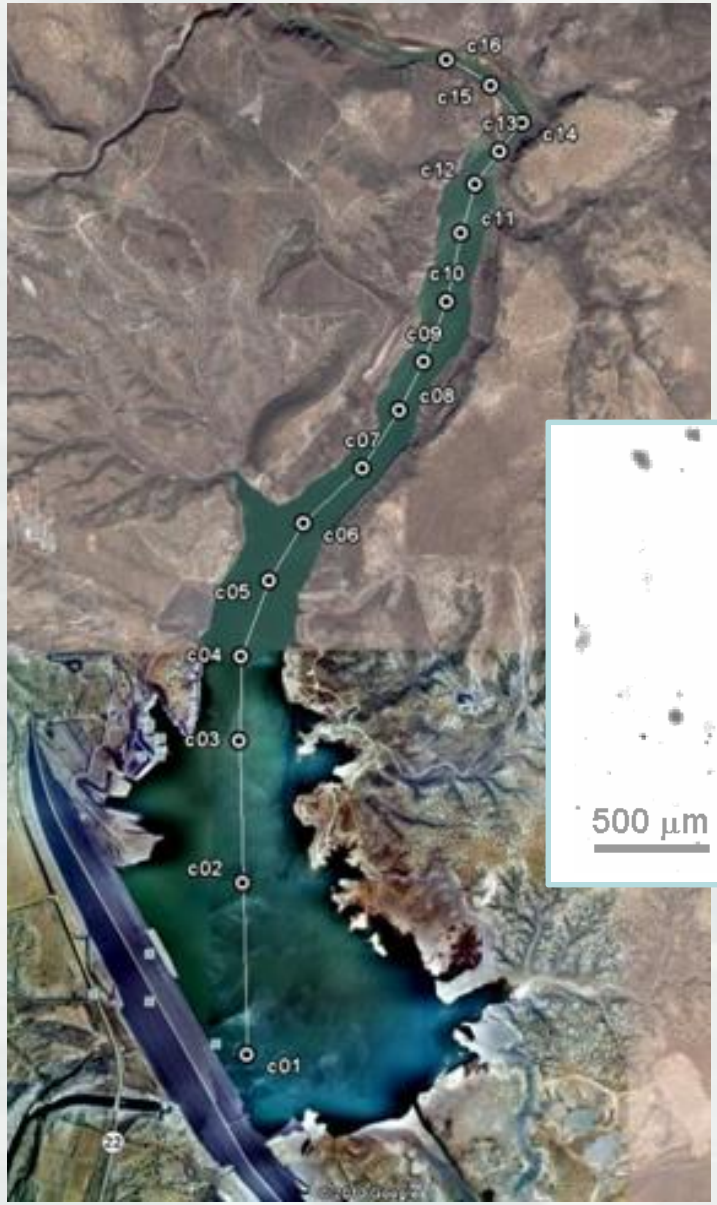


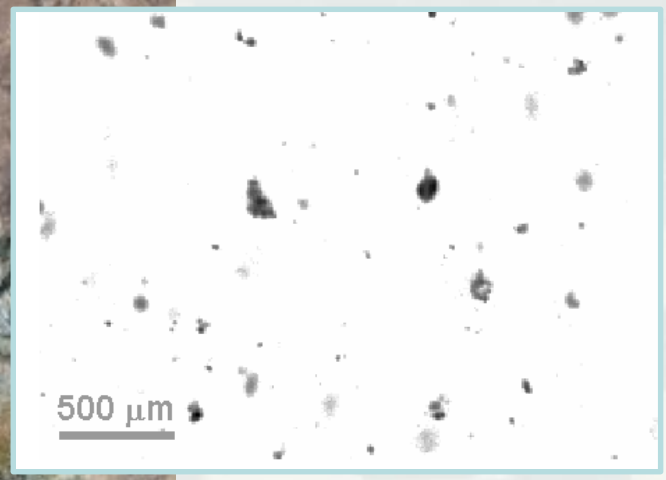
US Army Corps of Engineers®

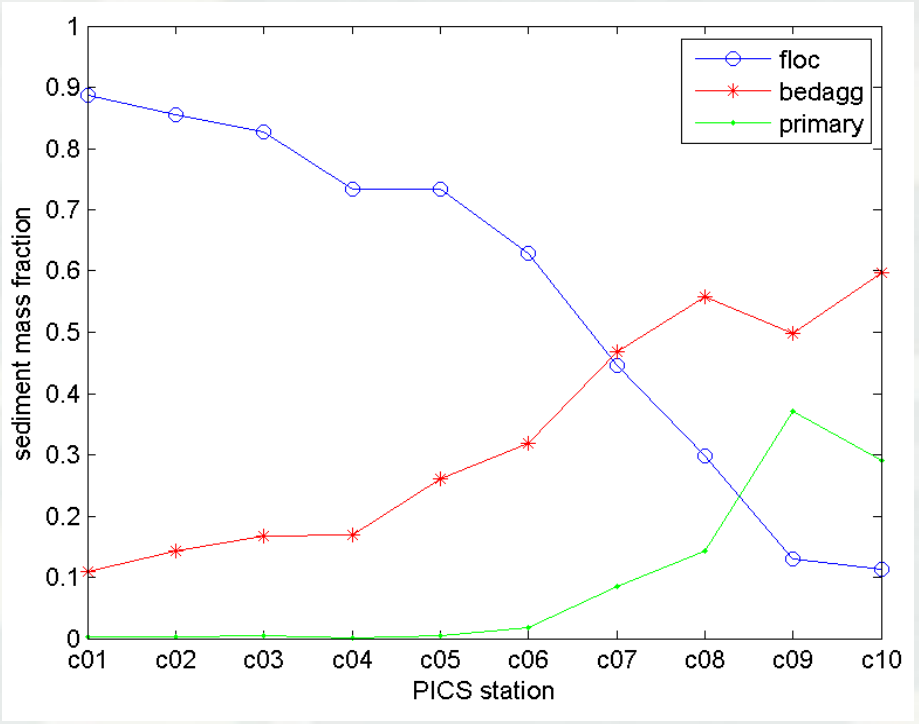
Mud Aggregates

Reservoir Sedimentation

Cochiti Lake, New Mexico



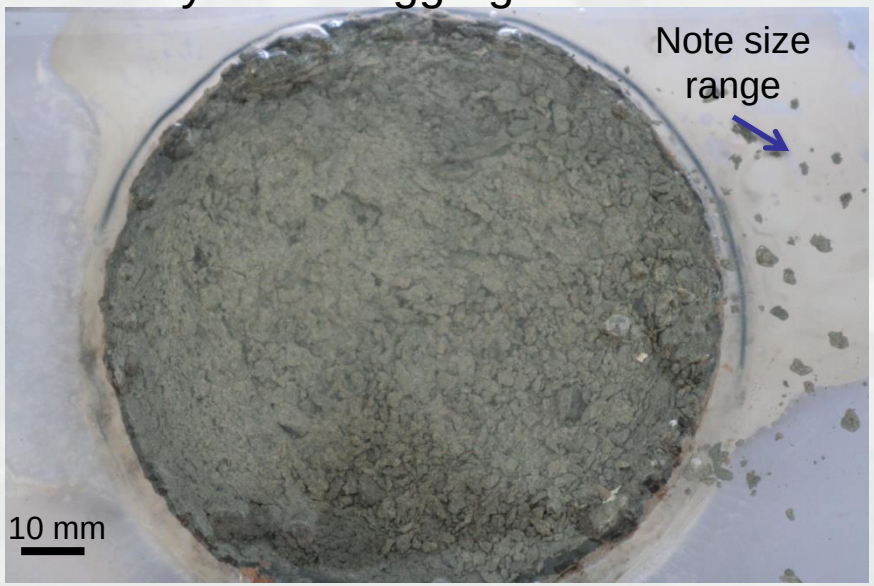




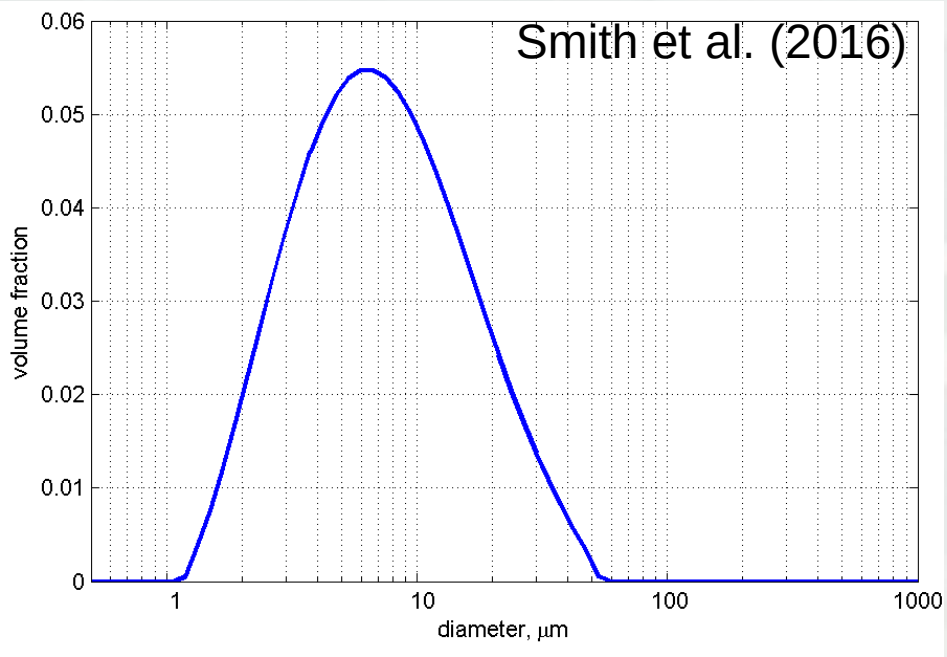
Smith et al. (2016)

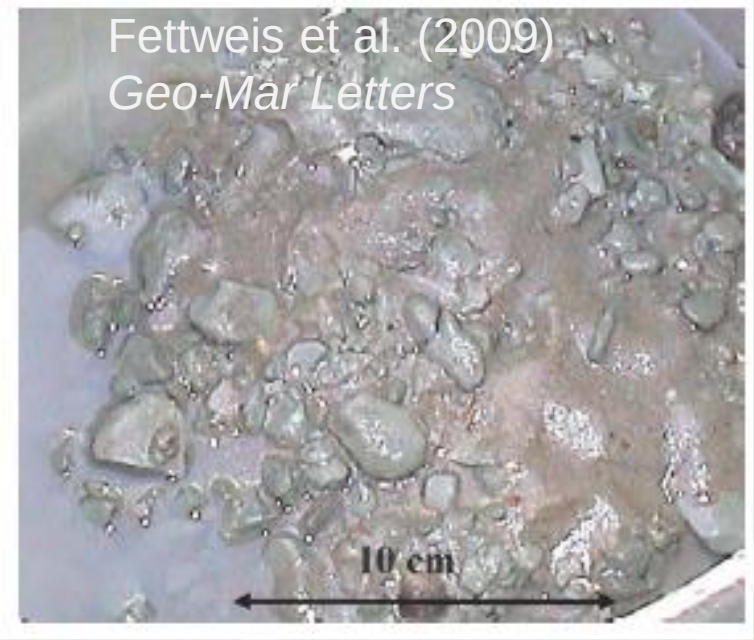
Durable Aggregates

Loosely bound aggregates



Heterogeneous aggregates



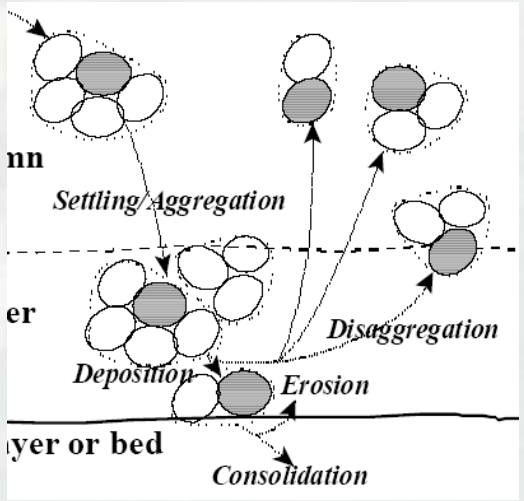


Transport Modes

Waves

Current

Turbulent Mixing



SUSPENDED LOAD

BEDLOAD

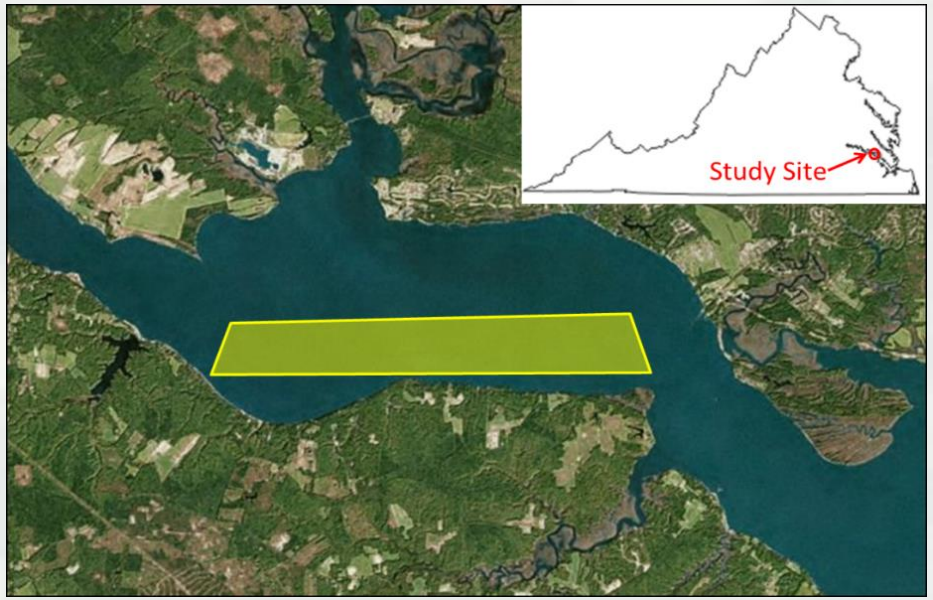
Suspension

Saltation

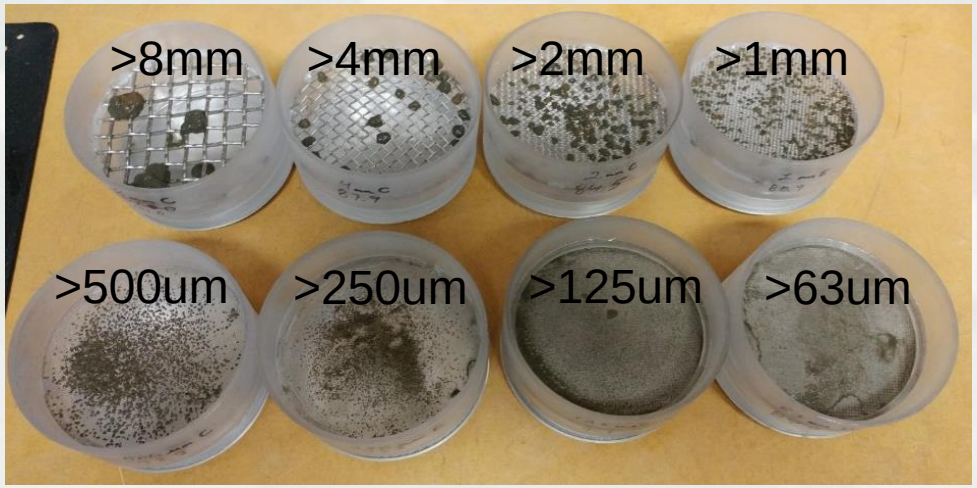
Rolling

At Rest

Navigation: Near-Channel Placement and Sedimentation

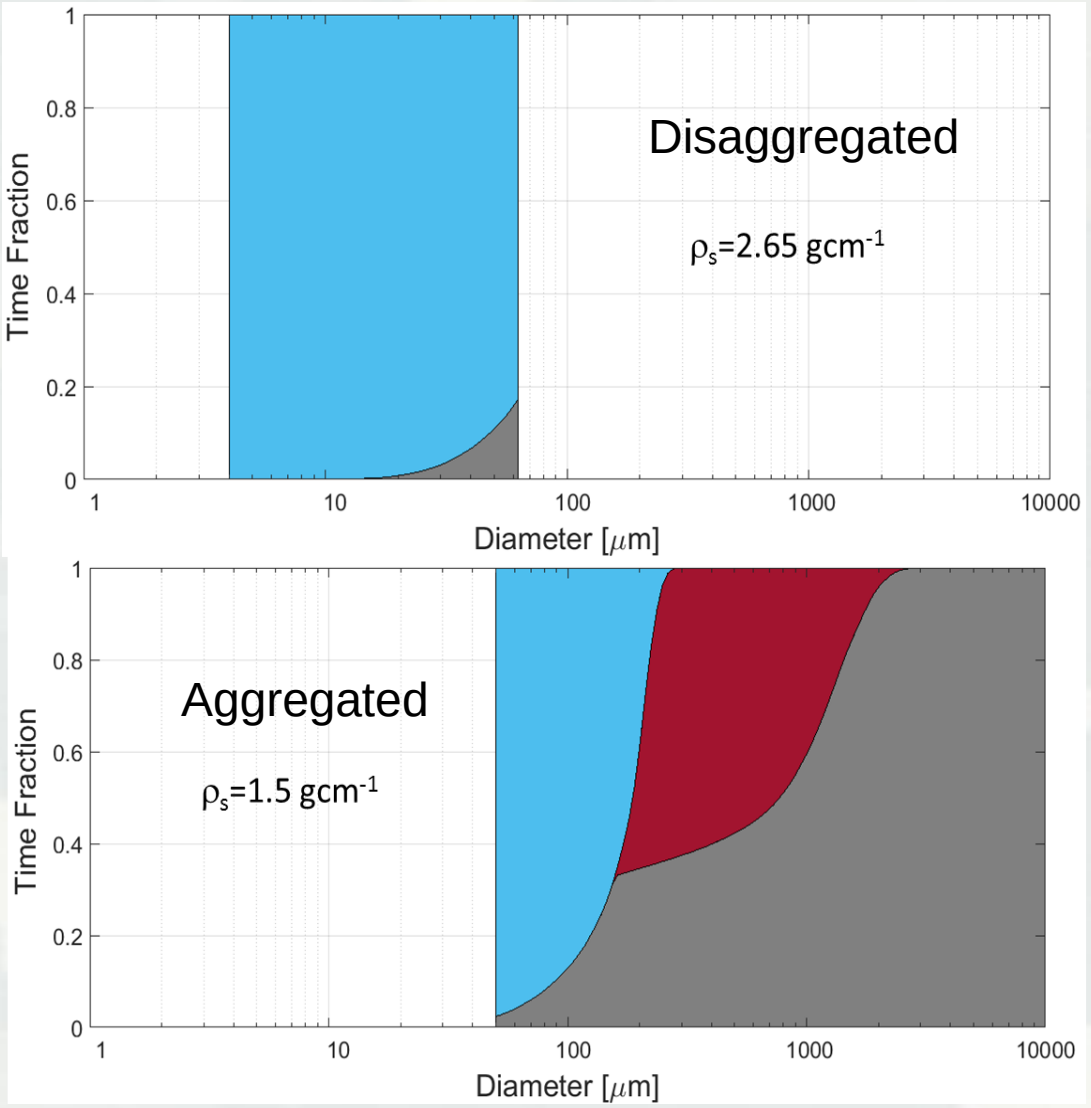


James River: Channel Adjacent Placement Area



Collected aggregates from erosion testing

Sediment Transport Modes



Research & Development -- Aggregate Transport

- Aggregate Erosion – Dave Perkey
  - What are the initial states of aggregation upon erosion? What sediment properties control aggregate size?
- Aggregate Durability – Jarrell Smith, Richard Styles
  - What rate do bed aggregates break-up? Is there a minimum size of breakup? What sediment properties relate to aggregate durability?

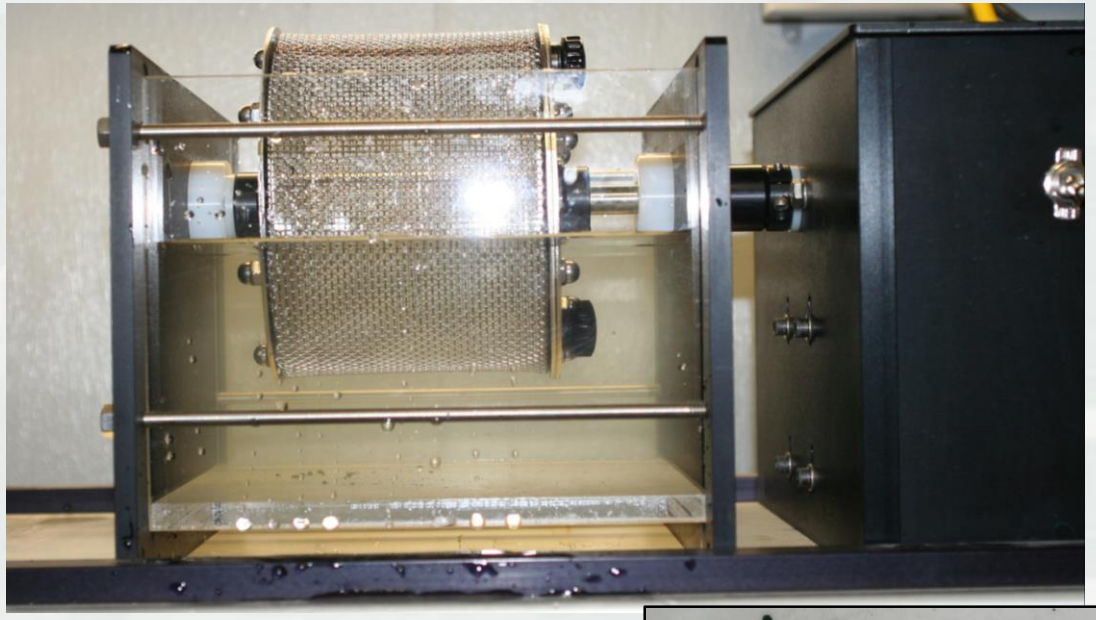
- Modeling Framework – Gary Brown
  - Presently developing a flexible modeling framework and library to accommodate aggregate transport processes.

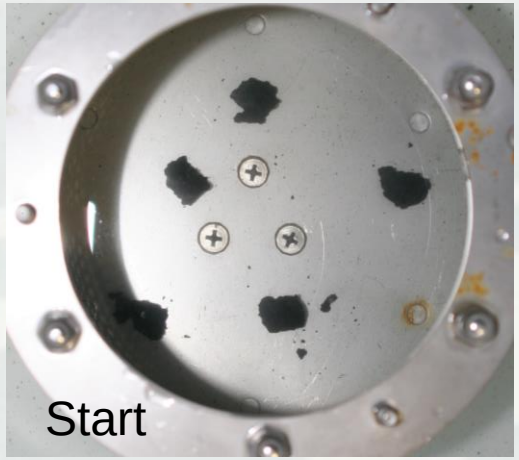
Materials

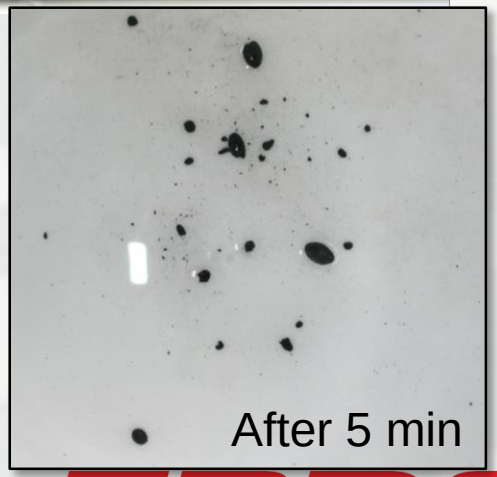
Sediment	Min Density [g/cm^3]	Max Density [g/cm^3]	Clay (%)	PI	Activity
Duluth Harbor	1.68	2.02	8	31	3.8
Houston Ship Channel	1.62	2.10	32	44	1.4
Gulfport, MS	1.35	1.90	15	110	7.4
James River, VA	1.48	1.90	13	60	4.6
Pascagoula Channel, MS	1.57	2.07	28	51	1.8

Aggregate Durability Apparatus

- Durability Apparatus
  - ▶ 140 mm diameter drum
  - ▶ Mesh size
    - 2mm (std)
    - 0.25mm (modified)
  - ▶ Rotation 30 rpm
    - Effective aggregate rolling speed (15 cm/s)
  - ▶ Exposures (2.5,5,10,20 min)
- Materials tested at five intervals between LL & PL

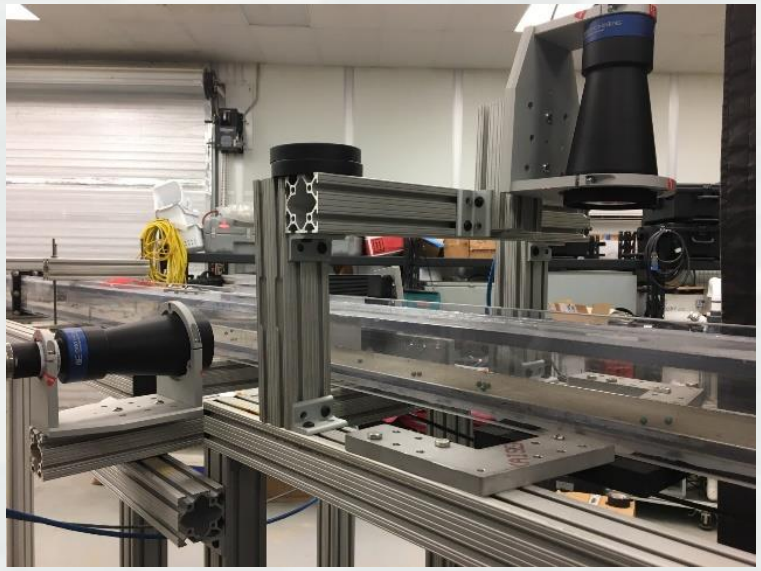


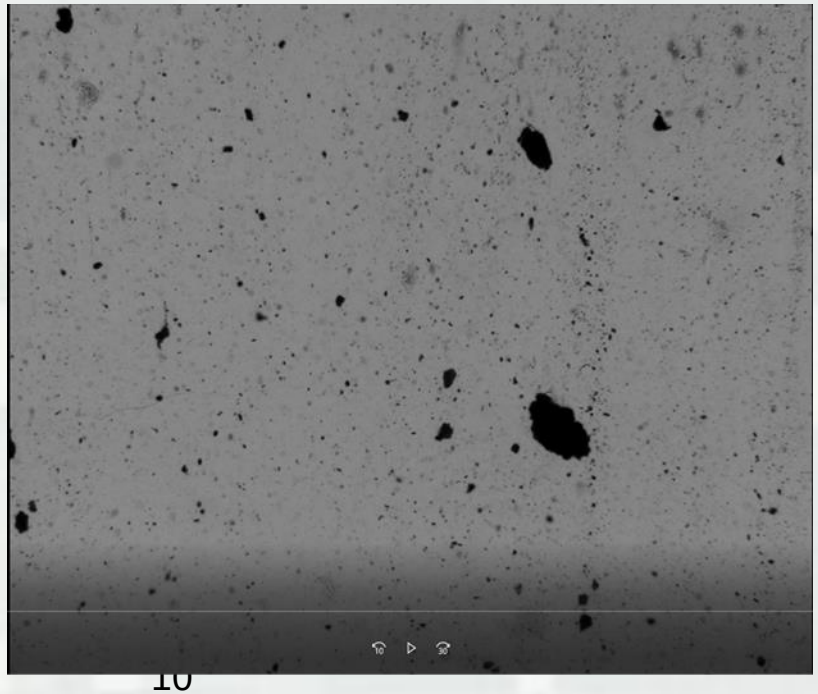




Durability Flume

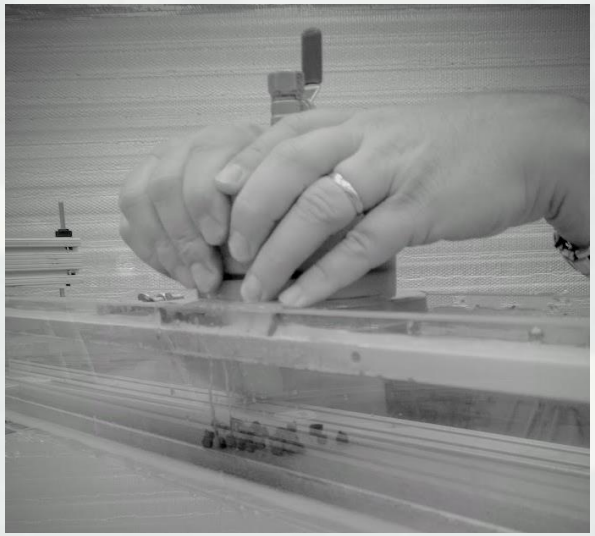
- Durability Flume
  - ▶ 12-m long
  - ▶ Oscill. Square Wave
    - Amplitude 30,40,50 cm/s
  - ▶ Exposures (indefinite)
- Materials tested at three intervals between LL & PL
- Size distributions over time
- Aggregate Velocity
- Size Distribution over vertical

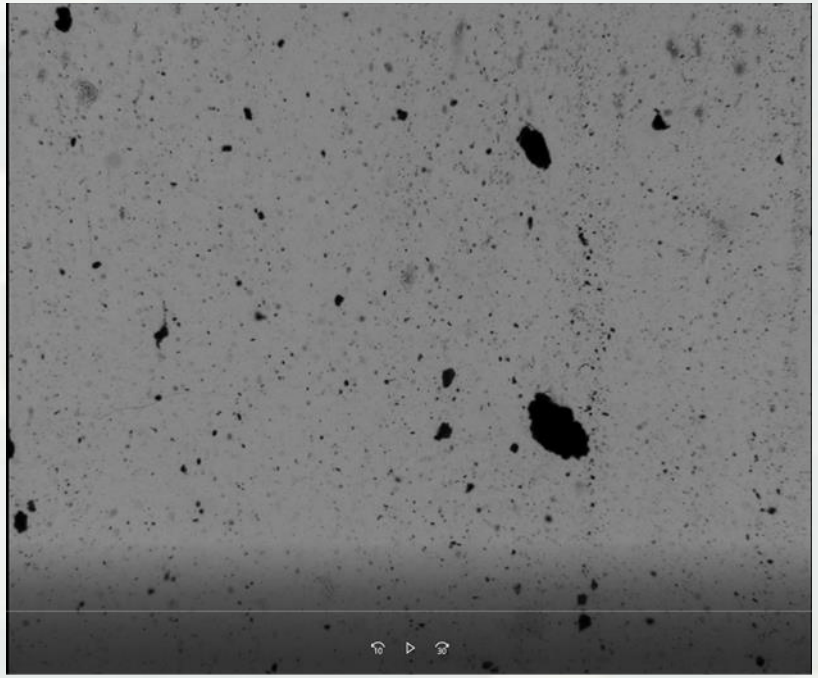




Durability Flume

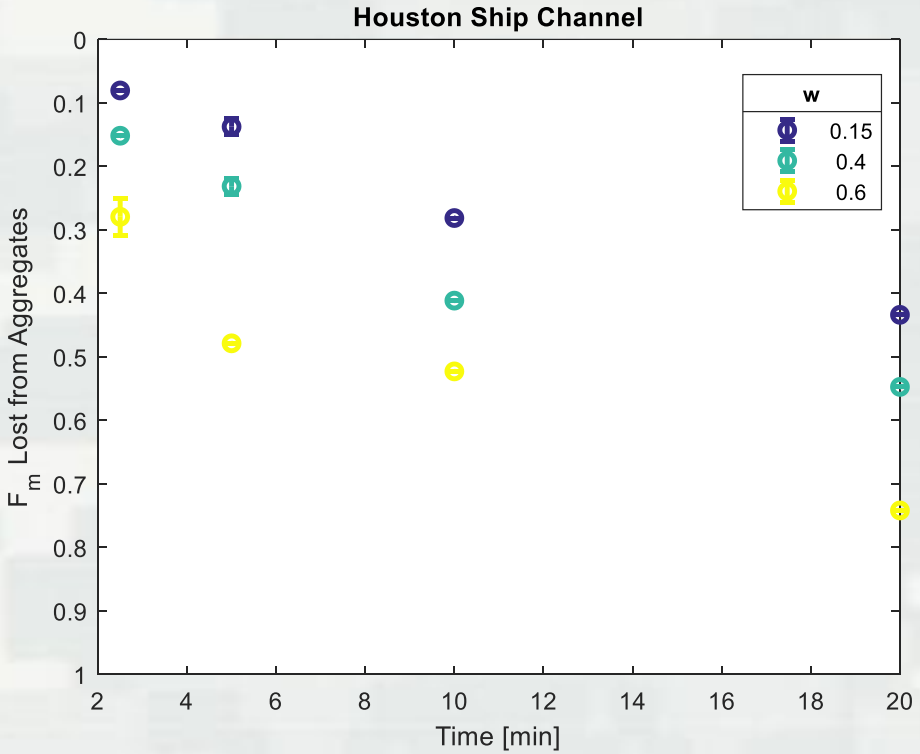
- Procedures
- Measurements
  - ▶ Size distributions over time
  - ▶ Aggregate Velocity
  - ▶ Size Distribution over vertical

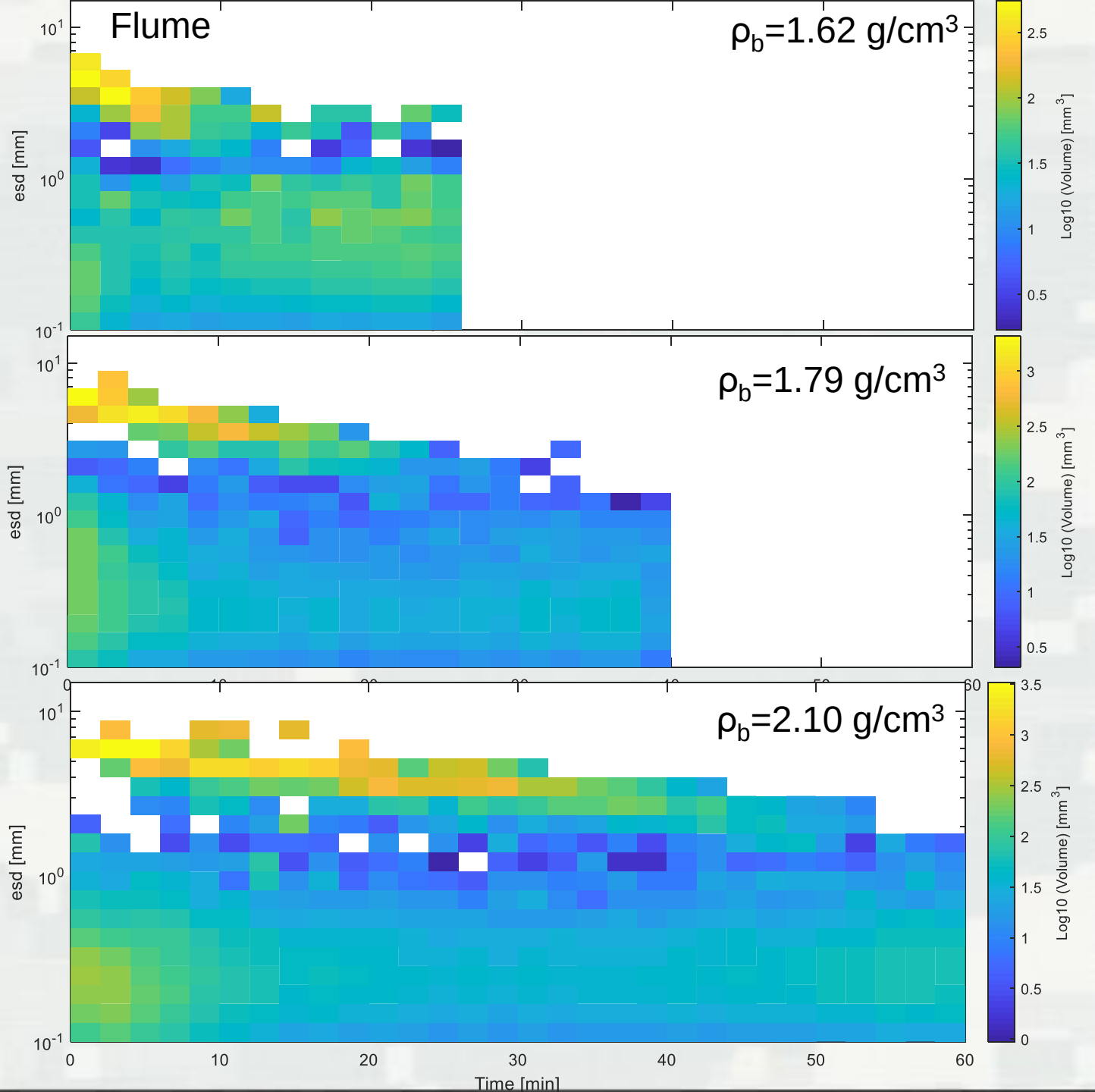


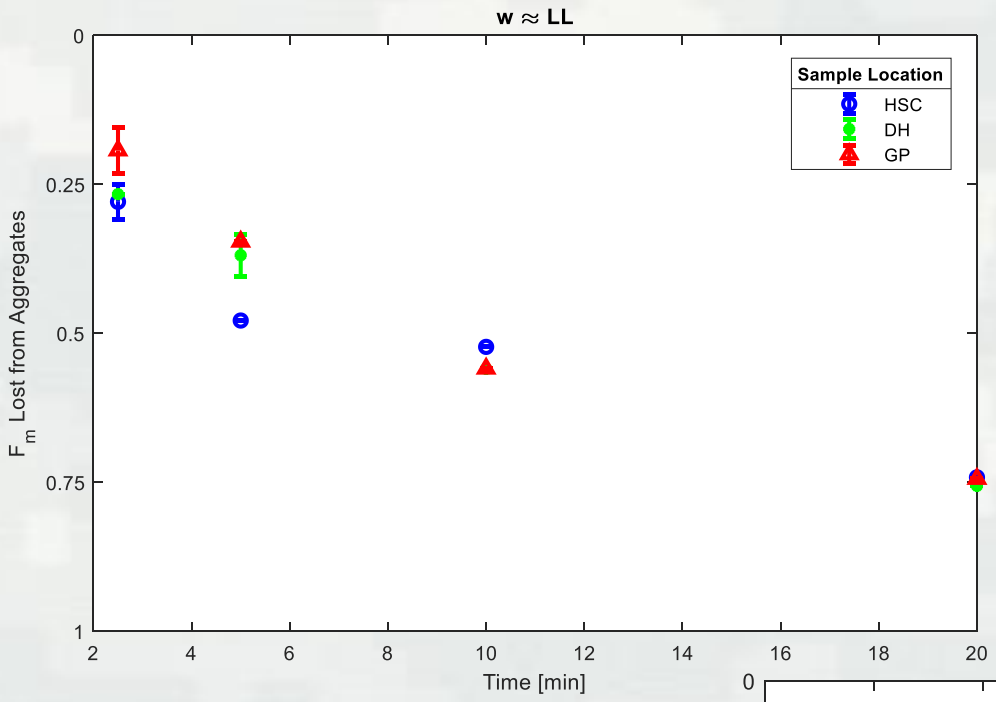


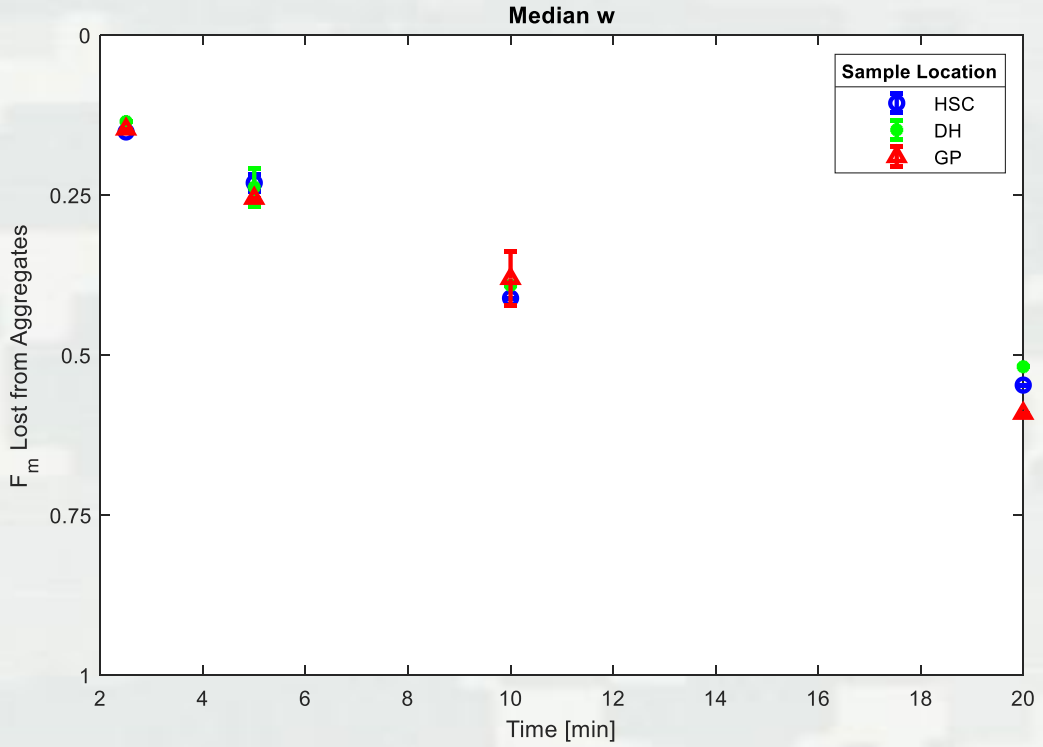
Houston Ship Channel Results

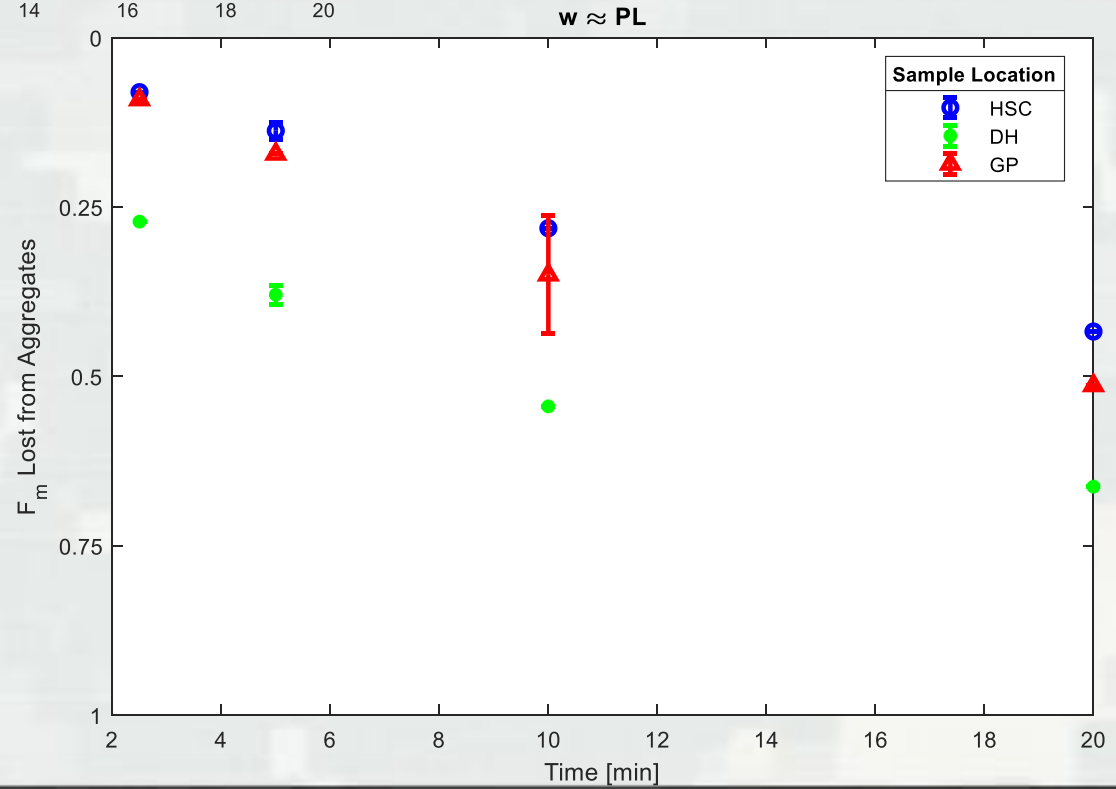
Aggregate Durability Apparatus






w ≈ LL
Sample Location
HSC
DH
GP
F_m Lost from Aggregates
Time [min]
0
0.25
0.5
0.75
1
2
4
6
8
10
12
14
16
18
20


Median w
Sample Location
HSC
DH
GP
F_m Lost from Aggregates
Time [min]
0
0.25
0.5
0.75
1
2
4
6
8
10
12
14
16
18
20


w ≈ PL
Sample Location
HSC
DH
GP
F_m Lost from Aggregates
Time [min]
0
0.25
0.5
0.75
1
2
4
6
8
10
12
14
16
18
20

Technical Transfer

- Testing Methods
  - Reference. Existing testing will serve as a reference of sediment properties contributing to aggregate formation and durability. (Atterberg-derived quantities: LL,PL,PI, A), clay content, clay mineralogy)
  - Aggregate Durability Apparatus. Quick, standardized testing method to assess durability.
  - Aggregate Durability Flume. Higher fidelity testing method, develops sediment specific breakup rates.
- Modeling Approach
  - Ignore. If testing indicates no aggregates formed or aggregates extremely fragile.
  - Static. Represent aggregates as a persistent and static class of particles.
  - Dynamic. Include Abrasion Model in modeling to account for size class dynamics and evolution of transport modes.