Settling and Entrainment Properties of Particulates in the STAs.

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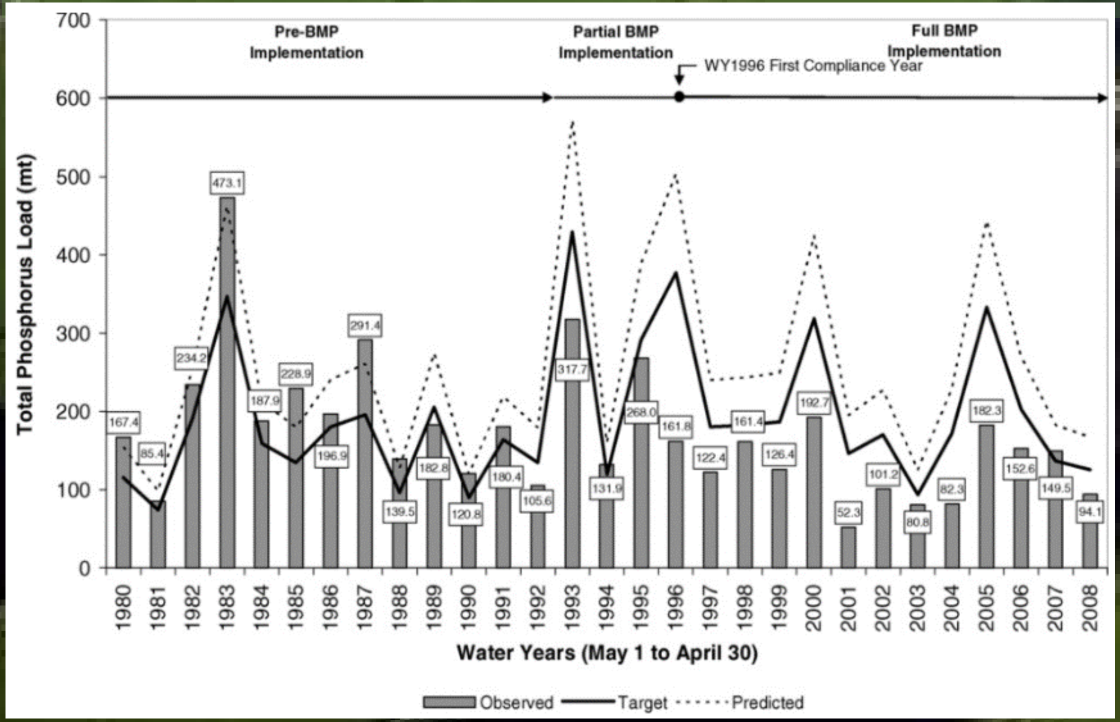
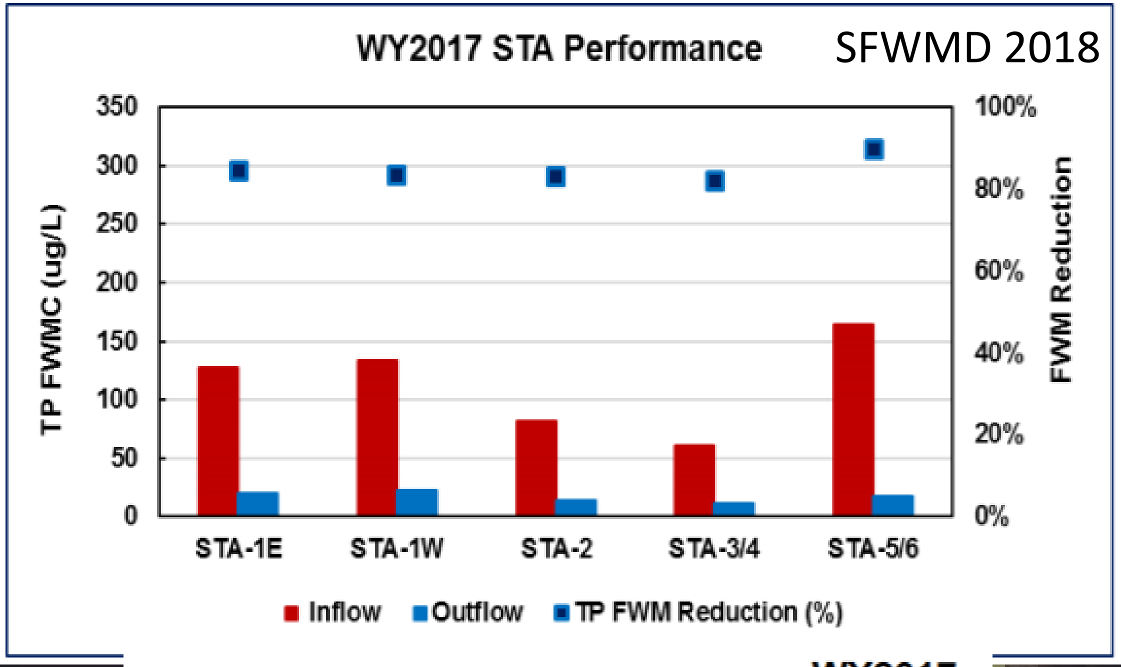
The EAA: Changes in Water Quality

BMPs

- Overall successful
- Approx. 50% long term average load reduction from EAA Basin
- Exceeding the 25% required by law (Daroub et al. 2009)





	WY2017
Total inflow (x10^6 ac-ft)	1.1
TP FWM (inflow/outflow) (µg/L)	96/15
TP load (inflow/outflow) (t)	129/20
Reduction % (FWM, Load)	(84%, 84%)

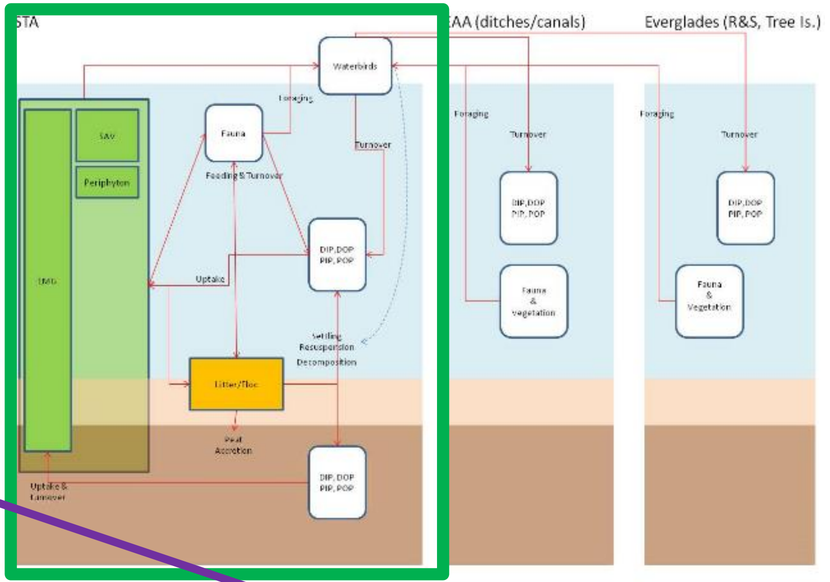
Estimates (SFWMD) suggest approx. 50% of STA outflow TP is Particulate-P (PP).

Overview of STA Conceptual Ecological Model (SFWMD)

Spatial Scale

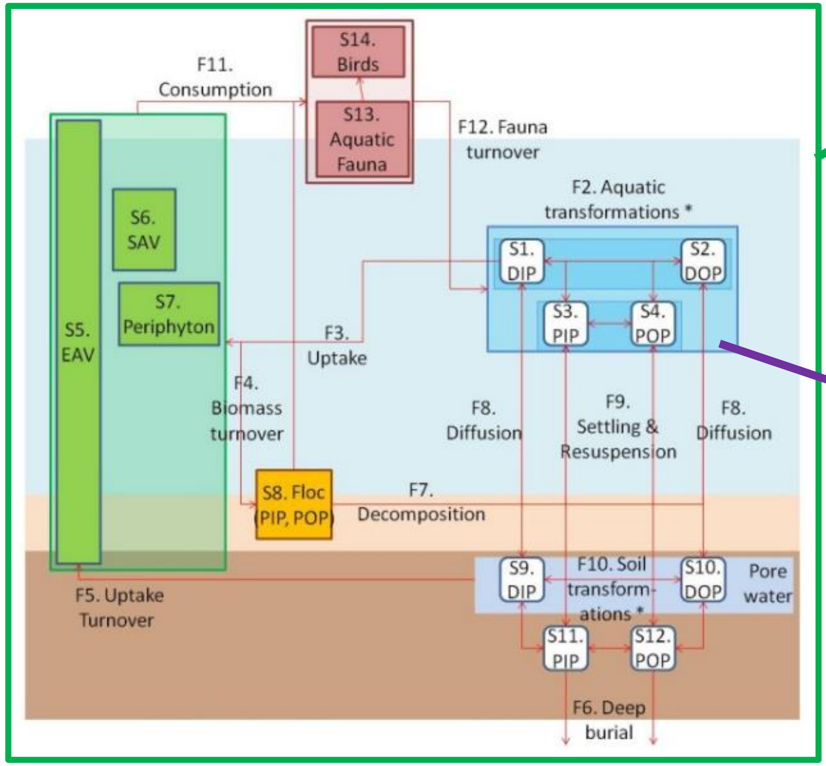
Tier 1 – Landscape (whole STA, STA interactions with EAA or EVR)

10-100 km



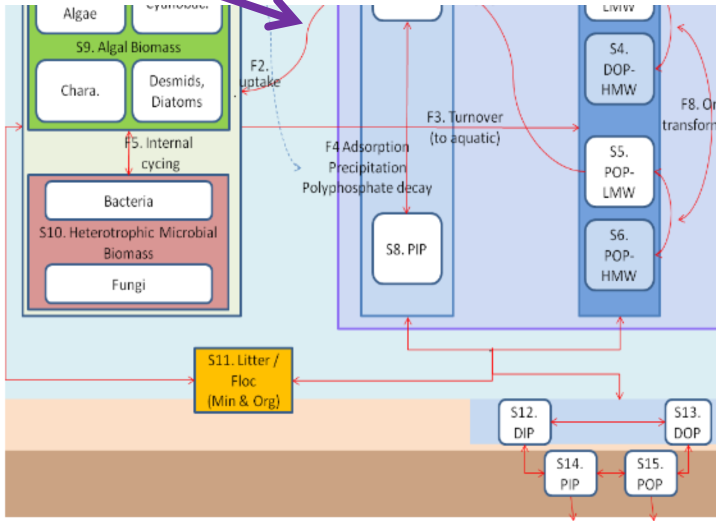
10 m -10 km

Tier 2 – Patch (habitat, cell, or linked habitats or cells)

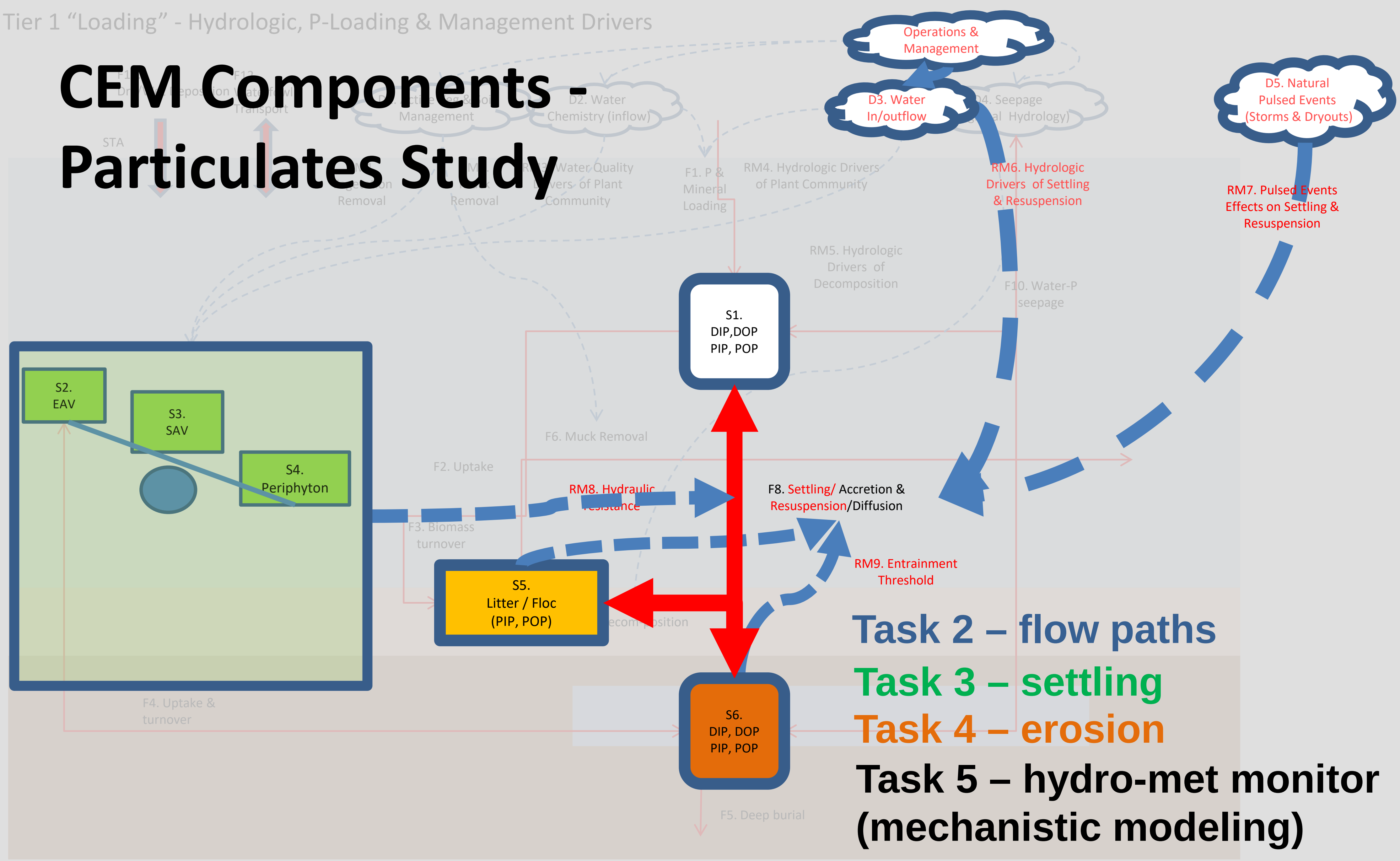


1 cm - 10 m

Tier 3 – Mesocosm (Microbial Community, Enzymatic Pathways, Individual Plant, Soil core, etc.)



CEM Components - Particulates Study



Task 2 – flow paths

Task 3 – settling

Task 4 – erosion

Task 5 – hydro-met monitor (mechanistic modeling)

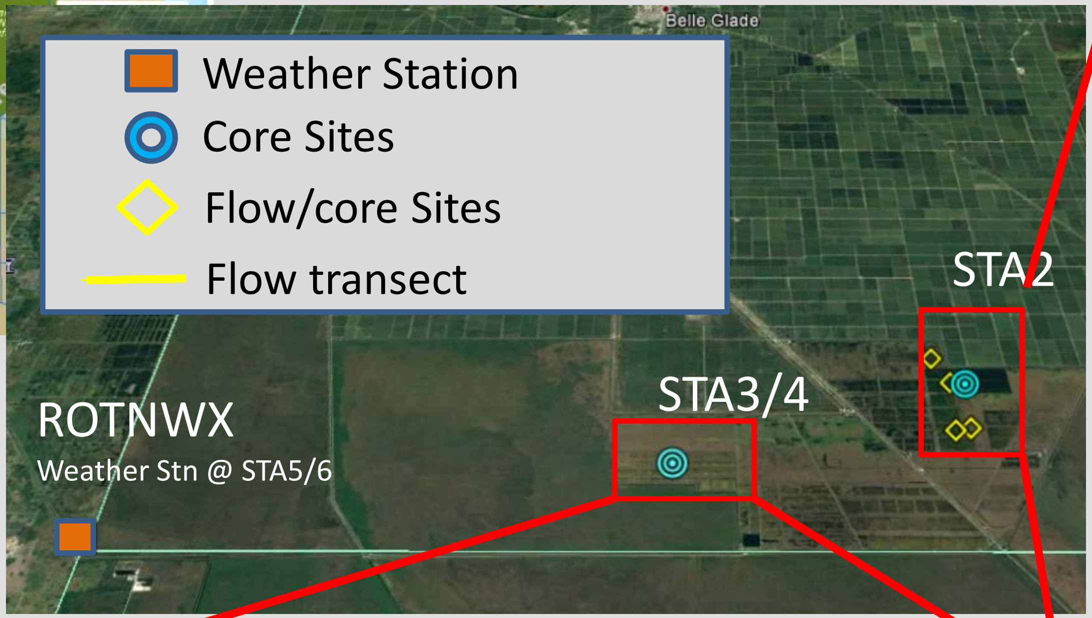
Objectives:

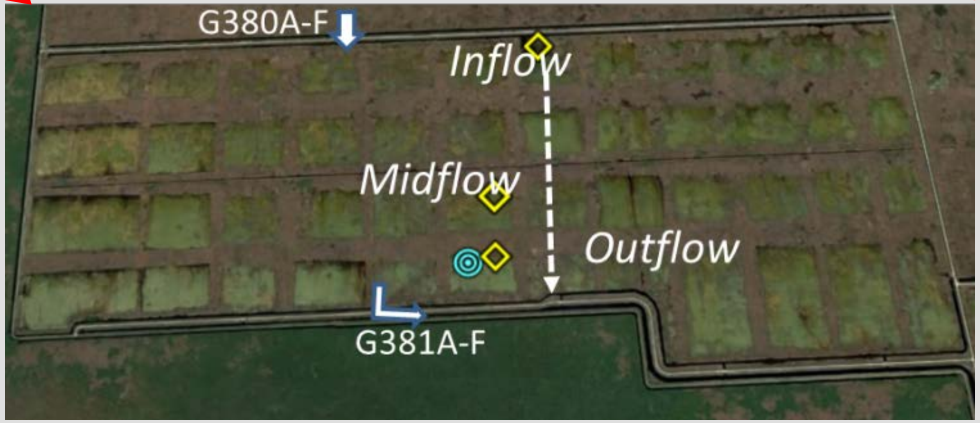
Identify the fundamental properties of Stormwater Treatment Area (STA) water column particulates to assist in the development of effective management options for controlling particulate phosphorus (PP).

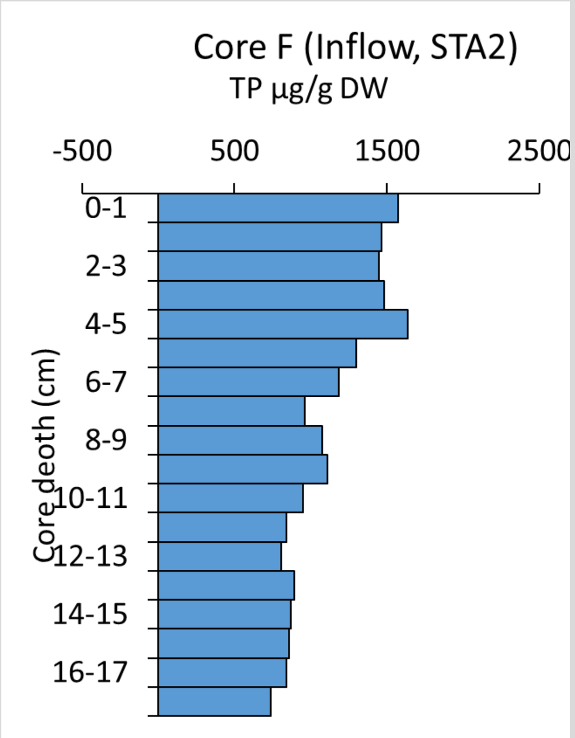
Key questions:

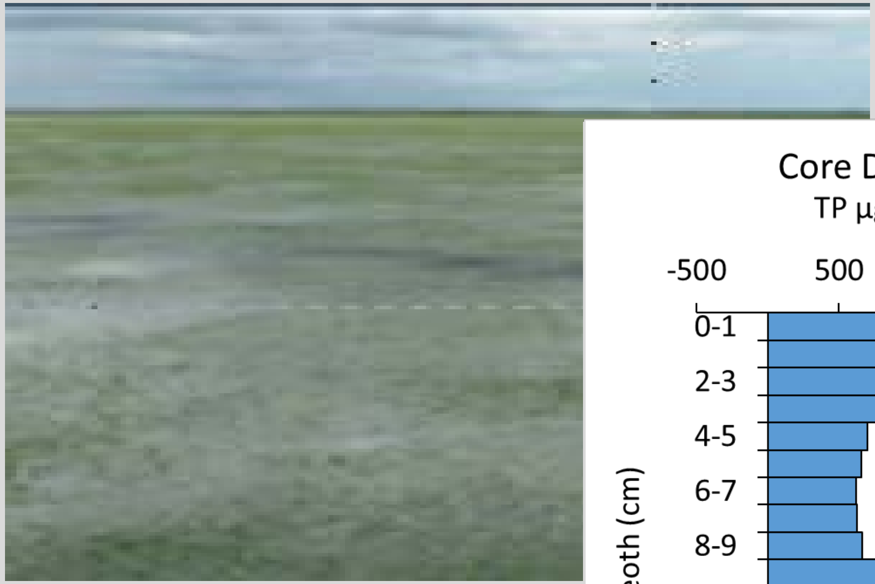
- **To what extent do flow fields near outflow areas exhibit velocities sufficient to entrain particles?**
- **How fast do STA-derived particles settle?**
- **What is the background concentration of particulates that do not settle?**
- **What velocities or shear stress are required to: (a) entrain particles and (b) to allow deposition?**
- **What are the quantitative correlations between particulate load and hydrologic and meteorological conditions that resuspend particles?**

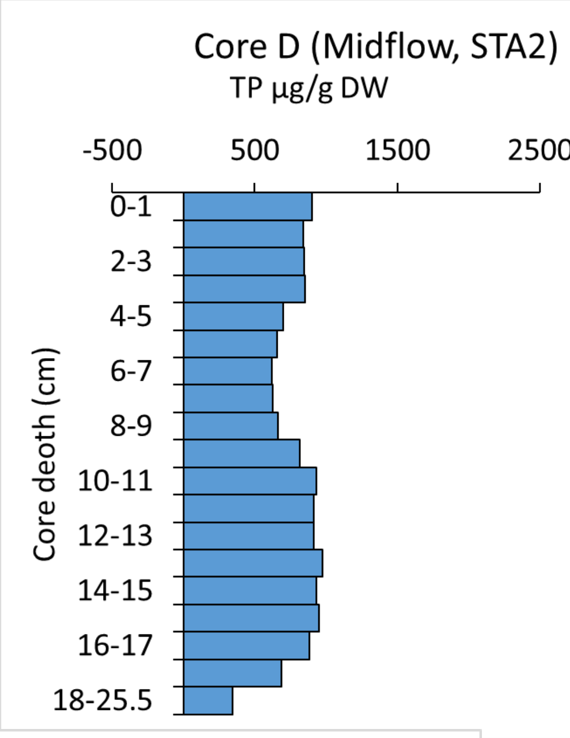
Study Areas:
STA2 Cell3 & STA 3 / 4 Cell 3

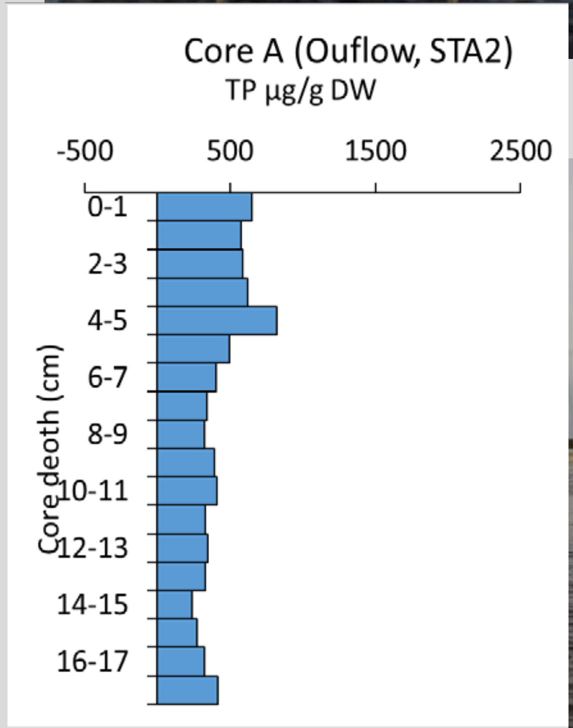


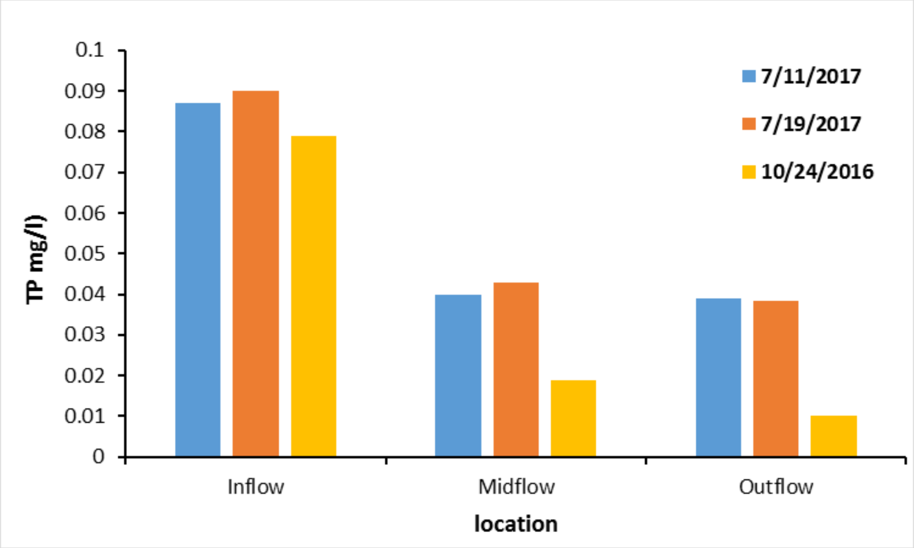


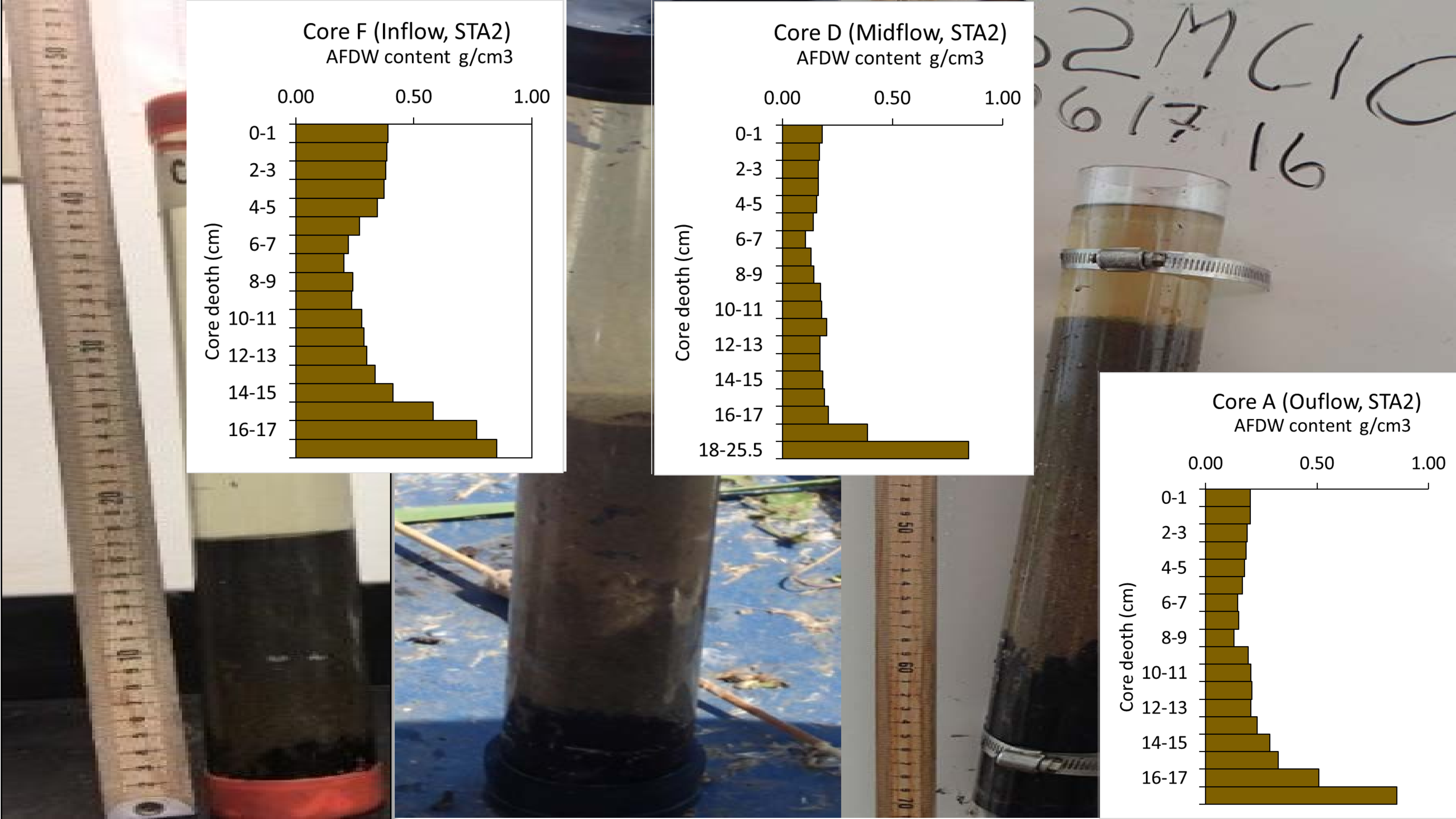

Core F (Inflow, STA2)
TP µg/g DW
-500
500
1500
2500
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
Core deoth (cm)




Core D (Midflow, STA2)
TP µg/g DW
-500
500
1500
2500
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
18-25.5
Core deoth (cm)


Core A (Ouflow, STA2)
TP µg/g DW
-500
500
1500
2500
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
Core deoth (cm)


TP mg/l
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
7/11/2017
7/19/2017
10/24/2016
Inflow
Midflow
Outflow
location


Core F (Inflow, STA2)
AFDW content g/cm3
0.00
0.50
1.00
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
Core deoth (cm)
Core D (Midflow, STA2)
AFDW content g/cm3
0.00
0.50
1.00
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
18-25.5
Core deoth (cm)
Core A (Ouflow, STA2)
AFDW content g/cm3
0.00
0.50
1.00
0-1
2-3
4-5
6-7
8-9
10-11
12-13
14-15
16-17
Core deoth (cm)

Flow Paths and Velocities

- Preferential flow path
  - Field measurement of 3D velocity
  - Continuous monitoring of velocity
- Micro-topography
  - Floc thickness, water depth
  - Field survey and satellite derived data
- Flow scenarios
  - Field measurement under Low and High flow conditions
- Inflow/Outflow Structures
  - analysis of inflow and outflow pattern
- Meteorological Factors
  - Data from ROTNWX weather station

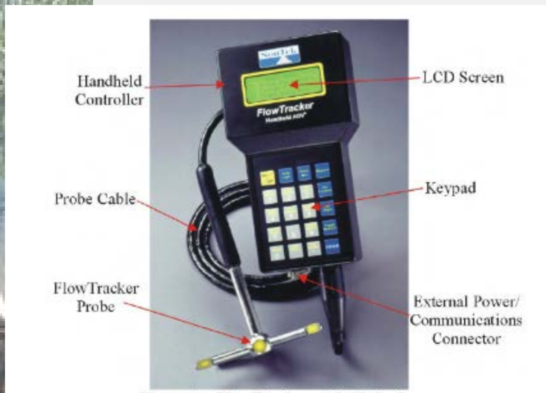
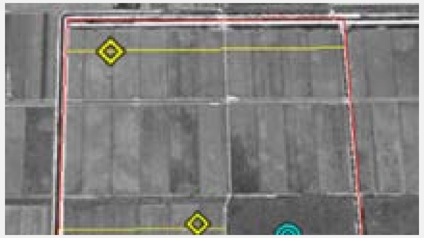
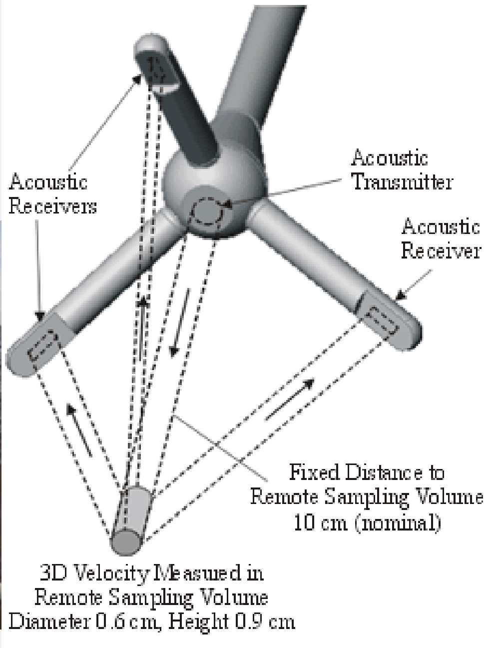


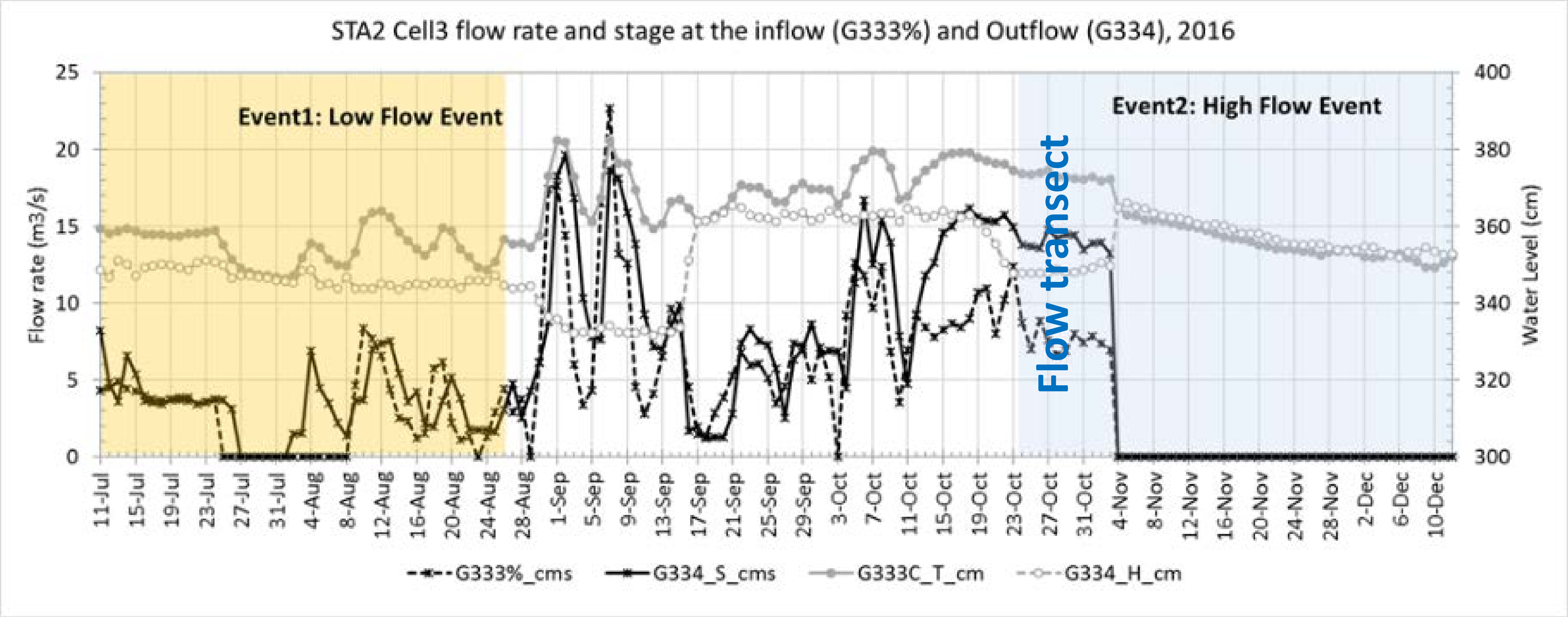
Figure 1 – FlowTracker with 2D Probe





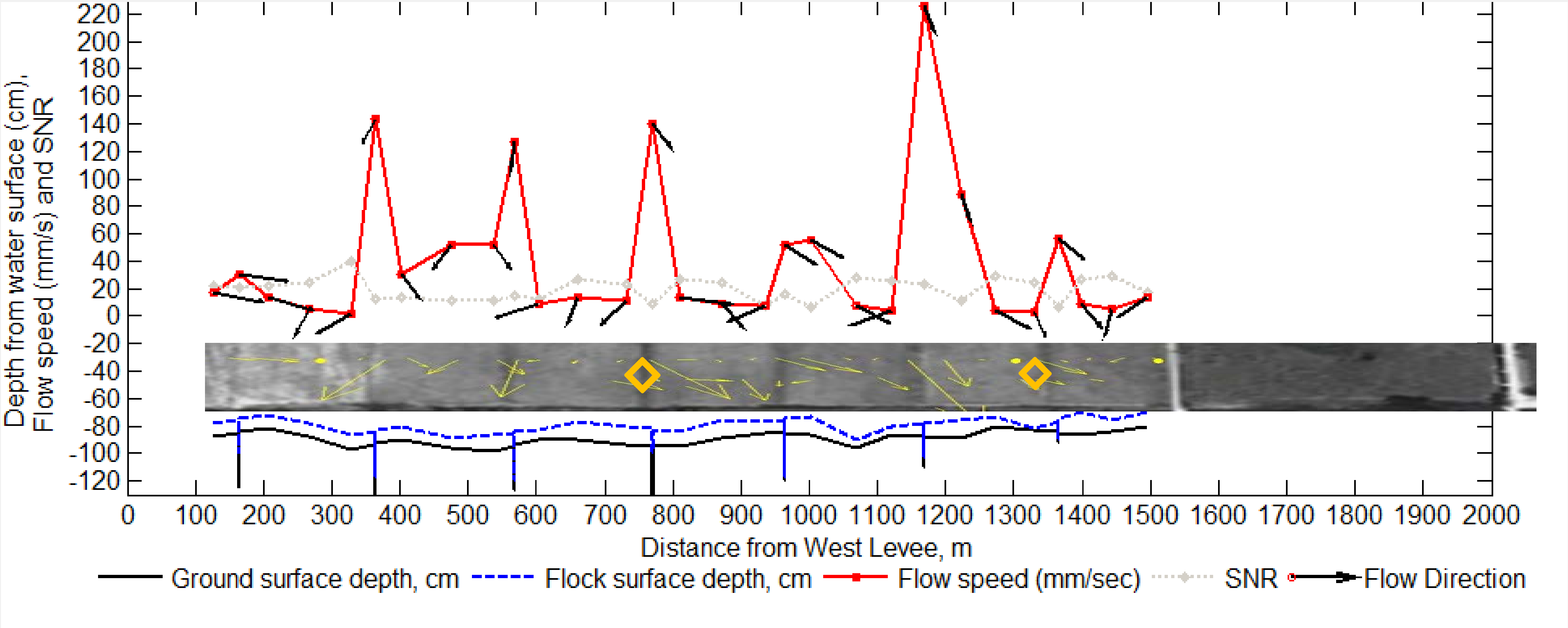
STA2: Flow and Stage, 2016

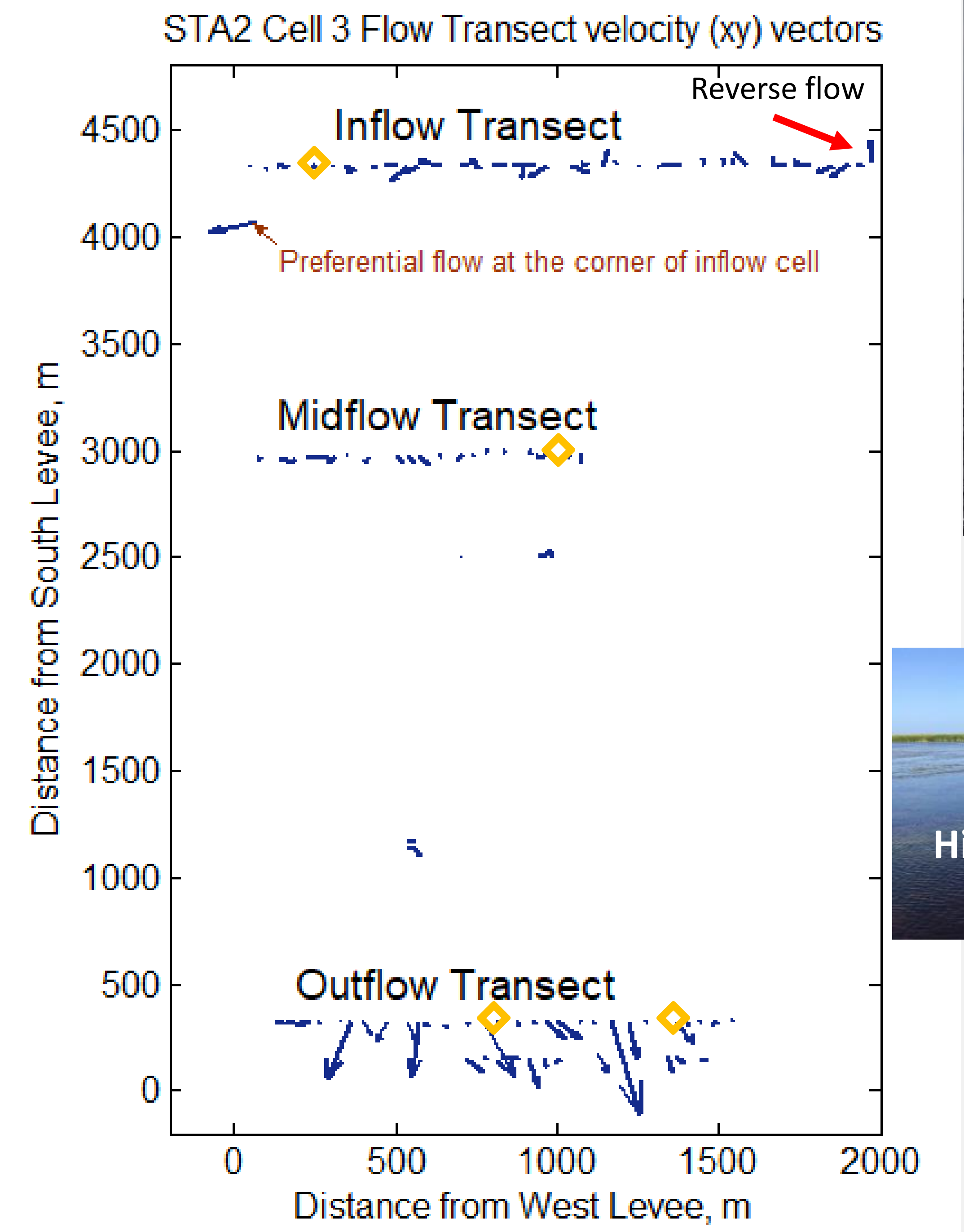
- Event 1: (Q_inf ~ $4m^3/sec$)
  - Low -> stagnant -> normal
- Event 2: (Q_inf ~ $8m^3/sec$)
  - High flow -> stagnant - Missed the normal flow
  - The outflow discharge was greater than the inflow

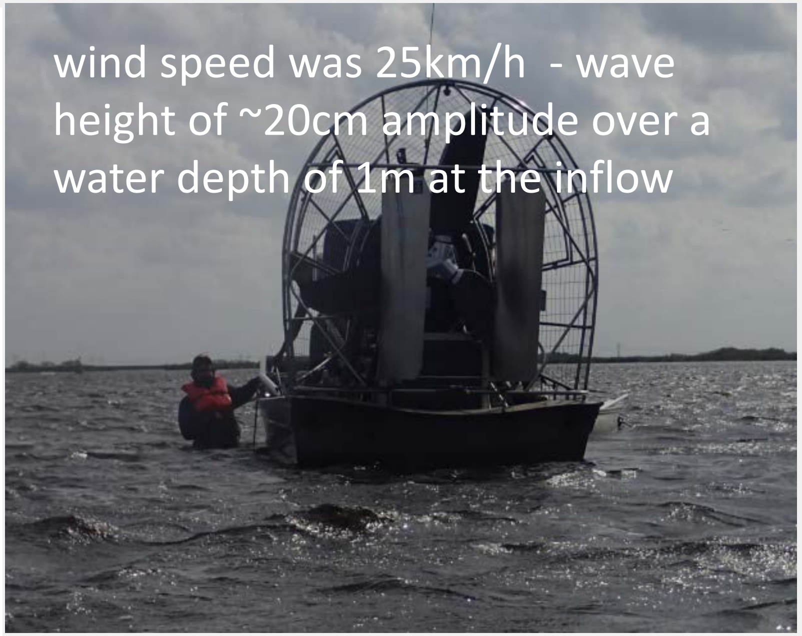


Flow vectors @Outflow

- High flow velocity along remnant canals
- Localized preferential flow path
- Low SNR due to clear water
- Thicker floc bed compared to inflow and midflow cells



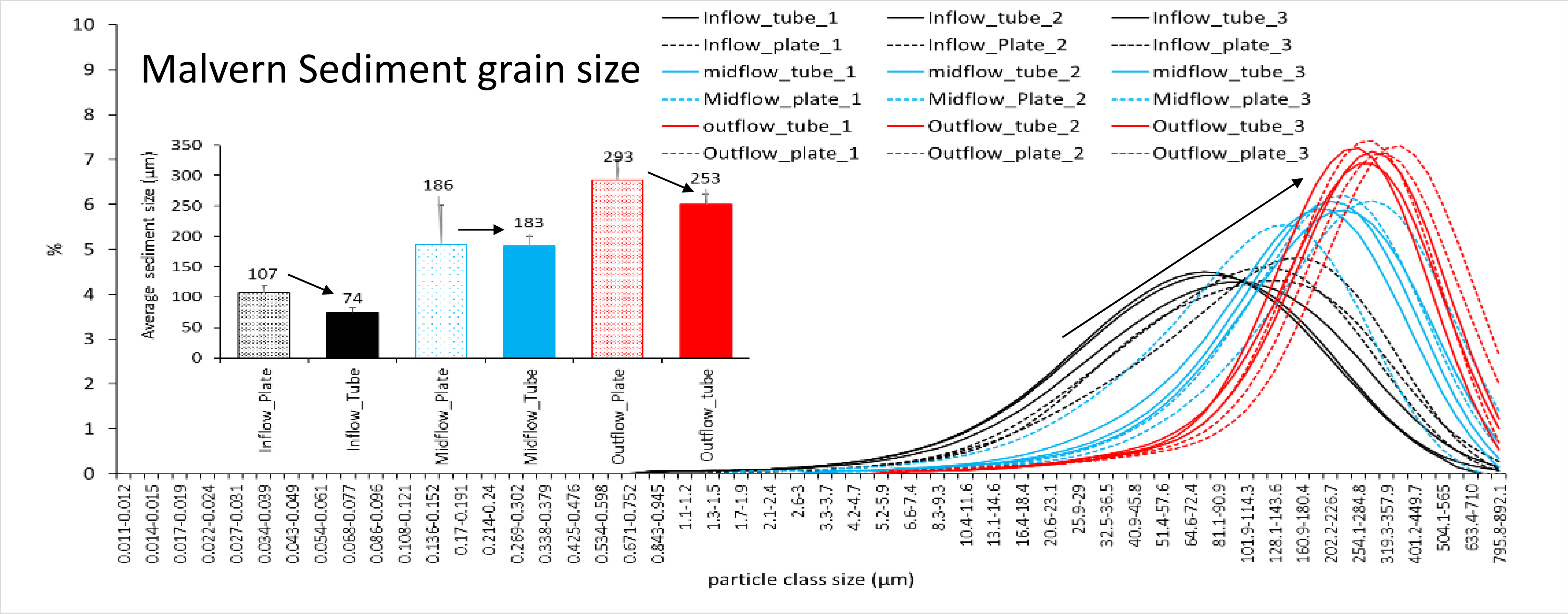


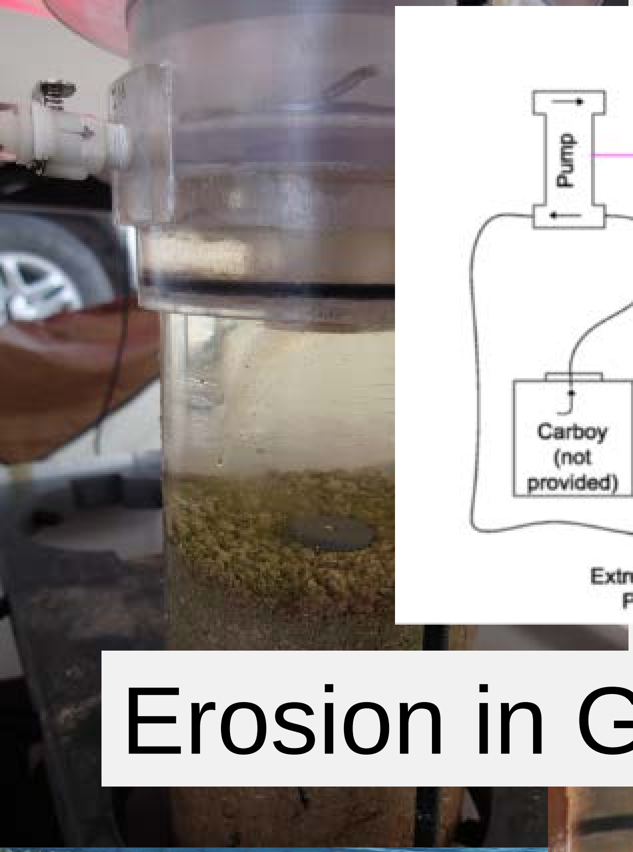


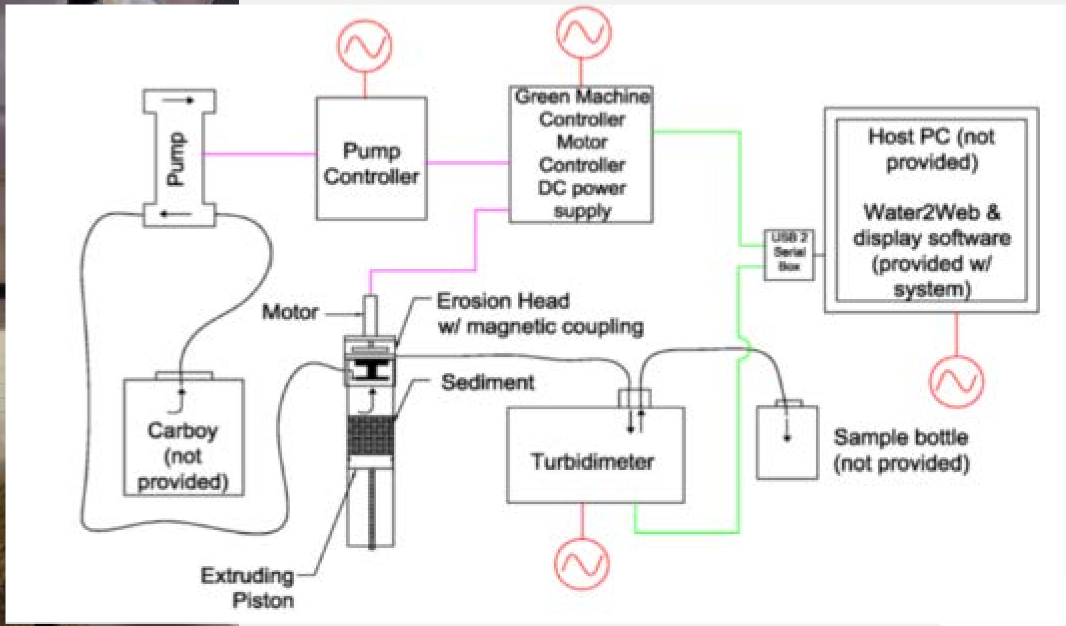
Preferential Flow Paths

- Circular and turbulent flow observed at inflow
- Preferential flow path along airboat crossing at inflow cell
- Relatively uniform flow at midflow
- Considerable preferential flow paths observed at the outflow transect

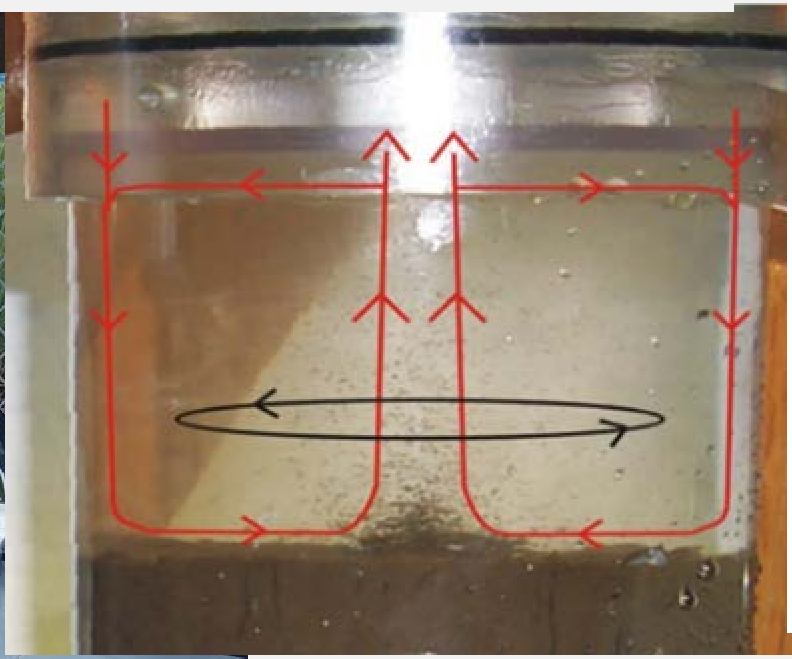
More abundant, larger particulate matter at the outflow than at the inflow

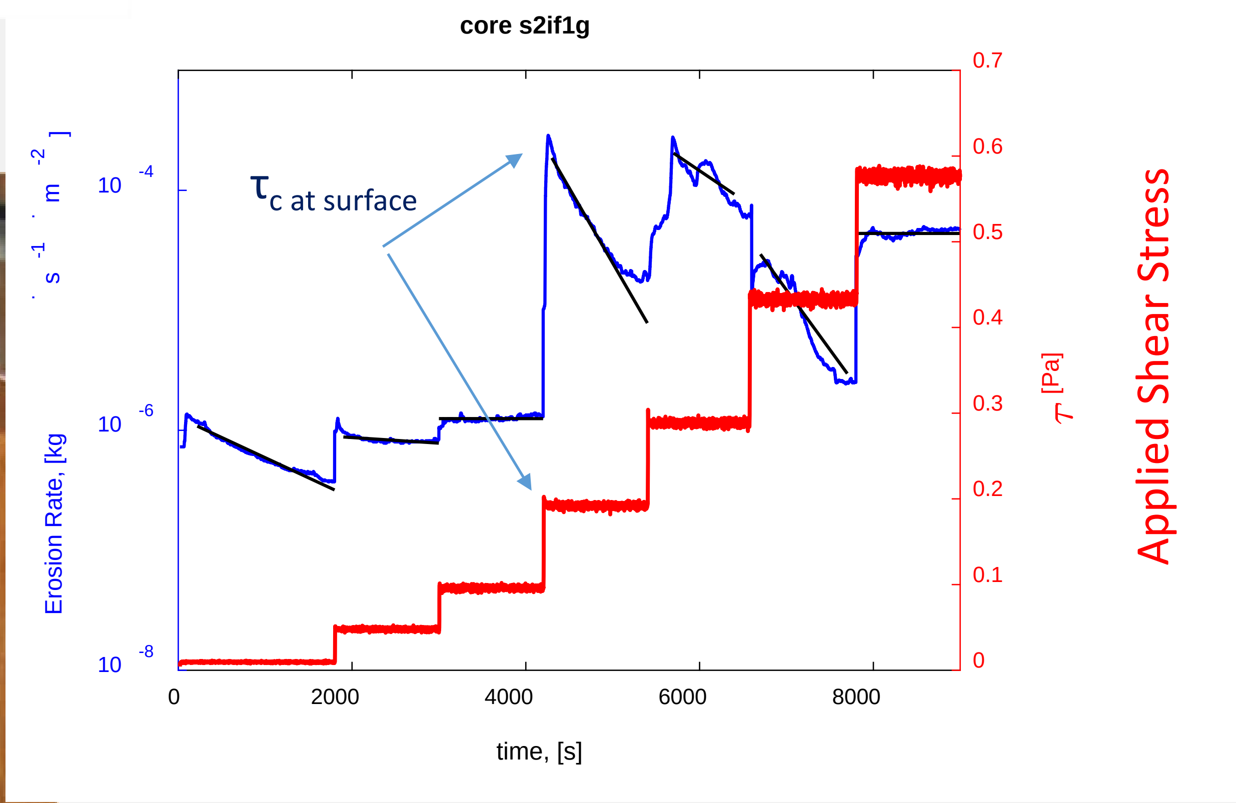






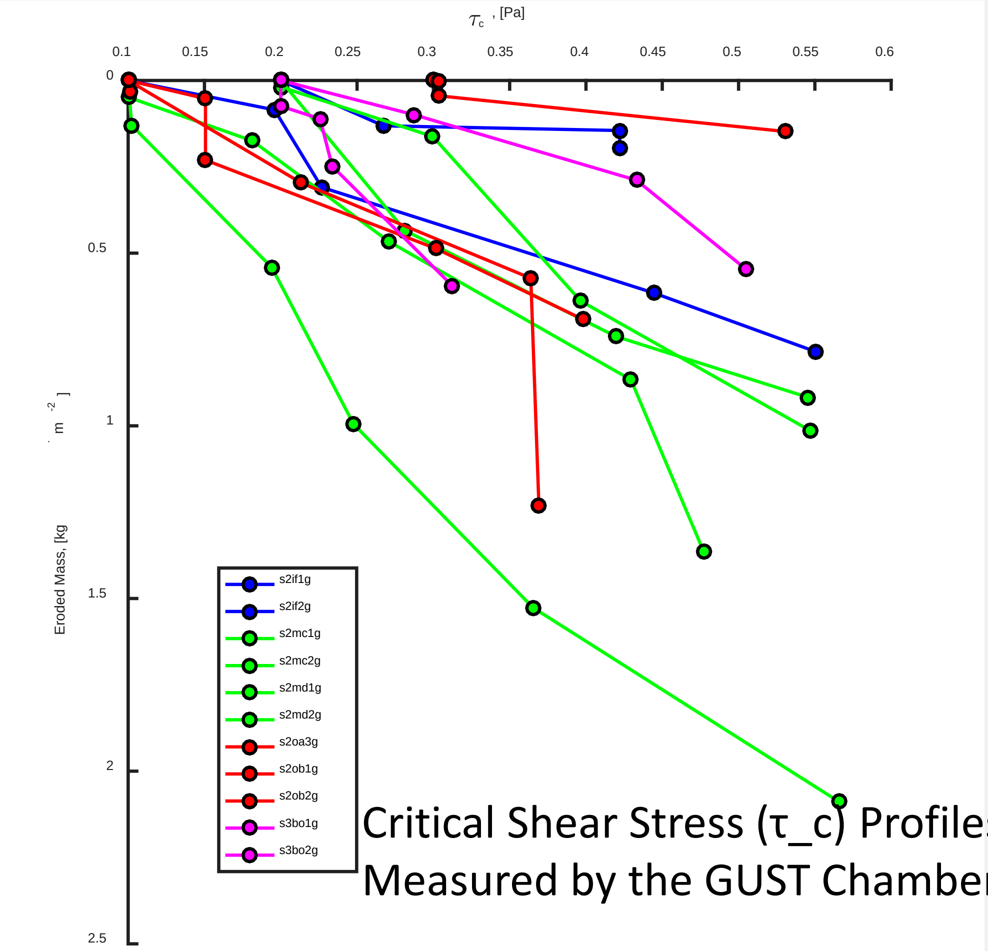
Erosion in Gust Chambers





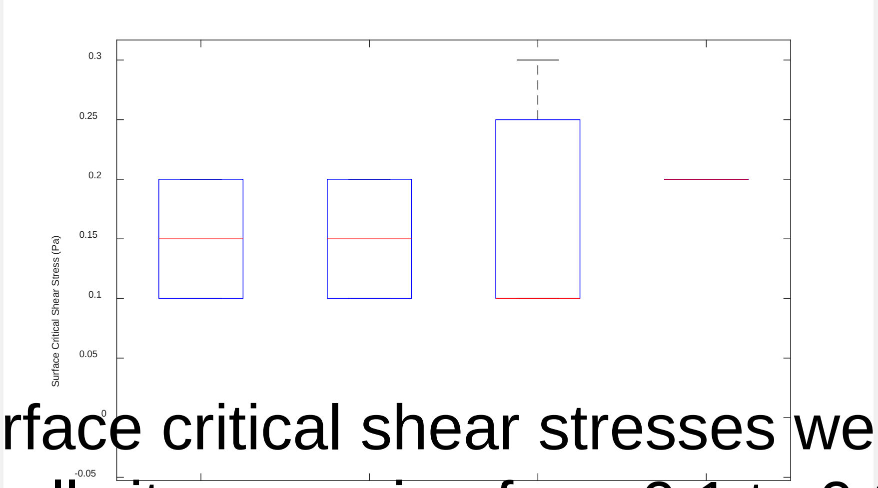
Gust Chambers

Video: https://1drv.ms/v/s!AtOz18n5P_pqnGlFxNF5NVrAnU2s

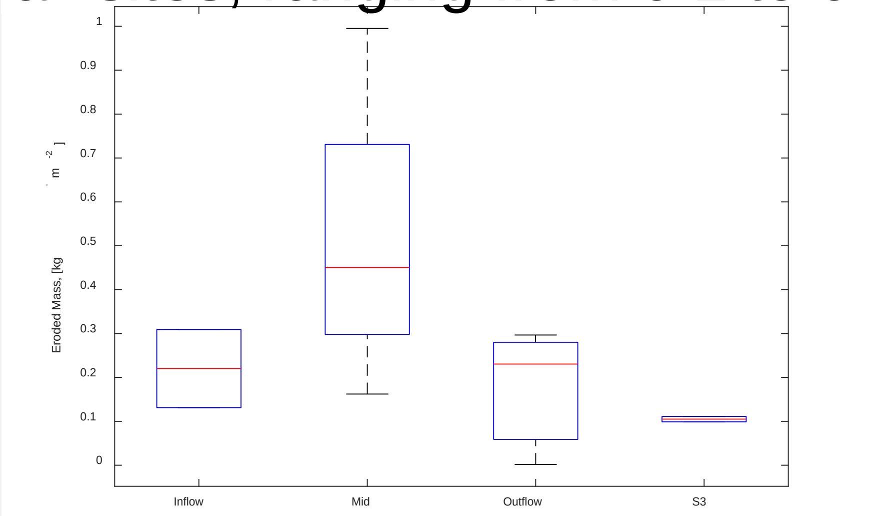


Critical Shear Stress (τ_c) Profiles Measured by the GUST Chamber

Eroded Mass is a proxy for depth. Usually only the first few surface millimeters are eroded, with the exception of two of the mid site cores which eroded a few centimeters



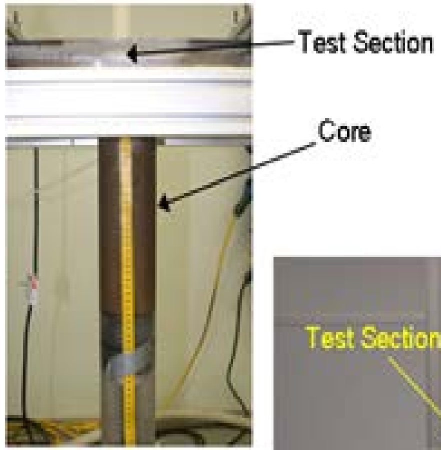
Surface critical shear stresses were similar for all sites, ranging from 0.1 to 0.3 Pa.

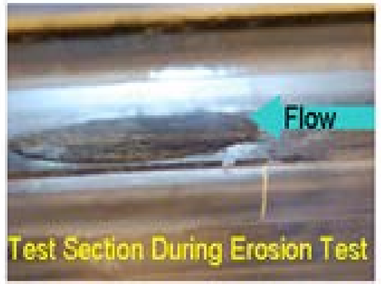


Total eroded mass at the end of the 0.45 Pa step greater (ns) erosion at midflow than the other sites.

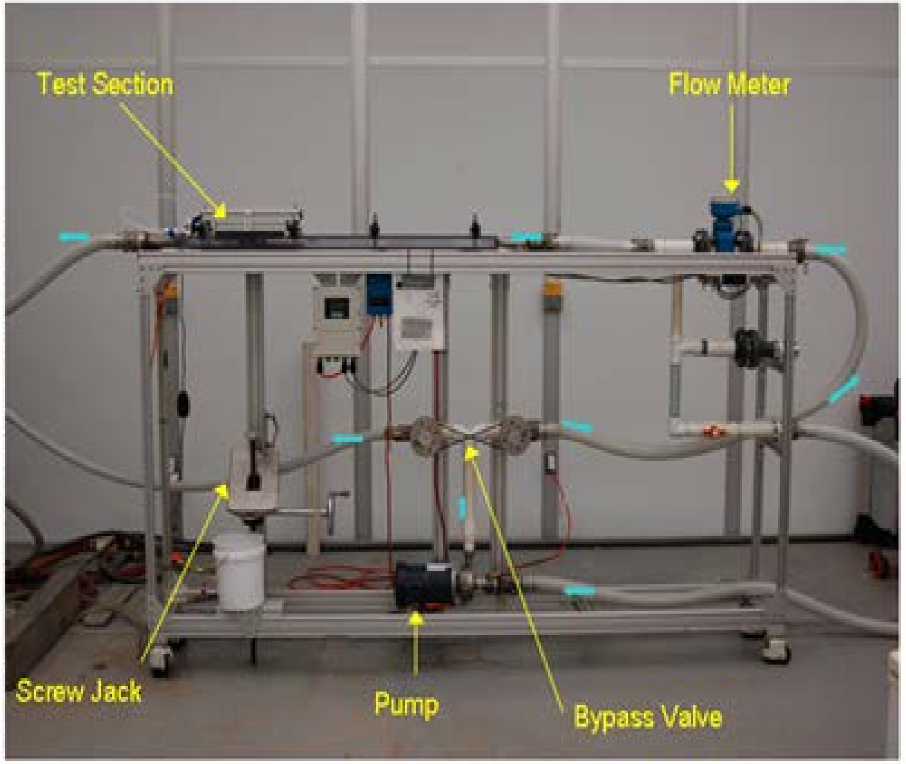
SEDFLUME -Erosion

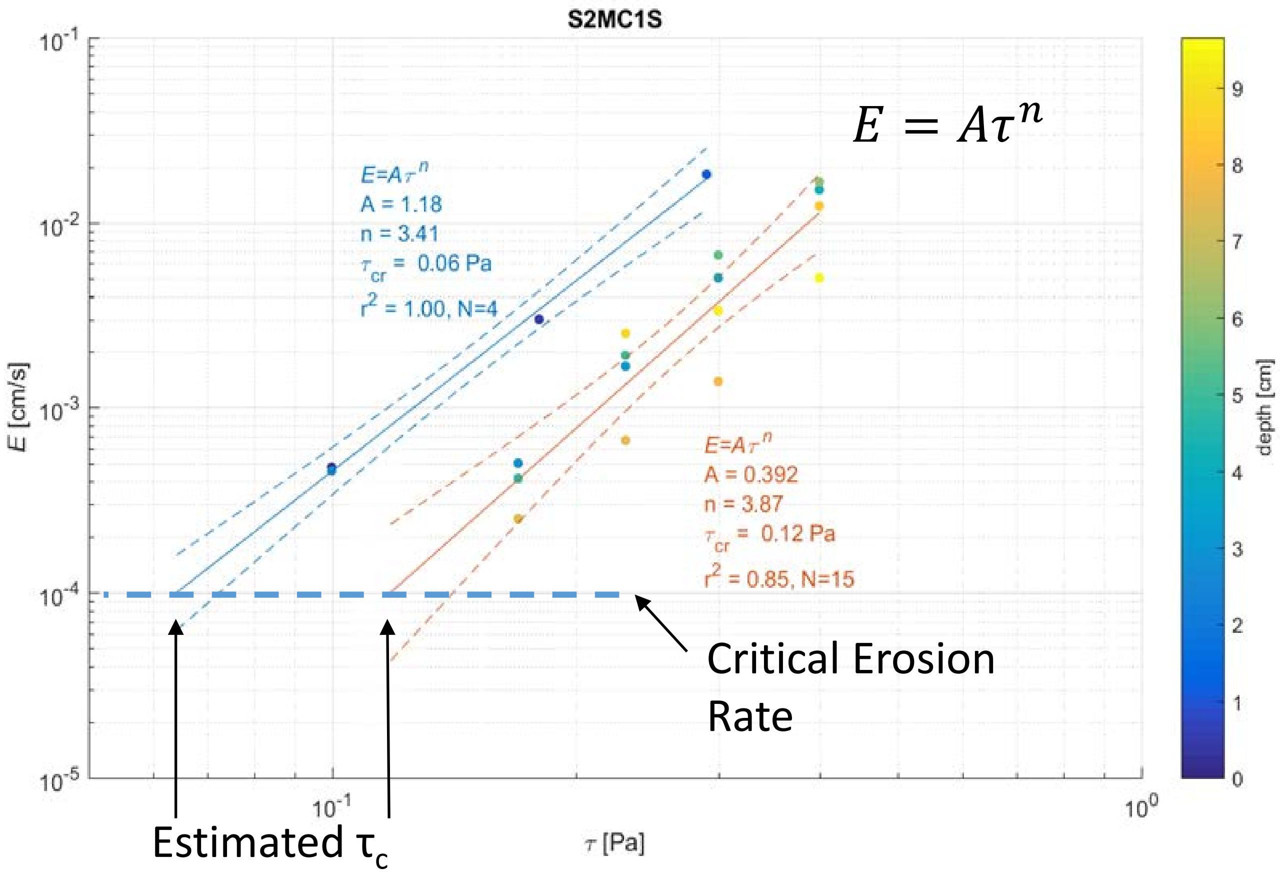
- 1-5 mm eroded per step
- Each step 20 s – 10 m duration





Shear stress t (Pa)	Flow Rate (GPM)
0.1	6.1
0.2	9.1
0.4	13.5
0.6	17.0
0.8	20.1
1.2	25.3
1.6	29.8
2.4	37.4
3.2	44.0
4	49.9
5	56.6
6.4	65.0
8	73.7
10	83.5
12	92.5
13	96.7
14	100.8



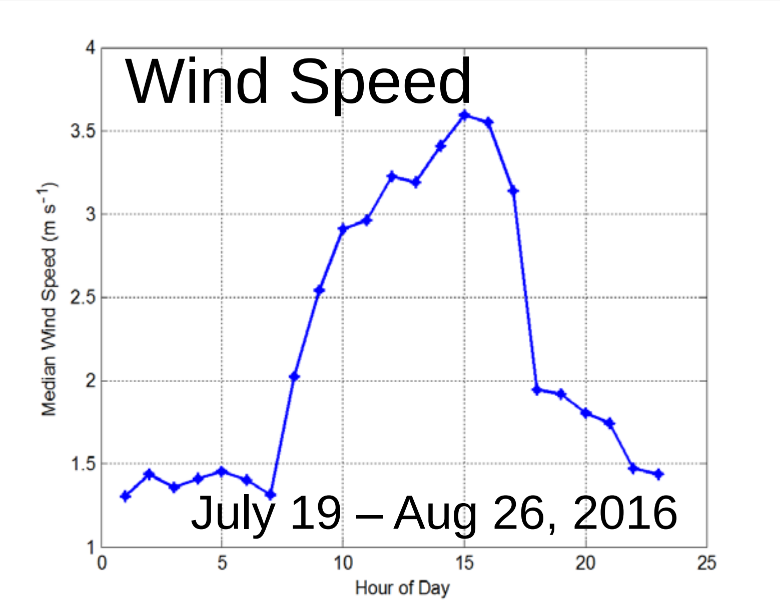


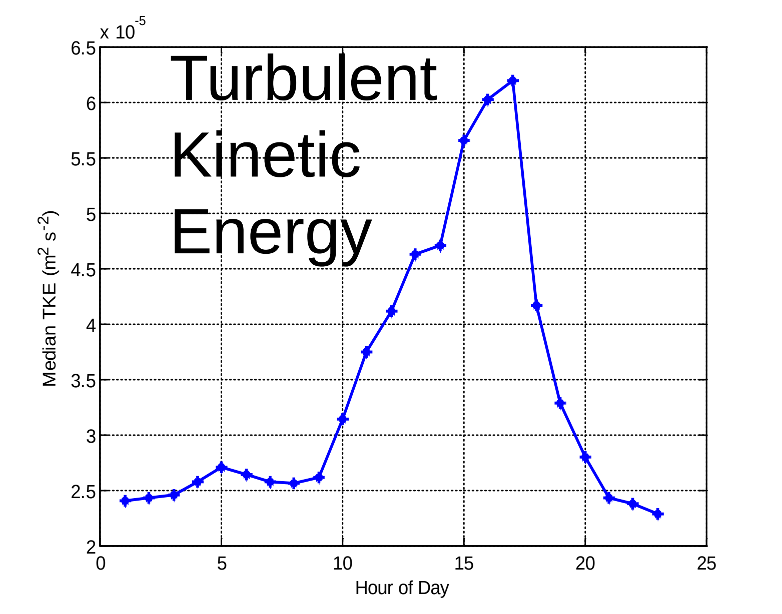
- Surface sediments have critical stress generally <0.1 Pa. Median value: 0.06 Pa.
- Erosion resistance increases with depth. Median critical stress >3 cm is 0.14 Pa.
- Replicate cores at each location were consistent in results.

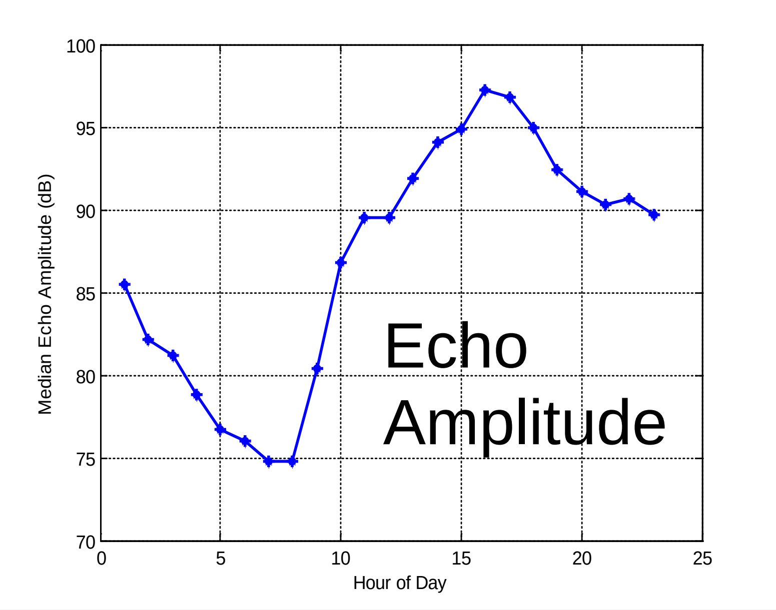
Meteorological Effects

O(2) less than τ_c of bed sediment!

- Current and suspended sediment conc.(SS) followed a diurnal pattern driven by peak afternoon winds.
- Both Turbulent Kinetic Energy (TKE) and Reynolds shear stress peak a few hours later.
- Echo Amplitude from the ADV provides a proxy for SS.
- Concentrations peak around the same time as maximum TKE and shear stress, but requires time for particles to settle out of the water column.
- Minimum concentrations are around 7-8 AM.







Conclusions

- Decreasing sediment TP conc. and increasing Ash content from Inflow to Outflow.
- Remnant canals, microtopography, proximity to outflows, and operations effect preferential flow patterns.
- Relatively higher critical shear stress at surface of sediment than shear stresses exerted by the water column.
- Diurnal variability of water column suspended sediment concentration
- Measurements of bottom critical shear stresses for erosion made with the Gust and SedFlume instruments showed no significant difference between sites and critical shear stresses ranged about 2 orders of magnitude greater than that measured in the water column! The dense lutocline creates a turbulent damping mechanism that makes it difficult to resuspend sediment from the bottom.
- Suspended sediment concentration peaks in the water column were likely due to wave turbulence resuspended material from aquatic vegetation leaves and stems.
- Size and abundance of particles increases downstream.

Most particulate flux is from recently deposited material upon leaves of aquatic vegetation that is easily resuspended during wind driven turbulence.


Thank You
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