# Benefits of V-SAM in Sediment Remediation:

## Trends observed from data collection and implications to future remedial costs

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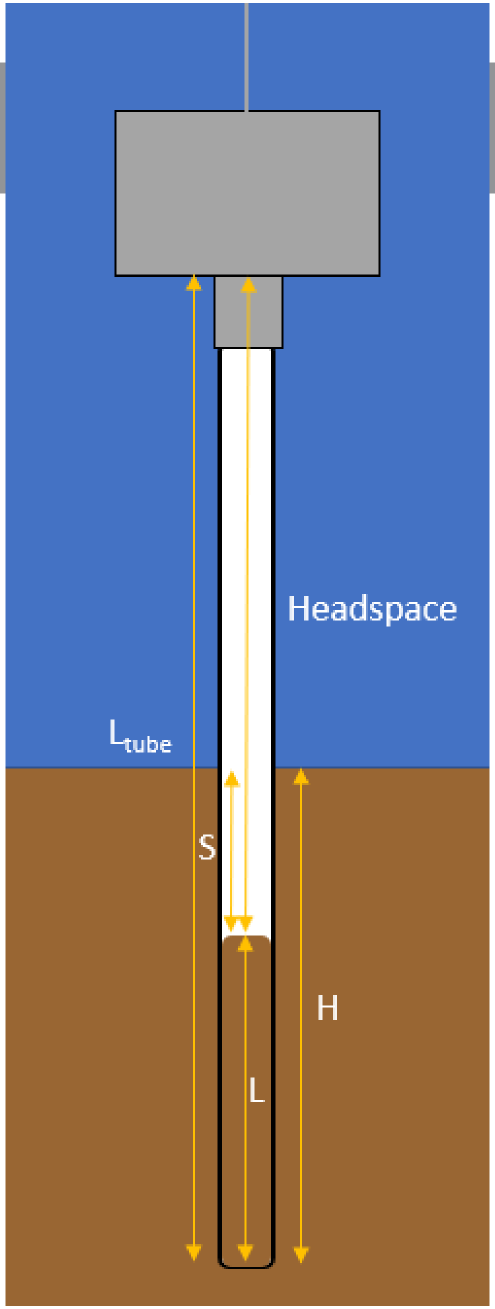
# Vibracore Measurements

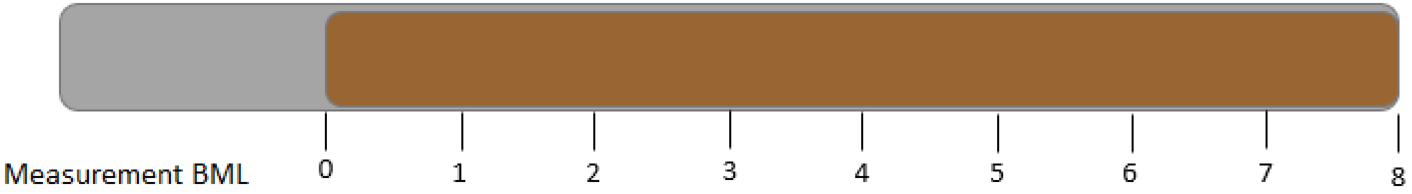
- Length of core tube ($L_{tube}$) – Headspace = recovered sediment (L)
- H is depth of penetration (field measured)
- For full penetration, H = $L_{tube}$ and S = Headspace
- Percent Recovery (%R) = L / H * 100

- **S measurement is where uncertainty lies in conventional vibracoring!**

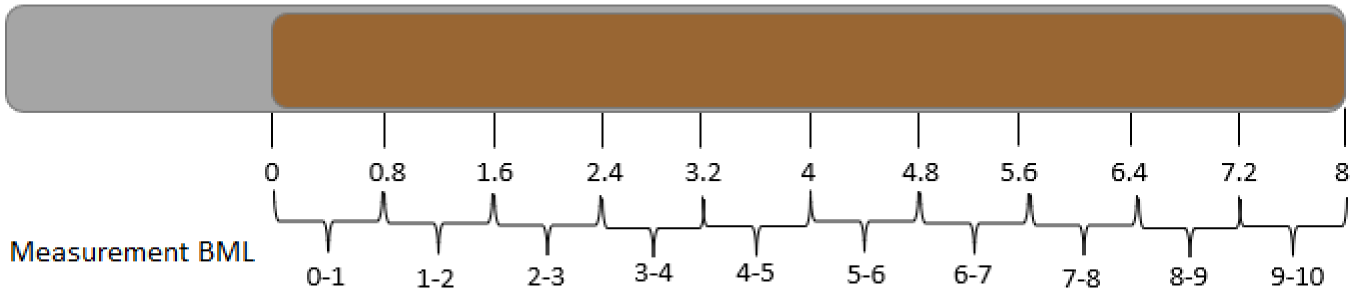


# Uncertainty in Conventional Techniques

- Static Method
  - Assumes all material loss is from bottom of core upon retrieval




- Stretch Method
  - Assumes uniform recovery throughout drive

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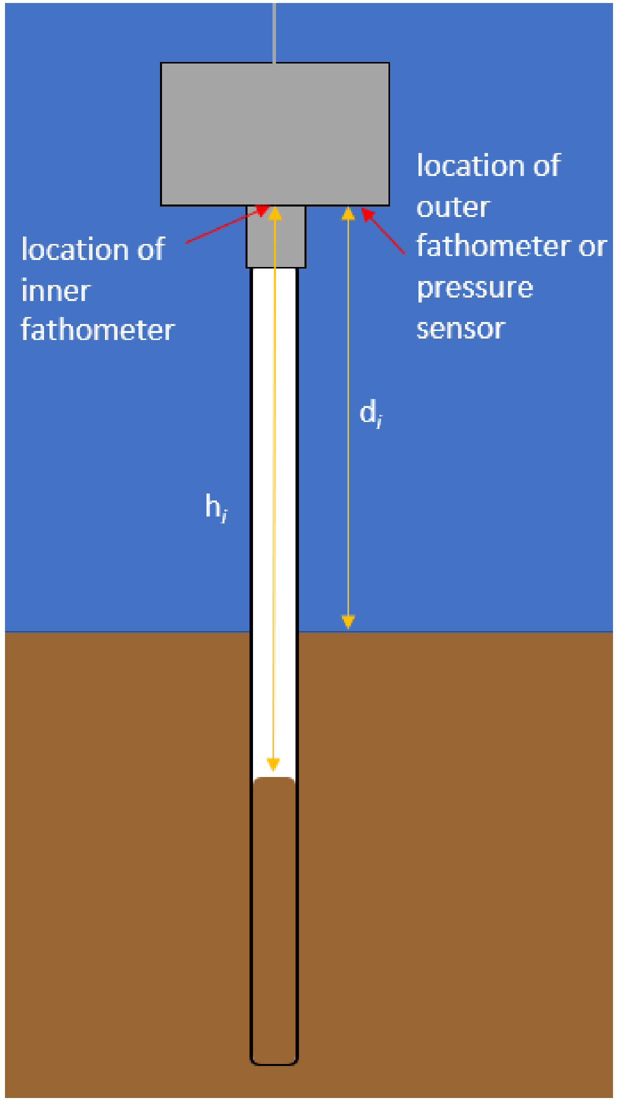
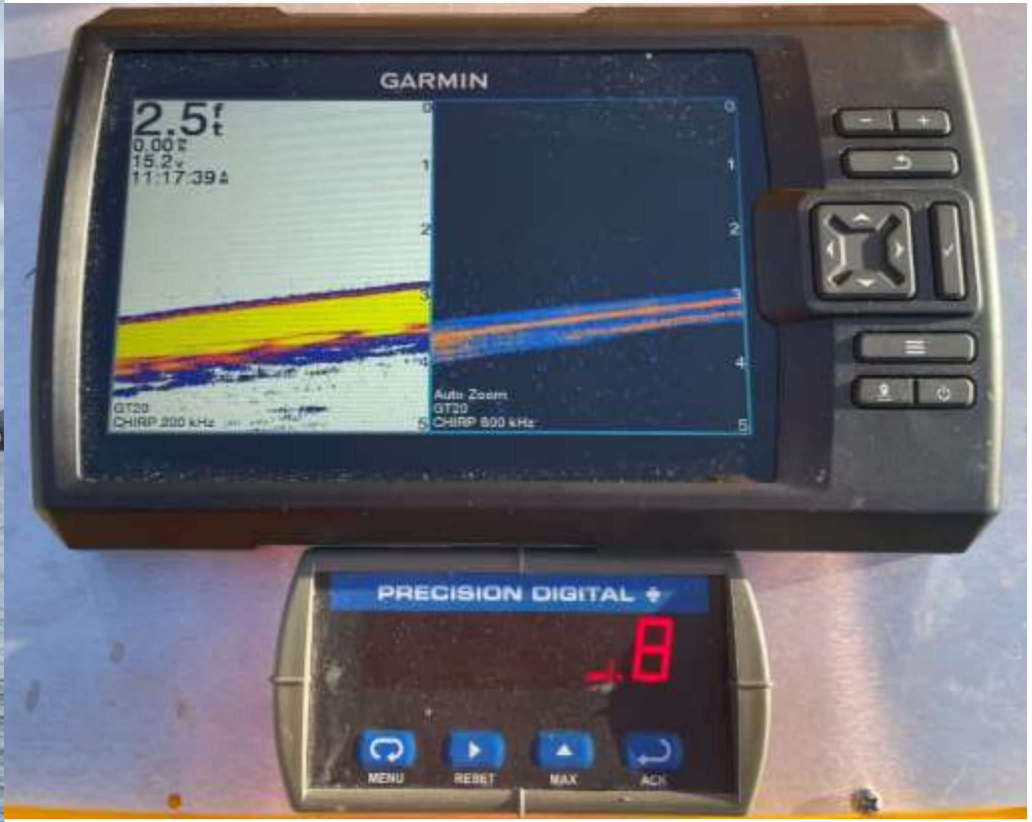
# Vibracoring Sediment Acquisition Monitoring (V-SAM)

- Measures incremental depth to mudline inside and outside of core tube
- Incremental depth of penetration ($d_i$) and incremental headspace ($h_i$) are recorded at various stages through the drive, typically in 1' to 3' intervals
- At start of drive, $h_i = L_{tube}$ with adjustments for location of fathometer
- Incremental L and H are calculated from obtained values



# Equipment


RESEARCH


GARMIN
2.5ft
0.00
15.2v
11:17:39
GT20
CHIRP 200 kHz
Auto Zoom
GT20
CHIRP 800 kHz
PRECISION DIGITAL
MENU
RESET
MAX
ACK

# Sample Data Collected with V-SAM

| Fathometer Readings | | TUBE (ft.) | | Increment | | Core Cut Plan (ft.) | |
|---|---|---|---|---|---|---|---|
| Depth | Acquire | Drive | Acquire | % Recover | Comment | In-Situ | Core |
| 12.1 | 20 | 0.0 | 0.0 | | | HS | 3.2 |
| 15 | 18.9 | 2.9 | 1.1 | 38% | | 0.0 | 0.0 |
| 18 | 17 | 5.9 | 3.0 | 63% | | 1.0 | 0.4 |
| 21 | 14.1 | 8.9 | 5.9 | 97% | | 2.0 | 0.8 |
| 24.1 | 10.7 | 12.0 | 9.3 | 110% | | 3.0 | 1.2 |
| 27.2 | 7.5 | 15.1 | 12.5 | 103% | | 4.0 | 1.8 |
| 30 | 4.8 | 17.9 | 15.2 | 96% | | 5.0 | 2.4 |
| 31.1 | 3.4 | 19.0 | 16.6 | 127% | | 6.0 | 3.1 |
| | | | | | | 7.0 | 4.1 |
| | | | | | | 8.0 | 5.0 |
| | | | | | | 9.0 | 6.0 |
| | | | | | | 10.0 | 7.1 |
| | | | | | | 11.0 | 8.2 |
| | | | | | | 12.0 | 9.3 |
| | | | | | | 13.0 | 10.3 |
| Process core? (y/n/b/x)* | | y | | | | 14.0 | 11.4 |
| | *n* | *Interpolated value* | | | | 15.0 | 12.4 |
| | * | "Accepted"/"Rejected"/"Bulk Sample Only"/"No Core Recovered" | | | | 16.0 | 13.4 |
| | | | | | | 17.0 | 14.3 |
| | | | | | | 18.0 | 15.3 |
| | | | | | | 19.0 | 16.6 |

# Considerations for the V-SAM System

- Drive increment
- Shallow water
- Soft sediment
- Losses upon retrieval
- Instrument precision
- Percent recovery
- Uncertainty
- Acceptance criteria

# Data Collection using V-SAM

- 3 projects in a riverine environment
- 140 cores collected using V-SAM
- ΔS is the difference between the final acquisition reading for headspace and the measured headspace after retrieval

| Number of Cores | Average Increment of Data Collection | Average %R, Total | Average ΔS (+/-) |
|---|---|---|---|
| 140 | 2.2 ft | 86% | 0.2 ft |

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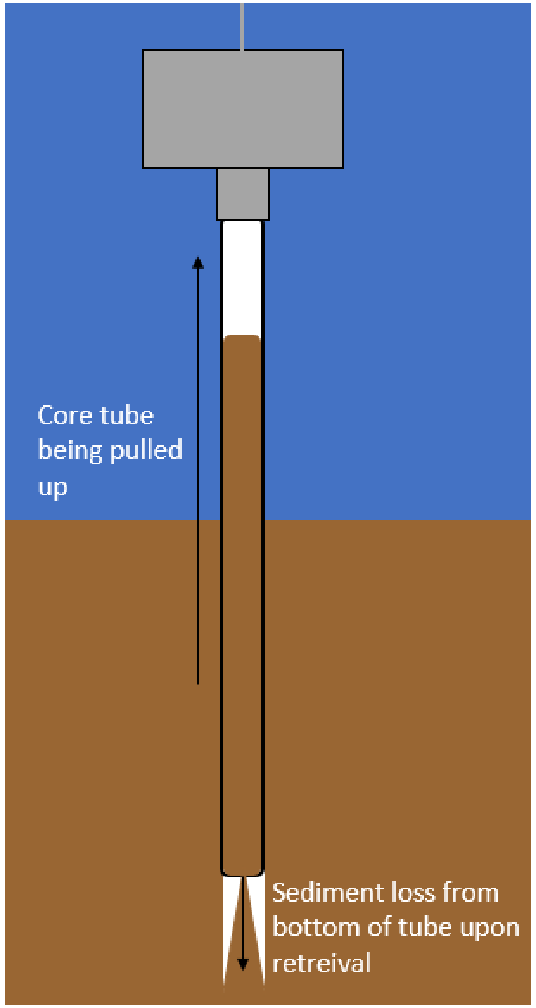
# Observed Sediment Trends using V-SAM




- Losses from Bottom of Core Tube during Retrieval
    - Only 4 cores out of the 140 cores collected had losses out the bottom of the core greater than 6” upon retrieval
    - Maximum loss out the bottom was 1.7’
    - Average change from the final acquisition reading to the measured headspace (ΔS) was 0.2’
    - Sediment loss from the bottom of the core was not a significant trend!

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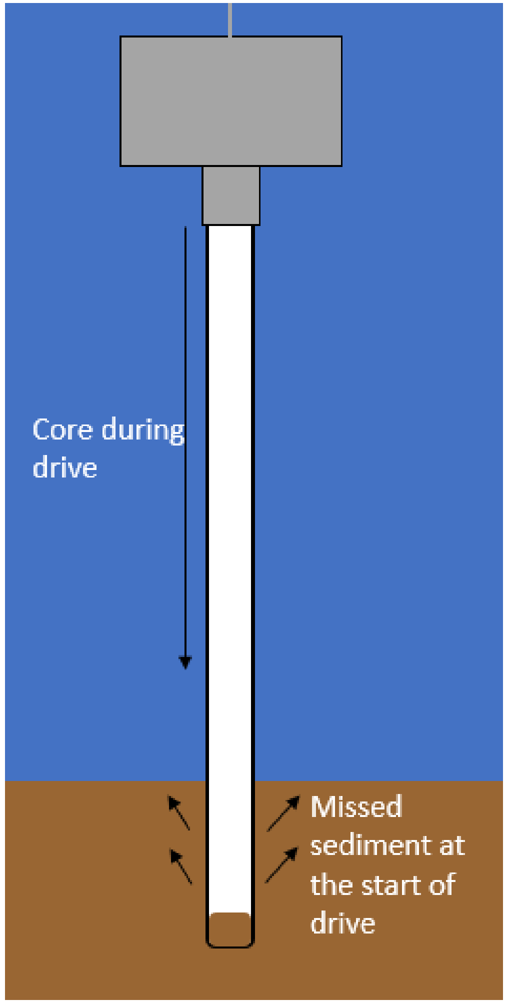
# Observed Sediment Trends using V-SAM




- Missing Sediment from the Start of the Drive
  - To determine how much sediment was missed in the start of the drive, %R for the first increment was compared with %R for other intervals
  - 30% of cores had a percent recovery of less than 50%
  - Over 40 cores missed at least 1.1 feet in the first increment of the drive
  - Some cores missed up to 5 feet of material from the start of the drive
  - Missed sediment from the start of the drive was much more significant than sediment lost from the bottom of the core!

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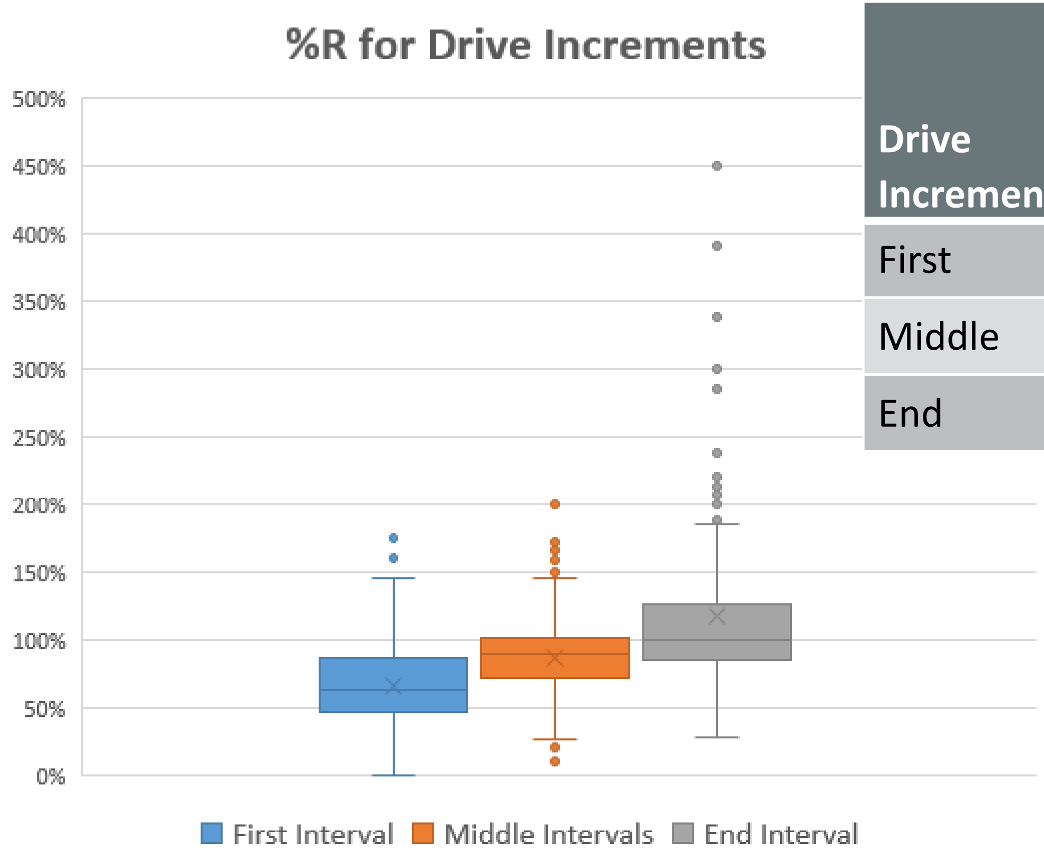
# Observed Sediment Trends using V-SAM

- Missing Sediment from the Start of the Drive




| Drive Increment | Average %R | Median %R | Percent of Intervals with Less Than 50% Recovery | Percent of Intervals with Greater Than 100% Recovery | Number of Samples |
|---|---|---|---|---|---|
| First | 66% | 63% | 30% | 9% | 140 |
| Middle | 87% | 90% | 9% | 25% | 516 |
| End | 118% | 100% | 7% | 47% | 140 |

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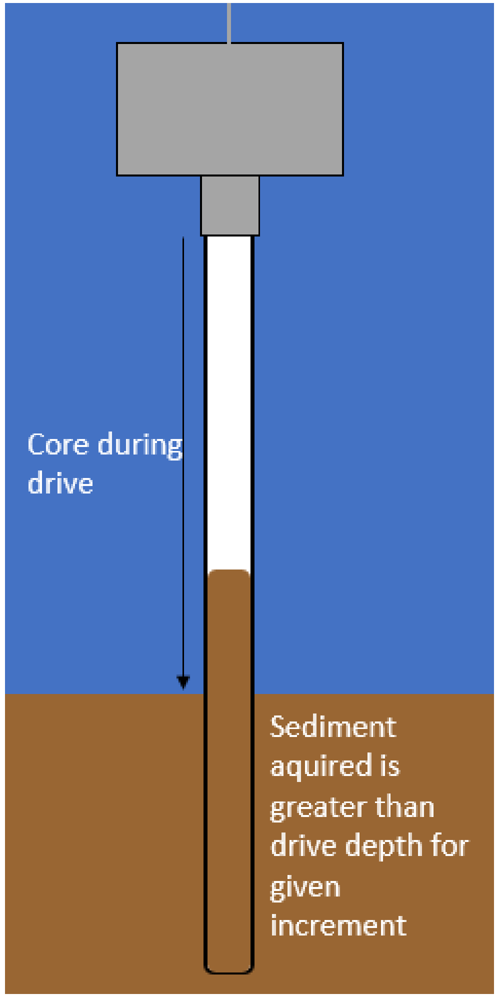
# Observed Sediment Trends using V-SAM




- Increments with Greater than 100% Recovery
  - Can be an indicator of material expansion within core tube
  - Over 47% of the final increment in a drive had %R>100
  - Likely due to additional vibration at end of drive to try and "break through" refusal point
  - Can mask earlier intervals of poor recovery when using conventional methods

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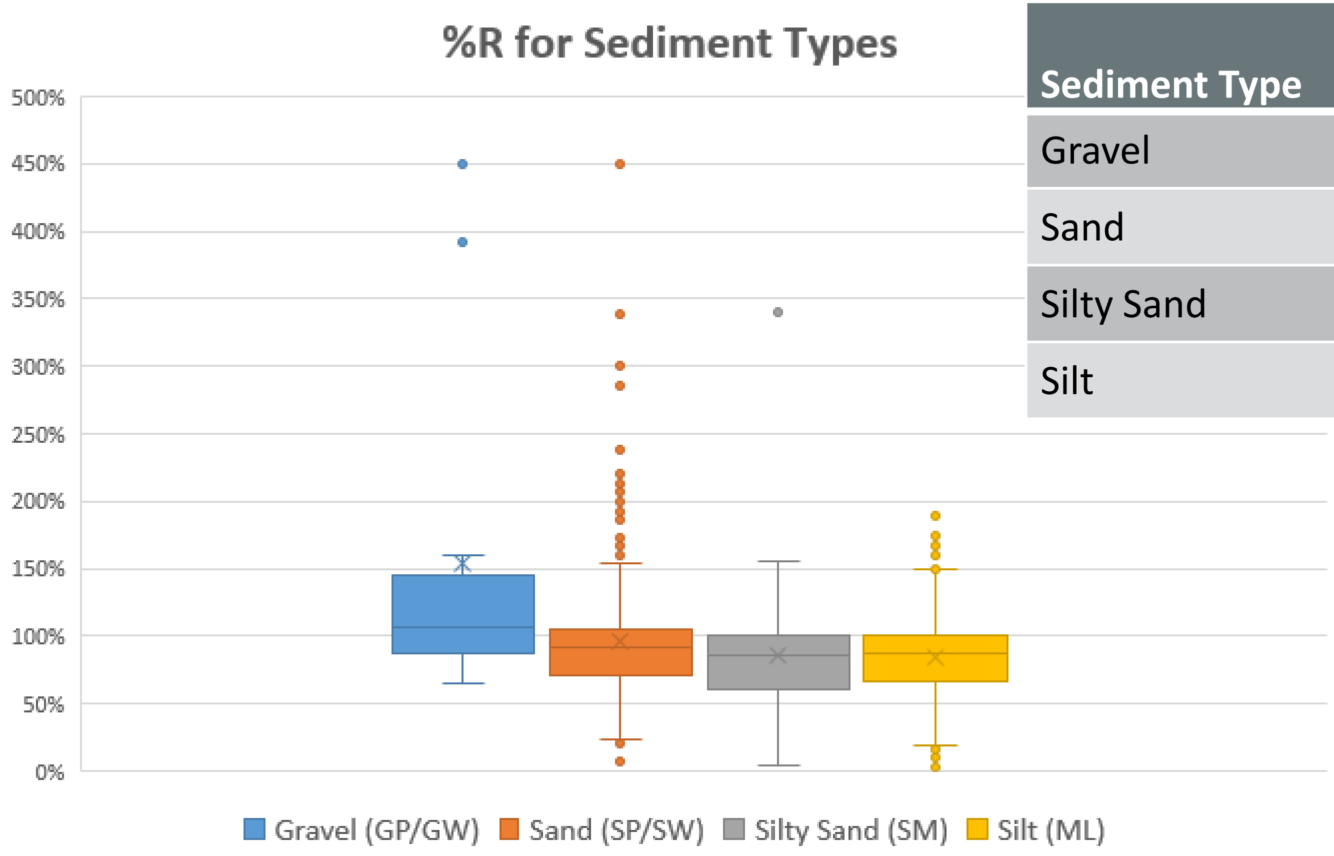
# Observed Sediment Trends using V-SAM

- Percent Recovery for Different Sediment Types




| Sediment Type | Average %R | Median %R | Number of Samples |
|---|---|---|---|
| Gravel | 153% | 106% | 13 |
| Sand | 92% | 92% | 251 |
| Silty Sand | 82% | 85% | 68 |
| Silt | 84% | 87% | 458 |

# Observed Sediment Trends using V-SAM

- Percent Recovery for Different Sediment Types
  - 58% of intervals were classified as primarily silt
  - Sediment that was missed during the drive (likely soft silts) would not be accounted for and would bias the silt percent recovery high
  - Small sample size for gravel
  - Clean sands had an average percent recovery 8 to 10% higher than silty sands or silts

# Potential Implications on Cost and Schedule

- The uncertainty associated with estimating in-situ DOC bml can limit the efficacy of precision remediation dredging, which can affect the cost, schedule, and overall success of remedial actions

**Sample** → **Assign Elevation of Contamination (EOC)** → **Remedial Design based on EOC**

# Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology
  - In order to estimate differences in calculated in-situ sample depth bml, an *arbitrary* sample depth of 5’ using the V-SAM method was selected
  - Actual data were taken and used to calculate equivalent sample depth for each core using the Static and Stretch methods

# Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology: EXAMPLE

| Fathometer Readings | | TUBE (ft.) | | Increment | | Core Cut Plan (ft.) | |
|---|---|---|---|---|---|---|---|
| Depth | Acquire | Drive | Acquire | % Recover | Comment | In-Situ | Core |
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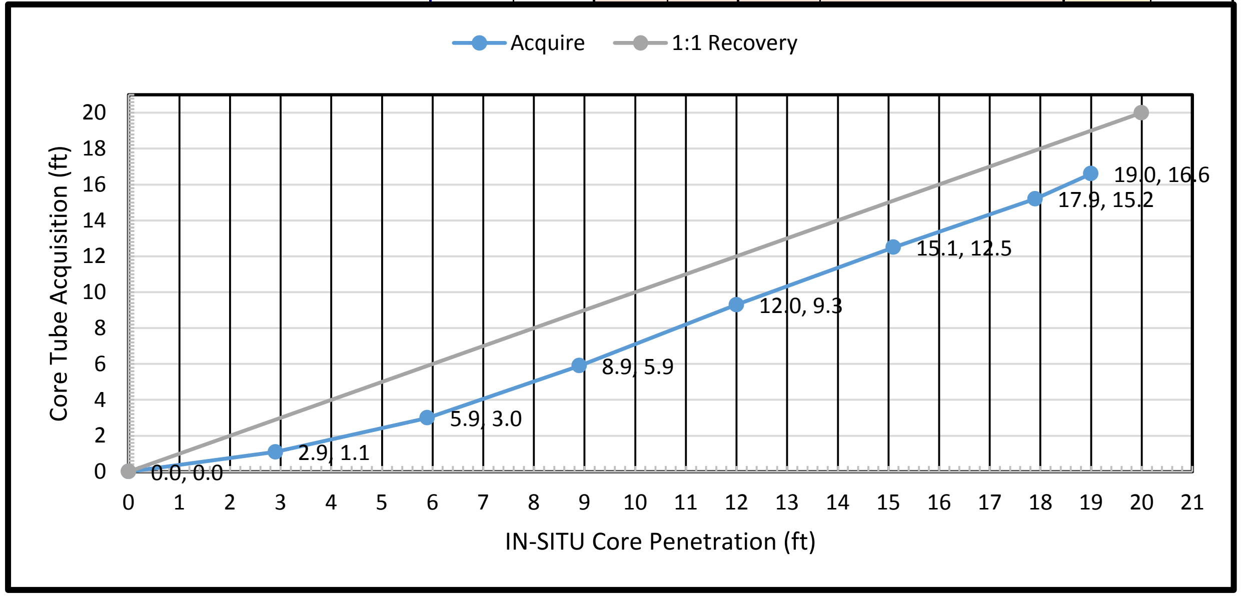



20’ core tube
3.2’ headspace
87% recovery

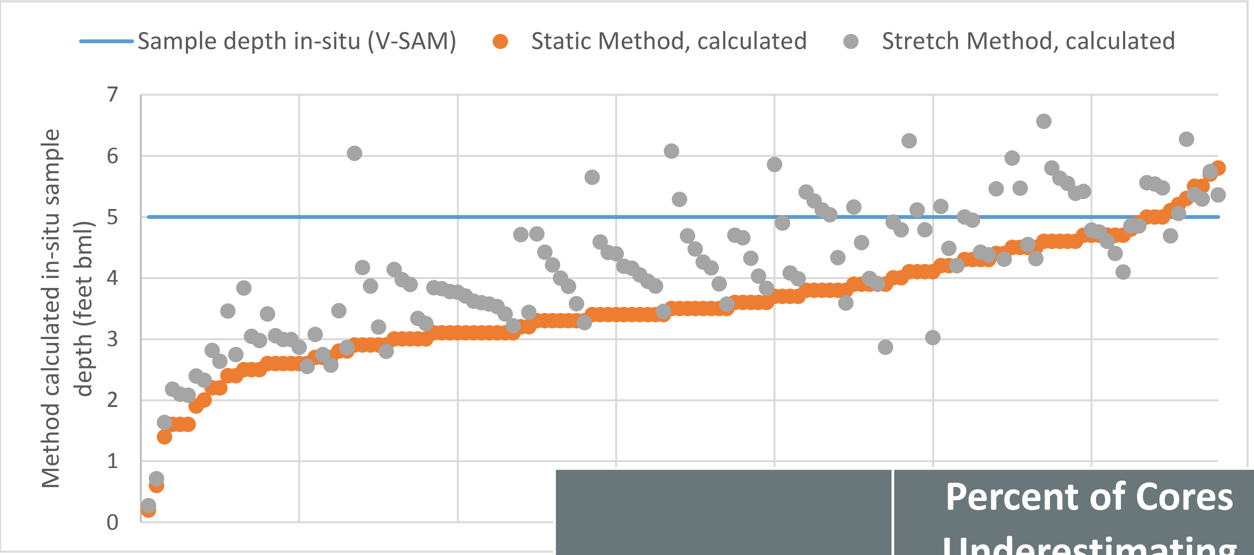
Deepest contaminated sample

<u>Calculated in-situ depth (bml)</u>

V-SAM: 5–6’ bml
Static: 2.4–3.1’ bml
Stretch: 2.8–3.3’ bml

# Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology




| Method of Calculation | Percent of Cores Underestimating Sample Depth for V-SAM at 5 ft | Average Distance above V-SAM Method | Percent of Cores Overestimating Sample Depth for V-SAM at 5 ft | Average Distance Below V-SAM Method |
|---|---|---|---|---|
| Static Method | 93% | 1.6 feet | 5% | 0.4 feet |
| Stretch Method | 76% | 1.3 feet | 23% | 0.6 feet |

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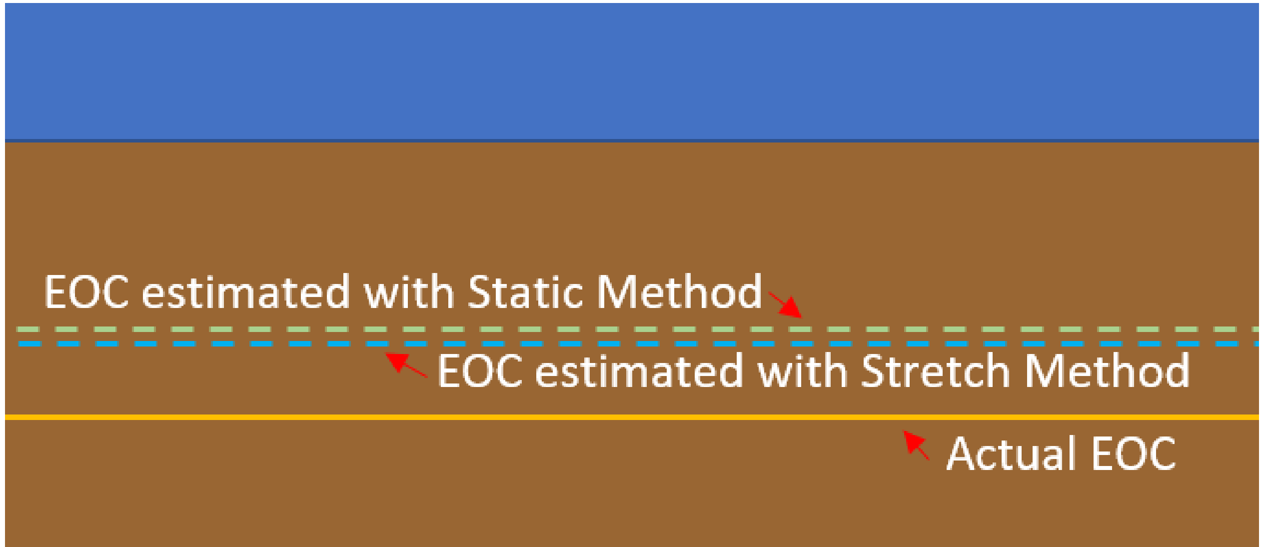
# Potential Implications on Cost and Schedule

- Theoretical Differences in Calculated In-Situ Sample Depth versus Using V-SAM Technology
- Assuming each core represents a 100’x100’ area for a total area of ~ 32 acres
  - Static Method – Could result in needing to re-dredge ~77,000 CY of material, and ~1,000 CY of presumed clean material would have been dredged
  - Stretch Method – Could result in needing to re-dredge ~51,000 CY, and ~ 7,000 CY of presumed clean material would be dredged

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# Potential Implications on Cost and Schedule

- For theoretical 32-acre project, associated costs with overdredging or having to redredge:

| Cost of Overdredging | | | | Static | | Stretch |
|---|---|---|---|---|---|---|
| **Dredging** | $ 31 | CY | $ | 32,000 | $ | 223,000 |
| **Disposal** | $ 111 | Ton | $ | 184,000 | $ | 1,300,000 |
| | | | *Subtotal $* | *220,000* | *$* | *1,520,000* |
| **Cost of Redredging** | | | | | | |
| **Re-MOB/DEMOB** | $ 1,000,000 | LS | $ | 1,000,000 | $ | 1,000,000 |
| **6" cap** | $ 34 | CY | $ | 1,600,000 | $ | 1,300,000 |
| **Resample** | $ 500,000 | LS | $ | 500,000 | $ | 500,000 |
| | | | *Subtotal $* | *3,100,000* | *$* | *2,800,000* |
| | | | Contingency (15%) $ | 465,000 | $ | 420,000 |
| | | | **TOTAL $** | **3,800,000** | **$** | **4,700,000** |

- Could also end up needing to re-characterize and redesign!

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# Potential Implications on Cost and Schedule

- Not to mention additional dredging that wouldn't have been budgeted for…

| Unbudgeted Costs | | | Static | Stretch |
|---|---|---|---|---|
| **Dredging** | $ 31 | CY | $ 2,000,000 | $ 2,000,000 |
| **Disposal** | $ 111 | Ton | $ 14,000,000 | $ 9,000,000 |
| | | **TOTAL** | **$ 16,000,000** | **$ 11,000,000** |

- Could be the difference in receiving a "No Further Actions" letter from the agencies or having to go back and have on-going remediation!

# Thank you

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