

From: [Deirdre Des Jardins](#)
To: Comment_Modifiedrulemakingprocess399@DeltaCouncil
Subject: Army Corps of Engineers modelling on Sea Level Rise within the Delta
Date: Thursday, May 09, 2013 5:00:03 PM
Attachments: [EFDCModelFrameworkPres.pdf](#)

Please put this into the administrative record.

Sincerely,

Deirdre Des Jardins
California Water Research

An Extended-Delta Hydrodynamic Model Framework for Sea Level Rise Analysis to Support Resource Management Planning for the Sacramento-San Joaquin River Delta

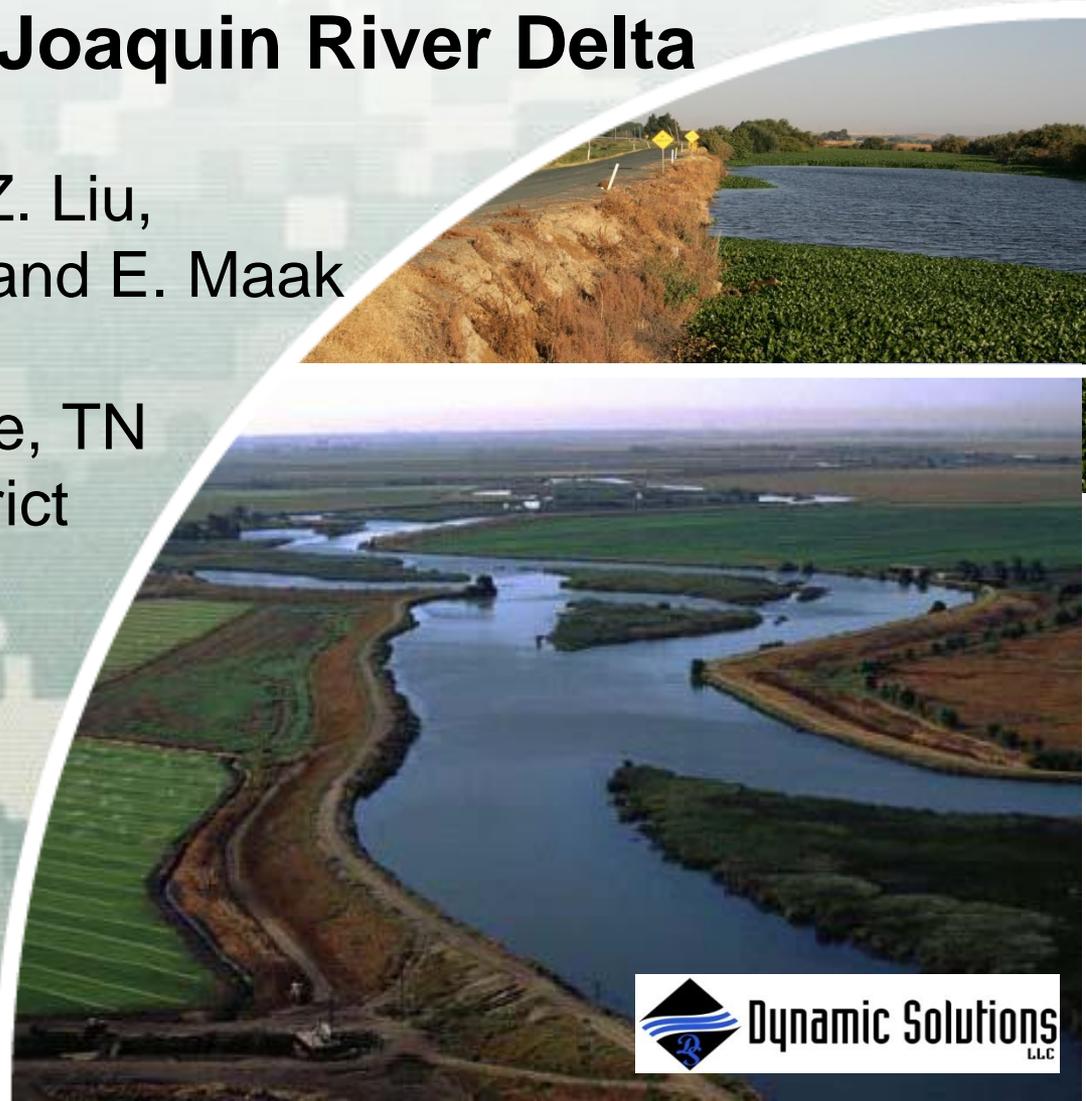
Lu, S., P. Craig, C. Wallen, Z. Liu,
A. Stoddard, W. McAnnally and E. Maak

Dynamic Solutions, Knoxville, TN
USACOE, Sacramento District

CWEMF 2012
Folsom, CA
16 April 2012



US Army Corps of Engineers
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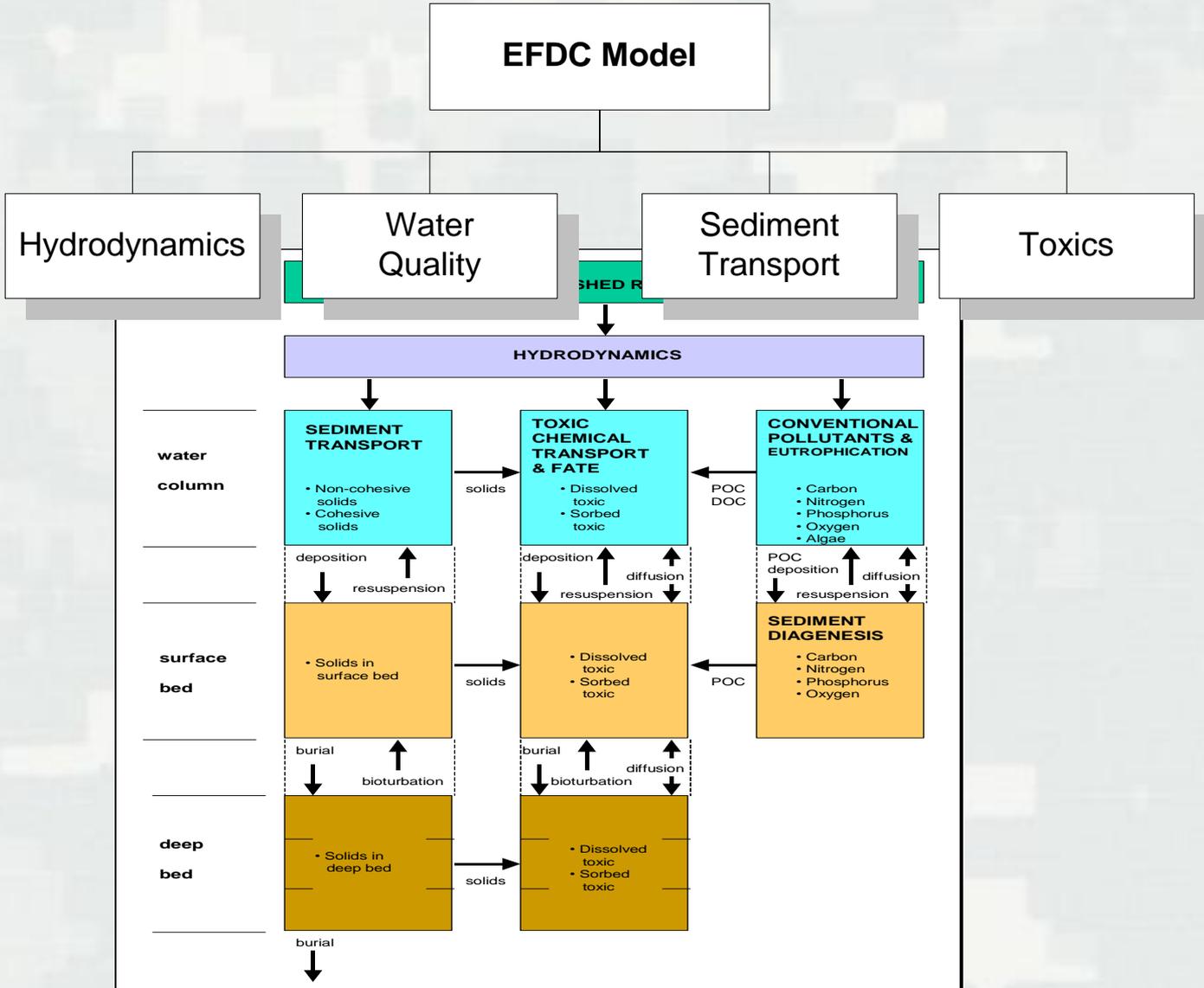
Climate Change Issues

- Global Warming
- Precipitation
- Hydrology
- Water Resources
- Flood Protection
- Sea Level Rise

Sacramento-San Joaquin Delta 3D EFDC Model Framework

- Hydrodynamic, sediment and water quality model developed by U.S. Army Corps of Engineers, Sacramento District to provide 3D modeling tool for planning evaluations & resource management
- Delta Model domain includes Sacramento River (Verona)-San Joaquin River (Vernalis) –Delta-Suisun Bay-Carquinez Strait
- Environmental Fluid Dynamics Code (EFDC)

EFDC Model

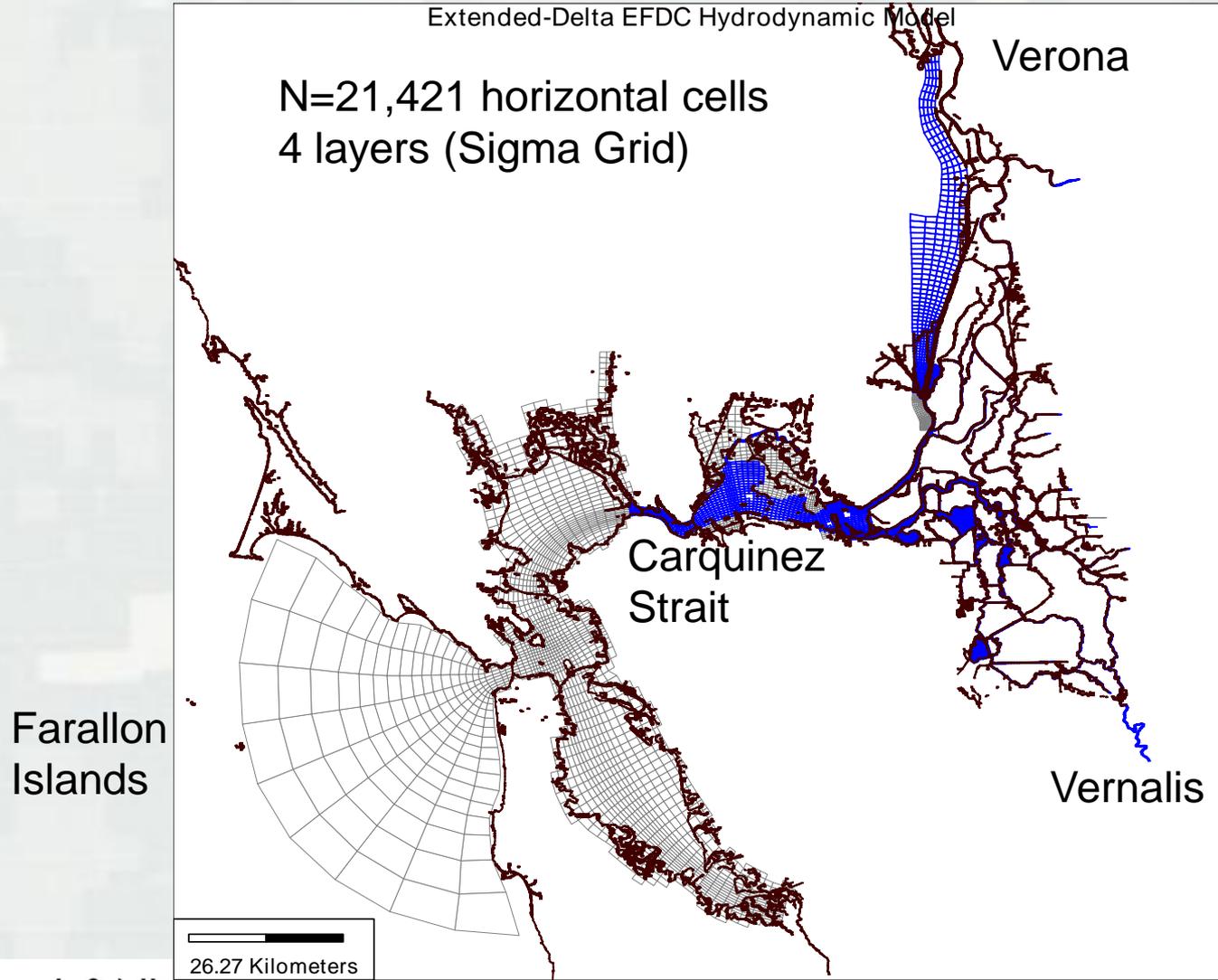


Extended-Delta EFDC Hydrodynamic Model

- Developed to evaluate potential impacts of Sea Level Rise on water level and salinity intrusion
- Domain extended to include San Pablo Bay, San Francisco Bay and Pacific Ocean 27 miles offshore to Farallon Islands
- Finer grid used for center deep channels in San Francisco Bay and San Pablo Bay

Extended-Delta EFDC Hydrodynamic Model

N=21,421 horizontal cells
4 layers (Sigma Grid)





Legend

▲ Extended Model Boundary

Extended-Delta_EFDC

Bathy

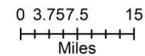
■ -92.327 - -20.075

■ -20.074 - -3.666

■ -3.665 - 16.350

■ 16.351 - 79.121

Extended Delta Model Domain and Grid



Extended Delta EFDC Model Model Calibration (2004)

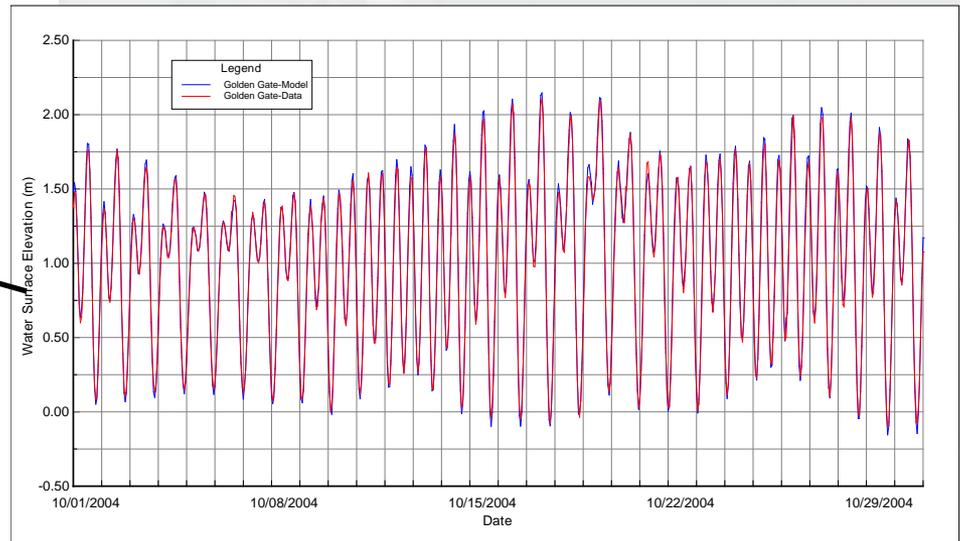
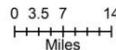
- Open ocean BC: water level at Point Reyes; water temperature & salinity at Farallon Is.
- Selected calibration results
 - ▶ Water surface elevation
 - ▶ Salinity
- 2004 calibration data used as base case for SLR scenarios

Water Surface Elevation Golden Gate, Oct 2004



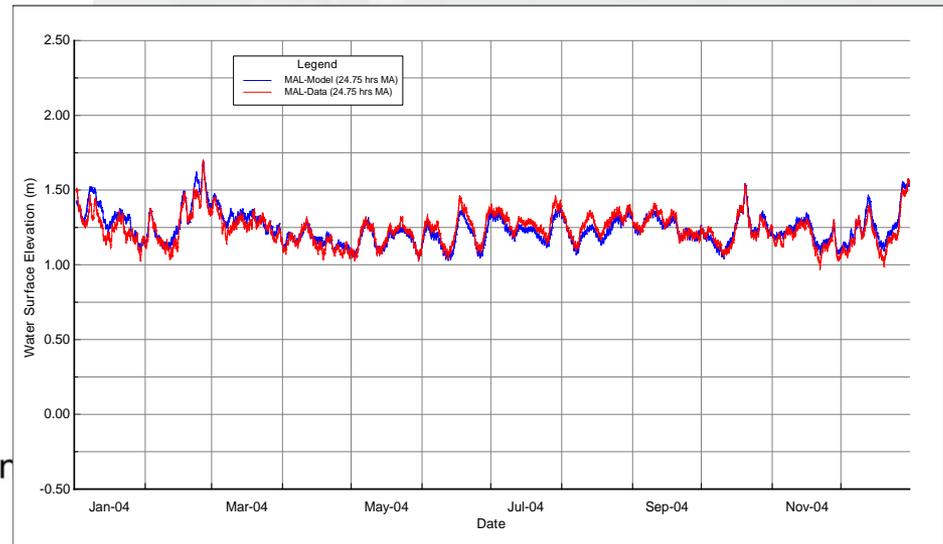
Stage Calibration and Validation
Stations in the Domain

- Legend**
- Stage Stations
 - Extended-Delta_EFDC



RMS=0.05 m; Relative RMS Error=1.6%

Water Surface Elevation Mallard Island (MAL) 24.75 hr Filtered Jan-Dec 2004



Stage Calibration and Validation
Stations in the Domain

- Legend**
- Stage Stations
 - Extended-Delta_EFDC



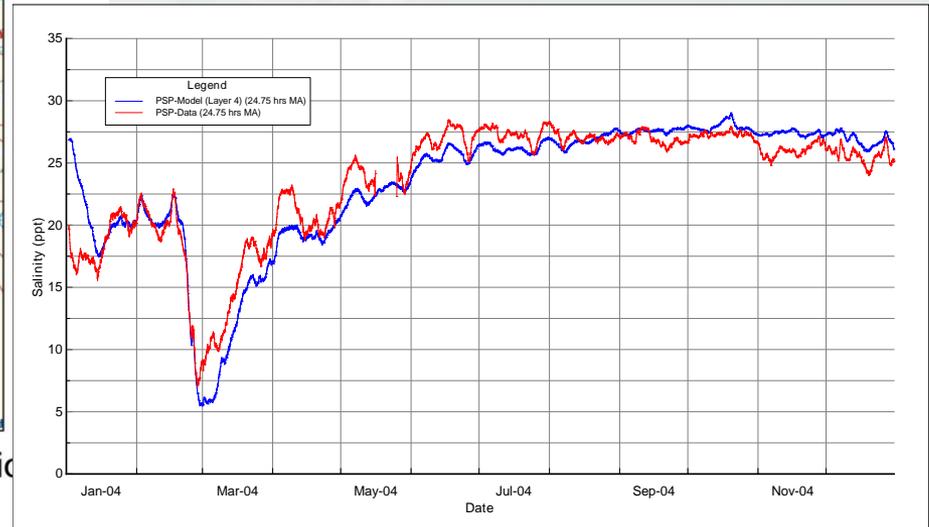
0 3.5 7 14
Miles

RMS=0.06 m; Relative RMS Error=3.6%



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Surface Salinity Port San Pablo (PSP) 24.75 hr Filtered Jan-Dec 2004



Salinity Calibration and Validation
Stations in the Domain

- Legend**
- Salinity Stations
 - Extended-Delta_EFDC



0 3.5 7 14
Miles

RMS=2.3 ppt; Relative RMS Error=8.1%

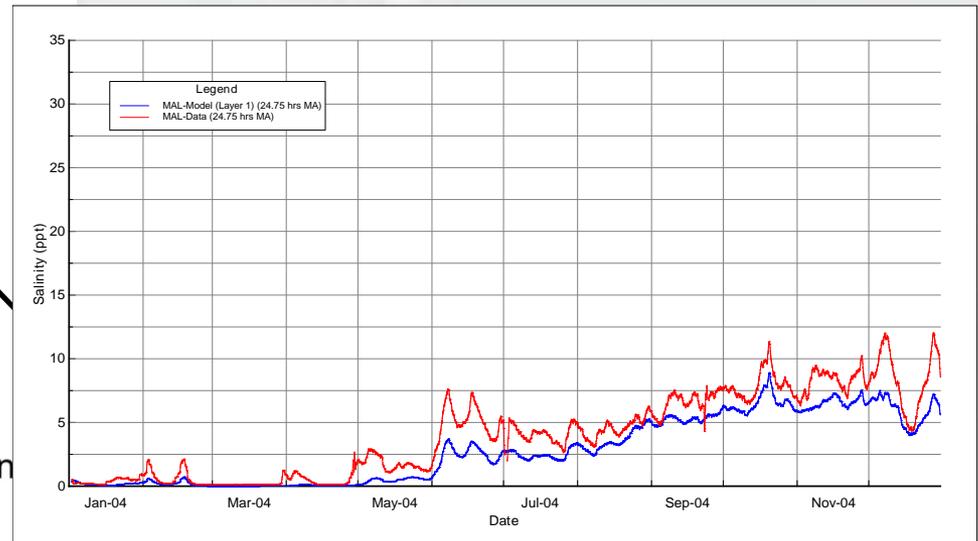
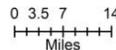


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Bottom Salinity Mallard Island (MAL) 24.75 hr Filtered Jan-Dec 2004



Salinity Calibration and Validation
Stations in the Domain

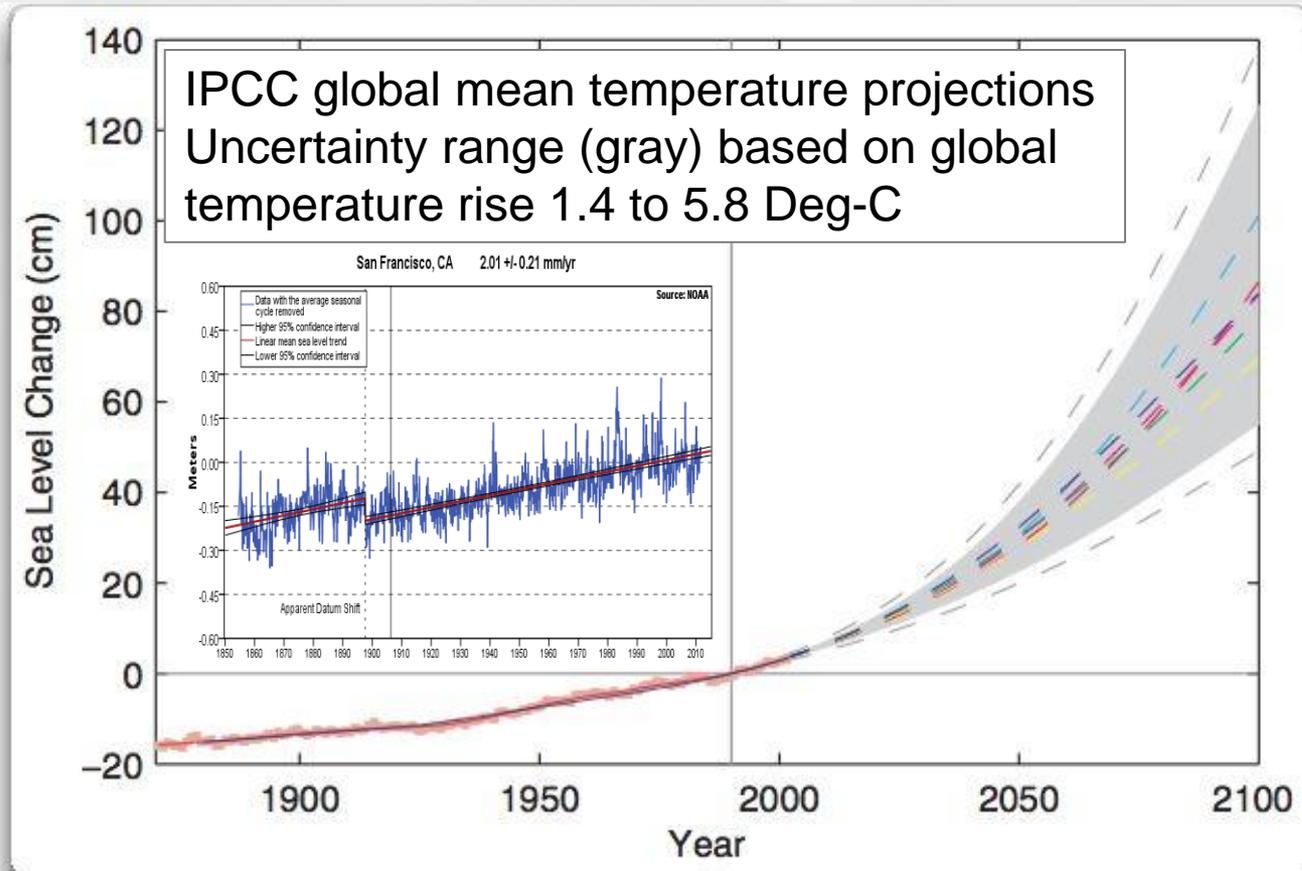


RMS=1.8 ppt; Relative RMS Error=9.3%

Extended Delta EFDC Model Sea Level Rise Analysis

- 3D 4-layer model-> barotropic/baroclinic flow
- Freshwater (Flow, T,S) and offshore open BC (T,S) from 2004 calibration (Base Case)
- Open BC for Water Level based on 2004 tide signal at Point Reyes + SLR (50, 100 yr)
- Land subsidence rate of 1.5 mm/yr defines offset in bathymetry of -0.15 m for 100 yr case

Sea Level Rise: Historical & Projections (Rahmstorf, 2007)



Extended Delta EFDC Model SLR Analysis (9 Cases)

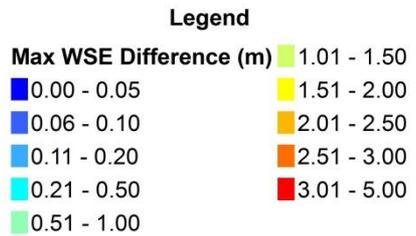
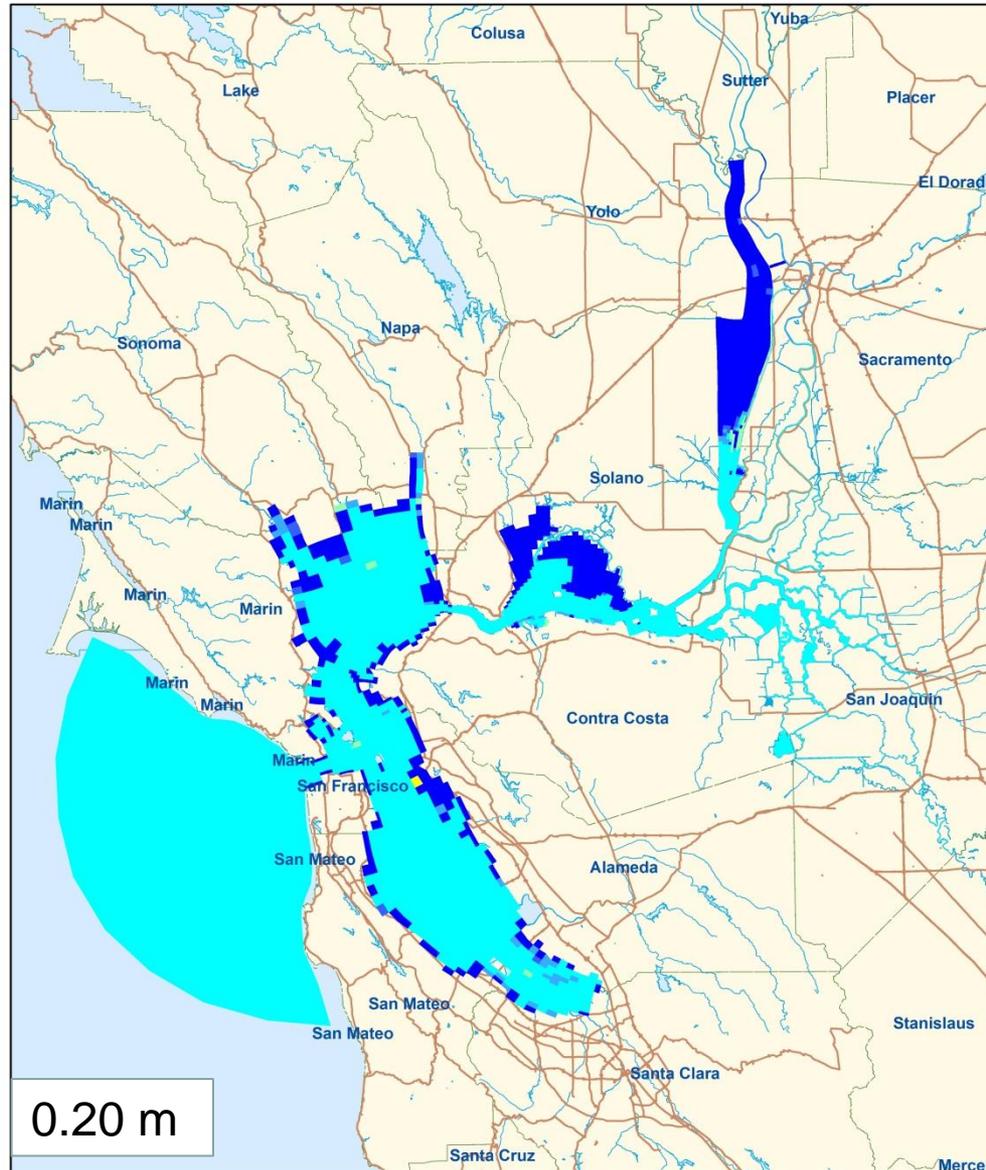
Land Subsidence (m)	0	0	-0.15
Sea Level Rise Scenario	50 Yr (m)	100 Yr (m)	100 Yr (m)
Low	0.10	0.20	0.2
Intermediate	0.20	0.52	
High	0.59	1.68	1.68
Source: USACOE (2009) EC 1165-2-211			

Literature	100 Yr (m)
Calif. Climate Change Center, CCCC (2006)	0.13 - 0.89
Int'l Panel Climate Change, IPCC (2007)	0.18 - 0.59
Delta Risk Mgmt Strategy, DRMS(2008)	0.20 - 1.40

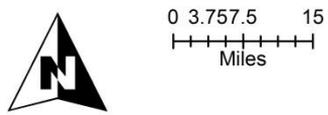
SLR Impact Metrics

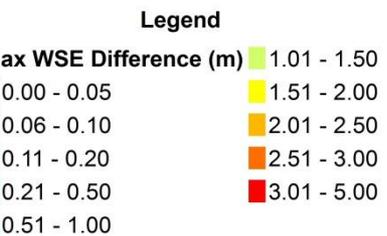
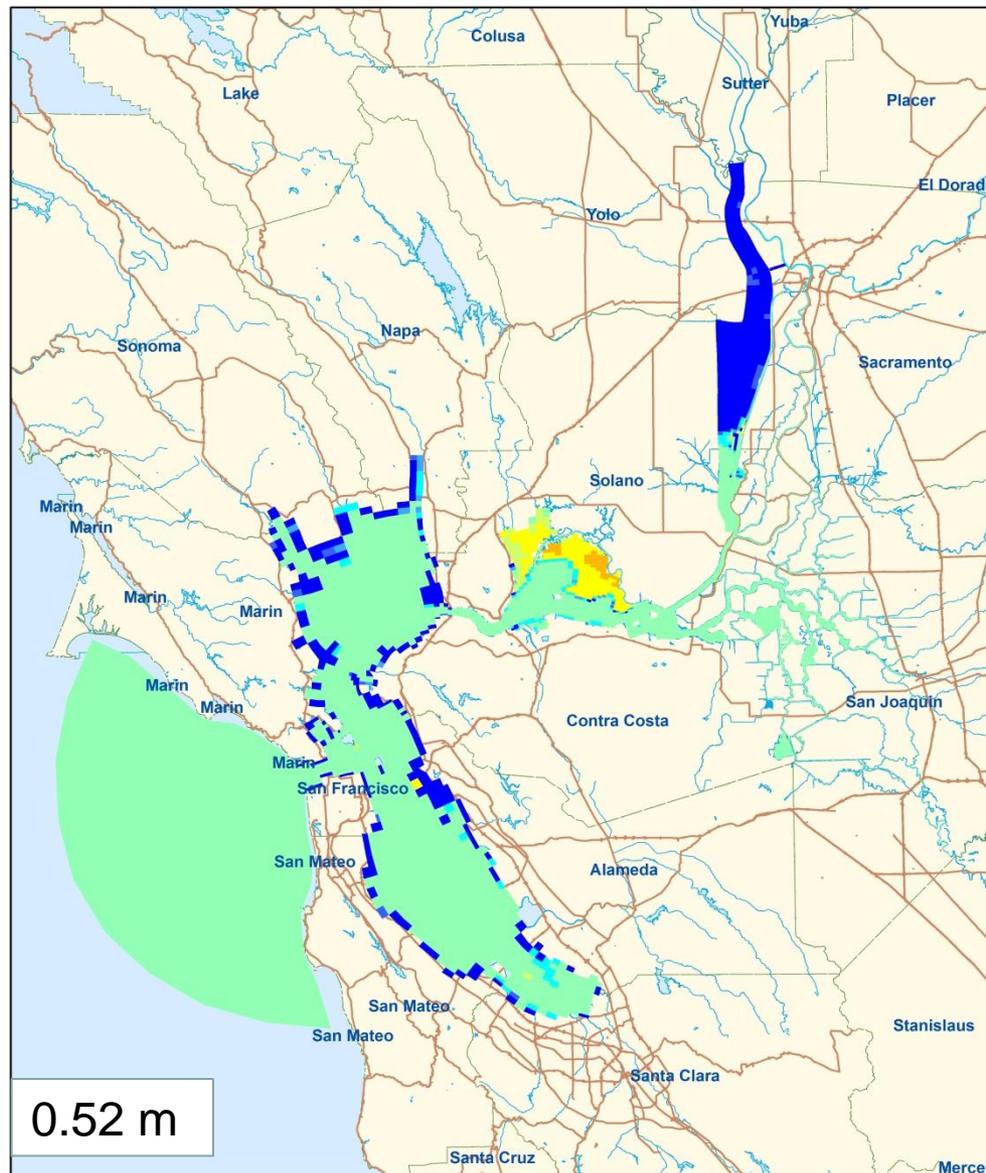
- Max Difference in Water Level & Depth-Avg Salinity tracked at each grid cell as [SLR Scenario – Base Case] over simulation period (Jan-Dec 2004)
- Bottom salinity sections: Golden Gate to Sacramento; Golden Gate to Clifton Court; wet spring & dry summer conditions

SLR Impact on Water Level

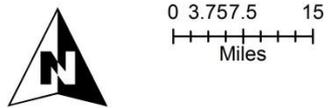


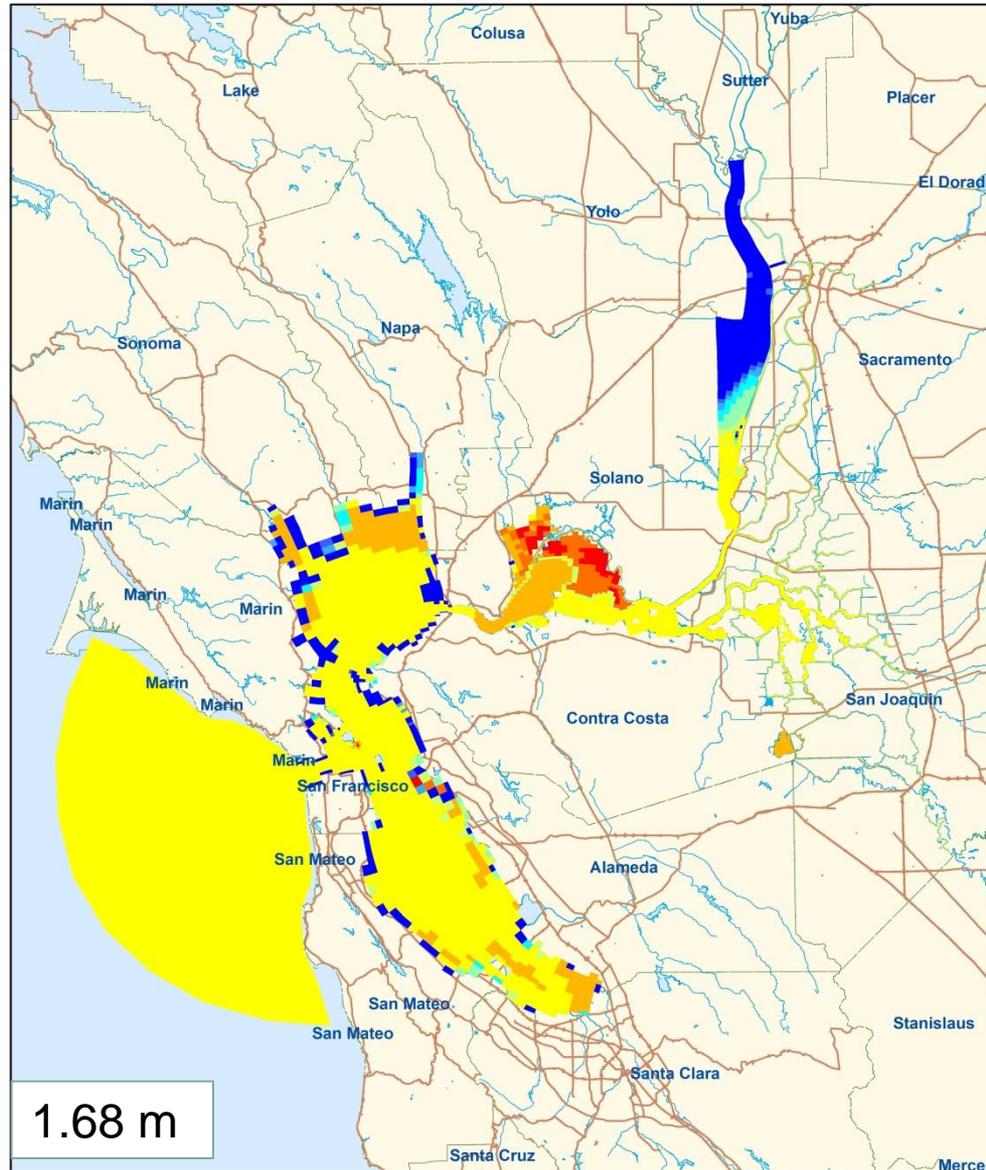
**Maximum Water Surface Difference
100-year Low SLR**





Maximum Water Surface Difference 100-year Intermediate SLR



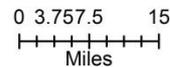


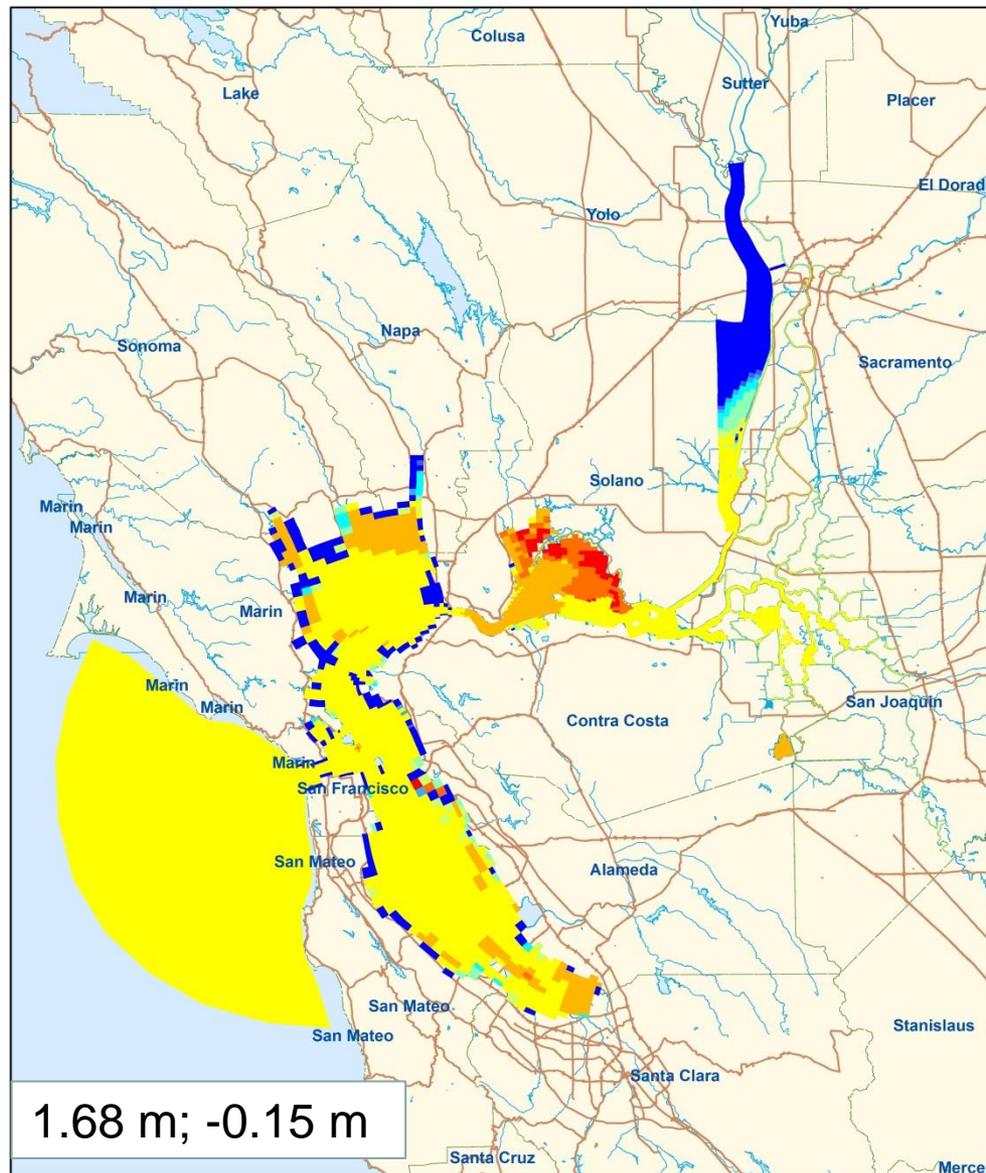
1.68 m

Legend

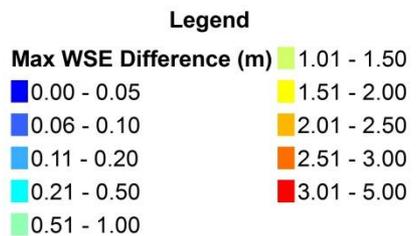
- | | |
|---|---|
| Max WSE Difference (m) |  1.01 - 1.50 |
|  0.00 - 0.05 |  1.51 - 2.00 |
|  0.06 - 0.10 |  2.01 - 2.50 |
|  0.11 - 0.20 |  2.51 - 3.00 |
|  0.21 - 0.50 |  3.01 - 5.00 |
|  0.51 - 1.00 | |

**Maximum Water Surface Difference
100-year High SLR**

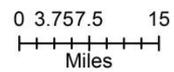




1.68 m; -0.15 m



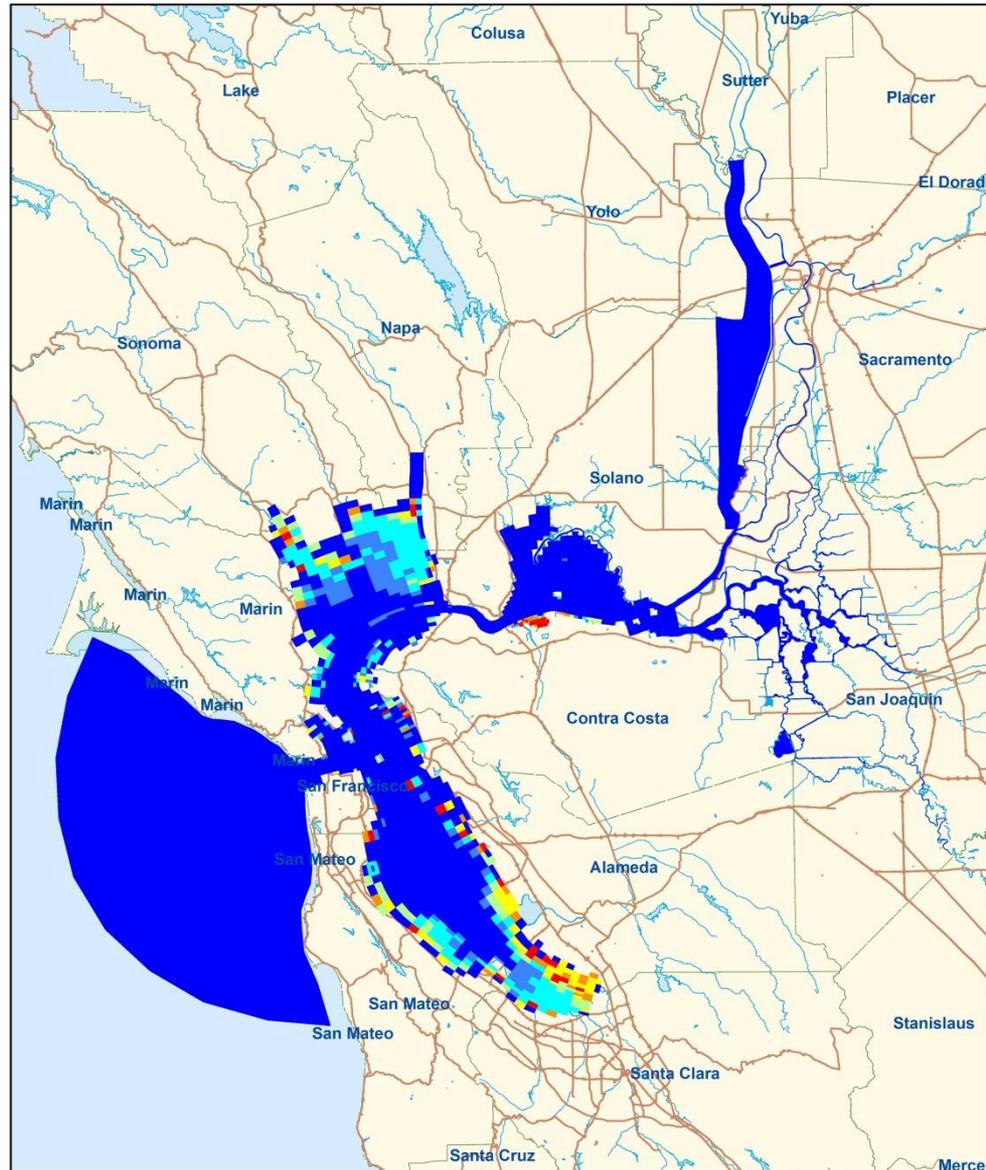
Maximum Water Surface Difference 100-year High SLR with Subsidence



SLR Impact on Water Level Findings

- Suisun Bay and South Yolo Bypass areas show largest Water Level impact from SLR
- Suisun Bay: largest increases during summer low flow from rivers; large shallow mud flats of marsh amplify tide signal with maximum Water Level related to low flow
- South Yolo Bypass: largest increase along fresh-salt water interface in wet spring season

SLR Impact on Salinity

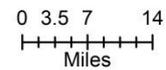


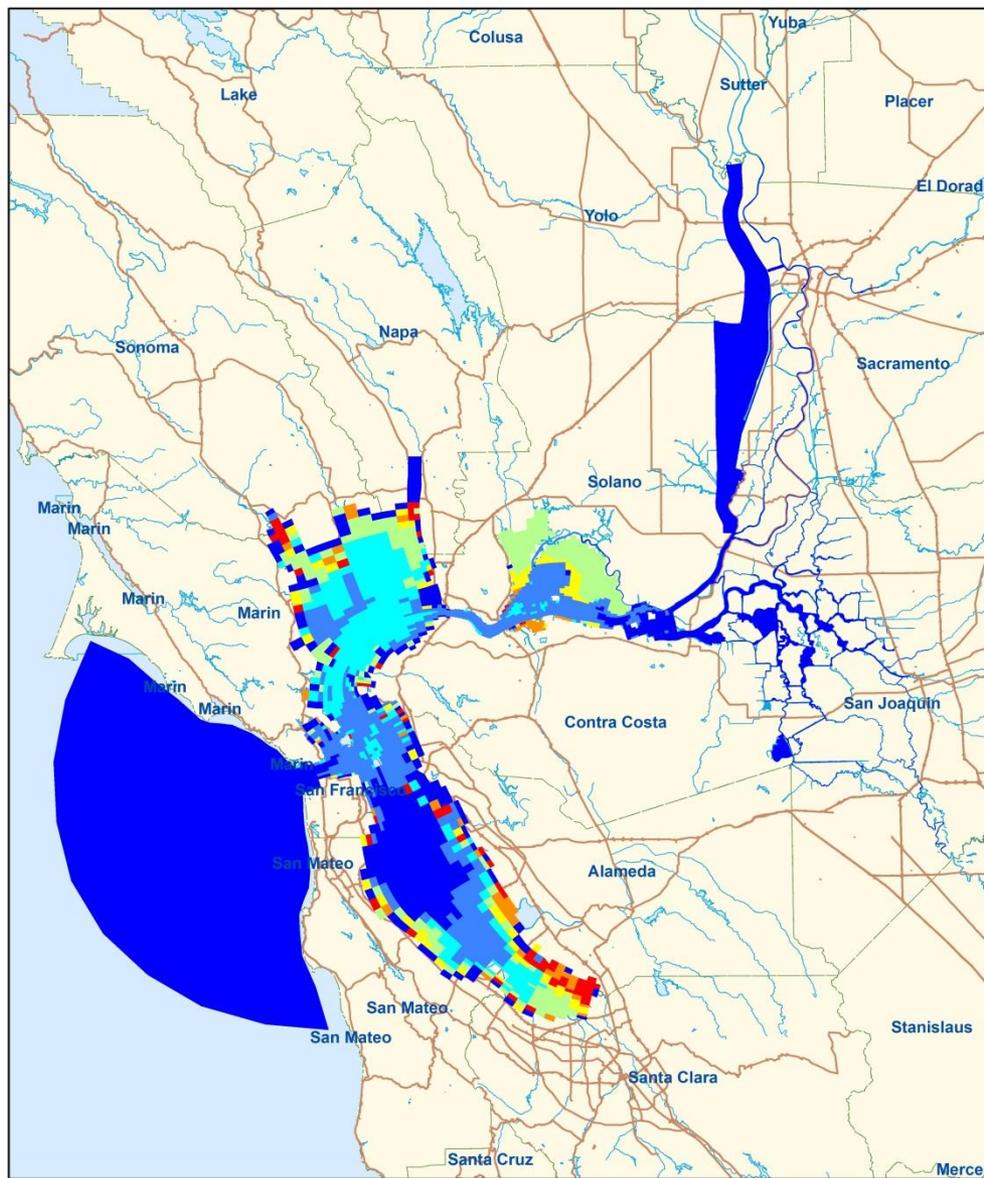
Legend

Max Salinity Difference (ppt)



**Maximum Salinity Difference
100-year Low SLR**



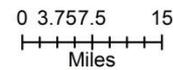


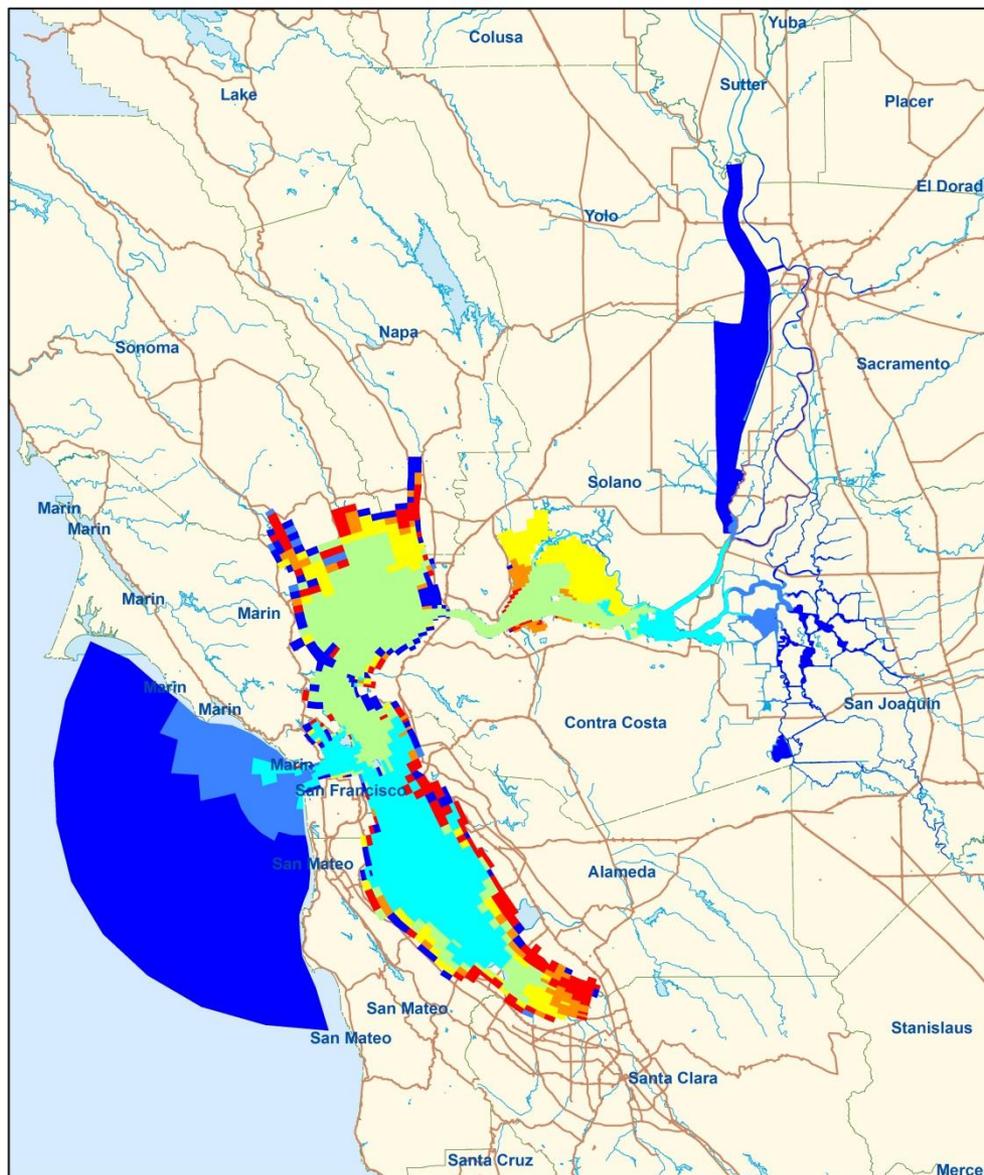
Legend

Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

**Maximum Salinity Difference
100-year Intermediate SLR**



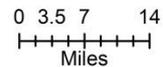


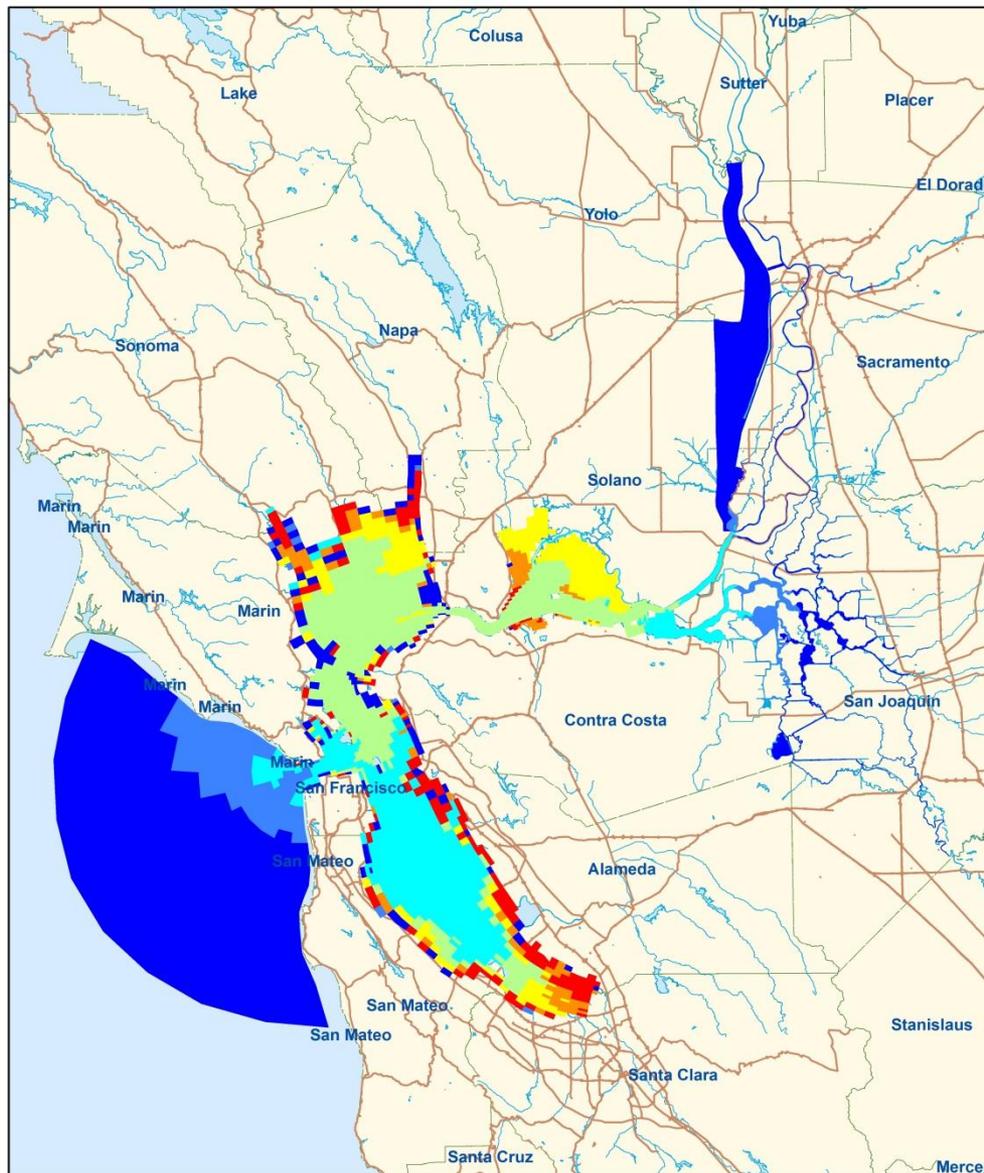
Legend

Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

**Maximum Salinity Difference
100-year High SLR**



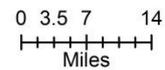


Legend

Max Salinity Difference (ppt)

- 0.00 - 1.00
- 1.01 - 2.00
- 2.01 - 5.00
- 5.01 - 10.00
- 10.01 - 15.00

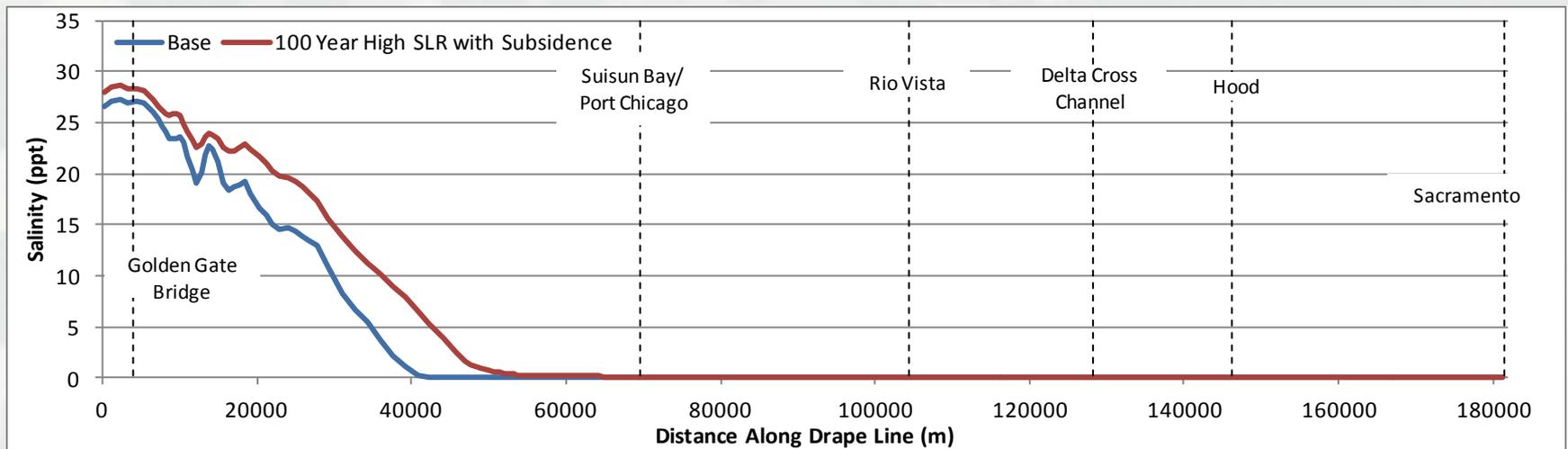
**Maximum Salinity Difference
100-year High SLR with Subsidence**



SLR Impact on Salinity Findings

- Bottom salinity increased in SF Bay and Delta by 0.45-8.7 ppt; Suisun Bay, San Pablo Bay & Carquinez Strait show largest salinity impact during wet spring conditions

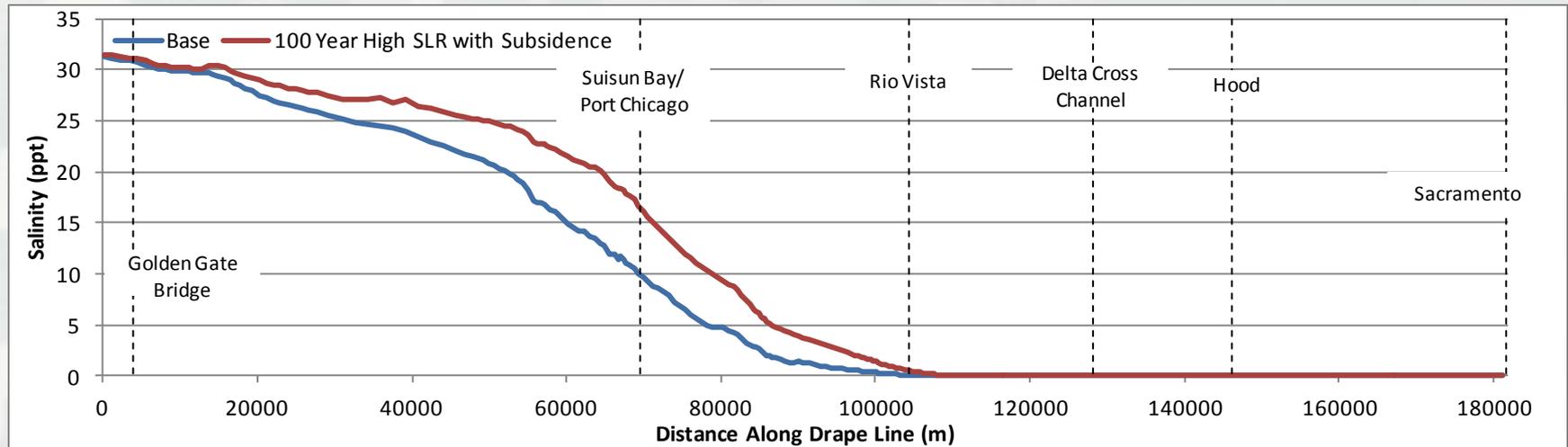
100 Yr, High SLR, Subsidence Flood Tide (3/1/2004 03:00) Golden Gate to Sacramento



100 Yr, High SLR, Subsidence

Ebb Tide (7/3/2004 05:00)

Golden Gate to Sacramento



SLR Impact on Salinity Findings

- Shift in bottom salinity intrusion for 2 ppt location for 100 Yr High SLR (1.68 m) with subsidence compared to Base Case:
 - ▶ ~ 12 km for dry summer conditions/ebb tide
 - ▶ ~ 10 km for wet spring conditions/flood tide

Extended Delta EFDC Model Summary

- Provides USACOE Sacramento District, other Federal/State agencies and Stakeholders with an advanced 3D model framework
- Essential tool for increased understanding of consequences of natural events and issues such as SLR for planning level evaluations
- Sets standard for determination of significance of project impacts

Discussion

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