An Analysis of Strategies for Adaptation to Sea Level Rise

Michael Volk: MLA Thesis Research, University of Florida Department of Landscape Architecture, 2008

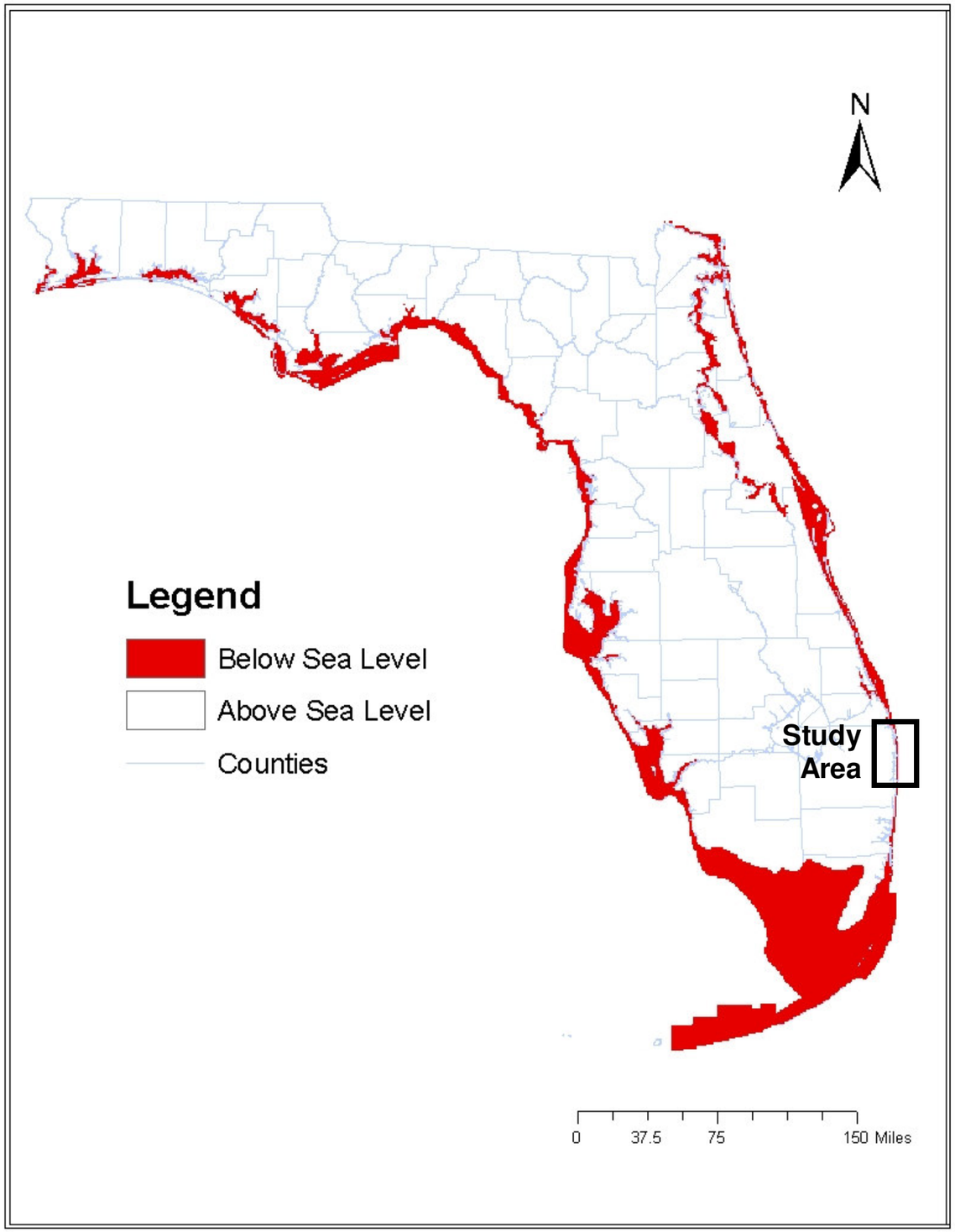

Positive proof of global warming.
18th Century
1900
1950
1970
1980
1990
2006

Sea Level Rise (SLR) Projections

SLR is caused primarily by thermal expansion of the oceans and glacier ice melt, triggered by warming of the atmosphere from greenhouse gasses.

•7-23” global SLR (IPCC 2007)

•36” possible if glacier ice melt is factored in (Mulkey 2007).

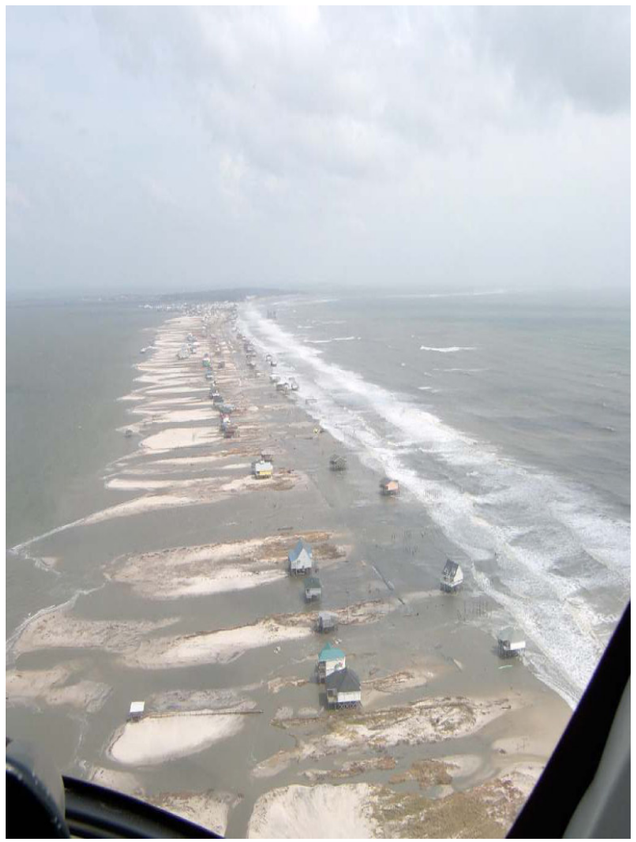


One meter sea level rise

Whittle 2008

Inland Hazards Caused by SLR:

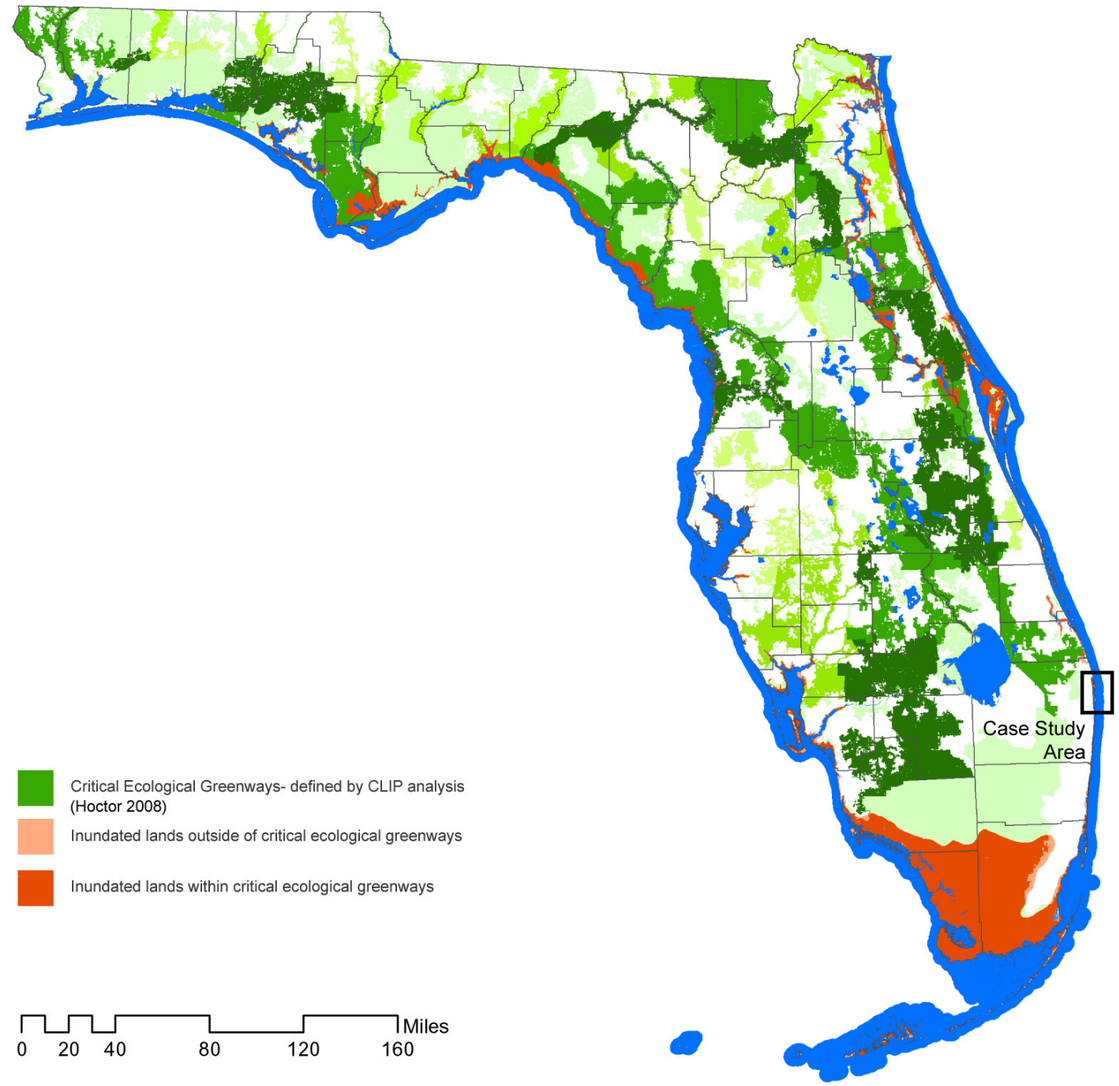
- Inland Inundation
- Saltwater Intrusion
- Increased Erosion
- Higher Storm Surge



Coburn 2008

Effects on Ecosystems:

- Precise effects still unclear, but degradation likely
- Two primary factors limiting ecosystem adaptation and recovery are
  - Coastal development that limits ability for ecosystems to retreat.
  - Greater than historic rates of sea level rise and climate change, that are greater than the speed at which ecosystems can adapt (i.e. sediment accretion, retreat).
- **Example:** Gulf Coast forest mortalities



Critical Ecological Greenways Inundated by 1 meter of Sea Level Rise

Gap_Icov 2000, Hoctor 2008

Effects on Coastal Development:

Coastal hazards are increasing

Coastal development is increasing:

- Population growth
- Coastal development trends- popularity and value
- Insurance subsidization
- Coastal tourism value

Coburn 2008

Options for Responding to SLR:

Protection: Traditional coastal hardening techniques such as **seawalls, and beach nourishment** that attempt to maintain a static shoreline position.

Managed Retreat: Moving development out of harm's way in a planned and controlled manner using techniques such as **abandonment, relocation, avoidance**

Accommodation: The use of strategies that allow for the use of vulnerable lands to continue, but that do not attempt to prevent flooding or inundation with shoreline protection. **Examples:** relocation friendly construction, short term uses, inundation friendly uses.

→

Financially Unsustainable- inequitable use of public funds, property damage costs, maintenance and construction costs, damage to recreational values.

Ecologically Unsustainable- Damages coastal ecosystems and processes, prohibits ecosystem retreat.

Coburn 2008

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Ecologically sustainable by allowing ecosystem processes and retreat.

Financially sustainable by avoiding costs associated with protection, particularly if long range planning occurs.

Issues include: Property loss, in-migration land use conflicts, 'takings', existing incentives for coastal development, tourism and tax base impacts, short term vs. long term costs

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→ Should be used as part of a larger plan for managed retreat- otherwise it will create similar financial and ecological costs as occur with protection

Necessity for Different Strategies:

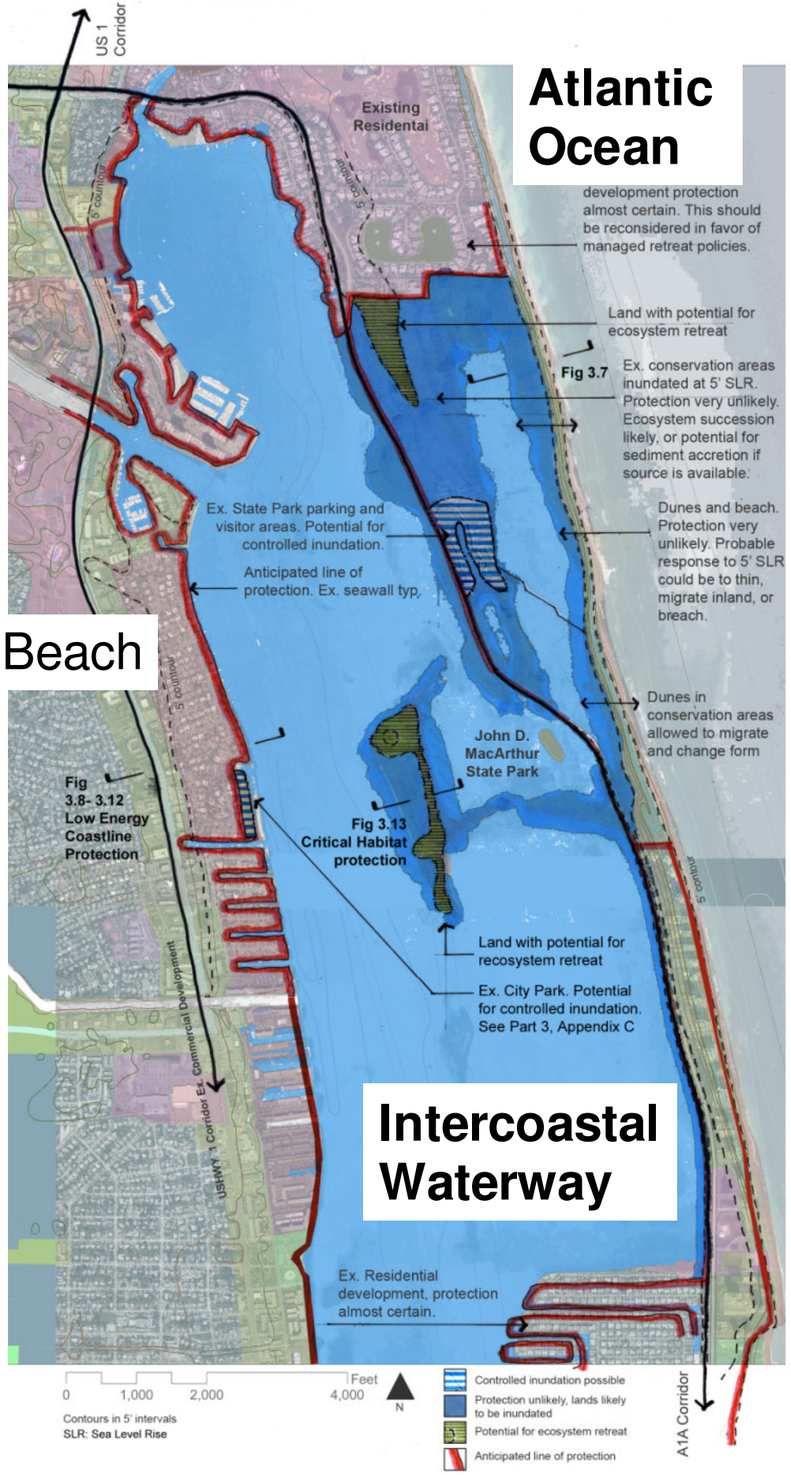
Natural Coastal Condition

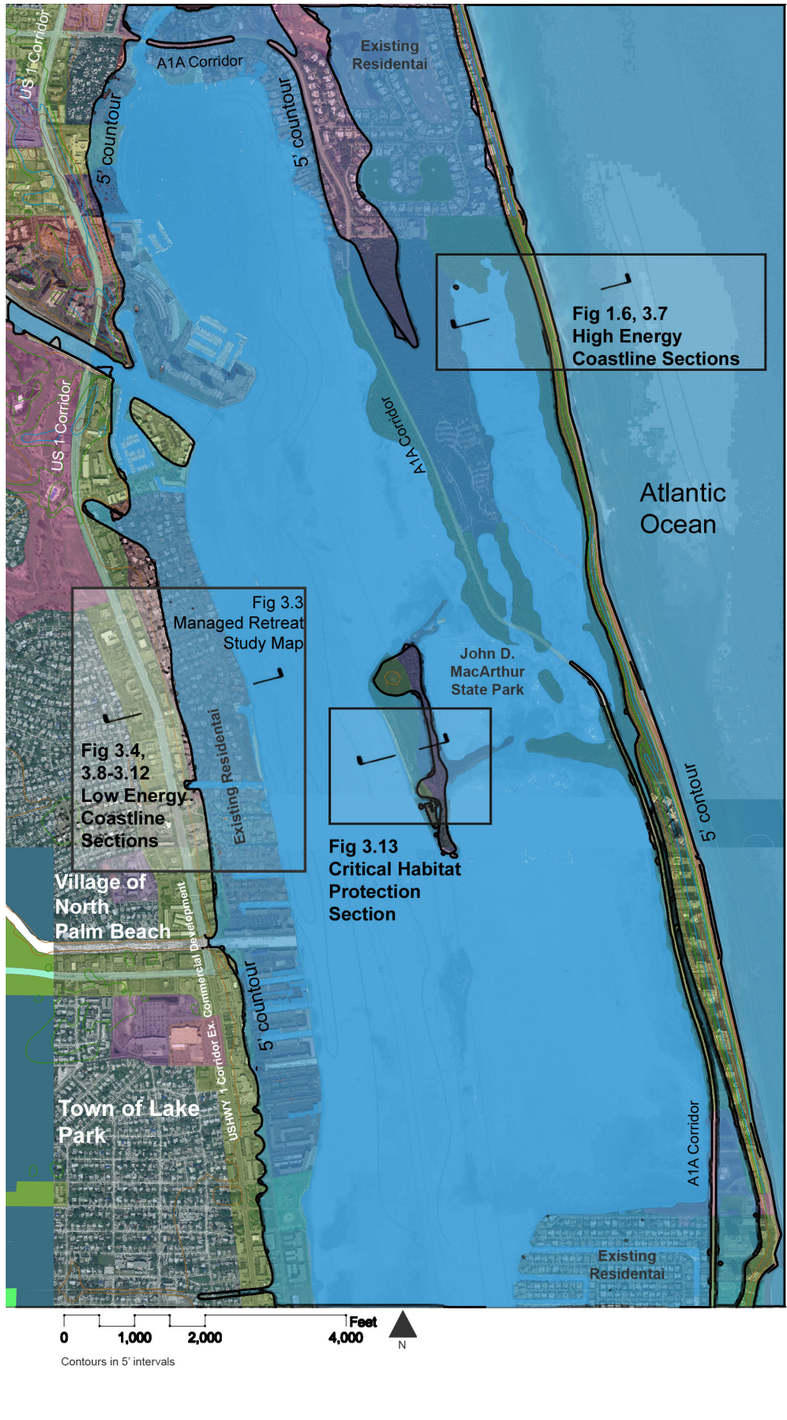
		Mangrove		Coastal Strand	Wetland	Inlet
		high % slope	low % slope			
Developed Condition	**Urban**					
	H Density					
	M Density					
	L Density					
	Ag					
	Conservation					

	High Energy Shoreline	Low Energy Shoreline
Developed		
Undeveloped		

Study Area:

North Palm Beach (Palm Beach County) was chosen as a study area for this research. Protection is anticipated for almost all of the coastline of Palm Beach County (TCRPC 2005).





Anticipated Shoreline Protection (TCRPC 2005)

Inundation from 5' Sea Level Rise with No Shoreline Protection

Gaps in Research and Application to Date:

•Solutions to coastline protection from sea level rise that are ecologically and financially sustainable

•Case study projects that address permanent inundation due to sea level rise, in particular from a design point of view.

•Graphic illustration of strategies for responding to sea level rise.

Purpose of Study:

To explore ecologically and financially sustainable recommendations and strategies for coastal development response to rising sea levels in Florida

Focus on coastal land use responses to permanent inundation and defining strategies for adaptation.

Did not explore strategies that were excessively unsustainable- financially or ecologically

Operational Definitions:

•Ecological Sustainability: The level to which coastal management strategies support and maintain fully functional natural coastal processes and healthy riparian, littoral, and aquatic ecosystems.

• Financial Sustainability: The ability of governments and private land owners to fund and maintain coastal management strategies without undue financial costs over the life of the project. Undue financial costs could be defined by the value of the coastal management strategy as evaluated against alternative strategies and within the framework of a broader budget.

Strategies and Recommendations for Coastal Communities

How to Proceed

Inundation Maps- What areas are in danger?

Shoreline Assessment- What are shoreline characteristics?

Suitability Analysis- What should be done where?

Define Goals and Objectives- What are our goals?

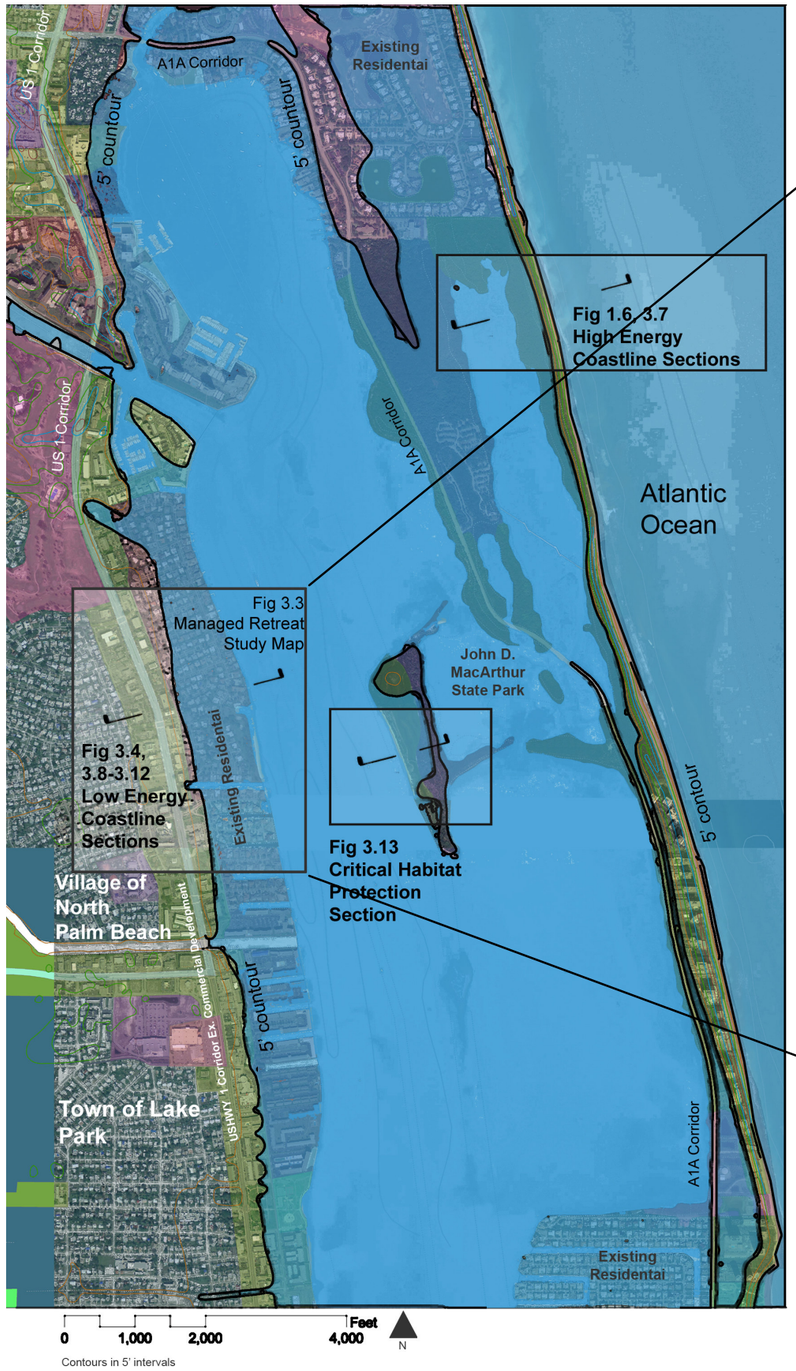
- Ecologically Sustainable
- Financially Sustainable
- Hazard Mitigation
- Good Waterfront Design Principles

Strategies for Adaptation to Sea Level Rise

Managed Retreat

Accommodation

Shoreline Protection



This map was based on a 5 foot sea level rise but could be applicable to any level of rise. The notes on this page should be considered as part of a rolling strategy adapting to a retreating shoreline.

Managed Retreat

gap_lcov 2000, TOPO 1997, LABINS 2008

Primary Points:

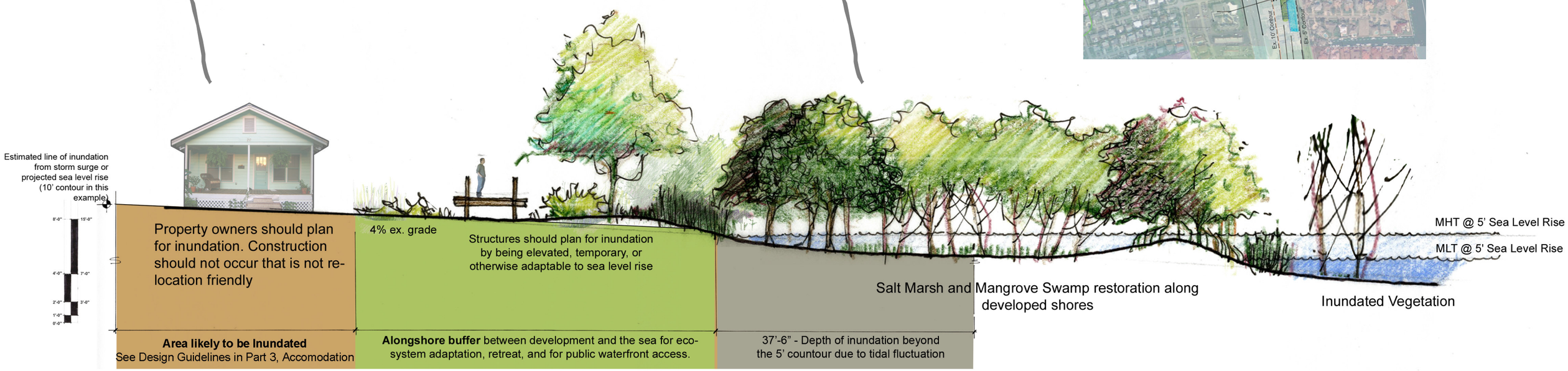
- Conduct shoreline assessments, suitability analysis and hazard projections.
- Implement rolling easements or similar policies that allow shoreline retreat.
- Designate a special overlay district in areas likely to be inundated by storm surge, sea levels, or eroded. Establish unique design guidelines in these areas. Minimize public financing
- Create an alongshore buffer/easement for ecosystem retreat, management, and adaptation via: property purchase, purchase of development rights, setbacks/deed restrictions, development disincentives, sale incentives.
    - Living Shoreline restoration
- Implement removal of inundated structures, infrastructure, and hazard mitigation. Creative reuse.
- Integrate good waterfront design principles, and adapt existing useable infrastructure for new evolving waterfront.

Managed Retreat

gap_lcov 2000, TOPO 1997, LABINS 2008

Development Retreat

Ecosystem and Shoreline Retreat



Area Likely to be Inundated

Alongshore Buffer (Upland of Mean High Tide Line)

Area Inundated by High Tide

Managed Retreat Shoreline Section

Guidelines for Areas Likely to be Inundated

Site Planning, Design, and Management

Land Use: Focus on land uses that are **water dependent, temporary, adaptable, or evolve** as sea levels rise. Maintain an alongshore easement for ecosystem adaptation and retreat.

Hazard Mitigation: Minimize hazards to coastal development through appropriate **lot and structure placement, design, and structure removal**.

Water Management and Conservation: Mitigate and plan for projected salt water intrusion and freshwater shortages. (i.e. water harvesting, reclamation, grey water use)

Shoreline Management: Maintain and support **natural coastal processes** such as sedimentation transport and allow natural **ecosystem migration** in response to sea level rise.

Ecosystem Adaptation and Retreat: Proactively assist in ecosystem adaptation. This entails various measures including ecosystem stabilization, restoration, and setting aside of lands for ecosystem retreat.

Guidelines for Areas Likely to be Inundated

New Construction and Existing Construction Modification

Function: Designs whose uses and function **adapt and change** over time in response to sea level rise. Zoning codes may be revised to take into account change of land use based on certain benchmarks of sea level rise.

Adaptability: Structures that are **non-permanent, relocation friendly, elevated, modular, floating, or decomposing.**

Plant Species: Planning for salt water inundation within life span of plant species (i.e. no long lived species close to shoreline that are not salt tolerant)

Cost: Appropriate cost of structure vs. life span of structure

Abandonment: Structures that are expected to be abandoned after a certain level of inundation should be constructed and managed to **minimize environmental hazards**.

Accommodation:

- Accommodation should be a short term strategy only as part of a long term managed retreat strategy
- Guidelines should be created for construction and land use in areas likely to be inundated.
- Support land uses that:
  - that are water dependent, temporary, adaptable, or evolve as sea levels rise
  - that are financially sustainable
  - that allow natural shoreline and ecosystem processes to continue
  - that integrate good waterfront design principles.

Protection:

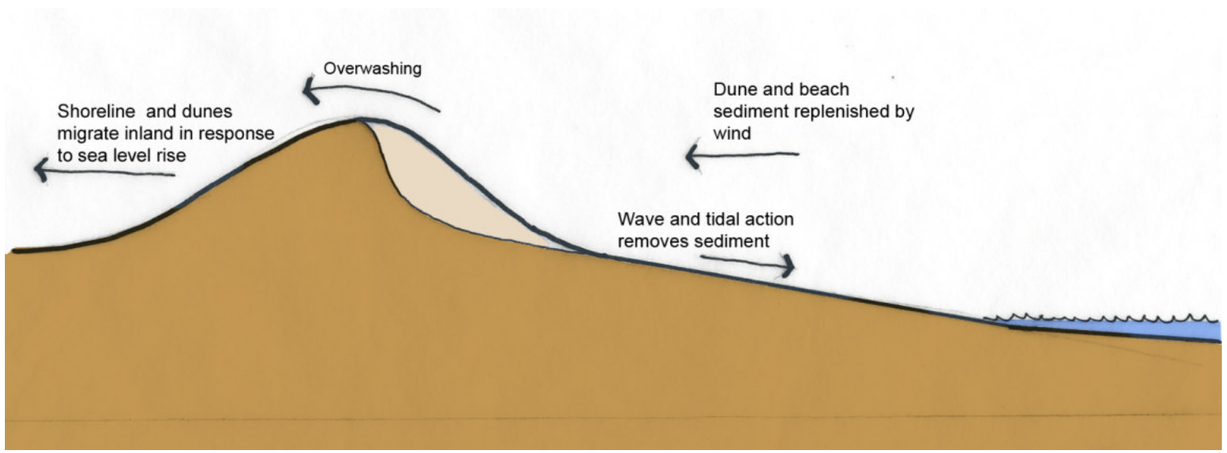
- High Energy Shoreline Development Protection
- Beach Protection through Nourishment
- Low Energy Development Protection through Ecosystem Restoration
- Low Energy Shoreline Conservation Land Protection
- Protection of Critical Lands

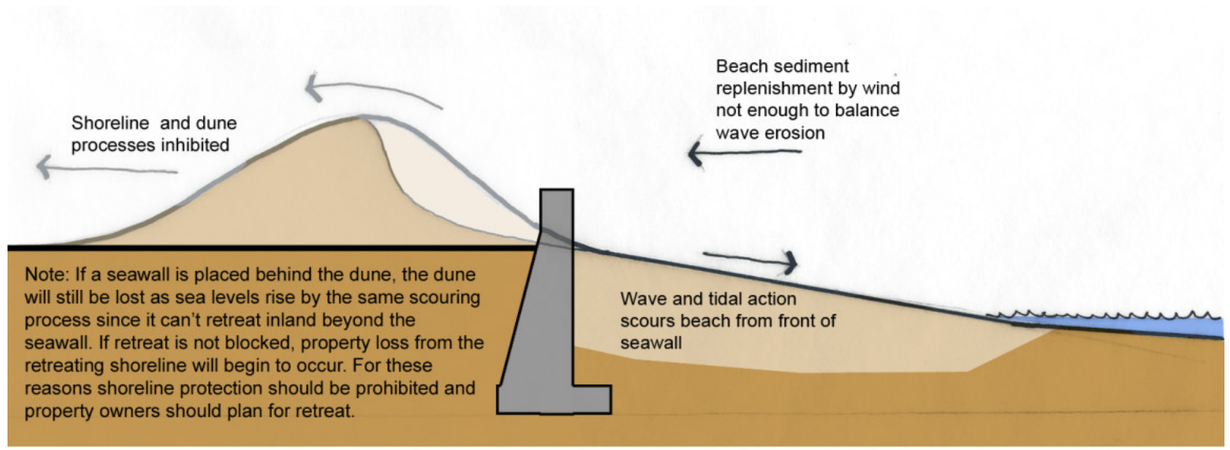
High Energy Shoreline Development Protection:

•Sustainable shoreline protection in response to sea level rise is probably not feasible.

•Property owners on barrier islands and on mainland coasts where inundation is projected must ultimately plan for retreat.

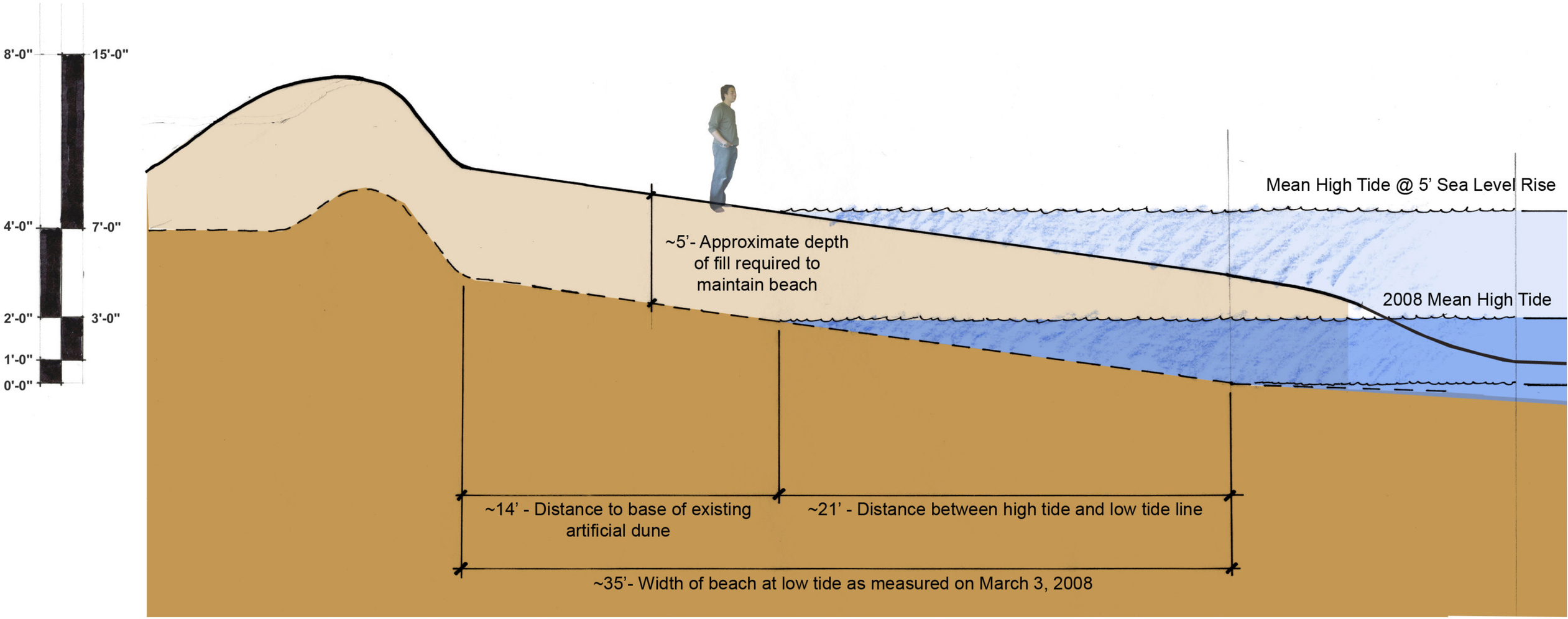
•Hard shoreline stabilization methods should be avoided. Protective methods if used should be limited to soft protection such as beach nourishment.





If a seawall is placed in front of the dune, the beach will be scoured away. The property will experience increased risk from storms as waves from rising sea levels overtop the seawall and since the natural buffer provided by the beach and dune no longer exists.

Beach Protection through Nourishment:



Note: This section is drawn through an existing beach in North Palm Beach at Lakeside Park immediately south of the section cutline. It illustrates the amount of artificial fill required to maintain the beach without allowing coastline retreat. This could be feasible because the beach is on a sheltered low energy coastline. It is probably not a financially or ecologically sustainable solution.

Protection: Beach Nourishment

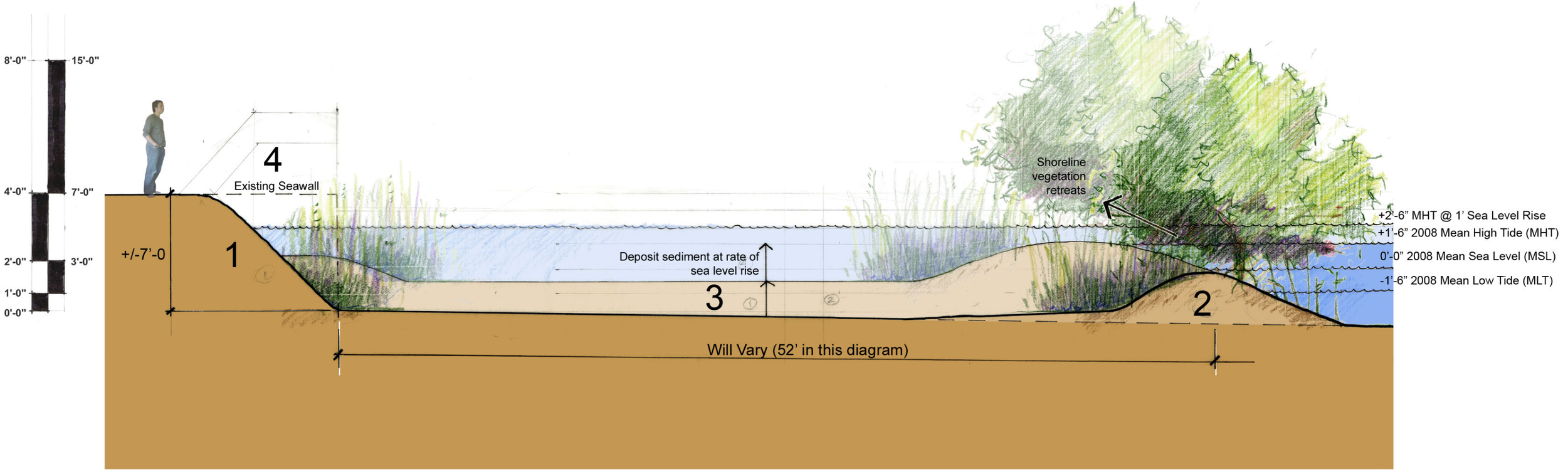
Low Energy Development Protection through Ecosystem Restoration:

•Property owners should ultimately plan for coastline retreat. Temporary protective measures may be possible that are relatively financially and ecologically sustainable.

•On low energy shorelines it may be possible to maintain reestablished ecosystems, while still maintaining existing shoreline positions in the face of sea level rise.

•This may be possible through establishment of ecosystems seaward of the existing shoreline, which can retreat up to the existing shoreline position (vs. retreat inland from the existing shoreline).

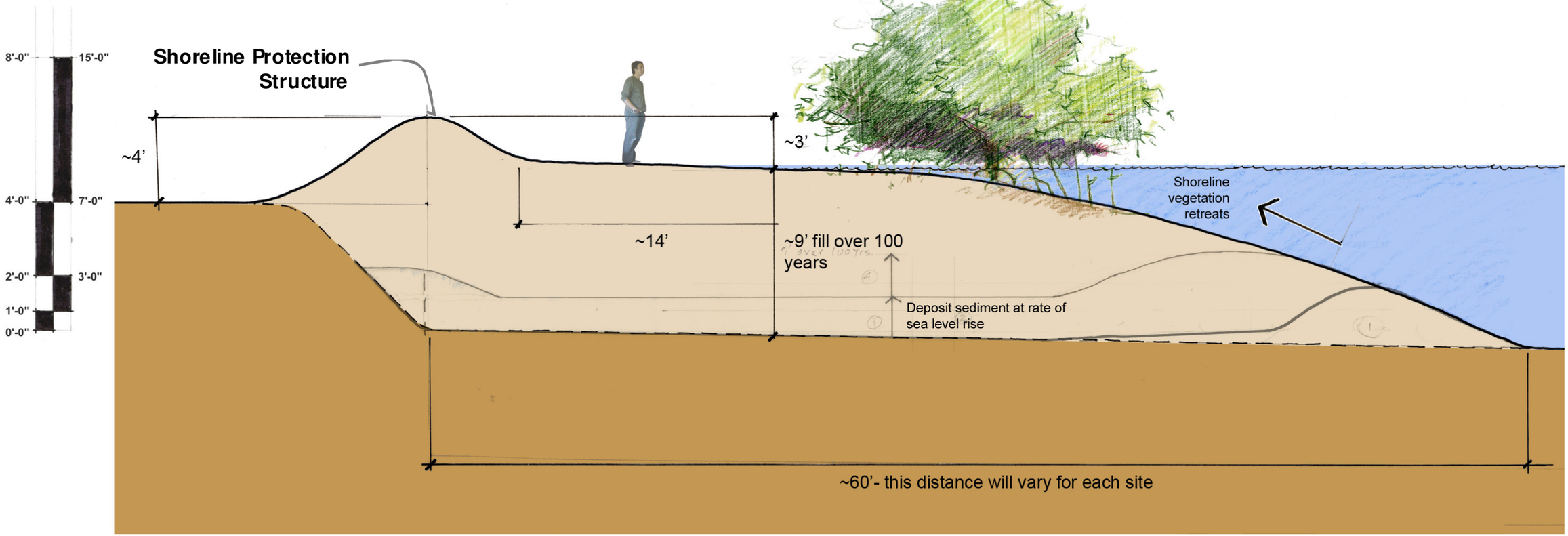
Protection: Low Energy Shoreline



Steps for Implementation of Low Energy Shoreline Development Protection

1. Prohibit coastal hardening. Offer incentives for removal of existing shoreline protection structures
2. Establish stabilizing vegetation on berms in shallow waters offshore. Create breaks and adjust height of berms to allow tidal flow.
3. In space between mainland and offshore plantings establish salt marsh grasses or other appropriate species. Deposit sediment at rate required to allow plantings to adapt to the rate of sea level rise (rate of SLR minus accretion rate of plantings).
4. Cost sharing between public and private sources.

Protection: Low Energy Shoreline



Goals

Same level of protection as gained through strengthening existing structure

Ecological sustainability: reestablishment of shoreline ecosystems, and facilitation of ecosystem adaptation to rising sea levels.

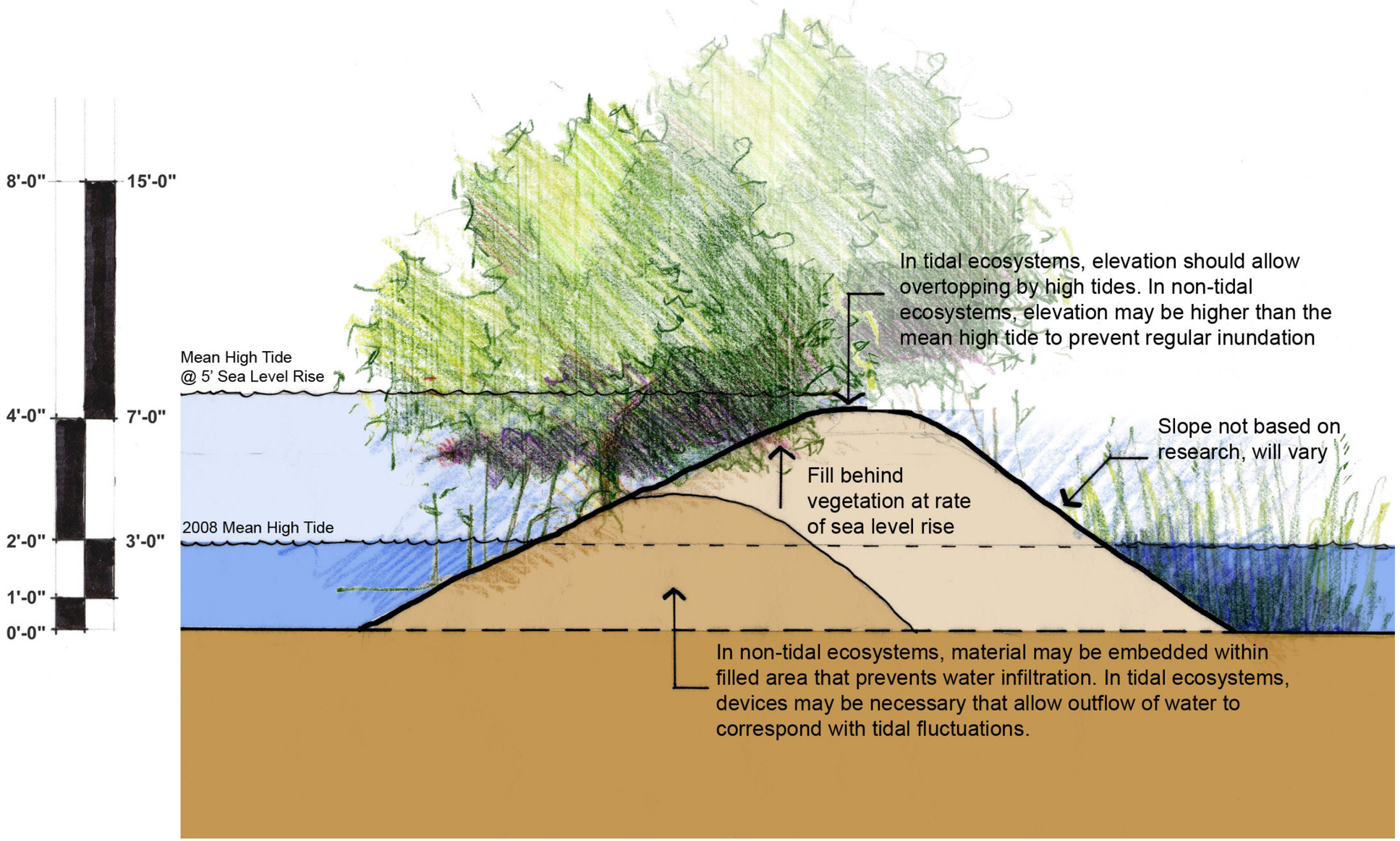
Financial sustainability: cost spread over a long period of time, in keeping with rate of SLR.

Issues

sediment source, taking of sovereign submerged lands.

Protection: Low Energy Shoreline

Low Energy Shoreline Conservation Land Protection:

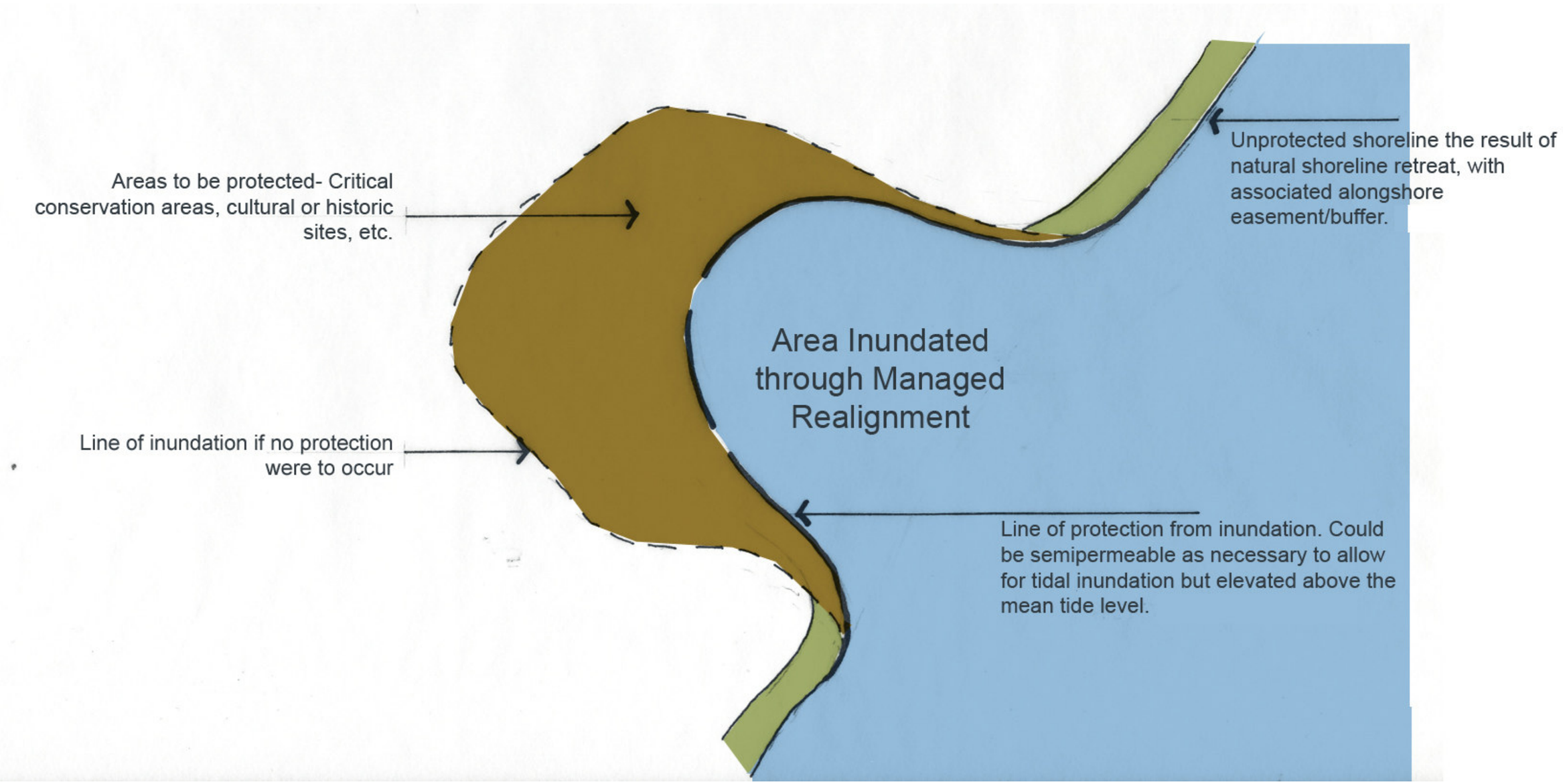


Inundated Lands

Protected Lands

Protection: Conservation Lands

Protection of Critical Lands:



Conclusions:

•Ecologically and financially sustainable shoreline protection is probably not possible particularly on high energy shorelines. Shoreline protection will only be feasible up to a certain amount of sea level rise, after which the financial costs will be too great to justify protection.

•As an alternative to shoreline protection, managed retreat policies should be implemented and shorelines should generally be allowed to retreat naturally.

•Proactive human action is necessary to facilitate ecosystem adaptation to sea level rise.

•Guidelines must be adopted for the use of areas likely to be inundated.

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