Building Coastal Resilience: Understanding Hazards, Adapting to Change
Part I

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“I’ve been dumping bodies here for years, and it seems to me that the sea level is rising.”
Science of Sea-Level Rise Projections

Variations in Coastal BFEs – It’s all about Waves!
Coastal Erosion: Sea-level Rise Accelerated Hazard

Effective FEMA DFIRM published 2008

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

2010 - Buildings uninhabitable

Legend:
- Dune Hazard Zone
- Bluff Hazard Zone
Wave Run-up May Increase Faster Than Sea-Level Rise

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

<table>
<thead>
<tr>
<th>Increase in sea level</th>
<th>Increase in total water level</th>
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<tbody>
<tr>
<td>1</td>
<td>2.2</td>
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<tr>
<td>2</td>
<td>4.3</td>
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<td>3</td>
<td>6.3</td>
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<td>9.6</td>
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<td>5.5</td>
<td>12.9</td>
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</tbody>
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Source: FEMA
DWR Technical Methods Manual: 
Relating Future Coastal Conditions to Existing FEMA Flood Hazard Maps
Different Shorelines Face Different Hazards
Flooding Associated with Coastal Lagoons

Jenner, CA
December 12, 2015
Increased Groundwater Elevations in Low-lying Areas
Bay flooding increases with sea-level rise …

… and so might precipitation & creek flooding!

Extant of Sea Level Rise (SLR) Impact
- Low SLR Scenario (8.3 in)
- High SLR Scenario (31 in)
- None
Approaches to Adaptation

CA Coastal Commission SLR Guidance

**Accommodate:**
- Siting and design standards
- Retrofit existing structures
- Stormwater management

**Protect:**
- Hard protection
- Soft protection/living shorelines
  - Protect agricultural barriers for flood protection

**Hybrid:**
- Accommodate over short-term, relocate over long-term
  - Update land use designations and zoning ordinances
  - Redevelopment restrictions
  - Permit conditions

**Retreat:**
- Limit new development in hazardous areas and areas adjacent to wetlands, ESHA, other habitats
- Removal of vulnerable development
  - Promote preservation and conservation of open space

**INTERVENTION OPTIONS**

**ACCOMMODATE**
- future sea level + extreme tide/storm
  - existing sea level

**PROTECT | ENGINEERED**
- future sea level + extreme tide/storm
  - existing sea level

**PROTECT | NATURAL**
- future sea level + extreme tide/storm
  - existing sea level

**REPEAT**
- future sea level + extreme tide/storm
  - existing sea level
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.

**Coastal Structures**

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

- **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.

• NOAA Living Shoreline report, 2015.
Example of Green/Gray Hybrids

Hayward Shoreline (ESA PWA, 2010)

Oro Lomo Sanitary District Pilot project (2016)

Corte Madera, Greenbrae

SAFER Ecotone Levee

Menlo Park, E. Palo Alto
Intentional & Phased Adaptation Planning

Increasing sea-level rise

0ft 1ft 2ft 3ft 4ft 5ft

Existing levees

Threshold

decision

Lead Time

Effective

Restore marshes, flood-proofing buildings

Upgrade pump station, community-scale levee upgrades

Realign functions?
Coastal Hazards: Where to Learn More

• At FMA 2017:
  – Building Coastal Resilience, Part 2 (2-3:30pm, Regency F)

• State & Federal
  – Ocean Protection Council
    • www.opc.ca.gov/climate-change
  – California Coastal Commission
    • www.coastal.ca.gov/climate/slrguidance.html
  – Our Coast, Our Future (Point Blue, with USGS)
    • http://data.pointblue.org/apps/ocof/cms/
  – DWR Relating Future Conditions to Existing Condition FEMA Maps
    • http://www.water.ca.gov/floodmgmt/lrafmo/fmb/fas/nfip/cca.cfm

• Regional
  – Bay Conservation & Development Commission
    • www.adaptingtorisingtides.org
  – AdaptLA
    • http://dornsife.usc.edu/uscseagrant/adaptla/
  – FEMA San Francisco Increased Flooding Maps
    • http://www.r9map.org/Pages/San-Francisco-Coastal-Bay-Study.aspx