Process-based Modeling and Measurement of Streambank Retreat in a NC Piedmont Stream

Division of Mitigation Services (DMS)

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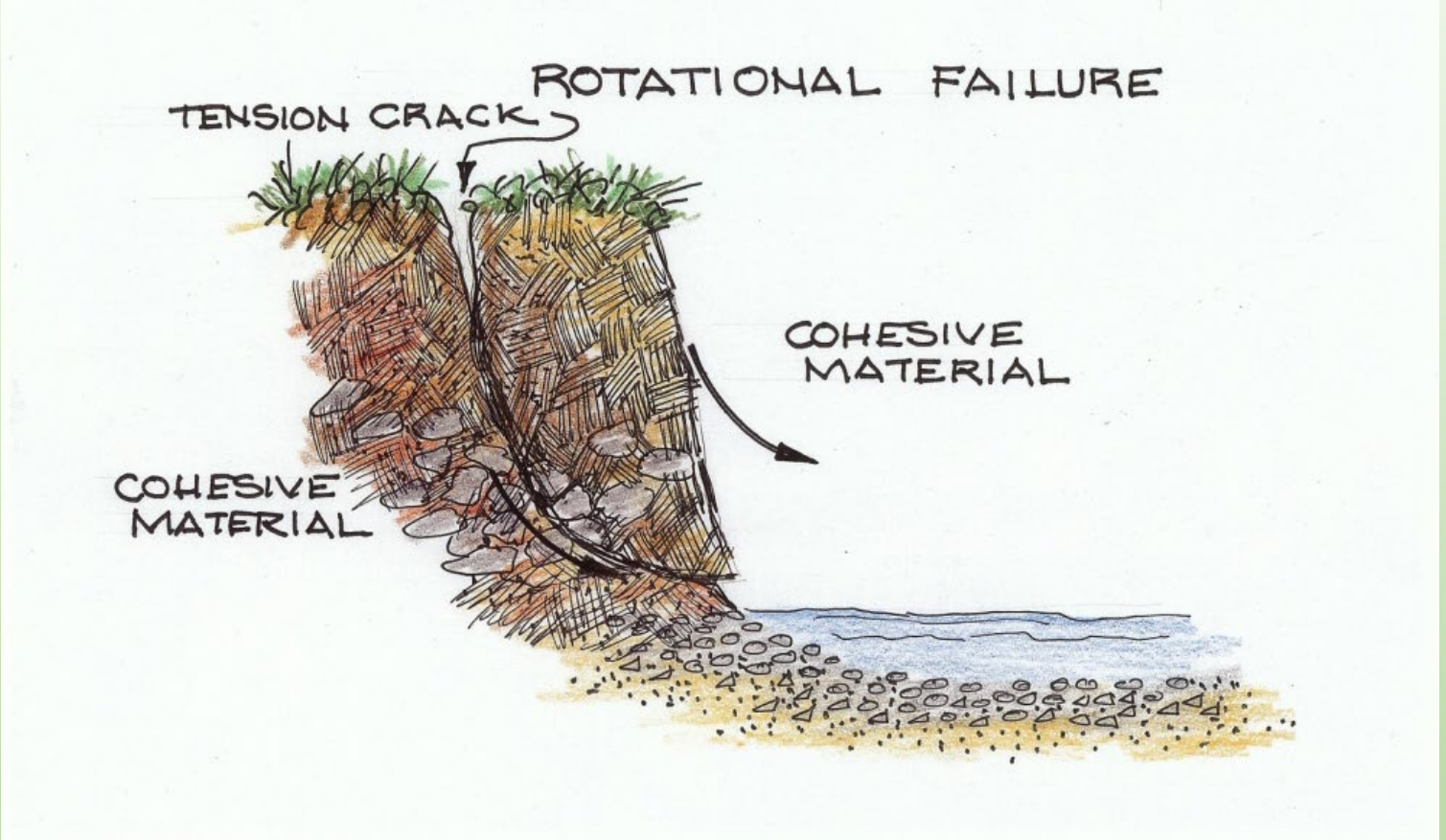
Bank Retreat: Consistent Questions Related to Restoration Projects

Pre and post construction
Why?
How much?
Local or Systemic?
Long-term or Short-term
Effect?

Need to understand

Bank Stability and Toe Erosion Model (BSTEM)

- Process-Based
- Fluvial and Geotechnical
- Physical properties of streambank
- Considers variable GW and surface flows over time
- Quantifies area and volume



Reckendorf & Associates 2006

Ultimate Goal:

Calibrate and regionalize BSTEM for ease of application in the NC Piedmont

Test the effectiveness of the processed-based BSTEM in predicting erosion rates

Expand modeling efforts to account for bank erosion and sediment transport processes

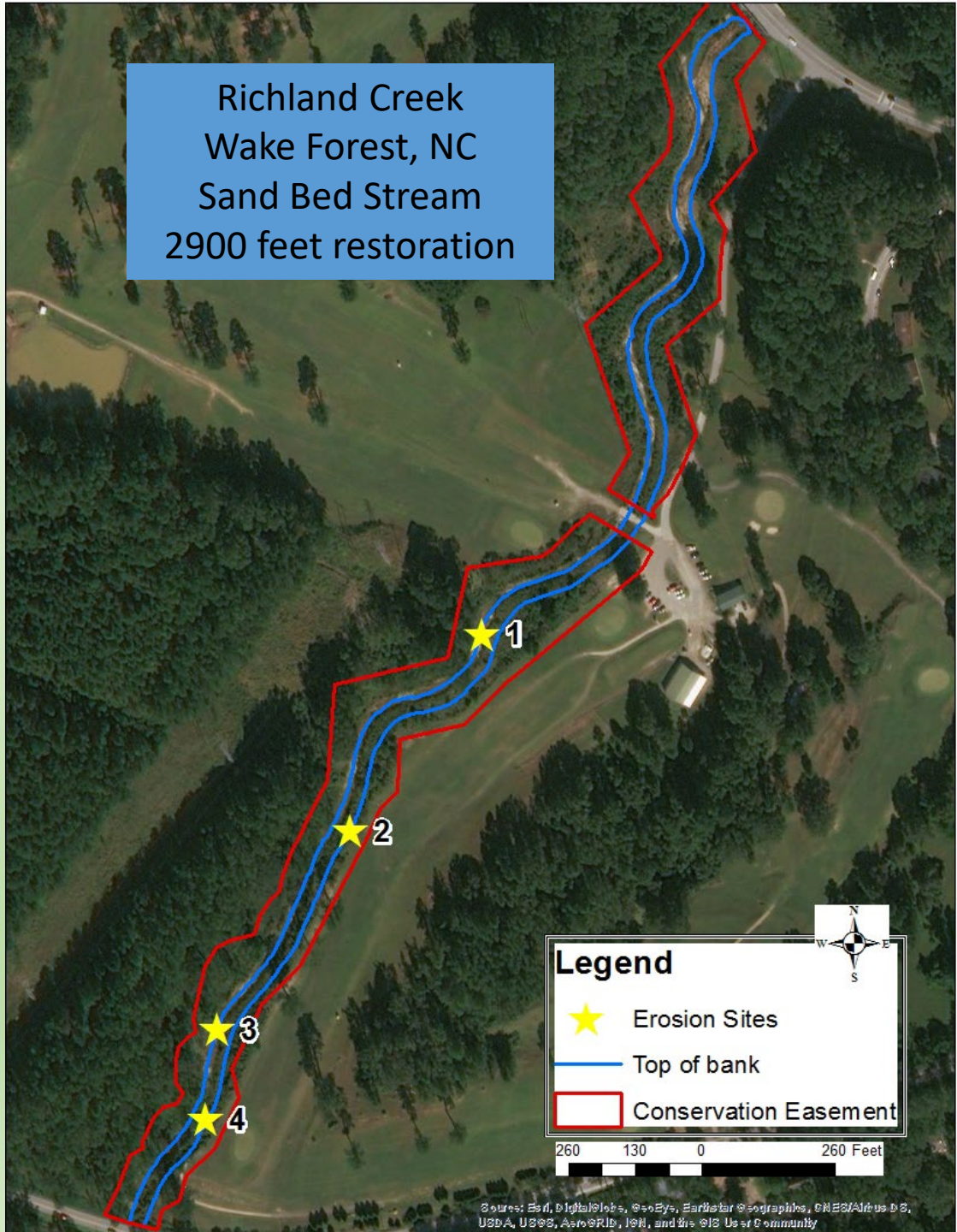
Test Site and Methods

- Completed 5 3D terrestrial laser scans from Oct 2017 – July 2018
  1 base, 4 at least .66Q_e
- Estimated erosion and deposition
- Modeled bank retreat – BSTEM (static)

  Jet Erosion Test (JET) to measure τ_c and K for each bank

  Soil samples - moisture content, bulk density

  Compared measured to modeled



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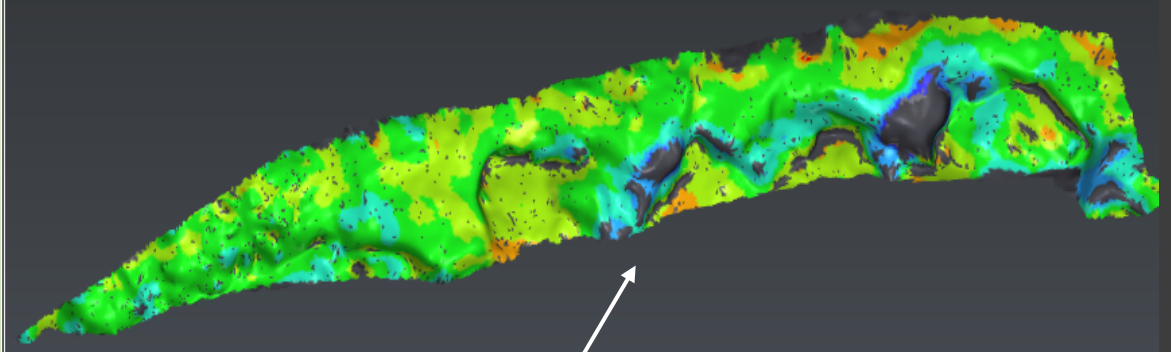
Richland Creek
Bank 3

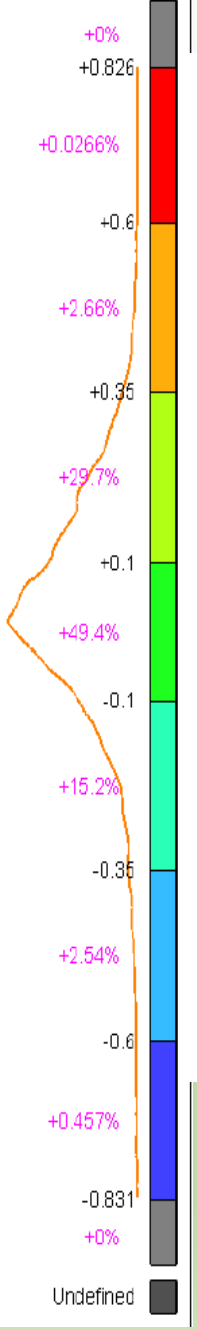
Richland Creek Bank 3
Scan 1 – Scan 5

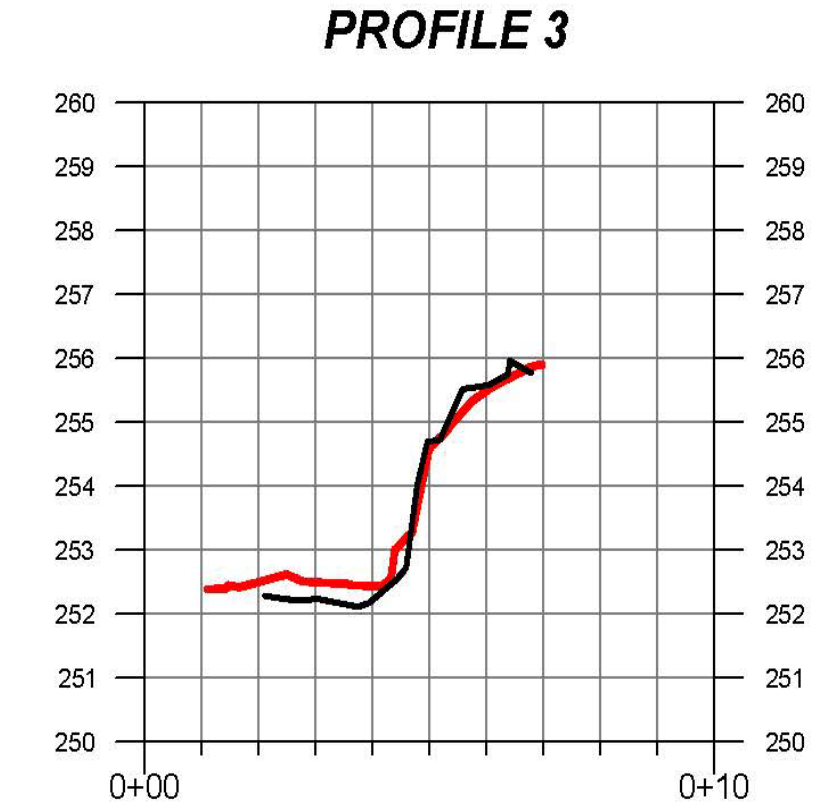


Water level

Erosion = 0.3 m^3

Deposition = 2.0 m^3





SCAN 1

SCAN 5

Richland Creek
Bank 4

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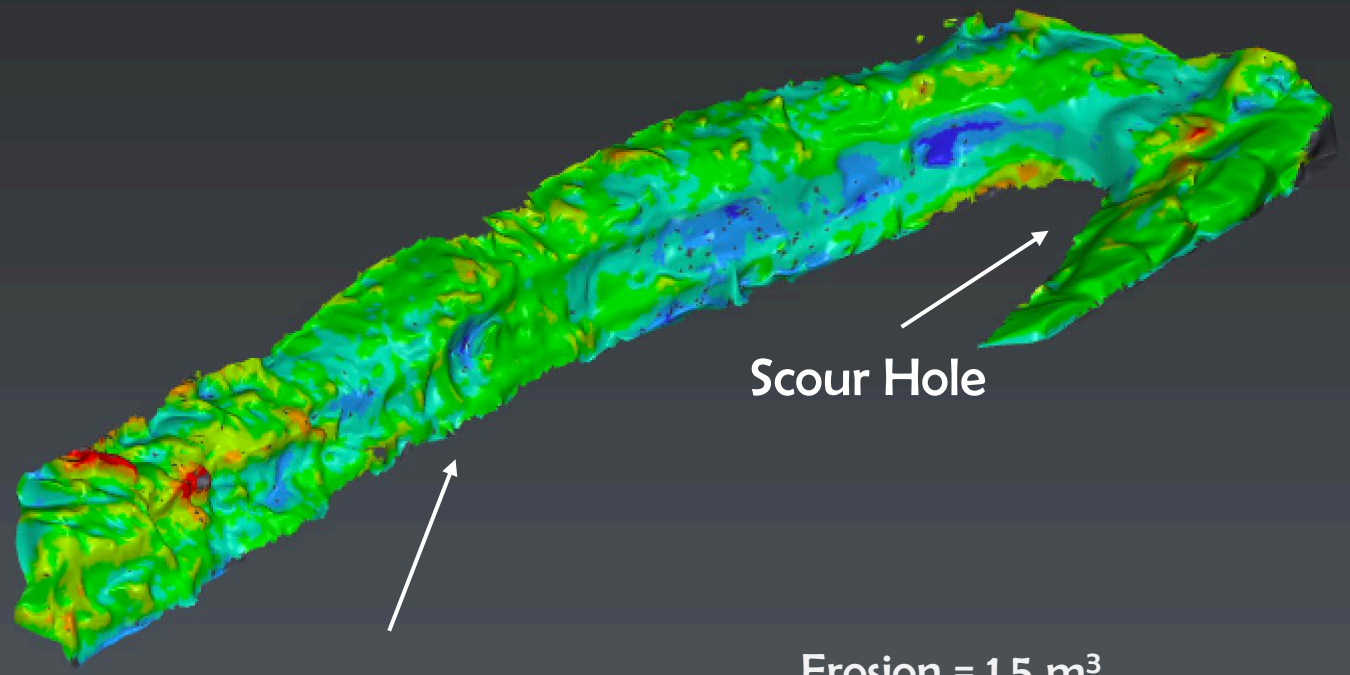
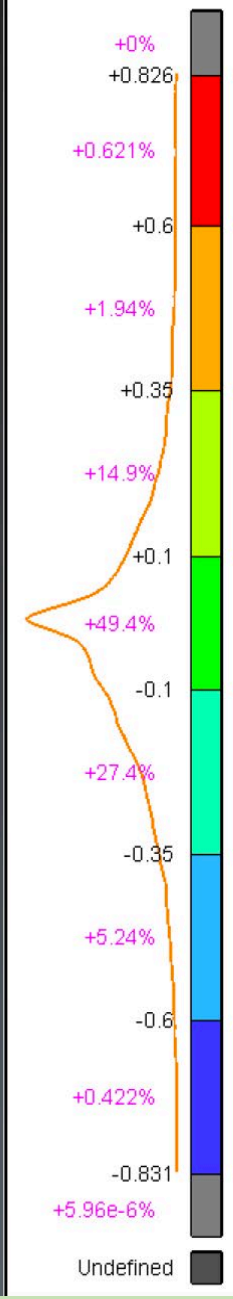
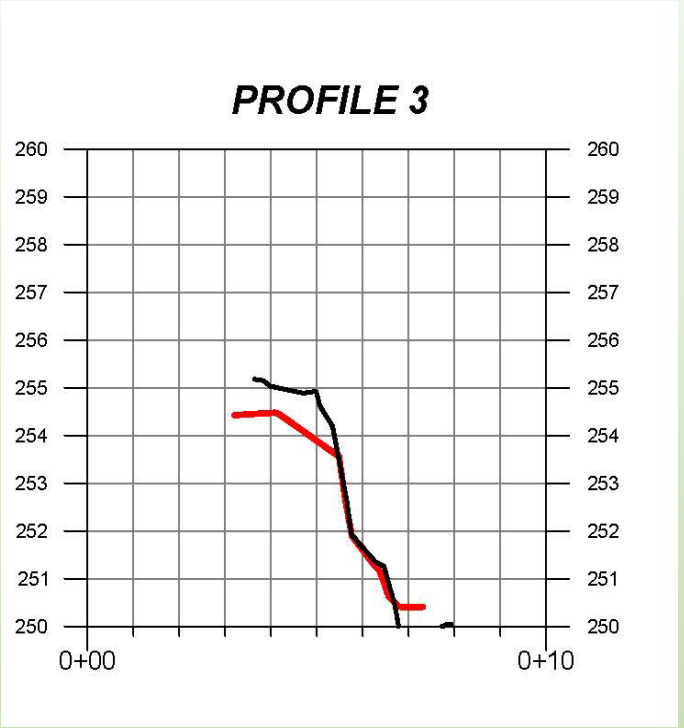
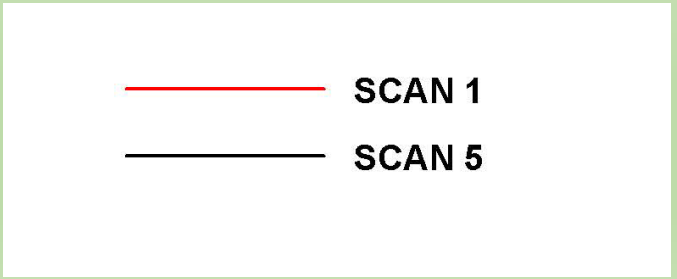
Richland Creek Bank 4
Scan 1 – Scan 5



Erosion = 1.5 m^3
Deposition = 1.0 m^3







	Stage (ft)	Factor of Safety	Stability
Bank 3	2.3 (.66Q_e)	0.35	Unstable
Bank 4	2.8 (.66Q_e)	0.13	Unstable

Next Steps…

- Expand research sites
- Measure additional τ_c and K bank sites
- Model Richland Creek as-built geometry
  - Dynamic BSTEM - 1D
  - HEC-RAS + BSTEM – 1D
  - Sedimentation and River Hydraulics (SHR- 2D)
- Understand the limitations of the different models
- Develop tools for general use

We hope to…

- Build knowledge and understanding about bank erosion processes
- Potential for accurate existing condition assessments to inform need
- Set baseline for functional framework
- Set restoration/mitigation expectations and describe uncertainty analysis

https://deq.nc.gov/about/divisions/mitigation-services/dms-science-data

Hanson, G. J., and Cook, K. R. (2004). "Apparatus, test procedures, and analytical methods to measure soil erodibility in situ." Applied Engineering in Agriculture, 20(4), 455-462.

Klavon K, Fox G, Guertault L, Langendoen E, Enlow H, Miller R, Khanal A. 2017. Evaluating a process-based model for use in streambank stabilization: insights on the Bank Stability and Toe Erosion Model (BSTEM). Earth Surface Processes and Landforms 42, 191-213.

Lai YG, Fox G, Thomas RE, Ozeren Y, Simon A, Greimann BP, Wu K. 2012. Coupling a Two-Dimensional Model with a Deterministic Bank Stability Model. Water Environmental and Water Resources Congress 2012.

Simon A, Pollen-Bankhead N, Thomas RE. 2011. Development and application of a deterministic bank stability and toe erosion model for stream restoration. In Stream Restoration in Dynamic Fluvial Systems, Simon A, Bennett SJ, Castro JM (eds). American Geophysical Union: Washington, DC. DOI. 10.1029/2010GM001006

Thorne, C. R. 1978. Processes of bank erosion in river channels. Doctoral dissertation. Univ. East Anglia, UK.