Town of Ocean City, Maryland
Nuisance Flood Plan

September 2020

Town of Ocean City, Maryland
Nuisance Flood Plan

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I. Executive Summary

Maryland House Bill 1350/1472 requires each coastal community that experiences nuisance flooding to prepare a Nuisance Flood Plan, to inform the public, and to take action in support of community resilience. Elements of the plan must include:

- Inventory of nuisance flood areas
- Thresholds for warning and response
- Documentation of Events and Response Activity

Ocean City MD experiences periodic nuisance flooding conditions (up to 1 foot deep* that cause inconvenience but not significant property damage). Nuisance flooding does not affect Ocean City uniformly – first to flood (lowest elevation) areas have been identified, along with areas that experience limited storm drainage capacity (flooding with heavy rainfall/flash flooding). Downtown streets along the bayside between the Inlet and 4th Street are the most frequently impacted, and create the greatest nuisance especially during the active tourist season.

Monitoring nuisance flooding for increasing **frequency**, **depth**, **duration** and **extent** is a likely first indicator of changing conditions which may require new mitigation actions. NOAA technical report 092, dated July 2020, identifies increased nuisance flooding risk up to 2 feet deep, based on a forecast that the number and intensity of events per year will increase rapidly over the next 10 to 15 years.

Ocean City is already implementing a Phase One response, with new strategies for monitoring and evidence-based response established under this Nuisance Flood Plan. Responsibility for implementation of the Plan is shared with property owners, business owners, organizations, and local/state/federal government. All must be informed, understand natural risks, take mitigation actions to reduce damage and share the cost. This plan is not a guarantee of protection from flooding impacts on a barrier island.

Approval of the Plan by the Mayor and City Council will allow elements and actions to be incorporated in the Hazard Mitigation Plan update in 2021 and the next Comprehensive Plan update in 2022. Projects may be incorporated into the Town Capital Improvement Plan. Recommendations for Code changes to improve the resilience of new construction may be adopted. Flood insurance coverage of all properties will continue to be encouraged.

Does nuisance flooding include 'flash flooding' caused by heavy rainfall, or increased impact from high tides due to off shore storm events?

For Ocean City, MD, nuisance flooding has to include the symptoms regardless of the source, because similar impacts may affect geographic areas of the Town other than those identified through a simple analysis of lowest elevation. It is difficult to evaluate high tide without considering the influence from wind, storms, and rainfall. For the purpose of this Plan, nuisance flooding will be defined as: less than 10 events per year (**frequency**); up to 1' depth of flooding (**depth**); related to one or more high tide cycles (**duration**); and affecting a specific area/street/number of structures (**extent**).

II. Nuisance Flood Plan

A Nuisance Flood Plan for the Town of Ocean City, MD is prepared to meet State criteria for Coast Smart Communities, and will be approved as an element of the Town Comprehensive Plan and Hazard Mitigation Plan.

Nuisance flooding is defined as high tide flooding that causes public inconvenience.

Nuisance flooding is typically up to 1 foot deep and unrelated to particular storm events, though it may be increased by long-duration wind events, high intensity rainfall, or passing storm systems. As such, it is frequently referred to as "sunny day flooding." Nuisance flooding disrupts daily activities with temporary road closures due to high water, inundation of yards and parks, and reducing the capacity of storm drain systems. Typically impacts are limited to only several hours during a normal tide cycle.

Water Resources Research, Volume: 54, Issue: 7, Pages: 4218-4227, First published: 25 May 2018, DOI: (10.1029/2018WR022828)

Maryland supports 'CoastSmart Communities' as a Department of Natural Resources program dedicated to assisting coastal communities address short- and long-term coastal hazards, such as coastal flooding, storm surge, and sea level rise. Effective July 1, 2018, House Bill (HB) 1350 adopted new coast smart siting and design criteria for state and local capital improvements, as well as the following new planning mandate:

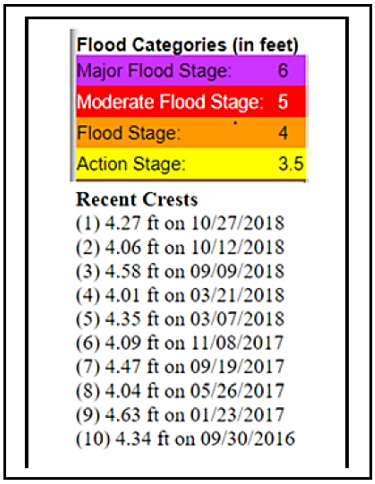
Local Plans to Address Nuisance Flooding

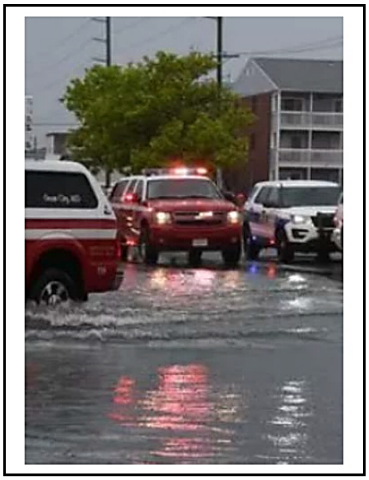
By July 1, 2019 (extended to October 1, 2020), a local jurisdiction that experiences nuisance flooding must develop a plan to address nuisance flooding - which must be submitted to the Maryland Department of Planning, published on the local jurisdiction's website, and updated at least once every five years.

In order to meet this requirement, DNR Chesapeake & Coastal Service provided guidance listed below on preparing a local plan for nuisance flooding. A work group made up of members of the Town Coastal Policy Advisory Committee (the Green Team) participated in the nuisance flood planning process for the Town of Ocean City, MD, see **Appendix I**.

Each Nuisance Flood Plan will have three critical components:

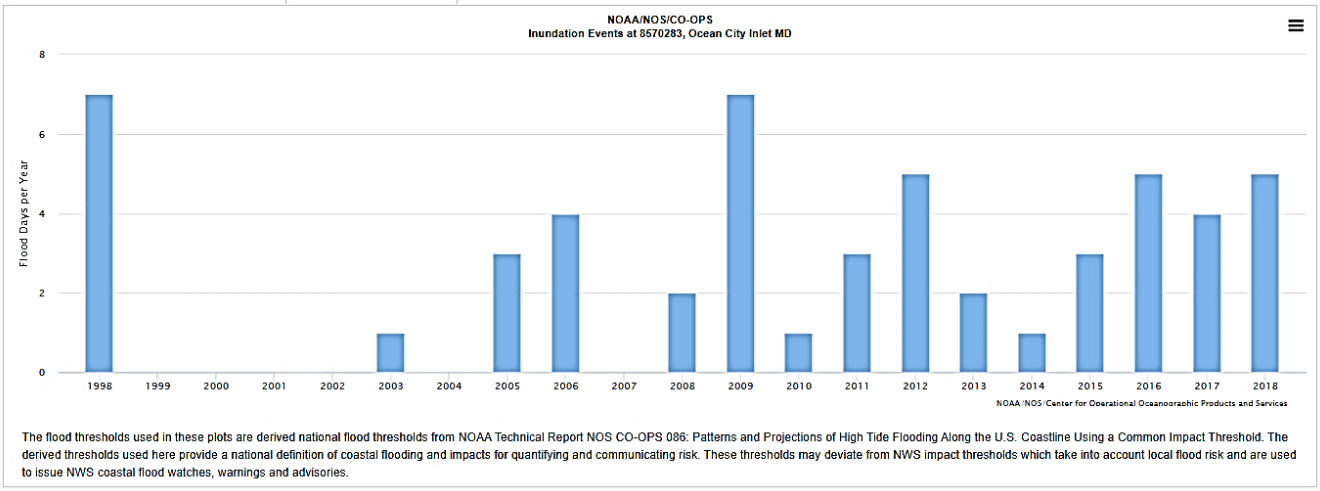
1. Inventory of known flood hazard areas where nuisance flooding occurs
2. Identification of flood thresholds which dictate appropriate warning and response
3. Documentation of nuisance flood events and response activities





Areas of Ocean City, MD are affected by repetitive shallow coastal flooding due to low land elevation and proximity to the Inlet and Coastal Bays. Known flood hazard areas where nuisance flooding occurs are identified by mapping tools, inventory of locations, and documentation of reported events.

Flooding impacts from high tides are currently limited to **less than 4 events per year** (NOAA 10-year average of inundation events) with many occurring during the 'off season'. Heavy rainfall events alone can **add 2 or more periods** of nuisance flooding per year that are not documented by the tide gauge. Property damage, power outages, and limited access to downtown areas are likely to increase in the future without proactive action to mitigate coastal flooding impacts.



In Ocean City MD, nuisance flooding occurs most frequently in low lying areas along the bayside of the community (in lower downtown, northbound lanes of Coastal Highway, and mobile home parks) and typically involves standing water in the streets and sidewalk areas during high tide conditions when underground storm drain systems are filled to capacity.

Directing surface drainage away from buildings toward storm drains in the public streets is 'by design', and required by current development codes. Capacity of a storm drain system is often the deciding factor in managing nuisance flooding. (see project description of Phase One actions in Ocean City, MD)

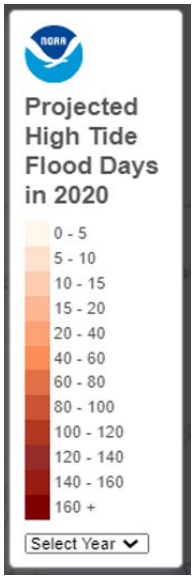
LOCAL KNOWLEDGE

Delmarva's brush with Hurricane Jose shows coastal vulnerability
Jerry Smith and Reed Shelton, The Daily Times Published 4:53 p.m. ET Sept. 21, 2017

In Ocean City, Public Works Director Hal Adkins said the resort suffered little damage from its brush with José, … Adkins did acknowledge that José caused some problems for residents.

> "We also, as we normally do in a storm of that sort, ended up with a lot of back-bay flooding on bayside streets and that happened this time around," he said. Ocean City, especially the lower end of town, is very low in elevation. The difference between the elevations between our roads and downtown isn't much different from our high tides.
>
> "Whether we're having a nor'easter or on the fringes of a Category 1 hurricane, it's not uncommon for us to have flooding in our downtown areas. It's commonplace. Picture overfilling your bathtub, it passively overflows onto the floor. When the tidal influence is strong enough in our bay, it's unable to go back out the inlet like it normally would. It's basically a large bathtub that overflows onto the bayside streets**. It's an unfortunate nuisance that happens two, three or four times a year depending on weather patterns.**"

Preparation of the required Nuisance Flood Plan for a local coastal community provides an opportunity to bring together current efforts of multiple plans, and City department work programs to formalize review processes that sometimes occur under separate management teams. This planning effort also allows communities to enact best practices within existing programs without the need to create another regulatory mechanism where one is not needed.



The State of High Tide Flooding in 2019 and the Outlook through April 2021

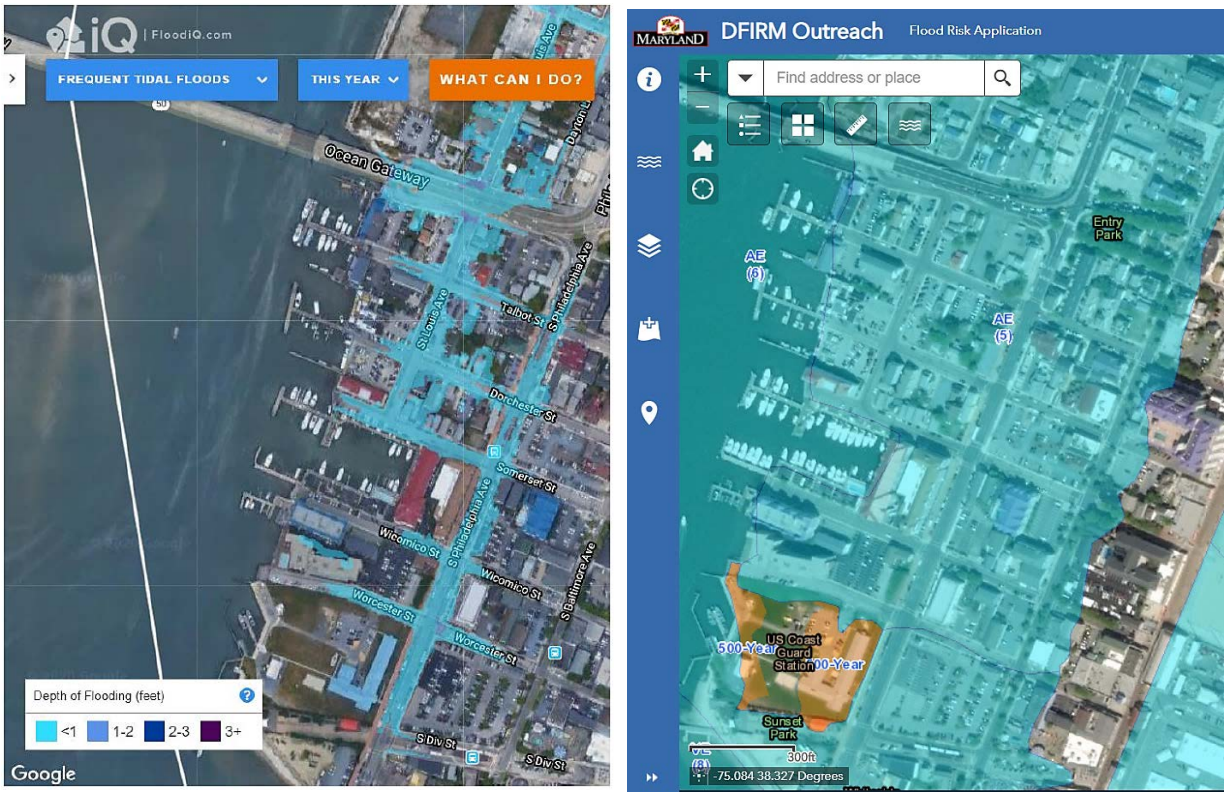
Coastal communities across the U.S. continued to see record-setting high-tide flooding in 2019, forcing their residents and visitors to deal with flooded shorelines, streets and basements — a trend that is expected to continue into 2021. Each year, NOAA documents changes in high-tide flooding patterns from the previous year at 98 NOAA tide gauges along the U.S. coast, and provides a flooding outlook for these locations for the coming year, as well as projections for the next several decades.

- **In 2019**, the national annual flood frequency reached **4 days** (median value).
- **Through May 2021**, the national high tide flood frequency is expected to accelerate, with U.S. coastal communities seeing an average of **2 to 6 days** of flooding in the coming year.
- **By 2030**, high tide flooding is likely to be in the range of **7 - 15 days.** These long-term outlooks are based on the range of relative sea level rise 'more likely' to occur by 2030 and 2050 using projections of the Fourth National Climate Assessment.

https://tidesandcurrents.noaa.gov/HighTideFlooding_AnnualOutlook.html

III. Mapping Risk Areas

Nuisance Flooding is a small portion of the flood risk area that is mapped by the FEMA Flood Insurance Rate Maps. These 'first to flood' areas are subject to more frequent disruption of daily life, to potentially higher risk of property damage, and can provide an early indicator of changing environmental conditions.

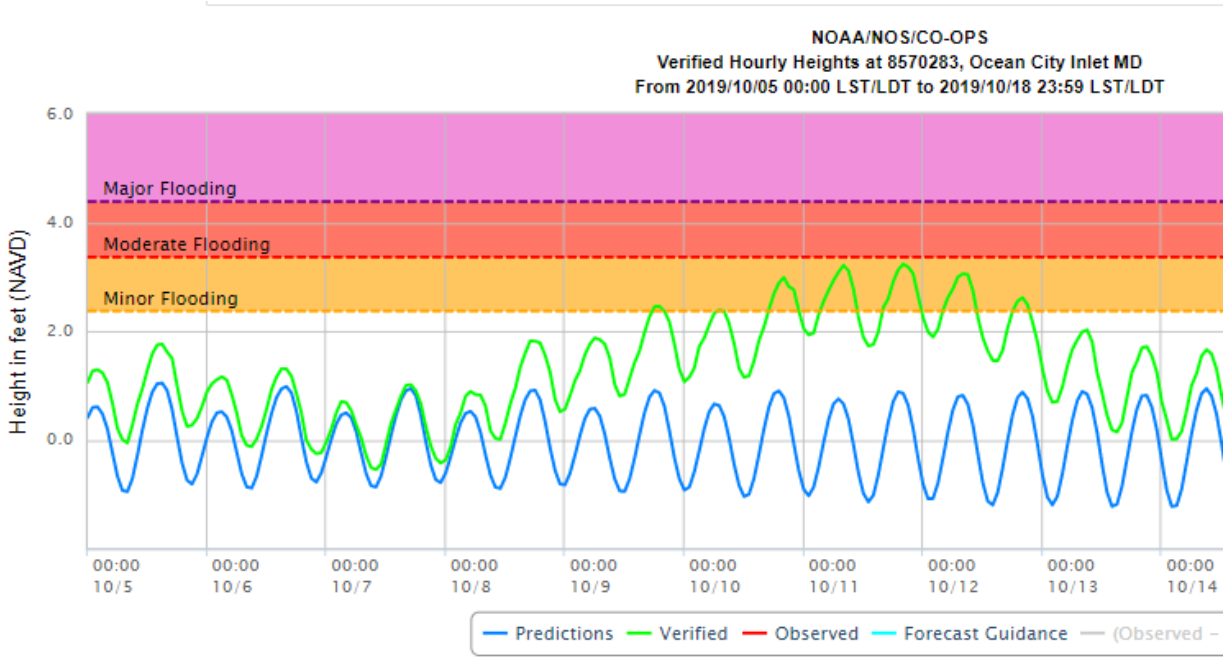


Comparison of Nuisance Flood Elevations (EL. 2.3 to 3.3) and FEMA Flood Insurance Rate Map Elevations (El. 5.0)

Public understanding of flood risk maps in Ocean City MD has primarily been through the adoption of FEMA flood insurance rate maps that illustrate specific flood depths and flood hazard areas for a particular storm event (1% chance or formerly 100-year flood). Additional flood risk awareness is provided through the Town's 'Know your Zone and Division' program and website alerts which highlight the flood warning system provided by the National Weather Service (NWS) specific to the tide gauge located at the Ocean City Inlet.

The Nuisance Flood Plan will be most effective when all stakeholders are well informed. One basic point of shared understanding must include the difference between FEMA measurements of vertical LAND elevations, and NWS measurements of vertical WATER elevations because they are not the same.

A conversion exhibit is illustrated below which converts flood warning elevations to match elevations shown on individual property elevation certificates. **Appendix II** provides detailed information about the vertical datum used for flood risk and warning systems.



NWS Flood Warning System Elevation (MLLW datum)

Flood Categories (in feet)	
Major Flood Stage:	6
Moderate Flood Stage:	5
Flood Stage:	4
Action Stage:	3.5
Low Stage (in feet):	-1

Stage	NWS Elevation (MLLW datum)	FEMA Elevation (NAVD88 datum)
Major	6.0+ feet	4.3+ feet
Moderate	5.0 feet	3.3 feet
Minor	4.0 feet	2.3 feet
Action	3.5 feet	1.3 feet

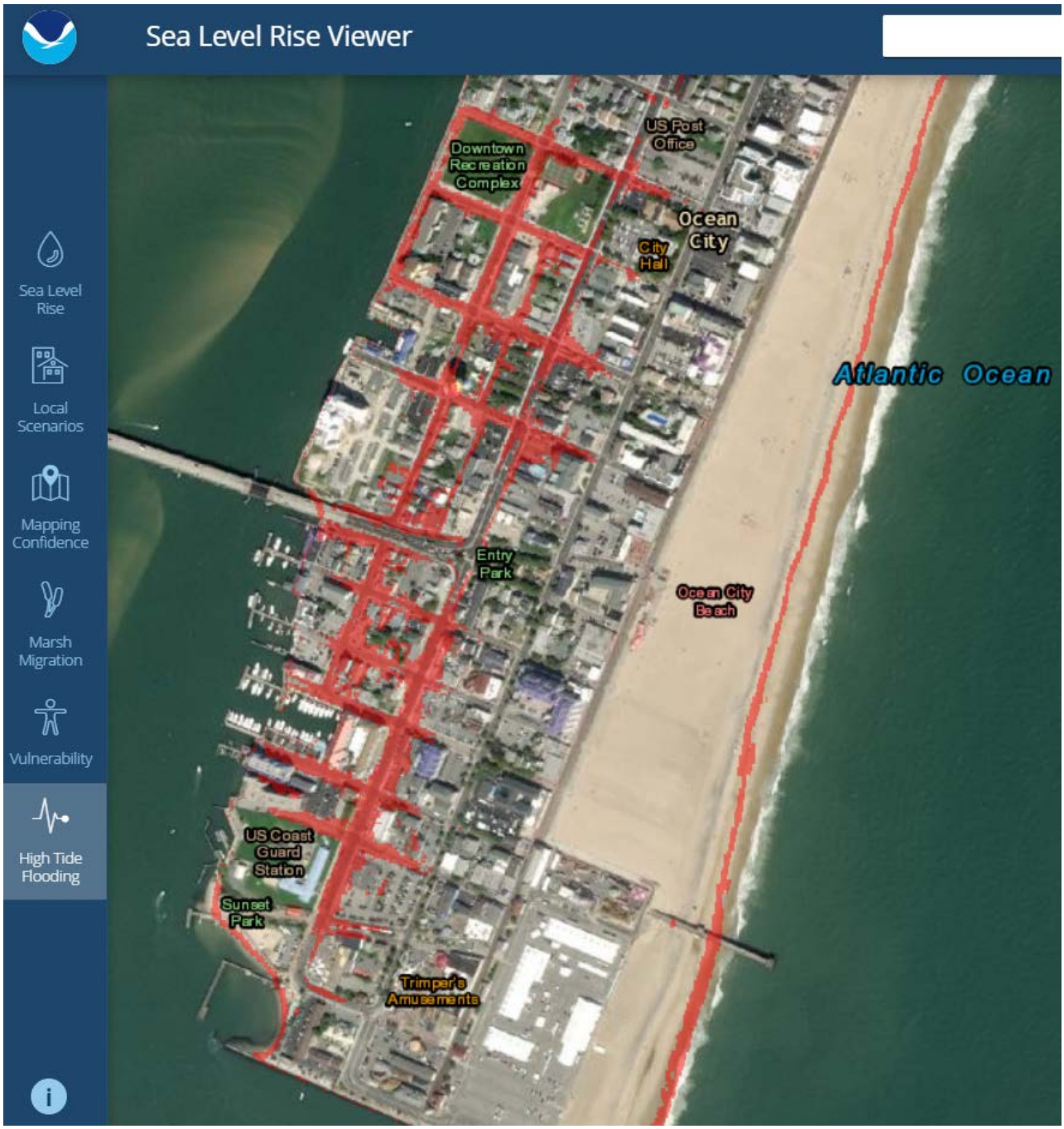
NWS Flood Tide Elevations (adjusted to land based vertical datum NAVD88)
[Minor Flooding/Stage 4 = Nuisance Flooding]

Mapping Tools

The Town of Ocean City MD reviewed the capabilities of numerous mapping tools that can be used to illustrate the extent and impact of nuisance flooding. Town staff has access to both **local knowledge of frequent flood areas** and the precision of **Geographic Information System** (GIS) technology.

Over the last 10 years many resources have also become available to evaluate future conditions such as Sea Level Rise (SLR), with online mapping of projected impact areas. In most cases these SLR tools have not been adequate to provide regular monitoring of local conditions in a format that is easy to use and understand for our coastal barrier island location because of the one foot flood increment controls.

The **NOAA Digital Coast mapping tool** is useful for identifying areas that may be inundated by high tide flooding. These 'first to flood' areas are further described in the Inventory of frequent flood locations. Working from this list, the goal of identifying pilot projects can then be quantified, designed and included in the 5-year Hazard Mitigation Plan to be eligible for grant funding, or proposed as a Town Capital Improvement Plan project.



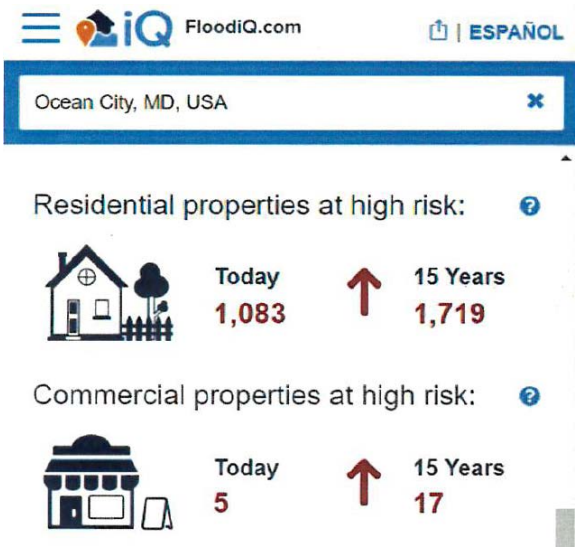
'Nuisance Flooding' is just one part of the planning and preparation that the Town of Ocean City completes for the National Flood Insurance Program. Recommended actions of this Plan tie in with Hazard Mitigation Plan priorities for all hazards including major storm events/floods, and also benefit from partnerships with State agencies and USACE for shoreline management.

Mapping current conditions, tracking changes in nuisance flooding, and evaluating increased risk to the community is the primary function of the Nuisance Flood Plan. Local decision making is also essential to verify national scale flood risk estimating tools like Flood Factor (FloodIQ), and future FEMA flood insurance changes such a Risk Rating 2.0 (currently deferred until October 2021).

Estimates of how many structures are at risk from tidal nuisance flooding are useful for planning and comparison purposes only. Based on sea level rise projections, the number of structures potentially impacted by tidal nuisance flooding may increase 2x in 10 years, or up to 3x in 15 years. Updates to local data on the proposed NFP 5-year cycle will provide valuable information to both local and state leaders.

Frequent Tidal Flood Impact Estimate
[1-foot depth]

Highest Tidal Flood + 15 years (includes SLR)
[2-foot depth]



Comparison of Nuisance Flood Inundation to FEMA Special Flood Hazard Area

	Nuisance Flood Area (Tidal)	Special Flood Hazard Area (FEMA)
Frequency	3.7 times per year average	0.1 times per year average
Depth	1 foot	2 to 4+ feet
Duration	One tide cycle (2 to 3 hours)	Multiple tide cycles (1 to 3 days)
Extent	Area 72 acres Buildable % 4% Structures 450	Area 1,157 acres Buildable % 58% Structures 2,500

IV. Best Practices from Other Coastal Communities

A community response to Nuisance Flooding includes individual action by property owners, business owners, builders, utility companies, and representative action from all levels of government.

Nuisance flooding impact on infrastructure is a difficult problem to solve, especially when time-tested design principles have directed water away from structures to collect in streets, storm drains and open spaces. To accomplish new solutions, strong partnerships between the Town's departments and allied agencies are necessary for Ocean City, MD to properly prepare for future conditions.

Preparation of a Nuisance Flood Plan includes an understanding of best practices from other coastal communities in order to evaluate a phased and cost-effective response. The top ten mitigation strategies identified by desktop data collection are listed below:

1	Hazard Disclosure/Public Notification	✓ **OCEAN CITY**
2	Elevation of Structures/Freeboard	✓ **OCEAN CITY**
3	Green Infrastructure (rain gardens, rain barrels, bioswales, infiltration basins, pervious paving, buffers, tree canopy/native plants)	✓ **OCEAN CITY**
4	Divert building rooftop drainage and paving to reduce runoff to stormwater drainage systems	✓ **OCEAN CITY**
5	Maintain, repair and clean sediment from storm drainage systems to increase capacity	✓ **OCEAN CITY**
6	Gray infrastructure upgrades (backflow preventers, replace and upsize degraded pipes, reconstruct streets for drainage flow)	✓ **OCEAN CITY**
7	Capital Improvement Projects (grants or bonds)	✓ **OCEAN CITY**
8	Street Elevation/Property elevation	*
9	Stormwater storage basins/Pump systems	*
10	Property acquisition/Density reduction/Relocation	*

* Ocean City, MD has accomplished indirect implementation of all Top 10 mitigation actions associated with critical infrastructure projects and other program goals: 65th Street elevation project, stormwater sediment control basins, Public Beach density transfer program

Appendix III includes Case Studies/Profiles of Coastal Community Responses to nuisance flooding.

A) Ocean City, MD – shoreline management, gray infrastructure reconstruction, tide gates
B) Toms River, NJ – street elevation, gray infrastructure reconstruction, house elevation
C) Norfolk, VA – 'living with water', street elevation, gray and green infrastructure
D) Annapolis, MD – stormwater system improvements

V. Inventory of Known Flood Hazard Areas

Maps

Three bayside areas are impacted regularly by nuisance flooding and storm enhanced rain and flood events. The northbound lanes of Coastal Highway have also been mapped to identify the lack of stormwater infrastructure necessary to provide regular stormwater drainage. (Source: Town of Ocean City GIS data)

Downtown Bayside streets (Inlet to 9th) | Midtown Bayside (33rd to Rte. 90) | Uptown Bayside (Route 90 to 94th Street)

Nuisance flood maps and preliminary inventory of known flood hazard areas can be found in **Appendix IV.**

Inventory of Known Flood Hazard Areas*

(based on NOAA Digital Coast illustration of current High Tide Flooding)

*Mitigation should be based on estimated future conditions

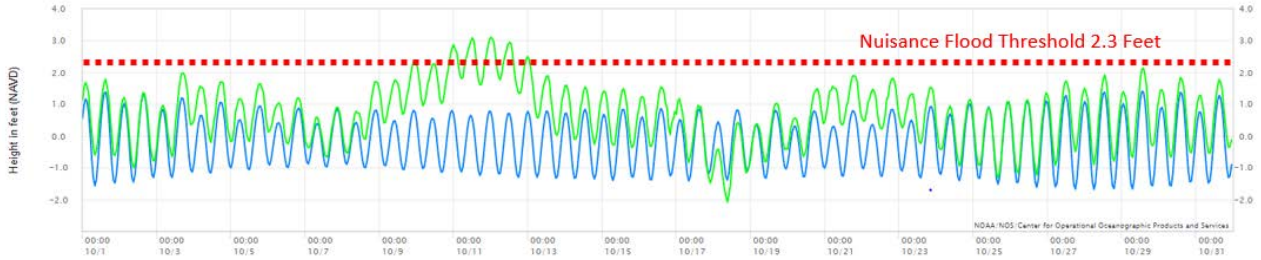
Location	Description	Flood Frequency	Flood Depth	Flood Duration	Extent
South Philadelphia Avenue/ Worcester Street	All directions	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Wicomico Street	All directions	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Somerset Street	North/South and West to Bay	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area

(Continued in Appendix IV)

Inventory of known nuisance flood areas is initially based on the NOAA Digital Coast illustration of high tide flooding extent and will be verified with annual inspections and records.

Tide Charts

Typical conditions that lead to nuisance flooding are well documented by the National Weather Service (NWS) based on accurate real-time data from the US Coast Guard Station tide gauge located near the Ocean City Inlet. NWS data provides an inventory of high tide/minor flooding events based on multi-year records as well as identifying the top 10 flood events. This information provides a baseline record, and can be used to isolate and identify nuisance flood events that affect the areas identified above.



NWS tide gauge data is typically tied to storm related events and does not necessarily monitor minor nuisance flooding, or intensive rainfall events. Tide gauge information is also location specific to the Inlet vicinity and does not completely represent bayside conditions to the north which are influenced by physical site conditions.

Monitoring monthly Tide Charts will provide verification of frequency and duration of tidal Nuisance Flood events. Adjustments to the NWS flood elevation warning benchmarks may be proposed to more accurately represent the flood risk of approximately 1-foot depth of inundation.

Appendix V provides a tabulation of the NWS historic and peak flood events, indicating Major, Moderate, and Minor flooding conditions. This information will be supplemented with locally documented intensive rainfall events that exceed capacity of the stormwater utility system. Annual tide charts are included for verification of frequency, depth and duration of nuisance flooding.

NWS	Elevation (Feet above MHHW)	Elevation (NAVD)	Event Date	Event Type
Minor Flooding	4.03	2.30	8/16/2020	Coastal Storm
			8/4/2020	TS Isaias 1.23" Rainfall Wind
			7/10/2020	TS Fay 5" Rainfall Event
	4.02	2.29	4/4/2020	Coastal Storm
	4.10	2.37	12/2/2019	Winter Storm
	4.30	2.57	11/18/2019	Coastal Storm
	4.72	2.99	10/12/2019	TS Melissa
	4.89	3.16	10/11/2019	Coastal Storm
	4.85	3.12	10/11/2019	Coastal Storm
	4.64	2.91	10/10/2019	Coastal Storm
	4.32	2.59	9/6/2019	H Dorian 1.63" Rainfall
	4.27	2.54	10/27/2018	Noreaster
	4.06	2.33	10/12/2018	TS Michael
	4.58	2.85	9/9/2018	H Florence/Isaac/Helene
			6/9/2018	7.5" Rainfall Event
	4.01	2.28	3/21/2018	Noreaster
	4.35	2.62	3/7/2018	Noreaster, TS Riley
	4.09	2.36	11/8/2017	Winter Storm
	4.47	2.74	9/19/2017	TS Jose
			7/28/2017	1.76" Rainfall
			7/14/2017	Flash Flood 1.2" Rainfall
	4.04	2.31	5/26/2017	Thunderstorms
	4.63	2.90	1/23/2017	Noreaster
	4.34	2.61	9/30/2016	H Matthew
	4.05	2.32	9/6/2016	TS Hermine
	4.30	2.57	2/9/2016	Winter Storm
	4.87	3.14	1/23/2016	Winter Blizzard
	4.88	3.15	1/23/2016	Winter Blizzard
	4.72	2.99	10/2/2015	H Joaquin
	3.83	2.10	9/26/2015	H Joaquin
			7/27/2015	2.43" Rainfall Event
	4.91	3.18	3/6/2013	Offshore Wind Low Pressure
	4.41	2.68	11/8/2012	Noreaster
	4.18	2.45	11/8/2012	WS Athena
	4.03	2.30	11/7/2012	Noreaster
Major	6.05	4.32	10/29/2012	Superstorm Sandy
Moderate	5.48	3.75	10/29/2012	Superstorm Sandy
	5.06	3.33	10/28/2012	Superstorm Sandy
Minor	4.21	2.48	6/5/2012	Thunderstorms
	4.27	2.54	6/4/2012	Thunderstorms
	4.46	2.73	10/29/2011	Winter Storm
	4.69	2.96	8/27/2011	H Irene
Moderate	5.25	3.52	11/13/2009	H Ida
	5.01	3.28	11/12/2009	H Ida

MyCoast App

The final inventory tool proposed to verify flood events is the MyCoast app that will collect photographic evidence of nuisance flooding in specific study areas. Volunteers from the Nuisance Flood work group and Town Staff will be alerted when a high tide or heavy rainfall event is predicted so that documentation from multiple locations can be obtained for use in the required 5-year NFP update.

MyCoast (https://mycoast.org/national-projects/nuisance-flooding) provides a citizen-based data collection source that captures image, location, weather conditions, time. Making this tool available to the public builds understanding and capacity for advocacy and action when critical thresholds are reached.

Nuisance Flooding Report by Patrick McLaughlin

"Corner of Worcester Street and Philadelphia Avenue"

04/04/2020 | 9:13 am

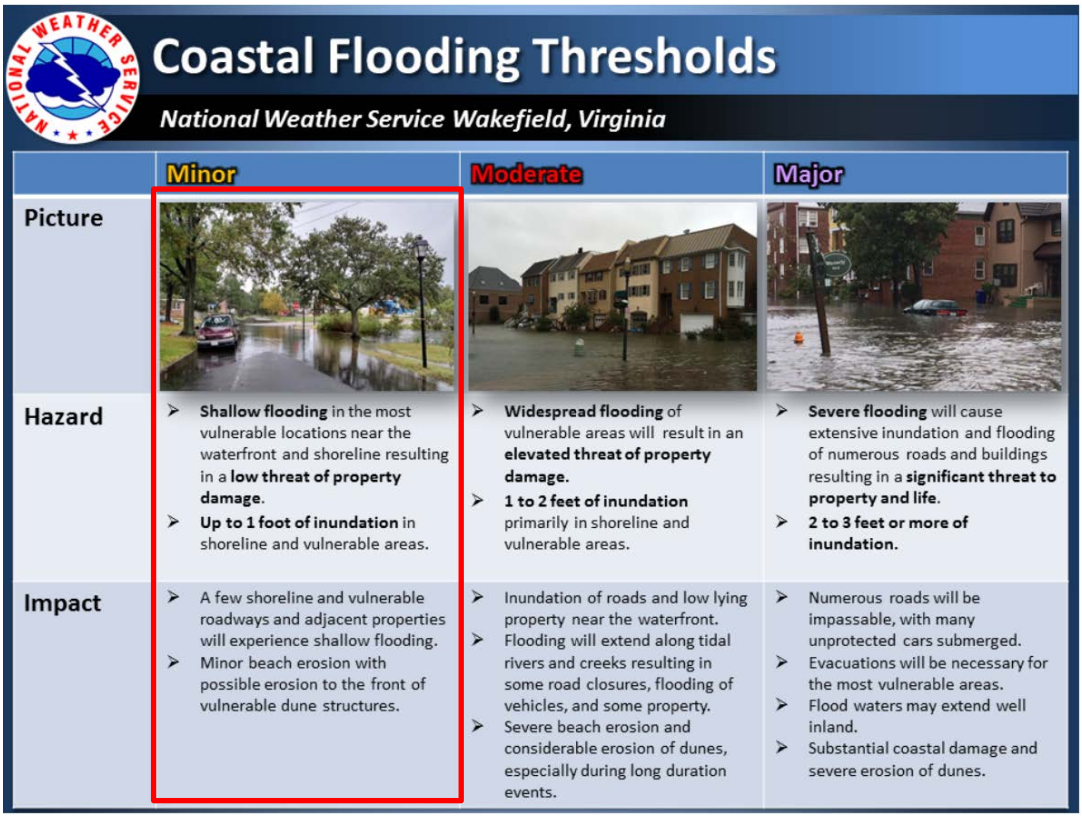
(3 hours 44 minutes after high tide)

Tidal Overview

Data from Ocean City Inlet (0.1 miles away)
Water Level: 3.2' (observed MLLW)
Predicted tide: 5:29 am, 2.3'

VI. Identify Nuisance Flood Thresholds

Prior sections and work efforts of the Nuisance Flood Plan come together to inform measuring tools or thresholds that will be used to evaluate current conditions and change over time.



Coastal Flooding Thresholds

National Weather Service Wakefield, Virginia

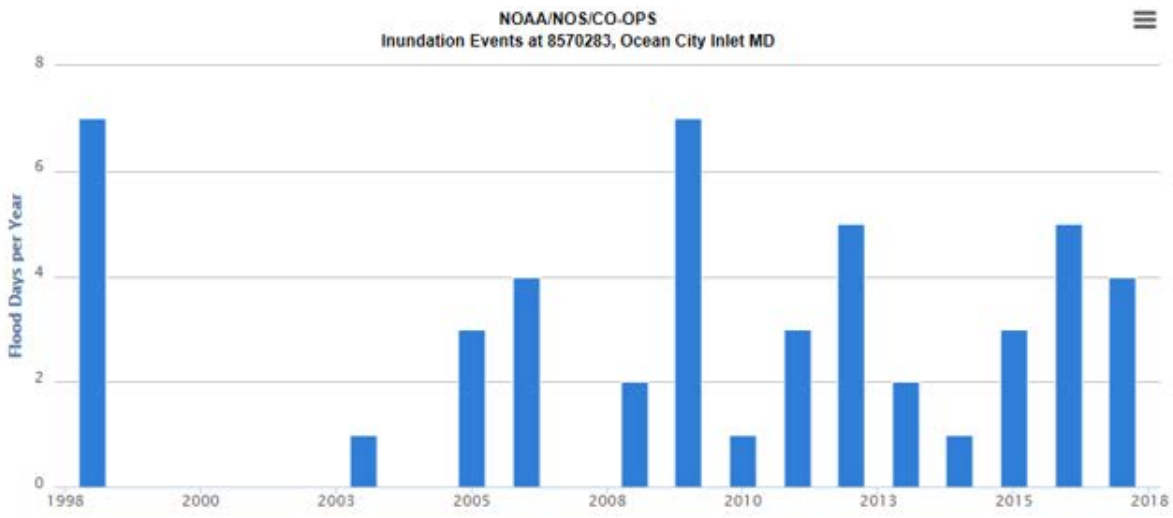
	Minor	Moderate	Major
Picture			
Hazard	➢ **Shallow flooding** in the most vulnerable locations near the waterfront and shoreline resulting in a **low threat of property damage.** ➢ **Up to 1 foot of inundation** in shoreline and vulnerable areas.	➢ **Widespread flooding** of vulnerable areas will result in an **elevated threat of property damage.** ➢ **1 to 2 feet of inundation** primarily in shoreline and vulnerable areas.	➢ **Severe flooding** will cause extensive inundation and flooding of numerous roads and buildings resulting in a **significant threat to property and life.** ➢ **2 to 3 feet or more of inundation.**
Impact	➢ A few shoreline and vulnerable roadways and adjacent properties will experience shallow flooding. ➢ Minor beach erosion with possible erosion to the front of vulnerable dune structures.	➢ Inundation of roads and low lying property near the waterfront. ➢ Flooding will extend along tidal rivers and creeks resulting in some road closures, flooding of vehicles, and some property. ➢ Severe beach erosion and considerable erosion of dunes, especially during long duration events.	➢ Numerous roads will be impassable, with many unprotected cars submerged. ➢ Evacuations will be necessary for the most vulnerable areas. ➢ Flood waters may extend well inland. ➢ Substantial coastal damage and severe erosion of dunes.

The Town of Ocean City, MD evaluates flood events by utilizing a combination of the NOAA and NWS advisory data to provide advance projections of tidal water elevations at the Ocean City Inlet and intensive rainfall events. The Nuisance Flood Plan advances this tracking and notification method by conversion of the flood elevations to match the FEMA RiskMap datum and by regular record keeping to monitor change in **frequency, depth, duration and extent** of minor flooding.

Ocean City, MD Nuisance Flood Plan thresholds for nuisance flooding (Stage One) are established as:

- **Frequency** - less than 10 events* per year at 4.0 feet minor flood level (2.3 feet land elevation) (*storm related nuisance flooding over several tide cycles may be counted as one event)
- **Depth** - up to 1-foot* deep standing water that is a result of high tide conditions
  *NOAA report identifies 2-foot depth as future nuisance flooding
- **Duration** – generally one high tide cycle (2 to 3 hours) and may include wind, rainfall or king tide influence
- **Extent** – Road and sidewalk inundation without significant impact to structures or property, less than 10% of buildable area of community flooded

NOAA Tides and Currents provides a list of the highest water levels per year and tide charts for the Ocean City Inlet tide gauge. A threshold line at 4.0' (2.3' NAVD88) yields a frequency count of nuisance flood events by year. The average frequency over the past 10-year period is approximately **4 events per year, plus additional intensive rainfall events**.



Minor flooding is typically accompanied by a NOAA/NWS flood advisory, and is what this plan refers to as 'high tide' flooding, **'nuisance flooding'**, or 'recurrent tidal flooding'.

Nuisance flood inundation can change over time beginning with little to no tidal flooding, then shifting as sea level rises to infrequent tidal flooding, then advancing further into frequent tidal flooding, which becomes effective inundation, and eventually permanent inundation.

One research paper (Dahl, KA, et al 2017), addresses flood **frequency** by defining recurrent, tidally driven coastal flooding as one of the most visible signs of sea level rise. For the purpose of a standardized national model, effective inundation was defined as having **10% or more of livable land area flooded at least 26 times per year**. This frequency causes an area to be so frequently flooded that it renders the area's current use no long feasible, and is the point at which a community may make additional changes to ensure its residents are safe and its infrastructure and services are functional.

Tracking the number of minor flooding days per year, and comparing prior years of data from the tide gauge provides an important planning tool to identify changing conditions. New community responses may be initiated when:

- ✓ **Nuisance Flooding exceeds 10 to 12 events per year**
- ✓ **Flood depths during nuisance flooding events reach 2 feet deep (moderate flooding) on a sustained annual basis**
- ✓ **Nuisance flood duration regularly exceeds one tide cycle**
- ✓ **When the extent of local nuisance flooding doubles in area, or exceeds 10% of the community buildable area**

When any one or more annual threshold(s) are exceeded, the Nuisance Flood Plan work group will meet to evaluate the data and community concerns, and will present a report to the Mayor and City Council with recommendations for action.

VII. Staged Response Plan for Nuisance Flooding

Nuisance flooding is the first stage, or indicator of increased risk, within a broader floodplain management plan for Ocean City, MD. Mapping risk areas and defining thresholds to measure minor flooding allows for a staged or incremental response. Combined with regular monitoring, Stage One also provides a current baseline to measure change in sea level, climate conditions, and community resilience over time.

STAGE ONE – below threshold

- Administer National Flood Insurance Program, CRS higher standards for building
- Provide Community information (Know Your Zone, Signage, Warning System)
- Encourage all property owners to obtain flood insurance
- Install temporary traffic control devices to prevent access to flooded areas when water in the public street reaches one-foot depth.
- Repair, Replace and Maintain streets and storm drain system
- Partner with State and Federal agencies for town wide resilience projects (beach, dunes, seawall, stormwater outfall gate valves)
- Collect data, prepare Nuisance Flood Plan, continue to implement best practices

STAGE TWO – exceeds one or more thresholds in localized areas

- Identify and implement increased flood risk adaptation measures
- Collect data to support FEMA cost/benefit analysis for grant funded projects
- Update Hazard Mitigation Plan strategies, pursue targeted mitigation project grants
- Adopt higher building/code standards to raise land elevation and shoreline bulkheads
- Identify pilot project areas, initiate design and engineering for mitigation measures
- Prepare street centerline survey, collect database of structure lowest floor elevations
- Establish sustainable funding mechanism for neighborhood level mitigation improvements
- Continue Stage One response

STAGE THREE – exceeds multiple thresholds town-wide

- Request assistance from State and Federal partners to renew and update the Atlantic Coast of Maryland Shoreline Protection project prior to the expiration date of 2044
- Prepare local feasibility/preliminary engineering for sub watershed management of perimeter flood measures and pump systems based on USACE best practices from the NJ Back Bays Flood Risk Management, and Norfolk Coastal Storm Risk Management studies
- Fund and construct Capital Improvement Plan projects directed toward nuisance flood risk management and community resiliency
- Create a stormwater utility fund or TIF district mechanism for area or townwide improvements
- Stockpile dredge material for infrastructure and block level elevation projects
- Transition individual City department responses to full Flood Management program with designated staffing and budget
- Continue Stage One and Two response

The Town of Ocean City, MD is currently in Stage One based on the information collected for this Plan. NOAA predictions for rapid change in tide-based flood risk impacts due to sea level are projected to double over the next 10 to 15 years for the Atlantic Coast (nuisance flooding up to 1-foot depth could double to 2-foot depth). This compares to the USACE predictions incorporated into the Town Sea Level Rise Policy (1-foot increase in sea level in approximately 15 to 37 years).

Nuisance flood impacts are currently well below the FEMA base flood elevation (plus local freeboard) that is administered under the Floodplain Ordinance by the Town of Ocean City, MD. While building codes now require new construction to meet a minimum 1-foot freeboard elevation above the base flood level as a safety factor, the Town of Ocean City has adopted a higher standard of 3-foot freeboard in the Special Flood Hazard Area, and 2-foot freeboard in other areas.

Any documented increase in nuisance flooding will likely impact public infrastructure (roads, sidewalks, utilities, etc.) first with mitigation as a shared responsibility. Mitigation for non-conforming property or structure elevation will be an individual responsibility.

VIII. Nuisance Flood Impact Mitigation Strategies

Both the Comprehensive Plan and the Hazard Mitigation Plan (HMP) for the Town of Ocean City, MD address measures by which the impacts of flooding can be mitigated, or lessened, by public or private structural and nonstructural means. The purpose of the Nuisance Flooding Plan will augment and support the information and recommended actions found in other planning documents. The Town's 2017 HMP includes several priorities that will be updated with the next review:

Table 12-2: 2016 Mitigation Action Items & Ratings

ACTION	LOCATION/ RESPONSIBLE ENTITY	GOALS	TIMEFRAME	HAZARD	RATING
PREVENTION: Government administrative or regulatory actions or processes that influence the way land and buildings are developed and built. These actions also include public activities to reduce hazard losses.					
Roadway Flooding – Roadway Flooding During Heavy Rain Events (Southbound) Coastal Highway @ Roadway 100 to 91st & 130-136th (Road Elevations and Drainage Issues) Standing Water, History of Flooding. Storm Drains located on straight need to be increased in size or multiple storm drains installed.	Town of Ocean City/State Highway Administration		TBD	Flooding	**HIGH**
PROPERTY PROTECTION: Actions that involve the modification of existing critical and public facilities, buildings, structures, and public infrastructure to protect them from hazards.					
65th/Bayside Flooding, Heavy Rain (Public Works Complex) – Elevate Street, Improve Drainage.	Town of Ocean City/State Highway Administration		TBD	Flooding	**HIGH**
Property Protection – Transformer Damage, No Power. Higher Elevation or Relocate Transformers	Public Works		TBD	Coastal Hazards	**HIGH**

The principles of floodplain management are fundamental to the proper mitigation of nuisance flooding in the Town of Ocean City, MD. Higher standards – such as freeboard elevation, redevelopment to meet current building codes, and public awareness, etc. – can be effective in mitigating the effects of both nuisance flooding and other major flooding events. Community level mitigation through beach renourishment, engineered dunes, seawalls and bulkheads have traditionally reduced risk for all properties.

Ocean City's HMP identifies four areas in which focus is directed regarding mitigation activity. These four areas include:

- Ensure that existing structures are resistant to flood-related damage,
- Create awareness of floodplain hazards and protective measures,
- Protect critical facilities, and
- Prepare/update/manage stormwater management solutions for various areas in the Town.

In addition to actions specified in the HMP, the NFP includes activities which Ocean City will implement or consider implementing to mitigate the impacts of nuisance flooding. These activities support the four areas of focus found in the Hazard Mitigation Plan. They also support recommendations and actions from Ocean City's Sea Level Rise Policy, and goals and strategies of the Comprehensive Plan.

- **Structural**
  - Enact floodplain ordinance or codes which mandate the use of freeboard to meet higher standards (CRS), and encourage neighborhood level design studies and projects.
  - Improve stormwater management infrastructure where possible and cost effective to more effectively convey water from flood-prone areas.
  - Conduct regular maintenance of drainage and stormwater control systems.
  - Implement green infrastructure solutions to meet adopted Critical Area requirements.
  - Identify street and structure elevation projects to mitigate the repetitive loss properties
- **Nonstructural**
  - Public Information
    - Communicate the risk and best management practices required to address nuisance flooding in non-emergency times to residents and businesses via mass mailings, social media, press releases, or automated phone calls.
    - Disseminate flood preparedness information to enable a safer and more aware public in the face of flooding.
    - Integrate nuisance flooding-related public messaging in Ocean City's existing public information plan and materials.
    - Conversion of current Elevation Certificates for existing structures to a searchable database with GIS data points for first floor elevation
  - Planning
    - Ensure Ocean City's NFP is kept up to date, referenced in the Hazard Mitigation Plan and incorporated into the Capital Improvement Plan with Stage Two implementation.
    - Schedule meetings of the Nuisance Flood Plan work group on an as-needed basis to address flood related issues and review plans
    - Provide annual report and update Town webpage
    - Maintain stormwater management planning and strengthen policies to reduce runoff and increase impervious surfaces.
    - Field data collection of first floor elevations for future study areas
  - Implementation
    - Educate and train Town staff on responsibilities under the NFP.
    - Encourage citizens and staff to participate in data collection using MyCoast/MD, manage MyCoast data as a pilot community
    - Coordinate efforts with Maryland Coastal Bays Program to enhance natural and nature-based features such as salt marsh, sea grass beds, and other shoreline protection resources that can reduce the impacts of flooding
    - Identify and propose code amendments that will assist with the long-term redevelopment of Ocean City and management of nuisance flooding
    - Actively promote pilot projects (Model Block, downtown redevelopment areas, neighborhood streets, ocean block pervious street paving, public infrastructure)

The Town of Ocean City, MD is a 'built out' community with significant investments in public infrastructure and private property improvement. The experience of senior staff and elected officials in directing this development over time should not be lost in creating new mitigation strategies for nuisance flooding. Selections from a recent article provide context for adopting any new strategies.

OC 'Simply Cannot Handle' Seven Inches Of Rain In Three Hours, City Engineer Explains

Jun 12,2018 by Shawn Soper

City Engineer Terry McGean this week explained the town's storm drainage system, which flows from east to west to outfalls along the bay, was inundated during the storm and simply couldn't keep up.

> "Ocean City is a barrier island, so that means we are very close to sea level, surrounded by water and flat," he said. "Plus, we are almost completely built out with very little pervious surface area left to absorb rainfall in the ground. What that means is that most of the rainfall runs directly into our storm drain system."

McGean said the natural topography on the narrow, 10-mile spit of sand makes it challenging to drain storm water efficiently during a major weather event.

> "The city ground and the storm drain system both drain from east to west into the bay," he said. "We use a gravity system to convey storm water. What that means is essentially the bigger the pipe and the steeper the slope, the more water you can move. Therefore, we are constrained by the ground elevation and the tide."

The relative flatness of the barrier island makes it difficult to get enough slope on the drain pipes that flow toward the outfalls on the bayside.

> "We are lucky to get a half of a percent in places," he said. "About the biggest pipe we can install at the highway end is 24 inches in diameter and we will double those up to increase capacity. In addition, fewer outfalls means more surface area has to drain to each outfall."
>
> "Our goal is to handle rainfall from a 10-year storm, or a storm that has a 10-percent chance of occurring in any given year," said McGean. "In our area, that equates to about one inch per hour during a three-hour storm duration, and quite frankly, we struggle to achieve even that and don't at high tide. Rain gauges in the north end of Ocean City registered seven inches in three hours on Saturday."

Essentially, the town does the best with the hydrology and topography it has to work with and when an epic rainfall event occurs, such as the one on Saturday, there is simply nowhere for all of the water to go.

https://mdcoastdispatch.com/2018/06/12/oc-simply-cannot-handle-seven-inches-or-rain-in-three-hours-city-engineer-explains/

Photo by Nicole Peterson from 136th Street

IX. Conclusion - Next Steps and Future Update

Ocean City, MD is a 'stage one' coastal community that is currently experiencing limited impacts from nuisance flooding. The Town manages its flood risk through a broad range of actions including:

1) Participation in the National Flood Insurance Program, adoption of the State Model Floodplain Ordinance, implementation of higher standards to qualify for Community Rating System Class 6
2) Partnering with State and Federal agencies for protection and enhancement of Maryland's Atlantic Coast shoreline with beach, dune, and seawall systems that reduce risk to the built environment
3) Managing a vibrant local economy based on natural resource recreation, tourism, and a strong real estate tax base to support Town services and infrastructure
4) Relying on many years of local knowledge, leadership and experience as a coastal community on a barrier island

New tools and best practices are available to help manage and monitor nuisance flooding impacts to the community. This Plan demonstrates the use of online flood mapping tools and MyCoast/MD to verify a baseline condition, explore the impact of future changes, and evaluate potential costs in property damage. By studying the best practices of other coastal communities, and working with State and Federal partners, Ocean City will continue to be prepared and prosperous.

So, is nuisance flooding still a nuisance? Yes, of course.

However, high tide events are usually short lived, risk for property damage is limited, and there are thresholds that direct action – both for individual property owners, and for Town government. Ocean City is already taking the necessary steps to meet the problem head on. The Nuisance Flood Plan will provide a tool to decide when new actions are needed.

NEXT STEPS

- ✓ The Town of Ocean City will monitor data made available by federal partners (NOAA, NWS USACE, FEMA), the State of Maryland, and other sources as it pertains to the community and local flood risks.
- ✓ These risks of increased nuisance flooding will be communicated appropriately to residents and decision makers and direct them to take appropriate action in the areas of emergency response and hazard mitigation.
- ✓ Elected officials and Town staff will utilize venues such as City Council, Planning Commission, and Emergency Management meetings to communication information on long-term flood risks.
- ✓ Future projections of sea level change and nuisance flooding will be integrated into land use planning, floodplain management, comprehensive planning, and capital investment planning.
- ✓ 5-year monitoring and updates will be incorporated into the Nuisance Flood Plan by October 1, 2025
- ✓ Ocean City will participate with affiliated organizations and local governments to share information and best practices.
- ✓ Specific recommendations for potential code revisions, best practices, pilot projects or capital improvements will be presented separately from the Nuisance Flood Plan for approval by the Mayor and City Council

To learn more about Nuisance Flooding and best practices from other coastal communities, visit the Town of Ocean City, MD website at: www.oceancitymd.gov

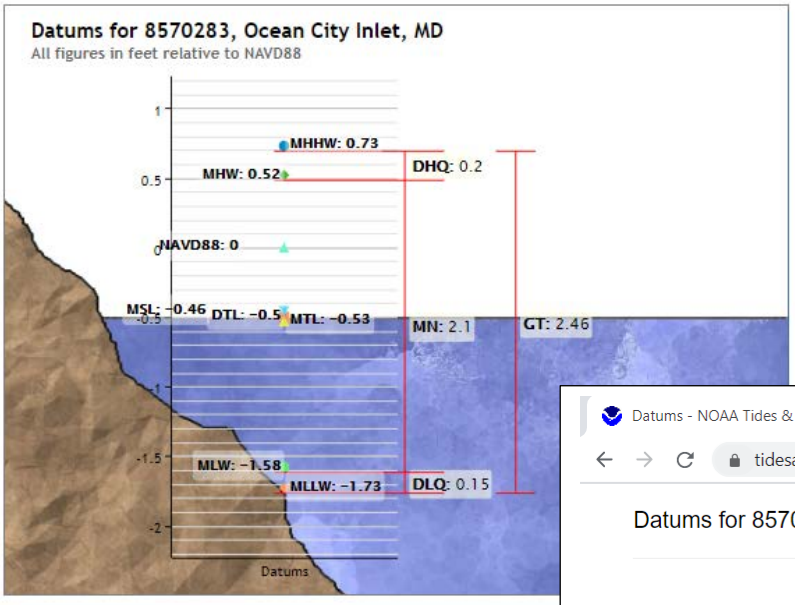
Appendix I

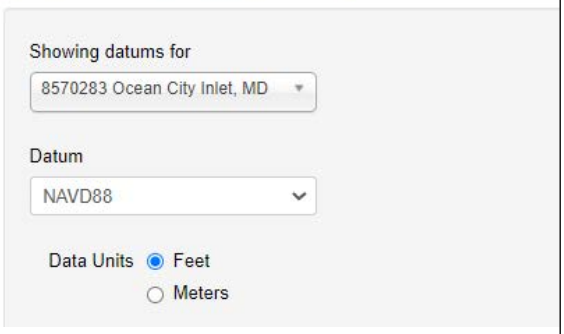
Town of Ocean City, MD
Nuisance Flood Plan Workgroup Members

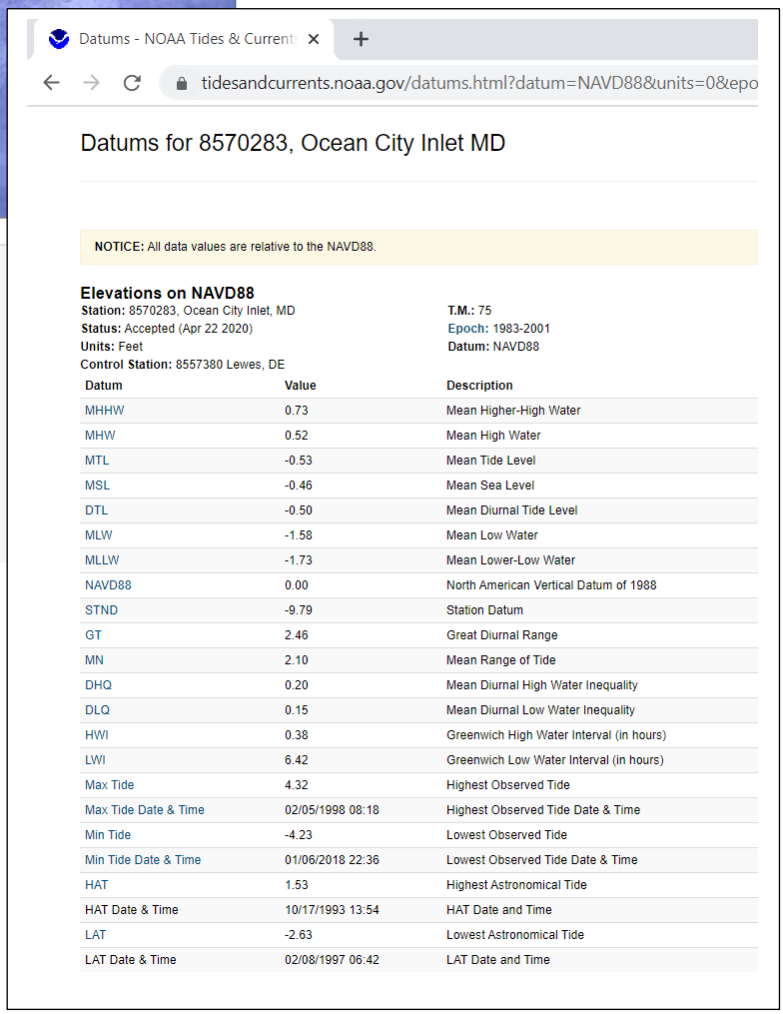
Name	Organization	Email	Dec 18	Feb 12	Apr 15	Jun 24	Aug 12
Tony Deluca	OC Town Council	TDeluca@oceancitymd.gov	✓	✓		✓	✓
Doug Miller	OC City Manager	DMiller@oceancitymd.gov	✓				
Bill Neville	TOC – Planning	BNeville@oceancitymd.gov	✓	✓		✓	✓
Jake Doub	TOC – Building	JDoub@oceancitymd.gov					
Terry McGean	TOC – Engineering	TMcgean@oceancitymd.gov		✓		✓	✓
Gail Blazer	TOC – Engineering	GBlazer@oceancitymd.gov	✓	✓		✓	✓
Hal Adkins	TOC – Public Works	HAdkins@oceancitymd.gov		✓			
Bob Rhode	TOC – Emergency Mgt	BRhode@oceancitymd.gov	✓				
Steve Farr	MD Coastal Bays Program	SFarr@mdcoastalbays.org	✓	✓		✓	
Melanie Pursel	Chamber of Commerce	Melanie@oceancity.org					
Susan Jones	Ocean City Hotel Motel Restaurant Assn	susanjones@ocvisitor.com					
Pat McLaughlin	Ocean City Development Corp	pat@eightyfiveandsunny.com	✓	✓			
Effie Cox	Worcester County Health Dept/Surfrider	Ecox3284@gmail.com					
Travis Brown	Worcester County Health Department	travis.brown1@maryland.gov					
Billy Weiland Kathy Phillips	Assateague Coastal Trust	billy@actforbays.org					✓
Ryan James	Mothers Cantina	Ryan@motherscantina.com	✓				
Mike Marvel	State Highway	MMarvel@mdot.maryland.gov		✓			
Karen Zera	TOC -GIS	kzera@oceancitymd.gov		✓			

Appendix II

Vertical Datum for Flood Mapping







Datum	Value	Description
MHHW	0.73	Mean Higher-High Water
MHW	0.52	Mean High Water
MTL	-0.53	Mean Tide Level
MSL	-0.46	Mean Sea Level
DTL	-0.50	Mean Diurnal Tide Level
MLW	-1.58	Mean Low Water
MLLW	-1.73	Mean Lower-Low Water
NAVD88	0.00	North American Vertical Datum of 1988
STND	-9.79	Station Datum
GT	2.46	Great Diurnal Range
MN	2.10	Mean Range of Tide
DHQ	0.20	Mean Diurnal High Water Inequality
DLQ	0.15	Mean Diurnal Low Water Inequality
HWI	0.38	Greenwich High Water Interval (in hours)
LWI	6.42	Greenwich Low Water Interval (in hours)
Max Tide	4.32	Highest Observed Tide
Max Tide Date & Time	02/05/1998 08:18	Highest Observed Tide Date & Time
Min Tide	-4.23	Lowest Observed Tide
Min Tide Date & Time	01/06/2018 22:36	Lowest Observed Tide Date & Time
HAT	1.53	Highest Astronomical Tide
HAT Date & Time	10/17/1993 13:54	HAT Date and Time
LAT	-2.63	Lowest Astronomical Tide
LAT Date & Time	02/08/1997 06:42	LAT Date and Time

Appendix III

Coastal Case Studies

A) Ocean City, MD – shoreline management, gray infrastructure reconstruction, tide gates
B) Toms River, NJ – street elevation, gray infrastructure reconstruction, house elevation
C) Norfolk, VA – 'living with water', street elevation, gray and green infrastructure
D) Annapolis, MD – stormwater system improvements

Ocean City, Maryland

Maryland's Atlantic Ocean Coast is defined by the 10-mile-long barrier island beach and resort town of Ocean City as well as the 22 miles of natural shoreline along Assateague Island National Seashore. Adapting to coastal storms since the Ash Wednesday Storm of 1962, Ocean City built a partnership with the US Army Corps of Engineers and the State of Maryland to protect significant community investments and mitigate the impact of high wind and flooding. The Town joined the National Flood Insurance Program in 1970 and the Community Rating System in 1991 to further implement higher protection standards for storm related flood impacts to the community.

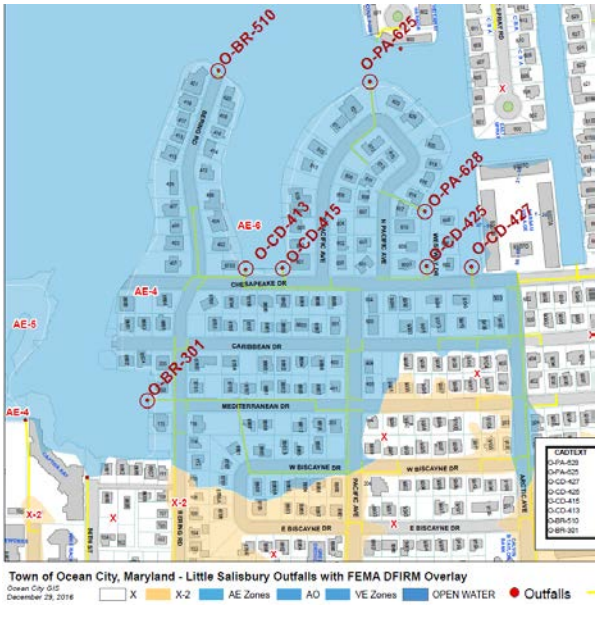
- **Ocean City adopted FEMA's RiskMAP in 2015 that recognized USACE dune protection reducing the SFHA by 50% and potential property damage by $900 million, CRS higher standards approved in 2017 for a Class 6 rating, OC continues to be a net contributor to the National Flood Insurance Program.**

Within this framework, Ocean City, MD joins other CoastSmart Communities in meeting the challenge of tidal nuisance flooding and intensive rainfall events that can overwhelm storm drain systems. Nuisance flooding (less than 1-foot depth) is occurring at least 4 days/year and typically along certain streets and sidewalks at the lowest elevations.

The Town of Ocean City, MD spends approximately $2.5 million annually for street paving through the Capital Improvement Program (63 miles of local streets in Town maintenance, 15 miles alleys, 4.4 square mile incorporated land area). Repairs and replacement for stormwater utility systems are completed incrementally through the annual repaving program. In addition, Hazard Mitigation Grant funds have helped to install 36 "Tideflex Checkmate" outfall check valves to limit bayside tidal flooding. Partnership with MD State Highway Administration and OC Public Works accomplished the first major storm drain cleaning project since 1985 after Hurricane Gloria, over a three-year period.

Mitigation Measures

- $100,000 annual Town budget allocation in FY20/21 for stormwater pipe cleanout in partnership with MD State Highway Administration
- $70,100 for Phase One tide gates (75/25)
- $118,323 for Phase Two tide gate (75/25)
- Bulkhead top elevation raised at or above BFE with any public project
- Street elevation/stormwater improvements of 65th Street, 46th Street and 1st Street
- Pervious surfaces, rain gardens, rain barrels, roof drain infiltration measures with all redevelopment
- 3-foot freeboard above BFE adopted (2015)
- Emergency Management warning, notice system for all storm/flood events



Stormwater outfall locations improved with check valves to reduce nuisance flooding, and tidal peak during base flood conditions.

Toms River Township, New Jersey

Toms River Township suffered more damage from superstorm Sandy than any other town in the State. In response, State agencies prepared a comprehensive coastal hazard mitigation strategy document called 'Sustainable and Resilient Coastal Communities'. This strategy linked the importance of a tourism-based economy with the need to make investments in mitigation projects.

Toms River Township is at risk from frequent tidal flooding, with media reports that nuisance flooding (less than 1-foot depth) was occurring at least 10 days/year and usually once a month, along certain streets. The Township spends approximately $3 million annually for street paving (400 miles of roadway in Town maintenance, 2,104 local streets, 42 square mile township area). In 2015, an $8.5 million bond was issued for street paving, repair of sewer lines and a pilot program to elevate certain streets. Engineering studies for the pilot program to elevate certain streets to 3.0 feet NAVD88 estimated the cost to be $4.5 to $5.0 million per mile. Total cost of $72 to $80 million for 16 miles of roadway would allow for improved access to 3,000 parcels.

Mitigation Measures

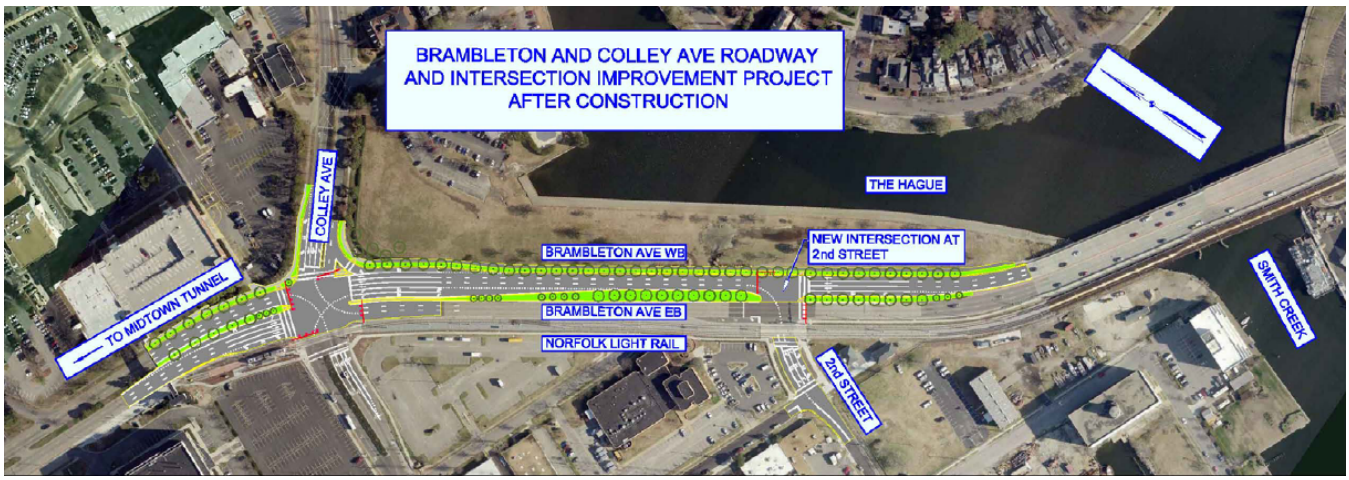
- $250,000 NJDOT grant for elevation of Washington Avenue and Creek Road
- $260,000 NJDOT grant awarded in 2017 for Bay Breeze Drive, Sea Breeze Road, Harbor Court, Harbor Drive, Canal Lane to elevate 2 feet above sea level – Estimated total cost of $1.17 million (grant 25 to 30% of cost)
- $475,000 NJDOT grant awarded in 2018 for elevation of Sixth Terrace, Harborside Drive and Spindrift Road
- Street Elevation Process
  - Engineering Department estimate
  - Grant award
  - Survey Road
  - Meet with Residents
  - Residents pick street elevation (typ. 12", 18" or 24")
  - Consultant prepares construction plans for preferred option
  - Signed right of entry forms
- Project funding with municipal capital improvement budget and state grants

Image from FloodIQ.com illustrating extent of frequent tidal flooding up to 1-foot depth

Study of Coastal Storm Risk Management from major storm events has also been underway with a USACE feasibility study for the New Jersey Back Bays. Recommendations for flood walls, levees, bay closures and other significant engineering projects are designed for protection from storm surge to elevation 13 feet NAVD88.

Elevating Roads in Norfolk, Virginia

The Norfolk, Virginia Department of Public Works invested $2.4 million in 2013-2014 to improve two waterfront streets, Brambleton and Colley Avenues, and reduce flood impacts. To reduce tidal flooding of the roadway the city elevated and widened a section of Brambleton Avenue and rebuilt the intersection of Brambleton and Colley Avenues. Brambleton Avenue is a principal artery in downtown Norfolk that runs along the Elizabeth River and crosses over an inlet called the Hague. The project was implemented to address recurrent flooding that was already occurring in the area, which had caused frequent road closures. At the time of initiating the improvement project in 2012, the area was flooding 2 to 3 times more frequently than it did in 1980, and was routinely flooded for 200 to 300 hours per year. The project was identified in Norfolk's Coastal Resilience Strategy as an example of structural projects that has successfully helped mitigate flood risk.



Norfolk is located in the Hampton Roads metropolitan region of Virginia along the Chesapeake Bay and is bypassed by two rivers, the Elizabeth and Lafayette rivers. The city has 144 miles of shoreline, including 7 miles along the Chesapeake Bay. The city is the home to the Norfolk Naval Station, one of the largest naval bases in the U.S. The Hampton Roads region is considered to be one of the areas in the U.S. most vulnerable to climate change impacts. Norfolk has a low-lying topography and land in the area is subsiding. Sea levels in the area have risen 1.5 feet over the past century and are rising faster than anywhere else along the East Coast. Some areas of the community already regularly flood at high tide, and the area is susceptible to coastal hazards such as flooding, erosion, hurricanes and nor'easters.

Prior to and concurrent with the implementation of the Brambleton Avenue project, multiple planning and assessment documents for Norfolk and the Hampton Roads region had examined long-term threats from sea-level rise and identified the need to adapt infrastructure, including roads. These efforts included the Hampton Roads region's long-range transportation plan, a federally-sponsored vulnerability assessment pilot project for the Hampton Roads Region, a Recurrent Flooding Study for Tidewater Virginia, Norfolk's 2012-2016 Capital Improvement Plan, and Norfolk's general plan updated in 2013 (known as "plaNorfolk 2030"), to name several.

Norfolk also invested in other projects to elevate roads and otherwise mitigate street flooding citywide, including a project to elevate a roadway over an inlet off Lafayette River near Haven Creek, at cost of $1 million, and the city budgeted additional funds to address street flooding citywide, considering cost-effective strategies to address sea-level rise and nuisance flooding.

More recently, the City of Norfolk participated in the former 100 Resilient Cities initiative, producing a Resilience Strategy, developed an additional element for plaNorfolk known as Norfolk Vision 2100, and completed a comprehensive update of its zoning ordinance with new overlay tools to ensure better protection of high-risk areas and to drive new development to lower-risk areas.

This Adaptation Clearinghouse entry was originally prepared with support from the Federal Highway Administration. This entry was last updated on June 12, 2020.

Publication Date: February 2014

Annapolis, MD

City Dock is an area located in the downtown historic district of the City of Annapolis that serves as an economic and tourist hub for the city. During high tides, City Dock experiences nuisance flooding, which inhibits tourism and business activities.

In 2009, there were nearly 60 reports of water on the roads and sidewalks, and 54 events in 2010 of standing water on the roads. In 2014, the National Oceanic and Atmospheric Administration (NOAA) released a report titled, "Sea Level Rise and Nuisance Flood Frequency Changes Around the United States," which identified Annapolis as the most significantly impacted city in America, with a predicted 925 percent increase from 2.8 events per year (1957-1963) to 39 events per year (2007-2013).

During these nuisance flooding events, tide water travels up the storm drain systems adjacent to City Dock, submerges underground storm drainage systems, and eventually comes out of drainage structures and onto the streets. High tides also overtop the existing bulkhead at areas along Market Slip, which results in overland flooding of nearby streets and businesses. Coupled with projected sea level rise, flooding events in the City of Annapolis are expected to continue to increase in frequency and severity.

The City of Annapolis is developing plans to deal with flooding at City Dock in a phased approach. The first phase seeks to mitigate nuisance flooding caused by high tide flowing upstream through the existing storm drain system and onto low points along adjacent streets. The next phase of the City's flood mitigation strategy will seek to protect this area from larger storm events and eventual sea level rise.

Mitigation Measures

- Regulatory response included code revisions to update flood elevations, adopt 2-foot freeboard for construction, floodproofing for commercial structures, minimum height for bulkheads, and backflow preventers in storm drain outfalls
- Raise perimeter bulkheads and piers to minimum established critical elevation for downtown City Dock area
- Install "Checkmate" storm drain backflow preventers on all outfall pipes
- Disconnect and divert higher elevation storm drain system, redirect lower storm drain system to 2 new pump stations
- Construct new wet wells, pumps and pump stations to collect storm water flows below critical elevation
- Design and expand system for 1 year, 10 year, up to 100-year storm events
- Projected 2017 cost estimate: $10.6 million plus annual maintenance and lifecycle costs

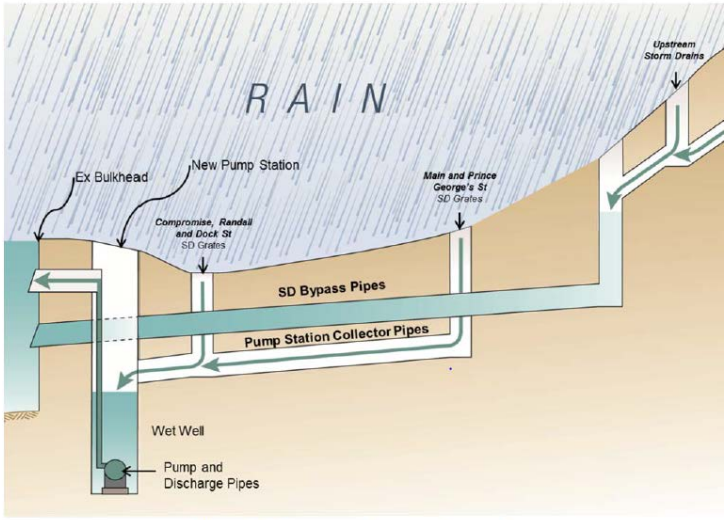


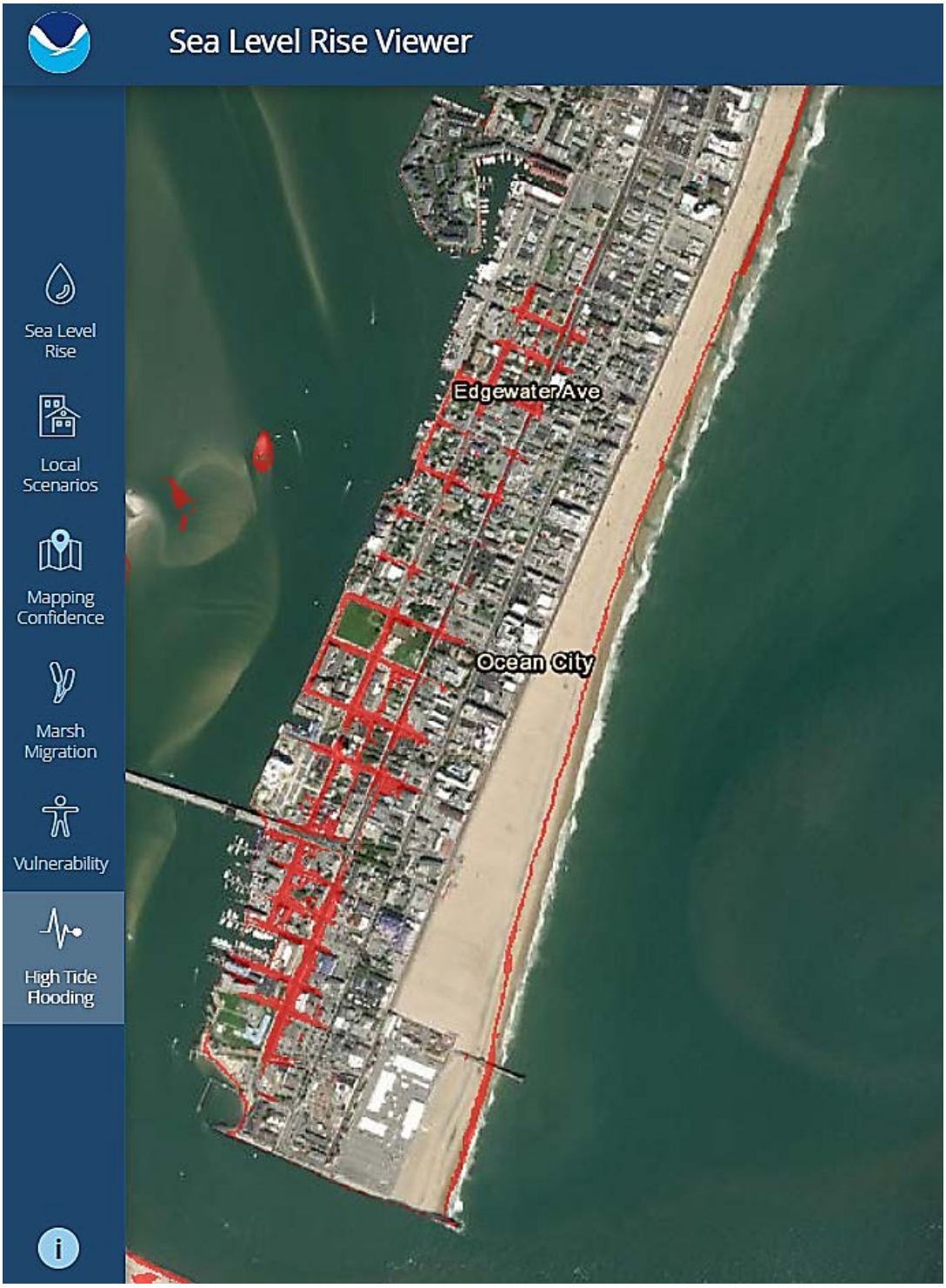
Figure 8: Proposed Concept Design Schematic

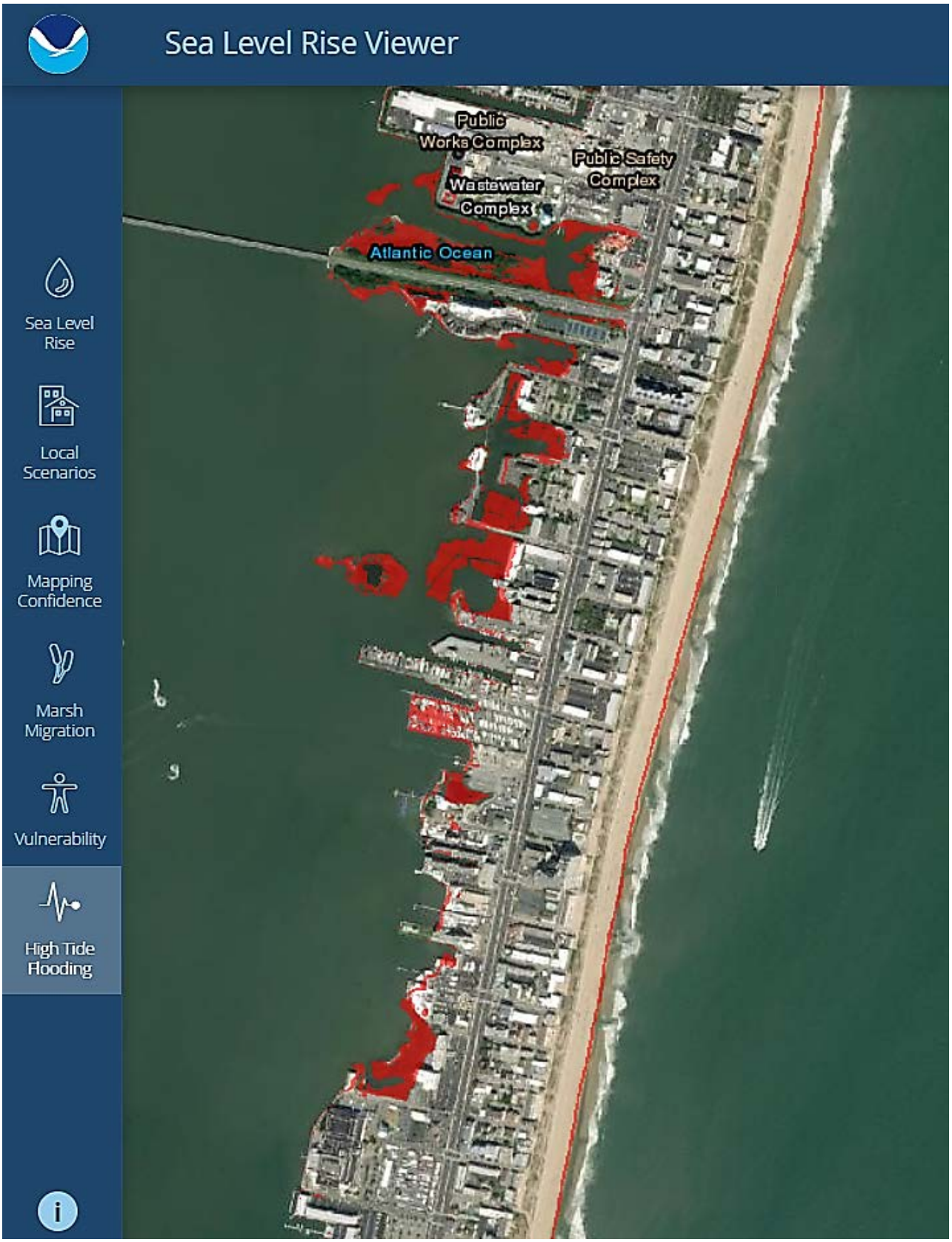
City of Annapolis, MD
Stormwater and Flood Mitigation, Engineering Design Services
Concept Design Report, AECOM Project Number: 60533093
May 2, 2017

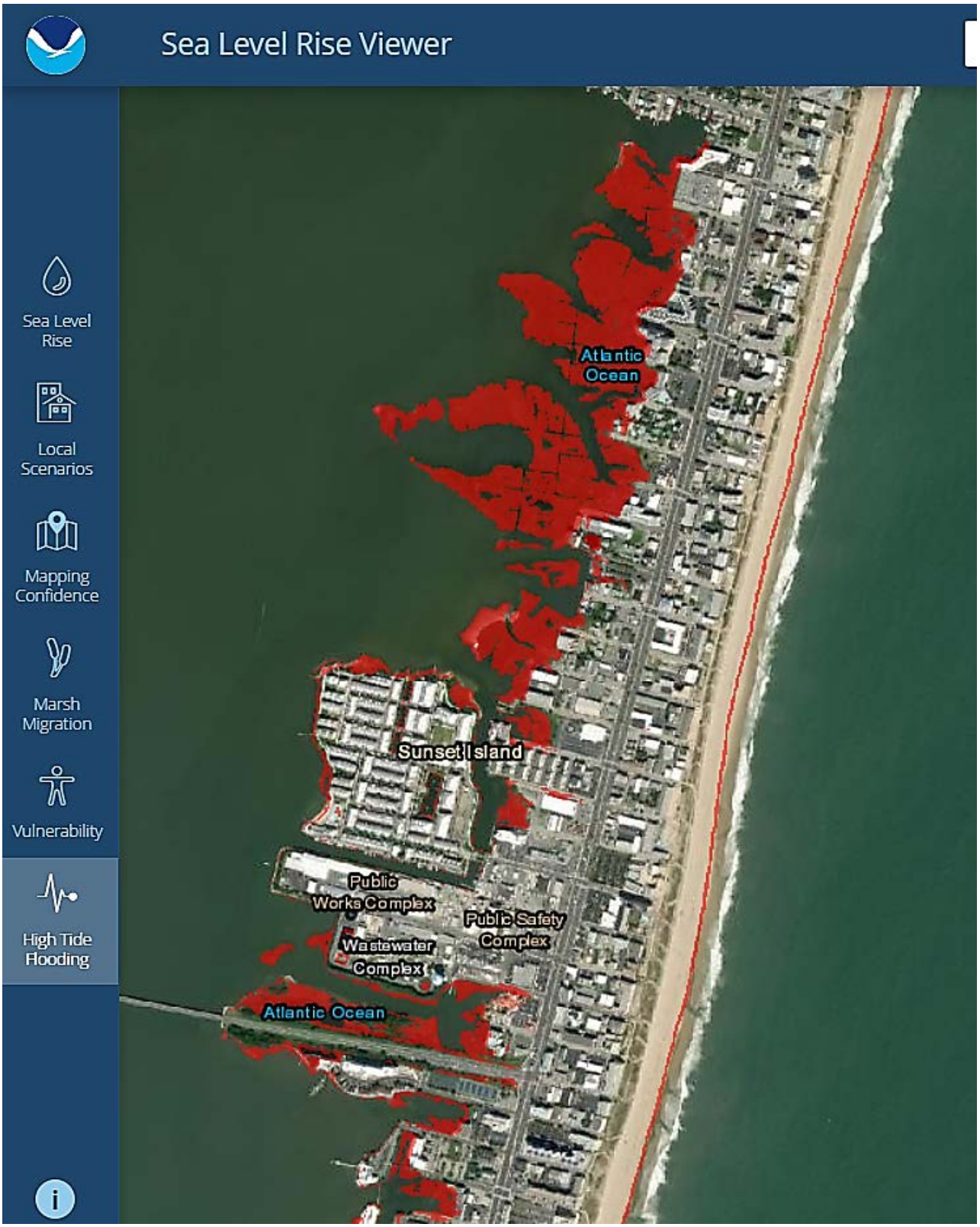
Appendix IV

Nuisance Flood Maps

Inventory of Known Flood Hazard Areas




Sea Level Rise Viewer
Public Works Complex
Public Safety Complex
Wastewater Complex
Atlantic Ocean
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding


Sea Level Rise Viewer
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Sunset Island
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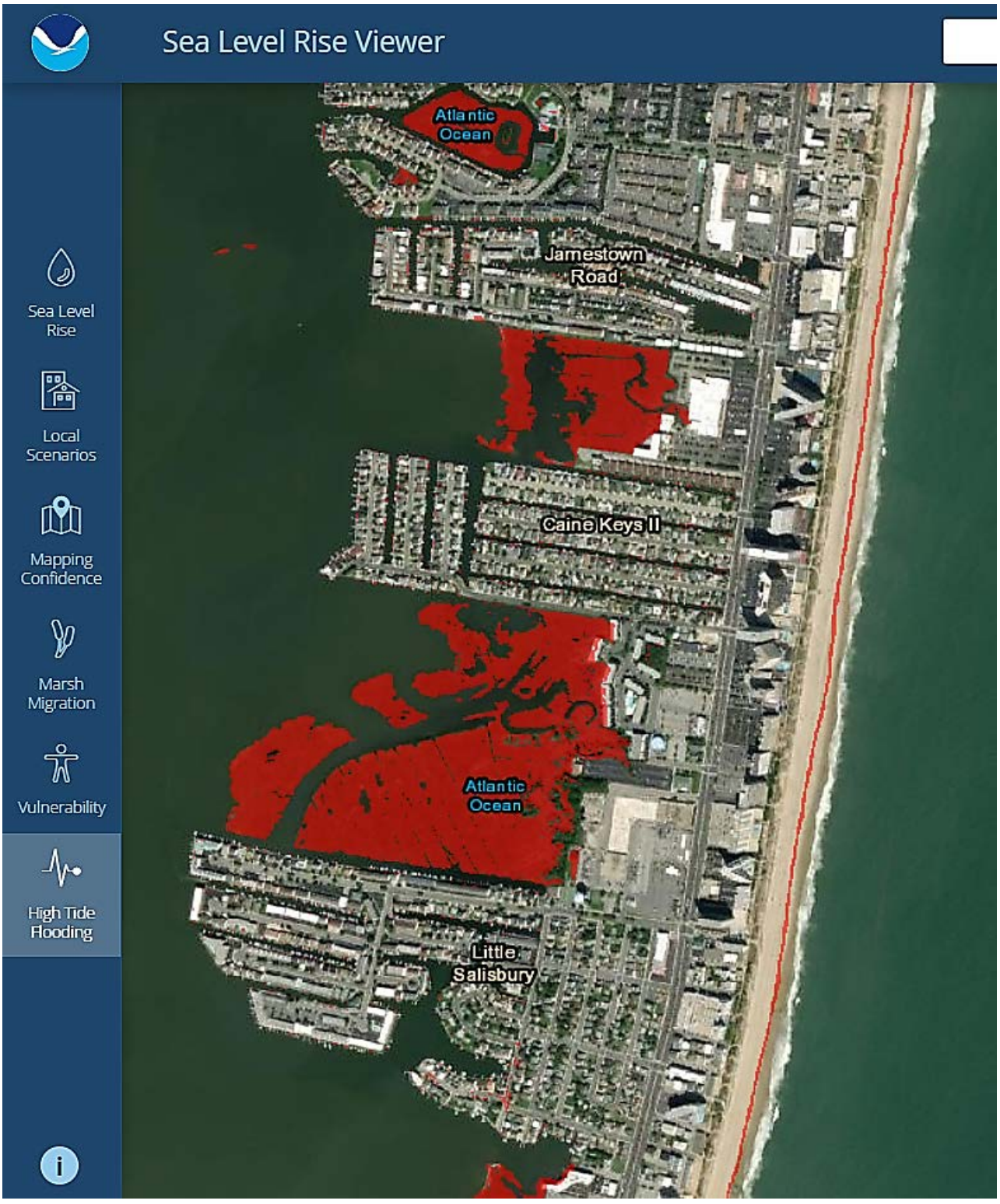
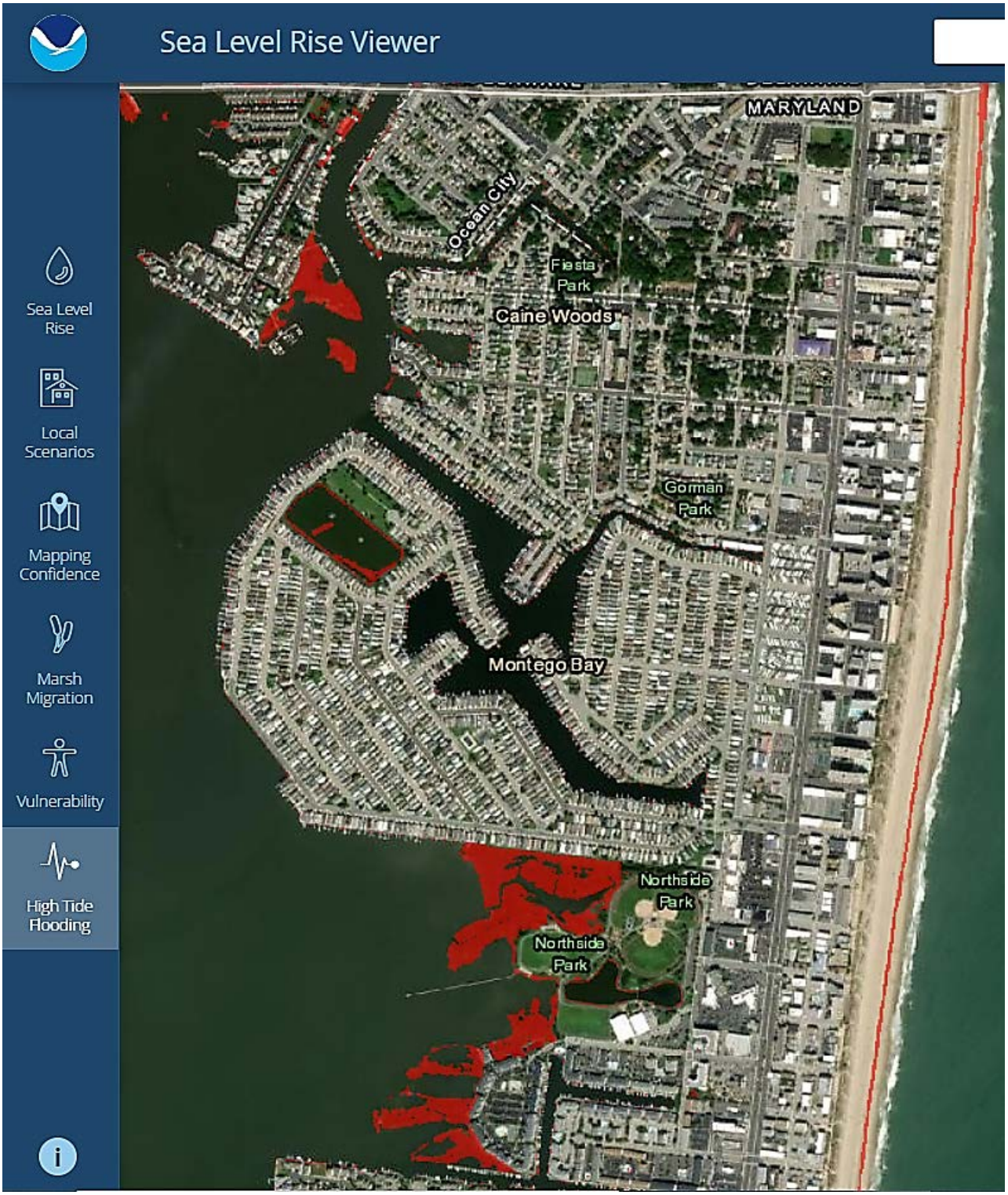
Public Safety Complex
Wastewater Complex
Atlantic Ocean


Sea Level Rise Viewer
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Atlantic Ocean
Jamestown Road
Caine Keys II
Atlantic Ocean
Little Salisbury


Sea Level Rise Viewer
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
MARYLAND
Ocean City
Fiesta Park
Caine Woods
Gorman Park
Montego Bay
Northside Park
Northside Park

Inventory of Known Flood Hazard Areas*

(based on NOAA Digital Coast illustration of current High Tide Flooding and Local Knowledge)
*Mitigation should be based on estimated future conditions

Location	Description	Flood Frequency	Flood Depth	Flood Duration	Extent
South Philadelphia Avenue/ Worcester Street	All directions	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Wicomico Street	All directions	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Somerset Street	North/South and West to Bay	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Dorchester Street	North/South and West to Bay	4x/year	<1 foot	2 to 3-hour tide cycle	Street, limited sidewalk area
South Philadelphia Avenue/ Talbot Street	North/South and West to Bay	6x/year	1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, parking area
St. Louis Avenue/ Somerset Street to Route 50 Ocean Gateway	North/South, West to Bay, East to S. Philadelphia Ave	6x/year	1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, parking area
St. Louis Avenue/ Route 50 Ocean Gateway to 4th Street	North/South, West to Bay, East to S. Philadelphia Ave	6x/year	1 to 1.5 feet	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard area
1st Street, 2nd Street, 3rd Street, 4th Street	West to Bay, East to Philadelphia Ave intersections	6x/year	1 to 1.5 feet	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard area
Edgewater Avenue/ 6th Street, 7th Street, 8th Street, 9th Street	North/South, Intersections	6x/year	1 to 1.5 feet	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard area
St. Louis Avenue/ 9th Street, 10th Street, 11th Street	North/South, East to Philadelphia Ave, Intersections	6x/year	1 foot	2 to 3-hour tide cycle, rainfall event	Street, limited sidewalk area
South Canal Street/ Hitchens Avenue and Trimper Avenue	All directions	6x/year	1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard area
Convention Center Drive	West to the Bay	4x/year	1 to 1.5 feet	2 to 3-hour tide cycle, rainfall event, wind	Street, sidewalk, parking area
42nd Street at the Bay	West to the Bay	4x/year	1 foot	2 to 3-hour tide cycle, rainfall event, wind	Street, sidewalk, parking area
45th Street Village	East of hotel	Unknown, new construction	<1 foot	Rainfall event	Parking areas
Middle Way Drive, 52nd Street/ Warren's Mobile Home Park	West of Coastal Hwy	4x/year	1 to 1.5 feet	2 to 3-hour tide cycle, rainfall event	Street, yard area, under mobile homes
56th Street to 60th Street/ Fagers Island	West of Coastal Hwy	4x/year	<1 foot	2 to 3-hour tide cycle, rainfall event, wind	Street, sidewalk, parking area

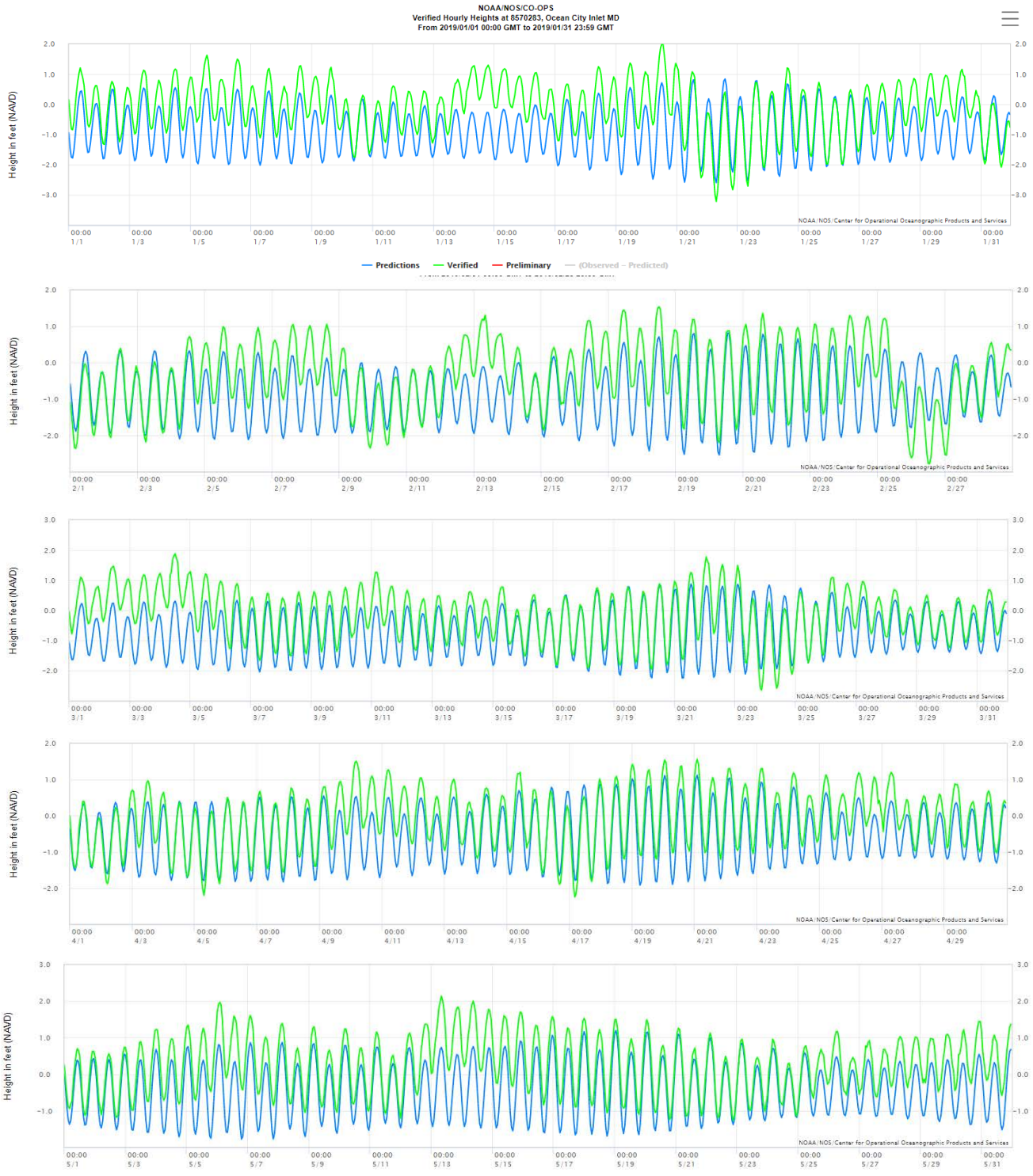
Route 90 Ocean City Expressway/ Coastal Highway MD 528	Right turn lane ramp connections southbound on Coastal Highway	6x/year	<1 foot	2 to 3-hour tide cycle, rainfall event	Street, crosswalks, limited sidewalk area
Coastal Highway MD 528 Northbound Lanes	Limited storm drain inlets to capture runoff from ocean block streets	6+x/year	1 foot	Rainfall events	Street, crosswalks, limited sidewalk area
64th Street, 66th Street west of Coastal Highway	West to Bay 65th Street elevated	4x/year	<1 foot	2 to 3-hour tide cycle, rainfall events	Street, limited sidewalk area
69th Street, 70th Street west of Coastal Highway	West to Bay	4x/year	<1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard areas
75th Street, 76th Street at the Bay	West to Bay	4x/year	<1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard areas
Bering Road/ Mediterranean Drive, Chesapeake Drive, Pacific Ave	Intersections	6x/year	<1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard areas
Bering Road/Chesapeake Drive/ Pacific Avenue	Street ext2 to 3-hour tide cycle, rainfall event ensions	4x/year	<1 foot	2 to 3-hour tide cycle, rainfall event	Street, sidewalk, yard areas
133rd Street, 134th Street, 135th Street west of Coastal Highway	Mobile Home Park	3x/year	1 to 1.5 feet	Rainfall event	Street, sidewalk, crosswalks, yard areas

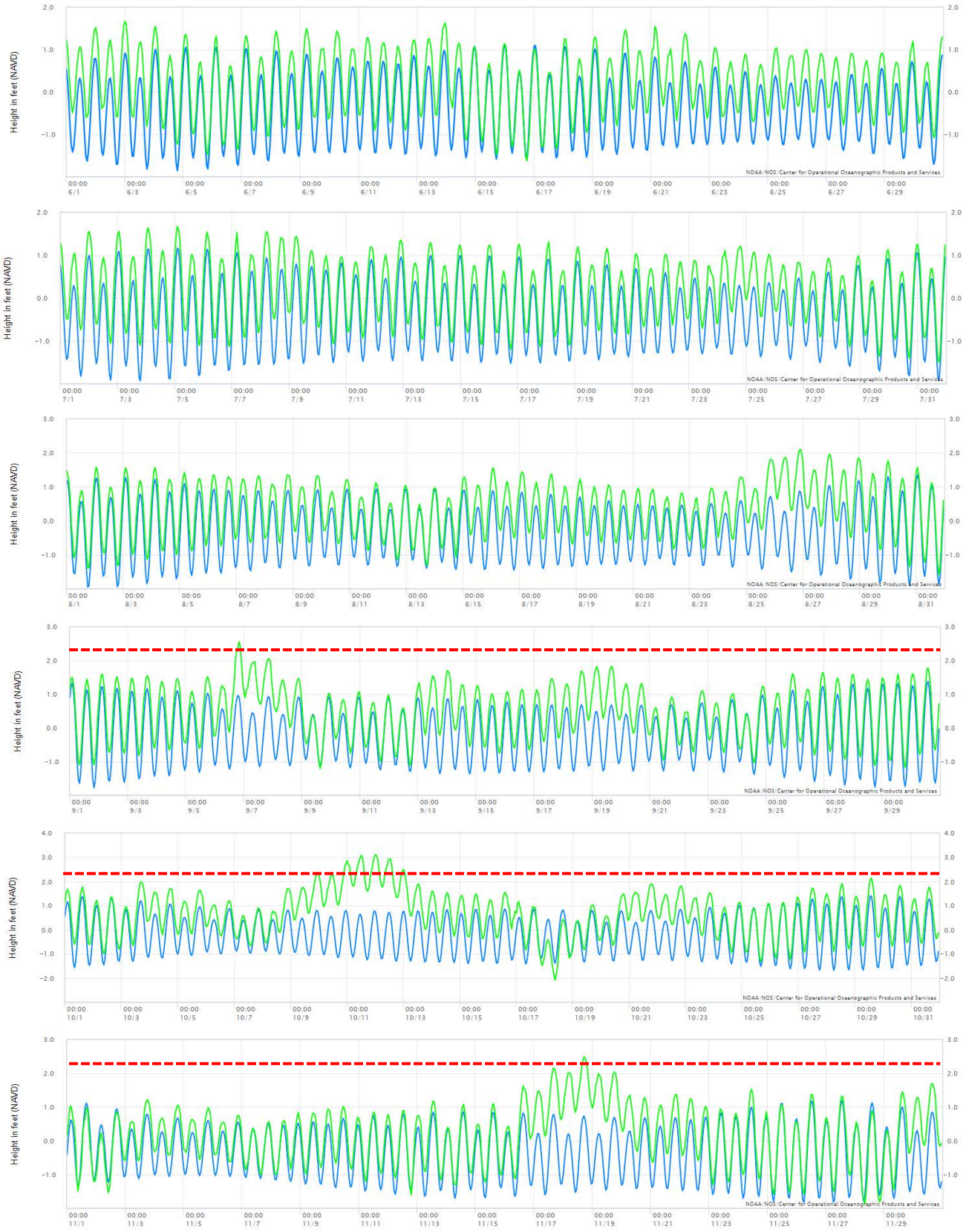
Appendix V

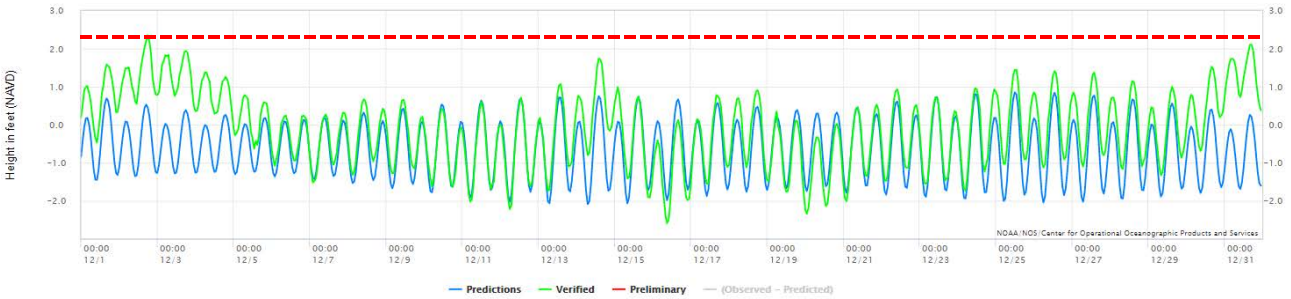
10 Year Flood Event Table and Tide Charts (2019)

NWS	Elevation (Feet above MHHW)	Elevation (NAVD)	Event Date	Event Type
Minor Flooding	4.03	2.30	8/16/2020	Coastal Storm
			8/4/2020	TS Isaias 1.23" Rainfall Wind
			7/10/2020	TS Fay 5" Rainfall Event
	4.02	2.29	4/4/2020	Coastal Storm
	4.10	2.37	12/2/2019	Winter Storm
	4.30	2.57	11/18/2019	Coastal Storm
	4.72	2.99	10/12/2019	TS Melissa
	4.89	3.16	10/11/2019	Coastal Storm
	4.85	3.12	10/11/2019	Coastal Storm
	4.64	2.91	10/10/2019	Coastal Storm
	4.32	2.59	9/6/2019	H Dorian 1.63" Rainfall
	4.27	2.54	10/27/2018	Noreaster
	4.06	2.33	10/12/2018	TS Michael
	4.58	2.85	9/9/2018	H Florence/Isaac/Helene
			6/9/2018	7.5" Rainfall Event
	4.01	2.28	3/21/2018	Noreaster
	4.35	2.62	3/7/2018	Noreaster, TS Riley
	4.09	2.36	11/8/2017	Winter Storm
	4.47	2.74	9/19/2017	TS Jose
			7/28/2017	1.76" Rainfall
			7/14/2017	Flash Flood 1.2" Rainfall
	4.04	2.31	5/26/2017	Thunderstorms
	4.63	2.90	1/23/2017	Noreaster
	4.34	2.61	9/30/2016	H Matthew
	4.05	2.32	9/6/2016	TS Hermine
	4.30	2.57	2/9/2016	Winter Storm
	4.87	3.14	1/23/2016	Winter Blizzard
	4.88	3.15	1/23/2016	Winter Blizzard
	4.72	2.99	10/2/2015	H Joaquin
	3.83	2.10	9/26/2015	H Joaquin
			7/27/2015	2.43" Rainfall Event
	4.91	3.18	3/6/2013	Offshore Wind Low Pressure
	4.41	2.68	11/8/2012	Noreaster
	4.18	2.45	11/8/2012	WS Athena
	4.03	2.30	11/7/2012	Noreaster
Major	6.05	4.32	10/29/2012	Superstorm Sandy
Moderate	5.48	3.75	10/29/2012	Superstorm Sandy
	5.06	3.33	10/28/2012	Superstorm Sandy
Minor	4.21	2.48	6/5/2012	Thunderstorms
	4.27	2.54	6/4/2012	Thunderstorms
	4.46	2.73	10/29/2011	Winter Storm
	4.69	2.96	8/27/2011	H Irene
Moderate	5.25	3.52	11/13/2009	H Ida
	5.01	3.28	11/12/2009	H Ida

Nuisance Flood Elevation at 2.3 feet NAVD88 vertical datum threshold




Height in feet (NAVD)
NOAA/NOS/Center for Operational Oceanographic Products and Services



Highest and Lowest Values

Station: 8570283 Begin Date: 20190101
Name: Ocean City Inlet, MD End Date: 20191231
Product: High/Low Units: Feet
Datum: NAVD Quality: Verified

Rank	Highest	Highest Date	Zone	Lowest	Lowest Date	Zone
1	3.12	20191012 00:24	GMT	-3.20	20190122 06:54	GMT
2	3.08	20191011 12:12	GMT	-2.83	20190226 12:30	GMT
3	2.98	20191012 12:18	GMT	-2.82	20190122 20:00	GMT
4	2.84	20191010 23:42	GMT	-2.66	20190123 07:48	GMT
5	2.51	20191118 17:24	GMT	-2.65	20190323 20:42	GMT
6	2.50	20190906 20:00	GMT	-2.63	20190226 00:06	GMT
7	2.48	20191013 00:00	GMT	-2.63	20190324 09:12	GMT
8	2.34	20191009 22:30	GMT	-2.59	20190227 00:30	GMT
9	2.30	20191202 18:00	GMT	-2.58	20191216 09:12	GMT
10	2.27	20191010 11:12	GMT	-2.45	20190121 19:30	GMT

NWS – mllw	FEMA – navd88
Action 3.5’	1.77’
Minor 4.0’	2.27’
Moderate 5.0’	3.27’
Major 6.0+’	4.27’