U.S. Army Corps of Engineers Design Considerations for Climate Preparedness and Resilience

City of Jacksonville Committee for

Storm Resilience and Infrastructure Development

March 29, 2019

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Planning and Policy Division

U.S. Army Corps of Engineers, Jacksonville District

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Presentation Outline

- USACE Guidance and Tools for Climate Preparedness and Resilience
- Other Information Sources related to Climate Preparedness and Resilience
- Sea Level Change (SLC) through Geologic Time
- Climate Change Concerns for Florida
- Florida SLC concerns and examples
- Risk Informed Planning and Decision Making
- Discussion

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USACE Mission Areas

Navigation
- Breakwaters and Jetties
- Harbors
- Navigation Channels and Ocean Disposal Sites

Hydropower

Reservoir Regulation; Water Supply

Coastal Storm Damage Reduction
- Beach fills
- Shoreline protection structures

Flood Damage Reduction
- Dams, levees, floodwalls

Ecosystem Restoration

Emergency Response

Recreation

Regulatory

Climate change has the potential to impact all USACE mission areas

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USACE Guidance and Tools Related to Climate Preparedness and Resilience

- ER 1100-2-8162, Incorporating Sea Level Changes in Civil Works Programs, 31 Dec 2013.
- ECB 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, 10 Sep 2018 to 10 Sep 2020.
- ETL 1100-2-1, Procedures to Evaluate Sea Level Change Impacts, Responses, and Adaptation, 30 June 2014 to 30 March 2019.
- ETL 1100-2-3, Detection of Nonstationarities in Annual Maximum Discharges, 28 April 2017 to 27 April 2021.
- Tool: Sea Level Change Calculator, http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html
- Tool: Sea Level Tracker, http://ec2-34-205-128-255.compute-1.amazonaws.com:8080/slr_app/

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Other Information Sources related to Climate Preparedness and Resilience

- Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report web site, http://www.ipcc.ch/report/ar5/
- National Climate Assessment 4 (NCA4), vol. I: *Climate Science Special Report,* Nov 3, 2017: https://science2017.globalchange.gov
- National Climate Assessment 4 (NCA4), vol. II: *Our Changing Climate,* Nov 2018: https://science2018.globalchange.gov
- Responses to Climate Change (RCC) web site – Provides up-to-date information on USACE climate change adaptation activities, http://www.corpsclimate.us/
- NOAA Hydrometeorological Design Studies Center – Precipitation Frequency Estimates, https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html

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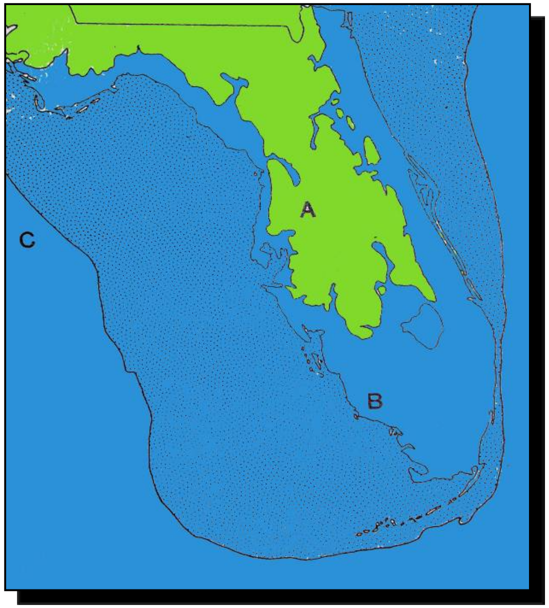
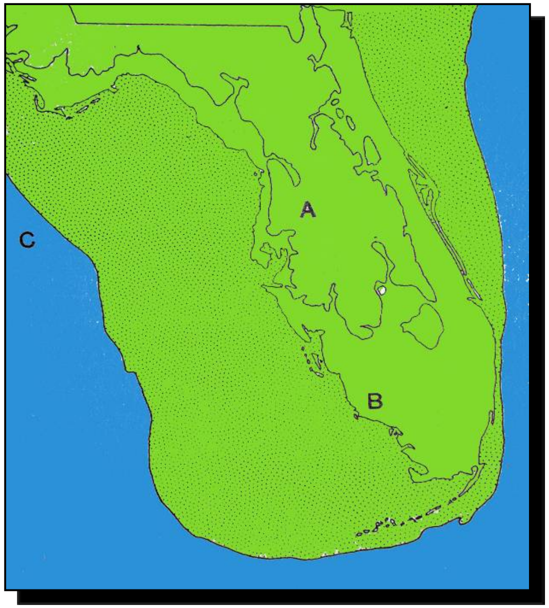
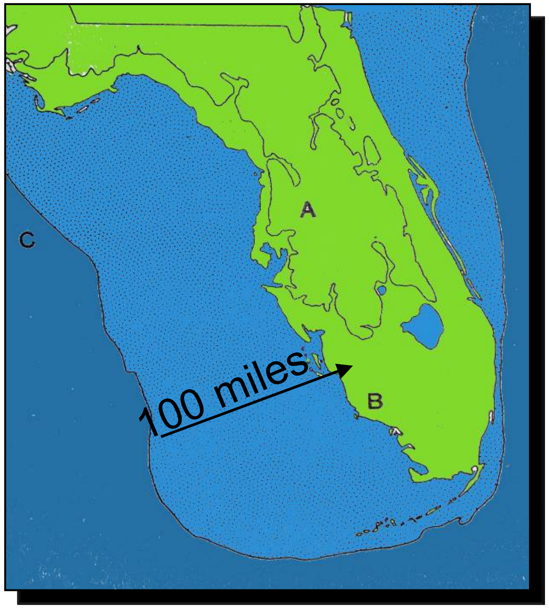
FLORIDA THROUGH TIME – SEA LEVEL CHANGE HAPPENS!



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



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



Today

*~ ½ from Greenland
*~ ½ from Antarctica

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

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Climate Change Concerns for Florida

- **Warmer Temperatures**
  - Evaporation losses up; water supply down?
  - Stresses on humans, plants, animals, upland and marine ecosystems
  - Changes in growing season, plant ranges and migratory patterns
  - Changes in water quality – lower dissolved oxygen, more acidic
- **NCA 2018** states average annual U.S. temperatures are 1.8^{o}F higher than in 1900, and forecast to increase about 2.5^{o}F more in the coming decades regardless of emissions scenarios. By 2100, average annual U.S. temps are forecast to be 3-12^{o}F higher. Oceans are believed to have absorbed 93% of excess heat since the mid-20th century and more than 25% of excess carbon dioxide.
- **Hydrologic Pattern Changes**
  - Potential for less frequent and more intense rain events
  - Potential increased tropical storm intensity or frequency
- **NCA 2018** indicates that daily (24-hr) rainfall totals for 20-year (return interval) events are expected to increase 9-12% by around mid-century (2050), and 13-21% by late 21st century.

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
  - Rising groundwater levels impact crop roots, roads and septic tanks

- **NCA 2018** indicates that, relative to year 2000, sea level is very likely to rise 1 to 4 feet by the end of the century (2100). Emerging science regarding Antarctic ice sheet stability suggests that, for higher emissions scenarios, a rise exceeding 8 feet by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed.

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RELATIVE SEA LEVEL CHANGE SCENARIOS FOR MAYPORT, FL (FEET)

Year	USACE and NOAA 2012 Low	USACE Intermediate NOAA 2012 Int-Low (Mod. NRC Curve I)	NOAA 2012 Int-High	USACE High (Mod. NRC Curve III)	NOAA 2012 High	NOAA 2017 Extreme 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	Global SLC +2.5m by 2100
1992	0.00	0.00	0.00	0.00	0.00	0.00
2020	0.22	0.29	0.45	0.51	0.62	0.79
2060	0.54	0.95	1.86	2.25	2.90	4.13
2100	0.85	1.89	4.18	5.18	6.81	10.50
2110	0.93	2.17	4.91	6.09	8.04	
2120	1.01	2.47	5.69	7.08	9.38	14.47

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 Regulation (ER) 1100-2-8162, dated 31 Dec 2013. This ER 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 2012 projections use the same ER equations modified for different global SLR scenarios. USACE guidance documents do not address SLR dates beyond 2100. All projections start from 1992 control for the national survey datum. NOAA Technical Report in Jan. 2017 recommended more scenarios, all starting in year 2000, and a global sea level change extreme scenario of +2.5m by 2100.

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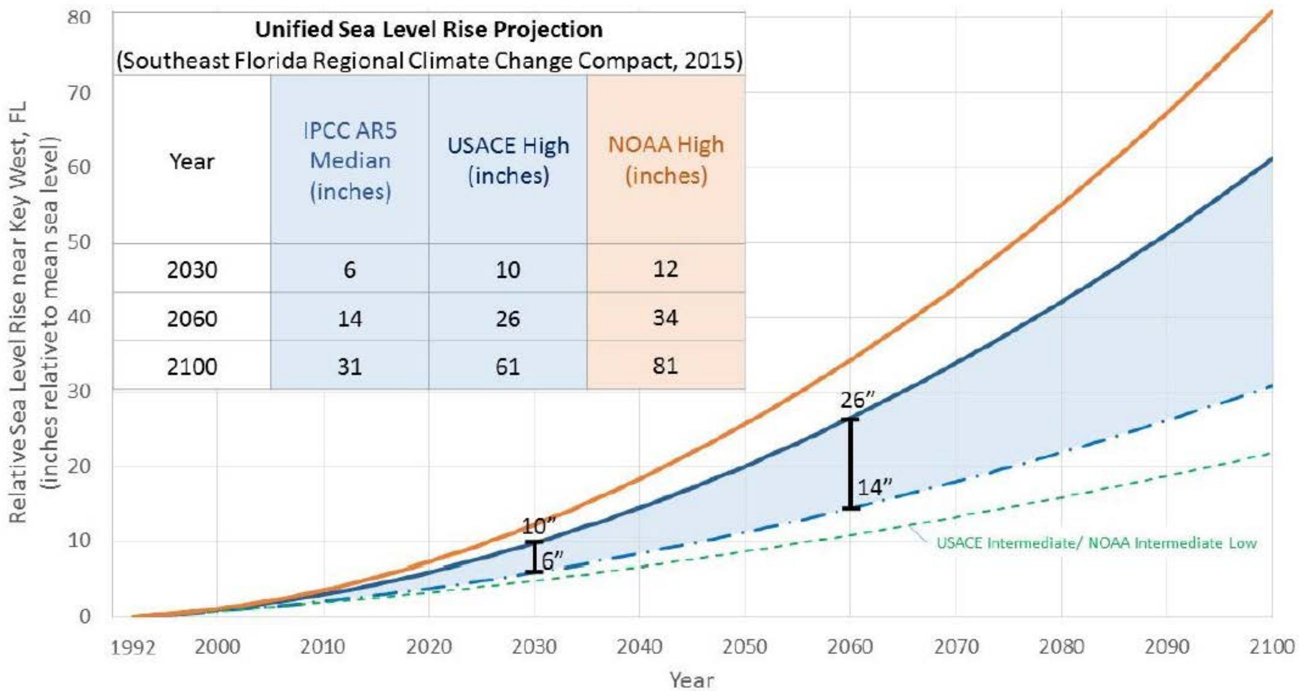
UNIFIED SEA LEVEL RISE PROJECTION

SE FL REGIONAL CLIMATE CHANGE COMPACT, 2015



Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81

Figure 1: Unified Sea Level Rise Projection. These projections are referenced to mean sea level at the Key West tide gauge. The projection includes three global curves adapted for regional application: the median of the IPCC AR5 RCP8.5 scenario as the lowest boundary (blue dashed curve), the USACE High curve as the upper boundary for the short term for use until 2060 (solid blue line), and the NOAA High curve as the uppermost boundary for medium and long term use (orange solid curve). The incorporated table lists the projection values at years 2030, 2060 and 2100. The USACE Intermediate or NOAA Intermediate Low curve is displayed on the figure for reference (green dashed curve). This scenario would require significant reductions in greenhouse gas emissions in order to be plausible and does not reflect current emissions trends.

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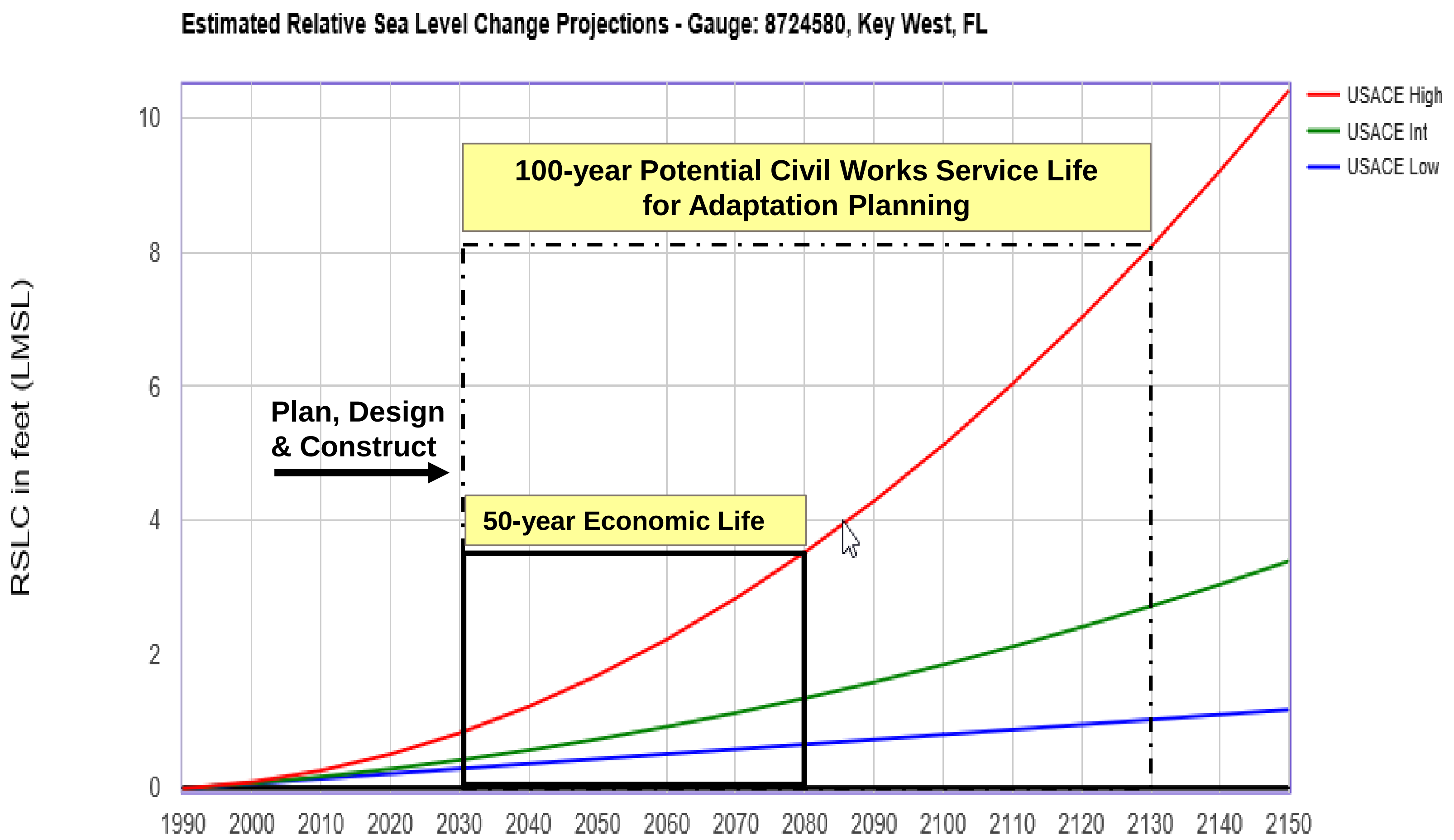
USACE SEA LEVEL CHANGE PROJECTION

KEY WEST, FL



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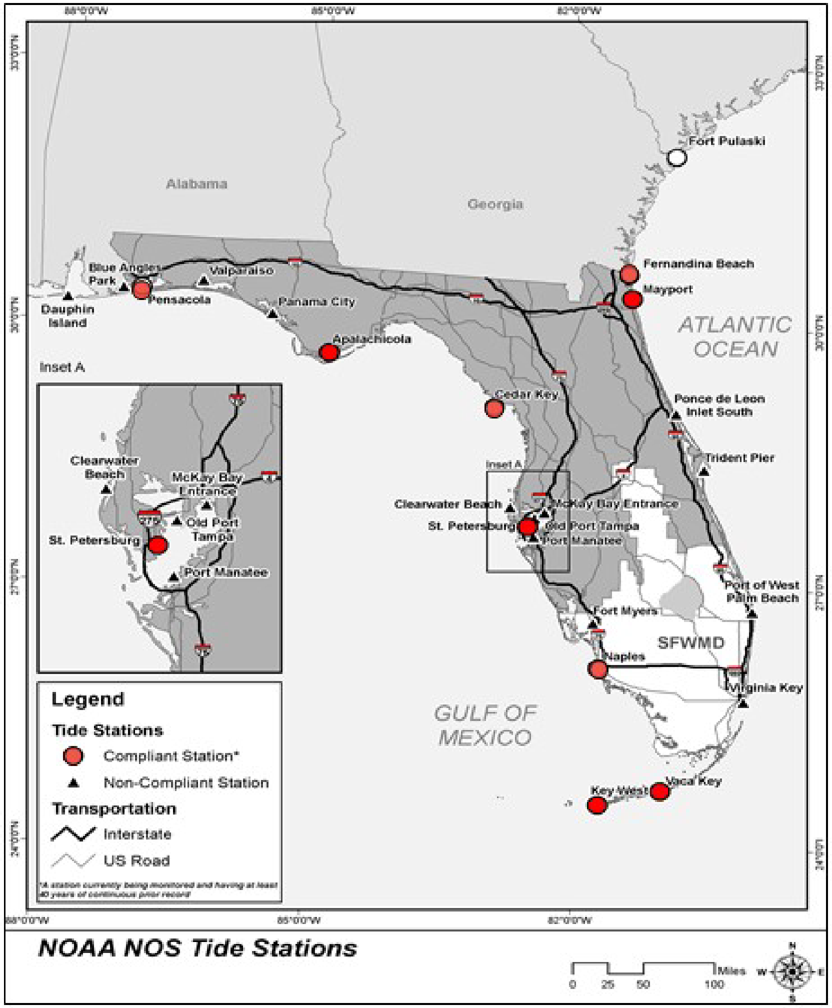
NOAA TIDE STATIONS IN FLORIDA

COMPLIANT STATIONS HAVE A CONTINUOUS 40-YEAR OR LONGER DATA RECORD FOR USE IN CALCULATING USACE AND NOAA SEA LEVEL CHANGE PROJECTIONS.



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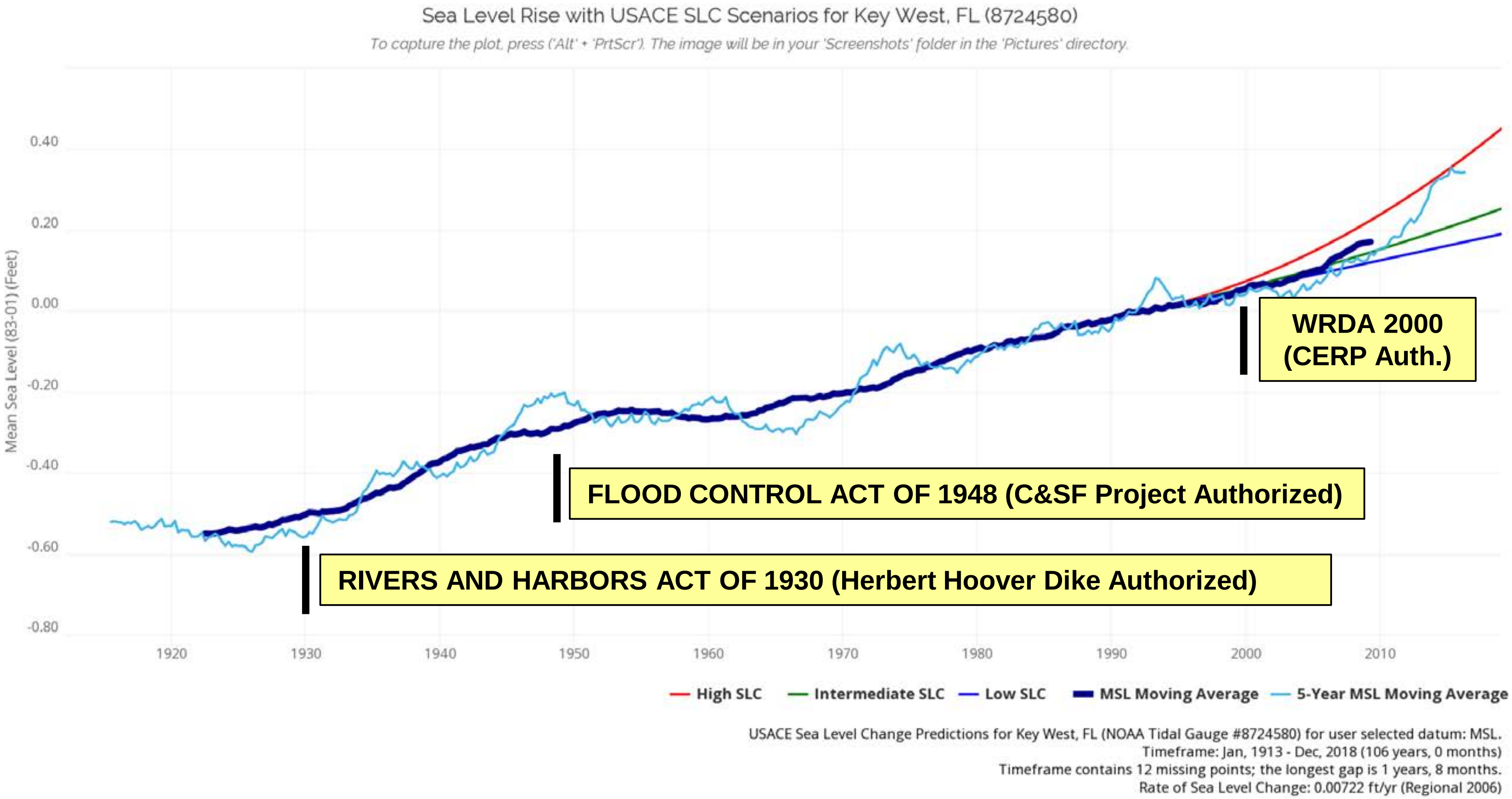
ACCELERATING SEA LEVEL CHANGE
105-YEARS JAN 1913 TO DEC 2018, KEY WEST, FL



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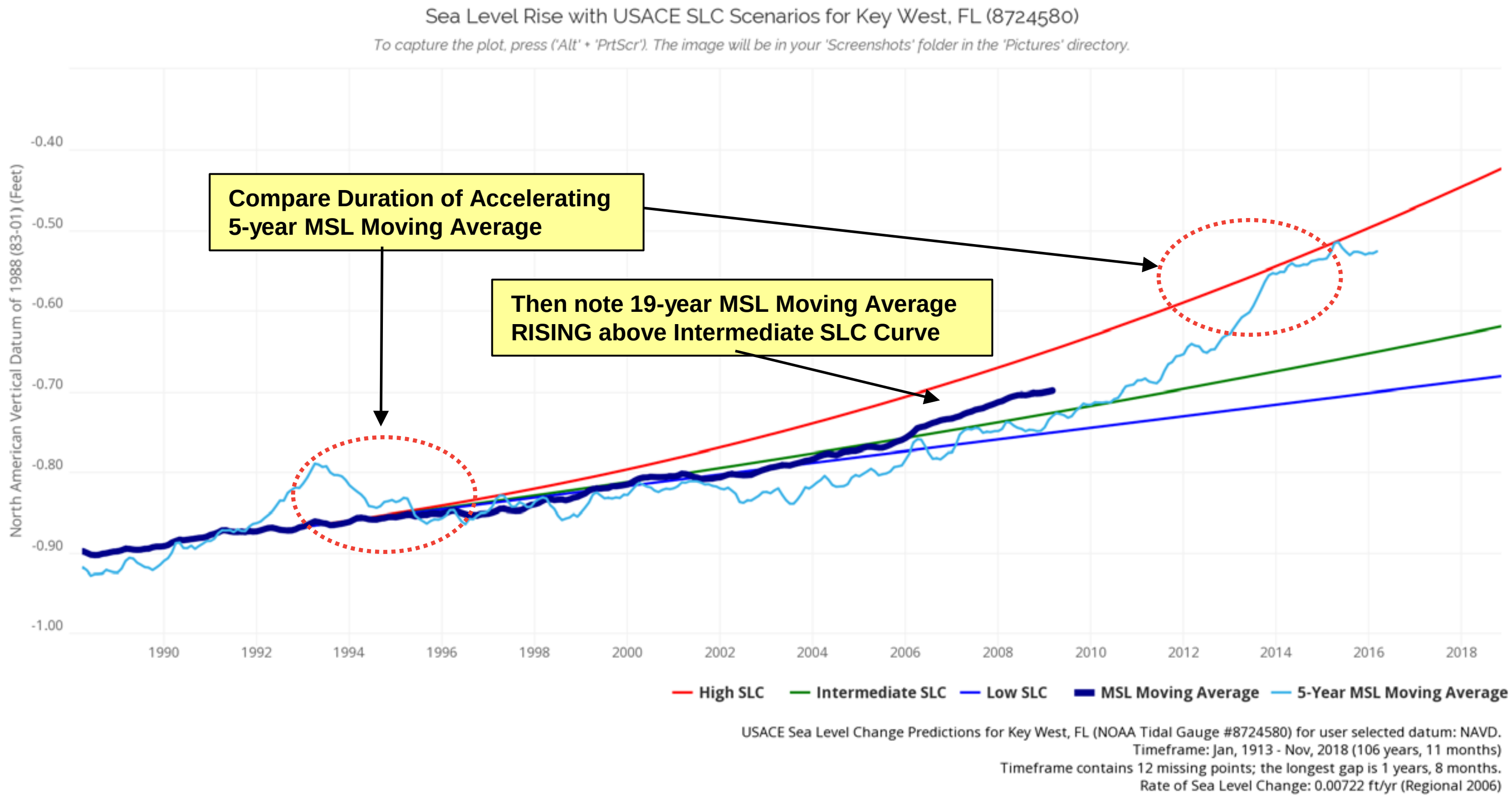
ACCELERATING SEA LEVEL CHANGE IN FLORIDA 30-YEARS 1988 TO NOV 2018, KEY WEST, FL



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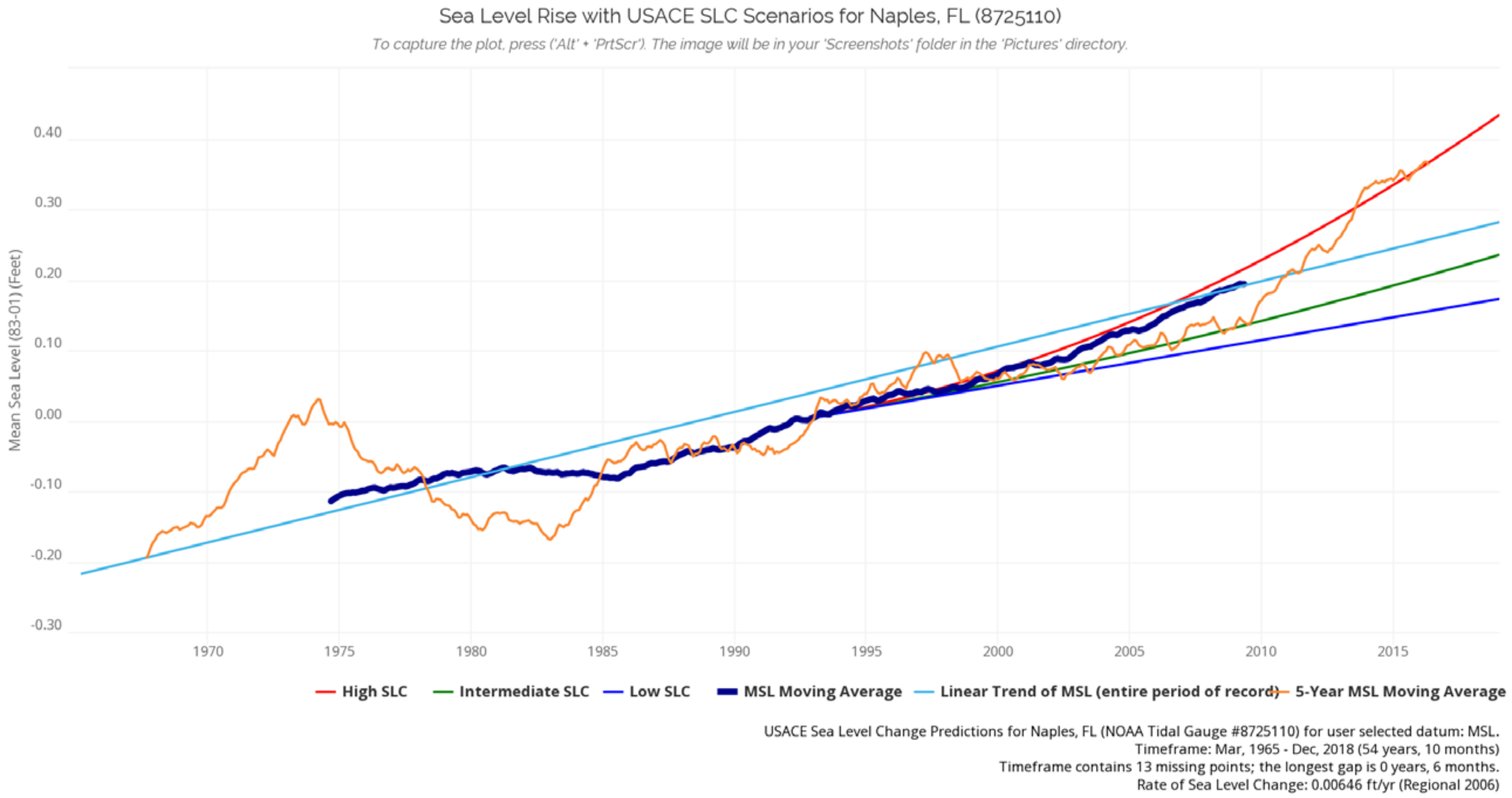
ACCELERATING SEA LEVEL CHANGE MAR 1965 TO DEC 2018, NAPLES, FL



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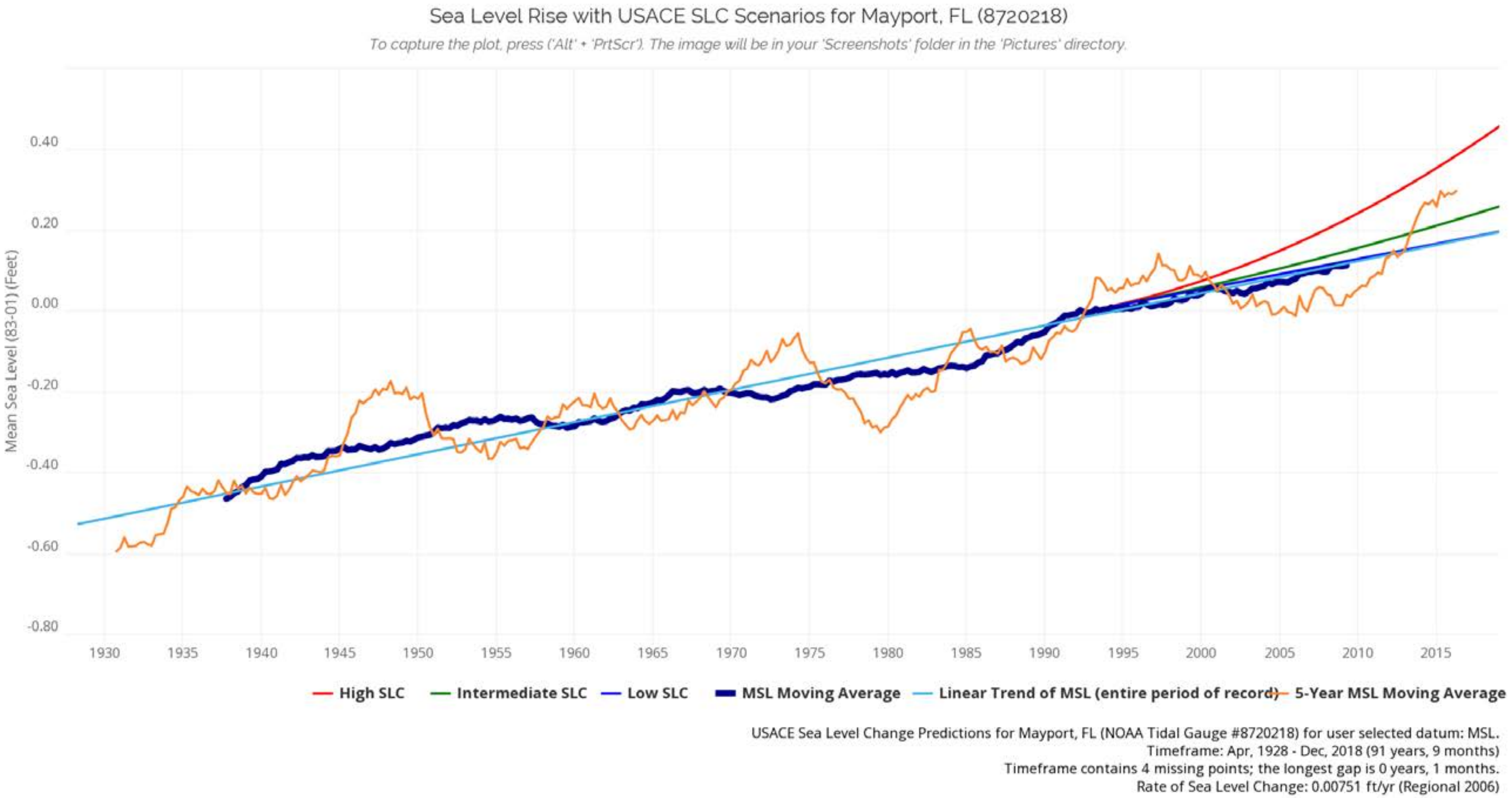
ACCELERATING SEA LEVEL CHANGE APR 1928 TO DEC 2018, MAYPORT, FL



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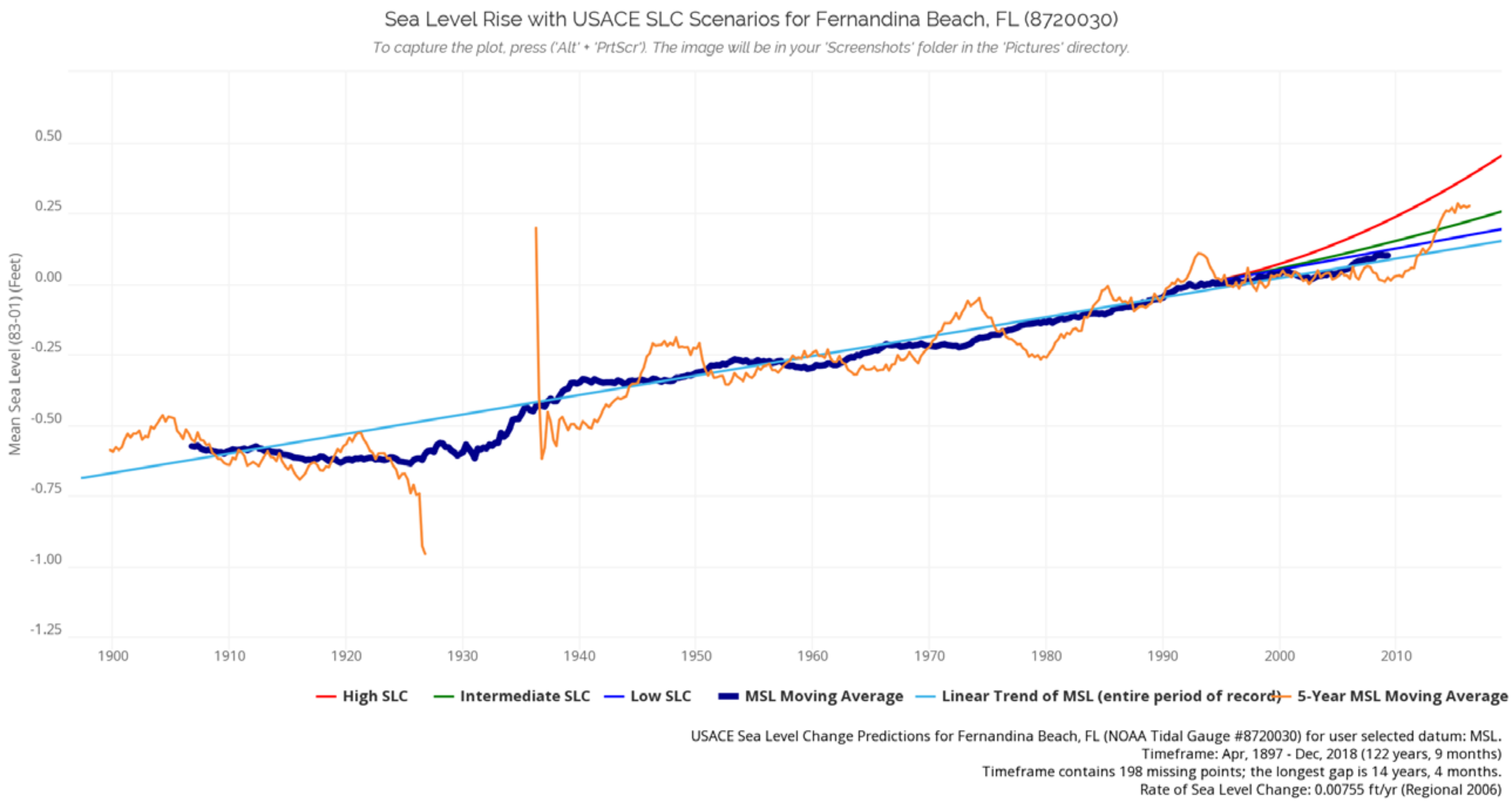
ACCELERATING SEA LEVEL CHANGE
JUN 1897 TO DEC 2018, FERNANDINA BEACH, FL



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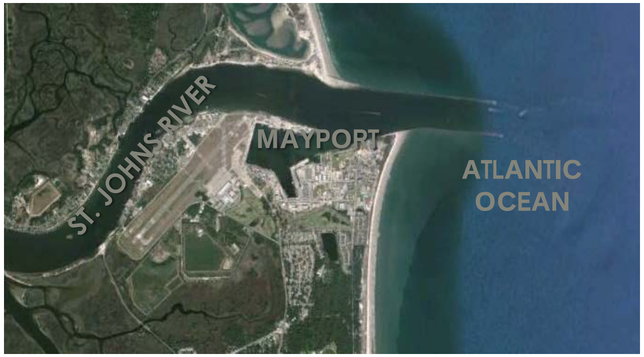
SEA-LEVEL RISE CONCERNS IN NORTHEAST FLORIDA

Direct Impacts (SLR + coastal storms on communities, businesses and Mayport NAS)

Flood Frequency and Drainage (increased flooding, particularly in low elevation areas and historic 500-year old St. Augustine)

Water Supply and Storage (saltwater intrusion in coastal areas, St. Johns River and some groundwater)

Natural System (coastal ecosystems and St. Johns River basin)



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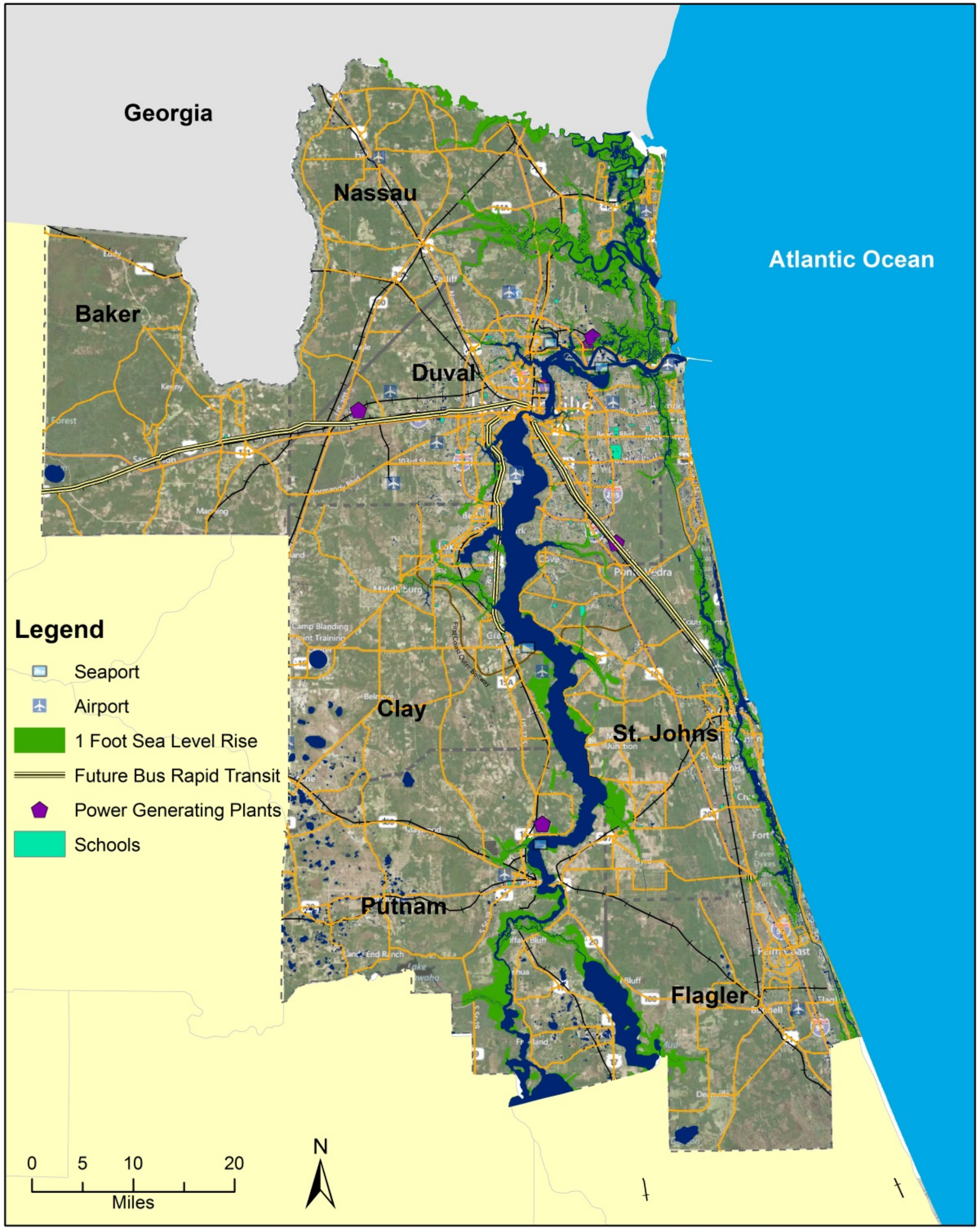

Northeast Florida Sea Level Rise - 1 Foot Rise

Credit: Northeast Florida Regional Council

SEA LEVEL RISE IMPACTS IN NORTHEAST FLORIDA

- Flood risks increase
- Salinity impacts on Coastal and River ecosystems, adjacent areas and groundwater
- Decreases surface storage of freshwater

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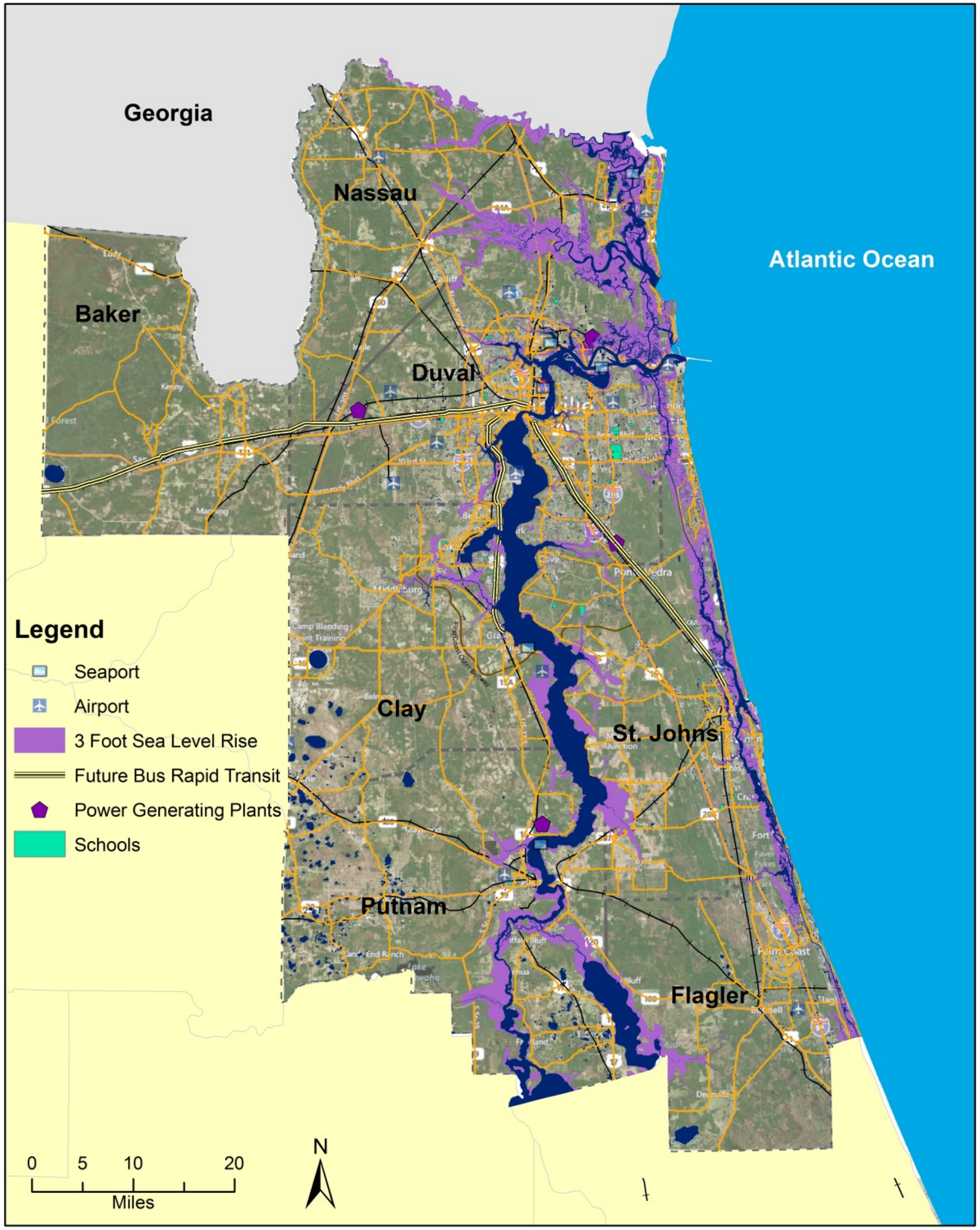

Northeast Florida Sea Level Rise - 3 Foot

Credit: Northeast Florida Regional Council

SEA LEVEL RISE IMPACTS IN NORTHEAST FLORIDA

+3 FEET

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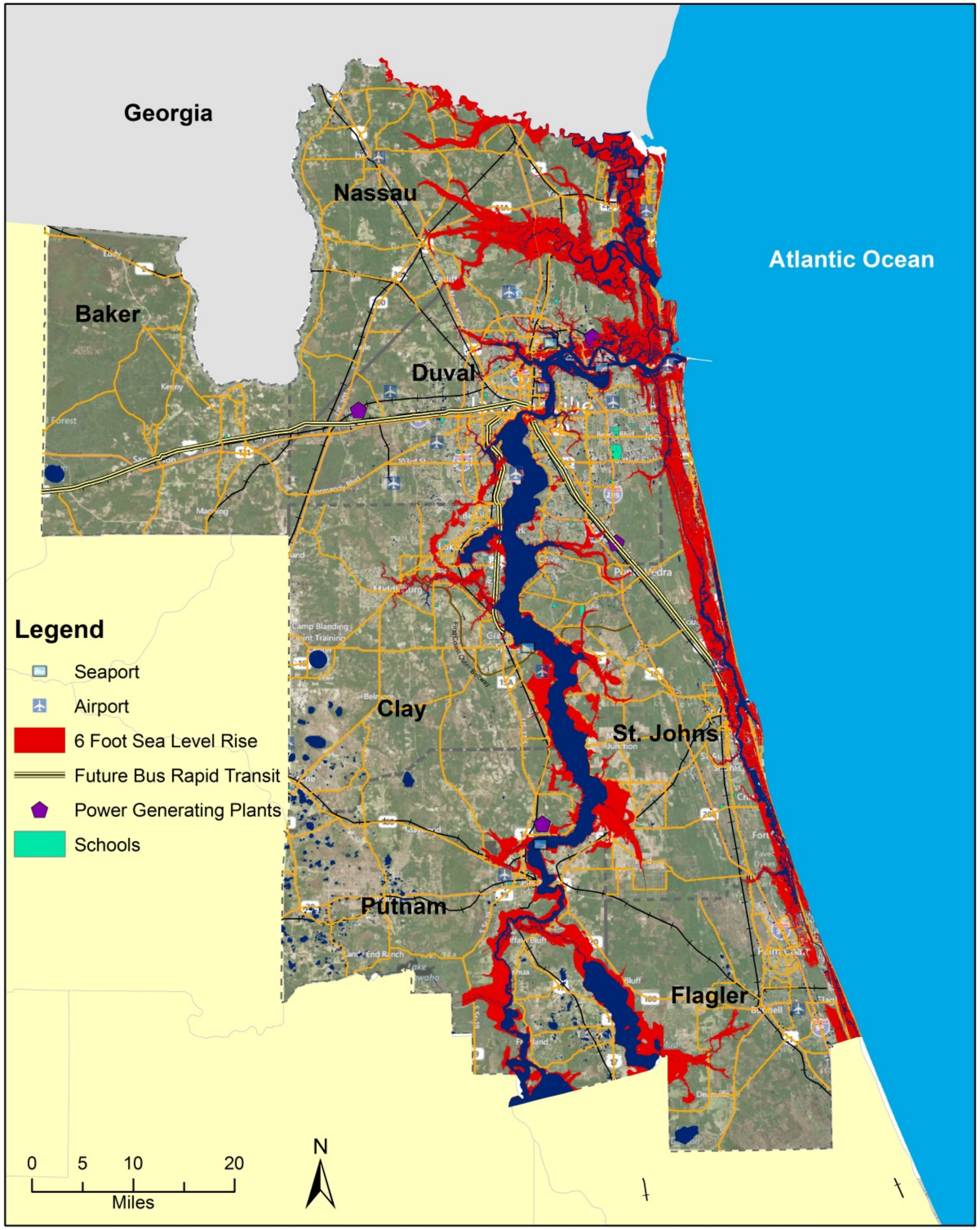
SEA LEVEL RISE IMPACTS IN NORTHEAST FLORIDA

+6 FEET



Northeast Florida Sea Level Rise - 6 Foot Rise

Credit: Northeast Florida Regional Council

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SALINITY CHANGES IN ST. JOHNS RIVER

- Hydrodynamic modeling for proposed Jacksonville Harbor deepening predicts “small” project-related 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.

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

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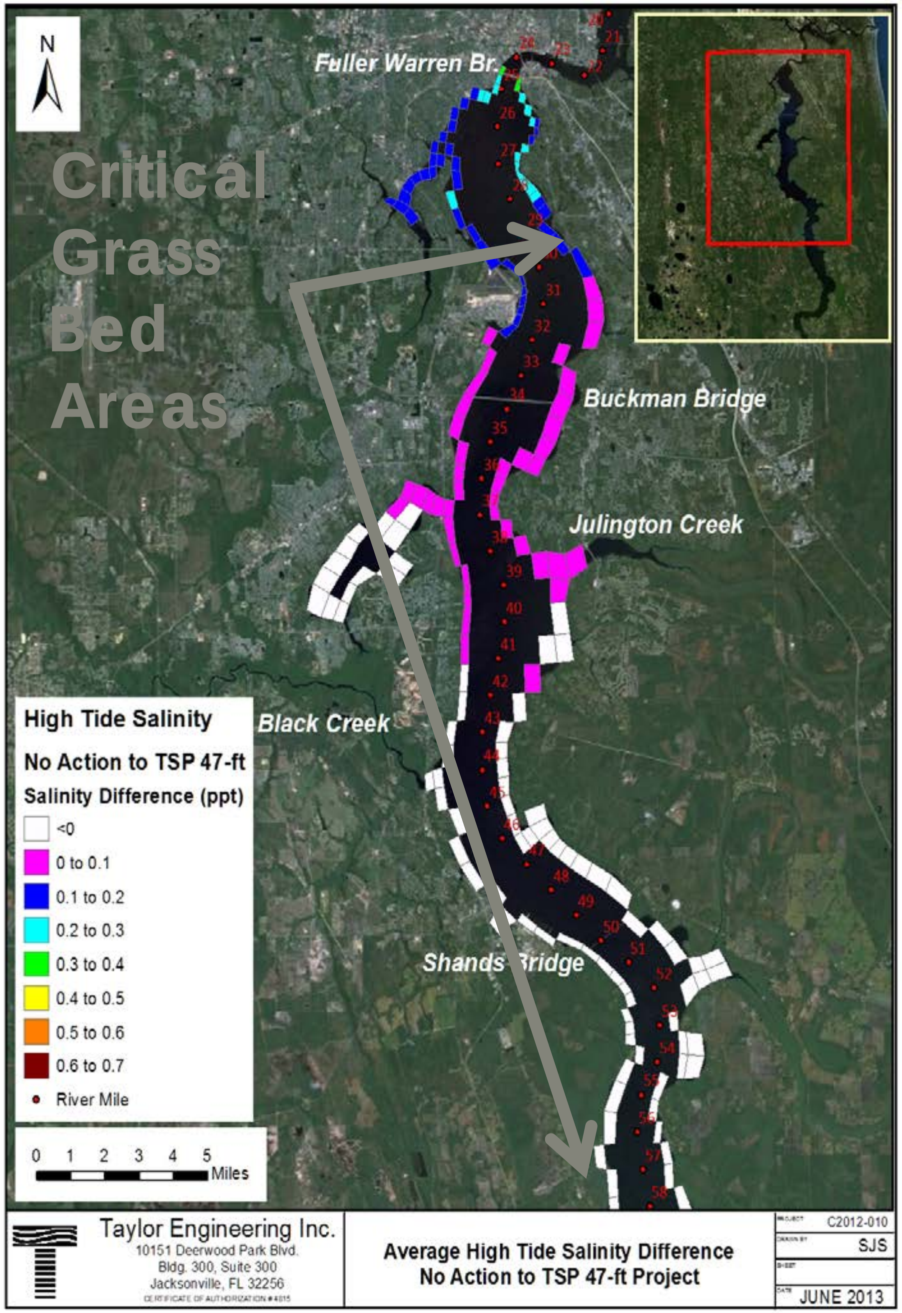

ST. JOHNS RIVER HIGH TIDE SALINITY

Changes with Proposed Jacksonville Harbor deepening to 47-foot depth

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

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RISK

Risk is a measure of the probability and consequences of uncertain future events

Consider low probability with high consequences

Risk includes

- Potential for gain (opportunities)
- Exposure to losses (hazards)

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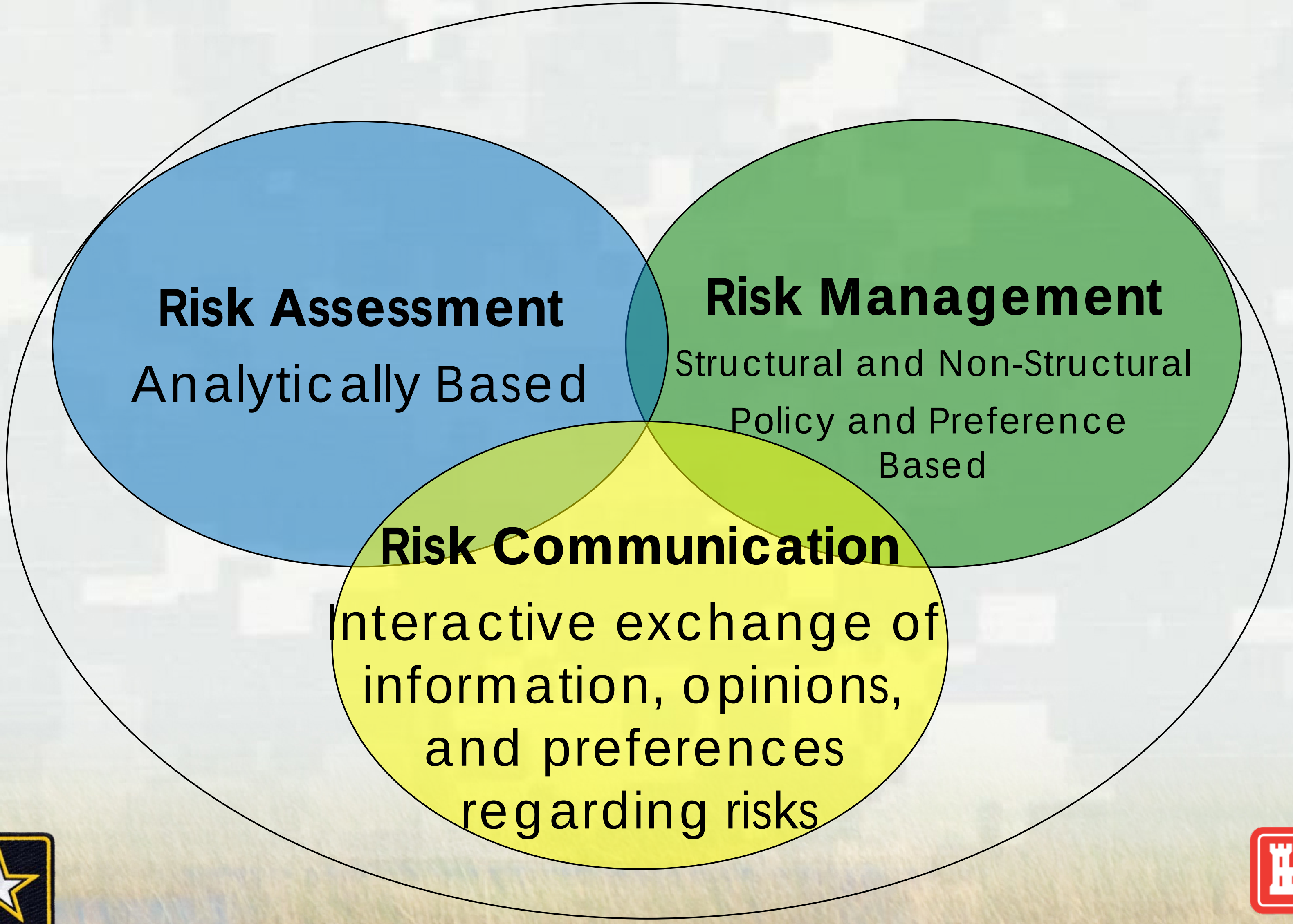
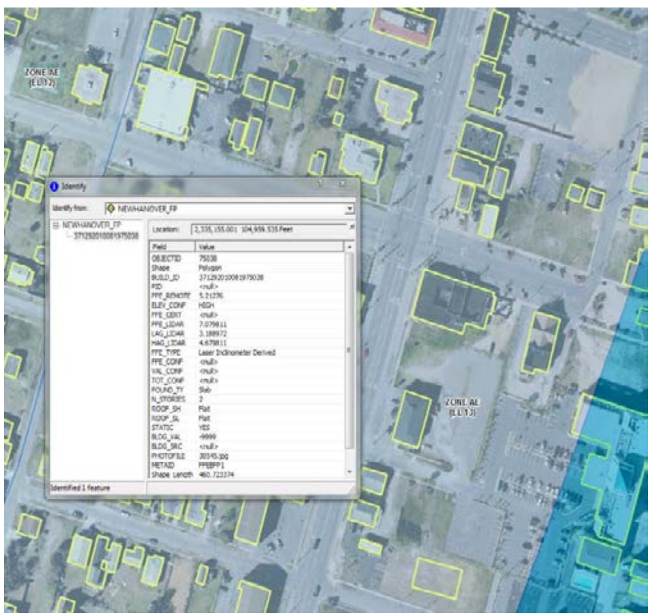
RISK ANALYSIS IN THREE TASKS



RISK ASSESSMENT
MOBILE LIDAR TECHNOLOGY FOR STREET AND STRUCTURE ELEVATION DATA



Credit: North Carolina Flood Risk Info System
and FL Dept. of Emergency Management

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RISK MANAGEMENT DECISION

- Sustainable
- Robust: performs well under a 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>**

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UNITED KINGDOM CLIMATE ADAPTATION APPROACHES: PRECAUTIONARY VERSUS MANAGED ADAPTIVE

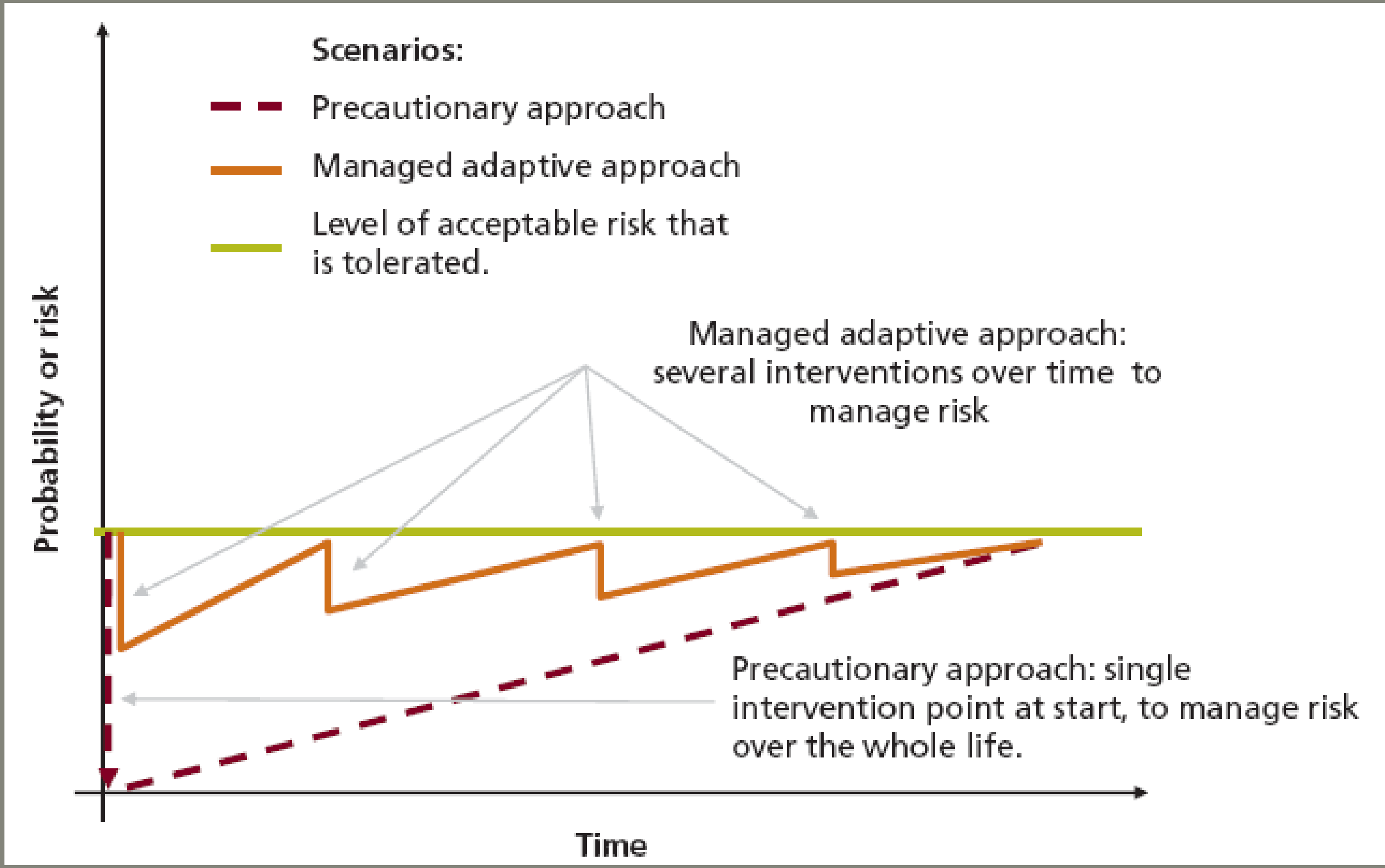

Figure courtesy of Jonathan Simm, HR Wallingford, UK

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CONCLUSIONS AND DISCUSSION IDEAS

Sea level rise PERMANENTLY increases coastal flood risks and frequency.

Anticipate SLR accelerating and likely continuing far beyond 2100.

Coastal and tidal ecosystems need suitable space for SLC adaptation

Buildings ***AND*** lands subject to SLR will depreciate as risks increase

Develop "Exit Strategies" to support timely voluntary actions

Protect existing built environment only as long as economically justified

Invest primarily in long term risk reduction and resilience building

Potential Federal role = Promote Regional Comprehensive Plans and Regional "Framework" Infrastructure to encourage growth in low risk areas
(i.e. regional water resources, power and transportation systems)

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“Begin with the end in mind.”

<u>The Seven Habits of Highly Effective People</u>

by Dr. Stephen R. Covey

Thank you!

For additional information, contact:

Glenn.B.Landers@usace.army.mil

RELATIVE SEA LEVEL CHANGE SCENARIOS FOR MAYPORT, FL (FEET)

PER USACE 2013 AND NOAA 2012 GUIDANCE

Year	USACE Low	USACE Int.		USACE High	
	NOAA Low	NOAA Int. Low	NOAA Int. High		NOAA High
1992	0	0	0	0	0
2000	0.06	0.07	0.08	0.09	0.10
2010	0.14	0.17	0.23	0.26	0.31
2020	0.22	0.29	0.45	0.51	0.62
2030	0.30	0.43	0.71	0.84	1.04
2040	0.38	0.58	1.04	1.23	1.56
2050	0.46	0.76	1.42	1.70	2.17
2060	0.54	0.95	1.86	2.25	2.90
2070	0.61	1.16	2.35	2.87	3.72
2080	0.69	1.38	2.91	3.56	4.65
2090	0.77	1.63	3.52	4.33	5.68
2100	0.85	1.89	4.18	5.18	6.81
2110	0.93	2.17	4.91	6.09	8.04
2120	1.01	2.47	5.69	7.08	9.38
2130	1.09	2.78	6.53	8.15	10.82
2140	1.17	3.11	7.43	9.29	12.35
2150	1.24	3.46	8.38	10.50	14.00
2160	1.32	3.83	9.39	11.79	15.74
2170	1.40	4.22	10.46	13.15	17.59
2180	1.48	4.62	11.58	14.58	19.54
2190	1.56	5.05	12.76	16.09	21.59
2200	1.64	5.48	14.00	17.68	23.74

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RELATIVE SEA LEVEL CHANGE SCENARIOS FOR MAYPORT, FL (FEET)

Per NOAA 2017 Guidance

Year	NOAA2017 VLM	NOAA2017 Low	NOAA2017 Int-Low	NOAA2017 Intermediate	NOAA2017 Int-High	NOAA2017 High	NOAA2017 Extreme
2000	0	0	0	0	0	0	0
2010	0.02	0.13	0.16	0.26	0.33	0.39	0.39
2020	0.04	0.26	0.33	0.46	0.62	0.72	0.79
2030	0.06	0.43	0.52	0.75	1.05	1.25	1.41
2040	0.07	0.56	0.69	1.05	1.44	1.80	2.10
2050	0.09	0.72	0.89	1.41	1.97	2.56	3.05
2060	0.11	0.85	1.05	1.77	2.59	3.44	4.13
2070	0.13	0.98	1.25	2.23	3.31	4.49	5.41
2080	0.15	1.12	1.44	2.72	4.17	5.71	6.92
2090	0.17	1.21	1.61	3.22	5.05	7.02	8.53
2100	0.19	1.35	1.77	3.77	6.07	8.56	10.50
2120	0.22	1.51	2.07	4.46	7.41	11.32	14.47
2150	0.28	1.71	2.56	6.20	10.86	17.19	22.11
2200	0.37	2.00	3.35	9.32	17.81	28.90	37.04

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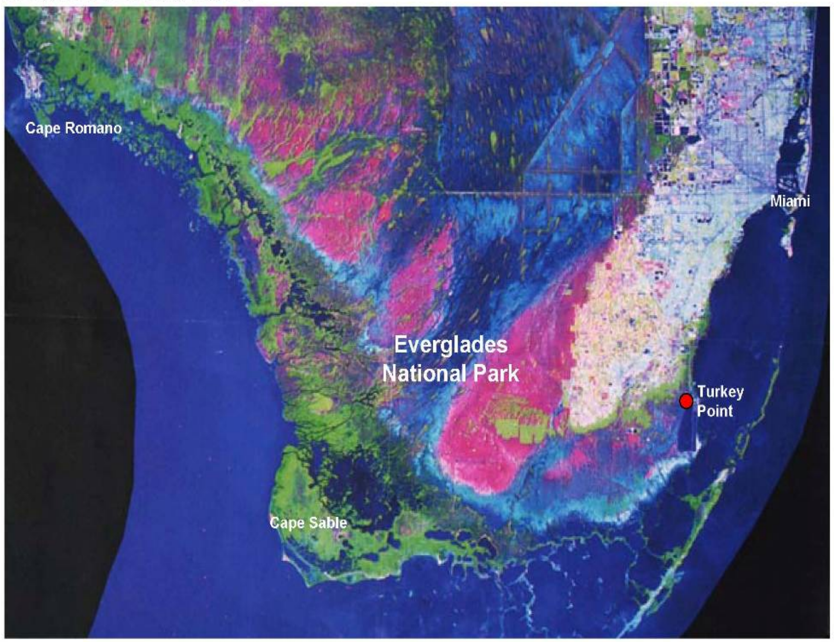
SEA LEVEL RISE IN SOUTH FLORIDA, 2 FT.

SLR was about 9 inches during the past century measured at Key West

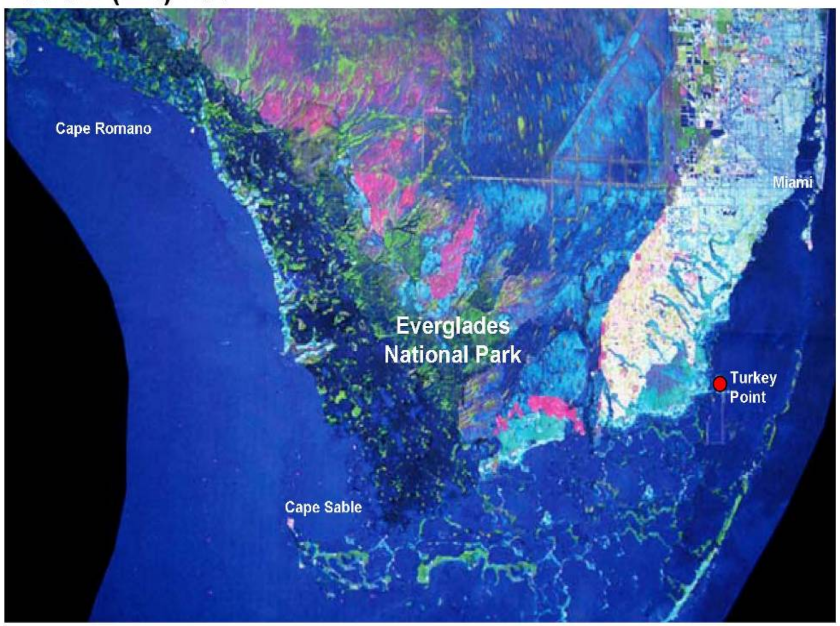
A 2 foot rise will have significant effects

South Florida 1995



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

+60 cm (2 ft) rise



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

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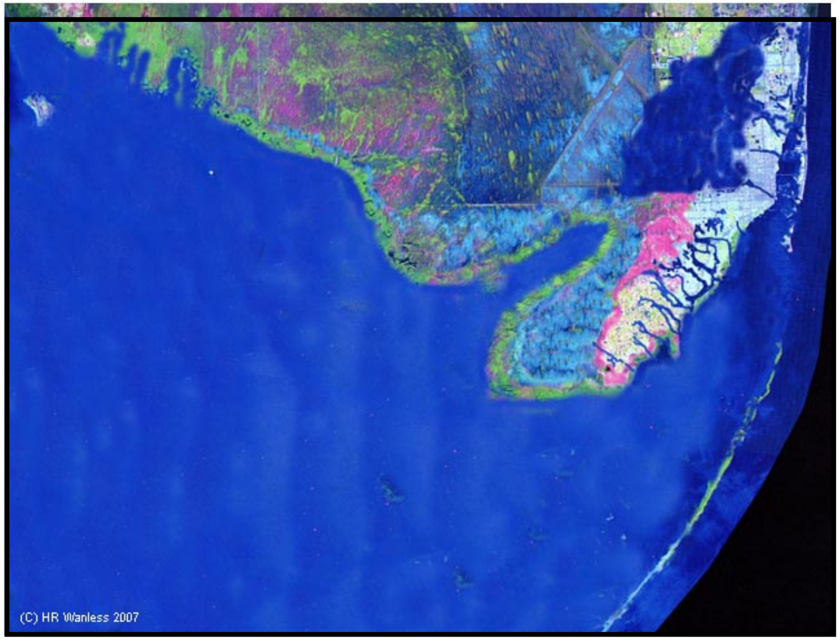
SEA LEVEL RISE IN SOUTH FLORIDA, 4-5 FT.

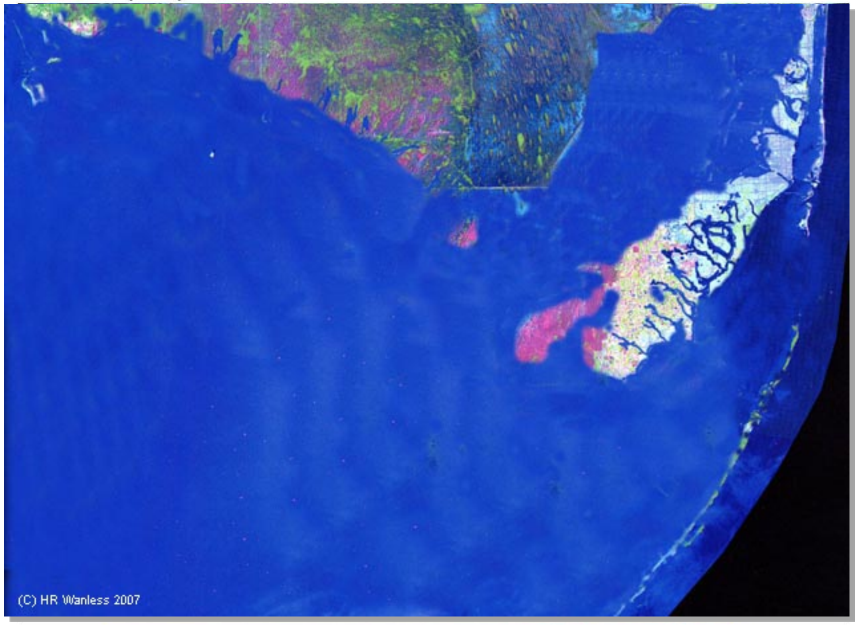
SLR was about 9 inches during the past century measured at Key West. A 4-5 foot rise will produce dramatic impacts in Florida

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

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