

Green Infrastructure in Coastal Areas

NOAA IN THE CARIBBEAN

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- **GI Practices**

- Living Shorelines
- Reefs
- Wetlands/Beach
- Stormwater GI
- Other

- **Selection & Design**

- Watershed function
- Climate-ready
- Hybrid designs
- Scale up

- **Case Studies**

- Smith Bay, STT
- Cane Garden, Tortola
- Kaopala, Maui



What are the conditions?

GREEN - SOFTER TECHNIQUES

GRAY - HARDER TECHNIQUES

Living Shorelines



VEGETATION ONLY -

Provides a buffer to upland areas and breaks small waves. Suitable for low wave energy environments.



EDGING -

Added structure holds the toe of existing or vegetated slope in place. Suitable for most areas except high wave energy environments.



SILLS -

Parallel to vegetated shoreline, reduces wave energy, and prevents erosion. Suitable for most areas except high wave energy environments.



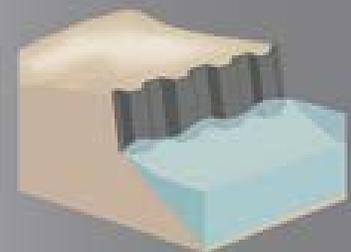
BREAKWATER -

(vegetation optional) - Offshore structures intended to break waves, reducing the force of wave action, and encourage sediment accretion. Suitable for most areas.



REVETMENT -

Lays over the slope of the shoreline and protects it from erosion and waves. Suitable for sites with existing hardened shoreline structures.



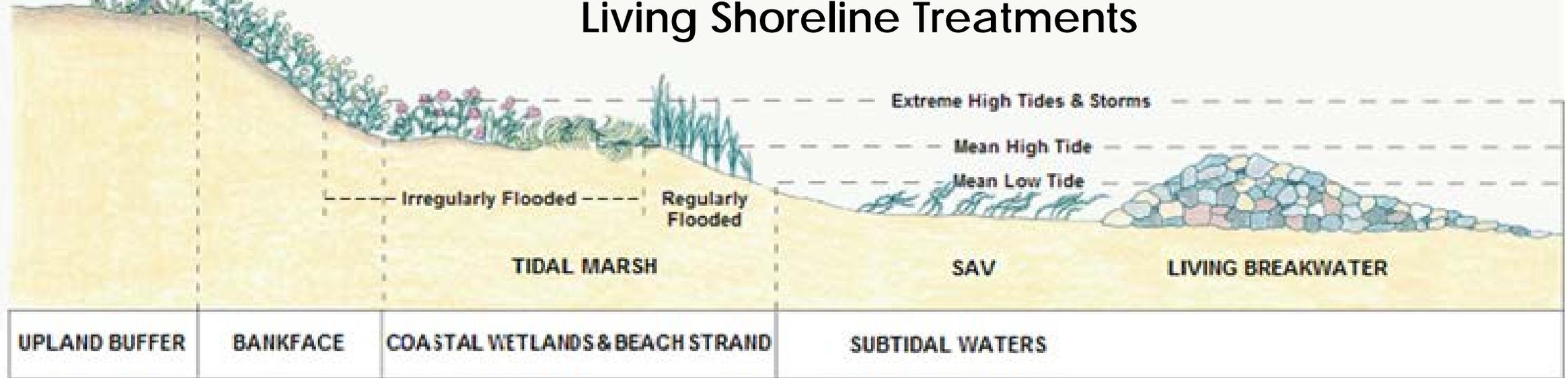
BULKHEAD -

Vertical wall parallel to the shoreline intended to hold soil in place. Suitable for high energy settings and sites with existing hard shoreline structures.

Coastal Structures



Coastal Shoreline Profile & Living Shoreline Treatments



Riparian Vegetation Management
Bank Grading
Fiber Logs

Tidal Marsh Enhancement
Tidal Marsh Creation
Beach Nourishment & Dune Restoration
Marsh Toe Revetment
Marsh Sill
Marsh With Groins

Living Breakwater
Offshore Breakwater System
Oyster Reef

Mustique, Google



Anegeada, BVI Monique Williams

Sometimes its all about the materials available

Retrofit



www.reefwall.com/



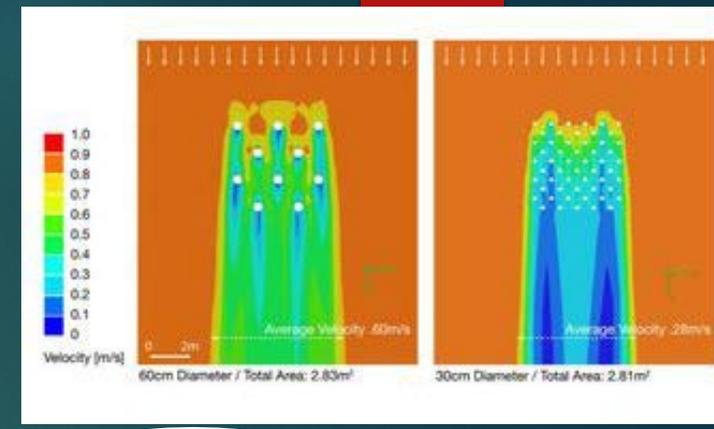
LOOK DOWN! What's on the seawall?

2016 SEAWALL ENHANCEMENT PROJECT
INSTALLED OCTOBER 10, 2016 AND MONITORED
BI-MONTHLY FOR BIOLOGICAL GROWTH

MANGROVE REEF WALLS

PROJECT SPONSORED BY:
WESTON'S WANNAB INN
THE CURTIS AND EDITH MUNSON FOUNDATION

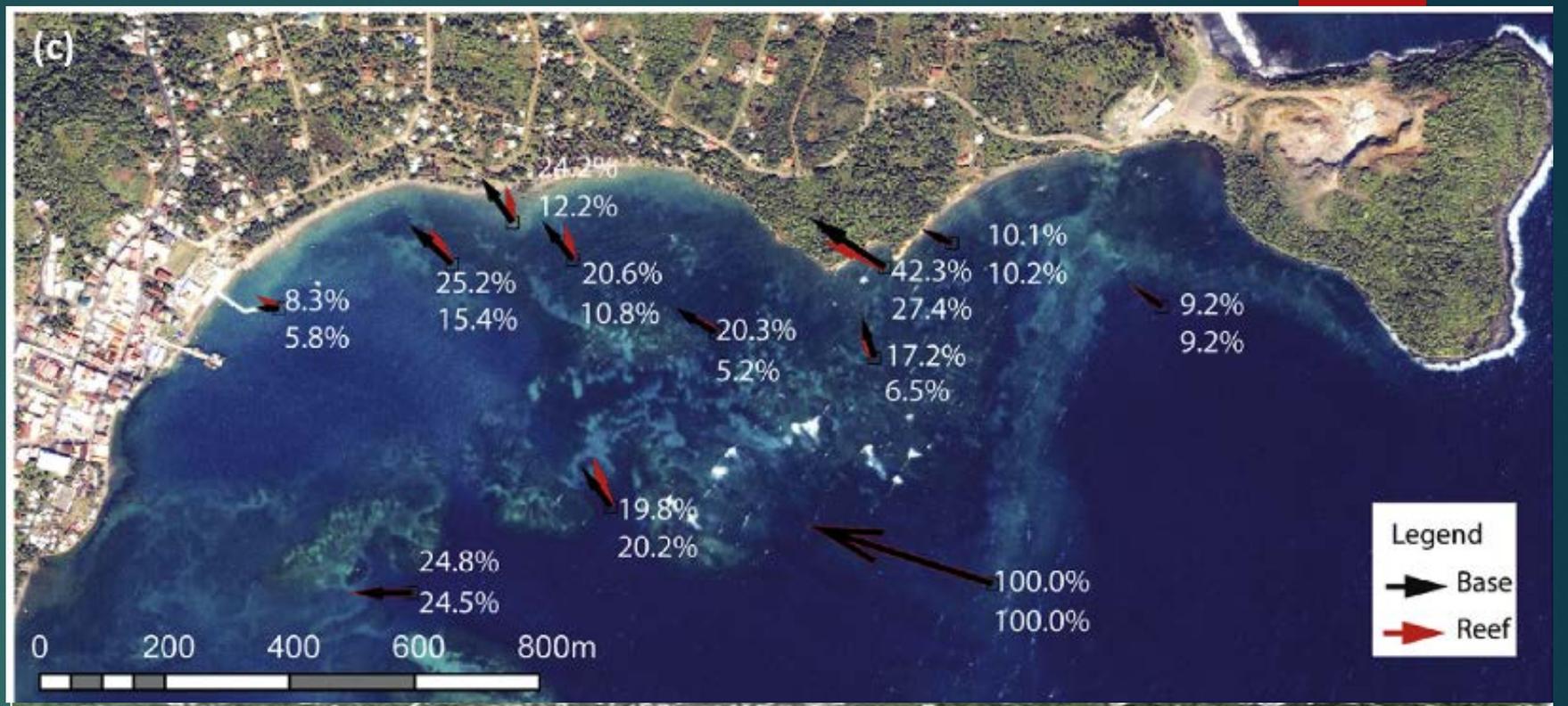
+INCREASE HABITAT
+DISSIPATE WAVE ENERGY
+IMPROVE THE ENVIRONMENT



Jessene Aquino-Thomas records GoPro footage of growth on the fake mangroves every two months to observe any growth of marine life.

Credit: Jessica Meszaros / WGCU News

Reguero et al. 2018
Grenada

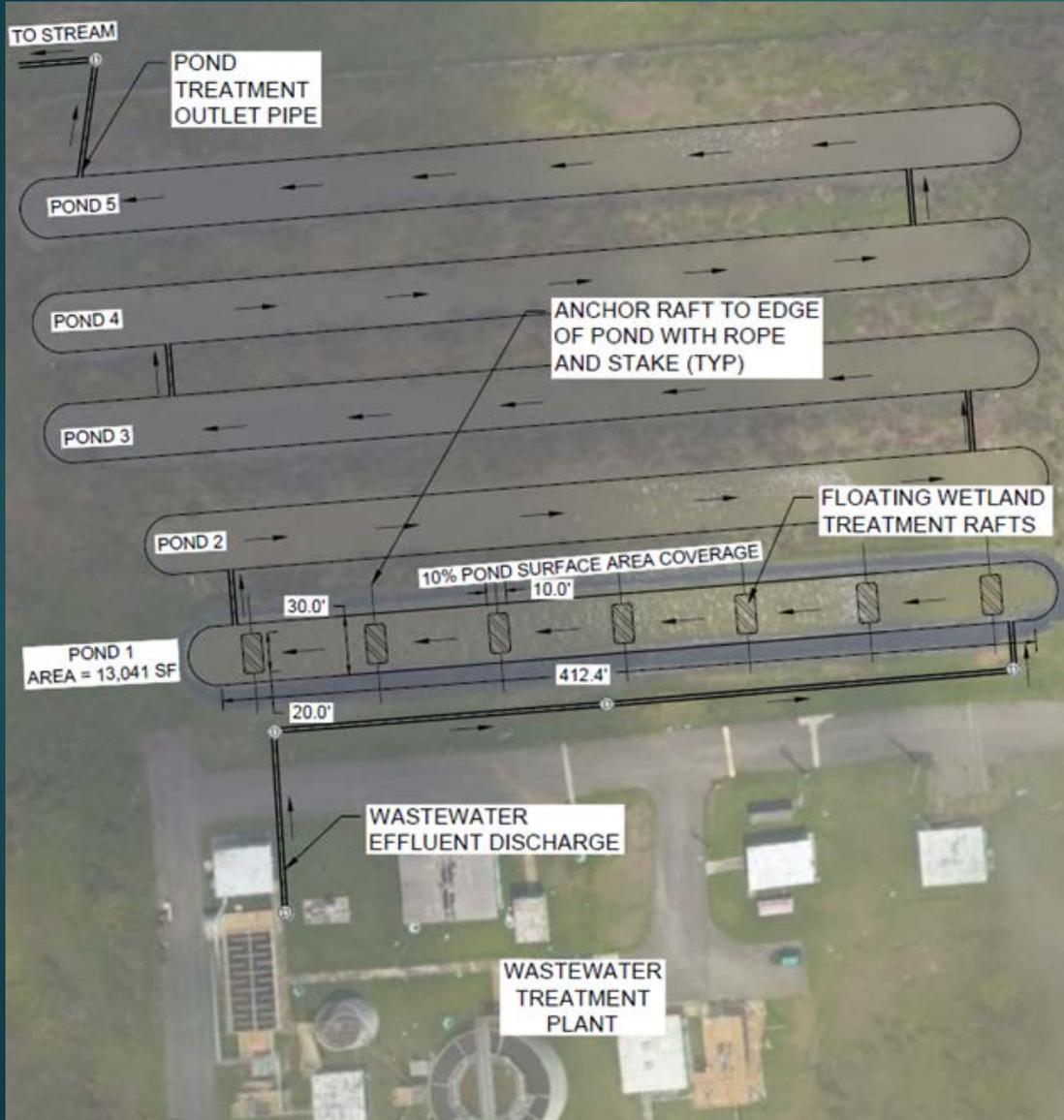


Can GI be a standard component of watershed repair/restoration projects?



- Coastal wetlands as buffers
- Native plants
- Re-establish flow regimes
- Restore watershed function (storage, habitat, WQ) with inland wetlands

Other applications for Nature-based systems?





Stormwater GI for WQ,
flooding, and biodiversity



Adapting to climate change with green roofs and permeable parking



Buzzards Bay, MA



St. Croix, USVI



Saipan, CNMI



Oahu, HI



Why don't islands do more of this?



Puerto Rico



St. Thomas, USVI





Climate-ready stormwater BMP designs

- Looked at ~40 coastal BMPs in MA
- Evaluated BMP vulnerability and performance issues related to:
 - Submerged outfalls
 - Higher groundwater tables
 - Salt, sand, and wind
 - Inundation
 - Plant survival
- Recommendations for siting, selection, sizing, redundancy, planning horizon, & maintenance
- GI is better adapter than conventional

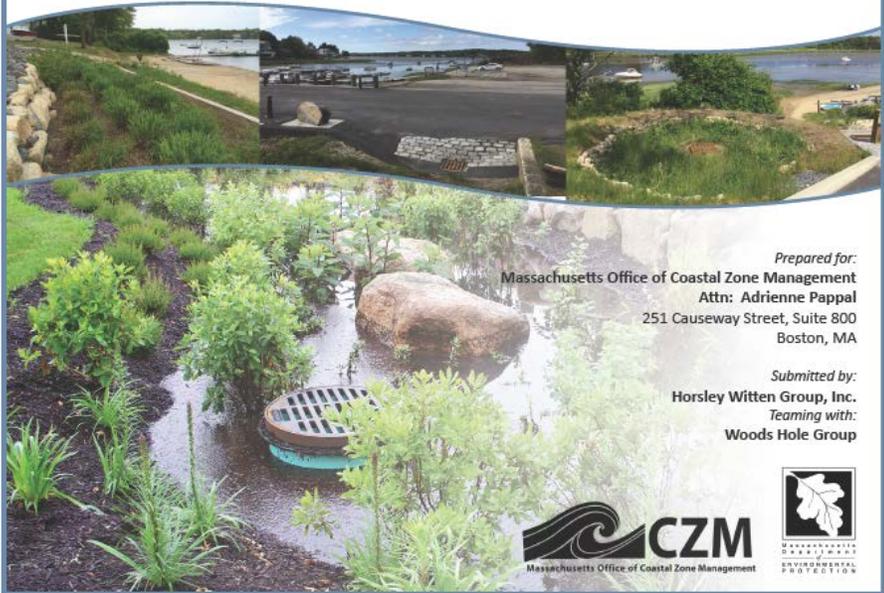
<http://www.mass.gov/eea/agencies/czm/>

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Assessment of Climate Change Impacts on Stormwater BMPs and Recommended BMP Design Considerations in Coastal Communities

December 2015

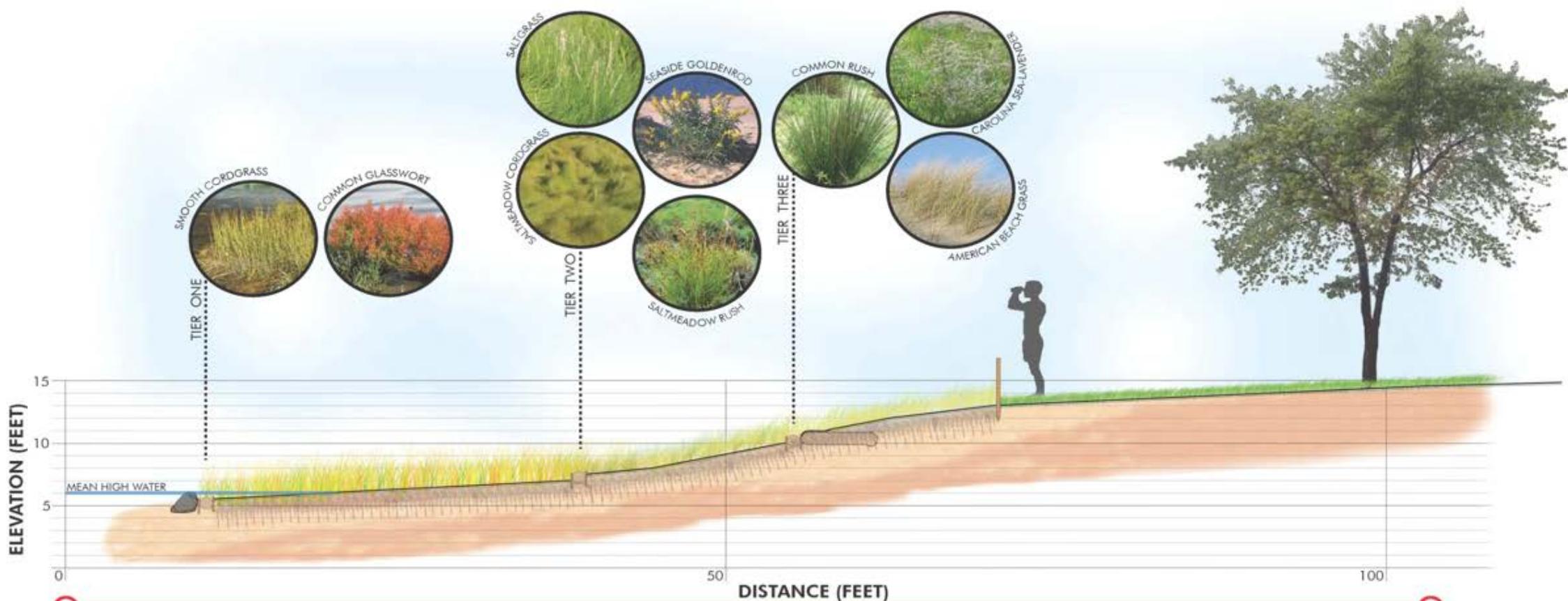


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Massachusetts Office of Coastal Zone Management



LIVING SHORELINE SECTION A - A'



FLUSH BOARDWALK SECTION B - B'

LIVING SHORELINE: SUGGESTED PLANT LIST

Key	Botanical Name	Common Name	Size	Spacing	Notes
AB	<i>Amorpha biqualis</i>	American Beach Grass	Bare Root	18" O.C.	TIER 3
DS	<i>Distichlis spicata</i>	Saltgrass	Bare Root	12" O.C.	TIER 2-3
JT	<i>Juncus effusus</i>	Common Rush	Bare Root	34" O.C.	TIER 2-3
JCS	<i>Juncus gerardi</i>	Saltmeadow Rush	Bare Root	18" O.C.	TIER 2-3
LL	<i>Limnium carolinianum</i>	Carolina Sea-Lavender	#1	24" O.C.	TIER 3
PA	<i>Panicum virgatum</i>	Switch Grass	#1	24" O.C.	TIER 1-2
SD	<i>Salicornia virginica</i>	Common Glasswort	#1	24" O.C.	TIER 1-2
DSG	<i>Solidago sempervirens</i>	Seaside Goldenrod	#1	18" O.C.	TIER 3
SFA	<i>Spartina alterniflora</i>	Smooth Cordgrass	2" plugs	18" O.C.	TIER 1-3
SFP	<i>Spartina patens</i>	Saltmeadow Cordgrass	2" plugs	18" O.C.	TIER 2-3

TIER 1 Intertidal zone / Foreline, Regularly Floods
TIER 2 Upper / High Marsh, Irregularly Floods
TIER 3 Top / Backside of Primary Dune, Rarely Floods

Breakwater Landing: Brewster, MA

- Multi-faceted approach to climate adaptation
- Improve existing WQ conditions
- Connect habitats
- Design considerations for coastal settings



2010



2016

Smith Bay Watershed



St. Thomas, USVI

Restoring watershed function w GI

Figure 3. Factors influencing hydrology in the Smith Bay watershed

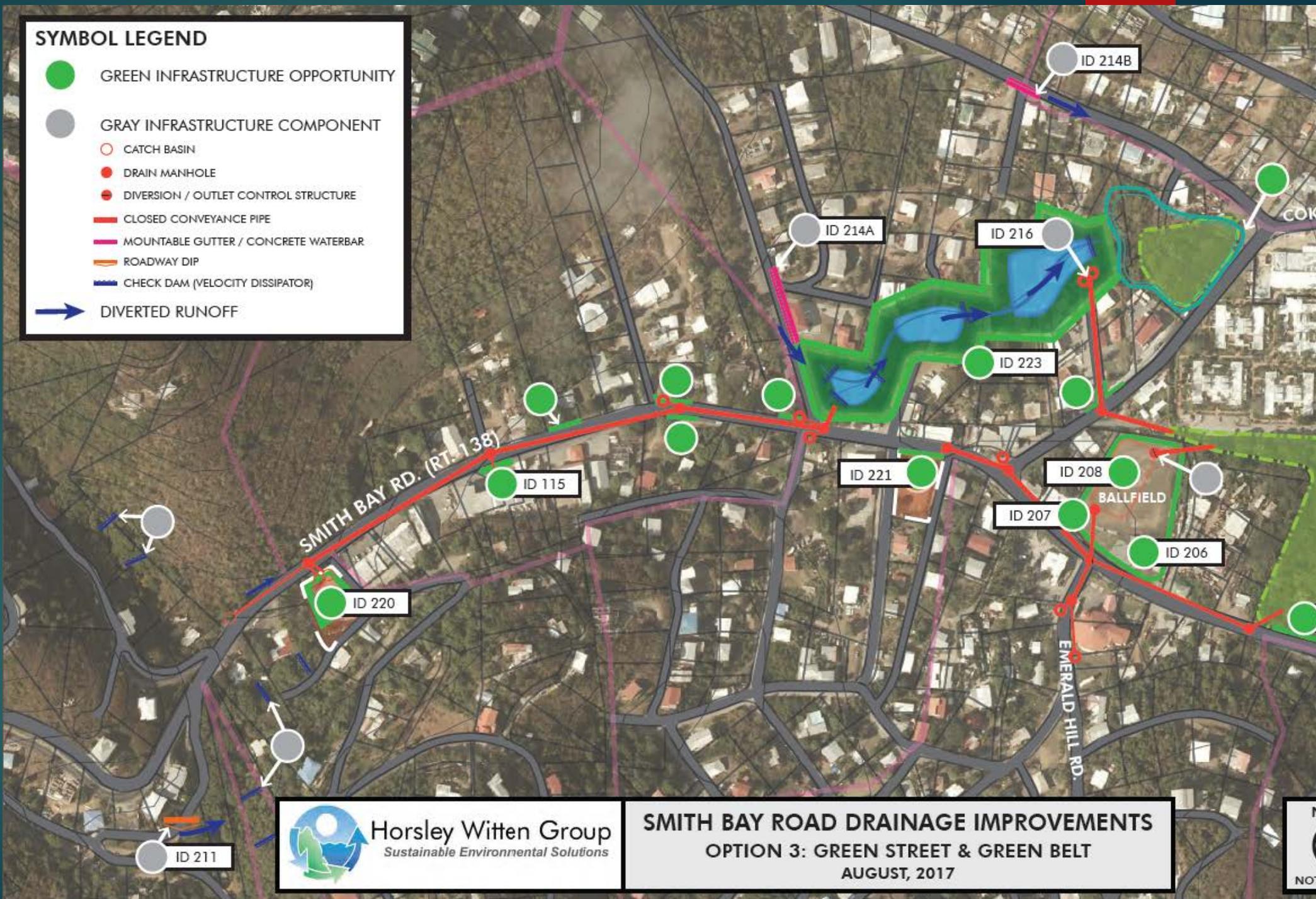
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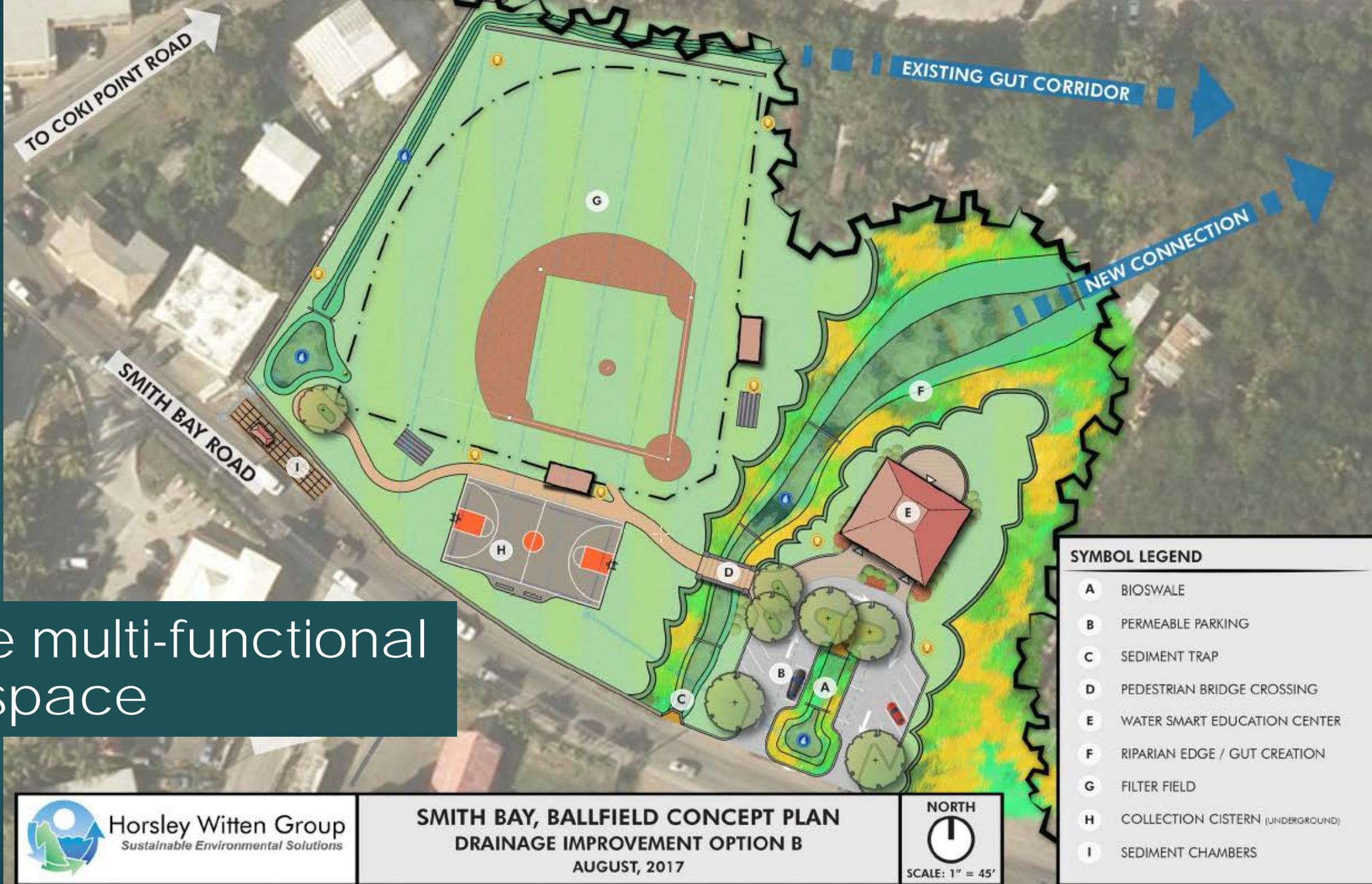
- Land acquisition
- Re-establish watershed functions
- Wetland restoration
- Add WQ with road repair
- Address community flooding
- FEMA Haz Mitigation Grant

SYMBOL LEGEND

- GREEN INFRASTRUCTURE OPPORTUNITY
- GRAY INFRASTRUCTURE COMPONENT
- CATCH BASIN
- DRAIN MANHOLE
- DIVERSION / OUTLET CONTROL STRUCTURE
- CLOSED CONVEYANCE PIPE
- MOUNTABLE GUTTER / CONCRETE WATERBAR
- ROADWAY DIP
- CHECK DAM (VELOCITY DISSIPATOR)
- ➔ DIVERTED RUNOFF

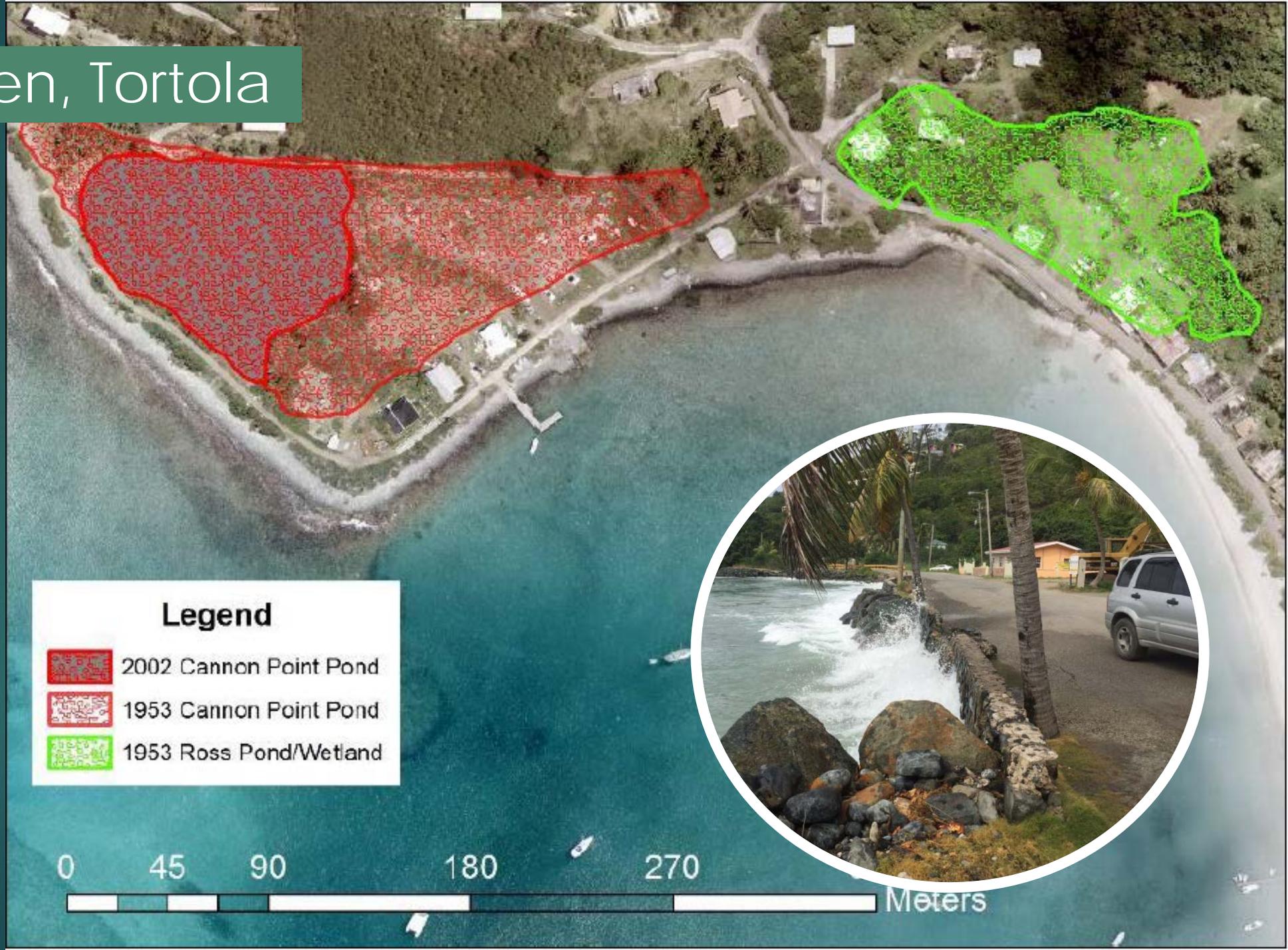


Create multi-functional open space



Cane Garden, Tortola

- Historic wetland loss
- Flooding
- Shoreline erosion
- Damaged infrastructure
- 3-pronged approach

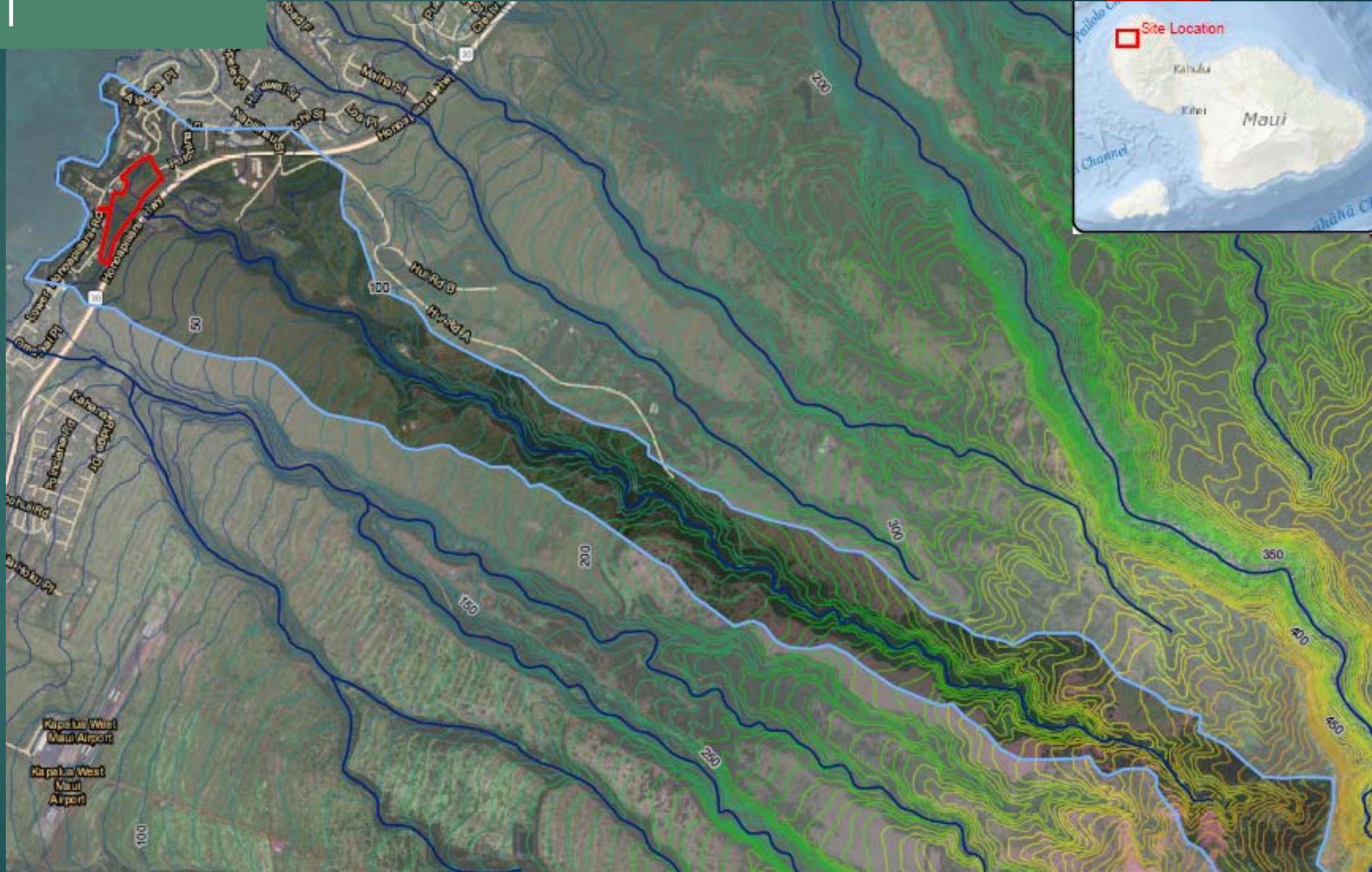


- Constructed stormwater mangrove
- Floodplain enhancement
- Private property
- Hurricane opens door for expanded storage facility



Kaopalo, Maui

- Unusual opportunity
- Address shoreline stabilization
- Infrastructure resiliency
- Flood storage & WQ
- Community amenity





1. How do you know what GI practice(s) to use?
2. Can you restore natural watershed function?
3. What climate-ready features have you considered?
4. Seize post-storm opportunities

