Development of Natural Berms In Barnegat Bay

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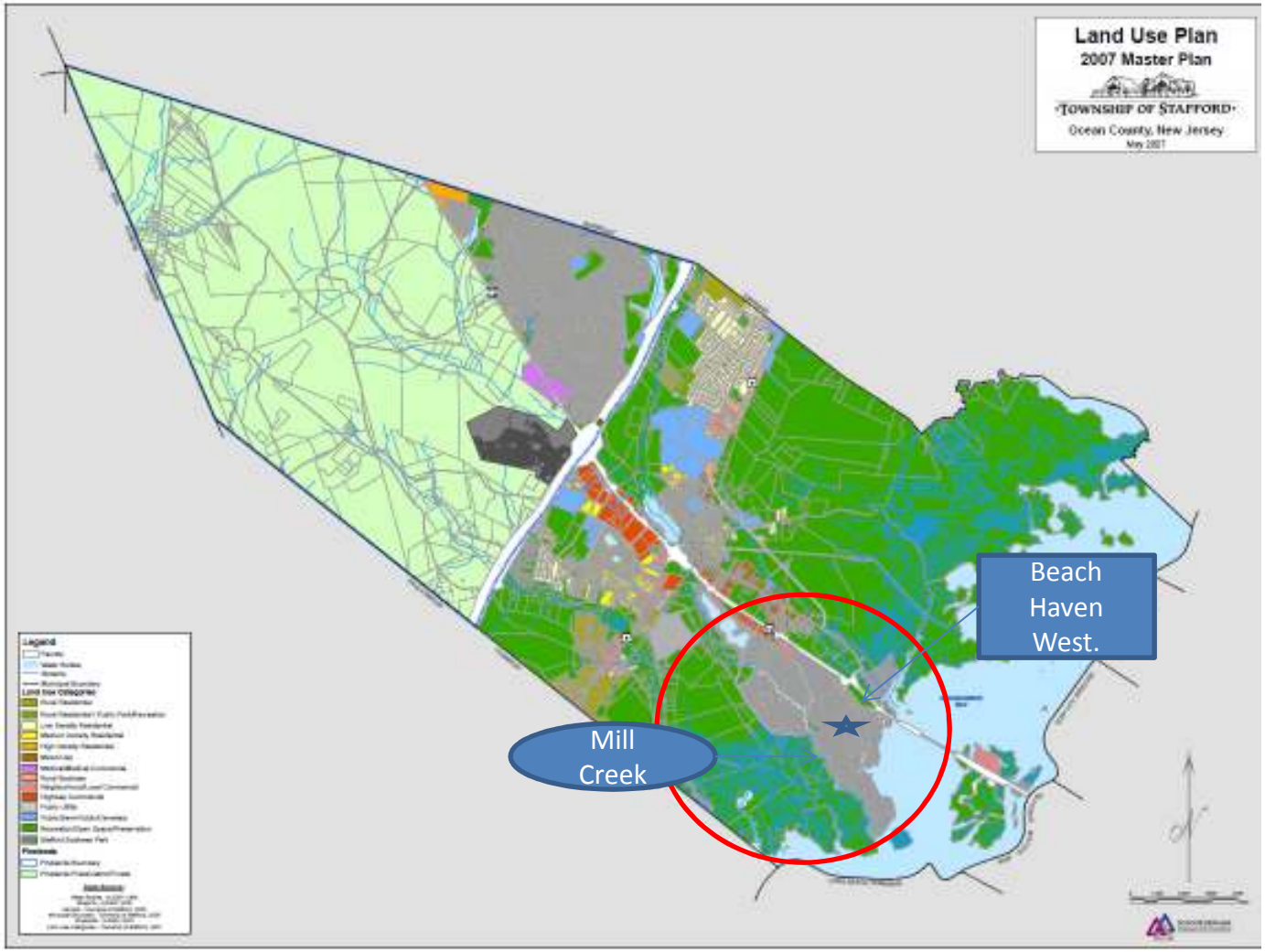
Controlling Water & Wave Velocity
Ecological/Marsh Restoration
Restoring Critical Wetlands
Dredging & Habitat Restoration
Reducing Risks to Lives & Property Damage

Stafford Township



Sandy Arrives

Monday, October 29, 2012

Sandy Impacts

- In Stafford Sandy Caused over $200 Million In Tax Base Losses (that effected not only the municipality but also the County and the School Systems.)
- Estimated overall damage $300 million in property losses. Unknown damages to eco-systems.
- Serious Damage To Beaches, Eco-Systems & Infrastructure. Damage to lagoons & creeks.
- Over $15 Million In Clean-Up Costs.
- Damage assessments indicate significant structural damage caused by waves, storm surge .
- Multi-Year Hardships In Rebuilding & Abandoned Properties, FEMA maps, ongoing tax burdens.

Storm Damaged Properties

- Roughly 4,800 or 1/3rd of Stafford Township's taxable properties are located on lagoon front, creek, or bay front.
- Approximately 4,100 properties sustained damage as a result of Super Storm Sandy.
- FEMA's Preliminary Damage Assessment Site Estimate Form, completed by township staff, was utilized during initial post storm inspections.
- The majority of damage (structural) was caused by water velocity and debris. Significant differences in structural damage documented to be adjacent to Mill Creek in area of no existing berm along southern side of Mill Creek.

Issues

- Storm damage associated with storm surge, waves, wave run-up and velocity of water. Damage from floating debris, ongoing issues with lagoons and creeks.
- Fetch (unencumbered distance over water) increases with RSL
- Wave dissipation factors (obstructions) decreases with RSL.
- Relationship of water velocity and storm surge indicated on USGS gages vs FEMA high water mark. FEMA HWM measured higher due to waves.
- Loss of marsh habitat, diversity of habitat impacts to surrounding habitat.
- Loss of natural redistribution of siltation on marsh due to RSL.
- RSL effect with future storms.
- Understand a 1-foot rise in sea level = 36% – 58% increase in annual damage, 3-foot rise = 102% -200% (FEMA)
- Need for dredging. Sandy deposited 395,592 cubic yards of sediments in our State channels alone. Not included is siltation washed into our lagoons and creeks. Much of this siltation needs to naturally distribute on our marsh to help keep pace with RSL.

Sea Level Rise Projections

- "Globally, sea level rise has been accelerating over the past century and is expected to continue doing so", *referencing data from the United Nations' Intergovernmental Panel on Climate Change*. "

- *NOAA Technical Report NOS CO-OPS 083 - January 2017* The projections and results presented in several peer-reviewed publications provide evidence to support a physically plausible GMSL rise in the range of 2.0 meters (m) to 2.7 m, (worse case scenario) and recent results regarding Antarctic ice-sheet instability indicate that such outcomes may be more likely than previously thought. Along regions of the Northeast Atlantic (Virginia coast and northward) and the western Gulf of Mexico coasts, GSL rise is projected to be greater than the global average for almost all future GMSL rise scenarios. In addition, the rate of GMSL rise since 1900 has been faster than during any comparable period over at least the last 2800 years.

- Higher sea levels worsen the impacts of storm surge, high tides, and wave action (*e.g., Theuerkauf et al., 2014),* even absent any changes in storm frequency and intensity. Even the relatively small increases in sea level over the last several decades have led to greater storm impacts at many places along the U.S. coast .

- "Sandy added at least 5.0 feet of water on the marsh surface area, making the entire bay surface area above the reservoir of water volume". Waves ride above this 5.0 foot water level. The deeper the water results in larger waves (*Stockton University)*

Enhance Improve and Extend Existing Berms Along Mill Creek

- "Natural and nature-based features can enhance the resilience of coastal areas challenged by SLR (Borsje et al. 2011) and coastal storms (e.g., Gedan et al. 2011, Lopez 2009). Dunes (berms) can act as a physical barrier that reduces inundation and wave attack on the coast landward, in many cases it also provides a sediment source for beach recovery after a storm passes. Berms will provide attenuation of wave energy and slow inland water transfer. [1]
- The Mill Creek area under consideration is a partial previously utilized (disturbed) dredge disposal site from the dredging of Mill Creek. The existing berm can be extended and enhanced to protect lives and properties. A damage comparison between the existing berm site and the area with no berm indicates the impacts of the berm.
- Location of existing berms along Mill Creek show a direct relationship to damage from waves and surge during Sandy in BHW. In addition, a degradation of area without berms.

1 Coastal Risk Reduction and Resilience USACE 9/2013.

How FEMA Addresses Waves

- In development of flood Zones FEMA uses;
  - Overland wave hazard modeling (LiMWA model).
  - Quality of the topography and bathymetry used in the models.

- "The Limit of Moderate Wave Action (LiMWA) is the location where the 1-percent-annual-chance wave height equals 1.5 feet. FEMA began showing the LiMWA on Flood Insurance Rate Maps to communicate the higher risk that exists in the area. Because the 1.5-foot breaking wave in the LiMWA zone can potentially cause foundation failure, communities are encouraged to adopt building construction standards similar to Zone VE in those areas."
- "Residents and business owners living or working in the LiMWA zone should be aware of the potential wave action along with floating debris, erosion and scour that could cause significant damage on their property. They are encouraged to build safer and higher to minimize the risk to life and property."

Berms

Strategically placed berms and topography variations utilizing dredge material from the creeks and lagoons could help reduce the fetch across the water & marsh, thereby dissipating waves, and reducing the velocity of water surges, allow natural sediment fallout on the marsh, and reduce wave run-up. This will allow the marsh to continually replenish naturally to keep up with sea level rise. In addition, the berms would help reduce the siltation from entering and filling our lagoons and creeks, which alter their natural eco-systems. Planting of these berms with proper indigenous species will provide both stabilization and habitat to replace critical nesting and nursery areas for local species.

“The dynamic effects of SLR on low-gradient coastal landscapes” - 5 June 2015

Coastal dynamics of sea level rise along estuarine shorelines:

- Existing mean sea level and tidal range govern biomass productivity in salt marsh systems.
- Higher water levels under SLR may erode the estuarine profile.
- As sea level rises, the marsh attempts to migrate landward.
- Under higher rates of SLR, the marsh may drown if uplands are not available for landward migration; higher water levels allow waves to erode the marsh boundary.
- Processes that increase sediment concentration in tidal creeks adjacent to marshes can also increase the marsh accretion rate. These processes include local suspension of sediments through increased tidal velocity, wind waves, proximity to estuarine turbidity, and an increase in background concentration due to offshore erosion [*Friedrichs and Perry*, 2001

CFR 40 Part 230 Section 404 (b) (1) Guidelines for Specification of Disposal Sites for Dredged or Fill Material (CWA)

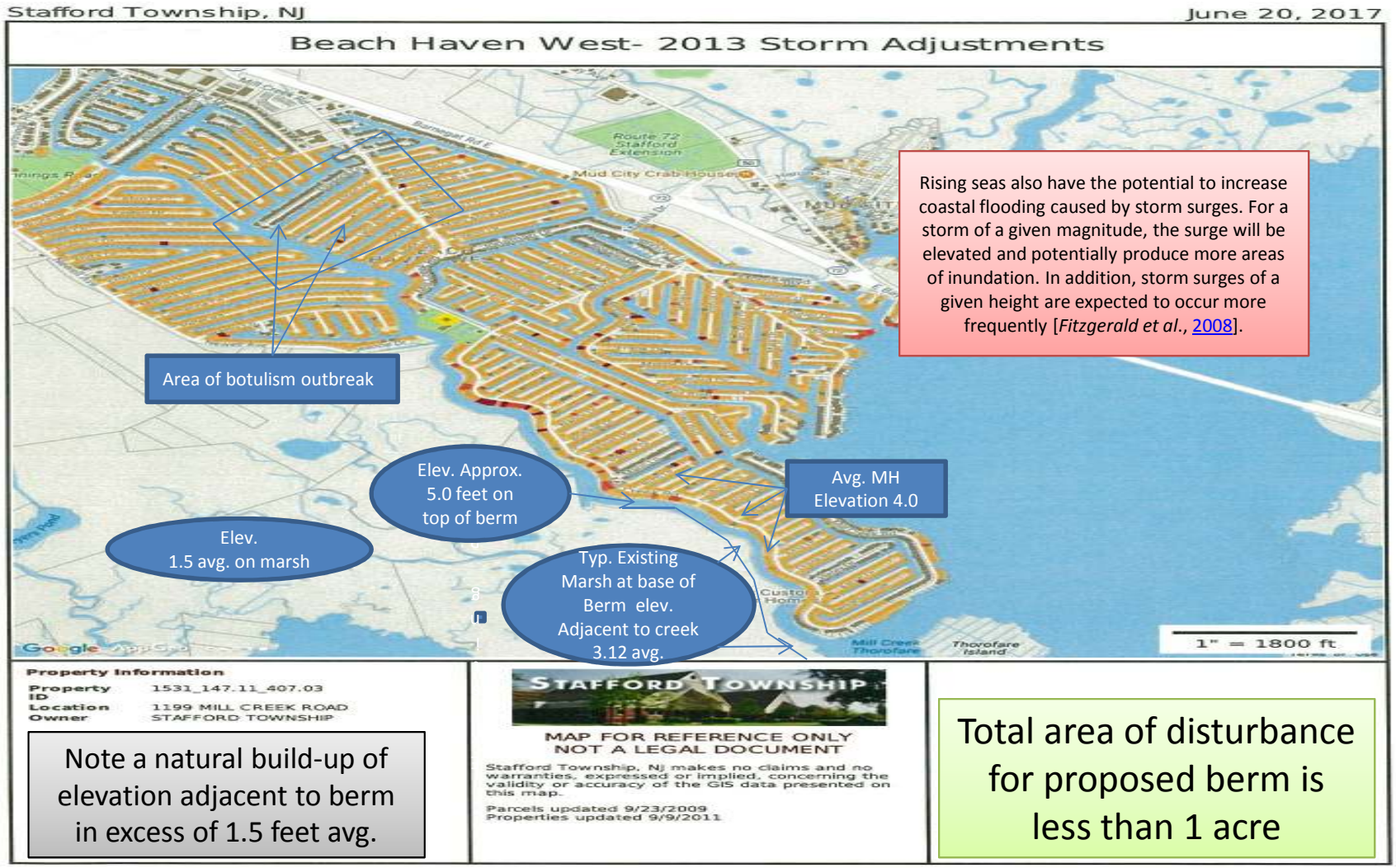
Subpart B – Compliance With Guidelines Sec. 230.10 Restrictions on discharge

(a) Except as provided under section 404 (b) (2), no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences.

(2) An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes. If it is otherwise a practicable alternative, an area not presently owned by the applicant, which could reasonable be obtained, utilized, expanded or managed in order to fulfill the basic purpose of the proposed activity may be considered.

An Analysis of Alternatives (AoA) has been completed and no practicable cost effective alternatives have been identified that can perform the function of protection of property and lives.

Overlay of relationship of properties having 60% to 90% damage from Sandy. 65% of the properties in BHW with 90% or more damage were along Mill Creek. The area of Mill Creek Protected by the existing berm had no major structural damage



Comparison of area with existing berm relative to area with no berm.

No Berm

- Significantly more documented damage to structures (60 -90% range) from water velocity/waves and debris.
- Lack of siltation redistribution on marsh resulting in lower marsh elevations.
- Greater siltation delivery into lagoons and Mill Creek causing shallowing and shoaling in lagoons and waterways.
- Likely a contributing factor to recent algae blooms and botulism outbreak resulting in over 70 mortalities of waterfowl and terrapin turtles (7/2017 – 8-2017).
- Less diversity and quantity of marsh species observed during site visit
- Marsh will be covered with water due to RSL at the projected intermediate low of 0.5 m (1.6 ft.) a major impact.

Existing Berm

- Less documented damage to structures from waves, water velocity and debris.
- On-site visits indicate area behind berms are trapping silt and debris, naturally raising the elevation of the marsh.
- Less shoaling observed and greater depth of Mill Creek.
- No recorded algae blooms or botulism outbreaks ever reported.
- Marsh behind berm was observed during site visit to have greater diversity and quantity of marsh species.
- Top of berm would continue to protect lives and property even at intermediate high projected RSL scenario of 1.2m (3.9 ft.) by attenuation of waves/surge.

Example of Manmade Berm

Gradual Steepening will Dissipate wave energy over a long shallow slope.

Proper planting, restoration, and eco-enhancement will further dissipate wave energy and trap sediment's & debris.

Having a salt marsh in front of a levee/berm will reduce incident wave height at the toe reducing structural damage and the amount of wave overtopping.

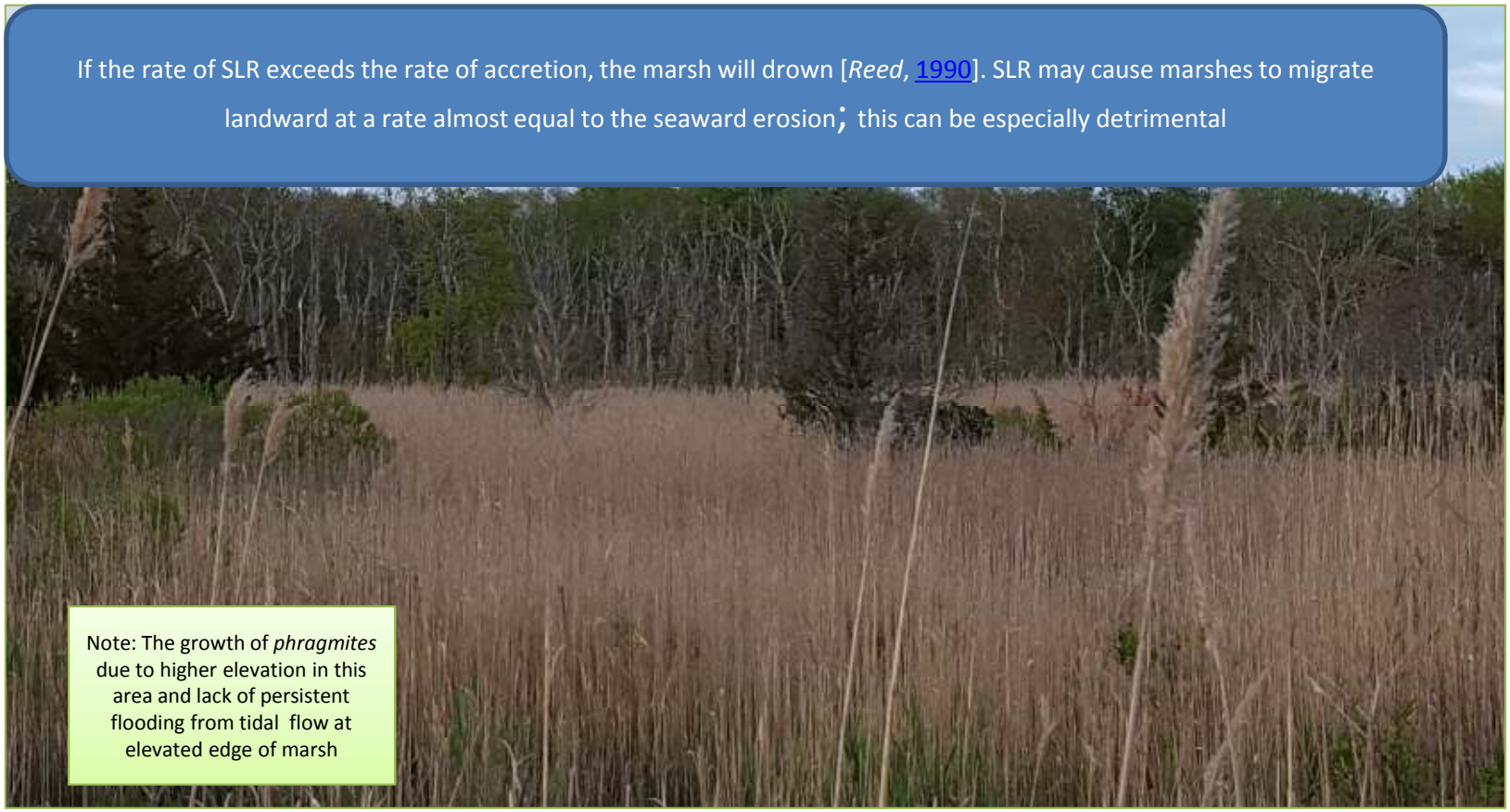
Levees/berms can therefore be built lower and with less armoring, reducing the total cost and size of the levee/berm by up to 30% in some cases (Turner and Dagley 1993).

Wave Attenuation

A relativity small obstruction can significantly reduce waves/surge

Storm surges are one of the most devastating aspects of land-falling hurricanes. Storm surges are the primary cause of death and a significant source of damage to ecological and structural systems. *(USAC Coastal Risk Reduction Report CWTS 2013-3).*

If the rate of SLR exceeds the rate of accretion, the marsh will drown [*Reed*, 1990]. SLR may cause marshes to migrate landward at a rate almost equal to the seaward erosion; this can be especially detrimental



Note: The growth of *phragmites* due to higher elevation in this area and lack of persistent flooding from tidal flow at elevated edge of marsh

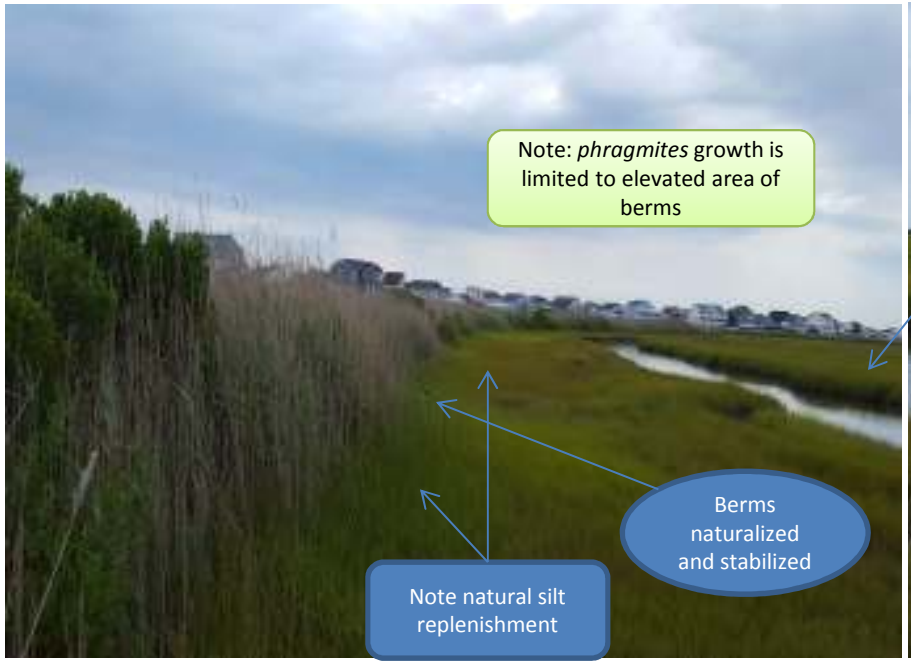
Dying Trees along salt marsh.

Likely the result of continuous higher than normal high tide cycles due to sea level rise. Cedar Run Dock Road 5/8/2017.

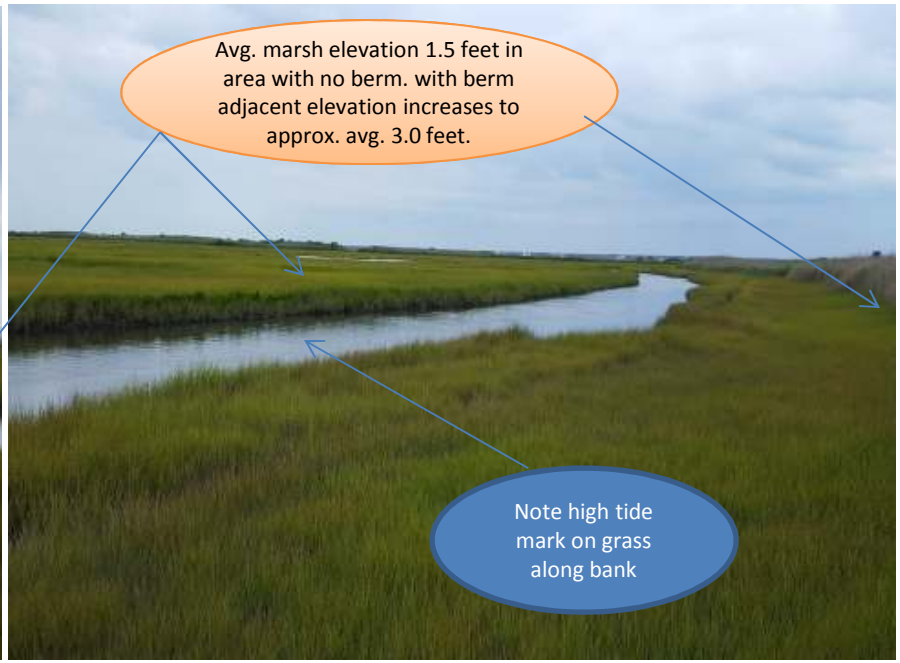
"*A steady increase in sea levels is pushing saltwater into U.S. wetlands, killing trees from Florida to as far north as New Jersey." (How Rising Seas Are Killing Southern U.S. Woodlands, Roger Drounin 11/1/16*

Mill Creek Saltmarsh

Southside of Berm low tide 8:21am 6/19/17 looking NE



Southside of Berm low tide 8:21am 6/19/17 looking South



Photos taken 10:09 am and 10:13am
Low tide 8:21 am
High tide 1:32 am

Southside of Berm showing ability to capture silt, debris, grasses etc.

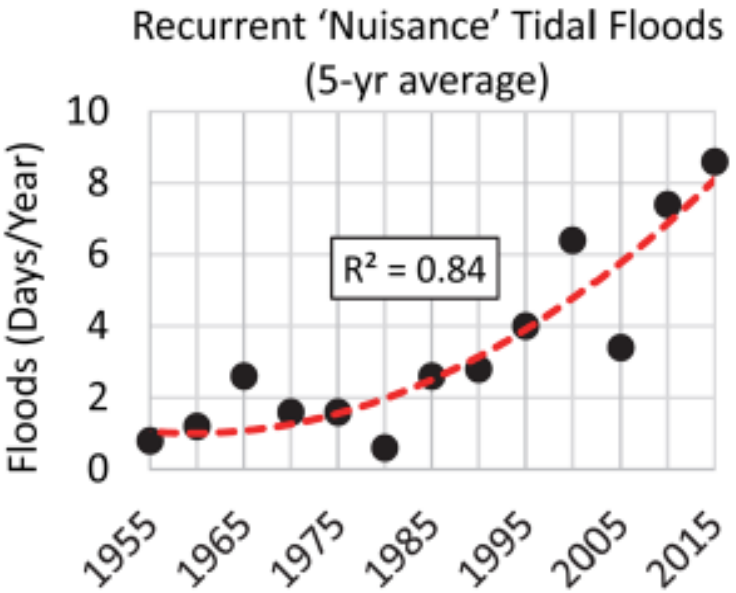
Low tide 6/19/2017

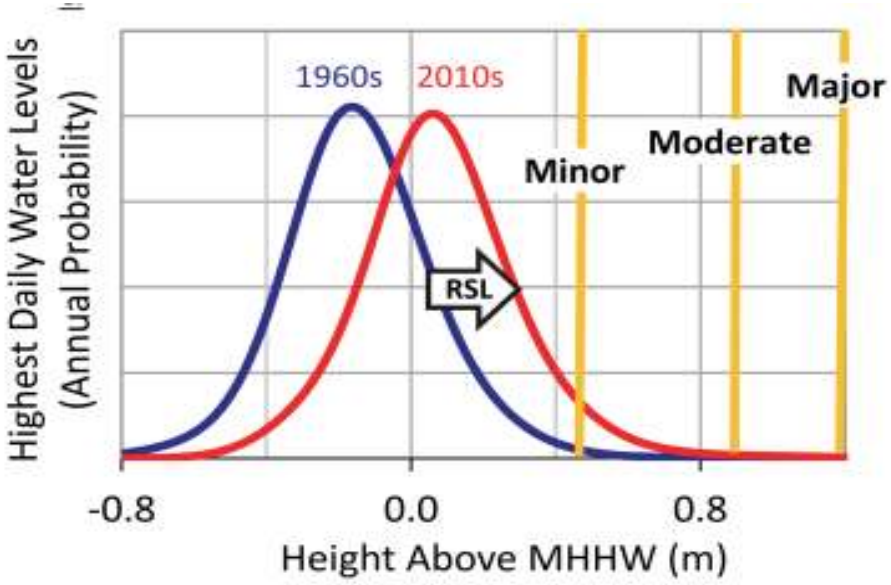
Low tide 6/19/2017

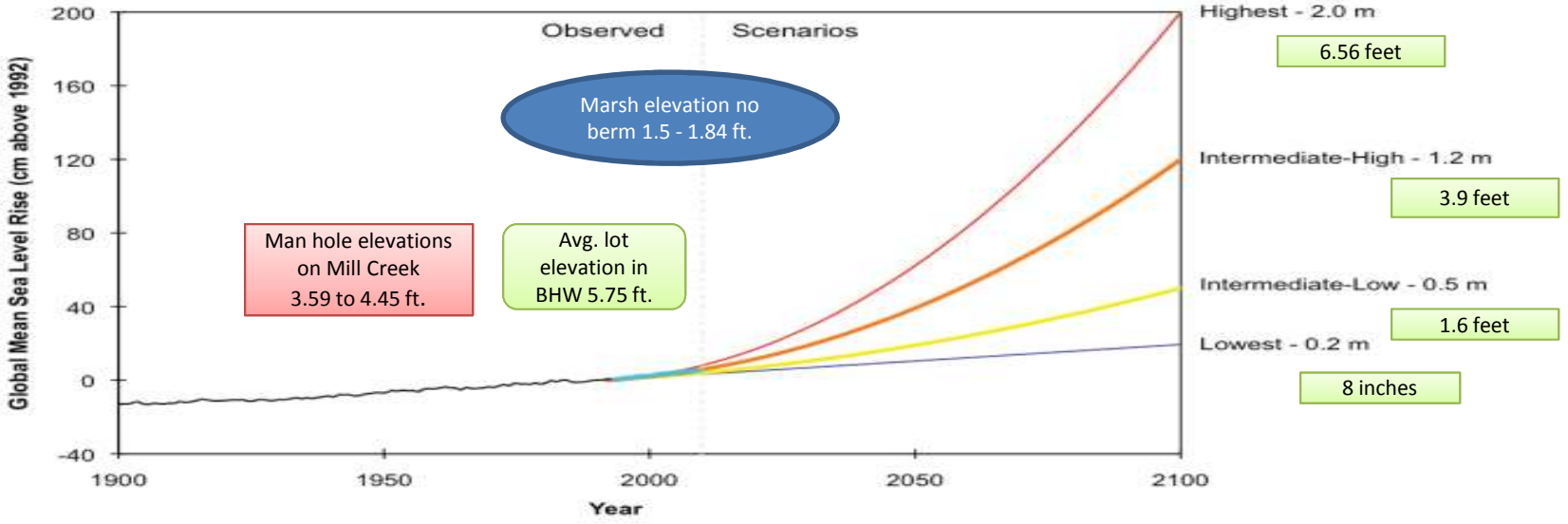
"Flooding alone is not considered an effective control even though *Phragmites* is intolerant of persistent flooding (Avers et al. 2014)." Site observations indicate the *Phragmites* growth at this location has remained limited to specific elevated areas that are not impacted by the persistent flooding from tidal action. Although the *Phragmites* is non-native, its ability to spread to the surrounding lower elevations appears to have been limited over past decades to within the existing elevated berm area. However, it should also be noted that this plant does help attenuate water velocity, stabilize the marsh surface, and control/capture debris. The persistent flooding of this marsh due to normal tidal cycles appears to limit the spread of this plant. "numerous studies confirm that feedbacks between sediment deposition, organic matter accretion, and biomass production generally allow salt marshes to be stable on the vertical direction and keep pace with sea level rise." *(e.g., Cundy and Croudance, 1996, van der Wal and Pye, 200; Temmerman et al., 2003, 2005; Temmerman and Kirwan, 2015; Kerwan et al., 2016; et al., 2015).*

The GMSL rise scenarios of Parris et al. (2012)
Projected Intermediate Low 1.6 ft., Intermediate High 3.9 ft.

NOAA Technical Report NOS CO-OPS 083 January 2017







Reutilization of Dredge Material

- On Dec. 10, 2016 the U.S. House of Representatives and Senate passed S.612, the Water Infrastructure Improvements for the Nation Act" or the "WIIN Act" (also known as the Water Resource Development Act (WRDA), which includes provisions to help protect, restore, and increase the resilience of U.S. coastlines. The bill passed the House 360-61 and the Senate 78-21.

Proper redistribution of normal siltation on the salt marsh will work to elevate the marshland. Historically this is how the process worked. Today we are losing marsh faster then we replenish.

Details of the WIIN Act

- "Sediment is a critical resource for building and restoring protective beach and dune systems and restoring coastal environments. S.612 establishes an important pilot program that would allow coastal communities, states and the U.S. Army Corps of Engineers to beneficially use dredged sediment," *said Derek Brockbank, executive director of American Shore & Beach Preservation Association (ASBPA).*
- "Supporting regional sediment management is just one way the WIIN Act helps coastal communities prepare for hurricanes and coastal storms. The WIIN also supports coastal resilience and sea level rise planning and tells the Corps of Engineers to assess the ability of natural and nature-based features – such as beaches, dunes and wetlands – to reduce flood risk."

What We Can't Control

- We cannot control rising sea levels & flooding.
- We cannot control storms.
- We cannot control tides or moon phases.
- We cannot remove existing development.
- We cannot control breaching of barrier islands.
- Storm surge builds on top of a higher base of water resulting from sea level rise = larger waves/surge.
- Triad of storm damage – Tides, Storm Water Runoff, Timing of Peak Storm Event.

We Can Help Control

- Water velocity & wave attenuation.
- Damage caused by floating debris.
- Waves and wave run-up.
- Habitat loss & creation of new habitat & diversity.
- Silt re-distribution on marshes vs. waterways.
- Storm water impacts – off-set peak flow events.
- Better pollutant & siltation removal.
- Building & Watershed management.
- Future Storm damage from wave velocity, run-up, and wave crests using innovative engineering principals.

“It’s no longer us against ‘Nature.’” Instead it’s we who decide what nature is and what it will be.”

We should not fight Nature we need to work with Nature toward solutions

We have a choice, to be part of the problem by finding excuses to not do anything, or spend years performing studies while our problems become worse. Or we can be part of the solution by developing result driven designs, and implementing sound engineering principles based on actual field observations and data using natural processes.

FEMA Hazard Mitigation Grant Program

- "Hazard Mitigation Grant Program (HMGP) funds may be used to fund projects that will reduce or eliminate the losses from future disasters. Projects must provide a long-term solution to a problem….In addition, a project's potential savings must be more than the cost of implementing the project."