Potential Impacts of sea-level rise on Transportation and Fuel Infrastructure

Modeling Climate Impacts in the California Delta, San Francisco Bay, California Coast

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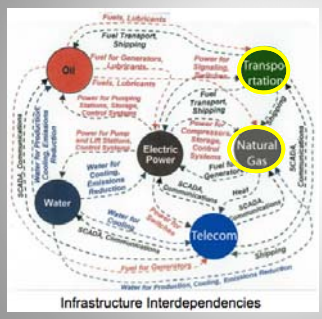
Sea Level Rise effects

- Science says: SLR up to 1.41m by 2100 — D. Cayan, UC Santa Cruz Climate Change Looking Glass Meeting 2/28-3/1 /2014
- People generally worried about areas that fall within SLR "borders"

… but, even if you live outside of that area, you will be affected

Assess vulnerability due to Sea Level Rise

The Domino Effect: Interconnected, Interdependent Infrastructure



Infrastructure Interdependencies

1. COMPLETED: Transportation study (CEC-500-2012-040)
2. PRESENT: Gas Pipeline Vulnerability (CEC-500-11-016)

Source: Don Boland, Executive Director, California Utilities Emergency Association

Both projects look at inundation

Transportation study:
- We model four sea-level rise (SLR_x) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- to which we add a 100-year extreme storm event (ESE_{100})
- we use a pathway (rather than bathtub) model

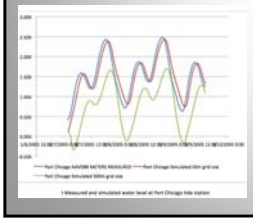
Over estimation of inundation with a 2.0 m (water Level) using a bathtub model

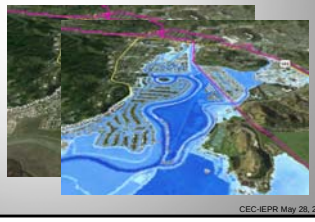
Improvement of inundation estimation with a 2.0 m (water level) with water pathway model

Both projects look at inundation

Gas Pipeline Vulnerability study:
- We model four sea-level rise (SLR_x) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- to which we add a near 100-year extreme storm event (ESE_{100})
- we use a dynamic process model that incorporates *Diurnal tides* and *Peak water levels* during storm even

Improvement of inundation estimation with a dynamic process model

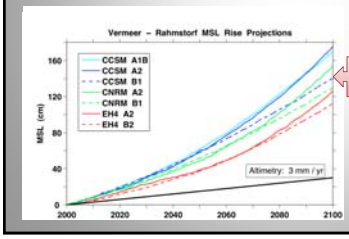




Components to estimate potential inundation areas

Inundation study:
- we model four sea-level rise (SLR_x) increments {x: 0m, 0.5m, 1.0m or 1.40m}
- which we add a 100-year extreme storm event (ESE_{100})
- inundate a land surface model comprised of: bathymetry, dem & dsm

Global circulation models:



(Source) Bromirski, P. D., D. R. Cayan, N. Graham, R. E. Flick and M. Tyree (Scripps Institution of Oceanography). 2012. Coastal Flooding Potential-Projections 2000-2100. California Energy Commission. CEC-500-2012-011

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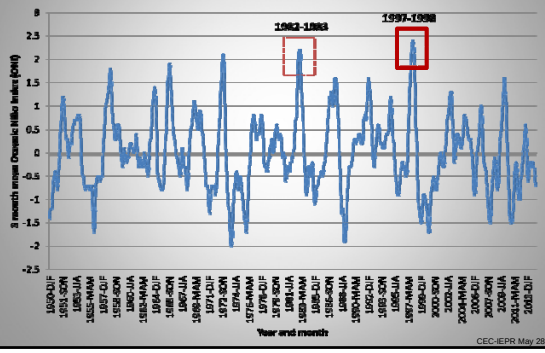
Extreme water level calculation from NOAA at San Francisco based on NAVD 88

Probability	Recurrence Interval	High water level
1.00%	100	2.60
10.00%	10	2.45
50.00%	2	2.29
99.00%	1	2.10

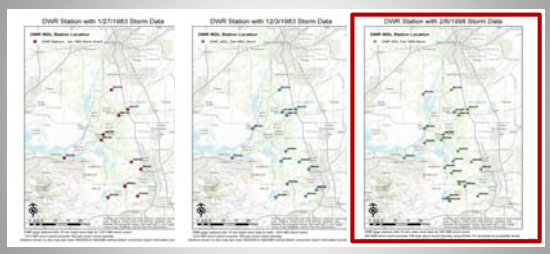
High and low water events which exceeded or was close to the 1% Annual Exceedance Probability Level

Station Number	Station Name	Date of High Water Event	Compare to 100-year storm
9414290	San Francisco	1/27/1983 – 2.707m	Exceeded
		12/3/1983 – 2.674m	Exceeded
		2/6/1998 – 2.587m	Not exceeded, but was close to it

a near 100-year extreme storm event (ESE_{100})

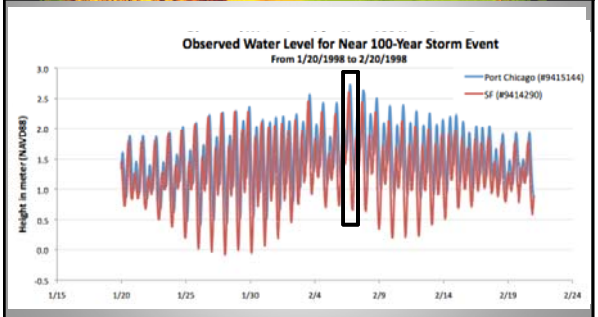


Gauging station data availability for model calibration



11 stations reporting | 14 stations reporting | 21 stations reporting

Observed water level for near 100 year storm event



Components to estimate potential inundation areas

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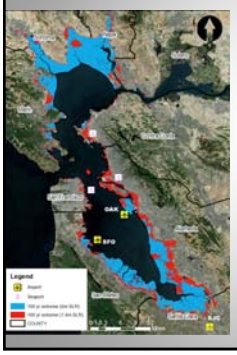
- **we inundate a land surface model comprised of: bathymetry, dem & dsm**

USGS California Coastal LiDAR Project

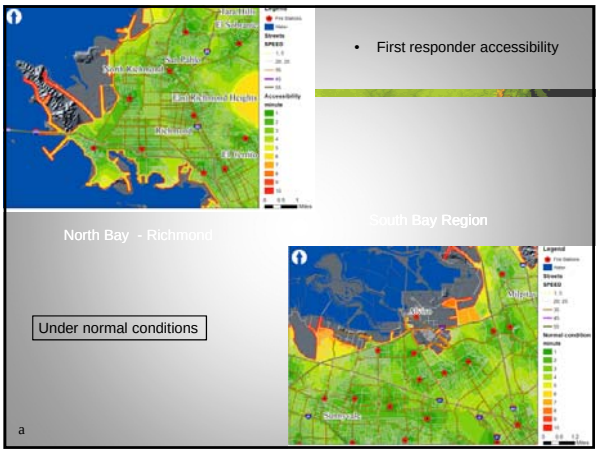
Insert 3d image of SF Bay surface model

Transportation study results (CEC-500-2012-040)



Assessing vulnerability of road network

- First responder accessibility
- Node-to-node accessibility impacts on the major traffic corridors
- Hinterland accessibility to major traffic corridor intersections



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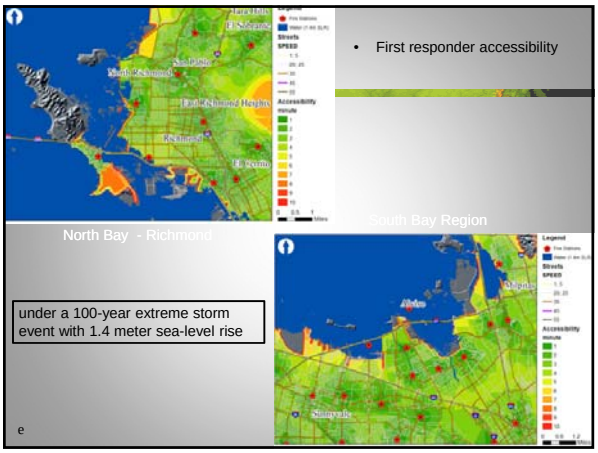

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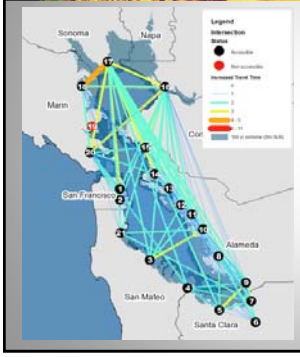

Increased Travel Time (as Multiples of Normal Travel Time) between Intersections after a 100-Year Extreme Event with Different Sea-Level Rise Scenarios

0 meter rise

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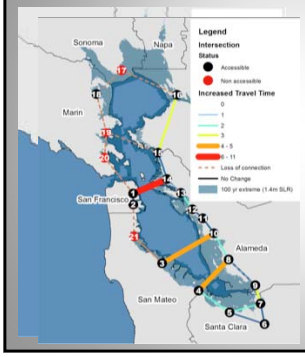
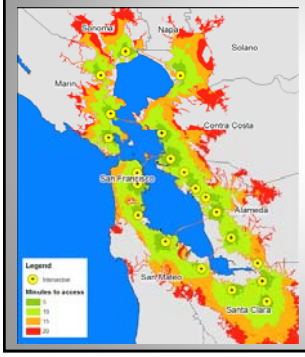


Increased Travel Time (as Multiples of Normal Travel Time) between Intersections after a 100-Year Extreme Event with Different Sea-Level Rise Scenarios

1.4 meter rise

- Hinterland accessibility to major traffic corridor intersections



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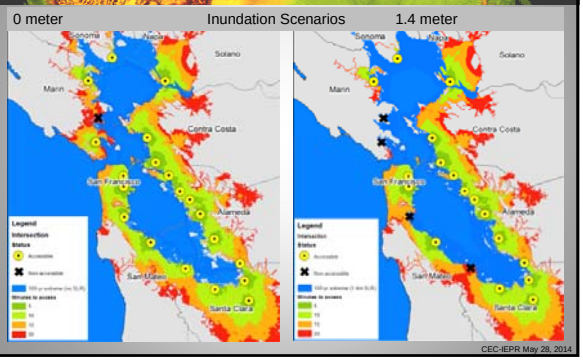

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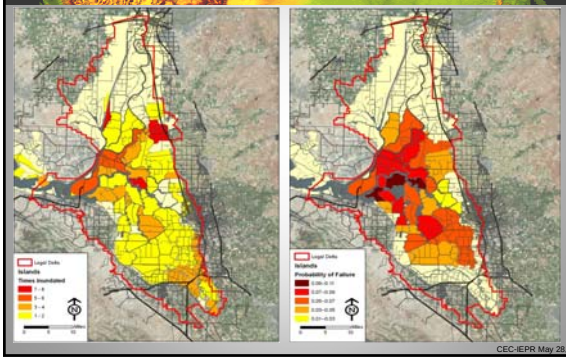
First responder accessibility: The Delta

Probability of Island (levee) failure



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Sherman Island 3Di simulation

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First responder accessibility: The Delta

DWR Delta LiDAR Project

Gaming: flood each island one at a time

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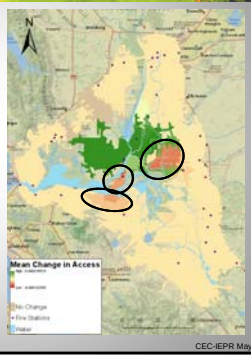
First responder accessibility: The Delta



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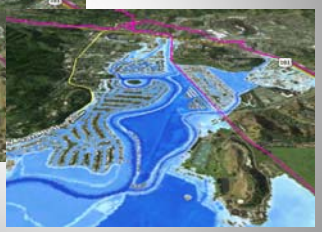
Gas pipeline vulnerability study (CEC-500-11-016)

Fort Hamilton region



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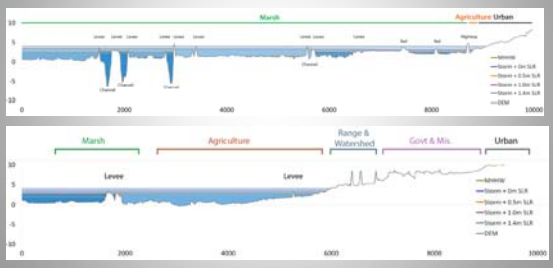
3Di model calibrated with 1998 storm event

Cross-section of inundation



Bay-Delta inundation simulations

Preliminary results: **Mission Bay 3Di Simulation**
Fort Hamilton region
Sherman Island

Inundated Pipeline in SF Bay Region

$PWL_{1.4} = SLR_{1.4} + ESE_{100}$