INVESTIGATION OF EROSION RATES OF FIELD SAMPLES USING FDOT'S ENHANCED SEDIMENT EROSION RATE FLUME (SERF)

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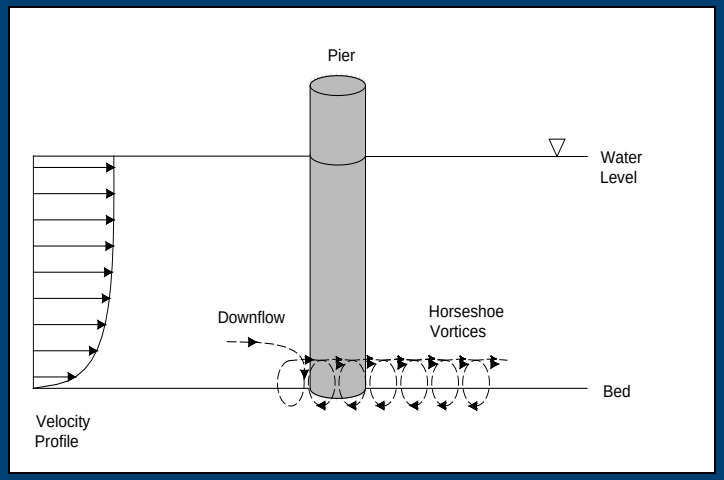
Bridge Scour

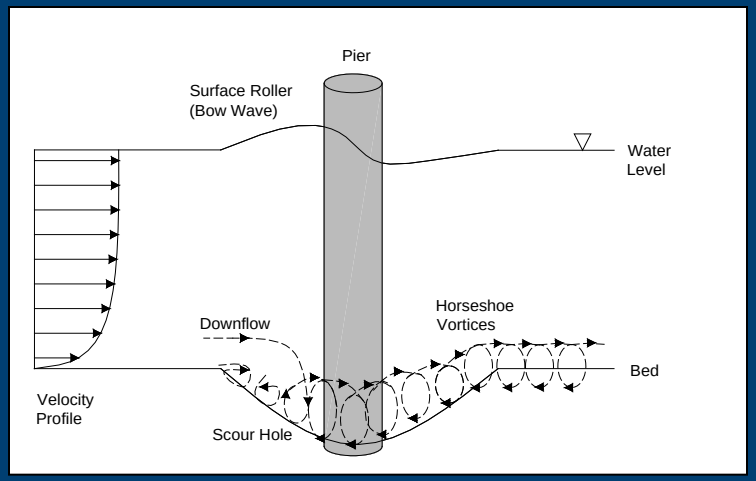
Bridge Scour Photograph

- 600,000 US Bridges; 200,000 are “Scour Critical”
- Causes 60% of US Bridge Failures
- Costs $50 Million Annually
- Design Codes Currently Assume all Bed Material is Non-Cohesive

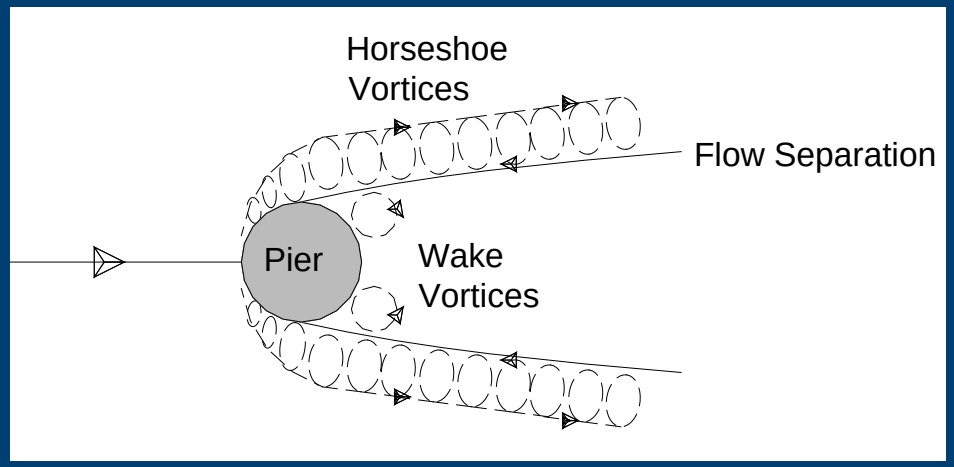
Local Scour



Definition Sketch Showing Beginning of Local Scour Hole Development

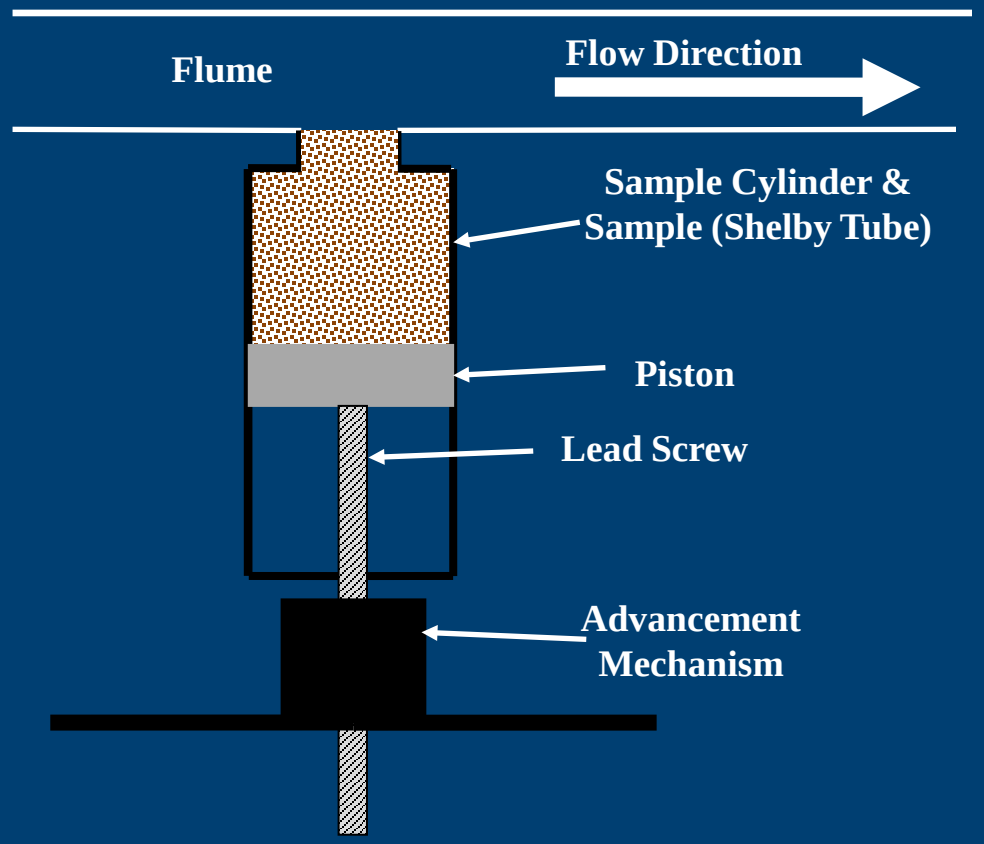


Definition Sketch Showing End of Local Scour Hole Development



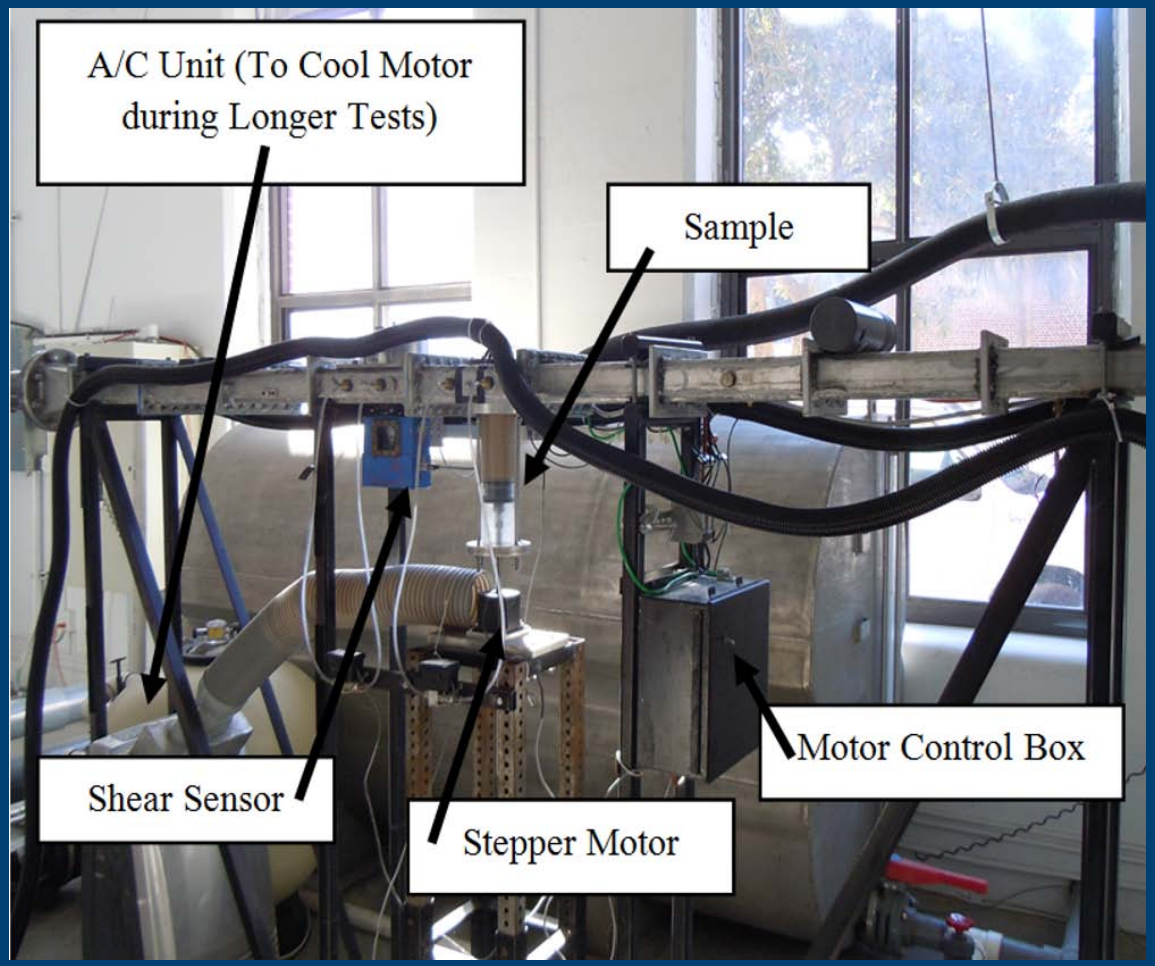
Local Scour, Top View

Flume-Style Erosion Rate Testing Devices



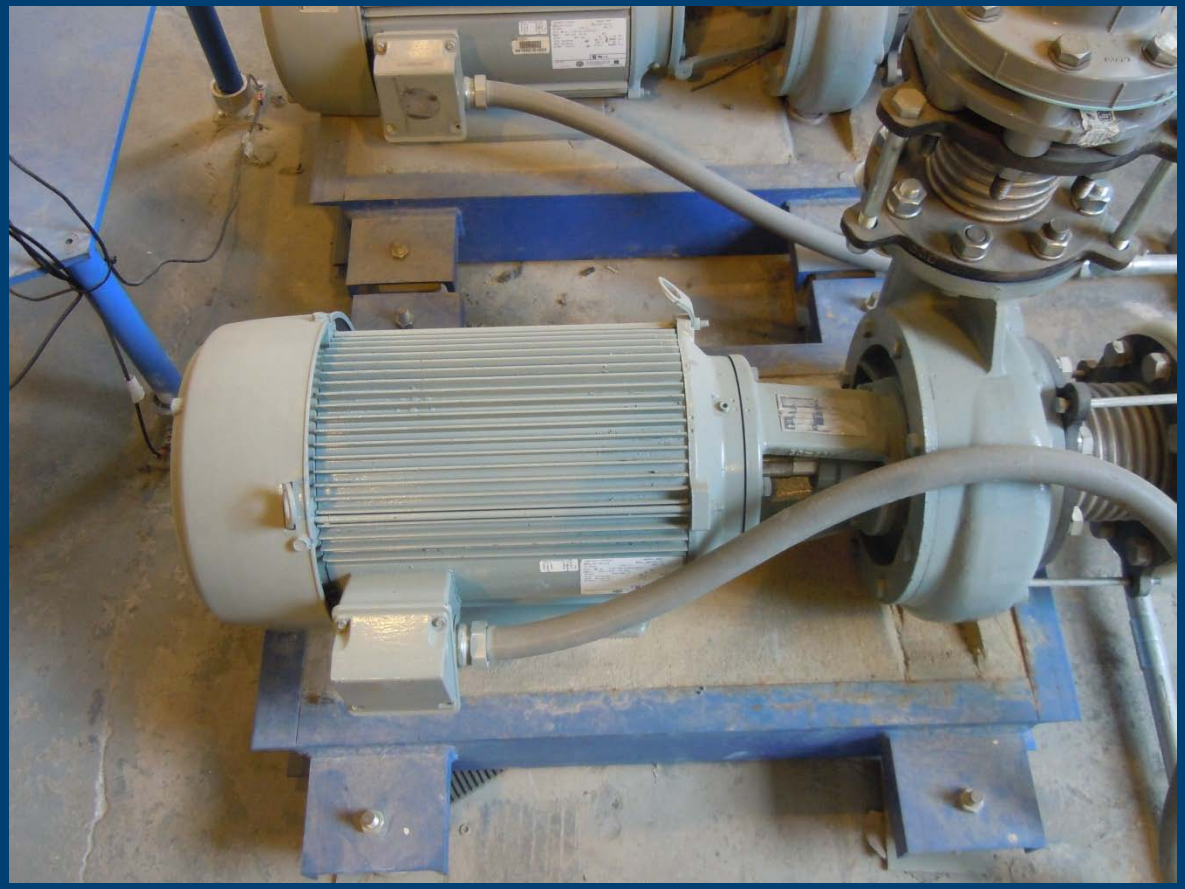
SERF Schematic

The Sediment Erosion Rate Flume (SERF, 2011)



SERF Photograph (Downstream Looking Upstream)

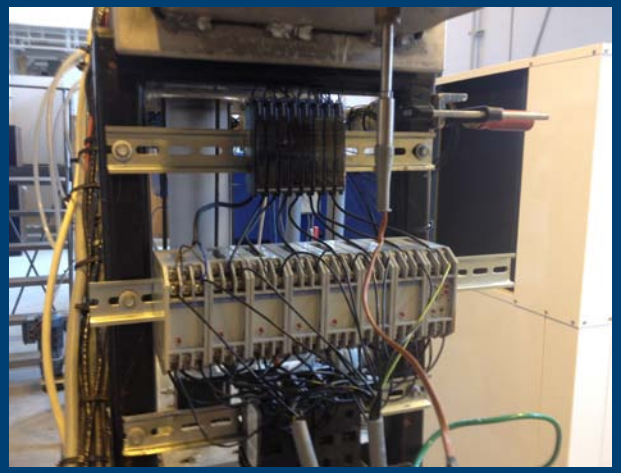
SERF Repairs – Primary Pump



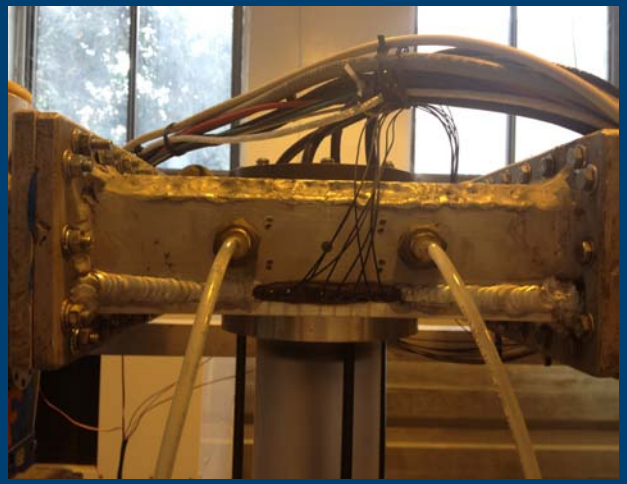
SERF Primary Pump

SERF Enhancements – Improved Laser Bank

Screenshot of new laser bank



New laser amplifiers and control boxes



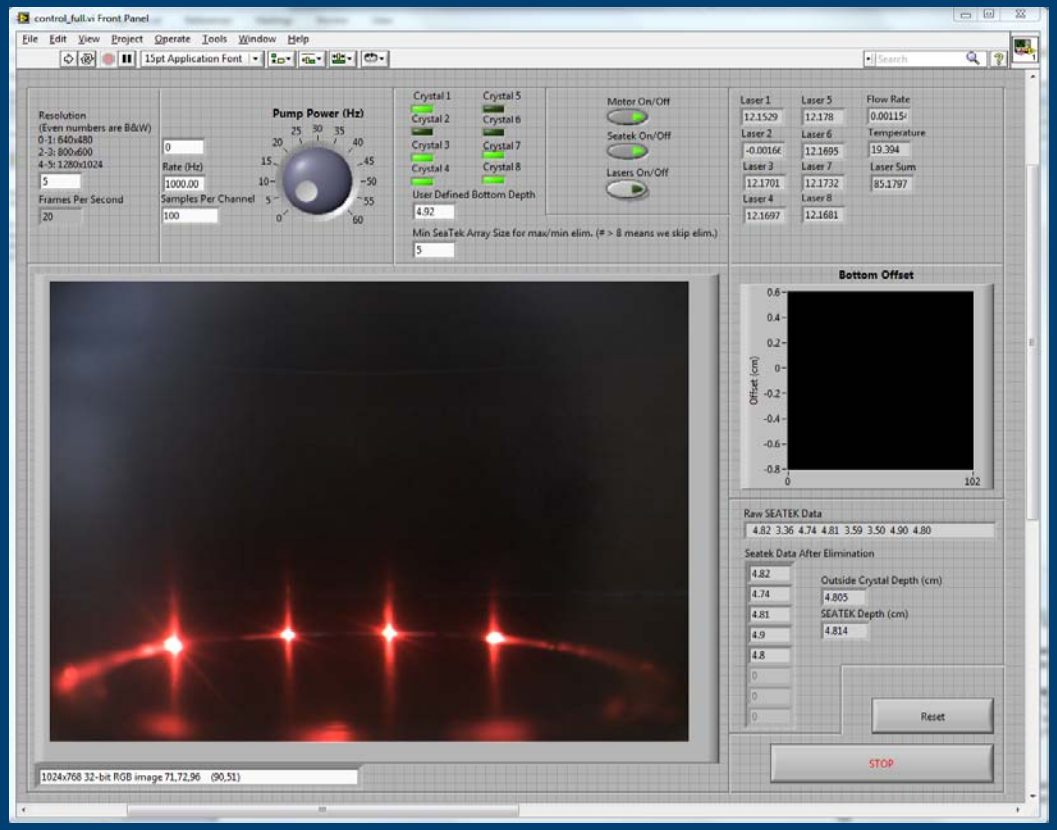
New laser fiber optic lines

SERF Enhancements: Large-Scale Filter

Large Filter (Looking North)

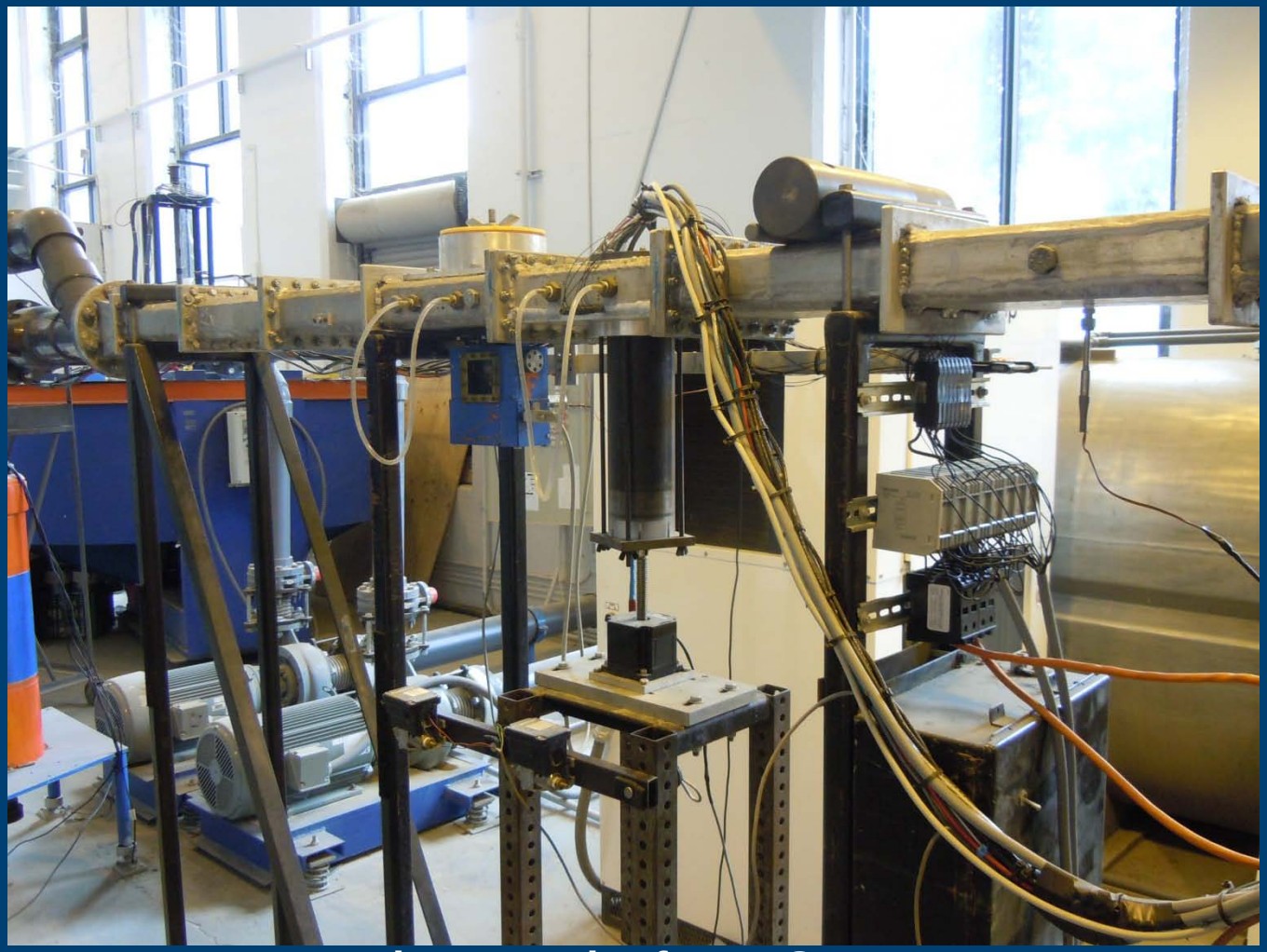
Large Filter (Looking South)

SERF Enhancements – Digital Camera/New User Interface



Screenshot of New User Interface

New SERF – Close up



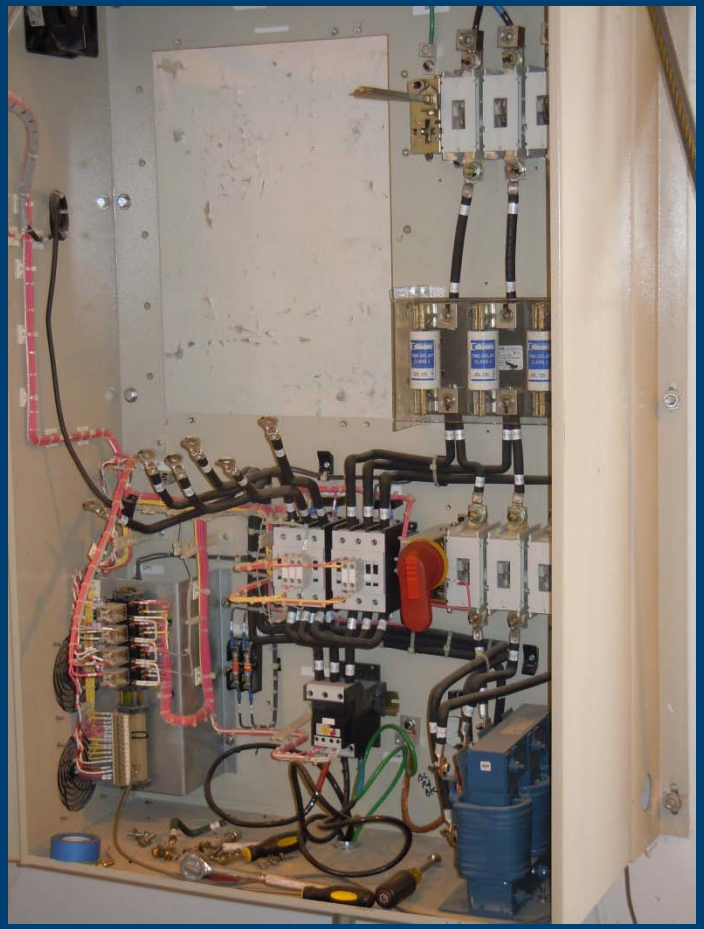
Photograph of New SERF

New SERF – Bird's Eye View

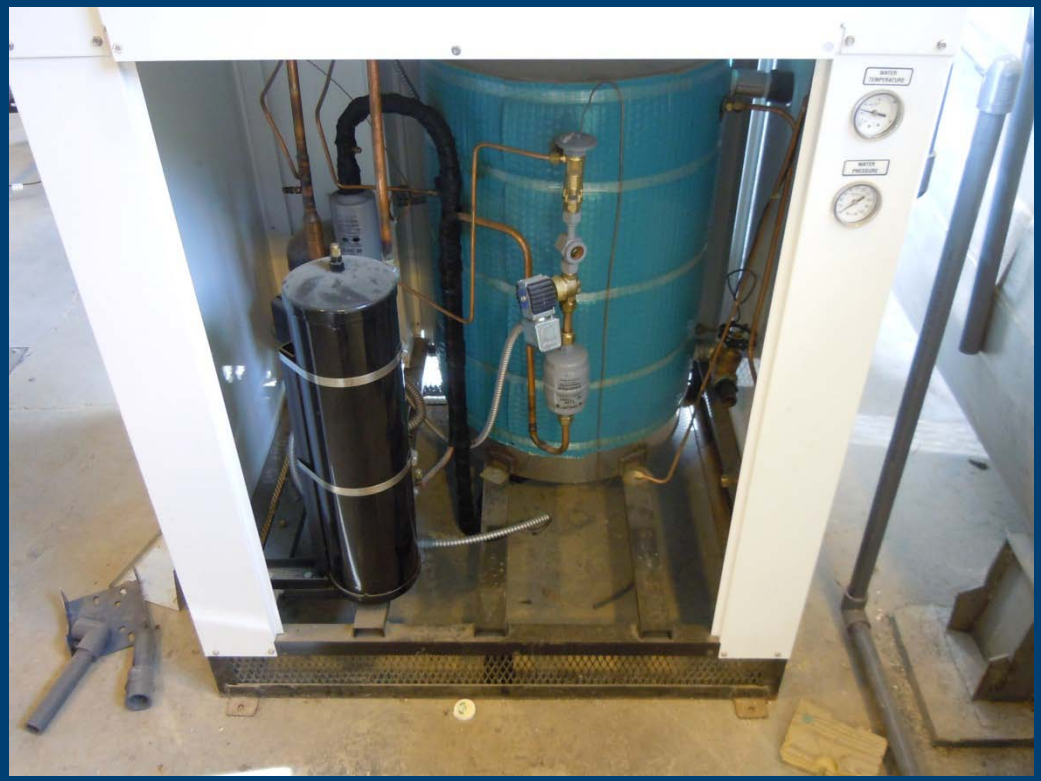
SERF (Looking North)

SERF (Looking South)

SERF – Current Status

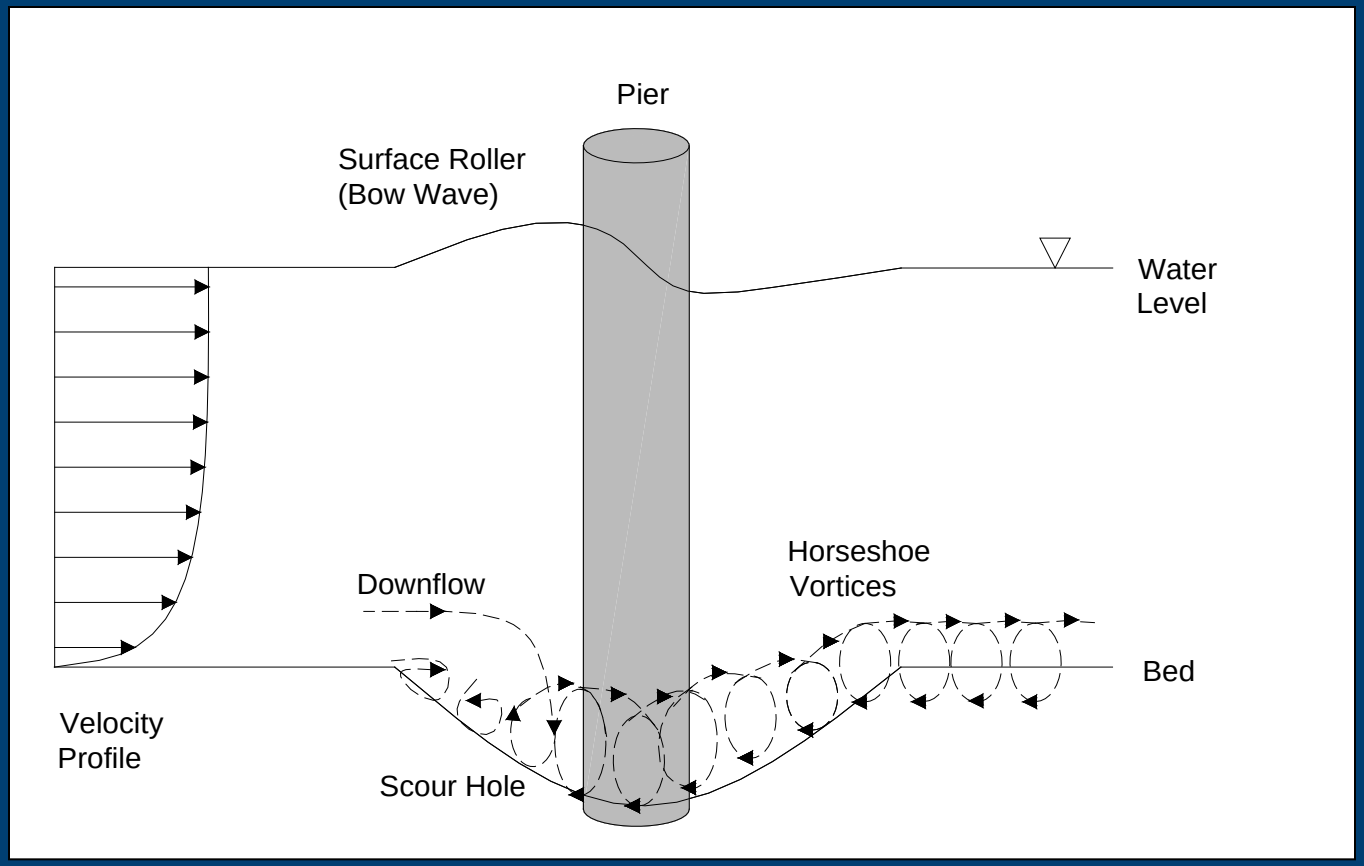


Pump Control Box



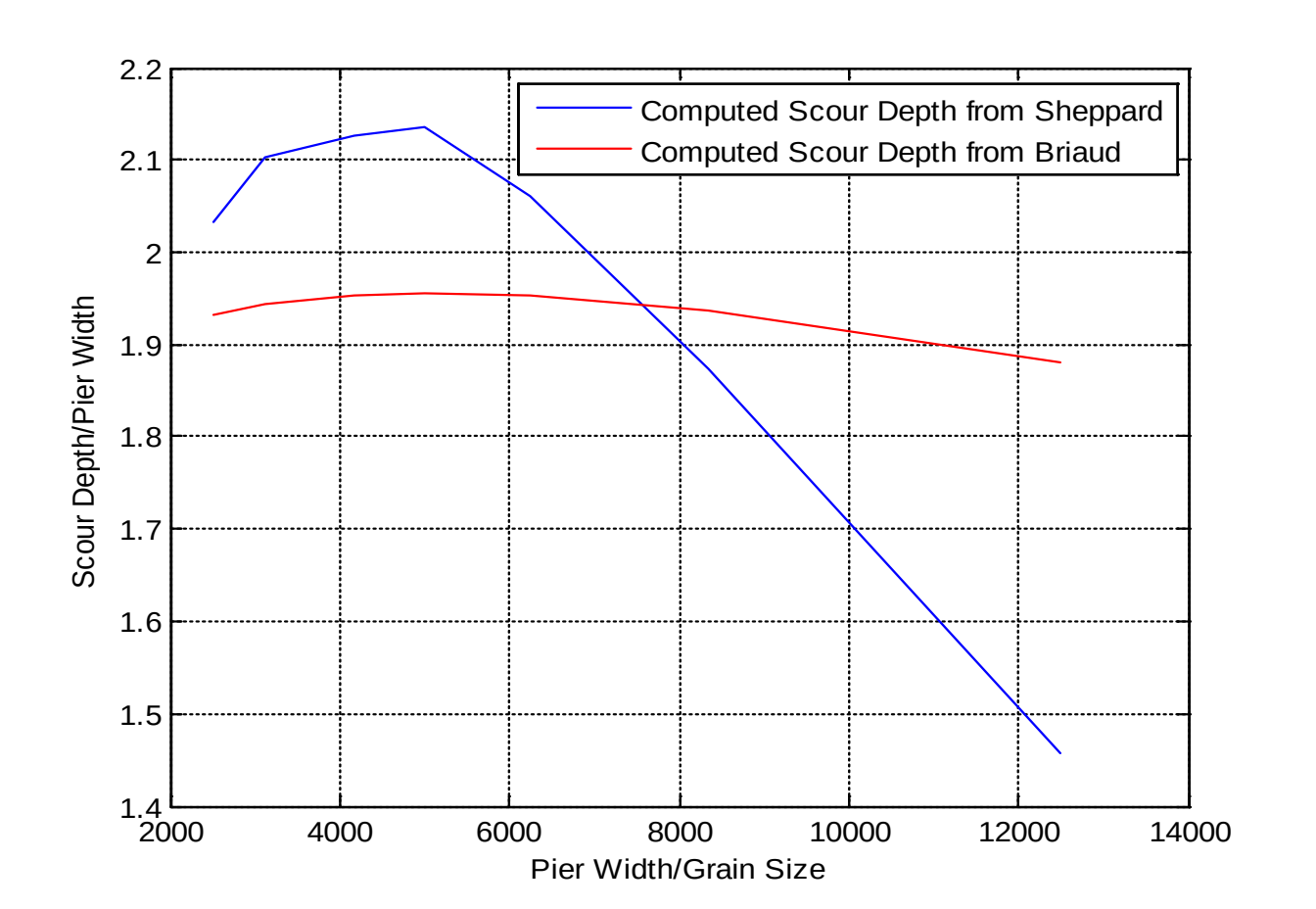
Inside the Water Chiller

Experimental Design



Definition Sketch Showing End of Local Scour Hole Development

Scour Depth Discrepancy



Comparison of FDOT Bridge Scour Manual and EFA-SRICOS Maximum Scour Depths (for Sands)

USGS Conte Laboratory Flume

USGS Conte Laboratory

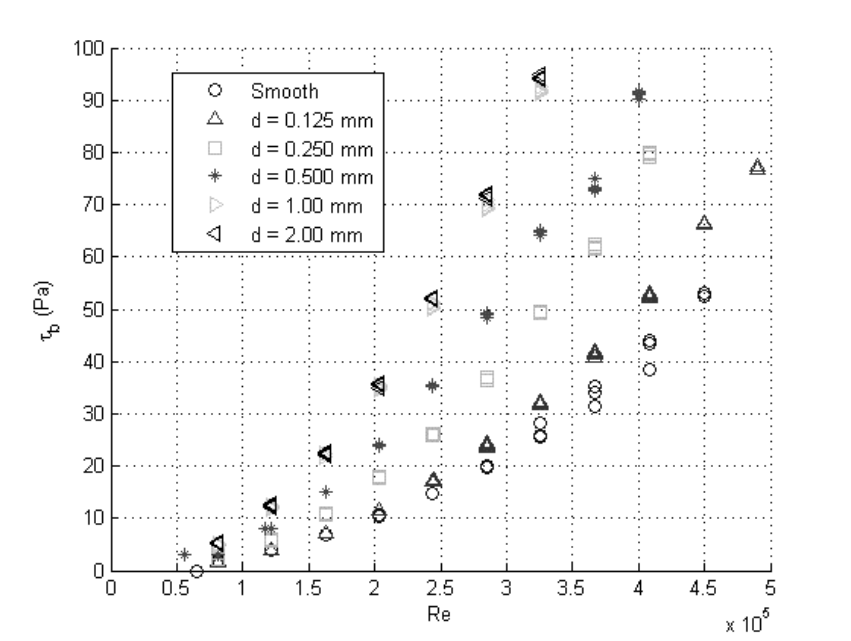
Conte Lab Flume

TFHRC In-Situ Erosion Rate Testing Device (ISTD)

Photograph of Turner-Fairbanks' Hydraulics Lab's ISTD

Need For CFD Models

- **"Target" for erosion rate tests.**
- **Rough samples produce higher shear stress than assumed smooth walls.**
- **Chunking and blocking during testing may affect localized shear stresses – local variability needs to be quantified.**

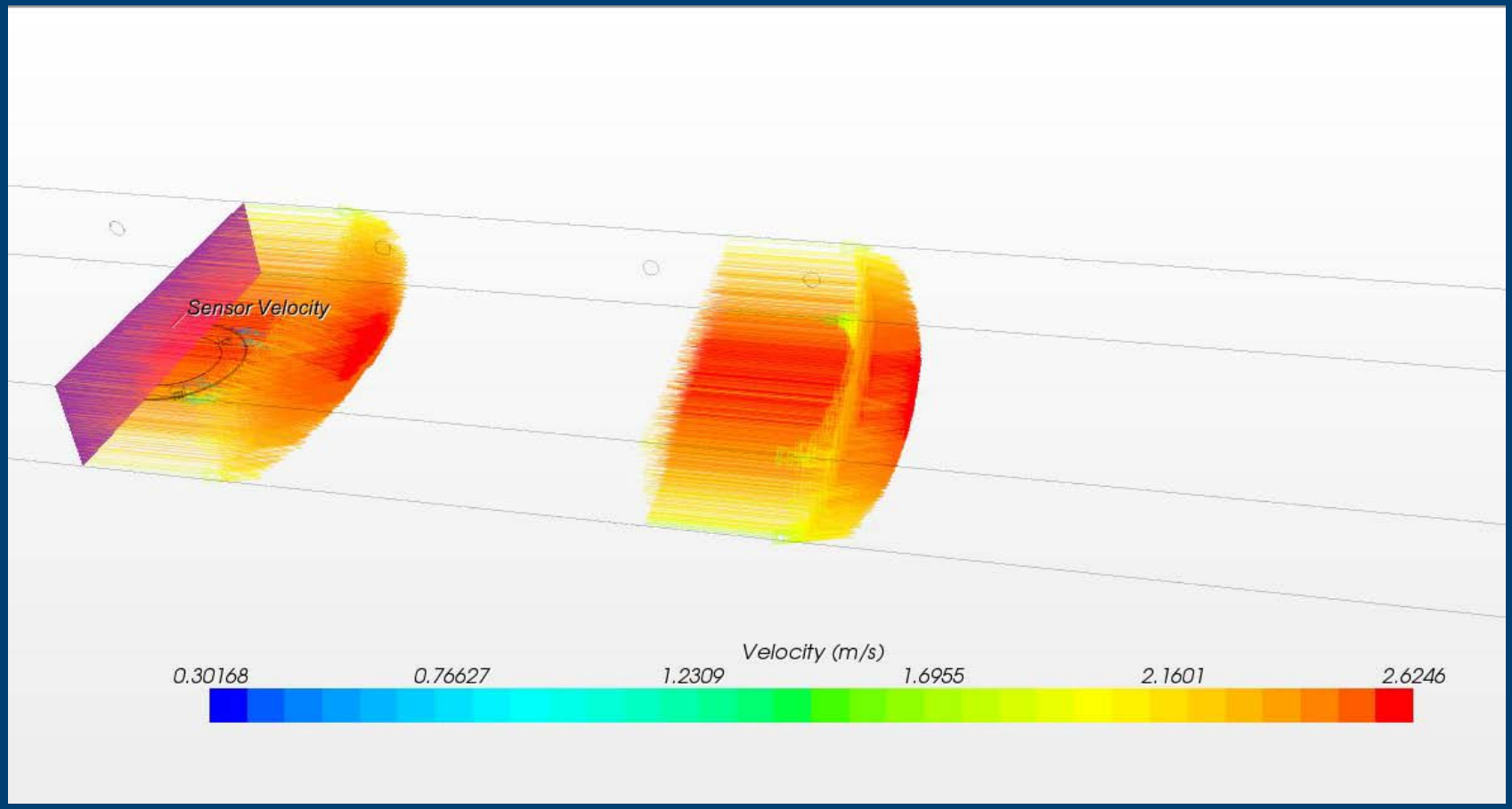


Shear Stresses in SERF for different roughnesses

CFD Modeling – SERF

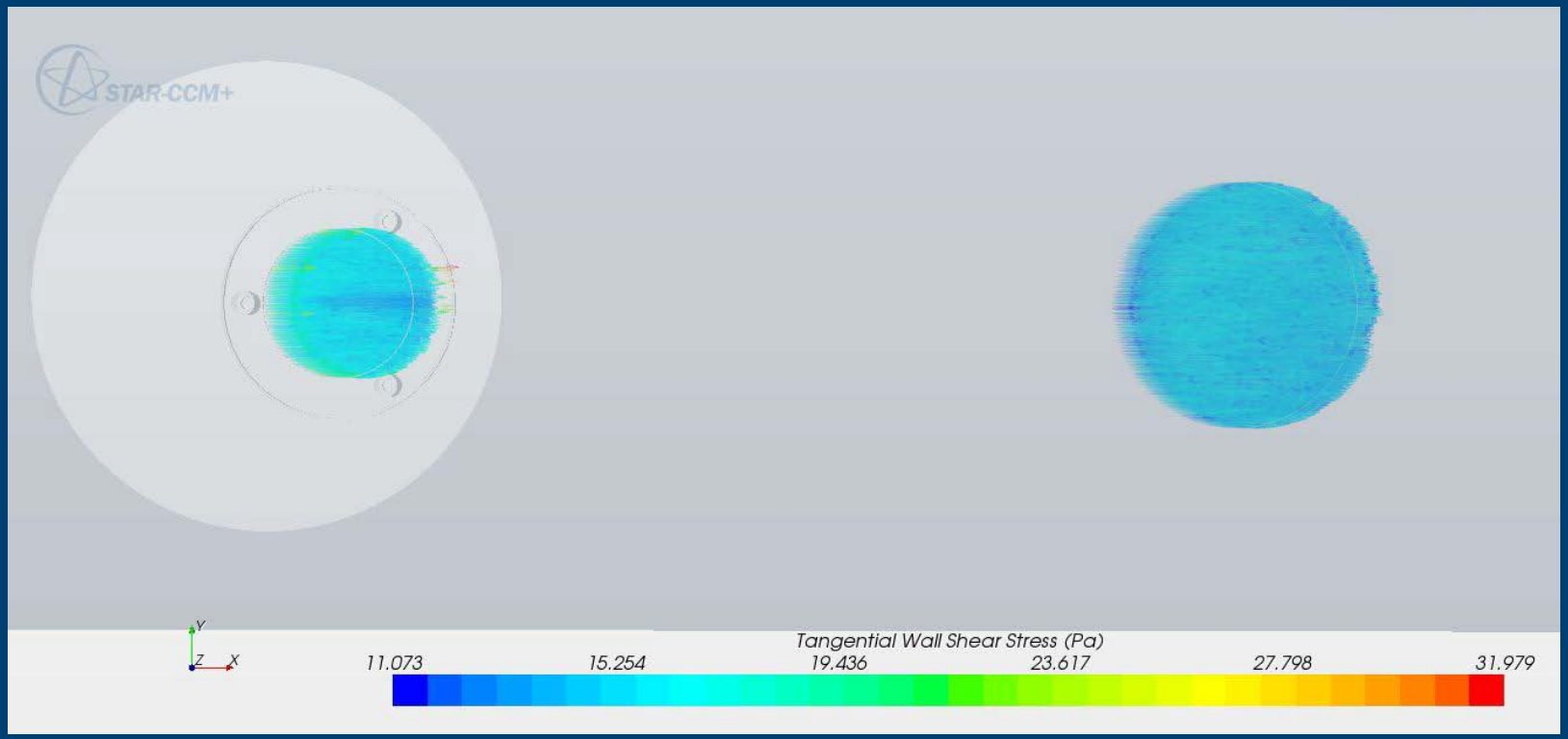
SERF Mesh

CFD Modeling - SERF



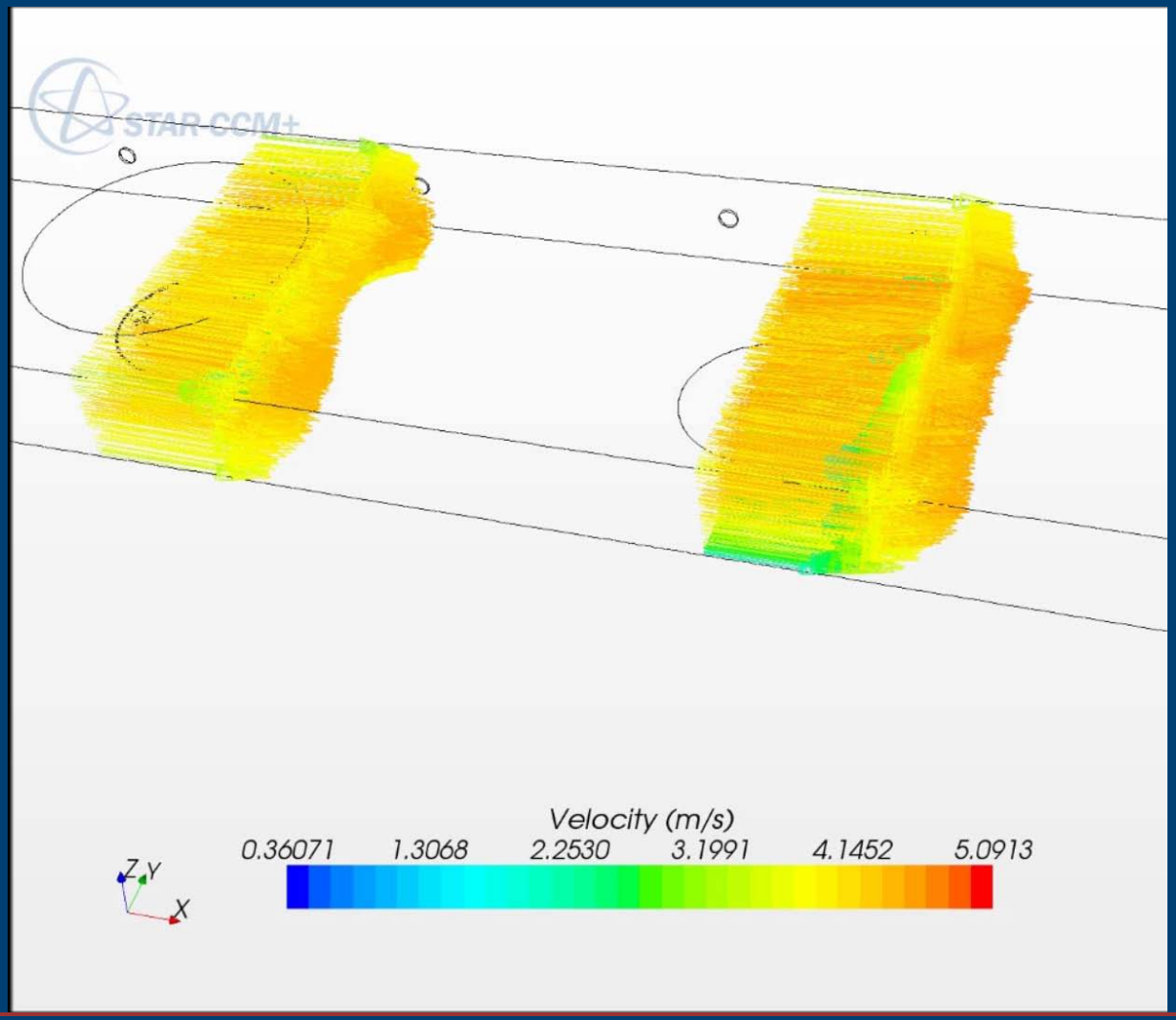
Velocity Profiles in SERF (Average Velocity = 2.0 m/s)

CFD Modeling – SERF

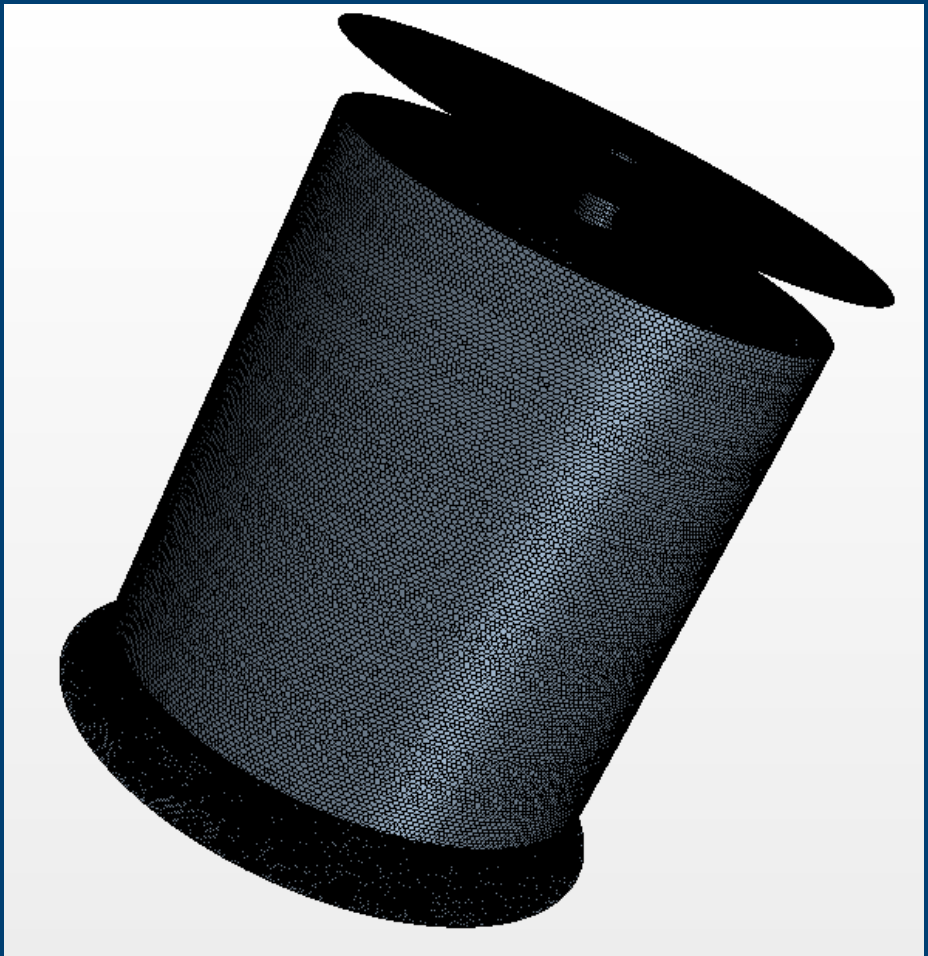


Wall Shear Stresses in SERF (2.0 m/s; steady-state)

CFD Modeling – SERF

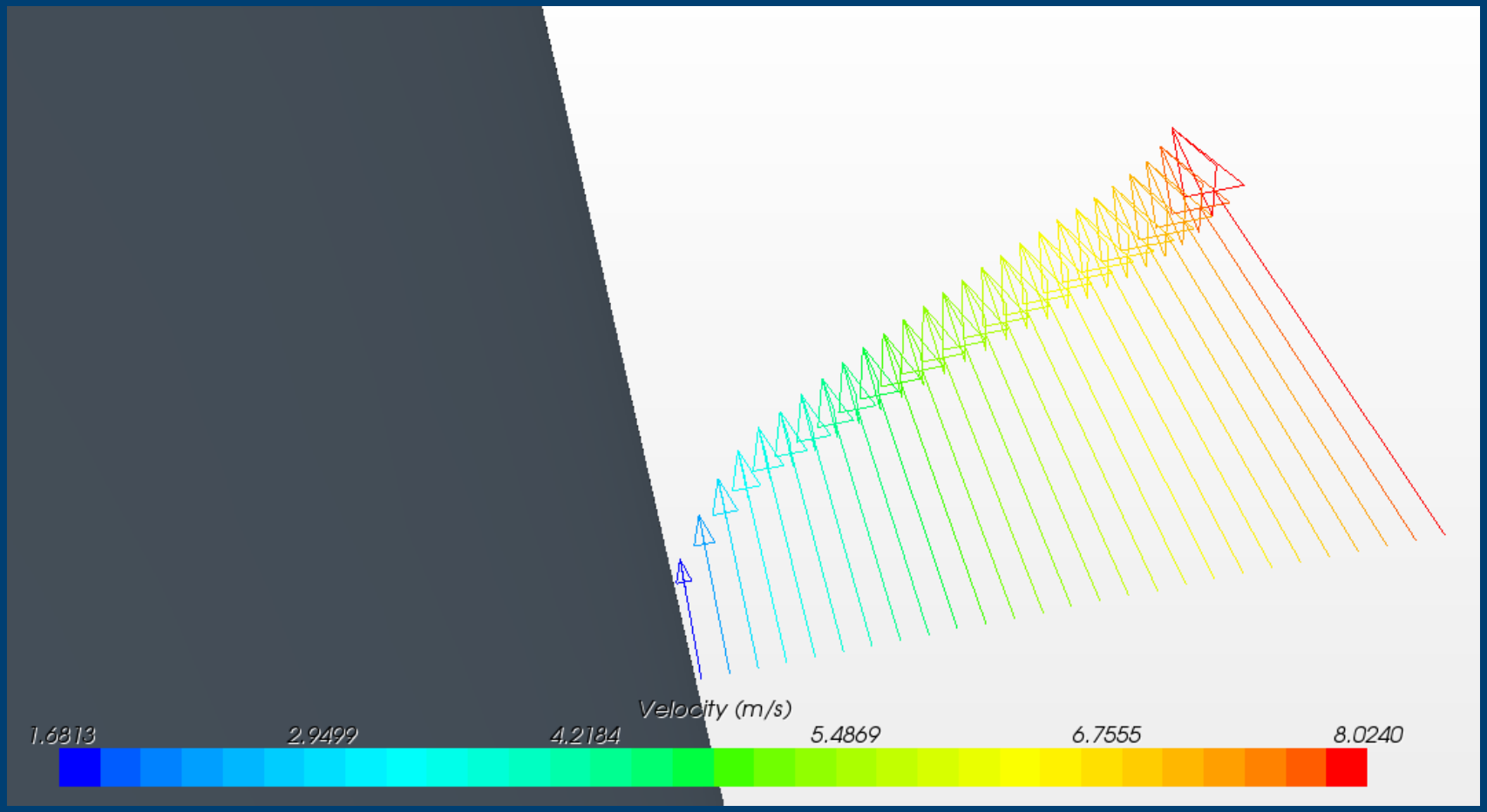


CFD Modeling - RETA



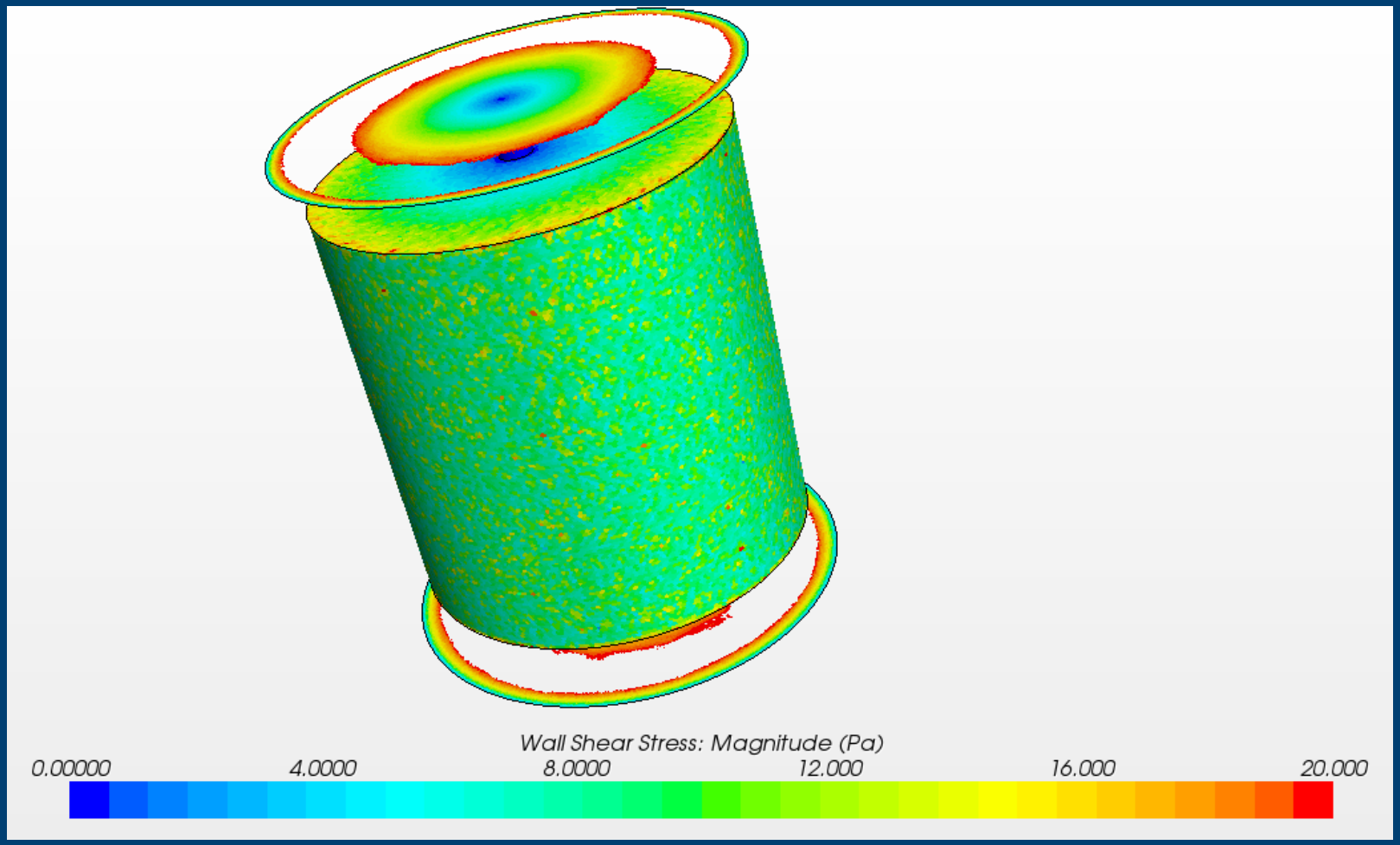
Four-Inch RETA Mesh (Outside Wall Hidden for Clarity)

CFD Modeling – RETA



Velocity Profile in RETA

CFD Modeling – RETA

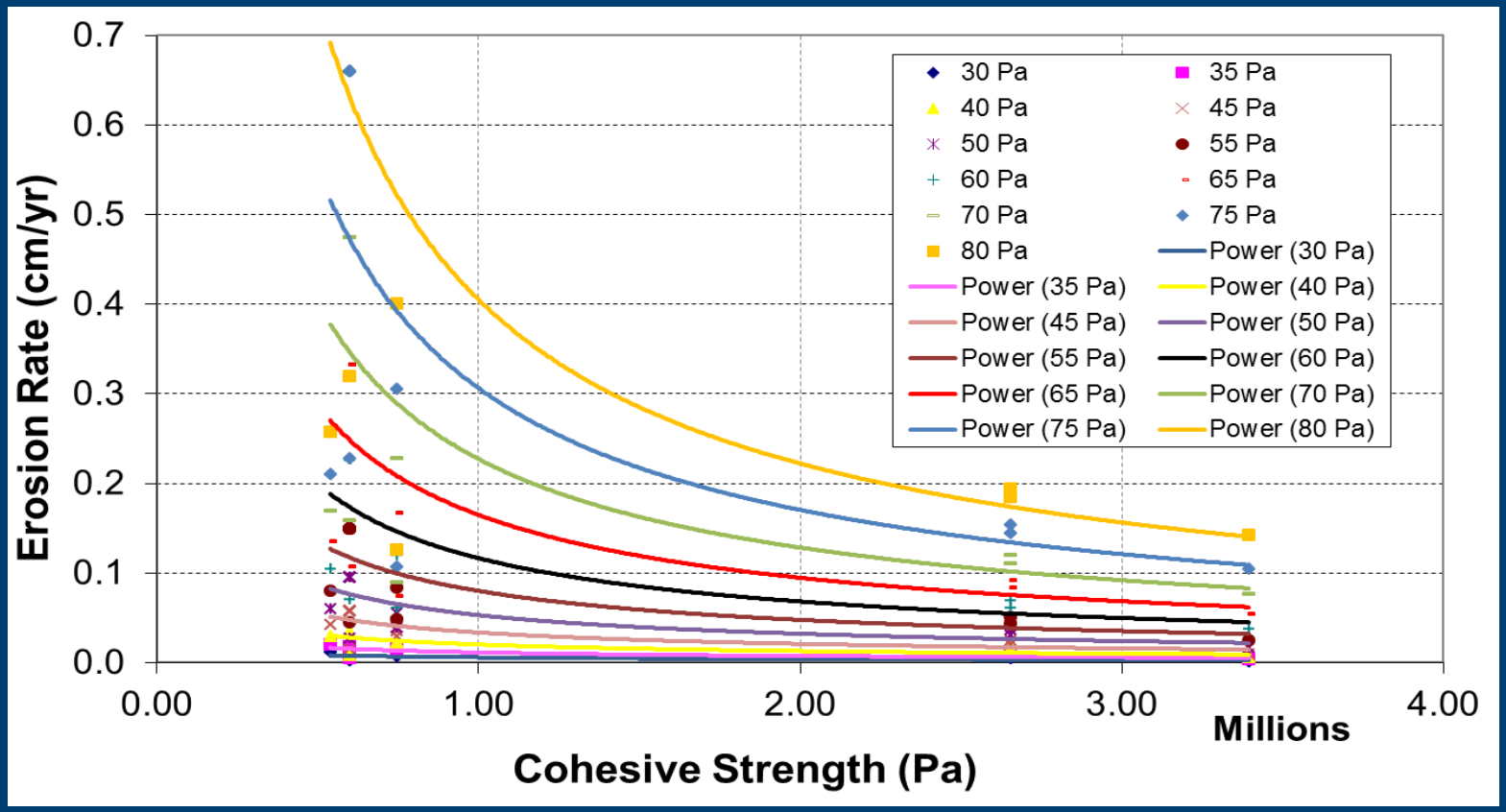


Surface Shear Stress in RETA (Smooth Surface; 1500 RPM)

Experimental Design Recommendations

- Conduct a series of tests at the USGS Conte Laboratory to quantify forcing near bridge pier.
- Use test results to develop CFD models for simple and complex pier geometries.
- Continue to CFD model SERF and RETA to ensure that these instruments properly mimic field conditions.
- Conduct a series of tests with TFHRC ISTD.

Old RETA Cohesion Erosion Model



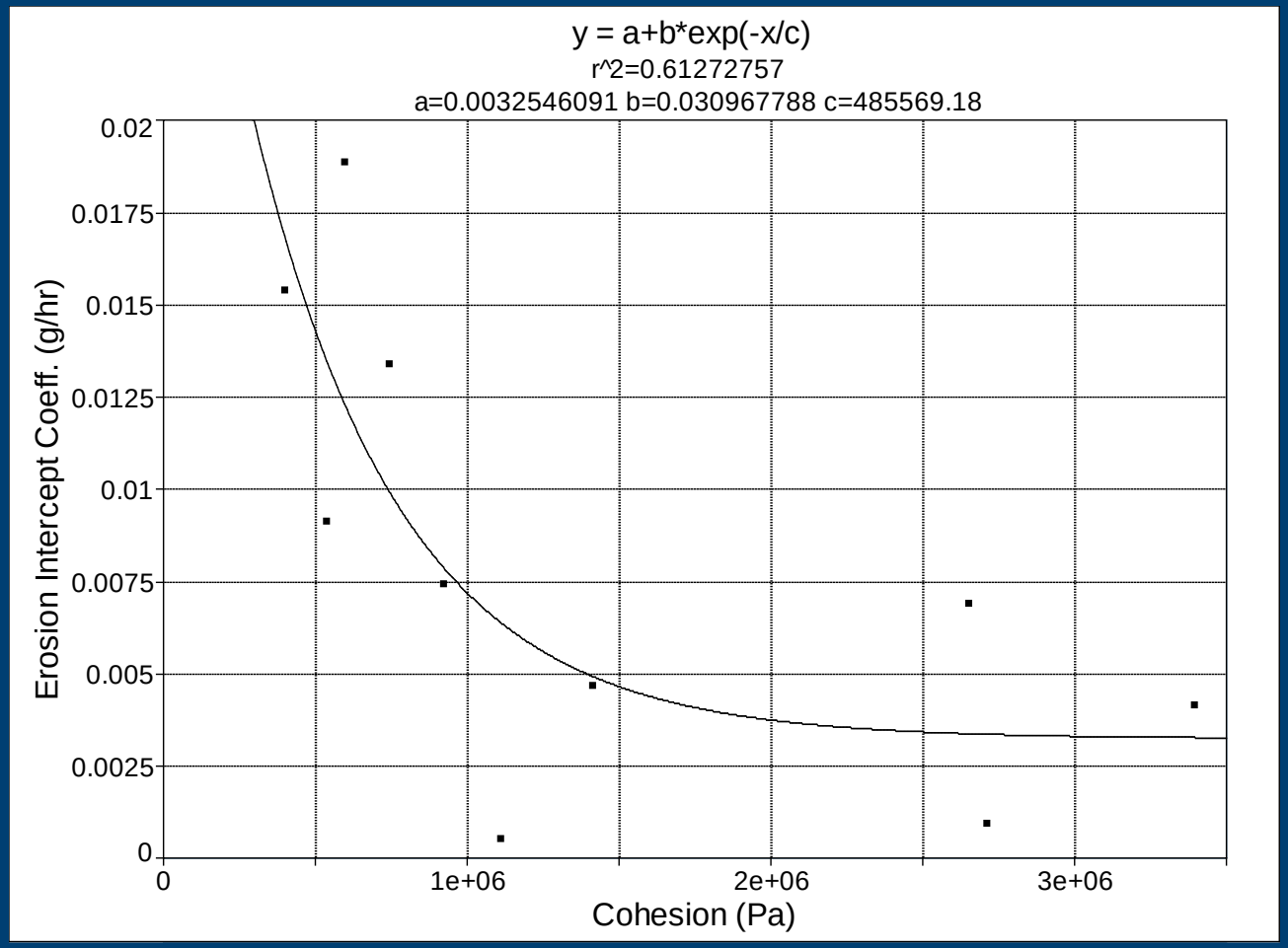
Slagle's Erosion Model Based upon RETA Data and Cohesion

New RETA Cohesion Erosion Model

- We know:
  - $E = M(\tau_b - \tau_c)$
  - $C = \frac{\sqrt{q_u}\sqrt{q_t}}{2}$
- Old Model:
  - $E = kC^{-n}$
- New Model:
  - $E = N\tau_b - Z$
  - $N, Z = a + be^{-C/c}$

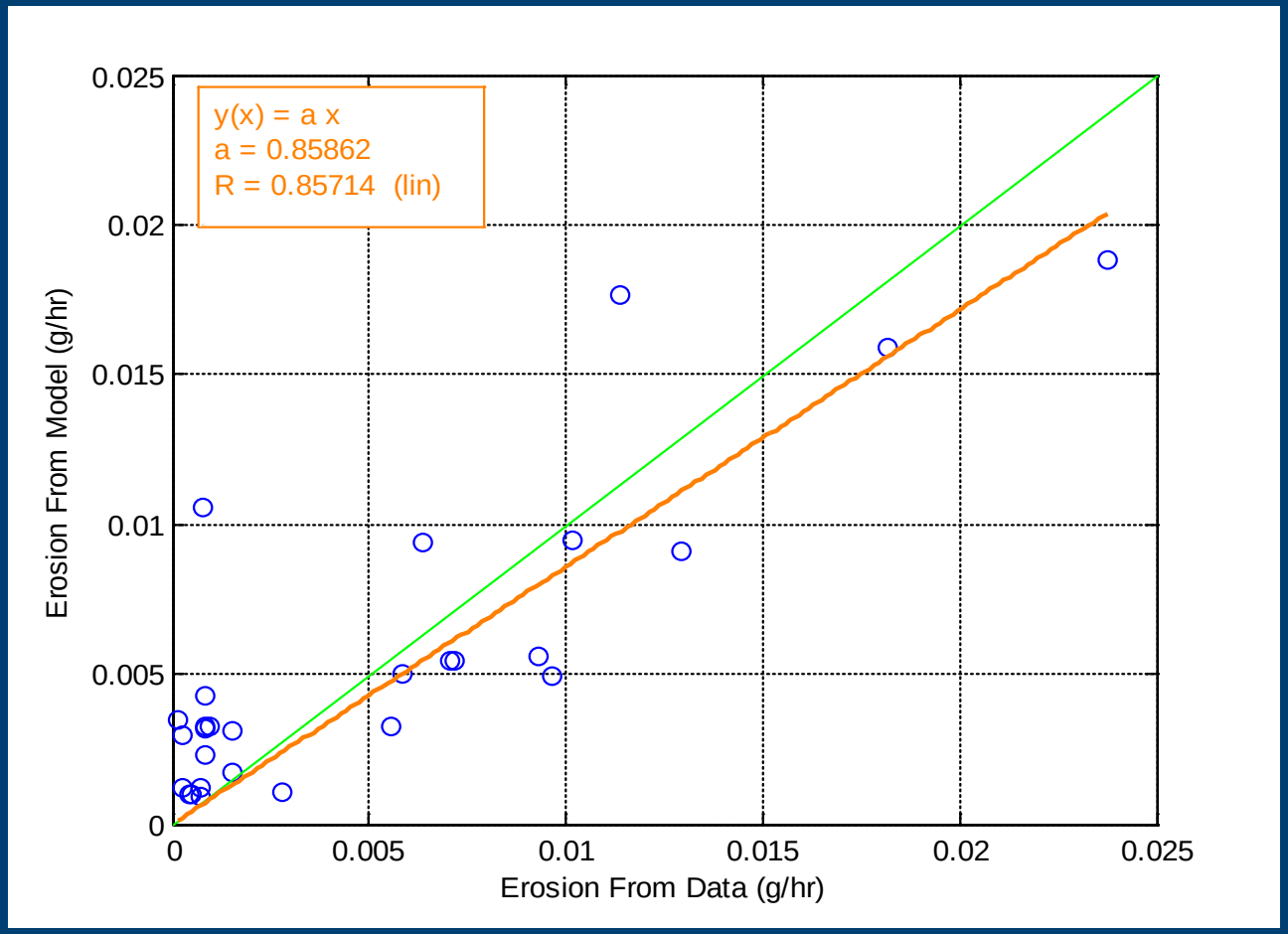
- ***E*** **= Erosion Rate**
- ***C*** **= Cohesion**
- q_u **= Ultimate (compressive) strength**
- q_t **= Tensile strength**
- τ_b **= Bed shear stress**
- τ_c **= Critical shear stress**
- ***N,Z*** **= New model constants**
- ***a,b,c,k,n*** **= regression coefficients**

Coefficient Regression Curves



Erosion Intercept Coefficient as a Function of Cohesion

New Erosion Model Results



Modeled results vs. Erosion Data

Continuing Work

- SERF Fields Tests
- Continue CFD Modeling of Devices
- Specify Experimental Design
  - Cost
  - Schedule

Questions?