Green/Duwamish River Watershed



Pollutant Loading Assessment

Technical Advisory Committee Meeting
April 6, 2016

DEPARTMENT OF ECOLOGY
State of Washington

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

TETRA TECH
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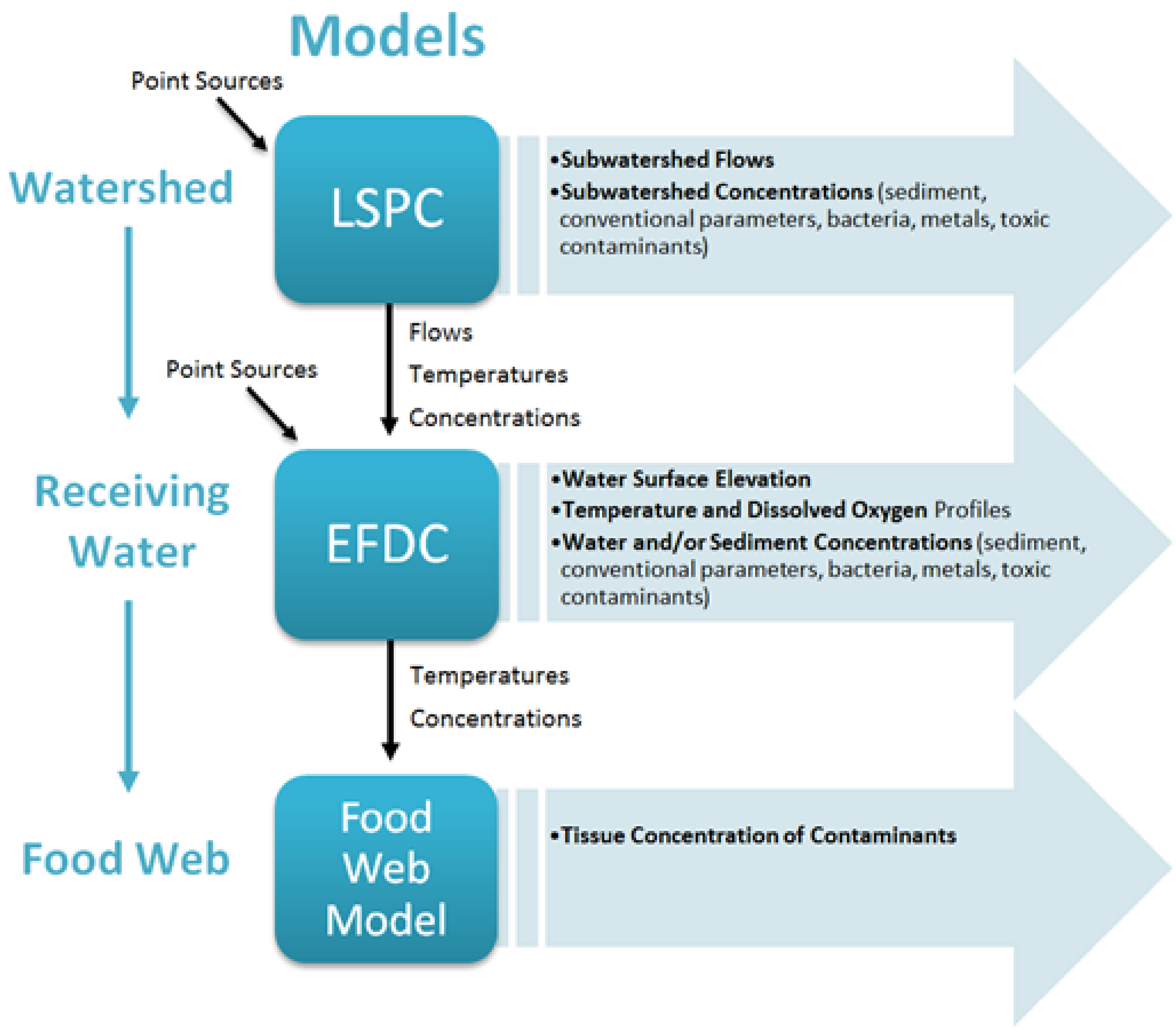
Model selection



EFDC Receiving Water Model

- EFDC model will provide a dynamic representation of:
  - hydrodynamic conditions, sediment transport, and toxic pollutant concentrations/loads in the tidally influenced portions of the Green/Duwamish River and LDW
- Building on the previous work
- Extend to simulate movement and storage of all project pollutants in both bed sediments and water column
- QAPP provides detailed approach for configuration and calibration of EFDC model for PLA.

Planned Refinements/Additions to Previous EFDC Models

- Utilize the original grid with extension upstream to free flowing river;
- Update hydrodynamic model including flow, velocity, water surface elevation, salinity and temperature;
- Update sediment transport model;
- Re-calibrate hydro and sediment transport models (if needed)
- Add total organic carbon and dissolved organic carbon to support toxics modeling;

Planned Refinements/Additions to Previous EFDC Models (cont.)

- Fate and transport modeling using 2-phase partitioning
  - Freely dissolved and sorbed phase

$$\frac{C_w}{C} = \frac{\varphi}{\varphi + K_{POC}\ POC}$$

$$\frac{C_{POC}}{C} = \frac{K_{POC}\ POC}{\varphi + K_{POC}\ POC}$$

- Inclusion of contaminant transport and transformation processes

PCBs
cPAHs
Arsenic
Copper
Zinc
Phthalates

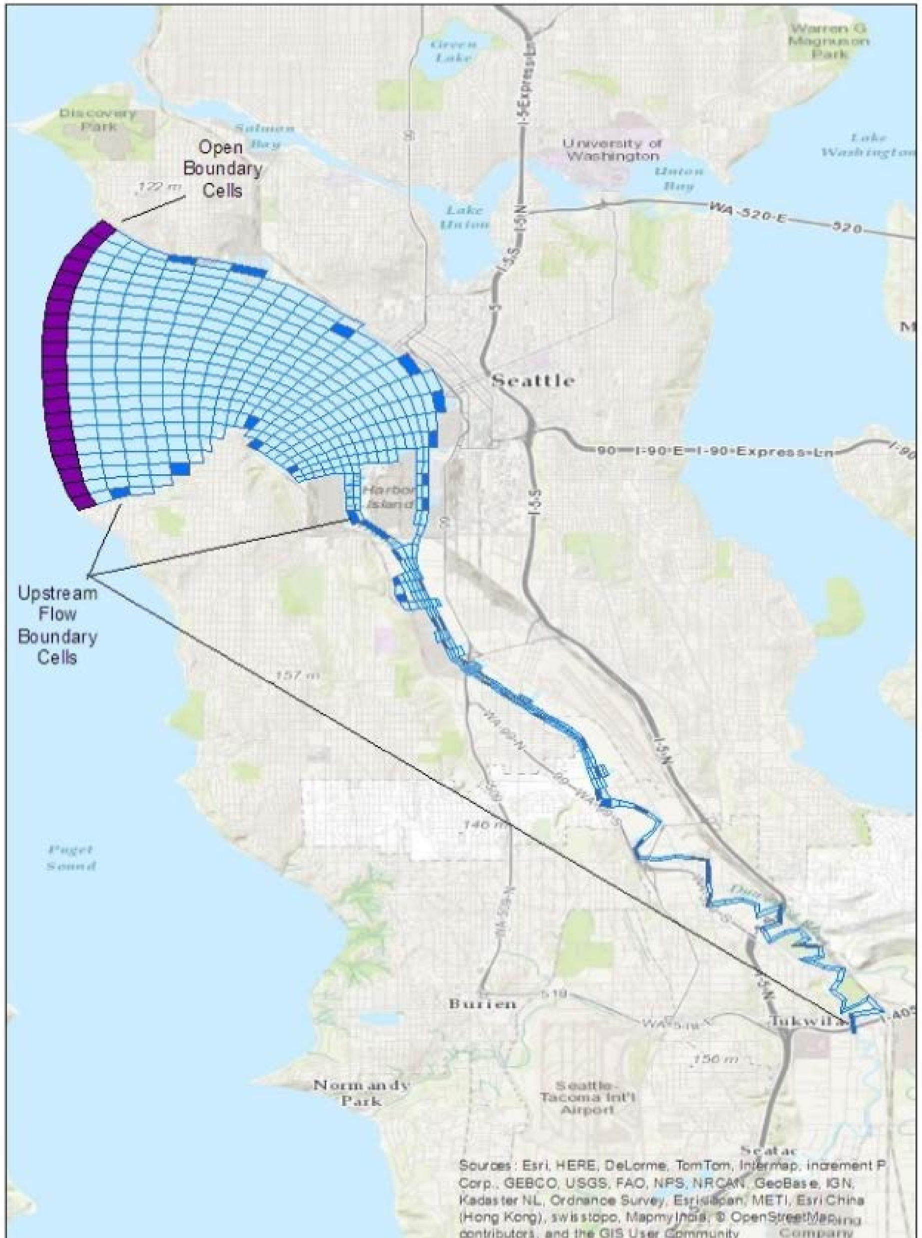
- Special emphasis on water column concentrations and the exchange between water column and bed sediments.

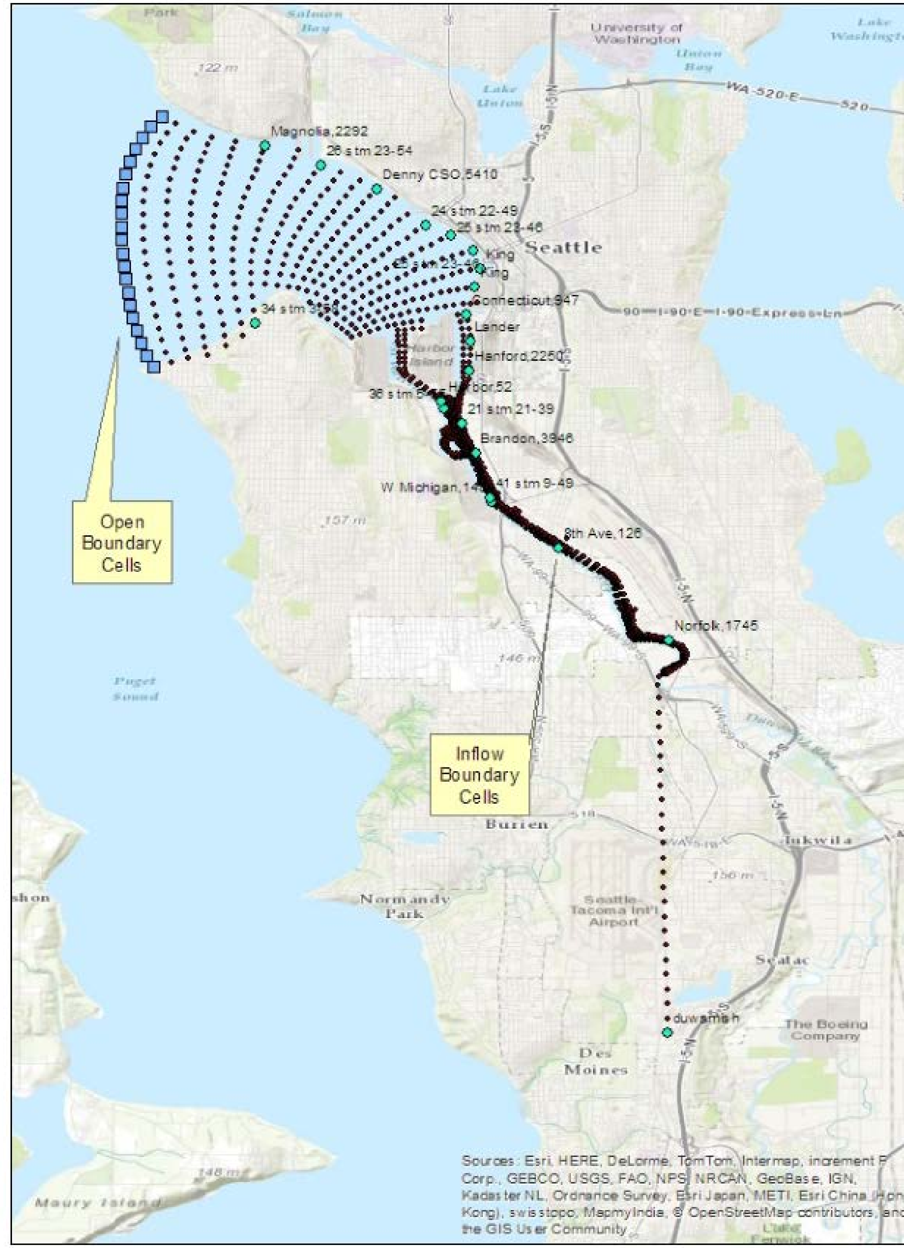
Contaminants in bed sediments

- Black carbon mediates organic contaminant transport
- Model does not simulate black carbon
- EFDC development will use black carbon concentrations, empirically, to adjust effective partition coefficients and resulting porewater concentrations
- Will rely on black carbon analysis by USACE (Gschwend et al., 2015)

EFDC Model Configuration

- Model Grid and Input File Development
- Boundary Conditions
- Initial Conditions


Open Boundary Cells
Upstream Flow Boundary Cells
Seattle
Harbor Island
Burien
Tukwila
Normandy Park
Seattle-Tacoma Int'l Airport
Seatac
Puget Sound
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community


Magnolia,2292
26 stm 23-54
Denny CSO,5410
24 stm 22-49
25 stm 23-46
King
King
Connecticut,947
34 stm 3
Lander
Hanford,2250
36 stm 6
Harbor,52
21 stm 21-39
Brandon,3946
W Michigan,14
41 stm 9-49
8th Ave,126
Norfolk,1745
duwamish
Open Boundary Cells
Inflow Boundary Cells
Seattle
Burien
Normandy Park
Seattle-Tacoma Int'l Airport
Des Moines
Tukwila
Seatac
Puget Sound
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Model Grid and Input File Development

- Model grid will be curvilinear-orthogonal
- Current model domain will be extended to RM17
  - EFDC will cover area of tidal influence
- Grid resolution (width x length) will remain similar
- Model layers
  - 10 water layers
  - 5 sediment layers
  - Might be adjusted during calibration
- Will evaluate utilizing multiple bathymetric datasets
  - Account for dredging activities

Dredging Activities

- ► Model input files utilize only 1 bathymetric dataset
- ► Calibrate model for smaller time period
- ► Change bathymetric dataset
  - Representative of different time period
  - Compare simulated results to measured data
  - Potentially adjust model parameters
- ► During model configuration, will determine # time periods to represent

Boundary Conditions

- Upstream Boundary
  - USGS station 12113000
  - LSPC simulated flows and concentrations
- Lateral Boundaries
  - LSPC simulated flows and concentrations
  - Existing monitoring/modeling of CSOs
- Downstream Open Boundary
  - Tidal Predictions from NOAA Stations
    - Duwamish Waterway, Eighth Ave. South (Id. 9447029)
    - Seattle, WA (Id. 9447130)
  - Elliott Bay data (quality)
- Atmospheric Deposition
  - Existing studies

Initial Conditions

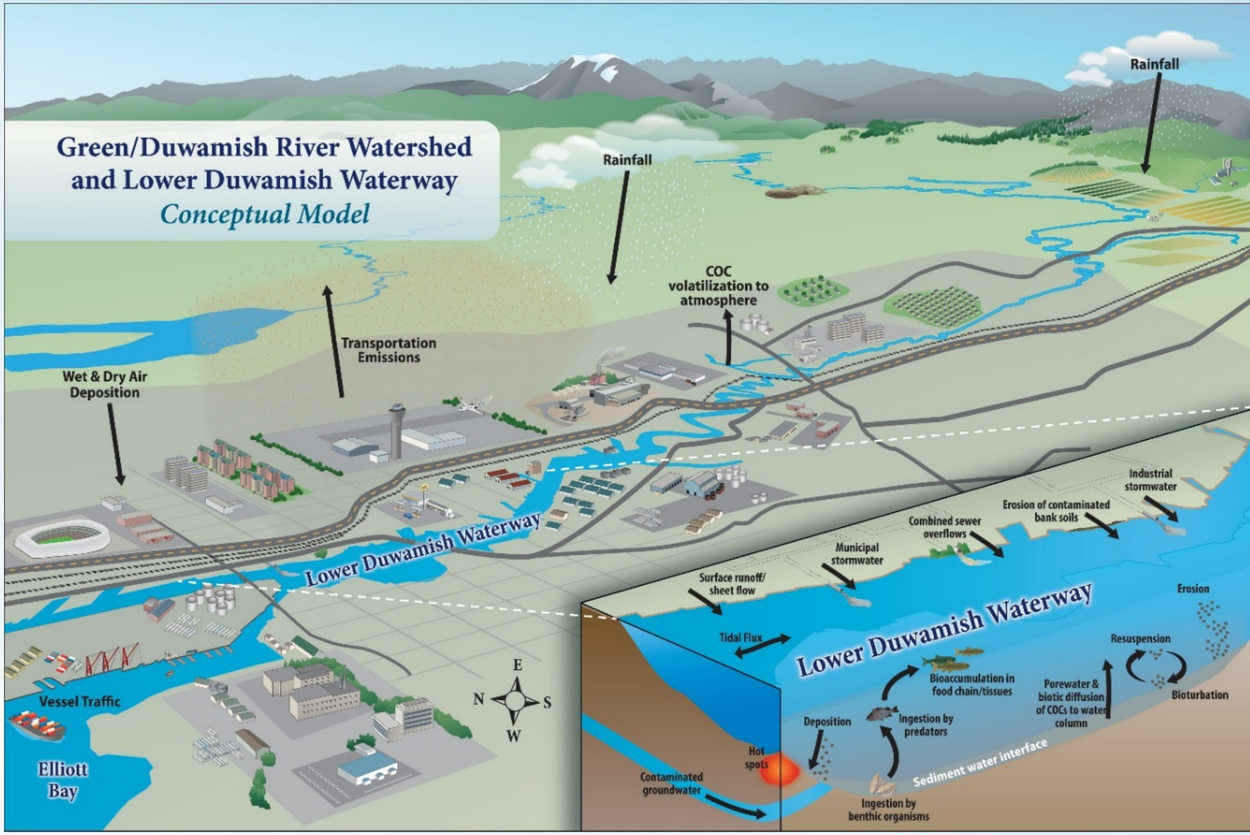
- Required for conventional pollutants, sediment and toxics
  - Water Column Layers
  - Bed Sediment Layers
- Water Column
  - Highly variable
  - Model “spin-up” period of a few months to a few years
- Bed Sediment
  - Will rely heavily on monitoring data
  - Model “spin-up” period of several years

EFDC Linkage to Other Models

- Outputs from LSPC
  - Flow
  - Sediment
  - Containment load (dissolved and sediment-sorbed)
- Outputs from CSO models
- Facilitate with scripting (e.g., Python)

EFDC Model Calibration

- Time Period and Approach
- Hydrodynamic Calibration and Evaluation
- Sediment Transport Calibration and Evaluation
- Water Quality Calibration and Evaluation

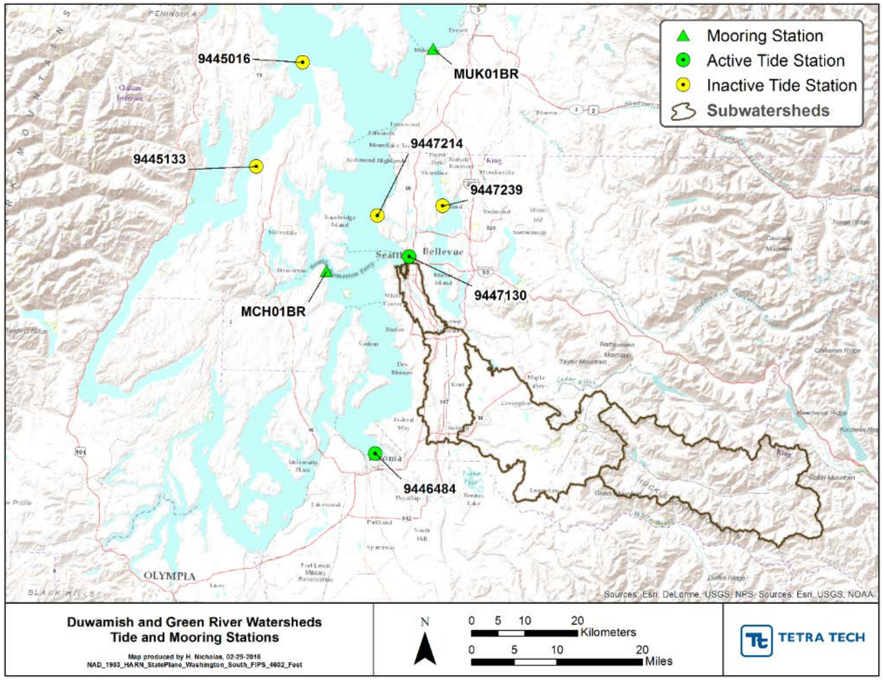


Time Period and Approach

- Calibration sequencing
  - Hydrodynamics
  - Sediment Transport
  - Water Quality
- Time Period
  - Initial focus on 1996-2007
  - Small time periods based on bathymetric data
  - Additional calibration and model testing beyond 2007 to take into account more recent data will also be conducted

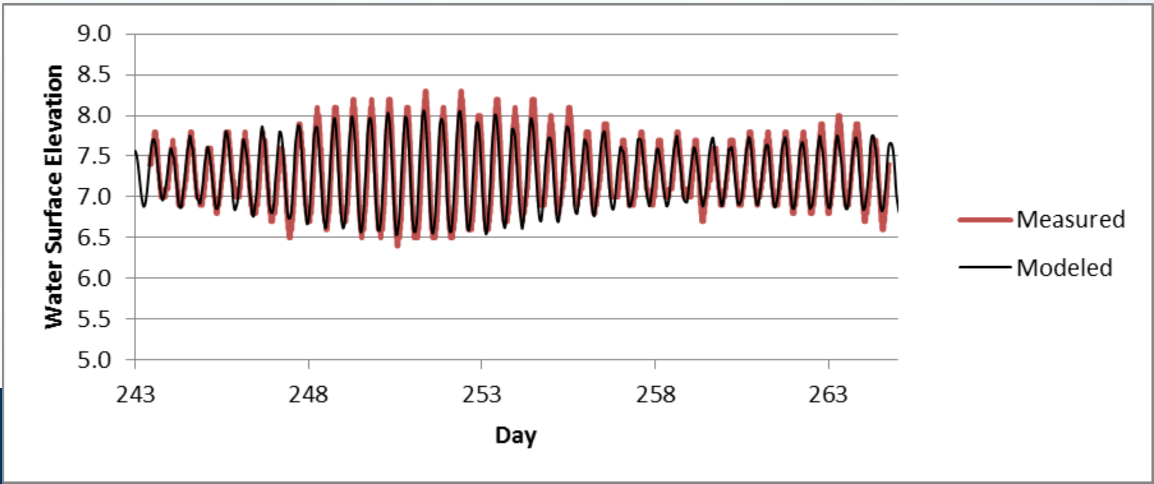
Hydrodynamic Calibration and Evaluation

- EFDC hydrodynamics will be calibrated for:
  - Water surface elevation
  - River velocities
  - Salinity
  - Temperature
- Calibration will be based on:
  - Graphical assessment
    - Various time periods
    - Trends
  - Statistical tests for goodness-of-fit

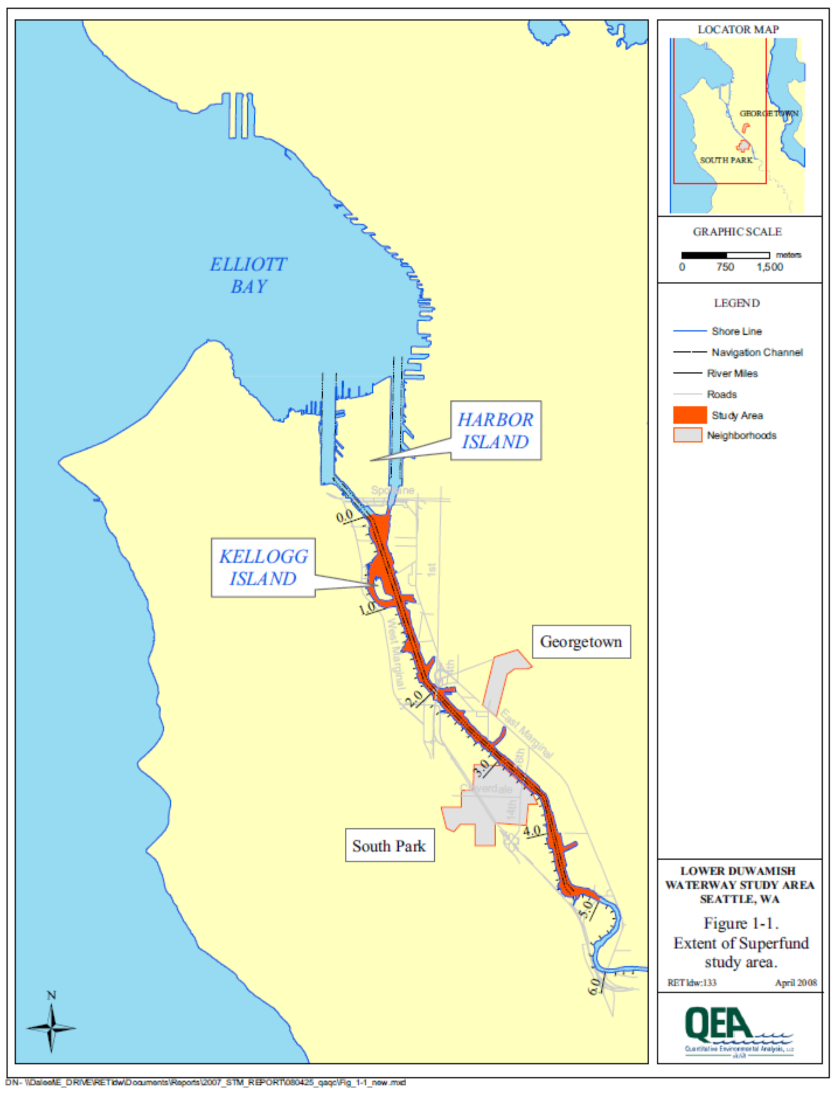


Hydrodynamic Calibration and Evaluation

- EFDC will be evaluated to reproduce
  - Water surface elevations
  - Flow distribution
  - Flow and current speed dynamics at different locations within the estuary
  - Temporal variations of salinity at different locations
  - Vertical salinity structure at different locations
  - Temporal variations of temperature
  - Vertical temperature structure at different locations



Previous Modeling (QEA, 2008)



Tide Calibration Example

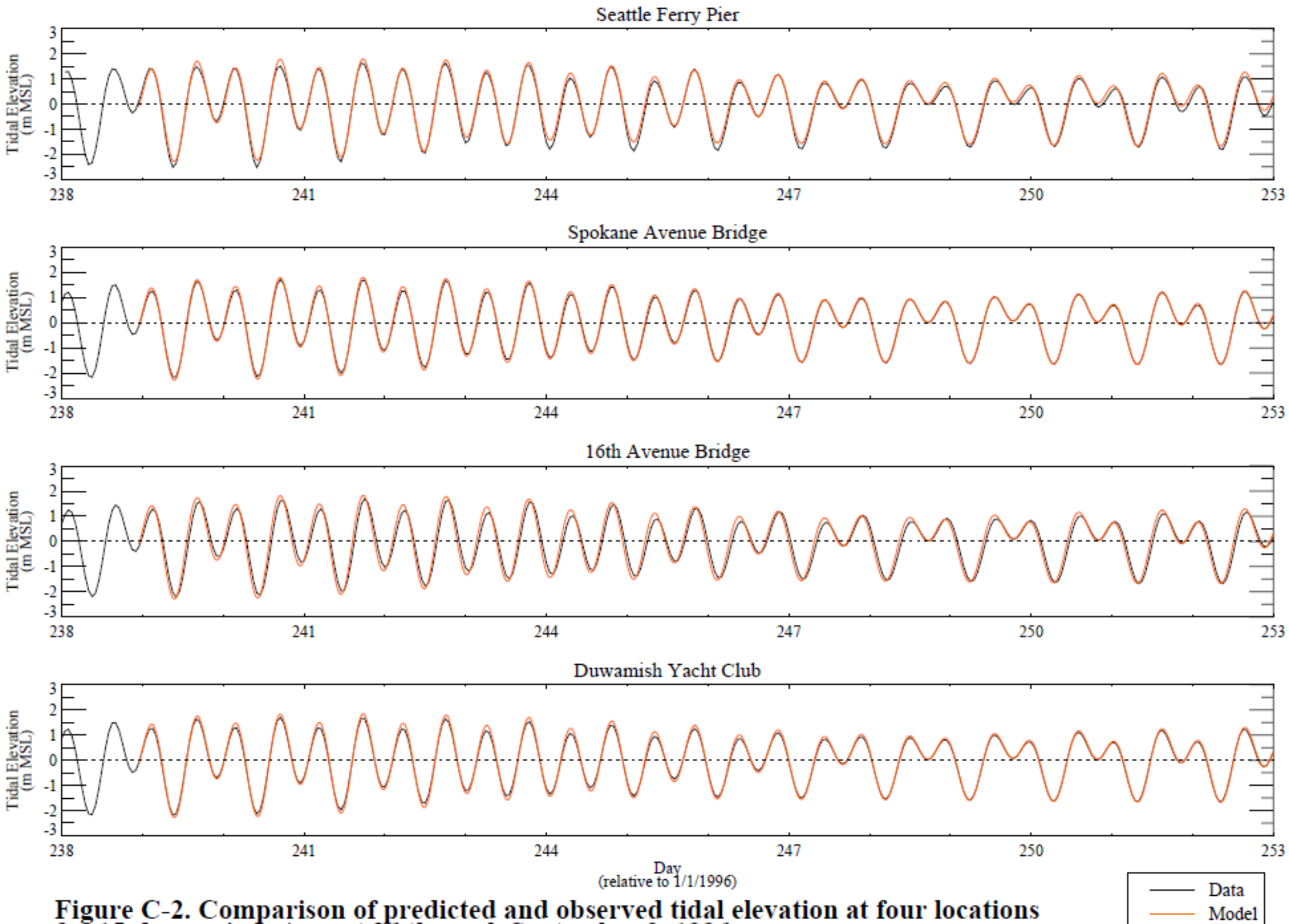


Figure C-2. Comparison of predicted and observed tidal elevation at four locations for 15-day period: August 26 through September 9, 1996.

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Mon Jun 11 13:34:38 2007

Velocity Calibration Examples

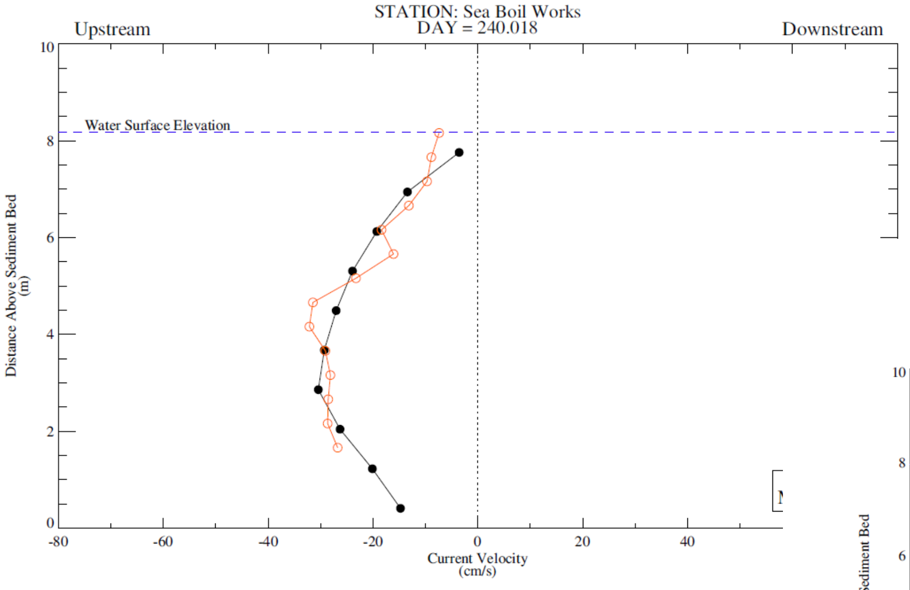

Figure C-8a. Comparison of predicted and observed current velocity at Sea Boil Worl during 10-hr period on August 28, 1996.

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Tue Jun 12 09:45:37 2007

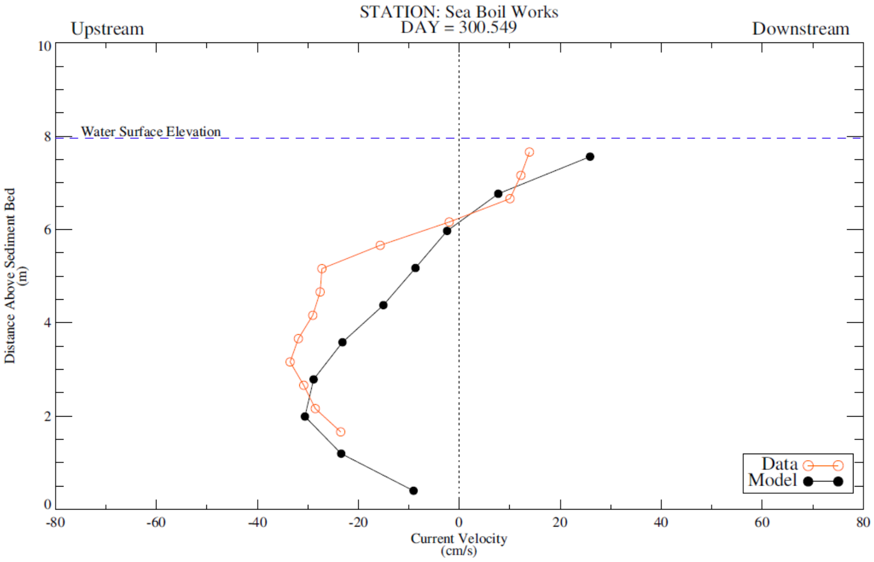

Figure C-13g. Comparison of predicted and observed current velocity at Sea Boil Works station (RM 2.35) during 20-hr period on October 27, 1996.

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Tue Jun 12 09:59:18 2007

Salinity Calibration Example

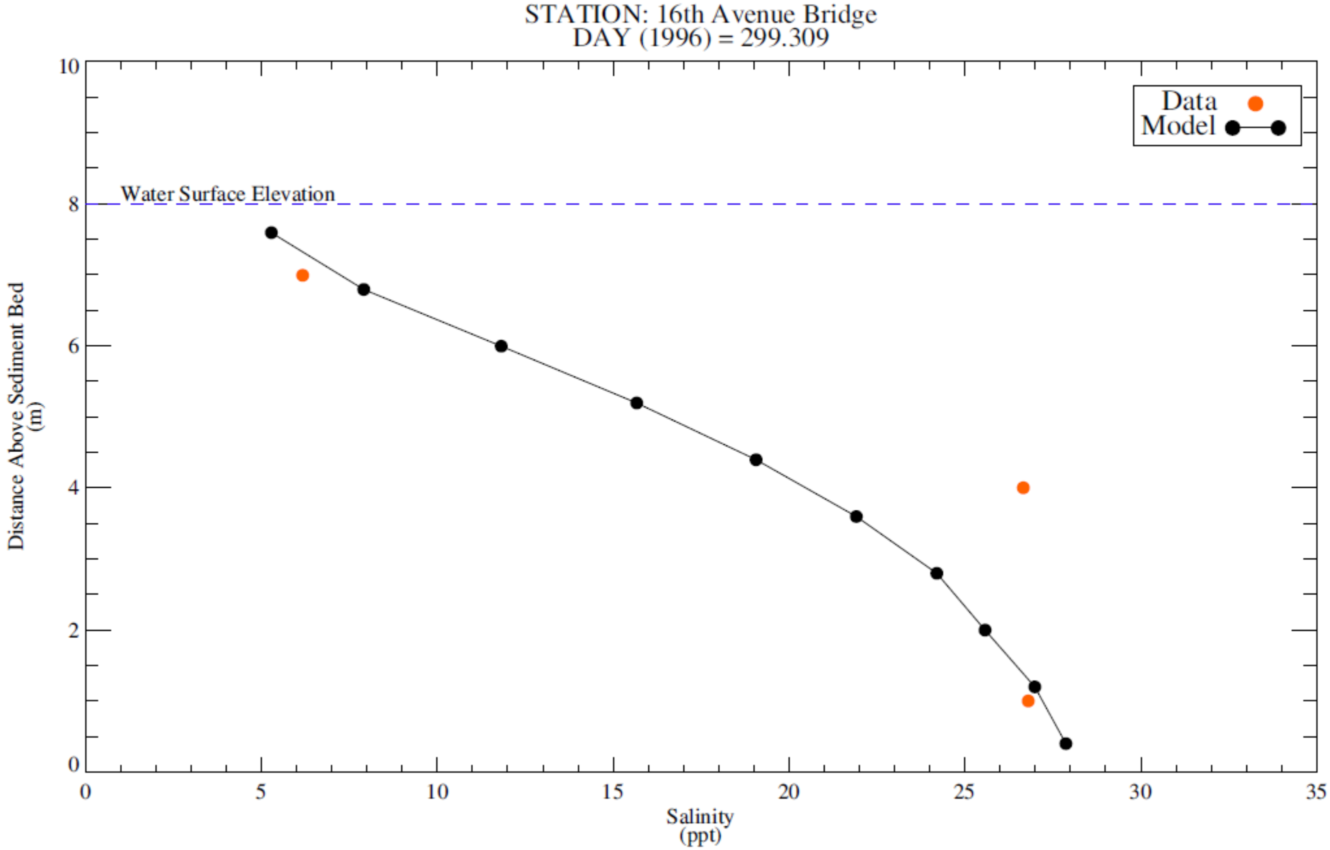

Figure C-14h. Comparison of predicted and observed salinity at 16th Avenue Bridge (RM 3.35) during 13-hr period on October 25-26, 1996.

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Tue Jun 12 10:23:51 2007

Hydrodynamic Calibration and Evaluation

- Statistical tests
  - Coefficient of Determination (R^2)
  - Mean Absolute Error (MAE)
  - Root Mean Squared Error (RMSE)
  - Normalized Root Mean Squared Error (NRMSE)
  - Index of Agreement (IA)

Sediment Calibration and Evaluation

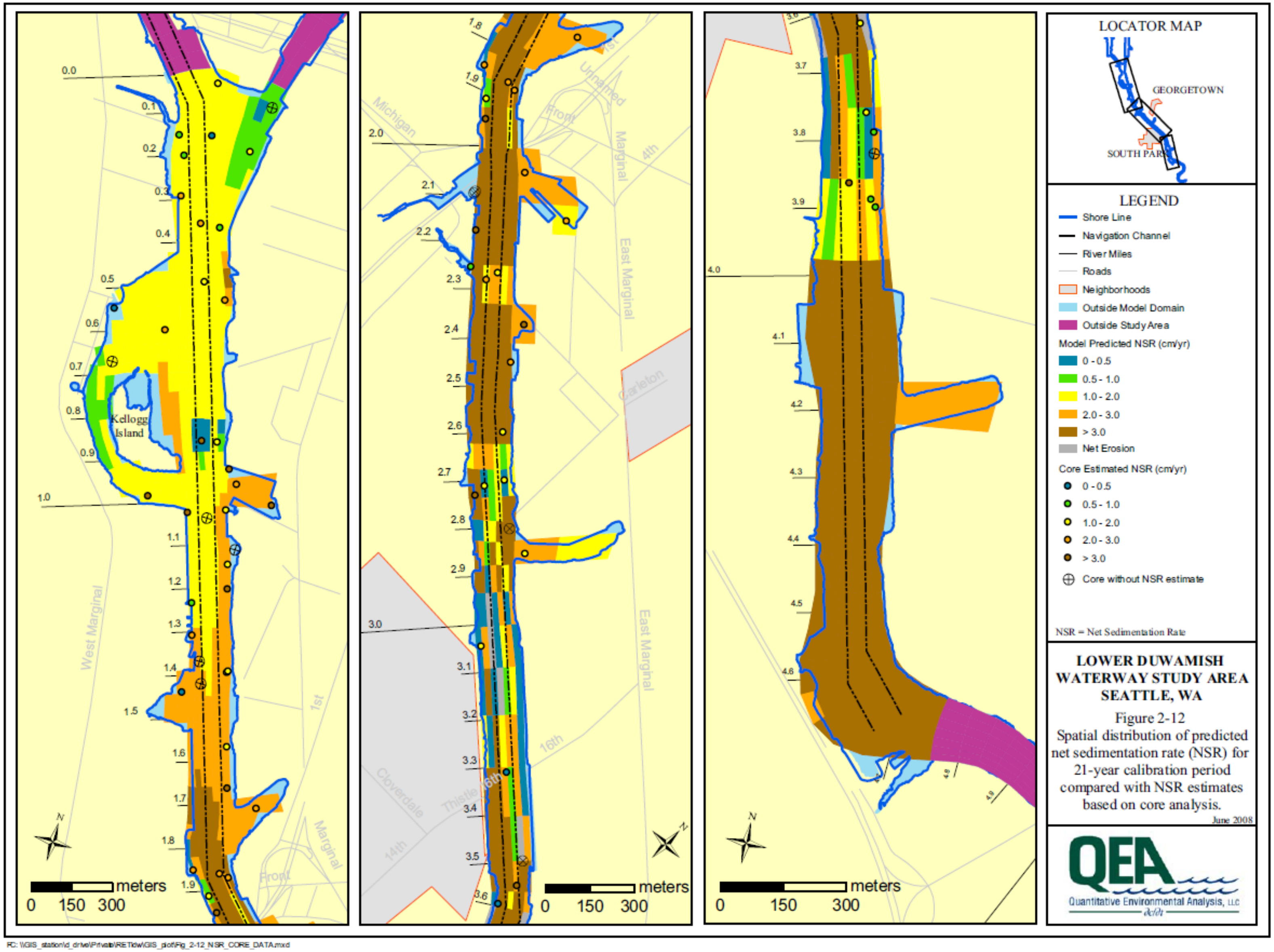
- Sediment Transport will be calibrated for:
  - Suspended sediment concentrations
  - Net flux of suspended sediment
  - Bed morphology changes at select locations

Sediment Calibration and Evaluation

- Calibration parameters include:
  - River, watershed, internal and point source suspended sediment loads and their distribution into modeled classes (sand, silt, clay)
  - Effective particle diameters and/or settling velocities
  - Erosion parameters
    - Critical stress and mass erosion rates for cohesive sediment

- Calibration will focus on graphical comparisons
  - If enough suspended sediment data are available, then a goodness-of-fit statistics analysis will be performed

Example calibration - net sedimentation rate



Example calibration - net sedimentation rate

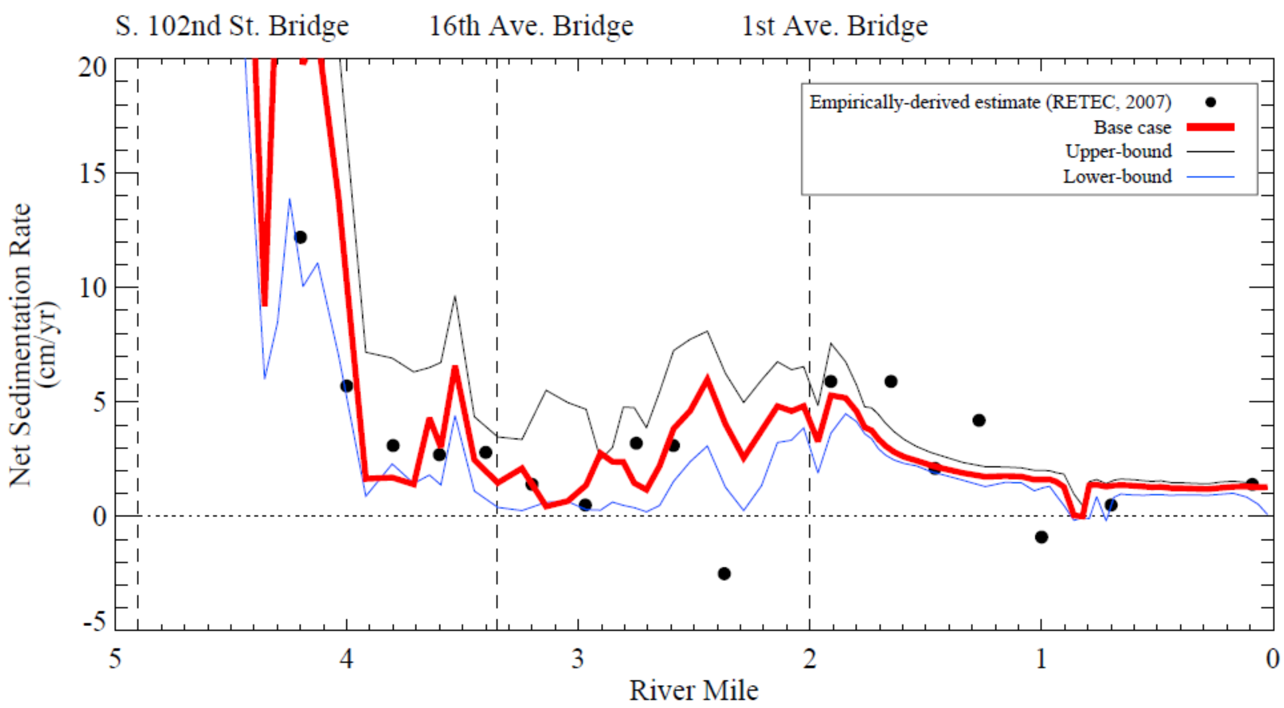


Figure 2-14. Comparison of predicted and empirically-derived estimates of net sedimentation rates in the navigation channel for 21-year calibration period.

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Thu Jun 19 11:03:59 2008

Additional Examples

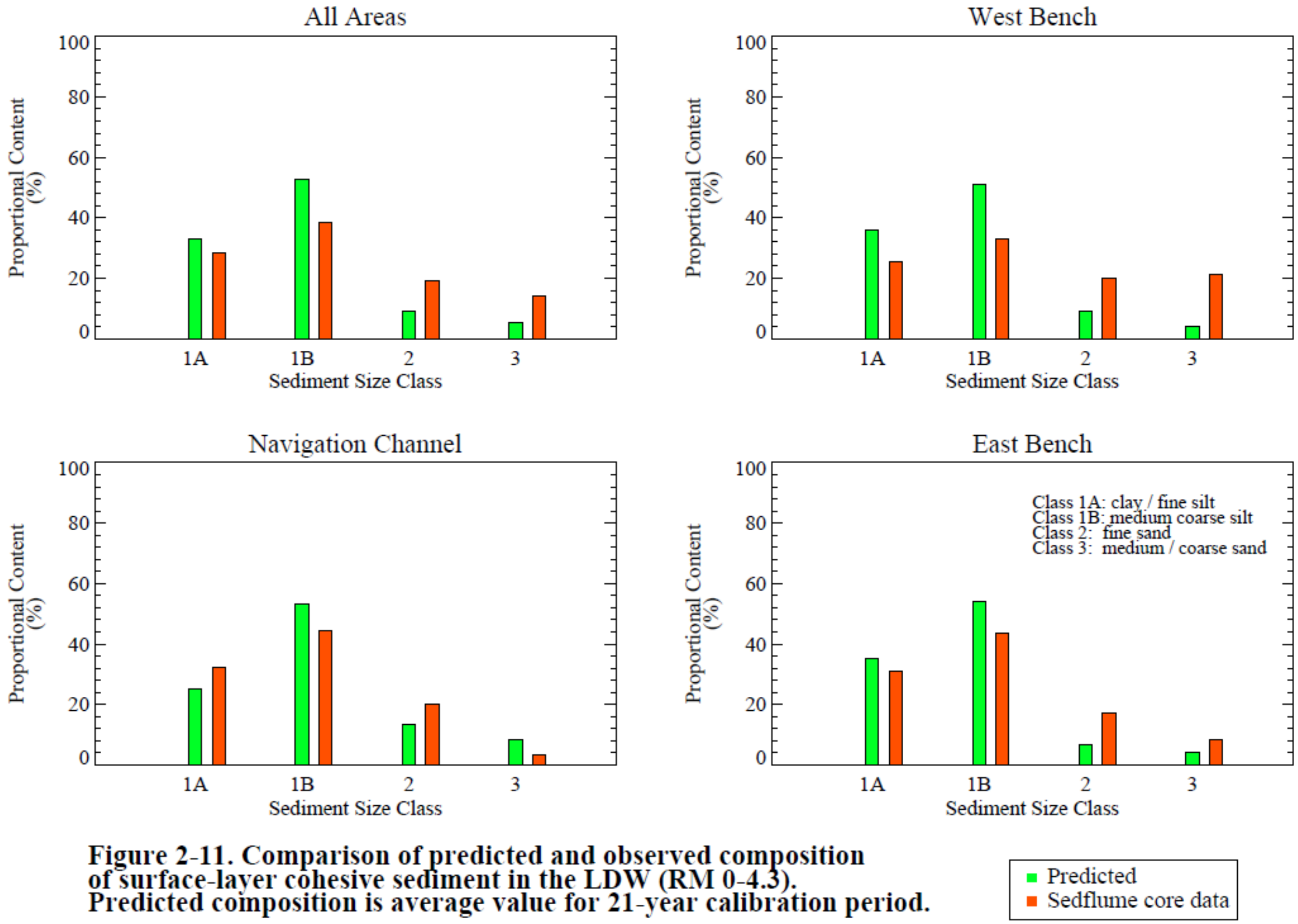

Figure 2-11. Comparison of predicted and observed composition of surface-layer cohesive sediment in the LDW (RM 0-4.3). Predicted composition is average value for 21-year calibration period.

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Wed Apr 30 08:56:50 2008

Water Quality Calibration and Evaluation

- Calibration approach similar to hydrodynamics:
  - Graphical and Statistical Comparisons
  - Statistics
    - R2, MAE, RMSE, NRMSE and IA
    - Computed mean, median, 5^{th} and 95^{th} percentiles
    - If measured data is less than 3 data values, average value of data compared to average simulated value
- Calibration conducted in Two-Stage approach
  - Visual Comparison
    - Reproducing trend and overall dynamics of system
  - Fine tuning the parameters and then calculating statistics

Questions and Discussion