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Risk-Based Vulnerability Assessment of the Indian River Lagoon to Climate Change

FINAL REPORT

Submitted October 1, 2018

Prepared for: Indian River Lagoon Council

Prepared by:

RWParkinson Consulting, Inc. & The Balmoral Group

RWParkinson Consulting, Inc.

The Balmoral Group

Climate Change Vulnerability Assessment of the Indian River Lagoon National Estuary Program's Comprehensive Conservation and Management Plan

October 1, 2018

Prepared by: RWParkinson Consulting, Inc., and The Balmoral Group
Prepared for: *Indian River Lagoon National Estuary Program*
United States Environmental Protection Agency (USEPA)

Contact Author:
Randall W. Parkinson, Ph.G., P.G.
RWParkinson Consulting, Inc.
Melbourne, Florida
(321) 373-0976
rwparkinson.inc@gmail.com

Contributing Authors:
Valeria Seidel
The Balmoral Group
Winter Park, Florida
(407) 629-2185
www.balmoralgroup.us

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EXECUTIVE SUMMARY

Results of a risk-based vulnerability assessment of the IRLNEP CCMP indicate 154 management objectives (aka Action Plans) are at risk to climate change. The assessment evaluated the effects of five climate change stressors on sediment and water quality, natural resources, and stakeholder engagement: warmer temperature, changing precipitation, increased storminess, acidification, and sea level rise. Each risk was ranked by numerical score and prioritized as *higher*, *high*, and *moderate* based upon: (1) magnitude of consequence, (2) likelihood, (3) spatial scale, and (4) time horizon.

Seventy-eight management objectives were determined to be at *higher* risk to climate change (i.e., decreased DO solubility due to warmer temperature), 62 at *high* risk (i.e., decreased volunteer participation in activities due to more frequent and intense storm events), and 14 at *moderate* risk (i.e., accelerated spread of exotic and invasive species from WWTP and OSTDS during more frequent and intense storm events).

Assessment results were informed by stakeholder input in a variety of formats including personal interviews, meetings, and real-time polling. The next step in this effort to become an EPA sanctioned Climate Ready Estuary is to integrate specific action plans, formulated to address priority risks, into the ongoing effort to update the IRLNEP CCMP.

INTRODUCTION

The National Estuary Program

The National Estuary Program (NEP) is a non-regulatory program established by the U.S. Congress and administered by the U.S. Environmental Protection Agency (USEPA). The NEP was authorized by Section 320 of the Clean Water Act in 1987. Each estuary in the NEP was designated by the U.S. Congress as an "Estuary of National Significance." Today, 28 estuaries located along the Atlantic, Gulf, and Pacific coasts and in Puerto Rico have been designated as estuaries of national significance (**Figure 1**).

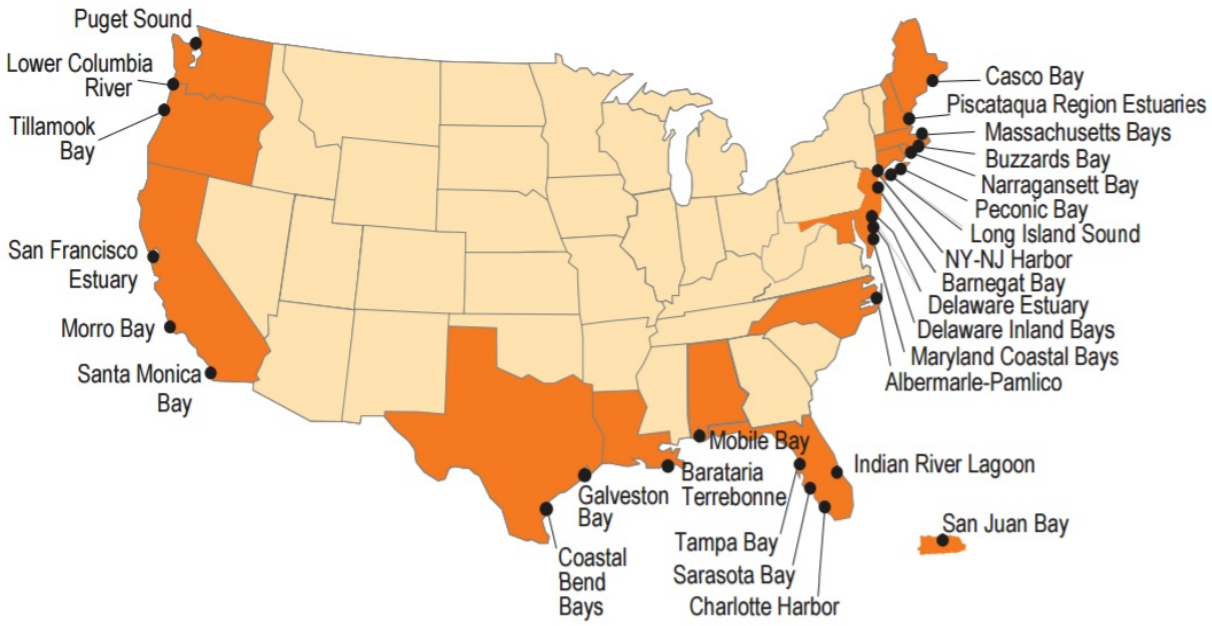


Figure 1. *National Estuary Program locations.*

NEPs reside in a variety of institutional settings, including state and local agencies, universities, and individual nonprofits. In overseeing and managing the national program, USEPA provides annual funding, national guidance, and technical assistance to the local NEPs.

The 28 NEPs develop and implement Comprehensive Conservation and Management Plans (CCMPs), which are long-term plans that contain actions to address challenges and priorities related to water quality and living resources. Work is focused within a study area that includes the estuary and its watershed. NEP challenges and priorities are defined by local, city, state, federal, private, and non-profit stakeholders. The NEP is a collaborative, effective, efficient, and adaptable coastal ecosystem-based network. With more than 20 years of experience implementing key provisions of the Clean Water Act, the NEP is the nation's principal watershed program — one that offers a viable, effective method for protecting and managing all types of watershed environments.

The IRL (**Figure 2**) was designated an "Estuary of National Significance" by Congress in 1990, providing the catalyst for the creation of the IRLNEP. The first CCMP was adopted in 1996. From 1991 to 2015, the St. Johns River Water Management District (SJRWMD) served as the host agency for the IRLNEP. Today, the IRLNEP is hosted by the IRL Council, an independent special district of the state of Florida pursuant to an Interlocal Agreement signed by Volusia County, Brevard County, Indian River County, St. Lucie County, Martin County, SJRWMD, South Florida Water Management District (SFWMD), and Florida Department of Environmental Protection (DEP). The IRLNEP is currently revising the existing CCMP (Indian River Lagoon National Estuary Program, 2008) and expects to complete this task by the end of 2018.

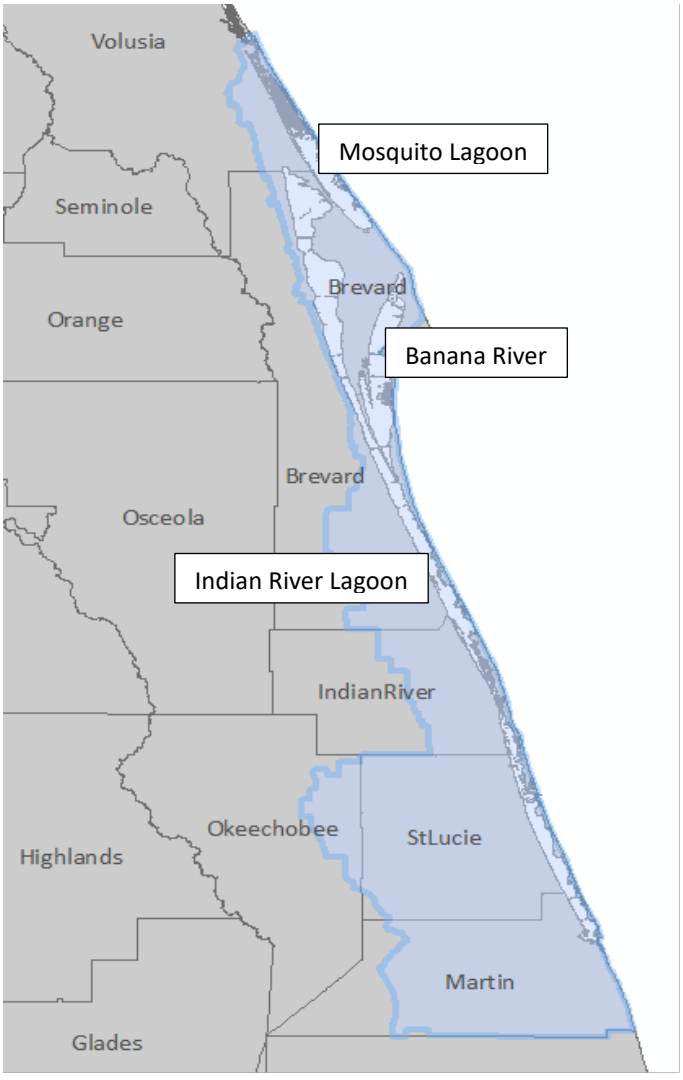


Figure 2. *Indian River Lagoon watershed.*

The Indian River Lagoon

An estuary is a coastal waterbody where freshwater tributaries (rivers and streams) meet the waters of the sea. It is this subtle, but important mixing of fresh and salt waters that make estuaries the most productive and fragile coastal ecosystems in the world. A lagoon is a special type of estuary that is oriented parallel to the coast and characterized by shallow coastal waters with restricted, but free, exchange with the adjacent open ocean. The Indian River Lagoon (IRL) is a microtidal system that has limited exchange with the ocean through five inlets (Ponce de Leon, Sebastian, Fort Pierce, St. Lucie, and Jupiter). Port Canaveral connects the ocean to the lagoon through an engineered lock system that is used specifically for access by maritime vessels.

The small tidal range on the east coast of Florida limits exchange between the ocean and the IRL system. In fact, most of the circulation of water in the IRL is driven by wind. Because of the long residence time in portions of the IRL system and restrictions from land-based development (i.e., causeways, wetland alterations, and past construction practice) in some compartments, the IRL is vulnerable to

nutrient and pollutant loadings from the watershed. Inputs from the watershed have increased during the past few decades, causing a decline in water quality and changes to the ecological and biological integrity of the ecosystem.

The IRL system is composed of three distinct and connected estuaries, the Indian River, Banana River, and Mosquito lagoons (**Figure 2**). The IRL system extends 156 miles from Ponce de Leon Inlet to Jupiter Inlet. It spans three climate zones, from temperate to subtropical to tropical. It encompasses almost 40% of the east coast of Florida and connects five counties (plus portions of two additional counties; Palm Beach and Okeechobee), 38 incorporated cities, and approximately 1.6 million residents. The lagoon watershed covers 2,284 square miles and the lagoon's waters span 353 square miles.

Climate Ready Estuaries

The Earth's climate is changing. Temperatures are rising, snow and rainfall patterns are shifting, and more extreme climate events—like heavy rainstorms and record-high temperatures—are already taking place. Scientists are highly confident that many of these observed changes are linked to the rising levels of carbon dioxide and other greenhouse gases in our atmosphere as a consequence of human activities. In 2008, the Climate Ready Estuaries (CRE) program was established as a partnership between USEPA and the NEPs to address climate change in coastal areas. This effort is building additional capacity in coastal communities as they prepare to adapt to the effects of climate change. The CRE mission is to support NEPs and their coastal communities in becoming "climate ready" by providing tools and assistance to:

- Assess climate change vulnerabilities
- Engage and educate stakeholders
- Develop and implement adaptation strategies
- Share lessons learned with other coastal managers

By 2011 only a few NEPs had undertaken efforts to become climate ready. So, in 2014 the EPA published a 'Workbook' (EPA, 2014) to assist organizations that manage NEPs to prepare a broad, risk-based climate-ready adaptation plan. To successfully implement a CRE plan, the Workbook outlines a two-part process consisting of (1) a stand-alone vulnerability assessment, followed by (2) an action plan. Since then nine NEPs – including the IRLNEP – have undertaken vulnerability assessments following workbook guidelines (**Figure 3**). One program has completed an action plan (**Table 1**).

Figure 3. *Ten step process described in EPA Workbook.*

Table 1. *Completion date of most recent CCMP, Climate Ready Estuaries Risk-Based Vulnerability Assessment (Phase 1) and Action Plan (Phase 2).*

Location	CCMP	Vulnerability Assessment	Action Plan
Casco Bay	2016	2017	
Charlotte Harbor	2013	2018	
Indian River Lagoon	2008	2018	
Lower Columbia Estuary	2011	2017	
Morro Bay	2012	2016	
San Juan Bay	2005	2013	2015
Santa Monica Bay	2013	2016	
Sarasota Bay	2017	2017	
Tampa Bay	2017	2017	

This Project

This project was designed to complete part 1 of the Workbook; a risk-based vulnerability assessment of the IRLNEP's mission to the risks associated with climate change stressors. This was achieved by completion of 5 steps:

Step 1. Communication and consultation - identify key stakeholders and prepare a schedule for stakeholder involvement.

Step 2. Establishing context - compile list of organizational goals and associated Action Plans (CCMP 2008) that are susceptible to climate change.

Step 3. Risk identification - create a broad list of climate change risks that might impact the ability of the IRLNEP to achieve its goals.

Step 4. Risk analysis - make an initial, high-level determination of the consequence, likelihood, spatial scale, and timeline of the impacts.

Step 5. Evaluation - develop a consequence/probability matrix prioritizing risks most likely to impact the goals and objectives (aka Action Plans) of the IRLNEP.

FINDINGS

Step 1. Communication and Consultation

Stakeholder outreach

One objective of Step 1 was to identify key stakeholders and learn their particular interests or concerns about climate change risks to the IRL. **Table 2** lists key stakeholders interviewed throughout the duration of this project. Stakeholder input was also acquired during technical meetings and the Q&A sessions that followed scheduled presentations made by members of the project team (**Table 3**)

Real-time polling

Feedback from stakeholders was collected using real-time polling at several stakeholder engagement meetings. As with stakeholder outreach, the purpose of this polling was to quantify stakeholder perceptions regarding the risk of climate change stressors on the IRL and IRLNEP management goals. Stakeholder responses are summarized in **Appendix C** and evaluated with regards to the findings of the project in the **Discussion** section of this report.

Step 2. Establishing Context

IRLNEP program vulnerability

The objective of this step was to identify IRLNEP organizational goals and CCMP Action Plans at risk to climate change stressors. To complete this step, the project team completed a review of the IRL 2008 CCMP (Indian River Lagoon National Estuary Program, 2008) and those available from other NEP programs that have completed or are were conducting a vulnerability assessment (**Table 1**). What was clear from that review is all other programs undertook the vulnerability assessment based upon a relatively recent version of their CCMP. As a consequence, their organizational Goals and associated Action Plans were written with a clear understanding of the risks posed by climate change stressors. In contrast, the Goals and Action Plans contained in the IRL 2008 CCMP do not acknowledge the breadth and scope of risks posed by future climate. Of the 85 Action Plans, 25 may be at risk, 21 possibly at risk, and 39 not at risk to climate change (**Table 4**). In consultation with the IRLC Management Conference, it was agreed moving forward Step 3 would not be constrained by the 2008 CCMP. Consideration would also be given to new organizational goals and/or related Action Plans associated with the ongoing and contemporaneous effort to update the 2008 CCMP.

Table 2. *Stakeholders interviewed throughout duration of project*

Stakeholder Outreach	Affiliation	Topic
Arpayoglou, Irene	DEP IRL Aquatic Preserves	Spoil Islands
Barile, Peter	Environmental Consultant	Nutrients
Beal, Jeff	ECERT	Natural Resources
Bell, Lexie	Morro Bay	NEP
Bohlan, Curtis	Casco Bay	NEP
Burke, Mya	Tampa Bay	NEP
Busha, Michael	TCRPC	Planning
Corbett, Catherine	Lower Columbia Estuary	NEP
Craghan, Michael	USEPA	General
Creswell, R	Florida Sea Grant	Climate stressors
Crosley, Mark	FIND	Spoil Islands
Culver, Matt	Brevard County	Boating & Waterways
Encomio, Vincent	FOS	Climate stressors
Evans, Jason	Stetson University	General
Gubles, Anthony	Brevard County	Wastewater
Hevia, Allison	Charlotte Harbor	NEP
Ilami, Fara	FWCC	Living shorelines
Johnston, Karina	Santa Monica Bay	NEP
LaMartina, Kathy	SFWMD	Surface water
Lindeman, Ken	FIT	General
Listopad, Claudia	Environmental Consultant	TMDL
Lunt, Jessica	Smithsonian Marine Station	Climate stressors
McClure, Bach	Brevard County	Storm Water
McCue, Tara	ECFRPC	Planning
McGee, Darcie	Brevard County	General
Middlebrook, Mike	St. Lucie County	NRM
Otega, Jorge	San Juan Bay	NEP
Roddenberry, Annie	NERT	Natural Resources
Ruppert, Thomas	Florida Sea Grant	Legal
Schaefer, Adam	HBOI	Biotoxins
Shafer, Dave	Sarasota Bay	NEP
Smith, Brandon	Brevard County	SOIRL Program
Souto, Leesa	MRC	Natural Resources
Spratt, Robbyn	Brevard County	Storm Water
Traylor, Aaron	City of Melbourne	Wastewater
Trefry, John	FIT	Muck
Weaver, Robert	IRLRI	Natural Resources
Winston, Keith	Brevard Zoo	Living shorelines
Zierden, David	Florida State Climatologist	Climate trends
Zimmerman, Janet	FIND	Spoil Islands

Table 3. *Summary of stakeholder meeting outreach activities*

Organization	Presentation (#)	Real-time polling
IRLC STEM Board	2	2
IRLC Management Board	1	1
Northeast Estuarine Restoration Team	2	1
East Central Estuarine Restoration Team	2	1

Table 4. *Risk Assessment of 2008 CCMP Goals and Action Plans to Climate Change*

Goal	Action Plan	Yes	Possibly	No
1	Water and Sediment Quality Improvements			
	Point source discharge	0	0	5
	On-site sewage treatment	0	2	1
	Fresh and storm water discharges	2	7	4
	Marina and Boat Impacts	0	4	3
	Atmospheric Deposition	1	0	0
	TMDLs	1	0	2
	Sum	4	13	15
2	Living Resources			
	Biodiversity	1	1	1
	Seagrass	1	0	0
	Wetlands	6	1	1
	Impounded marsh restoration and management	0	0	0
	Land acquisition and protection	0	2	2
	Endangered and threatened species	3	1	1
	Fisheries	3	0	0
	Biotoxins and Health	1	2	0
	Climate Change	3	0	0
	Invasive Fauna and Flora	1	1	2
	Sum	19	8	7
3	Public and Government Support and Involvement			
	Public involvement and education	1	0	3
	IRL CCMP Implementation	0	0	2
	Data and information management strategy	0	0	3
	Monitoring	1	0	2
	IRL scientific research	0	0	3
	Environmental incident assessment and response	0	0	3
	Sum	2	0	16
4	Financing IRL CCMP Implementation			
	Economic analysis	0	0	1
	Sum	0	0	1
	Sum (85 total action plans)	**25**	**21**	**39**

Source: RWP Work Product, 2018.

Other vulnerability assessments within the IRL watershed

This vulnerability assessment focused on the potential effects of climate change on natural resources within the IRL watershed. However, there are numerous vulnerability assessments that have been conducted on the urban landscape or 'built environment' within the IRL watershed. These include:

- "Space Coast Transportation Planning Organization Sea Level Rise Vulnerability Assessment". Prepared by East Central Florida Regional Planning Council (aka TPO) on behalf of Brevard County in 2018. This vulnerability assessment identified all transportation infrastructure (roads, railways, airports, and other critical transit facilities) likely to be affected by sea level rise. The focus was on flooding and the results can be used to develop adaptation strategies and to seek federal funding to support adaptation actions.
- "Brevard County Emergency Management – Hazard Summaries". Prepared by Brevard County Emergency Management in 2016. This hazard assessment provides a concise description of impacts from 21 different hazards, including tropical storms, sea level rise, drought, and wildfires. The assessment includes a list of hazards categorized into seven impact groups: public and responders, continuity of operations, property /facilities/ infrastructure, delivery of services, public confidence in government, economic condition, and the environment.
- "City of Satellite Beach Sustainability Action Plan". Prepared by the Florida Institute of Technology in 2017. This plan identifies stressors and recommendations for each of five broad categories: built environment, land and water systems, energy and transportation networks, community outreach, and quality of life.
- "Resilient Volusia County" Prepared by the East Central Florida Regional Planning Council in 2017. This assessment estimated impacts to critical assets from sea level rise and storm surge. One of the recommendations was for cities in Volusia County to be compliant with Florida SB 1094, by incorporating sea level rise in plans for development and redevelopment. Water quality and ecosystems assets were considered.
- "Regional Resiliency Action Plan". This project, under development by the East Central Florida Regional Planning Council, aims to improve resiliency efforts and teamwork among local and regional governments that are located along Florida's central Atlantic coastline. Project completion is scheduled for December 2018.

Step 3. Risk Identification

The objective of this step was to create a broad list of risks to the IRLNEP caused by climate change stressors. To complete this step, the first task was to identify specific climate change stressors that are likely to affect the goals and Action Plans of the IRLNEP. The second task was to evaluate the potential consequences (risks) of these stressors on each Action Plan. As noted above, it was agreed Step 3 would not be constrained by the Action Plans identified in the 2008 CCMP. Rather, consideration would also be given to new

organizational goals and/or related Action Plans identified during the ongoing and contemporaneous effort to update the 2008 CCMP. Based upon an evaluation of other Risk-Based Vulnerability Assessments conducted in NEPs located within and beyond the state of Florida (**Table 1**), stakeholder input, literature review (c.f. Chassignet et al., 2017), and the experience and expertise of project members, five climate changes stressors were identified as relevant to IRLNEP:

- Warmer temperatures - Warmer temperatures are one of the most direct signs that the climate is changing. Concentrations of heat-trapping greenhouse gases are increasing in the Earth's atmosphere. In response, average temperatures at the Earth's surface are increasing and are expected to continue rising.
- Changes in precipitation - As average temperatures at the Earth's surface rise more evaporation occurs, which in turn can locally increase or decrease rainfall rates and duration. Therefore, a warming climate is expected to change precipitation patterns in many areas.
- Increasing storminess - Climate change is expected to enhance storminess by increasing sea surface temperatures, a key factor that influences their formation and behavior.
- Acidification - As the concentration of carbon dioxide in the atmosphere increases, so too does it increase in the ocean via absorption. Rising levels of carbon dioxide dissolved in the ocean negatively affect some marine life, because carbon dioxide reacts with sea water to produce carbonic acid. This lowers the pH of seawater, making it more acidic.
- Sea level rise – As the earth absorbs more heat, ice melts and the oceans warm. The addition of melting water and thermal expansion of ocean water causes sea level to rise.

The basis of this selection is further demonstrated in the following sections, which describe both historical and future conditions that have and are likely to continue putting assets of the IRL at risk to climate change.

Historical Condition

Changes in water and air temperatures, rainfall, storminess, coastal water pH (aka acidification), and sea level have all been occurring in the IRL region in recent decades. The following five sections provide information about how these environmental variables have changed. The most recent (4th iteration) of the National Climate Assessment (NCA4) from the United States Global Change Research Program (USGCRP 2017) was utilized extensively to assess historical climate trends in Florida. Where more local information was needed, figures were adapted or developed from raw data.

Warmer temperatures

At 156 miles, the length of the IRL encompasses several regions with distinct climatological characteristics. Temperatures statewide increased approximately 1°F since the beginning of the 20th century (Runkle et al. 2017). This Florida statewide trend is similar to the increases in average temperatures in the five counties that border the IRL (**Figure 4**). While there has been no discernable daytime warming, the frequency of very warm nights (minimum temperature above 75°F) has risen sharply: the number of very warm nights during the first part of the 21st century has nearly doubled compared to the mid-20th century (1930–1954; see **Figure 5**; Runkle et al. 2017).

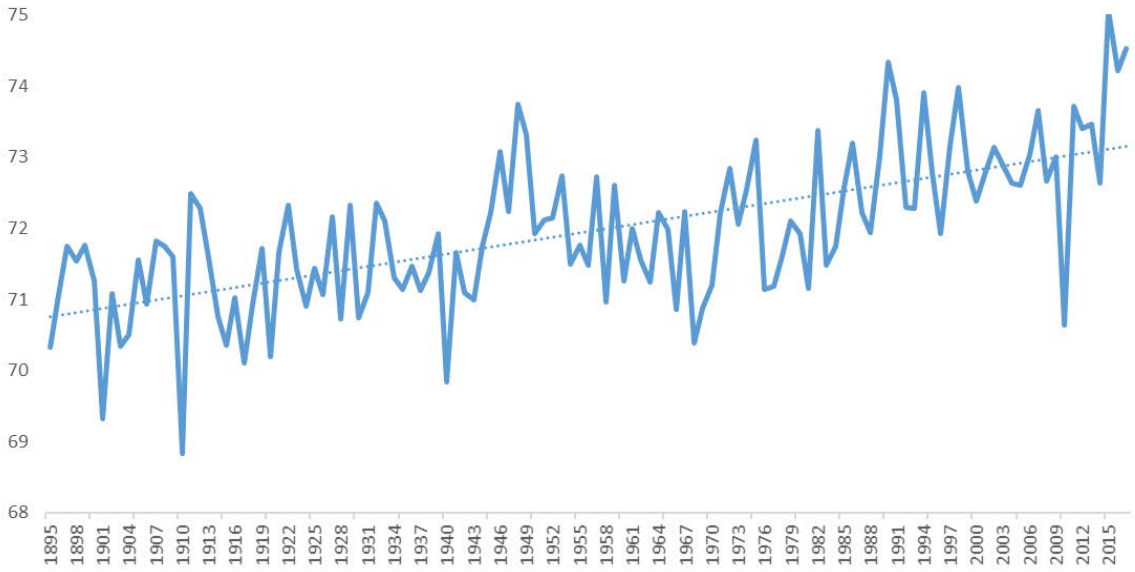


Figure 4. *Observed annual average temperatures for IRL watershed counties (1895-2017).*

Source: TBG Work Product, from NOAA nClimDiv dataset.

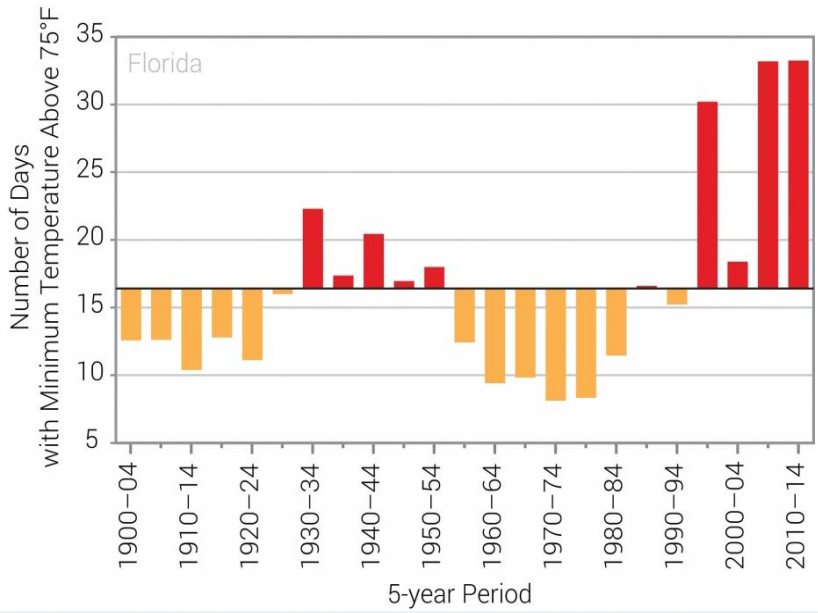


Figure 5. *Florida - observed number of nights above 75°F during 5-year periods from 1900-2014.*

Source: Runkle et al. 2017

The oceans have absorbed more than 90% of the heat associated with global atmospheric temperature increases. As a result, global sea surface temperatures (SST) have increased by about 1.3 °F per century from 1900 to 2016 (Jewett and Romanou 2017).

Changes in precipitation

Florida has experienced below average precipitation during the last decade (Runkle et al. 2017). Seasonal changes in the IRL watershed in recent decades indicate a tendency toward drier spring and fall conditions and increases in winter rainfall (**Figure 6**).

Changes in rainfall intensity may result in greater impacts to the IRL than changes in annual or seasonal totals, due to the potentially elevated sediment and pollutant loading resulting from extreme rain events. Historically, the number of high-intensity rain events (greater than 4 inches/day) in Florida has been highly variable; however, the highest number of days with more than 4 inches of rain occurred during the 2010–2014 period (Runkle et al. 2017). A study of regional changes in the daily rainfall amount associated with a 20-year storm found that in the Southeast U.S., it had increased by about 0.4 inches since the middle of the 20th century (Kunkel et al. 2013; **Figure 7**). Similarly, rain-gauge stations in the IRL watershed show there has been a substantial increase in extreme rains (>6 in/day) in the last 30 years compared to the previous 30-year period (Dourte et al.

2015; **Figure 8**). These observations suggest that high-intensity rain events are becoming more common.

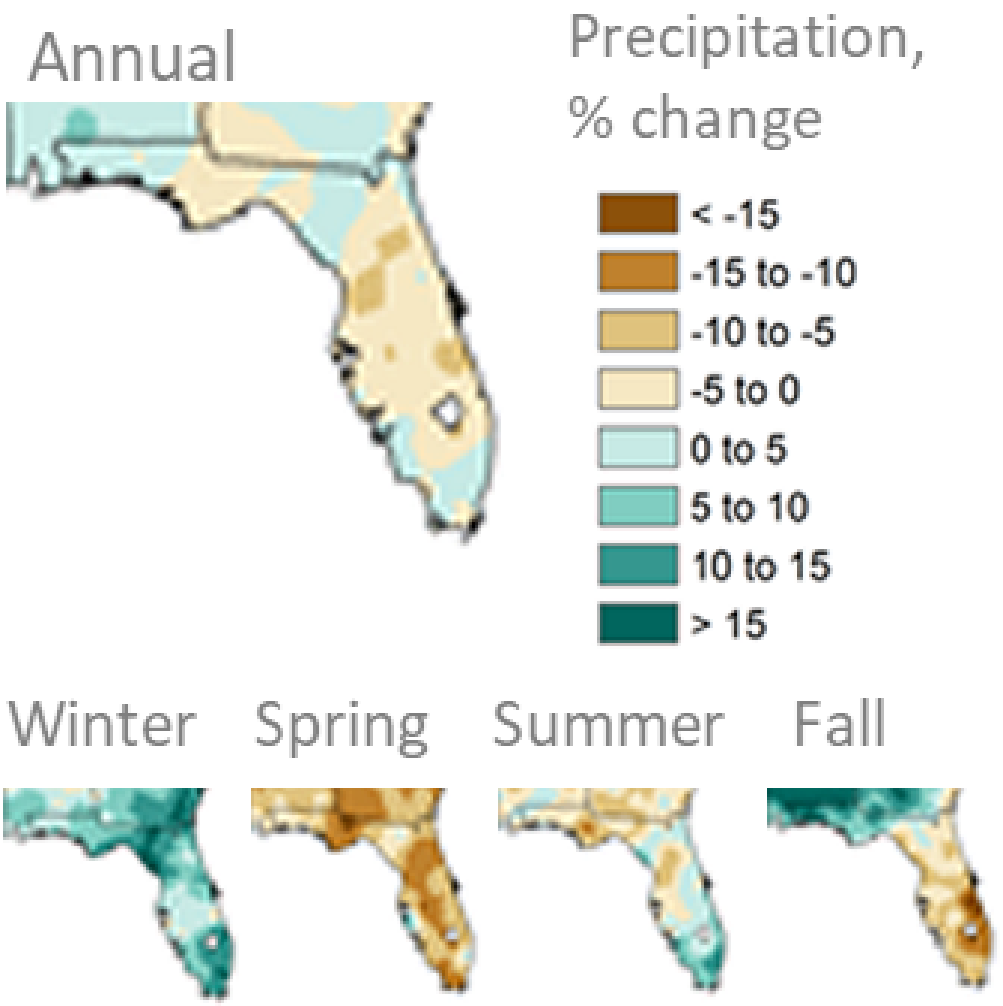


Figure 6. *Annual and seasonal percent change in rainfall amounts in Florida: recent period (1986-2015) minus early 20th century (1901-1960).*

Source: Adapted from Easterling et al. 2017

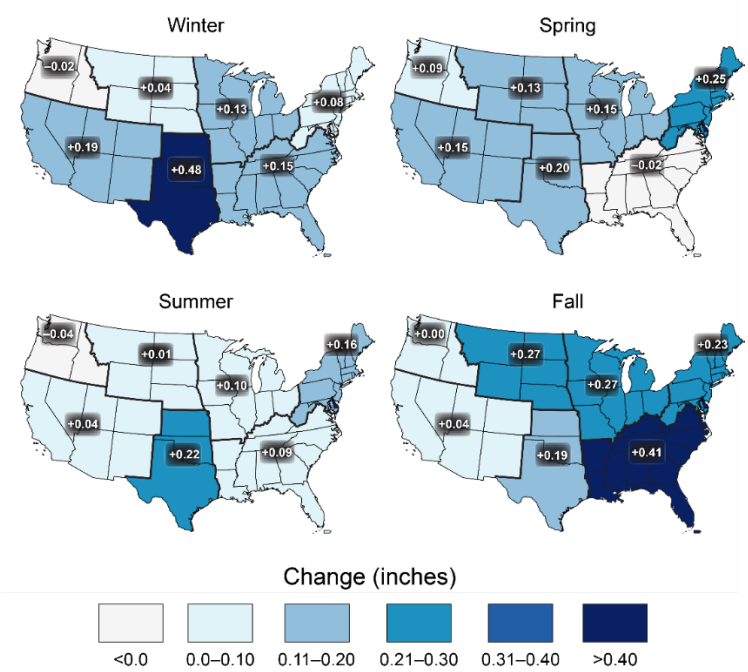


Figure 7. *Regional increases (from 1948-2015) in daily rainfall totals (inches) of a 20-year storm event.*

Source: Easterling et al. 2017.

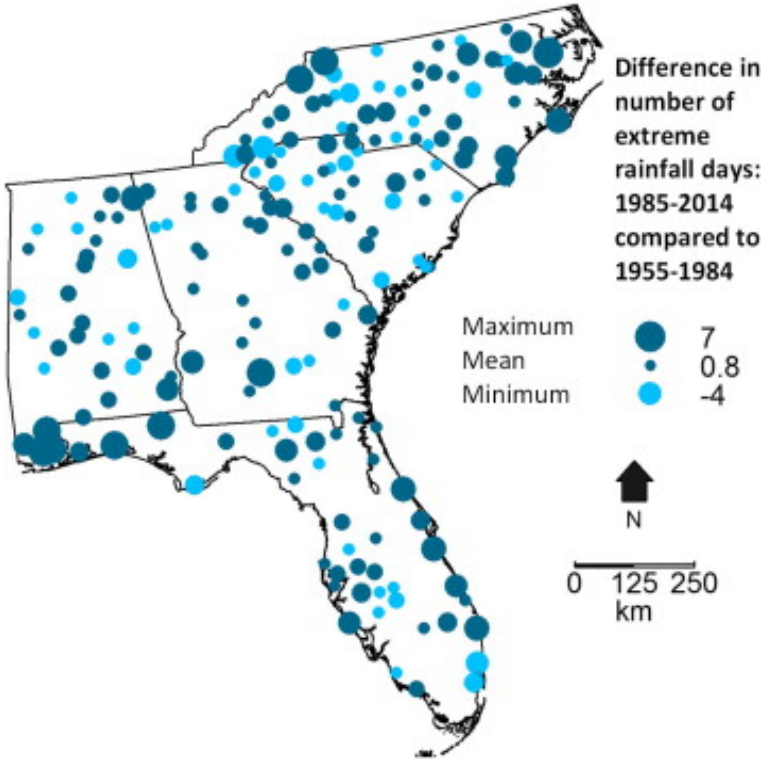


Figure 8. *Changes between 1985–2014 and 1955–1984 in numbers of extreme daily rain events.*

Source: Dourte et al. 2015

Note: Station-specific data; light-color dots correspond to decreases and dark-color dots correspond to increases in extreme rain events (> 6 in/day).

Increasing storminess

Storms cause erosion and flooding; both of which can have deleterious effects on the IRL watershed. Numerical modeling and the underlying theory both suggest that tropical cyclone (TC) activity should increase with rising atmospheric temperature, resulting in TCs of greater intensity in wind speeds and rainfall. However, the number of hurricane events to strike Florida from 1900-2017 (**Figure 9**) has not changed substantially over the last century (Runkle et al. 2017).

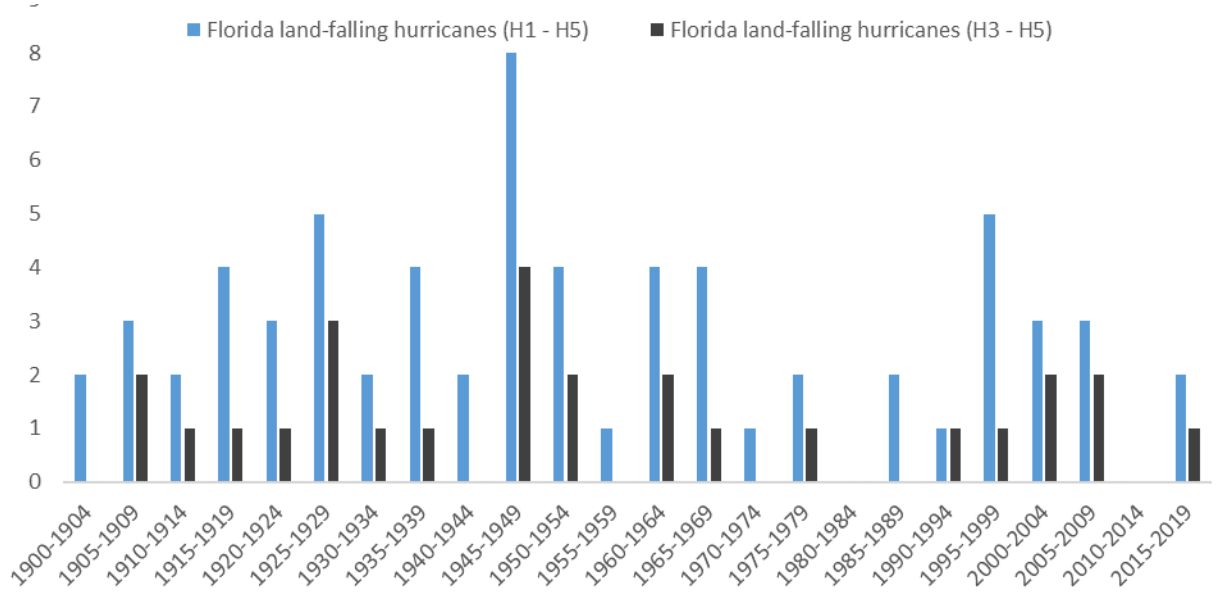


Figure 9. *Florida landfalling hurricanes, totals in 5-year increments, 1900-2017.*

Source: Adapted from Runkle et al. 2017, data from https://www.coast.noaa.gov/hurricanes/

Note: Category 1 to 5 hurricanes (blue); Category 3 to 5 hurricanes (gray).

In addition to tropical storms, severe convective storms and winter storms are also important extreme events in Florida's climate. Using tide gauges, one author determined that there has been a significant multi-decadal increase in the number of winter storms affecting the southeastern United States from the early to late 20th century (Thompson et al. 2013).

Acidification

Acidification of coastal and marine waters can place at risk some marine life; especially those species that depend upon calcified 'hard parts' (i.e., shells). A recent study compared pH, dissolved-oxygen, temperature, and salinity data from 10 Florida estuaries from 1980 to 2008 (Robbins and Lisle 2018). Collectively, eight out of the 10 estuaries – including the IRL – exhibited increasing acidification.

Sea level rise

Global sea level has risen about 8 inches since reliable record keeping began in 1880s. This increase is consistent with Florida water level records, which have recorded an

average annual increase of about 2 mm/yr. However, more recent data, based on satellite altimetry indicates the global average increase in sea level elevation since the early 1990s is now more than 3.0 mm/yr (Sweet et al. 2017). Records from the water level gauge at Fernandina Beach, Florida, (**Figure 10**) indicate an increase in height of about 10 inches since from 1897; an average annual increase of 2.1 mm/yr.

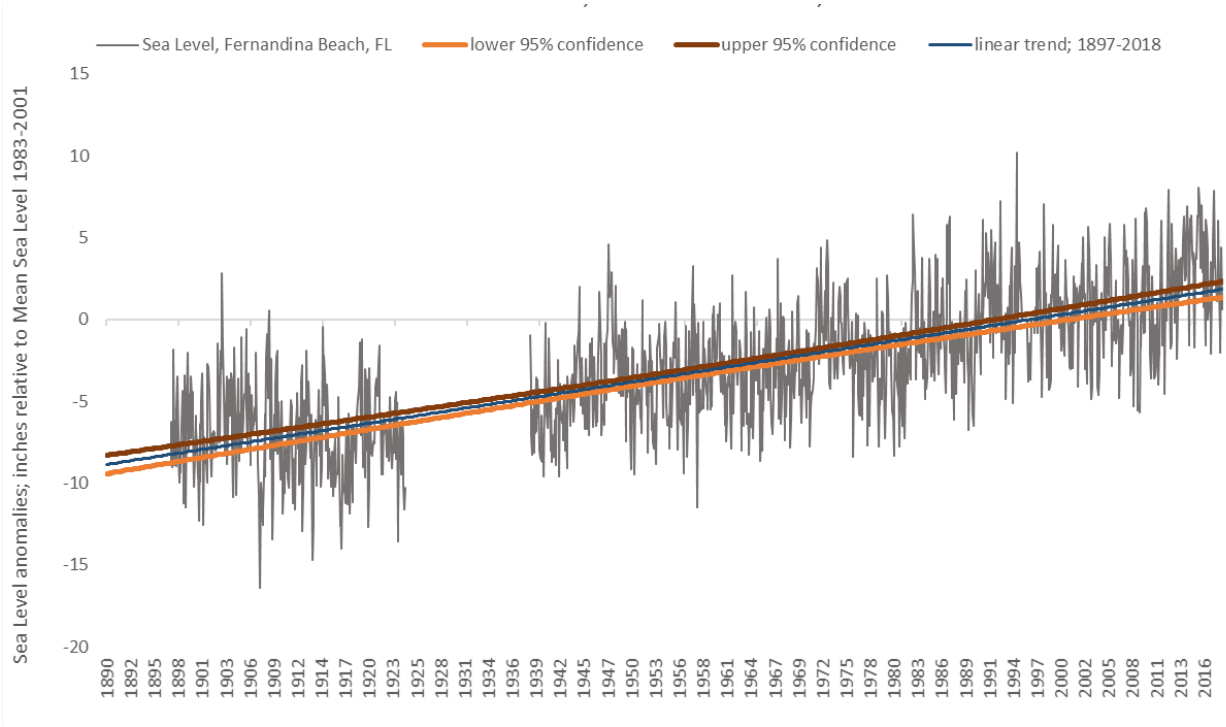


Figure 10. *Fernandina Beach, Florida, 1896-2017 anomalies in local sea level (inches)*

Source: NOAA tide gauge at Fernandina Beach, FL - Station ID: 8720030.

Note: Differences from the mean sea level datum for current tidal epoch (1983-2001).

Recent research has also identified the IRL as part of a global hotspot (Cape Hatteras to Miami) where sea level rise accelerates in bursts that last three to five years. The University of Florida determined that seas in the region rose nearly 10 times faster than the long-term rate and between 2011 and 2015 seas rose in the southeastern U.S. by more than six times the global average (http://news.ufl.edu/articles/2017/08/east-coasts-rapidly-rising-seas-explained.php).

Projected Future Condition

A summary of how each of the five climate stressors are forecast to change towards the end of the 21st century is described in the following sections. When possible, these are based upon regional assessments.

Warmer temperatures

Mean annual temperatures are projected to increase across the southeast United States throughout the balance of the 21st century (Runkle et al. 2017). By the end of the century,

temperatures across peninsula Florida are projected to be between 2°F and 11°F warmer than the 1901-1960 average (**Figure 11**). The greatest warming is projected to take place during the summer months. Maximum temperatures exceeding 95°F are expected to increase across the southeast, with the greatest increases in the southern half of Florida. In addition, the number of consecutive days exceeding 95°F, a metric used as a measure of heat waves, is expected to increase by at least 97%. An increase in the number of warm nighttime temperatures is also projected. Minimum temperatures below 10°F are expected to decrease in frequency by mid-century. The length of the freeze-free season is expected to increase as well. The combined and most relevant effects all of the changes on the IRL will be warmer water temperatures during both the summer and winter months, which may exert significant stress on native estuarine and coastal taxa.

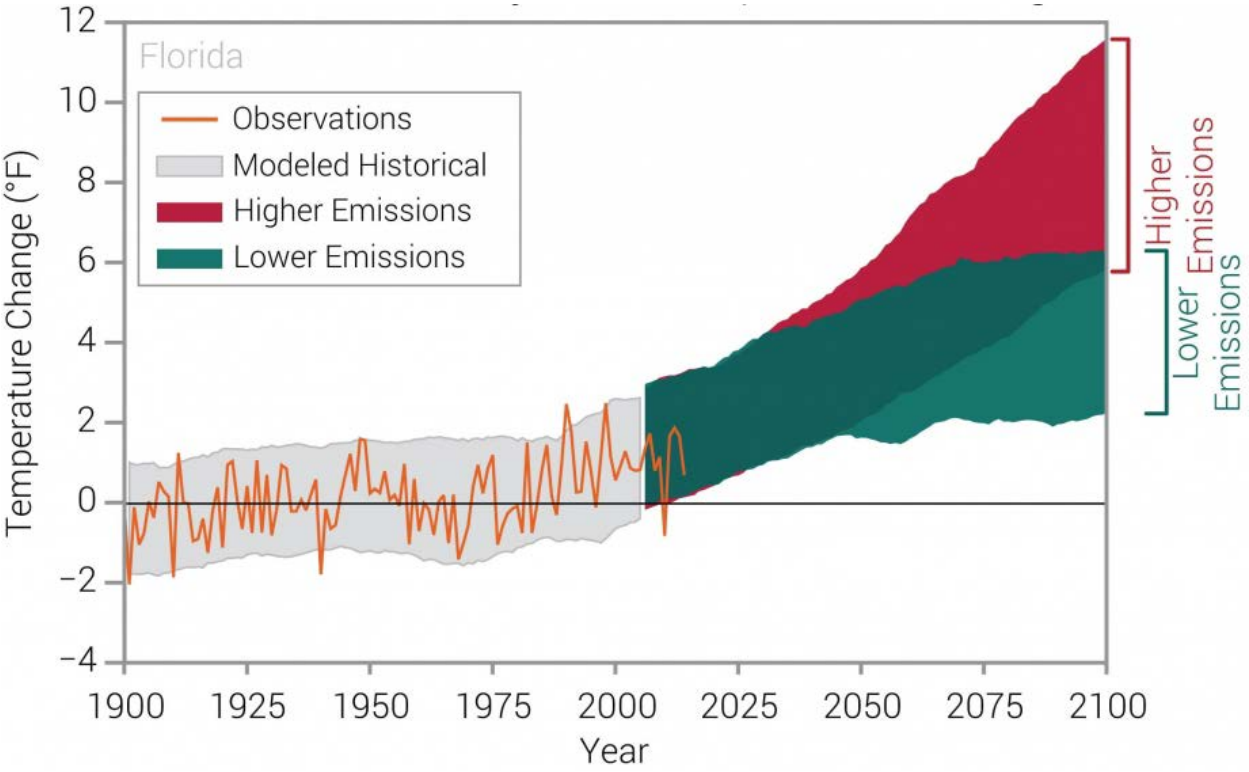


Figure 11. *Observed and projected changes in Florida temperatures compared to 1901-1960 average.*

Source: Runkle et al. 2017

Changes in precipitation

Precipitation is expected to increase by about 3% along the northern and central regions of the IRL as illustrated in **Figure 12** (Kunkel et al., 2013). No change from historical rainfall to a decrease of 3% is predicted in the south IRL. High-intensity rain events are projected to increase in Florida in the future. For example, even under a lower emissions scenario, the mid-century (2036-2065) and late-century (2071-2100) increases in the daily, 20-year rainfall amounts are projected to be 9% and 13%, respectively, in the Southeast U.S (**Figure 13**; Easterling et al. 2017). More frequent, high-intensity rainfall events will likely

result in an increase in the flux of fresh water and associated pollutants into the IRL, exerting evermore stress on native estuarine and coastal taxa.

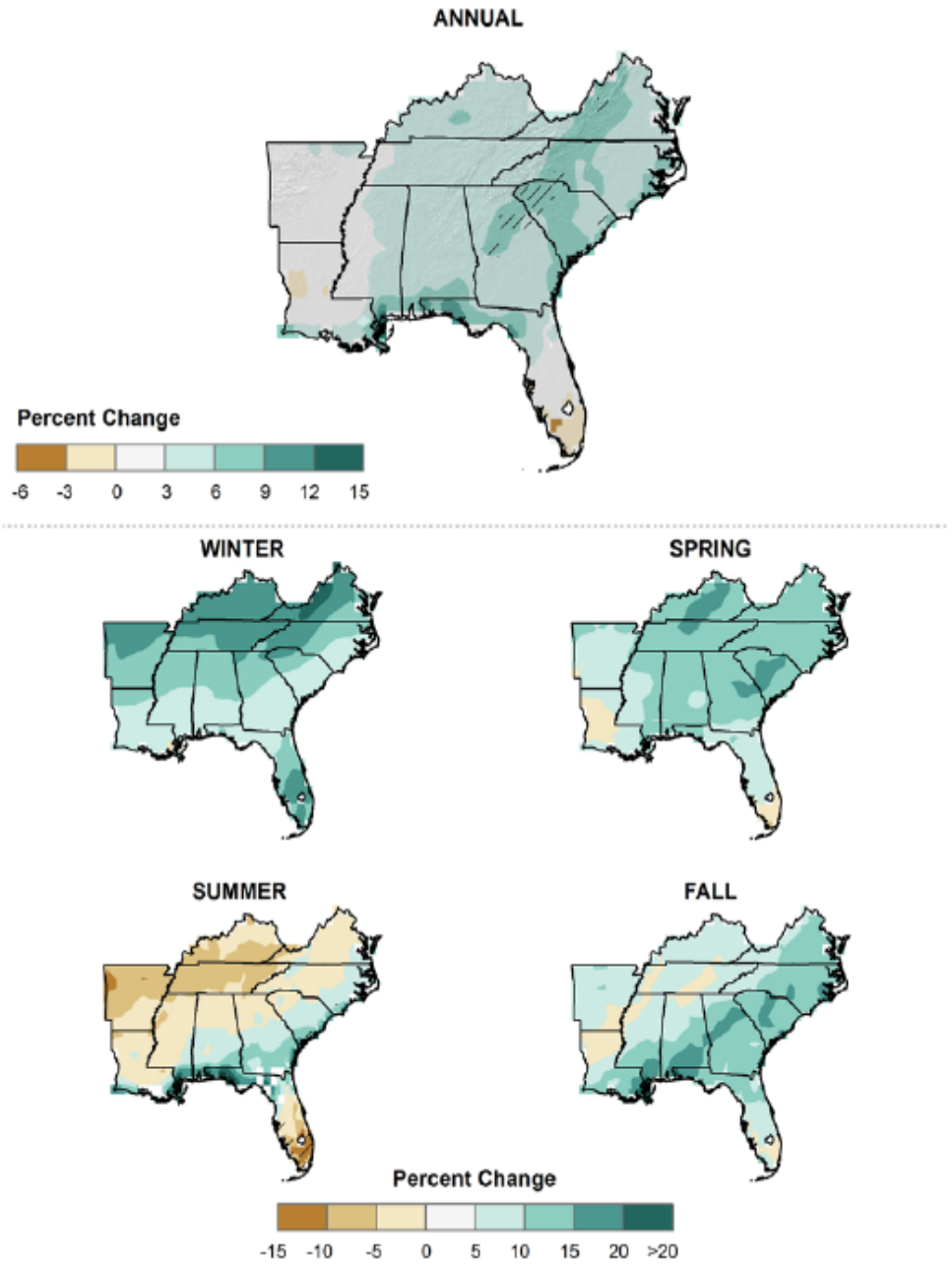


***Figure 12**. Simulated differences in annual and seasonal precipitation (%) by mid-century relative to reference period 1971 - 2000.*

Source: From Kunkel et al. 2013 using A2 (high) emissions scenario

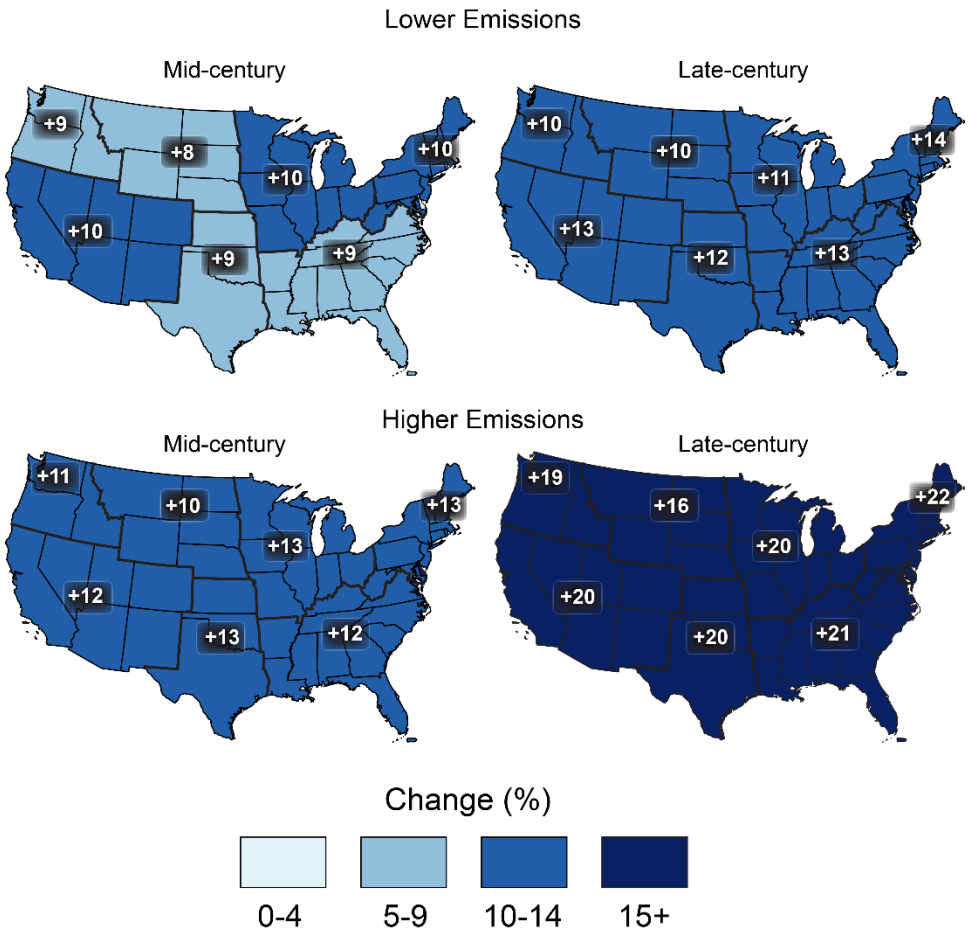


Figure 13. *Projected changes in the 20-year return period daily rainfall amount mid-century (left maps) and late-21st century (right maps) under lower and higher carbon dioxide emission scenarios.*

Source: Easterling et al. 2017

Increasing storminess

Hurricanes (c.f. **Figure 14**), tropical storms, and other intense rotating storms are grouped into this climate stressor category. When these encounter land, their intense rains, high winds, and associate storm surge can cause severe flooding and destruction. Recent modeling suggests storminess will become more intense over the 21st century (EPA, 2016; Ingram et al., 2013; Knutson et al., 2010). The combined and most relevant effects of increased storminess on the IRL will be an increase in the flux of freshwater (rainfall), erosion (waves and currents), flooding (storm surge), and destruction (rainfall, wind, waves, currents, storm surge) during event conditions. This may exert significant stress on native estuarine and coastal taxa.

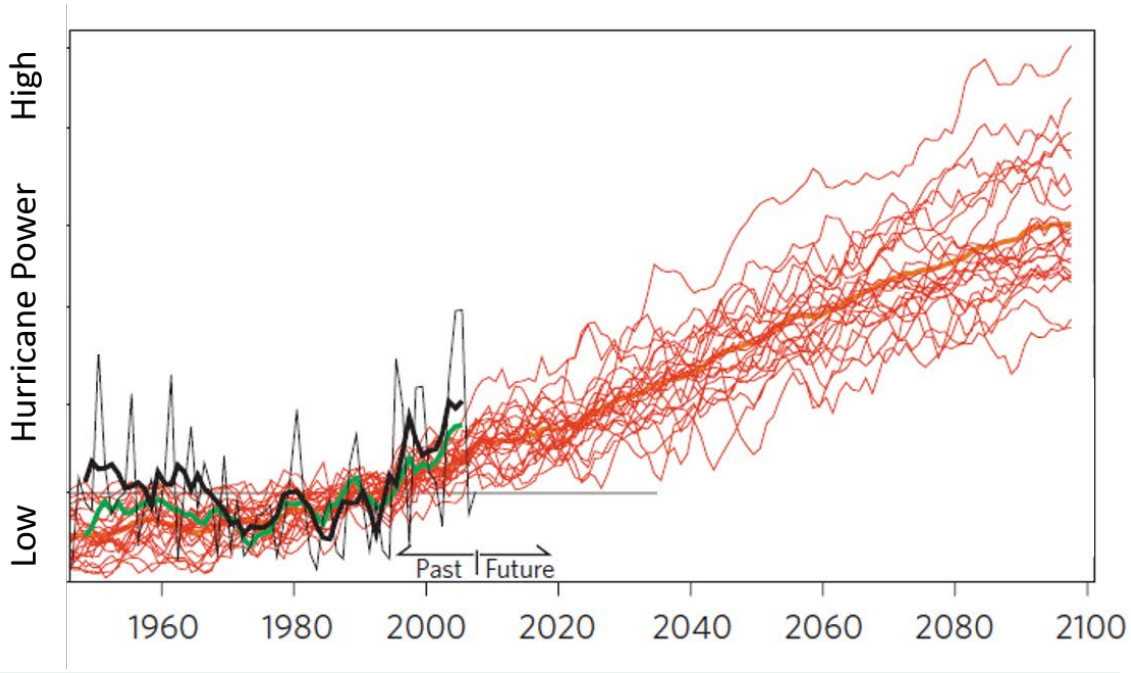


Figure 14. *Increasing hurricane power is forecast to accompany climate change throughout this century.*

Source: Modified from Knutson et al. 2010

Acidification

Carbon dioxide is predicted to increase throughout this century and so too is ocean acidity as illustrated in **Figure 15** (EPA, 2018). The increase in acidity makes it more difficult for shell fish and other calcifying taxa to produce and maintain their shells or exoskeletons. Hence, acidification can lead to changes in marine ecosystems, including finfish and shellfish populations and the people who depend on them.

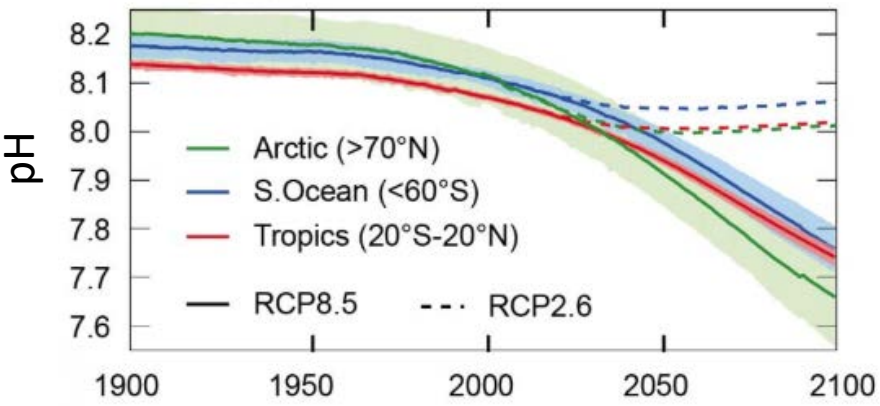


Figure 15. *Ocean acidification is projected to increase towards the end of this century.*

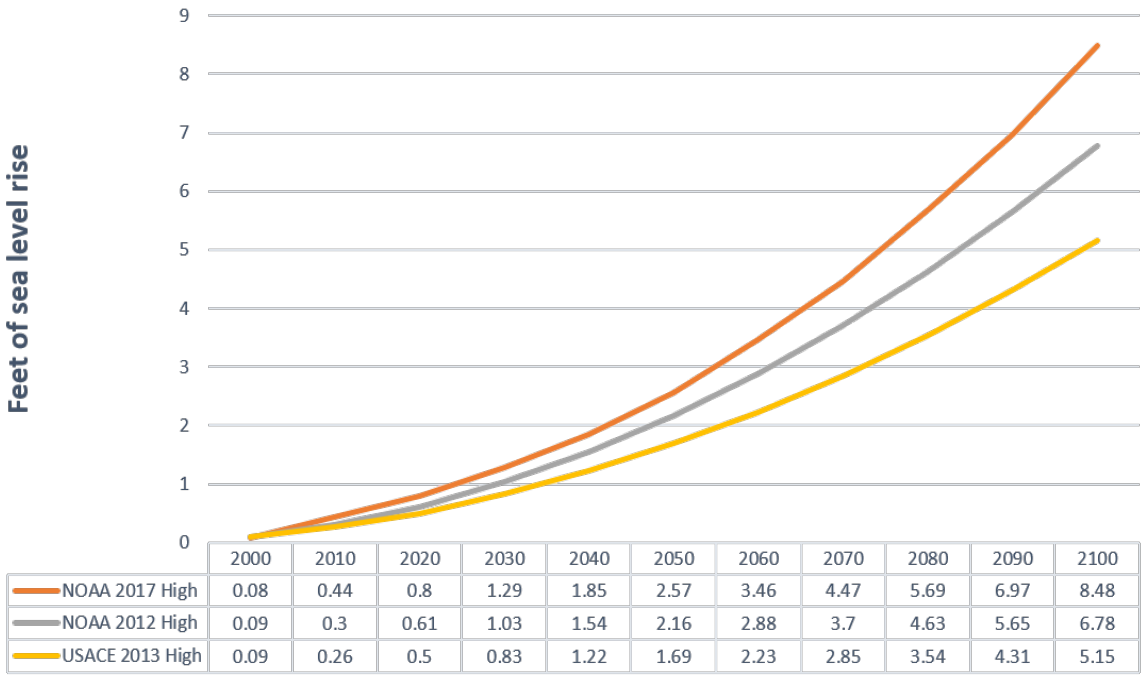
Source: Modified from EPA 2018

Sea level rise

As the temperature of the Earth changes, so does sea level elevation. Temperature and sea level are linked for two main reasons. First, rising temperatures cause glaciers and ice sheets to melt. This increases the volume of water in the ocean, which causes its level to rise. Second, as water warms, it expands slightly, causing an increase in elevation of sea level. This leads to the inundation of low-lying areas, shoreline erosion, and salt water intrusion. Higher sea level also makes coastal infrastructure more vulnerable to damage from storms due to an increased likelihood of flooding from higher storm surges. The most recent sea level rise scenarios (Sweet et al., 2017; USACE, 2013) applicable to the IRL suggest it will reach elevations of between 5 feet and 8.5 feet by the end of this century (**Figure 16**). These changes may exert significant stress on native estuarine and coastal taxa.

Summary of risks

Table 5 summarizes the risks identified during this step of the project. The risks poised to the IRL management goals (as proposed in the new CCMP) by the five climate stressors total 154. A detailed description of how each stressor influences each management goal is contained in **Appendix A - Risk Identification**.



	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
NOAA 2017 High	0.08	0.44	0.8	1.29	1.85	2.57	3.46	4.47	5.69	6.97	8.48
NOAA 2012 High	0.09	0.3	0.61	1.03	1.54	2.16	2.88	3.7	4.63	5.65	6.78
USACE 2013 High	0.09	0.26	0.5	0.83	1.22	1.69	2.23	2.85	3.54	4.31	5.15

Figure 16. *Sea level rise projections through 2100 based upon NOAA and USACE modeling.*

Table 5. *Number of potential risks to IRL management goals posed by five climate change stressors.*

Goal	Warmer temperature	Changes in precipitation	Increasing storminess	Acidification	Sea level rise	Sum
Sediment and Water Quality						
Wastewater	1	1	1	1	1	5
Surface water	3	1	1	1	2	8
Lagoon Hydrology	1	1	0	0	1	3
Marina and Boating Pollution	1	1	1	0	1	4
Atmospheric Deposition	1	1	1	0	0	3
Water Clarity	1	2	3	0	3	9
Dissolved Oxygen	3	2	3	0	2	10
Chlorophyll a	1	2	3	0	2	8
Legacy nutrient pollution	0	0	1	0	0	1
Sum	12	11	14	2	12	51
Natural Resources						
Biodiversity	3	3	3	1	3	13
Seagrass	4	3	3	1	2	13
Wetlands and impounded marshes	3	1	1	0	3	8
Rare, threatened, endangered species	4	3	3	1	3	14
Fisheries	3	3	3	1	2	12
Biotoxins, infectious agents, etc.	1	2	2	1	2	8
Exotic and invasive species	2	3	2	0	2	9
Living shorelines	1	1	1	1	1	5
Archeological resources	1	1	1	1	1	4
Sum	22	20	19	7	19	87
Stakeholder Engagement						
Public access	3	2	1	0	2	8
Public education and involvement	2	2	2	1	1	8
Sum	5	4	3	1	3	16
Grand Total	39	35	36	10	34	154

Step 4. Risk Analysis

The objective of this step was to make an initial determination of the consequence, likelihood, spatial scale, and urgency of the risks posed to the goals of the IRL NEP by the five climate stressors. Each risk was scored from 1 (low) to 3 (high) as shown in **Figure 17**.

Consequence	Spatial extent of impact
1. Low (could adjust, life will go on)	1. Site (bridge, stormwater outflow)
2. Medium	2. Place (wildlife refuge)
3. High (catastrophic, major disruption)	3. Region (watershed)

Likelihood	Time horizon
1. Low	1. > 10 years
2. Medium	2. 5-10 years
3. High (very likely, predictable)	3. Already occurring or < 5 years

Figure 17. *Risk analysis scoring matrix.*

Warmer temperatures

Results of the risk analysis to IRL sediment and water quality caused by rising air and water temperatures are shown in **Table 6**. Results of the risk analysis to IRL natural resources caused by rising air and water temperatures are shown in **Table 7**. Results of the risk analysis to IRL stakeholder engagement caused by rising air and water temperatures are shown in **Table 8**.

Changes in precipitation

Results of the risk analysis to IRL sediment and water quality caused by changes in precipitation are shown in **Table 9**. Results of the risk analysis to IRL natural resources caused by changes in precipitation are shown in **Table 10**. Results of the risk analysis to IRL stakeholder engagement caused by changes in precipitation are shown in **Table 11**.

Increasing storminess

Results of the risk analysis to IRL sediment and water quality caused by increasing storminess are shown in **Table 12**. Results of the risk analysis to IRL natural resources caused by increasing storminess are shown in **Table 13**. Results of the risk analysis to IRL stakeholder engagement caused by increasing storminess are shown in **Table 14**.

Acidification

Results of the risk analysis to IRL sediment and water quality caused by increasing acidification are shown in **Table 15**. Results of the risk analysis to IRL natural resources caused by increasing acidification are shown in **Table 16**. Results of the risk analysis to IRL stakeholder engagement caused by increasing acidification are shown in **Table 17**.

Sea level rise

Results of the risk analysis to IRL sediment and water quality caused by sea level rise are shown in **Table 18**. Results of the risk analysis to IRL natural resources caused by sea level rise are shown in **Table 19**. Results of the risk analysis to IRL stakeholder engagement caused by sea level rise are shown in **Table 20**.

Table 6. *Risks to sediment and water quality caused by warmer temperatures.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Increased pollutant loadings due to changes in solubility and/or toxicity caused by warmer temperature	1	1	2	2	6	Moderate
Surfacewater	Increased pollutant loadings (urban, rural) due to changes in solubility and/or toxicity caused by warmer temperature	2	3	2	2	9	Moderate
Surfacewater	Increased pollutant loadings due to increased use of chemical treatments in surface water storage and conveyance infrastructure to reduce more frequent algae blooms or expanding invasive plants caused by warmer temperature	1	1	2	2	6	Moderate
Surfacewater	Increased pollutant loadings due to increased maintenance (cuttings, chemical applications) of greenspace caused by warmer temperature	2	2	2	2	8	Moderate
Lagoon hydrology	Changes in thermohaline circulation due to warmer temperature	1	2	3	2	8	Moderate
Marina and Boat Pollution	Increased pollutant loadings from site runoff due to changes in solubility and/or toxicity caused by warmer temperature	1	1	1	2	5	Moderate
Atmospheric Deposition	Increased atmospheric deposition of nitrogen and other pollutants due to increasing demand for electricity caused by warmer temperature	1	2	3	2	8	Low
Water Clarity	Decreased clarity due to an increase in the growth rates and survival of algae and other taxa induced by warmer temperature	2	3	3	2	10	High
DO	Decreased DO solubility due to warmer temperature	3	3	3	3	12	High
DO	Decreased DO availability due to accelerated decomposition of organic matter caused by warmer temperature	1	3	3	2	9	Moderate
DO	Decreased DO availability due to more frequent algae blooms caused by warmer temperature	3	3	3	3	12	High
Chl a	Increased Chlorophyll a concentration due to more frequent algae blooms caused by warmer temperature	3	3	3	3	12	High

Table 7. *Risks to natural resources caused by warmer temperatures.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Increased habitat and species disruption due to warmer temperature	1	2	3	2	8	Moderate
Biodiversity	Increased habitat and species disruption due to elevated pollutant loadings caused by changes in solubility and/or toxicity induced by warmer temperature	1	2	3	2	8	Moderate
Biodiversity	Increased habitat and species disruption due to elevated pollutant loadings in surface water storage and conveyance infrastructure caused by caused by longer growing season induced by warmer temperature	2	2	2	2	8	Moderate
Seagrass	Increased habitat and species disruption due to warmer temperature	1	2	3	2	8	Moderate
Seagrass	Increased habitat and species disruption due to increased pollutant loading caused by changes in solubility and/or toxicity induced by warmer temperature	1	2	3	2	8	Moderate
Seagrass	Increased habitat and species disruption due to elevated pollutant loadings from surface water storage and conveyance infrastructure caused by warmer temperature	2	3	2	2	9	Moderate
Seagrass	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature	1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Increased habitat and species disruption due to warmer temperature	1	2	3	3	9	Moderate
Wetlands and Impounded Marshes	Increased habitat and species disruption due to changes in evapotranspiration	1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to warmer temperature	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature	1	2	3	2	8	Moderate

Table 7. *Risks to natural resources caused by warmer temperatures. (Continued)*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to lower oxygen availability cause by more frequent algae blooms induced by warmer temperature	1	2	3	2	8	Low
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to lower oxygen availability caused by accelerated growth and decay of invasive plants within basin induced by warmer temperature	1	2	3	2	8	Low
Fisheries	Increased habitat and species disruption due to warmer temperature	1	2	3	2	8	Moderate
Fisheries	Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature	1	2	3	2	8	Moderate
Fisheries	Increased habitat and species disruption due to lower oxygen availability cause by more frequent algae blooms induced by warmer temperature	1	2	3	2	8	Low
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health due to warmer temperature	2	2	3	2	9	Med
Exotic and invasive species	Accelerated spread of exotic and invasive species due to warmer temperature	1	2	3	2	8	Moderate
Exotic and invasive species	Accelerated spread of exotic and invasive species due to increased wildfires caused by warmer temperature	1	2	2	2	7	Moderate
Living shorelines	Increased habitat and species distribution due to warmer temperature	1	1	3	2	7	Moderate
Archeological resources	Increased biological and chemical degradation due to warmer temperature	1	1	3	2	7	Moderate

Table 8. *Risks to stakeholder engagement caused by warmer temperatures.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	Decreased recreational activities due to warmer temperature	1	1	3	2	7	Moderate
Public access	Decreased recreational activities due to accelerated spread of existing or new viral, bacterial, fungal, and parasitic infections caused by warmer temperature	2	2	3	3	10	High
Public access	Decreased recreational activities due to reduced water clarity caused by increased pollutant loadings	2	2	3	2	9	Moderate
Public education and involvement	Decreased volunteer participation in activities due to warmer temperature	1	1	3	2	7	Moderate
Public education and involvement	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues	1	1	3	2	7	Moderate

Table 9. *Risks to sediment and water quality caused by changes in precipitation.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Increased pollutant loadings from WWTP and OSTDS during high rainfall events	2	3	2	2	9	Moderate
Surfacewater	Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	3	10	Moderate
Lagoon hydrology	Changes in thermohaline circulation due to polyline conditions caused by intervals of higher rainfall and drought	1	2	3	2	8	Moderate
Marina and Boat Pollution	Increased pollutant loadings from site runoff during high rainfall events, especially after extended periods of drought	1	1	1	2	5	Moderate
Atmospheric Deposition	Increased atmospheric deposition of nitrogen and other pollutants during high rainfall events	1	2	3	2	8	Low
Water Clarity	Decreased clarity due to increased pollutant loadings from WWTP during high rainfall events	2	3	2	3	10	Moderate
Water Clarity	Decreased clarity due to increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	3	10	Moderate
DO	Increased pollutant loadings from WWTP and OSTDS high rainfall events	2	3	2	3	10	Moderate
DO	Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	3	10	Moderate
Chl a	Increased Chlorophyll a concentration due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	2	3	2	3	10	Moderate
Chl a	Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	3	10	Moderate
Legacy nutrients	na						

Table 10. *Risks to natural resources caused by changes in precipitation.*

Organizational goal	Climate Stressor	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	2	3	2	2	9	Moderate
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by high rainfall events	2	3	2	2	9	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	2	3	2	2	9	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	2	9	High
Wetlands and Impounded Marshes	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during high rainfall events	2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	2	9	Moderate

Table 11. *Risks to natural resources caused by changes in precipitation. (Continued)*

Organizational goal	Climate Stressor	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Fisheries	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Fisheries	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	2	3	2	2	9	Moderate
Fisheries	Changes in precipitation	Increased habitat and species disruption from surface water storage and conveyance infrastructure during high rainfall events	2	3	2	2	9	Moderate
Toxins, infectious agents, and other health threats	Changes in precipitation	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during high rainfall events	1	1	3	2	7	Moderate
Toxins, infectious agents, and other health threats	Changes in precipitation	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during high rainfall events	2	1	3	2	8	High
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive species due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive species from WWTP and OSTDS during high rainfall events	1	1	3	2	7	Moderate
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure during high rainfall events	1	1	3	2	7	Moderate
Living shorelines	Changes in precipitation	Increased habitat and species distribution due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	1	3	2	7	Moderate
Archeological resources	Changes in precipitation	Increased chemical degradation due to higher rainfall	1	1	3	2	7	Moderate

Table 11. *Risks to stakeholder engagement caused by changes in precipitation.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	Decreased recreational activities due to increased number of high rainfall events	1	1	3	2	7	Low
Public access	Decreased recreational activities due to increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	1	2	3	2	8	Moderate
Public education and involvement	Decreased volunteer participation in activities due to increased number of high rainfall events	1	1	3	2	7	Low
Public education and involvement	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	1	1	3	2	7	Moderate

Table 12. *Risks to sediment and water quality caused by increasing storminess.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Increased pollutant loadings from WWTP and OSTDS due to more frequent and intense storm events	2	3	2	3	10	Moderate
Surfacewater	Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events	2	3	2	3	10	High
Lagoon hydrology	na						
Marina and Boat Pollution	Increased pollutant loadings from access facilities and associated infrastructure due to increased coastal erosion caused by more frequent and intense storm events	1	2	1	2	6	High
Atmospheric Deposition	Increased atmospheric deposition of nitrogen and other pollutants due to more frequent and intense storm events	1	2	3	2	8	Low
Water Clarity	Decreased clarity due to erosion of seabed and shoreline caused by more frequent and intense storm events	1	2	2	2	7	High
Water Clarity	Decreased clarity due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events	2	3	2	3	10	High
Water Clarity	Decreased clarity due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events	2	3	2	3	10	High
DO	Decreased DO availability due to erosion of seabed and shoreline caused by caused by more frequent and intense storm events	1	2	2	2	7	High
DO	Decreased DO availability due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	High
DO	Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events	2	3	2	3	10	High
Chl a	Increased Chlorophyll a concentration due to erosion of seabed and shoreline caused by more frequent and intense storm events	1	2	2	2	7	Moderate
Chl a	Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	Moderate
Ch a	Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events	2	3	2	3	10	Moderate

Table 13. *Risks to natural resources caused by increasing storminess.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events	1	2	3	2	8	Moderate
Biodiversity	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	Moderate
Biodiversity	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events	2	3	2	2	9	Moderate
Seagrass	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events	1	2	3	2	8	Moderate
Seagrass	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	Moderate
Seagrass	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events	2	3	2	2	9	Moderate
Wetlands and Impounded Marshes	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events	2	3	3	2	10	High
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events	2	3	2	2	9	Moderate
Fisheries	Increased habitat and species disruption due to seabed and shoreline erosion caused by more frequent and intense storm events	1	2	3	2	8	Moderate
Fisheries	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events	2	3	2	2	9	Moderate

Table 14. *Risks to natural resources caused by increasing storminess (continued)*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Fisheries	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events	2	3	2	2	9	Moderate
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during more frequent and intense storm events	2	1	2	2	7	High
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during more frequent and intense storm events	1	1	2	2	6	High
Exotic and invasive species	Accelerated spread of exotic and invasive species from WWTP and OSTDS during more frequent and intense storm events	1	1	2	2	6	Moderate
Exotic and invasive species	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure during more frequent and intense storm events	1	1	2	2	6	Moderate
Living shorelines	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events	2	3	3	3	11	Moderate
Archeological resources	Increased physical and chemical degradation due to shoreline erosion and flooding during more frequent and intense storm events	2	3	3	2	10	High

Table 14. *Risks to stakeholder engagement caused by increasing storminess.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	Decreased recreational activities, especially boating related, due to failure of infrastructure caused by more frequent and intense storm events	2	2	3	2	9	Moderate
Public education and involvement	Decreased volunteer participation in activities due to more frequent and intense storm events	1	1	3	2	7	Low
Public education and involvement	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	1	1	3	2	7	Moderate

Table 15. *Risks to sediment and water quality caused by acidification.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification of lagoon water	1	1	2	2	6	Moderate
Surfacewater	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification	1	1	2	2	6	Moderate
Lagoon hydrology	na						
Marina and Boat Pollution	na						
Atmospheric Deposition	na						
Water Clarity	na						
DO	na						
Chl a	na						
Legacy nutrients	na						

Table 16. *Risks to natural resources caused by acidification.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	1	3	3	2	9	High
Seagrass	Decreased vitality of calcifying organisms (i.e., shellfish, epiphytes) and other habitat dependent taxa due to more acidic conditions	1	3	3	2	9	High
Wetlands and Impounded Marshes	na					na	
Rare, threatened, endangered, and SOSC	Decreased vitality of calcifying organisms (i.e., shellfish, epiphytes) and other habitat dependent taxa due to more acidic conditions	1	3	3	2	9	High
Fisheries	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	1	3	3	2	9	High
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health due to more acidic conditions	1	1	3	2	7	Moderate
Living shorelines	Increased habitat and species disruption due to more acidic conditions	1	1	3	2	7	Moderate
Archeological resources	na						

Table 17. *Risks to stakeholder engagement caused by increasing acidification.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	na						
Public education and involvement	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues	1	1	3	2	7	Low

Table 18. *Risks to sediment and water quality caused by sea level rise.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Increased pollutant loadings from WWTP and OSTDS due to rising water table and sea level (inundation, erosion)	2	3	2	2	9	High
Surfacewater	Increased pollutant loadings due to higher water table caused by sea level rise	1	1	2	2	6	Moderate
Surfacewater	Increased pollutant loadings due from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	3	10	High
Lagoon hydrology	Changes in circulation, groundwater and surface water hydrology due to rising water table and sea level (inundation, erosion)	2	3	3	2	10	High
Marina and Boat Pollution	Increased pollutant loadings due to failure of pump out facilities, portable toilet dump stations, fuel stations, and rest rooms caused by rising water table and sea level (inundation, erosion)	1	2	1	2	6	High
Atmospheric Deposition	na						
Water Clarity	Decreased clarity due to erosion of shoreline caused by sea level rise	1	2	2	2	7	High
Water Clarity	Decreased clarity due to increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)	2	3	2	3	10	High
Water Clarity	Decreased clarity due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	3	10	High
DO	Decreased DO availability due to Increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)	2	3	2	3	10	High
DO	Decreased DO availability due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	1	8	High
Chl a	Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Chl a	Increased Chlorophyll a concentration due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	3	10	Moderate
Legacy nutrients	na						

Table 19. *Risks to natural resources caused by sea level rise.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	2	3	2	2	9	High
Biodiversity	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	1	3	2	2	8	Moderate
Biodiversity	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	1	3	3	2	9	Moderate
Seagrass	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS in response to rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Seagrass	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure in response to rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Wetlands and Impounded Marshes	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	2	3	3	2	10	High
Wetlands and Impounded Marshes	Increased habitat and species disruption due to upland barriers to existing wetland migration into upland areas during sea level rise	3	3	3	2	11	High
Wetlands and Impounded Marshes	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature	1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	1	3	3	2	9	Moderate

Table 19. *Risks to natural resources caused by sea level rise. (continued)*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Fisheries	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (i.e., inundation, erosion)	2	3	2	2	9	Moderate
Fisheries	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	2	3	2	2	9	Moderate
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	2	2	2	2	8	Moderate
Toxins, infectious agents, and other health threats	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	1	1	2	2	6	Moderate
Exotic and invasive species	Accelerated spread of exotic and invasive species from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	1	1	2	2	6	Moderate
Exotic and invasive species	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure caused by rising water table and sea level (erosion and inundation)	1	1	2	2	6	Moderate
Living shorelines	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	2	3	3	2	10	High
Archeological resources	Increased physical and chemical degradation due to rising water table and sea level (inundation, erosion)	2	3	3	2	10	High

Table 20. *Risks to stakeholder engagement caused by sea level rise.*

Organizational goal	Risk	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	Decreased access due flooding of land or access infrastructure caused by rising water table and sea level	2	2	3	2	9	Moderate
Public access	Decreased access due increased presence of navigational obstacles caused by rising sea level	2	3	3	2	10	High
Public education and involvement	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	1	1	3	2	7	Moderate

Step 5. Evaluation

The objective of this step was to develop a consequence/probability matrix prioritizing risks most likely to impact the management goals and objectives (aka Action Plans) of the IRLNEP. Prioritization was based upon the preliminary score of each assessed risk (Step 4). The risks posed to each goal (i.e., sediment and water quality, natural resources, stakeholder engagement) and associated objectives were then sorted by the corresponding preliminary score and prioritized as either higher, high, or moderate. In some cases, a climate stressor had a beneficial outcome or caused no risk to the objective. Neither of these were considered in the risk evaluation. The higher the score, the greater the consequence, likelihood, spatial extent, and urgency of the risk. Scores of 0-6 posed the least risk and were characterized as a moderate priority. Scores of 9 – 12 posed the greatest risk and were characterized as highest priority. Scores of 7 – 8 were characterized as high priority. Scoring and prioritization was initially completed by the project team and then made available to stakeholders for review and comment. The results of this collaboration and prioritization are summarized in **Table 21**. Detailed results of this step are included as **Appendix B – Risk Evaluation**.

Risks to sediment and water quality goal and objectives

With regard to the IRLNEP goal of improving sediment and water quality, the management objectives at greatest risk to climate change are those associated with the water column: reduction in water clarity, lowering of DO, and elevating Chl a (**Table 21**). Also at risk are objectives formulated to mitigate pollutant loading into the basin from the surrounding watershed: wastewater (WWTP, OSTDS), and surface water (stormwater, freshwater). Least compromised are management goals related to lagoon hydrology, marina and boating pollution, atmospheric deposition, and legacy nutrient pollution. Four of the five climate stressors were determined to exert similar level of risk to the sediment and water quality management goals of the IRLNEP (**Figure 18**).

Risks to natural resource goal and objectives

With regard to the IRLNEP natural resources goal, the management objectives at greatest risk to climate change are biodiversity, seagrass, rare (etc.) species, and fisheries (**Table 21**). At slightly less risk are goals related to wetlands, health, and exotic species. Least compromised are management goals associated with living shorelines and archeological resources. The magnitude of risk to the natural resource objectives of the IRLNEP caused by climate change (**Figure 19**) are greater than those to sediment and water quality (**Figure 20**), but these too are similarly distributed amongst four of the five stressors.

Table 21. *Prioritization of risks to IRLNEP management goals and objectives caused by climate change.*

Goal	Warmer temperature			Changes in precipitation			Increasing storminess			Acidification			Sea level rise			Sum
Sediment and Water Quality	Higher	High	Moderate	Higher	High	Moderate	Higher	High	Moderate	Higher	High	Moderate	Higher	High	Moderate	
Dissolved Oxygen	3			2			2	1					2			10
Water Clarity	1			2			2	1					2	1		9
Surface water	1	1	1	1			1					1	1	1		8
Chlorophyll a	1			2			2	1					2			8
Wastewater			1	1			1					1	1			5
Marina and Boating Pollution			1			1			1						1	4
Lagoon Hydrology		1			1								1			3
Atmospheric Deposition		1			1			1								3
Legacy nutrient pollution								1								1
Sum	6	3	3	8	2	1	8	5	1	0	0	2	9	2	1	51
Natural Resources																
Biodiversity		3		2	1		2	1		1			2	1		13
Seagrass	1	3		2	1		2	1		1			2			13
Wetlands and impounded marshes	1	2			1		1						2	1		8
Rare, threatened, endangered species		4		2	1		2	1		1			3			14
Fisheries		3		2	1		2	1		1			2			12
Toxins, infectious agents, etc.	1				2			1	1		1			1	1	8
Exotic and invasive species		2			3				2						2	9
Living shorelines		1			1		1			1			1			5
Archeological resources		1		1			1			1			1			5
Sum	3	19	0	9	11	0	11	5	3	6	1	0	13	3	3	87
Stakeholder Engagement																
Public access	2	1			2		1						2			8
Public education and involvement		2			2			2			1			1		8
Sum	2	3	0	0	4	0	1	2	0	0	1	0	2	1	0	16
Grand Total	**11**	**25**	**3**	**17**	**17**	**1**	**20**	**12**	**4**	**6**	**2**	**2**	**24**	**6**	**4**	**154**

Risks to stakeholder engagement goal and objectives

The two management objectives associated with stakeholder engagement will likely be equally impacted by climate change with regards to the number of stressors (**Table 21**). However, the magnitude of risk to public access is higher than education and involvement. The number of risks to the stakeholder engagement goals of the IRLNEP caused by climate change is lower than the other two management goals and associated primarily with increasing temperatures and storminess (**Figure 21**).

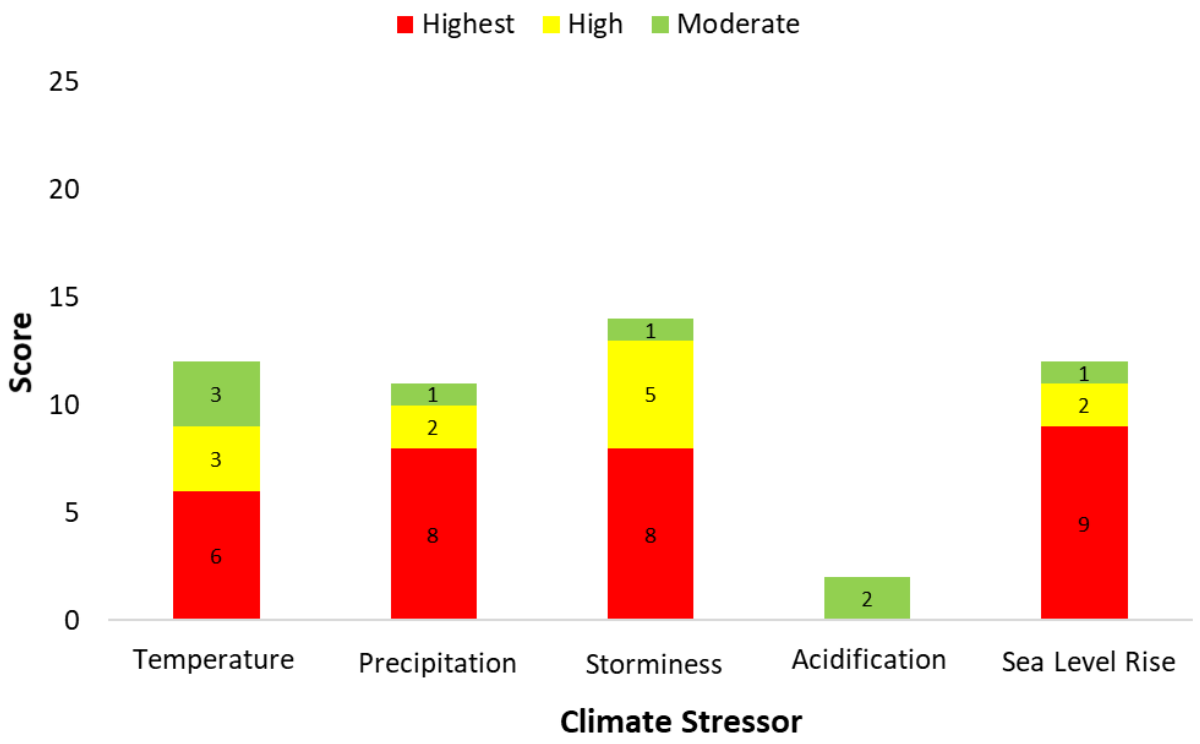


Figure 18. *Magnitude of risk to sediment and water quality goals caused by five climate change stressors.*

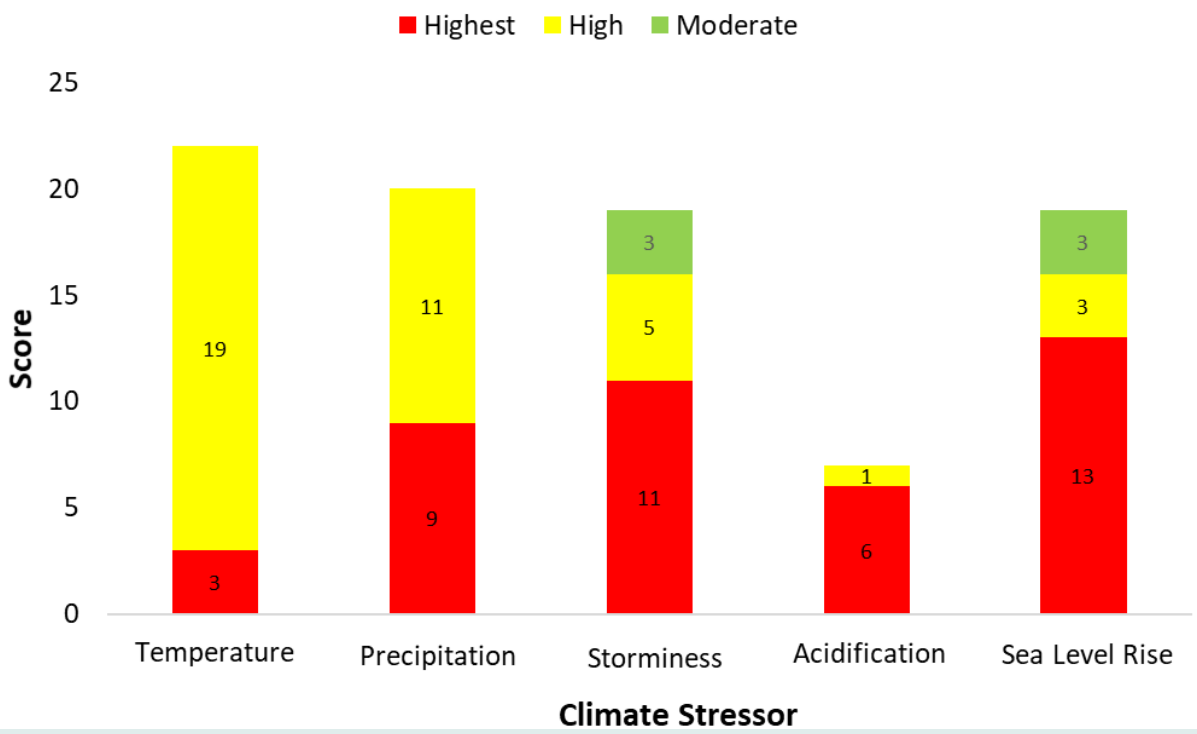


Figure 19. *Magnitude of risk to natural resource goals caused by five climate change stressors.*

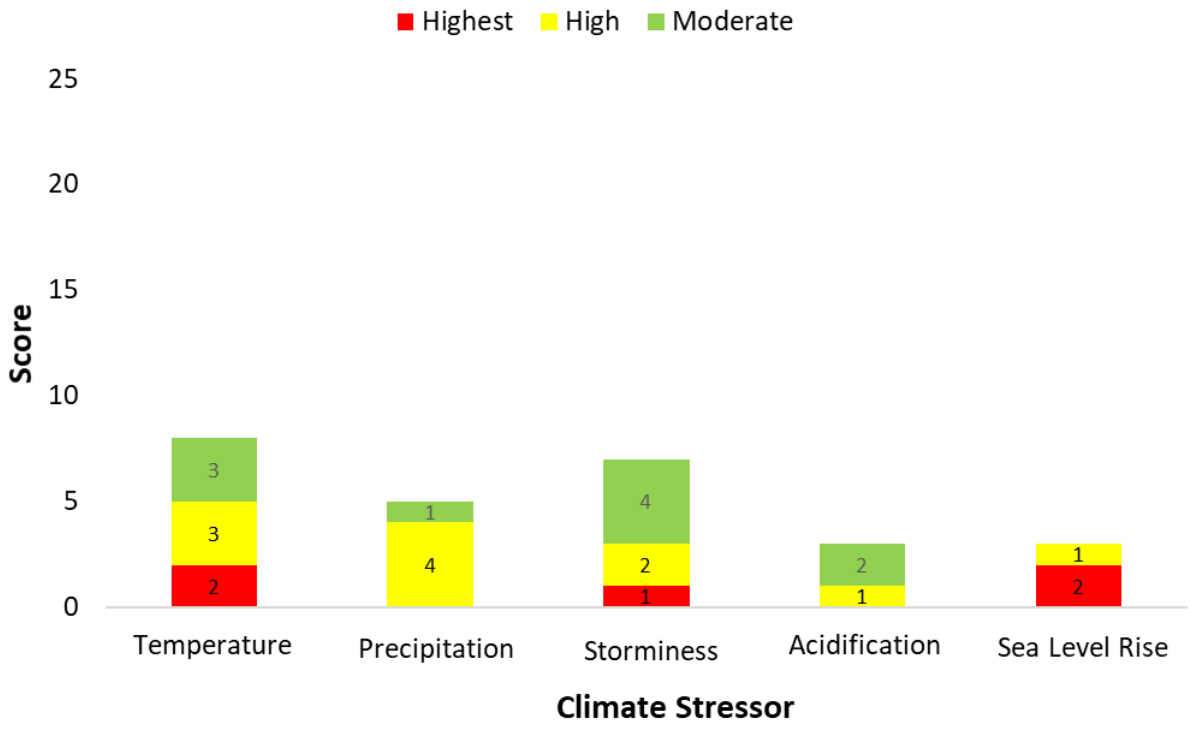


Figure 20. *Magnitude of risk to stakeholder engagement goals caused by five climate change stressors*

DISCUSSION

This project evaluated 20 IRLNEP management objectives, organized under three goals, at risk to five climate change stressors. A total of 154 risks were identified (**Table 21**). The scoring, ranking, and prioritization conducted during this project (Phase I) were designed to provide guidance during the revision of the current CCMP (2008) and formulation of specific new Action Plans to mitigate risks to the IRLNEP caused by climate change (i.e., Phase II).

The results of this risk evaluation were also informed by stakeholder comments and suggestions as described in Step 1 and summarized in **Appendix C – Results of Real-Time Polling.** This included input provided by real-time polling during stakeholder meetings. A comparison between the project team and stakeholder risk priorities to sediment and water quality and natural resources is illustrated in **Figure 21**. The diagonal line represents a 1:1 match: risks plotted above the line identify stakeholder priorities ranked higher than the project team; risks plotted below the line identify stakeholder priorities ranked lower than the project team.

Key to Figure 21	
BD	Biodiversity
DO+ Chl a	Dissolved oxygen and Chlorophyll a
F	Fisheries
LH	Lagoon hydrology
LNP	Legacy nutrient pollutants
LS	Living shorelines
SD	Surface water discharge
SG	Seagrass
T&E	Rare, threatened, endangered species
TX	Toxins, health threats
WET	Wetlands
WC	Water clarity
WTF	Wastewater treatment facilities

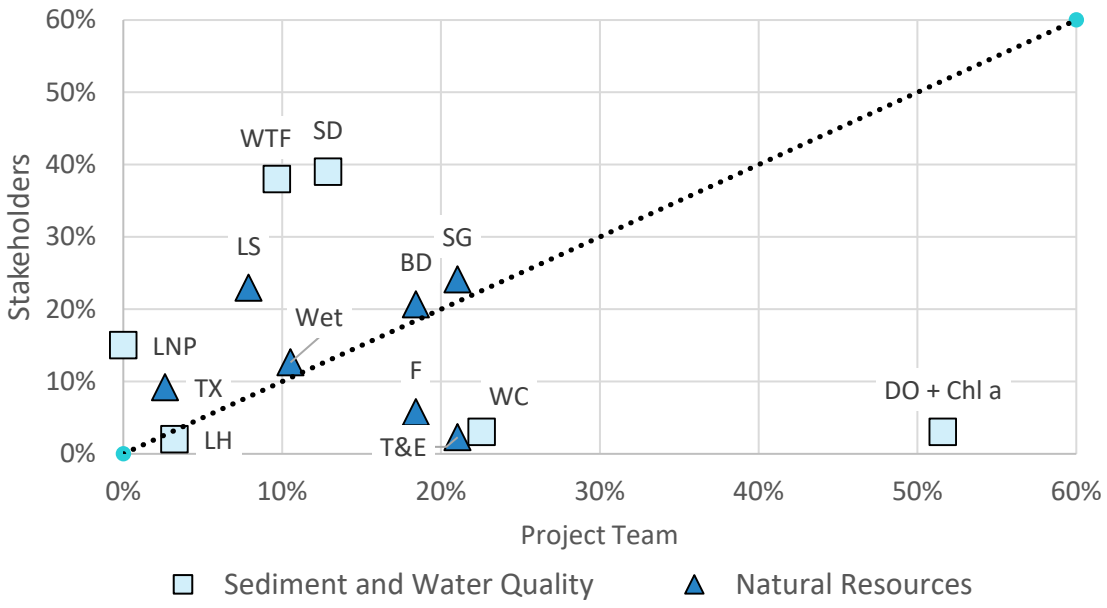


Figure 21. *Comparison between project team and stakeholder risk priorities as identified in real-time polling.*

There is a low negative correlation (-0.34) between the priority risks to sediment and water quality as identified by the project team and stakeholder groups. Inspection of risk priorities organized as a function of the county from which the stakeholder works (**Figure 22**) reveals distinctly different preferences as a function of geographic identity. This in turn likely correlates to regional distinctions in watershed geomorphology, infrastructure, land use, and etc. There is no correlation (-0.04) between the priority risks to natural resources identified by the project team and stakeholders. Again, this can be attributed to differences in geographic identity and regional differences within the watershed (**Figure 23**).

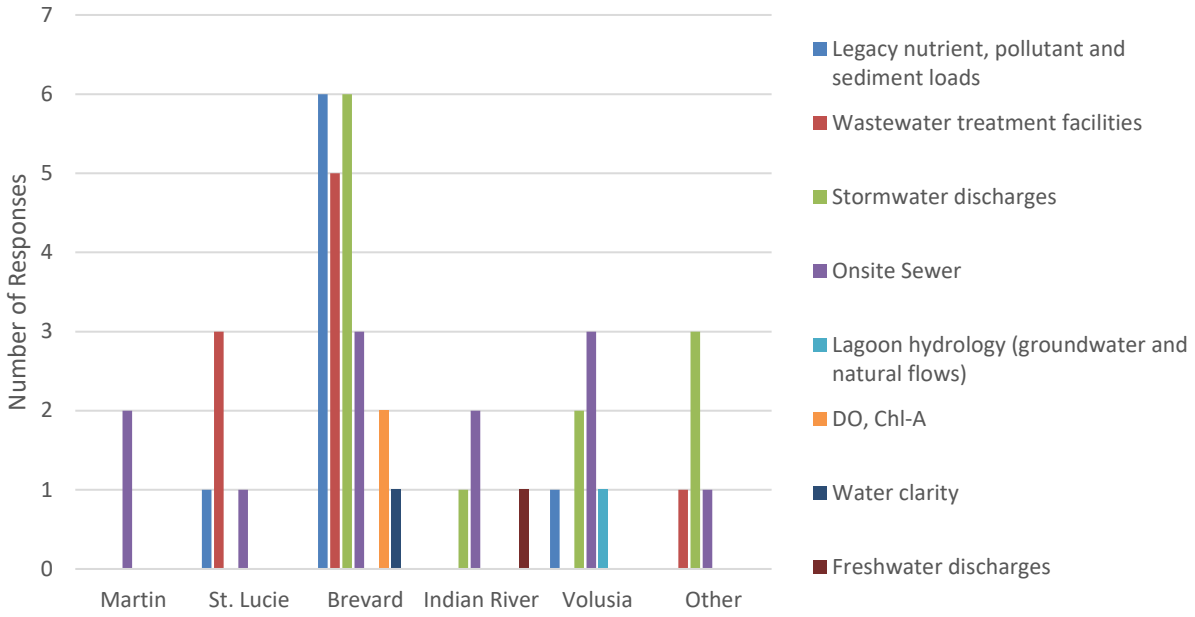


Figure 22. *Priority risks to water and sediment quality as a function of stakeholder identity.*

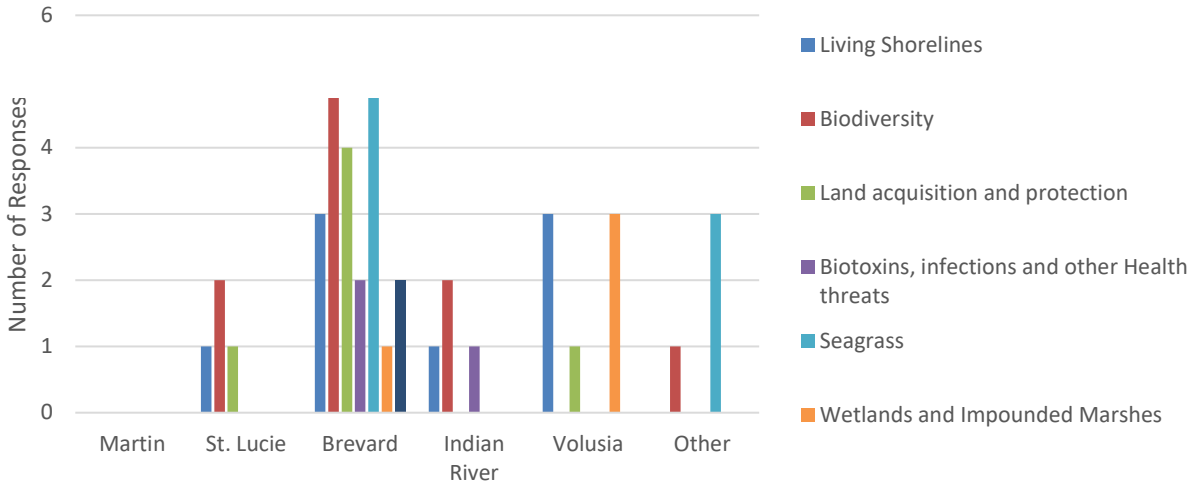


Figure 23. *Priority risks to natural resources as a function of stakeholder geographic identity.*

A comparison between the project team and stakeholder prioritization of climate stressors likely to impact to sediment and water quality and natural resources is illustrated in **Figure 24**. There is a strong positive correlation (0.69) between the priority climate stressors to sediment and water quality as identified by the project team and stakeholder groups **(Figure 24)**.

Inspection of climate stressors to sediment and water quality organized as a function of the county from which the stakeholder works (**Figure 25**) reveals their preferences are not a function of geographic identity. This in turn likely indicates stakeholder views regarding the potential effects of climate change stressors on sediment and water quality are equally applicable to the entire watershed and hence the strong positive correlation. There is also a strong positive correlation (0.72) between the climate stressors to natural resources identified by the project team and stakeholders (**Figure 24)**. Again, this likely indicates stakeholder views regarding the potential effects of climate change stressors on natural resources are equally applicable to the entire watershed (**Figure 26**).

Given the limited number of options, comparison between the project team and stakeholder prioritization of stakeholder engagement was not conducted.

Key to Figure 24	
Acid	Acidification
Ppt	Precipitation
SLR	Sea level rise
Storm	Storminess
Temp	Temperature

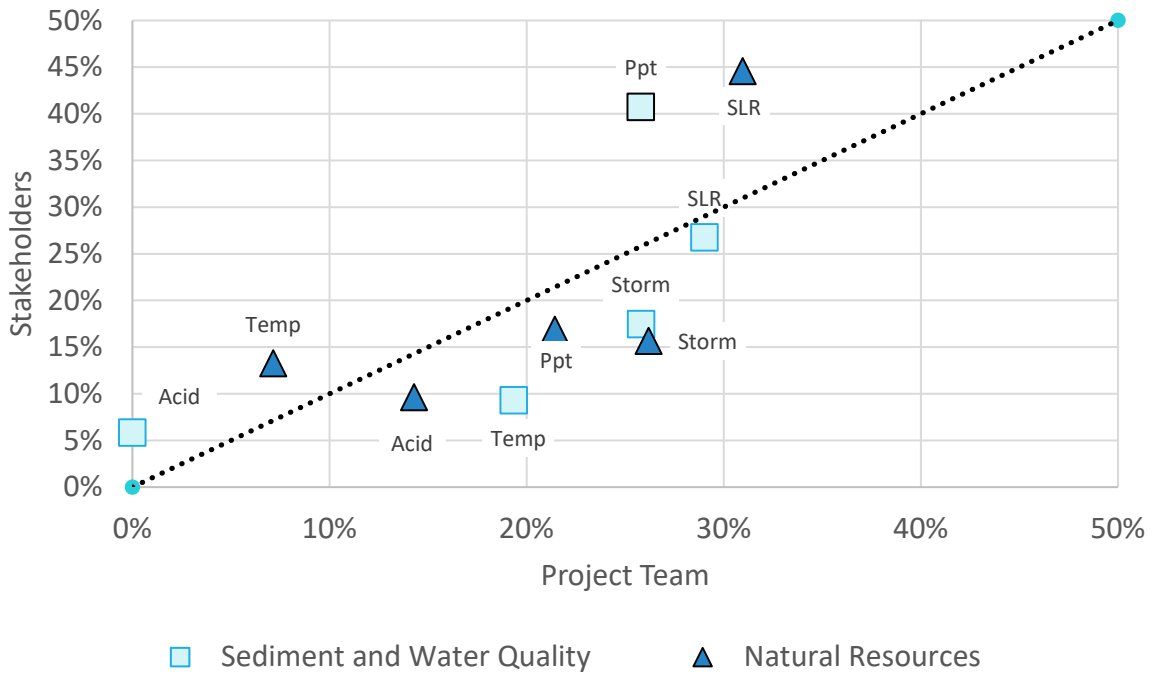


***Figure 24**. Comparison between project team and stakeholder climate stressor priorities as identified in real-time polling.*

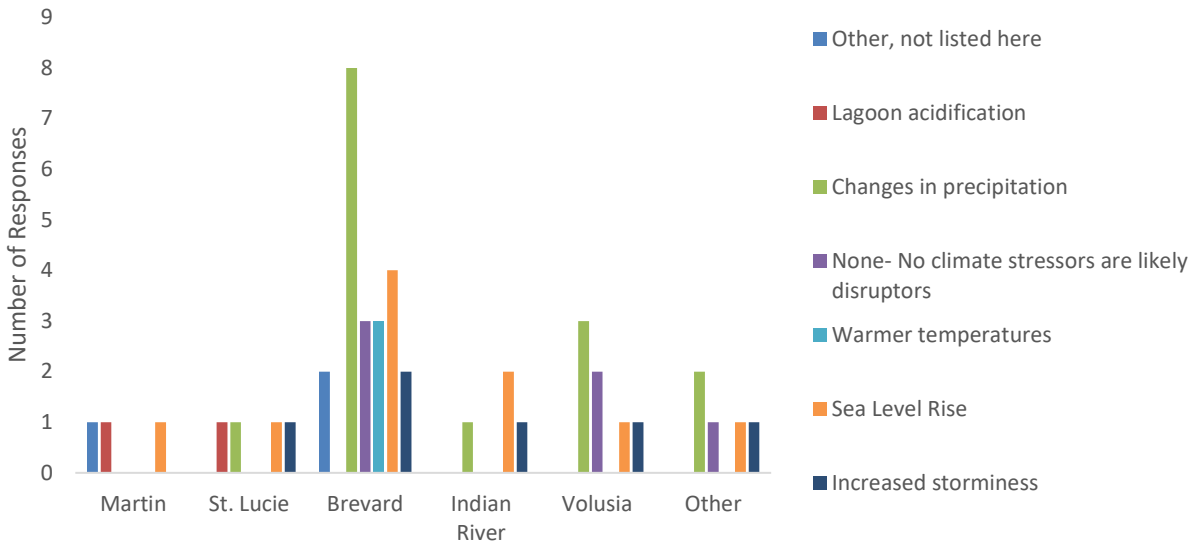


***Figure 25**. Priority stressors to water and sediment quality as a function of stakeholder identity.*

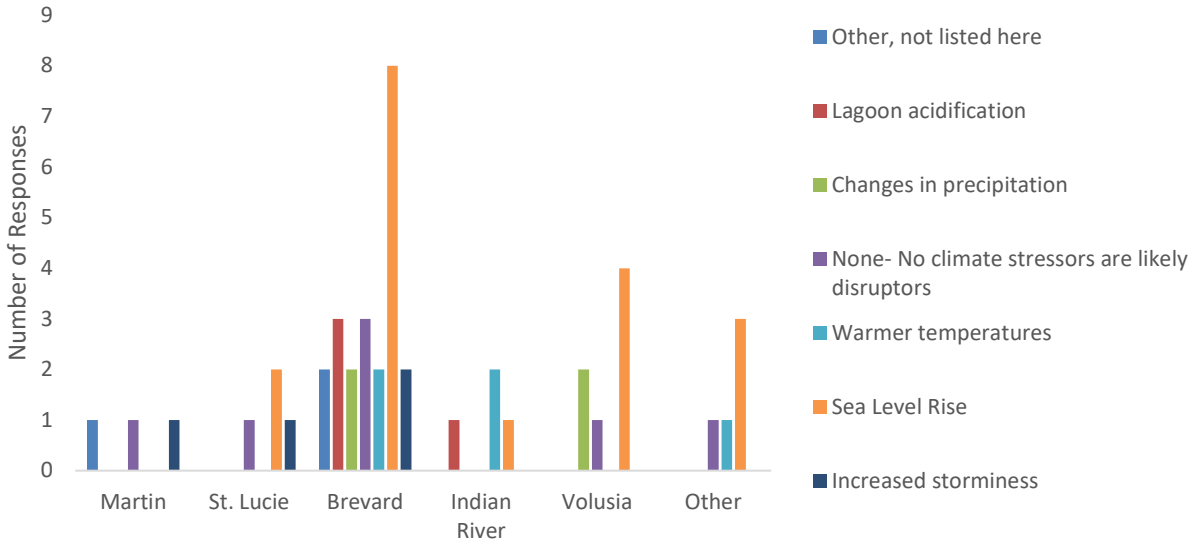


***Figure 26.** Priority stressors to natural as a function of stakeholder identity.*

The scoring, ranking, and prioritization conducted during Phase I of this project were designed to provide guidance during the revision of the current CCMP (2008) and formulation of specific new Action Plans to mitigate risks to the IRLNEP caused by climate change (i.e., Phase II). Based upon the results of this project, there exist distinct geographic differences in the perception of risk that must be assimilated into this process.

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APPENDICES

Appendix A - Risk Identification

					Consistency with draft 2030 CCMP
Issue: Wastewater					Updated
Action: Improve infrastructure to reduce or remove human sources of waste to IRL					
Objective: Attain and maintain water and sediment of sufficient quality to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Decreased pollutant loadings due to increased bioremediation effectiveness caused by warmer temperatures	Increased pollutant loadings from WWTP and OSTDS during high rainfall events	Increased pollutant loadings from WWTP and OSTDS due to more frequent and intense storm events	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification of lagoon water	Increased pollutant loadings from WWTP and OSTDS due to rising water table and sea level (erosion, inundation)	
Increased pollutant loadings due to changes in solubility and/or toxicity caused by warmer temperature					
Issue: Surface water (storm and fresh)					
Action: Reduce surface water discharge and pollutant loads to IRL					
Objective: Attain and maintain water and sediment of sufficient quality to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased pollutant loadings **(urban, rural)** due to changes in solubility and/or toxicity caused by warmer temperature	Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification	Increased pollutant loadings due to higher water table caused by sea level rise	
Increased pollutant loadings due to increased use of chemical treatments in surface water storage and conveyance systems to reduce more frequent algae blooms or expanding invasive plants caused by warmer temperature				Increased pollutant loadings due from water storage and conveyance infrastructure caused by rising water table and sea level (erosion, inundation)	
Increased pollutant loadings due to increased maintenance (cuttings, chemical applications) of greenspace caused by warmer temperature					

					Consistency with draft 2030 CCMP
Issue: Lagoon Hydrology (groundwater, natural flow)					New
Action: Enhance scientific understanding of basin hydrology					
Objective: Provide scientific knowledge to better inform and advise strategies to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Changes in thermohaline circulation due to warmer temperature	Changes in thermohaline circulation due to polyline conditions caused by intervals of higher rainfall and drought			Changes in circulation, groundwater and surface water hydrology due to rising water table and sea level (erosion, inundation)	
Issue: Marina and Boating Pollution					Updated
Action: Implement marina and boating education and management plans to reduce impacts to ecosystem					
Objective: Reduction of nutrient and chemical pollutant loading, seabed disturbance and trash					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased pollutant loadings from site runoff due to changes in solubility and/or toxicity caused by warmer temperature	Increased pollutant loadings from site runoff during high rainfall events, especially after extended periods of drought	Reduced pollutant loadings due to decrease in number of recreational boating days caused by more frequent and intense storm events		Increased pollutant loadings due to failure of pump out facilities, portable toilet dump stations, fuel stations, and rest rooms caused by rising water table and sea level (erosion, inundation)	
		Increased pollutant loadings from access facilities and associated infrastructure due to increased coastal erosion caused by more frequent and intense storm events			
Issue: Atmospheric Deposition					
Action: Research, develop and implement strategies to reduce or remove atmospheric pollutants					
Objective: Reduce nitrogen flux					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased atmospheric deposition of nitrogen and other pollutants due to increasing demand for electricity caused by warmer temperature	Increased atmospheric deposition of nitrogen and other pollutants during high rainfall events	Increased atmospheric deposition of nitrogen and other pollutants due to more frequent and intense storm events			

					Consistency with draft 2030 CCMP
Issue: Water Clarity					Not listed
Action: Implement strategies to improve water clarity					
Objective: Attain and maintain water clarity sufficient to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Decreased clarity due to an increase in the growth rates and survival of algae and other taxa induced by warmer temperature	Decreased clarity due to Increased pollutant loadings from WWTP and OSTDS during high rainfall events	Decreased clarity due to erosion of seabed and shoreline caused by more frequent and intense storm events		Increased clarity due to reduction in erosion of seabed caused by caused by increased bathymetry	
	Decreased clarity due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	Decreased clarity due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		Decreased clarity due to erosion of shoreline caused by sea level rise	
		Decreased clarity due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events		Decreased clarity due to Increased pollutant loadings from WWTP caused by rising water table and sea level (erosion, inundation)	
				Decreased clarity due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (erosion, inundation)	
Issue: DO					Not listed
Action: Implement strategies to increase DO content					
Objective: Reduce frequency and duration of low DO events sufficient to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Decreased DO solubility due to warmer temperature	Increased pollutant loadings from WWTP and OSTDS high rainfall events	Decreased DO availability due to erosion of seabed and shoreline caused by caused by more frequent and intense storm events		Decreased DO availability due to Increased pollutant loadings from WWTP caused by rising water table and sea level (erosion, inundation)	
Decreased DO availability due to accelerated decomposition of organic matter caused by warmer temperature	Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	Decreased DO availability due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		Decreased DO availability due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (erosion, inundation)	
Decreased DO availability due to more frequent algae blooms caused by warmer temperature		Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events			

					Consistency with draft 2030 CCMP
Issue: Chlorophyll a					Not listed
Action: Implement strategies to reduce Chlorophyll a					
Objective: Reduce frequency and duration of elevated Chlorophyll a events sufficient to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased Chlorophyll a concentration due to more frequent algae blooms caused by warmer temperature	Increased Chlorophyll a concentration due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	Increased Chlorophyll a concentration due to erosion of seabed and shoreline caused by more frequent and intense storm events		Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP caused by rising water table and sea level (erosion, inundation)	
	Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		Increased Chlorophyll a concentration due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (erosion, inundation)	
		Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events			
Issue: Legacy nutrient, pollutant, and sediment loads					Modified
Action: Implement strategies to remove and/or reduce muck					
Objective: Restore natural sediments, decrease turbidity and nutrient flux sufficient to support a healthy estuarine ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
		Decrease in water quality due to erosion and resuspension of seabed caused by more frequent and intense storm events		Decreased muck redistribution due to reduction in erosion of seabed by increased bathymetry	

					Consistency with draft 2030 CCMP
Target: Biodiversity					Updated
Action: Develop a management strategy based upon a comprehensive assessment of biodiversity					
Objective: Restore and protect biodiversity					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased habitat and species disruption/migration due to warmer temperature	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to seabed and shoreline erosion caused by more frequent and intense storm events	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	Decreased habitat and species disruption due to less seabed erosion caused by deepening bathymetry	
Increased habitat and species disruption due to elevated pollutant loadings caused by changes in solubility and/or toxicity induced by warmer temperature	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	
Increased habitat and species disruption due to elevated pollutant loadings in surface water storage and conveyance infrastructure caused by caused by longer growing season induced by warmer temperature	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by high rainfall events	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	
				Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	

Consistency with draft 2030 CCMP

Target: Seagrass				
Action: Support the implementation of a strategy to restore and protect seagrass habitat				
Objective: Restore and protect a functioning ecosystem				
Climate Stressor/Risk				
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**
Increased habitat and species disruption due to warmer temperature	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry
Increased habitat and species disruption due to increased pollutant loading caused by changes in solubility and/or toxicity induced by warmer temperature	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS in response to rising water table and sea level (inundation, erosion)
Increased habitat and species disruption due to elevated pollutant loadings from surface water storage and conveyance infrastructure caused by warmer temperature	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure in response to rising water table and sea level (inundation, erosion)
Increased in carbon sequestration due to increased coverage caused by warmer temperature				Increased habitat and species opportunities due to submergence and flooding of upland areas caused by sea level rise

					Consistency with draft 2030 CCMP
Target: Wetlands and Impounded Marshes					
Action: Support the implementation of a strategy to restore and protect wetland habitat					
Objective: Restore and maintain a functioning ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased habitat and species disruption due to warmer temperature	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events		Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	
Increased habitat and species disruption due to changes in evapotranspiration				Increased habitat and species opportunities due to submergence and flooding of upland areas caused by sea level rise	Updated
Increased carbon sequestration due to transition expansion of mangrove habitat caused by warmer temperature				Increased habitat and species disruption due to upland barriers to existing wetland migration into upland areas during sea level rise	
				Change in carbon sequestration due to habitat and species disruption caused by warmer temperature	

Target: Rare, Threatened, Endangered, and Species of Special Concern					Consistency with draft 2030 CCMP
Action: Support the implementation of a strategy to protect and manage species					
Objective: Species recovery					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased habitat and species disruption due to warmer temperature	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry	
Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during high rainfall events	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	
Increased habitat and species disruption due to lower oxygen availability cause by more frequent algae blooms induced by warmer temperature	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during high rainfall events	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	Updated
Increased habitat and species disruption due to lower oxygen availability caused by accelerated growth and decay of invasive plants within basin induced by warmer temperature				Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	

					Consistency with draft 2030 CCMP
Target: Fisheries (Forage, Recreational, Commercial)					Updated
Action: Support the implementation of a strategy to restore and protect fisheries					
Objective: Species recovery					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased habitat and species disruption due to warmer temperature	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to seabed and shoreline erosion caused by more frequent and intense storm events	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry	
Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	
Increased habitat and species disruption due to lower oxygen availability cause by more frequent algae blooms induced by warmer temperature	Increased habitat and species disruption from surface water storage and conveyance infrastructure during high rainfall events	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events		Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	
Target: Biotoxins, Infections, and Other Health Threats					Updated
Action: Support the implementation of a strategy to reduce threats to ecosystem health					
Objective: Biotoxins, infections, diseases					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Accelerated spread of existing or new threats to ecosystem health due to warmer temperature	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during high rainfall events	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during more frequent and intense storm events	Accelerated spread of existing or new threats to ecosystem health due to more acidic conditions	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	
	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during high rainfall events	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during more frequent and intense storm events		Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)	

					Consistency with draft 2030 CCMP
Target: Exotic and Invasive Species					Updated
Target: Remove exotic and invasive species to compliment habitat restoration					
Objective: Decrease exotic and invasive species competitive impacts on native habitats and species					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Accelerated spread of exotic and invasive species due to warmer temperature	Accelerated spread of exotic and invasive species due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Accelerated spread of exotic and invasive species from WWTP and OSTDS during more frequent and intense storm events		Reduction in upland exotic and invasive species due to rising water table and sea level (inundation, erosion)	
Accelerated spread of exotic and invasive species due to increased wildfires caused by warmer temperature	Accelerated spread of exotic and invasive species from WWTP and OSTDS during high rainfall events	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure during more frequent and intense storm events		Accelerated spread of exotic and invasive species from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)	
	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure during high rainfall events			Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure caused by rising water table and sea level (erosion and inundation)	
Target: Living Shorelines					New
Action: Support research to optimize function and resilience of installations					
Objective: Restore and protect shoreline habitat and ecosystem function					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased habitat and species distribution due to warmer temperature	Increased habitat and species distribution due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events	Increased habitat and species disruption due to more acidic conditions	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)	
Target: Archeological resources (shell works, mounds, middens)					New
Objective: Restore and protect					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Increased biological and chemical degradation due to warmer temperature	Increased chemical degradation due to higher rainfall	Increased physical and chemical degradation due to shoreline erosion and flooding during more frequent and intense storm events	Increased chemical degradation due to acidification of rain-, ground-, and lagoon-water	Increased physical and chemical degradation due to rising water table and sea level (inundation, erosion)	

					Consistency with draft 2030 CCMP
Target: Public Access					
Action: Implement strategies to increase public access					
Objective: Adequate and appropriate access					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Decreased recreational activities due to warmer temperature	Decreased recreational activities due to increased number of high rainfall events	Decreased recreational activities, especially boating related, due to failure of infrastructure caused by more frequent and intense storm events		Decreased access due flooding of land or access infrastructure caused by rising water table and sea level	
Decreased recreational activities due to accelerated spread of existing or new viral, bacterial, fungal, and parasitic infections caused by warmer temperature	Decreased recreational activities due to increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought			Decreased access due increased presence of navigational obstacles caused by rising sea level	**Not listed**
Decreased recreational activities due to reduced water clarity caused by increased pollutant loadings					
Target: Public education and involvement					
Action: Create a constituency of informed and involved stakeholders					
Objective: Achieve heightened public awareness of the ecosystem					
Climate Stressor/Risk					
Warmer temperature	**Changes in precipitation**	**Increasing storminess**	**Acidification**	**Sea level rise**	
Decreased volunteer participation in activities due to warmer temperature	Decreased volunteer participation in activities due to increased number of high rainfall events	Decreased volunteer participation in activities due to more frequent and intense storm events	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	**Updated**
Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues	Decreased volunteer participation in activities due to learned helplessness and self-efficacy issues			

Appendix B – Risk Evaluation

Final Report Appendix B. Risk Evacuation Consequence/Probability Matrix - Sediment and Water Quality

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
DO	Warmer temperature	Decreased DO solubility due to warmer temperature		3	3	3	3	12	High
DO	Warmer temperature	Decreased DO availability due to more frequent algae blooms caused by warmer temperature		3	3	3	3	12	High
Chl a	Warmer temperature	Increased Chlorophyll a concentration due to more frequent algae blooms caused by warmer temperature		3	3	3	3	12	High
Wastewater	Increased storminess	Increased pollutant loadings from WWTP and OSTDS due to more frequent and intense storm events		2	3	2	3	10	Moderate
Surfacewater	Changes in precipitation	Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	3	10	Moderate
Surfacewater	Increased storminess	Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events		2	3	2	3	10	High
Surfacewater	Sea level rise	Increased pollutant loadings due from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	High
Lagoon hydrology	Sea level rise	Changes in circulation, groundwater and surface water hydrology due to rising water table and sea level (inundation, erosion)		2	3	3	2	10	High
Water Clarity	Warmer temperature	Decreased clarity due to an increase in the growth rates and survival of algae and other taxa induced by warmer temperature		2	3	3	2	10	High
Water Clarity	Changes in precipitation	Decreased clarity due to increased pollutant loadings from WWTP during high rainfall events		2	3	2	3	10	Moderate
Water Clarity	Changes in precipitation	Decreased clarity due to increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	3	10	Moderate
Water Clarity	Increased storminess	Decreased clarity due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		2	3	2	3	10	High
Water Clarity	Increased storminess	Decreased clarity due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events		2	3	2	3	10	High

Score Key

Final Report Appendix B. Risk Evacuation Consequence/Probability Matrix - Sediment and Water Quality

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Water Clarity	Sea level rise	Decreased clarity due to increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	High
Water Clarity	Sea level rise	Decreased clarity due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	High
DO	Changes in precipitation	Increased pollutant loadings from WWTP and OSTDS high rainfall events		2	3	2	3	10	Moderate
DO	Changes in precipitation	Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	3	10	Moderate
DO	Increased storminess	Decreased DO availability due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events		2	3	2	3	10	High
DO	Sea level rise	Decreased DO availability due to Increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	High
DO	Sea level rise	Decreased DO availability due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	High

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Chl a	Changes in precipitation	Increased Chlorophyll a concentration due to increased pollutant loadings from WWTP and OSTDS during high rainfall events		2	3	2	3	10	Moderate
Chl a	Changes in precipitation	Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	3	10	Moderate
Chl a	Increased storminess	Increased Chlorophyll a concentration due to Increased pollutant loadings from surface water storage and conveyance infrastructure caused by more frequent and intense storm events		2	3	2	3	10	Moderate
Chl a	Sea level rise	Increased Chlorophyll a concentration due to increased pollutant loadings from water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	3	10	Moderate
Wastewater	Changes in precipitation	Increased pollutant loadings from WWTP and OSTDS during high rainfall events		2	3	2	2	9	Moderate
Wastewater	Sea level rise	Increased pollutant loadings from WWTP and OSTDS due to rising water table and sea level (inundation, erosion)		2	3	2	2	9	High
DO	Warmer temperature	Decreased DO availability due to accelerated decomposition of organic matter caused by warmer temperature		1	3	3	2	9	Moderate
DO	Increased storminess	Decreased DO availability due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		2	3	2	2	9	High
Chl a	Increased storminess	Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		2	3	2	2	9	Moderate
Chl a	Sea level rise	Increased Chlorophyll a concentration due to Increased pollutant loadings from WWTP caused by rising water table and sea level (inundation, erosion)		2	3	2	2	9	Moderate
Surfacewater	Warmer temperature	Increased pollutant loadings (**urban, rural**) due to changes in solubility and/or toxicity caused by warmer temperature		2	3	2	2	9	Moderate

Final Report Appendix B. Risk Evacuation Consequence/Probability Matrix - Sediment and Water Quality

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Surfacewater	Warmer temperature	Increased pollutant loadings due to increased maintenance (cuttings, chemical applications) of greenspace caused by warmer temperature		2	2	2	2	8	Moderate
Lagoon hydrology	Warmer temperature	Changes in thermohaline circulation due to warmer temperature		1	2	3	2	8	Moderate
Lagoon hydrology	Changes in precipitation	Changes in thermohaline circulation due to polyline conditions caused by intervals of higher rainfall and drought		1	2	3	2	8	Moderate
Atmospheric Deposition	Warmer temperature	Increased atmospheric deposition of nitrogen and other pollutants due to increasing demand for electricity caused by warmer temperature		1	2	3	2	8	Low
Atmospheric Deposition	Changes in precipitation	Increased atmospheric deposition of nitrogen and other pollutants during high rainfall events		1	2	3	2	8	Low
Atmospheric Deposition	Increased storminess	Increased atmospheric deposition of nitrogen and other pollutants due to more frequent and intense storm events		1	2	3	2	8	Low
Water Clarity	Increased storminess	Decreased clarity due to erosion of seabed and shoreline caused by more frequent and intense storm events		1	2	2	2	7	High
Water Clarity	Sea level rise	Decreased clarity due to erosion of shoreline caused by sea level rise		1	2	2	2	7	High
DO	Increased storminess	Decreased DO availability due to erosion of seabed and shoreline caused by caused by more frequent and intense storm events		1	2	2	2	7	High

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Chl a	Increased storminess	Increased Chlorophyll a concentration due to erosion of seabed and shoreline caused by more frequent and intense storm events		1	2	2	2	7	Moderate
Legacy nutrients	Increased storminess	Decrease in water quality due to erosion and resuspension of seabed caused by more frequent and intense storm events		1	2	2	2	7	High
Wastewater	Warmer temperature	Increased pollutant loadings due to changes in solubility and/or toxicity caused by warmer temperature		1	1	2	2	6	Medium
Wastewater	Acidification	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification of lagoon water		1	1	2	2	6	Moderate
Surfacewater	Warmer temperature	Increased pollutant loadings due to increased use of chemical treatments in surface water storage and conveyance infrastructure to reduce more frequent algae blooms or expanding invasive plants caused by warmer temperature		1	1	2	2	6	Moderate
Surfacewater	Acidification	Increased pollutant loadings due to changes in solubility and/or toxicity caused by acidification		1	1	2	2	6	Moderate
Surfacewater	Sea level rise	Increased pollutant loadings due to higher water table caused by sea level rise		1	1	2	2	6	Moderate
Marina and Boat Pollution	Increased storminess	Increased pollutant loadings from access facilities and associated infrastructure due to increased coastal erosion caused by more frequent and intense storm events		1	2	1	2	6	High
Marina and Boat Pollution	Sea level rise	Increased pollutant loadings due to failure of pump out facilities, portable toilet dump stations, fuel stations, and rest rooms caused by rising water table and sea level (inundation, erosion)		1	2	1	2	6	High
Marina and Boat Pollution	Warmer temperature	Increased pollutant loadings from site runoff due to changes in solubility and/or toxicity caused by warmer temperature		1	1	1	2	5	Moderate
Marina and Boat Pollution	Changes in precipitation	Increased pollutant loadings from site runoff during high rainfall events, especially after extended periods of drought		1	1	1	2	5	Moderate

Final Report Appendix B. Risk Evacuation Consequence/Probability Matrix - Sediment and Water Quality

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wastewater	Warmer temperature	Decreased pollut+C4:C19ant loadings due to increased bioremediation effectiveness caused by warmer temperatures	Yes					na	High
Lagoon hydrology	Increased storminess	na						na	
Lagoon hydrology	Acidification	na						na	
Marina and Boat Pollution	Increased storminess	Reduced pollutant loadings due to decrease in number of recreational boating days caused by more frequent and intense storm events	Yes					na	Low
Marina and Boat Pollution	Acidification	na						na	
Atmospheric Deposition	Acidification	na						na	
Atmospheric Deposition	Sea level rise	na						na	
Water Clarity	Acidification	na						na	
Water Clarity	Sea level rise	Increased clarity due to reduction in erosion of seabed caused by caused by increased bathymetry	Yes					na	Moderate

Final Report Appendix B. Risk Evacuation Consequence/Probability Matrix - Sediment and Water Quality

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
DO	Acidification	na						na	
Chl a	Acidification	na						na	
Legacy nutrients	Warmer temperature	na						na	
Legacy nutrients	Changes in precipitation	na						na	
Legacy nutrients	Increased storminess	na						na	
Legacy nutrients	Acidification	na						na	
Legacy nutrients	Sea level rise	Decreased muck redistribution due to reduction in erosion of seabed by increased bathymetry	Yes					na	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wetlands and Impounded Marshes	Sea level rise	Increased habitat and species disruption due to upland barriers to existing wetland migration into upland areas during sea level rise		3	3	3	2	11	High
Living shorelines	Increased storminess	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events		2	3	3	3	11	High
Wetlands and Impounded Marshes	Increased storminess	Increased habitat and species disruption due to shoreline erosion caused by more frequent and intense storm events		2	3	3	2	10	High
Wetlands and Impounded Marshes	Sea level rise	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)		2	3	3	2	10	High
Living shorelines	Sea level rise	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)		2	3	3	2	10	High
Archeological resources	Increased storminess	Increased physical and chemical degradation due to shoreline erosion and flooding during more frequent and intense storm events		2	3	3	2	10	High
Archeological resources	Sea level rise	Increased physical and chemical degradation due to rising water table and sea level (inundation, erosion)		2	3	3	2	10	High
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events		2	3	2	2	9	Moderate
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by high rainfall events		2	3	2	2	9	Moderate
Biodiversity	Increased storminess	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events		2	3	2	2	9	Moderate
Biodiversity	Increased storminess	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events		2	3	2	2	9	Moderate
Biodiversity	Acidification	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions		1	3	3	2	9	High
Biodiversity	Sea level rise	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)		2	3	2	2	9	High

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Sea level rise	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)		1	3	3	2	9	Moderate
Seagrass	Warmer temperature	Increased habitat and species disruption due to elevated pollutant loadings from surface water storage and conveyance infrastructure caused by warmer temperature		2	3	2	2	9	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events		2	3	2	2	9	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	2	9	High
Seagrass	Increased storminess	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		2	3	2	2	9	Moderate
Seagrass	Increased storminess	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events		2	3	2	2	9	Moderate
Seagrass	Acidification	Decreased vitality of calcifying organisms (i.e., shellfish, epiphytes) and other habitat dependent taxa due to more acidic conditions		1	3	3	2	9	High

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Seagrass	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS in response to rising water table and sea level (inundation, erosion)		**2**	**3**	**2**	**2**	**9**	**Moderate**
Seagrass	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure in response to rising water table and sea level (inundation, erosion)		**2**	**3**	**2**	**2**	**9**	**Moderate**
Wetlands and Impounded Marshes	Warmer temperature	Increased habitat and species disruption due to warmer temperature		**1**	**2**	**3**	**3**	**9**	**Moderate**
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during high rainfall events		**2**	**3**	**2**	**2**	**9**	**Moderate**
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during high rainfall events		**2**	**3**	**2**	**2**	**9**	**Moderate**
Rare, threatened, endangered, and SOSC	Increased storminess	Increased habitat and species disruption due to increased pollutant loading from WWTP and OSTDS during more frequent and intense storm events		**2**	**3**	**2**	**2**	**9**	**Moderate**
Rare, threatened, endangered, and SOSC	Increased storminess	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure during more frequent and intense storm events		**2**	**3**	**2**	**2**	**9**	**Moderate**
Rare, threatened, endangered, and SOSC	Acidification	Decreased vitality of calcifying organisms (i.e., shellfish, epiphytes) and other habitat dependent taxa due to more acidic conditions		**1**	**3**	**3**	**2**	**9**	**High**
Rare, threatened, endangered, and SOSC	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)		2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	2	9	Moderate
Rare, threatened, endangered, and SOSC	Sea level rise	Increased habitat and species disruption due to rising water table and sea level (inundation, erosion)		1	3	3	2	9	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Fisheries	Changes in precipitation	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during high rainfall events		2	3	2	2	9	Moderate
Fisheries	Changes in precipitation	Increased habitat and species disruption from surface water storage and conveyance infrastructure during high rainfall events		2	3	2	2	9	Moderate
Fisheries	Increased storminess	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS during more frequent and intense storm events		2	3	2	2	9	Moderate
Fisheries	Increased storminess	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure during more frequent and intense storm events		2	3	2	2	9	Moderate
Fisheries	Acidification	Decreased vitality of calcifying organisms (i.e., shellfish) and other habitat dependent taxa due to more acidic conditions		1	3	3	2	9	High
Fisheries	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from WWTP and OSTDS caused by rising water table and sea level (i.e., inundation, erosion)		2	3	2	2	9	Moderate
Fisheries	Sea level rise	Increased habitat and species disruption due to increased pollutant loadings from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		2	3	2	2	9	Moderate
Toxins, infectious agents, and other health threats	Warmer temperature	Accelerated spread of existing or new threats to ecosystem health due to warmer temperature		2	2	3	2	9	Med

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Biodiversity	Warmer temperature	Increased habitat and species disruption due to warmer temperature		1	2	3	2	8	Moderate
Biodiversity	Warmer temperature	Increased habitat and species disruption due to elevated pollutant loadings caused by changes in solubility and/or toxicity induced by warmer temperature		1	2	3	2	8	Moderate
Biodiversity	Warmer temperature	Increased habitat and species disruption due to elevated pollutant loadings in surface water storage and conveyance infrastructure caused by caused by longer growing season induced by warmer temperature		2	2	2	2	8	Moderate
Biodiversity	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Biodiversity	Increased storminess	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events		1	2	3	2	8	Moderate
Biodiversity	Sea level rise	Increased habitat and species disruption due to increased pollutant loading from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		1	3	2	2	8	Moderate
Seagrass	Warmer temperature	Increased habitat and species disruption due to warmer temperature		1	2	3	2	8	Moderate
Seagrass	Warmer temperature	Increased habitat and species disruption due to increased pollutant loading caused by changes in solubility and/or toxicity induced by warmer temperature		1	2	3	2	8	Moderate
Seagrass	Warmer temperature	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature		1	2	3	2	8	Moderate
Seagrass	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Seagrass	Increased storminess	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events		1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Warmer temperature	Increased habitat and species disruption due to changes in evapotranspiration		1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Warmer temperature	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature		1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Wetlands and Impounded Marshes	Sea level rise	Change in carbon sequestration due to habitat and species disruption caused by warmer temperature		1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Warmer temperature	Increased habitat and species disruption due to warmer temperature		1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Warmer temperature	Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature		1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Warmer temperature	Increased habitat and species disruption due to lower oxygen availability cause by more frequent algae blooms induced by warmer temperature		1	2	3	2	8	Low
Rare, threatened, endangered, and SOSC	Warmer temperature	Increased habitat and species disruption due to lower oxygen availability caused by accelerated growth and decay of invasive plants within basin induced by warmer temperature		1	2	3	2	8	Low

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Rare, threatened, endangered, and SOSC	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Rare, threatened, endangered, and SOSC	Increased storminess	Increased habitat and species disruption due to erosion of seabed and shoreline caused by more frequent and intense storm events		1	2	3	2	8	Moderate
Fisheries	Warmer temperature	Increased habitat and species disruption due to warmer temperature		1	2	3	2	8	Moderate
Fisheries	Warmer temperature	Increased habitat and species disruption due to lower oxygen solubility caused by warmer temperature		1	2	3	2	8	Moderate
Fisheries	Warmer temperature	Increased habitat and species disruption due to lower oxygen availability caused by more frequent algae blooms induced by warmer temperature		1	2	3	2	8	Low
Fisheries	Changes in precipitation	Increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Fisheries	Increased storminess	Increased habitat and species disruption due to seabed and shoreline erosion caused by more frequent and intense storm events		1	2	3	2	8	Moderate
Toxins, infectious agents, and other health threats	Changes in precipitation	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during high rainfall events		2	1	3	2	8	High
Toxins, infectious agents, and other health threats	Sea level rise	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)		2	2	2	2	8	Med
Exotic and invasive species	Warmer temperature	Accelerated spread of exotic and invasive species due to warmer temperature		1	2	3	2	8	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Natural Resources

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive species due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Toxins, infectious agents, and other health threats	Changes in precipitation	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during high rainfall events		1	1	3	2	7	Med
Toxins, infectious agents, and other health threats	Increased storminess	Accelerated spread of existing or new threats to ecosystem health from WWTP and OSTDS during more frequent and intense storm events		2	1	2	2	7	High
Toxins, infectious gents, and other health threats	Acidification	Accelerated spread of existing or new threats to ecosystem health due to more acidic conditions		1	1	3	2	7	Med
Exotic and invasive species	Warmer temperature	Accelerated spread of exotic and invasive species due to increased wildfires caused by warmer temperature		1	2	2	2	7	Moderate
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive species from WWTP and OSTDS during high rainfall events		1	1	3	2	7	Moderate
Exotic and invasive species	Changes in precipitation	Accelerated spread of exotic and invasive specie from surface water storage and conveyance infrastructure during high rainfall events		1	1	3	2	7	Moderate
Living shorelines	Warmer temperature	Increased habitat and species distribution due to warmer temperature		1	1	3	2	7	Moderate
Living shorelines	Changes in precipitation	Increased habitat and species distribution due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	1	3	2	7	Moderate
Living shorelines	Acidification	Increased habitat and species disruption due to more acidic conditions		1	1	3	2	7	Moderate
Archeological resources	Warmer temperature	Increased biological and chemical degradation due to warmer temperature		1	1	3	2	7	Moderate
Archeological resources	Changes in precipitation	Increased chemical degradation due to higher rainfall		1	1	3	2	7	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Stakeholder Engagement

Score Key

= higher **= high** **= moderate** **= not applicable**

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Toxins, infectious agents, and other health threats	Increased storminess	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure during more frequent and intense storm events		1	1	2	2	6	High
Toxins, infectious agents, and other health threats	Sea level rise	Accelerated spread of existing or new threats to ecosystem health from surface water storage and conveyance infrastructure caused by rising water table and sea level (inundation, erosion)		1	1	2	2	6	Med
Exotic and invasive species	Increased storminess	Accelerated spread of exotic and invasive species from WWTP and OSTDS during more frequent and intense storm events		1	1	2	2	6	Moderate
Exotic and invasive species	Increased storminess	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure during more frequent and intense storm events		1	1	2	2	6	Moderate
Exotic and invasive species	Sea level rise	Accelerated spread of exotic and invasive species from WWTP and OSTDS caused by rising water table and sea level (inundation, erosion)		1	1	2	2	6	Moderate
Exotic and invasive species	Sea level rise	Accelerated spread of exotic and invasive species from surface water storage and conveyance infrastructure caused by rising water table and sea level (erosion and inundation)		1	1	2	2	6	Moderate
Biodiversity	Sea level rise	Decreased habitat and species disruption due to less seabed erosion caused by deepening bathymetry	Yes					na	Moderate
Seagrass	Sea level rise	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry	Yes					na	Moderate
Seagrass	Sea level rise	Increased habitat and species opportunities due to submergence and flooding of upland areas caused by sea level rise	Yes					na	Moderate
Wetlands and Impounded Marshes	Acidification	na							

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Stakeholder Engagement

Score Key

= higher **= high** **= moderate** **= not applicable**

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Wetlands and Impounded Marshes	Sea level rise	Increased habitat and species opportunities due to submergence and flooding of upland areas caused by sea level rise	Yes					na	Moderate
Rare, threatened, endangered, and SOSC	Sea level rise	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry	Yes					na	Moderate
Fisheries	Sea level rise	Decreased habitat and species disruption due to less seabed erosion and increased water clarity caused by deepening bathymetry	Yes					na	Moderate
Exotic and invasive species	Sea level rise	Reduction in upland exotic and invasive species due to rising water table and sea level (inundation, erosion)	Yes					na	Moderate
Archeological resources	Acidification	na							

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Stakeholder Engagement

Score Key

= higher = high = moderate = not applicable

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
Public access	Warmer temperature	Decreased recreational activities due to accelerated spread of existing or new viral, bacterial, fungal, and parasitic infections caused by warmer temperature		2	2	3	3	10	High
Public access	Sea level rise	Decreased access due increased presence of navigational obstacles caused by rising sea level		2	3	3	2	10	High
Public access	Warmer temperature	Decreased recreational activities due to reduced water clarity caused by increased pollutant loadings		2	2	3	2	9	Moderate
Public access	Increased storminess	Decreased recreational activities, especially boating related, due to failure of infrastructure caused by more frequent and intense storm events		2	2	3	2	9	Moderate
Public access	Sea level rise	Decreased access due flooding of land or access infrastructure caused by rising water table and sea level		2	2	3	2	9	Moderate
Public access	Changes in precipitation	Decreased recreational activities due to increased habitat and species disruption due to polyhaline conditions caused by intervals of higher rainfall and extended periods of drought		1	2	3	2	8	Moderate
Public access	Warmer temperature	Decreased recreational activities due to warmer temperature		1	1	3	2	7	Moderate
Public access	Changes in precipitation	Decreased recreational activities due to increased number of high rainfall events		1	1	3	2	7	Low
Public education and involvement	Warmer temperature	Decreased volunteer participation in activities due to warmer temperature		1	1	3	2	7	Moderate
Public education and involvement	Warmer temperature	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues		1	1	3	2	7	Moderate
Public education and involvement	Changes in precipitation	Decreased volunteer participation in activities due to increased number of high rainfall events		1	1	3	2	7	Low
Public	Changes in	Decreased volunteer participation in activities		1	1	3	2	7	Moderate

Final Report Appendix B. Risk Evaluation Consequence/Probability Matrix - Stakeholder Engagement

Organizational goal	Climate Stressor	Risk	Opportunity	Consequence	Likelihood	Spatial Extent	Time Horizon	Preliminary Score	Confidence
education and involvement	precipitation	due to learned helplessness and self efficacy issues							
Public education and involvement	Increased storminess	Decreased volunteer participation in activities due to more frequent and intense storm events		1	1	3	2	7	Low
Public education and involvement	Increased storminess	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues		1	1	3	2	7	Moderate
Public education and involvement	Acidification	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues		1	1	3	2	7	Low
Public education and involvement	Sea level rise	Decreased volunteer participation in activities due to learned helplessness and self efficacy issues		1	1	3	2	7	Moderate
Public access	Acidification	na							Moderate

Appendix C – Results of Real-Time Polling

Summary of Surveys and Real-time Polling

Real-time polling and surveys were conducted during four stakeholder engagement meetings in 2018 and through follow-up communication via the IRLNEP. Stakeholder groups included subject matter experts from, for example, estuarine restoration councils, coastal observations, marine engineering, and local, state and federal government; each representing a respective constituency. Survey results are summarized in the following sections. Results represent a total (non-redundant) sample size of 66 respondents. These results were used by the project team as a means of ensuring the results of the risk-based vulnerability assessment were appropriately informed by stakeholders within the IRL watershed.

Focus Areas for Management Practices – Water and Sediment Quality

Respondents were asked to choose a single management target associated with sediment and water quality that was most important and could be realistically addressed. Stormwater discharges and onsite were most commonly selected by respondents, accounting for 27% and 24% of responses. **Figure C- 1** shows the breakdown of responses by target option.

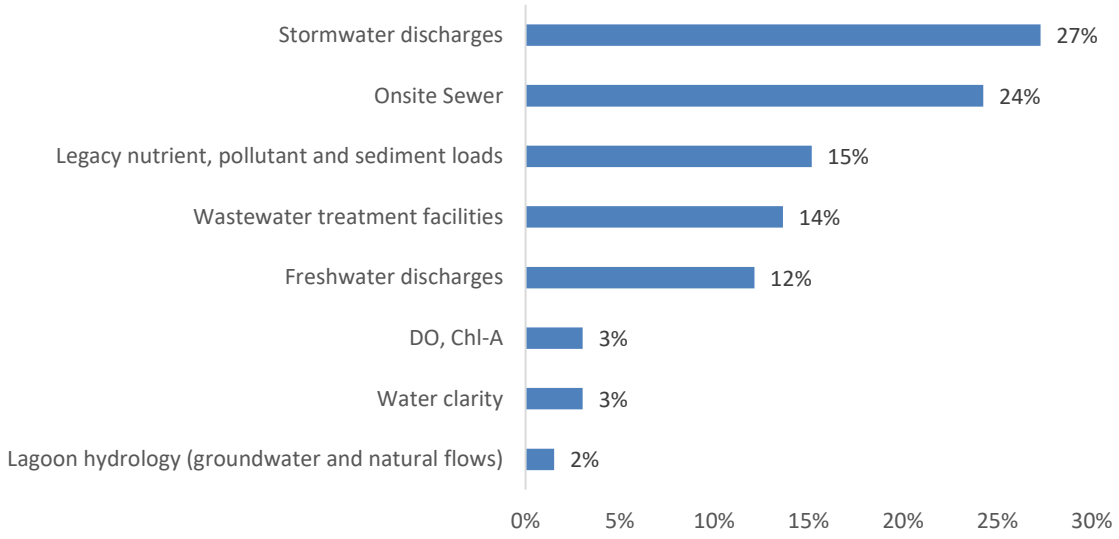

Figure C- 1. Targets for Management Actions – sediment and water quality

The breakdown of most important targets by county is shown in **Figure C- 2 (a**lthough it is important to note that the county-level breakdown has to be interpreted in the context of the varied level of response by county).

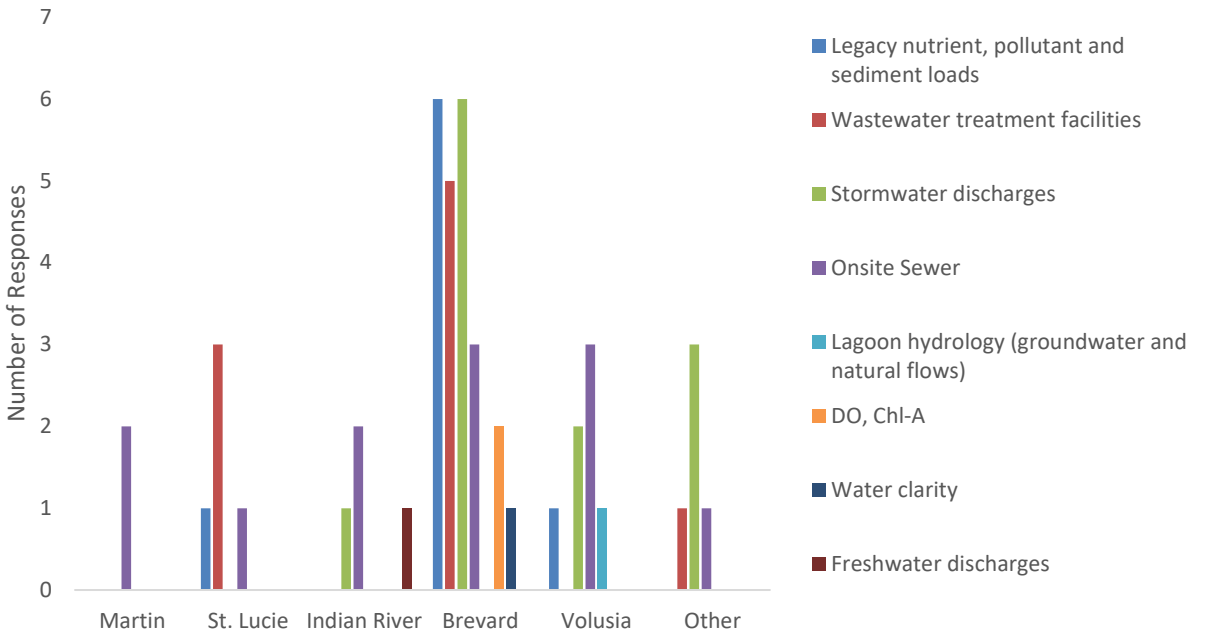

Figure C- 2: Most Important Targets by County – sediment and water quality

Scale of Impact, Time Horizon, Effects and Cost of Management Practices –water and sediment quality

The majority of respondents (63%) indicated that the effects of their chosen management targets would most likely be extensive, meaning that most of the watershed or estuary would be affected. About a quarter of respondents indicated that the place of region (e.g community, harbor, state park, wildlife refuge, sub-watershed) would be most impacted, while 10% indicated sites (e.g. a few waterfront lots, a bridge, a sewage treatment plant) would be affected (**Figure C- 3**). Respondents most commonly indicated that likely impacts would occur over the next 5 to 10 years (45% of responses; **Figure C- 4**). Concerning costs of the interventions associated with their selected management target, 70% of respondents indicated that cost of implementation is a major barrier and external sources for funding would be needed (**Figure C- 5**). The remaining 30% indicated that the funding needed is reasonable and local sources should be sufficient.

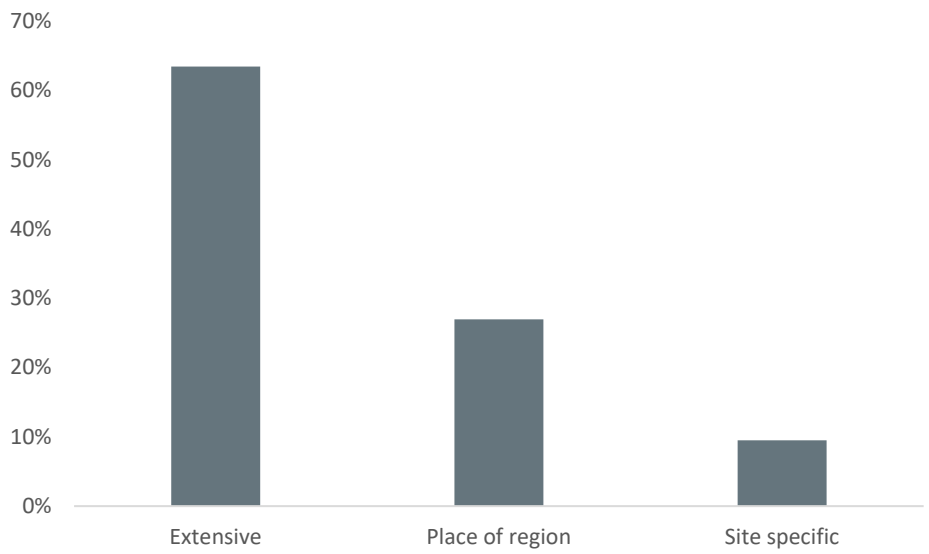

Figure C- 3: Spatial Extent of Impacts of Chosen Management Targets – Sediment and Water Quality

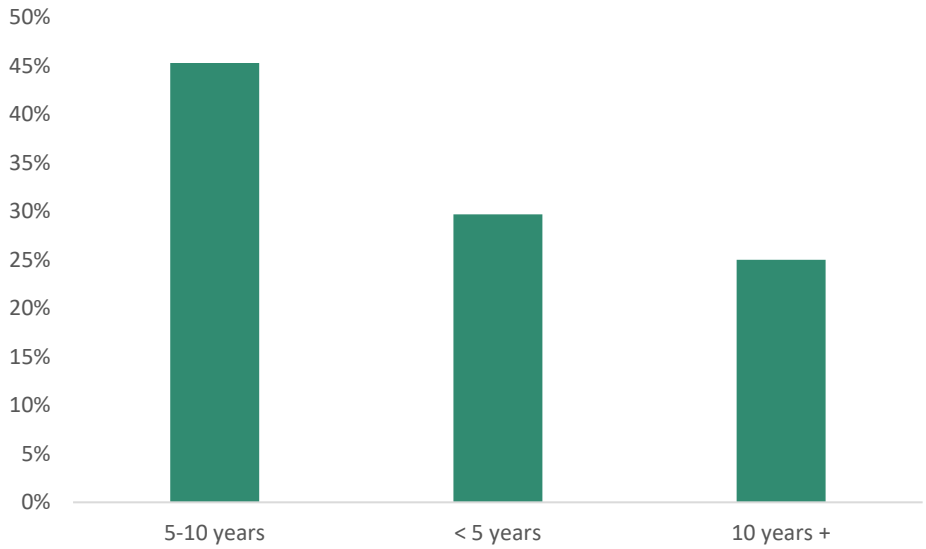

Figure C- 4: Timing of impacts of chosen management targets – sediment and water quality

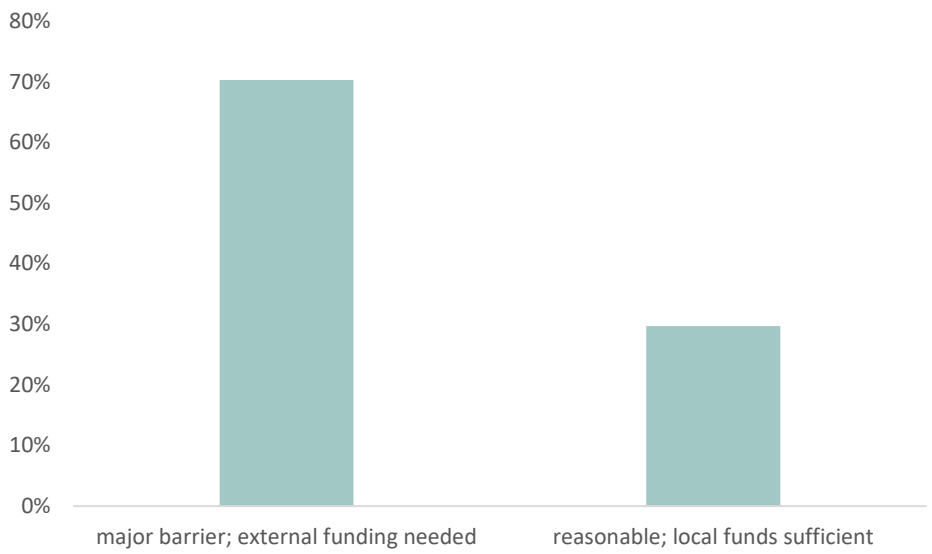

Figure C- 5. Perception of costs of chosen management targets – sediment and water quality

Impact of Climate on Management Targets – Water and Sediment Quality

Respondents were asked to consider how six potential climate stressors would affect their selected management target to address water and sediment quality. Changes in precipitation (35% of responses) and sea level rise (23% of responses) were most commonly selected (**Figure C- 6**). Prioritization as a function of stakeholder geography is illustrated in **Figure C- 7**.

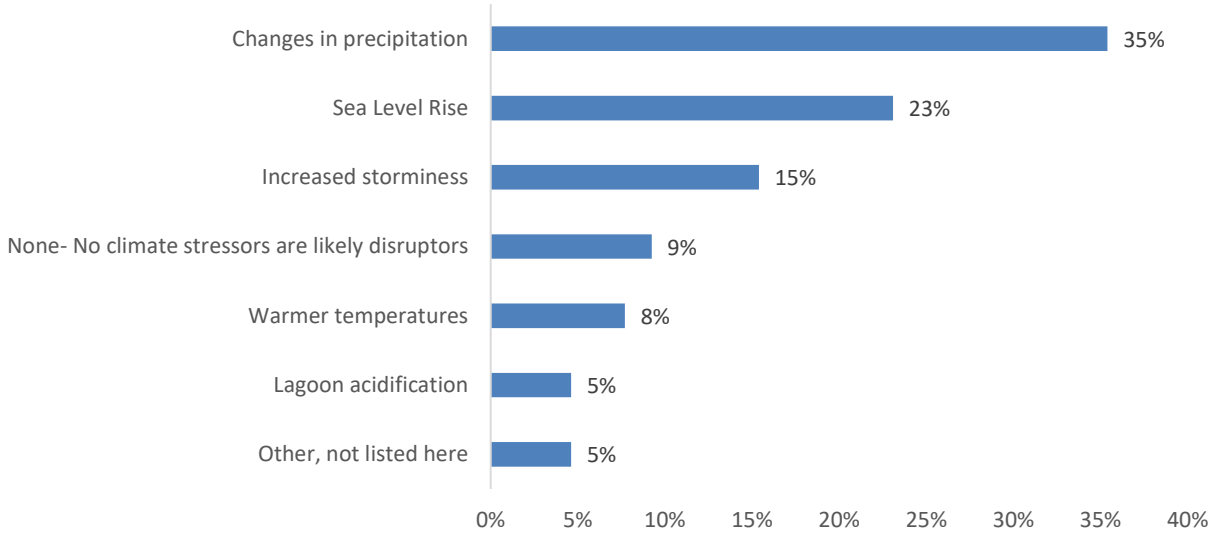

Figure C- 6. Potential Climate Stressors – sediment and water quality

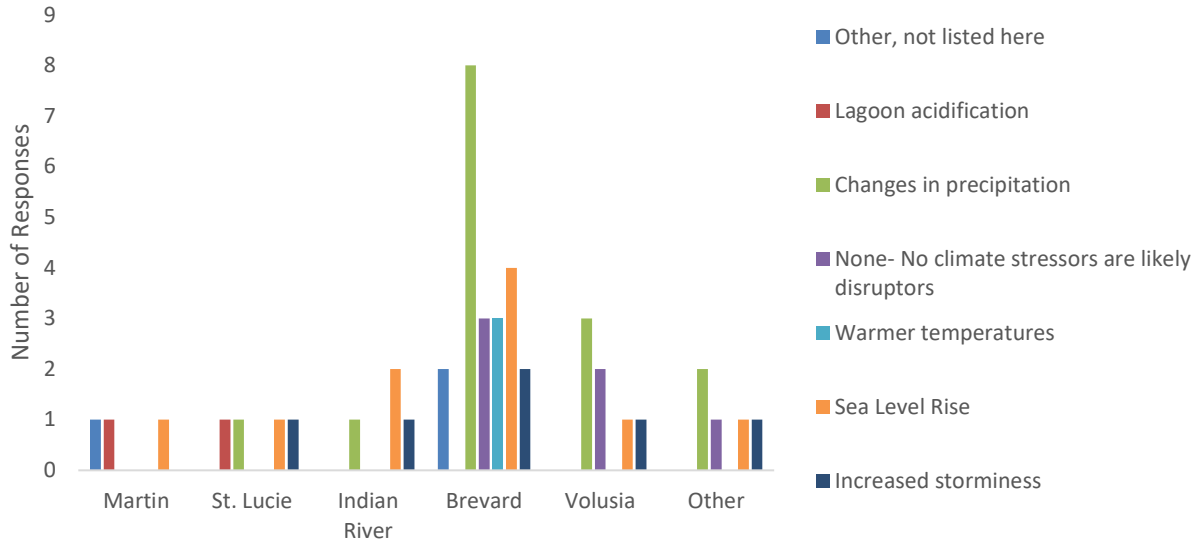

Figure C- 7. Potential Climate Stressors by County – Sediment and Water Quality

Survey respondents reported on the likelihood of occurrence of the climate stressor they selected as the most concerning. Medium confidence (40% of respondents) and high confidence (also 40% of respondents) were selected as the perceived likelihood of occurrence of the most-concerning climate stressor (**Figure C- 8)**. If the climate stressor did occur, the majority of survey respondents indicated that there would be moderate consequences in terms of impacts on their selected management target associated with water and sediment quality (**Figure C- 9**).

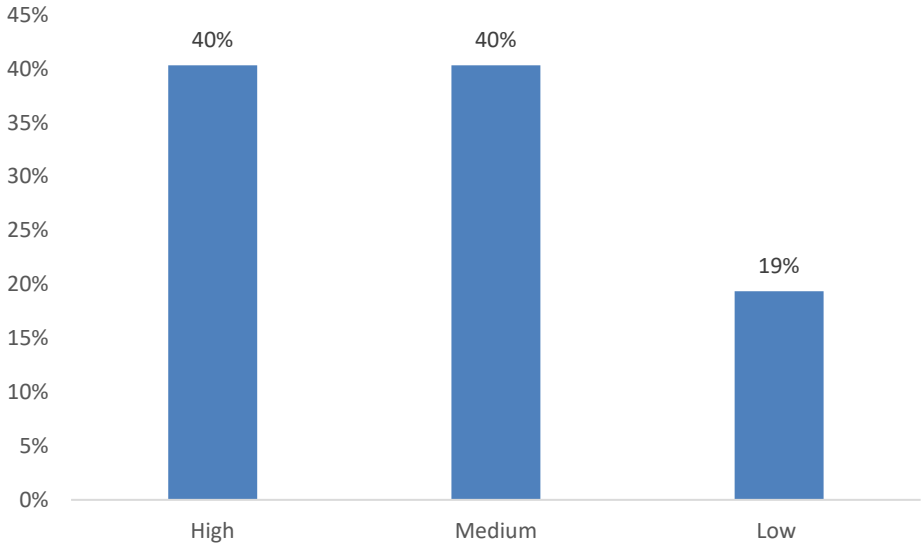

Figure C- 8: Likelihood Climate Stressor Will Occur – Sediment and Water Quality

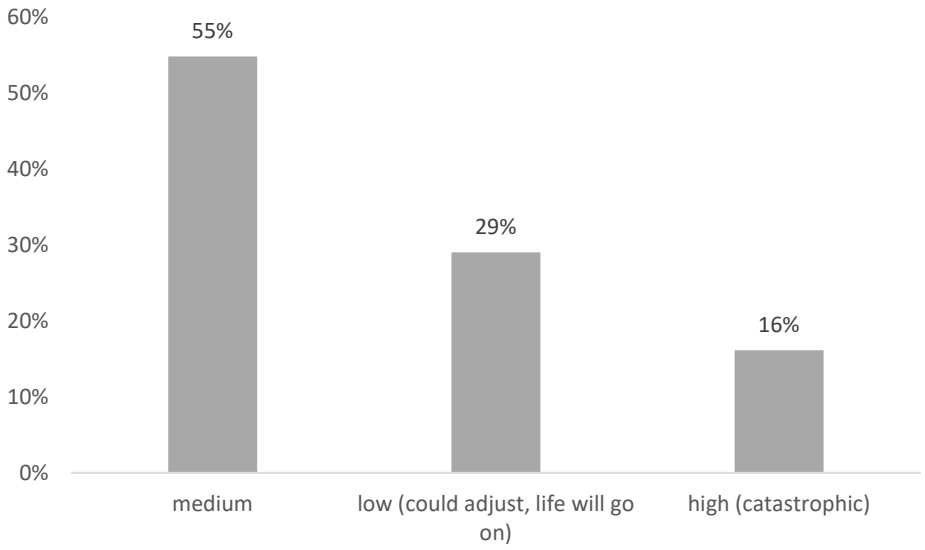

Figure C- 9: Consequences of Climate Stressor – sediment and water quality

Focus Areas for Management Practices – Natural Resources

Stakeholders were asked to select their top management target associated with natural resources. Management initiatives associated with seagrass (21% of responses), living shorelines (20% of responses), and biodiversity (18%) were the top three targets chosen. **Figure C- 10** shows the breakdown of responses by target option and **Figure C- 11** shows the breakdown by target option and by county.

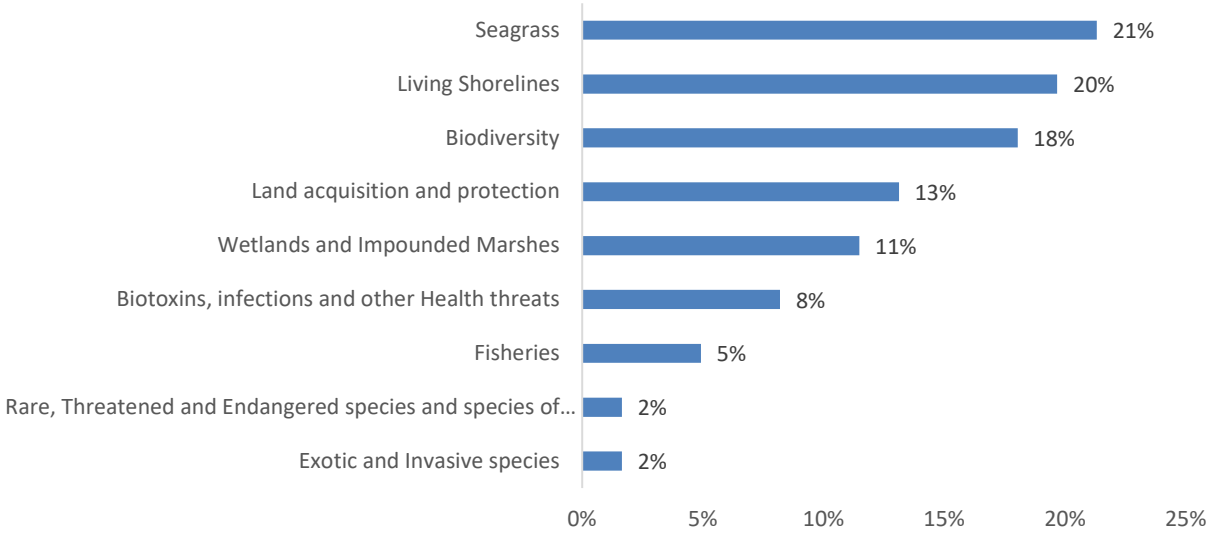

Figure C- 10. Targets for Management Practices – Natural Resources

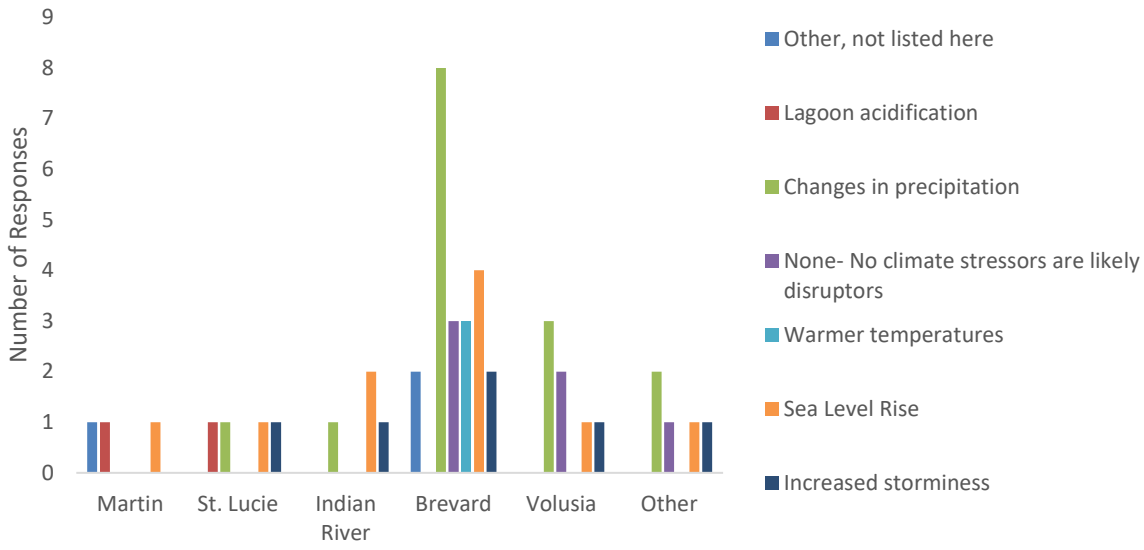

Figure C- 11. Most Important Target by County – Natural Resources

Scale of Impact, Time Horizon, Effects and Cost of Management Practices – Natural Resources

Respondents most commonly indicated that the effect of their chosen management initiatives would most likely be extensive, meaning that it would impact most of the watershed or estuary (57% of responses) (**Figure C- 12**).

Respondents most commonly indicated that the likely impacts of their chosen natural resources' management target would occur in 10+ years (38% of responses). Overall, the estimates of impact timing were relatively even in distribution: 5-10 years (35% of responses and less than 5 years (27% of responses) (**Figure C- 13**).

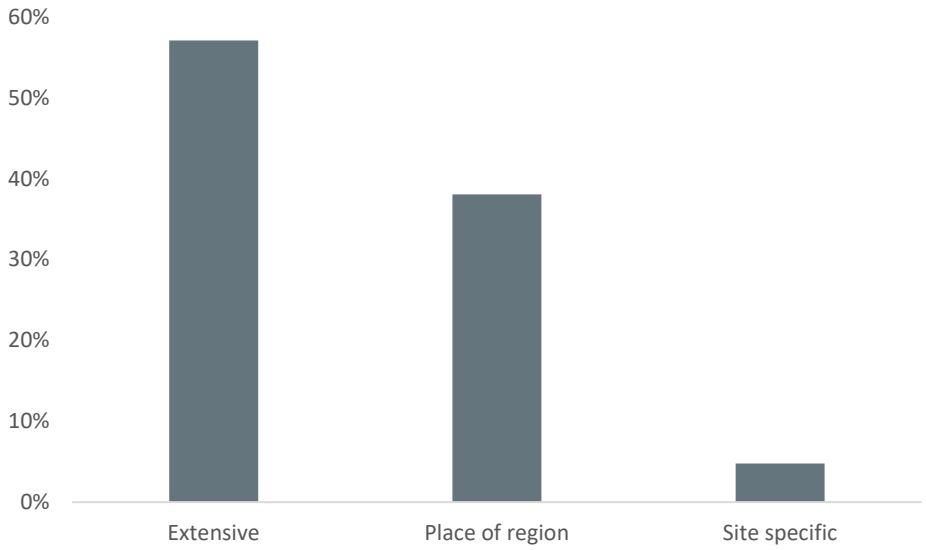

Figure C- 12: Spatial extent of impacts of chosen management targets – natural resources

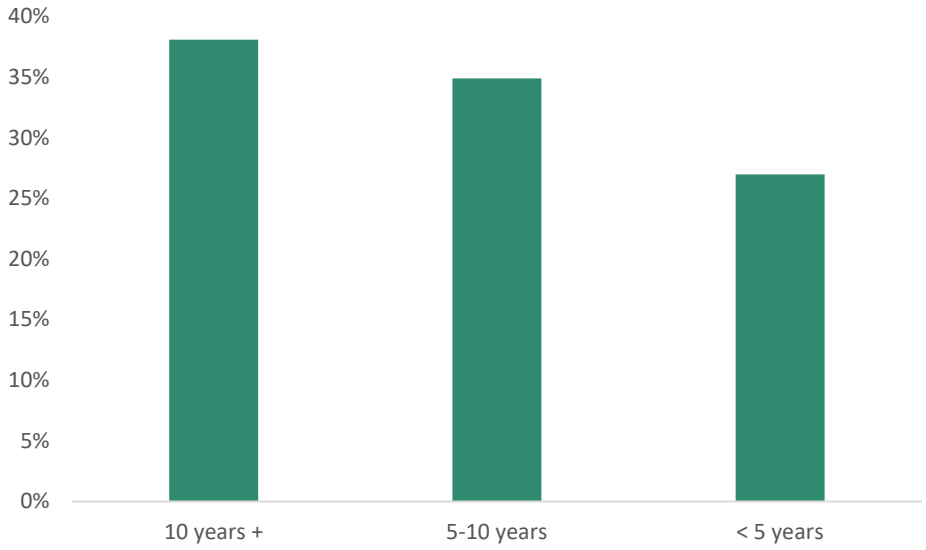

Figure C- 13. Timing of impacts of chosen management targets – Natural Resources

Concerning costs of the interventions associated with their selected management target, respondents were split on what the cost to implement their select management targets would be. Fifty-four % indicated that cost would be a major barrier and external sources for funding would be needed, and the remaining 46% indicated that the funding needed is reasonable and that local sources would be sufficient (**Figure C- 14).**

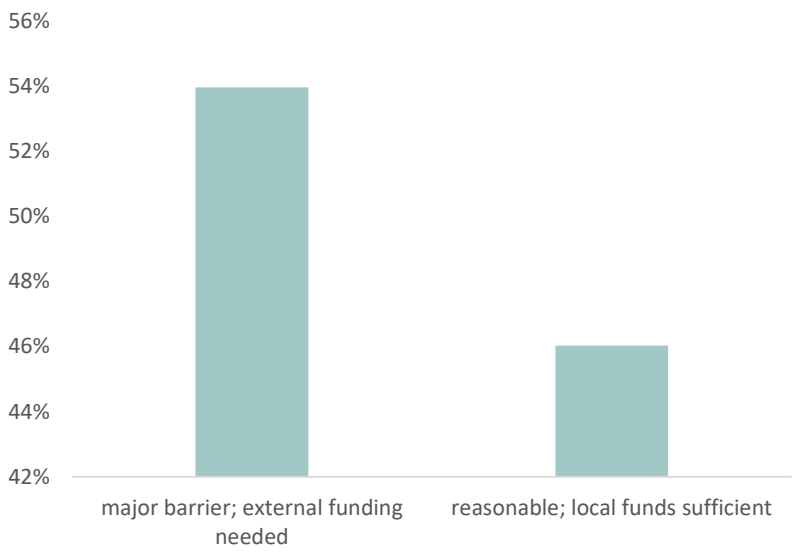

Figure C- 14. Perception of costs of chosen management targets – natural resources

Impact of Climate on Management Plans – Natural Resources

Respondents reported which climate stressor would most likely impact their chosen management approach associated with natural resources. Sea level rise was the leading perceived climate stressor to management targets (37% of the respondents), followed by precipitation changes (14% of responses) and increased storminess (13% of responses; **Figure C- 15**). Prioritization as a function of stakeholder geography is illustrated in **Figure C- 16**.

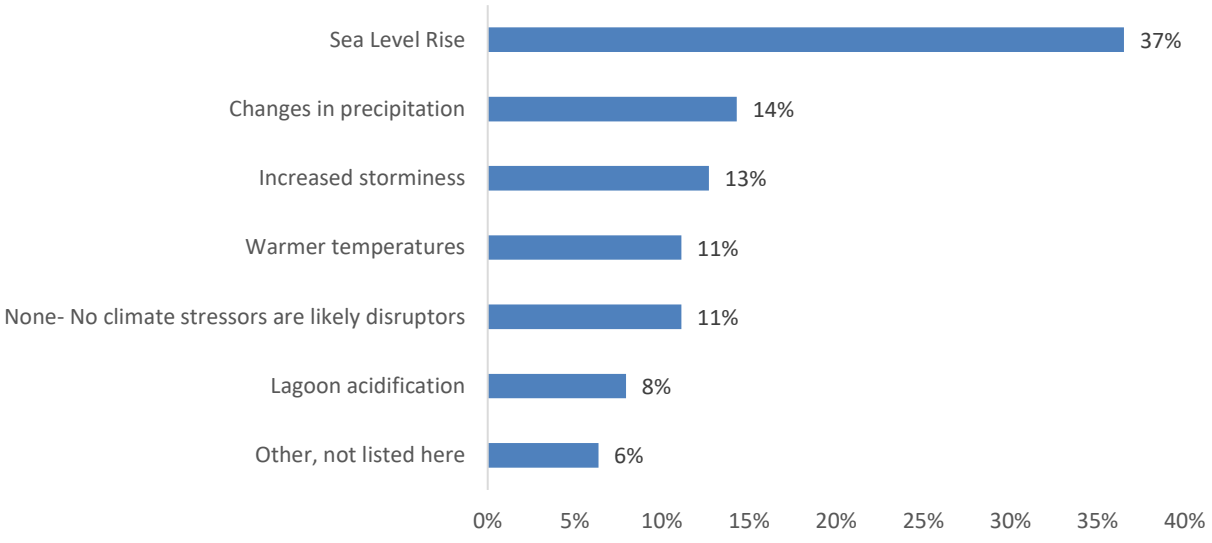

Figure C- 15: Potential Climate Stressors – Natural Resources

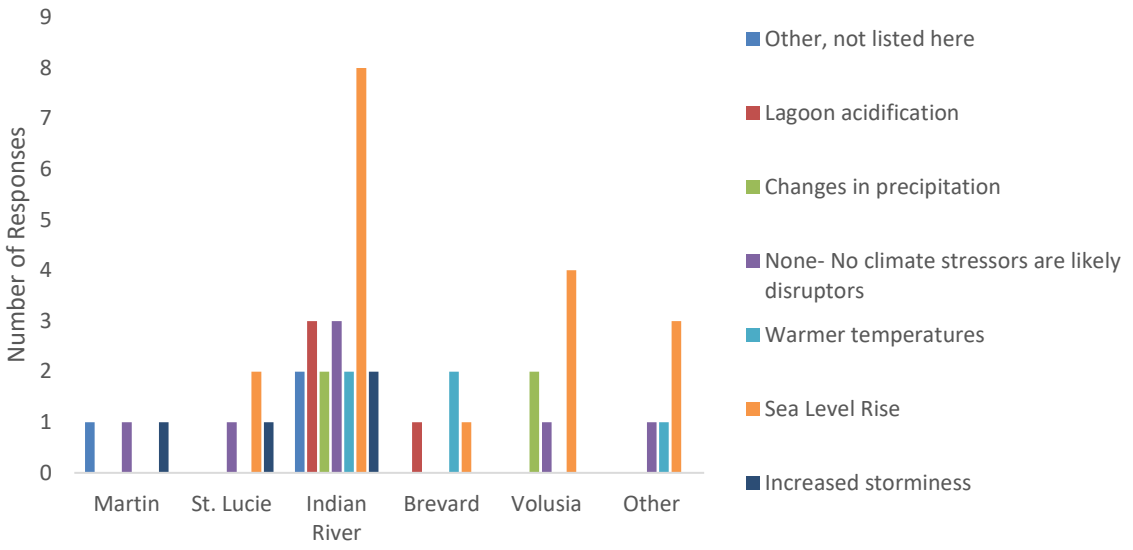

Figure C- 16: Potential Climate Stressors by county – Natural Resources

Survey respondents reported on the likelihood of occurrence of the climate stressor they selected as the most concerning to their chosen management target associated with natural resources. Medium confidence (40% of respondents) and high confidence (38% of respondents) were selected as the perceived likelihood of occurrence of the most-concerning climate stressor (**Figure C- 17**). If the climate stressor did occur, the majority of respondents (52%) indicated that the consequences would be moderate (**Figure C- 18**).

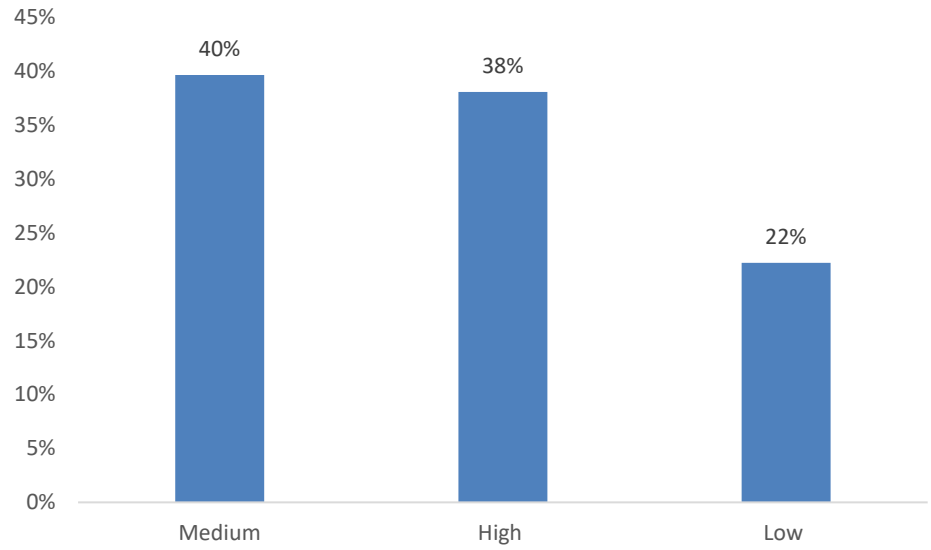

Figure C- 17: Likelihood Climate Stressor Will Occur – Natural Resources

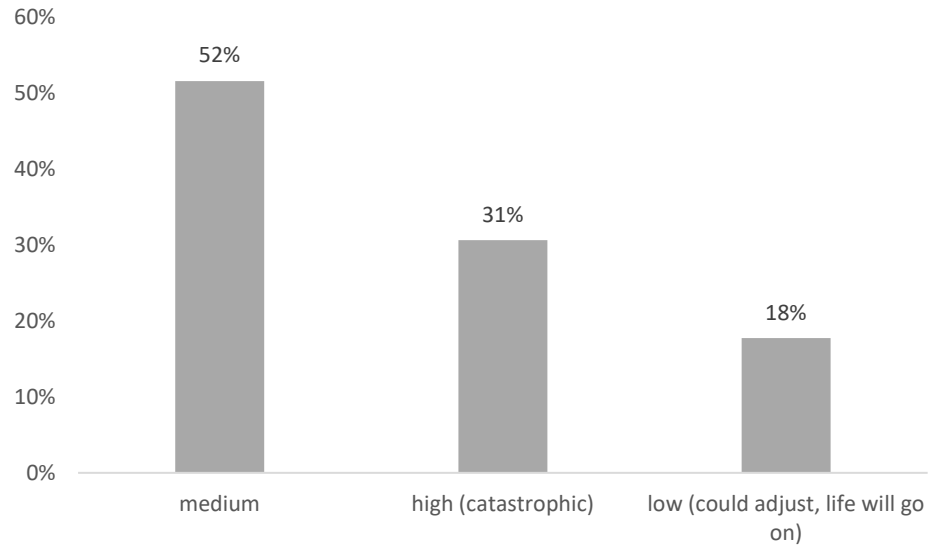

Figure C- 18: Consequences of a Climate Stressor – Natural Resources

Focus Areas for Management Practices – Stakeholder Engagement

During real-time polling exercises, respondents were asked to pick a third most important target that could effectively be addressed with management. The following section is an analysis of their responses.

Public education and involvement were widely selected that chosen target to improve stakeholder engage (92% of responses). **Figure C- 19** shows the breakdown of responses by target option. The breakdown of most important targets by county is shown in **Figure C- 20.**

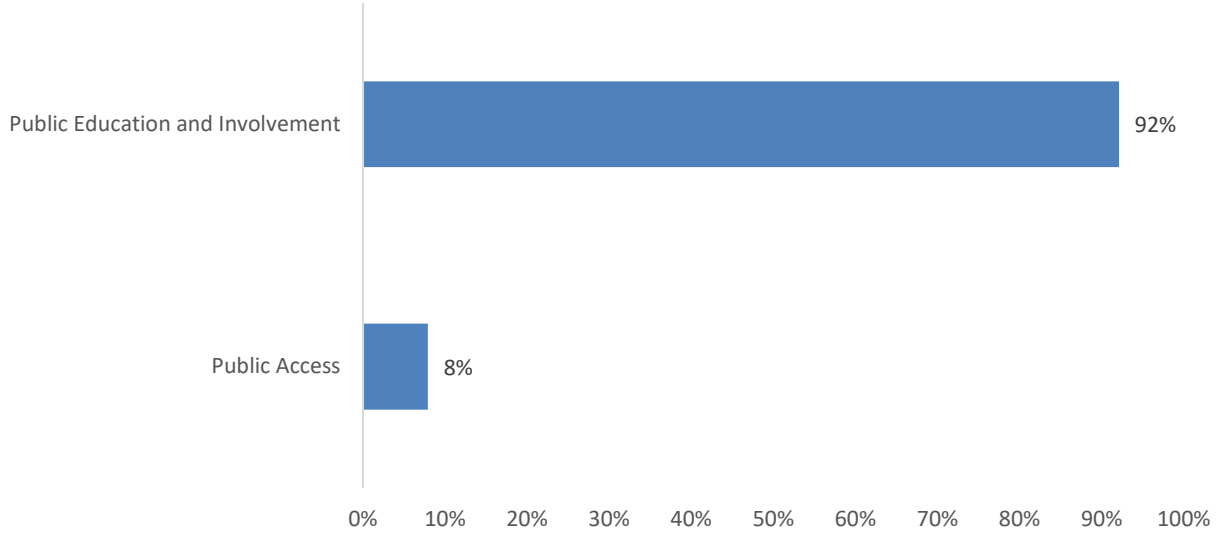

Figure C- 19: Targets for Management Practices – Stakeholder Engagement

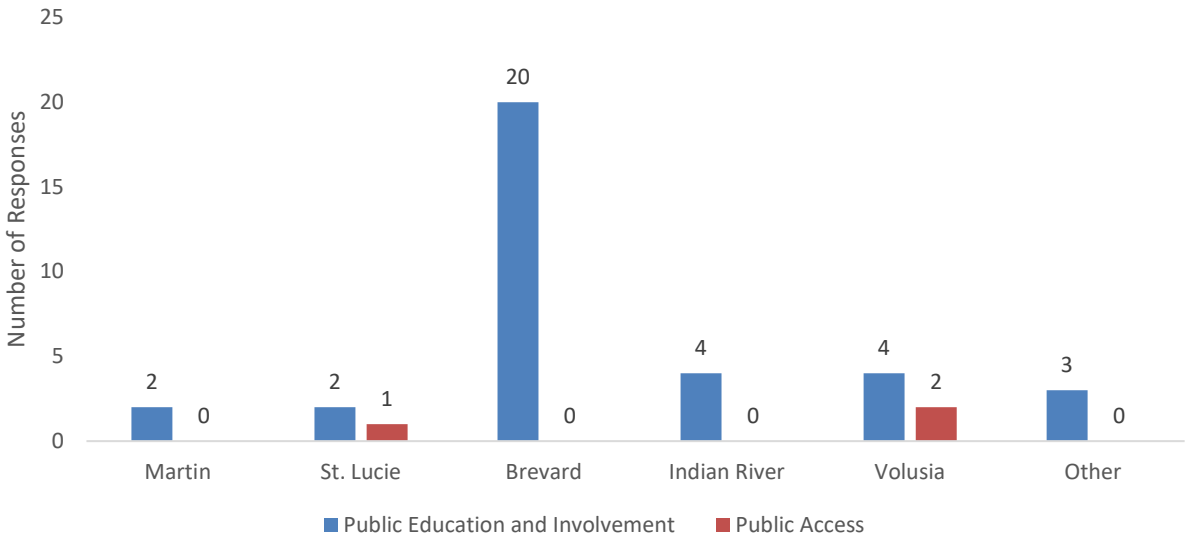

Figure C- 20: Most Important Target by County – Stakeholder Engagement

Scale of Impact, Time Horizon, Effects and Cost of Management Practices – Stakeholder Engagement

The majority of respondents believe that the effect of the potential management plans would most likely be extensive, meaning that it would impact most of the watershed or estuary. About two-thirds of respondents indicated that the secondary effects of their chosen management target would be extensive (65% of responses) (**Figure C- 21**). Most of respondents believe that the management plans would have an immediate impact (less than 5 years; **Figure C- 22**). Concerning costs to implement their selected stakeholder engagement target, 54% of respondents indicated that the funding needed is reasonable and that local sources would be sufficient (**Figure C- 23**).

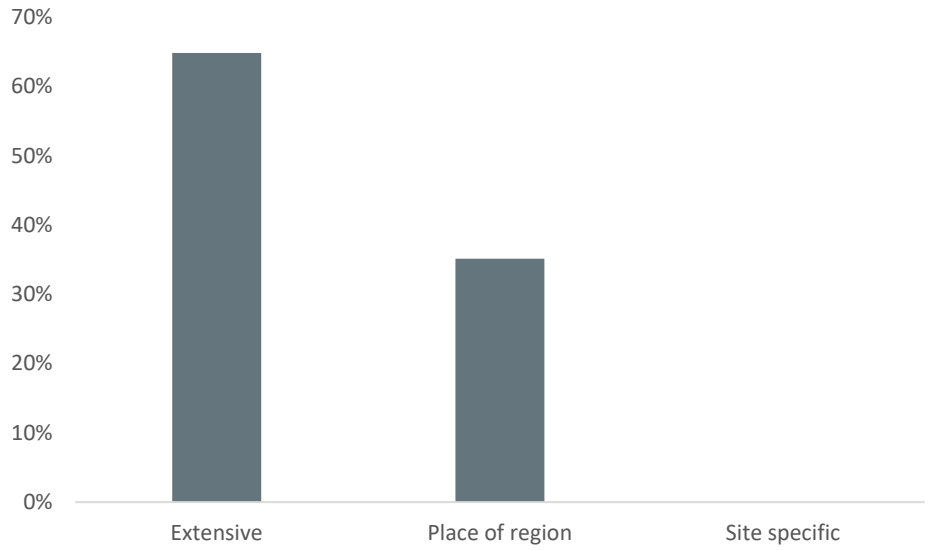

Figure C- 21: Spatial extent of impacts of chosen management targets – Stakeholder Engagement

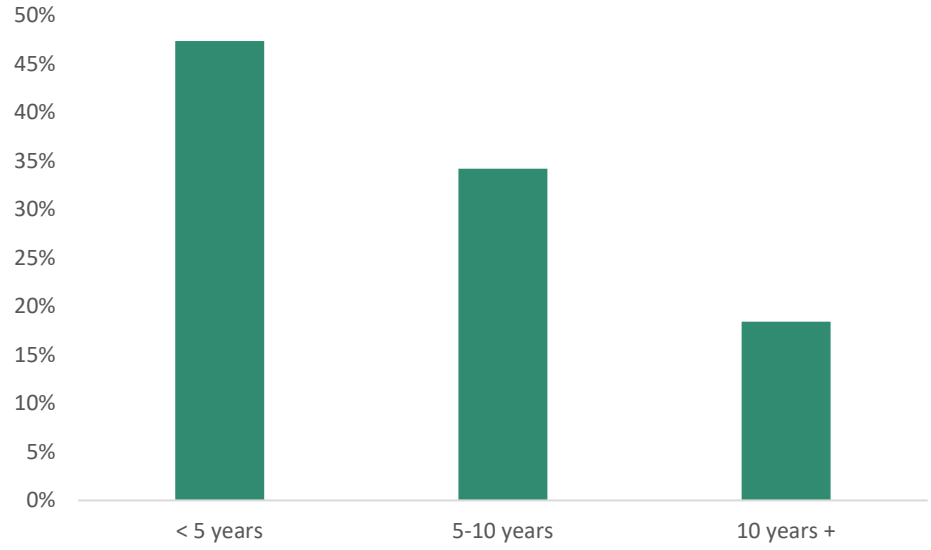

Figure C- 22: Timing of Impacts of Chosen Management Targets – Stakeholder Engagement

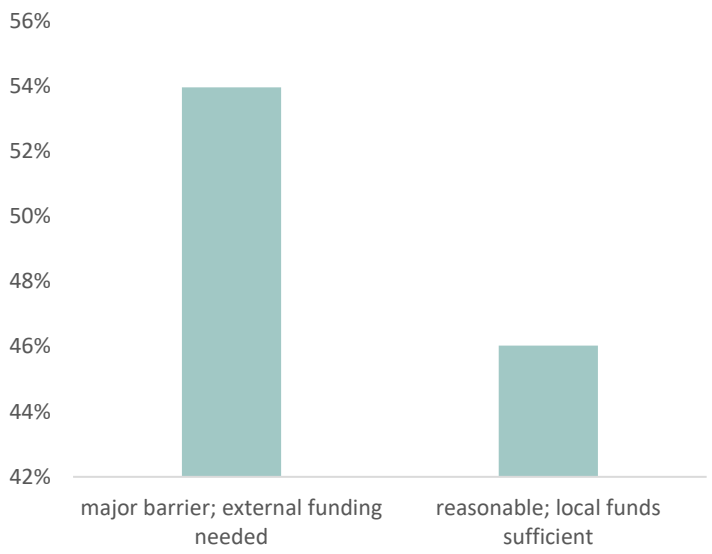

Figure C- 23: Perception of costs of chosen management targets – stakeholder engagement

Impact of Climate on Management Plans – Stakeholder Engagement

Respondents reported which climate stressor would most likely impact the management approach they chose, with 38% of the respondents indicating that no climate stressors would influence management plans and 24% of respondents indicating that sea level rise would likely influence their chosen management target (**Figure C- 24**). Prioritization as a function of stakeholder geography is illustrated in **Figure C- 25**).

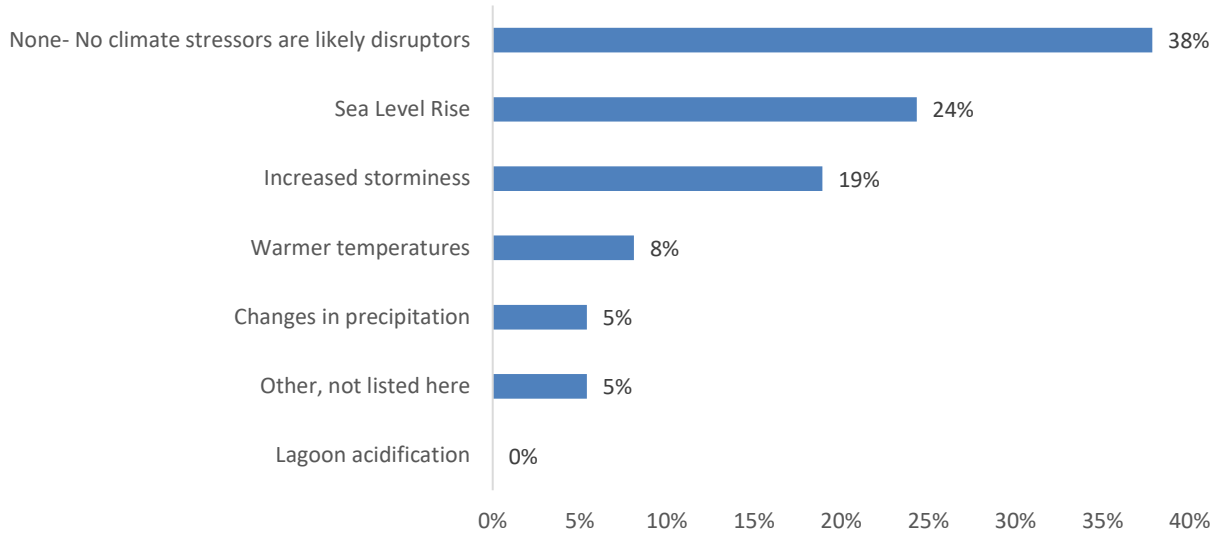

Figure C- 24: Potential Climate Stressors – stakeholder engagement

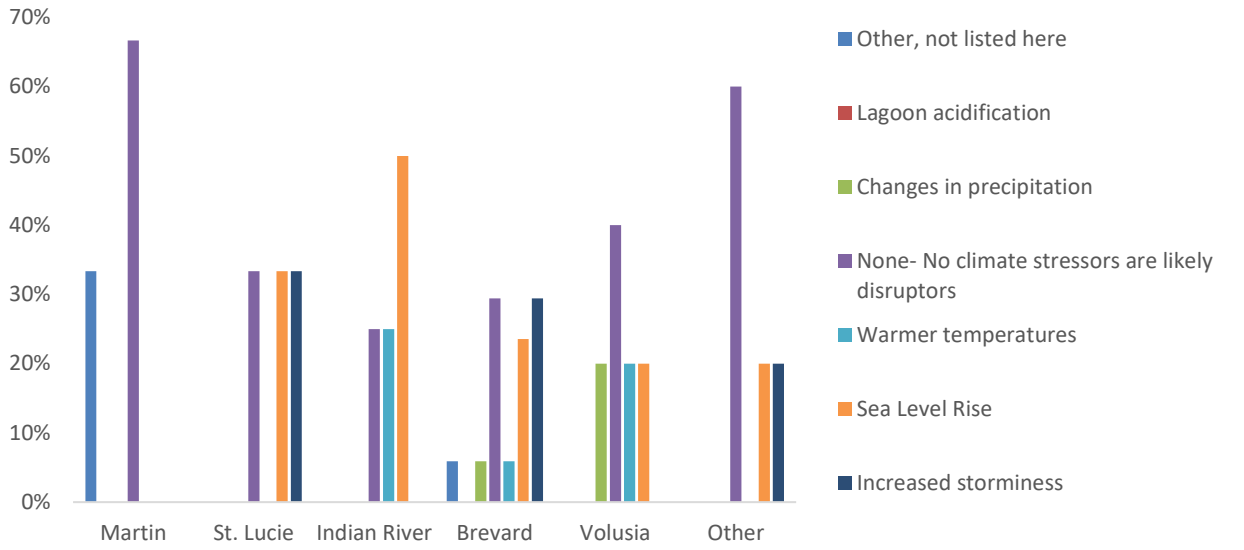

Figure C- 25: Potential Climate Stressors by County – Stakeholder Engagement

Survey respondents mainly believe that the occurrence of a climate stressor is low. The perceived likelihood of occurrence of the most-concerning climate stressor were as follows: 33% of respondents believe the likelihood is high that a climate stressor will occur, 21% believe the likelihood is medium and 46% believe the likelihood is low (less than 25%), as shown in **Figure C- 26**. If a climate stressor were to occur, respondents most commonly indicated the consequences associated with stakeholder engagement would be low (44% of responses; **Figure C- 27**).

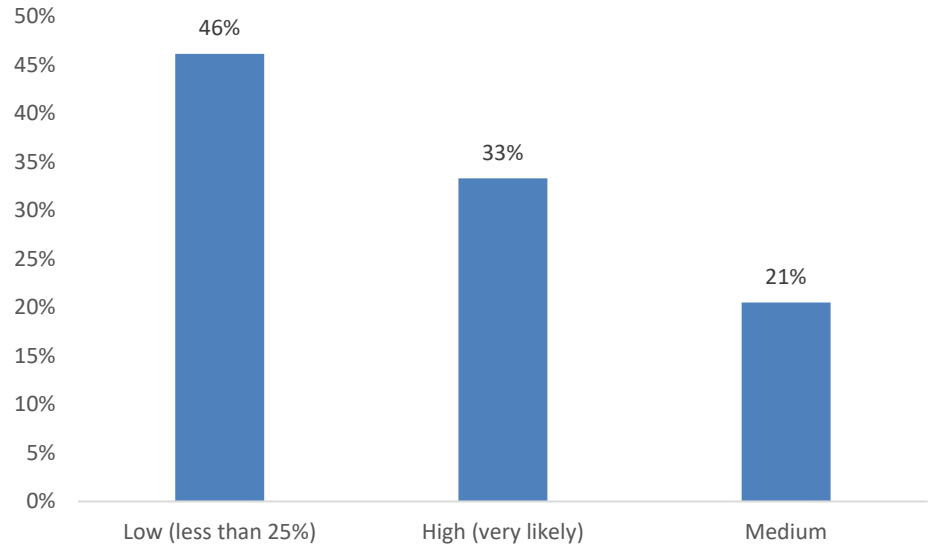

Figure C- 26: Likelihood Climate Stressor Will Occur – Stakeholder Engagement

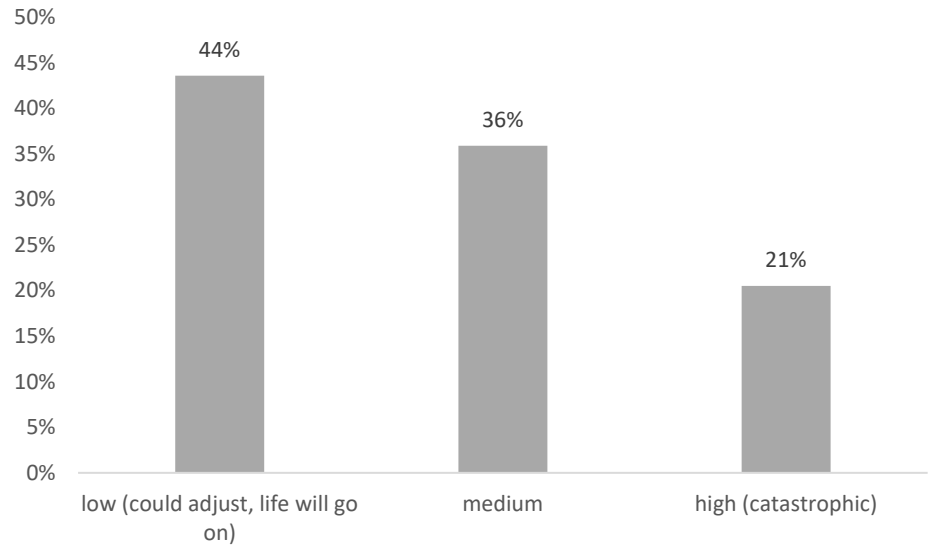

Figure C- 27: Consequences of a Climate Stressor – Stakeholder Engagement