Sea Level Rise Adaptation Strategy for San Diego Bay

January 2012

Prepared by ICLEI-Local Governments for Sustainability for the project's Public Agency Steering Committee, with the support of The San Diego Foundation.

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Many of the photographs in this document are provided by volunteers with the San Diego King Tide Photo Initiative. The project provided a platform for documenting shoreline conditions during the highest tides of 2010 and 2011, through a partnership between Tijuana River National Estuarine Research Reserve, San Diego Coastkeeper, and Surfrider San Diego Chapter. More information can be found at http://www.flickr.com/groups/sandiegokingtides/.
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Figure 4.4: San Diego Coastkeeper
Figure 4.5: Kristen Goodrich
Figure 4.6: San Diego Coastkeeper
Figure 4.7: Kristen Goodrich

The Strategy was prepared by Daniella Hirschfeld, Program Officer, and Brian Holland, Director of Climate Programs, with ICLEI-Local Governments for Sustainability USA.

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5. MANAGEMENT PRACTICES TOOLBOX

This section presents a toolbox of options for managing sea level rise that are generally more aggressive than the strategies recommended in previous sections. The comprehensive and targeted strategies presented in previous sections are mostly "no-regrets" approaches that can be implemented at relatively low cost, that can be integrated into existing work programs, and that have co-benefits for reaching other community goals. However, in the long run, no-regrets strategies will not be sufficient to ensure resiliency in the region's coastal zone. Successful implementation of the management practices described in this section will require significant technical and management capabilities, regional collaboration, financial investment, and political commitment.

Generally, sea level rise management practices can be classified into four categories: hard defense; soft defense; accommodation; and withdrawal. This toolbox illustrates specific practices in each of these categories through section diagrams and photographs. It also documents the opportunities and constraints of these four approaches, as determined in a map-based exercise in the second Stakeholder Working Group workshop. Each approach presents significant opportunities and constraints, and decision-making around these practices will require careful deliberation around the tradeoffs. Ultimately, a mix of hard defenses, soft defenses, accommodation, and withdrawal will likely emerge as the most optimal management approach, but existing frameworks for making these difficult decisions need to be enhanced, as recommended in Comprehensive Strategy #10.

strategy: HARD STRUCTURE

Hard defenses are designed to be impermeable structures intended to protect land, structures and investments along the water edge. Examples includes hard, impermeable defenses such as seawalls, revetments, dikes, and storm surge barriers that armor or “draw the line” between water and development and prevent flooding or erosion of edges.

Seawall at Lake Michigan, Chicago

opportunities:

- Stabilizes upland areas
- Protects existing development and infrastructure
- Maintains property values for bayfront and low-lying development
- Setbacks can be used for recreation, infrastructure and non-habitable structures.

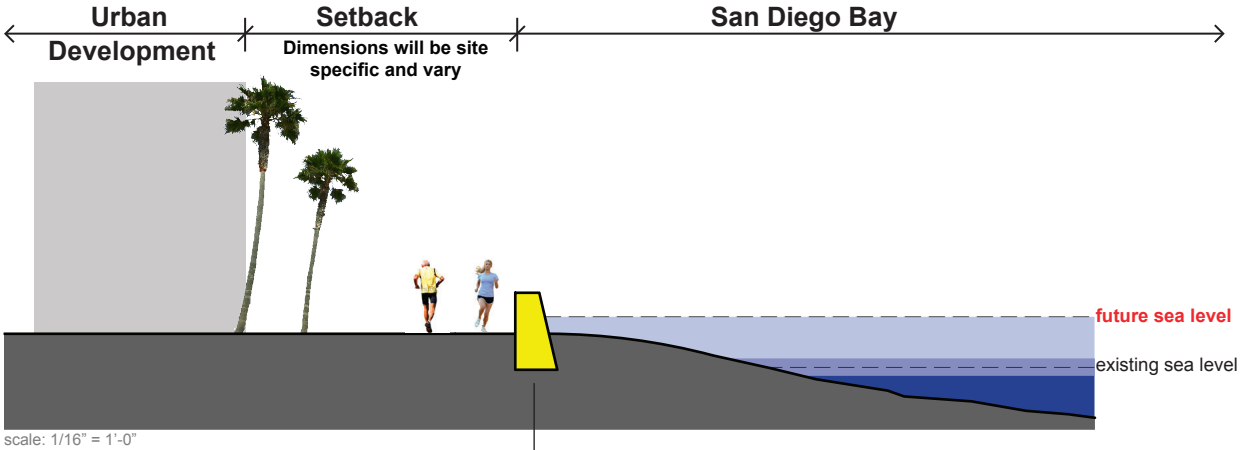
constraints:

- Expensive to construct, with annual maintenance required
- Areas outside of protective zone are often more subject to erosion and ecological degradation
- Shoreline habitats will be lost as space to migrate is eliminated

unknowns:

- Potential loss of public access and aesthetic link to waterfront

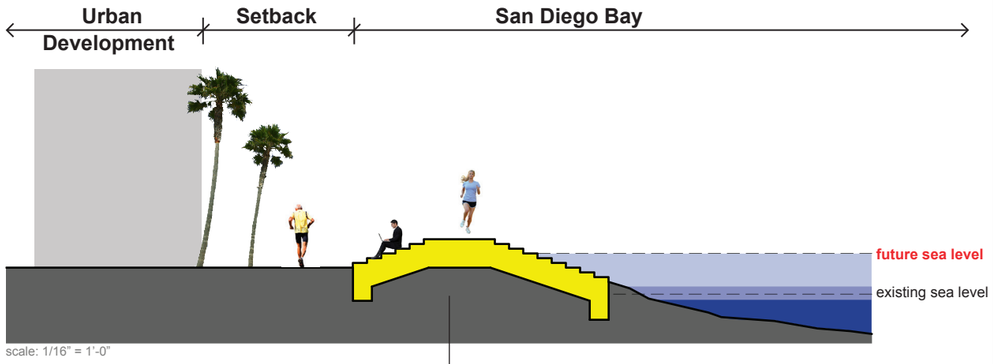
option A - Seawall - retaining



scale: 1/16” = 1’-0”

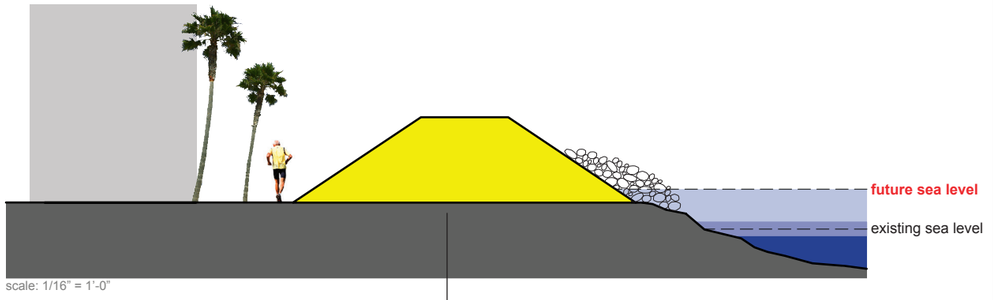
Seawalls are engineered, permanent barriers built parallel to shoreline to protect land and structures from flooding and erosion caused by wave action. Seawalls may be vertical or sloping, and massive gravity concrete walls or constructed of steel or timber.

option B - Seawall - widened/stepped



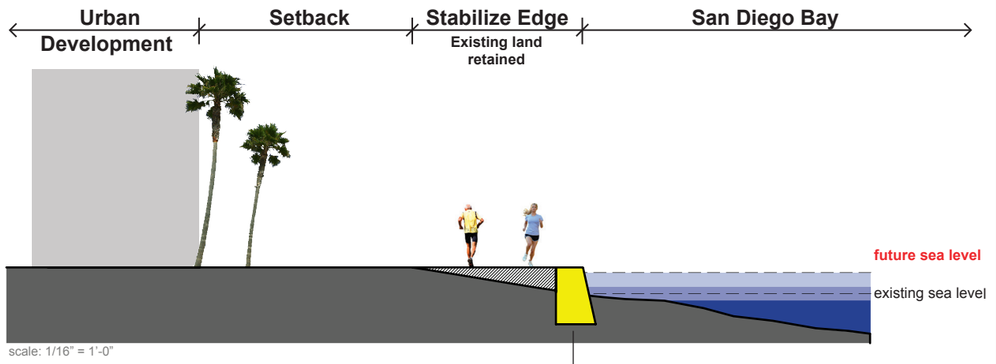
Seawalls may be stepped on both the bay and city sides, allowing for easier access and greater public uses while working to dissipate wave and tidal energy. More land would be required for this option, and construction expenses would increase.

option C - Levee



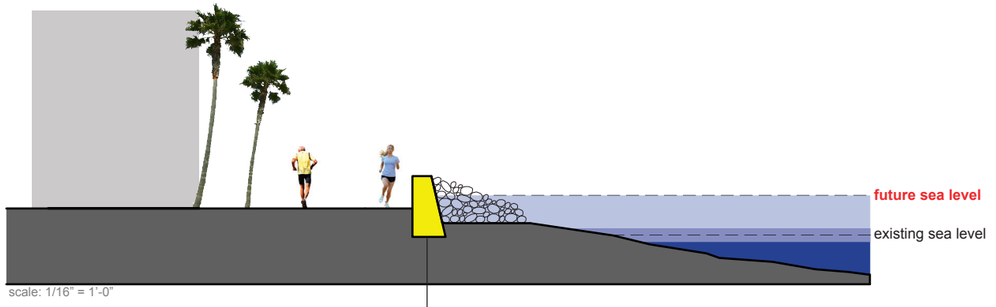
Levees are engineered, permanent, impermeable barriers constructed to protect low-lying inland areas from flooding. The mounds are constructed of earth, sand and clay; the sloped sides are stabilized and protected from erosion and wave action by rip-rap or concrete armor units.

option D - Bulkhead



Bulkheads are engineered, permanent walls that retain land and provide erosion-protection. Second-ary use to stabilize and protect upland areas from flooding. Bulkheads are soil retaining structures that may be constructed of concrete, rip-rap, or pilings with steel or timber.

option E - Rip-rap



Rip-rap is large, angular stone placed on existing beach, embankment, cliff or other shore edges to prevent erosion and help dissipate wave energy. Concrete armor units, such as tetrapods and cubes, perform similar functions.

strategy: **SOFT STRUCTURE**

Soft structures use natural systems and ecosystem services to protect development, investments, and ecosystem well-being. Soft defenses typically protect development through increasing the distance between the water and structures or through requiring space for percolation and retention of flood waters and runoff. Examples include wetland preservation and enhancement, and stormwater management with bioswales and detention basins to hold floodwaters.

Tijuana Estuary

opportunities:

- Reduction of intensity and frequency of flooding, correspondingly reducing size and cost of any required seawalls or hard structures
- Preserves or increases valuable habitat
- Provides recreation and open space areas
- Reduces water pollution in bay and enhances groundwater recharge

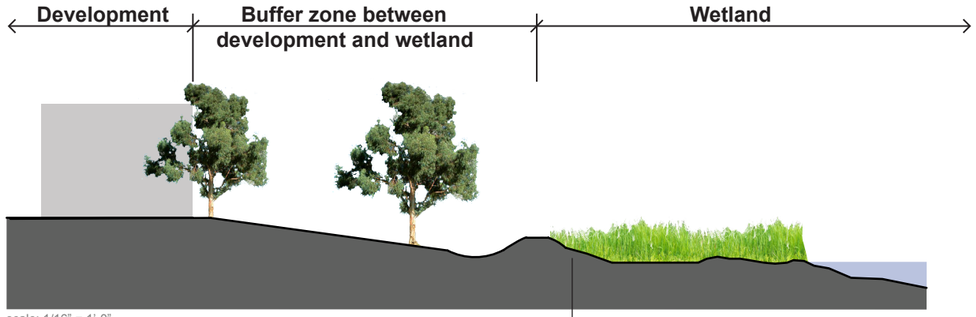
constraints:

- More extensive land required to provide benefits
- Continued maintenance required
- Green infrastructure is typically cost effective

unknowns:

- Time to establish new habitat

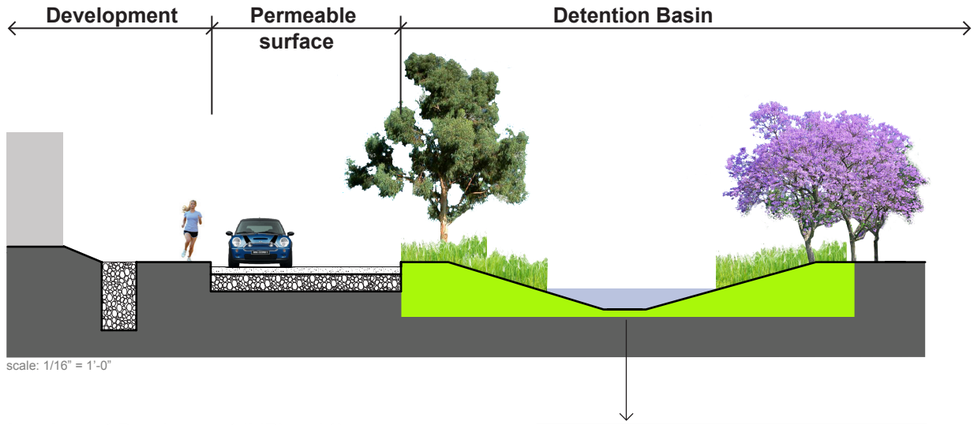
option A - **Wetland Restoration / Enhancement**



scale: 1/16" = 1'-0"

Wetland restoration/enhancement and their natural filtration and absorptive qualities provide flood water storage, buffers from wave and tidal energy, and shoreline stabilization. Wetlands are also particularly sensitive and will "naturally" shift upland with the increasing salinity and water depth that results from sea level rises. Wetlands provide ecosystem services to local communities in the form of improved water quality, support for fisheries, and recreation.

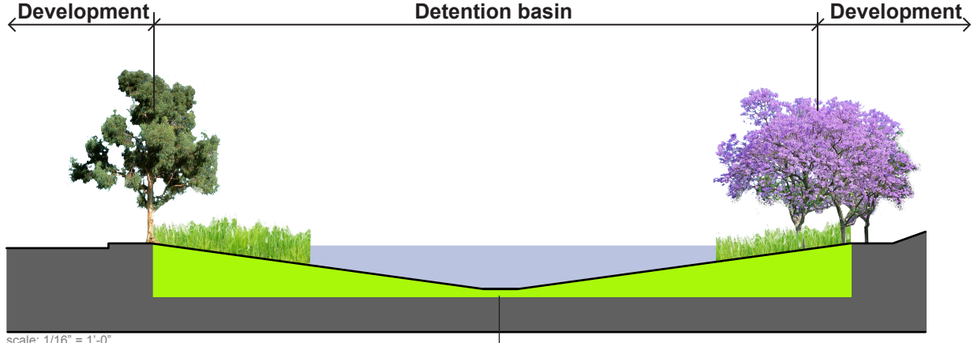
option B - **Low Impact Development (LID) and Green Infrastructure**



scale: 1/16" = 1'-0"

Low impact Development (LID) and Green Infrastructure work with natural systems to maximize the retention and percolation of stormwater. Green infrastructure includes the open, permeable spaces within a community, and seeks to adapt traditional "gray" infrastructure to allow for infiltration of stormwater and provide potential habitat.

option C - **Detention basins or upland "mini-floodplains"**



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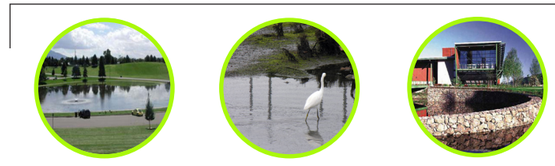
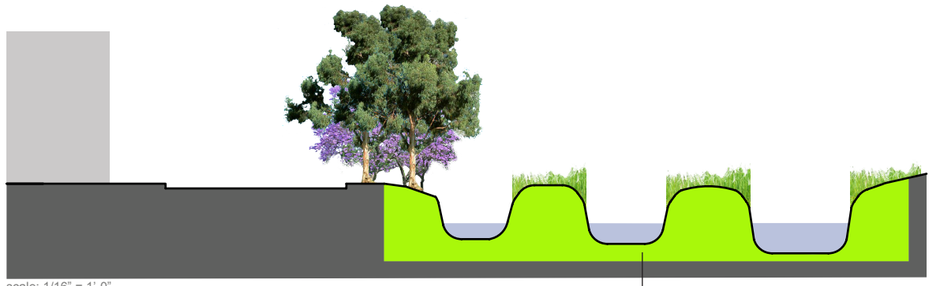
Detention Basins or Constructed Wetlands are engineered basins that collect stormwater, either allowing it to percolate on-site or releasing it after the major storm event has passed. Upstream basins help to prevent flooding by capturing it before it reaches the bay.



option D - Bioinfiltration / Stormwater Park



scale: 1/16" = 1'-0"

Bioinfiltration uses plants and topography to capture and filter stormwater, and create habitat areas. Examples are stormwater parks, rain gardens and small "pocket" wetlands that allow for "managed flooding".

option E - Bioswales and other vegetated drain channels

scale: 1/16" = 1'-0"

Bioswales and other vegetated drain channels direct flood waters away from development, slow runoff, and allow for percolation of storm or flood waters.

strategy: ACCOMMODATION

Accommodation realigns traditional methods of planning and building with changing conditions of high water and tidal fluctuations. New building methods accommodate new flood plains and various degrees of flooding.

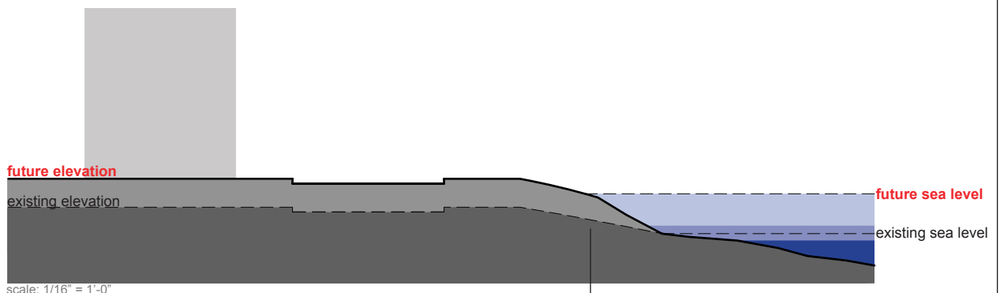
Loblolly House, Kieran Timberlake Architects

opportunities:
- Removes development from immediate threat of flooding
- May reduce flood insurance premiums• text here
- Property owner can control elevation of structure

constraints:
- Expensive to retrofit existing development
- Not useful in areas with permanent flooding
- Adding fill and raising grades may impact wetlands and other habitat

unknowns:
- Accessibility
- Costs of allowing flooding of development, even if temporary

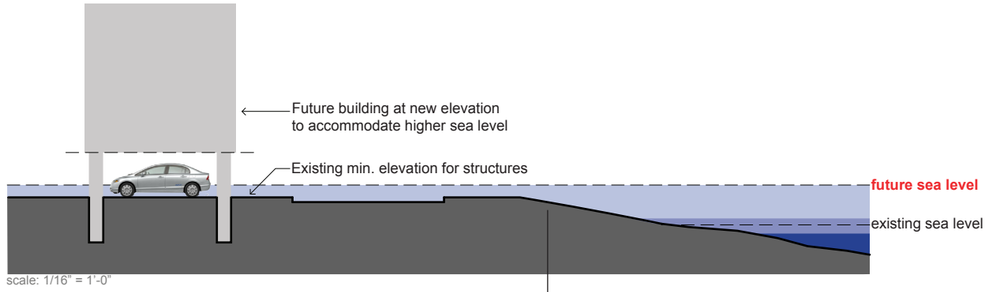
option A - Elevated Grade Surface



scale: 1/16" = 1'-0"

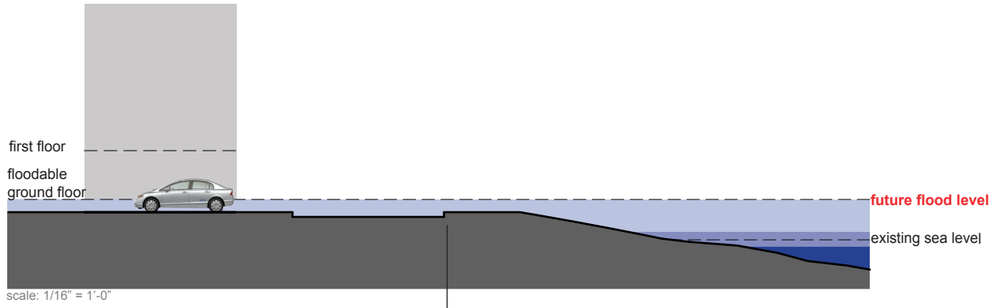
Elevated grade surfaces raise elevations of pads for new structures, infrastructure, and other land uses. Earth or gravel, or raised foundation walls, can be used to raise building pads and infrastructure up out of low-lying areas that might be expected to flood. Depending on edge conditions, elevated grades may require rip-rap and other armoring for protection. It may be possible to raise the land surface of wetlands.

option B - Elevated Structure



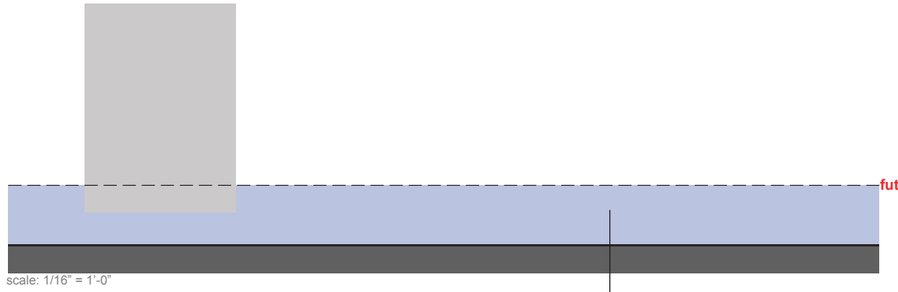
Elevated structures built in known flood plains are often constructed on pilings to allow for flood waters to flow under the structure.

option C - Floodable Development



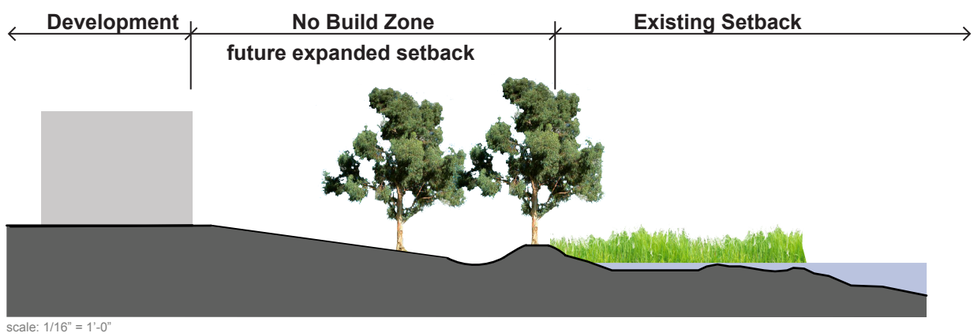
Floodable development allows for flooding of either built structures or open spaces. In built structures, the floodable area is designated as uninhabitable, and while habitable space is restricted to upper levels of development. Shore edge parks and plazas can also be flooded intermittently.

option D - Floating Structure

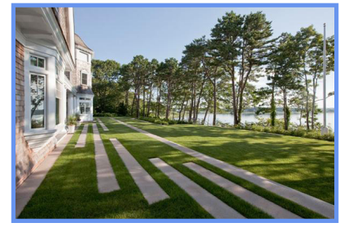


Floating structures range from houseboats to floating roadways and other infrastructure. The mooring or anchoring of the structure is critical to the success of this strategy.

option E - Buffers and Setbacks



Buffers and setbacks dedicate land to remain undeveloped and vegetated to protect adjacent land from flooding or other impacts. Setbacks from the water's edges are achieved through zoning, overlay zones, and land use restrictions. Buffers and setbacks are most effective when they are determined in conjunction with specific conditions, such as susceptibility to erosion or wave action, or capacity to provide valuable habitat. They may be established through regulation or land acquisition.



strategy: Withdrawal

Withdrawal from rising sea levels, or managed retreat, is a viable strategy when the economic and ecological costs of protecting development is prohibitive. The objective is to allow for flooding and rising sea levels through restricting development or moving structures out of the path of the water. New development would be prevented in vulnerable areas. Reducing federal or other subsidies for shore protection may help property owners manage the risk of bayfront development.

Shoreline in Dare County, North Carolina

opportunities:
- New space for tidal habitats
- New recreation and open space areas
- Increased or maintained public access to shoreline areas

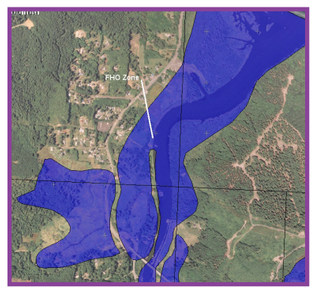
constraints:
- Property owner opposition
- More expensive than hard structure strategies in urban areas

unknowns:
- Legal and insurance issues
- Public perception

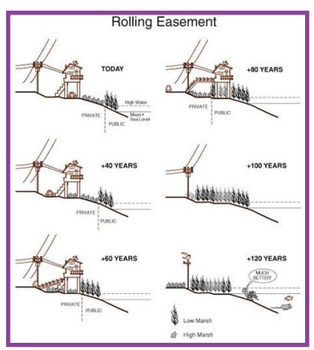
option A - Zoning and Overlay Zone

option B - Rolling Easements

Zoning and overlay zones guide the design and planning process for development and habitat areas through restricting land uses to avoid risks associated with flooding.



Rolling easements are a type of easement that prevents hard structures and armoring of the coastal edge, but otherwise doesn't prohibit land uses. The easement "rolls" or moves inland as the sea level rises, maintaining the area of public tidal lands, and allowing for shoreline habitats to also migrate inland. Structures may be moved elsewhere on the property, or elevated to allow for water flow.



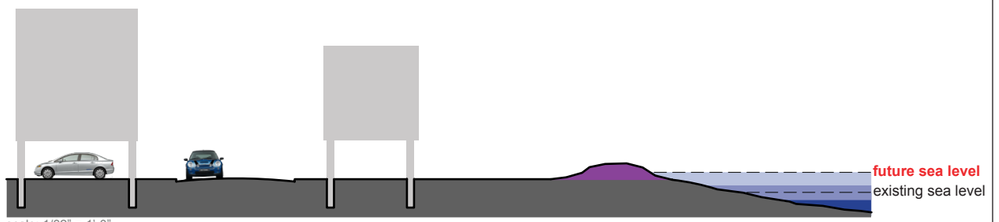
option C - Design for Disassembly

Design for Disassembly is a building process that plans for the future disassembly and reuse of building materials.

option D - Managed Retreat

scale: 1/32" = 1'-0"

Existing development exposed to coastal storms and flooding



scale: 1/32" = 1'-0"

Phase 1: Shorefront homes removed and housing elevated for flooding.

scale: 1/32" = 1'-0"

Phase 2: Shoreline buildings removed, dune built up with vegetative coastal buffer

Managed retreat moves human settlement away from the fluctuations of the water-land interface. Structures may be removed or relocated inland as sea level rises and the existing shoreline erodes. Plans for withdrawal from the water's edge can be incorporated in long-range plans and visions, and include the planned relocation and/or disassembly of valuable existing structures and land uses as well as planned abandonment of less essential structures.