Elk River Pilot Project:
Hydrodynamic and Sediment Transport Model

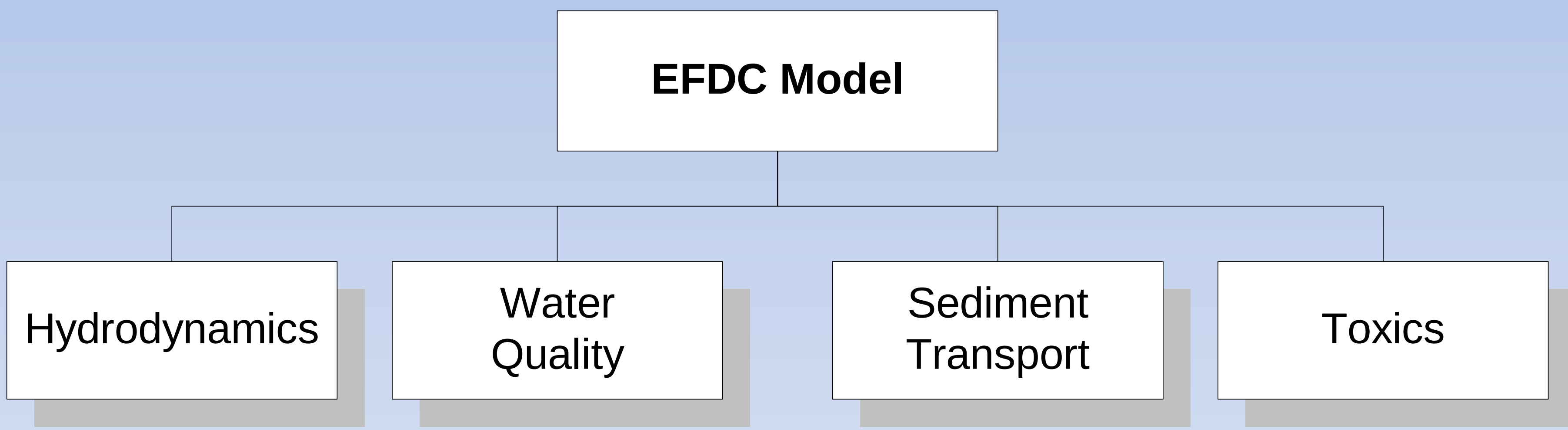
Presentation Overview

- Modeling system overview
- Modeling domain and grid development
- Hydrodynamic model calibration and results
- Sediment transport model calibration and results
- Wrap-up

Environmental Fluid Dynamics Code (EFDC)

- EFDC is a public-domain, EPA supported, surface-water modeling system that fully integrates hydrodynamic, water quality and sediment-contaminant simulation capabilities into a single source code.
- EFDC is extremely versatile and can be used for 3, 2 and 1-dimensional simulations in rivers, estuaries, coastal regions, lakes and wetlands.
- EFDC is one of the EPA recommended models for TMDL development, and has been used in 100's of TMDLs throughout the Country, including sediment TMDLs.

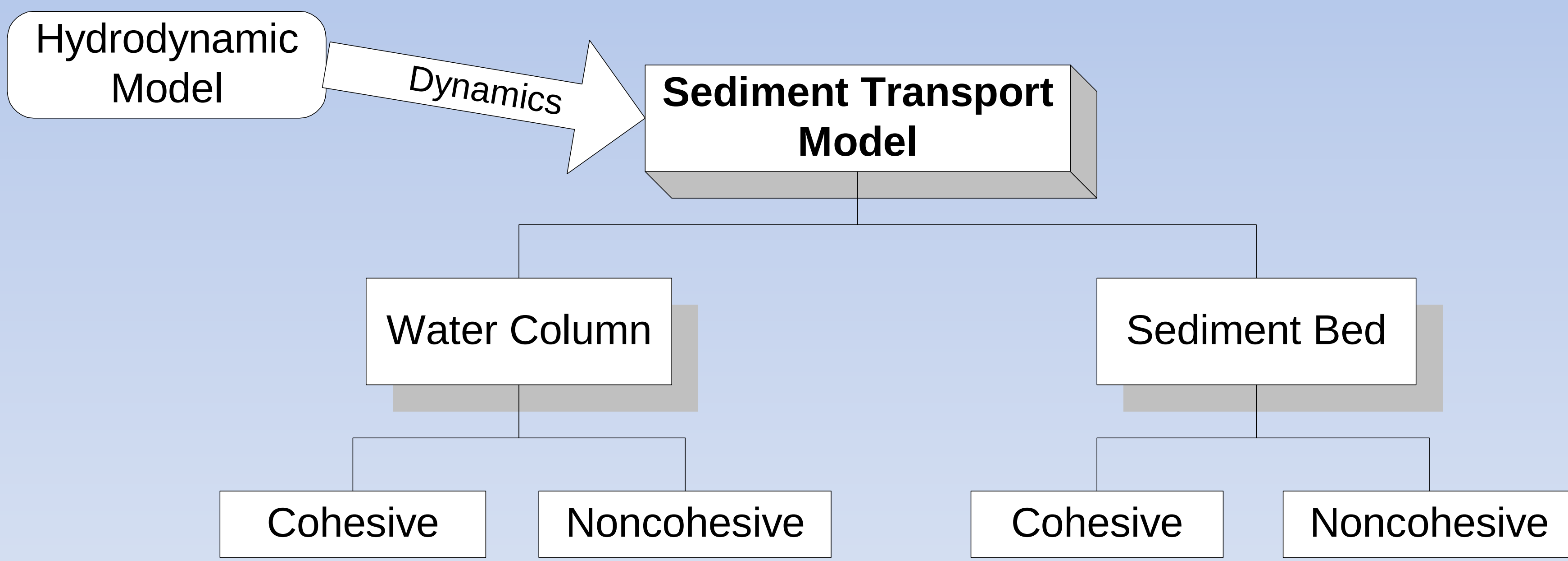
Primary Modules of EFDC Model



EFDC Sediment Transport Capabilities

- Multiple size class cohesive and non-cohesive suspended sediment transport
- Bedload transport of multiple size classes of non-cohesive sediment
- Includes sediment bed geomechanics with consolidation
- Bed morphology (scour and deposition)

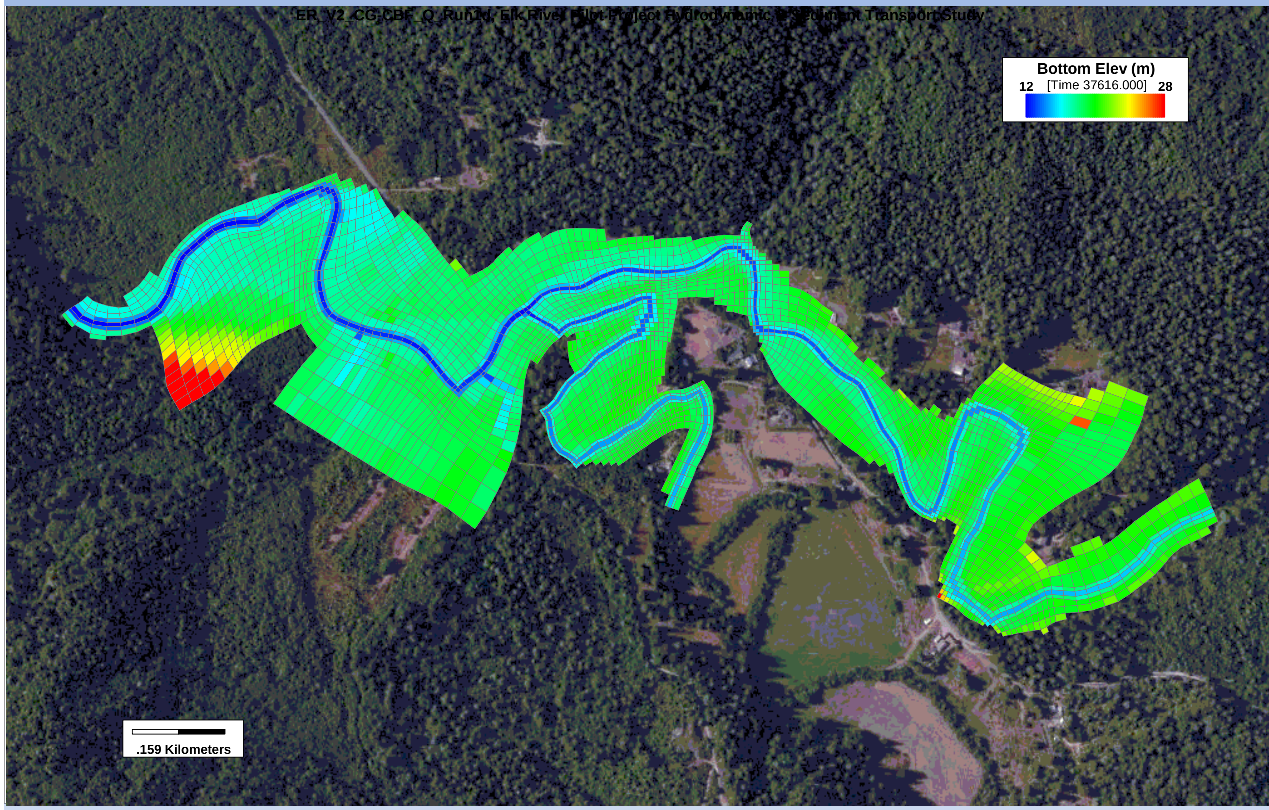
EFDC Sediment Transport Model

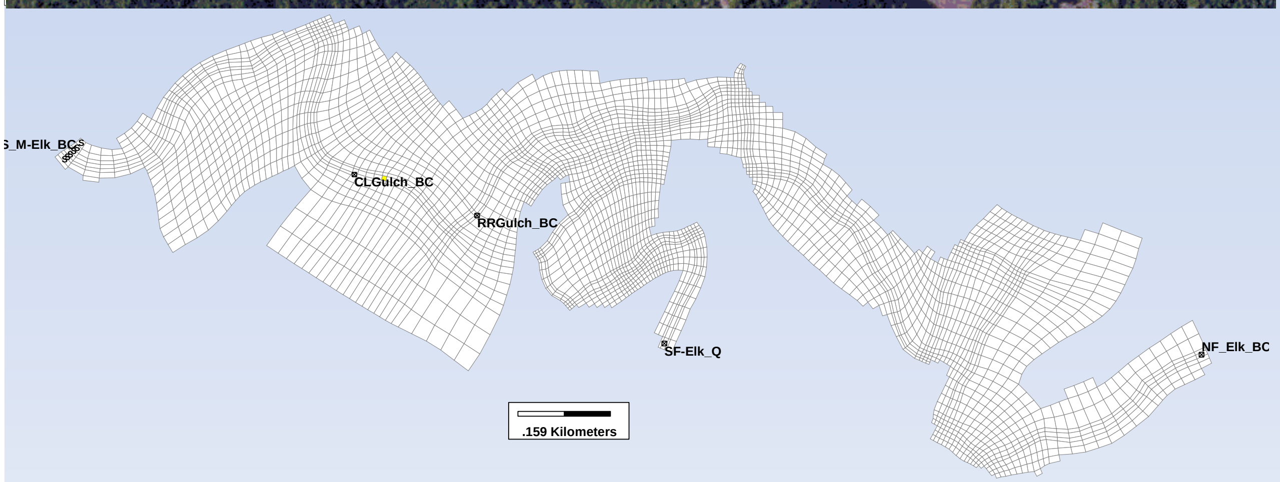


Elk River Hydrodynamic and Sediment Transport Pilot Project

- Pilot scale application of EFDC to demonstrate sediment transport capability in Elk River
- Pilot reach was chosen as a portion of the Elk River with known sediment deposition issues
- Moderate amount of data available to support application of model

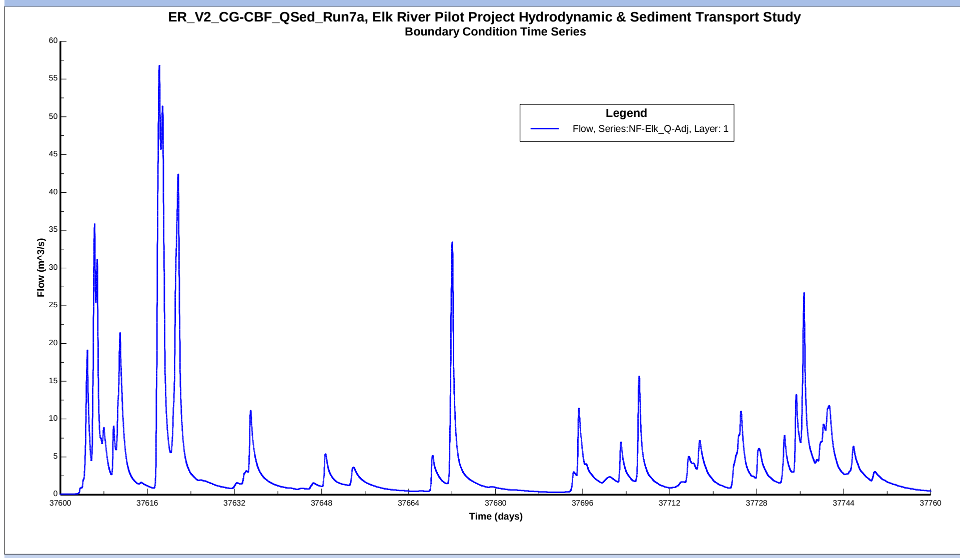
Model Grid Detail

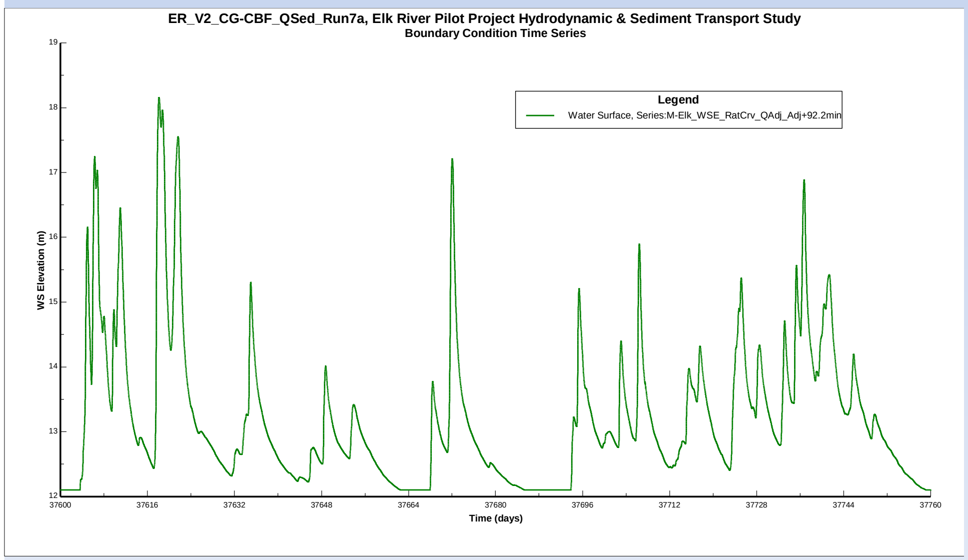




- 3,505 horizontal cells
- 1 vertical layer (2D model)
- Grid resolution:
  - 1 cell for channel bed
  - 1 cell for channel bank
  - Multiple cells on floodplain
- Grid elevations from adjusted LiDAR surface
- Model forcings:
  - Flow and SSC for NF & SF Elk and tribs
  - Downstream WSE

Hydrodynamic Model Setup





Upstream BC Flows:

- 10-min Q for NF & SF Elk River (SFO Data)
- Estimated Q for tributaries

Downstream BC Stage:

- Estimated WSE from HEC-RAS model

Channel Bed Roughness:

- Roughness height (Z_0) = 0.01 to 0.04 m (literature values)

Vegetation Drag:

- Plant density ($\#/m^2$), stem diameter (m), stem height (m), drag coef. (literature values)

Hydrodynamic Model Calibration

Calibration period:

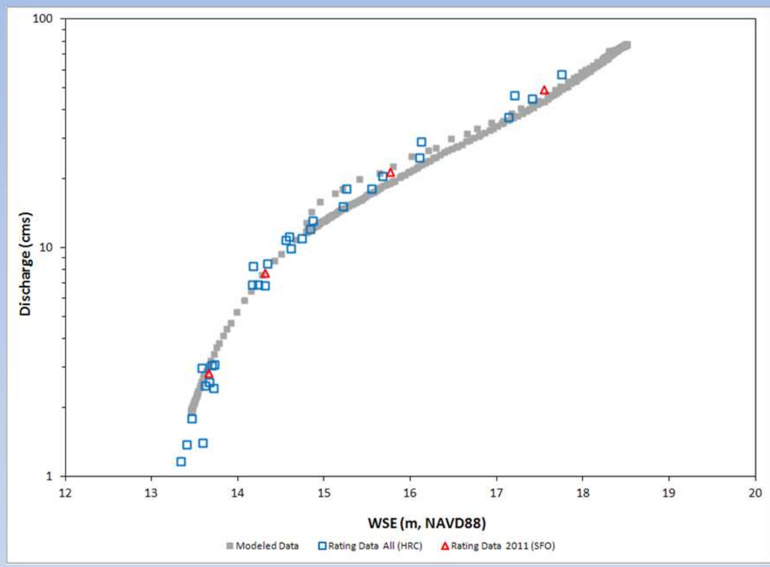
- Dec 25 to 30, 2002 (Dec 2002 flood)

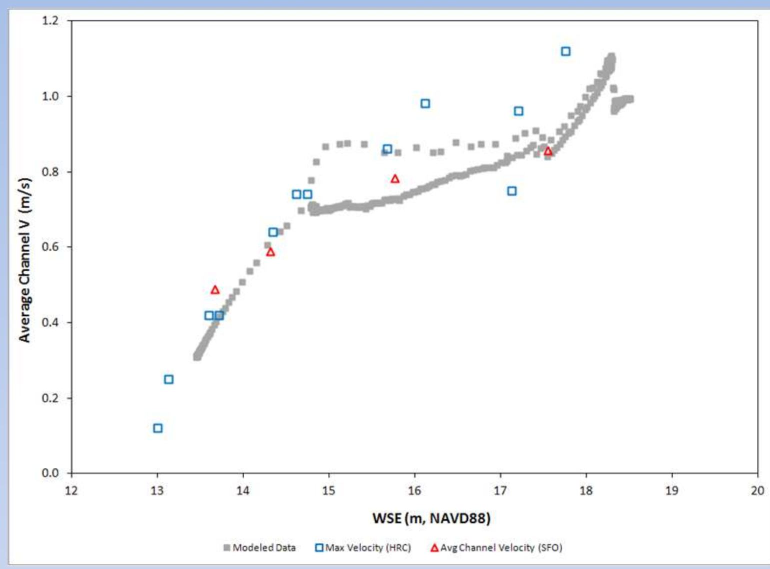
Calibration Strategy:

1. Adjust bottom roughness and bank vegetation drag to match observed discharge rating data at:
   - NF Elk River at Concrete Bridge (SFO data)
   - Mainstem Elk River at Steel Bridge (HRC data)
2. Adjust peak discharge values for NF & SF Elk River to match observed water surface elevations at:
   - Stage recorder data (KRW station) on NF Elk River (SFO data)
   - Dec 2002 high water mark at Red House on Mainstem Elk (K. Wrigley)
   - Dec 2002 high water mark at Steel Bridge on Mainstem Elk (HRC data)

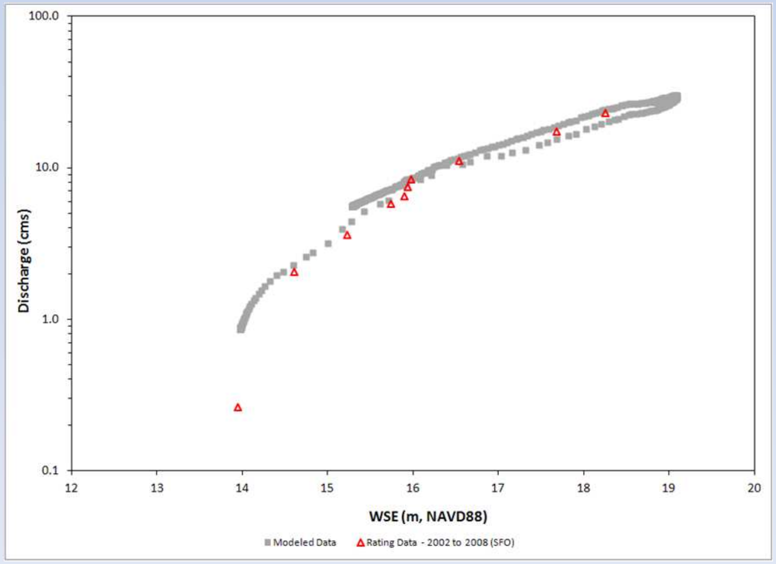
Measured and Predicted Stage-Discharge and Stage-Velocity Relationships

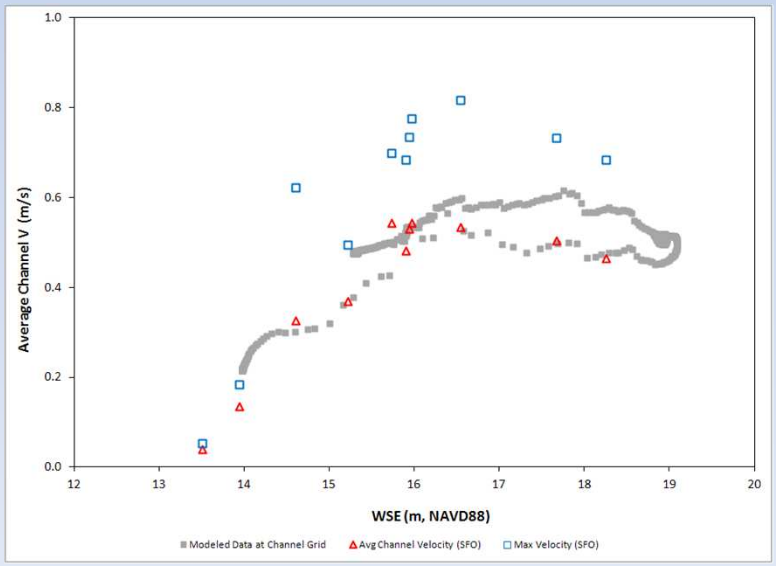
Steel Bridge (Sta 509) on Mainstem Elk River



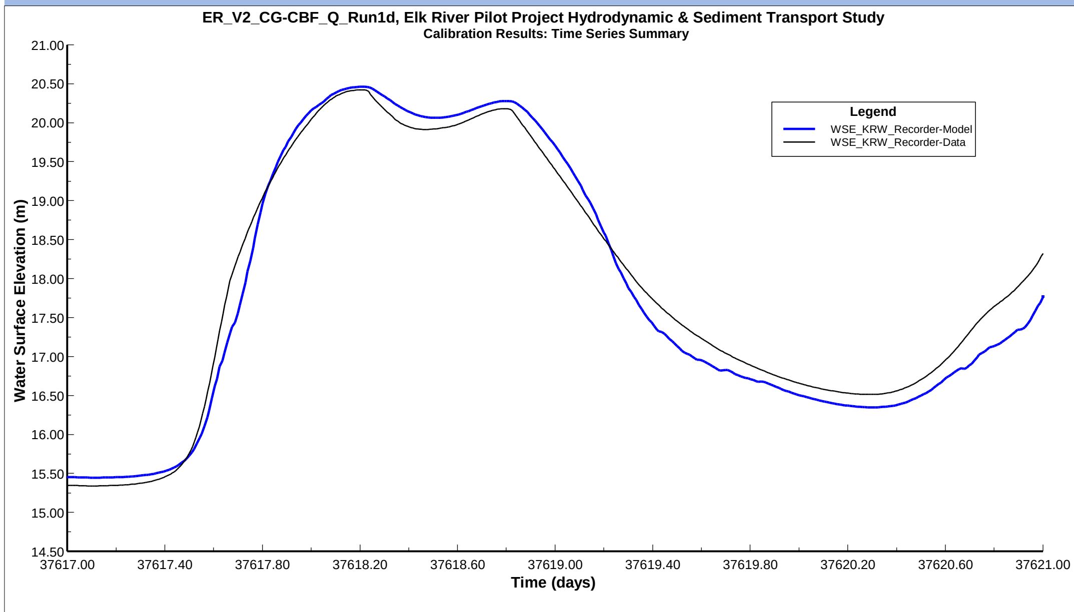


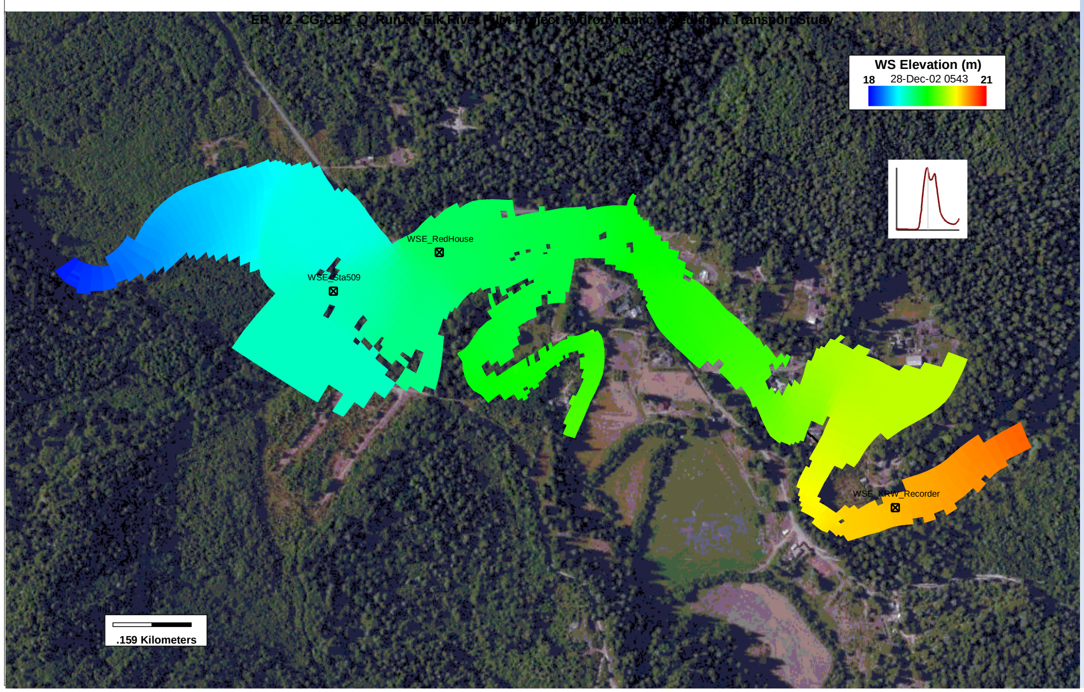
Concrete Bridge on NF Elk River





Measured and Predicted WSE





Calibration Results:

1. Measured and predicted WSE at NF Elk for stage recorder data (SFO)

2. High Water Marks

Red House (Sta_RedHouse):
Observed = 19.4 m
Predicted = 19.3 m

Steel Bridge (Sta 509) Silt Line:
Observed = 19.1 m
Predicted = 19.0 m

Results of Hydrodynamic Model Calibration

1. Semi-calibrated hydrodynamic model (calibrated to small data set)

   Calibrated to Dec 2002 flood event

2. Validation of model – still to be done

   Check against other water year flood events

3. Movie of Dec 2002 flood event

   Where’s the popcorn?

Sediment Transport Model

- Sediment transport model is work in progress
- Still working on calibration to observed deposition patterns and SSC
- We’ve made runs for WY 2003 for this workshop – but these are preliminary

Sediment Transport Model Setup

- Modeled 5 sediment classes:
  - 1 cohesive
  - 4 non-cohesive
    - Coarse silt and VF Sand
    - Fine to medium sand
    - Coarse to very coarse sand
    - Fine to medium gravel
- Modeled suspended load and bedload
- Modeled bed geomorphic change (scour and deposition)

Sediment Transport Model Input

Things we have:

- Semi-calibrated hydrodynamic model
- Measured data
  - Q, SSC, SSC sand fraction at Upstream BC
  - Bed, Bank and Floodplain material gradation, porosity, bulk density (we measured this)
  - SSC at Steel Bridge (Sta 509)

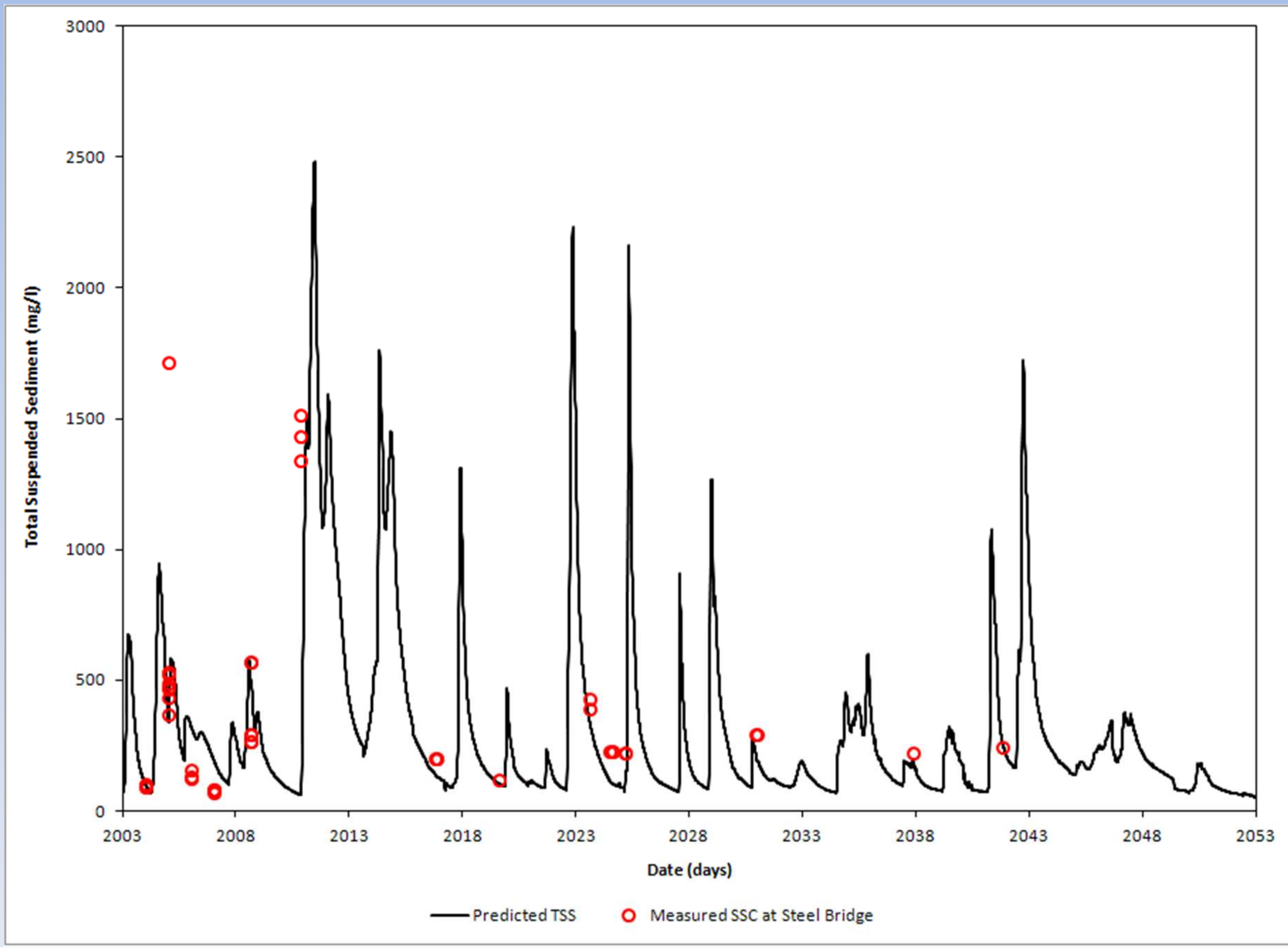
Things we did not have and assumed:

- SSC particle size distribution at Upstream BC
  - 1 cohesive ~85 to 90% of measured SSC (SFO data)
  - 4 non-cohesive ~10 to 15% of SSC applied to non-cohesive classes
  - Good thing is that we can collect this data

Adjusted through sediment calibration process:

- SSC particle gradations
- Shear stress partitioning between cohesive and non-cohesive sediment
- Bed configuration

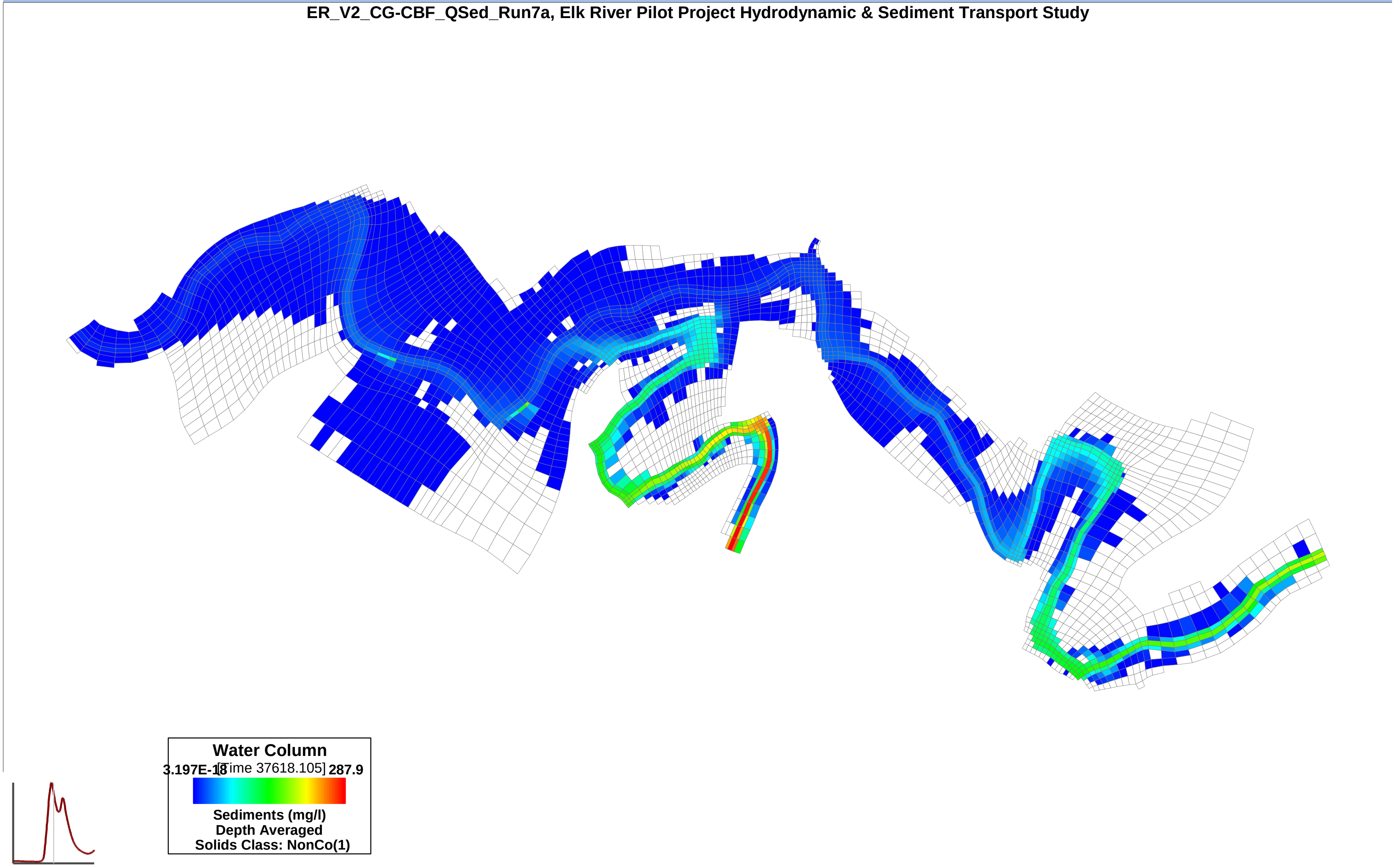
WY 2003 Measured and Predicted SSC at Steel Bridge (Sta 509) on Mainstem Elk River



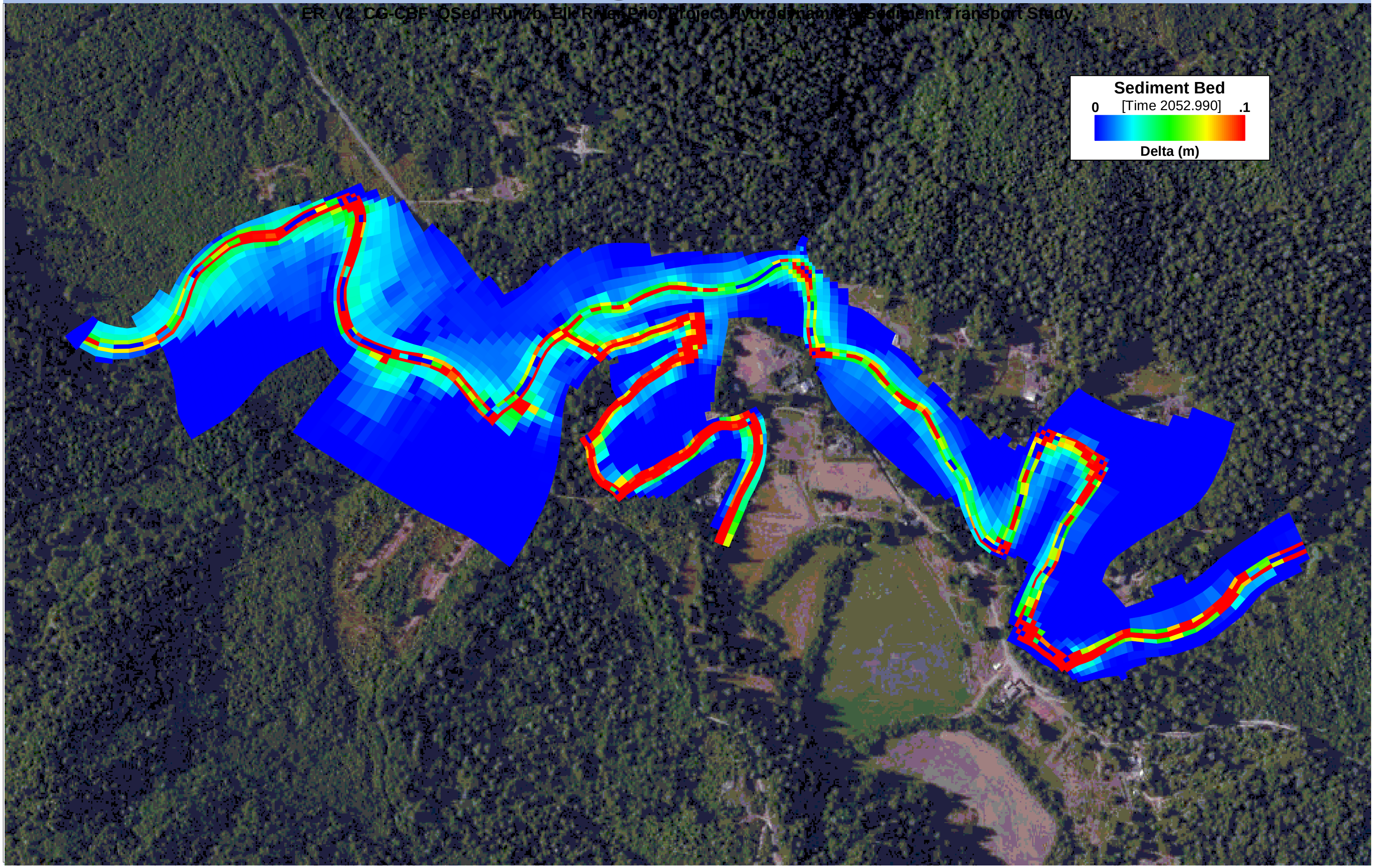
Movie clip of TSS Dec 2002 Flood

- Go to movie

Non-cohesive SSC during peak



Sediment Deposition Patterns for WY 2003 Existing Conditions

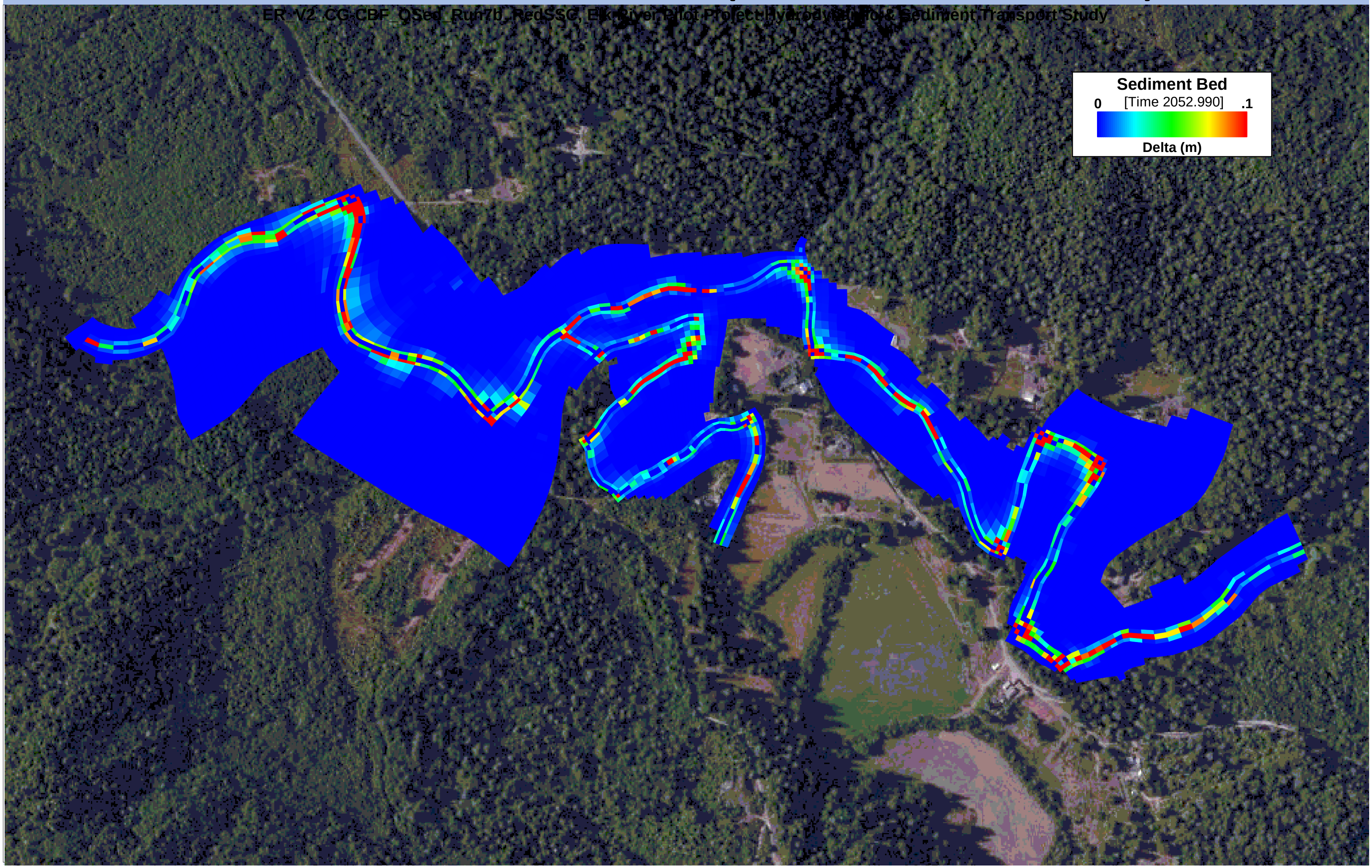


Reduced Sediment Run

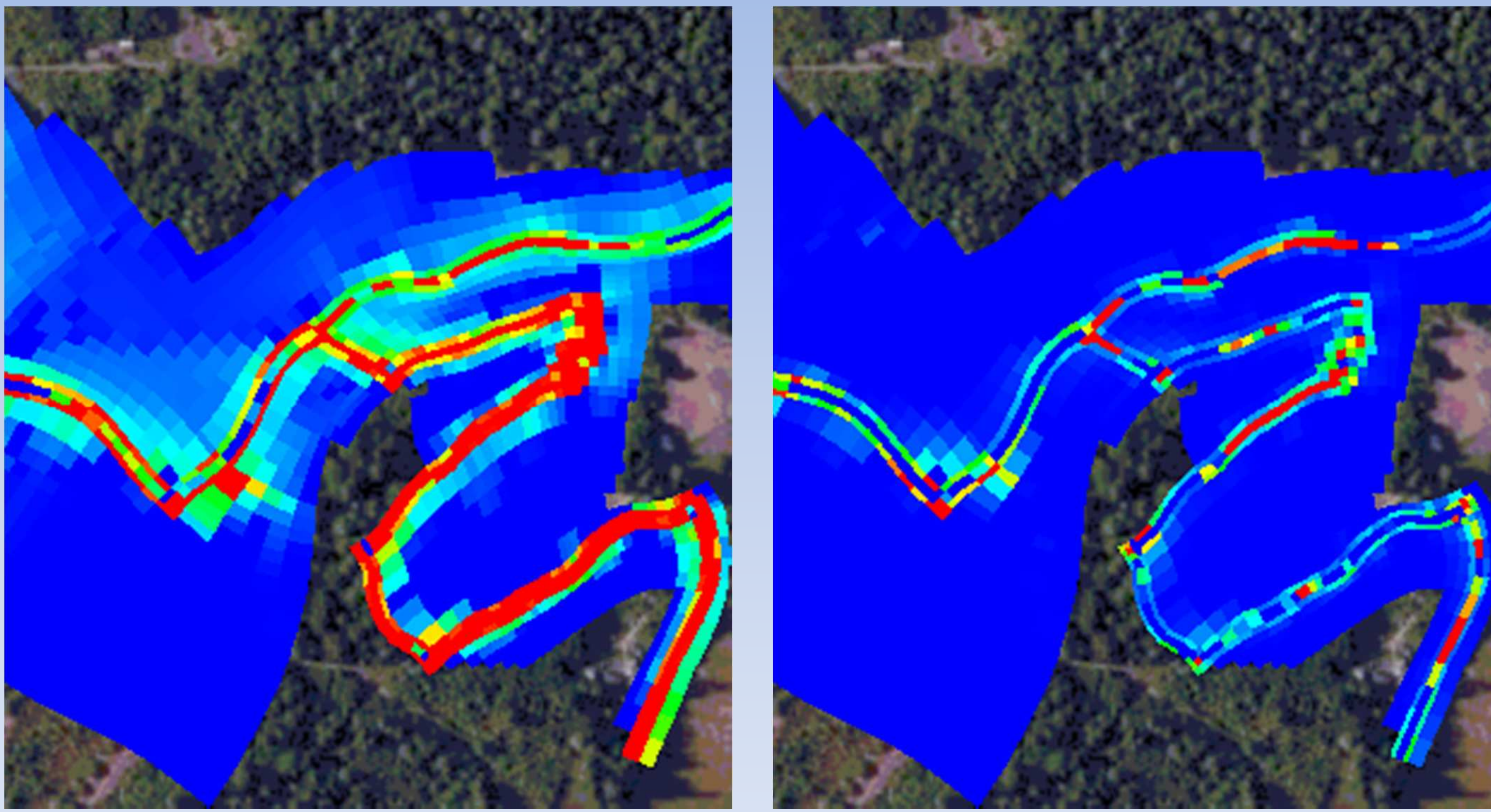
- Ran model for WY 2003 with 85% reduction in all SSC
- 85% reduction provided by Adona

Results are Preliminary so interpret with Caution!

Sediment Deposition Patterns for WY 2003 with Reduced SSC (85% reduction)



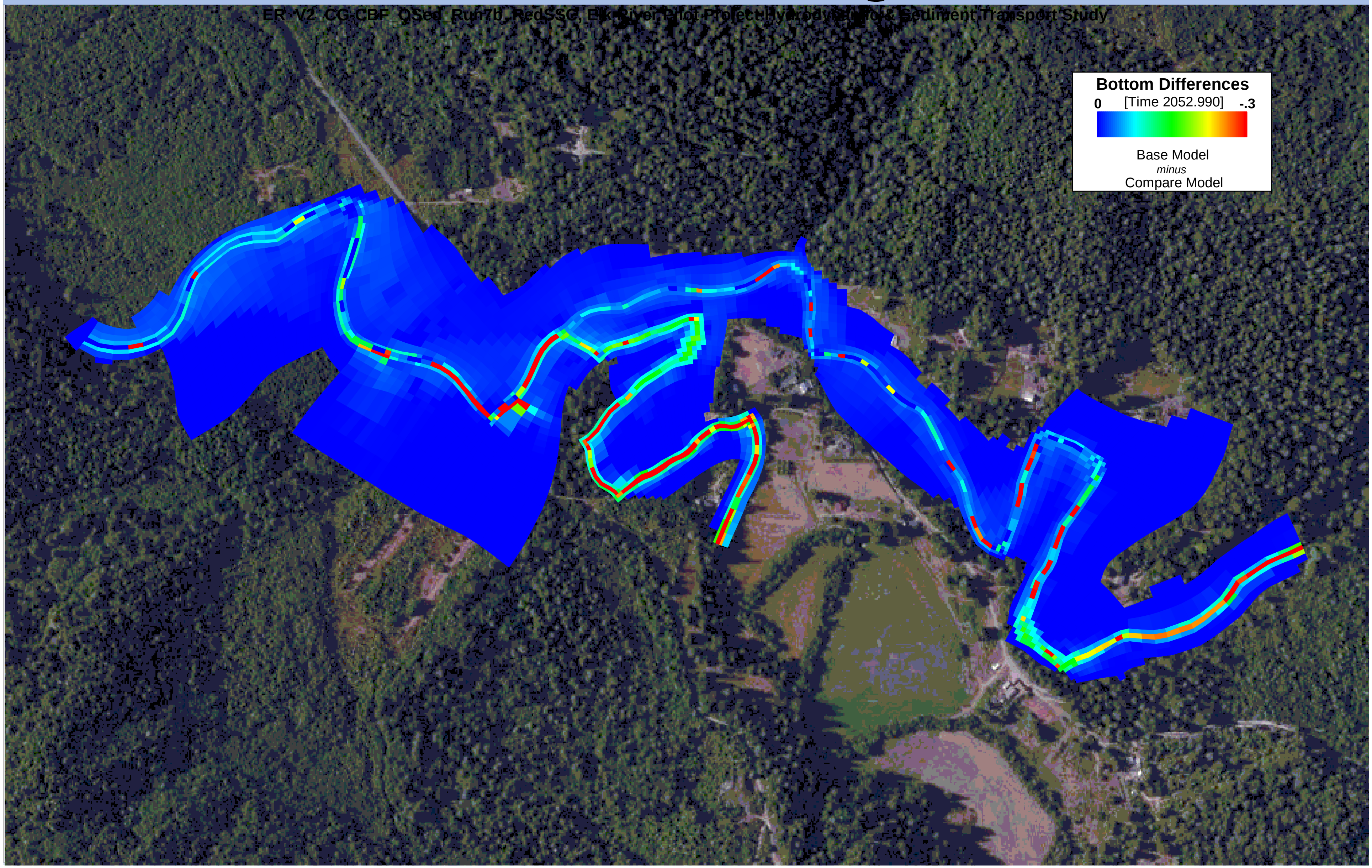
Sediment Deposition Patterns for WY 2003



Existing Conditions

Reduced SSC

Difference in Deposition Patterns Between Reduced SSC and Existing Condition



Conclusions – what did we learn from the pilot project modeling effort

- Make reasonable predictions WSE, V, SSC and depositional patterns in project reach of Elk River
- Gain more confidence in results by collecting additional input and calibration data
  - In channel topography
  - Channel bed material
  - Channel obstructions
  - Vegetation patterns
  - SSC particle breakdown
  - Collection of calibration data (WSE, V, SSC, deposition) at additional locations
  - Refine estimates of peak discharge
  - In-channel measurements of sediment erosion (SedFLUME)

That's all folks!