High-Tides and Flooding on Easy Street

A progress report and key findings

Prepared by:

Charles D. Larson, P.E.
Manager of Strategic Projects
Town of Nantucket

July 10, 2020

Introduction

Easy Street connects Candle Street to Lower Broad Street, along the edge of Nantucket Harbor and serves as an important transportation link between Steamboat Wharf and Straight Wharf. Easy Street is a single lane, one-way road that serves as the main artery for vehicles driving to the Steamship Authority ferry. The only other road at the Steamship Authority is Lower Broad Street, a one-way road leading away from the Steamship terminal. This makes Easy Street the only option for vehicles to arrive at the ferry (unless Lower Broad Street is made a two-way street in an emergency). Easy Street is also one of the only streets in the downtown providing direct access to the waterfront.

Easy Street can experience occasional high-tide flooding when water elevations in the Harbor exceed a certain threshold. Many of these recent events are non-storm related and are considered sunny-day flooding or nuisance flooding. Water elevations in the Harbor are driven by tidal influence and have a natural and expected range of variability. Easy Street is one of the first roads to flood because of its proximity to the water's edge, and is also one of the last roads to drain as flooding recedes.

Within very close proximity to Easy Street, there is a NOAA Tide Gauge that is continuously monitoring a range of weather and water conditions versus time. This information is available publicly at the NOAA website and electronic records exist back to 1965. These data are used for a range of scientific studies by NOAA and represent hyper-local data for the island. This information demonstrates that Sea-Level Rise (SLR) is happening on Nantucket.

To better understand the frequency and magnitude of flooding on Easy Street, observations of water levels and photographs were correlated to data from the tide gauge and elevation data. This report provides an overview of the investigation, demonstrates how SLR is impacting Easy Street, and provides recommendations for action.

Conditions Observed:

On several occasions, the high-tide flooding of Easy Street was observed and documented.

- Oct. 2, 2019, 3:55 PM, the confirmed water elevation was 1.1 feet MHHW. Photographs of the locations are shown in Figures 1 and 2, below. Rainfall in the previous 72 hours was recorded to be a total of 0.09 inches and is considered insignificant to the flooding observed on the roadway.
- Nov. 28, 2018, 4:04 PM, the confirmed water level was 1.65 MHHW. Photographs of this event are shown in Figures 3 and 4, below. Rainfall in the previous 48 hours was a totals 0.6 inches and seems unlikely as a contributor to storm water flooding on the roadway.

Coastal water elevations are referenced to a specific tidal datum which is defined in terms of a certain phase of the tide and water levels recorded in that specific area for 19 years (consisting of a tidal epoch). Multiple tidal datums exist for analysis and for this report the Mean Higher-High Water (MHHW) datum is used. MHHW represents the average of the higher-high water height of each tidal day observed during the tidal epoch. Elevation 0.0 feet MHHW is the average daily highest tide.

As a meaningful local reference for this measure, the top timber cap of Easy Street Bulkhead is set at 4.8 feet MHHW. It is also interesting to note that 4.3 feet MHHW (1991) is the highest recorded tide on record for Nantucket during the No Name Storm. The bulkhead was reconstructed by the Town in 2017, and the criteria used to establish the height of the timber cap is unknown. Also note that sea-level rise adds an additional 2.5 inches to the 1991 water level.

Figure 1, High-tide flooding on Easy Street at Oak Street on 10/2/2019 (15:55 local time)[1]

Figure 2, High-tide flooding on Easy Street at Broad Street on 10/2/2019 (15:56 local time)

[1] Photographs by C. Larson

Figure 3, High-tide flooding on Easy Street at Oak Street on 11/28/2018 (16:03 local time)[2]

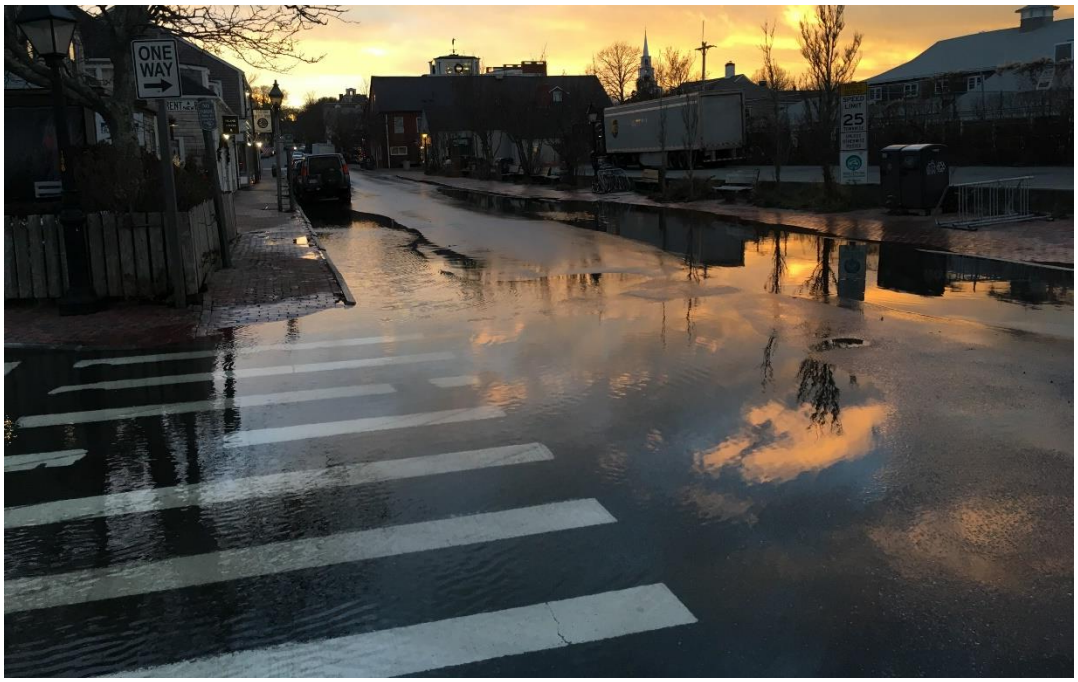

Figure 4, High-tide flooding on Broad Street at Easy Street on 11/28/2018 (16:04 local time)

[2] Photographs by C. Larson

Water elevations recorded by NOAA are shown in Figures 5 and 6.

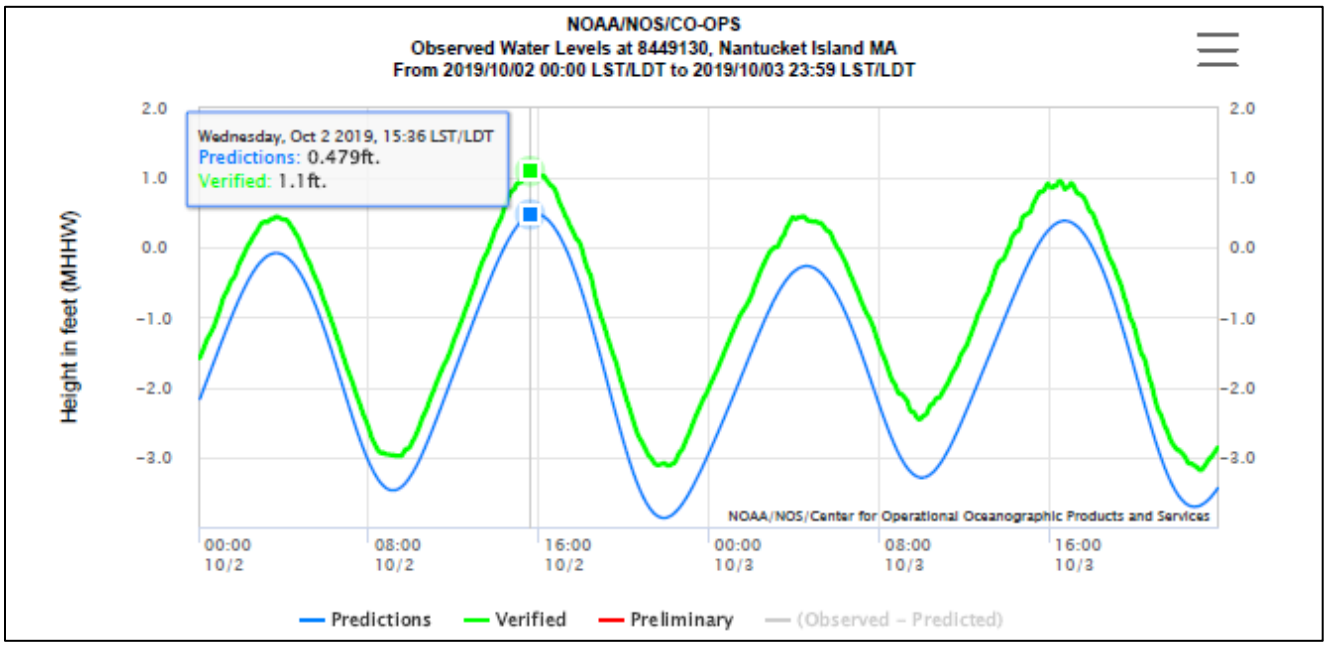

Figure 5, Water Levels Recorded for 10/2/2019 and 10/3/2019[3]

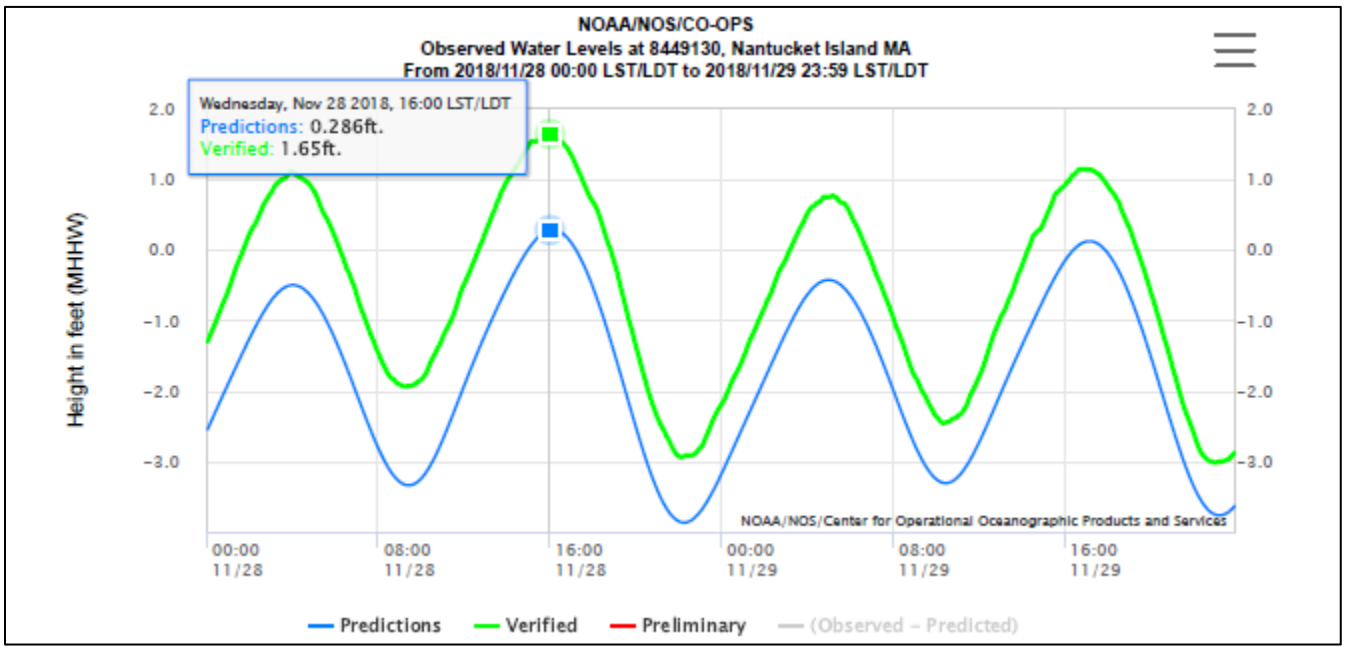

Figure 6, Water Levels Recorded for 11/28/2018 and 11/29/2018[4]

Water levels in the November 28, 2018 flooding event are approximately 6 inches deeper than the October 2, 2019 event. This difference can be seen in the photographs.

[3].https://tidesandcurrents.noaa.gov/waterlevels.html?id=8449130&units=standard&bdate=20191002&edate=20191003&timezone=LST/LDT&datum=MHHW&interval=6&action=

[4].https://tidesandcurrents.noaa.gov/waterlevels.html?id=8449130&units=standard&bdate=20181128&edate=20181129&timezone=LST/LDT&datum=MHHW&interval=6&action=

A simple illustration of high-tide flooding on Easy Street is shown in Figure 7[5].

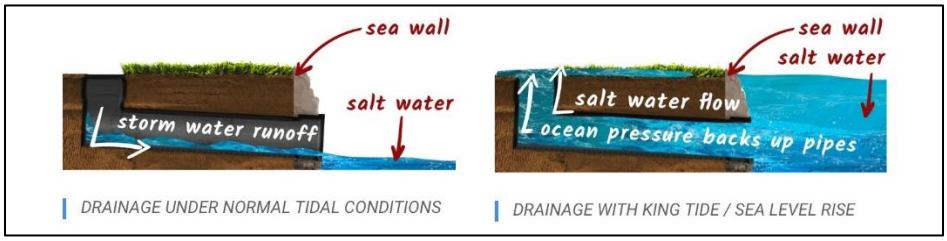

Figure 7, How High-tide Flooding Occurs

Research Questions:

1 How often do water levels cause flooding on Easy Street? What can be expected in the future?
2 What is the immediate problem causing roadway flooding and can something be done to fix it?

Data Analysis:

NOAA water level data for the Nantucket Harbor Tide Gauge were downloaded for the time period of January 1, 1980 through December 31, 2019, representing the last 40 years of available information. This data was summarized to produce Figure 8, showing the number of days per year that water levels were 1.1 feet MHHW or higher from 1980 through 2019. The 10-year average is also shown in Figure 8.

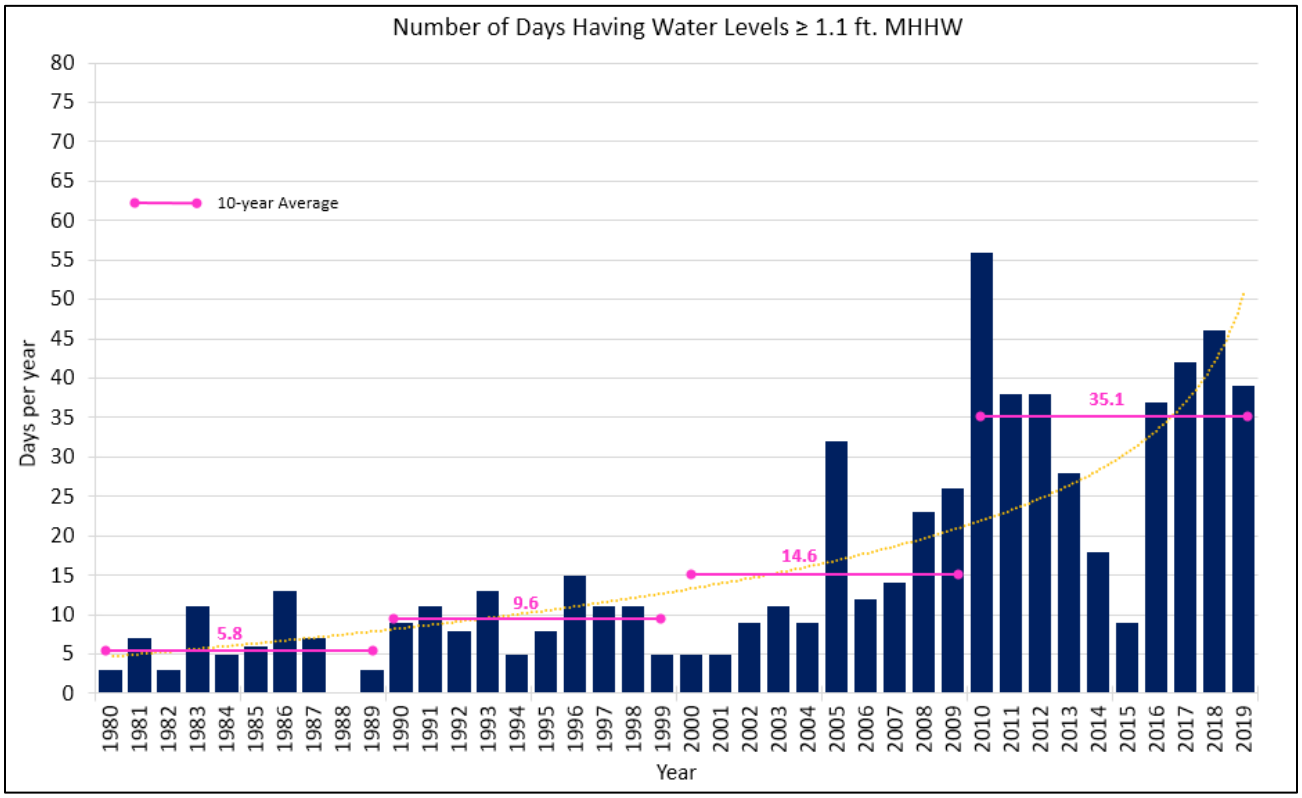

Figure 8, The Number of Days per Year with Water Levels at or Exceeding 1.1 feet MHHW

[5] www.sealevelrise.org

The long-term trend is clearly seen. The number of days with higher water levels is increasing in a pronounced manner over time.

- 1.1 feet MHHW occurred, on average, every 10 days in 2010-2019, an increase from an average of every 63 days in 1980-1989
- A six-fold increase in frequency in flooding occurred in the last 40 years
- The rate of change has been increasing in recent years
- A simple extrapolation of these data suggests this water level or greater may occur, on average, every week by 2030

Using additional information from NOAA and their sea-level rise projections:

- 1.2 ft. MHHW is the projected average highest daily high-tide in 2040 using the NOAA Intermediate SLR scenario
- Stated another way: In 2040, a water level of 1.2 ft. MHHW is expected to occur at least 180 days per year (i.e., on average every other day)
- NOAA has additional SLR scenarios for analysis of future tide levels based on GHG concentrations. The NOAA Intermediate-High scenario identifies 1.2 ft. MHHW in 2030 (essentially the impacts are expected 10-years sooner)
- Stated succinctly by NOAA, "Today's flood will become tomorrow's high- tide"

The same analysis was performed for the water elevation of 1.8 feet MHHW. This is a slightly higher elevation to the level of 1.65 MHHW shown above. 1.8 feet MHHW is an established NOAA Flooding Threshold for Nantucket[6]. The NOAA flooding thresholds were developed to provide a national definition of coastal flooding and impacts for quantifying and communicating risk. Shown in Figure 9:

- Minor flooding for Nantucket is 1.8 to 2.6 feet MHHW
- Minor Flooding is defined to have minimal or no property damage, but possibly some public threat. A FLOOD ADVISORY product is issued to advise the public of flood events that are expected not to exceed the minor flood category. Examples of conditions that would be considered minor flooding include:
    - no building flooded, but some water may be under buildings built on stilts (elevated)
    - personal property in low lying areas needs to be moved or it will get wet
    - water overtopping roads, but not very deep or fast flowing
- Moderate flooding is 2.7 to 3.9 feet MHHW
- Major flooding is 4.0 feet MHHW and higher

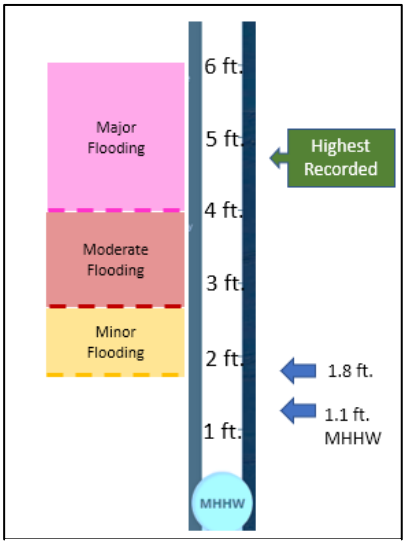

Figure 9, NOAA Flooding Thresholds for Nantucket

Figure 10 shows the number of days per year that water levels were 1.8 feet MHHW or higher from 1980 through 2019. The 10-year average is also shown.

Similar to the trends seen earlier, the number of days with higher water levels is increasing. 1.8 feet MHHW occurred on an average of 4.6 times a year for 2010-2019, a significant growth from an average of 1.8 times a year for 2000-2009, 1.4 times a year in 1990-1999, and just once in the decade preceding.

[6] NOAA Technical Report NOS CO-OPS 086, *Patterns and Projections of High Tide Flooding Along the U.S. Coastline Using a Common Impact Threshold, 2018.*

1.8 feet MHHW is the projected average highest daily high-tide in 2040 using the NOAA Intermediate-High SLR scenario (i.e., on average every other day).

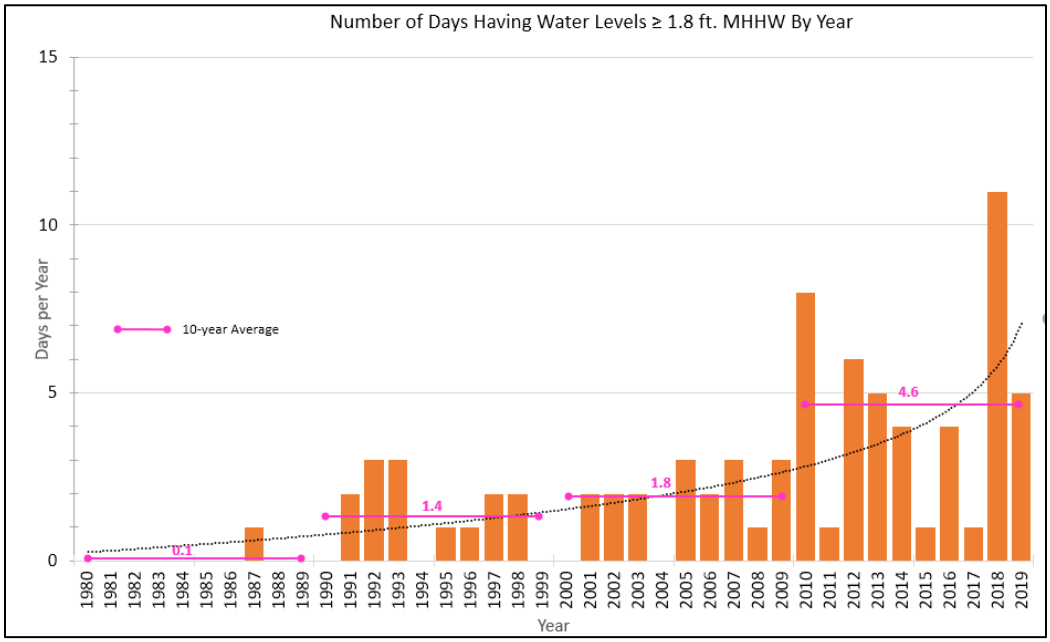

Figure 10, The Number of Days per Year with Water Levels at or Exceeding 1.1 feet MHHW

The impacts extend to areas beyond Easy St. and include properties, roadways and infrastructure at lower elevations. Figure 11 shows the areas impacted at 1.8 feet MHHW based on inundation modeling by NOAA[7].

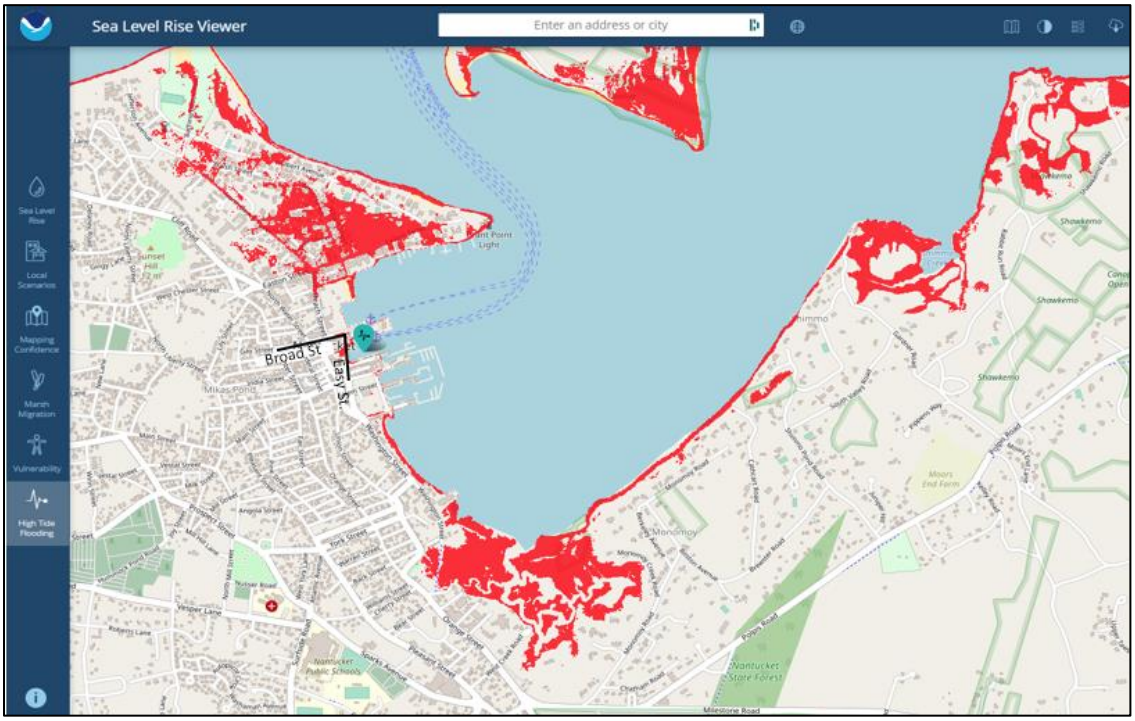

Figure 11, Areas with Flooding at 1.8 feet MHHW.

[7] https://coast.noaa.gov/slr/#/layer/fld/0/-7802972.396319044/5054219.157834657/15/satellite/16/0.8/2100/interHigh/midAccretion

NOAA has been monitoring sea-levels on Nantucket for decades. Figure 12 shows the monthly mean sea-level and data collected since 1965. The change from 1965 to 2018 represents 1.21 feet in 100 years.

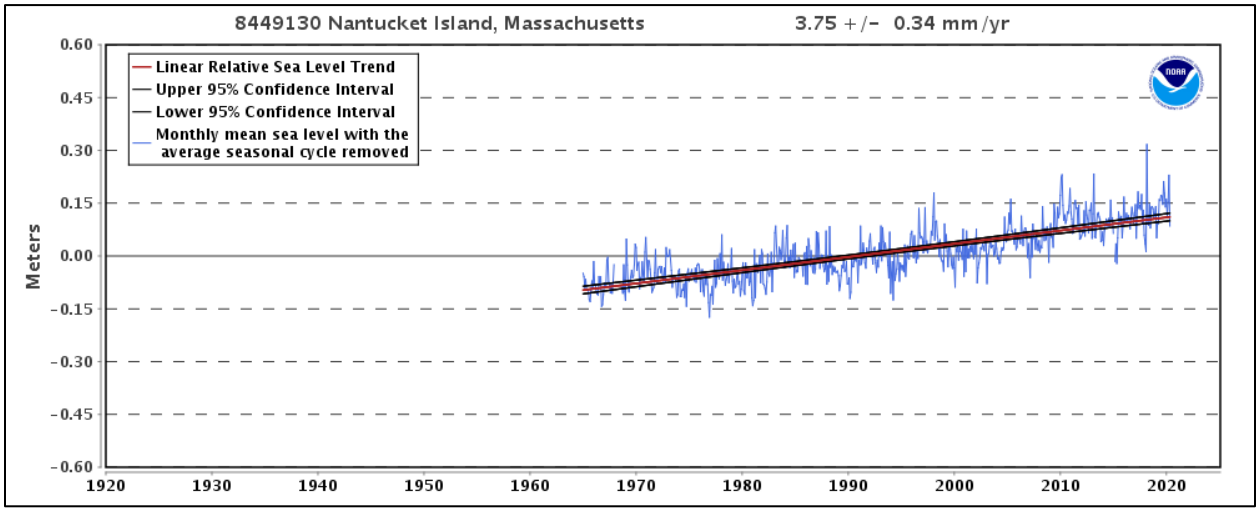

Figure 12, Nantucket's Relative Mean Sea-level the Trend Over Time

Findings for Question No. 1

- More frequent high-tide flooding has been observed and documented on Easy Street.
- 1.1 feet MHHW occurred, on average, every 10 days in 2010-2019, an increase from an average of every 63 days in 1980-1989.
- A simple extrapolation of these data suggests 1.1 feet MHHW or greater may occur, on average, every week by 2030.
- 1.2 feet MHHW is the projected average highest daily high-tide in 2030 using the NOAA Intermediate-High SLR scenario. Flooding at or above this level will occur every other day, on average.
- 1.8 feet MHHW, defined as Minor Flooding by NOAA, is the projected average highest daily high-tide in 2040 using the NOAA Intermediate-High Model. Flooding at or above this level will occur every other day, on average.
- Water levels of 1.1 feet MHHW causes a few inches of flooding on Easy Street and seems unlikely to present a serious issue for most roadway users. However, the frequency of flooding is expected to increase as described above. Increasing water depths and increasing frequency of flooding will likely impact future use of the roadway.

How Flooding Occurs on Easy Street

The roadway catch-basins and the storm water drainage system for Easy Street at Oak Street drains directly to Nantucket Harbor at the bulkhead. Backflow prevention valves were installed on the outfalls during the 2016 bulkhead construction project. The backflow valves were inspected in February 2020 and found to be deformed and deteriorated such that water at high-tide is able to backflow into the storm water system. Three outfalls were identified at the bulkhead and are shown in Figure 13.

Figure 13, Storm Water Outfalls and Check Valves at the Easy Street Bulkhead (2/13/2020)[8]

A closer examination of each valve is shown in Figure 14. The 12- inch diameter valve appears to have the largest amount of deformation and does not allow the valve to close to prevent backflow. Based on the available plans for the storm water system, the 12-inch diameter outlet is connected to the drains at the intersection of Easy Street and Oak Street. These are the locations with the flooding shown in Figures 1 and 3.

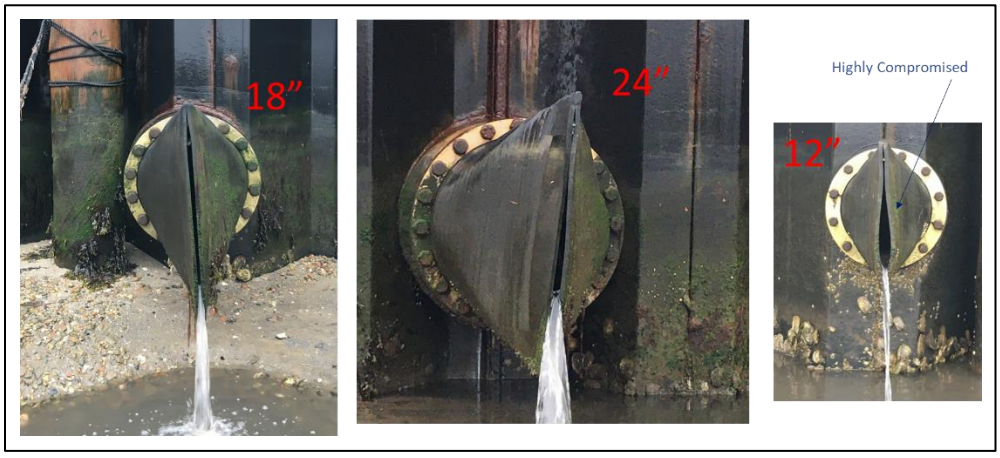

Figure 14, Visual Inspection of the ProFlex Check Valves at the Easy Street Bulkhead (2/13/2020)

Next Steps:

The valve manufacturer (ProFlex) and the regional distributor were contacted to discuss the problem. A representative of the manufacturer is willing to come on-site to evaluate the valves and determine if the manufacturer will provide replacements under warranty coverage.

[8] Photographs by C. Larson

The 2016 bulkhead project plans identify new ProFlex valves for these locations. The manufacturer's product brochure states: "All check valves are engineered in precise detail to ensure proper operation and will provide years of unhindered operation and trouble-free service." Given this information, a 5-year service life for Nantucket seems unusually low.

Plans for an on-site meeting with the manufacturer and local distributor was scheduled for March 2020. Precautions and travel restrictions due to COVID-19 have delayed the ability to have this meeting. Based on current trends and re-opening of the Island, it seems likely the site visit may occur in August or September 2020. After that meeting, the recommended strategy for replacement of the valves can be identified. As a likely worst case, the Town can purchase the replacement valves and install them using in-house or contracted resources in the fall of 2020.

It is possible that newer designs and/or better materials could be used for replacement. Several municipalities and an engineering firm have been contacted for information concerning their experience with these backflow products. Most recommendations lean toward staying with the same product and the current manufacturer due to their experience in the market. There is an option to consider another well-respected manufacturer that supplies this type of product. This investigation is ongoing.

Flooding on Lower Broad Street at Easy Street

Information reviewed for the storm water system draining lower Broad Street indicates that the roadway drainage is routed to a different outfall that is located in the harbor north-west of Steamboat Wharf. The outfall was not easily accessible and was observed to not have backflow prevention installed. Additional work to address this situation is beyond the scope of this report and should be pursued as a separate engineering project.

Findings for Research Question No. 2

- The immediate problem causing roadway flooding on Easy Street at Oak Street is attributable to the deformed and defective backflow devices for the outfalls at the bulkhead.
- The situation can be improved by replacement of the backflow devices.
- As sea-levels continue to rise, there will be a point in time in which backflow devices may not remain effective at stopping backflow. It is also likely that water levels that exceed the elevation of the street may find other paths to the roadway surface.
- Longer-term solutions should be considered knowing that water levels are rising. Options may include elevating (protecting) the roadway, adapting use of the roadway to more frequent flooding, and/or relocating the access route to Steamship Wharf.
- Flooding on lower Broad Street at Easy Street is found to be caused be a storm water outfall that has no apparent backflow device. This needs further investigation.