



03 - SUMMARY OF CLIMATE IMPACTS IN THE REGION

Flood Impact Assessment
Additional Climate Hazards Assessment

FLOOD IMPACT ASSESSMENT

This *Action Plan* seeks to reduce current and future risks due to flooding and additional climate hazards. Flooding is an ongoing issue in the region and climate change is making it worse.

The project team conducted a detailed flood impact assessment to evaluate the impacts of various types of flooding across the region and identify geographies, populations, and assets that may be vulnerable to flooding and other hazards both today and in the future. The project team used the results of this assessment to inform the development of risk reduction strategies guided by the community vision and priorities.

During the planning process the project team heard interest from stakeholders about the impacts of additional climate hazards and how the region could prepare for other threats. Based on this feedback, the team undertook a second analysis of additional climate hazards to examine how climate threats beyond flooding—such as extreme heat, air pollution, drought, wildfire, and others—are likely to impact the region in the future with climate change.

This section summarizes the key findings of the flood impact assessment. Additional information, including data sources and methodologies, is available in the full *Flood Impact Assessment*.

History of Flooding in RRBC

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 has been seen as a recreational amenity and the region's waterways have attracted new development. However, as Hurricanes Sandy and Irene, as well as the more recent flood events of summer 2021, have demonstrated, the proximity to water also presents a threat—one that is increasing due to climate change.

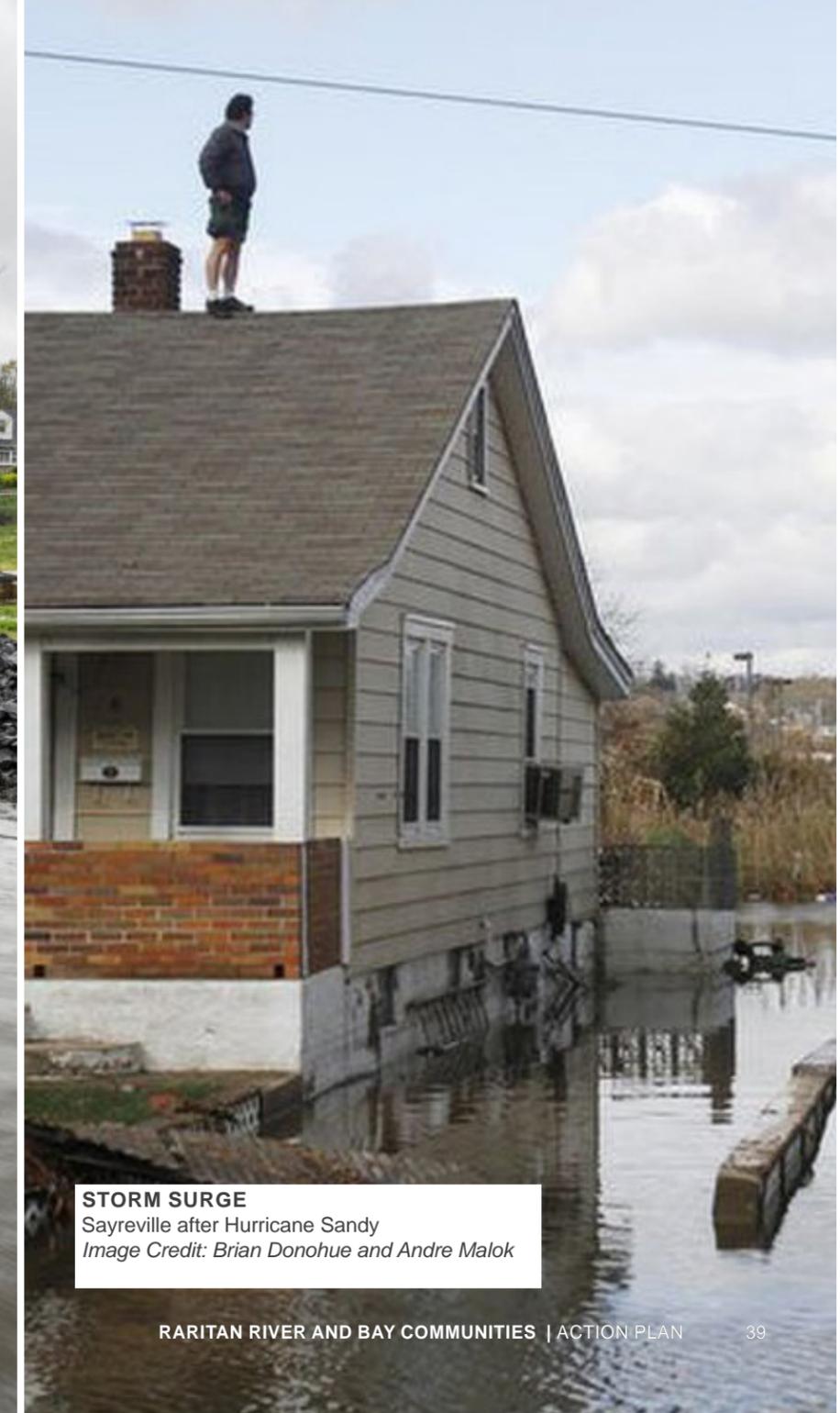
As the region was developed, many wetlands were filled in, locating development on low elevations susceptible to flooding and blocked natural drainage patterns. Much of the region was also developed prior to codes on stormwater or floodplain management, meaning development did not incorporate drainage elements or buildings designed to be safe from flooding. The stormwater infrastructure that was built out at the time, such as culverts and underground drainage networks, was not designed to manage the intense rainfall events that the region is now regularly facing.



RAINFALL FLOODING
Raritan River Flooding After Hurricane Ida in Piscataway, NJ



TIDAL FLOODING
May 7, 2022 King Tide near Pump Station on South River, Sayreville. Image Credit: High Water Report by Douglas Baumann via NJ MyCoast



STORM SURGE
Sayreville after Hurricane Sandy
Image Credit: Brian Donohue and Andre Malok

FLOOD IMPACT SUMMARY

As demonstrated by historic and more recent events—and supported by the most up-to-date climate science—the RRBC region faces high, and increasing, risks from heavy rainfall events, coastal storm surge, and tidal flooding. Each of these presents its own challenge. Many areas in the region face flood risks from multiple sources, demanding solutions that address the ways in which these flooding sources interact in order to provide holistic flood risk reduction.

Social Vulnerability

The region is varied and diverse, representing a wide range of social backgrounds, values, opportunities, and challenges. Parts of the region—especially in more heavily urbanized areas, such as parts of Perth Amboy—contain neighborhoods classified by the Centers for Disease Control and Prevention (CDC) as within the highest-ranking categories of “socially vulnerability.” Social vulnerability refers to the degree to which a community’s individuals and households 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

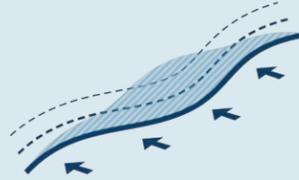
policies tend to make communities within certain demographics especially susceptible to the most severe impacts of flooding, especially Black, Brown, and Latinx communities, low-income populations, low English-speaking households, and people with disabilities.

An analysis of rates of social vulnerability within RRBC reveals very high rates of social vulnerability concentrated in Perth Amboy, Carteret, the area around Main Street in South River, and pockets of Sayreville. Some neighborhoods with high CDC Social Vulnerability Index (SVI) scores—which aggregates a variety of factors gathered from US Census data including socio-economics, housing composition and disability, minority status and language, and housing type and transportation access—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.

An alternative metric to assessing vulnerability is provided by NJDEP’s Office of Environmental Justice, which identifies “overburdened communities” (OBCs) across the state. OBCs are defined as census block groups which meet certain thresholds for rates of low-income households, residents identifying as minorities, and/or households that have limited English proficiency.

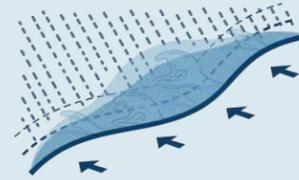
Sources Of Flooding In RRBC

Tidal Flooding



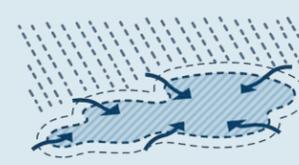
Tidal flooding is the temporary inundation of low-lying areas due to high tides. Sea level rise will cause tides to be higher than they are today, and some areas will flood daily if no actions are taken.

Storm Surge



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

Areal Flooding



Inches of rain can fall in a few hours during the peak of a storm, causing flooding in low-lying areas. These areas might be along waterways (riverine flooding) or inland where rainfall overwhelms storm drains.

OVERBURDENED COMMUNITIES

These maps corroborate many of the takeaways from the social vulnerability maps, revealing that most census block groups in RRBC are considered overburdened communities given the great number of minority populations who live across the region. However, some communities meet multiple thresholds of OBCs, with many households and residents identified as OBCs both on the basis of low income as well as minority status—with some also on the basis of limited English proficiency—concentrated in and around Perth Amboy.

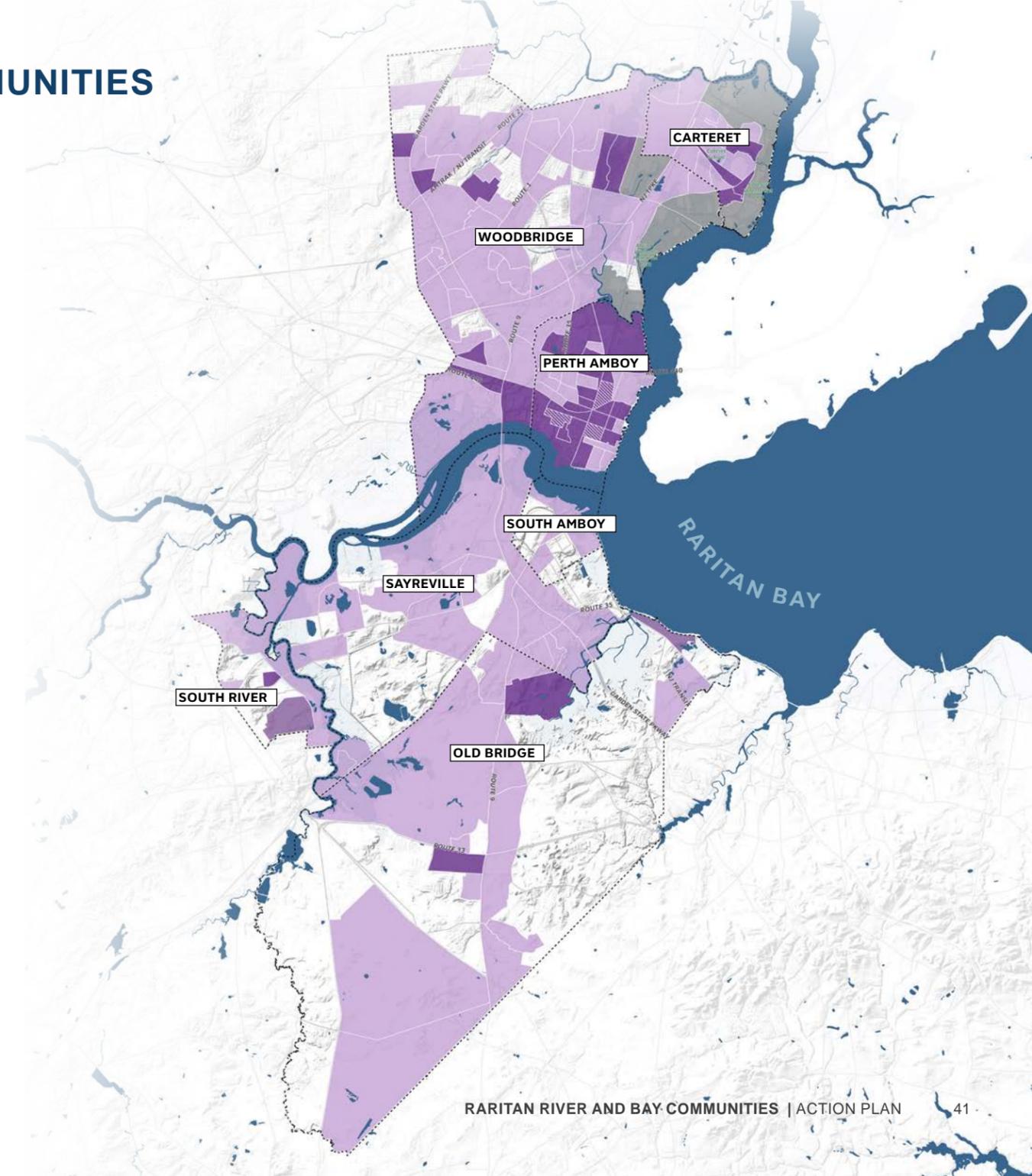
Lower income households with less savings are more vulnerable when faced with losing income. A history of exclusionary policy has inequitably distributed resources so that Black, Brown, and Latinx communities are disproportionately exposed to flooding and its most dangerous effects. Others, such as the elderly or people with disabilities, also face a higher degree of overall risk, as they tend to have limited ability to evacuate.

LEGEND

RRBC OVERBURDENED COMMUNITIES

- No Population, Adjacent to an OBC
- Minority (40%+)
- Low Income (35%+)
- Low Income (35%+) and Minority (40%+)
- Low Income (35%+), Minority (40%), and Limited English (40%+)

Data Source: NJDEP Environmental Justice Mapping, Assessment, and Protection Tool (2022)



Summary of Regional Flood Impacts

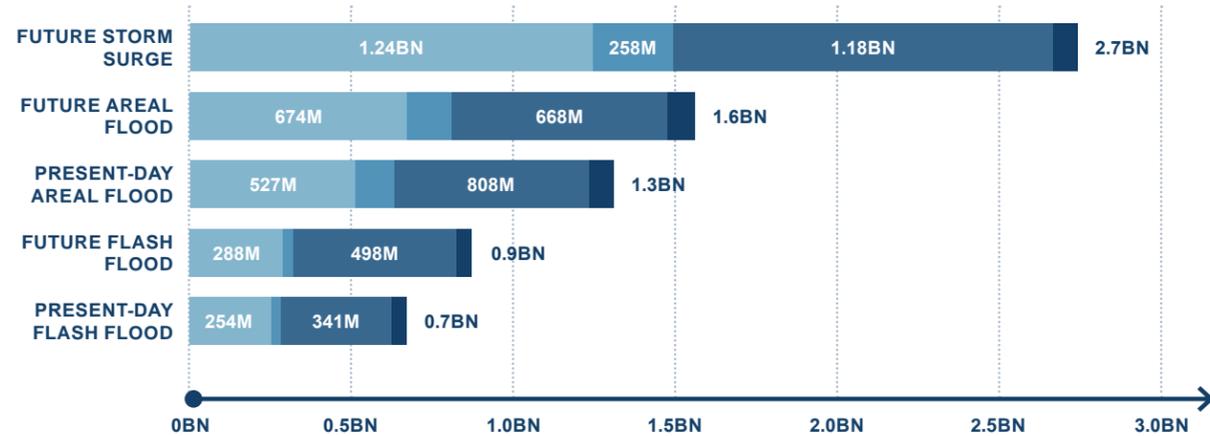
The RRBC region is home to numerous assets of regional importance, such as the Garden State Parkway, I-95, the North Jersey Coast Line, several power generation plants and wastewater treatment facilities, as well as many regional parks such as Cheesequake State Park. In addition, there are numerous critical assets in every town. These include buildings (such as schools, day care centers, hospitals, or fire stations), infrastructure (such as roads, bridges, and pipelines), or spaces that host community events (like farmer's markets). The [Flood Impact Assessment](#) identifies critical assets of regional importance that are vulnerable to flooding within each municipality.

The detailed *Flood Impact Assessment* evaluates exposure to current and future flooding and summarizes the potential monetary losses due to

physical damages to structures and their contents, human impacts, direct business impacts, and the loss of function of public and essential facilities.

These losses are summarized for each of the flood events assessed. Events assessed include future events that account for climate change: specifically, coastal storm surge and heavy rainfall—the latter of which includes both areal flooding and flash flooding. The future storm surge event is expected to cause the most amount of damage comparatively. While storm surge is expected to affect a smaller area of the region than either areal or flash flooding, the flood depths experienced are expected to be greater, leading to higher damage. However, it is important to note that the storm surge event analyzed is expected to happen much less frequently than flash floods or areal floods caused by heavy rainfall events within the region.

FLOOD IMPACT ASSESSMENT RESULTS



Flood Impact Assessment Damage Categories



DIRECT PHYSICAL DAMAGE

Damage to Structures, Contents and Inventory Loss



HUMAN IMPACTS

Residential Displacement, Mental Stress and Anxiety, Injuries, Lost Productivity



BUSINESS IMPACTS

Business Relocation, Loss of Employment, Economic Output Loss, Tax Revenue Impacts



LOSS OF FUNCTION

Public and Essential Services Cannot Operate



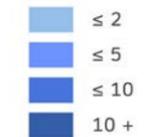
TIDAL FLOODING

Tidal flooding is the temporary 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.

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.

LEGEND

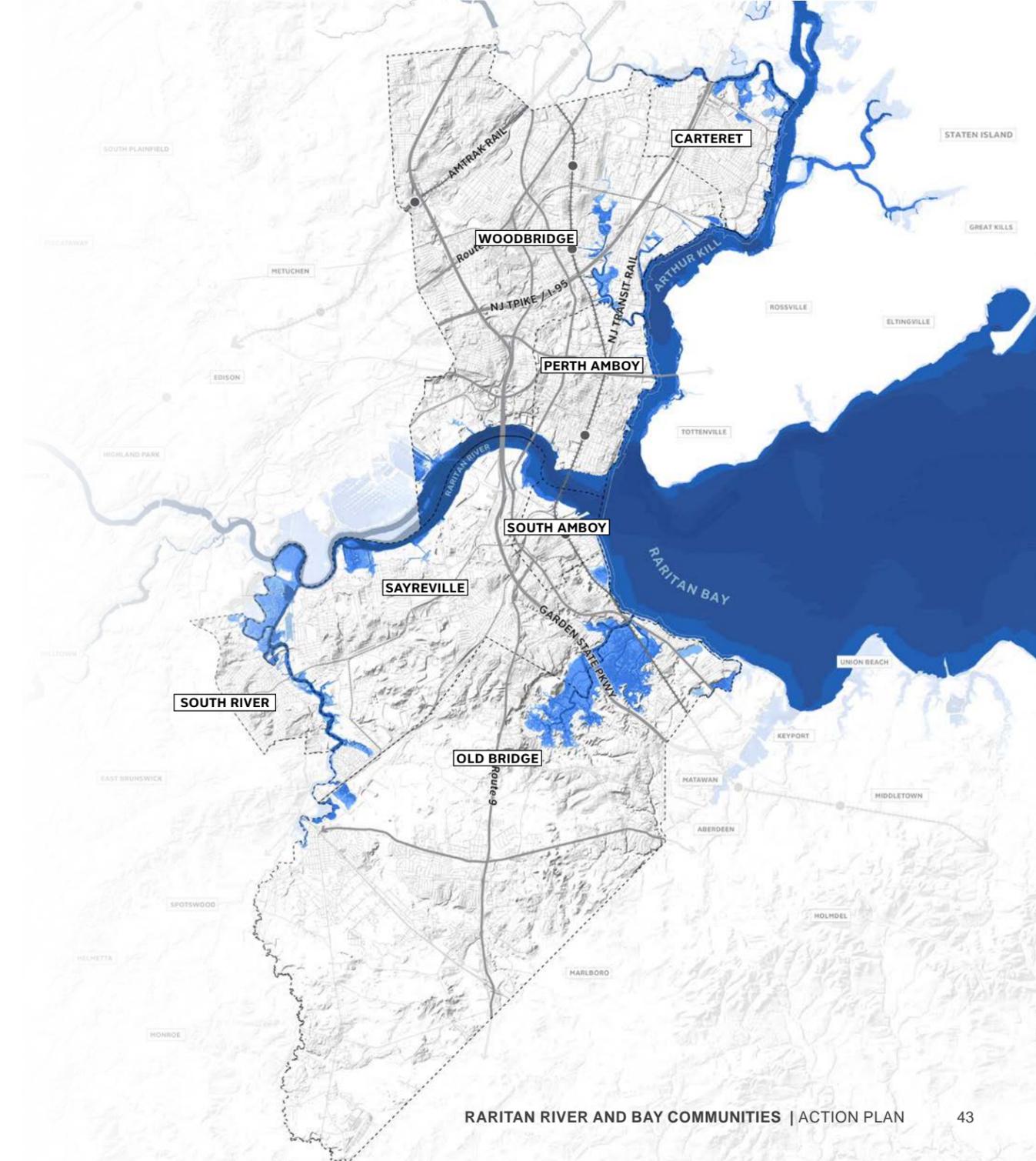
Future Tidal Flooding
Mean High High Water with Sea Level Rise - Flood Depth (feet NAVD88)



Basemap



Data Source: RRBC Project Team



STORM SURGE

Tropical storms, hurricanes, and nor'easters can raise water levels along the coast, resulting in storm surge. 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.

LEGEND

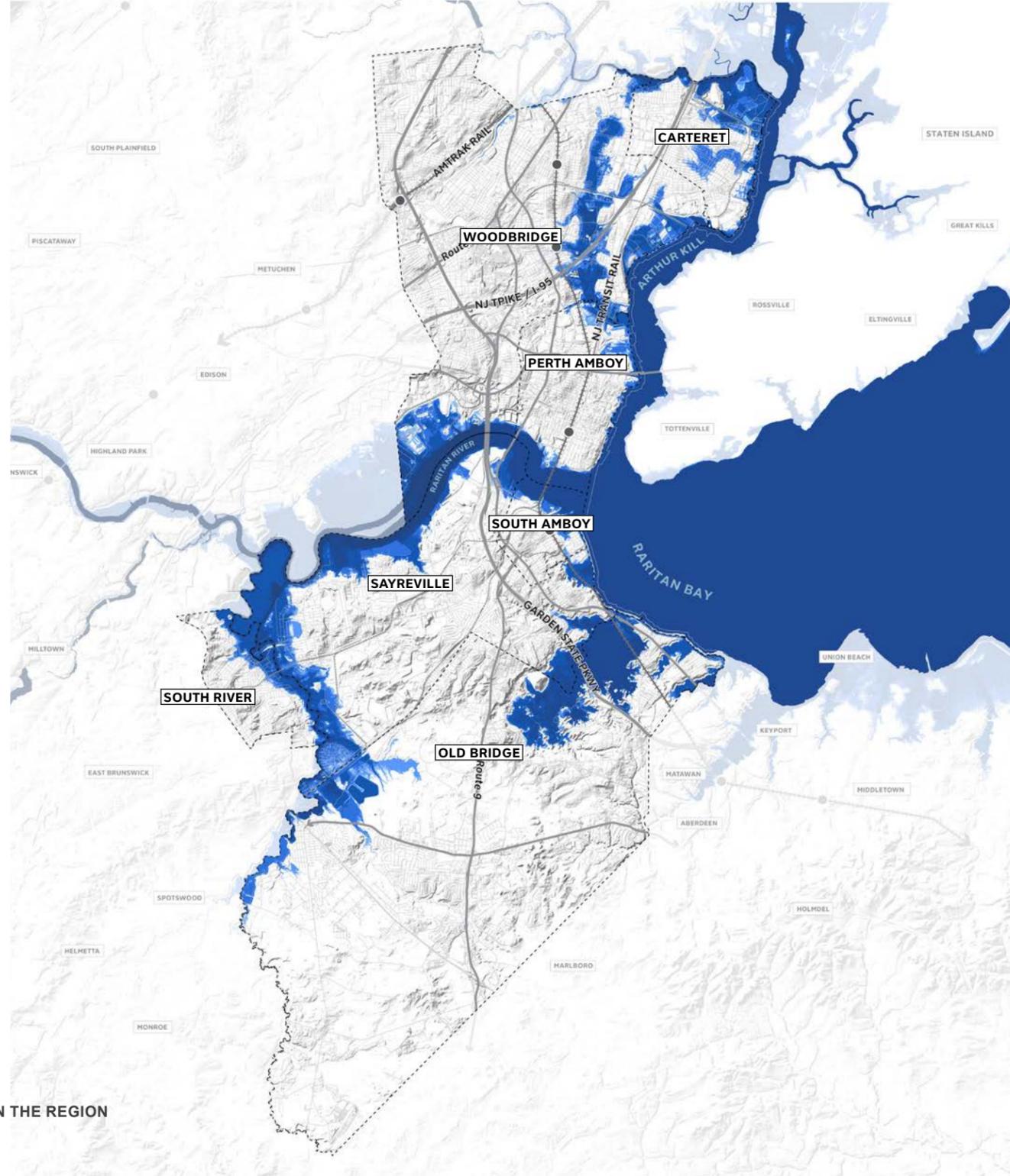
Future Coastal Storm Surge
with Sea Level Rise (2.4') - Flood
Depth (feet NAVD88)

- ≤ 2
- ≤ 5
- ≤ 10
- 10 +

Basemap

- Rail Network
- Main Roads
- Municipal Boundary

Data Source: RRBC Project Team



AREAL FLOODING

Inches of rain can fall in a few hours during the peak of a storm, causing flooding in low-lying areas. These areas might be along waterways (riverine flooding) or inland where rainfall overwhelms storm drains.

With a 10 percent increase in rainfall expected by 2070, but no change in the built environment or the number and locations of people, 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. Flash flooding could directly impact approximately 800 additional buildings and 4,000 additional residents, causing \$200 million more in losses.

LEGEND

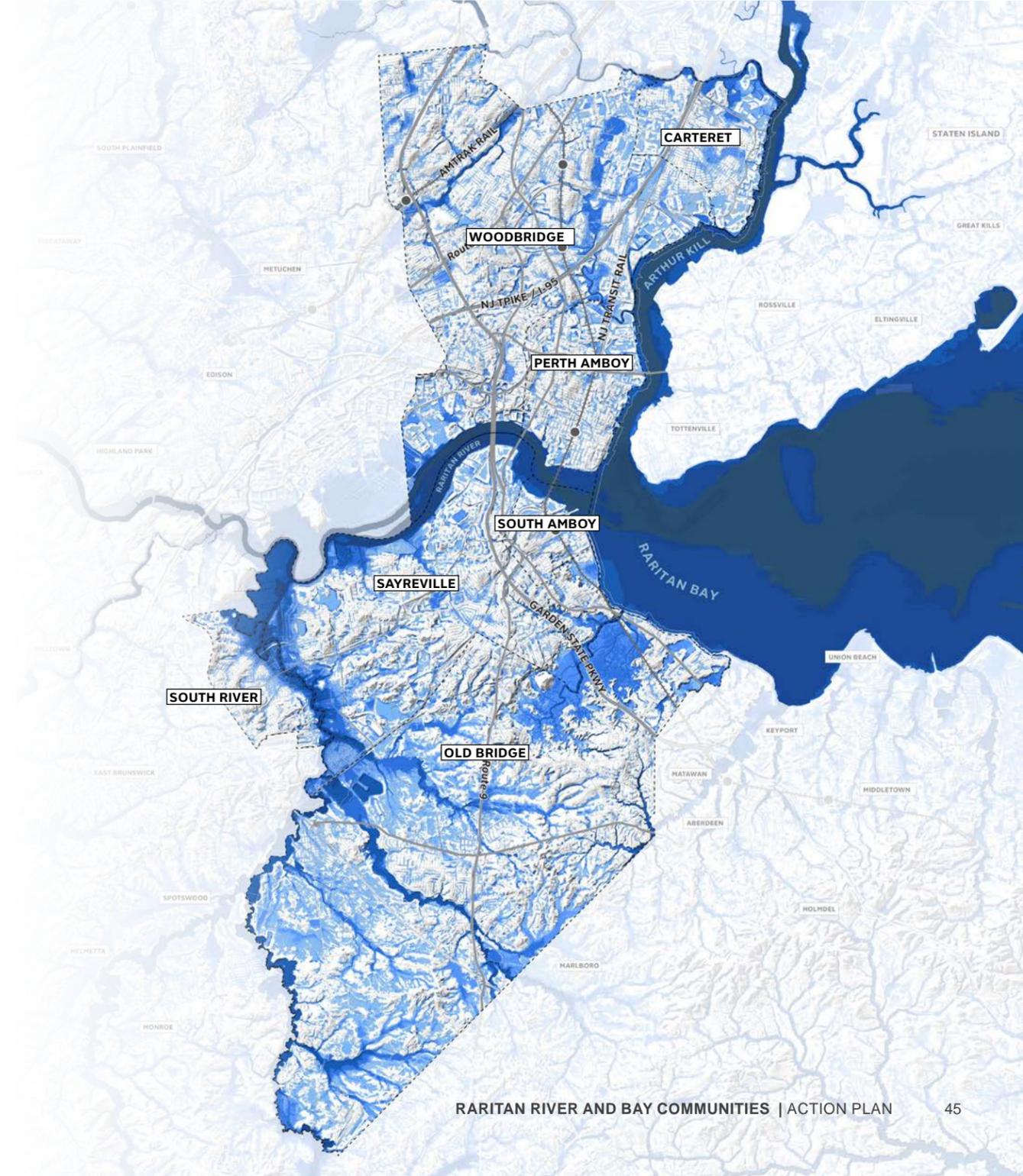
Future Areal Flooding
with 10% increase in rainfall
(flood depth in NAVD88)

- ≤ 2
- ≤ 5
- ≤ 10
- 10 +

Basemap

- Rail Network
- Main Roads
- Municipal Boundary

Data Source: RRBC Project Team



FUTURE FLOODING CARTERET, PERTH AMBOY, WOODBRIDGE

The social vulnerability analysis shows very high rates of social vulnerability in the RRBC region concentrated in Perth Amboy, Carteret, the area in South River around Main Street, and pockets of Sayreville. 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.

LEGEND

FUTURE FLOODING

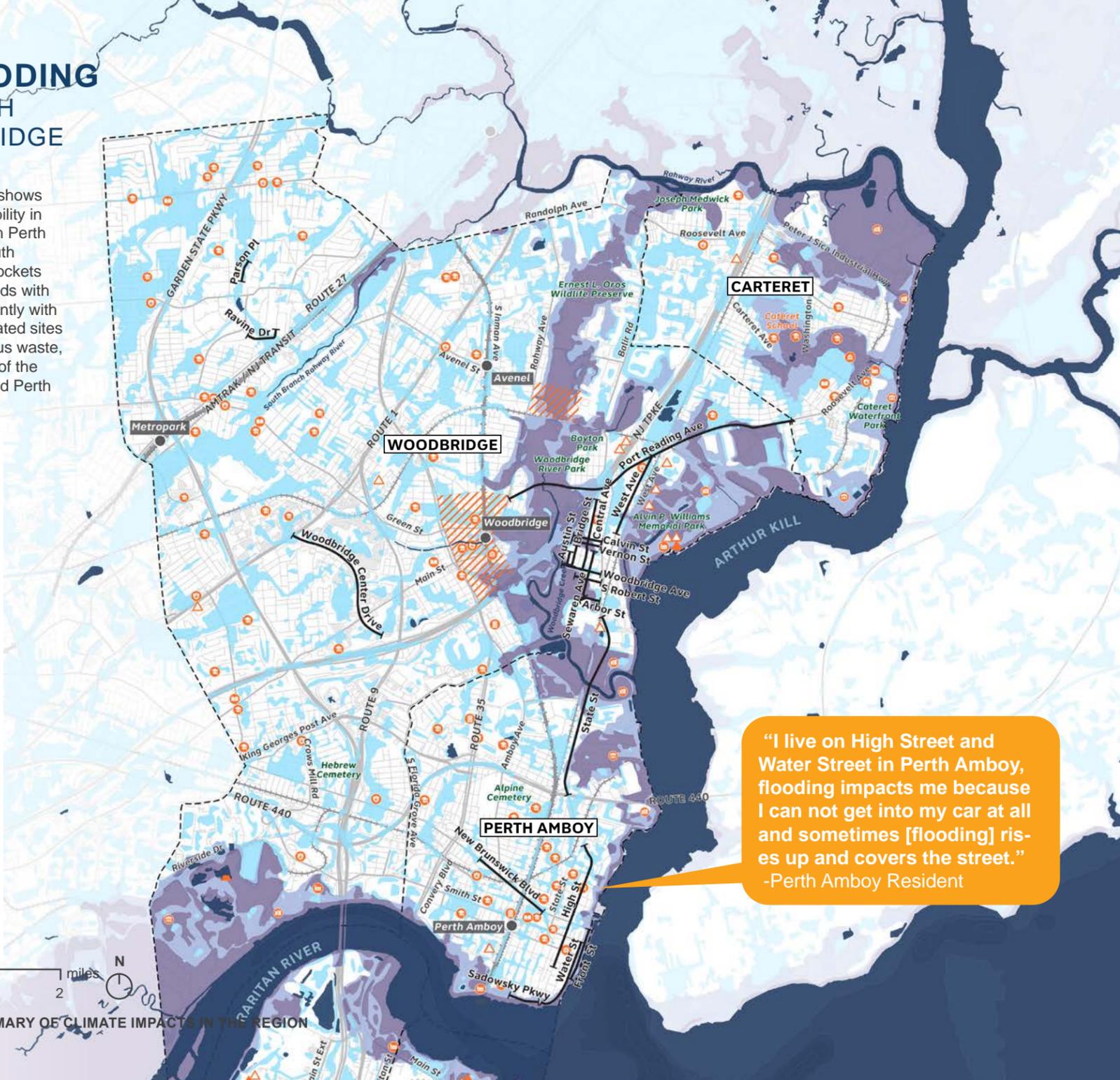
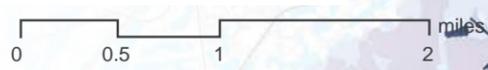
- Water bodies
- Areas flooded by both Future Coastal Storm Surge and Future Areal Flooding
- Areas flooded by Future Coastal Storm Surge
- Areas flooded by Future Areal Flooding

CRITICAL ASSETS

- Utilities & Facilities (inc. Power Generation, Wastewater Treatment, Heavy Industry, Warehousing)
- Community Assets (inc. Municipal Buildings, Nursing Homes, Schools & Colleges, Libraries, Fire Stations)
- Socially Vulnerable Communities (SVI > 0.75)

TRANSPORTATION

- Community reports of flood-prone streets
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Municipal Boundaries



“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

FUTURE FLOODING SAYREVILLE, SOUTH AMBOY, SOUTH RIVER, OLD BRIDGE

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

“Areas along Route 35 still wash out during heavy rain events.”
-Old Bridge Resident

LEGEND

FUTURE FLOODING

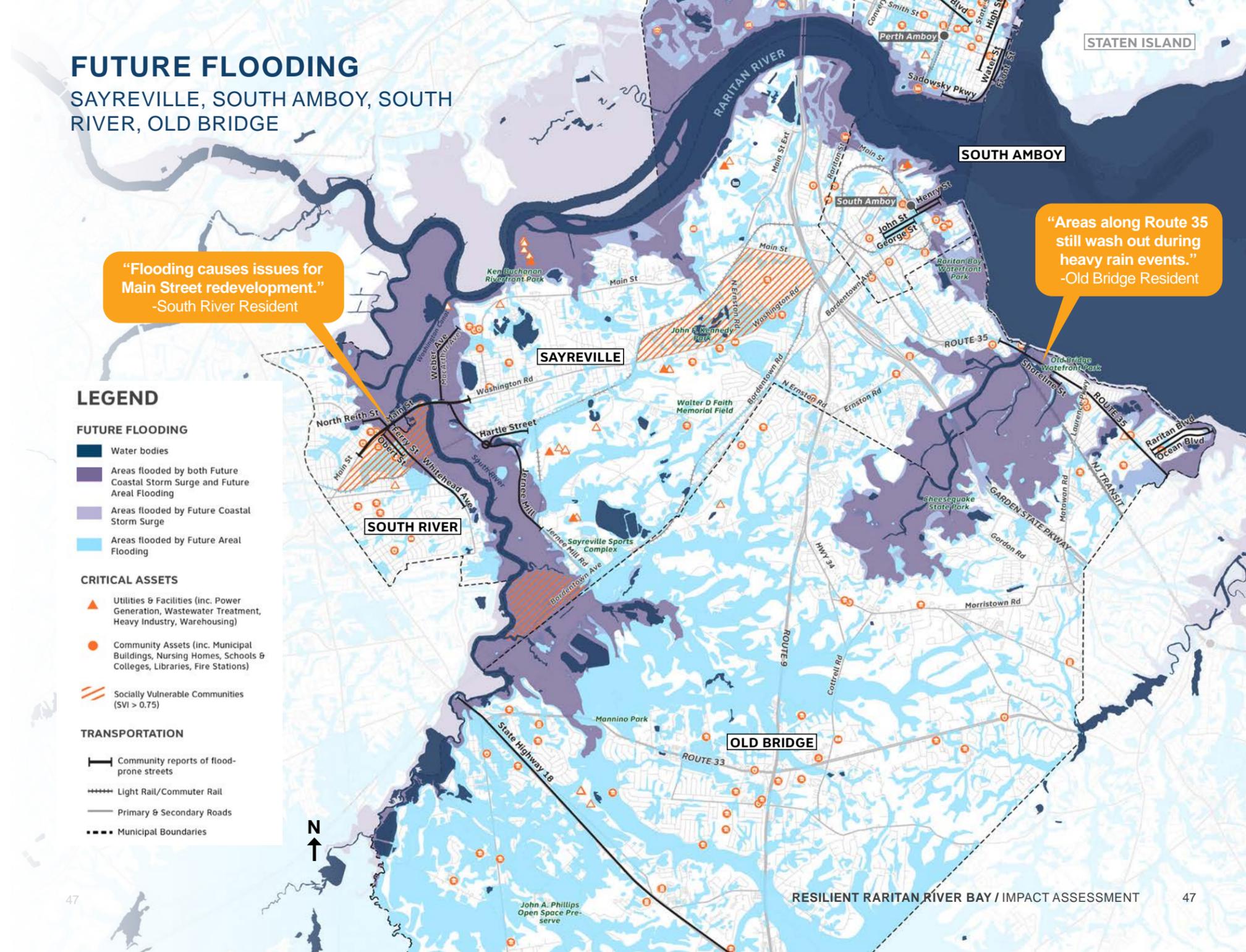
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- Socially Vulnerable Communities (SVI > 0.75)

TRANSPORTATION

- Community reports of flood-prone streets
- Light Rail/Commuter Rail
- Primary & Secondary Roads
- Municipal Boundaries



ADDITIONAL CLIMATE HAZARDS ASSESSMENT

Flooding is not the only climate hazard RRBC must worry about as increasing greenhouse gas emissions drive climate change.

This section summarizes the key findings of the Additional Climate Hazards Assessment. Additional information, including data sources and methodologies, is available in the *Additional Climate Hazards Assessment* appendix.

Increasing global temperatures, radical shifts in precipitation and weather patterns, sea level rise, and correlated groundwater table rise will interact in complex ways to threaten the region with various additional hazards. These include other (non-flooding) types of severe weather, various direct and indirect hazards posed by groundwater rise, increased drought and threats to water supply, extreme heat, worsening air quality, invasive species and vector-borne illnesses, increased risk of wildfire, and ocean acidification.

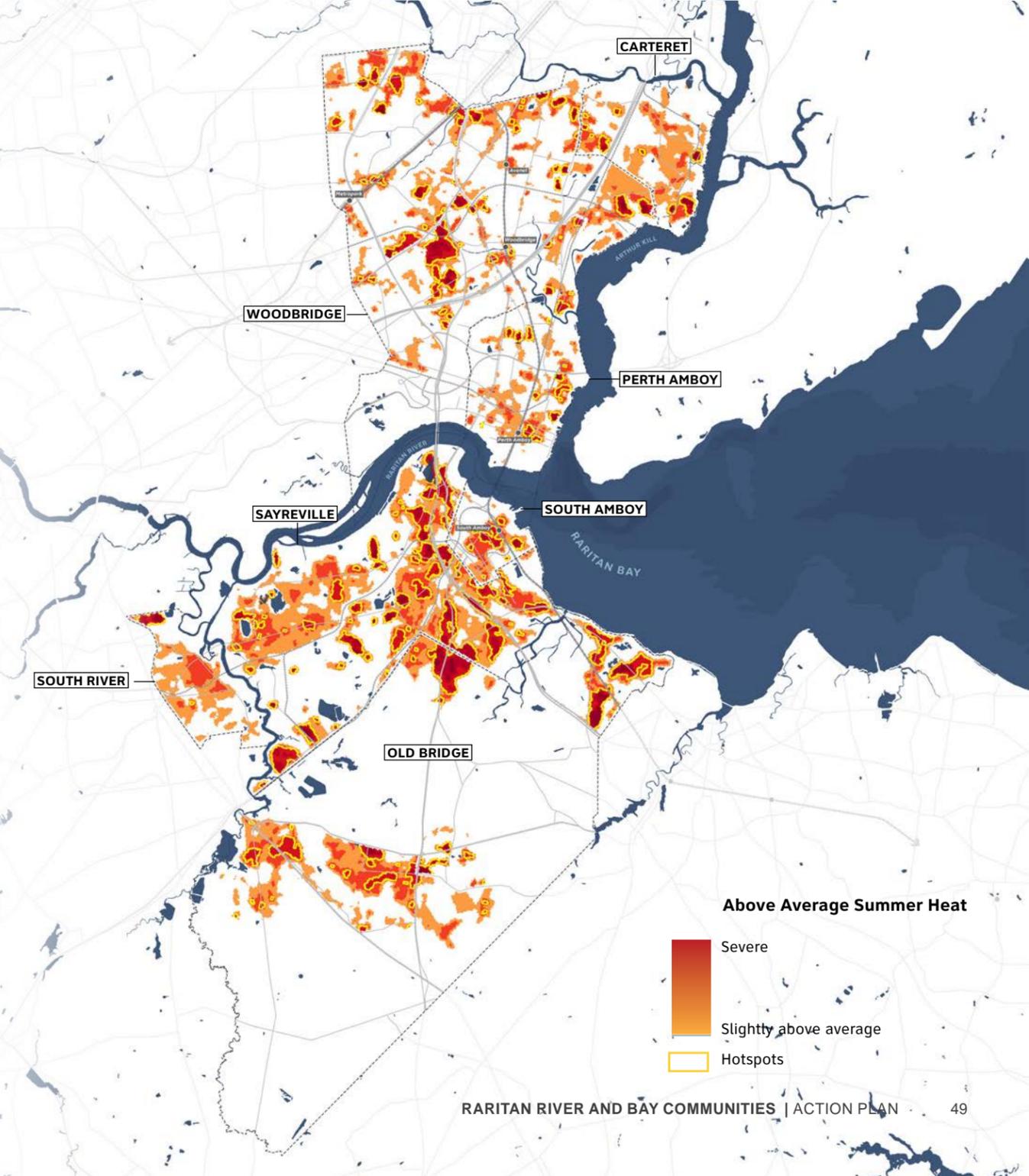
The project team conducted an additional assessment to evaluate the risks these hazards present to the region, how these risks will evolve as climate change progresses into the future, and the types of impacts to be expected to people and places—whether to public health, the provision of critical services, or the health and integrity of existing ecosystems and habitats the region's population depend on. The team relied on existing publicly available data and studies to complete this assessment. Key issues and needs identified through this assessment are detailed below. Recommended strategies to address these needs are discussed in the *Resilience Action Plan Implementation Framework* later in this report.

RISING TEMPERATURE

Rising global temperatures will have an increasingly acute localized effect on the region with serious impacts to public health. Rising temperatures will generate dangerous heat, contribute to worsening air quality, potentially disrupt critical services, threaten water supply and quality, food supply as a result of increased incidence of drought, increase the likelihood of wildfires, and increase the risk of vector-borne illnesses such as Lyme disease and West Nile Virus with longer seasonal periods. In addition, increasing temperatures can also facilitate the introduction of other invasive species with environmental impacts that could have other long-term implications and threaten the region's forests.

Localized urban heat island will be especially acute in the more heavily urbanized parts of the region, such as parts of Carteret and Perth Amboy. For example, by the end of the century, Carteret could see a nearly 300% increase in annual days with heat index equal to or greater than 90°F (compared with the 1971-2000 historical average)—an average of more than 90 days per year.

Projected higher temperatures and increased frequency of drought are likely to increase the length of the wildfire season in the region in the future—particularly in the area around Cheesequake State Park in Old Bridge. In addition to potential loss of life as well as the destruction of forests, brush, grasslands, field crops, public and private property, and damage to critical facilities, wildfire smoke can have additional implications for air quality.



SOCIAL VULNERABILITY

Some of the most socially vulnerable communities in the state—and in some cases, the country—reside in Perth Amboy and Carteret. They live in areas of extremely high urban heat, pollution, and proximity to hazardous waste.

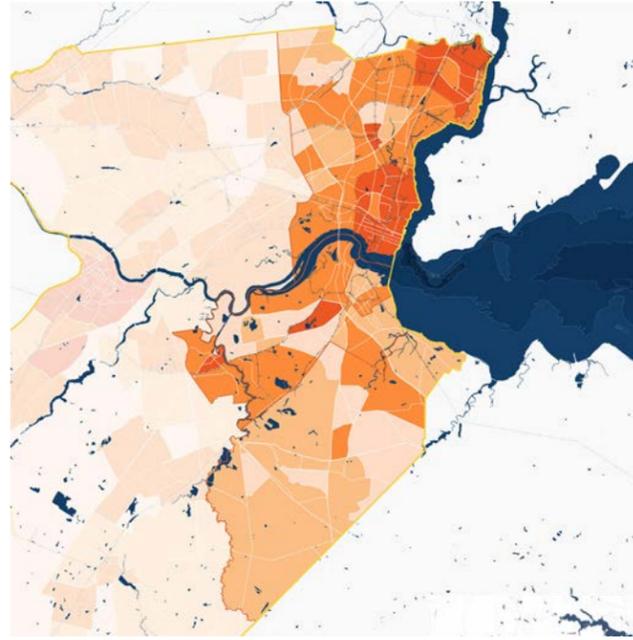
The CDC Social Vulnerability Index (SVI) scores aggregates a variety of factors gathered from US Census data including socio-economics, housing composition and disability, minority status and language, and housing type and transportation access

LEGEND

Social Vulnerability Index by Census Tract

- ≤0.25 (Lower Vulnerability)
- ≤0.5
- ≤0.75
- ≤1.00 (High Vulnerability)

Data Source: Centers for Disease Control and Prevention/ Agency for Toxic Substances and Disease Registry Social Vulnerability Index (2018)



AIR QUALITY

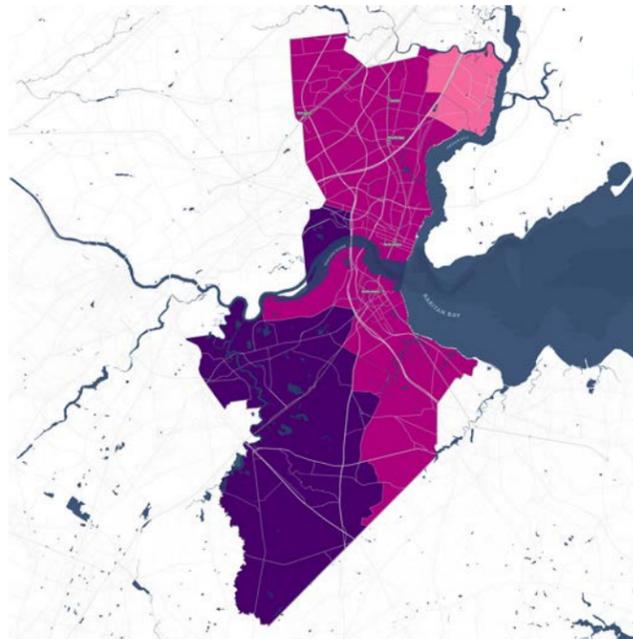
The two major sources of climate change-related air pollution—ground-level ozone (haze or smog) and PM2.5 (particulate matter, or aerosols)—are already a serious problem in the region, likely the cause of widespread “invisible” health effects, especially for the elderly and people with pre-existing health conditions, such as asthma. Compared to the rest of the state, the region has extremely high ambient ozone concentrations, especially in the southernmost parts of the region. Nearly the entire region is currently at the highest level of risk (90th to 99th percentile) for cancer due to air toxics, compared to the rest of the state.

LEGEND

Ambient Ozone Concentrations

- 40-60th percentile
- 60-80th percentile
- 80-100th percentile

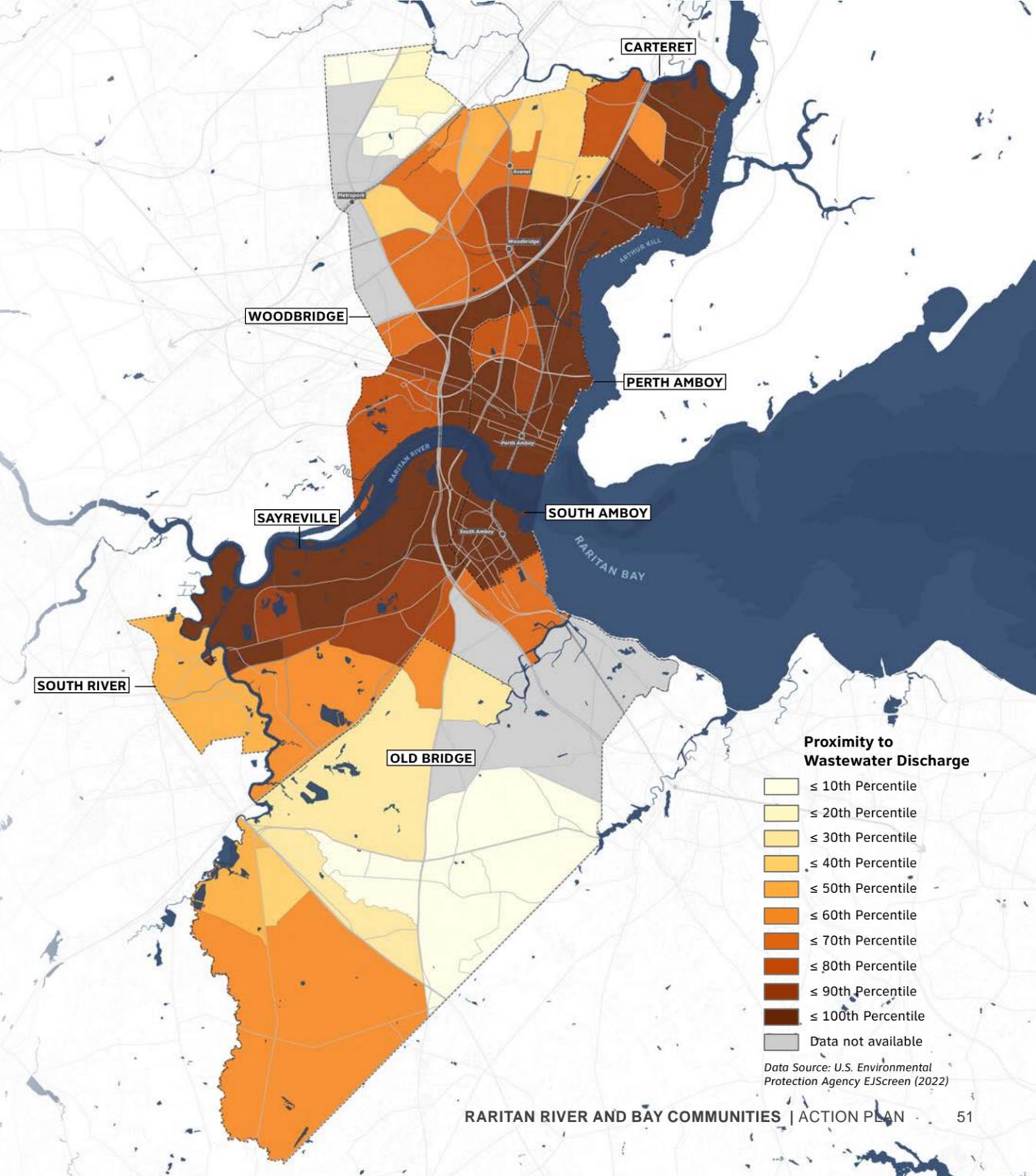
Data Source: U.S. Environmental Protection Agency EJScreen (2022)



WATER QUALITY

Throughout the Northeast U.S., it is anticipated that droughts lasting 3-6 months or longer will significantly increase in frequency under a “business-as-usual” high greenhouse gas emissions scenario and increase slightly in a low emissions scenario. RRBC, being primarily within the Raritan water region, draws its water supply from a mix of surface and unconfined groundwater sources. Municipalities relying more on surface water will feel the impacts of drought more immediately. In the future, the region may turn increasingly toward groundwater for its water supply as surface water sources struggle to maintain necessary capacity. This could lead to higher rates of groundwater pumping with implications for water quality. High concentrations of hazardous materials and wastewater discharge throughout the region can pose a serious risk to public health and safety as groundwater levels rise proportional to sea level rise. Contamination of groundwater aquifers could compromise existing sources of drinking water and limit the ability of other aquifers to serve as supplementary water supply sources in cases of prolonged drought. Remobilized contaminants can lead to contaminant plume spread and decrease water quality at partially remediated sites where contaminant levels in water had previously been improving.

In areas with low depth-to-groundwater, tidal and rainfall conditions combined with sea level rise can lead to risk of groundwater emergence and flooding of basements and underground infrastructure, parks, open spaces, and even streets. If the affected groundwater source is contaminated, this poses an additional risk of sustained exposure to toxic water.



Proximity to Wastewater Discharge

- ≤ 10th Percentile
- ≤ 20th Percentile
- ≤ 30th Percentile
- ≤ 40th Percentile
- ≤ 50th Percentile
- ≤ 60th Percentile
- ≤ 70th Percentile
- ≤ 80th Percentile
- ≤ 90th Percentile
- ≤ 100th Percentile
- Data not available

Data Source: U.S. Environmental Protection Agency EJScreen (2022)

CLIMATE HAZARD IMPACTS ON FISHERIES

As the ocean becoming more acidic threatens marine life along the coast, RRBC could experience ecological impacts to its estuarine habitats as well as potential longer-term economic stresses. Although the majority of economic impacts affecting commercial fishing-dependent communities will be concentrated in southern New Jersey, much of coastal Middlesex County is still likely to experience impacts of medium economic severity. Coastal waters in the region could start becoming unfavorable to shellfish by the end of the century.



CHEESEQUAKE STATE PARK, OLD BRIDGE

Image Credit: Ungvar Via Adobe

CRITICAL ISSUES

Through the *Flood Impact Assessment*, *Additional Climate Hazards Assessment*, and community engagement efforts described, a number of critical issues, problems, needs, and opportunities related to multiple climate hazards were identified in RRBC. These include:

- Widespread, current flood risk due to both coastal and rainfall events
- Increasing temperatures, urban heat island effects, and related health impacts
- Poor and worsening air quality
- Need for flood mitigation and resilience building resources for private property owners
- Need to incorporate resilience considerations into redevelopment policies and standards
- Need for increased capacity to address resilience issues at the local, county and state level
- Opportunity for continued coordination
- Opportunity to incorporate natural and nature-based strategies
- Aging drainage and coastal infrastructure not designed to manage the severity of heavy rainstorms the region has been experiencing recently, which will grow more frequent with climate change

The scenario development process and evaluation to determine the preferred scenario, as described in the following section, are guided by the region's vision for the future and the desire to begin addressing these critical issues through this *Action Plan*.