

Resilient Adaptation to Accelerating Sea Level Rise

Robert E. Deyle
Department of Urban and Regional
Planning
Florida State University



What is Resilient Adaptation?

- A resilient community
 - adapts to shocks and disturbances while continuing to maintain its most critical attributes
 - manages adaptively
 - balances robustness and flexibility

Impacts of Sea Level Rise

1. Inundation and high-tide flooding
2. Increased frequency and severity of flooding from coastal storms
3. Accelerated shoreline erosion and coastal wetland loss
4. Saltwater intrusion
5. Elevated coastal ground water tables

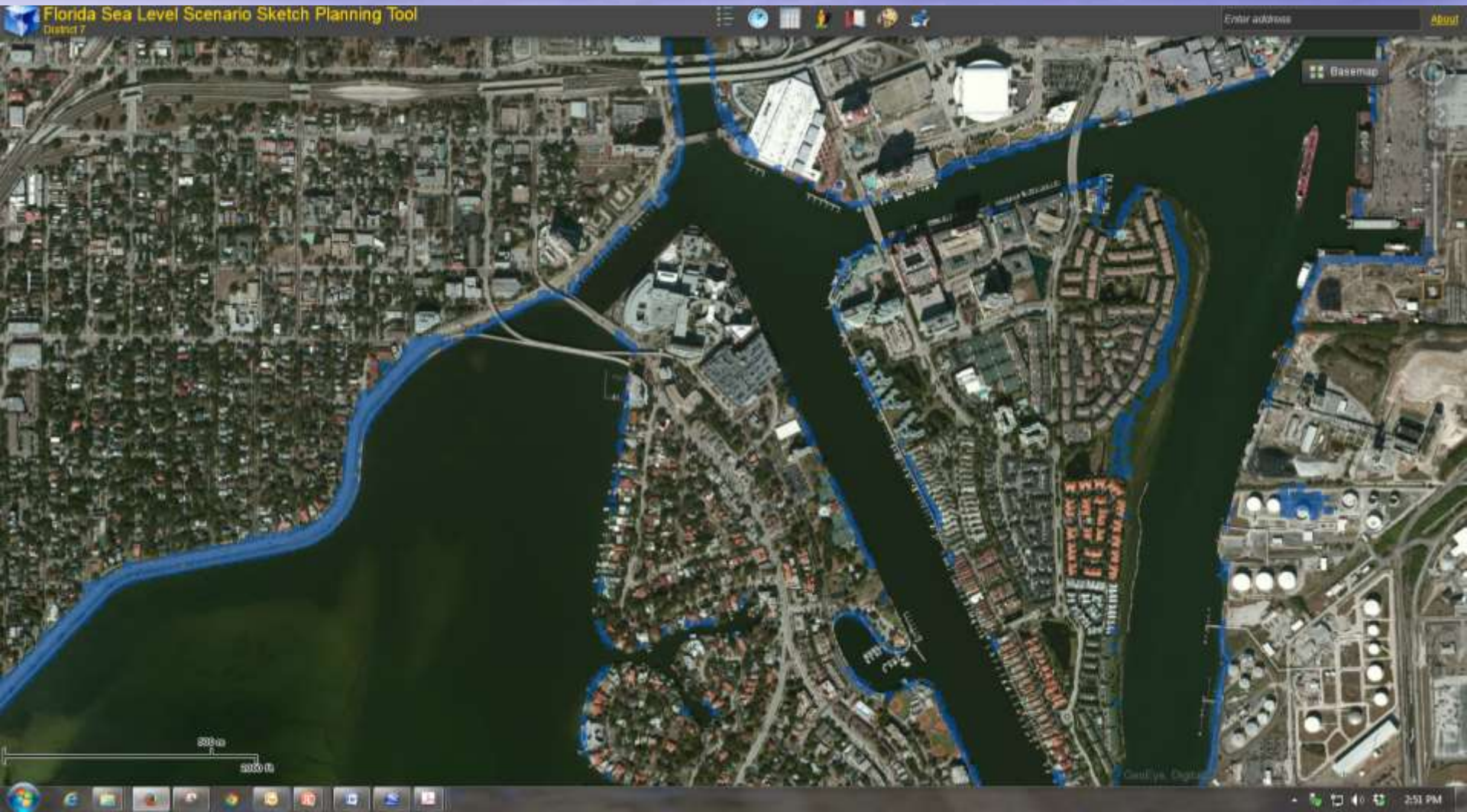
Impacts of Sea Level Rise

1. Inundation and high-tide flooding
2. Increased frequency and severity of flooding from coastal storms
3. Accelerated shoreline erosion and coastal wetland loss
4. Saltwater intrusion
5. Elevated coastal ground water tables

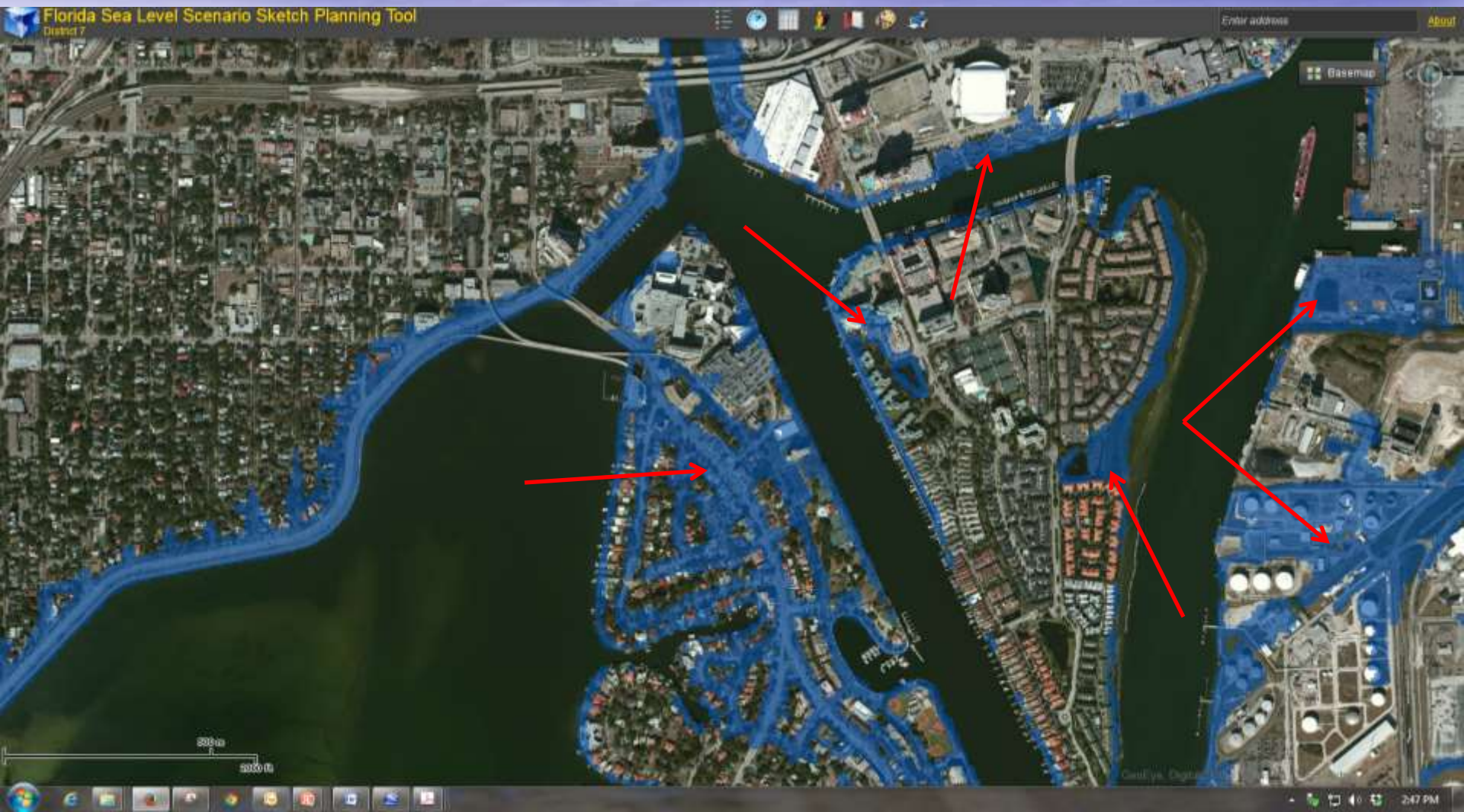
Inundation and High-Tide Flooding

- Gradual inundation of low-lying areas
- Spring high tide (high high tide) flooding
- FDOT Sketch Tool USACE intermediate (medium) and high projection scenarios for Mean High High Water (MHHW):
 - Tampa Bay
 - Clearwater
 - Tarpon Springs
 - Manatee River mouth

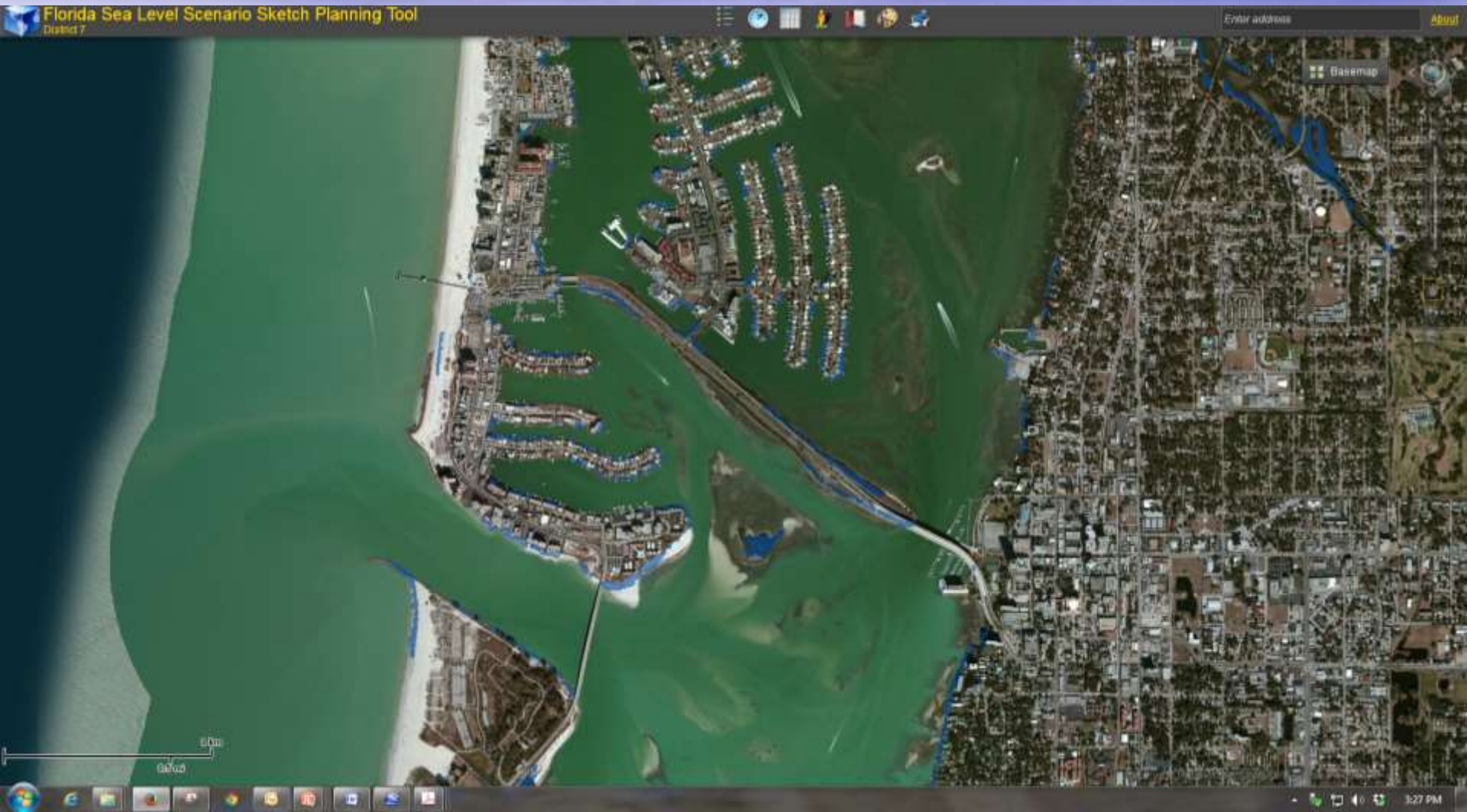
Tampa - 2080 MHHW USACE Medium: 32 inches (vs 1992)



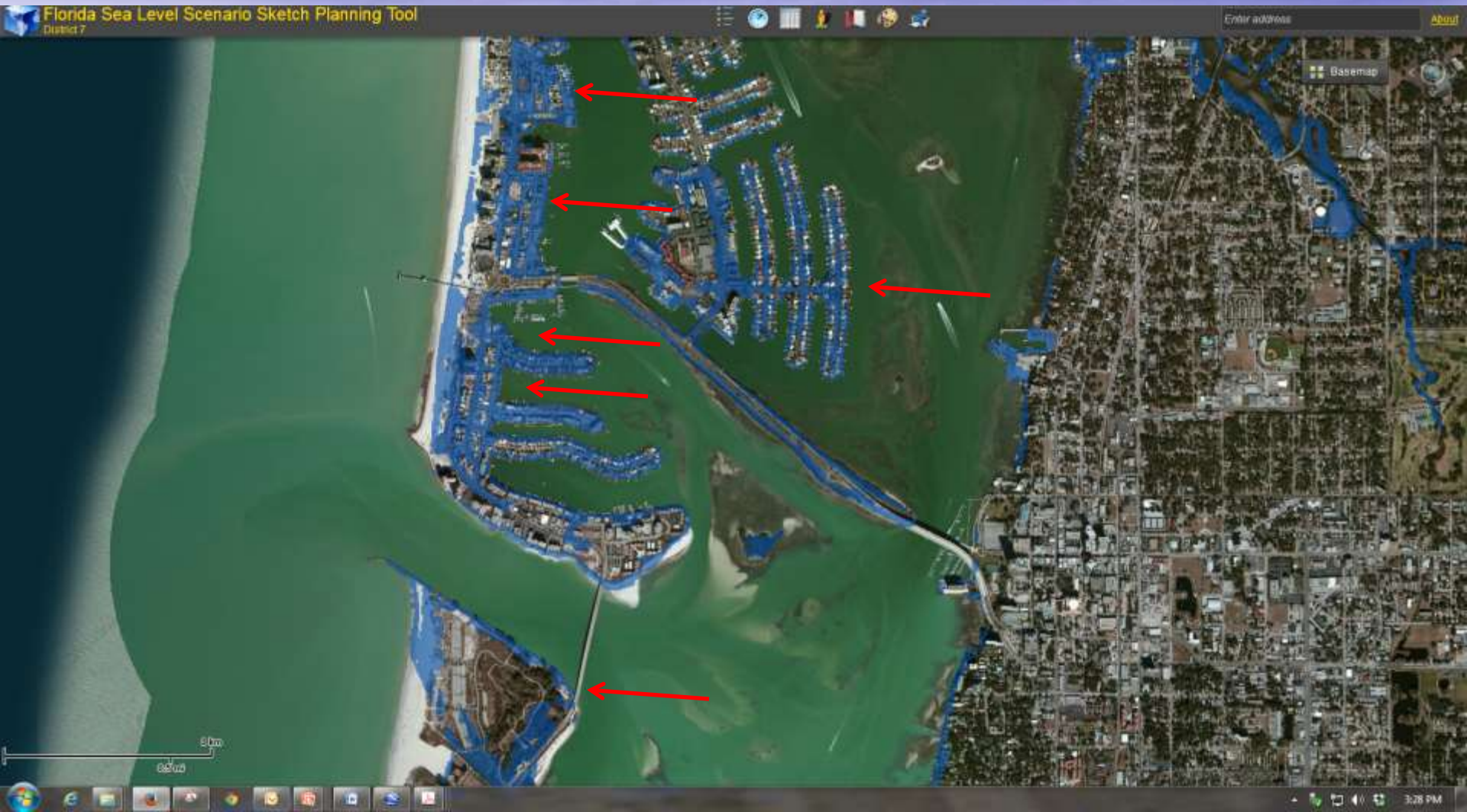
Tampa - 2080 MHHW USACE High: 58 inches (vs 1992)



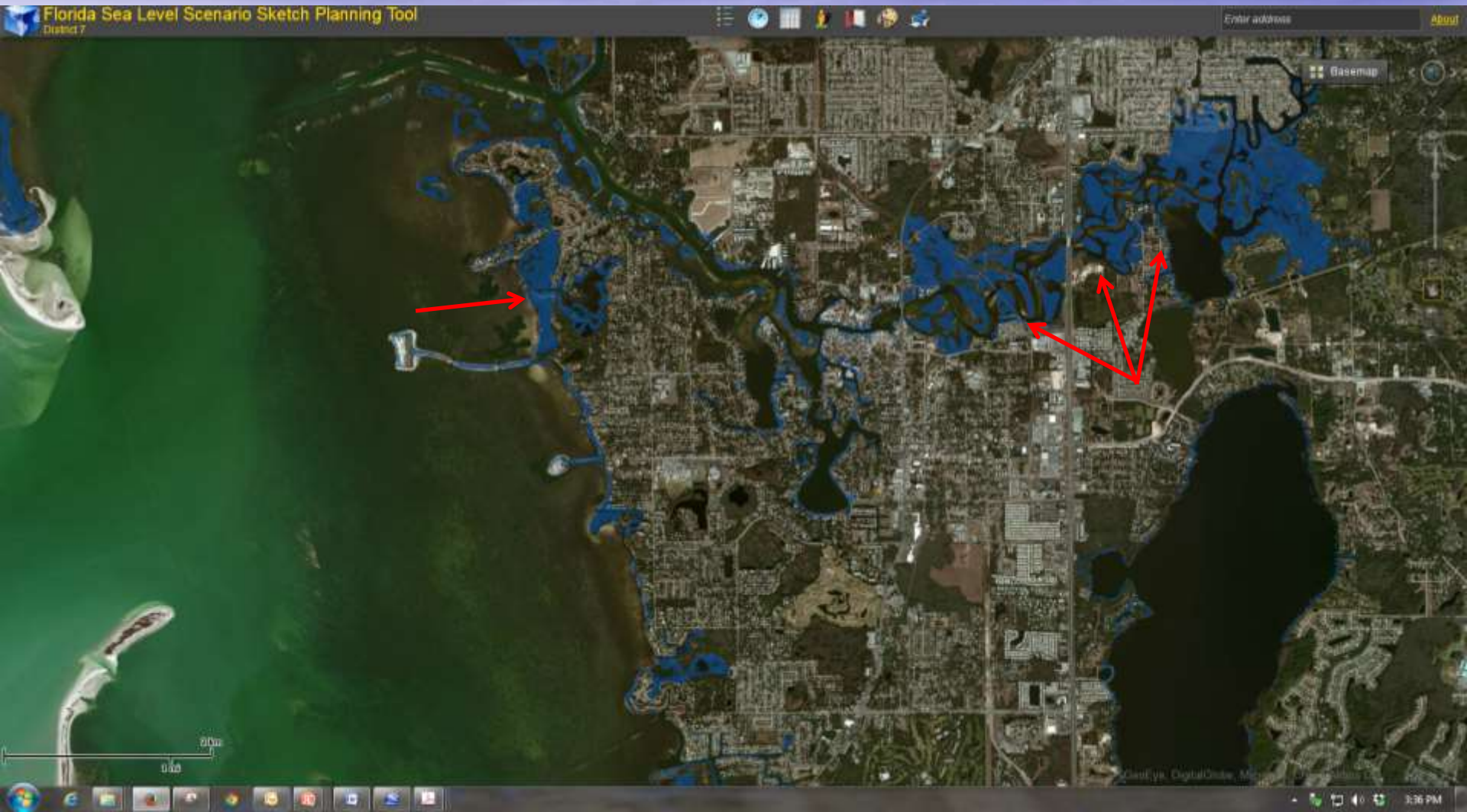
Clearwater - 2080 MHHW USACE Medium: 32 inches



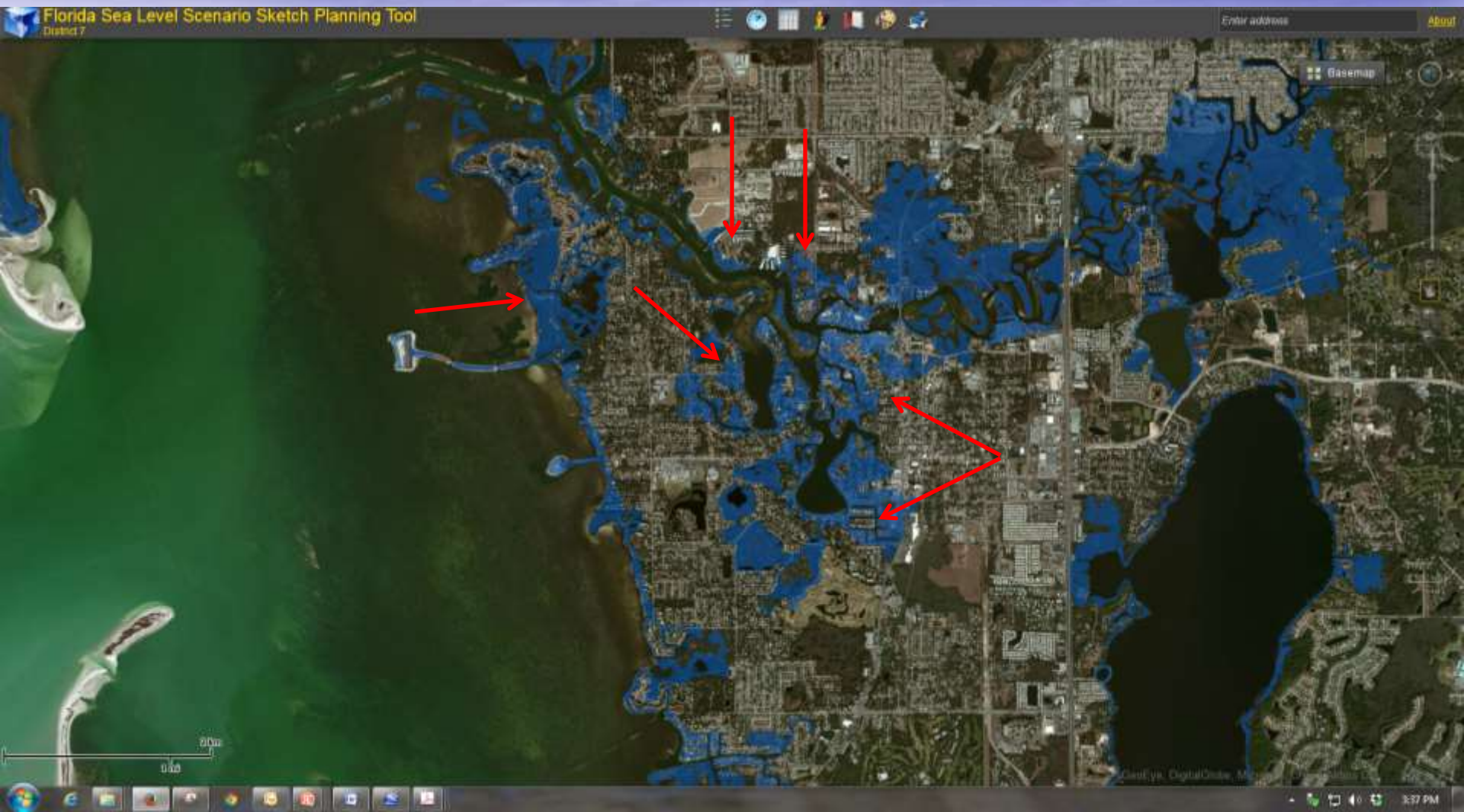
Clearwater - 2080 MHHW USACE High: 58 inches



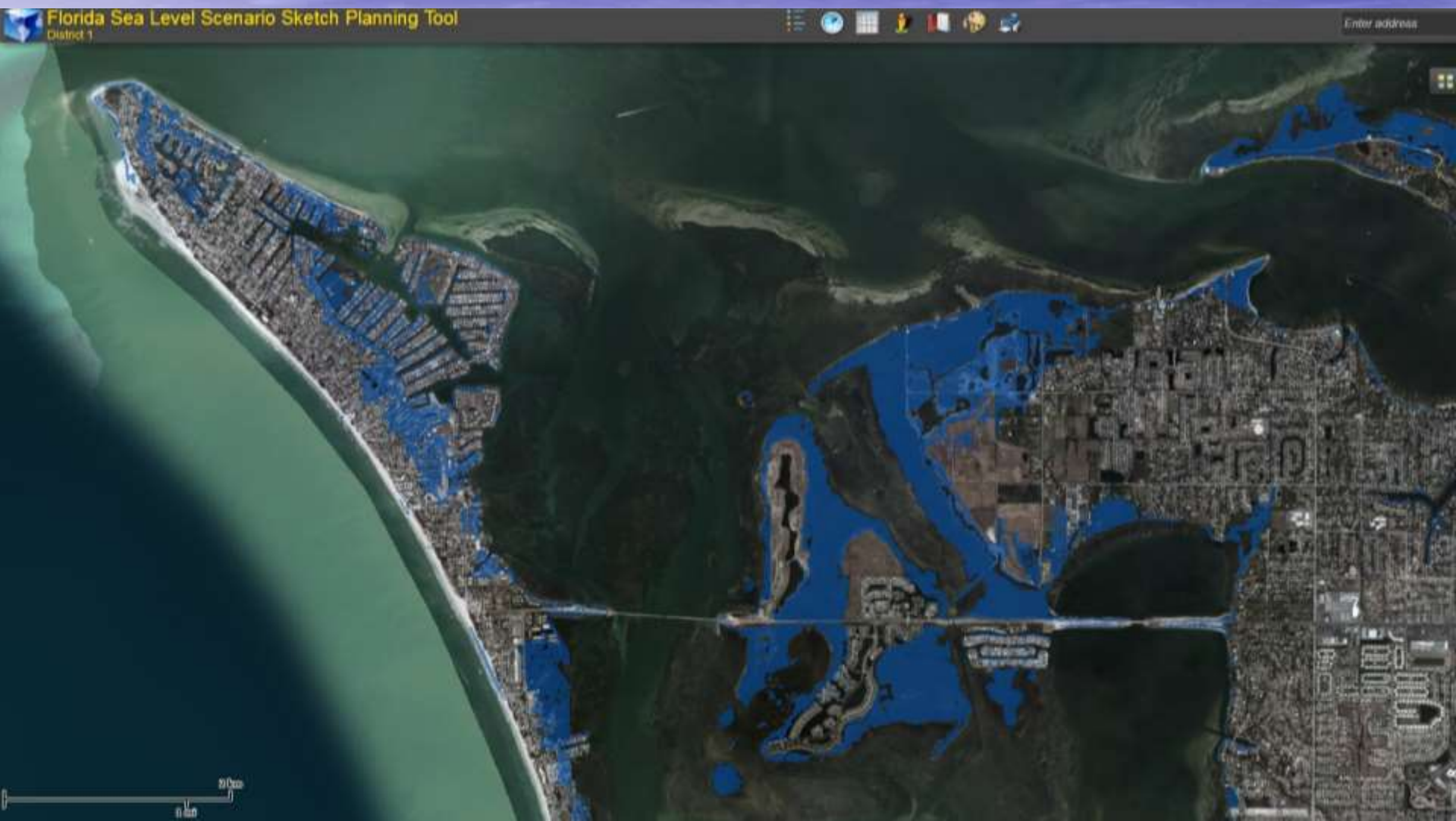
Tarpon Springs - 2080 MHHW USACE Medium: 32 inches



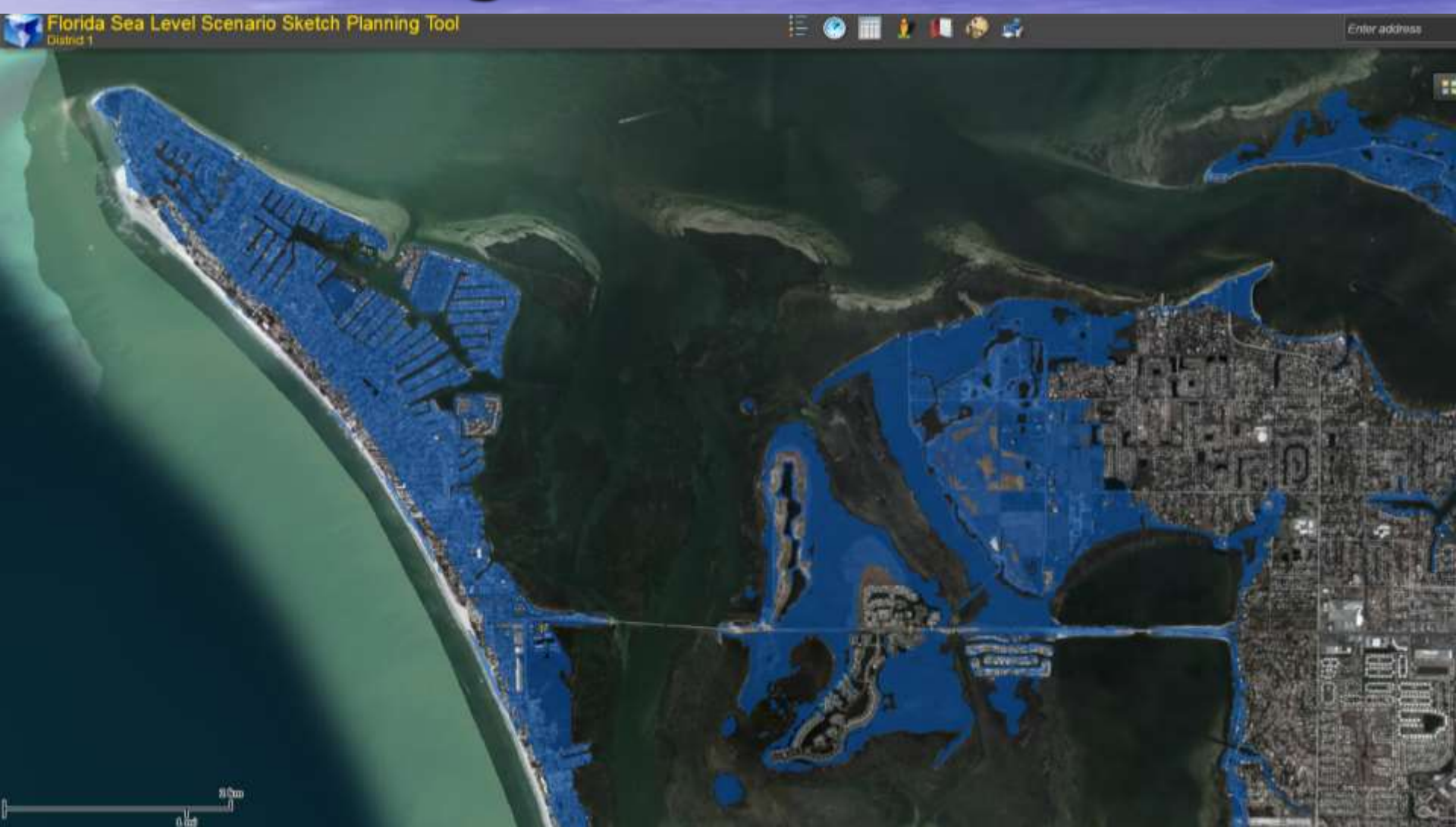
Tarpon Springs - 2080 MHHW USACE High: 58 inches



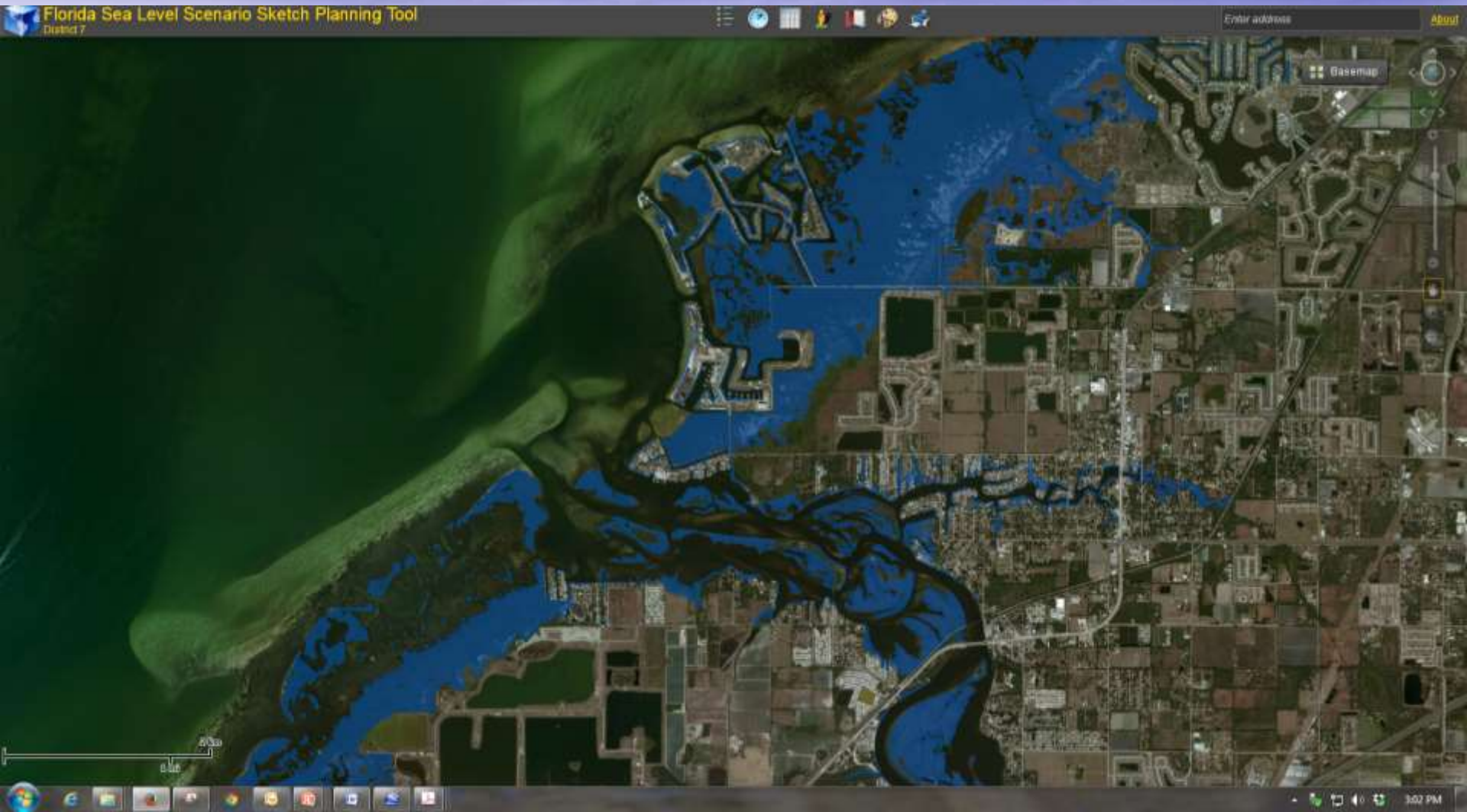
Manatee County - 2080 MHHW USACE Medium: 24 inches



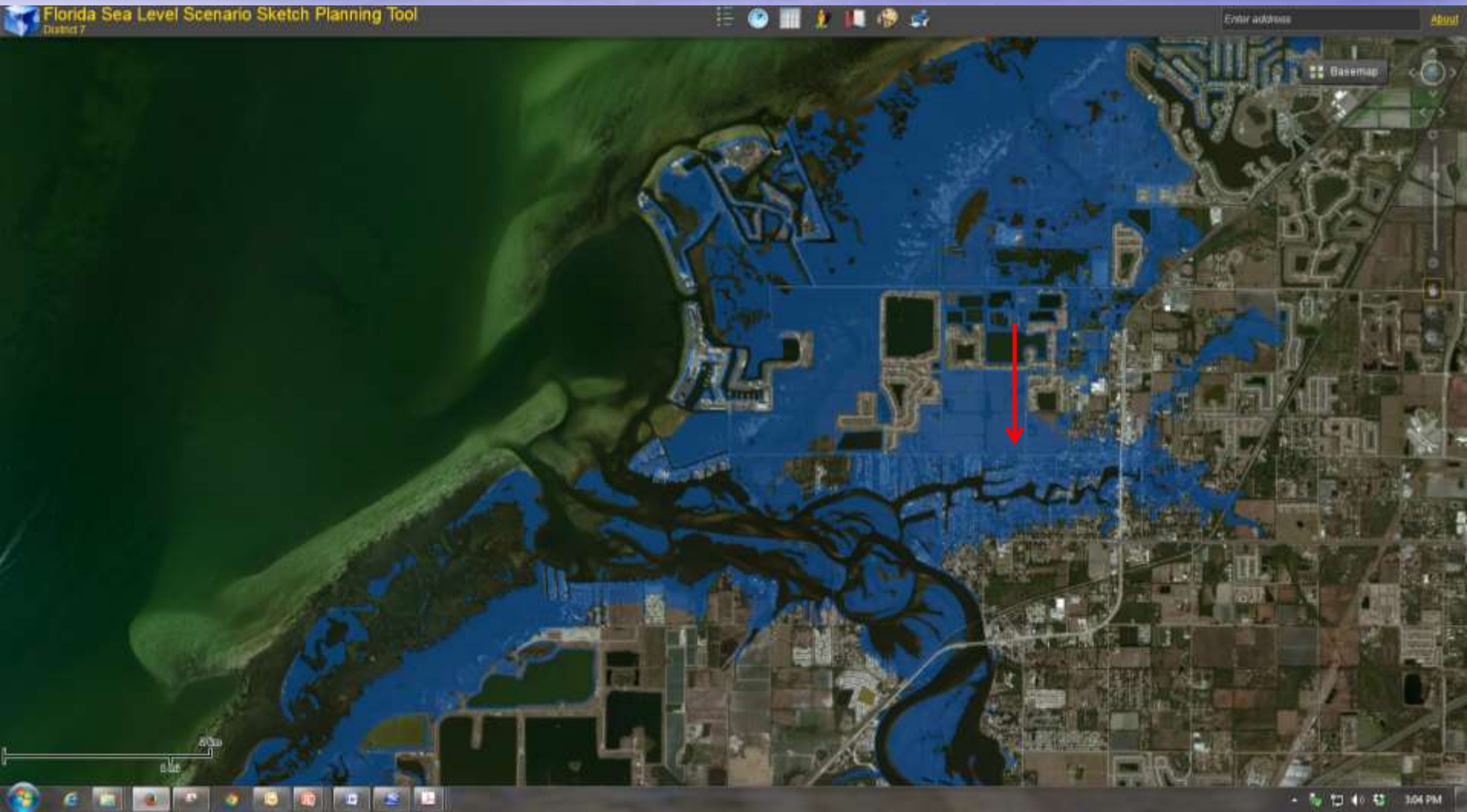
Manatee County - 2080 MHHW USACE High: 50 inches



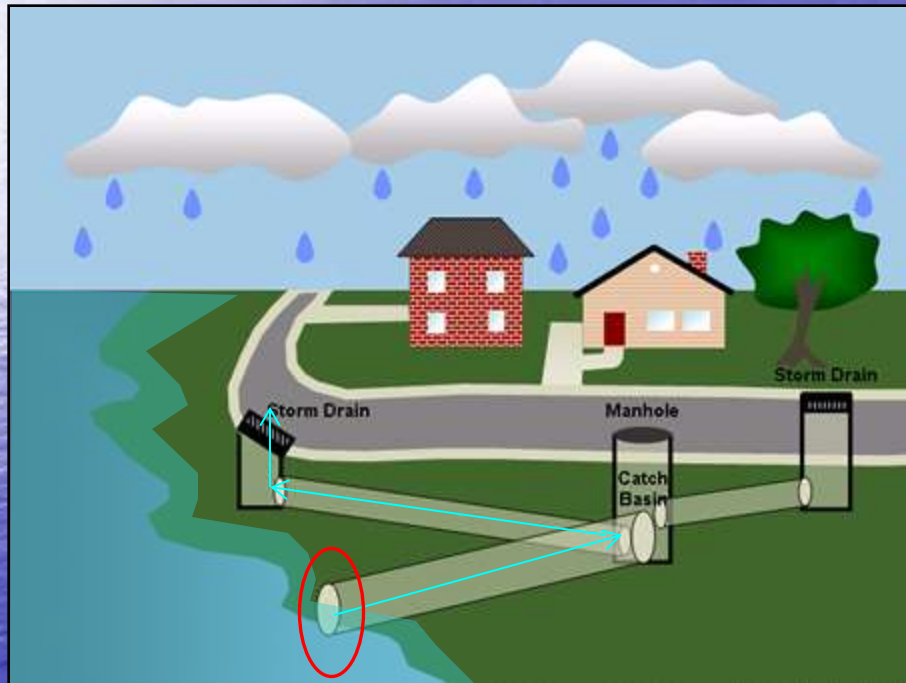
South County - 2040 MHHW USACE High: 30 inches



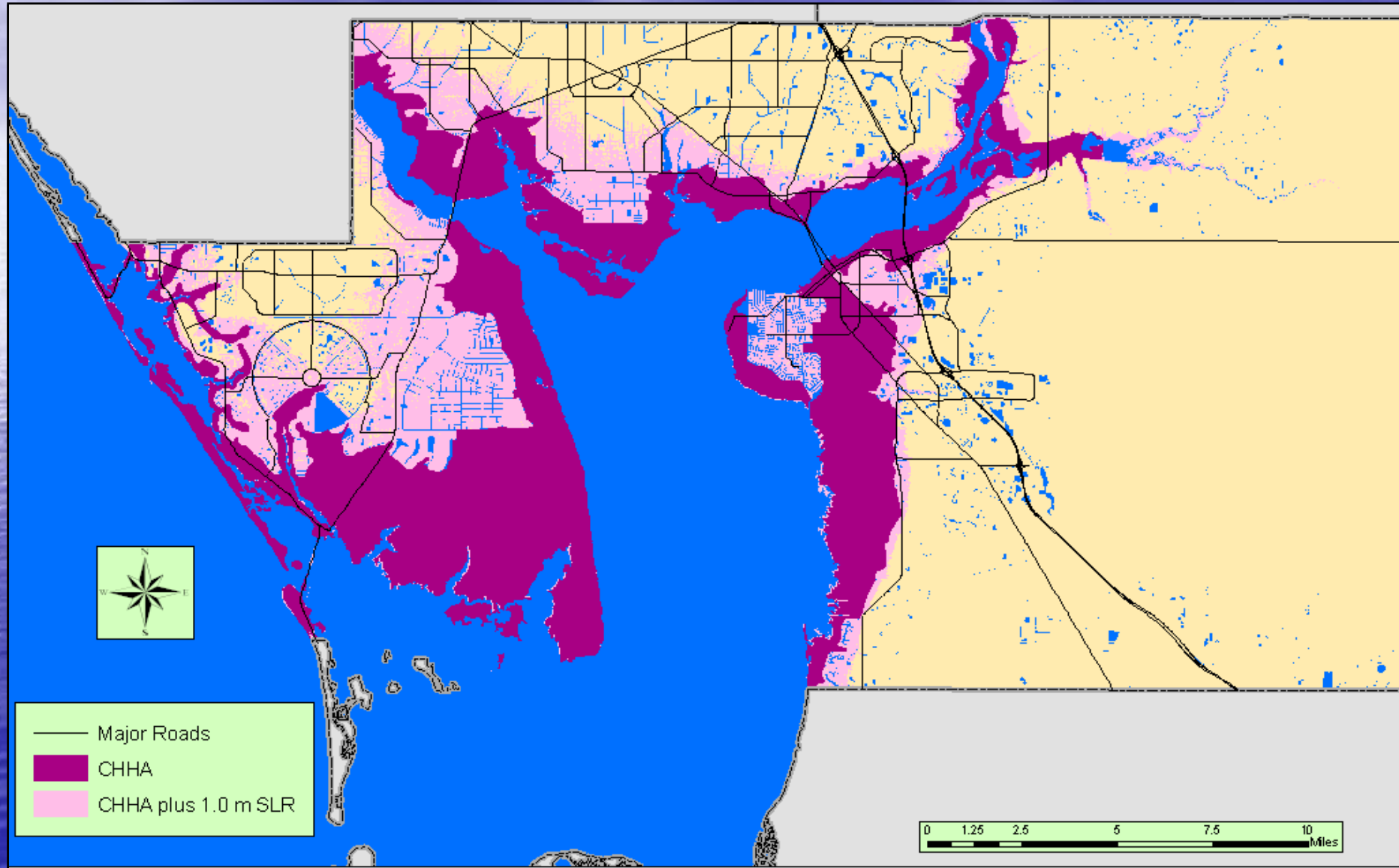
South County - 2080 MHHW USACE High: 58 inches



Inundation, High-Tide Flooding, and Navigation



Increased Coastal Storm Flooding



Increased Coastal Storm Flooding



Increased Coastal Storm Flooding



Accelerated shoreline erosion and coastal wetland loss



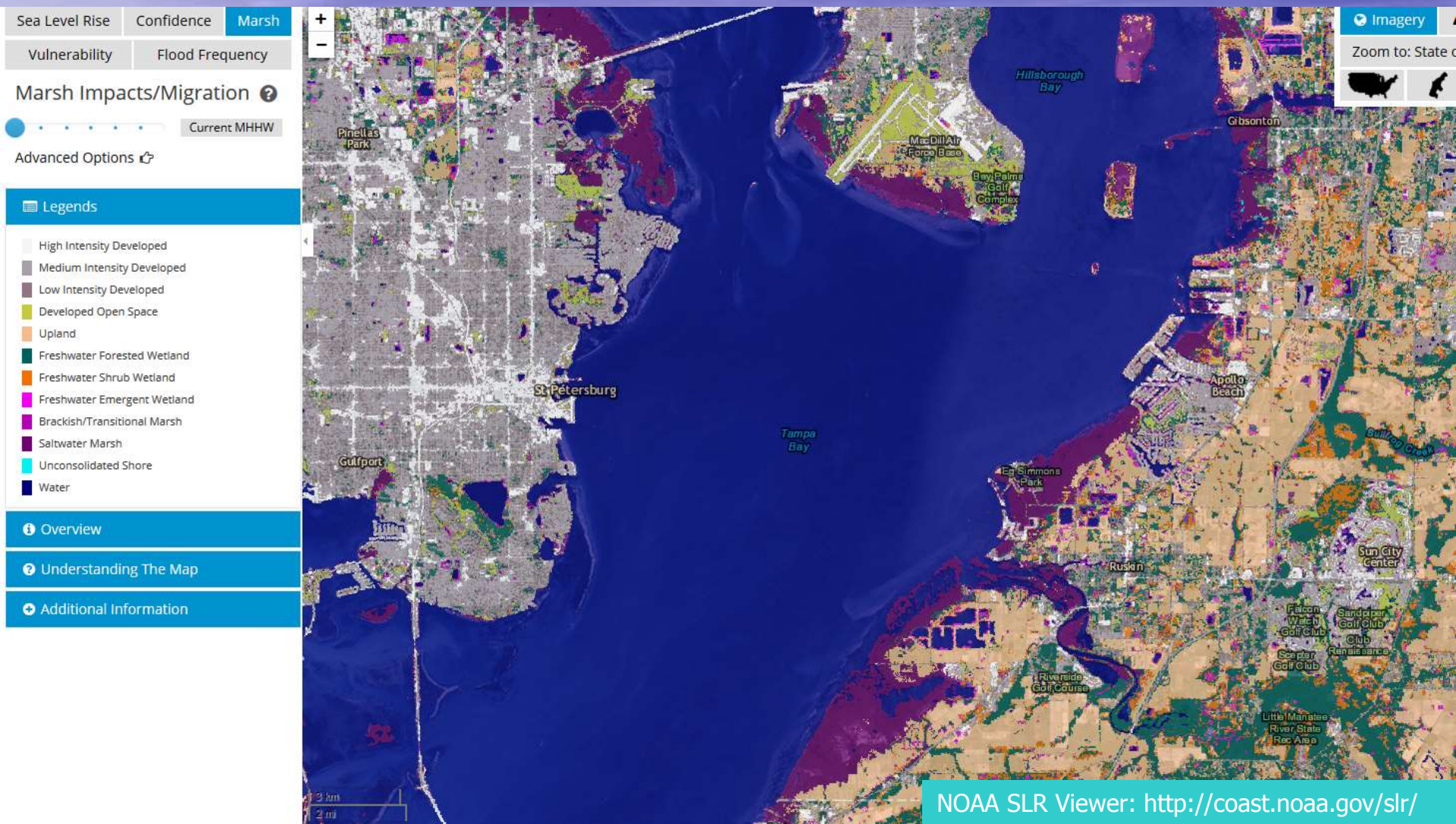
Accelerated shoreline erosion and coastal wetland loss



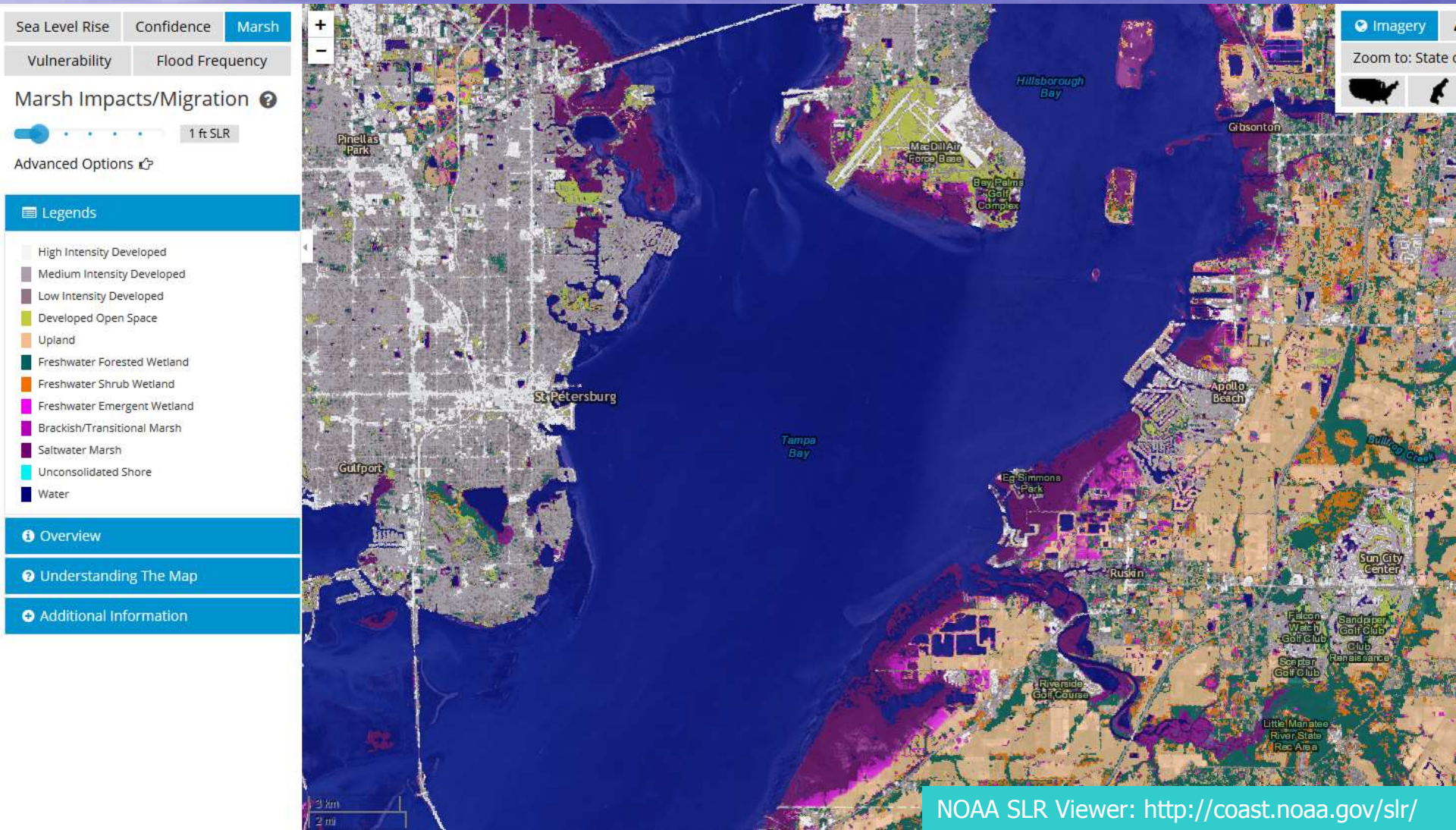
Accelerated coastal marsh erosion and mangrove loss



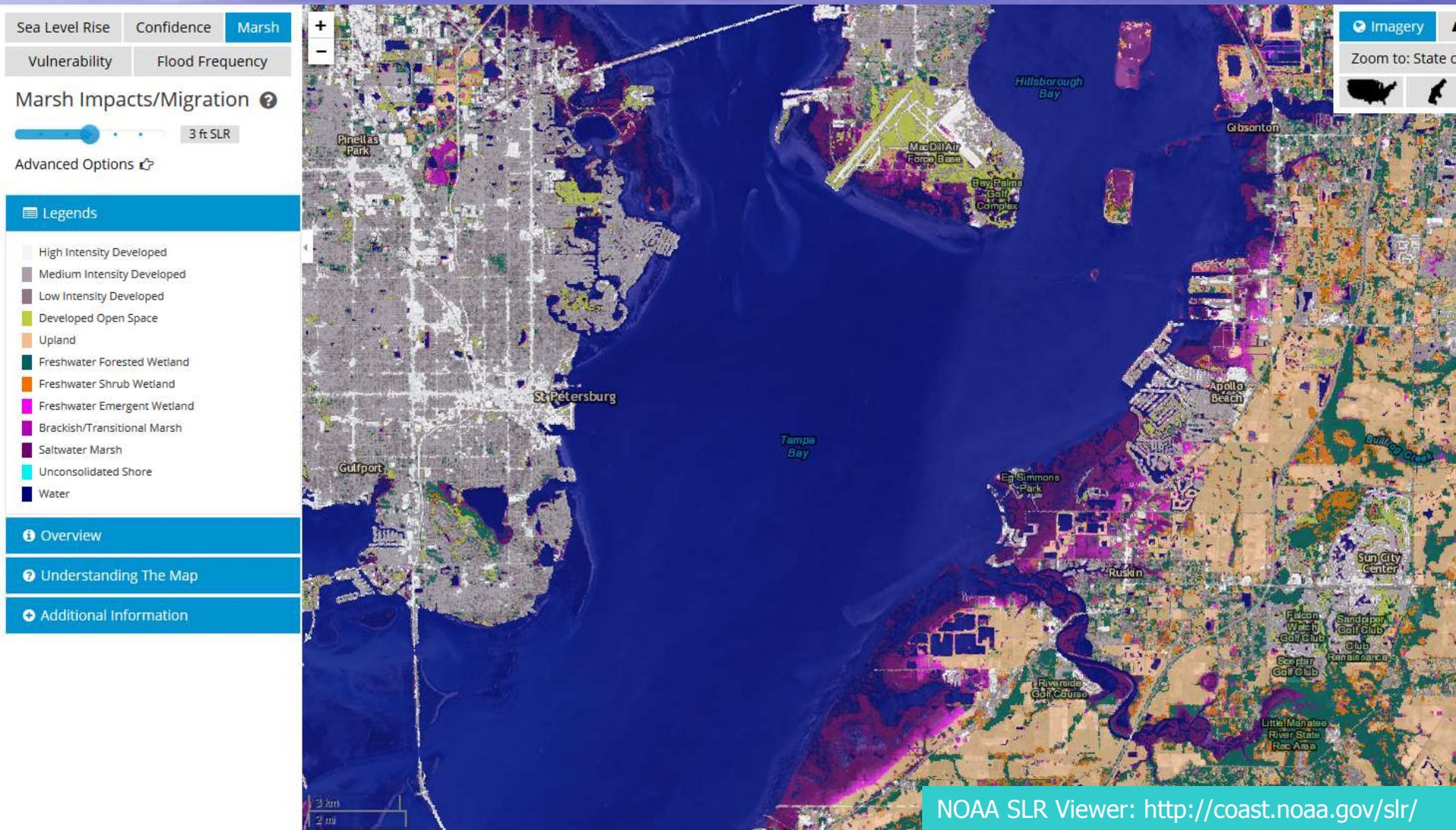
South County Wetlands – Current Extent



South County Wetlands – 1 foot Sea Level Rise



South County Wetlands – 3 foot Sea Level Rise



Alternative Adaptation Approaches

1. Protect: Stand and defend
2. Accommodate: Buy some time
3. Retreat/relocate: Get out of the way

Adaptation Goals

1. Maximize resilience:

- Robust performance
- Flexibility to adapt

2. Minimize costs:

- Risks to human and natural systems
- Capital and operating costs
- Opportunity costs
 - Spending scarce capital on adaptation
 - Precluding development

Protection Strategies

- Coastal armoring
- Beach nourishment
- Living shorelines
- Backflow prevention

Protect: Coastal Armoring



- Continued productive use
- Finite design limits & limited flexibility
- Beach/shore narrowing
- Prevent beach and wetland migration
- High capital costs: \$10-20 million/mi
- Ongoing costs: ~\$1.5 million/mi every 20-25 yrs

Protect: Beach Nourishment



- Continued productive use
- Less robust: re-nourish every 2-6 years
- More flexible
- Limited flood protection
- Maintains beach assets
- Allows beach migration
- High capital costs: \$4.3 million/mi
- Ongoing costs of renourishment

Protect: Living Shorelines



- Continued productive use
- Modest flood protection
- High flexibility
- Habitat restoration or enhancement
- Self-sustaining without armoring
- ~\$2.5 million/mi with armoring
- \$0.25-1.05 million/mi without armoring



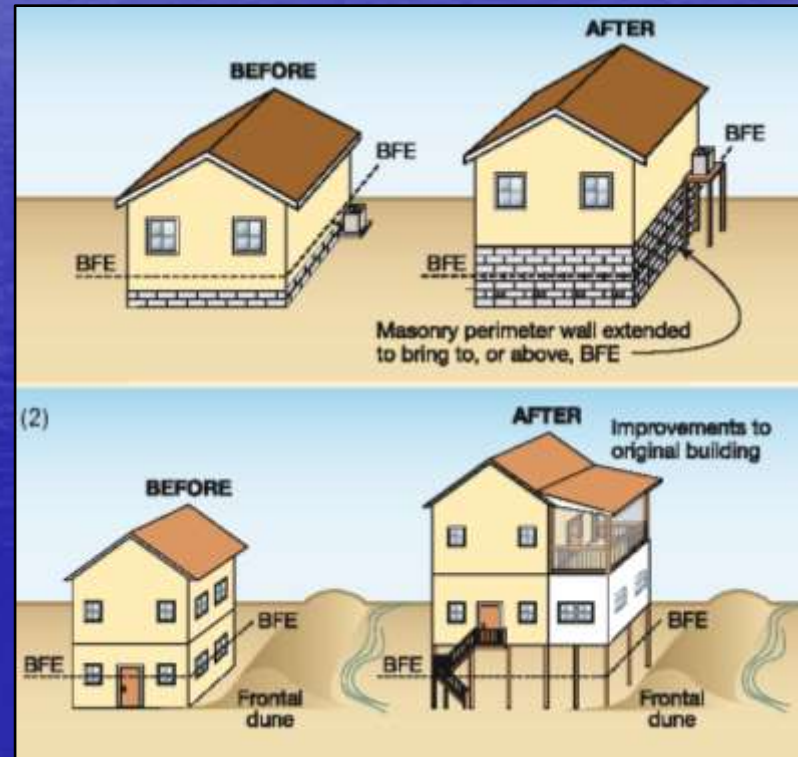
Protect: Backflow Prevention



Accommodation Strategies

- Flood proofing and elevating structures
- Large scale grade elevation
- Elevating infrastructure
- Restricting development within projected sea level rise inundation and flood areas

Accommodate: Flood Proof or Elevate



Accommodate: Flood Proof or Elevate



- Continued productive use
- Finite design limits
- Flexibility varies
- Impede beach and wetland migration unless on open pilings
- New construction cost: \$15-\$32/sq ft
- Retrofit cost: \$30-\$100/sq ft

Accommodate/Protect: Grade Elevation

Boston Deer Island Sewage Treatment Plant



Galveston Seawall & Grade Raising Project



- Beach/shore narrowing
- Prevent beach and wetland migration
- Capital costs >> protection
- Ongoing costs > protection

Accommodate: Elevate Infrastructure



Accommodate: Development Restrictions



- Prohibit development within projected hazard zones
- Site infrastructure outside of projected hazard zones

Accommodate: Development Restrictions



- Finite design limits
- Flexibility varies
- Allows beach/wetland migration
- High opportunity costs

Retreat/Relocation Strategies

- Rolling easements
- Infrastructure relocation/removal
- Buy outs
- Transfer of development rights

Retreat: Rolling Easement

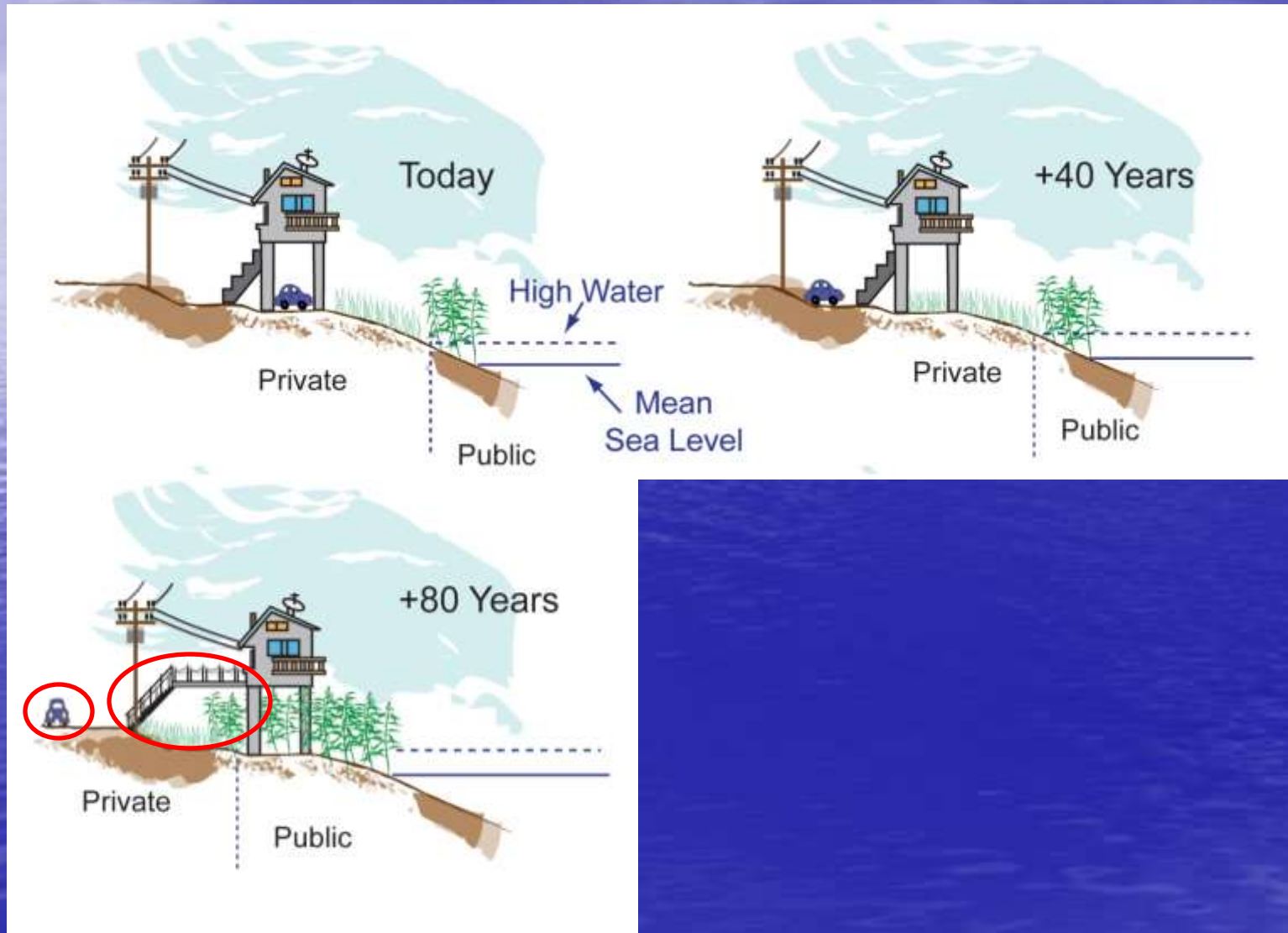


- Relocate when Mean High Tide Line reaches threshold position
- Structural protection prohibited

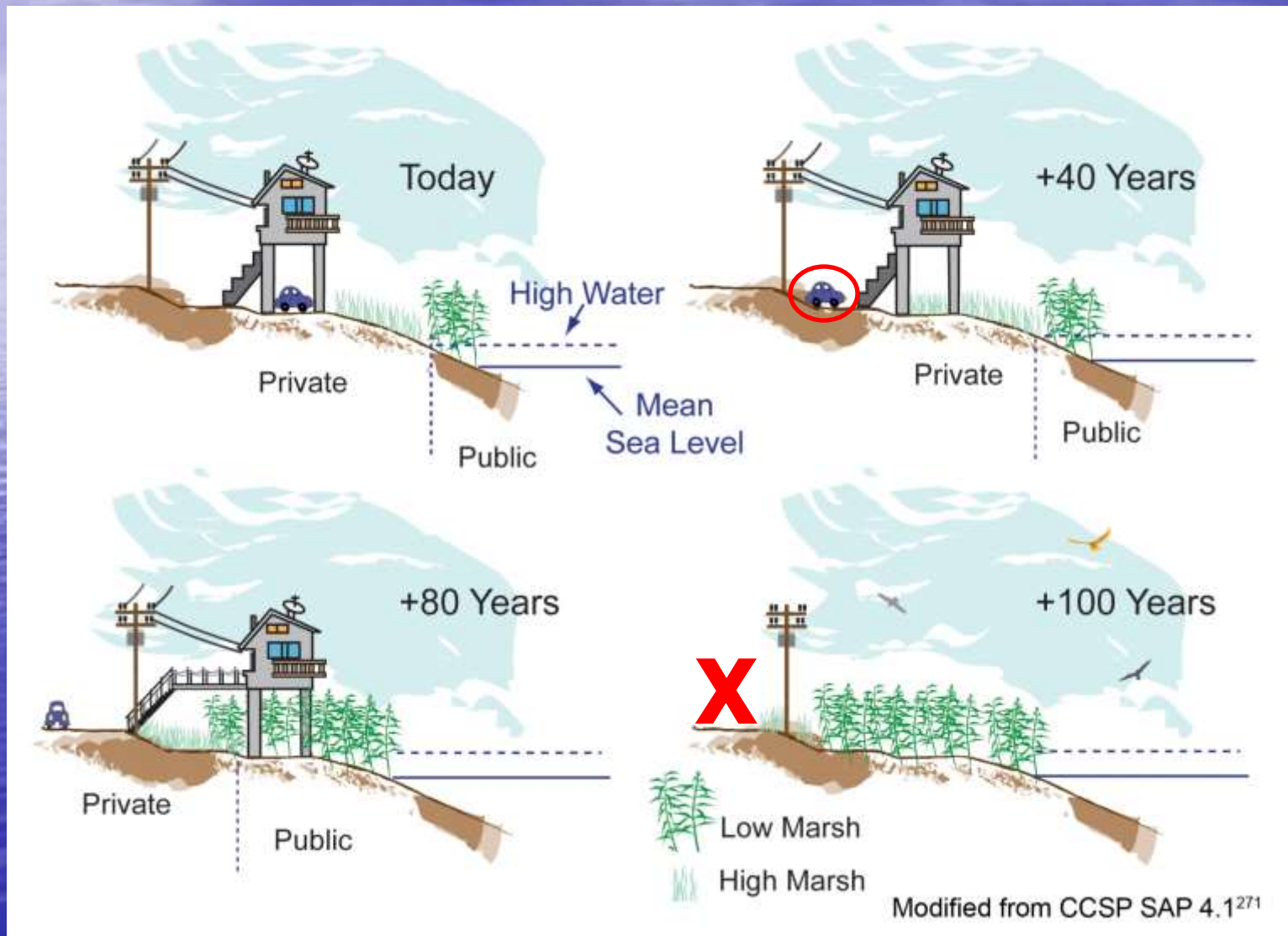
Retreat: Rolling Easement



Retreat: Rolling Easement



Retreat: Rolling Easement



Retreat: Rolling Easement

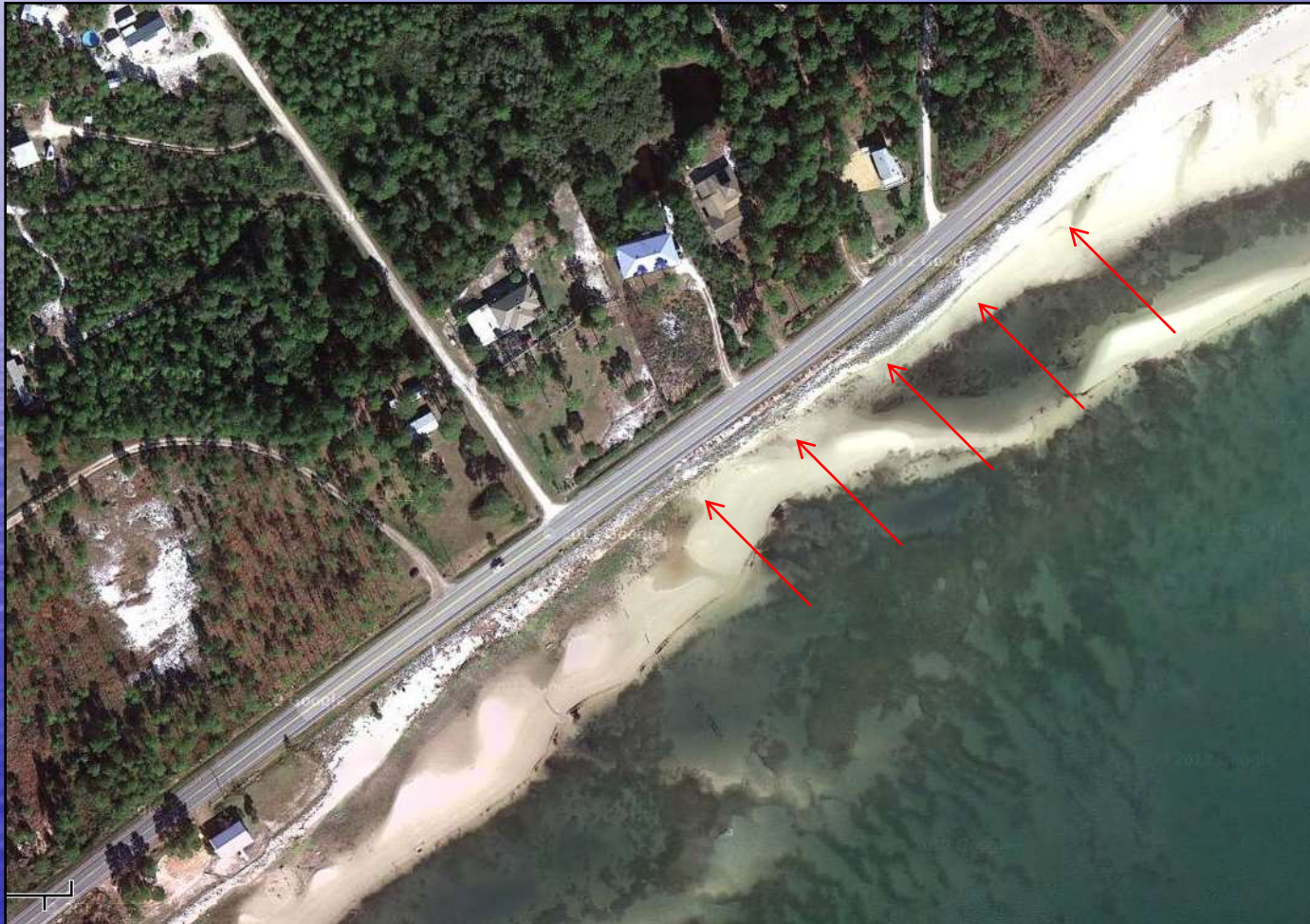


- Allows for productive use of uplands
- Flexible but . . .
What about infrastructure?
- Facilitates beach/wetland migration
- Costs: legal exposure and complexity

Retreat: Infrastructure Relocation/Removal



Retreat: Infrastructure Relocation/Removal



Retreat: Buy Outs



- Allow for productive use of uplands
- Infinitely adjustable
- Maximum beach/wetland migration
- Very high costs

Retreat: Transfer of Development Rights (TDR)



- Retreat area = sending zone
- Higher density development allowed within receiving zone with purchased development rights
- Similar effects as buy outs without the extreme costs

Choosing Strategies

- Account for constituency perceptions and attitudes:
 - risks of “under-adaptation”
 - opportunity costs of “over-adaptation”
 - high capital and operating costs
 - foregone economic development
 - trade-offs between protecting built and natural environments
 - tolerance for uncertainty
- We have an obligation to lead