



# RESILIENT NJ

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## RARITAN RIVER AND BAY COMMUNITIES

**FLOOD IMPACT ASSESSMENT**

*DRAFT - JULY 2022*

IMAGE CREDIT: UNGVAR VIA ADOBE

# SHARE YOUR FEEDBACK ON THIS DRAFT REPORT

PLEASE SHARE YOUR THOUGHTS USING THIS FORM:  
<https://forms.office.com/r/aTM3mWXvPK>

We share progress and ask for comments to make sure the project is on the right track. The [About Our Region report](#) (released spring of 2021) described key features of the region and its municipalities that are important to understand when planning for reduced flood risk and better quality of life in the future. This [Vision and Priorities draft report](#) summarizes what we have heard from people so far. The project team will bring your input on this report into the final action plan.

Please visit our website at [www.resilient.nj.gov/rrbc](http://www.resilient.nj.gov/rrbc) to learn more about the project and what we've done so far. We also welcome you to share your thoughts on the broader project:

- By email: [ResilientRRBC@dep.nj.gov](mailto:ResilientRRBC@dep.nj.gov)
- By hotline voicemail: 732-661-3808
- By social media: Twitter and Facebook: @Resilient\_RRBC
- Through our website: [www.resilient.nj.gov/rrbc](http://www.resilient.nj.gov/rrbc)
- Through the Irys app (download through Apple App Store or Google Play Store)



FEEDBACK FORM [www.renewjerseystronger.org](http://www.renewjerseystronger.org)

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# 01 - INTRODUCTION

# ABOUT RESILIENT NJ

Resilient New Jersey (RNJ) is a regional planning program that brings together resilience experts, local leaders, community organizations, residents, and regional infrastructure entities to discuss storm and flood-related issues and develop effective solutions to reduce flood risk and build resilience. The program is administered by the New Jersey Department of Environmental Protection (NJDEP) and funded by the U.S. Department of Housing and Urban Development (HUD).

## WHAT IS RESILIENCE?

*Resilience is the ability to adapt to changing conditions and grow in the face of challenges. In the context of flooding, we mean shaping communities that have strong social fabrics and infrastructure that can bounce back after storms and adapt to changing climate conditions.*

### RESILIENT NJ RARITAN RIVER AND BAY COMMUNITIES

VISION AND PRIORITIES  
DRAFT - JANUARY 2022

## RARITAN RIVER AND BAY COMMUNITIES' MISSION STATEMENT:

*The mission of Resilient Raritan River and Bay Communities (Resilient RRBC) is to create a watershed-based plan with a clear vision and roadmap for flood risk reduction, resilience, and environmental restoration to help the multi-municipal region survive and thrive. Plan development will employ the best available data and will engage stakeholders to identify social, environmental, and economic benefits and bring value to all who will share in the region's future.*

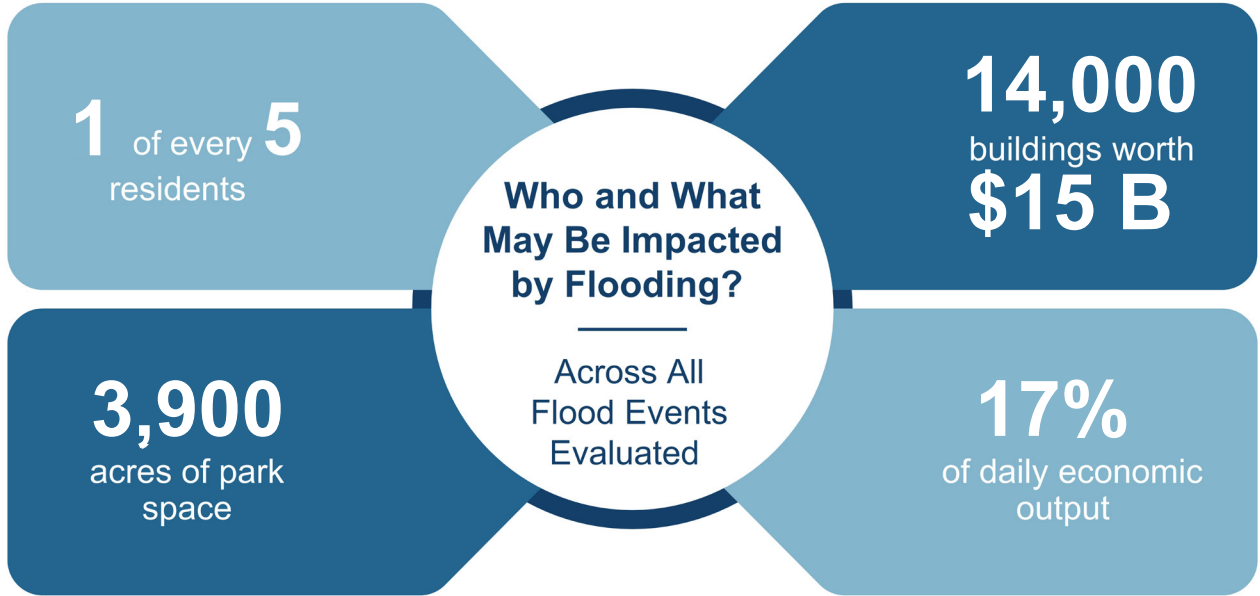
Resilient RRBC will develop a plan to address current and future flooding that builds toward long-term social, economic, and physical resilience. To do so, the Resilient RRBC team, community members, agencies, and others who have a stake in the region should understand where flooding occurs, how severe it is, and how it will change in the future. Through Resilient RRBC, Middlesex County has partnered with the municipalities of Carteret, Woodbridge, Perth Amboy, South Amboy, Sayreville, South River, and Old Bridge, as well as the YMCAs of Middlesex County.

# EXECUTIVE SUMMARY

The Raritan River and Bay Communities region is home to approximately 310,000 residents, 76,000 jobs, and numerous transportation and environmental assets of regional importance. Together the municipalities of Carteret, Woodbridge, Perth Amboy, South Amboy, Sayreville, South River, and Old Bridge are part of an interconnected and vibrant region that, in many ways, has always been defined by its relationship to the Raritan Bay, the Raritan River, and other waterbodies. Historically, these waterways provided opportunities for commerce and supported the growth of local manufacturing. More recently, the proximity to water is seen as a recreational amenity, and the region's waterways have attracted new development. However, as Hurricanes Sandy and Irene and the more recent flood events of summer 2021 have demonstrated, the proximity to water also presents a threat — one that will increase with climate change.

The Resilient New Jersey (RNJ) program, in conjunction with other actions of individual municipalities, the county, and state agencies, proves that this region is taking these impacts seriously by developing strategies to reduce future impacts and build resilience to future storms. These steps are critical given the scale of future flood impacts on the region's residents, businesses, and infrastructure.

While flooding will impact people of all types across the region, those with fewer resources or additional vulnerabilities face additional hardships. Lower income households with less savings are more vulnerable when faced with losing income. A history of exclusionary policy has inequitably distributed



resources so that African-American and Latino communities are disproportionately vulnerable to flooding. There are also specific communities such as the elderly or those with disabilities, that are less able to evacuate. These impacts and vulnerabilities demonstrate the ongoing need to prepare for and adapt to the realities of flooding and climate change.

**This Flood Impact Assessment summarizes what will likely happen if nothing is done to protect the region from current and future flooding. It builds on work summarized in the About Our Region and Vision and Priorities reports to achieve the following:**

- *Identify who and what is in the region*
- *Evaluate exposure to current and future flooding*
- *Qualitatively and quantitatively measure the impacts of flooding experienced by the community*
- *Provide a framework to understand the consequences of those impacts*
- *Outline next steps to develop solutions that reduce flood impacts in the region*

## KEY FINDINGS OF THE IMPACT ASSESSMENT

*By 2070, a heavy sustained rainfall event could cause \$4.9 billion in losses. Woodbridge and Perth Amboy face the highest risk with \$1.5 billion and \$700 million in losses respectively.*

*By 2070, a coastal storm like Hurricane Sandy could cause \$2.8 billion in losses. Woodbridge and Carteret face the highest risk with \$900 million and \$700 million in losses respectively.*

*By 2070, 32 structures and 44 residents will be impacted by daily tidal flooding. Compared to other flood types, tidal flooding will only impact a small geographic area within the region—largely concentrated in Carteret, South River, and Sayreville. In these areas, flooding may occur multiple times a day, making the area largely unlivable if actions are not taken to prevent flooding.*

This flood impact assessment describes the different sources of flooding, the different events used to represent current and future flooding, and how those events can be used to represent what may be affected flooding now and in the future. This assessment presents how the potential effects of flooding can be measured as estimated monetary damages, as well as by looking at the types of assets that will be impacted by flooding. The results of this report are presented regionally, by watershed (or areas where rainfall drains to the same point), and by municipality.

Results presented in this report have informed action plan development by helping to determine where and when actions should be taken to reduce flood risk. The results also help determine which actions are best suited for the region at different scales – from municipalities, to focus areas, to the region at large. The structure of this report starts at the highest level, summarizing findings at the regional scale, before honing into focus area and municipal-level consequences of flooding.

This impact assessment evaluates exposure of assets in RRBC to six different flood events. Unlike a risk assessment, an impact assessment considers likelihood of flooding in general terms and discusses storm events relative to storms that were experienced recently in the region. It does not calculate probability. As a result, flood events that happen more frequently (like high tide flooding) have much lower reported damages than larger, less frequent events (like large coastal storms). When reviewing the results, it is important to remember that, over time, more frequent flood events may pose a greater cumulative threat to the community, because they will cause harm more often. Throughout this report, the terms “risk” or “at risk” are used to describe when something is exposed to danger.

This report summarizes the potential monetary losses that are possible as a result of six different flood events, representing both current and future conditions. The results are categorized by structure type, community relevance, and location. Understanding what is happening, where damages are occurring, who will experience disruption and loss, and when these events could occur demonstrates why it is important to mitigate flood risk and helps



# ACRONYMS & DEFINITIONS

- ATSDR – Agency for Toxic Substances and Disease Registry
- CDC – Centers for Disease Control and Prevention
- FEMA – Federal Emergency Management Agency
- HUD – Housing and Urban Development
- MCUA – Middlesex County Utilities Authority
- MHHW – Mean Higher High Water
- MHW – Mean High Water
- MSL – Mean Sea Level
- NAVD88 – North American Vertical Datum of 1988
- NFIP – National Flood Insurance Program
- NJDEP – New Jersey Department of Environmental Protection
- RNJ – Resilient New Jersey
- RRBC – Raritan River and Bay Communities
- SVI – Social Vulnerability Index
- USACE – United States Army Corps of Engineers
- PVSC – Passaic Valley Sewerage Commission
- SLR - Sea Level Rise
- SVI – Social Vulnerability Index
- USACE – United States Army Corps of Engineers
- WWTP – Wastewater Treatment Plant

## Flooding Terminology

- 100-year Flood** – A commonly used term often referring to a 1 percent annual chance event. This terminology is misleading, as it implies that this sized event should only happen once every 100 years, which is not the case. Today’s 1 percent annual chance event has nearly a 40 percent chance of occurring at least once in the next 50 years.
- Annual Exceedance Probability** – The annual exceedance probability is the probability that a flood or rainfall event of a given size might be met or exceeded in any given year. It is based on long-term statistics of observed storms in the area.
- Areal Flooding** – Flooding caused by a wide-spread event that may not drain for a longer period. In this assessment, it is modeled as 8.7 inches in 24 hours for current conditions and 9.6 inches in 24 hours for future flooding. This represents a longer sustained rainfall event.
- Flash Flooding** – Flash flooding occurs due to a short duration, high rainfall period. In this assessment, it is represented by 3.2 inches of rainfall over 2 hours for current conditions and 3.5 inches over 2 hours for future flooding.
- Future Flooding** – In this assessment future flooding represents potential future conditions that may occur by 2070; however, due to changing understanding of the rate of climate change, this may occur sooner. This future scenario incorporates both sea level rise and increasing rainfall into the appropriate flood scenarios.
- Present Day Flooding** – In this assessment, the present day is represented by conditions in the early 2020’s. These conditions include population, building and land use types, and assessed values.

## Impact-related Terminology

- Critical Asset** – Critical assets are essential for a community to thrive. They include buildings, infrastructure, or spaces that host community events. Assets can include places where people gather, build relationships, and enjoy themselves.
- Prioritized Asset** – Prioritized assets are critical assets exposed to flooding which rank higher than other assets of a similar type. A high ranking indicates more exposure to flooding or a larger impact on the community if flooded.

## Other Terminology

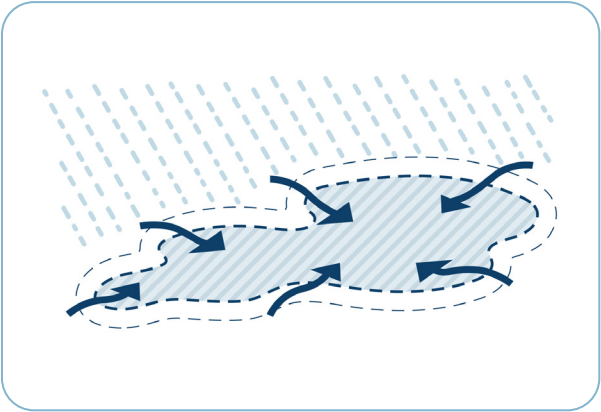
- Focus Area** – Subdivisions of the region identified to support technical assessment and implementation planning. The focus areas are based on local sub-watersheds and land uses.
- Watershed** – A watershed can most easily be thought of as an area within which, wherever water falls, it will all eventually flow to the same place. Watershed can cross municipal and state boundaries, which can present a challenge when planning for flooding and risk reduction.
- Mean Higher High Water** - Mean Higher High Water (MHHW) is the tidal state used to represent high tide. The MHHW metric represents the average of the higher of the two daily high tides, as opposed to Mean High Water (MHW), which represents the average of all high tides at a given location.

**NAVD88** - The North American Vertical Datum of 1988 (NAVD 88) is the vertical control datum established in 1991 for the North American Continent to act as a fixed height and leveling network for vertical surveying.

# SOURCES OF FLOODING

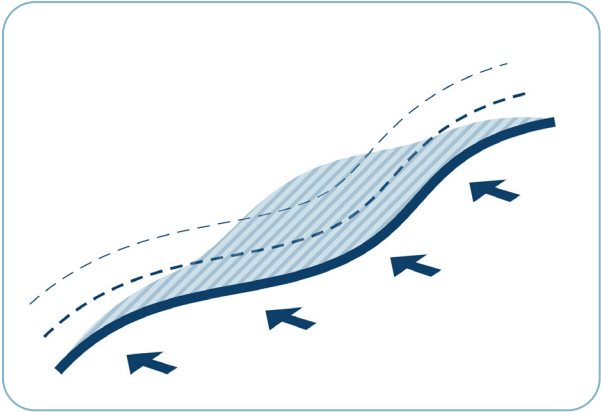
Quantifying flood impacts will help Resilient RRBC develop an action plan for reducing current and future flood risk. Resilient RRBC is considering flooding from rainfall, high tides, and coastal storm surge (also described in the draft [Vision and Priorities Report](#)).

## RAINFALL FLOODING



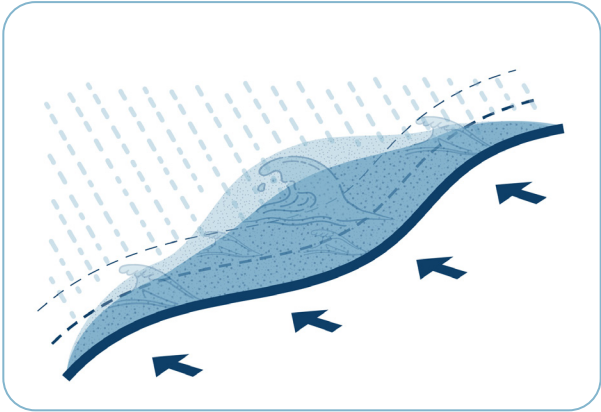
*Inches of rain can fall in a few hours during the peak of a storm, causing flooding in low-lying areas. This can include heavy sustained rainfall which causes area flooding, or shorter duration heavy intensity rainfall which causes flash flooding. The areas impacted might be along waterways (riverine flooding) or inland where rainfall overwhelms storm drains (stormwater flooding).*

## TIDAL FLOODING



*Tidal flooding is the inundation of low-lying areas due to high tides. Sea level rise will cause tides to be higher than they are today, and some areas will flood daily if no actions are taken.*

## STORM SURGE



*Tropical storms, hurricanes, and nor’easters can raise water levels along the coast.*

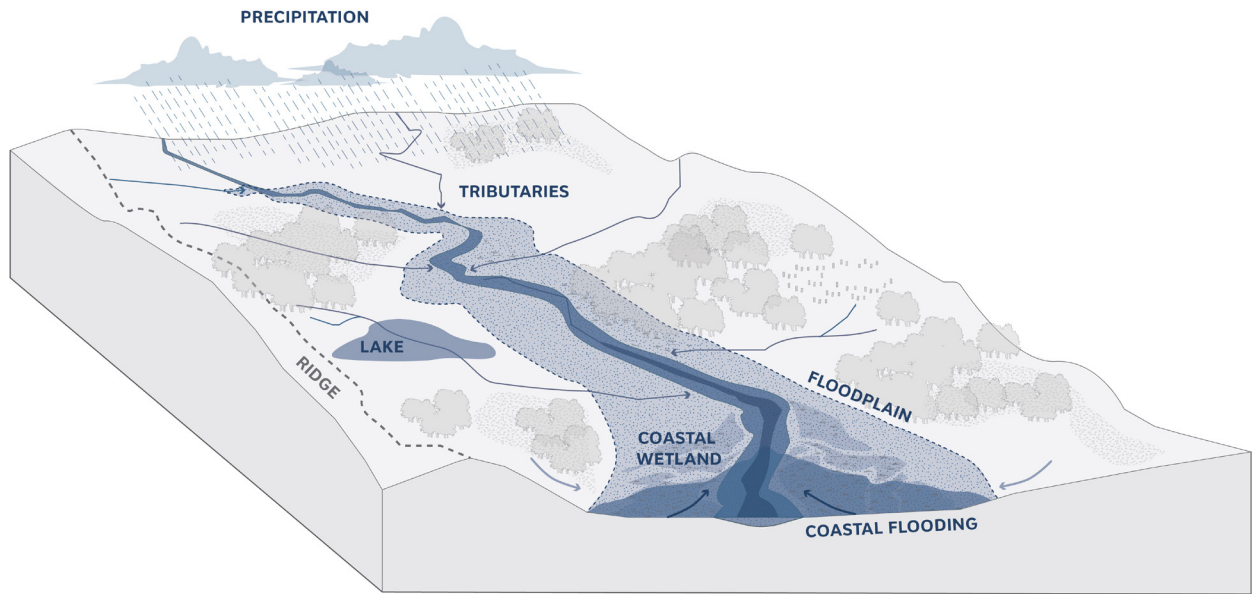


# WATERSHED-BASED FOCUS AREAS

## FOCUS AREA DEVELOPMENT

The Resilient RRBC team developed six focus areas within the region to support technical assessment and implementation planning. These focus areas are based on local sub-watersheds and land uses. Though feedback for this project has, and will continue to be, primarily collected at the municipal level, the project team uses the focus areas to develop resilience strategies that address flood risks across municipal boundaries. The results in this report are presented primarily by focus area, with supplemental information provided for each municipality.

The need for watershed-based planning was identified by stakeholders numerous times during the engagement process. As we move towards the delivery of an action plan in Summer 2022, a watershed-based planning approach will form the foundation of our recommended resilience strategies.



WATERSHED DIAGRAM  
Image Source: Project Team

**A watershed can most easily be thought of as an area within which, wherever water falls, it will all eventually flow to the same place. Watersheds can cross municipal and state boundaries, which can present a challenge when planning for flooding and risk reduction. Along coastal areas, the watersheds may overlap with coastal flooding areas.**

**South Branch of Rahway River/Pumpkin Patch** is bounded by the Woodbridge Creek subwatershed to the east, Raritan River subwatershed to the south and the Woodbridge municipal boundary to the north.

**Woodbridge Creek** is bounded by the Woodbridge Creek subwatershed and Rahway River to the north.

**Arthur Kill Industrial Waterfront** is bounded by Arthur Kill Waterfront Subwatershed (below Grasselli), Rahway River to the north and Harbortown to the south.

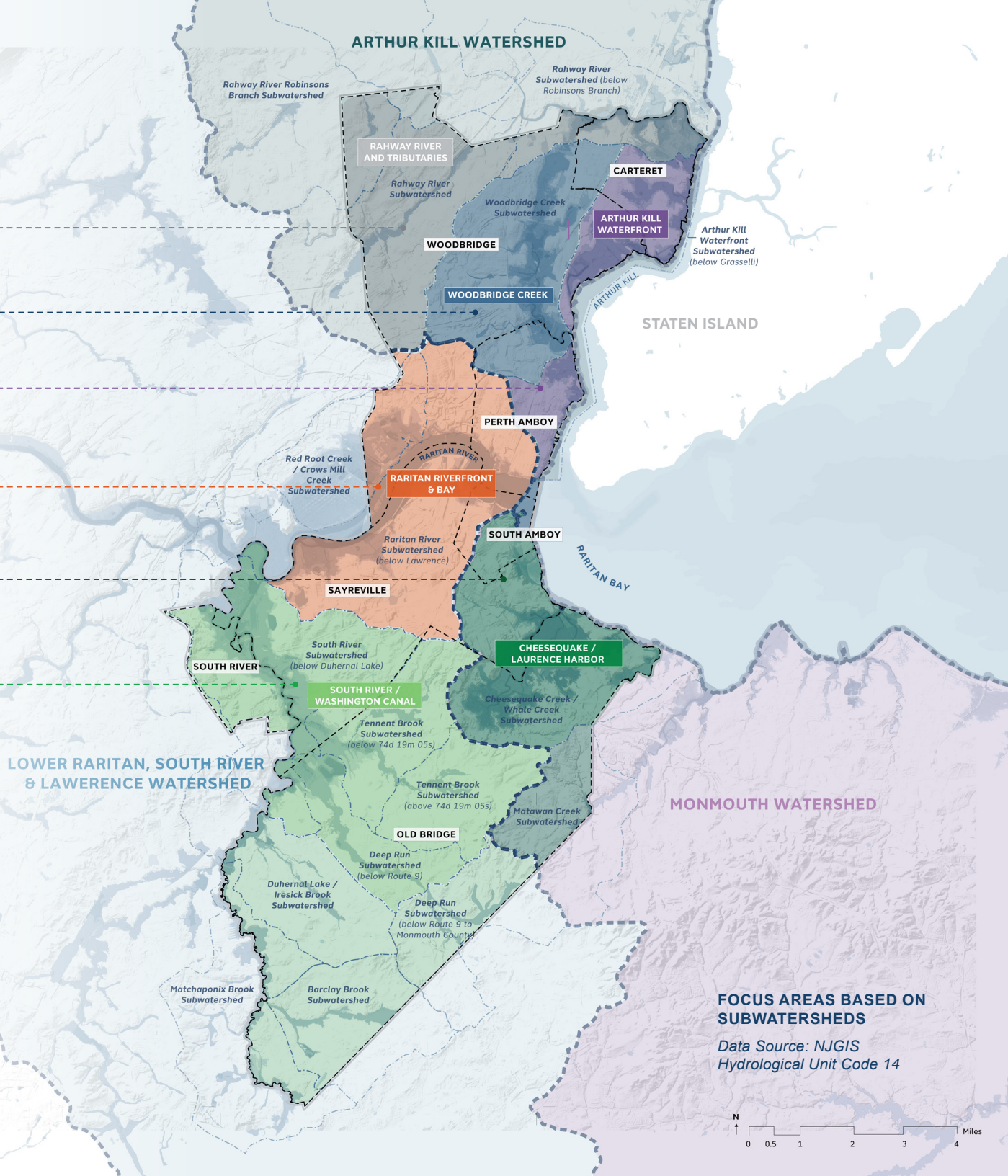
**Raritan Riverfront and Bay** is bounded by Harbortown to the north, Raritan River subwatershed (below Lawrence) to the south, Woodbridge and Sayreville municipal boundaries to the west.

**Cheesequake / Laurence Harbor** is bounded by Cheesequake Creek / Whale Creek subwatershed and the Old Bridge municipal boundary to the east.

**South River / Washington Canal** is bounded by South River Subwatershed (below Duernal Lake), Tennant Brook and Deep Run subwatersheds and the South River municipal boundary to the west.

### LEGEND - FOCUS AREAS (SUB-WATERSHEDS)

- Arthur Kill Industrial Waterfront
- Woodbridge Creek
- Rahway River and Tributaries
- Raritan Riverfront and Bay
- South River / Washington Canal
- Cheesequake / Laurence Harbor / Raritan Bay Waterfront Park



FOCUS AREAS BASED ON SUBWATERSHEDS  
Data Source: NJGIS  
Hydrological Unit Code 14



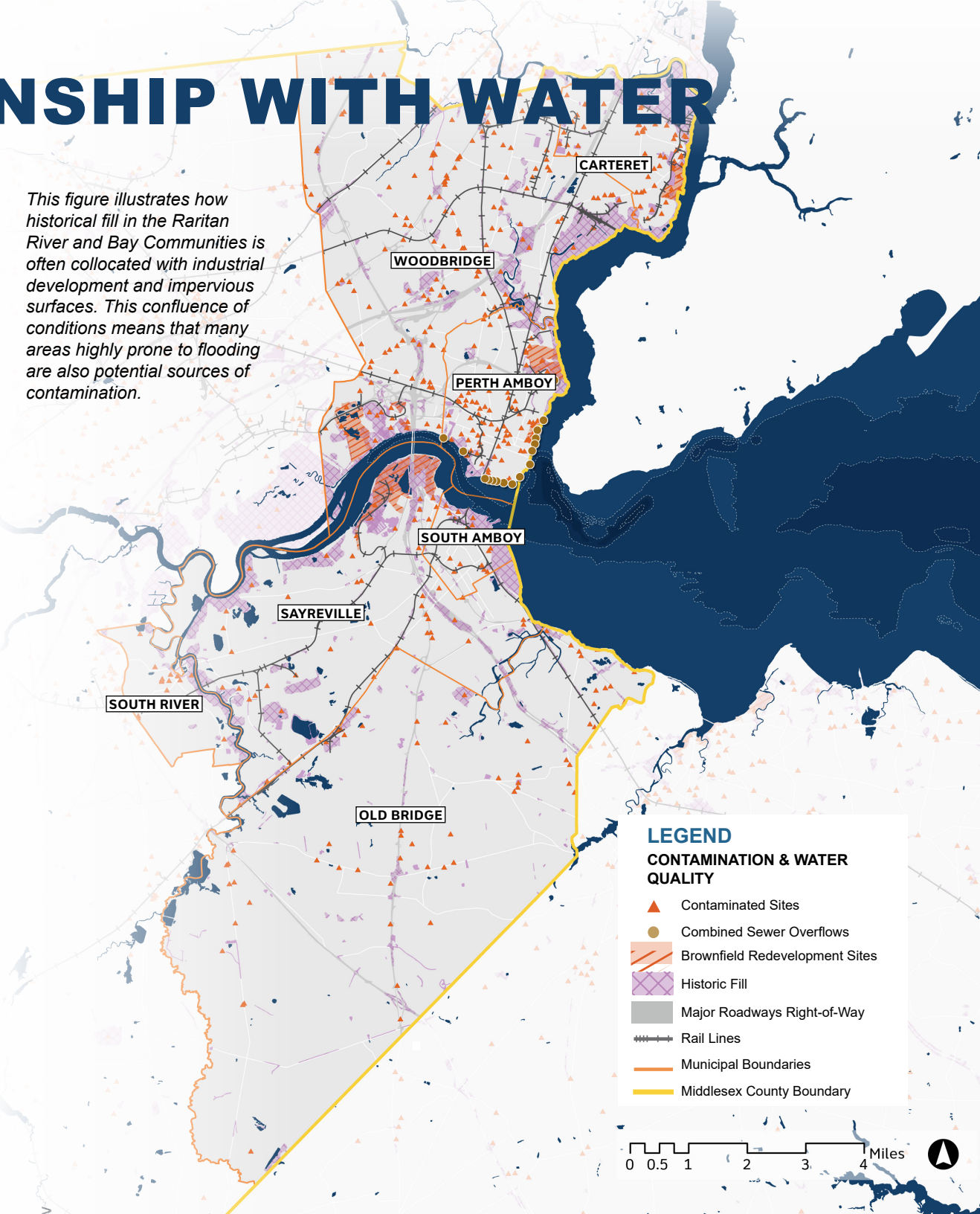
# OUR RELATIONSHIP WITH WATER

Heavy sustained rainfall, coastal storms, and tidal flooding all impact the region today. The impacts of flooding in the region are complex as a result of mixed land uses, the intersection of three watersheds, and the prevalence of tidally influenced rivers. There are various waterways and tributaries throughout the region, leading to extensive inundation during heavy sustained rainfall and, in some areas, expanding the extent of coastal flooding. With climate change, rainfall intensity will increase and sea levels will rise, exacerbating these flooding issues.

Additionally, the land along larger waterways, such as the Raritan River and the Arthur Kill Tidal Strait, were developed by filling tidal wetlands with largely impervious, or hard, surfaces. Increases in impervious surface, such as roads, buildings, and parking lots, mean that there is less pervious land, such as wetlands, to naturally absorb the rainwater into the ground and slowly seep into nearby streams. Instead, more stormwater runoff occurs – stormwater runoff is rainwater that must be collected by extensive drainage systems that combine curbs, storm sewers, and ditches to carry the runoff directly to streams. The stormwater enters the stream more quickly, resulting in an increased likelihood of more frequent and severe flooding.

Because much of the area’s historic development occurred in places with access to waterways, locations of potential contaminants tend to be collocated with these filled areas and impervious surfaces. Many of these areas were developed as industrial properties, which are now potential sources of contamination and are prone to flooding. Construction activities, increased use of impervious surfaces, and stream bank modification have all contributed to silt loads and local flooding. There is an increasing amount of runoff from urban services, roads, and storm sewers. These

*This figure illustrates how historical fill in the Raritan River and Bay Communities is often collocated with industrial development and impervious surfaces. This confluence of conditions means that many areas highly prone to flooding are also potential sources of contamination.*



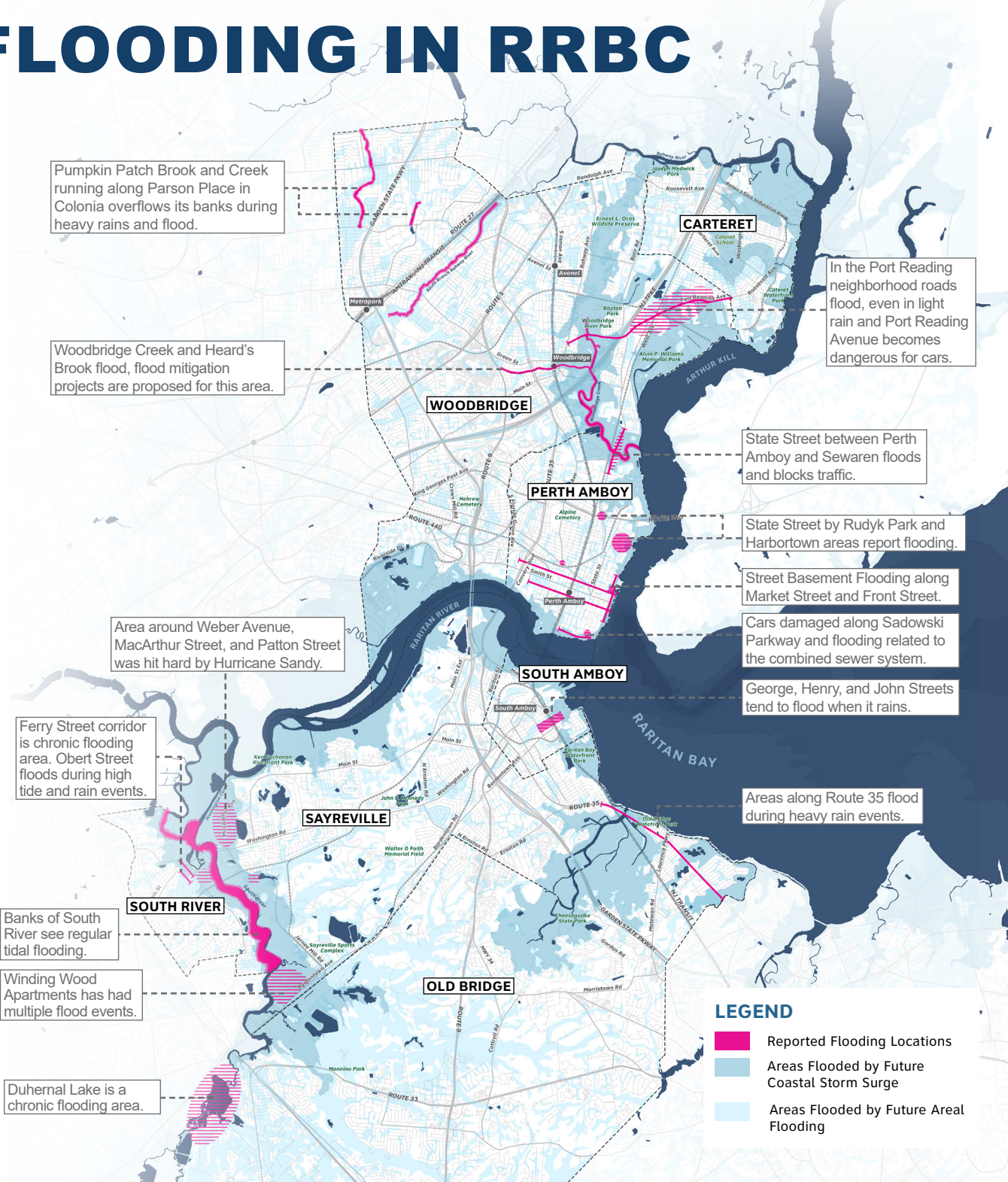
# IMPACTS OF FLOODING IN RRBC

Flooding can impact the community in many unique ways. The consequences of flooding are driven by the people, places, and things in harm’s way, and their relative resilience against flood impacts. This section introduces who and what is impacted by flooding in RRBC.

The **Resilient RRBC Flood Impact Assessment** evaluates the impact flooding may have on an extensive inventory of buildings and critical assets throughout the region. This inventory was built from the best available geospatial datasets and includes the following:

- *1,528 critical assets across around 50 unique asset types*
- *21,000 acres of parks and public open space*
- *536 miles of linear assets, such as roads, pipelines, and transmission lines*
- *89,000 buildings, including residences, businesses, industrial sites, religious spaces, and public services*

See Appendix A for more information about how assets were identified and prioritized,. These appendices include a full list of assets for each municipality in the region. Map to the right shows reported flooding locations, including along rivers and creeks, roads and neighborhoods.





# WHO IS AT RISK?

The RRBC communities are located in Middlesex County, at the mouth of the Raritan River. These communities include Carteret, Old Bridge, Perth Amboy, South Amboy, Sayreville, South River, and Woodbridge, with a combined population of more than 380,000. The region is varied and diverse, representing a wide range of social backgrounds, values, opportunities, and challenges. The region is heavily interconnected along major transportation networks and waterbodies, with a variety of cultures and industries. Parts of the region — especially in more heavily urbanized areas, such as parts of Perth Amboy — contain neighborhoods classified by the Center for Disease Control and Prevention (CDC) as among the highest-ranking “socially vulnerable” census tracts in the state and the country. Additional information about the demographics of each municipality can be found within the [About Our Region report](#).

The CDC’s Social Vulnerability Index (SVI) is based on the following 15 factors<sup>1</sup>:

- **Socioeconomic Status**
    - Below Poverty
    - Unemployed
    - Income
    - No High School Diploma
  - **Household Composition & Disability**
    - Aged 65 or Older
    - Aged 17 or Younger
    - Civilian with a Disability
    - Single-Parent Households
- **Minority Status & Language**
    - Minority
    - Aged 5 or Older who Speaks English “Less than Well”
  - **Housing Type & Transportation**
    - Multi-Unit Structures
    - Mobile Homes
    - Crowding
    - No Vehicle

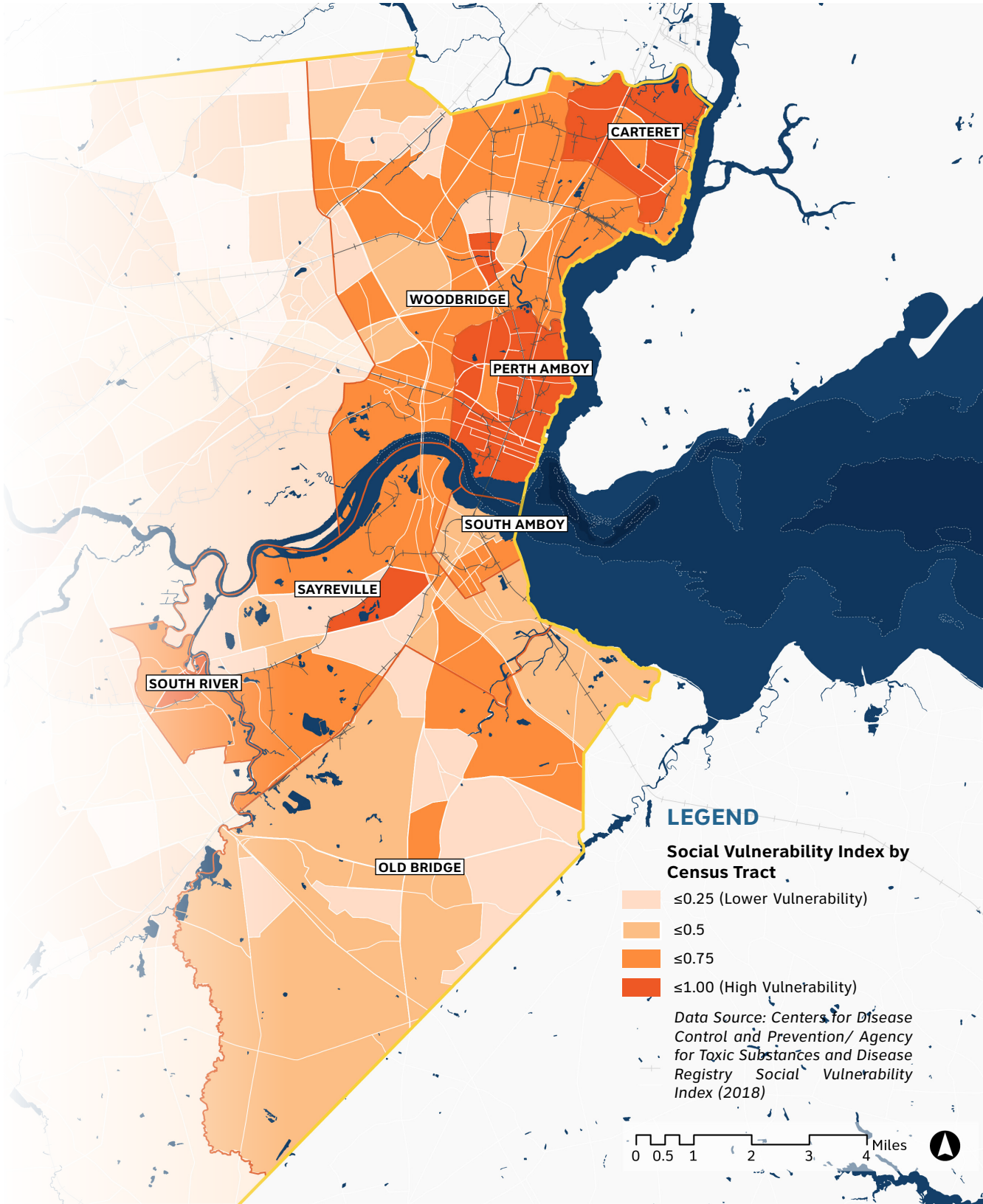
## SOCIAL VULNERABILITY

Social vulnerability refers to the degree to which a community’s people are challenged when faced with significant disruptions, such as natural disasters or disease. A variety of socio-economic factors play a pivotal role in understanding the degree of impact a community or household may experience because of flooding.

For example, lower income households have fewer resources to adapt to changing and dangerous circumstances — whether by moving to areas or homes less exposed to risk, by retrofitting their homes or securing appropriate flood insurance to withstand severe events, by having access to transportation to seek shelter in an emergency, or to financially recover from a destructive flooding event. Historical exclusion and inequitable policies tend to make communities within certain demographic categories especially susceptible to the most severe impacts of flooding, such as African-American and Latino communities, low-income populations, low English-speaking households, and people with disabilities.

The index shows very high rates of social vulnerability in RRBC concentrated in Perth Amboy, Carteret, the area in South River around Main Street, and pockets of Sayreville. Higher index values coincide with higher relative flood impacts for historically excluded or under-resourced communities. For example, flooding and downtime of a neighborhood grocery store has much more drastic consequences for a low-income neighborhood with minimal access to affordable food than for a higher-income neighborhood with high rates of car ownership and/or access to multiple alternative grocery stores.

In addition, communities with high SVI scores are often geographically located in areas with the greatest overall flood risk and impacts. Some neighborhoods with high SVI scores overlap significantly with high concentrations of contaminated sites and overall proximity to hazardous waste, particularly in the northern parts of the region in and around Carteret and Perth Amboy. Residents living within or near current and future flood-prone areas near hazardous waste face serious additional risks, as floodwaters can disrupt these sources of pollution and spread hazardous materials away from the site. These geographic factors trace their roots back to historical injustices, as marginalized and minority communities were previously forced to settle in areas facing chronic disinvestment and high industrial activity, even as the surrounding region came to depend on these areas as key economic hubs.





FLOOD-PRONE AREAS  
CARTERET, PERTH AMBOY,  
WOODBIDGE

FUTURE FLOODING

- Water bodies
- Areas flooded by both Future Coastal Storm Surge and Future Areal Flooding
- Areas flooded by Future Coastal Storm Surge
- Areas flooded by Future Areal Flooding

CRITICAL UTILITIES & FACILITIES

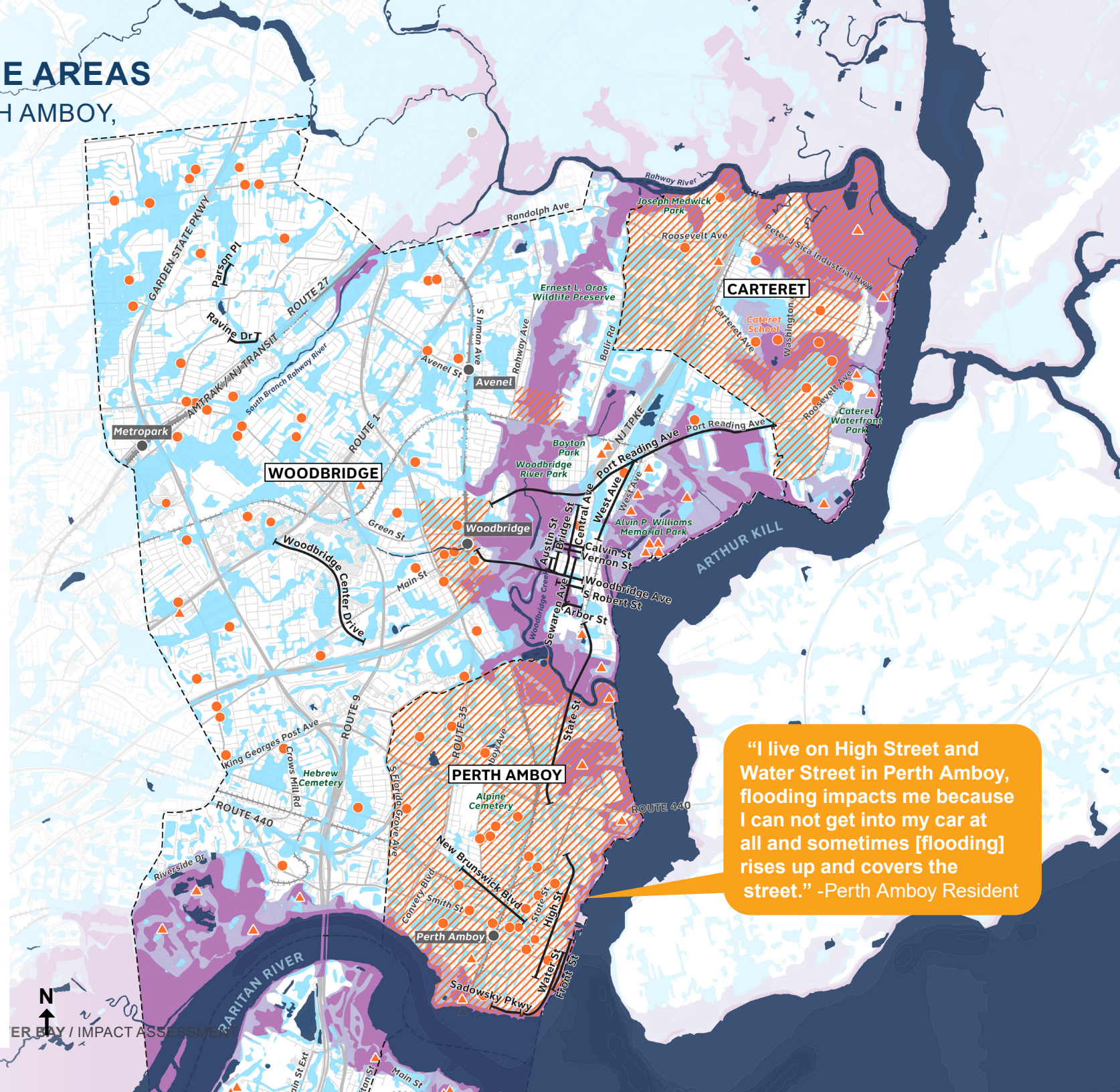
- Wastewater Treatment
- Substations
- Power Generation
- Heavy Industry
- Warehousing

COMMUNITY ASSETS

- Municipal Building
- Nursing Homes
- Schools & Colleges
- Library
- Fire Stations
- Socially Vulnerable Communities

TRANSPORTATION

- Flood-prone streets
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Municipal Boundaries



FLOOD-PRONE AREAS  
SAYREVILLE, SOUTH AMBOY, SOUTH  
RIVER, OLD BRIDGE

FUTURE FLOODING

- Water bodies
- Areas flooded by both Future Coastal Storm Surge and Future Areal Flooding
- Areas flooded by Future Coastal Storm Surge
- Areas flooded by Future Areal Flooding

CRITICAL UTILITIES & FACILITIES

- Wastewater Treatment
- Substations
- Power Generation
- Heavy Industry
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COMMUNITY ASSETS

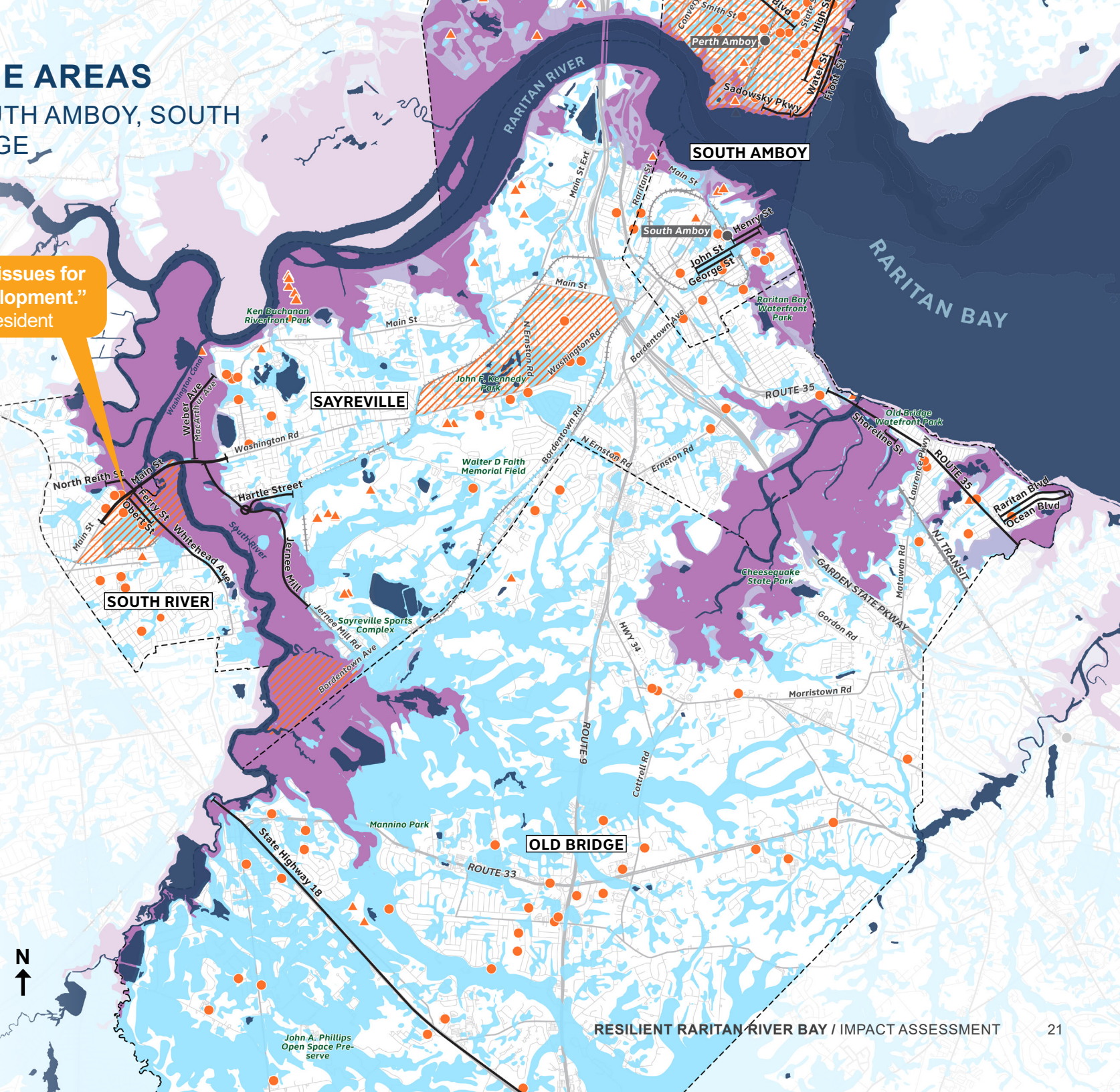
- Municipal Building
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TRANSPORTATION

- Flood-prone streets
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Municipal Boundaries

“Flooding causes issues for Main Street redevelopment.”  
-South River Resident

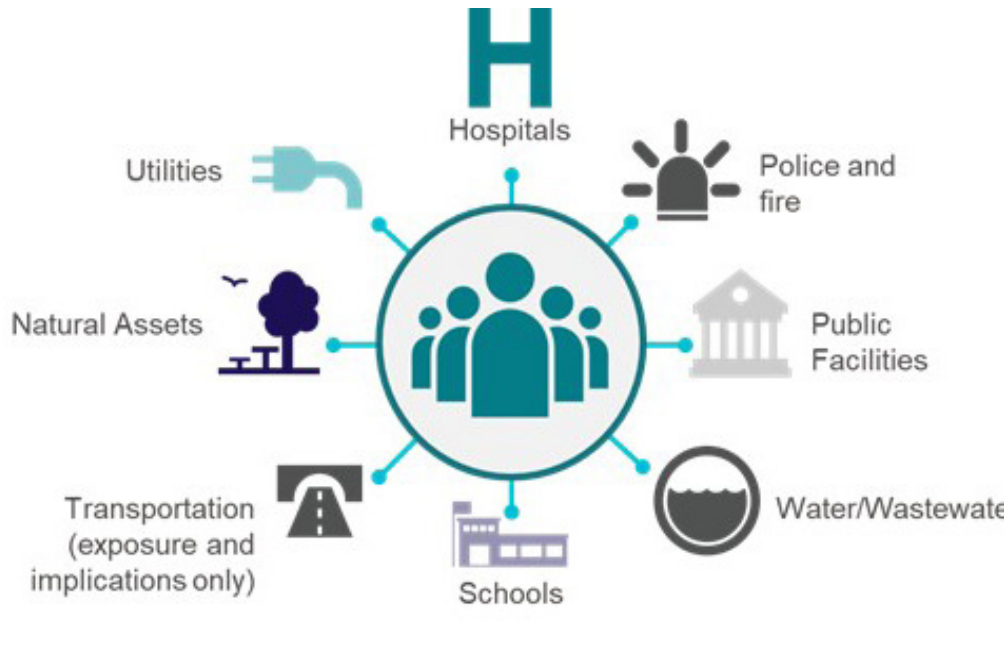
“I live on High Street and Water Street in Perth Amboy, flooding impacts me because I can not get into my car at all and sometimes [flooding] rises up and covers the street.” -Perth Amboy Resident





# WHAT IS AT RISK?

Assets are anything that provide a service or have value to the community – from homes where people live, to the businesses where they work, and the parks where they play. Critical assets are those that are most essential for a community to thrive. They provide governmental service and support the regional economy. These include buildings (like schools, day care centers, hospitals, or fire stations), infrastructure (like roads, bridges, and pipelines), or spaces that host community events (like farmer’s markets). Assets can be of regional importance or specific to a community and include places where people gather, build relationships, and enjoy themselves. Assets, such as schools or hospitals, are often the focus of flood impact assessments.



THIS IMPACT ASSESSMENT INCLUDES CRITICAL ASSETS TRADITIONALLY INCLUDED IN RISK ASSESSMENTS.





This report, however, looks at many non-traditional community assets, such as shared gardens or street festivals, that are just as important to providing community cohesion, character, and quality of life. Critical community assets are of special importance in areas with high social vulnerability, as the services tied to the assets can be critical to recovering from flood events for these populations.



ADDITIONALLY, THE RESILIENT RRBC ASSESSMENT ALSO CONSIDERS ASSETS CRITICAL TO A COMMUNITY THAT ARE OFTEN OVERLOOKED.

## What critical assets are we talking about?









Understanding the impacts of flooding on critical assets involves defining how each asset impacts the human experience. Assets may fit in one or more of the following five categories which consider the different ways the community interacts with assets and how assets affect their lives:

- Infrastructure**  
 Assets that ensure or impact movement of goods, services, information, and function of society, including *Transportation* assets that move people and goods, and *Utility* assets that move essential resources, services, and information. Examples include roads, bus routes, wastewater treatment plants, and electrical substations.
- Emergency Response**  
 Infrastructure or other assets that ensure or impact the functioning of society in an emergency. Examples include emergency shelters, fire stations, and hospitals.
- Public Health**  
 Assets not specifically identified as infrastructure or emergency response assets that ensure or impact the basic health, safety, and well-being of people. Examples include prisons, childcare centers, local parks, and municipal buildings.
- Quality of Life**  
 Assets that ensure or impact people’s positive relationships with themselves, one another, their community, or their environment. Examples include libraries, places of worship, and local festivals.
- Ecosystem & Environment**  
 Assets that ensure or impact the functioning of the natural environment. Examples include state parks, landfills, and known contaminant sites.

*This flood assessment looks at assets of all types (e.g., buildings, services, infrastructure, places, and events). The Resilient RRBC team collected data from dozens of sources to create a list of assets. These data sources are described in Appendix A. For many of those sources, the data directly characterize the assets – bus routes are identified as bus routes, parks are identified as parks. Buildings, make up a very large portion of the overall assets, and to characterize the buildings, we need to break them down by types.*

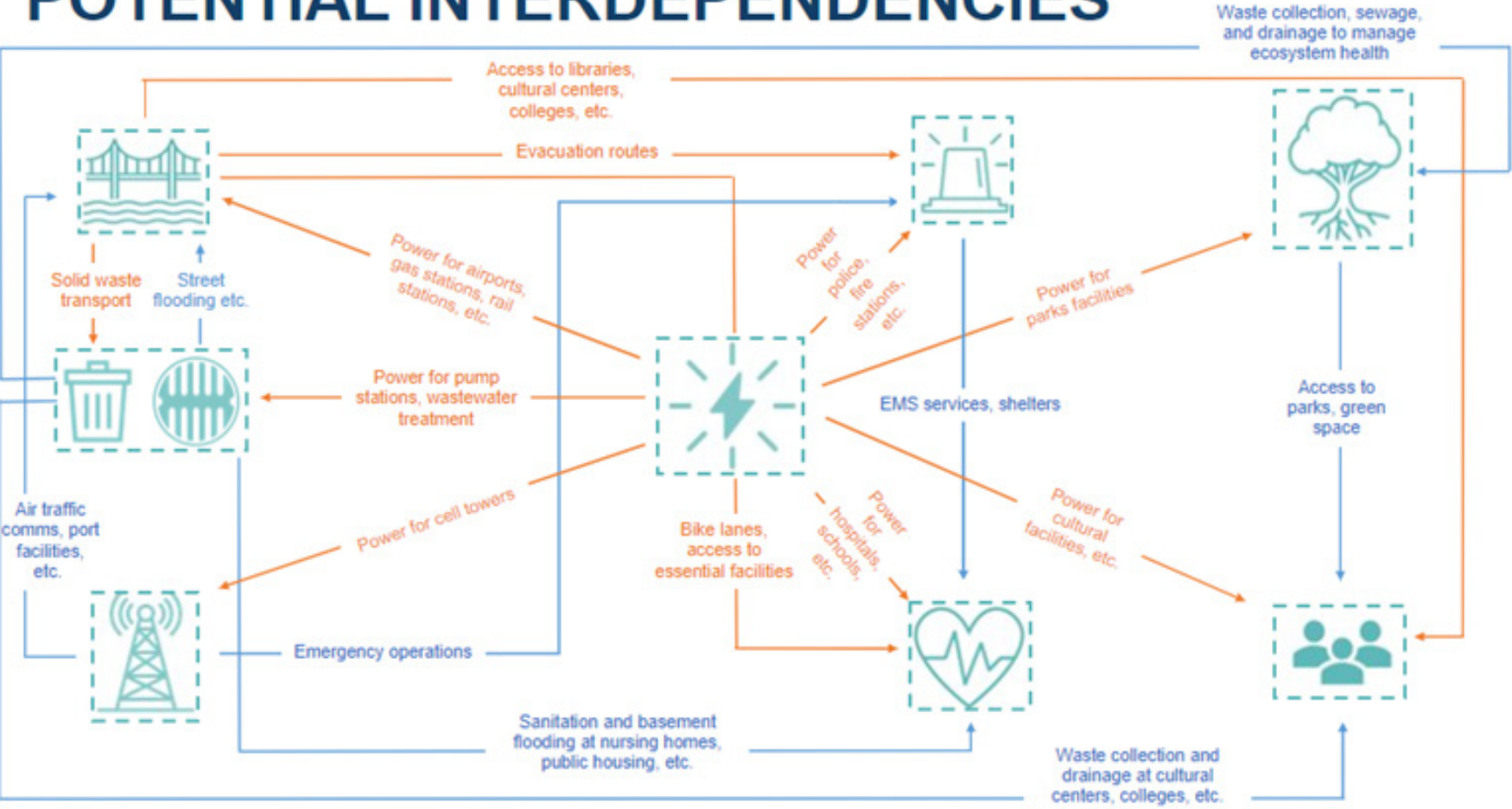
## What types of buildings are we talking about?

Understanding how buildings are used is a key part of understanding how flooding currently impacts and will impact the region. Risk to various building types demonstrates the ability of a community to function, recover, and thrive over time. The Resilient RRBC team categorized buildings in the region with the following use types:

- Commercial:** Structures providing economic services or goods  

- Government:** Judicial, municipal, and other government service buildings  

- Religious:** Places of worship  

- Industrial:** Warehouses or buildings within manufacturing campuses or facilities  

- Education:** Structures providing any form of education – from preschool to universities  

- Residential:** Structures that house community members  

- Emergency Services:** Emergency medical or social services, such as EMS, fire and police stations, and hospitals.  

- Transportation:** Structures supporting transportation infrastructure, such as railway stations and ferry terminals  




# POTENTIAL INTERDEPENDENCIES



THIS FIGURE ILLUSTRATES HOW FLOOD IMPACTS AT ONE CRITICAL ASSET CAN HAVE POTENTIAL CASCADING EFFECTS AT OTHER INTERDEPENDENT ASSETS.

At every scale – from the neighborhood level to the region, state, and beyond – critical community assets are not isolated. Impacts to one asset could generate cascading impacts to many others. Interdependencies may exist within and between different types of assets. They may include functional or operational dependencies, information or data dependencies, additional disruption due to geographic proximity, and management and financial implications.

# FLOOD MODELS

The New Jersey Department of Environmental Protection (NJDEP) developed flood models that will help the region predict and prevent flood damage. These models estimate the depths of flooding throughout the region, making them useful in highlighting potentially flood-prone areas, comparing possible flood mitigation options, and prioritizing action. Appendices B and C provide details on the development of these flood models.

Flood models developed for RNJ estimate both present (~2020) and future (~2070) flood risk. The future models consider climate change by incorporating increases in rainfall and sea level. Rutgers University provided projections for how much rainfall and sea level may increase given various assumptions detailed in the New Jersey’s Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel<sup>2</sup>.

NJDEP used Rutgers University’s high emissions or “business as usual” scenario for 2070, assuming that decisions that we make now about our infrastructure and communities will affect life in 50-years and beyond. Fifty years is also thought to be the time frame within which projections should be relatively accurate if nothing changes. Should the effects of climate change occur faster or slower than expected, a flood event like those modeled for 2070 may be experienced earlier or later than 2070.

### New Flood Models for the Resilient New Jersey Program

*The models developed for RNJ are large-scale planning models that are useful tools to compare and prioritize areas across a region.*



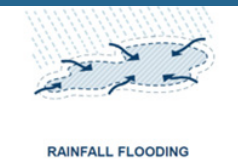
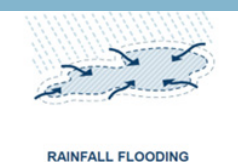


*Due to their scale, these models contain an inherent level of uncertainty. The model results are appropriate to examine flooding at regional, municipal, and focus area levels, but they should not be used to evaluate flooding at the individual property or structure level.*

*Appendices B and C describe the program-level model development methodology and refinements special for Resilient RRBC, respectively.*

### Do the NJDEP RNJ models replace FEMA’s flood maps?

No. The RNJ flood models and FEMA’s flood maps serve different purposes.

The Federal Emergency Management Agency (FEMA) maps riverine and coastal flooding to determine where flood insurance is required through the National Flood Insurance Program (NFIP) and where certain building code requirements apply. FEMA is currently updating the flood maps in our region. Visit the [FEMA Coastal Restudy Website](#)<sup>3</sup> to learn more.

Event Name	Primary Flood Source	Modeled Event	Description
PRESENT-DAY FLASH FLOOD		3.2 inches over 2 hours	A short duration, high intensity rain event likely to overload storm sewers and cause flooding but will recede quickly, limiting long-term impacts.
PRESENT-DAY AREAL FLOOD		8.7 inches over 24 hours	A longer duration rain event likely to overwhelm available drainage networks and cause widespread inland flooding across low-lying areas.
FUTURE (2070) FLASH FLOOD		3.5 inches over 2 hours (10% increase in rainfall) + sea level rise	A short duration, high intensity rain event likely to overload storm sewers and cause flooding but will recede quickly, limiting long-term impacts. To account for anticipated climate changes, this event includes the effects of sea level rise and increased rainfall.
FUTURE (2070) AREAL FLOOD		9.6 inches of rainfall over 24 hours (10% increase in rainfall) + sea level rise	A longer duration rain event likely to overwhelm available drainage networks and cause widespread inland flooding across low-lying areas. To account for anticipated climate changes, this event includes the effects of sea level rise and increased rainfall.
FUTURE (2070) TIDAL FLOOD		Mean higher high water + sea level rise	Temporary inundation of low-lying areas due to high tides. To account for anticipated climate changes, this event includes the effects of sea level rise.
FUTURE (2070) COASTAL STORM SURGE		Hurricane Sandy high water marks + sea level rise	Raised water levels along the coast due to tropical storms, hurricanes and nor’easters. To account for anticipated climate changes, this event includes the effects of sea level rise.

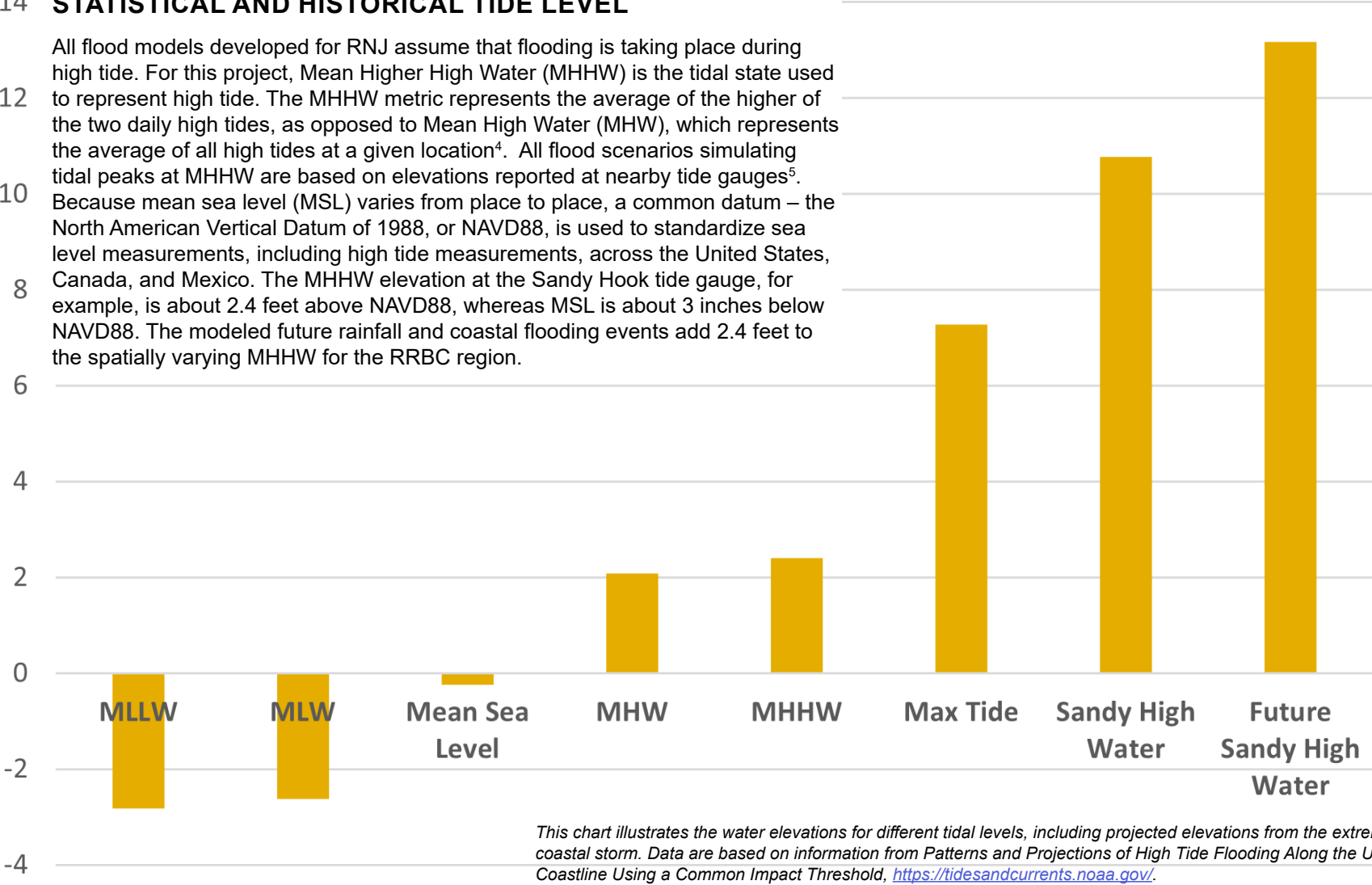
2. New Jersey’s Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel, <https://climatechange.rutgers.edu/>  
3. FEMA Coastal Restudy, <https://region2-fema.opendata.arcgis.com/apps/fema-coastal-restudy/explore>



# TIDAL STATE

## 14 STATISTICAL AND HISTORICAL TIDE LEVEL

All flood models developed for RNJ assume that flooding is taking place during high tide. For this project, Mean Higher High Water (MHHW) is the tidal state used to represent high tide. The MHHW metric represents the average of the higher of the two daily high tides, as opposed to Mean High Water (MHW), which represents the average of all high tides at a given location<sup>4</sup>. All flood scenarios simulating tidal peaks at MHHW are based on elevations reported at nearby tide gauges<sup>5</sup>. Because mean sea level (MSL) varies from place to place, a common datum – the North American Vertical Datum of 1988, or NAVD88, is used to standardize sea level measurements, including high tide measurements, across the United States, Canada, and Mexico. The MHHW elevation at the Sandy Hook tide gauge, for example, is about 2.4 feet above NAVD88, whereas MSL is about 3 inches below NAVD88. The modeled future rainfall and coastal flooding events add 2.4 feet to the spatially varying MHHW for the RRBC region.



4. Mean Lower Low Water (MLLW) and Mean Low Water (MLW) are defined similarly. Tidal Datums, <https://tidesandcurrents.noaa.gov/>  
5. Additional information on the applied tidal cycle is found in Appendix C, Attachment A.

# COASTAL STORM SURGE

Flooding from coastal storms is destructive due to higher flood depths caused by surge and forceful waves. As climate change progresses, warmer oceans will likely contribute to more frequent and more intense storms. Sea level rise will make the impacts of storm surge even greater, leading to substantial flooding.

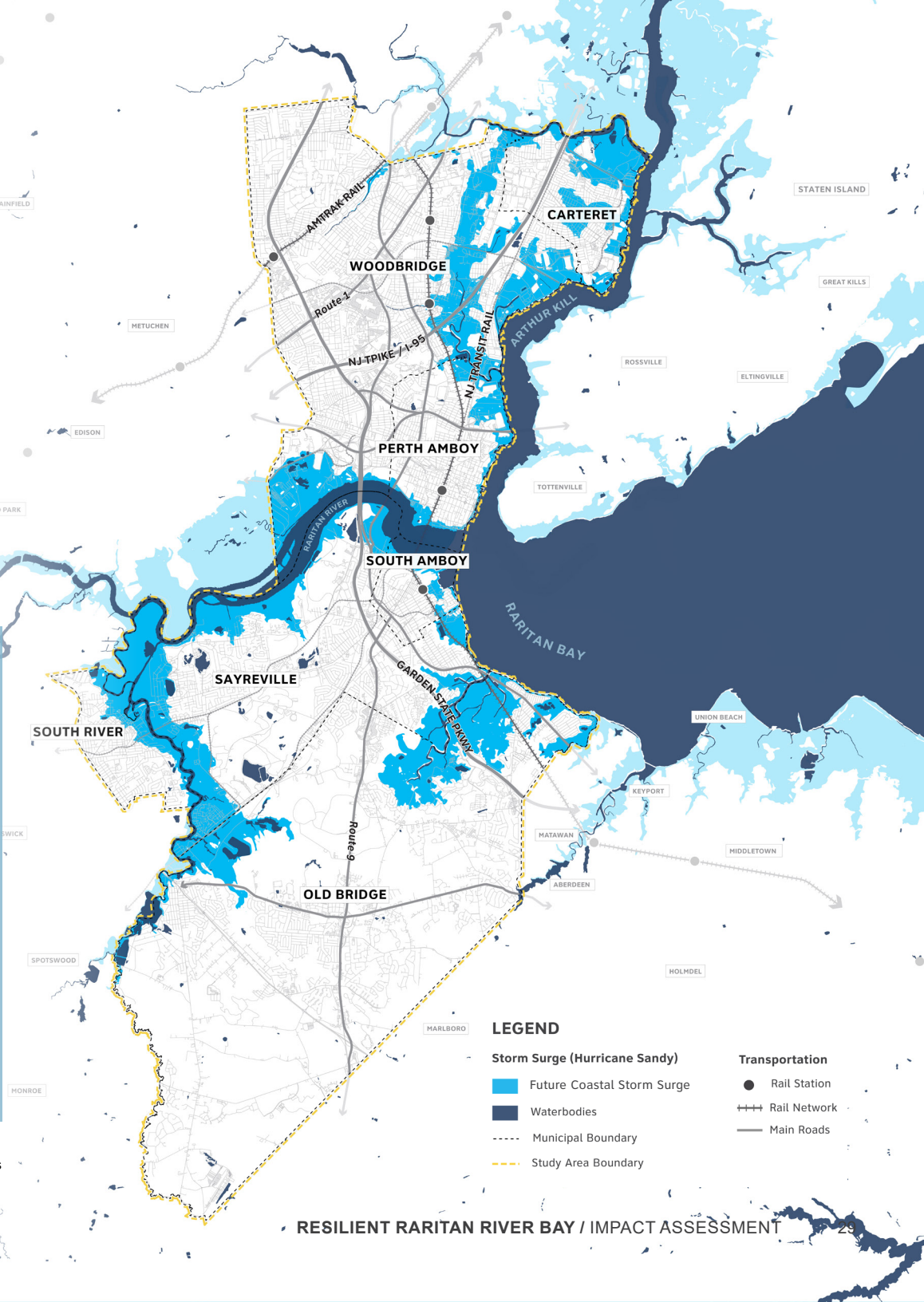
Resilient RRBC modeled a future extreme coastal storm surge event, developed by taking the observed high water marks experienced during Hurricane Sandy<sup>5</sup> and projecting them into 2070, assuming 2.4 feet of sea level rise. Storm surge from Hurricane Sandy in 2012 represented the highest water levels measured at the Bergen Point<sup>6</sup> tide gauge, with elevations nearly 9 feet higher than MHHW.

### INCORPORATING CLIMATE CHANGE INTO MODELS OF FUTURE FLOODING

Resilient NJ's models of 2070 flood risk consider climate change by incorporating increases in rainfall and sea level.

- 10% increase in rainfall. It is widely believed that precipitation amounts will increase within the next century. To account for uncertainty in the exact rate, NJDEP chose a 10% increase for these models as an estimate of increased rainfall in 2070.
- 2.4 feet of sea level rise. This increase represents the central estimate for sea level rise by 2070 based on the high emissions scenario.

5. USGS Flood Event Viewer, <https://stn.wim.usgs.gov/FEV/#Sandy>, accessed July 2021.  
6. Hurricane Sandy elevations are discussed in relation to Bergen Point, as an incomplete record for this event is available at the Sandy Hook tide gage.





# RAINFALL

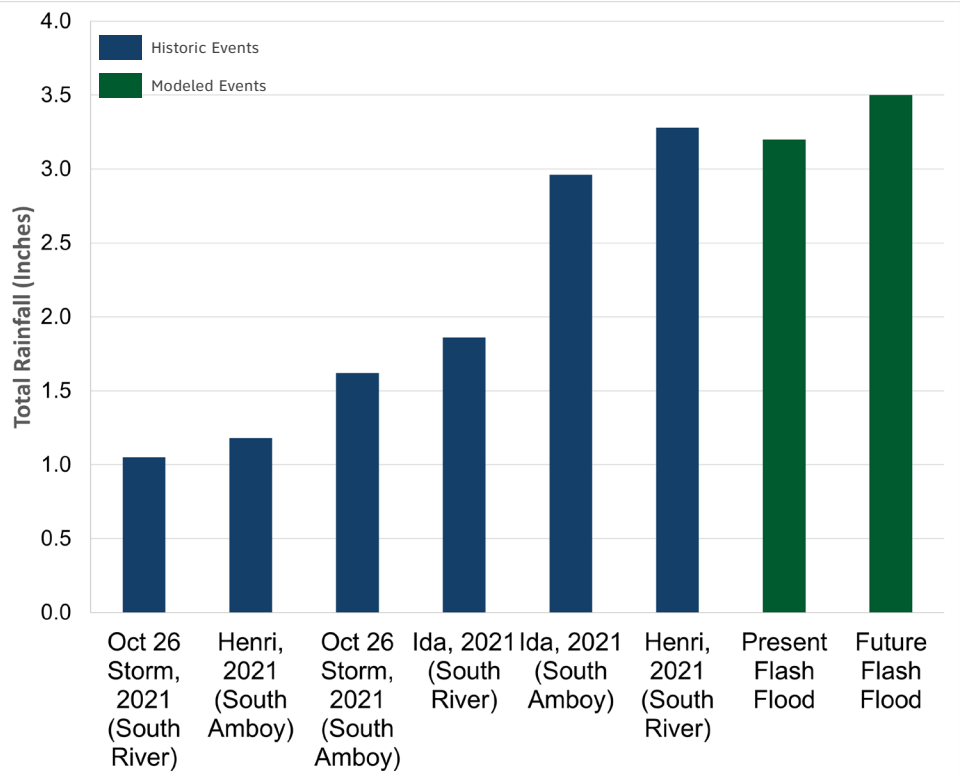
Resilient RRBC modeled two distinct rainfall scenarios to help clarify where and how severe flooding may be during different types of major rainstorms. The project team also cross-referenced the model results with flood locations reported by municipalities and community members to help confirm the findings. The two major types of rainstorms modeled were flash flooding and areal flooding. Both present and future (2070) flash flooding and areal flooding were modeled.

- Flash Flooding** occurs when there is a significant amount of rainfall over a short period of time. The model uses around 3 to 3.5 inches over two hours, which is a little worse than Floyd (1999) and Henri (2021) in most places. Around 3.2 inches of rainfall fell in 2 hours in South River during Henri. This short duration, high intensity rain event is likely to temporarily overload storm sewers and cause flooding, but the flood waters recede as the storm ends, limiting long-term impacts. Such a short storm may occur suddenly, providing little time for preparation or evacuation.
- Areal Flooding** occurs when flooding develops more gradually and comes from sustained rainfall over a longer period. The Resilient RRBC model uses around 8.5 to 9.5 inches over 24 hours, which is greater than Ida or Irene. During Ida, around 5.7 inches of rainfall fell in 24 hours over South Amboy and around 8.4 inches were measured at Newark Airport, not far north of Carteret. This longer-duration event models flood depths that may not drain for a longer period. Storms of this size are also likely to overwhelm any available drainage networks and, therefore, tell us where significant damage and disruption likely does and could occur. Though the term areal flooding may be new to many, it is not a typo! This term comes from the National Weather Service Hazardous Weather Warning System to represent inland flooding over widespread extents of low-lying areas. Throughout this report, areal flooding is also referred to as heavy sustained rainfall.

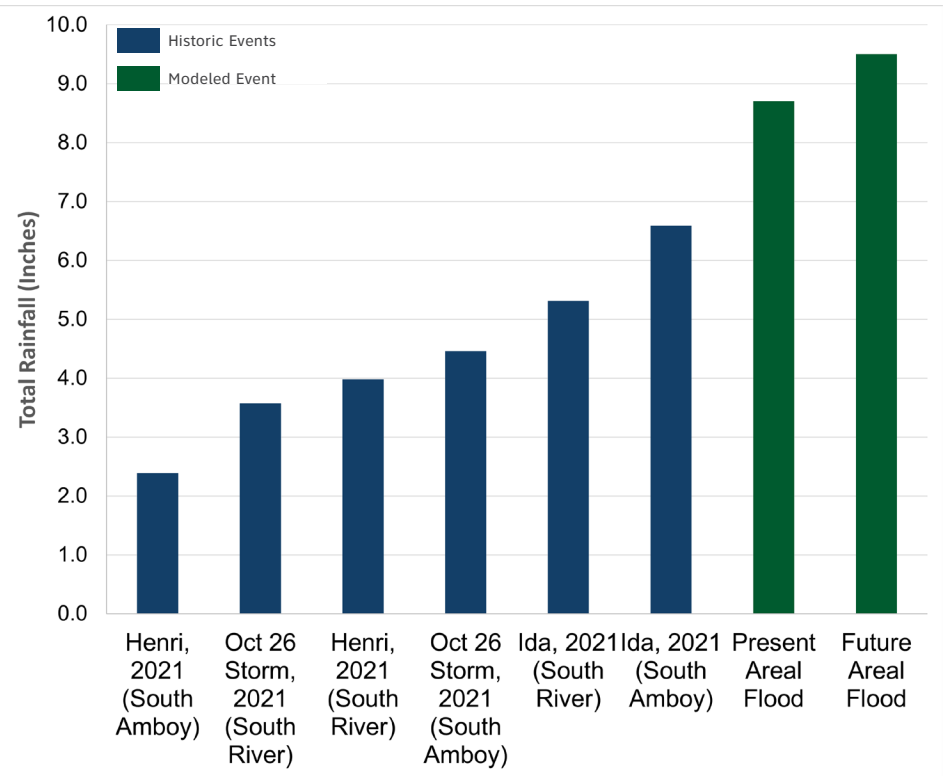


In actuality, rainfall does not fall evenly over a large area. Localized rainfall amounts may have been higher away from the official observation sites. Furthermore, the amount of flooding from an actual rainfall event will differ based on the conditions of an area (e.g., how much concrete there is or whether storm drains are clogged by leaves that day) and atmospheric conditions leading into the event. For example, Ida and Henri were on the heels of a very moisture rich summer.

The graphs below provide a comparison of the models to other events as they've been experienced in the region. The graph provides the location of the rainfall gathered for the past events because real rainfall does not fall evenly over a large area (whereas the models provide uniform rainfall across the region). Localized rainfall amounts for past events may have been higher or lower away from the official observation sites.



MODELED FLASH FLOODING COMPARED TO HISTORIC EVENTS



MODELED AREAL FLOODING COMPARED TO HISTORIC EVENTS



# MEASURING IMPACTS

With a baseline understanding of flood hazards, along with the people, places, and things throughout the region that may be impacted, the Resilient RRBC team quantified the range of impacts flooding has on the region using a variety of metrics. The team used methodologies developed by FEMA and USACE<sup>7</sup> to monetize four types of impacts to buildings and the people, businesses, and services they house:



- **Direct Physical Damage:** Replacement and restoration costs for buildings and their contents, including retail or wholesale inventory, expected to be damaged by flooding.
- **Human Impacts:** Costs associated with residential displacement, lost productivity, injuries, and mental stress and anxiety treatment for residents in the region as a direct result of impacts to their homes.
- **Direct Business Impacts:** Impacts to tax revenue, economic output, employment, and business relocation as a direct result of impacts to buildings. This only includes losses from businesses expected to be directly impacted by flooding and does not model any reverberating economic impacts.
- **Loss of Function:** Expected impacts associated with the time that public and essential services are out of use, approximated as the portion of annual operating costs associated with the downtime experienced from direct impacts of flooding. In this analysis, public and essential services included libraries, schools, fire stations, hospitals, police stations, nursing homes, rail stations, and electric substations.

This report provides **Total Direct Losses**, or the sum of these four types of damage for all buildings within the reporting area. In cases where total direct losses were either unavailable or inappropriate indicators, additional exposure metrics were used to quantify impacts, including **Population Counts, Asset Counts, Building and Contents Values, and Land Values**. The results presented in this report are complemented by community feedback on the types of flood impacts they’ve experienced or are most concerned about today and in the future.

7. More information about how the team estimated damage can be found in Appendix A.

# CONSIDERATIONS AND LIMITATIONS

*Estimates of building and contents values do not fully capture the complexities of the diverse spaces within the region.*

Some damage metrics were not evaluated in this analysis due to limited data availability or other project constraints, meaning the consequences presented in this report represent conservatively low estimates of the expected losses. For example, the business impacts reported do not include indirect economic impacts on business-to-business purchases in the supply chain or induced economic impacts stemming from changes in household income spending. Loss of function impacts were only captured for a limited number of essential services, but there are plenty of other assets that, if flooded, would cause cascading economic impacts throughout the community, such as childcare centers, wastewater treatment plants, and even street festivals. Furthermore, even the metrics themselves may underrepresent potential impacts. Using operating costs as a proxy for loss of function only captures a small portion of the reverberating impacts across the community.

Estimates of building and contents values do not fully capture the complexities of the diverse spaces within the region. Nonetheless, impacts presented in this report are based on the best available data for the region, and future analyses should continue to build on these findings and refine losses estimates to support the development of mitigation strategies.

*All of the results presented are estimates and are best used on a relative basis, which means comparing them to each other or to other values.*

The consequence analysis looks at the potential losses for a limited number of hypothetical events and uses high-level, large-scale planning models to evaluate impacts. Though the team used the best available data for the analysis, that does not mean the data is perfect. Modeled flood extents aren’t the same as a real, lived event. Specific buildings or assets may be miscategorized or even completely missing from the analysis.

All of the results presented are estimates and are best used on a relative basis, which means comparing them to each other or to other values. For example, the assessment compares which flood event cause larger losses and by what order of magnitude, rather than focusing on the exact dollar value of the losses for any single event.

*While damage metrics reported in this analysis are calculated based on a single occurrence of each flooding event, the flood conditions evaluated in this report have different expected probabilities of occurrence.*

For example, a tidal event representing the mean higher high water (MHHW) tide, or the average height of the highest daily tide, indicates frequent flooding, while a 1-percent exceedance probability event only has a 1 percent chance of occurring per year. In other words, tidal flooding will occur often (once or twice daily during spring tides) while a 1-percent flood generally occurs infrequently (possibly one storm in decades). However, the consequences of daily flooding do not imply that losses will be incurred daily. Rather, assets that face daily flooding may be deemed “unusable,” and the losses are often better represented as the total value of exposed assets (in other words, if the assets would flood daily, these assets may have to be abandoned constituting a one-time total value of the assets value).



The Raritan River and Bay Communities (RRBC) region was substantially damaged by the remnants of Tropical Storm Ida. Middlesex County declared a county-wide state of emergency due to widespread flooding and storm damage to every municipality. Streets were closed and barricades were put in place to ensure safety and monitor traffic. The observed water levels in the Raritan River were the highest seen in the last 50 years. Recovery from the storm and its impacts continues and will take years.

CARTERET FLOODING



Source: *The Lakewood Scoop*  
The remnants of Tropical Storm Ida flooded the Carteret Yeshiva and surrounding areas. The Yeshiva, an important community asset in Carteret, experienced severe basement and first-floor flooding in its Main Building and dormitories. Carteret as a whole experienced 9” of rainfall.

WOODBIDGE FLOODING



Source: *News 12*  
As parts of the Raritan River flooded during remnants of Tropical Storm Ida, this image from Woodbridge shows the rising water levels submerging neighborhood backyards. Nearby in New Brunswick, residents were evacuated.



Source: *NJ Spotlight News*  
In the aftermath of the September flooding devastation that Ida caused in Woodbridge, several flood victims have considered state buyouts of their properties. When Woodbridge asked homeowners there if they would consider selling their flood-prone houses through New Jersey’s Blue Acres program, many applied.

SOUTH RIVER FLOODING



Source: *Youtube*  
In South River, the Causeway area of South River experienced significant flooding during Hurricane Ida. Barricades were placed to close the area to traffic. The road flooding due to the hurricane also limited area evacuation route access.



MIDDLESEX COUNTY FLOODING



Source: *News 12 Bronx | CBS New York*  
Overall, Hurricane Ida impacted Woodbridge, Carteret, and South River most within the RRBC region. Throughout New Jersey 30 people died as a result of the floods.



# 02 - REGIONAL FLOOD IMPACTS

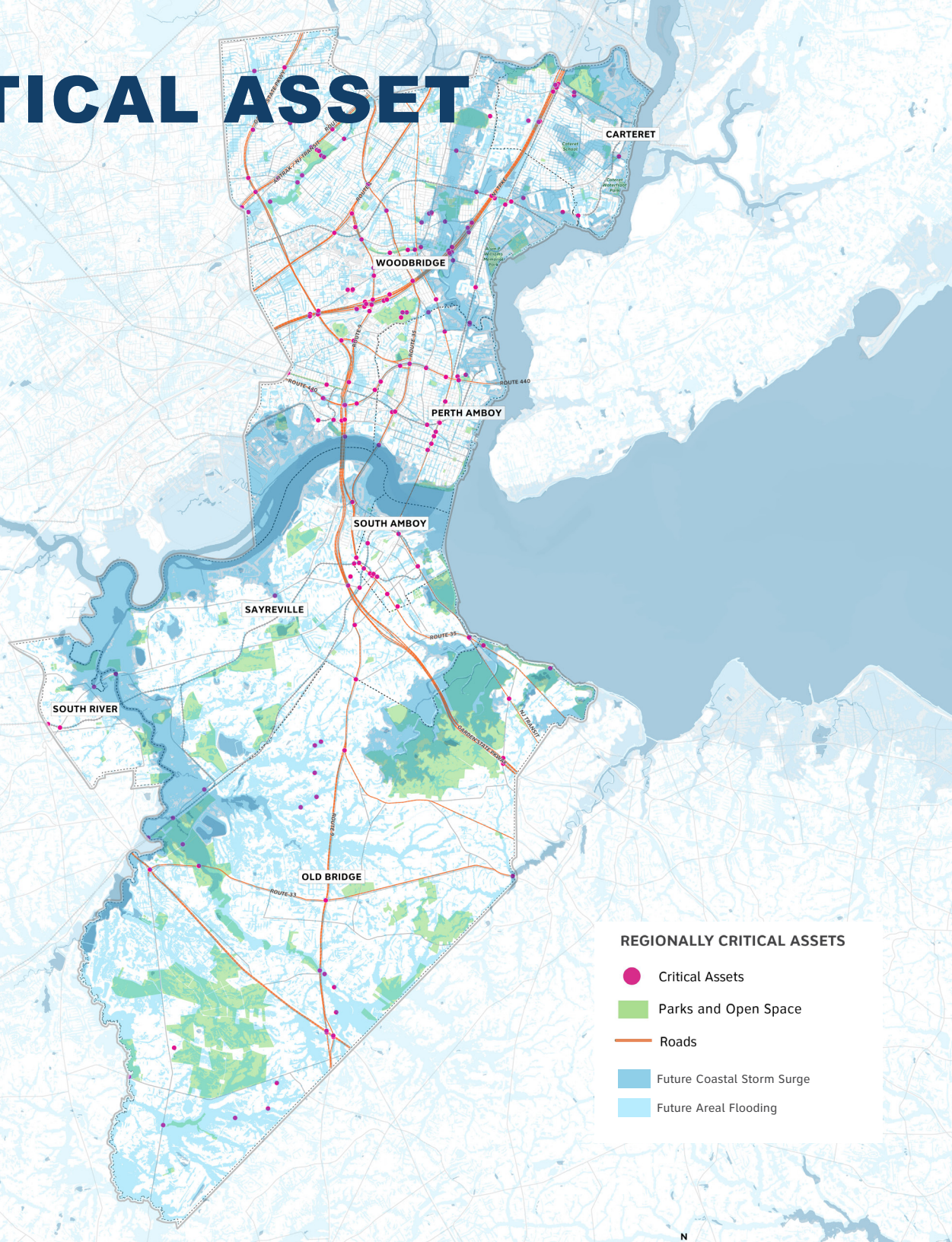
This section summarizes regional-scale flood impacts, starting with a qualitative discussion around the exposure of critical assets, before diving into the quantitative impacts of rainfall flooding, tidal flooding, and storm surge events. These results are then compared through lenses of the time frames, damage metrics, and building uses evaluated in this assessment.



# REGIONAL CRITICAL ASSET EXPOSURE

As described earlier in this report, Resilient RRBC categorized critical assets based on their relationship to the people they serve. The team prioritized community assets within each category based on the breadth of impact – how wide-reaching losses of the asset might be felt – as well as the magnitude of impact – approximated as the depth of flooding experienced across all flood events evaluated (see Appendix D). This section summarizes potential flood impacts across a selection of the highest priority regional assets identified by the team today. As the region grows and the climate changes, the identity of the area could shift, and new or existing assets could emerge as higher priorities in the event of a flood.

There are clear state and national interests to protect the region. The area is a transportation hub – an entryway to the rest of Middlesex County and a connection point between the Mid-Atlantic to New York City and New England. As a largely residential area spanning seven municipalities, there are critical assets and community services spread throughout the region. These assets protect and enrich the lives of the approximately 380,000 residents in the Raritan River region.



## INFRASTRUCTURE

**Transportation:** Multiple critical roads and highways are vulnerable to storm surge and precipitation events. These roads are critical to the region as evacuation routes and corridors for the movement of goods, services, residents, and commuters. Specific major roadways of regional importance that are vulnerable to flooding include the following:



### HIGHWAYS

- **The Garden State Parkway** is one of the major routes connecting north and south New Jersey. Flooding of this main artery would disrupt approximately 240,00 drivers daily.
- **Interstate-95** stretches through the northern section of RRBC and is vulnerable to rainfall and precipitation events. As one of the most important travel corridors along the east coast, closures and flooding have the potential to cause major disruptions to goods, services, and people. Approximately 98,000 vehicles travel on the tolled portions of the Turnpike daily, based on toll collection statistics from 2021.



### RAIL LINES

- **The North Jersey Coast Line** commuter rail line connects the Jersey Shore region to the metropolitan area in Northeastern New Jersey and New York City. With more than 24,000 daily riders, there is potential for flooding to greatly impact the region and its commuting population. Additionally, the rail line uses five moveable bridges that are vulnerable to high winds and storm surges during coastal storms. Vulnerable stations in the RRBC region are Woodbridge, Perth Amboy, and South Amboy.
- **Northeast Corridor Line** is a rail line that runs through Woodbridge and is vulnerable to rainfall flooding. This line connects the Trenton Transit Center to New York Penn Station and is a major commuter line for commuters. Total weekday ridership for the multiple services using the North East Corridor was reported as 822,000 passengers per day.



### ROAD INFRASTRUCTURE

- More than 100 **bridges** are vulnerable to flooding throughout the region. This may mean that a part of the bridge itself is flooded; however, even when a bridge structure may or may not be flooded, a bridge is vulnerable if access to the bridge is affected by flooding. When flooding cuts off access to a bridge, routes to leave flooded areas are limited. This may result in longer travel times or drivers taking risks on flooded roads. One example of a bridge vulnerable to flooding is the NJ Coast Rail bridge that crosses over Cheesequake Creek in the Laurence Harbor section of Old Bridge.



# INFRASTRUCTURE

**Utilities:** Multiple assets that provide critical services to the Raritan River and Bay region are also vulnerable to flooding. Regional utilities that may be impacted by flooding include the following:



- **Cell phone towers** may be flooded, resulting in service outages that can put citizens at risk during a storm event.
- **Power Generation Plants**, specifically five in Sayreville and two in Woodbridge, are exposed to flooding. These power plants are dispersed throughout the region, causing widespread power outages for the region. Some of these plants, such as the PSE&G Sewaren Generating Station, were flooded during Hurricane Sandy and have since been improved by elevating critical systems above federal guidelines for flood mitigation, ensuring their increased resilience to future flood events.



- **Wastewater Treatment Plant:** flooding will cause disruptions to sewage treatment and lead to the disposal of untreated water into river systems. Two plants vulnerable to flooding in the region include the Middlesex County Utilities Authority (MCUA) Central Treatment Facility, which treats wastewater from the majority of Middlesex County, and the Rahway Valley Sewerage Authority Plant in Woodbridge.
- **Water Treatment Plants:** Runyon Water Treatment Plant, operated by Middlesex Water, is in a flood-prone area. Flooding at a water treatment plant may interrupt water service to residents.

# BASIC PUBLIC HEALTH, SAFETY, AND PHYSICAL WELL-BEING



- **East Jersey State Prison**, home to 1,200 of the state's most socially vulnerable population, is vulnerable to rainfall flooding. Impacts to this facility could have reverberating effects on an already overstressed incarceration system, starting from the logistics of securely transporting incarcerated persons to new facilities in the event of an evacuation, to ensuring that there are sufficient resources to support the additional capacity at other locations.



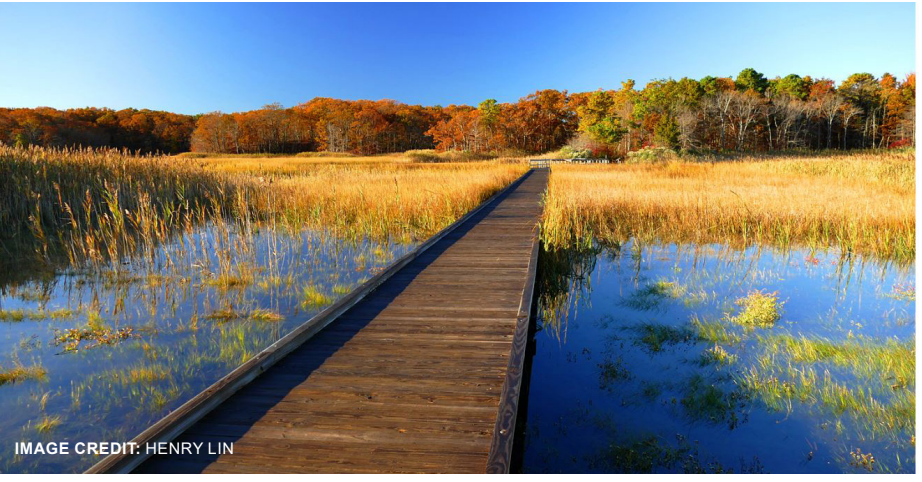
- **Public Parks** in the Raritan River and Bay Region are susceptible to flooding, including the John A. Phillips Preserve and Raritan Bay Waterfront Park. These areas have potential to mitigate flood risk by absorbing excess rainfall and minimizing storm surge. Parks provide the community with places to run, play, bike, or walk their dogs. Losing access to parks may affect mental health and wellness as well as physical fitness. Public parks may also be used for social gatherings and community events.

# ECOSYSTEM AND ENVIRONMENTAL HEALTH



- Three historic **landfills** in the region are exposed to flooding: Carteret Borough Landfill, Global Landfill in Old Bridge, and Sayreville Asbestos. While these landfills are not currently used, intense rainfall and flooding will make the flood protection and clean up mechanisms that currently exist vulnerable.
- There are a number of **known contaminated sites** in the region. Many of these are concentrated along the Arthur Kill and Raritan River and Bay waterfronts in areas historically filled to create additional land. Flooding at these sites has the potential to mobilize contaminants on site and into water bodies or other properties. While losses at these sites are not easy to quantify, they may include human health impacts as well as ecosystem impacts and are no less important to consider in the action planning process.
- **Public Open Space and Vegetation** is widespread throughout the Raritan River and Bay Region. These areas have ample vegetated land and public open space. These areas have potential to mitigate flood risk by absorbing excess rainfall and minimizing storm surge. As storms become more intense, these riparian and coastal wetland zones will be less effective as buffer zones.

# QUALITY OF LIFE



- **Cheesequake State Park** is susceptible to rainfall and coastal flooding. Cheesequake State Park lies in the transitional zone between two different ecosystems and is the natural habitat for diverse flora and fauna and is used by birders, hikers, campers, and others. As groundwater levels rise, saltwater intrusion will increase. The change in the water's salinity will impact the ecosystems in the state park, making them more vulnerable to damage and destruction.

7 More information about how the team estimated damage can be found in Appendix C.



# RAINFALL FLOODING IMPACTS

We know from past events – like Hurricane Floyd in 1999 and Hurricane Irene in 2011, and at least three major storms in 2021 – that heavy sustained rainfall is already flooding homes, businesses, roads, and other critical assets in our communities. Today, flash flooding and areal flooding events both have the potential to cause billions of dollars in losses in the form of direct physical damage, disruption, and stress. Resilient RRBC modeled both types of significant rain events to reflect present day and future expected conditions.

Analyses of four precipitation events reveal that rainfall events are already causing severe inundation to both roadways and structures throughout the region, as shown on the following maps. A 10 percent increase in precipitation will slightly increase the extent of flooding and damage from today’s conditions, however the extent and damages expected today are nearly as severe. The risk is here now. Even without sea level rise or a 10 percent increase in rainfall, coastal flooding and rainfall flooding are already widespread in the

These results affirm the narrative that the project team has heard from the community time and time again – residents across the region have experienced repetitive flooding during rainstorms that disrupt daily life. Many community members reported flooding from remnants of tropical storms Ida and Henri last year, and there is a community perception that the flooding is getting worse and showing up in new places. Throughout the region, existing storm sewer systems were never designed to manage this severity of rainfall, resulting in widespread urban stormwater flooding and impacts to mobility.

## Estimated Total Direct Losses

### Today across the region:

- Flash flooding could directly impact approximately **5,300 buildings** and **27,000 residents**, causing **\$670 million** in losses.
- Areal flooding could directly impact approximately **10,000 buildings** and **48,000 residents**, causing **\$1.3 billion** in losses – nearly double the losses expected due to a flash flood event.

With a 10 percent increase in rainfall expected by 2070, but no change in the built environment or the number and locations of people, the following is anticipated:

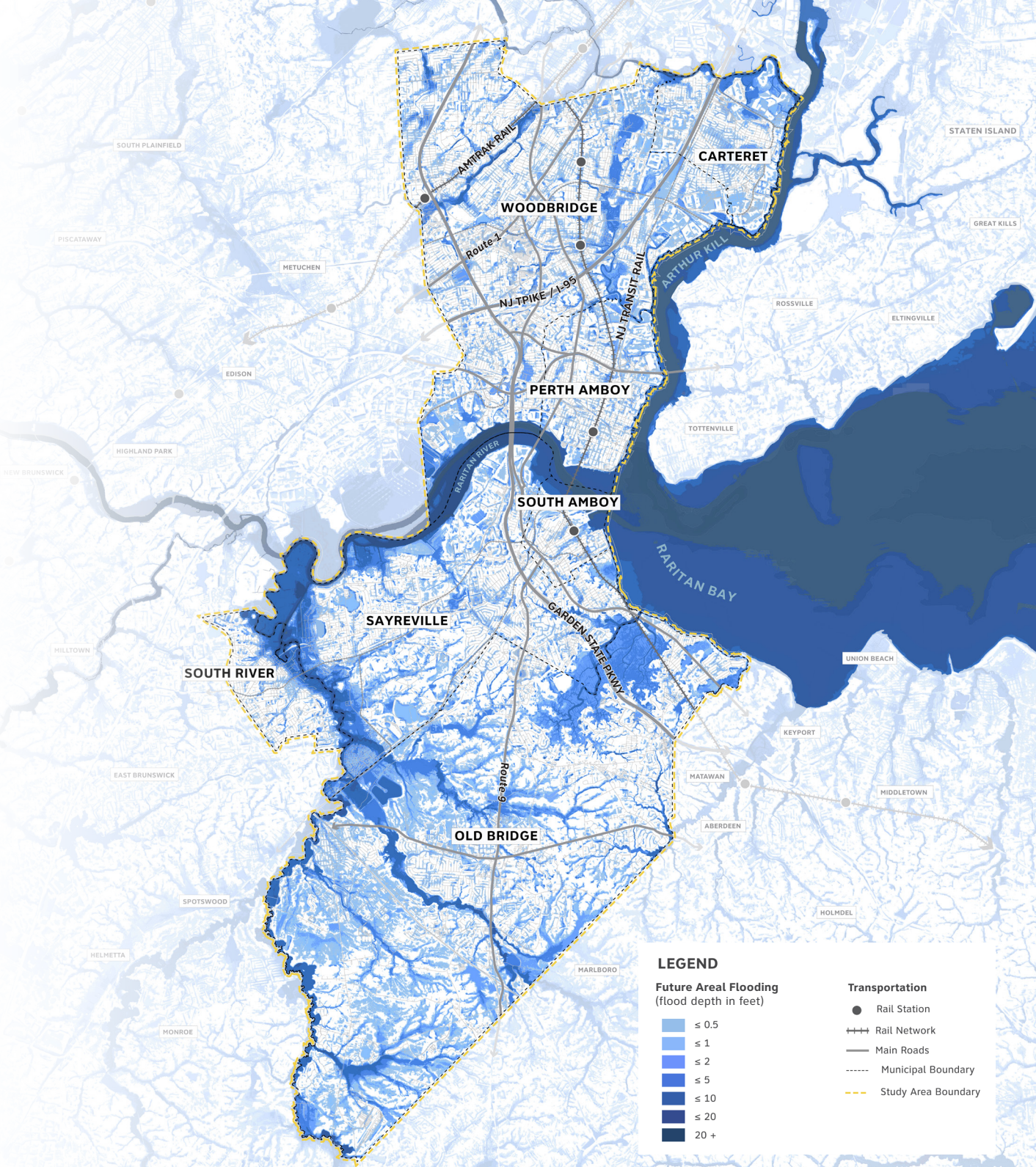
- Flash flooding could directly impact approximately **800 additional buildings** and **4,000 additional residents**, causing **\$200 million more in losses**.
- Areal flooding could impact approximately **1,500 additional buildings** and **8,000 additional residents**, causing more than **\$200 million more in damage** than from an areal flood event today.

**These conditions and perspectives underscore the need to act now, not just by 2070.** Though climate change will increase the impacts of rainfall flooding to some extent, rainfall flooding is already a widespread problem in the region that warrants significant attention and action. The map of the modeled present-day flash flood and areal flood events demonstrates that most of the region will be exposed to some level of rainfall flooding, much of it in areas where flood insurance maps do not examine flooding and where flood insurance is not required.

**Even the few areas not directly exposed are surrounded by places that are, meaning that power and other utilities, transportation, services, and the ability to evacuate could all be affected. In other words, all people who live, work, and play in the region face some level of risk today.** For those who do have flood insurance, insurance rarely covers the full cost to repair losses, and insurance rates are going up. Impacts to public services and daily life include power and water outages, mobility disruptions, and street closures.

*The flood models used in this analysis are regional level models, and as such, do not include the details of the drainage system. The Resilient RRBC team updated the models with assumptions about what amount of rainfall we could reasonably expect the current drainage system to take away.*

*Resilient RRBC has not modeled flooding from smaller, more frequent rainfall events. While this is a limitation of the study, community members and municipalities have shared reports of repeat flooding, and actions to reduce the impacts of major rainfall events should be designed to curtail the impacts of nuisance flooding.*





# TIDAL FLOODING IMPACTS

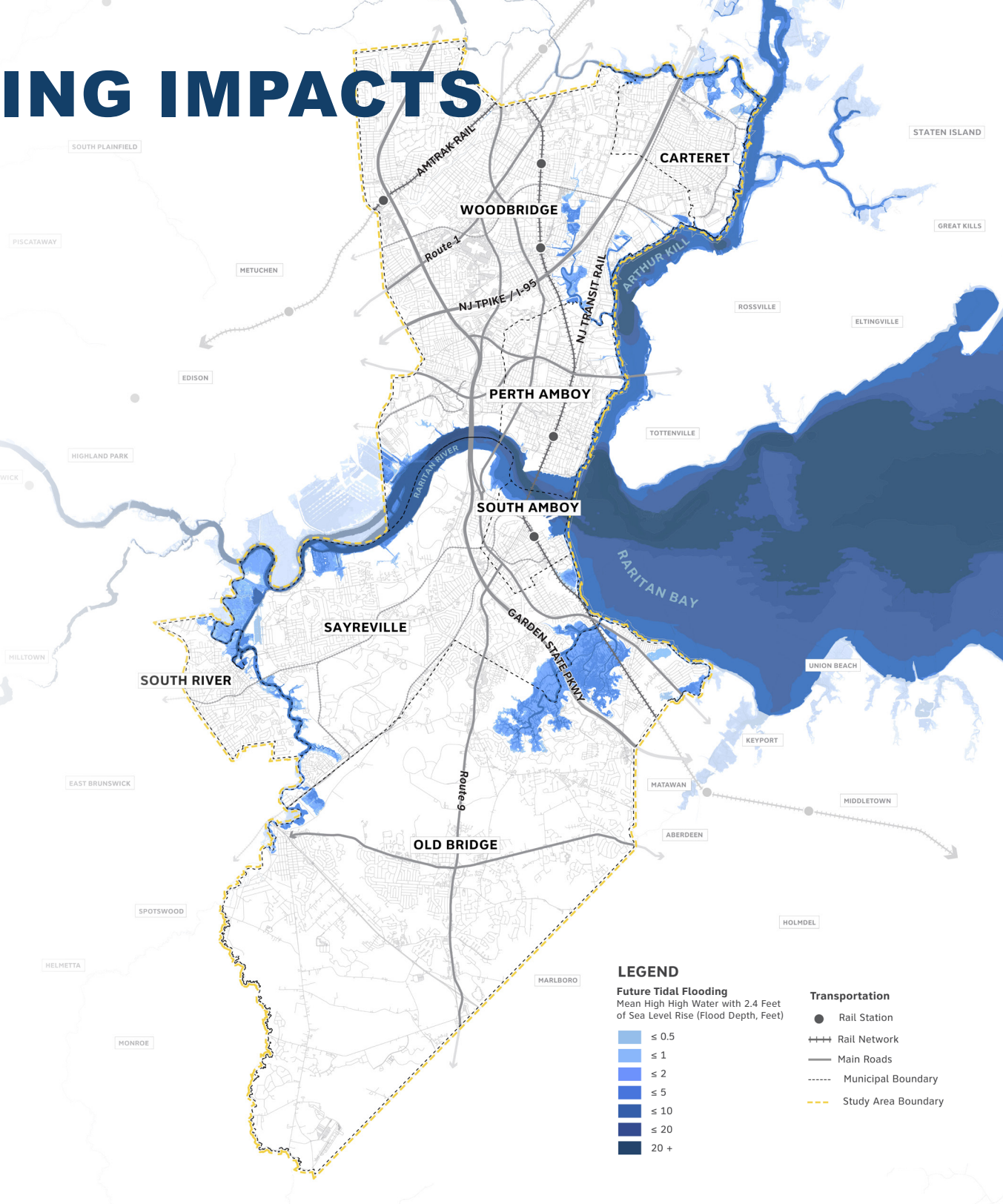
Large portions of the region are shown as inundated regularly during high tide, with 2.4 feet of sea level rise. However, much of this space is tidal wetlands and undeveloped land. Although the extent of impacts to developed lands is limited, these tidal events occur with a high frequency, resulting in regular flooding, up to twice daily. Areas, access routes, and buildings vulnerable to high tide will be permanently useless long before this level of inundation.

Depending on the area and uses, infrastructure and buildings may become unusable by the time they experience monthly, yearly, or even less frequent flooding, depending on water depths and the level of disruption.

While roadways can hold out longer, frequent flooding of roadways is extremely disruptive and areas along them can begin to experience reduction or withdrawal of investment in the region.

Rising groundwater levels can impact low lying areas. It is generally expected that within a kilometer of the coast, groundwater tables will rise at the same rate as sea levels will rise. Though the quantification of groundwater impacts is not evaluated in this analysis, it is important to recognize that rising tides have impacts beyond the extents shown on the map.

***With 2.4 feet of sea level rise, daily high tides will affect 3,000 acres where 32 buildings currently reside. These buildings have \$3.8 million in building and contents replacement value and house 44 people. The land value of the affected properties is \$110M.***



# STORM SURGE IMPACTS

## Estimated Total Direct Losses

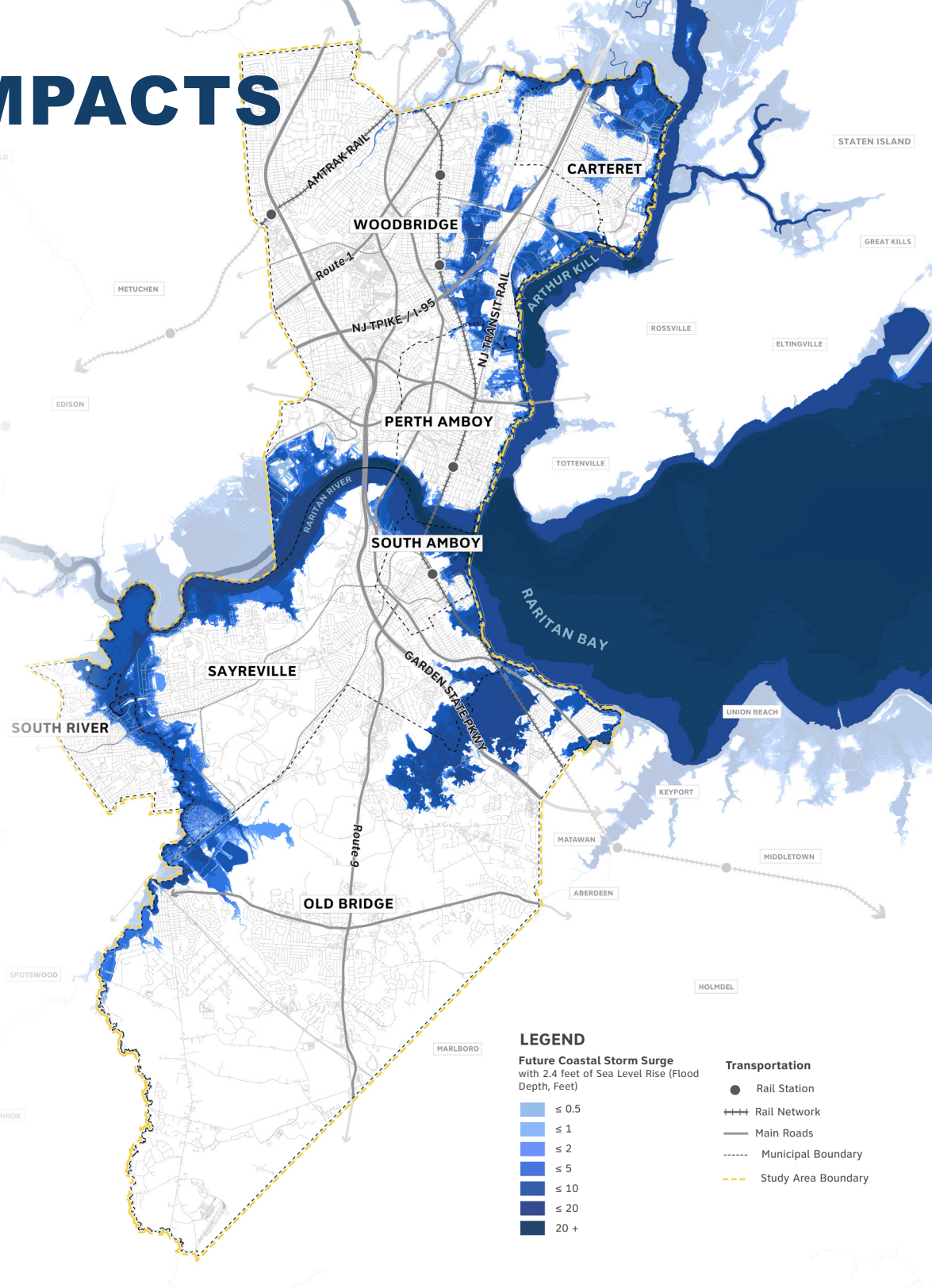
To understand how coastal flooding could impact the region in the future, the Resilient RRBC team modeled storm surge from Hurricane Sandy as it occurred in 2012, with **2.4 feet** of sea level rise.

A similar extreme storm surge event today could flood approximately **3,000 buildings** across the region and impact approximately **14,000 residents**, causing **\$1 billion** in losses. With an additional **2.4 feet** of sea level rise, this coastal flooding could impact approximately **2,000 more buildings** with **8,000 more people**, and almost tripling the losses.

Hurricane Sandy caused extensive flooding to coastal areas in 2012 that resulted in buyouts throughout the region after storm surge on the Raritan Bay reached more than 13.5 feet (NAVD88). Though flooding is concentrated in low-lying coastal areas along the Arthur Kill, Raritan River and Bay, it is not just a coastal issue. Flooding extends into tidally influenced tributaries like Woodbridge Creek and extends significantly inland in low-lying areas, like the Noes Creek inlet in Carteret. Much of the coastline in this area is protected by coastal structures and development is already raised or elevated, so exposure is relatively low when compared to the other events considered. However, sea level rise will worsen the storm surge associated with a storm of similar probability, erode beaches that provide natural coastal protection, and increase the level of protection needed to minimize structural damage along the coast.

To understand possible future flooding from extreme storm surge, Resilient RRBC modeled a future extreme storm surge event by adding 2.4 feet for sea level rise onto Hurricane Sandy high-water marks. The Resilient RRBC team estimates that \$1 billion of direct losses could be expected in a present-day extreme storm surge event. The areas affected would be similar to the areas impacted by Hurricane Sandy, with higher predicted flood depths and with flooding extending slightly further inland.

Extreme storms like Hurricane Sandy are less frequent than flash flood and areal flood events and much less frequent than the MHHW tidal event. Although the damage caused by this magnitude of flooding is extremely high, it is important to remember that it is expected to occur less frequently.





# COMPARISON OF RESULTS

When compared to models of future flash flooding or areal flooding events, the extreme storm surge event is expected to cause nearly twice as many losses due to the depth of flooding from coastal storms, despite covering a much smaller area. This difference is because the modeled flood depths in buildings for the future storm surge event (6.8 feet above ground level on average) are significantly higher than that for major rainfall events (around 2 feet above ground level on average), leading to significantly greater direct physical damage.

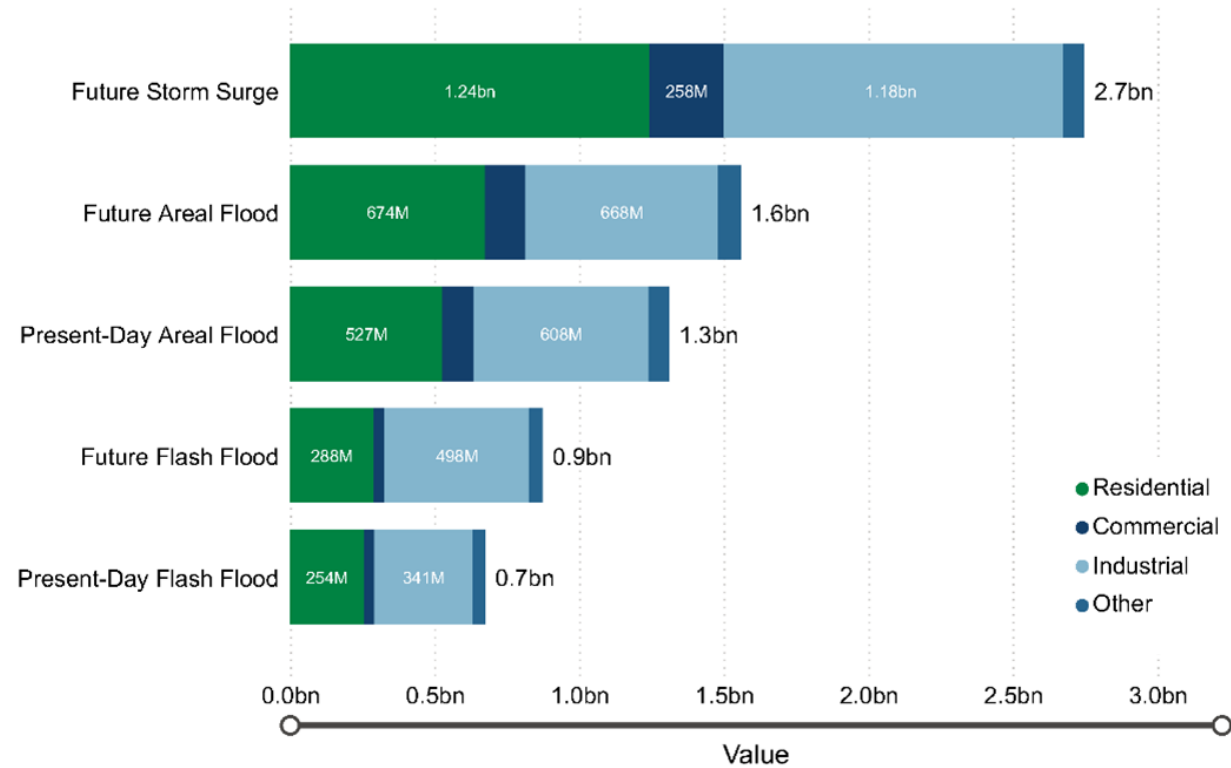
Future extreme storm surge flooding is expected to happen much less often than flash floods or areal floods caused by rainfall events within the region. Though the total rainfall-related impacts presented in this assessment may be less than the coastal impacts, flash flooding and areal flooding both have the potential to cause billions of dollars in losses today. Hurricane Irene in 2011, for example, caused between \$4 and \$6 billion of damage in New Jersey. Although this event was a coastal storm, rainfall was the primary driver of flooding in the region, not storm surge.

The second largest share of loss calculated comes through expected impacts to **residential buildings** – both because of the sheer number of affected homes and because estimation of losses to these structures is well-established and accepted by industry. These losses include direct physical damage to the homes and their contents, displacement and relocation costs to the residents within, as well as factors accounting for costs due to mental stress and anxiety and lost productivity of affected people.

Damages to **commercial structures** will impact the distribution of resources and materials needed by recovering communities. Business impacts reflect the losses from the downtown storefronts, strip malls, and industrial warehouses that will lose their function. These consequences should be considered by residents and businesses when making decisions about investments and next steps.

The largest share of loss calculated comes through expected impacts to **industrial buildings** – most of which are warehouses or regional dispatch centers. RRBC is critical to

the movement of goods throughout the tri-state area. Warehouses in the region range from Amazon holdings, food distribution and construction goods to oil tanks. Impacts to these facilities have far-reaching consequences in today’s interconnected global economy. Recent events have highlighted the critical importance of maintaining the supply chain, with effects on everyday lives, such as longer delivery times, shortages of goods on grocery store shelves, and inflation due to short supply.



# BREAKDOWN OF IMPACTS

As discussed earlier, analyzed four types of impacts to buildings and the people, businesses, and services they house. These were: direct physical damage, human impacts, business impacts and loss of function.



**Physical Damage** is the largest driver of losses, accounting for approximately 70 percent of the quantified losses across all six rainfall and coastal events modeled for RRBC. These damages represent repair and restoration costs that homeowners, business owners, utilities, state agencies, and federal government may face following a flood event.



**Business Impacts** occupy about 10- to 15- percent of losses and only include impacts of businesses that are directly flooded. These calculations do not include lost income and spending from employees that may follow business closures. They also do not include stress and impacts to employees and visitors who do not live directly within the affected area. This is a limitation of this assessment.



**Human Impacts** reflect the toll that flood events will have on the members of the community. The ability to gather, work together, and create a cohesive space is at risk.



Because **Loss of Function** impacts can be hard to quantify, these damages contribute a relatively small (<10 percent) portion of the estimated overall losses to the region. Nevertheless, the loss of function of public and essential service-related assets can have cascading impacts throughout the region. A school shutdown, as seen during the COVID-19 pandemic, can have broad impacts on the lives and livelihoods of students, parents, and teachers. These impacts are not captured in this assessment. Loss of function to transportation assets, like buses or trains, are also not captured, but could have significant impacts on people who rely on these assets.

Ultimately, an investigation of a wider range of flood frequencies would provide a clearer understanding of relative risk between rainfall and coastal storm events and how that risk will evolve over time. In the meantime, results presented in this report are best understood with the probability of occurrence and source of flooding in mind. As described in the next section of this report, a storm surge event is likely to impact different types of buildings (slightly more industrial and commercial) than a rainfall event. A rainfall event is likely to directly impact more residents (56,000) than a future storm surge event (22,000). Storm surge, flash floods, and areal floods cause severe losses within the region, but there is presently less investment in addressing stormwater flooding.

Socially vulnerable populations including low income, non-English speaking, minority, elderly, children, homeless, or physically disabled people are more likely to need support to prepare for, respond to, or recover from a flood event. These populations are more likely to have limited financial and physical resources and are more likely to be adversely affected by flooding. In socially vulnerable communities, critical community assets often play a key role in supporting the community’s recovery from flooding. Critical community assets are of special importance in socially vulnerable areas.

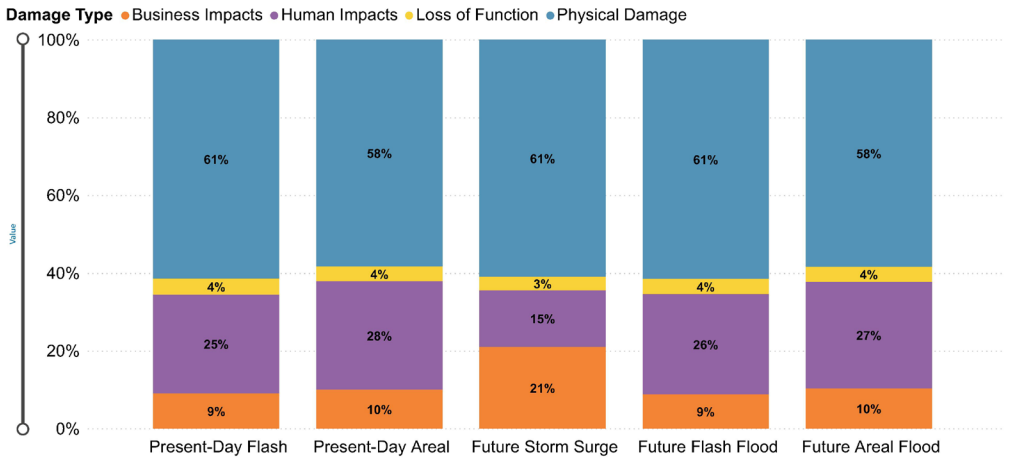




IMAGE CREDIT: TERRY MCKENNA

IMAGE CREDIT: NATURE IN THE BURBS ON FLICKR

## 03 - WATERSHED-BASED FOCUS AREAS

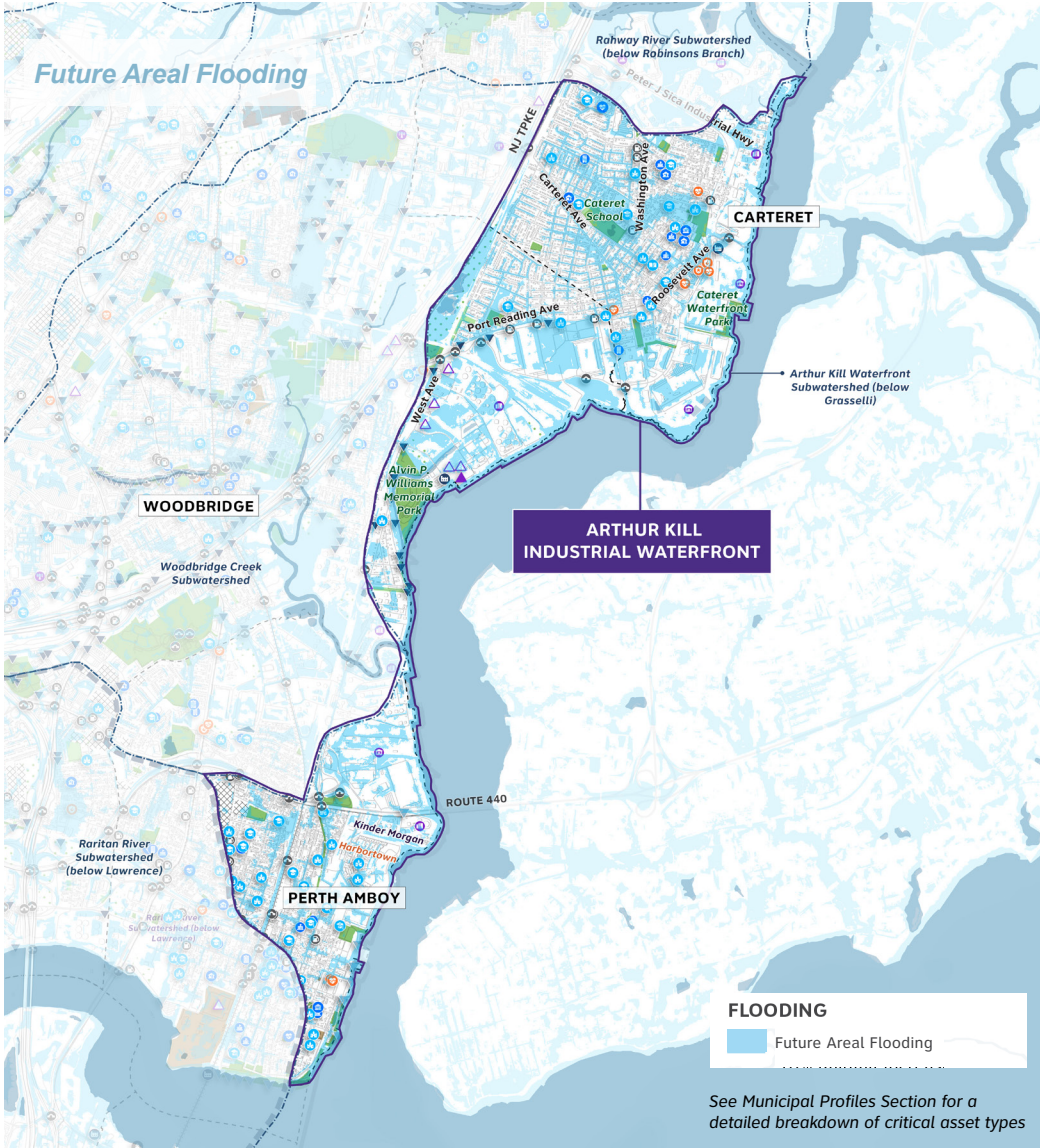
To understand the consequences of flooding throughout the region, the team organized the study area into focus areas defined by watersheds and land use patterns. A watershed is an area through which all water will eventually combine and exit into one water body through hydraulic movement.

By understanding risk through this lens, the team is best equipped to offer solutions that comprehensively address the source of flooding and the range of expected impacts. The analysis focuses on the future areal rainfall and future storm surge events because, while flood depths varied between the current and future events, changes in flood extent were limited – so the same assets that are flooded now will be flooded in the future.



# ARTHUR KILL INDUSTRIAL WATERFRONT

The Arthur Kill Industrial Waterfront includes industrial areas along the Arthur Kill coast in Carteret, Woodbridge, Perth Amboy, and the surrounding residential areas. This area is characterized by oil and gas terminals, in addition to more recent warehousing and distribution facilities, and new waterfront parks. Most buildings in this focus area are residential, but those with the highest potential damages are industrial. The residential areas of Carteret have some of the highest social vulnerability scores in the region that is largely driven by a high minority population and high poverty rates.



**Areal Rainfall Flooding**



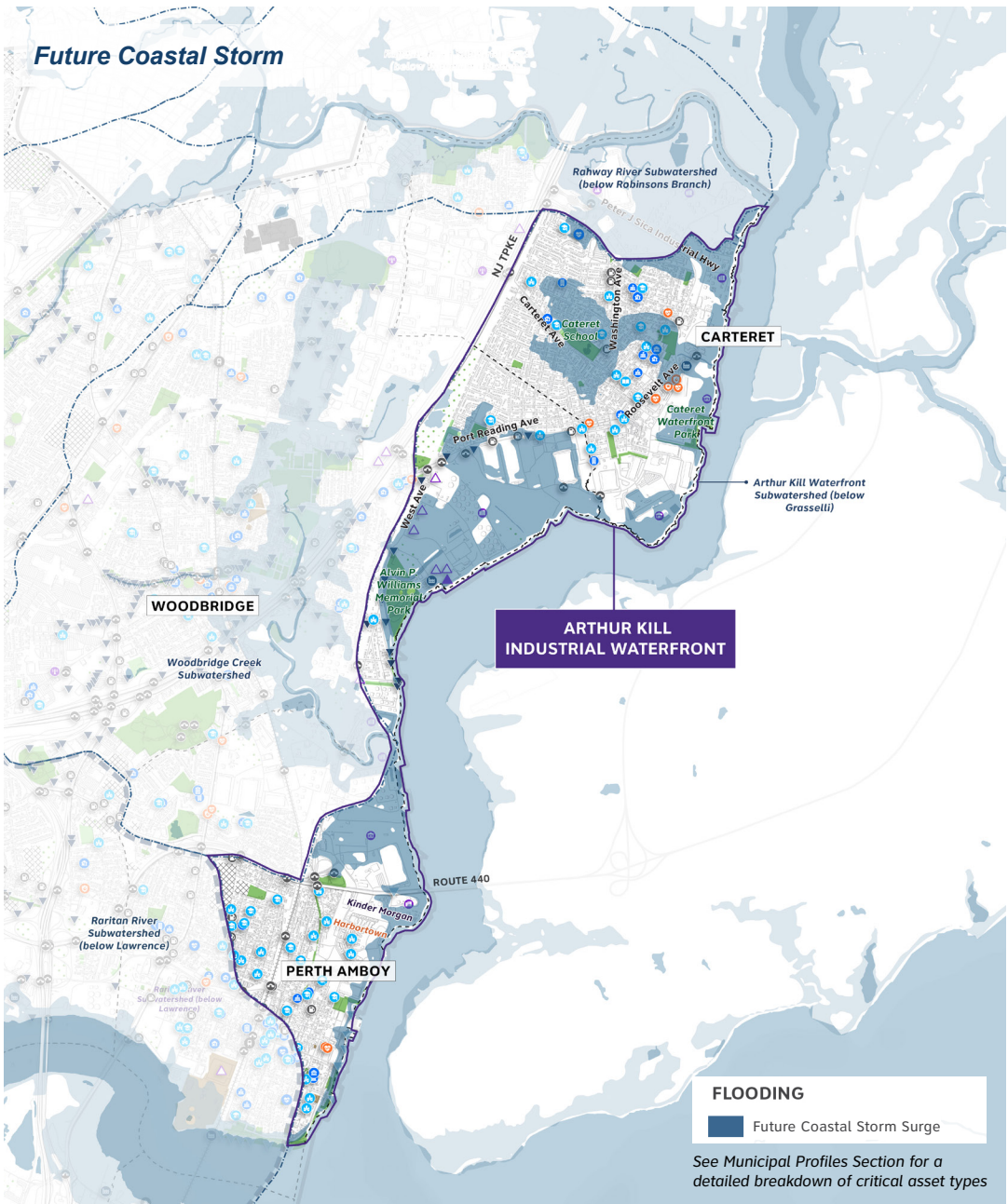
**\$400 Million**  
in expected losses



**1,300**  
buildings impacted

The Arthur Kill, the Rahway River, Woodbridge Creek, and Noes Creek are vulnerable to overflowing due to future heavy sustained rainfall events and flooding surrounding areas. Storm sewers further inland are expected to become inundated during heavy sustained rainfall events, causing pockets of flooding throughout neighborhoods in Carteret and Woodbridge. Flooding is expected to accumulate in the lowest lying areas that are also flooded by a coastal flood; however, a heavy sustained rainfall event is expected to flood many more local roads, making driving through or evacuating from the area a greater challenge. This area was once mainly oil and gas facilities, and many of these structures are still present. Recent developments are converting older warehouses into distribution facilities and big box retail stores.

A large portion of Carteret's downtown is expected to flood during rainfall events and expose community services to flooding, including Carteret Police Station, local emergency services, Carteret Fire Station, City Hall, Carteret Middle and High School, Yeshiva Gedolah School, and Carteret Library. This high number of services with expected damages will take time to recover from flood events, risking economic and social fluidity in the city. Further south in Woodbridge and Perth Amboy, industrial waterfront space and utilities are also exposed to rainfall inundation, disrupting movement of goods along the Perth Amboy waterfront and Port Reading Buckeye Global Marine Terminal and the utility services provided by the PSEG Seweran Generating Station. During future rainfall events, these assets are expected to flood, which can result in environmental contaminants entering the water if not mitigated. Post-Hurricane Sandy critical systems at the PSEG Sewaren Generating Station were elevated, which would protect its ongoing function in the event of a heavy sustained rainfall.



**Coastal Storm Surge**



**\$800 Million**  
in expected losses



**1,600**  
buildings impacted

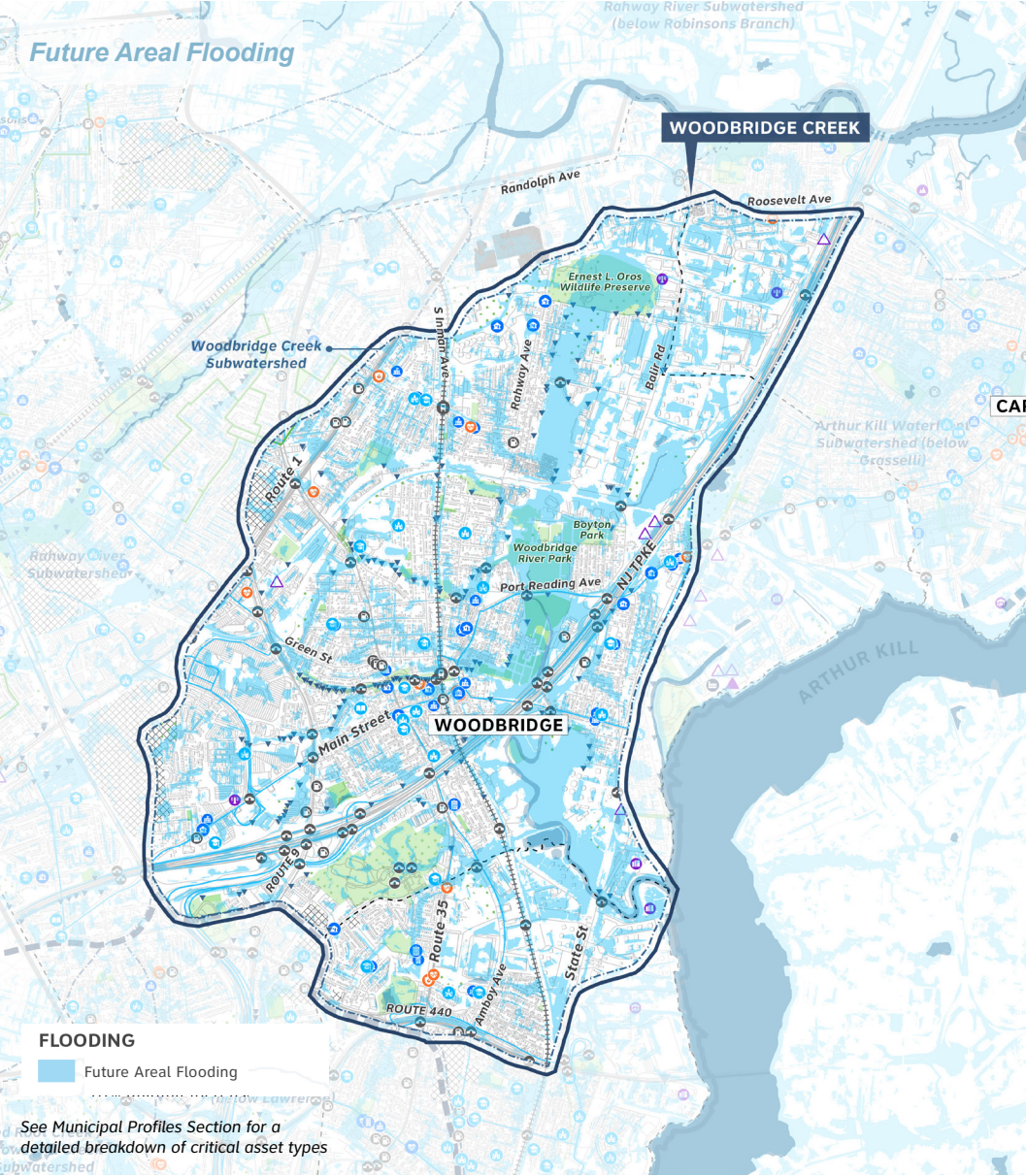
Across all building use categories, a future Category 1 hurricane (similar to Hurricane Sandy) is expected to cause the highest damages. The Arthur Kill, the Rahway River, Woodbridge Creek, and Noes Creek are significant pathways of coastal flood waters into this area. The focus area is primarily industrial, and future coastal storms are expected to inundate the following areas: landfill redevelopment along the Arthur Kill, shipping warehouses, oil tanks, and the Kinder Morgan Liquid Terminal. Flooding of these assets has the potential to contaminate the waterways and cause oil leakage.

The Noes Creek inlet is a low point leading to the flooding of the mixed-use residential and commercial community near Carteret High School. In this area, approximately 1,600 housing units will be inundated as well as Carteret High School, Yeshiva Gedolah School, and commercial structures along Washington Avenue. Evacuating this community poses challenges, because future storms are expected to flood the hurricane evacuation routes along the New Jersey Turnpike, Washington Ave, and Roosevelt Ave. Additionally, Carteret is densely populated, struggles with overcrowded housing, and has one of the higher social vulnerability indices in the region.

Further south in this focus area, additional waterfront industrial space and utilities are exposed to future coastal flooding. Two port terminals, Buckeye Global Marine Terminal, and Port of Perth Amboy, are a storage space for refined products and a transport hub. Multiple substations are located along the Arthur Kill River. During future storm surge events, these assets are expected to flood, which can result in environmental contaminants entering the water if not mitigated.



# WOODBIDGE CREEK



## Areal Rainfall Flooding



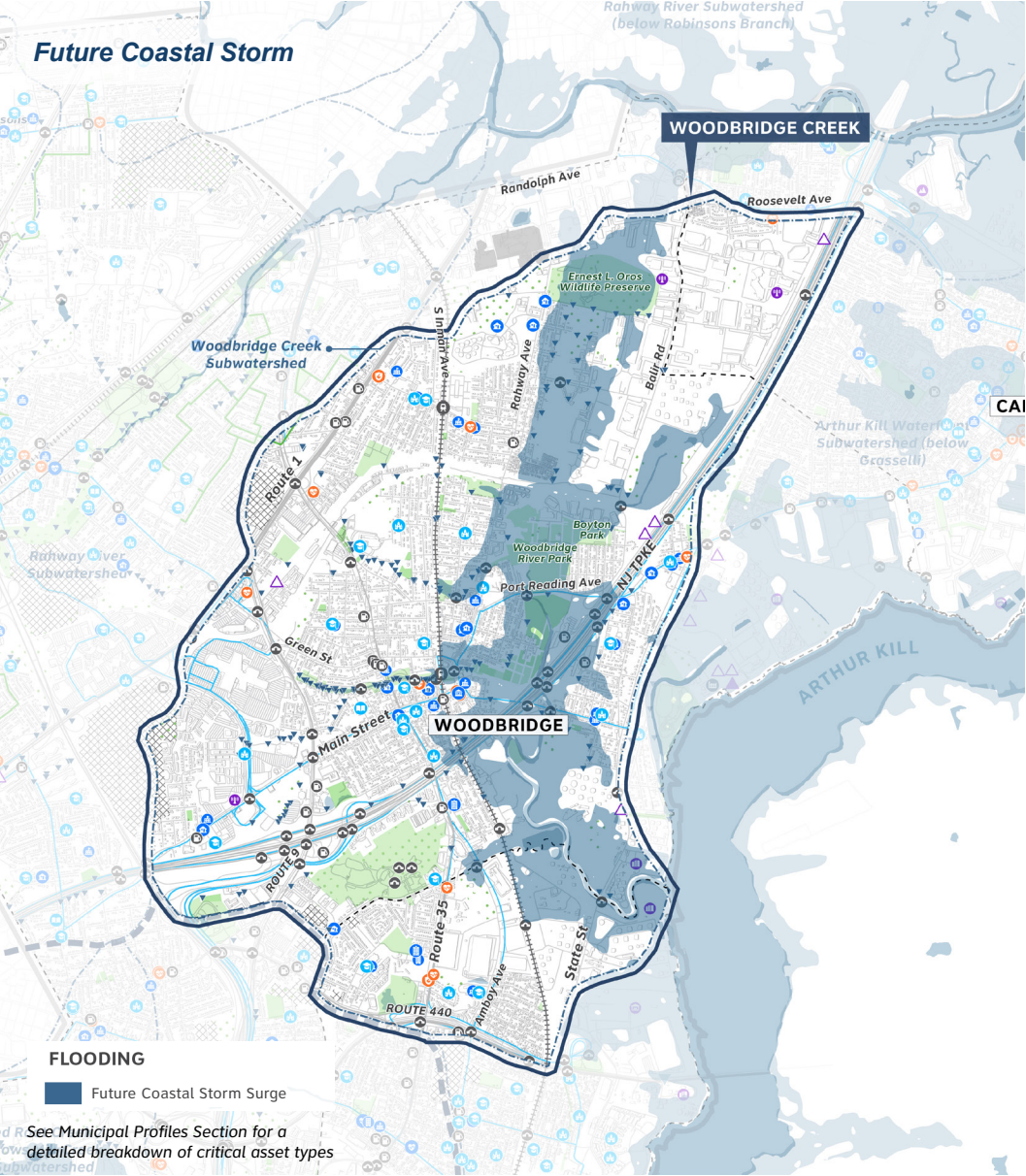
**\$140 Million**  
in expected  
losses



**2,000**  
buildings  
impacted

The Woodbridge Creek focus area includes residential and commercial areas in Woodbridge Township. Most buildings in this focus area are residential, but those with the highest potential damages are industrial and commercial. Across all building use categories, the future heavy sustained rainfall event is expected to cause the highest damages. In this area, there are many creeks that feed into Woodbridge Creek, some of which have been channelized. These creeks are a frequent source of flooding during heavy rain events, particularly in areas where flood waters back up behind culverts.

During future rainfall events, flooding is expected to extend along Woodbridge Creek and accumulate in lower lying spaces. As the southernmost point of the Arthur Kill Watershed, heavy sustained rainfall events throughout the rest of the watershed will accumulate in riverine flooding throughout this area into the creek's tributaries. Additionally, stormwater ponding is expected to impact residential, commercial, and industrial structures and roads adjacent to them. Extensive flooding will disrupt movement across the area, making evacuations and access to critical services difficult and dangerous. Areas around Woodbridge Creek have medium to high population densities and acts as a commuting corridor, with the Garden State Parkway and the New Jersey Coast Line Rail passing through. Some of the critical facilities exposed to flooding include Woodbridge and Port Reading Fire Department, the Woodbridge Library, and the East Jersey State Prison.



## Coastal Storm Surge



**\$680 Million**  
in expected  
losses



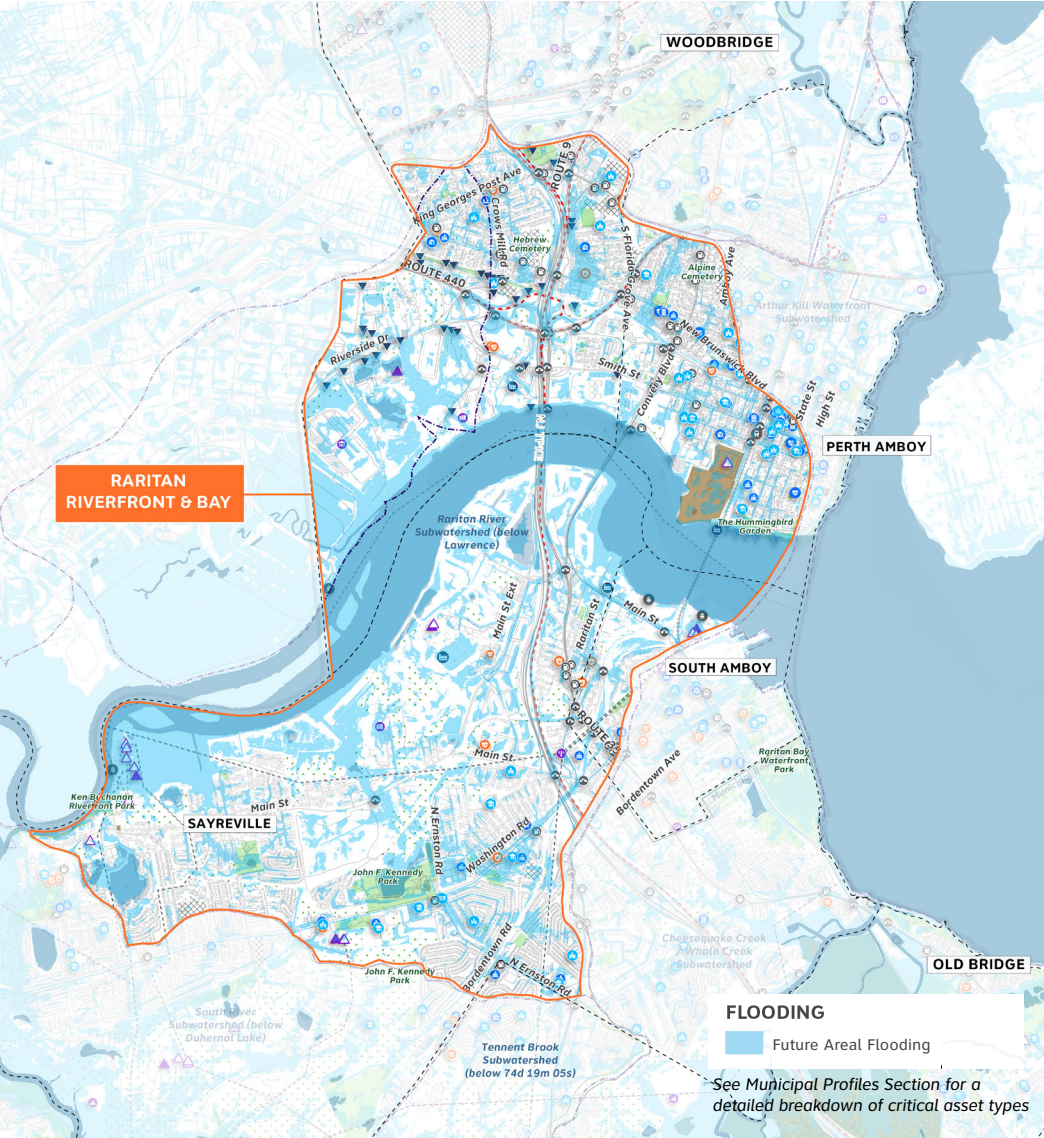
**1,400**  
buildings  
impacted

During future coastal storms, the Rahway and Arthur Kill Rivers are inundated and create significant flood pathways along these rivers' tributaries. Water is expected to accumulate around Woodbridge Creek and Woodbridge's downtown space, creating an island of eastern Woodbridge and Carteret. The area is a combination of industrial parks, medium density suburban residences, and car-oriented commercial areas located along Woodbridge Creek. Since the space around the creek is flat, it is prone to flooding and makes the roads in the community vulnerable to flooding in future-modeled storms. The New Jersey Turnpike and the New Jersey Coast Rail Line pass through, resulting in transitive and commuter populations being present.



# RARITAN RIVERFRONT AND BAY

The Raritan Riverfront and Bay focus area is characterized by the historic downtowns of South Amboy and Perth Amboy, which are both situated on higher ground just inland from the coast, as well as the area of Sayreville close to Raritan Bay. Recently, new developments in all municipalities have introduced new housing and open spaces along the waterfront. Most buildings in this focus area are residential, but those with the highest potential damages are industrial. Across all building use categories, the future heavy sustained rainfall storm is expected to cause the highest damages.



Areal Rainfall Flooding



\$340 Million  
in expected  
losses

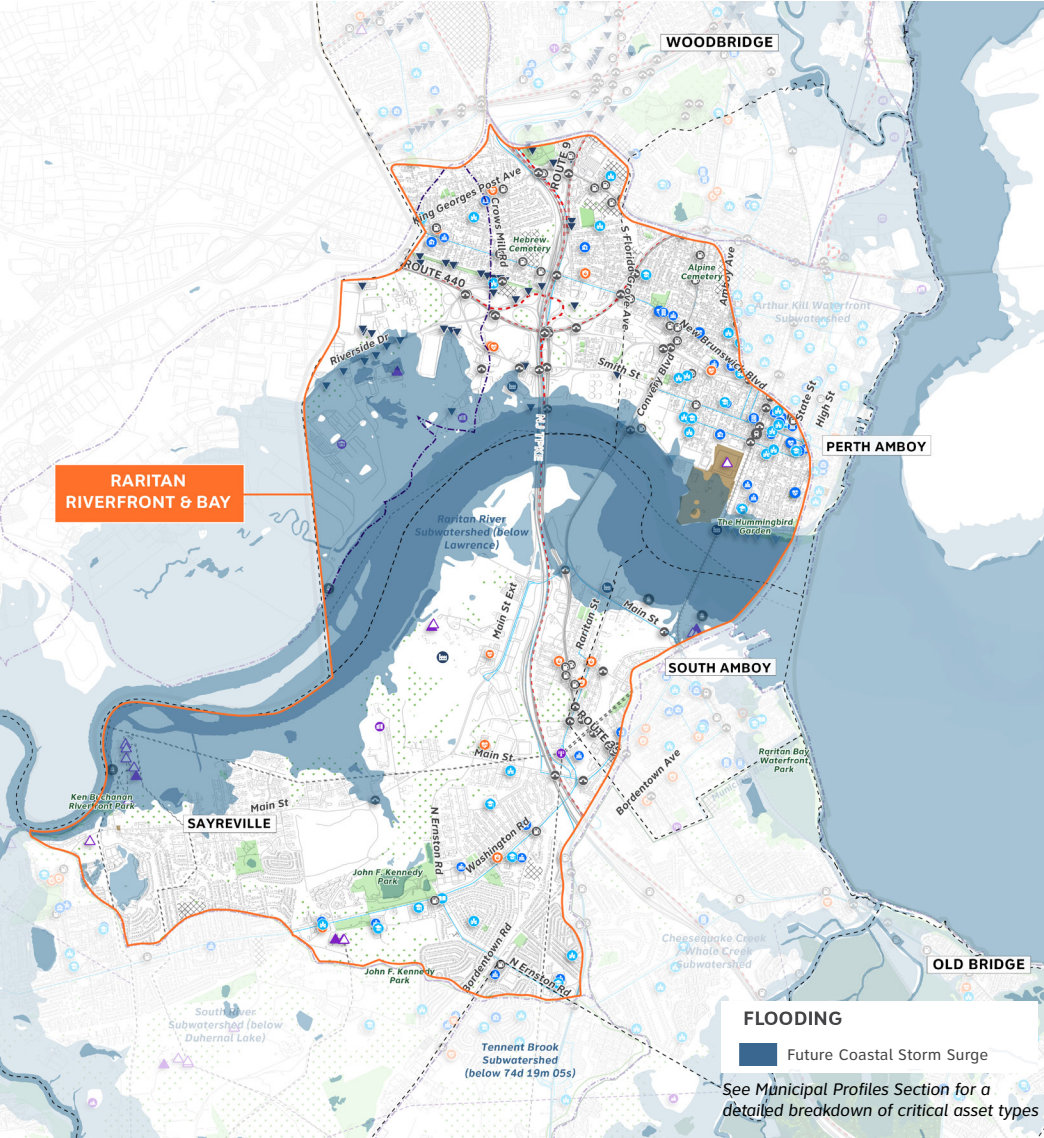


2,400  
buildings  
impacted

During modeled rainfall events, flooding will occur in the downtown areas of Perth Amboy and South Amboy, impacting residential, commercial, and educational structures as well as local parks and open spaces. At the southernmost point of the Lower Raritan, South River, and Lawrence Watershed, heavy sustained rainfall events throughout the rest of the watershed will accumulate in riverine flooding throughout the Raritan River’s tributaries. Similar to coastal storms, heavy sustained rainfall events will lead to flooding and disruption to assets and the industrial areas in Perth Amboy, and the MCUA Central Treatment Facility and its power generating plant in Sayreville.

Stormwater ponding is expected to impact residential, commercial, and industrial structures and roads adjacent to them. Areas around Burt Creek, Ernston Road, and Raritan River Tributaries have medium, suburban population densities. Sporadically located flood zones will disrupt movement across the area, making evacuations and access to critical services difficult and dangerous. Additionally, the industrial warehouses along the Garden State Parkway are expected to flood, disrupting trade and the movement of goods through the entire region.

During modeled, future coastal storms, the Raritan River is the most significant flood pathway and is expected to overflow and flood its tributaries. This flooding is expected to extend into the area’s urban and suburban communities, and downtown centers of Perth Amboy and South Amboy.



Coastal Storm Surge



\$680 Million  
in expected  
losses



380  
buildings  
impacted

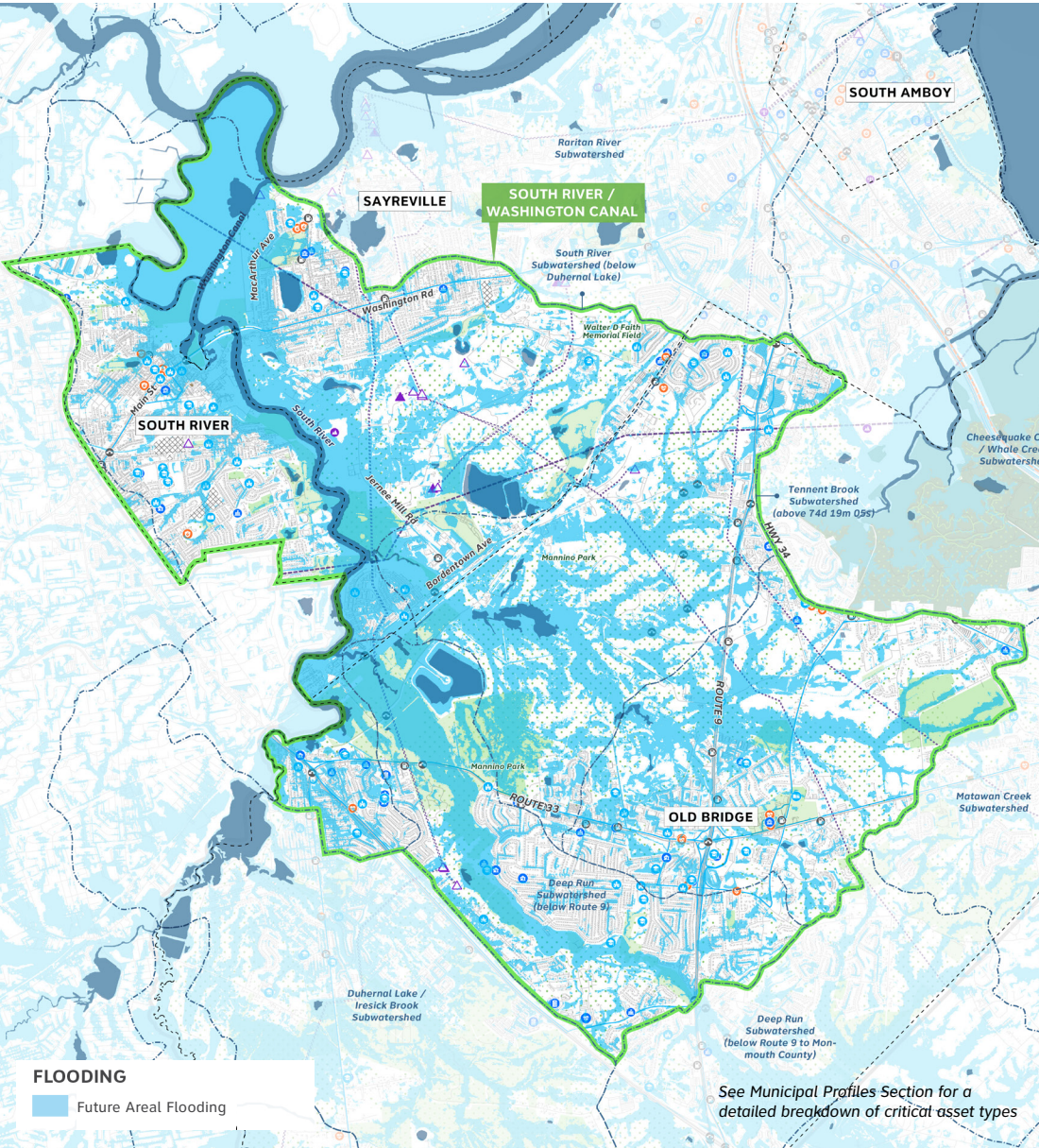
Perth Amboy has the highest social vulnerability index in the region, and 19 percent of the population is below the poverty line. Perth Amboy’s riverfront is vulnerable to future coastal flooding, calling for an assessment of the unique ecologies in parks, such as Sadowski Park. Sadaowski Park has large trees that may not be able to withstand the high amount of salt that a coastal surge could bring up the Raritan River from Raritan Bay.

The Raritan Riverfront and northern shore of the Raritan River are heavily developed with industrial parks and critical utility facilities that are exposed to future riverine flooding. These areas include the following critical assets: the Raritan Bay Buckeye Marine terminal, Woodbridge Recycling Center, a large industrial park with various warehouse storage spaces, and the Woodbridge Energy Center.

In Sayreville, a large housing development directly along the Raritan River and its tributaries is vulnerable to flooding during coastal storms. While this area is not densely populated, the MCUA Central Treatment Facility and the Middlesex Power Generating Facility in this area are vulnerable to coastal flooding. The planned Riveron development will bring additional population to this area. The development site is being raised above the FEMA 1 percent annual chance floodplain, as required by local floodplain ordinance and the state flood hazard act. The flooding of these assets will have large implications for the entire region, as the MCUA Treatment Facility treats sewage water for approximately 880,000 people, and the disruptions can result in contamination of local waterways and significant service disruptions.



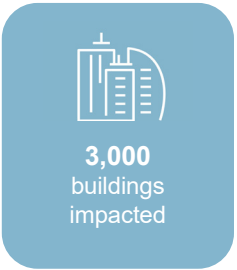
# SOUTH RIVER WATERSHED



## Areal Rainfall Flooding



**\$380 Million**  
in expected losses

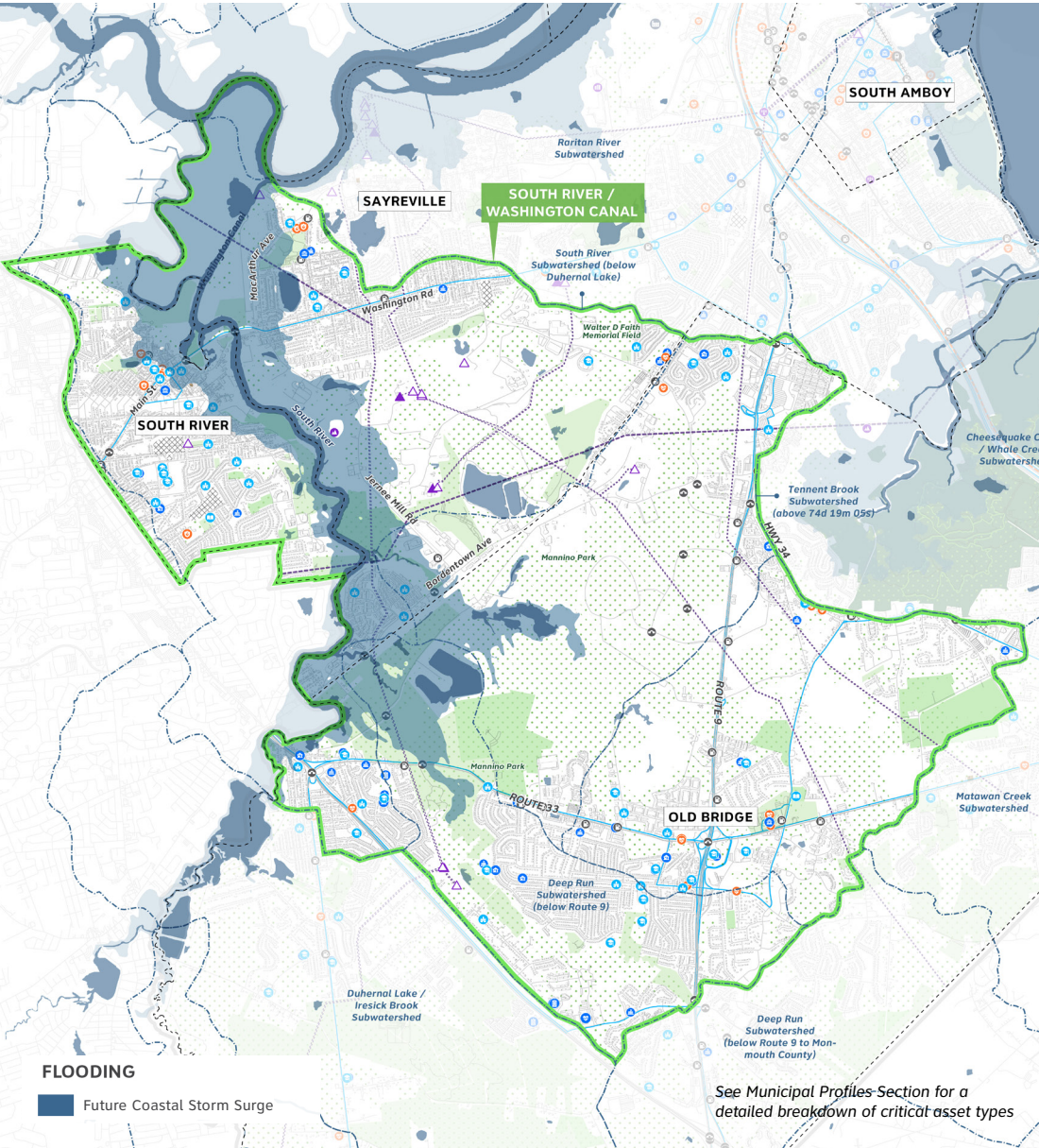


**3,000**  
buildings impacted

The South River extends south from the Raritan River into South River, Sayreville, and Old Bridge. It includes the mixed-use downtown of South River, in addition to residential and industrial areas along the river in all the municipalities. Most buildings in this focus area are residential, but those with the highest potential damages are industrial. Across all building use categories, the future heavy sustained rainfall event is expected to cause the highest damages.

During the modeled, future rainfall event, flooding is expected to spread through a much larger portion of the focus area, extending off the tributaries of the South River into larger portions of residential and vegetation spaces in South River, Sayreville, and Old Bridge. The downtown areas of these three towns are exposed to flooding during the modeled rainfall event.

The Madison Park Elementary School and M. Scott Carpenter Elementary School are expected to flood, putting young children at risk. Further north, multiple power generation plants in Sayreville are expected to flood, causing disruption and delays throughout the community and for rescue missions. The power plants vulnerable to flooding include the Sayreville Cogeneration Facility, the Parlin Power Plant, and Red Oak Power LLC. While this area is less densely populated, more people who commute through the area will be impacted by the widespread flooding, resulting in more far-spread disruptions throughout the region. The Consolidated Rail Corporation Rail Line goes through this area and is expected to flood, resulting in delays to goods and services to the rest of the region.



## Coastal Storm Surge



**\$740 Million**  
in expected losses



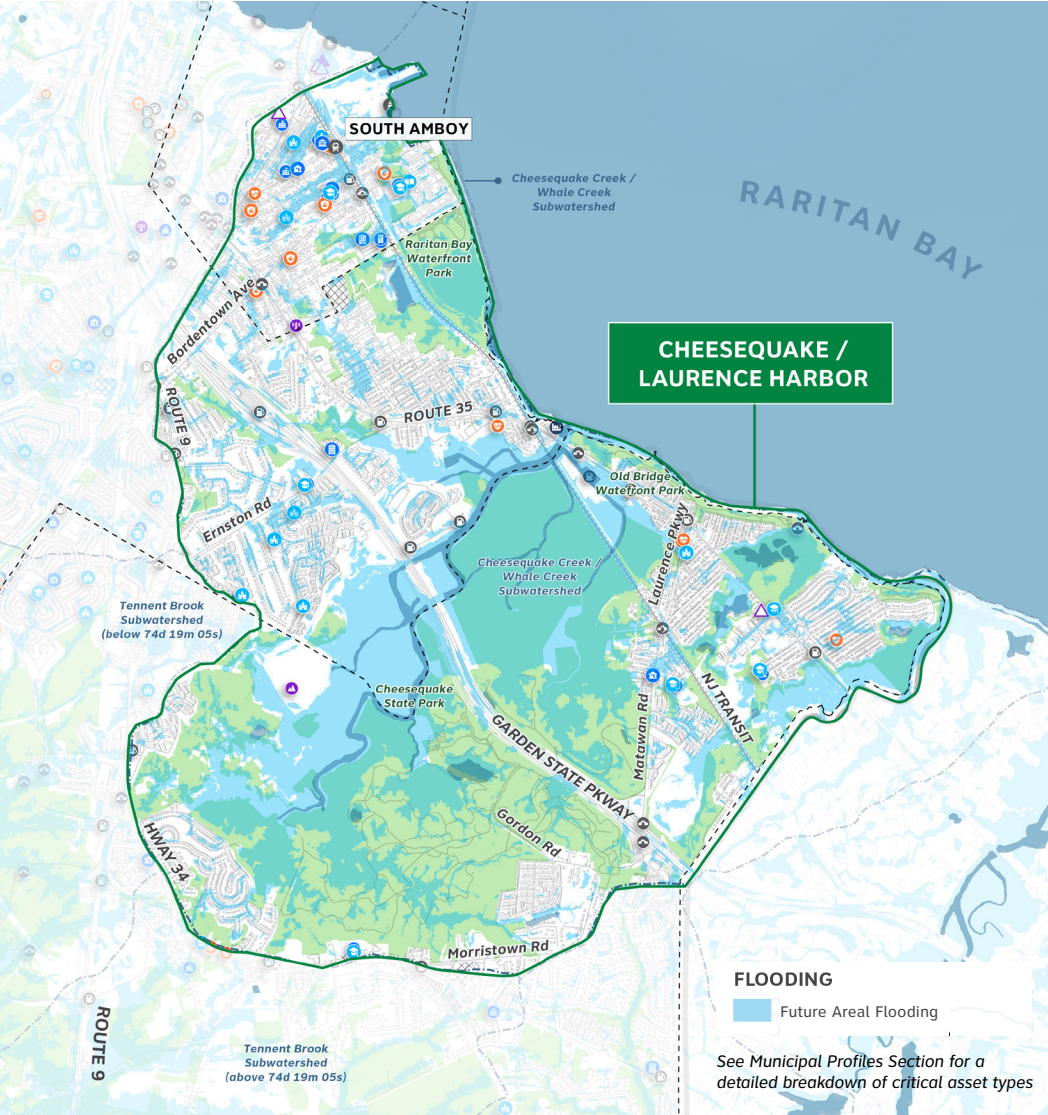
**1,230**  
buildings impacted

During modeled, future coastal storms, the South River is the most significant flood pathway and is expected to overflow, flooding its tributaries and the surrounding, low lying area. The riverbanks of the South River are highly developed, and riverine flooding is expected to impact both sides of the river, including the downtown South River, downtown Sayreville, residential developments in MacArthur Manor, and the Winding Woods development located within the South River's tidal zone. The area is a mixed use of residential, open space, and the main critical utilities are power generation stations. The space along the South River is highly populated, with between 20 to 50 people per acre. Additionally, South River's high social vulnerability index makes it more challenging to evacuate--the population is more likely to include residents living below the poverty line who may not have ready access to personal vehicles or elderly populations with limited mobility. The area is built on historic fill, impacting the ecology and flood paths for future coastal storms. Additionally, dredged lagoons near the South River's tributaries and residential areas expose more residents to flooding.



# CHEESEQUAKE & LAURENCE HARBOR

Cheesequake and Laurence Harbor includes expansive wetland areas and coastal beaches across parts of Sayreville, South Amboy, and Old Bridge. Most buildings in this focus area are residential, and the heavy sustained rainfall event is expected to cause the highest damages, specifically to commercial and residential structures. Since this area is exposed to Raritan Bay, the Army Corps implemented flood protection measures as part of the the Keansburg, East Keansburg, and Laurence Harbor Beach Nourishment project, which included beach fill and a levee with gated drainage structures. This analysis did not include these pieces of infrastructure, which may reduce the exposure identified as part of this impact assessment.



**Areal Rainfall Flooding**

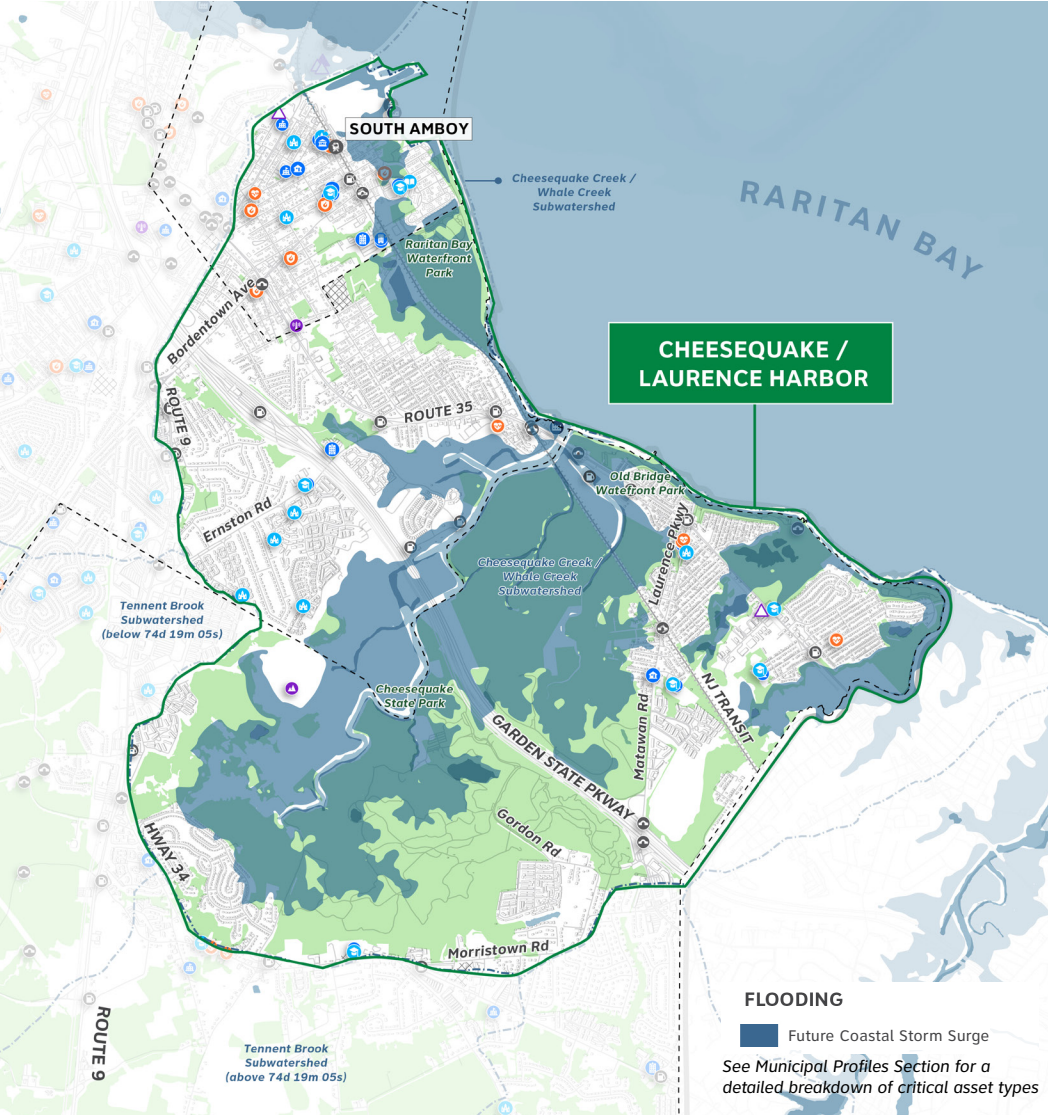


**\$90 Million**  
in expected losses



**970**  
buildings impacted

During modeled, future rainfall events, the rivers and open spaces flooded during future coastal storms are also expected to be inundated during heavy sustained rainfall events. Tributaries will overflow and flooding will spread further into residential areas in Old Bridge and Sayreville. While this focus area has relatively low population density and expansive green spaces, South Amboy and the area west of the Garden State Parkway are more densely populated. These areas also have higher social vulnerability indices, with larger immigrant populations. This area does not have many bus or evacuation routes, making evacuations in advance of a large storm all the more challenging. South Amboy's commercial and residential areas along 1st Street are vulnerable to flooding, and the critical assets of South Amboy Elementary School and the South Amboy Fire Department are exposed to flooding as well.



**Coastal Storm Surge**



**\$68 Million**  
in expected losses



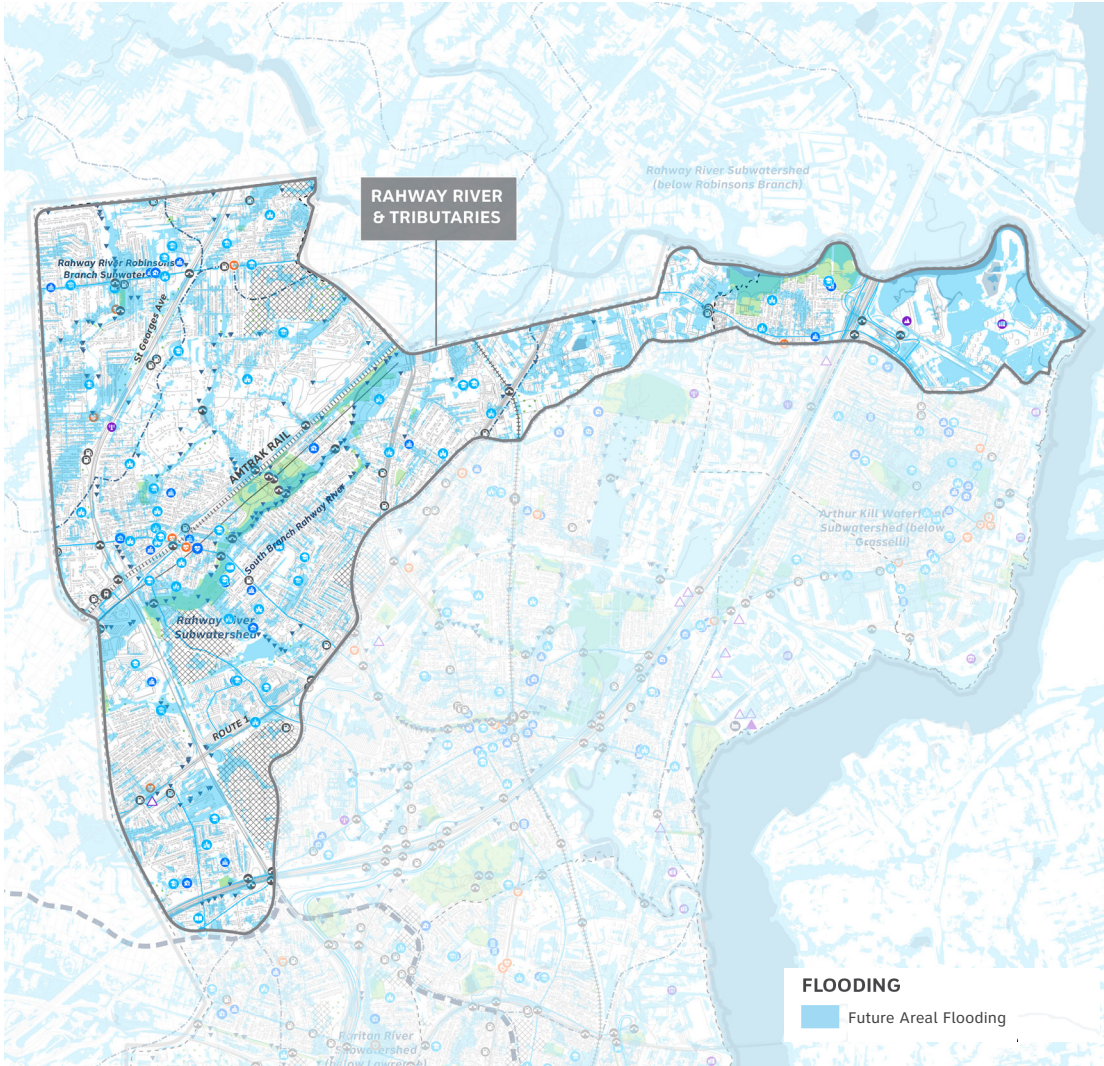
**270**  
buildings impacted

During modeled, future coastal storms, the Raritan Bay Waterfront Park and Joseph Hoffman Wildlife Refuge, Cheesequake State Park, Marquis Creek, and Whale Creek are all significant flood path entryways. Exposure to flooding is expected along Route 35 in South Amboy that consists of car-oriented commercial spaces. Primarily, the Cheesequake and Laurence Harbor focus area is a combination of beachfront recreation, wetland and forest space, and low density residential space. Homes along the Whale Creek Tributary and adjacent to Cheesequake State Park are expected to be flooded during future coastal storms. Major road infrastructure going through the area includes the Garden State Parkway and Route 35. Additionally, flood inundation is expected in wetland and park areas, which can result in ecological damage and higher vulnerability from more saltwater intrusion. While there are no train stops in this area, the North Jersey Coast Line commuter rail passes through expected future flood pathways, which would disrupt the daily flow of commuters.



# RAHWAY RIVER & TRIBUTARIES

Rahway River and Tributaries represents part of the Arthur Kill Watershed and includes the northeast portion of Woodbridge. This area is not expected to experience significant coastal flooding, because it is further inland at higher elevations, which protects it from storm surge. Most buildings in this focus area are residential, and the heavy sustained rainfall event is expected to cause the highest damages, specifically to commercial and residential structures.



See Municipal Profiles Section for a detailed breakdown of critical asset types



Areal Rainfall Flooding



\$200 Million  
in expected  
losses



200  
buildings  
impacted

During modeled, future rainfall events, flooding is expected to extend along Pumpkin Patch Brook and accumulate in lower lying spaces. Additionally, stormwater ponding is expected to impact residential, commercial, and industrial structures and the roads adjacent to them. Sporadically located flood zones will disrupt movement across the area, making evacuations and access to critical services difficult and dangerous. This focus area is primarily residential, and the assets exposed will disrupt community members daily lives. Assets and services exposed to flooding include Fords Middle School, Avenel Middle School, Iselin Middle School, Menlo Park Terrace Elementary School, Pennsylvania Avenue Elementary School, and Iselin Volunteer Fire Department House 2.





CHEESEQUAKE STATE PARK, OLD BRIDGE  
IMAGE CREDIT: PROJECT TEAM

# 04 - MUNICIPAL PROFILES

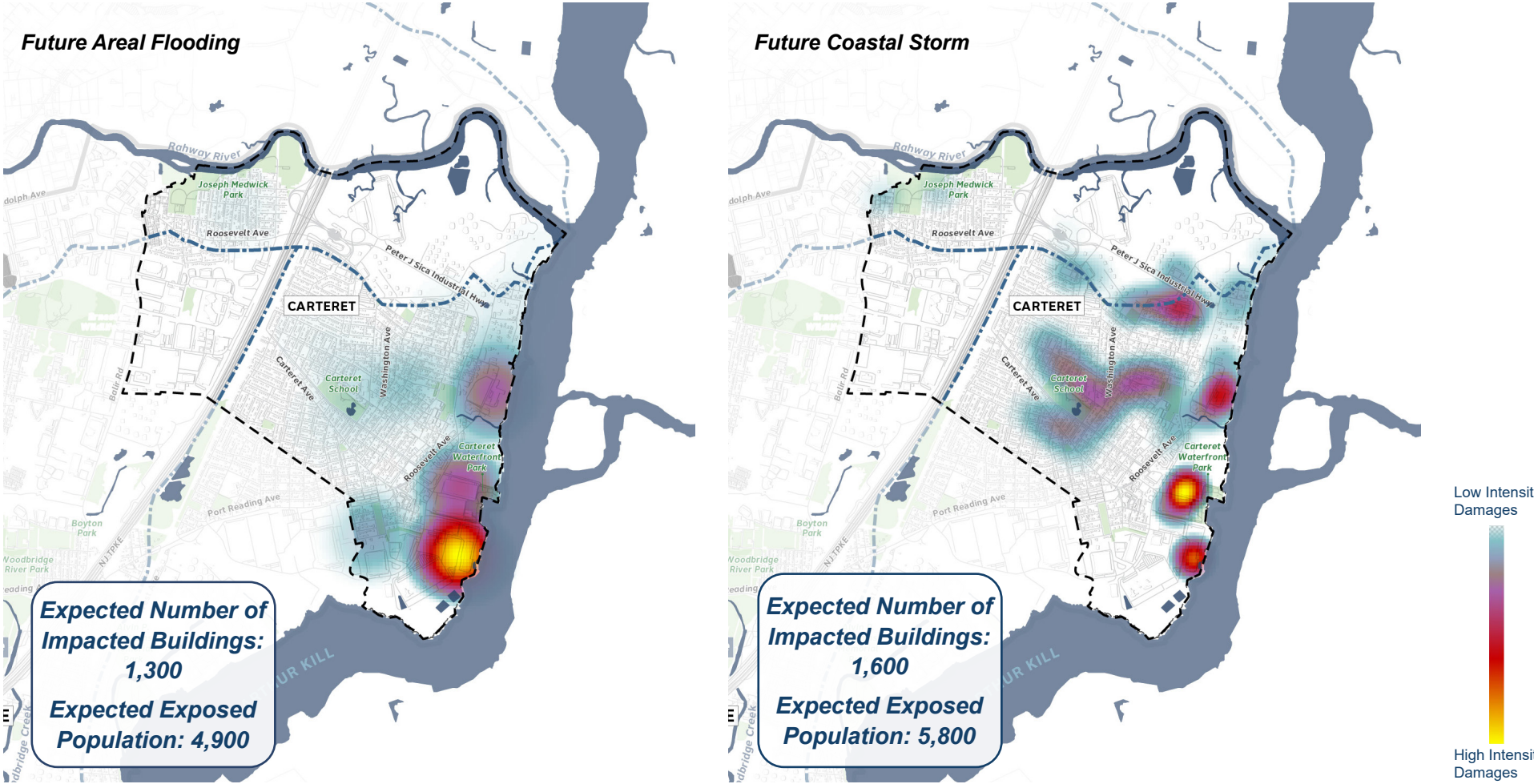


# CARTERET

The Borough of Carteret is located along the Arthur Kill and Rahway Rivers. The waterfront is dominated by industry, including major oil and gas terminals. In recent years, the town has pursued new open space and recreational assets along the waterfront, in addition to plans for mixed-use development and a new ferry terminal. A small inlet, Noes Creek, serves as a major entry point for storm surge. The creek once extended further inland but was filled as part of the town’s development, leading to a large portion of the downtown that is low-lying and also floods from heavy sustained rainfall.

This section summarizes damages that are possible if no action is taken to address flood risks that Carteret faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. Another storm, like Hurricane Sandy, which caused extensive coastal flooding along the coast will likely happen again and have greater impact due to sea level rise. Many areas of Carteret experience recurring flooding from heavy sustained rainfall, which can lead to significant damages.

The following maps show cocentration of physical damages from each event type.

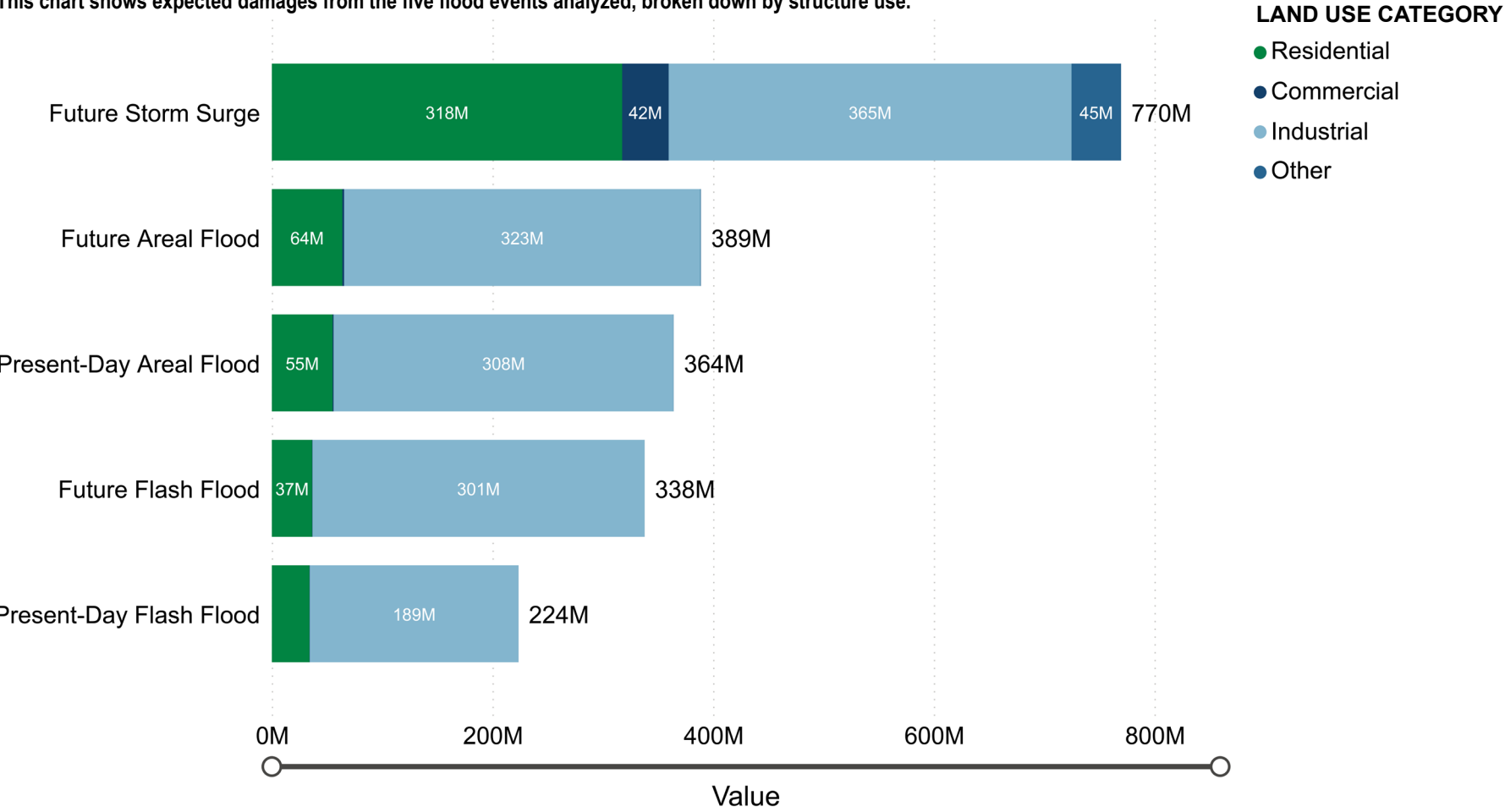


\*The values reflects current structures and populations in Carteret. In the future these numbers will change, potentially increasing what is at risk.

Under all of the flood scenarios considered in this assessment, flooding at industrial properties composes the largest portion of the damages in Carteret. However, flooding for the extreme coastal storm scenario also causes a significant amount of damage to residential areas.

Though the coastal storm surge event is expected to incur more than two times the estimated damages than the highest rainfall event evaluated, coastal storm surge events, like Hurricane Sandy, are much less frequent than the heavy sustained rainfall flooding event and significantly less frequent than tidal flooding. **Though it is important to understand the potential impacts of extreme coastal surge events like Hurricane Sandy, the impacts of more frequent, less severe rainfall events should be considered in order to better understand the relative risk between rainfall and coastal storm events.**

This chart shows expected damages from the five flood events analyzed, broken down by structure use.









PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within Carteret to demonstrate the variety of asset types impacted by flooding. The assets listed here are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in Carteret. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.*

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response <div></div>	Hurricane Evacuation Route*	New Jersey Turnpike	●	●	●	●
	EMS	Carteret Fire Department				●
Infrastructure <div></div>	Port Facilities	Kinder Morgan Terminal - Carteret	●	●	●	●
	Cell Towers	New Cingular Wireless PCS, LLC		●	●	
	Community	Future Ferry Terminal		●	●	●
Public Health <div></div>	Parks	Chrome Park		●	●	
	Public Housing	Jeanette Smith VLG				●
Quality of Life <div></div>	Places of Worship	Iglesia Manantial De Vida Inc			●	●
	Places of Worship	Catholic Daughters of the Americas			●	●
	Community	Latin Festival		●	●	●
	Community	4th of July Festival				●
	Community	911 Memorial		●	●	●
	Community	Memorial Day Festival	●	●	●	●

*\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.*

LEGEND - CRITICAL ASSETS

- INFRASTRUCTURE**

*Stormwater & Wastewater Infrastructure*

  - Wastewater Treatment
  - Stormwater Discharge
  - Combined Sewer Outfall
  - Other Surface Discharge

*Energy Infrastructure*

  - Substations
  - Power Generation
  - Natural Gas Pipelines
  - Powerlines

*Communications*

  - Cell Towers

*Waste Disposal*

  - Landfill

*Other*

  - Heavy Industry
  - Warehousing
- TRANSPORTATION**

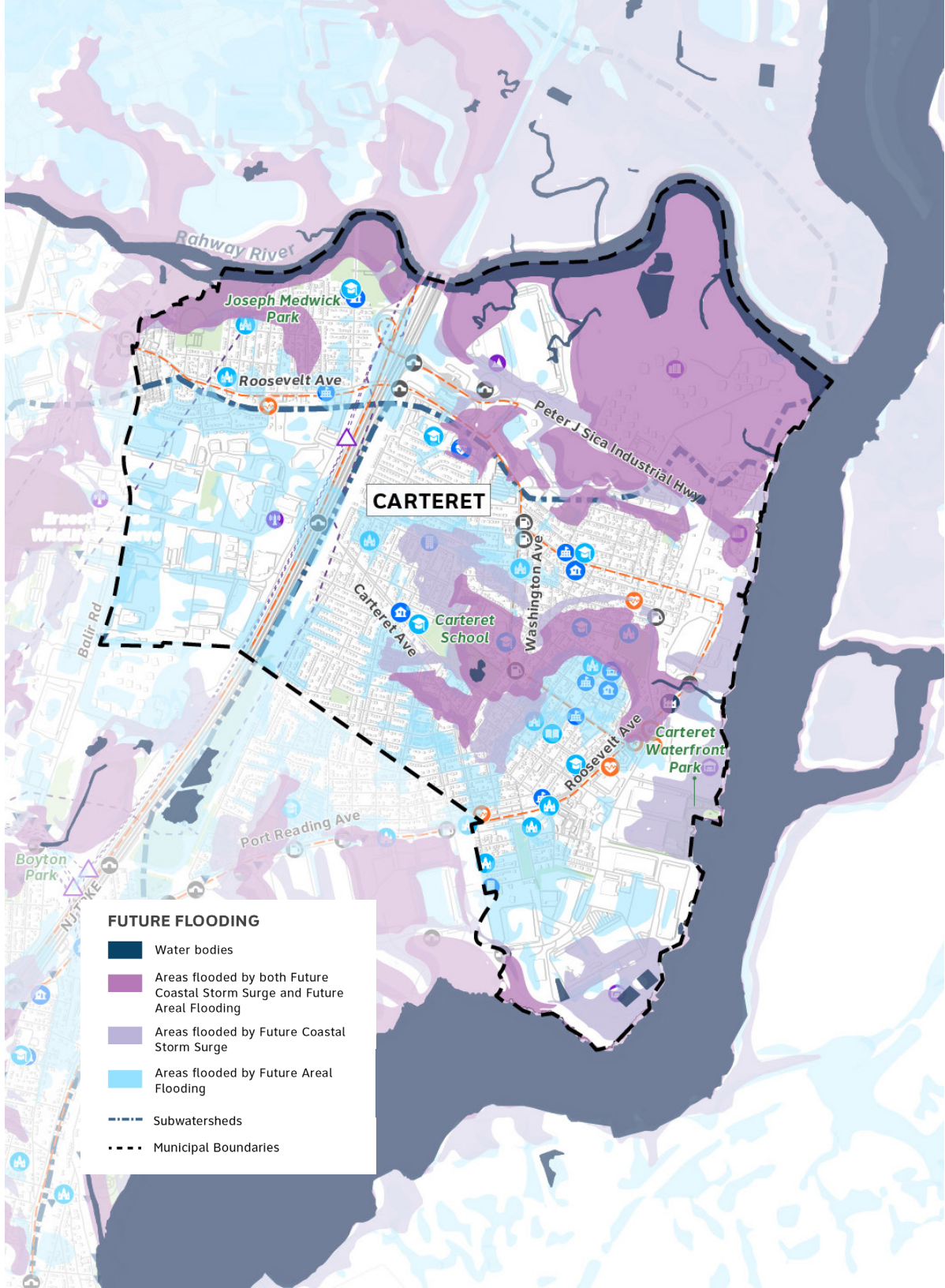
  - Bike Lanes
  - Bus Routes
  - Light Rail/Commuter Rail
  - Primary & Secondary Roads
  - Airport
  - Ferry Terminal
  - Port Facilities
  - Rail Stations
  - Bridges
  - Gas Stations
- ECOSYSTEM & ENVIRONMENTAL HEALTH**

  - Parks (Municipal and State Parks)
  - Cemetery
  - Parks and Forest Trails
- PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

  - Hospitals/Medical Centers
  - Municipal Building
  - Public Housing
  - Senior Housing
  - Shelters
  - Nursing Homes
  - Child Care Centers
  - Places of Worship
  - Schools & Colleges
  - Library
- EMERGENCY RESPONSE**

  - EMS
  - Fire Stations
  - Police Stations
  - Hurricane Evacuation Route

*People rely on places of worship to foster their religious and spiritual well-being, as well as places to connect with their larger communities. They are used for family services and celebrations, from weddings to funerals, as well as often supporting food pantries and shelters. Studies have found that areas with stronger community connections are more resilient.*



Key emergency response assets prone to flooding due to coastal storm surge include the Carteret Police Department and the Fire Department, which also supports EMS services. Flooding at these facilities could delay emergency response times.

Six places of worship are vulnerable to flooding, as well as the 911 Memorial and festivals held at Waterfront Park, including the Memorial Day Festival, the Fourth of July festivities, and the Latin Festival. These assets are all key parts of maintaining people's quality of life and sense of community. The location of the future ferry terminal was also identified by the community as a key asset that will support their community in the future. Most of these assets are prone to flooding under both rainfall and coastal storm surge events.

A number of parks and open space are predicted to flood under both rainfall and coastal surge conditions. People use parks and open space in multiple ways – places to run and play, bike, or walk their dogs. Losing access to parks and open space may affect mental health and wellness, as well as physical fitness. These facilities may also be used for social gatherings and community events.

While other types of assets, such as elevated roadways, transmission lines, gas pipelines, and bus routes pass through flooded areas vulnerable to future tidal flooding in Carteret, many may be either raised above ground elevation or buried. While they cross through flooded areas, they may not be affected by future tidal flooding conditions, where flood extents are not far beyond the current high tide line. However, many of these assets are exposed based on rainfall flooding and coastal storm surge events, where road drainage may be inadequate or lower-lying on-ramps flood.

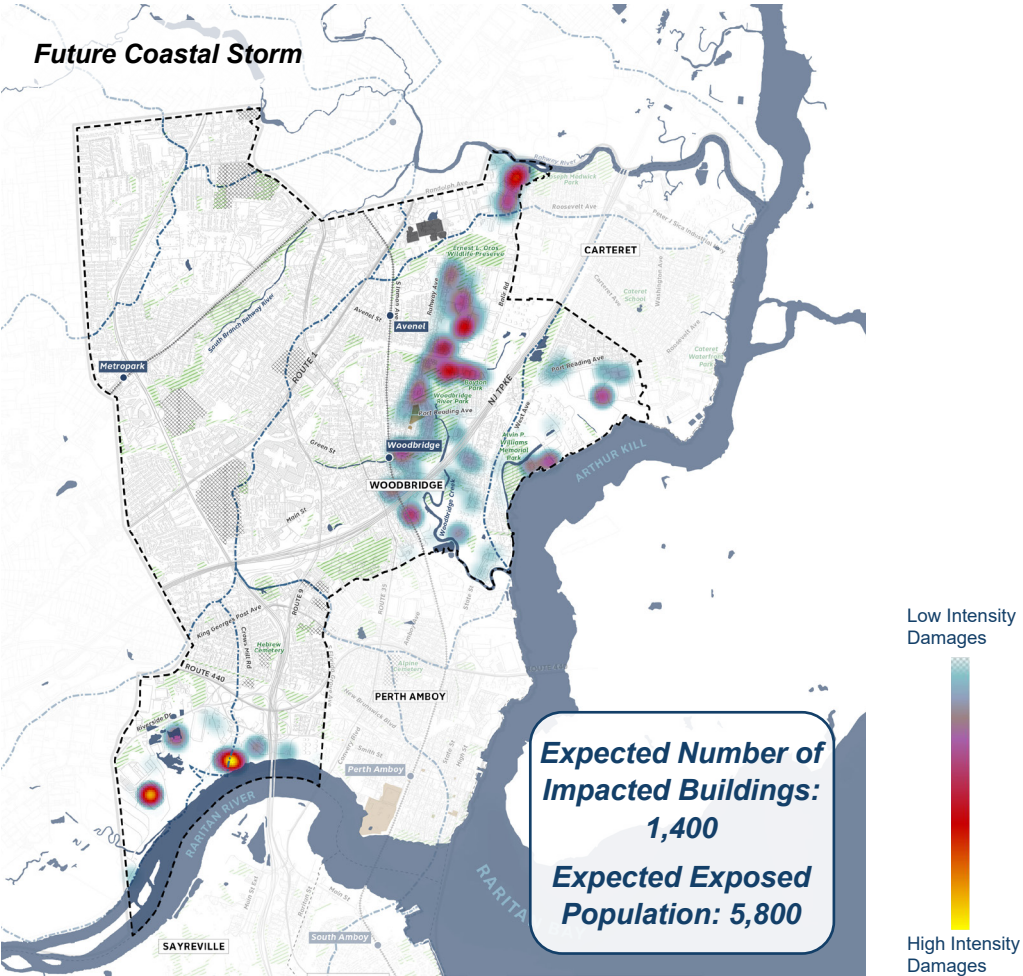
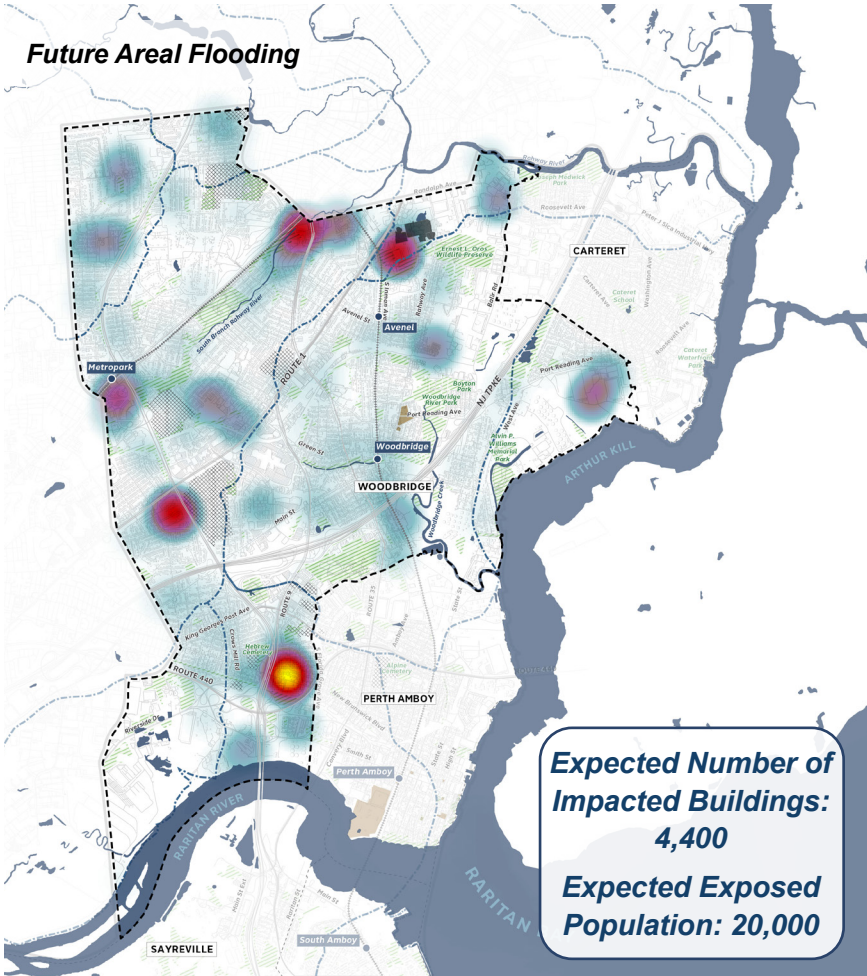


# WOODBIDGE

Woodbridge Township spans from the Rahway River to the Raritan River, with frontage along the Arthur Kill as well. It also includes inland tributaries like Woodbridge Creek, the South Branch of the Rahway River, and Pumpkin Patch Brook. While most of the areas in South Branch of Rahway River/Pumpkin Patch Brook are residential with corridors of commercial use, significant industrial areas are located along the Rahway River and Arthur Kill.

This section summarizes damages that are possible if no action is taken to address flood risks that Woodbridge faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. As the heavy sustained rainfall events of 2021 demonstrated, the town is experiencing impacts of heavy rain events now that can lead to significant damage.

The following maps show cocentration of physical damages from each event type.

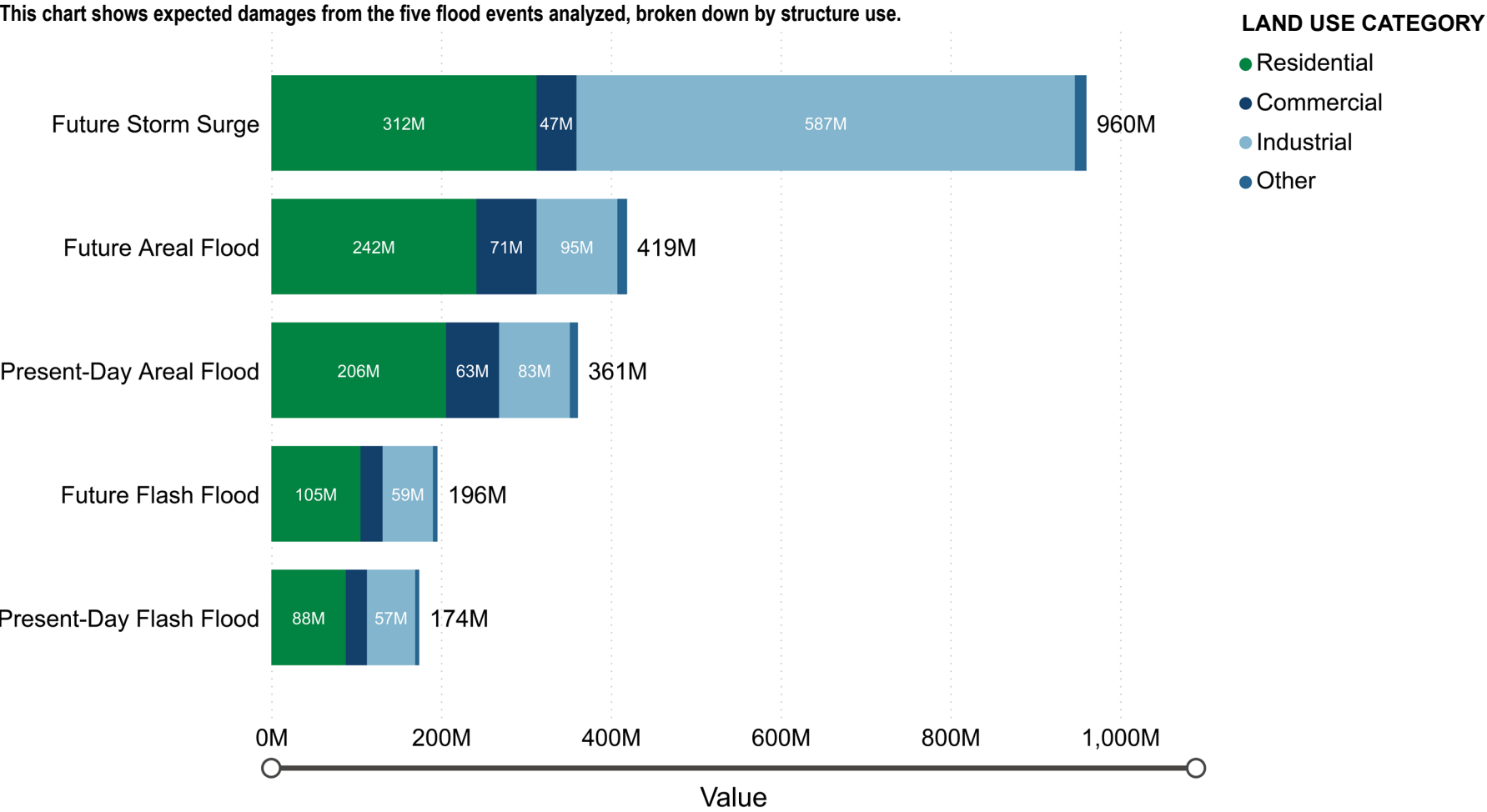


\*The values reflects current structures and populations in Woodbridge. In the future these numbers will change, potentially increasing what is at risk.

Damages in Woodbridge are predicted to be more than twice as high under the extreme coastal storm scenario as under the heavy sustained rainfall event. These damages are driven by flooding of industrial properties.

Though the coastal storm surge event is expected to incur more than two times the estimated damages than the highest rainfall event evaluated, coastal storm surge events, like Hurricane Sandy, are much less frequent than the heavy sustained rainfall flooding event and significantly less frequent than tidal flooding. **Though it is important to understand the potential impacts of extreme coastal surge events like Hurricane Sandy, the impacts of more frequent, less severe rainfall events should be considered in order to better understand the relative risk between rainfall and coastal storm events.**

This chart shows expected damages from the five flood events analyzed, broken down by structure use.









PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within Woodbridge to demonstrate the variety of asset types impacted by flooding. The assets listed are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in Woodbridge. A rull list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.*





Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
<div>Emergency Response</div> <div></div>	Hurricane Evacuation Route	US-1		<div></div>	<div></div>	<div></div>
	Fire Stations	Hopelawn Engine Company 1		<div></div>	<div></div>	
	Shelters	Fords Middle School			<div></div>	
	EMS	Woodbridge Township Fire District 2 Port Reading Fire Department & First Aid Squad		<div></div>	<div></div>	
	Community	US Coast Guard-Auxiliary				<div></div>
<div>Infrastructure</div> <div></div>	Port Facilities	Buckeye Global Marine Terminals - Port Reading	<div></div>	<div></div>	<div></div>	<div></div>
	Cell Towers	New Cingular Wireless PCS, LLC (Blair Road)		<div></div>	<div></div>	
	Cell Towers	New Cingular Wireless (Parkway and New Dover Road)		<div></div>	<div></div>	
	Substations	Cliff Avenue				<div></div>
	Community	Rahway Valley Sewerage Authority		<div></div>	<div></div>	<div></div>
<div>Public Health</div> <div></div>	Cemetery	St. Stephen Cemetery		<div></div>	<div></div>	
	Schools	Menlo Park Terrace Elementary School			<div></div>	
<div>Quality of Life</div> <div></div>	Places of Worship	ST ANTHONYS CHURCH		<div></div>		
	Places of Worship	SINGH SABHA INC		<div></div>	<div></div>	
	Places of Worship	CHABAD TOKYO JAPAN			<div></div>	
	Library	Henry Inman Branch Library			<div></div>	
	Community	Boat Launch		<div></div>	<div></div>	<div></div>
	Community	Woodbridge Animal Group				<div></div>
	Community	Cypress Recreation Center		<div></div>	<div></div>	
	Community	Farmers Market				<div></div>

*\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.*



LEGEND - CRITICAL ASSETS

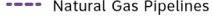
**INFRASTRUCTURE**

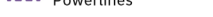
**Stormwater & Wastewater Infrastructure**

-  Wastewater Treatment
-  Stormwater Discharge
-  Combined Sewer Outfall
-  Other Surface Discharge


**Energy Infrastructure**

-  Substations
-  Power Generation


 Natural Gas Pipelines

 Powerlines



**Communications**

-  Cell Towers



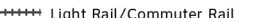


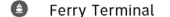

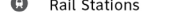
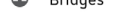
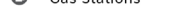
**Waste Disposal**

-  Landfill



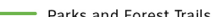
**Other**

-  Heavy Industry
-  Warehousing












**TRANSPORTATION**

-  Bike Lanes
-  Bus Routes
-  Light Rail/Commuter Rail
-  Primary & Secondary Roads
-  Airport
-  Ferry Terminal
-  Port Facilities
-  Rail Stations
-  Bridges
-  Gas Stations





**ECOSYSTEM & ENVIRONMENTAL HEALTH**

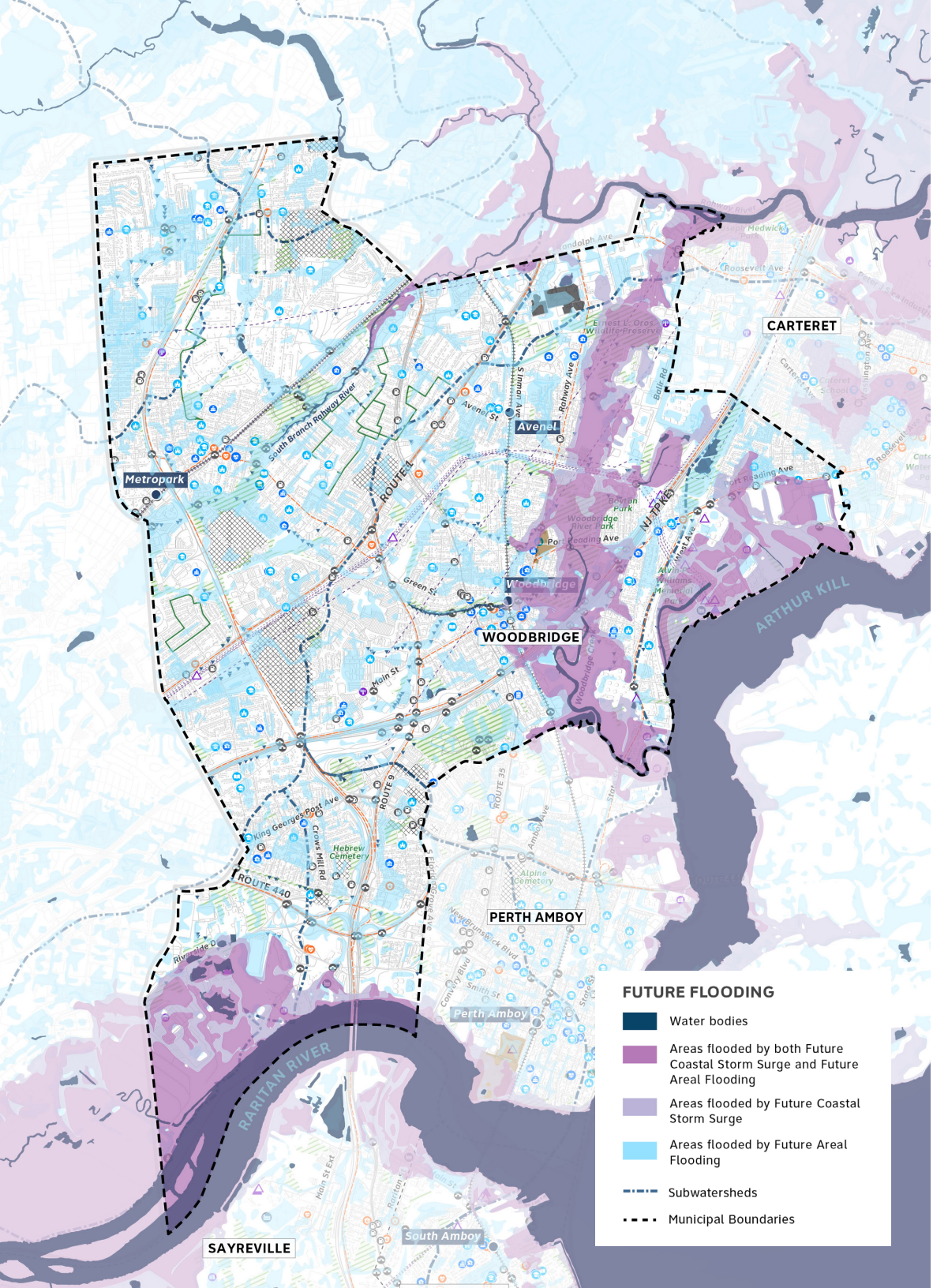
-  Parks (Municipal and State Parks)
-  Cemetery
-  Parks and Forest Trails

**PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

-  Hospitals/Medical Centers
-  Municipal Building
-  Public Housing
-  Senior Housing
-  Shelters
-  Nursing Homes
-  Child Care Centers
-  Places of Worship
-  Schools & Colleges
-  Library
-  Major Sports Venue

**EMERGENCY RESPONSE**

-  EMS
-  Fire Stations
-  Police Stations
-  Hurricane Evacuation Route



Key infrastructure assets exposed to flooding include three substations – the Woodbridge Sewer Pump Station on Woodbridge Avenue, the Rahway Valley Sewerage Authority Treatment Plant, and two cell towers. If not already protected from flooding, flood impacts at these key facilities could have cascading effects. For example, outages in the power system can propagate from one facility to another power facility, but power outages also affect other assets that rely on power for operation. Flooding at a treatment plant could cause overflow of untreated sewage into nearby water bodies. Most of these assets are prone to flooding due to rainfall, and many of them are also prone to flooding due to the coastal storm surge event.

Four middle schools (one of which also serves as a shelters) and two elementary schools are vulnerable to rainfall flooding, as are two childcare centers. During COVID-19, the critical role played by schools to the community was clearly demonstrated. Residents rely on schools on a regular basis for both education and care for their school-age children as well as for provision of meals, socialization and mental well-being support, fitness, and physical education programs. Loss of care of school-age children can also impact a parent's ability to work. In emergencies, some schools (such as Fords Middle School) act as shelters. This highlights how a community may depend on one facility for several different types of services.

While other types of assets, such as elevated roadways, transmission lines, gas pipelines, and bus routes pass through flooded areas vulnerable to future tidal flooding, many may be either raised above ground elevation (like the bus routes that use the Turnpike) or buried. While they cross through flooded areas, they may not be affected by future tidal flooding conditions, where flood extents are not far beyond the current high tide line. However, many of these assets are exposed based on rainfall flooding and coastal storm surge events, where road drainage may be inadequate or lower-lying on-ramps flood.

Community identified assets that are vulnerable to flooding include recreational facilities like the Cypress Recreation Center, boat launch and farmer's market, in addition to the U.S. Coast Guard Auxiliary, which promotes safety of the waterways, and Woodbridge Animal Group and Animal Shelter. A number of parks, bike lanes, and open space are predicted to flood under both rainfall and coastal surge conditions. People use these amenities in multiple ways – places to run and play, bike, or walk their dogs. Losing access to parks and open space may affect mental health and wellness, as well as physical fitness. These facilities may also be used for social gatherings and community events.

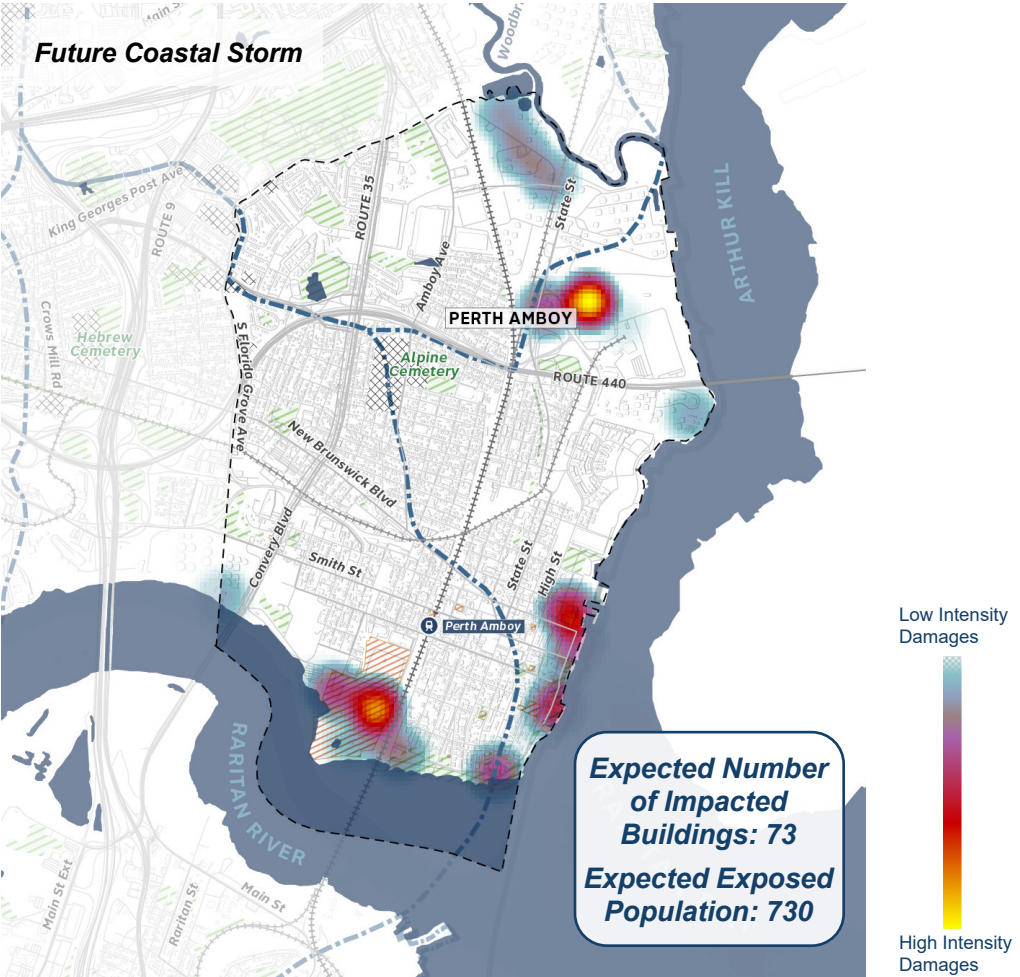
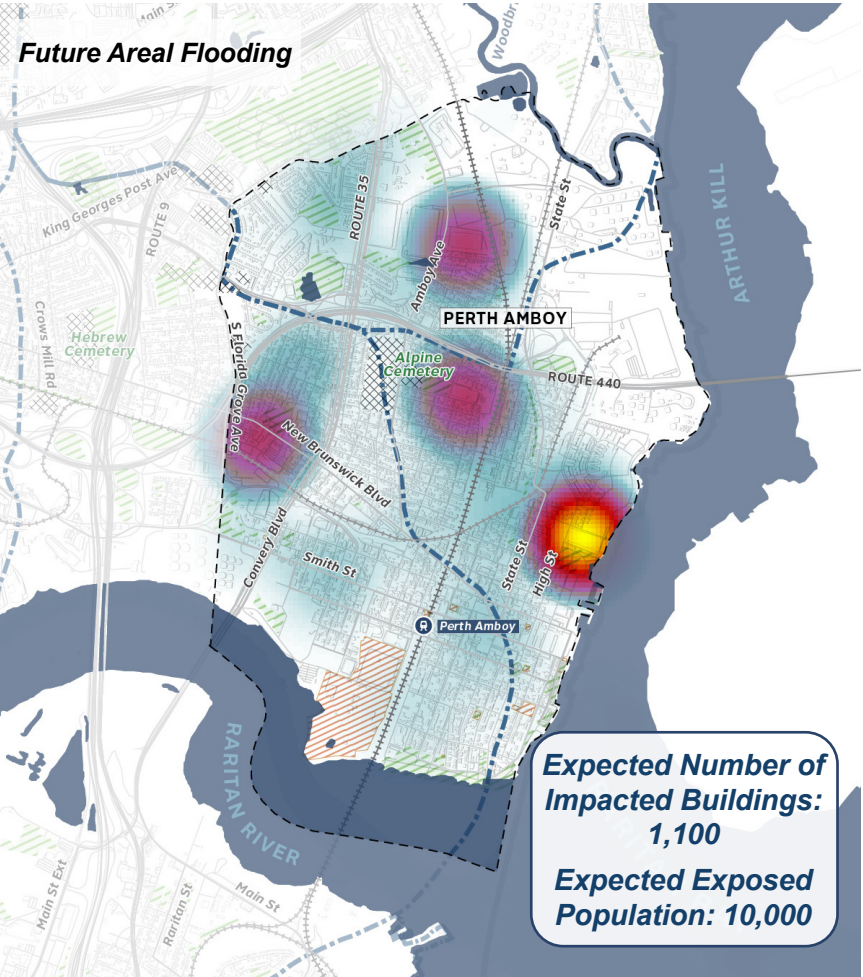


# PERTH AMBOY

The City of Perth Amboy lies at the mouth of the Raritan Bay and along the Arthur Kill. The historic town center is located on a bluff near the bay, with more industrial uses to the north along the Arthur Kill. For all storm scenarios, flood damages in Perth Amboy are driven by damages to industrial areas.

This section summarizes damages that are possible if no action is taken to address flood risks that face Perth Amboy now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. Many areas of Perth Amboy experience recurring flooding from heavy sustained rainfall, which results in significant damage. In addition, another storm like Hurricane Sandy, which caused extensive coastal flooding along the coast in Perth Amboy will likely happen again with greater impacts due to sea level rise.

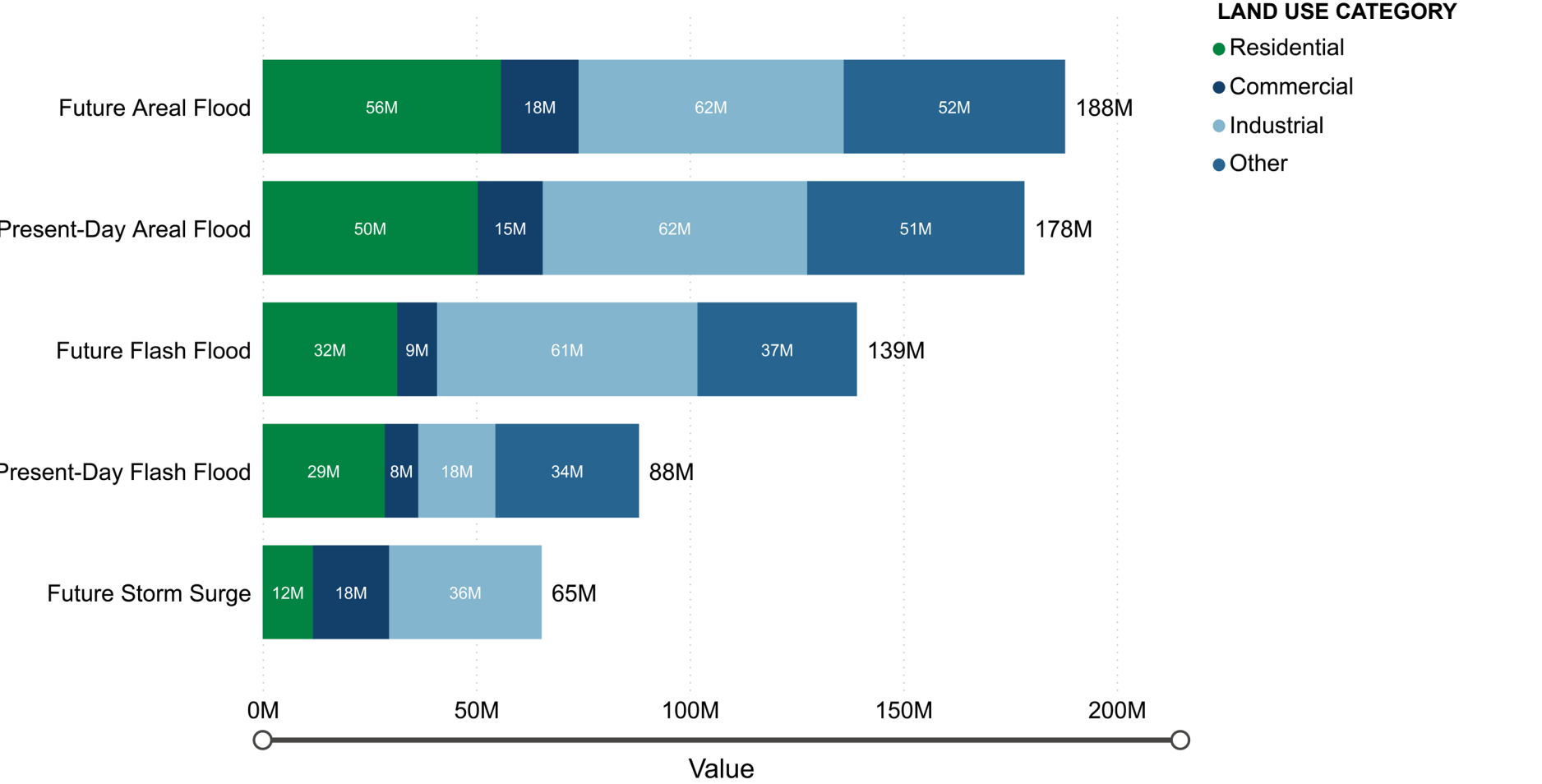
*The following maps show cocentration of physical damages from each event type.*



\*The values reflects current structures and populations in Perth Amboy. In the future these numbers will change, potentially increasing what is at risk.

As the only community in the region with a combined sewer system, Perth Amboy faces additional challenges during flood events. Flooding impacts are exacerbated by combined sewer systems and drainage capacity limitations. The combined sewer system collects rainwater runoff, sewage, and other wastewater all into the same pipe and then transports the water to a wastewater treatment plan for cleaning. Additionally, the city's aging drainage system contributes to waterway pollution during storm events. Sometimes, the system backs up into the communities when the outfalls are blocked by high tides.

This chart shows expected damages from the five flood events analyzed, broken down by structure use.





PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within Perth Amboy to demonstrate the variety of asset types impacted by flooding. The assets listed are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in Perth Amboy. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.*

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response	Hurricane Evacuation Route*	CR-611	●	●	●	●
	Police Stations	Perth Amboy Police Department			●	
Infrastructure	Port Facilities	Port of Perth Amboy	●	●	●	●
	Rail Stations	Perth Amboy		●	●	
Public Health	Parks	Seamen Street Playground			●	
	Child Care Centers	All Star's Academy, LLC			●	
Quality of Life	Places of Worship	Radiance Church			●	
	Community	Portuguese Sporting Club - Portuguese Folklore Festival		●	●	
	Community	Puerto Rican Festival		●	●	
	Community	Greek Grill by the Bay - Festival				●
	Community	Perth Amboy Dominican Festival				●
	Community	Paella Festival		●	●	●
	Community	Waterfront Arts Festival				●

*\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.*

LEGEND - CRITICAL ASSETS

- INFRASTRUCTURE**

**Stormwater & Wastewater Infrastructure**

  - Wastewater Treatment
  - Stormwater Discharge
  - Combined Sewer Outfall
  - Other Surface Discharge

**Energy Infrastructure**

  - Substations
  - Power Generation
  - Natural Gas Pipelines
  - Powerlines

**Communications**

  - Cell Towers

**Waste Disposal**

  - Landfill

**Other**

  - Heavy Industry
  - Warehousing
- TRANSPORTATION**

  - Bike Lanes
  - Bus Routes
  - Light Rail/Commuter Rail
  - Primary & Secondary Roads
  - Airport
  - Ferry Terminal
  - Port Facilities
  - Rail Stations
  - Bridges
  - Gas Stations

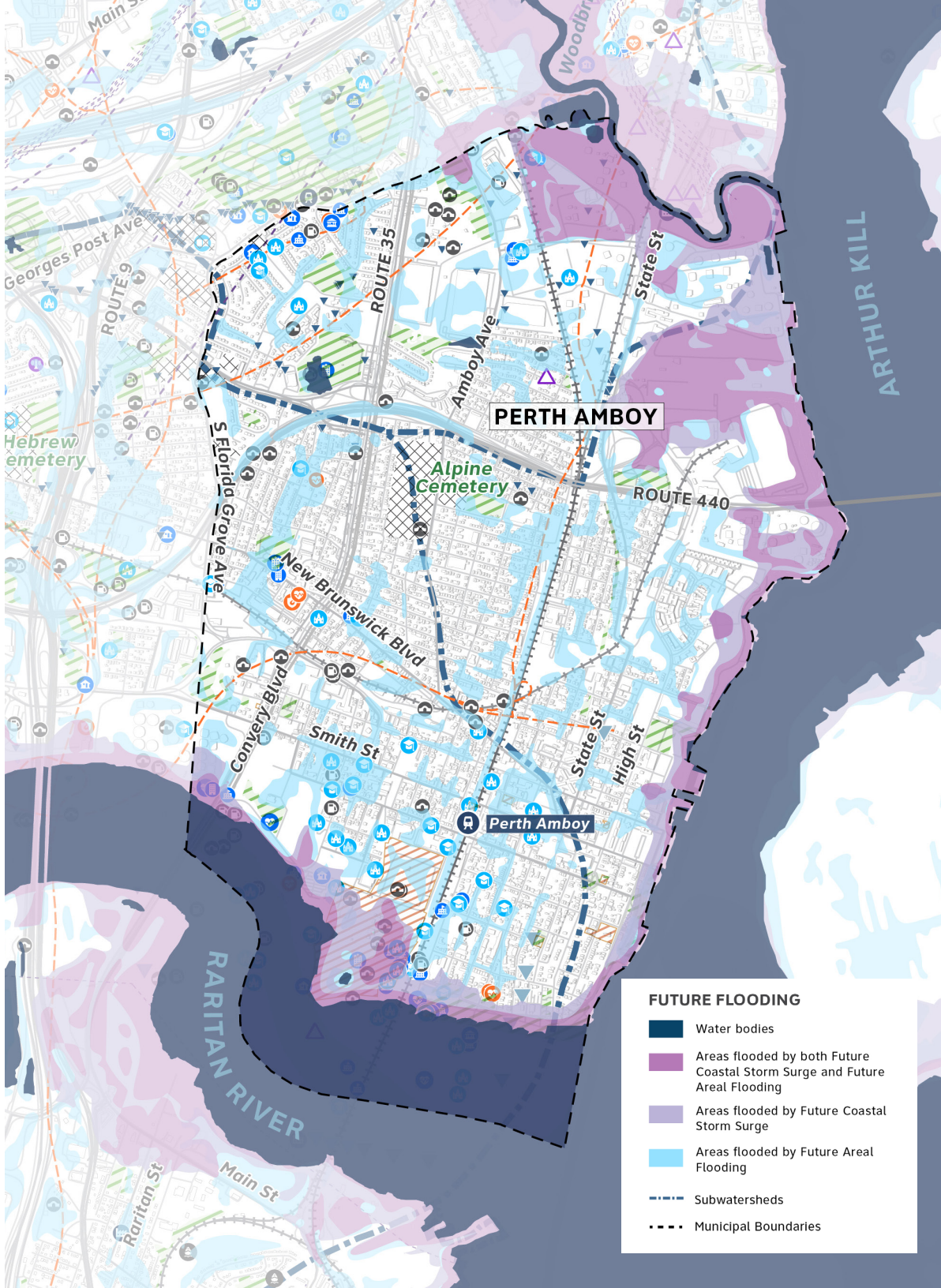
**ECOSYSTEM & ENVIRONMENTAL HEALTH**

  - Parks (Municipal and State Parks)
  - Cemetery
  - Parks and Forest Trails
- PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

  - Hospitals/Medical Centers
  - Municipal Building
  - Public Housing
  - Senior Housing
  - Shelters
  - Nursing Homes
  - Child Care Centers
  - Places of Worship
  - Schools & Colleges
  - Library
- EMERGENCY RESPONSE**

  - EMS
  - Fire Stations
  - Police Stations
  - Hurricane Evacuation Route

*People rely on places of worship to foster their religious and spiritual well-being, as well as places to connect with their larger communities. They are used for family services and celebrations, from weddings to funerals, as well as often supporting food pantries and shelters. Studies have found that areas with stronger community connections are more resilient.*



Critical emergency response assets are exposed to flooding, including the Perth Amboy Fire Department headquarters and the police department on Rector Street, which could result in longer response times to emergency calls. Key exposed infrastructure assets include three pump stations – the Main Pumping Station, State Street Pump Station, and Front Street Pump Station.

Additionally, Perth Amboy is the only community within the region with combined sewers. During times of heavy sustained rainfall, this system can be overloaded. In such cases, the overflow will discharge directly into waterways through combined sewer outfalls. Sea level rise is exacerbating these issues. With high tide, combined sewer outfalls can become blocked. During heavy sustained rainfall when the system is likely to be overloaded, this can lead to combined sewer backups directly into communities. While specific combined sewer outfalls are not singled out as priority assets, flooding at these assets would negatively impact the community. Flooding of the combined sewer system can cause discharge of untreated sewage to water bodies and system backups can result in overflows in populated areas.

Multiple community festivals and events that celebrate diversity are held in flood-prone areas, including the annual Paella Festival, Portuguese Folklore Festival, Puerto Rican Festival, and the Perth Amboy Dominican Festival. More than a dozen places of worship are also exposed to flooding. These assets are all key parts of maintaining people's quality of life and sense of community.

A number of parks are predicted to flood under both rainfall and coastal surge conditions. People use parks in multiple ways – places to run and play, bike, or walk their dogs. Losing access to park space may affect mental health and wellness, as well as physical fitness. Public parks may also be used for social gatherings and community events.

While other types of assets, such as elevated roadways, transmission lines, bus routes, and the New Jersey Commuter Rail, pass through flooded areas vulnerable to future tidal flooding in Perth Amboy, many may be raised above ground elevation or buried. While they cross through flooded areas, they may not be affected by future tidal flooding conditions, where flood extents are not far beyond the current high tide line. However, many of these assets are exposed to rainfall flooding and coastal storm surge events, where road drainage may be inadequate or lower-lying on-ramps flood.

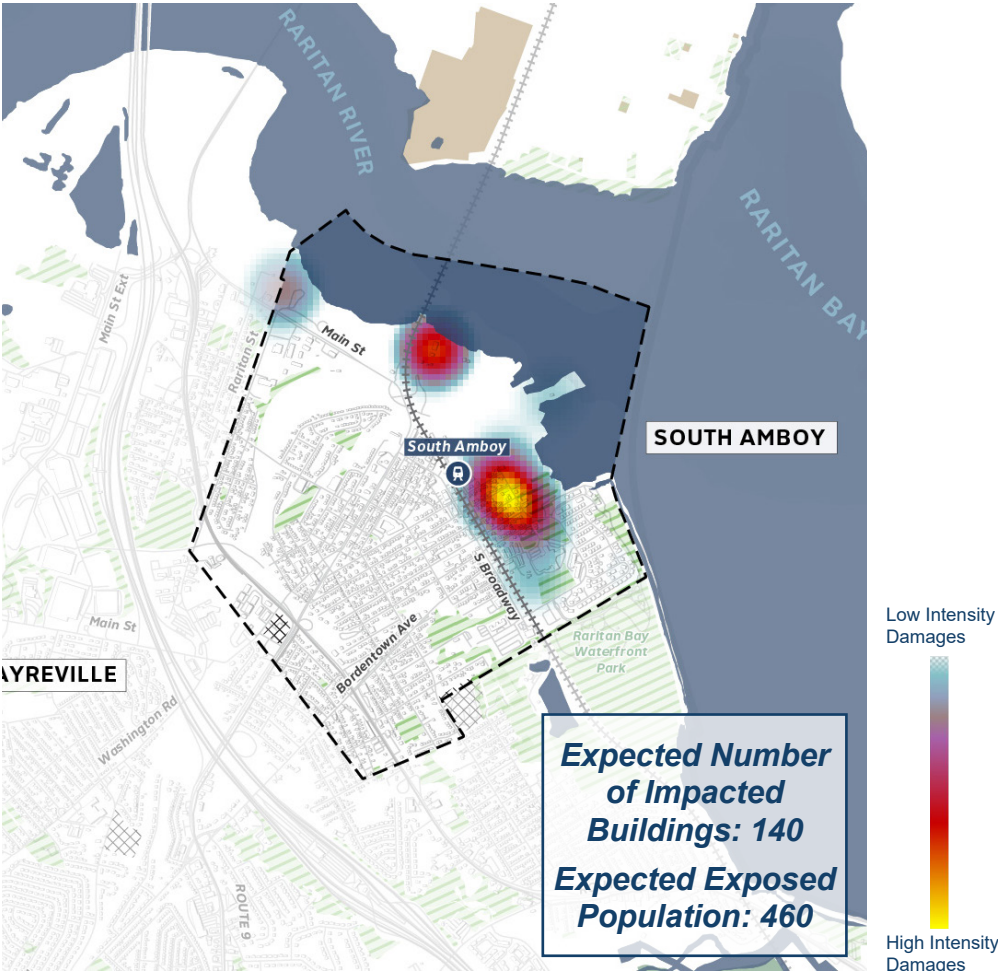
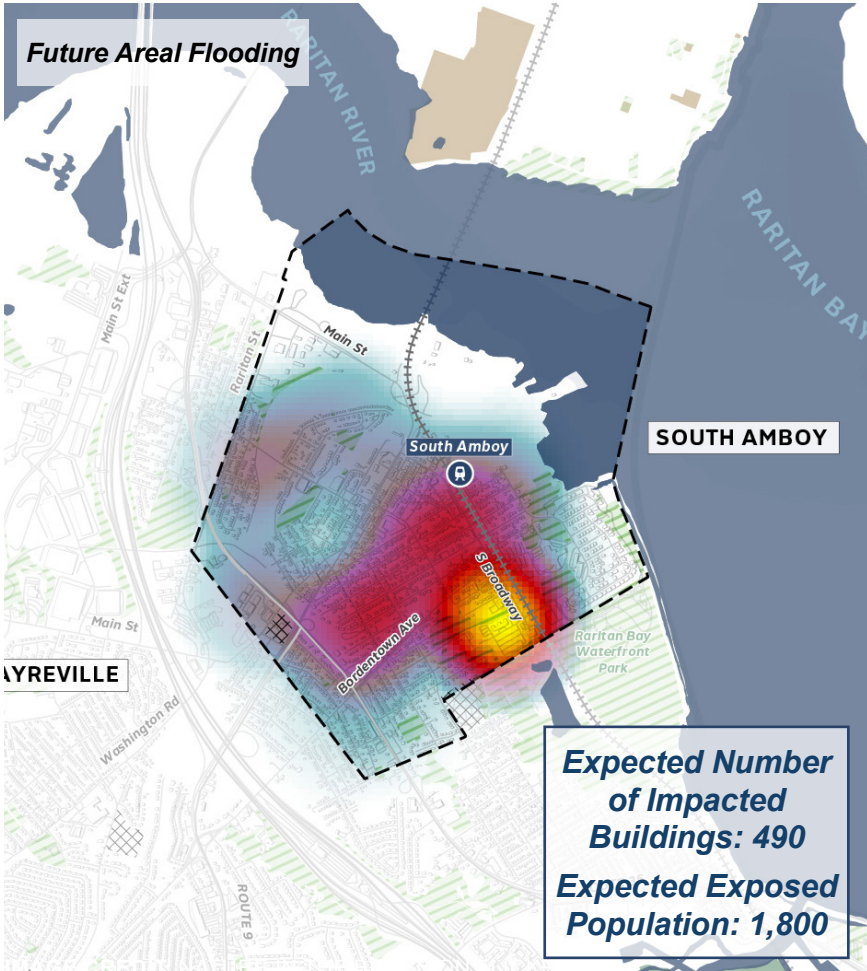


# SOUTH AMBOY

The City of South Amboy is located at the mouth of the Raritan River. The waterfront has been largely industrial, though recent and planned residential and mixed-use developments have transformed the coastal area.

This section summarizes damages that are possible if no action is taken to address flood risks that South Amboy faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. Another storm, like Hurricane Sandy, which caused extensive coastal flooding in South Amboy, will likely happen again with greater impacts due to sea level rise. In addition, there are potentially significant damages from heavy sustained rainfall as well.

*The following maps show cocentration of physical damages from each event type.*

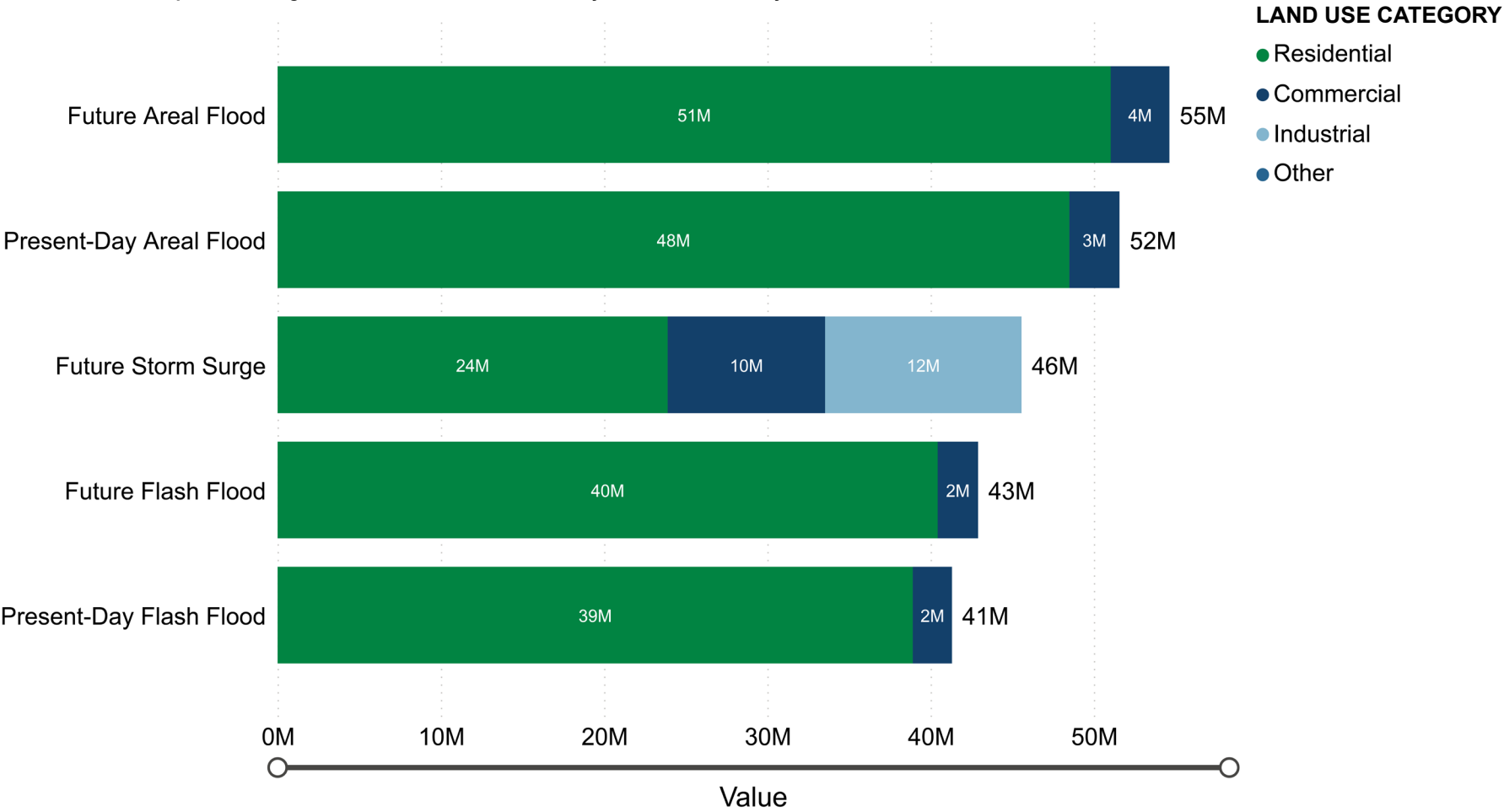


\*The values reflects current structures and populations in South Amboy. In the future these numbers will change, potentially increasing what is at risk.

Overall, damages in South Amboy are nearly equal when comparing extreme coastal storms and rainfall events. However, extreme storms like Hurricane Sandy are much less frequent than heavy sustained rainfall events.

*Though it is important to understand the potential impacts of extreme coastal surge events like Hurricane Sandy, the impacts of more frequent, less severe rainfall events should be considered in order to better understand the relative risk between rainfall and coastal storm events.*

This chart shows expected damages from the five flood events analyzed, broken down by structure use.









PRIORITIZED CRITICAL ASSETS

This chart highlights a selection of prioritized critical assets within South Amboy to demonstrate the variety of asset types impacted by flooding. The assets listed here are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in South Amboy. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response 	Fire Stations	South Amboy Fire Department Snorkel Fire Company		●	●	●
	Fire Stations	South Amboy Fire Mechanicsville Hose Comp			●	
	Shelters	First Reformed Church Of South River				●
Infrastructure 	Bus Routes	817		●	●	
	Pump Station	South Amboy Pump Station		●	●	●
	Substations	Main Street - 132954			●	●
	Bus Routes*	815	●	●	●	●
Public Health 	Parks	Rupek Road Basketball Court		●	●	
	Schools	South Amboy Elementary		●	●	
	Parks	John F Kennedy Park				●
Quality of Life 	Places of Worship	Christ Gospel Apostolic Church Inc		●	●	
	Places of Worship	Cherry Hill Associated Presbyterian Church				●

\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.

LEGEND - CRITICAL ASSETS

**INFRASTRUCTURE**

**Stormwater & Wastewater Infrastructure**

- Wastewater Treatment
- Stormwater Discharge
- Combined Sewer Outfall
- Other Surface Discharge

**Energy Infrastructure**

- Substations
- Power Generation
- Natural Gas Pipelines
- Powerlines

**Communications**

- Cell Towers

**Waste Disposal**

- Landfill

**Other**

- Heavy Industry
- Warehousing

**TRANSPORTATION**

- Bike Lanes
- Bus Routes
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Airport
- Ferry Terminal
- Port Facilities
- Rail Stations
- Bridges
- Gas Stations

**ECOSYSTEM & ENVIRONMENTAL HEALTH**

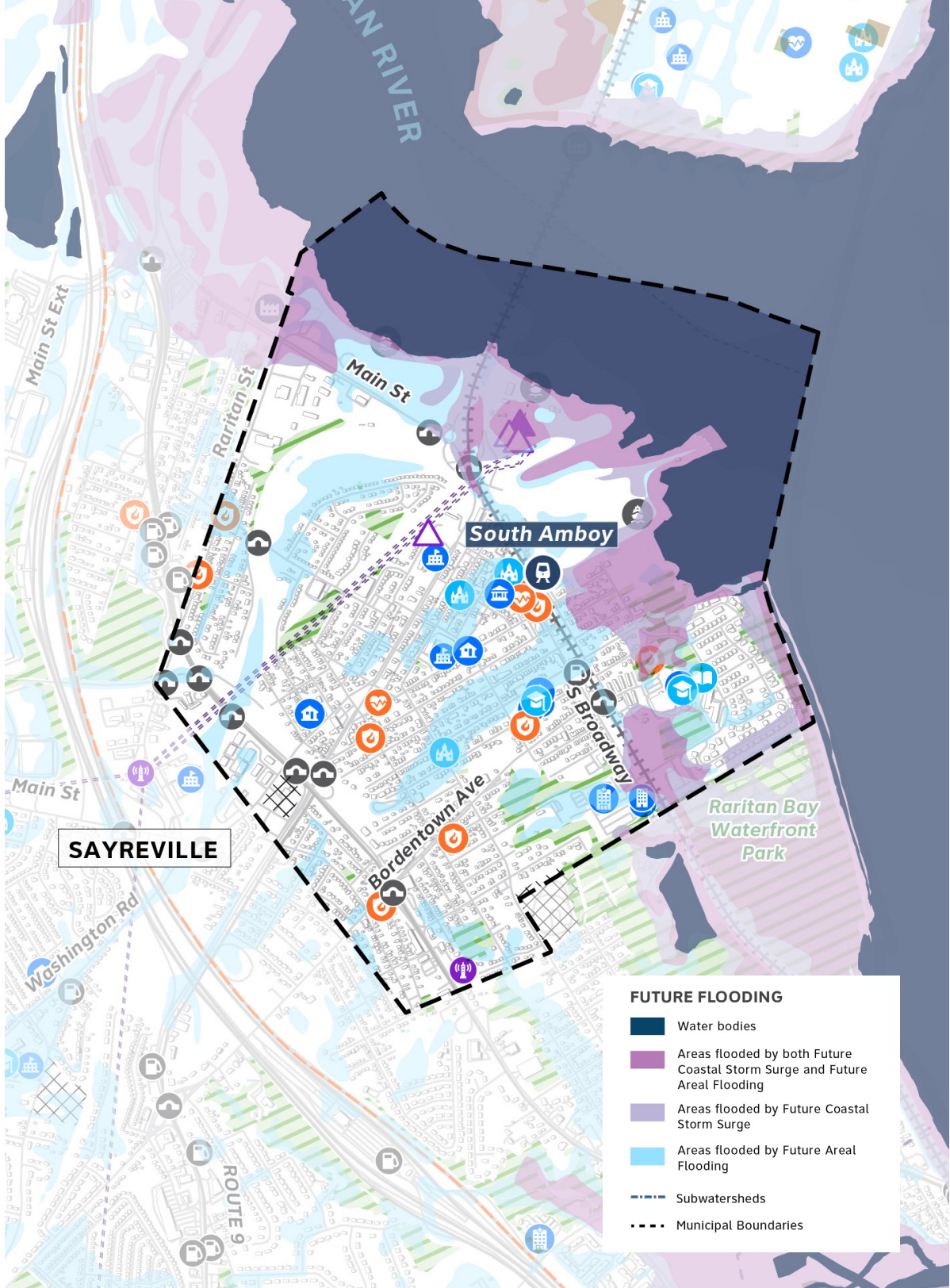
- Parks (Municipal and State Parks)
- Cemetery
- Parks and Forest Trails

**PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

- Hospitals/Medical Centers
- Municipal Building
- Public Housing
- Senior Housing
- Shelters
- Nursing Homes
- Child Care Centers
- Places of Worship
- Schools & Colleges
- Library

**EMERGENCY RESPONSE**

- EMS
- Fire Stations
- Police Stations
- Hurricane Evacuation Route



Flooding at a substation could have cascading impacts. Loss of power affects almost every aspect of our lives, from the effects we feel in our homes and places of work with loss of light, climate control, and refrigeration, to many of the services we use outside of our homes that also rely on power: traffic lights, emergency services, communications, pumps for water and wastewater services.

Key assets prone to flooding include the substation at Old Water Works Road, the Raritan Marina, and three schools: M. Scott Carpenter Elementary School, Madison Park Elementary School, and the Good Shephard Children’s Center. During COVID-19, the critical role schools play in the community was clearly demonstrated. Residents rely on schools for both education and care for their school-age children, as well as for provision of meals, socialization and mental well-being support, fitness and physical education programs. Loss of care of school-age children can also impact a parent’s ability to work. In emergencies, some schools (such as M. Scott Carpenter Elementary school and Madison Park Elementary School) also act as shelters. This highlights how a community may depend on one facility for several different types of services.

While other types of assets, such as roadways and railways, transmission lines, and gas pipelines pass through flooded areas in Old Bridge, many may be either raised above ground elevation or buried. So while they cross through flooded areas they may not be affected by future tidal flooding conditions, during which flood extents are not much larger than current high tide. However, many of these assets are exposed to rainfall flooding and coastal storm surge events, when road drainage may be inadequate and lower-lying on-ramps may flood. Community members in Old Bridge note that Route 35, which is part of bus routes 131 and 817, currently floods during heavy sustained rainfall.

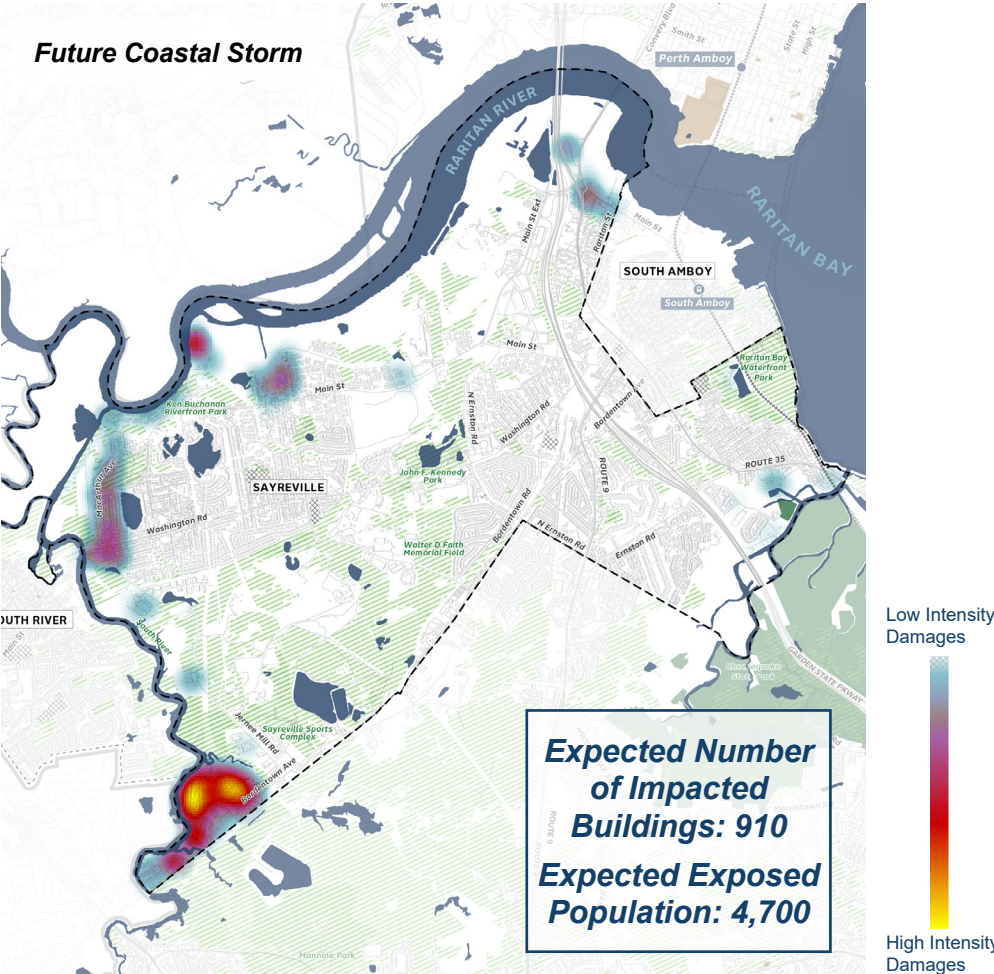
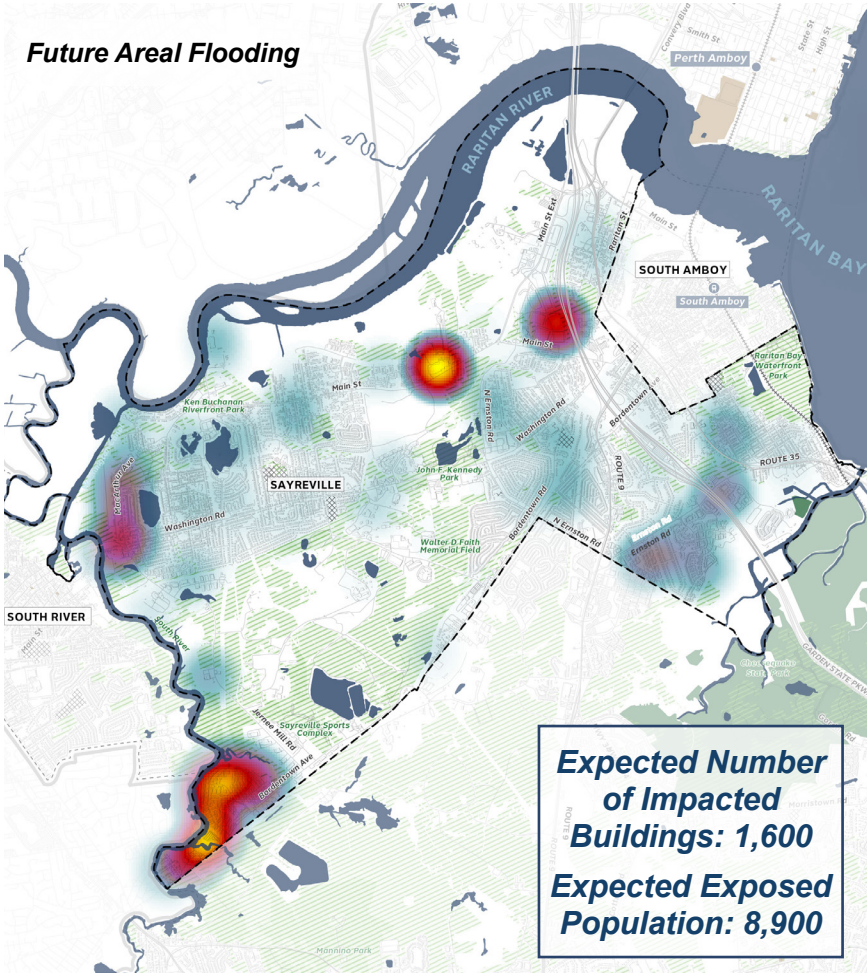


# SAYREVILLE

The Borough of Sayreville lies along the Raritan River with portions of the borough along the Atlantic Ocean and South River.

This section summarizes damages that are possible if no action is taken to address the flood risks that Sayreville faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. Another storm, like Hurricane Sandy, which caused extensive coastal flooding in Sayreville, will likely happen again with greater impacts due to sea level rise. In addition, there are potentially significant damages from heavy sustained rainfall as well.

*The following maps show cocentration of physical damages from each event type.*

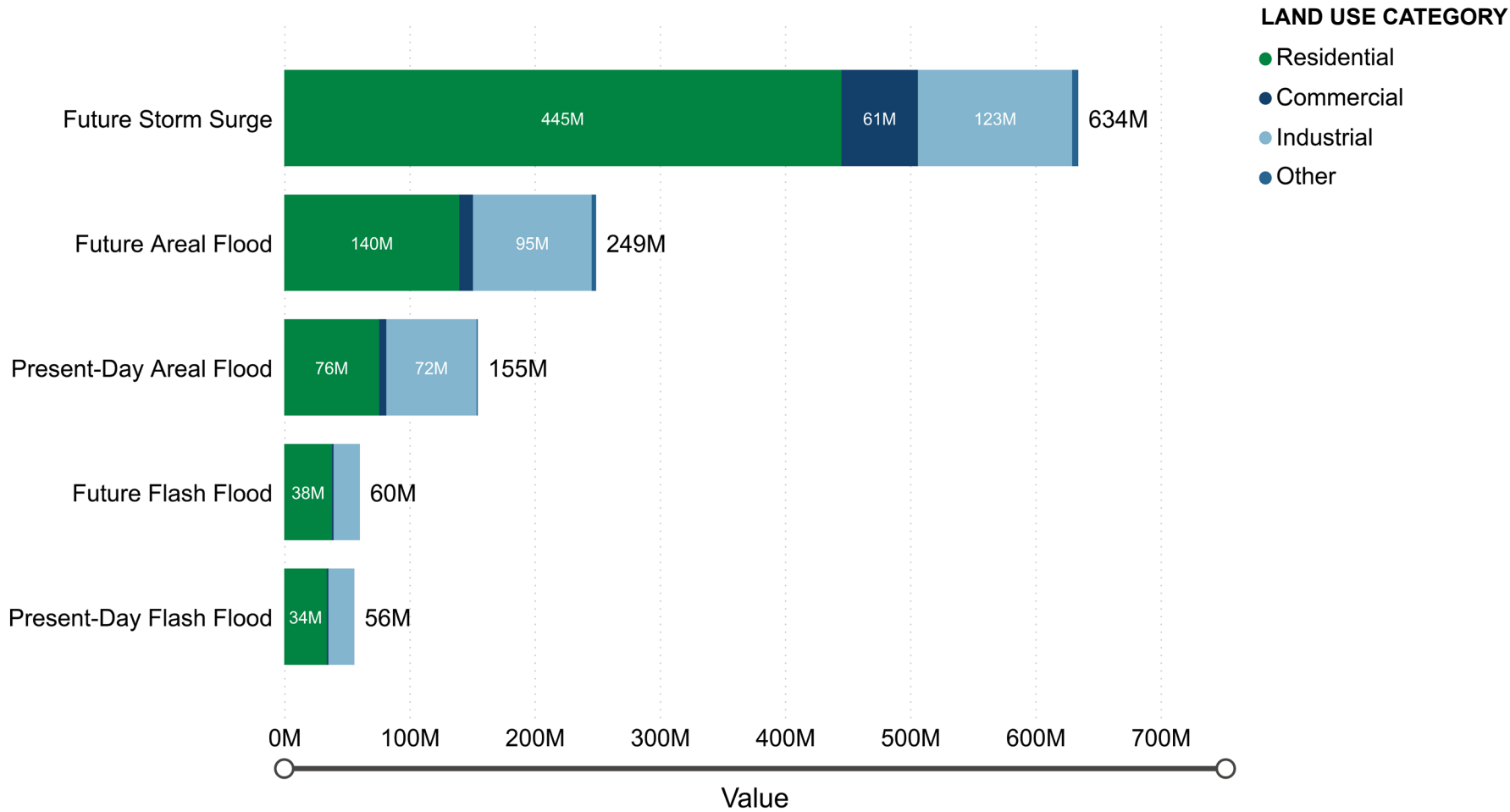


\*The values reflects current structures and populations in Sayreville. In the future these numbers will change, potentially increasing what is at risk.

While the land use in Sayreville is fairly diverse, including large residential and open space areas with patches of commercial and industrial use, the damages in Sayreville are dominated by residential properties.

*Though the coastal storm surge event is expected to incur more estimated damages than the highest rainfall event evaluated, coastal storm surge events, like Hurricane Sandy, are much less frequent than the heavy sustained rainfall flooding event and significantly less frequent than tidal flooding. Though it is important to understand the potential impacts of extreme coastal surge events like Hurricane Sandy, the impacts of more frequent, less severe rainfall events should be considered in order to better understand the relative risk between rainfall and coastal storm*

This chart shows expected damages from the five flood events analyzed, broken down by structure use.





PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within Sayreville to demonstrate the variety of asset types impacted by flooding. The assets listed here are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in Sayreville. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.*

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response	Hurricane Evacuation Route*	Garden State Parkway	●	●	●	●
Infrastructure	Power Generation	Middlesex Generating Facility		●	●	
	Substations	Unknown172907			●	●
	Substations	Sayreville			●	●
Public Health	Cemetery	Beth Israel Cemetery		●	●	
	Child Care Centers	Shish Prem dba Lightbridge Academy			●	
Quality of Life	Places of Worship	Heaven Belongs To You Ministries Corp		●	●	
	Places of Worship	Shri Bhaktinidhi Inc		●	●	
	Places of Worship	Ahavat Israel Inc				●
	Community	Starland Ballroom			●	●
	Community	Sabert Corporation		●	●	
	Community	ShopRite of Ernston Road		●	●	
	Community	DuPont - Parlin Site		●	●	

*\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.*

LEGEND - CRITICAL ASSETS

**INFRASTRUCTURE**

*Stormwater & Wastewater Infrastructure*

- Wastewater Treatment
- Stormwater Discharge
- Combined Sewer Outfall
- Other Surface Discharge

*Energy Infrastructure*

- Substations
- Power Generation
- Natural Gas Pipelines
- Powerlines

*Communications*

- Cell Towers

*Waste Disposal*

- Landfill

*Other*

- Heavy Industry
- Warehousing

**TRANSPORTATION**

- Bike Lanes
- Bus Routes
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Airport
- Ferry Terminal
- Port Facilities
- Rail Stations
- Bridges
- Gas Stations

**ECOSYSTEM & ENVIRONMENTAL HEALTH**

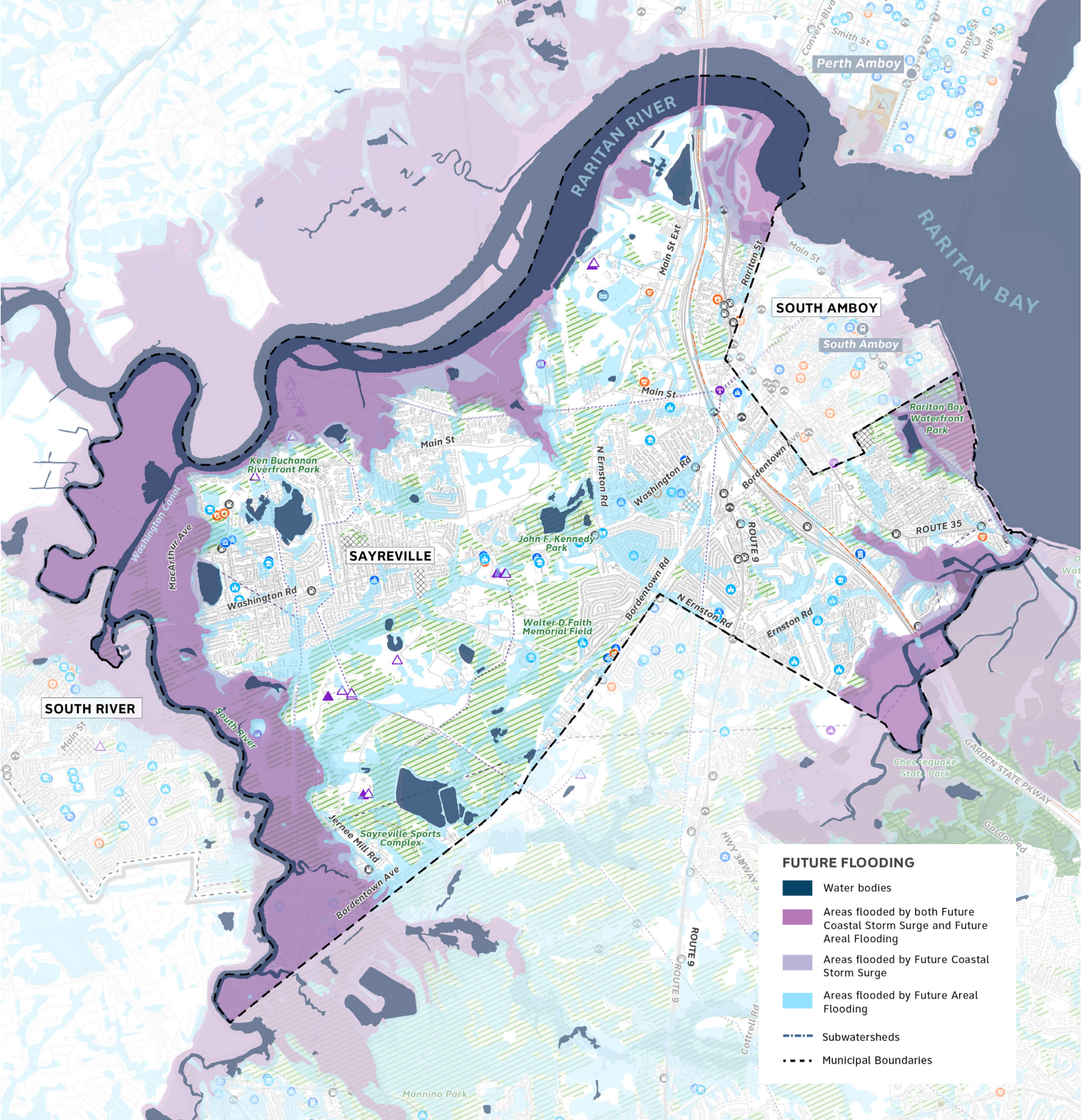
- Parks (Municipal and State Parks)
- Cemetery
- Parks and Forest Trails

**PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

- Hospitals/Medical Centers
- Municipal Building
- Public Housing
- Senior Housing
- Shelters
- Nursing Homes
- Child Care Centers
- Places of Worship
- Schools & Colleges
- Library

**EMERGENCY RESPONSE**

- EMS
- Fire Stations
- Police Stations
- Hurricane Evacuation Route



Key infrastructure assets that may flood include the Sayreville and Bordentown Avenue pump stations. The most critical category of assets exposed to flooding in Sayreville includes five power generating facilities – the Sayreville Plant, Middlesex Generating Facility, Sayreville Co-Generation Plant, the Parlin Power Plant, and Red Oak Power. These constitute the majority of power generation facilities in the region. Other than the Sayreville Plant, these facilities are exposed to flooding due to extreme rainfall. The Sayreville Plant property is also prone to flooding from coastal storm surge; however, the flood-prone portion of the property is currently undeveloped. Two substations are also exposed to flooding. The availability of power touches all aspects of our daily lives. When the power goes out, we feel it at home when our home appliances and internet do not work. Power outages can cascade to impact other regional assets, such as water and wastewater treatment plants, cell towers, hospitals, and train stations. To prevent these impacts, critical assets should be equipped with backup power generators.

Community identified assets that are exposed to rainfall flooding include the Starland Ballroom, a storied music venue that is also prone to coastal storm surge flooding, as well as major grocery stores, such as the Shoprite at Ernston Road. Major employers, like Sabert Corporation and Dupont Parlin, were also identified as critical community assets that may be impacted by rainfall flooding. Three childcare centers and nine places of worship are also vulnerable to flooding.

While other types of assets, such as elevated roadways (including hurricane evacuation routes), transmission lines, and gas pipelines, pass through flooded areas vulnerable to future tidal flooding in Sayreville, many may be raised above ground elevation or buried. While they cross through flooded areas, they may not be affected by future tidal flooding conditions, where flood extents are not far beyond the current high tide line. However, many of these assets are exposed based on rainfall flooding and coastal storm surge events, where road drainage may be inadequate or lower-lying on-ramps flood. Community members note that Route 35, which is part of bus routes 131 and 817, currently floods during heavy sustained rainfall.

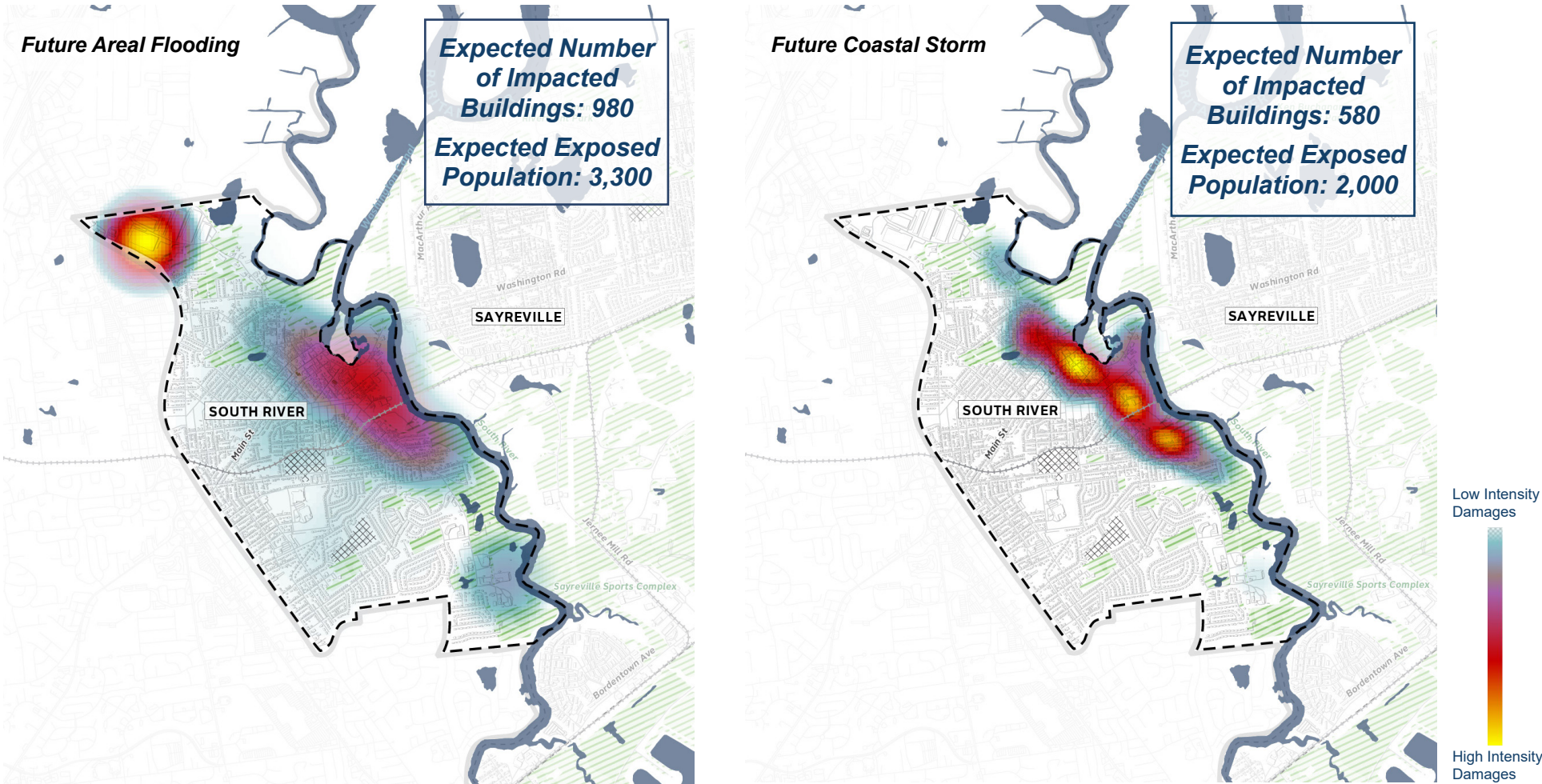


# SOUTH RIVER

The Borough of South River is located along its namesake river, which is a tributary of the Raritan River. It is a heavily developed residential area, with industrial areas along the South River.

This section summarizes damages that are possible if no action is taken to address the flood risks that South River faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. Another storm, like Hurricane Sandy, would cause extensive coastal flooding in the South River and will likely happen again with greater impacts due to sea level rise. In addition, there are potentially significant damages to this area from heavy sustained rainfall as well.

The following maps show cocentration of physical damages from each event type.

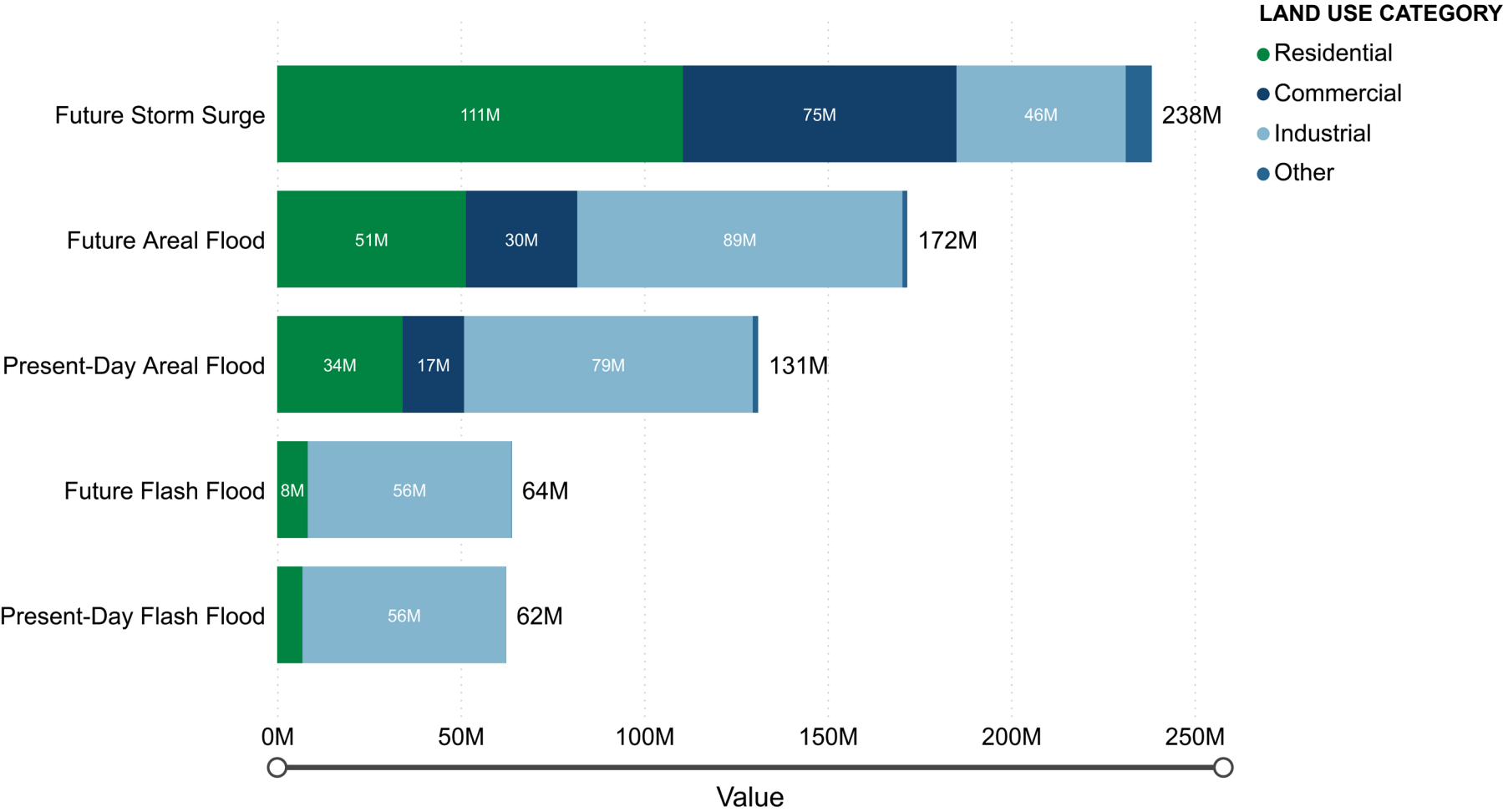


\*The values reflects current structures and populations in South River. In the future these numbers will change, potentially increasing what is at risk.

The highest estimated flood damages for South River are associated with coastal storm surge flooding when storm surge propagates up the South River. The flooding is expected to extend significantly inland into residential neighborhoods, with the majority of damages associated with residential properties. South River is also prone to damages from current rainfall flooding, which is expected to increase by 2070. Under this flood scenario, industrial damages are prevalent.

Though the coastal storm surge event is expected to incur more estimated damages than the highest rainfall event evaluated, coastal storm surge events, like Hurricane Sandy, are much less frequent than the heavy sustained rainfall flooding event and significantly less frequent than tidal flooding. **Though it is important to understand the potential impacts of extreme coastal surge events like Hurricane Sandy, the impacts of more frequent, less severe rainfall events should be considered in order to better understand the relative risk between rainfall and coastal storm events.**

This chart shows expected damages from the five flood events analyzed, broken down by structure use.














PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within South River to demonstrate the variety of asset types impacted by flooding. The assets listed here are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in South River. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to flood-proof critical facilities.*

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response 	Shelters	First Reformed Church of South River				
Infrastructure 	Bus Routes	815				
Public Health 	Parks	John F Kennedy Park				
Quality of Life 	Places of Worship	Cherry Hill Associated Presbyterian Church				

LEGEND - CRITICAL ASSETS

**INFRASTRUCTURE**

*Stormwater & Wastewater Infrastructure*

- Wastewater Treatment
- Stormwater Discharge
- Combined Sewer Outfall
- Other Surface Discharge

*Energy Infrastructure*

- Substations
- Power Generation

*Natural Gas Pipelines*

*Powerlines*

*Communications*

- Cell Towers

*Waste Disposal*

- Landfill

*Other*

- Heavy Industry
- Warehousing

**TRANSPORTATION**

- Bike Lanes
- Bus Routes
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Airport
- Ferry Terminal
- Port Facilities
- Rail Stations
- Bridges
- Gas Stations

**ECOSYSTEM & ENVIRONMENTAL HEALTH**

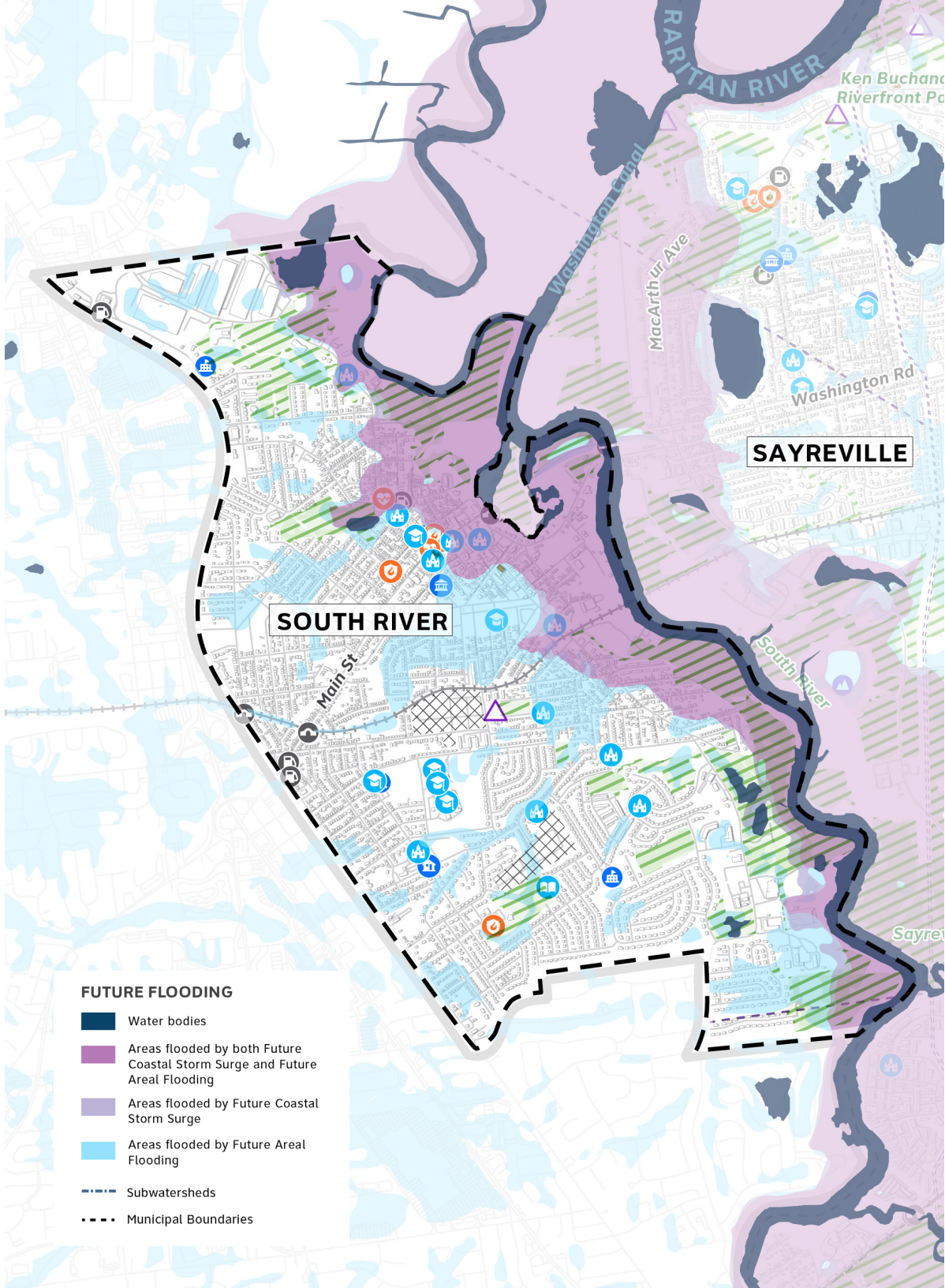
- Parks (Municipal and State Parks)
- Cemetery
- Parks and Forest Trails

**PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

- Hospitals/Medical Centers
- Municipal Building
- Public Housing
- Senior Housing
- Shelters
- Nursing Homes
- Child Care Centers
- Places of Worship
- Schools & Colleges
- Library

**EMERGENCY RESPONSE**

- EMS
- Fire Stations
- Police Stations
- Hurricane Evacuation Route



*People rely on places of worship to foster their religious and spiritual well-being, as well as places to connect with their larger communities. They are used for family services and celebrations, from weddings to funerals, as well as supporting food pantries and shelters. Studies have found that areas with stronger community connections are more resilient. Some may support specific communities, such as Redentor Presbyterian Church which serves the Brazilian community.*

Key assets prone to flooding include emergency response assets, such as the South River Fire Department and the emergency operation center at Prospect Street. Flooding of these facilities could delay emergency response times. Twelve places of worship are exposed to flooding. Of those, the First Reformed Church of South River also functions as a shelter during emergencies.

A number of parks and open spaces are predicted to flood under both rainfall and coastal storm surge conditions. The community uses parks and open spaces in multiple ways – places to run and play, camp, hike, bike, and observe wildlife. Losing access to open space may affect mental health, wellness, and physical fitness. Public parks and open space may also be used for social gatherings and community events.

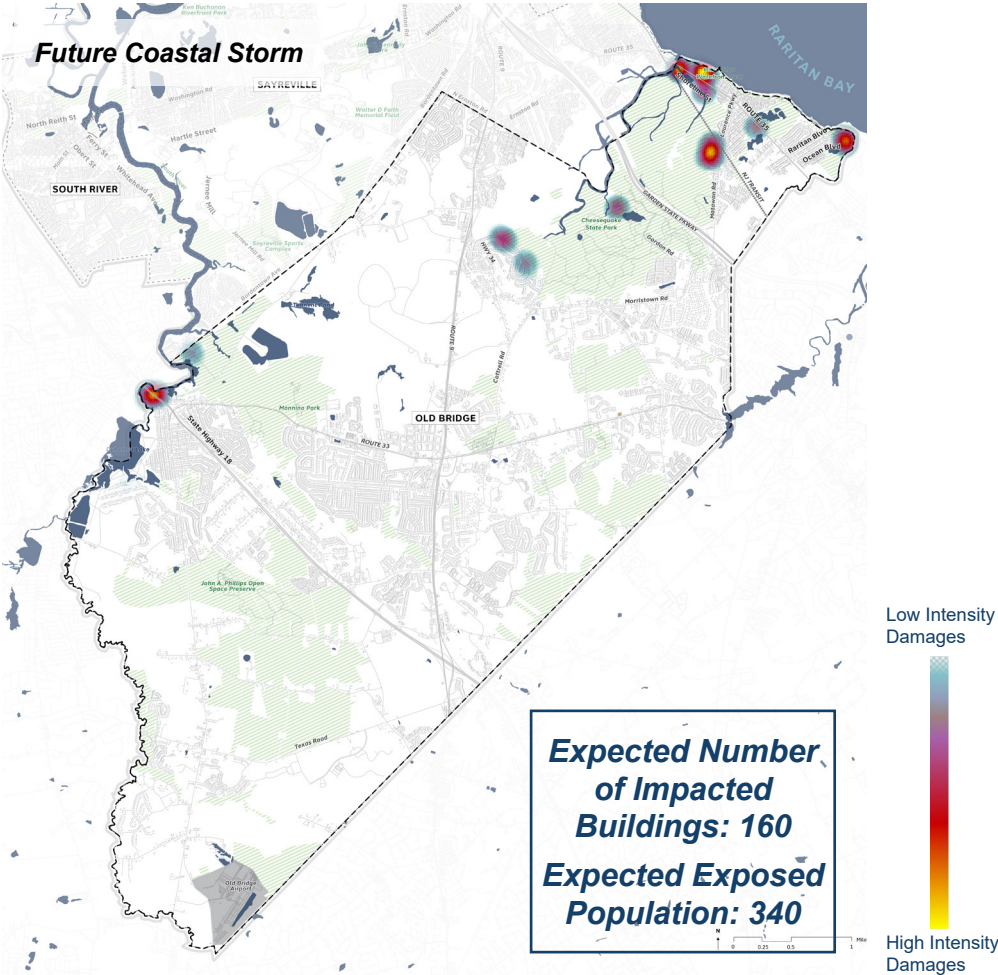
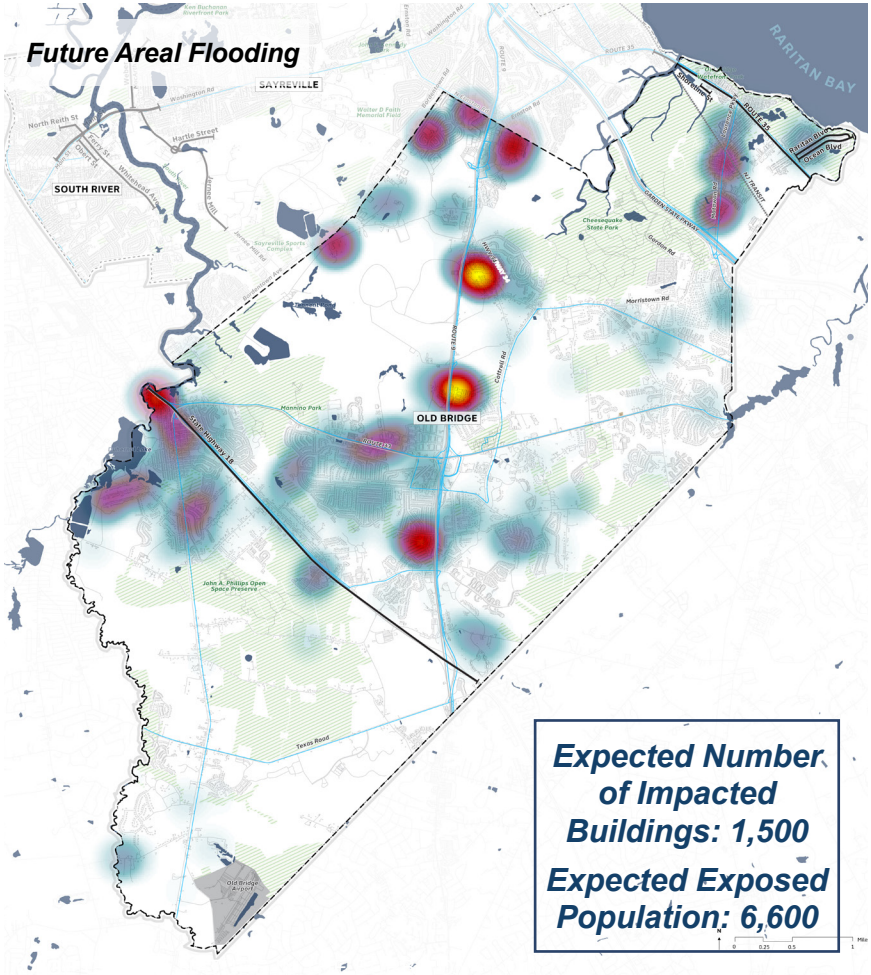


# OLD BRIDGE TOWNSHIP

Old Bridge Township is located along the Atlantic Coast and extends inland to encompass areas within the South River Watershed. While the coastal area, including Laurence Harbor, faces greater impacts from coastal storms, the area further inland within the South River Watershed faces greater impacts from rainfall events.

This section summarizes damages that are possible if no action is taken to address the flood risks that Old Bridge Township faces now. These risks will only increase in the future as climate change brings sea level rise and more intense storms. While the 2021 summer and fall storms did not flood Old Bridge to the same extent as other towns in the region, this impact assessment identifies the potential for significant damage from heavy sustained rainfall from future events. Damage to residential areas constitutes the majority of the damage in Old Bridge under all of the analyzed flood events. However, a number of critical community assets are also impacted by flooding.

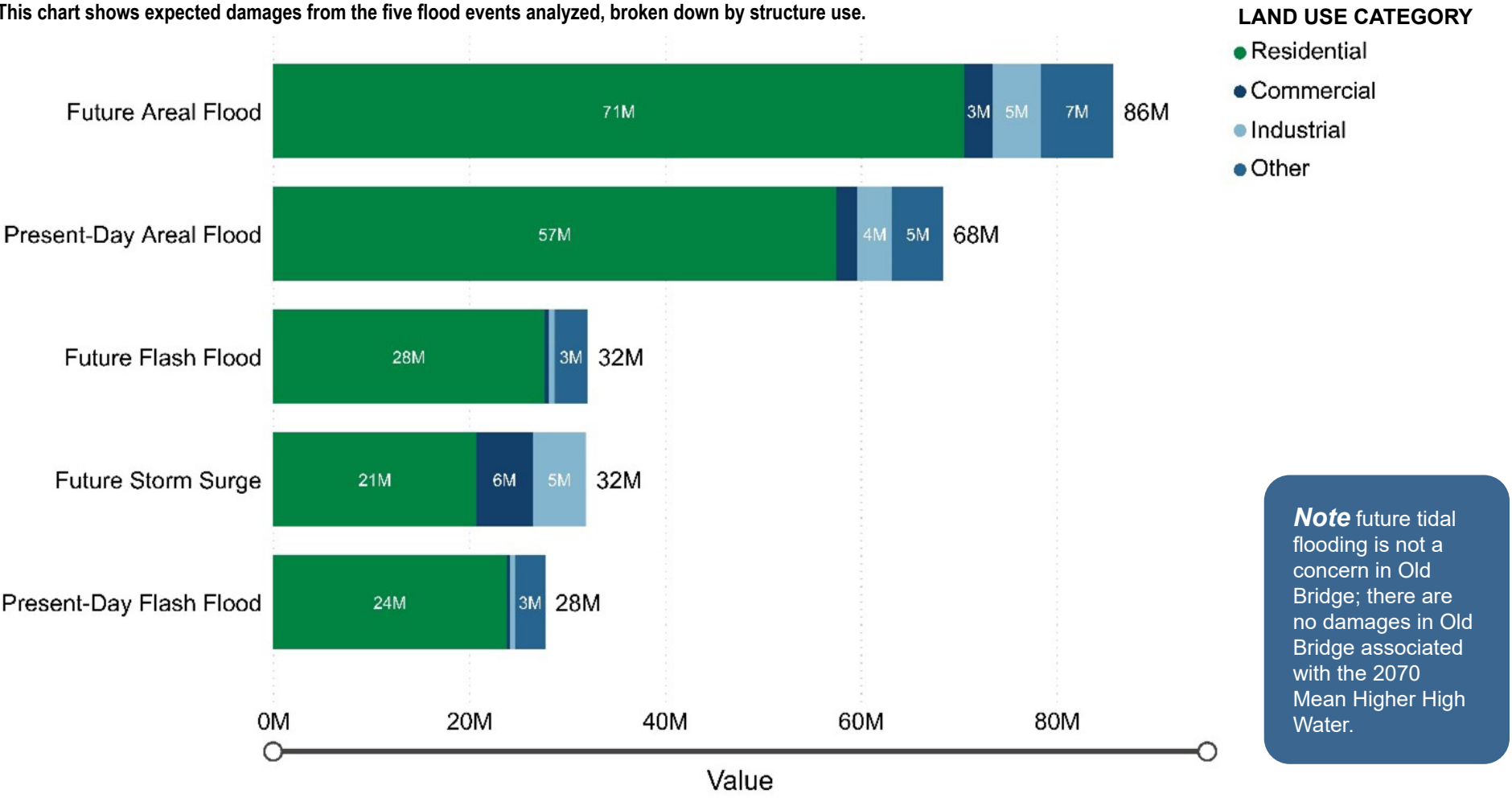
The following maps show cocentration of physical damages from each event type.



\*The values reflects current structures and populations in Old Bridge. In the future these numbers will change, potentially increasing what is at risk.

Old Bridge has more open space and parkland than other communities in the region and provides critical habitat, including a Heritage Priority site on its border with East Brunswick and the wetlands at Cheesequake State Park. Based on proximity to water bodies, these habitat sites are highly flood-prone, as are a number of other parks and open spaces in Old Bridge. The community uses parks and open spaces in multiple ways – places to run and play, camp, hike, bike, and observe wildlife. Losing access to open space may affect mental health, wellness, and physical fitness. Public parks and open space may also be used for social gatherings and community events. The Laurence Harbor Beachfront, which hosts Saltwater Day, is prone to flooding due to its location on the coast. This event fosters community unity but may be negatively impacted by flooding at the venue.

This chart shows expected damages from the five flood events analyzed, broken down by structure use.









PRIORITIZED CRITICAL ASSETS

This chart highlights a **selection** of prioritized critical assets within Old Bridge to demonstrate the variety of asset types impacted by flooding. The assets listed here are examples of critical assets that ranked high during the prioritization process. This list does not include all critical assets in Old Bridge. A full list of exposed critical assets can be found in Appendix D and the asset prioritization methodology can be found in Appendix A.

*Note that this impact assessment has identified that these assets are located in flood prone areas. It does not account for measures that may have been taken to floodproof critical facilities.*

Category	Asset Type	Name	Future High Tide	Future Flash Flood	Future Areal Flood	Future Coastal Storm
Emergency Response <div></div>	Hurricane Evacuation Route	NJ-18		<div></div>	<div></div>	
	Shelters	Madison Park Elementary School		<div></div>	<div></div>	
Infrastructure <div></div>	Bus Routes*	137	<div></div>	<div></div>	<div></div>	<div></div>
	Substations	TAP140899		<div></div>	<div></div>	
Public Health <div></div>	Cemetery	Ernst Memorial Cemetery		<div></div>	<div></div>	
	Schools	Good Shepherd Children's Center	<div></div>			
Quality of Life <div></div>	Places of Worship	Cherry Hill Associated Presbyterian Church			<div></div>	
	Community	Raritan Marina				<div></div>
	Community	Saltwater Day				<div></div>

*\*While future high tide flooding is indicated for this category because part of the asset crosses through an area flooded by future high tides, assets of this type are typically elevated and are likely to not be impacted. However, specific elevation data for the asset are not available and it is still identified as potentially affected.*

LEGEND - CRITICAL ASSETS

- INFRASTRUCTURE**

**Stormwater & Wastewater Infrastructure**

  - Wastewater Treatment
  - Stormwater Discharge
  - Combined Sewer Outfall
  - Other Surface Discharge

**Energy Infrastructure**

  - Substations
  - Power Generation
  - Natural Gas Pipelines
  - Powerlines

**Communications**

  - Cell Towers

**Waste Disposal**

  - Landfill

**Other**

  - Heavy Industry
  - Warehousing
- TRANSPORTATION**

  - Bike Lanes
  - Bus Routes
  - Light Rail/Commuter Rail
  - Primary & Secondary Roads
  - Airport
  - Ferry Terminal
  - Port Facilities
  - Rail Stations
  - Bridges
  - Gas Stations

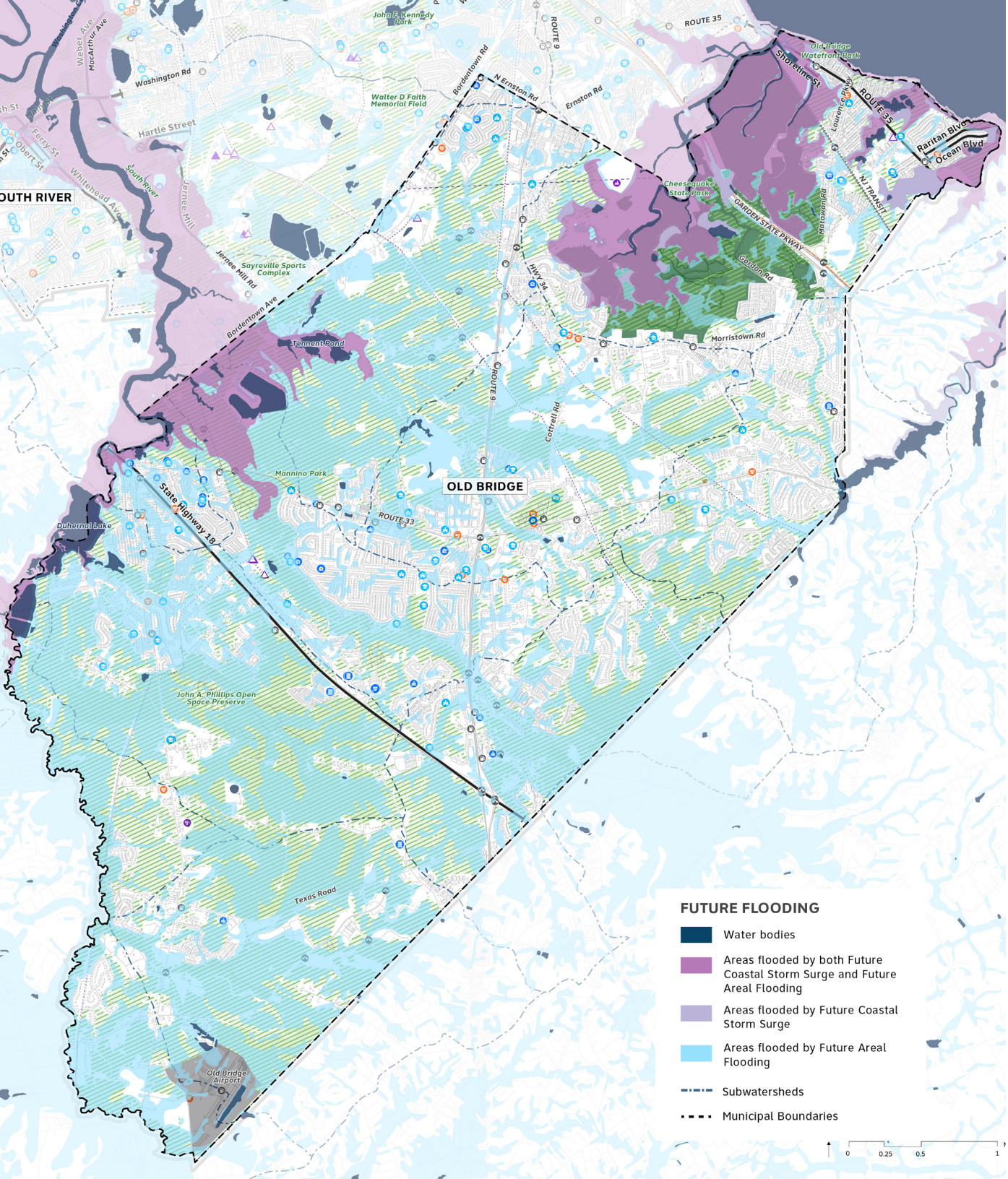
**ECOSYSTEM & ENVIRONMENTAL HEALTH**

  - Parks (Municipal and State Parks)
  - Cemetery
  - Parks and Forest Trails
- PUBLIC HEALTH, WELL-BEING & QUALITY OF LIFE**

  - Hospitals/Medical Centers
  - Municipal Building
  - Public Housing
  - Senior Housing
  - Shelters
  - Nursing Homes
  - Child Care Centers
  - Places of Worship
  - Schools & Colleges
  - Library

**EMERGENCY RESPONSE**

  - EMS
  - Fire Stations
  - Police Stations
  - Hurricane Evacuation Route



*Flooding at a substation could have cascading impacts. Loss of power affects almost every aspect of our lives, from the effects we feel in our homes and places of work with loss of light, climate control, and refrigeration, to many of the services we use outside of our homes that also rely on power, such as traffic lights, emergency services, communications, pumps for water and wastewater services.*

Key assets prone to flooding include the substation at Old Water Works Road, the Raritan Marina, and three schools: M. Scott Carpenter Elementary School, Madison Park Elementary School, and the Good Shepherd Children’s Center. During COVID-19, the critical role schools play in the community was clearly demonstrated. Residents rely on schools for both education and care for their school-age children, as well as for provision of meals, socialization and mental well-being support, fitness, and physical education programs. Loss of care of school-age children can also impact a parent’s ability to work. In emergencies, some schools (such as M. Scott Carpenter Elementary school and Madison Park Elementary School) also act as shelters. This highlights how a community may depend on one facility for several different types of services.

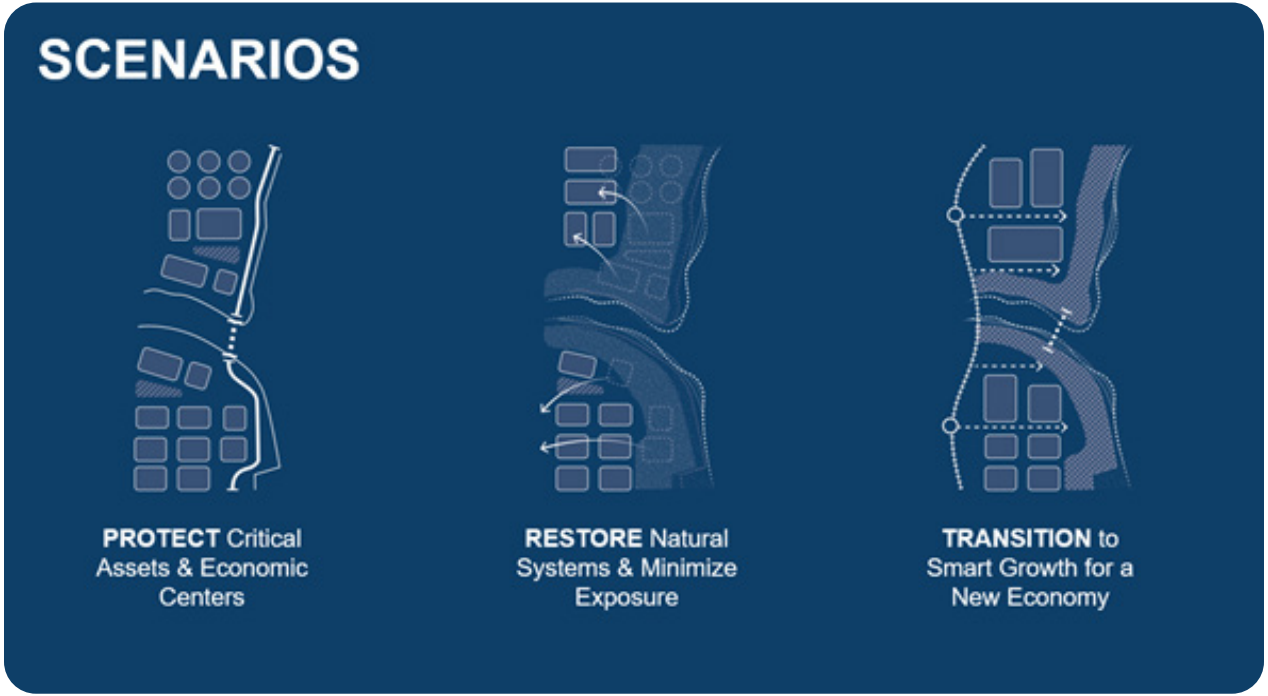
While other types of assets, such as roadways and railways, transmission lines, and gas pipelines, pass through flooded areas in Old Bridge, many may be either raised above ground elevation or buried. While they cross through flooded areas, they may not be affected by future tidal flooding conditions, during which flood extents are not much larger than current high tide. However, many of these assets are exposed to rainfall flooding and coastal storm surge events when road drainage may be inadequate and lower-lying on-ramps may flood. Community members in Old Bridge note that Route 35, which is part of bus routes 131 and 817, currently floods during heavy sustained rainfall.



# WHAT ARE OUR NEXT STEPS?



This flood impact assessment highlights what could happen to the community if nothing is done to reduce flood risk now and in the future. The Resilient RRBC team is using this assessment to prioritize what can and should be done. Even knowing what is at risk, though, does not define a single path forward. Multiple actions and combinations of actions each result in different benefits and costs. In order to set the course of action going forward, Resilient RRBC developed three scenarios using different approaches to reducing the impact of flooding, as described on the project website ([www.resilient.nj.gov/rrbc](http://www.resilient.nj.gov/rrbc)).



Scenarios allow stakeholders and decision-makers to understand the various pathways to enhancing resilience within the region over the next 50 years, given the challenges of climate change. These scenarios that align with the region's vision, address the flood risks identified, and are combination of a wide range of flood risk-reduction tools. Moving forward, these three scenarios will be refined and consolidated into a preferred scenario, which will be the basis of the action plan.

The results of this flood impact assessment help define the preferred scenario. By identifying what assets are protected under each scenario, the Resilient RRBC team can look at the costs associated with flooding that would be avoided and compare it to the cost of implementation. That, along with community priorities and vision, will be weighed as part of developing the preferred scenario.



**DESIGN LIFE / ADAPTABILITY**  
What is the design life of the strategy? Can it be adapted to future risks?



**COST AND FEASIBILITY**  
Can the strategy be implemented given technical, regulatory, funding, community support, operations and maintenance considerations?



**RISK REDUCTION / EFFECTIVENESS**  
Does the strategy reduce flood risks?



**ENVIRONMENT**  
How does the strategy affect the environment over time?



**COMMUNITY AND HEALTH**  
How does the strategy affect human communities over time?



**PARTNERSHIP AND EQUITY**  
Does the strategy help improve community wellbeing and build partnerships?



# GET INVOLVED!

- 1. We’re looking for your feedback on this report! Please share your thoughts using this [form](#).
- 2. Visit our [website](#) for more information and project updates.
- 3. Sign up for [Resilient NJ emails](#).
- 4. Keep an eye out for upcoming meetings and other engagement opportunities.

PROJECT FEEDBACK  
Please share your thoughts  
using the survey



FEEDBACK FORM

## SOCIAL MEDIA

@ResilientRRBC to find us  
on Twitter, Facebook, and  
Instagram.

## PROJECT HOTLINE

Leave a voicemail at 732-661-3808 in  
any one of 6 languages (English, Spanish,  
Portuguese, Mandarin, Hindi, Polish)

## PROJECT EMAIL ADDRESS

Reach us at  
ResilientRRBC@dep.nj.gov



# 05 - REFERENCES



# REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2020. CDC SVI 2018 Documentation – 1/31/2021. Available online at [https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI\\_documentation\\_2018.html](https://www.atsdr.cdc.gov/placeandhealth/svi/documentation/SVI_documentation_2018.html). Retrieved on April 19, 2022.

FEMA. 2022. FEMA Coastal Restudy – New York and New Jersey. FEMA Coastal Restudy. Available online at <https://region2-fema.opendata.arcgis.com/apps/fema-coastal-restudy/explore>. Retrieved on February 28, 2022.

NJDEP. 2022. Cheesequake State Park Overview. Available online at <https://nj.gov/dep/parksandforests/parks/cheesequakestatepark.html>. Retrieved on March 30, 2022.

NOAA. 2022. Tides and Currents – Tidal Datums. Available online at [https://tidesandcurrents.noaa.gov/datum\\_options.html](https://tidesandcurrents.noaa.gov/datum_options.html). Retrieved on April 19, 2022.

[https://resilientnewjersey.com/wp-content/uploads/2022/03/220308\\_Resilient-NJ-RRBC\\_Visioning-Report\\_spreads.pdf](https://resilientnewjersey.com/wp-content/uploads/2022/03/220308_Resilient-NJ-RRBC_Visioning-Report_spreads.pdf). Draft. March.

New York Times. 2022. Inflation Has Arrived. Here’s what You Need to Know. Available online at <https://www.nytimes.com/article/inflation-definition.html?smid=url-share>. January 10.

Resilient NJ. 2021. Resilient NJ: Raritan Rivers and Bay Communities – About Our Region Report. Available online at [https://resilientnewjersey.com/wp-content/uploads/2021/08/210817\\_Resilient-NJ\\_About-Our-Region-Report.pdf](https://resilientnewjersey.com/wp-content/uploads/2021/08/210817_Resilient-NJ_About-Our-Region-Report.pdf). Draft. August.

Resilient NJ. 2022. Resilient NJ: Raritan Rivers and Bay Communities – Vision and Priorities. Available online at

Rutgers University. 2019. New Jersey’s Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Available online at [https://climatechange.rutgers.edu/images/STAP\\_FINAL\\_FINAL\\_12-4-19.pdf](https://climatechange.rutgers.edu/images/STAP_FINAL_FINAL_12-4-19.pdf). November.

USGS. 2022. Flood Event Viewer – Hurricane Sandy. Available online at <https://stn.wim.usgs.gov/FEV/#Sandy>. Retrieved on April 19, 2022.

U.S. Census Bureau. 2022. Income and Poverty in the United States: 2020. Available online at [Income and Poverty in the United States: 2020 \(census.gov\)](https://www.census.gov/pov/data/income-poverty). Retrieved on April 19, 2022.

# 06- LIST OF APPENDICES



# LIST OF APPENDICES

## Appendix A

- \* RRBC Impact Assessment Methodology
- \* Attachment A - Data Source List

## Appendix B

- \* NJDEP Risk Assessment Methodology
- \* NJDEP Modeling Methodology

## Appendix C

- \* RRBC Model Updates

## Appendix D

- \* NJDEP Asset Assessment Table
- \* Critical Asset Inventory Database
- \* Scoring of All Critical Assets

## Appendix E

- \* Flood Impact Summary Tables