Town of Caroline
Climate Vulnerability Assessment

Compiled by
Cornell Cooperative Extension
of Tompkins County

ACKNOWLEDGEMENTS

This Climate Vulnerability Assessment is a collaborative effort between the Town of Caroline, Cornell Cooperative Extension, and the New York State Water Resources Institute. The template and structure of this document were originally developed by Cornell Cooperative Extension of Tompkins County as well as partially from the New York State Climate Smart Communities Program and Department of Environmental Conservation (NYDEC). This final report was created by Osamu Tsuda, CCE Tompkins Clean Energy and Climate Smart Planning Specialist under the supervision of Terry Carroll, Clean Energy Communities Coordinator for New York's Southern Tier Region as well as Kristen Hychka, Post-Doctorate Researcher at the New York State Water Resources Institute and Amy Gonzalez, Climate Resiliency and Adaptation Outreach Specialist. Mark Witmer, Town Supervisor of Caroline acted as a principal community representative for this Climate Vulnerability Assessment and provided strategic guidance on various town-related issues. Additional contributors include Scott Doyle from Tompkins County Planning Department and Ingrid Zabel from NYS Climate Change Science Clearinghouse who both provided technical expertise and guidance on the local, regional, and state levels.

EXECUTIVE SUMMARY

This Climate Vulnerability Assessment (CVA) intends to analyze data around climate change and its impacts on the Town of Caroline, and provide a basic guide for increasing resiliency and sustainability through long-term community planning. A completed Climate Vulnerability Assessment is considered a priority action within the New York State Department of Environmental Conservation's Climate Smart Communities program and is the first step to conducting a comprehensive climate resiliency vision for the Town. (See pages 2-3) The Town of Caroline became a Bronze Climate Smart Community in 2019 and this report has been part of an on-going process to help promote further climate awareness and resiliency.

The process of compiling this climate vulnerability assessment follows these main steps :

1. Research and compile climate change projections for the Town of Caroline.

2. Meet with members of the community to identify the Town's physical and social assets and discuss how they may be impacted by climate change.

3. Analyze the community's assets in the context of climate change projections to identify potential climate vulnerabilities and create educational tools to disseminate this information to a broad group of Town stakeholders.

4. Collect feedback from various Caroline stakeholders through workshops and surveys to understand how these climate vulnerabilities may impact life in Caroline for residents, businesses and local government.

5. Compile all the information gathered in previous steps into a report and presentation along with guidance on how the Town can address their climate vulnerabilities moving forward.

A goal from the outset was to make this an inclusive process that relied heavily on outreach and feedback from the community. The Town's state of infrastructure is important for the safety of the community, as well as the economic well-being of the entire region, and was factored into this evaluation **(See pages 52 - 64).**

This CVA was completed with the help of community members through organized workshops, formal and informal meetings, and surveys. Our intention has been to make this a community-driven and informed document that highlights both the physical and social vulnerabilities of the Town of Caroline in the face of a changing climate. Community stakeholders, such as local business owners, town committee members, and local activists were integral to the discussion of climate-related vulnerabilities within the municipality. The outreach process then branched out based on the recommendations given by the local community leaders, board members, and officials **(See pages 28 – 39).**

A virtual workshop was hosted by CCE with community members to inform participants of the potential impacts of climate change, including extreme weather and climate-related hazards within the Town of Caroline. Participants were then asked how they saw those climate vulnerabilities impacting their lives and the lives of their fellow residents and businesses. To enhance accessibility, a climate vulnerability

assessment survey was distributed via email, social media, and promotional posters. Interactive maps allowed participants to highlight areas of high vulnerability according to their experience. Through this process, coupled with research into climate change projections for the Town of Caroline we were able to identify both climate vulnerabilities and their possible affects **(See pages 68 – 73).**

In the coming years, Earth's climate is expected to change drastically, due to human-induced climate change, increasing the frequency and intensity of extreme weather events and natural disasters. These can have long-lasting social, cultural, and economic effects **(See page 7).** In Caroline, changing weather patterns increase the chance of flooding, droughts, and heatwaves. This report indicates that Caroline is particularly vulnerable to change in precipitation levels and rising temperatures. Workshop participants selected flooding to be the top vulnerability, with over half the participants reporting that they have experienced property loss or damage as a result of flooding **(See page 71).** Climate projections identify the local communities of Brooktondale, Speedsville, and Slaterville Springs as the areas at the highest threat for flooding, largely due to their proximity to steams and/or water bodies that are prone to flash floods and runoff along with their socio-economic characteristics **(See pages 41-42).** Flooding can also lead to erosion, which can potentially damage essential anti-flooding infrastructure. The concern of erosion is specially focused around Six Mile Creek, where there is evidence of significant erosion along road and creek **(See page 65).**

Droughts are another vulnerability to the surrounding region identified through this process. Even with an expected increase in overall precipitation, extended periods of no precipitation will contribute to the greater likelihood and intensity of droughts. Given the historic seasonal characteristics, particular communities are less equipped to handle a lack of water and extreme droughts **(See page 40-51).** This is expected to affect the region's agriculture, wildland cover/forests, and water supply. Although the Town of Caroline is not a major agricultural hub, agriculture is still an important sector that can have a major impact on the regional economy. Changing weather patterns can lead to significant losses and in the long run, affect the overall supply chain. The current vulnerable farming practices include large scale monoculture and lack of tile drainage **(See page 48).** Like agriculture, changing weather patterns can also have a major effect on the stability of forest life. Increasing temperatures and precipitation encourages non-native species and simultaneously weakens the current plant and tree species in the area. Non-native species pose a direct threat to native plants, wildlife, and human health **(See pages 48-49).** In the context of water supply, droughts pose a major vulnerability to the Town of Caroline because all residents in the Town are on private well water. Increased occurrence, duration, and severity of droughts can lead to a degraded water supply felt across the Town. Notably, the threat can vary from household to household, as those at higher elevations are less likely to have contaminated water than those located downstream **(See pages 49, 64).**

Heatwaves were the last vulnerability identified and assessed by this report. Heatwaves are particularly dangerous for communities not equipped to handle the detrimental effects posed by atypically high temperatures. In general, heat-related morbidity and mortality among vulnerable populations in the State will rise with the projected increase in frequency, intensity, and the duration of Extreme Heat (EH) events. Economic and social minorities would suffer the most, including the elderly, Black and Hispanic individuals, and those without access to air conditioning **(See page 50).** Within the Town of Caroline, many residents may not fit into these categories; racial diversity is low and the median income is rela-

tively stable. However, the town is aging and not increasing in population, which could leave it more vulnerable in the coming years. Additionally, 30% of the Town's population rent their homes, leaving them naturally more vulnerable to heatwaves, given their lack of rights to modify their living environment **(See page 51).**

At present, there is no organization or institution in the Town of Caroline helping to increase overall climate resiliency. This lack of resources has shown to be a disadvantage, as some vulnerabilities can be associated with a lack of community engagement in municipal governance. The Town of Caroline has not adopted a Zoning ordinance, Open Space Plan, or Natural Resource Conservation Plan, which all could increase Caroline's resiliency. A multi-hazard mitigation plan specific to the town of Caroline would also improve resiliency, along with the development of adaptation strategies especially those contextualized to high likelihood events, such as flooding in Brooktondale **(See page 41).** Community engagement and participation can be bettered through the implementation of public surveys and participatory mapping. **(See page 36, 76-77).** To improve Caroline's resiliency to flooding and floodplains, subdivision or zoning ordinances may encourage safe development in floodplains, protection of riparian buffers, as well as lower population density in floodplains. Additionally, a floodplain management plan, capital improvements plan, and economic development plan could help address climate resiliency **(See page 76).** To date, Caroline does not currently have any formal plans in place in case of emergency.

In accordance with the Climate Smart Communities program, we suggest that the Town of Caroline create task force to review climate vulnerabilities strategies, which may include the creation of an Emergency Response Plan, Short and Long-term Recovery Plan, Heat Emergency Plan and Evacuation Plan **(See page 75-76).** Caroline could prepare for severe weather incidents by establishing, or working with other municipalities to establish, an emergency operations center, a special needs registry, or a cooling center program **(See page 76).** Developing a Climate Action Plan would also be beneficial to the overall resiliency of the town, as well as joining FEMA'S Community Rating System to strengthen floodplain properties against floods while offering discounts on flood insurance premiums **(See page 77).** For more detailed information, please reference the Town of Caroline Climate Vulnerability Assessment.

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SECTION 1:

INTRODUCTION

The Town of Caroline Climate Vulnerability Assessment is a procedure to conduct research, outreach, and analyze data specifically around climate change and its impacts on the regional and local community. As the Town of Caroline, Tompkins County, and New York State brace for an increasingly unpredictable climate, extreme weather patterns, and rising temperatures due to global warming, it is necessary to create an action plan that can help local communities better understand their circumstances, how their present living environment can change over time, and prioritize what needs to occur to increase community resiliency to these extreme patterns. In other words, this document is meant to provide a roadmap for the Town of Caroline and its surrounding region on how to increase overall resilience and, ultimately, become a more sustainable community in the long run. There are many ways a community can increase resilience, such as rebuilding or improving existing infrastructure, conducting community education on climate change, shifting to a renewable and green economy, investing in innovative technology and green infrastructure, participating in regional or national programs that help guide communities on ways to increase community resilience, or developing long term community plans to guide municipal and community efforts in a strategic manner to streamline the process of intergovernmental, inter-municipal, inter-community, and inter-institutional collaboration.

In an effort to help the community better understand their strengths and weaknesses, this vulnerability assessment has taken place to help the community better meet its resilience and sustainability goals as a community. This exercise is also part of the Climate Smart Communities program and has been planned and designed in accordance with the guidance provided by the New York State Department of Environmental Conservation (NYDEC). A significant amount of research and data provided in this document is directly from the New York State ClimAID report originally developed in 2011 to help prepare the state and its municipalities for the projected changes expected to occur over the coming century.

The overall intent of the report is to compile what needs to be done by the community to prepare for increasing occurrences of extreme weather events. While the Tompkins County All Hazard Mitigation Plan (also quoted in this document) intends to identify existing vulnerabilities and community preparedness issues identified in Caroline and Tompkins County, the overall goal of the All Hazard Mitigation Plan is to address all hazards rather than just those related to climate and environment. Additionally, the Hazard Mitigation Plan takes an all-municipality approach to the vulnerability assessment process. While it is important to look at community vulnerabilities from an interconnected larger municipal level, those multi-municipal vulnerability identifications need to be done using a systematic and static assessment approach to climate and community vulnerabilities in orderto cross-reference and compare the different municipal vulnerabilities that make up the county-wide general vulnerabilities.

While a general formatted methodology is used for the process, the hazard identification process itself is significantly modifiedand influenced by the community input, which for some, might not qualify as an objective document. The intent is to integrate the community priorities and objectives into the climate vulnerability identification process and create a list of priorities that can be further processed and analyzed for the community's future development plans. Furthermore, it is highly discouraged to use the vulnerabilities identified in this assessment for other communities, even if they are close in geographic proximity. Social and political char-

acteristics can significantly influence the outcome of the vulnerability identification process, and therefore the results are specific to the Town of Caroline. However, to help support future community efforts to conduct their own vulnerability assessment, this report has laid out the process in full detail. The process and methodology used in this document for identifying community vulnerabilities and constructing climate vulnerability-based community goals and objectives are adoptable into future community climate vulnerability assessments, and thus can be an impetus to increase community-centered resilience and sustainable development.

Caroline Climate Vulnerability Assessment

The Caroline Climate Vulnerability Assessment is part of the Climate Smart Communities Program and is part of a larger effort to develop a town-wide climate action plan and resilience vision. As of 2019, the Town has started working on updating its comprehensive plan which was previously updated in 2006. As the Town has seen an increase in the number of extreme weather events such as flooding, severe winds, extreme temperatures, and droughts, the community aims to update its comprehensive plan to encourage sustainable and resilient development. Given the Town of Caroline's relatively rural characteristics, the community is well engaged and has been active in climate resilience and greenhouse gas reduction programs, even though the prior municipal plans and documents do not necessarily introduce and discuss topics such as climate change. However, while this continued effort has had a positive impact on the community, the overall work has not been enough to mitigate community vulnerabilities due to climate change. This climate vulnerability assessment aims to provide that additional guidance for the community as well as municipal operation.

This assessment consists of 4 phases. The first is an introduction to the community and geographic characteristics. The second is to discuss the historical climate trends as well as climate projections on a local, regional, state, and national level. The third is the climate vulnerability assessment itself which discusses the assessment methodology used, details on each step taken, and finally the results of the comprehensive assessment. The fourth and final step is to create a priority list of stated vulnerabilities based on the assessment and to review potential tools and solutions to the priority vulnerabilities in the community. While this list is meant to review and analyze the vulnerabilities that exist in the Town of Caroline, the entire process does not provide detailed information regarding each step the community needs to take to mitigate each vulnerability. Rather, as originally stated, this process is meant to identify the vulnerabilities in the community and provide a list of priority actions in need of addressing. Further steps to develop project plans can be created following this vulnerability assessment. Ultimately, this plan can provide the Town a better understanding of what projects and plans the Town needs to prioritize, as the number of projects around maintenance and improvement of municipal infrastructure and technology can otherwise be limitless. Thus, this vulnerability assessment was conducted not just to understand the vulnerabilities in the community, but also to suggest the best practices to utilize existing resources on current conditions within the municipality.

Town of Caroline

The Town of Caroline is a small Upstate New York community located in southeastern Tompkins County nestled in the Central New York Finger Lakes region. As a town that is characterized as

having the convenience of closeness to Ithaca, NY yet at the same time an area with abundant nature, the municipality has attracted many people over the years who were looking to live in a community that had great access to the outdoors. However, with overall changing weather pattern, much of the Town has struggled to adapt, especially due to its sparsely populated characteristics, it can be difficult to pinpoint a specific geographical location considered the center of the Town. This climate vulnerability assessment aims to help by understanding the vulnerabilities and creating specific areas of interest that might need particular attention over the coming years. As the Town has been actively involved in increasing climate resilience, investing in renewables and green technology, this climate vulnerability assessment is in coordination with this effort to facilitate the process of climate-smart planning and development across the municipality and beyond.

Social Economic

According to the US Census, approximately 3,282 people live in the Town of Caroline, a 12% increase since 2000 which reported a total population of 2,910. There are 1,161 households in the Town and the population density is 52.9 people per square mile. In terms of demographics, Caroline is 93% White. African American residents account for 3.09% of the population; 0.5% identify as Native American, 0.8% as Asian, and 2% from mixed race. As of 2010, 33.2% of the households in Caroline have children under 18, 50.9% consider themselves married or in domestic partnership while 35% consider themselves to be single or live as non-families.

The Town's age range percentage breakdown:

0-18:27.1%

18-24: 6.6%

25-44:28.5%

45-64: 27.9%

65 and older: 9.9%

Approximately 8% of the population is below the poverty line while the median income as of the 2000 census is $51,963 (in further sections 2010 data is used). Out of those individuals, 7.6% are under 18 and 3.1% are 65 and over. As previously mentioned, most residents who live in the Town of Caroline commute by car to work, most to urbanized areas like Syracuse, Binghamton, or Ithaca.

The Town of Caroline has an elementary school located near Slaterville Springs and is served by the Ithaca City School District, Dryden School District, Newark Valley School District, as well as the Village of Candor School. The Brooktondale Baptist School, located in Brooktondale, NY existed until 2002 and continues to operate in present times as a parish.

Geography

The Town of Caroline, located in the southeast corner of Tompkins County, encompasses 54.89 square miles, 54.76 square miles of land, and 0.13 square miles of water. There are several communities within the Town, including Brooktondale, Slaterville Springs, and Speedsville. The Town is characterized by its rolling hills and steep topographical characteristics. To the east, the Town

borders with the Tioga County. In the central and southern part of the Town, the community has especially complex water systems that join and separate, and often create flooding. Because of the variability in geography, the Town needs to figure out how to address existing land use issues through regulation and policy and encourage climate smart planning.

Environment

The environment in Caroline has historically been humid inland continental weather. The Town is especially used to getting high levels of snow due to lake effect precipitation from Lake Ontario. However, with the increased temperatures due to climate change, these existing characteristics and seasonal patterns are expected to change, and is the reason for this Climate Vulnerability Assessment.

SECTION 2:

CLIMATE CHANGE

Climate Change is a major issue the Town of Caroline and the rest of the world is struggling to understand and prepare for. The following sections will discuss the overall patterns seen and projected. Based on that information, the consequences for the Town of Caroline and the surrounding region will be discussed.

World Trends

Climate Change is a problem felt across theworld; from melting glaciers in the north, to increasing occurrences of extreme weather events in the south, this world-wide phenomenon has not just led to changing weather patterns, but also social and economic issues. In general, climate change has beena global phenomenon throughout Earth'sexistence and has led to many events that have caused significant disruption to the environment as well as animal and plant species. According to NASA, Earth's current climate change is primarily due to human activity since the mid-20thcentury, whereas prior events were mainly attributed to very small variations in the Earth's orbit that changed the amount of solar energy our planet receives (NASA 2020).

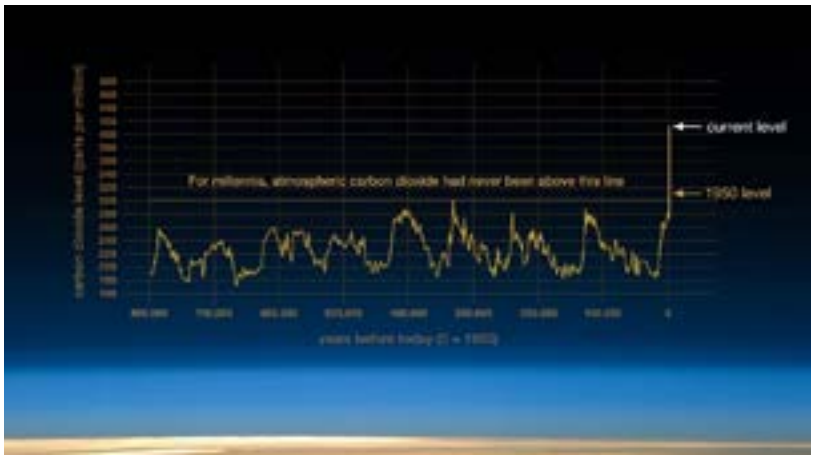


Figure 1: CO_2 Levels over the earth's history; NOAA

According to scientific studies conducted by NASA, much of the current climate change can be attributed to the increase in greenhouse gas emissions, especially Carbon Dioxide or CO2. Carbon Dioxide is a greenhouse gas that traps heat within the atmosphere and is primarily created through the combustion of fossil fuels to create energy. With the earth's population increasing at unprecedented rates, it comes as no surprise that the amount of greenhouse gas has also been increasing, both in developed and developing countries. The amount of pollution and greenhouse gasses has been increasing at an exponential rate and has led to environmental degradation and species extinction.

As Figure 2 depicts, a significant cloud of carbon dioxide can be detected around the continental U.S. which shows that human activity is likely a driving factor to increased carbon emissions. In addition to the burning of fossil fuels, other major sources of carbon dioxide can be attributed to deforestation which releases sequestered carbon dioxide into the air and can be accounted for approximately 20% of the global carbon emissions. While there are massive carbon sinks that can hold major quantities of carbon, such as the Atlantic and the Pacific Ocean, these storages are not able to keep up with the increased emissions. Land use changes, human activity, and global economic growth are all leading to significant changes to the Earth's atmosphere and climate.

As a result of increasing temperatures, nations across the planet have seen drastic changes

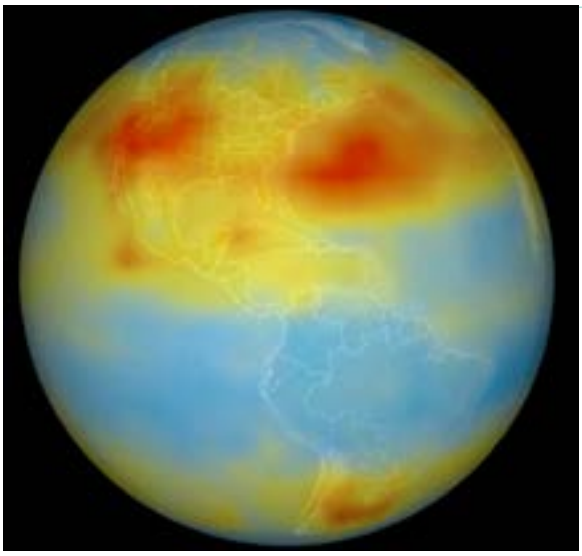


Figure 2: NASA instrument spacecraft high carbon accumulation detection map

to their local environments over the past half-century. Since 1969, the top 2,300 feet of water in the ocean has seen an overall increase in temperatures of about 0.4F degrees, which can have a detrimental effect on fragile ocean ecosystems (Levitus, et al. 2017). With warming oceans and surface temperatures, the arctic glaciers have been melting, and, as a result, sea levels have been rising at unprecedented levels. Coastal communities that are already close to sea level such as New York, Venice, Ho Chi Minh City, Shanghai, Mumbai, and others are currently threatened by sea level rise and flooding. In addition to sea level rise, projections show an increase in extreme weather, with an increase in extreme heat and a decrease in extreme cold weather. According to the U.S. Global Change Research Program, the overall amount of rain is expected to increase as temperatures rise. As the earth's atmosphere heats up, it collects, retains, and drops more water, changing weather patterns and making wet areas wetter and dry areas drier. Higher temperatures worsen and increase the frequency of many types of disasters, including storms, floods, heatwaves, and droughts. This can have devastating effects in communities not prepared for climate change, especially in developing countries where the lack of flood control infrastructure makes waterside and coastal populations especially vulnerable.

In addition to the increase in extreme weather events, the cascading social, economic, and health related effects are also of major concern. According to the World Health Organization, "climate change is expected to cause approximately 250,000 additional deaths per year" between 2030 and 2050. As global temperatures rise, so do the number of fatalities and illnesses from heat stress, heatstroke, and cardiovascular and kidney disease. With the increasing heat and contaminated natural resources, there is an expected rise of global pandemics like Zika Virus or Avian Influenza. As a result of the increasing deaths and diseases as well as the increased number of extreme storm events, the economy would also suffer significantly and cause major disruption to communities and lead to increased human migration and displacement. Additional effects with increas-

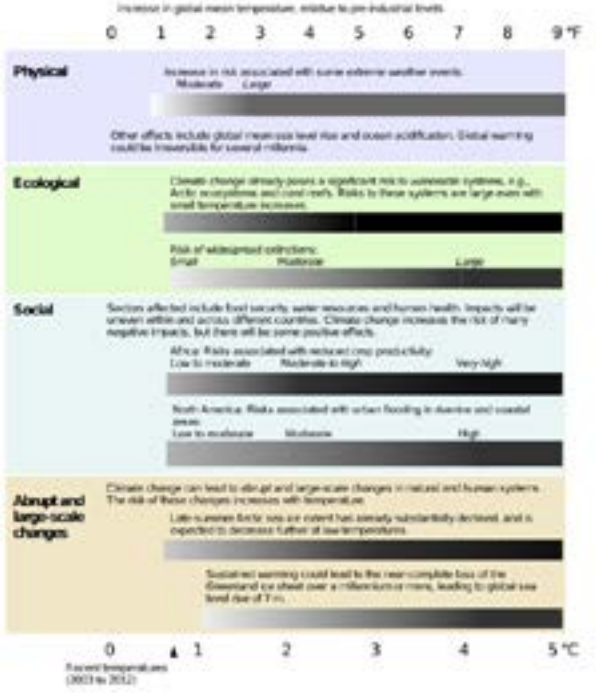


Figure 3: Effects from climate change based on average global temperature increase

ing temperature are available in Figure 3. In response to these projected trends, it is necessary for leading countries and economies such as U.S., China, and the EU to coordinate efforts to mitigate the projected devastating effects of climate change.

National Trends

In the United States, climate change vulnerabilities can range from severe droughts and wildfires on the West Coast, to sea level rise in major coastal cities, or riverine flooding for inland states. While historically, the Southern states have experienced hotter weather with annual hurricanes and tornadoes, Northern states dealt with colder and wetter weather and thus extreme precipitation events. However, with the average temperature increasing due to climate change, these historical trends have been, and are likely to continue to change. Figure 4 depicts the slow change in growing zones in the U.S. Comparing the 1990 map with the 2006 map, there is a noticeable change in warmer zones slowly creeping up north. For example, in the state of Texas, the 1990 USDA Plant Hardiness Zones ranged from six to nine across the state. Sixteen years later, in 2006, the new hardiness map included only zones seven through ten, with the vast majority of the state in zones eight and nine as opposed to seven and eight in 1990.

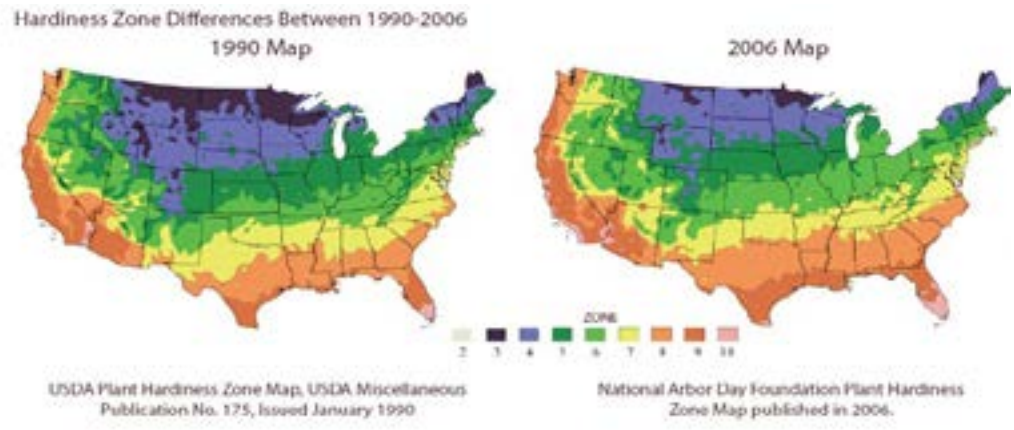


Figure 4: USDA Hardiness Zones Change 1990-2006

Figure 5 shows the annual max temperature change between 1981-2010 and 2050-2074. The general trend shows that there is an expected increase for the average annual maximum temperature between 8- and 10- degrees Fahrenheit. While there are other areas not expected to increase as much as 8 and 10 degrees, overall, the entire nation is expected to increase a minimum of 5 degrees, according to the National Oceanic and Atmospheric Association (NOAA). The seasonal trend line depicted in Figure 6 shows the average seasonal temperature change between 1981-2010 and 2050-2074. The projected season line shows a consistent increase in monthly temperature of about 5 degrees.

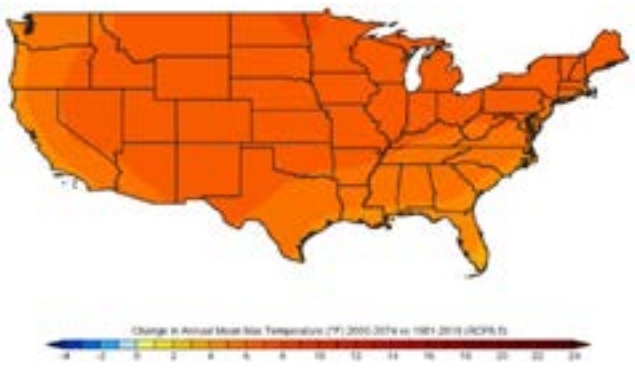


Figure 5: Annual Max Temperature Change

An important piece of information to note regarding national and global climate projection scenarios is the projection models used. The two most commonly used climate projection scenarios are the Representative Concentration Pathways, or RCP 4.5 scenario and RCP 8.5 scenario, both of which show how temperature increase can affect us over the next century (shown in Figure 7), but also how human activity and action can influence the final outcome and fate of this planet. These global climate models represent the planet as millions of grid boxes and then solve mathematical equations to calculate how energy transfers between those boxes using the laws of thermodynamics. These models of how energy cycles through all parts of the planet can be used to estimate dozens of environmental variables (winds, temperature, moisture, etc.). The models are tested by simulating historical conditions and then matching the results to historical observational records. If the models can adequately recreate the past, they are then run forward in time to predict what may happen in the future. The two model definitions are as follows:

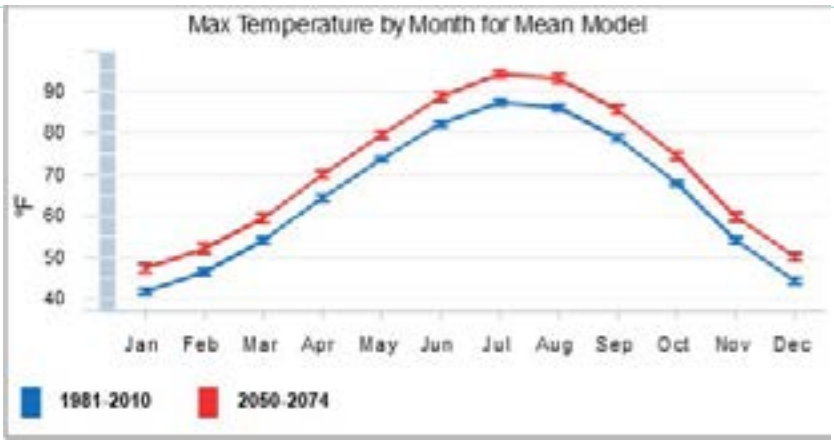


Figure 6: Average seasonal temperature change between 1981-2010 and 2050-2074.

RCP 4.5: The RCP 4.5 scenario is a stabilization scenario, which means the radiative forcing level stabilizes at 4.5 W/m2 before 2100 by employment of a range of technologies and strategies for reducing greenhouse gas emissions. In other words, this is a scenario in which overall human generated greenhouse gas emissions hit a peak by mid-21st century and begin to level off over the second half of the century.

RCP 8.5: Also known as the Climate Change Disaster Scenario, the radiative forcing level reaches 8.5 W/m2 characterized by increasing greenhouse gas emissions over time representative for scenarios in the literature leading to high greenhouse gas concentration levels. This model assumes that the global greenhouse gas emissions will continue to rise over time, as the world

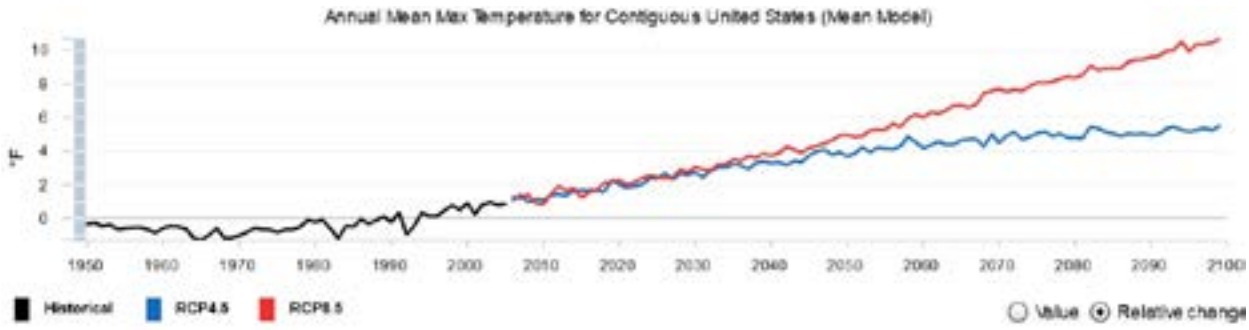


Figure 7: RCP Temperature Increase Trends USDA

population and development increases. Under RCP 8.5, the world's average temperature would rise by 4.9 degrees Celsius, or nearly 9 degrees Fahrenheit, which can have catastrophic consequences to all existing life on earth.

NOTE: While there is are many other different scenarios such as the RCP 2.6 and 6.0 scenario, for simplicity sake, this study will use 4.5 and 8.5 as default scenarios, as they are projections most commonly used across scientific studies. Also note that all of these scenarios are based on the timeline between 2006 and 2100.

As previously mentioned, the increasing temperatures do not just mean warmer winters and hotter summers, but also a general change in the amount and intensity of precipitation. According to the USDA, the overall amount of precipitation is expected to increase over time. As Figure 8 depicts, in a world that follows the RCP 8.5 model, overall precipitation is expected to increase in the eastern part of the continental United States, while overall precipitation can expect to decrease in the southwestern states. When comparing the seasonal trend lines in Figure 9, the consistency is less clear, though the general temperatures between the two time periods are still differentiable.

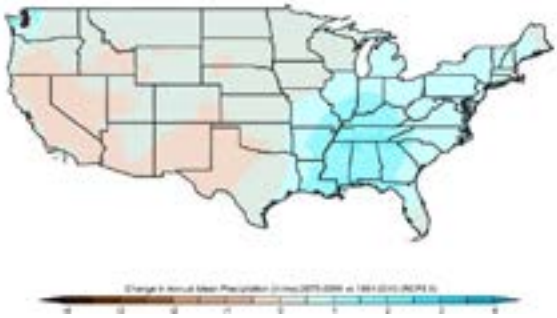


Figure 8: Precipitation Projections

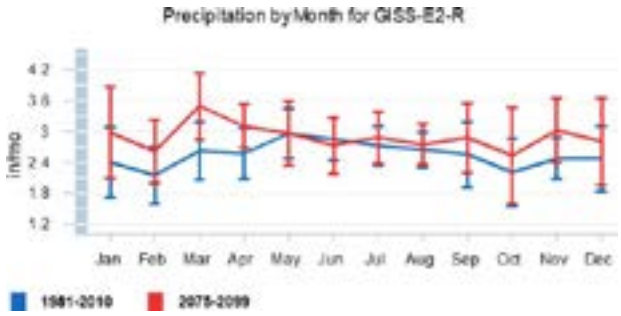


Figure 9: RCP 8.5 precipitation scenario seasonal trends

In the case of RCP 4.5, the general national precipitation patterns depicted on Figure 10 and seasonal trends on Figure 11 which show that, if overall greenhouse gas emissions reduced over time, the overall precipitation increase observed will be minimal in the northeast region, though the northwestern, Midwest, and southern states will still experience an increase in precipitation increase, when comparing 1981-2010 to 2075-2099. When comparing the seasonal trends, the overall change between years is less significant, though the projection is still higher than the historical record. As increasing precipitation is inevitable, understanding the implica-

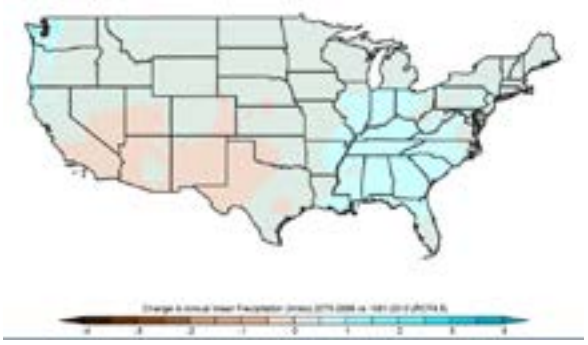


Figure 10: RCP 4.5 Precipitation Scenario

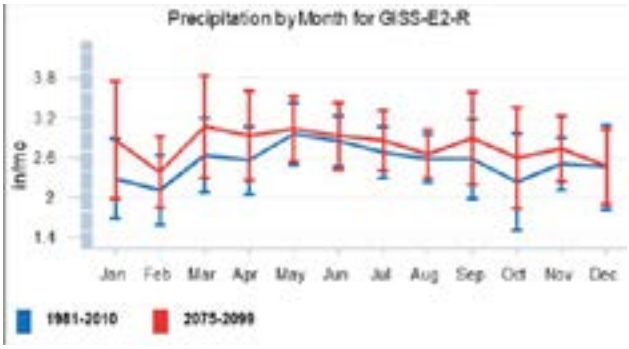


Figure 11: RCP 4.5 precipitation projection seasonal trends

tions of this increase and developing mitigation measures to decrease the amount of damage caused by extreme precipitation can be beneficial to all communities throughout the United States. Furthermore, the amount of snow in northern states is likely to decrease while the overall amount of rain is likely to increase over time. It is important to understand that these are national climate projections, and while climate change is by no means a regional problem, conditions and patterns can vary significantly between regions and within each state.

In general, while the amount of precipitation is expected to increase, the type of precipitation that is likely to increase is short but intense rain/ snow events (Levitus, et al. 2017). This trend will likely also include droughts or long periods where there is no precipitation. This in turn will result in land that dries up the surface of the ground, inhibiting the ability for water absorption by the soil and will subsequently alter the overall land cover characteristics over time. While this pattern will be discussed further in the state/regional section, this trend is notable because, while the increase in precipitation may appear modest in the above maps, the amount of runoff produced, and thus flooding can increase significantly, causing erosion and waterbody/ riverine and storm water overflow.

State Trends

Introduction to New York State and its weather characteristics:

Due to the large geographical area New York covers as a state (27th largest in the USA), the weather characters and patterns can vary greatly. These weather patterns are not just due to general temperature differences between north and south, but also due to influence from the existing water bodies as well as the topographical characters that can significantly alter the wind direction, humidity, and temperature. On average, New York State has a humid continental climate. This is found to be more so in Upstate New York, while downstate, or the New York City and Lower Hudson's weather characteristics are a Humid Subtropical climate zone. While winters in Upstate New York can have constant sub-zero temperatures, the lower Hudson and NYC Metro usually does not typically get below freezing temperatures.

Nor'easters occur along or close to the coasts, whereas lake effect snow from the Great Lake affects communities lying westward. Many urban centers besides New York, such as Buffalo, Rochester, and Syracuse also deal with increased heat waves due to the existing concrete and cement infrastructure. At the same time, smaller communities might also be experiencing a localized heatwave in the center of their town.

Changing Weather Patterns Across State:

According to ClimAID, the expected impacts from climate change are as follows:

> *Climate change is already affecting and will continue to affect a broad set of activities across New York State. Its geographical and socioeconomic diversity means that New York State will experience a wide range of effects. There will be opportunities to explore new varieties, new crops, and new markets associated with higher temperatures and longer growing seasons. New York's relative wealth of water resources, if properly managed, can contribute to resilience and new economic opportunities. On the other hand, higher temperatures and increased heat waves have the potential to*

increase fatigue of materials in the water, energy, transportation, and telecommunications sectors; affect drinking water supply; cause a greater frequency of summer heat stress on plants and animals; alter pest populations and habits; affect the distribution of key crops such as apples, grapes, cabbage, and potatoes; cause reductions in dairy milk production; increase energy demand; and lead to more heat-related deaths and declines in air quality. Projected higher average annual precipitation and frequency of heavy precipitation events could also potentially increase the risks of several problems, including flash floods in urban areas and hilly regions; higher pollutant levels in water supplies; inundation of wastewater treatment plants and other vulnerable development in floodplains; saturated coastal lands and wetland habitats; flooded key rail lines, roadways, and transportation hubs; and travel delays. Sea level rise will increase risk of storm surge-related flooding, enhance vulnerability of energy facilities located in coastal areas, and threaten transportation and telecommunications facilities.

Across the varied geography of New York State, many individuals, households, communities, and firms are at risk of experiencing climate change impacts. Some will be especially vulnerable to specific impacts due to their location and lack of resources.

As a result, the three climate/weather related effects are flooding, droughts, and heatwaves, which are evident across all of New York State. It is important to clarify and establish the direct and indirect effects of climate change before further identifying links between climate change and vulnerabilities.

- Direct effects of climate change used in this assessment can be known as direct weather changes and their physical effects. Such examples can be those already mentioned such as increased precipitation, increased temperatures, and increasing extreme weather events. These are associated with weather patterns. Their physical effects are the short term and direct product created as a result of a changing weather pattern. For example, flooding, droughts, snow and ice accumulation, and erosion which are not weather patterns in and of themselves, but rather the short-term direct aftereffects of weather changes.
- Indirect effects can be more complexly related to and might not solely be due to climate change. Because of their complexity they will not be addressed in this vulnerability assessment. Such effects can be associated with more long-term effects of climate change and can be things such as change in land cover/increasing invasive species, increasing foreign pests and insects, public health problems, water contamination, war/civil conflict, and increasing refugee crisis, and other long-term phenomena that can be related to climate change, but are just too unpredictable and complex to address in a report and community workshop series.

Changing Weather Patterns by Region (NYSERDA): Dominant Climate Hazards by region (shown in Figure 12)

- North Western NY (Region 1)
  This region will experience inland flooding as well as additional snow precipitation due to the increased temperatures and moisture in the air and lake effect snow. The region

should also prepare for flash flooding due to the overall nature of the topography.

Figure 1.1 ClimAID climate regions. Circles represent meteorological stations used for the climate analysis

Figure 12: NYSERDA Service Region

- Hudson Valley (Region 2)
  This region will experience coastal flooding as well as increased temperatures/ heat waves that will not just threaten existing ecosystems but also human health.

- Southern Tier (Region 3)
  The majority of inland flooding occurs in the Southern Tier region with specific attention to the city of Binghamton and its surrounding communities. In the 2006 flood, 3,350 parcels with an aggregate value of $560 million flooded. (The actual property losses were much less than the total value of property within the flood zone.). At the same time, this area is significantly underfunded and does not have enough resources to combat climate change and come up with resiliency measures.

- NYC (Region 4)
  Extreme urban heat weaves will affect this region, as the temperature increases over the years. This will not just have a toll on public health but also the existing electrical power grid that is usually in the highest demand and at maximum capacity during the summer, as this is when most people are using the air conditioner, which consumes a great deal of energy. In addition, this region will experience increased coastal flooding due to sea level rise which will not just have a toll on the existing infrastructure but will also threaten the existence of the many communities living close to the sea.

- East Hudson and Mohawk River Valley (Region 5)
  Similar to the Hudson Valley, this region will not just experience inland flooding but also coastal flooding as well which will not just affect the communities living close to waterbodies, but also in regions that lack vegetation and can experience increased flash floods.

- Watertown (Region 6)
  This region is likely to experience coastal flooding as well as increased winter precipitation. While the precipitation itself will be creating increased flooding frequencies, the general weather fluctuation with the Great Lakes will also lead to an increase in tidal patterns.

- Indian Lake (Region 7)
  This region will likely experience increased winter precipitation.

Overall, projections show that New York State will see an increase in precipitation (see Table

Table 1: Baseline climate and mean annual changes for the 7 ClimAID regions

		Baseline[1] 1971–2000	2020s	2050s	2080s
Region 1					
Stations used for Region 1 are Buffalo, Rochester, Geneva and Fredonia.	Air temperature[2]	48°F	+1.5 to 3.0°F	+3.0 to 5.5°F	+4.5 to 8.5°F
	Precipitation	37 in	0 to +5%	0 to +10%	0 to 15%
Region 2					
Stations used for Region 2 are Mohonk Lake, Port Jervis, and Walton.	Air temperature[2]	48°F	+1.5 to 3.0°F	+3.0 to 5.0°F	+4.0 to 8.0°F
	Precipitation	46 in	0 to +5%	0 to +10%	+5 to 10%
Region 3					
Stations used for Region 3 are Elmira, Cooperstown, and Binghamton.	Air temperature[2]	46°F	2.0 to 3.0°F	+3.5 to 5.5°F	+4.5 to 8.5°F
	Precipitation	38 in	0 to +5%	0 to +10%	+5 to 10%
Region 4					
Stations used for Region 4 are New York City (Central Park and LaGuardia Airport), Riverhead, and Bridgehampton.	Air temperature[2]	53°F	+1.5 to 3.0°F	+3.0 to 5.0°F	+4.0 to 7.5°F
	Precipitation	47 in	0 to +5%	0 to +10%	+5 to 10%
Region 5					
Stations used for Region 5 are Utica, Yorktown Heights, Saratoga Springs, and the Hudson Correctional Facility	Air temperature[2]	50°F	+1.5 to 3.0°F	+3.0 to 5.5°F	+4.0 to 8.0°F
	Precipitation	51 in	0 to +5%	0 to +5%	+5 to 10%
Region 6					
Stations used for Region 6 are Boonville and Watertown.	Air temperature[2]	44°F	+1.5 to 3.0°F	+ 3.5 to 5.5°F	+4.5 to 9.0°F
	Precipitation	51 in	0 to +5%	0 to +10%	+5 to 15%
Region 7					
Stations used for Region 7 are Warrakenna, Indian Lake, and Peru.	Air temperature[2]	42°F	+1.5 to 3.0°F	+3.0 to 5.5°F	+4.0 to 9.0°F
	Precipitation	39 in	0 to +5%	0 to +5%	+5 to 15%

1). As previously noted in the national climate trends, overall precipitation is likely to become more intense and sporadic. As the climate changes and weather becomes hotter, the likelihood of intense tropical storms and heatwaves that have the ability to cause significant damage to a community rises. Historically, such unpredictable weather patterns have been most common in Southern states. However, as those weather patterns in the South have been seeing an increased intensity in tropical storms and hurricanes, the Northeast region and New York State has seen a significant increase in intense precipitation events. According to the Cornell University Department of Climatology, 100-year storms, or storms that used to have a 1 percent chance of occurring in a given year, have significantly increased, as much as doubling in occurrence since 1960 (Center 2018). Figure 13 depicts the overall extreme precipitation increase in New York State over the next century. As the graphics depict, the average increase in 100-year floods is expected to increase by approximately 25% between 2010 and 2100.

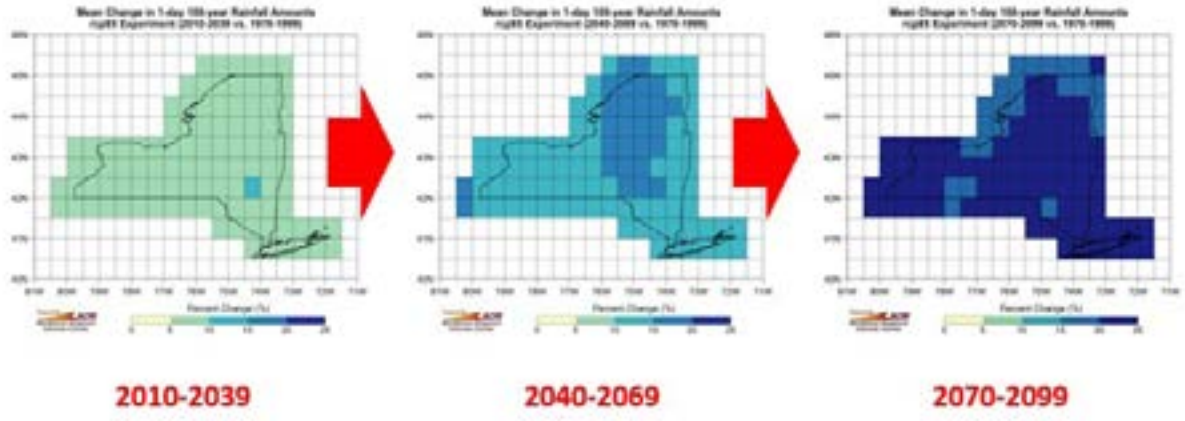


Figure 13: Increase in 100-year storm events

Seasonal Change and Ecological and Social Vulnerability in NYS

At the same time, as the amount of extreme precipitation increases, the number of droughts is also expected to increase. This pattern is likely caused by the increasingly long warm months. According to the New York State Department of Environmental Conservation, the average season for New York State has and will continue to change over the years. The summer months will likely increase in length and lead further into the fall season (Figure 14) . The spring season would then arrive earlier which would cause a significant shortening of the snowy months. This trend is especially concerning to farmers who are not resilient to the changing climate patterns and can be severely affected by significant seasonal changes.

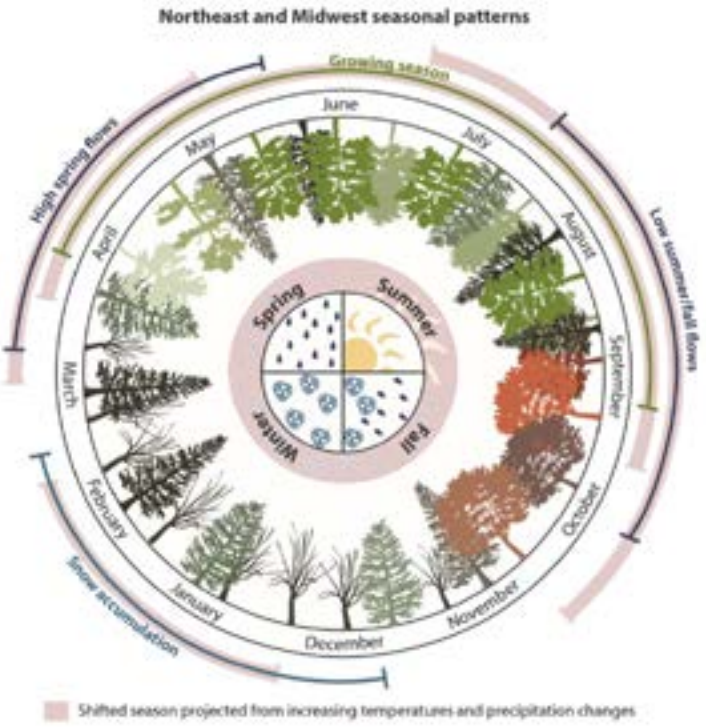
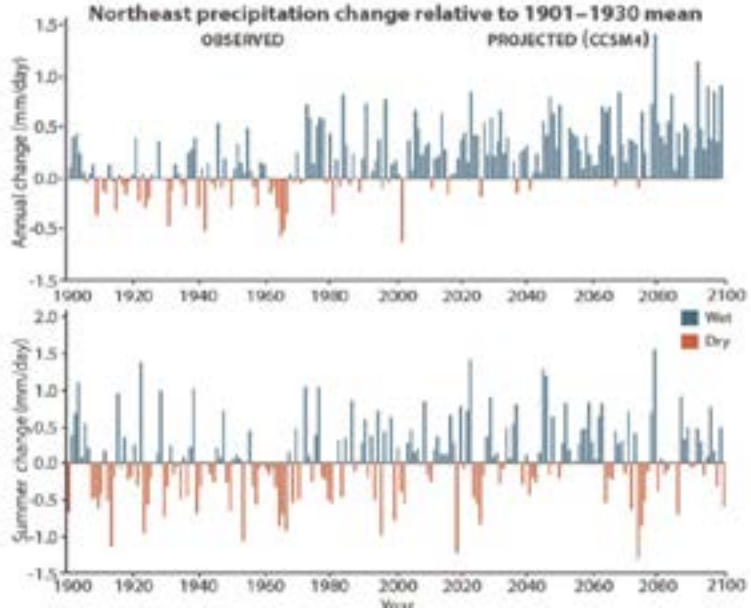


Figure 14: Seasonal Change (DEC)

As extreme precipitation becomes more common, the volume of precipitation in a given time increases (Figure 15). Thus, when considering total volume, the amount of precipitation will be significantly higher than historical records. However, when considering the total annual number of days with constant rain, these overall numbers are likely to decrease, leading to extended periods of no precipitation. During those times of non-wet days, droughts and water shortages are likely to occur more often. Increased incidents of contaminated groundwater, landslides, flooding, and ground erosion will likely result from these inconsistent precipitation patterns. Additionally, temperature increases will also contribute to more frequent drought events due to the higher evaporation rate of water from soil and waterbodies.



Due to the current ecological and environmental characteristics in New York State is dependent upon the historical cold and wet northeastern temperatures, climate change will significantly modify the existing natural environment.

Figure 15: Precipitation intensity projections for North East

Some natural resources that affected by this change include (Centers 2019):

Northeastern Mixed Forests: Much of the northeastern forests are not well adapted to the projected change that will occur over the next century. Droughts in particular are a major hinderance to the existing New York forests, especially those located in the northern Adirondack region. While soils are the primary source of nutrients for trees and vegetation, without adequate water supply, existing soil characteristics can change quickly, depriving trees of necessary water and nutrition in order to survive. The dry soil and weakened tree root also lead to potential risk of erosion and landslides. Projections show that the range of economically important tree species, like sugar maple, will shrink within the U.S. as their preferred climate shifts north. Warmer temperatures will also lead to increased outbreaks of forests pests and pathogens, including Hemlock Woolly Adelgid. Warmer winters and reduced snow cover result in higher deer populations and greater damage to understory layers.

Global Waterfowl Population: The Prairie Pothole region in New York State is one of the most important and largest (50-80%) breeding areas for continental duck breeding. Climate models project increased drought conditions for this region, resulting in northward shifts in breeding distributions, lower reproduction, higher mortality, and dramatically reduced populations across the rest of the country.

Coastal Populations: As previously mentioned coastal communities such as those who live in the lower Hudson Valley, New York City, and Long Island are at significant risk to sea level rise. Sea level rise threatens freshwater aquatic ecosystems are threatened by sea level rise; as saltwater enters into freshwater territory, the existing environment drastically changes, which in turn can have a cascading effect of the surrounding communities that rely on the existing ecosystems. Changes in the delivery of freshwater and nutrients to coastal waters will also affect the timing, magnitude, and strength of mixing (stratification), and likely increase hypoxia (low oxygen) events that can have devastating consequences on critical habitats.

Drought Sensitive Habitats: These habitats can include freshwater waterbodies, wetlands, vernal pools, etc., and are considered highly productive areas within the environment. Many species that are already vulnerable to existing environmental damages are further susceptible to increasing temperatures and reduced water availability. These two factors may have the potential to influence the timing of important ecological events, causing birds to migrate sooner or plants to bloom and leaf out earlier. The result is a mismatch between food availability and key species that could create further destruction.

Infrastructure

Ecological and environmental vulnerabilities are only some of the challenges faced by communities and ecological resource in New York State. Other vulnerabilities in the state and across the nation include outdated and crumbling infrastructure. According to the U.S. Army Corps of Engineers, the United States received a D+ in its infrastructure maintenance, which was the same grade the country received as in 2013. In comparison, New York State received a cumulative grade of a C+, further details on the grade are available in Figure 16. Discussion of regional and community infrastructure related topics takes place in further sections.

Figure 16: New York Infrastructure

Regional and Local Climate Trends

Town of Caroline and its surrounding communities has historically been subject to moderate to high levels of snowfall and precipitation. This is primarily due to warmer continental air from the south clashing with the northern polar air from the north. Historically, the region experiences all four seasons, though with climate change this is likely to change. During the spring months, the region experiences moderate levels of precipitation, either in snow or rain form with an average of 2 inches a month. In the summer months where the amount of rain increases, averaging approximately 7 inches of rain every month. Average rainfall for the Town of Caroline is an annual total of 36 inches per month, while the Town sees approximately 70 inches per year of snowfall.

These historical trends are changing and will likely continue to do so as weather patterns become more extreme and torrential downpours become more common in the region. Figure 17 depicts the overall seasonal change and its projections in regards to precipitation. From 1901-1930 the maximum monthly amounts of precipitation topped off at approximately 90mm in July. Between 1990 and 2010 the maximum peaks increased to top off at approximately 110 mm, also in July. This comparison depicts how overall amounts of precipitation has increased over time. While this precipitation patterns might be consistent across the county, the overall historical trends show that overall amounts of rain have increased over time. As previously noted, the overall precipitation increases and projected further instances of extreme precipitation events are correlated.

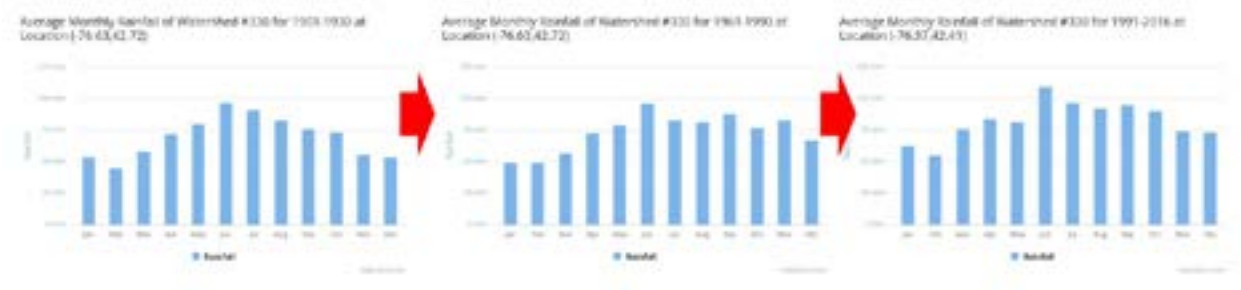


Figure 17: Historical Precipitation Records in Tompkins County

In comparison to the historical observations of precipitation, ClimAID expects the number of annual heat wave occurrences to almost triple between 2020 and 2099, and extreme precipitation to double over the 21st century (Table 2). Additionally, as the amount of extreme precipitation increases, the number of drought days are also expected to increase. As described above, while overall projections show an expected increase of the overall amount of precipitation between now and 2100, there will also be an increase in the number of extended droughts. One of the more notable droughts in recent history was the 2016 drought which saw a county-wide water

Table 2: Projected precipitation and heat waves from ClimAID

Elmira (Region 3): Full range of changes in extreme events: minimum, [central range*], and maximum

	Extreme event	Baseline	2020s	2050s	2080s
Heat Waves & Cold Events	Number of days per year with maximum temperature exceeding				
	90°F	10	11 [14 to 18] 25	15 [21 to 33] 45	19 [26 to 58] 70
	95°F	1	2 [2 to 4] 7	2 [4 to 10] 18	4 [7 to 24] 38
	Number of heat waves per year*	1	1 [2 to 3] 3	2 [3 to 4] 5	2 [3 to 5] 9
	average duration	4	4 [5 to 5] 5	4 [4 to 5] 5	4 [5 to 5] 7
	Number of days per year with min. temp. at or below 32°F	152	135 [122 to 134] 145	86 [106 to 122] 168	68 [87 to 114] 134
Intense Precipitation	Number of days per year with rainfall exceeding				
	1 inch	5	5 [5 to 7] 8	5 [6 to 7] 9	5 [5 to 8] 10
	2 inches	0.6	0.5 [0.6 to 0.9] 1	0.5 [0.6 to 1] 1	0.4 [0.7 to 1] 2

shortage and, as a result, a mandatory water conservation order was enacted for multiple months (Figure 18). While such droughts are not common in places like New York where water is abundant, and the weather is relatively humid and wet, overall fluctuations can change over time as temperatures increase. As shown in Figure 13, there is a projected increase in 100 year storm events.. Surprisingly according to historical assessment, there were times where droughts were a more common occurrence than any experienced in the 21st century.

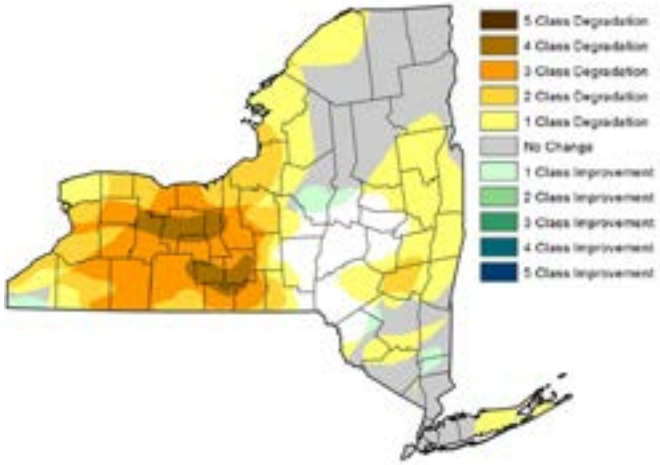


Figure 18: Map of Affected areas from 2016 Drought

Tables 3 and 4 as well as the Figures 19 and 20 show the different RCP scenarios for intense precipitation. The RCP 8.5 and 4.5 shows the projections in the pink section, versus the blue section which shows the current levels of intense precipitation. As shown in the RCP 8.5, the curve is much higher than that for the 4.5 scenarios, though both of

Table 3: Intense precipitation forcasts RCP 4.5

Duration (hrs)	Projected 2070-2099 Intensity Ensemble Member 10th	Mean	90th	Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds Low CI	Mean	High CI
1	2.27	2.54	2.83	1.96	2.31	2.45
2	1.41	1.60	1.82	1.28	1.48	1.52
3	1.00	1.21	1.37	0.93	1.06	1.15
6	0.66	0.75	0.85	0.57	0.67	0.71
12	0.41	0.46	0.53	0.36	0.42	0.44
18	0.31	0.35	0.40	0.27	0.31	0.33
24	0.25	0.29	0.33	0.22	0.26	0.27

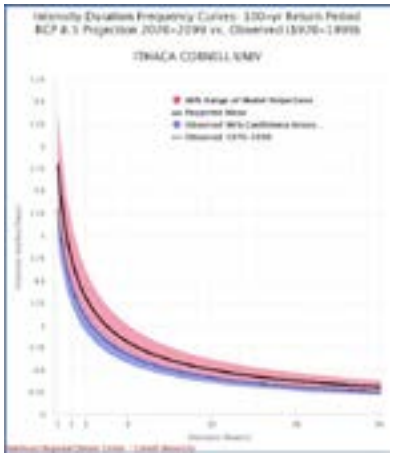


Figure 19: Intense precipitation forcasts RCP 4.5

Table 4: Intense precipitation forcasts RCP 8.5

Duration (hrs)	Projected 2070-2099 Intensity Ensemble Member 10th	Mean	90th	Observed 1970-1999 Intensity with Confidence Interval (CI) Bounds Low CI	Mean	High CI
1	2.44	2.88	3.45	1.96	2.31	2.45
2	1.51	1.74	2.14	1.23	1.43	1.52
3	1.14	1.31	1.61	0.93	1.06	1.15
6	0.71	0.81	1.00	0.57	0.67	0.71
12	0.44	0.50	0.62	0.36	0.42	0.44
18	0.33	0.38	0.47	0.27	0.31	0.33
24	0.27	0.31	0.38	0.22	0.26	0.27

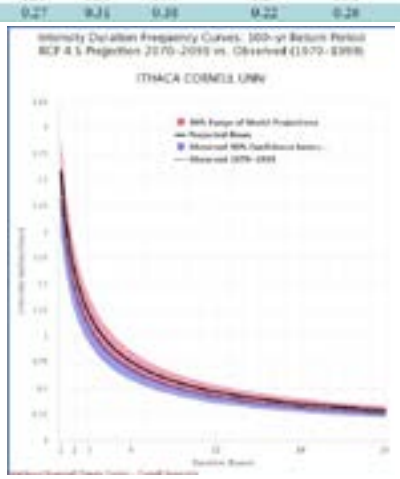


Figure 20: Intense precipitation forcasts RCP 8.5

them show an increase in precipitation. As the Y axes shows inches of rain versus the x axes shows time, as the curve rises, that relationship shows that the overall intensity of precipitation will increase over time. Thus, as intensity increases, the amount of rain per hour also increases. This means that larger amounts of rain can accumulate in a shorter period of time.

Figure 21 shows that over time, the amount of precipitation has increased in Tompkins County. What this also implies is that the overall amount of runoff is also expected to increase which can lead to water contamination and erosion, besides other extreme events like droughts and intense snowstorms. While intense snowstorms might seem counterintuitive, given the increasing temperatures, however, according to the ClimAID report this phenomenon is likely to occur because of the Great Lakes, which have seen an 8% decrease in ice cover during the winter. As a result, increased moisture rises into the air, causing increased lake effect snow in the Finger Lakes and Southern Tier region (NYSERDA 2015).

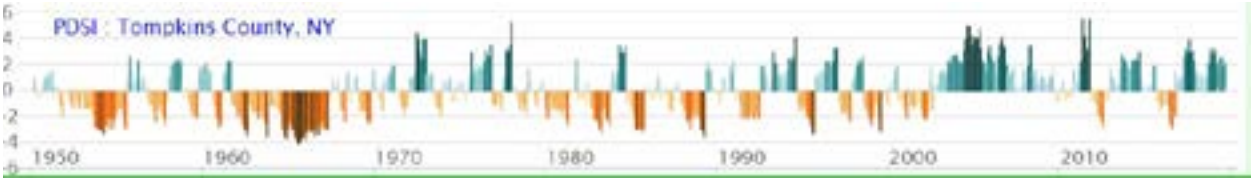


Figure 21: Tompkins County Precipitation Records and Projections

This can cause significant disruption to not just the environment, but also to the economy of the region and its community. Some major changes due to this vulnerability specific to Tompkins County identified in the ClimAID report are potential flooding increases, agricultural losses due to changing weather, increased pests, and invasive species as the climate warms. While urban areas are vulnerable to flooding, rural areas, including places like the Town of Caroline are more vulnerable to, and have less capacity to cope with, extreme events such as floods, droughts, ice storms, and other climate-related stressors. Regions that depend on agriculture and tourism (such as fishing, skiing, and snowmobiling) may be especially in need of adaptation assistance; and low-income urban neighborhoods, especially those within flood zones, are less able to cope with climate impacts such as heat waves and flooding.

Additionally, the ClimAID report has also identified other populations that are specifically vulnerable to these regional climate projections. One of these identified groups are the elderly, disabled, or others with compromised health such as respiratory issues and thus are more vulnerable to extreme climate events. Other vulnerable populations are low income individuals, who might not be able to afford energy costs and climate resilient building; farmers who will have to deal with the increased number of invasive species and pests, as well as droughts and might have reduced yields/ profits as a result; individuals without cars that rely on public transit and are less likely to have the ability to evacuate during an extreme weather event; and small businesses that might not be able to afford the costly damage caused by climate change and extreme weather events. While there are other populations not identified thus far, these are the primary groups that are considered to be most vulnerable to climate change (NYSERDA 2015). Thus, for the southern tier region, in which Tompkins County and the Town of Caroline are located, the major climate related vulnerabilities are flooding and extreme precipitation, droughts, and heatwaves. While there are other vulnerabilities associated with climate change, these are

the primary vulnerabilities that can have the largest effects on Tompkins County and specifically the Town of Caroline, both on a physical level as well as on a social and economic level. These vulnerabilities are also identified in the 2013 Tompkins County All Hazard Mitigation Plan and are defined as high risk in the FEMA Hazard Identification and Risk Assessment (HIRA) Manual. More information on the FEMA HIRA Manual can be found on the FEMA website at: https://www.fema.gov/hazard-identification-and-risk-assessment .

SECTION 3:

ASSESSMENT METHODOLOGY

This section goes over the methodology used in this process, from developing hazard definitions to identification of hazards, to prioritization and ranking of identified hazards. Because the process and definition of climate vulnerability assessments can vary significantly, based on the characteristics and goals of the community, this section aims to establish a basic definition of a climate vulnerability assessment for the Town of Caroline and based on definition, define the overall vulnerability identification process. Finally, this section will also give detailed descriptions of the community outreach and engagement strategy undertaken and how the community will influence the overall outcome of the entire process.

Climate Smart Communities Program

The New York Climate Smart Communities Program is an inter-agency program led by the Department of Environmental Conservation (DEC) state-wide. The initiative helps municipalities of all sizes to increase climate resilience, reduce greenhouse gas emissions, and help build a healthier, more sustainable green economy. The program has hundreds of participating communities throughout the state and has helped municipalities connect to resources for their community, ranging from grant awards to technical assistance. The CSC program itself has various participation stages. First, a community must pass a municipal pledge in order to be considered a participating Climate Smart Community. Second, a community then needs to attain 120 or 300 points by completing actions that range in topic from flood resilience to GHG reduction. Once the community receives over 120 points, the municipality becomes a designated Climate Smart Community at the Bronze level. They may become a "silver" community be achieving over 300 points.

In 2019 the Town of Caroline officially became a certified Bronze Climate Smart Community. This process entailed completing various different actions including developing a greenhouse gas inventory, natural resource inventory, installing solar and EV charging stations, and even installing energy efficient fixtures such as LED lights. While the Town has successfully become a designated Bronze community, the community has continued its participation in the program by pursuing other Climate Smart Communities actions such as this climate vulnerability assessment which is considered a priority action by the CSC program and is the first step to conducting a comprehensive climate resilience vision which follows the vulnerability assessment.
In the Climate Smart Communities Program, the process of a climate vulnerability assessment is defined as follows:

1. Research relevant studies of climate change projections.
2. Identify potential impacts on various community assets and systems, as appropriate
3. Identify and assess vulnerabilities of each asset or system (exposure, sensitivity, and adaptive capacity).
4. Prioritize vulnerable assets and systems.
5. Report on the findings of this study and analysis

The methodology for hazard identification and impacts is defined in the following section, but it is important to note that while the above procedural list is the basic procedure this climate vulnerability assessment will use, it is by no means the only method available. A general climate vulnerability assessment process and report can be creative and unique for each municipality based on its objectives and goals of the process.

Assessment Method

There are various methods available to assess climate vulnerabilities in a community. There is a wealth of basic knowledge that is attainable through general research and outreach to the community. In the case of Caroline, this general knowledge and data was attained through regional institutions, municipal, state, and federal sources and websites. While it is important to note that some of the data and information used in this document is not directly available in the public domain, much data is accessible upon request to the respective sources (provided in citation).

For the Caroline Climate Vulnerability Assessment process, a method developed and used by Cuyahoga County, Ohio Planning Commission (https://www.countyplanning.us/projects/climate-action-plan/vulnerability-assessment/) has been chosen to be the most useful and relevant evaluation method for the Town of Caroline. The Cuyahoga County Climate Vulnerability Assessment was part of a larger project to help the county develop a comprehensive climate change action plan (https://www.countyplanning.us/projects/climate-action-plan/) that not just focused on the direct climate related effects on the county, but also the social and economic vulnerabilities that exist in each community. In the Cuyahoga Climate Action Plan, the vulnerability assessment was only a part of the entire plan. In regard to the Caroline Climate Vulnerability Assessment, this final report and assessment was originally planned to primarily focus on the vulnerability aspect rather than the adaptation measures/solutions. By identifying the vulnerabilities and the geographical characteristics of the area, the final product intends to help the community plan for future resilience related projects by creating a prioritization list of identified vulnerabilities in the municipality. This tool can help guide the Town of Caroline and its community towards smarter planning and municipal policy land use regulation implementation.

In the methodology used for this Climate Vulnerability Assessment, there are two different types of vulnerabilities that are considered: social vulnerabilities and physical vulnerabilities. While the general definition of an environmental or climate related vulnerability is not necessarily a contested issue, the cause and chain effect of a vulnerability is not at all a well-defined concept. For example, while a community might be specifically vulnerable to inland flooding, the damage caused by a single storm or hurricane not only has immediate negative consequences but can eventually lead to chronic social and economic problems, for example, a community located in a flood zone is less likely to have a growing population and robust economy. In historical examples like Hurricane Katrina or Harvey, the population most affected by the storm were those who were economic or racial minorities, and their cascading effects continue to be a felt to this day. However, quantifying such prolonged damage can be extremely complicated, especially since this process is to consider all extreme weather types projected to increase over the course of the next century. Therefore, creating boundaries and official definitions, as well as defining the general effects of each weather event can make the quantification process of understanding the vulnerabilities can simplify the overall assessment process. Both vulnerabilities defined for this assessment are as follows:

Physical Vulnerabilities: These are vulnerabilities are those that directly impact the natural and built environment due to climate change and extreme weather events. Extreme heat, flooding, ice storms, wind, and other climate related events that in turn, cause significant damage to the

existing structure, land, or other feature that is within the vulnerable zone, can affect physical vulnerabilities. One example can be an old bridge that is experiencing erosion and material decay (rusting, disintegration, etc.) either due to disrepair or the overall aging structure. In this example, the bridge is particularly vulnerable because it might not have the ability to withstand increasing flashfloods. By ignoring the decay of this infrastructure, the bridge can ultimately buckle and or in a worst-case scenario collapse due to the unbearable pressure. Unfortunately, while such vulnerabilities will primarily affect the users of the bridge, the bridge can also be a direct threat to the surrounding community. This infrastructure would not impact just localized traffic, but it could also harm the local ecosystem, cause erosion problems, and trigger flooding to surrounding lands. In conclusion, physical vulnerabilities such as these have a direct locational placement within the community and can be mitigated and or solved through direct physical modifications (infrastructural/ land use/ conservation/ etc.).

Social Vulnerabilities: These vulnerabilities are ones that, unlike physical vulnerabilities, are not associated with a particular location, rather they are interconnected with the community and thus are more complex issues typically not solvable through physical reconstruction. Social vulnerabilities, however, can be connected to or affected by physical vulnerabilities (Figure 22). As an example, rural communities have less communication infrastructure, such as cell service or internet connection. This, in turn, can lead to pockets in the community that lack digital connection. These residents are socially vulnerable due to the lack of communications infrastructure in their area. As this example illustrates, social vulnerabilities are not necessarily associated with vulnerable infrastructure but can be interconnected with the physical characteristics of the community. At the same time, in some scenarios, there is no single solution to such social vulnerabilities. On the other hand, unlike physical vulnerabilities, these vulnerabilities do not necessarily require major physical modifications to existing areas within the municipality.

Figure 22: Social and Physical Vulnerability Factor Association

In short, physical vulnerabilities identify the direct vulnerabilities associated with climate change, while the social vulnerabilities are specifically associated with the indirect vulnerabilities and effects of climate change. Table 5 contains the different factors that were considered in this vulnerability assessment for the Town of Caroline. Note that these vulnerabilities are categorized based on social and physical factors. This list is by no means comprehensive, rather it provides a baseline of vulnerable factors to consider. For those who are looking to conduct an assessment in their own community, it is highly advised to conduct public outreach and engagement sessions to better understand what social and physical vulnerability factors to include for that specific community.

Table 5: Climate Vulnerability Assessment Evaluation Criteria

Climate Vulnerability Assessment Evaluation Criteria	
Social Factors	**Physical Factors**
Lacking Internet/utility connection	Land is eroding
Children and or elderly people reside here	Structure/House Located in FEMA flood Zone
Resided by a disabled/ill individual/group	Experiencing groundwater flooding
Low income poverty	Lacking healthy vegetation
Lives in apartment	Property contains hazardous waste/or is a landfill
Lives in long emergency response zone	Land producing significant runoff
	Steep/rough topography threat to landslide
	House type and age

Scoring for each factor ranges

between 0 – 2 points. Zero points are assigned if the factor is N/A or insignificant. One point is assigned if the factor is moderately significant (Physical factors: there is a physical presence of the vulnerability, but not an immediate threat to that location; Social factors: the threat and vulnerability might exist, but would not lead to critical situations which significantly escalate the overall vulnerability of the area.) Two points are assigned if the factor is significant (Physical factors: there is a presence of the vulnerability which is a threat to the immediate surrounding community and needs to be addressed ASAP; Social factors: the threat and vulnerability exists and can significantly alter the overall vulnerability of the individual/place.) Addressing this issue would significantly increase the overall resilience of the individual/place/ community.

Table 6: Scoring detail for physical and social factors

Key Name	Definition/ Details
Children and or elderly people reside here	Households/facilities/neighborhoods with younger children/elderly people tend to be at higher risk of any climate related events. This is primarily because these groups are often dependent on others which can be a major issue during a natural disaster or are at higher risk of being affected by extreme weather (extreme heat/cold). Because it is impossible to count each person in the municipality, this scoring process can use census block data and base the score off of an average percentage of those who are under 10, and over 65. Based on census categorization.
Experiencing groundwater flooding	This phenomenon often experienced in regions with high humidity/ precipitation and in locations that have relatively rough topography. While groundwater flooding in Caroline is relatively region specific, this phenomenon has been associated with extreme precipitation. According to the Penn State Cooperative Extension, water table overflow/groundwater flooding often occurs primarily because the ground is not able to absorb the extreme amount of rain that has fallen in a short period of time. This is especially true for areas that already have shallow water tables which can be found in hilly or mountainous regions. Thus, areas that are relatively steep but are developed for residential/commercial purposed are given higher scores.
House type and age	Older houses or structures that are in disrepair can often be considered potential areas of vulnerability. While it is not necessarily true that older structures are less climate resilient, the amount of repair needed goes up over time. Thus, while age will be a primary determining factor, other factors will also be considered such as the building/ property assessment value, as well as a visual appearance from a birds-eye view.
Lacking healthy vegetation	Ground vegetation often signals areas of potential vulnerability. While some basic cross-comparison analysis can be done using LULC datasets to show how the land cover has changed over time, this only shows how climate change has affected the overall characteristics. It does not show how the land cover changes will affect the level of vulnerability. Areas with high vulnerability tend to be barren and lack any vegetative cover; these areas are considered lands with high vulnerability.
Lacking Internet/ utility connection	Storm and extreme temperature can easily affect basic utility connection and infrastructure in rural municipalities in Caroline. The population that depends on this infrastructure is therefore vulnerable to disconnection, which can be a problem during a natural disaster/ storm. Areas with high vulnerability will be those that either do not have any or limited connection to internet or cell service, which can be assessed based on internet coverage databases.

Land is eroding	Eroding land often occurs in areas that were previously not intended for occupation by water. This phenomenon can cause significant damage to land and structures and can even change the water conditions. As a result, eroding land can be an indicator to show that the region or area is significantly more vulnerable to flooding than those not affected by erosion.
Land producing significant runoff	If land cover is either impermeable due to extreme heat and dry weather or by human alteration of the existing surface (cement, blacktop, etc.), significant runoff can be produced large amounts of runoff can trigger erosion. Erosion can be triggered by large amounts of runoff. Additionally, this runoff, if not managed, can potentially lead to flash floods which can cause property structural damage.
Lives in apartment	While living in an apartment itself is not necessarily a vulnerability, the inability for the tenant to control their right to make their living environment suitable to their needs could potentially place them in a more vulnerable place. For example, if a person lives in an apartment and does not have air conditioning in their unit, they do not necessarily have the ability to change their living environment, especially if it is up to their landlord. In other words, as the tenant does not have the exclusive rights to make changes to the property, this places them at a disadvantage to make the changes needed to create a safe living environment.
Lives in a long emergency response zone	Parts of the Town of Caroline have long emergency response times that can be a significant disadvantage to those that might need immediate assistance during a natural disaster/ flood. While the response time can vary across the Town, the overall slow response time can be a significant vulnerability to residents and thus can lead to unintended consequences that could have otherwise been avoided.
Low-income poverty	Not surprisingly, climate vulnerability can especially affect low income and marginalized populations in the Town. Due to the lack of resources and public services that are in the region, low-income population could especially be affected during a natural disaster and climate change in general. While this factor cannot be traced by all the people that live in the Town, there can be an overall assessment based on census block and median income. Those blocks that are the lowest income will be categorized as potentially vulnerable areas within the Town of Caroline.
Property contains hazardous waste/ or is a landfill	In general, hazardous waste/ landfill sites are strictly regulated to prevent any unnecessary contamination of the neighboring land/ waterbodies. However, as the climate changes, these threats of potentially hazardous waste spill/ contaminated runoff entering neighboring properties is increasingly more likely. The exact of all municipal and state landfills will be mapped and all neighboring properties marked as vulnerable, and the parcels that are in close proximity to, but not adjacent would be considered semi-vulnerable areas and would receive 1 point.
Resided by a disabled/ ill individual/ group	Disabled and ill individuals who live in a household or facility are significantly more vulnerable to natural disasters than healthy people. This can make evacuation and potential for injury more likely for these populations and thus marked as vulnerable.

Steep/ rough topography threat to landslide	Steep and rough topography is the leading cause of many of the above problems already mentioned. While a well vegetated area can help a slope be less prone to flooding and landslides, any vegetative change or erosion can lead to potential flood hazard zones and or areas that are more likely to experience groundwater flooding. Any erosion of a steep slope can also lead to landslides during extreme weather events and thus are extremely vulnerable to community and those individuals that live in close vicinity to a steep slope. The Town of Caroline has many areas that are rough in topography and considered as a vulnerable factor within specific regions of the Town.
Structure/House Located in FEMA flood Zone	FEMA flood zones are also areas that are especially prone to erosion and flooding. Unfortunately, there are many structures and houses located in or in close proximity to flood zones. Additionally, high flood risk areas are often areas in the valley and tend to be well suited for infrastructure development (roads/ bridges/ etc.). As climate and extreme weather events are expected to increase, the flood zone is also expected to change and the number of structures in or surrounding the region might no longer be resilient enough to withstand extreme storms. Thus, infrastructure and properties in the flood zones will be marked as vulnerable, while the areas surrounding the floodplain will be marked with 1 point.

Community Stakeholder Meetings

For the Town of Caroline, there are various groups and individuals that were identified by Cooperative Extension or through community outreach to discuss climate related vulnerabilities within the municipality. The process began with meetings with the town board and advisory board/ council members, as well as municipal staff. The outreach process then branched out based on the recommendations given by the local community leaders, board members, and officials. Following this initial outreach process, the following groups and individuals were identified for the next stage of outreach and each meeting was guided using questions developed to understand the community's priorities and objectives around climate vulnerabilities.

Preliminary Community engagement:

List of key stakeholders that were identified as key conversations prior to hosting a community workshop:

- Town Supervisor – Mark Witmer
- Town committee members
- Local business owners
- Highway Department/ DPW
- Code enforcer
- Local activists
- Major landowners/ farmers
- Educators (teachers)
- Additional people can be added to this list as needed

In each interview or meeting scheduled with the above groups, the following list of questions were deemed as critically important to be addressed:

- What is the goal of this climate vulnerability assessment?
- What is the target audience for this assessment?
- What characteristics of the community act as a threat to the community?
- What can be done to best address the community's concern?
- What are the main barriers to fixing the vulnerabilities?
- How do you define resilience?

Based on the answers to the questions above, Cooperative Extension then created a plan for hosting a community workshop specific to the Town of Caroline. That plan included:

1. Defining the meeting purpose and objectives
2. Creating a "critical participant" profile and identifying how to solicit their participation
3. Establishing roles
4. Developing an agenda
5. Identifying background materials
6. Planning a meeting space

Workshop

In order to assess climate vulnerabilities in a community, it was deemed necessary to coordinate the vulnerability identification with community members. While large datasets and resources are available through the internet and state/national archives, this information can only tell a portion of the story and does not give a holistic vision that represents the community. Similar to a comprehensive plan, understanding the struggles, underlying circumstances, and the perceived root causes within a community can be crucial information in order to solve existing problems. Collecting this information around climate resilience can be difficult, especially if the community does not have a community central node at which valuable input could be collected. Such a node can be public squares, parks, and community centers at which local citizens congregate and interact with one another. In the case of the Town of Caroline, the community of Brooktondale, Slaterville Springs, and Speedsville are primary population clusters and are also considered community nodes at which community events and interactions occur.

The workshop meeting format was planned in accordance with the format of the Community Resilience Building Workshop model, which was originally developed and templatized by the Nature Conservancy and National Oceanic and Atmospheric Association (NOAA). The intention of this model was to develop a workshop that employs a unique community-driven process, rich with information, experience, and dialogue, where the participants identify top hazards, current challenges, and strengths and then develop and prioritize actions.

The overall objectives of this facilitated workshop were to define extreme weather and natural and climate-related hazards; identify existing and future vulnerabilities and strengths; develop and prioritize actions for the community and broader stakeholder networks, and identify opportunities for the community to advance actions to reduce risks and build resilience. While the overall idea of this workshop was incorporated into the Caroline Climate Vulnerability Assess-

ment, the entire process, unfortunately, was not feasible, given the size, capacity, and overall intention of this vulnerability assessment. Additionally, the workshop took place in the backdrop of the early months of the COVID-19 pandemic. Because of this, the lead organization for this project, Cornell Cooperative Extension Tompkins County, was ultimately forced to convert the format of this workshop to a virtual meeting. However, the overall outcomes of the meeting were paralleled with the core format of the Community Resilience Building Workshop.

1. **Establish a core team with goals:**
   The instructions for this step include the following:
   Engage and secure the consent of leadership (i.e., mayor, commissioner, CEO, or equivalent) to hold Workshop and assign key staff to the core team, if appropriate. Establish a core team—with clear roles and responsibilities—and organize the implementation of the Community Resilience Building Workshop. Define specific Workshop goals by asking why the community needs to discuss current and future impacts of hazards. In addition, predetermine how the community will use the information and decisions constructed during the Workshop. Finally, develop a reasonable timeline over which all Workshop steps ("before ", "during", "after ") will be completed. Reconnect with leadership once core team with goals/timeline is secure.

   In accordance with this first step:

   Cornell Cooperative Extensions has previously worked with the Town of Caroline on the Climate Smart Communities Certification Process and as a result, has an established working relationship with the community. As the Town of Caroline worked toward becoming a certified Climate Smart Community, an active community taskforce was established. The Town Supervisor, along with other taskforce members were key contributors to this climate vulnerability assessment process. In addition, representatives from the New York Water Resources Institute, one of which was also a resident of Caroline, were also actively involved in the community engagement process. Therefore, while there was no official designation process for a climate vulnerability assessment taskforce, due to the already existing framework and working relationship with the community, it was not necessary to establish a brand-new group to facilitate the assessment operation process.

2. **Engage stakeholders (core team):**
   The instructions for this step include the following:
   Identify stakeholders for Workshop engagement. Invite a wide range of people to participate based on their background, experience, authority, and where they work and live. Consider individuals or entities — across the entire community — affected in the past by hazards and likely to be impacted in the future? Consider individuals or entities that influence, guide, and/or have the authority to make decisions? Generate a list of potential stakeholders, identify date for Workshop, develop outreach material if needed, and begin to secure Workshop participants. Allow six weeks between initial "save the date" invitations and Workshop. Typical Workshop formats include one day (6-8 hours) or two half-days (4 hrs. apiece) ideally spaced two weeks apart.

In accordance with this second step:

As previously mentioned, before the climate vulnerability assessment process began in the Winter of 2019, a working group comprised of a mixture of people, from private residents to municipal officials and workers as formed. The number of people in this core group was modest in number. Therefore, it was necessary to expand outreach efforts and meet with other stakeholder groups. As previously discussed in preliminary community engagement, it was necessary to reach out to various political and social services groups such as the Town Planning Board, Brooktondale Community Center, Town Code Enforcement, and many others. These meetings, which were relatively brief, provided basic information to community members to discuss potential vulnerabilities in their community. Unfortunately, while many groups were interviewed, due to the word of mouth nature of the process, it is likely that some groups were left out during the process. There were also some groups that did not reply to the invitation, and thus were also left out during the process. In conclusion, this multi-group interview process was meant to provide this assessment with a better foundation on community knowledge, and create an assessment methodology that would produce a representative vulnerability assessment and prioritize vulnerable areas previously identified by the community The overall outcome of this meeting series was incorporated into the final assessment rating system.

3. **Prepare materials for workshop (core team)**

The instructions for this step include the following:

Gather and synthesize pertinent information related to the impacts of and responses to hazards in the community including:

a. Existing maps and online tools, natural hazard mitigation plans, photos, historical information, damage assessments and claims, and people's stories to help the core team prepare.

b. Consider sending a pre-workshop Community Characterization Survey to identified participants to efficiently capture core information about how the community currently perceives, assesses, and acts to reduce risks.

An additional approach, if situations and time permit, is a preworkshop listening session for stakeholders to verbally and visually present their stories, photos, scientific information on hazards, and future projections. Information shared can be synthesized with other materials in preparation for Workshop.

In accordance with this third step:

A large amount of research was conducted prior to the launching of the various discussion meetings and workshop. In this research, some of the primary materials used were the NYS ClimAID Report, the Tompkins County All Hazard Mitigation Plan, and the Town of Caroline Comprehensive Plan. Other materials and resources compiled and used separate from these state and municipal documents were the NYS Climate Change Science Clearinghouse, NOAA Climate Projection Tools, US Climate Resilience Toolkit, the NYS GIS Clearinghouse for GIS data, Cornell Climate Smart Farming, and FEMA Flood Mapping Resources/ Data. All of this information was used for the localized presentation materials,

maps, fact sheets, and this report.

Additional materials were used to develop a community survey. This community survey intends to act as an alternate outlet at which individuals who would otherwise not be able to attend the meeting would have the opportunity to provide feedback and any additional information in this survey. The workshop meeting modeled the overall payout, and is meant to educate the participant on local climate projections as well as understand that specific individual's struggles and worries in order to address the underlying problems the community faces.

In conclusion, step three was satisfied with a combination of research and outreach collected throughout the CVA process.

4. **Decide on participant grouping for workshop (core team).**
The instructions for this step include the following:
Central to the successful application of the Community Resiliency Building Workshop is to open (Section B-1) and close (Section E) the Workshop with large team (all participants) sessions; with small team sessions in between (Section B-2 through Section D). This "large-small-large" team dynamic allows for detailed input from individuals along with a collective synthesis for comprehensive community resilience building. The critical step of assigning participants to small teams depends on attendance with 40-50 participants and 6-8 people per small team (no more than 10) as the ideal. Careful consideration should be directed to diversifying small team membership based on rank, position, roles, responsibilities, and expertise of participants.

In response to this fourth step:

The original structure for the Climate Vulnerability Assessment Workshop (which would have required preregistration but be open to anyone in the community) for Caroline was to conduct a general introductory presentation that would provide context and general information to the community around the intent of the workshop; local and regional geographic and climate characteristics, climate projections, and some examples of the implications and vulnerabilities due to climate change. A breakout session would have then followed, with groups each assigned a topic (flooding, droughts, heatwaves) and asked to go through the following questions:

1. How would you define flooding/droughts/heatwaves (select one)?
2. What do you think are current problems in Caroline and Tompkins County that you think need to be addressed?
3. What groups/ individuals/ things are most vulnerable?
4. What are the consequences if these problems are not addressed properly?
5. If money was not an issue, what do you think is the proper way to address this issue?

The meeting would have ended with a wrap up session where teams would report back to the main group and final plans for the vulnerability assessment would be announced before dismissal.

Unfortunately, due to the unforeseen COVID-19 pandemic, a virtual workshop replaced the in-person workshop. While the change in plans did have an effect on the overall assessment in terms of turnout and audience participation, the virtual meeting, scheduled approximately a week after the originally scheduled workshop date, provided much needed community feedback on the vulnerabilities the Town of Caroline faced. As this meeting was open to the public, rather than just the Town of Caroline residents, there was a mixture of county representatives, neighboring town residents, as well as Caroline residents. The meeting lasted approximately 2 hours in length and, while the entire session was based on a presentation that was adapted for virtual meetings, participants had the opportunity to provide feedback, concern, or ask questions between each topic within the presentation, followed by a longer discussion on community vulnerabilities and problems. The overall structure of this virtual meeting was as follows:

1. **Community Introduction – give everyone the opportunity to introduce themselves**
2. **Town of Caroline Introduction – discuss the vulnerability assessment process in Caroline**
3. **National/ regional/ town-specific projections on flooding and potential vulnerabilities**
    - o Followed by 5-10-minute discussion session
4. **National/ regional/ town-specific projections on heat waves and potential vulnerabilities**
    - o Followed by 5-10-minute discussion session
5. **National/ regional/ town-specific projections on droughts and potential vulnerabilities**
    - o Followed by 5-10-minute discussion session
6. **Summary on physical versus social vulnerabilities identified as a result of the climate projections**
    - o Followed by a 30-minute continued discussion on various vulnerabilities

Survey

Content of Survey

As discussed above, the climate vulnerability assessment survey was originally intended to make the workshop more accessible, especially for those who would not be able to attend the meeting. Emails, list serves, social media and posters were used to distribute the survey (see Figure 24). There was also a page that was dedicated on www.southerntierCEC.org that was meant to provide public access to the survey and a pre-presentation PowerPoint. As this survey was meant to serve the same purpose as the workshop itself, the questions and resources used were similar to the actual workshop. The following describes the general structure of the survey:

1. General Contact Information:

This section collected basic information about the individual. While all personal information was kept confidential, the fields on contact information are left optional for those who would rather not be contacted. This block included the following questions:

- How would you like to be contacted? (phone/email/mail/do not contact me)

Please provide your contact information in the text box (if selected one of first three)

2. Tell us about yourself:

This section asked participants how they are related with the Town of Caroline. This was to better understand each participant's background and understanding of the community.

- How are you affiliated with the Town of Caroline? (live in Caroline/ Work in Caroline/ Used to live in Caroline/ Other)
- What kind of house do you live in? (Single Family/ Duplex/ Mobile Home/ Apartment Building/ Other)
- Do you own or rent your home (own/ rent/ live with family/ other)?

3. Climate Hazards you have observed:

This section was used to see what kind of climate hazards the individual has observed in order to narrow down the questions that will be asked (flooding/droughts/ heatwaves)

- In the map below, what are the main areas you think are most vulnerable to extreme weather events? Scroll and click the areas that you think are potential hazard areas (would click on polygon, see Figure 23)
- What weather/ environmental problems have you seen in Caroline? (Extreme heat/ drought/ heat waves/ flash floods/ forest fires/ different seasonal patterns/ river flooding/ groundwater flooding/ wildfires/ pest infestation/ invasive species/ other)

Figure 23: Map from Survey

4. Flooding:

This section was dedicated to vulnerabilities around flooding and asked questions to better understand what type of flooding the individual experiences and how often this type of flooding occurs.

- What is a flood to you? Please check all that apply (loss of life/ damage/ displacement/other property damage/flooded roads/ backed up culverts/loss of streamside vegetation/ erosion/ abnormal flow/ other)
- Have you or someone you know in the Town been directly affected by flooding (Y/N)
- If so, how did it affect you/ someone you know (property damage/ road closure/ crop damage/ water contamination/ other)
- For as far back as you remember, how has your community responded to flooding? Please check all that apply. (not sure/ do nothing/ cleanup/ temp housing/ rebuilt infrastructure/ restore stream/ sought external funding/ other)
- Generally, how often does flooding (that is your definition of a flood) occur within

your community's geographical area (e.g. about once every n years)? (text answer)
- Do you know if there are any actions that can be taken at the individual level to reduce flooding risks? If so, what? (text answer)

5. Droughts:

This section discussed the types of droughts that have been observed in the Town of Caroline. It also tried to understand what needs to be done to mitigate future droughts.

- As a resident of Caroline, how have droughts affected you? (lack of water/ dying crops/ property damage/ vegetation loss/ all or most of the above/ other)
- As long as you lived in Caroline, do you feel droughts are becoming more frequent/ regular occurrences? (no difference/yes/ no)
- What do you think needs to be prioritized to mitigate the effects of droughts? Please drag and re-rank the following to your preference. (water conservation/ reduce farming activity/ change land use/ other)

6. Heat Waves:

Heat waves often create vulnerabilities that are dangerous on an environmental and social level. This section aimed to better understand the struggles the community faces as a result of heat waves and explores what can possibly be done in order to mitigate the negative effects of heatwaves.

- Have you or someone you know suffered from extreme heat/ heat stroke within the past few years? (yes/ no)
- With the warming weather and changing seasonal patterns, how have invasive species affected you? (yard/ field infestation/ got poisoned by invasive species/ property damage/ other)
- How do you stay cool during extreme heat days? (Have AC/ go to a place with AC/ get cool through natural means/ I do not have the ability to cool down/ other)
- Over the years, have you seen a change in your house heating/ cooling usage (this change in usage can be for personal/household OR external factor related reasons)? (Heating: using more/less/ no change; cooling: using more/less/no change)
- What do you believe could be the solution to heatwaves/ increasing temperatures? Rank the following in the order you think should be prioritized. (cooling stations/ upgrading emergency services/ invest in cooling structure/ plants/ increase vegetation/ change building code/ other)

Interactive map: For each section, the participant has the ability to enter an interactive map to enter a datapoint to mark an area that they think is vulnerable in the community:

Interactive Map

To collect input from community members, a participatory interactive map was constructed as a part of the survey and climate vulnerability assessment. The overall concept of the map was to better understand the geographical locations of certain climate hazards, in addition to basic information on the vulnerability that the individual identified.

As part of the climate vulnerability assessment, the primary scope of the participatory vulnera-

bility map was to create a public database that would record participant input values and keep track of all vulnerable points in the Town of Caroline. In addition to being a storage of community recorded vulnerabilities, this list could also act as a warning system that could help the municipal and county government understand what and where the specific problems are, and what factors might be contributing to the vulnerability of that specific region. This effort was a pilot project to better understand how participatory mapping could help identify climate related vulnerabilities and ultimately help solve complex problems by providing information from the community members that could help municipal workers and officials understand the underlying problems in context.

Having access to many useful tools that can help with community led data collection through ESRI and other mapping services, communities throughout the United States and across the world have been developing tools to collect data, some around environmental and natural hazard observation, and others for recording occurrences of certain types of observations that required geographical locational recording. While access to technology can be an issue, municipalities ranging from large cities like New York and Los Angeles, to small rural communities, have used digital community-based data collection. Such data collection is available either online, or via phone using an app to make the data collection process easier and faster for the participating community (Administration 2017).

According to NOAA, participatory mapping is commonly used in the following ways:

- To create maps that represent resources, hazards, community values, usage (e.g., for recreation or other visitor use), perceptions, or alternative scenarios
- To gather traditional knowledge and practices and to collect information (hazards, environmental, socioeconomic, visitor use, etc.) for assessments or monitoring
- To identify data gaps
- To inform other data collection methods (e.g., formal surveys, interviews, etc.)
- To evaluate existing programs, plans, and activities
- To facilitate the decision-making process
- To assist with data gathering for research
- To empower stakeholders
- To conduct trends analysis
- To educate stakeholders about issues and interrelationships of resources outside

While participatory mapping can be an empowering tool to help a community work towards climate resilience, understanding when and where to use this tool can significantly help with the overall goals and objectives for developing a participatory mapping tool in the first place.

Instances where participatory flood mapping is useful/appropriate:

- Rather than objectified data, it can be useful to have information from community members that, while might not be objective to other regions, can provide community knowledge and information, as well as feedback to understand a more complex situation.
- Validating existing data to help communities understand and identify gaps in their data
- Help stakeholders and decision makers with decision making and facilitate cooperation between the municipal government and the local communities.

- And, through much discussion can help foster successful implementation.

One case study conducted in a rural community in a developing nation is the surveillance of the African trypanosomiasis in Shimba hills, Kenya [Sarah A. O. Wamwenje 2019]. In this specific scenario, communities were seeing an increase in the number of cases of a disease that was spread through a parasite that could only be controlled by a trypanocide in farms. However, because not all farmers were not recording the incidents of this parasite, it was impossible to control the spread of the endemic. To solve this data gap, community members and farmers were asked to collect incident data manually on their phones by downloading an app and recording every case they observed. While this operation would have been a large expense for government officials to execute on their own, with active community participation, the dataset grew at a rapid pace and the tracking eventually led to a decrease in the number of this parasite caused endemic. While not everyone has a computer, it is more likely that there is a larger population with phones (specifically smartphones), especially in rural areas. By creating readily accessible and interactive, easy to use maps, collecting data and creating large community made datasets can help with further analysis and understanding of the specific situation.

Another example where participatory mapping proved to be a success is in Hawaii to guide the development of a stream management plan and to integrate hazard resilience goals into the community planning process. In this project, the Global Positioning System (GPS) data points were collected from the physical waterhead system, high-risk areas, and resilience assets within the valley. It was firstly important to involve the community in this process because of the small amount of resources available for this project and thus the inability to hire a consultant. Secondly, by involving the public especially the indigenous tribes that also lived within the region, the results could help with sensitive cultural understandings and ties that would have otherwise been ignored or misinterpreted by a consultant. While there were some challenges, as well as some individuals not being able to locate their point of interest due to the low-quality areal imagery used, the overall product turned out to be a valuable asset that contributed a significant amount of depth into the planning process.

In the step by step methods recommended by NOAA, it is necessary to prepare baseline data in order to give community members a better context on their challenges and to start a conversation to guide participants to draw their own conclusions, as it is unreasonable to expect community members to be willing to come up with information without being given some guidance. Additionally, it is necessary to consider the overall audience and their technical background. In the case of Caroline, given the overall population is rural and elderly, but on average a higher level of educational attainment, while the technical aspect of the maps is a challenge, the overall data and complex relationships between land use, environment, and climate projections should not be a major issue.

In the baseline map, to assist the community with general context, an aerial imagery map with building polygon has been provided to help community members easily locate their point of interest. Additionally, a road map with some general labels has also been provided in order to better assist with the locating process. In order to clearly mark the specific jurisdiction that would be responsible for road maintenance, structural damage, etc., these roads were classified

based on state and county. (Note: often, it is left up to the specific municipality to maintain their own roads/ structures and thus the point of contact would be different (i.e. State Roads: maintained by state highway office/ DOT; County Road: maintained by county highway department; Town Roads: maintained by local/ municipal highway department/ DPW). Finally, to help community members identify their land boundaries, a parcel tax map was also provided, and contains information such as the address and owner of the property.

In addition to base map information, additional layers have also been included to provide a better understanding of specific topics and problems within the Town. One layer is ditch map/ stormwater layer that provides the locations and flows of ditches and their overall connectivity to the larger stream network (which is also included), that ties into the watershed). The stream layer, separate from the stormwater layer, follows the Department of Environmental Conservation (DEC) protected streams/ non-protected streams classifications. Note that the ditch mapping shapefile has been developed by the Tompkins County Soil and Water Conservation District. In addition, there is a state database of state and municipal dams, for the purpose to help the community know the conditions of existing flood control infrastructure. The final layer included in this map is the FEMA flood map that shows areas within 100-year/ 50-year flood zones. This dataset is meant to help community members understand that the flood maps are significantly outdated. If anything, it can be safe to assume that the flood zones have expanded over time, and thus are larger than represented in the flood maps. Therefore, by including this data layer and having the community participate in the process of mapping vulnerabilities, each member can help reshape and update the existing flood map and provide a better understanding in regards to how flood zones might have changed over time.

In regards to the participatory layers, the map also contains four editable layers (flooding/ droughts/ heatwaves/ other) in which community members can add/delete/edit points of interest in regard to climate vulnerabilities. Basic data entry fields include a description of vulnerability, observance date, observance frequency, possible damage occurred, type of priority (high, medium, low), and other notes. This layer and map will continue to exist and be modified by the community.

Finally, an additional layer that has been included in the map, since the completion of this report is the vulnerability assessment layer that depicts specific areas of vulnerability classified based on social or physical vulnerabilities. This dataset will also continue to exist online and will be accessible to the public, but unfortunately will not be editable, as the results are based on the specific methodology used in this report. Note that the recommendations provided in this vulnerability assessment (see page 78) are based on these results and are meant to help the community conduct further analysis around climate resilience planning and development.

The survey can be accessed through the following link:
https://cornell.qualtrics.com/jfe/form/SV_56JNMQRkihkUlff

The interactive map can be accessed through Cornell Cooperative Extension GIS portal:
https://ccegeomaps.maps.arcgis.com/apps/Edit/index.html?appid=34324e51780041db-ba7b0be699dd186e

Note that the interactive map data is equivalent to the data used in this climate vulnerability assessment.

Figure 24: Caroline CVA Workshop Poster

SECTION 4:

ASSESSMENT RESULTS

This climate vulnerability assessment was originally conducted with the intention to better understand the community vulnerabilities in the Town of Caroline in the context of climate change. The overall intention was not just to understand and list each vulnerability based on scientifically proven methods and facts, but also to incorporate the social participatory process to create a product that would represent the community objectives and priorities in order to pursue further action around climate resilient planning and development. It is important to reiterate, however, that though this participatory process has the tendency to skew results and only be applicable to the community that conducted the assessment, the entire process itself can be duplicated and customized for other communities.

The following sections state the vulnerabilities identified based on the preliminary research, community outreach and meetings, survey, and workshop results.

Research

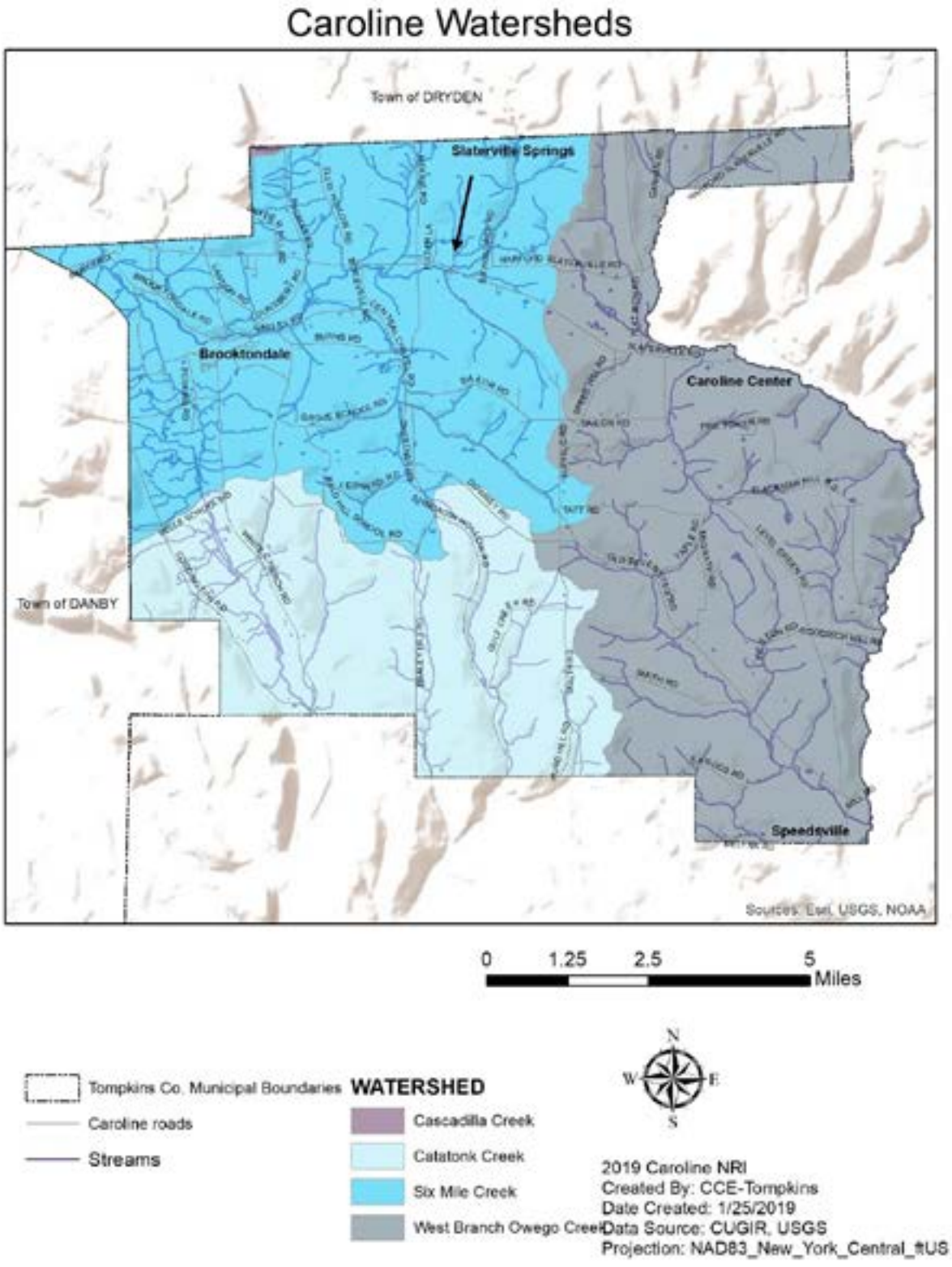
The Town of Caroline faces various vulnerabilities in the municipality. As mentioned above, because of the Town's relatively rural characteristics, there is no organization or institution in the community that is guiding the Town to increase climate resilience and, while the municipal government has been working to help increase the overall resilience of the community, the lack of resources and capacity has been a significant disadvantage. While the environment is the cause for many climate vulnerabilities, some of the vulnerabilities are associated with the lack of community engagement in municipal governance. The following vulnerabilities identified by the community have also been identified in preliminary research:

Flooding:The community is located in a relatively water-abundant region, which can be a benefit to many community members. However, without proper management measurements, this can also cause significant damage. In preliminary research, based on FEMA flood maps, the community of Brooktondale, Speedsville, and Slaterville Springs, appear to beat the highest threat for flooding. While there are other individuals/communities that are at high risk of flooding, when considering the overall number of people affected, these three locations tend to have the highest population density and thus, any flooding will affect that many more individuals.

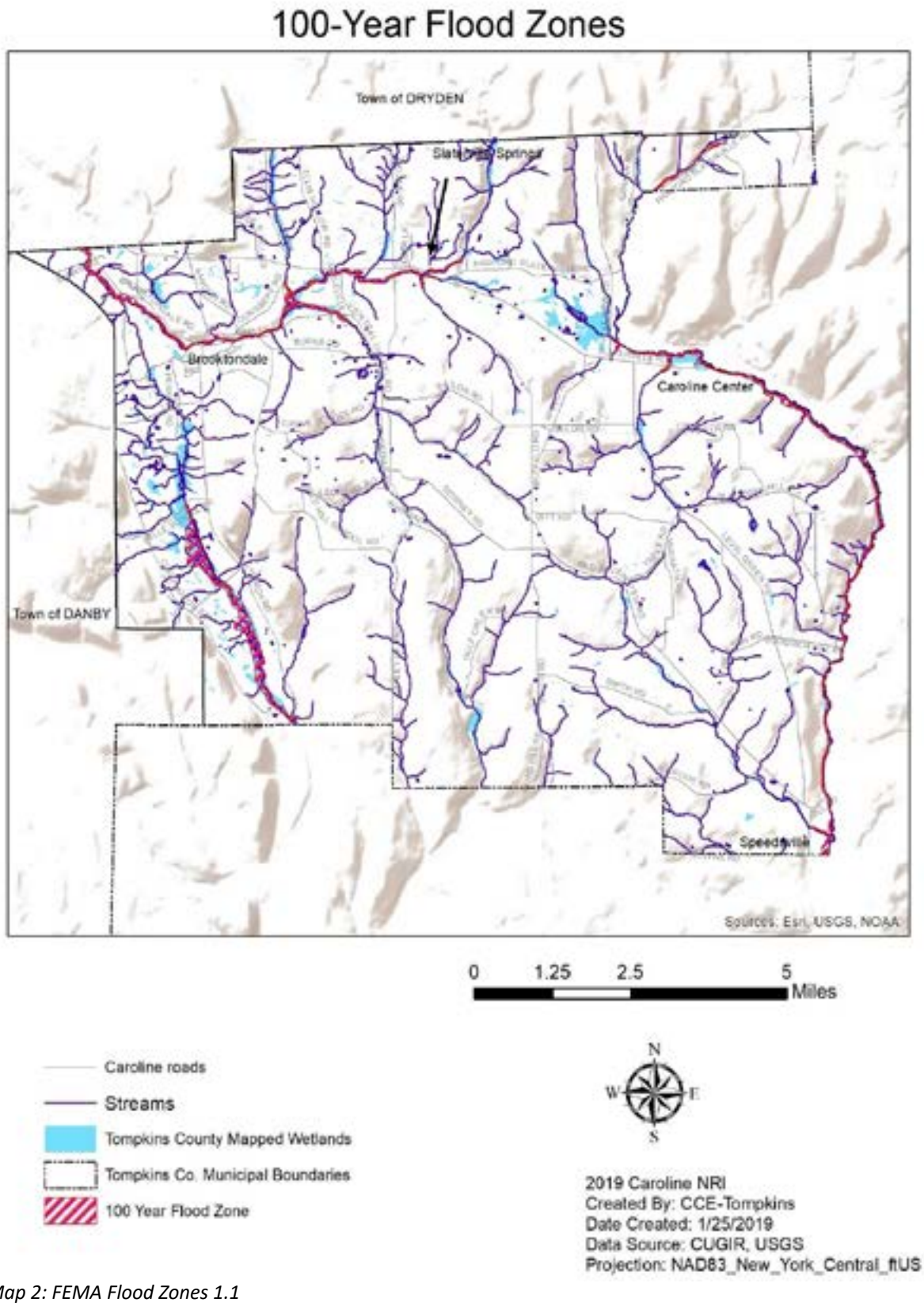
Additionally, these three communities are all located along a streamor waterbody that discharges a significant amount of runoff during high precipitation. The community of Speedsville, is located in a valleythat has two creeks joining, Boyer Creek to West Branch Owego Creek, which flows south to through the West Branch Owego Creek Watershed (Map 1). The convergence between the two creeks. While the creeks are not major rivers and do notvisually appear as a threat to the community, with increasing flashfloods and runoff, these creeks have the ability to overflow and cause flood damage. According to the FEMAFlood Map as shown inMap 4, the community of Speedsville which is cut off by the Tompkins County Boundary, is in large part located in a 100-year floodplain. At the same time, the community has a great deal of ditches and culverts that pour into these creeksfrom route 115 according to Map 5. Note that the arrows mark the flow of the water within the ditches. For Brooktondale and Slaterville, there are also a significant number of ditches that converge as well as creeks, specifically Six-mile Creek that flows northwest to the Cayuga Lake inlet which is an entirely separate watershed from the West

Branch Owego Creek Watershed.

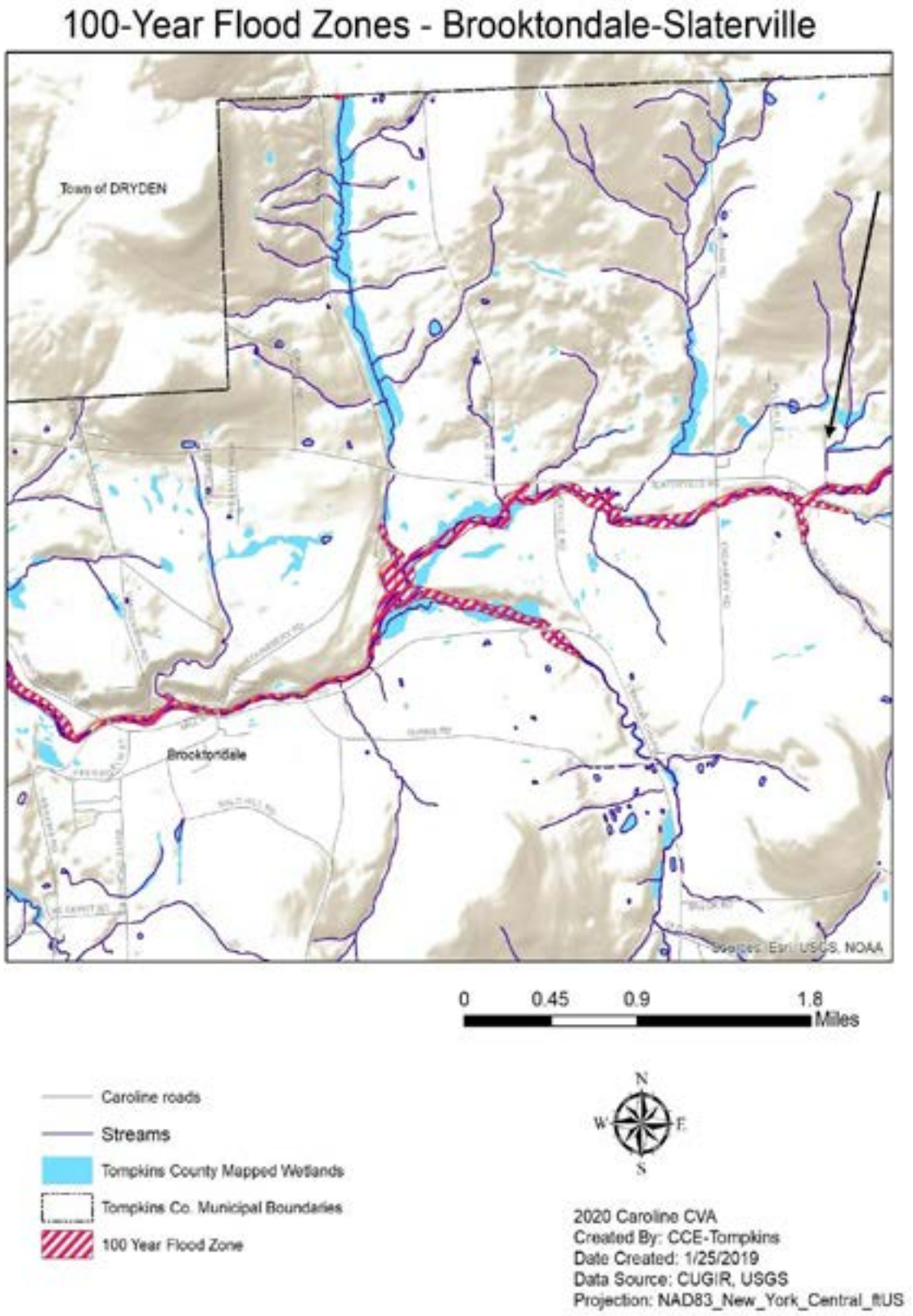
Overall,community centers located along the water or at junctions between waterbodies and/or stormwater infrastructure converging with creeks or rivers are areas of significant concern that can lead to eventual flash flooding as well as erosion. According to the Cornell Local Roads program, it is important to not only keep existing ditch infrastructure clear from any debris, but also when dredging, it is important to keep the ditches vegetated in order to reduce the overall runoff as well as erosion (DItch Maintainence Decisions n.d.).



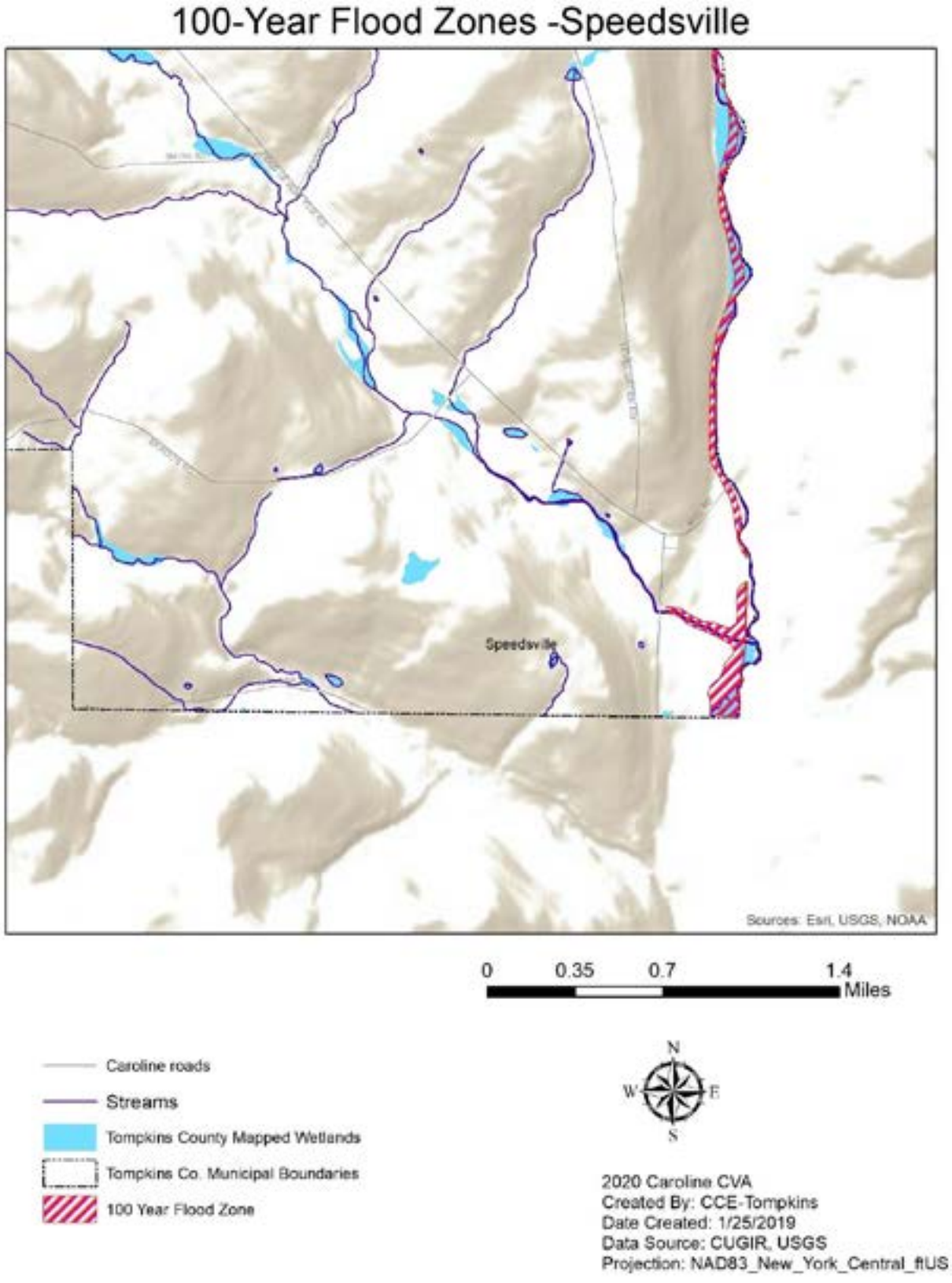
Map 1: Watersheds



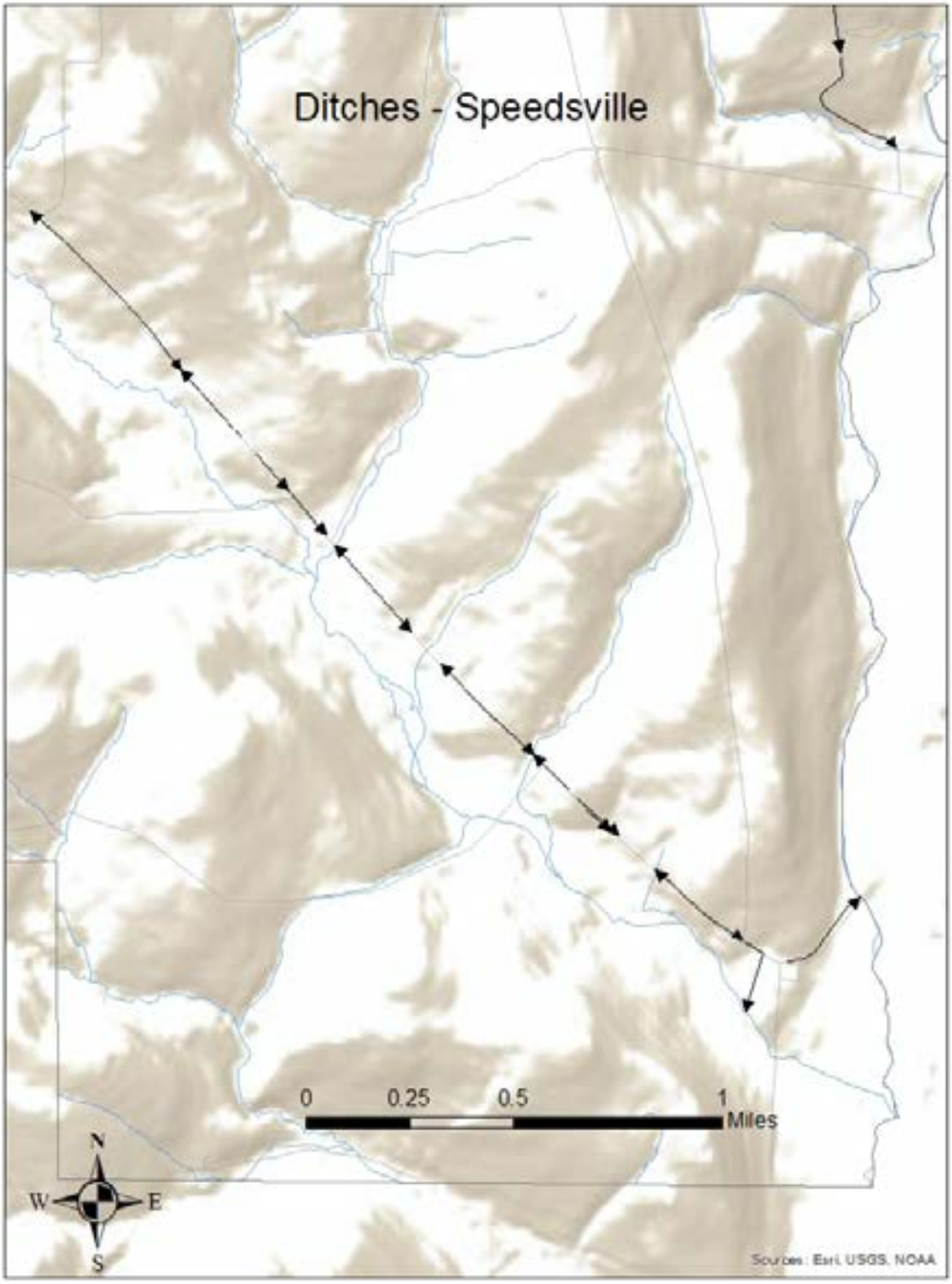
Map 2: FEMA Flood Zones 1.1



Map 3: FEMA Flood Zone 1.2



Map 4: FEMA Flood Zone 1.3



Map 5: Ditchflow Speedsville

Droughts: The Town of Caroline is fortunate to be in a region that is abundant with water. As an Upstate New York Community, Caroline has historically had relatively wet and humid weather. As a result, there are many brooks, streams, ponds, wetlands, and even active water springs throughout the Township. However, as weather patterns have changed throughout New York and in the Town of Caroline, prolonged droughts and water scarcity have become more of a reality even in the face of extreme weather events becoming more frequent. As previously mentioned, increased extreme precipitation events caused by climate change will also bring on extended periods where there is no precipitation. Given the historic seasonal characteristics, entire regions are likely not equipped to handle a lack of water and extreme droughts. Identified areas of concern and the reasons for their vulnerabilities are as follows:

- **Agriculture**: The Finger Lakes region and much of Upstate New York were historically large agricultural areas that provided food for large parts of the country. As things have shifted in the state and agriculture is no longer the primary economic driver, the Finger Lakes region remains one of the last areas where agriculture still plays a large role in the regional economy. Caroline, while not the most active agricultural townships, is still within the Finger Lakes Region and can be adversely impacted by regional economic impacts, including agricultural risks associated with droughts. Because agriculture is predominantly reliant on stable and predictable weather, increasing extreme weather patterns can cause significant losses in yield and can have a cascading effect on the overall supply chain not only in the region but throughout the nation. This problem is not just a potential threat in Caroline, but also all farms throughout the United States. It is therefore important to change agricultural practices by using resources such as Cornell Climate Smart Farming that provide climate resilient methodologies to prevent losses in agricultural yield. Current vulnerable practices include large scale monoculture, lack of tile drainage, and no buffer between fields, roads, and stream systems.

- **Wild Land Cover/ Forests:** Land cover and forests are similar to agriculture in that they rely on existing weather conditions to not change significantly. While trees and stable indigenous vegetation can handle a slight flux in weather and temperature, as temperatures increase and precipitation patterns change, this not only causes weakening of native wild plant and tree species, but it also encourages new non-native species, known as invasive species, to enter the region. These invasive species are not only harmful to the native plant species, but also to human health and wildlife that depend on the existing ecology of the region in order to survive. Some well-known invasive species include the following:

  Common Buckthorn: Buckthorn out-competes native plants, degrades wildlife habitat, serves as a host to crown rust fungus and soybean aphid, and lacks any natural "controls" such as insects or diseases

  Exotic Bush Honeysuckle: Exotic bush honeysuckles can rapidly invade and overtake a site, forming a dense shrub layer that crowds and shades out native plant species

  Giant Hogweed: One of NY's top threatening invasive species that can cause major

swelling and infection to human skin when sap comes into contact with humans. The plant also can threaten other vegetation by overpopulating an area that can creating a thick canopy, thus making an inhospitable environment to other species that are not able to gain access to sunlight, as the hogweed is a very large plant.

Japanese Barberry: Prevalent in the East and Midwest of the United States, it forms dense stands that compete with native trees and plants

Kudzu: A vine that spreads rapidly, and while not harmful to humans, can spread across fields and up trees, depriving all other vegetation of sunlight and thus killing off all vegetation within its vicinity.

Multiflora Rose: Currently, multiflora rose is found in 41 states. The U.S. Forest Service classes it as the top forest invasive plant species for the northeastern area.

Tree of Heaven: It crowds out native species; damages pavement and building foundations in urban areas

Wild Parsnip: This plant is commonly mistaken with goldenrod and can be found all over Tompkins county along the side of the road. The yellow flower being an identifier, along with its stem sap can cause significant irritation to the skin and thus be dangerous to human health. Similar to other invasive species, it also has the tendency to overcrowd and push out native species.

Cornell Cooperative Extension iMap Invasive compiled a list of confirmed invasive species along with the number of cases:https://www.nyimapinvasives.org/data-and-maps

Degraded Water Supply: Water supply degradation is another threat caused by significant drought. Given the Town of Caroline does not have any municipal water supply, residents are dependent on private water supply, degraded water supply can have significant implications on public health. Water is a necessity and threats to supply can be catastrophic. While loss of water supply is a threat that's more endemic to other parts of the United States, a changing climate is greatly increasing the local risks. Water supply is not only a physical vulnerability, but also intrinsically a social vulnerability. Those that can afford to purchase or source water from non-private sources are less vulnerable than those without the means to source water from alternative sources. In the case of drought that leads to degraded water supply and "dry" wells, it is critically important to consider how residents might gain access to safe, affordable water supplies.

Heat Waves: New York State is a diverse state, both in terms of socio-economic and environmental characteristics. In parallel to this, heatwaves can have a varying range of effects, based on the characteristics of the population. While vulnerable populations can vary across the state, more commonly, such populations can be economic and social minorities that would be affected at the highest rate. In general, heat-related morbidity and mortality among vulnerable pop-

ulations in New York State (NYS) could rise with the projected increase in frequency, intensity, and the duration of Extreme Heat (EH) events. The New York State Department of Public Health classifies the following categories of individuals as vulnerable populations to heatwaves:

- **Individuals over 65 years of age:** The elderly are at greater risk of adverse heat-related health outcomes with elevated hospitalization and mortality rates especially during EH events in the summer, probably due to excess strain exerted on pre-existing morbidities. Social isolation is also thought to be another factor that makes this group more vulnerable to heat waves.

- **Black and Hispanic individuals:** While social factors are also at play for this demographic category, it has been seen that Black or Hispanic individuals are naturally more susceptible to heat-related morbidities and mortality. While Hispanic individuals tend to not necessarily die from intense heat, it has been reported that these individuals are more likely to call in distress.

- **Language Barrier:** In American governmental operations and hospitals, it is often a disadvantage for those who are not able to speak or read English, as most signs and informational warning systems are only in English. As a result, non-native speakers are more vulnerable to extreme heat and are less likely to know what they need to do to prevent any problem caused by extreme heat.

- **Socioeconomic status:** Low income, racial minorities, and low levels of education are also indicators that can increase a population's vulnerability to extreme heat. Whether it is access to adequate air conditioning or inability to understand signs of heat strokes and what to do can be major disadvantages and significantly increase overall vulnerability to high heat and potential for heat strokes, dehydration, etc.

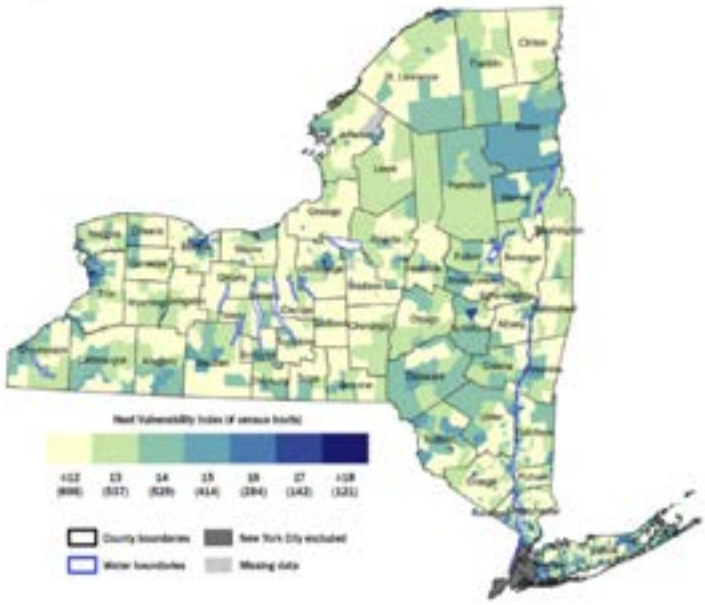
- **Surrounding Land Use and Land Cover**: Populations living in urban conditions that lack greenery are extremely vulnerable to heat waves. Land use and land cover can significantly alter local temperatures, worst being concrete surfaces. As concrete and blacktop surfaces are dark in color, they naturally absorb light and generate heat, causing extreme heat islands that can raise the temperature to unbearable rates. Additionally, as concrete is a hard and thick surface, it contains heat for a long period of time and thus continues to generate heat, even during the night when the sun has gone down, and the temperature is supposed to decrease.

- **Access to AC:** In general, air conditioning usage varies greatly across the state. On average however, economically disadvantaged individuals are less likely to have access to air conditioning and thus are one group of individuals that are vulnerable to heat waves. Additionally, it is fair to assume that older homes/ buildings are less likely to have installed air conditioning units (with an exception to window units), and thus are more vulnerable to ho potential extreme heat events.

In the case of the Town of Caroline, as overall temperatures increase, so will the chances of

extreme heat events. However, relative to more urbanized areas such as the City of Ithaca, Caroline is less vulnerable to extreme heat. Consider the factors above: Caroline is relatively rural and has large amounts of greenery and shade throughout the Town. In general, the Town of Caroline is relatively homogenous with a diversity score of 21 out of 100, with a score of100 considered extremely diverse. There is not a large population of minorities and non-English speaking individuals are found at a lower rate than in more urban/diverse areas. The median income within the town is also not particularly low at $61,212.

With that said, it is still important to note that the population of the Town is aging, and the community is increasing given the active development happening in the City of Ithaca. There is also a significantly large population of renters. Approximately 30% of Town residents are renters and do not own their own home. While renting does not necessarily mean that the population is economically disadvantaged, it is reasonable to state that renters are naturally more vulnerable to heat waves, given their lack of rights to modify their living environment. Finally, as one of the oldest states in the Country, New York is home to some of the oldest buildings and houses. This is especially true in the Town of Caroline where the average house is between 50-100 years old (US Factfinder). While many houses were likely updated since their original construction, air conditioning is not necessarily a top priority for many families living in upstate New York, especially in rural areas like Caroline where greenery and tree cover is abundant and where the historical climate has been more milder. However, with the changing weather, the demand for air conditioning installation is likely to increase over time.



Map 6: Heat Vulnerability Index

To conclude, the Town of Caroline is not a highly vulnerable community when it comes to heat waves, even with the projected increase. The generalized population are less likely to experience heat strokes and other related illnesses. The map above in Map 6 depicts the overall vulnerability to extreme heat, relative to the rest of the state (note that New York City is excluded in this scenario). However, it is important that this analysis is generalized to the population of Caroline as a whole. Individual residents will still be vulnerable to extreme heat events, and as the temperature increases there will be an increase in heat related hospitalizations and deaths. Developing heat emergency plans and cooling shelters can be a useful preparatory step to mitigate the number of heat stroke or heat-related incidents within the Town of Caroline even if the threat to the Town as a whole is somewhat more marginal.

State of Infrastructure

As previously mentioned, infrastructure in the United States, according to the Army Corps of Engineers is poorly maintained and is therefore extremely vulnerable to climate change. For New York State, the overall state of infrastructure is one letter grade higher, or a C+, than the nation. But what does this assessment mean for a place like Tompkins County and the Town of Caroline? How is the local and municipal comparable to the rest of the state, and what needs to be done to mitigate vulnerability? These are some questions that this section aims to answer by focusing on relevant infrastructure categories and that exist within the Town of Caroline and its surrounding region. It can be extremely beneficial to identify the vulnerabilities in local, given its importance for safety and economic well-being.

Bridges: Bridges, both large and small, are a critical component of daily life and safety in New York State. Ownership of bridges in New York State is shared by numerous agencies and municipalities across the state's jurisdictional boundaries. NYSDOT identifies three main ownership categories:

1. State owned bridges (many of which are eligible to receive federal funding for repairs)
2. Bridges owned and managed by authorities (such as the Port Authority of New York and New Jersey)
3. "Local" bridges owned by cities, towns, and counties

NYS has approximately 22% of structures that are in critical condition and require immediate repair or closure (currently there are 100 bridges statewide that are closed due to severe structural damage). However, due to the lack of capacity on the state level, it is impossible to keep up with the demand across the state, especially those structures located in more rural areas like Caroline and much of Tompkins County.

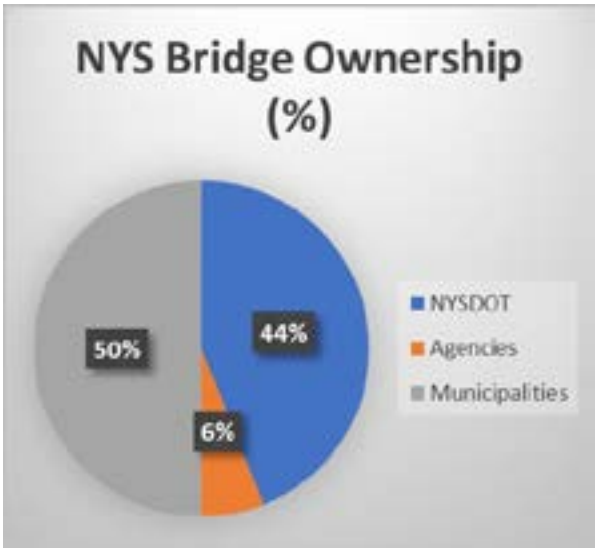


Figure 25: NYS Bridge Ownership

According to the State bridge inventory, the following conclusions can be made:

- NYS ranks #13 with the highest number of bridges in the US, with a total number that is equivalent to having one bridge of every 7 miles of road in the state.
- New York is the 12th worst state in structurally deficient bridges. Structurally deficient bridges require significant maintenance, rehabilitation, or replacement
- New York ranks 2nd worst in the nation in functionally obsolete bridges, which means that over 27% of the state's bridges do not meet current bridge operational and design standards such as substandard lane widths, lack of shoulders, and height restrictions.
- Over 100 bridges are currently closed across the state but do not have any repair scheduled and will remain closed indefinitely.

To address some of these problems, NYS DOT has adopted a bridge preservation program that

would rehabilitate rather than demolish the existing bridge. As a result, the number of structurally deficient bridges has decreased from 57% in 1992 to 12% in 2014.

While a large portion these disrepairs across the state are due to the lack of funding available, another reason is due to the lack of coordinated effort between the municipal/state/federal government, as well as the bureaucratic inefficient framework that causes significant delays in projects that could cost less, if done properly from the beginning. In some cases, a municipal government that applies for funding might not do so until the last minute at which it takes the federal government to respond, after which the municipality might need to apply for a new permit.

Note that when locally owned bridges are included in federally funded bridge rehabilitation work, FHWA will provide 80% of the cost of the work, but the state and or local government must provide the remaining 20%. However, when the municipality does not have enough funding, this can cause additional expenses that would have otherwise been avoidable.

Caroline Bridges:
Being a town that is located in an area with abundant water, Caroline has many bridges located throughout the municipality. A large majority of the paved roads are owned and maintained by the county highway department which is also responsible for all bridges that are along county routes. While most bridges are short to medium length, many roads throughout Tompkins County and the Town of Caroline depend on these bridges to connect across the many streams and rivers that flow through the valleys.

Regarding to the characteristics of the bridges located within the Town of Caroline, overall inventory from the NYSDOT database shows that as of 2020, bridges are mostly in good condition within the Township. As for ownership, the Town of Caroline does not own any existing bridges and therefore is not responsible for the maintenance and upgrading of existing infrastructure. At the same time, the Town cannot take control of the bridges and their construction within the Town. As of current, the Town of Caroline has one bridge that is considered to be in poor condition. This bridge is located on old route 76 and crosses a tributary to Boyer creek. While the bridge is not a significantly old structure (built in 1987), the existing bridge has been categorized as potentially vulnerable and thus should be noted to be a point of concern for the community. Even though Old Route 76 is not a busy road, the thoroughfare is a primary road that connects the community of Speedsville with the rest of Tompkins County.

Below is a database of bridges that are located within the Town of Caroline (Table 7).

Table 7: Bridge Inventory for Caroline

County	Municipality	ID	Location	Feature Carried	Feature Crossed	Owner	Year Built	Poor status
Tompkins	Caroline	3314040	.9 MI W SLATERVILLE SPNGS	BOICEVILLE ROAD	SIXMILE CREEK	30 - County	1942	N
Tompkins	Caroline	3314050	.3 MILE S OF SPEEDSVILLE	OLD SEVNTY SIX RD	BOYER CREEK	30 - County	2009	N
Tompkins	Caroline	3314060	1.5 MI NW OF SPEEDSVILLE	OLD SEVNTY SIX RD	TRIB BOYER CREEK	30 - County	1987	Y
Tompkins	Caroline	3314080	IN SPEEDSVILLE	OLD SEVNTY SIX RD	W BR OWEGO CREEK	30 - County	2001	N
Tompkins	Caroline	3314190	2.8 MI W SLATERVLLE SPNGS	HARFORD ROAD	W BR OWEGO CREEK	30 - County	1977	N
Tompkins	Caroline	3314100	1.6 MI SOUTH OF BESEMER	CR113LOUN SBERRYRD	SIXMILE CREEK	30 - County	1988	N
Tompkins	Caroline	3209710	2 MI N OF SPEEDSVILLE	Blackman Hill Rd.	W BR OWEGO CREEK	30 - County	1994	N
Tompkins	Caroline	3209720	1 MI SOUTH OF BESEMER	MIDDAUGH ROAD	SIXMILE CREEK	30 - County	1978	N
Tompkins	Caroline	3209730	.5 MILE EAST OF BESEMER	BANKS ROAD	SIXMILE CREEK	30 - County	2008	N
Tompkins	Caroline	3209740	.4 MI W SLATERVILLE SPGS.	CREAMERY ROAD	SIXMILE CREEK	30 - County	1977	N
Tompkins	Caroline	3209750	IN SLATERVILLE SPRINGS	BUFFALO ROAD	SIXMILE CREEK	30 - County	1993	N
Tompkins	Caroline	103590	3.6 MI NW TIOGA CL; RTE 79	79 79 36051035	SIX MILE CREEK	NYSDOT	1963	N
Tompkins	Caroline	1045990	AT BROOKTONDALE	COOKS CORS BRK RD S	SIX MILE CREEK	30 - County	1966	N
Tompkins	Caroline	1046000	5 MI S OF WEST SLATERVLE	VALLEY ROAD	BOICE CREEK	30 - County	1966	N
Tompkins	Caroline	1046010	1 MI SE OF W. SLATERVILLE	CENTRAL CHAPEL RD	BOICE CREEK	30 - County	1966	N
Tompkins	Caroline	1046020	4.9 MI SE JCT RTS. 330&79	CENTRAL CHAPEL RD	BOICE CREEK	30 - County	1987	N
Tompkins	Caroline	1046030	AT GUIDE BOARD CORNERS	CENTRAL CHAPEL RD	BOICE CREEK	30 - County	1966	N
Tompkins	Caroline	1094700	.3 MI E JCT SH 79 & CR162	79 79 36051041	TRIB SIX MILE CRK	NYSDOT	1963	N

Source: https://www.dot.ny.gov/main/bridgedata/

Dams:

As of 2017, New York State has over 7000 dams that provide for essential control and protection of drinking water, irrigation, flood control, fire protection, recreation, hydropower, navigation, and wildlife habitats. As the many of these dams are quite old, an average of 69 years, approximately 400 are considered to be in extremely high hazard conditions, 660 in moderate to high hazard, and 4209 in moderate to low hazardous conditions. These classifications go as follows:

- High Hazard (Class 'C') Dams - Failure may result in widespread or serious damage to homes, main highways, industrial or commercial buildings and/or important utilities such that the loss of human life or a widespread substantial economic loss is likely.
- Intermediate Hazard (Class 'B') Dams - Failure may result in damage to isolated homes and main highways, and may result in the interruption of important utilities, but are otherwise unlikely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.
- Low Hazard (Class 'A') Dams - Failure is unlikely to result in damage to anything more than undeveloped lands and buildings; is unlikely to result in the interruption of important utilities, and/or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.

As for inspection, there are only 11 individuals employed by the state to conduct maintenance and inspection of approximately 5300 dams. Currently, approximately 49% of dams are owned publicly, while the remaining 51% is privately owned by corporations and private institutions. For all dams, it is required by law that the owner of the facility conduct the following:

- An Inspection and Maintenance Plan
- An Emergency Action Plan: As of 2009, the owner of a dam that assigned a Hazard Classification of Class 'C' or 'B' is required to prepare an EAP and annual updates are to be submitted to the NYSDEC and local emergency management officials.
- An Annual Certification
- Notification of Auxiliary Spillway Flow
- Recordkeeping and Response to Request for Records
- Notices of Property Transfer
- Safety Inspections: In New York, dam owners of High Hazard, Class 'C', or Intermediate Hazard, Class 'B' dams are required to undertake Safety Inspections regularly as identified in the Inspection and Maintenance Plan for each dam. These inspections are required to be performed by a licensed and registered professional engineer.
- Engineering Assessments: New York Dam Safety Regulations requires the preparation of an Engineering Assessment (EA) Report, which must be submitted to the NYSDEC for all High Hazard, Class 'C' and Intermediate Hazard, Class 'B' dams every 10 years.

While funding for rehabilitation of dams is available, it is primarily up to the owner of the dam to come up with the necessary resources to keep their dams in adequate repair. Current regulations allow NYSDEC to seek civil penalties. A violation of a dam permit requirement is a misdemeanor punishable by a fine of up to $10,000 or imprisonment of up to one year, or both, in addition to a civil penalty of up to $5,000. Violation of an order to repair or remove a dam is punishable by a fine of up to $5,000 for each offense; in case of a continuing violation, every day's continuance is a distinct offense.

Approximately $152 million is needed to repair the deficient High Hazard and Intermediate Hazard dams in New York State. It is important to note that most of these dams are privately owned and are not controlled by federal/ state/ or municipal government. In New York's 1996 Clean Water/Clean Air Bond Act devoted $1.75 billion to protect and restore the state's environment. In 2012's budget, approximately 18.5 million was in the budget to repair NYS DEC dams.

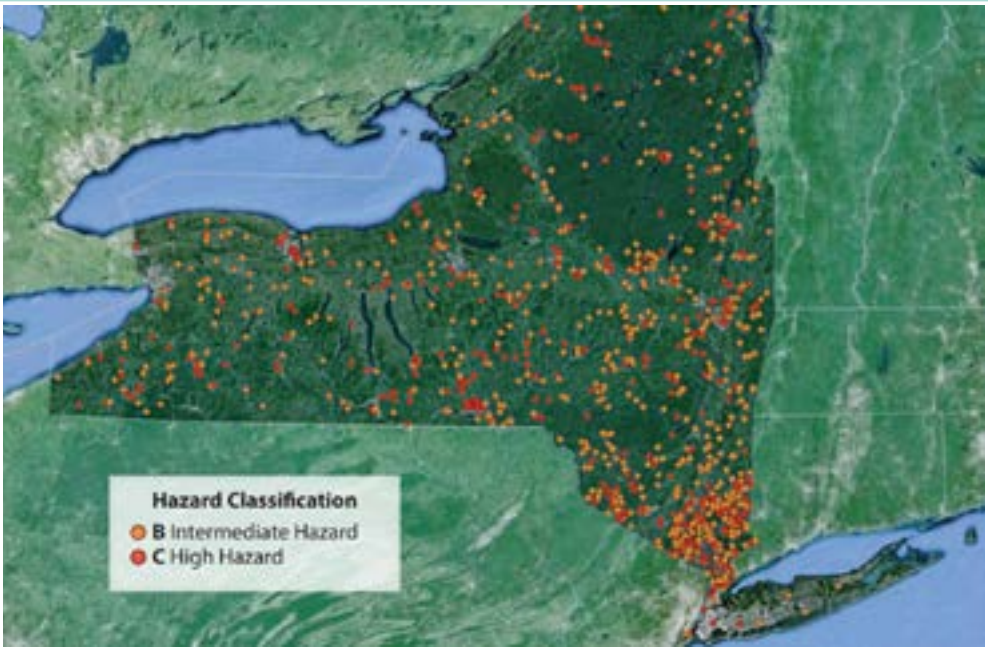


Figure 26: NYS Dam Hazard Index

Caroline Dams:
New York State Department of Environmental Conservation has created a standard code designation for the conditions of dam infrastructure in New York. The map shown in Figure 26 depicts these dams that are classified as hazardous. Map 7 depicts the different dams that are located within the Town of Caroline. Each one is classified based on its hazard category. These categories include the following:

Class "A" or "Low Hazard" dam: A dam failure is unlikely to result in damage to anything more than isolated or unoccupied buildings, undeveloped lands, minor roads such as town or county roads; is unlikely to result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/or is otherwise unlikely to pose the threat of personal injury, substantial economic loss or substantial environmental damage.

Class "B" or "Intermediate Hazard" dam: A dam failure may result in damage to isolated homes, main highways, and minor railroads; may result in the interruption of important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; and/ or is otherwise likely to pose the threat of personal injury and/or substantial economic loss or substantial environmental damage. Loss of human life is not expected.

Class "C" or "High Hazard" dam: A dam failure may result in widespread or serious damage to home(s); damage to main highways, industrial or commercial buildings, railroads, and/or important utilities, including water supply, sewage treatment, fuel, power, cable or telephone infrastructure; or substantial environmental damage; such that the loss of human life or wide-

spread substantial economic loss is likely.

Class “D” or “Negligible or No Hazard” dam: A dam that has been breached or removed, or has failed or otherwise no longer materially impounds waters, or a dam that was planned but never constructed. Class “D” dams are considered to be defunct dams posing negligible or no hazard. The department may retain pertinent records regarding such dams.

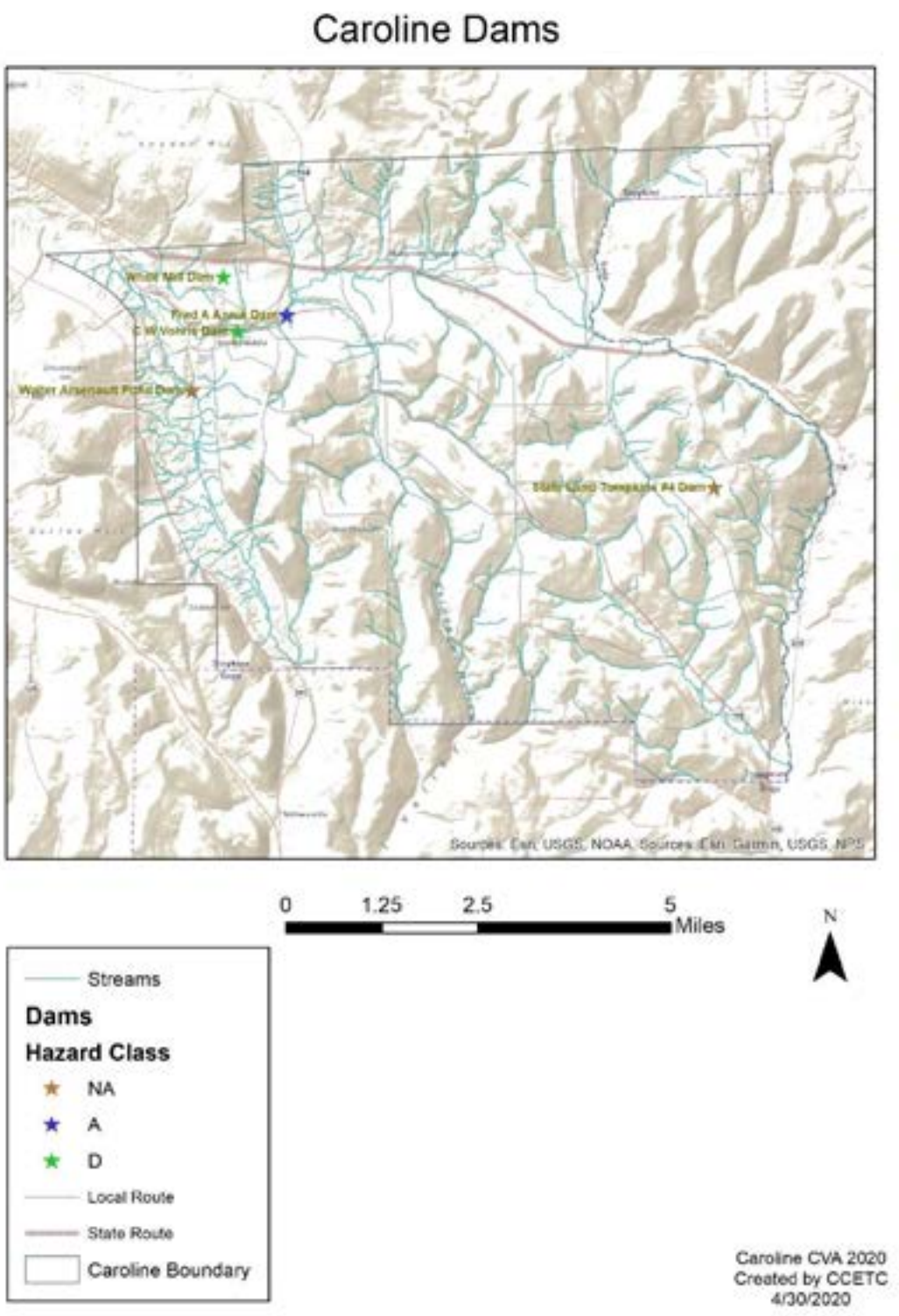
The above classification was developed by the NYS DEC and can be found in the DOW TOGS 3.1.5 – GUIDANCE FOR DAM HAZARD CLASSIFICATION Manual through the following link: https://www.dec.ny.gov/docs/water_pdf/togs315.pdf

Overall based on the data available in the Town of Caroline, two dams are Class D “Negligible or No Hazard” as they are either no longer operational or have been shut down due to high hazardous conditions. Two dams that are marked “NA” which means that they have not yet been assigned a hazard value and thus data is not available. One dam is categorized as Class B, or low hazard, known as Fred Annis Dam and is located along Six Mile Creek. The owner type is categorized as private and owned by Fred Annis used for hydroelectric power. As the overall classification is Low Hazard, there moderate to no concern regarding immediate needs for maintenance and reconstruction. However, for those that have not been rated, it is advised to investigate the reason for this classification and conduct an assessment as needed. The table below (Table 8) provides the necessary information regarding the characteristics and owner of the dams in Caroline:

Table 8: Caroline Dams

State ID	Federal ID	NAME	Hazard Code	River	Year Built	Construction Type	Owner	Owner Type	Purpose
075-0738	NY11604	White Mill Dam	D	SIX MILE CREEK	1907	ST - Laid Up Stone	JOHN M WHITE	N/A	Hydroelectric
075-0739	NY14234	C W Voorhies Dam	D	SIX MILE CREEK	1896	OT - Other	Not Found	Not Found	Other
075-2226	NY11613	State Land Tompkins 04 Dam	NA	WILLOW CREEK	1954	RE - Earth	NYS DEC	State	Other
075-2358	NY11614	Walter Arsenault Pond Dam	NA	TR-WILLSEYVILLE CREEK	1955	RE - Earth	WALTER ARSENAULT	N/A	Recreation
075-0736	NY11603	Fred A Annis Dam	A	SIX MILE CREEK	1800	CN - Concrete Gravity	FRED A ANNIS	N/A	Hydroelectric

Source: https://gis.ny.gov/gisdata/inventories/details.cfm?DSID=1130



Map 7: Dams in Caroline

Parks:
New York State is one of the first states to have a state park designation. As the usage of state and municipally owned parks has increased, the overall conditions have degraded and the number of parks that are considered critical in terms of a need for updated facilities is growing. Much funding that covers the operation and maintenance costs of state parks is sourced from state taxes (57%), while fees and charges charged by its users cover the second majority (41%). In 2010, approximately 90 parks were shut down due to the inability of the state to provide funding. However, with concern voiced by the public, approximately 11 million dollars in funding was provided the same year to invest across all state parks. New York has begun many capital improvements projects to help parks across the state and increase the overall grade of publicly owned parks in New York.

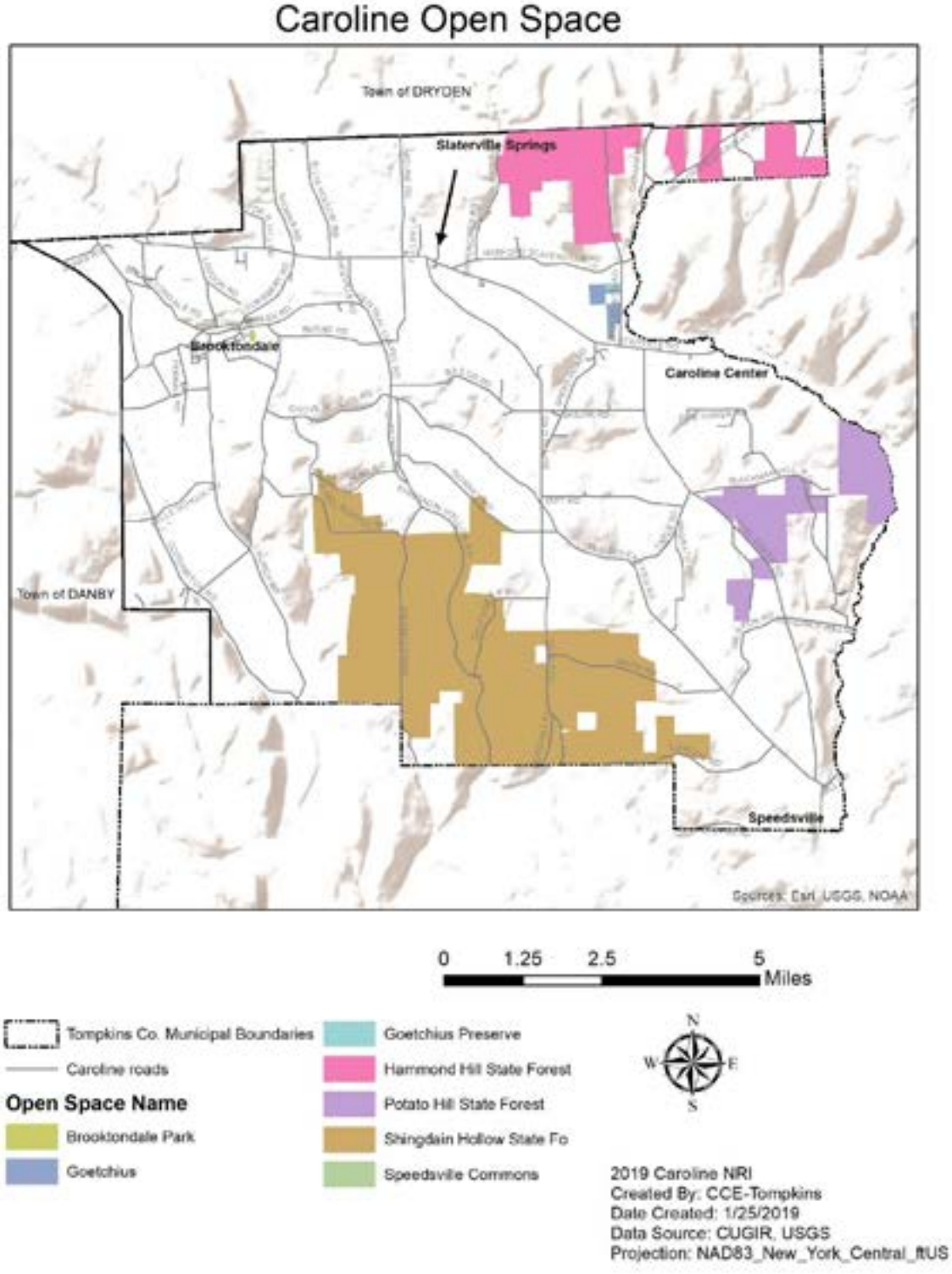
Caroline Parks:
Caroline has a large amount of land that is dedicated to open space and parks that are owned by the municipality, state, or private landowners (see Map 8). As of 2020, there are no recorded vulnerabilities that have been reported. The table below (Table 9) discusses the general information about each park as well as the ownership and responsible party/ institution.

Table 9: NYS Parks

Name	Owner	Agency	Description
Hammond Hill State Forest	STATE OF NEW YORK TAXABLE/NYS Bond Project	NYSDEC	STATE FOREST
Potato Hill State Forest	STATE OF NEW YORK TAXABLE	NYSDEC	STATE FOREST
Shingdain Hollow State Forest	STATE OF NEW YORK TAXABLE	NYSDEC	STATE FOREST
Brooktondale Park	BROOKTONDALE VOL FIRE CO	NA	REC FACILITY/ Muni Park o White Church Road
Speedsville Commons	NYS PARK	NA	REC FACILITY/ Muni Park in Speedsville
Goetchius Preserve	Armitage	FLLT	Nature Preserve
Goetchius	FINGER LAKES LAND TRUST	FLLT	Nature Preserve

Roads:
New York State has received a below average grade of a D- and is categorized as usable, but in catastrophically hazardous conditions, both in rural and urban areas. At the same time, the quality of roads does vary by region as this infrastructure is owned and funded by various governmental agencies across the state. Decrepit road infrastructure leads to delays, road closures, congestion, and other problems that lead to an inefficient economy. While data is skewed towards urbanized areas, New York remains to be the 4th busiest state in terms of vehicle traffic. Due to the extremely low grade and hazardous infrastructure, the state has created various programs including the following that have been developed to prioritize state roads and major arterials:

- Multi-Modal Transportation Program Submission
- Capital Program
- Two-Year Capital Program (Stop-Gap pending passage of a new FA Multi-Modal funding bill and new Surface Transportation Program and stabilization of the State's economy



Map 8: NYS Parks

- New York Works For Investment in Transportation Infrastructure (Forward Four Program) – approximately doubled the overall budget of road maintenance and construction

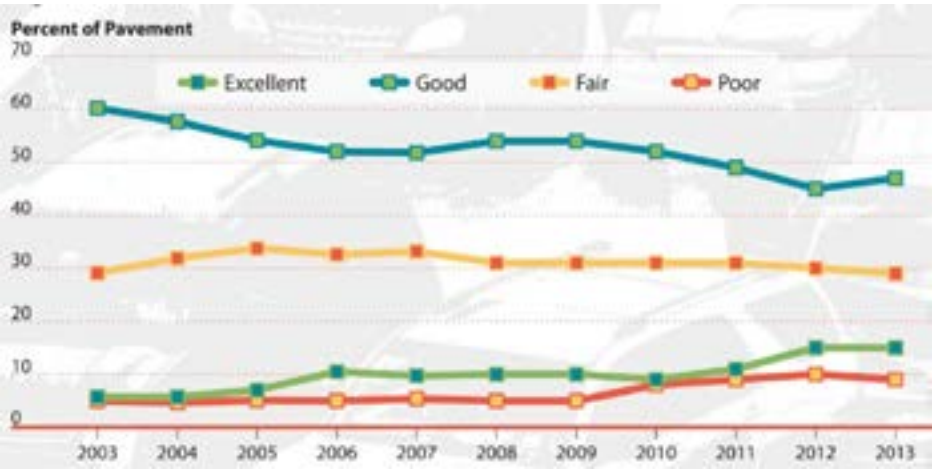


Figure 27: Road Pavement Quality in NYS

With the levels of investment envisioned in recent capital programs and the priority given to addressing the most heavily used highway segments, NYSDOT expects some improvement in pavement by the close of the program in 2015 on higher level roadways. However, regionally operated Highway System and local Federal Aid highways will experience a decline in condition. Finally, the overall quality of road pavement has been declining over the years as shown in Figure 27 published by the ACoE.

Surface Scoring: Surface scorings are the markings on the surface of the road to help guide traffic. According to the ACoE report, the overall scoring is above average and 15% considered to be excellent, 50% to be good, approximately 30% to be considered fair, while only 5% is considered to be poor.

Funding: while there have been various funding programs initiated by the state, many of these programs are not permanent. According to a report Multimodal Investment Needs and Goals for the Future used by the ACoE, approximately $40 Billion is needed over a 20-year timeline to fully restore the entire state's infrastructure, which is approximately $2 Billion per year. In comparison, the state has spent over $400 million on statewide pavement improvements, which is still not close to the needed amount. While in given years, the government has infused over $2 billion, unless this funding is provided consistently, such investments are inadequate and barely touch on addressing the state's most critical infrastructural problems. While some solutions include the preservation of existing infrastructure, rather than repaving or reconstruction, these recommendations only reduce costs by a modest level and do not provide the necessary means to adequately maintain roads across the state.

In regards to public safety, it costs the State approximately 19.5 billion for the total number of fatalities and accidents caused due to unsafe roads; that is when considering medical costs, lost productivity, travel delays, workplace costs, insurance costs, and legal costs. With increasing extreme weather events and the erosion of existing road infrastructure, this cost is likely to continue to rise.

Town of Caroline Roads:
The Town of Caroline has roads that are maintained under various jurisdictions. These include

State, County, Town, and private seasonal roads. As the Town of Caroline controls approximately 69.96 miles of centerline miles of road and 114.58 lane miles. In comparison, the county controls 29.06 centerline miles and 58.12 lane miles. According to the NYS DOT, most roads are paved, however, some town roads are not paved and are seasonal. Road maintenance responsibility is according to the ownership and is shown in Figure 28. Roads in Figure 29 shows the roads that are eligible for state and federal aid. According to the Pavement quality report produced by the NYS DOT, most county and state roads are considered to be average to above average in pavement quality/ maintenance, while town roads can vary significantly, especially in rural areas where it is assumed that overall maintenance is not required. More information on road quality can be found through the annual road quality report: https://www.dot.ny.gov/divisions/engineering/technical-services/pavement-management

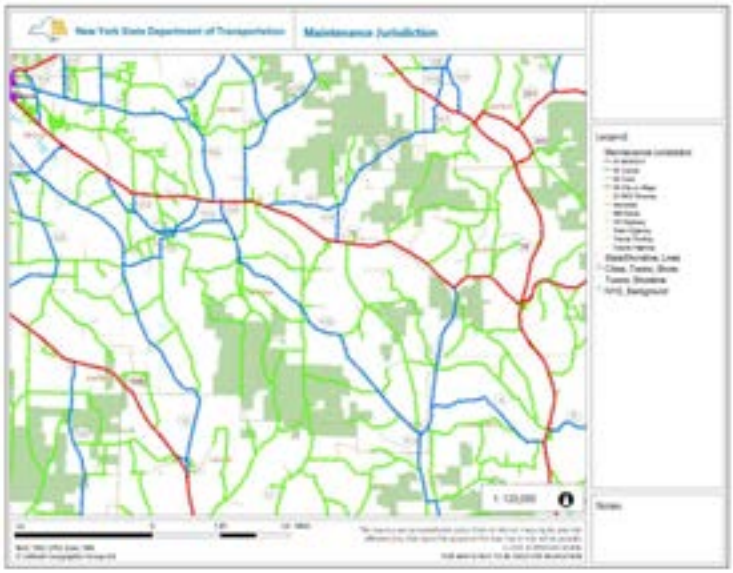


Figure 28: Maintenance Jurisdiction

Additional information on road inventory (which is updated every year can be found at the following page: https://www.dot.ny.gov/highway-data-services/lhi-county-roads

Overall, according to the NYSDOT, it is recommended to use permeable pavement in areas that experience a great deal of flooding. While in general, it can be difficult to keep up with the maintenance of all municipal roads, permeable pavement is supposed to be more durable and flexible and is less likely to produce cracks and potholes during the winter months. There are also other methods to reduce erosion and runoff. These methods can be found by in additional information and resources found in the Cornell Local Roads Program Website: https://www.clrp.cornell.edu/

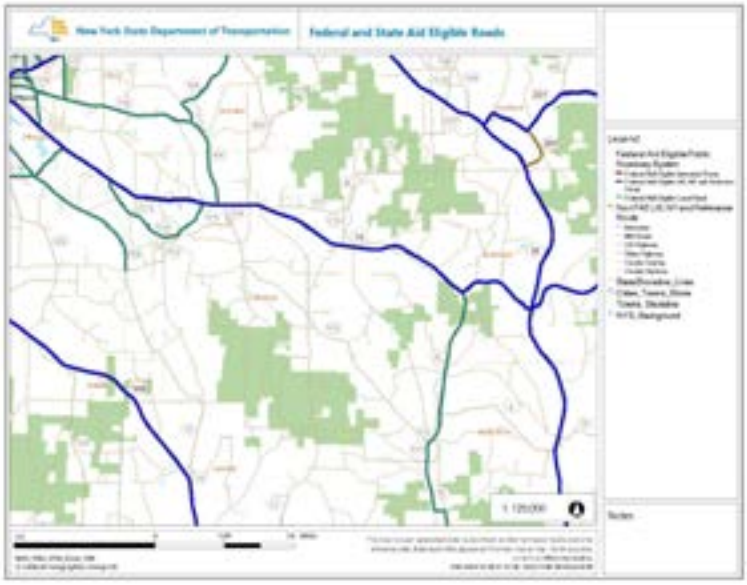


Figure 29: State/ Federal Aid Eligible Roads

Solid Waste:

Solid Waste systems and facilities are considerably well-maintained given the state of other infrastructure. This above average maintenance is partially due to the state's overall decrease in solid waste as reported in Table 10, thus leading to the capping and closure of many facilities.

Table 10: Tons of Solid Waste NY

Year Recorded	Tons of Solid Waste
2012	7.7 Million Tons
2009	10.6 Million Tons
1990	14.6 Million Tons

The number of active municipal solid waste (MSW) landfills in New York has been drastically reduced. In 1987, there were 348, mostly unlined, MSW landfills in New York. As of 2012, New York State had 59 landfills, categorized by its deposited material:

- 26 municipal solid waste (MSW) landfills (everyday wastes from households, industries, and commercial establishments).
- 16 Industrial/commercial waste landfills (coal ash, paper mill sludge and similar materials).
- 12 construction and demolition (C&D) landfills (debris from building or destruction projects); and
- 5 Long Island landfills, two of which were ash monofill landfills (ash from the combustion of MSW).

In 2010, the number of municipal waste combustors (MWC) also decreased from 13 to 10 for several reasons, including financial and technical issues

In regards to ownership, the majority of landfills are privately owned and thus the responsibility of public safety management and climate resilience development is solely up to the operator and owner. While most landfills are relatively well maintained, these are still areas of concern given the volatility of these sites and the amount of polluted and contaminated runoff that can leak out of these sites, especially those that are still operating.

Caroline Solid Waste:

Solid waste in the Town of Caroline is managed by non-municipal facilities. Within the Town there are not any major garbage or waste disposal sites. However, there are inactive landfills that exist within the Township (Table 11). According to Tompkins County, municipal waste is exported out of the county to various facilities across NYS. Therefore, vulnerability in regards to actively operating landfills is non-existent within the Township.

Table 11: Landfills in Caroline

Name	Cover Status	Usage	Acres	Owner	Observations	BND Status
Downey Road Dump #2	Covered	Public	1.639	Robert & Minnie Brill	Regenerated to coniferous/deciduous forest.	General
Downey Road Dump #1	Covered	Public	0.801	Carlton Plunkett	Location of site very sketchy.	Very Poor
Level Green Road Dump #2	Covered	Public	1.5	Don & Bruce McPherson	Regenerated to mixed forest.	General
Level Green Road Dump #1	Covered	Public	0.377	Don & Bruce McPherson	Regenerated to mixed forest.	General
Shendagin Hollow Road Dump	Visible	Public	4.357	NYS	Observations of new garbage being dumped - 1992. Regenerated to deciduous forest.	General
Town of Caroline Dump	Unknown	Public	0.701	Nathan Shevalier	Located off Buffalo Hill Road, back of Nathan Shevalier and/or Cornell family property. Located near tributary of 6-mile creek.	Very Poor

However, according to Table 11, there are multiple sites of concern within the Town of Caroline that are known to be old landfills/no longer active landfill sites. Sites that have an exposed or visible status are also especially areas of concern. While the Town and state are responsible for

keeping their landfills according to state and federal compliance, it can be useful to discuss compliance issues with private owners to make sure all safety precautions are being taken.

Wastewater Treatment:
In New York State there are approximately 610 wastewater treatment plants. Much infrastructure that connects wastewater, and stormwater are on average over 60 years old. While the current wastewater infrastructure is in operation, much of this infrastructure needs to be upgraded and is estimated to cost the state approximately $36.2 billion. In the 1990s, the federal Construction Grants Program was replaced by a low-interest loan Clean Water State Revolving Fund (CWSRF) program, which requires locals to match federal investments making it harder for many communities to address their infrastructure needs. In total, the program has helped fund 1550 projects across the state and has totaled approximately $12.5 billion.

While urban infrastructure is in critical condition, the rural areas are not much better off, as a significant amount of wastewater either is treated by significantly outdated treatment plants or are not treated at all and enter the local streams and waterbodies. Much of stormwater infrastructure, for example, unlike urban sewer systems do not enter any treatment process and instead flows directly into waterbodies. This endangers the environment, wildlife and public health that live downstream and can lead to contaminated waterbodies that are infested by algal bloom. According to the ACoE, the most problematic stormwater related issues are nutrient eutrophication as well as hazardous stormwater runoff.

With increased flooding events, it is forecasted that not only will stormwater infrastructure be threatened and cause significant environmental damage at its current state, but existing wastewater treatment facilities are vulnerable to flooding and can contaminate local waterbodies, which in turn will lead to contaminated watersheds. Therefore, state and local governments work closely to increase the resilience of the existing infrastructure.

Caroline Wastewater:
The Town of Caroline does not have wastewater treatment as all residents have their own septic system on site or within a close vicinity to their residence/structure. Currently, the Township does not have any treatment process or facility to manage stormwater drainage across the Town. Water contamination can lead to problems like algal bloom in Cayuga Lake and overflowing of ditches that can lead to flooding in other ditches and streams across the watershed.

According to a study conducted by the Cornell University Department of Natural Resources, in order to move stormwater out of the landscape, roadside ditches need to be maintained and cleared. The methods used by 73% of highway managers to “clean” all or parts of the ditch involves scraping out the ditch substrates with a backhoe or rubber-tired excavator. About half (49%) of highway managers report scraping once every 1-4 years. this practice removes accumulated debris, soil and plant roots are also removed, leaving the exposed soil vulnerable to the next storm event. Re-seeding can help counteract some of the negative impacts of scraping by facilitating plant regrowth.

According to the Town of Caroline Stormwater Management Plan, addressing stormwater runoff

issues is a particular concern to the community to mitigate contaminants such as sediment nutrients and pathogens from entering the water. Sources of these pollutants include agricultural activities, stream bank erosion, failing on-site systems, chemicals used on residential lawns, and construction site runoff. As a participating MS4 community, the Town has mapped ditches and ditch flow across the Town. This map can be seen in Map 9.

Based on the analysis conducted in Caroline:
Waterbodies of concern include Cayuga Lake plus major tributaries: Six Mile Creek, West Branch Owego Creek. Methods to mitigate excess runoff include enforcing the practice of maintaining riparian buffers, mitigate direct flow into ditches from tile drainage systems, and develop infiltration basins and green infrastructure to filter out contaminants out of the runoff water.

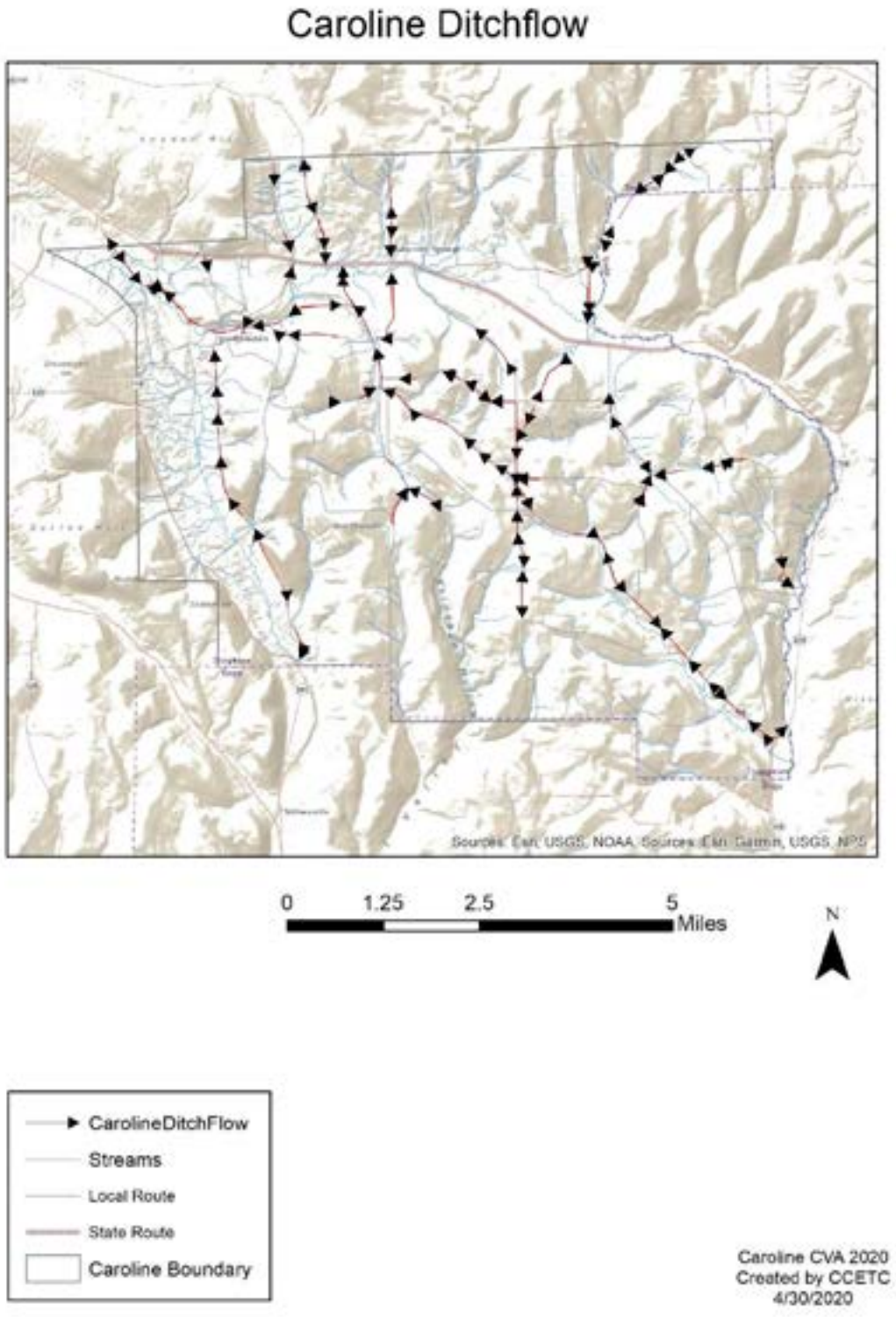
Areas of concern are those located at the end of ditch flow at which water volume is at a maximum and erosion occurs at culverts that are usually perpendicular to existing ditches. In order to mitigate erosion in these areas, as previously mentioned, green infrastructure and hydroseeding is needed in order to mitigate overall flow speed within the ditch as well as discharge volume.

Community Meetings

The Town of Caroline Climate Vulnerability Assessment process involves various exercises involving the community to understand the priorities and concerns within the municipality. The facilitation process involves various methods, as discussed above in the methodology section. To gain insight into the community's perspective, multiple community meetings were conducted as well as a climate vulnerability assessment workshop. The results of these meetings are as follows.

Community meeting attendance:
For preliminary community assessments, various community meetings were attended between September of 2019 and March of 2020. While these meetings were scheduled as monthly committee meetings, Cornell Cooperative Extension associates requested to reserve approximately 30 minutes per meeting to have a discussion on climate vulnerabilities. These meetings were not necessarily designed according to the Community Resilience Building methodology, but rather general announcements to inform citizens of the climate vulnerability assessment as well as to get general guidance on what the community thought as concerning or specific topics that would guide Cornell Cooperative Extension's preliminary research on the community. The following groups were identified as primary stakeholders in this assessment process:

- Town Supervisor
- Town committee members – Watershed Committee, Energy Independent Caroline, Planning Board
- Local business owners
- Highway Department/ DPW
- Code enforcement officer
- Local activists
- Major landowners/ farmers
- Educators (teachers) – Caroline School District/ PTA
- Town Council Members – Town Council officials



Map 9: Ditch Flow

- County representatives – Soil and Water Conservation District and County Planning

These groups were identified and contacted to schedule a 30-minute session where CCE would provide some basic introductions and then ask the community the following questions in order to encourage and facilitate feedback. While not all groups responded to the request from CCE, those that did respond included:

- Town of Caroline Supervisor
- Caroline Town Council
- Town of Caroline Planning Board
- Town of Caroline Watershed Committee
- Brooktondale Community Center
- Energy Independent Caroline

At each meeting, a basic introduction was provided about the climate vulnerability assessment and the following questions were asked to solicit community feedback and concerns around climate vulnerability:

- What are the key concerns directly related to climate change in your community (flooding, droughts, heatwaves, etc.?
- What do we need to know when collecting data points for vulnerabilities? Location (obviously), type of vulnerability, roads affected, people affected, etc.?
- What are some key points to assess each vulnerability (for the rubric)?
  For example: Do we need to know how many people does it affect? What roads will be closed due to this vulnerability? How frequently does an event occur? Etc.
- Any other communities/ stakeholders that we should reach out to?
- What are some town-wide key concerns when it comes to climate related vulnerabilities (i.e. stormwater system, electricity, sewage, roads, etc.)?
- What areas are most prone to climate vulnerabilities (please mark on maps provided)?

Based on these questions, similar concerns and feedback were provided by each party and the summary of this feedback is as stated below and is ranked based on the most to least number of times mentioned by the community members.

Community Comments:

- Brooktondale stormwater infrastructure is currently a major concern within the Town. Many people who live in the hamlet are concerned about the overflow of stormwater infrastructure and Six Mile Creek
- All residents have private wells as the Town does not have a public water supply. The water quality varies across the Town, especially during droughts and floods; it might be necessary to look into aquifer characteristics and what aquifers are confined vs not confined.
- Groundwater overflow is a problem for many residents within the Town. Groundwater overflow is often due to shallow aquifers that tend to overflow after extreme storm events. Problem people are experiencing include basement flooding as well as backyard flooding after extreme weather. Most locations where this occurs has been identified as properties that have or surrounded by steep slopes.

- Agricultural runoff is another issue that was expressed as a concern to many individuals in the Town of Caroline. While the agricultural industry has been declining within Tompkins County and Caroline, the existing farms have been known to be a significant contributor to high nutrient levels in waterbodies. While major intervention is necessary, it is unreasonable to expect all farmers to comply due to the costs and time that are involved in reducing runoff. However, with increasingly extreme weather events, it is necessary to figure out a way to implement land use practices and laws that will reduce the overall runoff, not just from farms, but other land cover surfaces as well.
- Heat Waves are an increasing concern in the community especially with the number of elderly individuals that live in the community without air conditioning. As historically Caroline has been a cooler and damp region, not just in the country but also in the region, most houses in the municipality do not have air conditioning. While more individuals are installing newer and energy efficient heating cooling systems in their houses like heat pumps, it is still uncommon to have a cooling system, especially in older houses. Therefore, it might be worth building or designating a public cooling center that can be used by individuals that do not have air conditioning.
- Emergency services are another concern within the community. Currently, there are no permanent emergency medical services in the Township. For ambulance and medical services, the Town relies on Bangs Ambulance services located in Ithaca, and while this service has sustained the community until this point, community members are concerned that given the increased extreme weather events that are expected to increase, emergency medical service distance and lack thereof, can directly be a vulnerability to the Town, especially to those that might have chronic health issues or are immobile.
- Finally, as the Town does have multiple landfills in the Town, that are either privately or publicly owned, the vulnerability of these existing sites needs to be examined; as extreme weather becomes more frequent, the threat of these sites contaminating local water sources or even land is increasingly probable. Therefore, it is necessary to prepare these sites by constant monitoring and implementing strategies to mitigate the threats of these sites.

Workshop:

In addition to the community meetings, Cornell Cooperative Extension hosted a Workshop that, due to the COVID-19 pandemic, became a virtual meeting. The virtual workshop included similar elements as the original workshop, but is expected to have changed the overall results. The feedback and discussion that was generated during this meeting was a crucial element of this assessment process and the results can be summarized as follows:

Flooding:

Speedsville, Brooktondale, Slaterville, and the northeastern section of Caroline are believed to be points of vulnerability in regards to flooding. In the meeting it was noted that groundwater flooding is especially prevalent in areas where topographical characteristics are rough and steep. The road that borders the Town of Caroline and Tioga County is especially threatened by major erosion and ditch overflow. The problem with many of the exiting ditch management practices is that revegetation is not commonly done by the different highway departments. While the coun-

ty has advised its municipalities to conduct hydroseeding to prevent erosion and reduce runoff, the response has been underwhelming. In general, the Town is looking to improve its stormwater management, but needs external assistance and resources, in order to meet its future goals being developed in the new comprehensive plan.

Heatwaves:
In regards to heatwaves, the community is concerned for those that do not have access to air conditioners. While there have been efforts to encourage residents to install renewable energy and energy efficient technology such as Energy Independent Caroline and Heat Smart, these programs have had significant but limited effects on the community's heating and cooling. Some community members believe that the current programs are fine and just need to be continued, while some believe it is not enough and the Town needs to better promote the installation of heat pumps (a two in one AC and Heating System) and potentially build or designate a cooling shelter where people can go to get relief from the heat. Other threats the community pointed out are the increasing possibilities of heat strokes and the necessity for adequate emergency response. As of current, the only emergency medical services in the Town of Caroline are volunteer fire depots located in Brooktondale and Speedsville and Bangs medical services that are located in Ithaca, NY. Caroline is expected to have the slowest 911 response rate, between 14-21 minutes after the initial call, according to a study conducted by a Systems Engineering Student at Cornell University. Thus, while the Town of Caroline is not particularly the most vulnerable population in New York, there are still vulnerabilities within the community as the ones identified above that makes the community vulnerable to heat waves.

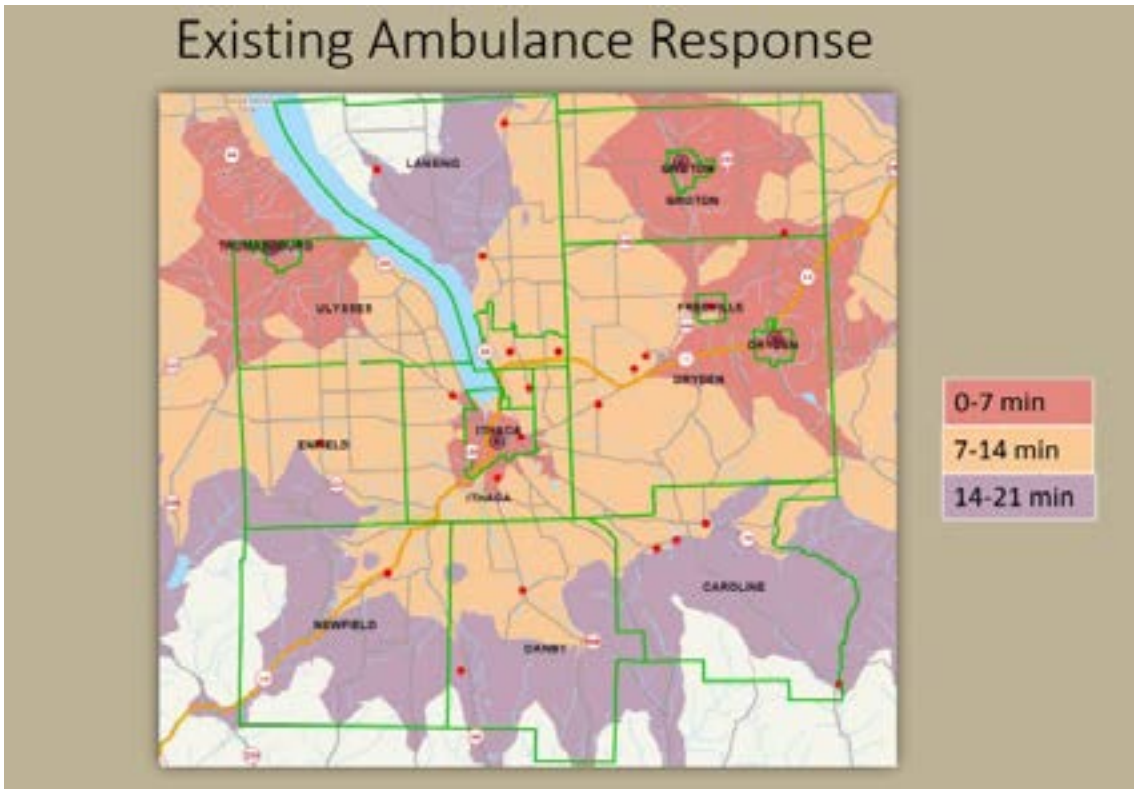


Figure 30: Existing Ambulance Response Tompkins County (Based on 2016 Data)
Credit: Thomas Stilley (Cornell Systems Engineering Masters Student); Irene Weiser (Caroline Town Council)

Droughts:
Droughts have historically not been a major issue within New York State and Caroline; however, with the increasing extreme precipitation it is also expected that droughts will increase over time, as emphasized by a Caroline town councilperson. Agriculture is no longer a major focus within the Town, as the community has slowly transitioned to a bedroom community. However, there is growing concern, especially with no municipal water services, that the existing private water infrastructure is not adequate and vulnerable to droughts, at least in parts of the community. While there are confined aquifers in the Town which tend to not become contaminated due to their isolated characteristics, not all community members have access to these safer water sources. Additional vulnerabilities identified are the vulnerability to dehydration and lack of public access to safe water supplies. While more information is needed on this topic, some community members expressed the need to develop an emergency water supply system for the entire community.

Conclusion:
In regards to climate vulnerabilities, there are no significant revelations in regards to vulnerabilities within the community. Most vulnerabilities mentioned in the community meetings as well as the workshop were mostly already identified in the preliminary research. Some vulnerability aspects that not identified and/or not considered to be particularly notable included groundwater flooding and groundwater contamination concerns. Other topics not identified as vulnerabilities, but rather because of their disconnected association with climate vulnerabilities included social network and emergency response. This was especially a concern to the community specifically not just because of the rural characteristics of the Town, but also the overall aging population. There have been various efforts to create a better community network system that could deal with emergency response. However, this group has primarily been formed in Caroline and Tompkins County in response to COVID-19. While social resilience is a key component to overall community resilience to climate change, that is beyond the scope of this assessment and not covered.

Survey

The survey for the climate vulnerability assessment is meant to solicit feedback from community members in and surrounding the Town of Caroline. Although we encouraged all community members to attend the workshops and community meetings, those who were not able to attend still had the opportunity to provide in depth feedback via the survey. The survey launched at the end of February/ beginning of March and was open until the end of April.

The summary of the survey results are as follows:

- Overall: 32 respondents (5 were not from Caroline)
- Number of people who chose flooding as top vulnerability: 29
- Number of people who chose heat waves as top vulnerability: 2
- Number of people who chose droughts as top vulnerability: 0
- Number of people who chose Other as top vulnerability: 1 (the response was extreme snowstorms)

As noted above, the majority of individuals in the Town of Caroline noted that the top vulnerability within the Town is flooding, and the second being heat waves, third being extreme snow, which also falls in the category of extreme precipitation. Overall based on feedback from the survey, participants did not think droughts posed a major threat to the community, though there was concern that less water to lead to degraded and contaminated water quality. The following will go over each section of the survey in further detail:

Flooding:
This was the overwhelmingly selected top vulnerability in the Town of Caroline. And given the feedback and discussion from the community meetings, this does not come as a surprise as most individuals expressed great concern around increased flooding and precipitation (including snowstorms). The average time period selected in regards to the frequency of these events was between once every other year and has been consistently increasing in frequency over the years. Over half of the individuals mentioned that they experienced property damage or loss due to flooding, and of those people, approximately 25% signified that they have not yet repaired existing damage caused by flooding. In regards to mitigation measures, a majority selected "change land use practices and policies", while the second most selected was "change building codes", and the third most selected was "improve stormwater management". A significant number expressed frustration with farmers in the Town not complying with state, county, and town regulations around land use management. While this information around land use and its current practices shows that there needs to be a drastic change, starting with small change can also be an effective measure.

Heatwaves:
While heatwaves were the second most selected primary vulnerability within Caroline, the number of times selected was significantly less than flooding. While droughts are not considered primary threats, the concerns around heatwaves and droughts were very similar. However, over ¾ of the survey participants expressed concern about rising temperatures in the region and the lack of air conditioning in existing houses and buildings. Approximately 50% selected "have air conditioning" while the other 50% selected "no air conditioning/other". However, some individuals who selected "no-air conditioning/ other" stated that they are in the process of installing heat pumps/air conditioning systems which shows that the number of people with air conditioning is increasing. At the same time, over 50% selected that the Town needs a public cooling shelter for its residents as there is growing concern for the elderly and individuals with chronic illnesses for getting heat strokes. A heat emergency plan was also something advised by one participant. In regards to advised mitigation strategies, most participants selected "change building code" while the second most selected was "change land use management/ decrease concrete surfaces". The overall takeaway from this section was that while heat waves are not yet a major concern, community members are increasingly aware of the temperature increases in their town.

Droughts:
The Town of Caroline does not consider this category a primary vulnerability. However, due to the interconnectivity between droughts and heatwaves, the concerns expressed by the participants around heatwaves were very much interconnected with the effects of droughts. For

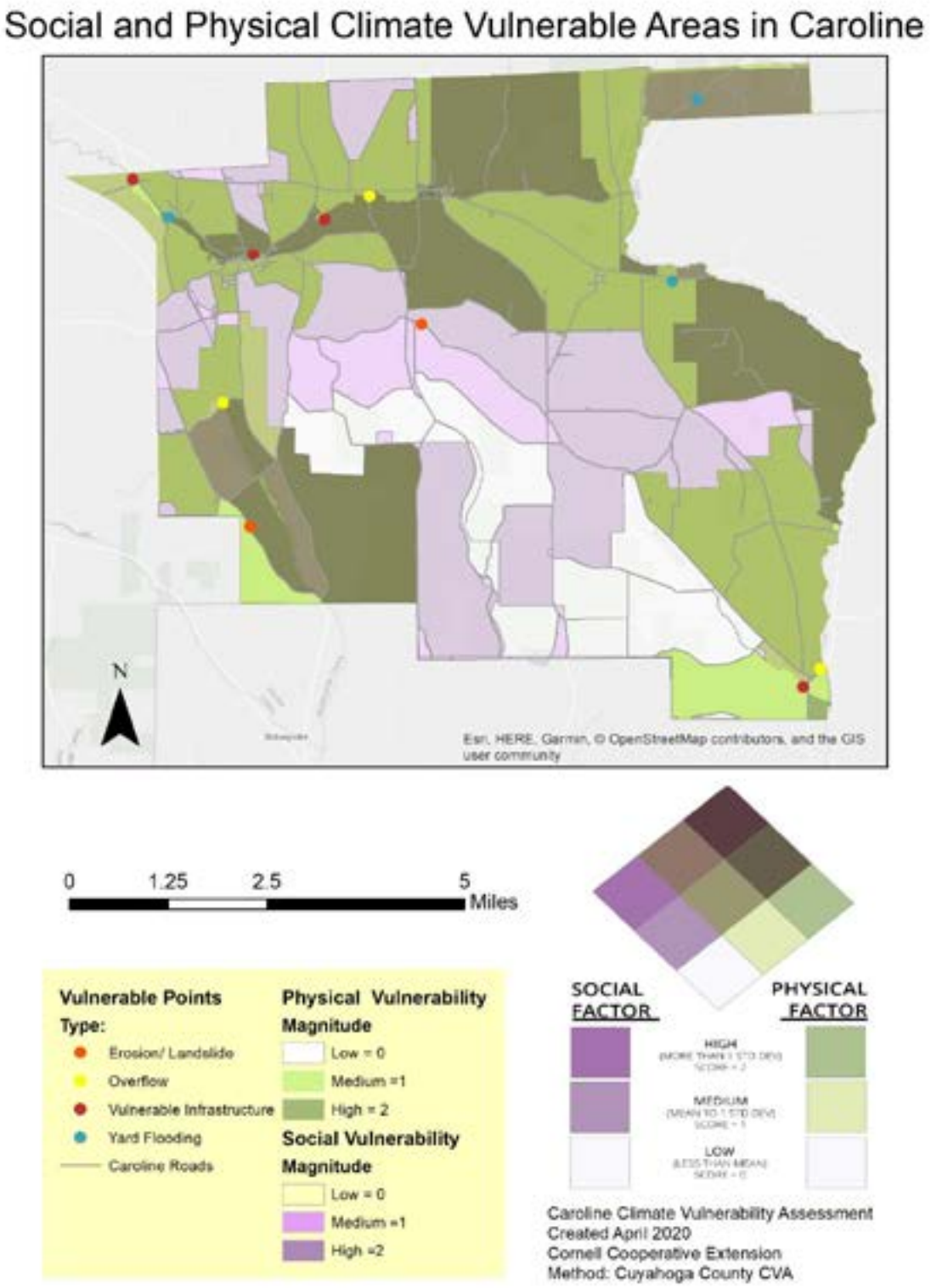
the results on major concerns around droughts, over 50% showed concern for potential water degradation due to decreasing water table levels thus lack of water supply. Many also expressed concern for potential dehydration due to increasing temperatures. Another concern expressed in the survey was in regard to farming/ gardening and the inability to provide plants with adequate water supply during droughts. Some recommendations that were changing agricultural practices to increase tree and wild vegetation to prevent the soils from drying up (less than 50%) while others suggested the need for water conservation and more water efficient technology (toilets/ washing machines, etc.) (40%). Some others recommendations include the development of a municipal water supply system and a water recycling system. Overall, the majority of individuals expressed concern for droughts, but given the characteristics of the Town and the overall flooding issues, droughts in the midst of climate change are not a primary concern, at least for the participants of the survey. However, because the weather continues to change and the possibility of more droughts occurring in the future (similar to 2016), it is reasonable to assume that people's opinion on this topic is expected to change over time.

Summary:
Overall, the survey shows that the opinion of climate vulnerabilities is relatively in line with the workshop and community meetings. While there approximately 30% of the survey participants that also attended a meeting/workshop, it is safe to assume that the overall majority believe that flooding/ extreme precipitation is the major vulnerability within the Town of Caroline. Droughts and heatwaves are also a concern, but at a significantly lower level than flooding. And for the recommendations, the majority believed that changes in land use practices and implementation of smart land planning, as well as green infrastructure development, is necessary in order to mitigate the effect of flooding, droughts, and heatwaves. Participants also believe that the installation of energy efficient technology such as heat pumps can also be helpful in order to mitigate the vulnerability to extreme weather.

Mapped Vulnerable Areas in Caroline

The Cuyahoga Assessment Method stated in the Methodology Section was used for Map 10. Map 10 summarized all social and physical categories: Purple represents the social categories while the green represents the physical vulnerabilities. Regions that are not considered to have significant vulnerabilities within the Township, both for physical and social vulnerabilities, are in white. The vulnerable points are points of interest that have either been identified by community members or through the assessment process. Categorization based on the type of event that is experienced in that specific area. The following section will discuss the specific prioritization of the vulnerabilities based on this assessment conclusion.

NOTE: Darker colored areas can be interpreted as more vulnerable.



Map 10: CVA Summary Map

SECTION 5:

CONCLUSION

As the climate continues to change, incidents of severe weather and natural disasters are projected to increase. This change can pose a danger to communities that are not adequately prepared. As a means to assist the Town of Caroline to become more climate-resilient, Cornell Cooperative Extension has conducted this Climate Vulnerability Assessment. This process aimed to identify and evaluate the most endangered aspects of Caroline, and how climate change will affect the local region, and how to best prepare for future effects.

The results of the assessment show that in the Town of Caroline, flooding, droughts, and heatwaves are major vulnerabilities, with flooding garnering the most concern from Caroline residents. Concerns around flooding include erosion, stormwater runoff, and less directly, water contamination. Brooktondale, Slaterville Springs, and Speedsville are the neighborhoods at the highest risk for flooding, given both their location and their population demographics. Heatwaves and projected rising temperatures are expected to affect the particularly vulnerable populations of Caroline. This may include those who do not have access to air conditioners or those with social and economic barriers to receiving emergency medical services. Although droughts were not considered a priority by the community, they were still identified as crucial vulnerabilities to the Town, with worrying effects on agriculture and drinking water.

Given these results, the following actions are suggested as a means to instill climate resiliency and prepare for the future. These actions include steps in municipal planning that the Town can take, including the creation of various community and emergency response plans as well as prioritized and recommended tasks that can directly address identified problems, such as erosion, stormwater flooding, and more.

Next Steps

The Town of Caroline is a relatively small community that has an overall aging population. At the same time, due to the current characteristics, it is likely that the Town does not have the capacity to make significant changes on a structural level. As the Town faces increasing threats to climate change, it is important to identify that the community does not have the overall ability to make major changes in a short period of time.

These characteristics are not unusual and quite common for many municipalities in Upstate New York. In an effort to help build resilience in communities, New York State has taken various measures through programs and funding to lead rural municipalities that do not have the means to adapt in the midst of climate change and extreme weather events.

The Climate Smart Communities is one such program to help municipalities become resilient and to adapt to a changing climate. The Clean Energy Communities program is another program geared more towards reducing emissions related to energy. The Town of Caroline has gone through both of these programs and is now a certified Bronze Climate Smart Community as well as a designated Clean Energy Community. During the process of becoming a Climate Smart Community, the Town went through a Climate Smart Evaluation process conducted by Cornell Cooperative Extension to assess the Town's strengths and weaknesses around climate resilience. While recommendations were also given (which will be discussed in the recommendations section), the vulnerabilities identified in six different sections include the following:

Community Plans Checklist:
The Town of Caroline has yet to formally adopt a Zoning Ordinance, an Open Space Plan, or a Natural Resource Conservation Plan. These plans could significantly increase Caroline's resiliency and there has been discussion within the Town about beginning the work on creating some of these documents. The Town of Caroline is also in the process of updating its comprehensive plan and while the community is looking to incorporate aspects of climate change into the overall plan, it can be especially useful if the plan looks at long term community planning from a climate resilience perspective.

Vulnerability and Risk Assessment:
Although there is a countywide multi-hazard mitigation plan, Caroline could improve resiliency if they were to create their own local plan. Another area that Caroline could potentially expand would be the development of adaptation strategies for the most damaging hazards to the Town of Caroline, which could then reduce the cost of damages and investment in redevelopment.

Public Outreach and Engagement:
From an improvement standpoint, Caroline could focus more on effectively integrating the public in planning processes through participatory mapping, public surveys, and stakeholder meetings. The adoption of different methods of fortification distribution could improve storm-preparedness. For example, having a publicly accessible website that provides effective methods of protection against storm and wind damage could help the public increase Caroline's resiliency.

Integration of Municipal Plans:
There is still room for improvement, within many of the existing municipal plans and with the establishment of new plans, to strengthen Caroline's resiliency. One area for continued focus for Caroline is flooding and floodplains. Two potential improvements could be the further use of subdivision or zoning ordinances to encourage safe development in floodplains as well as the adoption of a No Adverse Impact strategy. The No Adverse Impact floodplain management approach makes it so that no action made by any party can negatively impact the resources or rights of others. These impacts could include increased flood peaks, stages, velocities, or increased erosion and sedimentation. A Floodplain Management Plan, a Capital Improvements Plan, and an Economic Development Plan could be created to help Caroline address climate resiliency. Additionally, Caroline could establish a stormwater utility that would be capable of funding efforts to reduce damages associated with large weather events.

Disaster Preparedness and Recovery:
Since Caroline does not currently have any formal plans in place to deal with emergencies there is a lot of opportunity for improvement. An Emergency Response Plan, Short-term Recovery Plan, Long-term Recovery Plan, Evacuation Plan, as well as a Continuity of Operations Plan could improve climate resiliency Caroline could also establish an emergency operations center, a special needs registry, or cooling center program. The National Weather Service offers a Storm Ready Community program that would help Caroline prepare for severe weather incidents. The public could be provided with information to help increase their household's resiliency through the distribution of pre-disaster mitigation measures such as installing ponds to capture stormwater, planting inundation-tolerant vegetation, or managing land to improve the soil's water

retention.

Hazard Mitigation Implementation:
Caroline could improve its hazard mitigation efforts by adopting a Climate Action Plan, which could take into account the potential change in hazard frequency or magnitude in the future and create appropriate mitigation strategies. Caroline could enroll in FEMA's Community Rating System (CRS) program which helps strengthen floodplain properties against floods and avoid flood damage for new development while also giving discounts on flood insurance premiums. The Town may also wish to develop programs to reduce the spread of invasive plant species and increase habitat preservation within the Town. Finally, more tools to manage development in hazard-prone areas include conservation overlay districts or cluster development, rolling easements, and buyouts of vulnerable properties.

Other proposals:
In the future, the Town of Caroline can implement various changes to become more resilient to climate change. These changes may range from green and grey infrastructure to community engagement opportunities. The following discusses ideas for the Town of Caroline to become more climate-resilient and prepared for the future.

To alleviate the effects of flooding, where possible, permeable pavers can replace concrete or asphalt pavement. Permeable pavement will reduce the effects of a flood by molding to the landscape rather than repelling against it. It will soak up rainwater, runoff and melting snow, which would otherwise go unabsorbed on traditional pavement. Water can penetrate through the surface, creating an environment that adapts to precipitation rather than working against it. There are various choices of pervious pavement options, including pervious asphalt, pervious concrete, interlocking pavers, and plastic grid pavers. Choosing pervious pavement over traditional paving can also help with water quality, as it can also act as a filter for pollutants. Permeable pavement has been used in several locations, including Cornell University, as a means to establish climate resiliency. Permeable pavements are usually also lower cost and lower maintenance while reducing damage from excess water.

The Town of Caroline could also benefit from the establishment of a microgrid. A microgrid is a local energy grid that, while usually connected to the traditional grid, can disconnect and operate on its own. The interconnected nature of the traditional grid system can be inconvenient when the grid does down, such as in event of a storm. However, a microgrid can operate on its own using local energy generation, making it a more durable and reliable form of energy. A microgrid would increase disaster preparedness as is also more cost-efficient and environmentally friendly than traditional grid systems. While it would be unrealistic for the Town as a whole to become a microgrid, it may be worth exploring the possibility of creating centers that are able to "island" off the overall electricity grid in case of emergency.

While physical infrastructure is an integral part of increasing climate resiliency, public outreach and engagement are critical to forming a strong community base. The Town of Caroline could collaborate with community members in the form of committees or task forces. Each of the many interest groups in Caroline likely has their particular concerns and experiences with

climate change and different understandings of what climate resiliency is and should look like. Forming a group for Caroline small business owners or Caroline residents with a focus on climate resiliency, adaptation and awareness could be beneficial, but creating a space for those who work and live in Caroline to focus on climate change as a specific topic. Additionally, there may be a task force specifically for those who are particularly vulnerable to climate events such as drought and heatwave, such as individuals over 65, renters, non-English speakers, and racial minorities. Creating specific initiatives to address climate change and resiliency may help to offset some of the inequalities and threats to these groups, as well as establish how to better accommodate them as underserved communities.

Lastly, The Town of Caroline could become a certified sliver Climate Smart Community by completing the next required actions to reach the 300 points necessary. As of 2019, Caroline is a designated bronze community. To become a silver certified Climate Smart Community the Town of Caroline needs to obtain 176 more points. The silver certification can be obtained by completing actions that Caroline is yet to complete. For example, the town of Caroline is yet to put together a Community GHG Inventory, an action worth 16 points. Other uncompleted actions the Town could consider include: providing Incentives for Employee Carpooling & Transit, Compost Bins for Residents, and Implementing a Safe Routes to School Program. Completion of these, or other actions, will increase the Town of Caroline's climate resiliency and help to shape it for the coming future.

Prioritization/ Recommendation

Based on the assessment the following factors and areas have been identified and are ranked based on priority (Highest to Lowest Priority).

Vulnerability	Sites Identified	Tasks
Erosion	The stream channels are not properly maintained – Six Mile Creek is a major focus	Need to evaluate existing land use policies in the Town and enforce climate smart land use measures that are meant to mitigate erosion
	Canaan Road along the county boundary between Tompkins and Tioga County – Significant erosion along road and creek.	Increase green infrastructure that can help reduce overall erosion
	Brooktondale Six Mile creek and road junction between Brooktondale Road/Landon Road/and Valley Road: significant erosion and maintenance needed to mitigate continued erosion	Increase riparian buffer widths
	Speedsville Rejmer Road and Mill Road significant erosion occurring along West Branch Owego Creek	Consider requiring all landowners to maintain riparian buffers on their property (for those that live near streams/ have ditches)
	Six Mile Creek Along Slaterville Road; major erosion along the creek and continued degradation of riparian buffers.	Coordinate efforts with the county SWCD and highway department to facilitate hydroseeding and proper and consistent ditch management practices across the county
		Source: gre.graduateshotline.com

Stormwater Flooding	Canaan Road has been experiencing significant stormwater issues	Ditch maintenance is a crucial part of flood prevention. Increase green infrastructure to prevent erosion. Hydroseeding can be a great first step to prevent the erosion of existing ditches.
	Valley Road has been experiencing with stormwater infrastructure	Makes sure all ditches are being cleared of debris and sediment
	Level Green Road is reported to have major issues around stormwater infrastructure	Install culverts in areas where water is accumulating in ditches
	West Creek Road from Speedsville all the way up to Route 79 has a large amount of runoff and is concerning with the overall steep hillsides that produce a significant amount of runoff	Redesign and rebuild existing ditches that currently are accumulating a large amount of sediment and or continue to have problems around flooding
	Brooktondale has been experiencing increasing amounts of runoff and as a result stormwater flooding	To increase the capacity of water flow within the ditch, rather than digging deeper, widen the overall width of the ditch as well as the type of culvert that is currently in place
	Buffalo Road has reported to have major ditch flooding in the past	
Structural Damage due to Flooding	Brooktondale Valley Road Bridge and Six Mile Creek Gutter	There are multiple roads in the Town that do qualify for federal aid. Additional funding for structural problems can be coordinated with the county highway department and or federal programs like the FEMA Mitigation Assistance Grant Program or Climate Smart Communities Grant Program.
	A bridge that crosses a tributary of Boyer Creek and is part of Old 76 Road	The FEMA Community Rating System is an insurance credit program that awards lower flood insurance rates to residents that complete certain mitigation actions.
	Caroline Landfill is of particular concern because of the overall lack of management of the existing site	
	West Creek Road has multiple sites of concern that appear to be eroding	
	Ellis Hollow Road	
	Canaan Road	
	The northern section of the Town towards Dryden has seen a significant number of groundwater flooding events, especially those that live along hillsides.	

Structural Damage due to Flooding	Brooktondale Valley Road Bridge and Six Mile Creek Gutter	There are multiple roads in the Town that do qualify for federal aid. Additional funding for structural problems can be coordinated with the county highway department and or federal programs like the FEMA Mitigation Assistance Grant Program or Climate Smart Communities Grant Program.
	A bridge that crosses a tributary of Boyer Creek and is part of Old 76 Road	The FEMA Community Rating System is an insurance credit program that awards lower flood insurance rates to residents that complete certain mitigation actions.
	Caroline Landfill is of particular concern because of the overall lack of management of the existing site	
	West Creek Road has multiple sites of concern that appear to be eroding	
	Ellis Hollow Road	
	Canaan Road	
Groundwater Flooding	The northern section of the Town towards Dryden has seen a significant number of groundwater flooding events, especially those that live along hillsides.	
	While individual properties have not been identified, people who live in areas with rough terrain have reported incidents of groundwater flooding	Investigate the groundwater characteristics of a site before installing a basement, pool, or septic system. If you are close to a river, stream, lake, or wetland, it is more likely that the water table will be close to the surface. Talk to neighbors and the local code enforcement officer. They may be able to give you valuable information about the water under your property.
		There are no good solutions to the basement flooding problems that result from groundwater inundation. If these problems are chronic, the cost of running a sump pump can be high. No government assistance is available to help you cope with groundwater flooding problems. Flood insurance only covers flood damage if the water enters your building from the surface. Whether your problems are chronic or occasional, your groundwater problems are your responsibility.

		Contact the municipal Code Enforcement Officer and/or County Soil and Water Conservation District for information about known high water table conditions. The County and State Departments of Health can assist with septic system design.
		For municipality: change building codes to enforce preventative measures for house construction and reduction in groundwater leakage into basements.
		Source: http://www.stcplanning.org-/usr/Program_Areas/Flood-_Mitigation/Groundw-aterFloodingFact.pdf
Excessive Runoff	Along Route 162	Cut down on fertilizers, pesticides and herbicides.
	White Church Road	Remove part or all of your lawn. Lawns require a lot of watering, mowing and caring. Replace part of your lawn with native, drought-resistant plants. Add compost to planting soil and dress it with mulch to improve plant growth and reduce stormwater runoff.
	Valley Road (near Brooktondale)	Require residents to properly maintain and inspect septic system
	Boiceville Road and Creamery Road	Keep away from streams as much as possible. Any activity around streams can pose contamination downstream
	Central Chapel/ Bailer Road	Reduce impervious surfaces on public and private properties
	Speed Hill Road (closer towards route 79)	Promote smart land use laws and policies that are intended to reduce runoff and promote flood resilience. For more information visit:
		https://www.dos.ny.gov/lg/public-ations/Creating_the_Community_-You_Want.pdf
Degradation of Municipal Water Supply	All houses and facilities in Town of Caroline	Promote natural resource conservation, wetland protection, and riparian buffer protection and development.
		Enforce smart land use control law and policies that can help protect existing water quality
		Promote the use of water filtration system and educational programs on the damagers of potential water contaminants in local water supply

Stormwater Infrastructure Degradation	Brooktondale Valley Road	Coordinate with County and State to facilitate the rehabilitation of existing stormwater systems
	White Church Road	Other alternate methods to reduce stormwater can be through
	Speedsville (intersection)	Green Roofs
	Canaan Road	Rain Barrels and Cisterns
	Level Green Road	Permeable Pavements
	Hammond Hill Road	Bioretention Areas
	600 Road	Vegetated Swales/Dry Swales
	Buffalo Road	Curb and Gutter Elimination
	Old 76	Vegetated Filter Strips
		Sand and Organic Filters
		Constructed Wetlands
		Riparian Buffers
		Click the links above which will redirect you to the EPA's stormwater management toolkit
Heat Strokes	Elderly population	Develop shade structures in public space
	Chronically ill population	Designate and or develop a cooling center for public access
	Individuals/ tenants without air conditioning system	Develop a Heat Emergency Plan
	Residents without automobiles	Continue Promoting programs like Heat Smart that help people install energy efficient cooling systems
		Develop a neighborhood pod/ check-in system to aid those in need in times of extreme heat and other dangerous events
Emergency Management and Community Response Planning	Community of Speedsville, Brooktondale, and Slaterville Springs	Currently, the county is coordinating with Caroline and bangs Ambulance service to provide faster response rate to residents in Caroline.
	Individuals living in rural areas and are solely reliant on their vehicle to access adequate medical services	Consolidate existing volunteer emergency services to coordinate faster service and meet the demand of the community's needs
		Coordinate with neighboring municipalities like Dryden to increase efficiency and capacity for emergency response

Lack of Emergency Shelters	No current heat emergency shelters	While heat emergency shelters might not seem like a necessity at this time, designating a specific site, not just for during intense heat, but also for flood evacuation, and other types of emergency needs can be beneficial and streamline the process of emergency response.
	No current flood emergency shelters	Developing/ updating an emergency evacuation plan for all residents and establishing an emergency evacuation route can provide community members with a better understanding of what needs to be done in the time of a crisis/ disaster.
	No community emergency evacuation plan/ evacuation route	
	No community emergency needs center/ facility	

SECTION 6:

RESOURCES

EPA Green Infrastructure and Stormwater Toolkit: https://www.epa.gov/green-infrastructure
For green infrastructure development

Social Explorer: https://www.socialexplorer.com/explore-maps
For demographic data

Tompkins County GIS: https://www2.tompkinscountyny.gov/gis/maps/census
For Tompkins County Census Data

NYS Department of State Municipal Options for Land Use Control: https://www.dos.ny.gov/lg/publications/Creating_the_Community_You_Want.pdf
Land Use Tools for Municipal Officials

NYSDOT Infrastructure Database: https://www.dot.ny.gov/divisions/engineering/technical-services/highway-data-services
Has data as well as GIS shapefiles, as well as reports on pavement quality and conditions.

Road Inventory Data: https://www.dot.ny.gov/divisions/engineering/technical-services/hds-repository/NYSDOT_2019_LHI_Local_Roads_and_Streets_Tompkins_County.pdf

Ground Water Flooding Resources and Guidance STC Planning: http://www.stcplanning.org/usr/Program_Areas/Flood_Mitigation/GroundwaterFloodingFact.pdf

NOAA Stakeholder Engagement and Participatory Mapping Tools: https://coast.noaa.gov/digitalcoast/training/participatory-mapping.html

Report used in this assessment Stakeholder Engagement Strategies: https://coast.noaa.gov/data/digitalcoast/pdf/participatory-mapping.pdf

Climate Science Special Report: https://science2017.globalchange.gov/chapter/7/ - for climate projections

Extreme Precipitation Modeling Tool (Cornell): http://precip.eas.cornell.edu/

Northeast Regional Climate Center: http://www.nrcc.cornell.edu/wxstation/gauges/gauges.html#nycthr
For Climate Trends and Projections

Army Corps of Engineers Infrastructure Assessment National Report: https://www.asce.org/infrastructure/
State Report available at: https://www.infrastructurereportcard.org/state-item/new-york/

NYS DOT Bridge Inventory Data: https://www.dot.ny.gov/main/bridgedata/repository/Tompkins-BridgeData.pdf

Precipitation Intensity Projection Model: http://ny-idf-projections.nrcc.cornell.edu/

FEMA Hazard and Risk Assessment Guidance: https://www.fema.gov/hazard-identification-and-risk-assessment

US Climate Resilience Toolkit: https://toolkit.climate.gov/learning-progressions/community-resilience-building-workshop

Community Resilience Building: https://www.communityresiliencebuilding.com/crbworkshop-guide

Rural Community Resilience Policy Guidance: https://www.ruralclimatenetwork.org/sites/default/files/2015_11_25_RuralPolicyPriorities.pdf

New York Invasive Species Clearinghouse: http://nyis.info/?action=invasive_detail&id=20
Interactive Map: https://www.nyimapinvasives.org/data-and-maps

Cornell Local Roads Program (resources section): https://www.clrp.cornell.edu/researchprojects/Ditching.html

NYS Heat Vulnerabilities Index: https://www.sciencedirect.com/science/article/pii/S003335061730327X

Research and a study conducted around Ditch and Culvert Management (Rebecca Schnyder): https://ecommons.cornell.edu/bitstream/handle/1813/56080/RPB-May2017-Draft-2.pdf

New York Climate Change Science Clearinghouse: https://www.nyclimatescience.org/

New York State ClimAID Report: https://nescaum-dataservices-assets.s3.amazonaws.com/nyclimatescience.org/ClimAID-Report.pdf

2013 Tompkins County All Hazard Mitigation Plan: https://tompkinscountyny.gov/files2/planning/HazMitRpt/Tompkins%20County%20HMP%20Final%20Draft%20-%20July%202013%20-%20ALL.pdf

NOAA Climate Change Projection Model: https://sos.noaa.gov/datasets/climate-model-temperature-change-rcp-60-2006-2100/

US Climate Change Viewer: https://www2.usgs.gov/landresources/lcs/nccv/viewer.asp
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