WATERSHED MANAGEMENT PLAN

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Introduction

The Borough of Stone Harbor, Cape May County, New Jersey has compiled past documents and reports dealing with aspects of tidal and rainfall flood hazards and combined these with appropriate municipal ordinances, policies and rules governing land use, lot coverage and stormwater management to focus on severe weather events having an impact on this barrier island community. The goal is to maximize citizen safety and protection from natural disasters and provide future planning for sea level rise driven by a warming climate. In accordance with the requirement for the Watershed Management Plan, this plan will be reviewed in five (5) years to determine whether it is still current and to provide documentation.

Background

Originally home to the Lenni Lenape Indians who likely spent warmer seasons on the island, the European occupation commenced in the late 19th Century at a level of development beyond the occasional fishing shack or stock herder's residence. Stone Harbor was established April 2, 1914 by an act of the New Jersey Legislature from portions of The Township of Middle, Cape May County, NJ based on a referendum held on April 28, 2014. A portion of the Borough of Avalon was added to Stone Harbor on December 27, 1941.

The Borough consists of 1.962 square miles of land (1,256 acres) and 0.564 square miles of water (361 acres) as the southern portion of Seven-Mile Island, Cape May County, New Jersey. Originally less forested than Avalon to the north, development generally leveled dune topography to fill lower areas and extend the landward margin to the main tidal channel on the western margin of the barrier island. As of the 2010 census, there were 866 individuals and 441 households residing in Stone Harbor. There were 3,247 housing units (average density of 2,323 per square mile). Development stops at 123rd Street, extending south from the Avalon boundary at 80th Street. There is 1,100 feet of undeveloped land between 123rd St. and a terminal rock groin defining the end of managed beach/dune area. The barrier island south of the rock groin is Borough owned, and dedicated to open space with public access allowed with seasonal restrictions imposed by the US Fish & Wildlife Service and the NJ Endangered Species Program. Presently this barrier beach spit is 7,500 feet in length south into Hereford Inlet separating Stone Harbor from the City of North Wildwood.

The governing body consists of a mayor and a Borough Council comprising six council members, all elected at large on a partisan basis each November general election. The mayor is elected every four years as a separate election. The governance is in the form of a weak mayor/strong council government in which the council members act as the legislative body with the mayor presiding at meetings and only voting in case of a tie. Stone Harbor is located in the 2nd Congressional District and is part of the 1st NJ state legislative district. In 2015 there were 42 elementary students enrolled in the local island schools with high school students going to the Middle Township High School on the mainland.

The Borough has 24.11 miles of roadways split 21.38 miles with municipal maintenance and 2.73 miles managed by Cape May County.

Figure 1. Aerial imagery location map including the South Point Open Space

Project Goals

The goals of the Stormwater Management Plan are to:

- Evaluate future conditions and long-duration storms
- Evaluate the impact of sea level rise and climate change
- Identify wetlands and natural areas
- Address the protection of natural channels
- Provide a dedicated funding source for implementing the plan

NFIP CRS Program

The Community Rating System (CRS) is a voluntary program for National Flood Insurance Program (NFIP) participating communities. The goals of the CRS are to reduce flood damages to insurable property, strengthen and support the insurance aspects of the NFIP, and encourage a comprehensive approach to floodplain management (FEMA 2014). Certain activities credited under the CRS provide direct benefit to agents/producers writing flood insurance. Stone Harbor (Community #345323) entered the program in 1994 and achieved a Class 5 rating in 2013.

Credit Points	Class	Premium Reduction SFHA*	Premium Reduction Non-SFHA**
4,500+	1	45%	10%
4,000 – 4,499	2	40%	10%
3,500 – 3,999	3	35%	10%
3,000 – 3,499	4	30%	10%
2,500 – 2,999	5	25%	10%
2,000 – 2,499	6	20%	10%
1,500 – 1,999	7	15%	5%
1,000 – 1,499	8	10%	5%
500 – 999	9	5%	5%
0 – 499	10	0%	0%
** Special Flood Hazard Area*			

Activity 450 – Stormwater Management Regulation

Impact Adjustment Ratio

Seven Mile Island occupies the boundary between upland runoff and tidal influence. Locally dredged marinas and navigation channels connect to Great Sound to the west and flow north then east towards the Atlantic Ocean via Ingram Thorofare then Townsend's Inlet. Alternatively, the tidal flow extends southwest exiting into the Atlantic Ocean via Hereford Inlet. This Watershed Management Plan determines quantity and frequency of runoff from precipitation events and with impacts from tidal influences for the entirety of the municipality.

The Watershed Master Plan (WMP) covers the entirety of the Borough of Stone Harbor (2,025 acres; 1,278 acres land). There are neither rivers nor streams running through the Borough and no towns downstream of the Borough. The Borough, as part of a barrier island, is separate from the rest of the watershed (WMA 16 - 214,098 acres). The area falling within the Special Flood Hazard Area is 1,278 acres. The barrier island acts as its own sub-watershed where runoff does not flow into other communities but into the bay and actions taken by the community do not impact other communities. Barrier island communities are not located within the sub-watershed of any landward stream. Therefore, because Watershed Master Plan encompasses the entirety of the Borough of Stone Harbor's sub-watershed, the impact adjustment ratio is determined to be 1.0.

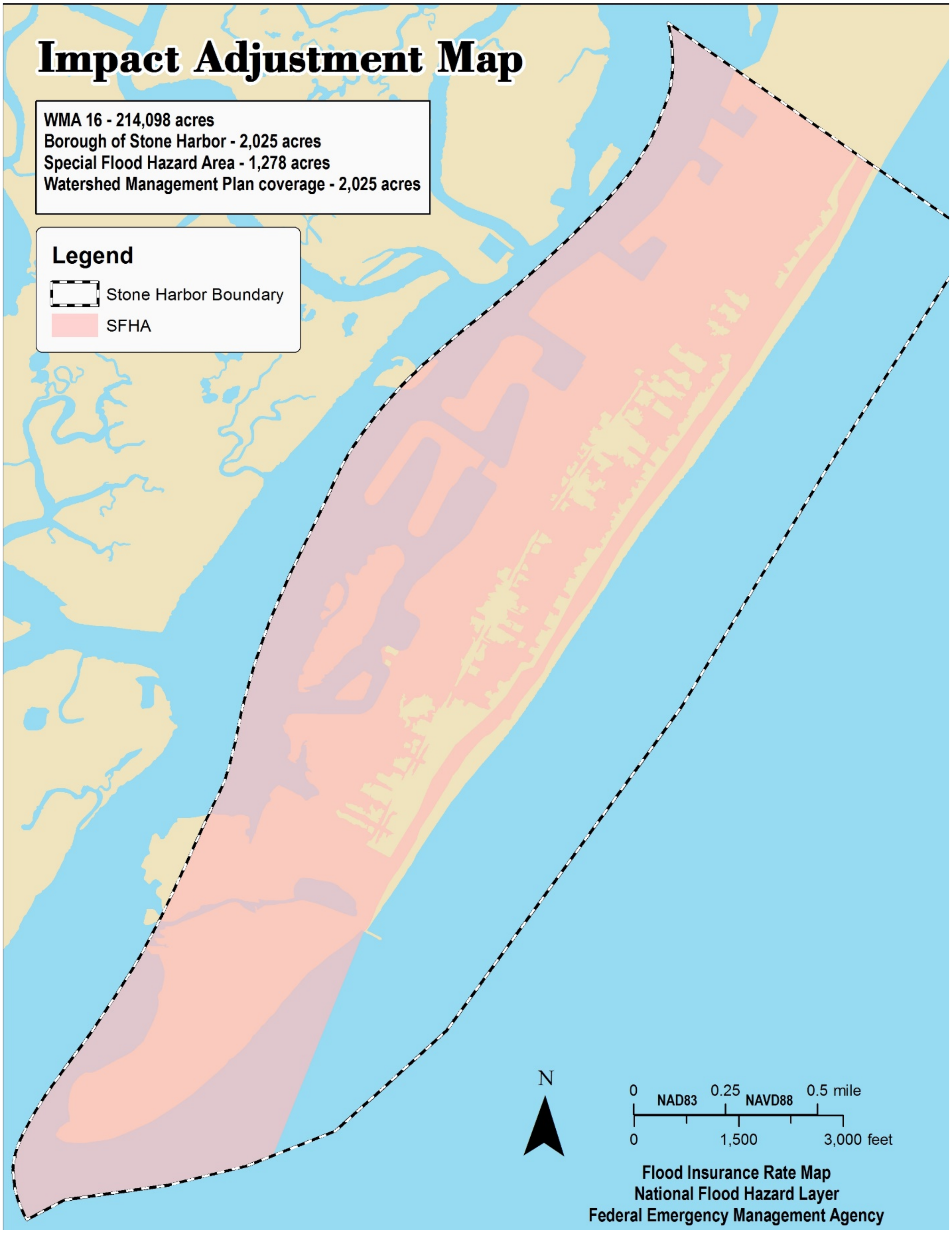

Figure 2. Impact Adjustment Map

452.b Watershed Management Plan

WMP1

(1) A copy of the ordinance adopting a watershed management plan affecting the community that identifies the natural drainage system and constructed channels.
(2) A copy of the ordinance adopting regulatory standards based on the plan
(3) The regulatory standards must require future peak flows to be no more than current peak flows
(4) The standards must address at least the 25-year event
(5) If more than five years old the community must determine if the plan is still current and provide documentation.

WMP2 The plan and the community's regulations manage the runoff from all storms up to and including the 100-year event. These must include the 10-year storm, a storm larger than the 10-year, but less than the 100-year and the 100-year storm.

WMP3 The plan manages peak flows and volumes to not increase over the existing values.

WMP4 The plan manages runoff from all storms up to and including the 5-day event.

WMP5 The plan identifies existing natural open space to be preserved from development so that natural storage of runoff is maintained.

WMP6 The plan prohibits development, alteration, or modification of existing natural channels.

WMP7 The plan requires channel improvement projects use natural approaches rather than hard techniques.

WMP8 If there is a dedicated funding source to implement the plan.

Existing Elements

WMP1

A copy of the ordinance adopting this watershed management plan is included within the appendices. A copy of an ordinance adopting regulatory standards based on this plan is included in the appendices. The Borough enforces the minimum standards of stormwater runoff quantity by including New Jersey's Stormwater Management rules (N.J.A.C. 7:8) under ordinance § 470-4 F (1) (c).

WMP2

This plan models runoff from rainfall events up to and including the 100-year event.

§ 470-4 F (1) (c) restates N.J.A.C 7:8-1 et seq. within its ordinances.

New Jersey's Stormwater Management rules (N. J. A. C. 7:8) defines "major development" as one that disturbs "one or more acres of land or increasing impervious surface by one-quarter acre or more."

The following are State requirements for controlling stormwater runoff quantity impacts (7:8-5.4(a)3):

i. Demonstrate through hydrologic and hydraulic analysis that for stormwater leaving the site, post-construction runoff hydrographs for the two, 10, and 100-year storm events do not exceed, at any point in time, the pre-construction runoff hydrographs for the same storm events;

ii. Demonstrate through hydrologic and hydraulic analysis that there is no increase, as compared to the pre-construction condition, in the peak runoff rates of stormwater leaving the site for the two, 10, and 100-year storm events and that the increased volume or change in timing of stormwater runoff will not increase flood damage at or downstream of the site. This analysis shall include the analysis of impacts of existing land uses and projected land uses assuming full development under existing zoning and land use ordinances in the drainage area;

iii. Design stormwater management measures so that the post-construction peak runoff rates for the two, 10 and 100-year storm events are 50, 75 and 80 percent, respectively, of the pre-construction peak runoff rates. The percentages apply only to the post construction stormwater runoff that is attributable to the portion of the site on which the proposed development or project is to be constructed; or

iv. In tidal flood hazard areas, stormwater runoff quantity analysis in accordance with i, ii, and iii above shall only be applied if the increased volume of stormwater runoff could increase flood damages below the point of discharge.

In the case of barrier island communities, lot sizes rarely qualify for the 1-acre “major development” requirement set forth by the State except in the cases of condominiums. This plan recommends an amendment to local ordinances to include “new development or substantial improvements” as required to manage changes in post development runoff quantity. This plan also recommends that ordinances be amended to include the management of stormwater runoff of either the 25- or 50-year storm event to ensure that flood flows downstream of new development do not increase due to the development.

WMP3

This plan includes Best Management Strategies that, when implemented, will reduce or maintain post-development runoff quantities through the use of on-site storage, absorption, recharging the groundwater table, and reduction of impervious coverage.

The following existing ordinances address maintaining or reducing future runoff rates:

§345-62B. Drainage

The applicant shall demonstrate that the stormwater runoff from the site will not adversely impact an adjacent property. Detailed stormwater runoff calculations shall be submitted with the application documenting the evaluation. As a minimum the applicant shall evaluate the two-, ten- and twenty-five-year design storm using either the Rational Method of the USDA Soil Conservation Service (TR-55) method. Where feasible the surface drainage from the site shall be directly connected to the Borough's stormwater drainage systems.

§345-62C. Landscaping

The applicant shall provide and maintain landscaping in any open areas of the site utilizing native (salt tolerant) species of vegetation. This vegetation shall consist of a mixture of low and high plantings along with ground cover to provide natural appearing relief to the landscape.

§470-4F Stormwater management requirements for major development

(c) In order to control stormwater runoff quantity impacts, the design engineer shall, using the assumptions and factors for stormwater runoff calculations at § 470-5, complete one of the following:

- *[1] Demonstrate through hydrologic and hydraulic analysis that for stormwater leaving the site, post-construction runoff hydrographs for the two-, ten-, and one-hundred-year storm events do not exceed, at any point in time, the preconstruction runoff hydrographs for the same storm events;*
- *[2] Demonstrate through hydrologic and hydraulic analysis that there is no increase, as compared to the preconstruction condition, in the peak runoff rates of stormwater leaving the site for the two-, ten-, and one-hundred-year storm events and that the increased volume or change in timing of stormwater runoff will not increase flood damage at or downstream of the site. This analysis shall include the analysis of impacts of existing land uses and projected land uses assuming full development under existing zoning and land use ordinances in the drainage area;*
- *[3] Design stormwater management measures so that the post-construction peak runoff rates for the two-, ten- and one-hundred-year storm events are 50%, 75% and 80%, respectively, of the pre-construction peak runoff rates. The percentages apply only to the post-construction stormwater runoff that is attributable to the portion of the site on which the proposed development or project is to be constructed. The percentages shall not be applied to post-construction stormwater runoff into tidal flood hazard areas if the increased volume of stormwater runoff will not increase flood damages below the point of discharge; or*

[4] In tidal flood hazard areas, stormwater runoff quantity analysis in accordance with Subsection F(1)(c)[1], [2] and [3] above shall only be applied if the increased volume of stormwater runoff could increase flood damages below the point of discharge.

WMP4

The Flood Model section covers potential impacts of rainfall events up to and including the 3-day event. See the Flood Model section and Rainfall Runoff Volume subsection for the justification of a 72-hour event being the appropriate "worst-case" runoff event. Minimal events have little to no flood impacts; whereas medium events may lead to temporary street flooding. This temporary flooding can be mitigated in the future by upgrading the stormwater drainage network and by maintaining or reducing impervious surface runoff and maintain or increase on-site storage.

Northeasters are the most likely long-duration rain event that will impact barrier island communities. These systems often travel slowly and pass through in two to five days. The model uses the 72-hour (3-day) event as the locally appropriate "worst-case" runoff event as it replicates the duration of multiple northeaster events that have inundated barrier islands in the past. Not only are there heavy rains during a northeaster, but tidal stacking often occurs as well. This means that any gravity-driven drainage system without pumping stations are unable to flush out its system and, as a consequence, are completely inundated leading to widespread roadway flooding. See the "Historic Flooding and Rain Events" section in this plan for more historical rainfall events.

The maximum rainfall event for this part of New Jersey occurred August 20th and 21st in 1997 when 13.52" of rain fell over a 48-hour period. It rained 7.57" at the Atlantic City International Airport on the 20th and 5.95" on the 21st.

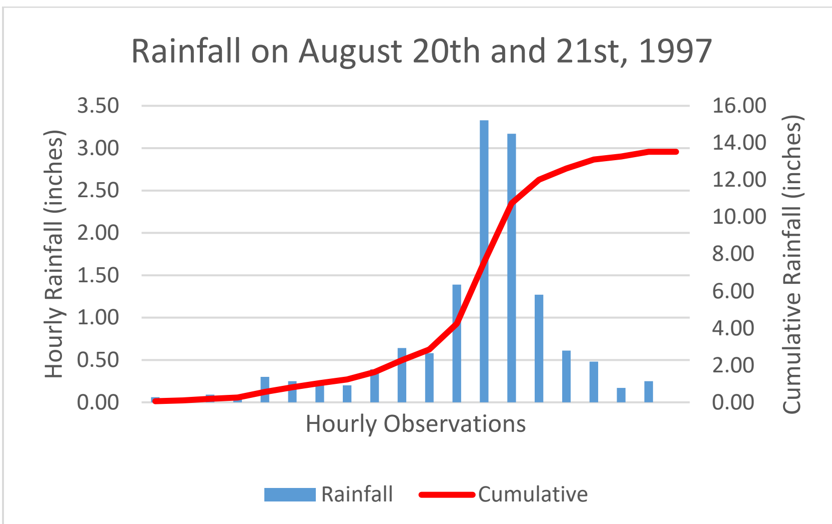

Figure 3. Historical Rainfall Data from KACY (https://www.wunderground.com/history/airport/KACY/1997/8/20/)

WMP5

The Borough requires that designated natural open space be protected from future development in order to maintain the natural storage of runoff. See Section Zoning Subsection Open Space within this plan for the identification of existing natural open space.

Ordinance §1561, Sect. 1, Chapter 345, Article XII was recently enacted to specifically prohibit modification, development, dredging in any natural channels within the Borough of Stone Harbor. Any channel clearing, deepening, or straightening requires a NJ Dept. of Environmental Protection permit, but in no situation shall concrete or other hard structures be utilized.

A. This applies to channels draining the South Point natural area in Stone Harbor
B. It applies to the channels draining the 5.5 city block bird sanctuary.
C. This applies to projects contemplated along either Sanctuary Bay or Paradise Bay where the municipality borders on tidal channels east of Sanctuary Island marsh.

Ordinance §156-23 covers the following unlawful activities that destabilize natural dune features:

A. To construct or attempt to construct any structure within the dune area.
B. To remove or cart away, by any means, any sand, sand fencing or dune vegetation from the dunes or from the area around the dunes.
C. To willfully or intentionally relocate or damage any sand fencing or any other type of dune protection device, or to hang any objects thereon.
D. To cut, burn or destroy any dune vegetation.
E. For any person, either on foot or on some form of conveyance, to:
(1) Disturb or destroy dune vegetation;
(2) Trespass within any area enclosed by sand fencing, or enclosed by sand fencing and the bulkhead along the beaches;
(3) Enter into those areas of the Public Use District and the Conservation Management District south of 122nd Street in all locations where dunes, dune grasses, or other forms of vegetation planted for the development of dunes exist;
(4) Enter into any other areas as may from time to time be specifically posted by order of the governing body.
F. To cross over the dunes by means other than using the pathways and elevated walkways constructed for that purpose.
G. To use and/or operate motor vehicles on the beach other than in accordance with Article II, Vehicles on Beaches, of this chapter.
H. To harvest beach sand or scrape beach sand or dunes without written approval by the Borough.

Ordinance §156-24 details necessary actions needed to replenish the damaged dune system to maintain the protection it provides residential properties:

A. Dune replenishment activity shall take place during periods prescribed by specific regulations, except in the case of emergency circumstances which constitute an immediate threat to the public health, safety and welfare as declared by appropriate Borough officials.
B. Replenished dunes shall be protected by planting appropriate vegetative cover in accordance with specifications set forth in Executive Policy 98-B-001.
C. Replenished dunes shall be immediately protected by the erection of sand fences in accordance with specifications set forth in Executive Policy 98-B-001.
D. In the event that the replenishment sand, or a portion thereof, is obtained from an off-site location, the added sand shall be of such grain size, shape, color and other characteristics as will be compatible with the existing on-site sand.

Ordinance §560-24 prohibits permanent structures within the Conservation Management CM District:

A. Use regulations. No building or structure may be constructed in this district except those structures authorized by the Borough Council for recreation, protection of the environment, to enhance nature walking, for beach access, bird watching and fishing, and to protect the district from erosion, it being the intention of the Borough that this district be protected to serve as a wildlife habitat and as a recreational-educational area for the public.

Ordinance §470-4E(2) encourages disturbed areas to: *(c) Maximize the protection of natural drainage features and vegetation, (e) Minimize land disturbance including clearing and grading,* and *(h) Provide vegetated open-channel conveyance systems discharging into and through stable vegetated areas.*

WMP6

Ordinance §1561, Sect. 1, Chapter 345, Article XII, B-Drainage (1) states that any applicant shall demonstrate that storm water runoff from a site will not adversely impact an adjacent property. At a minimum, the applicant shall evaluate the two-, ten-, and 24-year design storm event using the USDA Soil Conservation Service (TR-55) methods.

Ordinance §300-4 outlines the methods implemented in the reduction of flood losses:

C. Controlling the alteration of natural floodplains, stream channels, and natural protective barriers, which help accommodate or channel floodwaters;
D. Controlling filling, grading, dredging, and other development which may increase flood damage; and
E. Preventing or regulating the construction of flood barriers which will unnaturally divert floodwaters or which may increase flood hazards in other areas.

WMP7

The Borough implements nonstructural stormwater management strategies, meaning it chooses green solutions over grey solutions. Ordinance §470-4 E (2) outlines natural solutions to preserving existing natural drainage features and vegetation through the minimization of land disturbance and maximization of maintaining pre-development conditions.

Nonstructural stormwater management strategies

(a) Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss;
(b) Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces;
(c) Maximize the protection of natural drainage features and vegetation;
(d) Minimize the decrease in the time of concentration from preconstruction to post-construction. "Time of concentration" is defined as the time it takes for runoff to travel from the hydraulically most distant point of the watershed to the point of interest within a watershed;
(e) Minimize land disturbance including clearing and grading;
(f) Minimize soil compaction;
(g) Provide low-maintenance landscaping that encourages retention and planting of native vegetation and minimizes the use of lawns, fertilizers and pesticides;
(h) Provide vegetated open-channel conveyance systems discharging into and through stable vegetated areas;
(i) Provide other source controls to prevent or minimize the use or exposure of pollutants at the site, in order to prevent or minimize the release of those pollutants into stormwater runoff. Such source controls include, but are not limited to:
[1] Site design features that help to prevent accumulation of trash and debris in drainage systems, including features that satisfy Subsection E(3) below;
[2] Site design features that help to prevent discharge of trash and debris from drainage systems;
[3] Site design features that help to prevent and/or contain spills or other harmful accumulations of pollutants at industrial or commercial developments; and
[4] When establishing vegetation after land disturbance, applying fertilizer in accordance with the requirements established under the Soil Erosion and Sediment Control Act, N.J.S.A. 4:24-39 et seq., and implementing rules.

WMP8

Dedicated funding to implement the Watershed Management Plan currently consists of:

1. *$6,000 annually in the operating budget to implement any aspect of CRS activity actions.*
2. *$20,000 annually in the NR Capital budget for Flood Mitigation efforts*
3. *$5,000 annually in the OE Engineering budget to CRS activity actions.*

Recommended Ordinances

WMP 1

This plan recommends that ordinances be amended to include the management of stormwater runoff of either the 25- or 50-year storm event to ensure that flood flows downstream of new development do not increase due to new construction.

WMP 2

In the case of barrier island communities, lot sizes rarely qualify for the 1-acre “major development” requirement set forth by the State except in the cases of condominiums. This plan recommends an amendment to local ordinances to include “new development or substantial improvements” as required to manage changes in post development runoff quantity.

WMP 8 if done by ordinance delete this section

The following are excerpts of “Funding Stormwater Programs” by the United States Environmental Protection Agency in 2009. This document can be used as a guide for the implementation of a dedicated funding source in the future for stormwater infrastructure improvement projects.

Types of Stormwater Utilities

1. Equivalent Residential Unit
    a. Bills an amount proportional to the impervious area on a parcel, regardless of the parcel’s total area
    b. Based on the effect of a typical single-family residential home’s impervious area footprint
2. Intensity of Development
    a. Based on the percentage of impervious area relative to an entire parcel’s size
    b. Suggested monthly rates per 1,000 square feet
        i. Vacant/Undeveloped (0%) $0.08
        ii. Light development (1% to 20%) $0.12
        iii. Moderate development (21% to 40%) $0.16
        iv. Heavy development (41% to 70%) $0.24
        v. Very heavy development (71% to 100%) $0.32
3. Equivalent Hydraulic Area
    a. Based on stormwater runoff stormwater runoff generated by their impervious and pervious areas
    b. Parcels are billed on the basis of individual measurements of pervious and impervious areas

Review of Past Studies

Master Plan

The following were observations and recommendations by the Stone Harbor Borough Planning Board in 2009.

1. Buildings with attached garages allowable coverage is 25%
2. Buildings with detached garages and other accessory structures can have 75% of the lot covered
3. Mature trees were lost to construction and were either not replaced or replaced with young trees that do not provide a similar shade area
4. A landscaping ordinance should be prepared and adopted to prevent mature trees and vegetation in the Borough from being razed without considering alternatives or providing replacements
5. The Light Industry District has no industry and only residential use. This designation should be removed from the zoning plan
6. A green building ordinance is recommended to promote green building practices

Green Purchasing Policy

Policy number F-011 refers to the Environmentally Preferable Purchasing Policy (Green Purchasing Policy) and was adopted by Resolution 2017-S-214 on November 7, 2017.

1.4.5 Landscaping & Hardscaping

All landscape renovations, construction and maintenance performed by the Borough, including workers and contractors providing landscaping services for the Borough, shall employ sustainable landscape management techniques for design, construction and maintenance whenever & where possible, including, but not limited to, integrated pest management (IPM), grass recycling, drip irrigation, composting, and the procurement and use of mulch and compost that give preference to those products produced from regionally generated plant debris and/or food and sludge waste programs.

Plants should be selected to minimize waste by choosing species for purchase that are appropriate to the microclimate, species that can grow to their natural size in the space allotted to them, and perennials rather than annuals for color variations should be utilized. Native and drought-tolerant plants that require no or minimal watering once established are preferred over others when & where practicable.

Hardscapes and landscape structures constructed of recycled content materials are encouraged to be utilized. The Borough shall limit the amount of impervious surfaces in the landscape, when & where practicable. Permeable substitutes, such as permeable asphalt or payers, are encouraged for walkways, patios and driveways.

Cape May County Multi-Jurisdictional Hazard Mitigation Plan

The following were current and recommended activities of Stone Harbor as documented in 2016 by the Hazard Mitigation Plan (Tetra Tech 2016):

1. Support purchase or relocation of structures located in hazard-prone areas to protect structures from future damage, with repetitive loss and severe repetitive loss properties as priority
2. Continue stormwater drainage improvements throughout the Borough to increase capacity
    a. 105th St. Stormwater drainage improvement project
3. Installed a remote tide gauge at CMC Bridge Comm. And 80th Street Marina
4. Consider pursuing tying in a live feed camera to the remote tidal gauges
5. Borough has purchased a weather subscription service that provides daily weather predictions
6. Elevate Stone Harbor Boulevard (Long-term) – County's responsibility
7. Maintain the 12 outfall pipes along the beachfront
8. Maintain flood siren warning systems throughout the Borough to alert residents in the event of an emergency

Infrastructure Improvement Projects

Past

Stone Harbor received a $2.7-million grant from the Christie Administration on December 20, 2016. These funds were allocated towards stormwater and storm-surge mitigation projects including the major evacuation route. Remotely operated tide-control valves were installed to close stormwater discharge pipes to prevent surcharge when bay waters are high.

Present

Stockton Coastal Research Center conducted a survey of existing residential bulkhead elevations in the beginning of October 2017. GPS equipment was used to collect multiple points along bulkheads to determine the distribution of bulkhead elevations (in NAVD88). The lowest bulkhead was found to be 2.3 feet while the highest was found to be 9.4 feet. The average elevation was 6 feet. The ordinance on bulkhead heights states: *Bulkheads shall be built along the existing bulkhead line and the finished elevation of the bulkhead shall be [8] feet above mean sea level* (§199-2B).

Home owners with bulkhead elevations below 5.0 feet will have five (5) years to comply with this new elevation. The new ordinance also requires that all new bulkheads be flood proofed above the existing grade on the land side of the bulkhead with either concrete or an approved sealant applied to the exposed portion above grade.

A new lot-grading ordinance requires a plan submitted for municipal approval that conducts all roof and impervious surface lot runoff into ground water recharge.

Future

Stormwater Master Plan

Remington, Vernick & Walberg Engineers have drafted in 2018 a Stormwater Master Plan. The following are observations of and recommendations for the stormwater drainage system.

1. Insufficient bulkhead heights – Enforce new required bulkhead elevation standards (8.0 ft. NAVD 1988)
2. Installation of stormwater pump stations for each major drainage area with bayside force main outfalls that would replace existing outfalls
3. Missing or malfunctioning tidal check valves – Install remotely controlled wireless tide control valves
4. Undersized storm drainage pipes - Increase stormwater pipe diameters
5. Poor stormwater piping network coverage - Install new drop inlets and lay more underground pipes
6. Insufficient number and coverage of inlets – Increase number and coverage
7. In 2018 Stone Harbor funded a 1-year flooding study to document flood duration, frequency, and depth utilizing HOBO water pressure sensors installed in 14 community stormwater drainage vaults that record all water pressure contact events. Every 90 days the accumulated data is downloaded and reviewed for events to create a document on frequency, extent and duration of what is termed “nuisance flooding” of the streets in multiple locations throughout the Borough.

Remington & Vernick Engineers designed a new pumping station proposed at the intersection of 93rd Street and 3rd Avenue. The drainage system will terminate with a 54” ductile iron pipe discharge main connected to a manifold that will discharge stormwater to the bay at the end of 93rd Street through eight individual 24” discharge points. This project is designed to mitigate flooding for a 10-year event using two pumps in parallel and up to the 25-year rainfall event using three pumps in parallel. This pumping station plan coordinated with Cape May County roads department to both raise 3rd Avenue in elevation (as part of an evacuation route improvement) and redirect a series of county stormwater outfall lines that pass under homes without easements to the 93rd Street pumping station as a remedy.

Stone Harbor will continue reporting all street sweeping, gutter cleaning, and stormwater drainage vault inspections and clean-out work under the NJDEP MS-4 reporting update mechanism.

A plan is in development to remove the 111th and 122nd Street ocean outfall lines and going to a groundwater recharge system with pumping station back up for extreme events.

The Borough continues to upgrade its GIS-based digital mapping program as the guidance tool used to make propositions and proposals available to officials and the general public including its capital investment program where batches of up to five local roadways are upgraded annually with improved utility function for sewage and stormwater management

Watershed Description

Stone Harbor is a part of the Cape May Watershed Management Area 16, which is one of twenty watershed management planning areas within the State of New Jersey as delineated by the New Jersey Department of Environmental Protection (NJDEP). The 214,098 acre watershed consists of 35 municipalities (21 municipalities in Atlantic County, 6 in Camden County, 4 in Cape May County, 1 in Cumberland County, and 3 in Gloucester County). Its headwater begins in Gloucester and Camden Counties and drains southeast into Atlantic County via Great Egg Harbor River, Tuckahoe River, Absecon Creek, and Patcong Creek. Waters are classified as saline coastal, saline estuary, non-trout freshwater subject to man-made wastewater discharges, and pinelands waters (NJDEP 2017). Stone Harbor also lies within the Cape May Bays hydrological unit (02040302) and some coastal portions fall within the Atlantic Ocean unit.

The Borough of Stone is bound to the east by the Atlantic Ocean, to the west by Great Channel, to the south by Hereford Inlet, and to the north by the Borough of Avalon. It lies within two hydrological units: the Atlantic Coast (Townsends to Hereford Inlet) and Cape May Bays. The drainage divide falls along 2nd Avenue with natural runoff to the east traveling to the Atlantic Ocean and to the west Great Channel.

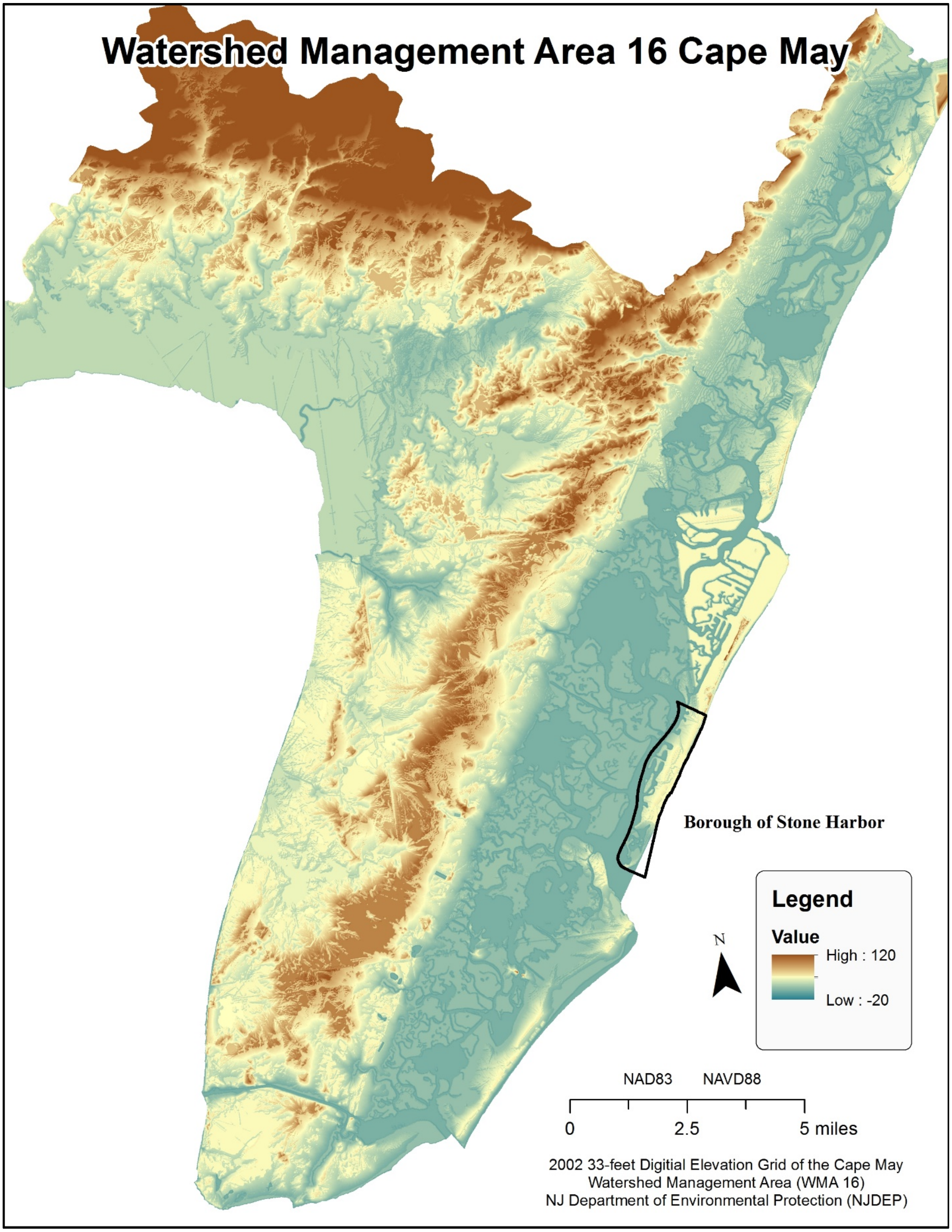

Figure 4. Watershed Management Area 16

Figure 5. Hydrological Units

Figure 6. Waterbodies

Physical and Natural Features

Precipitation

For coastal New Jersey, the wettest months are March and August with monthly rainfall averages above 4 inches. February is recorded as accumulating the most snowfall. Just this past year, through winter storms and northeasters, the coast has received nearly a month's amount of rain over just a few days. It is these extensive rain events that overwhelm normal storm drain systems and lead to costly flood events.

Table 1. Climate and Precipitation Monthly Averages

Climate data for Stone Harbor Beach, New Jersey (1981 – 2010 averages).													
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Year**
Average high (°F)	42.2	44.0	50.9	60.4	69.6	78.5	83.3	81.7	76.1	66.2	56.5	46.9	63.0
Average low (°F)	27.0	28.8	34.9	44.1	53.2	62.9	68.4	67.4	60.7	49.6	40.5	31.6	47.4
Average precipitation (inches)	3.36	2.86	4.20	3.66	3.55	3.21	3.81	4.21	3.40	3.61	3.31	3.67	42.85
Average snowfall (inches)	4.3	6.5	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	2.5	15.4

Source: PRISM Climate Group, Oregon State University

Table 2. Average Recurrence Intervals of Precipitation Frequency

	Average recurrence interval (Years)					
Hours	**1**	**5**	**10**	**25**	**50**	**100**
1	1.18	1.72	2.04	2.40	2.72	3.03
3	1.58	2.33	2.79	3.34	3.84	4.33
6	1.96	2.86	3.44	4.15	4.82	5.49
12	2.34	3.42	4.15	5.08	5.99	6.93
24	2.68	4.24	5.09	6.37	7.50	8.77
48	3.09	4.88	5.84	7.30	8.57	10.00
72	3.24	5.10	6.08	7.57	8.85	10.30

Source: NOAA Atlas 14 Point Precipitation Frequency Estimates

Historic and Flooding and Rain Events

Hurricanes and major storms have produced significant rainfall and/or tidal flooding conditions on the southern New Jersey coast. March 6th to 8th, 1962 brought the Ash Wednesday Storm to the east coast and the Atlantic City Steel Gauge Pier recorded 5.8 ft. NAVD88 tidal flood elevation. In 1971 from August 26th to 28th, it rained 3 to 11 inches in New Jersey over a 32-hour period. Hurricane Irene (August 28, 2011) dropped 10 inches of rain in parts of New Jersey. Hurricane Sandy (October 29, 2012) brought water levels to 6.14 ft. NAVD88 (8.76 ft. MLLW) at Steel Pier (Table 3; NCDC 2016). At the beginning of this year (2018), Winter Storm Grayson precipitated 13.2 inches of snow in Atlantic County and even more in Ocean County.

Table 3. Storm tide levels (NAVD88FT) and rain/snow S (inches) historical storm events

Event	**Month**	**Day**	**Year**	**NAVD88 *feet***	***inches***
Nor'easter	March	6 - 8	1962	5.8	2.22
Tropical Storm Doria	August	26 - 28	1971	4.4	3.34
Perfect Storm	October	28 – 31	1991	6	-
Nor'easter	December	11	1992	6.4	2.92
Blizzard	January	7 - 8	1996	4.77	0.72
Rain Event	August	20 - 21	1997	4.04	13.52
Nor'easter	January	28 - 29	1998	4.56	1.55
Severe Winter Coastal Storm	February	4 - 8	1998	4.60	0.91
Hurricane Floyd	September	16 - 18	1999	2.98	2.46
Nor'easter	October	15 - 18	2009	4.77	2.50
Tropical Depression Ida & Nor'easter	November	11 - 15	2009	4.70	2.15
Hurricane Irene	August - September	26 - 5	2011	4.05	7.75
Hurricane Sandy	October	29 - 31	2012	6.19	6.00
Winter Storm	January	2 - 3	2014	4.57	6.50^S
Hurricane Joaquin	September – October	27 – 7	2015	4.42	3.49
Blizzard (Winter Storm Jonas)	January	22 - 24	2016	5.23	10.10^S
Blizzard (Winter Storm Mars)	February	8	2016	4.62	-
Nor'easter	January	23-24	2017	4.33	2.79
Nor'easter / Winter storm	March	13 - 14	2017	4.97	3.30
Sustained northeast winds	May	22 - 28	2017	4.39	3.06
Thunderstorm	July	13 – 14	2017	4.63	1.47
Thunderstorm	July	29	2017	3.19	5.41
Hurricane Jose	September	18 – 23	2017	4.3	-
Winter Storm Grayson	January	4	2018	4.3	13.20^S
Perigeen Blue Moon	January	30 - 31	2018	4.19	0.19
Blizzard / Nor'easter (Winter Storm Riley)	March	2 – 3	2018	4.36	0.8^S

"S" is snow. Mean tidal range is 4.0 ft. Great Diurnal Range is 4.6 ft.

** Hourly precipitation amounts come from either the Atlantic City (COOP: 280325) or Atlantic City International Airport (COOP: 280311) rain gauge.*

Topography

The Borough of Stone Harbor has an average elevation of 9 feet. The area from 80th Street to 90th Street from 2nd Avenue to Sunset Drive is low lying with an average elevation of 2 feet. First Avenue is the highest roadway stretch at 7.5 feet (Second Avenue dips to 6.5 feet and Third Avenue sits at or below 4.9 feet). A man-made primary dune system runs from 80th Street to 122nd Street. Its crest ranges from 13 to 20 feet with an average elevation of 14.7 feet. An elevation profile running from the ocean to the bay peaks at the dune crest of 16.4 feet and slopes from 10 feet on the landward dune toe to 4.9 feet along the bay roadways (Figure 7). Sedge Island rises to a maximum of 8.2 feet and supports high marsh grass.

Stone Harbor Point is preserved as a wildlife conservation area for bird nesting habitats. Its area varies with storm erosion or sand accretion, but it serves Piping Plover nesting and other shore birds. It is entirely Borough owned and dedicated to conservation in perpetuity.

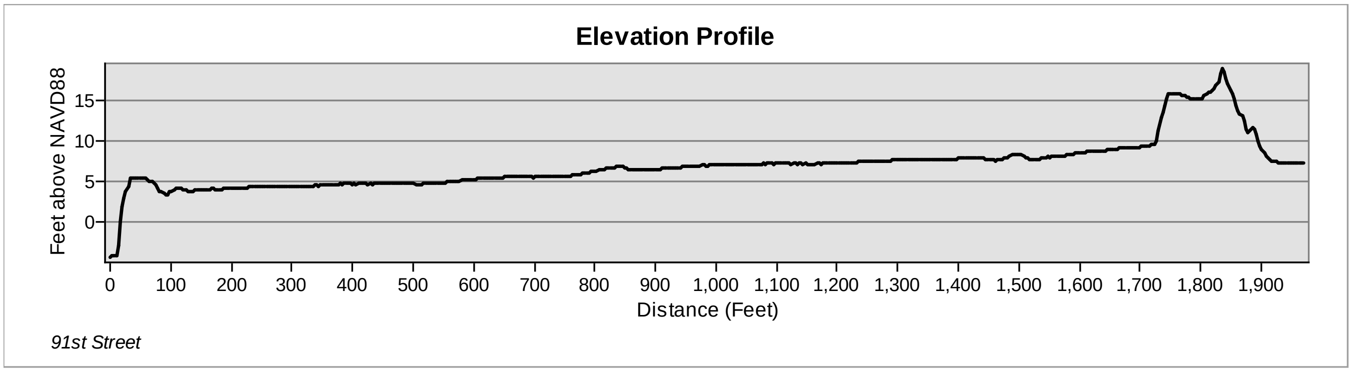

Figure 7. Cross-sectional profile along 91st Avenue from the bay to the ocean

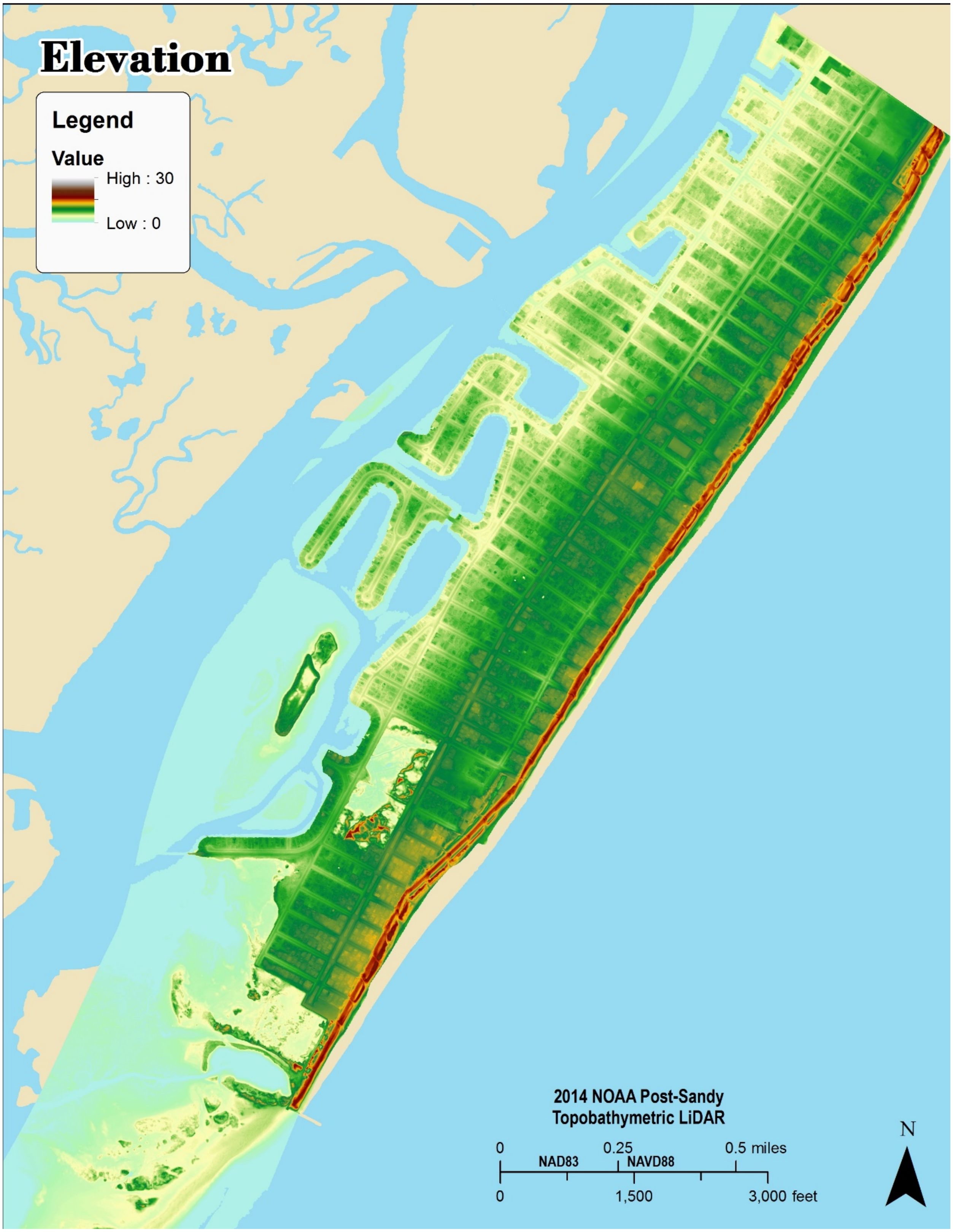

Figure 8. 2014 Digital Elevation Model (NAD83, NAVD88FT)

Soils

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Soils are classified into four hydrologic soil groups and three dual groups. In dual groups, the first letter is for drained areas while the second if for undrained areas. Certain wet soils grouped into Group D are due to the presence of a water table within 24 inches of the surface. Soil Group A have high infiltration rates when thoroughly wet and so low runoff potential. Soil Group B have a moderate infiltration rate when thoroughly wet. These soils are moderately well drained or well drained. Soil Group C have a slow infiltration rate when thoroughly wet and have a horizon that impedes percolation of water. Soil Group D have a very slow infiltration rate and, therefore, a high runoff potential, when thoroughly wet. Horizons include clays such as vertisols, that shrink and expand as moisture levels fluctuate (USDA 2017).

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates. For residential properties built upon excessively drained soil and given no prior rain event or raised water table, drainage in these areas have a high infiltration rate where rainwater quickly percolates down into the soil – either recharging groundwater or entering the stormwater system.

Most residential properties are built upon Urban-land Psamments (USPSBR). This young, sandy soil is well-drained and rarely flooded. The soils that make up the beaches and dunes were once a part of the natural barrier island. These areas are excessively drained, but it should be noted only down to the water table. As the ocean and bay levels fluctuate, so does the water table.

Soil types from the Soil Survey Geographic (USDA 2017) are:

Beaches (BEADV) have 0 to 15 percent slopes, are frequently flooded, and are excessively drained. Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Order Entisols, Sub-Order Psamments.

Hooksan sand (HorDr) have 2 to 15 percent slopes, are rarely flooded, and are excessively drained. Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Order Entisols, Sub-Order Psamments.

Pawcatuck-Transquaking complex (PdwAv) have 0 to 1 percent slopes, are very frequently flooded, and are very poorly drained. Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Order Histosols, Sub-Order Hemists.

Psammaquents (PstAt), sulfidic substratum have 0 to 3 percent slopes, are frequently flooded, and are very poorly drained. Psamments (PsvAr) have a wet substratum, 0 to 2 percent slopes, and are rarely flooded. It occurs on flats along the footslope. Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Order Entisols, Sub-Order Aquents.

Urban land-Psamments (USPSAS), sulfidic substratum complex have 0 to 2 percent slopes, and are occasionally flooded. Urban land-Psamments (USPSBR), wet substratum complex have 0 to 8 percent slopes, and are rarely flooded. Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. It is excessively drained. Order Entisols, Sub-Order Psamments.

Table 4 . Soil Classification and Soil Group

SYM	Name	HSG	Acres
BEADV	Beaches	A/D	136.3
HorDr	Hooksan sand	A	125.4
PdwAv	Pawcatuck-Transquaking complex	D	104.1
PstAt	Psammaquents	A/D	16.1
USPSAS	Urban land-Psamments	A	120.3
USPSBR	Urban land-Psamments	A	446.3

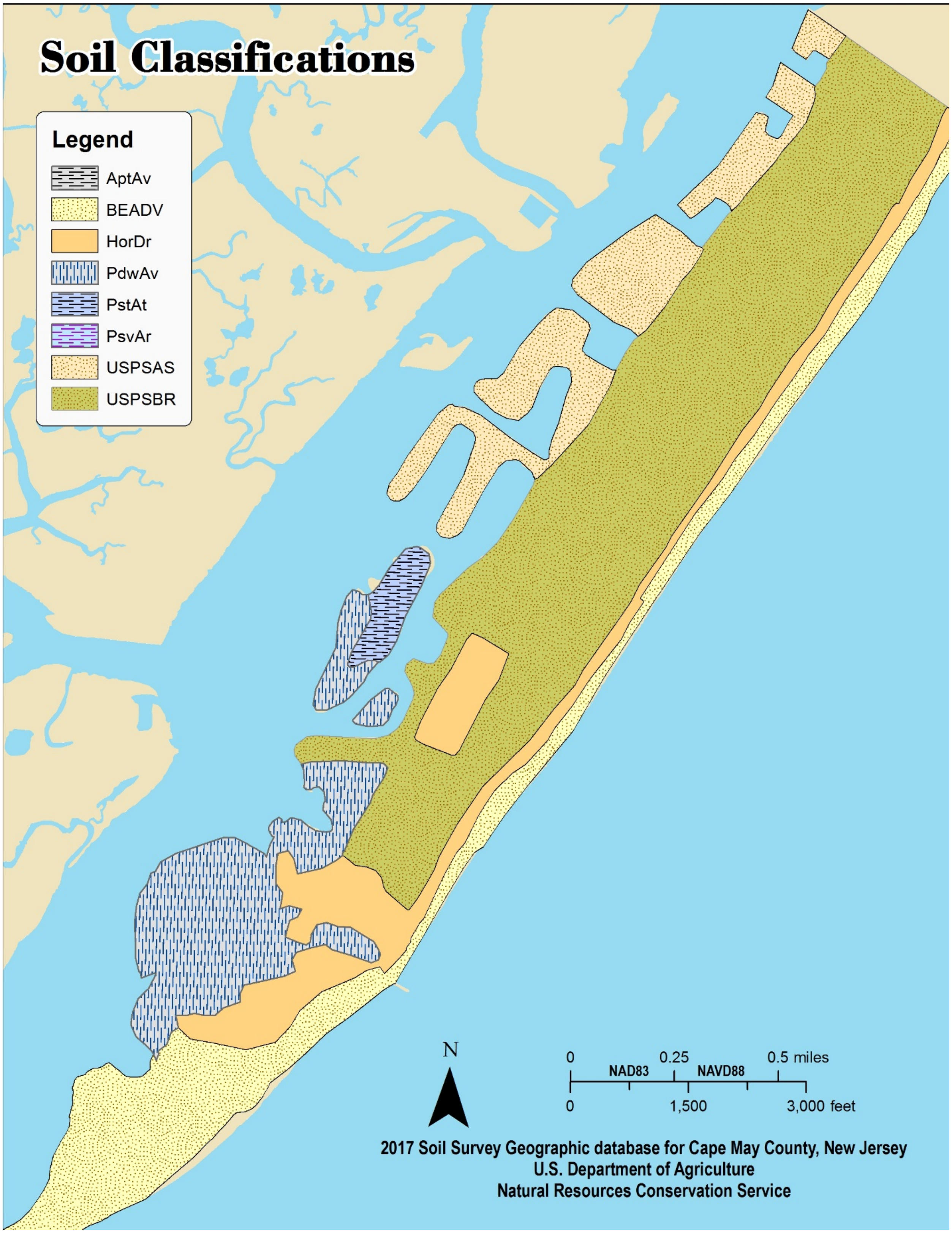

Figure 9. Soil Map

Zoning

Stone Harbor has eight (8) zoning districts. Thirty-two percent (32%) of the zoned area is for residential use. A large area (194 acres) is zoned for public use and includes the dune and beach system. Stone Harbor Point is zoned under Conservation Management and encompasses 15% of land use area (221 acres).

Stone Harbor approved its Sustainable Land Use Pledge in May of 2017 (Resolution 2017-S-121, Appendix). Land-use zoning, natural resource protection and other ordinances were appended as a result of this adoption. Stone Harbor pledged to:

1. Complete a Natural Resources Inventory
2. Zone for a mix of residential, retail, commercial, recreational and other uses
3. Incorporate the principles of green design and renewable energy generation into municipal buildings

The following table is a breakdown of current land use and coverage and its relative percentage of total land area.

Table 5. Land Use and Land Cover

Category	Acres	Percentage of Total Land Area
Beach	191	19%
Dunes	70	7%
Forest	11	1%
Groin	<1	<1%
Open Space	20	2%
Wetlands	174	18%
Urban	527	53%

Open Space

The following section identifies existing natural open space to be preserved from development as to maintain the natural storage of runoff (WMP5). There is a total of 466 acres of open space; of this, 32 acres are attributed to recreational areas (Table 8). These areas include both impervious (courts) and pervious surfaces (fields). Open space and recreation areas were mapped using August 26, 2016 Google$^{(TM)}$ Earth aerial imagery and Google Earth Pro polygon mapping tool. Neither vacant lots nor parking lots were included.

The Wildlife Conservation Area known as “The Point” is a dynamic spit accreting into Hereford Inlet. Due to the deep navigational channel, sediment is transported into Great Channel onto the backside of the spit. This area is constantly changing both in length and width. Due to its low elevation, it is frequently overwashed, moving sediment from the beach across its width and depositing it into the bay as a fan. Therefore, the area and boundary of this Point is constantly in flux. As of August 2016, South Point covered 142 acres. The “Bird Sanctuary” located East of 3rd Avenue between 111th and 117th Avenues encompasses 21.4 acres of Mixed Deciduous/Coniferous Brush/Shrub and Phragmites dominated interior wetlands.

Wetlands

Wetland is environmentally and biologically important as it attenuates wave energy from swells or boat wakes and provides habitat and breeding grounds for birds and fish. Often called "nature's kidneys", it filters sediment and pollutants from runoff water leaving the uplands before it enters the main water bodies. Plant vegetation reduces or eliminates contaminants such as nitrates and phosphorus that are products of fertilizers sprayed on lawns and gardens.

Saline Marshes are associated with salinities greater than one part per thousand (> 1 ppt). Low marsh vegetation is dominated by *Spartina alternifloria* where elevations are frequently flooded. Low marsh vegetation is inundated during spring tides, has salinities less than 10 parts per thousand (< 10 ppt, brackish), and is dominated by Spa*rtina patens*. Average elevation for low salt marsh is 2 ft. above 0.0 ft. NAVD88. Phragmites Dominate Wetlands contain saline marsh areas where *Phragmites australis* (Common reed) is an invasive plant species that outcompetes any other possible vegetation, which creates a thick forest of reedy stalks that is nearly impenetrable by wildlife; therefore, where Phragmites exist, bird and rodent habitats do not.

Wetlands account for 18% of Stone Harbor's land usage (Table 5) and 37% of its open space (Table 6). Seventy-five percent (75%) of its wetlands fall into the low saline marsh category (131 acres), while only nineteen percent (19%) are non-tidal wetlands (Table 7). These non-tidal wetlands include: Coniferous, Deciduous, and Mixed Scrub/Shrub Wetlands, Herbaceous Wetlands, and Phragmites Dominate Interior Wetlands.

Table 6. Open Space Permeable Surfaces

Category	Acres	Percentage of Open Space
Beach	**191**	**41%**
Dunes	**70**	**15%**
Forest	**31**	**7%**
Deciduous Brush/Shrub	2	
Mixed Deciduous/Coniferous Brush/Shrub	8	
Old Field (< 25% Brush Covered)	1	
Athletic Fields (Schools)	1	
Open Space	11	
Recreational Land	7	
Wetlands	**174**	**37%**
Coniferous Scrub/Shrub Wetlands	3	
Deciduous Scrub/Shrub Wetlands	11	
Disturbed Tidal Wetlands	5	
Herbaceous Wetlands	6	
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	7	
Phragmites Dominate Interior Wetlands	6	
Saline Marsh (High Marsh)	6	
Saline Marsh (Low Marsh)	131	

Table 7. Classification of Wetlands

Wetlands	Acres	Percentage of Wetlands
Non-Tidal	**33**	**19%**
Coniferous Scrub/Shrub Wetlands	3	2%
Deciduous Scrub/Shrub Wetlands	11	6%
Herbaceous Wetlands	6	4%
Mixed Scrub/Shrub Wetlands (Deciduous Dom.)	7	4%
Phragmites Dominate Interior Wetlands	6	3%
Tidal	**142**	**81%**
Disturbed Tidal Wetlands	5	3%
Saline Marsh (High Marsh)	6	3%
Saline Marsh (Low Marsh)	131	75%

Table 8. Open Space and Recreation Areas

Location	Open Space and Recreation Areas	Acres
80th St & 2nd Ave		**7.85**
	Playground	0.45
	Tennis Courts	1.79
	Baseball Field	2.96
	Soccer Field	2.27
	Basketball / Hockey Courts	0.38
96th St & 1st Ave		**1.25**
	Playground	0.27
	Tennis Courts	0.71
	Basketball	0.17
	Shuffle Board	0.1
Chelsea Place		**0.31**
	Playground	0.14
	Volleyball Courts	0.17
111th to 117th & 3rd Ave	Bird Sanctuary	21.4
93rd St & 3rd Ave	Elementary School Playground	1.2
South of 122nd St	South Point	142
122nd to 80th Street	Public Beaches	53
2nd Avenue	Grassy Medians	6.16

Figure 10. Open Space and Recreation Areas

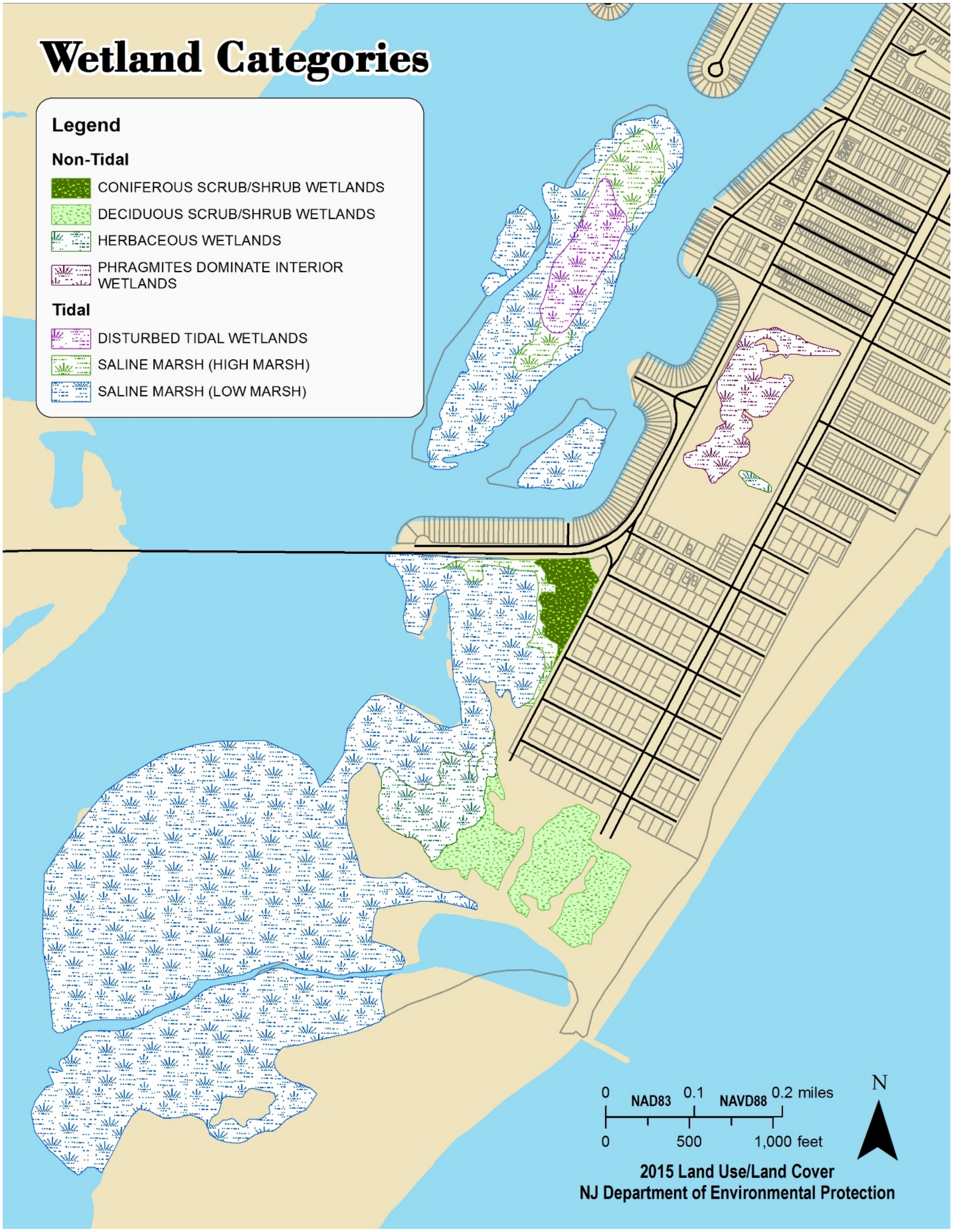

Figure 11. Wetland Classifications

Developed Areas

Residential and commercial lot coverage are the percent area covered with impervious material such as roofs, driveways, and parking lots. Maximum percentage of impervious coverage for building zones are typically 70% and maximum building coverage is 25% for single family residents (§560-13). All roadways are impervious and their buffers include adjacent sidewalks. Runoff from these sources enter the stormwater system and may overwhelm it during high rainfall events.

Given an opportunity to repair or construct impervious areas, consideration should be made to increase permeability through the use of pervious pavement or an on-site reservoir. Increase in native vegetation plantings should be encouraged surrounding large parking lots. These areas can be rebuilt with a slight slope that directs sheet flow to a catchment basin. Here, water-tolerant (or hydrophilic) plants would absorb excess nutrients and baffle suspended sediment, thus improving the quality of water entering the stormwater system.

Fifty-three percent (53%) of Stone Harbor's land use is urban. Of the urban area, 56% is made up of high density or multiple dwelling residential and 36% falls under transportation (i.e. roadways).

Table 9. Urban Land Use

Urban Land Use	Acres	Percentage of Urban Area
Commercial/Services	29	5%
Industrial	1	< 1%
Mixed Urban Or Built-Up Land	< 1	< 1%
Recreational Land	4	1%
Residential, High Density Or Multiple Dwelling	293	56%
Residential, Single Unit, Low Density	1	< 1%
Residential, Single Unit, Medium Density	11	2%
Transportation	188	36%
	527	

Table 10. Zoning Districts

Zoning	Districts	Acres	Percent
B	Business	42.55	3%
B-P	Residential B Parking	0.63	0.04%
CM	Conservation Management	220.81	15%
LI	Light Industry	5.35	0.36%
P	Public Use	193.63	13%
RA	Residential A	289.79	20%
RB	Residential B	132.93	9%
RC	Residential C	46.81	3%

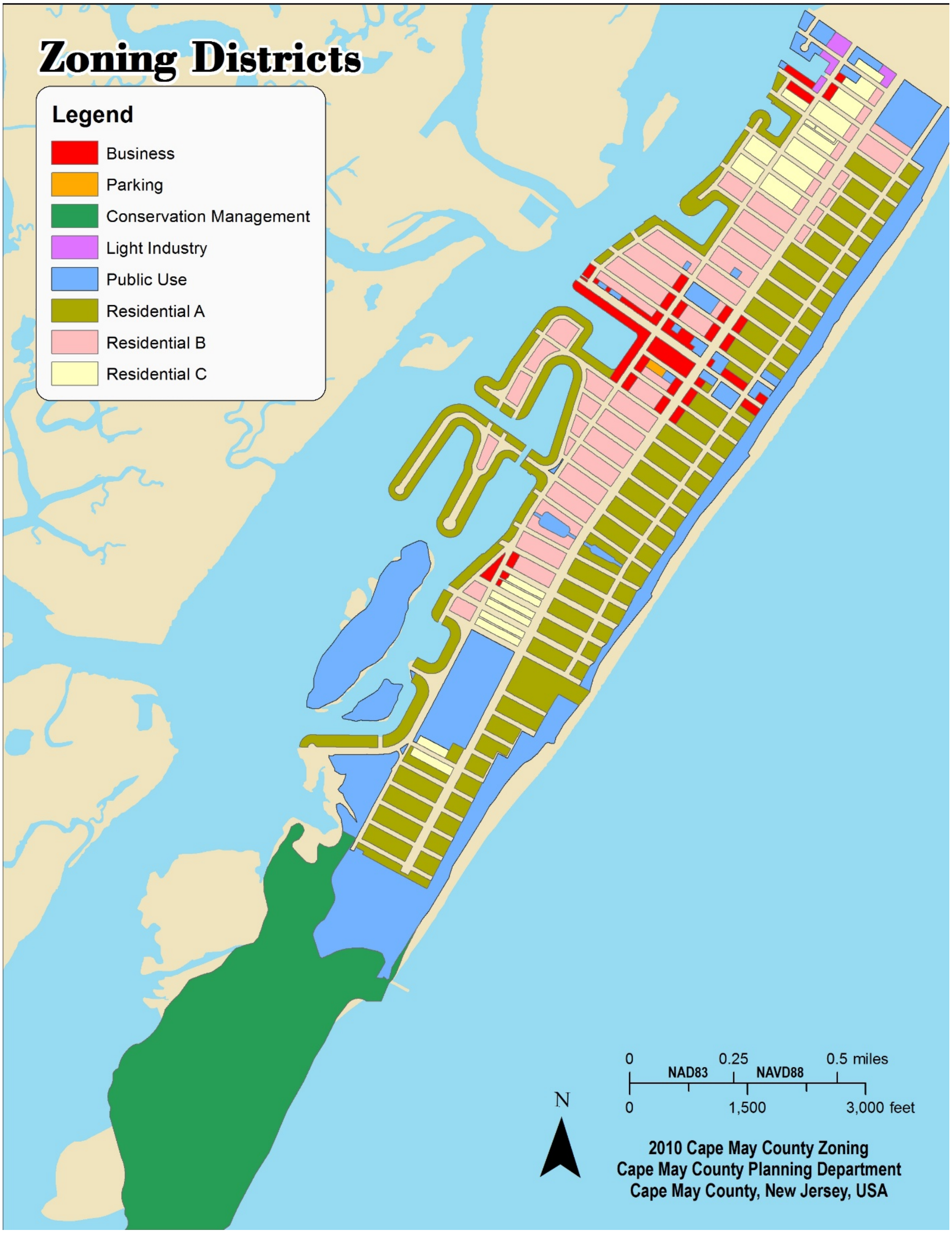

Figure 12. Zoning Districts

Figure 13. Urban Development: Commercial, Recreational, Residential, and Transportation

Buildout Analysis

In 2010 there were 20 vacant lots (3.1 acres) according to the 2010 Cape May County Hazard Mitigation Plan. Vacant or developable lots were identified by analyzing Google™ Earth Imagery from August 2016. Parcels were selected based on areas not currently occupied by housing and enough space for extensions or detachable garages to be built. Comparison of 2015 to 2016 imagery revealed demolition of pre-existing buildings that could be rebuilt in the future. As of the 2016 imagery, Seventy (70) lots in that were deemed vacant or buildable for a total of 5.46 acres. Otherwise, Stone Harbor is completely developed and future changes will be in the demolition, renovation, or redevelopment of either residential or commercial districts.

Transportation Infrastructure

Evacuation Routes

Borough officials should call for evacuations in reasonable time before the approaching storm inhibits road crossing due to flooding. Residents are encouraged to take County Road 657 (Stone Harbor Boulevard) west into Middle Township. Without traffic, it should take 6 minutes to travel the 3.5 miles upon entering Stone Harbor Boulevard to the Garden State Parkway ramp entrances.

One can also head north via Ocean Drive into Avalon by following Route 619 and then heading west along Route 601 (Avalon Boulevard) until the Garden State Parkway is reached. Without traffic, this 6.7mile route should take 14 minutes without traffic.

One can also head south along Route 619 over the Stone Harbor Bridge and then turning west on Route 147 (North Wildwood Boulevard) and enter the Parkway in Burleigh. This journey is 5.9 miles and will take 10 minutes without traffic.

All of the above travel routes involve crossing over bridges and driving through tidal wetlands that, during a storm surge, will be inundated first. It is therefore imperative that residents are giving ample evacuation warnings and mandates to allow for dry driving conditions and prevent travel during road closures due to impassable conditions.

The first evacuation route option – traveling west along Stone Harbor Boulevard – is highly recommended and encouraged.

Figure 14. Evacuation Routes

Flood-Prone Roadways

A majority (51%) of Stone Harbor's roads are a foot above current sea level. Forty-six percent (46%) of the roads are two feet above MSL. Second Avenue from 94th Street to 80th Street is a foot lower than the same road to the north. Third Avenue rises only slightly from 3.9 feet at 80th Street to 5.25 feet at 100th Street with localized low points at intersections along the way. Improper drainage of storm drains due to clogging from dirt, leaves, and trash result in reduction or impediment of existing inlet drains, which causes localized roadway flooding.

The following intersections are at or below zero elevation:

1. Third Avenue & 82nd Street;
2. Third Avenue & 84th Street;
3. Third Avenue & 86th Street;
4. Third Avenue & 89th Street;
5. Third Avenue & 92nd Street
6. Sunset Drive & 92nd Street; and
7. Sunset Drive & 93rd Street.

The following is a list of streets vulnerable to flooding:

1. Sunset Drive from 92nd Street to 95th Street;
2. 3rd Avenue (Rt 619) from 81st Street to 87th Street;
3. West of 2nd Avenue from 80th Street to 93rd Street;
4. Sunset Drive from 107th to 110th Street; and
5. 3rd Avenue from 80th Street to 111th Street including streets to the west.

Table 11. Distribution of Road Elevation

Road Elevation	Acres	Percentage
-1	0.03	<1%
0	2.25	1%
1	95.46	51%
2	86.71	46%
3	3.11	2%
4	0.01	<1%

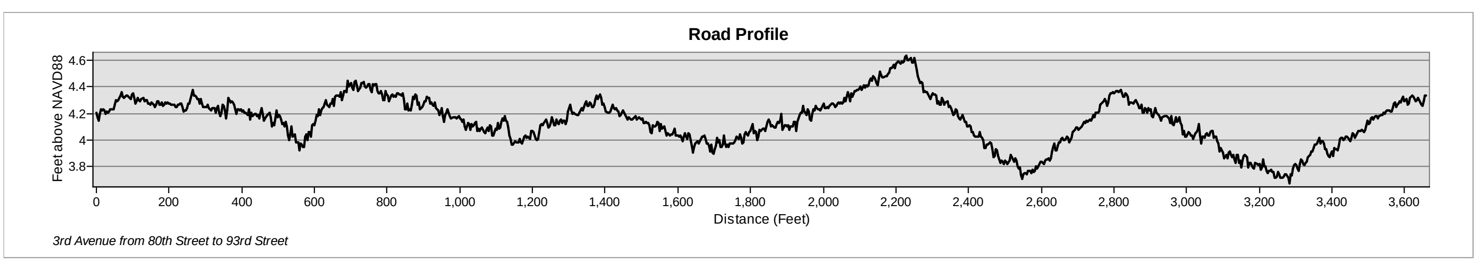

Figure 15. Road profile from 80th street to 93rd Street showing elevation undulations

Figure 16. Flood-prone roadways given various increases in water levels due either to sea-level rise or storm-surge effects

Flood Insurance Rate Map

The first Flood Insurance Rate Map for Stone Harbor was put into effect on January 8, 1971 and was revised on July 15, 1992. The following panels cover Stone Harbor and have an effective date of October 5, 2017: 34009C0234F, 34009C0241F, 34009C0242F, 34009C0243F, 34009C0244F, and 34009C0261F.

The Flood Insurance Rate Map (FIRM; FEMA 2017) displays flood risk information to develop risk data. The primary risk classifications used are the 1-percent-annual-chance flood event, the 0.2-percent-annual-chance flood event, and areas of minimal flood risk. Within the flood zones are “the computed elevation to which floodwater is anticipated to rise during the base flood”, or base flood elevation (BFE). Moderate to low risk areas are Zone X/B (X shaded), the 100-to-500-year flood and Zone X/C (X unshaded), above 500-year flood. High-risk areas are those within the special flood hazard area (SFHA).

The Special Flood Hazard Area (SFHA) is the area in which the calculated flood elevation is achieved during a 1% annual chance of occurrence storm event. This flooding is independent of any incident rainfall accompanying the storm. Clearly, this watershed requires planning designed to mitigate both the rainfall and storm surge events. Unfortunately, if the storm surge raises water levels equal to or 3 feet above the local topographic surface of the barrier island, there is no possibility for incident rainfall to drain properly until the tide level falls to the elevation of the storm-water outlets, which extend to the bay shoreline. Nearly all residents reside in either AE (44%) or VE (48%) flood zones (Table 12).

FEMA defines a Repetitive Loss (RL) property as "any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978." A Severe Repetitive Loss (SRL) is defined as "a single family property (consisting of 1 to 4 residences) that is covered under flood insurance by the NFIP and has incurred flood-related damage for which four or more separate claims payments have been paid under flood insurance coverage, with the amount of each claim payment exceeding $5,000 and with cumulative amount of such claims payments exceeding $20,000; or for which at least 2 separate claims payments have been made with the cumulative amount of such claims exceeding the reported value of the property."

As of 2018, there are 92 repetitive loss properties within the Borough of Stone Harbor. Eight (8) properties and four (4) alternate properties were approved for the HMGP Jonas Grant Funding to elevate homes. Six (6) additional grant applications were submitted for the FEMA 2017 Hazard Mitigation Grant to elevate homes.

Table 12. FIRM Flood Zone Distribution

Flood Zone	Acres
AE	606
AO	5
VE	668
X	101

Coastal Transects

Four FEMA coastal transects represent Stone Harbor (Figure 19, Table 13). The 10-year still water elevations are 6.5 feet, for 50-year recurrence interval 8.4 feet, and 9.2 feet for a 100-year event. Significant wave heights for the 100-year event are over 12 feet for all areas except for transect 45, which lies within the conservation area.

Table 13. Stillwater Elevations and Flooding Sources along Coastal Transects

FLOOD SOURCE	TRANSECT	Starting Wave Conditions for 1% Annual Chance	Starting Stillwater Elevations (NAVD88FT)		
	Number	Significant Wave Height	10% Annual Chance	2% Annual Chance	1% Annual Chance
Atlantic Ocean	42	12.82	6.5	8.4	9.2
	43	12.76	6.6	8.4	9.2
	44	12.12	6.6	8.4	9.2
	45	7.21	6.5	8.3	9.1

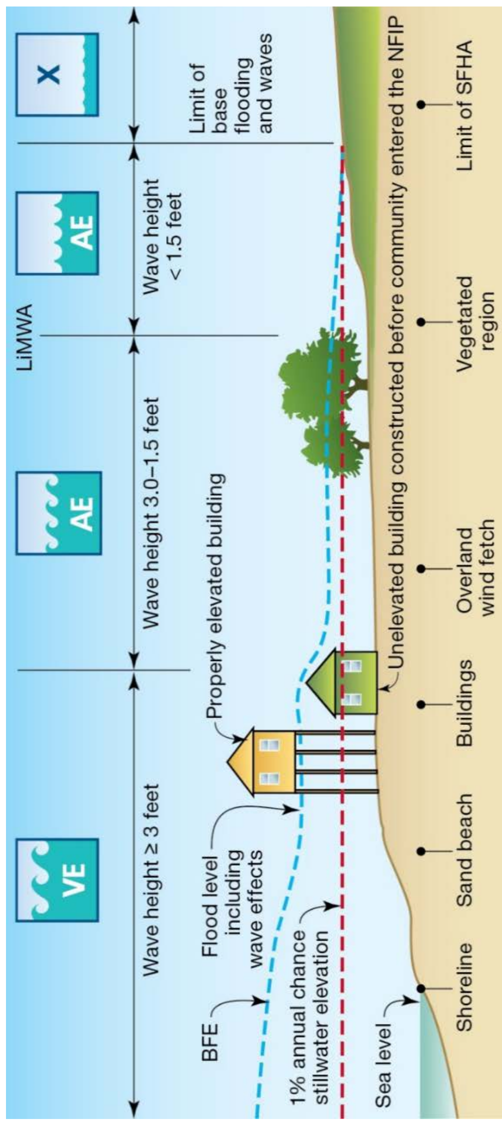

Figure 17. FEMA Flood Zones Diagram

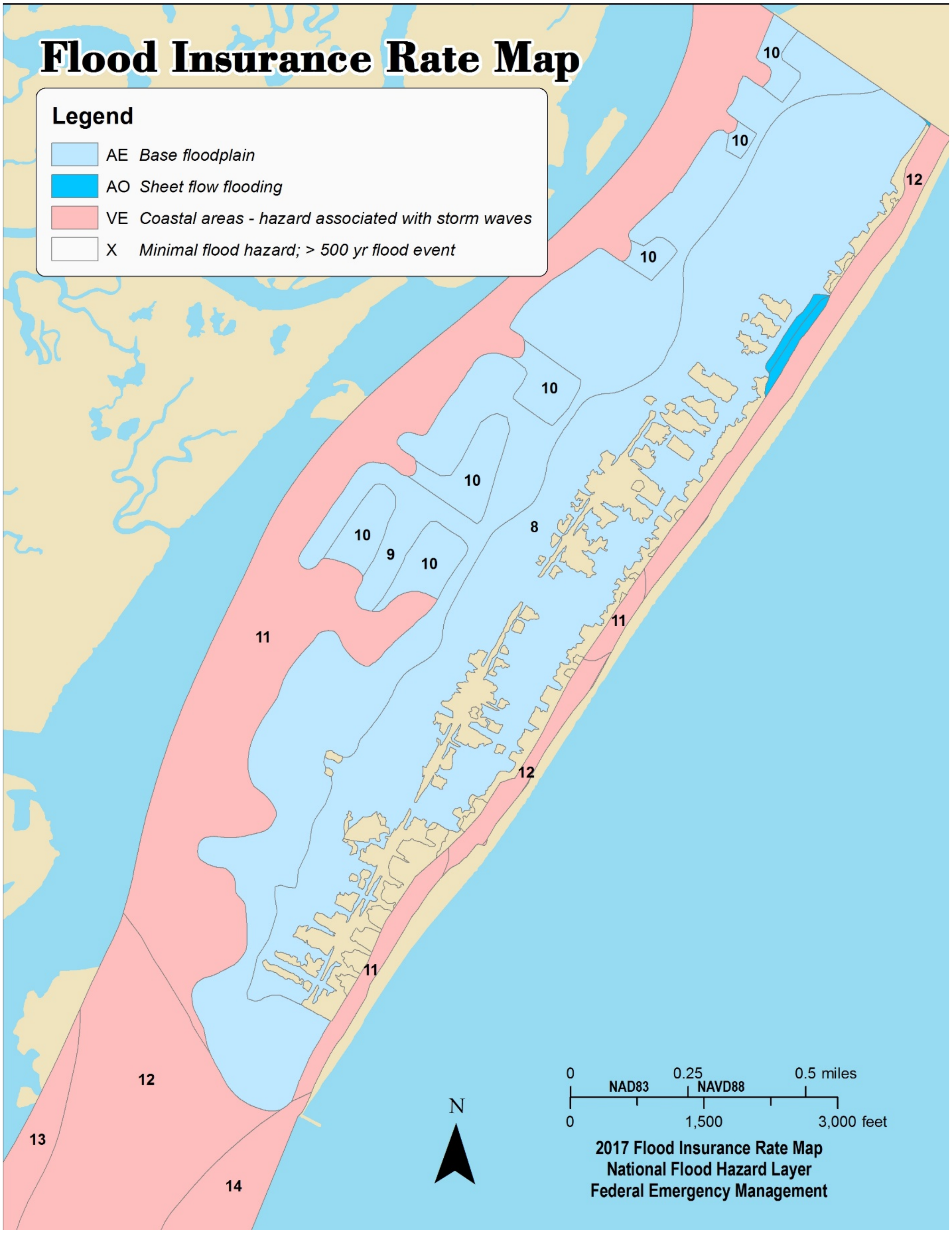

Figure 18. FIRM Flood Zones with BFEs

Figure 19. Coastal Transect Location Map

Potential Sea Level Rise Impacts

Sea Level Rise Projections

As of 2017, predictions for 2100 sea levels ranged over the following scenarios: Lowest 0.98 ft., Intermediate-Low 1.64 ft., Intermediate 3.28 ft., Intermediate-High 4.90 ft., High 6.56 ft., and Extreme 8.20 ft. "Intermediate-high" projections of global mean sea level (GMSL) by 2100, according to NOAA, is 1.5 meters (4.9 feet) above the 2000 mean sea level. This is "based on an average of the high end of semi-empirical, global SLR projections. Semi-empirical projections utilize statistical relationships between observed global sea level change, including recent ice sheet loss, and air temperature" (NOAA 2017).

Global, or eustatic sea-level rise, does not include localized isostatic changes that affects resulting water levels for coastal areas. Local sea-level rise rates may be influenced by surficial and bedrock geologic responses to previous geologic events having impact on the earth's crust. Along high-latitude coastlines, glacial retreat was more recent than mid-latitude areas so that the continental crust is still rebounding, thus leading to localized stable to dropping of sea-level elevations. A secondary impact caused by the weight of the continental ice sheet was the generation of a localized surficial bulge upward in sediments for about a hundred miles beyond the maximum ice front position. This produced a relatively small surficial rise in the southern New Jersey coastal plain that has been subsiding since general ice retreat commenced 25,000 years ago. Therefore, while crustal depression in Maine resulted in marine deposits of post-ice age maximum positions that are located over a hundred feet above current sea level (Presumpscot Formation, coastal Maine, Bloom, A. 1959), the New Jersey coastal plain was forced upward during glaciation and is now slowly subsiding. Another effect is the broad utilization of groundwater obtained from aquifers up to 1,000 feet below the coastal plain surface along the New Jersey coast where towns are built on alluvial deposits. This has induced an additional local apparent sea level rise as the sediments compact.

The global mean sea level (GMSL) rise trend is 3 mm/yr., or +0.3 m (0.98 ft.) in a hundred years (GMSL rise Scenario "Low"). The relative sea level (RSL) trend for Atlantic City, New Jersey is 4.07 mm/yr. from 1911 to 2016 (Figure 20, NOAA 2013), which is equivalent to a change of 1.34 feet in 100 years. By factoring in this increase in RSL from GMSL, an "Intermediate-High" GMSL of 4.9 feet becomes a RSL of 5.28 feet. Using NOAA's Vertical Datum Transformation v3.5 and the coordinates 39° 03' 14.66" N 74° 45' 44.33" W, the North American Datum of 1988 (NAVD88) is -0.30 feet above local mean sea level; therefore, in 2100, this area given an "Intermediate-High" rise in sea level would translate to 4.98 feet. This would put the high tide water level 2.90 feet above the present MHHW.

Table 14. Local datums along the bay

Datums	NAVD88 FT
MLLW	-2.49
MLW	-2.33
LMSL	-0.30
MHW	1.68
MHHW	2.08
2100 SLR	4.98

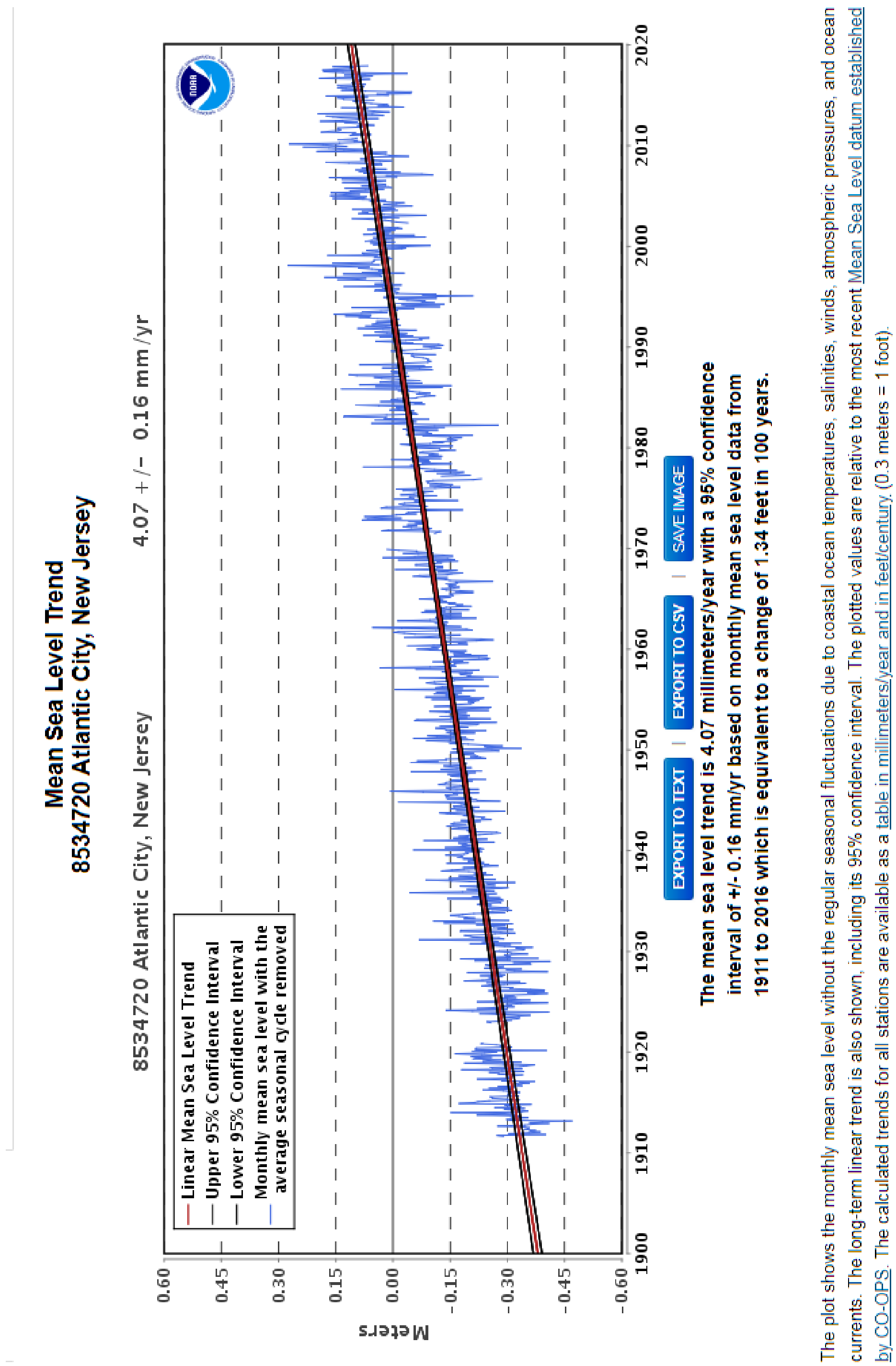

Figure 20. Mean Sea Level Trend for Atlantic City, New Jersey based on monthly mean sea level data from 1911 to 2016 (NOAA 2013)

Sea Level Rise Models

NOAA's Sea Level Rise and Coastal Flooding Impacts v 2.0

Maps produced by the National Oceanic and Atmospheric Administration depict mean higher high water (MHHW) levels based on global mean sea-level rise trends (https://coast.noaa.gov/slr/). This tool illustrates potential flooding and does not account for erosion, subsidence, or future construction. In addition to water depths on land as sea level rises, low-lying areas are identified as further flood prone from any additional water level increases, such as from spring tides or storm surge.

The tool's disclaimer reads: "The data and maps in this tool illustrate the scale of potential flooding, not the exact location, and do not account for erosion, subsidence, or future construction. Water levels are relative to Mean Higher High Water (MHHW) (excludes wind driven tides). The data, maps, and information provided should be used only as a screening-level tool for management decisions. As with all remotely sensed data, all features should be verified with a site visit. The data and maps in this tool are provided 'as is', without warranty to their performance, merchantable state, or fitness for any particular purpose. The entire risk associated with the results and performance of these data is assumed by the user."

New Jersey Flood Mapper

New Jersey Flood Mapper is available for this area and can be found at http://www.njfloodmapper.org/slr/. "The purpose of this data viewer is to provide coastal managers and scientists with a preliminary look at sea level rise and coastal flooding impacts" (Rutgers 2013). This application includes a section with a focus on Flood Hazard Areas/Storm Surge that overlays Preliminary Flood Insurance Rate Maps (PFIRMs) for a given area. Another layer overlays Storm Surge Sea, Lake, and Overland Surges from Hurricanes (SLOSH) models for hurricanes of category between 1 and 4. SLOSH is a computerized model from the National Hurricane Program that takes into account factors to compute surge inundation above ground level or simple inundation. Using factors such as storm size, pressure, speed, path, wind speed, bathymetry, and topography, the worst surge impacts are displayed. Still another layer displays FEMA's most recent special flood hazard areas (SFHA). A layer displaying the location of various community facilities and evacuation routes allows a community to identify vulnerable locations as hypothetical water levels (MHHW) are tested.

Future Vulnerabilities

Given the above metrics, Stone Harbor will have 66% of its buildable area above the new waterline. Twenty-nine percent would be at future mean sea level and five percent would be below (Table 14).

If all of the bayside becomes a uniform height as all bulkheads are standardized, static bay water will not be able to inundate the land. Tidal check valves on outfall pipes prevent water backflow into the stormwater drainage system. Unfortunately, one cannot build a bulkhead wall surrounding the entire barrier island. Water is well known for finding and exploiting weaknesses. Any inconsistency in the bulkhead, any cracks or weakened structures, will be taken advantage of, resulting in inland flooding, perhaps even producing a catastrophic bulkhead failure. Until that time, and as long as bulkheads remain the primary line of defense, rain falling from the skies can still flood roadways and pond as drainage is made impossible if the tidal check valves that keep the bay out are closed because of bay water levels are above the discharge elevation.

Stormwater pumping stations have been added and should continue to be installed, as they are able to overcome hydrostatic pressure and force stormwater out of the system that would remain under existing, but less effective gravitational stormwater drainage systems.

Residential and commercial buildings should continue to be raised and, when possible, have the building footprint elevation be raised as well. In some communities, residents are raising their driveway to provide a safer space for their parked vehicle from rain or storm tidal flooding. The municipality should budget for and prepare to raise frequently inundated major roadways. Sunset Avenue and parts of Pacific Avenue are two areas where roadway raising or installation stormwater pumps (if not already in progress) would be beneficial to decreasing standing water and increasing resilience.

Table 15. Future Area above 2100 MSL

Elevation (feet) given 2100 MSL	Percentage of Buildable Area
Above	66%
At	29%
Below	
1	3%
2	1%
<= 3	1%

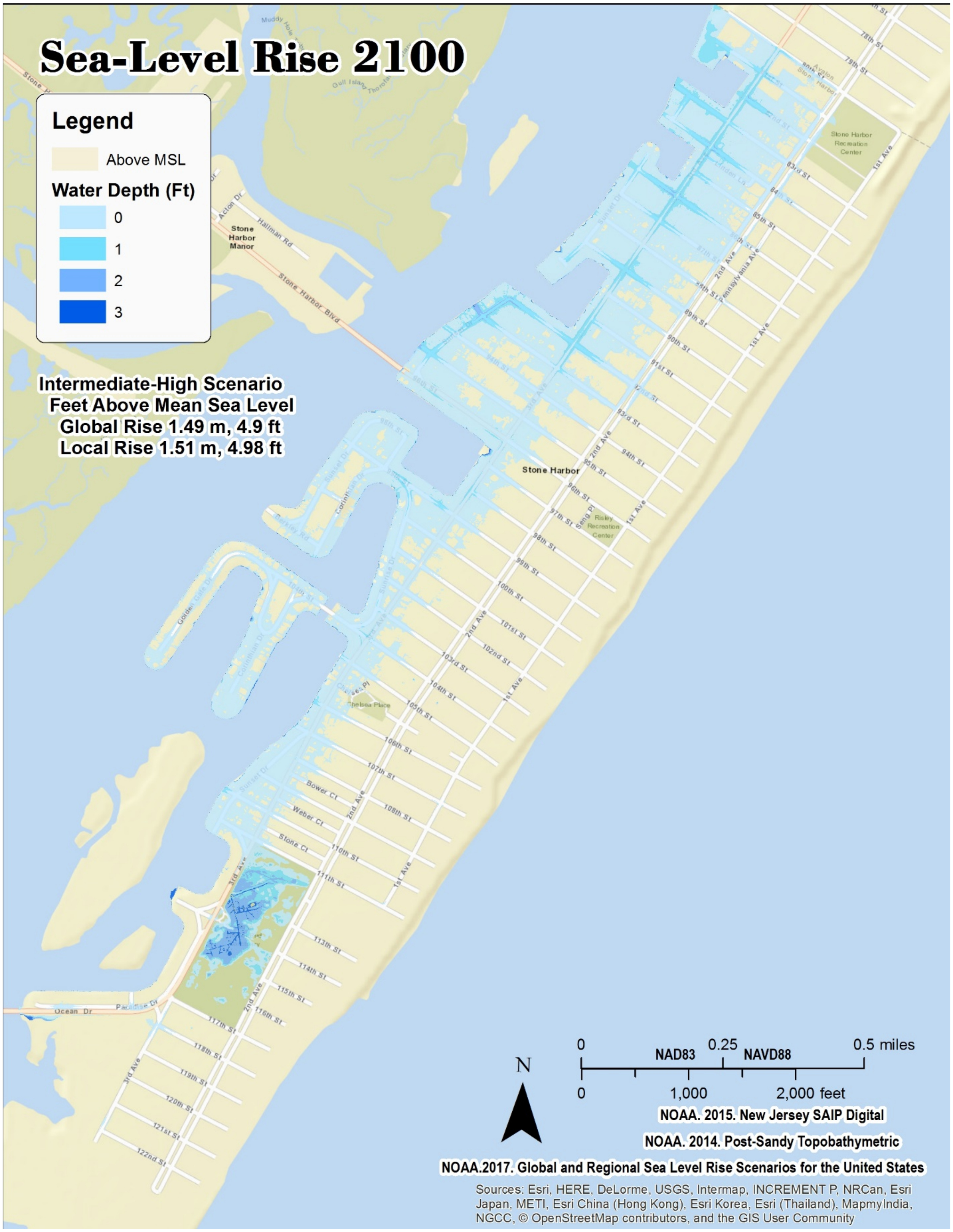

Figure 21. 2100 Sea Level and Resulting Water Depths

Mitigation Strategies

Shoreline Stabilization

Some arrangement of dikes, levees or high bulkheads will be required to maintain the current parcel occupation along the water's edge. A planned composition of greater protection and retreat could also mitigate the impact of 3 to 4.7 feet of sea level rise. Protection using levees, dikes or bulkheads is only as good as the height of the design structure combined with its resistance to failure from horizontal pressures. These structures must also account for increased storm surge elevations because any storm over-topping results in area flooding that does not abate after the storm unless pumped out. A third alternative would require some form of bulkhead/levee combined with regional fill to raise the affected zones above the new flood elevation that includes, structures plus associated lots, infrastructure, utilities, and street access.

A common solution to bayside flooding in coastal towns have been mandating that residents construct bulkheads to elevations above the land surface. While this hard structure solution is effective, not only is the construction and maintenance costly, but the environmental impact is great as well. Wetlands are nature's natural stormwater system and help to filter and provide storage for stormwater runoff. The combination of organic matter and peat allow for great volumes of water to be absorbed and retained during large rain or surge events. Tidal wetlands serve a vital role in absorbing and slowing storm waves and wind. They also filter out pollutants and trap excess sediment and nutrients running off uplands. The biological role they play in migration, nurseries, and feeding areas is unparalleled and cannot be mimicked by man-made constructs other than through the rebuilding of new wetlands.

As sea level rises the natural response of wetlands is to shift laterally inland to maintain a sensitive tidal range. When hard structures lie in the way, wetlands cannot retreat and drown in the process, thus destroying them permanently. Bulkheads or hard structures should be discouraged as these can and will lead to reduction in viable wetlands.

Retreat

One particularly painful suggestion is to encourage gradual retreat from the most flood prone community areas as sea level rises. Voluntary, but deftly encouraged property buy-outs of destroyed or seriously damaged structures followed Hurricane Sandy in 2012. The State coordinated with federal assistance and local cooperation to purchase repetitive loss properties, remove them and return the land to open space. Up to 2,870 points are credited for open space preservation (FEMA 2017 Activity 420). These actions could be voluntary or mandated through municipal code. Regulations could spell out when particular repetitive loss properties had to be purchased, removed and the land to revert to natural open space (O'Neill, 2014; NJDEP, 2016; The Sandpaper, 2016; Associated Press, 2014).

Stormwater Infrastructure

Existing stormwater systems rely on conveyance of stormwater runoff along street curbs and through underground pipes. This results in an increase in runoff velocity, potential for erosion, and frequent ponding when rainfall rates exceed system carrying capacity. Best Management Practices and Blue-Green Infrastructure should be encouraged to improve rainwater infiltration and slow runoff rates. A simple example of a soft-structure approach would be the shift away from curbs and towards vegetated swales. Rain falling on roadways would then flow into grass and be held in bio-swales instead of running straight into inlets and entering the stormwater drainage system. Many existing roadways have a curb with a grass strip between the curb and a sidewalk. During proposed major road reconstruction, consider removal of the curb and creating a grass swale between the edge of the pavement and the sidewalk. The pavement edge could have the warning ribs embossed to warn drivers approaching the edge of paving and when parking so they can avoid the grass swale.

Retention / detention ponds need more land area necessarily available in built-up coastal communities. Instead, rain gardens can be implemented for individual properties. They take up little space, are visually pleasing, provide wildlife habitat, and retain rooftop runoff on the property.

Timeline

Short Term

1) Raise roadways, build higher bridges
2) Raise buildings above the BFE and prevent ground dwellings
3) Flood proof larger residential and commercial buildings
4) Encourage Blue-Green Infrastructure and Best Management Practices
5) Implement living shorelines and wetland restoration
6) Upgrade the stormwater drainage system by increasing pipe diameters and ensuring adequate connection transitions
7) Continue installing stormwater pump stations with generators

Long Term

1) Reclaim land from repetitive loss structures to revert to natural open space
2) Raise ground elevation for new or improved properties
3) Raise drainage systems if and when possible including drainage pipes, outfall pipes, and pumping stations
4) Alter zoning ordinances to prevent infrastructure from encroaching on open space or floodplains
5) Implement coastal retreat

Stormwater System

Stone Harbor keeps a detailed record of stormwater infrastructure maintenance and activities conducted by the Public Works Department. They log inspection and video surveillance, installation and fixing of storm drains, and street sweeping (Appendix).

There are seven (7) drainage sub-basins that are separated by topography and the stormwater conveyance system.

Table 16. Sub-basin Acreage and Number of Outfalls

Subbasin	Acres	# Outfalls	Average Elevation of Outfall Pipes
1	109	10	-2.59
2	70	10	-1.18
3	125	15	-2.43
4	122	11	-2.59
5	22	9	-0.85
6	66	7	-1.21
7	50	5	1.28

Four-hundred and forty-eight (448) inlets capture runoff from the streets to the stormwater system. Of these, 183 are of an undocumented type, 207 are Type "A", 17 are Type "B", and 41 are Type "E" Inlets. Sixty-seven outfall pipes drain stormwater into the bay. Twenty-one (21) outfall pipes are owned by Cape May County and two (2) by Stone Harbor Yacht Club. Outfalls to the ocean were eliminated in 2013 to reduce ocean pollutants. In their place, an underground chamber collects sand, dirt, and litter – that will be cleaned regularly – and allows for the natural recharge of groundwater. The system is gravity driven and does not have pump assistance. Many of the outfall pipes are below local mean sea level (LMSL -0.34 feet).The Borough will be installing tide check valves on existing and future bayside outfall pipes in order to eliminated surcharge during high tide events that currently lead to roadway flooding as bayside waters use existing open pipes as conduits to the streets. Stormwater is transported via pipes that range in diameter from 6 inches to 42 inches and vary in material from PVC, P-ethylene, 2P-ethylene, ductile or corrugated iron pipes, to high-density polyethylene (HDPE).

Stone Harbor has in effect plans to install stormwater pumping stations to force water from the stormwater drainage pipes into the bay even if tides are high. The following are locations of future pump stations:

Table 17. Future Stormwater Pump Stations

Location	Pumps	Q (gpm)	HP
93rd Street	3	63,734 (10-yr); 76,301 (25-yr)	250

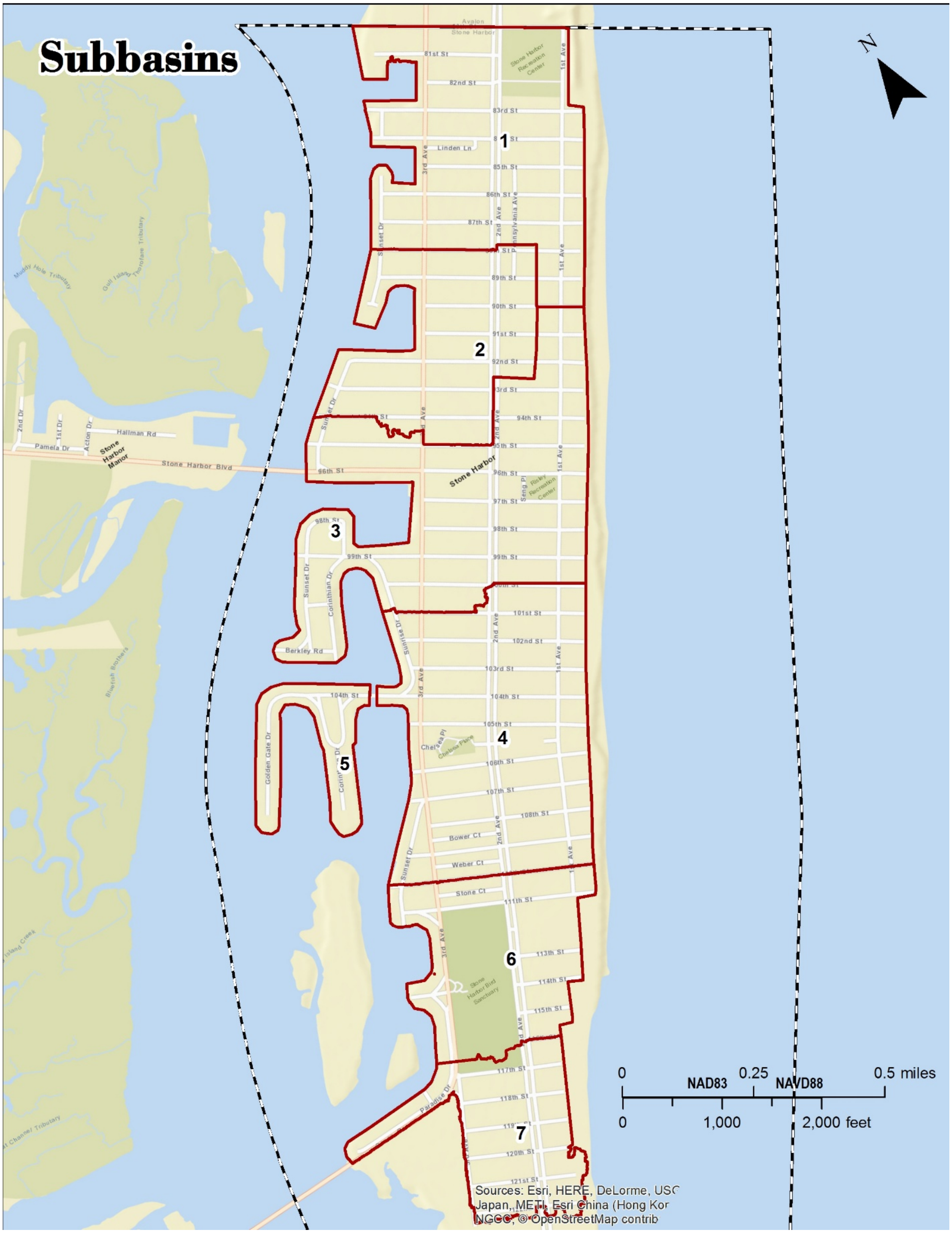

Figure 22. Drainage Sub-basins

Flood Model

Introduction

The following characteristics influence the resulting runoff from a given rainfall event:

1. High intensity rainfall will generally produce a greater peak discharge than a rainfall that occurs over a longer period.
2. Highly porous or permeable soils that can rapidly infiltrate rainfall generally produce less runoff volume than soils with more restrictive infiltration.
3. Dense vegetation such as woodland intercepts and help infiltrates rainfall, thereby reducing runoff volumes and rates.
4. Conversely, impervious areas such as roadways and rooftops prevent infiltration and increase runoff volumes and rates.
5. Drainage areas with shorter times of concentration (Tc) will have higher peak runoff rates than those with a longer Tc.

Results from the flood model created for this management plan appears in Appendix I. Inputs include land use and land cover, infiltration and runoff rates, and rainfall rate and duration. This model utilizes the Rational Method for runoff calculations, using a weighted area for pervious and impervious surfaces based on runoff coefficients for land use. A runoff coefficient adjustment factor is included as a factor of rainfall intensity recurrence interval.

Outputs include discharge rates (in gallons per minute) of outfall pipes for subbasins as a result of rainfall rate and tidal variations. Since most if not all outfall pipes have tidal check valves to prevent backflow into the streets, its discharge effectiveness is a direct result of bay water elevations. Included are graphical representations of outfall pipe discharge rates based on three rainfall distribution rates. Also included is a hypothetical depth of standing water if all undrainable rainfall were evenly distributed amongst the available roadways within that subbasin.

Tidal check valves should be regularly maintained and especially checked immediately prior to a known severe storm or rain event. Failure to do so can lead to backflow from the bay into the pipes and potential for ‘bubble ups’ into the street, leading to street flooding. Check valves remain closed unless the outflow force exceeds any opposing force such as hydrostatic pressure during high tides. Tideflex® Duckbill Check Valves from Red Valve Company, Inc. of Carnegie, PA are an examples of a rubber tide gate; it consists of a flexible tube that tapers to flattened sections with two or more sets of sealing lobes vertically oriented. Forward hydraulic head opens the lobes to release flow; reverse hydraulic head collapses the lobes together, preventing reverse flow. The most common malfunction of these tide gates occurs when debris causes incomplete closure of the gate. In most cases, the flexibility and length of a rubber duckbill tide gate is able to close around debris, essentially creating a tight seal; yet this is not always the case. Subsequent high volume outflow events often clear away trapped debris, acting as a self-cleaning service; however, branches, limbs, flotsam, and other objects are sometimes able to create enough of a disturbance to allow for inflow from the bay.

“Land development can dramatically alter the hydrological cycle of a construction site and eventually an entire watershed. Vegetation coverage, ground cover, and installation of impervious material alter infiltration and runoff rates. Impervious areas connected through gutters, channels, and storm drains can transport runoff more quickly than open space areas. This shortening of the travel time quickens the rainfall-runoff response of the drainage area. Filtration of runoff and removal of pollutants by surface and channel vegetation is eliminated by storm drains that discharge directly into the bay” (Previti 2005).

Hyetographs

Three hyetographs represent rainfall distribution rates during a storm event: Steady State, Gaussian distribution (normal distribution), and an early peak deluge (Figure 23). The total amount of rainfall during a given frequency storm event of a certain duration is distributed as a percentage of the total for shorter time increments.

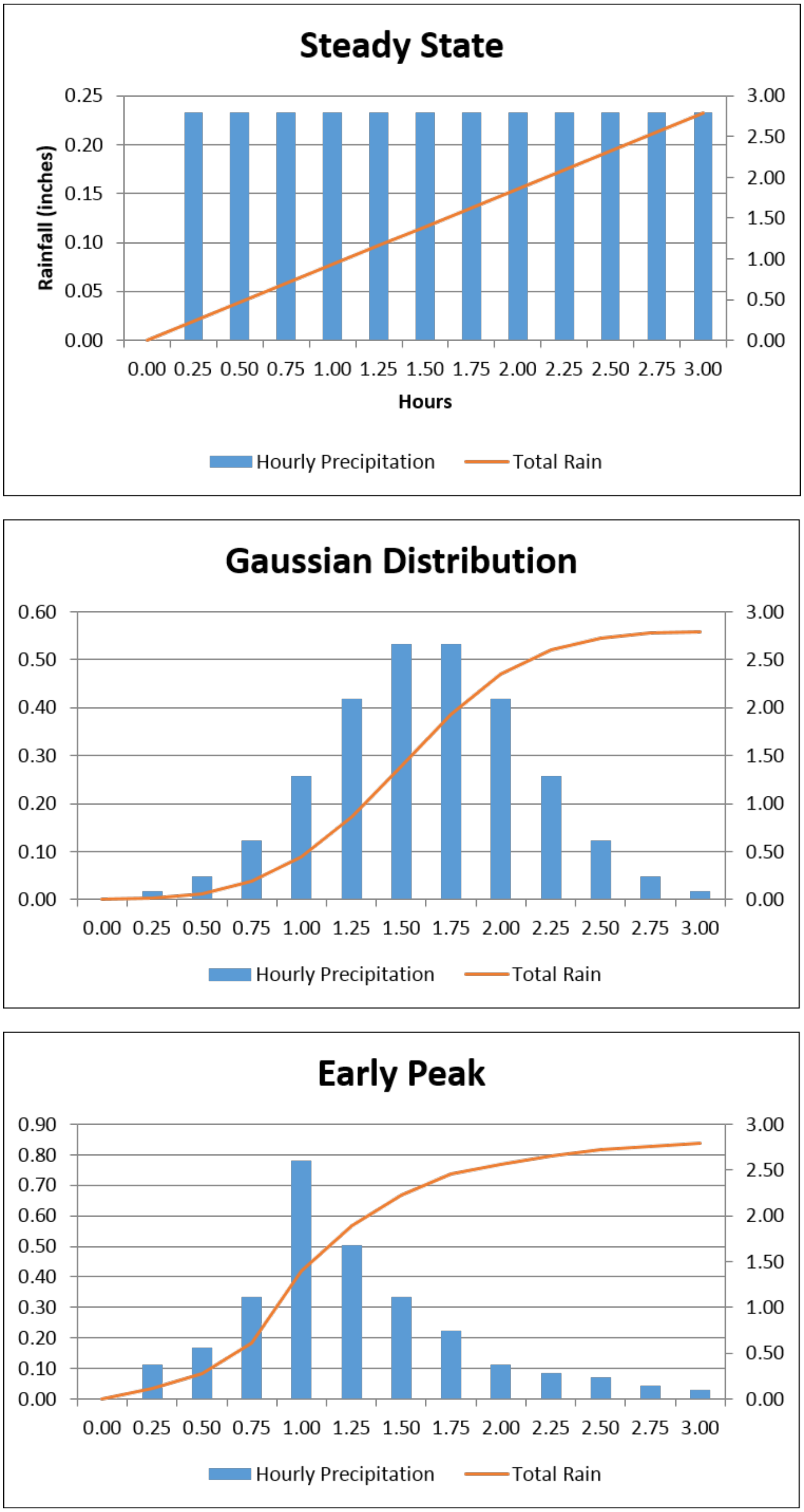

Figure 23. Hyetographs – Rainfall distribution scenarios for a one hour rain event

Outfall Pipe Discharge Rate

Each drainage basin has a number of outfall pipes with variable pipe diameters and elevations that affect discharge rate. The discharge rate is dependent on pipe friction, slope, and diameter. Smoother material (PVC) allows for faster flow than rougher material (corrugated metal). The average slope of the pipes within a barrier island is 0.001, or a one foot drop in elevation over a thousand feet. For outfall pipes with tidal check valves, their flow reduces as the valve closes during a rising tide, ultimately preventing flow at the time of complete pipe submersion. The discharge from a pipe reduces from full flow to no flow as the tide rises. The model uses the Hazen-Williams formula for a gravity-fed full pipe flow:

$$Q = 0.28 \times C \times D^{2.63} \times s^{0.54}$$

Where Q is discharge gallons per minute, C is a unitless Hazen-Williams friction coefficient, D is pipe diameter in inches, and s is slope.

Infiltration Rate

Land coverage is divided into pervious and impervious surfaces. Pervious surfaces are further subdivided into percentages of parcel lot coverage, forested areas, open areas such as parks and golf courses, wetlands, and open water. Impervious surfaces are subdivided into percentages of parcel lot coverage, transportation such as roads, and urban or built-up land such as disturbed land from road construction. These land use / land coverage categories are assigned runoff coefficient that reflects the amount of rainfall running off the land type and potential to enter the drainage system. This weighted area reflects the percentage of water either being infiltrated or running off. Forested area with organic soil and open beaches comprised of sand will capture and retain rainfall during an event in contrast to parking lots, roofs, and roads that direct water into the storm drain system that will potentially overwhelm an older drainage network.

Rainfall Runoff Volume

The flood model requires three inputs: 1) recurrence interval, 2) duration, and 3) water level. Given the first two parameters, the rainfall rate for this area is extracted from a NOAA Point Precipitation Frequency Estimates table. The model accepts any water level; however, suggested water levels are listed for the area as MLW, MSL, MHW, flood stage, and a moderate flood stage.

Nor'easters are the most likely long-duration rain event that will impact barrier island communities. These systems often travel slowly and pass through in two to five days. The model uses the 72-hour (3-day) event as the locally appropriate "worst-case" runoff event as it replicates the duration of multiple nor'easter events that have inundated barrier islands in the past. The 1962 "Ash Wednesday" Storm was a four day event that caused tidal stacking through five consecutive spring high tides. Some reported as much as four feet of standing water on the barrier islands. A 'fast' moving nor'easter from January 2 to 4, 1992 the mid-Atlantic and followed the 1991 "Perfect Storm". The Steel Pier in Atlantic City reported a peak tide of about 8 feet. A state of emergency was declared for Cape May, Atlantic, Ocean, and Monmouth counties. Not only are there heavy rains during a nor'easter, but tidal stacking as well. This means that any gravity driven drainage system without pumping stations are unable to flush out its system and, as a consequence, are completely inundated leading to widespread roadway flooding.

The model's outputs are as follows: 1) storm duration partitioned into twelve (12) intervals, 2) inches of rainfall per time partition taken from the representative hyetograph, 3) rainfall volume as gallons over time calculated by surface area contributing to rainfall runoff multiplied by rainfall intensity, 4) constant rate of outfall pipe drainage for a basin in gallons per minute multiplied by the time interval, 5) residual volume of rainwater not removed from the roadways via the stormwater drainage network and outfall pipes, and 6) potential standing water if the residual water volume were evenly distributed in residential roadways. A graphical output of the rise and fall of standing water in the streets shows whether there may be residential street flooding in that particular drainage basin and an estimation of its residence time.

Total rate of runoff is calculated as the product of surface area (acres) and rainfall rate (inches per hour) that result in a rate of in-acre/hr. The conversion between in-acre/hr. to gallons per hour is as follows:

Gallons per minute = in-acre per hour x 27,154 gallons/acre-in x 1 hr./60 min

The resulting residual gallons of water not discharge through the pipe is projected on the roadway surface. The length of roadway it would cover is given under the conditions of 6" of standing water and a 35' roadway width.

$$\text{Roadway Length (feet)} = \frac{\text{gallons x acre-ft. / 325,851 gallons x 43,560 square feet / acre}}{\text{0.5 ft. x 35 ft.}}$$

Table 18. Outfall Pipe Flow Performance by Water Level

Water Level	Full Flow	Reduced Flow	No Flow
MLLW	32	22	13
MLW	32	19	16
LMSL	16	4	47
MHW	11	3	53
MHHW	9	4	54
Minor Flood	5	3	59
Moderate Flood	4	1	62
SLR 2100	2	3	62

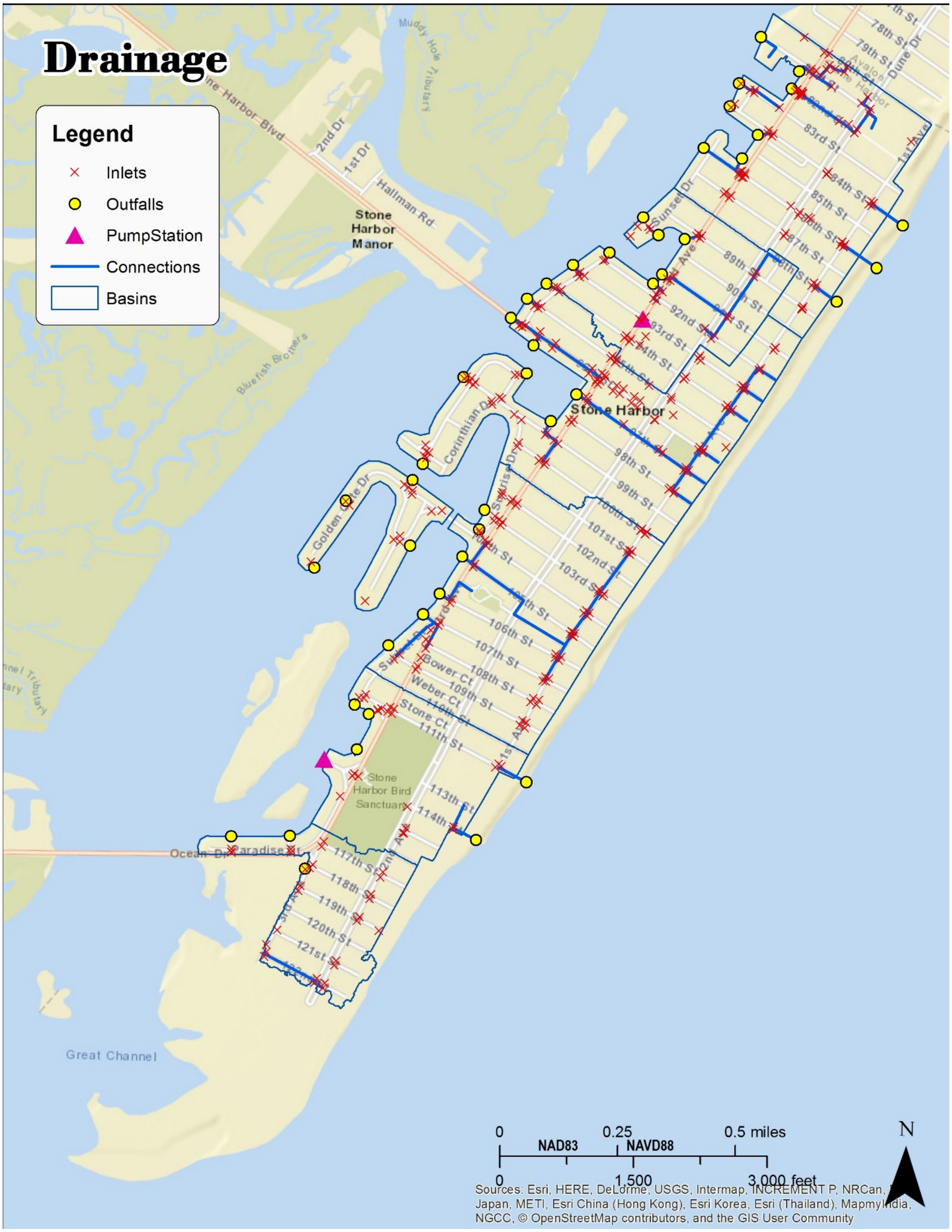

Figure 24. Stormwater drainage and basins

Model Results and Recommended Improvements

The three options for the behavior of any particular storm event were simulated for the 1-yr, 5-yr, 10-yr, 25-yr and 100-yr storm events. The steady state model presumes a constant rate of precipitation during the storm episode. Therefore, even the 100-year rainfall value of 10.10 inches over 72 hours yields only 0.14 inches of rain per hour, while the peak discharge event results in 3.04 inches of rain per hour during the peak of the event. The Gaussian distribution yields 2.08 inches per hour during its peak rainfall episode. Therefore, it is the Gaussian and especially the "Deluge Event" that produce the majority of the street flooding during storms.

The 1, 5, and 10-year storm events did not produce significant street flooding unless the tide level was raised to the NOAA 2100 elevation of 4.98 feet NAVD88. In that scenario, Sub-basins #1, 2, 4, and 6 had residual water volumes in the streets in excess of a half million gallons. When the tide elevation was reduced to Mean Higher High Water, the residual water volume fell to about 170,000 gallons except for Sub-basins #1 and #6 which remained near the half million gallon mark. When the tide elevation was reduced to -2.49 feet NAVD88, (MLLW), street flooding dropped to less than 100,000 gallons of water during the Deluge Event for two hours, just in Sub-basin #1. The other 6 Sub-basins did not flood.

The 25-year event's results are posted in the Appendix as output graphics with water volume tables for a 25-year storm intensity event occurring at both the MLLW and MHHW tide elevations. Here the only Sub-basin not to flood is Sub-basin #3 where a 70,000 gallon per minute stormwater discharge pump has been installed at 93rd Street. Neither tide level produced street flooding in Sub-basin #3. The gravity discharge Sub-basins were subjected to residual flood water in the streets for varying times with the maximum water volume at the MHHW tide elevation remaining in Sub-basin #1 where 200,000 gallons remained after 3.0 hours of Gaussian model rainfall. However, during this event the water was successfully discharged before the end of the event at 5.5 hours. The Deluge Model peak residual was a bit greater, but was successfully discharged 4.5 hours into the Deluge event model because the peak occurred at 2.0 hours into the event. When the MLLW tide level was used, Sub-basin #1 retained flood water for 1.5 hours during the Deluge model (80,000 gallons) and 1.0 hours during the Gaussian model runs (12,000 gallons). No water remained in #1 during the Steady State model run. The other 5 sub-basins retained flood water in the street, but managed to successfully discharge the accumulated water at a minimum of 30 minutes before the event ended. Again, the Steady State model produced the least street flooding due to the consistency in the rate of rainfall.

Shifting to the 100-year storm event, the maximum rainfall was 10.10 inches over 72 hours duration. The Sub-basin #3 storm water pumping station managed to keep the streets free of water under both the MLLW and MHHW tide elevation scenarios. It even remained standing water free during the NOAA 2100 scenario with a 4.98-foot tide elevation. The gravity drained Sub-basins all flooded to varying degrees with Sub-basin #1 the worst retaining 1.255 million gallons of water under the NOAA 2100 scenario. The MHHW scenario resulted in retaining 1.218 million gallons of water, while during the MLLW scenario, the retention dropped to 153,000 gallons. Tide level really matters during major rain events.

The other five sub-basins retained amounts of floodwater which varied between:

Sub-Basin	NOAA 2100	MHHW	MLLW
#1	1,255,708 gallons	1,218,000 gallons	153,000 gallons
#2	730,508 gallons	510,935 gallons	53,173 gallons
#3	Zero	Zero	Zero
#4	1,450,275 gallons	1,394,880 gallons	Zero
#5	42,774 gallons	13,079 gallons	Zero
#6	379,319 gallons	197,937 gallons	64,750 gallons
#7	57,388 gallons	28,233 gallons	25,433 gallons

Based on the summary of the above values, the Stone Harbor Sub-basins with the most pronounced flooding problems are basins number 1, 2, and 4. The other sub-basins manage to discharge stormwater even during the NOAA 2100 intermediate high value for projected sea level rise.

Future Stormwater Evacuation Improvement

Four of the seven distinct stormwater sub-basins currently handle the 25-, and 100-year events modeled quite well with each managing to evacuate stormwater from the streets prior to the end of the event. Only the Deluge model regularly left water in the streets, and the Gaussian distribution model occasionally left water in the streets. The Steady State rain event model did not produce street flooding in the best sub-basins.

Sub-basin #7 is scheduled to receive a pumping station in 2019, which should actively manage the stormwater accumulation under projected sea level rise and current scenarios.

Sub-basins 1, 2 and 4 are candidates for future pumping station installation with all due diligence focused on finding grants, or using capital budgeting to construct them over the next half decade.

The Borough of Stone Harbor does perform diligent stormwater system management, maintenance and where funding exists, conduct improvements. The majority of the bayside stormwater discharge pipes have duck-bill valves installed to at least prevent or retard tidal recharge of the stormwater system and upwelling into the streets during significant storms.

Best Management Practices

Low-Impact Development

The purpose of low-impact development (LID) is "integration of site design and planning techniques that conserve natural systems and hydrologic functions on a site." Common practices include:

1) Preserve Open Space and Minimize Land Disturbance;
2) Protect Natural Systems and Processes (drainage ways, vegetation, soils, sensitive areas);
3) Reexamine the Use and Sizing of Traditional Site Infrastructure (lots, streets, curbs, gutters, sidewalks);
4) Incorporate Natural Site Elements (wetlands, stream corridors, mature forests) as Design Elements; and
5) Decentralize and Micromanage Storm Water at its Source.

Permeable Pavement

Company: Interlocking Concrete Pavement Institute https://www.icpi.org/

Low-velocity roadways, parking lots, driveways, and walkways can be resurfaced with interlocking bricks overlying large aggregate reservoirs and filled in with finer aggregate. Parking spaces consisting of interlocking porous pavers allow direct ground infiltration and filtration of vehicle pollution. Pavers interlock vertically, horizontally, and rotationally resulting in a very strong and sustainable permeable pavement.

Porous Concrete

Company: Pervious Pavement http://www.perviouspavement.org/

Pervious concrete pavement captures has a high infiltration rate, allowing stormwater to percolate into the ground naturally without sheet flow. Converting large, flat surface areas such as parking lots into permeable surface creates more efficient land use by reducing or even eliminating the need for retention ponds, bio-swales, or other runoff reduction methods. Infiltration rate can amount to around 480 inches per hour.

Bio-swales and Rain Gardens

Bio-swales are stormwater conveyance systems that provide an alternative to storm sewers. Bio-swales should consist of multiple compartments and comprise of gravel and sand to channel runoff away from roadways and increase residence time, which allows for increased infiltration and groundwater recharge potential. Rain gardens are designed to utilize excess rainfall and stormwater runoff directed into a swale by planting plants tolerant of inundated conditions. The plants will provide nutrient uptake of nitrogen and phosphorous.

http://www.lowimpactdevelopment.org/raingarden_design/whatisaraingarden.htm

Rain Barrels and Green Roofs

Rain barrels act as a reservoir for roof runoff. Stored water can later be used for gardens, lawns, and toilets. A single rain barrel does not provide much runoff reduction, but if many households in a residential area participate, the combined reduction in stormwater significantly increases. Another method of reducing rooftop runoff is to convert it into a green roof. Given an acceptable climate, vegetation may be planted upon roofs within a synthetic growing medium. The plants and sediment act as a sponge, both absorbing and slowing rainfall runoff. An added benefit is temperature regulation in summer and winter due to the thermal insulation of the soil and vegetation.

http://www.lakesuperiorstreams.org/stormwater/toolkit/greenroofs.html

Urban Trees

The planting of trees in urban neighborhoods slow the velocity of incoming raindrops; provide evapotranspiration, shade, temperature regulation, wind break, erosion control, wildlife habitat; and act as a carbon sink.

https://www.epa.gov/green-infrastructure/what-green-infrastructure

Stormwater Runoff and Drainage Solutions

Tidal Check Valves

Company: Red Valve www.tideflex.com/tf/

Tideflex® check valve protects stormwater outfalls from surcharging by providing reliable backflow prevention and maximizing upstream storage capacity due to the Tideflex® valve's low cracking pressure. It can be installed on pumped or gravity-fed outfalls of various pipe diameters. The bill opens when there is positive pressure during outflow, whereas reverse pressure seals the bill to prevent backflow that allows achievement of the tightest possible seal, particularly at low flow rates. Each elastomer duckbill check valve is custom built to customer specifications.

Stormceptor System

Company: Imbrium www.imbriumsystems.com

Stormceptor system is a water quality treatment device works to treat stormwater and protect the environment from non-point source pollution carried by stormwater. Stormceptor is a stormwater treatment device designed to remove total suspended solids (TSS) as well as free oils (total petroleum hydrocarbons; TPH), heavy metals and nutrients that attach to fine sediment. The system slows incoming stormwater to create a non-turbulent treatment environment, allowing free oils and debris to rise and sediment to settle. The patented scour prevention technology of Stormceptor ensures pollutants are captured and contained during all rainfall events, even extreme storms.

Road Designs

Most residential roadways feature curbs that direct water towards gutters that drain directly into the stormwater system. This allows polluted runoff to enter a stormwater system at a high velocity and with a high sediment load. In addition, grated inlets can become clogged with debris, reducing its effectiveness in drainage capabilities. Simple modifications to this system include incorporating gaps in curbs to allow runoff into swales or other vegetated areas. New roadways could eliminate the use of curbs and gutters to allow road runoff to drain directly into vegetated bio-swales. Directionally sloped parking lots would guide runoff towards vegetated bio-swales lined with cobbles or gravel.

Retention Ponds

Stormwater runoff is diverted to a wet retention pond by pipes connecting storm drains. A large amount of runoff may enter the pond during a rain event and an outlet releases the water at a lower rate to reduce erosion and pollution levels. Retention ponds can include wetland vegetation that store and purify water as roots lock away contaminants. This method is known as phytoremediation. Phytoremediation is the direct use of plans for *in situ* removal or containment of contaminants from impervious runoff. Retention ponds could potentially provide mosquito breeding habitat in the form of stagnate water; therefore, it is important to create surface turbidity by installing aerators or fountains, introduce fish populations, and plant water lilies. In addition to controlling mosquito populations, this practice will also reduce to risk of algae blooms.

http://info.wesslerengineering.com/blog/stormwater-basins-detention-retention-ponds

Regulations

Flood Hazard Control Act

Flood Hazard Area Control Act (N.J.S.A. 58:16A) states:

51. As used in this act, unless the context indicates another or different meaning or intent:

(a) "Channel" means a watercourse with definite bed and banks which confine and conduct continuously or intermittently flowing water;

(b) "Floodway" means the channel of a natural stream and portions of the flood hazard area adjoining the channel, which are reasonably required to carry and discharge the flood water or flood flow of any natural stream;

(c) "Flood hazard area" means the floodway and the flood fringe area as determined by the department under section 3 hereof;

(d) "Relative risk" means the varying degrees of hazard to life and property in a flood hazard area which are occasioned by differences in depth and velocity of flood waters covering and flowing over it;

(e) "Flood fringe area" means that portion of the flood hazard area not delineated as the floodway;

(f) "Department" means the Department of Environmental Protection.

(g) "Person" means and shall include corporations, companies, associations, societies, firms, partnerships and joint stock companies as well as individuals, and shall also include all political subdivisions of this State or any agencies or instrumentalities thereof.

52.3.a. The department shall study the nature and extent of the areas affected by flooding in the State. After public hearing upon notice, and pursuant to the "Administrative Procedure Act," P.L.1968, c.410 (C.52:14B-1 et seq.), the department shall adopt rules and regulations which delineate as flood hazard areas such areas as, in the judgment of the department, the improper development and use of which would constitute a threat to the safety, health, and general welfare from flooding. These delineations shall identify the various sub-portions of the flood hazard area for reasonable and proper use according to relative risk, including the delineation of floodways necessary to preserve the flood carrying capacity of natural streams. The department shall, within the limits of funds appropriated or otherwise made available therefor, update delineations of flood hazard areas as appropriate as provided in subsection b. of this section. The department shall update its delineations of flood hazard areas at least once every 15 years and shall prioritize the preparation of updates based upon flood risk. The department may, after public hearing upon notice and pursuant to the "Administrative Procedure Act," revoke, amend, alter, or modify such regulations if in its judgment the public interest so warrants.

55.a. The department is authorized to adopt, amend and repeal rules and regulations and to issue orders concerning the development and use of land in any delineated floodway which shall be designed to preserve its flood carrying capacity and to minimize the threat to the public safety, health and general welfare. Such rules and regulations or orders may require the approval of the department for specified changes in the use of land within any such floodway. (b) Provision shall be made by the department for the waiver, according to definite criteria, of strict compliance with the rules and regulations, where necessary to alleviate hardship.

55.2.a. No structure or alteration within the area which would be inundated by the 100 year design flood of any non-delineated stream shall be made, rebuilt or renewed by any person without the approval of the department and without complying with such conditions as the department may prescribe for preserving such area and providing for the flow of water therein to safeguard the public against danger from the waters impounded or affected by such structure or alteration. No such approval by the department shall impair or affect any property rights otherwise existing which might be invaded by the construction or maintenance of any such structure or alteration.

55.2. b. The department is authorized, pursuant to the "Administrative Procedure Act" P.L.1968, c. 410 (C. 52:14B-1 et seq.), to adopt, amend or repeal rules and regulations and to issue orders concerning the making, rebuilding or renewing of any structure or alteration and the development or use of land in the area which would be inundated by the 100 year design flood of any non-delineated stream, which rules and regulations shall be designed to preserve the flood carrying capacity of the stream to minimize the threat to the public safety, health and general welfare. Such rules and regulations shall include a provision which exempts, according to definite criteria, certain minor structures or alterations of a specific size or type from the provisions of subsection a. of this section.

100. Flood early warning system

a. The Commissioner of the Department of Environmental Protection shall, in consultation with the United States Army Corps of Engineers and in coordination with the Office of Emergency Management in the Division of State Police, develop a flood early warning system.

b. The flood early warning system shall consist of weather, rainfall and stream data collection devices required to enable the National Weather Service to predict with reasonable accuracy what areas are likely to flood, at what levels, and the specific locations of overflow.

Coastal Area Facility Review Act

The Coastal Area Facility Review Act (N.J.S.A. 13:19) states:

2. The Legislature finds and declares that New Jersey's bays, harbors, sounds, wetlands, inlets, the tidal portions of fresh, saline or partially saline streams and tributaries and their adjoining upland fastland drainage area nets, channels, estuaries, barrier beaches, near shore waters and intertidal areas together constitute an exceptional, unique, irreplaceable and delicately balanced physical, chemical and biologically acting and interacting natural environmental resource called the coastal area, that certain portions of the coastal area are now suffering serious adverse environmental effects resulting from existing development activity impacts that would preclude or tend to preclude those multiple uses which support diversity and are in the best long-term, social, economic, aesthetic and recreational interests of all people of the State; and that, therefore, it is in the interest of the people of the State that all of the coastal area should be dedicated to those kinds of land uses which promote the public health, safety and welfare, protect public and private property, and are reasonably consistent and compatible with the natural laws governing the physical, chemical and biological environment of the coastal area.

It is further declared that the coastal area and the State will suffer continuing and ever accelerating serious adverse economic, social and aesthetic effects unless the State assists, in accordance with the provisions of this act, in the assessment of impacts, stemming from the future location and kinds of developments within the coastal area, on the delicately balanced environment of that area.

The Legislature further recognizes the legitimate economic aspirations of the inhabitants of the coastal area and wishes to encourage the development of compatible land uses in order to improve the overall economic position of the inhabitants of that area within the framework of a comprehensive environmental design strategy which preserves the most ecologically sensitive and fragile area from inappropriate development and provides adequate environmental safeguards for the construction of any developments in the coastal area.

3. "Beach" means a gently sloping un-vegetated area of sand or other unconsolidated material found on tidal shorelines, including ocean, inlet, bay and river shorelines, and that extends landward from the mean high water line to either: the vegetation line; a man-made feature generally parallel to the ocean, inlet, bay or river waters such as a retaining structure, seawall, bulkhead, road or boardwalk, except that sandy areas that extend fully under and landward of an elevated boardwalk are considered to be beach areas; or the seaward or bayward foot of dunes, whichever is closest to the ocean, inlet, bay or river waters;

"Dune" means a wind- or wave-deposited or man-made formation of vegetated sand that lies generally parallel to and landward of the beach, and between the upland limit of the beach and the foot of the most inland slope of the dune. Dune includes the foredune, secondary and tertiary dune ridges, as well as man-made dunes, where they exist;

"Industrial development" means a development that involves a manufacturing or industrial process, and shall include, but need not be limited to, electric power production, food and food by-product processing, paper production, agri-chemical production, chemical processes, storage facilities, metallurgical processes, mining and excavation processes, and processes utilizing mineral products;

"Residential development" means a development that provides one or more dwelling units;

Stormwater Management Planning

Stormwater Management (N.J.A.C. 7:8) under the New Jersey Administrative Code states:

2. General Requirements for Stormwater Management Planning

2.2.a. All stormwater management plans and stormwater control ordinances shall be designed to:

1. Reduce flood damage, including damage to life and property;
2. Minimize, to the extent practical, any increase in stormwater runoff from any new development;
3. Reduce soil erosion from any development or construction project;
4. Assure the adequacy of existing and proposed culverts and bridges, and other instream structures;
5. Maintain groundwater recharge;
6. Prevent, to the greatest extent feasible, an increase in nonpoint pollution;
7. Maintain the integrity of stream channels for their biological functions, as well as for drainage;
8. Minimize pollutants in stormwater runoff from new and existing development in order to restore, enhance and maintain the chemical, physical, and biological integrity of the waters of the State, to protect public health, to safeguard fish and aquatic life and scenic and ecological values, and to enhance the domestic, municipal, recreational, industrial and other uses of water; and
9. Protect public safety through the proper design and operation of stormwater management basins.

5. Design and Performance Standards for Stormwater Management Measures

5.1.a. This subchapter establishes design and performance standards for stormwater management measures for(a) major development intended to minimize the adverse impact of stormwater runoff on water quality and water quantity and loss of groundwater recharge in receiving water bodies.

5.2 Stormwater management measures for major development

a. Stormwater management measures for major development shall be developed to meet the erosion control, groundwater recharge, stormwater runoff quantity, and stormwater runoff quality standards at N.J.A.C. 7:8-5.4 and 5.5. To the maximum extent practicable, these standards shall be met by incorporating nonstructural stormwater management strategies at N.J.A.C. 7:8-5.3 into the design. If these measures alone are not sufficient to meet these standards, structural stormwater management measures at N.J.A.C. 7:8-5.7 necessary to meet these standards shall be incorporated into the design.

c. Stormwater management measures shall avoid adverse impacts of concentrated flow on habitat for threatened and endangered species as documented in the Department's Landscape Project or Natural Heritage Database established under N.J.S.A. 13:1B-15.147 through 15.150, particularly *Helonias bullata* (swamp pink) and/or *Clemmys muhlnebergi* (bog turtle).

5.3. Nonstructural Stormwater management strategies

a. To the maximum extent practicable, the standards in N.J.A.C. 7:8-5.4 and 5.5 shall be met by incorporating nonstructural stormwater management strategies at N.J.A.C. 7:8-5.3 into the design. The person submitting an application for review shall identify the nonstructural strategies incorporated into the design of the project. If the applicant contends that it is not feasible for engineering, environmental, or safety reasons to incorporate any nonstructural stormwater management strategies identified in (b) below into the design of a particular project, the applicant shall identify the strategy and provide a basis for the contention.

b. Nonstructural stormwater management strategies incorporated into site design shall:

1. Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss;
2. Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces;
3. Maximize the protection of natural drainage features and vegetation;
4. Minimize the decrease in the "time of concentration" from pre-construction to post-construction. "Time of concentration" is defined as the time it takes for runoff to travel from the hydraulically most distant point of the drainage area to the point of interest within a watershed;
5. Minimize land disturbance including clearing and grading;
6. Minimize soil compaction;
7. Provide low-maintenance landscaping that encourages retention and planting of native vegetation and minimizes the use of lawns, fertilizers and pesticides;
8. Provide vegetated open-channel conveyance systems discharging into and through stable vegetated areas; and
9. Provide other source controls to prevent or minimize the use or exposure of pollutants at the site in order to prevent or minimize the release of those pollutants into stormwater runoff. These source controls include, but are not limited to:
   - i. Site design features that help to prevent accumulation of trash and debris in drainage systems;
   - ii. Site design features that help to prevent discharge of trash and debris from drainage systems;
   - iii. Site design features that help to prevent and/or contain spills or other harmful accumulations of pollutants at industrial or commercial developments; and
   - iv. When establishing vegetation after land disturbance, applying fertilizer in accordance with the requirements established under the Soil Erosion and Sediment Control Act, N.J.S.A. 4:24-39 et seq., and implementing rules.

5.4 Erosion control, groundwater recharge and runoff quantity standards

(a) This section contains minimum design and performance standards to control erosion, encourage and control infiltration and groundwater recharge, and control stormwater runoff quantity impacts of major development.

1. The minimum design and performance standards for erosion control are those established under the Soil Erosion and Sediment Control Act, N.J.S.A. 4:24-39 et seq. and implementing rules.
2. The minimum design and performance standards for groundwater recharge are as follows:
   - i. The design engineer shall, using the assumptions and factors for stormwater runoff and groundwater recharge calculations at N.J.A.C. 7:8-5.6, either:
     - (1) Demonstrate through hydrologic and hydraulic analysis that the site and its stormwater management measures maintain 100 percent of the average annual pre-construction groundwater recharge volume for the site; or
     - (2) Demonstrate through hydrologic and hydraulic analysis that the increase of stormwater runoff volume from pre-construction to post-construction for the two-year storm is infiltrated.
   - ii. This groundwater recharge requirement does not apply to projects within the "urban redevelopment area," or to projects subject to (a)2iii below.
   - iii. The following types of stormwater shall not be recharged:
     - (1) Stormwater from areas of high pollutant loading. High pollutant loading areas are areas in industrial and commercial developments where solvents and/or petroleum products are loaded/unloaded, stored, or applied, areas where pesticides are loaded/unloaded or stored; areas where hazardous materials are expected to be present in greater than 'reportable quantities' as defined by the United States Environmental Protection Agency (EPA) at 40 CFR 302.4; areas where recharge would be inconsistent with a remedial action work plan approved pursuant to the Administrative Requirements for the Remediation of Contaminated Sites rules, N.J.A.C. 7:26C, or a Department approved landfill closure plan; and areas with high risks for spills of toxic materials, such as gas stations and vehicle maintenance facilities; and
     - (2) Industrial stormwater exposed to "source material." "Source material" means any material(s) or machinery, located at an industrial facility, that is directly or indirectly related to process, manufacturing or other industrial activities, which could be a source of pollutants in any industrial stormwater discharge to groundwater. Source materials include, but are not limited to, raw materials; intermediate products; final products; waste materials; by-products; industrial machinery and fuels, and lubricants, solvents, and

detergents that are related to process, manufacturing, or other industrial activities that are exposed to stormwater.

iv. The design engineer shall assess the hydraulic impact on the groundwater table and design the site so as to avoid adverse hydraulic impacts. Potential adverse hydraulic impacts include, but are not limited to, exacerbating a naturally or seasonally high water table so as to cause surficial ponding, flooding of basements, or interference with the proper operation of subsurface sewage disposal systems and other subsurface structures in the vicinity or down gradient of the groundwater recharge area.

3. In order to control stormwater runoff quantity impacts, the design engineer shall, using the assumptions and factors for stormwater runoff calculations at N.J.A.C. 7:8-5.6, complete one of the following:

i. Demonstrate through hydrologic and hydraulic analysis that for stormwater leaving the site, post-construction runoff hydrographs for the two, 10 and 100-year storm events do not exceed, at any point in time, the pre-construction runoff hydrographs for the same storm events;

ii. Demonstrate through hydrologic and hydraulic analysis that there is no increase, as compared to the pre-construction condition, in the peak runoff rates of stormwater leaving the site for the two, 10 and 100-year storm events and that the increased volume or change in timing of stormwater runoff will not increase flood damage at or downstream of the site. This analysis shall include the analysis of impacts of existing land uses and projected land uses assuming full development under existing zoning and land use ordinances in the drainage area;

iii. Design stormwater management measures so that the post-construction peak runoff rates for the two, 10 and 100-year storm events are 50, 75 and 80 percent, respectively, of the pre-construction peak runoff rates. The percentages apply only to the post-construction stormwater runoff that is attributable to the portion of the site on which the proposed development or project is to be constructed; or iv. In tidal flood hazard areas, stormwater runoff quantity analysis in accordance with (a)3i, ii and iii above shall only be applied if the increased volume of stormwater runoff could increase flood damages below the point of discharge.

6. SAFETY STANDARDS FOR STORMWATER MANAGEMENT BASINS

6.2 Requirements for trash racks, overflow grates and escape provisions

(a) A trash rack is a device designed to catch trash and debris and prevent the clogging of outlet structures. Trash racks shall be installed at the intake to the outlet from the stormwater management basin to ensure proper functioning of the basin outlets in accordance with the following:

1. The trash rack shall have parallel bars, with no greater than six-inch spacing between the bars;

2. The trash rack shall be designed so as not to adversely affect the hydraulic performance of the outlet pipe or structure; 3. The average velocity of flow through a clean trash rack is not to exceed 2.5 feet per second under the full range of stage and discharge. Velocity is to be computed on the basis of the net area of opening through the rack; and 4. The trash rack shall be constructed of rigid, durable, and corrosion resistant material and designed to withstand a perpendicular live loading of 300 lbs./ft. sq.

(b) An overflow grate is designed to prevent obstruction of the overflow structure. If an outlet structure has an overflow grate, the grate shall comply with the following requirements:

1. The overflow grate shall be secured to the outlet structure but removable for emergencies and maintenance;

2. The overflow grate spacing shall be no greater than two inches across the smallest dimension; and

3. The overflow grate shall be constructed of rigid, durable, and corrosion resistant material and designed to withstand a perpendicular live loading of 300 lbs./ft. sq.

(c) Stormwater management basins shall include escape provisions as follows:

1. If a stormwater management basin has an outlet structure, escape provisions shall be incorporated in or on the structure. Escape provisions include the installation of permanent ladders, steps, rungs, or other features that provide easily accessible means of egress from stormwater management basins. With the prior approval of the reviewing agency pursuant to N.J.A.C. 7:8-6.3, a free-standing outlet structure may be exempted from this requirement;

2. Safety ledges shall be constructed on the slopes of all new stormwater management basins having a permanent pool of water deeper than two and one-half feet. Safety ledges shall be comprised of two steps. Each step shall be

four to six feet in width. One step shall be located approximately two and one-half feet below the permanent water surface, and the second step shall be located one to one and one-half feet above the permanent water surface.
3. In new stormwater management basins, the maximum interior slope for an earthen dam, embankment, or berm shall not be steeper than three horizontal to one vertical.

Wetlands Act of 1970

The Wetlands Act of 1970 (N.J.S.A. 13:9A) states:

1.a. The Legislature hereby finds and declares that one of the most vital and productive areas of our natural world is the so-called "estuarine zone," that area between the sea and the land; that this area protects the land from the force of the sea, moderates our weather, provides a home for water fowl and for 2/3 of all our fish and shellfish, and assists in absorbing sewage discharge by the rivers of the land; and that in order to promote the public safety, health and welfare, and to protect public and private property, wildlife, marine fisheries and the natural environment, it is necessary to preserve the ecological balance of this area and prevent its further deterioration and destruction by regulating the dredging, filling, removing or otherwise altering or polluting thereof, all to the extent and in the manner provided herein.

2. The Commissioner may from time to time, for the purpose of promoting the public safety, health and welfare, and protecting public and private property, wildlife and marine fisheries, adopt, amend, modify or repeal orders regulating, restricting or prohibiting dredging, filling, removing or otherwise altering, or polluting, coastal wetlands. For the purposes of this act the term "coastal wetlands" shall mean any bank, marsh, swamp, meadow, flat or other low land subject to tidal action in the State of New Jersey along the Delaware bay and Delaware river, Raritan bay, Barnegat bay, Sandy Hook bay, Shrewsbury river including Navesink river, Shark river, and the coastal inland waterways extending southerly from Manasquan Inlet to Cape May Harbor, or at any inlet, estuary or tributary waterway or any thereof, including those areas now or formerly connected to tidal waters whose surface is at or below an elevation of 1 foot above local extreme high water, and upon which may grow or is capable of growing some, but not necessarily all, of the following: Salt meadow grass (*Spartine patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardi*), saltmarsh grass (*Spartina alterniflora*), saltworts (*Salicornia Europaea*, and *Salicornia bigelovii*), Sea Lavendar (*Limonium carolinianum*), saltmarsh bulrushes (*Scirpus robustus* and *Scirpus paludosus var. atlanticus*), sand spurrey (*Spergularia marina*), switch grass (*Panicum virgatum*), tall cordgrass (*Spartina pectinata*), hightide bush (*Iva frutescens var. oraria*), cattails (*Typha angustifolia*, and *Typha latifolia*), spike rush (*Eleocharis rostellata*), chairmaker's rush (*Scirpus americana*), bent grass (*Agrostis palustris*), and sweet grass (*Hierochloe odorata*).

4.a. For purposes of this section "regulated activity" includes but is not limited to draining, dredging, excavation or removal of soil, mud, sand, gravel, aggregate of any kind or depositing or dumping therein any rubbish or similar material or discharging therein liquid wastes, either directly or otherwise, and the erection of structures, drivings of pilings, or placing of obstructions, whether or not changing the tidal ebb and flow. "Regulated activity" shall not include continuance of commercial production of salt hay or other agricultural crops or activities conducted under section 7 of this act.

Freshwater Wetlands Protection Rules

Freshwater Wetlands Protection Act Rules (N.J.A.C. 7:7A) was amended in 2017 and states:

N.J.A.C. 7:7A-5.11 General permit 11--Outfalls and intake structures (a) General permit 11 authorizes activities in freshwater wetlands, transition areas, and State open waters necessary for the construction of:

1. A stormwater outfall structure; 2. An outfall structure that discharges other than stormwater into state open waters, and which is covered by a valid NJPDES permit issued by the Department under N.J.A.C. 7:14A; 3. An intake structure located in a State open water, for which all approvals required by the Department other than this general permit authorization have been obtained; 4. A well that is part of a non-public water system, as defined under the Department's Safe Drinking Water Act rules at N.J.A.C. 7:10-1.3, (this includes certain small private potable water wells) provided that: i. There is no alternative onsite location for the well that would have less environmental impact; ii. The source of the water supply to the well does not affect the hydrology of the freshwater wetlands; and iii. All

approvals required by the Department other than this general permit authorization have been obtained; 5. Conveyance structures, such as pipes and headwalls, associated with an outfall or intake listed in 1, 2, or 3 above; and 6. Energy dissipation structures, such as rip-rap, gabion baskets, and scour holes, associated with an outfall or intake listed in 1, 2, or 3 above. (b) General permit 11 does not authorize the construction or placement of a detention or retention facility in freshwater wetlands, transition areas, or State open waters. (c) Activities under general permit 11 shall comply with the following limits: 1. The activities shall disturb no more than one quarter acre of freshwater wetlands, transition areas, and/or State open waters, including both temporary and permanent disturbance; 2. The area disturbed during construction of a conveyance structure shall be no wider than is necessary to comply with the United States Occupational Safety and Health Administration safety standards for excavations, set forth at 29 CFR Part 1926, Subpart P; and 3. The amount or rip-rap or other energy dissipating material placed shall be the minimum necessary to prevent erosion, and shall not exceed 10 cubic yards of fill per outfall, unless a larger amount is required in order to comply with the Standards for Soil Erosion and Sediment Control in New Jersey at N.J.A.C. 2:90. (d) In addition to meeting all other requirements under general permit 11, an intake structure shall: 1. Be designed and equipped so as to minimize impacts to fish and other fauna through measures including, but not limited to, the following: i. The structure's location and orientation; ii. Protective structures that prevent entrapment of fauna in the structure itself, or in a diversionary canal or embayment; iii. Protective structures that prevent aquatic biota from being sucked up against the structure (impingement) or being sucked up into the structure (entrainment). Examples of such structures are radial wells, fish bucket screens, and wedge-wires; and 2. Be designed so as to ensure that the wetlands are not drained; 3. Have an intake velocity no greater than 0.5 feet of water per second; and 4. Comply with all applicable requirements for intake structures in the Department's Safe Drinking Water Act rules at N.J.A.C. 7:10-11.8(c). (e) All activities under general permit 11 shall comply with the specifications and requirements in the Standards for Soil Erosion and Sediment Control in New Jersey at N.J.A.C. 2:90, including activities which are exempted from or not regulated by those Standards.

(f) For any excavated area in freshwater wetlands, transition areas, and/or State open waters, the following requirements apply: 1. The excavation shall be backfilled to the preexisting elevation; 2. The uppermost 18 inches of the excavation shall be backfilled with the original topsoil material if feasible; and 3. The area above the excavation shall be replanted, in accordance with applicable BMPs, with indigenous wetlands species. (g) Any pipes laid through wetlands, transition areas, or State open waters shall be: 1. Properly sealed so as to prevent leaking or infiltration; 2. Designed so as not to form a path for groundwater to be discharged or drained from the wetland; and 3. Placed entirely beneath the pre-existing ground elevation unless the applicant shows that placing some or all of the pipe above ground would be more environmentally beneficial. (h) A swale in a wetland or transition area shall not be used as a substitute for stormwater treatment. However, a swale may be used to convey stormwater through a wetland or transition area if: 1. Conditions on the site make it impracticable to use a buried pipe; and 2. The applicant demonstrates that the swale will not result in drainage of the wetlands or transition areas. To demonstrate this, the applicant shall provide profiles and cross sections along the entire length of the swale, and any other information necessary to demonstrate that drainage will not occur.

(i) Mitigation shall be performed for all permanent loss and/or disturbance of 0.1 acres or greater of freshwater wetlands or State open waters. Mitigation shall be performed for permanent loss and/or disturbance of less than 0.1 acres of freshwater wetlands or State open waters unless the applicant demonstrates to the Department that all activities have been designed to avoid and minimize impacts to wetlands. For purposes of this subsection, “minimize” means that the project is configured so that most or all of it is contained in the uplands on the site, and that the wetlands are avoided to the greatest extent possible. An applicant is not required to reduce the scope of the project or to consider offsite alternatives to comply with this requirement. 1. The mitigation shall meet the substantive and procedural requirements at N.J.A.C. 7:7A-15.5 and shall be submitted to the Department for review and approval no later than 120 days prior to the initiation of regulated activities authorized by this general permit. Mitigation shall be performed prior to or concurrently with general permit activities.

(j) Activities under general permit 11 shall comply with all applicable requirements at N.J.A.C. 7:7A-4.3, Conditions that apply to all general permits, and N.J.A.C. 7:7A-13.2, Establishing permit conditions.

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