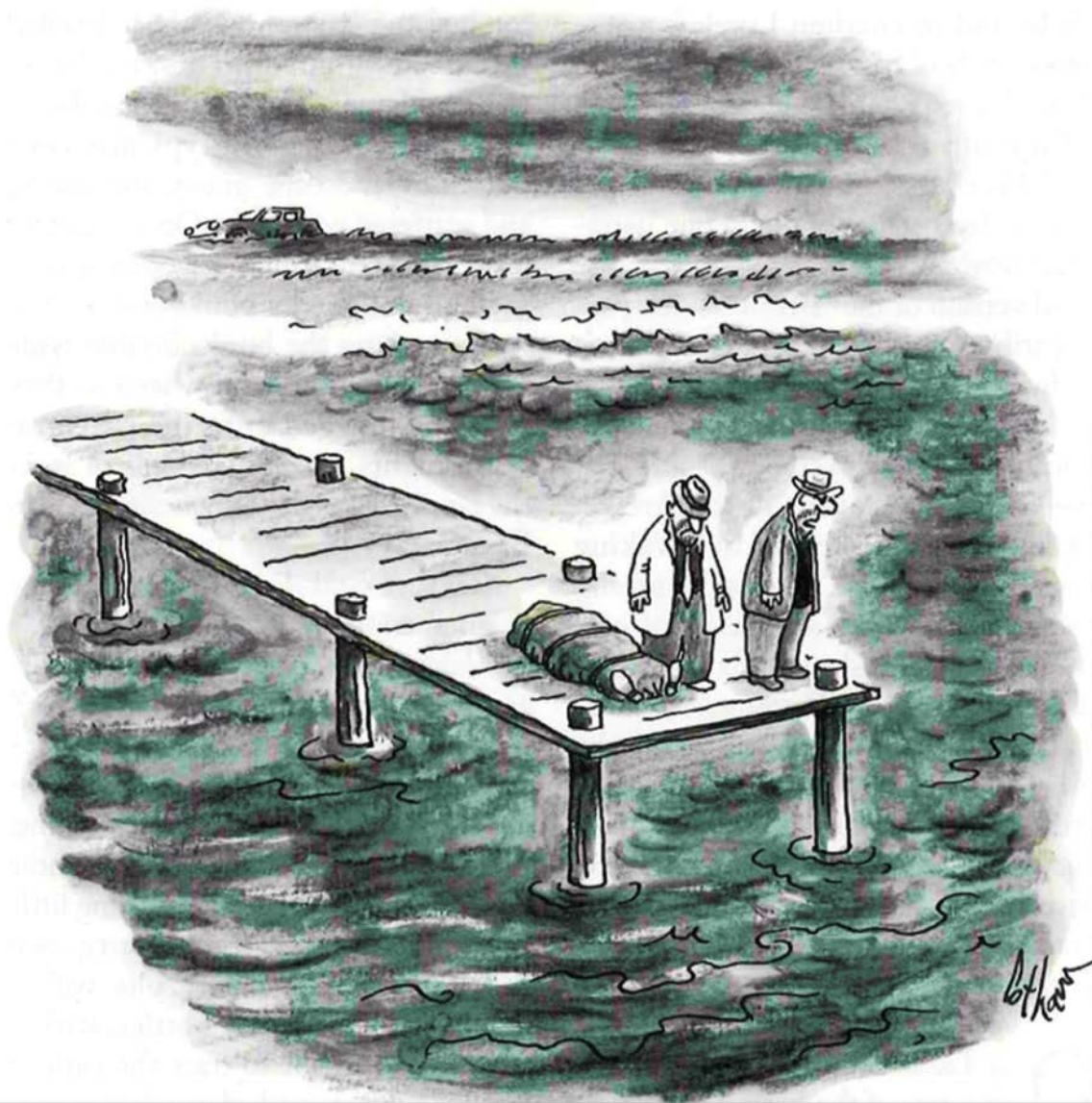


Identifying and Adapting to Sea-level Rise Vulnerabilities

Matt Brennan, PhD, PE

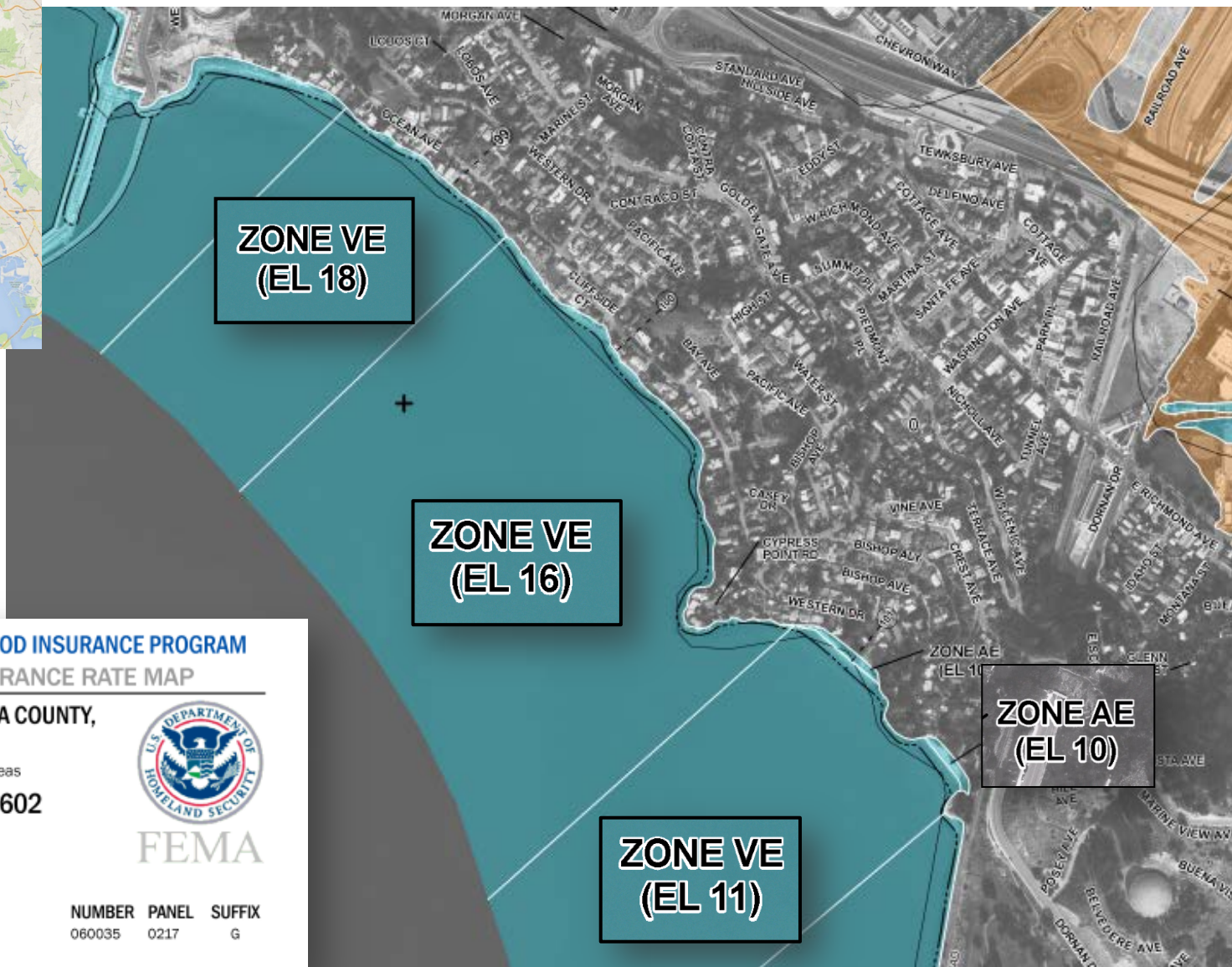
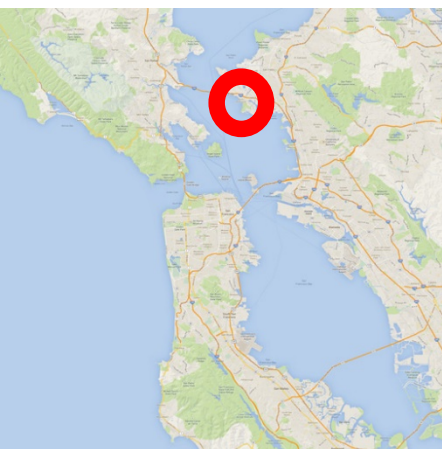
mbrennan@esassoc.com

AEP – May 20th, 2017



"I've been dumping bodies here for years, and it seems to me that the sea level is rising."

FEMA Flood Maps – Now with Waves!



NATIONAL FLOOD INSURANCE PROGRAM FLOOD INSURANCE RATE MAP

**CONTRA COSTA COUNTY,
CALIFORNIA**

and Incorporated Areas

PANEL **217** OF **602**



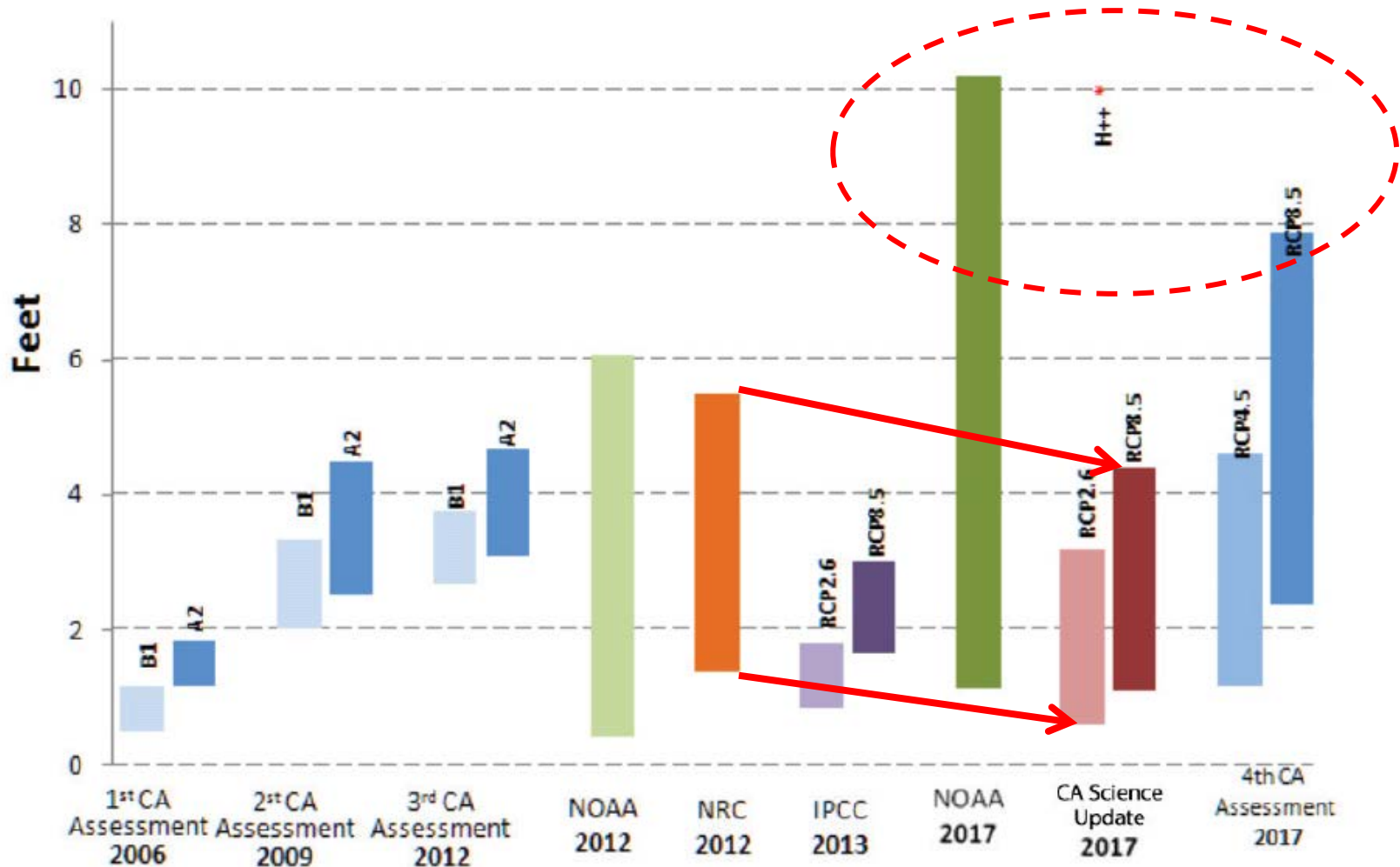
FEMA

Panel Contains:

COMMUNITY
RICHMOND, CITY OF

NUMBER	PANEL	SUFFIX
060035	0217	G

Evolution of Sea-Level Rise Projections



Source: Griggs et al. 2017. Rising Seas in California: An Update on Sea-Level Rise Science.

FEMA + Sea-Level Rise

Legend

Contra Costa (Effective 9/30/2015)

Coastal Transects

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Increased Flooding Scenarios

Increase: +1ft



Increase: +2ft



Increase: +3ft

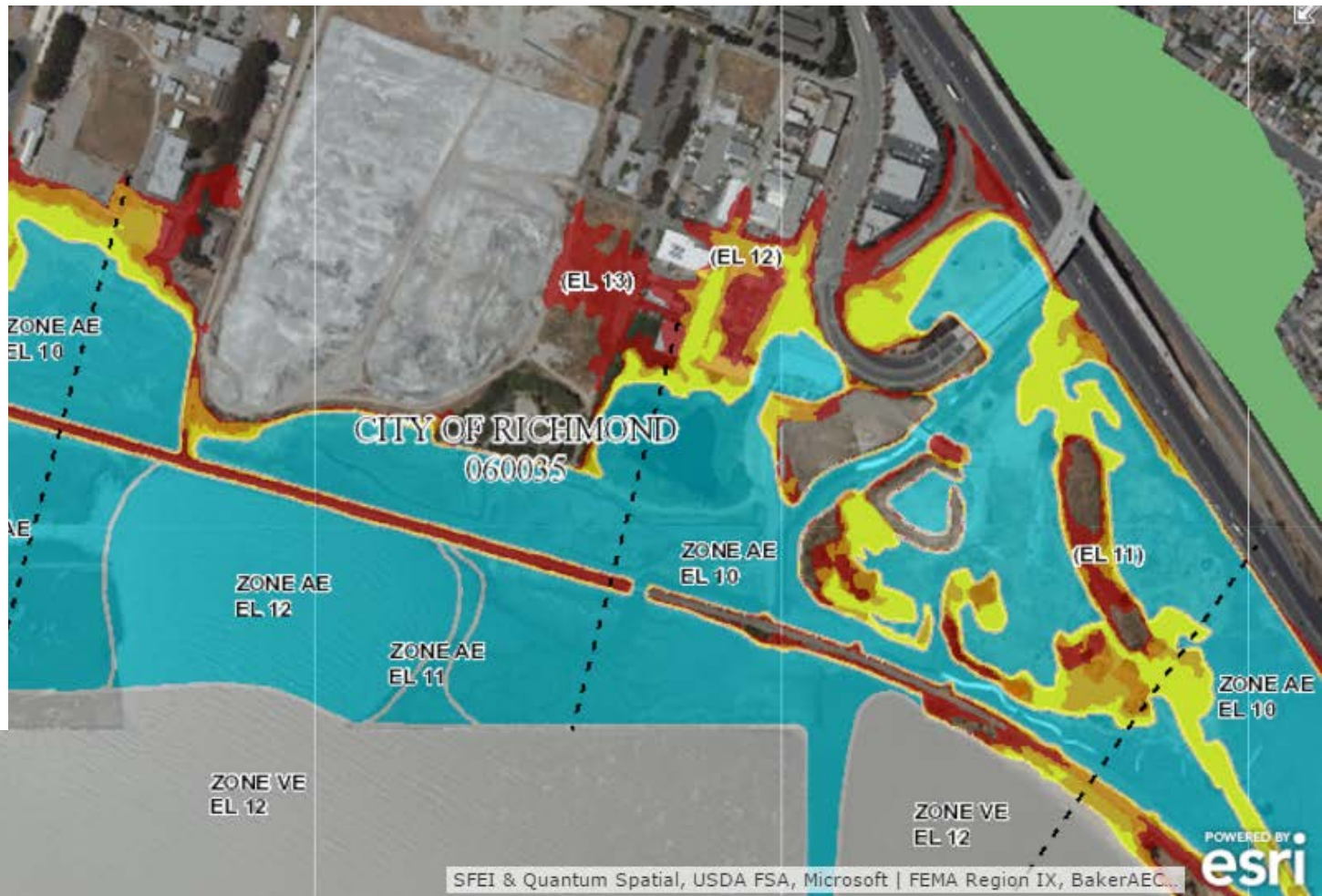


Coastal Special Flood Hazard Areas

AE

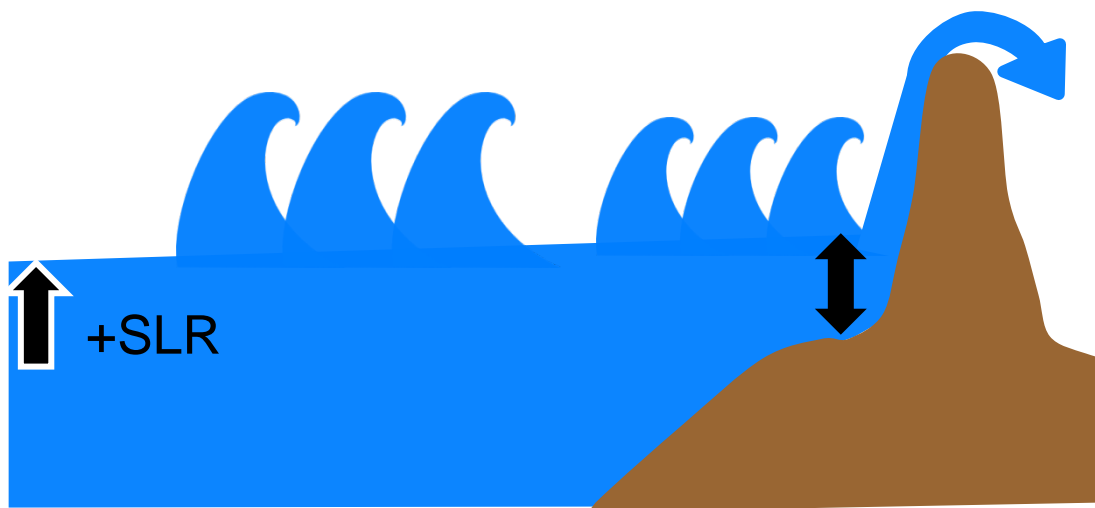
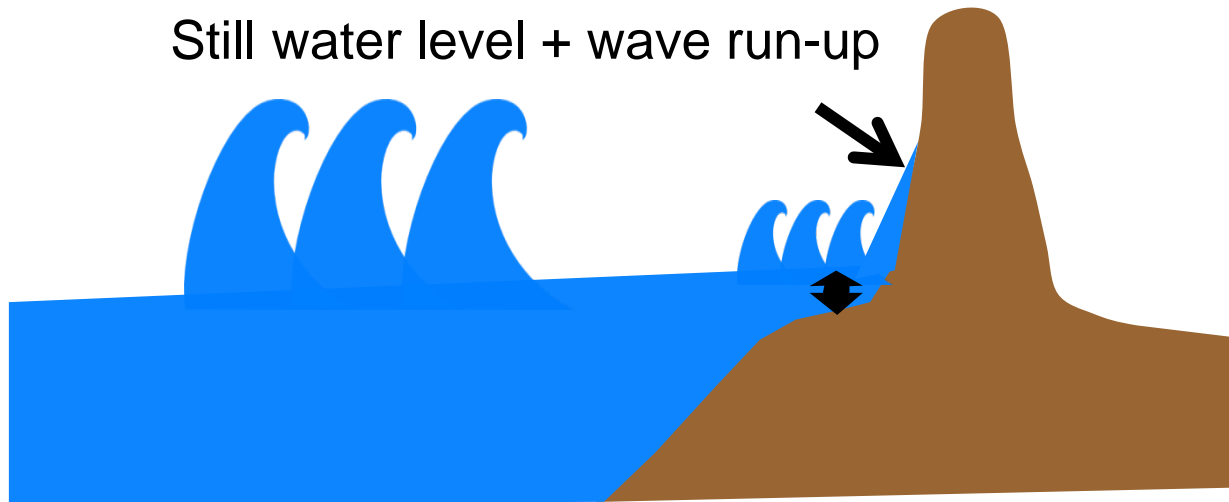
VE

0.2 Pct Annual Chance Flood Hazard



Wave Run-up Can May Faster Than Sea-Level Rise

Total water level =
Still water level + wave run-up



Increase in sea level	Increase in total water level
1	2.2
2	4.3
3	6.3
4	9.6
5.5	12.9

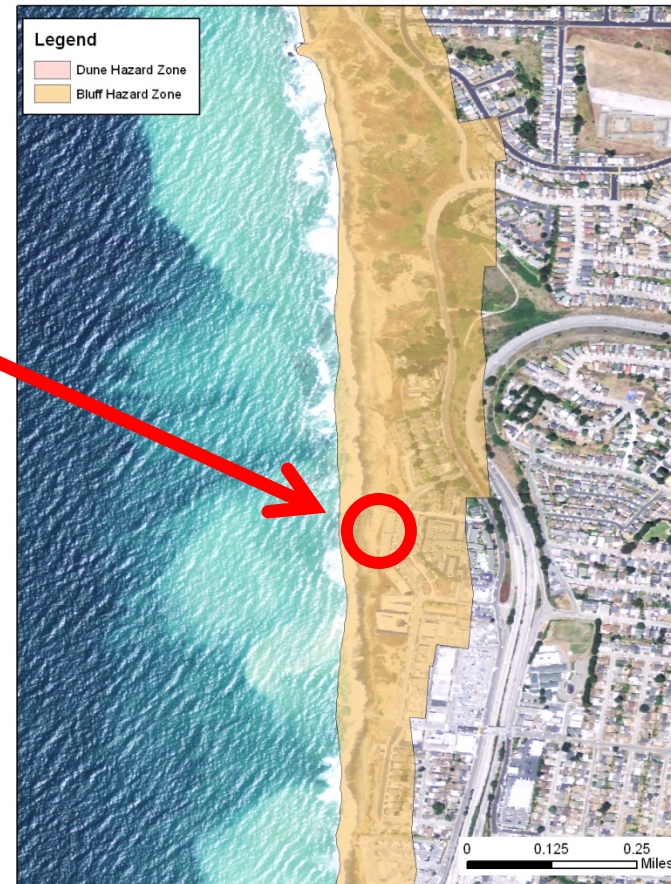
Source: FEMA

Coastal Erosion: Sea-level Rise Accelerated Hazard

Effective FEMA DFIRM
published 2008



Estimated – ESA PWA, potential
erosion by 2100, published 2009

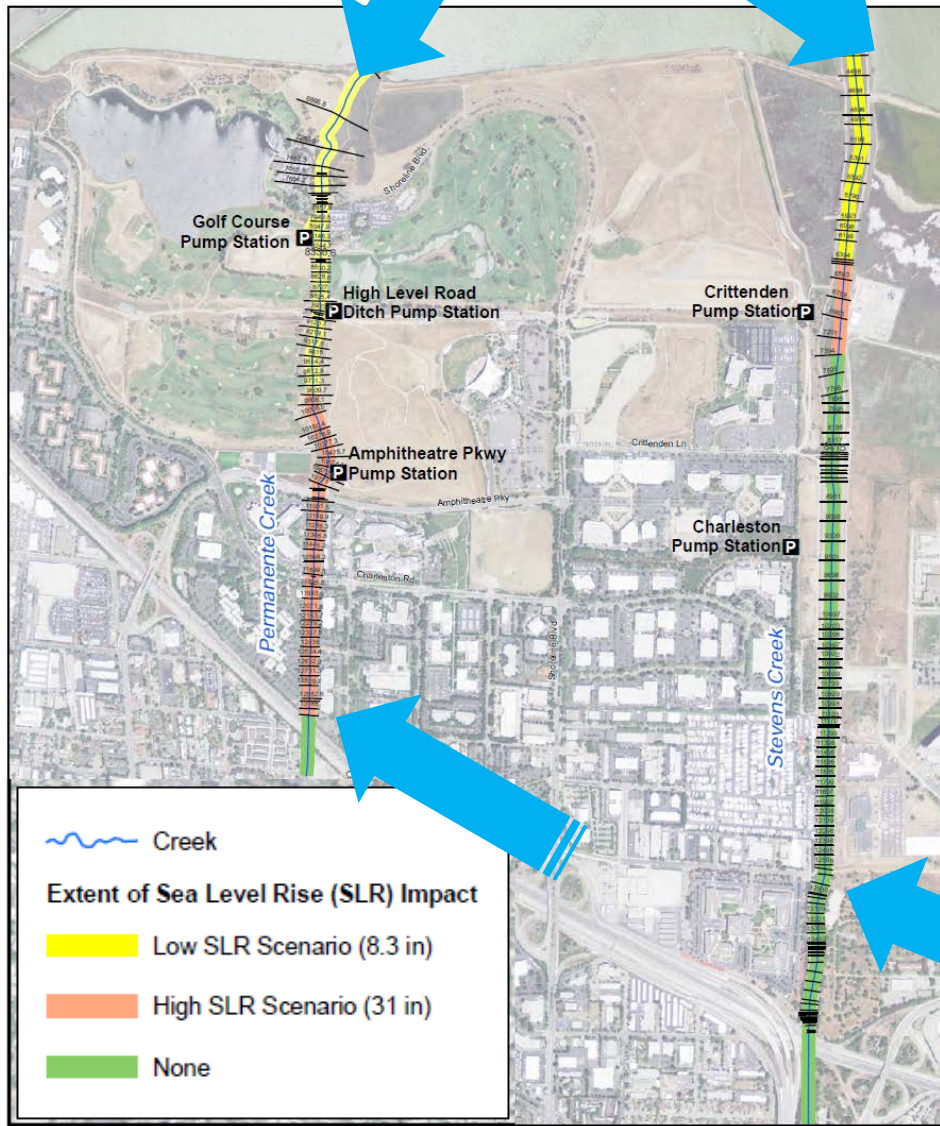


2010 - Buildings
uninhabitable

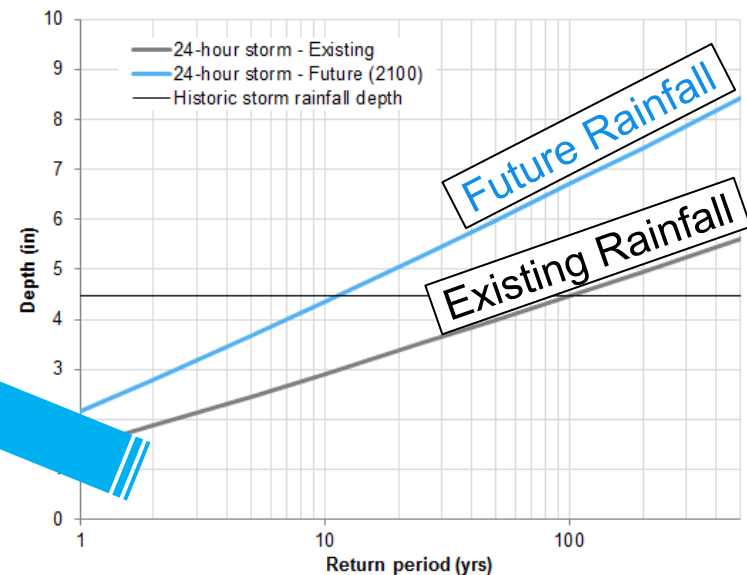


Climate Change, Precipitation, and Creek Flooding

Bay flooding increases with sea-level rise ...



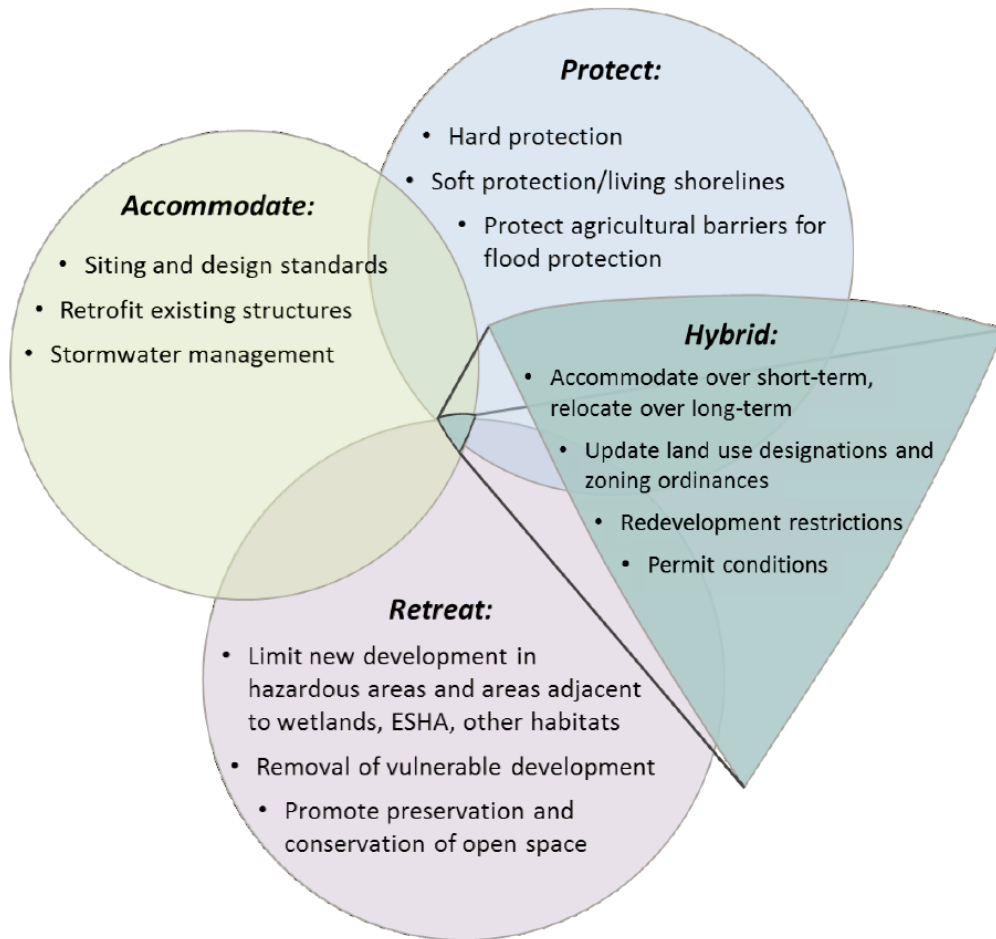
... and so might precipitation & creek flooding!



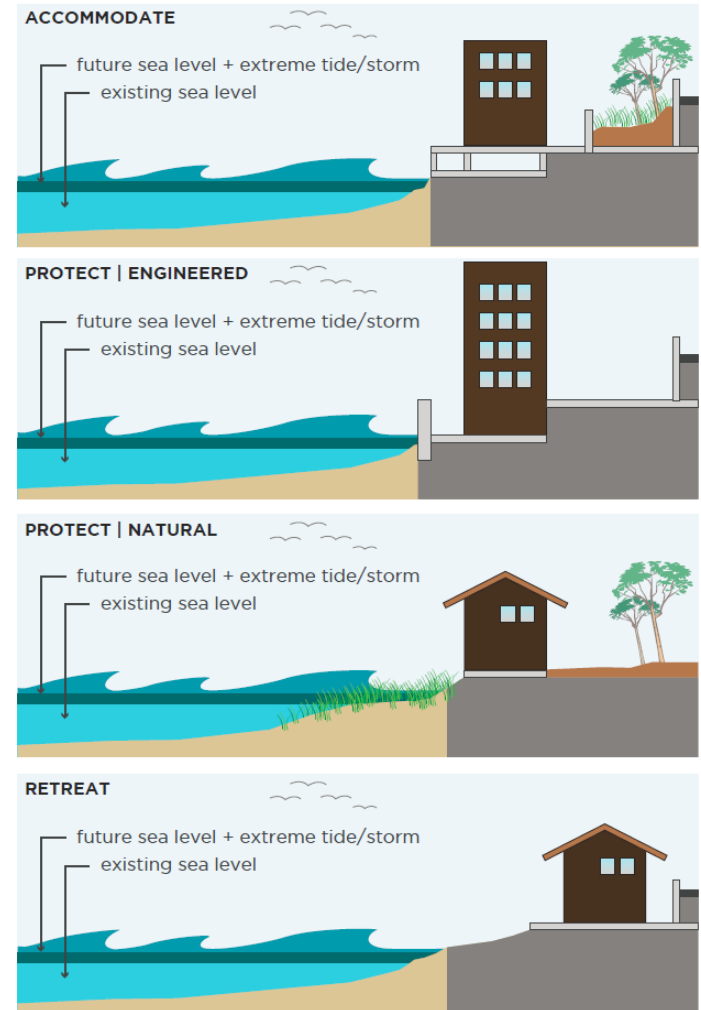
Different Shorelines Face Different Hazards



Approaches to Adaptation



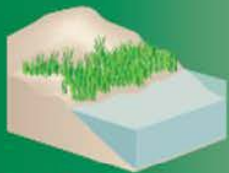
INTERVENTION OPTIONS



Protecting with Green & Gray

GREEN - SOFTER TECHNIQUES

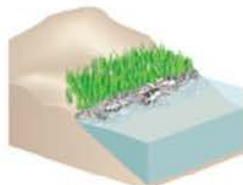
Living Shorelines



VEGETATION ONLY -
Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.



EDGING -
Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.



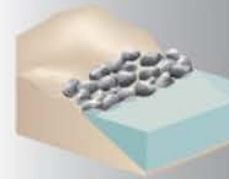
SILLS -
Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.



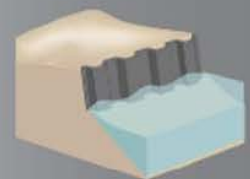
BREAKWATER -
(vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.

GRAY - HARDER TECHNIQUES

Coastal Structures

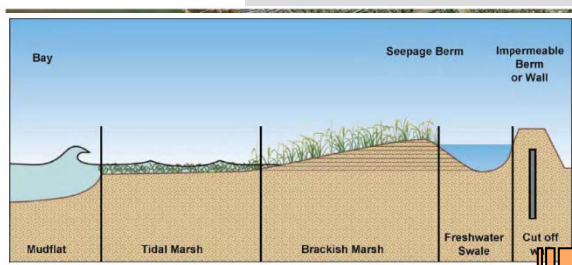


REVETMENT -
Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



BULKHEAD -
Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

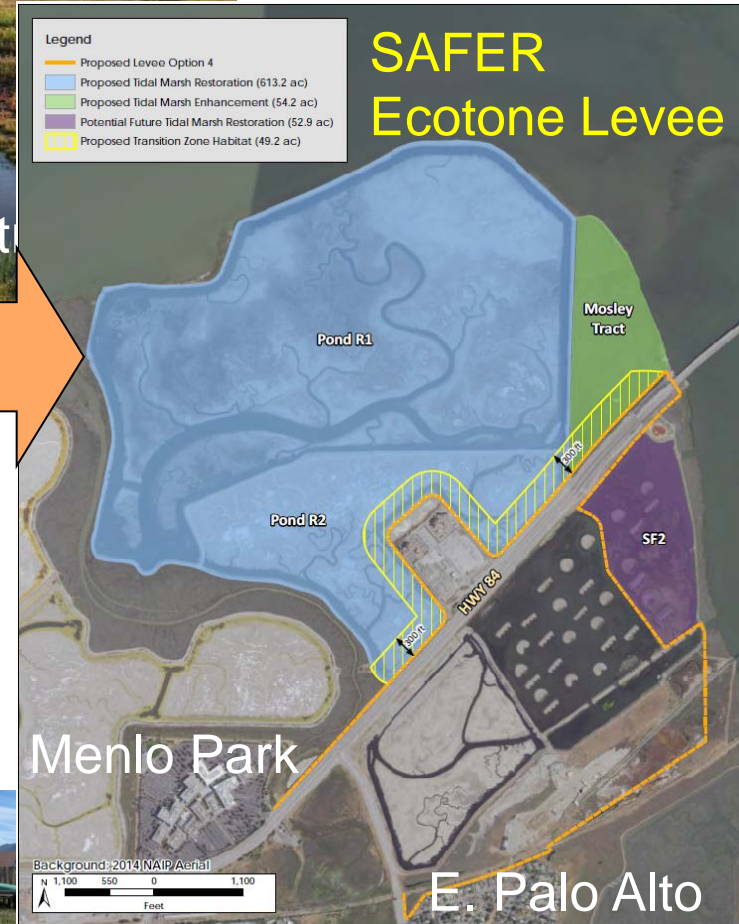
Example of Green/Gray Hybrids



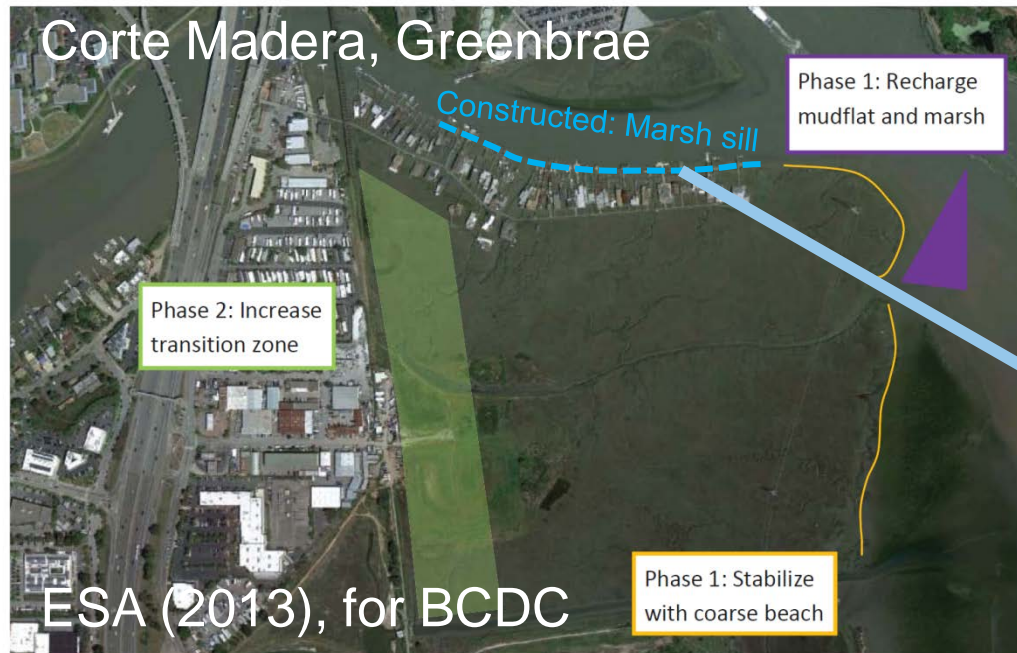
Hayward Shoreline
(ESA PWA, 2010)



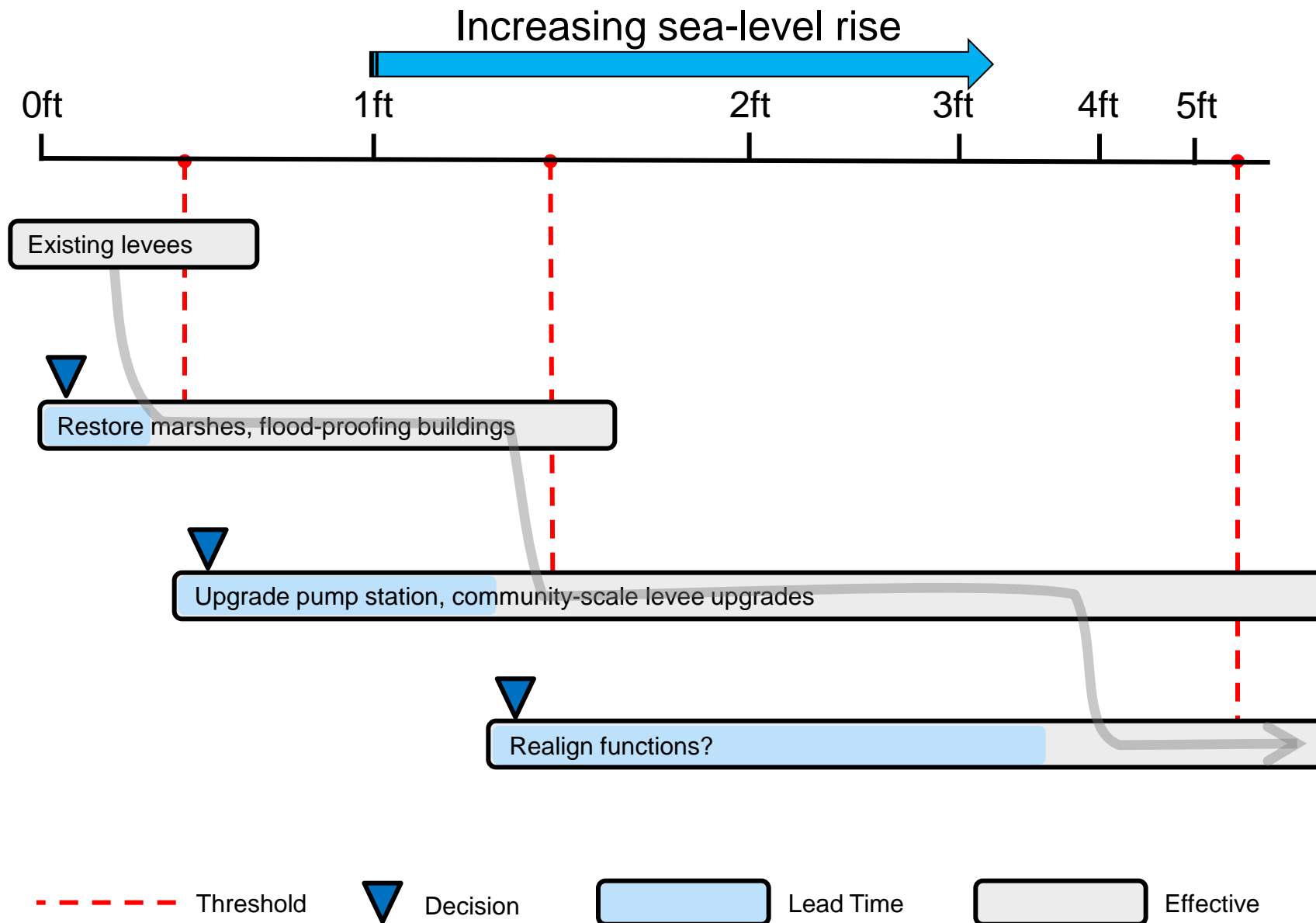
Oro Lomo Sanitary District
Pilot project (2016)



Corte Madera, Greenbrae



Intentional & Phased Adaptation Planning



Where to Learn More

- At AEP 2017:
 - Ocean Beach MP: Multi-Objective Adaptation to Sea Level Rise along San Francisco's Pacific Ocean Shore
 - Friday, May 19 @ 9-10:30am
 - Sea Level Rise Mapping: The Past, the Present, and the Future
 - Saturday, May 20 @ 1:45-3:15pm
- State
 - OPC
 - www.opc.ca.gov/climate-change
 - California Coastal Commission
 - www.coastal.ca.gov/climate/slrguidance.html
- Bay Area
 - Bay Conservation & Development Commission
 - www.adaptingtorisingtides.org