Los Angeles and Long Beach Harbors and San Pedro Bay Modeling

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Presentation Outline

- Modeling Approach
- Overview of Draft Hydrodynamic Modeling Report
- Response to Comments
- Improving the Calibration
- Sediment Transport Model
- Contaminant Transport Model
- Schedule for Remaining Task

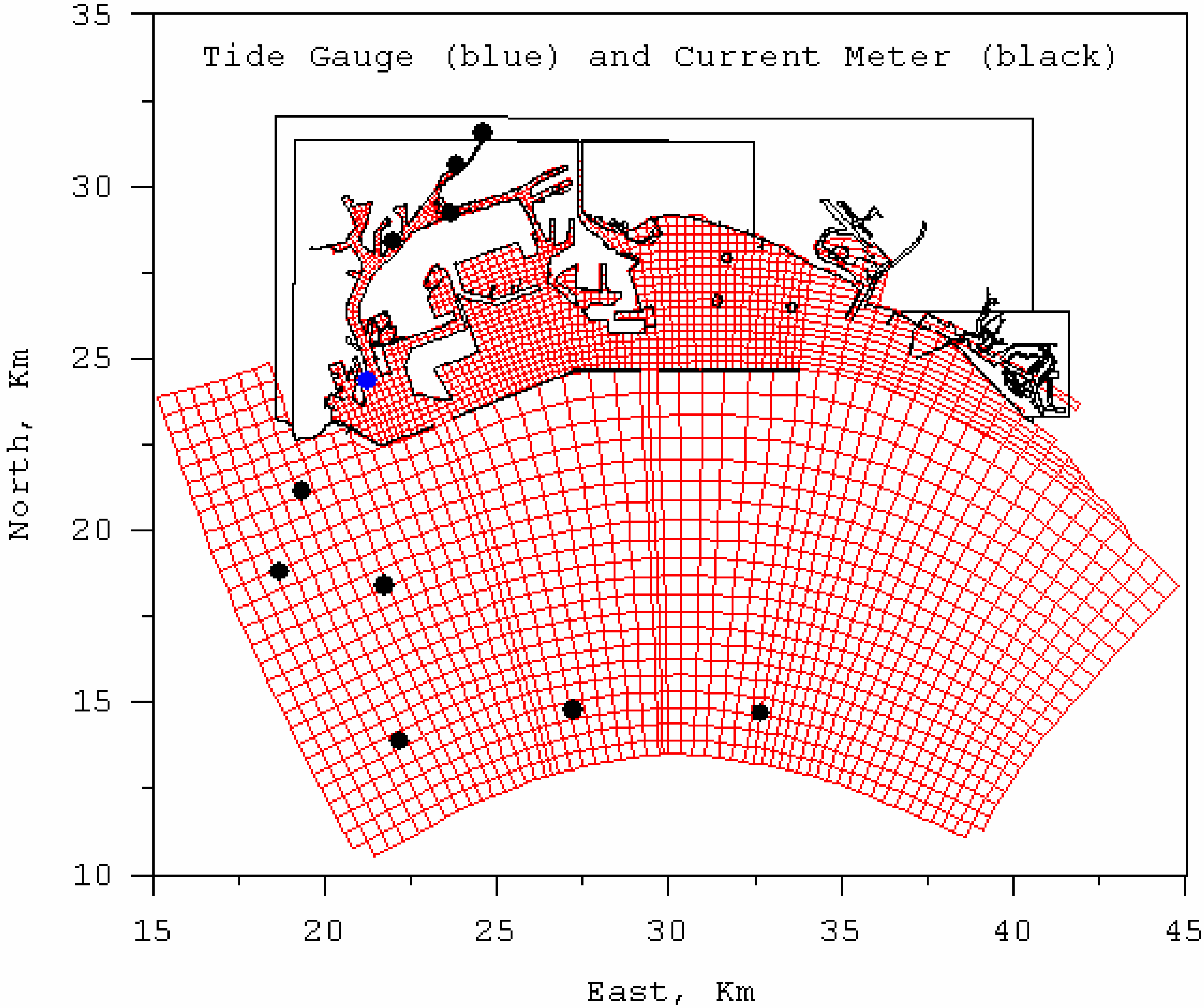
Greater Harbors Modeling Approach

- Multi-Component EFDC Modeling System
- Model Configuration
- Observational Data to Support Model Configuration and Calibration
- Model Calibration
- TMDL Scenario Simulations

Hydrodynamic Model Configuration

- Model Grid and Bathymetry
  - Bathymetry Updated with Most Recent Data
  - Grid Extended to Include Dominguez Channel (Not Shown if Figures or Noted in Text)
- Hydrodynamic Open Boundary Conditions in San Pedro Bay
  - Hydrodynamic BCs Based on Inverse/Optimization Procedure (To Be Documented in Revised Report Appendix)

Model Grid System



Hydrodynamic Open Boundary Condition

ζ and **u** are unknown on 3 open boundaries

ζ_R is constructed for each open boundary using an inverse optimization scheme to minimize the least squares error between observed and model predicted ζ and **u** in the interior of the model domain

$$\zeta - \frac{\mathbf{n}\cdot\mathbf{u}H}{\sqrt{gH}} = 2\zeta_R$$

$$\zeta_R = \zeta_{RLF} + \sum_{m=1}^{M}\left(\zeta_{RCm}\cos\left(\omega_m t\right) + \zeta_{RSm}\sin\left(\omega_m t\right)\right)$$

Hydrodynamic Model Configuration

- Salinity and Temperature Open Boundary Conditions in San Pedro Bay
  - Salinity Set to Constant Value and Supported by Available Observational Data
  - Temperature Set to Constant Value
  - Temperature Responses to Local Atmospheric Conditions
  - Temperature Modeled to Predict Evaporation Which Is of Secondary Importance

Hydrodynamic Model Configuration

- Atmospheric Forcing
  - Wind Speed and Direction
  - Atmospheric Conditions to Simulate Air-Sea Heat Exchange
  - Direct Water Surface Rainfall Included
- Atmospheric Forcing Data Sources
  - Long Beach Airport
  - CIMS Stations
  - Off Shore Wind Buoy
  - NOAA Ports (Unable to Obtain Data At Present)

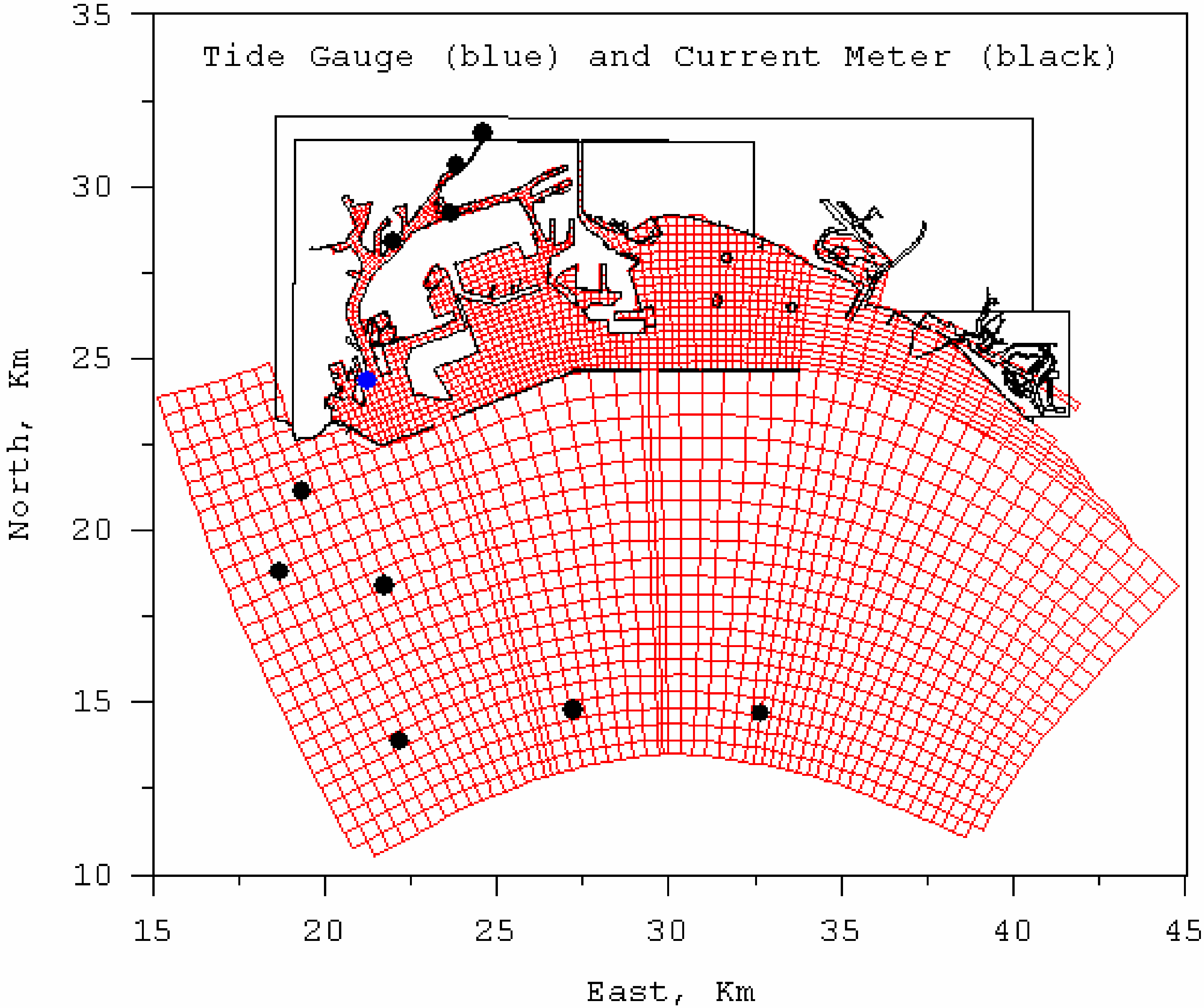
Hydrodynamic Model Configuration

- Freshwater Inflows
  - Used Both Observed and Watershed Model Generated Flows for Dominguez Channel, LA River and San Gabriel River
  - Watershed Model Generated 63 Near Shore Sub-Watershed Flows Distributed Into 435 Horizontal Grid Cells

Water Level and Current Calibration

- Water Level and Current Observations
  - 5 WL Stations Including NOAA LA Harbor and 4 DCEMS Station
  - 10 Current Meter Stations Including 6 in San Pedro Bay and 4 DCEMS Station
- Harmonic Analysis at Tidal Frequencies
- Time Series Analysis at Tidal and Sub-Tidal Frequencies
  - Sub-Tidal Current Analysis To Be Added to Revised Report

Model Grid System



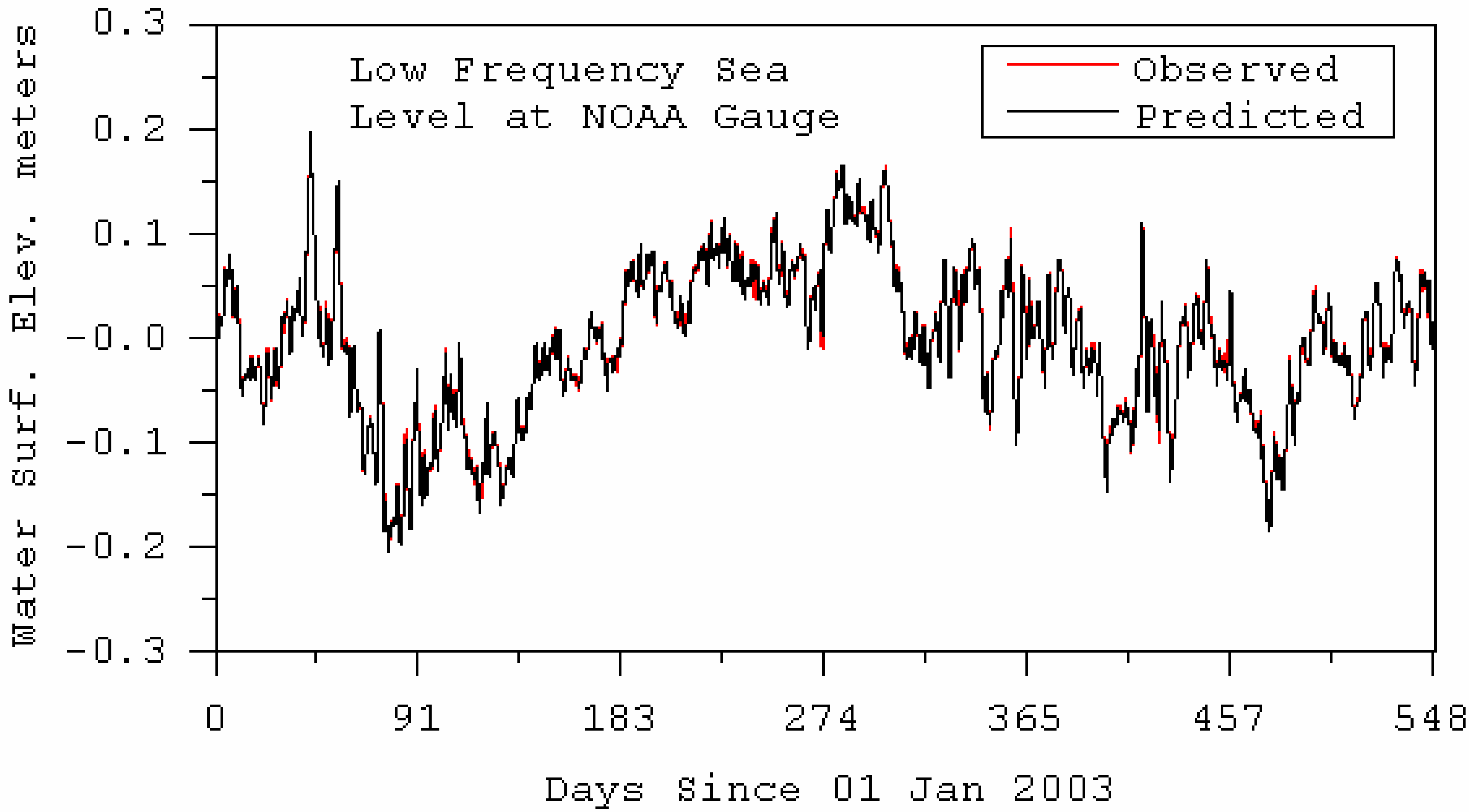
WL Harmonic Analysis (Tables 3-7)

Tidal Constituent	Observed Amplitude (meters)	Modeled Amplitude (meters)	Amplitude Error (|Observed-Modeled|/Observed)	Observed Phase (seconds)	Modeled Phase (seconds)	Phase Error (Seconds)
M2	0.503	0.505	0.004	27434	27498	64
S2	0.203	0.202	0.005	31335	31149	186
N2	0.119	0.119	0.000	31824	31657	167
K1	0.371	0.364	0.019	19854	19095	759
O1	0.246	0.240	0.024	7829	7082	747
P1	0.107	0.102	0.047	22894	26560	3666

WL Time Series Analysis (Table 8)

Statistical Measure	Instantaneous	Low Frequency
Mean Error (meters)	0.001	0.001
Absolute Mean Error (meters)	0.122	0.003
Maximum Absolute Error (meters)	0.670	0.047
RMS Error (meters)	0.168	0.004
RMS Error/RMS Observed	0.324	0.058
Linear Regression Intercept (meters)	0.001	0.001
Linear Regression Slope	0.959	0.993
Correlation Coefficient	0.986	0.997
Skill (0 to 1, 1 being perfect)	0.973	0.999

Sub-Tidal Water Level Comparison



Tidal Current Harmonic Analysis for San Pedro Bay Stations (Figures 9-14)

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
PV A6	0.053	0.023	9126	8091	160	170
PV A7	0.096	0.047	10840	9709	179	180
PV A8	0.047	0.060	5084	4326	145	152
PV A9	0.069	0.059	7843	9190	171	15 (195)
PV AB	0.053	0.077	2731	5080	141	161
PV AD	0.052	0.050	21788	3125	126	117

Tidal Current Harmonic Analysis for DCEMS Stations (Figures 15-20)

Station	Observed Major Amplitude (m/s)	Modeled Major Amplitude (m/s)	Observed Phase (seconds)	Modeled Phase (seconds)	Observed Angle (degrees CCW from East)	Modeled Angle (degrees CCW from East)
206 B	0.021	0.017	19382	21780	1	14
200G	0.023	0.019	15881	14407	57	29
173	0.020	0.026	10989	12645	59	53
DC PA	0.365	0.317	17542	17306	64	60

Water Level and Current Calibration

- Is the Calibration Good Enough?
- Comparison Can Be Made with Other Modeling Studies
- NOAA Standards for Water Level and Current Prediction
- This Information Will Be Added to Appendix B

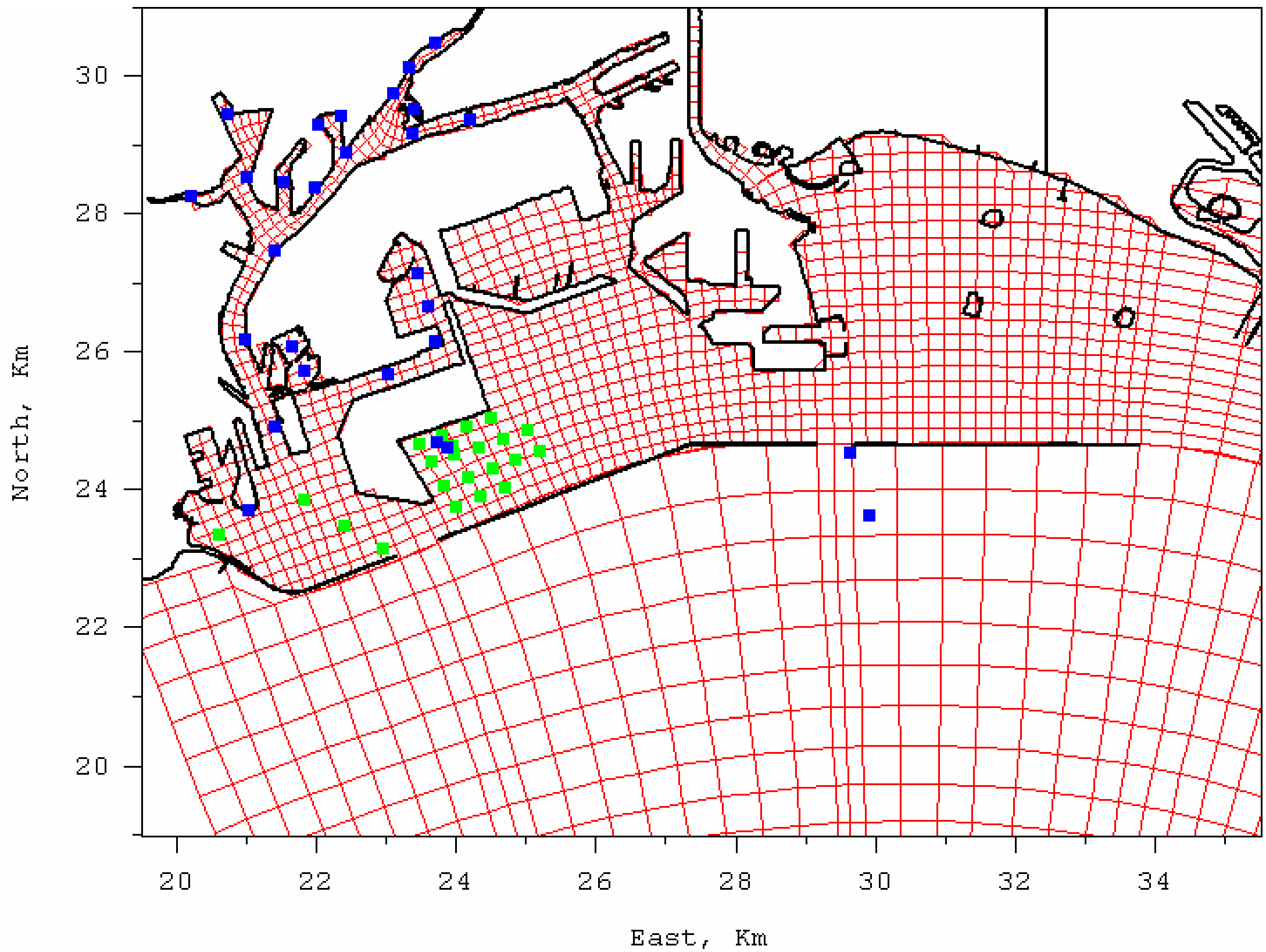
Salinity and Temperature Calibration

- Compare Model Predictions with Observational Data
- Significant Salinity Variability Associated with Inflow Events
- Temperature Simulation Activated to Account of Direct Rainfall and Evaporation But Did Not Improve Salinity Predictions
- Otherwise Temperature Is of Secondary Importance

Salinity Calibration Data

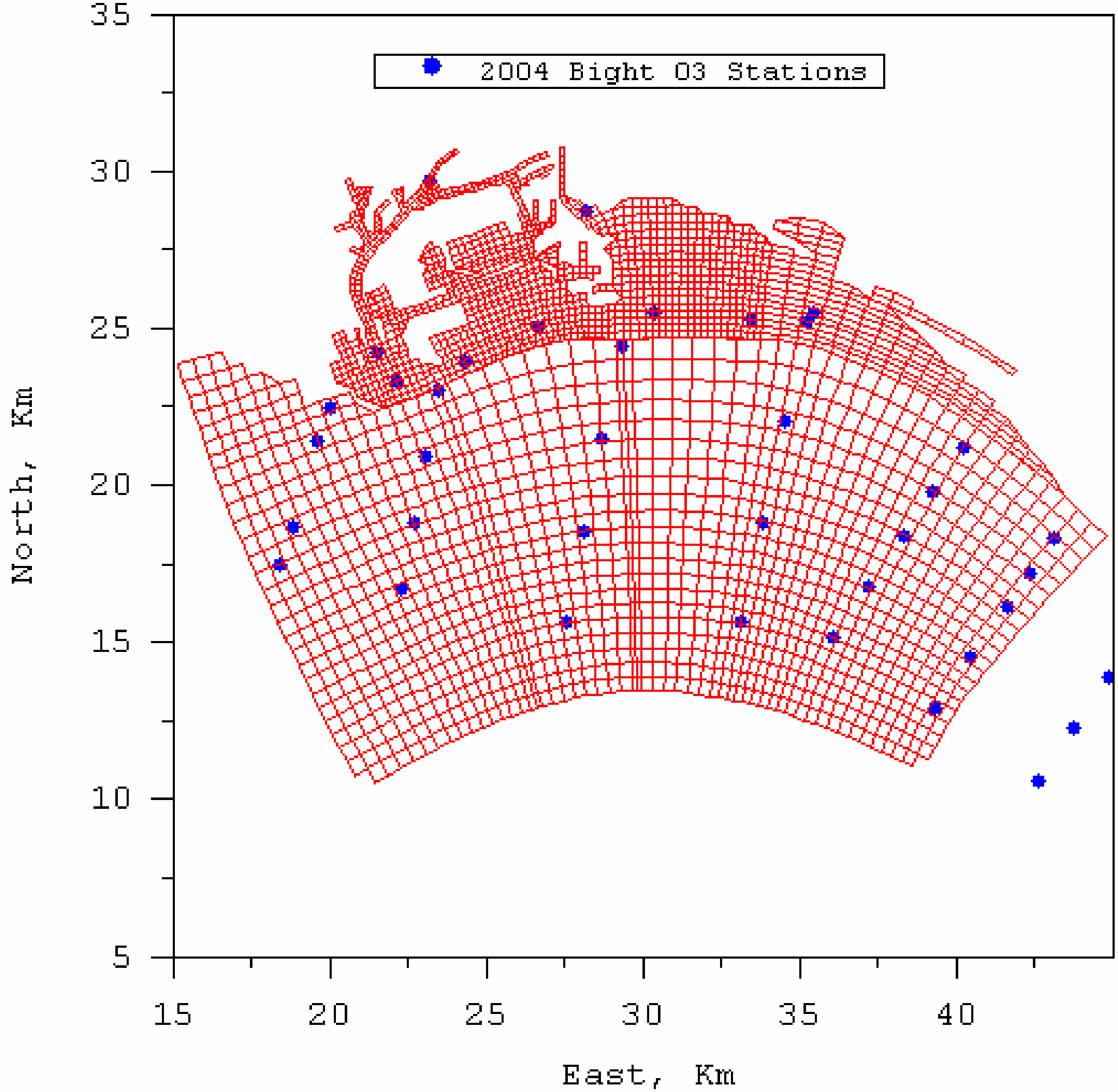
- Observational Data Used to Date
  - LA Harbor Monitoring Data
  - Bight 03 Event Sampling Data
- Other Data That Could Be Used
  - DCEMS Data Sets

Salinity Monitoring Stations, LA Harbor



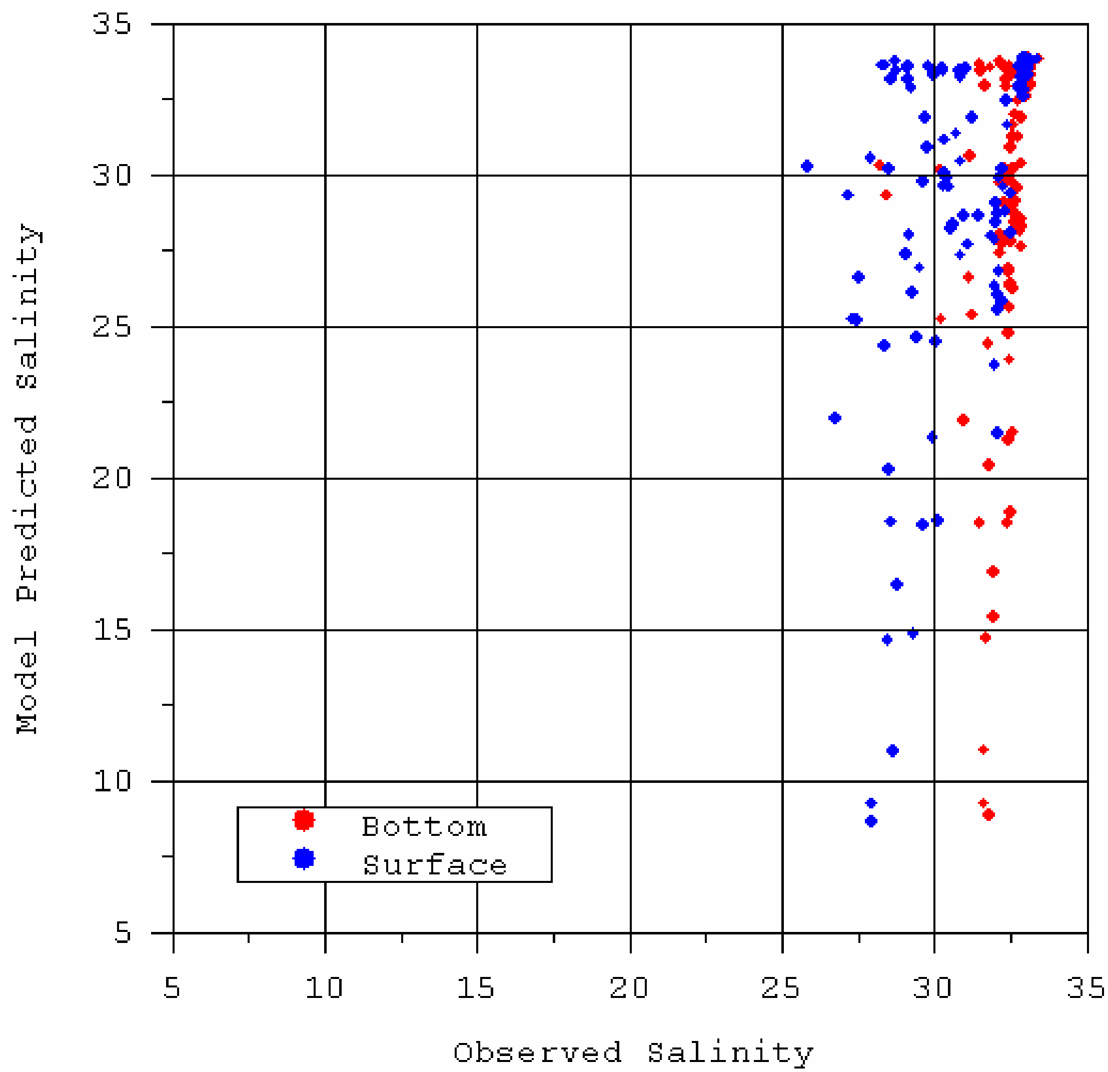
Bight 03 Event Station

Only 6 Stations Have Significant Variability



Comparison of 20 Stations Near Pier 400

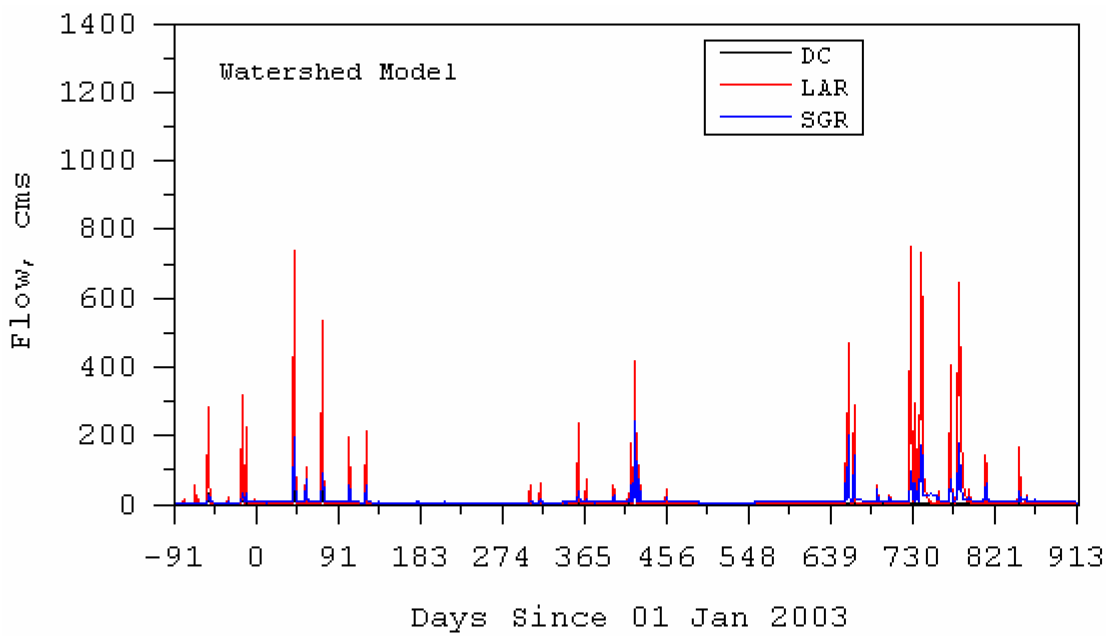
(Figure 6)

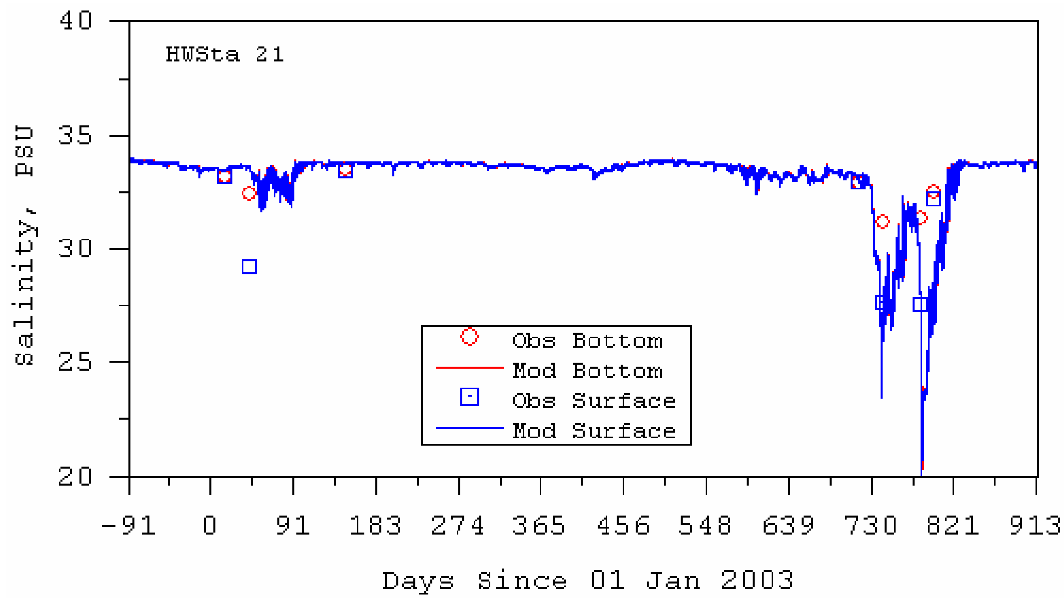


Salinity Calibration

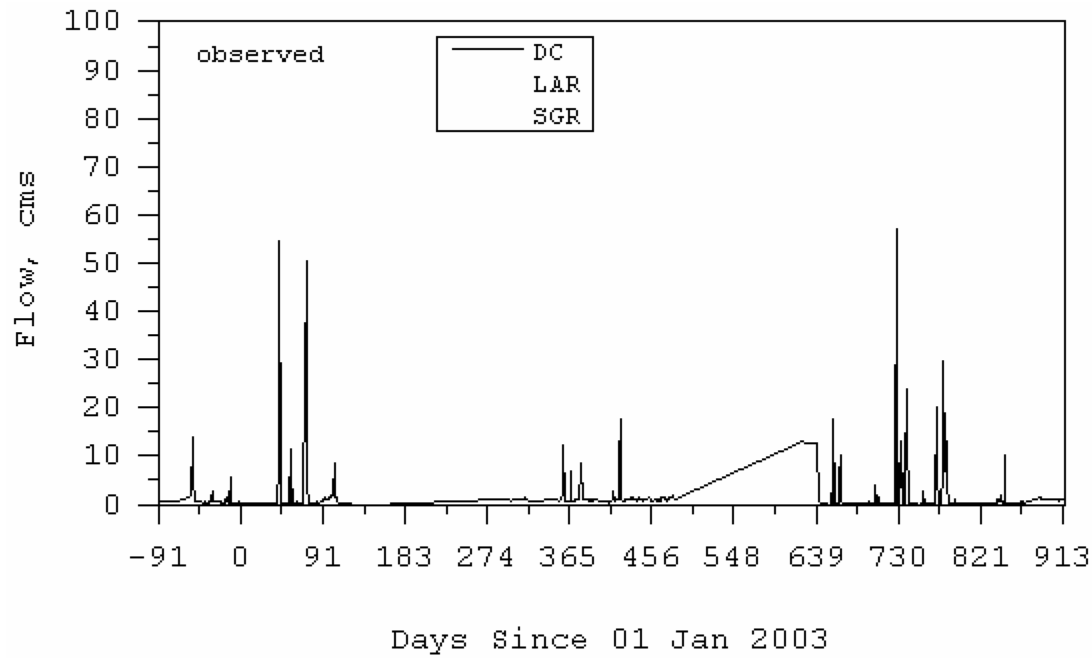
- Current Calibration Is Poor
- Under Prediction of Salinity and Stratification at Stations Near Pier 400
- Potential Causes Being Investigated
  - Freshwater Inflow
  - Errors in Tide and Wind Induced Transport
  - Excessive Vertical Mixing
- Include Comparisons with DCEMS Data Sets

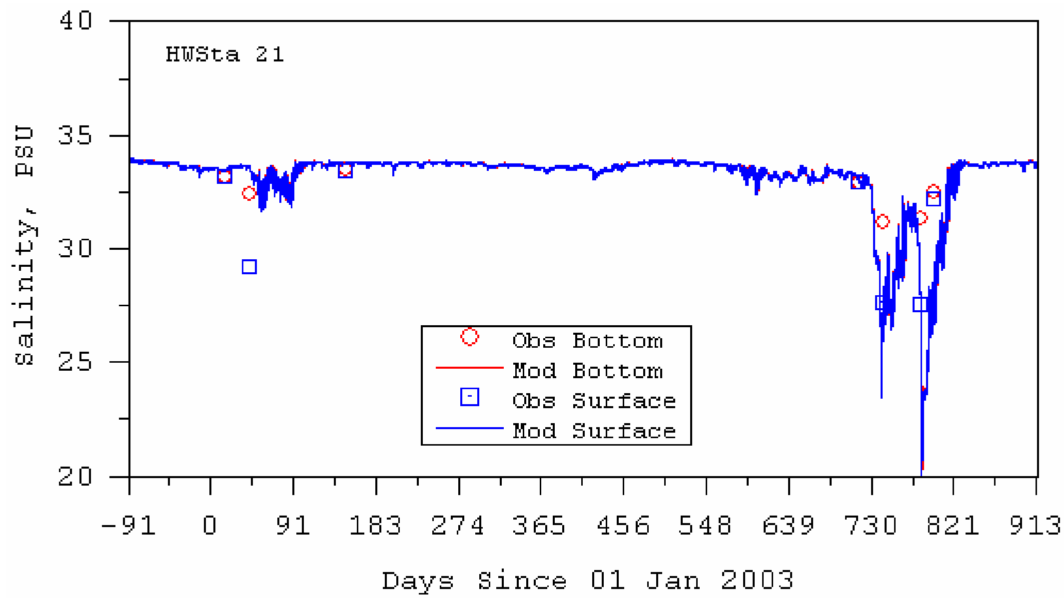
River Flows and Salinity Response Over 3 Year Simulation Period



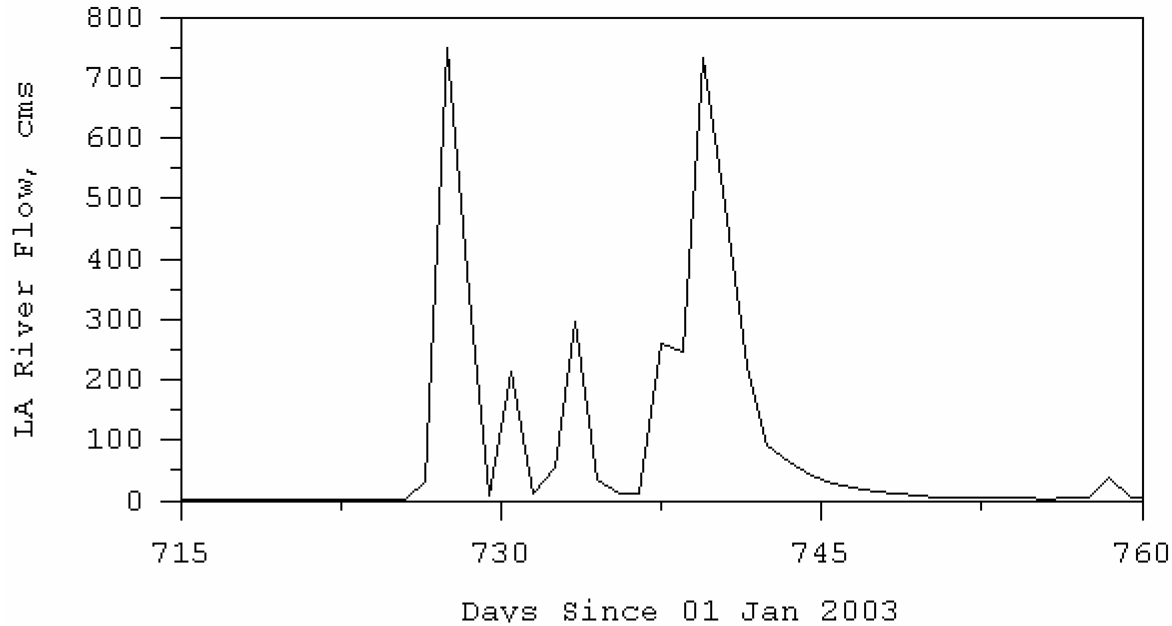


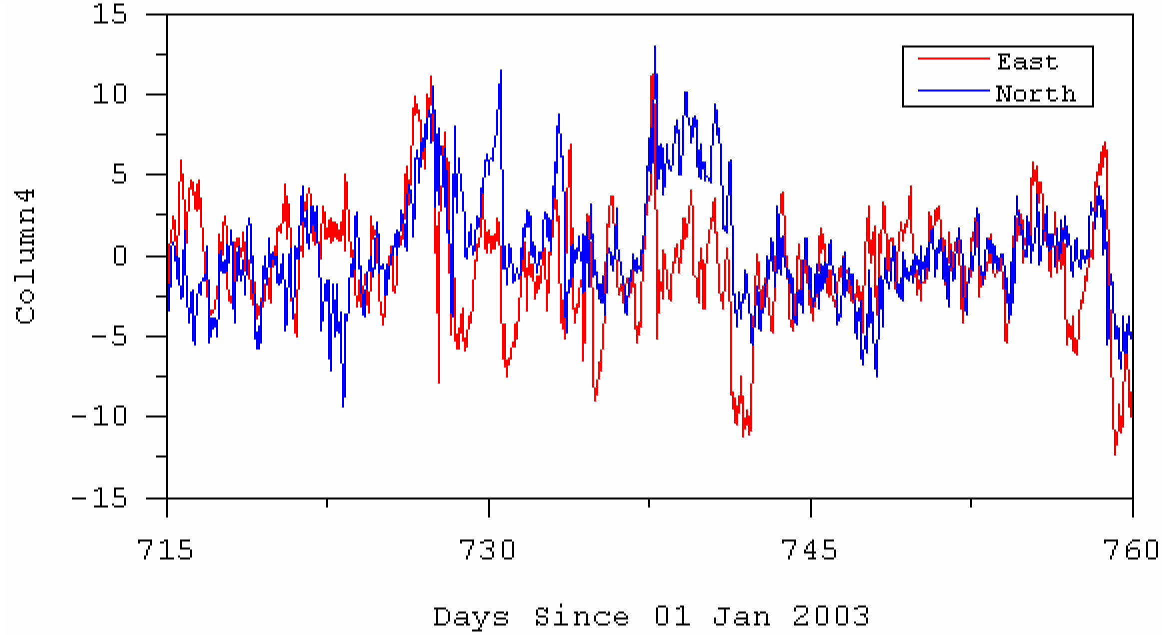
River Flows and Salinity Response Over 3 Year Simulation Period



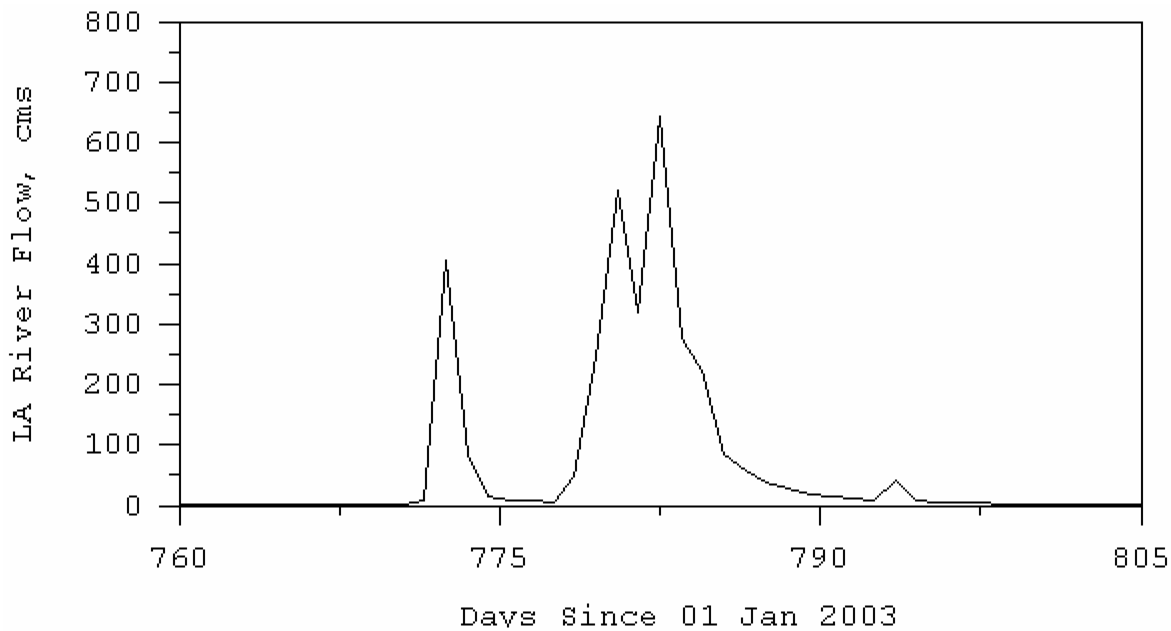


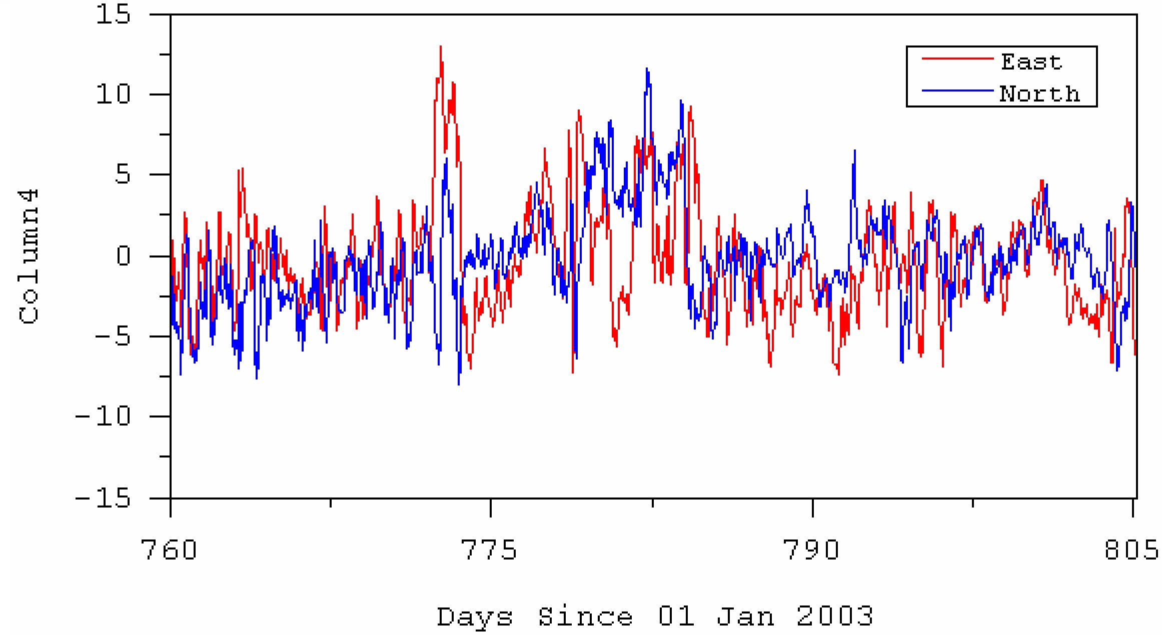
LA River Flow and Offshore Wind During 1st Early 2005 Event





LA River Flow and Offshore Wind During 2nd Early 2005 Event





Hydrodynamic Model Status

- Salinity Calibration Problem Resolution Is High Priority
- Response to Comments Provided
- Report to Be Revised

Sediment and Contaminant Transport Model Status

- Configuration and Calibration of Sediment Transport Model Underway
- Followed by Preliminary Configuration of Contaminant Transport Model
- Both Subject to Revision as Current Field Work Progresses

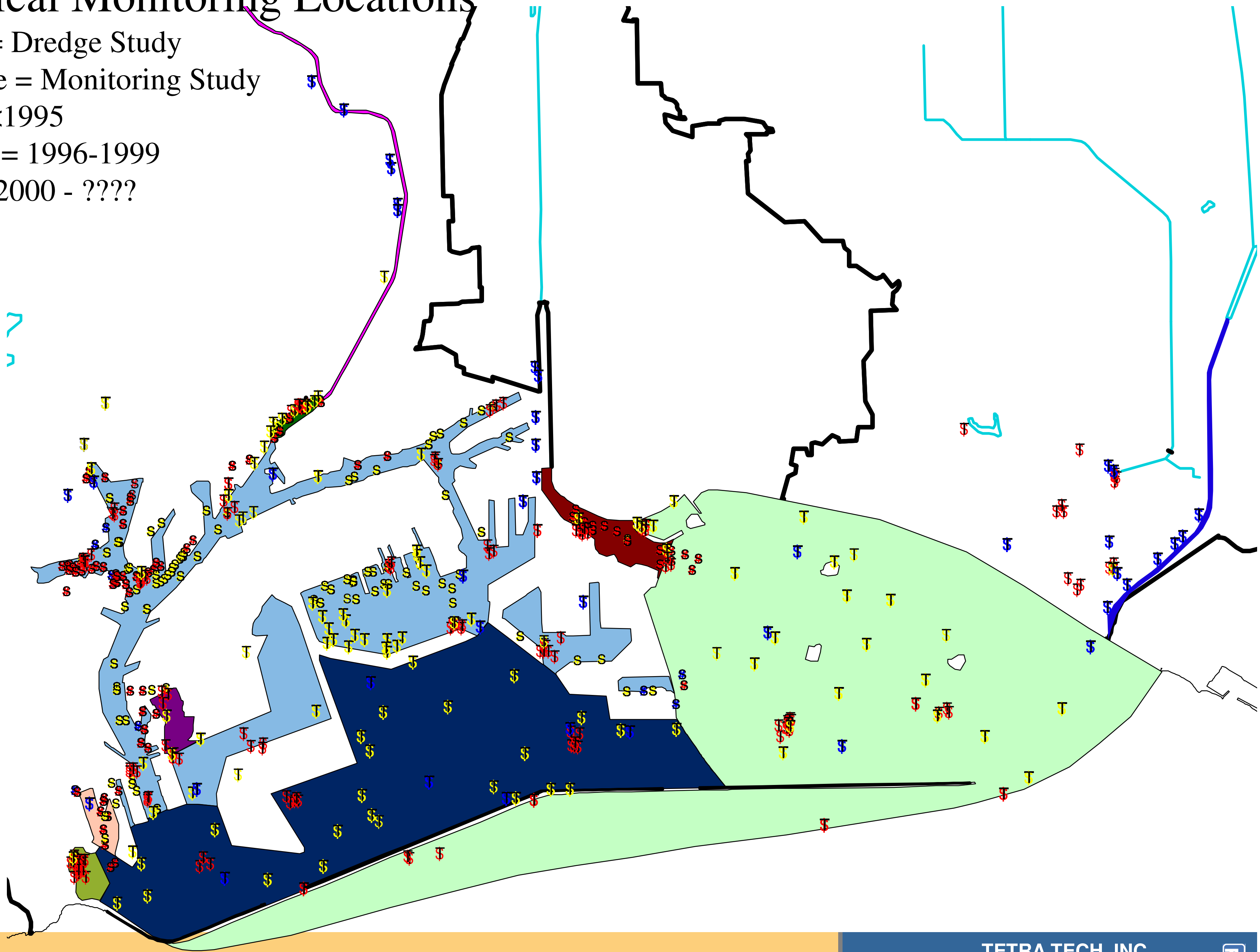
Following Slides Not Used

Sediment Transport Modeling Approach

- Focus on Initialization of Bed Conditions
- Sediment Physical Properties Data Currently Being Used for Bed Initialization
  - Sediment Size and Type
  - Void Ratio or Water Content
  - Surface and Profile Data
- Erosion Potential
  - Site Specific Study to Parameterize Erosion
- Calibration to Water Column TSS

Physical Monitoring Locations

Circle = Dredge Study
Triangle = Monitoring Study
Red = <1995
Yellow = 1996-1999
Blue = 2000 - ????

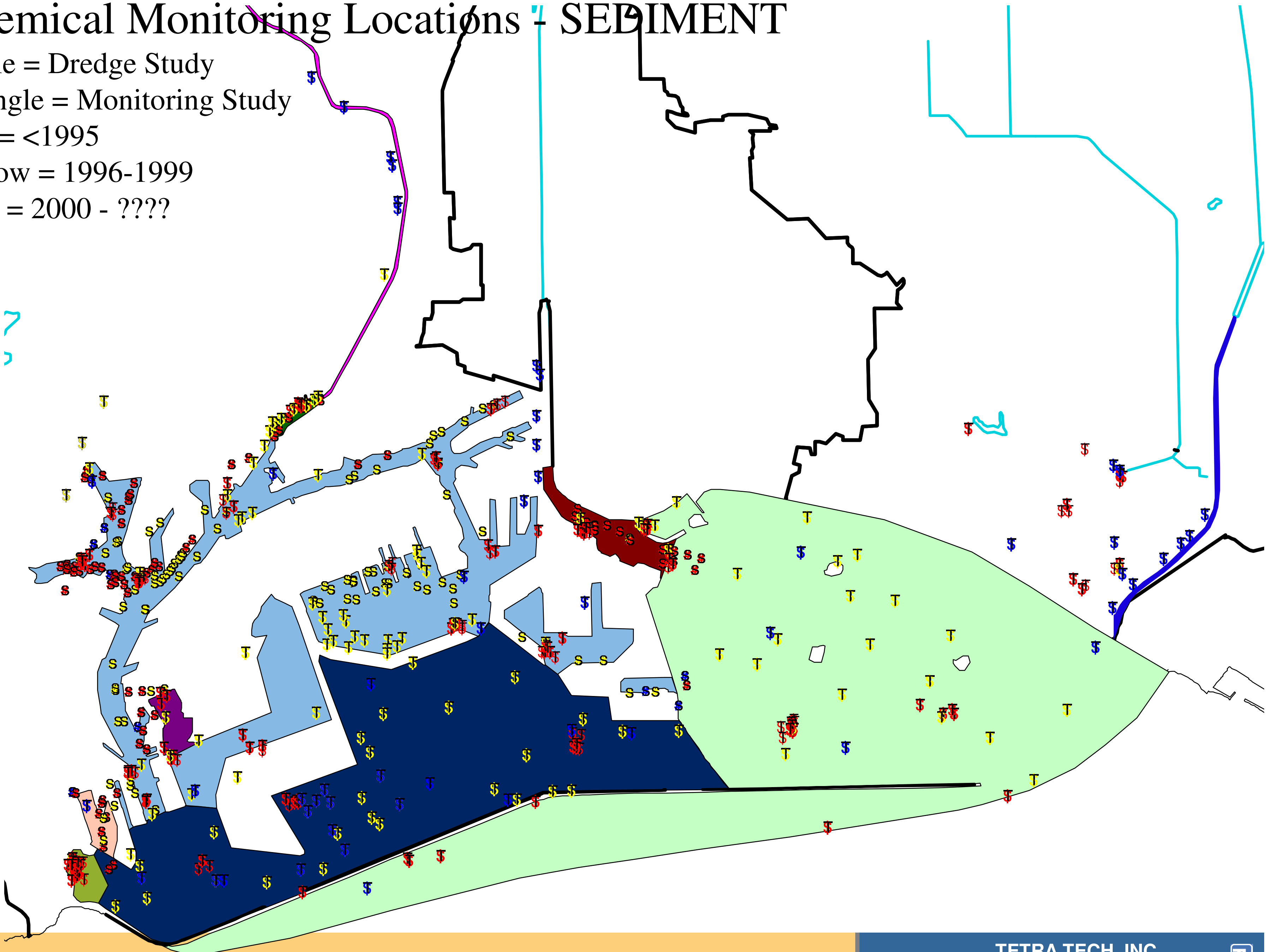


Contaminant Transport Modeling Approach

- Focus on Initialization of Contaminant Levels in Bed and Estimation of Partition Coefficients
  - Initial Contaminant Levels
  - Particulate and Dissolved Organic Carbon Levels Desirable with Respect to Hydrophobic Organics
  - Site Specific or Literature Values for Partition Coefficients
- Calibration to Contaminant Concentrations In Water Column

Chemical Monitoring Locations - SEDIMENT

Circle = Dredge Study
Triangle = Monitoring Study
Red = <1995
Yellow = 1996-1999
Blue = 2000 - ????



Erosion Rate As Function of Bed Stress and Bulk Density (UCSB Study)

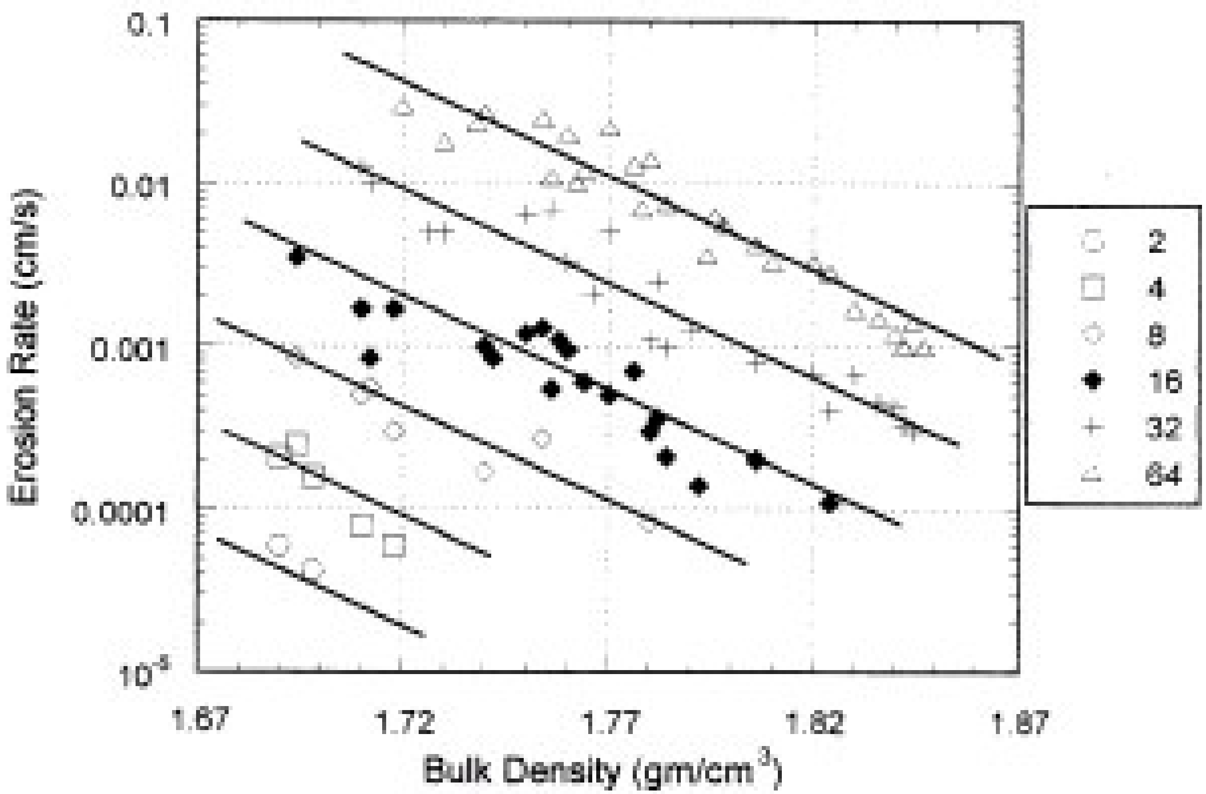


Figure 19. Erosion rates as a function of bulk density for the composited sediments. Erosion rates for shear stresses of 2, 4, 8, 16, 32, and 64 dynes/cm^2 are shown.

Bulk Density as Function of Depth in Sediment Bed (UCSB Study) (void ratios 0.95 to 1.35)

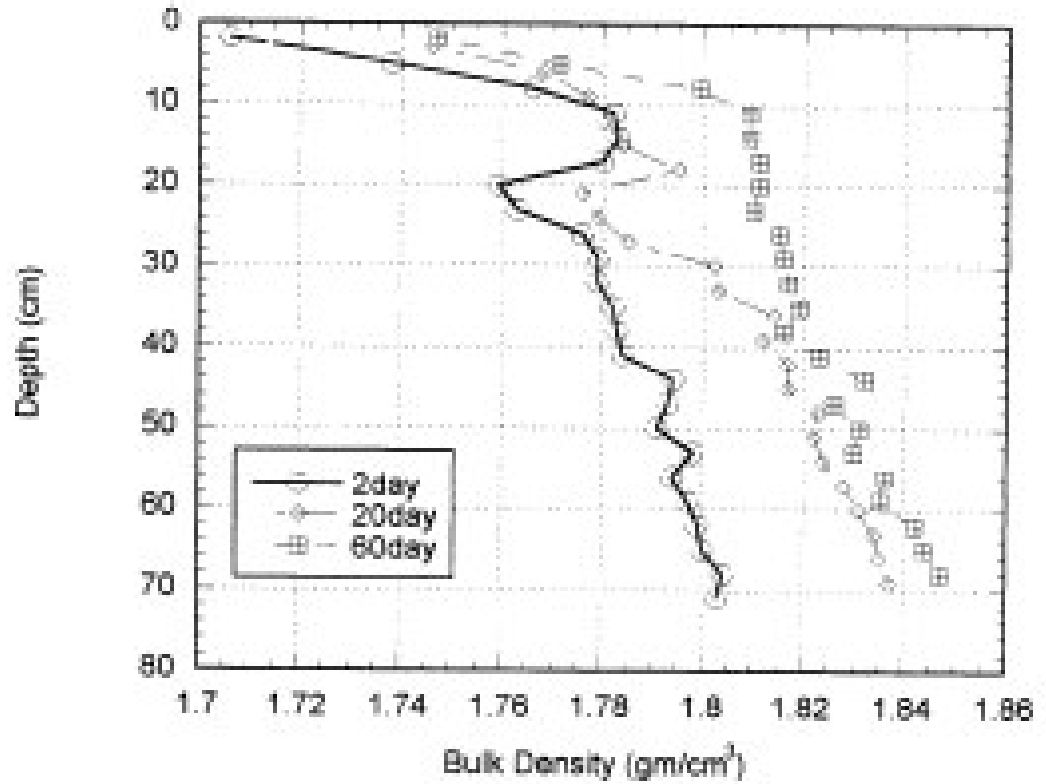


Figure 13. Bulk density as a function of depth for the 80 cm composited sediment cores at consolidation times of 2, 20, 60 days.

Contaminant Field Studies, Summer 2006

- Flux Measurements
  - Measured Flux Depends of Pore Water Concentration (DOC, Koc)
  - Gives Sediment to Water Exchange Coefficient (Diffusion, Biological Mixing)
  - Possible to Infer Pore Water Concentration
- Sediment Chemistry
  - Measure Total and Particulate Concentration
  - Measure DOC and POC in Sediment
  - Gives Partition Coefficient

Sediment to Water Diffusive Flux

$$F_d = \frac{D}{\delta}\left(C_{db} - C_{dw}\right)$$

$$D = diffusion\ coefficient, \quad \delta = diffusion\ length\ scale$$

$$C_{dbed} = \left(\frac{n + n \cdot DOC_{bed} \cdot K_{oc}}{n + n \cdot DOC_{bed} \cdot K_{oc} + f_{POCbed} \cdot S_{bed} \cdot K_{oc}}\right) = bed\ \ pore\ water\ conc$$

$$C_{dwat} = \left(\frac{1 + DOC_{wat} \cdot K_{oc}}{1 + DOC_{wat} \cdot K_{oc} + f_{POCwat} \cdot S_{wat} \cdot K_{oc}}\right) = water\ column\ dissolved\ conc$$

$$n = porosity$$

$$f_{poc} = fraction\ \ particulate\ organic\ carbon$$

$$K_{oc} = organic\ carbon\ to\ water\ \ partition\ coefficient$$

$$S = sediment\ concentration$$

Sediment to Water Particulate Flux

$$F_p = \max\left(w_e S_{bed}, 0\right)\left(\frac{f_{POCbed} \cdot K_{ow}}{n + n \cdot DOC_{bed} \cdot K_{oc} + f_{POCbed} \cdot S_{bed} \cdot K_{oc}}\right)$$

$$+\min\left(w_s S_{wat}, 0\right)\left(\frac{f_{POCwat} \cdot K_{oc}}{1 + DOC_{wat} \cdot K_{oc} + f_{POCwat} \cdot S_{wat} \cdot K_{oc}}\right)$$

$$w_e = erosion\ velocity\ (function\ of\ sediment\ size\ fraction,\ void\ ratio, bed\ stress)$$

$$w_s = settling\ velocity\ (function\ of\ sediment\ size)$$