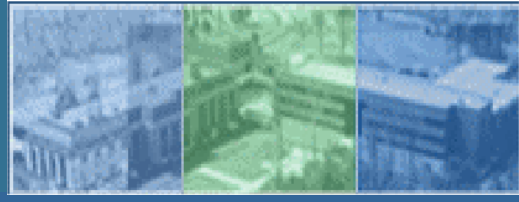


Feather River Bridge Pier Scour Study

presented

by

Oscar Suaznabar, Li Chen

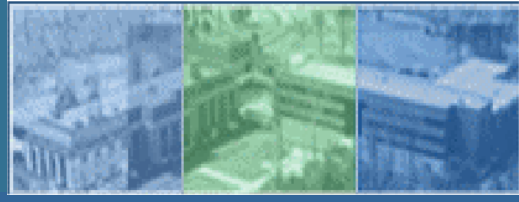
and Kornel Kerenyi

at the

National Hydraulics Engineering Conference

Thursday, August 21, 2014

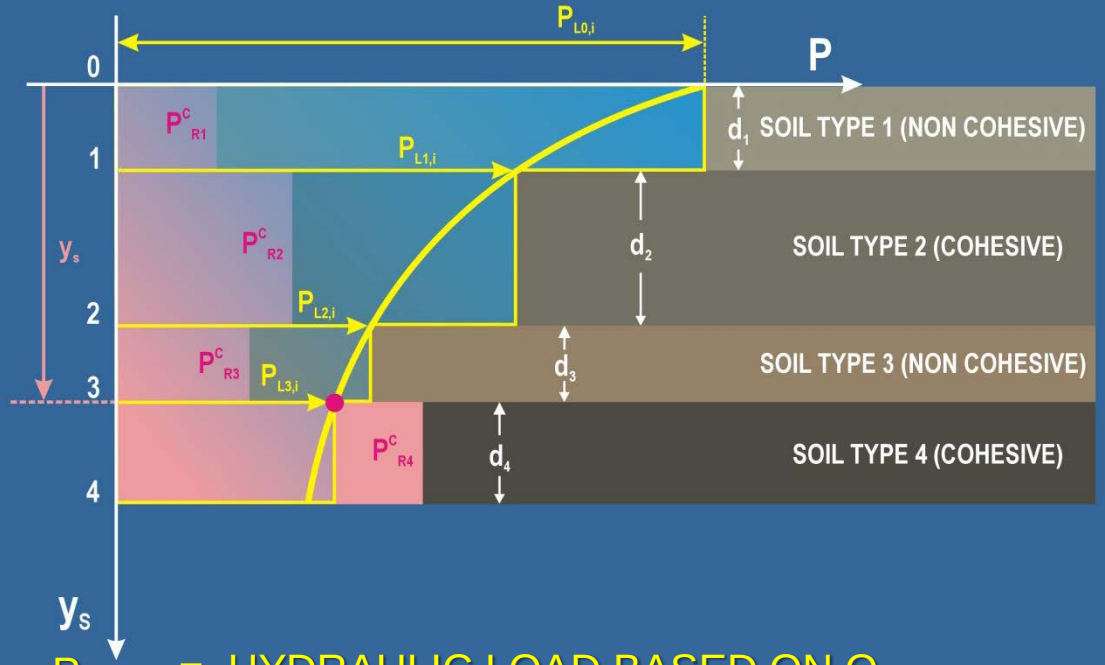
Iowa City, IA



Outline

- Background
- Phase I: Hybrid Modeling Approach
- Phase II: Full Scale 3D CFD Modeling
- Preliminary Results

Hydraulic Loading Decay Function and Critical Soil Resistance



$\rightarrow P_{L0,i} > < P^C_{R1,i}$

$\rightarrow P_{L1,i} > < P^C_{R2,i}$

$\rightarrow P_{L2,i} > < P^C_{R3,i}$

$\rightarrow P_{L3,i} > < P^C_{R4,i}$

$P_{L,i}$ = HYDRAULIC LOAD BASED ON Q_{100}

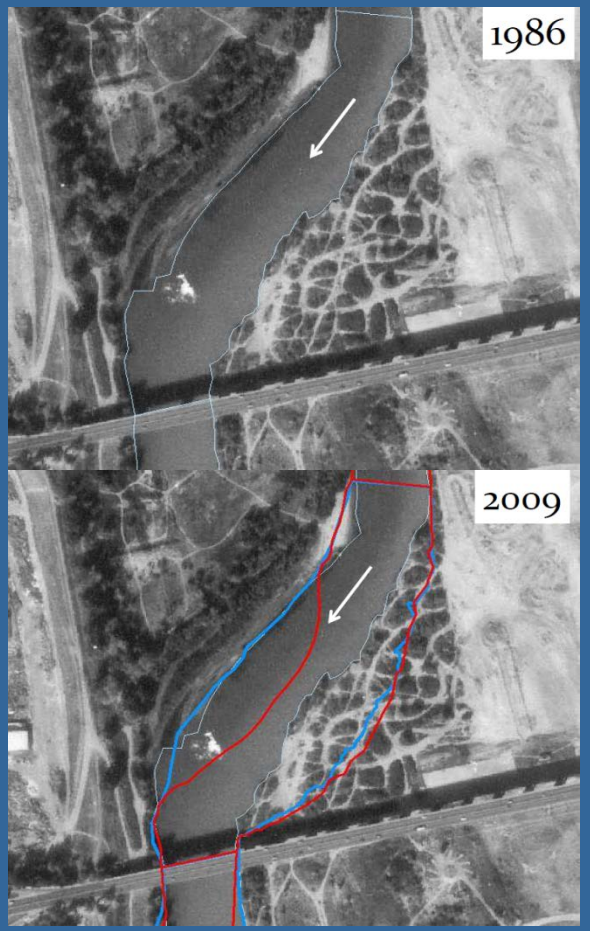
$P^C_{R,i}$ = CRITICAL SOIL RESISTANCE

y_S = SCOUR DEPTH

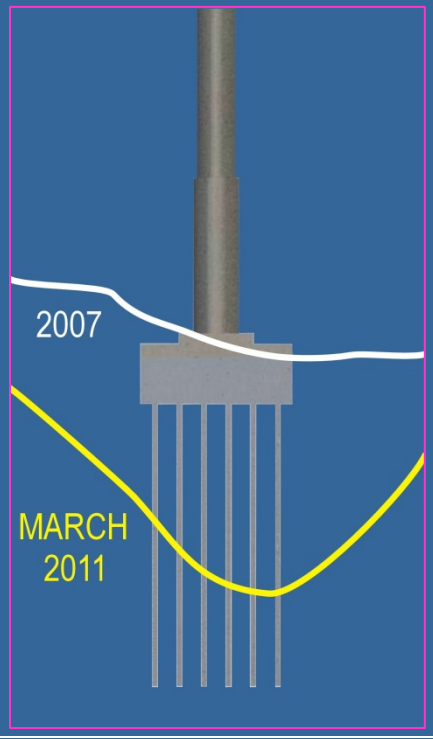
$y_{S\,MAX} \rightarrow P_{Lj,i} < P^C_{Rj+1,i}$

Background

Feather River Bridge No 18-0009
Sacramento, California (2012)

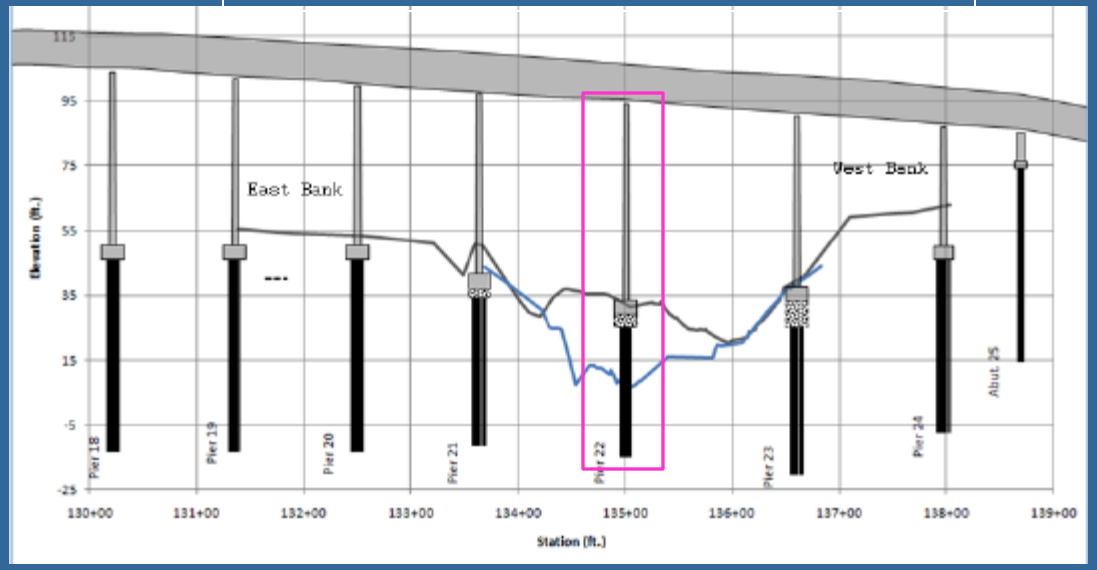


Damage from March 2011 Flows



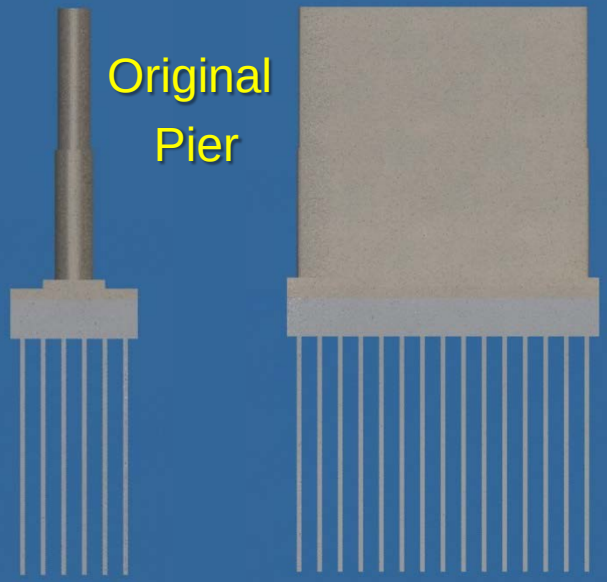
Scour Hole around Pier 22
19 feet of piles exposed

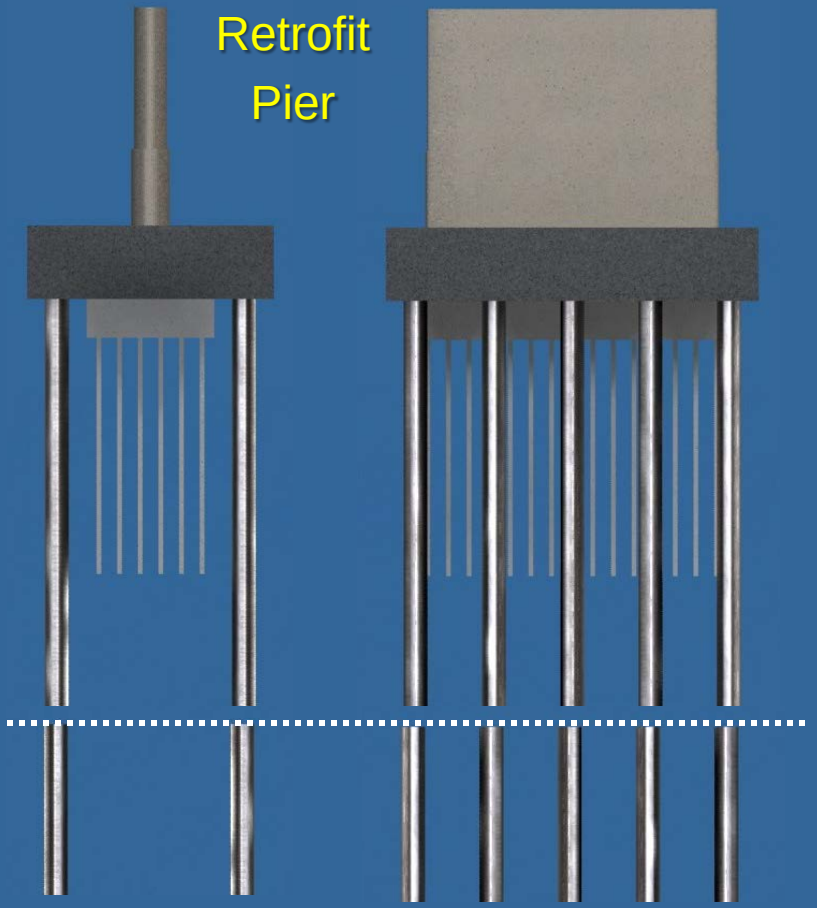
Roughly a 5-year Flood Event



Results from a bathymetric Survey
Upstream Cross- Section Comparison
2007 and March 2011

Long-term Pier Retrofit Design

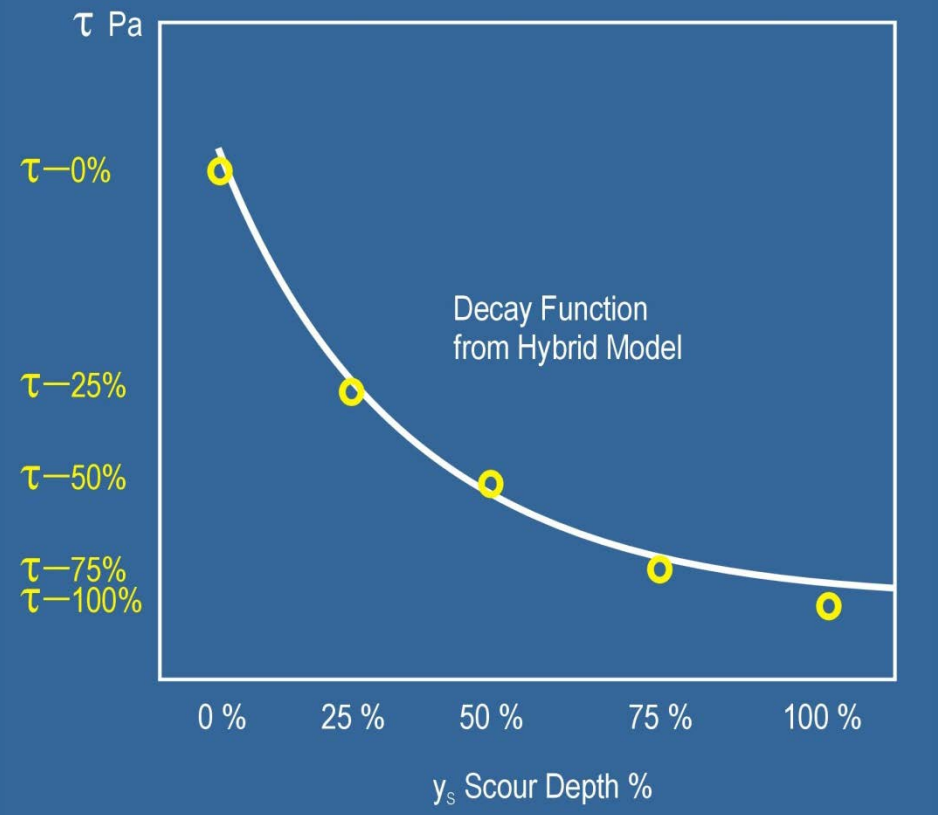




Original Pilecap with 90 square H-piles was retrofitted with 10 4-foot diameter x 180-foot long CISS Piles tied into a new enlarged Pilecap

Phase I: Hybrid Modeling Approach

CFD Modeling

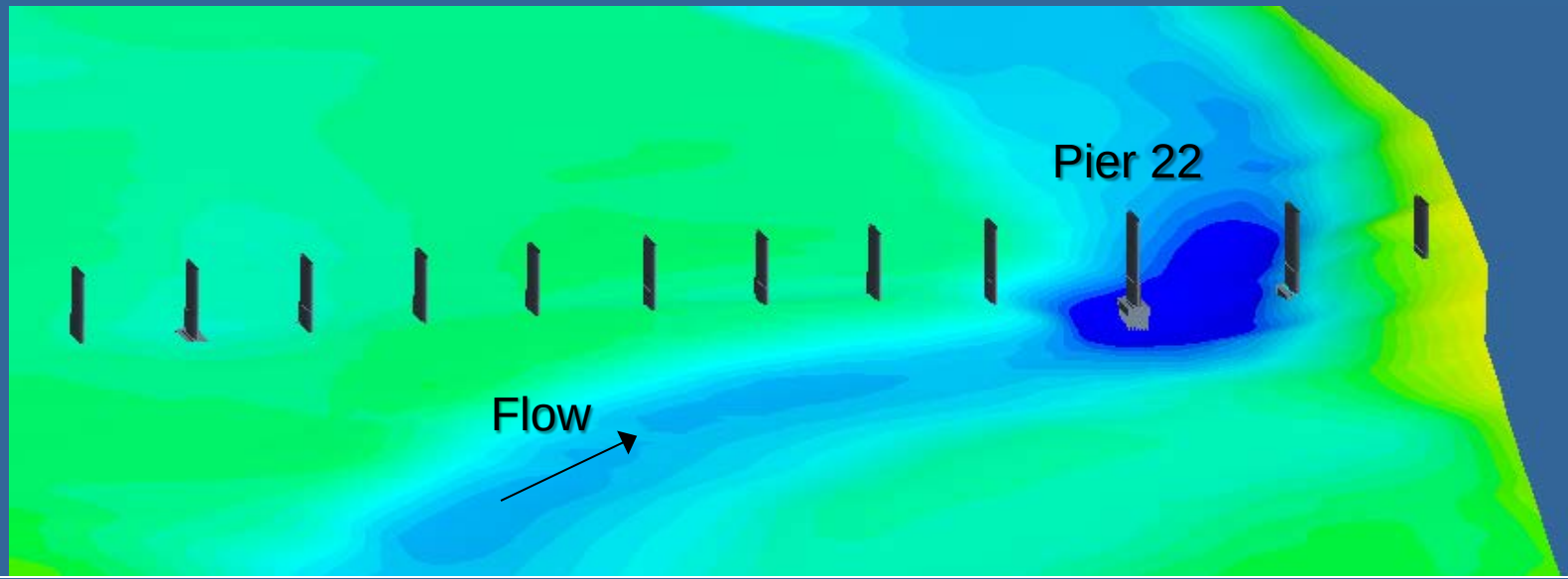


Physical Modeling

Hydraulic Load Decay
VS.
Time-rate of Scour

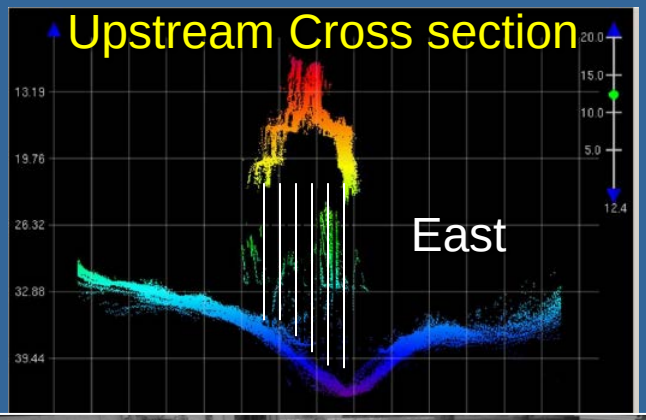
- 2 Pier Models:
  Original and Retrofit Pier
- 2 Flow Conditions:
  March 2011 and Q_{100}

Phase II: Full Scale CFD Modeling Using River Bed Bathymetric Surveys

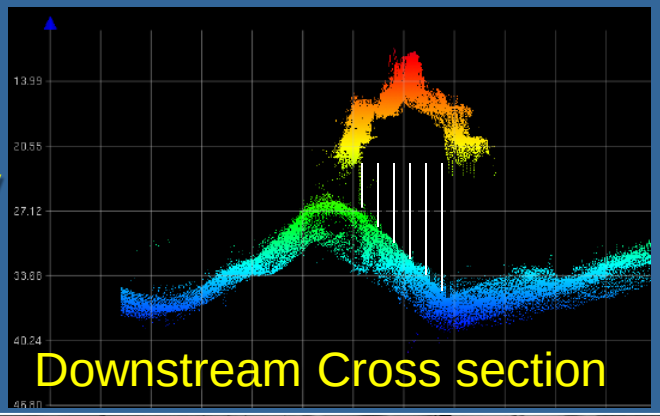


- Bathymetry surveys from 2007 and 2011 (Scour Hole around Pier 22), DEM
- March 2011 flood event and Q_{100}
- Goals: Change of hydraulic loading and identify new potential scouring spots

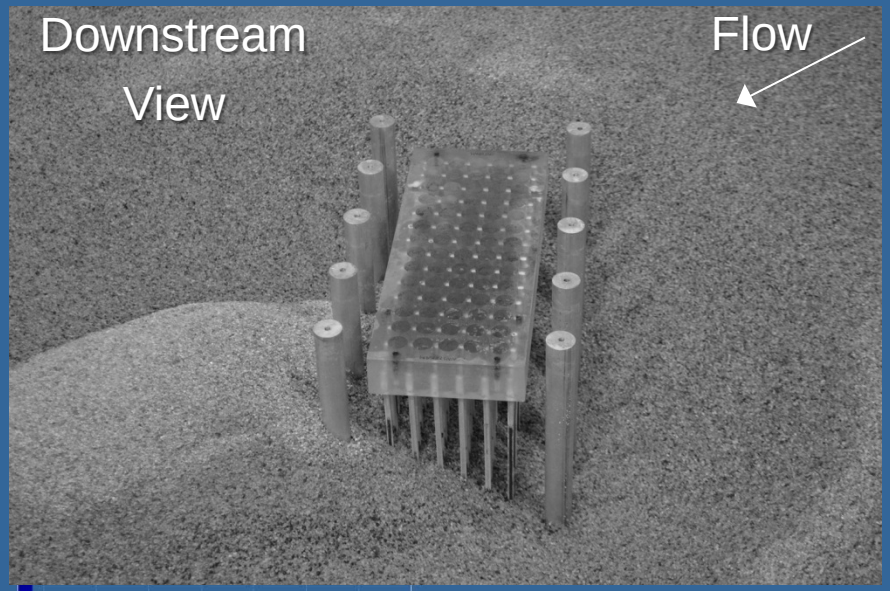
Physical Modeling in the TFHRC Flume



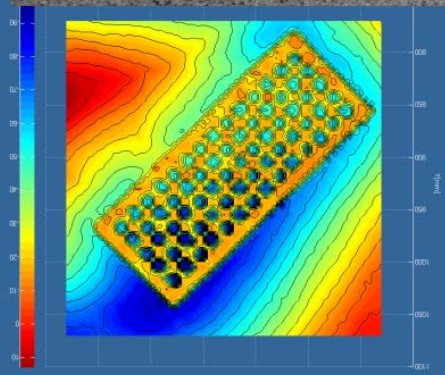
Sonar
Bathymetry Survey
K. Flora, Caltrans



Physical Modeling in the TFHRC Flume

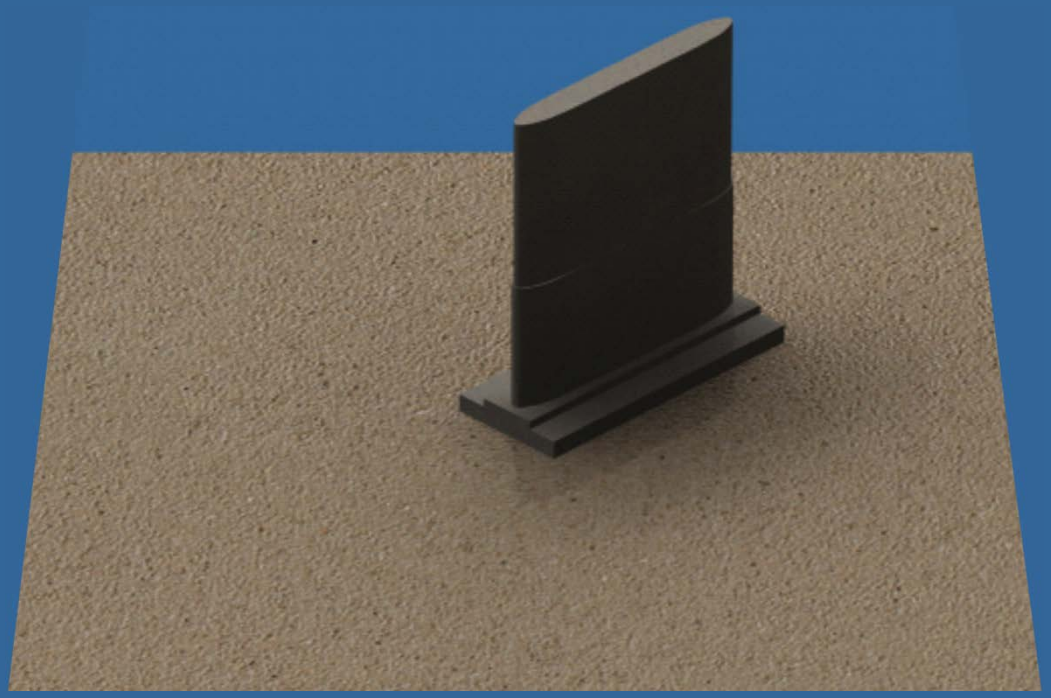


Hydraulic Skew 45 Degrees
based on 2D Modeling



Scour
Bathymetry
underneath
the Pile Cap

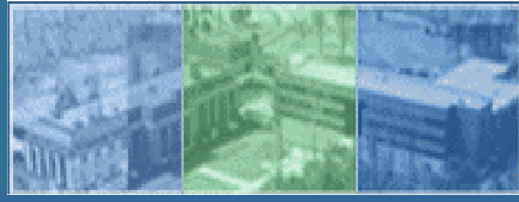
Retrofit Pier March Flow Bathymetry Results



Time= 0

~ 25 %

Time= 12 [min]



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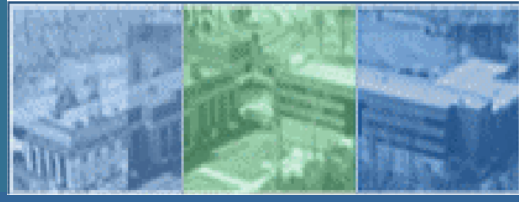
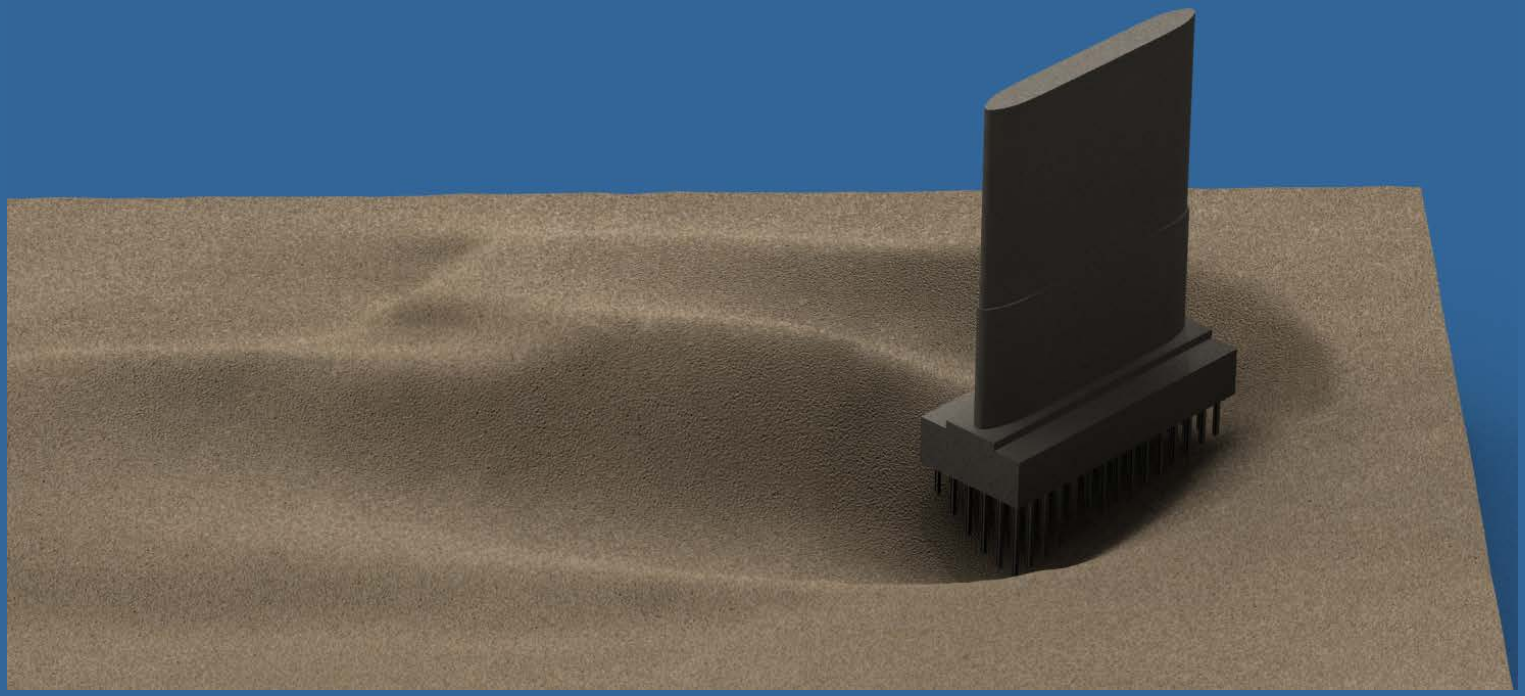
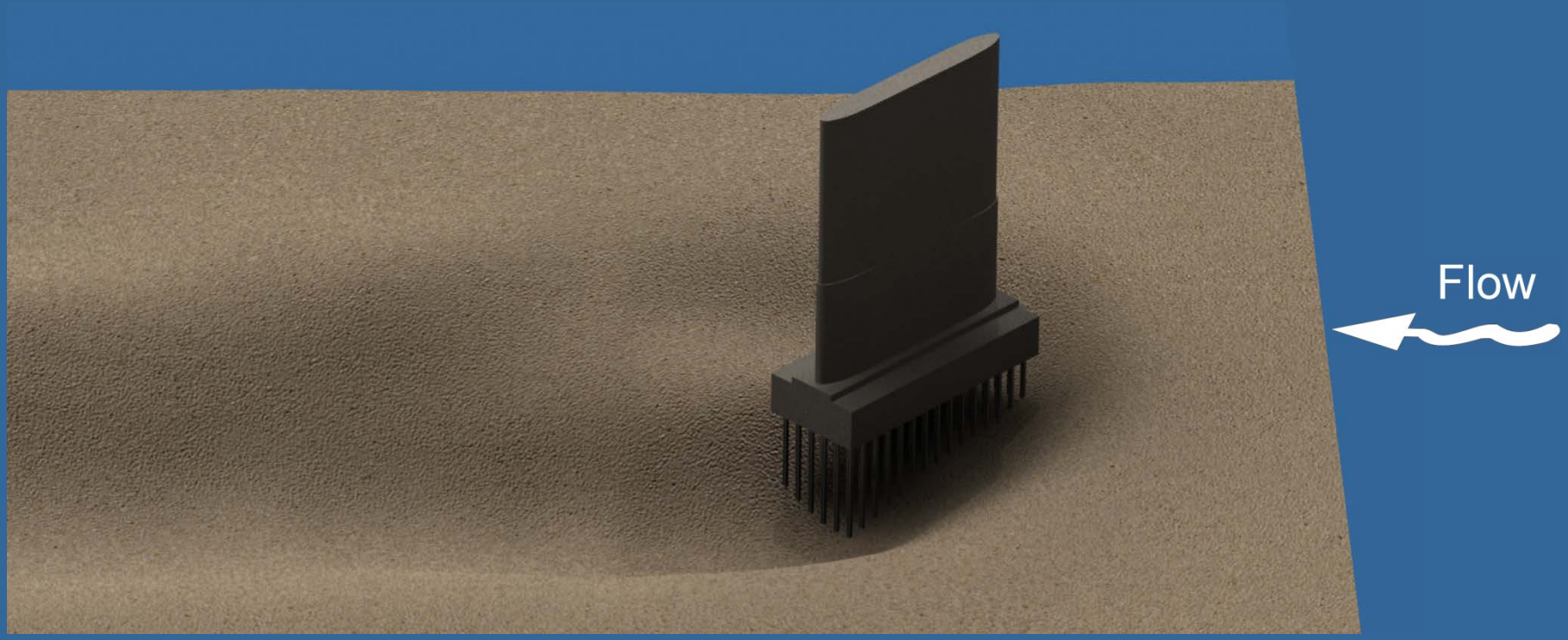


~ 75 %



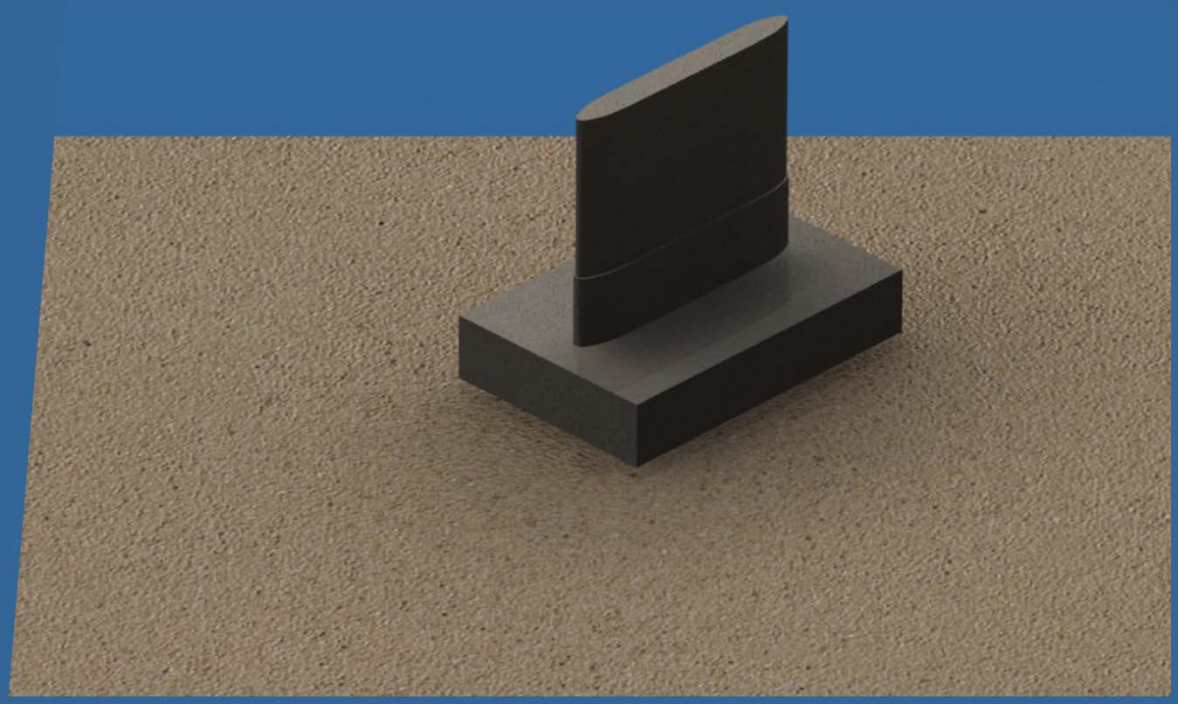
Time= 2 [hours]

Maximum Equilibrium Scour ~100%

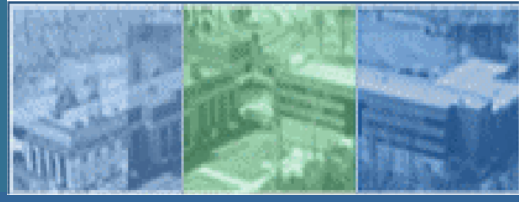


Time= 24 [hours]

Retrofit Pier March Flow Bathymetry Results



Time= 0



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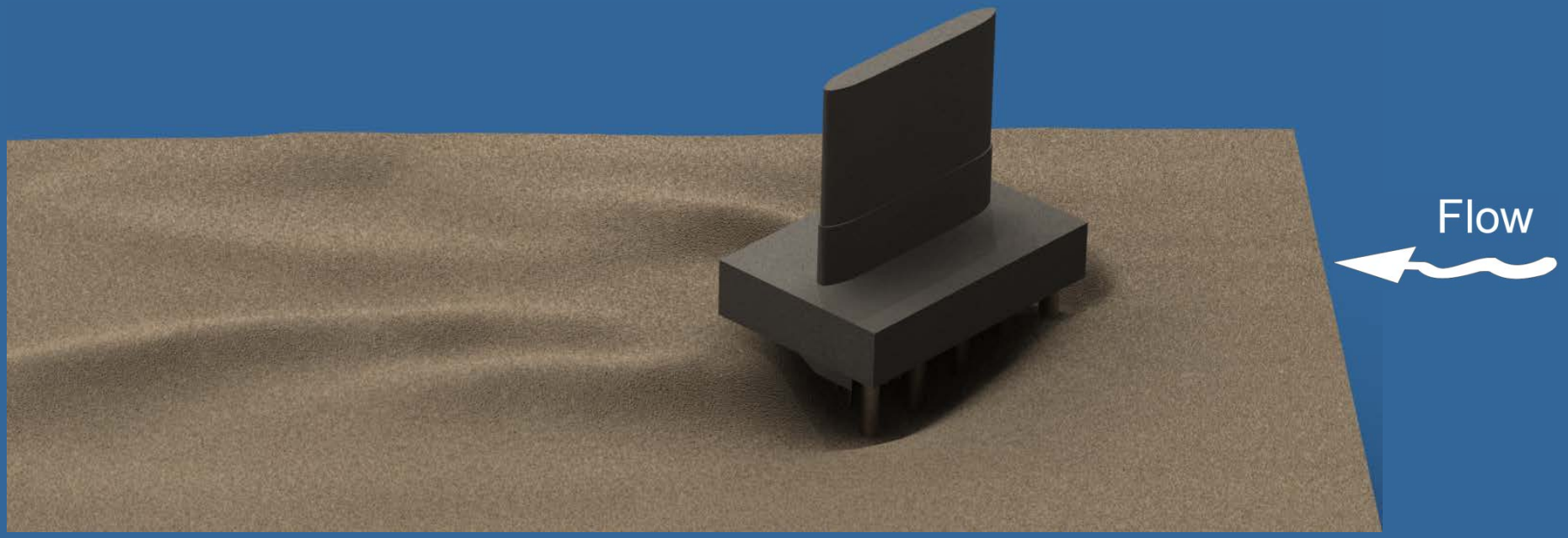

Time= 12 [min]

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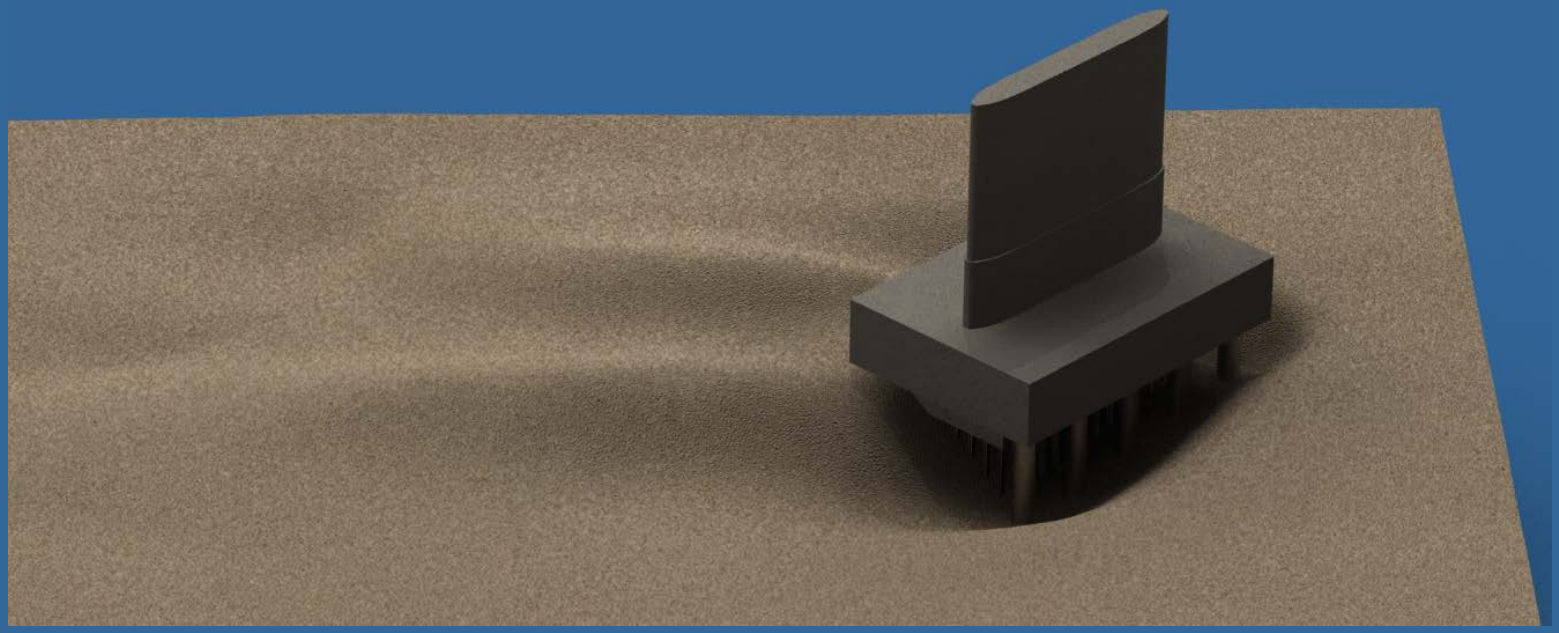

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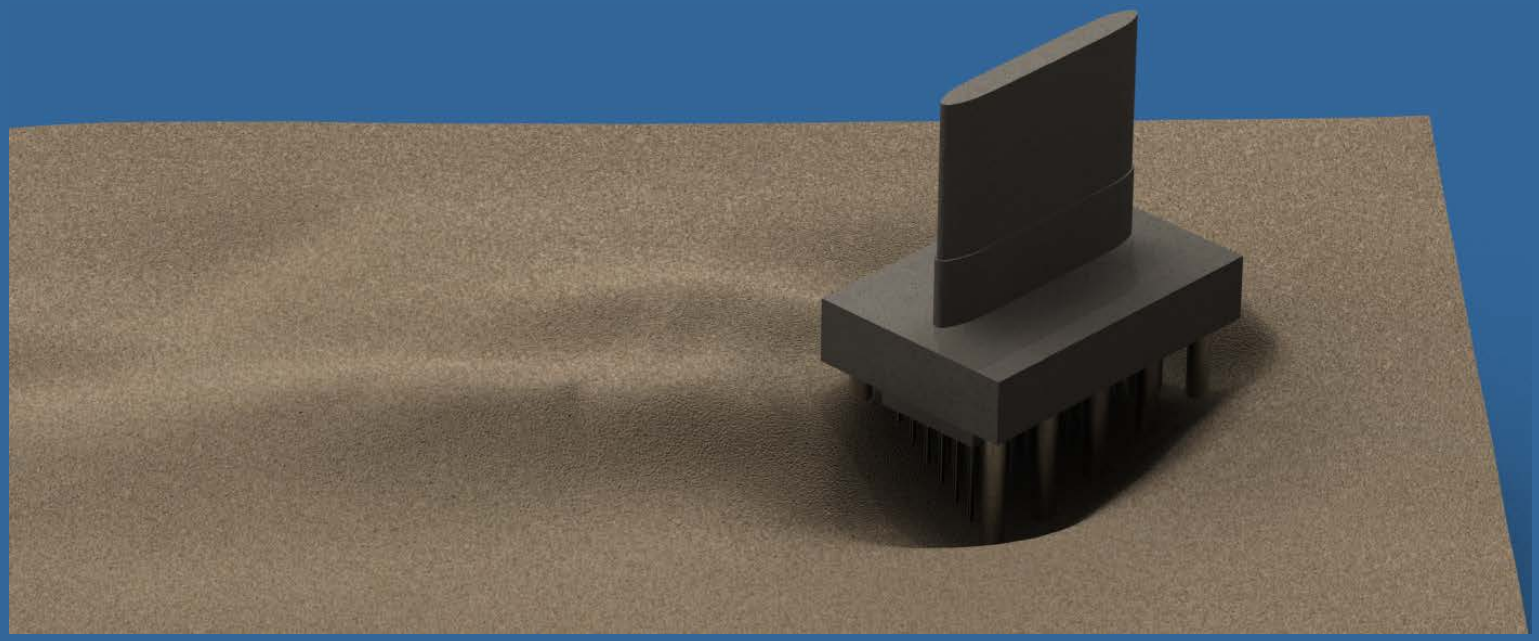
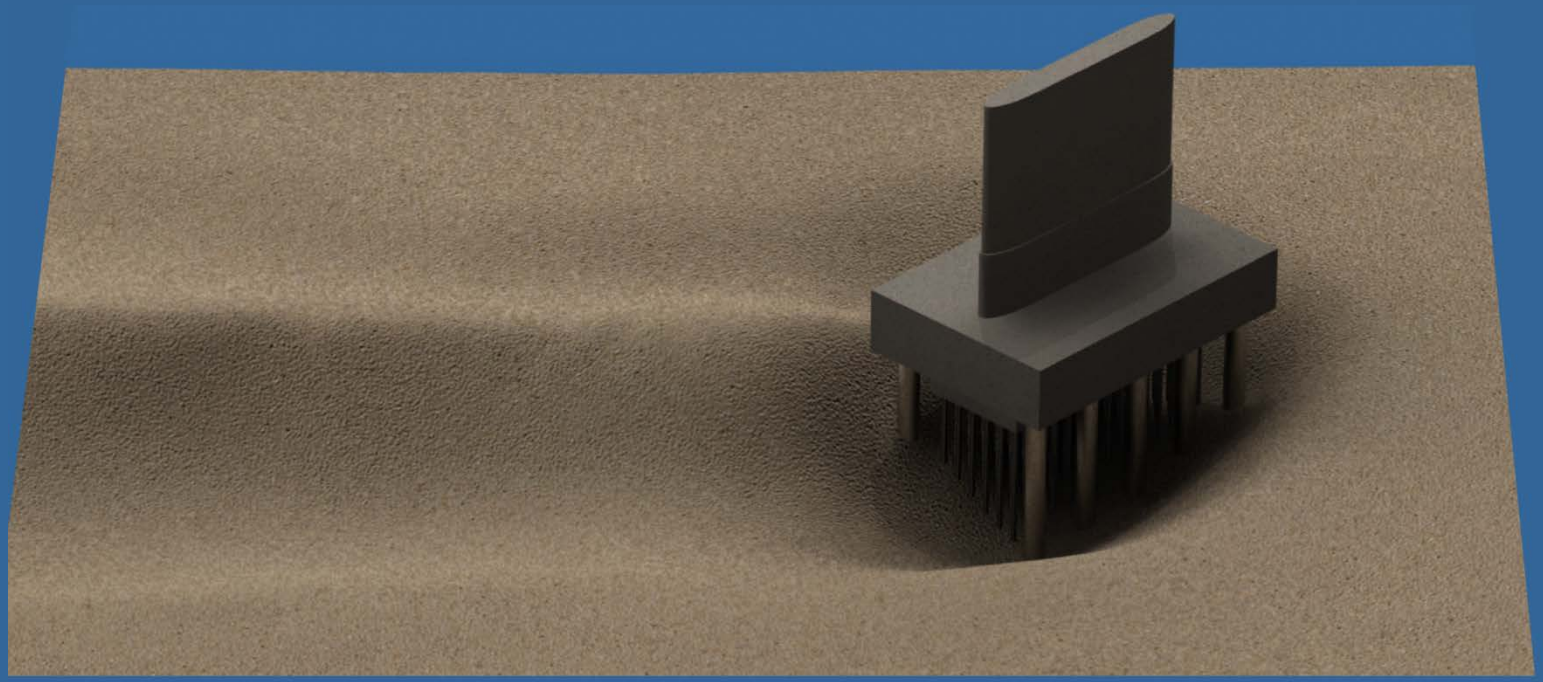
~ 75 %



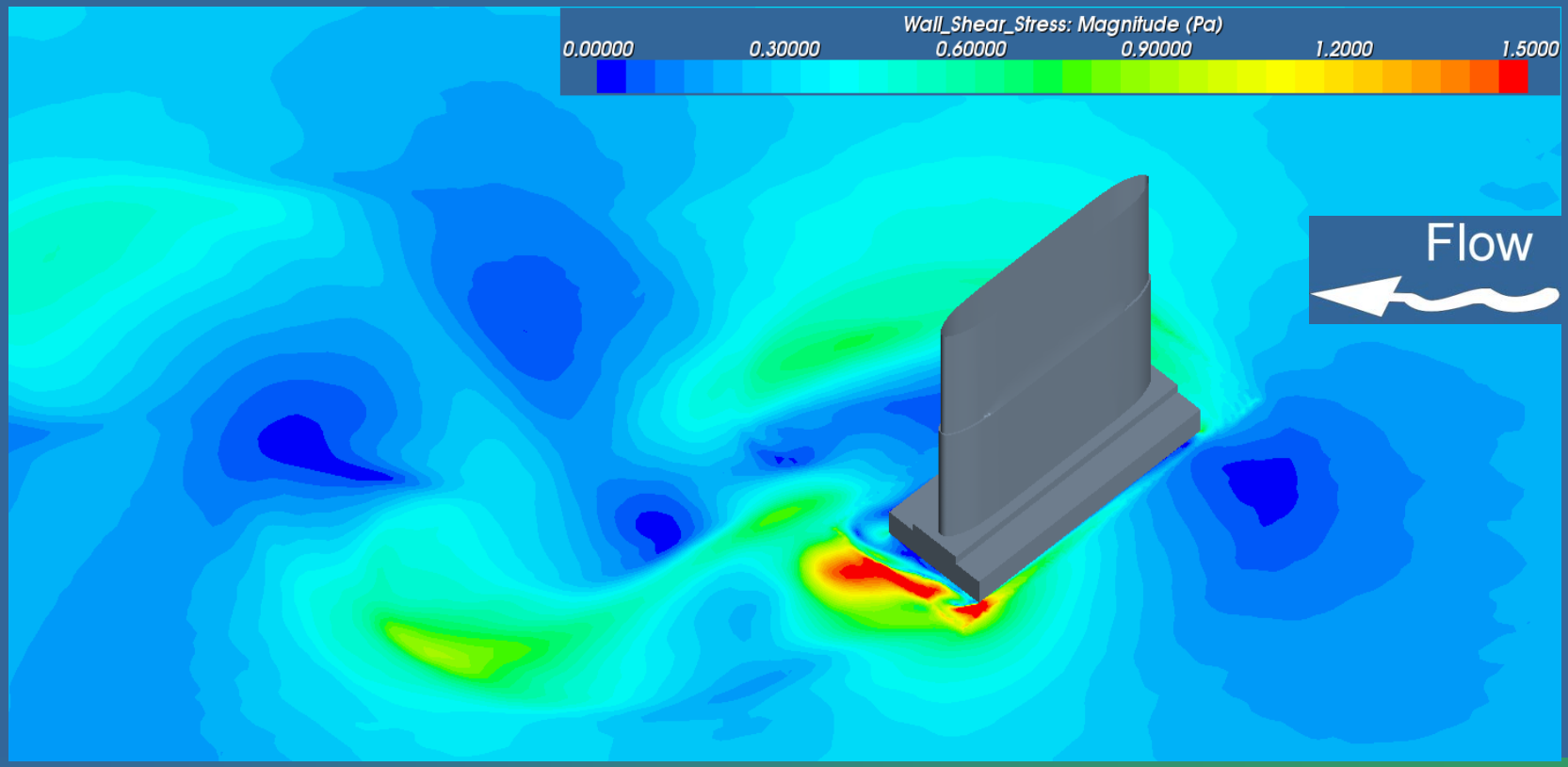
Time= 2 [hours]

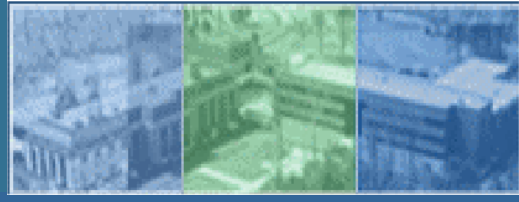
Maximum Equilibrium Scour ~ 100 %



Time= 24 [hours]

CFD Wall Shear Stress – March Flow Unscoured Bed





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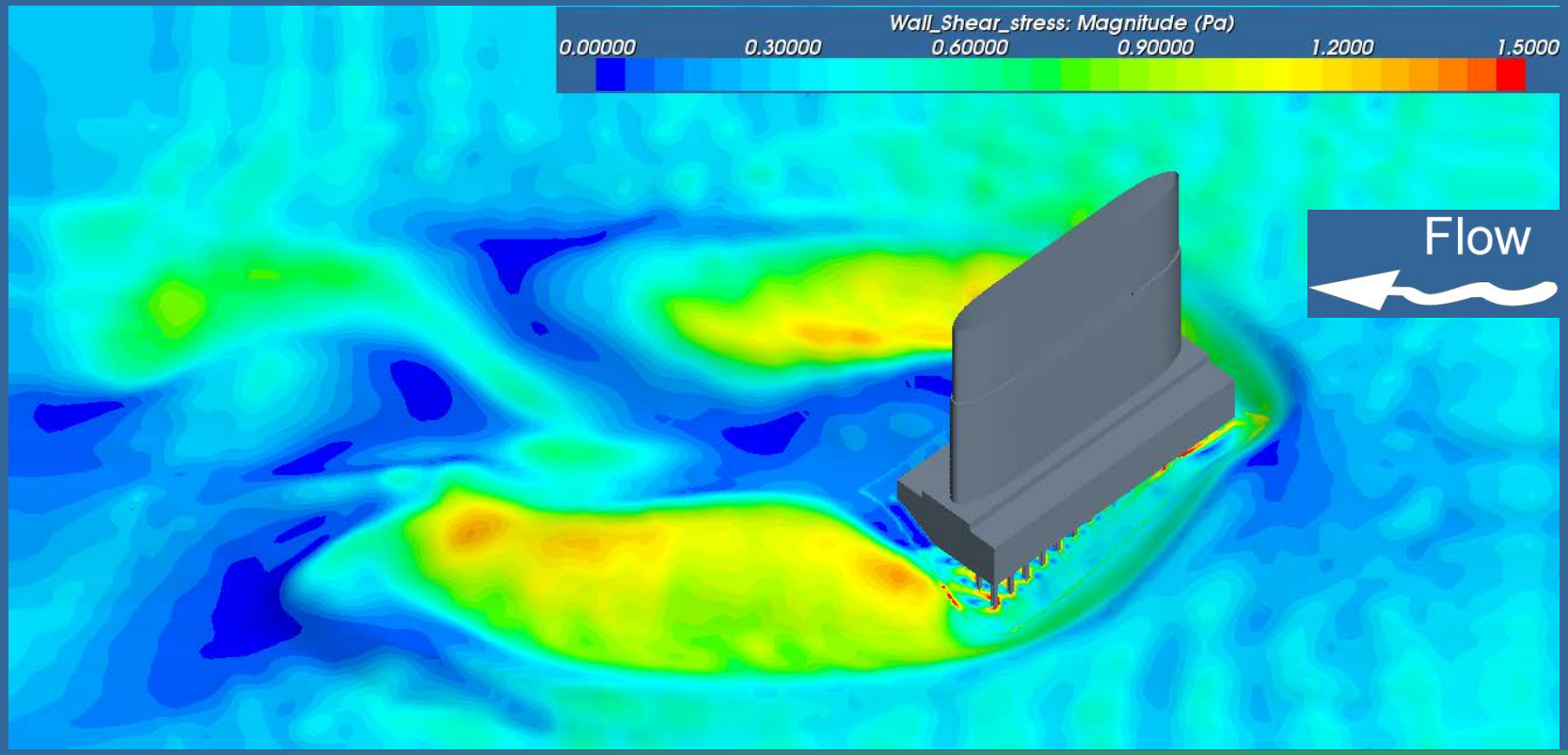
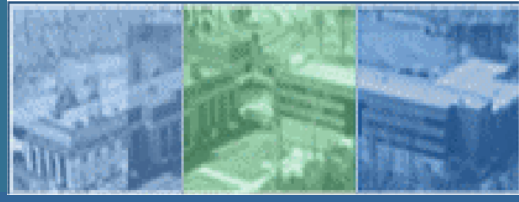
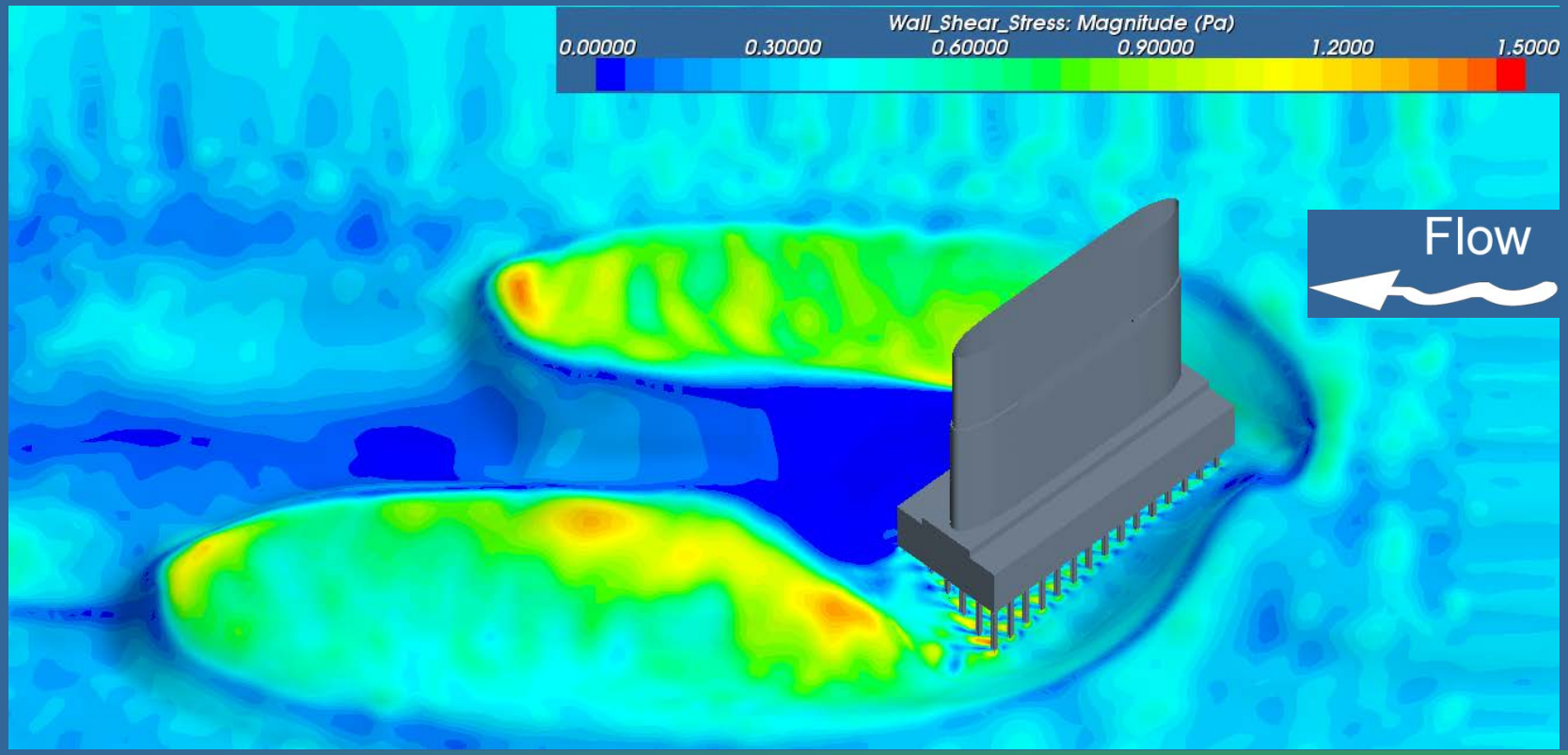
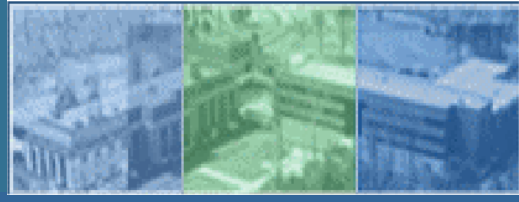

Wall_Shear_stress: Magnitude (Pa)
0.00000
0.30000
0.60000
0.90000
1.2000
1.5000
Flow

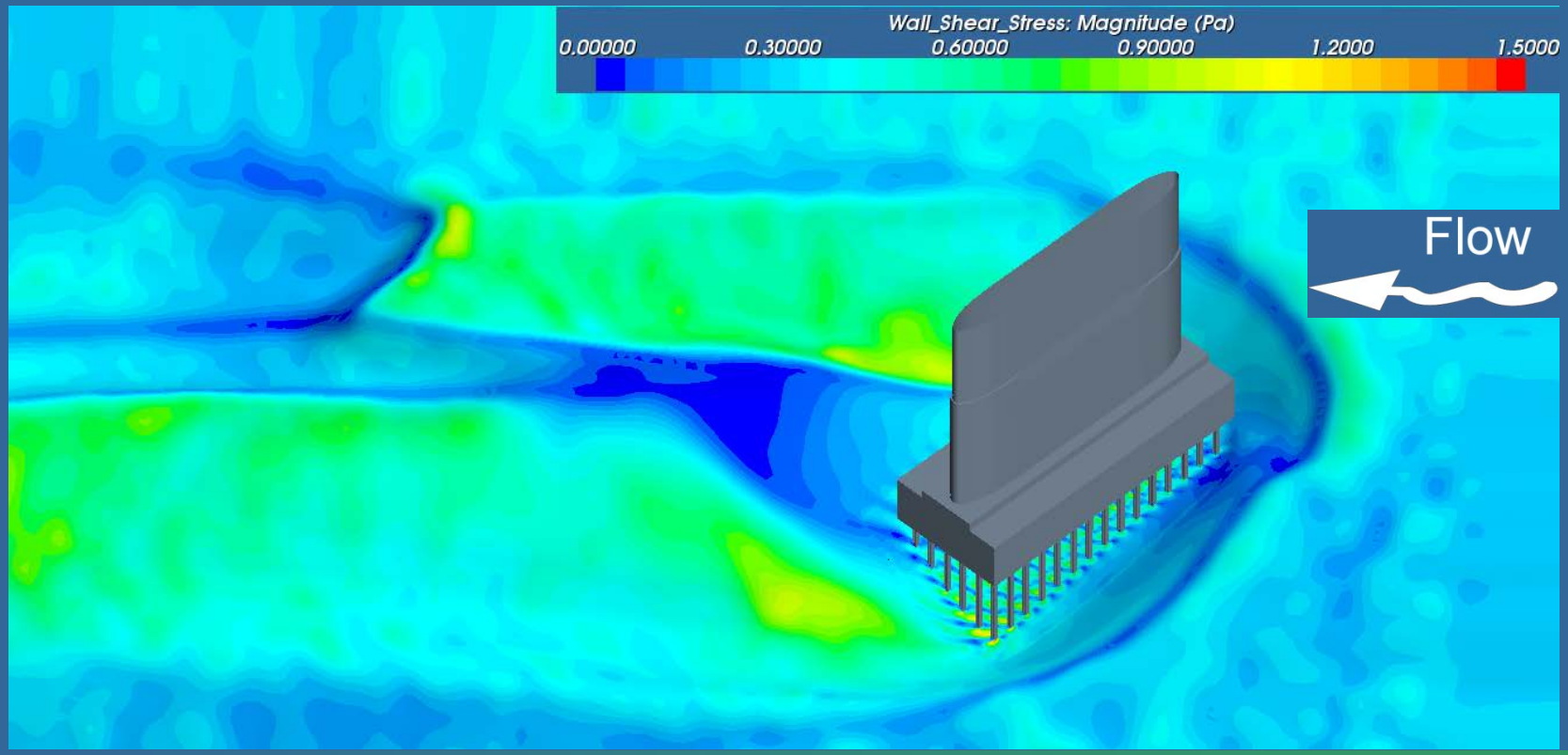


~ 50 %

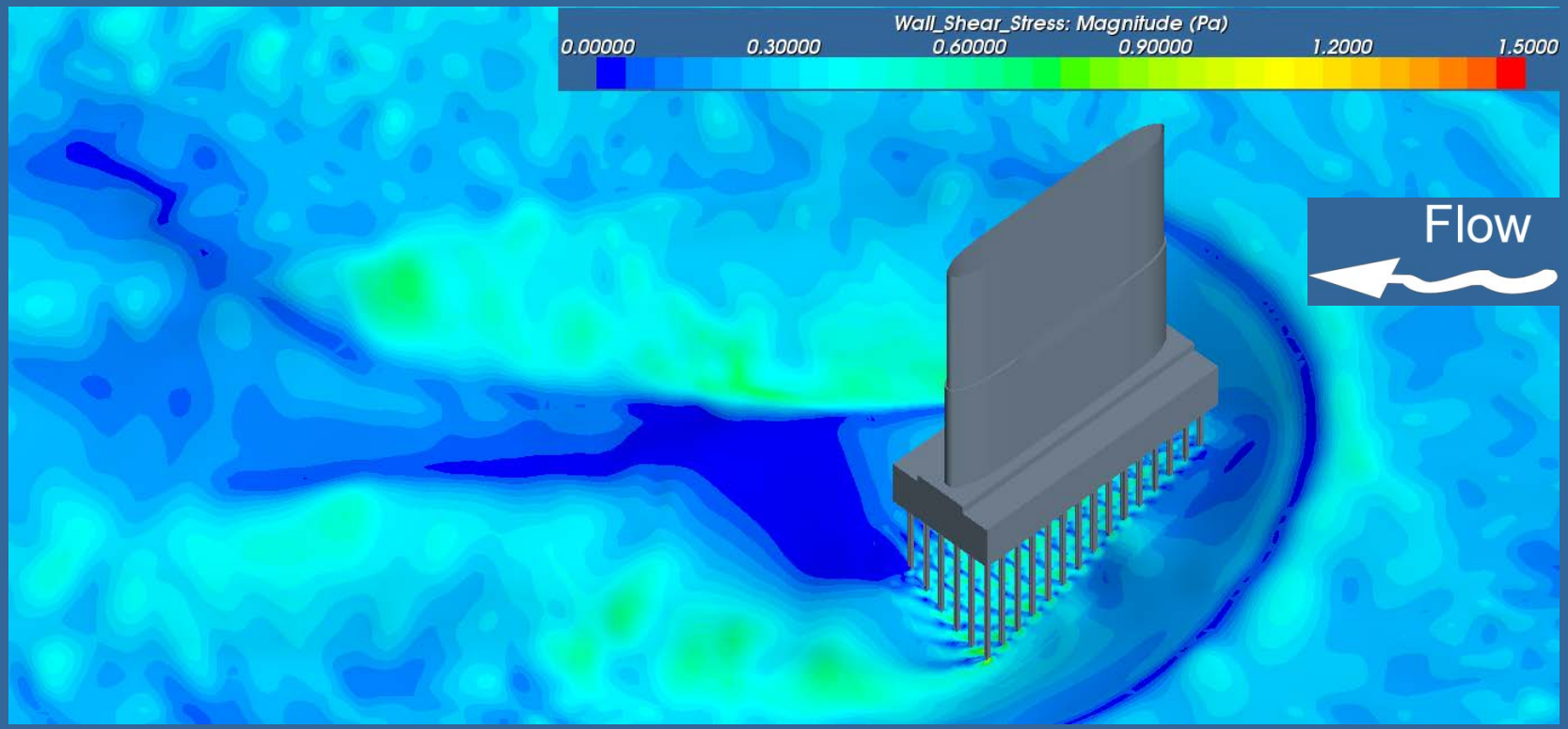

Wall_Shear_Stress: Magnitude (Pa)
0.00000
0.30000
0.60000
0.90000
1.2000
1.5000
Flow



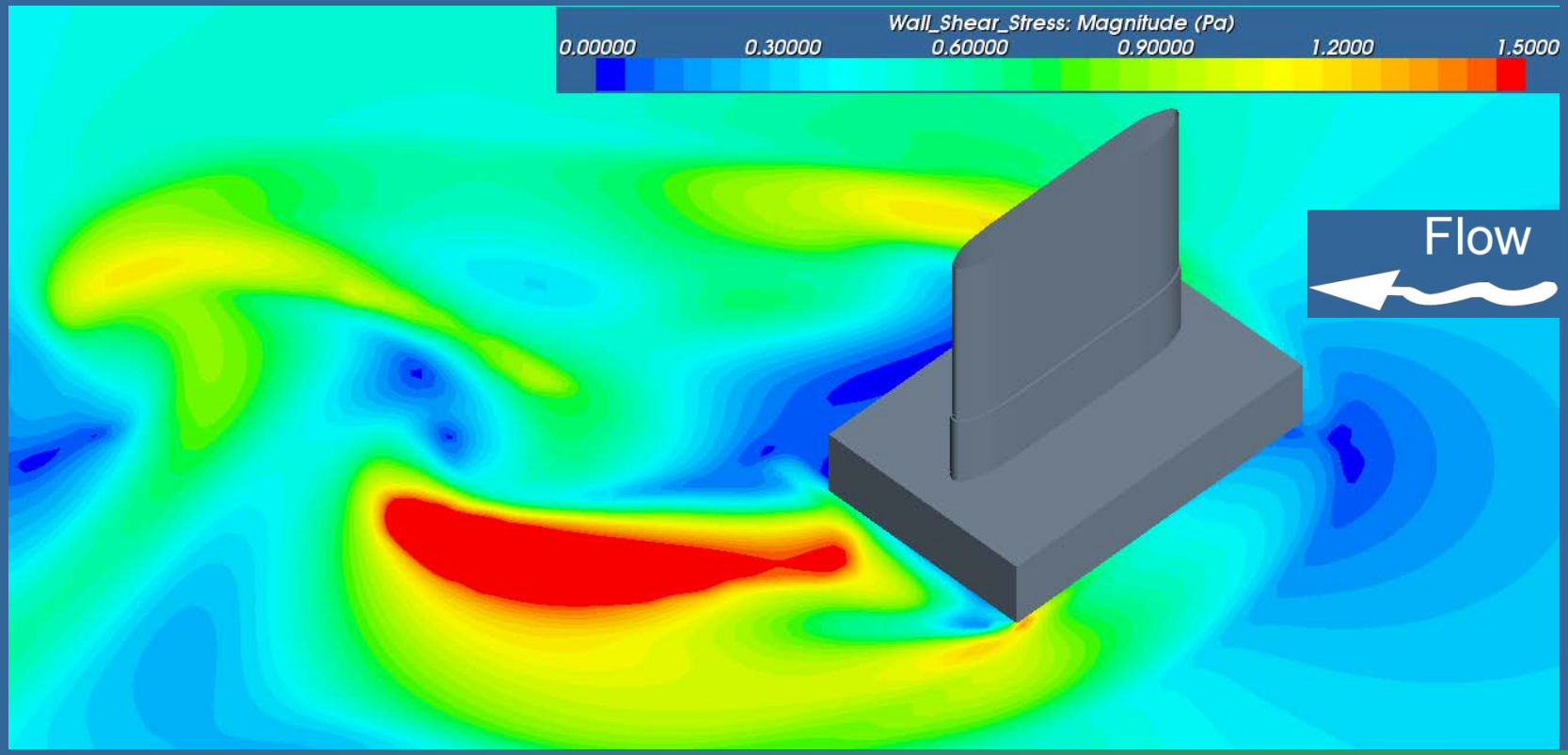
~ 75 %

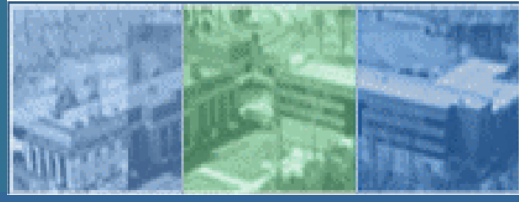

Wall_Shear_Stress: Magnitude (Pa)
0.00000
0.30000
0.60000
0.90000
1.2000
1.5000
Flow

Maximum Equilibrium Scour ~100%



CFD Wall Shear Stress – March Flow Results Unscoured Bed





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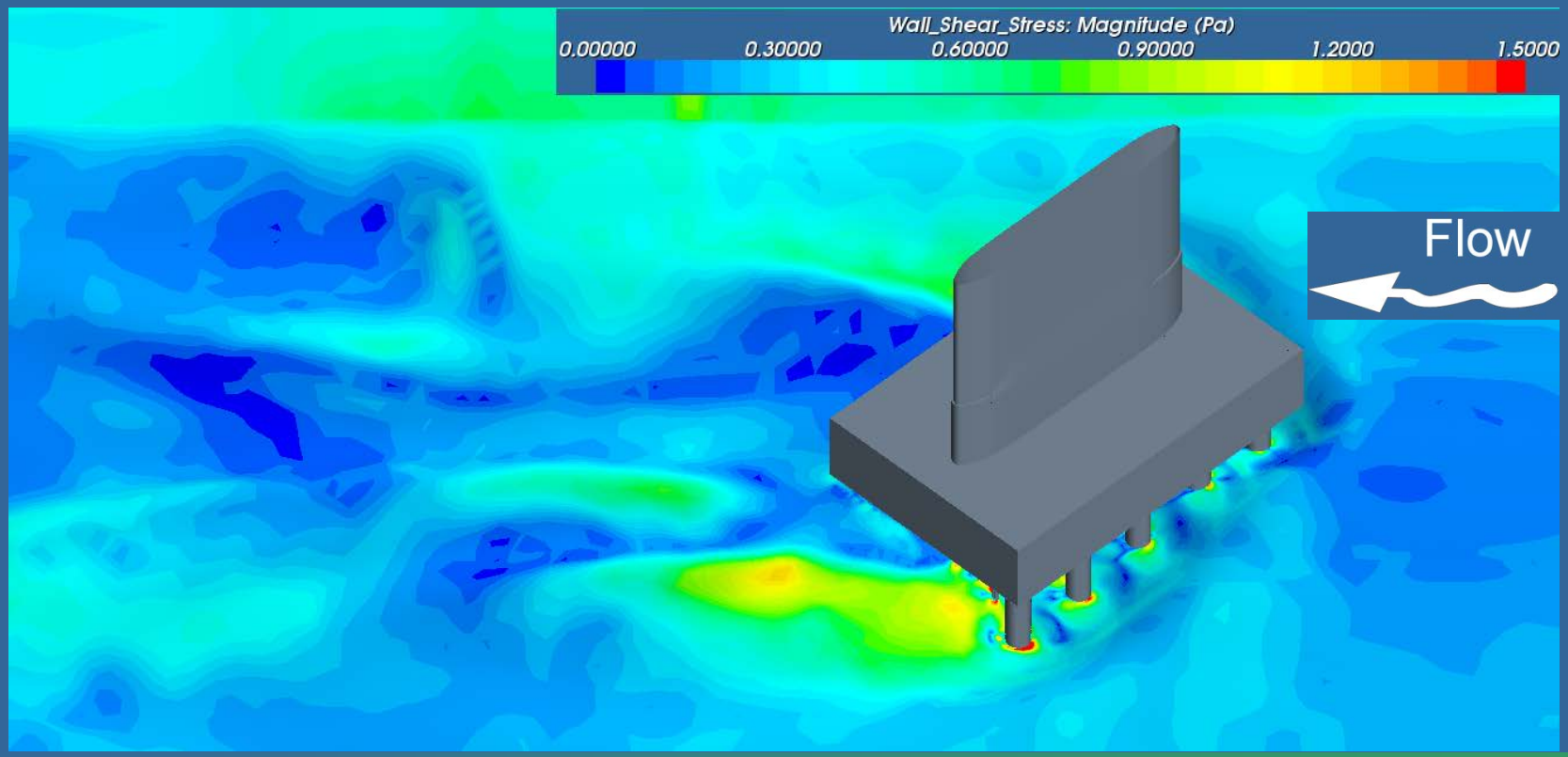
Wall_Shear_Stress: Magnitude (Pa)
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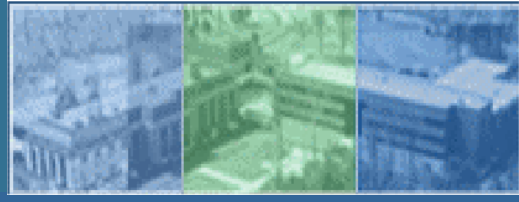
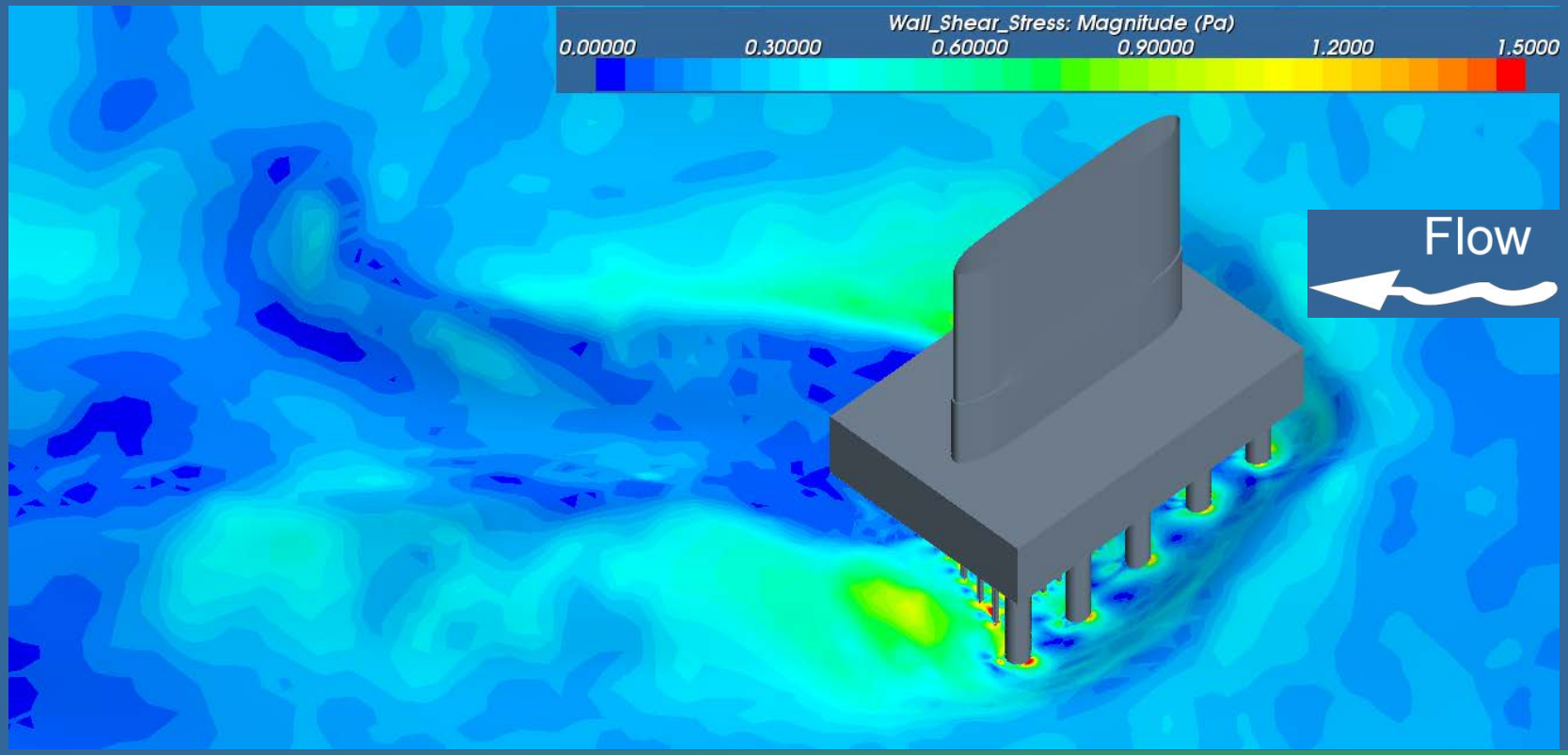
Flow



~ 50 %


Wall_Shear_Stress: Magnitude (Pa)
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0.60000
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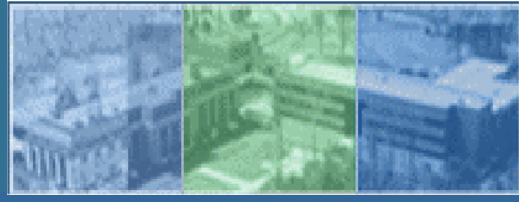
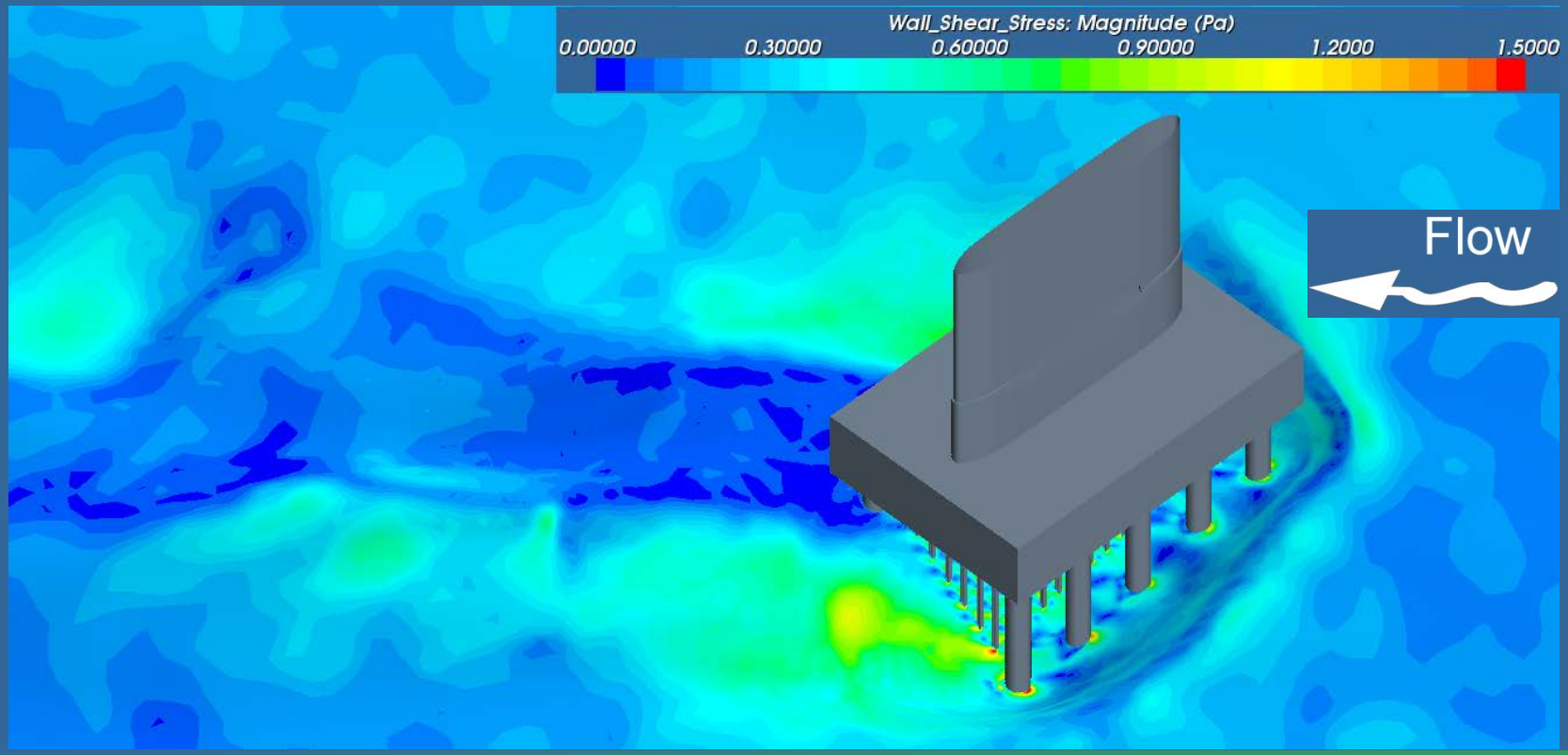
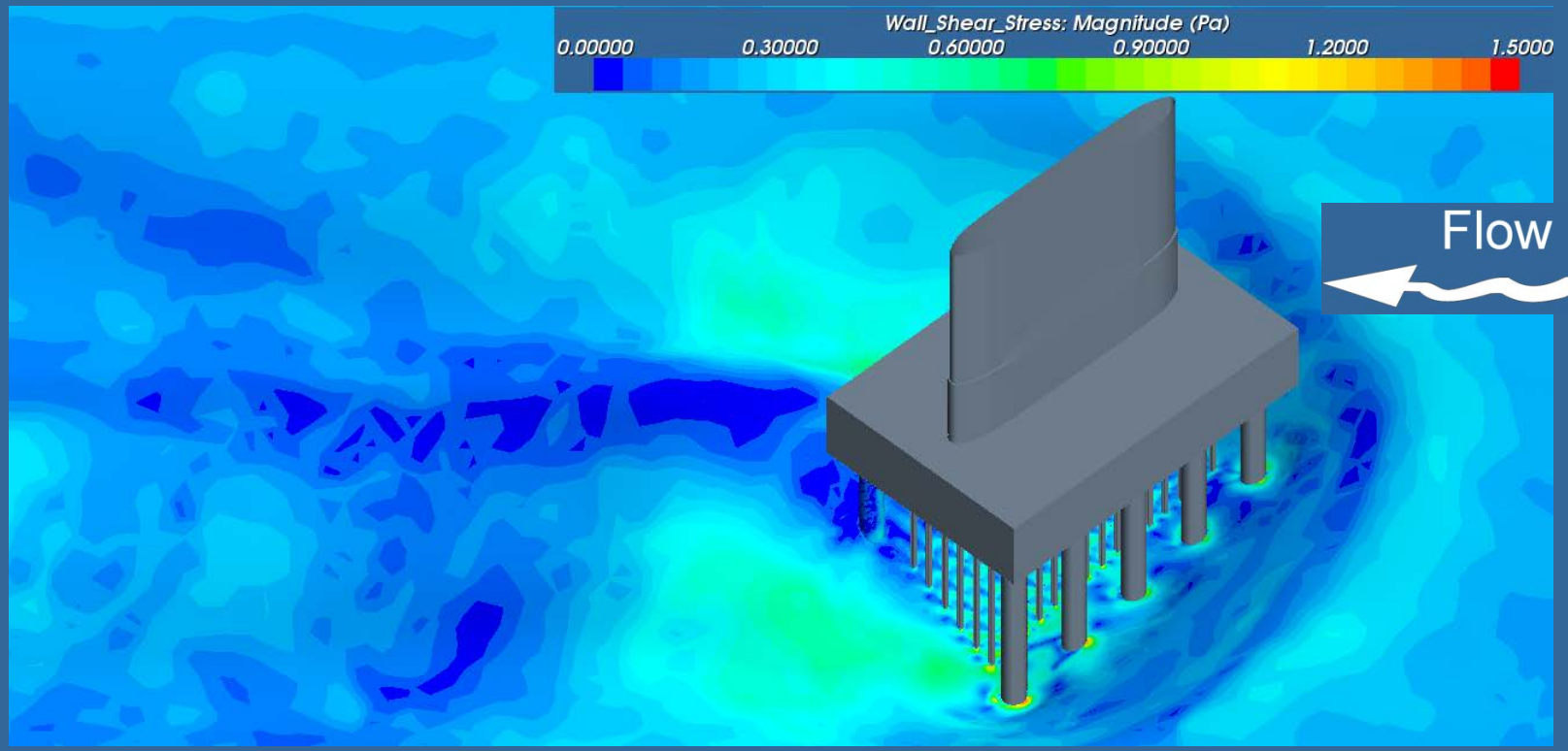
1.2000
1.5000
Flow



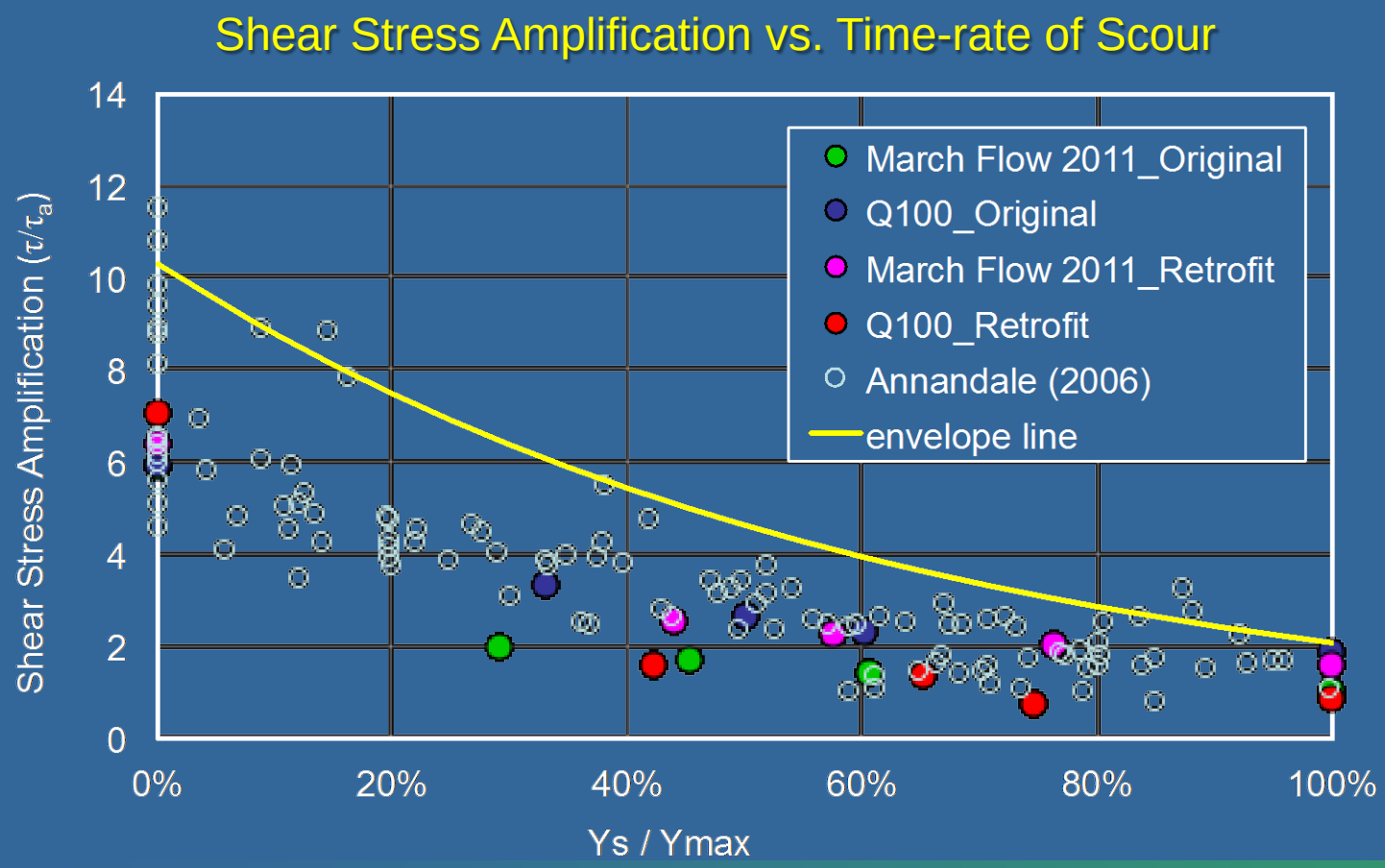
~ 75 %

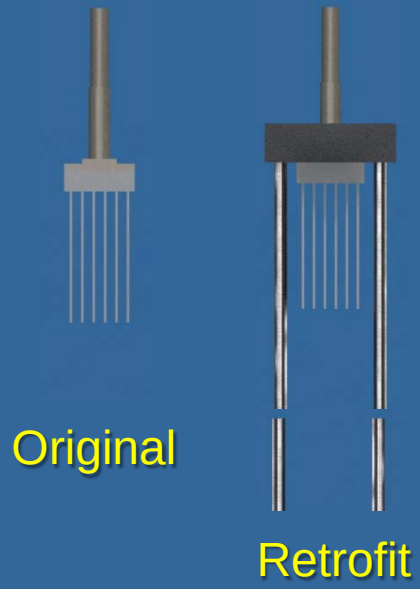

Wall_Shear_Stress: Magnitude (Pa)
0.00000
0.30000
0.60000
0.90000
1.2000
1.5000
Flow

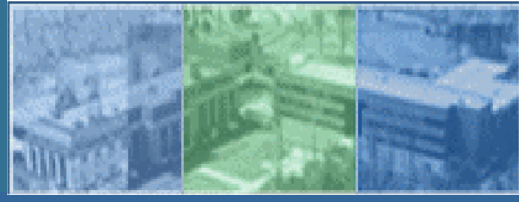
Maximum Equilibrium Scour ~100%



Decay Function



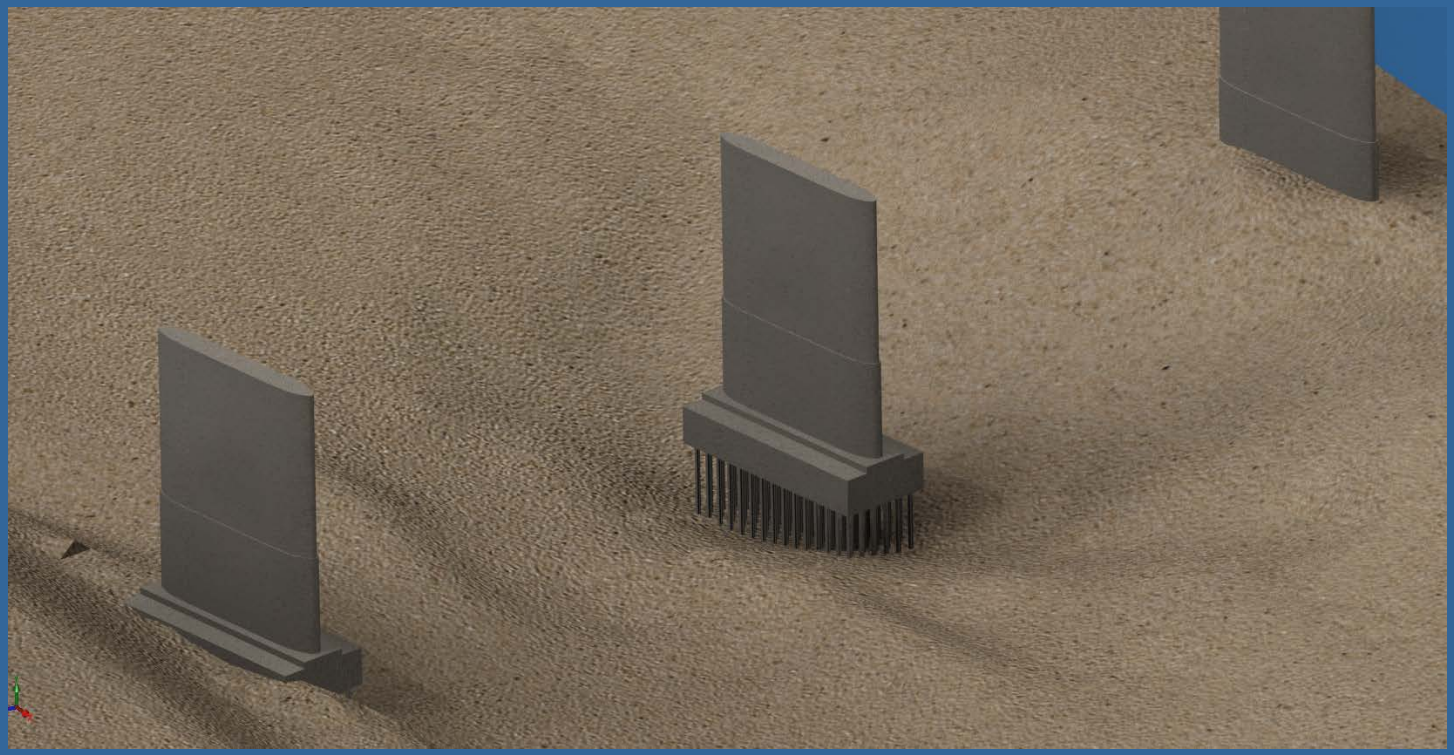




Time-rate of Scour: Decay Function of Shear Stress

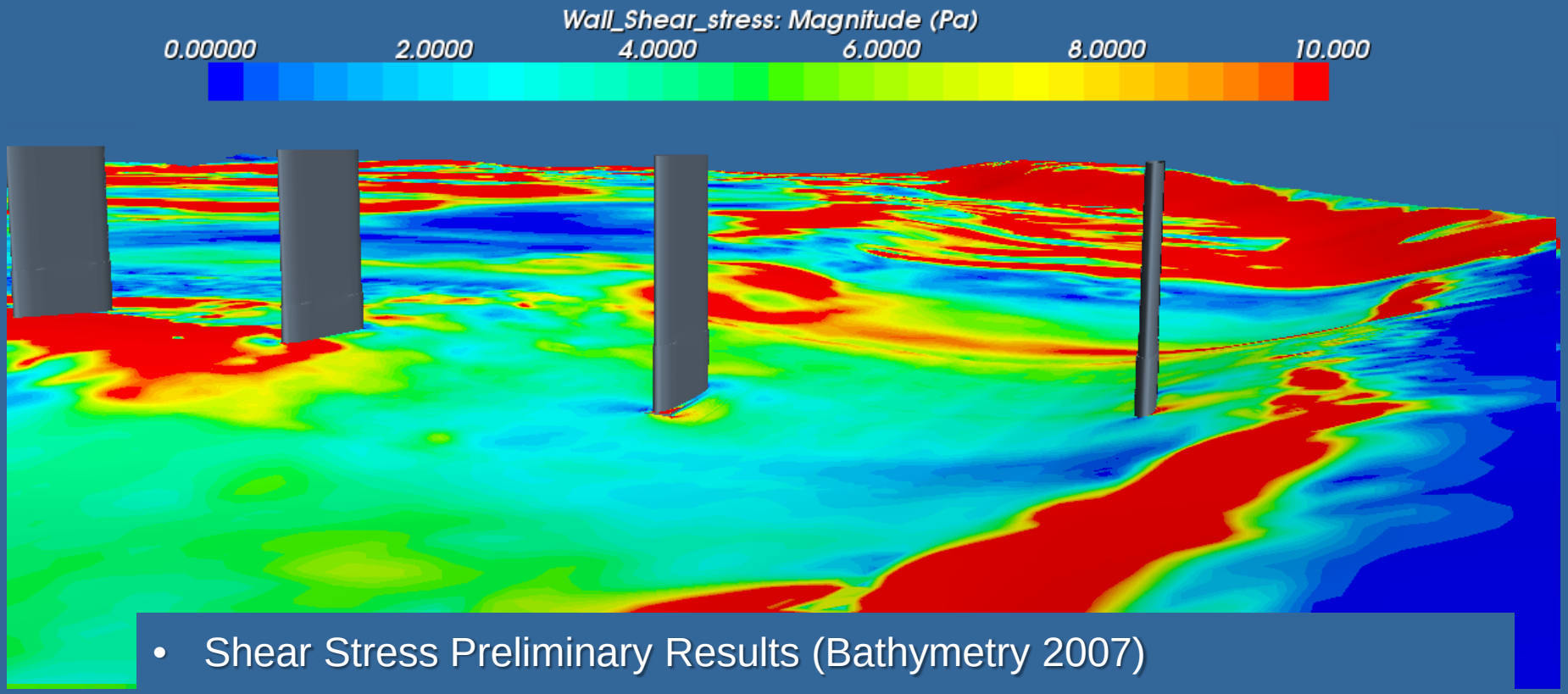
$$\frac{\tau_{Pier}}{\tau_{upstream}} = 10\exp\left(-1.6\frac{Y_{scour}}{Y_{max}}\right)$$

Full Scale 3D Surface Generation

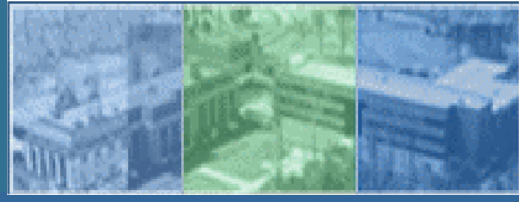


- Sonar Bathymetry Survey from Flood Event occurred in March 2011
- 3D Surface Generation from XYZ Point Cloud Data

Full Scale 3D CFD Preliminary Results



- Shear Stress Preliminary Results (Bathymetry 2007)
- Shear Stress Preliminary Results (Bathymetry 2011- March Flood)

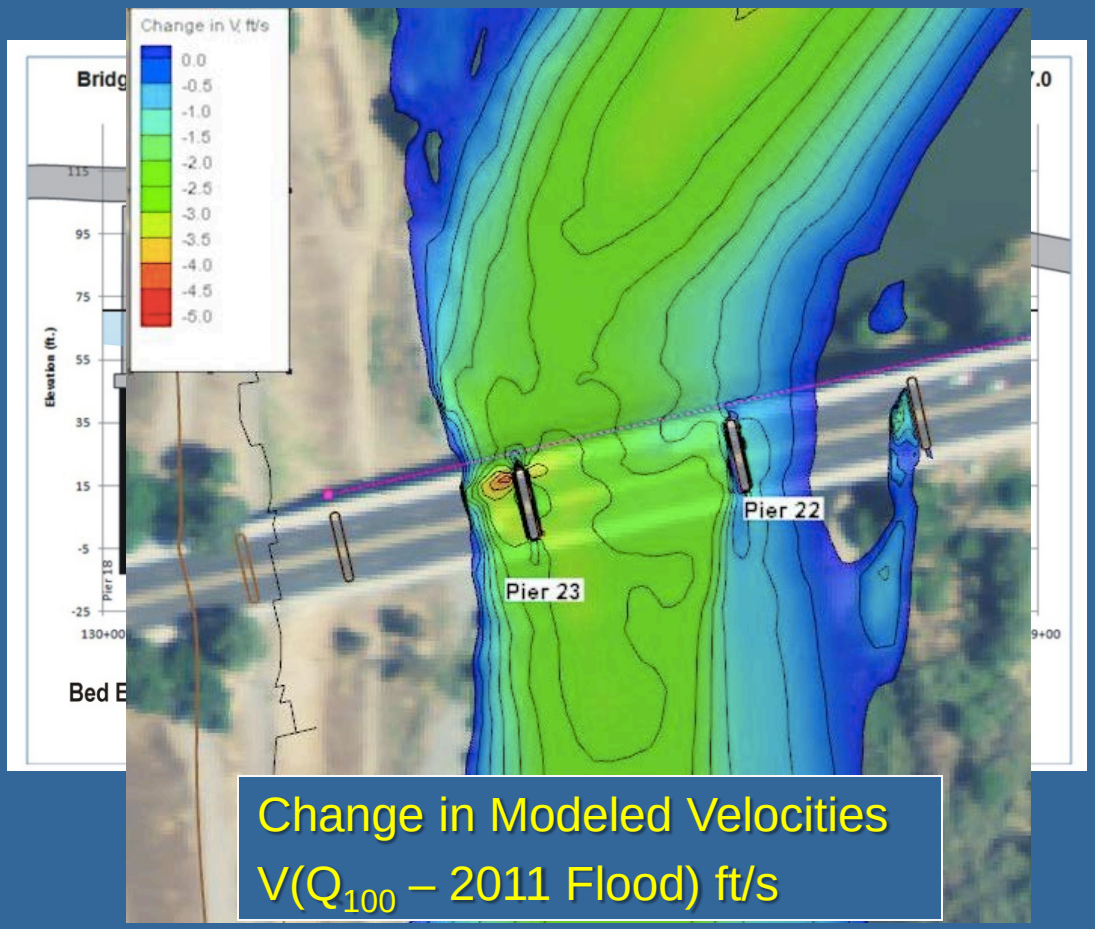


Acknowledgements:

Kevin Flora, Caltrans

Thank You

Caltrans 2-D Modeling



Change in Modeled Velocities
$V(Q_{100}$ – 2011 Flood) ft/s

March 2011 Flood: 44,500 [cfs]
Q_{100} Flood: 160,800 [cfs]

45 Degree Hydraulic Skew

Higher Velocities during the lower discharge Event