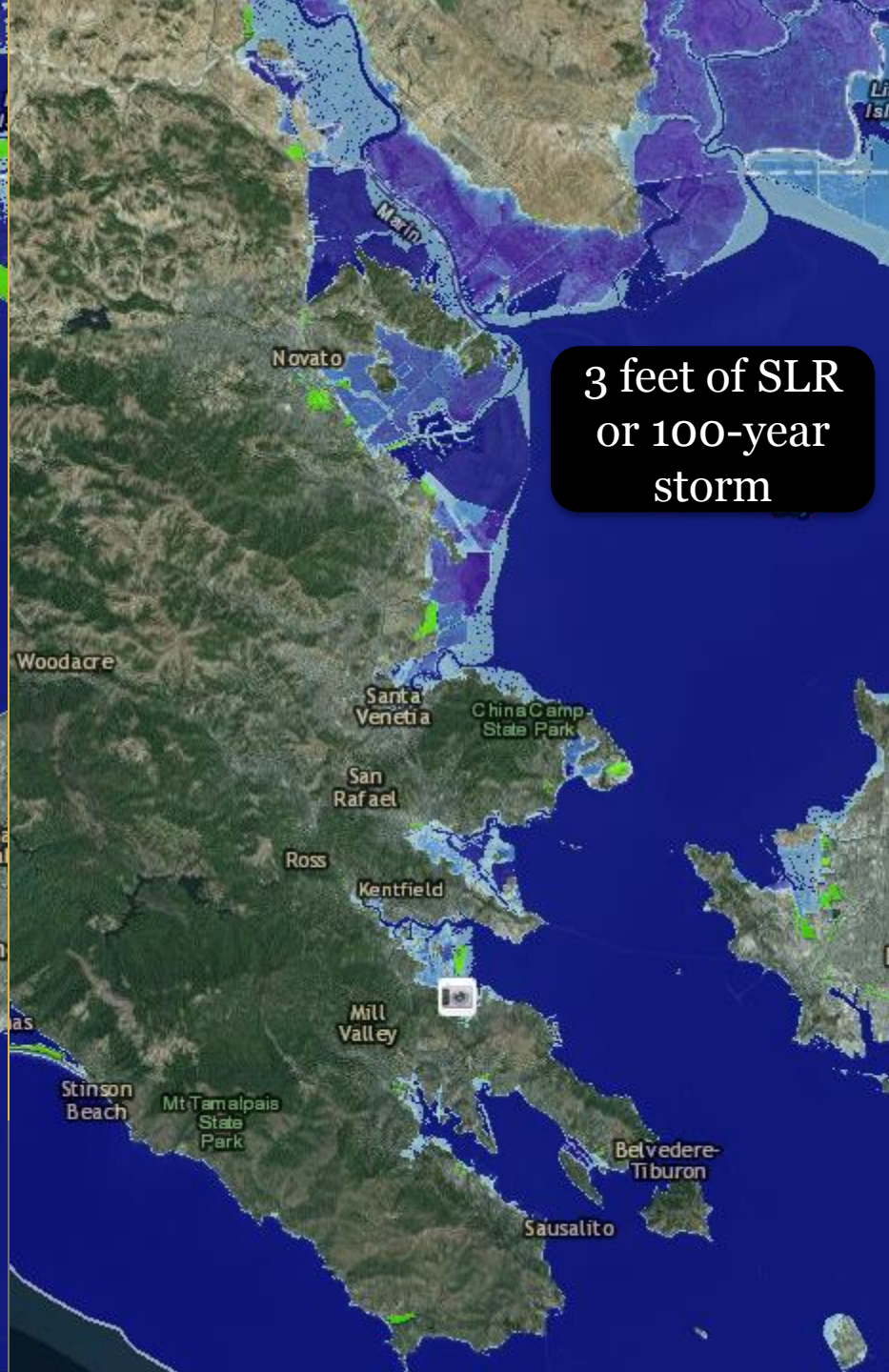




The Game of Floods

SEA LEVEL RISE IS COMING



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 phased managed retreat



Noah went for accommodation
(floodable structures)



Major Adaptation Strategies

Hard

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

Soft

- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/ Lifestyle

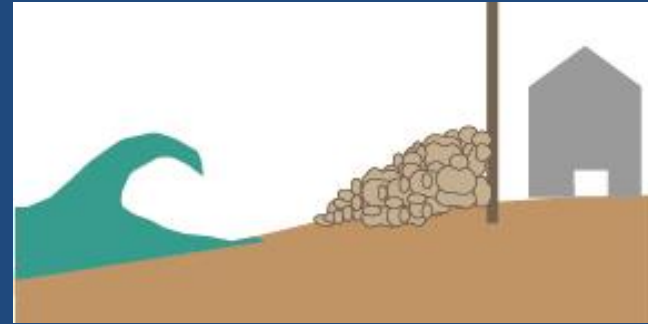
- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat

PROTECT

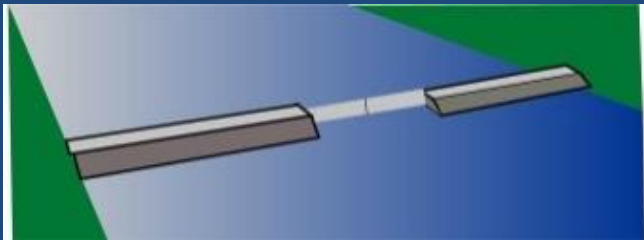
Hard (Traditional) Engineering



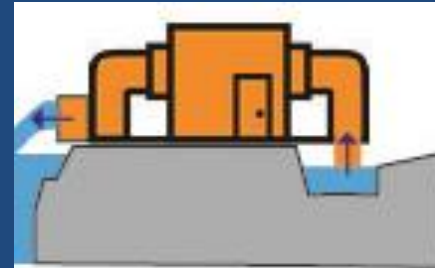
Traditional levee



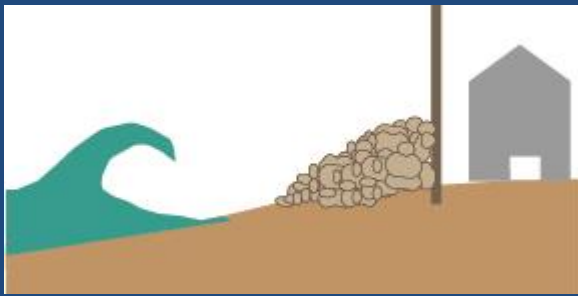
Seawall/revetment



Tide gate



Flood wall & pump station



Seawall

Pros: Limited ROW required
Cons: Cost, Impacts



Bulkhead seawall in Seadrift neighborhood

Westhoff



Levee

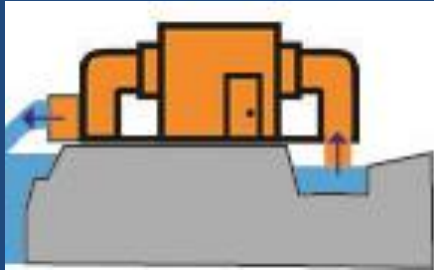


Pros: Stability if maintained,
cost lower than wall

Cons: Large ROW required

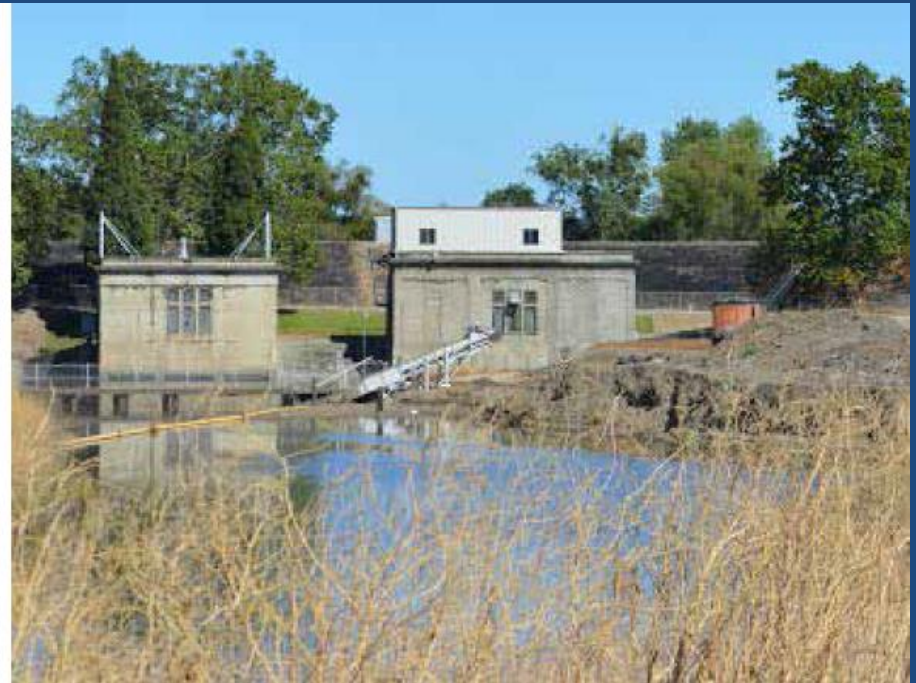


Flood wall & pump station

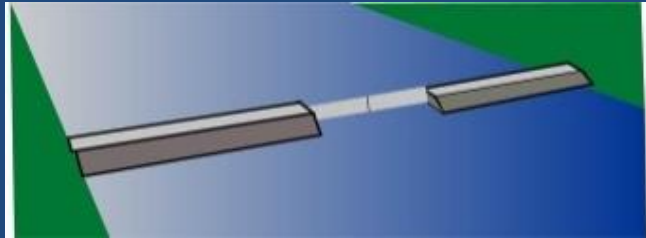


Pros: Lower ROW than levees

Cons: Capital and maintenance costs

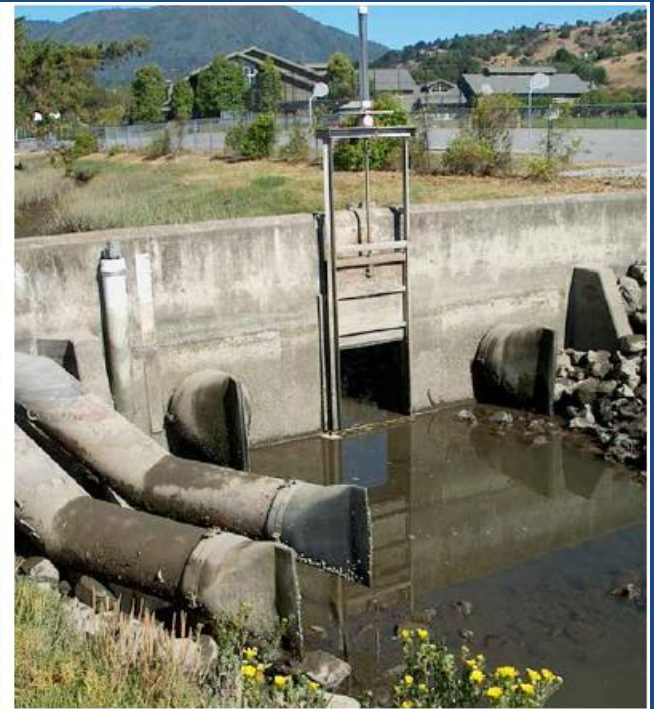


Tide gate



Pros: Temporary 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

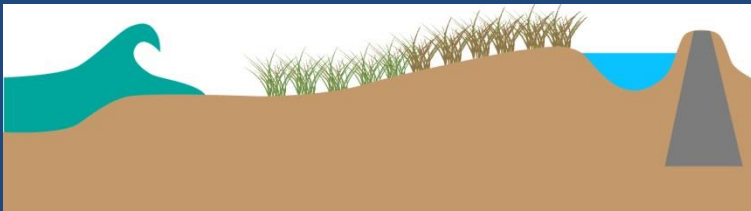
- Ecotone Levees
- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/ Lifestyle

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

PROTECT

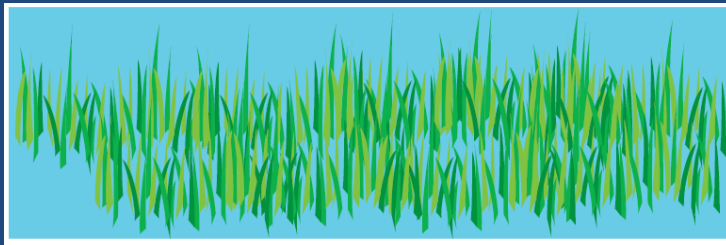
Soft (Nature-based) Engineering



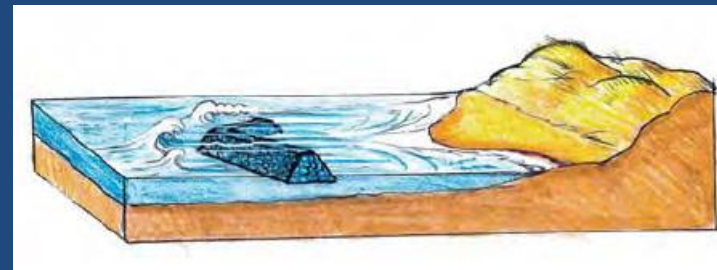
Horizontal levee



Dune restoration & Beach maintenance

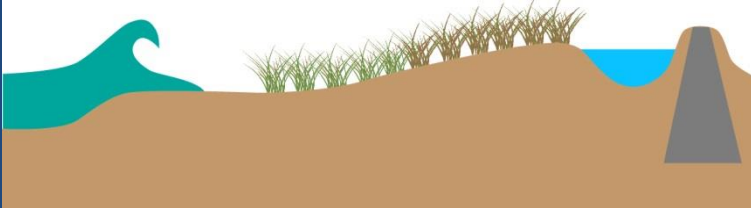


Wetland/ shoreline vegetation



Offshore structure

Horizontal levee

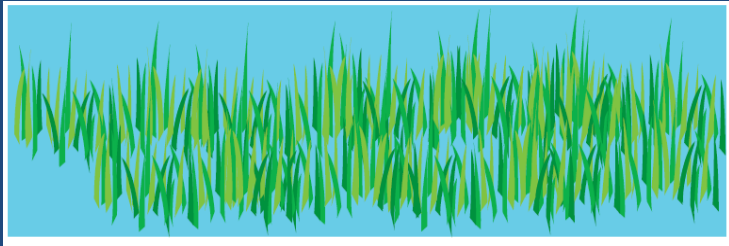


Pros: Uses landscape to attenuate waves, provides habitat

Cons: Cost for earthwork, larger ROW



Wetland/ shoreline vegetation



Pros: Habitat improvement and flood reduction

Cons: Large ROW required

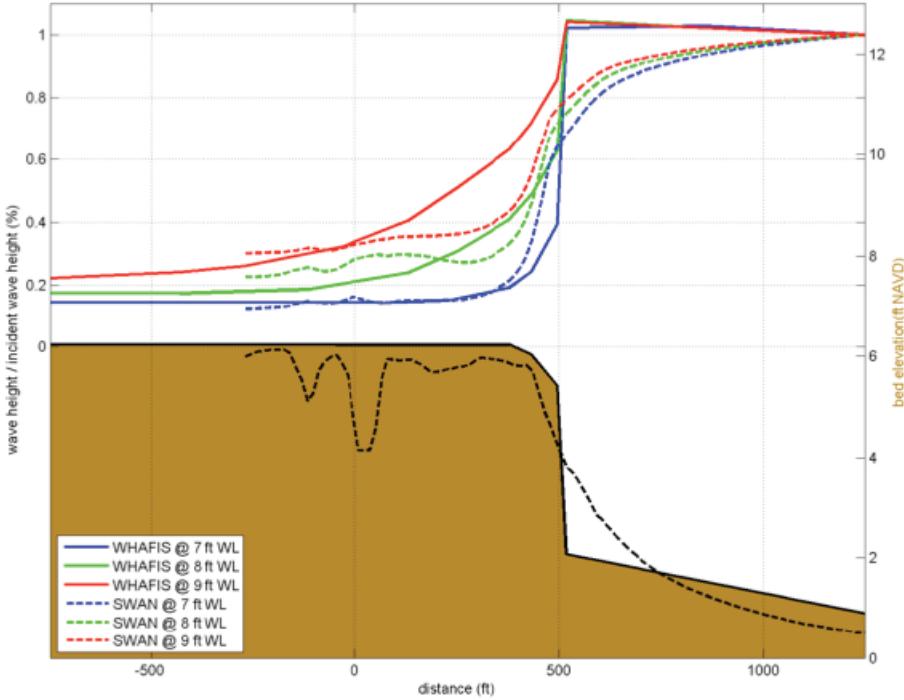


Giacomini Wetland Restoration, 2008

Tidal wetlands and Eco levees



Wave modeling (1-D WHAFIS, 2-D SWAN)



Dune restoration & beach maintenance



Pros: Recreation and flood reduction benefits

Cons: Costs for replenishment



Sandy Foreshore Construction 2012



Placing larger wood groins – eucalyptus logs



Engineered Bay Beach

Spring-Summer 2013 Aramburu Beach

Winter storm gravel and shell
berm persists

Sand beachface slope
accretes, steepens



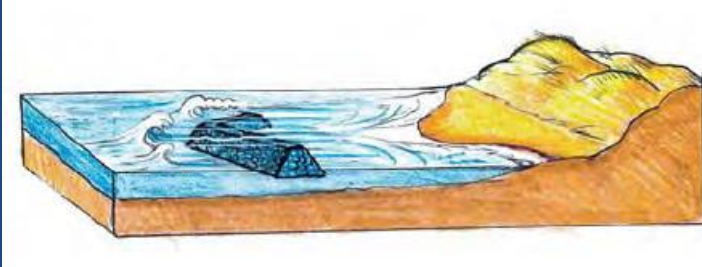
Sand partially buries
winter storm berm



Offshore structures

Pros: Reduces waves impacts – more when structure is higher

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



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

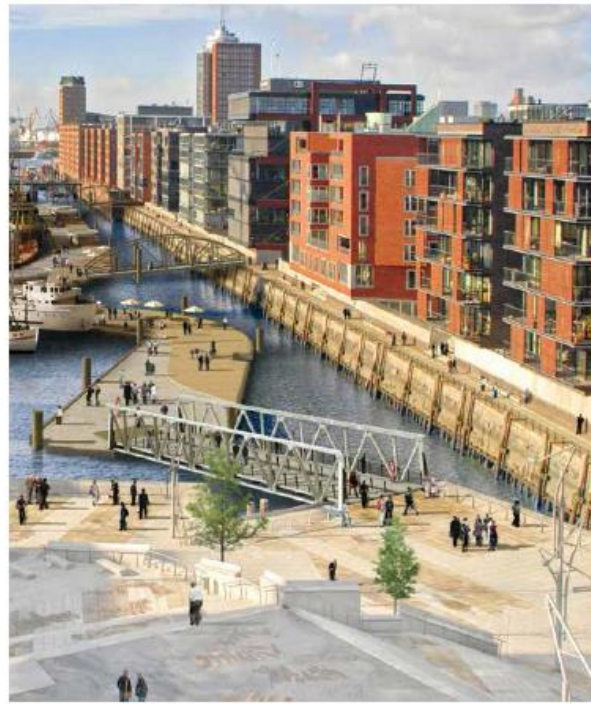




Floodable development

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



3. RETREAT



Retreat



Rebuild here



Post-storm
prohibitions



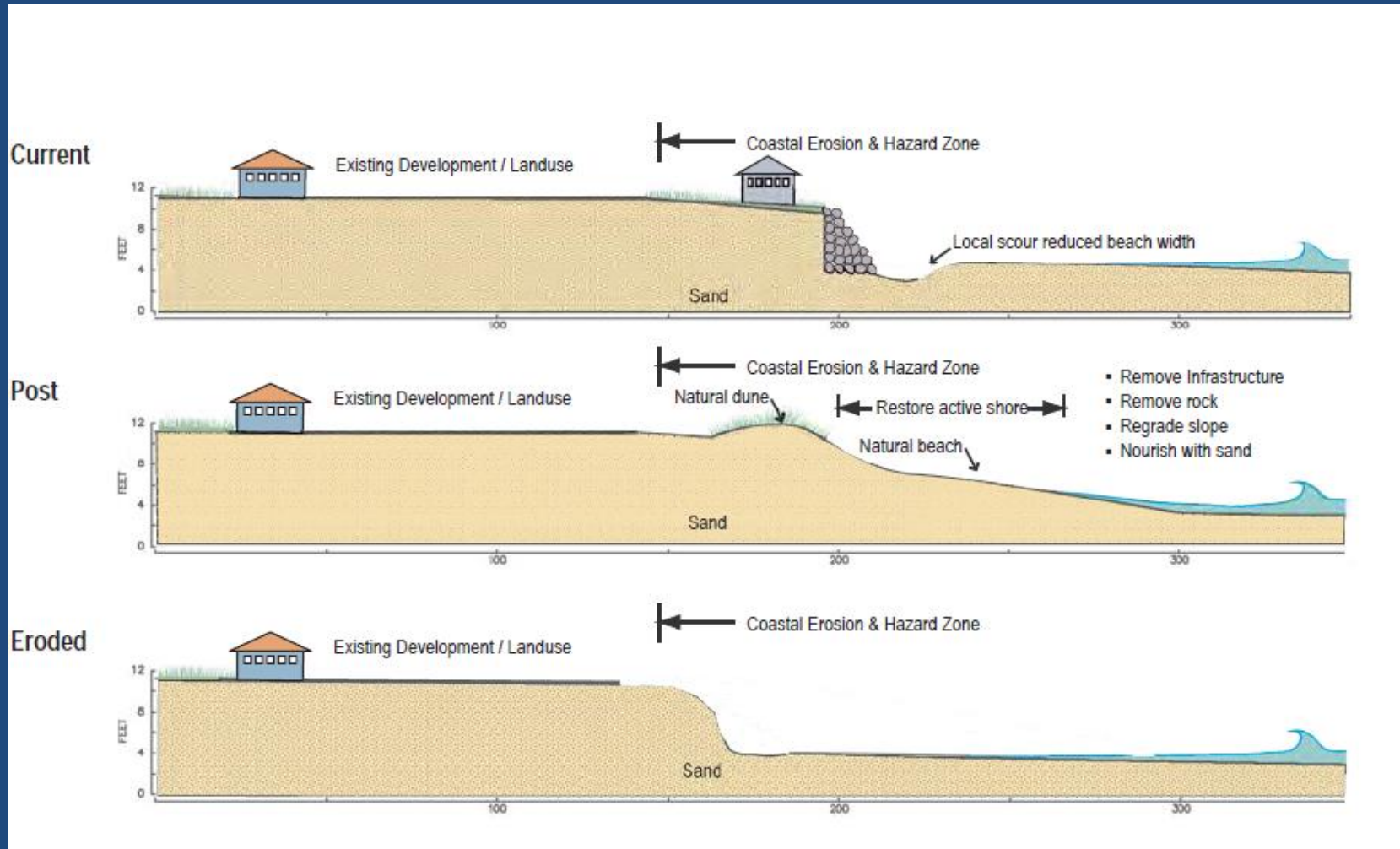
Stricter land use zoning



Managed Retreat

Pros: Lower costs if no buy-out

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



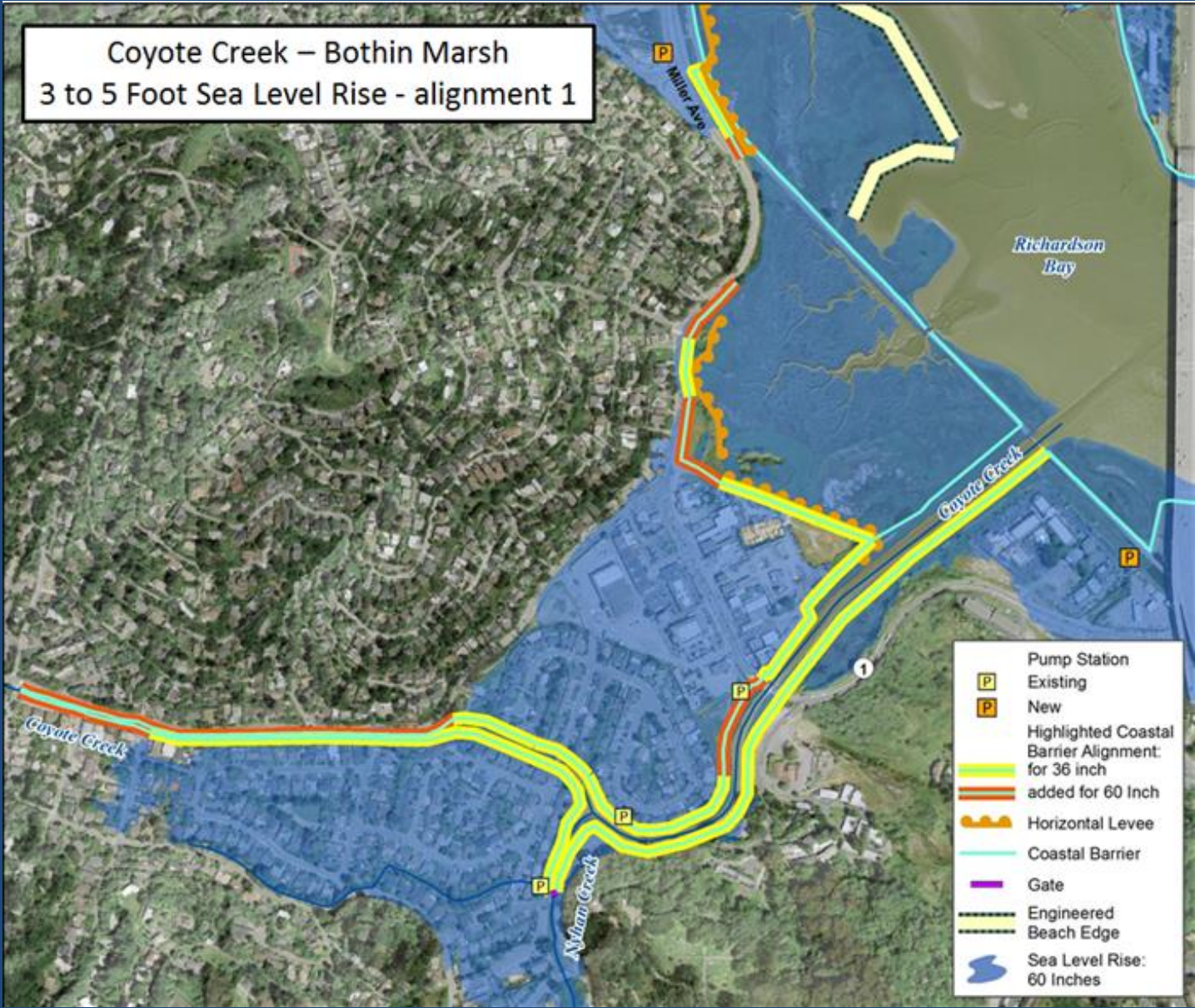
Post Storm Restrictions and Stricter Land Use Zoning



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

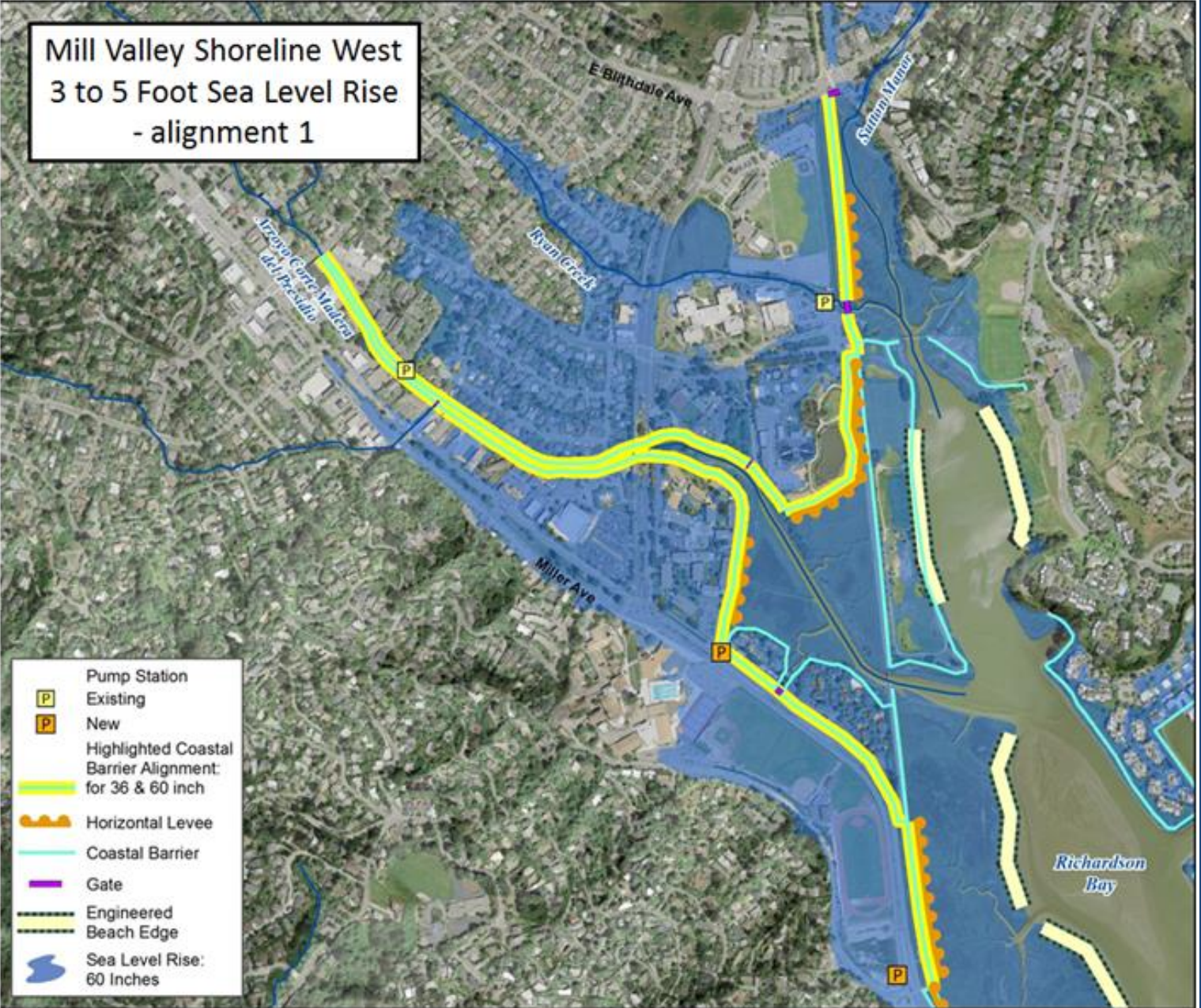


Coyote Creek – Bothin Marsh
3 to 5 Foot Sea Level Rise - alignment 1



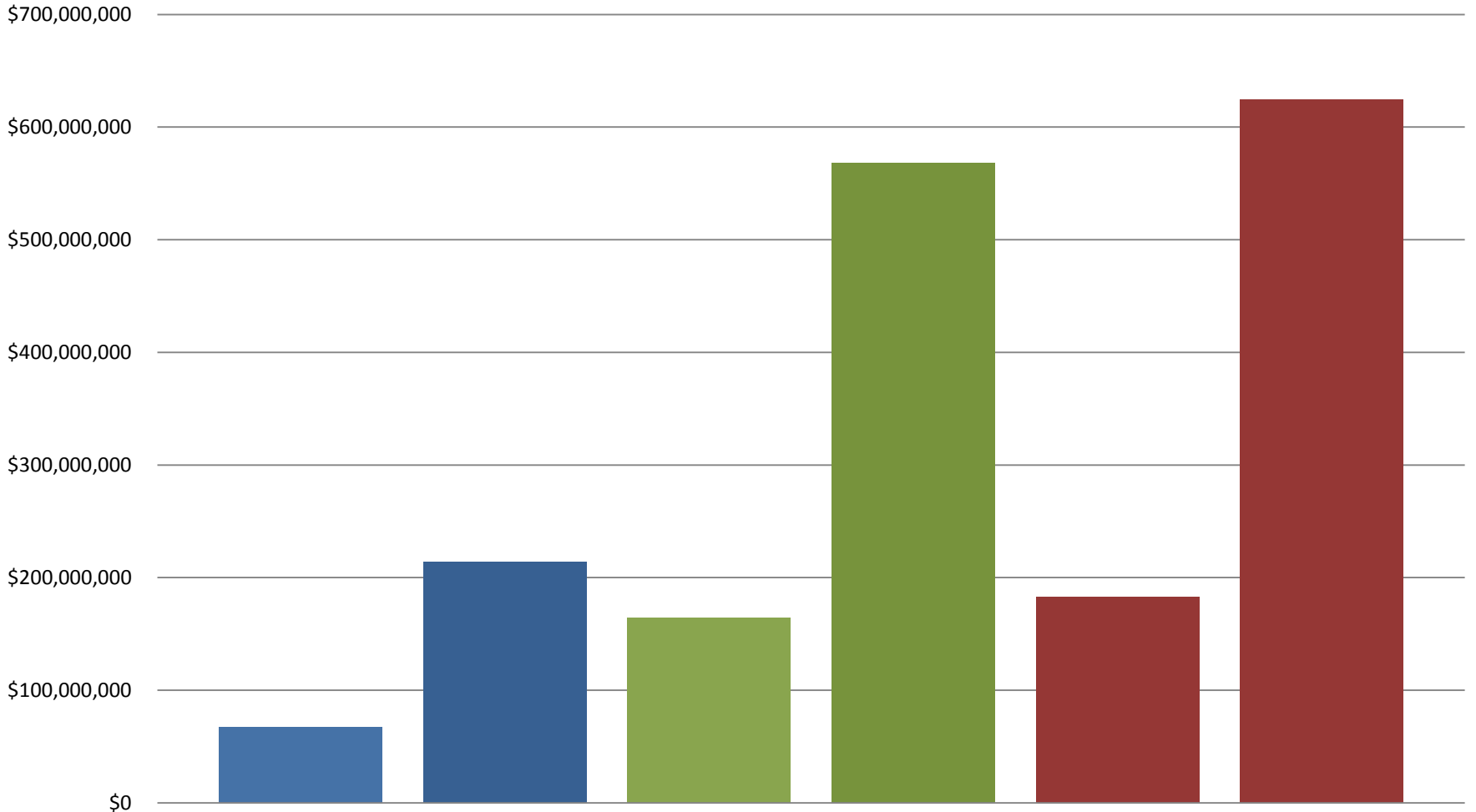
- Pump Station
- Existing
- New
- Highlighted Coastal Barrier Alignment:
 - for 36 inch
 - added for 60 Inch
- Horizontal Levee
- Coastal Barrier
- Gate
- Engineered Beach Edge
- Sea Level Rise: 60 Inches

Mill Valley Shoreline West
3 to 5 Foot Sea Level Rise
- alignment 1



- Pump Station
- Existing
- New
- Highlighted Coastal Barrier Alignment: for 36 & 60 inch
- Horizontal Levee
- Coastal Barrier
- Gate
- Engineered Beach Edge
- Sea Level Rise: 60 Inches

Total Shoreline Cost for Lowest/Highest Cost Alignment by Reach



- Total Shoreline 12-Inch SLR Scenario - Low End Estimate
- Total Shoreline 12-Inch SLR Scenario - High End Estimate
- Total Shoreline 36-Inch SLR Scenario - Low End Estimate
- Total Shoreline 36-Inch SLR Scenario - High End Estimate
- Total Shoreline 60-Inch SLR Scenario - Low End Estimate
- Total Shoreline 60-Inch SLR Scenario - High End Estimate



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

THE GAME OF FLOODS

Your Island

START



- Evacuation Route
- Merrina
- Mammal Habitat
- Ranch
- Grocery
- Water
- School Site
- Parking
- Hospital
- Storm Shelter
- Gas Station
- Sewage Lift Station
- Electrical Sub Station
- Homes on public water & private septic use propane tanks for heat.
- Homes on public water & sewer requiring lift station. Use propane tanks for heat.
- Homes on private wells & septic. Use propane tanks for heat.
- Seabird Colony
- Agriculture
- Sheep
- Agriculture
- Home
- Beach
- Restaurant
- Boat Launch
- Library
- Historic Church
- Fire Station
- Post Office

LEGEND

Managed Retreat

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

Accommodate Water

- Elevate Buildings
- Elevate/New Road
- Floodable Buildings

Hard Engineering

- Revetment/Seawall
- Tide Gate
- Traditional Levee
- Wall & Pump Station

Soft Engineering

- Horizontal Levee
- Offshore Structure
- Wetland/shoreline vegetation
- Beach Maintenance

Sea Level Rise 2050 Scenario Key

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

1. 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.
2. Next, in turn, each player places and states aloud their preferred adaptation strategies to avoid the island. Conflicting strategies are allowed.
3. Consider the following factors to inform the proposal: (1) cost/benefit, (2) Private property impacts, (3) Environmental impacts, (4) Equity/social justice/economic, (5) Others. Use your worksheet to take notes.
4. 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.
5. Next, in turn, each player places and states aloud their preferred adaptation strategies to avoid the island. Conflicting strategies are allowed.

Sea levels are rising worldwide 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. Adaptation planning is essential to help communities develop a sea level rise adaptation plan using the strategies (game pieces).

1. To begin, each player needs the sea level rise scenario about.
2. Players must enroll. Players take turns in clockwise order.





① 5/14/14 Club (E3 + N20)

- 1. Clubhouse
- 2. Golf Course
- 3. Maintenance
- 4. Security
- 5. Other

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
- Sanitary sewage treatment plant



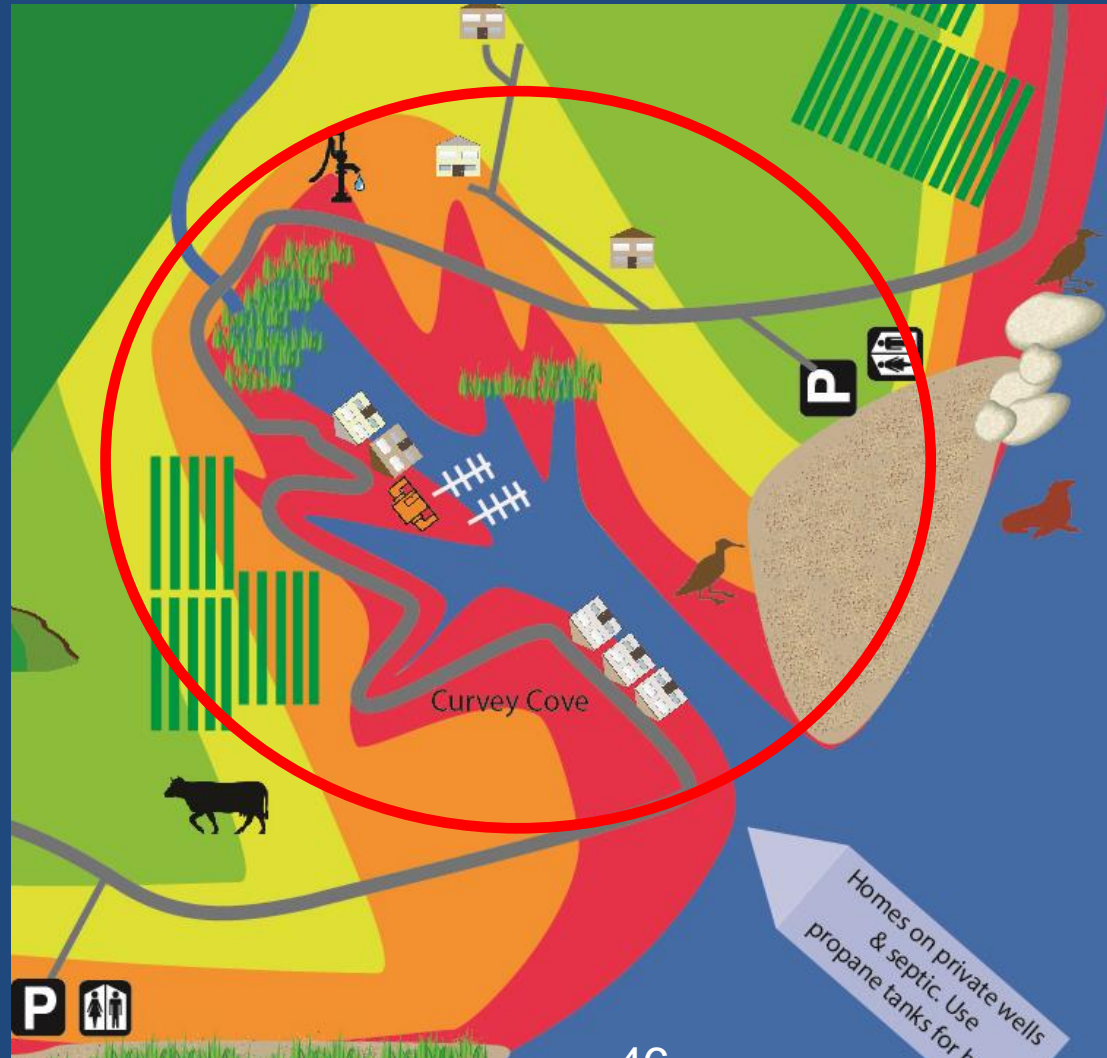
Shoreline Marina

- 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 agricultural 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 \$\$\$



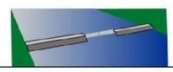


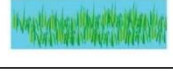

Real World – costs are messy and depend on many factors

- + 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> • Viable in sheltered estuaries and lagoons. |
| Wetland/shoreline vegetation |  | Acre | \$\$\$ | E | short-med | Protects against temporary flooding, storm surge, and wave impacts. <ul style="list-style-type: none"> • Viable in sheltered estuaries and lagoons. |
| Dune Restoration and Beach Maintenance (nourishment & groins) |  | Mile | \$\$\$ | EE | short/med | Protects against temporary flooding and storm surge. <ul style="list-style-type: none"> • Even nourished beaches can erode and expose infrastructure to wave damage. |

THE GAME OF FLOODS

Your Island

START



Sea levels are rising worldwide as warming oceans expand and melt glaciers and ice sheets. 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).

- To begin, one player reads the sea level rise scenario aloud.
- Players must decide together who goes first. The highest roll goes first. If a tie occurs, the tied players must re-roll. Players take turns in clockwise order.

- In turn, each player selects an asset to accommodate, defend, or retreat from. No need to announce.
- In turn, each player places and moves about their preferred adaptation strategies so or around the island. Conflicting strategies are allowed.
- Use the remaining time to finalize the group's proposal (1) Coordinating, (2) Private property impacts, (3) Supply/Service/Utilities, (4) Services, (5) Pay for what you want.
- Consider the following factors to inform the proposal (1) Coordinating, (2) Private property impacts, (3) Supply/Service/Utilities, (4) Services, (5) Pay for what you want.
- Use the remaining time to finalize the group's proposal (1) Coordinating, (2) Private property impacts, (3) Supply/Service/Utilities, (4) Services, (5) Pay for what you want.

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

LEGEND

| | | | |
|---|--|---|--|
| <p>Managed Retreat</p> <ul style="list-style-type: none"> Retreat Move here Post-storm prohibitions Stricter land use zoning | <p>Accommodate Water</p> <ul style="list-style-type: none"> Elevate Buildings Floodable Buildings Elevate/New Road | <p>Hard Engineering</p> <ul style="list-style-type: none"> Revetment/Seawall Traditional Levee Tide Gate Wall & Pump Station | <p>Soft Engineering</p> <ul style="list-style-type: none"> Horizontal Levee Wetland/shoreline vegetation Offshore Structure Beach Maintenance |
|---|--|---|--|

GAME PIECES

Suggestions for the game

- Start with one community: identify what's at risk and what infrastructure is essential
- What must be protected to allow the community to function?
- Adaptation options: discuss pros and cons of measures individually and combined
- Consider: mitigation, permits, and grants; options that provide multiple benefits
- Add up the costs and stick your group's measures on the board

Governance and Planning

Questions from the Inside

- How to give bad news?
 - No win-wins, trade-offs, costs
- Private property rights
 - Half a wall doesn't work
- Value and limitations of green solutions (i.e. wetlands)
- Comprehensive planning (now and in 50 years)
- Power of demonstration projects
- How will retreat happen?

Game over?

- Who in your organization is planning/strategizing around sea level rise?
- What other organizations are also planning/strategizing?
- What are the benefits or drawbacks of interagency discussion/planning/strategizing?
- Is interagency planning happening?

Or just beginning?

- Was the game helpful?
- Any improvements?
- Would you be willing to recommend this game to your staff?

Thank You

Visit www.MarinSLR.org for more information

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Novato Creek at Highway 101. Credit: Marin County staff



North Bay Watershed Association
Marin Sea Level Rise Planning
February 5, 2016 | www.marinslr.org