Does Restoration Create Habitat?

Quantifying Instream Habitat Using Two-dimensional Hydrodynamic Analysis

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State of the Science

"River restoration is an increasingly popular management strategy for improving the physical and ecological conditions of degraded urban streams."

Bernhardt and Palmer, 2007

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State of the Science

"…stream restorations are implicitly assumed to restore biological diversity, no urban stream restoration to our knowledge demonstrates substantial, long-term biological increase."

Stranko et. al, 2011

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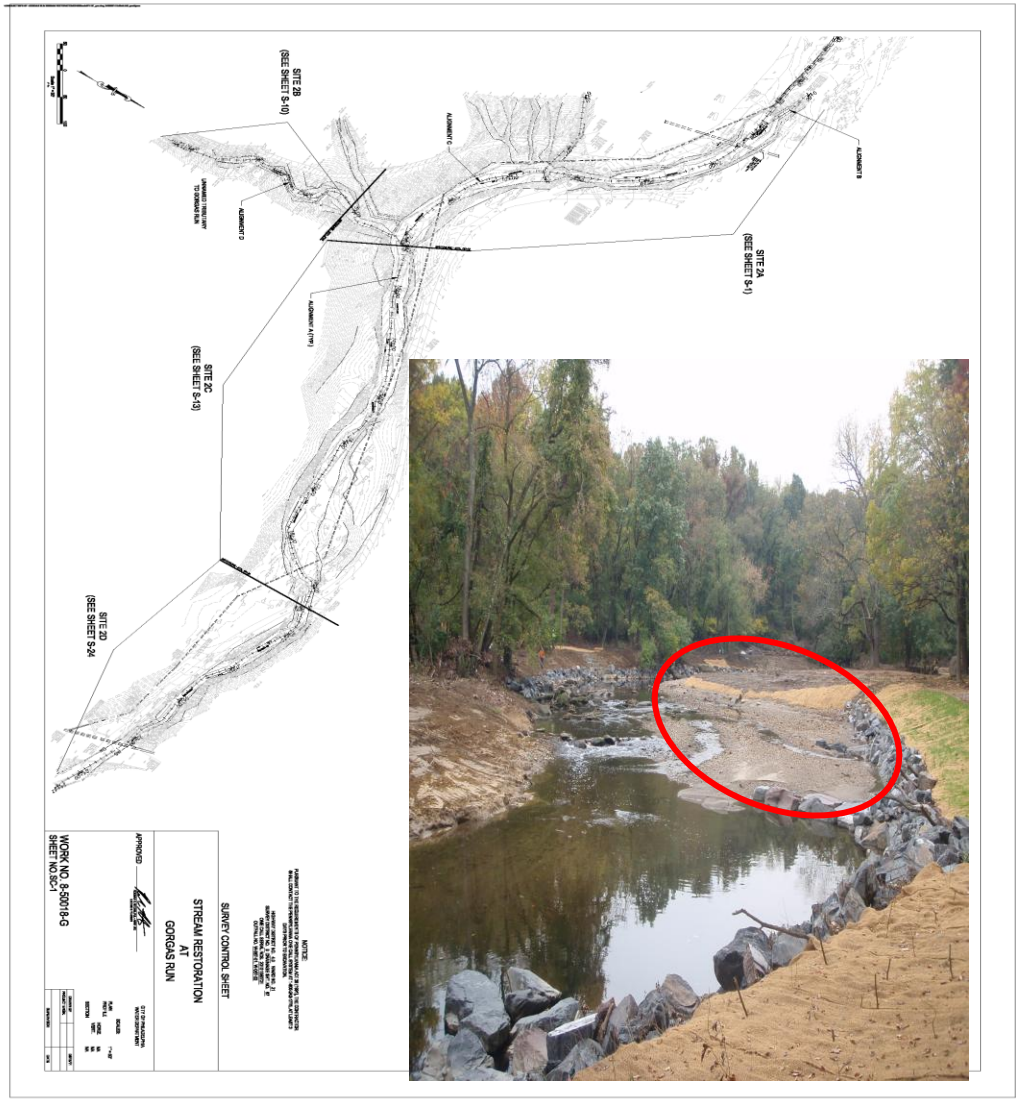
PWD's Ecological Restoration Unit

- Assessment
- Implementat
- Monitoring



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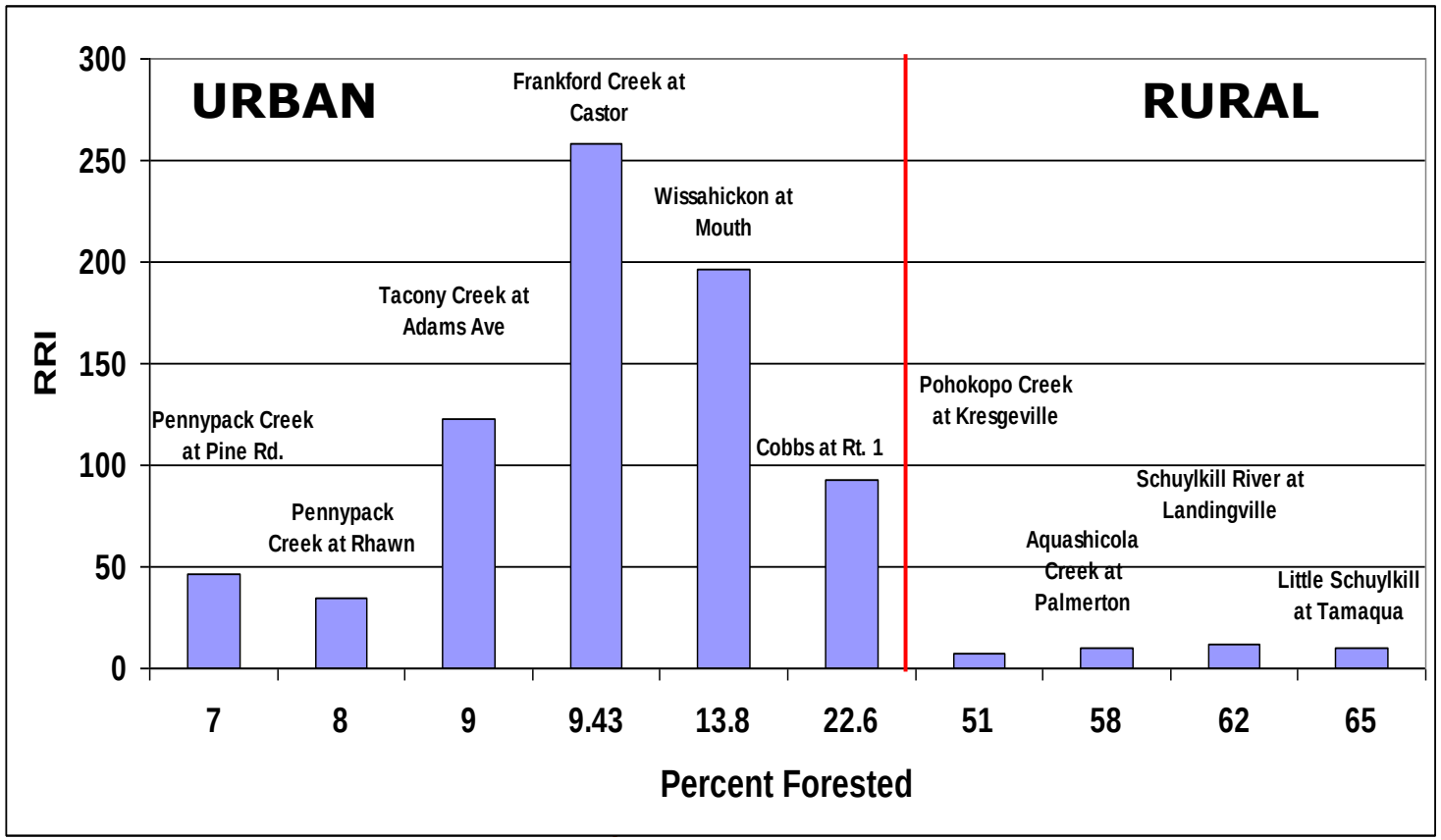
Why is Monitoring Important [to PWD]?



$$RRI = \frac{Q_{1yr}}{Q_{base}}$$

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[Photo]Monitoring?

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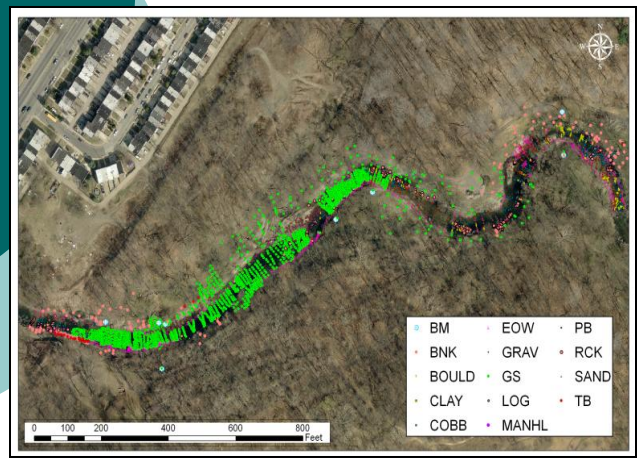
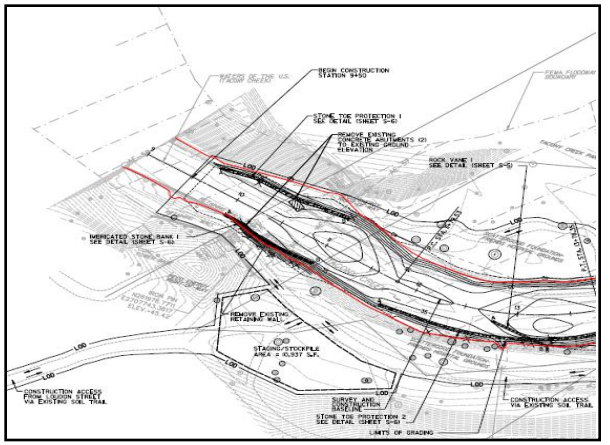
Closing the Loop....



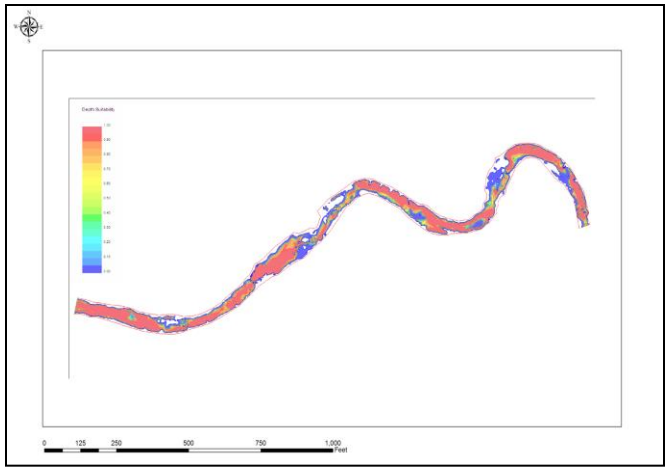


Assessment

Design

Monitoring

Construction



River2D Hydrodynamic Model

- University of Alberta (Steffler and Blackburn, 2003)
- Depth-averaged finite element 2D hydrodynamic model
  - **Conservation of mass & momentum → depth, velocity$_x$ & velocity$_y$**

R2D Model suite:

- River2D_BED
- River2D_MESH
- River2D Hydrodynamic Model
  - **Spatially explicit output…(*e.g.* velocity, depth, Froude #, shear velocity)**
  - **Habitat Evaluation Module**
    - **Customized for evaluation of fish habitat** (PHABSIM)

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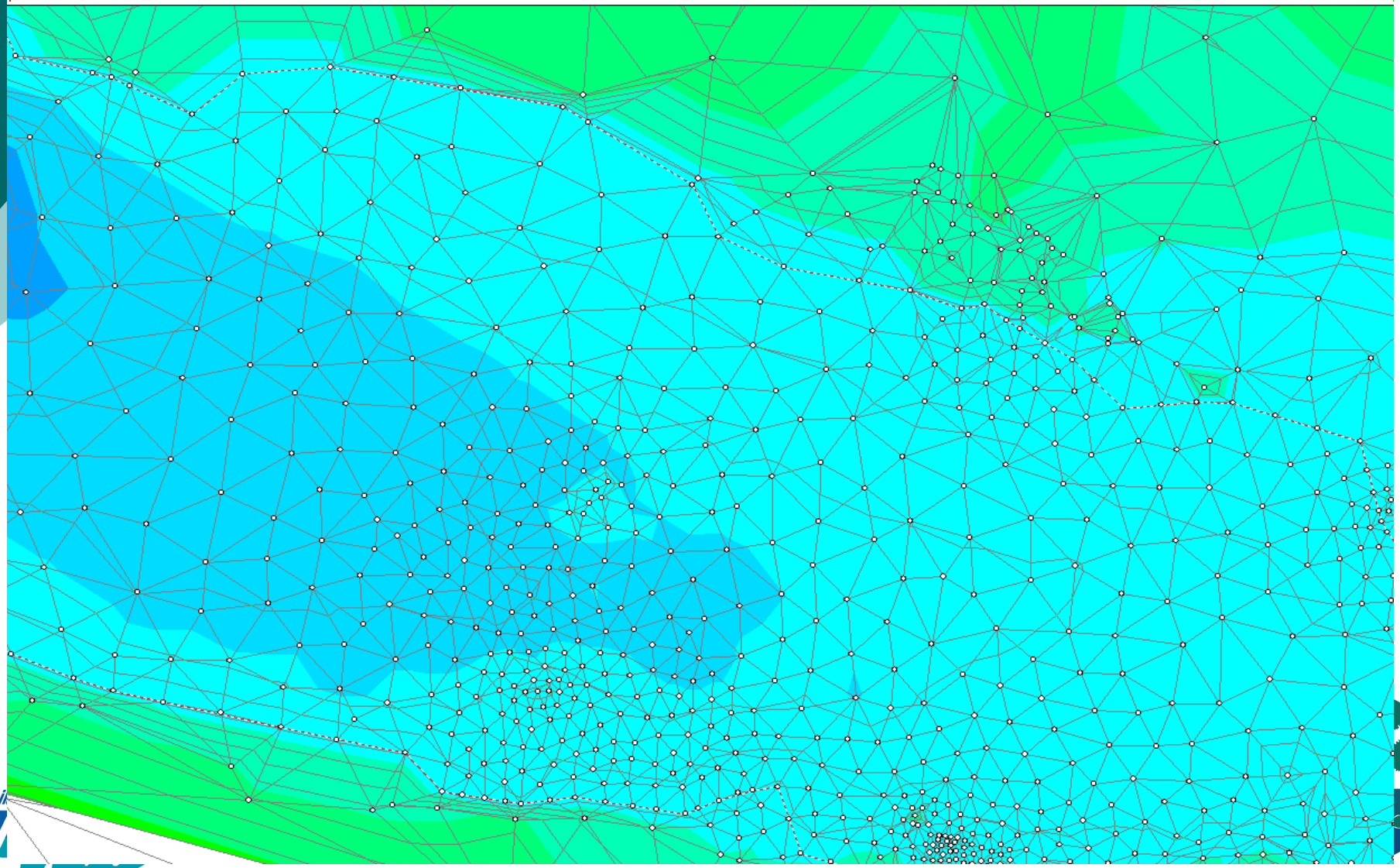
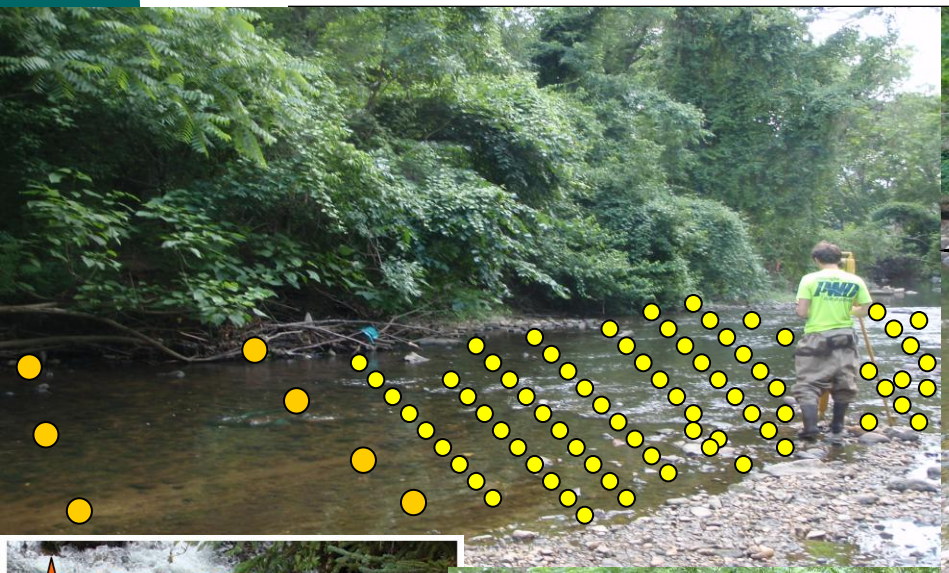
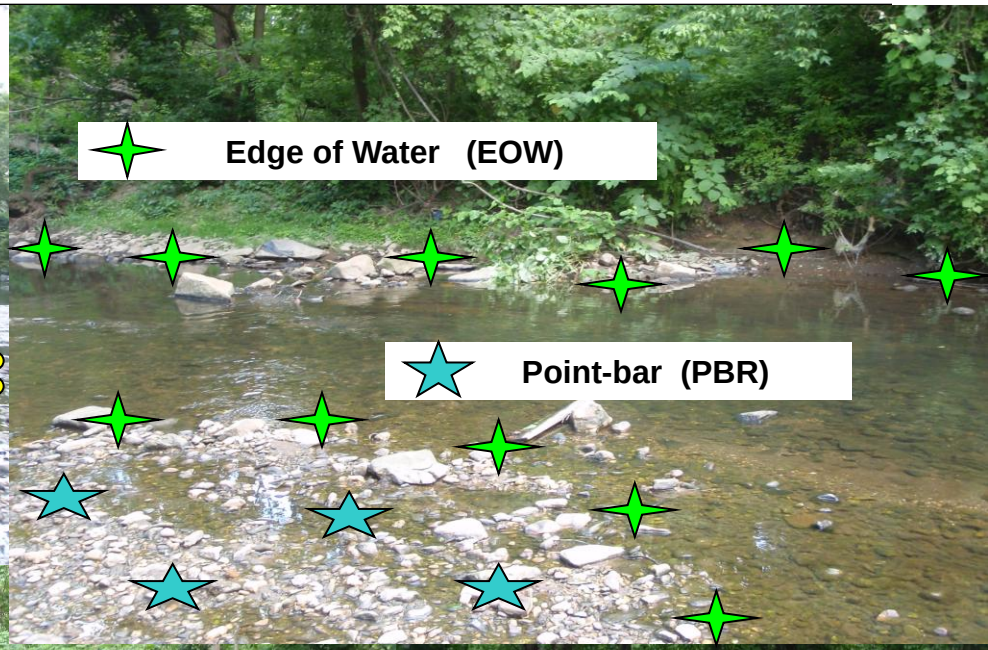
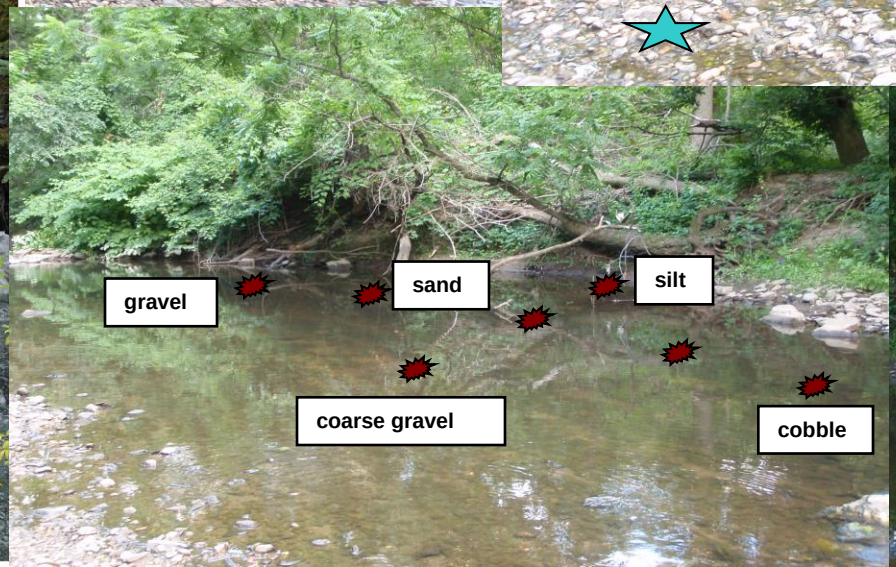
River2D BED preprocessor

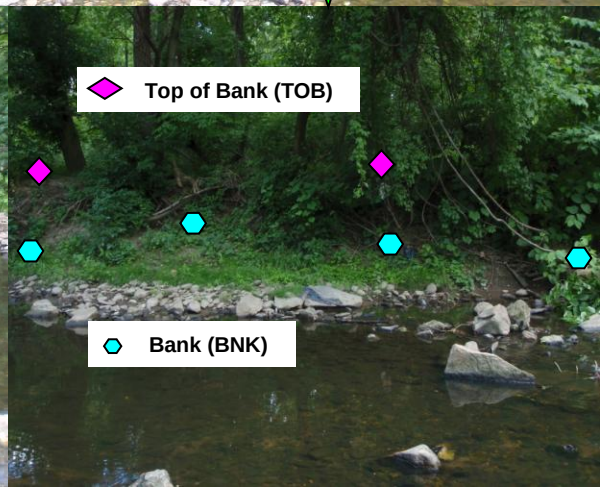


Survey Considerations

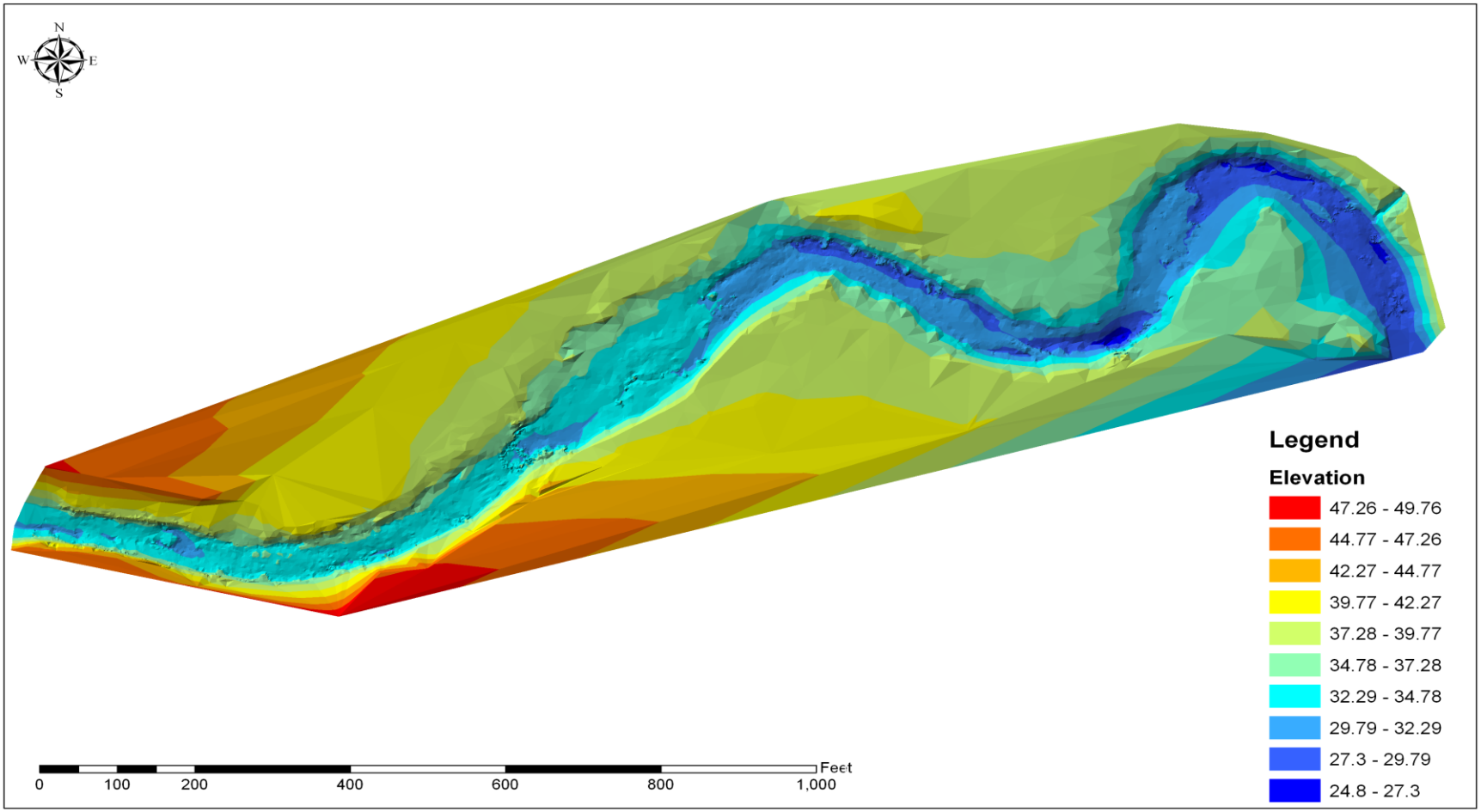




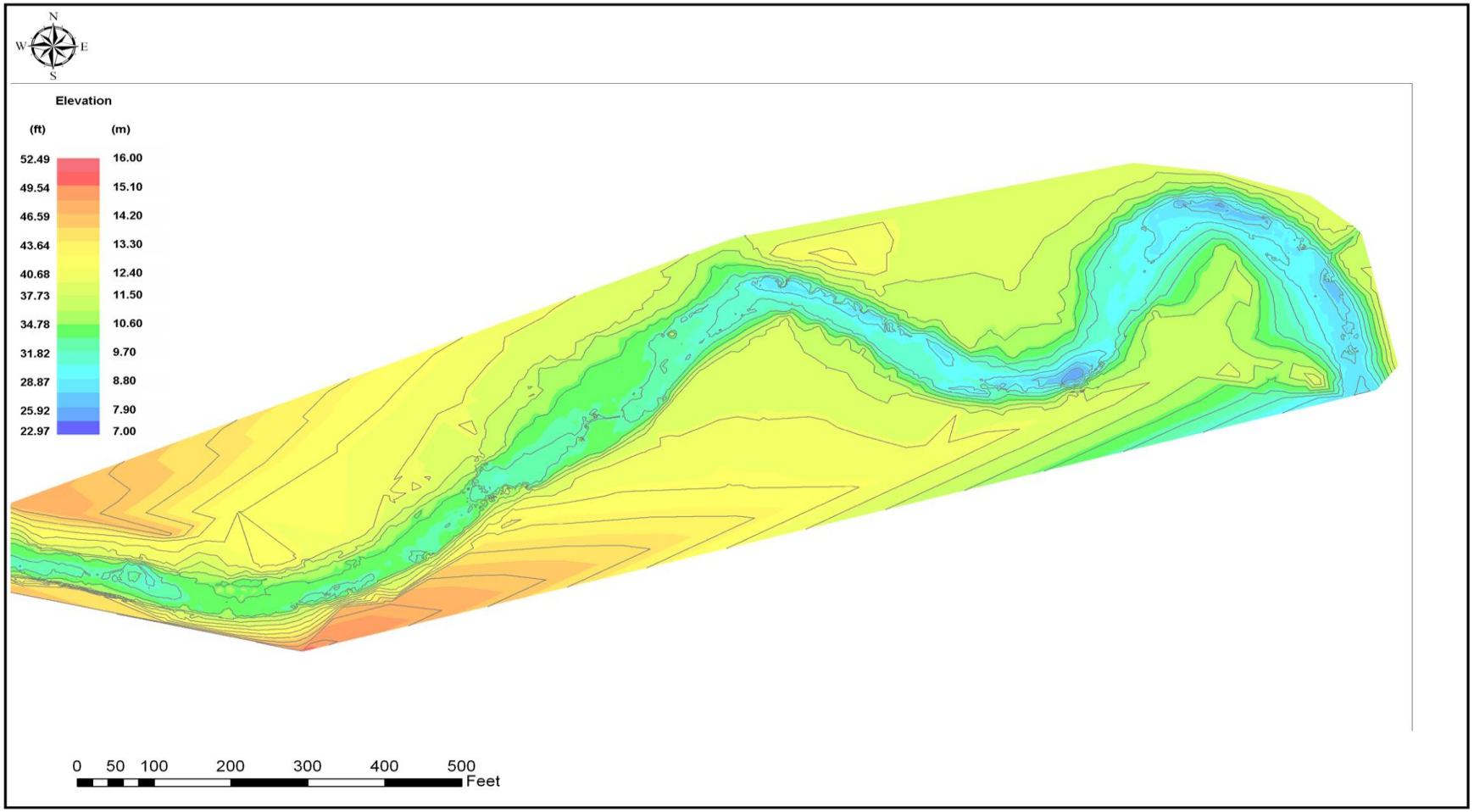




Topographic Survey



River2D Bed


N
W
E
S
Elevation
(ft)
(m)
52.49
16.00
49.54
15.10
46.59
14.20
43.64
13.30
40.68
12.40
37.73
11.50
34.78
10.60
31.82
9.70
28.87
8.80
25.92
7.90
22.97
7.00
0
50
100
200
300
400
500
Feet

River2D_MESH

- Develop computational mesh
  - Import .BED files
- Boundary Conditions
  - Inflow → Discharge
  - Outflow → WSE
- Optimize mesh density
  - # nodes vs. computational time vs. flow solution quality
  - Mesh Quality Index (QI) > 0.35

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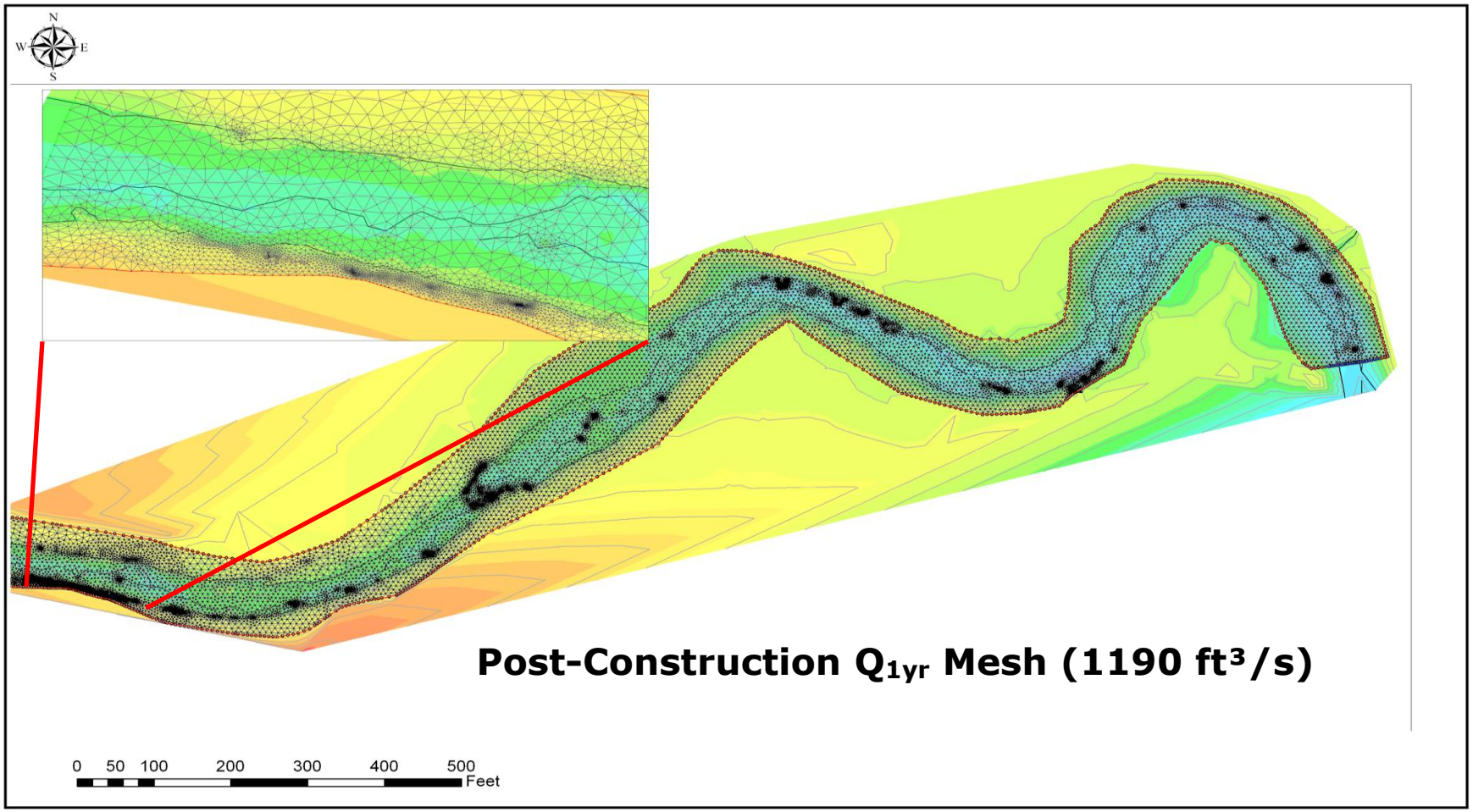
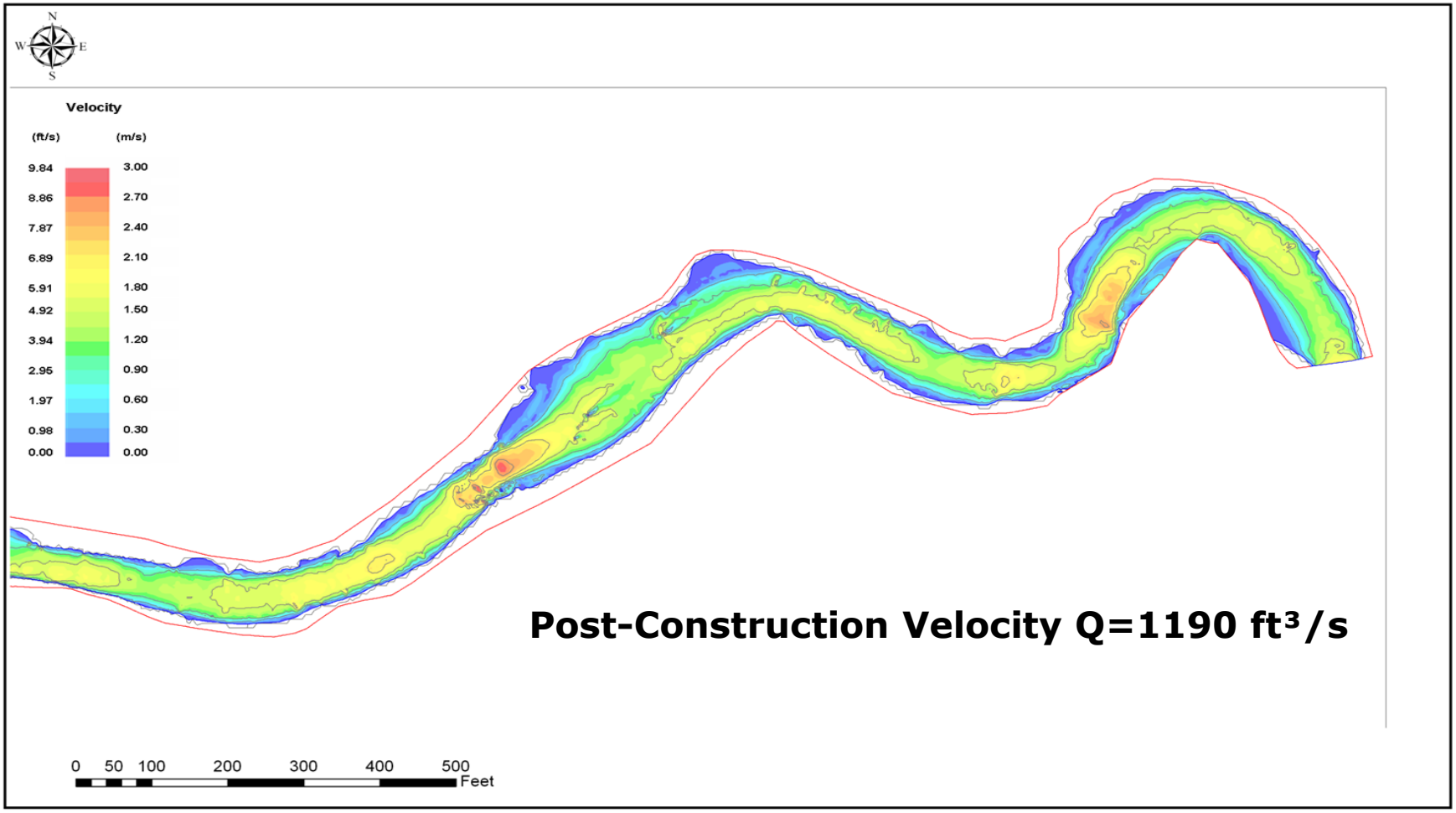
River2D Mesh



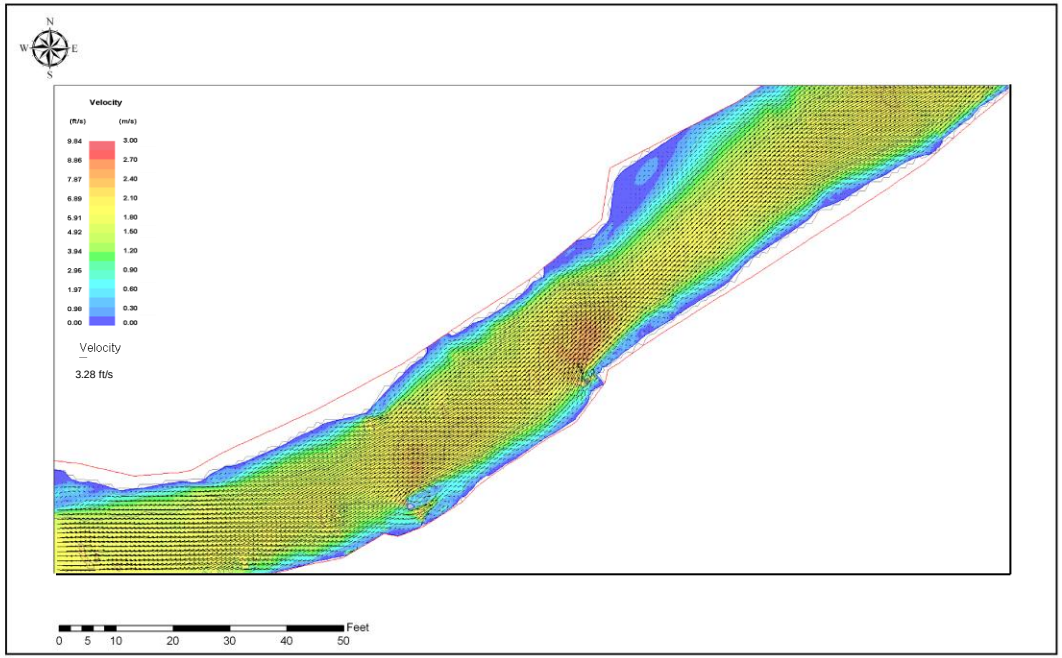
Post-Construction Q_{1yr} Mesh (1190 ft^3/s)

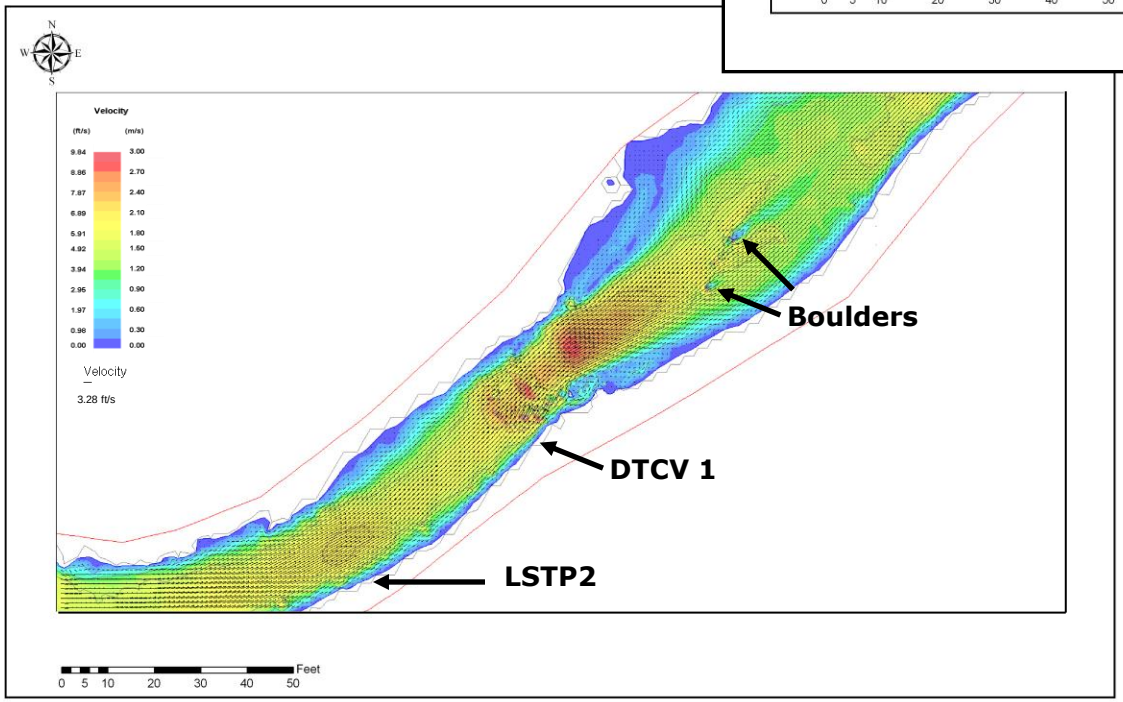
River2D Hydrodynamic Output



Velocity Distribution between Stations 14+00 – 18+00 at the Q_{1yr} Discharge

Pre-Construction →



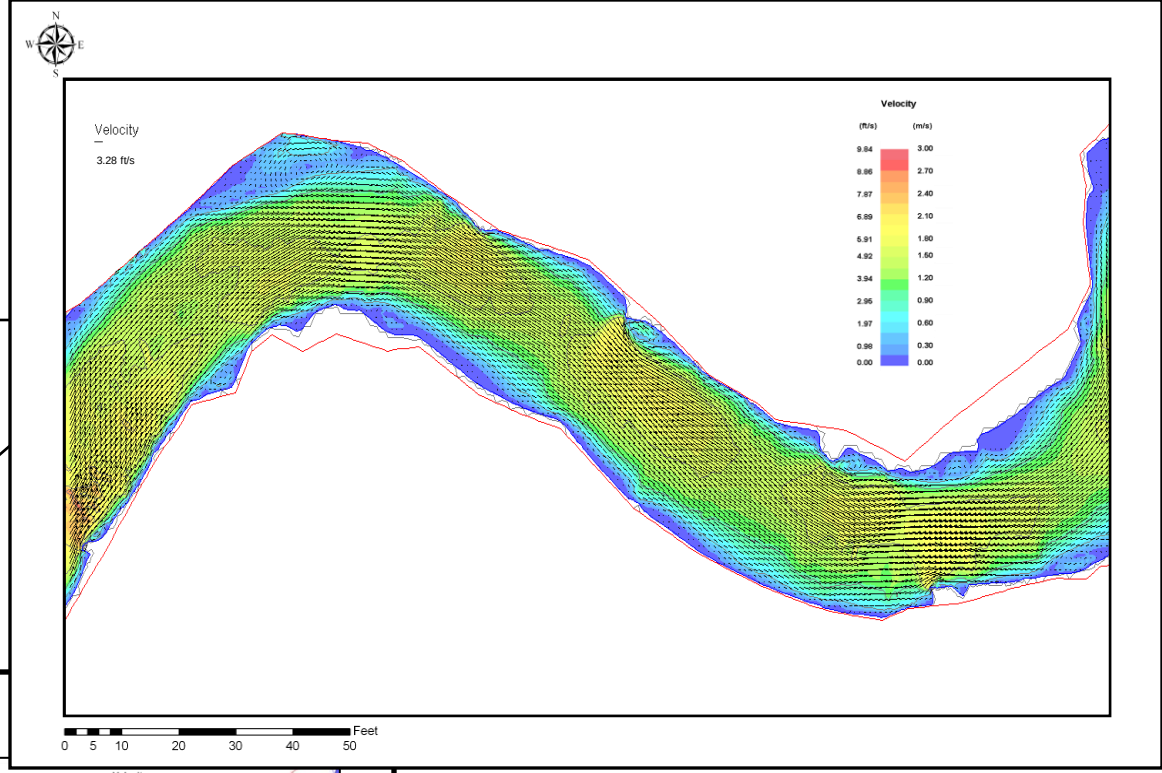


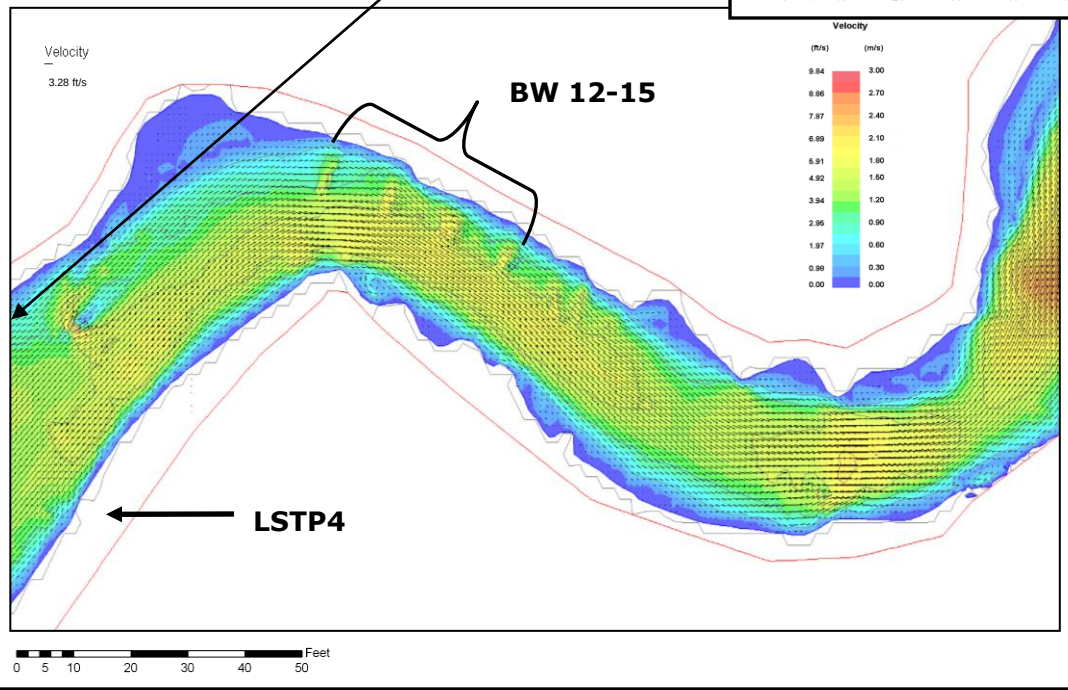
Velocity Distribution between Stations 14+00 – 18+00 at the Q_{1yr} Discharge

← Post-Construction

Velocity Distribution between Stations 19+50 – 26+00 at the Q_{1yr} Discharge

Pre-Construction domain →



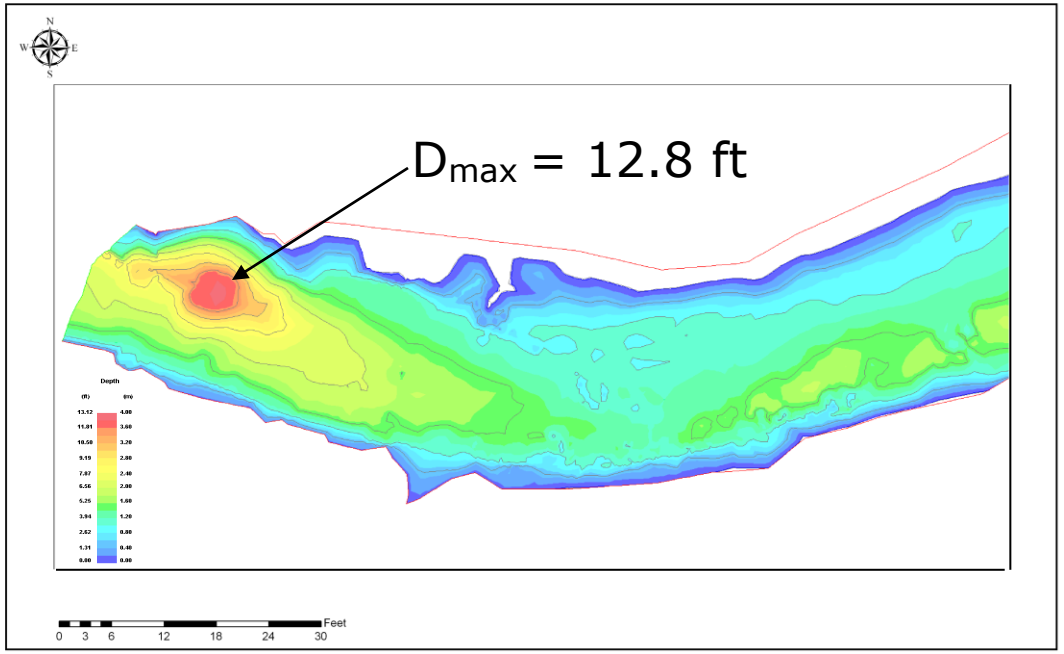


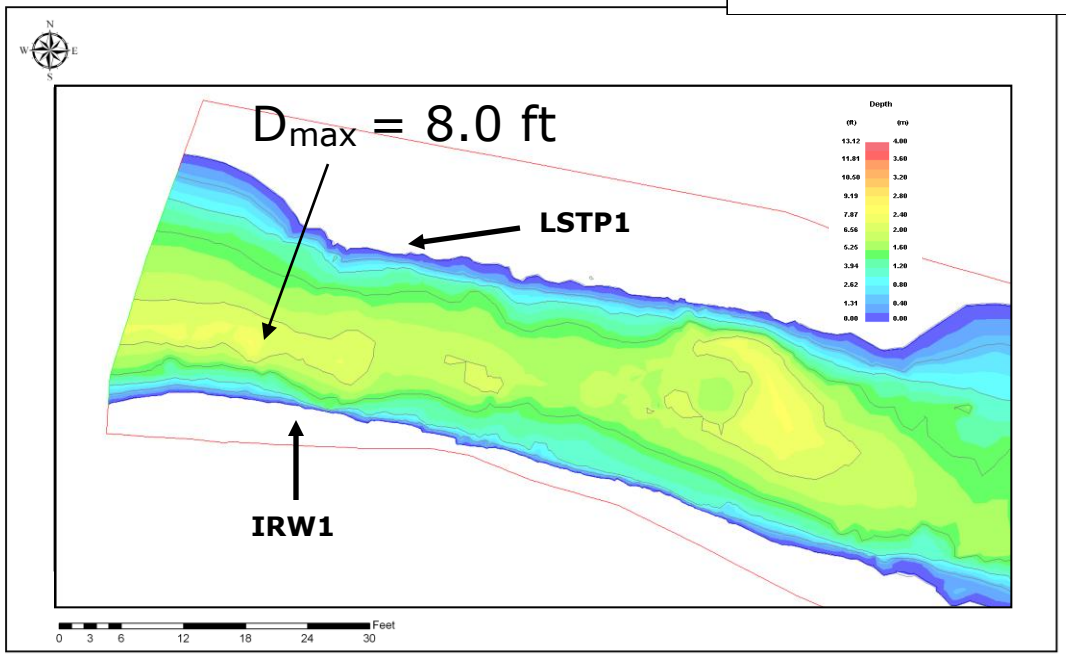
Velocity Distribution between Stations 19+50 – 26+00 at the Q_{1yr} Discharge

←Post-Construction domain

Depth Distribution between Stations 10+00 – 11+50 at the Q_{1yr} Discharge

Pre-Construction →





Depth Distribution between Stations 10+00 – 11+50 at the Q_{1yr} Discharge

← Post-Construction

River2D Habitat Module

WUA based on species-specific suitability criteria

- Depth
- Velocity
- Substrate

} HSI

$$WUA = SI_{Depth} \times SI_{Velocity} \times SI_{Substrate} \times Area_{Element}$$

Where: SI = Suitability Index value (0.0 – 1.0)

Hypothetical HSI for 3 "guilds"

- Pool (*e.g.* smallmouth bass, large sunfish)
- Riffle (*e.g.* margined madtom, longnose dace,*sensitive macros)
- Generalist (*e.g.* American Eel, Creek Chub, Sunfish)

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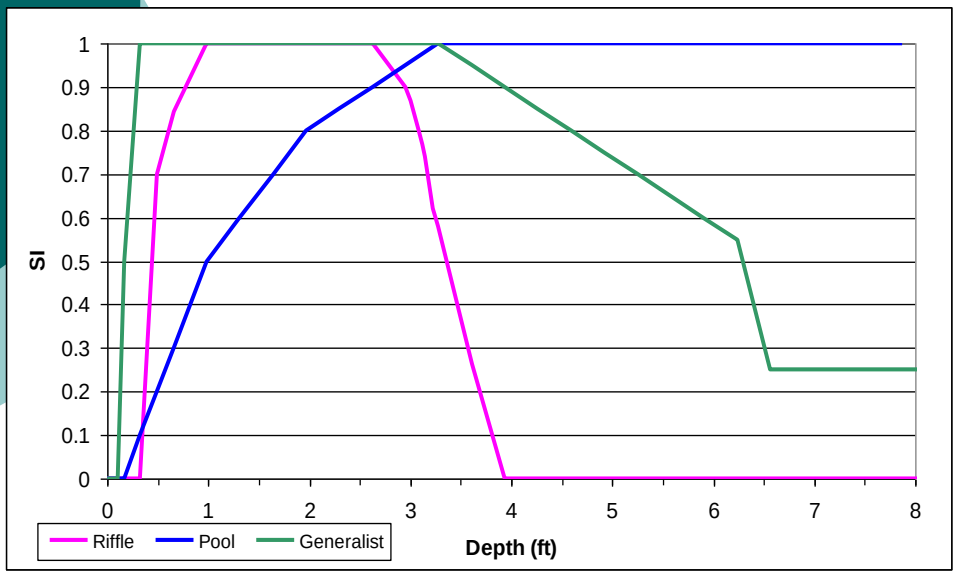
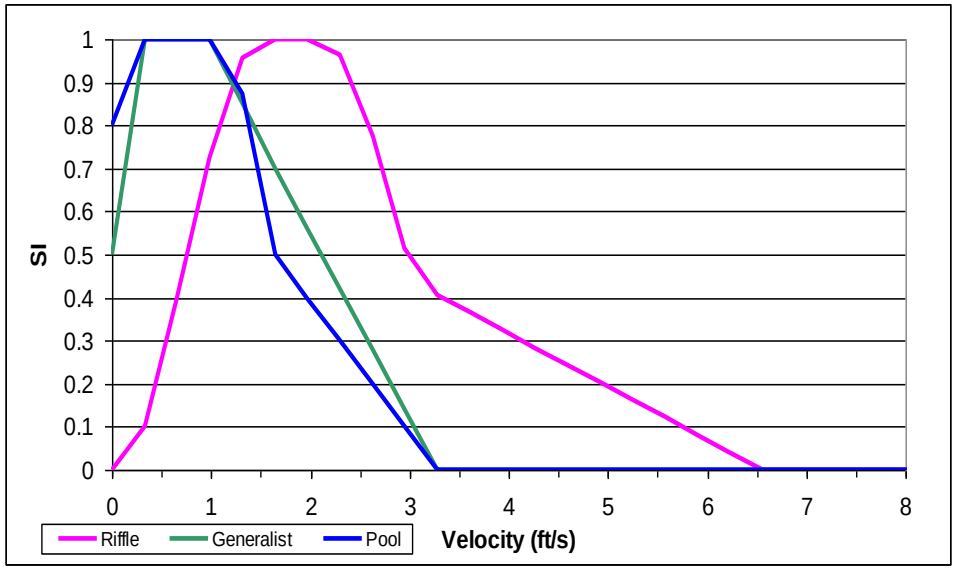
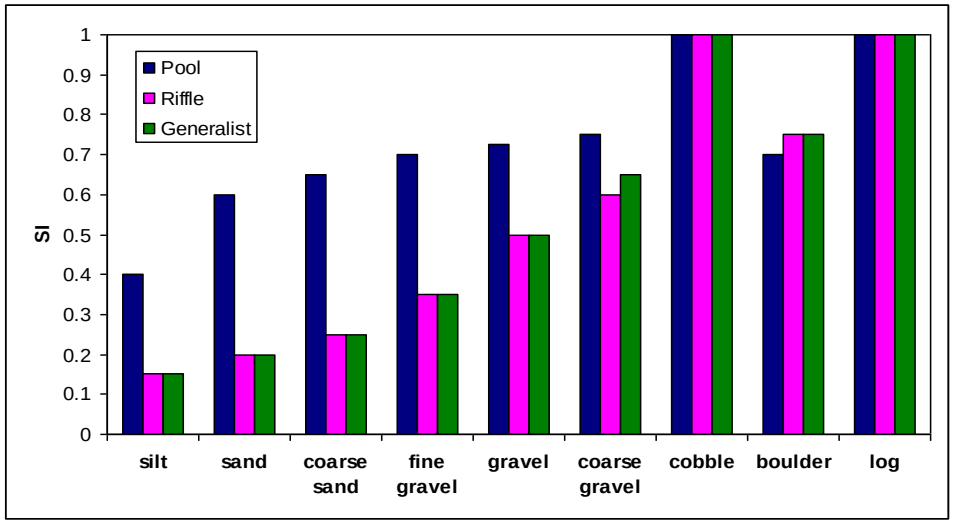
River2D Habitat Module







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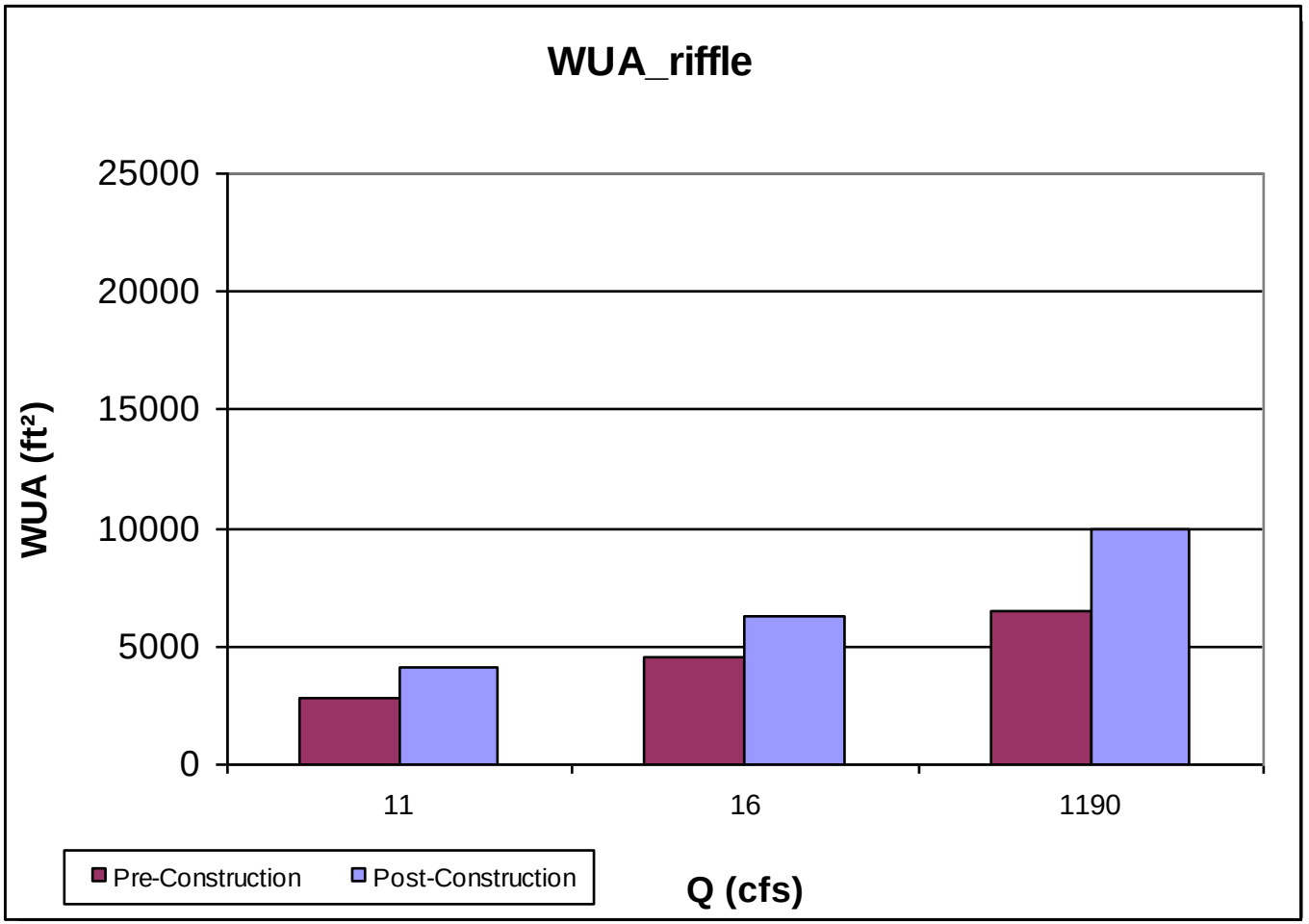
Habitat Analysis: WUA Comparison



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Habitat Analysis: WUA Comparison

Pre-Construction				
Q (ft^3)	WUA_g (ft^2)	WUA_r (ft2)	WUA_p (ft^2)	SA (ft^2)
11	18,818.76	2,809.43	21,393.38	84,060.94
16	20,789.74	4,540.65	23,593.95	89,174.24
1,190	75,52.39	6,498.29	10,981.77	169,169.85

Post-Construction				
Q (ft^3)	*WUA_g (ft^2)	**WUA_r (ft2)	***WUA_p (ft^2)	SA (ft^2)
11	22,019.41	4,137.75	19,998.05	84,424.39
16	24,360.61	6,237.04	22,297.65	89,360.60
1,190	11,283.38	9,917.01	12,822.83	185,416.30

*ΔHg= +16.72% **ΔHr= +41.86% ***ΔHp=-6.31%

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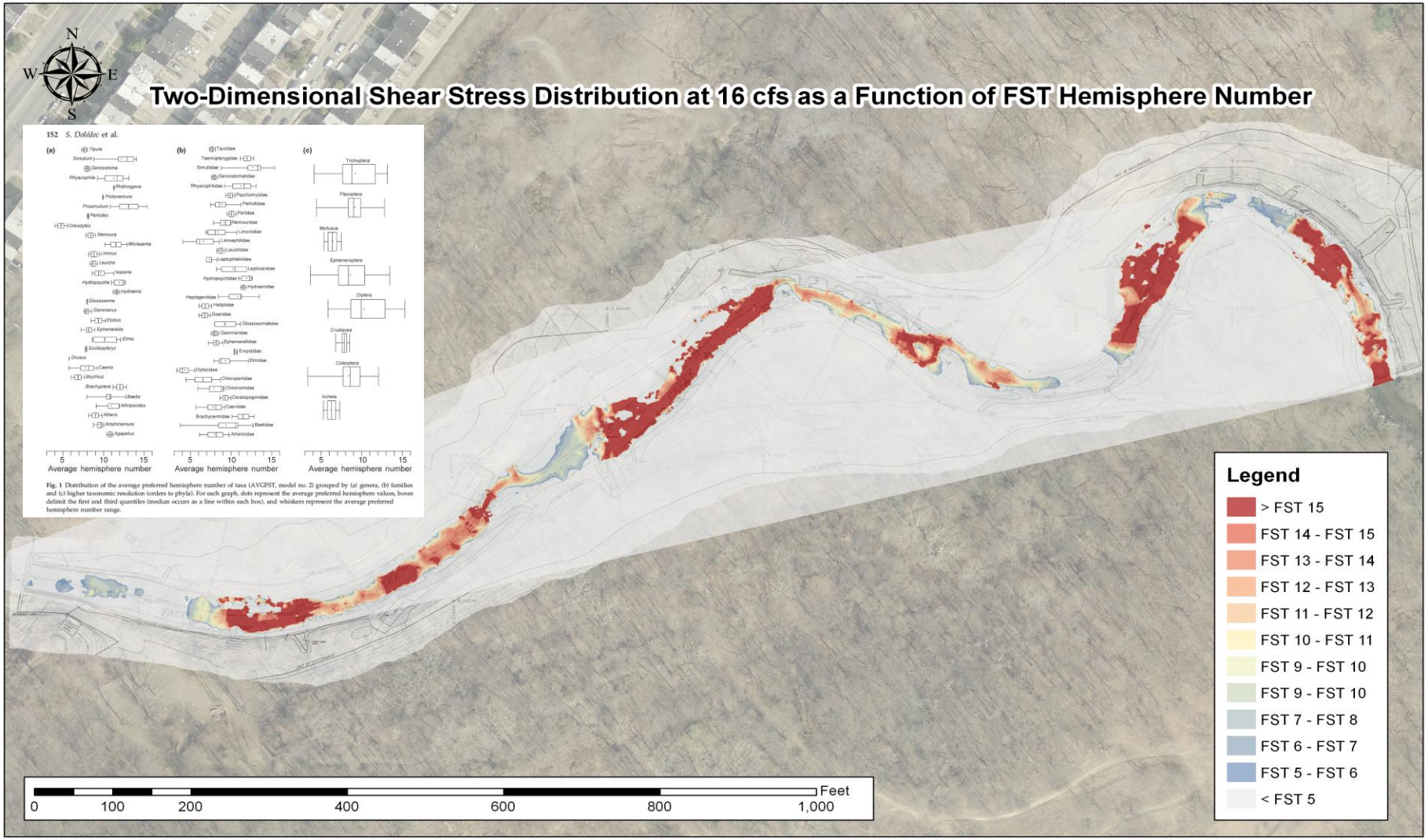
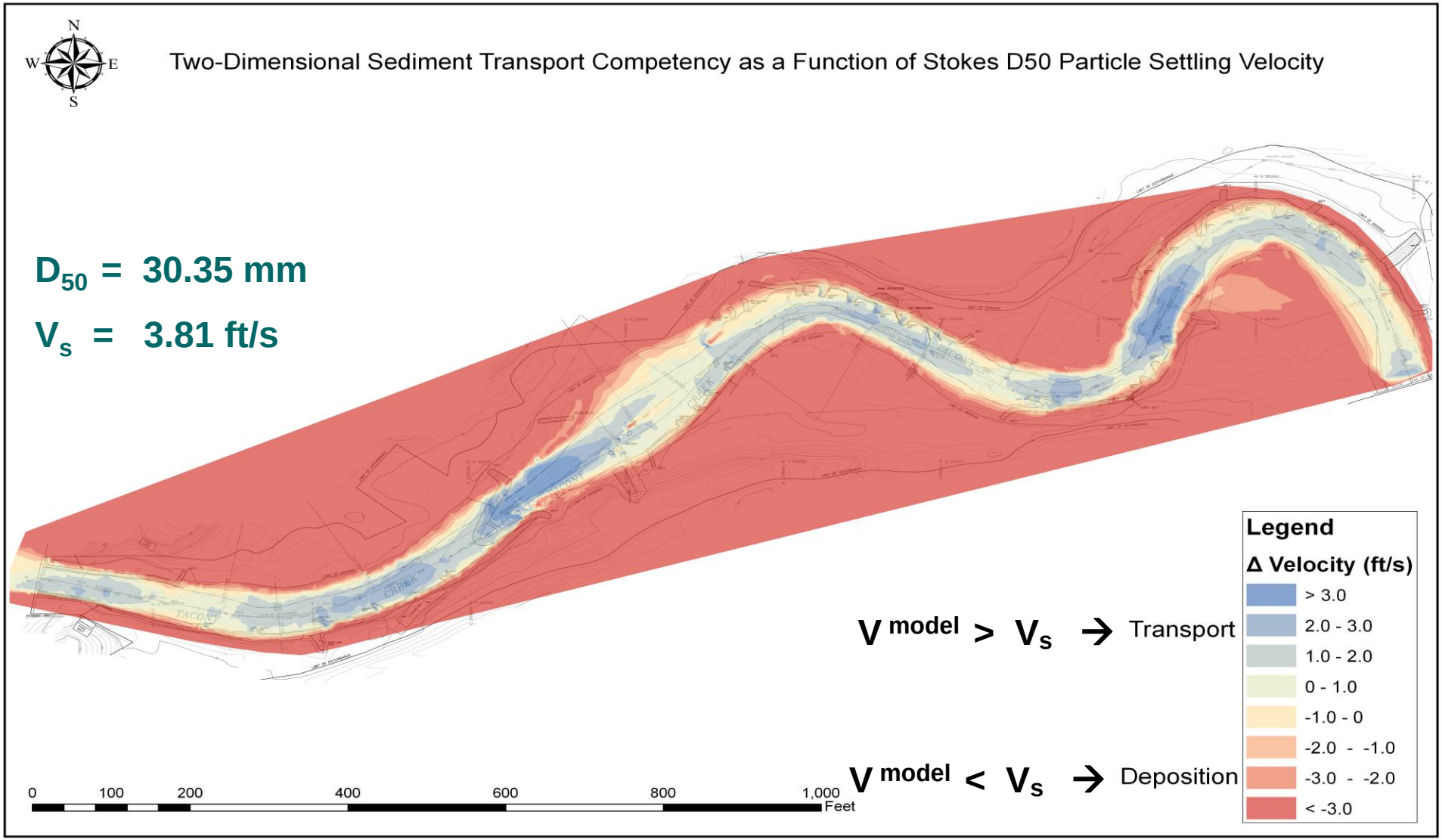
R2D as a Management Tool

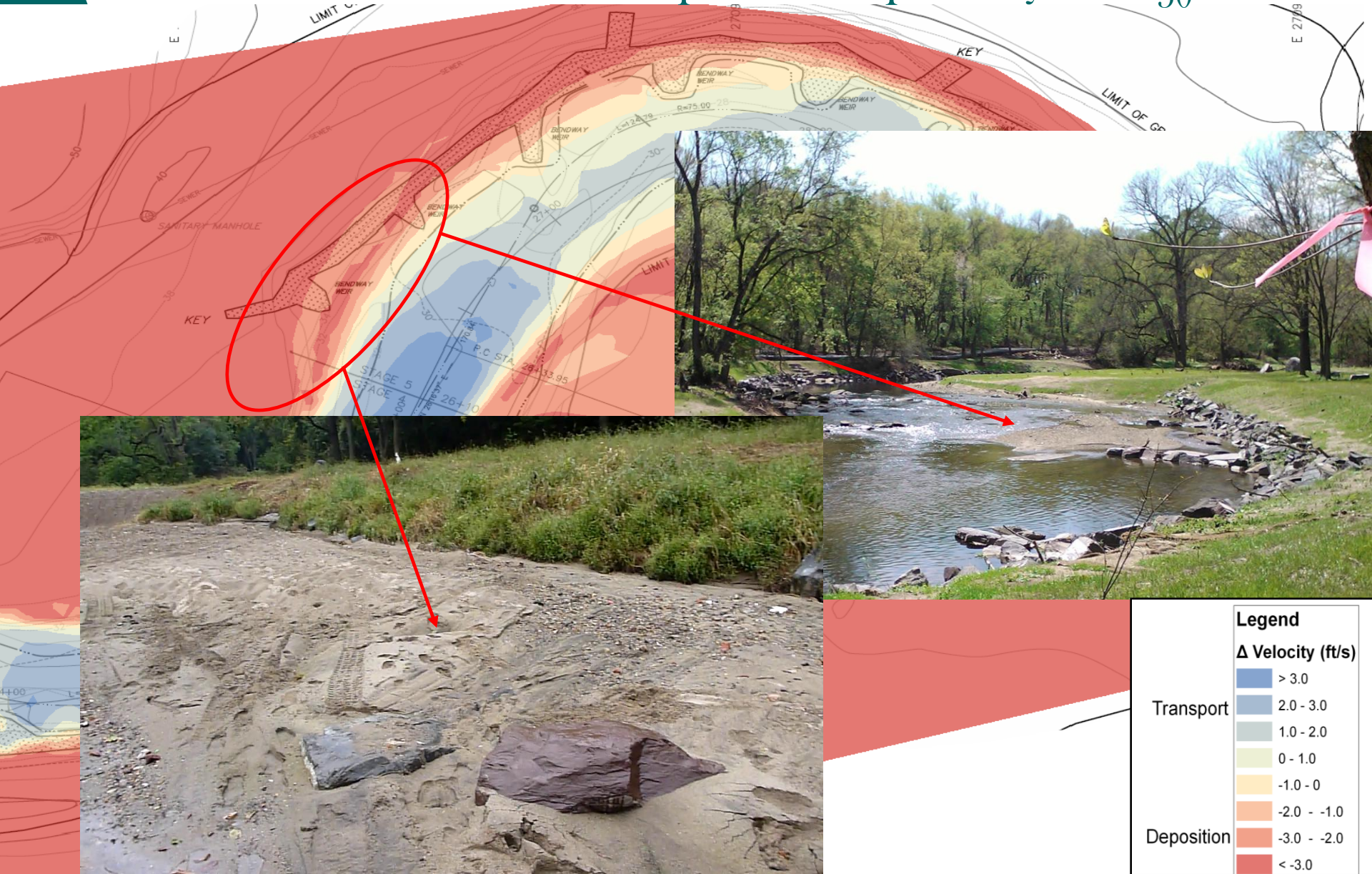


River2D Model Predictions :
Sediment Transport Competency of D_{50}



River2D Model Predictions:

Sediment Transport Competency of D_{50}



Closing the loop in Practice

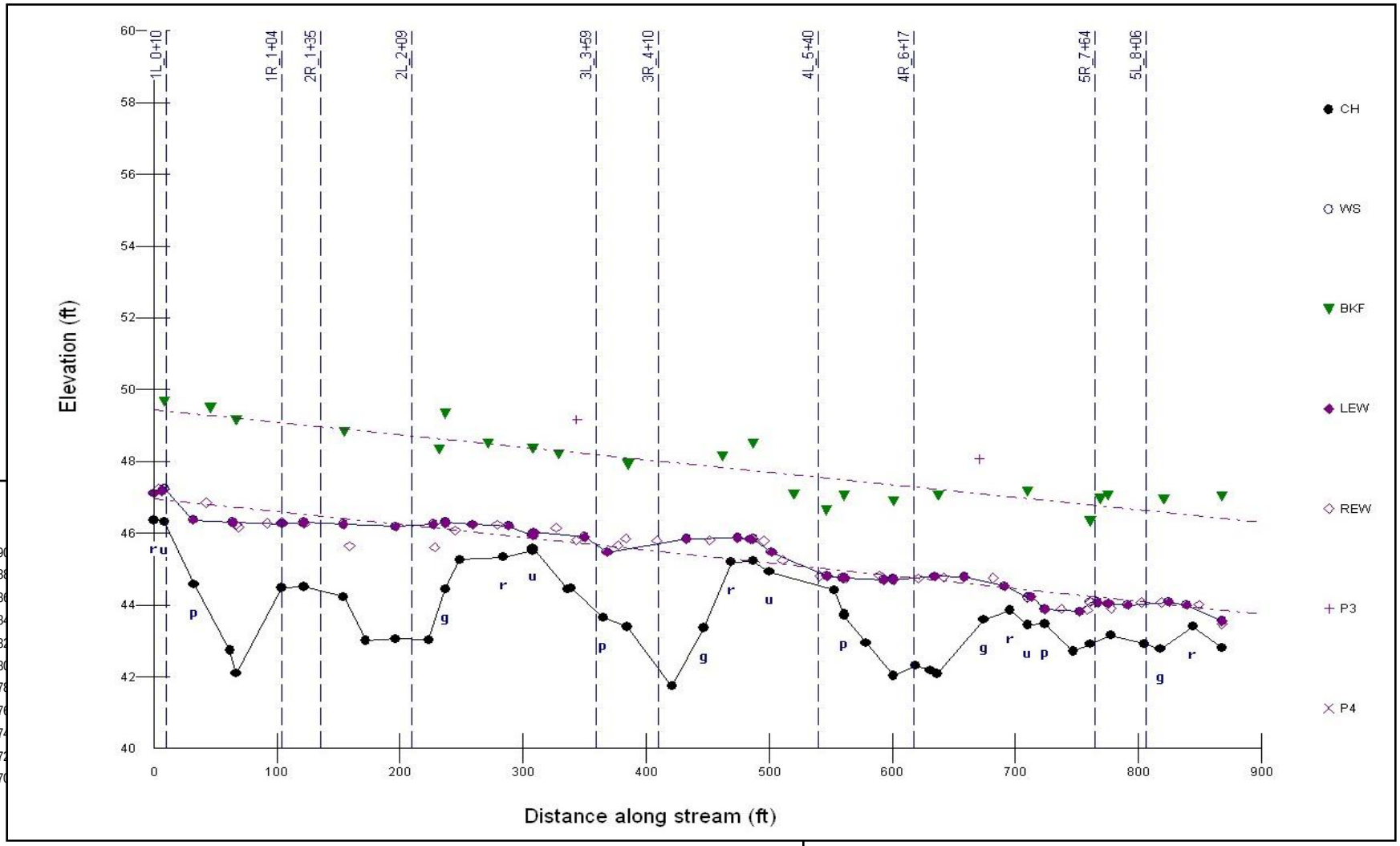
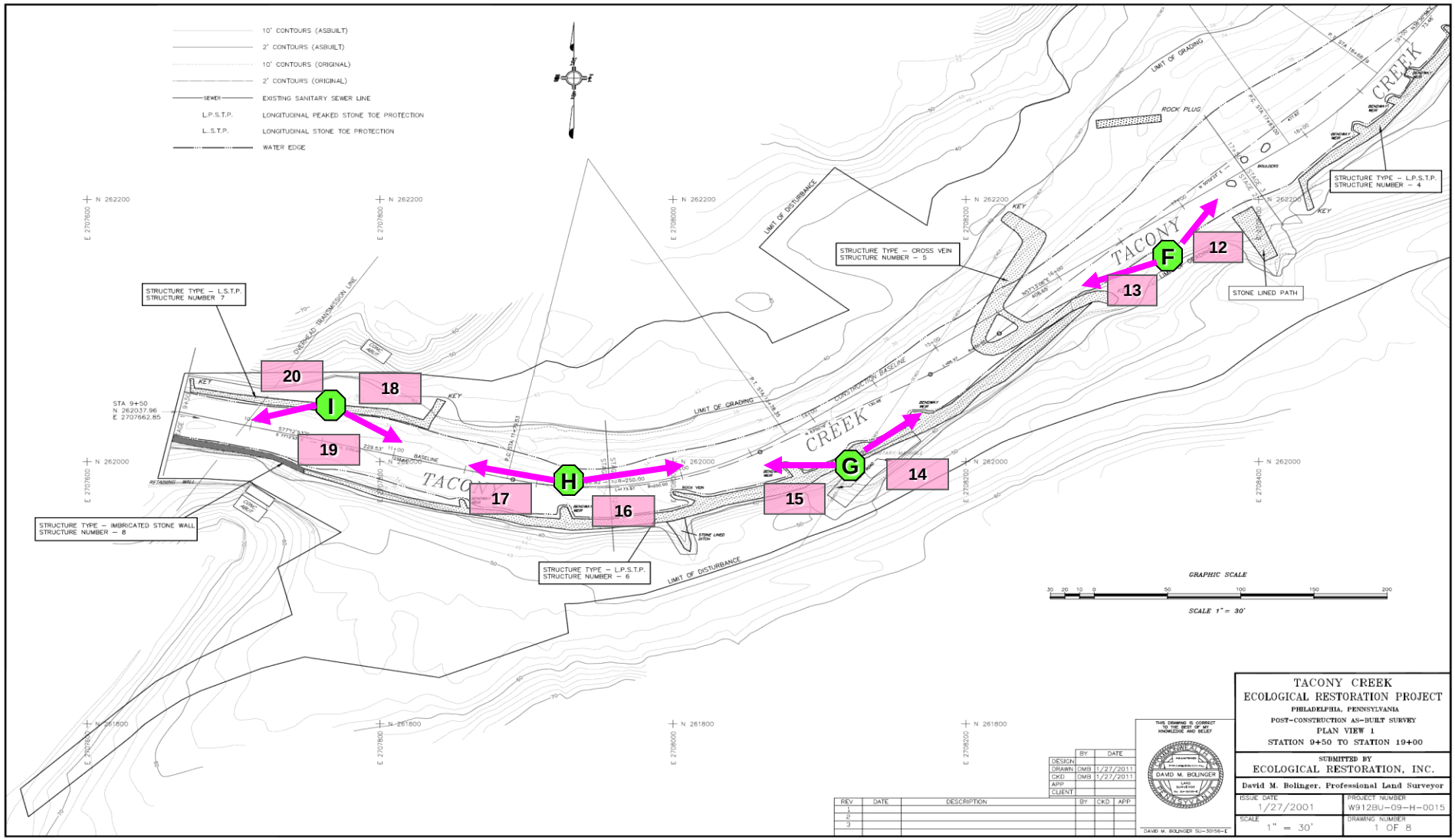
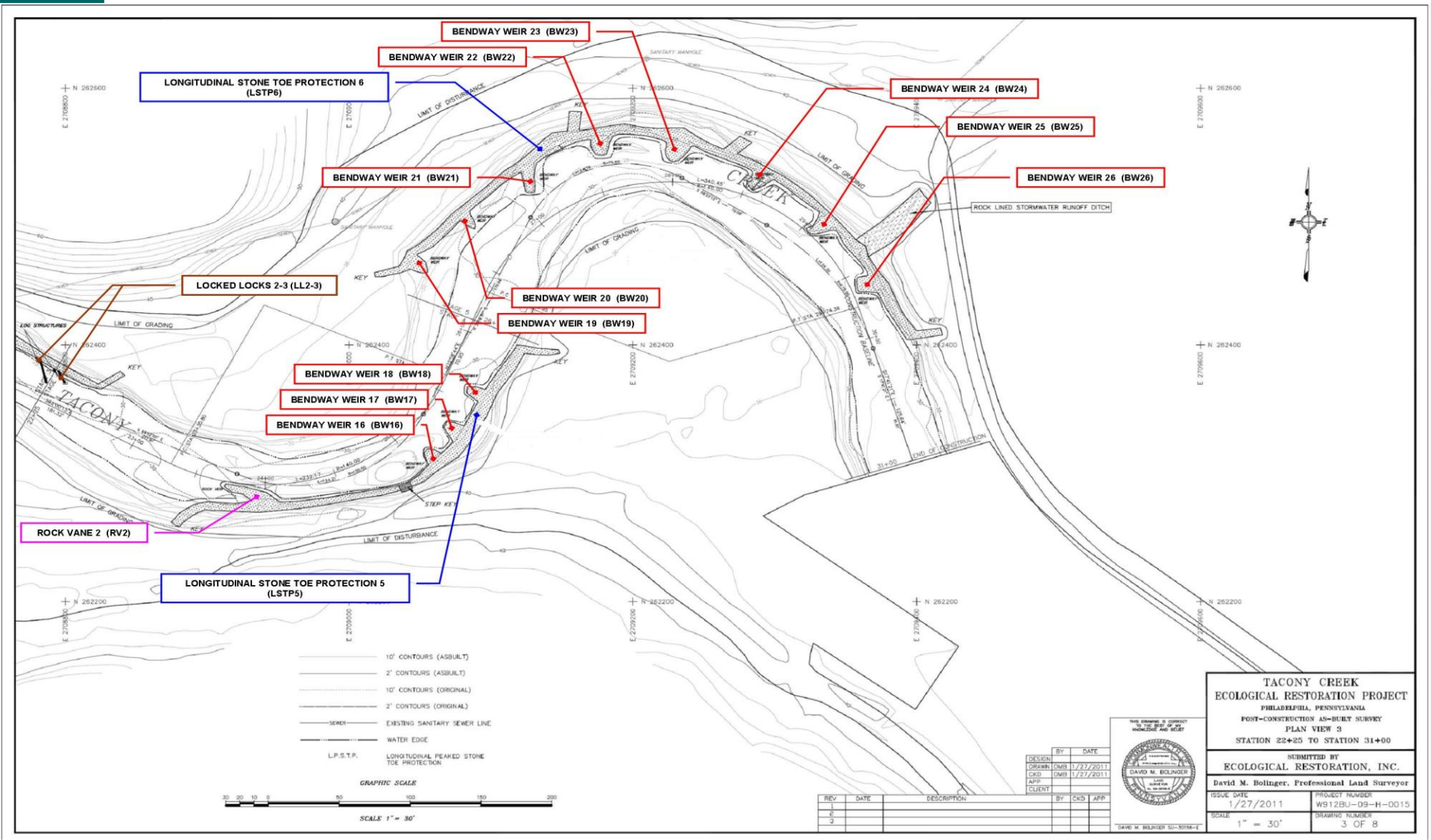


Photo-Monitoring



Instream Structure Monitoring

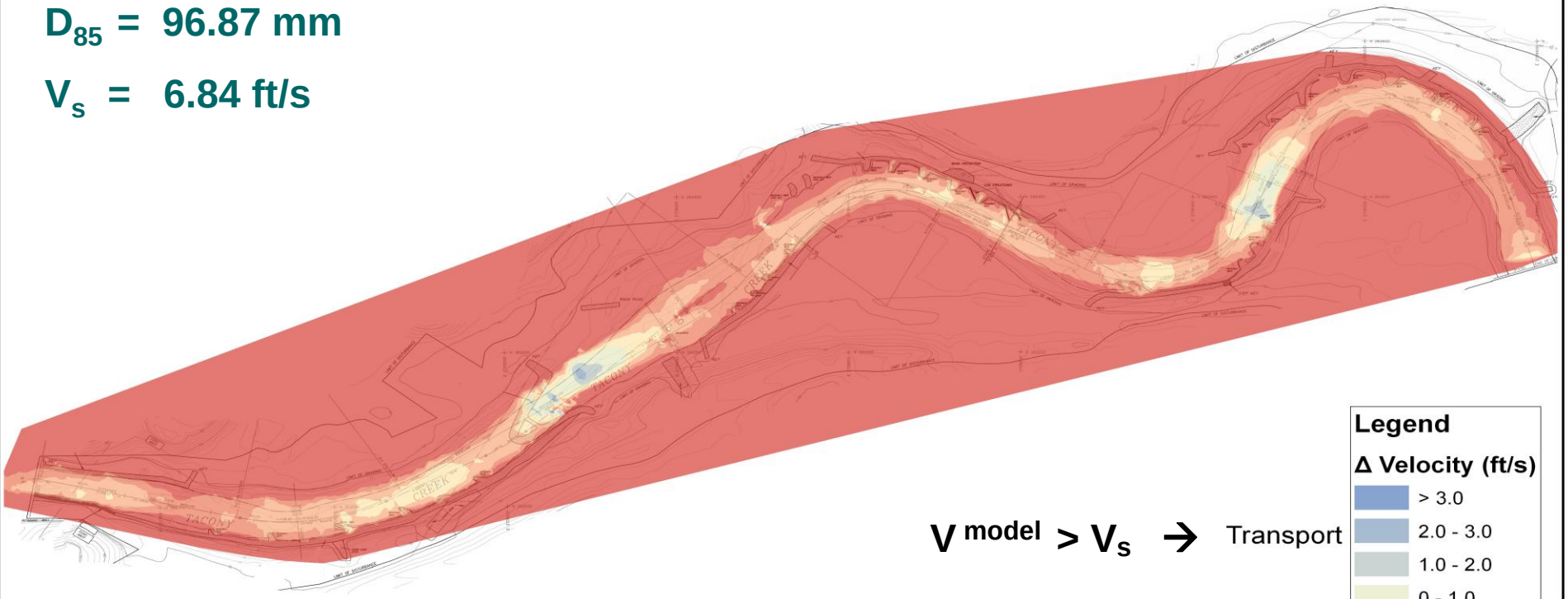


River2D Model Predictions :
Sediment Transport Competency of D_{84}

Two-Dimensional Sediment Transport Competency as a Function of Stokes D84 Particle Settling Velocity

D_{85} = 96.87 mm

V_s = 6.84 ft/s



$V^{model} > V_s$ → Transport

$V^{model} < V_s$ → Deposition

Legend

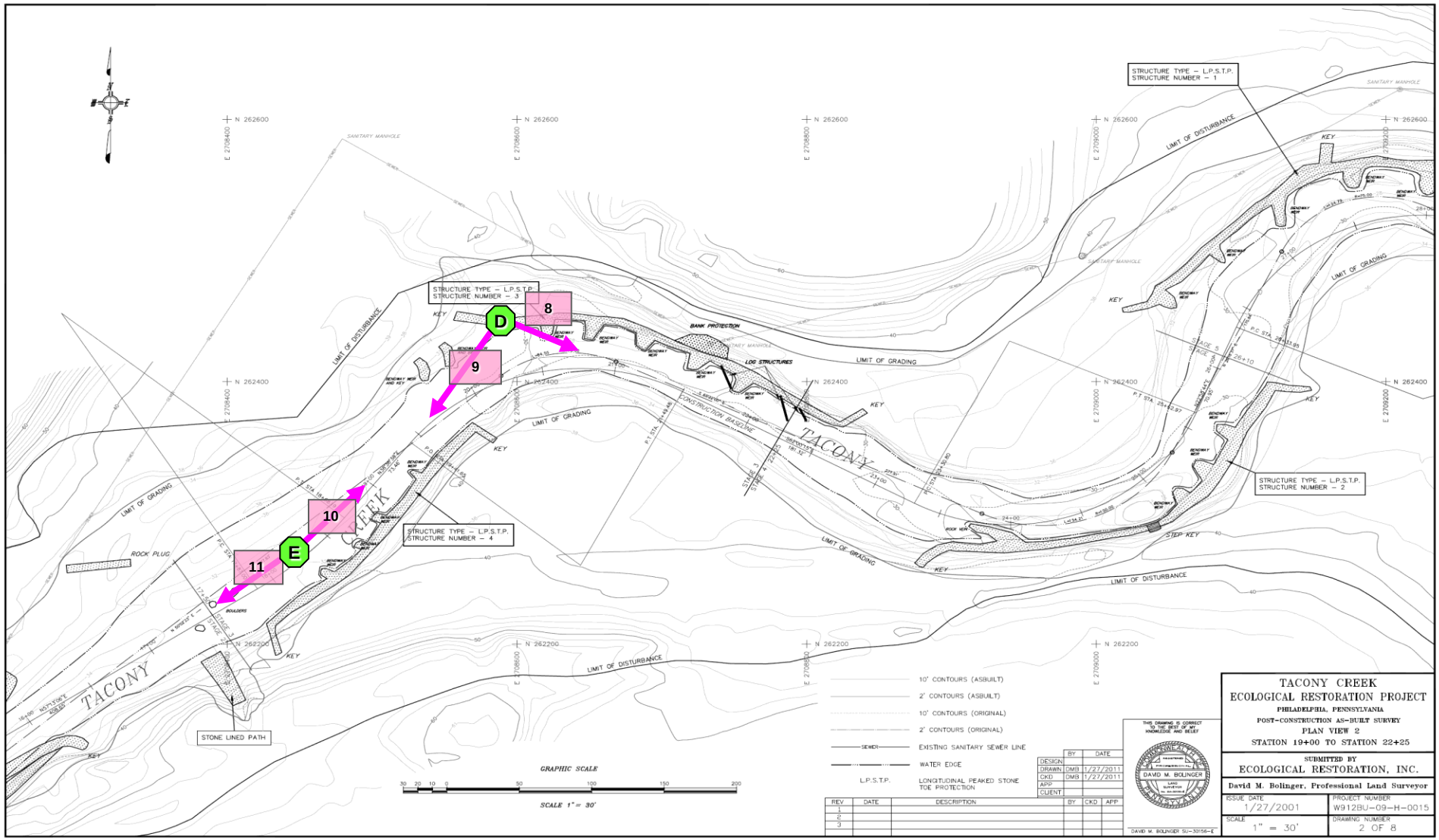
Δ Velocity (ft/s)

- > 3.0
- 2.0 - 3.0
- 1.0 - 2.0
- 0 - 1.0
- -1.0 - 0
- -2.0 - -1.0
- -3.0 - -2.0
- < -3.0

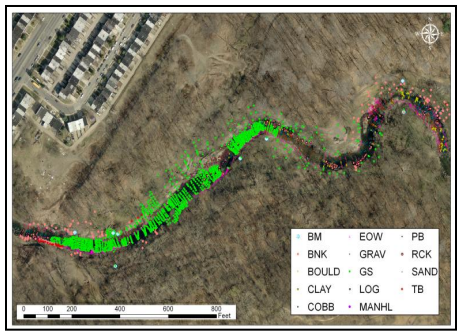
0 100 200 400 600 800 1,000 Feet

River2D Model Predictions :

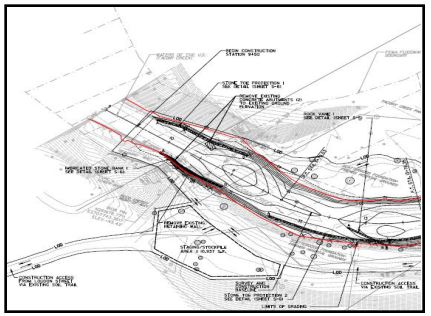
Sediment Transport Competency of D_{84}



A New Paradigm....



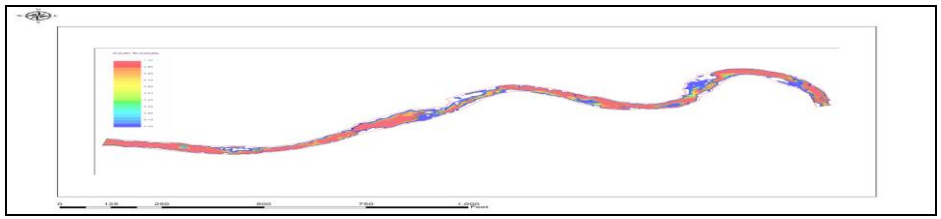
Assessment



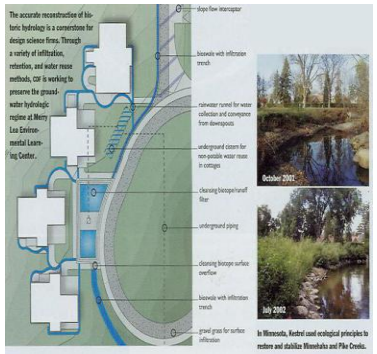
Design

Construction

Monitoring



Best Management Practices



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For the future.....

- Development of regional indices
  - Depth, velocity & substrate at sampling sites
- $$$
  - In-lieu fee and mitigation banking
- ΔMorphology?
  - River2D Morphology
- **Cobb's Creek Reaches 6-8 and Tacony Creek Reaches 4-5**

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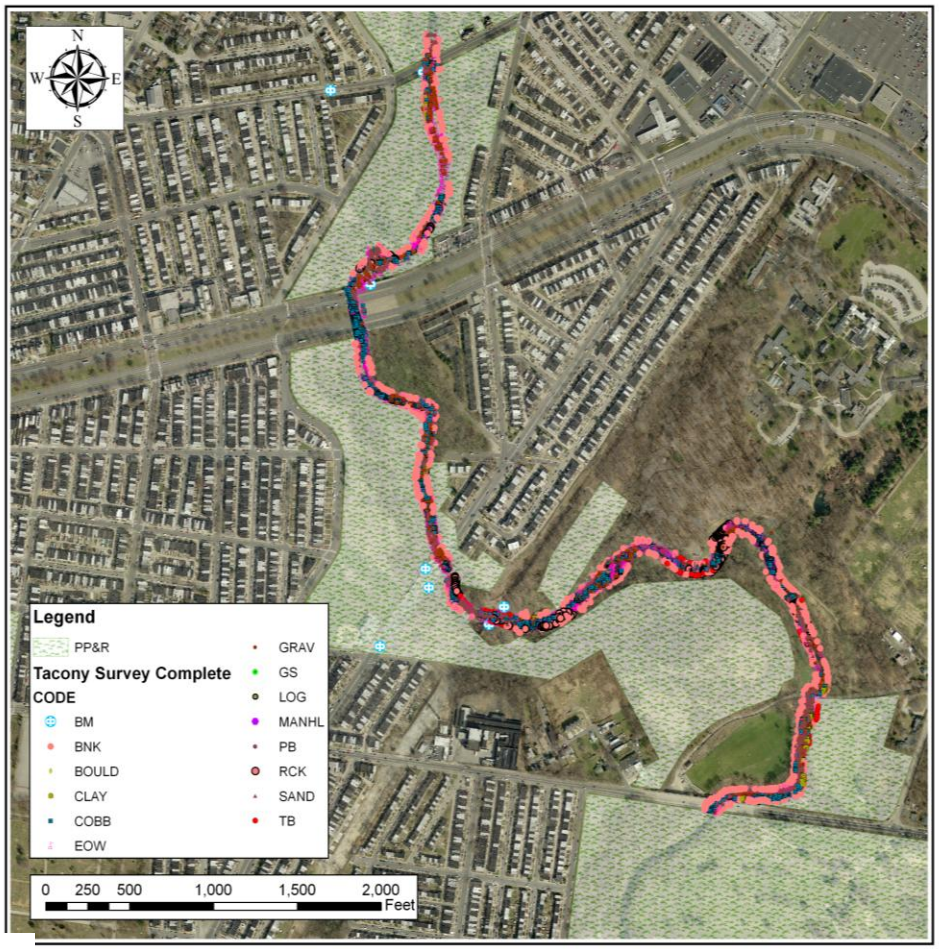
Tacony Creek Reaches 4-5



- Approx. 8000 LF
  - Pre/post models
- Habitat/WUA
- Sediment transport
- Transient model
  - T-08

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WHAT IS STREAM RESTORATION