The Game of Floods

SEA LEVEL RISE IS COMING


1 foot of SLR
or King Tide
3 feet of SLR
or 100-year
storm
Little
Island
Marin
Novato
Woodacre
Santa
Venetia
China Camp
State Park
San
Rafael
Ross
Kentfield
Richm
Mill
Valley
Stinson
Beach
Mt Tamalpais
State
Park
Belvedere-
Tiburon
Sausalito

Major adaptation strategies

Protect

- HARD
  - Build dikes, seawalls
  - Install tide gates
  - Raise grades
  - Increase pumping
- SOFT
  - Natural beach systems
  - Tidal wetlands
  - Horizontal levees

Manage Retreat

- Land and structure acquisition /relocation
- Building/Planning code and regulation changes
- Allow erosion /migration of natural areas

Accommodate

- Elevate buildings and infrastructure
- Floodproof critical structures
- Floodable buildings/tiered developments

…and combinations of any above

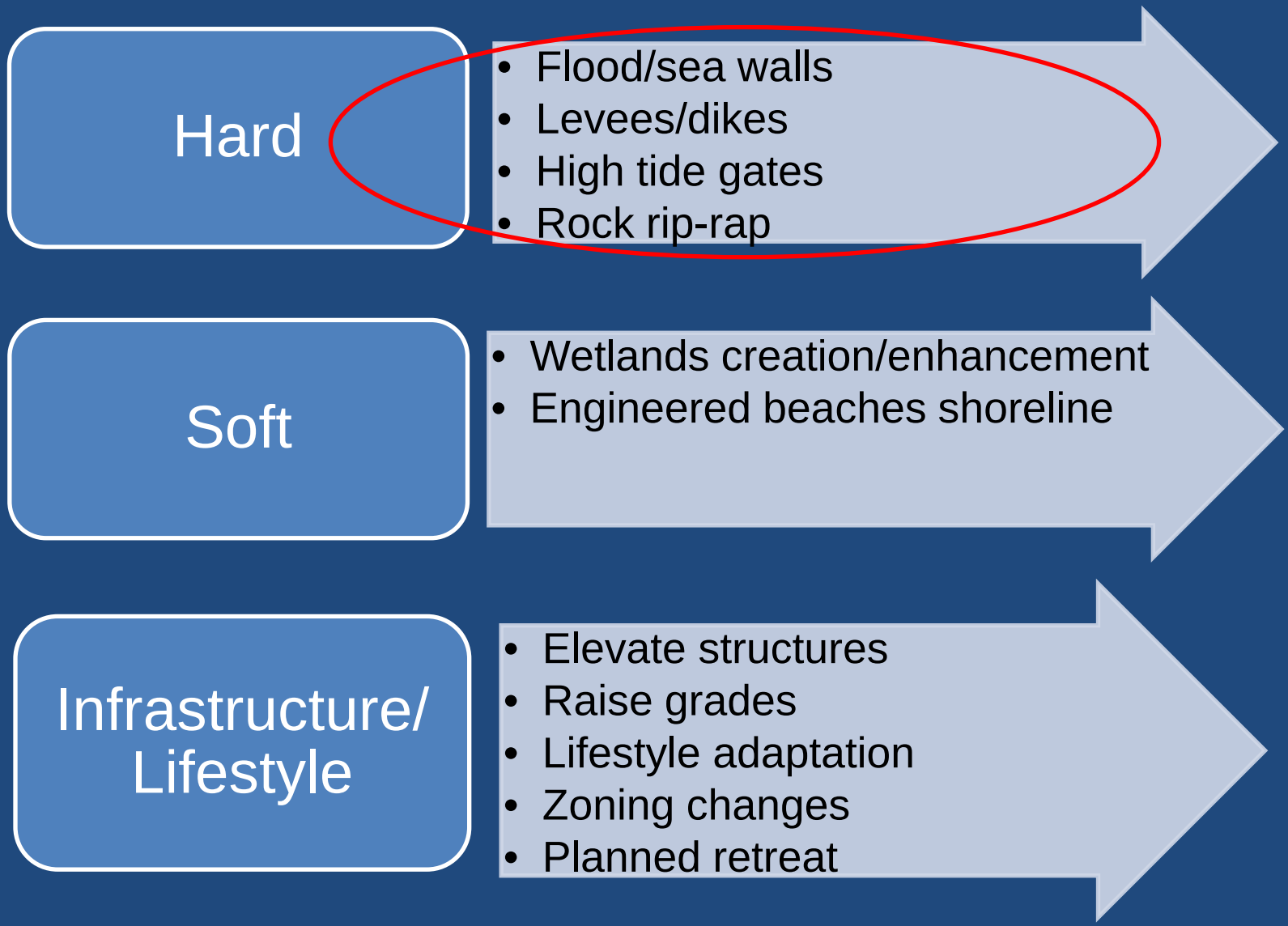
Famous adaptors throughout history…

Dutch Boy built protection

Moses implemented managed retreat

Noah went for accommodation (floodable structures)

Major adaptation strategies

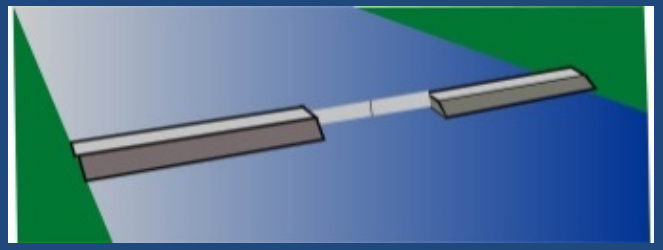


PROTECT

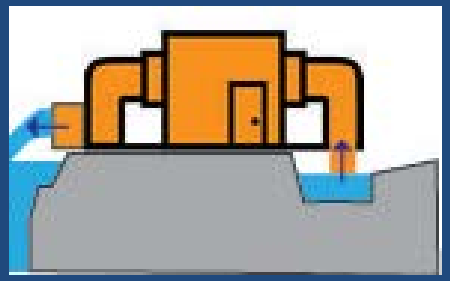
Hard (traditional) engineering

Traditional levee

Seawall/revetment



Tide gate



Flood wall & pump station

Sea wall

Pros: Limited ROW required

Cons: Cost, Impacts

Bulkhead seawall in Seadrift neighborhood

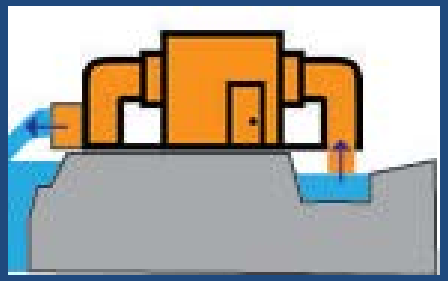
Westhoff

Levee

Pros: Stability if maintained, Cost lower then wall

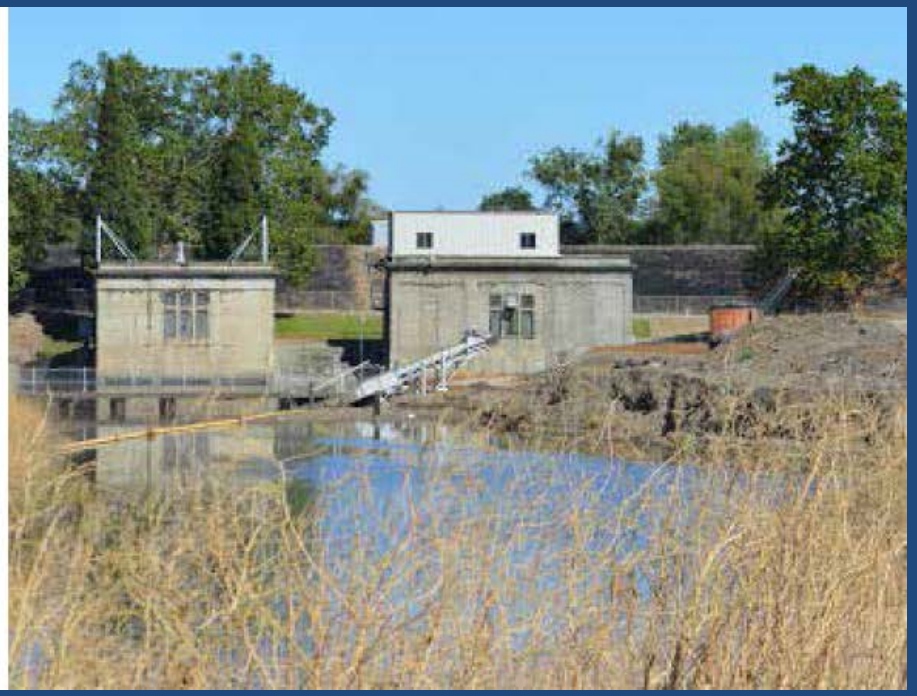
Cons: Large ROW required

Flood wall & pump station

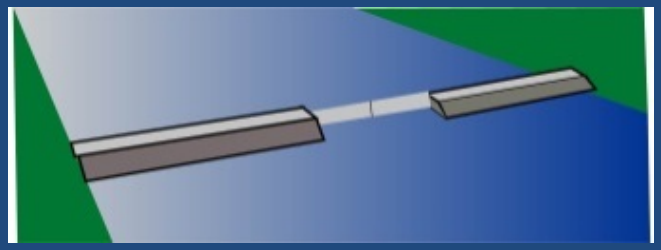


Pros: Lower ROW than levees

Cons: Capital and maintenance costs

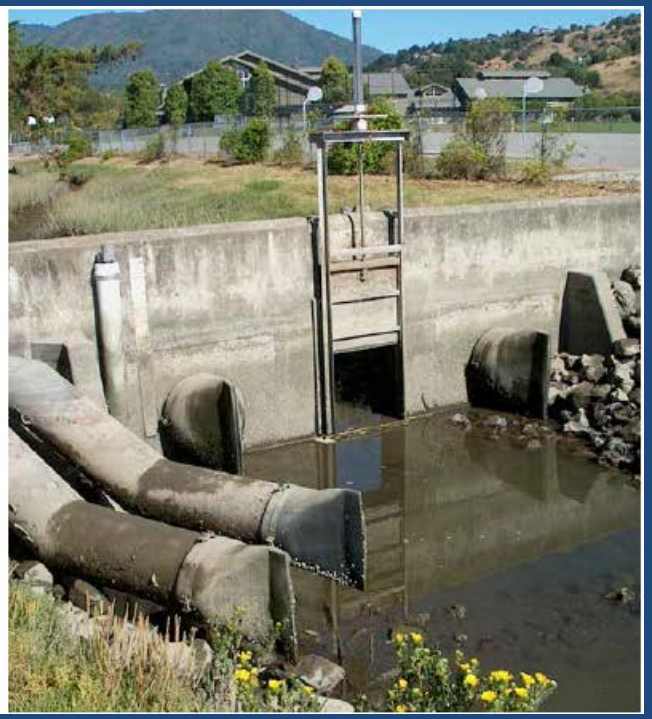


Tide gate



Pros: Temp solution to tidal riverine flooding

Cons: Cost, limited effectiveness over time



Major adaptation strategies

Hard

- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft

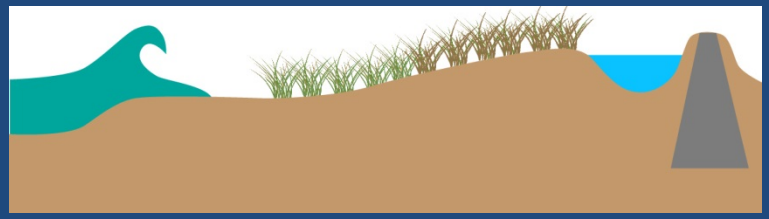
- Ecotone Levees
- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/ Lifestyle

- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

PROTECT

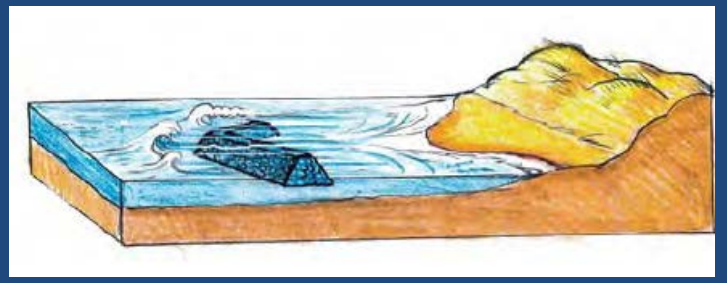
Soft (nature-based) engineering



Horizontal levee

Dune restoration &
Beach maintenance

Wetland/ shoreline vegetation



Offshore structure

Horizontal levee

Pros: Uses landscape to attenuate waves, provides habitat

Cons: Cost for earthwork, larger ROW

Wetland/ shoreline vegetation

Pros: Habitat improvement and flood reduction

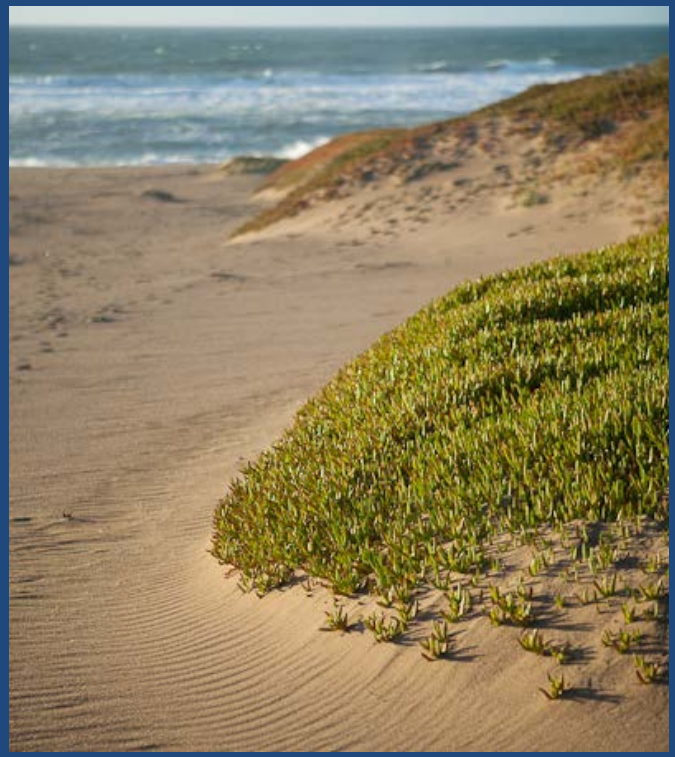
Cons: Large ROW required

Giacomini Wetland Restoration, 2008

Dune restoration & beach maintenance

Pros: Recreation and flood reduction benefits

Cons: Costs for replenishment



Aramburu sandy foreshore construction 2012

Placing larger wood groins – eucalyptus logs

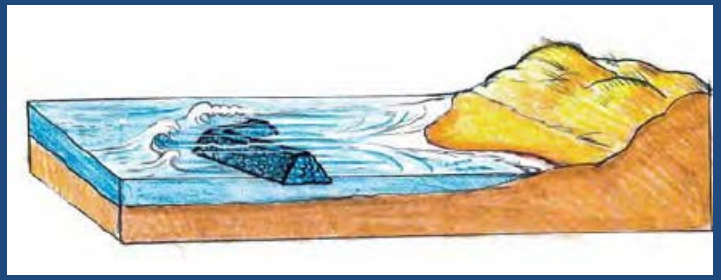
Aramburu engineered bay beach spring-summer 2013

Winter storm gravel and shell berm persists

Sand beachface slope accretes, steepens

Sand partially buries winter storm berm

Offshore structures



Pros: Reduces waves impacts – more when structure is higher

Cons: Costs to construct, maintain and limited effectiveness for SLR

San Rafael "Living Shorelines"

Living Shorelines – Oysters/Reefs

- Living shorelines project – M. Latta (CC) and K. Boyle, (SF State)
- Off San Rafael
- Multi-year successful project

www.sfbaylivingshorelines.org

Major adaptation strategies

Hard

- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft

- Wetlands creation/enhancement
- Engineered beaches shoreline
- T-zone creation

Infrastructure/ Lifestyle

- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

ACCOMMODATE

New floodable development

Elevate buildings

New/ elevated road

Elevate buildings

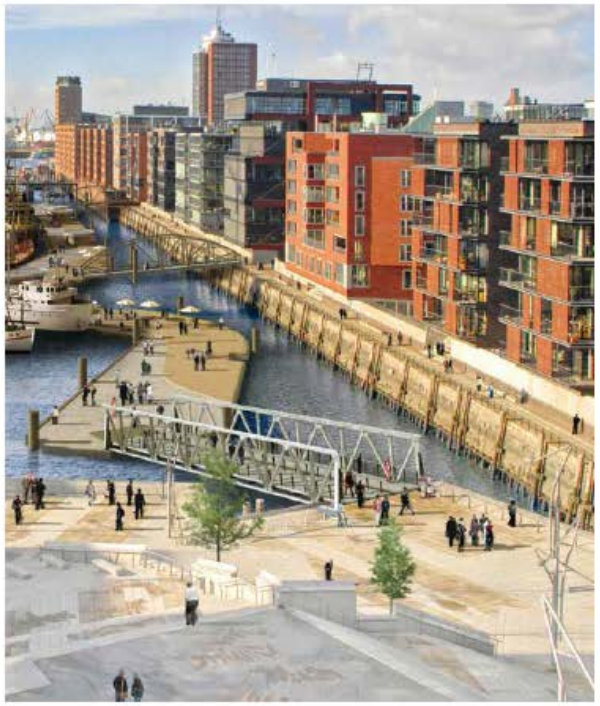
Pros: Effective for storm flooding

Cons: Costs, not effective for permanent tidal flooding

Floodable development

Pros: Potential solution that generates revenue

Cons: Impacts from more development – higher density to pay for costs



New/elevated road

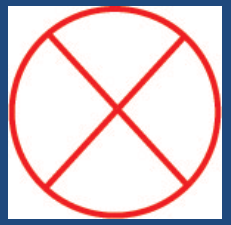
Pros: Protects roads when designed correctly

Cons: Very high cost, ROW

RETREAT

Retreat

Rebuild here



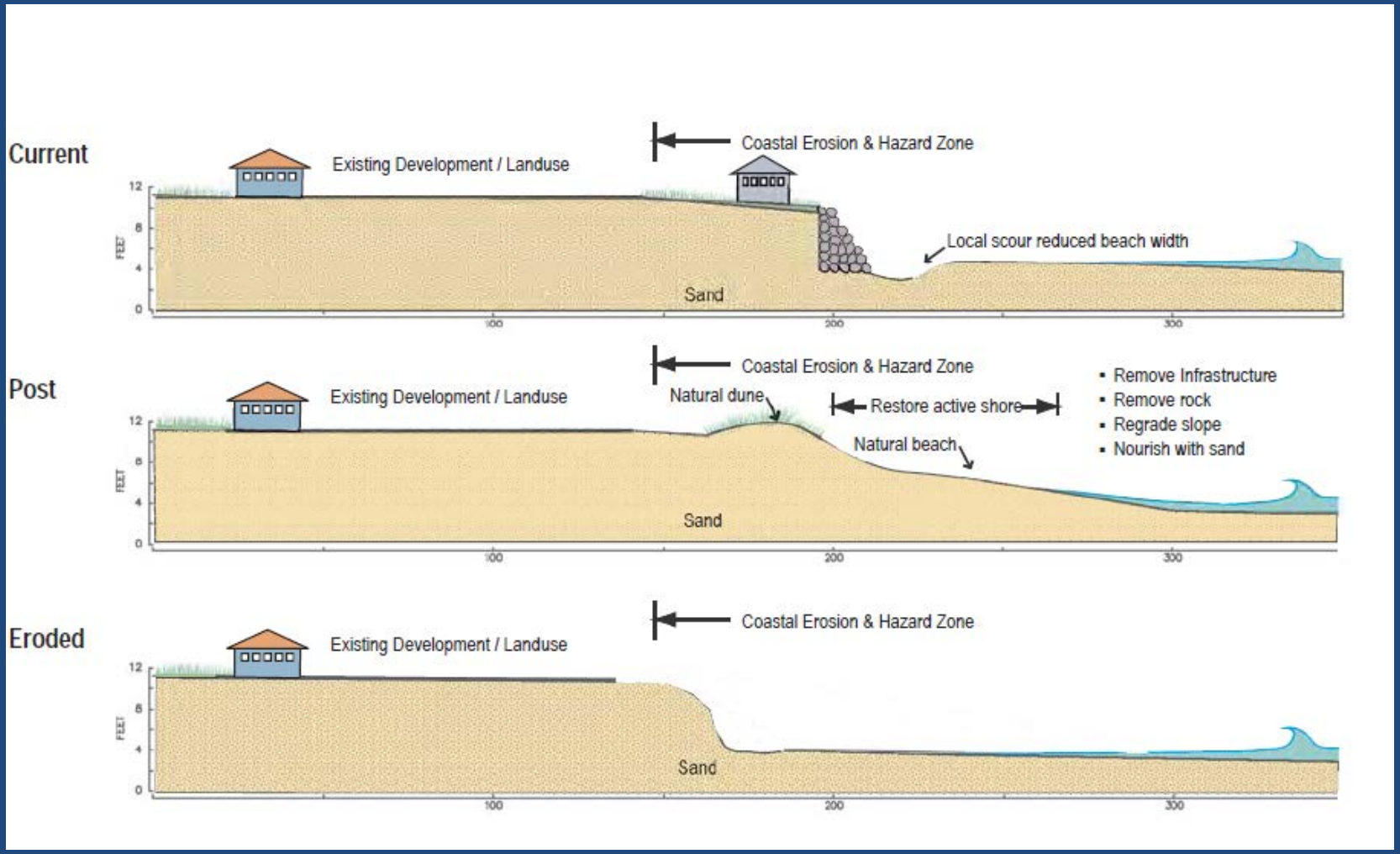
Post-storm prohibitions

Stricter land use zoning

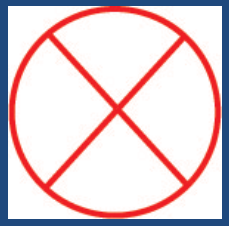
Managed Retreat

Pros: Lower costs if no buyout

Cons: Costs for buy-out and community impacts, new infrastructure



Post Storm Restrictions and Stricter Land Use Zoning



- No or restricted rebuilding after storms?
- Rolling easements
- Extra technical studies
- Use of stricter codes (FEMA V)

The Game of Floods

Community Driven Adaptation Planning for Sea Level Rise along the Inner Richardson Bay Shoreline

Just like HBO's Game of Thrones except for no sex and violence - but with lots more urban planning

Roger Leventhal, P.E., CFM

START

THE GAME OF FLOODS *Your Island*

Sea levels are rising world-wide as warming oceans expand and melt glaciers and ice sheets. Stronger storms coupled with rising seas can significantly damage— even destroy— property, infrastructure, public facilities, natural habitats, and other resources we depend on. In the face of these threats, you are tasked with collaboratively developing a Sea Level Rise Adaptation Plan using the strategies (game pieces).

1. To begin, one player reads the sea level rise scenario aloud.
2. Role the di to determine who goes first. The highest roll goes first. If a tie occurs, the tied players must re-roll. Players take turns in clockwise order.
3. In turn, each player selects an asset to accommodate, defend, or retreat from. No need to duplicate assets. Use the worksheet provided to record your choice, costs, and pros and cons.
4. Next, in turn, each player places and states aloud their preferred adaptation strategies on or around the island. Conflicting strategies are allowed.
5. Use the remaining time to finalize the group's proposal by resolving conflicts. Consider the following factors to inform the proposal: (1) Costs/funding, (2) Private property impacts, (3) Environmental impacts, (4) Equity/social justice concerns, (5) Others. Use your worksheet to take notes.

Sea Level Rise 2050 Scenario Key

RED AREA = Permanent Sea Level Rise Flooding
ORANGE AREA = Temporary Annual Storm Flooding
YELLOW AREA = Temporary 100-Year Storm Flooding

LEGEND

Evacuation Route · Storm Shelter · Electrical Sub-Station · Marina · Gas Station · Sewage Lift Station · Mammal Habitat · Seabird Colony · Aquaculture · Ranch · Agriculture · Sheriff · Grocery · Public Well · Home · Water · Roadway · Beach · School Site · Restaurant · Boat Launch · Parking · Library · Historic Church · Hospital · Fire Station · Post Office

GAME PIECES

Managed Retreat
- Retreat $$$
- Post-storm prohibitions $
- Move here $$$
- Stricter land use zoning $

Accommodate Water
- Elevate Buildings $$$
- Elevate/New Road $$$$$
- Floodable Buildings $$$$$

Hard Engineering
- Revetment/Seawal $$$
- Tide Gate $$$$$
- Traditional Levee $$$$
- Wall & Pump Station $$$

Soft Engineering
- Horizontal Levee $$$$
- Offshore Structure $$
- Wetland/shoreline vegetation $$$
- Beach Maintenance $$$

C-SMART Program
May 2015


EXIT


Spotted Owls (K3 + VLO)

Communities of North Bay Island

- Downtown Norbay
- Eroding Cliff Heights
- Mudflat Manors
- Desolation Court
- Shoreline Marina
- Twig Cove
- Seaspray Homes

Downtown Norbay

- Commercial hub of the island
- Protected by undersize levees and vulnerable to both riverine and tidal flooding

Eroding Cliff Heights

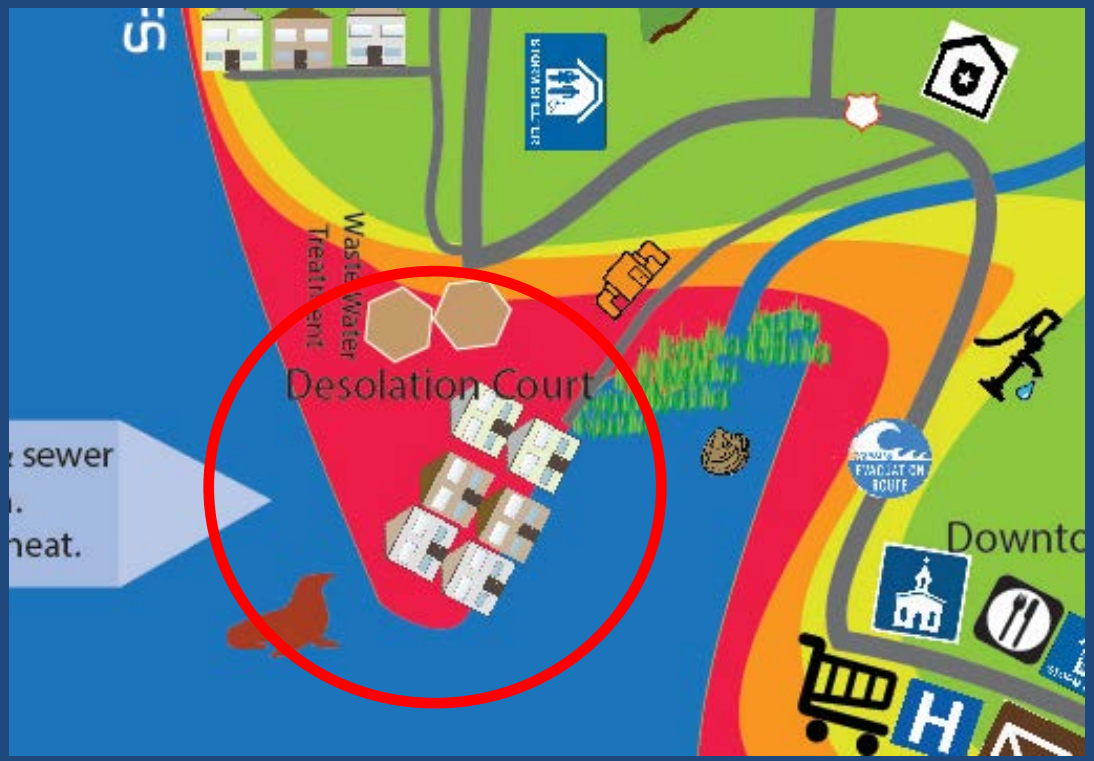
- Residential community threatened by cliff erosion
- Zoning and shoreline protection challenges

Mudflat Manor

- Large residential community threatened by SLR
- Vocal community of property owners demanding protection

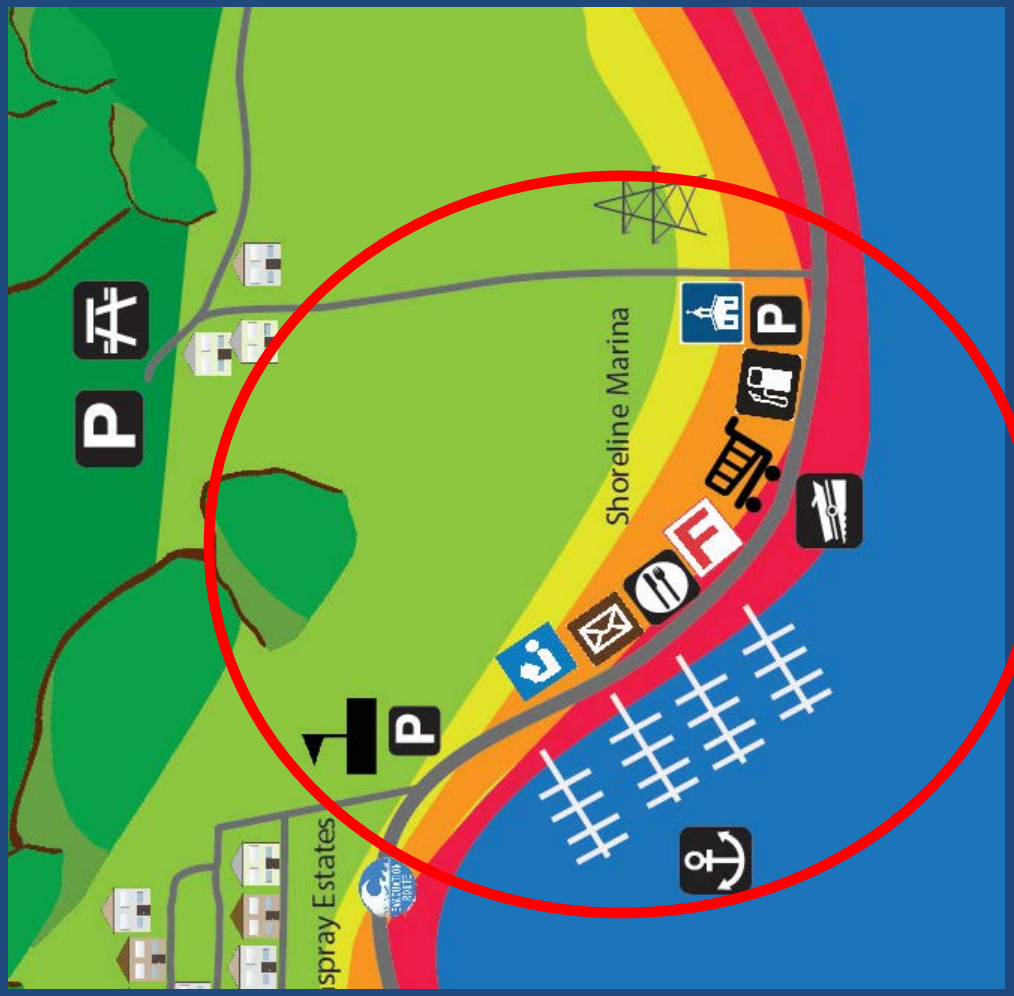
Desolation Court

- Small poor isolated community threatened by SLR
- In danger of being cut-off from services



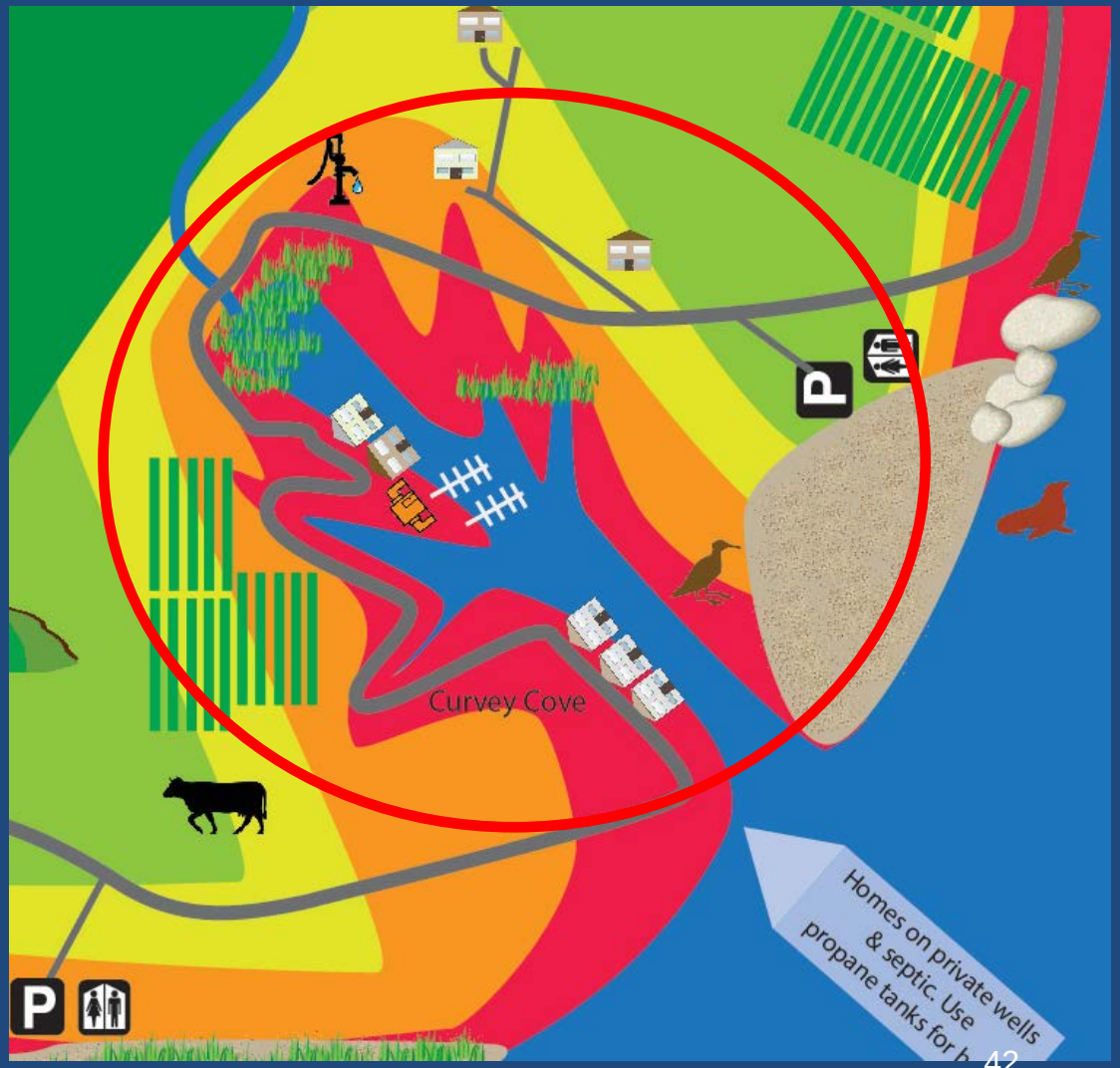
Shoreline Marina

- Water-based commercial business and associated businesses threatened by SLR
- In danger of being cut-off from road access at high tides



Curvey Cove

- Historic Ag based community with access and crops threatened by SLR
- In danger of being cut-off from road access at high tides



Seaspray Estates

- Large vacation and second home community with access and homes threatened by SLR
- In danger of being cut-off from road access at high tides

Costs $$$

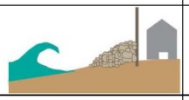
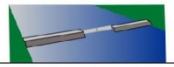
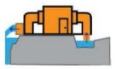
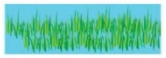
Real World – costs are messy and depend on many factors

+ planning & engineering
+ permitting
+ mitigation
+ maintenance & repair

Game World – costs are simpler one-time costs and given to you per unit (i.e. mile or # of buildings)

Game of Floods Marin Island

Adaptation Game Piece Reference Sheet

Name	Piece	Units	Cost ($)	Env. Impact EEE or EE or E	Flood Protection Short, med, or long-term	Uses and Notes
Hard (Traditional) Engineering						
Traditional Levee		Mile	$$$$	EEE	med	Protects against temporary flooding, storm surge and some sea level rise. • Can increase wave run-up and overtopping. • In high wave energy environment on coast, need to armor levee slope.
Seawall/Revetment		Mile	$$$	EEE	med	Protects against erosion. • Can increase wave run-up and overtopping. • Increase erosion in adjacent areas.
Tidal Gate		Feet	$$$$$	EEE	med	Protects against temporary flooding, storm surge and some sea level rise. • High environmental impacts to hydrology. • Viable in sheltered estuaries and lagoons.
Flood wall & pump station		Mile	$$$	EEE	short	Protects against temporary flooding, storm surge and some sea level rise. • Can increase wave run-up and overtopping. • Require electricity and maintenance.
Soft Engineering						
"Horizontal" Levee		Mile	$$$$	E	med/long	Protects against temporary flooding, storm surge, some sea level rise, and wave impacts. • Viable in sheltered estuaries and lagoons.
Wetland/shoreline vegetation		Acre	$$$	E	short-med	Protects against temporary flooding, storm surge, and wave impacts. • Viable in sheltered estuaries and lagoons.
Dune Restoration and Beach Maintenance (nourishment & groins)		Mile	$$$	EE	short/med	Protects against temporary flooding and storm surge. • Even nourished beaches can erode and expose infrastructure to wave damage.

1

Suggestions for the game

- Start with one community: what's at risk and what infrastructure is essential?
- What must be protected to allow the community to function. What other options exist?
- Adaptation options: discuss pros and cons of measures alone and combined - phasing
- Consider: mitigation, permits, and funding; options that span more than one community
- Add up the costs and stick your group's measures on the board

Game over?

1) Who in your organization is planning/strategizing around sea level rise?
2) What other organizations are also planning/strategizing that you may need to coordinate with?
3) What are the benefits or drawbacks of interagency discussion/planning/ strategizing?
4) Any improvements or suggestions?

Thank You

Visit www.MarinSLR.org for more information

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Novato Creek at Highway 101. Credit: Marin County staff