# FY21 RSM Mid-Year IPR
# Improving Floodplain Sedimentation Analysis

John Shelley (NWK) Stanford Gibson (HEC) and Michael Mansfield (NWK)

**BLUF**: One-dimensional sediment models consistently overpredict floodplain deposition. This work unit improves these methods, tests them against experimental data and applies them to measurements on the Missouri River.

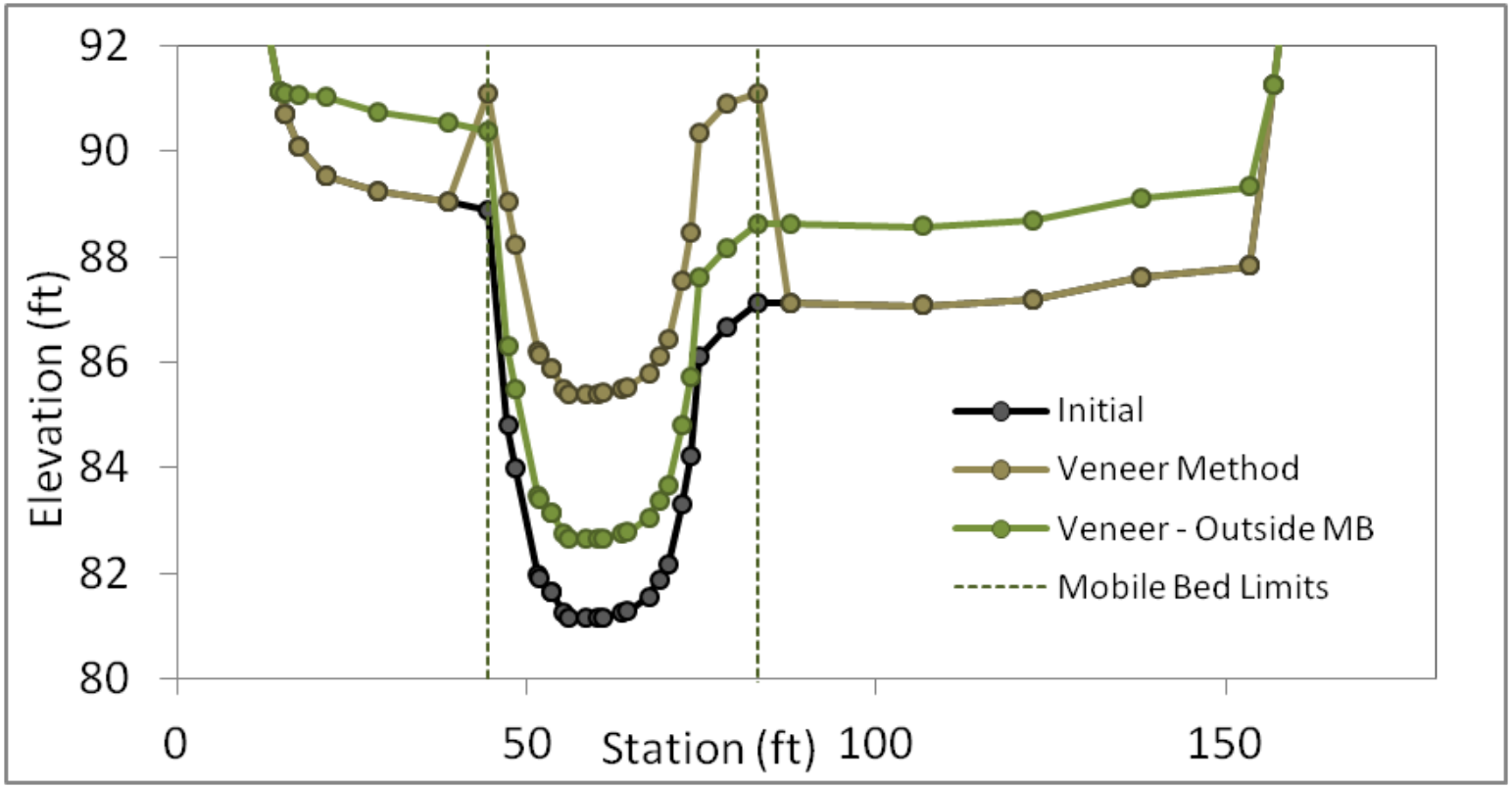
## Activities:

1. Solicited input from USACE SMEs and External Researchers
2. Developed Algorithms, Pseudo Code, and Design Document
3. Developed 1D and 2D sediment Models of Flume Data Set (for V&V)
4. Collected Sediment Samples from Missouri Floodplain Deposition
5. Developed 1D and 2D Sediment Models of Missouri River Reach
6. NWK/HEC Collaborative Modeling Week
7. HEC-RAS Development

Floodplain deposition at Locust Creek State Park, MO

# **BLUF** (summary): The Veneer Method Stinks!

(…for floodplain deposition)



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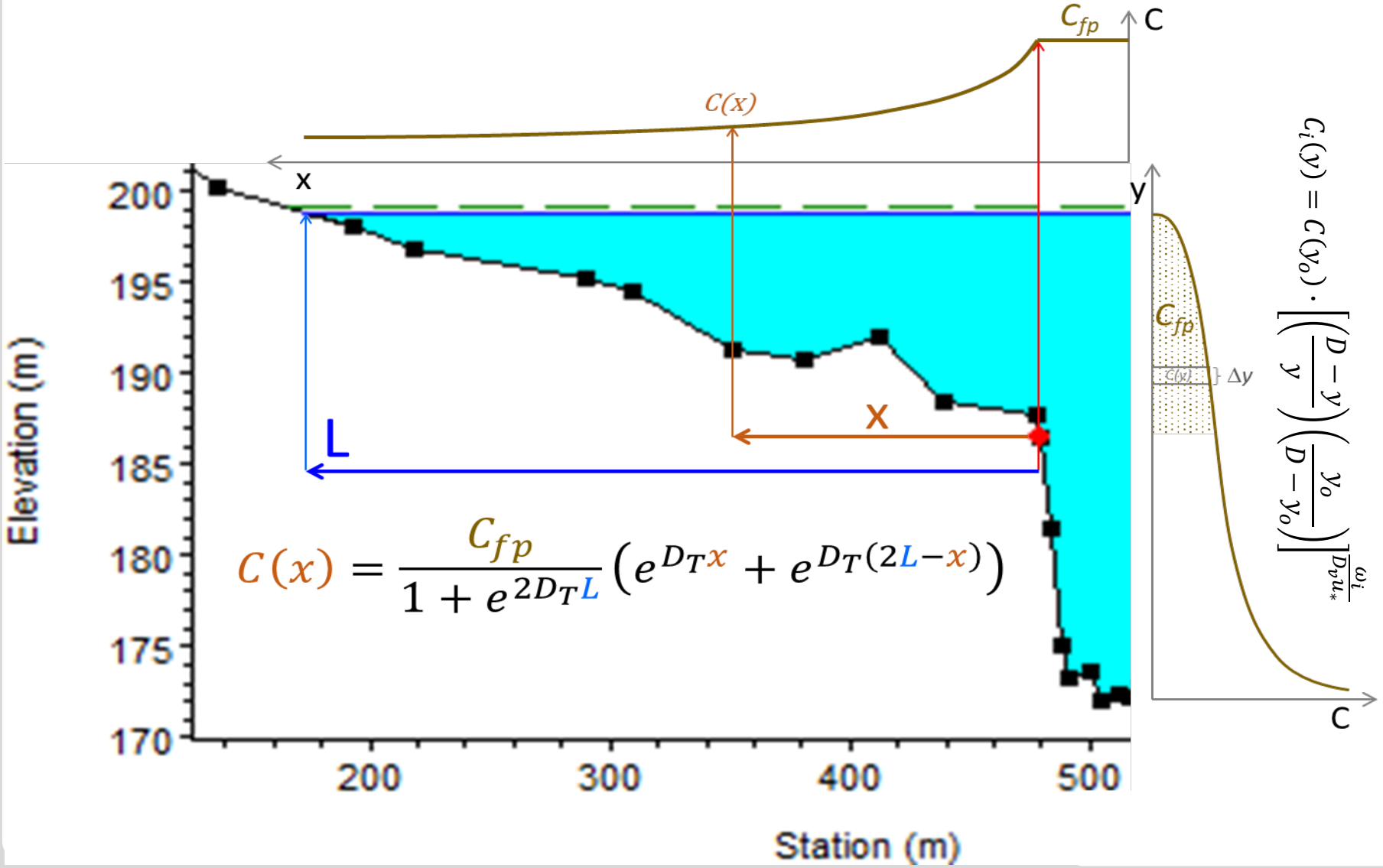
# Improving Floodplain Sedimentation Analysis



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# Improving Floodplain Sedimentation Analysis

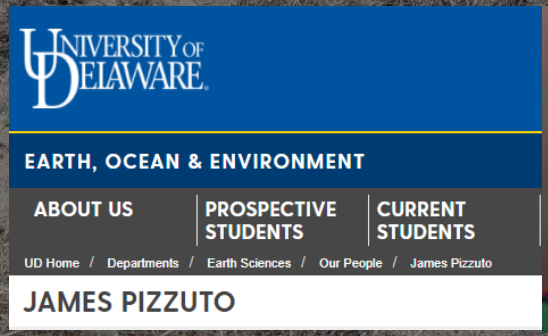
1. Solicited input from USACE SMEs and External Researchers

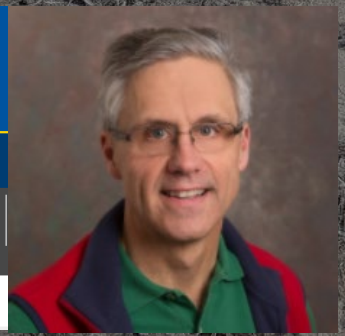
**Project Team:**
**Dr. John Shelley (NWK)**
**Dr. Stanford Gibson (IWR-HEC)**
**Michael Mansfield (NWK)**

Q1 – Literature Review

12/8/2020 – Met with USACE sediment transport SMEs Dr. Calvin Creech (SAM), Zachary Corum (NWS), and Jonathan AuBuchon (SPA) to present the proposed algorithms and solicit feedback about floodplain deposition issues in other morphological settings.

2/22/2021 - Met with Dr. Jim Pizzuto, University researcher who has been most prolific on floodplain deposition.



Floodplain deposition at Elwood Conservation Area Missouri River 2019 Flood

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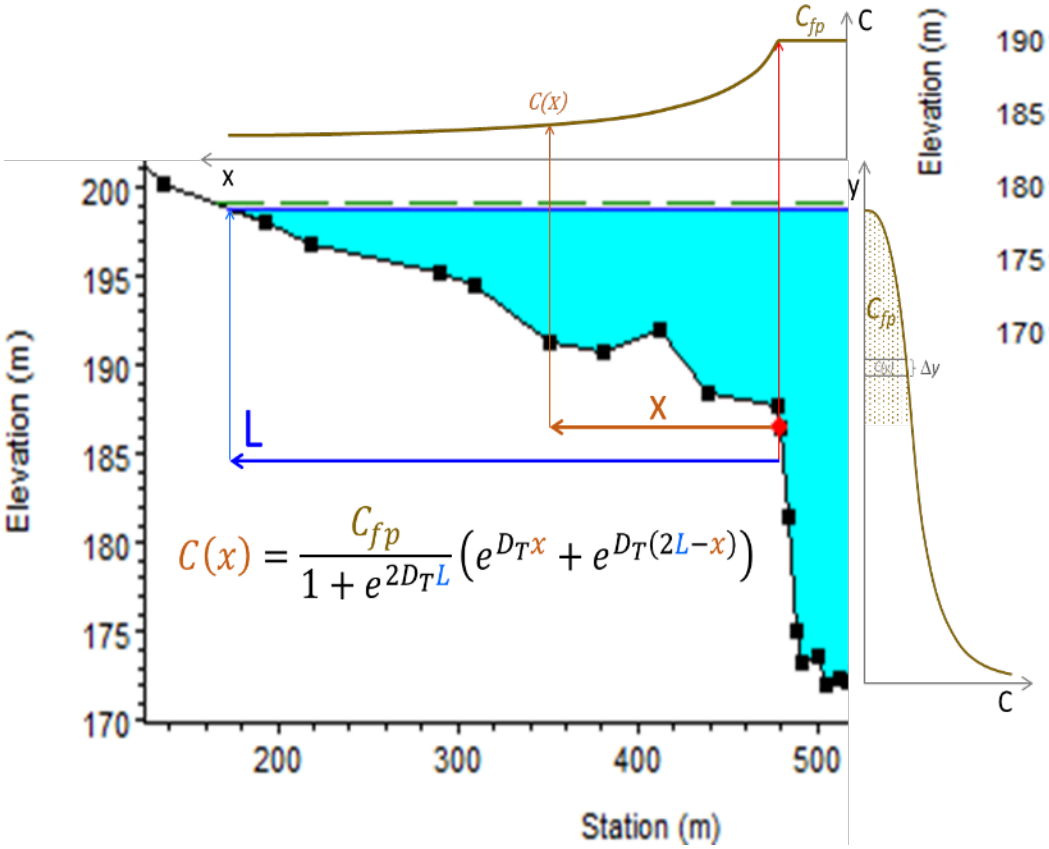
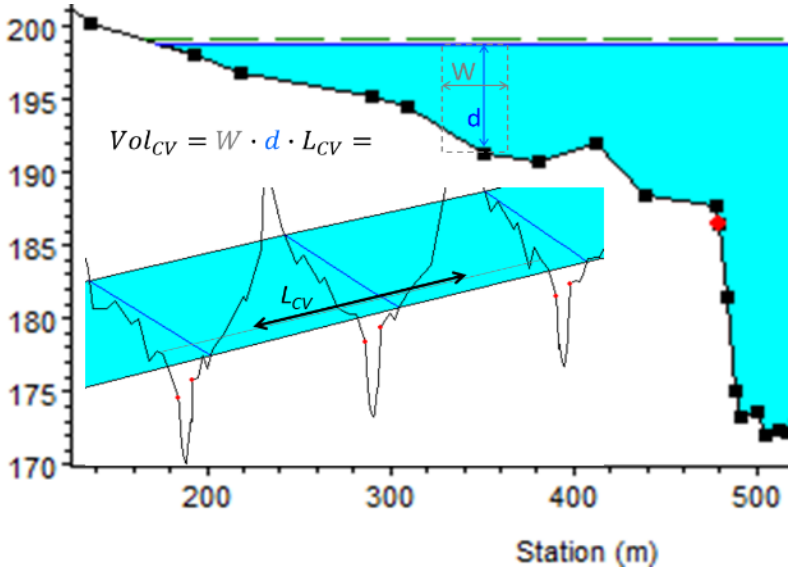
## 2. Developed Algorithms, Pseudo Code, and Design Document



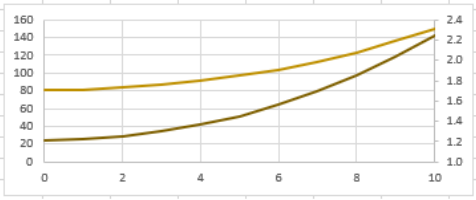

Design document:

1) Communicates design to solicit SME feedback
2) Formalizes algorithms for contract bid
3) Documents algorithm for the user manual.

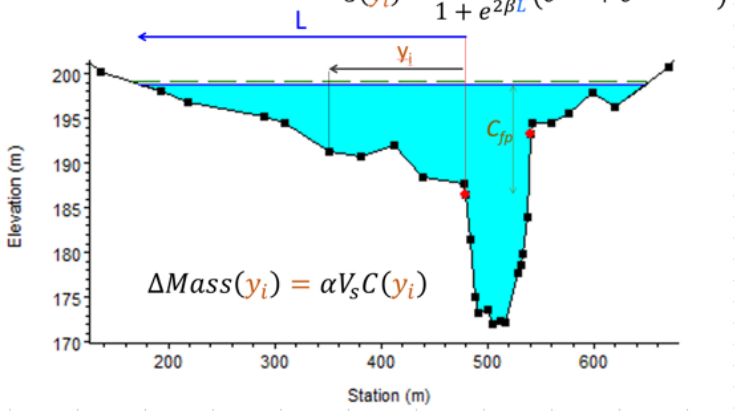
# FY21 RSM IPR
# Improving Floodplain Sedimentation Analysis

## 2. Developed Algorithms, Pseudo Code, and Design Document

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Vs | 0.03 | m/s | Fall Velocity | | | | | | | | |
| 2 | Cfp | 150 | mg/L | Concentration at the edge of a floodplain (x=0) | | | | | | | | |
| 3 | Alpha | 0.5 | | Adaptation Coefficent | | | | | | | | |
| 4 | Dy | | | Transvers Dispersion | | | | | | | | |
| 5 | Beta | 0.12247 | | | | | | | | | | |
| 6 | L | 10 | | Innundation Extent | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | Conc | Channel | | | | | | | | | | Farthest |
| 10 | ↑Bank | Bank | | | | | | | | | | Wet Node |
| 11 | | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
| 12 | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 13 | Conc | 150 | 136 | 123 | 113 | 104 | 97 | 91 | 87 | 84 | 82 | 81 |
| 14 | Depositi | 2.3 | 2.0 | 1.8 | 1.7 | 1.6 | 1.5 | 1.4 | 1.3 | 1.3 | 1.2 | 1.2 |

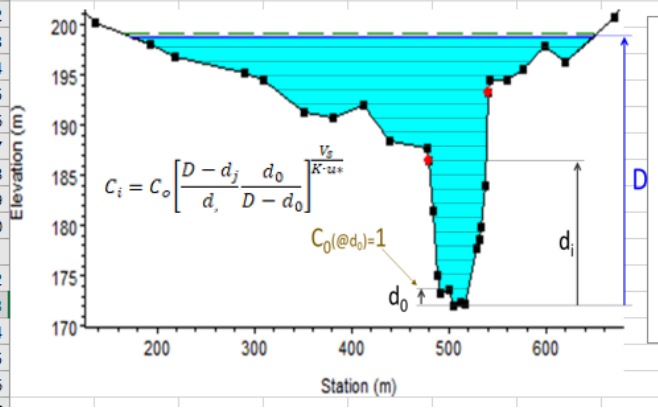


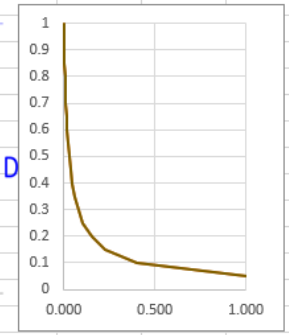

$$C(y_i) = \frac{C_{fp}}{1 + e^{2\beta L}}\left(e^{\beta y_i} + e^{\beta(2L - y_i)}\right)$$




| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Co | 1 | | Refernce Concentration at d0 - 5% (1/20th) up the | | | | | | | |
| 2 | K | 0.41 | | Von Karmen Constant | | | | | | | |
| 3 | Vs | 0.1 | m/s | Fall Velocity for Grain Class | | | | | | | |
| 4 | u* | 0.2 | m/s | Shear Velocity | | | | | | | |
| 5 | Vs/u* | 0.5 | | Ratio of Fall Velocity to Shear Velocit (dimensionless) | | | | | | | |
| 6 | Depth | 15 | m/s | Actual Water Depth (WSE-thalweg) | | | | | | | |
| 7 | B | | | Calibration Factor | | | | | | | |
| 8 | Mass Flux | 300 | tons | Sediment Transported into control volume during time step | | | | | | | |
| 9 | do | 0.05 | | distance to first layer (1/n layers - where n is 20) | | | | | | | |
| 10 | | | | | | | | | | | |
| 11 | | | Parker | Classic | | | | | | | |
| 12 | i | relative di | Ci/C0 | Ci/C0 | | | | | | | |
| 13 | 20 | 1 | 0.000 | 0 | | | | | | | |
| 14 | 19 | 0.95 | 0.001 | 0.001 | | | | | | | |
| 15 | 18 | 0.9 | 0.002 | 0.002 | | | | | | | |
| 16 | 17 | 0.85 | 0.003 | 0.003 | | | | | | | |
| 17 | 16 | 0.8 | 0.005 | 0.005 | | | | | | | |
| 18 | 15 | 0.75 | 0.007 | 0.007 | | | | | | | |
| 19 | 14 | 0.7 | 0.010 | 0.010 | | | | | | | |
| 20 | 13 | 0.65 | 0.013 | 0.013 | | | | | | | |
| 21 | 12 | 0.6 | 0.017 | 0.017 | | | | | | | |

Pseudo-Code



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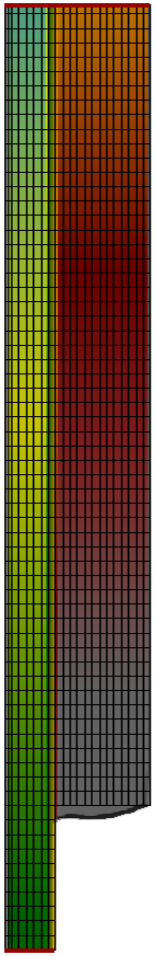
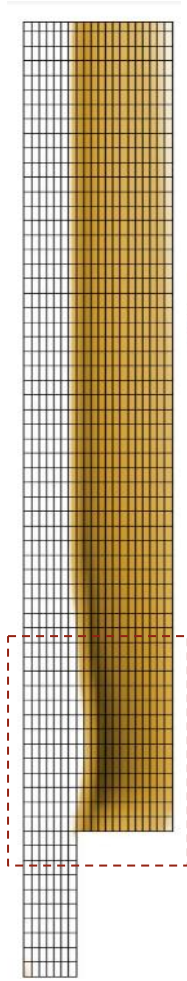
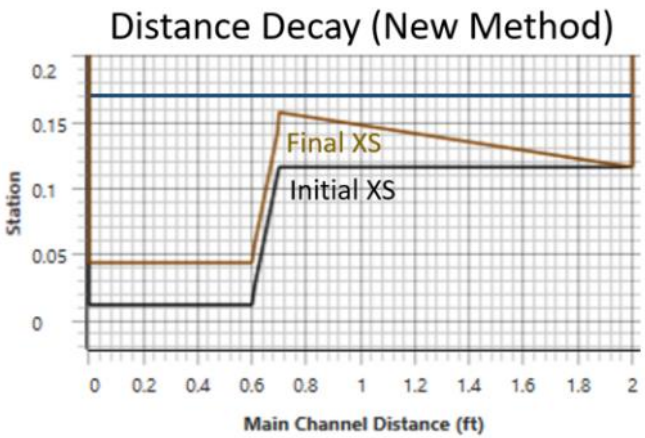
## 3. Developed 1D and 2D sediment Models of Flume Data Set (for V&V)

Flow Direction →

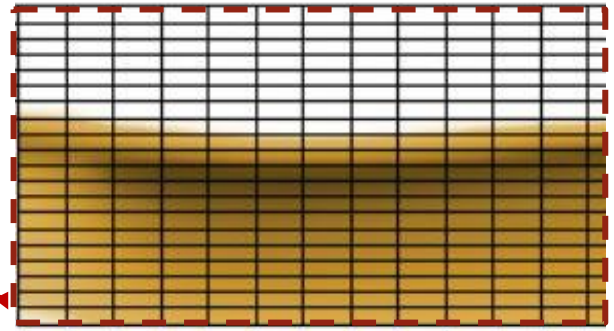




1D HEC-RAS Deposition




2D HEC-RAS Deposition



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## 4. Collected Sediment Samples from Missouri Floodplain Deposition


# Elwood, KS Sediment Sampling

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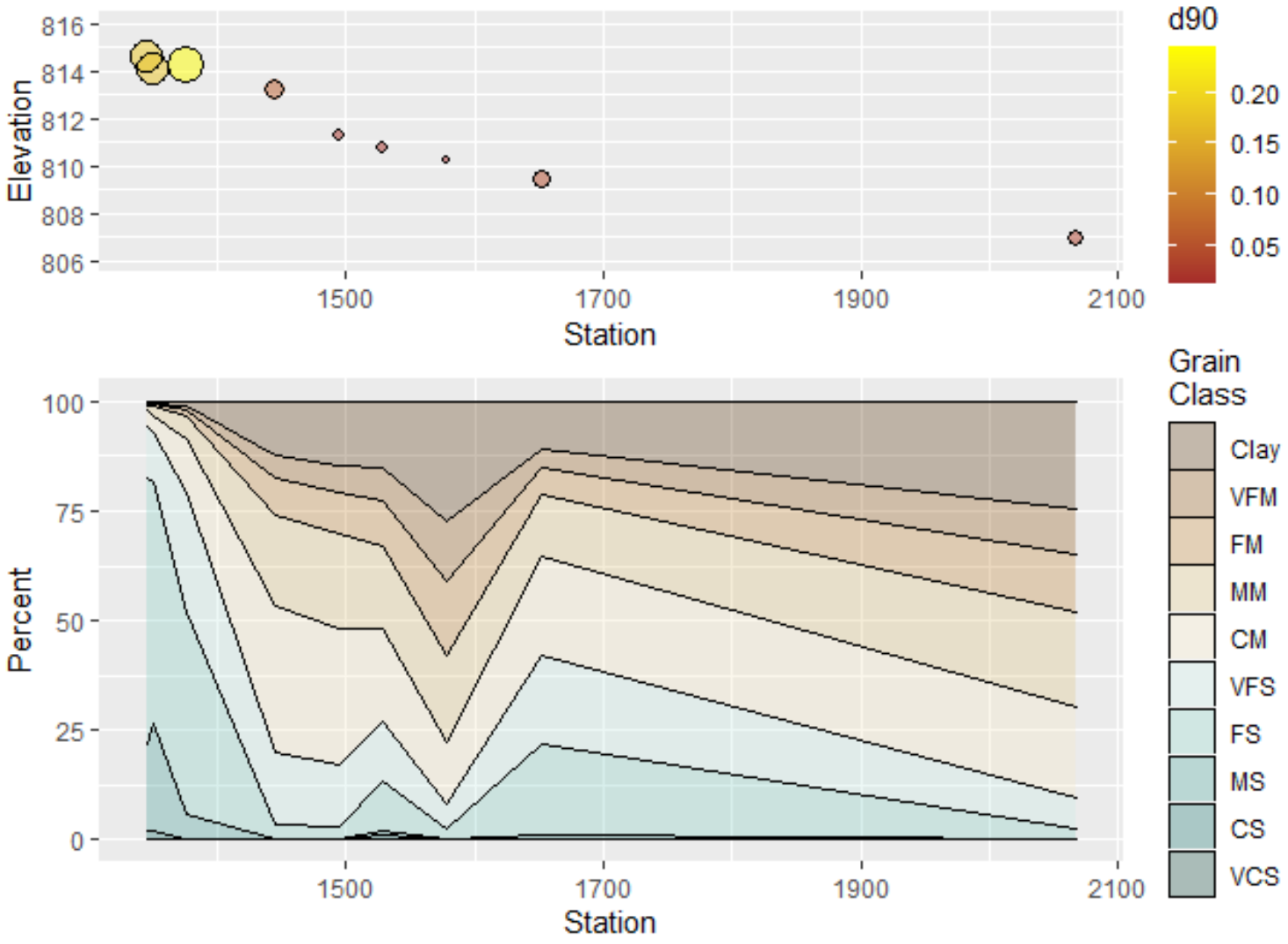

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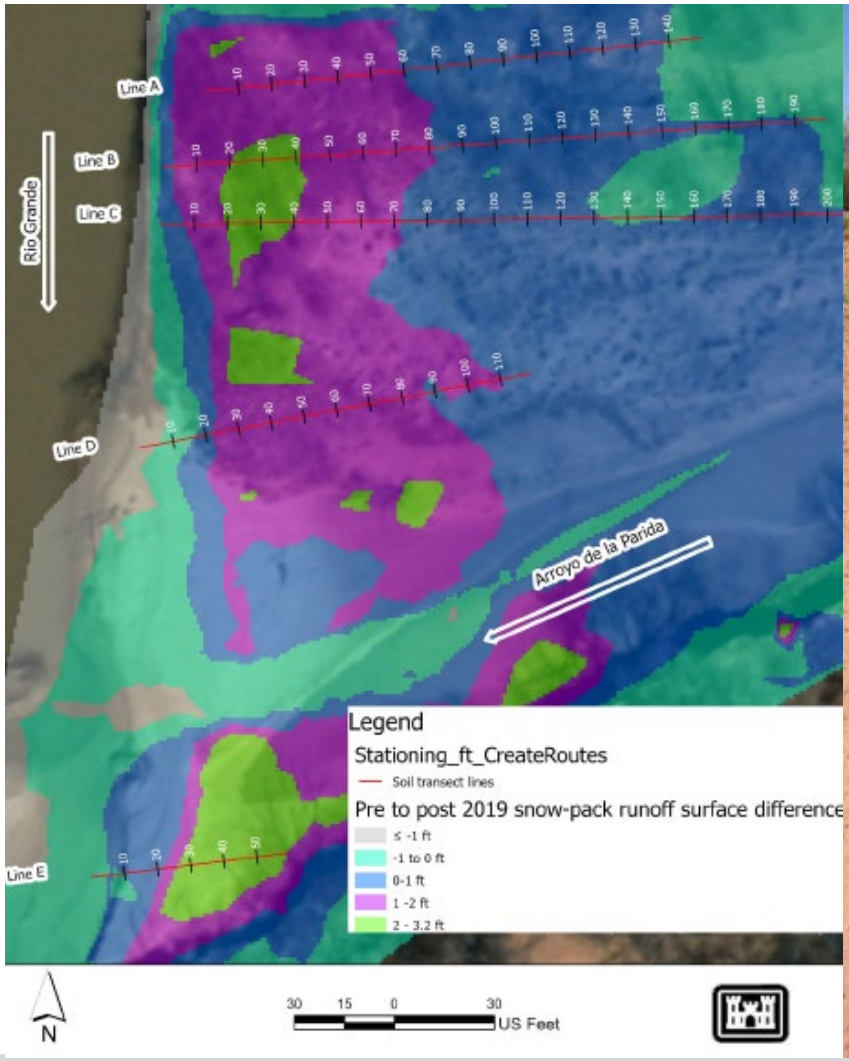
## 4b. Collected Sediment Samples from Rio Grande Floodplain (Bonus)

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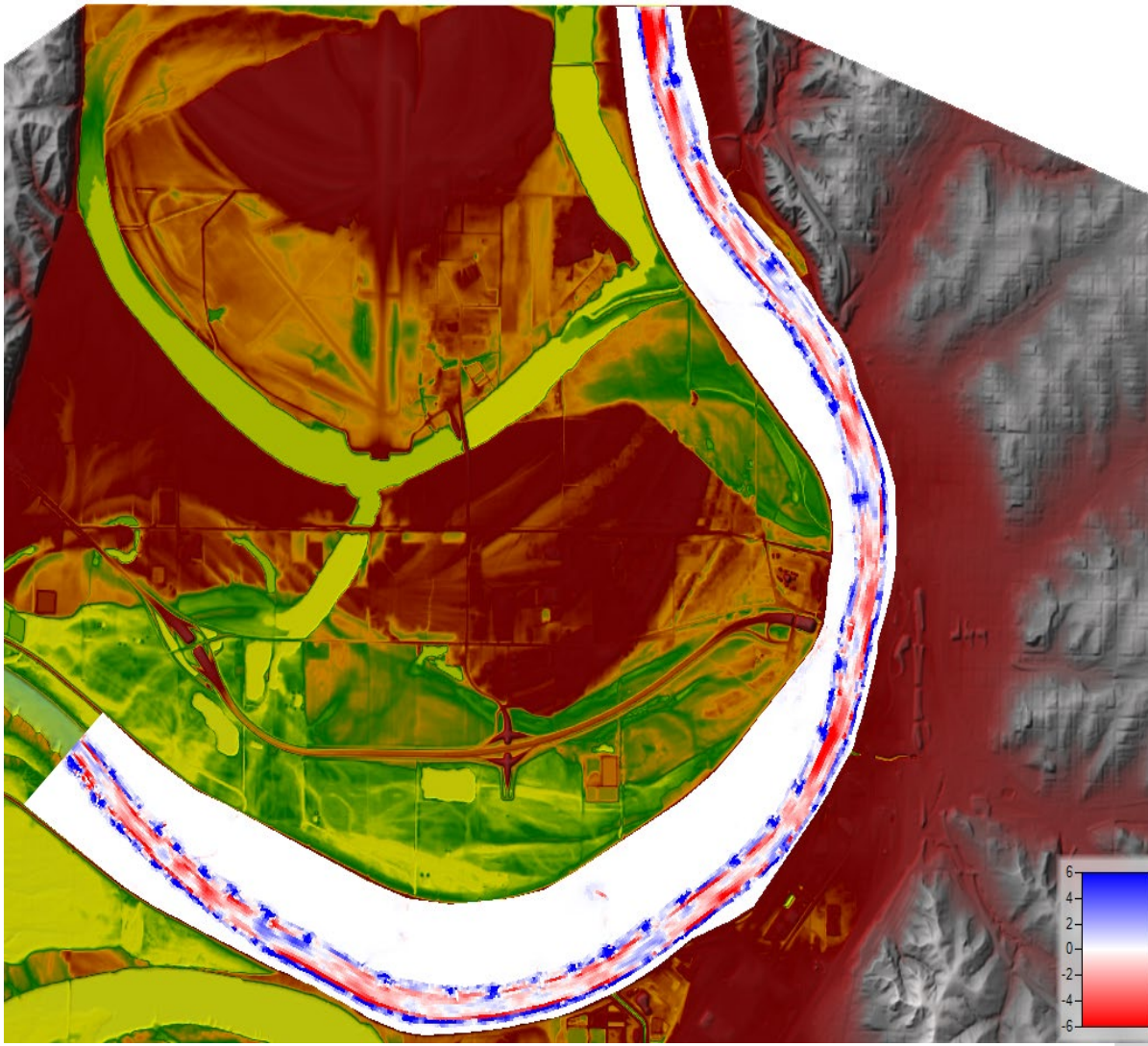
## Improving Floodplain Sedimentation Analysis

5. Missouri River Model

Added DSS Sediment Boundary Conditions for 2D Models to HEC-RAS Version 6.1

6. Collaborative Modeling Session




Bed Change on Draft Missouri River Model shows erosion in the channel and deposition in the floodplain

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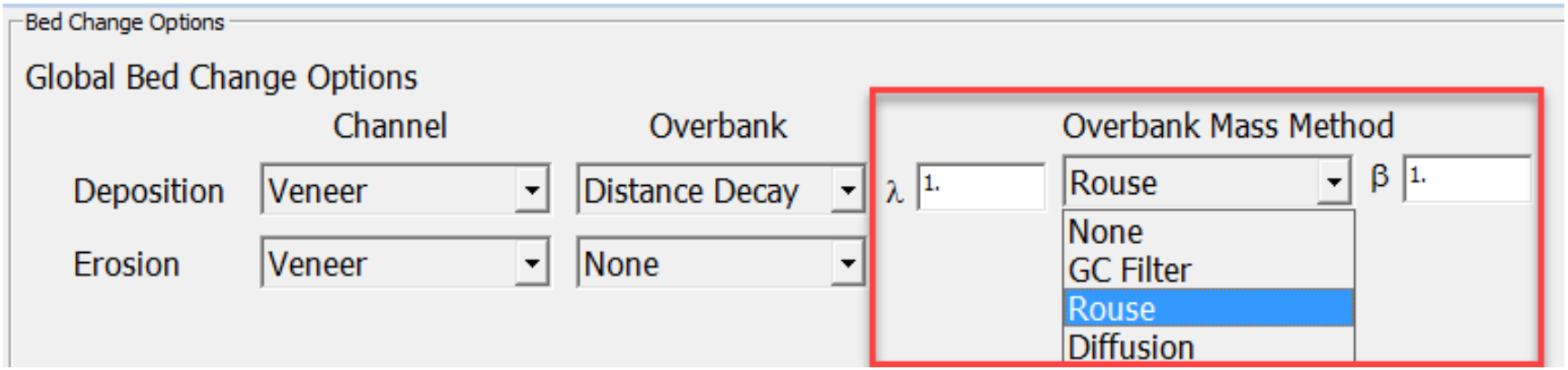
# Improving Floodplain Sedimentation Analysis

## 7. HEC-RAS Development




- Actively Developing
- Interface complete, 80% prototype of computations.
- Delayed by contracting
- Features targeted for 6.1 (January) and 6.2 (Late Q2/Early Q3)

## What challenges did you face?

- Contracting
- Advection > Dispersion
- The Math Got Weird

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# District, Title

## How is this project benefiting the USACE and Nation?

- The Missouri River deposited over 25 million $m^3$ in the floodplain (according to conservative calculations by Alexander et al, 2013) during the 2011 event alone. The channel lost over 20 million $m^3$ in the same time period, in approximately the same locations (Gibson and Shelley, 2019). Scour on the Missouri has caused $300 million of infrastructure impacts. Understanding, predicting, and managing floodplain deposition can help the USACE and their partners mitigate scour damages.

- Incorporating floodplain algorithms into 1D sediment models will save time and money on sediment analyses and could avoid costly failure modes in our projects that emerge from the numerical issues with the legacy methods.