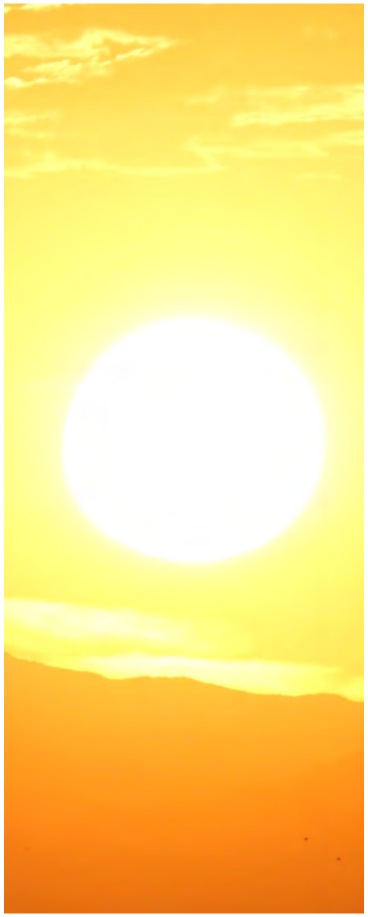
Hennepin County Climate Vulnerability Assessment




March 2021

Hennepin County Climate Vulnerability Assessment

This guidance document was created by Barr Engineering Co. for Hennepin County.

Executive Summary

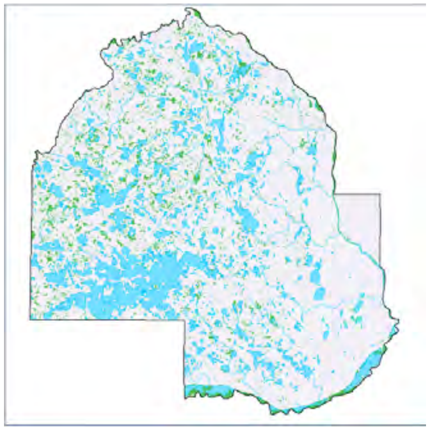
Purpose

This vulnerability assessment presents the risks posed by existing and projected climate trends in Hennepin County and identifies the people and operations within the county that are most vulnerable to the impacts of our changing climate. Its purpose is to provide Hennepin County staff with data that identifies climate change vulnerabilities within the county's water, transportation, and natural systems, as well as risks to public health, public services, and the built environment. The document is intended to serve as a foundation and technical reference for the Hennepin County Climate Action Plan, where the county intends to present strategies, initiatives, and actions aimed at building resilience to these risks. It can also serve as a useful reference for Hennepin County's 45 municipalities, 11 watershed management entities, and two park districts.

Vulnerability to the impacts of climate change in Hennepin County varies by location and by social, jurisdictional, and economic factors. There are many ways to define the term vulnerability as it relates to climate change. For the purposes of this assessment, climate change vulnerability is a function of exposure to climate hazards and associated impacts, sensitivity to these hazards, and capacity of a system or community to adapt or cope with the adverse effects. Existing health, social, economic, and racial disparities reduce a community's ability to leverage resources for adapting to and overcoming the adverse effects of climate change hazards.

When climate-driven events unfold, the impacts disproportionately affect vulnerable populations and place additional strain on the County's budget, its operation, and its personnel. Those impacts are communicated in this document through a series of over 40 maps depicting flood susceptibility, susceptible infrastructure and natural resources, vulnerable populations, and much more.

The primary existing and projected climate change trends in Hennepin County include increased warming, heat, and humidity; warmer winters; extreme precipitation; and drought. The prevalence of surface water and the density of development throughout Hennepin County, as well as existing disparities, increase the vulnerability of the county's population and operations to the impacts of many of these climate trends. Hennepin County, encompassing 611 square miles, is bordered by three major river systems (Crow River, Mississippi River, and Minnesota River) and includes 200 lakes larger than 10 acres, 640 miles of streams, and 45,000 acres of wetlands. Close proximity to surface waters increases exposure to the risk of flooding resulting from extreme precipitation.



The many lakes, river, streams (shown in blue) and wetlands (shown in green) in Hennepin County improve our quality of life, but also increase our vulnerability to climate change.

The primary climate change hazards in Hennepin County (warmer winters; increased extreme precipitation; warming, heat, and humidity; drought) and the associated impacts are detailed in this vulnerability assessment and summarized below.

Warming, Heat, and Humidity

Yearly average maximum temperatures in Hennepin County are slowly increasing at a rate of 0.09°F per decade, and projected climate scenarios show that the frequency and magnitude of hot days, warm nights, and heat waves are likely to increase by mid-century. Humidity, or dew-point temperature (a measure of water vapor in the air), is also increasing. And, increased heat and humidity are favorable conditions for severe storms with high wind, hail, or tornados—severe weather events that are projected to increase beyond mid-century. Some specific anticipated impacts include:

- Increased frequency and severity of heat-induced illness.
- Exacerbated physical and mental health issues due to periods of high heat and humidity.
- Increased air pollution and reduced air quality, exacerbating existing health conditions such as asthma or chronic obstructive pulmonary disease (COPD).
- Increased frequency and severity of non-local wildfires, reducing local air quality.
- Warming surface waters, which can result in algal blooms and fish kills.
- Forest die-offs of plant species that can no longer tolerate warmer, more humid growing conditions.
- Greater demand for air conditioning and community cooling options.
- Increased energy use, causing:
    - Rising energy costs for cooling, which puts additional strain on county operations and economically disadvantaged renters/owners.
    - Increased air pollution.
- Disruption and damage to the transportation system, including:
    - Pavement buckling caused by excess heat and humidity and subsequent traffic interruptions and emergency repair costs.
    - Increased electrical system malfunctions and signal interruptions caused by storm events and subsequent traffic interruptions.
- More frequent power outages resulting from severe storms or high energy demand.

Warming Winters

A distinct climate change trend occurring in Hennepin County is warmer winters. Based on data collected at the Minneapolis-St. Paul airport, winter temperatures since 1969 have increased at a surprising rate of approximately 2.2°F per decade. With increased winter temperatures come more freeze-thaw cycling and less consistent lake ice cover. Although average annual snowfall is steady or increasing, warmer winter temperatures result in less snow cover, shorter snow-cover season, and decreased snowpack thickness. Other impacts include:

- Increased freeze-thaw cycling, causing:

    - Hazardous walking and driving conditions.
    - Increased use of salt and sand to mitigate icy conditions, which negatively impacts downstream waterbodies and habitat.
    - Decline in pavement life cycle and increased costs for maintenance and replacement.
- Increased occurrence of winter flooding resulting from rainfall on frozen ground and waterway ice dams that cause an unpredictable rise in spring flood stages.
- Increased power outages from ice events, causing economic and social disruption from the loss of electricity, heating, and communication systems.
- Increased risk of human illness resulting from over-wintering survival of insects that carry pathogens like Lyme disease, West Nile virus, and human anaplasmosis, now found locally.
- Increased survival of existing invasive species and arrival of new invasive species, causing much loss of habitat and additional expense to manage or control the invasive species.
- Increased survival of destructive tree pests such as emerald ash borer and the pine bark beetle.

Disruptions to winter recreational activities and associated economic impacts.

Extreme Precipitation

Hennepin County has and will continue to experience more wet conditions caused by increased precipitation. Precipitation increases are occurring in each season of the year, with the largest increases in spring and summer. Not only has total precipitation increased, but the intensity and frequency of large events have also increased, with significant potential impacts on Hennepin County residents and operations, including:

- Increased frequency and severity of localized and large-scale regional flooding along streams or river systems, adjacent to lakes, and near wetlands or other low-lying areas, causing:
    - Increased safety risks from moving or deep water on roadways, roadway failure, unstable slopes, disrupted emergency access, and contaminated water.
    - More frequent and extreme property damage to public and private property, including Hennepin County owned or leased facilities, roadways, and infrastructure.
    - More construction and flood clean-up debris generated and needing disposal.
    - More frequent disruption of traffic corridors, including roadways, sidewalks, and trails.
    - Increases in the cost of future roadway design and construction to adapt to impacts of increased flood risk and to retrofit existing under-designed roads and infrastructure.
- Fluctuations in groundwater levels and more prolonged groundwater rise, causing:

    - More flooding of public and private property in areas that previously have not experienced flooding.
    - More flooded or wet basements and associated property damage, mold and bacteria issues, and stress.
    - Impacts to underground infrastructure and building foundations, including potential to mobilize historic contamination, plumes, and vapors, and the formation of sinkholes.
- Saturated soils on steep slopes, causing slope failures and landslides.

Drought

Several historic droughts have occurred across Hennepin County dating back to 1863, including the Dust Bowl period in the 1930s. An increase in drought conditions has not been observed in recent data, and projected scenarios only show a slight possibility of increasing drought conditions by the mid-century. However, it is important to remember that severe drought, such as the Dust Bowl period, is part of normal climate fluctuation and should be expected. Increased drought conditions will have negative impacts on Hennepin County residents and operations, including:

- Increased demand for water for public and private use (including agriculture), resulting in drawdown of aquifers and additional water supply costs for public utilities and water users.
- Limitations on availability or allowable use of water for personal use and property irrigation.
- Stress to crops and vegetation, causing:
    - Lower productivity in agricultural crops.
    - Additional costs for maintaining, watering, or replacing landscaping.
    - Increased stress on roadside vegetation.
- Stress to wetlands and lake ecosystems, including:
    - Warming surface waters, which can result in algal blooms and fish kills.
- Increased risk of wildfires, flash flooding, and erosion.
- Drought in areas outside of Hennepin County. This may increase demand to ship local water supplies out of Minnesota, disrupt the fuel and food supply system, and increase costs. Drought-driven wildfires, local or distant, will adversely impact air quality.

Population Vulnerability

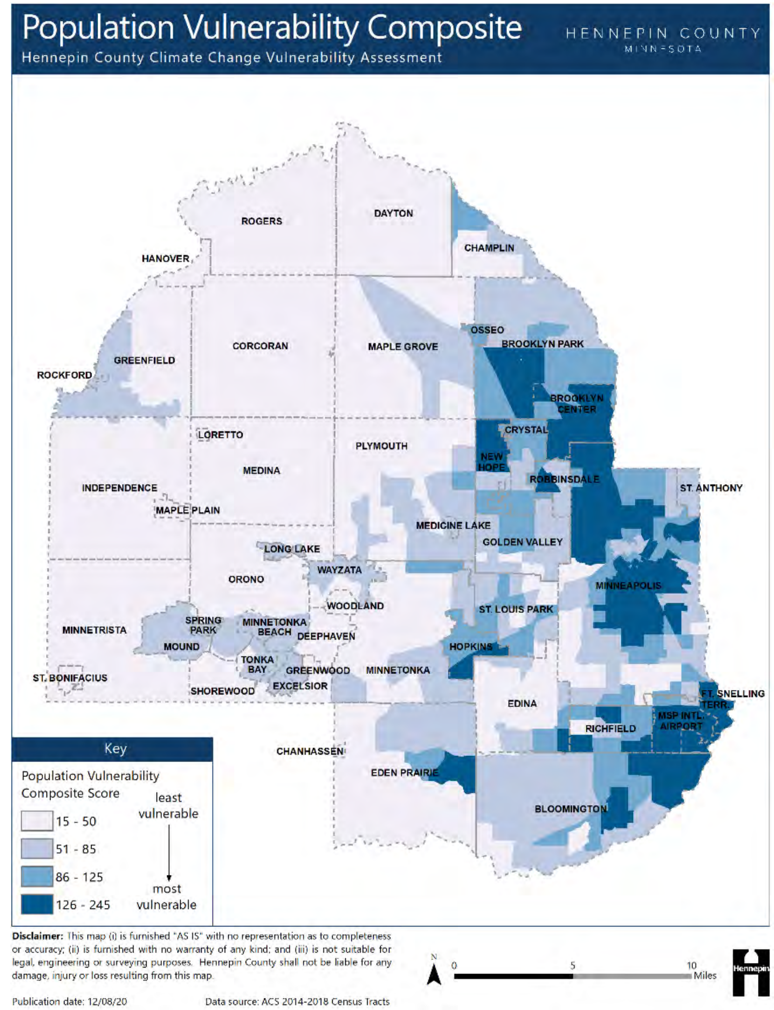
Vulnerability to climate change throughout Hennepin County will be exacerbated by existing health, social, economic, and racial disparities that affect exposure and sensitivity to climate hazards. Disparities partly determine a community's ability to respond to impactful events, overcome the adverse effects of climate change hazards, and proactively adapt for similar, or worse, future occurrences. A composite population vulnerability map was developed using 14 demographic variables to help assess the influence of these factors on climate change vulnerability and vulnerability scores were assigned to census tracts for each equally considered variable. A composite score was then computed for each census tract: the higher the value, the greater the population's vulnerability to climate change. This composite population vulnerability map can be used as a tool by local government to prioritize climate change response actions.

Hennepin County Climate Adaptation Work Groups

As part of its climate resiliency and adaptation planning, Hennepin County developed five work groups, organized by county core functions. Discussion of key climate change impacts and vulnerability is organized in this document by these work groups, which include: (1) people, health, and disparities; (2) natural resources, agriculture, and land use; (3) buildings and energy; (4) transportation infrastructure; and (5) waste and materials.

Conclusions

Hennepin County is getting warmer and wetter. These trends are projected to continue with heavy precipitation and warmer winter temperatures occurring more frequently. Other climate change manifestations such as an increase in drought and severe weather (tornados and high-wind events) have not, yet, been documented, but still have the possibility to increase by mid-century. Local severe-weather events create uncertainty and will disproportionately impact businesses, county operations, and residents. Residents already experiencing health, social, economic, and racial disparities are placed at greater risk of experiencing negative consequences in their daily lives.



The composite population vulnerability map includes 14 demographic variables that influence vulnerability to climate change impacts. Areas of greater vulnerability, based on social, political, and economic indicators, are shown in darker blue.

A challenge that Hennepin County faces is that the dramatic climate change images seen in the news (wildfires, extreme heat waves, rising ocean levels) don't match up with how we are experiencing climate change in Minnesota. Because of this mismatch, it can be harder for people to grasp the county's current and potential vulnerabilities. However, as noted above, there are many local impacts from changing climate conditions. Events elsewhere do eventually impact Hennepin County and its residents when far-away wildfires diminish local air quality, or supply chains for food, fuel, and resources are impacted and higher costs are passed on to local consumers and businesses.

Next Steps

This vulnerability assessment is intended to serve as a foundation and technical reference for the Hennepin County Climate Action Plan, where the county work groups intend to present strategies, initiatives, and actions aimed at building resilience to the risks posed by climate change.

Hennepin County Vulnerability Assessment

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1 Introduction

Climate change is a large, complex issue that is affecting—and will increasingly affect—the way we live. Understanding the changes occurring now and predicted to occur will allow for a better response to climate change. This assessment presents the risks posed by existing and projected climate trends in Hennepin County, specifically to its water system, natural system, built environment, transportation system, economic system, public health, cultural assets, and public services. This assessment also helps identify the people and operations most vulnerable to climate change impacts based on exposure, sensitivity, and adaptive capacity (i.e., the capacity to prepare for, cope with, and recover from climate change impacts).

Climate change is caused primarily by the excess release of greenhouse gases—most notably carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)—that accumulate in the atmosphere. Many of the excess greenhouse gas emissions come from human activities. We continue to burn fossil fuels that emit greenhouse gases into the atmosphere. These gases do not dissipate, and the buildup acts like a blanket that traps heat around the world, disrupting our climate. Climate change exacerbates existing challenges for county operations and residents, makes underlying disparities even more difficult to overcome and places additional strain on the county's budget, operation, personnel, and other human resources.

The purpose of this vulnerability assessment is to provide Hennepin County staff with data that identifies and locates climate change vulnerabilities within the county's water system, natural system, built environment, transportation system, economic system, public health system, cultural assets, and public services. It provides background information to serve as a foundation for the Hennepin County Climate Action Plan. This assessment discusses:

- **Climate Trends—**observations indicate that past climate patterns are not completely indicative of what may happen in the future and must be adjusted with future projections to bring key vulnerabilities forward in planning discussions. See Section 2, Climate Trends.
- **What** is being impacted? See Section 4, which is organized by climate hazard.
- **Who** is at risk? See Sections 3 and 4 for maps highlighting vulnerable populations, businesses, municipalities, infrastructure, operations, and natural resources within the county.
- **Where** are the areas that are most susceptible to climate change impacts? See Sections 4 and 5 for the mapping of climate change impacts and key locations of vulnerability in Hennepin County.

This study's findings demonstrate that conducting a vulnerability assessment is an important exercise to prepare for and ultimately adapt to the impacts of climate change. As the county develops its Climate Action Plan and targeted strategies, it will further assess vulnerabilities to the health and well-being of residents, the natural environment, and infrastructure (e.g., buildings, the transportation system, and other infrastructure).

1.1 Hennepin County Climate Adaptation Work Groups

As part of its climate resiliency and adaptation planning, Hennepin County developed five work groups, organized by county core functions and priorities. The work groups are described further in the table below. Assessment of climate change impacts and identification of vulnerabilities focused on these five work groups.

Table 1 Hennepin County's Five Work Groups

	**People: Health, Behavior, and Disparity Reduction** This group identified strategies to protect the health and well-being of Hennepin County residents, including building resilience in the community and protecting people most vulnerable to climate impacts.
	**Transportation and Infrastructure** This group identified strategies to reduce greenhouse gas emissions from the transportation sector, especially emissions associated with county roads. The group developed strategies to adapt to a changing climate and build resilience in the transportation system and infrastructure in partnership with other entities.
	**Buildings and Energy** This group expanded on the existing work with county facilities and other publicly owned buildings to identify strategies to reduce greenhouse gas emissions from public and privately owned buildings and energy sources. The group also identified strategies to adapt to a changing climate by increasing the capacity of public properties to both manage and treat stormwater and sequester carbon.
	**Waste and Materials** This group identified strategies to reduce greenhouse gas emissions associated with what we buy (i.e., sustainable purchasing) and how we dispose of waste. Priority strategies focused on preventing waste, increasing the reuse/recycling of materials, and recovering energy from waste.
	**Water, Natural Resources, and Land Use** This group identified strategies to reduce greenhouse gas emissions and carbon sequestration opportunities associated with natural resources and land use. The group also developed strategies to adapt to climate change, mitigate threats to the natural environment (e.g., invasive species), and leverage the intersections of the natural and built environment to help protect people and places.

2 Climate Trends

Hennepin County faces significant challenges resulting from the environmental, societal, and economic impacts of climate change. More and more, Hennepin County residents are noticing the effects of climate change, including warming winter temperatures, more rain and snowfall, and an increase in extreme precipitation events.

2.1 Warmer Winters

A distinct climate change trend occurring in Hennepin County is warmer winters, which are warming much faster than our summers. Specifically, winter minimum nighttime temperatures are distinctly warming. Based on data from 1895 through 2019, average minimum winter temperatures are increasing at a rate of 0.35°F per decade (Figure A), compared to average maximum summer temperatures increasing at a rate of 0.09°F per decade (Reference (1)). Since 1969, however, the winter temperatures have increased at a surprising rate of approximately 2.2°F per decade based on data collected at the Minneapolis-St. Paul International Airport (Figure B). This rate is significantly faster than the rate of increase of maximum summer temperatures. With increased winter temperatures comes more freeze-thaw cycling, which can cause additional infrastructure damage. Although average annual snowfall is steady or increasing, warmer winter temperatures result in less snow cover, shorter snow-cover season, decreased snowpack thickness, and less lake ice cover. These conditions may impact ecosystem functions, timing of spring flooding, ice safety, recreation season expectations, etc.

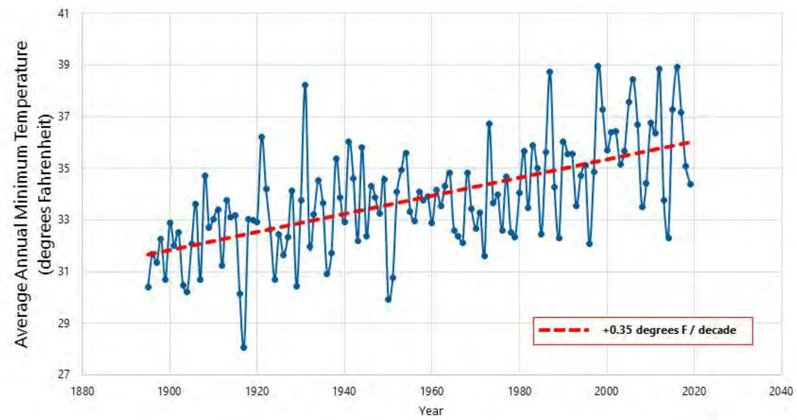


Figure A Average annual minimum temperatures from 1895 to 2019 for Hennepin County (State Climatology Office)

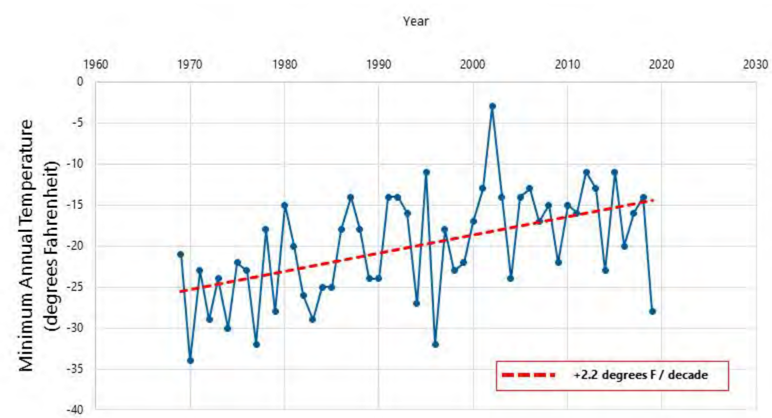


Figure B Minimum annual temperature at Minneapolis-St. Paul International Airport 1969 to 2019 (NOAA)

2.2Extreme Precipitation

Hennepin County has been and will continue to experience more wet conditions caused by increased precipitation. In fact, 2010–2019 was the wettest decade on record statewide (Reference (2)). Precipitation increases are occurring in each season of the year, with the largest increases in spring and summer. Figure C shows how annual precipitation has been increasing since the 1890s.

Not only has the total precipitation increased, but the intensity and frequency of large events have also increased and are projected to continue increasing. Data indicates that the frequency of 2- to 3-inch rainfall events is increasing in Hennepin County, as shown in Figure D. According to *Adapting to Climate Change in Minnesota: Preliminary Report of the Interagency Climate Adaptation Team*, 1-inch rainfall events have increased by up to 26% from 1977 to 2017.

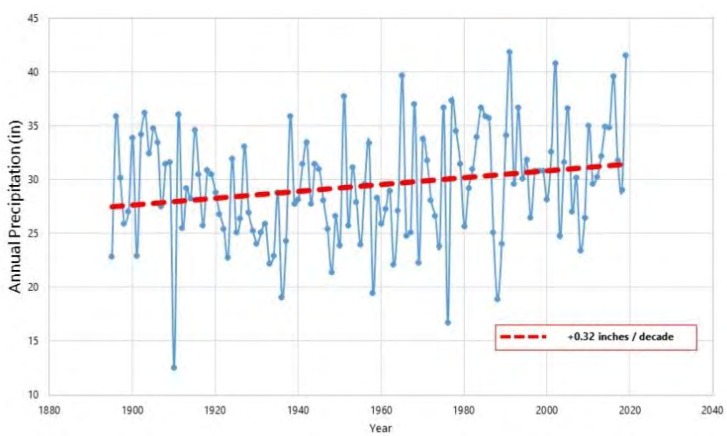


Figure C **Average annual precipitation for Hennepin County from 1895 to 2019 (State Climatology Office)**

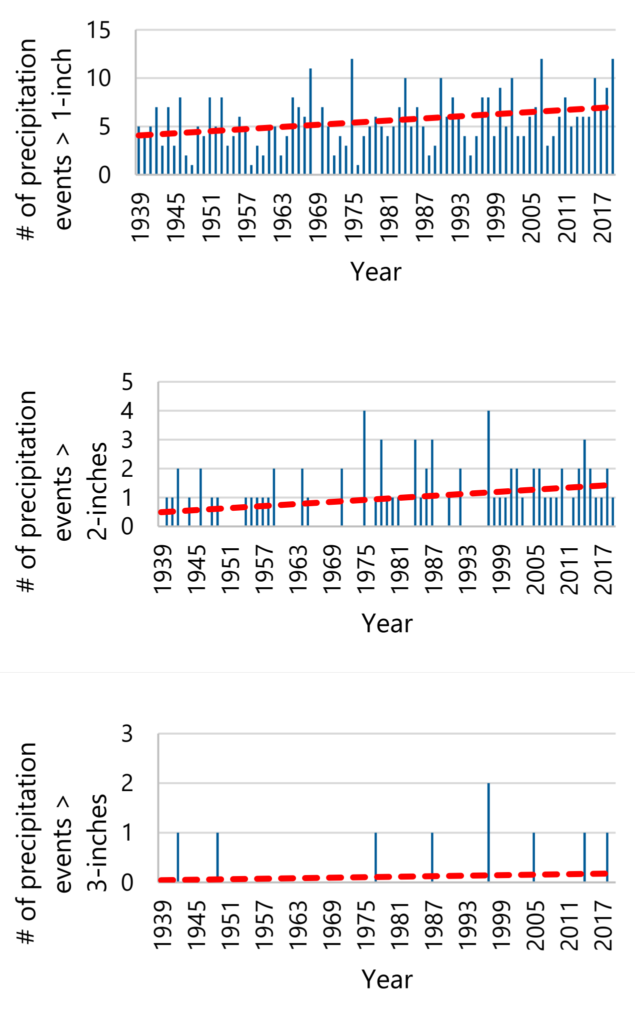


Figure D **Number of precipitation events greater than 1, 2, and 3 inches each year at Minneapolis St. Paul Airport**

They also report that the single heaviest rainfall amount recorded on a 10-year interval has approximately doubled during that same period, as shown in Figure E (Reference (4)). Rainfall "super storms" are events in which 6 inches of rain cover more than 1,000 square miles and the core of the event tops 8 inches, occurring unpredictably and causing catastrophic flood damage. Minnesota Department of Natural Resources (MnDNR) observations indicate the frequency of these super-storm events is also increasing in Minnesota (Reference (5)).

Increased precipitation amounts, intensity, and frequency have significant impacts on Hennepin County operators and residents. Localized flooding and large-scale regional flooding are expected to increase in areas that are landlocked (i.e., topographically low areas without an outlet), along stream or river systems, adjacent to lakes, near wetlands, or other low-lying areas served by undersized infrastructure. Many drainage systems in the county were designed decades ago using older precipitation data that did not account for the increased, unpredictable timing of severe rainfall events. Flash flooding risk will increase. Landlocked areas are sensitive to the interaction of surface water and groundwater as the increasing volume of seasonal precipitation can drive groundwater and lake levels upward.

The change in total snowfall amount is steady or increasing, but at a slower rate than rainfall increases. Warmer winter conditions favor larger snowfall events, as evidenced in historic data. Figure F shows that the average annual snowfall is steady or increasing and that the number of days each winter with more than 4 inches of snowfall (i.e., large snowfall storms) has increased since the late 19th century (Reference (2)). Spring melt runoff and flooding will likely increase because of these larger and more frequent winter precipitation events. This depends on their timing, fall soil moisture leading into winter, winter warming patterns, and how the snowmelt thaw progression unfolds each spring. Intense rainfall that coincidentally occurs at the same time of spring flooding can put strain on community drainage systems.

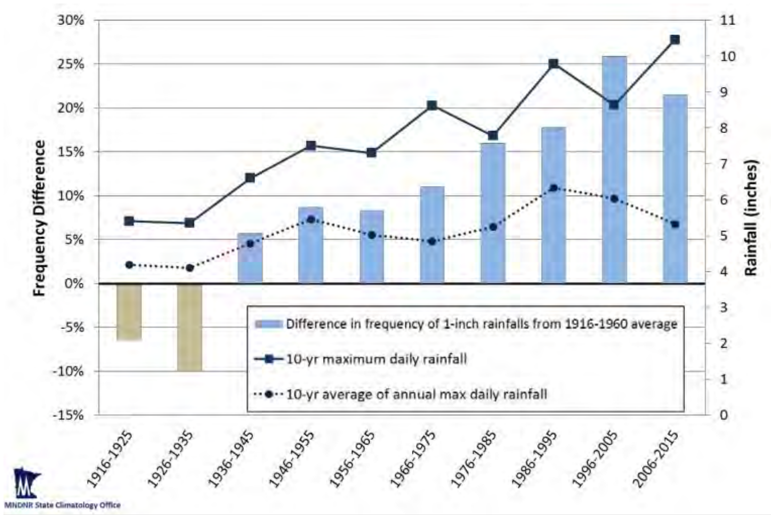


Figure E Changes in the frequency of 1-inch rainfalls relative to the 1916 to 1960 average, from 40 long-term stations in Minnesota

Shown in Figure E is the 10-year average (lower dotted line, right axis) and 10-year maximum values (upper solid line, right axis) of the heaviest single rainfall amount recorded each year at any of the 40 stations. Note that the 10-year maximum value has doubled from just over 5 inches at the beginning of the record, to just over 10 inches at the end of the record (State Climatology Office; MPCA, 2017).

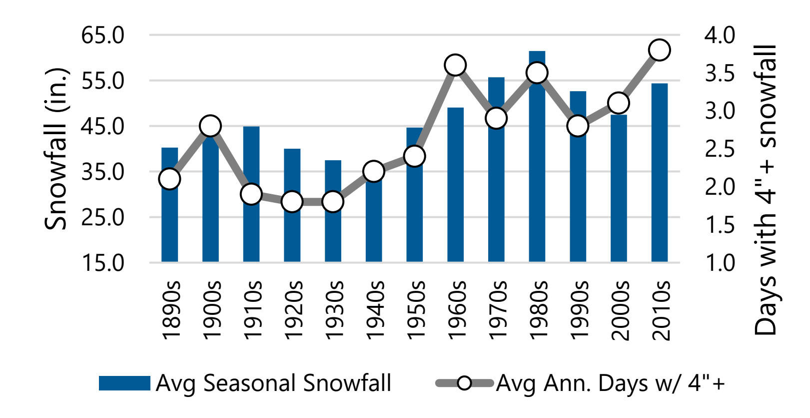


Figure F **Average annual snowfall by decade compared to the average number of days with 4 or more inches of snowfall using Minneapolis-St. Paul International Airport data (Reference (2))**

Another consequence of increased winter temperatures and precipitation is more frequent ice storms (i.e., freezing rain). As precipitation falls from a warmer atmosphere, it forms super-cooled drops (water that is at freezing temperatures but not frozen) that freeze upon impact with cold surfaces rather than developing as snow. As this form of precipitation lands on surfaces with less snowpack, it has the potential to create a pedestrian hazard, dangerous driving conditions, and downed power lines—along with negative consequences for trees and wildlife.

2.3Warming, Heat, and Humidity

Currently in Hennepin County, yearly average maximum temperatures are slowly increasing at a rate of 0.09°F per decade (Reference (1)), as shown in Figure G. Though current trends do not show an increase in extreme heat events, projected climate scenarios show that the frequency and magnitude of hot days, warm nights, and heat waves are likely to increase by mid-century (Reference (2)). The change in the predicted number of days above 95°F by mid-century is shown in Figure H.

In addition to warming, a primary indicator of climate change in Hennepin County is increased humidity, or dew point temperature, which is a measure of water vapor in the air. Data from the Minnesota Climatology Office shows that the number of days with dew point temperatures higher than 70°F is increasing. High humidity can exasperate heat-induced illnesses (Reference (3)).

Increased heat and humidity create conditions that are favorable for the development of severe storms with high wind, hail, or tornados. Currently, these severe weather trends are not increasing. However, severe weather events are projected to increase in frequency beyond mid-century (Reference (2)).

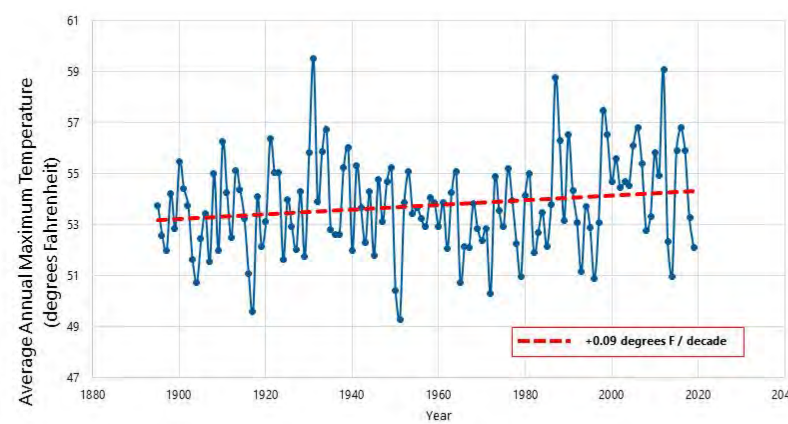


Figure G **Average maximum daily temperature for Hennepin County from 1895 to 2020 (State Climatology Office)**

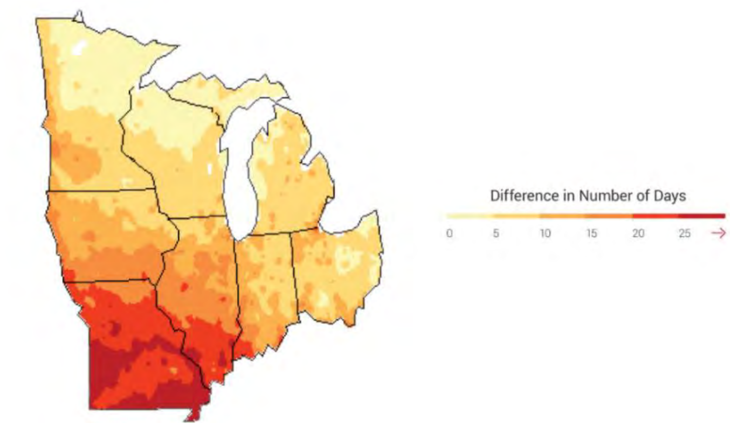


Figure H **Predicted change in number of days each year above 95 degrees for the Midwest by mid-century as compared to the 1971 to 2000 period (2014 National Climate Assessment, Midwest Chapter)**

2.4Drought

Several historic droughts have occurred across Hennepin County dating back to 1863, including the Dust Bowl period in the 1930s. These events cause severe impacts on agriculture and the economy, as well as increasing wildfire potential. An increase in drought conditions has not been observed in current trends, and projected scenarios only show a slight possibility of increasing drought conditions by the mid-century (Reference (2)). Increased drought conditions may have negative consequences on the county's ecosystems, agricultural industry, water supply, and water quality and could increase the potential for flash flooding and erosion. Additionally, increased drought conditions across the country (e.g., wildfires) have the potential to adversely impact air quality in Hennepin County. It is important to remember that severe drought, such as the Dust Bowl period, is part of normal climate fluctuation and should be expected.

2.5 Conclusions

Climate records document that Hennepin County is getting warmer and wetter and will continue to get warmer and wetter—with more frequent heavy precipitation and warmer winter temperatures. Other climate change manifestations, such as increased occurrences of drought and severe weather (tornados and high wind events), have not, yet, been documented, but are projected to increase by mid-century.

Local severe weather events create uncertainty and impact vulnerable residents, businesses, and county operations. One challenge that Hennepin County faces is that the dramatic climate change images seen in the news of wildfires, extreme heat waves, and rising ocean levels don't match up with how we are experiencing climate change in Minnesota. Because of this, it can be harder for people to grasp the threat that climate change poses to them and their community. However, these events elsewhere do eventually impact Hennepin County and its residents when supply chains for food, fuel, and resources to/from afar are impacted. The increased costs and scarcity are often passed along to local consumers and businesses.

3 Population Vulnerability

Understanding potential climate change impacts and assessing vulnerabilities across Hennepin County are important first steps in preparing and adapting to climate change. Impacts of and the vulnerability to climate change vary by location, economic sector, and society, among other factors. Understanding of the unique vulnerabilities across Hennepin County programs, operations, natural resources, and communities will aid development of climate change management actions that are targeted and impactful. This vulnerability assessment is one tool intended to inform the county's future climate action planning by identifying those residents most at risk from the adverse impacts of climate change.

3.1 Definition of Climate Change Vulnerability

There are many ways to define the term vulnerability as it relates to climate change. For the purposes of this assessment, climate change vulnerability is defined as a function of exposure to climate hazards, sensitivity of a system or population to these hazards, and capacity of a system or population to adapt or cope with the adverse effects.

3.2 Composite Population Vulnerability

Changes in climate are occurring both gradually, like summer warming and humidity trends, and abruptly—like extreme storm and flash flood events. The first are less acutely noticeable, whereas the latter are devastating and expensive. All of society is vulnerable to the gradual and abrupt changes in climate, but underlying disparities cause some populations to be more sensitive to climate change impacts and have fewer resources to respond or adapt.

For the purposes of this assessment, climate change vulnerability is defined as a function of exposure to climate hazards, sensitivity of a system or population to these hazards, and capacity of a system or population to adapt or cope with the adverse effects.

Residents of Hennepin County are more or less vulnerable to the impacts of climate change depending on social, economic, and demographic variables. Vulnerable populations include those with low income, historically disadvantaged communities of color, those with limited English proficiency, persons with disabilities, young children, older adults, persons with underlying health conditions, and vulnerable occupational groups. For example, individuals with low incomes may not be able to afford the cost of air conditioning or added insulation to protect from extreme heat. And non-English speakers may not understand warnings of extreme storms or know how to effectively access resources after a flood.

Some people or communities have greater susceptibility to health risks related to climate change impacts depending on social, political, and economic factors collectively known as social determinants of health. People who are disproportionately disadvantaged by social determinants of health (e.g., poverty, educational attainment, racial discrimination, employment, underlying health conditions), often have limited resources and opportunities for health-promoting behaviors and living and/or working conditions. These factors create larger hurdles to overcoming negative impacts and adapting for the future, resulting in disproportionate impacts. At times, these factors reinforce the elements of vulnerability by contributing to the community members' increased exposure, increased sensitivity, and reduced adaptive capacity. For example, community members with limited economic resources living in areas with old, underground sewer systems are more susceptible to impacts and less able to recover following extreme events, which increases vulnerability to climate change impacts and results in these communities bearing a more disproportionate burden of the impacts.(Reference (6)).

The factors of vulnerability considered in this assessment were compiled in collaboration with the county work groups and are based on similar factors considered by the following regional precedents:

- Centers for Disease Control and Prevention's Social Vulnerability Index, Hennepin County
- Minnesota Pollution Control Agency's Environmental Justice datasets
- Metropolitan Council disparities datasets
- Hennepin County disparities datasets
- Ramsey County Vulnerability Assessment

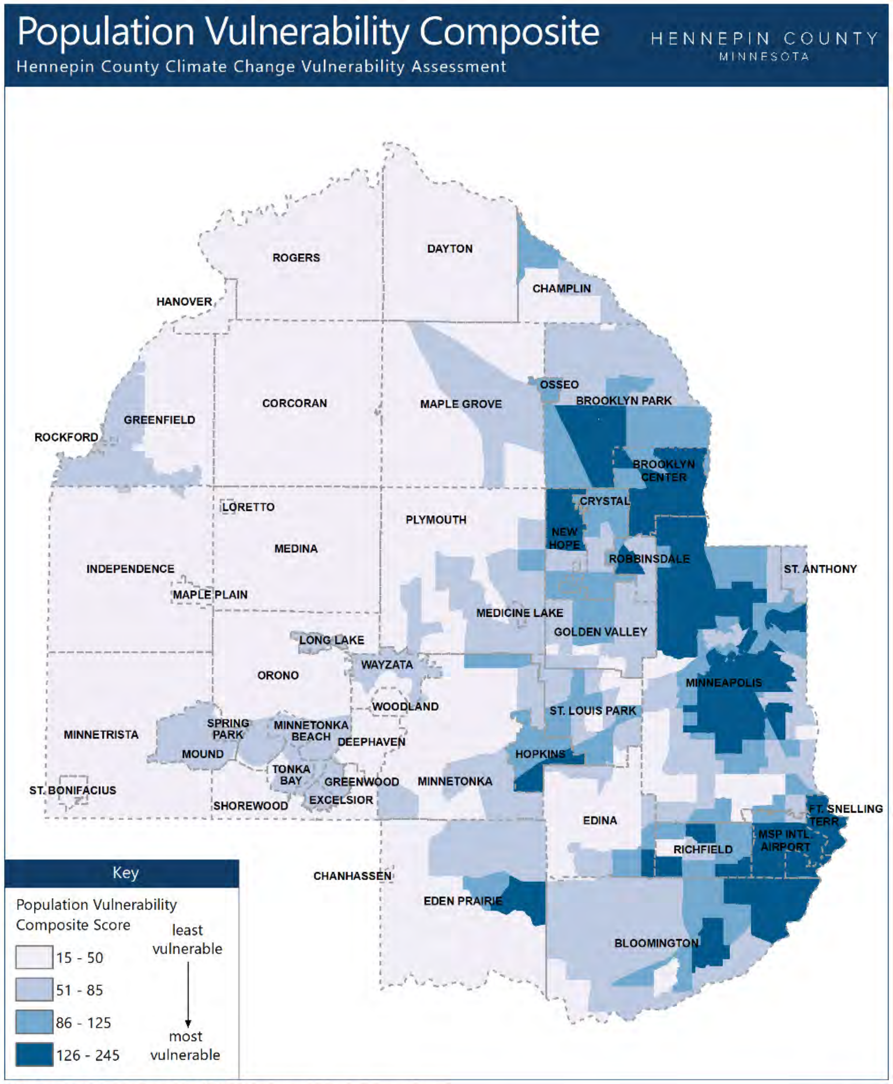
To help assess the influence of social determinants of health on climate change vulnerability, a composite map was developed using 14 social, demographic, and economic variables. The map was developed by assigning composite scores per census tract for each equally weighted variable and then computing a composite score. The higher the value, the greater the population's vulnerability to climate change.

The composite population vulnerability map is shown on the following page. Scores are classified into four groupings, with the highest scores (i.e., highest vulnerability) in dark blue. The composite scores were originally classified into five natural groupings. The two groups with the highest scores were subsequently combined to better include suburban vulnerabilities. There are pockets of high vulnerability scattered throughout the eastern half of the county.

The 14 demographic variables considered for the composite population vulnerability map are included in Table 2, below.

Table 2 Demographic Variables

Asthma Hospitalization Rates
COPD Hospitalization Rates
Households with No Vehicle
Limited English Proficiency
Median Household Income
No High School Degree
People of Color
Population 5 and Under
Population below 185% Poverty Threshold
Population Density
Population over 65
Population with Any Disability
Renter Housing Units
Unemployment Rates



Disclaimer: This map (i) is furnished "AS IS" with no representation as to completeness or accuracy; (ii) is furnished with no warranty of any kind; and (iii) is not suitable for legal, engineering or surveying purposes. Hennepin County shall not be liable for any damage, injury or loss resulting from this map.

Publication date: 12/08/20 Data source: ACS 2014-2018 Census Tracts

0 5 10 Miles

Individual maps for each of the 14 demographic variables considered for the population vulnerability composite (as listed in Table 2) are included in Appendix A. Unless otherwise noted, all data are from the 2014–2018 American Community Survey (ACS, US Census Bureau) and only available at the census-tract level.

The following maps of additional demographic factors that can impact vulnerability to climate change were developed and are included in Appendix B:

- Areas of Concentrated Poverty
- Historical Neighborhood Appraisals and Racial Covenants
- Average Household Size
- Commute Time 30 Minutes Plus
- Commute via Transit
- Commute via Walking
- Cost-Burdened Households
- Food Deserts
- Home Ownership
- Homework Gap
- Households with Children
- Households without an Internet Subscription
- Housing Density
- Housing Stock Built Pre-1940
- Housing Stock Built 1990 to 2018
- Median Home Value
- Median Rent
- Non-Single-Family Housing Units
- Per-Capita Income
- Population under 18
- Vacant Housing

4 Vulnerability by Climate Hazard

The following sections summarize the key impacts of and vulnerability to climate change in Hennepin County—specifically to its residents, water and natural systems, built environment, transportation system, economic system, public health, cultural assets, and public services. The key climate change impacts are summarized based on the following climate hazards:

- Warmer Winters (Section 4.1)
- Extreme Precipitation (Section 4.2)
- Warming, Heat, and Humidity (Section 4.3)
- Drought (Section 4.4)

For each of these climate hazards, key climate change impacts are summarized by work group, representing core functions of Hennepin County, including 1) People: Health, Behavior, and Disparity Reduction; 2) Water, Natural Resources, and Land Use; 3) Buildings and Energy; 4) Transportation and Infrastructure; and 5) Waste and Materials.

The following sections also highlight some of the areas within Hennepin County that are more vulnerable to the impacts of climate change due to location (increased exposure) or population vulnerability resulting in increased sensitivity to impacts and diminished capacity to adapt or cope.

4.1 Warmer Winters

A distinct climate change trend occurring in Hennepin County is warmer winters. Based on data collected at the Minneapolis-St. Paul airport, winter temperatures since 1969 have increased at a surprising rate of approximately 2.2°F per decade. With increased winter temperatures come more freeze-thaw cycling and a less consistent, shorter duration of lake ice cover. Although average annual snowfall is steady or increasing, warmer winter temperatures result in less snow cover, shorter snow-cover seasons, and decreased snowpack thickness. Key climate change impacts resulting from warmer winters are listed in Table 3, categorized by the Hennepin County climate adaptation work group.

Table 3 Key Climate Change Impacts Based on Warmer Winters

Work Group	Impacts	Maps
People, Health, and Disparities	Increased freeze/thaw results in: • Hazardous driving conditions. • More frequent or severe ice on walkways, which can result in falls and potential long-term health impacts. Increased deicing also increases costs. • More frequent or severe ice events, which impact access to transit, work, school, and services. • More frequent or severe issues with ice dams on roofs.	• Commute via Walking • Households with No Vehicle
	Increased occurrences of ice events, when coupled with wind, may increase risk of power outages that can cause: • Loss of heat source. • Interruption of remote/at-home work due to loss of electricity and/or internet access.	
	Increased over-wintering survival of insects and the pathogens detrimental to people: • Lyme disease (tick) • West Nile virus (mosquito) • Human anaplasmosis (tick)	
	Residents and businesses in the County that depend on reliable winter snow or ice conditions are negatively impacted (socially, economically) when conditions require events to be relocated or cancelled (e.g., skiing events and pond hockey tournaments).	
	Increased occurrences of unsafe ice conditions, affecting recreational use of frozen waterbodies	

Water, Natural Resources, Agriculture, and Land Use	Increased survival of terrestrial and aquatic invasive species: • New invasive species encroach because they can survive through warmer winters. Additional expense is incurred for their control and pesticide use increases. Species on the MnDNR Early Detection Watch List* include teasel, Dalmatian toadflax, giant hogweed, *Phragmites australis*, Grecian foxglove, Japanese knotweed, Japanese hops, multiflora rose, oriental bittersweet, tree of heaven, and yellow star thistle.	
	Longer growing season allows for additional weed growth, requiring control.	
	Increased over-wintering survival of insects and pathogens such as: • Lyme disease (tick). • West Nile virus (mosquito). • Human anaplasmosis (tick).	
	Increased survival of tree-destructive insects which can result in extensive tree death such as: • Eastern larch beetle. • Pine bark beetle. • Eastern spruce budworm.	
	Lack of snow stresses some vegetation and wildlife species because of lack of cover and protection from cold.	
	Trend of earlier ice-out on lakes affects fish spawning.	
	Warming waters are shifting the fish species components of natural waterbodies from cool-water species such as walleye to warm-water species such as small mouth bass.	
	Increased freeze/thaw results in increased icing of roadways, trails, sidewalks, and parking lots, resulting in the need for increased salting. Chlorides degrade lake water quality and impact aquatic life. Chlorides also degrade soil and can kill landscape plantings.	
Buildings and Energy	Increased risk of icing at county-owned and privately owned facilities often leads to increased risk of pedestrian falls and injury. This, in turn, drives additional salt and sand use that negatively impacts downstream waterbodies. Ice events impact access to transit, schools, and services.	• Commute via Walking • Population over 65 • Population with Any Disability • Households with No Vehicle
	Increased occurrences of ice events, when coupled with wind, may increase risk of power outages. The range of impacts includes: • Facilities and residents lacking backup power or the resources to furnish a new backup power system are more vulnerable.	

	• Interruption of remote/at-home work due to loss of electricity and/or internet access.	
	Increased occurrences of ice events on roadways that connect the county's low-density development and sprawling urbanized development leads to high per-capita miles driven by residents. The range of impacts includes: • Ice events that create safety risks to drivers, often times fatal. • Additional salt and sand use that negatively impacts downstream waterbodies. Vulnerable residents have fewer resources to overcome expenses due to ice-induced automobile crashes and injury.	• Commute Time 30 Minutes Plus • Commute via Walking • Population over 65 • Population with Any Disability • Households with No Vehicle
Transportation Infrastructure	Increased frequency of winter temperatures near or above the freezing point and increased frequency of liquid precipitation during winter. Potential impacts include: • Public safety risks from more frequent roadway icing/melting. • Increased salting from more frequent roadway icing, increasing costs and impacts to downstream waterbodies. • Winter flooding due to runoff from frozen ground.	
	Increased number of freeze/thaw cycles. Potential impacts include: • Decline in pavement conditions and associated disruptions to traffic flow. • Decline in length of pavement life cycle. • Increased costs related to pavement repair/replacement.	
	Increased frequency of heavy snowfall. Potential impacts include: • Public safety risks from dangerous road conditions during more frequent heavy snowfall. • Increased snow-removal costs.	

4.2 Extreme Precipitation

Hennepin County has and will continue to experience more wet conditions caused by increased precipitation. Precipitation increases are occurring in each season of the year, with the largest increases in spring and summer. Not only has total precipitation increased, but the intensity and frequency of large events have also increased, with significant potential impacts on Hennepin County residents and operations. Key climate change impacts from extreme precipitation are listed in Table 4, categorized by Hennepin County climate adaptation work group.

Table 4 Key Climate Change Impacts Based on Extreme Precipitation

Work Group	Impacts	Maps
People, Health, and Disparities	Increased frequency and severity of flooding of waterbodies and other low-lying areas. Potential impacts include: • Public safety risks include moving water and potential roadway failure at stream crossings and other flooded areas, hazardous water depths, dangerous traffic disruptions, and disruption of emergency vehicle routes. • Property damage. • Traffic congestion, road closures, and disruption of regional traffic patterns. • Temporary loss of land use (e.g., inundated parking lots, ball fields, golf courses, etc.). • Reduced water quality. • Potential pathogens and environmental contaminants in flood waters that are detrimental to human health. • Increased need for flood insurance outside of the 100-year floodplain and/or the increased cost of flood insurance. • Increased nuisance drainage issues.	• Flooding Susceptibility and Population Vulnerability • Structures Vulnerable to Flooding by Census Tract
	High groundwater levels result from prolonged wet periods. Potential impacts include flooding of basements and associated implications to property, health, and well-being.	• Depth to Groundwater Table
	Vulnerable populations may have fewer economic resources to buy flood insurance, overcome expenses due to extreme flooding impacts to their business, home, etc., or to invest in flood-prevention measures.	• Population Vulnerability Composite • Flood Susceptibility and Population Vulnerability
	Increased stress on the homeless due to lack of shelter.	

	Mental health vulnerability is exacerbated by post-flood-disaster impacts to health, employment, and the challenges inherent in repairing or replacing damaged homes, communities, and workplaces.	
	Renters experiencing flood impacts may not have the ability to mitigate and/or prevent future impacts.	• Renter Housing Units
	Prolonged wetness can create or exacerbate mold issues in homes and businesses, causing health issues.	
	People with limited English proficiency may not understand warnings of extreme storms or know how to effectively access resources after a flood.	• Limited English Proficiency
Water, Natural Resources, Agriculture, and Land Use	Prolonged groundwater rise can result in the expansion of wetlands, ponds, and lakes, resulting in habitat loss. Crop productivity is reduced by prolonged flooding.	• Depth to Water Table
	Extreme storm events erode topsoil, which results in decreased crop productivity and nutrients washed into natural waterbodies. Soil erosion occurs within forests where earthworms have degraded the forest floor.	• Agricultural Degradation • Hydrologic Soil Groups
	Floodwaters can add pathogens and environmental contaminants dangerous to people and livestock.	• Imperviousness
	Landslides can occur on steep slopes where soils are saturated.	
	Stormwater management features become overwhelmed and have reduced effectiveness for controlling the rate of runoff or pollutant capture. Increased sediment and contaminants enter natural waterbodies.	
	Fluctuating water levels in wetlands from very wet to very dry periods are amplified through climate change. Wetland plants and animal life cycles are interrupted, and their survival is threatened.	
Buildings and Energy	There is damage to or failure of county-critical infrastructure due to intense rainfall events and/or river flooding.	• Flooding Susceptibility and Population Vulnerability • Facilities Susceptible to Flooding
	There is damage to county-owned and county-leased facilities due to intense rainfall events and/or river flooding.	• Flooding Susceptibility and Population Vulnerability • Facilities Susceptible to Flooding

	Privately owned property in the county is damaged by increased frequency and intensity of flash flooding. There is increased runoff and flash flooding as the large events intensify and become more common.	
	County facilities, water wells, county infrastructure, and privately owned property is damaged by prolonged regional groundwater rise shifts. The rising water table impacts basements, tanks, structures, foundations, etc. Groundwater movements can mobilize historic contamination, plumes, and vapors and create exposure pathways to populations.	• Depth to Water Table • What's in My Neighborhood
Transportation Infrastructure	Increased frequency and severity of roadway flooding at stream crossings and other low-lying areas. Potential impacts include: • Public safety risks—moving water and potential roadway failure at stream crossings and other flooded areas, hazardous water depths, dangerous traffic disruptions, and disruption of emergency vehicle routes. • Traffic congestion and disruption of regional traffic patterns—further exacerbated because simultaneous flooding of adjacent roadways (county or city) may eliminate obvious alternate routes. • Increased time and costs related to maintenance and/or repair. • Flooding and potential damage to private properties adjacent to county roads.	• County Road Network-Centerline Road Miles • Roadway Flood Susceptibility • County Road Network-Flooding Events 2014–2018
	Increased flooding of sidewalks and trails. Potential impacts include: • Dangerous conditions for bikers and trail users. • Inundated walking and biking trails that divert users to roadways, causing potential safety concerns. • Disruption of sidewalk and trail use/services. • Increased distances those with few transportation choices (sidewalk and trail users) must travel to reach their destination. • Increased time and cost related to maintenance and/or repair.	• County Road Network-Sidewalks • County Road Network-Trails • Flood Susceptibility of Sidewalks • Flood Susceptibility of Trails • Commute via Walking • Households with No Vehicle
	Urban portions of Hennepin County roadways are more vulnerable to impacts of flooding than suburban/rural areas. More compact roadway corridors with smaller setbacks, denser adjacent development, and higher land values limit options for adapting transportation infrastructure to minimize flood potential.	• County Road Network by Metropolitan Area Designation
	Increased stream or river flooding. Potential impacts include: • Increased bridge scour (and associated monitoring). • Erosion of adjacent roadways.	

	Increased potential for damage to or failure of stormwater infrastructure (storm sewer, drainage basins). Potential impacts include: • Sinkholes, slope failures, localized flooding, roadway damage, or washout and associated safety issues. • Private property damage. • Increased time and cost related to infrastructure maintenance or replacement. • Increased staff burden.	
	Increased potential for damage to or failure of retaining walls along county roads. Vulnerability is affected by factors such as: • Height of retaining wall. • Whether the retaining wall was designed with or without a drainage system. • Whether the retaining wall is supporting the roadway or side slopes adjacent to roadway.	
	There is increased potential for damage to or failure of sloped embankments.	
	More complicated and time-consuming design process for transportation infrastructure projects due to increased precipitation frequency estimates, revised design standards, and additional flooding issues. Potential impacts include: • Stormwater infrastructure upgrades which will increase the cost of projects. • More land purchase to provide stormwater/floodwater storage, increasing costs and design time. • Greater evaluation of downstream capacity restrictions, increasing stormwater storage volume, compensatory storage, large conveyance structures (bridges and large culverts), and road elevations—resulting in increased costs, increased design/permitting time, and increased interaction with partners and permitting entities (cities, state, watershed management organizations).	
	Increased involvement in evaluation of local and regional flood issues due to interspersed nature of county stormwater infrastructure within larger city- or state-owned stormwater management systems. Potential impacts include: • Increased staff burden. • Increased cost for participation in evaluation and implementation of flood-resiliency projects.	
	There is increased disruption to construction projects, including delays due to extreme precipitation and high groundwater levels from prolonged wet periods.	• Depth to Groundwater Table
	Complex jurisdictions and shared responsibilities with other local governments can help and hinder the county's capacity to implement adaptation strategies, due to:	• Municipalities in Hennepin County

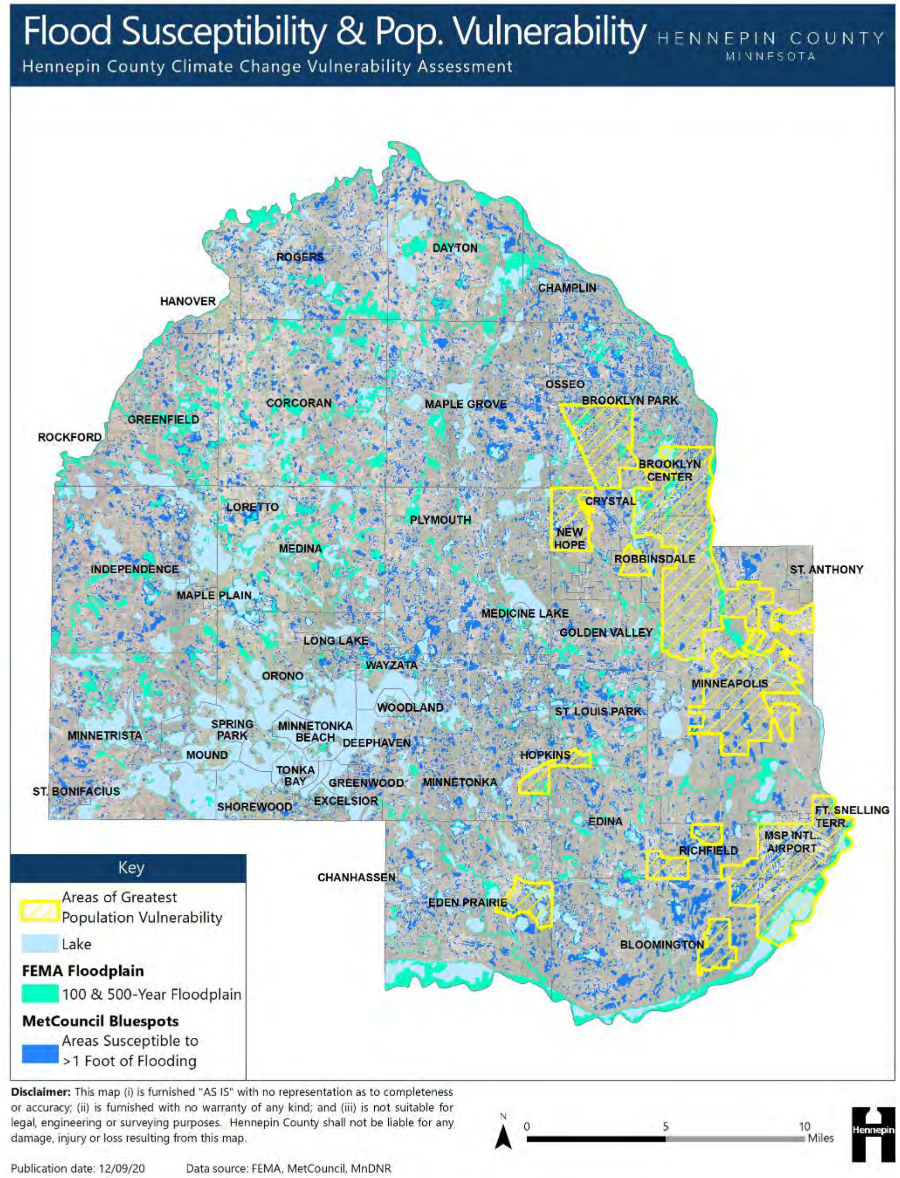
	• The interconnected nature of the transportation and stormwater management infrastructure systems. • The large number of municipal and water management organization partners and associated financial and authoritative relationships.	• Watershed Management Organizations in Hennepin County
Waste and Materials	Increased frequency and intensity of urban flash flooding. Potential impacts include: • Water inundation of hazardous materials, causing nonpermitted releases and exposure of populations nearby or downstream. • Building materials and other waste disposal becomes a problem after disasters. • Missed waste collections occur due to extreme weather.	• Flood Susceptibility and Population Vulnerability
	Increased annual volume of precipitation driving fluctuating groundwater levels, often raising groundwater. Potential impacts include: • Potential for mobilization of underground contamination, causing exposure to populations nearby.	• Depth to Water Table • What's in My Neighborhood
	Community sanitary sewage systems not protected from rising shallow groundwater, inundation, inflow, and infiltration can inadvertently surcharge and generate a wastewater discharge to surface water. Residents, ecosystems, and natural resources can be exposed to this waste stream.	• Flood Susceptibility and Population Vulnerability
	With rising surface water elevations and groundwater table, individual septic systems can become noncompliant with setback and separation distance requirements.	• Flood Susceptibility and Population Vulnerability • Depth to Water Table
	Increasing moisture content of waste being delivered to county solid waste facilities. Wet waste requires more energy to burn at the Hennepin Energy Recovery Center (HERC) facility. Wet recyclables are also more difficult to separate.	
	Increased volume of mixed construction waste and solid waste following property damage due to extreme flooding. Recyclable construction demolition materials are instead landfilled.	• Structures Susceptible to Flooding by Census Tract

4.2.1 Flood Susceptibility

4.2.1.1 Flood Susceptibility—Overview

The amount of rainfall during extreme storm events has increased and is anticipated to continue increasing. The map to the right shows a generalized overview of flood susceptibility throughout Hennepin County, with areas of greatest population vulnerability highlighted in yellow (from the composite population vulnerability map). With so many waterbodies and low-lying areas throughout Hennepin County, the flood potential is widespread.

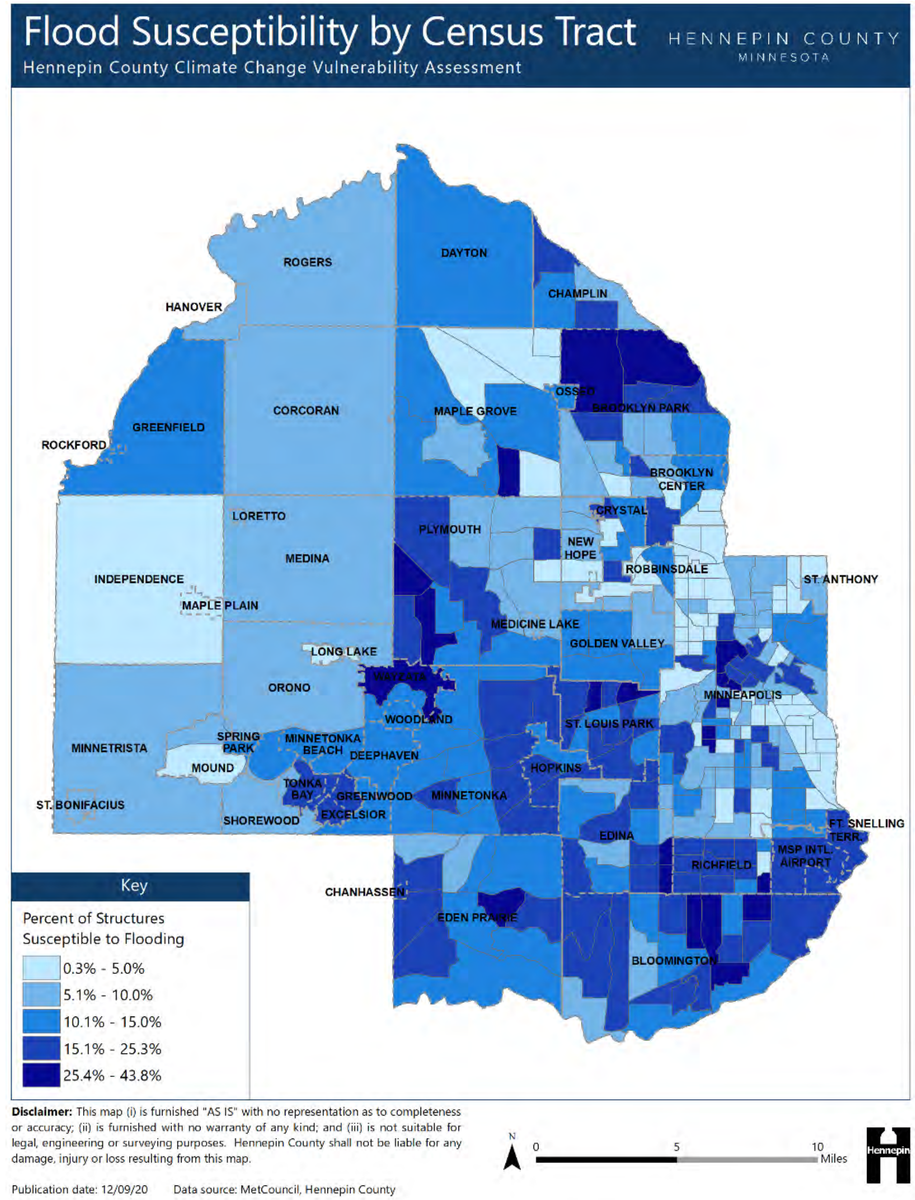
The flood susceptibility map is a combination of Federal Emergency Management Agency (FEMA) floodplain mapping (green areas are 100-year and 500-year recurrence intervals) and low-lying areas susceptible to more than 1 foot of flooding (blue areas, i.e., "Bluespots") based on the Metropolitan Council Localized Flood Map Screening Tool. One of the key challenges in assessing flood vulnerability countywide is the lack of consistent flood risk information and mapping. FEMA floodplain maps are outdated, not yet reflecting the precipitation frequency estimates updated by the National Oceanic Atmospheric Administration (NOAA) in 2013, which generally increased. Detailed models that use Atlas 14 precipitation estimates have been developed for some portions of Hennepin County, but are not available countywide. In the absence of countywide flood risk modeling, results from the Metropolitan Council "Bluespots" analysis are shown on the Flood Susceptibility map. The Bluespots analysis identifies low-lying areas with no topographic outlets that are potentially susceptible to flooding. However, the analysis does not consider whether low-lying areas are drained by storm sewer and does not associate the flood potential with a specific amount of rainfall or recurrence interval.



Structures Susceptible to Flooding by Census Tract

The map to the right depicts the estimated percentage of structures susceptible to flooding by census tract. Identification of structures susceptible to flooding was based on a combination of Federal Emergency Management Agency (FEMA) floodplain mapping (100-year and 500-year recurrence intervals) and low-lying areas susceptible to more than 1 foot of flooding (Bluespots analysis conducted by the Metropolitan Council). Although the flood susceptibility dataset has limitations, the comparison of structures susceptible to flooding by census tract highlights areas of greater vulnerability.

As mentioned previously, the Bluespots analysis identifies low-lying areas with no topographic outlets that are potentially susceptible to flooding. Therefore, in some areas, the flood susceptibility results may be heavily influenced by large, topographic depressions, but flood potential is not necessarily high (e.g., areas in Brooklyn Park).

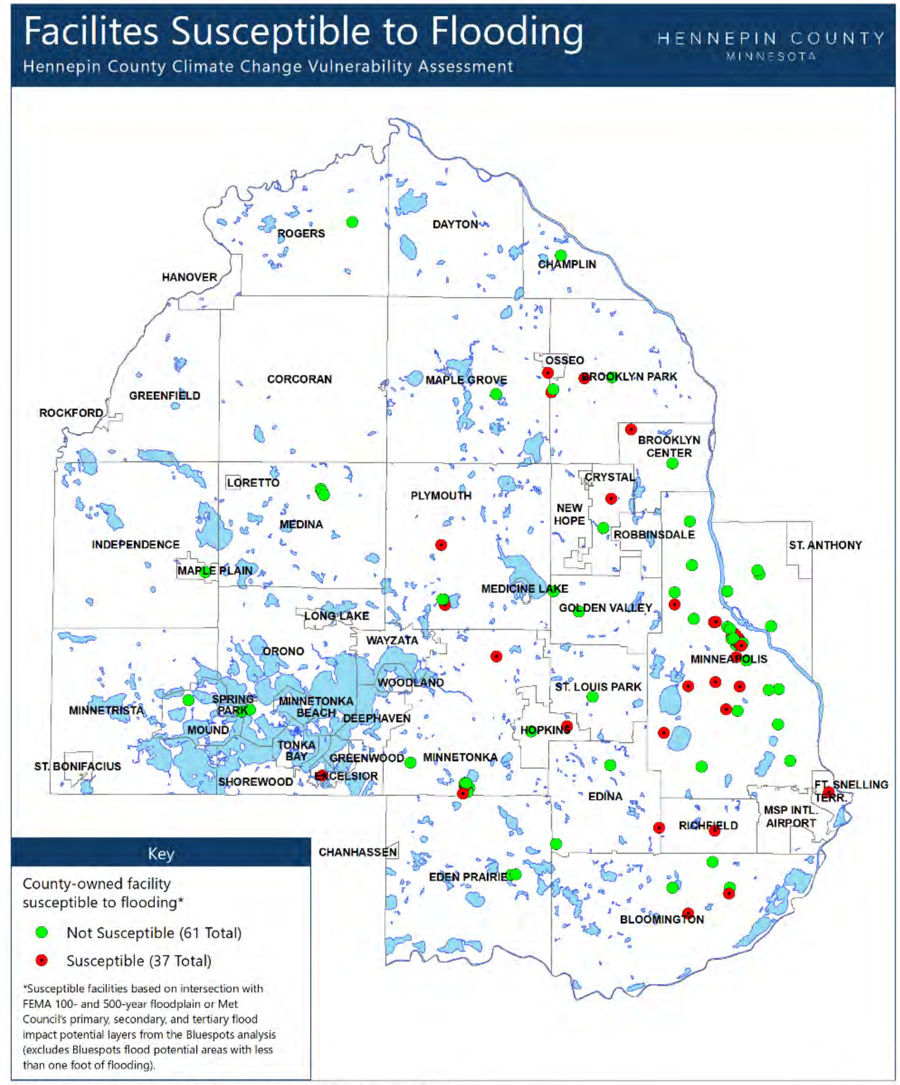


4.2.1.2 Flood Susceptibility—Hennepin County Facilities

Flood Susceptibility

Hennepin County owns approximately 100 properties. The map to the right shows the locations of these facilities which are susceptible to flooding based on a combination of Federal Emergency Management Agency (FEMA) floodplain mapping (100-year and 500-year recurrence intervals) and low-lying areas susceptible to more than 1 foot of flooding (Bluespots analysis conducted by the Metropolitan Council). Although the flood susceptibility dataset has limitations, identifying potential flood susceptibility of Hennepin County facilities helps to highlight areas of greater vulnerability.

While useful as a screening tool for identifying potential flooding locations, the Met Council analysis was developed with elevation data from 2011 and does not consider whether a specific location is drained by the storm sewer network or otherwise adapted to reduce flood risk. The existing stormwater conveyance systems or site design may mitigate the flood risk at many locations.



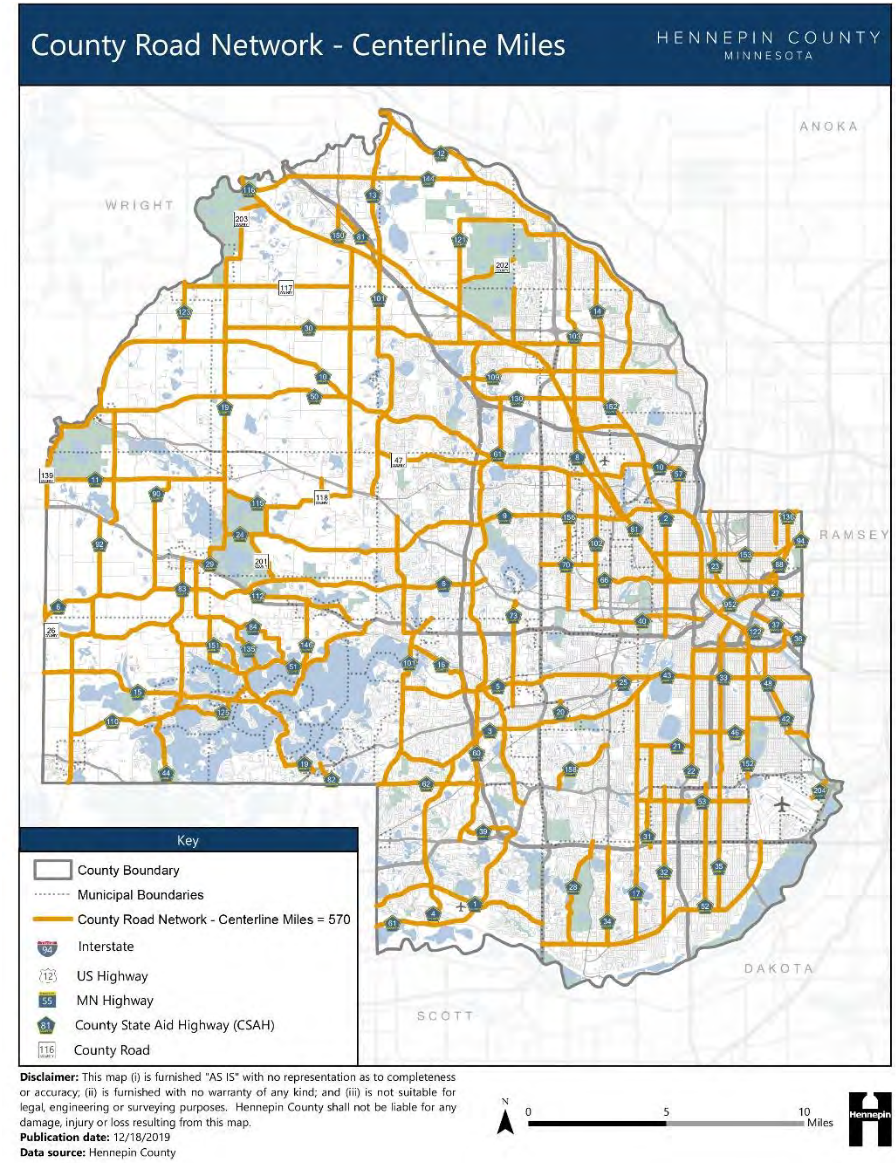
Disclaimer: This map (i) is furnished "AS IS" with no representation as to completeness or accuracy; (ii) is furnished with no warranty of any kind; and (iii) is not suitable for legal, engineering or surveying purposes. Hennepin County shall not be liable for any damage, injury or loss resulting from this map.

Publication date: 02/23/21 Data source: Metroplitan Council

4.2.1.3 Flood Susceptibility—Transportation Infrastructure

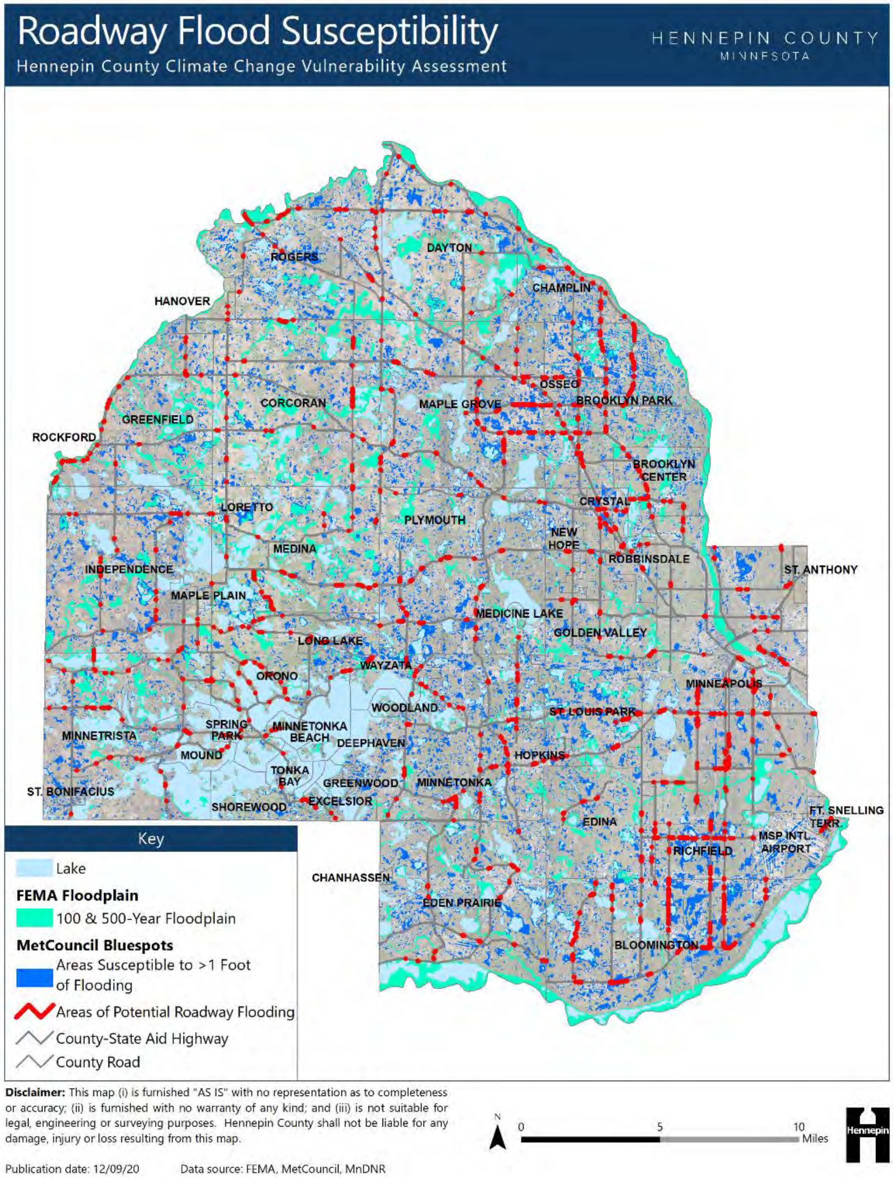
Hennepin County manages an extensive transportation system and associated infrastructure. The Hennepin County transportation network consists of more than 2,200 lane miles of roadway and right-of-way drainage that extend throughout the county (Reference (8)). The county roadways play an important role in providing emergency services and serve as connectors between state- and local-transportation systems. Truck traffic moves 83 percent of goods (by weight) in Hennepin County and 65 percent by value. Hennepin County is also responsible for other infrastructure, including more than 800 traffic signals, 40,000 signs, 148 bridges, 400 miles of sidewalks, 775 miles of bikeways, 100 miles of trails, miles of storm sewer pipes and numerous drainage basins, retaining walls, and sloped embankments (Reference (9)). More than 30% of county roads are more than 50 years old and are nearing the end of their useful life.

The map to the right shows the Hennepin County road network (in orange), including county state aid highways and county roads.



Roadway Flood Susceptibility

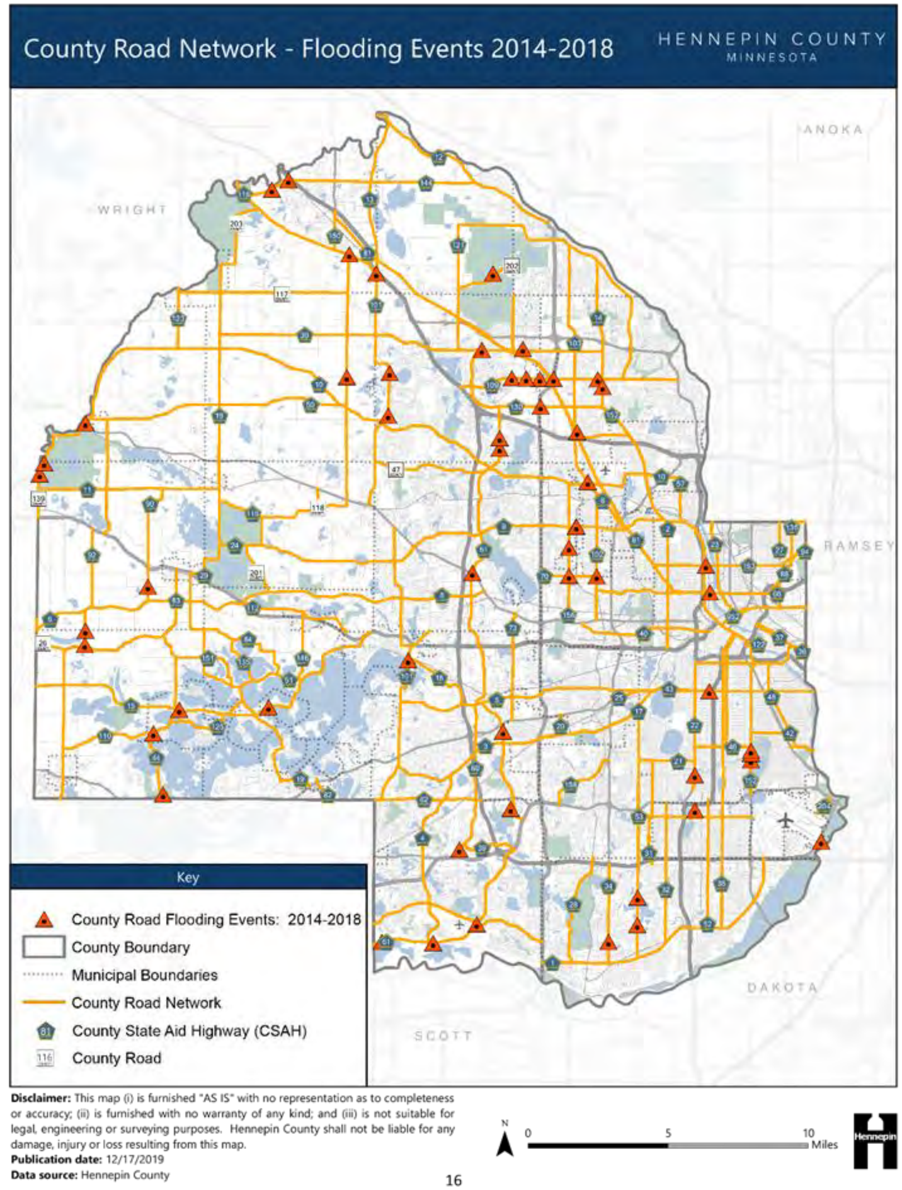
The map to the right shows a generalized overview of periodic flood susceptibility throughout Hennepin County, with areas of potential roadway flooding on county roads and county state aid highways (CSAHs) shown in red. This map does not reflect the existing storm sewer network built to prevent road inundations. During extreme precipitation events, seasonal flooding, or both, these locations are at risk of overtopping or flooding, causing an interruption of service to users. See the summary of the Flood Susceptibility and Population Vulnerability map in Section 4.2.1.1 for more information about the data sources and map limitations.



County Road Network—Flooding Events 2014–2018

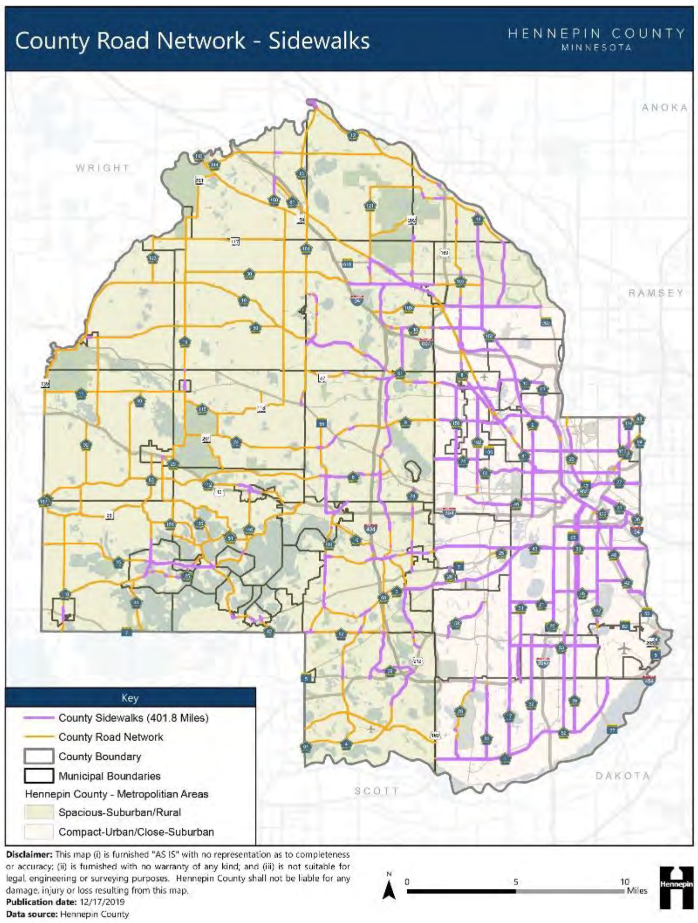
The map to the right shows flooding events reported on county roads or county state aid highways (CSAH) between 2014–2018.

Data source: Appendix 8 of Draft Hennepin County Transportation Infrastructure Resiliency report

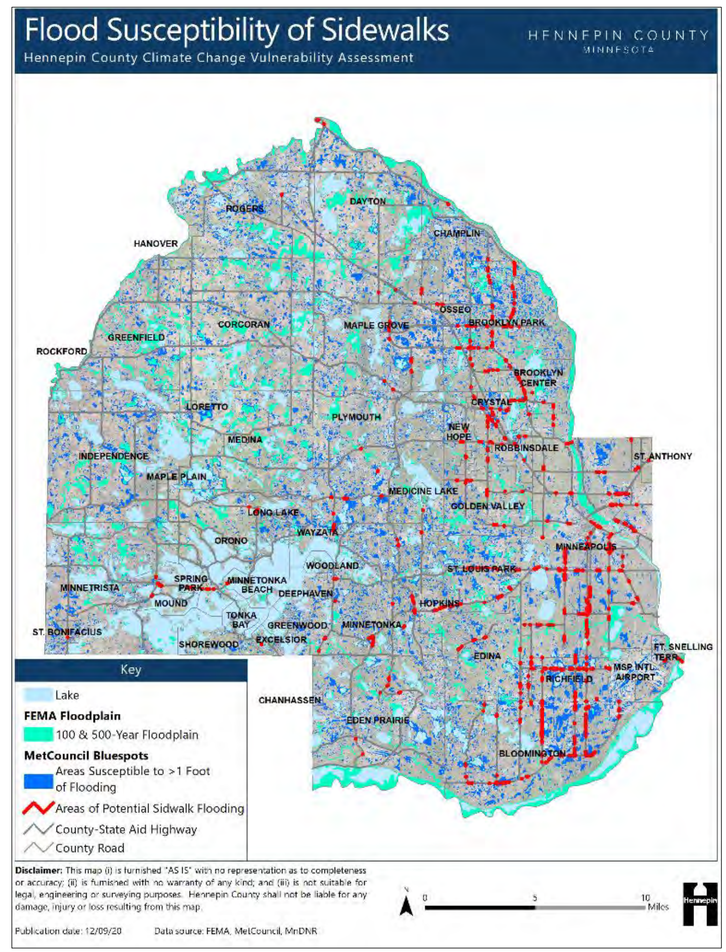


Flood Susceptibility of Sidewalks

Hennepin County owns and operates approximately 400 miles of sidewalks. As shown in the map below, sidewalks accompany most of the county roadways within the compact urban or inner-ring suburban portions of the county. Sidewalks are less prevalent in the less densely developed outer-ring suburban/rural portion of Hennepin County.

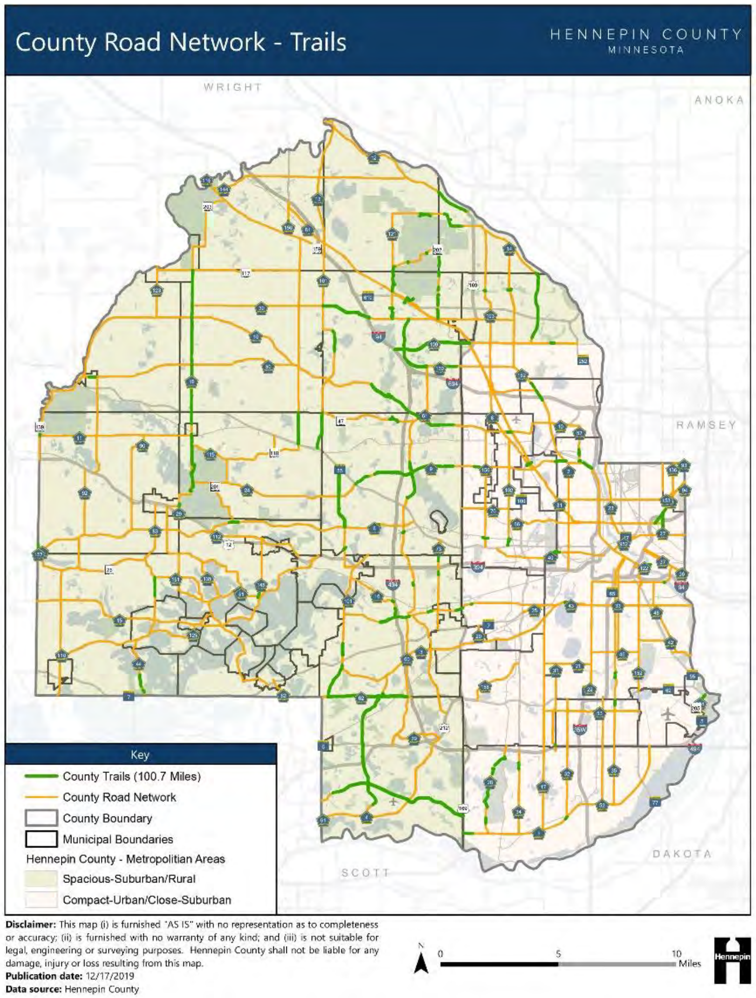


The map below shows a generalized overview of flood susceptibility throughout Hennepin County, with areas of potential sidewalk flooding along county roads and county state aid highways (CSAHs) shown in red. Sidewalk flooding adversely impacts residents that do not own a car and rely on transit or walking to get to work, shop, or obtain services. See the summary of the Flood Susceptibility map in Section 4.2.1.1 for more information about the data sources and map limitations.

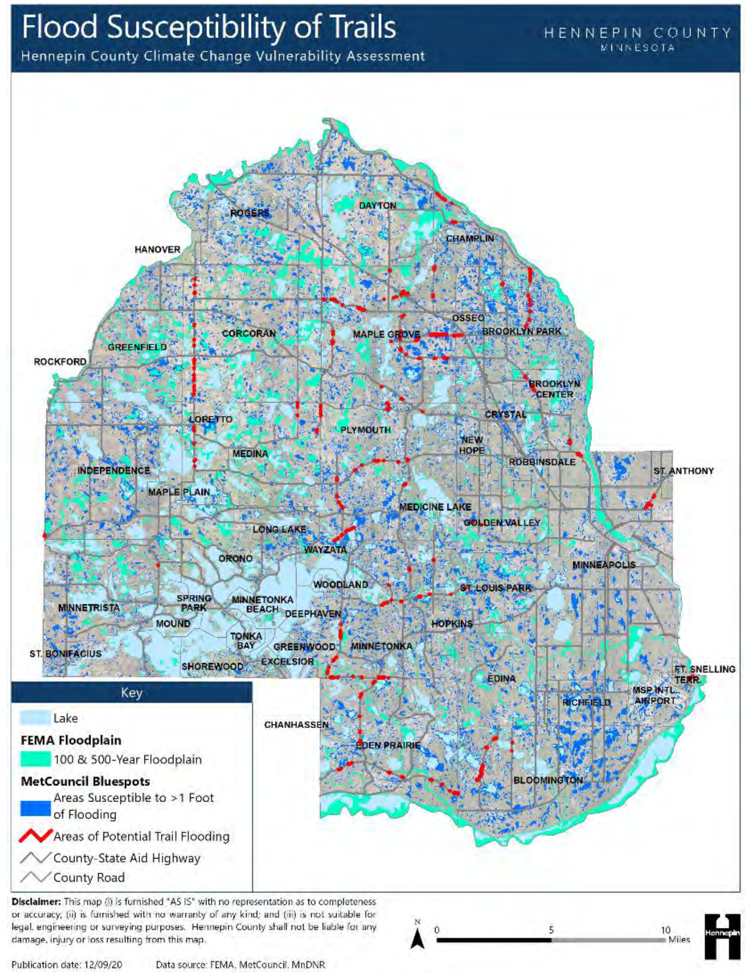


Flood Susceptibility of Trails

Hennepin County owns approximately 100 miles of trails. As shown in the map below, trails are more prevalent in the less densely developed suburban/rural portion of Hennepin County.



The map below shows a generalized overview of flood susceptibility throughout Hennepin County, with areas of potential trail flooding shown in red. See the summary of the Flood Susceptibility map in Section 4.2.1.1 for more information about the data sources and map limitations.



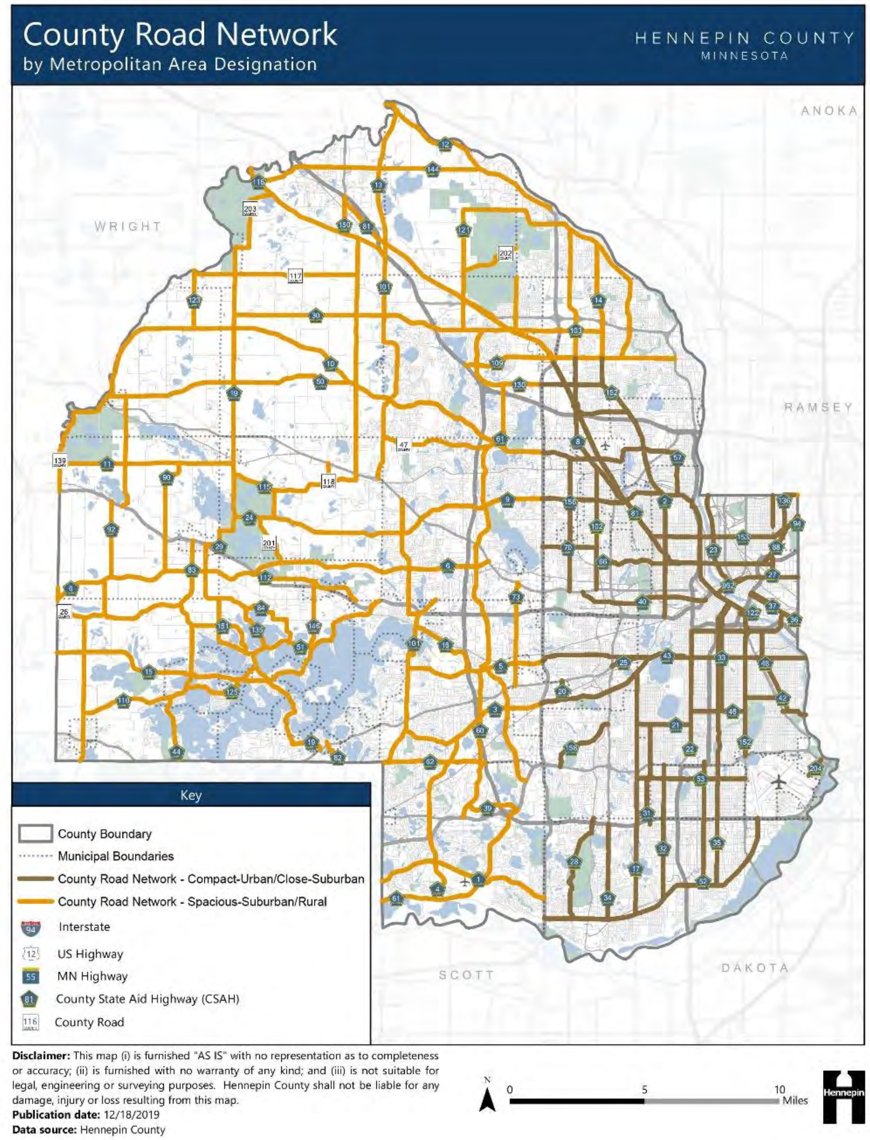
County Road Network by Metropolitan Area Designation (Urban vs. Suburban)

The vulnerability of Hennepin County's transportation infrastructure to flooding can vary depending on whether in urbanized or suburban/rural areas. Factors that differentiate the urbanized and suburban areas include:

- Road corridor width that is generally more compact for the urbanized settings and wider in suburban and rural settings.
- Urbanized settings that are more densely developed and have more impervious surfaces.
- Urbanized settings that have fewer wetlands, fewer trees, and much less greenspace.

Urban areas within Hennepin County are generally more vulnerable to extreme precipitation events, and the flooding impacts on urban county roads are considered to be more serious in terms of public safety, public health, and public service delivery (Reference (9)). Options to mitigate flood impacts in the urbanized areas are limited because roadway corridors are generally narrower. With higher property values per square foot in urban areas it is much more expensive for Hennepin County and/or urban and suburban cities to mitigate flooding next to county roads.

In suburban/rural areas, the availability of alternate routes for flooded county roads is more limited, which may impact emergency services in those areas. Accordingly, mitigation actions may be necessary before the service life of these roads has been reached.

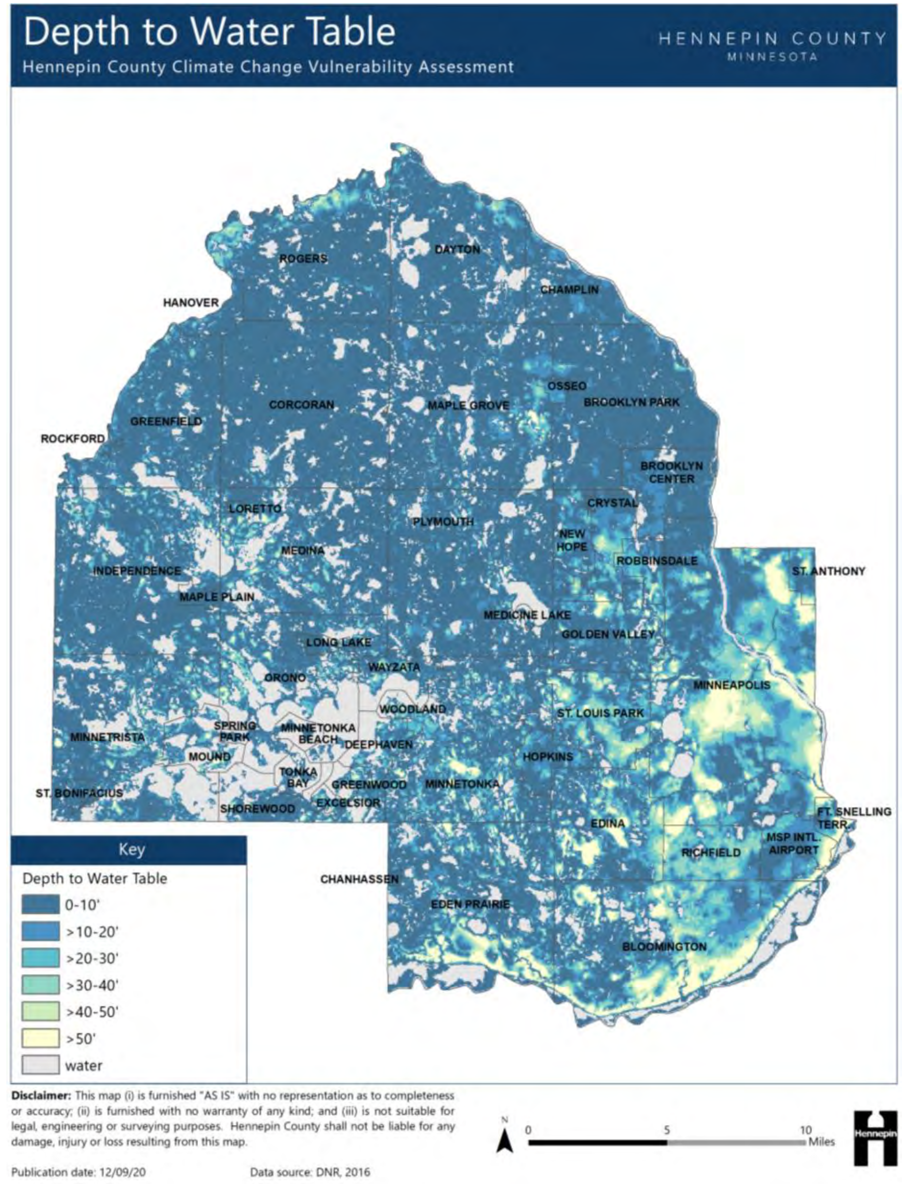


4.2.2 Depth to Water Table

Increased precipitation and associated increases in groundwater recharge can drive changes in the county's water balance. Factors such as annual precipitation volume and pumping influence surface water-groundwater interactions, surface water elevations, and depth to groundwater.

A large portion of Hennepin County is vulnerable to impacts from rising water tables due to the generally shallow nature of the water table. The map to the right shows the approximate depth to water table throughout Hennepin County. Dark blues on this map indicate shallow depths to the water table. With the exception of portions of Minneapolis, Richfield, and parts of Bloomington, the water table in most parts of the county is within 10 feet of the surface. This already puts basements, buried infrastructure, and buried hazardous materials at risk of flooding. With additional precipitation expected in the coming years, depths to the water table may further decrease across the county, causing increased risk of damage to basements and infrastructure.

Many newly developing areas have groundwater within10 feet of the surface. The shallower water table across western portions of the county places basements and underground tanks, etc. at an increased risk of groundwater impacts if depth to groundwater changes by only a few feet. In some areas, changes to surface water elevations are closely tied to regional groundwater levels.

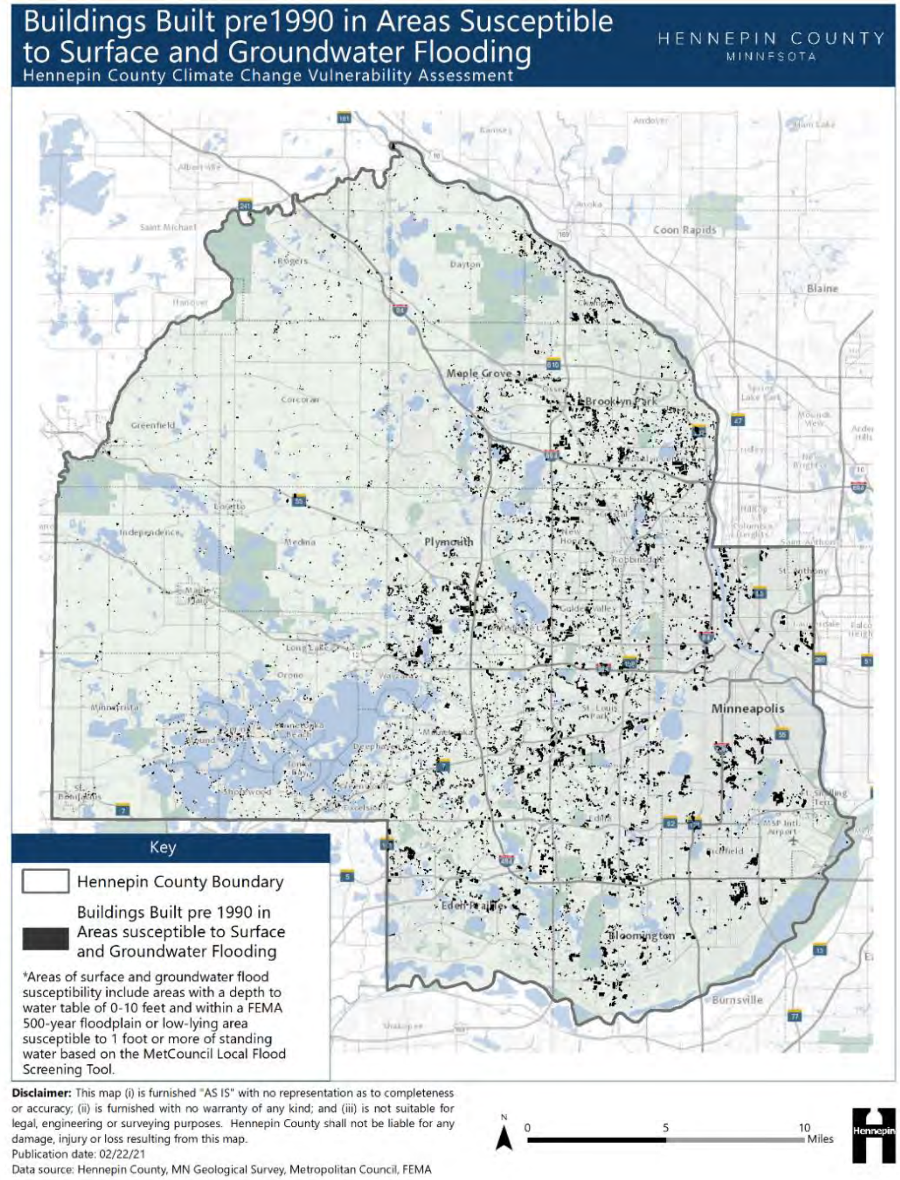


4.2.2.1 Buildings Built pre1990 in Areas Susceptible to Surface and Groundwater Flooding

The map to the right combines the flood susceptibility layers from Section 4.2.1.1, the depth to water table data for 0–10 feet from Section 4.2.2, and highlights where buildings were built in these areas before Minnesota created a legal framework mandating the protection or replacement of wetlands.

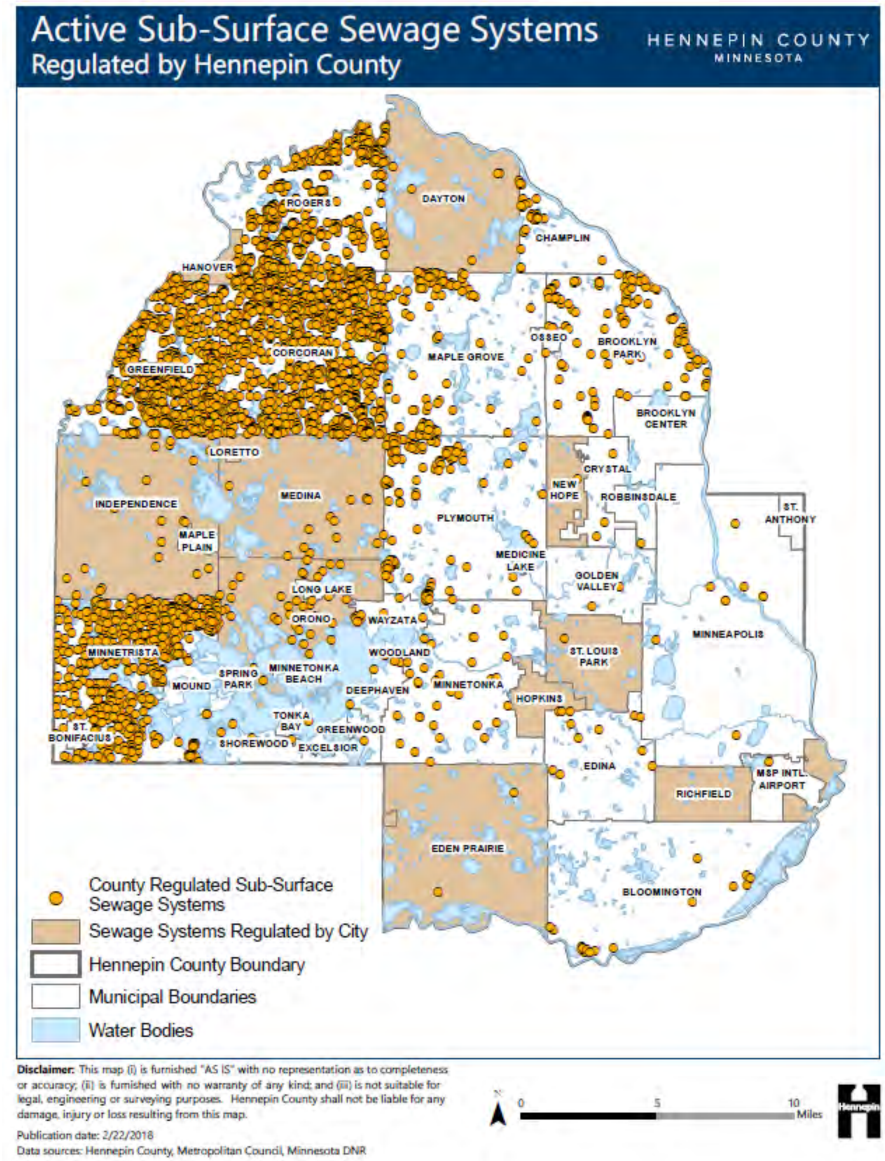
As the Depth to Water Table map (Section 4.2.2) demonstrates, groundwater is not far from the surface in most of Hennepin County. Groundwater flooding is a much less well understood phenomena than surface water flooding. We know that increased precipitation will affect groundwater levels, but we do not yet have robust tools to indicate where and how impacts may occur due to rising groundwater. Future analyses will incorporate larger and broader datasets with the goal of refining flood susceptibility models.

Wetlands are a crucial piece to natural stormwater management because they detain and infiltrate stormwater. In 1991 the Minnesota Wetland Conservation Act prohibited the draining and filling of wetlands unless they are restored or replaced by creating new wetlands of at least equal public value. State rules were created to achieve an overall goal of no net loss of wetlands (Minnesota Rules, part 8420.0105).



4.2.3 Active Sub-Surface Sewage Systems

Locations of county-regulated subsurface sewage systems are shown on the map at the right. A majority of these septic systems are also in areas with relatively shallow groundwater (map source: Hennepin County 2040 Comprehensive Plan)



4.3 Warming, Heat, and Humidity

Yearly average maximum temperatures in Hennepin County are slowly increasing at a rate of 0.09°F per decade, and projected climate scenarios show that the frequency and magnitude of hot days, warm nights, and heat waves are likely to increase by mid-century. In addition, humidity, or dew point temperature (a measure of water vapor in the air), is also increasing. Increased heat and humidity create more favorable conditions for severe storms with high wind, hail, or tornados—severe weather events that are projected to increase in frequency later this century. Some specific anticipated climate change impacts related to warming, increased heat, and humidity are detailed in Table 5, categorized by the Hennepin County climate adaptation work group.

Table 5 Key Climate Change Impacts Based on Warming, Heat, and Humidity

Work Group	Impacts	Maps
People, Health, and Disparities	Increase in extreme heat-related illnesses, including acute illnesses and worsening of chronic conditions exacerbated by urban heat island. Physical and mental health issues are exacerbated by extended heat and humidity periods.	• Urban Heat Island—August Daytime Temperature and Population Vulnerability • Urban Heat Island—August Nighttime Temperature and Population Vulnerability
	Increased hospitalizations due to prolonged exposures to high temperatures	
	Increase in heat-related deaths	
	Warming can contribute to drought, which can disrupt the food and energy supply chain.	
	Decreased air quality due to temperature inversions, wildfires (local and remote), and atmospheric reactions driven by heat	• Air Pollution Sources
	Vulnerable populations are more at risk of experiencing health difficulties due to high humidity and temperatures during heat waves, particularly when nighttime temperatures remain high and air conditioning is not available. • The urban heat island effect disproportionately impacts vulnerable populations. • Air pollution increases with high humidity and temperatures, exacerbating chronic respiratory health conditions. • Older populations are more vulnerable to the effects of increased heat.	• Population Vulnerability Composite • Population Density • Population over 65 • Households with No Vehicle • Population below 185% Poverty Threshold

Work Group	Impacts	Maps
	• Populations without access to a vehicle will have less access to cooling centers. There is increased risk of mold and bacteria formation in older, poorly ventilated structures.	• COPD Hospitalization Rates • Asthma Hospitalization Rates • Housing Stock Built Pre-1940
	Increased stress on homeless and low-income populations without shelter or air conditioning	• Population below 185% Poverty Threshold
	Longer growing season extends periods of weed growth and extends allergy season.	
	People using public transportation or walking to work have greater exposure to heat while waiting.	• Households with No Vehicle • Commute via Transit • Tree Planting Prioritization • Commute via Walking
	Increased exposure to extreme heat conditions for outdoor workers	
	Increased potential for severe storms with high wind, hail, or tornados due to increases in heat and humidity	
	Renters may have little control of the heating and cooling systems in their rental unit. Cooling costs, if paid by the renter, may be a burden. AC may not be available.	• Renter Housing Units • Home Ownership • Cost-Burdened Households
	Low-income homeowners often own older, poorly insulated housing stock which becomes more expensive to cool.	• Housing Stock
	People with limited English proficiency may not understand warning messages or how to effectively access resources (e.g., cooling centers).	• Limited English Proficiency
Water, Natural Resources, Agriculture, and Land Use	Decreased air quality due to temperature inversions, wildfires, and atmospheric reactions driven by heat	
	Poor air quality stresses livestock and wildlife.	
	Warming can contribute to drought, which can limit food production.	
	There are warmer temperatures in surface waters; impacts can include: • Increased algal blooms and pathogen growth, which can be detrimental for humans, wildlife, and aquatic communities.	

Work Group	Impacts	Maps
	• Loss of fish habitat for some fish species (e.g., walleye, trout) and replacement with other species (e.g., bass and carp)	
	Heat stress can kill vegetation, leaving soils open to erosion.	
	Shift of species (especially plants) resulting in extinction of some plant species from Hennepin County and the introduction of neonatives	• Ecological Corridors
	Increased heat can either increase or reduce crop production, causing producers to modify land use to adapt.	• Agricultural Degradation
	Stressed natural forests and the urban forest: • As trees diminish or die, shading of pavement is eliminated, resulting in increased urban heat-island effect. This further stresses living beings while increasing cooling costs. • There are cost increases for dead tree removal and the planting of new trees. • Tree disease and insect infestations increase as trees are weakened. • Native tree species that require cool temperatures are stressed and die. Some, such as paper birch and sugar maple, could eventually be eliminated in Hennepin County.	• Forest and Urban Tree Canopy
Buildings and Energy	County-owned and County-rented facilities are at greater risk of increasing energy consumption for heating and cooling. Extreme temperature patterns are prolonged by jet stream pattern changes.	• Average Energy Burden • Building Age, Energy Density, and Vulnerability
	Privately owned and rented facilities are at greater risk of increasing energy consumption for heating and cooling. Dependence on nonrenewable, high-carbon sources of energy places vulnerable populations at long-term risk of rising costs and interrupted supply chains bringing fuel to the community from afar. A thermal load cluster is defined as "a cluster or grouping of potential users of thermal energy for heating and cooling homes, commercial and institutional buildings, and industrial processes (in other words, district energy)." Proximity to a thermal load cluster might offer better opportunity for district-scale heating and cooling for better efficiency than for properties far removed from thermal load clusters (areas with high annual thermal heating and cooling energy usage).	• Average Energy Burden • Building Age, Energy Density, and Vulnerability
	Privately owned and rented facilities are at greater risk of an increasing cost burden due to the increased energy consumption required for heating and cooling. Vulnerable populations and renters have fewer resources to invest in upgrades.	• Average Energy Burden • Building Age, Energy Density, and Vulnerability • Renter Housing Units

Work Group	Impacts	Maps
Transportation Infrastructure	There is an increase in pavement buckling; potential impacts include: • Traffic safety hazard. • Disruption to traffic flow. • Increased time and cost related to repair.	
	There are increased electrical system malfunctions • Traffic safety hazard • Disruption to traffic flow • Increased time and cost related to repair	
	Disruption to construction projects due to limitation on work hours	
Waste and Materials	There is increased intensity and duration of extreme heat and humidity exacerbating air pollution; potential impacts include: • Health impacts to vulnerable populations. Residents are vulnerable to the impacts of diesel and gasoline-fueled auto traffic, including increased solid waste hauling.	• Air Pollution Sources • COPD Hospitalization Rates • Asthma Hospitalization Rates
	Lack of proper air conditioning and refrigeration can lead to disposal of spoiled food on larger scale during prolonged heat waves. Often times this is not separated for organics recycling, but instead delivered mixed with solid waste to landfills. The loss of food and cost to replace it disproportionately affects economically disadvantaged populations.	• Food Deserts • Urban Heat Island • Average Energy Cost Burden
	Renters are less likely to be empowered to make choices or changes about waste collection. This responsibility is typically that of the property owner.	• Renter Housing Units • Home Ownership
	There is increased waste generation, primarily building materials and personal belongings, from severe storms with high wind, hail, or tornados.	

4.3.1 Urban Heat Island

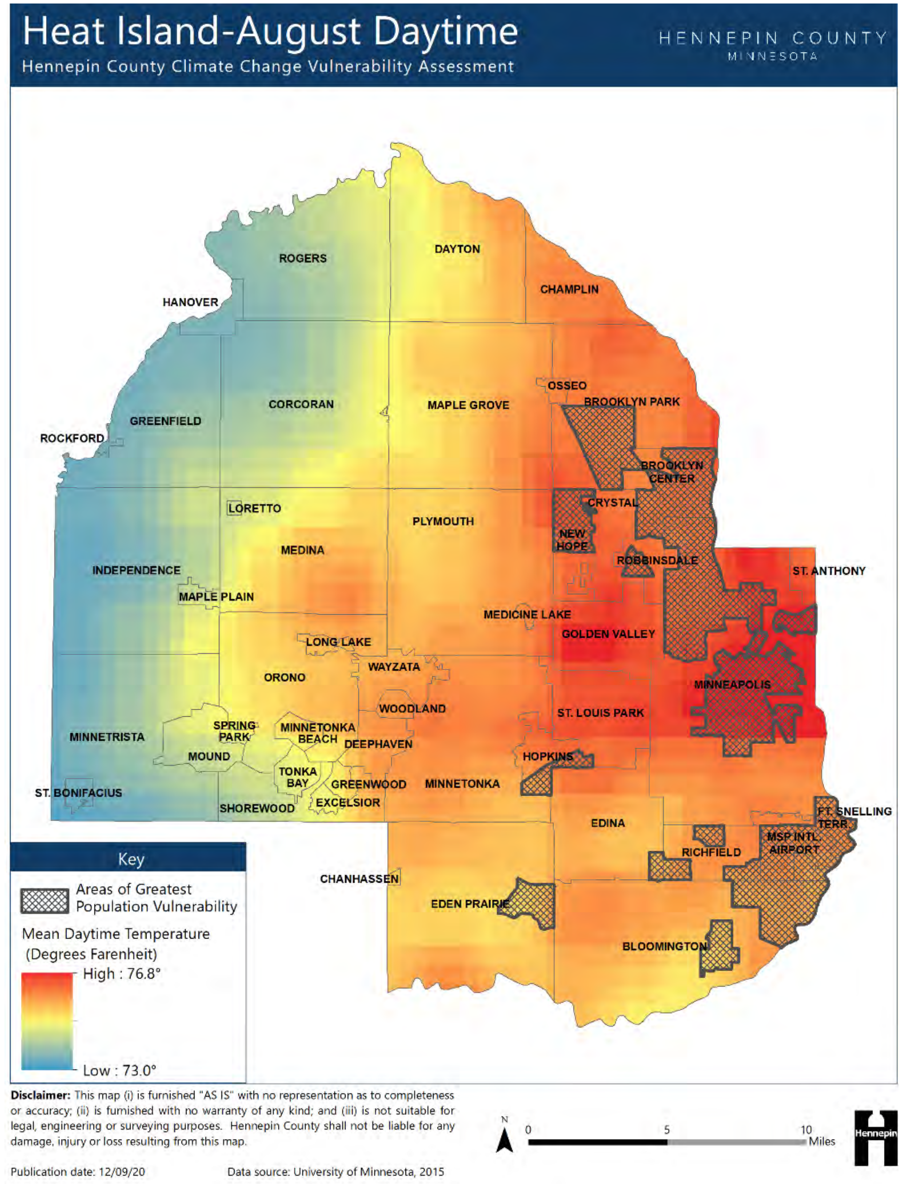
The impacts of climate change are exacerbated by the urban heat island effect. Warmer temperatures stress many systems in developed areas as discussed below.

4.3.1.1 Urban Heat Island—August Daytime Temperature and Population Vulnerability

A heat island describes temperature increases caused by heat held by hard, largely impermeable surfaces such as buildings, streets, and parking lots. These increases warm the atmosphere and hold temperatures higher than in surrounding rural landscapes.

The map at right illustrates the heat-island effect, in which the areas with the densest levels of development (more hard surfaces such as concrete, asphalt) are the warmest. The blue-to-red gradient shows mean daytime temperatures for the month of August, averaged over a 3-year study period from August 2011 to August 2014. Cooler temperatures are shown in blue, while warmer temperatures are represented by red hues. As shown in the map, mean temperatures varied by nearly 4 degrees across the county, with warmer temperatures observed in the eastern portion of the county where development is denser.

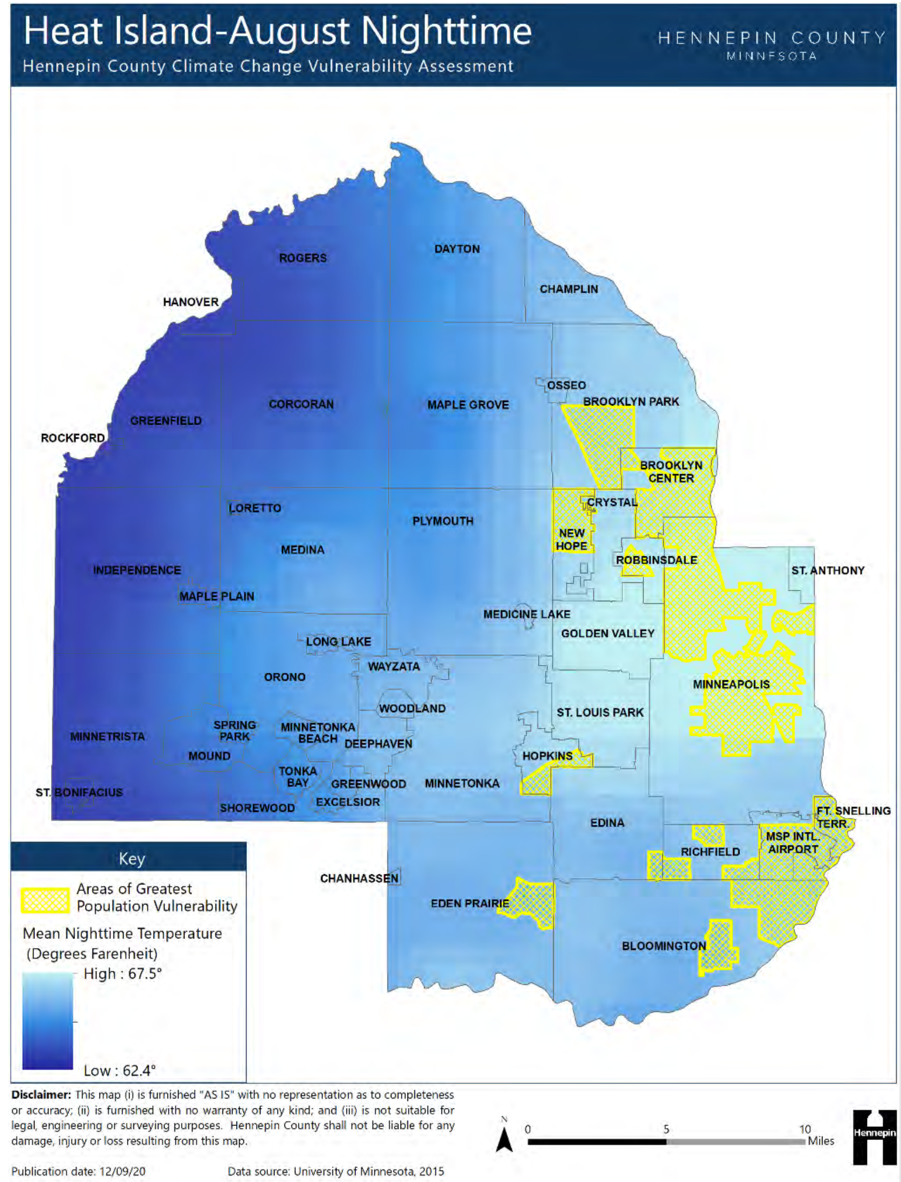
Grey hatching indicates areas with the greatest population vulnerability to climate change. As shown in the figure, these areas coincide with the warmer end of the temperature gradient. People in these areas, especially those without access to air conditioning or with underlying health conditions, may be more vulnerable to heat-induced stresses and have increased exposure and sensitivity and reduced capacity to cope with the extreme heat.



4.3.1.2 Urban Heat Island—August Nighttime Temperature and Population Vulnerability

The map at right helps illustrate the heat-island effect, in which the areas with the densest development (more hard surfaces such as concrete, asphalt, and buildings) are the warmest. The blue gradient shows nighttime mean temperatures for the month of August, averaged over a 3-year study period from August 2011 to August 2014. Cooler temperatures are shown in dark blue while warmer temperatures are represented by light blue. This figure helps illustrate the heat-island effect. Long after the sun has gone down, areas with the highest levels of development remain the warmest. As shown in the map, mean nighttime temperatures varied by over 5 degrees across the county, with warmer temperatures again observed in the eastern portion of the county where development is denser.

Yellow hatching indicates areas of greatest overall population vulnerability to climate change. As shown on the map, these areas coincide with the areas that tend to be warmer at night when it's important to cool down for sleep. People in these areas, especially those without access to air conditioning, are more susceptible to heat-induced stresses.



4.3.2 Air Quality

4.3.2.1 Air Quality and Climate Change in Hennepin County

Poor air quality is associated with health impacts in a variety of ways, most notably as inhalation exposure to toxic chemicals and substances when the concentration of pollutants is high. Exposure to poor air quality is associated with both chronic, long-term health effects and acute health impacts. Higher concentrations of pollutants, such as particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) and ozone, are associated with increased hospitalizations and emergency room visits related to respiratory conditions such as asthma and chronic obstructive pulmonary disease (Reference 15)). In any population, underlying health conditions increase the likelihood of health impacts from exposure to poor air quality. Because communities with higher populations of people of color or people living in poverty tend to have higher rates of underlying health conditions, these communities are more vulnerable to poor air quality events (Reference (16)).

While the increased temperatures and greater temperature variations associated with climate change are not likely to directly impact the concentration of primary pollutants, the responses to these changes may drive an increase in energy consumption, leading to greater emissions of primary pollutants. It is important to note that concentration of pollutants in air are related to emissions, but geography, meteorology, and source characteristics also impact how emissions impact these concentrations. Power production facilities are generally not located in highly populated areas and have tall sources, so emissions associated with higher electricity demand may be expected to have a small, or even negligible, impact on the concentration of pollutants in air in Hennepin County. Emissions from vehicles, buildings, small sources, and wood-burning stoves are smaller but close to population centers and near the ground and, therefore, may lead to localized concentrations of pollutants. Increases in these, or similar activities, as a result of climate change may indirectly impact the concentration of airborne pollutants.

Ozone, which is a respiratory irritant, is a secondary pollutant, meaning it is not emitted directly, but forms in the atmosphere via reaction with other pollutants in the presence of sunlight. Nitrogen oxides (NO_X) and volatile organic compounds (VOCs) are the principle precursor pollutants to ozone formation. As with all reactions, higher temperatures, such as those associated with climate change, will lead to increased rates of the atmospheric reactions that produce ground-level ozone (Reference 17)). The highest concentrations of ozone are often associated with atmospheric inversions (in which warmer air is held over cooler air and acts as a "cap" to trap pollutants near ground level), which are known to provide conditions that lead to ozone formation. Hennepin County is not prone to atmospheric inversions because of its topography. Thus, it is not known to what extent the higher temperatures associated with climate change could lead to more frequent or prolonged high ozone concentrations in Hennepin County

To protect human health, including sensitive populations, national ambient air quality standards (NAAQS) are established to limit concentrations of key pollutants. The economy and population of Hennepin County are expected to grow into the future. With growth, increased industrial activity and transportation will result in increased emissions of all airborne pollutants including NO_X, VOCs, and $PM_{2.5}$. Climactic extremes will also result in increased emissions through higher energy consumption. These increases, if large and frequent enough, may make it difficult for Hennepin County to meet NAAQS requirements in the future. Additionally, the negative respiratory health impacts associated with poor air quality, particularly in vulnerable populations, may result in increased emergency room visits and hospitalizations in Hennepin County. Of concern are increased smoke in the atmosphere due to climate-induced wildfires, and increased allergens in the atmosphere due to the extended growing season as a result of warming. Plant pollen and fungal spores are released for longer periods.

The two biggest sources of air pollution in Hennepin County are vehicles and buildings. The more vehicles on the road moving goods and people, the more air pollution we have within the road corridors. Increased heating and cooling of buildings also increases emissions.

The map below depicts the distribution of air pollution sources that increase the risk for negative health impacts that may be accelerated or amplified by climate change. The risk factors shown are building emissions, industrial sources of air pollutants, and vehicle emissions along transportation corridors—which are associated with emissions of air pollutants. The risk factors depicted on the map are based on emissions sources and not air pollutant concentration data. Concentration data is dependent on air-monitoring stations, which are only sparsely located and more suited to average or background characterizations of air quality. Instead, emissions, especially ground-level emissions, can be used as a surrogate to indicate areas at risk for localized high concentrations of toxic air pollutants. The risk factors may also be compared with locations of population vulnerability (see Section 3) to determine areas of stacked vulnerability. Areas with multiple layers of risk—vulnerable populations, industrial emissions, and transportation emissions—are the areas with the highest vulnerability to air quality impacts related to climate change and are the areas that will likely experience the highest burden related to climate change.

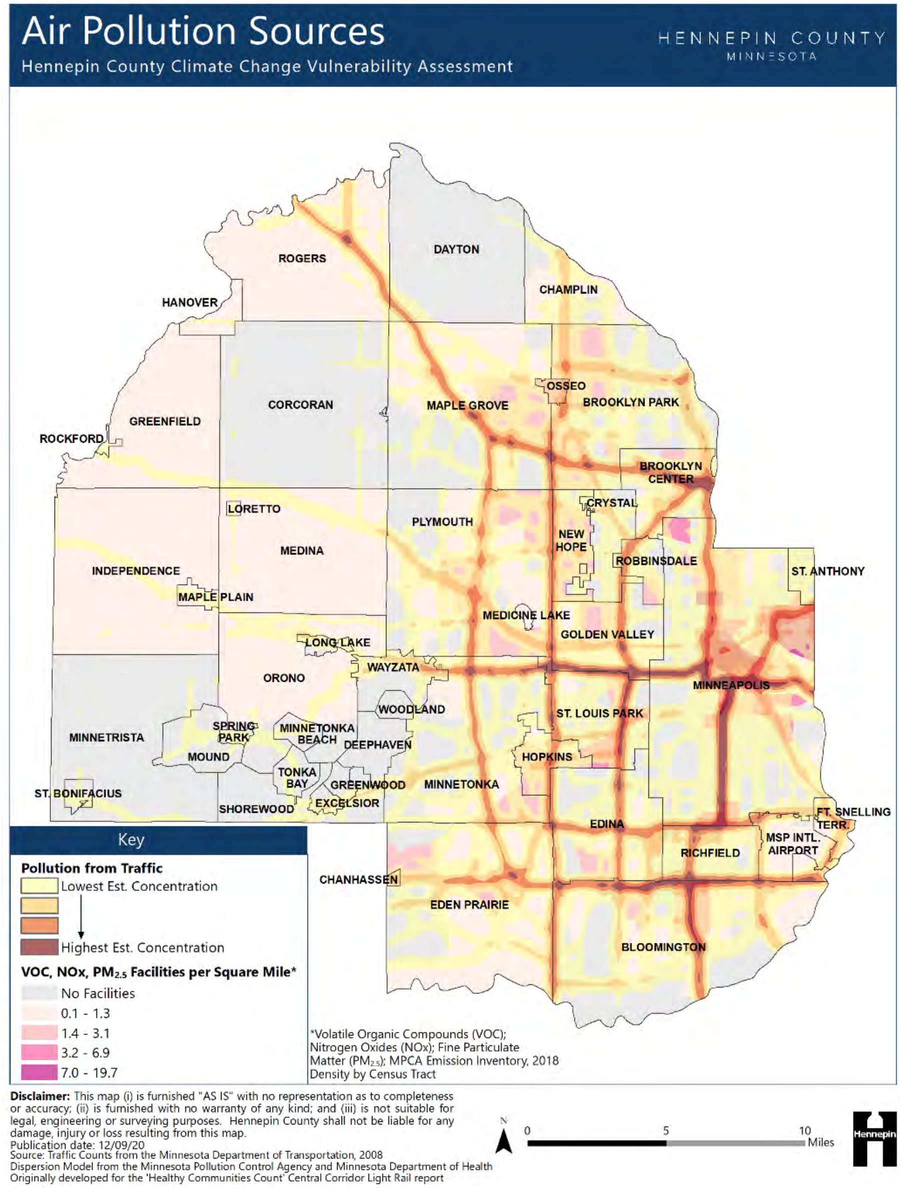
4.3.2.2 Air Pollution Sources

Climate change increases air pollution, which can cause or aggravate respiratory diseases such as asthma and COPD. The map to the right shows several air pollution sources.

The two components are:

1. Permitted pollution sources—*Density of facilities that emit nitrogen oxides (NO_X) and volatile organic compounds (VOCs) and particulate matter less than 2.5 microns in diameter ($PM_{2.5}$) (per square mile)* are represented by a pink gradient on the map.

2. Traffic pollution sources—*Estimated traffic air pollution concentrations* are represented by a yellow-to-orange gradient. Areas in dark orange have the highest concentration of pollution sources.

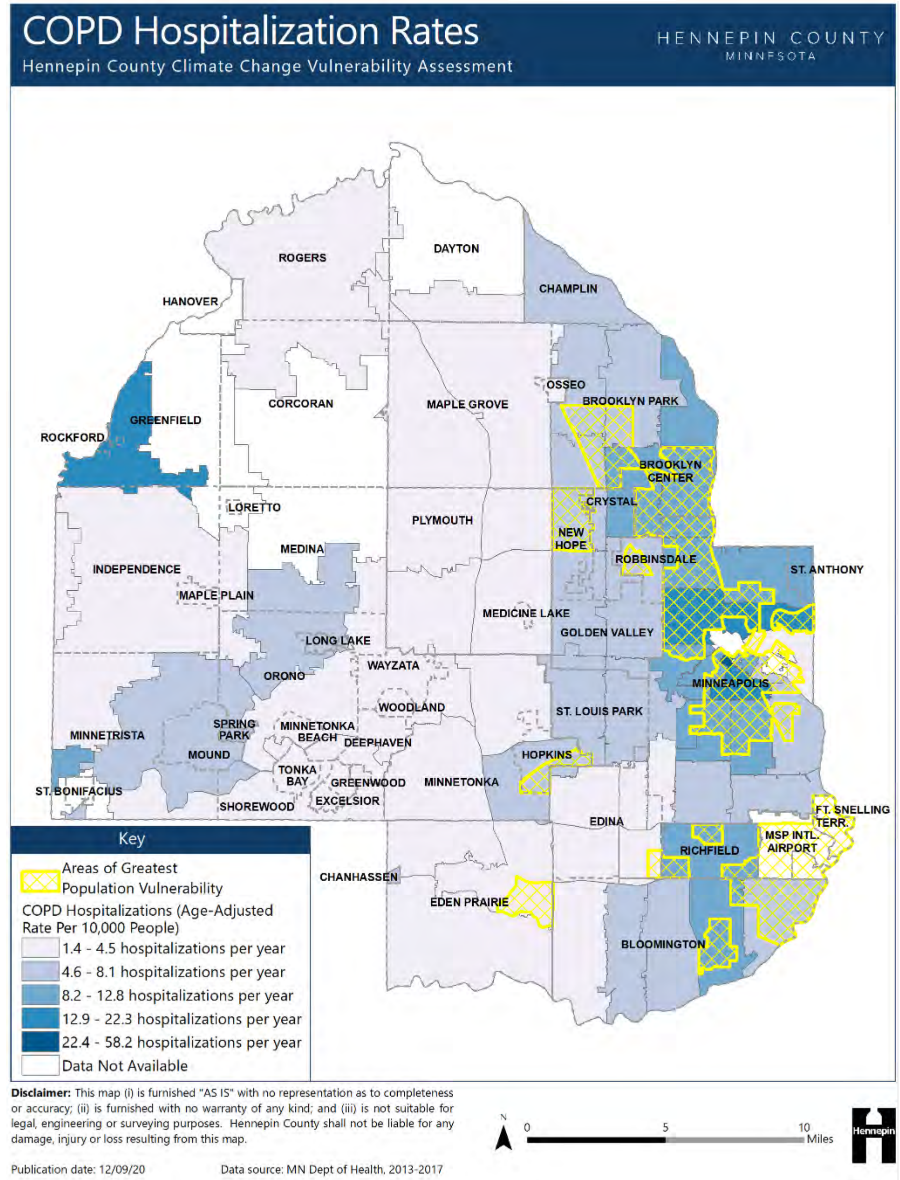


4.3.2.3 COPD Hospitalization Rates and Population Vulnerability

Climate change can have disproportionate effects on individuals suffering from chronic obstructive pulmonary disease (COPD). COPD is a chronic inflammatory lung disease that causes obstructed airflow from the lungs (Reference (12)). People with COPD are more vulnerable to the effects of air pollution, which is increased by climate change. Exposure to air pollution has been linked to increases in COPD-related emergency department visits and hospitalizations (Reference (13)).

The map to the right presents age-adjusted COPD hospitalization rates in Hennepin County by zip code (blue shades on the map), based on data from the Minnesota Department of Health (MDH) from 2013–2017. (Age-adjusted describes the statistical process applied to rates of disease, death, injuries, or other health outcomes that allows communities with different age structures to be compared.) The darkest colors represent the highest rates. Populations living in these areas are more vulnerable to poor air quality, which is exacerbated by increasing air temperatures. Note: According to MDH zip code boundaries, the zip code encompassing the city of Rockford extends past the County line to fully contain the city of Rockford. Therefore, the relatively high COPD hospitalization rate shown in the figure for this zip code may reflect persons living outside of Hennepin County.

For comparison, yellow hatching indicates areas of greatest overall population vulnerability; people in these areas are likely to be more vulnerable to impacts of climate change.

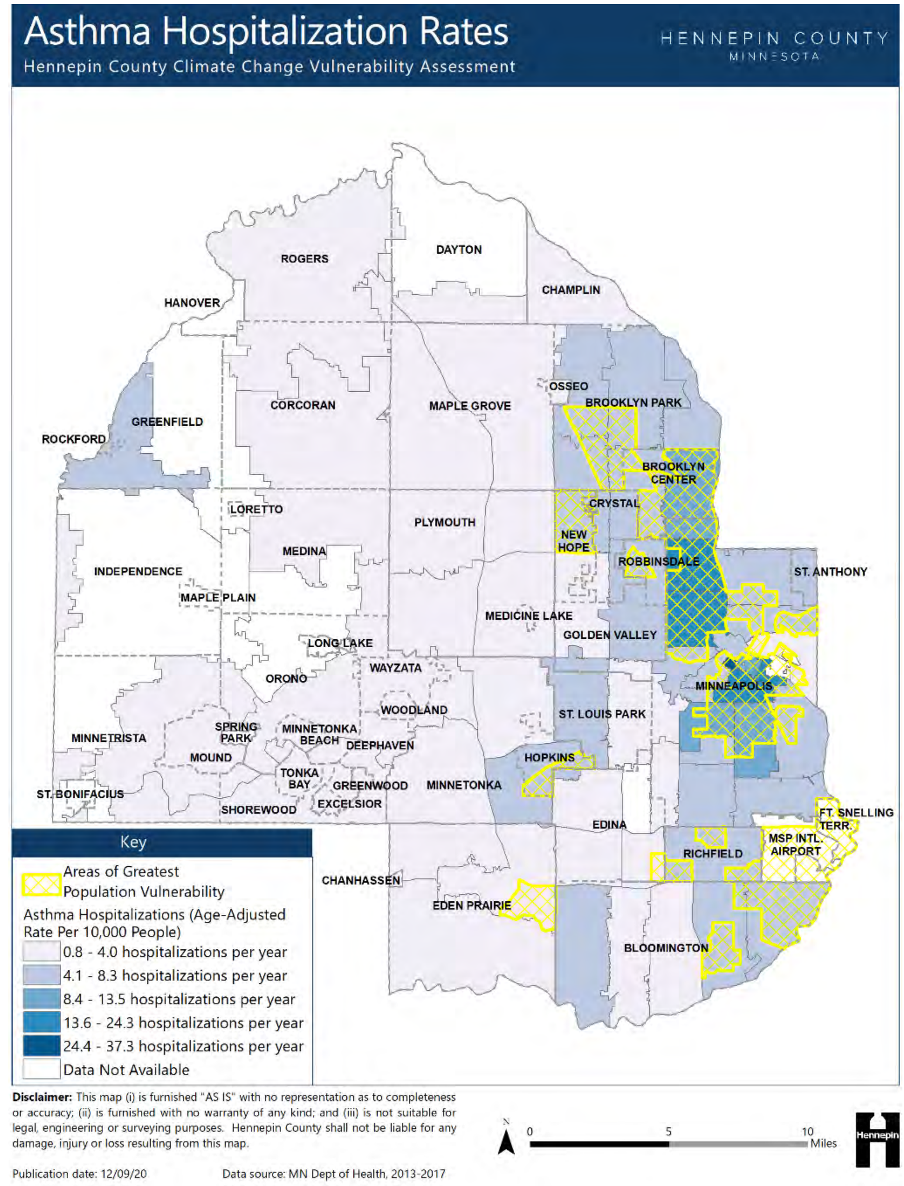


4.3.2.4 Asthma Hospitalization Rates and Population Vulnerability

Climate change increases air pollution, which can cause or aggravate respiratory diseases, such as asthma, and increase exposure to risk factors. Warmer temperatures promote more ground-level ozone pollution, which is a lung irritant that can trigger asthma attacks. Warmer temperatures and drought result in increased frequency and intensity of wildfires in areas outside of Hennepin County, increasing the amount of harmful particulate matter in the air, which can also trigger asthma attacks. Warmer temperatures can also increase the duration of the pollen season—another trigger for asthma attacks (Reference (7)).

The map to the right summarizes age-adjusted asthma hospitalization rates in Hennepin County, by zip code (blue shades on the map), with the darkest colors having the highest rates. The data is from the MDH from 2013–2017.

For comparison, yellow hatching indicates areas of greatest overall population vulnerability; people in these areas are likely to be more vulnerable to impacts of climate change.



4.4 Drought

Several historic droughts have occurred across Hennepin County dating back to 1863, including during the Dust Bowl period in the 1930s. An increase in drought conditions has not been observed in recent data, and projected mid-century scenarios only show a slight possibility of increasing drought conditions, but end-of-the-century projections show a greater likelihood of drought. While severe drought, as occurred during the Dust Bowl, is part of normal climate fluctuation and should be expected, the severity of the drought is further expected to be exacerbated by climate change. Increased drought conditions will have negative impacts on Hennepin County residents and on Hennepin County operations. Also, drought in other areas of the United States and Canada can increase wildfires. If the smoke from these wildfires reaches our region it can impact our air quality. Some key climate change impacts resulting from drought, as categorized by the Hennepin County climate adaptation work group, are listed in Table 6.

Table 6 Key Climate Change Impacts Based on Drought

Work Groups	Impacts	Maps
People, Health, and Disparities	There is increased stress on local agricultural producers and neighborhood gardens, resulting in disrupted food supply and negative dietary impacts.	• Food Deserts—The Availability of Fresh Food is Reduced
	Water shortages and extended heat may increase stress on homeless and vulnerable populations.	• Population Vulnerability Composite
	Mental health vulnerabilities are exacerbated by extended drought impacts on employment and physical health for residents whose livelihood is based on landscaping, agriculture, and the businesses that are supported by these fields.	
	There are limitations on availability or allowable use of water for personal use (e.g., irrigation).	
	Increased particulate matter can be blown into the atmosphere as vegetation dries and soil is exposed to wind, negatively impacting air quality.	
Water, Natural Resources, Agriculture, and Land Use	Drought stress on plants makes them vulnerable to insects and disease. Landscaping requires additional maintenance and replacement. Crop production diminishes and crops may require more inputs such as organic matter or irrigation. Forestry production diminishes.	• Urban Sprawl 2001–2016 • Agricultural Degradation
	Crop and lawn irrigation increase the drawdown of aquifers and reduces future water supplies.	

Work Groups	Impacts	Maps
	Low lake levels and dry wetland conditions allow for invasive species encroachment.	
	Lower stream base flow degrades fish habitat.	
	Invasive species encroach where native communities have been impacted by drought.	
	Dead vegetative cover can result in soil erosion from wind and water.	
	There is decreased water quality from topsoil erosion into natural waterbodies.	
	Wildlife populations diminish from lack of water.	
Buildings and Energy	County facilities without drought-tolerant landscaping will require resources for maintenance, watering, etc.	
	Privately owned property without drought-tolerant landscaping will require resources for maintenance, watering, etc. Vulnerable populations and renters have fewer resources to invest in upgrades.	
Transportation Infrastructure	Increased stress on roadside vegetation	

5 Other Climate Change Considerations

5.1 Water, Natural Resources, Agriculture, and Land Use

The county's natural resources provide residents with incredible ecological services essential to life. Some of these include the following:

- Air quality improvement
- Temperature mitigation
- Carbon sequestration
- Soil improvement
- Food production
- Water purification
- Pleasure (exercise, recreation, contemplation)
- Wildlife habitat
- Natural heritage

Hennepin County's natural resources are vulnerable to the impacts of climate changes. Increased heat, drought, extreme storms, etc. are occurring and will increase in the future.

Natural systems are weakened when land is altered by urban sprawl with its impermeable surfaces, polluting industrial processes and agricultural practices, and the introduction of new invasive species. Weakened systems provide fewer ecological services and create new challenges that may be mitigated using expensive man-made means. Natural resources in Hennepin County are already stressed; climate change will impact them further.

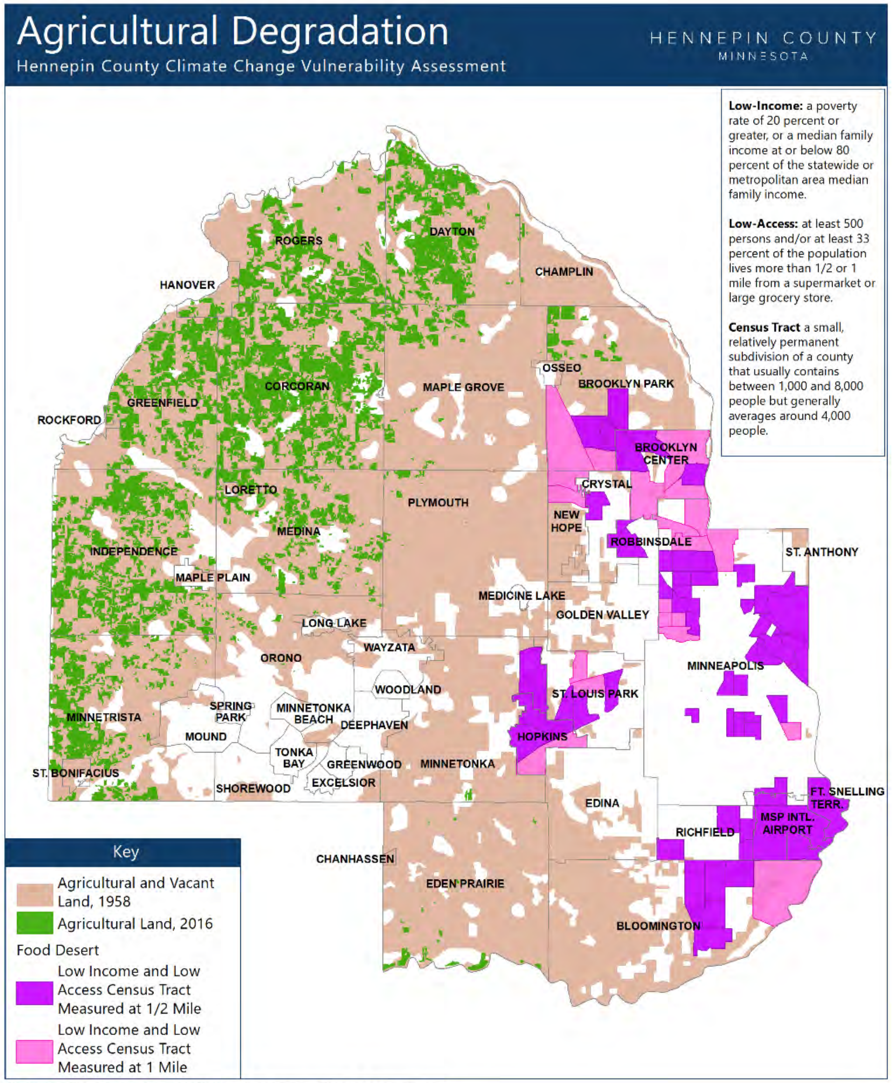
Hennepin County's open space of forest, prairies, abandoned fields, and wetlands provide the valuable service of carbon sequestration. Through photosynthesis plants capture CO_2 from the atmosphere that is used to build plant tissues, especially roots. As roots decay they leave carbon in the soil (the black of black dirt), thus sequestering it from the atmosphere. The loss of open space in the county has resulted in the loss of land available to sequester carbon.

Natural resources planning for the purpose of bolstering resilience must start by addressing direct impacts. Natural resources must be protected so they can regenerate. As that is occurring, we can take further steps to aid natural resources in the transition to an unknown climate.

5.1.1 Agricultural Degradation

Much of the agricultural land within Hennepin County has been lost to development since 1958. Green areas on the map represent the remaining agricultural land as of 2016. As we look ahead to potential climate scenarios, importing food could become difficult as sea levels rise and drought-driven desertification occurs. Preserving and expanding the availability of locally grown food increases resilience to climate change. Increasing locally grown food options also reduces GHG emissions associated with long-distance food transport and preservation (refrigeration). Locally grown food is less susceptible to climate-change-driven disruptions to the energy and transportation systems. The need for locally grown food may greatly increase. Preserving agricultural land today will serve future county inhabitants well.

Concurrent with the loss of agricultural land is the emergence of food deserts. These areas, in purple and pink on the map, represent low-income census tracts where at least 33 percent of the population lives more than a half-mile or mile from a supermarket or large grocery store, respectively. People in these areas have less access to affordable, nutritious food, which can contribute to poor nutrition.



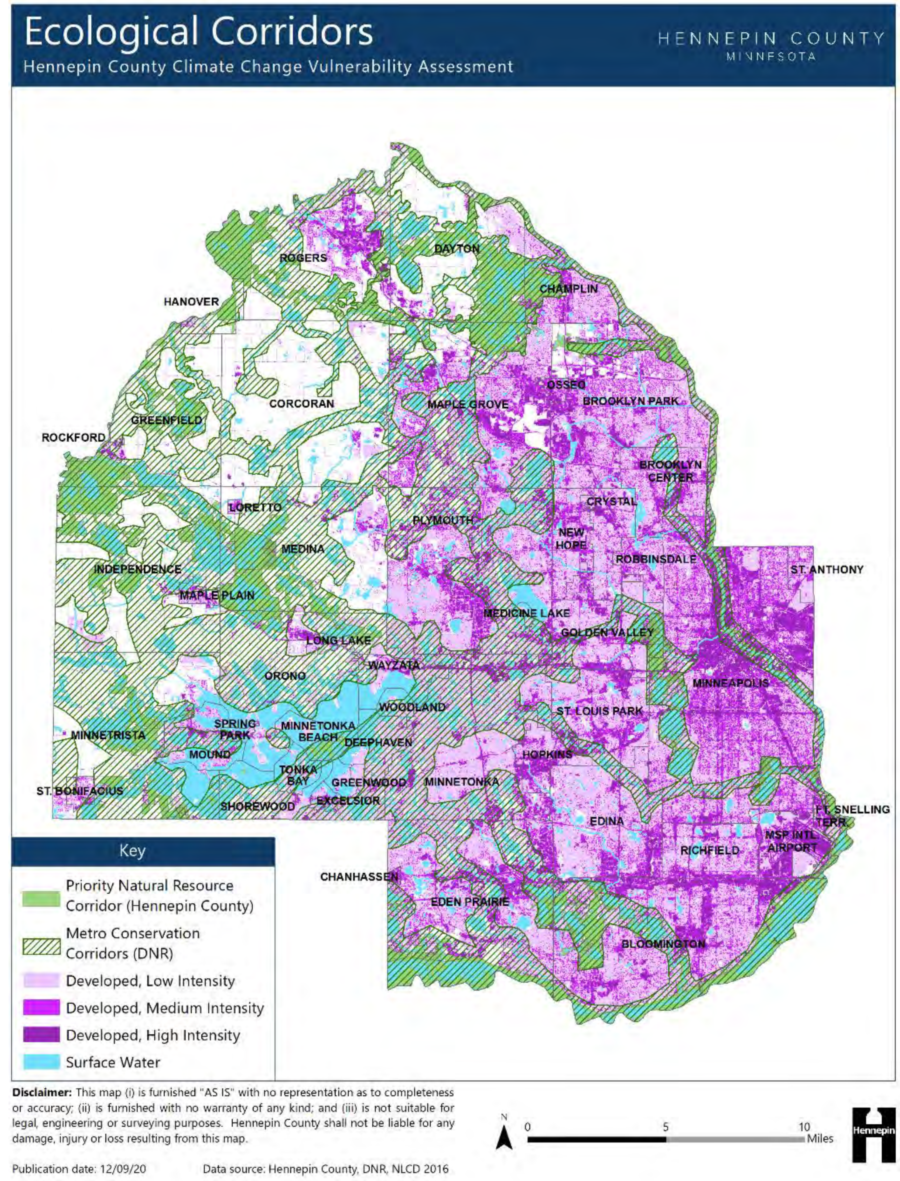
Disclaimer: This map (i) is furnished "AS IS" with no representation as to completeness or accuracy; (ii) is furnished with no warranty of any kind; and (iii) is not suitable for legal, engineering or surveying purposes. Hennepin County shall not be liable for any damage, injury or loss resulting from this map.

Publication date: 12/09/20 Data source: USDA, MetCouncil 2016, U of MN

5.1.2 Ecological Corridors

Existing Hennepin County Priority Natural Resource Corridors and DNR Metro Conservation Corridors are shown in green on the map. Purples indicate levels of development, with light purple corresponding to low-intensity development. The low-intensity development areas provide the greatest opportunity for conversion to natural habitat. However, they are also most at risk of being converted into high-intensity development areas, which would have a detrimental effect on natural resources.

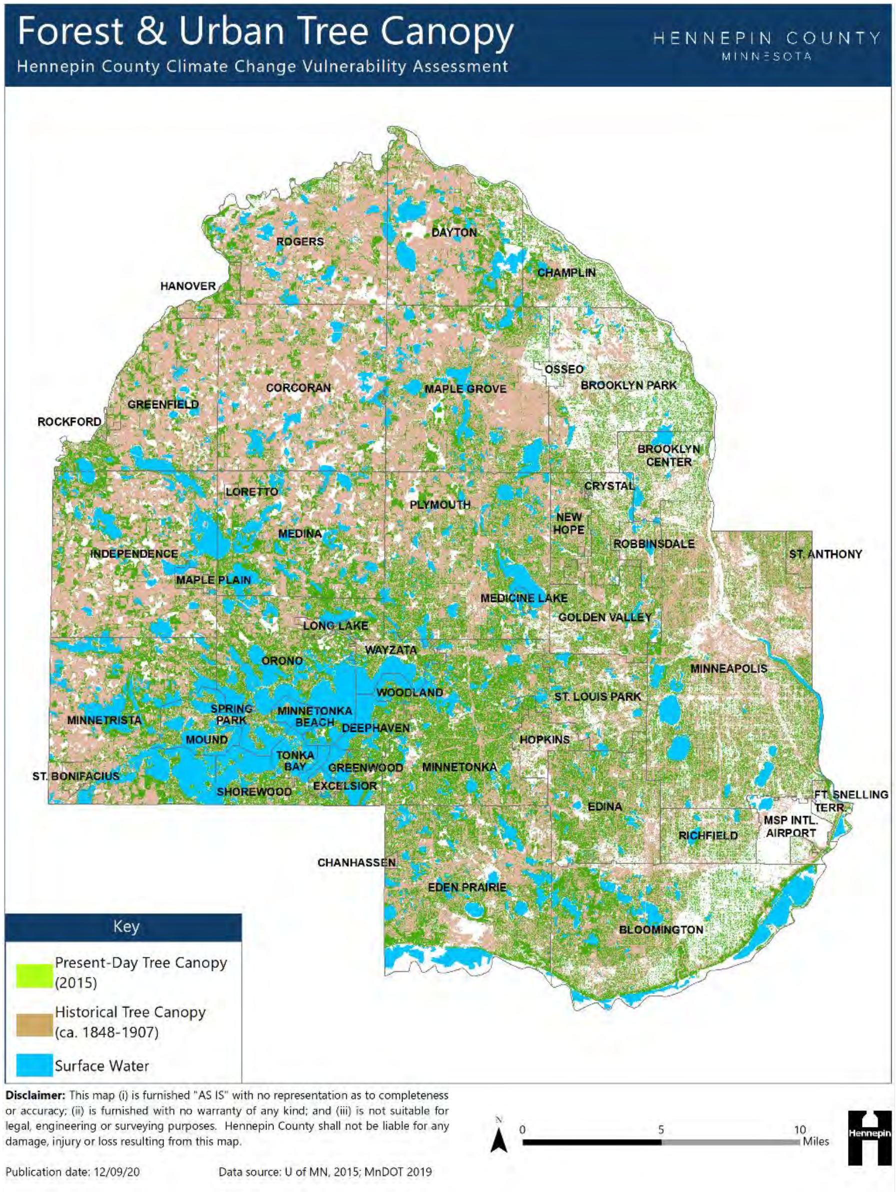
As the climate changes, some species (especially plants) will be eliminated from the county and others will move in from the south. This shift can be desirable to maintain ecological diversity and to develop a new ecological balance. Ecological corridors provide habitat spaces through which species can move. Many species of plants and animals cannot cross large areas of development or highways. Preserving and restoring natural corridors through which species can move using tools such as conservation easements, strategically expanding parkland, and open space preservation will allow them to shift with the changing climate.



5.1.3 Forest and Urban Tree Canopy

The brown color on the map represents the extent of historical tree canopy that has been lost since 1907. Present day tree canopy is shown in green. Much of Hennepin County's historical tree canopy has been lost to development or agriculture, and the remaining tree canopy is at risk of further degradation from continued land-use changes and climate-change-facilitated invasive pests.

Tree canopy and urban forest provide many benefits. They help cool and purify the air (reducing air-conditioning needs/costs and pollution), reduce stormwater runoff, and provide wildlife habitat. As we remove trees for further development or agriculture or lose trees to invasive pests without replacement, we decrease these benefits. Furthermore, as trees become stressed and die from the extremes of climate, we are more likely to lose them in areas of tough growing conditions, such as urban areas where they may have limited space for root growth.



5.1.4 Hydrologic Soil Groups

A hydrologic soil group is a group of soils with similar properties—particularly direct runoff potential. The groups are defined as follows:

Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures.

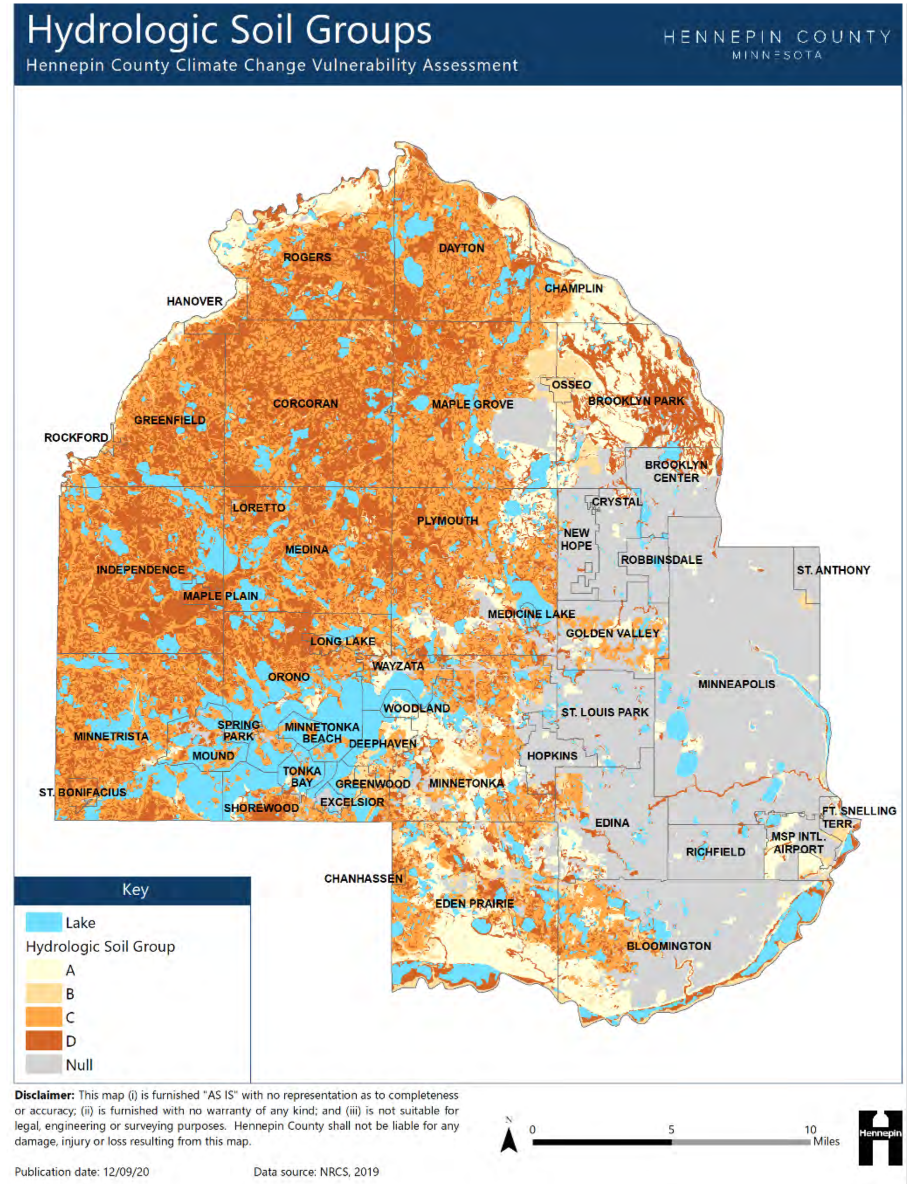
Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 and 20 percent clay and 50 to 90 percent sand and have loamy sand or sandy loam textures.

Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 and 40 percent clay and less than 50 percent sand. Textures are loam, silt loam, sandy clay loam, clay loam, and silty clay loam.

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures.

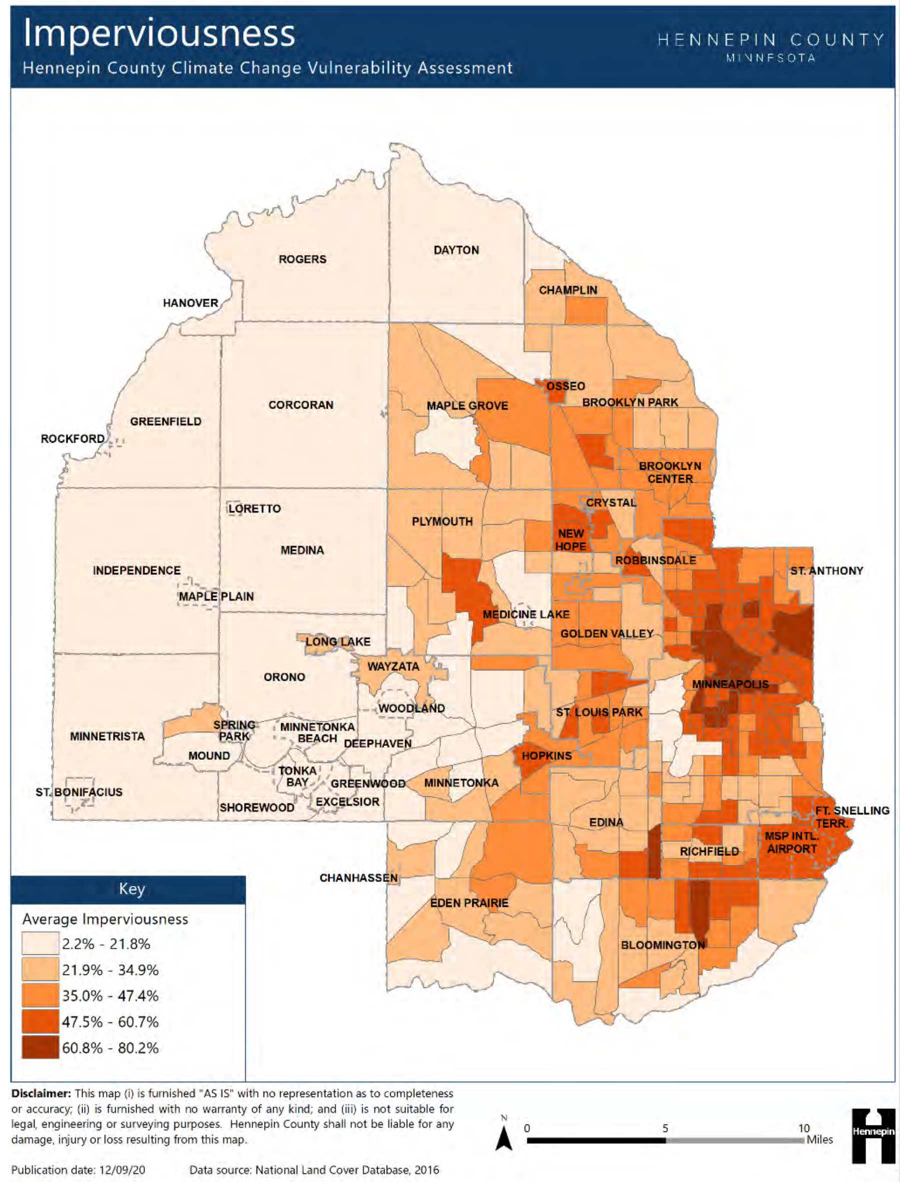
Null —Areas where there is a lack of soils data due to urban development before original soil surveys were conducted.

Type A and B soils have potential for less flooding because of their well-drained characteristics. They are, however, susceptible to droughts. Poorly drained soils—type C and D—dominate the county. Because these soils have a higher clay content, they hold more water and do not drain as easily, which can contribute to flash-flooding.



5.1.5 Imperviousness

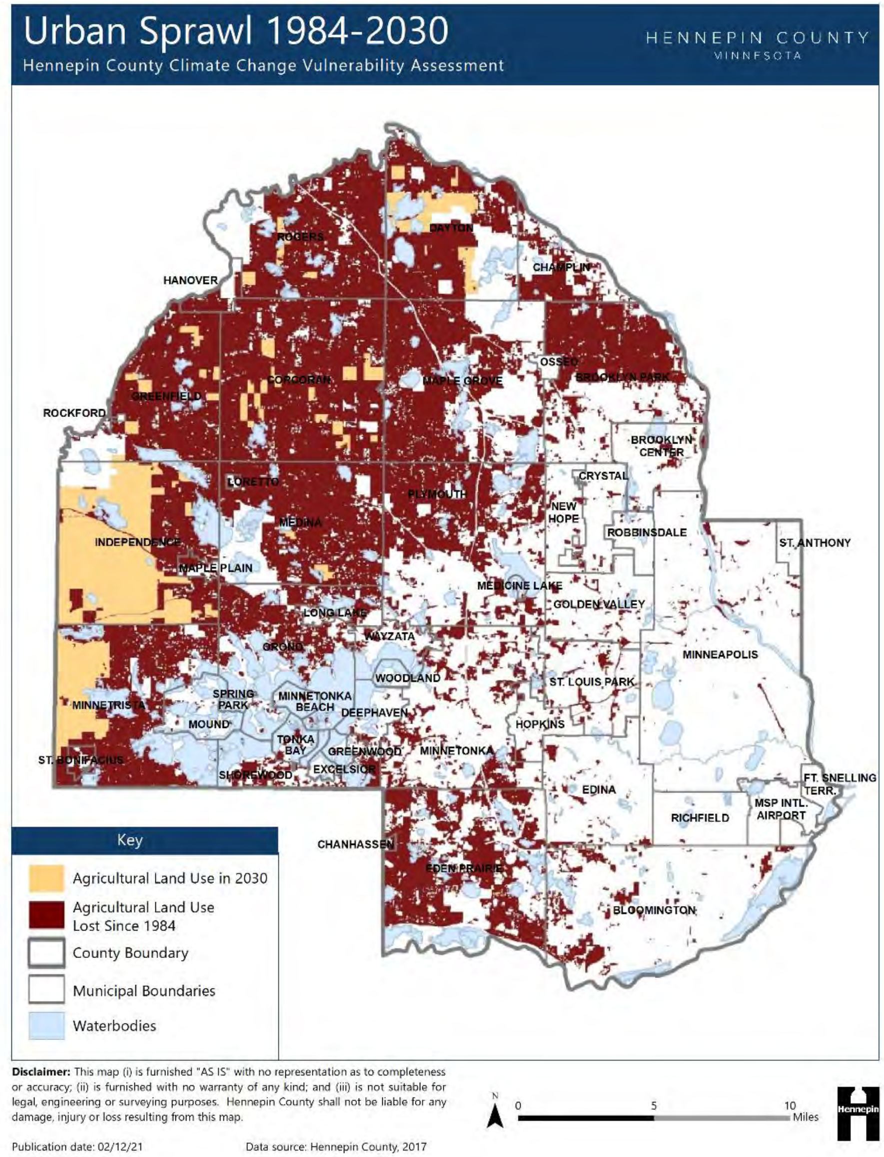
This map at right shows average land imperviousness by census tract. Areas in dark orange have the most paved and developed surfaces (roofs, streets, parking lots, etc.) and the least amount of greenspace. Precipitation runs off these surfaces rather than soaking into the ground and can cause flooding. Areas with higher percentages of hard surfaces contribute more to the urban heat-island effect and are more prone to drought because rain drains into storm sewers rather than to landscaped areas.



5.1.6 Urban Sprawl 1984–2030

Development continues in Hennepin County. Areas in maroon are agricultural lands lost to development since 1984, while areas in orange are projected to be remaining agricultural land in 2030. The loss of natural habitat and agricultural lands is ongoing and shows no signs of abating. Although this is an issue primarily affecting the rural areas of the county, the loss of natural habitat may exacerbate urban heat-island effect as pavement increases and natural areas decrease. Natural habitats fragment with development and are, therefore, more prone to the impacts of climate change as they become smaller and disconnected. As we lose the multiple benefits of natural areas and agricultural land, we become more susceptible to the impacts of precipitation, drought, and storms.

Based on Metropolitan Council projections from 2015 to 2030, open space in Hennepin County is expected to decline from 39 percent to 23 percent and agricultural land is expected to decline from 12 percent to 6 percent.

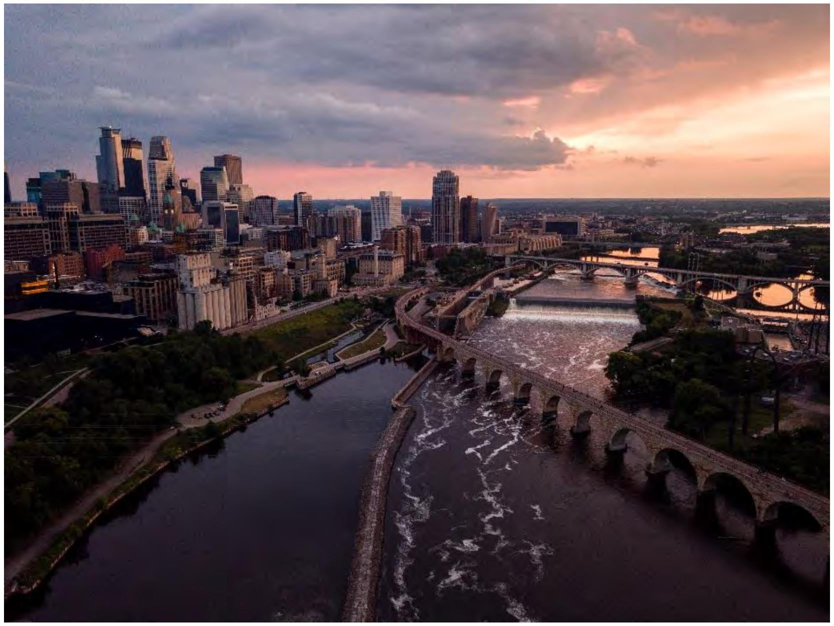


5.2 Buildings and Energy

Residents, governments, and businesses save money by conserving energy and climate-proofing buildings. Building managers typically operate and maintain their facilities to withstand climate patterns based on past climate records. Looking forward, opportunity exists to use future climate projections to better climate-proof buildings and sites. Buildings that are older, less energy-efficient, prone to flooding, or owned by economically disadvantaged populations are more likely to be impacted by changing climate trends. When inefficient buildings are heated and cooled thermal energy is wasted that could otherwise be repurposed for greater efficiency. This inefficiency makes the county more vulnerable to increasing energy demands from weather extremes. Concentrated areas of buildings using and wasting thermal energy may provide prime opportunities to develop efficiency strategies, such as district energy systems, that tie together Hennepin County's goals of reducing disparities and reducing greenhouse gas emissions.

Numerous factors affect the vulnerability of buildings, sites, and energy consumers to climate change, including but not limited to:

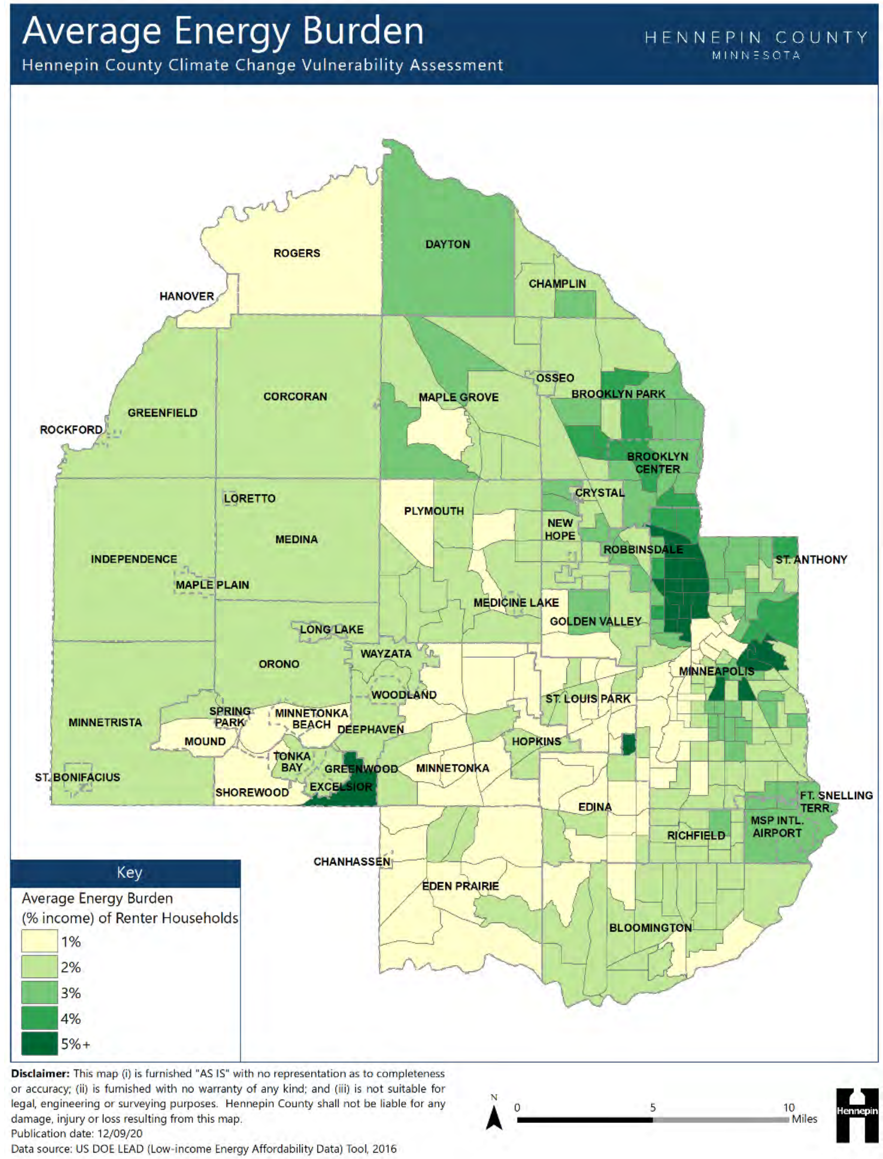
- Owner-occupied vs. renter-occupied.
- Age of construction and relevant upgrades for heating, cooling, and energy efficiency.
- Urban heat island and the site's microclimate.
- Owner's energy cost burden—the proportion of household income spent on energy.
- Flood susceptibility.
- Elevation relative to groundwater.



- Historic contamination impacts to soil and groundwater.
- Neighborhood vulnerability, context, landscape, and connectivity.

5.2.1 Average Energy Cost Burden

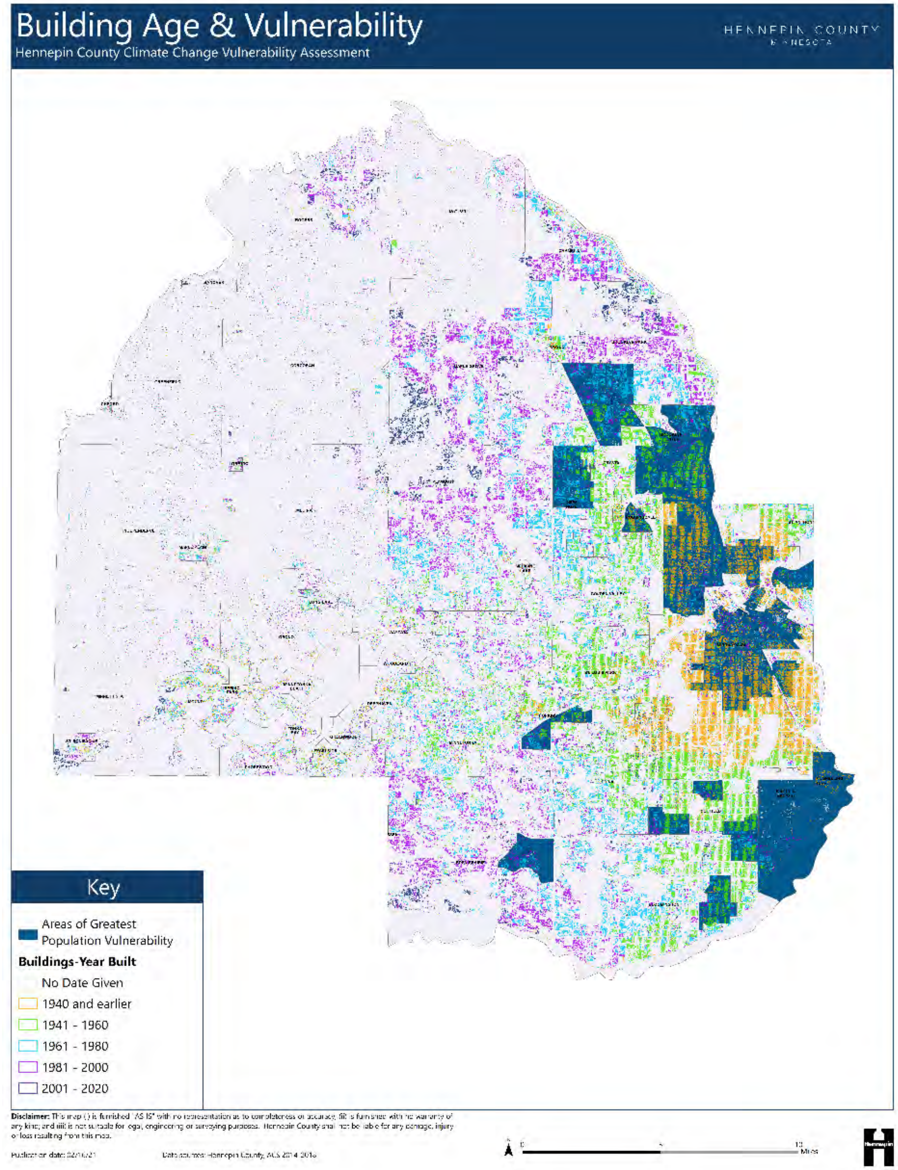
The map to the right shows the average energy cost burden for renter households, by census tract, based on the percentage of income. Renters, on average, spend a higher proportion of their income on energy than homeowners. Energy cost burden is defined as the average annual housing energy costs divided by the average annual household income (the proportion of household income spent on energy). Areas in dark green are renter households that spend the greatest percentage of their incomes on electricity and gas. Populations living in these areas will be more vulnerable to increasing cooling costs brought on by climate change. The data is from the US Department of Energy (DOE) LEAD (Low-Income Energy Affordability Data) Tool, 2016. It focuses on rental property, which is one aspect included in the CCVA composite social vulnerability. Similar energy burden data, organized for owner-occupied homes by median income and other factors is available at: https://www.energy.gov/eere/slsc/low-income-energy-affordability-data-lead-tool.



5.2.2 Building Age and Vulnerability

This map summarizes building ages throughout the county in association with energy efficiency (or lack of). For this map, building age serves as a surrogate for energy efficiency, with older buildings requiring more energy for heating and cooling. This data does not indicate whether those buildings have been renovated or substantially upgraded. The building age is based on the Hennepin County Tax Assessor parcel information for "date of construction." Many buildings in these areas were constructed before 1960; if not improved with energy conservation and efficiency measures, they are typically not as energy efficient as newer construction. Areas in dark blue indicate populations most vulnerable to climate change, where investing in energy efficiency upgrades may be more cost-prohibitive to the individual property owner.

Note: Given the amount of detailed information on this map, it is best viewed at a larger scale.

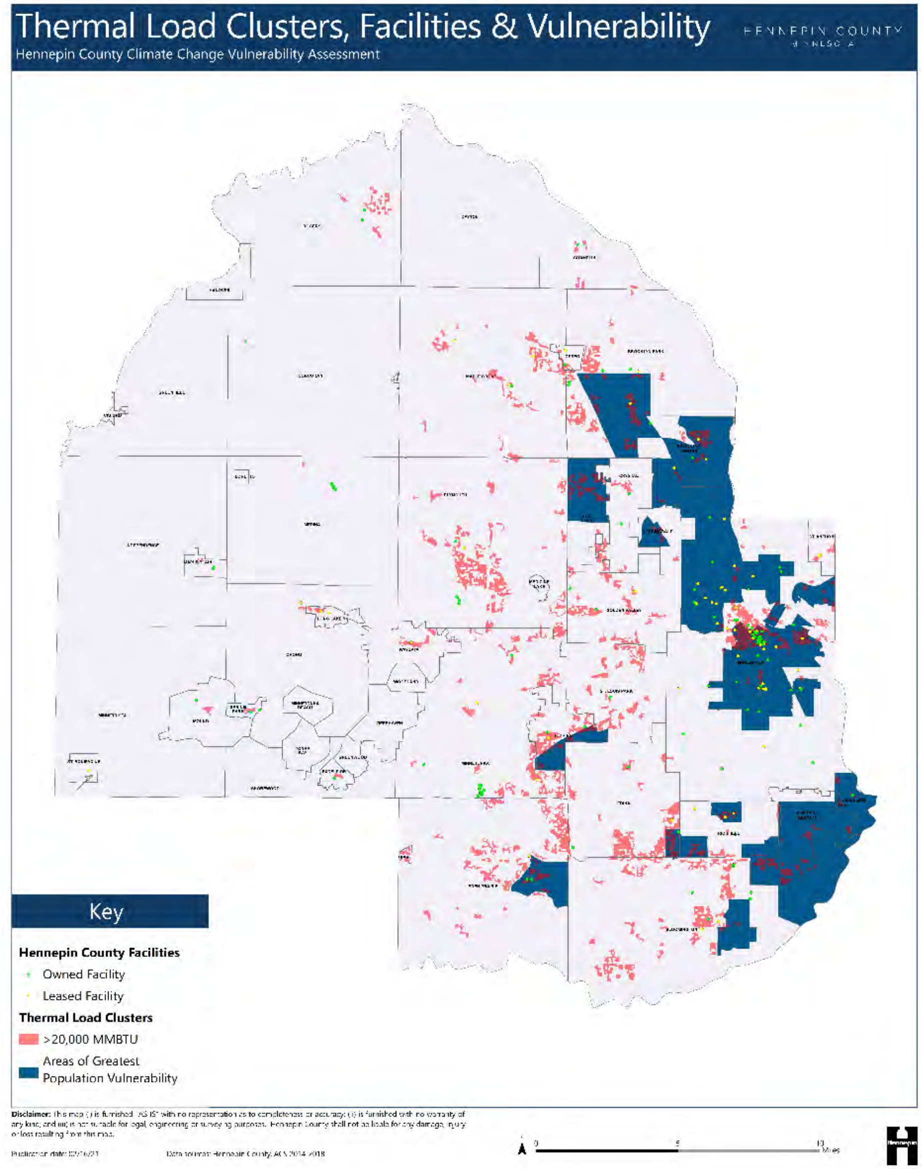


5.2.3 Thermal Load Clusters, County-Owned Facilities, and Vulnerability

This map summarizes the density of natural gas thermal energy consumption per square foot in the vicinity of county-owned versus leased facilities. The county may have less leverage at leased facilities to enact energy-conservation measures or make energy efficiency upgrades to reduce heating or cooling costs. County-owned facilities may be candidates for high-efficiency retrofits and/or district-scale energy systems, depending on the individual facility's context and operations. Areas in dark blue indicate populations most vulnerable to climate change, where investing in energy efficiency upgrades may be more cost-prohibitive to the area's property owners.

Areas shown in red have been identified by the Minnesota Department of Commerce as candidate districts for microgrid implementation and high-efficiency district thermal heating and cooling improvements. Each thermal load cluster is defined as "a cluster or grouping of potential users of significant thermal energy for heating and cooling homes, commercial and institutional buildings, and industrial processes (in other words, district energy)." They are classified as an area with an annual energy usage above 20,000 MMBTU (million British thermal units) in relatively close proximity. Proximity to a thermal load cluster might offer better opportunity for microgrids and high-efficiency district-scale heating and cooling.

Additional background and data is available in *Mapping Thermal Grid Integration Opportunities in Minnesota,* Minnesota Department of Commerce, 2019. The report describes the identification of existing and potential sites for thermal grids. https://mn.gov/commerce-stat/pdfs/mapping-thermal-grid-opportunities.pdf

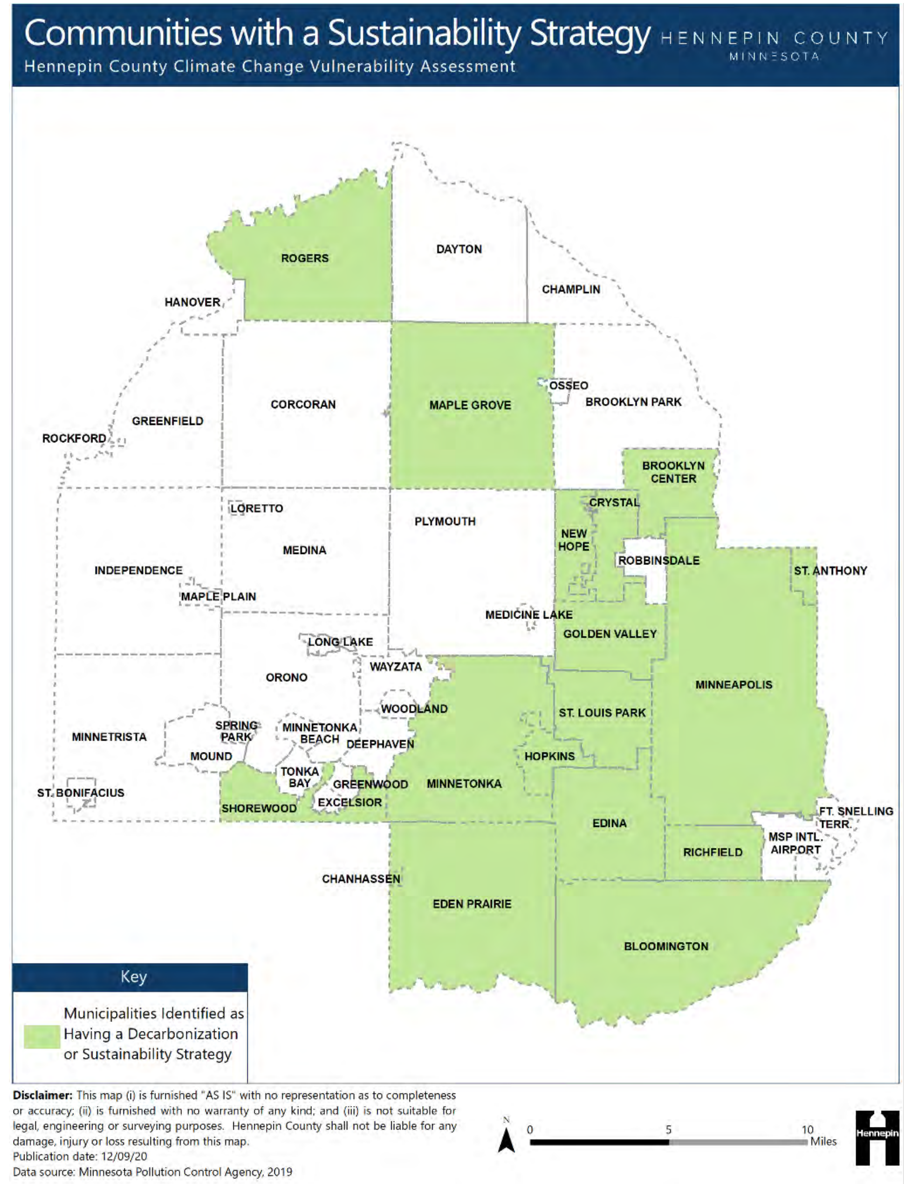


5.2.4 Communities with a Sustainability Strategy

This map summarizes municipalities that (as of 2019) had active community energy strategies being implemented for decarbonization. Communities not actively implementing a strategy may be delaying important advancements toward higher energy efficiency and transition toward renewable energy sources, which could place them at risk long-term. Strategies inventoried and mapped include an adopted city policy or plan, participation in GreenStep Cities, Clean Energy Resource Team (CERTs) Grants, Property-Assessed Clean Energy (PACE) funding, and use of Xcel Energy's Partners in Energy program.

Dependence on nonrenewable, high-carbon sources of energy for heating and cooling places vulnerable populations at long-term risk of rising costs and interrupted supply chains bringing fuel to the community from afar. To address this, numerous communities in Hennepin County are actively implementing sustainable energy strategies aimed at decarbonization.

Additional background and data is available in the data source: *Mapping Thermal Grid Integration Opportunities in Minnesota*, Minnesota Department of Commerce, 2019. http://mn.gov/commerce-stat/pdfs/mapping-thermal-grid-opportunities.pdf



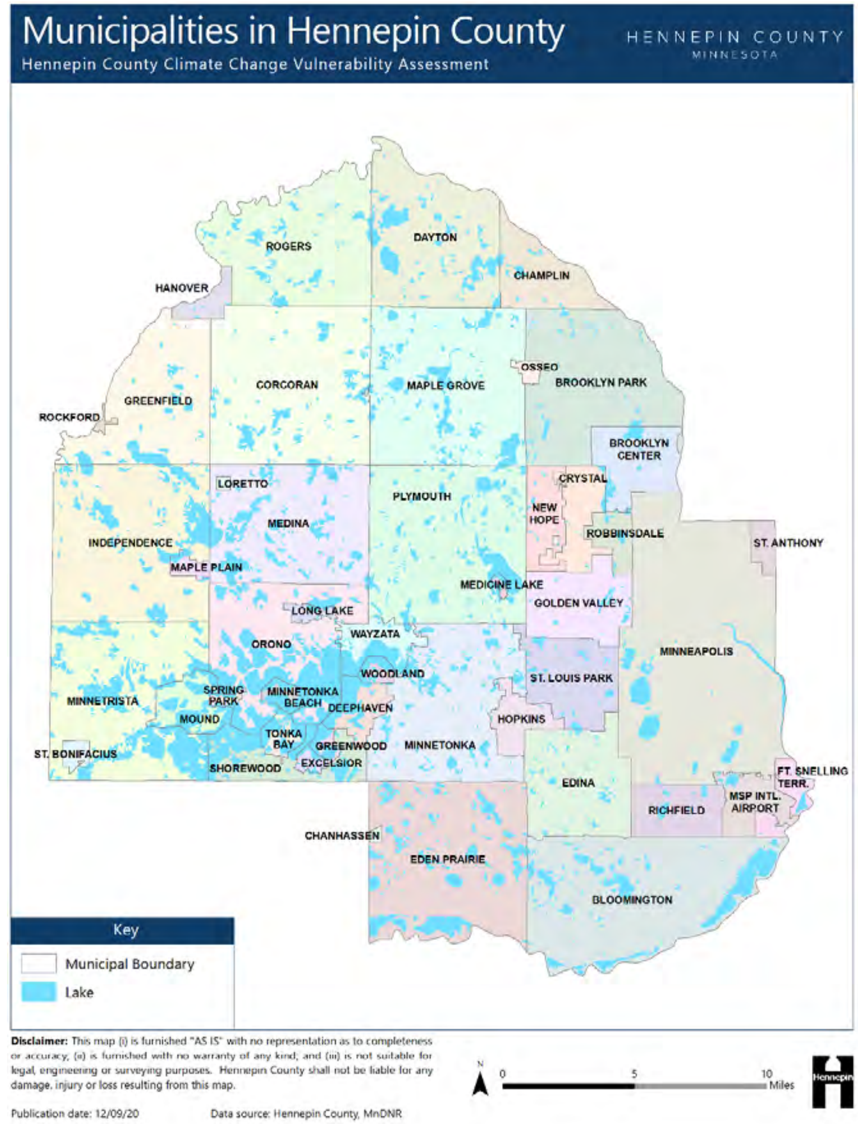
5.3 Transportation Infrastructure

5.3.1 Complex Jurisdictions

Responding to climate change vulnerabilities within the county's transportation system involves working closely with municipalities, watershed districts, other counties, the Minnesota Department of Transportation, and other state agencies—all with their own jurisdictions and authorities.

5.3.1.1 Municipalities in Hennepin County

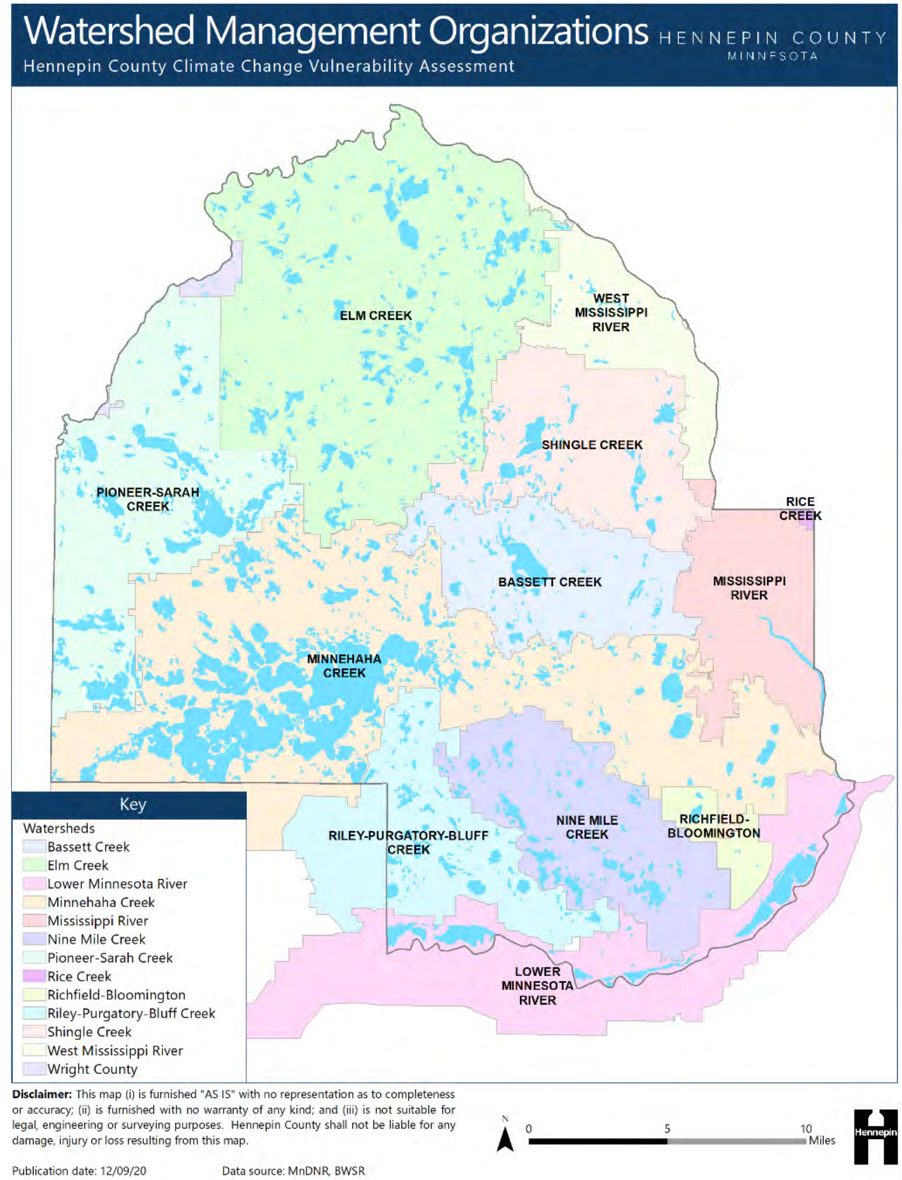
Hennepin County encompasses 45 individual municipalities, shown in the map to the right. The county must coordinate with the municipalities and state agencies in design, construction, cost participation, and maintenance of its transportation system. County, city, and state stormwater management systems are often intertwined, requiring close coordination to avoid causing or exacerbating flood impacts upstream or downstream of county roads when considering infrastructure modifications. The intertwined nature of the stormwater management systems also means Hennepin County often becomes involved at some level in addressing more localized flooding issues, which has time and financial implications.



5.3.1.2 Watershed Management Organizations in Hennepin County

Thirteen individual watershed management organizations (WMOs) are located partially or entirely within Hennepin County, shown in the map to the right. Some of the WMOs operate as watershed districts (a special unit of local government operating under Minnesota Statutes Chapter 103B and concurrently operating under Minnesota Statutes Chapter 103D) and others are organized with a joint powers agreement between the cities and townships within the watershed. The structure of these organizations often affects the available funding, size of organization (number of staff, if any), and scope of programs, among other things. Each WMO must prepare and implement a comprehensive surface water management plan, which identifies unique organizational goals and implementation plans to manage and protect water and natural resources within watershed boundaries.

Many of the WMOs have permitting authority over the management of stormwater runoff, including management of runoff from county road rights-of-way. While watershed management organizations can serve as a valuable resource, the number of different WMOs throughout the county and the differences in organizational structure, permitting programs, and funding programs among individual organizations require close coordination.



5.4 Waste and Materials

The hazards of climate change—particularly increased heat and increased precipitation—create additional challenges for residents, solid waste companies, and county staff as they manage solid waste. Vulnerabilities in this system include, but are not limited to:

- Occupants of rental-occupied housing most likely have fewer options than a single-family homeowner to request more frequent trash pickup, organics collection, recyclable collection, or to change haulers. On average, every multifamily unit in the county generates 4.76 pounds of waste per day (4.13 pounds of municipal solid waste and 0.63 pounds of recyclables). This equates to a recycling rate of 13% or 229 pounds of recyclables per year, per multifamily unit (2017 data).
- Many communities still lack organics recycling even though organics make up 25% of the solid waste stream.
- Hennepin County may be vulnerable to increased generation of solid waste, landfilling, and byproducts of landfilling such as methane, a potent greenhouse gas. For example, extreme storms or flooding events result in property damage and waste generation. The number and severity of these events is likely to increase. Additionally, post-flood debris may be wetter and more difficult to divert from landfills.
- A wetter climate may result in wetter solid waste, which is more difficult to incinerate at the Hennepin Energy Recovery Center (HERC) or more difficult to separate into recyclables at material recovery facilities. In addition, when post-flood cleanup is performed, construction debris is often not

separated and recycled, and is instead landfilled. The current recycling rate for construction and demolition waste is only 30 percent.

- Hennepin County's residents may be vulnerable to historic waste and pollutants becoming mobilized by climate-induced flooding, rising water tables, or groundwater movements. Waste stored in at-grade storage sites, underground tanks, or inadvertently released into plumes or vapors underground, could be inundated, mobilized, and spread in ways that increase resident exposure to unhealthy contaminants.
- Extreme weather events can result in missed solid waste collection.
- Roughly 40 percent of food in the United States goes to waste. Power outages from extreme weather can cause

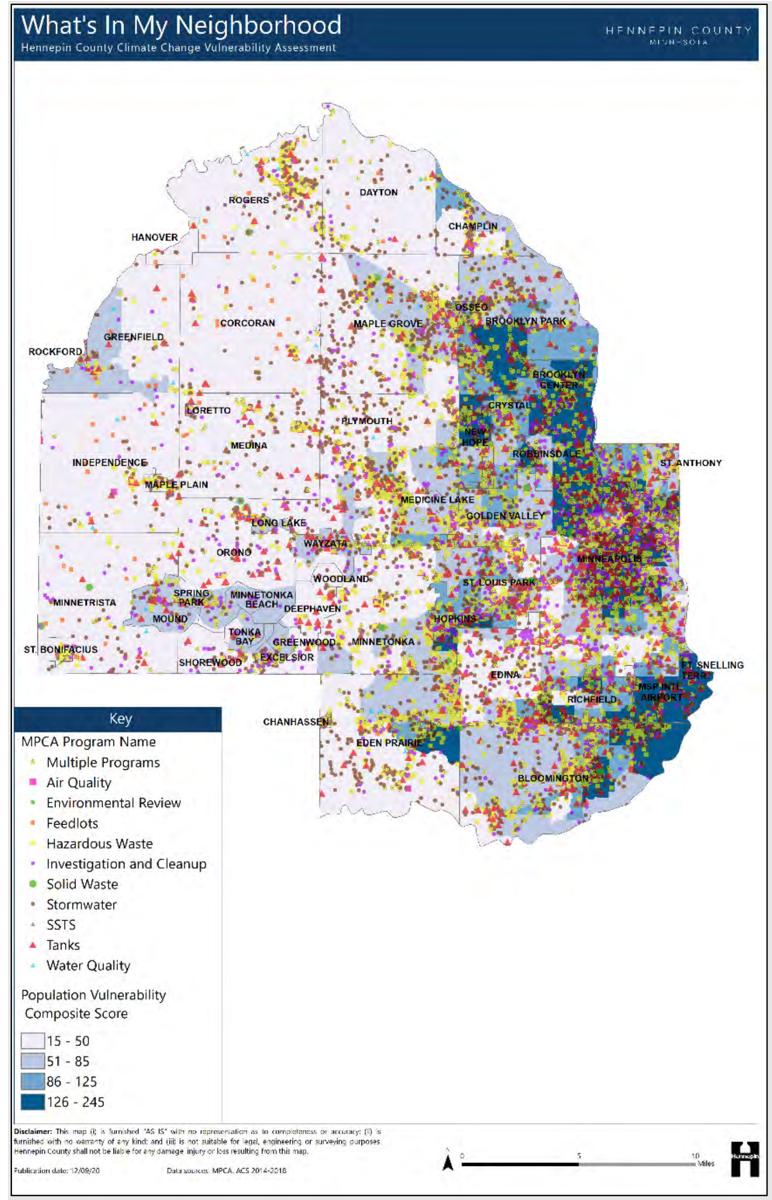
refrigeration to fail and food to spoil. The loss of food and the cost to replace it is especially impactful to economically disadvantaged residents.

The county's waste sector vulnerabilities could be looked at as targets for adaptations to increase efficiency, reduce greenhouse gas emissions, and better climate-proof these essential services.

5.4.1 MPCA What's in My Neighborhood

The colored dots on this map show the location of types of MPCA-identified contamination locations and permitted pollution sources, including generators of solid and hazardous waste and regulated air emissions sources. Areas in dark blue represent populations most vulnerable to climate change. Urban and highly developed areas have a higher density of pollution sources that may put vulnerable populations at increased risk if climate hazards mobilize contamination and create new exposure pathways to the population. While many of these pollution risks have been mitigated, the pollution mitigation decisions may not account for future climate trends. These include greater risk of flooding due to increased precipitation and degraded air quality due to inversions caused by heat episodes.

Note: Given the amount of detailed information on this map, it is best viewed on the state's website.



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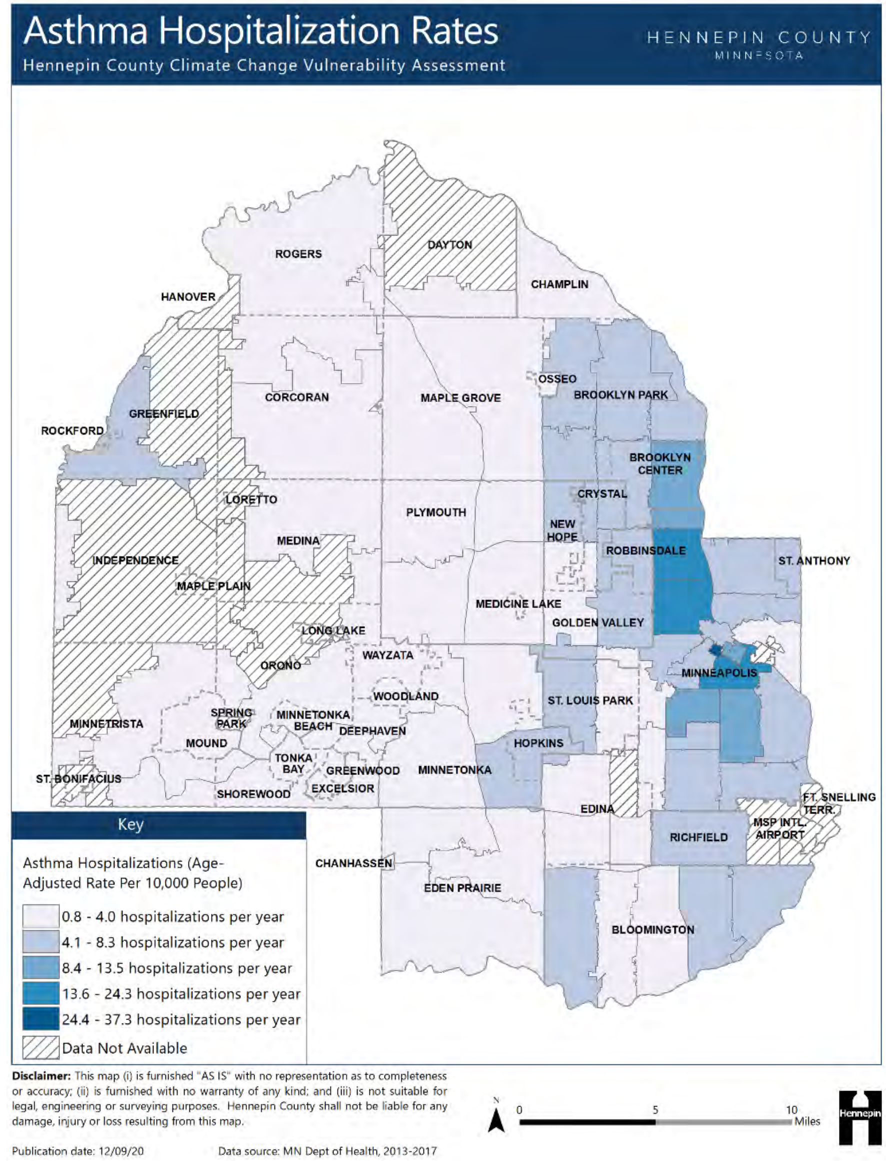
7 Appendix A

Maps for 14 Demographic Variables Contributing to Population Vulnerability Composite

Map A-1 Asthma hospitalization rates

Climate change increases air pollution, which can cause or aggravate respiratory diseases, such as asthma, and increases exposure to risk factors. Warmer temperatures promote more ground-level ozone pollution, which is a lung irritant that can trigger asthma attacks. Given the manner in which ground level ozone forms, the greatest concentrations of this ozone will occur outside of Hennepin County. Warmer temperatures and drought result in increased frequency and intensity of wildfires, increasing the amount of harmful particulate matter in the air, which can trigger asthma attacks. Warmer temperatures can also increase the duration of the pollen season, which can trigger asthma attacks (Reference (6)).

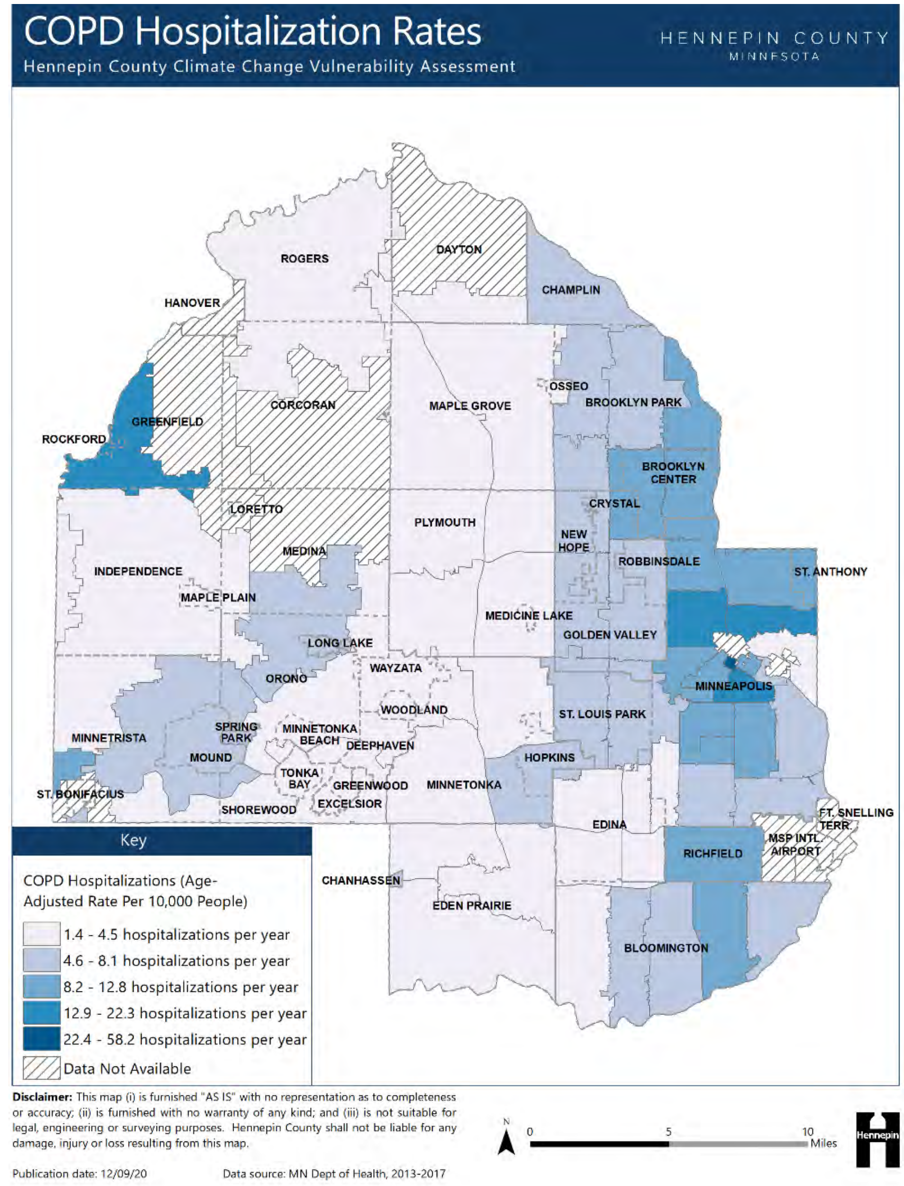
The map to the right summarizes asthma hospitalization rates in Hennepin County, by zip code, based on data from the MDH from 2013–2017 (Reference (11)).



Map A-2 COPD hospitalization rates

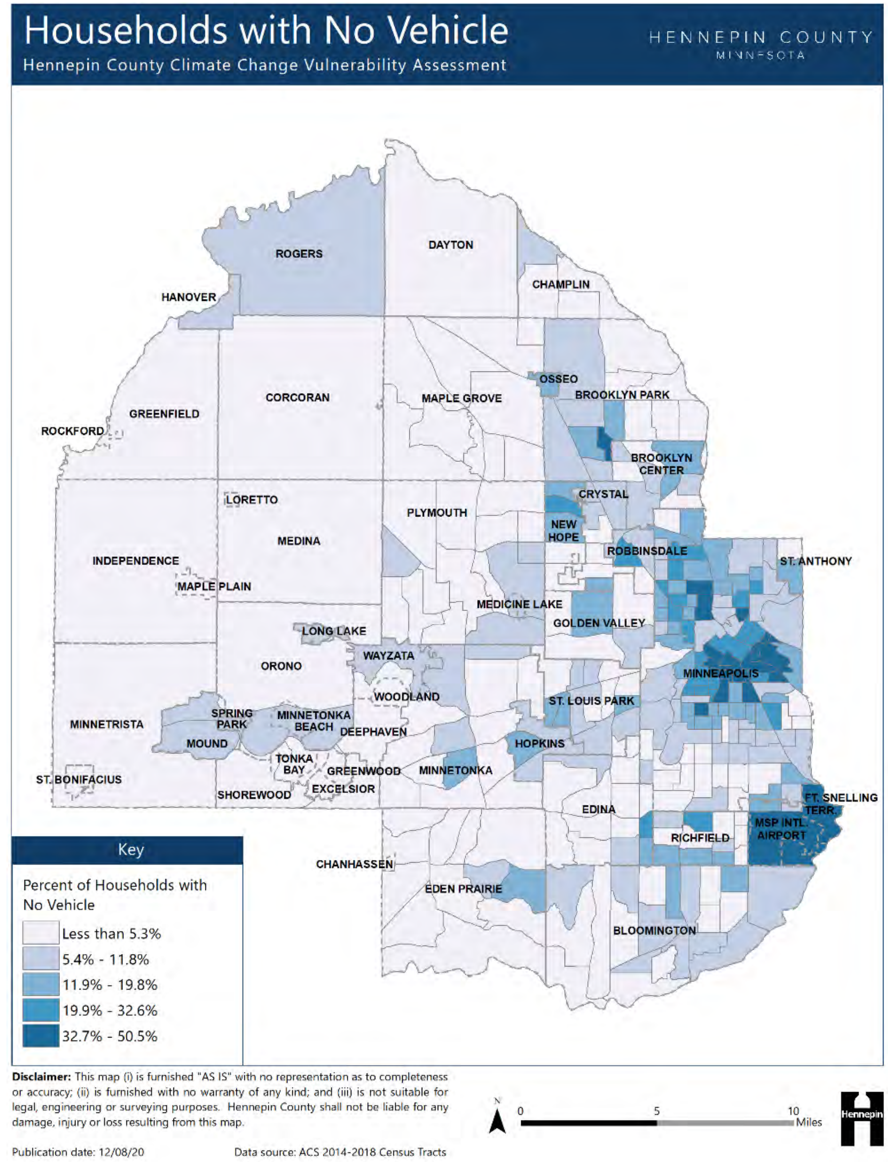
Climate change can have disproportionate effects on individuals suffering from chronic obstructive pulmonary disease, a chronic inflammatory lung disease that causes obstructed airflow from the lungs (Reference (7)). People with COPD are more vulnerable to the effects of air pollution, which is increased by climate change. Exposure to air pollution has been linked to increases in COPD-related emergency department visits and hospitalizations (Reference (8)). COPD hospitalization rates are a more accurate predictor of adverse effects of air quality than asthma.

The map to the right summarizes COPD hospitalization rates in Hennepin County, by zip code, based on data from MDH from 2013–2017 (Reference (14)).



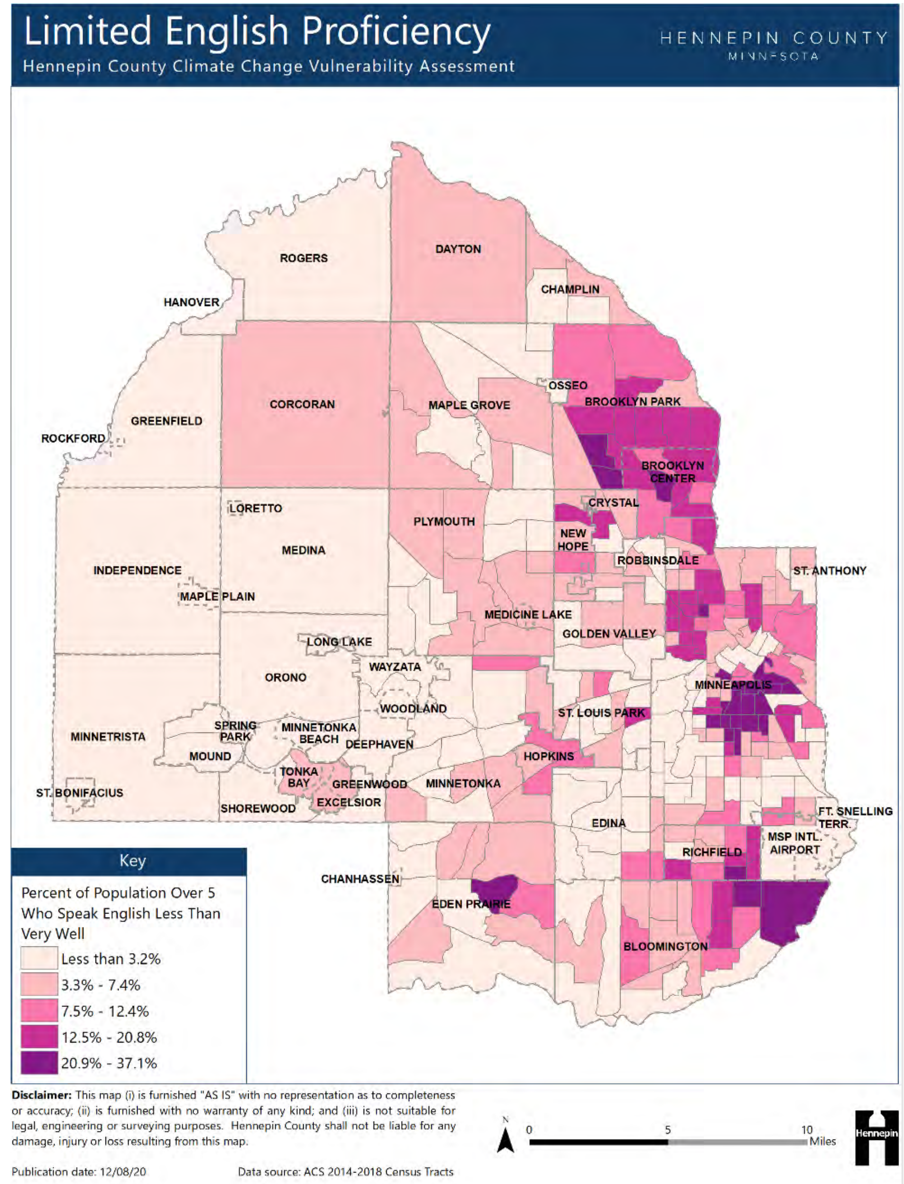
Map A-3 Households with no vehicle

Households that lack a vehicle are more dependent on public transportation and/or walking or biking, increasing exposure and sensitivity to climate hazards (flooding, increased heat, increased icy conditions on sidewalks, roadways, and trails). Households that lack a vehicle are less able to access cooling centers during heat waves and may be less able to respond to flooding (or flooding clean-up).



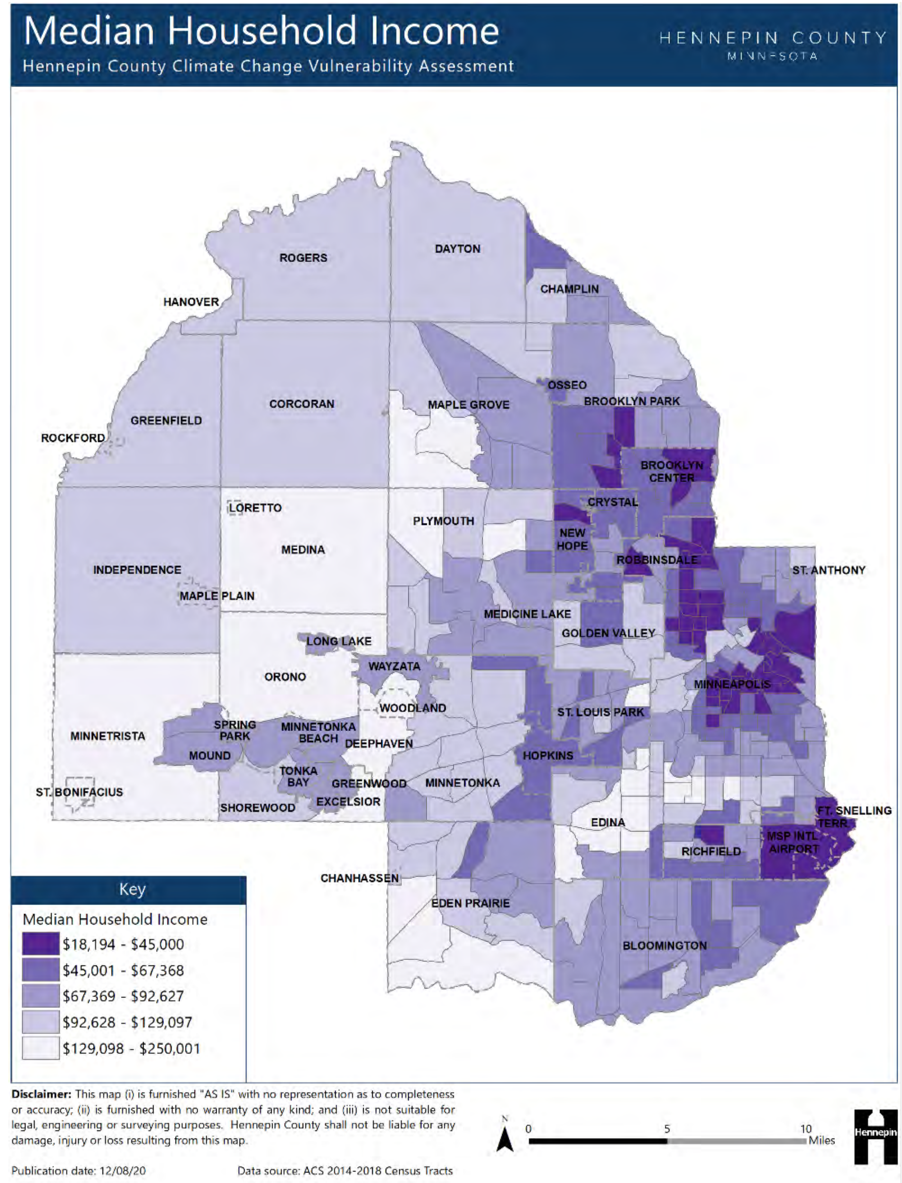
Map A-4 Limited English proficiency

Individuals with limited English proficiency may have less awareness or understanding of immediate climate change impacts from climate change hazards, such as flooding resulting from extreme precipitation events, or long-term impacts, such as increased air pollution and associated greater incidence of asthma. During crises, government communication to individuals or households with limited English proficiency may be misunderstood or delayed. These individuals or households may also not understand how to access resources to help prevent or recover from impacts.



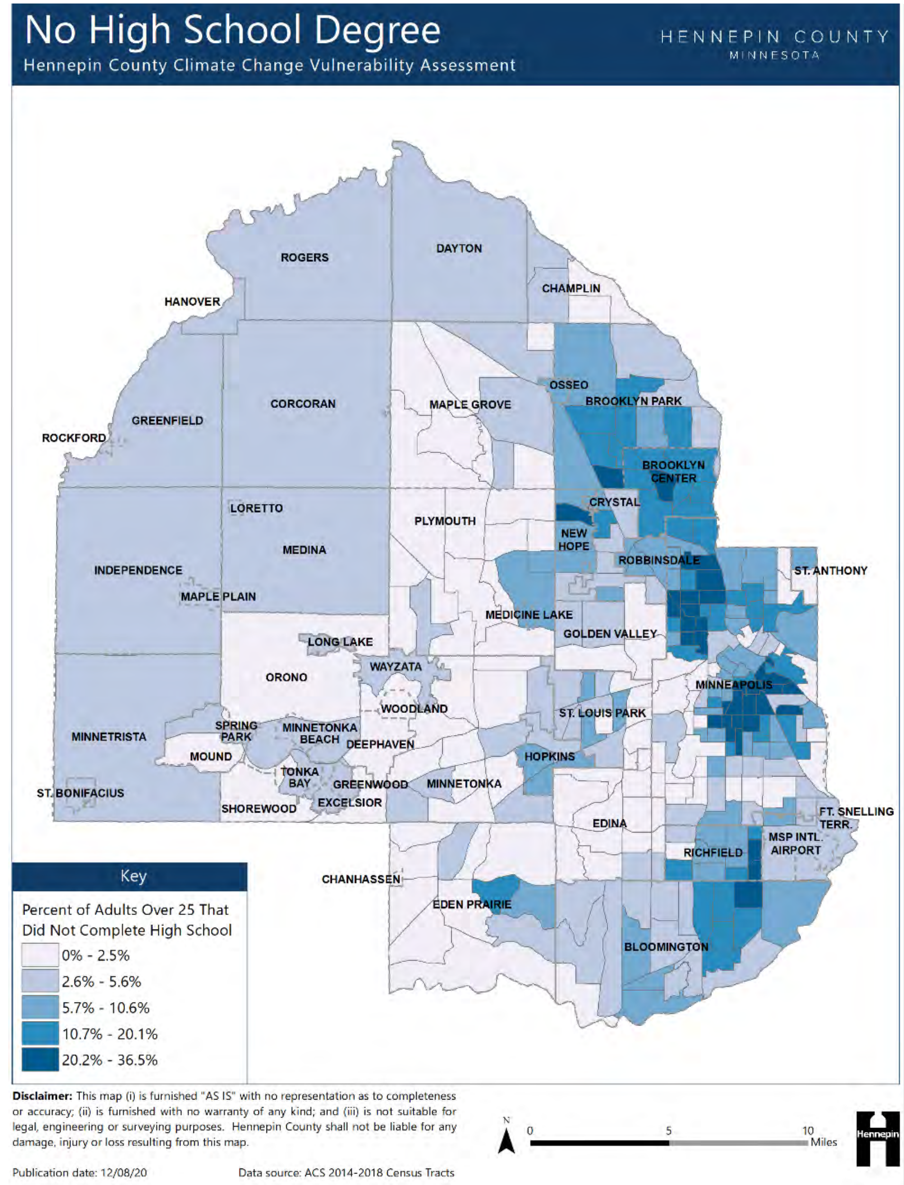
Map A-5 Median household income

Household income often affects where people live. Living in low-lying, flood-prone areas can be more affordable, but increases exposure to flood risks. More or less household income can also affect a household's sensitivity to climate change impacts and capacity to cope or respond. With less income there are fewer resources to direct toward responding to the effects of climate change or implementing flood prevention and mitigation measures, such as purchasing flood insurance.



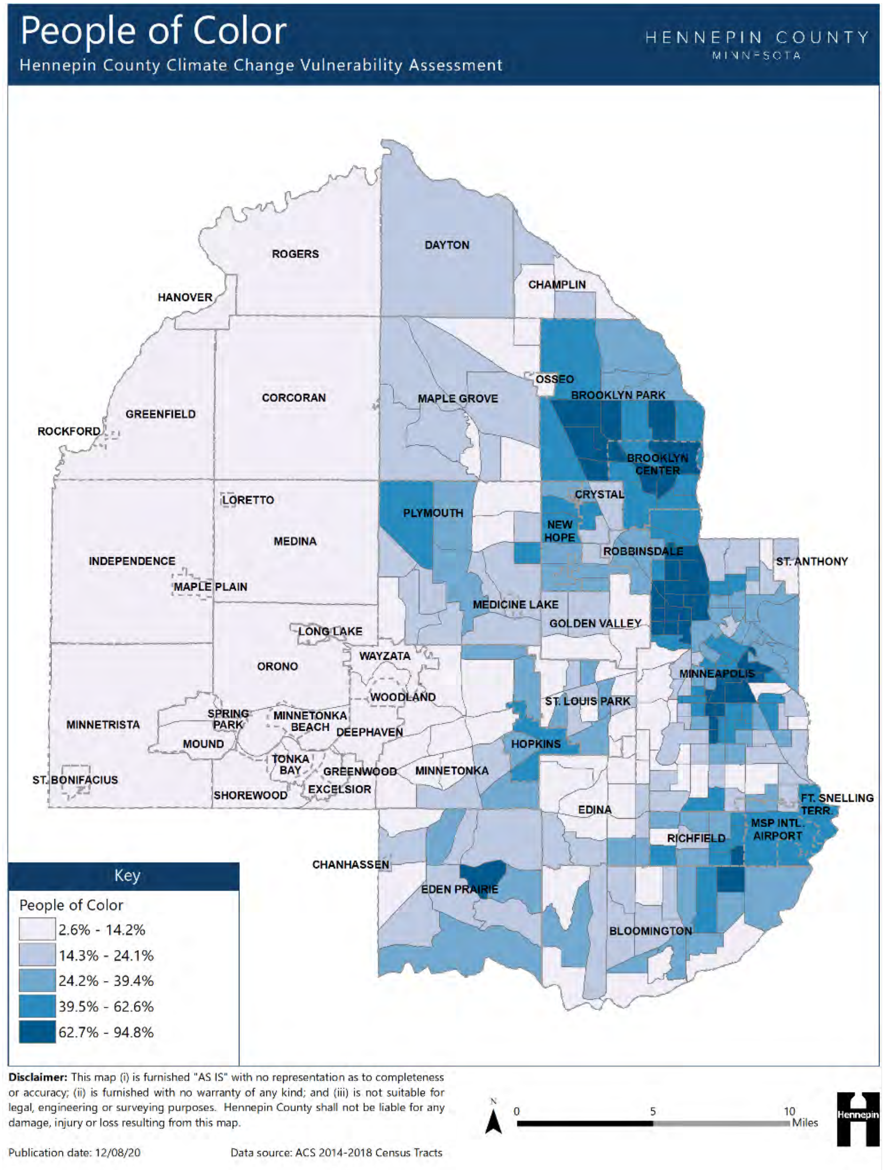
Map A-6 No high school degree

Individuals without a high school degree have, on average, less income than those with a degree. As such, they are more vulnerable to the impacts of climate change and have fewer resources to respond. The map to the right shows the percent of adults over 25 years of age that did not complete high school, by census tract.



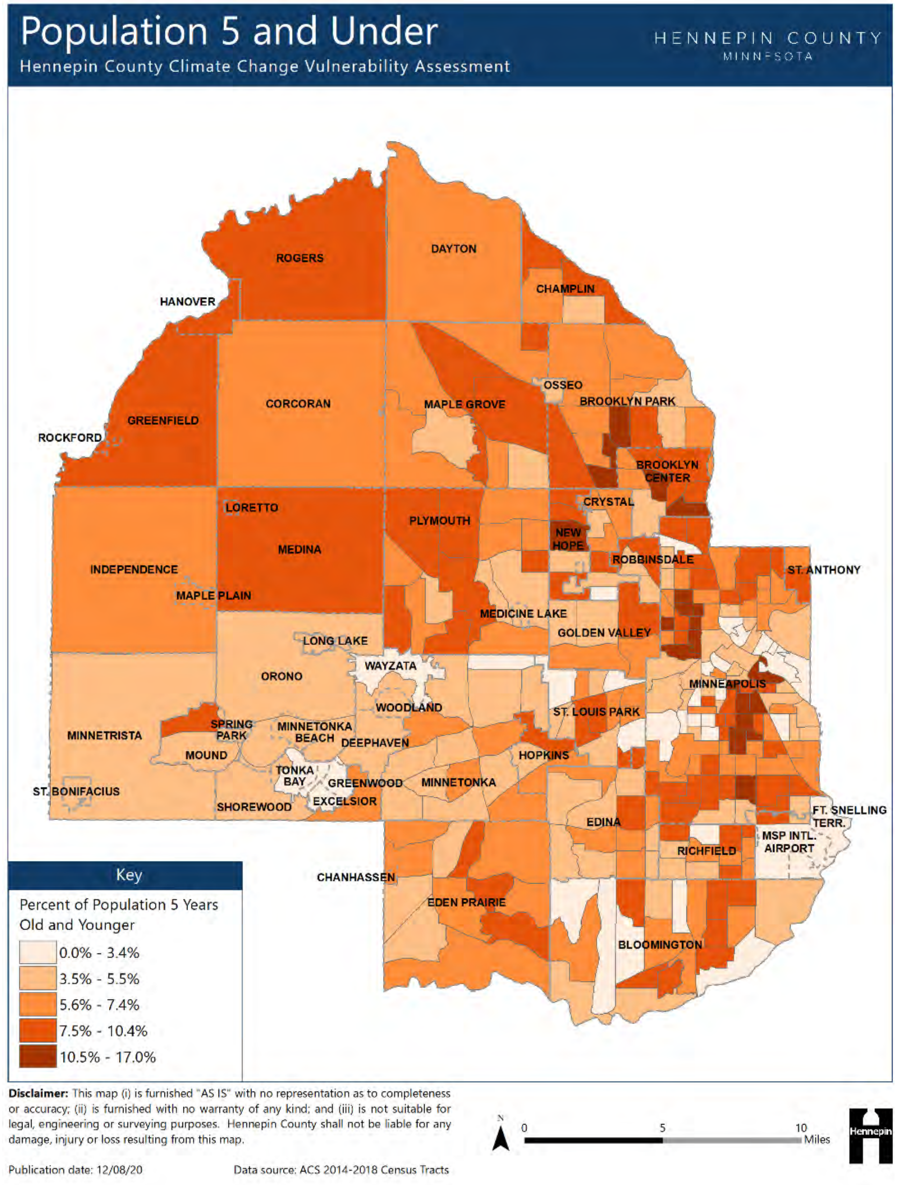
Map A-7 People of color

Individuals that identify as non-White non-Hispanic have historically been marginalized, both in where they live (via the practices of red-lining and restrictive covenants in deeds) and in their access to well-paying jobs, making them more vulnerable to the impacts of climate change. The map to the right shows the percent of the population that are people of color (defined here as non-White, non-Hispanic), by census tract.



Map A-8 Population 5 and under

Individuals 5 years old and under are dependent on older individuals for transportation, food, information, etc. Children, particularly those under 5 years old, are more vulnerable to climate change, especially potential health impacts. The map to the right shows the percentage of the population that is 5 years old or younger, by census tract.



Map A-9 Population below 185% poverty threshold

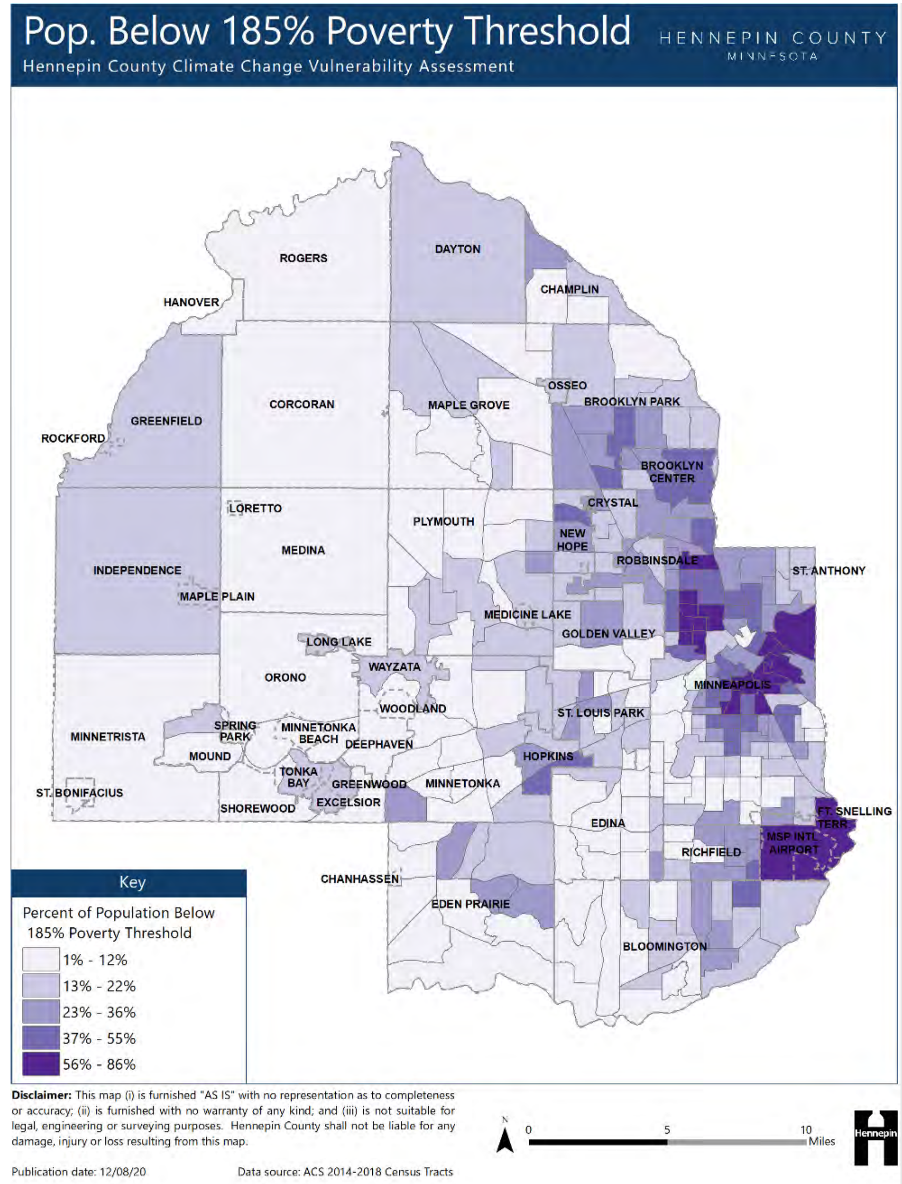
Individuals living in poverty are more vulnerable to the impacts of climate change, often living in substandard housing with greater exposure to flooding and extreme heat, greater sensitivity to health risks, and limited resources and opportunities for health-promoting behaviors (e.g., high-quality food). The map to the right shows the percentage of the population with a household income below the 185% poverty threshold (defined below), by census tract. The poverty threshold in the U.S. in 2020 was approximately $26,000 for a family of four.

The federal poverty guidelines are used as an eligibility criterion by Medicaid and a number of other federal programs. Some federal programs use a percentage multiple of the guidelines (for example 185%), as noted in the authorizing legislation or program regulations. The entity that administers the program is responsible for determining the definition for family and income.

2020 Annual Poverty Guidelines[1]

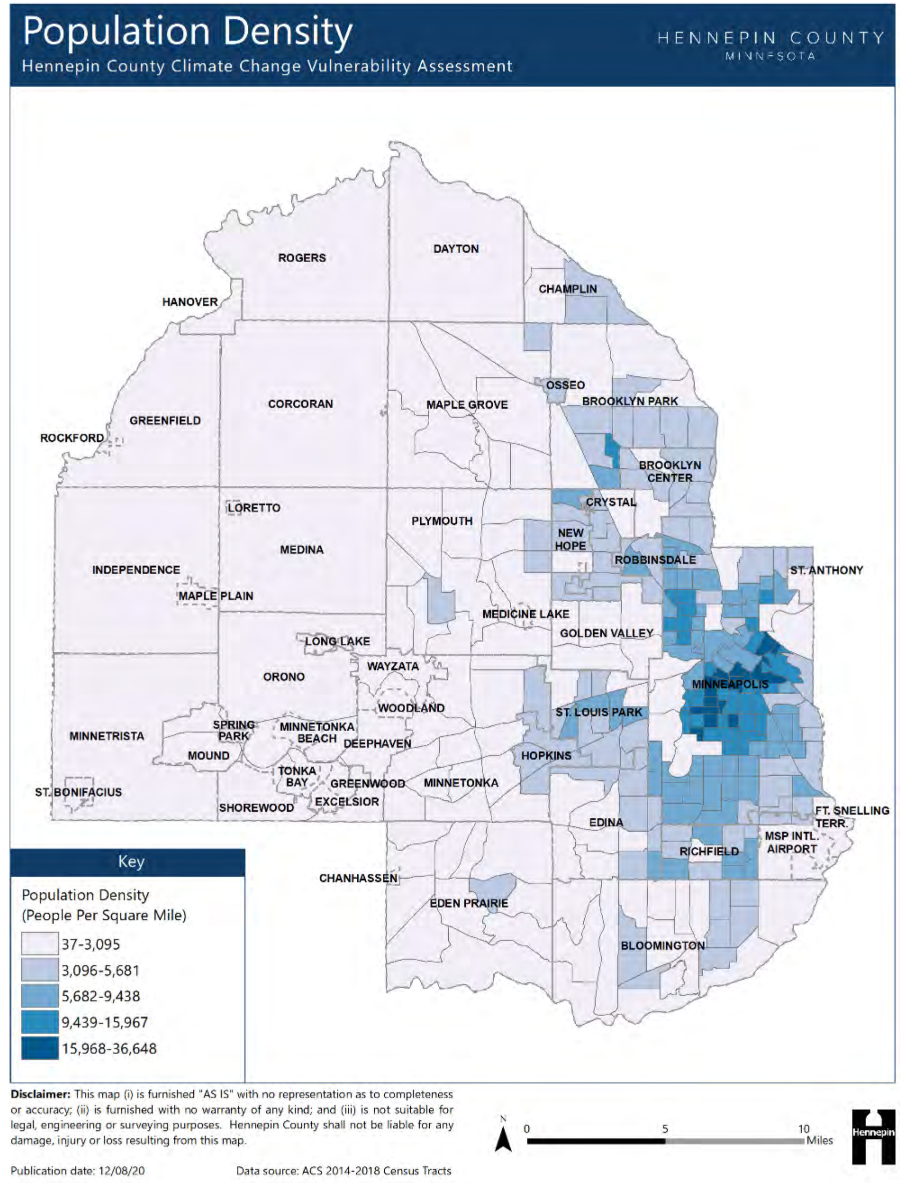
Household/ Family Size	100%	185%	200%
4	$26,200	$48,470	$52,400

[1] U.S. Department of Health and Human Services (HHS)



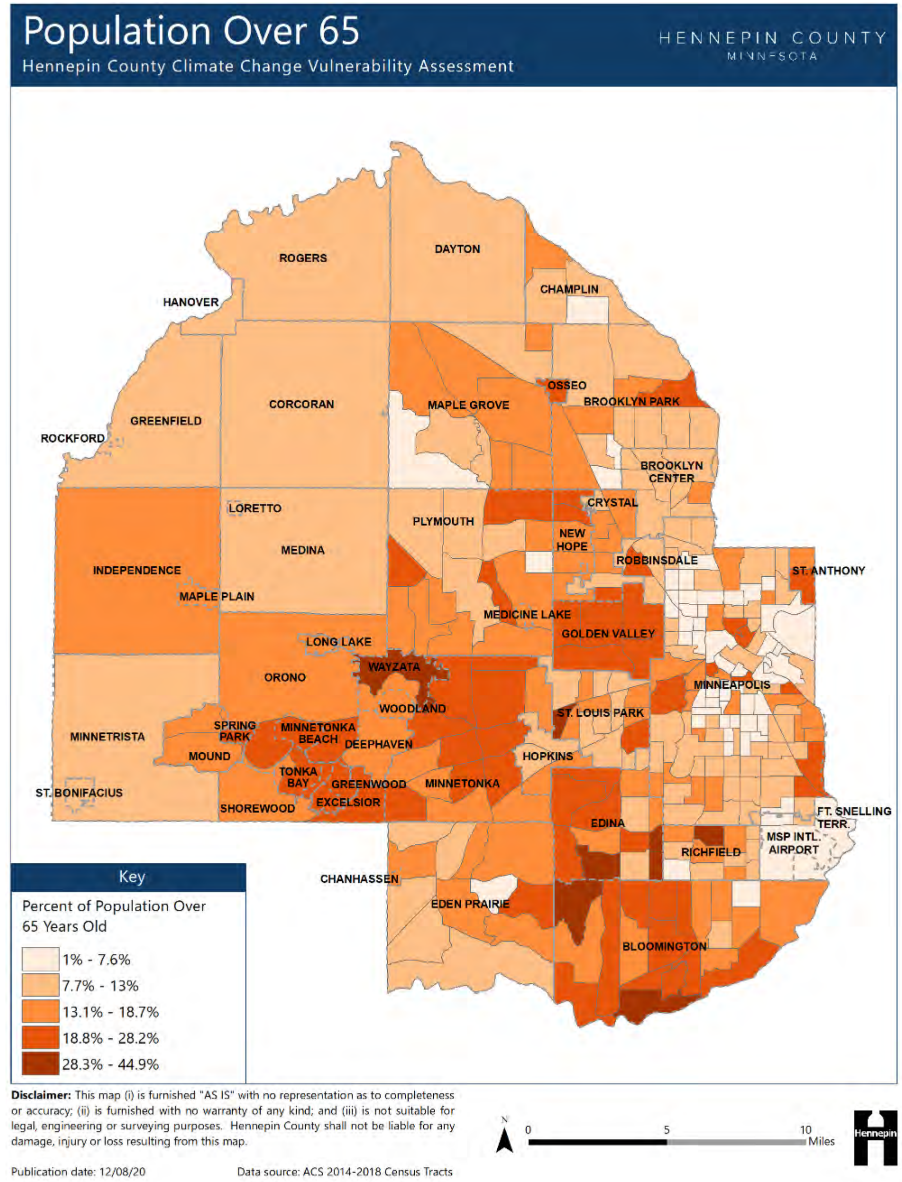
Map A-10 Population density

The greater the population density, the more people there are in a given area who are vulnerable to the impacts of climate change, such as flooding and extreme heat. Areas of higher population density typically have more hard surfaces—roofs, sidewalks, roads, buildings, and parking lots—which contribute to heat islands of warmer temperatures. During times of extreme heat, the heat island effect can exacerbate conditions, making people living or working in these areas more vulnerable. These hard surfaces are also impervious and create more stormwater runoff. In large precipitation events, the storm sewers may not be able to handle the large amount of runoff, and flooding can occur. The map to the right shows the population per census tract.



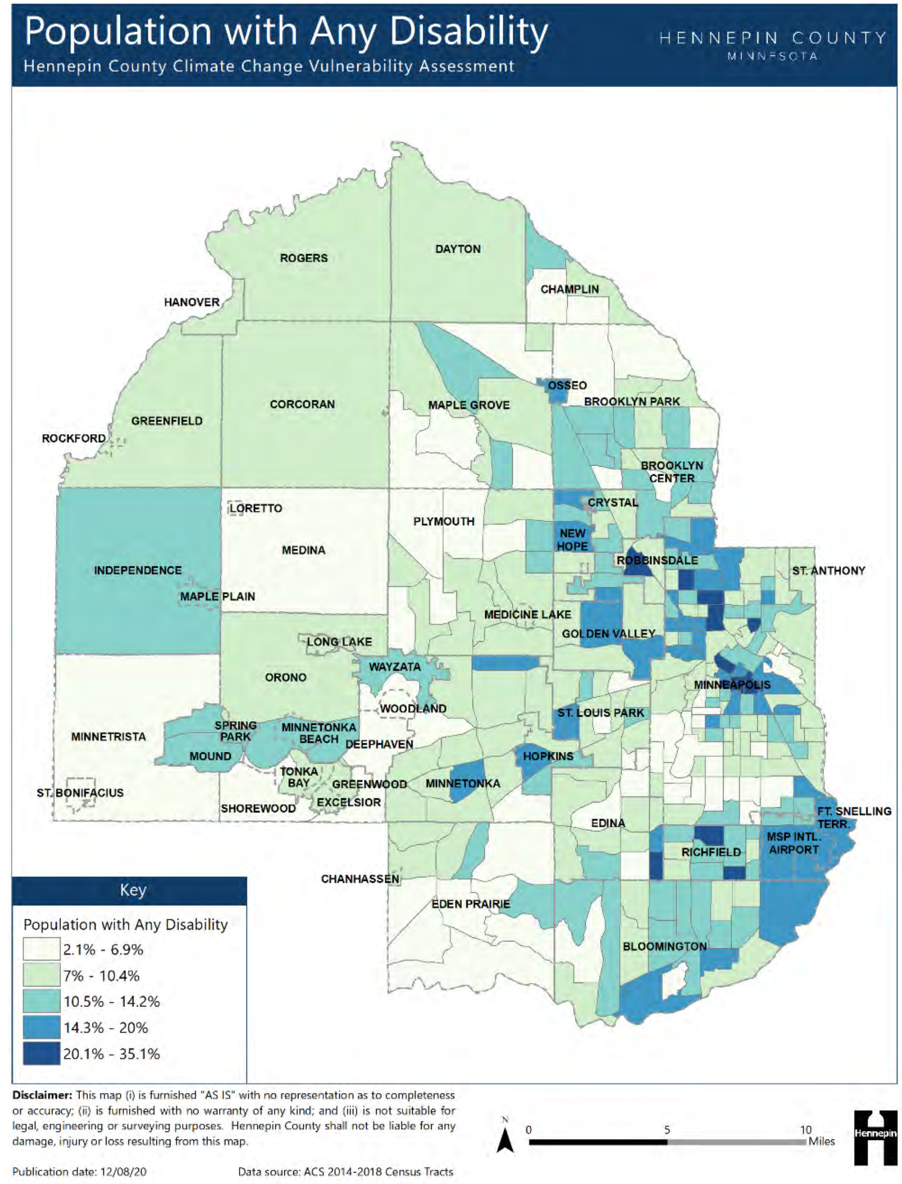
Map A-11 Population over 65

Older adults can be more vulnerable to climate change impacts, especially health-related impacts. This is due to a higher prevalence of underlying health conditions and increased sensitivity to extreme heat, degraded air quality, flooding, more frequent icy conditions on roadways and sidewalks, and large snowfalls. Older adults can also have less capacity to cope with or respond to climate change impacts (e.g., flooding or extreme heat) due to factors such as physical limitations or fixed incomes. The map to the right shows the percentage of the population that is over 65 years of age, by census tract.



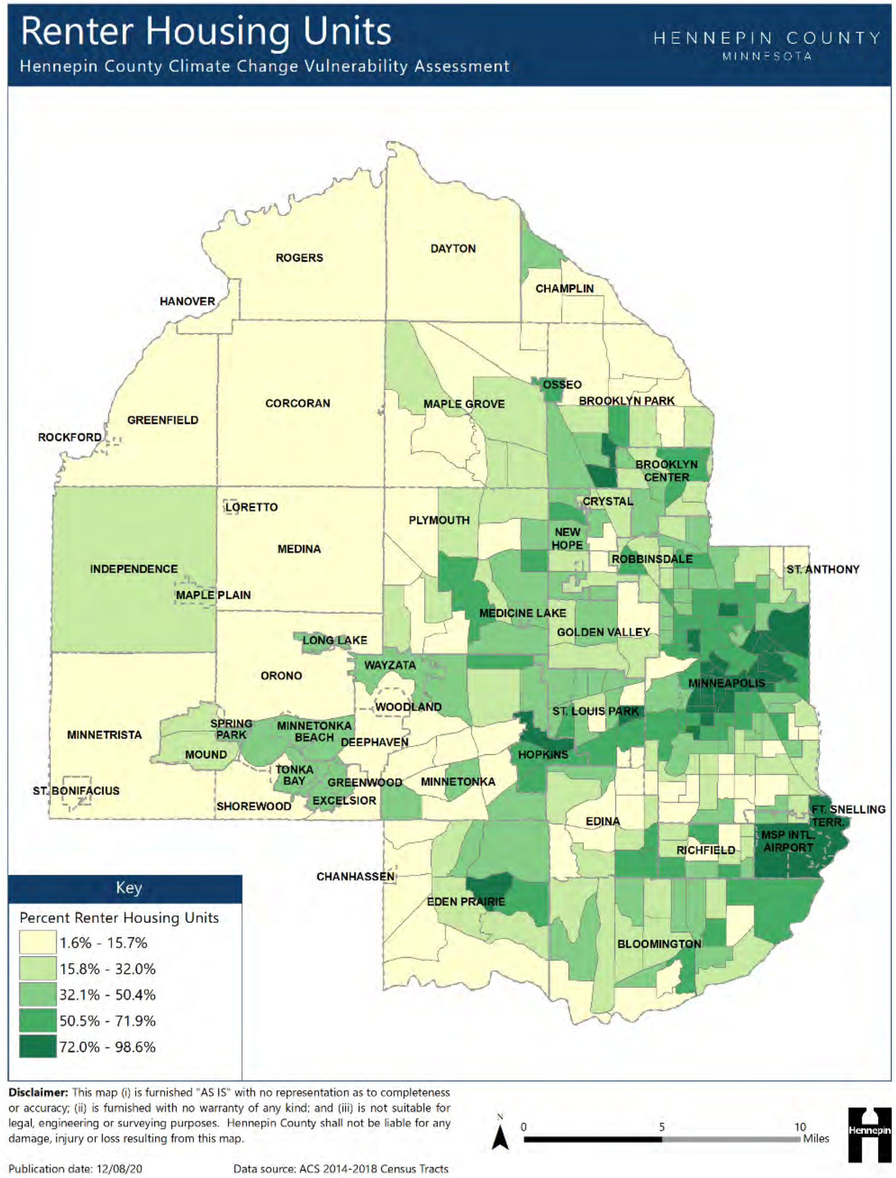
Map A-12 Population with any disability

People with disabilities have greater vulnerability to climate change impacts. They are more reliant on transit and are likely to have less mobility to seek cooling centers during heat waves. People with disabilities have higher rates of other socioeconomic factors, such as poverty and lower educational attainment. This compound the risks posed by disabilities and can disrupt planning and emergency response (Reference (9)). The map to the right shows the percentage of the population with any disability, by census tract.



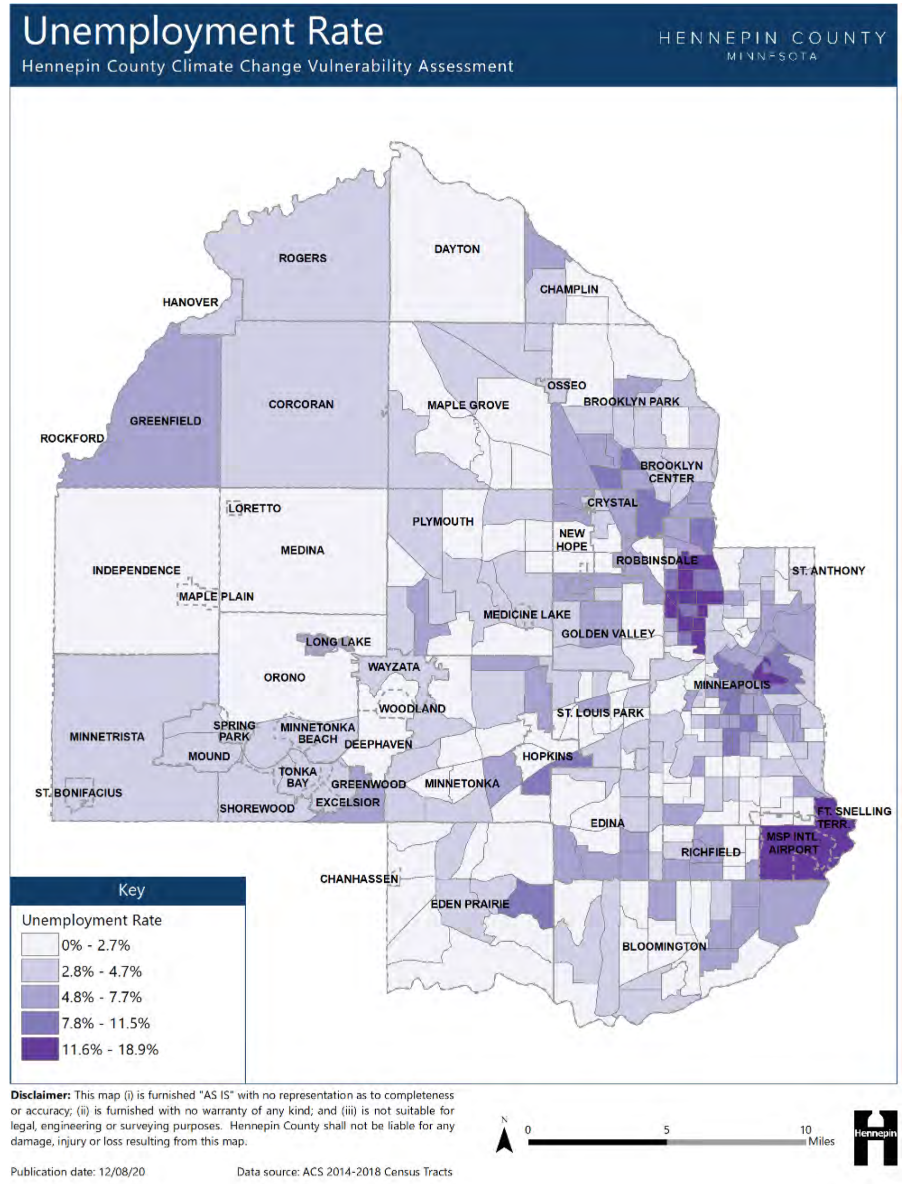
Map A-13 Renter housing units

As the Renter Housing Units Map shows, rental housing in Hennepin County tends to be concentrated in the areas that are most subject to the urban heat island effect. Individuals living in rental housing have less ability to proactively implement strategies to reduce climate change impacts, such as flood-proofing their structures, improving insulation within their homes, installing air conditioners, or planting trees. Owners of rental property who live remotely may be less inclined to proactively make improvements to mitigate climate change or may be less inclined to repair climate-change-related damage to their rental properties.



Map A-14 Unemployment rate

The unemployment rates on the adjacent map are based on 5-year estimates from the Census Bureau's 2014–2018 American Community Survey. According to the Minnesota Department of Employment and Economic Development, the unemployment rate for Hennepin County in December 2019 was 2.6%. The Minnesota state unemployment rate for December of 2019 was 3.5%.



8 Appendix B

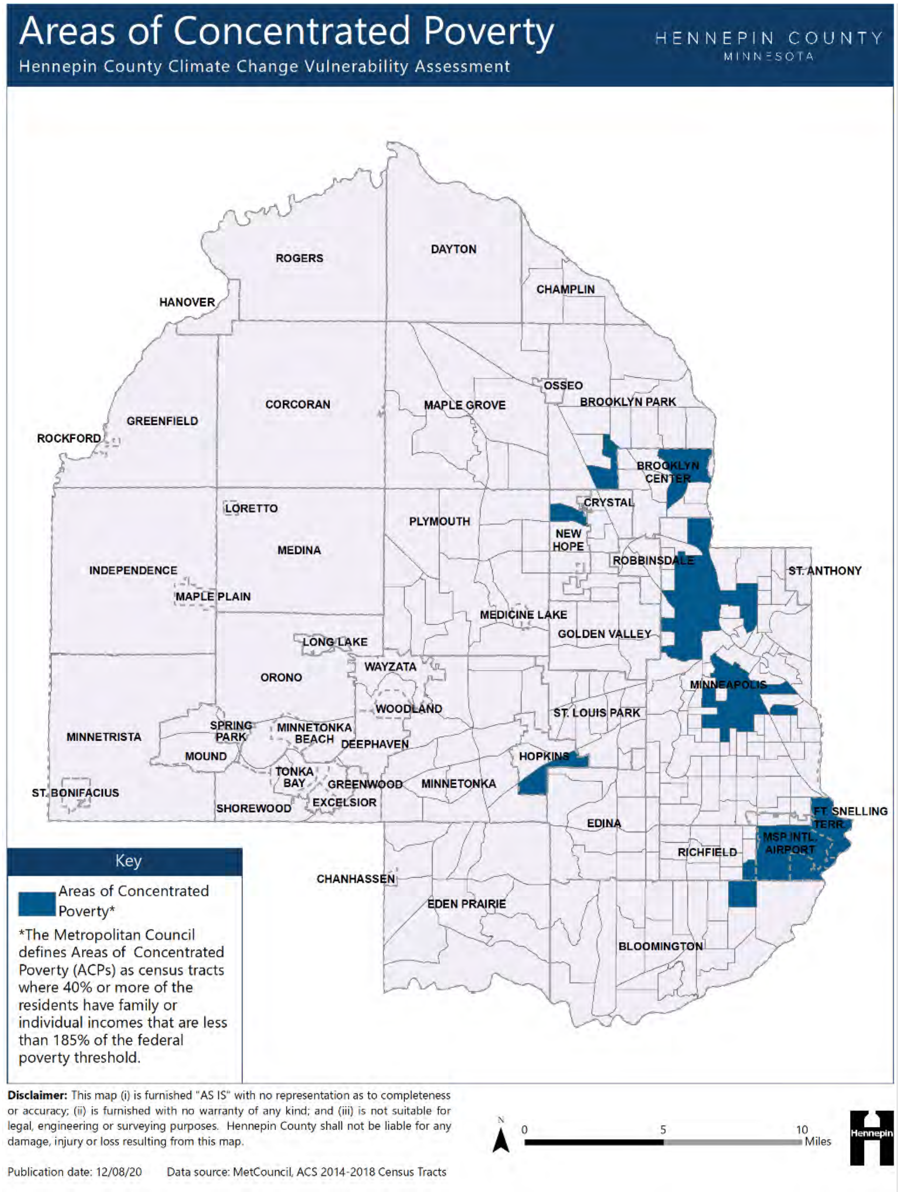
Additional Demographic Maps

Additional demographic and socioeconomic variables are important to consider when planning for climate adaptation. The demographic data in the maps below, however, were not used to develop the composite vulnerabilities map.

Unless otherwise noted, all data presented in the maps below are sourced from the 2014–2018 American Community Survey (US Census Bureau) and are only available at the census tract level. The maps are arranged in alphabetical order.

Map B-1 Areas of concentrated poverty

This data is provided by the Metropolitan Council from 2014–2018 ACS Census Data. The Met Council defines areas of concentrated poverty as census tracts where 40% or more of residents have family or individual incomes that are less than 185% of the federal poverty threshold.



Map B-2 Historical neighborhood appraisals and racial covenants

This map is based on data from the 1934 Home Owner's Loan Corporation, via Met Council. Per the Met Council: "In 1934, the Federal Housing Administration created a financial mortgage system that rated mortgage risks for properties based on various criteria but was centered on race and ethnicity. Neighborhoods shaded red were deemed too hazardous for federally backed loans. These "red-lined" neighborhoods were where most African American residents lived, and this rating system propagated racial segregation that in many ways persists today."

The FHA Underwriting Handbook incorporated color-coded real estate investment maps that classified neighborhoods based on assumptions about a community, primarily their racial and ethnic composition, and not on the financial ability of the residents to satisfy the obligations of a mortgage loan. These maps, created by the Home Owner's Loan Corporation, were used to determine where mortgages could or could not be issued.

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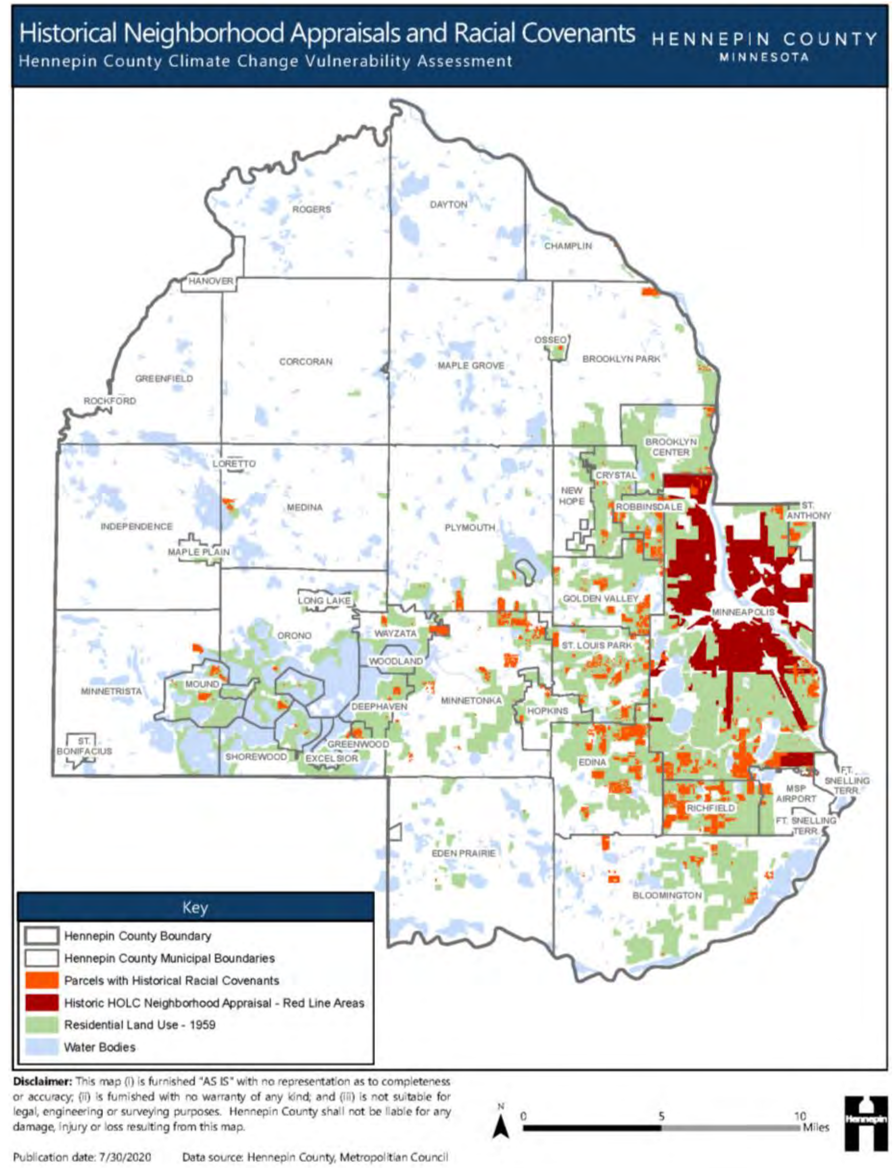
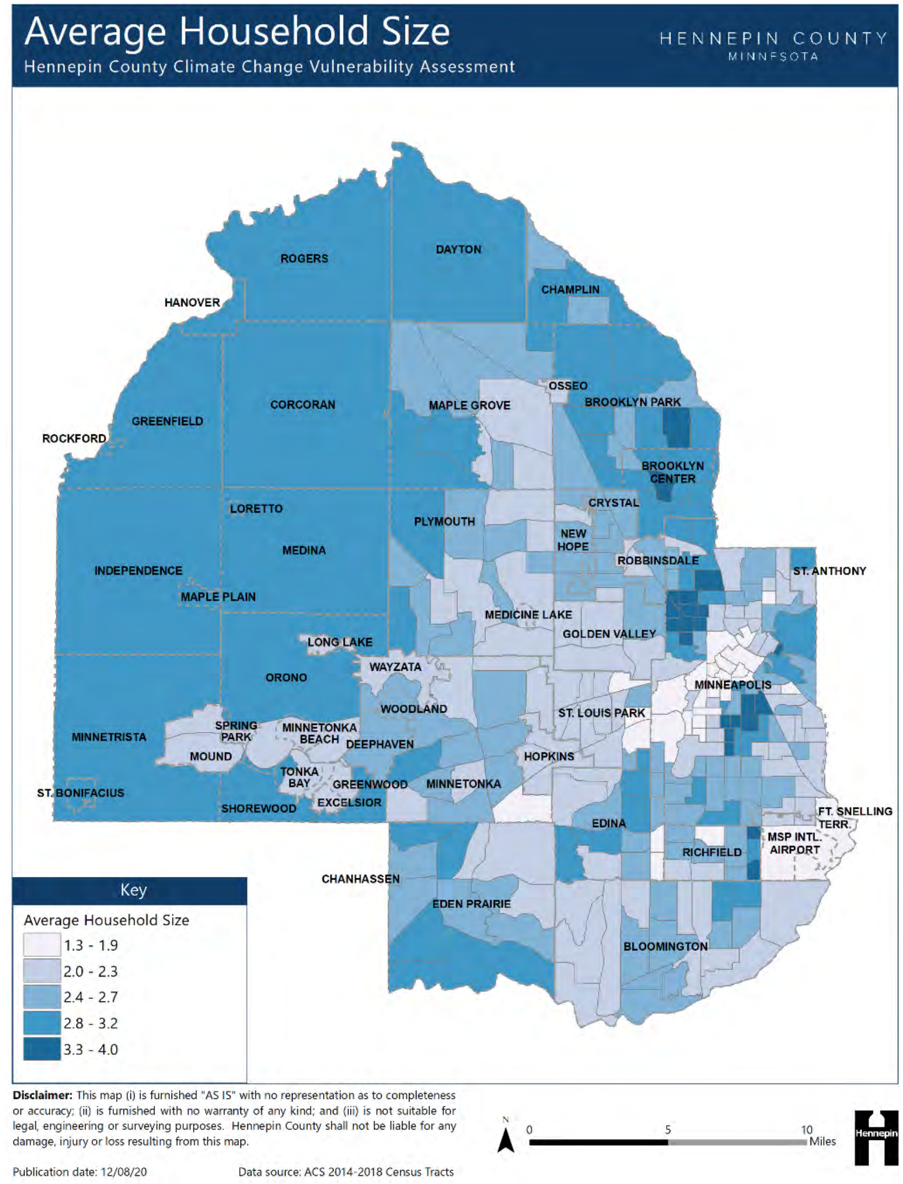


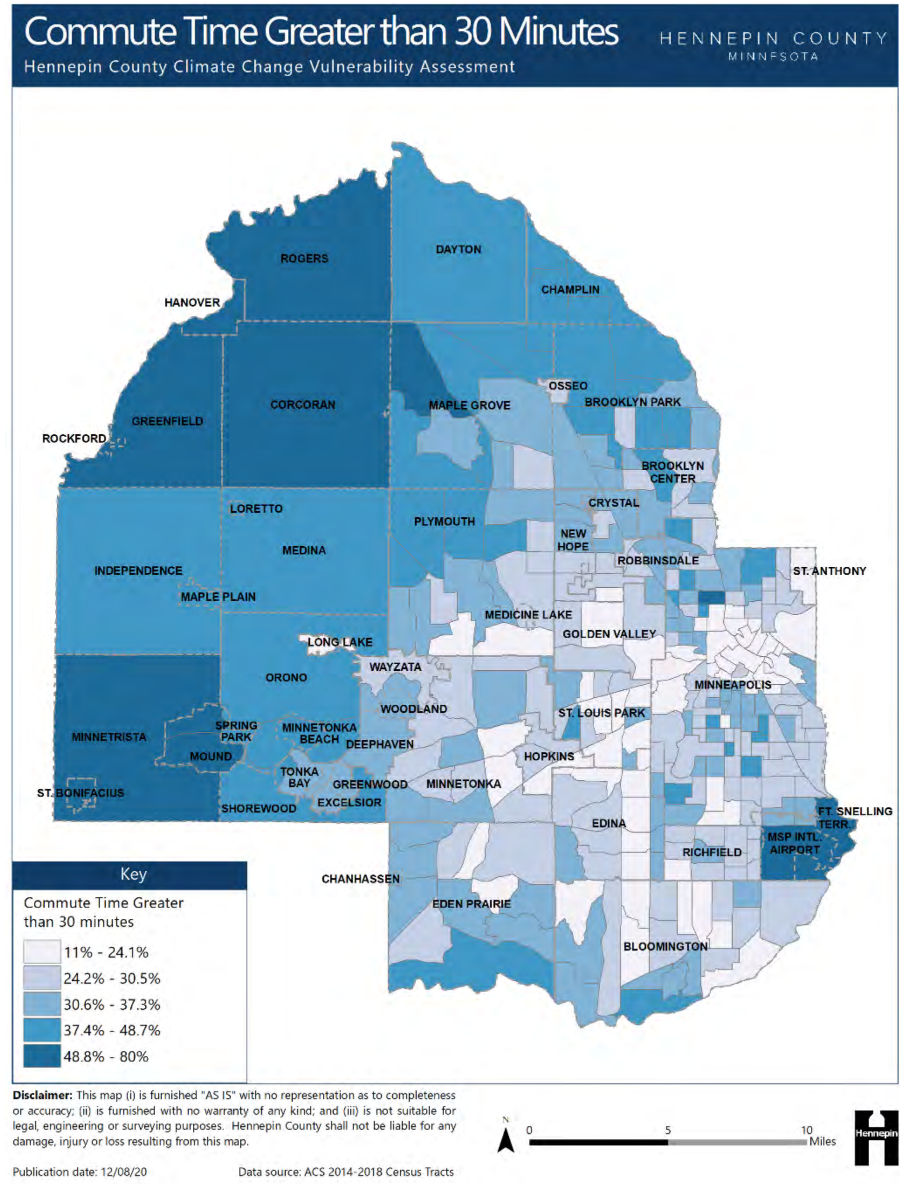
Map B-3 Average household size

This map depicts the average number of people per household, by census tract.



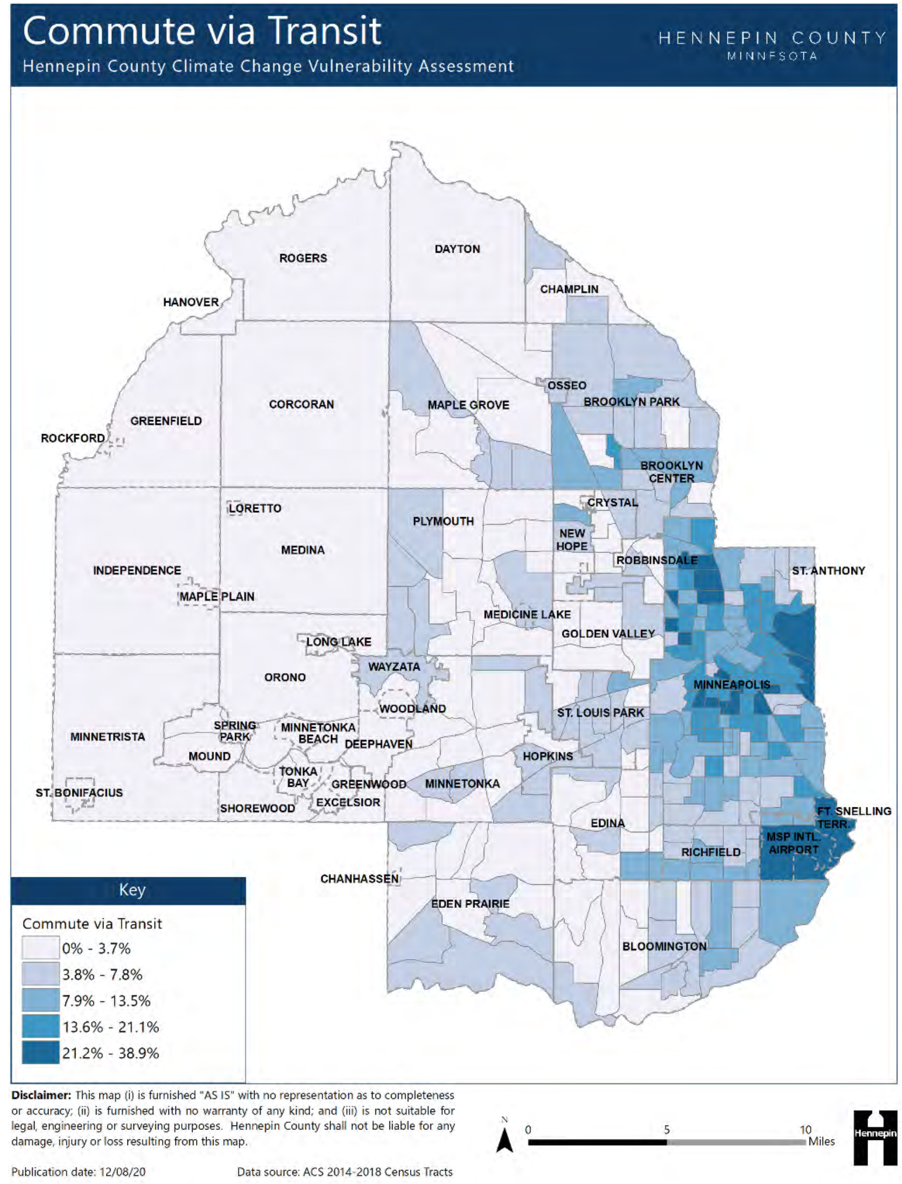
Map B-4 Commute time greater than 30 minutes

This map depicts the percentage of working individuals whose one-way commute exceeds 30 minutes, by census tract. These individuals will have more exposure to climate-related transportation system disruptions.



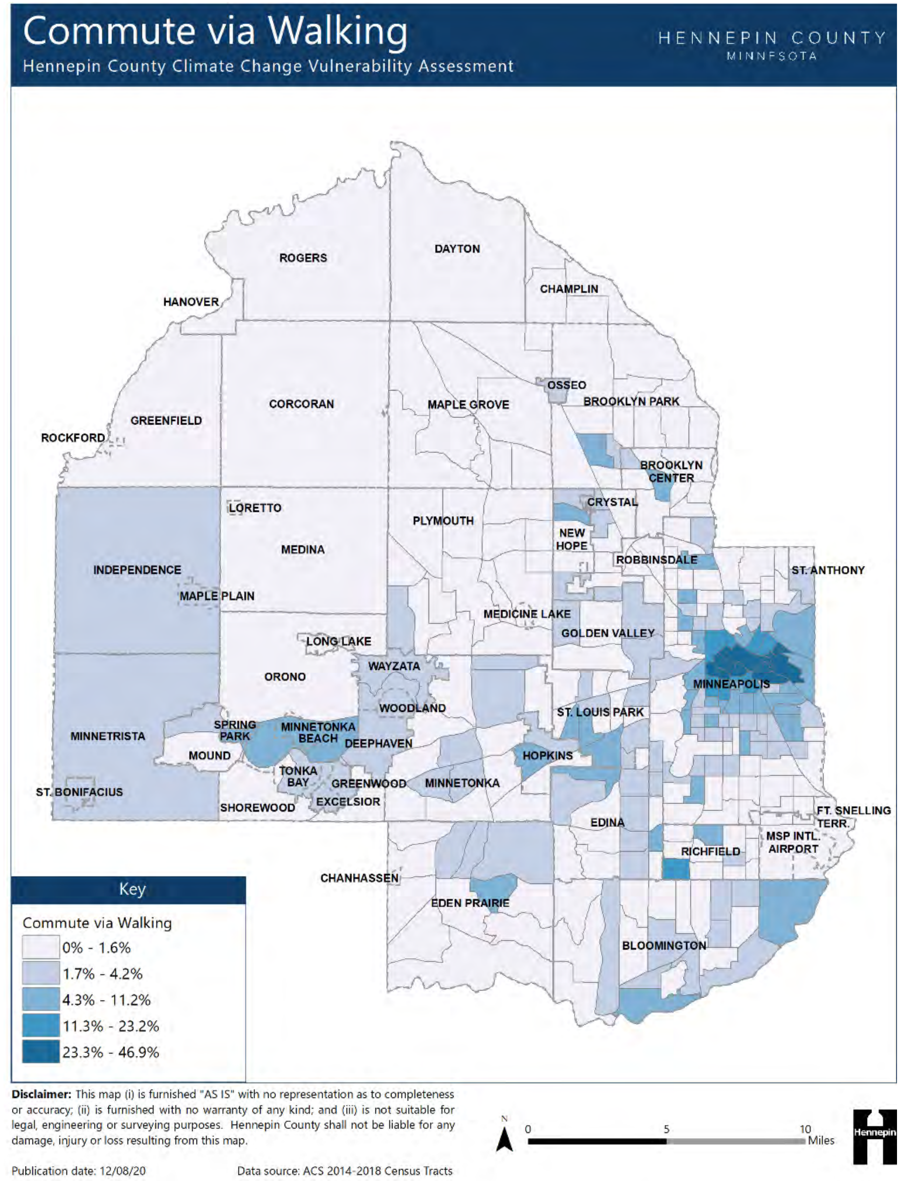
Map B-5 Commute via transit

This map depicts the percentage of working individuals who commute via public transit, by census tract. These people may have increased exposure to climate change impacts such as flooding, extreme heat and humidity events, and icy crosswalks and sidewalks.



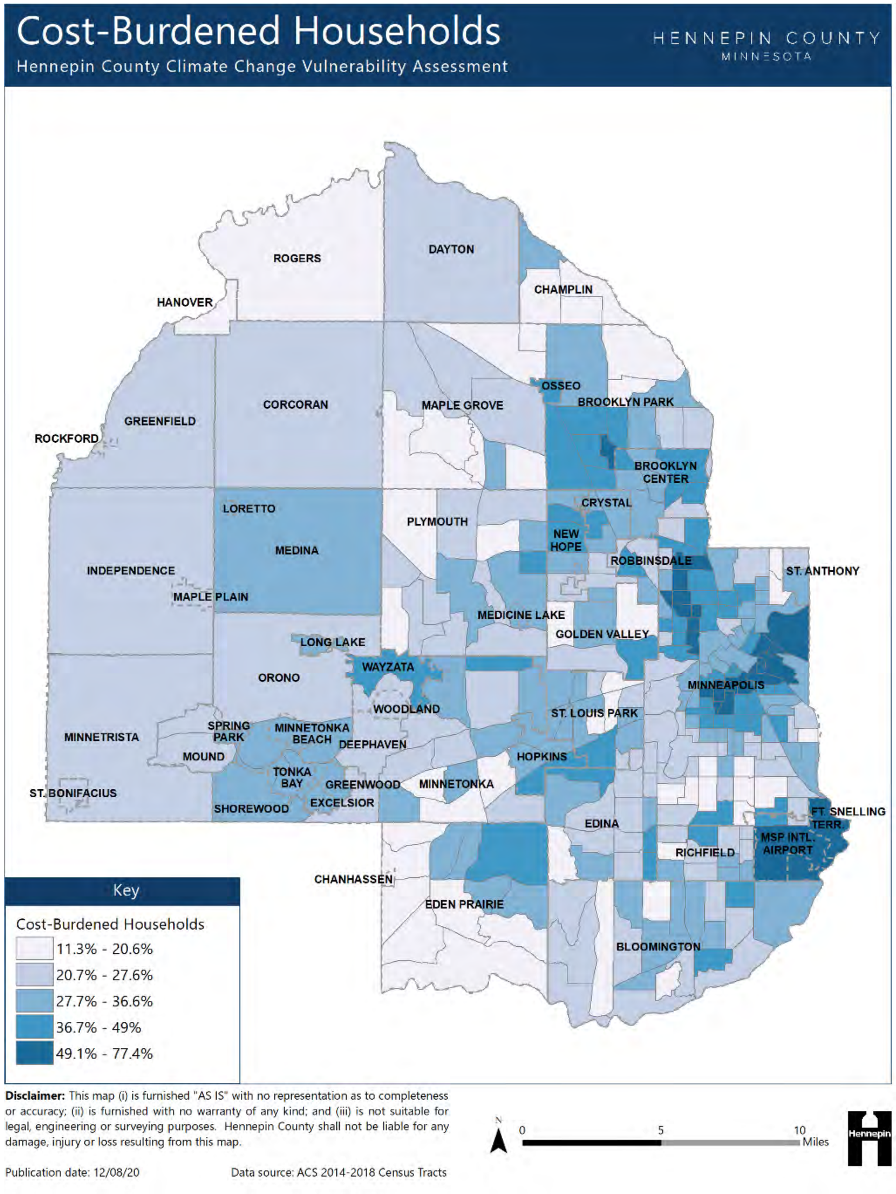
Map B-6 Commute via walking

This map depicts the percentage of working individuals who commute via walking, by census tract. These people may have increased exposure to climate change impacts such as flooding, extreme heat and humidity events, and icy crosswalks and sidewalks.



Map B-7 Cost-burdened households

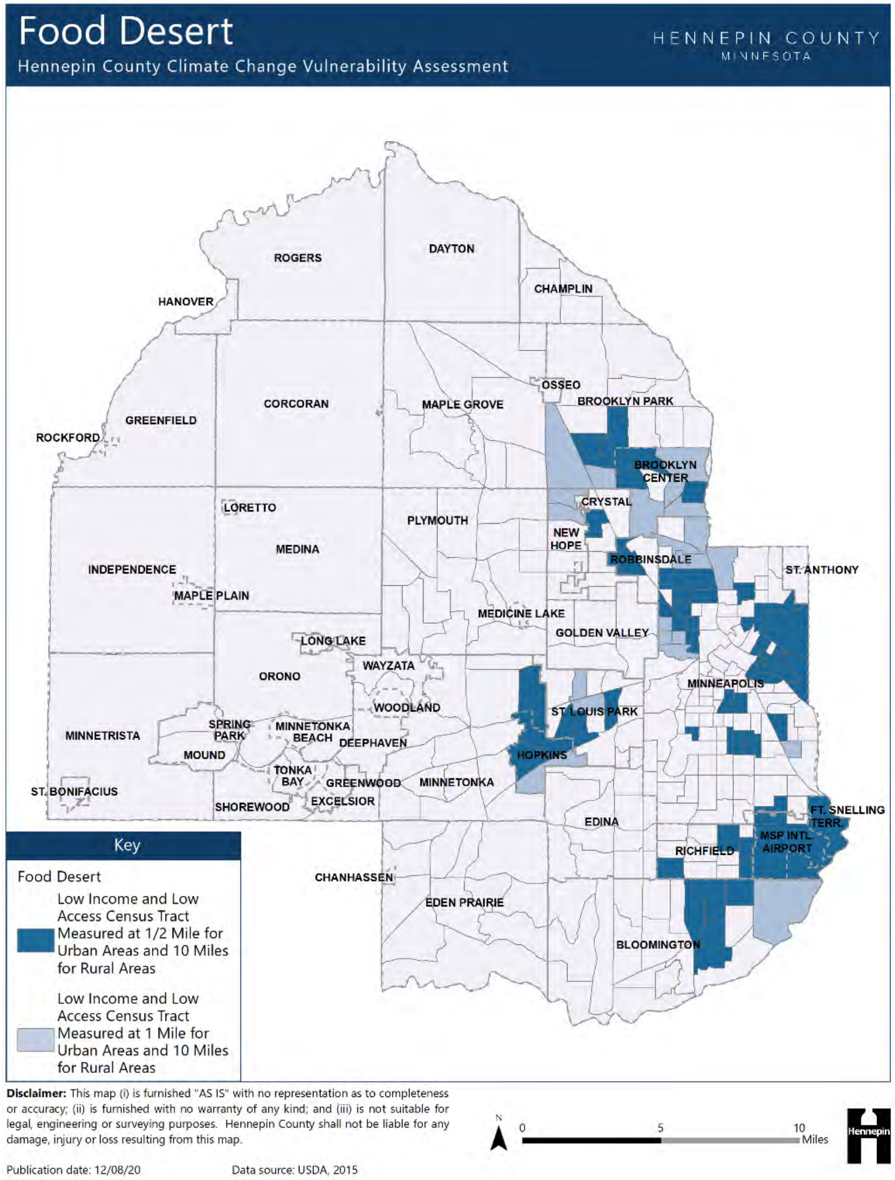
The U.S. Department of Housing and Urban Development defines cost-burdened families as those who pay more than 30 percent of their income for housing and may have difficulty affording necessities such as food, clothing, transportation, and medical care. This map depicts the percentage of cost-burdened households, by census tract. These households have fewer financial resources available to address the impacts of climate change such as the cost of energy for cooling.



Map B-8 Food deserts

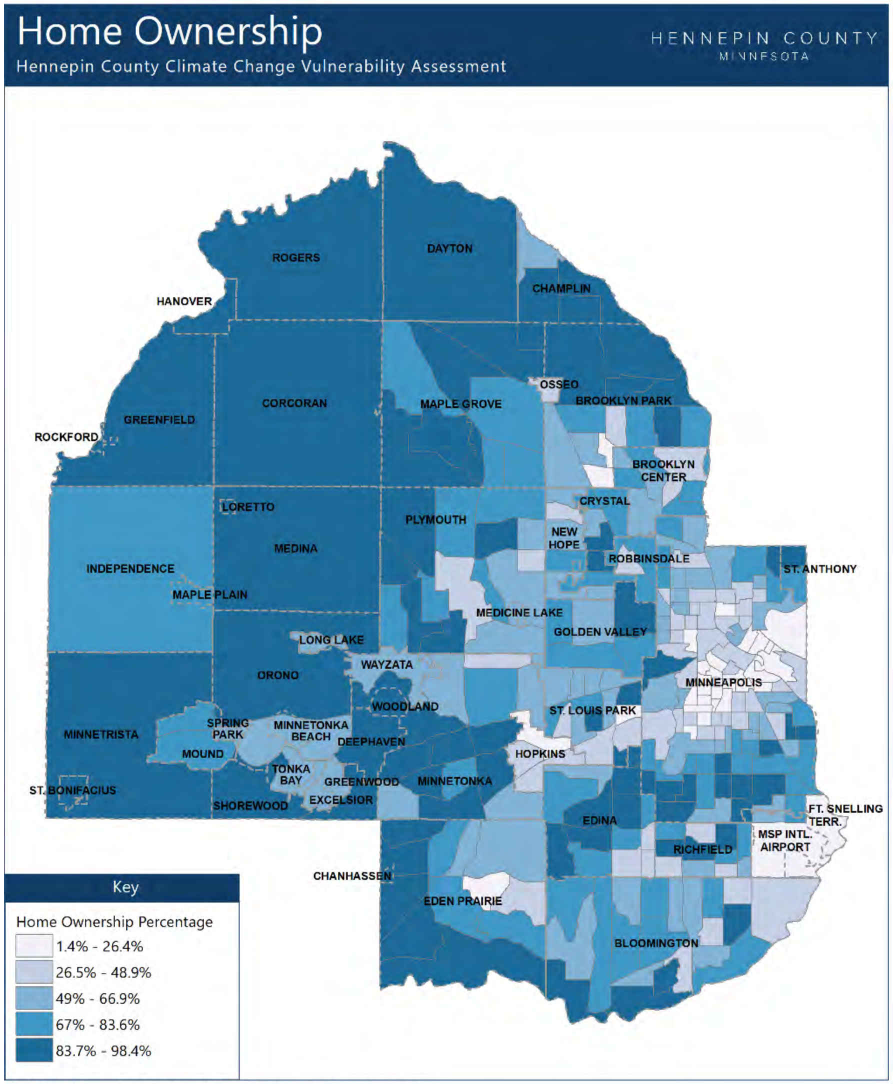
Food deserts are locations without easy access to fresh, healthy, and affordable foods.

Two food desert attributes have been combined and mapped at the census-tract level: 1) low income and 2) low access (to grocery stores). Low income is defined as a poverty rate of 20 percent or greater, or a median family income at or below 80 percent of the statewide or metropolitan area median family income. Low access is defined as at least 500 persons and/or at least 33 percent of the population living more than one-half or 1 mile from a supermarket or large grocery store. Data source: USDA, 2015.



Map B-9 Home ownership

This map shows the percentage of households that own their place of residence, by census tract.



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Publication date: 12/08/20

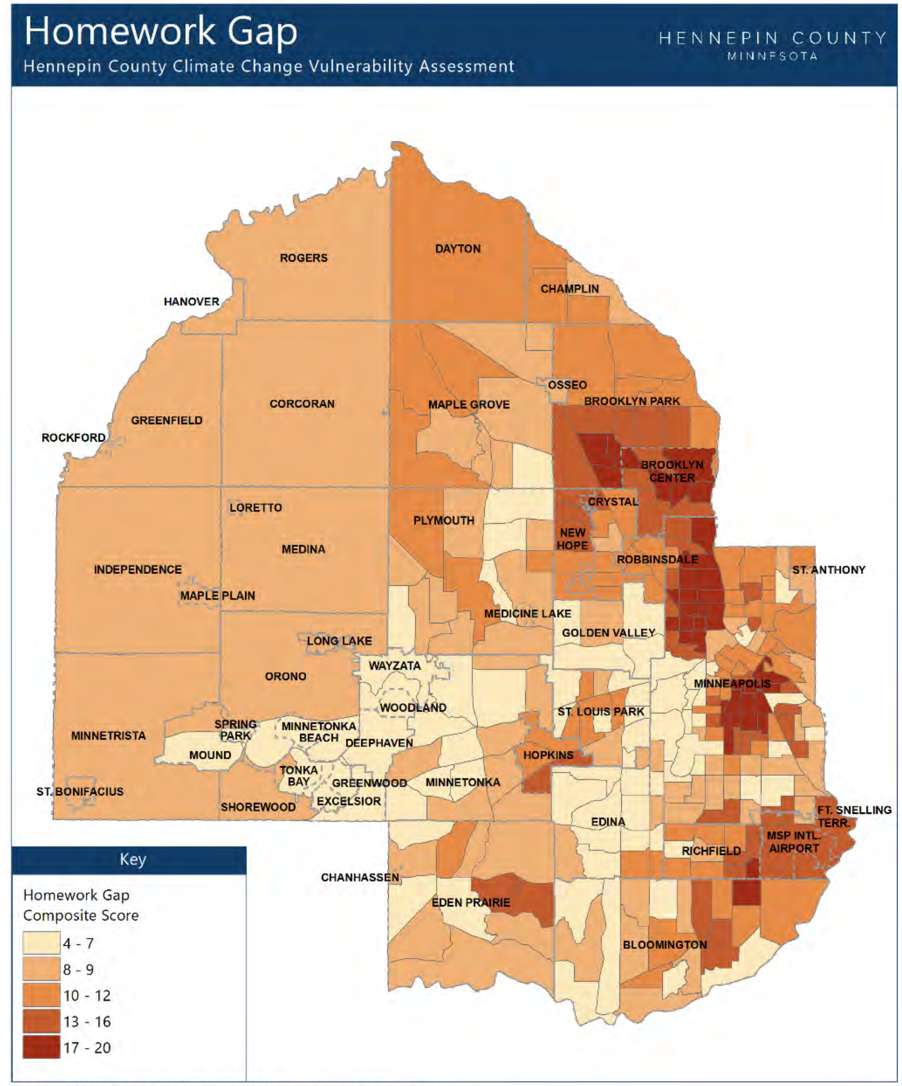
Data source: ACS 2014-2018 Census Tracts

Map B-10 Homework gap

Homework gap refers to the barriers students face completing homework assignments without access to high-speed internet service at home (primarily for financial reasons). The higher the score, the greater the indication of disparity in access to high-speed internet and digital devices. It mimics the trends seen in the Population Vulnerability map.

This map shows homework gap composite scoring, by census tract, created by Hennepin County. To calculate the composite score of each census tract the demographic indicators listed below were ranked. Each indicator was given a score of 1–5 based on the percentage of the population that carried the characteristic in each tract. The score for each factor was added together giving each tract a composite score between 4 and 20.

- Non-White
- Poverty
- High school diploma or below
- Age under-18



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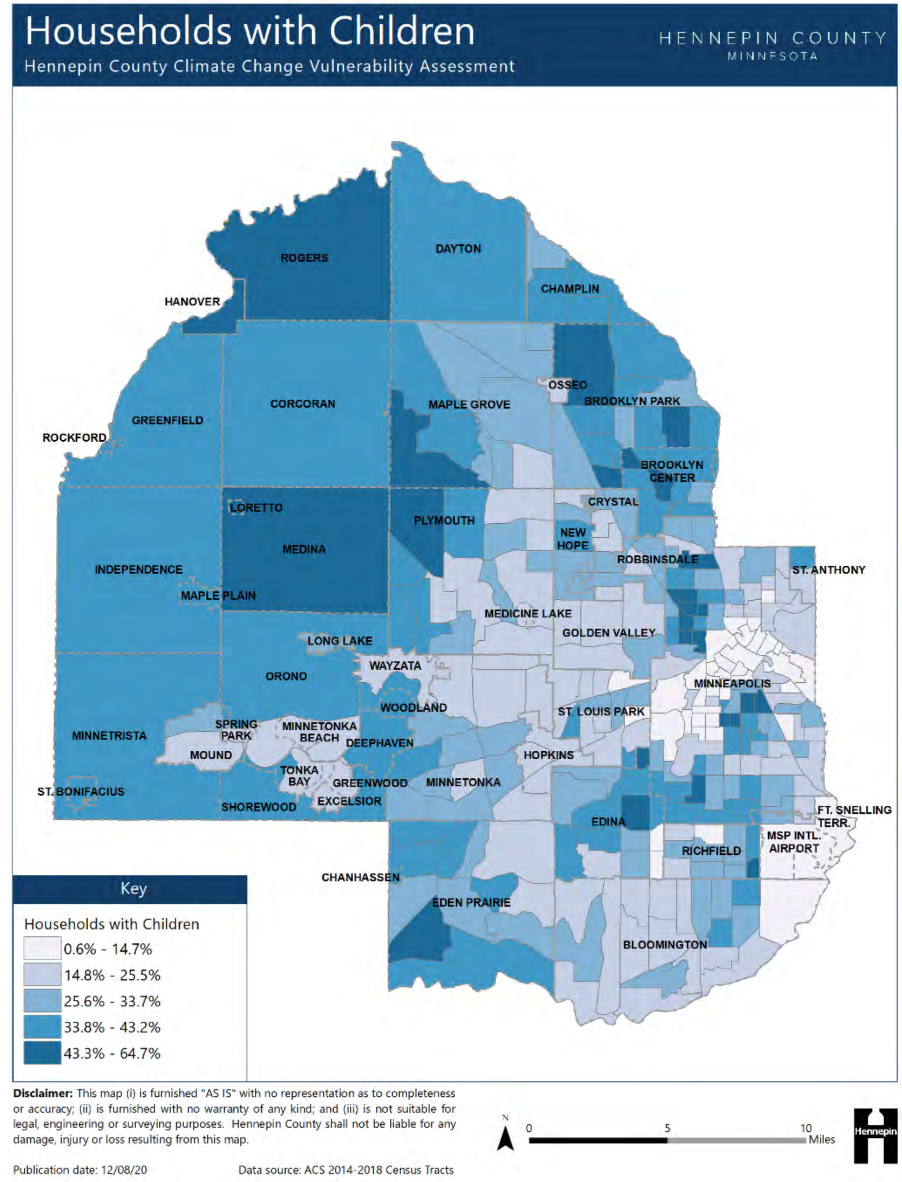
N 0 5 10 Miles

Publication date: 12/08/20 Data source: ACS 2014-2018 Census Tracts

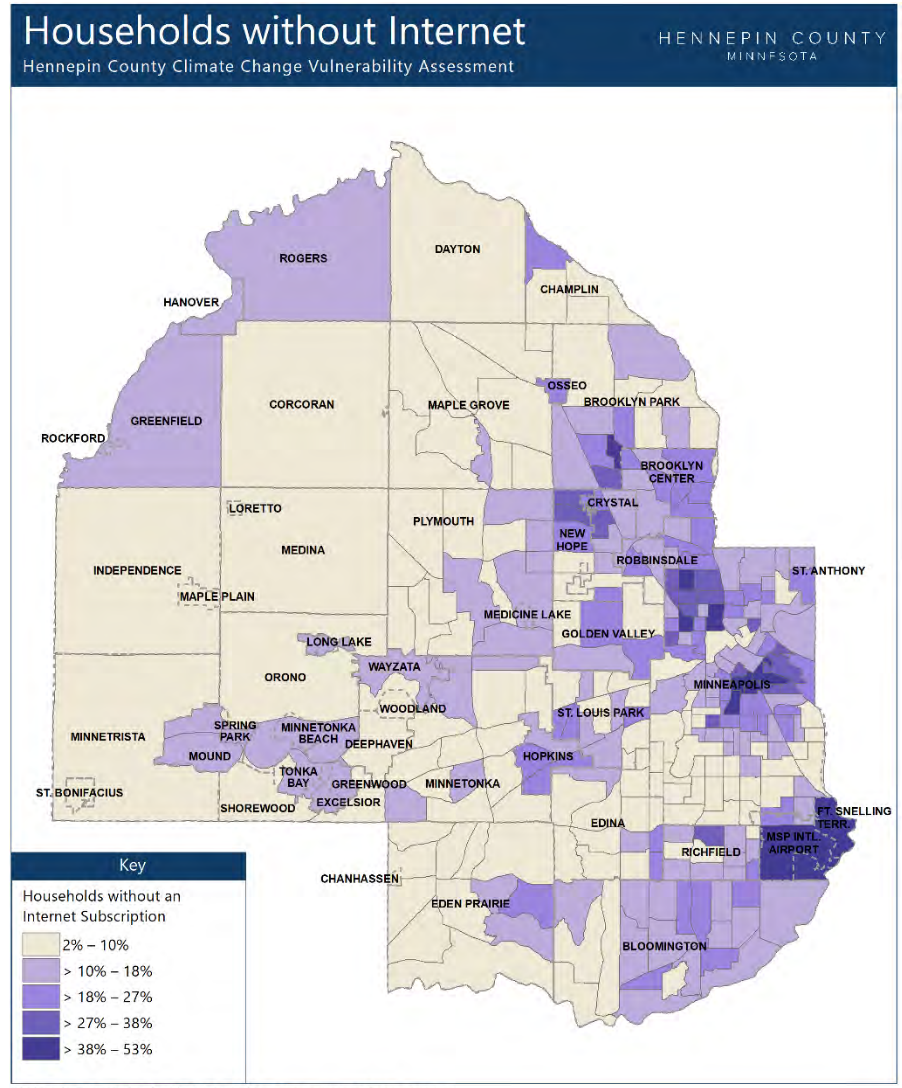
Map B-11 Households with children

Children may be more vulnerable to the impacts of climate changes, especially when they live in impoverished households. This map shows the percentage of households with children under 18 years old, by census tract.



Map B-12 Households without an internet subscription

Households lacking an internet subscription are at a disadvantage when preparing for or responding to the impacts of climate change. They will have less access to information, financial services, government services, etc. This map depicts the percentage of households without an internet subscription, by census tract. The map does not consider phone-based internet access due to lack of data.



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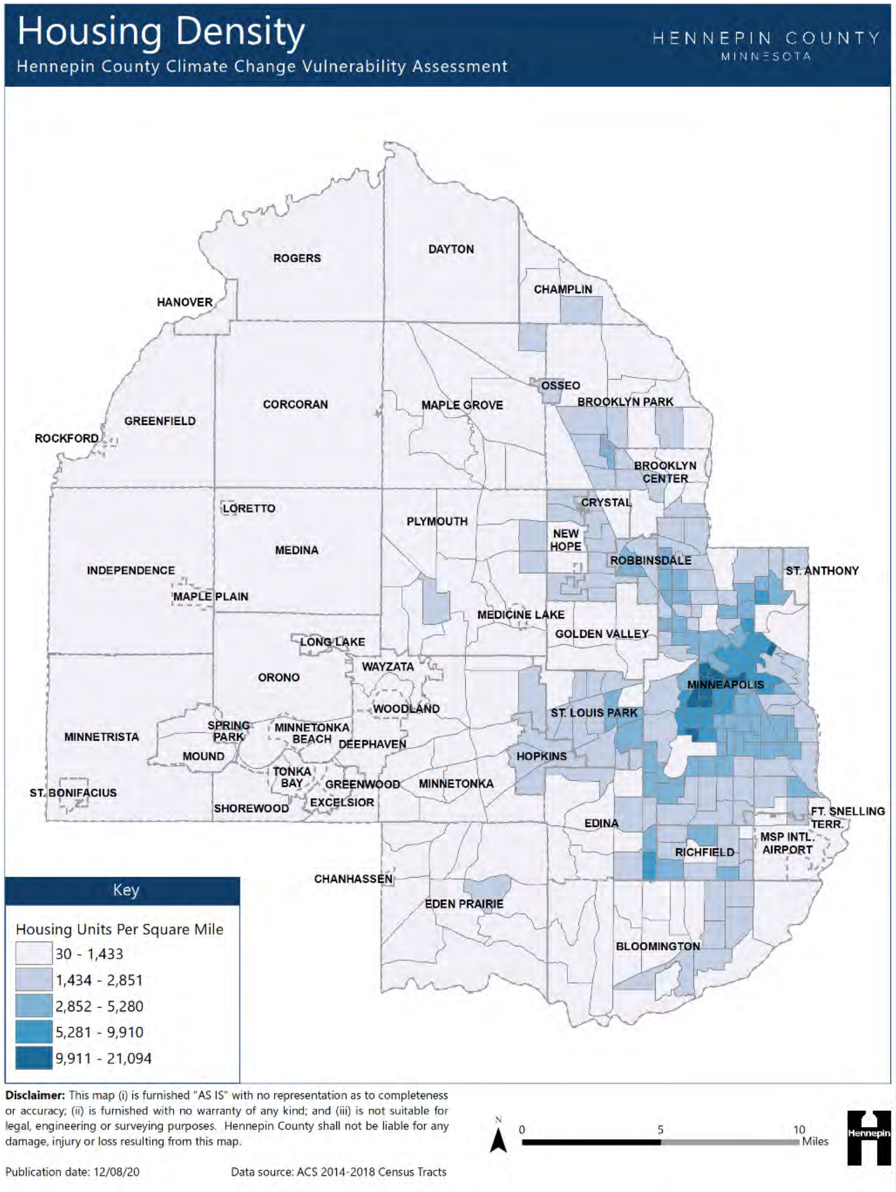
0 5 10 Miles

Publication date: 12/08/20

Data source: ACS 2014-2018 Census Tracts

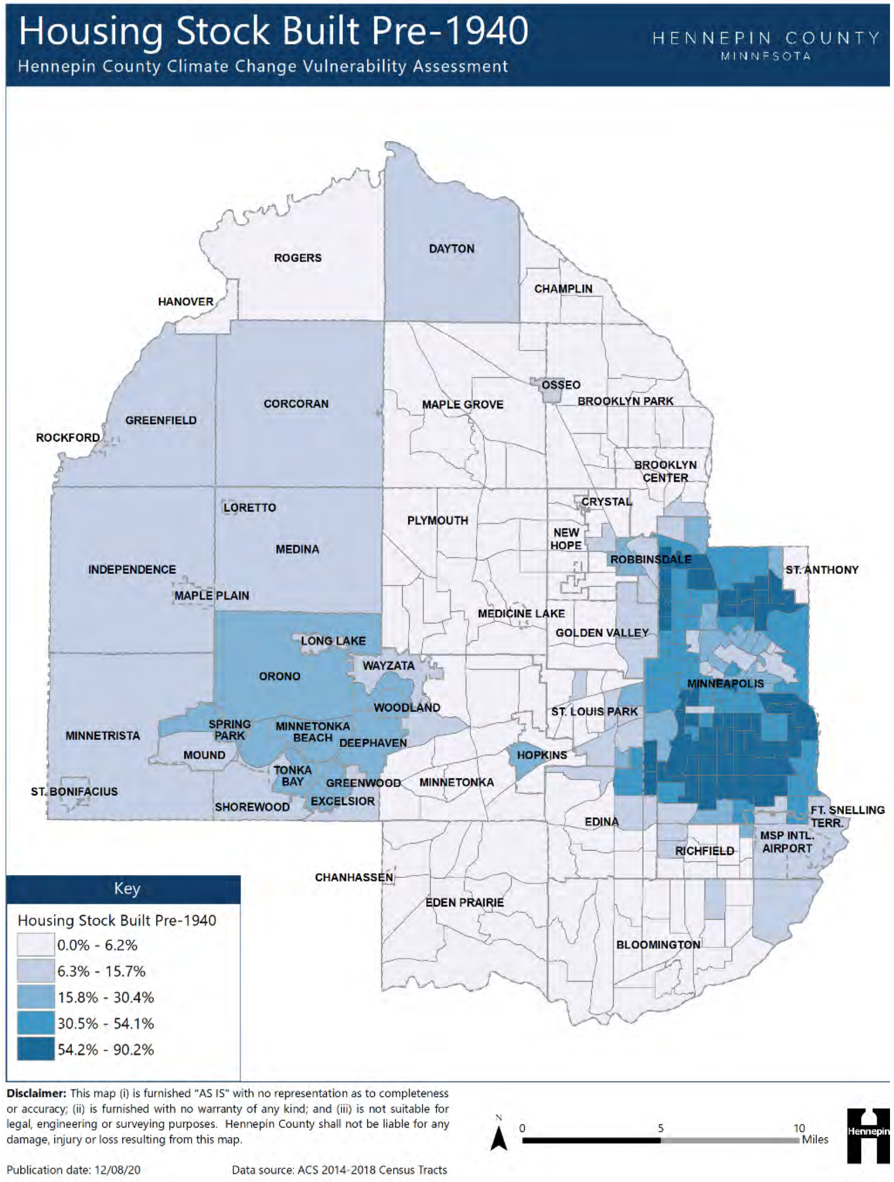
Map B-13 Housing density

Greater density translates to more individuals potentially vulnerable to climate change and a greater demand for resources in times of extreme need.



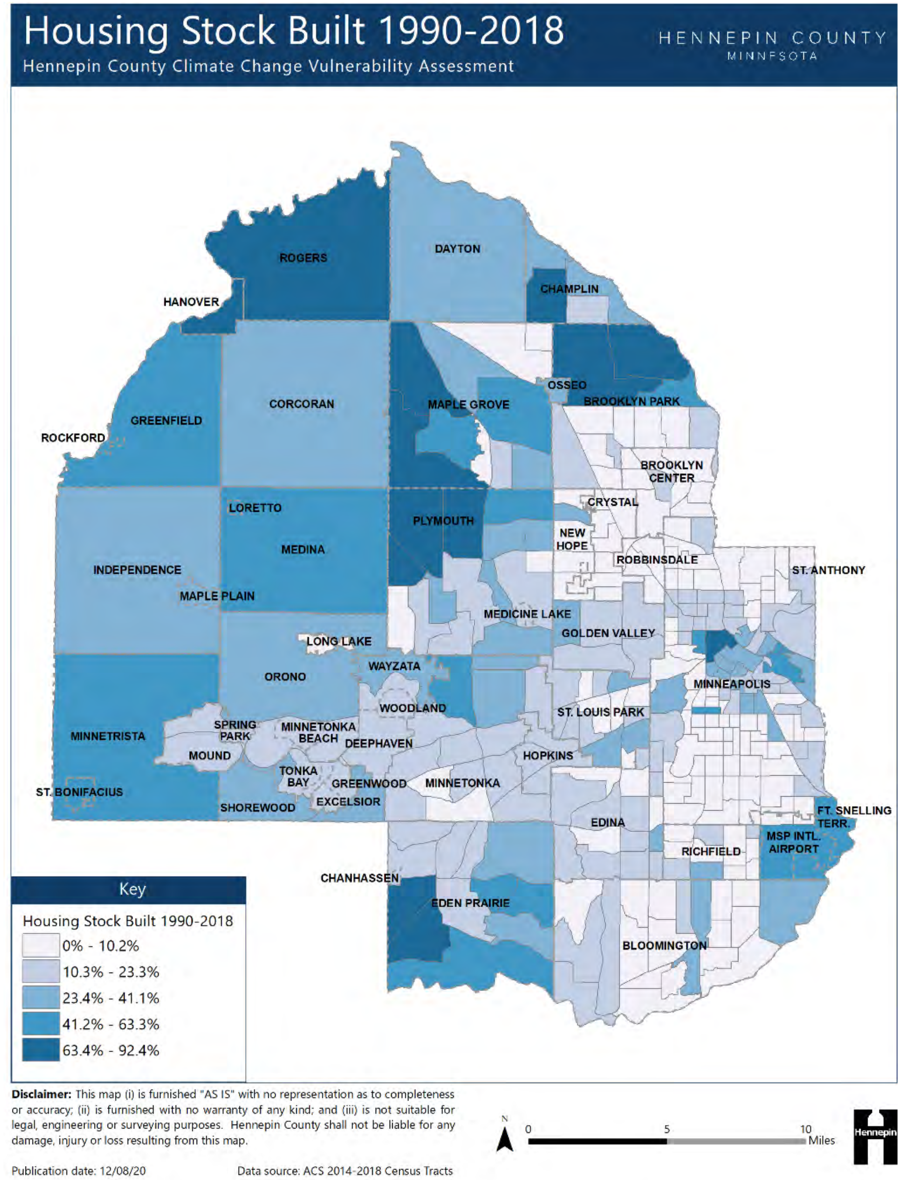
Map B-14 Housing stock built pre-1940

Older housing stock is less energy efficient than newer housing stock. Costs of air conditioning increase.



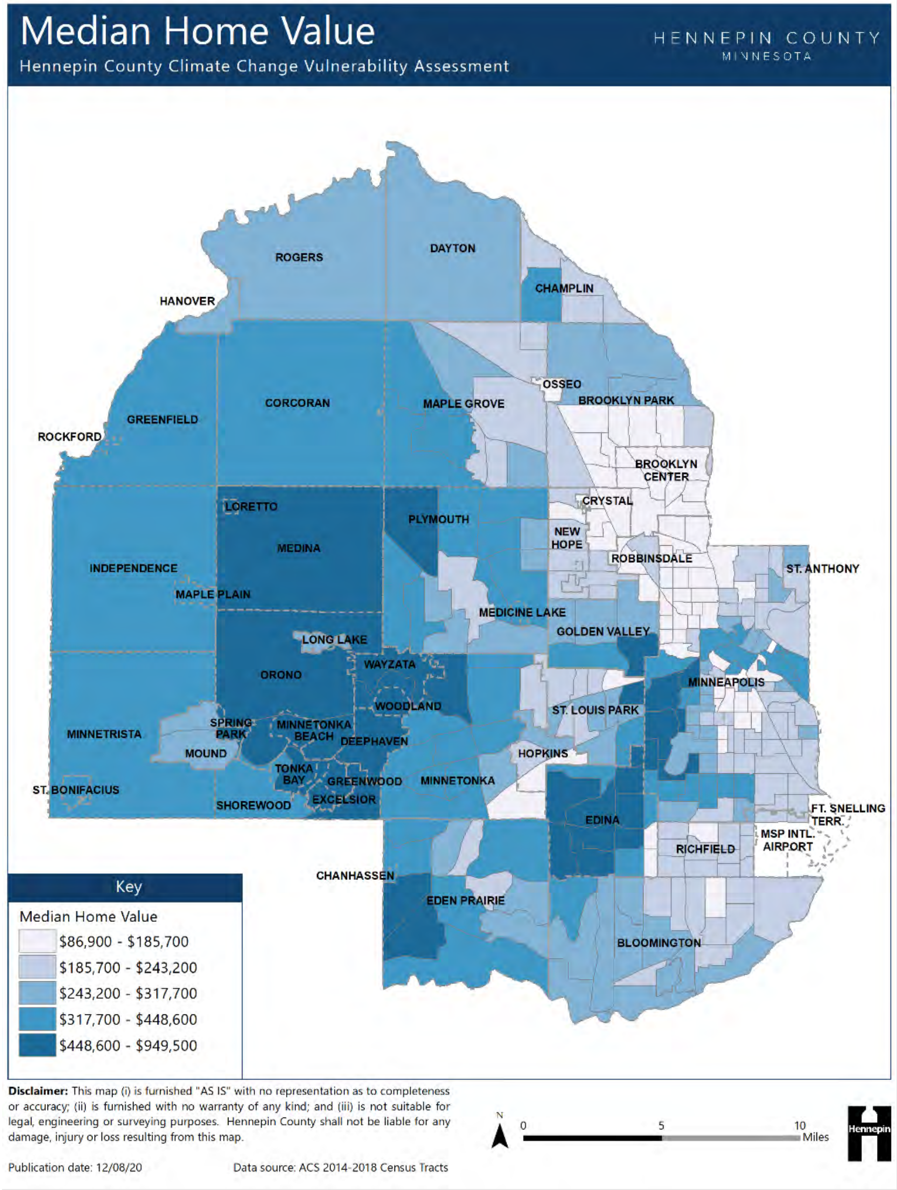
Map B-15 Housing stock built 1990 to 2018

This map was created to illustrate the percentage of housing stock built after the Wetlands Conservation Act of 1991. Stock built before this period may have been constructed in areas susceptible to lowland flooding.



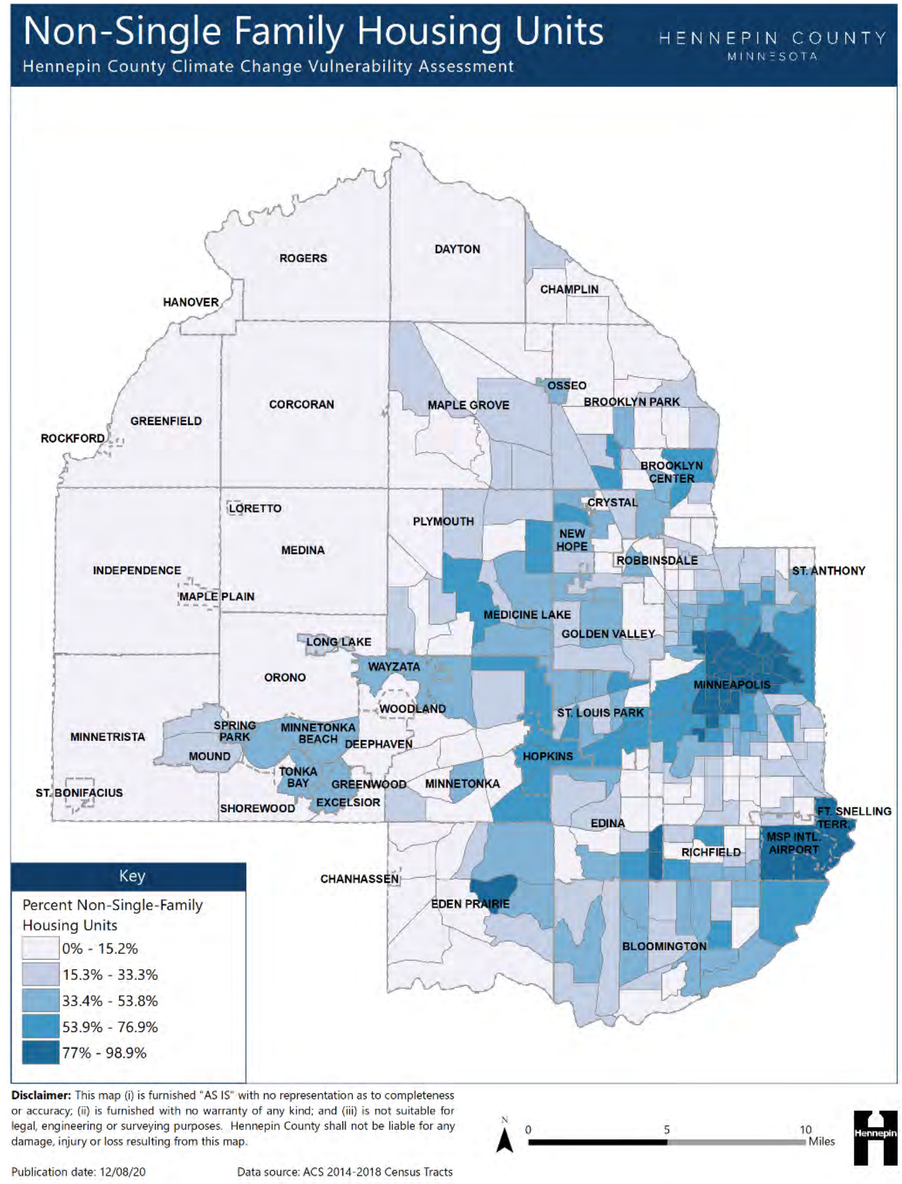
Map B-16 Median home value

This map illustrates median home value by census tract.



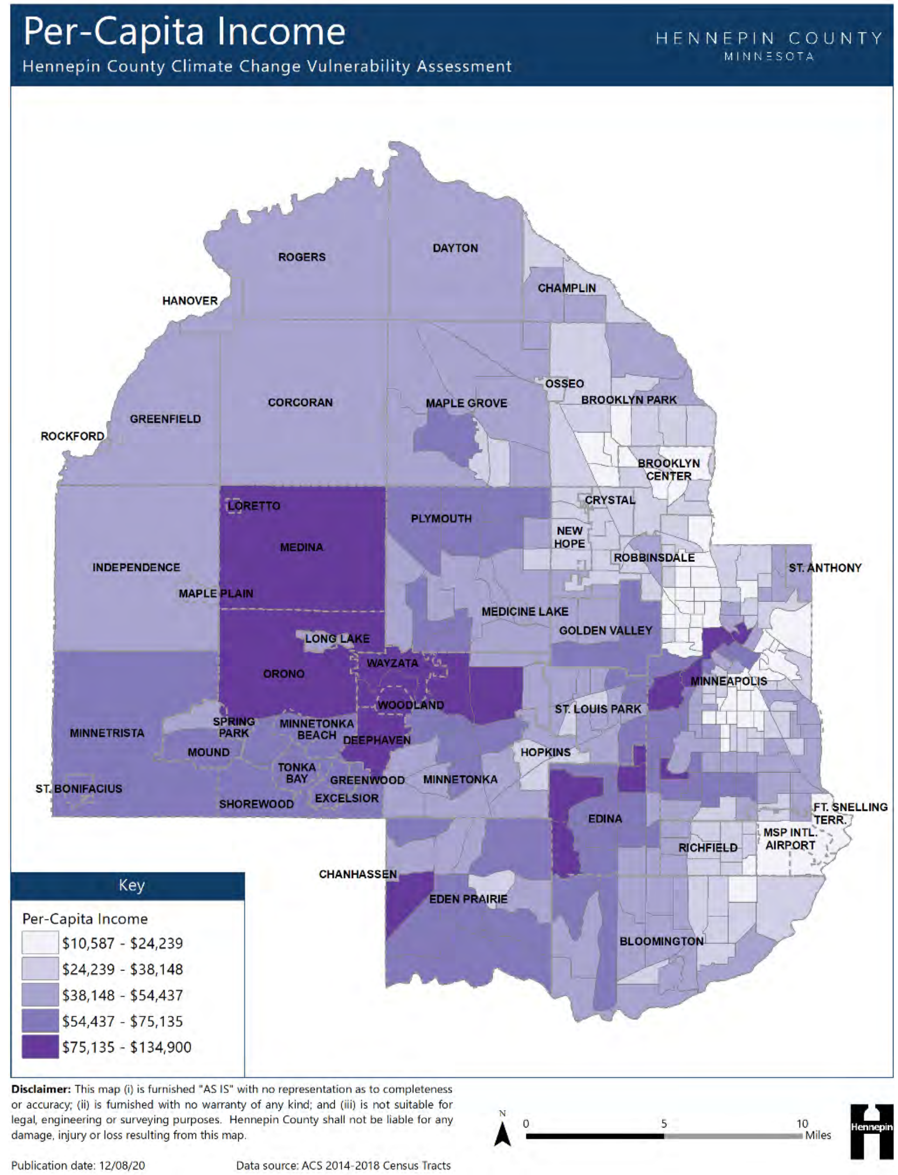
Map B-17 Non-single-family housing units

This figure shows the percentage of total housing units that are not single-family housing units, i.e., housing units in duplexes, three- or four-unit buildings, larger buildings, and manufactured or mobile home units.



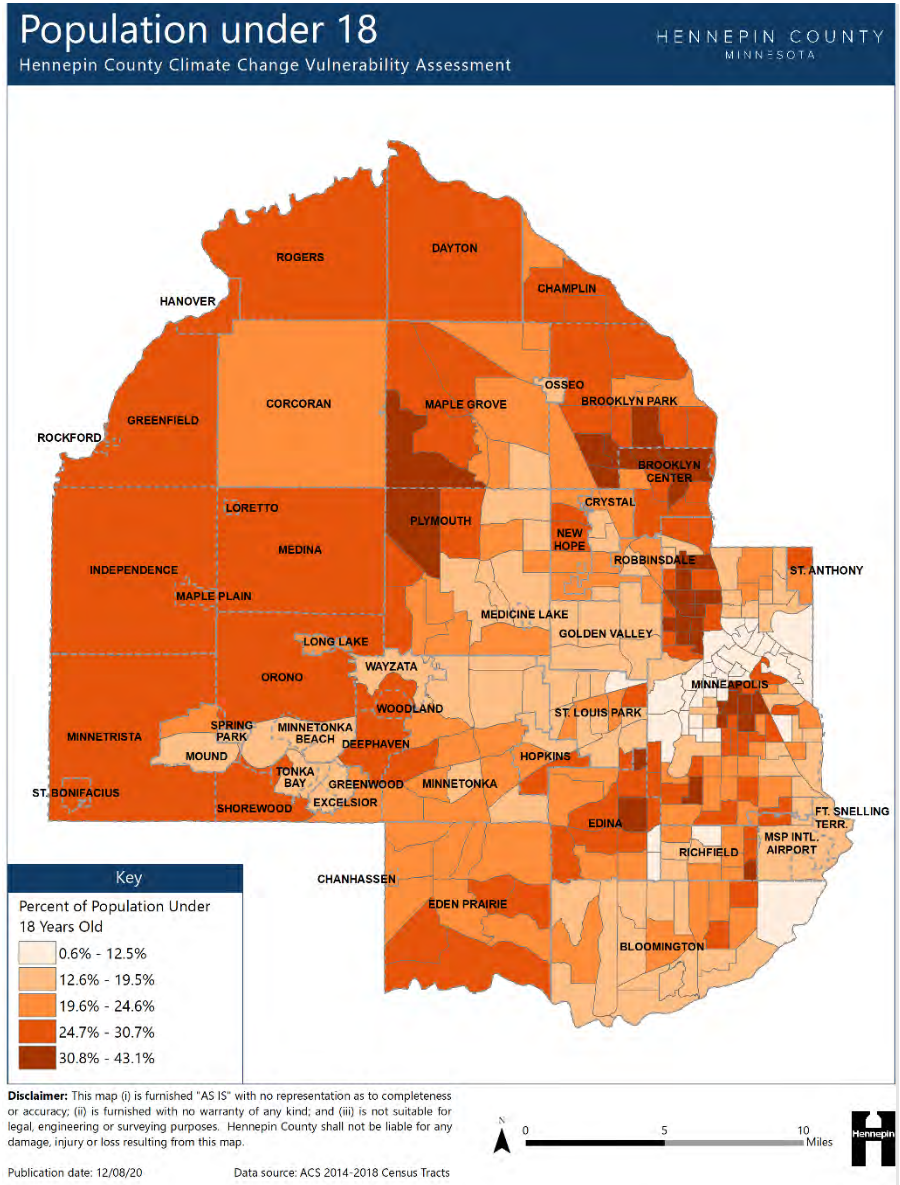
Map B-18 Per-capita income

Areas with low per-capita income have fewer resources available to address issues caused by climate change.



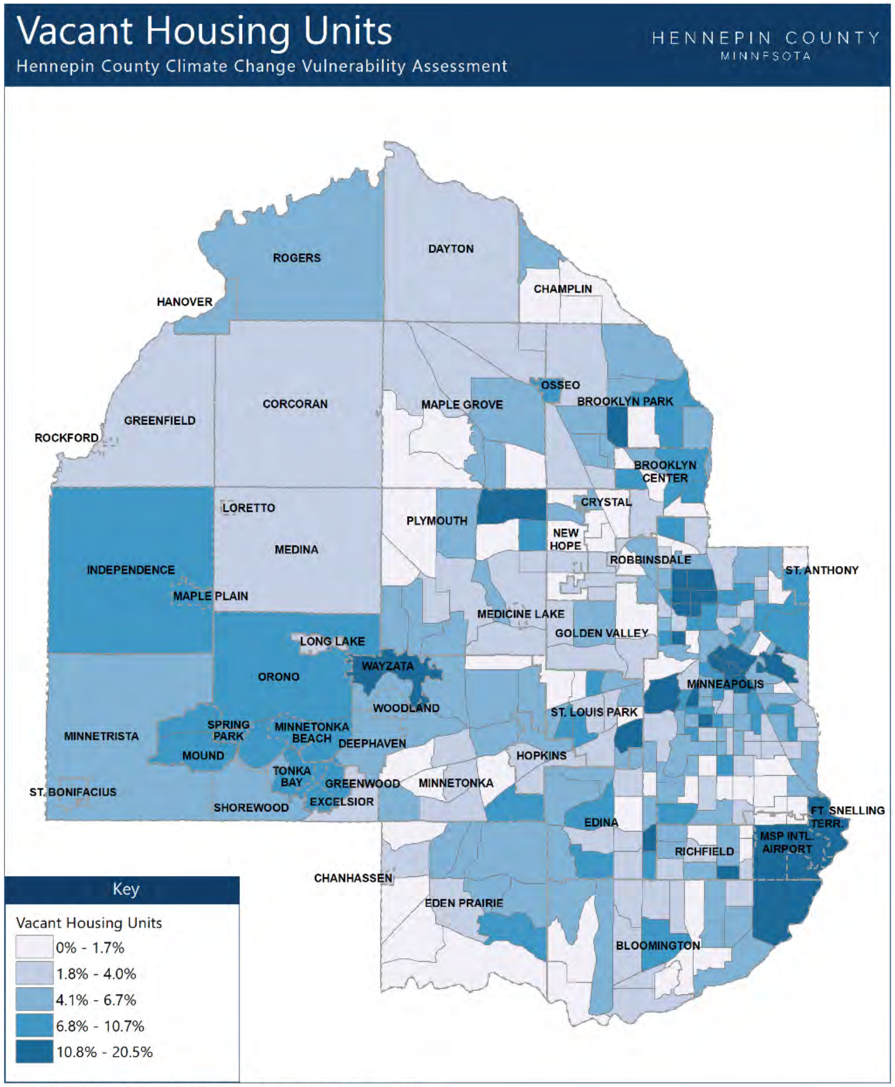
Map B-19 Population under 18

This map illustrates the percentage of the population under 18 years of age. Individuals 18 and under have fewer available resources (financial, information, etc.) to deal with climate change.



Map B-20 Vacant housing units

This map shows the percent of housing units that are vacant.



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