CHAPTER 4

ENVIRONMENTAL CONSIDERATIONS

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What's in this chapter?

Watershed Area

The Lake Ontario and Genesee River watersheds are defining features of Monroe County and its communities. Both are important aesthetic, economic, environmental, and cultural resources for the county and the CLEAR Study Area.

Watershed

Monroe County has roughly 36.5 miles of Lake Ontario shoreline. Between 40 and 50 rivers, creeks, and streams (not including tributaries) flow into Monroe County from the Lake. The Lake Ontario and Minor Tributaries Watershed is comprised of smaller drainage areas that lie between the larger rivers emptying into Lake Ontario. This watershed encompasses 2,460 square miles of land in New York State. Two sub-basins of this watershed, the Lake Ontario West Sub-Basin and the Lake Ontario Central Sub-Basin, drain into Lake Ontario through Monroe County. The Lake Ontario West Sub-Basin encompasses the Towns of Hamlin, Parma, and Greece and includes the Long Pond tributary. The Genesee River Sub-Basin bisects the City of Rochester and includes the western half of the city and a small portion of the Towns of Greece and Irondequoit. The Genesee River runs through this sub-basin. The Lake Ontario West Sub-Basin includes the eastern half of the City of Rochester and the Towns of Irondequoit, Webster, and Penfield.

Each of these three basins drains into the Rochester Embayment of Lake Ontario, a broad bay at the mouth of the Genesee River. The Embayment encompasses roughly 35 square miles of Lake Ontario between Nine Mile Point in Webster and Bogus Point in Parma. This bay drains approximately 3,000 square miles of upland including Monroe County.

Shoreline Characterization

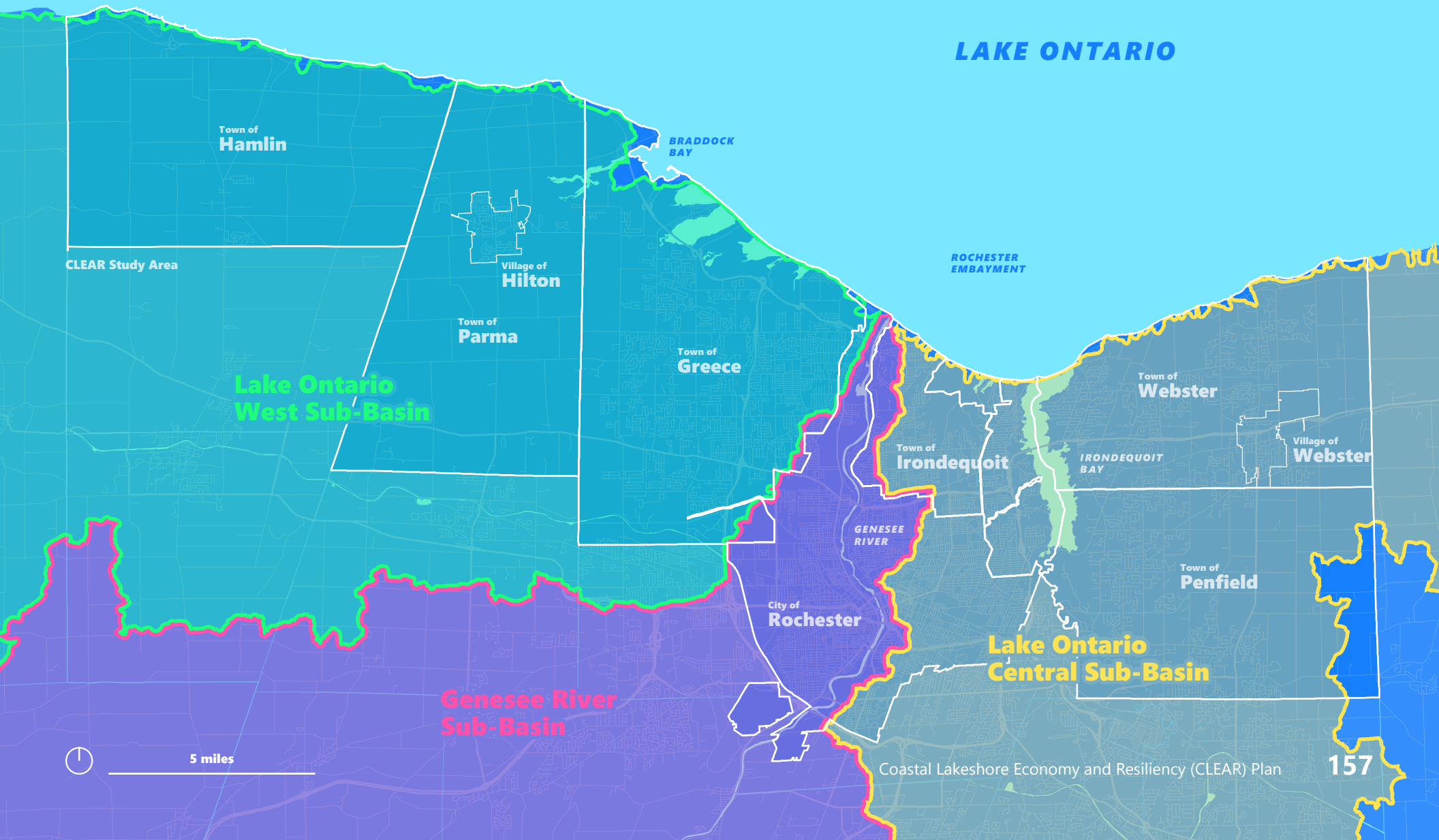
The majority of New York State's Lake Ontario shoreline is natural and can be characterized as sand or cohesive bluffs, coarse beaches, artificial or sandy beaches, or dunes. Approximately 43% of the shoreline also has some type of structural armoring with ad hoc concrete rubble/riprap, seawalls, bulkheads, and revetments being most common. However, these shoreline hardening techniques may contribute to erosion and beach loss.

What is a Watershed?

A watershed is an area of land that channels rainfall and snowmelt to creeks, streams, and rivers, and eventually to outflow points such as bays, lakes, and oceans.

Watershed Boundaries

Map #33



Coastal Habitats

The Lake Ontario shoreline provides important habitats for coastal fish and other wildlife, especially in the Braddock and Irondequoit Bay areas. Several stressors, including increased development, variable lake levels, and wind-driven erosion, threaten these habitats and put their environmental and economic benefits at risk.

Land Cover

Between 1975 and 2016, developed areas increased in Monroe County, and agriculture, forested and scrub/shrub areas decreased. As the county continues to develop, the amount of impervious surface cover will continue to increase and simultaneously decrease the natural drainage capacity of the land. Increased impervious surface cover increases the volume and velocity of runoff, which can cause streambank erosion and increase the likelihood of a flood event. Climate change may compound the increased rates of flooding due to increased impervious surface cover and decreased riparian buffer areas.

Wetlands

There are over 16,000 acres of wetlands in Monroe County. Low wetlands make up much of the Lake Ontario shoreline from Hamlin to Irondequoit Bay. These wetlands clean water, protect shorelines, and provide habitat for many species. However, since 1975, Monroe County has lost over 3% of its wetland land-cover due to stressors like urban development and agriculture. Furthermore, almost all coastal wetlands on Lake Ontario have been degraded by nutrient enrichment, sedimentation, or both. Past regulation of water levels on Lake Ontario has adversely affected coastal wetland habitat.

Lucien Morin Park Wetlands
The Lucien Morin Park Wetlands in Penfield are popular for canoeing and kayaking and provide access to Irondequoit Bay.


Wetlands in Braddock Bay
Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil, all year or for varying periods of time during the year.
Wetland Vegetation
The prolonged presence of water in wetlands favors the growth of aquatic plants like reeds, sedges, and water lillies.

Coastal Habitats

Rochester Embayment Area

The Rochester Embayment and a six-mile reach of the Genesee River (from the mouth to the Lower Falls) are influenced by water levels in Lake Ontario and designated as Areas of Concern (AOC) under the 1987 Great Lakes Water Quality Agreement. Over the last 100 years, wave-driven erosion has caused a gradual loss of the protective barrier beach and over 100 acres of protective wetlands. Further, decreased fluctuations in water levels since regulation began in 1954 has resulted in a loss of diverse habitat that once existed in the area.

Federal, state, and local partners are addressing these problems through habitat restoration at Braddock Bay and the Buck Pond marsh system. Restoration helps these natural resources remain environmental, economic, and recreation assets in Monroe County for years to come.

Significant Coastal Habitats

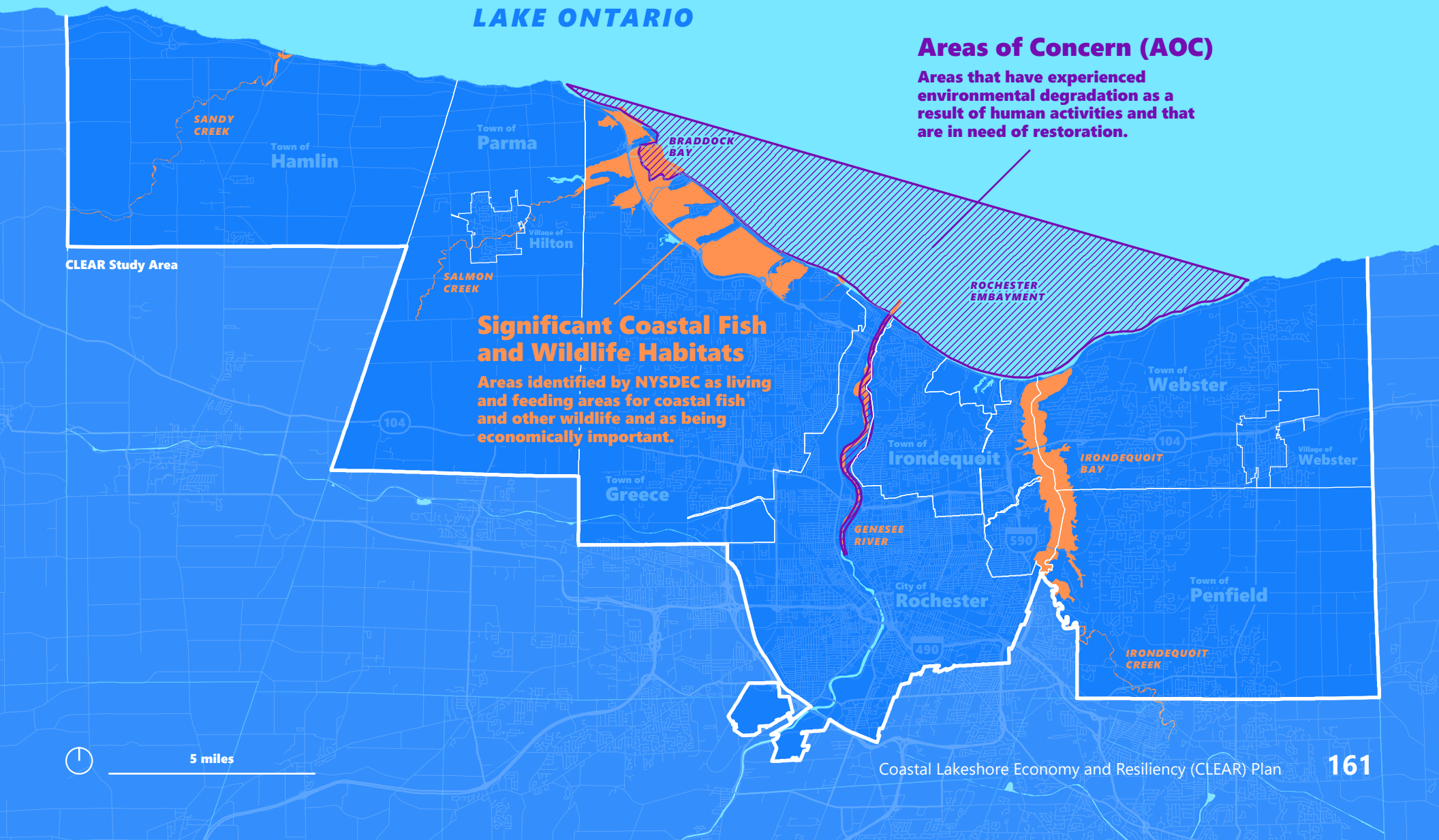
In Monroe County, DEC has designated Braddock Bay, Salmon Creek, and Irondequoit Bay and Creek as "significant coastal fish and wildlife habitats." These areas include riverine wetlands, riparian corridors, bay and harbor bottoms, and other habitats that provide living and feeding areas for coastal fish and other wildlife. The Braddock Bay and Salmon Creek freshwater wetland complex in the Towns of Greece and Parma is one of the largest and most important in New York State, with 5,000 acres of fish and wildlife habitat.

Natural Protective Feature Areas

Some beaches, dunes, bluffs and near-shore areas in Monroe County are designated as Natural Protective Feature Areas (NPFA) by DEC. These areas protect natural habitats, infrastructure, structures, and human life from erosion and high-water events. Human activities such as development or modification of beaches can decrease or remove the erosion-buffering capacity of natural protective features. To prevent this degradation, these areas are regulated by the State under the CEHA permit program. Greece, Hamlin, and Rochester are certified CEHA communities and administer this program for their respective municipalities.

Significant Habitats and Areas of Concern

Map #34



Coastal Processes of Change

The dynamic coastal environment of Lake Ontario is an integral part of everyday life in the CLEAR Study Area, particularly for lakeshore residents and business owners. However, everyday coastal processes, like storm surge, elevated lake levels, waves and erosion can become hazards when they pose a threat to the lives and livelihoods of coastal populations.

Erosion

Erosion along Lake Ontario's southern shore has been ongoing since the Last Ice Age when the region was a riverine watershed beneath a piece of glacial ice. Today, erosion — caused by wave action, fluctuating lake levels, and sedimentation — still plays an important part in shaping the coastline of Lake Ontario in Monroe County.

Erosion is influenced by a number of factors including wave energy that reaches the shoreline, availability of sediment and the shoreline's composition, topography, and orientation relative to winds and waves. Artificial structures like breakwaters and shoreline armoring can also limit the availability and transport of sediment, contributing to shoreline erosion and beach loss.

Longer-term erosion caused by more frequent, smaller storms can cause beaches and bluffs to retreat inland. During storm events, a significant amount of erosion can happen in a short time causing stark changes to the coastline. Erosion can lead to the loss of natural features (like beaches and bluffs) and infrastructure built near the shoreline (like piers and even lakefront home foundations).

Erosion and Sediment

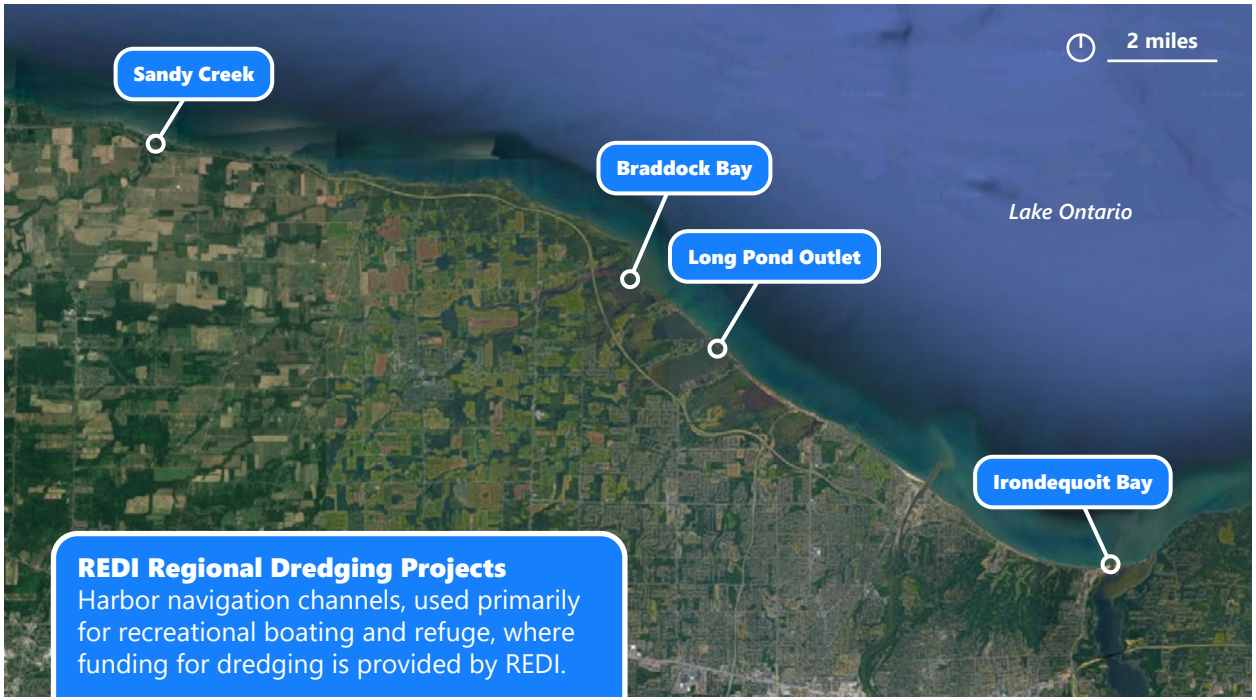
Assessment of the potential impacts of erosion and erosion management requires an understanding of the availability and movement of sediment along Lake Ontario. Logging and agriculture in Lake Ontario's watershed in the 1800s and early 1900s gradually increased the amount of sediment entering the lake. As development increased and dams were built for transportation, power and water supply, the amount of sediment entering Lake Ontario drastically decreased, making the shoreline more vulnerable to erosion.

Coastal Processes of Change

Dredging

The deposition of sediment in the channels, harbors, and marinas of Monroe County is an ongoing concern. Dredging, or the removal of sediment from the bottom of a waterway, is an ongoing need for federal and non-federal harbors and channels to meet the needs of commercial, recreation, fishing, and boating sectors and users.

REDI's regional dredging project includes funding for 20 dredging sites, four of which are in Monroe County. Through these efforts, sediment will be removed from the channels and harbors and will be repurposed to rebuild the shoreline in areas where there has been significant erosion.



REDI Regional Dredging Projects
Harbor navigation channels, used primarily for recreational boating and refuge, where funding for dredging is provided by REDI.

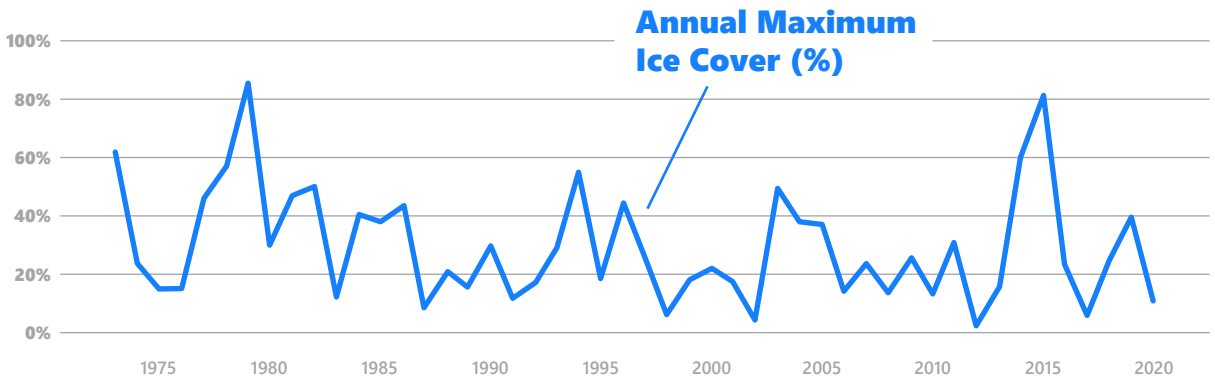
Coastal Processes of Change

Ice Cover

The extent and duration of ice cover on the Great Lakes varies greatly from year to year and can have significant impacts on a number of water-dependent industries like hydropower and fishing. From 1973 to 2020, annual maximum ice cover on Lake Ontario varied considerably, from almost none to more than 80%. Over this period, the average annual maximum ice cover was 30%.

Lake Ontario Ice Cover 1973-2020

Figure #16



Coastal Processes of Change

Water Levels

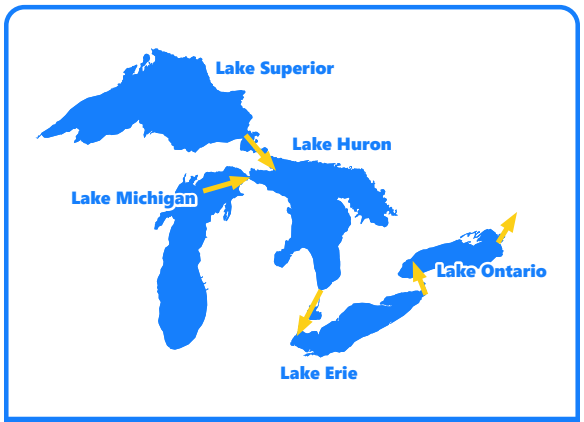
Lake Ontario's water levels fluctuate depending on three main factors:

1. Rain and snowfall over the lakes;
2. Evaporation over the lakes; and
3. Runoff that enters each lake from the surrounding land through tributaries and rivers.

Water flows from Lakes Superior and Michigan and through Lake Huron and Erie before reaching Lake Ontario. As a result, precipitation throughout the larger Great Lakes' watershed and input flows from the rest of the system influence Lake Ontario's water levels as well. These factors can cause lake levels to change significantly — on the order of feet. The upstream dam and locks at Sault Ste. Marie, Michigan can also influence lake levels, but these engineering controls can only influence the lake levels on the order of inches.

Short-Term Fluctuations

Unlike most coastal areas, the Great Lakes do not experience measurable tides. They do however have regular "seiches" caused by wind conditions. Seiches are the oscillation of the lake surface, much like water sloshing in a large bowl. Seiches can be caused by storm surges. When a storm moves over the lake, and the wind and atmospheric pressure no longer push on the water, the piled-up water moves to the opposite end of the lake. The water sloshes back and forth, diminishing over time due to friction. Seiches on Lake Ontario have a period of about six hours. Wind can also cause short-term lake level fluctuations and is a dominant driver of storm surge on the Great Lakes. Strong and sustained winds push water towards land and cause a rise in the water level, or a storm surge. Wind surges can raise local water levels by as much as 1.4 feet on Lake Ontario.



Great Lakes Direction of Water Flow
Water flows from Lakes Superior and Michigan into Lake Huron then into Lake Erie before finally entering Lake Ontario and leaving to the Atlantic Ocean through the St. Lawrence River.

Coastal Processes of Change

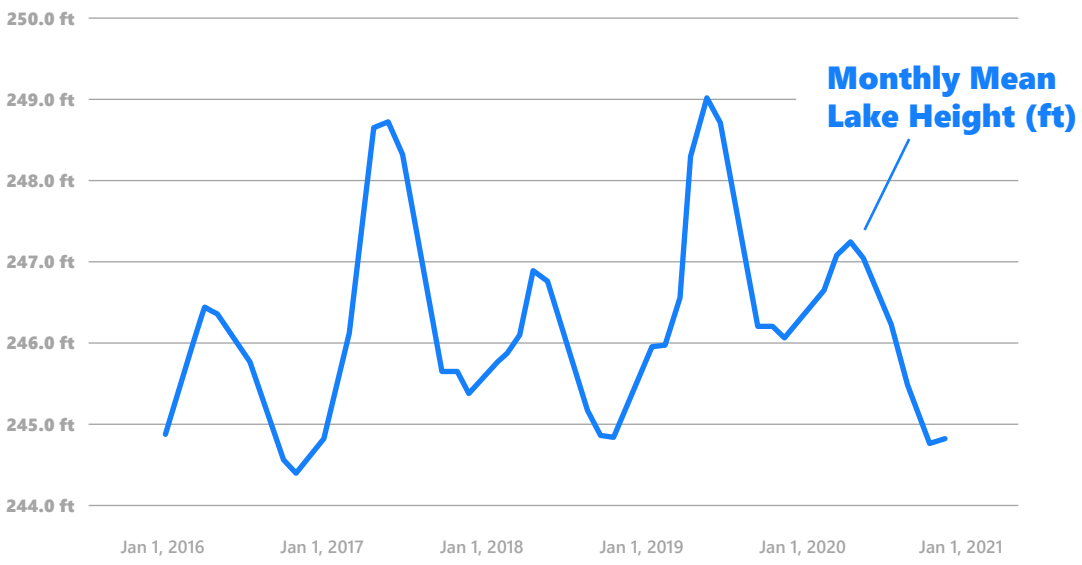
Water Levels Continued

Seasonal Fluctuations

Seasonal changes in water level are caused by changes in precipitation, ice cover, temperature, and evaporation. Generally, lake levels are lowest in the winter with levels increasing in the spring as snow melts and runoff increases. In fall, evaporation and outflow increase causing lake levels to drop.

Lake Ontario Level Jan. 2016-Jan. 2018

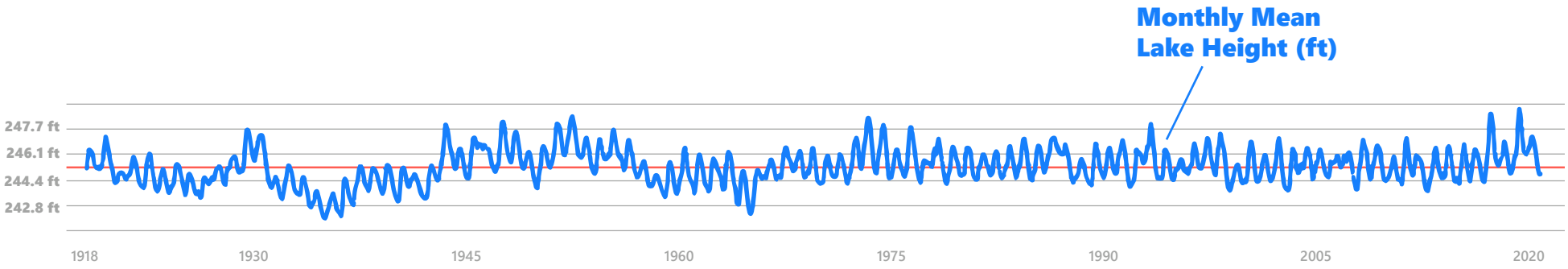
Figure #17



Coastal Processes of Change

Lake Ontario Level 1918-2020

Figure #18



Long-Term Fluctuations

Between 1918 and 2020, Lake Ontario's monthly mean water levels in Rochester have ranged from 241.9 to 249.3 feet. These changes are caused in part by isostatic rebound, which is the adjustment of earth's crust in response to the retreat of glaciers at the end of the Last Ice Age and continuing today. Isostatic rebound is causing the northern and southern shores of Lake Ontario to rise while the western end is sinking.

Global climate change — which influences regional precipitation, runoff, temperature, ice cover, and snowmelt — and man-made changes that alter Lake Ontario's basins, watershed, shorelines, and land use, can also impact lake levels.

Flood Hazards

Flooding is the primary natural hazard in New York State, causing millions of dollars' worth of damage to homes and businesses each year. With its 36.5 miles of Lake Ontario shoreline and between 40-50 rivers, creeks, and streams (not including tributaries), Monroe County has significant risk associated with the probability of flooding.

Flooding in Monroe County

According to the Monroe County Hazard Mitigation Plan (2017), "Flood Hazard" was ranked as a medium hazard due to exposure and potential impact both countywide and for each jurisdiction in the CLEAR Study Area.

"Severe Storm" – which includes windstorms and other influencing weather conditions like thunderstorms, hurricanes and tropical cyclones, hail, lightning, and tornadoes – was considered a high risk countywide and by each jurisdiction.

Monroe County experiences two types of major flooding: coastal and riverine flooding. As was experienced in 2017 and 2019, most damaging floods from Lake Ontario occur when lake levels are high or during severe storms. Both scenarios create a temporary rise in the lake level and wave run-ups. Although these floods may occur throughout the year, they are most probable in spring.

Riverine flooding is most severe around major creeks and riverbeds, including Sandy Creek, Cowsucker Creek, Brush Creek, Salmon Creek, Buttonwood Creek, Black Creek, Northrup Creek, Larkin Creek, Round Pond Creek, Slater Creek, the Genesee River, Irondequoit Creek, Allens Creek, Shipbuilders Creek, Mill Creek, and Four Mile Creek.

According to the County's 2008 Flood Insurance Study, major floods can occur on Irondequoit Creek and lower Genesee River any time of year, although most result from rainfall or snowmelt in the basin. Flood problems along the Genesee River are most visible in low-lying areas, and high water periodically inundates primary residences and vacation homes.

Quantifying Flood Risk

National Flood Insurance Program

The National Flood Insurance Program (NFIP) was created in 1968 by Congress to help people financially protect themselves from flooding. The NFIP offers flood insurance to homeowners, renters, and business owners if their community participates in the NFIP and enforces floodplain management regulations. These regulations include minimum construction requirements in SFHA. The SFHA is a "high-risk flood zone."

Flood Hazards

FEMA Flood Zones
Flood risk zones are determined by FEMA on a community's FIRM. Zones beginning with the letter "A" are high-risk flood areas, which are subject to inundation during a 100-year flood. This is the "base flood" or flood elevation that has a 1-percent-annual-chance of being equaled or exceeded each year. The SFHA includes all "A" and "V" FIRM zones (V Zones apply in coastal situations with additional hazards associated with storm-induced waves). Low-to-moderate flood risk areas are subject to the 500-year flood, which means a flood of that size or greater has a 0.2-percent-annual-chance (or 1 in 500 chance) of occurring each year. They are shown on the FIRM as Zone B or Shaded Zone X. Zone C or Unshaded Zone X are outside the 1-percent and 0.2-percent-annual-chance floodplains with low risk.

Land in Flood Zones 2017

Table #5

Municipality	Total Area (acres)	1% Flood Event Hazard Area (acres)		0.2% Flood Event Hazard Area (acres)	
Town of Greece	9,805	1,372	14.0%	4,589	14.5%
Town of Hamlin	27,751	1,619	5.8%	1,619	5.8%
Town of Irondequoit	9,785	356	3.6%	363	3.7%
Town of Parma	25,825	1,738	6.7%	1,905	7.4%
Town of Penfield	23,985	1,733	7.2%	2,411	10.1%
Town of Webster	20,454	1,468	7.2%	1,590	7.8%
City of Rochester	23,487	1,109	4.7%	1,225	5.2%

Structures in the SFHA with mortgages from federally regulated or insured lenders are required to have flood insurance. A resident will not be able to purchase a flood insurance policy if their community does not have floodplain regulations that meet or exceed NFIP criteria. All of the municipalities in the CLEAR Study Area enforce local floodplain regulations.

Flood Hazards

Monroe County Risk Assessment

Lake Ontario Risk Review Meetings

Monroe County was one of six counties and the Seneca Nation that were part of the Lake Ontario and Lake Erie Flood Risk Review Meetings that occurred in 2017. These meetings were part of FEMA's Great Lakes Coastal Flood Study to discuss results and plans for updating FIRMs around the Great Lakes region.

DOS Risk Area Mapping

Results from the Risk Review Meetings were refined by the DOS Risk Area Mapping Project. This project assesses flood risk for all communities in the CLEAR Initiative, including Monroe County.

DOS's risk mapping compiles data from multiple sources and aggregates it to classify areas as either at moderate, high, or extreme risk of flooding.

Risk is quantified by indexing:

- **National Flood Hazard Layer (FEMA)** to show FEMA flood zones
- **Soil characteristics (NRCS, SSURGO)** to identify soils prone to flooding
- **Riparian buffer (NYNHP)** to represent the 50-year flood height
- **Dynamic natural shoreline features (NYSDEC, FEMA, USACE, OGS)** to identify shorelines that may be more susceptible to flooding and erosion
- **Lake Ontario regulated high-water level elevation (247.3 ft) and the base flood elevation plus two feet** to visualize effects of high water

What is Risk?

Risk is the chance that an asset, like homes, schools, and telecommunications systems, will be damaged or destroyed by flooding.

What is Resilience?

Coastal resilience is the capacity of a community and its ecosystem to withstand extreme events, like flooding and other risks. It considers the community's ability to function in the aftermath of a disaster, and whether it will be able to recover the interconnected social, economic, and ecological systems that allowed it to function pre-disaster. It also considers the community's capacity to adapt to future conditions and develop measures to cope with a rapidly changing environment.

Flood Risk

Map #35

Flood Hazards

Areas of Particular Concern
Almost the entire extent of the Lake Ontario shoreline in Monroe County is at some risk for coastal flooding. Many towns are also susceptible to riverine flooding along creeks and tributaries.

Areas of particular concern include the Braddock Bay/Pond complex, where many of the wetland and marsh areas south of the ponds are at extreme risk for flooding. Several neighborhoods in this area are also at high, and in some cases, extreme risk of riverine flooding from nearby creeks including Northrup and Larkin Creeks.

The Irondequoit Bay shoreline is also at extreme risk for flooding, particularly along Lake Road and along the eastern shore. The western shoreline by Sea Breeze Drive is comparatively less vulnerable, but is still considered a high risk area.

The area south of Irondequoit Bay along Irondequoit Creek is at extreme flood risk as well. Though much of the floodable area is in wetlands or Ellison Park, the Panorama area in southwestern Penfield is one of the more at-risk developed areas in the Study Area. Homes and businesses along Panorama Trail and in Panorama Plaza and along floodable tributaries like Allen's Creek and Thousand Acre Brook are at either high or extreme risk to flooding.

With the increasing occurrence of intense storms and precipitation events, the probability of future flooding is high—especially in these areas of concern—but the physical, social, and economic effects of flooding will likely be felt community-wide.

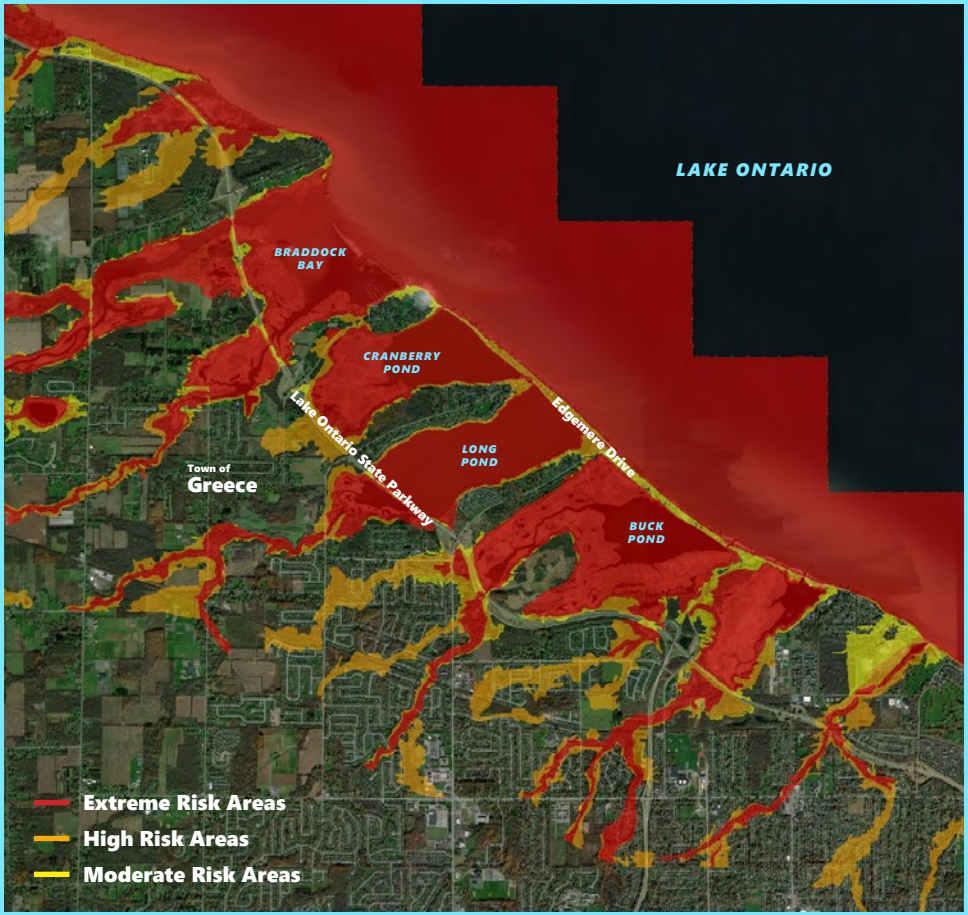
Possibility for Increased Localized Flooding

Urban drainage flooding, caused by increased water runoff due to urban development and drainage systems, will also cause more localized flooding. Localized flooding problems are usually not part of flood insurance studies. The First Street Foundation, a non-profit research and technology group committed to defining America's flood risk, developed a Flood Model that makes use of open government data and builds upon decades of research, modeling, and expertise. A 2020 National Flood Report shows that 6,953 properties are at risk of flooding in the City of Rochester, with a 2.8% projected increase in risk by 2050.

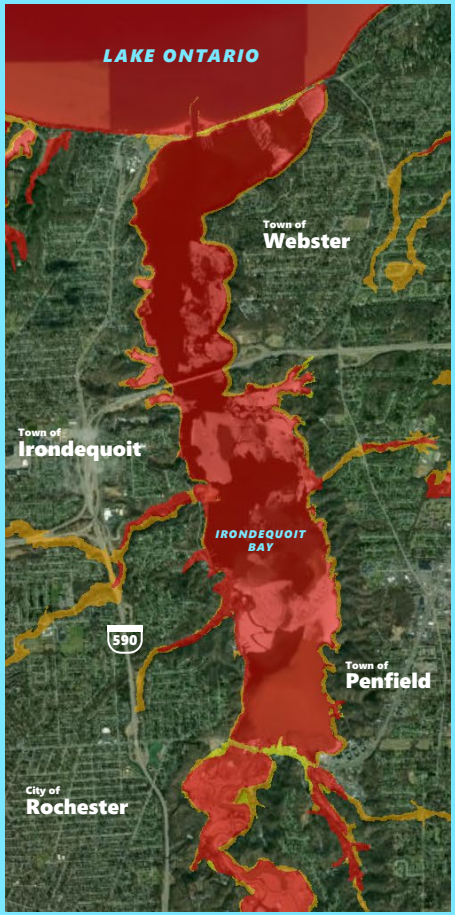
Areas of Particular Concern

Figure #19

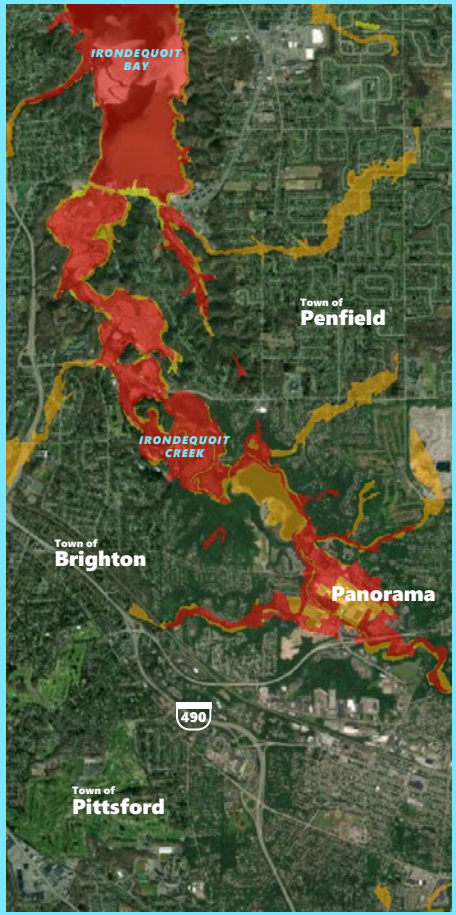
Braddock Bay/Pond Complex



Irondequoit Bay



Irondequoit Creek



Climate Change Projections

Climate change trends such as warmer air and water, decreased ice cover, lower lake levels over the long term, and increased extreme precipitation events, including lake-effect snowstorms, will have a myriad of impacts on the communities of Lake Ontario. In Monroe County, it's likely that climate change will exacerbate ongoing risks and issues such as fluctuating water levels, ongoing shoreline erosion, need for maintenance of natural and man-made shoreline protective features, and degradation of natural resources.

Weather Patterns

Weather in Monroe County is strongly influenced by its proximity to Lake Ontario. Monroe County tends to be fairly humid with regular precipitation across all seasons. Generally, there are more frequent storms in the winter months when heavy snowfall occurs at irregular intervals.

Temperature and Precipitation

From 2000-2009 the average annual temperature was 48.7°F and average annual rainfall was 34.6 inches.
From 2010-2019 the average annual temperature was 49.7°F and average annual rainfall was 36.4 inches.

In the spring and fall months, lake temperatures stabilize the climate, resulting in relatively dry periods. Summers are warm and sunny with average temperatures around 70°F. Temperatures rarely reach the triple digits.

Winters in Monroe County are generally cold, cloudy, and snowy with an average temperature of 34.8°F in the 2019-2020 season. About half of the region's snowfall is caused by the "lake effect" process, which creates localized, variable conditions. Lake effect snowfall most impacts the eastern portion of the county due to winds blowing off Lake Ontario. Total seasonal snowfall ranges from 70 inches in southern parts of the county to about 90 inches in the City of Rochester. The eastern part of the county along the shores of Lake Ontario can see over 120 inches of snow.

Lake Effect Snowfall
Bands of snow sweep over Lake Ontario into Monroe County in this satellite image.

Climate Change Projections

Great Lakes Climate Trends

Temperature

The Great Lakes Basin has experienced a greater temperature increase than the rest of the contiguous United States, on average. Relative to 1901-1960, the Great Lakes Basin annual mean temperature has increased 1.6°F for the period 1985 to 2016. This exceeds average changes of 1.2°F for the rest of the contiguous United States. From 1901-2016, the global annual-average temperature has increased by 1.8°F (1.0°C).

Precipitation

The Great Lakes Region has also seen a higher percent increase in annual precipitation than the U.S. average. Overall, U.S. annual precipitation increased 4% between 1901 and 2015, but the Great Lakes region saw an almost 10% increase over this interval. Since 1951, total annual precipitation has increased by over 13% in the region.

Precipitation Events

The frequency and intensity of extreme precipitation events in the Great Lakes region has increased. A greater proportion of the overall amount of precipitation in the region came during unusually large events in the period between 1901 and 2015. The total amount of precipitation falling during extreme events has also increased over the last five decades in the region. From 1951-2017, the region saw a 35% increase in heavy precipitation events (defined as the top 1% of storms).

Lake Surface Temperatures

Lake Ontario's summer surface temperatures have increased faster than surrounding air temperatures. Between 1994 and 2013, summer surface water temperature in Lake Ontario increased at the rate of 0.01 to 0.18°F per year in the vicinity of Monroe County. Between 1973 and 2013, the duration of seasonal ice cover decreased in most areas of the Great Lakes. However, recent years show upward trends.

Is Weather the Same as Climate?

Weather reflects short-term conditions of the atmosphere and can change day-to-day and even minute-to-minute. Climate is the average daily weather at a place over a much longer period of time. Weather is a combination of factors like temperature, precipitation, humidity, and cloudiness. Climate describes the "normal" weather at a place, as well as its range of weather extremes.

Climate Change Projections

Temperature and Precipitation Trends

Temperatures in the Great Lakes Region have been rising over the past several decades. Since 1951, the annual average air temperature has increased 2.3°F. Temperatures in winter and at night are increasing faster than other seasons or during the day. Across the Great Lakes region, the number of days over 90°F per year is expected to increase.

Increasing air temperatures may have cascading effects on lake surface temperature, lake ice cover, and lake effect snow. Lake surface temperatures may rise by as much as 7°F by 2050 and 12.1°F by 2100. Increased temperatures will reduce lake ice cover and enhance evaporation leading to increased lake effect snowfall in the nearer term. But, over the longer term, rising temperatures will cause more precipitation to fall as rain than as snow.

Projections for future precipitation are less certain than those made for temperature. Generally, more precipitation is expected on average but not during all seasons. Storms are expected to increase in both intensity and frequency across the region.

Lake Levels and Water Availability

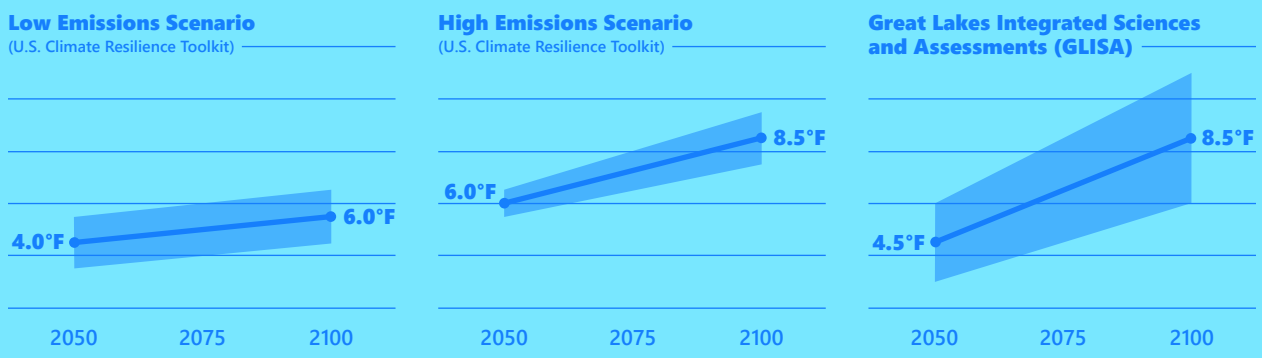
Lake levels are driven by precipitation, evaporation, and runoff and they fluctuate naturally over the short, seasonal, and long-term. These natural processes determine the lakes' net basin supply and also drive lake levels. Engineered solutions like the Moses-Saunders Dam (on the St. Lawrence River near Massena, New York) have the ability to control lake levels on the scale of inches and are the subject of Plan 2014 and the ongoing lawsuit between the International Joint Commission and the State of New York.

Between the 1990s and mid-2010s, there was a period of low lake levels. However, since 2014, lake levels have risen at an unprecedented rate, contributing to record highs in 2017 and 2019 and flooding throughout the region. Modeling of future lake levels is not certain; however, the strongest current evidence indicates that, with climate change, there will be increased variability in lake levels.

Great Lakes Climate Trends

Figure #20

Projected Changes in Average Air Temperature (2050-2100)



Change in Annual Temperatures

(Yearly Average, 1985-2016)

+1.6°F Great Lakes Region

+1.2°F U.S. Average

Change in Annual Precipitation

(Yearly Average, 1901-2015)

+10% Great Lakes Region

+4% U.S. Average

Data Applicability to the Great Lakes

Many globally relevant and vetted climate change projection models do not appropriately consider the dynamics of the Great Lakes region and the influence of the lakes on local weather and climate. The lakes themselves influence daily weather by moderating temperatures, increasing cloud cover and precipitation in the winter, and decreasing summertime clouds and rainfall. To address these challenges and better understand uncertainties in the region, a suite of locally appropriate, downscaled climate change projections are being developed by Great Lakes Integrated Sciences and Assessments (GLISA). The evolving resources of GLISA and other trusted sources should be consulted periodically to ensure decision making in Monroe County is informed by the best available and most locally-relevant datasets.

Climate Change Projections

Lake Levels Continued

Low and high lake levels have impacts on how people use and interact with the lake and shorelines.

High water levels can lead to:

- Increased bluff recession and loss of beaches
- Loss of wetlands and habitat
- More armoring (and armoring maintenance) along the shoreline
- Deeper channels for shipping and boating
- Implementation of zoning setback regulations and ordinances
- Increased flooding and flooding further inland

Low water levels can lead to:

- Expanded dry beach width
- Damage to wood shoreline infrastructure
- Encroachment of structures with decreased perception of erosion and flood risk
- Increased need for dredging
- Decreased boating, docking, and beaching access due to shallow waters
- Water intake and outfall misalignment with low lake levels
- Decreased groundwater levels and degradation of wetlands in the short-term

Though precipitation is expected to increase, the region is likely to become drier overall with the increase in temperature and evaporation rates. More frequent summer droughts can decrease soil moisture and surface and groundwater supply. The seasonality of the water cycle is likely to change with warmer temperatures, leading to increased winter rain and earlier peak stream flows.

The projected impacts of climate change on the Great Lakes region's water budget or the movement of water into and out of the lakes is not yet well known. According to GLISA, it is difficult to determine how water budgets will change because climate change modeling is done at a different scale than the determination of water budgets. This is an area where future research is needed.

Potential Climate Change Impacts

Table #6

Increased Water Temperature	Increased algal blooms and decreased water quality.
	Threats to freshwater aquatic ecosystems and species, including coldwater fish, amphibians, freshwater mussels, and stream invertebrates. Could negatively impact recreational fishing industry.
Increased Extreme Precipitation Events	Flooding of agricultural lands.
	Flood damage to waterfront assets.
	Evacuation and displacement of waterfront populations due to flooding.
	Decreased water quality.
	Increased risk of waterborne diseases, causing illness and loss of tourism revenue.
	Water intrusion in buildings, causing mold growth.
	Road closures, bridge scoring, and increased risk of traffic accidents due to flooding.
	Increased risk of Combined Sewer Overflow (CSO) events.
Decreased Lake Ice in Water	Longer shipping season, offering regional commercial benefits.
	Increased coastal erosion and shoreline maintenance.
Increased Air Temperature and Increased Frequency of Heat Waves	Increase in heat-related illness and death, especially for urban and socially vulnerable populations.
	Material stress on transportation infrastructure.
	Decreased air quality in urban areas (ground-level ozone).
	Increased electricity demand particularly in summer and urban areas.
Warmer Winters and Longer Warm Season/Growing Season	Short-term increased agricultural productivity.
	Increase in blue-green and toxic algae. Algal blooms can cause hypoxic dead zones.
	Increased competition from pests and weeds, leading to increased pesticide use and potential human chemical exposure.
	Increased risk of vector-borne diseases from ticks, rodents, etc.