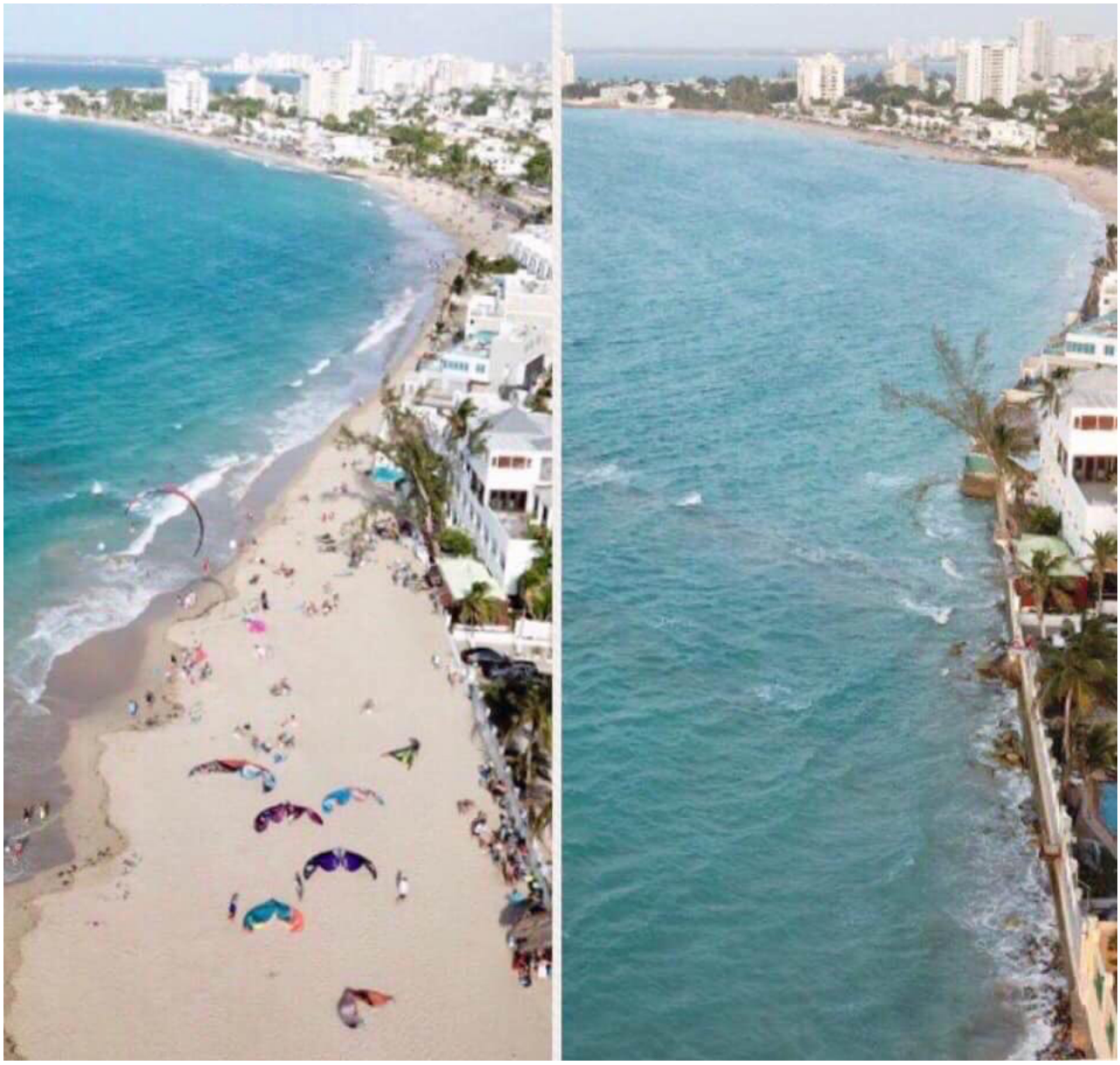
NOAA in the Caribbean August 2019 Partner Meeting Report

San Juan, Puerto Rico
St. Croix, Virgin Islands



NOAA in the Caribbean Initiative

4th Partner Meeting Summary Report

August 19-20, 2019

Ana G. Méndez University, Cupey Campus, San Juan, Puerto Rico

August 22-23, 2019

University of the Virgin Islands, St. Croix, Virgin Islands

EDITORS

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ACKNOWLEDGEMENTS

This publication was made possible with support from the NOAA Southeast and Caribbean Regional Team (SECART) and the NOAA in the Caribbean Steering Committee members and partners who assisted on the Planning Team and participated in the workshops as presenters and facilitators. Dr. María Ortíz Calixta and Carlos Morales-Agrinzoni of Ana G. Méndez University provided facilities and support for the San Juan workshop. The Virgin Islands Experimental Program to Stimulate Competitive Research and the University of the Virgin Islands provided facilities and logistical support for the St. Croix workshop. Staff of the University of Miami Cooperative Institute for Marine & Atmospheric Studies provided planning and logistical support. The Puerto Rico Department of Natural and Environmental Resources provided supplies and logistical support, and information for the San Juan working sessions. The Virgin Islands Department of Planning and Natural Resources provided transportation and other support, and information for the St. Croix working sessions. A special thank you to Helena Antoun and Dr. Aurora Justiniano for equipment and logistical support for the San Juan workshop.

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Anne Kitchell, Horsley-Witten Group
Elizabeth Wheaton, City of Miami Beach
Camilo Trench, University of the West Indies at Mona, Jamaica

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Dr. Rosana Grafals-Soto, University of Puerto Rico – Río Piedras
Antonio Matta, Willis Towers Watson
Dr. Tamaki Bieri, The Nature Conservancy

Virgin Islands: Brian Daley, Geographic Consulting/Horsley-Witten Group
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FOR MORE INFORMATION

For more information about NOAA Carib, visit our website: https://www.regions.noaa.gov/secar/index.php/noaa-in-the-caribbean/.

For more information about the 2019 workshops or this report, please visit the NOAA Carib website for the workshop: https://www.fisheries.noaa.gov/southeast/noaa-caribbean-stakeholder-workshop.

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CITATION

NOAA Carib, 2020. Fourth Partner Meeting Summary Report. San Juan, Puerto Rico, August 19-20, 2019. St. Croix, Virgin Islands, August 22-23, 2019. NOAA in the Caribbean Initiative, National Oceanic and Atmospheric Administration, Silver Spring, MD.

Cover page photos provided by Jackie Torres showing beach erosion in Ocean Park, San Juan, Puerto Rico between June 2018 and June 2019

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Puerto Rico and Virgin Islands (U.S. and British) Google Earth: Image Landsat/Copernicus

LIST OF ACRONYMS AND ABBREVIATIONS

CZM – Coastal Zone Management

DTOP – Department of Transportation and Public Works

FEMA – Federal Emergency Management Agency

FHA – Federal Highway Administration

FWS – Fish and Wildlife Service

NEPA – National Environmental Policy Act

NFWF – National Fish and Wildlife Foundation

NGO – Non-Governmental Organization

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NOAA Carib – NOAA in the Caribbean Initiative

PRASA – Puerto Rico Aqueduct and Sewer Authority

PRDNER – Puerto Rico Department of Natural and Environmental Resources

SECART – Southeast and Caribbean Regional Team

VIDPNR – Virgin Islands Department of Planning and Natural Resources

USACE – U.S. Army Corps of Engineers

USVI – U.S. Virgin Islands

UVI – University of the Virgin Islands

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EXECUTIVE SUMMARY

This document summarizes the presentations and discussions that were part of the fourth in-person partner event sponsored by the National Oceanic and Atmospheric Administration (NOAA) in the Caribbean (NOAA Carib) Initiative. The workshops were held the week of August 19, 2019 in San Juan, Puerto Rico at the Ana G. Méndez University – Cupey Campus and in St. Croix, Virgin Islands at the University of the Virgin Islands. The objectives of the workshop were to:

- Continue NOAA Carib engagement with partners in the region;
- Address priorities identified by Puerto Rico and the U.S. Virgin Islands (USVI) in response to the 2017 hurricanes;
- Obtain recommendations for implementable green infrastructure/nature-based solutions to address issues such as coastal erosion; and
- Obtain recommendations for adaptation planning.

Initiated by NOAA's Southeast and Caribbean Regional Team (SECART), NOAA Carib is a forum for communication, partnership, and user engagement that supports the delivery of the agency's mission in the domestic and international Caribbean.

The fourth in-person partner meeting was delayed due to the 2017 hurricane season and the needed recovery efforts in 2018. In part because of the 2017 hurricanes and their effects on the region, the presentations during the 2019 workshops in Puerto Rico and Virgin Islands covered topics critical to coastal communities in the U.S. Caribbean. Topics included the use of nature-based solutions to combat coastal erosion and flooding, including due to hurricanes, and adaptation planning in response to global climate change.

MEETING OVERVIEW

The fourth in-person partner meeting of the National Oceanic and Atmospheric Administration (NOAA) in the Caribbean (NOAA Carib) Initiative was held August 19-20, 2019 in San Juan, Puerto Rico at the Ana G. Méndez University – Cupey Campus; and August 22-23, 2019 in St. Croix, Virgin Islands at the University of the Virgin Islands (UVI). Attendees included local and federal agency staff and political representatives, private industry, academia, and conservation groups.

The meeting objectives were to:

- Continue NOAA Carib engagement with partners in the region;
- Address priorities identified by Puerto Rico and the U.S. Virgin Islands (USVI) in response to the 2017 hurricanes;
- Obtain recommendations for implementable green infrastructure/nature-based solutions to address issues such as coastal erosion; and
- Obtain recommendations for adaptation planning.

The presentations during the workshops covered topics critical to coastal communities in the U.S. Caribbean related to the use of nature-based solutions to combat coastal erosion and flooding, including due to hurricanes, and adaptation planning in response to global climate change. Presentations and panel discussions included examples from the Caribbean and Florida. The second day included discussions of novel strategies such as the use of insurance for infrastructure with examples from the City of Miami Beach and a project in Mexico to insure a coral reef in Quintana Roo. Each day participants were tasked with devising solutions for priority sites identified in advance of the workshops by the Puerto Rico Department of Natural and Environmental Resources (PRDNER) and the Virgin Islands Department of Planning and Natural Resources (VIDPNR). The sites identified by the PRDNER and the VIDPNR are threatened by issues like hurricanes, coastal erosion, and flooding.

The complete presentations and case studies are available on the workshop webpage: https://www.fisheries.noaa.gov/southeast/noaa-caribbean-stakeholder-workshop.

The first day of the workshops, breakout groups developed a suite of green infrastructure and nature-based recommendations and considered challenges and solutions to address those challenges. The second day, breakout groups were tasked with brainstorming adaptation strategies and again considering challenges and solutions and ways to implement these solutions in coastal communities.

NOAA Carib

NOAA has a broad portfolio of activities in the Caribbean region, both nationally and internationally. Given the extent of locations, mission, and partners throughout the region, communication and coordination across these activities can be challenging.

In order to improve delivery of NOAA's products and services in the region, SECART initiated NOAA Carib as a forum for communication, partnership, and user engagement that supports the delivery of the agency's mission in the domestic and international Caribbean.

Goals of NOAA Carib

To identify and respond to local and regional challenges, needs, and opportunities in the Caribbean region by increasing communication and providing a platform that connects NOAA, its core partners, and key users in the region.

Objectives of NOAA Carib

- Facilitate the identification of local and regional needs and opportunities in the Caribbean, and work within NOAA to inform and champion resourcing of and support for Caribbean efforts.

- Improve coordination and application of NOAA capabilities by enhancing internal NOAA communications on Caribbean efforts and facilitating two-way exchange of information between NOAA, its partners, and its user community.
- Support NOAA's Caribbean Strategy by tracking and communicating NOAA's progress towards achieving the Strategy's goals and objectives, and by using the Strategy as a primary organizational framework for NOAA Carib activities and composition.

Workshop Agenda

Applying Concepts of Engineering with Nature/Green Infrastructure

The first day of the workshops focused on "Applying Concepts of Engineering with Nature/Green Infrastructure." Presentations were given by:

- Dr. Jeffrey (Jeff) King from the U.S. Army Corps of Engineers (USACE) about the Engineering with Nature$_{TM}$ Initiative;
- Anne Kitchell from Horsley-Witten Group with examples of green infrastructure in coastal areas;
- Elizabeth Wheaton, City of Miami Beach with an implementation perspective related to reviews of living shoreline/green infrastructure proposals; and
- Camilo Trench from the University of the West Indies at Mona, Jamaica; Tamara Orozco Rebozo with the Pontifical Catholic University of Puerto Rico (in San Juan); Dr. Rosana Grafals-Soto with the University of Puerto Rico – Cayey; Brian Daley of Geographic Consulting/Horsley-Witten Group (in St. Croix); and Dr. Gregory (Greg) Guannel with UVI who served as panelists presenting examples of living shorelines and green infrastructure projects in the Caribbean.

Green infrastructure incorporates aspects of the natural environment into constructed systems to mimic natural processes in an integrated way benefitting nature and people. Green infrastructure is a term that can

encompass a wide array of practices. For example, green infrastructure can be a cost-effective, resilient approach to stormwater runoff.

A living shoreline is a protected, stabilized coastal edge made of natural materials such as vegetation, sand, or rock. Living shorelines are a green infrastructure technique using native vegetation alone or in combination with offshore sills to stabilize the shoreline. Living shorelines are not static and grow over time.

The U.S. Army Corps of Engineers Engineering with Nature$_{TM}$ Initiative enables more sustainable delivery of economic, social, and environmental benefits associated with water resources infrastructure. Engineering with Nature uses science and engineering to produce operational efficiencies, uses natural processes for maximum benefit, broadens the range of benefits provided by a project, and works collaboratively.

Reinsurance and Adaptation Planning

The second day of the workshops focused on "Reinsurance and Adaptation Planning." Presentations were given by:

- Antonio (Tony) Matta of Willis Towers Watson about insuring nature-based infrastructure in the Caribbean;
- Dr. Tamaki Bieri of The Nature Conservancy about reef and resilience insurance; and
- Elizabeth Wheaton of the City of Miami Beach with examples of applications of adaptation planning and reinsurance.In St. Croix, there was also a presentation by Stevie Henry from the Federal Emergency Management Agency (FEMA) about adaptation/resilience planning in the Virgin Islands.

Adaptation planning is the process of analyzing, selecting, and prioritizing ways to respond to things like climate change. Adaptation strategies are the broadest level of adaptation efforts while adaptation actions are the specific activities to be implemented in support of an adaptation strategy (or strategies). Strategies that address climate risks include projected increased intensity of storms in the Caribbean and sea level rise, particularly in Puerto

Rico where data show this is occurring. Vulnerability assessments may be performed as part of or prior to adaptation planning in order to determine the sensitivity of target resources to the impacts of climate change, the degree of exposure of these resources to these impacts, and the adaptive capacity of resources to respond to climate impacts.

Examples of adaptation strategies for coastal communities, facilities, and cultural resources include reducing non-climate stressors, retrofitting structures using new materials or technologies to improve resistance to extreme events, relocating structures and facilities, and establishing design requirements that consider climate predictions. See other examples of adaptation strategies: https://www.climate.gov/climate-and-energy-topics/adaptation-strategies-0

WORKING SESSIONS

Applying Concepts of Engineering with Nature/Green Infrastructure

The purpose of this working session was to develop a suite of recommendations for agencies/entities associated with the case studies selected by PRDNER and VIDPNR for the respective working sessions in Puerto Rico and USVI. The recommendations covered how to address the issues at the selected sites using green infrastructure/nature-based solutions, including how to overcome any challenges to implementation of solutions.

Objectives:

- To identify opportunities for integrating green infrastructure/living shorelines into recovery for areas impacted by things like coastal erosion and flooding through new design and construction, retrofitting existing structures, plantings, implementation of technological solutions, or other interventions;
- To identify barriers, such as design challenges, permitting requirements, community perceptions/buy-in, political will, and solutions for moving forward with the implementation of the green infrastructure/living shorelines projects; and
- To identify other sites where the suggestions for interventions would apply after considering interventions, challenges, and solutions for overcoming challenges.

Participants were assigned to groups to work together on a particular case study to develop opportunities and discuss challenges and solutions for implementing green infrastructure/living shorelines projects. Each person in the group was required to respond individually to a series of questions and then everyone had to discuss the questions as a group in order to reach

consensus regarding the interventions proposed to address the issue at their site using green infrastructure/living shorelines.

The questions participants were asked to answer were:

1. What are possible interventions based on the information provided in the case study write-up or personal knowledge of the site? These could include retrofitting existing structures/infrastructure, new design and construction, plantings, use of new technology, etc.
    a. The group was then asked to provide its final group recommendations regarding possible interventions.
2. What are some of the barriers to implementation of the interventions the group discussed (e.g., design challenges, permitting challenges, construction challenges, operational/maintenance challenges, potential use conflicts, fiscal/financial challenges, community engagement and/or buy-in challenges, etc.)? What are the solutions to these barriers the group discussed?
    a. The group was asked to provide its final decision regarding the most important challenges and ways to overcome them.
3. Are there other sites where the group thinks one or more of the recommended interventions would apply? Would the challenges and solutions remain the same for these sites?

Puerto Rico: Case Studies

The locations for the two case studies used on Day 1 are shown in Figure 1.

Figure 1. Google Earth image of Puerto Rico showing the locations of the two Day 1 case studies.

Punta Guilarte – Arroyo

Issue: Coastal Erosion at Municipal Property, Punta Guilarte Vacation Center

Punta Guilarte National Park is a property of the Municipality of Arroyo located on the southeast coast of Puerto Rico. The property is composed of several rental villas and a camping area.

In recent years, erosion of the coast has occurred in front of the buildings, while accretion has occurred at the other extreme (western part) of the coast in the park.

Figure 2 shows coastal erosion and accretion comparing 2004 and 2019.

Figure 2. Image on left is from 9/30/2004. Image on right is from 3/18/2019.

Working Session Summary Recommendations for Punta Guilarte

One group worked on this case study. The **final group recommendations regarding possible interventions** were to:

- Stabilize the shoreline using best available data to determine methodology – stabilize by regrading with sand and adding vegetation, including mangroves
- Vegetate shoreline
- Partially demolish compromised buildings and reconstruct out of the hazard zone

- Elevate roadway on piles; protect roadway infrastructure and allow flow between wetland and beach
- Research benthic conditions to determine the feasibility of offshore intervention such as reef restoration
- Low maintenance infrastructure for access (boardwalks)
- Establish new vacation center

The group identified the following **barriers and possible solutions to overcome them**:

- **Barrier:** funding; there is no federal funding available because of the Coastal Barrier Resources Act (the area is within a designated coastal barrier) so private sources of funding are needed; **Possible solutions:** public/private partnership; non-governmental organization(NGO) purchasing area for conservation; private funding source
- **Barrier:** permitting; **Possible solutions:** phase project; coordinate with permitting agencies early in process to get buy-in and work collaboratively
- **Barrier:** user conflict; **Possible solutions:** community/stakeholder engagement throughout process to make them part of the project

The group did not identify other sites in Puerto Rico where these interventions, barriers and possible solutions might apply.

Parcelas Suárez – Loíza

Issue: Coastal Erosion

Parcelas Suárez is located on the northeast coast of Puerto Rico in the Municipality of Loíza. Coastal erosion in this area is threatening critical infrastructure, including a public road, a public school, and a community center, along approximately 1,050 feet of shoreline. The erosion in this area was exacerbated by impacts from Hurricanes Irma and Maria in 2017. Road protection is an immediate critical need because the 2017 hurricanes worsened shoreline erosion, causing partial failure of the public road (see Figure 3). The USACE and the PRDNER have been working on an Integrated Feasibility Report and Environmental Assessment for this area and a draft of

the report was published in March 2018. The assessment recommends the construction of a continuous rock revetment along the 1,050-foot length of shoreline in front of the public road, Head Start public school, and community center to provide emergency shoreline protection. Due to existing public sidewalk damage, the remaining sidewalk may need to be demolished and replaced with an overwash protection zone. The overwash protection zone would consist of a high performance turf reinforcement mat between the existing road and the proposed revetment. However, the PRDNER and the Municipality want a living shoreline design for some of this area rather than the recommended continuous rock revetment.

Figure 3. Photos showing coastal erosion problems, including damage to roads and recreation areas along the beach.

Working Session Summary Recommendations for Parcelas Suárez

Two groups worked on this case study. Below are the summaries from each of the group discussions.

Group 1: The **final group recommendations regarding possible interventions** (Figure 4) were to:

- Remove the roadways and parking lot, retrofit street blocks and reconfigure parking
- Use green streeting
- Create living shorelines and an offshore breakwater/artificial reef
- Demolish the Head Start and community center buildings and move them inland, reuse materials as fill where needed
- Undertake a dune restoration project

The group identified the following **barriers and possible solutions to overcome them**:

- **Barrier:** costs due to size and extent of project; **Possible solutions:** look for funding from National Fish and Wildlife Foundation (NFWF), U.S. Environmental Protection Agency, Department of Justice, and Federal Emergency Management Agency (FEMA) (pre-hazard mitigation)
- **Barrier:** permitting; **Possible solutions:** create a task force to examine permitting issues and work to overcome them
- **Barrier:** user conflict – community may not want to move out of flood zone/critical areas; **Possible solutions:** meet with community and engage them in project; do community education

The group identified other areas at the mouth of a river where the interventions, barriers, and possible solutions discussed for Parcelas Suárez might also apply as the public beach and Punta Santiago Sector are located in Humacao.

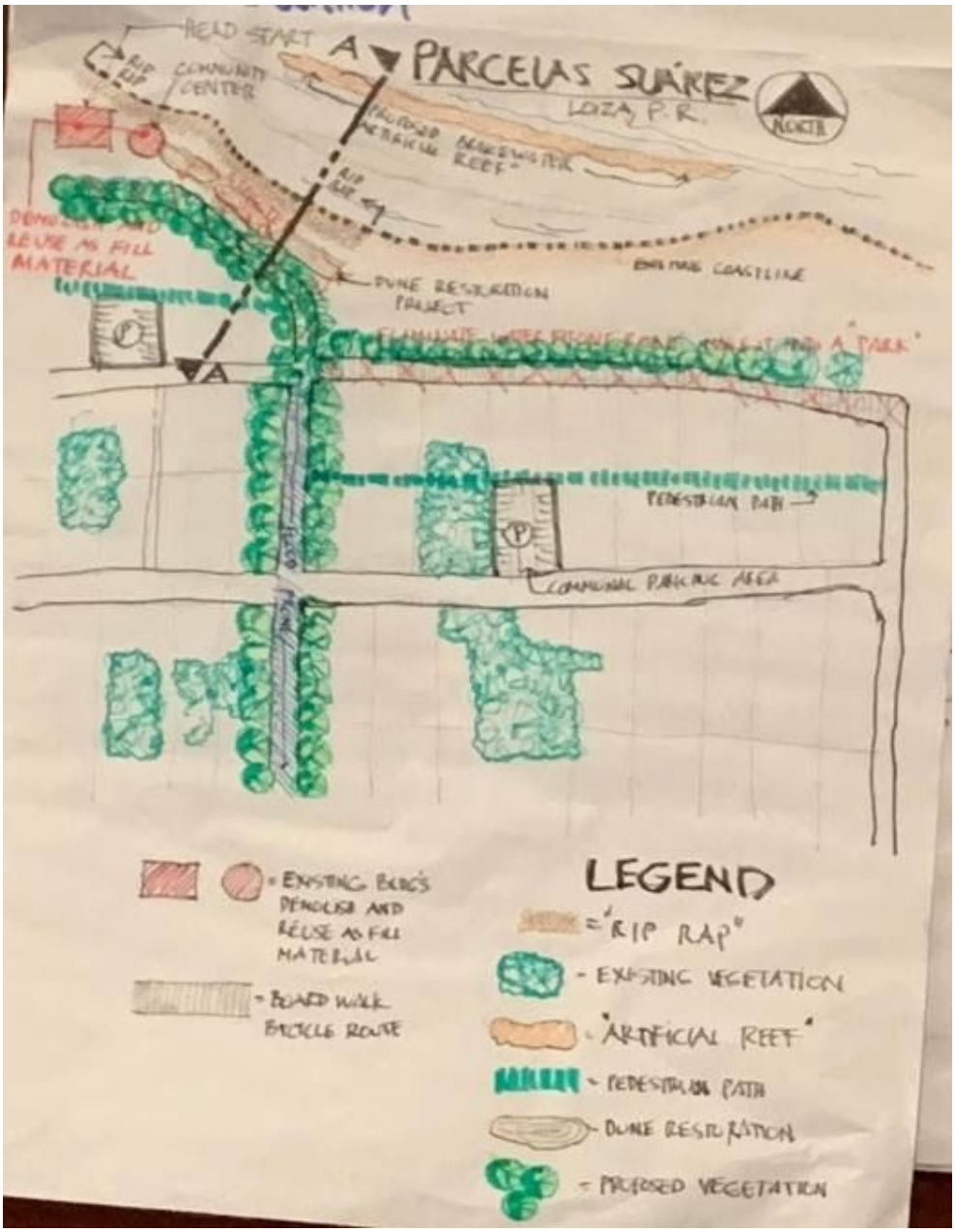

Figure 4. Photo of plan developed by group showing components of suggested interventions for Pacelas Suárez.

Group 2: The group determined that the rock revetment proposed by the USACE should not be the preferred option for this project. The **final group recommendations regarding possible interventions** were to:

- Consider the construction of sand dunes with submerged infrastructure (reef enhancement, artificial reefs)
- Consider retreat from shore/relocation of structures further inland with natural protections used for redeveloped areas
- If relocation is considered, land must be protected and not redeveloped

The group identified the following **barriers and possible solutions to overcome them**:

- **Barrier:** need to understand the natural environment and dynamics in area because things like discharge from the Río Grande de Loíza likely have an impact; **Possible solutions:** critical to do hydrodynamic modeling, evaluate whether dredged material from the marina (at Torrecillas Lagoon) could support project in the long-term as a sand source
- **Barrier:** community buy-in; **Possible solutions:** stakeholder engagement should be a priority

The group did not identify other areas where the interventions, barriers, and possible solutions discussed for Parcelas Suárez might also apply.

Virgin Islands: Case Studies

The locations for the case studies used in St. Croix are shown in Figure 5. Note that the Great Pond site was only used in the Day 1 working session but the other two sites were used both days.

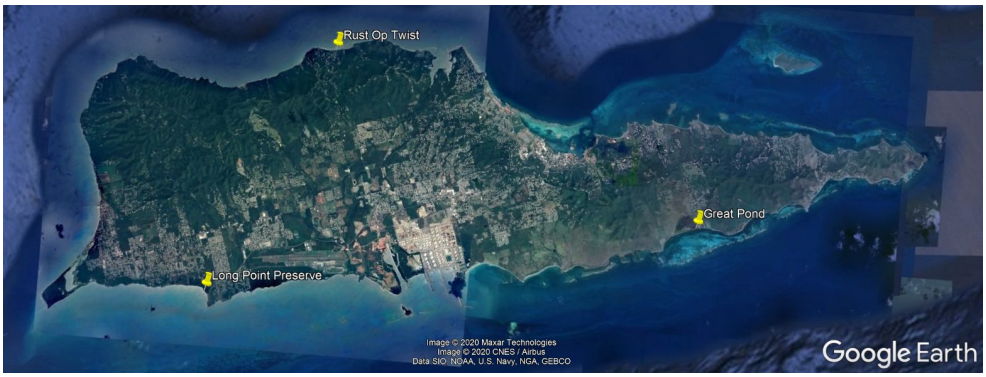

Figure 5. Google Earth image of St. Croix showing the locations of sites used during working sessions. Great Pond was only used for Day 1.

Mangroves at Great Pond

Issue: Closure of Channel Due to Mangrove Growth Affecting Water Levels/Exchange

Great Pond is a 50-hectare, mangrove-fringed, saline lagoon situated on the southeastern shore of St. Croix. Great Pond is contained on the south by a vegetated berm. The berm measures approximately 1,100 meters long with a maximum width of 105 meters and separates Great Pond from Great Pond Bay. The pond level and area fluctuate because of rainfall and tidal flow. Groundwater discharge and runoff from the 470 hectares of hills and pastures in the watershed result in a large influx of freshwater and sediment to Great Pond during and following heavy rainfall.

Like all lagoons in the USVI, the government owns Great Pond. Fishers historically used the pond to catch baitfish but changes to the pond over time have led to changes in fish species' composition with cichlid species (tilapia) dominating. Fishers have asked the VIDPNR to reopen the channel (Figure 6) and the Department is examining alternatives for reestablishing flow and restoring the fishery function of the lagoon.

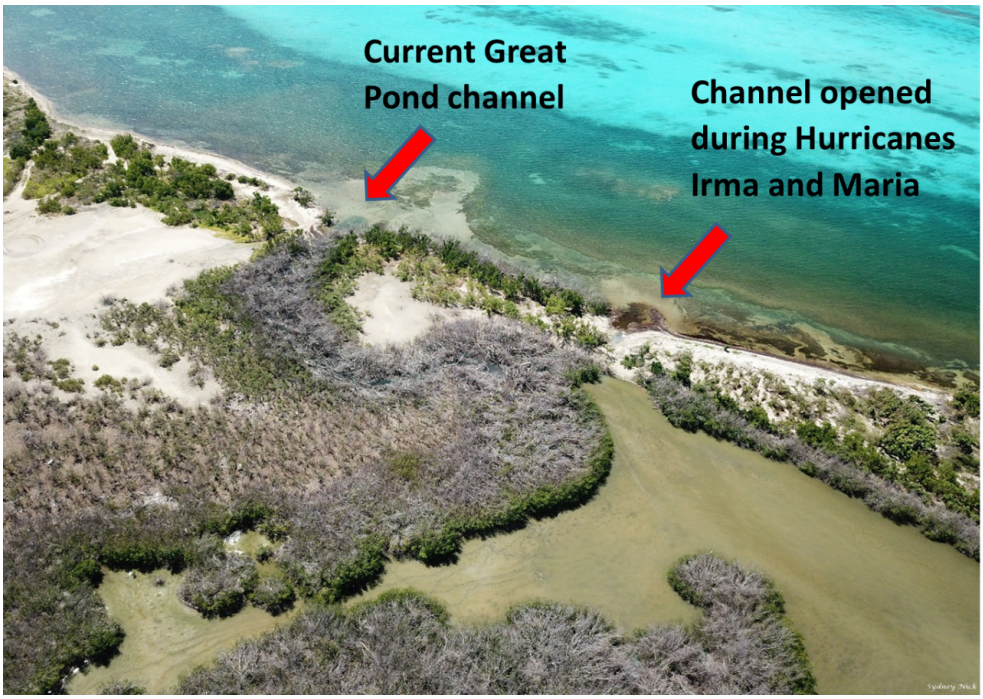

Figure 6. Aerial image showing Great Pond mangrove die-off, historic channel, and channel opened during 2017 hurricanes (Image from VIDPNR)

Working Session Summary Recommendations for Great Pond

One group worked on this case study and presented the following **final group recommendations regarding adaptation strategies** (see Figure 7):

- Dredge the channel's inlet; create deep pockets and a channel through wetland
- Land conservation (surrounding areas)
- Watershed erosion control/perimeter stormwater management
- Address tilapia ponds
- Use design charette to generate consensus on concept designs
- Compile data for informing design and case for restoration imperative (i.e., economic case; scientific case; groundwater; sediment rate; etc)
- Establish community buy-in
- Utilize as fish hatchery for growing native species

- Create trails, parking, and access to community assets
- Pre-Columbian historical elements used as focus for education, recreation, and tourist attraction

The group identified the following **barriers and possible solutions to overcome them** (see Figure 7):

- **Barrier:** data needs; **Possible solutions:** design charrettes
- **Barrier:** permits; **Possible solutions:** beneficial use of dredged sediments
- **Barrier:** economic case; **Possible solutions:** engage local community for input and also develop site as tourism attraction and recreation for local community.
- **Barrier:** Sargassum seaweed; **Possible solutions:** Sargassum management plan

The group did not identify other areas where the interventions, barriers, and possible solutions discussed for Great Pond might also apply.

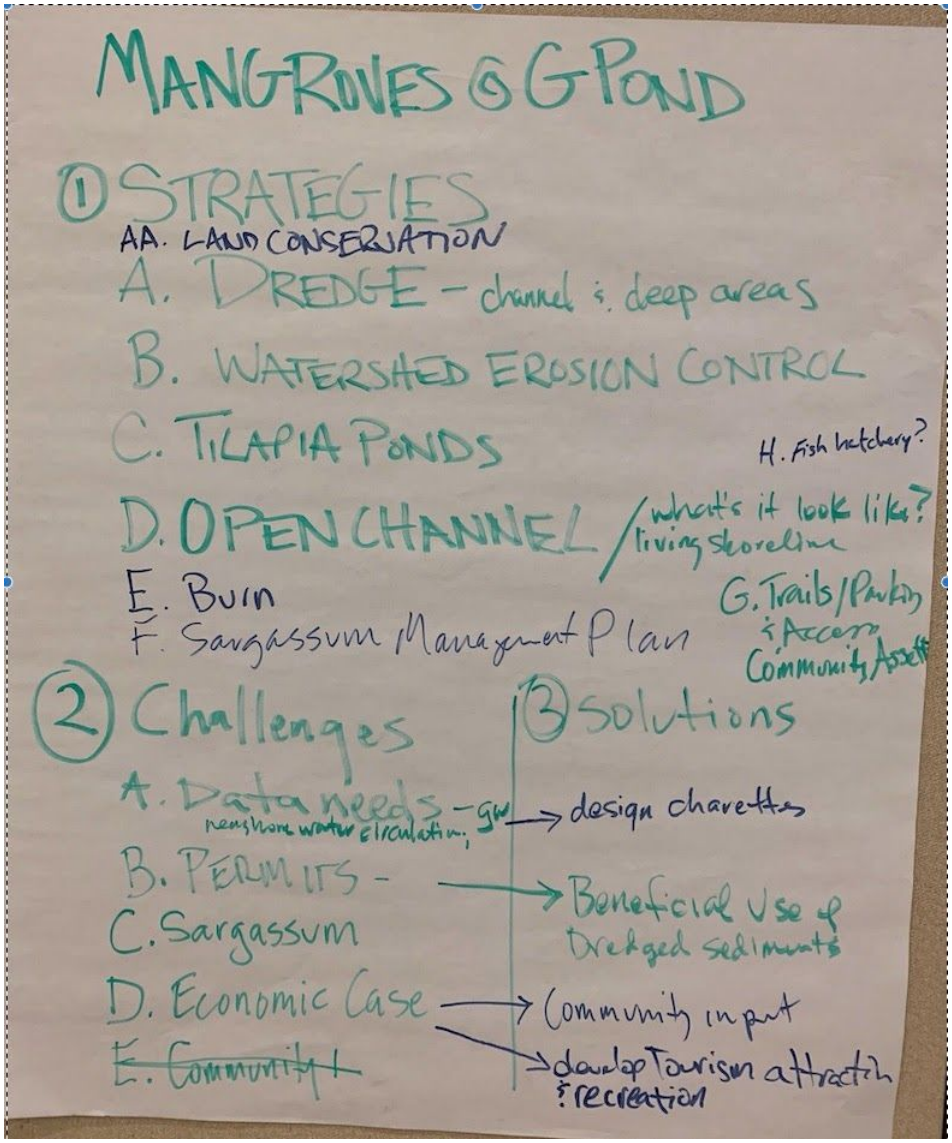

Figure 7. Photo of identified strategies, challenges, and solutions developed by the group working on the Great Pond case study.

Long Point – South Shore

Issue: Erosion and Runoff from Private Properties and Effects to Sea Turtle Nesting Beaches

The shoreline of Long Point borders historically residential areas on the south shore of St. Croix. Anecdotal accounts from residents indicate the area used to have mangroves but property owners have been eliminating the trees over time, leading to slow shoreline erosion. There is a remaining small stand of mangroves and the VIDPNR Division of Fish and Wildlife has been looking into ways to protect and improve this wetland. The remaining mangroves are part of the privately owned Long Point Preserve.

Along the shore, there is a lot of terrestrial-based sediment that is resuspended regularly during storms and swells (Figure 8). There is no stormwater management in the area. Stormwater takes the form of sheet flow from the hills to the north to the Hope and Carlton homestead lands along the shore.

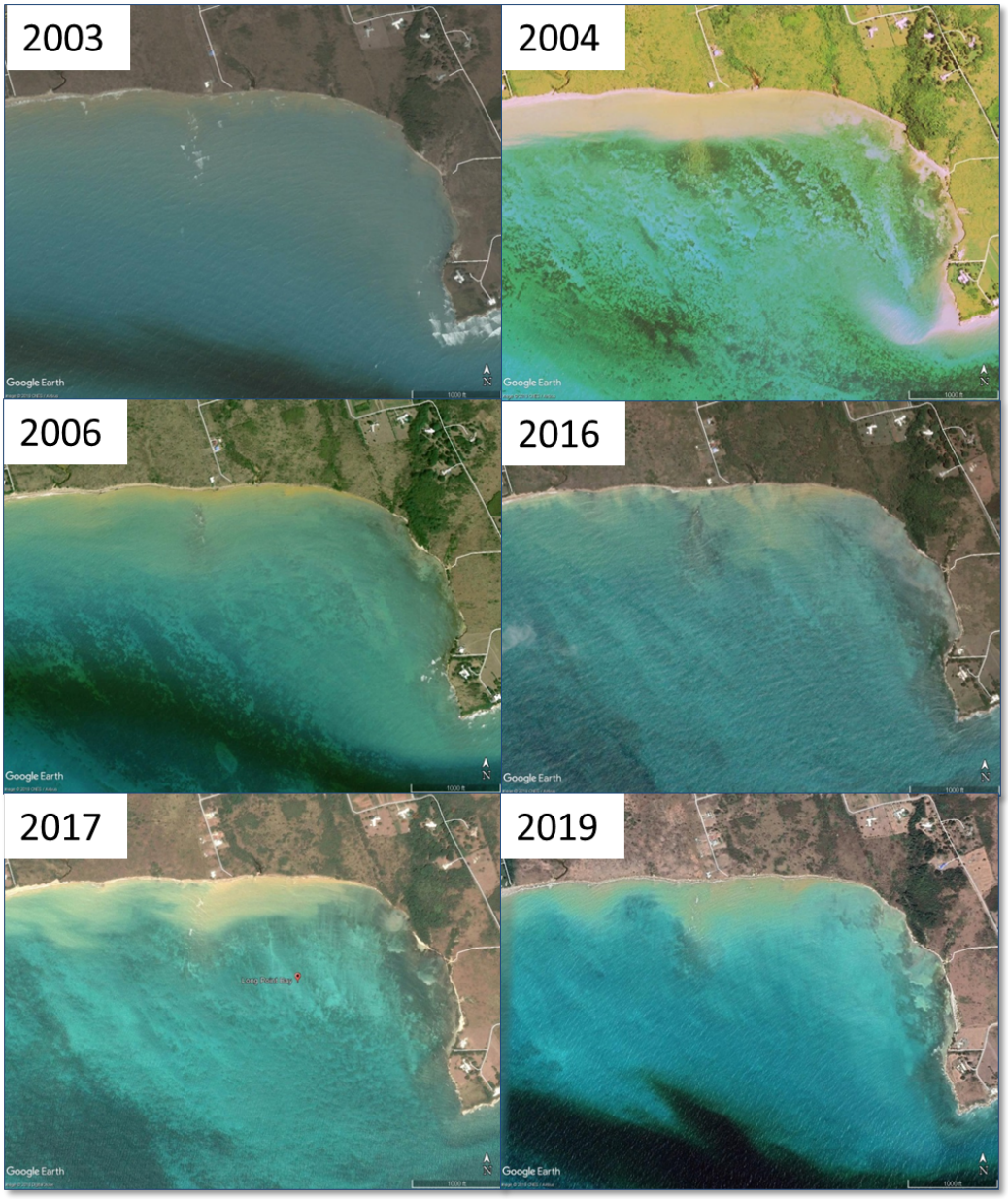

Figure 8. Google Earth images showing resuspended sediment over time in Long Bay.

Working Session Summary Recommendations for Long Point

One group worked on this case study and presented the following **final group recommendations regarding adaptation strategies** (see Figure 9):

- Check dams to slow velocity of water and include wetland vegetation
- Leverage support for project by providing private property access through improved roadway
- Establish wetland at a 30:1 slope along coast using The Nature Conservancy land and shallow nearshore coastal barrier (compensatory mitigation) and use excavated material for dredging project
- Install artificial reef, including coral restoration areas offshore of wetland
- Collect mangrove propagules and develop maintenance plan for herbaceous wetland & mangrove
- Build boardwalk and wildlife viewing area to encourage public education and recreation
- Create volunteer management program

The group identified the following **barriers and possible solutions to overcome them:**

- **Barrier:** maintenance and funding – the work required to remedy the issues at Long Point is difficult and would require skilled manpower; federal funding from grants doesn't cover operations and DPNR doesn't have structural/operational authority; **Possible solutions:** public/private partnership; private funding source
- **Barrier:** water quality at the site continues to be an issue; **Possible solutions:** development of stronger regulations for wastewater, rum effluent, and stormwater
- **Other Barriers:** weather-dependent construction and drug trafficking enforcement concerns; cost of collecting mangrove propagules and maintenance; feasibility of check dams; permits from the USACE and accessing 301 funds under the Clean Water Act.

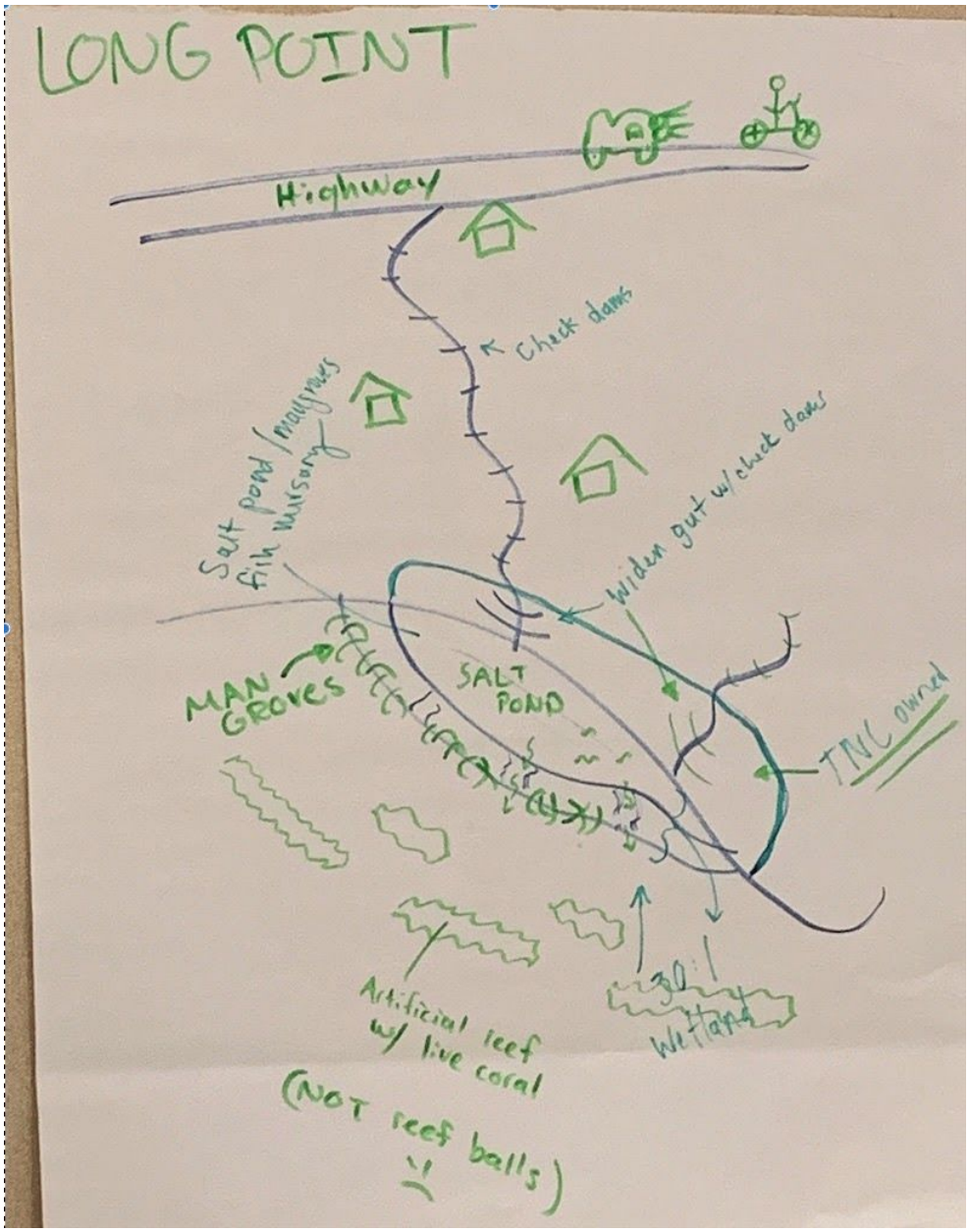

Figure 9. Photo of plan developed by group showing components of suggested interventions for the Long Point study site.

Rust Op Twist – North Shore

Issue: Shoreline Erosion

The north shore of St. Croix is significantly different from the south shore due in part to high-energy waves and the small insular shelf along the north coast. Coastal erosion along the shoreline is severe. There is one site in particular where a property owner has been losing land for the last couple of years (Figure 10), but coastal erosion extends east and west of the property along the shoreline. Because of the history of coastal erosion in the area, at some point in time the VIDPNR placed riprap along a portion of the shoreline. The riprap is to the east of the Rust Op Twist property and appears to have exacerbated coastal erosion to the west of the riprap, which includes the homeowner's property. Reef flats and seagrass beds characterize the nearshore area. The beach is rocky but the cliffs behind the beach are highly erodible. The property owner is interested in green infrastructure options, but needs help deciding on preferred options.

Figure 10. View to the south looking toward property from beach (Photo from VIDPNR)

Working Session Summary Recommendations for Rust Op Twist

The group that worked on this case study presented the following **final group recommendations regarding adaptation strategies** (see Figure 11):

- Retreat Roadway and relocate home
- Invest in a design solution that offered features such as a public viewing area on top of the cliff, elevated above current sea level, installation of terraced limestone planters of native species also offering food sovereignty
- Include community engagement such as public meetings, design competition for determined concept, hearings, education through participatory planting, and signage
- Conduct ongoing maintenance of the plantings and required sea level rise modifications

The group identified the following **barriers and possible solutions to overcome them**:

- **Barrier:** skilled labor and lack of capacity; **Possible solutions:** use the site for training and vocational education and leverage the UVI Caribbean Green Technology Center
- **Barrier:** design challenges included far extended reef, strong currents, dynamic and high erosion area; **Possible solutions:** include public viewing from top of cliff, elevate above current sea level, include limestone planters and native species, as well as cobblestone and cleats/piles to support structure
- **Barrier:** potential use conflict; **Possible solutions:** community/stakeholder engagement throughout process to make them part of project, public meetings, design competition, info plaques

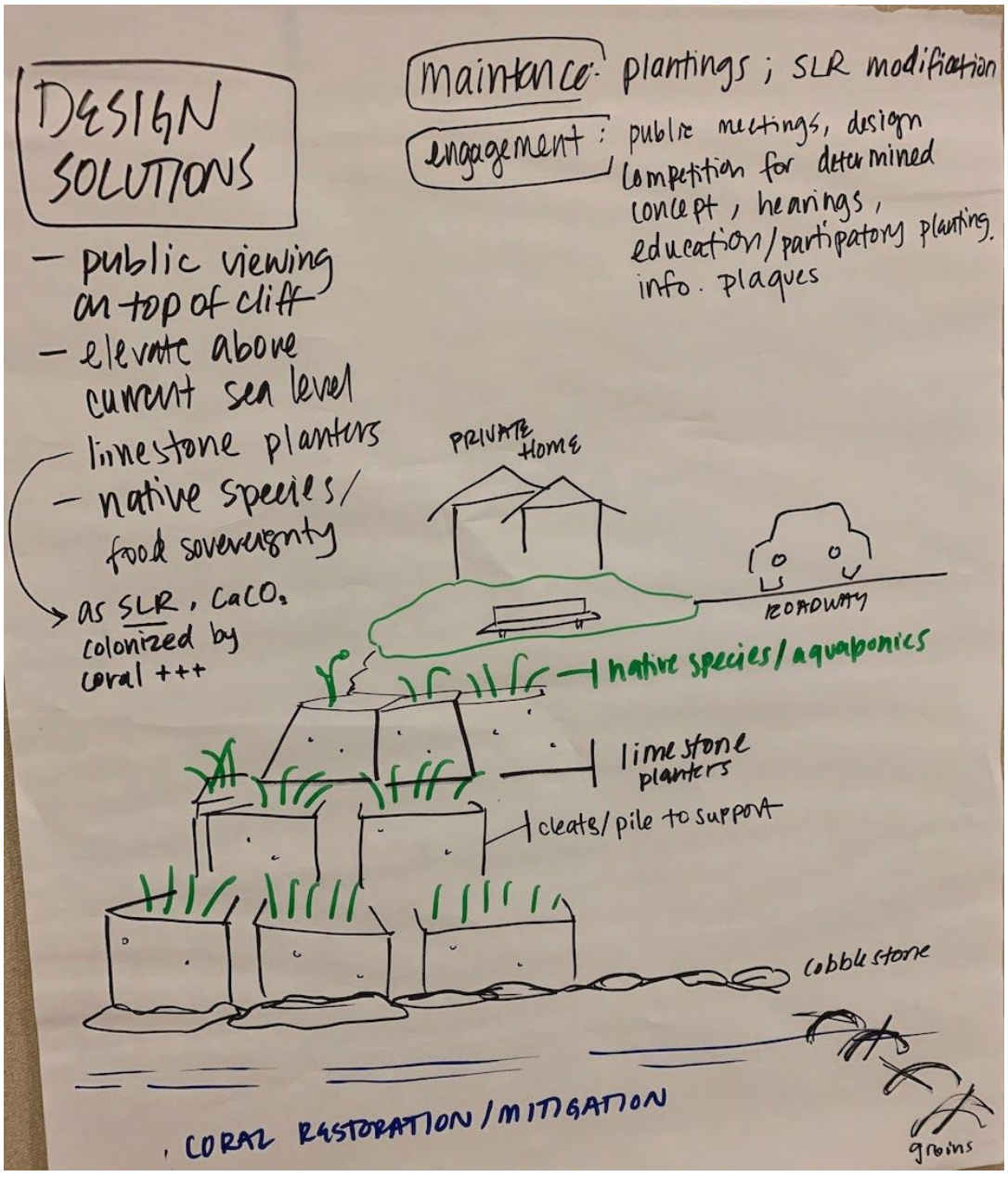

Figure 11. Photo of plan developed by group showing components of suggested interventions for the Rust Op Twist study site.

The group identified other coastal communities where the natural and nature-based infrastructure strategies recommended for the case study, as well as the challenges and solutions, would be applicable. These sites included areas along the south shore of St. Croix, areas near The Buccaneer Hotel, examination of old groins near Divi Hotel & Casino, and all coastal communities with shallow coastlines.

Adaptation Planning

This working session used case studies as a basis for developing a suite of adaptation strategies for agencies/entities to address the impacts of climate change. Participants also discussed how to overcome potential challenges to implementation.

Objectives:

- To identify adaptation strategies for coastal communities to respond to the impacts of climate change that lead to things like "nuisance" flooding, coastal erosion, lack of system capacity for stormwater management, and declines in water quality;
- To identify barriers to development and implementation of adaptation strategies, such as community involvement and/or buy-in, political will, and ways to overcome them in order to develop and implement adaptation strategies and their associated actions in these communities; and
- To provide information about other communities where the adaptation strategies proposed for a case study could apply, including whether the challenges to implementation and ways to overcome them would be the same or different from the case study.

Participants were assigned to groups to work together on a particular case study to develop adaptation strategies. Each person in the group was required to respond individually to a series of questions and then everyone had to discuss as a group in order to reach consensus regarding proposed adaptation strategies for a site.

The questions participants were asked to answer were:

1. What are some adaptation strategies for the coastal community (or communities) at this site to respond to the impacts of climate change (such as increased tropical storms and associated effects like declines in water quality, coastal erosion, and lack of capacity to manage stormwater)?
    a. The group was then asked to provide its final group decision on adaptation strategies recommended for the site.
2. What are some of the challenges and possible solutions to implementing the adaptation strategies recommended by the group?
    a. The group was asked to provide its final decision on the most important challenges and solutions to overcome them.
3. What are some of the challenges and possible solutions to prepare for and assess risk and vulnerability of the site from the impacts of climate change (e.g., sea level rise, increased frequency of tropical storms, or other climate-driven impacts) in order to develop a complete adaptation plan?
    a. The group was asked to provide its final decision regarding the most important challenges and solutions to developing a complete adaptation plan for the site to respond to climate change.
4. What are some of the challenges and possible solutions to implement an adaptation plan for this site?
    a. The group was asked to provide its final decision regarding the most important challenges and solutions to overcome them in order to implement an adaptation plan for the site in response to climate change.
5. Are there other coastal communities where the group thinks the adaptation strategies recommended for the case study would also be applicable? Would the challenges and solutions be the same? Would it be more beneficial to develop and implement a complete adaptation plan and, if so, what would the obstacles be to this and possible ways to overcome them?

Puerto Rico: Case Studies

The locations for the case studies used on Day 2 are shown in Figure 12.

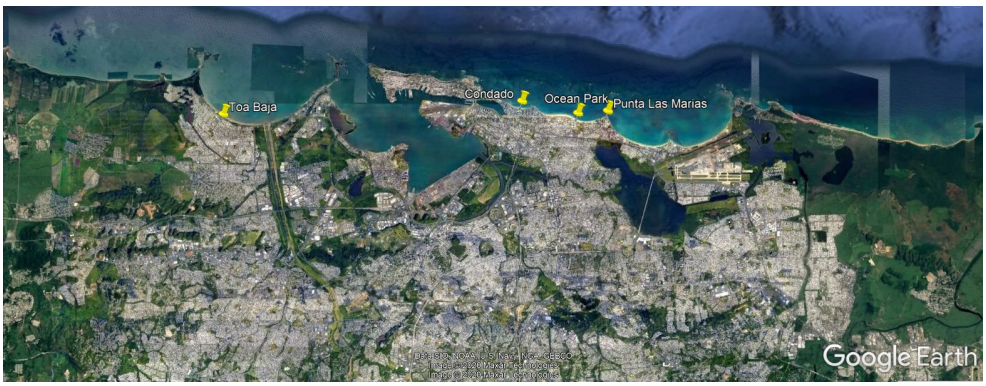

Figure 12. Locations of Day 2 case studies.

Municipality of San Juan

Issues: Sea Level Rise/"Nuisance" Flooding; Stormwater Management; Water Quality; Erosion

The case study included the area from Condado Lagoon to Punta Las Marías in the Municipality of San Juan. The area has been impacted by coastal erosion; poor water quality and stormwater management; and flooding from storm surges, swells, and sea level rise; among others.

Condado Lagoon is a marine coastal lagoon located in the Municipality of San Juan. It was designated as the Condado Lagoon Estuarine Natural Reserve under Law Number 112 of 2013. The lagoon receives freshwater inputs from the storm drainage system in the area, as well as runoff from adjacent lands. An evaluation carried out by the Municipality in 2014 identified 15 storm sewer system drains that discharge into the southern portion of the lagoon (Figure 13). Other pluvial pipes that discharge into the lagoon from the residential complexes in the north-northeast of the lagoon were identified. When the tide rises, water enters through these pipes, flooding the area. With an increase in sea level, floods are expected to be more frequent if adequate adaptation strategies are not developed and implemented. In addition, the backup and release of storm drains and flooding of lands adjacent to the lagoon present sources of contamination to the reserve.

Stormwater management is also an issue in Ocean Park and Punta Las Marías. The PRDNER has flood control pump stations; however, this area still floods from stormwater runoff, in addition to flooding from swells and storm surge. Some of the residents (community group Condado in Action) have identified discharge in the stormwater drainage channels to the coast as appearing to be contaminated or containing wastewater discharge.

Communities like Condado, Ocean Park, and Punta Las Marías, among others in the area, have experienced a significant amount of coastal erosion, putting commercial and residential buildings at risk (Figure 14). Around 12 vertical feet and 110 horizontal feet of beach eroded in the summer of 2019.

Figure 13. Photos of areas of "nuisance flooding" and storm drainage system in south/southwest portion of lagoon (Photos: PRDNER).

Figure 14. Swells and erosion in Ocean Park (Photo on far right from Dr. Miguel P. Sastre, July 2019; other photos PRDNER).

Working Session Summary Recommendations for Municipality of San Juan

The group that worked on this case study presented the following **final group recommendations regarding adaptation strategies**:

- Improve water pumps and pipe systems (more capacity, including water quality upgrade similar to City of Miami Beach project presented by Elizabeth Wheaton)
- Rescue abandoned properties to convert into green infrastructure
- Install stormwater backflow preventer
- Restore dunes, coral reefs, and mangroves
- Establish San Juan Marine Protected Area and improve enforcement of existing regulations
- Develop future renovation standards
- Research current development codes and enforce
- Reform permitting process
- Ensure transparency and community consultations and involvement

The group identified the following **challenges and possible solutions to overcome them** related to the implementation of adaptation strategies:

- **Challenge:** funding; **Possible solutions:** hotel and Airbnb taxes for a watershed improvement fund, stormwater utility fees, property tax reassessment
- **Challenge:** lack of awareness; **Possible solutions:** education about coastal issues, one-on-one outreach, learn from Cantera example
- **Challenge:** lack of trust in government; **Possible solutions:** community engagement, repeat efforts showcasing examples where adaptation planning has been used and worked

The group identified the following as the **most important challenges and solutions to developing a complete adaptation plan** for the site to respond to climate change as data needs related to:

- Deep wells to correlate sea level rise with water table levels/groundwater flow
- Drainage capacity (partner with Puerto Rico Aqueduct and Sewer Authority, Municipality)
- Beach dynamics
- Coral reef dynamics

- Location of damaged areas
- Benthic mapping
- Water quality baseline and monitoring and tracking of point source pollution

The group also identified writing a climate adaptation plan as a challenge, as well as a solution to overcome issues related to climate change in the community.

The group noted the **most important challenge to implementation of an adaptation plan** for the site in response to climate change is financial support.

The group identified the Cantera community in San Juan as another coastal community where they think the adaptation strategies recommended for the case study, as well as the challenges and solutions, would be applicable.

Municipality of Toa Baja

Issues: Erosion; Flooding; Sea Level Rise

The Municipality of Toa Baja was one of the municipalities most affected by Hurricane María due to flooding and storm surge.

The northern portion of the Municipality is on a coastal plain with elevations ranging from approximately one to five meters. There are marshes and mangrove areas, and a substantial part of the land is flooded seasonally or permanently. The southern part of the Municipality is characterized by the presence of hills and limestone mogotes (generally isolated steep-sided residual hills with a rounded, tower-like form composed of limestone, marble, or dolomite surrounded by nearly flat alluvial plains).

Most of the Municipality is susceptible to floods. Toa Baja has large urban areas in the coastal plain, mostly in flood-prone areas. The Municipality has channels to manage stormwater runoff and prevent flooding (Figure 15). However, the outfalls for some channels (i.e., the points at which they discharge into the ocean) do not work properly due to sediment deposition and high sea level. In addition, like many coastal municipalities, Toa Baja has significant coastal erosion problems (Figure 15).

Figure 15. Photos showing coastal erosion and channels through which stormwater drains (Photos from PRDNER).

Working Session Summary Recommendations for Municipality of Toa Baja

The group that worked on this case study presented the following **final group recommendations regarding adaptation strategies**:

- Remove coastal debris and restore natural areas
- Refine and expedite the process of public nuisance law(s)
- Rehabilitation of wetlands, including *Pterocarpus*
- Stormwater system management
- Mogotes (karst hills) stabilization and reforestation
- Installation of pumping system with backup system following City of Miami Beach example to create a redundant system
- Use second floor of structures, make them hurricane resistant and increase housing density
- Maintain channels
- Use a tax that can be reinvested in the beach
- Consider relocation of families
- Create a program for selective demolition
- Integrate a multidisciplinary group
- Promote the use of permeable pavement instead of asphalt
- Conduct educational campaigns to integrate the community
- Start with a prioritization process for the community and local government
- Meandric design for channels

The group identified the following **challenges and possible solutions to overcome them** related to the implementation of adaptation strategies:

- **Challenge:** acquiring private lands; **Possible solutions:** create a trust, go over "nuisance laws" for taking/acquiring damaged property
- **Challenge:** lack of funds; **Possible solutions:** redirect a percentage when there is a single lottery winner to a fund for adaptation, create a stormwater ordinance, create a land transfer tax
- **Challenge:** need for long-term plans; **Possible solutions:** develop master plans including risk analysis/assessment
- **Challenge:** stakeholder buy-in; **Possible solution:** cost/benefit analyses

The group identified the following as the **most important challenges to developing a complete adaptation plan** for the site to respond to climate change:

- Massive relocation of communities will be required
- Government will not be paying
- There is not sufficient attention to climate change impacts and no agreement on the projections
- Adjacent municipalities (i.e., Cataño, Dorado) are probably impacted by the issues in this watershed
- Old stormwater infrastructure

The group identified the following as the **most important solutions to developing a complete adaptation plan** for the site to respond to climate change:

- Look at the City of Miami Beach example and other case studies to replicate
- Bring scientists to the discussion to make informed decisions
- Exchange with communities that have made a decision on adaptation strategies and take action as examples and to track why they believe it is a good decision
- Data and information are available so should integration communicators and expand the scope to include public health issues

The group noted the **most important challenges and solutions to implementation of an adaptation plan** for the site in response to climate change are:

- **Challenge:** political will due to a lack of knowledge, short terms of four years for politicians; **Solutions**: there should be integration with schools and more community engagement and involvement
- **Challenge:** financial support due to a lack of knowledge regarding how to apply for federal grants; **Solutions:** a regional/state grant office assisting municipalities, visitor's tax like what is done in Hawaii and a bottle deposit
- **Challenge:** technical support; **Solutions:** free available resources from agencies like NOAA, require more local hiring, use resources in academia

The group identified other coastal communities where they think the adaptation strategies recommended for the case study, as well as the challenges and solutions, would be applicable, including Cataño and Dorado, which are adjacent to Toa Baja, Punta Santiago (Humacao) and Yabucoa, and all coastal communities with shallow coastlines.

Virgin Islands: Case Studies

The case studies used in St. Croix were Long Point and Rust Op Twist, which were also used as Day 1 case studies (see Figure 5).

Working Session Summary Recommendations for Long Point

The group that worked on this case study presented the following **final group recommendations regarding adaptation strategies**:

- Restoration of mangroves through replanting to slow wave energy and also assist with stormwater management of accumulated sediments from the nearby dirt road
- Install Reef Balls™ to slow flow
- Access National Park System (NPS) program for potential installation of rain garden, pervious pavers, and swale

- Develop an education initiative in association with neighboring homeowners and community engagement component to establish baseline indicators and ongoing crowd sourced citizen science initiatives
- Conduct coastal processes assessment of current, wind, fetch, and modeling for interventions
- Conduct hydrodynamic study to better understand scouring and associated synthesis of historical data
- Investigate B-WET model for possible lessons learned
- Develop a portal to share flood and storm surge maps and co-locate data on Digital Coast.

The group identified the following as the **most important challenges to developing a complete adaptation plan** for the site to respond to climate change:

- Creative and thoughtful approach to community compliance
- Effective mangrove restoration design
- Lack of tax credit incentives
- Ability to ensure ongoing maintenance and lack of best management practices
- Permitting
- Retaining expertise
- Lack of community activism

Working Session Summary Recommendations for Rust Op Twist

The group that worked on this case study presented the following **final group recommendations regarding adaptation strategies**:

- Remove riprap
- Enhance offshore breakwater with hybrid reef
- Identify stabilization mechanism for terrace system
- Design terrace feature in a way that additional terrace pieces can be added to extend further from the shoreline
- Address areas of flooding and prevent erosion of reef and seagrass bed

- Develop watershed management plan for north shore runoff using sediment catchment systems
- Relocate road and install features to slow and filter runoff

The group identified the following as the **most important challenges to developing a complete adaptation plan** for the site to respond to climate change:

- Cost of green infrastructure and upgrades to storm/wastewater system may be prohibitive
- Roadside culverts might require permits
- Septic system adaptation might prove difficult, eroding land might not bear weight
- Hawksbill nesting site
- Sediment transport impacts unclear

The group suggested that some of the adaptation strategies recommended for the case study could be utilized at the "The Beast" on the North Shore of St. Croix near Carambola Hotel & Resort. It was specifically noted that the installation of permeable pavement should be considered as a solution to ensure nearshore water quality.

APPENDICES

Appendices I and II contain notes transcribed from the worksheets completed by participants in the Puerto Rico and USVI workshops, respectively. These notes are from individual participants and are not the same as the group summaries presented in the body of the report. Appendix III is the list of workshop participants.

Appendix I. Puerto Rico Working Sessions

Applying Concepts of Engineering with Nature/Green Infrastructure

The responses submitted by individual participants are grouped by case study and summarized below for each of the questions on participant worksheets, which were as follows:

1. What do you think are possible interventions based on the information provided in the case study write-up or your personal knowledge of the site? These could include retrofitting existing structures/infrastructure, new design and construction, plantings, use of new technology, etc.
2. Now think about some of the barriers to implementation for each of the interventions you brainstormed. (Note that the list below contains examples and there may be others you think of or have encountered.) You do not have to write something for each one – you can choose to focus on a particular challenge or challenges and solutions based on your experience.)
    a. What are some of the design challenges for the interventions? What are some solutions to address these challenges?
    b. What are some of the permitting challenges for the interventions (e.g., regulatory staff knowledge and expertise in evaluating these types of projects; presence of ESA resources, etc.)? What are some solutions to address these challenges?
    c. What are some of the construction challenges associated with the interventions? What are some solutions to address these challenges?
    d. What are some of the operational/maintenance challenges associated with these interventions? What are some solutions to address these challenges?
    e. What are some of the potential use conflicts with implementing these interventions? What are some solutions to address these challenges?
    f. What are some of the fiscal/financial challenges associated with implementing these interventions? What are some solutions to address these challenges?

g. What are some of the community engagement and/or buy-in challenges associated with these interventions? What are some solutions to address these challenges?
h. Are there other challenges? Solutions to these?

3. Are there other sites where you think one or more of the interventions would apply? Would the challenges and solutions be the same?

Punta Guilarte – Arroyo

Intervention Recommendations:

- Stabilize shoreline – check grain size and composition and bring in sand; do habitat reconstruction with vegetation, mangrove planting (but need to consider water source for plantings)
- Truck sand back to the eroded area
- Heavily plant area with coastal vegetation
- Improve circulation
- Coral reef restoration/series of artificial reefs to attenuate wave energy
- Remodel buildings or relocate/demolish, replace some areas with camping site, add observation tower/lighthouse
- Relocate the facility and make it a camping site

Barriers to Implementation:

- *Design challenges:* hydrology; wave model; bathymetry
- *Permitting challenges:* USACE, local permits; FWS, NMFS, CZM
- *Construction challenges:* shallow draft barge; proper design of breakwaters/reefs; water supply
- *Operational/maintenance challenges:* recurring beach nourishment
- *Potential use conflicts:* local municipality will want to keep site as is rather than shift design/location; source of income for municipality to replace revenue
- *Fiscal/financial challenges:* long-term maintenance budget; existing condition of structures; Coastal Barrier Resources Act that prevents receipt of federal funds; cost of plantings and shoreline stabilization and reef restoration/construction
- *Community engagement/buy-in challenges:* public perception
- *Other challenges:* project timeline; existing condition of structures

Solutions to Address Barriers:

- *Permitting:* phasing for permitting
- *Fiscal/Financial:* NGO funds for conservation; public/private partnership
- *Community engagement/buy-in:* Stakeholder engagement; cooperative type of management with local NGO

Other sites where these interventions might apply:

- Naguabo PR3
- Ceiba Beach

Parcelas Suárez – Loíza

Intervention Recommendations:

- Apply planned retreat by relocating the line of houses and structures from the high-risk area, which are the structures closest to the maritime zone. Combine with restoration of dunes and wetlands; demolish roads and restore areas; create other access.
- Community relocation of residents; relocate community building and school
- Beach renourishment
- Parking lot removal; partial road removal and designation of community parking area
- Pocket parking on abandoned/empty lots
- Complete street remodeling; consider rerouting of sewer force main
- Living shoreline/terraced horizontal levee; dune restoration
- Reef restoration/offshore breakwater
- Reforestation with native trees and shrubs
- Río Herrera watershed improvement as a whole with mangrove and seagrass restoration
- Turn area into a national park and let nature do its work
- Retrofitting (conversion of first floors to not be residences but instead parking/retail that may flood)

Barriers to Implementation:

- Expropriation of houses may be difficult
- *Design challenges:* area must be studied to understand and assess geomorphology, sediment transport dynamic, sea level rise projections,

and other aspects related to the existing flooding risk; important to study the development pattern, urban characteristics, history and culture; need more space for dune development

- *Permitting challenges:* may require compliance with the PR Environmental Policy Law or NEPA; USACE, FEMA
- *Construction challenges:* demolition of structure to rehabilitate the land and management of debris; could displace flooding to other communities; construction of things like a breakwater wall could exacerbate erosion issues at either end of the wall depending on the design; phreatic level; urban sprawl
- *Operational/maintenance challenges:* if lands are restored to their natural state, probably need low to no maintenance; important to restore lands according to the habitat that was there before development; who manages and monitors?; could continue to have erosion issues that would require annual maintenance; PR doesn't budget for maintenance
- *Potential use conflicts:* would need measures to prevent invasion or future development; public safety; community could still be subject to flooding; need to engage transportation authorities like FHA (if it's a state road) and DTOP; property rights; lack of coordination with property owners
- *Fiscal/financial challenges:* insufficient money to finance project; PR is in fiscal crisis so no local funding can be expected; lack of financial resources; tax base not large enough to fund and sustain; maintenance not budgeted for adequately
- *Community engagement/buy-in challenges:* lack of confidence in government; environmental justice; public has adversarial relationship with government
- *Other challenges:* timing – reef and other restoration takes time; political and cultural challenges; water quality may be too poor to support reefs so reef restoration would not be successful; flooding from Loíza River from behind project area

<u>Solutions to Address Barriers:</u>

- *Design:* studies are already done from USACE work

- *Permitting:* more open integration amongst stakeholders/regulators
- *Construction:* eliminate construction and allow area to revegetate; relocate residents to a safer place in an existing community; deal with abandoned buildings
- *Operational/Maintenance:* integrate the community in management
- *Use:* lands must be in a conservation easement and measures must be implemented to prevent invasion or future development; strict implementation of public nuisance law; create coordination with all stakeholders
- *Fiscal/Financial:* implement project incrementally and identify sources of funds; Environmental Justice, NFWF Coastal Resiliency Fund for design and permitting, FEMA pre-disaster mitigation funds, EPA to pay for watershed work; PRASA could do rate hike; create a grant team or use one from NGO; use comprehensive municipal development plan with DTOP, Mitigation, and Emergency offices to then be able to request funds from multiple sources
- *Community engagement/buy-in:* Municipality has to be part of process; more community meetings with communications; talk with community about costs and other challenges

Other sites where these interventions might apply:

- Other areas at the mouth of a river along coast
- Punta Santiago (Humacao)
- Humacao Public Beach
- Puerto Nuevo channelization

Adaptation Planning

The responses submitted by individual participants are grouped by case study and summarized below for each of the questions on participant worksheets, which were as follows:

1. What are some adaptation strategies for the coastal community (or communities) at this site to respond to the impacts of climate change (such as increased tropical storms and associated effects such as declines in water quality, coastal erosion, and lack of capacity to manage stormwater)?

2. What do you think are some of the challenges and possible solutions to implementing the adaptation strategies you identified?
3. What do you think are some of the challenges and possible solutions to prepare for and assess risk and vulnerability of the site from the impacts of climate change (e.g., sea level rise, increased frequency of tropical storms, or other climate-driven impacts) in order to develop a climate adaptation plan?
    a. Identifying and obtaining human, technical, and financial resources?
    b. Finding data and information on past and future climate impacts?
    c. Understanding climate projections and predicting future impacts?
    d. Identifying critical infrastructure, key economic structures, and vulnerable populations that may be at risk from impacts associated with climate change such as higher water levels, storm surge, and flooding?
    e. Identifying and engaging stakeholders and being able to communicate risk from climate impacts to different target audiences?
    f. Others?

Municipality of San Juan

We received one adaptation strategy suggestion from an individual, which was to do wetland restoration. The rest of the information using the Municipality of San Juan as a case study is included in the main body of this report.

Municipality of Toa Baja

<u>Adaptation Strategy Recommendations:</u>

- Maintain stormwater channels/restore estuarine areas
- Install pumping systems with backup generators and photovoltaic/battery systems for redundancy as a second line of defense (like in the City of Miami Beach example that was presented during workshop)

- Promote core insulated concrete panel construction (light construction, hurricane resistant) for a second floor on all (or many) urban dwellings in flood-prone areas and leave first floor for secondary uses
- Integrate permeable pavement, rain gardens, etc. (green infrastructure) into the developed area for stormwater management
- Offshore breakwater/artificial reefs (once water quality is improved)
- Demolish and remove non-functioning channels – move to areas above sea level (enough above to prevent effect from estimated sea level rise)
- Dune restoration, revegetation of beaches
- Remove damaged infrastructure from beach area
- Mangrove and marsh restoration; River renaturalization
- Upgrade stormwater system (e.g., pumps, filtration prior to discharge); Maintenance of equipment
- Raise buildings
- Move buildings out of flood-prone area to hillside
- Educational campaign
- Mangrove protection
- Removal of sediment

<u>Challenges and Solutions to Implementing Strategies:</u>

- *Challenges:* resources (always); dunes may not be natural in the area; coral reefs may not be in good shape;
  Solutions: look into a wide variety of funding mechanisms ranging from local to federal; conduct a study to determine whether dunes are naturally formed and will stay in area long-term; conduct a study to determine status of corals and if restoration/artificial reefs would be feasible
- *Challenges:* financing; stakeholder/community/political buy-in;
  Solutions: hazard mitigation funds; green bonds; community rating system; tax/fees from tourism; direct exchange with and input from other communities with similar issues that have implemented adaptation strategies (e.g., City of Miami Beach)
- *Challenges:* short-term solution thinking; funding;
  Solutions: clearly present benefits of long-term solutions
  Solutions: initiate coastal restoration projects funded with taxable access to Punta Salinas Beach; use parametric insurance funded by beach

access fee (coastal restoration project may lower cost of parametric insurance); relocate population that is in extremely vulnerable areas (maybe to the new second floor of existing houses with lower risk or to new, more resilient and less risky sites; acquire private land – when there is a single lottery winner of more than $10 million, require donation of 40% of the total to finance green infrastructure programs

Challenges and Solutions for Risk and Vulnerability Assessments toward Development of an Adaptation Plan:

- *Challenges:* identifying and obtaining human, technical, and financial resources; data and information on past and future climate impacts; understanding of climate projections and prediction of future impacts; identifying critical infrastructure, key economic structures, and vulnerable populations that may be at risk from impacts associated with climate change; identifying and engaging stakeholders and being able to communicate risk from climate impacts to different target audiences; different focus of decision-makers that doesn't align with climate change preparation; very costly and probably has a lot of pushback; data availability and differences in measurements in the past and now (different methodologies); people have other worries and priorities so it can be hard to get everyone to work together on something many believe will not affect them now or in the near future;
  Solutions: look for a wide range of funding sources; involve locals, community; use available data as possible and consider different scenarios; consider different audiences and spend time and money to get stakeholders to buy into climate change risk reduction; educate, work together to create and implement plans; give ownership to communities for these projects in ways that are possible
- *Challenges:* in general, the data (bathymetry, reefs, mangroves, topography, census, building value, sea level rise projections) are available or not difficult to collect, but the challenge is to obtain funding to run the models and for an insurance solution to do the detailed legal and technical assessments; stakeholder outreach will also require significant time and financial investment;

Solutions: philanthropy could help with the initial assessments but long-term funding will have to come from more sustainable sources (e.g., tax, trust fund)
Solutions: partner with universities, NGOs and search for grants; charge for services in beach areas with funds going toward projects; do the research – reach out to universities and NGOs that do this type of work; do a task force with key municipal employees as well as lay people from other areas to identify what will be affected; create a clear campaign explaining risks, why it happens, why it needs to change, what options are available, and the expected results, as well as maintenance
Solutions: Develop organic master planning as suggested by Architect Christopher Alexander in his book, The (University of) Oregon Experiment; promote not-for-profit community corporation with a granted endowment. Interest coming from the endowment can be used to fund a continuously monitored maintenance program for the stormwater channels

<u>Challenges and Solutions in Implementation of an Adaptation Plan:</u>

- *Challenges:* political will, financial support, technical support, community involvement and/or buy-in;
  Solutions: need to gain support by integrating with communities, being present and open and adapt plans and implementation to something that works with the community and that they can agree with
- *Challenges:* political will, financial support, technical support, community involvement and/or buy-in;
- *Solutions:* political alliances
- *Solutions:* address political will through municipal efforts driven by the potentially affected communities with the use of organic master plans as per "The Oregon Experiment" project by Christopher Alexander

<u>Other Coastal Communities for Adaptation Strategies/Planning:</u>

- Adjoining municipalities including Dorado and Cataño
- Most coastal towns

Appendix II. USVI Working Sessions

Applying Concepts of Engineering with Nature/Green Infrastructure

The responses submitted by individual participants are grouped by case study and summarized below for each of the questions on participant worksheets, which were as follows:

1. What do you think are possible interventions based on the information provided in the case study write-up or your personal knowledge of the site? These could include retrofitting existing structures/infrastructure, new design and construction, plantings, use of new technology, etc.
2. Now think about some of the barriers to implementation for each of the interventions you brainstormed. (Note that the list below contains examples and there may be others you think of or have encountered. You do not have to write something for each one – you can choose to focus on a particular challenge or challenges and solutions based on your experience.)
    a. What are some of the design challenges for the interventions? What are some solutions to address these challenges?
    b. What are some of the permitting challenges for the interventions (e.g., regulatory staff knowledge and expertise in evaluating these types of projects; presence of ESA resources, etc.)? What are some solutions to address these challenges?
    c. What are some of the construction challenges associated with the interventions? What are some solutions to address these challenges?
    d. What are some of the operational/maintenance challenges associated with these interventions? What are some solutions to address these challenges?
    e. What are some of the potential use conflicts with implementing these interventions? What are some solutions to address these challenges?
    f. What are some of the fiscal/financial challenges associated with implementing these interventions? What are some solutions to address these challenges?

g. What are some of the community engagement and/or buy-in challenges associated with these interventions? What are some solutions to address these challenges?
h. Are there other challenges? Solutions to these?

3. Are there other sites where you think one or more of the interventions would apply? Would the challenges and solutions be the same?

Great Pond

Feedback on strategies, barriers, and solutions to implementation for the Great Pond site is included in the main body of this report.

Long Point – South Shore

Adaptation Strategy Recommendations:

- Create check dams to slow velocity of water and include wetland vegetation
- Use excavated material from dredging projects
- Use as compensatory mitigation for Port Authority dredge projects

Barriers to Implementation:

- DPNR does not have structural/operational authority
- Requirement of CZM and USACE permits
- Funding from federal grants cannot cover operations

Solutions to Address Barriers to Implementation:

- Leverage support for project by providing private property access through improved roadway

Rust Op Twist – North Shore

Adaptation Strategy Recommendations:

- House relocation (single property owner)
- Implement hard structures to reduce wave energy along 100m west and 200m towards roadway
- Breakwater in sand areas north of cliff and beach renourishment component
- Extend shoreline then rebuild/replant mangroves
- Cliff face receives high bulkhead structure
- Terraced system of plantings that are installed up the eroded brake

- Cobblestone beach at the foot of the terrace structure
- Reef flats return with seagrass beds

Barriers to Implementation:

- Sensitive bottom
- Maintaining integrity of pile supports for terraced system (needs gentle sloping base)
- Using protected coral species (permitting)
- Determining appropriate substrate for breakwaters
- Far extended reef with strong currents and high erosion areas
- Cost of multi-tier permit approval
- Permitting for fill designated for cobblestone beach
- Public access and pedestrian traffic is affected
- Costs are significant for all of the interventions

Solutions to Address Barriers to Implementation:

- Consider sea level rise needs in the design
- Groins and jetties that keep cobblestones in place
- Use pile to support terrace and fill with cobblestone
- Hospitality surcharge to fund interventions
- Owner may consider second mortgage to fund interventions

Adaptation Planning

The responses submitted by individual participants are grouped by case study and summarized below for each of the questions on participant worksheets, which were as follows:

1. What are some adaptation strategies for the coastal community (or communities) at this site to respond to the impacts of climate change (such as increased tropical storms and associated effects such as declines in water quality, coastal erosion, and lack of capacity to manage stormwater)?
2. What do you think are some of the challenges and possible solutions to implementing the adaptation strategies you identified?
3. What do you think are some of the challenges and possible solutions to prepare for and assess risk and vulnerability of the site from the impacts of climate change (e.g., sea level rise, increased frequency of tropical

storms, or other climate-driven impacts) in order to develop a climate adaptation plan?

a. Identifying and obtaining human, technical, and financial resources?
b. Finding data and information on past and future climate impacts?
c. Understanding climate projections and predicting future impacts?
d. Identifying critical infrastructure, key economic structures, and vulnerable populations that may be at risk from impacts associated with climate change such as higher water levels, storm surge, and flooding?
e. Identifying and engaging stakeholders and being able to communicate risk from climate impacts to different target audiences?
f. Others?

Long Point – South Shore

Feedback on strategies, barriers, and solutions to implementation for the Long Point site is included in the main body of this report.

Rust Op Twist – North Shore

Adaptation Strategy Recommendations:

- Remove riprap
- Stabilize shore with geo-textiles and plants
- If possible, enhance offshore breakwater (hybrid reef)
- North shore buyouts
- Setback standards should be tied to coastal erosion rate

Challenges and Solutions to Adaptation Strategy Recommendations

- Permitting and construction of the initial design solutions may be time and cost prohibitive
- Limited expertise to construct terraced structure would require on-island technical training in this field (X-Prize consideration)
- Though there is limited data available locally on climate impacts, NOAA and USACE could be considered as resources (SLAMM modeling)
- Address potential use conflicts by working with local community to engage public and get buy-in

- Seasonal recreation use
- Septic tank vulnerability
- Objections from neighbors to remove riprap

Challenges and Solutions for Risk and Vulnerability Assessments toward Development of an Adaptation Plan:

- Plan would classify as huge capital improvement project
- *Challenge:* Lacking technical expertise on island
  Solutions: Tap into technical/human capital at local and U.S. universities. Funding the studies will be a challenge but local government and FEMA funds could potentially support the studies since these will be essential for future planning processes.
- *Challenge:* lacking data;
  Solutions: Data and information is available from the IPCC and NOAA etc.
- *Challenge:* Stakeholders likely aware of risks, but challenges exist to engage in forward planning exercises;
- *Solution:* Explain the cost-to-benefit of investing in resilience.

Appendix III. List of Workshop Participants

Puerto Rico Meeting Participants:

Abruña, Fernando - U.S. Green Building Council, Caribbean Chapter

Alicea, Eileen - NOAA Coral Reef Conservation Program

Alicea Pou, Jose - FEMA, Unified Federal Environmental and Historic Preservation Review

Bieri, Tamaki - The Nature Conservancy

Caballero, Raphael - Ana G. Méndez University, Cupey Campus

Calixta Ortiz, Maria - Ana G. Méndez University, Cupey Campus

Chaparro, Ruperto - Puerto Rico Sea Grant College Program

Cruz Motta, Juan - University of Puerto Rico at Mayagüez

de León, Pedro A. - Municipality of Caguas

Diaz, Ernesto– PR Department of Natural and Environmental Resources

Espinoza, Raimundo - Conservación Conciencia

González, Melissa - U.S. Coral Reef Management Fellow (DNER)

González, Pedro - DUNE-CAT (Conservation Action Team for Dunes)

Grafals, Rosana - University of Puerto Rico at Cayey

Justiniano Santos, Aurora - NOAA

King, Jeff - US Army Corps of Engineers

Kitchell, Anne - Horsley-Witten Group

Lopez, Felix - US Fish and Wildlife Service

López, Paco - Reserva Marina Arrecife de la Isla Verde

Marrero, Vanessa - PR Department of Natural and Environmental Resources

Matta, Tony - Willis Towers Watson

Mercado, Alberto - The Nature Conservancy

Nunez, Yvette - Citizens for Responsible Energy Solutions, Puerto Rico

Olmeda, Manuel - Graduate Student, University of Puerto Rico

Orozco, Tamara - Pontificia Universidad Católica de Puerto Rico

Ortíz Díaz, Rose - Puerto Rico Planning Board

Pabón, Aitza - Jobos Bay National Estuarine Research Reserve

Lillian Ramírez – Puerto Rico Sea Grant Program

Rivera-Dueno, Camilie - Office of Congresswoman Jenniffer González-Colón

Rivera Herrera, Luis - FEMA

Rosado, Juliann M. - Para la Naturaleza

Serbia, Maruha - DUNE-CAT (Conservation Action Team for Dunes)

Suleiman, Samuel - Sociedad Ambiente Marino

Torres, Jackie - U.S. Green Building Council

Trench, Camilo - University of the West Indies Mona

Valeiras Mini, Evelio - Sociedad Geográfos de Puerto Rico

Villanueva, Luis - FEMA

Wheaton, Elizabeth - City of Miami Beach, FL

USVI Meeting Participants:

Balkaran, Kavita - Federal Energy Management Program, Environmental and Historical Preservation

Bieri, Tamaki - The Nature Conservancy

Clendinen, Cletis - Office of Congresswoman Stacey Plaskett

Daley, Brian - Geographic Consulting/HWG

Davis, Olassee - University of the Virgin Islands

Dempsey, Amy - BioImpact, Inc

Evans, Michael - Sandy Point National Wildlife Refuge

Farchette III, John - East End Marine Park

Guannel, Greg - University of the Virgin Islands

Henderson, Leslie Marie - USVI Department of Planning and Natural Resources

Henry, Stevie - Federal Emergency Management Agency

Hibbert, Marlon - USVI Department of Planning and Natural Resources

Jackson, Melanie - National Sea Grant Program Office

Juilien, Alex - Federal Emergency Management Agency

Keularts, Ben - USVI Department of Planning and Natural Resources

Kitchell, Anne - Horsely-Witten Group

King, Jeff - US Army Corps of Engineers

Lohmann, Hilary - Department of Planning and Natural Resources

Matta, Tony - Willis Towers Watson

Meyers, Rennie - National Sea Grant Program Office (NOAA)

Nelson, Stephanie - Office of Senator Benta

O'Beirne, Bill - NOAA Office for Coastal Management

Poblete, JoAnna - Claremont Graduate University

Pott, Caroline - East End Marine Park

Reale-Munroe, Kynoch - University of the Virgin Islands

Richardson, Delia - St. Croix Long Term Recovery Group

Ruffo, Ashley - NOAA Fisheries

Storall, Austen - USVI Department of Planning and Natural Resources - East End Marine Park

Trench, Camilo - University of the West Indies

Wheaton, Elizabeth - City of Miami Beach, FL

Valiulis, Jennifer - St. Croix Environmental Association

Yrigoyen, James - US Fish and Wildlife Service