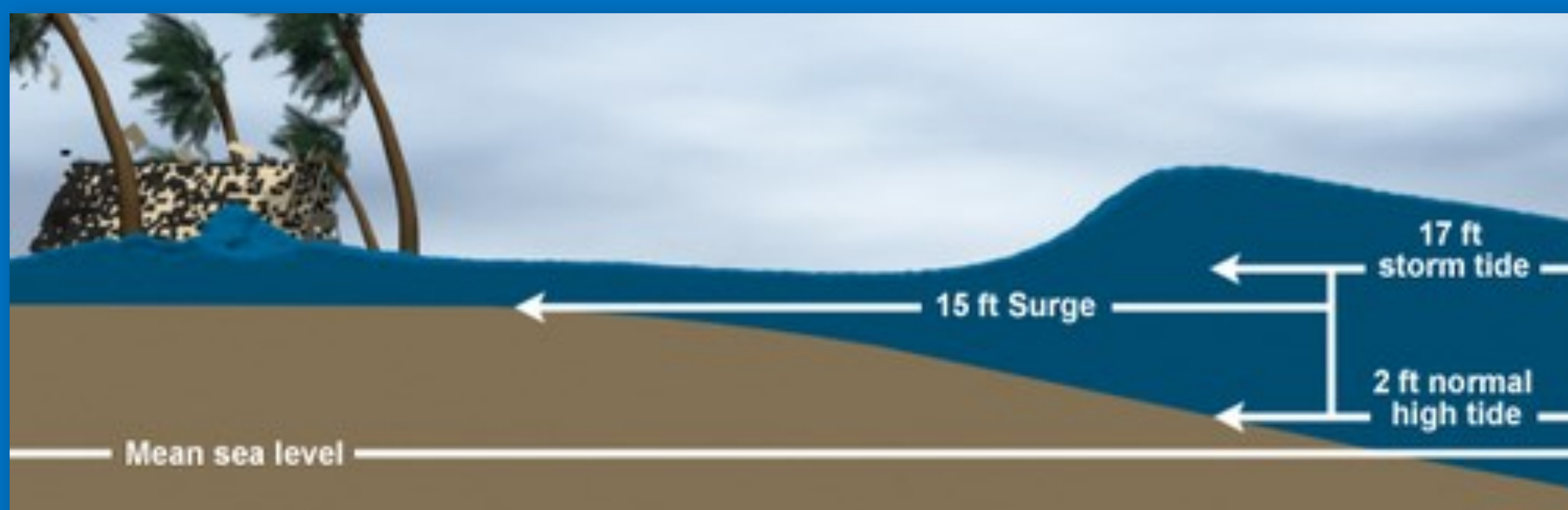
Climate Change in Chelsea: Sea Level Rise

Sea Level has risen 11 inches since 1890 in Boston Harbor.

The oceans are absorbing more than 90% of the increased atmospheric heat associated with greenhouse gas emissions from human activity. Sea Level Rise is caused mostly global warming temperatures. Warmer temperatures are melting glaciers and ice-sheets adding more water to the ocean and warmer temperatures are causing oceans to take up more space (since water expands as it warms).



Coastal Storms cause greater flooding with storm surge.

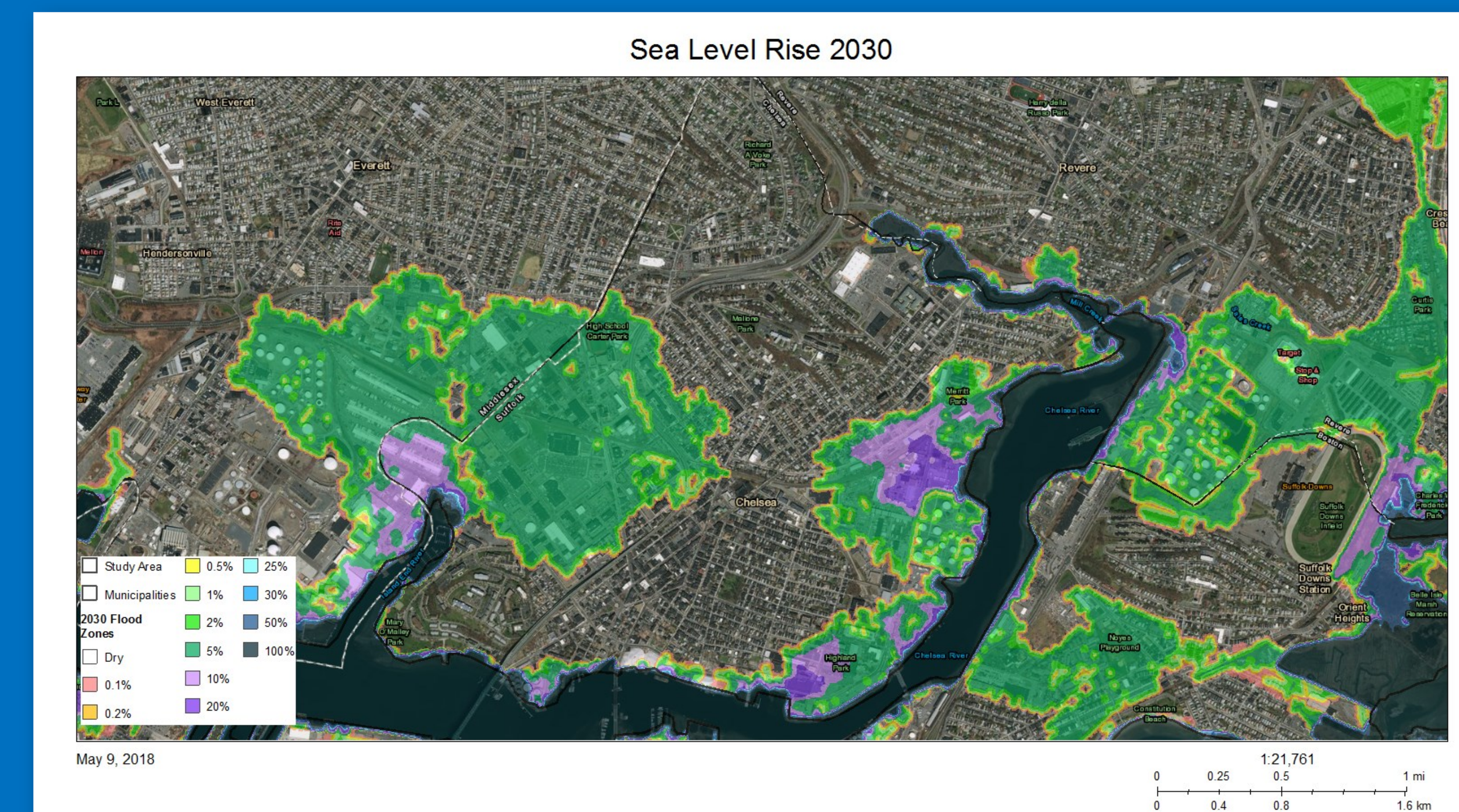
Chelsea is surrounded by four coastal rivers. The Mystic, Island End, Chelsea Creek and Mill Creek. Because it is low-lying at the shoreline, there is an even greater risk to flooding with coastal storms combined with sea level rise.

Sea level could rise another 8 in. in just 12 years and 7 ft. by 2100.

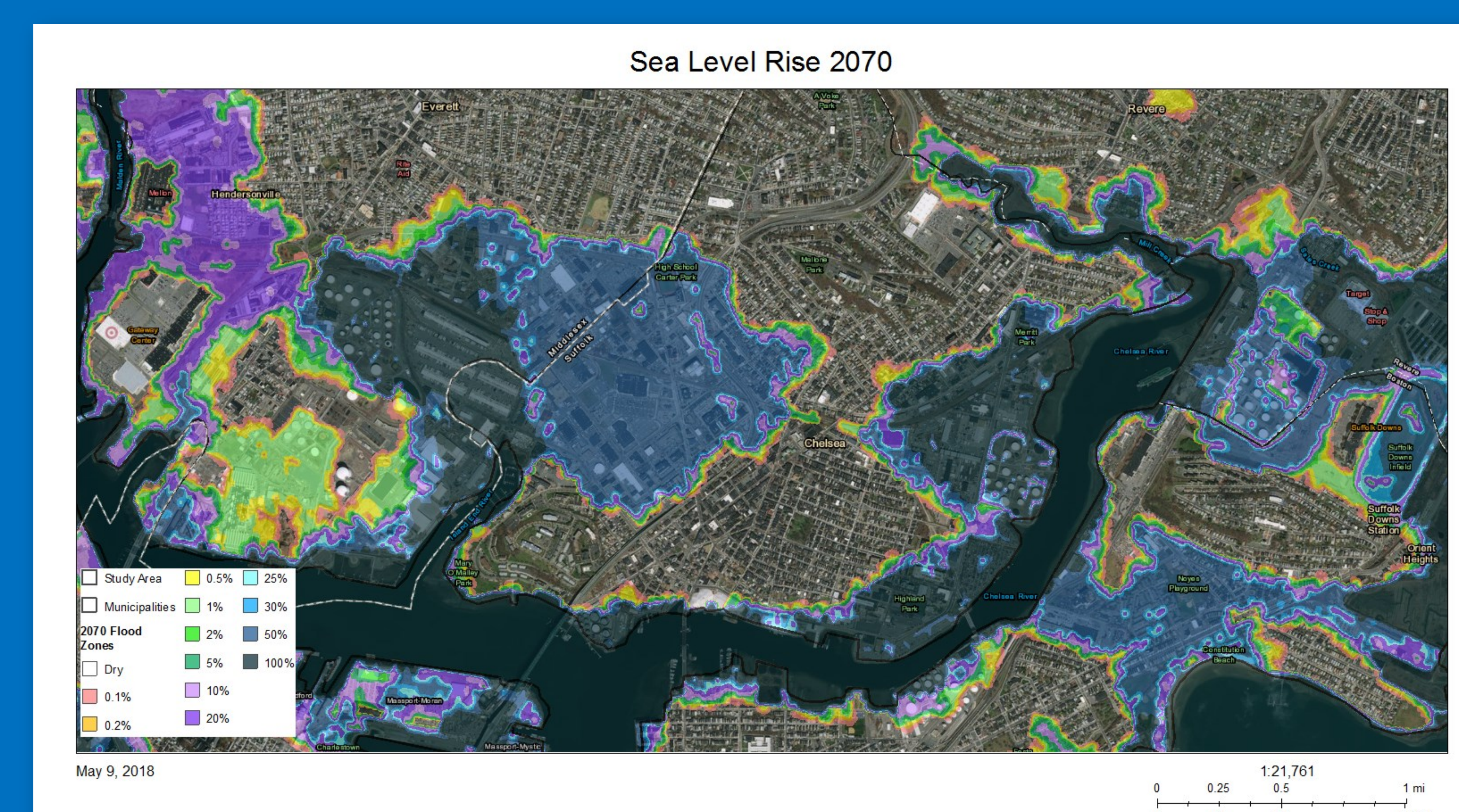
Scientists have created models that anticipate sea level rise based upon greenhouse gas emission trends, topography, tides, storms, rivers, and winds. The Boston Harbor Flood Risk Model (BH_FRM) is one of the most detailed models of coastal flooding. The Boston Tide Gauge Model was completed by UMass Amherst but does not account for glacial melting.

SLR Model	2030	2050	2070	2100
Boston BH_FRM [1]	8.00 in	1.50 ft.	3.10 ft.	7.40 ft.
Boston Tide Gauge [3]	0.4-0.9 ft	0.8-1.5 ft.	1.3-2.4	2.0-4.0

Chelsea is surrounded by four rivers and is low-lying along the shoreline. This map shows the probability of coastal flooding in 2030 using the BH_FRM. The greatest extent of coastal flooding in the map below could occur 2% of the time in any given year in the 2030 time frame.



By 2070, the geographic extent of flooding does not increase, but the depth and probability of flooding does increase. This map shows that the areas of flooding that had a 2% chance of flooding in any given year increases to 50-100% chance of flooding toward the end of the century.

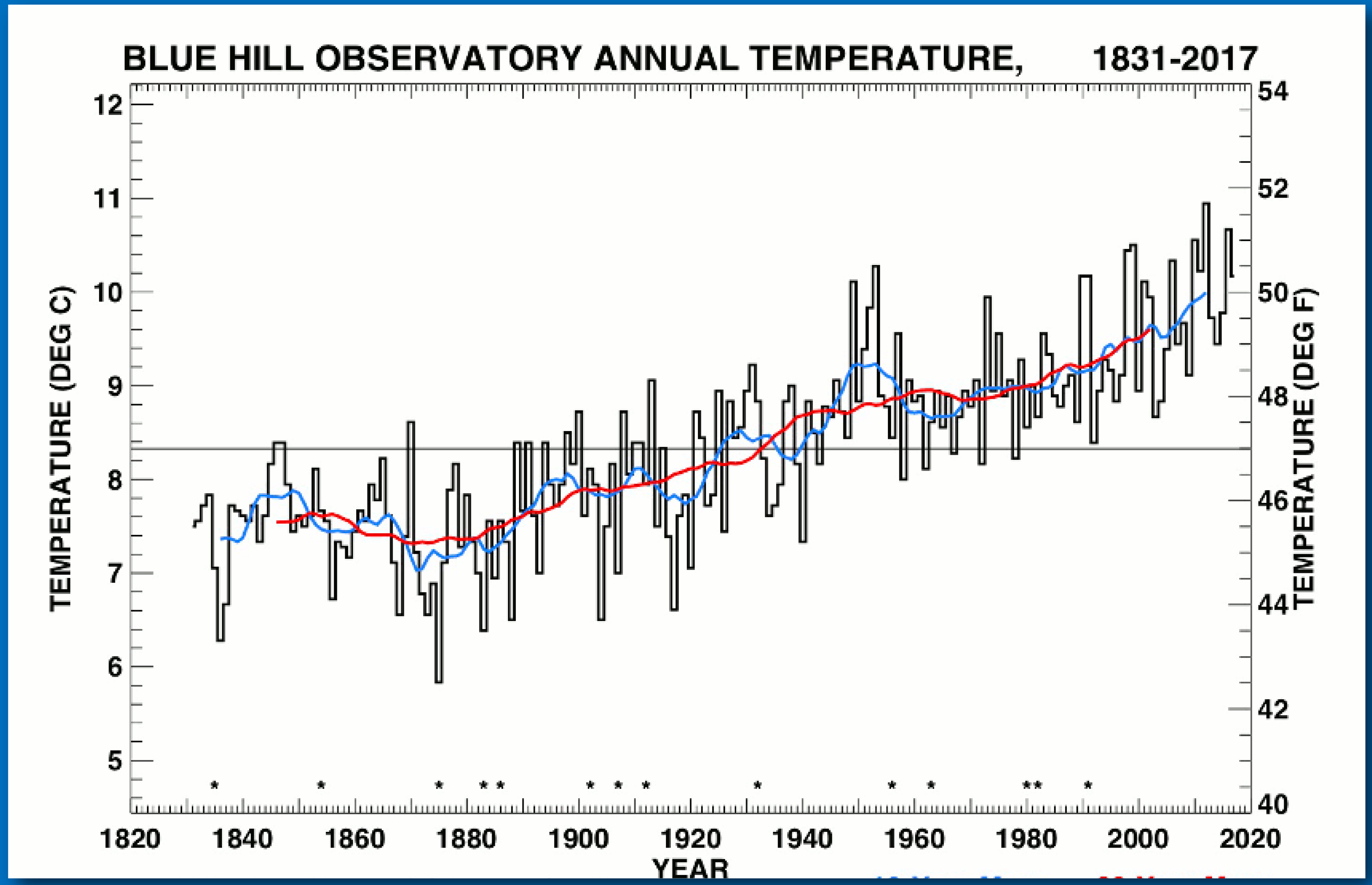


Designing Coastal Community Infrastructure for Climate Change. Stantec and Woods Hole Group, January 2017

Climate Change in Chelsea: Extreme Heat

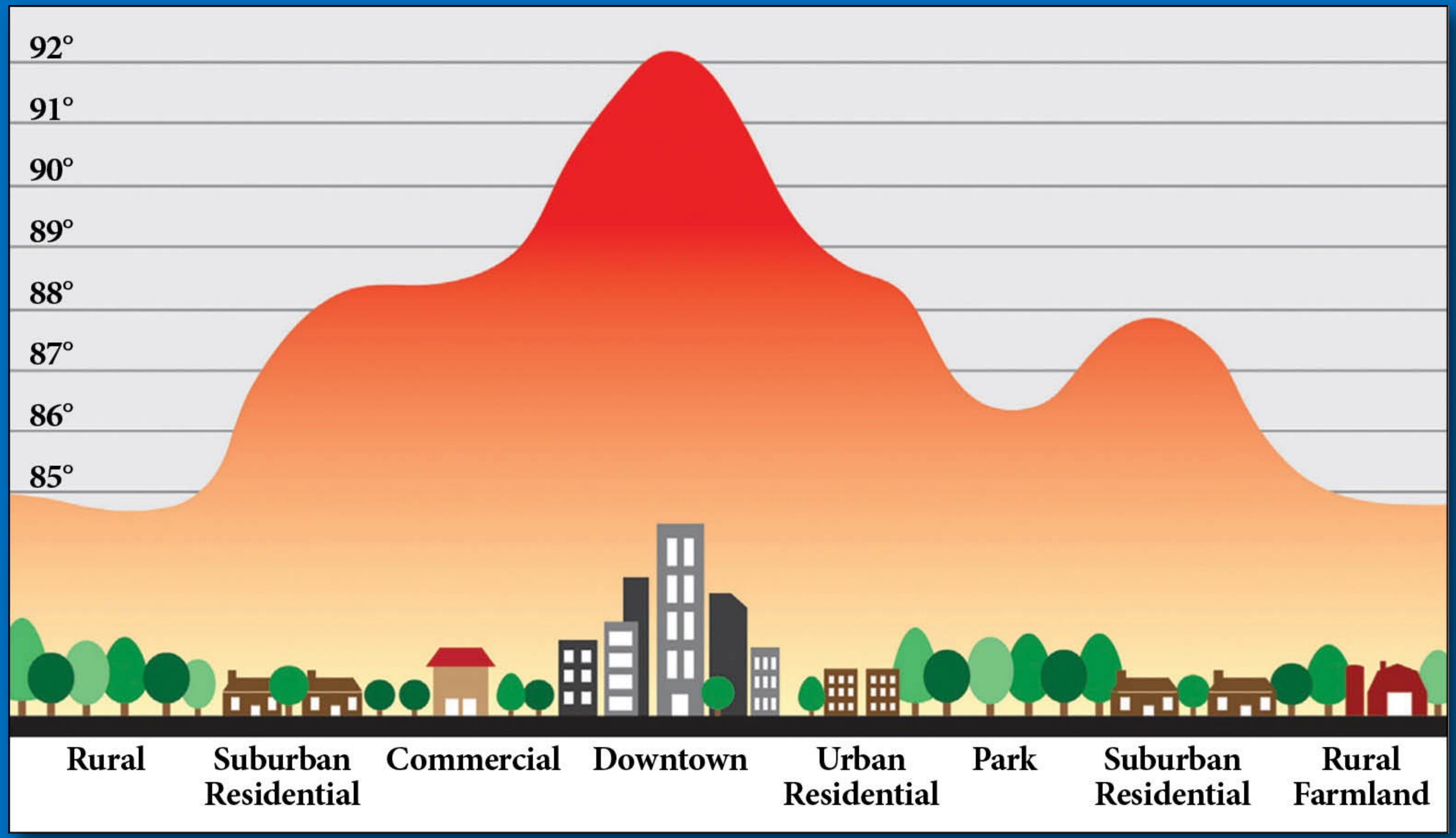
Global Temperatures have risen nearly 2° over the last century.

2016 was the warmest year on record and the worst drought in MA since the 1960s. 2015 was the second warmest and 2017 was the third warmest year. Even a small increase in temperature has a major impact on glacial melting and changing weather patterns. For example, since 1980, the Northeast US has increased its growing season by 10 days.



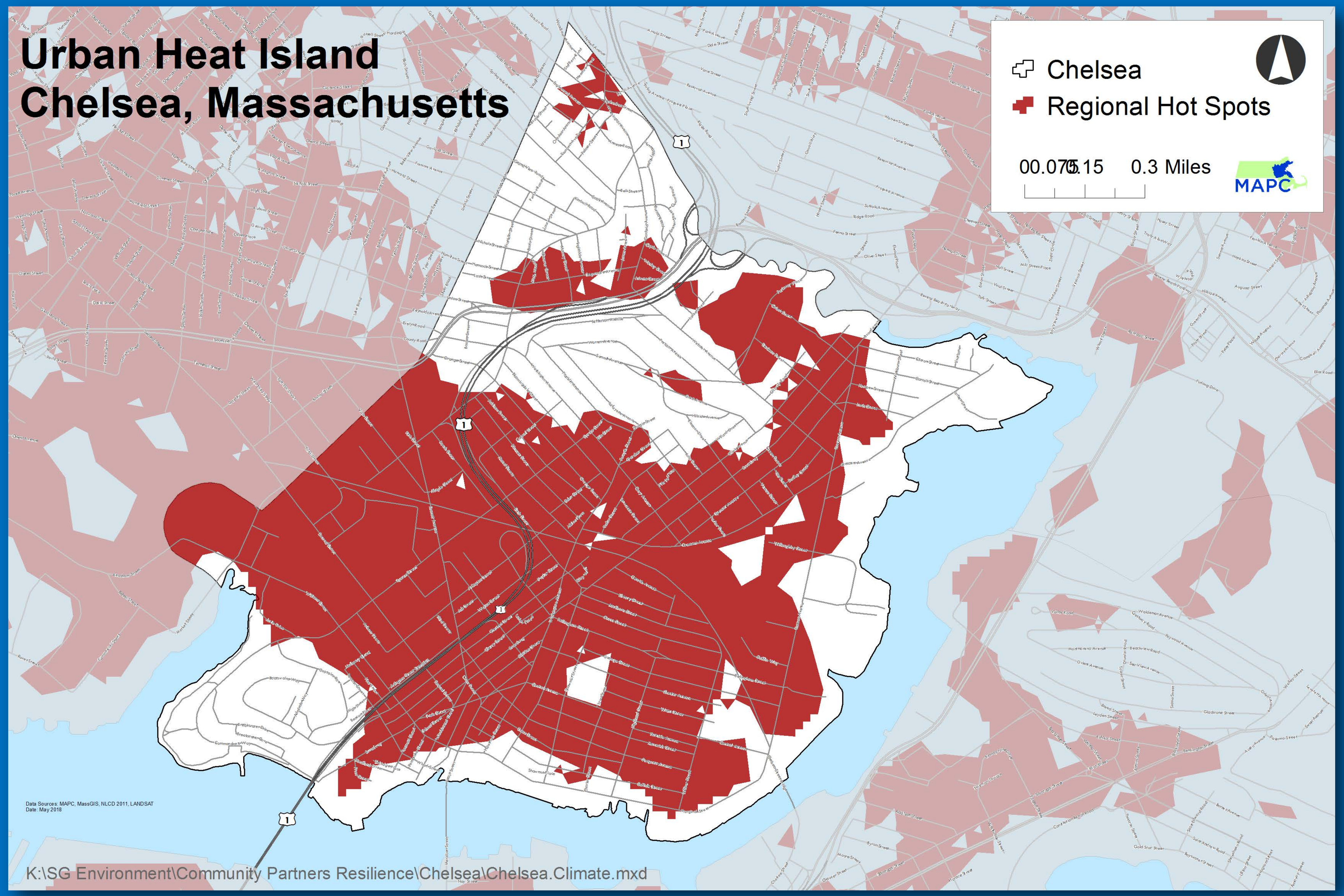
Chelsea could have 40-90 days with temperatures above 90° by 2100.

If so, our climate in Massachusetts will shift toward a climate more like Georgia or Alabama by the end of the century. This extreme heat will have a greater impact on Chelsea which has extensive asphalt and buildings. These surfaces capture and hold heat creating hotter days than areas with more trees and natural vegetation.



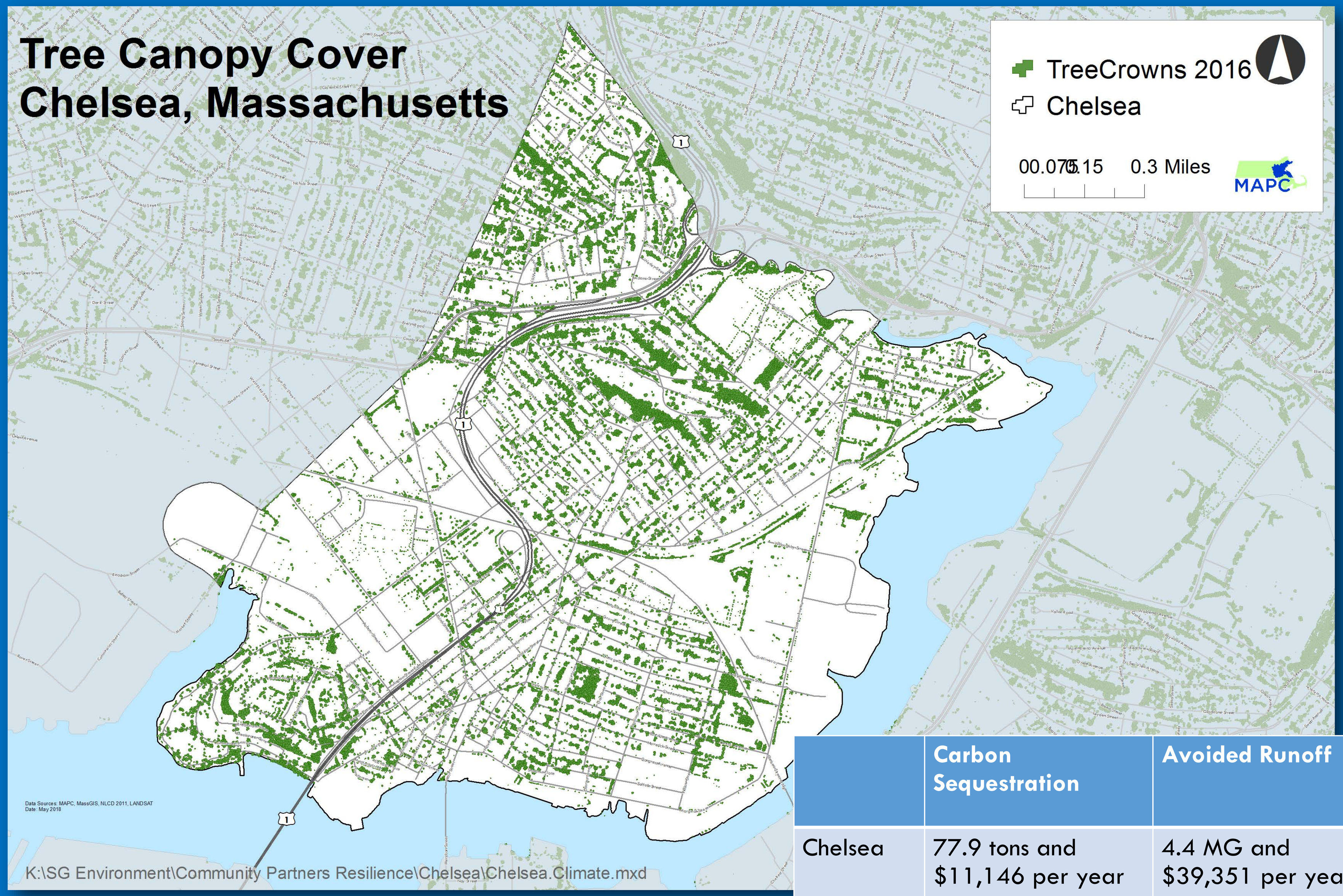
Chelsea is already at very high risk to the urban heat island effect.

More than 50% of Chelsea is an urban heat island. The areas in red in the map below indicate not only Chelsea's hottest areas but also the top 5% warmest areas in Metro Boston.



Chelsea has trees that improve heat, air quality, stormwater, and health.

Trees and vegetation cool temperatures by 20-45°F in comparison to unshaded/ developed areas by providing shade and through evapotranspiration. Trees also capture carbon, stormwater runoff, and air pollutants from vehicles. This map illustrates Chelsea's trees. Chelsea is already planting more trees but more are needed for greater benefits and public health.

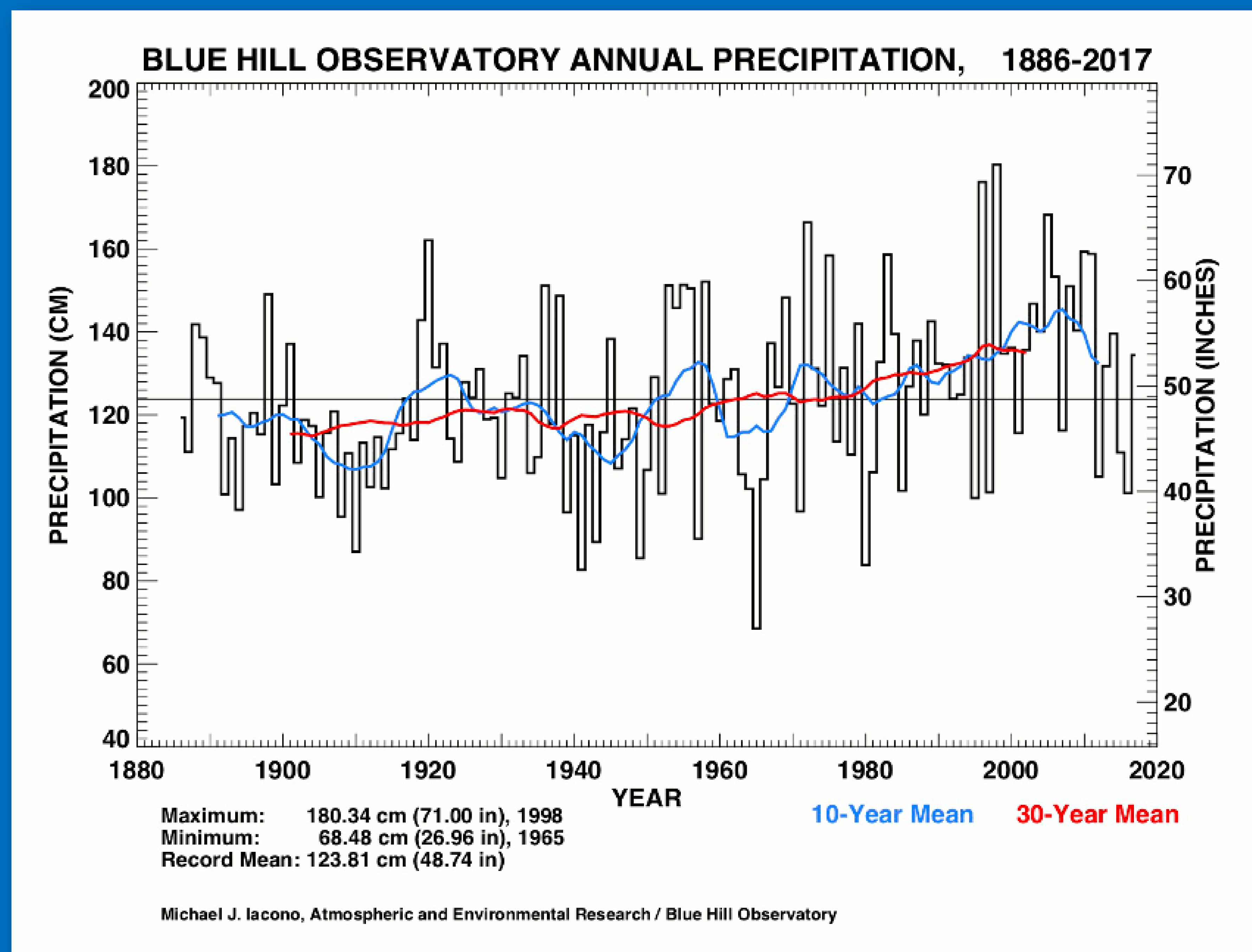


	Carbon Sequestration	Avoided Runoff	Air Pollutant Mitigation
Chelsea	77.9 tons and $11,146 per year	4.4 MG and $39,351 per year	4,470 lbs and $82,659 per year

Climate Change in Chelsea: Precipitation

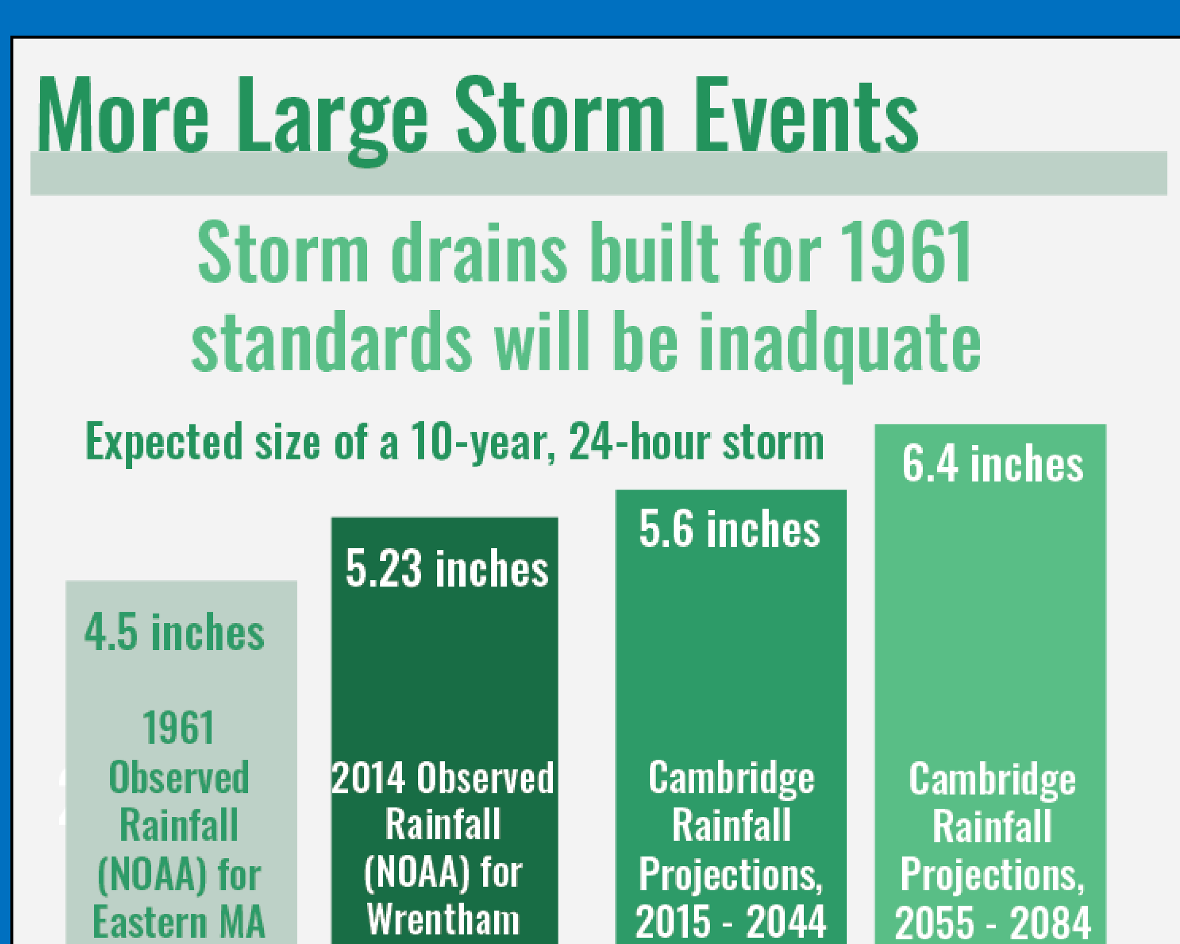
There has been a 10% increase in precipitation in Boston area since 1970.

In the last 50 years, precipitation in the Northeast US increased 71% in the amount of rain that falls in the top 1% of storm events.



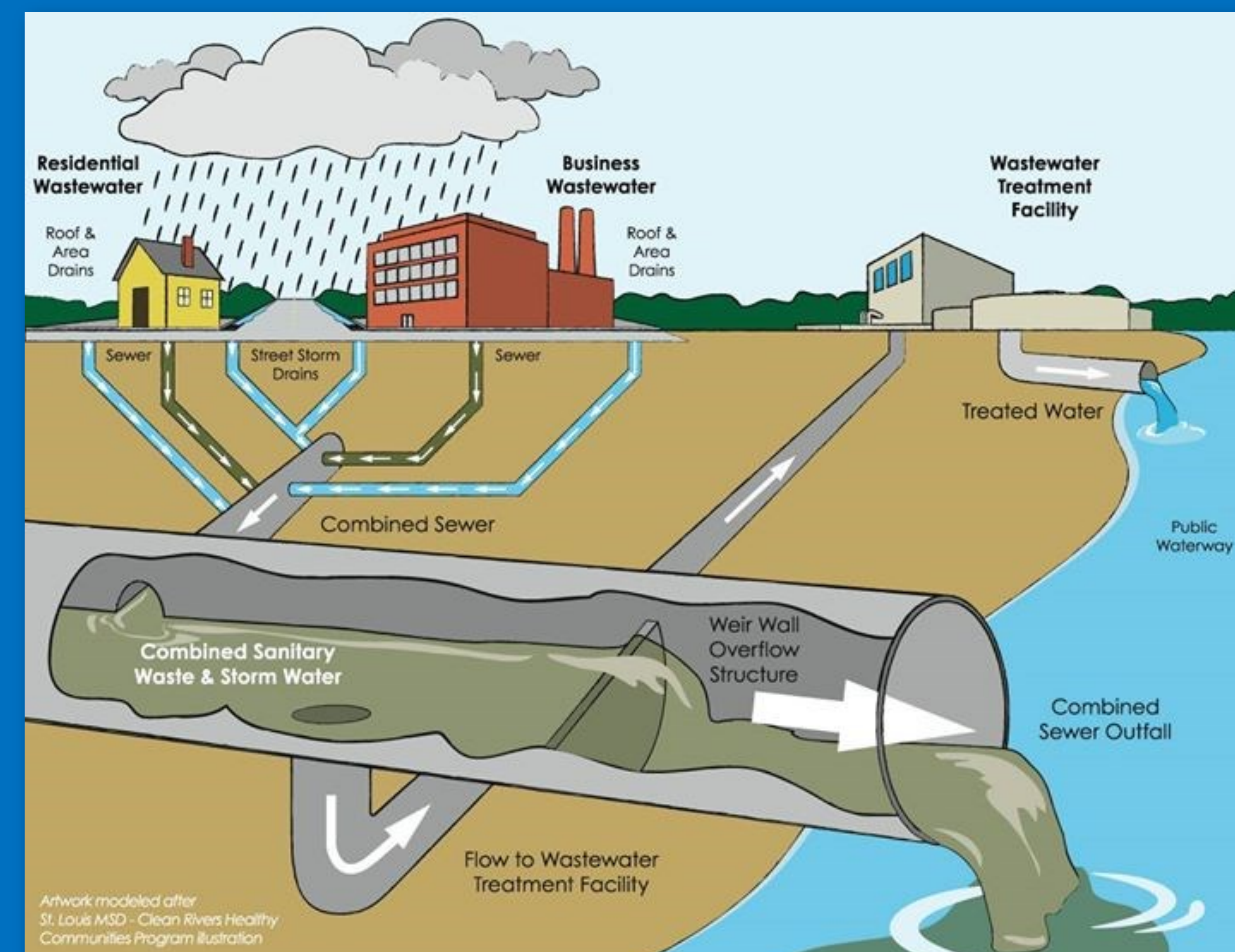
Chelsea could have 10 days of storms with >1" of rain by 2100.

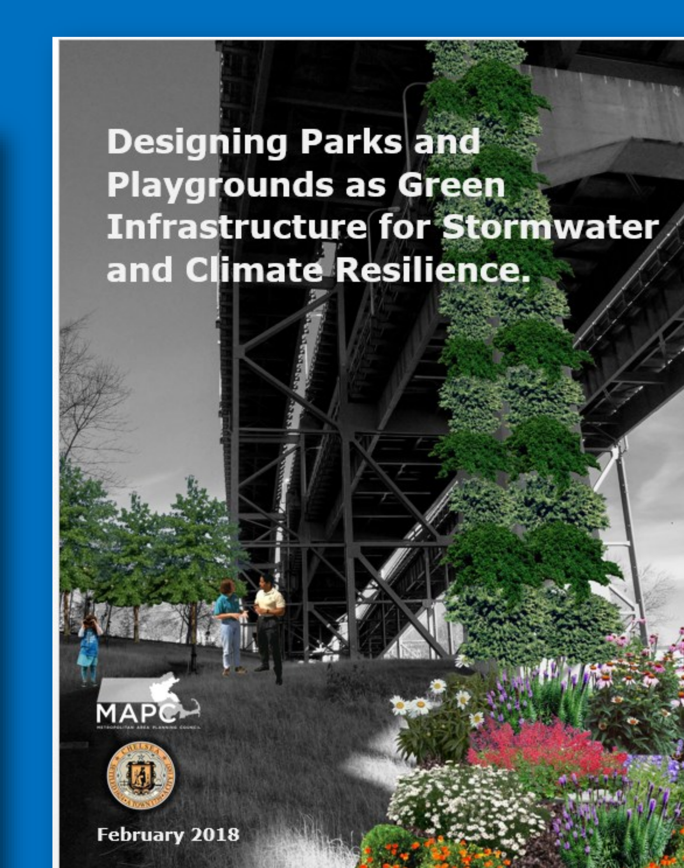
Projections for future precipitation suggest an increase in total precipitation, changes in precipitation patterns, and increased frequency of extreme storms such as hurricanes and nor'easters. For example, a 10-year storm today can produce 5 inches of rain. That same storm could produce over 6 inches by the end of the century. Most of the increased precipitation will occur during the winter but warmer temperatures could also lead to increased drought.



More precipitation will risk Chelsea's rivers, recreation, and public health.

Chelsea is serviced by a combined sewer designed to collect both wastewater and stormwater. Most, 70%, of its wastewater is transported to Deer Island Waste Water Treatment Plant. During periods of intense precipitation, the capacity of the combined sewer is exceeded and stormwater then flows into a combined system overflow (CSO) which directly empties into nearby waterbodies. This stormwater is untreated carrying not only stormwater with pollutants from impervious services but also potentially untreated wastewater and debris. Chelsea is working to upgrade and separate its system, but bringing water back into the ground before entering the system will enhance Chelsea's resilience and its rivers.





Climate Change in Chelsea: People

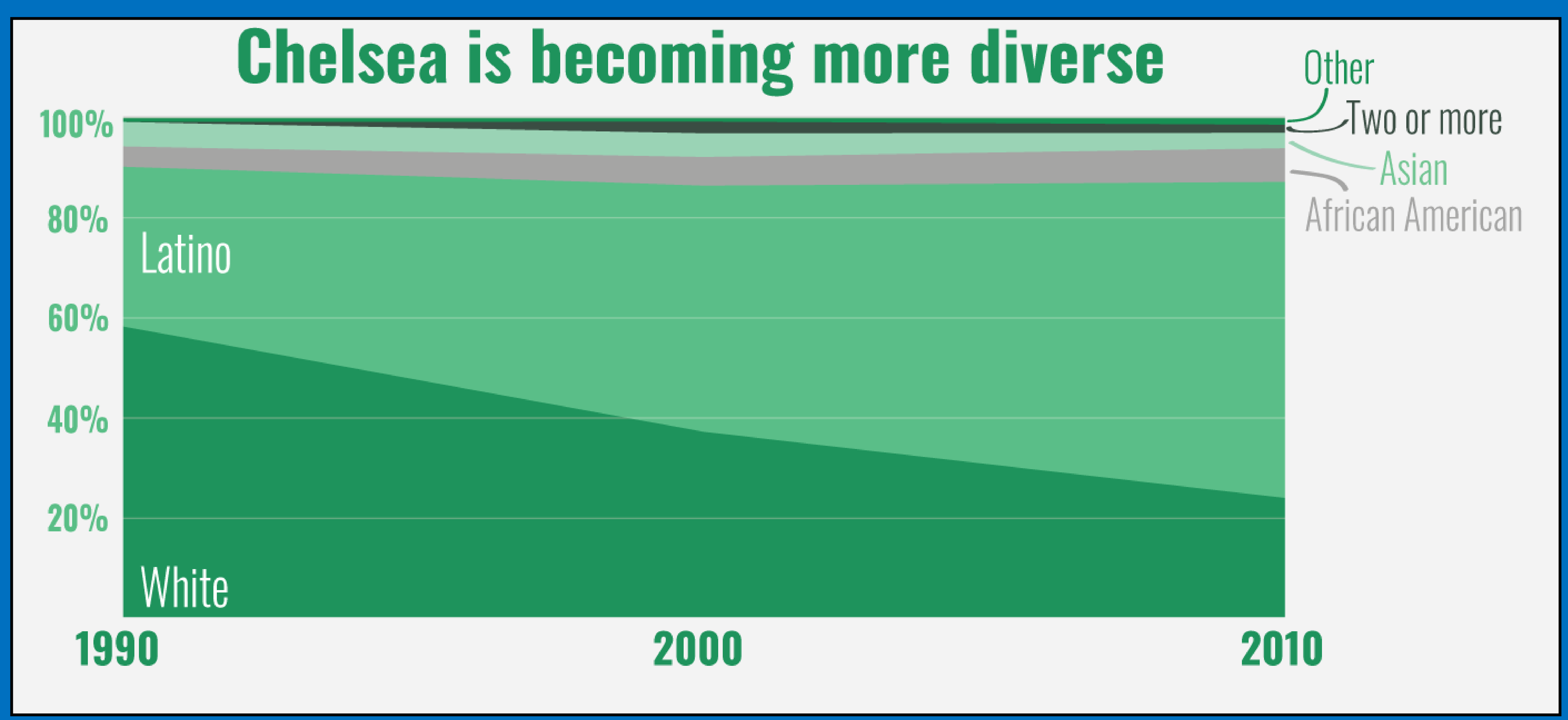
Who is most at risk from climate change impacts?

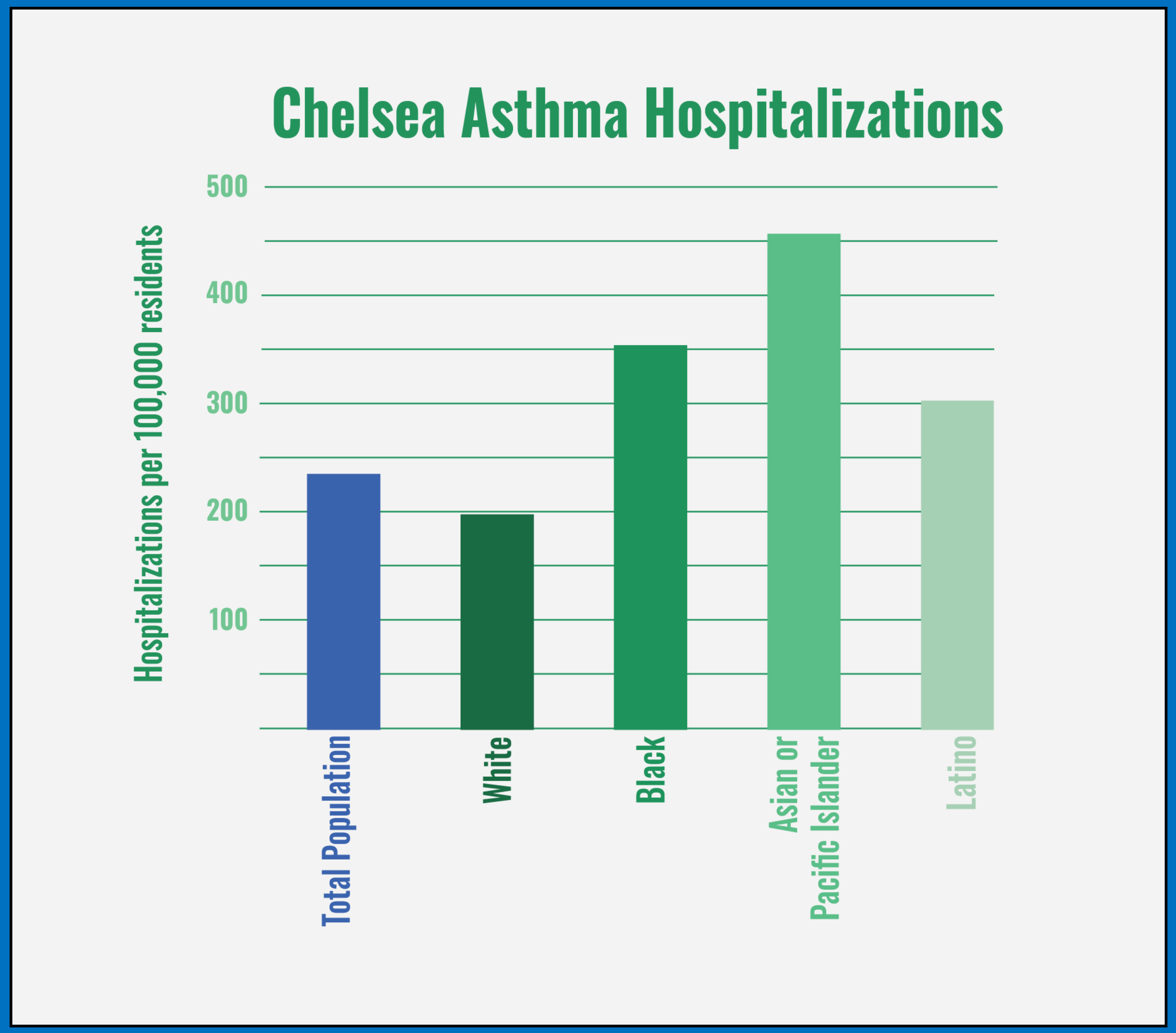
Social vulnerability refers to social, economic, demographic, or health factors that may make some people less able to adapt to or recover from climate change impacts or extreme weather events. Climate resilience strategies should prioritize first helping those at greatest risk.

63% ± 5% Households in Chelsea that are low-income

19% ± 2.5% Households in Chelsea that are below poverty level

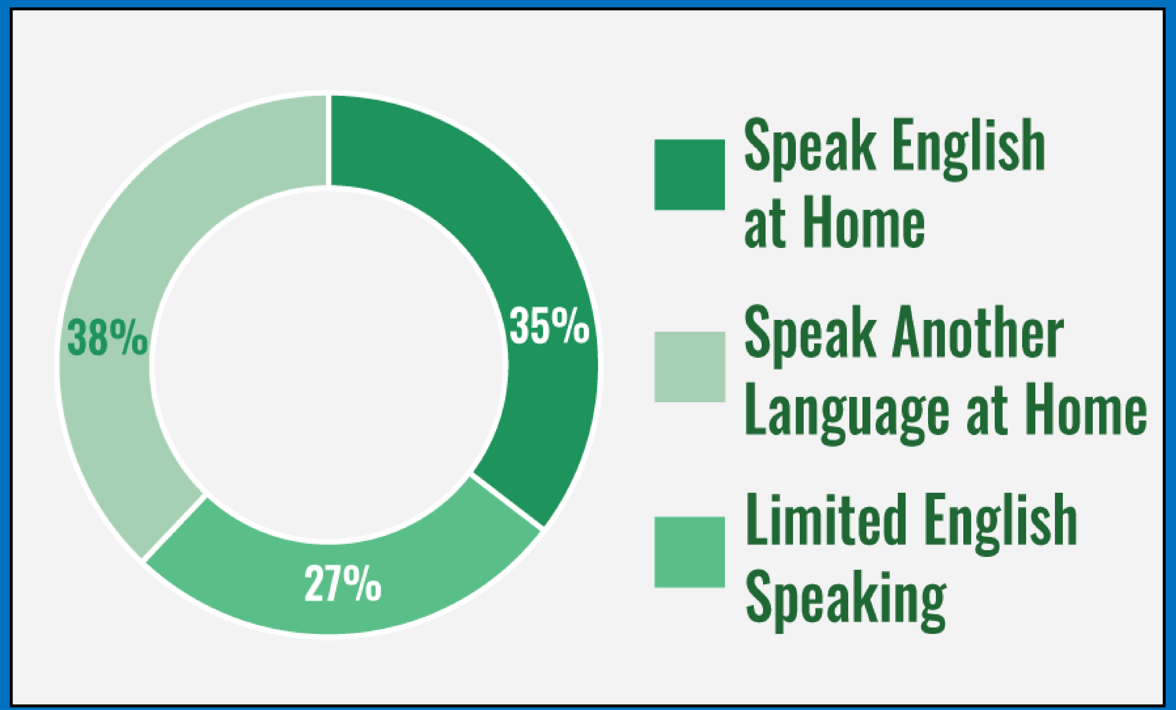
*A four-person household earning less than $78,150 is considered low-income; a four-person household earning less than $24,563 is below poverty level





People who have certain health conditions: These may include older adults, very young children, pregnant women, people with disabilities, and/or people with chronic medical conditions. They may be more physically vulnerable to extreme heat and poor air quality caused by climate change. Individuals with mobility constraints, such as people with disabilities and seniors, may need additional assistance with emergency response.

People who have difficulty adapting to, preparing for, or recovering from extreme weather events: Characteristics such as income, language, and household status can cause people tobe more at risk to climate change. For example, low-income people and families may have greater financial shocks after extreme weather events if their homes are damaged, if their work transportation is impaired by weather, if their medical needs are not met due to loss of transportation or financial shocks.



People in social isolation, such as individuals living alone, single-parent households, or individuals with limited English-speaking abilities, can limit access to critical information, city resources, and social support systems.

People who live or work in vulnerable locations such as areas with historic and projected flooding, areas prone to heat islands and extreme heat, and neighborhoods prone to power outages. Outdoor workers, first responders, and those working in hot indoor environments are also vulnerable.

Climate Change in Chelsea: Possible Solutions

What are your solutions for a healthy, vibrant, livable Chelsea through climate change?

As a member of the Chelsea community, you are all the experts for place. And this workshop is seeking your input to protect the people and places of Chelsea most vulnerable to climate change. Below are some examples from plans that have addressed climate change and extreme weather events combined with some possible solutions. These can be used to help think of new climate resilience action items for Chelsea with this workshop.

Example Climate Vulnerability	Possible Solutions
Flooding by Market Street and Food Distribution Center	Install earthen berms at Island End Park that provide additional waterfront accessibility. Investigate salt marsh restoration and floating wetlands to minimize flooding and improve water quality.
Stormwater system overflows into streets and rivers during heavy rain events.	(a) Install rain gardens, trees, and bioswales (green infrastructure) through the city to bring water back into the ground. (b) Upgrade stormwater pipes and infrastructure to include future precipitation projections.
Sea Level Rise Flooding at Mill Creek, flood multiple retail stores like Walgreens, Auto Store, Lowes	Seek funding to perform ecological restoration to Mill Creek to improve flow of water. Could include dredging, invasive species removal, marsh/wetland restoration. Create better public access to Mill Creek with river parks. Expand the floodplain by protecting land around Mill Creek and constructing wetlands.
Flooding at Chelsea Housing Authority	Clear drainage ditch to prevent future flooding. Upgrade infrastructure toward future precipitation/flood patterns. Add more parks/natural vegetation to the area to capture stormwater, beautify neighborhood, and improve air quality.
Sea level rise/storm surge risking Chelsea's waterfront businesses.	Upgrade floodplain zoning and conservation regulations to be consistent with existing and future flood zones. Assess Chelsea waterfront from additional sea/flood wall protection as well as living shorelines and earthen berms.
Loss of electricity during severe storms	Require all new development to put utilities underground.
Children and seniors living in urban heat islands.	Increase tree canopy cover to cool the city and mitigate air pollution . Create an Extreme Heat Program with transportation that brings seniors to cooling centers that also provides food and other programs for socialization.
City Yard Chelsea DPW is in a flood zone.	Install deployable flood fences, seek alternative sites for new facility.
Chelsea is one of the hottest areas in Metro Boston, with significant urban heat island.	Consider green roof regulations to include raised garden beds and/or solar panels to cool the city. Use energy efficient electrical and mechanical equipment that reduces heat emissions, energy costs, and greenhouse has emissions.
Flooding of sites with hazardous materials could expose toxics to people of Chelsea.	Asses the risk of water-reactive chemicals stored in flood-prone buildings. Design guidelines and prioritization for better enforcement of flood proofing standards.
People live, work, and play in flood prone and extreme heat areas potentially exposing health issues, building damage, and hazardous conditions.	Ensure Emergency Management and Operations will protect the most vulnerable people from climate change. Create a multi-lingual network to inform residents of emergency situations, emergency shelter, and services to recover from extreme weather events.

Chelsea's most vulnerable buildings at risk to flooding.[1]

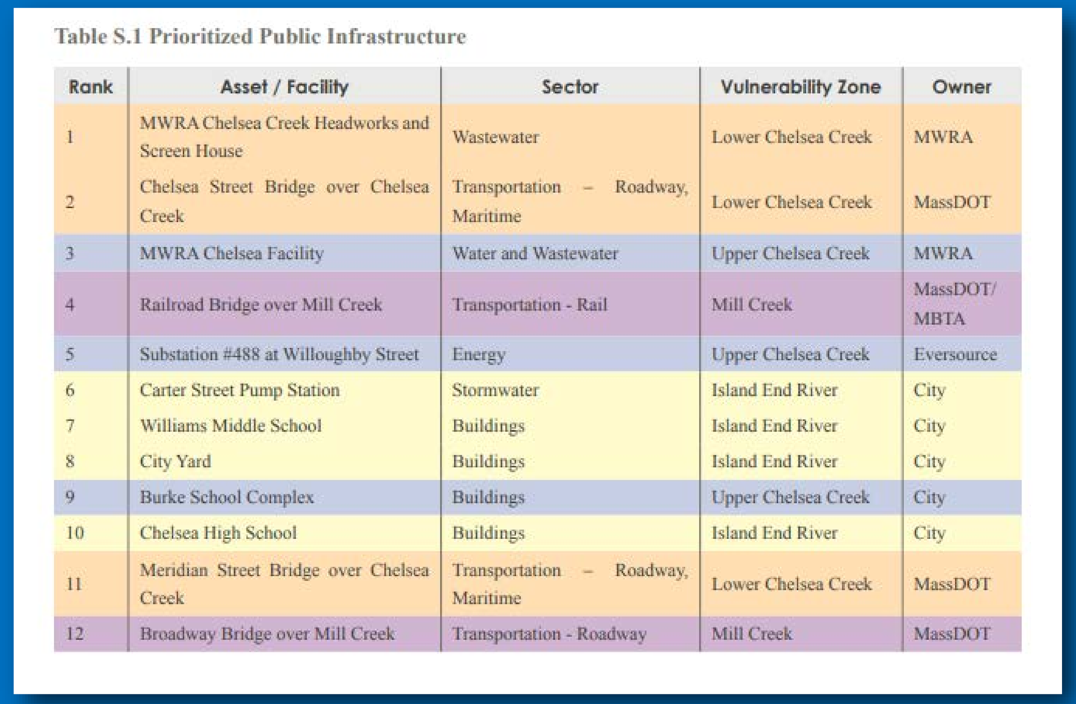
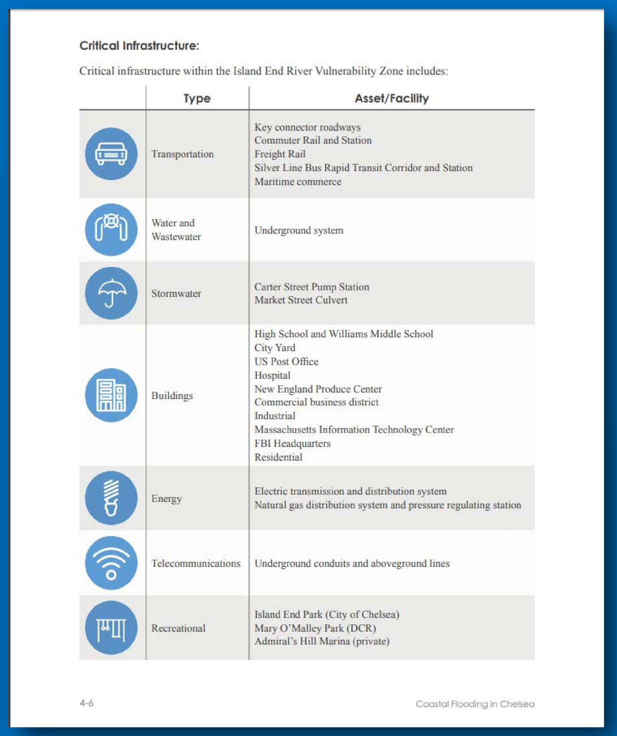


Table S.1 Prioritized Public Infrastructure

Rank	Asset / Facility	Sector	Vulnerability Zone	Owner
1	MWRA Chelsea Creek Headworks and Screen House	Wastewater	Lower Chelsea Creek	MWRA
2	Chelsea Street Bridge over Chelsea Creek	Transportation – Roadway, Maritime	Lower Chelsea Creek	MassDOT
3	MWRA Chelsea Facility	Water and Wastewater	Upper Chelsea Creek	MWRA
4	Railroad Bridge over Mill Creek	Transportation - Rail	Mill Creek	MassDOT/ MBTA
5	Substation #488 at Willoughby Street	Energy	Upper Chelsea Creek	Eversource
6	Carter Street Pump Station	Stormwater	Island End River	City
7	Williams Middle School	Buildings	Island End River	City
8	City Yard	Buildings	Island End River	City
9	Burke School Complex	Buildings	Upper Chelsea Creek	City
10	Chelsea High School	Buildings	Island End River	City
11	Meridian Street Bridge over Chelsea Creek	Transportation – Roadway, Maritime	Lower Chelsea Creek	MassDOT
12	Broadway Bridge over Mill Creek	Transportation - Roadway	Mill Creek	MassDOT

Island End River Vulnerability Zone. Examples of infrastructure at risk to sea level rise/storm surge and possible solutions to prevent flooding.[1]



Critical Infrastructure:

Critical infrastructure within the Island End River Vulnerability Zone includes:

Type	Asset/Facility
Transportation	Key connector roadways Commuter Rail and Station Freight Rail Silver Line Bus Rapid Transit Corridor and Station Maritime commerce
Water and Wastewater	Underground system
Stormwater	Carter Street Pump Station Market Street Culvert
Buildings	High School and Williams Middle School City Yard US Post Office Hospital New England Produce Center Commercial business district Industrial Massachusetts Information Technology Center FBI Headquarters Residential
Energy	Electric transmission and distribution system Natural gas distribution system and pressure regulating station
Telecommunications	Underground conduits and aboveground lines
Recreational	Island End Park (City of Chelsea) Mary O'Malley Park (DCR) Admiral's Hill Marina (private)

4-6 Coastal Flooding in Chelsea

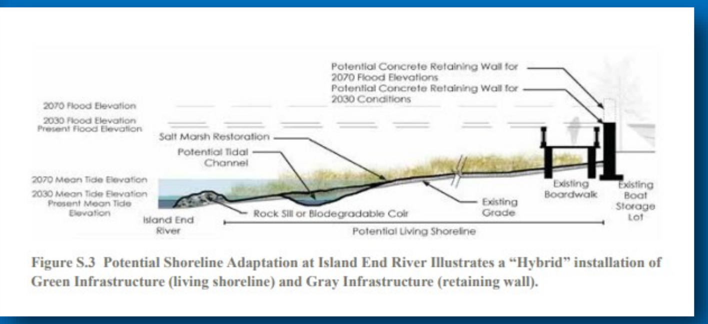
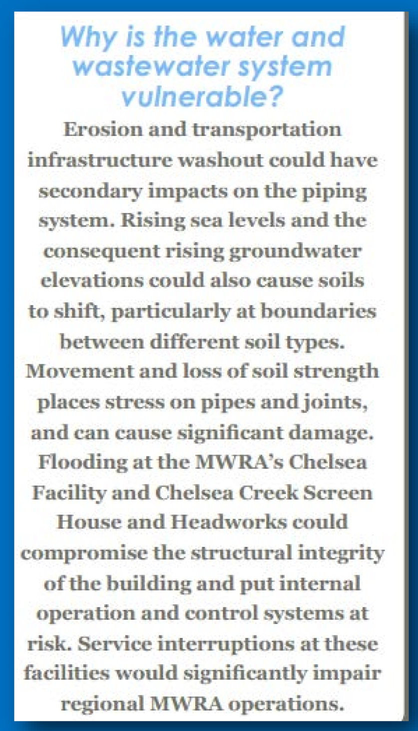


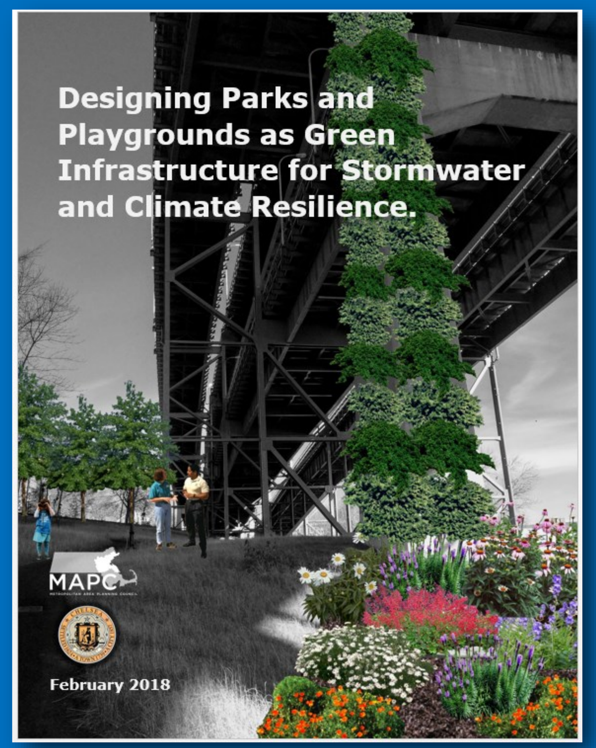
Figure S.3 Potential Shoreline Adaptation at Island End River Illustrates a "Hybrid" installation of Green Infrastructure (living shoreline) and Gray Infrastructure (retaining wall).

Example of how the wastewater system is vulnerable to flooding and a potential solution. [1]



Why is the water and wastewater system vulnerable?

Erosion and transportation infrastructure washout could have secondary impacts on the piping system. Rising sea levels and the consequent rising groundwater elevations could also cause soils to shift, particularly at boundaries between different soil types. Movement and loss of soil strength places stress on pipes and joints, and can cause significant damage. Flooding at the MWRA's Chelsea Facility and Chelsea Creek Screen House and Headworks could compromise the structural integrity of the building and put internal operation and control systems at risk. Service interruptions at these facilities would significantly impair regional MWRA operations.



[1]Designing Coastal Community Infrastructure for Climate Change. Stantec and Woods Hole Group, January 2017