Sea Level Change and Long Range Water Resources Planning for Florida

Miami-Dade Sea Level Rise Task Force

April 4, 2014 Miami, FL

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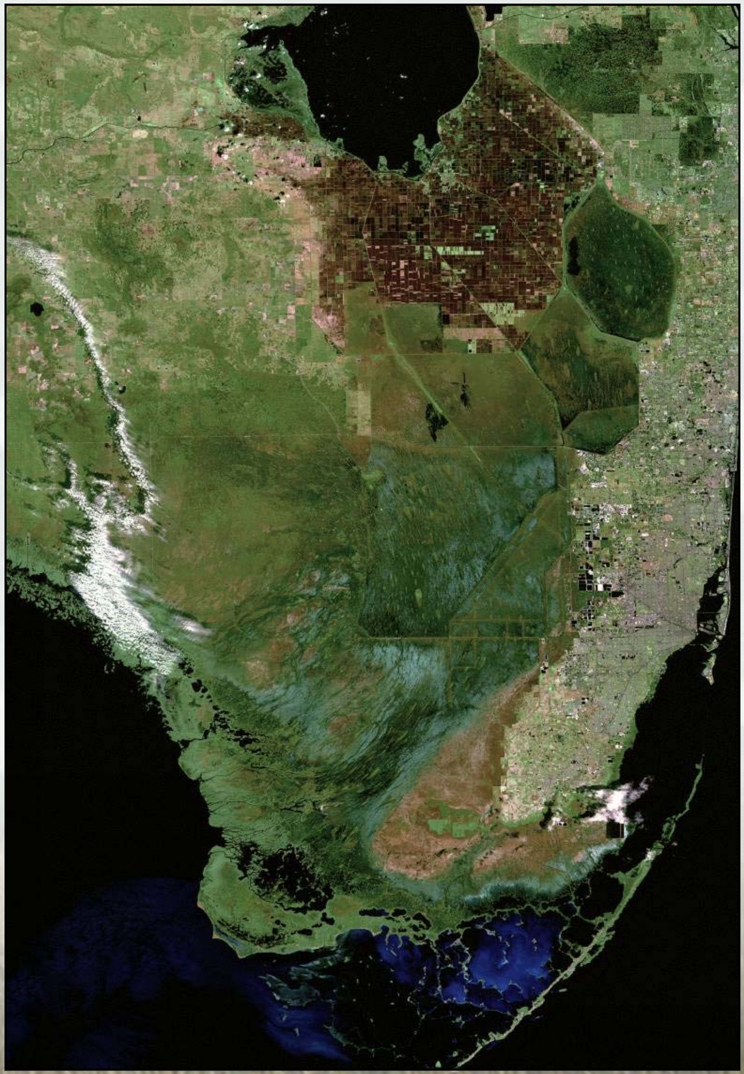
Presentation Outline

- Current USACE & NOAA guidance on Sea Level Change projections
- Florida SLC Trends & Projections
- SLC beyond 2100
- SLC Concerns in Florida – Current & Future; Direct & Indirect
- Systems Approach to Adaptation
- Building a More Resilient Future with Public/Private Partnerships?



US Army Corps of Engineers Civil Works Mission Areas

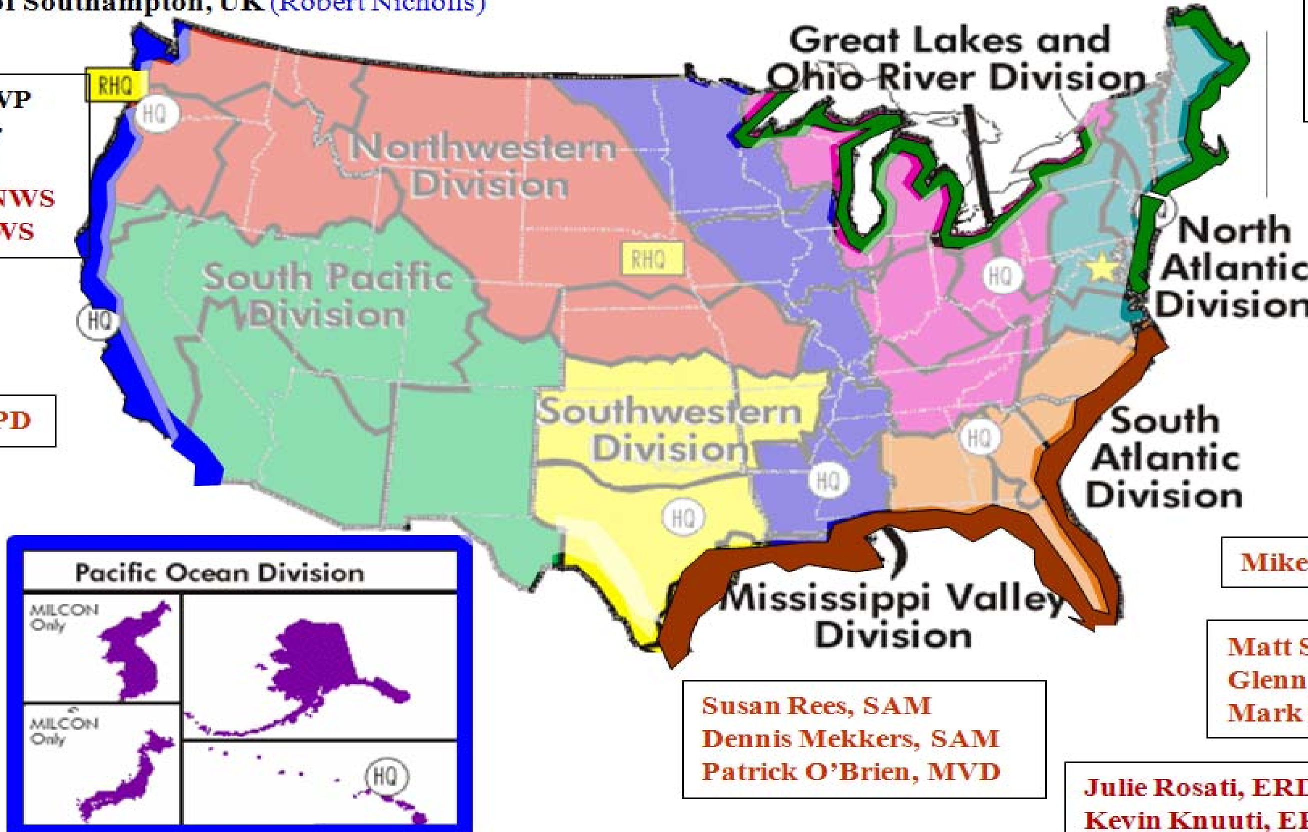
- **Navigation**
  - Breakwaters and Jetties
  - Harbors, Navigation Channels and Ocean Disposal Sites
- **Hydropower**
- **Reservoir Regulation; Water Supply**
- **Coastal Storm Damage Reduction**
  - Beach fills and Shoreline protection structures
- **Flood Damage Reduction**
  - Storm Drainage, Dams, levees, floodwalls
- **Ecosystem Restoration**
- **Emergency Response**
- **Recreation**
- **Regulatory**

Climate change has the potential to impact all USACE mission areas

USGS (Robert Thieler, Nate Plant, Jeff Williams)
NOAA (Steve Gill, Billy Sweet, Kristen Tronvig, Carolyn Lindley)
Navy (Tim McHale, Shun Ling)
Bureau of Reclamation (Mike Tansey)
FEMA (Mark Crowell , Tucker Mahoney)
NPS (Rebecca Beavers, Maria Honeycutt, Jodi Eshleman)
US Naval Academy (Dave Kriebel)
FHWA (Kevin Moody)
Moffatt & Nichol (John Headland)
HR Wallingford, UK (Jonathan Simm, Peter Hawkes)
University of Southampton, UK (Robert Nicholls)

Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation

Civil Works Technical Letter Team



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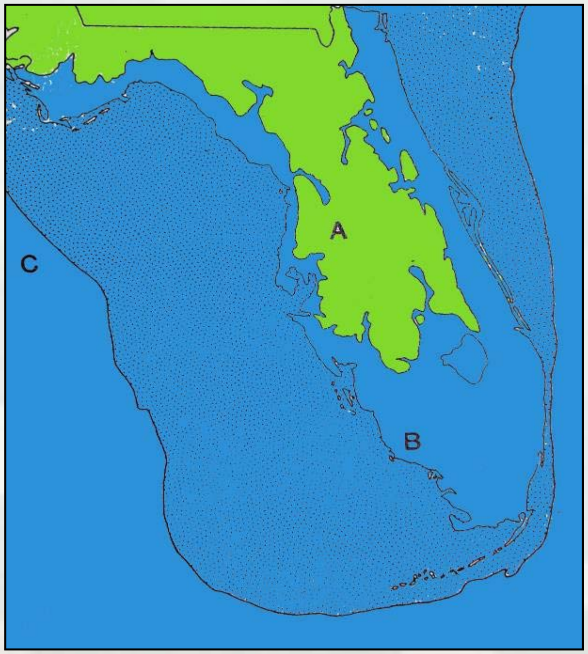
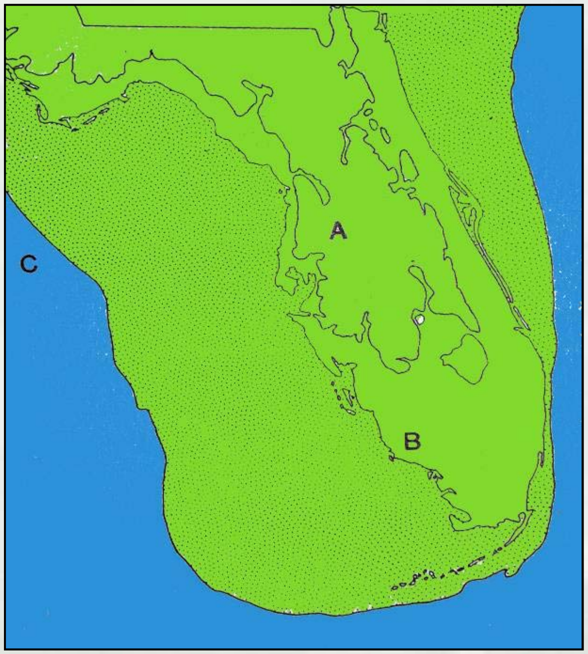
Climate Change Concerns for Florida

- **Sea Level Rise**
  - Salinity changes in coastal bays, plus tidally influenced creeks and rivers
  - Shoreline retreat with natural habitat changes/losses
  - Increasing flood frequency and depth in coastal areas
  - Saltwater intrusion in water supply wells, OR higher canal stages and flood risks
  - Uncertainties and risks in rate and depth of sea level rise
- **Warmer Temperatures**
  - Evaporation losses up; water supply down
  - Stresses on plant, animal, and marine ecosystems
  - Changes in growing season and migratory patterns
  - Changes in water quality
- **Hydrologic Pattern Changes**
  - Potential for less frequent and more intense rain events
  - Potential increased tropical storm intensity or frequency

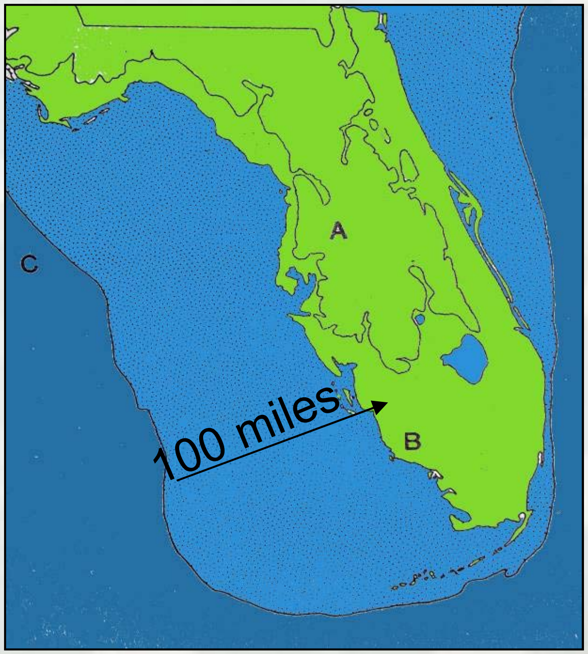
Florida Through Time – Sea Level Change Happens!



120,000 years ago
+ 6 meters (20')*



18,000 years ago
- 120 meters (420')

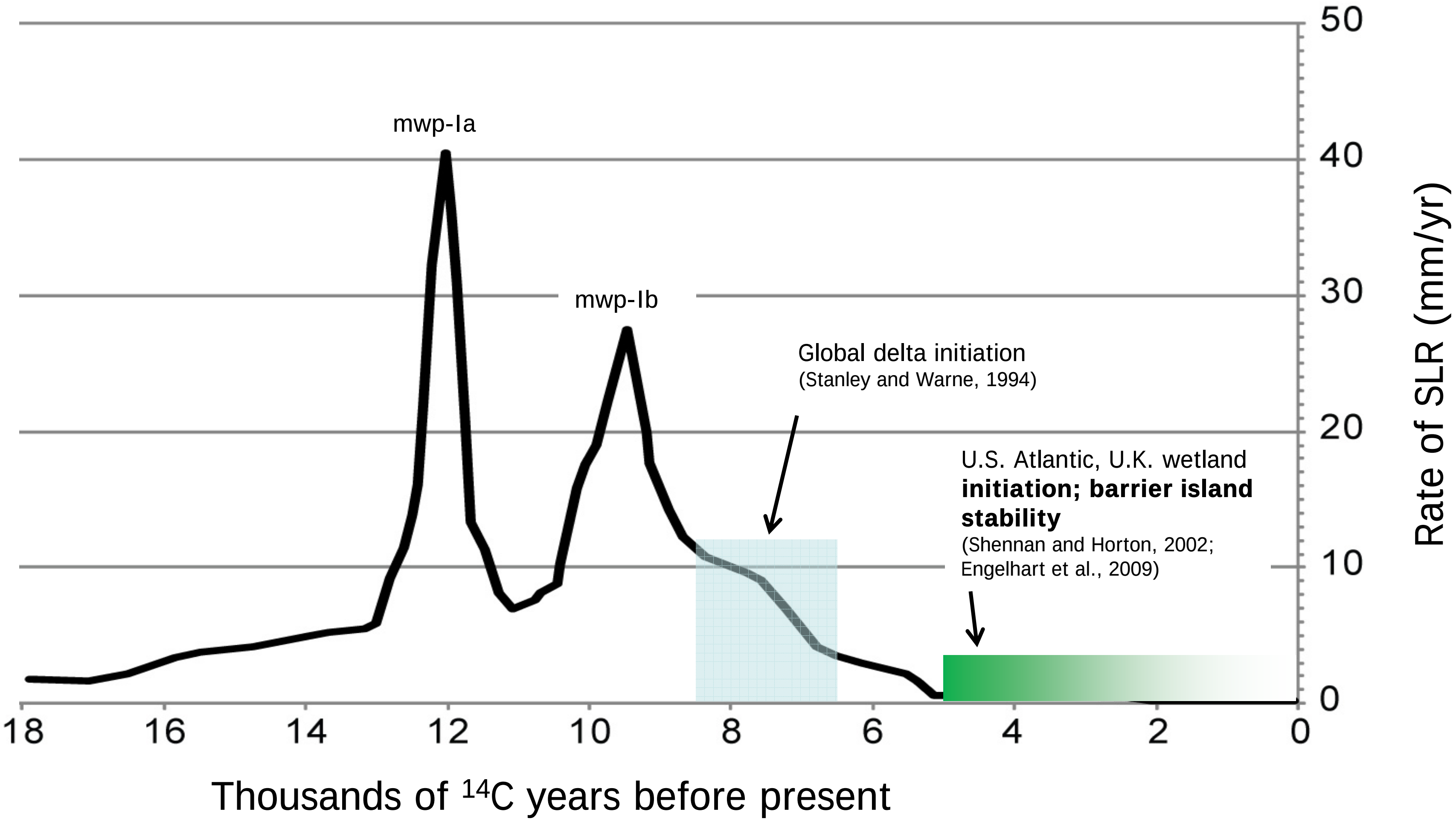


Today

*~ ½ from Greenland
*~ ½ from Antarctica

Credit: **Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force**

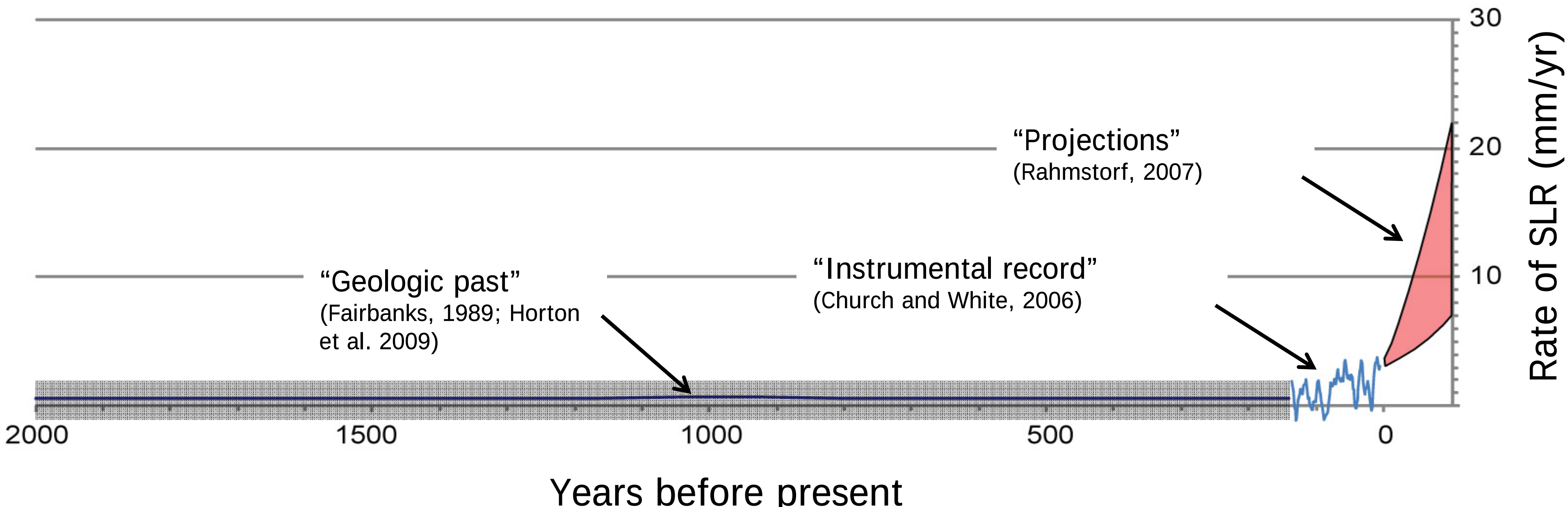
Rates of Sea-level rise since the Last Glacial Maximum



(Slide courtesy of Rob Thieler, USGS)

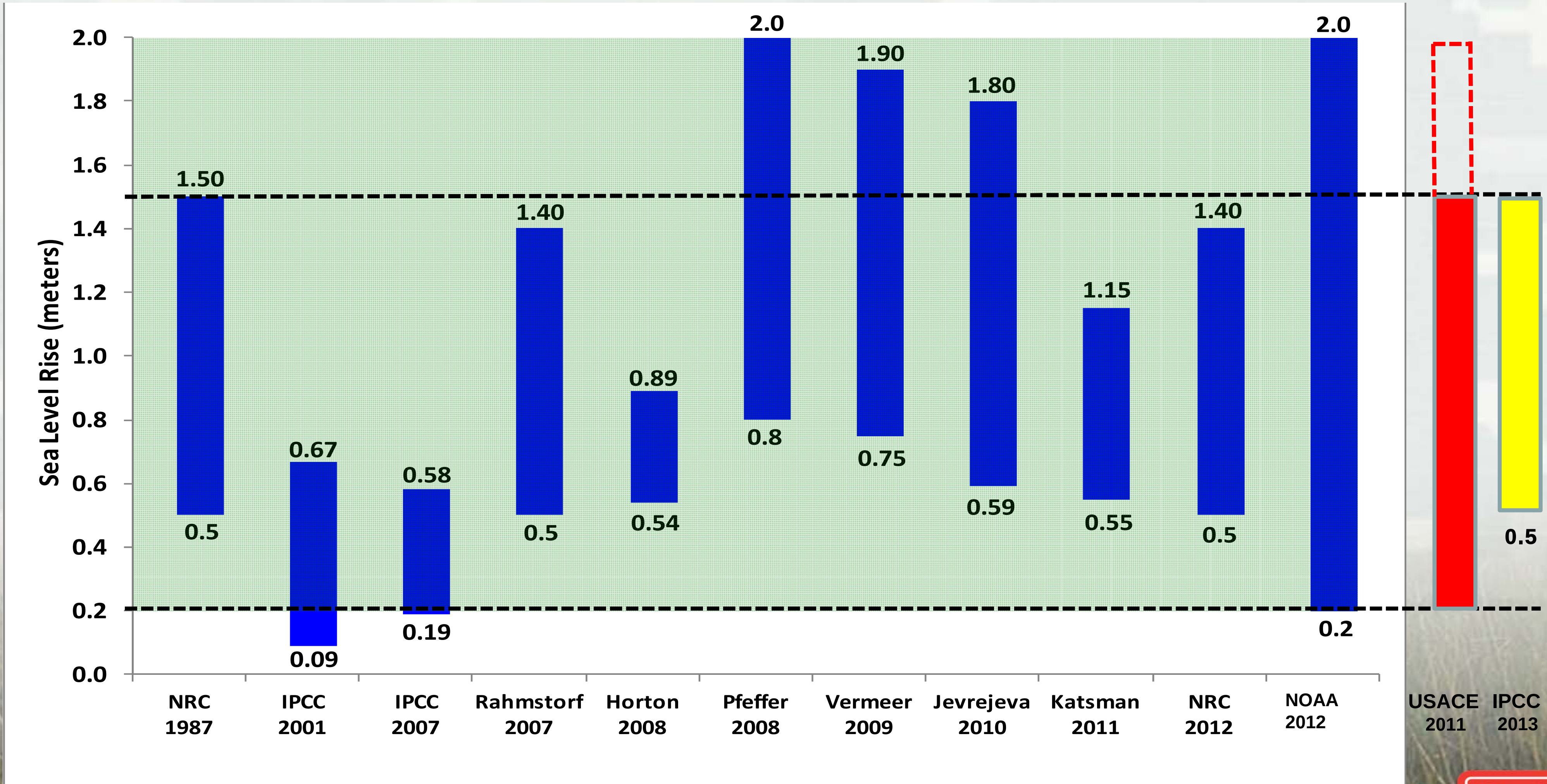
(SLR rate based on Fairbanks, 1989)

Past, present, and potential future <u>rates</u> of sea-level rise



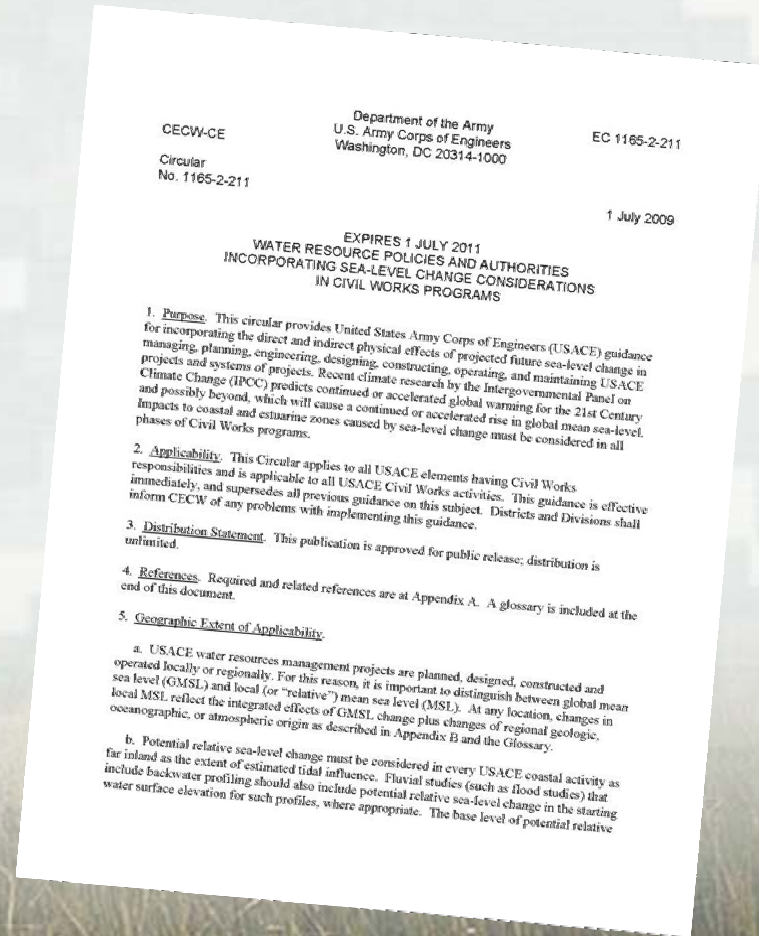
(Slide courtesy of Rob Thieler, USGS)

Estimates of Global Sea Level Change by 2100



USACE Guidance on Incorporating Sea Level Change Considerations

- EC 1165-2-212 was replaced with ER 1100-2-8162 on 31 Dec. 2013
- Permanent Design Requirement
- Applies to <u>all phases</u> of Corps Civil Works activities as far inland as extent of new tidal influence
- **ETL _____, *<u>Procedures To Evaluate Sea Level Change: Impacts, Responses and Adaptation</u>* effective 31 March 2014 to 31 March 2019 calls for analysis of 20, 50 and 100-year epochs**



CECW-CE
Circular
No. 1165-2-211

Department of the Army
U.S. Army Corps of Engineers
Washington, DC 20314-1000

EC 1165-2-211

1 July 2009

EXPIRES 1 JULY 2011
WATER RESOURCE POLICIES AND AUTHORITIES
INCORPORATING SEA-LEVEL CHANGE CONSIDERATIONS
IN CIVIL WORKS PROGRAMS

1. <u>Purpose</u>. This circular provides United States Army Corps of Engineers (USACE) guidance for incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects. Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. Impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs.

2. <u>Applicability</u>. This Circular applies to all USACE elements having Civil Works responsibilities and is applicable to all USACE Civil Works activities. This guidance is effective immediately, and supersedes all previous guidance on this subject. Districts and Divisions shall inform CECW of any problems with implementing this guidance.

3. <u>Distribution Statement</u>. This publication is approved for public release; distribution is unlimited.

4. <u>References</u>. Required and related references are at Appendix A. A glossary is included at the end of this document.

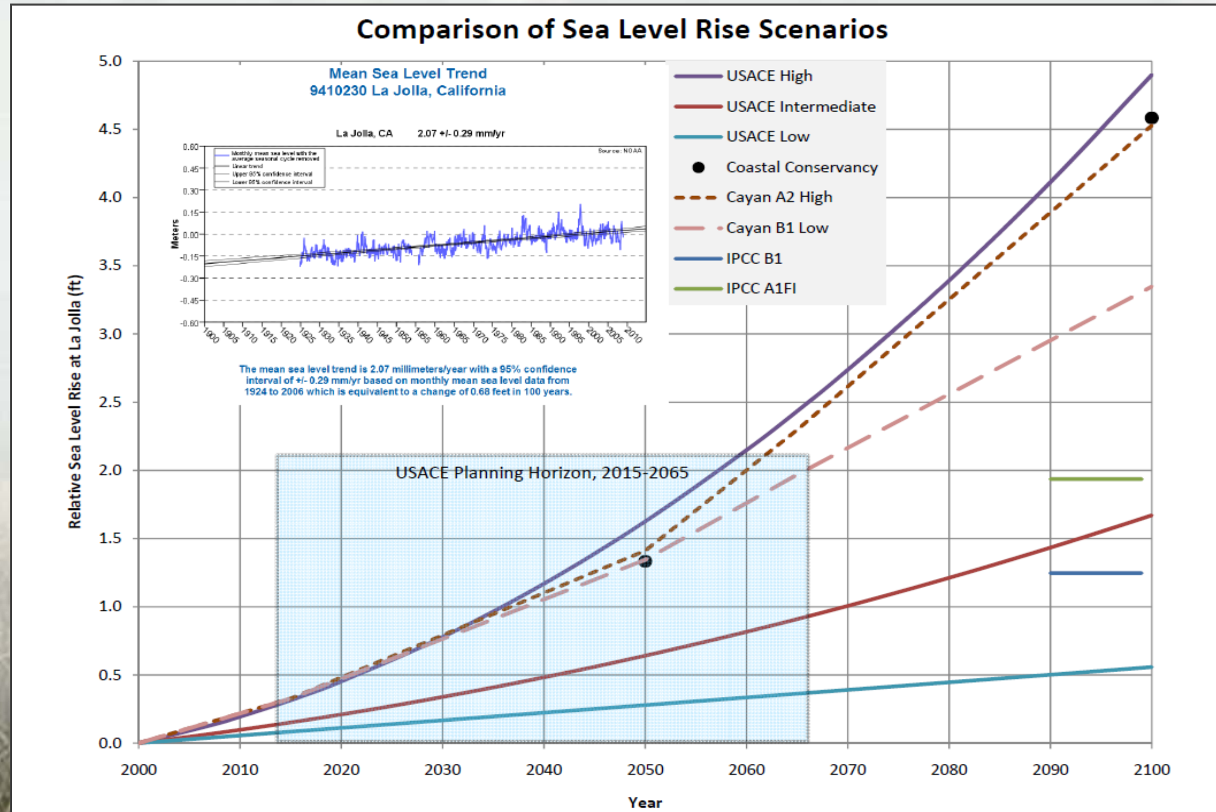
5. <u>Geographic Extent of Applicability</u>.

a. USACE water resources management projects are planned, designed, constructed and operated locally or regionally. For this reason, it is important to distinguish between global mean sea level (GMSL) and local (or "relative") mean sea level (MSL). At any location, changes in local MSL reflect the integrated effects of GMSL change plus changes of regional geologic, oceanographic, or atmospheric origin as described in Appendix B and the Glossary.

b. Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Fluvial studies (such as flood studies) that include backwater profiling should also include potential relative sea-level change in the starting water surface elevation for such profiles, where appropriate. The base level of potential relative

ER 1100-2-8162 Incorporating Sea Level Change Considerations in Civil Works Programs

- Three estimates of future SLC must be calculated for all Civil Works Projects within the extent of estimated tidal influence:
  - Extrapolated trend
  - Modified NRC Curve I
  - Modified NRC Curve III
- Requires creativity, funds to evaluate options



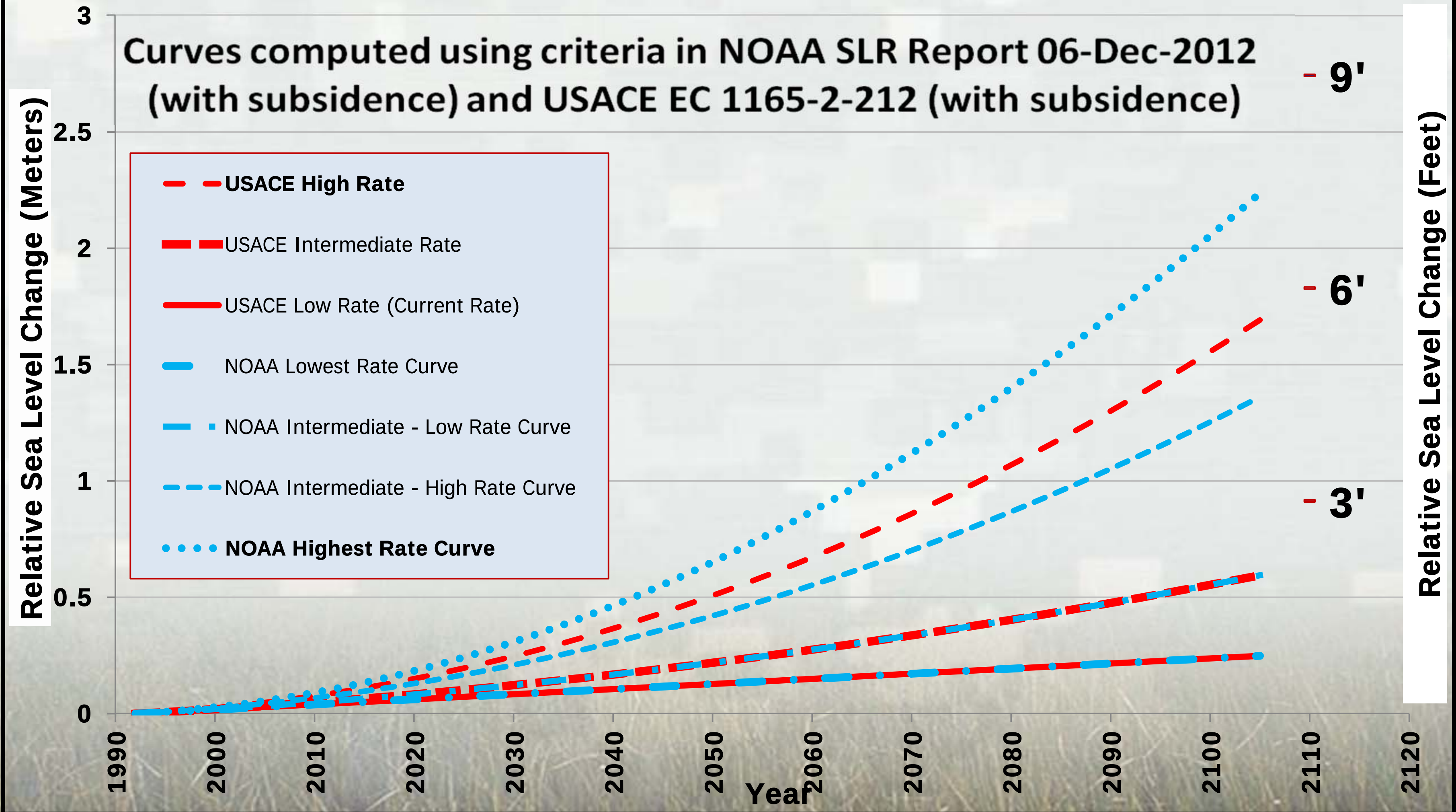
Florida Atlantic Coast
Historic Relative Sea Level Change

Relative Sea Level Change = Estimated Global Sea Level Trend (1.7 mm/yr) + local Vertical Land Motion

Reference: NOAA Technical Report NOS CO-OPS 065, *Estimating Vertical Land Motion from Long-Term Tide Gauge Records*, May 2013

Tide Station (# and Name)	mm/yr
8720030 Fernandina Beach (1897 to present)	2.30
8720218 Mayport	2.29
8721120 Daytona Beach *(Inactive)	2.32*
8723170 Miami Beach *(Inactive)	2.39*
8723970 Vaca Key **(<40 years)	2.90**
8724580 Key West (1913 to present)	2.20

Key West, FL: 2.20 (mm/yr)



Relative Sea Level Change Scenarios for Key West, FL (feet)

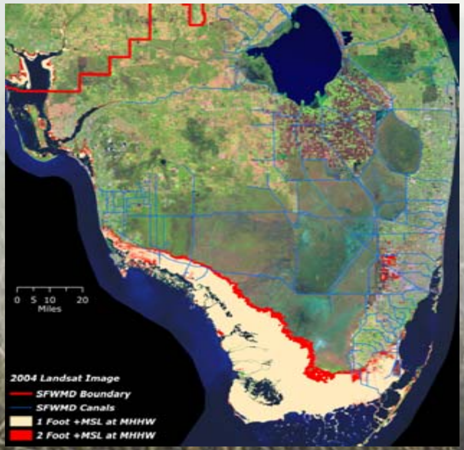
Year	USACE and NOAA Low	USACE Intermediate NOAA Int-Low (Mod. NRC Curve I)	NOAA Int-High	USACE High (Mod. NRC Curve III)	NOAA High
Scenario >	Continue Historic Relative SLC	Global SLC +0.5m by 2100	Global SLC +1.2m by 2100	Global SLC +1.5m by 2100	Global SLC +2.0m by 2100
1992	0.0	0.0	0.0	0.0	0.0
2010	0.1	0.2	0.2	0.3	0.3
2060	0.5	0.9	1.8	2.2	2.9
2100	0.8	1.8	4.1	5.1	6.7
2110	0.9	2.1	4.8	6.0	8.0
2120	0.9	2.4	5.6	7.0	9.3

Notes: USACE projections are for historic, modified NRC Curve I and modified NRC Curve III rates of sea level change developed for Key West, Florida per USACE Engineering Circular (EC) 1165-2-212. This EC is based on guidance in the National Research Council (NRC) report, *Responding to Changes in Sea Level; Engineering Implications* dated September, 1987. The projections are developed using the local historic rate of sea level rise at Key West as reported by NOAA (2.20 mm/yr). NOAA projections use the same EC equations modified for different global SLR scenarios. The USACE and NOAA guidance documents do not address dates beyond 2100. All projections start from 1992 control for the national survey datum.

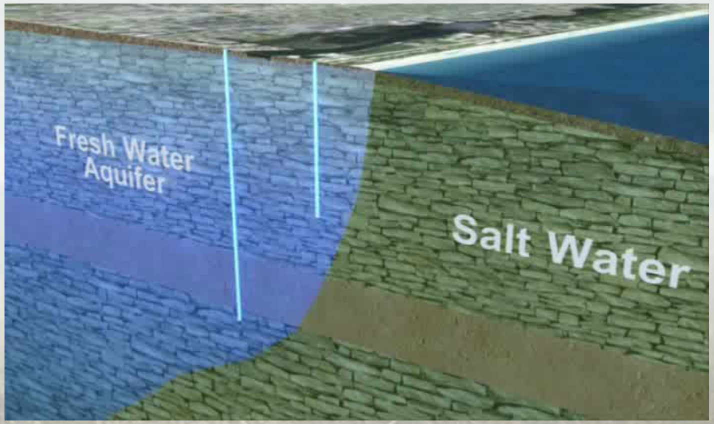
Sea Level Change Beyond 2100

- Anticipate accelerating SLC continuing well beyond 2100
- Very long term SLC may total 2.3m (7.5ft) for each degree Celsius in global warming. In geologic history, this may have taken a total of 1000 years. Impacts of modern high greenhouse gas levels?
- Protect existing built environment as long as economically feasible
- <u>Buildings AND developed land will depreciate</u> as SLR risks increase
- Develop "Exit strategies" to support timely <u>voluntary</u> actions
- Coastal ecosystems need suitable space for SLC adaptation
- <u>Prioritize long term risk reduction.</u> Shift from projects "optimized" for static future conditions to "robust and adaptable systems"

SLR Concerns in Florida

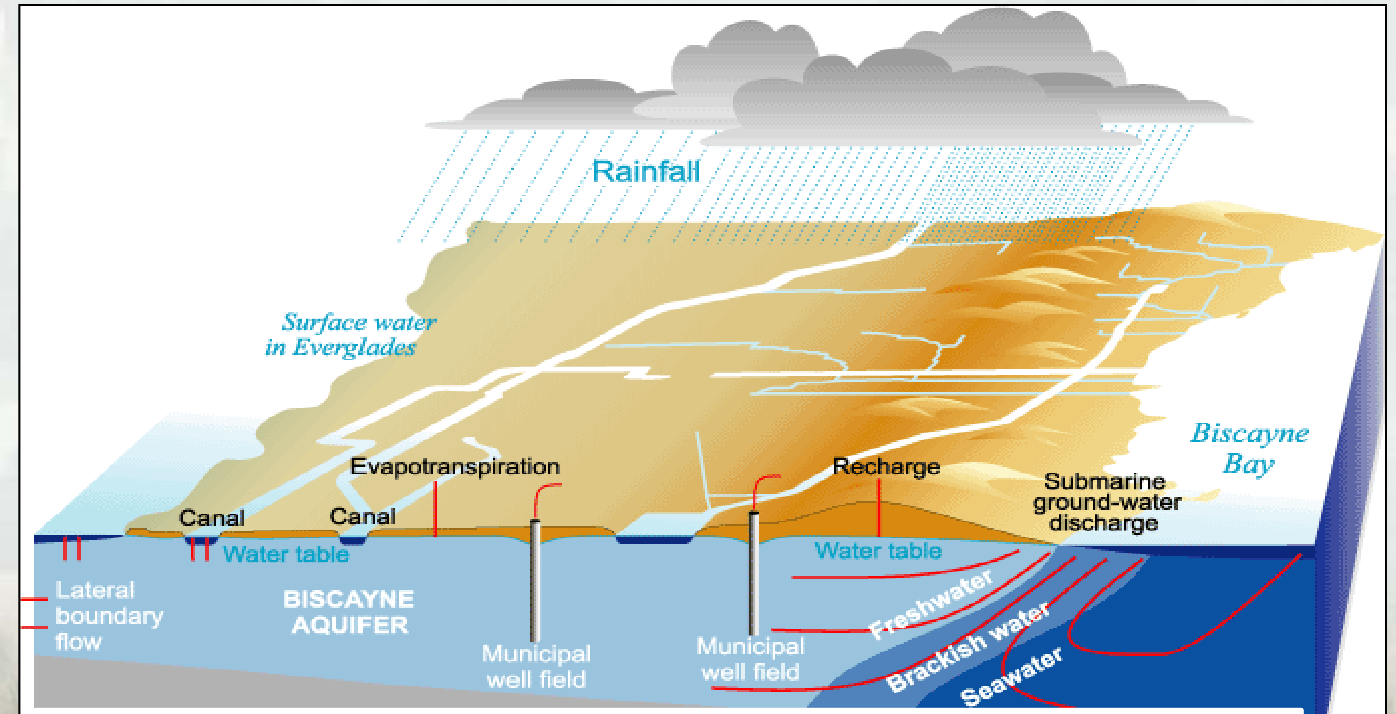


- Direct Impacts
  (SLR + waves or storm surge)
- Flood Drainage
  (increased frequency, depth and/or duration of interior areas flooding)
- Water Supply
  (**saltwater intrusion**)
- Natural System
  (coastal ecosystems and **rapid peat loss**)



(SFWMD, 2011)
(FAU, 2008)

Flood Risk vs Water Supply Concerns

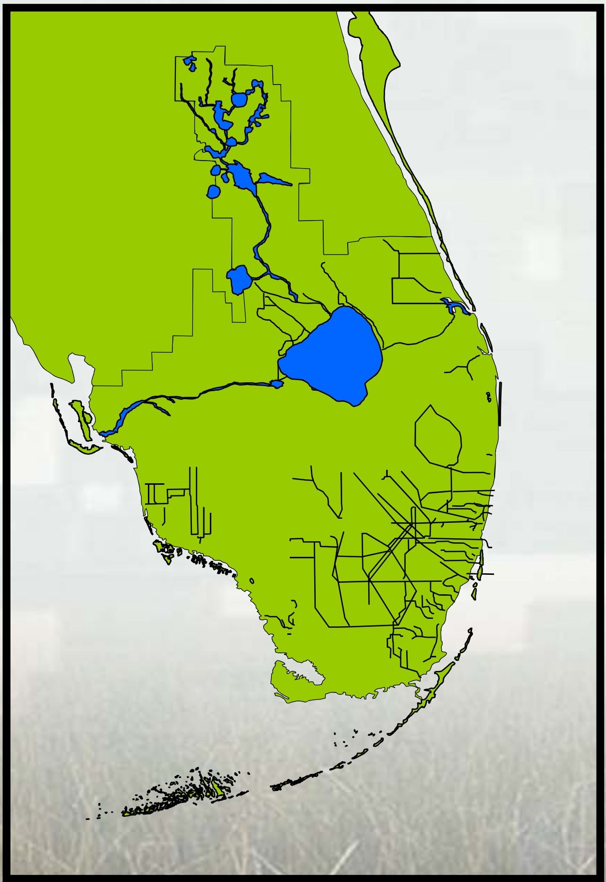


Conceptual diagram of hydrologic system of south Florida (Langevin, USGS, 2000)

- **Shallow wells are the primary source of drinking water in South Florida communities**
- **Continued sea level rise will cause saltwater intrusion into wells and create a need for new freshwater sources**
- **--- OR ---**
- **Protecting water supply wells with higher canal stages will increase flooding in many low elevation communities**

Water Supply Concerns

Kissimmee River Basin and Lake Okeechobee

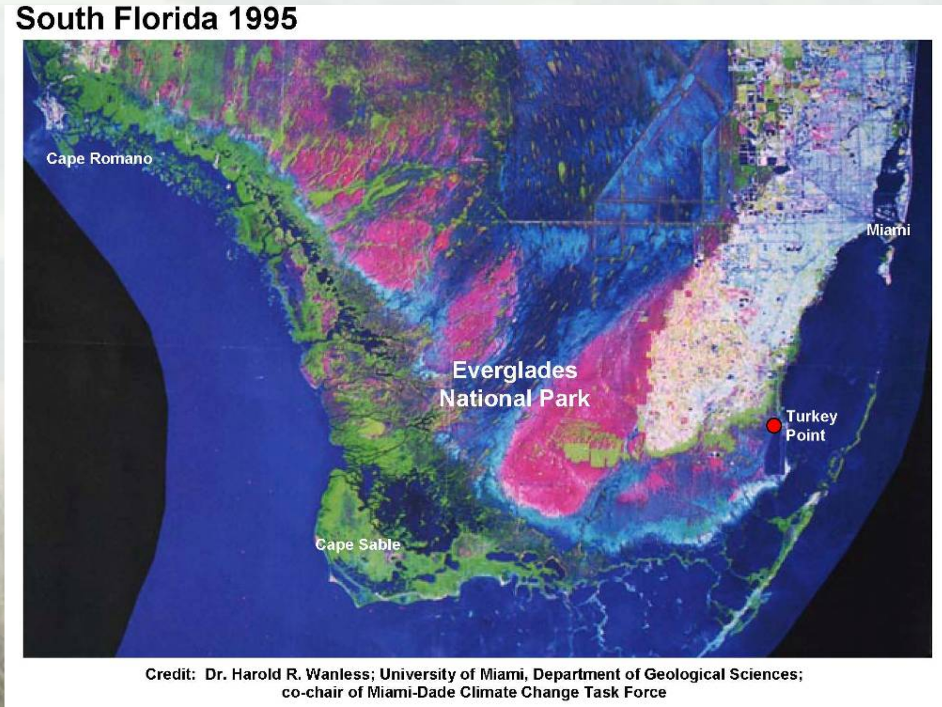


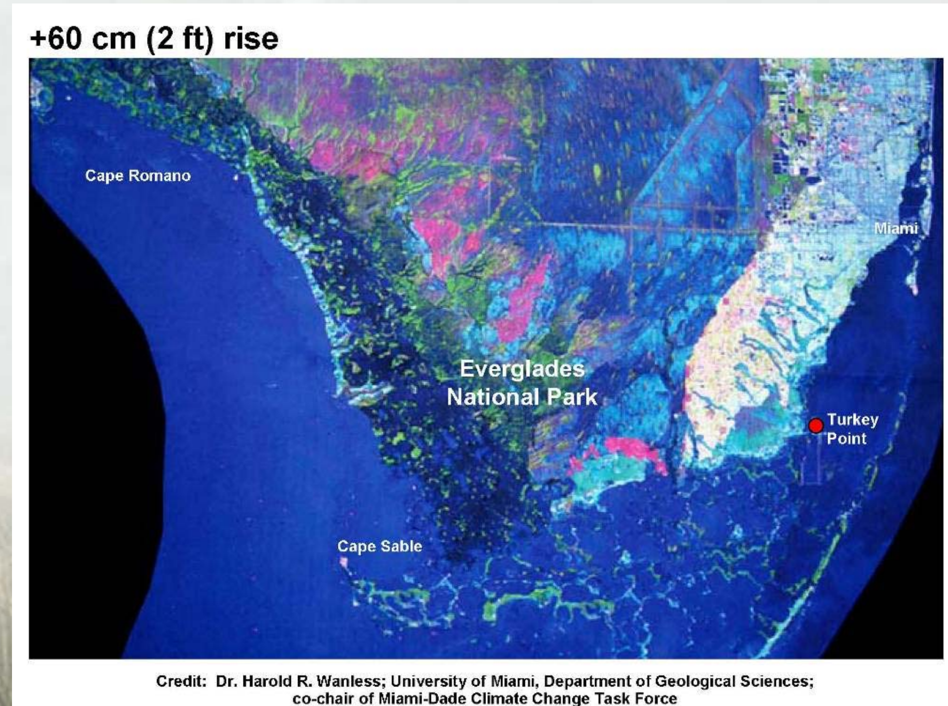
Lake Okeechobee Drought

- **Potential saltwater intrusion into coastal water supply wells, plus climate change impacts on rainfall patterns and evaporation will increase water supply demands and water storage needs**

Sea Level Rise in South Florida

- A little less than 1 foot during the past century measured at Key West
- A 2 foot rise would have significant effects

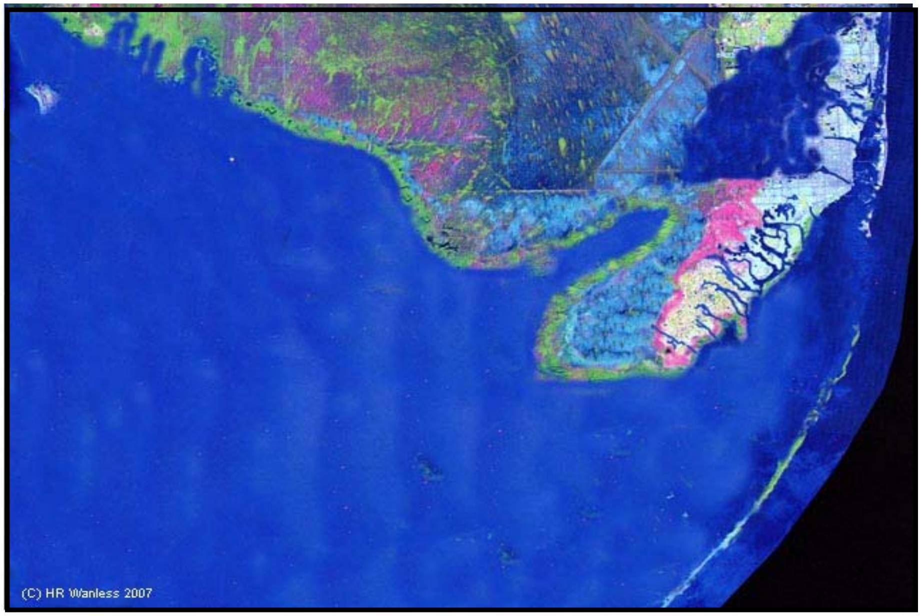




Sea Level Rise in South Florida

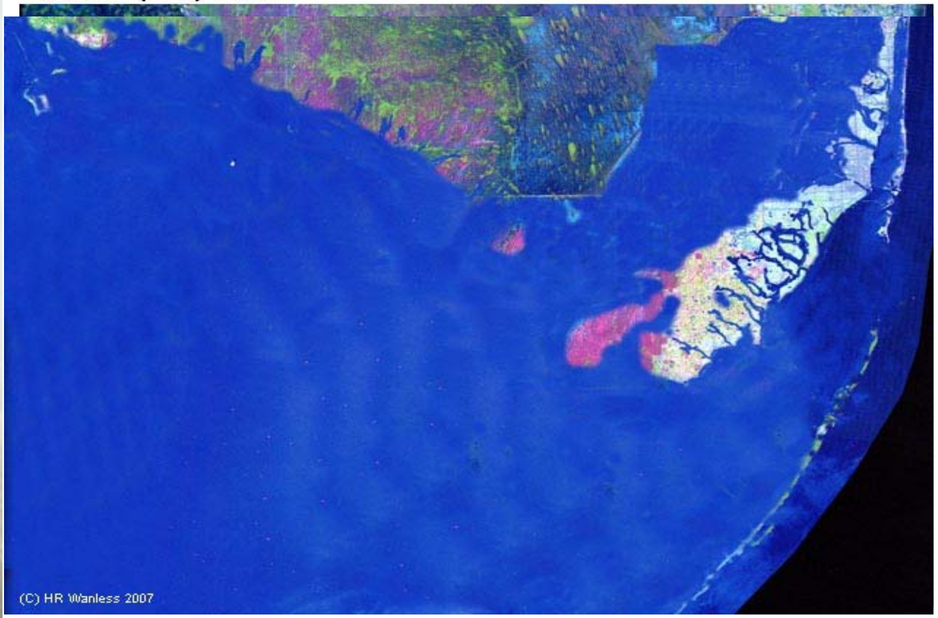
- A little less than 1 foot during the past century measured at Key West
- A 4-5 foot rise would have dramatic impacts

MHHW +120 cm (4 ft) rise

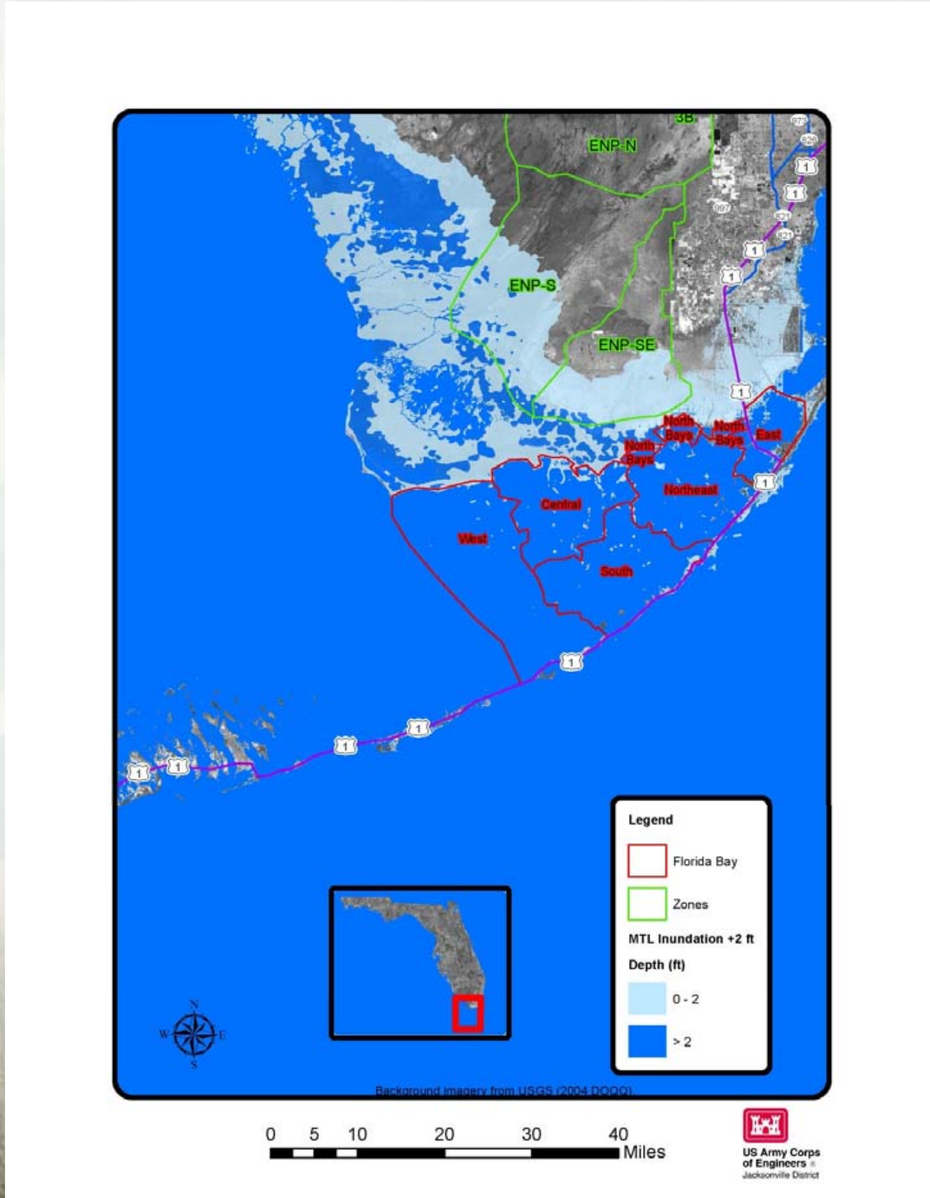


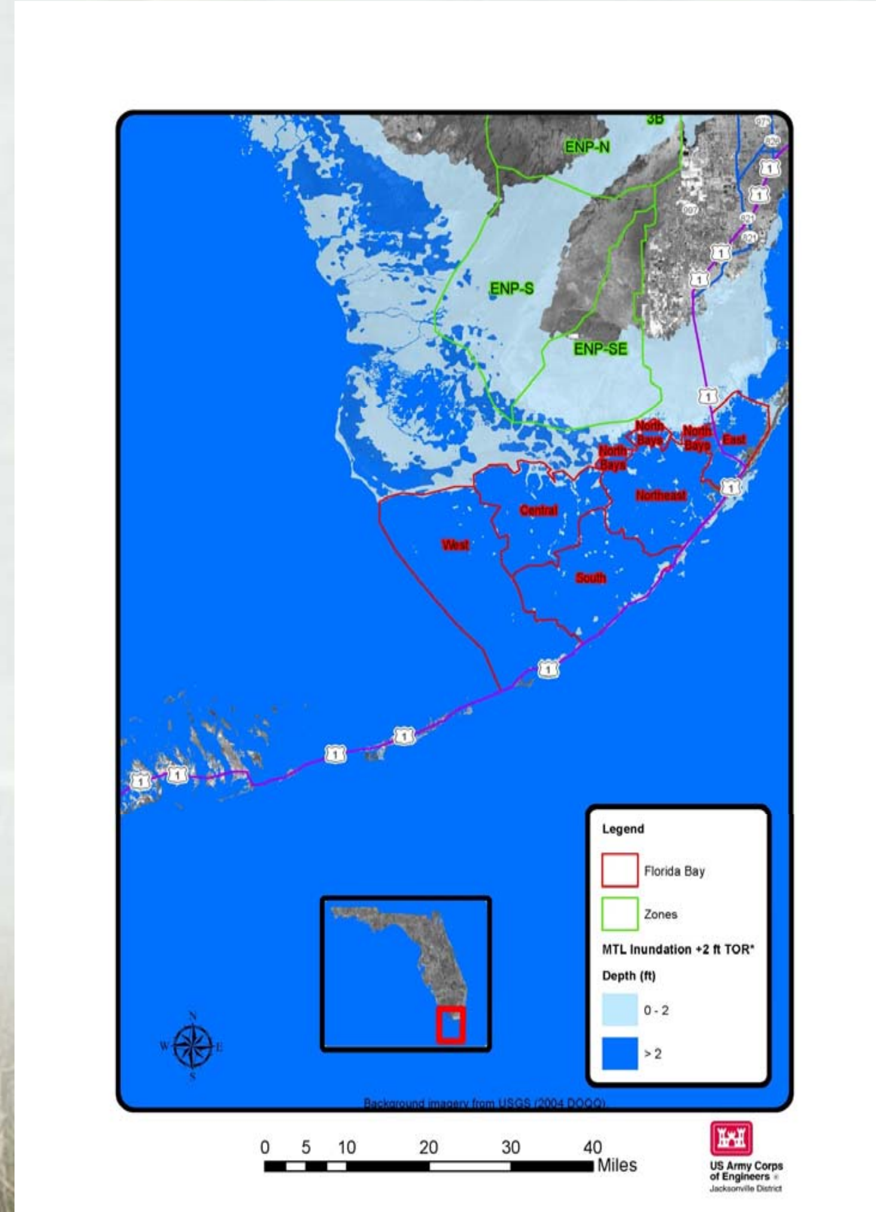
Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force

MHHW +150 cm (5 ft) rise



Credit: Dr. Harold R. Wanless; University of Miami, Department of Geological Sciences; co-chair of Miami-Dade Climate Change Task Force





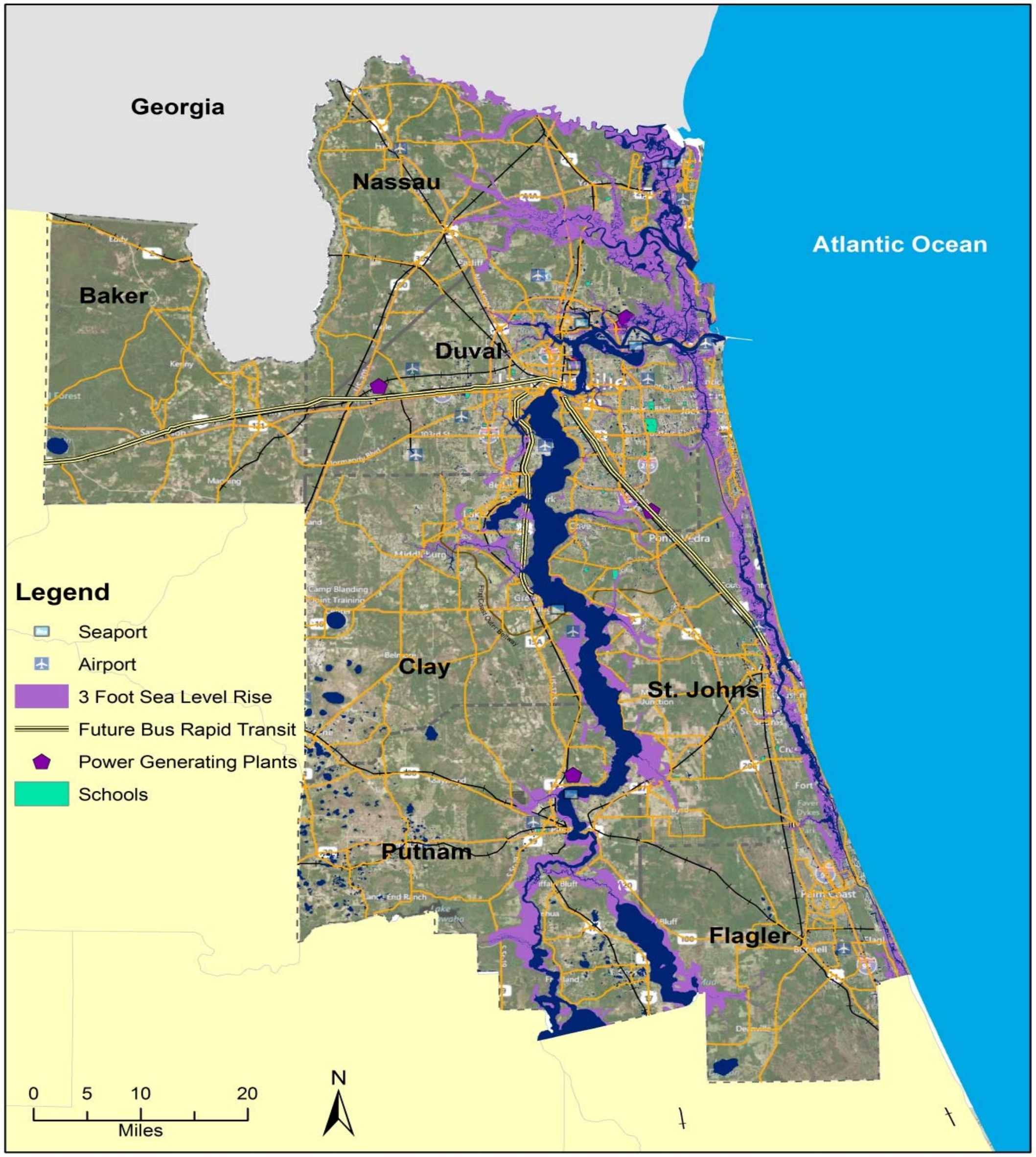
GIS projections of 2 ft of SLR over Everglades topography with / without Peat Soils

Northeast Florida Sea Level Rise - 1 Foot Rise

Credit: Northeast Florida Regional Council

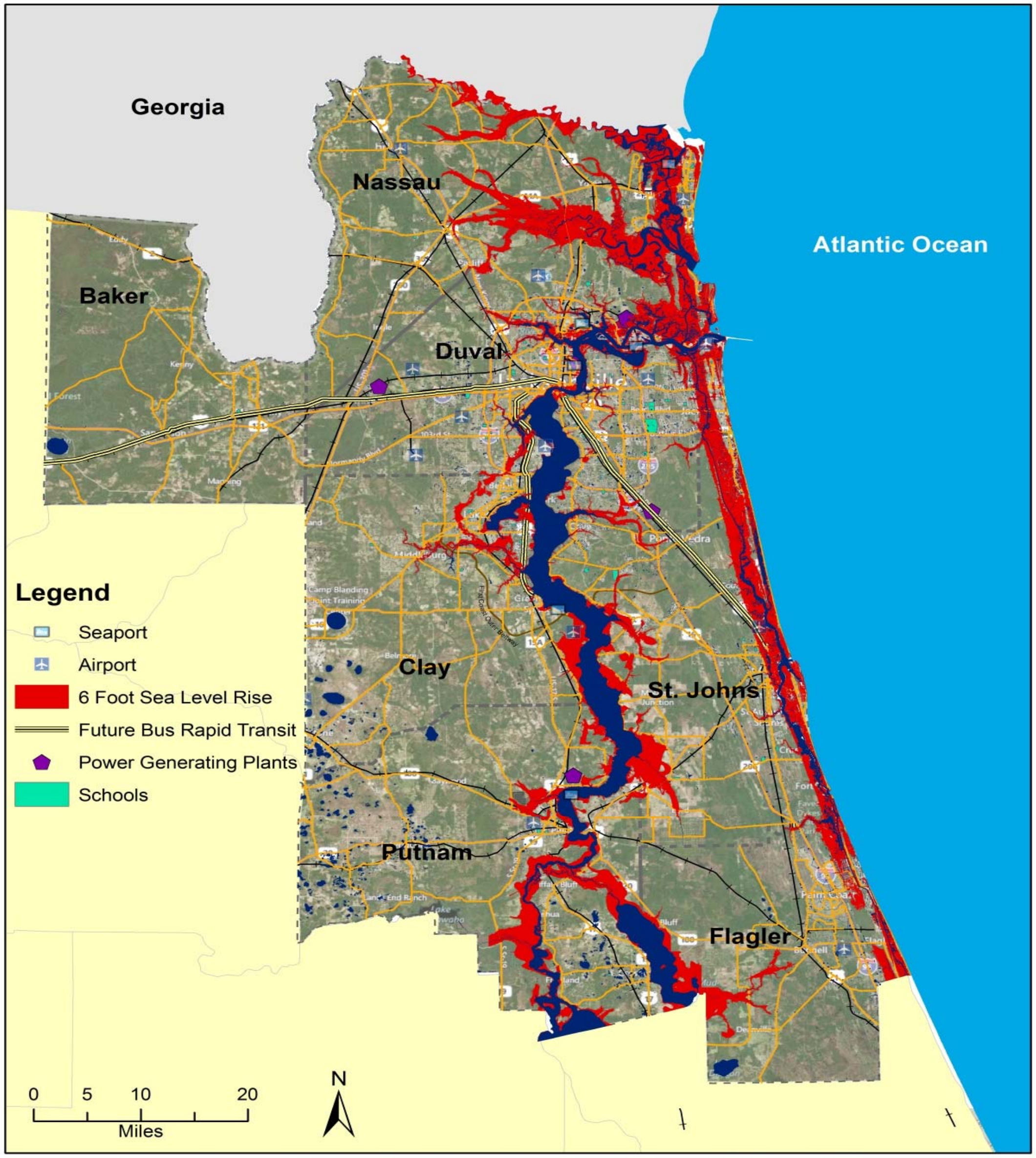
Sea Level Rise in St. Johns River

- Increases Flood Risks
- Increases Salinity in River and adjacent groundwater
- Decreases surface storage of freshwater



Northeast Florida Sea Level Rise - 3 Foot

Credit: Northeast Florida Regional Council



Northeast Florida Sea Level Rise - 6 Foot Rise

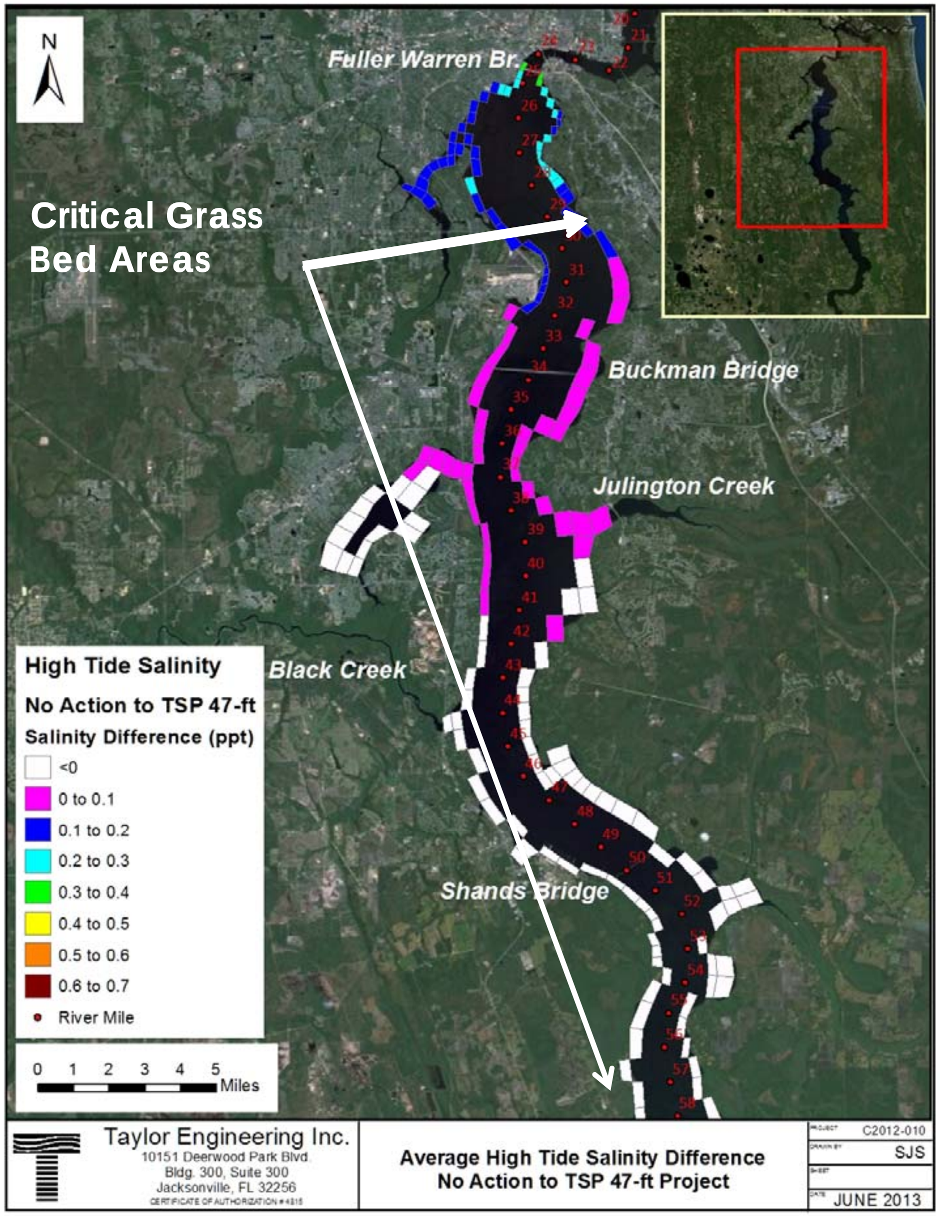
Credit: Northeast Florida Regional Council

Changes to Salinity

- Hydrodynamic modeling predicts “small” increases in salinity levels within the St. Johns River main stem
- Small in comparison to other factors that can influence salinity such as drought, ocean level, sea level rise, etc.
- Tributary modeling is still ongoing, but effects are expected to be commensurate with findings in the mainstem.

Example, at Buckman Bridge, (Mile 34)

- Without-project average salinity = 2.0 ppt
- With-project average salinity increase < 0.1 ppt
- Extreme dry year (2011) average salinity = 7.3 ppt



	Time - Days			
Salinity	1	7	30	90
25			Extreme Stress	
15	Low Stress		Moderate Stress	
10			Low Stress	
5		No Effect		Low Stress
3			No Effect	

Increasing Flood Risks from Long Term Sea Level Change

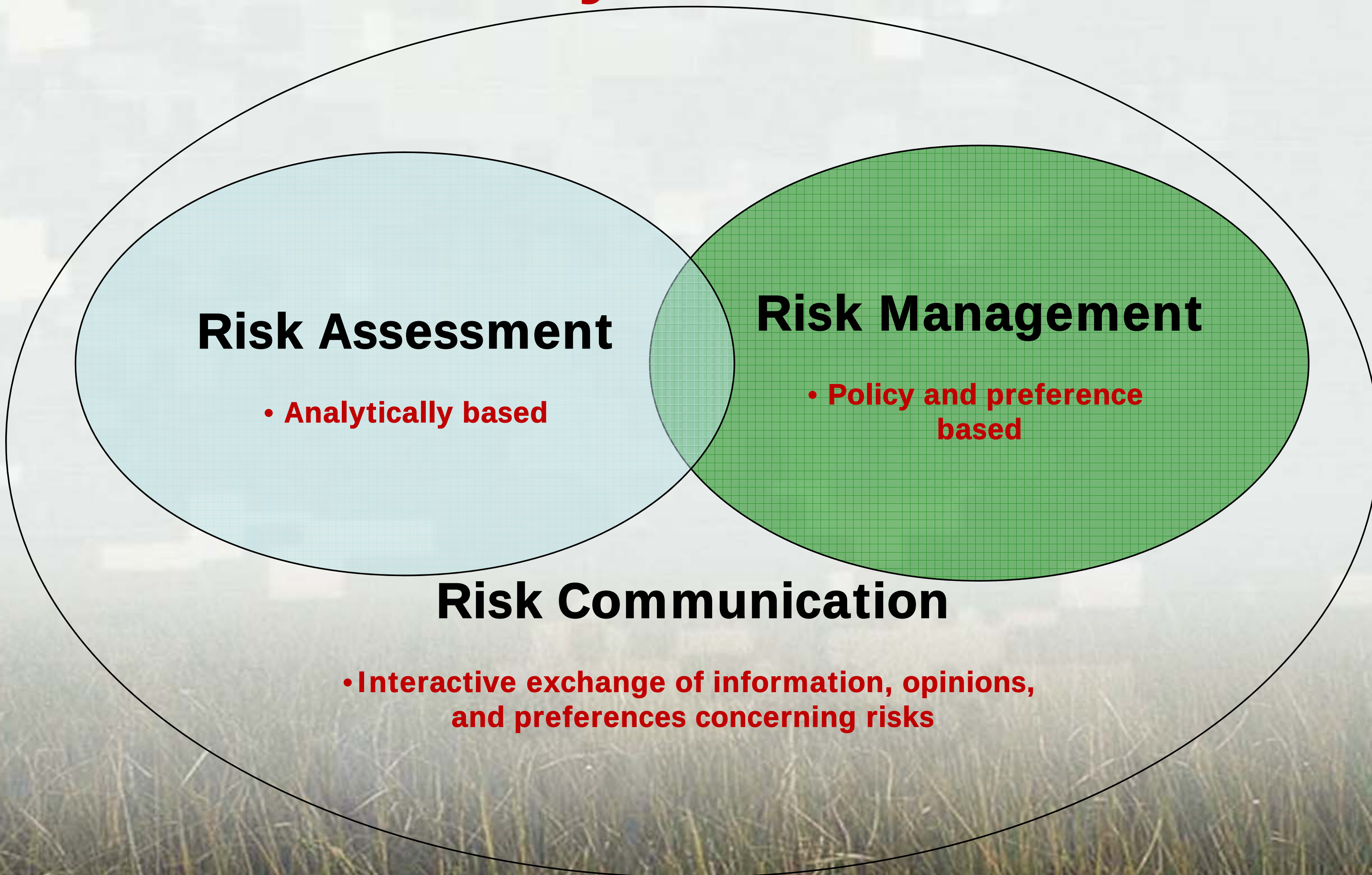
These estimates were created using the existing min/max elevations found in the county DEM data. All percentages are for full county area, including natural areas and parks.

County:	Percent below elevation 5ft:	Percent below elevation 10ft:	Percent below elevation 20ft:	Percent below elevation 30ft:
Dade	61	97	99+	99+
Brevard	17	26	64	96
Duval	15	27	51	67

Risk

- Risk is a measure of the probability and consequence of uncertain future events
- Risk includes
  - Potential for gain (opportunities)
  - Exposure to losses (hazards)

Risk Analysis in Three Tasks



United Kingdom Climate Adaptation Approaches: Precautionary versus managed adaptive

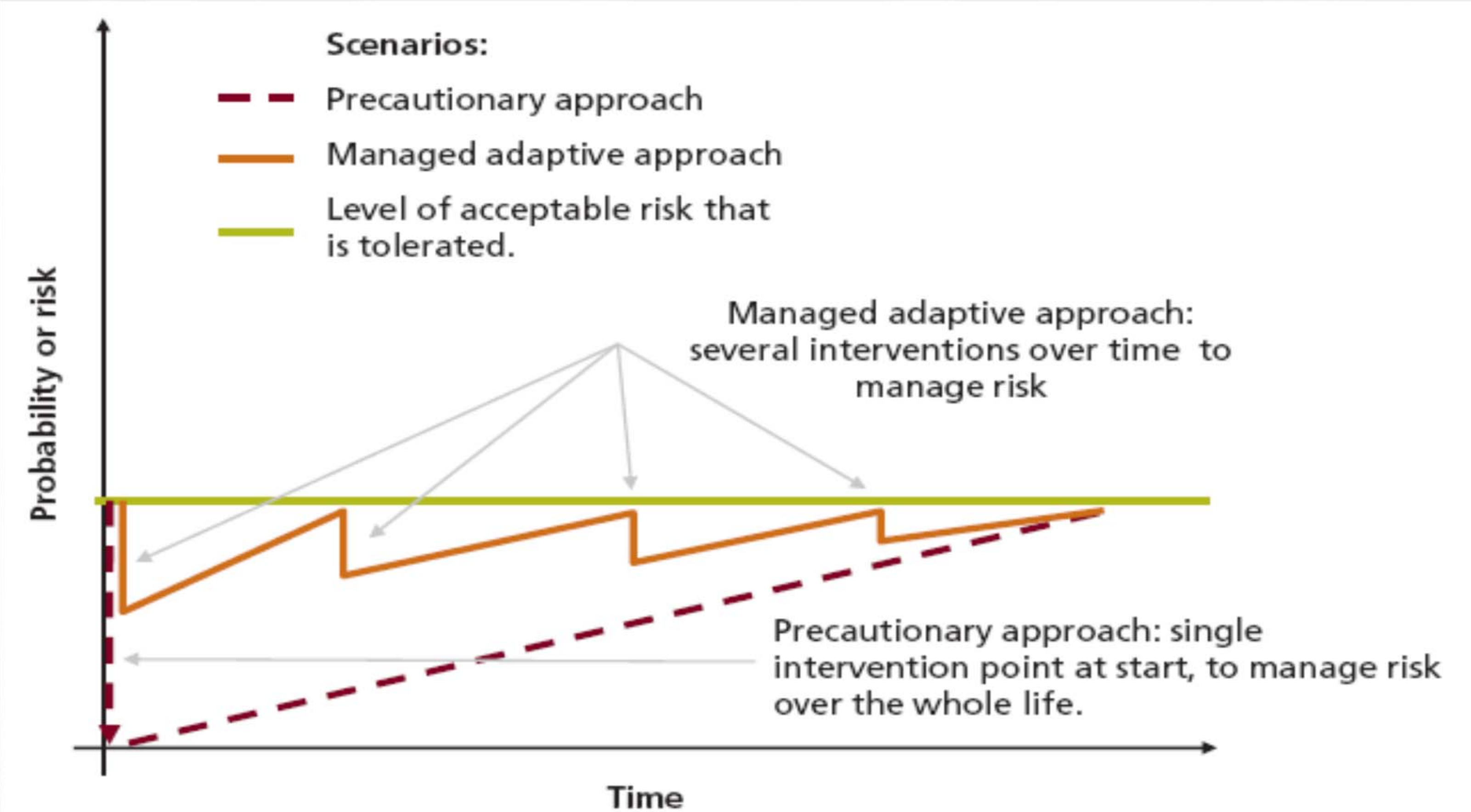


Figure courtesy of Jonathan Simm, HR Wallingford, UK

Risk Management Decision

- Sustainable
- Robust – performs well under wide range of future conditions
- Cost-risk trade-offs
  - Regret-based approach
  - If cost-cost trade-off, no firm rule
  - If trade-off of cost vs. safety, precautionary with respect to safety risk, <u>minimize worst-case outcome</u>

Systems Approach to Adaptation

- Two problems: short AND long term (100 yr++) risk reduction
- Recognize need for interagency collaboration and shared planning
- Address the combined needs of human and natural systems
- Prioritize long term risk reduction. Shift from projects "optimized" for static future conditions to "robust and adaptable systems"
- Encourage Public Investment in "Framework" Infrastructure in low risk areas (water supply, major roads, flood risk reduction, power, sewer, etc.).
- Provide Incentives for Private Development in low risk areas
- Hurricanes and other disasters are opportunities to redevelop in lower risk areas. Implement pre-storm relocation agreements.

Florida Sea Level Rise Concerns
Take Away Points

- USACE SLR projections are based on guidance from the National Research Council, are site specific and include local uplift or subsidence. Does not address wave and storm surge frequency.
- **SLR PERMANENTLY increases coastal flood frequency**
- Leading Indicators of Sea Level Rise, such as the reduction in polar ice caps, and the recent rapid increases in the rate of glacier melting worldwide forecast significant SLR rate increases
- **Long Term Sea Level Rise Adaptation Strategies** are needed at project, community, watershed, and national scales
- **USACE Watershed Planning Authority** – With local support, might be an option for coordinated interagency regional SLR adaptation planning. Cost share up to 75/25 federal/local.

Ideas for Discussion

- Focus on short AND long term (100 yr+) risk reduction
- Recognize many buildings are remodeled or rebuilt after 50 years
- Shift planning from projects "optimized" for static future conditions to "robust and adaptable systems" that support long term risk reduction plans
- Establish unified sea level rise scenarios for watersheds or other broad areas for coordinated planning purposes
- Remember how the Interstate Highway System changed city development patterns. Build "Framework" Infrastructure (major roads, power, water, sewer, etc.) in low risk areas and strongly encourage private development in these areas.
- Hurricanes and other disasters are opportunities to redevelop in low risk areas. Implement pre-storm relocation agreements.

Thank you!

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