CITY OF PLYMOUTH
AGENDA
Regular Environmental Quality Committee
Medicine Lake Room
3400 Plymouth Boulevard, Plymouth, MN
March 11, 2026, 7:00 PM

1. CALL TO ORDER

2. PUBLIC FORUM - Individuals may address the committee about any item not contained on the regular agenda. A maximum of three minutes is allotted per individual with a total of 15 minutes for the forum. If the full 15 minutes are not needed for the forum, the committee will continue with the agenda. The committee will take no official action on items discussed at the forum, with the exception of referral to staff for future report.

3. PRESENTATIONS AND PUBLIC INFORMATION ANNOUNCEMENTS

4. APPROVE AGENDA - Environmental Quality Committee members may add items to the agenda for discussion purposes or staff direction only. The committee will not normally take official action on items added to the agenda.

5. CONSENT AGENDA - These items are considered to be routine and will be enacted by one motion. There will be no separate discussion of these items unless a committee member or individual so requests, in which event the item will be removed from the consent agenda and placed elsewhere on the agenda.

5.1 Adopt proposed minutes
1. EQC 02-11-2026

6. GENERAL BUSINESS

6.1 Climate Action and Resiliency Plan Update
1. City of Plymouth Climate Action Baseline Assessment
2. Plymouth Climate Vulnerability Assessment
3. Plymouth GHG Inventory Report
4. Plymouth Ground Cover, Heat Island, and Carbon Sequestration Study
5. Plymouth Renewable Potentials Study

6.2 Water Resources Education and Outreach Plan
1. Draft Water Resources Education and Outreach Plan

6.3 Plymouth Environmental Academy

7. REPORTS AND STAFF RECOMMENDATIONS

8. FUTURE MEETINGS -

8.1 Upcoming Events

9. ADJOURNMENT

Regular Environmental Quality Committee
March 11, 2026
Agenda Number: 5.1

To:	Dave Callister, City Manager
Prepared by:	Ben Scharenbroich, Water Resources Supervisor
Reviewed by:	Michael Payne, City Engineer/Deputy Public Works Director
Item:	**Adopt proposed minutes**

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1. Action Requested:
Adopt proposed Environmental Quality Committee minutes from February 11, 2026

2. Background:
N/A

3. Budget Impact:
N/A

4. Attachments:
1. EQC 02-11-2026

Proposed Minutes
Environmental Quality Committee Meeting
February 11, 2026

Acting Chair Babcock called a Regular Meeting of the Plymouth Environmental Quality Committee to order at 7:00 p.m. in the Medicine Lake Room of City Hall, 3400 Plymouth Boulevard, on February 11, 2026.

COMMITTEE MEMBERS PRESENT: Committee members Babcock, Matthiesen, Polzin, and Tinjum.

COMMITTEE MEMBERS ABSENT: Committee members Vavreck, Dmytrenko, and Blakely.

STAFF PRESENT: Water Resources Supervisor Scharenbroich, Environmental Stewardship Coordinator Anderson, Deputy City Clerk Gottschalk, and City Engineer/Deputy Public Works Director Payne.

OTHERS PRESENT: Councilmember Gregor.

Plymouth Forum

There was no one present to address the Committee.

Presentations and Public Information Announcements

There were no presentations or public information announcements.

Approval of Agenda

Motion was made by Committee member Polzin and seconded by Committee member Matthiesen to approve the agenda as presented. With all members voting in favor, the motion carried.

Consent Agenda

Motion was made by Committee member Matthiesen and seconded by Committee member Polzin to approve the consent agenda that included the following item:

(5.1) Adopt January 14, 2026, Regular Environmental Quality Committee Minutes

With all members voting in favor, the motion carried.

General Business

(6.1) Training session on open meeting law, data practices, conflict of interest, gift law, and rules of order

Deputy City Clerk Gottschalk conducted a training session with the committee on open meeting law, data practices, conflict of interest, gift law, and rules of order.

(6.2) Election of environmental quality committee chairperson and vice chairperson

Water Resources Supervisor Scharenbroich stated that each year, a chairperson and vice chairperson are elected.

Motion was made by Committee member Polzin and seconded by Committee member Matthiesen to elect Committee member Tinjum as chairperson and Committee member Vavreck as vice chairperson of the EQC for 2026. With all members voting in favor, the motion carried.

(6.3) Review and approve the environmental quality committee mission/organization statement

Water Resources Supervisor Scharenbroich commented that a redline version was provided in the packet, which incorporated the comments from the discussion at the last meeting. He stated that the document adopted tonight will be presented to the city council, and the council could determine if any changes are necessary.

The committee had additional discussion and suggestions for the organization statement.

Motion was made by committee member Polzin and seconded by Committee member Matthiesen to approve the environmental quality committee mission/organization statement as discussed.
With all members voting in favor, the motion carried.

(6.4) Plymouth environmental academy

Water Resources Supervisor Scharenbroich stated that at the last meeting, there was a lengthy discussion about the environmental academy and potential changes to the program, including reframing, renaming, and marketing for the events. He recognized that the EQC members want to remain as the primary coordinators, and tonight they should discuss the reframing and rebranding ideas. He suggested that there be quarterly talks on the topics rather than academy sessions.

The committee had further discussion on the concept of hosting talks as a series on different environmental topics. A committee member stated that they would support staff talking over the coordinator role for the series, with the EQC falling into the supportive role.

Water Resources Supervisor Scharenbroich noted that the intent would not be to create additional work for staff but to feature topics within the series that staff are already working on and to provide information that homeowners could also implement.

A committee member suggested that they become more focused, choosing a theme that could be reiterated at each series, which would show progress towards that item or goal at the end of the year. They also suggested that short video clips from the speaker be used to share that message on the website for people to revisit and for those who were not able to attend in person.

A committee member suggested that they coordinate with other events already planned, using the example of an event at the maintenance facility, where a table could be set up and could provide information on salt use.

Water Resources Supervisor Scharenbroich commented that staff were already planning to do that. He noted that they could plan two tour events and then provide some supplemental education at other events. He noted that he can bring back additional details at the next meeting and will speak with communications about potential branding. He noted that perhaps the branding is that the EQC is hosting two tours, one in the spring and one in the fall.

Reports and Staff Recommendations

Water Resources Supervisor Scharenbroich recognized that spring is a busy time, and a list of events was provided in the packet through the end of March.

Future Meetings

Noted.

Adjournment

Acting Chair Babcock adjourned the meeting at 8:09 p.m.

Regular Environmental Quality Committee
March 11, 2026
Agenda Number: 6.1

To:	Environmental Quality Committee
Prepared by:	MK Anderson, Environmental Stewardship Coordinator
Reviewed by:	Michael Payne, City Engineer/Deputy Public Works Director
Item:	**Climate Action and Resiliency Plan Update**

1. Action Requested:
Discuss Climate Action and Resiliency Plan.

2. Background:
Implementation of a Climate Action Plan has been identified as a strategy under the Council's strategic priority of Environmental Stewardship. The city selected paleBLUEdot as the consultant to lead development of a Climate Action and Resiliency Plan. In late 2025, paleBLUEdot completed baseline assessments, including a greenhouse gas inventory, climate vulnerability assessments, a ground cover study, and a renewable energy potential study. These assessments will inform development of the full Climate Action and Resiliency Plan. paleBLUEdot will present the baseline findings, which are attached. Staff requests feedback on the preliminary goals outlined in the assessments.

3. Budget Impact:
N/A

4. Attachments:
1. City of Plymouth Climate Action Baseline Assessment
2. Plymouth Climate Vulnerability Assessment
3. Plymouth GHG Inventory Report
4. Plymouth Ground Cover, Heat Island, and Carbon Sequestration Study
5. Plymouth Renewable Potentials Study

City of Plymouth

Climate Action Baseline Assessment and Strategic Goal Recommendations

December, 2025
Revised 2/04/26

Prepared by:

making change personal
paleBLUEdot LLC

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Appendix B	**Summary of Estimated New Job Potential of Modeled Reductions**

Plymouth

Section 01 Introduction

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Background

In July 2025, the City received a Climate Planning Grant from the Minnesota Pollution Control Agency (MPCA) and engaged paleBLUEdot to prepare a series of baseline assessment documents to inform development of its Climate Action and Resilience Plan (CARP). The CARP will serve as the City's roadmap for equitably advancing climate action and strengthening community resilience. This Climate Action Baseline Assessment and Strategic Goal Recommendations document is one of multiple planning process documents, referred to as "Baseline Documents" being created to support the planning team in their work.

The intent of this document is to summarize some of the key preliminary findings and considerations found in the work from all of the Baseline Documents for each of the plan sectors anticipated in the final CARP plan. The document seeks to facilitate collaborative dialogue and action identification by the CARP Planning Team. Each section includes preliminary strategic goals. The strategic goal recommendations included in this document should be understood as **preliminary only** and created solely for the purpose of supporting a fully collaborative planning team process in which planning team members are empowered to identify and finalize the goals which will guide the CARP.

Plymouth CARP Baseline Documents

In addition to this recommendations document, paleBLUEdot has created four foundational research documents which are available to the team in support of their work. These documents may also serve the City in identification of metrics and data to collect and maintain through the CARP implementation timeframe to support evaluation of the plan's progress. The foundational documents most relevant to each section of this Baseline Assessment are shown, and linked, in the title band of each section. The foundational documents include (click icon to view):

Climate Vulnerability Assessment

Greenhouse Gas (GHG) Inventory

Renewable Energy Potentials Study

Ground Cover, Heat Island and Carbon Sequestration Study

Introduction

Climate Action and Resilience Plan Framework

Achieving citywide climate action and resilience advancements requires addressing considerations across a wide range of sectors. This Climate Action Baseline and Strategic Goal Recommendations report is organized around a unifying framework of equitable community driven solutions , and includes eight citywide sectors. Each sector has over-arching Strategic Goals (or "Strategies") established to organize or provide direction for detailed implementation actions which are to be created in collaboration with the CARP Team.

Addressing Climate Change

Sector Strategies include considerations for Climate Change Mitigation, Climate Adaptation, or both. Sectors which have GHG reduction potential summarize the estimated GHG reductions possible through successful implementation of the draft recommended strategies. The total potential GHG reduction is summarized on the following pages.

Climate Action Sectors

The City of Plymouth Climate Action and Resilience Plan will include the following community-wide sectors:

- Transportation and Land Use
- Buildings and Energy
- Waste Management
- Water and Wastewater
- Local Food and Agriculture
- Greenspace and Ecosystems
- Health and Safety
- Climate Economy

Strategies: are specific statements of direction that expand on the Climate Action vision GHG reduction goals and guide decisions about future public policy, community investment, and actions.

Actions: are detailed items that should be completed in order to carry out the vision and strategies identified in the plan.

Climate Mitigation: addresses the root causes of climate change through the reduction or prevention of greenhouse gas (GHG) emissions.

Climate Adaptation: seeks to lower the risks posed by the impacts of climate change which are now inevitable or likely.

Introduction

Climate Mitigation Goals in Global Context

Considering a plan's GHG emission reduction goals within a global context can help validate the appropriateness of the goal. An effective approach for evaluating goals within that global context is to consider the most current GHG emission reduction recommendations formulated by the Intergovernmental Panel on Climate Change (IPCC). The scientific consensus of the international IPCC working groups is to reduce global GHG emissions as needed in order to limit global warming to 1.5°C. In addition, the Paris Agreement aims to limit global warming to 1.5 to 2 degrees C above pre-industrial levels, considered to be the threshold for dangerous climate change.

The UNEP Emissions Gap Report published in November 2019 established science-based GHG reduction goals. That report calculates that by 2030, global emissions will need to be 25% lower than 2018 and 80% lower by 2050 to put the world on the least-cost pathway to limiting global warming to below 2°C. To limit global warming to 1.5°C, the same report finds emissions would need to be 55% lower than in 2018 by 2030 and carbon neutral by 2050.

The City's Long-Range Goal and Recommended Interim Goal

To be in alignment with the IPCC science-based GHG reduction goals, this Baseline Assessment recommends establishing an interim goal for 2035 citywide GHG emission reductions of 44% below 2016 levels.

paleBLUEdot suggests the City's CARP planning team finalize interim 2035 goals for all sectors and detailed actions to achieve them. By taking this approach, the City will have greater ability to track near-term progress against a long-range goal decades away. This will enable the City to closely monitor the implementation of the first phase of Climate Action and Resilience Plan efforts prior to establishing the next interim goal and detailed actions through the next phase.

Based on the illustrated potential reductions included in this document and summarized on the next page, we recommend the following as a preliminary GHG interim reduction goal statement for consideration by the planning team:

Interim Goal (draft)

Recommended City of Plymouth GHG interim reduction goal:

"To reduce citywide GHG emissions 38% below 2016 levels by 2035."

Long-Term Goal

City of Plymouth's long-term GHG climate action and resilience goal:

"To reduce citywide GHG emissions 80% below 2016 levels by 2050."*

* Goal aligns with IPCC recommended reduction targets for capping global warming to <2°C.

Introduction

Projected Emission Reductions Achieved by Draft Strategies

The following sections of this Baseline Assessment document include preliminary strategic goal recommendations for consideration by the planning team. These recommendations are based on the summary research presented in each section and are intended as preliminary statements for the purpose of supporting a collaborative team process which will result in the final strategic goal statements. These preliminary strategical goals generally align with current IPCC science-based GHG reduction goals.

Reductions through 2035 are shown in the chart below.

Share of Total Projected Potential Emission Reductions by Sector by 2035 from 2016 Baseline (preliminary estimate):

24.8%	Reductions Achieved + BAU Reductions
4.6%	Transportation Reductions
8.1%	Buildings and Energy Reductions
0.9%	Waste Management Reductions
0.2%	Water + Wastewater Reductions
61.3%	Remaining Emissions

BAU = 'Business-as-Usual' Reductions are anticipated reductions resulting from existing requirements or commitments, which are outside the scope of this plan.

Introduction

Preliminary Sector Strategic Goals

In line with the data outlined in the foundational documents, the following are initial goals for each of the Climate Action and Resilience Plan sectors. These are preliminary and meant to aid collaborative planning, empowering team members to shape final plan goals. More information can be found in the sections of this document.

Transportation and Land Use (click for section)

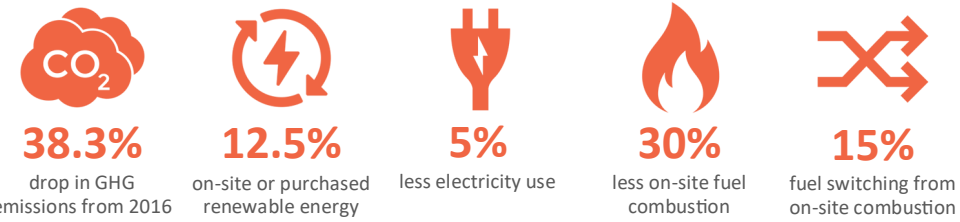
Enhancing the resilience of our community's mobility while reducing environmental impacts of transportation.

Potential 2035 Goals:

Buildings and Energy (click for section)

Increasing the resilience of our community's building stock while reducing environmental impacts through increased energy efficiency, use of renewable energy, and reduction of on-site combustion.

Potential 2035 Goals:



Waste Management (click for section)

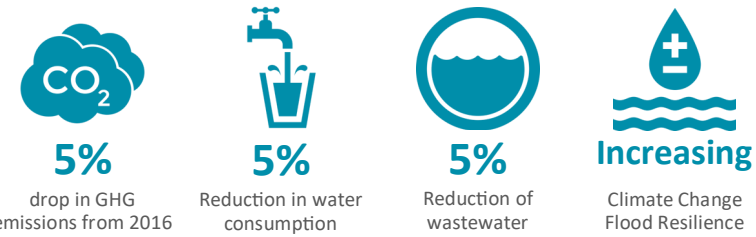
Reducing environmental impacts and increasing our community's sustainability through an increase in recycling and re-use of materials, organics collection, and a reduction in total waste generated.

Potential 2035 Goals:

Water and Wastewater (click for section)

Reducing impacts associated with water consumption and wastewater treatment while increasing our community's flooding and stormwater resilience.

Potential 2035 Goals:



Local Food and Agriculture (click for section)
Increasing resilience of our food systems, improving food access and security, and preserving agricultural land while reducing their impacts.

Potential 2035 Goals:

Growing
More locally produced food

Increasing
Access to local food

Reducing
hunger and food waste

Greenspace and Ecosystems (click for section)
Supporting community adaptation through expanded green infrastructure and enhanced ecosystem resilience.

Potential 2035 Goals:

3%
More tree canopy coverage

3%
Less turf / more prairie grass

3%
Less dark impervious surfaces

Increase
Climate Resilient land management

Health and Safety (click for section)
Improving community resilience through healthy community connections, infrastructure, and systems.

Potential 2035 Goals:

Reduce
Vulnerability

Increase infrastructure
Resilience

Increase community
Awareness

Economy (click for section)
Increasing the preparedness of our businesses and workforce and leveraging economic opportunity of climate action.

Potential 2035 Goals:

Grow
equitable climate workforce and entrepreneurship

Help
local businesses build climate resilience

Establish
sustainable funding for climate action implementation

Section 02

Transportation and Land Use

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Additional Information (click icon)

Vulnerability Assessment

GHG Inventory

Transporting people, products, and services is energy-demanding, and the vehicles used are resource -heavy. Off-road machinery, such as construction and recreational gear, also uses substantial fossil fuels and emits more greenhouse gases (GHGs) and pollutants per gallon than road vehicles due to inefficient combustion and lax emission controls.

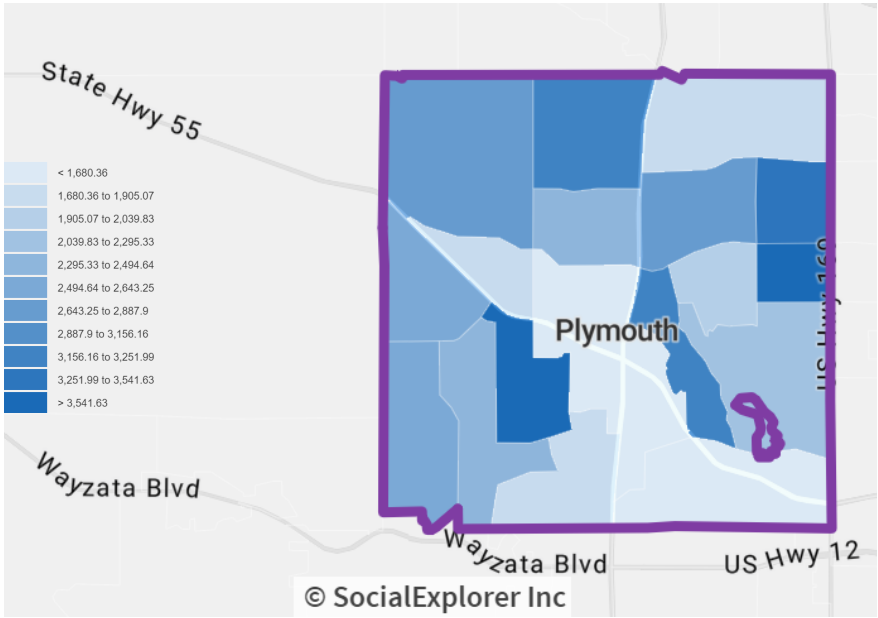
Transportation and machinery significantly affect the environment, contributing to 20%-25% of global energy use and CO2 emissions. In Plymouth, transport and land use generate 42% of the city's GHG emissions. While Vehicle Miles Traveled (VMT) may rise, emission rates could drop as we switch to electric vehicles and cleaner energy sources.

Enhancing our transport systems' sustainability can also boost living standards and fairness. Promoting shared transport and reducing reliance on single-occupancy vehicles can cut environmental damage and enhance equitable mobility. Cycling, e-bikes, and scooters offer health benefits and lower pollution. Furthermore, innovations in electric and autonomous vehicles and car-sharing could significantly streamline vehicle use, potentially clearing 90% of cars from the roads and improving transport options.

City of Plymouth Residential Density

The City's developed land totals 11,227 acres - 49.3% of the total area of the City.* This land supports a population of 80,067 for an average of 7.1 residents per developed acre. The map to the right shows the population density per square mile throughout the city.

* Source: Social Explorer Table T001 ; Land Area Coverage Environmental Summaries 2011; National Historical Geographic Information System (NHGIS)



Transportation and Land Use

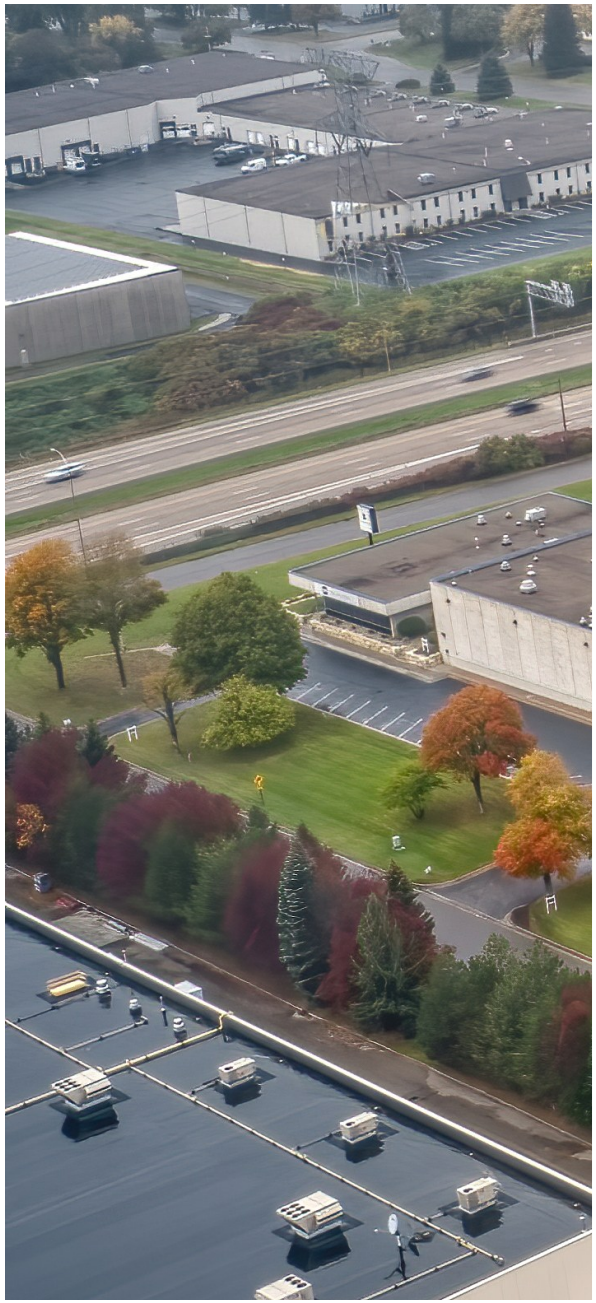
Plymouth Land Use Density Reduction Potential

The Metropolitan Council projections Plymouth's population to be 83,850 by 2035 for a growth of 5.4% and 91,700 by 2050 for a growth of 15.3%.

The study "The Influence of Urban Form on GHG Emissions in the U.S. Household Sector" (Lee, S., and Lee, B. 2014) shows that a 1% rise in urban density reduces household travel CO2 emissions by 0.48% and residential energy emissions by 0.35%. Consequently, zoning ordinances and land use policies promoting higher land density, combined with a focus on supporting alternative transportation, can lower community-wide emissions per household.

With policies guiding future population growth towards increased land use density rather than increased developed land area, the potential 5.4% population increase by 2035 could result in an increase of average population per developed acre from 7.1 to 7.5 residents per developed land use acre. Applying the figures established in the Lee study, this could equate to an emissions reduction of up to 2.7% for transportation related emissions compared to the same projected population at the city's current population density levels.

GHG emissions reduction associated with a 2.7% increased residential land use density by 2035: **9,010** Metric Tons.



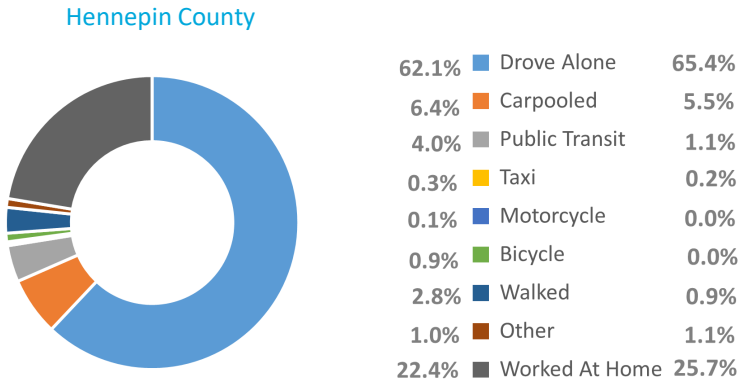
Transportation and Land Use

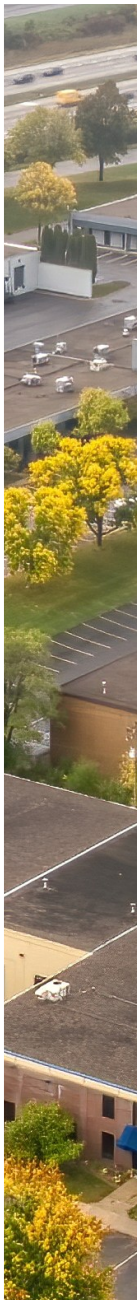
City of Plymouth Commute

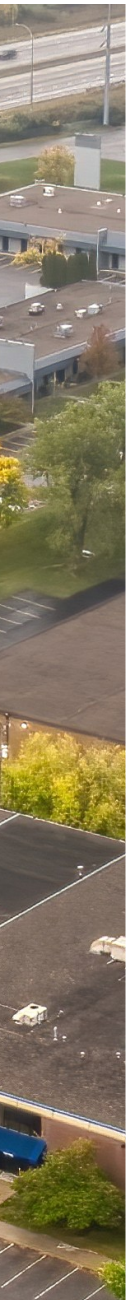
Since 2013, overall average commute time in the City of Plymouth has increased from 22.4 to 22.6 minutes. 91% of those employed in the city commute from outside the city while 81% of Plymouth residents who are employed commute to jobs outside of the city. The city has also seen some change in commuter modes with commuters driving alone decreasing 16.2% (from 81.6% to 65.4%), while working from home increased 20.4% while carpooling, public transit, walking, and biking to work all decreased. These trends indicate strategies focusing job development near residential density and encouraging alternative commute modes like public transit, carpooling, walking, and working at home will decrease commuter impacts.

Comparing the commuter trends of the City of Plymouth against the commuter trends of all of Hennepin County, the city could reduce it's transportation emissions by decreasing commuters driving alone as well as increasing commuters carpooling, biking or walking, and those working at home to match the county-wide averages. See charts below.

Commuter Transport Share by Mode 2021

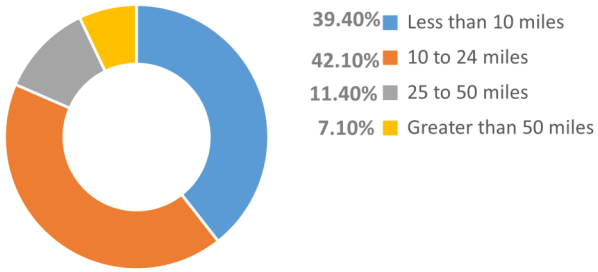






Transportation and Land Use

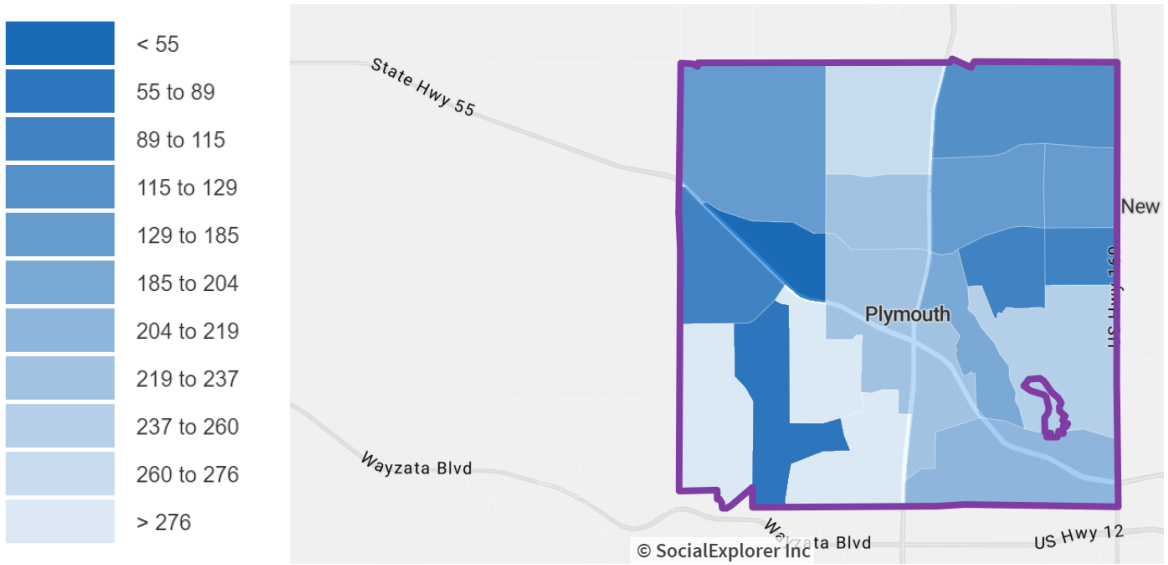
Commuter Share by Commute Distance



Plymouth Commuter Mode Share Reduction Potential

39% of all commuters in the City of Plymouth, over 21,000 workers, have a commute of less than 10 miles. Due to the shorter commute, the distances traveled by these workers may well support alternative transportation modes like walking or biking. For every 1% reduction in the number of solo drivers - by promoting alternative transportation methods, carpooling, telecommuting, and other tactics - could cut vehicle miles traveled by almost 2.8 million miles, save commuters $2.2 million and avoid up to **1,348** metric tons of greenhouse gases annually. The map below identifies areas in the city which may benefit most from actions to support alternative commuting for shorter-distance commuters.

Workers with 10 Minute or Less Commute Time



Transportation and Land Use

Plymouth's Housing and Transportation Affordability

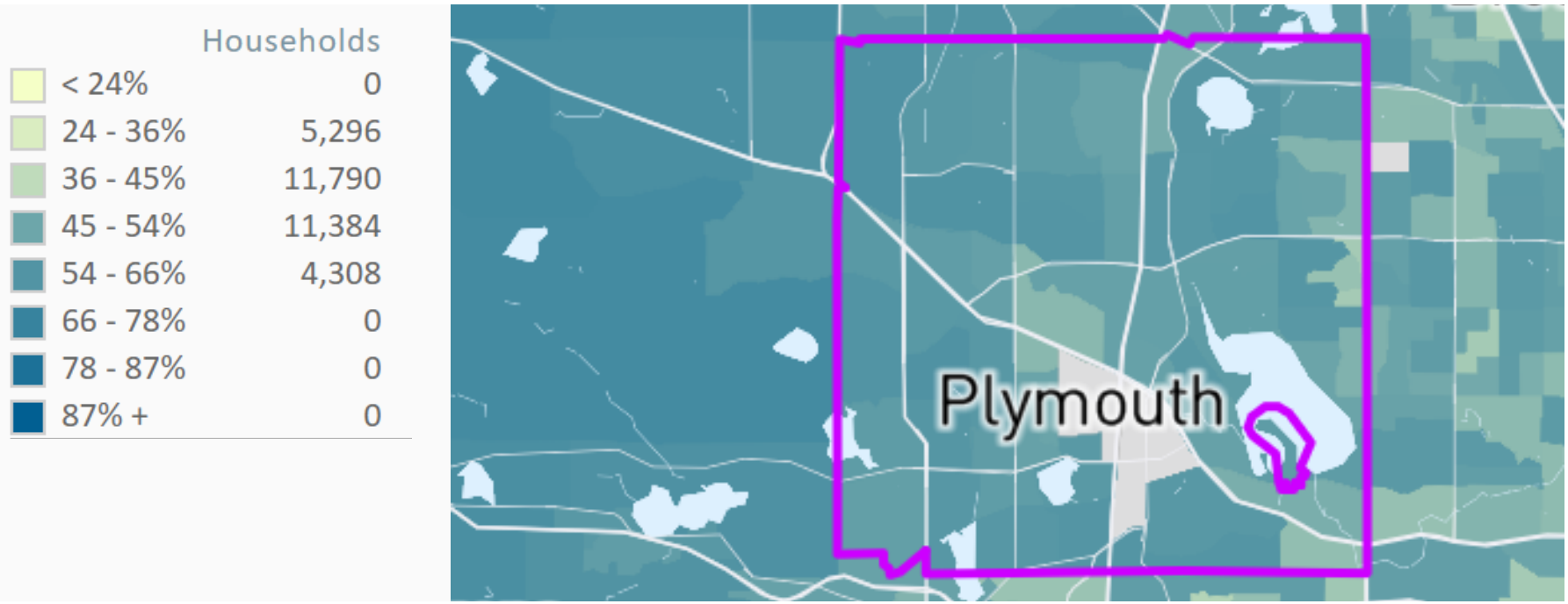
Land Use density, job locations, and transportation significantly impact living costs, particularly housing and transportation affordability. According to HUD, housing is affordable when the occupant is paying no more than 30 percent of gross income for housing costs, including utilities. According to the US Department of Energy, the average household spends 15-16% on transportation, setting a total transportation and housing burden of 45% of income. The map to the right, from Center for Neighborhood Technology, indicates the average Housing and Transportation affordability index for each of the census blocks within the City of Plymouth.

The Citywide average housing and transportation burden (H+T) is 44% (28% on housing and 16% on transportation). As shown on the Housing + Transportation Costs % Income, over 15,692 households - 47.8% of all in the City of Plymouth - have a combined H+T burden that is *more than* 45% of household income. This trend indicates strategies that continue to focus job development nearest sections of residential density, increased housing affordability, and increased affordable mobility options may support decreasing cost of living, particularly associated with transportation.

Housing + Transportation Costs % Income

H+T® Fact Sheet
TRUE AFFORDABILITY AND LOCATION EFFICIENCY

CNT



Transportation and Land Use

Plymouth's Walkability and Bike-ability

The measure of a community's walkability and bike-ability are an important metric of the community's ability to advance sustainable transportation. Bike and walk scores will vary across the City based on location specific parameters. Below are average transit, walk and bike scores for the City of Plymouth (Source: WalkScore.com). The citywide averages are moderate and indicate opportunity for increasing alternative mobility options such as walking, biking, and public transit.

Car-Dependent
Almost all errands require a car

Somewhat Bikeable
Minimal bike infrastructure

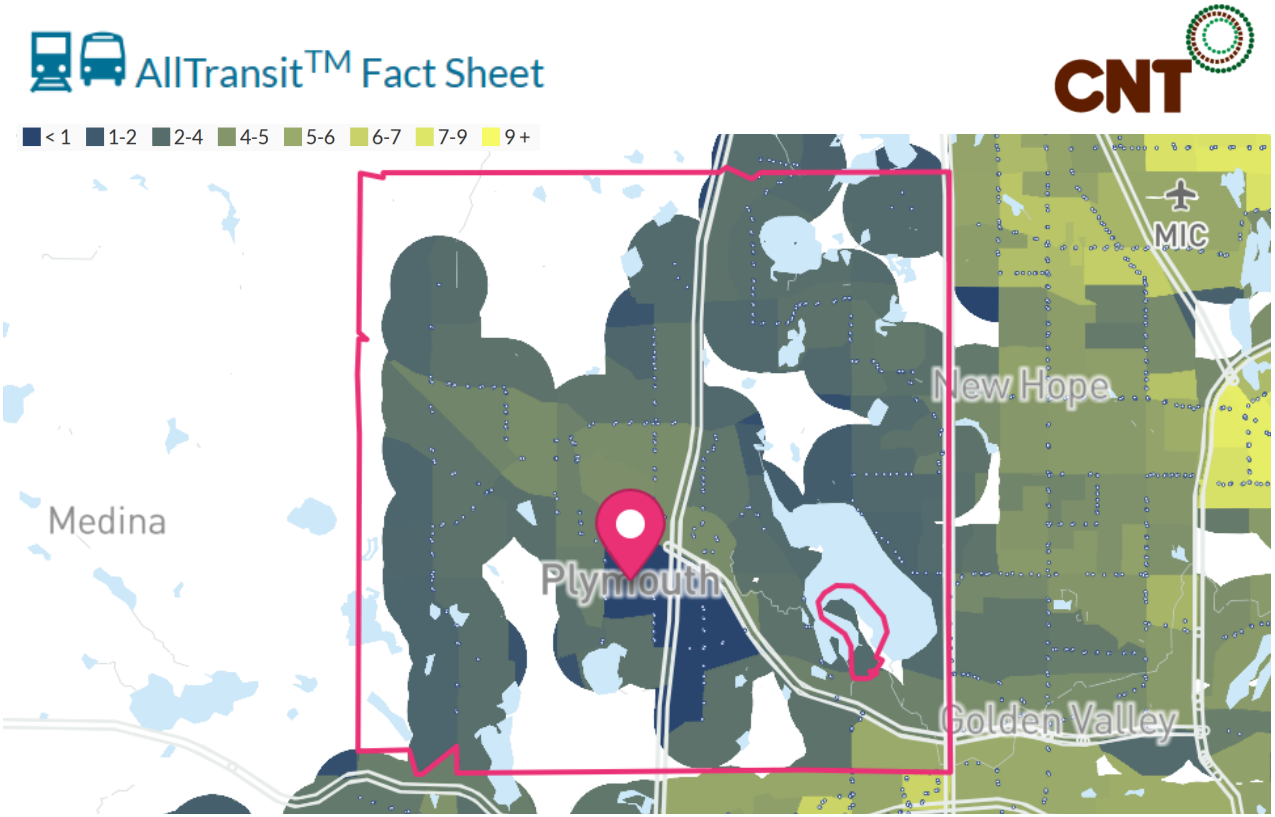
Plymouth Bike/Walk Reduction Potential

A 0.5% rise in biking or walking to work can cut vehicle miles by 1.4 million, save $1.1 million, and reduce **674** metric tons of GHG emissions. If 2.7% of commuters with under 10-mile commutes switched, this impact could be achieved.

Transportation and Land Use

Public Transit Indicators

The map below illustrates the community area served by transit options and the corresponding "Performance Score". Areas of lighter color have higher performance scores which represent a mixture of overall trips per week, number of jobs accessible, number of weekly commuters using the transit options, and equity of transit system. (Source: Alltransit)



Plymouth's Transit Score

AllTransit score rating at connectivity, access to jobs, and frequency of service:

AllTransit ™ Performance Score

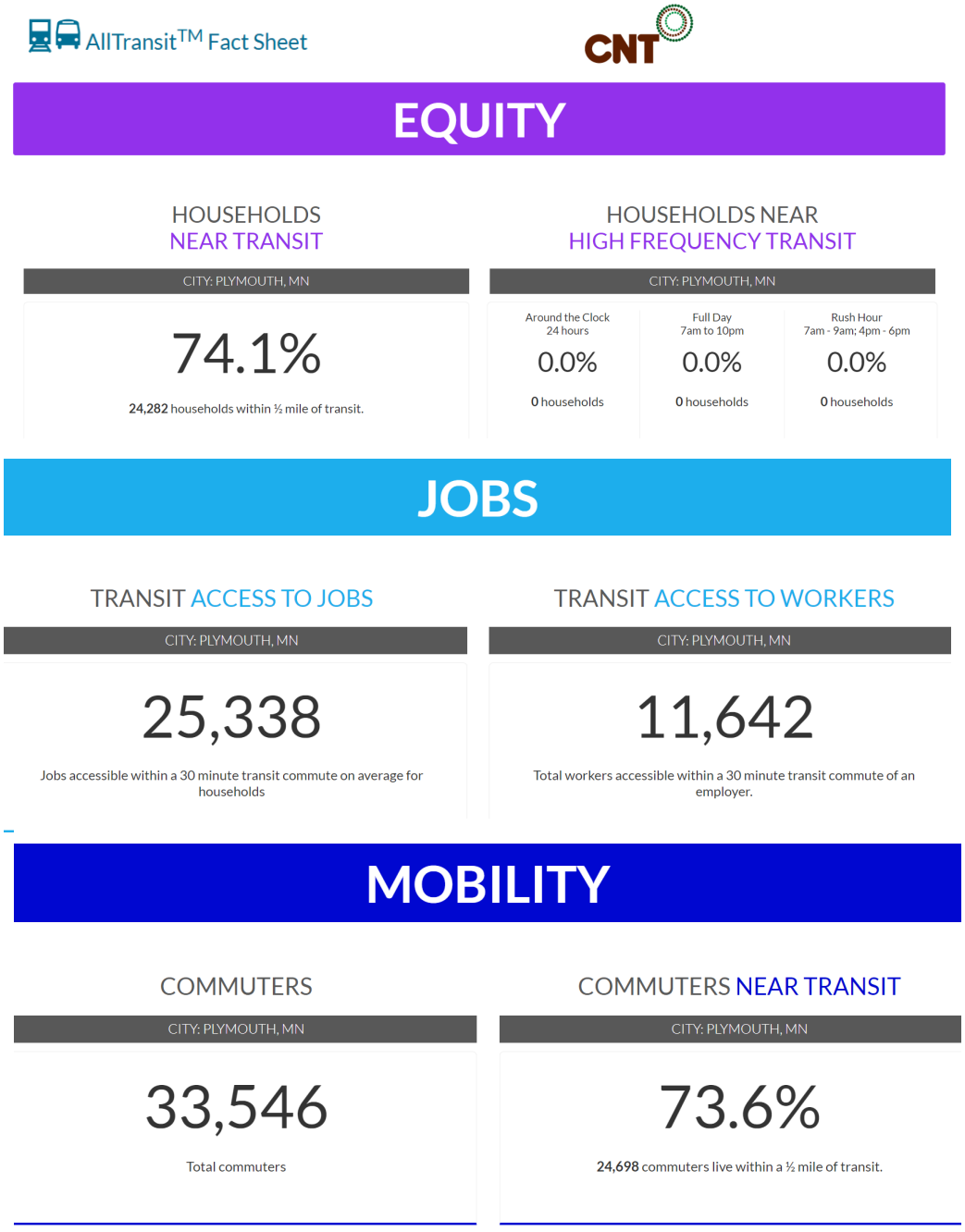
2.1

City: Plymouth, MN
Very low combination of trips per week and number of jobs accessible enabling negligible number of people to take transit to work

On Average Households have:

132	Transit Trips per Week within ½ Mile
2	Transit Routes within ½ Mile
25,338	Jobs Accessible in 30-minute trip
1.36%	Commuters Who Use Transit

Source: AllTransit by Center for Neighborhood Technology: https://alltransit.cnt.org/



Transportation and Land Use

Plymouth Public Transit Reduction Potential

The average commute in the City of Plymouth is 22.6 minutes, or approximately 15 to 17 miles. Meanwhile, AAA estimates that the cost per mile for operating a vehicle is $0.77 while Metro Transit provides 30 day unlimited passes for $100.

Consequently, every 1% increase in commuter utilization of public transit in the City of Plymouth may decrease vehicle miles traveled by over 2.8 million miles, save commuters $1.55 million (after purchase of public transit fares) and avoid up to **1,348** metric tons of greenhouse gases annually. If just 5.4% of commuters with under 10-mile commutes switched, this impact could be achieved.

Transportation and Land Use

Vehicle Ownership in City of Plymouth

The US Census reveals that in Plymouth, 38% of households have one vehicle, 37% two, 12% three, 4% four, and 1% five or more. Citywide, 8% lack a vehicle. Around 345,000 vehicles are estimated in total.

Existing City of Plymouth Electric Vehicles and Infrastructure

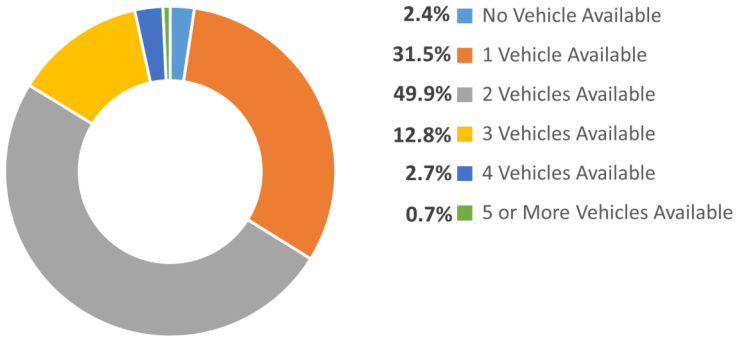
The chart to the right illustrates the total number of electric vehicles and charging infrastructure in the City of Plymouth compared with the state. As of December 2024, the City of Plymouth had an estimated 1,709 battery electric vehicles* (BEV). Comparing the City of Plymouth's EV rolling stock against statewide vehicle counts (47,599 BEVs), it is clear that the City's adoption rate is above the state average. The City's current public charging infrastructure, however, is slightly behind state average for DC Fast charging and at state average for Level II charging.**

Plymouth Electric Vehicle Reduction Potential

Transitioning this rolling vehicle stock from fossil fuel combustion to low and no emission alternative is critical in meeting significant long-range emissions reductions in this sector. For every 1% of vehicles converted to EV or low/no emission fuel alternatives up to **2,000** metric tons of GHG emissions can be eliminated annually after accounting for estimated increases in electricity emissions.

* Source: State of Minnesota Department of Transportation
** Source: US DOE Alternative Fuels Data: https://afdc.energy.gov/data_download

Vehicle Ownership by Household



Existing City of Plymouth Electric Vehicles and Infrastructure

Type of Electric Vehicle	Vehicles in State	Vehicles in City*	EV % of All Vehicles in City	City Share of State	Share Compared to Population Share
BEV	**47,599**	**1,709**	**2.9%**	**3.6%**	**2.6x population**
Electric Vehicle Charging	**Chargers in State**	**Chargers in City**		**City Share**	**Share Compared to Population Share**
DC Fast Ports	768	10		1.3%	0.9x population
Level II Ports	2,007	29		1.4%	1x population

EV Charging Infrastructure Required in the US by 2030

(serving 18.7 million EV's in use)

According to the Edison Foundation, Electric Vehicle stock in the United States is projected to reach 18.7 million in 2030, up from slightly more than 1 million at the end of 2018. This means EV's will make up at least 7% of the vehicles on the road by that time.

Sources: US Department of Energy, Alternative Fuels Data Center, US Census, Edison Foundation "Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030"

Graphic: "Electric Vehicle Sales Forecast and the Charging Infrastructure Required Through 2030"

Why Public EV Chargers Matter

1. Many People Can't Charge at Home.

Over a third of Americans live in apartments or rentals where installing a Level 2 charger isn't possible. Without public chargers, these drivers can't confidently switch to EVs.

2. Plug-In Hybrids Need Frequent Charging.

PHEVs are a key bridge to full EV adoption, and accessible charging helps ensure they deliver their intended environmental benefits. Meanwhile, PHEV drivers can cover most daily miles on electricity if they can plug in during the day. More public chargers = more electric miles, less gasoline use, and lower emissions.

3. Chargers Drive Local Spending.

When drivers stop to charge, they stay to eat, shop, or explore. Studies show nearby businesses see sales rise 1–3% after chargers are installed.

4. Visible Chargers Build Confidence.

Seeing chargers around town reassures residents that electric driving is practical — helping more people choose EVs.

Public charging is about more than convenience — it's about **access, equity, and opportunity**.

Learn more here: https://palebluedot.llc/carbon-copy/2025/10/24/four-reasons-communities-need-more-public-ev-charging-stations

Minimum EV Infrastructure Needed in The City of Plymouth by 2035

Anticipating EV charging equipment needs within the community is important in order to ensure barriers to electric vehicle adoption are overcome. NREL's Electric Vehicle Infrastructure Projection (EVI-Pro Lite) tool estimates the EV charging infrastructure needed in an area to meet demand. Developed with the California Energy Commission, EVI-Pro uses data on travel patterns, EV features, and charging station details to project the quantity and type of infrastructure required.

Based on the EVI-Pro Lite tool, the anticipated EV charging infrastructure for Plymouth is shown in the chart to below.*

Required Public EV Charger Ports for Preliminary EV Vehicle Share Target*

Example EV Share Target:	15%
Multi Family Ports	294
Public Charging Ports	365
Public DC Fast Charging Ports	18
Total	**678**

*https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports

Transportation and Land Use

Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Transportation and Land Use Strategic Goals:

TL 1: Decrease community wide Vehicle Miles Traveled (VMT) 5% by 2035.

TL 2: Increase public transit commuter ridership from 1.1% to 2.5% by 2035.

TL 3: Increase average population per developed acre by 4.2% by 2035. (from 7.1 to 7.4 ppl/acre—goal is equal to 50% of Met Council projected community growth occurring within existing developed acreage)

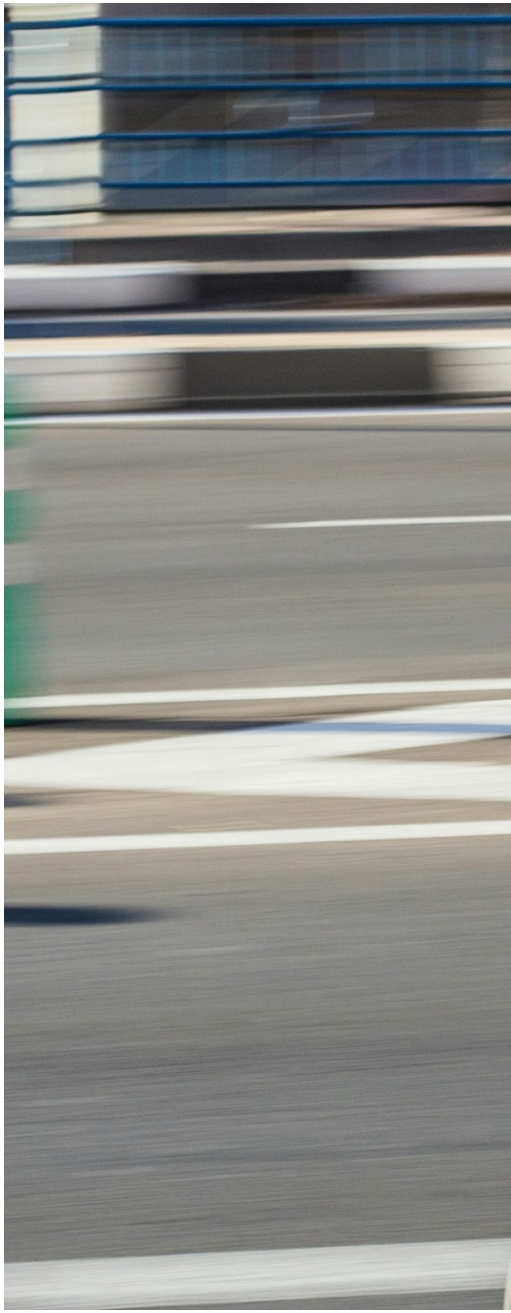
TL 4: Increase battery electric vehicle (BEV) use to 15% of vehicles on the road by 2035 (from approximately 1,709 vehicles to 9,174 vehicles citywide).

Strategic Goal Recommendations - Municipal Operations

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Transportation and Land Use Strategic Goals:

TL 5: Achieve 20% conversion of municipal operations non-emergency light and medium duty gasoline vehicles and equipment within City fleets to EV's by 2035.

TL 6: Achieve 15% conversion of municipal operations diesel fuel utilization to renewable fuels and increase fuel efficiency of remaining combustion engine fleet 5% by 2035.



Projected Sector Emission Reductions Achieved by Draft Strategies

31.9%	Reductions Achieved + BAU Reductions
3.2%	Reduce Community Wide VMT
1.0%	Increase Public Transit Commuting
5.2%	Increase EV Utilization
1.6%	Increase Land Use Density
57.2%	Remaining Emissions

BAU = 'Business-as-Usual' Reductions are anticipated reductions resulting from existing requirements or commitments, which are outside the scope of this plan.

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Section 03

Buildings and Energy

Click here to return to TOC

Additional Information (click icon)

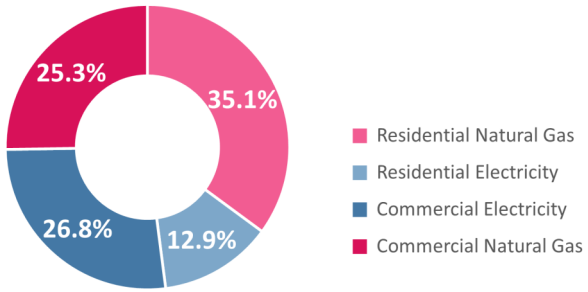
Vulnerability Assessment

GHG Inventory

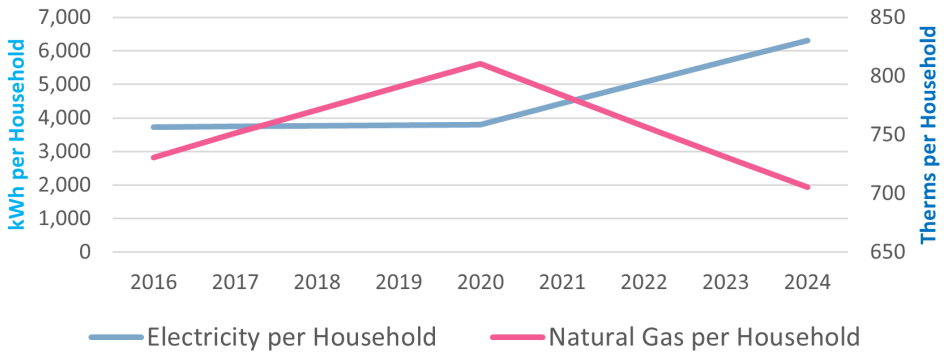
Renewable Energy Study

Building energy use is a major contributor to greenhouse gas (GHG) emissions. The Building Energy sector includes all residential, commercial, and industrial buildings. Greenhouse gas emissions from this sector come from **direct emissions** – from fossil fuels burned *on-site* for heating or cooking needs – as well as **indirect emissions** – from fossil fuels burned *off-site* in order to supply that building with electricity. Building design plays a large role in determining the future efficiency and comfort of facilities. Increasing energy efficiency can help reduce GHG emissions and result in significant cost savings for both homes and businesses. The City of Plymouth community can also achieve climate resilience, environmental, social, and economic benefits through enhancements to the built environment.

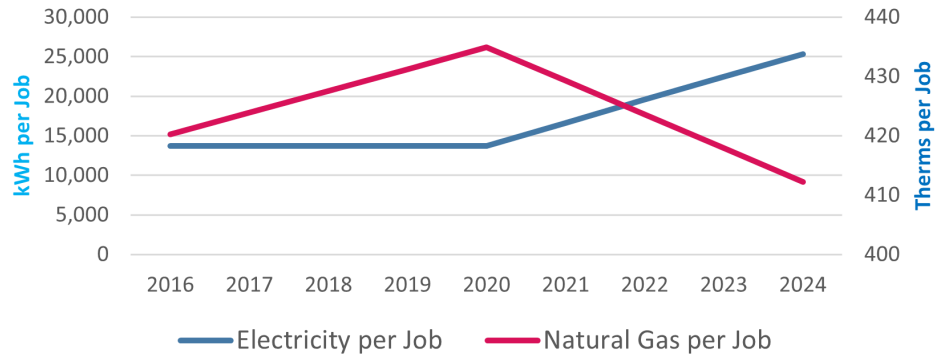
Electricity and Stationary Combustion (Natural Gas) Emissions Share of 2024 GHG Emissions by Sub-Sector



Residential Energy Use Trends



Commercial and Industrial Energy Use Trends



New Building Construction Permits in Plymouth

New Housing Permits in Last 3 Years: **342**

New Housing Units in Last 3 Years: **342**

(1.05% of citywide housing stock)

New Commercial Building Permits in Last 3 Years: **12**

Commercial Renovation Permits in Last 3 Years: **416**

(combined, 17.9% of citywide commercial establishments)

Buildings and Energy

Plymouth Energy Use Profile - Citywide

Residential:

According to 2024 citywide data, the residential sector in the City of Plymouth consumes over 267 million kWh annually. This is equal to 8,235 kWh per household. The sector also consumes over 22.8 million therms of natural gas annually, equal to 706 therms per household. Residential energy GHG emissions total 194,634 metric tons annually, approximately 48.6% of Citywide building energy sector emissions.

Commercial and Industrial:

The City of Plymouth commercial and industrial sector in 2024 consumed nearly 489.5 million kWh, equal to 9,112 kWh per job. These sectors also consume over 16.4 million therms of natural gas annually, or approximately 308 therms per job. Commercial and industrial energy GHG emissions total 205,145 metric tons annually, approximately 51.3% of Citywide buildings energy sector emissions.

Potential for Change in The City of Plymouth

Based on the City's recent new building permit history (shown to the left), as much as **3.5%** of the city's housing stock and **50%** of the city's commercial building stock may be added, renovated or replaced over a 10 year timeframe. This means that a significant portion of the city's building infrastructure could be positively impacted and influenced through climate action strategies that guide increased energy efficiency and increased renewable energy adoption.

Buildings and Energy

City of Plymouth's Building Stock Efficiency

The measure of a community's existing building stock, certified high performance buildings, and housing characteristics provides a basis for determining the current and potential energy efficiency gains for the community. Energy and water efficiency upgrades are one of the simplest and most effective ways to conserve resources, save money, and reduce greenhouse gas emissions.

Residential Energy Efficiency Potential:

New building technology has increased energy efficiency significantly in recent decades. Although newer U.S. homes are 30 percent larger, they consume a similar amount of total energy as older homes - meaning they are more energy efficient per square foot of space. According to the US Energy Information Administration, homes built between 2000 and 2009 used 15% less energy per square foot than homes built in the 1980s, and 40% less energy than homes built before 1950.

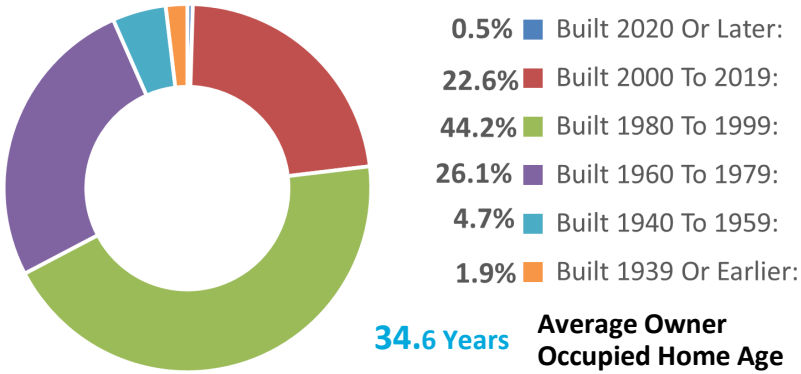
Consequently, this means that retrofitting older homes with some of these technologies provides ample opportunity to improve energy efficiency throughout the community. The charts to the right illustrate the distribution of owner occupied and renter occupied homes based on age throughout the City of Plymouth.

Code Adoption By State

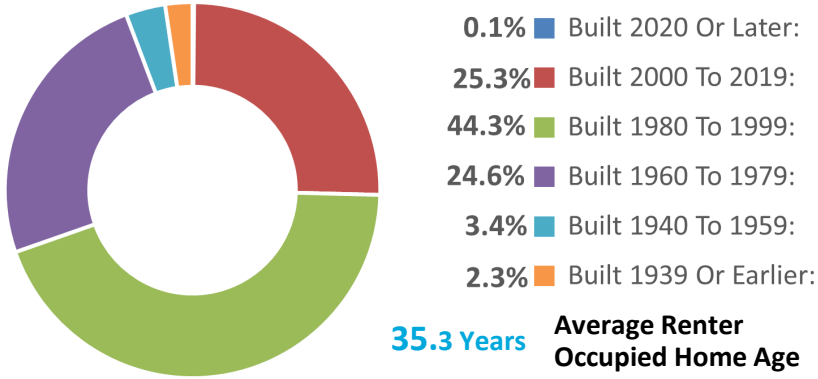
Building codes are the main tool for improving energy efficiency in new construction and renovations. Code adoption varies by state - see map. Eight states require statewide codes, while some allow local modifications, and sixteen leave adoption to cities and counties. Where local adoption is permitted, municipalities can accelerate the shift to energy-efficient building practices.

Relevant for the City of Plymouth, the State of Minnesota **does not allow** local building code adoption.

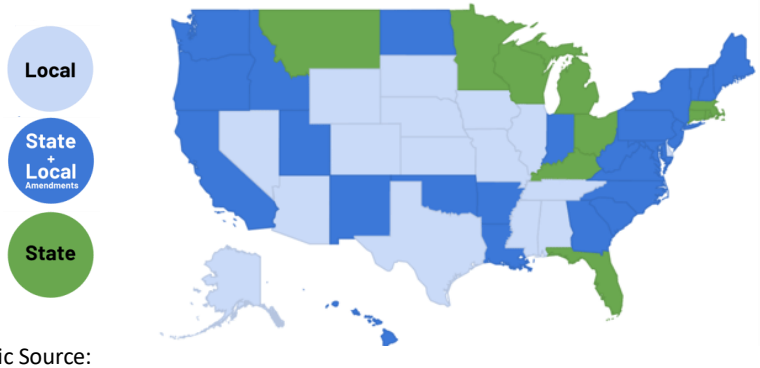
City of Plymouth Owner Occupied Homes by Age



City of Plymouth Renter Occupied Homes by Age



Code Adoption By State



Graphic Source:
https://www.oneclickcode.com/blog/building-code-adoption-states-local

Plymouth Residential Building Energy Efficiency GHG Reduction Potential (based on 2021 US Census Data)

The chart below outlines the estimated annual energy savings potential for households within the City. Anticipating an energy efficiency improvement participation of 6,545 of the citywide total 32,727 housing units by 2035 (20% participation rate) with an average energy efficiency improvement of 15% each would yield an annual citywide energy reduction of 8 million kWh of electricity and 690,000 therms. This reduction would achieve an annual GHG reduction of **5,839** metric tons by 2035. Note, this reduction model anticipates a participation focus for residential units built prior to 1980.

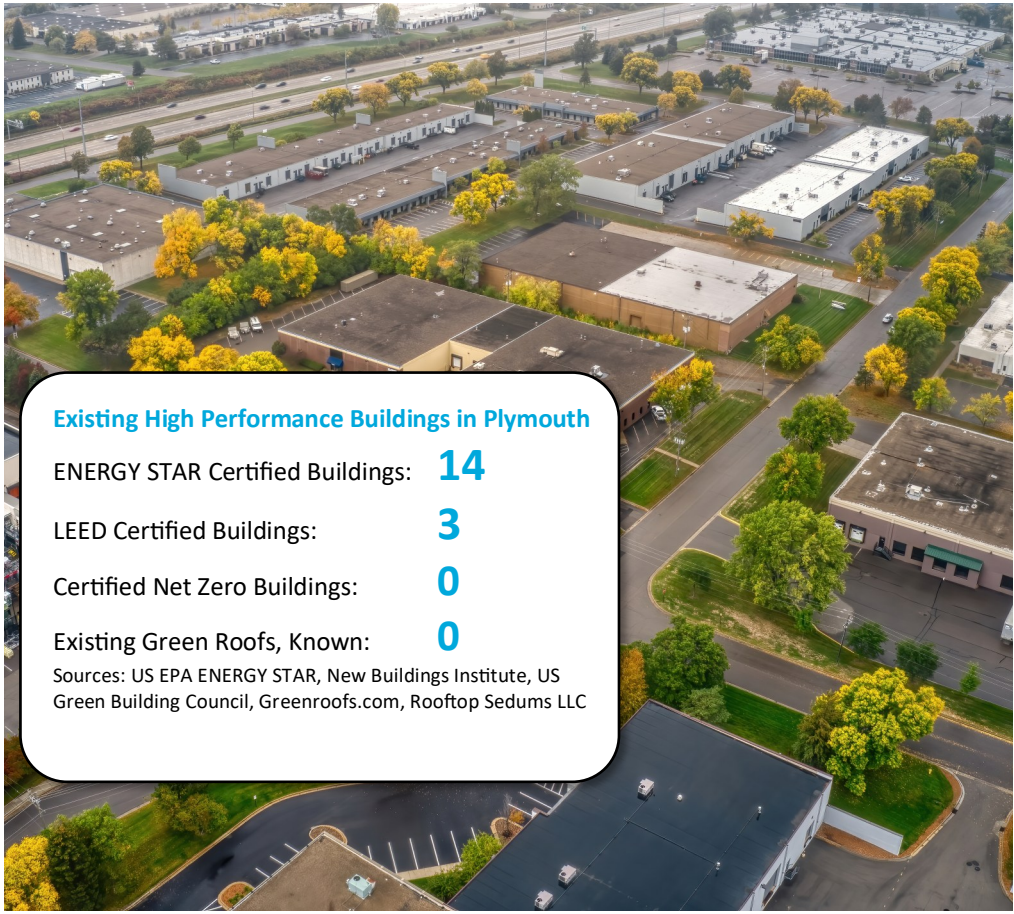
Home Age and Occupancy	Total Estimated Housing Units		Est Electricity Consumption (Million kWh)	Electric Savings at 15% Improvement (Million kWh)	Est Thermal Energy Consumption (Million Therms)	Potential Thermal Energy Savings at 15% Improvement (Million Therms)	Targeted Energy Improvement Participation at 20% (households)	Anticipated Annual Electric Savings (Million kWh)	Anticipated Annual Thermal Energy Savings (Million Therms)	Estimated GHG Reduction (Metric Tons)
	Estimate									
Total:	32,727						6,545			
Owner Occupied:	**24,413**	**74.6%**	**199.19**	**29.88**	**17.06**	**2.56**	**4,883**	**5.98**	**0.51**	**(4,356)**
Built 2020 Or Later:	115	0.4%	0.94	0.14	0.08	0.01				
Built 2000 To 2019:	5,525	16.9%	45.08	6.76	3.86	0.58				
Built 1980 To 1999:	10,795	33.0%	88.08	13.21	7.55	1.13				
Built 1960 To 1979:	6,363	19.4%	51.92	7.79	4.45	0.67	3,591	4.39	0.38	(3,203)
Built 1940 To 1959:	1,152	3.5%	9.40	1.41	0.81	0.12	922	1.13	0.10	(822)
Built 1939 Or Earlier:	463	1.4%	3.78	0.57	0.32	0.05	370	0.45	0.04	(330)
Renter Occupied:	**8,314**	**25.4%**	**67.84**	**10.18**	**5.81**	**0.87**	**1,663**	**2.04**	**0.17**	**(1,483)**
Built 2020 Or Later:	11	0.0%	0.09	0.01	0.01	0.00				
Built 2000 To 2019:	2,101	6.4%	17.14	2.57	1.47	0.22				
Built 1980 To 1999:	3,679	11.2%	30.02	4.50	2.57	0.39				
Built 1960 To 1979:	2,044	6.2%	16.68	2.50	1.43	0.21	1,280	1.57	0.13	**(1,142)**
Built 1940 To 1959:	284	0.9%	2.32	0.35	0.20	0.03	227	0.28	0.02	**(203)**
Built 1939 Or Earlier:	195	0.6%	1.59	0.24	0.14	0.02	156	0.19	0.02	**(139)**
Total Reduction Potential								**8.01**	**0.69**	**(5,839)**

Buildings and Energy

Plymouth Commercial Building Energy Efficiency GHG Reduction Potential (based on 2021 US Census Data)

Similarly to residential construction, older commercial buildings or newer commercial buildings with under-performing energy efficiency represent a significant potential energy efficiency increase. This means that retrofitting older commercial buildings with some of these technologies provides ample opportunity to improve energy efficiency throughout the community. The chart below outlines the estimated annual energy savings potential for commercial buildings within the City of Plymouth.

Anticipating an energy efficiency participation of 20% of commercial buildings by 2035 based (approximately 508 of a total estimated 2,538 commercial establishments) with an average energy efficiency improvement of 15% would yield an annual citywide energy reduction of 15.6 million kWh of electricity and 490,000 therms of thermal energy. This reduction would achieve an annual GHG reduction of **74,980** metric tons by 2035.



Existing High Performance Buildings in Plymouth

ENERGY STAR Certified Buildings:	**14**
LEED Certified Buildings:	**3**
Certified Net Zero Buildings:	**0**
Existing Green Roofs, Known:	**0**

Sources: US EPA ENERGY STAR, New Buildings Institute, US Green Building Council, Greenroofs.com, Rooftop Sedums LLC

Commercial Building Stock	Total Estimated Commercial Establishments		Est Electricity Consumption (Million kWh)	Electric Savings at 15% Improvement (Million kWh)	Est Thermal Energy Consumption (Million Therms)	Potential Thermal Energy Savings at 15% Improvement (Million Therms)	Targeted Energy Improvement Participation at 20% (establishments)	Anticipated Annual Electric Savings (Million kWh)	Anticipated Annual Thermal Energy Savings (Million Therms)	Estimated GHG Reduction (Metric Tons)
	Estimate									
Commercial Establishments	**2,538**	100.0%	**485.95**	**72.89**	**16.47**	**2.47**	**508**	14.58	0.49	**(6,154)**
Total Reduction Potential								**14.58**	**0.49**	**(6,154)**

Residential Building Heating Fuel Switch GHG Reduction Potential

Home Age and Occupancy		Total Estimated Housing Units		Est Electricity Consumption (Million kWh)	Heating Fuel Emissions Remaining After Energy Efficiency Targets	Targeted Additional Fuel Switching Participation at 10% (households)	Estimated Heating Fuel Emissions Reduction From Fuel Switching (Metric Tons)**
		Estimate					
Total:		32,727					
Owner Occupied:		**24,413**	**74.6%**	**199.19**	**87,709**	**2441.3**	**(7,017)**
	Built 2020 Or Later:	115	0.4%	0.94	426	11.5	(34)
	Built 2000 To 2019:	5,525	16.9%	45.08	20,464	552.5	(1,637)
	Built 1980 To 1999:	10,795	33.0%	88.08	39,983	1079.5	(3,199)
	Built 1960 To 1979:	6,363	19.4%	51.92	21,573	636.3	(1,726)
	Built 1940 To 1959:	1,152	3.5%	9.40	3,755	115.2	(300)
	Built 1939 Or Earlier:	463	1.4%	3.78	1,509	46.3	(121)
Renter Occupied:		**8,314**	**25.4%**	**67.84**	**29,870**	**831.4**	**(2,390)**
	Built 2020 Or Later:	11	0.0%	0.09	41	1.1	(3)
	Built 2000 To 2019:	2,101	6.4%	17.14	7,782	210.1	(623)
	Built 1980 To 1999:	3,679	11.2%	30.02	13,626	367.9	(1,090)
	Built 1960 To 1979:	2,044	6.2%	16.68	6,860	204.4	(549)
	Built 1940 To 1959:	284	0.9%	2.32	926	28.4	(74)
	Built 1939 Or Earlier:	195	0.6%	1.59	636	19.5	(51)
Total Reduction Potential					**117,579**	**3,273**	**(9,406)**

Commercial Building Heating Fuel Switch GHG Reduction Potential

Commercial Building Stock	Total Estimated Commercial Establishments		Est Electricity Consumption (Million kWh)	Heating Fuel Emissions Remaining After Energy Efficiency Targets	Targeted Additional Fuel Switching Participation at 10% (establishments)	Estimated Heating Fuel Emissions Reduction From Fuel Switching (Metric Tons)**
	Estimate					
Commercial Establishments	**15,641**	100.0%	**485.95**	**84,668**	**1564**	**(6,773)**
Total Reduction Potential						

** Fuel Switching emission reduction Includes estimated emissions associated with increased electrical use. Emissions reductionns are calculated based on "Greenhouse gas emission forecasts for electrification of space heating in the US" University of California Davis

Residential and Commercial Building Heating Fuel Switch GHG Reduction Potential

(based on 2021 US Census Data)

As Plymouth's electric grid nears carbon neutrality, building heating fuel will become an increasingly important target for emission reductions. Reduction, and ultimately the elimination of all fossil fuel heating (oil, propane, natural gas) will be required in order to achieve citywide carbon reductions.

Heating fuel switch options include:

- Conversion to electric heat (e.g. heat pump).
- Conversion to solar thermal systems.
- Switching fuel oil or diesel fuels to renewable fuels.

The charts on this page outline the potential annual GHG reductions with achieving a heating fuel switch for 10% of Plymouth households and commercial establishments by 2035. Prior to any energy efficiency strategies, these reductions would achieve a reduction in annual GHG emissions of **9,406** metric tons for residential and **6,772** metric tons for commercial and industrial.

Buildings and Energy

Residential and Commercial Building Electricity Fuel Switching Potential (on-site renewable) Citywide

Based on commitments by electric utilities in the region, the GHG emissions associated with electricity use can be anticipated to continue to reduce over the years. Generally, however, increasing utilization of on -site renewable energy has multiple benefits for a community beyond GHG emissions reductions. The range of community benefits of increased on-site renewable energy include energy cost savings and increased energy resilience potential. For these reasons, we still recommend inclusion of strategic goals to increase on-site renewable energy.

paleBLUEdot has assessed the rooftop solar PV potential throughout the City of Plymouth. This assessment has been conducted based on citywide satellite data (sources: NREL, NOAA, and NASA). Generating capacity was calculated by roof orientation and tilt category. The projected potential for roof characteristics likely to result in economically viable solar arrays were then summarized—see "Total Citywide Optimized Rooftop Solar PV Potential" chart on following page.

Plymouth's Solar Share Based on 2024 Data:	State*	Plymouth	Plymouth's Share
Population	5,737,915	79,526	**1.39%**
Number of Solar Installations	20,899	215	**1.03%**
Solar Installations / 1,000 households	9.26	6.57	**70.92%**
Estimated Solar Capacity (MW)	241.97	5.83	**2.41%**
Est. Electricity Generated Annually (GWH)	297.91	7.18	**2.41%**
Average Array Size (KW)	11.58	27.13	**234%**
Solar Industry Businesses	164	4	**2.44%**

*State data based on US EIA State Profiles reported

Total Citywide Optimized Rooftop Solar PV Potential

			Flat	Low Tilt	Mid-Low Tilt	Mid-High Tilt	High Tilt
Subtotal Flat							
Suitable Buildings	782	3.7%	**782**				
Suitable Roof Planes	642	3.7%	**642**				
Square Footage	362,284	6.2%	**362,284**				
Capacity (KW dc)	3,790	5.0%	**3,790**				
Generation (KWH)	5,154,878	5.5%	**5,154,878**				
Subtotal South Facing							
Suitable Buildings	10,746	51.1%		**1,604**	**6,615**	**2,524**	**4**
Suitable Roof Planes	8,819	51.1%		**1,316**	**5,429**	**2,071**	**3**
Square Footage	3,025,127	52.1%		**503,568**	**1,933,758**	**587,318**	**483**
Capacity (KW dc)	31,653	41.4%		**5,269**	**20,232**	**6,145**	**8**
Generation (KWH)	43,046,320	45.7%		**7,165,178**	**27,515,117**	**8,356,854**	**9,171**
West + Southwest							
Suitable Buildings	8,199	39.0%		**1,434**	**6,765**		
Suitable Roof Planes	6,729	39.0%		**1,177**	**5,552**		
Square Footage	2,059,536	35.5%		**391,989**	**1,667,548**		
Capacity (KW dc)	34,933	45.7%		**6,649**	**28,284**		
Generation (KWH)	39,125,214	41.5%		**7,446,647**	**31,678,567**		
East + Southeast							
Suitable Buildings	1,309	6.2%		**1,309**			
Suitable Roof Planes	1,074	6.2%		**1,074**			
Square Footage	360,039	6.2%		**360,039**			
Capacity (KW dc)	6,107	8.0%		**6,107**			
Generation (KWH)	6,839,693	7.3%		**6,839,693**			

Grand Total		**Subtotals: Flat Roof**		**Low Tilt**		**Mid-Low Tilt**		**Mid-High Tilt**		**High Tilt**	
Suitable Buildings	21,036	782	3.7%	4,346	20.7%	13,380	63.6%	2,524	12.0%	4	0.0%
Suitable Roof Planes	17,264	642	3.7%	3,567	20.7%	10,981	63.6%	2,071	12.0%	3	0.0%
Square Footage	5,806,986	362,284	6.2%	1,255,595	21.6%	3,601,306	62.0%	587,318	10.1%	483	0.0%
Capacity (KW dc)	76,484	3,790	5.0%	18,024	23.6%	48,516	63.4%	6,145	8.0%	8	0.0%
Generation (KWH)	94,166,104	5,154,878	5.5%	21,451,517	22.8%	59,193,684	62.9%	8,356,854	8.9%	9,171	0.0%

Share of Community Electricity Use Met Through **12.9%**

Buildings and Energy

Solar PV Rooftop Market Absorption Scenario

paleBLUEdot then explored potential new solar PV market absorption scenarios through 2035 building on the existing installed capacity within the City. The market projection we recommend using for guidance on potential new solar installations uses the City of Plymouth's share of State population, adjusted for the City's share of statewide installed solar capacity, and applies that to the statewide new solar PV projections.

The resulting scenario outlined to the right anticipates a 25% initial growth rate. This scenario would result in approximately 7.6% of current Citywide electrical consumption being met through rooftop solar PV by 2035.

Ground Mounted and Carport Capacity

In addition to roof mounted solar PV potential, the City of Plymouth has significant solar PV potential associated with ground mounted arrays as well as arrays mounted over parking—known as "Carport" arrays. The 2023 City of Plymouth Solar Renewable Energy Potentials Study outlined potential scenarios for each of these. The resulting recommended total distributed renewable energy potentials projection for 2035 is outlined to the right.

GHG Reduction Potential of Customer Owned Solar in Plymouth

GHG emissions reduction associated with increased rooftop solar projection by 2035: **14,262** Metric Tons.

Share of Projected Statewide Annual Increase

Based on Community's Share of Total Existing State-Wide Installed Capacity (net metered)

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of Community Electric Consumption	This is Equivalent to adding (x) 9KW Residential Arrays Annually:	Or Equivalent to adding (x) 40KW Commercial Arrays Annually:
2030	18,023	22,190,335	**3.04%**	**271**	**60.9**
2035	45,312	55,787,417	**7.63%**	**606**	**136**
2040	74,243	91,407,790	**12.51%**	**321**	**72**

Total Distributed Renewable Energy Potentials Projection—2035

Source Potential	Cumulative Installed (KW)	Annual Generation (KWH)	Share of Demand
Estimated Existing	5,834	7,182,167	0.98%
New Rooftop	45,312	55,787,417	7.63%
New Carport	959	1,303,877	0.18%
New Ground Mounted	4,836	6,577,492	0.90%
New Wind Energy	953	3,654,723	0.50%
Total Potential	**57,893**	**74,505,676**	**10.19%**

To achieve this solar PV Capacity, the city would need to achieve the following solar PV installation coverage by 2035:

Rooftop Coverage	2,997,363	Square Feet
Parking Lot Coverage	2.1	Acres
Lawn / Bare Ground Coverage	20.9	Acres
New Micro Wind Generators	318	3KW ave size

Energy Burden In Plymouth

Based on US Department of Energy data 1,130 households in Plymouth, nearly 4% of all households in the city, have high energy burdens. The data shows that households in the <30% AMI income range are likely to have high energy burden, regardless of the age of their home, while households within the 30%-60% AMI income range are more likely to have high energy burden if their home was built prior to 1940. The data shown in the "by Building Type" and "by Building Age" charts also suggests that households living in buildings with 2, 3-4 or 5-9 units are likely to have larger disparities between household income and overall energy burden.

As outlined in the City's Renewable Energy Potentials Study, the city of Plymouth may be able to impact energy burden within the community by ensuring programs and policies include a focus on the following households:

- All households in the 0-30% AMI income range, especially those in single family homes
- LMI households living in buildings built before 1980, with a particular focus on buildings built before 1940.
- Qualifying households based on existing program qualifications such as Low Income Home Energy Assistance Program (LIHEAP)

Housing Type By Income Level	Households with High Energy Burden
Income 0-30% AMI:	**45,186**
Income 30-60% AMI:	**39,106**
Total LMI Households With High Energy Burden:	**84,292**

Why Focus on Low Income Energy Solutions For Climate Resilience

Plymouth's Climate Vulnerability Assessment reveals that its low-income residents face increased climate risks and live in homes with poor energy efficiency. Urban heat islands, areas with elevated temperatures due to human activity, exacerbate health risks and discomfort for these communities. As outlined in the City of Plymouth's Ground Cover, Carbon Sequestration, and Heat Island study, low income community members are more likely to live in areas with increased heat island impacts. This link means these households which already tend to live in less energy efficient homes are also more likely to experience higher temperatures during extreme weather events. The study "Climate change impacts on future residential electricity consumption and energy burden: A case study in Phoenix, Arizona" found elderly and low-income groups can anticipate 5% to 15% higher energy use and energy burden due to the impacts of climate change compared with higher income households.

Reducing this energy divide is essential to enhance the climate resilience of Plymouth's most exposed residents.

Example Local Government Programs for LMI Solar Solutions

Appendix A of the 2025 City of Plymouth's Solar Renewable Energy Potentials Study provides a review of a range of example municipal programs. Learn more here: https://view.publitas.com/palebluedot/plymouth-renewable-potentials-study/page/44

Buildings and Energy

Strategic Goal Recommendations— Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following citywide Buildings and Energy Use Strategic Goals:

BE 1: Improve total Citywide building energy efficiency 5% for electricity and 15% for natural gas by 2035.

BE 2: Achieve "fuel switching" of 15% of buildings using on-site fossil fuel combustion to electrification or renewable fuels by 2035. (14.2% of existing households use electric heat according to census and natural gas utility data. Goal would result in 29.2% of households using electric heat).

BE 3: Increase customer owned or purchased renewable electricity to 12.5% of citywide building electric use by 2035 (5% on-site and 7.5% green source purchase - existing is 1% on-site and 2.5% green source purchase).

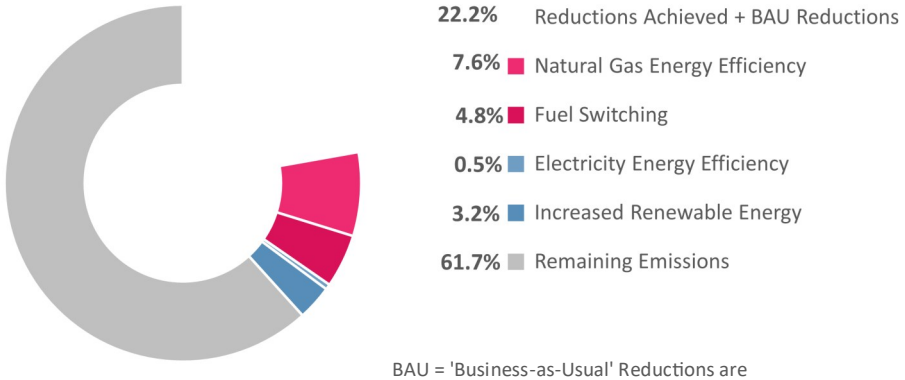
Strategic Goal Recommendations - Municipal Operations

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Buildings and Energy Strategic Goals:

BE 4: Improve total government building energy efficiency 5% for electricity and 10% for natural gas by 2035. (including water distribution and wastewater pumping infrastructure).

BE 5: Achieve 50% government building renewable electricity use and 25% "fuel switching" from on-site fossil fuel combustion to electrification by 2035. (renewable electricity to include on-site and green source purchase)

Projected Sector Emission Reductions Achieved by Draft Strategies



BAU = 'Business-as-Usual' Reductions are anticipated reductions resulting from existing requirements or commitments, which are outside the scope of this plan.

Section

04

Waste Management

Click here to return to TOC

Additional Information (click icon)

GHG Inventory

Renewable Energy Study

Waste Management

Waste management refers to both municipal solid waste (MSW) and recycling, and includes consideration of volume, demand and service capacity, and infrastructure associated with collection and disposal.

Citywide MSW volumes are based on the city's pro-rata share of reported Hennepin County volumes. In 2024, citywide MSW totaled 83,571 tons. Of the MSW handled an estimated 23,515 tons (28.1% of total) were recycled, 12,008 tons (14.4%) were organics collection, 23,983 (28.7%) were used as fuel stock for waste-to-energy, and the remaining 24,006 tons (28.8%) were landfilled. Source: Minnesota Pollution Control Agency SCORE Report.

Plymouth MSW Trends

Total MSW handled in 2016 was 67,482 tons. As noted above, by 2024 the total was 83,571 for an increase of 23.8%. When viewed on a per-capita basis, however, the increase in total MSW handled is lower at 17%. The share of MSW being diverted for recycling has also increased from 16,954 tons in 2016 to 23,515 tons in 2024, an increase of 12% in the share of total MSW diverted for recycling. Organics diversion also has increased from 8,514 tons in 2016 to 12,008 tons in 2024 - representing an increase of 13.9% in the share of total MSW diverted for organics collection.

These numbers illustrate an opportunity to build on the momentum of increasing landfill diversion, as well as an opportunity to focus on decreasing total MSW generated.

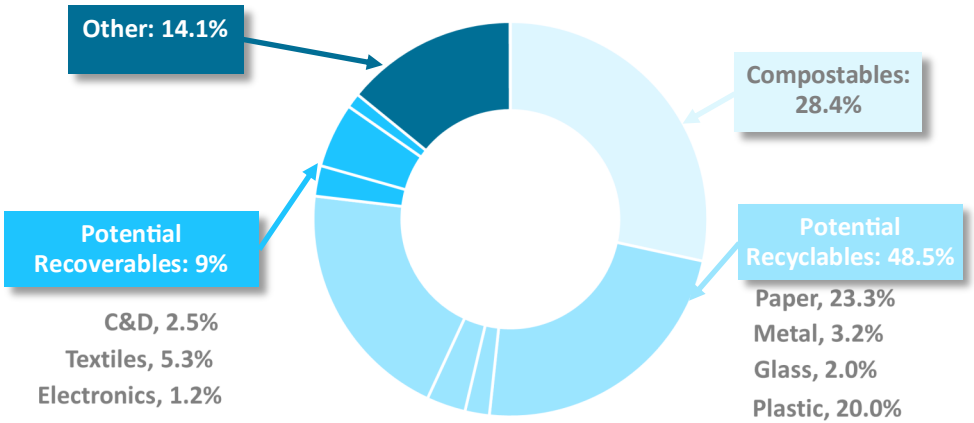
2024 Community MSW Generation	tons	% of total	Change since 2016
Total Solid Waste Handled	**83,571**	**100.0%**	23.8%
Recycling (tons)	**23,515**	**28.1%**	38.7%
Organics / Yard Waste / Trees (tons)	**12,008**	**14.4%**	41.0%
MSW diverted as waste-to-energy (tons)	**23,983**	**28.7%**	-10.1%
Solid waste sent to landfill (tons)	**24,066**	**28.8%**	56.9%
Diversion rate*		**71.2%**	-7.8%

* diversion rate = MSW kept from landfills through recycling or reuse

Minnesota's Waste Handling Hierarchy

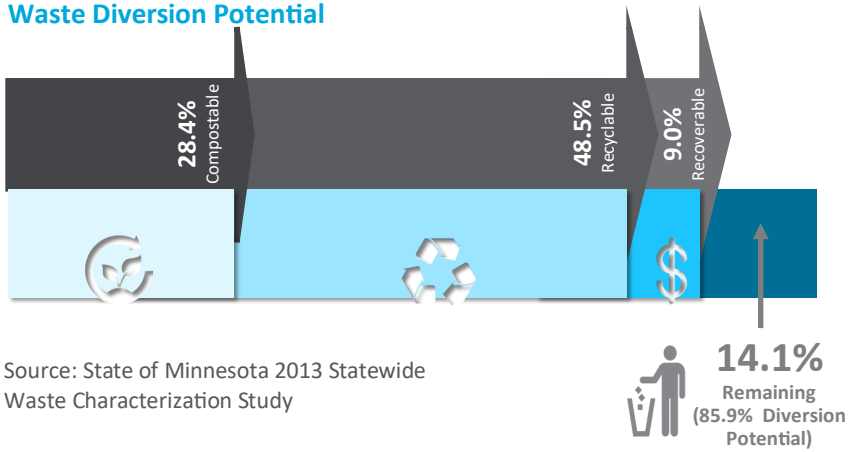
Source: State of Minnesota Sustainable Materials Management and Solid Waste Policy Report

MSW Characterization



Source: State of Minnesota 2013 Statewide Waste Characterization Study

Waste Diversion Potential



Source: State of Minnesota 2013 Statewide Waste Characterization Study

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Waste Handling Hierarchy

The Environmental Protection Agency (EPA) formulated the non-hazardous materials and waste management hierarchy acknowledging that a one-size-fits-all strategy does not work for every material and waste stream under all conditions.

This hierarchy organizes different management tactics according to their environmental benefit, from the most to the least favorable. It prioritizes reduction, reuse, recycling, and composting as fundamental components of responsible materials management. These approaches help to cut down on greenhouse gas emissions as well as reduce consumption of natural resources.

State of Minnesota Waste Characterization Study

In 2013, the State of Minnesota conducted a comprehensive, quantitative waste sort evaluation to understand the make up of the current waste stream (materials not diverted through recycling or organics collection). The findings of the waste characterization study are shown in the graph to the left. This graph groups the classifications of waste sent to the landfill defined into broad categories based on their diversion potential including: Compostables, Potential Recyclables, Potential Recoverables, and Other.

Waste Diversion Potential

Based on the State of Minnesota Waste Characterization Study, there may be waste diversion potential of up to 85.9% in the current landfilled materials (idealized maximum). Although diversion of these materials in their entirety for beneficial use may not be possible, the large share of potentially divertable materials indicates significant opportunity. Below is the breakdown of the estimated total maximum potential waste diversion (excluding waste reduction):

Compostables	28.4%
Potentially Recyclable Materials	48.5%
Potentially Recoverable Materials	**9.0%**
Other Materials (remaining landfill waste)	**14.1%**

Waste Management

State of Minnesota Packaging Waste Reduction Focus

Minnesota is the fifth state to pass an Extended Producer Responsibility (EPR) law for packaging, joining California, Colorado, Oregon, and Maine. They law, Packaging Waste and Cost Reduction Act which was signed into law in May 2024, includes several recent packaging laws:

- **Extended Producer Responsibility (EPR)**: Producers of packaging and paper products must pay for a portion of the costs of recycling and managing their packaging. Producers must also join a Producer Responsibility Organization (PRO) by July 1, 2025.
- **Packaging redesign**: Producers must redesign their packaging to be recyclable, reusable, or compostable by 2032. They can delay this deadline until 2040.
- **Shared responsibility**: Producers must pay at least 50% of the costs of recycling and managing their packaging by 2029, 75% by 2030, and 90% by 2031.
- **Reuse and refill**: Materials that cannot be reused, refilled, composted, or recycled must be banned by January 1, 2032.

Sources:
State of Minnesota Pollution Control Agency: https://www.pca.state.mn.us/air-water-land-climate/extended-producer-responsibility-for-packaging

No Emission Biomass-to-Power - Gasification

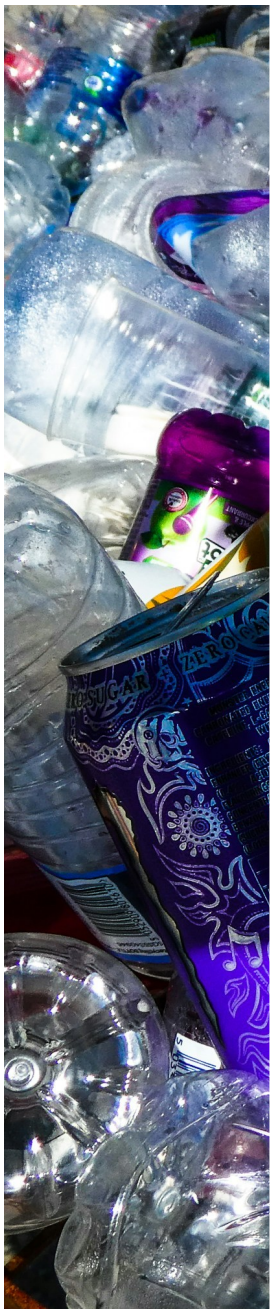
Plasma gasification converts city waste into energy-rich gas and solid slag without burning. Using an electric arc hotter than the sun, it breaks waste into syngas for power or fuel and slag for construction materials, generating extra heat for electricity. Unlike incineration, plasma gasification is cleaner, running in a sealed system with lower emissions, especially carbon-neutral when using biomass. It offers an eco-friendly waste management alternative that reduces emissions and waste while producing reusable materials. Plants processing 100 tons of waste daily are financially sustainable, providing communities with revenue from energy and byproducts.

Plymouth Solid Waste Gasification GHG Reduction Potential

According to Sierra Energy, based on the City of Plymouth's total landfilled municipal solid waste, the current waste stream within Plymouth could support the following gasification derived energy potential:

Hennepin County Total		City of Plymouth
303,509,885	**kWh Electricity** annually	19,175,878
	or	
67,181,121	**Pounds Hydrogen Fuel** annually. Usable as a fuel alternative for fuel cells or engine generator sets	4,244,531
	or	
163% of Community Diesel Consumption: 16,760,084	**Gallons of Renewable Diesel** annually. Usable as a fuel alternative for vehicles	1,058,909 **664%** of Municipal Diesel Consumption
	or	
377,863,712	**Pounds of Ammonia** annually. Usable as a fuel alternative for fuel cells or engine generator sets	23,873,583

Source: Sierra Energy



Waste Management

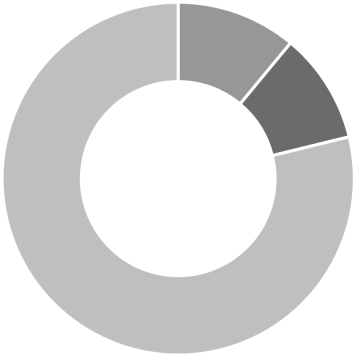
Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Waste Management Strategic Goals:

WM 1: Decrease total annual municipal solid waste handled 10% by 2035.

WM 2: Increase solid waste diversion to 23% for organics by 2035. (existing is 21.8% recycle diversion and 14.4% organic diversion)

Projected Sector Emission Reductions Achieved by Draft Strategies



0.0%	Reductions Achieved + BAU Reductions
11.0%	Waste Reduction
10.2%	Organics Diversion
0.0%	Recyclables Diversion
78.8%	Remaining Emissions

BAU = 'Business-as-Usual' Reductions are anticipated reductions resulting from existing requirements or commitments, which are outside the scope of this plan.

Section

05

Water and Wastewater

Click here to return to TOC

Additional Information (click icon)

Vulnerability Assessment

GHG Inventory

Water and Wastewater

Water and Energy Nexus

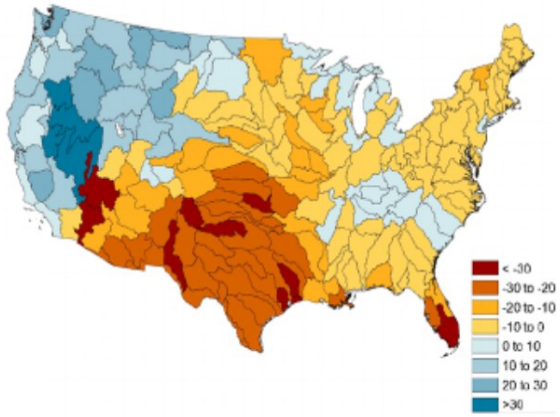
Water and energy serve as critical pillars in our contemporary world. The processes of producing, distributing, consuming, and treating water require significant energy. Conversely, generating energy—especially through the burning of fossil fuels—demands substantial water resources. The interconnection between the amount of water needed for energy generation and transmission, and the energy required for water management—including its collection, purification, transportation, storage, and disposal—is referred to as the water-energy nexus. Typically, the production of fresh water and the treatment of wastewater account for the greatest energy usage and carbon emissions in a community's infrastructure. Curtailing water use not only conserves energy during the production and distribution of potable water but also in the wastewater collection and treatment processes.

Regional Water Stress

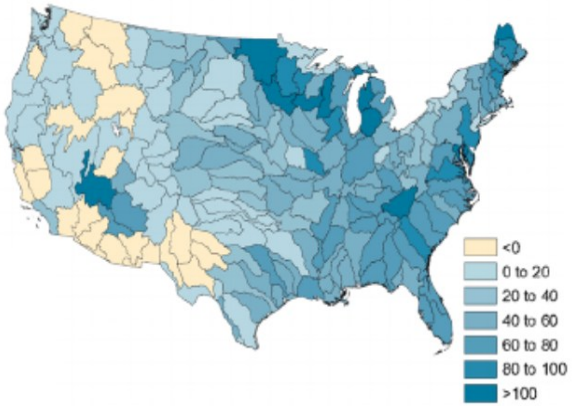
According to a 2019 projection by the World Resources Institute, as of 2025 1.8 billion individuals likely reside in regions afflicted by a lack of water, while two-thirds of the global population will inhabit areas facing water stress. The Plymouth region has experienced a decline in water yield of about 10% since 1985. Looking ahead to 2050, the region should prepare for a surge in water demand that could exceed 20%.

(Maps from "Adaptation to Future Water Shortages in the United States Caused by Population Growth and Climate Change." Additional sources: World Resources Institute, USGS).

Change in Water Yield Since 1985

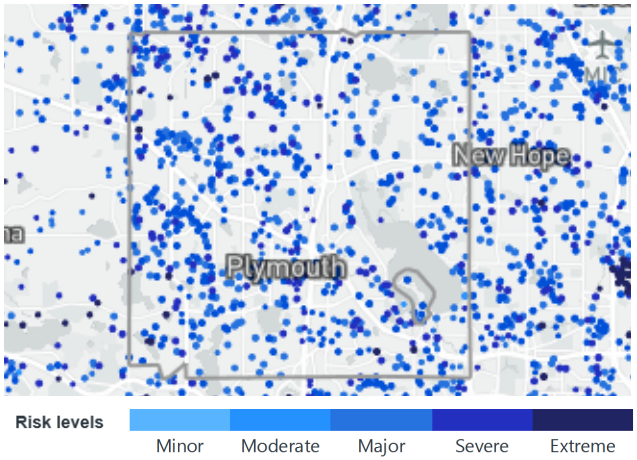


Projected Change in Water Demand by 2050



Mitigating Flood Impacts

According to the US National Climate Assessment, the ten rainiest days can contribute up to 40% of the annual precipitation in the Minnesota region. By 2070, the Plymouth area can anticipate an increase of up to 24% in the total annual precipitation. In addition, the timeframe between rains is expected to continue to increase. Under this scenario, it is likely that certain periods of the year, like spring, may be significantly wetter with storms producing heavier rains. In anticipation of that, it is appropriate to review the areas of the City with flood risk and to review current storm water management capacity against future extreme rainfall event projections.



Properties at Risk

According to First Street Foundation (map below), there are 3,278 properties in the City of Plymouth at risk of flooding over the next 30 years. This represents 12% of all properties in the city. Properties at risk in the city are illustrated in the map graphic.

Source: First Street Foundation, FEMA

Best Management Practices (BMPs)

BMPs are essential tools for improving water quality developed lands and open spaces. They employ natural elements like plants and engineered soils to manage runoff. Stormwater BMPs include rain gardens and underground water storage, which filter runoff before it reenters groundwater or reaches existing bodies of water. Implementing and increasing the use of BMPs can support the increased sustainability of our land uses. BMPs include the following:

Bioretention and Biofiltration (Rain Gardens)
Infiltration Swales
Permeable Pavements
Underground Infiltration Systems
Rainwater Harvesting and Utilization
Native Landscape Restoration

(see palebluedot.llc/carbon-copy/2025/10/15/tools-for-improving-community-water-quality for more information)

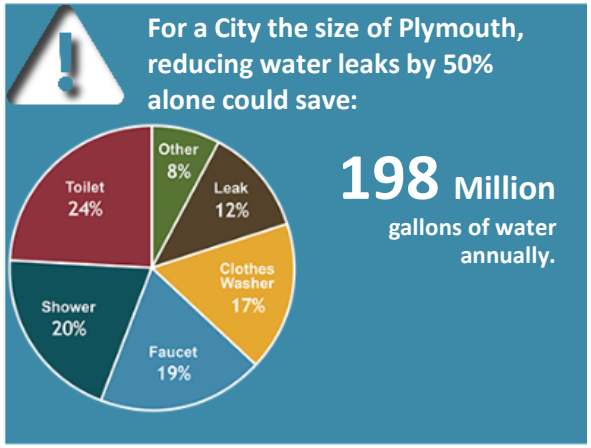
Water and Wastewater

Water Conservation Potential

According to "Residential End Uses of Water," by the Water Research Foundation, on average, 12% of municipal water distribution is lost through leaks in water mains and water pipes on private property.

Cutting Resilient Communities use would lower city GHG emissions associated with water treatment and distribution. Moreover, conservation aids in sustaining aquifers and bolstering climate change resilience through fluctuating rainfall.

Illustration Water Conservation Potential



Source: Water Research Foundation, Residential End Uses of Water, Version 2, 2016; https://www.circleofblue.org/wp-content/uploads/2016/04/WRF_REU2016.pdf

Plymouth Wastewater Beneficial Use GHG Reduction Potential

Municipal wastewater holds untapped resources such as heat, water, energy, and nutrients, which frequently pass through wastewater treatment plants (WWTPs) without being reclaimed.

Anaerobic Digestion (AD)

Anaerobic digestion is a process where bacteria break down organic material without oxygen, creating biogas and digestate. This method reduces sludge volume, cuts pathogen levels, and lessens odors, while biogas can be converted into renewable natural gas, offering energy solutions and decreasing greenhouse emissions. Although widely used in wastewater treatment, AD's contribution to total methane emissions is minimal, yet it offers considerable environmental benefits.

Electricity Generation and Combined Heat and Power (CHP)

Biogas from AD can power electricity and CHP systems at wastewater treatment facilities, often more cost-effectively than conventional grid power. Between 2010-2017, the U.S. added 126 CHP systems at such plants, with California leading the growth. However, only 1% of U.S. plants harness this energy, with reciprocating engines being the preferred technology. Co-digestion can boost biogas production, supporting the case for CHP despite the higher costs of some systems.

Hydrothermal Liquefaction (HTL)

HTL transforms wet biomass into liquid fuels using high pressure and temperature. More efficient than AD in processing biomass, HTL isn't yet widely commercialized. Requiring hydrogen and electricity, it generates renewable fuels and gases—with the latter potentially powering CHP systems—and produces ash and char, which could have carbon sequestration benefits.

Waste Heat Recovery

The U.S. disposes of vast amounts of heat energy in wastewater, with the potential to power millions of homes. Capturing this heat in underground tanks, it's transferred via heat exchangers to heat pumps, supplying energy to buildings. This recaptured energy helps meet sustainability goals and contributes to climate action.

Water and Wastewater

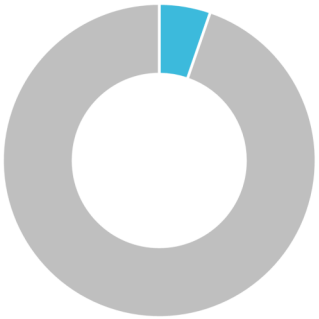
Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Water and Wastewater Strategic Goals:

W 1: Promote reduced water consumption and wastewater generation Citywide with a targeted reduction of 5% each by 2035.

W 2: Update design standards and implement plans to meet projected climate change storm water and flood mitigation requirements.

Projected Sector Emission Reductions Achieved by Draft Strategies



Emissions associated with water processing included in Buildings and Energy.
BAU = 'Business-as-Usual' Reductions are anticipated reductions resulting from existing requirements or commitments, which are outside the scope of this plan.

Section

06

Local Food and Agriculture

Click here to return to TOC

Additional Information (click icon)

Vulnerability Assessment

Ground Cover Assessment

Local Food and Agriculture

Transporting food over great distances involves significant fossil fuel consumption, which in turn releases greenhouse gases into the atmosphere. Extended transport times necessitate more refrigeration, which is also a significant source of carbon emissions. The less we rely on transportation and refrigeration for our food, the more sustainable our food supply becomes.

The US EPA states that in 2018, agriculture was responsible for 9.9% of the U.S. total greenhouse gas emissions. Of this, livestock management was the source of 42% of these emissions, equating to around 259 million metric tons of CO2 equivalents. The remainder arises from soil management and the energy required to run agricultural machinery and operations. Additionally, tillage methods impact soil health and carbon levels, water quality, and the use of energy and pesticides by farmers.

Economic Potential of Local Food Purchases

Purchasing food from local producers can diminish the carbon footprint of our diets and bolster the local small business economy. According to the 2008 Journal of Hunger and Nutrition article “The Food System as an Economic Driver: Strategies and Applications for Michigan” every $1 million in revenue produced by farms participating in local markets, about 32 jobs are created, whereas wholesale-focused farms generate merely 10.5 jobs. Additionally, community gardens and neighborhood gardening foster outdoor and social engagement, which enhances social bonds, encourages activities across different ages, promotes gentle forms of exercise, and nurtures habitats for plants, animals, and pollinators.

Local Food Resources in Plymouth

Community Gardens Per 100,000 Residents

United States:	**5.5**
Twin Cities Metro:	**18.3**
City of Burnsville:	**4.9**
City of Eagan:	**7.3**
City of Edina:	**1.9**
City of New Brighton:	**0**
City of Woodbury:	**0.8**
City of Falcon Heights:	**19.1**
City of Roseville:	**5.5**
City of Plymouth: (1 community garden)	**1.3**

Farmer's Market Locations

City of Plymouth:	**1**

Sources: American Community Gardening Association, City of Plymouth

Local Food and Agriculture

Climate Change and Food Security

Our food system is vulnerable to impacts of climate change. These vulnerabilities include physical impacts like extreme precipitation and heat, crop and livestock vulnerabilities like animal heat stress, biological impacts like increasing invasive insect infestations, interruptions to natural annual cycles, and socioeconomic impacts.

Pacific states are particularly sensitive to reduced water supplies, warmer winters, and more variable spring weather. Grain production is vulnerable to more variable weather, warmer winters, heat wave, and hot summer nights and flooding in the Great Plains and the Midwest. Beef, pork, and poultry production is vulnerable to increased frequency and intensity of extreme weather in the Great Plains and the Southeast as well as sensitive to interruptions in feed, water, and power supplies that can occur with extreme weather events and other climate change drivers.

Although all community members may feel any affects of climate change impacts on the food system, individuals who are already experiencing low income or food insecurity will very likely experience these affects more profoundly. Today, food insecurity—disruption of nutrition availability because of lack of money, access, or other resources—is inequitably felt: people experiencing low income are nearly three times more likely to experience food insecurity. We should anticipate that the climate change vulnerabilities of our national food system will exacerbate the inequities of food security in all communities

Increased local food system capacity can help increase resilience, food security, job creation, and community wealth building benefits

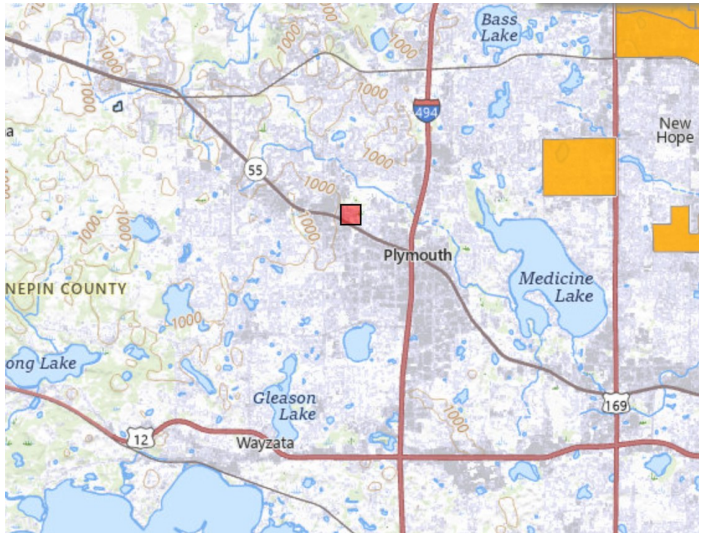
Local Food and Agriculture

Individuals with Possible Food Insecurity in Plymouth

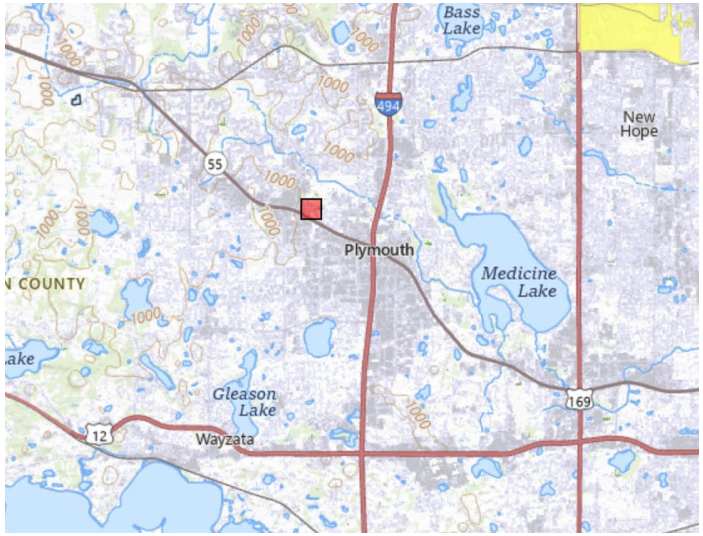
Those in economic stress are also frequently food insecure. In Minnesota, food insecurity affects 1 in 11 adults and 1 in 7 children. According to Feeding America's Map The Meal Gap tool and USDA data, Hennepin County has an estimated total food insecure population of 130,460. This represents an estimated average county level food insecure rate of 10.3%. Children under 18 experience food insecurity at a higher rate of 14.4% countywide.

On the maps below, highlighted sections represent low-income census tracts (tracts where 20% or more of the population is at or below poverty, or where family median incomes are 80% or less of State median) where a significant number (at least 500 people) or share (at least 33 percent) of residents are distant from the nearest supermarket. In sections which are green, residents are more than 1 mile (urban) or 10 miles (rural), while in orange sections residents are more than ½ mile (urban) or 10 miles (rural) from nearest supermarket. Sections that are yellow represent low-income census tract where more than 100 housing units do not have a vehicle and are more than ½ mile from the nearest supermarket.

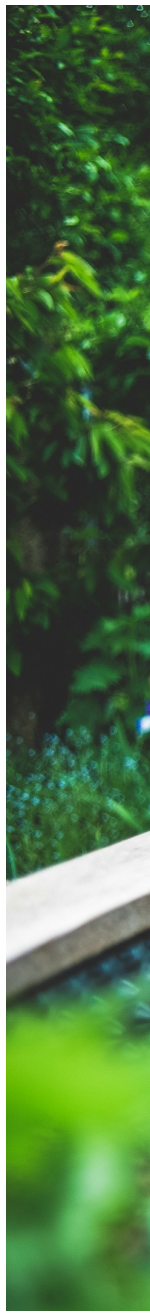
Distant from Supermarket



Distant from Supermarket Without Vehicle Access



Sources: Feeding America Map the Meal Gap; USDA Food Access Research Atlas



Local Food and Agriculture

Strategic Goal Recommendations— Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Local Food and Agriculture Strategic Goals:

FA 1: Increase and support local food production and access—especially programs and initiatives that serve low-income and food-insecure residents.

FA 2: Reduce food waste and food insecurity Citywide.

Section 07

Greenspace and Ecosystems

Click here to return to TOC

Additional Information (click icon)

Vulnerability Assessment

Ground Cover Assessment

Trees and Climate Resilience

Trees and natural ground covering play a central role in supporting community health, improving air and water quality, helping to reduce building energy use, and supporting climate mitigation. Recent studies like “The importance of greenspace for mental health” by Jo Barton and Mike Rogerson have shown that sometimes, going to a park, or even looking a single tree can significantly improve a person’s health and stress levels. Our understanding of the value of trees has been expanded to include mental and physical health benefits. Trees are critical in filtering air, removing harmful pollutants, such as Carbon Monoxide, particulate matter, and Ground-level Ozone - pollutants that can be toxic at high levels and which can cause asthma and other respiratory impacts.

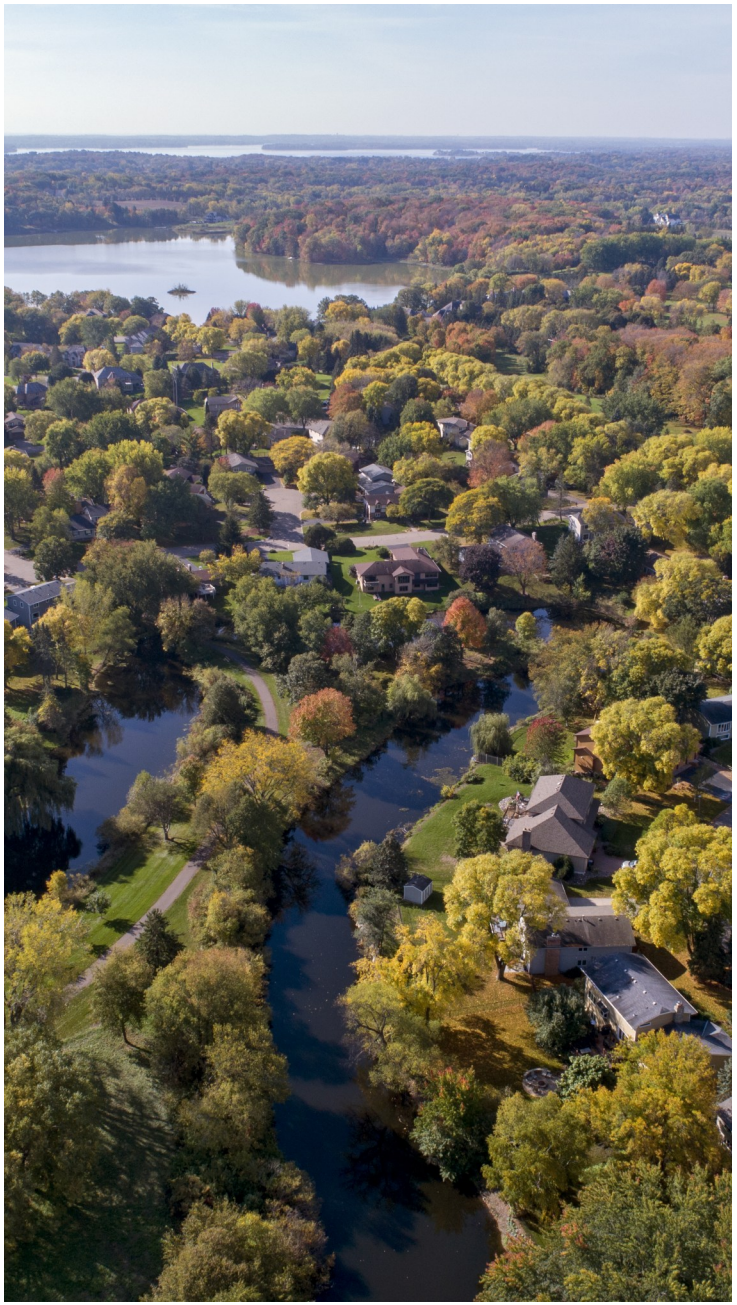
Lawns, Native Grasses and Climate Resilience

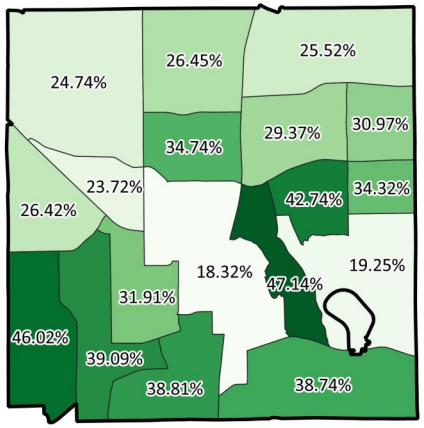
Manicured lawns often consist of non-native grass species that demand high levels of maintenance, contributing to carbon emissions through constant mowing. These grasses tend to have shallow root systems which sequester very little carbon and do not contribute significantly to soil health while offering little to no shelter or food for native fauna, reducing biodiversity.

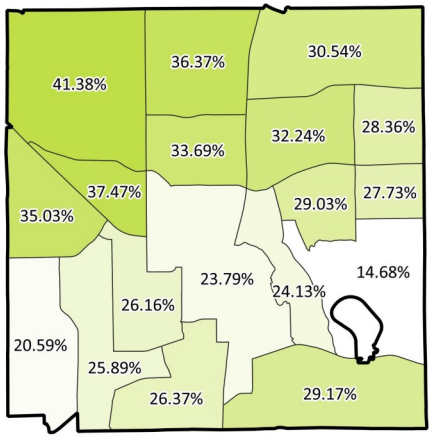
Converting manicured lawns to native grasses and prairie restoration offer an opportunity to enhance climate resilience. These indigenous grasses are adept at surviving broader weather extremes, are drought tolerant, and require no chemical fertilizers to thrive – reducing nitrogen runoff. Their deep root systems increase soil health, prevent erosion, enhance water infiltration, and sequester significantly more carbon better mitigating greenhouse gas emissions. Native grasses and prairies support greater biodiversity, providing habitats for local wildlife, including pollinators, which are essential for maintaining healthy ecosystems.

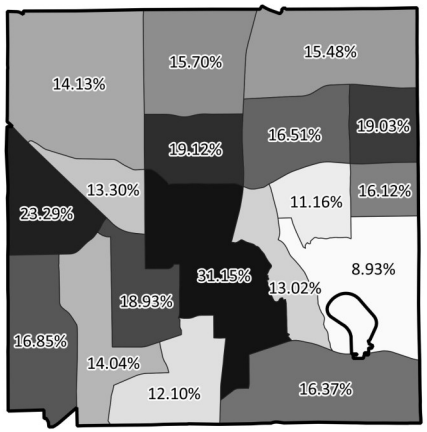
Impervious Surfaces and Climate Resilience

Conversely, higher levels of impervious surfaces (pavement and buildings) within a community will increase the heat island of the community. Heat island refers to the phenomenon of higher atmospheric and surface temperatures occurring in developed areas than those experienced in the surrounding rural areas due to human activities and infrastructure. Increased heat indices during summer months due to heat island effects raise human discomfort and health risk levels in developed areas, especially during heat waves. Based on a 2006 study done by Fi Yuan and Marvin Bauer and Minnesota State University and the University of Minnesota, the relationship between impervious surface percentage of a City and the corresponding degree of heat island temperature increase can be understood as a ratio. (See “Impervious Surface Reduction Potential” for more.)









Greenspace and Ecosystems

Tree Canopy Coverage

City Average: **30.6%**

City High: **47.1%** Tract 026505

City Low: **18.3%** Tract 026514

Lawn and Grass Coverage

City Average: **29.7%**

City High: **41.4%** Tract 026616

City Low: **14.7%** Tract 026516

Dark Impervious Surface Coverage (buildings + pavement)

City Average: **17.2%**

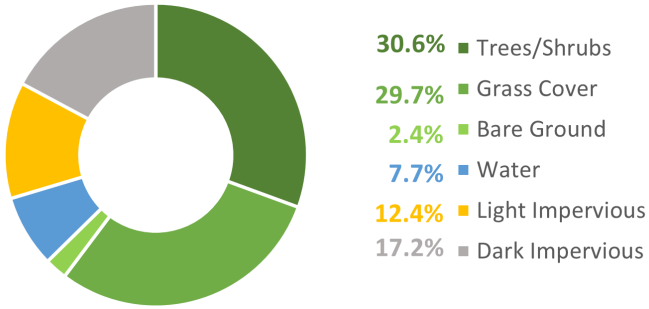
City High: **31.2%** Tract 026514

City Low: **8.9%** Tract 026516

Greenspace and Ecosystems

Citywide Ground Cover Breakdown by Type

The chart to the left shows the total share of ground cover by type citywide. See the Plymouth Ground Cover, Heat Island, and Carbon Sequestration study for more information.



Plymouth's Tree Canopy Benefits

The condition and health of a community's Tree Canopy and green infrastructure and the magnitude and nature of impervious surfaces have meaningful consequences on the area's environment. Trees and greenspace offer significant benefit to a community including stormwater management, heat island mitigation, pollution absorption, and economic benefit. Those benefits are often not evenly distributed.

Through the ground cover study those benefits can be mapped and areas of improved resilience need can be identified. The maps on the following page indicate areas of potential increased stormwater management and heat island mitigation need as well as a comparison of the city's tree canopy economic benefits per household.

See the City of Plymouth Ground Cover, Heat Island and Carbon Sequestration Study for more information.

Annual Pollution Absorption and Carbon Sequestration Value of Trees

$3,907,829

Annual Energy Savings Value of Trees

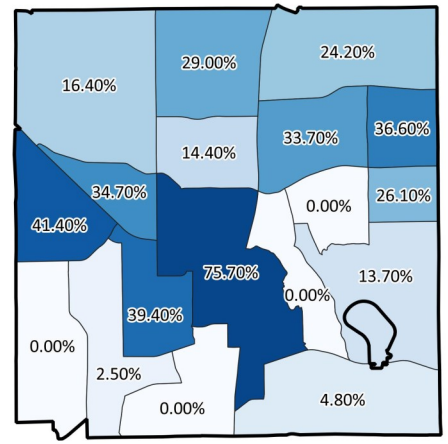
$1,478,800

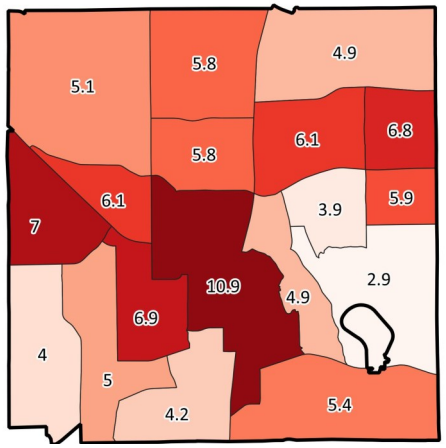
Annual Carbon Sequestration by Grasses

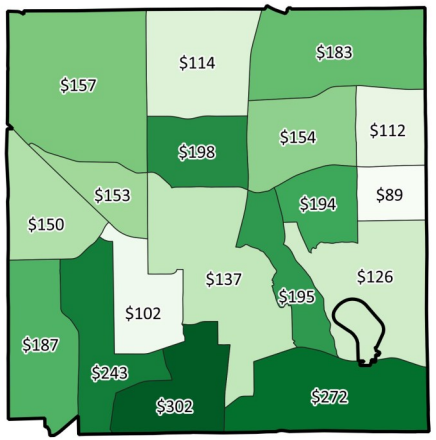
4,191 Metric Tons

Annual Carbon Sequestration by Trees

22,911 Metric Tons







Greenspace and Ecosystems

Estimated Stormwater Runoff Uptake Need Potentially Unmet by Green Infrastructure

City Average: **27.4%** of estimated potential runoff

City High: **75.7%** of estimated potential runoff—Tract 026514

City Low: **0%** of estimated potential runoff—Multiple Tracts

Estimated Micro Heat Island Contribution of City of Plymouth Impervious Surfaces (summer values)

City Average: **5.9°F**

City High: **10.9°F** Tract 026514

City Low: **2.9°F** Tract 026516

Numbers represent the potential increase in summer-time temperatures experienced due to ground cover characteristics

Tree Canopy Benefit Value of Pollution Absorption and Energy Savings Per Household

City Average: **$165**

City High: **$302** Tract 026609

City Low: **$89** Tract 026511

Greenspace and Ecosystems

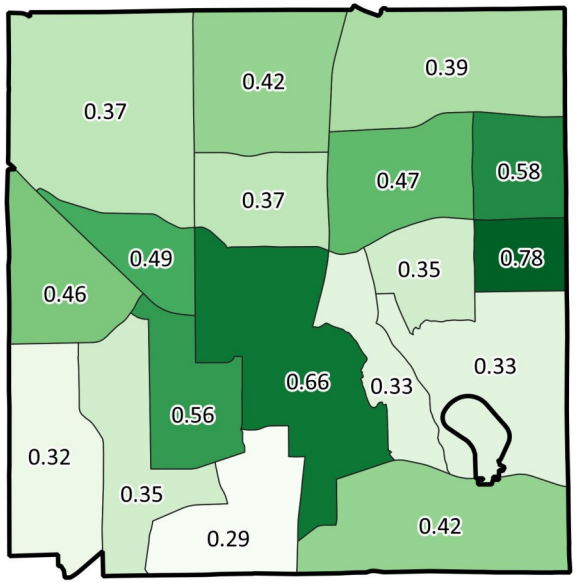
Prioritizing Tree Canopy Increases

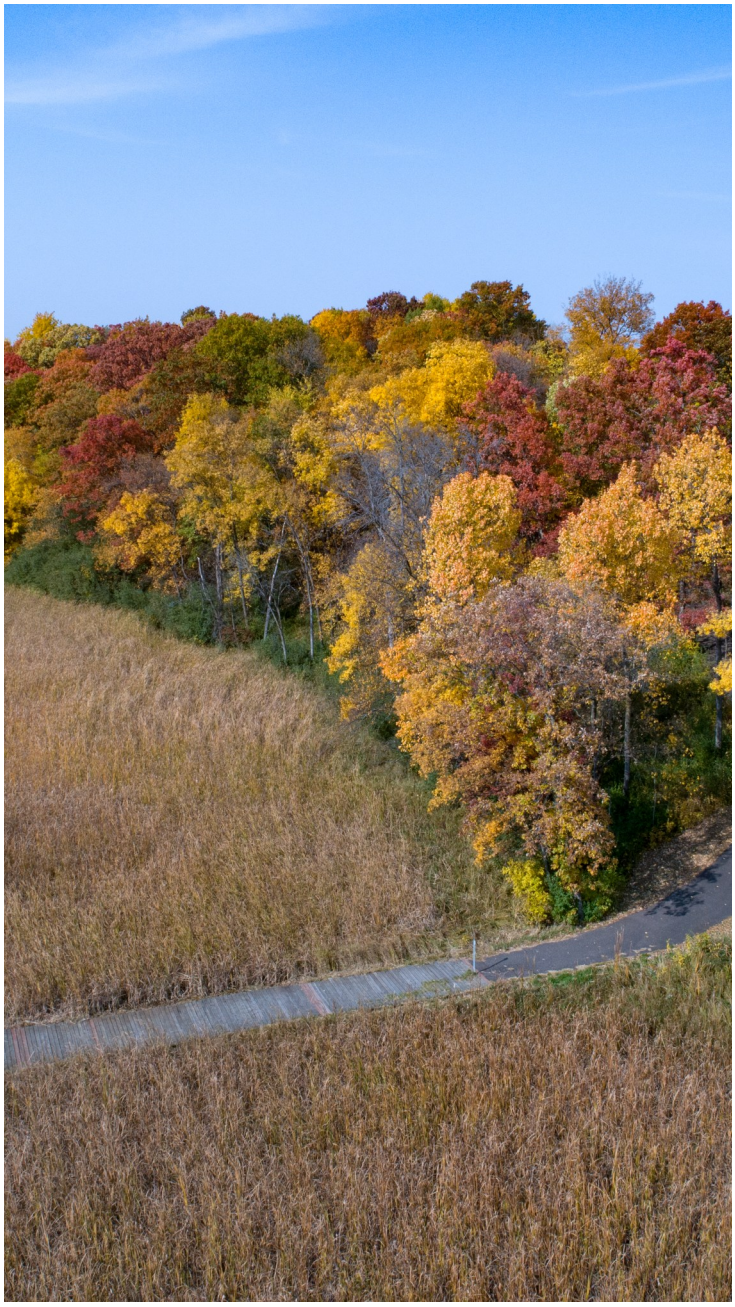
The ground cover study employed an equity-focused method for green infrastructure expansion, using an "environmental equity index" that assesses each census tract's landscape and population features.

The weighted prioritization for tree canopy increase looks to balance the potential for increased tree canopy with the opportunity to improve tree canopy benefit equity, potential to positively impact as many households as possible, and the need for mitigation of heat island impacts. The priorities above are weighted as follows:

- Potential for new trees: 15%
- Population density: 15%
- Low Income Population density: 30%
- Heat Island mitigation need: 40%

The proposed framework does not include land in use as agriculture in calculations of potential tree canopy increases. The map below shows the weighted prioritization results. See the City of Plymouth Ground Cover, Heat Island and Carbon Sequestration Study for more information.





Calculating Potential Tree Canopy Goals

The Ground Cover Heat Island and Carbon Sequestration study provides a sample tree canopy goal to assist the city's CAP planning team. The goals here are initial benchmarks for planning and help the team grasp the connection between tree canopy objectives, potential effects, and the extent of effort needed to achieve them.

The CAP plan is anticipated to have 2035 interim goals and 2050 long-range goals. Given the uncertainties and variables in setting multi-decade objectives, this report proposes a 2040 goal, with the 2050 target to be determined after implementing the CAP plan.

Based on the weighted priority tree canopy increase methodology previously reviewed, the recommended, or example, tree canopy increase goals are:

For area in the top 1/3rd Priority: **10%**

For areas in middle 1/3rd Priority: **6.25%**

For areas in bottom 1/3rd Priority: **2.5%**

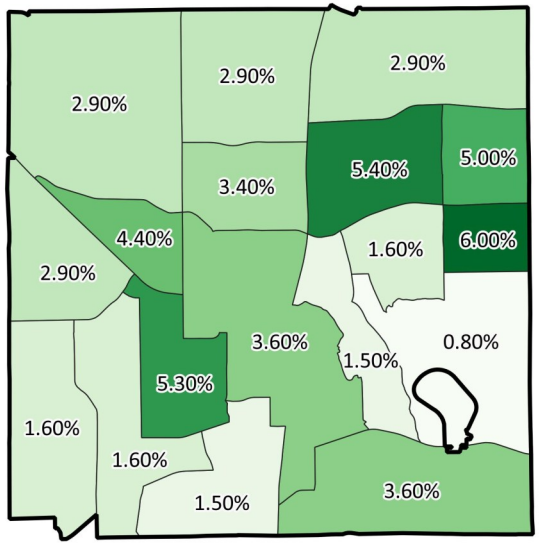
See the maps to the right for the resulting tree canopy increases in absolute ground cover increase and increase over existing tree canopy cover.

Tree Canopy Goal as Increase in Absolute Ground Cover Percentage

City Average: **3%**

City High: **11%**
Tract 59.01

City Low: **0.7%**
Tract 73.17

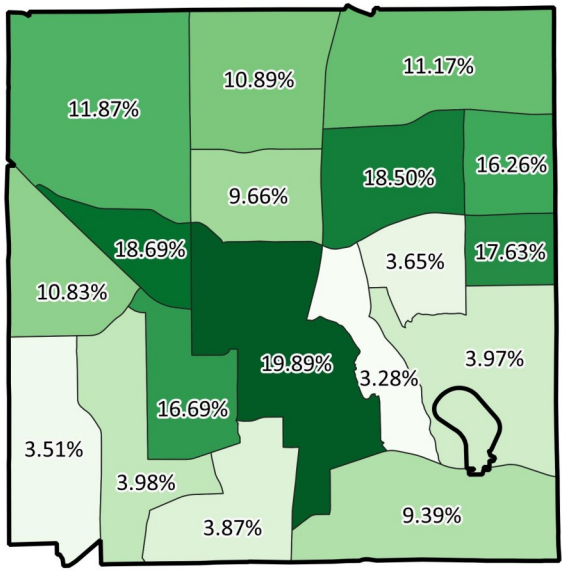


Tree Canopy Goal as Percentage Increase Over Existing Tree Canopy Area

City Average: **11.9%**

City High: **1,552%**
Tract 39

City Low: **3%**
Tract 73.03



Greenspace and Ecosystems

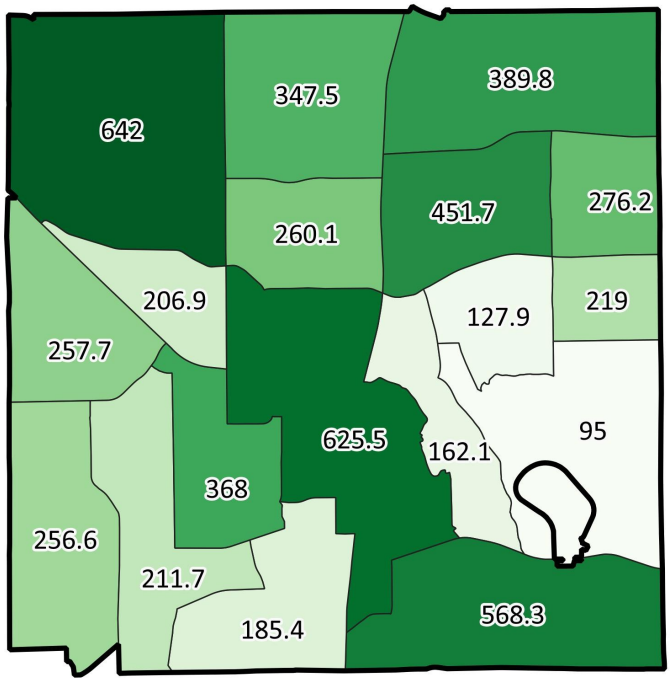
New Annual Tree Planting to Meet Potential Tree Canopy Goal

Based on the recommended, or example, tree canopy increase goals outlined on the previous page, the annual number of new tree plantings required to meet the goal can be calculated. These calculations include estimated tree growth and mortality and are provided to establish a link between tree canopy goal setting and new trees required to achieve them. The proposed framework does not include land in use as agriculture in calculations of potential tree canopy increases.

Citywide Total:
(Note, Acreage represents the canopy coverage at year of planting, with an assumed new tree crown radius of 5’ planted no more than 22’ apart):

City Total Annual New Planting Target Required for Goal:

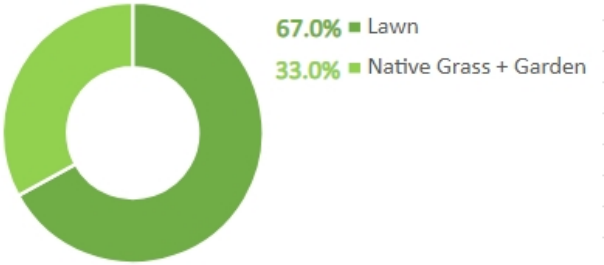
63 Acres **5,652** New Trees



Other Ground Cover Goal Potentials

In addition to opportunities to expand and improve the City's tree canopy, the findings of the ground cover study as outlined in the City of Plymouth Ground Cover, Heat Island, and Carbon Sequestration Study may be used to identify additional opportunities for increased heat island mitigation and increased native grass installations.

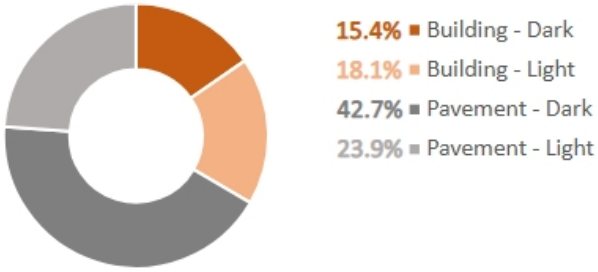
Comparing Lawn and Native Grass Coverage



Turf Reduction Potential

As illustrated in the chart to the left, an estimated 33% of all grass ground cover in the City of Plymouth are native and wildflower grasses. The remaining 67% are manicured lawns - representing a great opportunity for turf reduction. Turf reduction can increase stormwater uptake, reduce potable water use, and increase soil carbon. Prioritization of these strategies should focus on portions of the city with higher unmet stormwater uptake need and heat island impacts. Note, these ground cover calculations do not include agricultural / crop lands.

Comparing Dark Impervious Surface Coverage



Impervious Surface Reduction Potential

The city's experiences of heat island are directly impacted by the level of impervious surface coverage—particularly dark roofs and pavement. Based on a 2006 study done by Minnesota State University and the University of Minnesota*, the relationship between impervious surface percentage of a City and the corresponding degree of heat island temperature increase can be understood as a ratio. As the diagram to the left illustrates dark pavements make up 41.7% while dark roof structures make up 15.4% - meaning 57% of all impervious surfaces being classified as "dark." These represent significant opportunities for decreasing heat island impacts in the community through "cool" and "green" roof and pavement strategies and exploration of de-pavement opportunities. For every 1% decrease in impervious surfaces in a neighborhood of City of Plymouth, that area's likely experience of summer time heat island temperatures may decrease 0.17°F. Prioritization of these strategies should focus on portions of the city with higher heat island impacts.

See City of Plymouth Ground Cover Survey and Carbon Sequestration study for more information.

**Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery.* Fi Yuan and Marvin Bauer, February 2007

Greenspace and Ecosystems

Park Accessibility

Park spaces, and convenient access to them, offer numerous benefits: they enhance physical and mental well-being, drive economic gains by bolstering businesses and rejuvenating neighborhoods, and foster community engagement by creating venues for neighborly interaction and cooperative local improvement efforts. Environmental advantages of park areas include the reduction of air pollution, air cooling to counteract urban heat islands, better water quality, and increased flood resistance.

Data from the Trust for Public Land indicates that in Plymouth, 97% of residents can reach a park within a 10-minute walk.

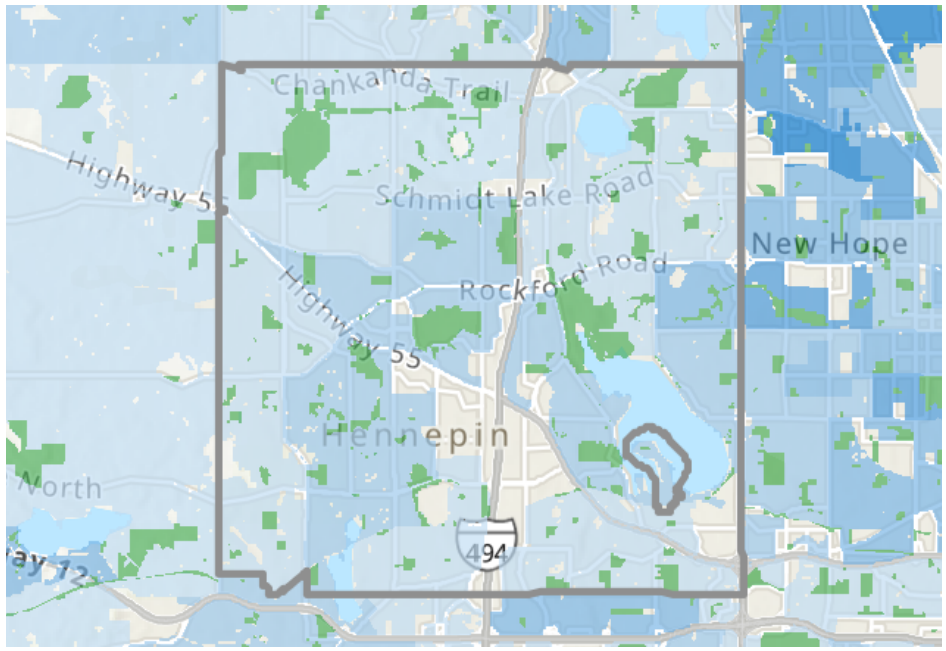
97% of Plymouth residents live within a 10 minute walk of a park.
National Average: 55%

Data and map sources: Trust for Public Land

Physical Inactivity and available park space

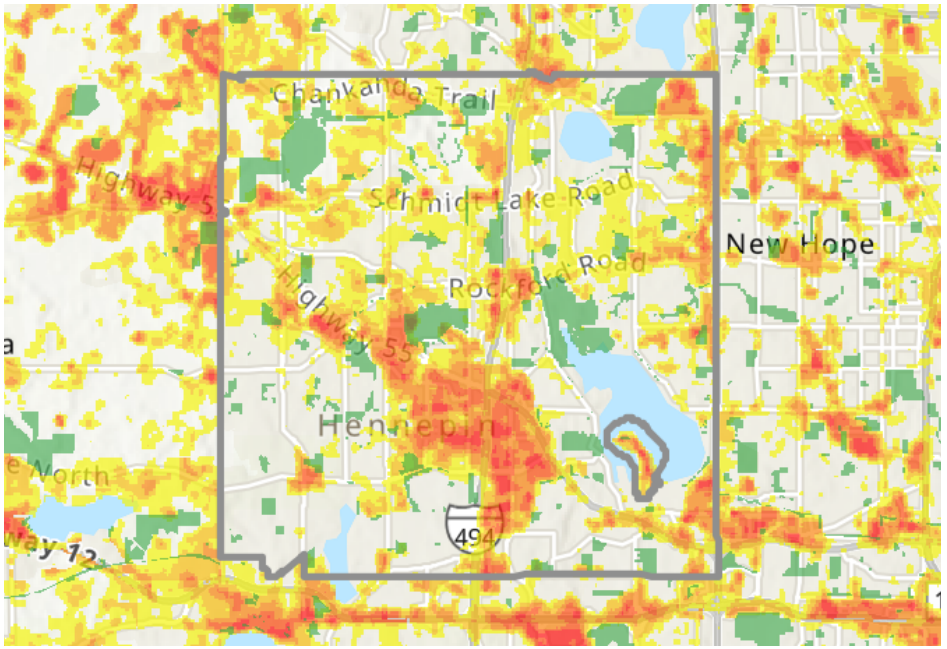
- Very High
- High
- Medium
- Low
- Very Low
- **Park with Public Access**

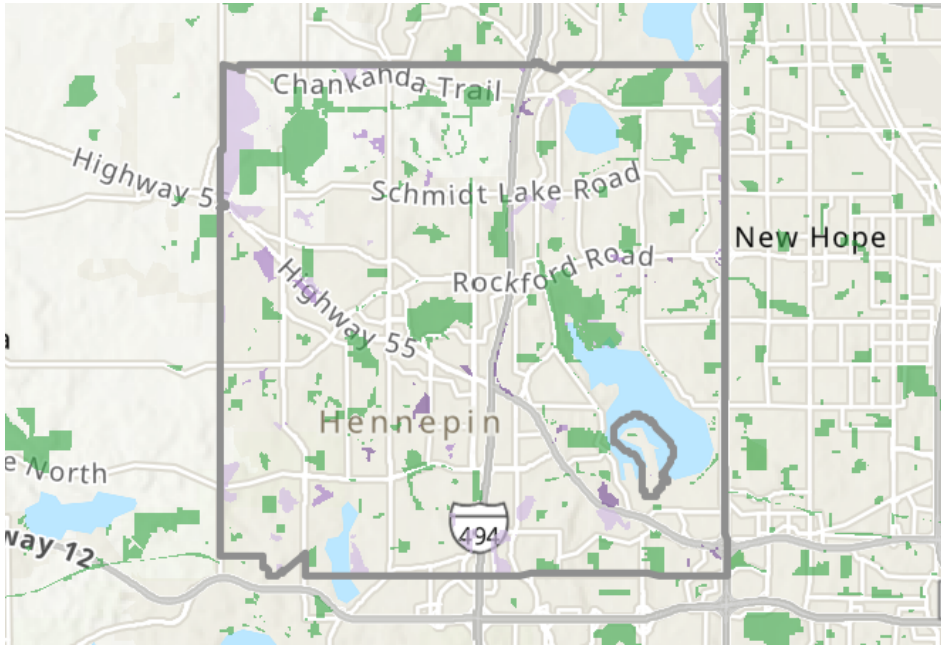
Data: CDC Places 2022



Heat Island Hazard and available park space

- Moderate
- Moderately Severe
- Severe
- Very Severe
- Extreme
- **Park with Public Access**



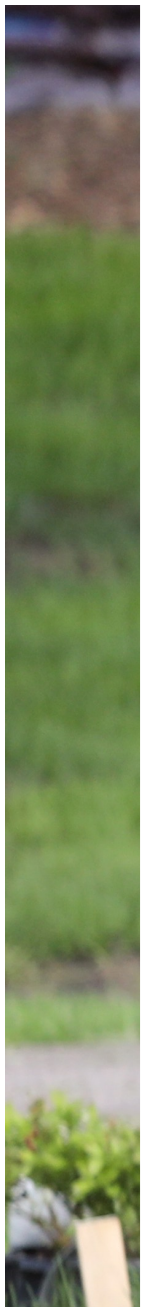


Very High
High
Moderate
Park with Public Access

Greenspace and Ecosystems

Potential Priority Areas for New Park Space

The map to the left indicate potential priority areas for new park or open green space. These areas represent potential locations which could improve overall accessibility.



Greenspace and Ecosystems

Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Greenspace and Ecosystems Strategic Goals:

GE 1: Increase tree cover, particularly in the priority neighborhoods, from 30.6% to 33.6% by 2040 with growth coming from non-invasive species and an emphasis on climate adaptive species (an increase of 10% over existing tree canopy area).*

GE 2: Increase pollinator supportiveness and achieve a 3% turf replacement with native grasses and wildflowers citywide by 2035 (approximately 14 acres annually).

GE 3: Reduce heat island effect through citywide "dark" impervious surface coverage reduction of 3% by 2035, particularly in neighborhoods identified with higher heat island impacts (approximately 11 acres annually).

GE 4: Use and promote land management practices that enhance climate resilience.

*The proposed framework does not include land in use as agriculture in calculations of potential tree canopy increases.

Section 08 Health and Safety

Click here to return to TOC

Additional Information (click icon)

Vulnerability Assessment

Ground Cover Assessment

A vital connection exists between human health and the state of the environment. The quality of the air, the purity of our water, and our very existence hinge on the health of Earth's ecosystems. This essential bond informs the urgency of addressing climate change impacts, a key focus of the City's 2024 Climate Vulnerability Assessment. Shifts in climate patterns—like rising temperatures and more severe storms—escalate health risks. Such impacts from climate change threaten our well-being by compromising the air quality, altering weather conditions, and affecting our food, water, and the way we interact with our surroundings. With ongoing climatic shifts, the peril to human health only intensifies.

Just as local authorities and healthcare providers advocate for healthy living through proper diet and exercise, it's crucial for agencies to acknowledge the intertwining of climate initiatives, environmental care, and public health. After all, the condition of our environment directly influences the public's health.

Projected Economic Impacts Through 2100[1]

According to research from the University of California at Berkeley, the total annual economic costs for the county and Glencoe's pro rata share by 2100 will be (2019 dollars)*:

County: $881,145,000 annually
Plymouth: $55,671,000 annually

* Value does not include potential increased property damage nor increased healthcare costs due to extreme weather events.

1: "Estimating economic damage from climate change in the United States" Solomon Hsiang, et al.

Climate Change Projections Plymouth

A child in Plymouth today can expect in their life: Climate Conditions	Baseline	Mid-Century (2050 averages)	End of Century (2100 averages)
Average Daily Maximum Temperature	55° F	61°F	62°F to 66°F
Number of Days Per Year > 95° F	2	21	24 to 49.5
Number of Days Per Year < 32° F	160	134	133 to 109
Change in Growing, Allergy, and Vector-Borne Disease Season	9 days	25 days	25 to 40 days
Average Annual Precipitation and Projected Increases	26"	23%	4 to 35%
Increase in Heavy Precipitation Events	N/A	31%	31 to 63%
Baseline Air Conditioning Demand (CDD) and Projected Increases	600	133%	133 to 250%
Estimated Increase In Residential Per Capita Electricity	N/A	39%	39 to 59%

Climate Impact Risks to The City's Population

The projected changes to the community's climate in the coming decades represent potential risks to residents. Below are some of the more significant risks to the community's population:

Direct Climate Risks

Economic Risks

Assessing Risk Level to The City's Population

Climate risks can be reviewed by occurrence likelihood and impact on vulnerable populations. The Prioritizing Climate Risks Summary Chart to the right provides a review of each risk.

Prioritizing Climate Risks Summary Chart

Health Impacts	Likelihood of Occurrence	Impact Level (Sensitivity Ranking Summary)	Timeframe	Risk (Likelihood x Impact x Timeframe)
Extreme Weather / Temperature	Likely	High	Short-term	Very High
Flooding	Possible	Moderate	Medium-term	Low
Drought	Possible	Low	Medium-term	Very Low
Air Quality Impacts	Likely	High	Short-term	Very High
Vector-Borne Diseases	Likely	Moderate	Medium-term	Moderate
Food Insecurity	Likely	High	Medium-term	High
Water Quantity / Quality Impacts	Possible	Low	Long-term	Very Low
Waterborne Disease	Unlikely	Low	Medium-term	Very Low
Power / Infrastructure Failure	Likely	High	Medium-term	High
Wildfire	Possible	Moderate	Medium-term	Low
Crop Failure	Unlikely	Moderate	Medium-term	Very Low
Mortality	Possible	Low	Long-term	Very Low
Energy Costs	Likely	Moderate	Medium-term	Moderate
Property Crime	Possible	Moderate	Long-term	Very Low
Violent Crime	Unlikely	Low	Long-term	Very Low

Likelihood of Occurrence: Unlikely = 1; Possible = 2; Likely = 3
Impact Level: Low= 1; Moderate= 2; High = 3
Timeframe: Long-term = 1; Medium-term = 2; Short-term = 3; Current = 4
Resulting risk levels are based on the resulting total scores as follows:
Very Low < 5; Low < 9 ; Moderate < 18; High < 27; Very High => 27

Health and Safety

Who is Most Vulnerable?

Throughout the United States, there are variations in how individuals and communities experience, are affected by, and adapt to the threats of climate change. Community members who are most vulnerable include:

As outlined in the City of Plymouth Climate Vulnerability Assessment, based on the total estimated population count for each vulnerable population and considering the risks each demographic is most sensitive to, the population vulnerabilities can be considered from highest sensitivity (more vulnerable individuals) to lowest sensitivity (fewer vulnerable individuals). It should be noted that risks which appear to have lower sensitivity levels should not be considered irrelevant for the community.

See the City of Plymouth Climate Vulnerability Assessment for more information.

Prioritizing Population Risks and Vulnerabilities

Climate change touches everyone. Climate adaptation planning requires analysis to set priorities without neglecting any City population, regardless of their "vulnerable" status. An effort to prioritize adaptation measures should not be seen as an indication that any risk should be ignored or the needs of any population within the City - whether or not it is defined as one of the “vulnerable” populations - should be discarded. Prioritization, however, is necessary to ensure the greatest impact and effectiveness of limited City resources.

Based on the review outlined in the Climate Vulnerability Assessment, the City’s adaptive efforts may be most effective by prioritizing strategies which address the climate risks as follows:

Primary Prioritization:
Extreme Weather, Air Quality, Food Insecurity, Power Failure

Secondary Prioritization:
Flooding, Energy Costs

Tertiary Prioritization:
All Other Risks

With all adaption measures attention should be paid to strategies which are most of effective for mitigating and reducing risks in vulnerable populations. For the City of Plymouth, particular attention should be paid to **People of Color, Seniors over 65, and those in Economic Stress.**

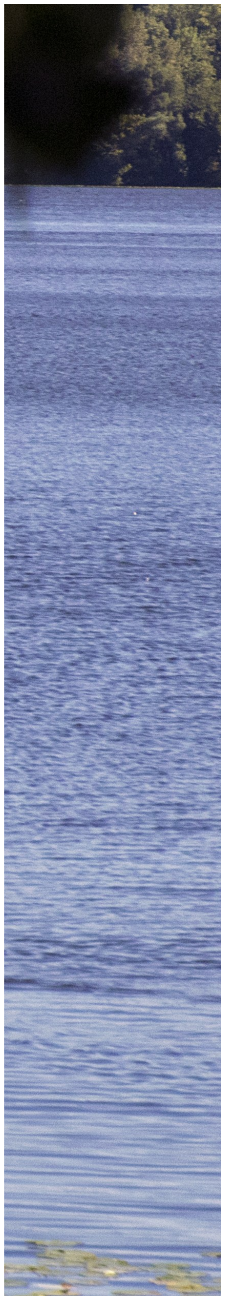
Health and Safety

Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Health and Safety Strategic Goals:

HS 1: Assist the City's climate vulnerable population in preparing for and mitigating climate change impacts (prioritized based on elevated risk sensitivities as outlined in the City's Climate Vulnerability Assessment).

HS 2: Educate, engage, and empower the public on health and safety risks of climate change impacts.



Section

09

Climate Economy

Click here to return to TOC

Additional Information (click icon)

Renewable Energy Study

Climate Economy

Climate change and the Climate Economy are deeply interconnected. Without action, human-caused climate change could cost the United States billions annually by century's end. The EPA's *Multi-Model Framework for Quantitative Sectoral Impacts Analysis* estimates that differences between low- and high-range IPCC climate scenarios could result in up to $224 billion in annual economic losses by 2090. A 2019 World Bank report found that a carbon price of $50–$100 per ton by 2030 is needed to meet Paris Agreement goals, while other studies place the true cost of carbon at $200–$400 per ton. In 2023, Minnesota revised its utilities law to require the Public Utilities Commission to use the EPA's updated social cost of greenhouse gas (SC-GHG) estimates, setting the 2030 social cost of carbon between $140 and $380 per ton.

To create a City of Plymouth specific value, we can use the calculation outlined in Section 7 of the Plymouth Climate Vulnerability Assessment (projected localized annual economic impacts of climate change divided by annual community-wide GHG emissions), a minimum localized cost for carbon is estimated at $70 per metric ton. Using that figure, every 1% in community-wide emissions reductions will generate over $556,000 in social community benefits alone, not including other economic savings or revenue generation.

Climate Action and Economic Development

The economy is integral to climate action. While some fear Climate Action may harm the economy, proactive measures help avoid future costs from environmental degradation and climate-related disruptions. Evidence increasingly shows that reducing fossil fuel use and addressing climate change can strengthen, not weaken, economic stability.

Sustainable practices—such as transitioning from fossil fuels, improving public transportation, and supporting local agriculture—keep wealth within communities and expand local job opportunities. Climate Economy jobs are typically more labor-intensive and less resource-dependent, boosting employment while reducing material consumption.

In 2023, Minnesota legislators advanced this vision through the 100 Percent Clean Energy Law, requiring utilities to deliver 100 percent carbon-free electricity by 2040, with progress reports every five years. This transition will generate economic opportunities in renewable energy, energy efficiency, and public transit, while reducing energy costs and fossil fuel dependence.

Energy Efficiency and Renewable Energy Jobs

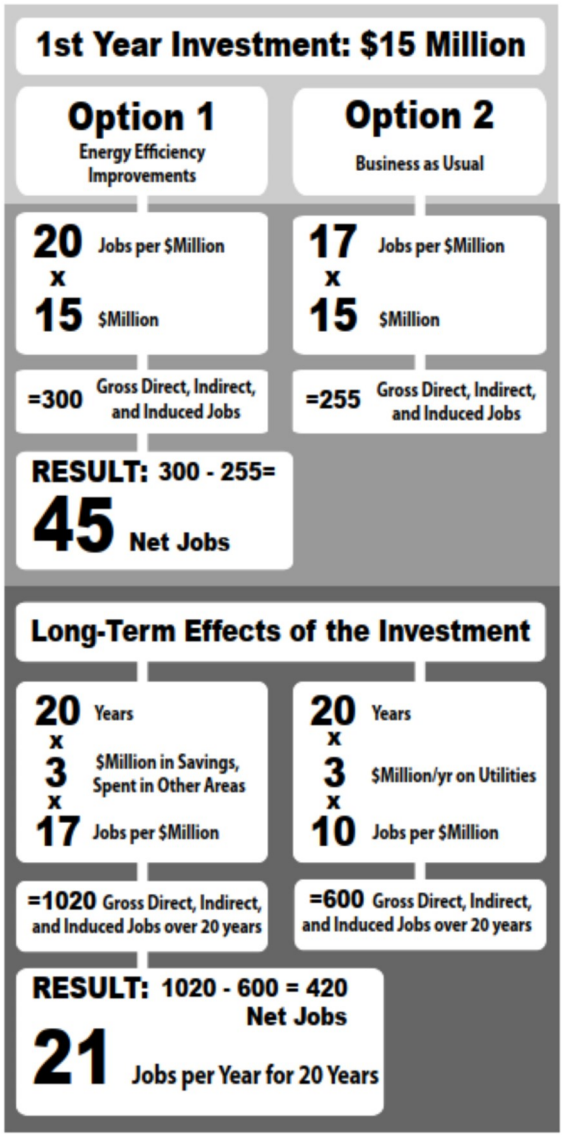
Increases in community-wide energy efficiency, fuel switching, and renewable energy installations all require energy retrofits and renovations within existing building stock. This construction effort provides new opportunities for construction laborers, efficiency experts, and testing agents. The specialty niche also provides opportunities for new businesses to be created to address the demand. "How Does Energy Efficiency Create Jobs?" by the American Council for an Energy-Efficient Economy (ACEEE) illustrates that a $15 million investment in energy efficient facilities, when compared against "business-as-usual," would increase local employment by 45 jobs in year one along with on-going impacts creating up to 20 additional jobs annually for 20 years.

Public Transit Jobs

Transit is key to both creating jobs and increasing access to existing jobs. "What We Learned from the Stimulus" by Smart Growth America found that investments in public transit created almost twice the number of jobs than the same level of spending in auto-centric transportation systems. Cities with better public transportation systems also have lower levels of unemployment, and greater reductions in unemployment among young people according to "Spatial Mismatch and Youth Unemployment in US Cities: Public Transportation as a Labor Market Institution" by Christof Brandtner and Anna Lunn of Stanford University. According to "Economic Impact Of Public Transportation Investment" by the American Public Transit Association, for every $1 invested in public transportation $5 in economic returns are generated. Investing in more buses and drivers both creates jobs directly and makes local labor markets function better.

Economic Savings

Investments in energy efficiency, public transportation, renewable energy, and many other Climate Action strategies ultimately result in cost savings for community businesses and residents. These savings contribute to an increase in the quality of life for residents and represent a potential for increased spending within the community on goods and services which would provide additional, indirect and induced economic development potential for the community.



Graphic Source:
"How Does Energy Efficiency Create Jobs?" ACEEE

Clean Economy

Job Potential of Buildings and Energy for Plymouth*

We can estimate job potential from residential energy efficiency and fuel switching improvements in Plymouth using the ACEEE report, *"How Does Energy Efficiency Create Jobs?."* We can also estimate the job potential of increased renewable energy installations. This analysis is based on the preliminary goals outlined in the Buildings and Energy section and total:

Building and Energy Jobs: **60**

Annual Income Potential (at $55,000) **$3,326,714**

Job Potential of Transportation for Plymouth*

Using reports and data from the American Public Transportation Association (APTA), the National Renewable Energy Laboratory (NREL), and others, we can estimate the local job potential associated with increased public transit use as well as those associated with increased electric vehicle charging stations to supporting the transition to electric vehicles. This analysis is based on the preliminary goals outlined in the Transportation and Land Use section and total:

Transportation Jobs: **185**

Annual Income Potential (at $55,000) **$10,168,136**

Job Potential of Waste Management for Plymouth*

Using reports and data from the Institute for Local Self Reliance, the Tellus Institute, and others, we can estimate the local job potential associated with increased organics and recycling diversion. supporting the transition to electric vehicles. This analysis is based on the preliminary goals outlined in the Waste Management section and total:

Waste Management Jobs: **10**

Annual Income Potential (at $45,000) **$452,521**

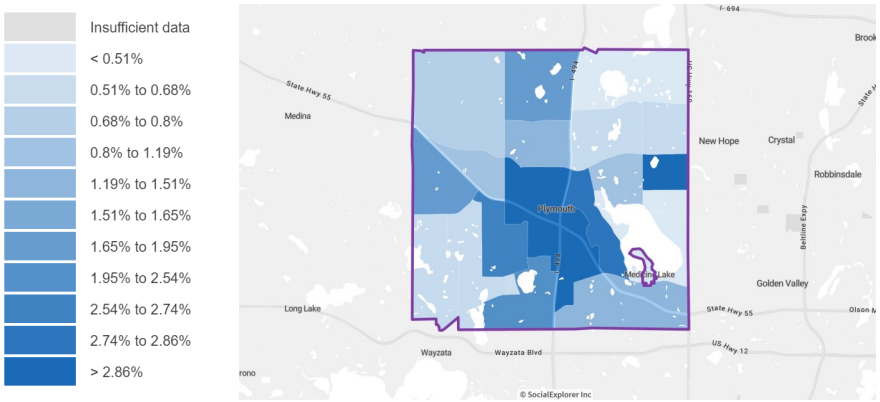
Additional Economic Benefit of Customer Owned Solar for Plymouth

Plymouth residents and businesses that invest in solar PV will see direct economic benefits through reduced energy costs, increasing local economic potential. By 2035, these savings are estimated at $500,000–$700,000 per year.

* see "Summary of Estimated New Job Potential of Modeled Reductions" appendix

Unemployment in City of Plymouth

In 2023, community-wide unemployment in Plymouth averaged 1.4%, according to the US Census. However, some census tracts experienced unemployment as high as 3.2% (see map below). Local job creation through Climate Action strategies could significantly improve employment opportunities and quality of life for the city's most vulnerable populations, making it a key resilience strategy.



Sustainable Job Growth Goal

Based on the job growth projections in the City's GHG Inventory emissions forecast, this illustrates a potential sustainability job goal for Plymouth.

Total jobs by 2035

59,000

Increase over 2024

5,506

% increase over 2024

10.3%

Target Sustainability job share of increase

5%

New Sustainability Jobs target

275

New Sustainability Jobs Goal per year

27.5

Climate Economy

Strategic Goal Recommendations - Citywide

Based on the reviews outlined in this section, we recommend the City of Plymouth explore establishing the following Climate Economy Strategic Goals:

Adaptation

E 1: Develop the equitable workforce and entrepreneur opportunities of Climate Action in the economy to increase new sustainability careers within Plymouth.

E 2: Support local businesses operations in building climate resilience.

E 3: Establish sustainable financing for the City's climate action implementation.

Section A

State and County Climate Action Plans

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State of Minnesota Priority Climate Equity Action Plan

The Minnesota Pollution Control Agency (MPCA) secured an EPA grant under the Climate Pollution Reduction Grants (CPRG) initiative, part of the Inflation Reduction Act. The funds support developing state and local climate plans to cut GHG emissions.

MPCA created a Priority Climate Action Plan (PCAP) March 1, 2024, and will be creating a Comprehensive Climate Action Plan (CCAP) by late summer 2025. The PCAP proposed immediate, impactful emission reduction strategies, while the CCAP will look at broader, long-term solutions across economic sectors. Both will involve low-income and underserved groups and assess benefits to these communities. After the PCAP submission, Minnesota entities may be able to seek grants to implement the outlined strategies.

To view the State of Minnesota's PCAP plan visit:
https://www.pca.state.mn.us/sites/default/files/aq1-70.pdf

State of Minnesota Climate Action Framework

Climate change is already impacting communities across Minnesota, bringing serious challenges that will only intensify without action. Yet, this crisis also presents a powerful opportunity to strengthen our economy, protect public health, and build a more just and equitable future for all Minnesotans. To chart a clear path forward, the State of Minnesota created the Climate Action Framework—a comprehensive plan that outlines the steps needed to reduce emissions, enhance resilience, and move toward a carbon-neutral and equitable future. The Framework establishes both immediate priorities and long-term strategies to ensure Minnesota is prepared to meet the challenges and opportunities of a changing climate.

To view the State of Minnesota's Climate Action Framework visit:
https://climate.state.mn.us/minnesotas-climate-action-framework

Metropolitan Council Priority Climate Equity Action Plan

In addition to the Statewide Priority Climate Action Plan outlined above, the Metropolitan Council also received an EPA grant under the CPRG grant to develop a climate plan for the Minneapolis St Paul Metropolitan Area. After the PCAP submission, local governments located within the metropolitan area may be able to seek grants to implement the outlined strategies.

To view the Metropolitan Council plan visit:
https://www.epa.gov/system/files/documents/2024-03/metropolitan-council-twin-cities-msa-priority-climate-action-plan.pdf

Hennepin County Climate Action Plan

In 2021, the county established a Climate Action Plan, which outlines near-, mid-, and long-term strategies designed to address climate challenges. The plan includes 5 goals, 29 strategies, and 145 tactics. The strategies focus on cutting greenhouse gas emissions and adapting to the changing climate in ways that reduce vulnerabilities and ensure a more equitable and resilient Hennepin County.

To view the Hennepin County plan visit:
https://www.hennepin.us/en/climate-action

Section B

Summary of Estimated New Job Potential of Modeled Reductions

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Summary of Estimated New Job Potential of Modeled Reductions

City of Plymouth

Climate Action Plan

Total Community Job Potential Estimate

The following is an estimate of the local job potential of achieving plan goals for the community. See detail and assumptions in sector break-downs that follow.

Building and Energy Jobs Estimate	77
Transportation Jobs Estimate	248
Waste Management Jobs Estimate	10
Total Community Job Potential Estimate:	**334**
Total Estimated Annual Income Potential:	**$18,283,854**

Notes

Building and Energy Jobs Estimate

[1]Energy Efficiency and Fuel Switching - Residential	13
[1]Energy Efficiency and Fuel Switching - Non-Residential	7
[2]Renewable Energy - Residential	20
[2]Renewable Energy - Non-Residential	37
Building and Energy Jobs:	**77**
Annual Income Potential (at $55,000)	**$4,214,339**

1: Assumptions & Rationale: Calculated at 45 jobs per $15 million in investment based on “How Does Energy Efficiency Create Jobs?” by the American Council for an Energy-Efficient Economy (ACEEE) which illustrates that a $15 million investment in energy efficient facilities, when compared against “business-as-usual,” would increase local employment by 45 jobs in year one along with on-going impacts creating up to 20 additional jobs annually for 20 years. See "Summary of Estimated Cumulative Savings of Modeled Reduction" for investment value calculations and assumptions. Source: https://www.aceee.org/fact-sheet/ee-job-creation

2: Assumptions & Rationale: Calculated based on average values from the National Renewable Energy Laboratory (NREL) The Jobs and Economic Development Impacts (JEDI) Solar Photovoltaics (PV) Model for construction and professional services jobs https://www.nrel.gov/analysis/jedi/pv See "Summary of Estimated Cumulative Savings of Modeled Reduction" for investment value calculations and assumptions.

Notes

Transportation Jobs Estimate

[3]Public Transit	244
[4]Fuel Switching - Electric Vehicle Infrastructure	3
Transportation Jobs:	**248**
Annual Income Potential (at $55,000)	**$13,616,993**

3: Assumptions & Rationale: An additional 1,000 daily transit riders generate roughly 500,000–700,000 annual passenger trips (assuming round trips), requiring several dozen new local transit workers such as drivers, mechanics, and support staff. Because public transit is labor-intensive—employing over 430,000 people nationwide—ridership growth directly boosts local employment. Indirectly, expanded service also supports jobs through supplier contracts and improved access to employers. While APTA estimates that public transit supports millions of jobs economy-wide, the 30–40 jobs per 1,000 new riders figure reflects only the direct local employment impact.. Sources: New APTA Data Shows Public Transportation Drives Economic Growth, Creates Jobs, and Powers U.S. Mobility - American Public Transportation Association; https://www.apta.com/news-publications/press-releases/releases/new-apta-data-shows-public-transportation-drives-economic-growth-creates-jobs-and-powers-u-s-mobility/

4: Assumptions & Rationale: A national study projects over 160,000 U.S. jobs by 2032 from expanding the EV charging network to support roughly 40 million EVs. These positions are inherently local, including electricians, technicians, and trained auto service staff maintaining charging infrastructure and EV systems. While EVs require less routine maintenance than gasoline vehicles, job gains stem from new sectors—charging installation, grid upgrades, battery servicing, and software support. Calculations for new EVSE demand are based on the US DOE Alternative Fuels Data Center Electric Vehicle Infrastructure Toolbox. Calculations for jobs potential per EVSE installations are based on National Renewable Energy Laboratory's 2017 National Demand for Electric Vehicle Charging Infrastructure. Values per EVSE based on Table 11 Workforce estimates in job-years in order to meet 2030 charger demand estimated by NREL of "Workforce Projections to Support Battery Electric Vehicle Charging Infrastructure Installation" by Energy and Environmental Research Associates, LLC. Sources:US DOE Alternative Fuels Data Center Electric Vehicle Infrastructure Toolbox https://afdc.energy.gov/evi-x-toolbox#/evi-pro-ports?region_type=cbsa; https://www.etcommunity.org/wp-content/uploads/2024/03/Workforce-ProjectionstoSupportBatteryElectricVehicleChargingInfrastructureInstallation.pdf
Additional Sources: "New Study Estimates Over 160,000 Jobs to be Created by U.S. Electric Vehicle Charging Infrastructure Buildout by 2032" - International Council on Clean Transportation; https://theicct.org/pr-new-study-estimates-over-160000-jobs-to-be-created-by-uss-ev-charging-infrastructure-buildout-jan24/ ; "3 Trends in the US EV Industry" - World Resources Institute; https://www.wri.org/insights/trends-electric-vehicle-workforce-us

Waste Management Jobs Estimate

Notes		
[5]	Organics Diversion and Composting	4
[6]	Recycling Diversion	6
	Waste Management Jobs:	**10**
	Annual Income Potential (at $45,000)	**$452,521**

5: Assumptions & Rationale: Establishing organics collection and composting programs also generates local jobs, though on a somewhat smaller scale than recycling. Composting facilities need workers for tasks like waste hauling, site operations (turning and curing compost), and marketing the finished compost. A reasonable estimate is around 0.5 to 1.0 jobs per 1,000 tons of organic waste diverted from landfill to commercial composting. Sources: "More Jobs, Less Po lution: Growing the Recycling Economy in the U.S" - Tellus Institute; https://tellus.org/wp-content/uploads/2023/05/More-Jobs-Less-Pollution-Growing-the-Recycling-Economy-in-the-US.pdf ; "Composting for Community | Composting Makes ene: Jobs through Composting & Compost Use" - Institute for Local Self Reliance ; https://ilsr.org/article/composting-for-community/composting-sense-tables/

6: Assumptions & Rationale: Diverting waste from landfills to recycling is more labor-intensive than disposal, and thus creates local jobs in collection, processing, and downstream manufacturing. Studies show approximately 1–2 jobs per 1,000 tons of materials recycled (diverted) instead of landfilled. Sources: "Jobs & Economic Benefits of Zero Waste" - Eco-Cycle: https://ecocycle.org/learn-about-zero-waste/jobs-and-economic-benefits/ ; "What Are the Benefits of Recycling in the Community?" - Okon Recycling; https://www.okonrecycling.com/consumer-recycling-initiatives/learn-about-recycling/benefits-of-recycling-community/

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City of Plymouth
Climate Vulnerability Assessment

October 2025
Revised: February 2026

Prepared by:

making change personal
paleBLUEdot LLC

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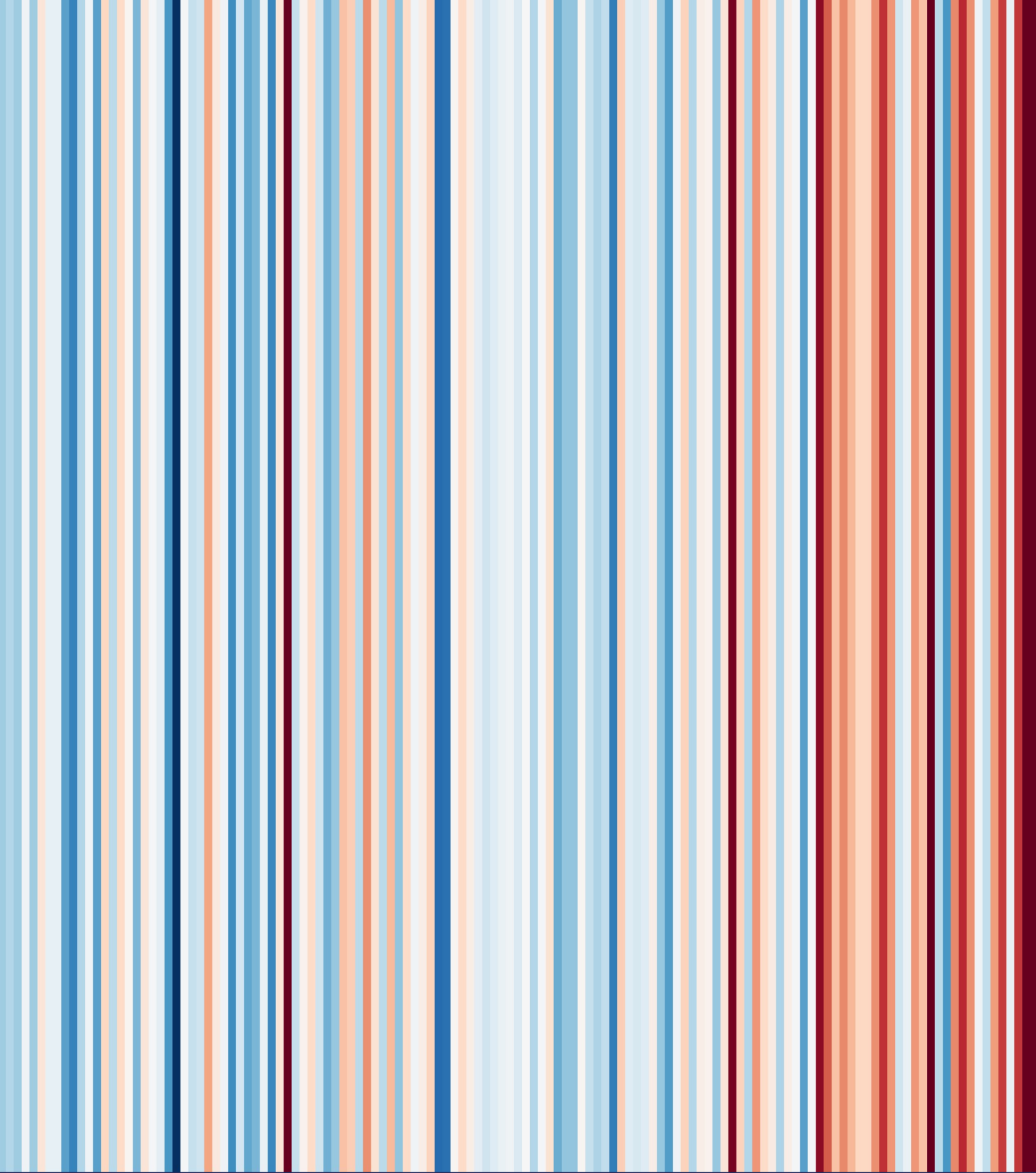

Each stripe represents the temperature Hennepin County averaged over a year. Blue = Below Average Red = Above Average

SECTION 01

Introduction

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Introduction

Protecting the environment is a central priority for the City of Plymouth. The community has long invested in preserving natural areas through open-space protection, urban forestry, and water-resource stewardship. In recent years, Plymouth has expanded this work by advancing efforts to reduce its carbon footprint, cut waste, and lower overall energy use.

In July 2025, the City received a Climate Planning Grant from the Minnesota Pollution Control Agency (MPCA) and engaged paleBLUEdot to prepare a series of baseline assessment documents to inform development of its Climate Action and Resilience Plan (CARP). The CARP will serve as the City's roadmap for equitably advancing climate action and strengthening community resilience. This Climate Vulnerability Assessment one of several "Baseline Documents" supporting the planning process.

Climate Change and Its Causes

Climate change is driven by human-made emissions of Greenhouse Gases (GHG). Since the late 1700s, carbon dioxide levels have risen by 40%. Other greenhouse gases are also increasing. In the past 50 years, the Earth has warmed by about 1.8°F. Since 1970, global temperatures have been rising at a rate of 1.7°C per century, a stark contrast to the previous slow decline of 0.01°C over 7,000 years. This warming results in more evaporation, leading to increased humidity, higher rainfall averages, and in some areas, stronger rainstorms while causing droughts elsewhere. Minnesota is seeing warmer winters, more intense precipitation, and rising temperatures. Future heat extremes in Minnesota are predicted to break past records.[1, 2]

What is Climate Change Vulnerability?

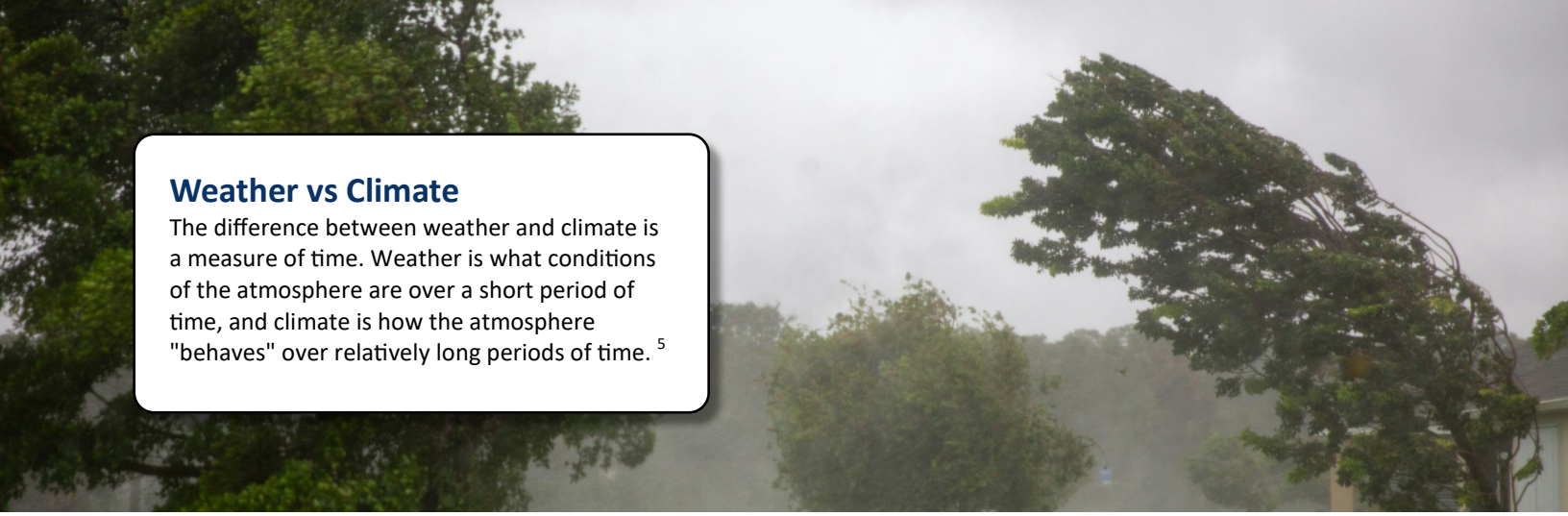
According to the Intergovernmental Panel on Climate Change, vulnerability is defined as the extent to which a system can be affected by, or is incapable of managing, the negative impacts of climate change, including climate variability and extremes.[3] Vulnerability depends on the impacts, which are the effects of climate change and variability on a specific system or resource, and on the adaptive capacity, which is the capability of the economy, infrastructure, resources, or population to adapt effectively to these events and changes.

Why Consider Climate Change Vulnerability?

Weather and climate influence community health and the economy. Temperature affects energy use in buildings and outdoor work conditions. Rainfall and temperature impact our drinking water and sectors like agriculture, tourism, and recreation. Extreme events such as tornadoes, hail, droughts, and floods cause significant damage.

State-Wide Extreme Weather Impacts Since 2000 [4]

Fatalities	Injuries	Property Damage (million $)	Crop Damage (million $)	Total Damage (million $)
107	543	$1,145.38	$1,569.19	$2,714.57



Weather vs Climate

The difference between weather and climate is a measure of time. Weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time. [5]

What Can We Do About Climate Vulnerability?

The science of climate change is complex, but many solutions align with the City of Plymouth's local government expertise. Often, addressing climate change doesn't mean overhauling operations, but adapting current plans to reflect changing risks in public health, infrastructure, and emergency management. Using this knowledge safeguards our communities from increasing risks. In addition, climate adaptation strategies can boost jobs, enhance public health, and uplift community livability. Resilience strategies benefit communities in both emergencies and prosperity.

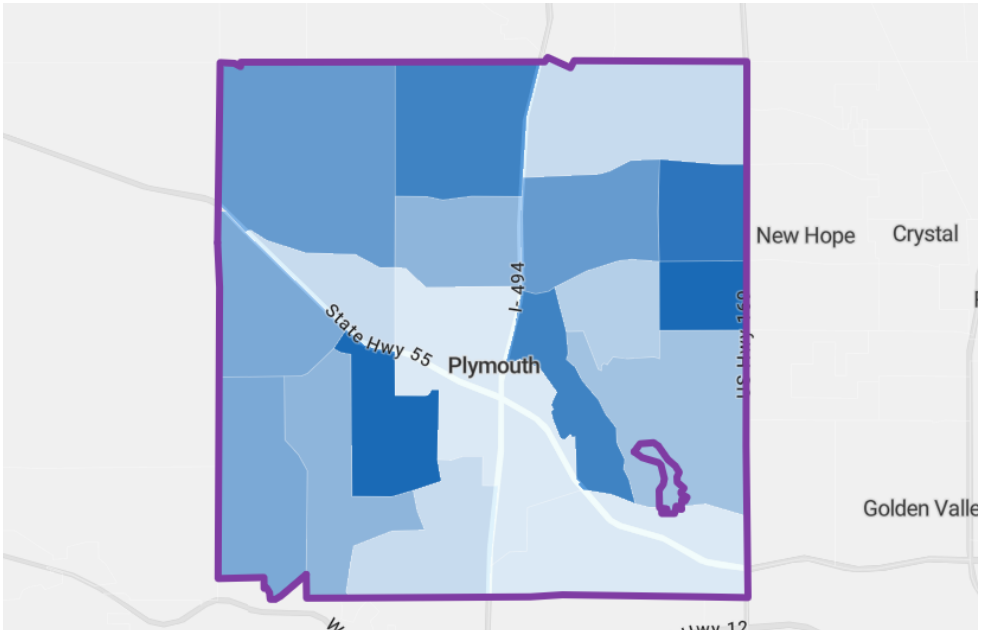
Community Statistics

Land area (sq mi)	**32.9**
Population	**80,067**
Households	**32,640**
Density (people/sq mi)	**2,434.9**
Jobs	**53,494**

Source: US Census Bureau

Population Density by Census Tract

(Source: US Census Bureau)



< 1,680.36
1,680.36 to 1,905.07
1,905.07 to 2,039.83
2,039.83 to 2,295.33
2,295.33 to 2,494.64
2,494.64 to 2,643.25
2,643.25 to 2,887.9
2,887.9 to 3,156.16
3,156.16 to 3,251.99
3,251.99 to 3,541.63
> 3,541.63

Mapping in This Report

This assessment contains maps generated at the Census Tract or Block Group level. They aim to convey, or relate to, relevant US Census Bureau data. Census boundaries, set by the Bureau, may not always match community boundaries. We choose boundaries that support the study without skewing aggregated community data. All areas within community boundaries are included in the plan this Baseline Document supports, even if not shown on a map.

Climate Change Projections for City of Plymouth

Over their lifetime, a child in Plymouth can expect:[1,2]				
Climate Conditions	**Baseline**	**Mid-Century** (2050 avg)	**End of Century** (2100 avg—change from baseline)	**Related Climate Risks to People** (See Section 4)
Average Daily Maximum Temperature	55° F	61°F	62°F to 66°F	Extreme Weather / Temp, Air Quality, Food Insecurity, Water Quality, Power Failure, Crop Yield
Number of Days Per Year with Maximum > 95° F	2	21	24 to 49.5	Extreme Weather / Temp, Air Quality, Food Insecurity, Water Quality, Power Failure, Wildfir, Crop Yield, Mortality, Energy Costs, Property Crime, Violent Crime
Number of Days Per Year With Minimum < 32° F	160	134	133 to 109	Vector-Borne, Power Failure
Change in Growing, Allergy, & Tick/ Mosquito Season[3, 4]	+9 days (over last 3-4 decades)	+25 days	+25 to 40 days	Vector-Borne
Change in Annual Precipitation [5]	26"	23%	4 to 35%	Flood, Vector-Borne, Waterborne, Crop Yield
Increase in Heavy Precipitation Events (Days Per Year with > 1" Rainfall)	N/A	31%	31 to 63%	Extreme Weather / Temp, Flood, Water Quality, Waterborne, Power Failure, Crop Yield, Mortality
Increase in Air Conditioning Demand (Cooling Degree Days)	600	133%	133 to 250%	Power Failure
Increase In Air Conditioning Related Electricity Use[6]	N/A	39%	39 to 59%	Energy Costs

SECTION 02

Climate Change
Trends + Projections

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Climate Trends and Projections for City of Plymouth

To consider vulnerability to climate change, we first look to understand the changes that have already occurred as well as those that the City is likely experience over the next 30–80 years. The following information summarizes historical trends and future projections in climate factors that are likely to impact the community, which include air temperature, extreme heat, precipitation (rain and snow), extreme precipitation, storms, flooding, and drought.

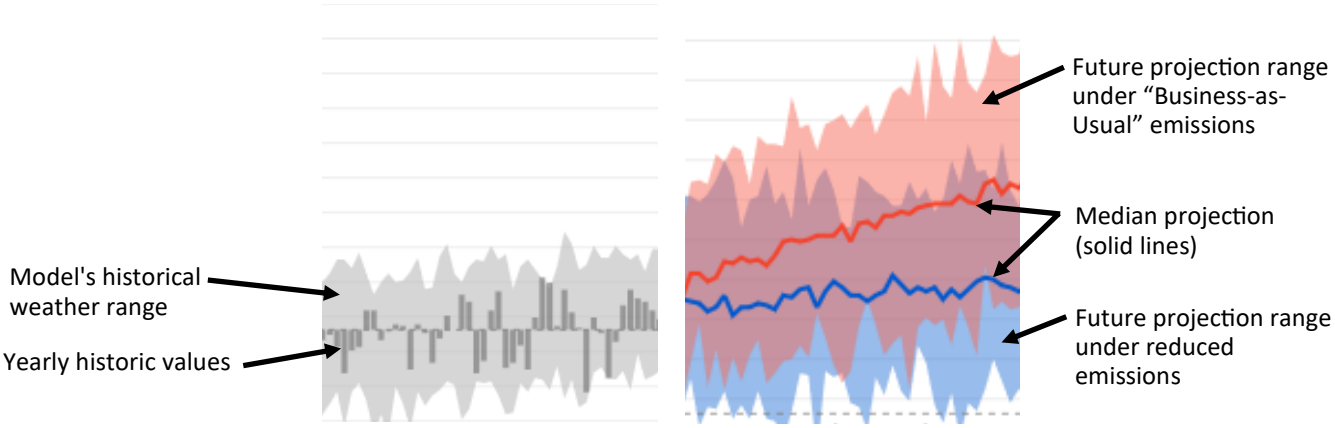
How To Read The Climate Projection Charts in This Section

On the charts produced by the US Climate Resilience Toolkit Climate Explorer which follow in this section, the vertical dark gray bars on the left represent yearly historic values.[1] The horizontal gray dashed line signifies the county average from 1960-1989. Bars above the line indicate above-average years, while below means under-average. The light gray area displays the climate model's historical weather range.

The red-toned area represents future projections if greenhouse gas emissions persist, also known as the "Business-as-Usual" emissions projection. The dark red line marks the median projection. Risk-averse individuals often focus on this.

The blue-toned area depicts projections if emissions stabilize in line with the United Nations International Panel on Climate Change (IPCC) recommendations. The dark blue line indicates its median. While no median guarantees future outcomes, both red and blue lines show projected trends.

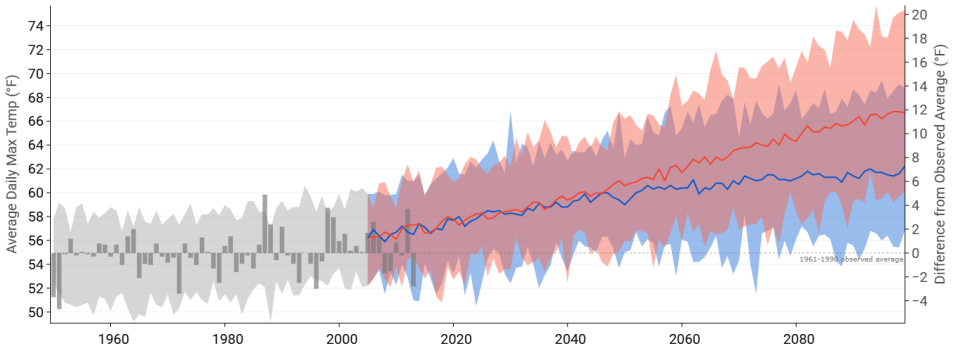
Example Chart



Air Temperature

Temperatures in Minnesota have risen more than 2.5°F since the beginning of the 20th century.[2] The rate of change has increased in recent decades, especially in the winter. By mid-century (2041–2060), average daily maximum temperatures in Hennepin County are likely to increase by 5-6°F, and by late-century (2081–2100) annual temperatures are likely to be 7-12°F higher compared to 1961-1990 average.[1]

City of Plymouth Average Daily Maximum Temperature Projections[1]



1961-1990 Average:
Ave Daily Maximum: 54.9°F

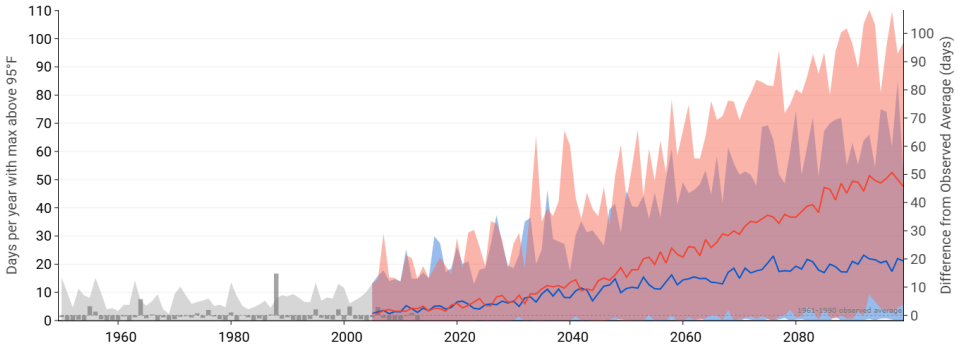
By 2050:
Ave Daily Maximum: 60.1 - 61.3°F
(5-16°F increase)

By 2100:
Ave Daily Maximum: 61.7 - 66.4°F
(7-12°F increase)

Extreme Heat

Extreme heat events are likely to increase significantly over the coming decades. The number of days in Hennepin County with maximum temperatures over 95°F are likely to increase from an average of 1.9 per year to 13 to 21 days per year by mid-century compared to 1961-1990 average.[1] By the end of the century, Hennepin County may experience an average of 21 to 49 days per year with high temperatures over 95°F, as much as an 2,505% increase in extreme heat days annually.

City of Plymouth Days Above 95° Projections[1]



1961-1990 Average:
Days over 95°F: 1.9 annual avg.

By 2050:
Days over 95°F: 12.8 - 21 annual avg.
(574% - 1,005% increase)

By 2100:
Days over 95°F: 21 - 49.5 annual avg.
(1,005% - 2,505% increase)

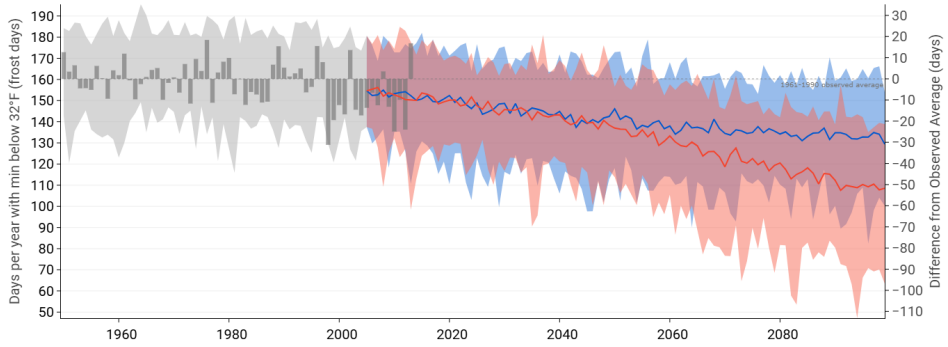
Cause of Warming

Burning fossil fuels and other human activities increase greenhouse gases (GHG) in the atmosphere. GHGs let sunlight in but prevent heat radiation from exiting, trapping solar radiation and warming Earth.[4,5]

Days Below Freezing / Growing Season

Since 2000, there has been a decline in very cold days, reaching a historic low between 2000–2004 due to the winter warming trend.[2] By mid-century (2041–2060), average annual days with minimum temperature below 32°F are likely to decrease to a total of 134 - 140. By late-century (2081–2100) they are likely to decrease to a total of 109 - 133 days annually compared to 1961-1990 average.[1]

City of Plymouth Days with Minimum Temperature Below 32°F Projections[1]



1961-1990 Average:
Days below 32°F: 160.3 annual avg.

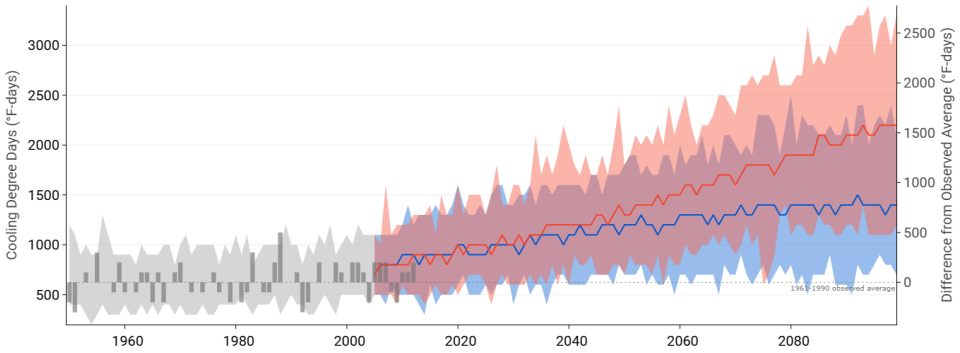
By 2050:
Days below 32°F: 140 - 134 annual avg.
(13% - 16% decrease)

By 2100:
Days below 32°F: 133.1- 109.4 annual avg.
(17% - 32% decrease)

Cooling Demand

Cooling degree days (CDD) quantify how often and by how much the temperature exceeds a set threshold in a unit of "°F-days." CDD indicate the energy required for air conditioning. The annual total CDD in Hennepin County are likely to increase to an average of 1200 to 1400 by mid-century and to an average of 1400 to 2100 compared to 1961-1990 average.[1] These projections could mean an increase of up to 49% in per capita electricity consumption by the end of the century.[8]

City of Plymouth Cooling Degree Days Projections[1]



1961-1990 Average:
CDD °F-days: 600 annual avg.

By 2050:
CDD °F-days: 1200 - 1400 annual avg.
(100% - 133% increase)

By 2100:
CDD °F-days: 1400 - 2100 annual avg.
(133% - 250% increase)

Longer Growing Season Impacts

Longer warm seasons expand the habitats of disease vectors like mosquitoes and ticks, raising disease exposure risks for humans. Extended growing seasons also elevate pollen levels, intensifying allergic reactions and asthma episodes.[6,7]

Precipitation

Minnesota is projected to see increases in overall precipitation and in intense rainfall. Spring precipitation could see more than a 15% rise by 2050. Since 1985, the state has seen an increase in rain events with 2-inch or more or rain. The increase in extreme precipitation is projected to increase meaning an increase in the likelihood of flooding within the state.[1, 2]

Since 1970:

Change in precipitation: 5-10% [22]

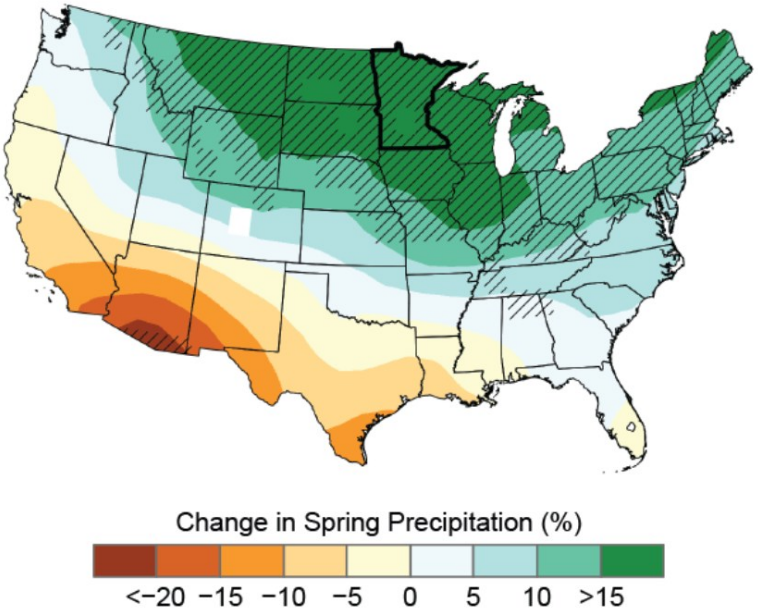
By 2050:

Change in precipitation: 17%[1, 21]
(over current)

By 2100:

Change in precipitation: 23% [1, 21]
(over current)

Projected Change in Spring Precipitation[9]



Graphic source: NOAA, North Carolina Institute of Climate Studies

Heavy Precipitation

In the Great Lakes, rainfall from the top four heaviest days annually has grown by 42% since 1901. In future decades, heavy rains will constitute a larger share of total precipitation, with expected increases in winter and spring. These patterns heighten flood risks.[1, 10, 11]

Since 1970:

Change in heavy precipitation: 20%[23]

By 2050:

Change in heavy precipitation: 31%
(over current)[1]

By 2100:

Change in heavy precipitation: 63%
(over current)[1]

Climate Change and Precipitation

As the Earth's surface temperatures increase, evaporation rates also rise. This leads to greater overall precipitation, causing storms to become more frequent and intense.[12, 13]

Drought

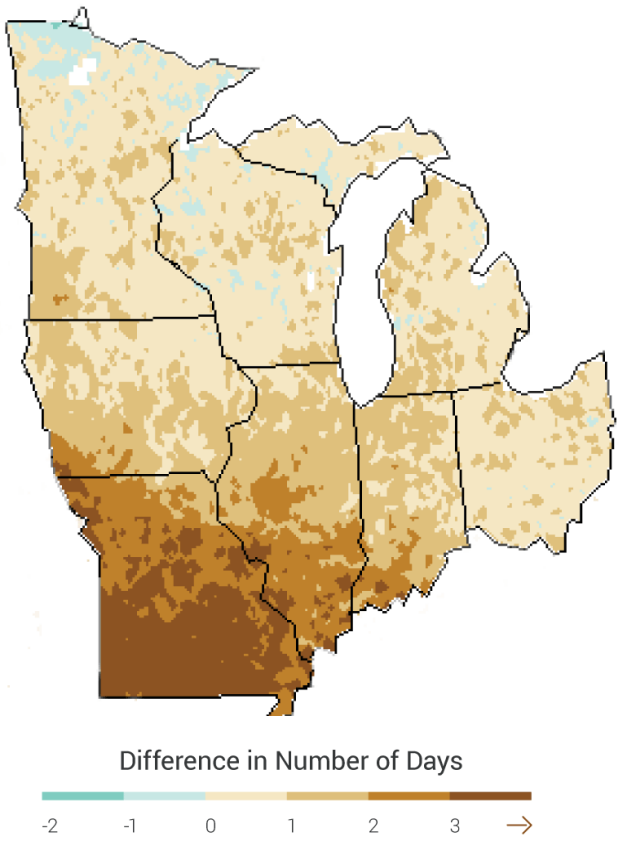
Even with rising precipitation, higher temperatures in the future could lead to more intense droughts due to faster soil moisture depletion. The state might experience 1-3 more consecutive dry days than in the past.[2]

Consecutive Days Without Measurable Precipitation

2050 Projection:[21] **19.0 days**

2100 Projection:[21] **14.0 days**

Change in Consecutive Dry Days[14]



Cause of Drought

Higher temperatures boost evaporation, leading to less surface water and drier soils and plants. Also, while we might get more rain in the future, it's expected to happen over fewer days, resulting in extended periods without rain.[12, 13]

Extreme Weather Events

Extreme precipitation, which is strongly associated with severe flooding events, has been increasing over the last several decades. The number of days with 2" or larger rain events is projected to increase as much as 100% by 2100.[1] There are few detailed projections for storm activity because the complex forces involved in storm processes are difficult for scientists to model. However, according to the Nature Communications study "More frequent intense and long-lived storms dominate the springtime trend in central US rainfall" by Feng, L. R. et al, the amount of precipitation associated with spring storms in the United States increased by 25% per decade from 1979 to 2014.[17]

Billion Dollar Disasters in Minnesota[19]

From 1980-2024, there were 62 confirmed weather/climate disaster events with losses exceeding $1 billion each to affect Minnesota. These events included 12 drought events, 6 flooding events, 1 freeze event, 38 severe storm events, 2 wildfire events, and 3 winter storm events. The 1980–2024 annual average is 1.4 events (CPI-adjusted); the annual average for the most recent 5 years (2020–2024) is 4.6 events (CPI-adjusted) indicating a rise in extreme weather occurrences.

Extreme Weather Events, Hennepin County[18]

From June 2000 to June 2025:

1,007 events

Storm Damage 2000-2025:

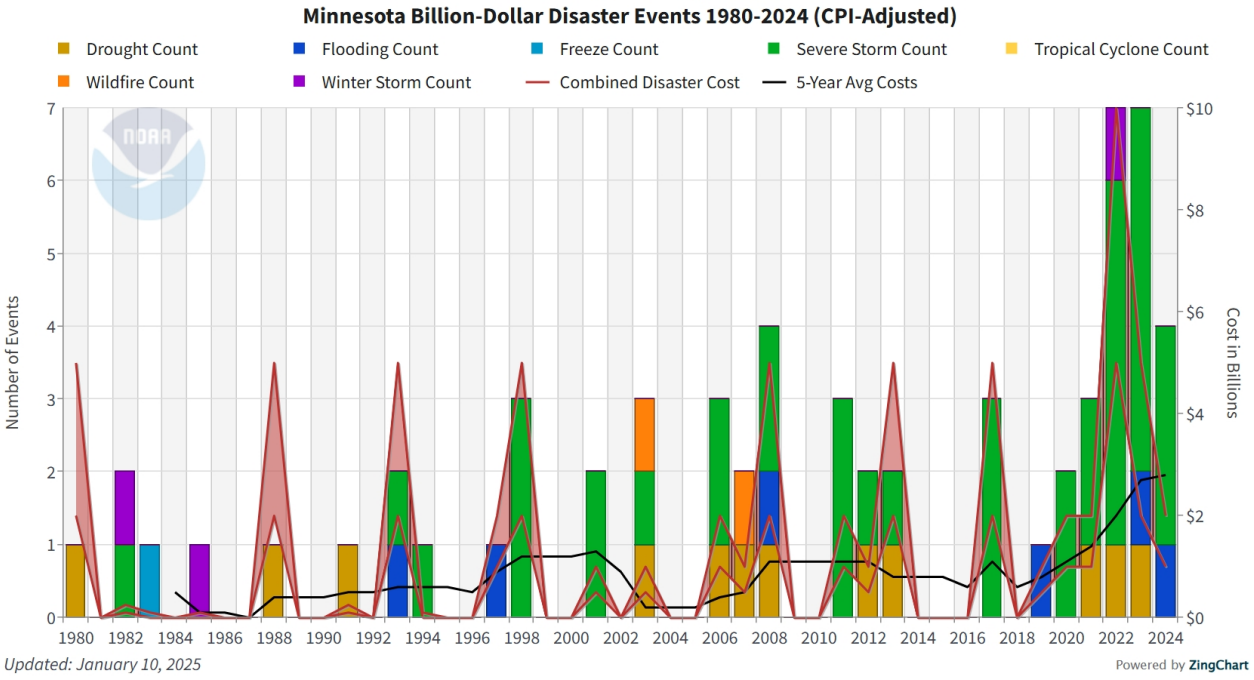
$451,700,000

90 injuries

6 deaths

The Link Between Global Warming And Extreme Weather

Due to human-caused GHG emissions, Earth's atmosphere is warming and holding more water vapor. This added heat and vapor increase the amount of energy driving storms and extreme weather.[15, 16]



SECTION 03

Community On The Move

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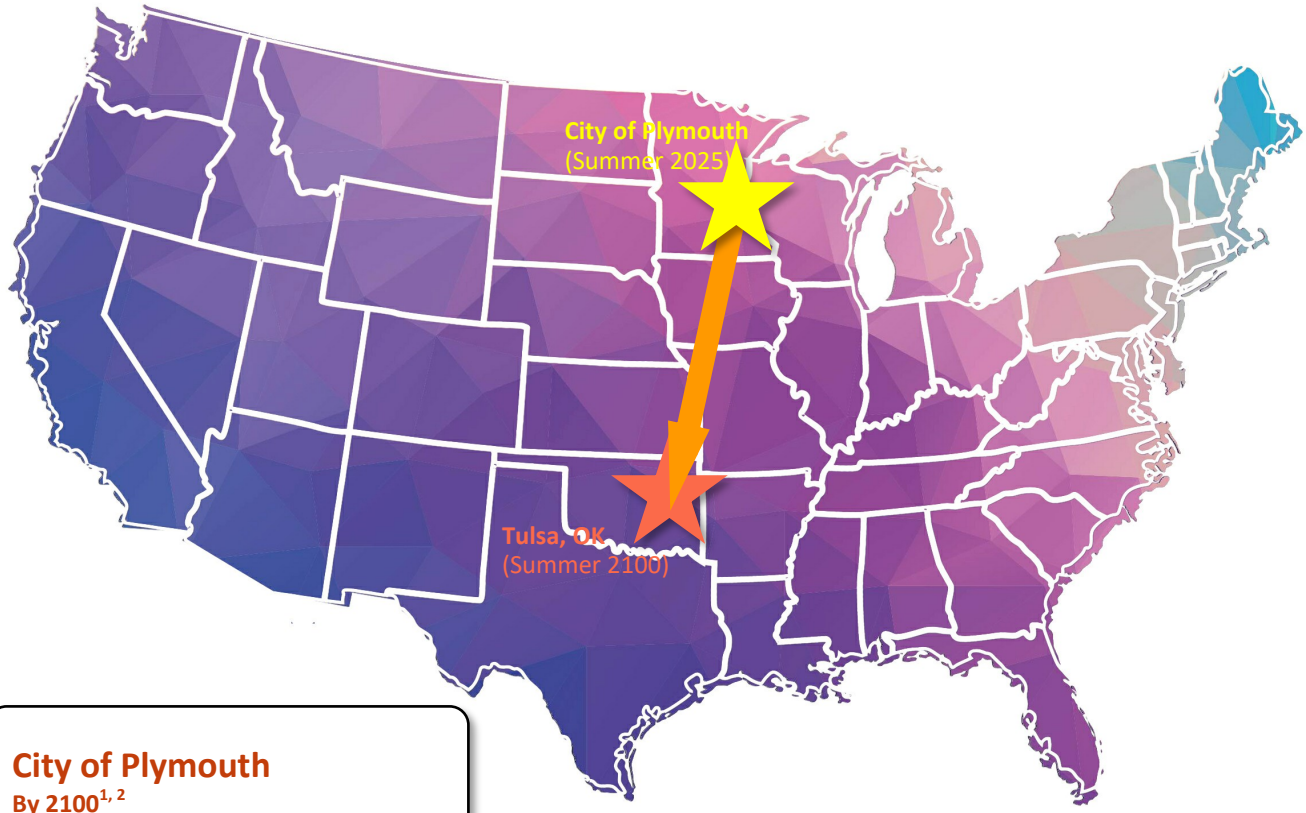
Projected changes in annual average temperatures and growing seasons will result in a change in the overall climate of City of Plymouth. Summertime conditions for mid-twenty first century in City of Plymouth are projected to be similar to the conditions currently felt 350-400 miles or further to the South. By the end of the century, summertime temperatures in City of Plymouth will be similar to those felt 700 miles further to the South.[1, 2]

9 Miles Distance southward City of Plymouth's climate experience moves every year.

Which is equal to moving **130 Feet** every day



City of Plymouth
By 2100[1, 2]
Average Summer High:

+ 10°F

SECTION 04

Climate Risks To The Population

Click here to return to TOC

The projected changes to the community's climate in the coming decades represent potential risks to residents. These risks are particularly acute in populations especially vulnerable to them such as children under 5, seniors over 65, and those with disabilities – see Vulnerable Populations section for more information. Below are some of the more significant direct climate risks to the community's population:

Extreme Weather / Temperature

Certain groups face higher risks from extreme weather events, leading to injuries, carbon monoxide poisoning, asthma attacks, hypothermia, mental health issues, and even death. Events like tornadoes, wildfires, and heatwaves can pose threats. Heat stress vulnerability rises due to health conditions such as diabetes, heart issues, socio-demographic factors like age (e.g., those over 65 living alone), and environmental aspects like low tree canopy coverage. US studies link heatwaves to increased heat-related deaths and a surge in emergency medical service calls and hospital admissions.

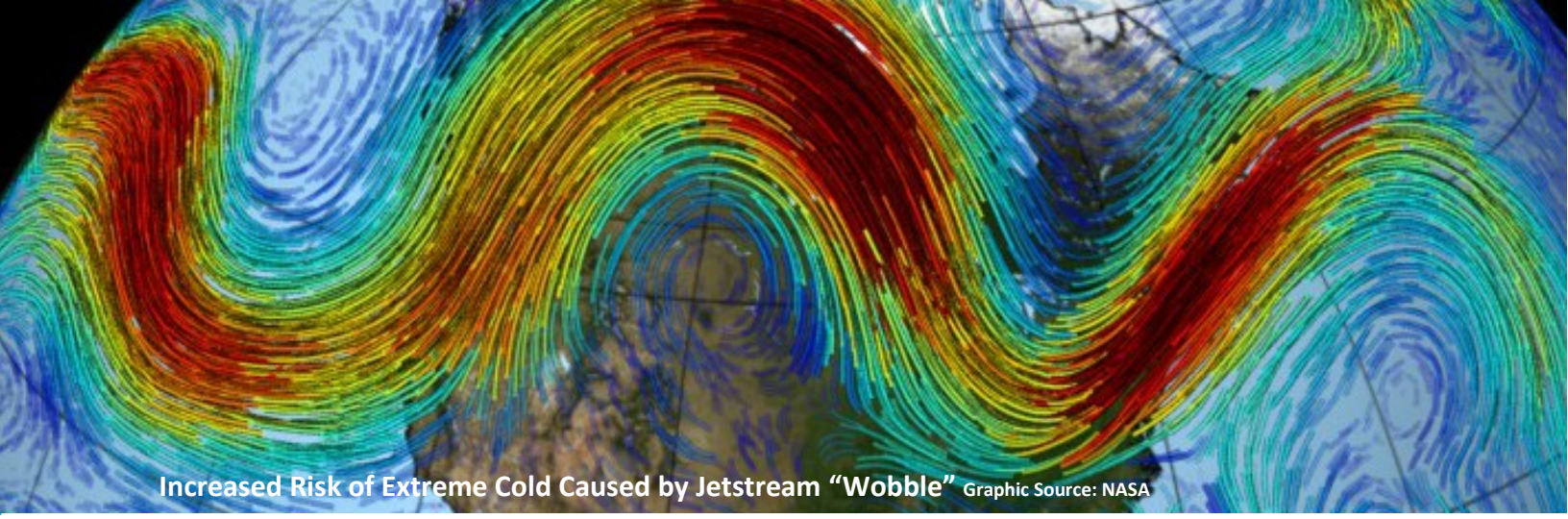
According to the US National Climate and Health Assessment:

> "While it is intuitive that extremes can have health impacts such as death or injury during an event (for example, drowning during floods), health impacts can also occur before or after an extreme event as individuals may be involved in activities that put their health at risk, such as disaster preparation and post-event cleanup. Health risks may also arise long after the event, or in places outside the area where the event took place, as a result of damage to property, destruction of assets, loss of infrastructure and public services, social and economic impacts, environmental degradation, and other factors. Extreme events also pose unique health risks if multiple events occur simultaneously or in succession in a given location, but these issues of cumulative or compounding impacts are still emerging in the literature."[1]

In addition, extreme weather can cause economic stress. Property damage, business closure, crop loss, job loss, and employment "down time" can all be caused by extreme storms, weather, and temperatures. These economic impacts can affect individuals, families, businesses, and communities at large. According to the North American Electric Reliability Corporation, the leading cause of electric transmission outages (in terms of electric outage count) in the United States is weather.[2]

Increased Risk of Extreme Cold

Despite global warming, the City may face heightened risks of extreme cold spells during winter due to changes in the jet stream, influenced by warming oceans and Arctic temperatures. The jet stream, a significant high-altitude wind flow, governs the Northern Hemisphere's weather by moving moisture, cold and warm air, and storm systems. It's primarily driven by the temperature contrast between the Arctic and equatorial regions. Climate change has caused the Arctic to warm faster than temperate zones, diminishing this temperature contrast and thereby weakening the jet stream. This weakening results in periods where the jet stream "wobbles," making pronounced southward coils, dragging severe arctic cold with it. Research suggests that as Arctic warming persists, these pronounced wobbles and resultant cold snaps could become more frequent.



Increased Risk of Extreme Cold Caused by Jetstream "Wobble" Graphic Source: NASA

Flood and Drought Vulnerability

The latest National Climate Assessment reveals that the occurrence of intense precipitation events has risen both nationally and specifically in Minnesota. Predictions suggest that Minnesota will experience more of these heavy rainfalls in the future. This escalation in extreme and overall rainfall is a factor in the uptick of severe flood incidents in several communities. Among all weather-related dangers in the U.S., floods rank as the second most lethal. Following heavy rains and floods, there's an increase in water-related illnesses and mold growth due to water intrusion in buildings. This can negatively impact indoor air quality and heighten respiratory issues, including asthma and pneumonia, for those in humid environments.[3]

Floods cause economic harm, including property and crop damage. But the effects go further. They disrupt local economies by reducing work hours and GDP, as resources shift to recovery instead of regular tasks.[4] The damage also affects businesses connected to farmers. For instance, in 2019, heavy rain in the U.S. Corn Belt led to $6 billion in lost corn sales. Additionally, firms linked to farming faced a $2.9 billion decline in direct sales and $4.5 billion in total losses.[5]

Wildfire

Wildfires present considerable dangers to homes, ways of life, and health, particularly as communities encroach further on natural habitats. Between 1980 and 2021, the U.S. experienced 20 wildfires that resulted in damages exceeding a billion dollars each.[6] According to the National Oceanic and Atmospheric Administration, 16 of these catastrophic fires took place after 2000.[7] Climate change is amplifying the duration of the wildfire season, intensifying the frequency of fires, and expanding the affected areas. Elements such as warmer springtime temperatures, longer summer droughts, and arid ecosystems are aggravating this situation. Earlier snow melts in spring and reduced snowpack decrease water reserves during sweltering times, heightening fire hazards. As a result, fires not only start more readily but also blaze more fiercely. The pattern of prolonged wildfire durations and more severe fires is expected to continue due to increasing and enduring droughts. Furthermore, the smoke from wildfires degrades air quality across the country and research has shown wildfire smoke contribution to poor air quality has grown substantially in the US has over the last two decades.[8] While smoke exposure is detrimental to all, those with underlying health issues, such as cardiac and respiratory disorders, as well as older adults, children, and expectant mothers are at an even greater risk.[9]

Air Quality Impacts

Based on existing research, there's a strong link between air pollution and a range of health concerns such as premature death, higher hospital admissions for respiratory and cardiovascular issues, unfavorable birth outcomes, and lung cancer. The U.S. Environmental Protection Agency (EPA) uses the Air Quality Index (AQI) to offer a consistent and straightforward method for communicating daily air quality conditions. The AQI values for each state are derived from hourly measurements of five pollutants: fine particles (PM2.5), ground-level ozone (O3), sulfur dioxide (SO2), nitrogen dioxide (NO2), and carbon monoxide (CO). The concentrations of these pollutants can be influenced by both climate effects and the greenhouse gas emissions that are modifying Minnesota's climate dynamics.[10]

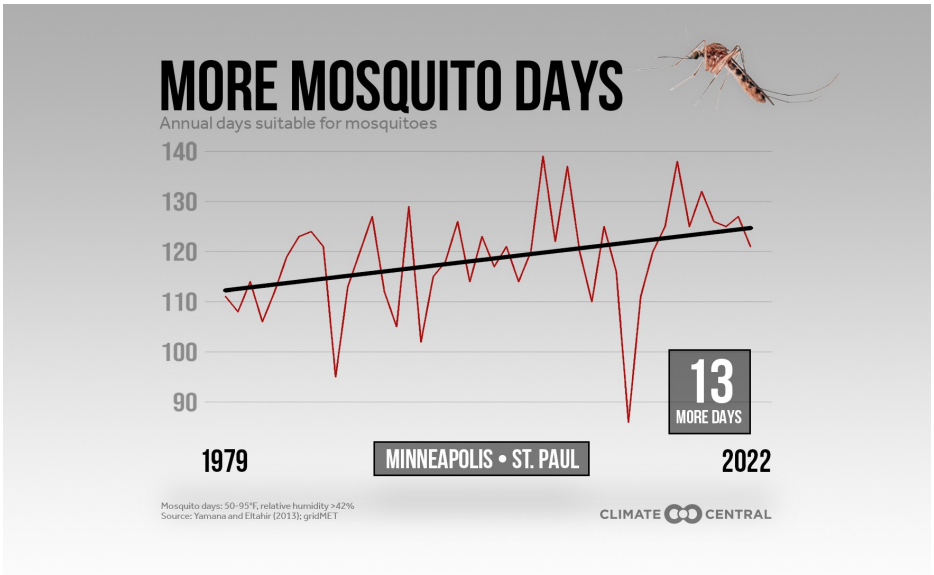
The health outcomes stemming from these pollutants can differ significantly. For example, coming into contact with ozone might lead to issues like difficulty in breathing, chest pain during deep breaths, coughing, wheezing, a temporary decrease in lung capacity, and infections within the lower respiratory tract. Prolonged exposure to fine particulate matter (PM2.5) is associated with various health concerns. Elevated levels of PM2.5 correlate with higher death rates from lung cancer, increased cardiopulmonary fatalities, and a surge in overall death rates. The annual average of PM2.5 provides a perspective on its long-term patterns and the related health risks.[11]

Anticipated shifts in climate are expected to influence air quality in multiple ways, such as heightened surface temperatures, variations in rainfall, drought, wildfires, allergen production and intensity, and increased levels of ozone, PM2.5, and dust. Several of these pollutants can directly induce or exacerbate respiratory ailments, particularly in vulnerable groups like children and the elderly. Other air quality concerns related to health include allergens, pollen, and wildfire smoke (even minor amounts that can cause respiratory problems can travel vast distances). All these factors are projected to rise due to climate change. [12]

For current and forecasted air quality throughout the state visit: https://cfpub.epa.gov/airnow.
You can also download Plume Lab's free mobile phone air quality monitoring app: https://plumelabs.com/en/air/

Vector-Borne Diseases

Diseases transmitted by carriers like ticks and mosquitoes are known as vector-borne diseases. The expected consequences of climate change are believed to amplify the dissemination of such diseases, including West Nile virus and Lyme disease. This is because changes in climate conditions can influence the life cycle and dynamics of these carriers and the pathogens they transport. A rise in global temperatures has the potential to expand the habitats of these disease-spreading insects. Additionally, increased rain, flooding, and humidity create more suitable environments for their breeding and hasten the breeding process.[13] Moreover, the extended growing season and milder winters in Minnesota can boost the numbers of these disease carriers and may introduce the region to new species.[14]



Graphic source: Climate Central

Food Insecurity and Food-borne Diseases

Our national food infrastructure is susceptible to the effects of climate change. Factors such as extreme weather conditions, threats to crops and livestock like excessive heat, the rise of invasive insect populations, alterations in natural yearly cycles, and socioeconomic challenges all play a role.[15]

Within a highly integrated national food system, a wide range of regional vulnerabilities are all linked to impacts that can be felt in Minnesota. States in the Pacific region are especially at risk due to diminished water resources, warmer winter seasons, and unpredictable springtime conditions. Grain cultivation faces threats from inconsistent weather, hotter winters, heatwaves, sultry summer nights, and flood risks, especially in the Great Plains and the Midwest. Beef, chicken, and pork production is at risk due to the heightened occurrence and severity of extreme weather conditions in areas like the Great Plains and the Southeast.[16] These productions are also vulnerable to disruptions in essential resources such as feed, water, and electricity, which can be affected by extreme weather and other climate-induced factors.

Currently, the challenge of food insecurity, which is the disruption in the availability of nutritious food due to financial constraints or lack of access, is disproportionately borne by those with lower incomes. They are almost three times more prone to face this issue.[17] As we move forward, we should expect climate change to influence the earnings and lives of food cultivators, especially those who operate on a smaller scale. Climate-induced disruptions in our food system can lead to price fluctuations, making food access even more challenging for already vulnerable populations.[18]

Water Quality/Quantity

Water risks pertain to both the amount and purity of water. Quantity issues stem from changing rainfall patterns, water supply fluctuations, and increased consumption due to population growth and warmer climates. Water demand can increase during periods of extreme temperatures, exacerbating water quantity concerns. Stress on water supplies can also negatively impact agriculture, causing potential crop losses, limited food availability, and rising food costs. It's vital for all communities to focus on water conservation, particularly those at greater risk of water shortages.[19]

Water quality is also compromised by climate events. More rain or fast-melting snow can lead to flooding, bringing contamination from sewage and pollutants. Rising temperatures may cause harmful algae growth, reduced oxygen in water, shifts in fish species, and more mercury in fish. Intense rainfalls can further muddy waters, reducing clarity and quality.[20, 21]

Waterborne Illness

Climate change threatens U.S. surface water quality and increases waterborne disease risks. Rising temperatures and frequent extreme weather events, like heavy rain and flooding, cause more runoff of contaminants, including bacteria, viruses, and protozoa, often mixed with agricultural and industrial pollutants. Warmer water also promotes harmful algal blooms, which produce toxins affecting water and wildlife. These conditions heighten the risk of illnesses like giardiasis, dysentery, and E. coli infections, especially in areas with aging water infrastructure. Robust public health measures and infrastructure upgrades are needed to protect water quality and public health.[22,23]

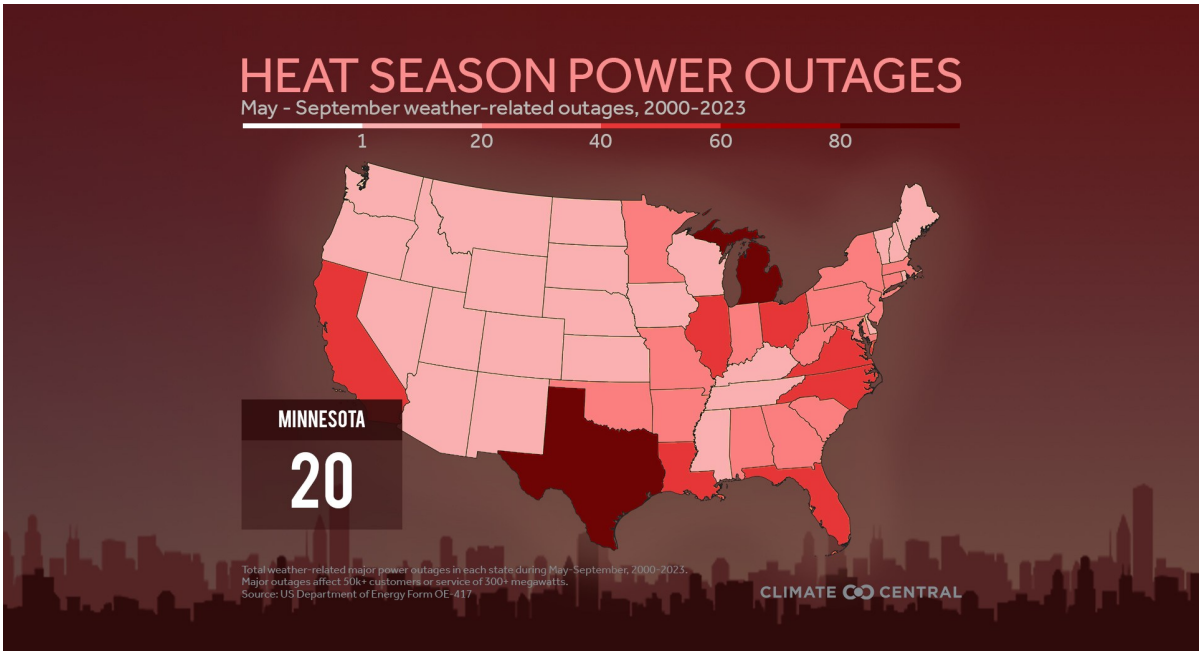
These impacts exacerbate the risks associated with recreational activities like swimming and other direct contact with surface water. Warmer temperatures and increased nutrient runoff can lead to more frequent and severe harmful algal blooms, which pose health risks to swimmers through skin contact and accidental ingestion. Pathogens such as Cryptosporidium and Giardia, which cause gastrointestinal illnesses, can also become more prevalent in warmer waters. These conditions make it crucial for public health authorities to monitor water quality closely and issue advisories to protect swimmers and other recreational water users.[24,25]

Power and Infrastructure Failure

Climate change can increase electricity demand while jeopardizing its supply. Our current power grid, much of which is above ground, was designed for a bygone climate, making it vulnerable to modern weather extremes like intense rainfall, powerful winds, severe droughts, and escalating wildfires. As such, disruptions in power supply and delivery are growing.[26] A Climate Central study found that from 2011-2021, the U.S. saw a 64% rise in major power outages compared to the previous decade. Of the outages across these two decades, 83% were weather-induced, with such outages seeing a 78% annual increase in the latter decade.[27]

Beyond the power grid, other infrastructure, including roads, bridges, and transit systems, is also at risk from climate effects. Extreme temperatures can warp roads and rail lines, while fluctuating cold and heat cause pavement damage. Intense rainfalls can result in floods, disrupting major transport routes and business districts.[28]

Since 1980 the United States has had 371 extreme weather and climate disasters whose damage exceeded $1 Billion (CPI adjusted dollars to 2023). The statistics also clearly show an increasing rate of these billion-dollar storms. During the 1980s, there was an average of 3.3 events annually; this number rose consistently, reaching an average of 13.3 events annually in the 2010s and further increasing to 18 events annually between 2018 and 2022.[29]



Graphic source: Climate Central

Indirect Economic Risks

Besides the main climate change effects discussed earlier, there are several related economic consequences. Researchers from the University of California at Berkeley have found that for every 1°C rise in average global temperature, there's an expected annual loss of 1.2% in gross domestic product on a per-county basis.[30] Here are the major economic outcomes highlighted in their study:

Crop Yield

As outlined in "Food Insecurity, current and projected climate change impacts threaten US agriculture production and the food system. Research illustrates that although increased CO2 levels are anticipated to offset a portion of these yield loses, the impact for much of the United States will be a net negative. The agricultural system in many regions in the country face serious economic effects of the projected climate impacts. These economic impacts, in turn, are likely to result in price volatility increasing food insecurity risks for vulnerable populations.[30,31]

Mortality

Studies indicate global death rates are likely to increase due to climate change by 4.2% for higher income regions and as much as 6.2% for regions with high poverty. In the United States, research indicates mortality impacts due to climate change are likely to be unevenly experienced. Southern areas of the U.S. are generally better equipped to handle heat, so additional warming might not notably raise death rates, and they may even witness a drop in cold-related deaths. In contrast, Northern areas, being less accustomed to heat, could see a significant rise in heat -related deaths that surpasses any decrease in cold-related mortality.[30, 32, 33]

Energy Costs

Every region in the United States is experiencing increasing temperatures. With the warming climate, it's anticipated that Americans will consume more energy, primarily in the form of electricity, for cooling purposes. This surge in demand raises the likelihood of power outages or disruptions. While the need for heating during winter months may decrease due to warmer conditions, the heightened energy requirements during summer for cooling are projected to eclipse any savings from reduced winter heating. Given these rising temperatures, economists predict a rise in net energy expenses for almost every area of the contiguous United States, except the chilliest regions.[30]

Property Crime

Research suggest that colder weather curbs property crime and highlight a connection between fewer cold days and a rise in property crime rates. According to a Harvard study, the United States may experience 3.1 million additional burglaries through the end of the century due to climate change.[30, 34]

Violent Crime

Research indicates that violent crime rates also increase as temperatures increase. For violent crime, the relationship is relatively consistent linear relationship with a violent crime increase of nearly 1% for every 1°C increase in global mean temperature. Throughout the United States, this impact is estimated to be millions in combined additional murders, rape, assaults, robberies, and theft through the end of the century due to climate change.[30, 35]

FEMA National Risk Index

According to the FEMA National Risk Index, the City of Plymouth has an overall climate change risk score of 95.6.[35] This means that the community is in the 96th percentile of risk nation-wide. This risk score is considered "relatively high."

Risk Index scores for specific hazard types are derived using data related solely to that hazard. They take into account a community's anticipated yearly loss value, relevant risk factors, and the adjustment factor applied to determine the risk value.[35]

About the National Risk Index
The National Risk Index is a digital tool and dataset that showcases the U.S. communities most susceptible to 18 natural disasters.[36] FEMA, in tandem with academic experts, governmental bodies at various levels, and the private sector, developed this tool.

The equation underpinning the Risk Index consists of three parts: a section detailing natural hazards,[37] a segment that amplifies consequences,[38] and a part that minimizes consequences.[39] The data for the natural hazards section uses estimates in 2022 U.S. dollars. For the latter two components, datasets have been standardized using a min-max normalization method before being integrated into the National Risk Index's risk assessment.

Compared to the rest of the United States, the City of Plymouth's risk for each hazard type is:

Avalanche	N/A
Coastal Flooding	N/A
Cold Wave	
Drought	
Earthquake	
Hail	
Heat Wave	
Hurricane	N/A
Ice Storm	
Landslide	
Lightning	
Riverine Flooding	
Strong Wind	
Tornado	
Tsunami	N/A
Volcanic Activity	N/A
Wildfire	
Winter Weather	

Overall Risk Index:
96

Addressing Risks in Community Resilience

Even risk factors which are identified as “Minor” or “Moderate” for a community should be carefully considered to be addressed in community resilience efforts based on their potential magnitude of impact.

SECTION 05

Climate Risks To Infrastructure

Click here to return to TOC

The projected changes to the community's climate in the coming decades represent potential risks to the community's infrastructure. Many of the risks have the potential of co-occurring, such as extreme heat and drought immediately followed by extreme precipitation events. Potential risks to infrastructure include:

Housing

Warming temperatures will increase demand for air conditioning. Although most homes have air conditioning currently, the increased demand will mean increased costs. An estimated 3-4% of households in the City are already live under high energy burden (households spending 6% or more of total income on energy).[1, 2] Rising energy costs may be very difficult for these and other households to bear, increasing their vulnerability to extreme weather events. Heavier rains may cause more local flooding, which could cause damage and limit mobility for some neighborhoods in more flood-prone areas of the city.

Stormwater Management

Increasing precipitation will increase demands on stormwater infrastructure and increase flash flooding risks.[3] The City's stormwater infrastructure may not be able to handle the amount of runoff that is expected in the future, and considerable resources would be needed to make needed upgrades.

Transportation

Flooding is not a significant concern for City of Plymouth now, but increasing likelihood of heavy-precipitation events in the future may increase the risk of local flooding, potentially blocking roadways and trails. Increasing temperatures and more days with maximum temperatures over 95° may increase damage to transportation infrastructure including buckling and cracking of road pavement and warping of rail lines.[4] The high reliance on personal vehicles and limited transit services within portions of the City limits residents' options, especially during times of extreme events.

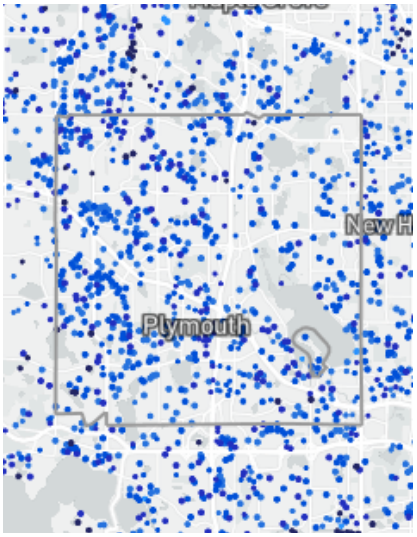
Power Distribution

Increased extreme temperature events are likely to increase demand on power generation and distribution systems and may increase potential for power failure.[5] Increased potential for drought combined with increased risk of heavy rain events pose an increased risk of fallen trees.[6] In turn, this may increase the risk of damage to power lines, particularly during extreme weather events when power demand may be highest.

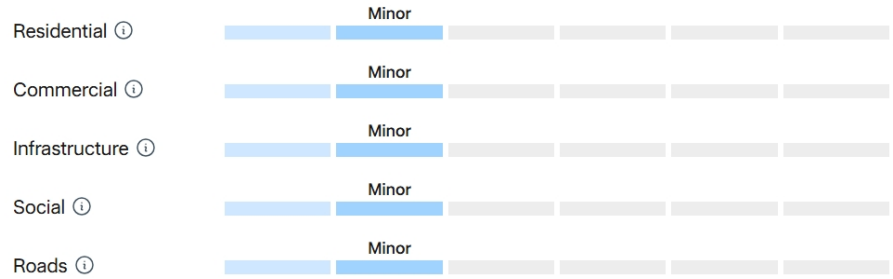
Critical Facilities

Critical facilities in the community include medical facilities, first responder facilities like police and fire, emergency communications facilities, nursing homes, power plants, water and wastewater treatment facilities, schools, and security facilities. Increased risk of extreme temperatures may place increased stress on heating and cooling systems critical facilities and increase potential of system failure during times of highest demand. Increased potential of extreme weather events may pose an increased risk to facilities from high winds, falling trees, sleet/hail, or other impacts. The projected increase of heavy precipitation may pose increased risk to facilities from flooding and flash flooding, even in areas without history of flooding.

City of Plymouth Flood Risk Factor:[7] Minor

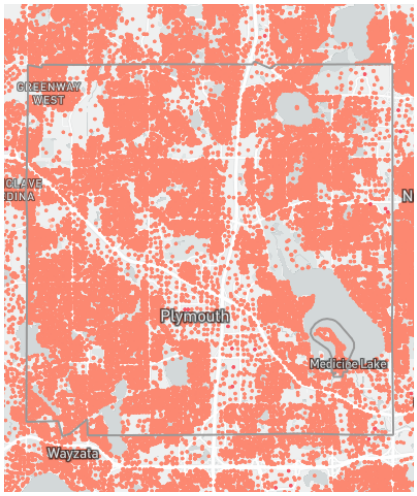


Flooding can damage property and disrupt essential services like utilities, emergency response, and transportation, affecting a region's economy. Plymouth faces a moderate flood threat over the next 30 years, potentially impacting daily life. This estimate focuses on the severity of risk to properties, with 12%, or 3,278 properties, at risk of flooding within that time.[7]

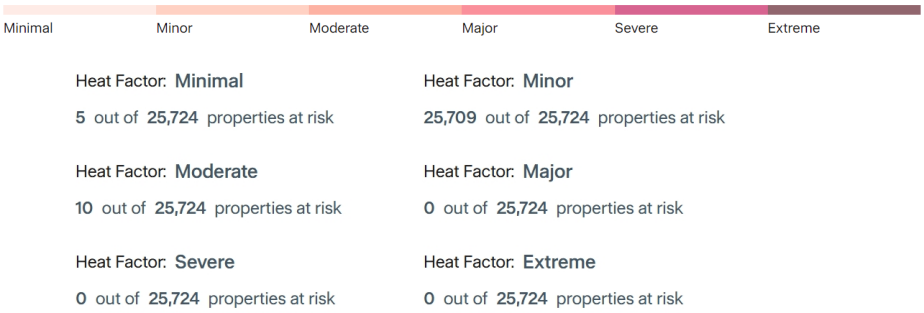


(Source: First Street Foundation)

City of Plymouth Heat Risk Factor:[7] Minor

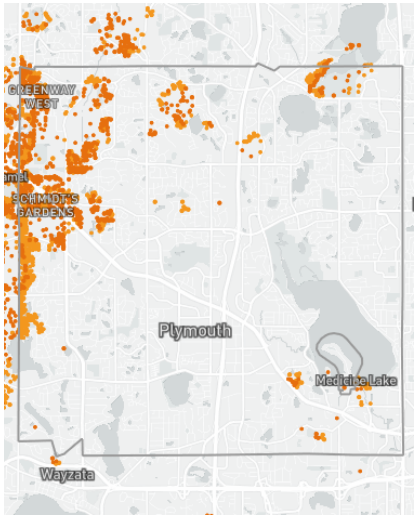


Plymouth faces a minor risk from heat, largely due to rising "feels like" temperatures and the fact that 100% of homes in the area have a minor heat risk.[7]

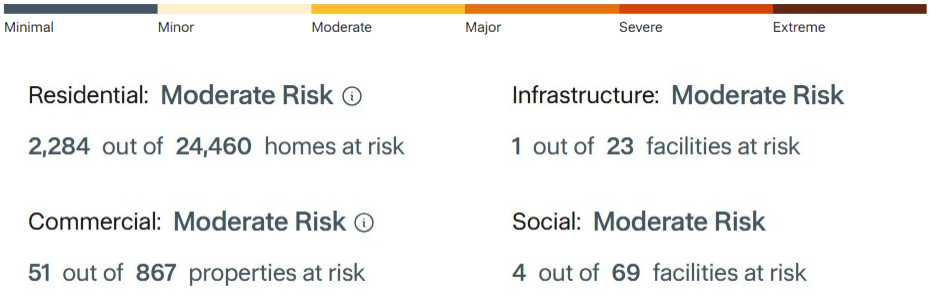


(Source: First Street Foundation)

City of Plymouth Wildfire Risk Factor:[7] Moderate



In Plymouth, 2,456 properties, or 9% of all properties, face some wildfire risk over the next 30 years. Overall, the area has a moderate wildfire risk, based on the severity of risk to these properties rather than the number affected.[7]



(Source: First Street Foundation)

SECTION 06

Vulnerable Populations
In the City of Plymouth

Click here to return to TOC

Climate change causes economic impacts, which in turn, increase the unpredictability and inequity of future economic outcomes.[1] Some populations may also be subjected to multiple pressures including both climate change impacts as well as non-climate related stressors. For instance, those residing in economically disadvantaged urban zones, remote rural regions, flood-prone areas, or places with a history of significant chemical pollution are more exposed not only to severe weather and ongoing climate shifts but also to socio-economic challenges. Often, these challenges can appear in tandem or one after the other.[2]

Individuals or communities may experience varying levels of health risk vulnerabilities based on factors like age, socio-economic conditions, and political influences, commonly referred to as social determinants of health. Some demographics are unfairly impacted by these determinants, which restrict their access to resources and opportunities for promoting healthier living conditions, such as favorable living/working environments and medical care access. Certain populations are especially at risk when it comes to the effects of climate change. This increased risk can be attributed to a group's exposure, sensitivity, or their ability to adapt to climatic changes.[2]

Who is Most Vulnerable?

Throughout the United States, there are variations in how individuals and communities experience, are affected by, and adapt to the threats of climate change. The subsequent sections outline factors that might lead to unequal climate change impacts on different groups. Included are maps that show the concentration of these populations in the City's census tracts. These maps can assist government representatives and the climate planning team in identifying potential inequalities and understanding the circumstances that lead to them.

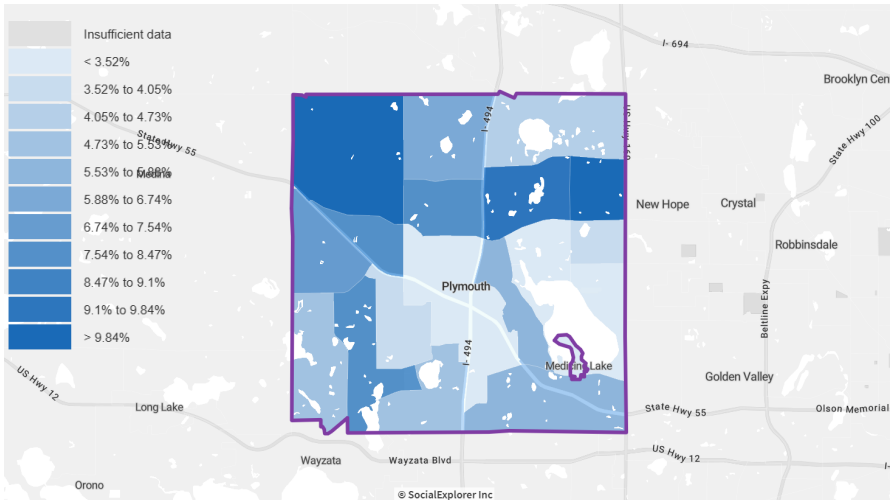
This information may be used as a preliminary guide and indicator of areas where special attention may need to be paid to potential disparities in climate-related hazards (e.g., flooding, extreme heat, air pollution) and/or to ensuring just distribution of the benefits of actions designed to address these climate impacts.

Community members who are most vulnerable include:[2, 3, 4, 5, 6]

Children Under 5

Children are more susceptible to negative health consequences from environmental factors because of their still-developing bodily systems, distinct ways they encounter these factors, their heightened biological reactions, and limited adaptability. Kids consume a notably larger amount of air, food, and water compared to their body size than adults do. Moreover, their specific behaviors and how they engage with their surroundings might raise their chances of coming into contact with pollutants like dust, pesticides, mold particles, and allergens.[2]

Children are particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



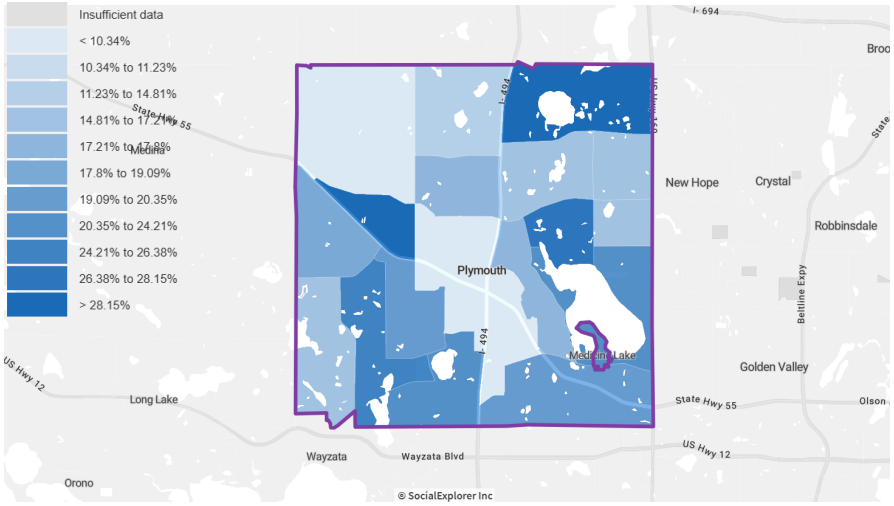
Total in demographic in City: **5,306**
6.6%
of total population

Extreme Weather / Temp · Air Quality · Vector-Borne · Food Insecurity · Waterborne · Power Failure

Seniors Over 65

Elderly individuals are particularly susceptible to health issues linked with climate change and extreme weather conditions. It's important to note that vulnerabilities among the elderly vary widely since this group is diverse, encompassing various sub-groups. These can be differentiated not just by age but also by factors such as race, level of education, economic standing, social support structures, general physical and mental well-being, and any disabilities. As stated by the US Global Change Research Program, the potential health consequences of climate change for the elderly encompass rising temperatures and heatwaves; a heightened chance of severe floods, droughts, and wildfires; deteriorating air quality; risks of infectious diseases; and other climate -induced threats[2]

Older Adults are particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk



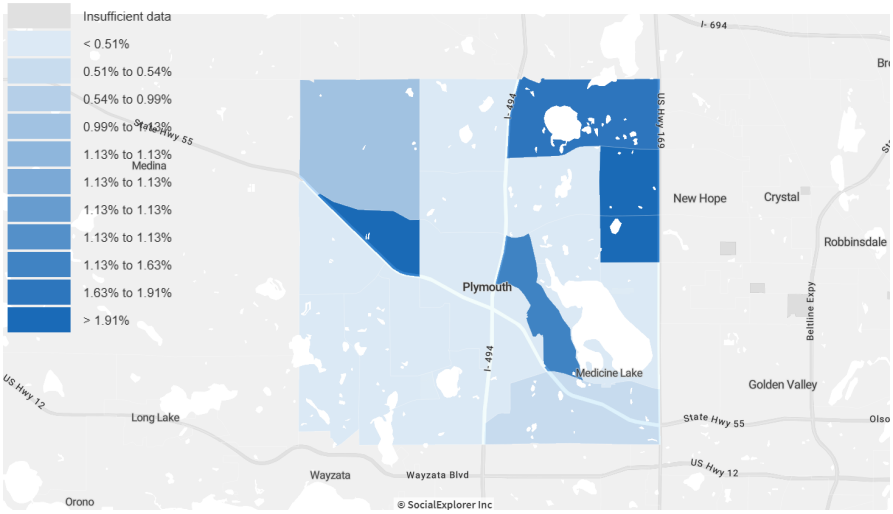
Total in demographic in City: **13,543**
16.9%
of total population

Extreme Weather / Temp · Flood · Air Quality · Vector-Borne · Food Insecurity · Power Failure · Wildfire

Individuals with Disabilities

Individuals with disabilities often face elevated levels of social challenges, including poverty and limited education, which can lead to worse health results during severe incidents or climate-driven crises. These challenges amplify the risks arising from functional limitations and hinder effective preparation and emergency reactions. A disability is defined as any physical or mental condition that restricts an individual's capability to engage in specific tasks or reduces their participation in typical life activities like education, employment, or leisure activities.[2]

Individuals with disabilities are particularly sensitive to the following Risks (see Section 4 for Climate Risk information)



Total in demographic in City:

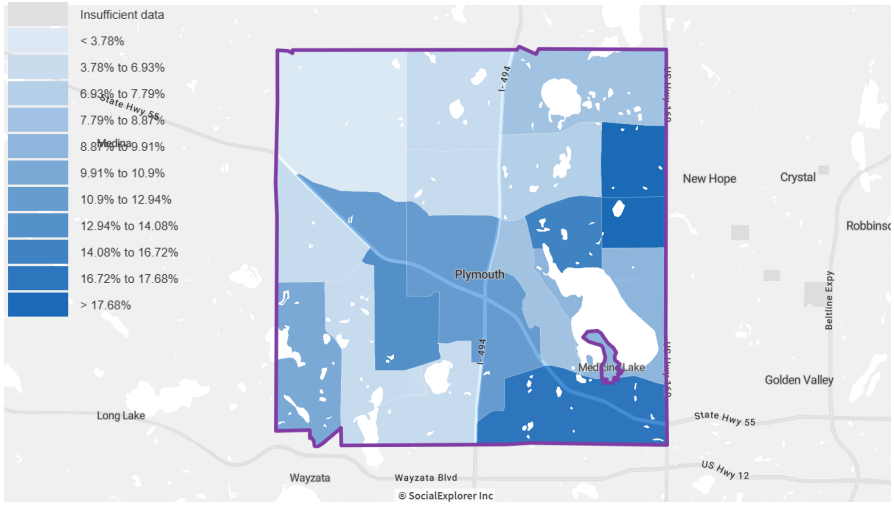
6,792
8.5%
of total population

Extreme Weather / Temp | Flood | Air Quality | Food Insecurity | Power Failure | Wildfire

Individuals in Economic Stress

Individuals and families living under economic stress, defined here as “low income” individuals (200% poverty level), are frequently the most adaptive demographic group in our communities. Those living under economic stress exhibit on-going adaptation capabilities simply navigating day-to-day challenges with less than needed resources. This adaptive capacity, however, is overwhelmed in times of emergency as lack of sufficient economic resources greatly reduce the range of options available in response to crisis. For those living in poverty, extreme weather events or illness in the family can lead to devastating financial setbacks.[2]

Individuals experiencing economic stress, defined as those at 200% poverty level (the common definition of “Low Income”) are particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City:

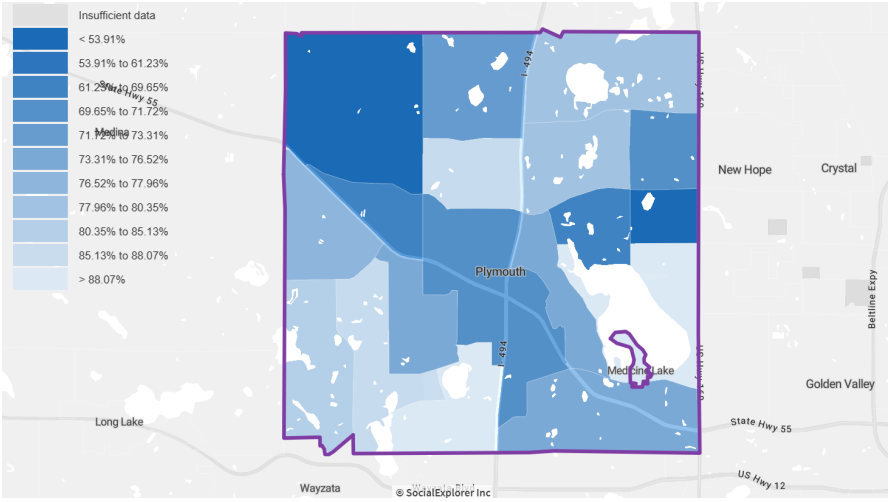
7,755
9.8%
of total population

Extreme Weather / Temp | Flood | Air Quality | Vector-Borne | Food Insecurity | Water Quality | Waterborne | Power Failure | Wildfire

People of Color

These groups face a heightened exposure risk because they are more likely to reside in areas prone to dangers, zones with aging or inadequately maintained infrastructure, or regions burdened by pollution. Furthermore, these segments of the population often have a greater prevalence of ongoing health issues, which can be intensified by the effects of climate change. Their ability to prepare for, react to, and handle health risks associated with climate change might be hindered by socio-economic challenges, restricted transportation options, limited health access, and social isolation due to language differences.[2, 7]

People of Color may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City: **21,326**

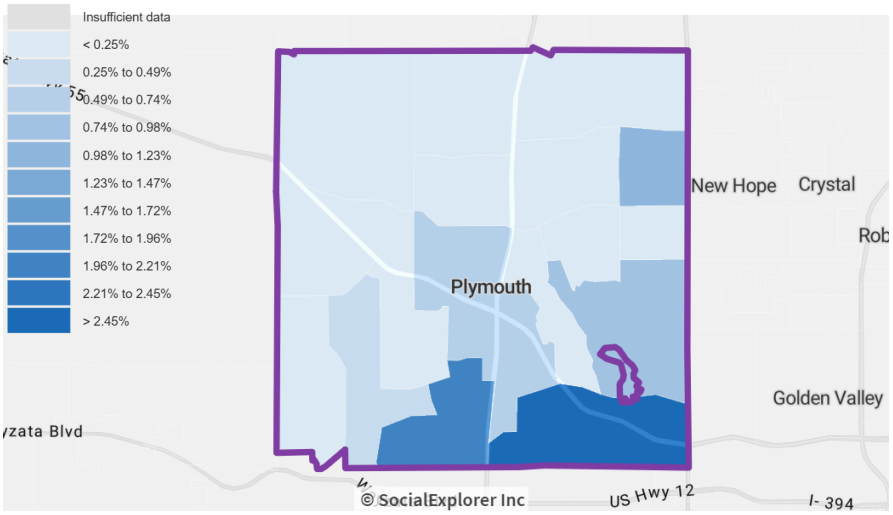
26.7%

of total population

Limited English Speakers

Individuals with limited English language skills may be more socially isolated. Their limited English also likely limits their access to public information and notifications, potentially resulting in a knowledge gap related to community resources, programs, or education which may be relevant in preparing for and recovering from climate impacts. In addition, communication barriers may create challenges for limited English speakers in understanding critical information or instructions given in public address during an extreme weather event. Though not specifically a "person of color" category, individuals with limited English frequently overlap with populations of color, making this group potentially doubly vulnerable.[2, 7]

Limited English Speakers may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City: **1,219**

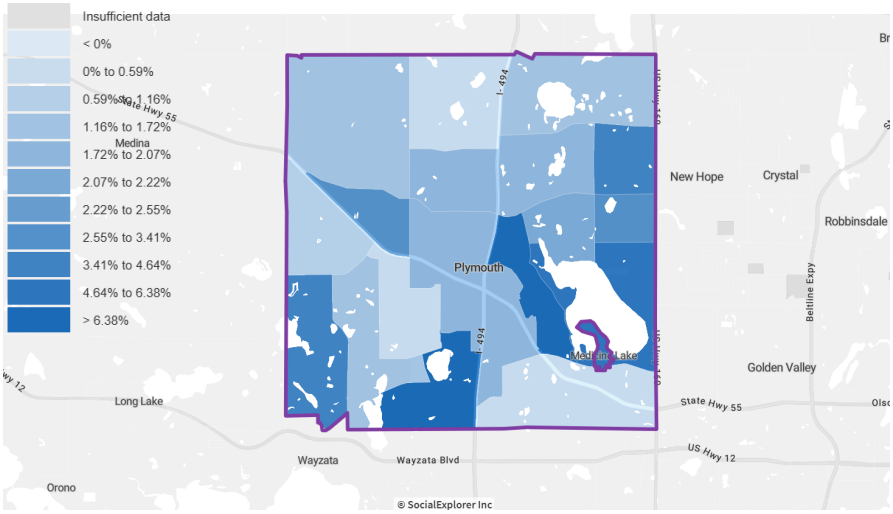
1.5%

of total population

At Risk Workers

Climate change is likely to intensify the frequency and severity of job-related environmental hazards. As our environment evolves, new occupational risks may also arise. We can anticipate that climate change will impact the well-being of outdoor workers due to rising average temperatures, frequent and prolonged heatwaves, diminishing air quality, severe weather events, diseases transmitted by vectors, and exposure in industrial settings. Those impacted by these climatic shifts encompass agricultural professionals, workers in heated indoor settings, construction personnel, emergency medical staff and other first responders, as well as those in transportation roles.[2]

Individuals employed in at-risk occupations may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City:

5,091
6.4%
of total population

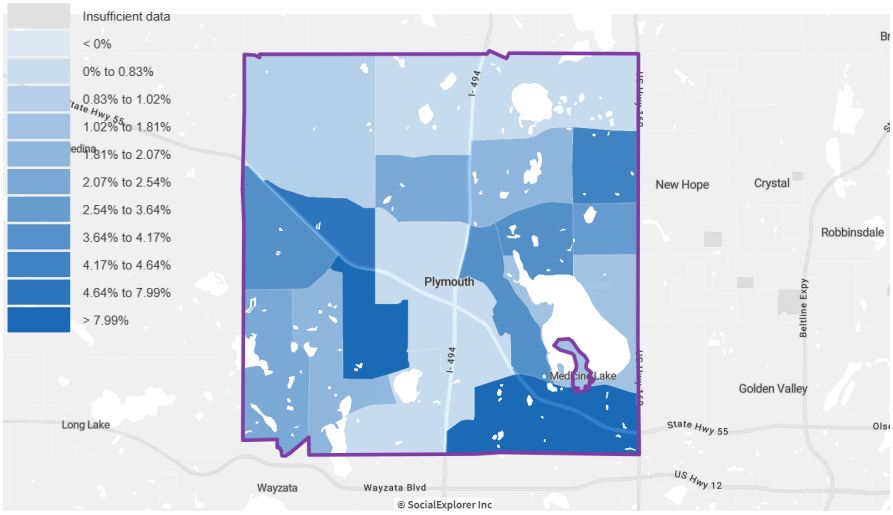
9.5%
of workers in community

Extreme Weather / Temp | Air Quality | Vector-Borne | Food Insecurity | Waterborne | Power Failure

Individuals with Possible Limited Mobility

Climate action seeks to reduce single occupant vehicles and promote public transit and alternative transport. For vulnerable populations, limited mobility from insufficient public transit and lack of vehicle access can complicate emergency evacuations, particularly in high-risk areas. This limited mobility can also hinder access to cooling stations during heatwaves or to medical facilities. Those with limited vehicle access, often under economic strain or older adults, face amplified climate vulnerabilities.[2, 9]

Individuals with limited mobility may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):



Total in demographic in City:

2,397
3.0%
of total population

Extreme Weather / Temp | Flood | Air Quality | Vector-Borne | Food Insecurity | Power Failure | Wildfire

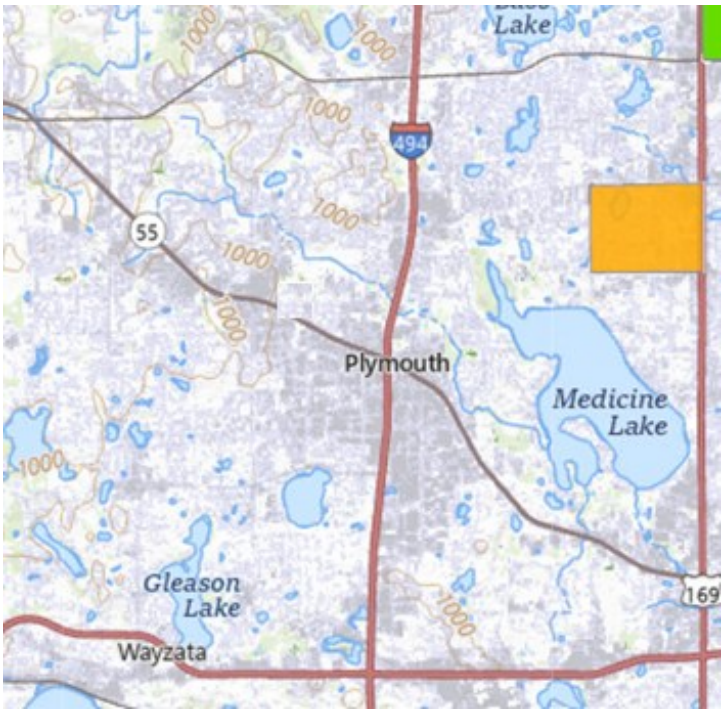
Individuals With Possible Food Insecurity

Those in economic stress are also frequently food insecure. In Hennepin County, food insecurity affects 1 in 10 people and 1 in 7 children.[10] Many of the projected climate change impacts are likely to affect agricultural production and distribution, which in turn, may cause spikes in food costs and increase food and nutrition insecurity among those in economic stress. Climate change affects agriculture in a number of ways such as through changes in average temperatures, rainfall, and extreme weather events. As the food distribution system becomes more stressed, individuals with less readily available access are more likely to be negatively impacted by the resulting cycles of food shortages and food price increases.

Individuals experiencing food insecurity may be particularly sensitive to the following Climate Risks (see Section 4 for Climate Risk information):

Food Insecurity

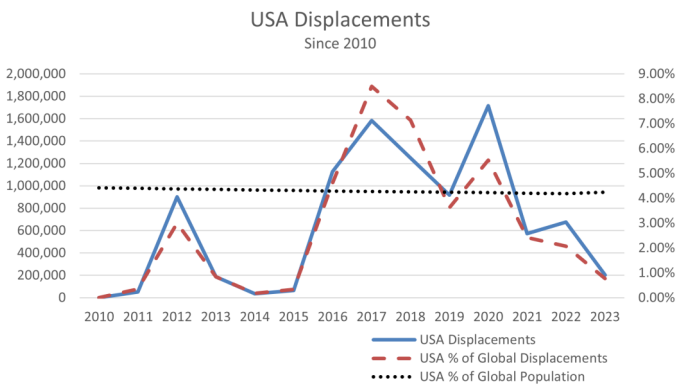
On the map to the right from the USDA Food Access Research Atlas, highlighted sections represent low-income census tracts (tracts where 20% or more of the population is at or below poverty, or where family median incomes are 80% or less of State median) where a significant number (at least 500 people) or share (at least 33 percent) of residents are distant from the nearest supermarket.[11] In sections which are green, residents are more than 1 mile (urban) or 10 miles (rural), while in orange sections residents are more than ½ mile (urban) or 10 miles (rural) from nearest supermarket.[11]

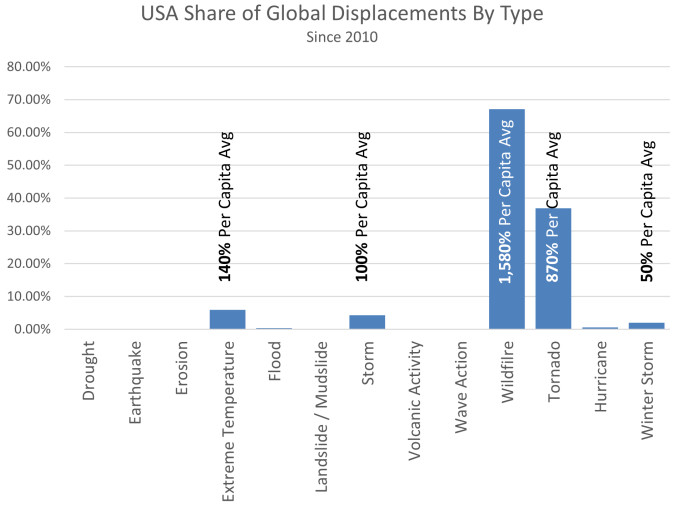


Climate Displacements

Since 2008, 11.3 million people in the U.S. have been displaced due to disasters, making up 2.8% of global displacements. In 2022 and 2023 a total of 875,000 U.S. residents were uprooted, ranking the U.S. second in the Americas, only behind Colombia.[12]

Over four of the past nine years since 2016, the U.S. had above its per-capita global displacement share. Especially stark is the U.S.'s impact in three categories: extreme temperatures at 140%, tornadoes at 540%, and wildfires at 1,580% of the global average. Clearly, climate-driven displacement is a pressing concern for American communities.[12]





Climate Migrant Populations

In the coming decades, US coasts will endure frequent flooding, endangering numerous homes. The Union of Concerned Scientists reports that by decade's end, 170 US communities will often face sea level floods, with many in vulnerable regions. By 2060, this could rise to 360 and surpass 670 by 2100. Areas like Oakland, Miami, St. Petersburg, and most New York City boroughs will face regular flooding. This might displace 13 million Americans by 2100. The UN anticipates 25 million to 1 billion global environmental migrants by 2050.[13, 14]

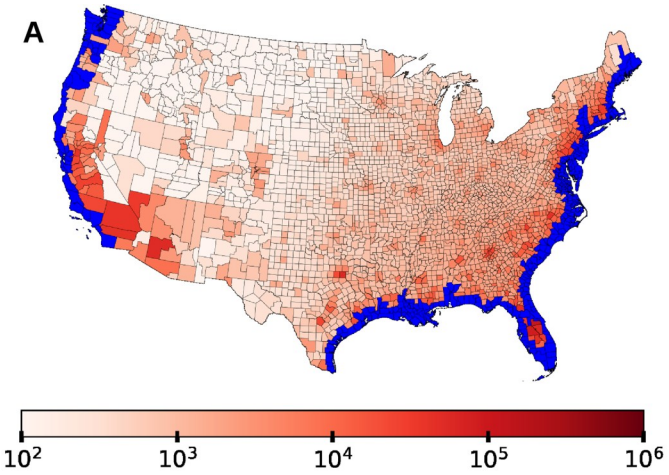
Understanding climate-driven migration, different from regular patterns, is key for informed policies, given its heightened impacts on receiving communities.

What This Means For Plymouth

Inland regions will experience increased migration. Estimates indicate 86% of communities with populations of over 10,000 will face climate migration impacts this century. While Plymouth isn't immune to climate change, it's poised to receive many climate migrants in the coming decades.[15]

This migration can strain labor and housing markets but also boost workforce diversity and human capital. Adapting to climate effects and preparing for migration are vital for community resilience while increasing the attraction of Plymouth as a choice for households seeking to relocate to avoid worse climate impacts elsewhere.

Modeled Migration Patterns Due To Sea Level Rise[15]



Projected Climate Migration To Hennepin County From Sea Level Rise Alone:[15]

10,000 - 20,000

SECTION 07

Findings

Click here to return to TOC

Based on the estimated Total Instances of Potential Vulnerability by Category and considering the risks each demographic is most sensitive to, the population vulnerabilities can be considered from highest sensitivity (more likely instances of vulnerability to that risk) to lowest sensitivity (fewer likely instances of vulnerability to that risk). It should be noted that risks which appear to have lower sensitivity levels should not be considered irrelevant for the community.

The Vulnerable Population Risk Sensitivity Chart tabulates the instances of vulnerable population which are particularly sensitive to each of the Climate Risks to the Population as outlined in Section 4 and calculated in Section 6. The left side of the chart includes all of the primary climate risks while the right side includes the economic climate risks.

Vulnerable Populations Risk Sensitivity Chart - City-Wide

		Direct Climate Risks to The Population									Indirect Economic Risks				
Vulnerable Demographic	Population	Extreme Weather/Temp	Flooding	Air Quality	Vector-Borne Disease	Food Insecurity	Water Quality	Waterborne Disease	Infrastructure Failure	Wildfire	Crop Yield	Mortality	Energy Costs	Property Crime	Violent Crime
Children Under 5	5,306	5,306		5,306	5,306	5,306		5,306	5,306		5,306	5,306	5,306		
Seniors Over 65	13,543	13,543	13,543	13,543	13,543	13,543			13,543	13,543	13,543	13,543	13,543	13,543	
Individuals with Disabilities	6,792	6,792	6,792	6,792		6,792			6,792	6,792		6,792	6,792	6,792	
Est Total Low Income	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755	7,755		7,755	7,755	7,755
People of Color	21,362	21,362	21,362	21,362	21,362	21,362	21,362	21,362	21,362	21,362	21,362		21,362	21,362	21,362
Limited English	1,219	1,219	1,219	1,219	1,219	1,219	1,219	1,219	1,219	1,219	1,219		1,219	1,219	1,219
At-Risk Workers	5,091	5,091	5,091	5,091			5,091								5,091
Limited Mobility	2,397	2,397	2,397			2,397			2,397	2,397	2,397				
Total Instances of Potential Vulnerability by Category*		**63,465**	**58,159**	**61,068**	**54,276**	**58,374**	**30,336**	**40,733**	**58,374**	**53,068**	**51,582**	**25,641**	**55,977**	**50,671**	**35,427**
Percentage of Total Instances of Potential Vulnerability		9.1%	8.3%	8.8%	7.8%	8.4%	4.4%	5.8%	8.4%	7.6%	7.4%	3.7%	8.0%	7.3%	5.1%
Rank by Share of Total Instances of Potential Vulnerability		**1**	**2**	**1**	**3**	**1**	**6**	**5**	**1**	**3**	**4**	**6**	**2**	**4**	**5**

* It is possible, and even likely, for individuals to be members of more than one vulnerable population. Individuals who have more than one instance of potential vulnerability (for example a person who is over 65, an individual living below 200% poverty level, and a limited english speaker) may have an increased range of potential risks to which they may be sensitive, as well as the potential for increased sensitivity to a given risk when compared to others.

To account for these considerations, the “Total Instances of Potential Vulnerabilities by Category” is not intended to represent the number of vulnerable individuals, but instead estimates the total number of potential instances of vulnerability within the community to each risk. The "Percentage of Total Instances of Potential Vulnerability" then divides that category's total by the sum of all "Instances of Potential Vulnerability by Category" to create a weighted comparison of each risk against all others. The resulting "Rank by Share of Total Instances of Potential Vulnerability" establishes a ranking based on the order of magnitude within the community's total population of likely instances of vulnerability to each risk.

Vulnerable Population Sensitivities

Based on the vulnerable population review in Section 6 and the Vulnerable Populations Risk Sensitivity Chart on the previous page, the risks with the highest likely community-wide sensitivities can be identified. For the City of Plymouth, those are Extreme Weather / Temperature, Air Quality, Flooding, Vector-Borne Disease, Food Insecurity, Power/Infrastructure Failure, and Wildfire.

See the Climate Risk Sensitivity Ranking Summary to the right for a summary of all risks.

Prioritizing Climate Risks

Climate change touches everyone. Climate adaptation planning requires analysis to set priorities without neglecting any city population, regardless of their "vulnerable" status. An effort to prioritize adaptation measures should not be seen as an indication that any risk should be ignored or the needs of any population within the city - whether or not it is defined as one of the “vulnerable” populations - should be discarded. Prioritization, however, is necessary to ensure the greatest impact and effectiveness of limited City resources.

Climate risks are ranked by occurrence likelihood (Sections 2 and 4, including FEMA National Risk Index) and impact on vulnerable populations (section 6 and “Sensitivity Ranking Summary). See Prioritizing Climate Risks Summary Chart for review of each risk.

Based on these reviews, the City’s adaptive efforts may be most effective by prioritizing strategies which address the climate risks as follows:

Primary Prioritization:

Extreme Weather, Air Quality, Food Insecurity, Power Failure,

Secondary Prioritization:

Flooding, Energy Costs

Tertiary Prioritization:

All Other Risks

With all adaptation measures, particular attention should be paid to strategies which are most effective for **People of Color, Seniors over 65, and those in Economic Stress.**

Prioritizing Climate Risks Summary Chart

The following health impact risks are calculated by multiplying Likelihood of Occurrence by Impact Level and by Timeframe using values described below the chart.

Health Impacts	Likelihood of Occurrence (Trends + Projections)	Impact Level (Sensitivity Ranking Summary)	Timeframe	Risk (Likelihood x Impact)
Extreme Weather / Temperature	Likely	High	Short-term	Very High
Flooding	Possible	Moderate	Medium-term	Low
Drought	Possible	Low	Medium-term	Very Low
Air Quality Impacts	Likely	High	Short-term	Very High
Vector-Borne Diseases	Likely	Moderate	Medium-term	Moderate
Food Insecurity	Likely	High	Medium-term	High
Water Quantity / Quality Impacts	Possible	Low	Long-term	Very Low
Waterborne Disease	Unlikely	Low	Medium-term	Very Low
Power / Infrastructure Failure	Likely	High	Medium-term	High
Wildfire	Possible	Moderate	Medium-term	Low
Crop Failure	Unlikely	Moderate	Medium-term	Very Low
Mortality	Possible	Low	Long-term	Very Low
Energy Costs	Likely	Moderate	Medium-term	Moderate
Property Crime	Possible	Moderate	Long-term	Very Low
Violent Crime	Unlikely	Low	Long-term	Very Low

Likelihood of Occurrence: Unlikely = 1; Possible = 2; Likely = 3
Impact Level: Low= 1; Moderate= 2; High = 3
Timeframe: Long-term = 1; Medium-term = 2; Short-term = 3; Current = 4
Resulting risk levels are based on the resulting total scores as follows:
Very Low < 5; Low < 9 ; Moderate < 18; High < 27; Very High => 27

Anticipating Economic Impacts of Climate Change

A 2017 study from the University of California at Berkeley assessed the economic impact of current climate projections throughout the United States on a county-by-county basis.[1] The sectors assessed, and the findings for Hennepin County and the City of Plymouth is below:

Crop Yield: Agricultural output is anticipated to decrease as Global Mean Surface Temperature rises, compounded by changes in precipitation patterns. While elevated CO2 levels might counterbalance some of these losses, the overarching effect across much of the U.S. is expected to be negative. Even for communities without a significant agricultural presence, these economic impacts may be felt through increases in food costs.

Energy Costs: With the rise in average annual temperatures, there will be a heightened demand for energy, leading to greater energy costs.

Labor Productivity: Labor productivity is negatively affected by rising temperatures. The extent of this impact varies; "low-risk" workers, primarily those working indoors, face different challenges compared to "high-risk" workers, who are identified as "At Risk Workers" in Section 4 and are more exposed to external conditions.

Crime: Research suggests that as cold days become less frequent, property crime may see an increase due to the crime-deterrent effect of cold days. Violent crime rates seem to have a direct relationship with temperature, increasing by a consistent 0.88% for every 1°C rise.

Projected Economic Impacts Through 2100[1]

According to research from the University of California at Berkeley, the total annual economic costs for the county and Plymouth's pro rata share by 2100 will be (2019 dollars)*:

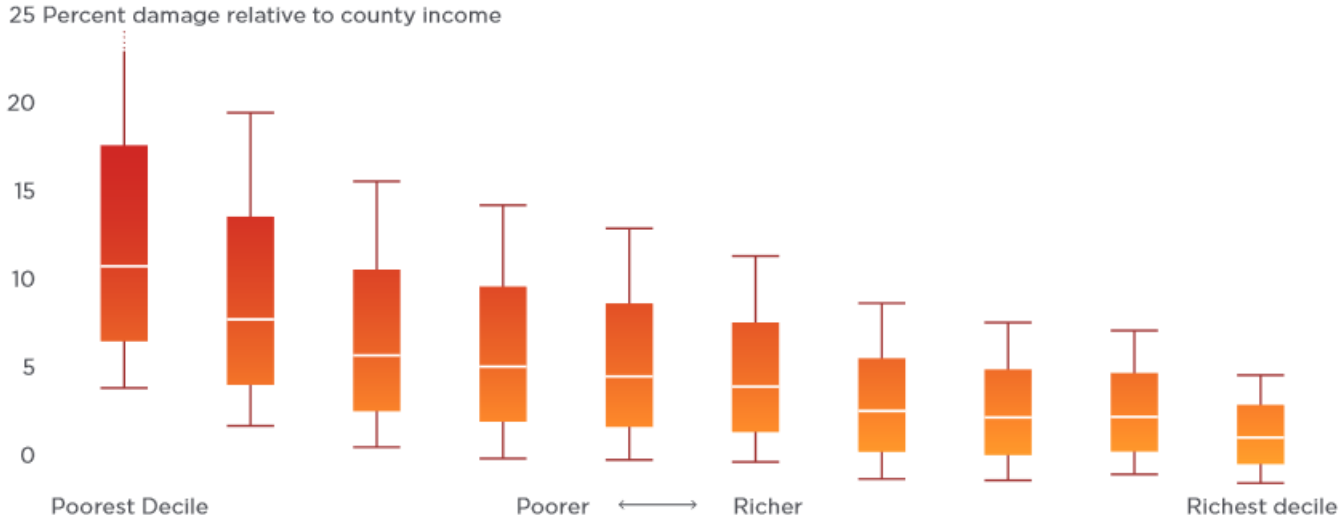
County: **$881,145,000** annually

Plymouth: **$55,671,000** annually

* Value does not include potential increased property damage nor increased healthcare costs due to extreme weather events.

Inequity of Economic Impacts Through 2100[1,2]

Climate change will amplify the uncertainty and disparity of upcoming economic results. The anticipated economic consequences are not evenly distributed. As depicted in the graphic below, the economic burdens on the poorest 10%



Note: Counties are arranged into deciles of county-level production/income and aggregate impacts as a percent of income are averaged across deciles. Boxplots denote median (white line), "likely" range (17 percentile-83 percentile, box), and 5 percentile-95 percentile (whiskers).

Graphic source: Amir Jina, Assistant Professor, Harris School of Public Policy, "Climate Change & the U.S. Economic Future"

could be 5 to 10 times greater than those faced by the wealthiest 10% in the community.

Estimating Social Cost of Carbon

The "Social Cost of Carbon," also known as the "Avoided Cost of Carbon," aims to precisely measure the detrimental effects of greenhouse gas emissions and the ensuing climate change repercussions. When this cost is factored into strategic planning, it enables organizations and businesses to more effectively evaluate their policies and decisions concerning greenhouse gas emissions. In essence, the "Social Cost of Carbon" quantifies the economic repercussions stemming from the emission of one ton of carbon dioxide into the atmosphere.

The “Projected Economic Impacts” illustrated on the previous page can be used to establish a reasonable localized social cost of carbon for the City. The methodology is to simply take the projected annual climate impact value and divide by the current City-wide GHG emissions:

Estimating the total annual economic impact for City of Plymouth ÷ **Current Total City-Wide GHG Emissions** = **Localized Social Cost of Carbon**

State of Minnesota Public Utilities Commission Social Cost of Carbon Value

Alternatively, the value range used by the Minnesota PUC could be used. Minnesota Statute § 216B.2422 Subdivision (3) (a) instructs the PUC to determine and set environmental costs for every electricity generation method. The Minnesota PUC, in a 2018 Order, set a cost range of $9.05 to $43.06 per short ton of CO2e ($10 to $47.30 per metric ton) to be implemented by 2020 for all commission deliberations on resource selections.

> **The measure of a country's greatness should be based on how well it cares for its most vulnerable populations.**
>
> Mahatma Gandhi

Appendix A

FEMA National Risk Index Report for Hennepin County*

Click to Return to TOC

* FEMA, National Risk Index for Natural Hazards; https://www.fema.gov/flood-maps/products-tools/national-risk-index

National Risk Index

November 01, 2025

Hennepin County, Minnesota

Summary

Risk Index is **Relatively High** Score **95.6**

Expected Annual Loss is **Relatively High** Score **96.2**

Social Vulnerability is **Relatively Low** Score **39.6**

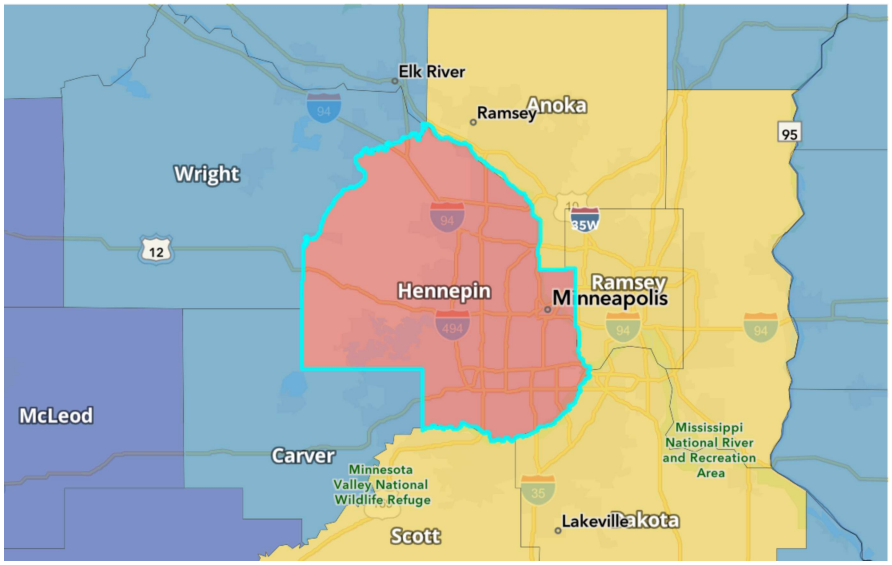
Community Resilience is **Very High** Score **98.4**

While reviewing this report, keep in mind that low risk is driven by lower loss due to natural hazards, lower social vulnerability, and higher community resilience.

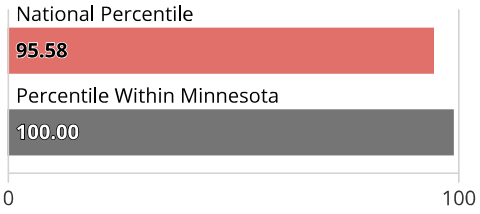
For more information about the National Risk Index, its data, and how to interpret the information it provides, please review the **About the National Risk Index** and **How to Take Action** sections at the end of this report. Or, visit the National Risk Index website at hazards.fema.gov/nri/learn-more to access supporting documentation and links.

Risk Index

The Risk Index rating is **Relatively High** for **Hennepin County, MN** when compared to the rest of the U.S.



Score **95.58**



96% of U.S. counties have a lower Risk Index

100% of counties in Minnesota have a lower Risk Index

Risk Index Legend

Very High | Relatively High | Relatively Moderate | Relatively Low | Very Low

No Rating | Not Applicable | Insufficient Data

Hazard Type Risk Index

Hazard type Risk Index scores are calculated using data for only a single hazard type, and reflect a community's Expected Annual Loss value, community risk factors, and the adjustment factor used to calculate the risk value.

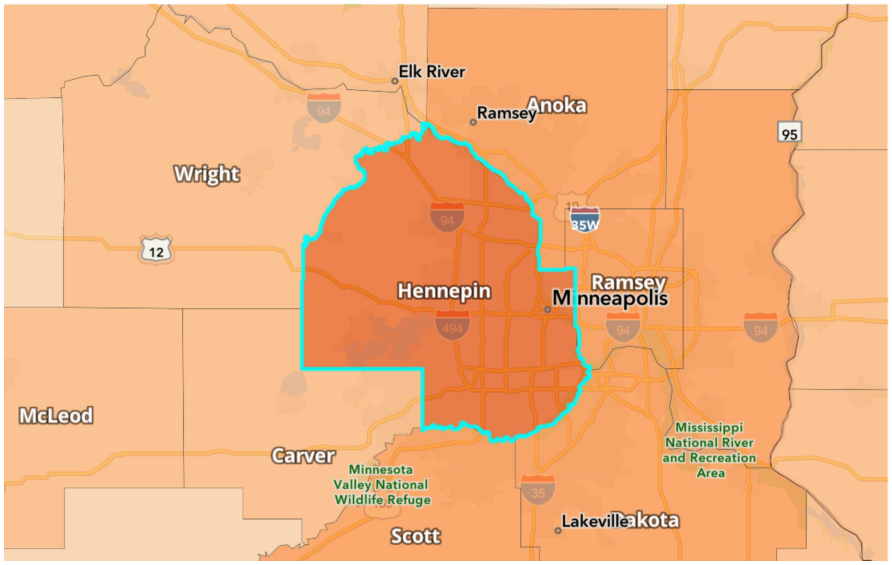
Hazard Type	Risk Index Rating	Risk Index Score	National Percentile
Avalanche	Not Applicable	--	
Coastal Flooding	Not Applicable	--	
Cold Wave	Very High	99.8	0 100
Drought	Very Low	25.2	0 100
Earthquake	Very Low	53.9	0 100
Hail	Relatively High	98.9	0 100
Heat Wave	Relatively High	97	0 100
Hurricane	Not Applicable	--	
Ice Storm	Relatively Moderate	65.4	0 100
Landslide	Relatively Moderate	92.9	0 100
Lightning	Relatively Moderate	84	0 100
Riverine Flooding	Relatively Moderate	80.8	0 100
Strong Wind	Very High	99.6	0 100
Tornado	Very High	99.7	0 100
Tsunami	Not Applicable	--	
Volcanic Activity	Not Applicable	--	
Wildfire	Relatively Low	84.6	0 100
Winter Weather	Relatively High	94.2	0 100

Risk Factor Breakdown

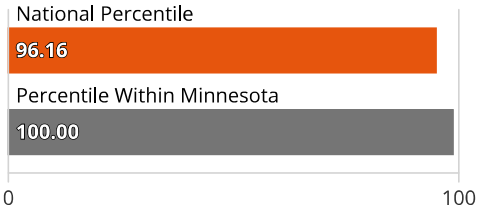
Hazard Type	EAL Value	Social Vulnerability	Community Resilience	CRF	Risk Value	Risk Index Score
Tornado	$74,082,128	Relatively Low	Very High	0.99	$73,451,429	99.7
Strong Wind	$14,146,710	Relatively Low	Very High	0.99	$13,799,426	99.6
Hail	$8,803,974	Relatively Low	Very High	0.99	$8,531,761	98.9
Cold Wave	$6,444,237	Relatively Low	Very High	0.99	$6,467,959	99.8
Heat Wave	$3,918,791	Relatively Low	Very High	0.99	$3,936,410	97
Riverine Flooding	$2,086,687	Relatively Low	Very High	0.99	$1,977,093	80.8
Wildfire	$1,026,452	Relatively Low	Very High	0.99	$813,525	84.6
Winter Weather	$664,880	Relatively Low	Very High	0.99	$645,049	94.2
Lightning	$430,184	Relatively Low	Very High	0.99	$427,787	84
Landslide	$229,233	Relatively Low	Very High	0.99	$210,499	92.9
Earthquake	$182,853	Relatively Low	Very High	0.99	$189,737	53.9
Ice Storm	$144,107	Relatively Low	Very High	0.99	$138,348	65.4
Drought	$2,947	Relatively Low	Very High	0.99	$2,042	25.2
Avalanche	--	Relatively Low	Very High	0.99	--	--
Coastal Flooding	--	Relatively Low	Very High	0.99	--	--
Hurricane	--	Relatively Low	Very High	0.99	--	--
Tsunami	--	Relatively Low	Very High	0.99	--	--
Volcanic Activity	--	Relatively Low	Very High	0.99	--	--

Expected Annual Loss

In **Hennepin County, MN**, expected loss each year due to natural hazards is **Relatively High** when compared to the rest of the U.S.



Score	96.16



96% of U.S. counties have a lower Expected Annual Loss

100% of counties in Minnesota have a lower Expected Annual Loss

Expected Annual Loss Legend

Very High | Relatively High | Relatively Moderate | Relatively Low | Very Low

No Expected Annual Losses | Not Applicable | Insufficient Data

Composite Expected Annual Loss	**$112,163,182.14**
Composite Expected Annual Loss Rate National Percentile	**14.6**

Building EAL	**$59,607,683.07**	Population EAL	**4.51** fatalities
Building EAL Rate	**$1 per $4.46K of building value**	Population EAL Rate	**1 per 283.94K people**
Agriculture EAL	**$215,308.98**	Population Equivalence EAL	**$52,340,190.10**
Agriculture EAL Rate	**$1 per $311.96 of agriculture value**		

Expected Annual Loss for Hazard Types

Expected Annual Loss scores for hazard types are calculated using data for only a single hazard type, and reflect a community's relative expected annual loss for only that hazard type.

13 of 18 hazard types contribute to the expected annual loss for **Hennepin County, MN**.

Hazard Type	Expected Annual Loss Rating	EAL Value	Score
Tornado	Very High	$74,082,128	99.7
Strong Wind	Very High	$14,146,711	99.8

Hazard Type	Expected Annual Loss Rating	EAL Value	Score
Hail	Relatively High	$8,803,974	99.2
Cold Wave	Very High	$6,444,237	99.8
Heat Wave	Relatively High	$3,918,791	97.2
Riverine Flooding	Relatively Moderate	$2,086,688	84.8
Wildfire	Relatively Moderate	$1,026,452	87.1
Winter Weather	Relatively High	$664,880	95.3
Lightning	Relatively Moderate	$430,184	86.1
Landslide	Relatively Moderate	$229,233	94.5
Earthquake	Very Low	$182,853	55.2
Ice Storm	Relatively Moderate	$144,107	69.3
Drought	Very Low	$2,947	30.6
Avalanche	Not Applicable	--	--
Coastal Flooding	Not Applicable	--	--
Hurricane	Not Applicable	--	--
Tsunami	Not Applicable	--	--
Volcanic Activity	Not Applicable	--	--

Expected Annual Loss Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	--	--	--	--	--
Cold Wave	$6,444,237	$24,985	$6,381,759	0.55	$37,494
Drought	$2,947	n/a	n/a	n/a	$2,947
Earthquake	$182,853	$139,589	$43,265	0.00	n/a
Hail	$8,803,974	$8,586,733	$161,674	0.01	$55,567
Heat Wave	$3,918,791	$845	$3,908,760	0.34	$9,186
Hurricane	--	--	--	--	--
Ice Storm	$144,107	$140,194	$3,912	0.00	n/a
Landslide	$229,233	$208,431	$20,802	0.00	n/a
Lightning	$430,184	$139,038	$291,145	0.03	n/a
Riverine Flooding	$2,086,687	$156,099	$1,843,994	0.16	$86,595

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Strong Wind	$14,146,710	$12,220,925	$1,904,783	0.16	$21,003
Tornado	$74,082,128	$36,587,950	$37,492,610	3.23	$1,568
Tsunami	--	--	--	--	--
Volcanic Activity	--	--	--	--	--
Wildfire	$1,026,452	$750,867	$275,522	0.02	$63
Winter Weather	$664,880	$652,029	$11,964	0.00	$887

Exposure Values

Hazard Type	Total	Building Value	Population Equivalence	Population	Agriculture Value
Avalanche	--	--	--	--	--
Coastal Flooding	--	--	--	--	--
Cold Wave	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406
Drought	$6,620,106	n/a	n/a	n/a	$6,620,106
Earthquake	$15,132,143,754,000	$265,989,754,000	$14,866,154,000,000	1,281,565.00	n/a
Hail	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406
Heat Wave	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406
Hurricane	--	--	--	--	--
Ice Storm	$15,122,302,459,726	$265,930,581,856	$14,856,371,877,870	1,280,721.71	n/a
Landslide	$3,462,915,045,205	$80,353,828,646	$3,382,561,216,558	291,600.10	n/a
Lightning	$15,127,588,219,168	$265,993,019,168	$14,861,595,200,000	1,281,172.00	n/a
Riverine Flooding	$115,007,695,640	$2,399,020,153	$112,603,865,033	9,707.23	$4,810,454
Strong Wind	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406
Tornado	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406
Tsunami	--	--	--	--	--
Volcanic Activity	--	--	--	--	--
Wildfire	$830,553,997,024	$15,327,766,165	$815,212,120,772	70,276.91	$14,110,087
Winter Weather	$15,127,655,387,574	$265,993,019,168	$14,861,595,200,000	1,281,172.00	$67,168,406

Annualized Frequency Values

Hazard Type	Annualized Frequency	Events on Record	Period of Record
Avalanche	--	--	--

Hazard Type	Annualized Frequency	Events on Record	Period of Record
Coastal Flooding	--	--	--
Cold Wave	1.5 events per year	24	2005-2021 (16 years)
Drought	0.3 events per year	35	2000-2021 (22 years)
Earthquake	0.006% chance per year	n/a	2021 dataset
Hail	6.5 events per year	221	1986-2021 (34 years)
Heat Wave	2.5 events per year	40	2005-2021 (16 years)
Hurricane	--	--	--
Ice Storm	0.5 events per year	33	1946-2014 (67 years)
Landslide	0 events per year	3	2010-2021 (12 years)
Lightning	39.8 events per year	875	1991-2012 (22 years)
Riverine Flooding	1.8 events per year	43	1996-2019 (24 years)
Strong Wind	4.8 events per year	164	1986-2021 (34 years)
Tornado	0.4 events per year	31	1950-2021 (72 years)
Tsunami	--	--	--
Volcanic Activity	--	--	--
Wildfire	0.024% chance per year	n/a	2021 dataset
Winter Weather	5.9 events per year	95	2005-2021 (16 years)

Historic Loss Ratios

Hazard Type	Overall Rating
Avalanche	--
Coastal Flooding	--
Cold Wave	Very Low
Drought	Relatively Moderate
Earthquake	Very Low
Hail	Relatively Low
Heat Wave	Very Low
Hurricane	--
Ice Storm	Very Low
Landslide	Very Low
Lightning	Very Low

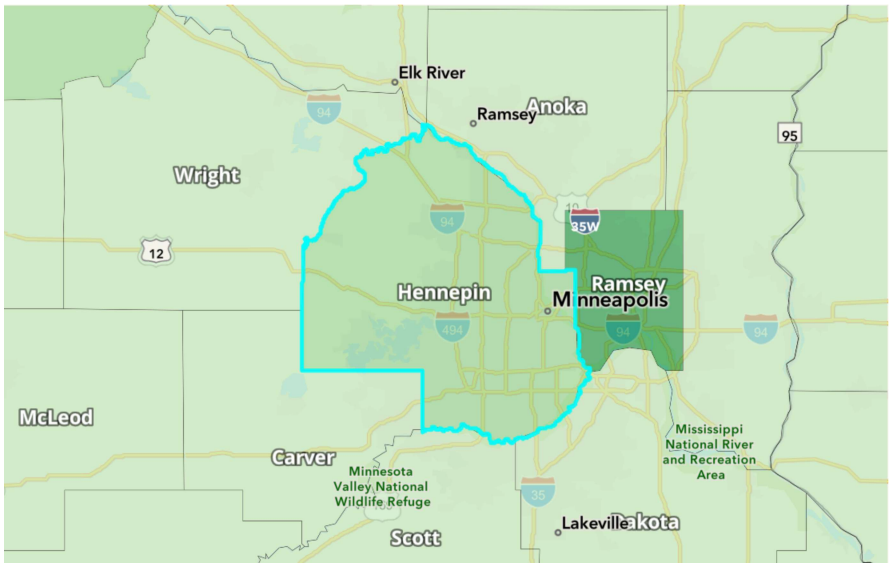
Hazard Type	Overall Rating
Riverine Flooding	Very Low
Strong Wind	Relatively Low
Tornado	Relatively Moderate
Tsunami	--
Volcanic Activity	--
Wildfire	Relatively Low
Winter Weather	Very Low

Expected Annual Loss Rate

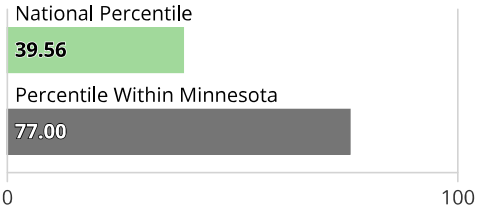
Hazard Type	Building EAL Rate (per building value)	Population EAL Rate (per population)	Agriculture EAL Rate (per agriculture value)
Avalanche	--	--	--
Coastal Flooding	--	--	--
Cold Wave	$1 per $10.65M	1 per 2.33M	$1 per $1.79K
Drought	--	--	$1 per $22.80K
Earthquake	$1 per $1.91M	1 per 343.51M	--
Hail	$1 per $30.98K	1 per 91.92M	$1 per $1.21K
Heat Wave	$1 per $314.94M	1 per 3.80M	$1 per $7.31K
Hurricane	--	--	--
Ice Storm	$1 per $1.90M	1 per 3.80B	--
Landslide	$1 per $1.28M	1 per 714.42M	--
Lightning	$1 per $1.91M	1 per 51.05M	--
Riverine Flooding	$1 per $1.70M	1 per 8.06M	$1 per $775.67
Strong Wind	$1 per $21.77K	1 per 7.80M	$1 per $3.20K
Tornado	$1 per $7.27K	1 per 396.39K	$1 per $42.85K
Tsunami	--	--	--
Volcanic Activity	--	--	--
Wildfire	$1 per $354.25K	1 per 53.94M	$1 per $1.07M
Winter Weather	$1 per $407.95K	1 per 1.24B	$1 per $75.76K

Social Vulnerability

Social groups in **Hennepin County, MN** have a **Relatively Low** susceptibility to the adverse impacts of natural hazards when compared to the rest of the U.S.



Score **39.56**



40% of U.S. counties have a lower Social Vulnerability

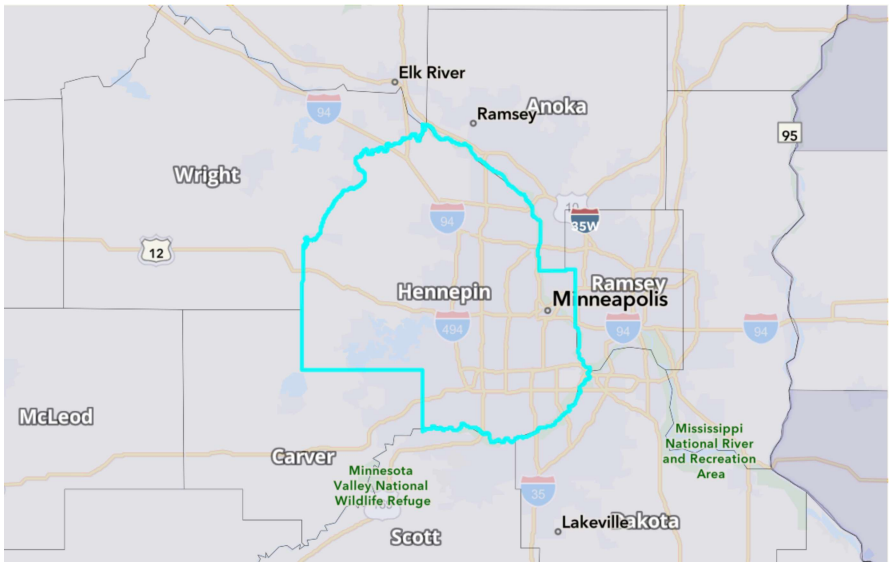
77% of counties in Minnesota have a lower Social Vulnerability

Social Vulnerability Legend

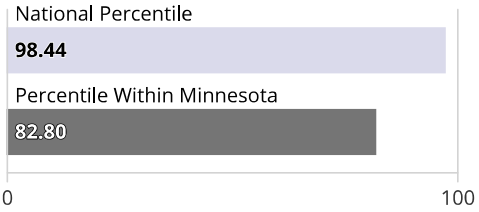
Very High | Relatively High | Relatively Moderate | Relatively Low | Very Low | Data Unavailable

Community Resilience

Communities in **Hennepin County, MN** have a **Very High** ability to prepare for anticipated natural hazards, adapt to changing conditions, and withstand and recover rapidly from disruptions when compared to the rest of the U.S.



Score **98.44**



2% of U.S. counties have a higher Community Resilience

17% of counties in Minnesota have a higher Community Resilience

Community Resilience Legend

Very High | Relatively High | Relatively Moderate | Relatively Low | Very Low | Data Unavailable

About the National Risk Index

The National Risk Index is a dataset and online tool to help illustrate the United States communities most at risk for 18 natural hazards: Avalanche, Coastal Flooding, Cold Wave, Drought, Earthquake, Hail, Heat Wave, Hurricane, Ice Storm, Landslide, Lightning, Riverine Flooding, Strong Wind, Tornado, Tsunami, Volcanic Activity, Wildfire, and Winter Weather.

The National Risk Index leverages available source data for Expected Annual Loss due to these 18 hazard types, Social Vulnerability, and Community Resilience to develop a baseline relative risk measurement for each United States county and Census tract. These measurements are calculated using average past conditions, but they cannot be used to predict future outcomes for a community. The National Risk Index is intended to fill gaps in available data and analyses to better inform federal, state, local, tribal, and territorial decision makers as they develop risk reduction strategies.

Explore the National Risk Index Map at **hazards.fema.gov/nri/map**.

Visit the National Risk Index website at **hazards.fema.gov/nri/learn-more** to access supporting documentation and links.

Calculating the Risk Index

Risk Index values are calculated using an equation* that combines values for Expected Annual Loss (EAL) due to natural hazards, with the Community Risk Factor (CRF), which is a function of Social Vulnerability and Community Resilience:

$$\text{Risk Index} = \text{Expected Annual Loss} \times \text{Community Risk Factor}$$

$$\text{where Community Risk Factor} = f\left(\frac{\text{Social Vulnerability}}{\text{Community Resilience}}\right)$$

*County-level risk values are derived by summing the risk values of all Census tracts within that county.

Risk is presented as a composite value and score for all 18 hazard types, as well as individual values and scores for each hazard type.

For more information, visit **hazards.fema.gov/nri/determining-risk**.

Calculating Expected Annual Loss

Expected Annual Loss values are calculated using an equation* that combines values for exposure, annualized frequency, and historic loss ratios for 18 hazard types:

$$\text{Expected Annual Loss} = \text{Exposure} \times \text{Annualized Frequency} \times \text{Historic Loss Ratio}$$

*Excluding Avalanche, Drought, Earthquake, and Tornado, EAL values for each hazard are calculated at the Census block level and summed together to determine Census tract and county-level hazard type EAL values.

Expected Annual Loss is presented as a composite value and score for all 18 hazard types, as well as individual values and scores for each hazard type.

For more information, visit **hazards.fema.gov/nri/expected-annual-loss**.

Calculating Social Vulnerability

Social Vulnerability is measured using the Social Vulnerability Index (SVI) published by the Centers for Disease Control and Prevention (CDC).

For more information, visit **hazards.fema.gov/nri/social-vulnerability**.

Calculating Community Resilience

Community Resilience is measured at the County level using the Baseline Resilience Indicators for Communities (HVRI BRIC) published by the University of South Carolina's Hazards and Vulnerability Research Institute (HVRI).

For more information, visit **hazards.fema.gov/nri/community-resilience**.

Values, Scores, and Ratings

The National Risk Index provides three different types of results for Risk and each component used to derive Risk: EAL, Social Vulnerability, and Community Resilience:

Values. Values for Risk and EAL are in units of dollars, representing the community's average economic loss from natural hazards each year. For Social Vulnerability and Community Resilience, values are the index values for the community provided by the source data sets.

Scores. Scores represent the national percentile ranking of the community's component value compared to all other communities at the same level (county or Census tract).

Ratings. Ratings refer to the qualitative terms that describe the relative risk of an area within the same geographic level. These rating categories range from "Very Low" to "Very High". Ratings for Social Vulnerability and Community Resilience are based on quintiles of those components' scores, while Risk and EAL ratings are based on more advanced statistical calculations on values . As a result, there is no fixed range of scores or values that correspond to the rating categories.

How to Take Action

There are many ways to reduce natural hazard risk through mitigation. Communities with high National Risk Index scores can take action to reduce risk by decreasing Expected Annual Loss due to natural hazards, decreasing Social Vulnerability, and increasing Community Resilience.

For information about how to take action and reduce your risk, visit **hazards.fema.gov/nri/take-action**.

Disclaimer

The National Risk Index (the Risk Index or the Index) and its associated data are meant for planning purposes only. This tool was created for broad nationwide comparisons and is not a substitute for localized risk assessment analysis. Nationwide datasets used as inputs for the National Risk Index are, in many cases, not as accurate as available local data. Users with access to local data for each National Risk Index risk factor should consider substituting the Risk Index data with local data to recalculate a more accurate risk index. If you decide to download the National Risk Index data and substitute it with local data, you assume responsibility for the accuracy of the data and any resulting data index. Please visit the **Contact Us** page if you would like to discuss this process further.

The methodology used by the National Risk Index has been reviewed by subject matter experts in the fields of natural hazard risk research, risk analysis, mitigation planning, and emergency management. The processing methods used to create the National Risk Index have produced results similar to those from other natural hazard risk analyses conducted on a smaller scale. The breadth and combination of geographic information systems (GIS) and data processing techniques leveraged by the National Risk Index enable it to incorporate multiple hazard types and risk factors, manage its nationwide scope, and capture what might have been missed using other methods.

The National Risk Index does not consider the intricate economic and physical interdependencies that exist across geographic regions. Keep in mind that hazard impacts in surrounding counties or Census tracts can cause indirect losses in your community regardless of your community's risk profile.

Nationwide data available for some risk factors are rudimentary at this time. The risk profiles for the vast majority of hazard types are based on historical frequency and loss data. They represent risk and expected annual loss based on average past conditions, not future predictions. The National Risk Index will be continuously updated as new data become available and improved methodologies are identified.

For comprehensive details about how the Risk Index can help you and its limitations, see the **National Risk Index Technical Documentation**

Assumption of Risk

In view of the identified limitations of the National Risk Index associated data, by using the data, you acknowledge and agree that FEMA makes no representations or warranties about the accuracy, completeness, or fitness for any particular purpose of the data; that the data is provided "as is" without warranty of any kind; that you assume full responsibility for any consequences that may arise, including financial losses, legal disputes, or other adverse outcomes; and that you release FEMA and the federal government from any liability that may arise to the extent allowable by law.

Attribution, No Endorsement

Please attribute your use of the National Risk Index and its associated data to the Federal Emergency Management Agency.

However, you acknowledge and agree that nothing herein constitutes and endorsement of you or your work by FEMA or the federal government, and you shall not imply through use of the National Risk Index or its associated data or through providing attribution, that FEMA or the federal government endorses you.

Preferred citation for the National Risk Index:

Zuzak, C., E. Goodenough, C. Stanton, M. Mowrer, A. Sheehan, B. Roberts, P. McGuire, and J. Rozelle. 2023. National Risk Index Technical Documentation. Federal Emergency Management Agency, Washington, DC.

The National Risk Index Contact Us page is available at **hazards.fema.gov/nri/contact-us**.

Appendix B

The US Climate Vulnerability Index Report for City of Plymouth*

Click to Return to TOC

*The U.S. Climate Vulnerability Index: https://climatevulnerabilityindex.org/

Tract 27053026514, Minneapolis, MN

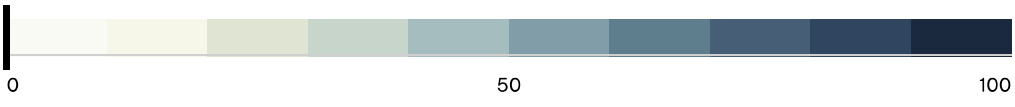
Minnesota

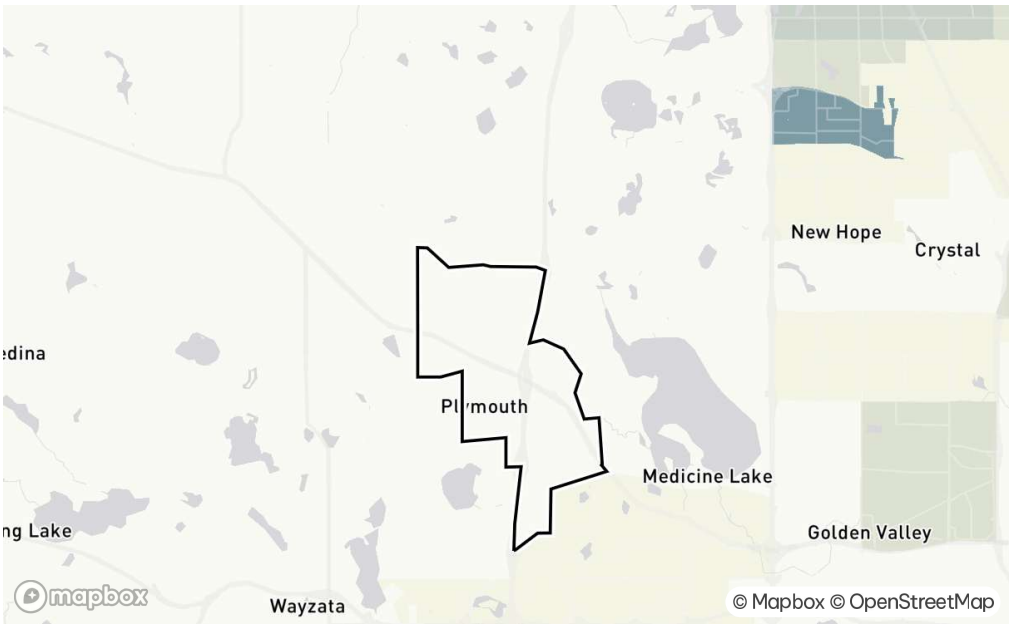
Overall Climate Vulnerability

Score combining environmental, social, economic, and infrastructure effects on neighborhood-level stability.

Ranks **914** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **8th** national vulnerability percentile





DEMOGRAPHIC PROFILE	total	percent
Population	4,997	
Race: White	3,340	66.8%
Race: Asian	978	19.6%
Race: Black	337	6.7%
Race: Two+	194	3.9%
Race: Other	148	3%
Race: Native	0	0%
Race: Islander	0	0%
Age: 65 Years And Over	479	9.6%

Top Drivers of Overall Climate Vulnerability

Climate Impacts

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Temperature	94th	706th
Infectious Diseases	93rd	3rd
Social Stressors	77th	760th

Community Baseline

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Transportation Sources	97th	20th
Exposures & Risks	79th	466th
Infectious Diseases	57th	3rd

Composition of Overall Climate Vulnerability

Climate Impacts

How a community is vulnerable to environmental and economic disruptions.

This tract ranks **811** out of **1,338 Tracts** in **Minnesota**

lower vulnerability **28th** national vulnerability percentile

Social & Economic

Social and economic costs and impacts associated with change in climate.

60th national vulnerability percentile

Extreme Events

Historical and projected extreme weather event occurrences.

45th national vulnerability percentile

Health

Expected changes in community health resulting from warming climate.

18th national vulnerability percentile

Community Baseline

The long-standing inequities shaping resilience to climate impacts.

This tract ranks **830** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **9th** national vulnerability percentile

Environment

Environmental factors that pose a threat to community's well-being.

67th national vulnerability percentile

Health

Factors reflecting baseline or overall state of population health.

9th national vulnerability percentile

Social & Economic

Social and economic stressors that impact community resilience.

8th national vulnerability percentile

Infrastructure

Essential structures, services, resources that affect community resilience.

5th national vulnerability percentile

Tract 27053026514, Minneapolis, MN

Minnesota

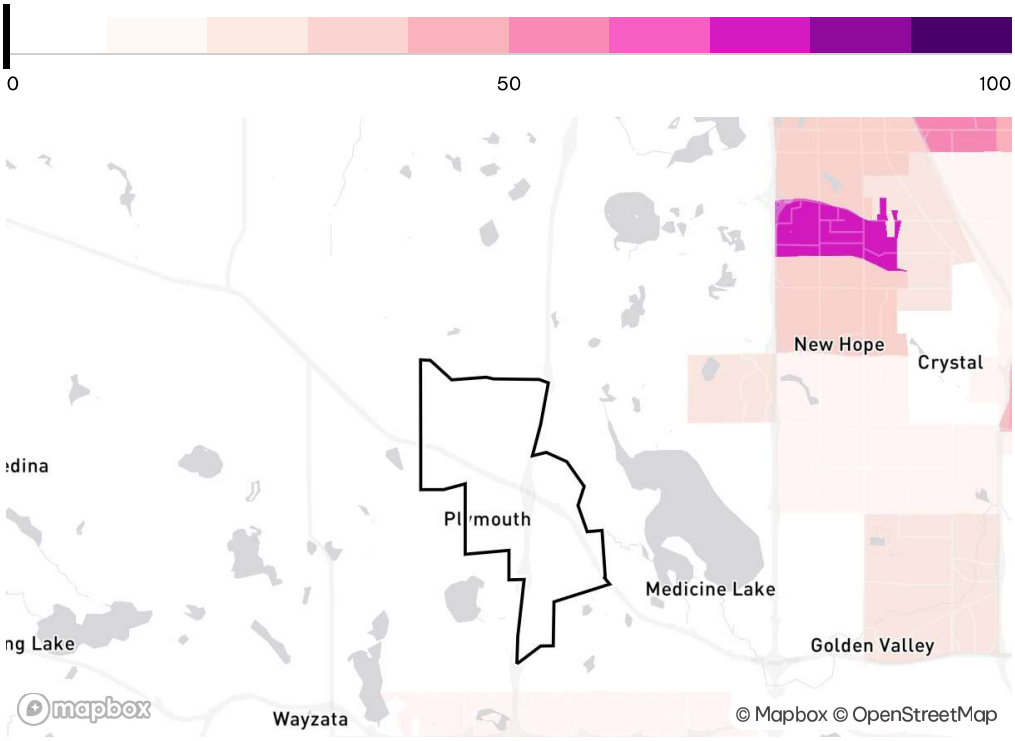
Overall Climate Vulnerability

Community Baseline

The long-standing inequities shaping resilience to climate impacts.

Ranks **830** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **9th** national vulnerability percentile



DEMOGRAPHIC PROFILE	total	percent
Population	4,997	
Race: White	3,340	66.8%
Race: Asian	978	19.6%
Race: Black	337	6.7%
Race: Two+	194	3.9%
Race: Other	148	3%
Race: Native	0	0%
Race: Islander	0	0%
Age: 65 Years And Over	479	9.6%

Top Drivers of Community Baseline

Environment

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Transportation Sources	97th	20th
Exposures & Risks	79th	466th
Land Use	51st	454th

Health

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Infectious Diseases	57th	3rd
Mental Health & Deaths of Despair	42nd	331st
Child & Maternal Health	26th	336th

Social & Economic

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Housing Type & Transportation	41st	820th
Minority Status & Language	23rd	826th
Socioeconomic Stressors	9th	1,062nd

Infrastructure

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Financial Services	45th	200th
Energy	37th	706th
Food, Water, and Waste Management	14th	1,035th

Composition of Community Baseline

Environment

Environmental factors that pose a threat to community's well-being.

This tract ranks **263** out of **1,338 Tracts** in **Minnesota**

higher vulnerability **67th** national vulnerability percentile

Transportation Sources

The kinds of infrastructure that are available and the ways a community gets around.

97th national vulnerability percentile

Exposures & Risks

The kinds of exposure and the risks to community health.

79th national vulnerability percentile

Land Use

The amount of land that has been developed.

51st national vulnerability percentile

Pollution Sources

The number and kinds of polluters in a community.

48th national vulnerability percentile

Criteria Air Pollutants

The amount of the primary air pollution regulated by the government.

16th national vulnerability percentile

Health

Factors reflecting baseline or overall state of population health.

This tract ranks **830** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **9th** national vulnerability percentile

Infectious Diseases

The presence of diseases that can spread from person to person.

57th national vulnerability percentile

Mental Health & Deaths of Despair

The impact of depression, addiction, and hopelessness.

42nd national vulnerability percentile

Child & Maternal Health

The well-being of mothers and children under 18 years old.

26th national vulnerability percentile

Access to Care

The availability, affordability, and closeness to health care.

24th national vulnerability percentile

Overall Physical Health

The health issues and life expectancy of a community.

16th national vulnerability percentile

Chronic Disease Prevention

The number of adults who get regular preventive tests or examinations.

2nd national vulnerability percentile

Chronic Disease

The number of adults diagnosed with long-term health conditions.

2nd national vulnerability percentile

Social & Economic

Social and economic stressors that impact community resilience.

This tract ranks **1,105** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **8th** national vulnerability percentile

Housing Type & Transportation

The availability of housing and mobility options in a community.

41st national vulnerability percentile

Minority Status & Language

The number of people who might experience different kinds of exclusion and underrepresentation.

23rd national vulnerability percentile

Socioeconomic Stressors

The aspects of a person's identity and daily lives that can increase stress.

9th national vulnerability percentile

Housing Composition & Disability

The quality and accessibility of housing in a community.

7th national vulnerability percentile

Infrastructure

Essential structures, services, resources that affect community resilience.

This tract ranks **1,154** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **5th** national vulnerability percentile

Financial Services

The ways people in a community manage their money.

45th national vulnerability percentile

Energy

The sources, availability, and affordability of energy.

37th national vulnerability percentile

Food, Water, and Waste Management

The access a community has to food and the way waste is disposed.

14th national vulnerability percentile

Communications

The ways people in a community access and share information.

12th national vulnerability percentile

Governance

The extent of publicly funded services and resources.

10th national vulnerability percentile

Transportation

The quality and accessibility of transportation options.

8th national vulnerability percentile

Tract 27053026514, Minneapolis, MN

Minnesota

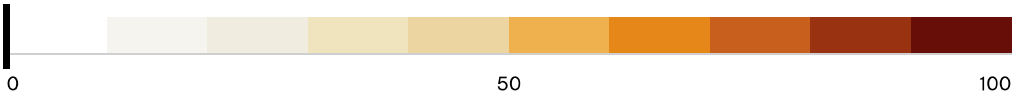
Overall Climate Vulnerability

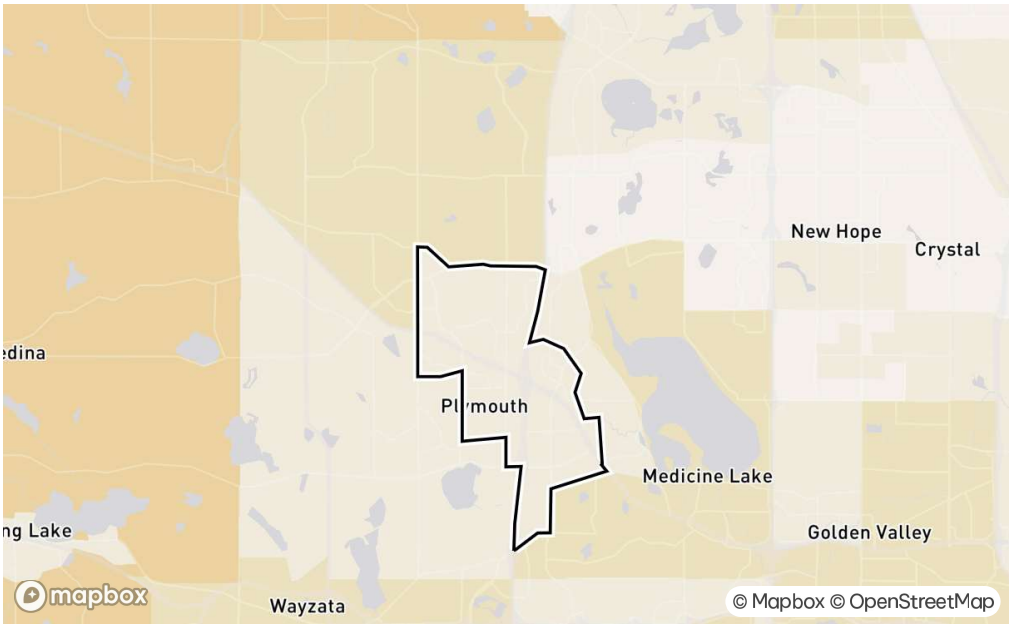
Climate Impacts

How a community is vulnerable to environmental and economic disruptions.

Ranks **811** out of **1,338 Tracts** in **Minnesota**

lower vulnerability **28th** national vulnerability percentile





DEMOGRAPHIC PROFILE	total	percent
Population	4,997	
Race: White	3,340	66.8%
Race: Asian	978	19.6%
Race: Black	337	6.7%
Race: Two+	194	3.9%
Race: Other	148	3%
Race: Native	0	0%
Race: Islander	0	0%
Age: 65 Years And Over	479	9.6%

Top Drivers of Climate Impacts

Social & Economic

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Social Stressors	77th	760th
Economic & Productivity Losses	61st	348th
Transition Risks	38th	991st

Extreme Events

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Temperature	94th	706th
Precipitation	59th	952nd
Wildfires	51st	1,046th

Health

National vulnerability percentile

Vulnerability Rank in **MN**, out of **1,338** tracts

Infectious Diseases	93rd	3rd
Disaster-related deaths	41st	1st
Temperature-related deaths	25th	226th

Composition of Climate Impacts

Social & Economic

Social and economic costs and impacts associated with change in climate.

This tract ranks **666** out of **1,338 Tracts** in **Minnesota**

higher vulnerability **60th** national vulnerability percentile

Social Stressors

How climate change could alter crime rates.

77th national vulnerability percentile

Economic & Productivity Losses

How climate change could affect people's ability to work.

61st national vulnerability percentile

Transition Risks

How climate change could threaten farming and energy costs.

38th national vulnerability percentile

Costs of Climate Disasters

How climate change could increase the costs of disaster preparation and recovery.

9th national vulnerability percentile

Extreme Events

Historical and projected extreme weather event occurrences.

This tract ranks **889** out of **1,338 Tracts** in **Minnesota**

average vulnerability **45th** national vulnerability percentile

Temperature

How climate change is impacting the number of severely hot and cold days.

94th national vulnerability percentile

Precipitation

How rainfall and snow could change from the past to 2050.

59th national vulnerability percentile

Wildfires

How often wildfires occurred and how they harmed the air, 2021-2022.

51st national vulnerability percentile

Flooding

How sea level rise and other floods could change from the past by 2050.

44th national vulnerability percentile

Storms

The number of hurricanes, tornadoes and winter storms each year.

44th national vulnerability percentile

Drought

How long and how often droughts occurred, 2021-2022.

1st national vulnerability percentile

Health

Expected changes in community health resulting from warming climate.

This tract ranks **711** out of **1,338 Tracts** in **Minnesota**

lowest vulnerability **18th** national vulnerability percentile

Infectious Diseases

How climate change could change the transmission of disease.

93rd national vulnerability percentile

Disaster-related deaths

How climate disasters could increase deaths in a community.

41st national vulnerability percentile

Temperature-related deaths

How hotter temperatures could increase deaths in a community.

25th national vulnerability percentile

Air pollution-related deaths

How more air pollution could increase deaths in a community.

21st national vulnerability percentile

Air pollution-related illnesses

How more air pollution could harm community health.

1st national vulnerability percentile

Appendix C

Glossary of Climate Adaptation and Vulnerability Terms

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Abbreviations

ADU	Accessory Dwelling Unit
BAU	Business as usual forecast
BEV	Battery electric vehicle
BIPOC	Black, Indigenous, people of color
C&D	Construction and demolition
CAP	Climate Action Plan
CE	Carbon Equivalent
CDP	Carbon Disclosure Project
CFC	Chlorofluorocarbons
CH_4	Methane
CHP	Combined Heat and Power
CO_2	Carbon dioxide
CO_2 e	Carbon dioxide equivalent
CSG	Community Solar Garden
DCFC	Direct Current Fast Charger
DOE	U.S. Department of Energy
EMS	Emergency medical services
EPA	U.S. Environmental Protection Agency
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FEMA	Federal Emergency Management Agency
FTE	Full-time equivalent
GCoM	Global Covenant of Mayors
GDP	Gross Domestic Product
GHG	Greenhouse gas
GWP	Global warming potential
HFC	Hydrofluorocarbons
HVAC	Heating, Ventilation, and Air Conditioning
ICE	Internal Combustion Engine vehicle
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt-hour
LEED	Leadership in Energy and Environmental Design
LEV	Low emission vehicle
LIDAC	Lower Income and Disadvantaged Community
MWH	Megawatt hour – 1,000 Kilowatt-hours
MSW	Municipal Solid Waste
MT	Metric ton equivalent to 1,000 kg (also known as Metric Tonne)
MMT	Million Metric tons
MMBTU	Million British Thermal Units
MT CO_2 e	Metric tons of carbon dioxide equivalent
NGO	Non-Governmental Organization
N_2O	Nitrous Oxide
NO_x	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NZE	Net-Zero Emissions
O_3	Ozone
ODS	Ozone Depleting Substances
PACE	Property Assessed Clean Energy
PFC	Perfluorocarbons
PHEV	Plug-in hybrid electric vehicle
PM2.5	Particulate matter of 2.5 micrometer diameter or less
POC	People of color
PPA	Power Purchase Agreement
PUB	Public Utilities Board
PV	Photovoltaic (solar photovoltaic)
REC	Renewable Energy Credit
RCP	Representative Concentration Pathway
SO_2	Sulfur Dioxide
SF_6	Sulfur Hexafluoride
SULEV	Super ultra-low emission vehicle
t	Ton equivalent to 2,000 lbs (United States)
TOG	Total Organic Gasses
USGS	U.S. Geological Survey
VMT	Vehicle miles traveled
VHT	Vehicle hours traveled
ZEV	Zero emission vehicle
ZNEB	Zero Net Energy Building

A

Accessory Dwelling Unit (ADU)
A secondary dwelling unit associated with a primary single-family home, which can be located within or attached to the main residence, or in a separate accessory building on the same property.

Action
Specific tasks set out to realize the objectives and methods highlighted in a given plan.

Activity Data
Information regarding the scale of human actions that lead to emissions or removals within a specified timeframe. This includes data like energy consumption, metal production, land coverage, management procedures, and usage of lime, fertilizers, and waste generation.

Adaptation
Refer to “Climate Readiness or Resilience”

Adaptive Capacity
The combination of societal, technological, and monetary abilities that individuals or groups possess to initiate and sustain actions against climate change.

Aerosols
Airborne particles, either solid or liquid, typically ranging between 0.01 and 10 micrometers. These particles, which can be of natural or human-made origin, can persist in the atmosphere for extended periods. They can affect climate by directly interfering with radiation or indirectly by influencing cloud properties.

Afforestation
The process of establishing forests on lands that weren't previously forested.

Air Pollutant
Any substance, either originating from human activities or naturally, present in the atmosphere that might have detrimental impacts on humans, fauna, flora, or materials.

Anthropogenic
In relation to greenhouse gas records, "anthropogenic" denotes emissions and removals directly stemming from human actions or from natural processes influenced by human activities.

Atmosphere
The layer of gases encasing the Earth. It mainly consists of nitrogen and oxygen, along with trace gases like argon, helium, and certain greenhouse gases like carbon dioxide and ozone. The atmosphere also encompasses varying amounts of water vapor and contains other components like clouds and aerosol particles.

B

Baseline Emissions
A reference point, either through measurement, calculation, or a specific timeframe, for making comparisons. It represents emission levels in scenarios devoid of policy changes or project implementations. Such evaluations are crucial to gauge the impact of emissions-reducing measures.

Base Year
The initial year used for data gathering. Emission-reducing goals are often set with this year as a reference.

Beneficial Electrification
Beneficial electrification is the process of replacing fossil fuels with electricity to reduce energy costs and greenhouse gas emissions. It can be applied to many sectors, including transportation, residential buildings, and commercial buildings.

Biogenic
Derived from the biological activities of living entities. The term "biogenic" exclusively pertains to recently formed biological materials. The IPCC suggests categorizing peat as fossil carbon due to its lengthy replacement cycle.

Biogeochemical Cycle
The continuous transfer of essential chemicals, crucial for life, within Earth's systems, including carbon, nitrogen, oxygen, and phosphorus.

Biomass
Refers either to (1) the combined weight of all living organisms within a designated area or species, usually represented as dry weight or (2) Organic substances originating from or recently derived from

living beings, excluding peat, and encompasses derived products and waste.

Biomass Waste
Biological, non-fossil substances of biological origin that are either residual or discarded. This definition includes biogenic municipal waste, landfill gas, and other forms of biomass but excludes certain fuels and biofuels. EIA's data on "biomass waste" also count energy crops produced specifically for power generation.

BIPOC
Defined as "Black, Indigenous, and people of color", this U.S.-specific term emphasizes the experiences of Black and Indigenous communities, showcasing or influencing the broader socio-economic dynamics encountered by all non-white individuals.

Black Carbon
A type of aerosol characterized based on its capacity to absorb light, its chemical reactivity, and/or thermal resistance; comprises elements like soot and charcoal.

Blue Carbon
Carbon that's absorbed and retained by coastal ecosystems and wetlands, aiding in countering climate change impacts.

British Thermal Unit (BTU)
A conventional measure of thermal energy, representing the energy needed to elevate the temperature of a pound of water by a single degree Fahrenheit.

Business As Usual Forecast (BAU)
The Intergovernmental Panel on Climate Change (IPCC) describes this as the predicted emission levels if upcoming trends emulate historical ones and no additional policy amendments are enacted. This projection presumes no further emission-curbing actions will be adopted beyond existing or committed measures. BAU forecasts do include anticipated reductions resulting from existing requirements or commitments, such as federal vehicle fuel efficiency standards and electric utility carbon-reduction commitments, which are outside the scope of this plan.

C

Carbon Cycle
The systematic flow and storage of carbon across different reservoirs. This involves four primary carbon storage areas: the atmosphere, the terrestrial environment (including freshwater systems), oceans, and sediments (which encompass fossil fuels). The carbon exchanges between these reservoirs are driven by a mix of chemical, physical, geological, and biological factors. Though the ocean holds a significant amount of near-surface carbon, its exchange with the atmosphere is relatively slow.

Carbon Dioxide (CO_2)
A gas found naturally in the environment, but also produced from burning fossil fuels, biomass, through land-use alterations, and various industrial activities. As the main human-induced greenhouse gas, it impacts the Earth's ability to reflect heat. Other greenhouse gases are often measured relative to CO_2, which has a Global Warming Potential set at 1.

Carbon Dioxide Equivalent (CO_2 e)
A standard for comparing the emissions from different greenhouse gases based on their potential to warm the planet. It's determined by equating the amount of a gas emitted to the amount of CO_2 that would have the same global warming impact.

Carbon Disclosure Project (CDP)
A global initiative allowing organizations and cities to publicly share their environmental impacts, notably related to climate risks. CDP stands as one of the recognized disclosure platforms endorsed by GCoM.

Carbon Emissions
The process of releasing carbon dioxide into the atmosphere, primarily through human activities like burning fossil fuels for energy.

Carbon Equivalent (CE)
A metric for comparing emissions from various greenhouse gases based on their capacity to influence global warming. Carbon equivalents are derived from carbon dioxide equivalents using a specific conversion factor related to molecular weights.

Carbon Free
Activities, systems, or products that don't emit carbon dioxide or other greenhouse gases. Often

associated with sustainable or renewable energy discussions, not every "carbon free" source is renewable. For instance, while both wind and nuclear energy are carbon-free, only wind is renewable.

Carbon Intensity
The ratio of carbon emitted for every unit of energy used. A typical measure of this is the carbon weight per British thermal unit (Btu) of energy. When considering a single fuel type, carbon intensity and the emission coefficient are the same. With multiple fuels, it's an aggregate value.

Carbon Neutral / Carbon Neutrality
Achieving a balance where the amount of CO_2 produced annually is equal to the amount removed or offset, leading to net-zero CO_2 emissions by a specific date. Carbon Neutrality is also sometimes applied to all greenhouse gas emissions. In those instances the term is sometimes used interchangeably with “Net Zero” or “Climate Neutral”

Carbon Offsets
Mechanisms to counterbalance carbon dioxide or other greenhouse gas emissions by funding equivalent reductions elsewhere. They are quantified in metric tonnes of CO_2 -equivalent and can be traded to neutralize emissions from an entity's operations.

Carbon Sinks
Natural environments, such as forests or oceans, recognized for their ability to absorb and store carbon dioxide from the atmosphere.

Carbon Sequestration
The process of capturing and storing CO_2, either in oceans, terrestrial environments like forests and soils, or in geological formations underground.

Chlorofluorocarbons (CFCs)
Gases, regulated under the 1987 Montreal Protocol, used in several applications like refrigeration and air conditioning. Since they don't break down in the lower atmosphere, they reach the upper atmosphere and can deplete ozone. Their usage is being phased out in favor of alternative compounds, some of which are greenhouse gases under the Kyoto Protocol.

Circular Economy
A sustainable economic model that deviates from the traditional linear approach (produce, use, discard) by focusing on reducing resource inputs and waste. It emphasizes durable product design, repair, reuse, and recycling to minimize waste.

Clean Energy
Clean, or “carbon-free,” energy is electricity produced by facilities that do not release greenhouse gases, like carbon dioxide, during the generation process.

Climate
Often described as the "typical weather" of an area, climate is a statistical representation of weather patterns over extended periods, typically 30 years as per World Meteorological Organization (WMO) standards. It encompasses averages and variability of factors like temperature and precipitation. On a broader scale, climate is the comprehensive state of the climate system, including statistics.

Climate Adaptation or Resilience
The ability of ecosystems or communities to anticipate, stand against, respond, and recover from disruptive events. It involves adjusting to changing climate conditions to lessen risks and vulnerabilities.

Climate Action Plan
A comprehensive strategy detailing steps that a municipality, business, or government will take to decrease greenhouse gas emissions and prepare for climate change, fostering sustainable and resilient growth.

Climate Change
Any significant, lasting change in the average or variability of climate conditions over extensive periods. It can stem from natural processes, persistent changes in atmospheric composition due to human activities, or alterations in land use.

Climate Hazard
A climate event or situation that can negatively affect human health, resources, or livelihoods, encompassing sudden shifts in climate systems like heavy rainfall or prolonged droughts.

Climate Migration

The relocation of individuals due to the effects of climate change impacting their way of life or degrading their living conditions. This can result from changing water supplies, altered agricultural yields, or factors like rising sea levels and increased storm intensity.

Climate Model
A mathematical representation used to simulate the key components of climate, including the atmosphere, oceans, land, and ice. These models are used to forecast potential future climate changes.

Climate Neutral / Climate Neutrality
Achieving a balance where the amount of all GHG emissions produced annually is equal to the amount removed or offset, leading to net-zero GHG emissions by a specific date. "Climate Neutral" is sometimes used interchangeably with "Carbon Neutral", however, "Carbon Neutral" often interpreted as addressing CO_2 emissions only, whereas "Climate Neutral" is intended to address all GHG gases.

Climate Scenario
A structured and logical narrative of potential future climatic conditions, built on a set of assumptions about potential future events.

Climate Risk
The potential negative outcomes due to climatic changes, where valuable assets are at risk. The risk is calculated based on the likelihood of certain climate events or changes happening and the potential impact of those changes. It is a product of the system's vulnerability and the climate hazards faced.

Climate Vulnerability
The extent to which a system is at risk from adverse climate changes, including climate variability and extremes. It depends on how exposed the system is to these changes, its inherent sensitivity, and its ability to adapt. Vulnerability can be described as the potential negative impact minus the system's adaptive capacity.

Climate Vulnerability Assessment
An analysis aiming to pinpoint and categorize the threats posed by climate change. It guides the creation of strategies to address these threats and can cover diverse areas like food security, socio-economic factors, and extreme weather patterns.

Co-Benefit
Additional advantages or benefits (e.g., health, economic, societal) that arise indirectly from climate adaptation and mitigation measures.

Co-generation
A facility or system that simultaneously and efficiently produces multiple forms of energy, usually heat and power, in an integrated manner.

Community Choice Aggregation (CCA)
CCA programs, or sometimes known as "Community Power Aggregation", empower local governments to source power for their citizens, businesses, and municipal facilities from alternative providers, while still utilizing the distribution services of their existing utilities. Setting up a CCA generally needs state-level legislation. For more details, one can visit EPA's dedicated CCA website: [EPA's CCA webpage https://www.epa.gov/green-power-markets/community-choice-aggregation]

Combined Heat and Power (CHP)
A system designed to concurrently generate electricity and useful heat, aiming for optimal energy use. Some utilities might sell the heat produced for public use, while certain industries might sell surplus electricity to other businesses or utility companies.

Community Power Aggregation
Refer to "Community Choice Aggregation"

Community Solar / Community Solar Garden (CSG)
Shared solar installations that allow community members to benefit from solar energy without installing panels on individual properties. Participants receive bill credits based on their share of the generated power. Generally, the electricity from community solar farms is priced lower than traditional utility rates.

Complete Streets
A street design concept that ensures streets are made to accommodate all users safely and efficiently, regardless of their mode of transportation or age.

Consistency

Ensuring that an inventory remains uniform in its methodologies and data over time. If the same methods and datasets are consistently applied over years, then the inventory is considered consistent.

Continuous Emission Monitor (CEM)
A monitoring system placed within smokestacks or other emission sources that continuously measures and reports air emissions.

Cool Roof
Roofing materials engineered to reflect more sunlight and absorb less heat, thereby reducing the heat transferred to the building or its surroundings.

Cool Pavement
Pavement materials designed to reflect sunlight and decrease heat absorption, minimizing heat transfer to the nearby environment.

Criteria Air Pollutant
Specific air pollutants for which permissible exposure levels are determined, and corresponding air quality standards are established. Examples include carbon monoxide, ozone, and various particulates. The term arises from the U.S. EPA's obligation to define these pollutants and their impacts on health and the environment. Standards can be reviewed and updated based on new scientific information.

D
Decarbonization
The transition towards reducing carbon emissions by adopting cleaner energy sources, enhancing energy efficiency, or capturing and storing released carbon. The ultimate aim is to minimize the climate impact and move towards a carbon-neutral society.

Deforestation
The conversion of forested areas into non-forest uses. Deforestation is often linked to the amplified greenhouse effect for two main reasons: the combustion or decay of wood releases carbon dioxide, and the removed trees no longer absorb atmospheric carbon dioxide through photosynthesis.

Demand Side Management (DSM)
Initiatives designed to modify consumer energy consumption patterns using methods like education and financial incentives. DSM seeks to reduce energy consumption, particularly during peak demand periods, and shift usage to times when demand is typically lower.

Direct Current Fast Charger (DCFC)
DCFC charging is designed to deliver more power at faster speeds than Level 2 chargers with outputs ranging from 50 kW to 350 kW. They can recharge an EV battery to 80% in anywhere from 15 minutes to 45 minutes, depending on the vehicle's voltage capacity. DCFC is also sometimes known as “Level 3 charging”, or “Rapid Charging”.

Distillate Fuel Oil
A category of petroleum products obtained through standard distillation processes. This encompasses diesel fuels and fuel oils, including types like No. 1, No. 2, and No. 4 diesel fuel. These products are used in various engines, from road vehicles to trains and agricultural equipment. Additionally, No. 1, No. 2, and No. 4 fuel oils are typically employed for heating spaces and generating electricity.

District Heating
A system that distributes heat, generated at a centralized point, via a network of pipes to provide heating for homes and businesses in a specified area or community.

E
Ecosystem Services
The benefits ecosystems offer to human welfare. These benefits range from tangible resources like water and food to services like air purification, flood control, and climate stabilization.

Electric Vehicle (EV)
A vehicle that can be powered by an electric motor that draws electricity from a battery and is capable of being charged from an external source. An EV includes both a vehicle that can only be powered by an electric motor that draws electricity from a battery (all-electric vehicle) and a vehicle that can be powered by an electric motor that draws electricity from a battery and by an internal combustion engine (plug-in hybrid electric vehicle).

Electric Vehicle Supply Equipment (EVSE)
The infrastructure that allows electric vehicles to charge from an electricity source. It's also known as an EV charging station, EV charger, or charging dock. EVSE takes electrical power from the grid and transfers it to the vehicle's battery.

Emissions
The act of discharging certain substances, often gases in the context of climate change, into the environment.

Emission Factor
A value that signifies the amount of a gas emitted or removed per unit of activity. This coefficient is usually derived from a collection of measurement data and provides a representative emission rate for a set of specific conditions.

Emission Inventory
A calculation of the total pollutants released into the atmosphere from various significant sources, measured over a defined period, such as daily or annually.

Emission Rate
The quantity of a specific pollutant released over a set duration, commonly expressed in units like tons per year.

Energy Burden
The fraction of a household's total income spent on energy costs. An "high" energy burden is identified when energy costs comprise 6% or more of the household income, while it's deemed "severe" if above 10%.

Energy Savings / Energy Efficiency
Refers to the sustainable reduction in the amount of energy consumed for the same level of output or performance. For instance, a modern heater that requires less energy to provide the same warmth results in energy efficiency improvements.

Energy Tariff
A pricing structure, or utility tariff, that dictates how consumers are charged by energy providers for their electric or gas consumption. Energy tariffs are subject to government approval and review.

Environmental Justice
The equitable treatment and active participation of all individuals, regardless of their race, ethnicity, income, or origin, in the processes related to environmental laws, policies, and regulations.

Equity
Being just and fair in treatment, acknowledging that people have diverse circumstances and providing them with the necessary resources and opportunities to achieve equal outcomes. In terms of climate change, equity encompasses both shielding from environmental hazards and ensuring access to environmental benefits, irrespective of socio-economic factors.

F

Federal Emergency Management Agency (FEMA)
A federal agency that leads the country's response to disasters, including natural disasters, man-made incidents, and terrorist events.

Fluorocarbons
Molecules made up of carbon and fluorine, which can also include elements like hydrogen, chlorine, or bromine. Some well-known types are chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

Flux
(1) Materials, like limestone and dolomite, used to moderate the heat or energy demands of mineral processing, like metal smelting. They can also function as agents to produce slag. (2) The rate or volume of a liquid or gas moving across a specific area over time, such as the " CO_2 absorption rate by forests".

Fossil Fuel
Deposits of hydrocarbons formed from ancient organic matter, including coal, oil, and natural gas.

Fuel Combustion
The intentional burning of materials in a device designed to provide heat or mechanical energy. This process can be for direct application or use elsewhere.

Fuel Switch (see also “Beneficial Electrification”)

The process of transitioning from one energy source to another, commonly from non-renewable sources like fossil fuels to renewable ones like wind or solar, to reduce both costs and emissions.

Fugitive Emissions
Unintentional leaks of gases from surfaces such as seals or underground pipelines due to deterioration or faults.

G

Geologic Carbon Sequestration
The practice of capturing CO_2, often from sources like coal-powered plants, and injecting it deep underground for storage. With careful site selection and management, this approach has potential in reducing atmospheric CO_2 levels.

GHG
Refer to “Greenhouse Gas”

Global Environmental Change
Significant, accelerated alterations to Earth's natural systems, encompassing climate shifts, biodiversity loss, resource depletion, pollution, and other large-scale environmental disruptions.

Global Warming
The average rise in atmospheric temperature near the Earth's surface and within the troposphere, which can lead to shifts in global climate. This warming can arise from both natural phenomena and human activities. Typically, "global warming" is used to refer to the temperature increase resulting from the enhanced emissions of greenhouse gases due to human actions. See also Climate Change.

Global Warming Potential (GWP)
An index that calculates the radiative effects of greenhouse gases, considering their ability to trap heat compared to carbon dioxide over a specified timeframe. The GWP evaluates the cumulative effect of these gases in the atmosphere based on their longevity and their potential to absorb infrared radiation. The Kyoto Protocol uses GWPs derived from 100-year timespan emissions.

GCoM Global Covenant of Mayors
GCoM represents the world's largest alliance dedicated to urban climate leadership. Comprising over 10,000 city and local governments, GCoM's goal is to encourage and support action on climate and energy at the grassroots level globally.

Green Streets
An urban design approach that incorporates plant life, soil, and engineered structures to manage, slow, and purify stormwater runoff from surfaces that don't absorb water.

Greenhouse Effect
A natural process where specific gases in the atmosphere trap heat near the Earth's surface, leading to a warming effect. If concentrations of these greenhouse gases increase, this effect intensifies, leading to a gradual increase in the Earth's temperature.

Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories
A comprehensive and transparent framework adopted globally for cities and local governments to consistently measure, calculate, and report their greenhouse gas emissions.

Greenhouse Gas
A gas that can absorb and emit infrared radiation, contributing to the greenhouse effect. Some common greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and certain industrial gases like hydrofluorocarbons.

Greenhouse Gas Reduction
Efforts aimed at diminishing the amount of greenhouse gases released into the atmosphere, thereby mitigating potential adverse climate impacts.

Green Infrastructure
Green infrastructure encompasses a diverse array of green spaces and features, both in urban and rural areas, that serve to enhance the well-being of communities and provide environmental advantages. It extends beyond traditional open spaces like parks and playing fields to include a range of measures that use plant or soil systems, permeable pavement and surfaces, stormwater harvest and reuse, or landscaping to manage stormwater and reduce flows to sewer systems or to surface waters. This approach helps counter water pollution in urbanized areas caused by stormwater carrying contaminants.

Green Roof
A roof that incorporates vegetation over a waterproof layer. Green roofs can be categorized as extensive, intensive, or semi-intensive based on the depth of planting medium and amount of maintenance they require. They offer benefits like mitigating the heat island effect, managing stormwater, and enhancing green space in urban areas.

Green Wall
This is a vertical extension of the green roof concept, where vegetation is grown on building exteriors.

Gross Domestic Product (GDP)
The total value of goods and services produced within a country's borders in a specific timeframe, typically a year. It doesn't account for the depreciation of assets or depletion of natural resources.

Groundwater
Water located beneath the Earth's surface, filling the spaces between soils and rocks.

H
Halocarbons
A group of organic compounds composed partially of halogens. They encompass chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), halons, and more. Many halocarbons have significant Global Warming Potentials and some also contribute to ozone layer depletion.

Hazard
The potential for an event, whether natural or human-induced, to cause harm to people, property, infrastructure, or the environment.

Heat Island
An urban area that exhibits higher temperatures than its surrounding rural areas due to human activities. This phenomenon is attributed to factors like heat-absorbing surfaces and structures. See also “Micro Heat Island”.

Heating, Ventilation, and Air Conditioning (HVAC)
Systems that regulate and move heated and cooled air throughout buildings. HVAC systems are used to improve air quality and maintain a comfortable indoor climate.

Hydrocarbons
Compounds made up of only hydrogen and carbon atoms. The term can also refer to petroleum compounds which might contain elements like sulfur, nitrogen, or oxygen. Unsaturated hydrocarbons contain either double or triple carbon-carbon bonds.

Hydrofluorocarbons (HFCs)
Molecules made up of hydrogen, fluorine, and carbon. These were developed as replacements for ozone-depleting substances and are used in a variety of industrial processes. While HFCs don't deplete the ozone layer, they are potent greenhouse gases with varying Global Warming Potentials.

I
ICLEI Local Governments for Sustainability
An association of local governmental entities focused on reducing carbon emissions and fostering sustainable urban growth. ICLEI members, along with a team of specialists, collaborate through capacity building, partnerships, and peer interaction to effect change towards urban sustainability.

Impact
A consequence or effect that arises due to climate change on any system's structure or functioning. Examples include severe heatwaves, sea-level rise, or alterations in rainfall causing floods or droughts.

Indicator
A numerical representation highlighting a specific facet of vulnerability to climate change. For instance, a forecasted alteration in annual average temperature or the count of species at risk.

Internal Combustion Engine Vehicle (ICE)
Vehicles which ignite and combust fuel within an internal combustion engine. Fuels used in ICE vehicles are typically gasoline and diesel.

Intergovernmental Panel on Climate Change (IPCC)
Founded in 1988 by the World Meteorological Organization and the United Nations Environment Programme, the IPCC is tasked with evaluating scientific and technical information related to all aspects of climate change. The IPCC informs

governments about the state of knowledge of climate change by examining all the relevant scientific literature on the subject. The IPCC is scientific entity and is not a legislative body.

K

Kilowatt Hour (kWh)
A unit representing electrical energy consumption, equivalent to using 1,000 watts continuously for an hour.

Kyoto Protocol
A supplement to the United Nations Framework Convention on Climate Change (UNFCCC) ratified in Kyoto, Japan, in 1997. This protocol incorporates legally binding obligations to reduce greenhouse gas emissions. Countries listed in the Protocol's Annex B pledged to reduce their emissions of six major greenhouse gases by at least 5% from 1990 levels between 2008 and 2012. The Protocol became effective on February 16, 2005.

L

Land Use and Land Use Change
Land use pertains to the human activities performed on a certain type of land cover. Meanwhile, land use change denotes alterations in how land is managed or utilized by humans, which can influence land cover. Changes in land cover and land use can affect climate properties such as surface albedo and greenhouse gas sources/sinks, potentially influencing climate on various scales.

Leadership in Energy and Environmental Design (LEED)
LEED is a certification system for evaluating and promoting sustainable building and design practices. Developed by the U.S. Green Building Council (USGBC), LEED provides a framework for environmentally responsible construction, aiming to improve energy efficiency, reduce water usage, and decrease greenhouse gas emissions. Buildings can earn LEED certification at different levels (Certified, Silver, Gold, or Platinum) based on their performance across several criteria, including energy use, indoor environmental quality, and sustainable site development.

Level 1 Charger
An electric vehicle charging device that provides charging through a common residential 120-volt (120V) AC outlet. Level 1 chargers can take 40-50+ hours to charge a BEV to 80 percent from empty and 5-6 hours for a PHEV.

Level 2 Charger
An electric vehicle charging device with a higher AC charging capacity than Level 1 chargers. They typically operate at 240V for residential use or 208V for commercial use. Level 2 chargers can charge a BEV to 80 percent from empty in 4-10 hours and a PHEV in 1-2 hours.

LIDAC Communities
Low Income / Disadvantaged Communities (LIDACs): Communities where residents have low incomes, limited access to resources, and face disproportionate environmental or climate burdens.

Living Streets
"Living streets" amalgamate the principles of green streets and complete streets while emphasizing the enhancement of residents' life quality in urban areas.

LULUCF
An abbreviation for "Land Use, Land Use Change, and Forestry," a category in greenhouse gas inventory documentation.

M

Megawatt Hour (MWH)
An electrical energy unit denoting the consumption of a million watts over an hour.

Methane (CH_4)
A hydrocarbon that acts as a greenhouse gas with a global warming potential estimated to be 28 times stronger than carbon dioxide. Methane arises from several sources, including decomposition in landfills, flooded rice fields, digestion in animals, and fossil fuel production. The GWP value is sourced from the IPCC's Fifth Assessment Report (AR5).

Metric Ton
Equivalent to a Megagram or 1,000 kilograms, a metric ton, sometimes referred to as a metric tonne, is a standard international unit for mass.

Micro Heat Island
Smaller localized zones within urban environments experiencing elevated temperatures in comparison

to surrounding areas. Such hotspots might include asphalt roads, non-green roofs, or barren parking lots. The microclimate and unique built environment conditions heavily influence these micro heat islands. Refer also to "Heat Island".

Million Metric Tons (MMT)
A standard measurement often utilized in greenhouse gas documentations, equivalent to a Teragram (Tg).

Mitigation
Efforts to reduce or curb the extent or speed of long-term climatic warming and its associated effects. Mitigation typically encompasses the reduction of human-induced greenhouse gas emissions.

Mobile Sources
Transportation means that emit pollutants, including cars, motorbikes, trucks, off-road vehicles, boats, and planes.

Mode Share
The proportion of travelers opting for a specific mode of transportation. Mode share serves as a vital metric when shaping sustainable transportation strategies in a city or region, as it highlights the prevalent use of different transport options. This metric showcases the effectiveness of infrastructures, policies, investments, and urban designs in facilitating various transport modes.

Model
A model serves as a numerically-based representation of real-world scenarios, often omitting or simplifying certain details to emphasize core elements.

Municipal Power Aggregation
Refer to “Community Choice Aggregation.”

Municipal Solid Waste (MSW)
Waste originating from homes and certain non-hazardous industrial, institutional, and commercial sources. Typically, this waste is directed to municipal disposal sites.

N

National Oceanic and Atmospheric Administration (NOAA)
A US agency responsible for weather forecasting, monitoring oceanic and atmospheric conditions, charting the seas, conducting deep-sea exploration, and managing fishing and protection of marine mammals and endangered species in the US exclusive economic zone.

Natural Sources
Emission sources that aren't human-induced, including biological, geological sources, wildfires, and dust carried by the wind.

Net Energy Metering (NEM)
Net Energy Metering, commonly referred to as Net Metering, enables residential and business consumers generating their own solar energy to sell their surplus electricity back to the grid. The rate schedule for NEM determines compensation for this electricity. While net metering laws exist in many states, in others, utilities may offer these programs either voluntarily or due to regulatory decisions.

Net Zero Emissions (NZE)
Pertains to a community, business, institution, or building that produces the same amount of energy it consumes through renewable and GHG emission-free sources, resulting in zero net emissions over a year. With a net zero target, only a small portion of residual emissions, no more than 5-10%, should be offset using high-quality carbon removal methods.

Nitrogen Fixation
The process where atmospheric nitrogen gas transforms into forms beneficial for plants and other organisms, achieved through lightning, bacteria, and blue-green algae. This process is integral to the nitrogen cycle.

Nitrogen Oxides (NOx)
Gaseous compounds comprising nitrogen and oxygen. These gases emerge from vehicle exhaust and power generation. As they can form photochemical ozone, impact visibility, and harm health, they're deemed pollutants.

Nitrous Oxide (N_2O)
A potent greenhouse gas with a warming potential 265 times greater than carbon dioxide. Key sources encompass soil management practices, fossil fuel burning, and biomass combustion. Its global

warming potential is derived from the IPCC's Fifth Assessment Report (AR5).

Non-Governmental Organization (NGO)
A group that works independently of governments to improve social conditions. NGOs are often non-profit institutions that are established at the community, national, or international level.

O

Ozone (O_3)
A gaseous compound composed of three oxygen atoms. In the troposphere, ozone forms naturally and through photochemical reactions involving human-produced gases. In the stratosphere, it forms when solar UV radiation interacts with diatomic oxygen. While tropospheric ozone is a greenhouse gas, stratospheric ozone is vital for blocking harmful UV radiation.

Ozone Depleting Substances (ODS)
Compounds causing the depletion of the stratospheric ozone layer. This category includes substances like CFCs, HCFCs, halons, and more. These substances, predominantly stable in the troposphere, degrade in the stratosphere under UV radiation, releasing ozone-depleting chlorine or bromine.

P

Perfluorocarbons (PFCs)
Man-made compounds solely composed of carbon and fluorine. Used as substitutes to ozone-depleting substances and emitted during certain industrial processes. Despite not depleting the ozone, they are formidable greenhouse gases. (IPCC's Fourth Assessment Report (AR4))

Phantom Load
Refers to the power consumed by electronic devices and appliances even when switched off. Devices drawing "phantom loads" constantly utilize electricity.

Photosynthesis
A biological process where plants absorb carbon dioxide to produce carbohydrates, releasing oxygen in the process. The mechanism varies based on different atmospheric carbon dioxide concentrations.

Plug-in hybrid electric vehicle (PHEV)
A type of vehicle that combines features of both gasoline-powered and electric vehicles. PHEVs use batteries to power an electric motor, and another fuel, such as gasoline or diesel, to power an internal combustion engine or other propulsion source. PHEVs can charge their batteries through charging equipment and regenerative braking.

Plug Load
Refers to the energy consumption of devices plugged into electrical outlets. In offices, major plug loads include computers, printers, and copiers. As buildings become more energy efficient, the relative importance of plug loads increases.

POC
An acronym for “people of color” or “person of color”, encompassing all non-white demographic groups. See also “BIPOC.”

Point Sources
Specific locations emitting pollutants into the atmosphere, like industrial smokestacks.

Power Purchase Agreement (PPA)
A contract where one party, the generator, produces electricity, and the other, the buyer, agrees to purchase it. Individual or grouped customers can forge PPAs with energy developers. PPAs enable long-term renewable energy commitments and can serve as direct renewable energy investments.

Property-Assessed Clean Energy (PACE)
A financial structure allowing property owners to fund renewable energy and energy efficiency improvements. Eligible properties include residential, commercial, and industrial sites. Upgrades can be geared toward energy efficiency, renewable energy, and water conservation.

Process Emissions
These are emissions resulting from chemical transformations in industrial processes that are distinct from burning.

R

RCP 8.5
A Representative Concentration Pathway climate model frequently considered the climate model representing “business as usual” forecasts if global

GHG emissions are not reduced and fossil fuels are continued to be used.

Radiative Forcing
A shift in equilibrium between incoming sunlight and outgoing infrared radiation. Ordinarily, the Earth's incoming and outgoing radiations are almost balanced. However, the introduction of greenhouse gases captures more infrared radiation, reflecting it back to Earth's surface, leading to a warming effect.

Reforestation
The act of reintroducing forests on lands that once held forests but were later repurposed.

Regeneration
The process of reestablishing young trees, either naturally or through human intervention, typically preserving the existing forest type after the previous forest has been removed.

Renewable Energy
Energy sourced from naturally renewable elements such as the sun, wind, water, and geothermal heat.

Renewable Energy Credits (RECs)
Certificates representing the benefits and attributes of electricity generated from renewable sources. Each REC represents one megawatt-hour (MWh) of renewable electricity dispatched to the grid. The largest reduction in Evanston's emissions is attributed to REC purchases.

Representative Concentration Pathway (RCP)
climate change scenarios to project future greenhouse gas concentrations. These pathways describe future greenhouse gas concentrations and have been formally adopted by the IPCC. There are a range of RCP climate models from RCP 2.6 to RCP 8.5 reflecting a range of potential human-made GHG emission scenarios. The numbers represent the expected change in radiative forcing through the end of the 21st century.

Residence Time
The typical duration a single atom or molecule remains in a particular storage area. In the context of greenhouse gases, it generally refers to the duration a molecule lingers in the atmosphere.

Resilience / Resiliency
The capacity to foresee, ready for, counteract, and promptly bounce back from climate-induced threats, ensuring minimal damage to society, economy, and natural settings.

Resilience Hub
A resilience hub is a community-serving facility that supports residents and communities before, during, and after emergencies. Resilience hubs can also provide resources to support communities in reducing greenhouse gas emissions.

Reservoir
Either (1) a part of the climate system where a greenhouse gas or its precursor is housed; or (2) human-manipulated water bodies where significant variations in water area might occur due to water regulation.

Respiration
A biological process where living entities transform organic substances into carbon dioxide, using up oxygen and releasing energy in the process.

Retro-commissioning
A comprehensive approach to enhance a building's operational efficiency by ensuring its control systems operate optimally and align with the building's intended and actual usage.

Ride-share
A system where individuals share transport means, usually through carpooling or joining a vanpool. Typically facilitated by a platform connecting drivers with potential riders.

S

Scope 1
Refers to emissions discharged directly within the city's boundaries due to fossil fuel combustion and the decomposition of waste in landfills and wastewater facilities.

Scope 2
Refers to emissions generated outside the city resulting from the city's consumption of electricity.

Scope 3
Pertains to emissions linked to local government functions that can be quantified and disclosed but

don't fall under Scope 1 or 2. Examples include outsourced activities and commuting of employees.

Short Ton
A standard ton measurement in the U.S., equivalent to 2,000 lbs or about 0.907 metric tons.

Sink
Any activity, process, or mechanism responsible for removing a greenhouse gas, aerosol, or their precursor from the atmosphere.

Social Cost of Carbon
An estimation of the economic damage due to climate change effects, calculated as the monetary value of total damages arising from emitting a single ton of carbon dioxide.

Solar Radiation
The sun's emitted electromagnetic waves. This radiation, also known as shortwave radiation, has wavelengths mainly in the visible spectrum due to the Sun's temperature.

Solar Photovoltaic (PV)
A system that directly transforms sunlight into electricity using semiconductors, primarily silicon. Suitable for homes, businesses, and large-scale operations, solar PV systems can be roof-mounted, ground-based, or integrated into building structures to produce renewable energy.

Source
Any process or activity that introduces greenhouse gases, aerosols, or their precursors into the atmosphere.

Stationary Sources
Fixed locations like power stations, manufacturing plants, and refineries that emit pollutants into the air.

Strategy / Strategic Goal
Detailed directions built upon the foundation of the sustainability vision and GHG reduction objectives that guide future policy decisions, community investments, and initiatives.

Sulfur Dioxide (SO_2)
A molecule made of one sulfur atom and two oxygen atoms. Released both naturally and by human activity, it can transform into sulfate aerosols in the atmosphere. These aerosols can cool the Earth's surface, contribute to acid rain, and decrease visibility.

Sulfur Hexafluoride (SF_6)
A colorless gas that mixes well with alcohol and ether but less so with water. It's an extremely potent greenhouse gas, with a global warming potential much higher than carbon dioxide (CO_2). SF6 is predominantly used in electricity transmission and as an insulator in electronics. Its global warming potential is derived from the IPCC's Fourth Assessment Report (AR4). It is a potent greenhouse gas with a warming potential 23,500 times greater than carbon dioxide.

T
Terrestrial Carbon Sequestration
The process where trees, plants, and crops absorb carbon dioxide (CO_2) from the atmosphere through photosynthesis and store it as carbon in biomass (like tree stems, branches, and roots) and soil. This stored carbon creates "sinks" which counteract emissions when the absorbed carbon is greater than the released carbon over time.

Therm
A unit of energy equivalent to 100,000 British Thermal Units, roughly akin to the energy in 100 cubic feet of natural gas. Commonly used to gauge natural gas consumption for billing.

Total Organic Gases (TOG)
Organic gases that encompass both reactive and relatively non-reactive compounds, such as methane.

Transparency
Clear presentation of methodologies and assumptions used in an inventory so users can easily replicate and evaluate the inventory. Transparency is crucial for effective communication and consideration of information.

Tree Bank
A designated location, such as a school or public park, where property owners or developers may donate and plant a portion of zoning ordinance-required trees if planting them within their own project site is not practical.

Trend
A measure of a quantity's change over time. A positive trend signifies growth, while a negative one indicates a decline. It's expressed in percentage or fractional terms concerning the quantity's initial value.

U
Urban Tree Canopy
The composition and traits of trees in urban settings.

U.S. Department of Energy (DOE)
A federal agency that oversees the nation's nuclear infrastructure, energy policy, and funds scientific research in the field.

U.S. Environmental Protection Agency (EPA)
A federal agency tasked with safeguarding human health and the environment. It offers technical support for recovery planning, long-term cleanup, and environmental surveillance. This includes assistance with public health infrastructure, such as wastewater treatment plants, and addressing threats through monitoring, assessment, and decontamination efforts.

V
Vehicle Miles Traveled (VMT)
Represents the distance traveled by vehicles, be it cars, trucks, or motorcycles. Each mile is counted as one vehicle mile, irrespective of the number of passengers.

Vision Zero
A strategy focused on eliminating severe injuries and fatalities from traffic accidents, aiming to provide safe and equal mobility for all individuals.

Vulnerability
The extent to which a system is exposed to, sensitive to, or unable to handle the adverse impacts of climate change. This encompasses:

- Exposure: The presence of assets or organisms in areas potentially adversely impacted by climate change.
- Sensitivity: The level at which assets or organisms are impacted by climate change.
- Adaptive capacity: The capability of systems, assets, or organisms to adjust to detrimental impacts.

W
Water Vapor
The predominant greenhouse gas present in the form of water in its gaseous state in the atmosphere. Water vapor is a natural part of the greenhouse effect. Its concentration is not significantly altered by human activities, but it amplifies the greenhouse effect due to positive feedback mechanisms. Water vapor also plays a vital role in climate regulation by forming clouds and precipitation.

Weather
Weather represents the immediate atmospheric conditions at a specific time and place, while climate refers to the long-term average of these conditions in a particular region over an extended period. In simpler terms, weather is what you experience outdoors on any given day, while climate describes the typical weather patterns you'd anticipate for a particular season and location.

Z
Zero Emission Vehicles (ZEV)
A vehicle that doesn't release harmful pollutants during its operation. Examples include electric cars, hydrogen-fueled vehicles, and bicycles. These emissions, when released, can have detrimental effects on both the environment and human health.

Zero Net Energy Building (ZNEB)
Also known as a Net-Zero Energy Building is one that is optimally efficient, and over the course of a year, generates renewable energy onsite equal to or greater than the total amount of energy consumed onsite.

Zero Waste
An approach focusing on the efficient utilization of resources through responsible production, consumption, and recovery. This means products, packaging, and materials are reused and recycled without causing harm to the environment or health, and without resorting to incineration or releases to land, water, or air.

Appendix D

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City of Plymouth
Climate Vulnerability Assessment
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paleBLUEdot LLC

City of Plymouth

Community Greenhouse Gas Emissions Inventory

November 2025

Prepared by:

making change personal
paleBLUEdot LLC

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Without data, you're just another person with an opinion.

W. Edwards Deming, Engineer, Professor, and Management Consultant

Introduction

Background

Protecting the environment is a longtime priority for Plymouth. The City has preserved natural areas through open-space protection, urban forestry, and water stewardship, and is now expanding efforts to cut emissions, waste, and energy use.

In July 2025, Plymouth received an MPCA Climate Planning Grant and partnered with paleBLUEdot to develop baseline assessments for its Climate Action and Resilience Plan (CARP). The CARP will guide equitable climate action and community resilience. This Greenhouse Gas Inventory is one of the baseline documents supporting that planning process.

The Value of Greenhouse Gas Inventories

The goal of the City of Plymouth Greenhouse Gas (GHG) Emissions Inventory is to estimate the GHG emissions associated with the activities of the people who live, work, learn, travel, visit, and recreate within the City's geographical boundaries during the subject years of 2016, 2020, and 2024.

Measuring the energy aspects of human activities and the associated GHG emissions offers a unique way to compare the effectiveness of various energy and Environmental Stewardship best management practices. Greenhouse gas emissions and energy serve as common denominators for the comparison of kilowatts of electricity, natural gas therms, tons of coal, and gallons of liquid fuels consumed; as well as vehicle miles traveled and tons of waste processed.[1] In short, maintaining and updating citywide GHG emissions inventories for the City can effectively track progress in the implementation of the City's Climate Action and Resilience Plan and help to identify priorities for future implementation focus.

[1] Energy is expressed as kBtu (a thousand British thermal units) or MMBtu (a million Btus).

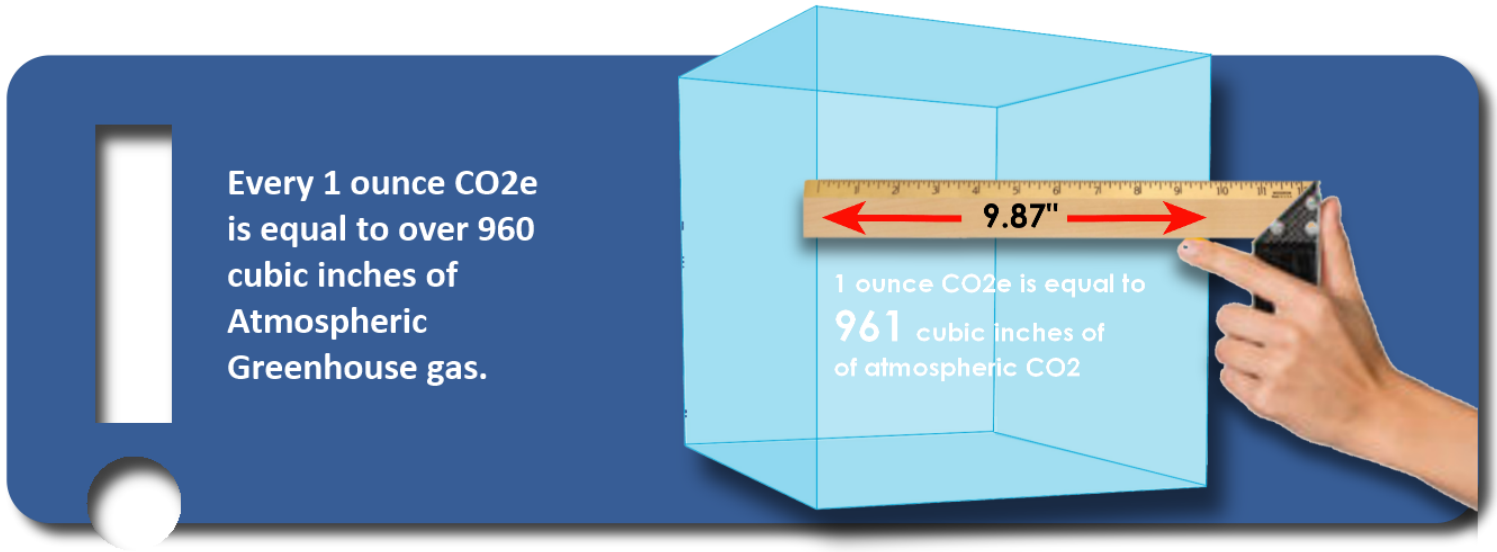
Introduction

The Carbon Cycle and the Role of Greenhouse Gases

The Carbon Cycle is exchanged among the oceans, atmosphere, and ecosystem. This cycle has been a closed, balanced system for hundreds of thousands of years. This cycle is present in the atmosphere primarily as carbon dioxide and methane. These two primary greenhouse gases uniquely allow light to pass while capturing infrared energy. This "Greenhouse Effect" directly impacts Earth's atmospheric energy and temperatures – without the historic levels of greenhouse gases present in the atmosphere, the average surface temperature of the Earth would be 0 degrees Fahrenheit.

Graphic Representations

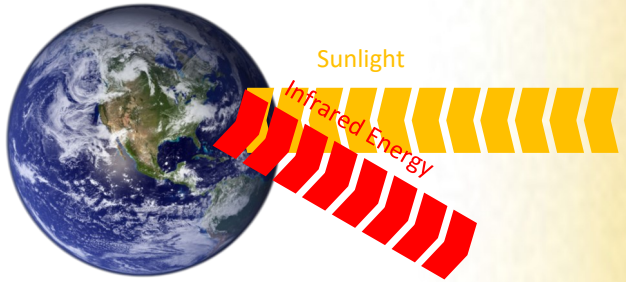
Greenhouse Gas Inventories quantify gas emissions in terms of weight - typically Metric Tons. It is important to understand that these references to Metric Tons refer to gaseous pollution emissions which enter and occupy Earth's atmosphere. To help facilitate an increased awareness of the order of magnitude our collective GHG emissions represent, some of the emissions data reported in this report are also graphically represented in terms of volume of atmosphere. These volumes illustrate the amount of atmospheric space the referenced greenhouse gas emissions will occupy where they will remain, actively impacting our climate for as long as 200 years.



Introduction

Earth's Infrared Energy

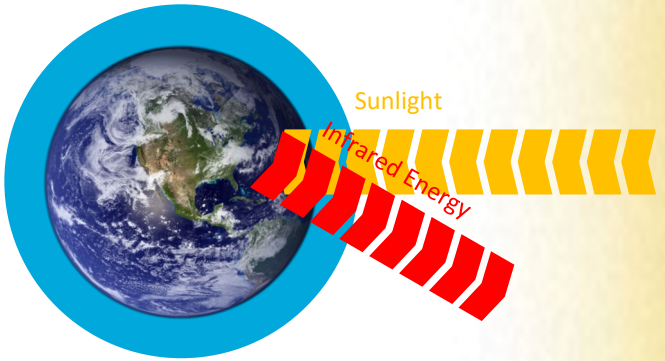
When sunlight strikes the Earth, it warms the surface and becomes heat energy – or infrared energy. This infrared energy then radiates back towards space.



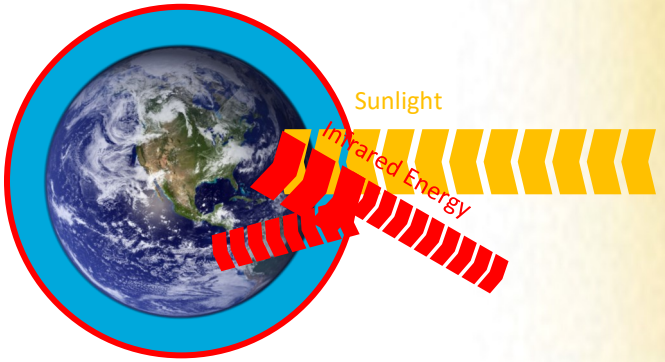
The Greenhouse Effect

Our atmosphere is made up of both Non-Greenhouse and Greenhouse Gases gasses.

Non-Greenhouse Gases do not react to visible light, nor infrared energy. That means both sunlight and infrared energy pass through them unaffected, allowing Earth's heat energy to radiate into space.



Greenhouse Gases also do not react to visible light, however, they DO react to infrared energy, trapping and reflecting Earth's heat energy back, warming the planet. This is known as the Greenhouse Effect.



Introduction

What is a Greenhouse Gas Inventory?

A community Greenhouse Gas (GHG) Inventory follows a standard protocol to quantify a city's emissions, including CO2, CH4, N2O. GHG inventories fluctuate year-to-year as we change our energy consumption, get access to better data, or gain new knowledge about how GHGs impact the atmosphere.

What Are GHG's?

Greenhouse Gases (GHG) absorb radiation and trap heat in the Earth's atmosphere. They are the basis of the Greenhouse Effect. The more GHGs there are, the more heat that is trapped in our atmosphere, leading to Global Warming and Climate Change. GHGs measured in this inventory include carbon dioxide, methane, and nitrous oxide.

Why Measure GHG?

As described by David Osborne and Ted Gaebler "If you don't measure results, you can't tell success from failure. If you can't see success, you can't reward it. If you can't see failure, you can't correct it." GHG inventories are useful. Planners need them, elected officials want them, and the future may see their development as a basic requirement of state and federal funding.

What is CO2e?

Carbon Dioxide (CO2) is a GHG emitted naturally and from fossil fuel combustion for energy and heat. Global warming contributions from other greenhouse gases are referred to in terms of "carbon dioxide equivalent" or CO2e, which represents the amount of CO2 that would have the same global warming potential as other GHGs. Community GHG inventories are tracked in terms of metric tons of CO2e.

Methodology, Sources, and Terminology

This GHG inventory follows the Greenhouse Gas Protocol standards for businesses and communities set by GHG Protocol (www.ghgprotocol.org/) and aligns with ICLEI Local Governments for Sustainability guidelines. Our report's terms match global Carbon Footprinting standards. Emissions shown here, unless specified, are in CO2e: Carbon Dioxide Equivalent, which equates the impact of all greenhouse gases, like methane (CH4), nitrous oxide (N2O), and CFCs, to CO2.

Generally, GHG inventories estimate emissions in sectors by multiplying consumption data, like electricity used, with an emissions factor. This factor reveals the greenhouse gases released per consumption unit. The chart to the right shows the data sources used in the GHG calculations.

GHG Emission Sector	Project Resource
Electricity (Residential, Commercial, and Industrial)	Data Source: Xcel Energy, Wright-Hennepin Cooperative Electric Association
	Emissions Factors: Same as above or US EPA eGrid if unavailable from Utility
Stationary Combustion (Residential, Commercial, and Industrial)	Data Source: Centerpoint Energy
	Emissions Factors: US EPA Emission Factor Hub
Mobile Combustion - On Road	Data Source: State of Minnesota DOT
	Emissions Factors: US EPA Emission Factor Hub
Solid Waste	Data Source: Hennepin County, State of Minnesota
	Emissions Factors: EPA Waste Reduction Model (WARM), Organic Chapters, EPA FLIGHT tool
Wastewater	Data Source: US EPA Local GHG Inventory Tool
	Emissions Factors: Above emission factors for electricity and natural gas consumption, US EPA Local GHG Inventory Tool.
Water	Energy consumption included in Electricity and Stationary Combustion sectors above

Greenhouse Gas Sectors

Where do GHGs come from?

Energy (electricity + stationary combustion)

Emissions are produced from the combustion of natural gas, coal, and other fossil fuels primarily for heating, cooling, and electricity generation.

Mobile Combustion

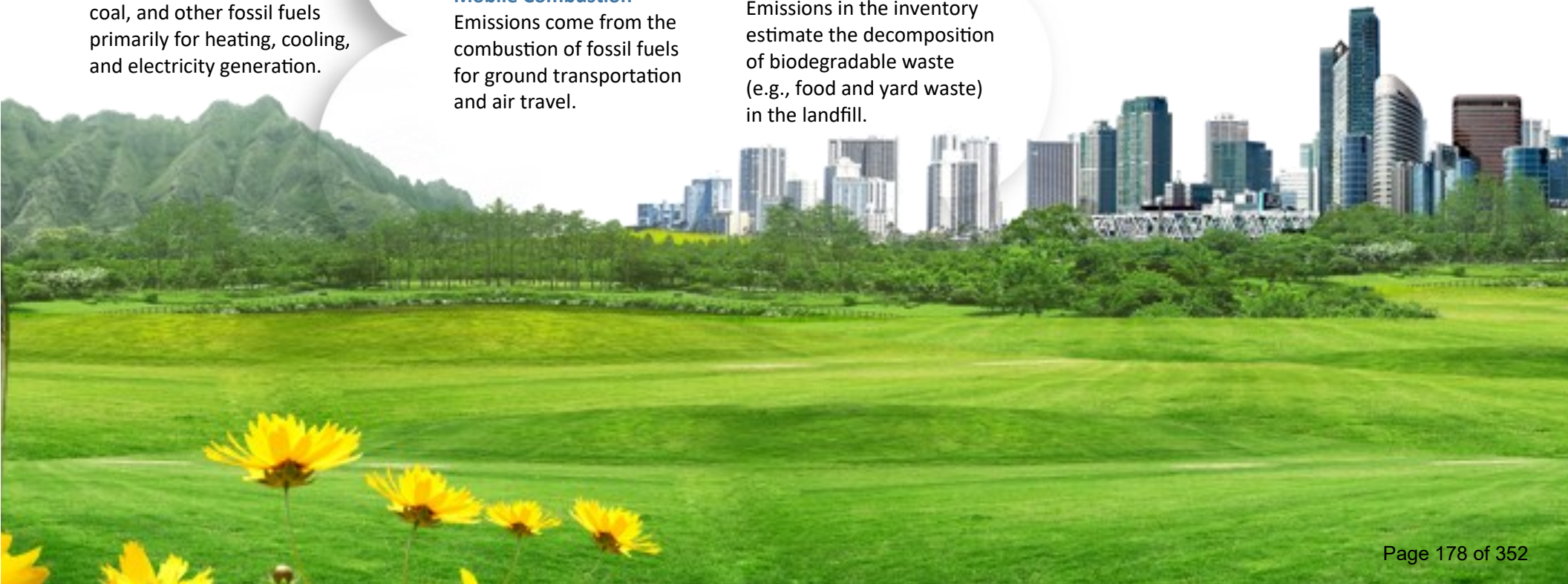
Emissions come from the combustion of fossil fuels for ground transportation and air travel.

Solid Waste

Emissions in the inventory estimate the decomposition of biodegradable waste (e.g., food and yard waste) in the landfill.

Wastewater

Emissions from energy uses are calculated for the collection and treatment of wastewater.



Section 02

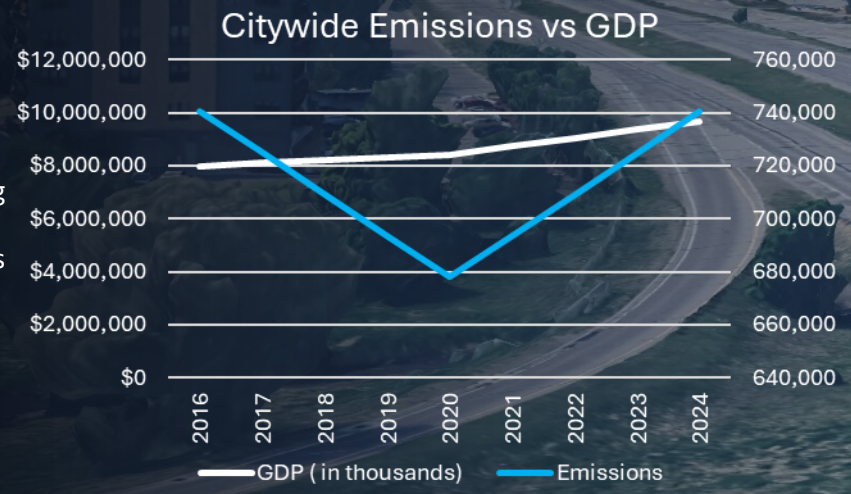
Findings In Brief

Click here to return to TOC

	2016 By The Numbers	2024 By The Numbers	8 Year Trend
GHG Emissions	816,838	794,946	-21,892 -2.68%
	10.88 MT Per-Capita	10.00 MT Per-Capita	-0.88 MT Per-Capita
	14.87 MT / Job	14.86 MT / Job	-0.01 MT/ Job
	0.1022 MT / $1,000 GDP	0.0821 MT / $1,000 GDP	-0.02 MT / $1,000 GDP
Population	75,105	79,526	+4,421 +5.89%
GDP	$7,992,181,077	$9,676,889,096	+$1,684,708,0+21.08%
	$106,413 GDP Per-Capita	$121,682 GDP Per-Capita	+$15,269 GDP Per-Capita
Employment	54,935	53,494	-1,441 -2.62%

City of Plymouth GHG Emissions Overview

Emissions in the City of Plymouth dropped 2.7% from 816,838 metric tons in 2016 to 794,946 in 2024. During this time, the population grew 5.9%, leading to a 8.1% decrease in emissions per person. Meanwhile GDP grew 21.1%, clearly indicating economic growth can happen in the City of Plymouth while GHG emissions decrease.



How Large Are Community wide GHG Emissions?

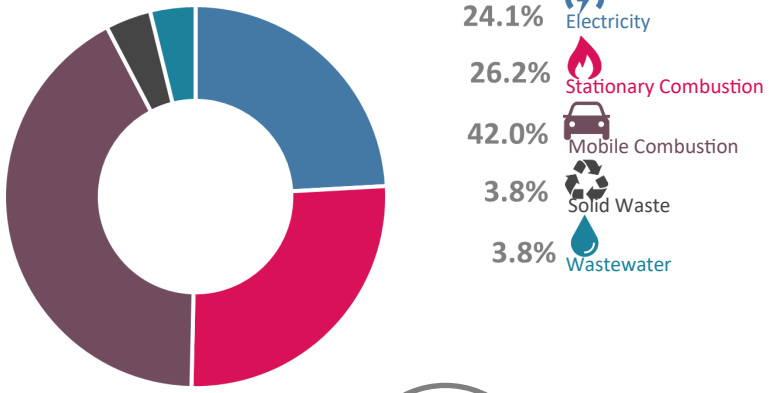
The City's total emissions for 2024 are equal to **15.6 Billion** cubic feet of human-made greenhouse gas. This volume of atmosphere is equal to a cube **2,499** feet on each face shown here west of Highway 55 and Plymouth Boulevard as viewed from Highway 55 and US 169 over **3.5 miles away**.

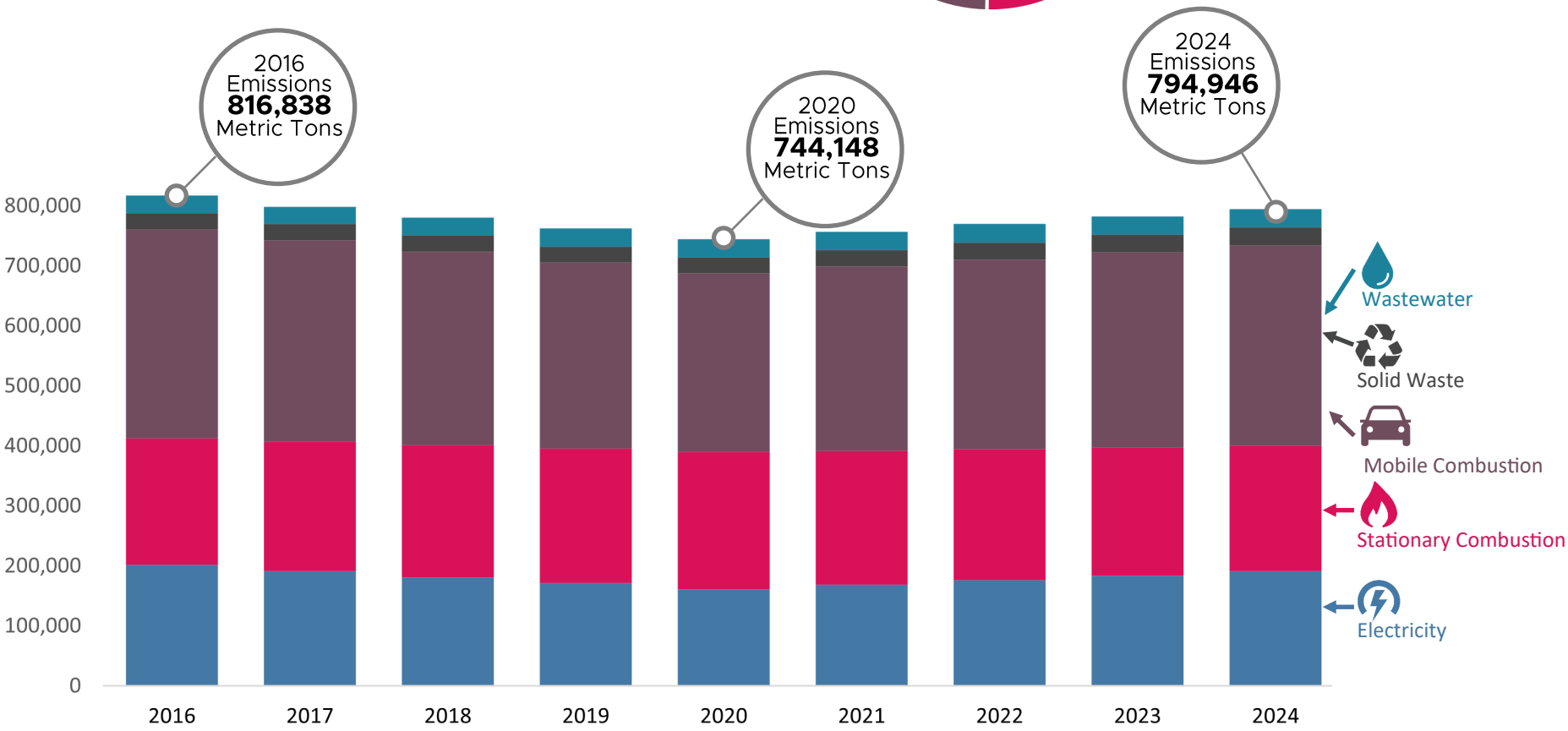
Findings in Brief: Citywide

Citywide Annual GHG Emissions

Total GHG emissions in the City of Plymouth dropped 8.9% between 2016 and 2020. Since 2020, emissions increased 6.8%, resulting in a total of 794,946 metric tons in 2024. The mobile combustion (transportation) sector makes up the largest share of total emissions at 42.0% followed by stationary combustion (building natural gas use) at 26.2%. Electricity made up 24.1% of citywide emissions. Finally, solid waste and wastewater made up 3.8% of total emissions each in 2024. Trends by sector are detailed on the following page.

Citywide GHG by Sector

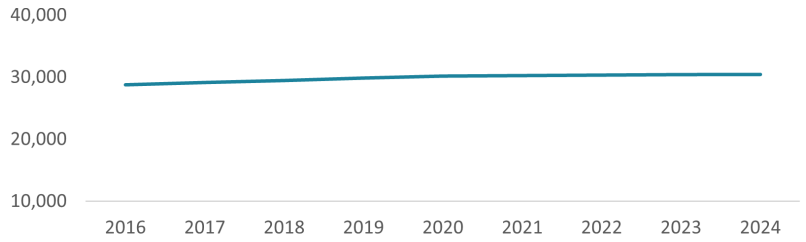


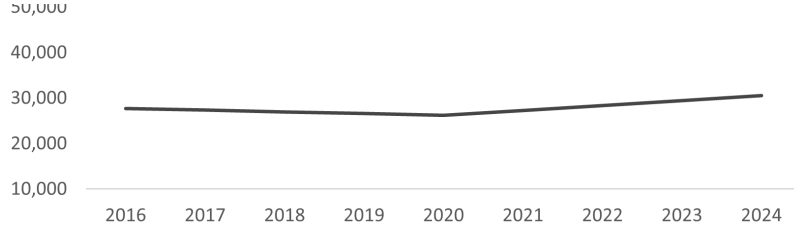


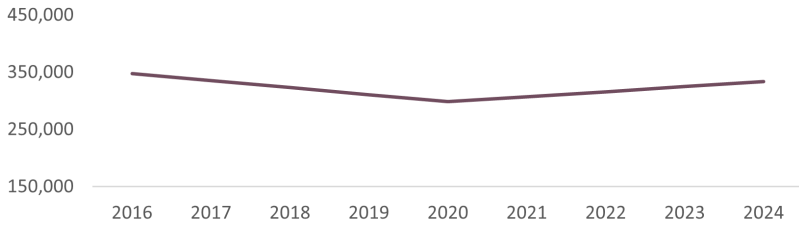
Citywide Sector GHG Trend Lines

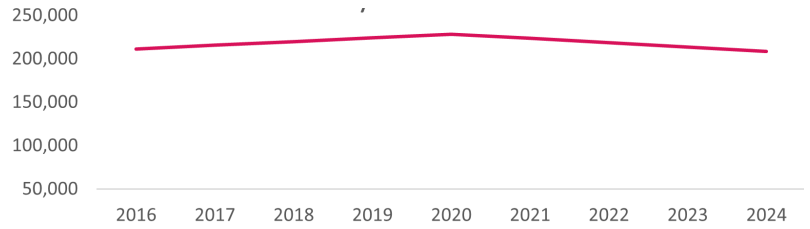
Findings in Brief: Citywide

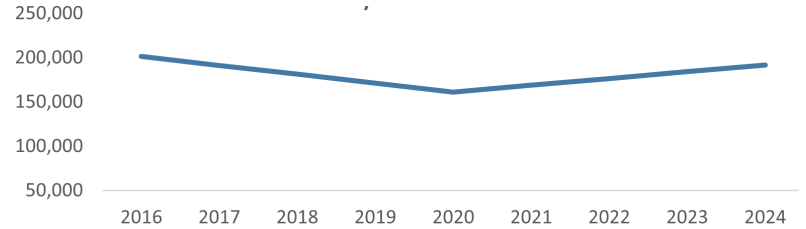
	2016	2024	Change	
Wastewater	28,769 Metric Tons	30,462 Metric Tons	+5.9%	✗
Solid Waste	27,722 Metric Tons	30,556 Metric Tons	+10.2%	✗
Mobile Combustion	347,747 Metric Tons	333,733 Metric Tons	-4.0%	✓
Stationary	211,294 Metric Tons	208,501 Metric Tons	-1.3%	✓
Electricity	201,337 Metric Tons	191,695 Metric Tons	-4.8%	✓











Findings in Brief: Citywide

Consumption Trends - Energy

Residential Electricity

As outlined to the right, the city's ***total*** residential electric consumption has increased 61.6% since 2016, however, due to population increases electricity consumption increased slightly less at 52.1% on a ***per-household basis***.

Residential Stationary Combustion (Heating)

Over the same timeframe, ***total*** residential heating fuel use increased 2.3%. When population increases are considered, heating fuel consumption decreased 3.5% on a ***per-household basis***.

Non-Residential Electricity

The city's ***total*** non-residential electric consumption has increased 60.1% since 2016. When compared to citywide employment trends, the increase in electricity consumption is somewhat more at 64.4% increase on a ***per job basis***.

Non-Residential Stationary Combustion (Heating)

Over the same timeframe, ***total*** non-residential heating fuel use decreased 5.9%. Again, when compared to citywide employment trends, the change in heating fuel consumption is slightly less at a 3.4% decrease on a ***per job basis***.

2024 Energy Consumption

		Change since 2016
Electricity Residential (MWh)	**267,025**	61.6%
Electricity Non-Residential (MWh)	**487,435**	60.1%
Stationary Combustion Residential (MMBtu)	**2,287,067**	2.3%
Stationary Combustion Non-Residential (MMBtu)	**1,646,909**	-5.9%

MWh = megawatt hours; MMBtu = million British thermal units

Per Capita Energy Consumption

		Change since 2016
Electricity Residential (MWh / household)	**8.24**	52.5%
Electricity Non-Residential (MWh / job)	**9.11**	64.4%
Stationary Combustion Residential (MMBtu / household)	**70.53**	-3.5%
Stationary Combustion Non-Residential (MMBtu / job)	**30.79**	-3.4%

MWh = megawatt hours; MMBtu = million British thermal units

2024 On-Road Transportation

		Change since 2016
Vehicle Miles Driven (miles in millions)	**704**	0.9%
Vehicle Miles Driven Per Person (miles / year)	**8,852**	-4.7%
Vehicle Miles Driven Per Household (miles / year)	**21,712**	-4.8%
Vehicles Per Household	**1.84**	-0.3%
Total Vehicles	**59,732**	5.7%
Electric Vehicles*	**1,709**	1062.6%
Share of Vehicles That are Electric*	**2.9%**	1000.3%
Public EV Charging Stations (Level 2)	**29**	N/A
Public EV Charging Stations (DC Fast Charger)	**10**	N/A

* includes full electric vehicles only

2024 Solid Waste Generation

		% of total	Change since 2016
Residential Solid Waste Handled (tons)	**38,443**		23.8%
Solid Waste Per Household (lbs / year)	2,371		16.9%
Solid Waste Per Person (lbs / year)	967		17.0%
Non-Residential Solid Waste Handled (tons)	**45,128**		23.8%
Solid Waste Per Job (lbs / year)	1,687		24.8%
Total Solid Waste Handled	**83,571**	**100.0%**	23.8%
Recycling (tons)	**23,515**	**28.1%**	38.7%
Organics / Yard Waste / Trees (tons)	**12,008**	**14.4%**	41.0%
MSW diverted as waste-to-energy (tons)	**23,983**	**28.7%**	-10.1%
Solid waste sent to landfill (tons)	**24,066**	**28.8%**	56.9%
Diversion rate*		**71.2%**	-7.8%

* diversion rate = solid waste kept from landfills through recycling or reuse

Consumption Trends - Transportation

Citywide vehicle miles traveled (VMT) increased 0.9% between 2016 and 2024. However, it should be noted that pre-COVID pandemic VMT trends were increasing at a much higher rate of 18.9% between 2016 and 2019. Based on community population increases, VMT decreased 4.8% on a ***per-household basis***.

Total vehicle count in the city has increased 5.7% since 2016, with vehicles per household decreasing slightly by 0.3%. The share of vehicles in the community which are electric is increasing and, as of 2024, 2.9% are electric vehicles (EV).

Consumption Trends - Solid Waste

The city's ***total*** solid waste handled increased 23.8% since 2016. When population increases are considered, total solid waste increases were less at 17% on a ***per capita basis***.

The share of total solid waste sent to the landfill increased from 22.7% of total solid waste collected in 2016 to 28.8% in 2024. Total tonnage of solid waste sent to the landfill decreased 56.7% for the timeframe.

Recycling diversion decreased from 25.1% of total solid waste collected in 2016 to 28.1% in 2024. Meanwhile, organics / yard waste diversion increased from 12.6% of total solid waste collected in 2016 to 14.4% in 2024.

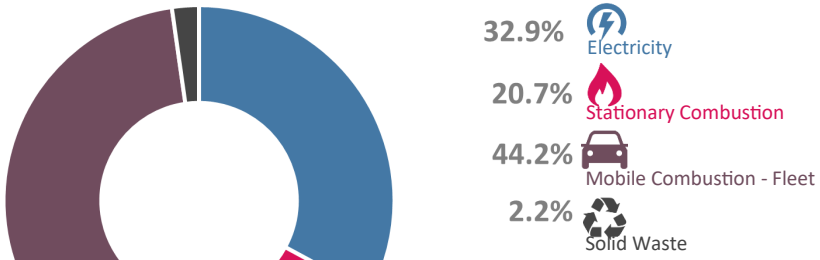
Findings in Brief: City Operations

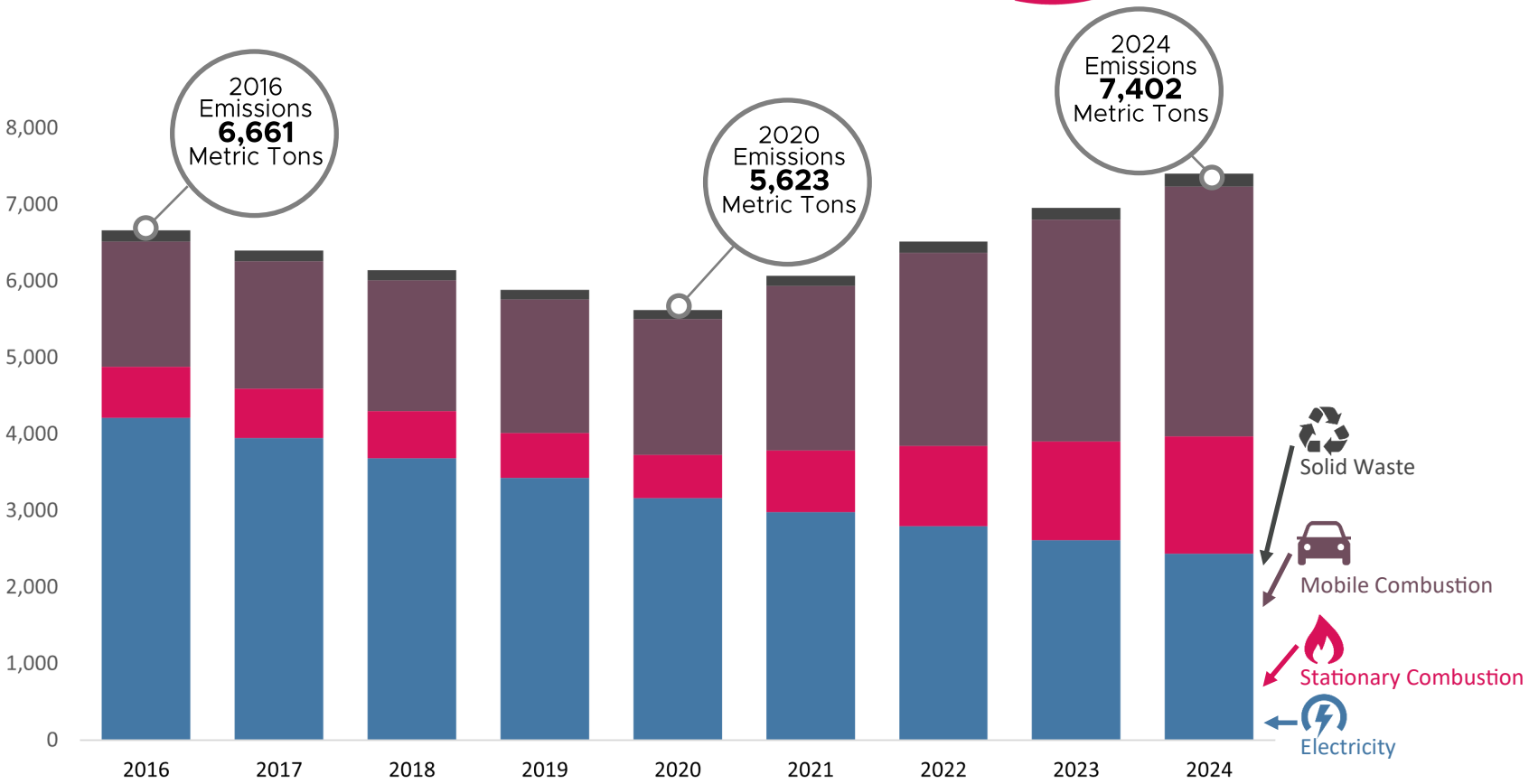
City Operations Annual GHG Emissions

Total GHG emissions for City of Plymouth operations increased from 6,661 metric tons in 2016 to 7,402 metric tons in 2024, a total increase of 11.1%. City buildings (electricity and stationary combustion) makes up 53.6% of total emissions, while mobile combustion makes up 44.2% and solid waste is estimated at 2.2%. Trends by sector are detailed on the following page.

(Note: city operations emissions are included in the previous Citywide emissions)

City Operations GHG by Sector

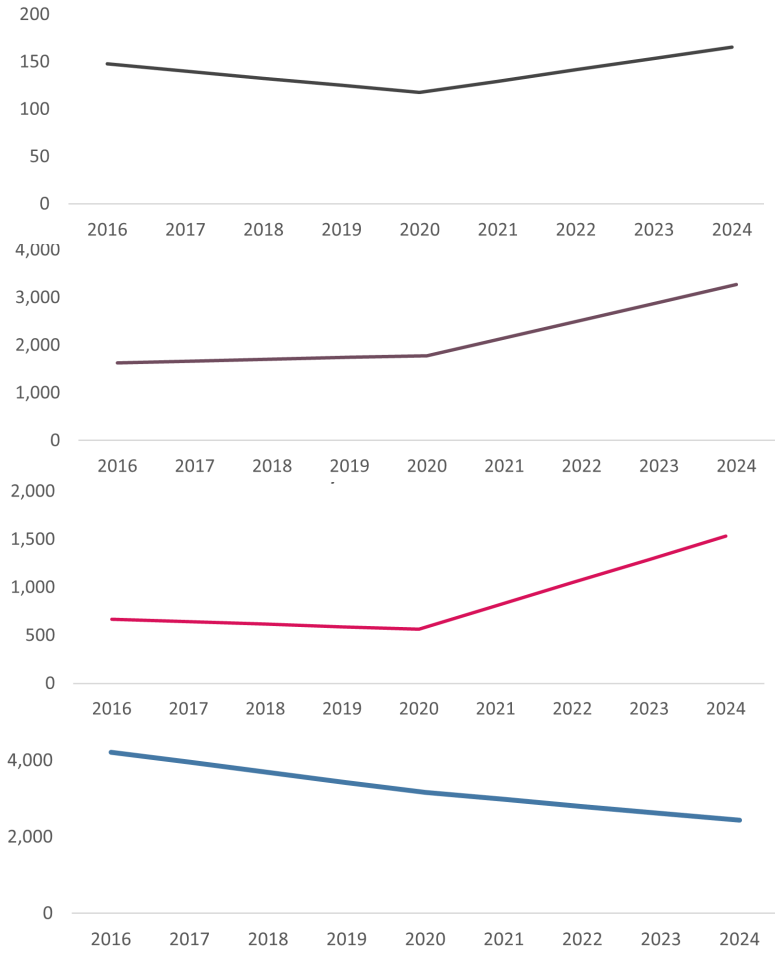




City Operations Sector GHG Trend Lines

Findings in Brief: City Operations

	2016	2024	Change	
Solid Waste	148 Metric Tons	165 Metric Tons	+11.9%	✗
Mobile Combustion	1,631 Metric Tons	3,271 Metric Tons	+100.5%	✗
Stationary Combustion	670 Metric Tons	1,532 Metric Tons	+128.7%	✗
Electricity	4,212 Metric Tons	2,434 Metric Tons	-42.2%	✓



Section

03

Per Capita GHG Comparison

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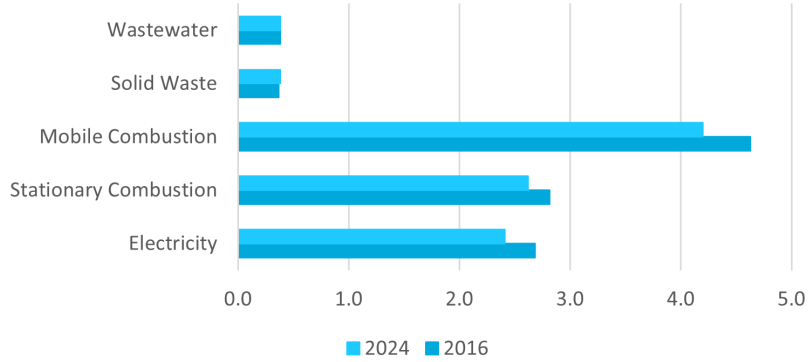
Per Capita GHG Comparison

The results of community GHG inventories vary somewhat due to the information collected and variations in inventory methodology. We believe, however, that as an emerging practice, municipalities should look towards building and sharing data in order to develop a stronger understanding of where each municipality can advance efficiencies and meet Greenhouse Gas reduction goals. In support of this goal, comparing total community emissions between communities can be effectively done by looking at per capita emissions.

Understanding City of Plymouth's Per Capita GHG Emissions

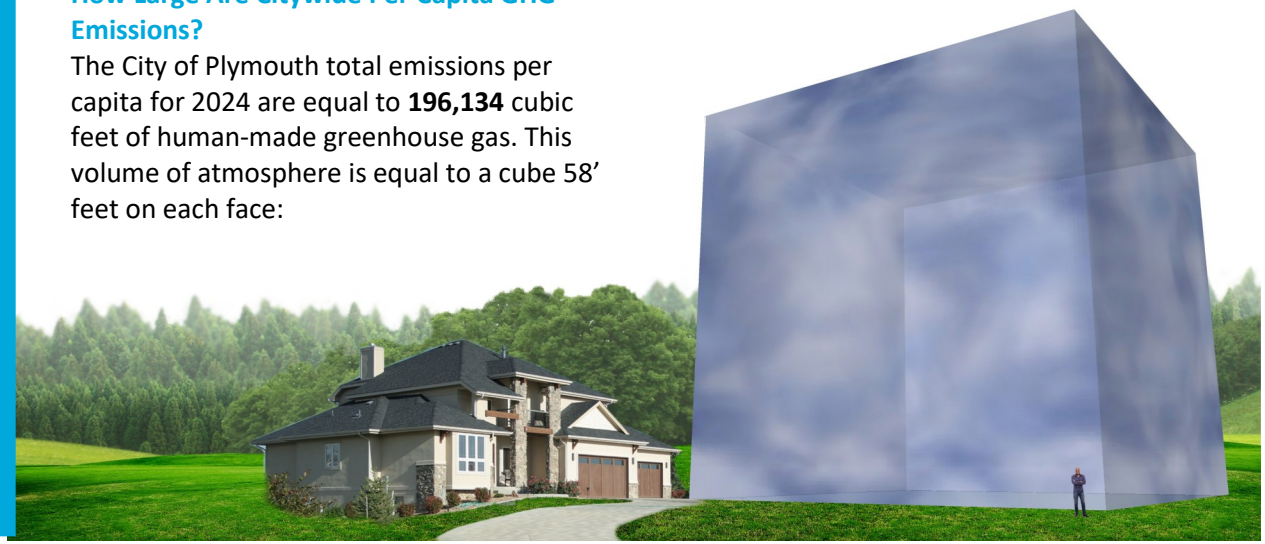
2016 per capita emissions for the City were 10.9 metric tons. The 2024 citywide emissions for the City of Plymouth totaled 794,946 metric tons for a per capita GHG emissions average of 10 metric tons (MT). This represents an 8.1% reduction in per capita emissions for the community. The chart to the right indicates the breakdown by sector.

Per Capita GHG Emissions 2016 vs 2024 (MTCO2e)



How Large Are Citywide Per Capita GHG Emissions?

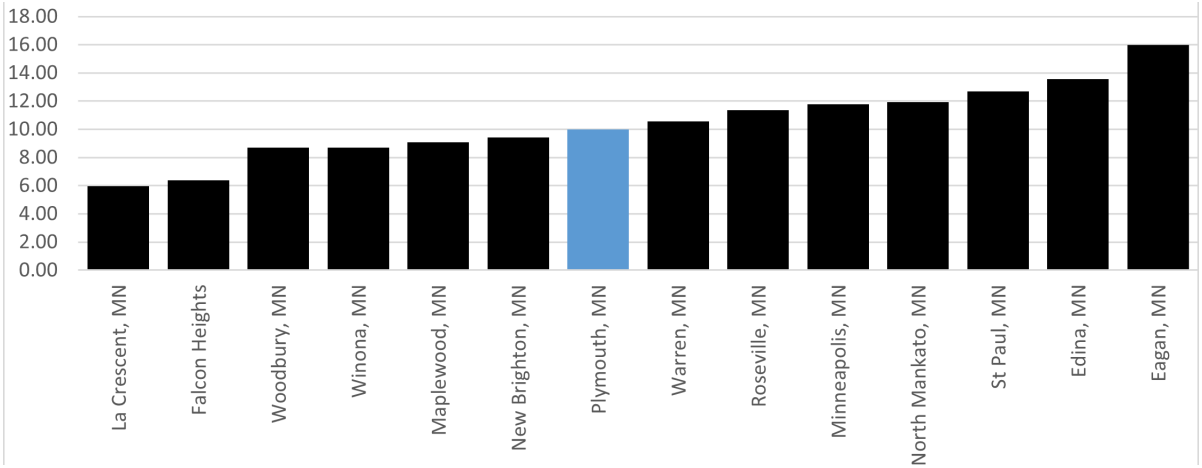
The City of Plymouth total emissions per capita for 2024 are equal to **196,134** cubic feet of human-made greenhouse gas. This volume of atmosphere is equal to a cube 58' feet on each face:



Minnesota Municipal Per Capita GHG Emission Comparison

Minnesota Comparison Average: **11.7 MT**

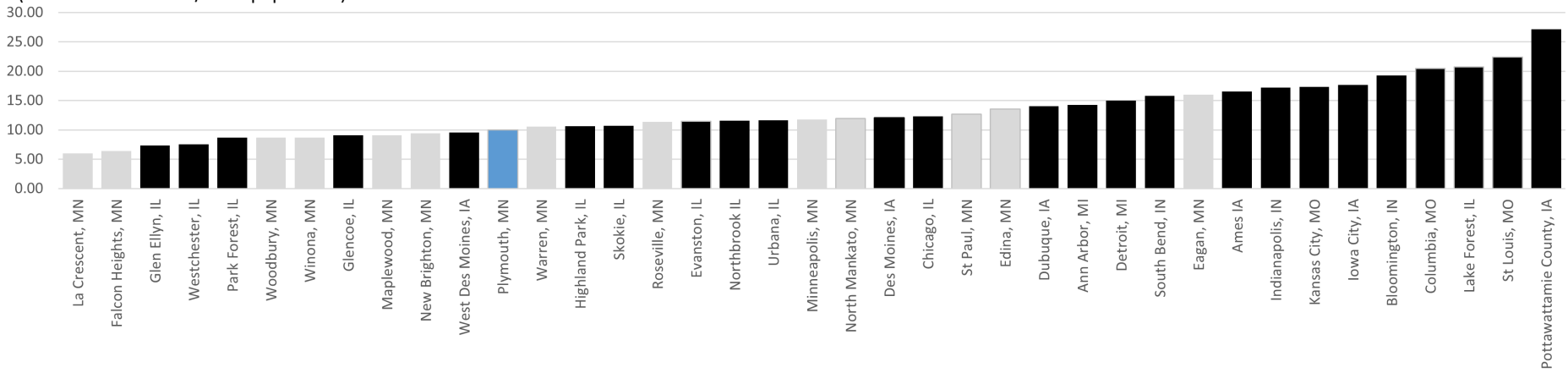
(total GHG emissions / total population)



Regional Municipal Per Capita GHG Emission Comparison

Regional Comparison Average: **14.2 MT**

(total GHG emissions / total population)



Note: Emissions shown for other communities are based on publicly available data from community's reported GHG inventory or CDP reporting database. Inventories represented are from various reporting years and may have changed.

Section

04

GHG Emissions Forecast

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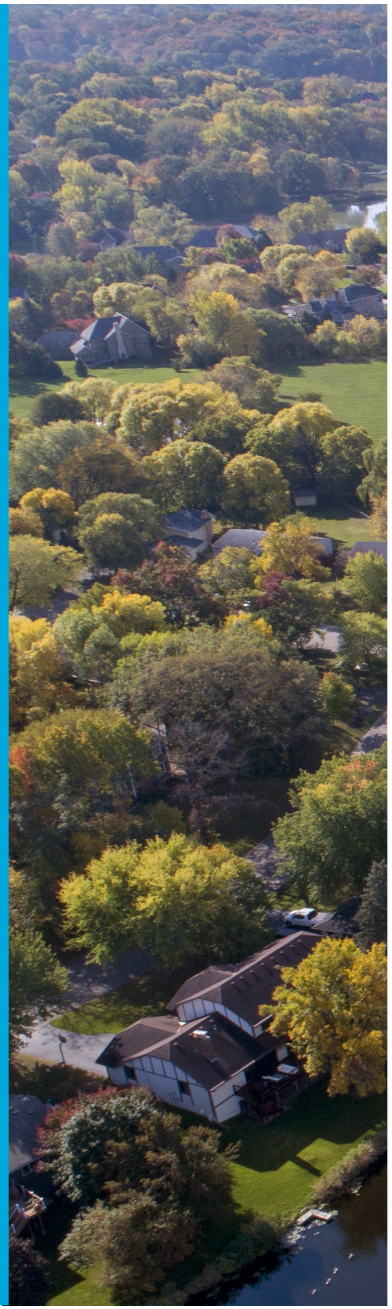
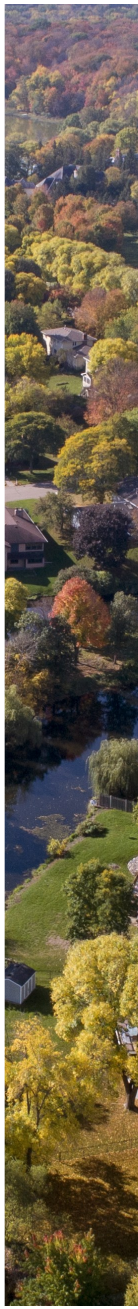


GHG Emissions Forecast

Why Create a GHG Emission Forecast?

Rising levels of greenhouse gas emissions, which in turn increase atmospheric concentrations, will lead to a variety of changes in our global, regional, and local climates. Anticipated shifts include a hotter atmosphere, warmer and increasingly acidic oceans, stronger storms, greater fluctuations in weather, and altered rainfall patterns. The scope of these future climate alterations hinges on our continuing levels of greenhouse gas emissions. The more we release into the atmosphere, the more significant the climate changes we can expect. In simpler terms, the degree of climate change we'll face in the future is directly influenced by the environmental policies communities adopt and the individual actions we take to cut down on greenhouse gas emissions.

A GHG emission forecast supports GHG reduction planning efforts by anticipating what emissions may be like if actions are not taken. The potential future trends illustrated in the forecast supports planners in identifying emission sectors which may benefit from prioritization or which may harbor the greatest potential benefits for reduction strategies. Finally, the completed GHG emission forecast, combined with the underlying assumptions used to create the forecast model, can be used as a ***GHG reduction projection tool*** during future Climate Action and Resilience Planning efforts.



GHG Emissions Forecast

Business-As-Usual Forecast

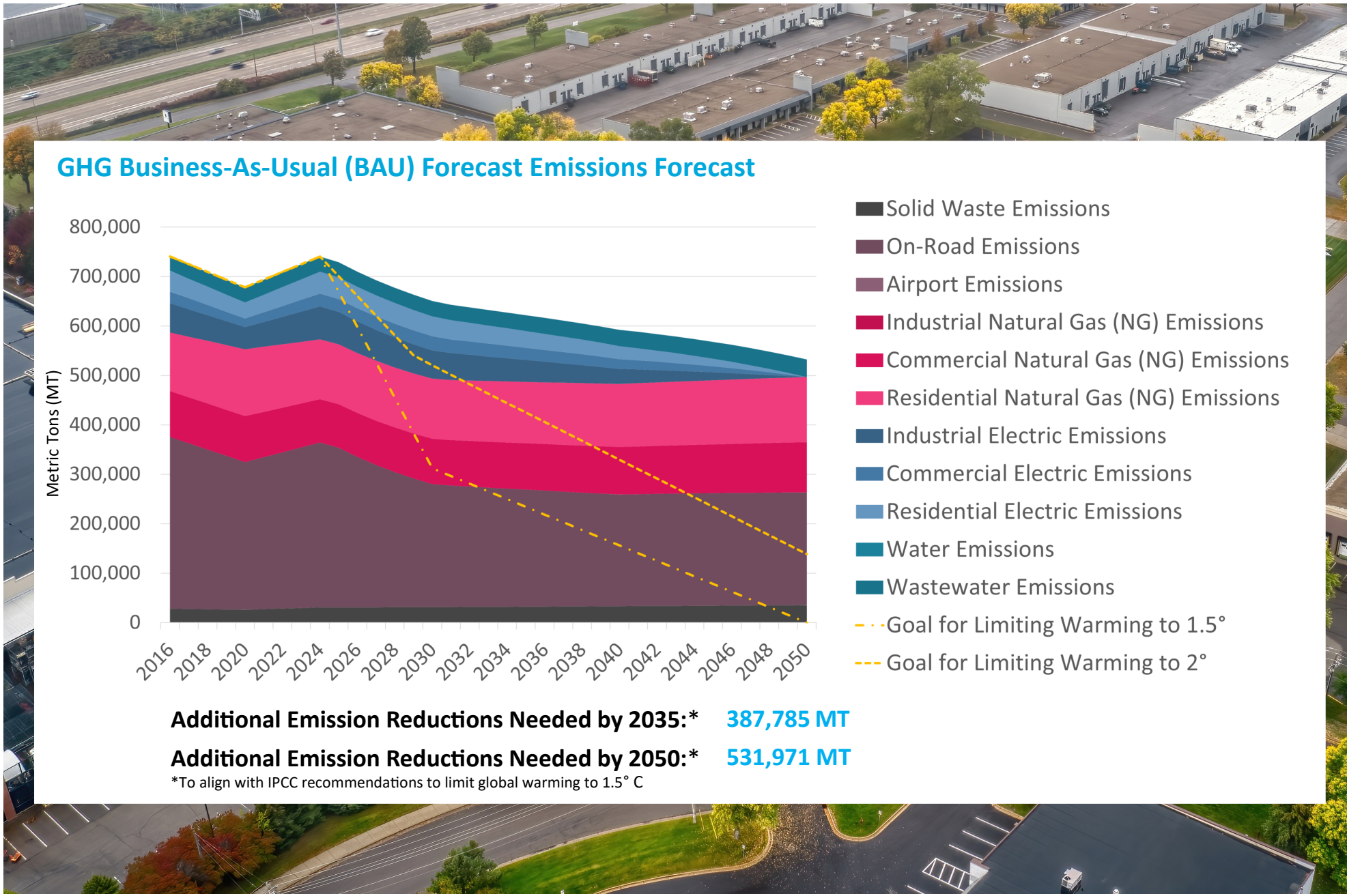
Emissions are often predicted using a business-as-usual (BAU) approach. The IPCC describes BAU as the emissions outcome if future trends mirror historical ones without policy changes. Such forecasts don't factor in new emission-reduction efforts beyond current commitments and consider expected demographic shifts like population and job trends in a community.

This method evaluates a community's potential emissions growth before pinpointing reduction strategies. BAU projections highlight the scale of needed cuts before accounting for actions like federal vehicle efficiency standards, technological progress like energy-efficient devices, or local conservation initiatives such as green building codes.

For assumptions shaping this BAU forecast, see the appendix.

Uncertainty

Forecasts for GHG emissions are not definitive predictions of future events, but instead are projected outcomes based on specific assumptions and methodologies. The GHG projections in this report should be viewed with an awareness of the underlying assumptions and the inevitable limitations associated with any modeling attempt, as detailed in the provided forecast assumptions. It's essential to recognize that these forecast outcomes carry a degree of uncertainty. Factors like shifts in industrial structures, the specific effects of policies, evolving weather patterns, and economic shifts all introduce variability in the anticipated future emissions trajectories.

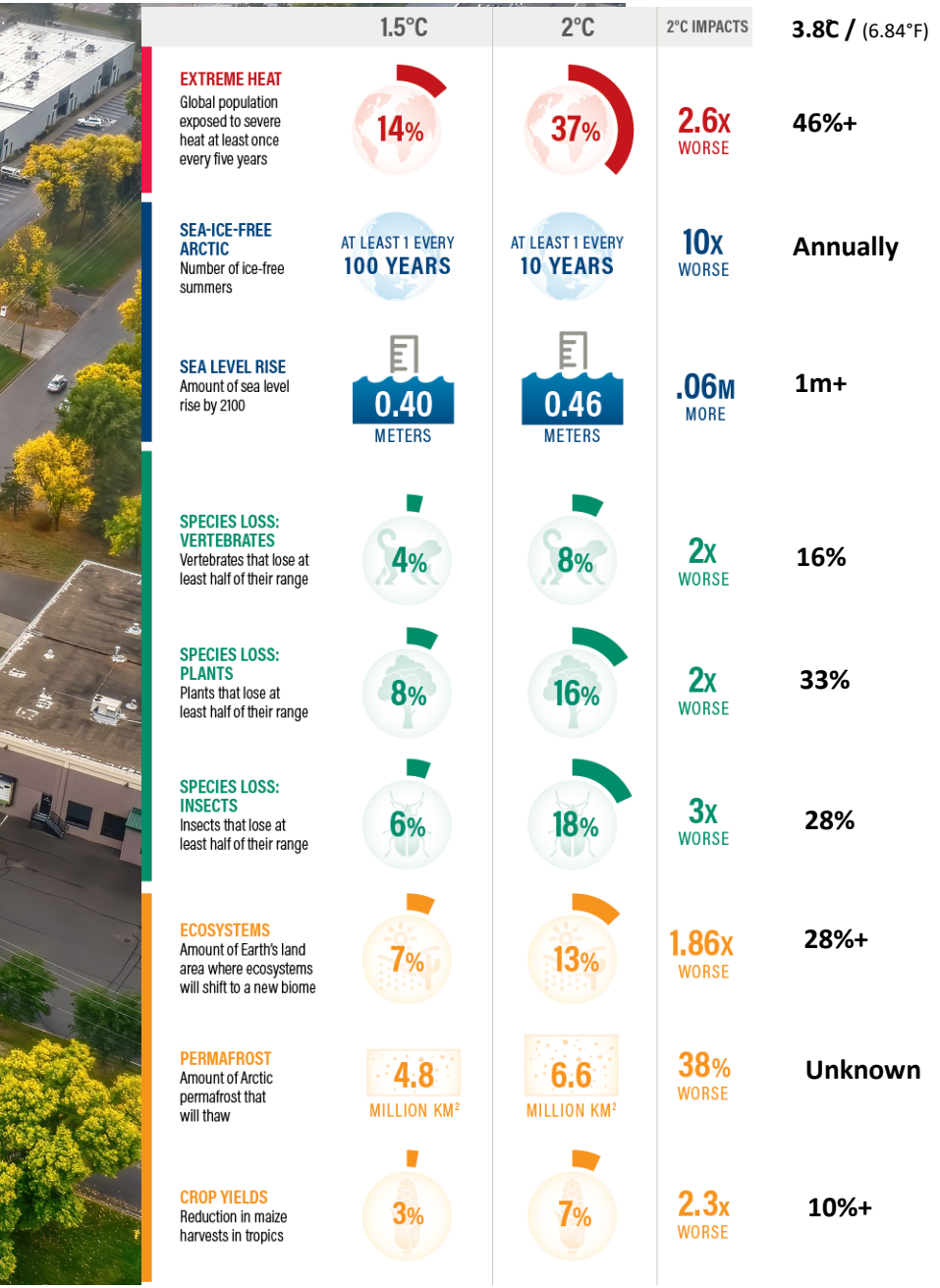


GHG Business-As-Usual (BAU) Forecast Emissions Forecast

Additional Emission Reductions Needed by 2035:* **387,785 MT**

Additional Emission Reductions Needed by 2050:* **531,971 MT**

*To align with IPCC recommendations to limit global warming to 1.5° C



Where BAU Projections Are Aiming

	1.5°C	2°C	2°C IMPACTS	3.8℃ / (6.84°F)
EXTREME HEAT Global population exposed to severe heat at least once every five years	14%	37%	2.6X WORSE	46%+
SEA-ICE-FREE ARCTIC Number of ice-free summers	AT LEAST 1 EVERY 100 YEARS	AT LEAST 1 EVERY 10 YEARS	10X WORSE	Annually
SEA LEVEL RISE Amount of sea level rise by 2100	0.40 METERS	0.46 METERS	.06M MORE	1m+
SPECIES LOSS: VERTEBRATES Vertebrates that lose at least half of their range	4%	8%	2X WORSE	16%
SPECIES LOSS: PLANTS Plants that lose at least half of their range	8%	16%	2X WORSE	33%
SPECIES LOSS: INSECTS Insects that lose at least half of their range	6%	18%	3X WORSE	28%
ECOSYSTEMS Amount of Earth's land area where ecosystems will shift to a new biome	7%	13%	1.86X WORSE	28%+
PERMAFROST Amount of Arctic permafrost that will thaw	4.8 MILLION KM²	6.6 MILLION KM²	38% WORSE	Unknown
CROP YIELDS Reduction in maize harvests in tropics	3%	7%	2.3X WORSE	10%+

GHG Emissions Forecast

Understanding Impacts of BAU Forecast

To better grasp the BAU (Business-as-Usual) forecast for the City of Plymouth, it's helpful to compare local emission projections with the bigger picture of global climate change. By doing this, we can see the effects of 1.5℃, 2℃, and 3.8℃ increases in global temperatures.

The Intergovernmental Panel on Climate Change (IPCC) is a group under the United Nations Environment Programme (UNEP) that studies climate change science and helps shape policies to address it. The experts at the IPCC broadly agree that we need to cut global emissions to prevent temperatures from rising more than 1.5°C. Similarly, the Paris Agreement seeks to keep the temperature increase below 1.5 to 2 degrees C from pre-industrial times, which is seen as a crucial tipping point.

A report from UNEP in November 2020 showed that by 2030, the world needs to produce 25% less emissions than it did in 2020. And by 2050, we should aim for an 80% reduction if we want to keep warming under 2°C. To be even safer and target just 1.5°C, the report says we'd need to cut emissions by 55% compared to 2020 and then aim for carbon neutral by 2050.

On the left, there's a graphic made by the World Resources Institute. It shows how different the world could look if we limit warming to 1.5°C compared to 2°C. We've also included a look at what might happen with a 3.8°C increase, which is what the current projections for the City of Plymouth suggest if things continue as they are.

Source and Graphic: World Resources Institute

Section A

GHG Inventory Calculation Summaries

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Emissions Sectors	2016 Consumption	2016 MMBtu	2016 GHG	2020 Consumption	2020 MMBtu	2020 GHG	Change from Prior Study Year	2024 Consumption	2024 MMBtu	2024 GHG	Change from Prior Study Year	MMBtu / Consumption Change Since 2016	GHG Change Since 2016
	Population:[a] 75,105 Households:[a] 30,602 Jobs:[a] 54,935			Population:[a] 78,879 Households:[a] 31,470 Jobs:[a] 53,891				Population:[a] 79,526 Households:[a] 32,425 Jobs:[a] 53,494					
Electricity[1]:													
Notes: **Gross Consumption (Wright Hennepin)**							Consumption				Consumption		
2 Residential (Xcel)	51,345	175,190	30,743	61,794	210,842	30,552	20.4%	62,546	213,405	28,938	1.2%	21.8%	-5.9%
2 Small Commercial / Ind (Xcel)	57,754	197,058	34,580	55,494	189,346	27,437	-3.9%	48,897	166,835	22,623	-11.9%	-15.3%	-34.6%
2 Large Commercial / Ind (Xcel)	17,931	61,181	10,736	16,326	55,704	8,072	-9.0%	6,236	21,276	2,885	-61.8%	-65.2%	-73.1%
2 Streetlights (Xcel)	481	1,640	288	386	1,317	191	-19.7%	348	1,188	161	-9.8%	-27.6%	-44.0%
Notes: **Gross Consumption (Xcel)**							Consumption				Consumption		
2 Residential (Xcel)	132,958	453,654	48,549	139,639	476,450	38,261	5.0%	238,773	814,694	53,485	71.0%	79.6%	10.2%
2 Small and Large Commercial (Xcel)	66,488	226,858	24,278	64,550	220,244	17,687	-2.9%	133,027	453,888	29,798	106.1%	100.1%	22.7%
2 Iindustrial (Xcel)	160,952	549,170	58,771	163,028	556,251	44,670	1.3%	297,787	1,016,048	66,704	82.7%	85.0%	13.5%
2 Streetlights (Xcel)	928	3,168	339	928	3,168	254	0.0%	1,141	3,892	256	22.9%	22.9%	-24.6%
3 **Subtractions (Xcel)**							Subtractions				Subtractions		
Residential - Wind Sourced (Xcel)	-	-	-	(374)	(1,277)	-	N/A	(4,761)	(16,243)	-	1171.9%	N/A	
Residential - Solar Sourced (Xcel)	-	-	-	(267)	(912)	-	N/A	(1,139)	(3,886)	-	326.2%	N/A	
Commercial - Wind Sourced (Xcel)	-	-	-	(20)	(67)	-	N/A	(12,983)	(44,296)	-	65848.1%	N/A	
Commercial - Solar Sourced (Xcel)	-	-	-	(1,380)	(4,709)	-	N/A	(5,550)	(18,937)	-	302.2%	N/A	
Industrial - Wind Sourced (Xcel)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Industrial - Solar Sourced (Xcel)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Streetlights - Wind Sourced (Xcel)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Streetlights - Solar Sourced (Xcel)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Net Consumption With Emissions (Xcel)							GHG Emissions				GHG Emissions		
Residential (Xcel)	132,958	453,654	48,549	138,998	474,261	38,085	-21.6%	232,874	794,565	52,164	37.0%	75.1%	7.4%
Commercial (Xcel)	66,488	226,858	24,278	63,150	215,468	17,303	-28.7%	114,494	390,654	25,647	48.2%	72.2%	5.6%
Industrial (Xcel)	160,952	549,170	58,771	163,028	556,251	44,670	-24.0%	297,787	1,016,048	66,704	49.3%	85.0%	13.5%
Streetlights (Xcel)	928	3,168	339	928	3,168	254	-25.0%	1,141	3,892	256	0.5%	22.9%	-24.6%
Subtotals (Xcel + Wright Hennepin)	**488,839**	**2,156,757**	**208,283**	**502,146**	**2,215,467**	**166,564**	**-20.0%**	**788,754**	**3,479,981**	**199,376**	**19.7%**	61.4%	-4.3%
5 Blended emission factor (WH tonnes per MW	0.599			0.494				0.463			-6.4%		N/A
5 Blended emission factor (Xcel tonnes per MW	0.365			0.274				0.224			-18.2%		N/A
Electricity as a % of total citywide amounts		19.7%	25.3%		21.0%	22.2%	-12.1%		29.1%	24.8%	11.8%		-1.8%
Electricity per Household (kWh)	4,345			4,437			2.1%	7,364			66.0%	69.5%	
Electricity per Job (kWh)	4,140			4,223			2.0%	8,053			90.7%	94.5%	

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Population:[a]	75,105			78,879				79,526					
Households:[a]	30,602			31,470				32,425					
Jobs:[a]	54,935			53,891				53,494					
Stationary Combustion - Heating Fuel[1]:													
Notes: **Gross Consumption**							Consumption				Consumption		
Residential		**2,235,746**	**118,495**		**2,549,575**	**135,127**	**14.0%**		**2,287,067**	**121,215**	**-10.3%**		
6 Natural Gas (therms)	22,362,801	2,235,746	118,495	25,501,841	2,549,575	135,127	14.0%	22,876,135	2,287,067	121,215	-10.3%	2.3%	2.3%
Small and Large Commercial		**1,750,936**	**92,800**		**1,759,287**	**93,242**	**0.5%**		**1,646,909**	**87,286**	**-6.4%**	-5.9%	-5.9%
6 Natural Gas (therms)	17,513,544	1,750,936	92,800	17,597,075	1,759,287	93,242	0.5%	16,473,027	1,646,909	87,286	-6.4%	-5.9%	-5.9%
Subtotals		**3,986,681**	**211,294**		**4,308,862**	**228,370**	**8.1%**		**3,933,976**	**208,501**	**-8.7%**	-1.3%	-1.3%
9 Natural Gas mission factor (tonnes per MMBt	0.053			0.053				0.053					
9 Emission factor - Propane (MT per MMBtu)	0.063			0.063				0.063					
9 Emission factor - Oil (MT per MMBtu)	0.073			0.073				0.073					
9 Emission factor - Wood (MT per MMBtu)	0.001			0.001				0.001					
9 Emission factor - Wood Pellets (MT per MMBt	0.004			0.004				0.004					
Heating as a % of total citywide amounts		36.5%	25.6%		40.8%	30.5%		Therm Equivalen	32.9%	26.0%			
Heating energy per Household (BTU)	731	73		810	81		10.9%	706	71		-12.9%	-3.5%	
Heating energy per Job (BTU)	319	32		327	33		2.4%	308	31		-5.7%	-3.4%	

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Population:[a]	75,105			78,879				79,526					
Households:[a]	30,602			31,470				32,425					
Jobs:[a]	54,935			53,891				53,494					
Mobile Combustion - Transportation:													
Notes: **Ground Transportation**							Consumption				Consumption		
10 Vehicle miles traveled (thousands of miles)	697,949			607,331			-13.0%	704,001			15.9%	0.9%	
11 Estimated number of vehicles in community	56,534			59,338				59,732			0.7%	5.7%	
12 Registered electric vehicles in community (BE	147	0.3%		334	0.6%			1,709	2.9%		411.7%	1062.6%	
Estimated EV Share of VMT	1,815			3,419				20,142					
12 Registered plug-in hybrid vehicles in commun	121	0.2%		185	0.3%			528	0.9%		185.4%	336.4%	
25 Estimated PHEV Share of VMT (30%)	448			568				1,867					
VMT With Emissions	696,134		**347,717**	603,912		**298,291**		683,859		**333,733**			-4.0%
13 Average MPG	17.95			18.24				18.36					
Estimated Fuel Consumed (total)	38,766,550	4,781,340		33,076,993	4,038,301		-14.7%	37,135,733	4,529,335		12.3%	-5.3%	
14 Estimated Gasoline / e10 Gasoline Share	28,440,220	3,415,955	241,939	23,341,309	2,803,525	198,563		26,873,495	3,227,775	228,611		-5.5%	-5.5%
14 Estimated Diesel Share	10,326,330	1,365,385	105,778	9,735,683	1,234,777	99,728		10,262,238	1,301,560	105,121		-4.7%	-0.6%
14 /e Emission factor (tonnes per thousand VMT)	0.5144			0.5081			-1.2%	0.5034			-0.9%		N/A
Subtotals		**4,781,340**	**347,717**		**4,038,301**	**298,291**	**-14.2%**		**4,529,335**	**333,733**	**11.9%**	-5.3%	-4.0%
16 Gasoline / e10 Emission Factor	0.009			0.009				0.009					
16 Diesel Emission Factor	0.010			0.010				0.010					
16 Avgas Emission Factor	0.008			0.008				0.008					
16 Jet Fuel Emission Factor	0.010			0.010				0.010					
Transportation as a % of total citywide amounts		43.8%	42.2%		38.2%	39.8%			37.9%	41.6%			
Vehicle Miles Traveled (VMT) per Household	22,807			19,299			-15.4%	21,712			12.5%	-4.8%	

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Population:[a]	75,105			78,879				79,526					
Households:[a]	30,602			31,470				32,425					
Jobs:[a]	54,935			53,891				53,494					
Solid Waste:													
Notes: **Gross Consumption**							Consumption				Consumption		
Residential Estimated Share													
17 46.0%	**31,042**			**35,458**			**14.2%**	**38,443**			8.4%	23.8%	
17 Recycled (tons)	7,798.77	25.1%		9,529.80	26.9%		22.2%	10,816.72	28.1%		13.5%	38.7%	
17 Organics / Yard Waste / Trees	3,916.29	12.6%		5,551.38	15.7%		41.8%	5,523.64	14.4%		-0.5%	41.0%	
17 MSW managed as RDF (tons)	12,268.95	39.5%		9,291.84	26.2%		-24.3%	11,032.02	28.7%		18.7%	-10.1%	
17 Landfill (tons)	7,057.82	22.7%		11,085.38	31.3%		57.1%	11,070.41	28.8%		-0.1%	56.9%	
Recovered / Reused (tons)	-	0.0%		-	0.0%		N/A	-	0.0%				
Diversion Rate	77.3%			68.7%				71.2%					
Non-Residential Estimated Share													
17 54.0%	**36,440**			**41,625**			**14.2%**	**45,128**			8.4%	23.8%	
17 Recycled (tons)	9,155	25.1%		11,187	26.9%		22.2%	12,698	28.1%		13.5%	38.7%	
17 Organics / Yard Waste / Trees	4,597	12.6%		6,517	15.7%		41.8%	6,484	14.4%		-0.5%	41.0%	
17 MSW managed as RDF (tons)	14,403	39.5%		10,908	26.2%		-24.3%	12,951	28.7%		18.7%	-10.1%	
17 Landfill (tons)	8,285	22.7%		13,013	31.3%		57.1%	12,996	28.8%		-0.1%	56.9%	
Recovered / Reused (tons)	-			-			N/A	-					
Diversion Rate	77.3%			68.7%				71.2%					
Total Estimated Solid Waste Handled	**67,482**			**77,083**			14.2%	**83,571**			8.4%	23.8%	
Recycled (tons)	16,954	25.1%	0	20,717	26.9%	0	22.2%	23,515	28.1%	0	13.5%	38.7%	N/A
Organics / Yard Waste / Trees	8,514	12.6%	-766	12,068	15.7%	-1,086	41.8%	12,008	14.4%	-1,081	-0.5%	41.0%	41.0%
MSW managed as RDF (tons)	26,672	39.5%	21,454	20,200	26.2%	16,222	-24.3%	23,983	28.7%	20,603	18.7%	-10.1%	-4.0%
Landfill (tons)	15,343	22.7%		24,099	31.3%		57.1%	24,066	28.8%		-0.1%	56.9%	
Recovered / Reused (tons)	-	0.0%	0	-	0.0%	0	N/A	-	0.0%	0			
Diversion Rate	77.3%			68.7%				71.2%					
Landfill Emissions (Residential and Non-Residential)													
Non-Biogenic Emissions	15,343		7,034	24,099		11,048		24,066		11,033			56.9%
18 Biogenic Emissions	15,343		1,025	24,099		1,893		24,066		-			-100.0%
Subtotals (excluding Biogenic Emissions)			**27,722**			**26,184**	**-5.5%**			**30,556**	**16.7%**	N/A	10.2%
Emission factors													
19 RDF (MT per ton)	0.80			0.80				0.86					
20 Collected Organics (MT per ton)	(0.09)			(0.09)				(0.09)					
19 Landfill Non-Biogenic (MT per ton)	0.46			0.46				0.46					
19 Landfill Biogenic (MT per ton)	0.07			0.08				0.00					
Solid Waste as a % of total citywide amounts			3.4%		0.0%	3.5%			0.0%	3.8%			
Total Solid Waste per Capita (lbs)	827			899			8.8%	967			7.5%	17.0%	

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Community Wide Emissions Inventory Data Calculations

Emissions Sectors	2016 Consumption	2016 MMBtu	2016 GHG	2020 Consumption	2020 MMBtu	2020 GHG	Change from Prior Study Year	2024 Consumption	2024 MMBtu	2024 GHG	Change from Prior Study Year	MMBtu / Consumption Change Since 2016	GHG Change Since 2016
	Population:[a] 75,105 Households:[a] 30,602 Jobs:[a] 54,935			Population:[a] 78,879 Households:[a] 31,470 Jobs:[a] 53,891				Population:[a] 79,526 Households:[a] 32,425 Jobs:[a] 53,494					
Wastewater:													
Notes: **Gross Consumption**							Consumption				Consumption		
23 Wastewater Flows (gallons in millions)	0.0			0.0			N/A	0.0			N/A	N/A	
24 Emissions from wastewater treatment			28,769			30,215	5.0%			30,462	N/A		5.9%
Subtotals			**28,769**			**30,215**	**5.0%**			**30,462**	**0.8%**		5.9%
Emission factor -Wastewater (tonnes per m	N/A			N/A				N/A					
Wastewater as a % of total citywide amounts		0.0%	3.5%		0.0%	4.0%			0.0%	3.8%			
Total Wastewater per Capita (gallons)	0			0			N/A	0			N/A	N/A	
Citywide Totals (Scope 1 & 2):	Total MMBTU:	10,924,778	**823,785**	Total MMBTU:	10,562,630	**749,623**	**-9.0%**	Total MMBTU:	11,943,292	**802,628**	**7.1%**	**9.3%**	**-2.6%**
		Per-Capita:	10.97		**Per-Capita:**	9.50	-13.4%		**Per-Capita:**	10.09			-8.0%

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Community Wide Emissions Inventory Data Calculations

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Emissions Sectors	2016			2020			Change from Prior Study Year	2024			Change from Prior Study Year	MMBtu / Consumption Change Since	GHG Change Since
	Population:[a] 75,105 Households:[a] 30,602 Jobs:[a] 54,935			Population:[a] 78,879 Households:[a] 31,470 Jobs:[a] 53,891				Population:[a] 79,526 Households:[a] 32,425 Jobs:[a] 53,494					
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG		2016	2016

Notes:

a Population and household demographic data is from US Census Bureau American Community Survey (ACS) accessed via Social Explorer (https://www.socialexplorer.com/) Census data may be generated at the Census Tract or Block Group level. Census boundaries, set by the Bureau, may not always match community boundaries identically. Jobs data is from US Census Beurea accessed bia the Census tool OnTheMap (https://onthemap.ces.census.gov/)

1 Electricity in MWh, natural gas in therms. Carbon dioxide equivalents (GHG) are expressed in metric tonnes, which equal 1,000 kilograms, 2,204.6 pounds, or 1.102 US tons.

2 Source: Utility annual reporting. Xcel 2016 use is estimated based on 2020 per capita values due to utility data unavailability.

3 Excludes distributed renewable energy under incentivized programs in which utility retains the renewable energy credits. Green attributes of these installations are understood to be applied to the community-wide standard grid emission factors. Source: Utility annual reporting and city data.

4 Not Used

5 Source: Electric utility annual reporting.

6 Source: Natural Gas utility annual reporting

7 Not Used

8 Not Used

9 EPA emission factors https://www.epa.gov/climateleadership/ghg-emission-factors-hub

10 Source: State of Minnesota Department of Transportation Roadway Data https://www.dot.state.mn.us/roadway/data/

11 Total number of vehicles in community is based on US Census data ACS 5-year estimates Table A10030 ; Housing Units by Vehicles Available

12 Registered Electric Vehicles in Community do not inlcude HEV or PHEV categories and is based on registration data reported by state of Minnesota https://mn.gov/puc/activities/economic-analysis/electric-vehicles/ and EV Hub https://www.atlasevhub.com/materials/state-ev-registration-data/ Data reflects BEV vehicles registered as reported in the last "DMV Snapshot" for the subject year (may be January the following year).

13 Average MPG calculated using data from the Federal Highway Administration Table VM-1

14 Estimated fuel share of community-wide VMT and average emission factor per VMTcalculated using data from the Federal Highway Administration Table VM-1. According to the US EIA, "Blends of petroleum-based gasoline with 10% ethanol, commonly referred to as E10, account for more than 95% of the fuel consumed in motor vehicles with gasoline engines." Accordingly, emission factors used for gasoline consumption are based on e10. https://www.eia.gov/todayinenergy/detail.php?id=26092

15 Not Used

16 Emission factors based on US EPA Emission Factors for GHG Inventories: https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf Emission factor for wood pellet heating is calculated based on EPA "residential wood stoves" report https://www.epa.gov/sites/default/files/2020-09/documents/1.10_residential_wood_stoves.pdf All wood heating emission factors treat CO2 portion of emission as carbon neutral based on EPA reporting https://www.epa.gov/archive/epa/newsreleases/administrator-pruitt-promotes-environmental-stewardship-forestry-leaders-and-students.html

17 Prorata community share of County data reported by MPCA SCORE reportshttps://www.pca.state.mn.us/air-water-land-climate/understanding-solid-waste Estimated share of residential and non-residential MW sources based on national average MSW waste generation rates reported by the EPA MSW Residential/Commercial Percentage Allocation – Data Availability U.S. Environmental Protection Agency Office of Resource Conservation and Recovery July 2013: https://www.epa.gov/sites/default/files/2016-01/documents/rev_10-24-14_msw_residential_commercial_memorandum_7-30-13_508_fnl.pdf Data for 2023 is used in lieu of 2024 due to data unavailability.

18 Biogenic emissions shown for information only and not included in total. From "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model" November 2020 page -14 "GHG emissions from bio-energy are treated as biogenic emissions that do not contribute to the GHG emission factor" https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf

19 RDF emission factors based on reported data on EPA Facility Level Information on GreenHouse gases Tool (FLIGHT) , total reported category GHG emissions divided by total reported facility solid waste collection for year. https://ghgdata.epa.gov/ghgp/main.do Where regional facility is not reported, average emission factors are used. Landfill emission factors based on US EPA Emission Factors for Greenhouse Gas Inventories, see charts "Estimated Composition of Landfill Waste and Blended Emission Factor Calculation" and "Landfill Solid Waste Emission Factors"

20 Emission Factor for organics based on based on US EPA Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model November 2020, Exhibit 1-10 "Mixed Organics - Composting" https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf NOTE: Negative values represent net GHG emission reductions or carbon storage from a waste management practice.

21 Not Used

22 Not Used

23 As reported by utility or municipality. Where data is not available wastewater flows are estimated as share of water distribution.

24 As reported by facility. Where emission calculations are not avaible from facility, calculations are based on US EPA Local GHG Inventory Tool (LGGIT) https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool LGGIT calculations assume all wastewater treatment uses anaerobic treatment and nitrification / denitrification.

25 "Share of VMT" is a calculation of the estimated number of miles driven with zero tailpipe emissions. EV share is calculated at 100% of estimated EV vehicle VMT reflecting zero tailpipe emissions for vehicle class. PHEV share is calculated at 30% of estimated VMT reflecting PHEV average reduction in tailpipe emissions over ICE vehicles of 30-60% according to the US DOE (https://fueleconomy.gov/feg/phevtech.shtml ; https://www.energy.gov/sites/prod/files/2014/05/f15/52723.pdf)

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Municipal Operations Emissions Inventory Data Calculations

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Emissions Sectors	2016 FTE 542			2020 FTE 448			Change from Prior Study Year	2024 FTE 536			Change from Prior Study Year	MMBtu Change Since 2016	GHG Change Since 2016
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			
Electricity[1]:													
Notes: **Gross Consumption**							Consumption				Consumption		
2 Buildings, Grounds, Streetlights	11,536	39,360	4,212	11,536	39,360	3,161	0.0%	10,867	37,078	2,434	-5.8%	-5.8%	-42.2%
Subtractions							Subtractions				Subtractions		
Buildings and Grounds - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Buildings and Grounds - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Streetlights - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Streetlights - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
(other)- Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
(other) - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
2 Waste, Water, Wastewater Process	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Buildings, Grounds, Streetlights	11,536	39,360	4,212	11,536	39,360	3,161	-25.0%	10,867	37,078	2,434	-23.0%		-42.2%
Subtotals	**11,536**	**39,360**	**4,212**	**11,536**	**39,360**	**3,161**	**-25.0%**	**10,867**	**37,078**	**2,434**	**-23.0%**		-42.2%
Blended emission factor (tonnes per MWI	0.365			0.274				0.224			-18.2%		N/A
Building Square Footage	-	**N/A**	**EUI Electricity**	-	**N/A**	**EUI Electricity**		-	**N/A**	**EUI Electricity**	N/A	N/A	
Electricity as a % of total citywide amounts		52.8%	63.2%		52.7%	56.2%			33.4%	32.9%			
Stationary Combustion - Heating Fuel[1]:													
Notes: **Gross Consumption**		**12,640**			**10,636**		Consumption		**28,908**		Consumption		
Natural Gas (therms)	126,429	12,640	670	106,385	10,636	564	-15.9%	289,150	28,908	1,532	171.8%	128.7%	128.7%
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Buildings and Grounds		12,640	670		10,636	564	-15.9%		28,908	1,532	171.8%		128.7%
Subtotals	**-**	**12,640**	**670**	**-**	**10,636**	**564**	**-15.9%**	**-**	**28,908**	**1,532**	**171.8%**		128.7%
Natural Gas mission factor (tonnes per MI	0.053			0.053				0.053					
Emission factor - Propane (MT per MMBtu	0.063			0.063				0.063					
Emission factor - Oil (MT per MMBtu)	0.073			0.073				0.073					
Emission factor - Wood (MT per MMBtu)	0.001			0.001				0.001					
Emission factor - Wood Pellets (MT per M	0.004			0.004				0.004					
Building Square Footage	-	**N/A**	**EUI Heating**	-	**N/A**	**EUI Heating**		-	**N/A**	**EUI Heating**	N/A	N/A	
Combined Electricity+Heating EUI		**N/A**	**EUI Combined**		**N/A**	**EUI Combined**			**N/A**	**EUI Combined**	N/A	N/A	
Natural gas as a % of total citywide amounts		16.9%	10.1%		14.2%	10.0%			26.0%	20.7%			

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Emissions Sectors	2016 FTE 542			2020 FTE 448			Change from Prior Study Year	2024 FTE 536			Change from Prior Study Year	MMBtu Change Since 2016	GHG Change Since 2016
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			
Mobile Combustion - Fleet and Fuel:													
Notes: **Fleet Fuel**			**1,631**			**1,781**	Consumption			**3,271**	Consumption		
Diesel (gal.)	64,176	8,817	657	62,438	8,578	640	-2.7%	159,417	21,901	1,633	155.3%	148.4%	148.4%
BioDiesel B20 (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Gasoline (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
e10 Gasoline (gal.)	114,466	13,760	974	134,145	16,126	1,141	17.2%	192,503	23,142	1,638	43.5%	68.2%	68.2%
e85 (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Compressed Natural Gas	-	-	0.0	-	-	0.0	N/A	-	-	-	N/A	N/A	N/A
Total Vehicles in Fleet	-			-				-					
Electric Vehicles in Fleet	-			-				-					
Airport			**0**			**0**	**N/A**			**0**			**N/A**
3 Gasoline (gal.)	0	0	0	0	0	0	N/A	0	0	0	N/A	N/A	N/A
3 Diesel (gal.)	0	0	0	0	0	0	N/A	0	0	0	N/A	N/A	N/A
3 Avgas	0	0	0	0	0	0	N/A	0	0	0	N/A	`	N/A
3 Jet Fuel	0	0	0	0	0	0	N/A	0	0	0	N/A	N/A	N/A
Subtotals		**22,577**	**1,631**		**24,704**	**1,781**	**9.2%**		**45,042**	**3,271**	**83.7%**		100.5%
Transportation as a % of total citywide amounts		30.3%	24.5%		33.1%	31.7%			40.6%	44.2%			
Solid Waste:													
Notes: **Solid Waste Share**	Community Wid	City Ops Share		Community Wid	City Ops Share			Community Wid	City Ops Share				
Estimated Commercial Share of MSW	54.0%			54.0%				54.0%					
4 Community Wide Solid Waste Handled	67,482	360		77,083	346			83,571	452				
Recycled (tons)	16,954	90	0	20,717	93	0		23,515	127	0		38.7%	
Organics / Yard Waste / Trees	8,514	45	(4)	12,068	54	(5)		12,008	65	(6)		41.0%	
MSW managed as RDF (tons)	26,672	142	114	20,200	91	73		23,983	130	111		-10.1%	
Landfill (tons)	15,343	82	37	24,099	108	50		24,066	130	60		56.9%	
Subtotals		**360**	**148**		**346**	**118**	**-20.4%**		**452**	**165**	**40.7%**		11.9%
Solid waste as a % of total citywide amounts		0.5%	2.2%		0.0%	2.1%			0.0%	2.2%			
City Operations Totals (Scope 1 & 2):		**74,577**	**6,661**		**74,700**	**5,623**	**-15.6%**		**111,029**	**7,402**	**31.6%**	**48.9%**	**11.1%**
		Per-FTE:	12.3		**Per-FTE:**	12.6	2.1%		**Per-FTE:**	13.8			12.4%
		Share of Citywide	0.8%		**Share of Citywide**	0.8%			**Share of Citywide**	0.9%			

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Emissions Sectors	2016			2020			Change from Prior Study Year	2024			Change from Prior Study Year	MMBtu Change Since 2016	GHG Change Since 2016
	FTE 542			FTE 448				FTE 536					
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			

Notes:

1 Electricity in MWh, natural gas in therms. Carbon dioxide equivalents (GHG) are expressed in metric tonnes, which equal 1,000 kilograms, 2,204.6 pounds, or 1.102 US tons.

2 Not Used

3 Consummption volumes as reported by local airport authority. When data not available, total airport fuel use estimated based on reported airport total annual enplanements share of national total emplanements multiplied by the total domestic flight fuel consumption
Sources: Airport annual enplanements: https://www.flyoma.com/omaha-airport-authority/airport-facts-stats/ ; National enplanement data: https://www.bts.gov/newsroom/full-year-2022-us-airline-traffic-data ; Total annual fuel consumption: https://www.statista.com/statistics/197690/us-airline-fuel-consumption-since-2004/

4 Municipal Operations share of Solid Waste is estimated ProRata share of commercial portion of MSW based on FTE share of community-wide employment.

5 As reported by facility. Where emission calculations are not avaible from facility, calculations are based on US EPA Local GHG Inventory Tool (LGGIT) https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool . LGGIT calculations assume all wastewater treatment uses anaerobic treatment and nitrification / denitrification.

Section B

GHG Inventory Sources and Methodologies

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GHG Inventory Sources and Methodologies

GHG Sector	Project Resource	Methodology
Electricity (Residential, Commercial, and Industrial)	Data Source: Electric Utilities Emissions Factors: Same as above or US EPA eGrid if unavailable from Utility	Electricity GHG emissions are calculated using raw energy consumption data (MWH) multiplied by local grid standard GHG emission factors. Subtractions are made from emissions for known MWH generation of distributed renewable energy installations as reported by local utility. Grid standard emission factors used are as reported by utility. Where utility reported emission factors are unavailable, regional average reported by US EPA eGrid is used.
Stationary Combustion (Residential, Commercial, and Industrial)	Data Source: Centerpoint Energy Emissions Factors: US EPA Emission Factor Hub	Natural Gas GHG emissions are calculated using raw energy consumption data (therms) multiplied by emission factors. For regions without full natural gas utility coverage, fuel consumption for non-natural gas heating is estimated based on US Census data reported share of heating fuel by type applied to US DOE SLOPE tool total heating fuel MMBTU minus known natural gas use. Emission factors used are from US EPA Emission Factors for GHG Inventories.
Mobile Combustion - On Road	Data Source: State of Minnesota DOT Emissions Factors: US EPA Emission Factor Hub	On Road transportation GHG emissions are calculated using reported VMT data (pro rated to City share from County share if needed). Estimated share of community VMT and average MPG by vehicle classification are calculated based on Federal Highway Administration national statistics (Table VM-1). These are then used to calculate the esimated fuel consumption by fuel type. Emissions are calculated based on estimated fuel consumption using emission factors from US EPA Emission Factors for GHG Inventories.
Solid Waste	Data Source: Hennepin County, State of Minnesota Emissions Factors: EPA Waste Reduction Model (WARM), Organic Chapters, EPA FLIGHT tool	Solid waste volumes, by disposition (landfilled, refuse derived fuel, recycled, organics collection/ compost) volumes are based on State of Minnesota MPCA SCORE reporting. Total municipal solid waste volumes by disposition are then calculated against category emission factors. Sources for emission factors are as follows: Collected Organics / Composted factor: EPA Waste Reduction Model (WARM), Organic Materials Chapters, Exhibit 1-10 "Mixed Organics - Composting" Solid Waste Landfill (non-biogenic and biogenic) and RDF (non-biogenic only) emission factors based on reported data on EPA Facility Level Information on GreenHouse gases Tool (FLIGHT) , total reported category GHG emissions divided by total reported facility solid waste collection for year. Where regional facility is not reported, average emission factors are used.
Wastewater	Emissions Factors: US EPA Local GHG Inventory Tool. Energy consumption included in Electricity and Stationary Combustion sectors above	Facility electricity and heating fuel emissions are included under Commercial/Institutional energy sector above. Where emission calculations are not avaible from facility, calculations are based on US EPA Local GHG Inventory Tool (LGGIT) https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool LGGIT calculations assume all wastewater treatment uses anaerobic treatment and nitrification / denitrification.

Common Conversion and Emission Factors

(note, not all may be used in inventory calculations)

Conversion factors	Multiply By	Emission Factor MT CO2e/	Source
US ton to metric ton	0.9072		1
Natural gas: cubic feet to **therm**	0.0104	0.0053	2, 8
Natural Gas therm to **BTU**	100,000	0.00000005	3, 8
Natural Gas therm to **MMBTU**	0.1	0.0531	3, 8
MWh to MMBtu	3.412		4
MMBtu to MWH	0.293		4
Liquid fuels to kBtu:	**Multiply By**	**Emission Factor MT CO2e/**	**Source**
Propane (gallon)	91.5	0.0057	3, 8
Diesel (gallon)	137.4	0.0102	3, 8
BioDiesel B20 (gallon)	123.8	0.0101	5, 8
Gasoline (gallon)	120.2	0.0088	3, 8
E10 gasoline (gallon)	120.2	0.0085	3, 8
E 85 (gallon)	89.7	0.0062	6,8
Ethanol (pure) (gallon)	80.4	0.0058	6,8
Aviation Gas (gallon)	120.2	0.0083	7,8
Jet Fuel (gallon)	135.0	0.0098	7,8

1: US EIA FAQ: https://www.eia.gov/tools/faqs/faq.php?id=7&t=11

2: US EIA FAQ: https://www.eia.gov/tools/faqs/faq.php?id=45&t=8

3: US EIA Units and Calculators Expained: https://www.eia.gov/energyexplained/units-and-calculators/british-thermal-units.php

4: US EIA Conversion Calculators: https://www.eia.gov/energyexplained/units-and-calculators/energy-conversion-calculators.php

5: US Department of Energy Alternative Fuels Data (blended rate): https://afdc.energy.gov/fuels/biodiesel_basics.html

6: US Deparment of Energy: https://afdc.energy.gov/files/u/publication/fuel_comparison_chart.pdf

7: US Bureau of Transportation Statistics: https://www.bts.gov/content/energy-consumption-mode-transportation

8: US EPA Emission Factors for GHG Inventories: https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

MPG Calulcaitons Using Data From The Federal Highway Administration Table VM-1 [1]

Year	Light Duty Vehicles, Short Wheelbase [2]	Motorcycles	Buses	Light Duty Vehicles, Long Wheelbase [3]	Single-Unit Trucks	Combination Trucks	All Motor Vehicles
All urban (millions of vehicle miles)							
2023	2,173,555	20,181	17,701	705,521	134,101	195,758	**3,246,817**
2020	1,896,549	17,632	15,104	672,196	124,880	177,261	**2,903,622**
2016	2,191,764	20,445	16,350	657,954	113,338	174,557	**3,174,408**
Percent of total VMT							
2023	66.9%	0.6%	0.5%	21.7%	4.1%	6.0%	**100%**
2020	65.3%	0.6%	0.5%	23.2%	4.3%	6.1%	**100%**
2016	69.0%	0.6%	0.5%	20.7%	3.6%	5.5%	**100%**
Fuel consumed (thousands of gallons)							
2023	88,145,179	459,065	2,396,495	39,334,720	17,162,839	29,296,989	**176,795,288**
2020	74,932,021	400,937	2,053,899	36,998,124	16,377,768	28,421,740	**159,184,488**
2016	91,487,810	465,802	2,225,795	37,818,755	15,338,479	29,554,641	**176,891,282**
Average mpg							
2023	24.66	43.96	7.39	17.94	7.81	6.68	**18.36**
2020	25.31	43.98	7.35	18.17	7.62	6.24	**18.24**
2016	23.96	43.89	7.35	17.40	7.39	5.91	**17.95**
GHG (tonnes per million gallons of gasoline and diesel) [4]							
	8,887	8,887	10,180	8,887	10,180	10,180	**9,238**
GHG (tonnes)							
2023	783,346,204	4,079,713	24,396,324	349,567,661	174,717,703	298,243,346	**1,634,350,951**
2020	665,920,868	3,563,123	20,908,692	328,802,330	166,725,675	289,333,311	**1,475,253,999**
2016	813,052,167	4,139,582	22,658,593	336,095,276	156,145,716	300,866,245	**1,632,957,580**
GHG (tonnes per million VMT)							
2023	360.4	202.2	1,378.3	495.5	1,302.9	1,523.5	**503.4**
2020	351.1	202.1	1,384.3	489.1	1,335.1	1,632.2	**508.1**
2016	371.0	202.5	1,385.8	510.8	1,377.7	1,723.6	**514.4**

Energy Consumption (MMBtu)

Year	E10 Gasoline		B-5 Diesel		Total Btu (billions)	Total MMBtu per Gallon	% share Gas	% share Diesel
	Gallons (thousands)	Btu (Billions)	Gallons (thousands)	Btu (Billions)				
2023	127,938,965	15,366,749	48,856,323	6,196,448	21,563,197	0.12197	72.4%	27.6%
2020	112,331,081	13,492,086	46,853,407	5,942,418	19,434,504	0.12209	70.6%	29.4%
2016	129,772,367	11,044,548	47,118,915	10,772,645	21,817,193	0.12334	73.4%	26.6%

Notes:

1 Source: Federal Highway Administration, https://www.fhwa.dot.gov/policyinformation/statistics/ (insert year) Or main page: https://www.fhwa.dot.gov/policyinformation/statistics.cfm

2 Includes passenger cars, light trucks, vans, and SUVs with a wheelbase equal or less than 121 inches.

3 Includes large passenger cars, light trucks, vans, and SUVs with a wheelbase larger than 121 inches.

4 Source: US EPA Emission Factors for GHG Inventories: https://www.epa.gov/system/files/documents/2023-03/ghg_emission_factors_hub.pdf

Emission Factors based on EPA Reported Emissions (1)

RDF Facility Totals

EPA Reported Emissions and emission factors

Facility Reported: Hennepin Energy Recovery Center

Reporting Year	Total Annual Waste Disposal Quantity (Metric Tons)	Total tons	EPA reported "Total Facility Emissions in metric tons CO2 equivalent (mt CO2e) (AR4 GWPs, excluding Biogenic CO2)"	EPA reported emission Factor (excluding biogenic)
2024	175,341	193,280	166,044	**0.859**
2020	169,211	186,523	149,790	**0.803**
2016	181,509	200,079	160,937	**0.804**

(1) Based on US EPA Facility Level Information on GreenHouse gases Tool (FLIGHT) https://ghgdata.epa.gov/ghgp/main.do

(2) From "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model" November 2020 page -14 "GHG emissions from bio-energy are treated as biogenic emissions that do not contribute to the GHG emission factor" https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-

Emission Factors based on EPA Reported Emissions (1)

Landfill Facility Totals

EPA Reported Emissions and emission factors

Facility Reported: BURNSVILLE SANITARY LANDFILL

Reporting Year	Total Annual Waste Disposal Quantity (Metric Tons)	Total tons	EPA reported "Total Facility Emissions in metric tons CO2 equivalent (mt CO2e) (AR4 GWPs, excluding Biogenic CO2)"	EPA reported emission Factor (excluding biogenic)	EPA reported "Biogenic Carbon Dioxide (CO2)"	EPA reported emission Factor (biogenic only)
2024	294,128	324,220	39,396	**0.122**	0	**0.000**
2020	211,191	232,797	55,751	**0.239**	18,283	**0.079**
2016	322,329	355,307	55,709	**0.157**	23,741	**0.067**

(1) Based on US EPA Facility Level Information on GreenHouse gases Tool (FLIGHT) https://ghgdata.epa.gov/ghgp/main.do

(2) From "Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model" November 2020 page 14 "GHG emissions from bio-energy are treated as biogenic emissions that do not contribute to the GHG emission factor" https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf

(3) See Estimated Composition of Landfill Waste and Blended Emission Factor Calculation chart for calculated landfill methane and CO2e emission factors based on waste characterization study.

Collected Organics Emission Factors based on EPA Reported Emissions (1)

MTCO2e / Short Ton

Material	Net Source Reduction Emissions	Net Recycling Emissions	Net Composting Emissions	Net Combustion Emissions	Net Landfilling Emissions	Net Anaerobic Digestion Emissions[a]
Food Waste	(3.66)	NA	(0.12)	(0.13)	0.50	(0.04)
Food Waste (non-meat)	(0.76)	NA	(0.12)	(0.13)	0.50	(0.04)
Food Waste (meat only)	(15.10)	NA	(0.12)	(0.13)	0.50	(0.04)
Beef	(30.09)	NA	(0.12)	(0.13)	0.50	(0.04)
Poultry	(2.45)	NA	(0.12)	(0.13)	0.50	(0.04)
Grains	(0.62)	NA	(0.12)	(0.13)	0.50	(0.04)
Bread	(0.66)	NA	(0.12)	(0.13)	0.50	(0.04)
Fruits and Vegetables	(0.44)	NA	(0.12)	(0.13)	0.50	(0.04)
Dairy Products	(1.75)	NA	(0.12)	(0.13)	0.50	(0.04)
Mixed Organics	NA	NA	(0.09)	(0.15)	0.18	(0.06)

Note: Negative values denote net GHG emission reductions or carbon storage from a materials management practice. NA = Not applicable.

NA = Not applicable.

a Emission factors for dry digestion with curing of digestate before land application .

(1) Data from US EPA "Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model" November 2020, Exhibit 1-10
https://www.epa.gov/sites/default/files/2020-12/documents/warm_organic_materials_v15_10-29-2020.pdf

City of Plymouth Estimated Composition of Landfill Waste and Blended Emission Factor Calculation

Category Share				Emission Factor Calculation (CO2e)	Blended Emission Factor Calculation (CO2e)
	Landfill Gas (LFG) Recovery in Place:	Yes			
	Food (indluded in organics below)		16.2%	0.68	
	Yard (indluded in organics below)		12.2%	0.36	
28.4%	**Compostables**	Organics	28.4%	0.54	0.154
48.5%	**Recyclables/Containers**	Paper	23.3%	0.89	0.207
		Glass	2.0%	0.02	0.000
		Metal	3.2%	0.02	0.001
		Plastic	20.0%	0.02	0.004
12.8%	**Potential Recoverables**	C&D	6.3%	0.02	0.001
		Textiles	5.3%	0.58	0.031
		Electronics	1.2%	0.02	0.000
10.3%	**Other Materials**	Other	10.3%	0.58	0.060
		HHW	0.0%	0.00	0.000
			100%	Ave Emission Factor:	**0.458**

Landfill Solid Waste Emission Factors

Waste Component	CO2e / Ton With LFG Recovery (1)	LFG Recovery Efficiency Rate (2)	CO2e / Ton (no LFG Recovery) (3)
MSW	**0.58**	60%	**0.97**
Newspaper	**0.39**	59%	**0.66**
Office paper	**1.41**	59%	**2.39**
Corrugated containers	**1.00**	56%	**1.79**
Magazines/third-class mail	**0.46**	54%	**0.85**
Food scraps (4)	**0.68**	52%	**1.31**
Grass	**0.28**	41%	**0.68**
Leaves	**0.28**	49%	**0.57**
Branches	**0.58**	54%	**1.07**
Dimensional lumber	**0.17**	58%	**0.29**
Glass	**0.02**	58%	**0.03**
Metal	**0.02**	58%	**0.03**
Plastics	**0.02**	58%	**0.03**
Electronics	**0.02**	58%	**0.03**
Mixed Paper Estimate	**0.89**	59%	**1.51**
Mixed Yard Waste	**0.36**	48%	**0.76**
Mixed C&D	**0.02**	60%	**0.03**

Sources

1: US EPA Emission Factors for Greenhouse Gas Inventories.

2: Average LFG recovery rates for landfills with methane recovery systems are based on the US EPA Waste Reduction Model (WARM) Documentation for Greenhouse Gas Emission and Energy Factors, 2020, “Exhibit 6-11: Waste Component-Specific Collection Efficiencies by Landfill Moisture Condition with Landfill Gas Recovery for Energy." The "Typical Landfill Scenario, National Average" is used for the LFG Recovery Efficiency Rate.

3: Estimated by dividing average CO2e per ton with LFG recovery by the average LFG recovery efficiency.

4: Estimated by averaging meet only and non-meat values.

Section C

GHG Forecast Assumptions

Click here to return to TOC

Demographics:

Population: Total Population projections through 2050 are projected based on city provided population projections.

Households: Total household counts through 2050 are projected based on applying current population per household averages to city provided population projections.

Jobs: Total commercial and industrial jobs through 2050 are projected based on city's current per-capita job count applied to city provided population projections.

Climate Data

Cooling Degree Days (CDD): Projected climate changes for the region will include increased summer temperatures. The increase in temperatures will result in an increase, or variability, in air conditioning demand. The forecast calculates annual changes in air conditioning demand based on projections provided by the "Climate Explorer" tool developed by US NOAA in support of the National Climate Assessment work. https://crt-climate-explorer.nemac.org/

Heating Degree Days (HDD): Projected climate changes for the region will include increased winter temperatures. The increase in temperatures will result in a decrease, or variability, in building heating demand. The forecast calculates annual changes in heating demand based on projections provided by the "Climate Explorer" tool developed by US NOAA in support of the National Climate Assessment work. https://crt-climate-explorer.nemac.org/

Electricity:

Residential: Demand is based on a per household basis and modified based on the projected Cooling Degree Days for each year, assuming 16% of electricity is used for cooling (RCP 8.5 model) based on national averages reported by US Energy Information Administration (https://www.eia.gov/tools/faqs/faq.php?id=1174&t=1). 50% of projected increased electrical vehicle usage is attributed to residential EV charging.

Commercial and Industrial: Demand is based on a per job basis and modified based on projected cooling degree days for each year, assuming that 12% of commercial electricity is used for cooling (RCP 8.5 model) based on national averages reported by US Energy Information Administration (https://www.eia.gov/tools/faqs/faq.php?id=1174&t=1). EIA reporting does not include projections for share of industrial sector electricity used for cooling, consequently we assume a lower value of 6% of industrial electricity used for cooling (RCP 8.5 model). 50% of projected increased electrical vehicle usage is attributed to commercial EV charging

All electricity emission factors are calculated using estimated emissions factors for 2030, 2040, and 2050 based on current, known, supplier commitments or state requirements. For electrical suppliers with unknown or unestablished emission commitments, and for electricity purchased from the SERC grid, electricity emission factors are calculated based on EPA forecasts (https://fas.org/sgp/crs/misc/R45453.pdf) with estimated emissions factors are reduced 5% by 2030, 10% by 2040, and 15% by 2050.

Natural Gas:

Residential: Demand is based on a per household basis and modified based on the projected Heating Degree Days for each year, assuming 75% of natural gas is used for heating (RCP 8.5 model) based on national averages reported by US Energy Information Administration (https://www.eia.gov/todayinenergy/detail.php?id=57321).

Commercial and Industrial: Demand is based on a per job basis and modified based on projected heating degree days for each year, assuming that 70% of natural gas is used for heating (RCP 8.5 model) based on national averages reported by US Energy Information Administration (https://www.eia.gov/energyexplained/use-of-energy/commercial-buildings.php). EIA reporting does not include projections for share of industrial sector natural gas used for heating, consequently we assume a lower value of 20% of industrial natural gas used for cooling with the balance used for industrial process needs (RCP 8.5 model).

Natural Gas emissions factors are projected to be unchanged.

Transportation:

Vehicle Miles Traveled is based on US Department of Transportation VMT per capita projections through 2050 (1.1% annual growth rate through 2037 and 0.8% annual growth rate from 2038 through 2050. https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.cfm

Vehicle fuel use is calculated based on US Energy Information Agency projected rolling stock average fuel efficiency projections, modified to 85% projected MPG to account for heavy duty vehicle MPG share (based on US Department of Transportation data on current light duty to average all vehicle MPG ratios) https://www.eia.gov/todayinenergy/detail.php?id=31332

Total vehicle stock is based on per household projections maintaining existing average number of vehicles per household through 2050 (1.7).

Electric Vehicle Adoption: National projections expect an increased uptake of electric vehicles in coming years. The Edison Electric Institute has estimated that electric vehicle will be 7% of all vehicles on the road in the country by 2030. (http://www.ehcar.net/library/rapport/rapport233.pdf, https://berla.co/average-us-vehicle-lifespan/).

Solid Waste:

Total Solid Waste handled is based on total number of households and maintaining existing volume per household and emissions factors per ton handled.

Wastewater:

Total Wastewater handled is based on total number of households and maintaining existing volume per household and emissions factors per household.

Note:

GHG emissions forecasts are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies. GHG forecasts in this report should be interpreted with a clear understanding of the assumptions that inform them and the limitations inherent in any modeling effort.

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City of Plymouth MINNESOTA

Ground Cover, Heat Island and Carbon Sequestration Study

October 2025
Revised: February 2026

Prepared by:

making change personal
paleBLUEdot LLC

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Section 01	**Introduction and Methodology**
Section 02	**Land Coverage Characteristics**
Section 03	**Land Cover Impacts and Benefits**
Section 04	**Tree Canopy Economic Value**
Section 05	**Findings**
Section 06	**Calculating Potential Goals**
Section 07	**Recommendations**
Appendix 1	**i-Tree Technical Notes**
Appendix 2	**Climate Adaptive Tree Species**

The true meaning of life is to plant trees, under whose shade you do not expect to sit.

Nelson Henderson

Introduction

Protecting the environment is a central priority for the City of Plymouth. The community has long invested in preserving natural areas through open-space protection, urban forestry, and water-resource stewardship. In recent years, Plymouth has expanded this work by advancing efforts to reduce its carbon footprint, cut waste, and lower overall energy use.

In July 2025, the City received a Climate Planning Grant from the Minnesota Pollution Control Agency (MPCA) and engaged paleBLUEdot to prepare a series of baseline assessment documents to inform development of its Climate Action and Resilience Plan (CARP). The CARP will serve as the City's roadmap for equitably advancing climate action and strengthening community resilience.

This Ground Cover, Heat Island, and Carbon Sequestration Study is one of several "Baseline Documents" supporting the planning process. Together, these assessments summarize existing conditions across a wide range of climate-mitigation and climate-adaptation considerations, providing a robust foundation for collaborative dialogue and action development throughout the CARP process.

Why Study the City Wide Tree Canopy?

Trees play a central role in supporting community health, improving air and water quality, helping to reduce building energy use, and supporting heat island and climate mitigation.

Community Health Benefit of Trees

Recent studies have shown that sometimes going to a park, or even looking at a single tree can significantly improve a person's health and stress levels. Our understanding of the value of trees has been expanded to include mental and physical health benefits. Trees are also critical in filtering air, removing harmful pollutants, such as Carbon Monoxide, particulate matter, and Ground-level Ozone - pollutants that can be toxic at high levels and which can cause asthma and other respiratory impacts.

Stormwater Management

Every tree catches the rain as it comes down, increasing the soil's capacity to retain water longer. A mature White Oak can intercept up to 12,010 Gallons of water in a single year. This water stays in the leaves until it's absorbed by the tree or evaporates to cool our air. Within an urban environment, this prevents that water from needing to be piped or treated by other stormwater infrastructure.

Introduction

Pollution Absorption

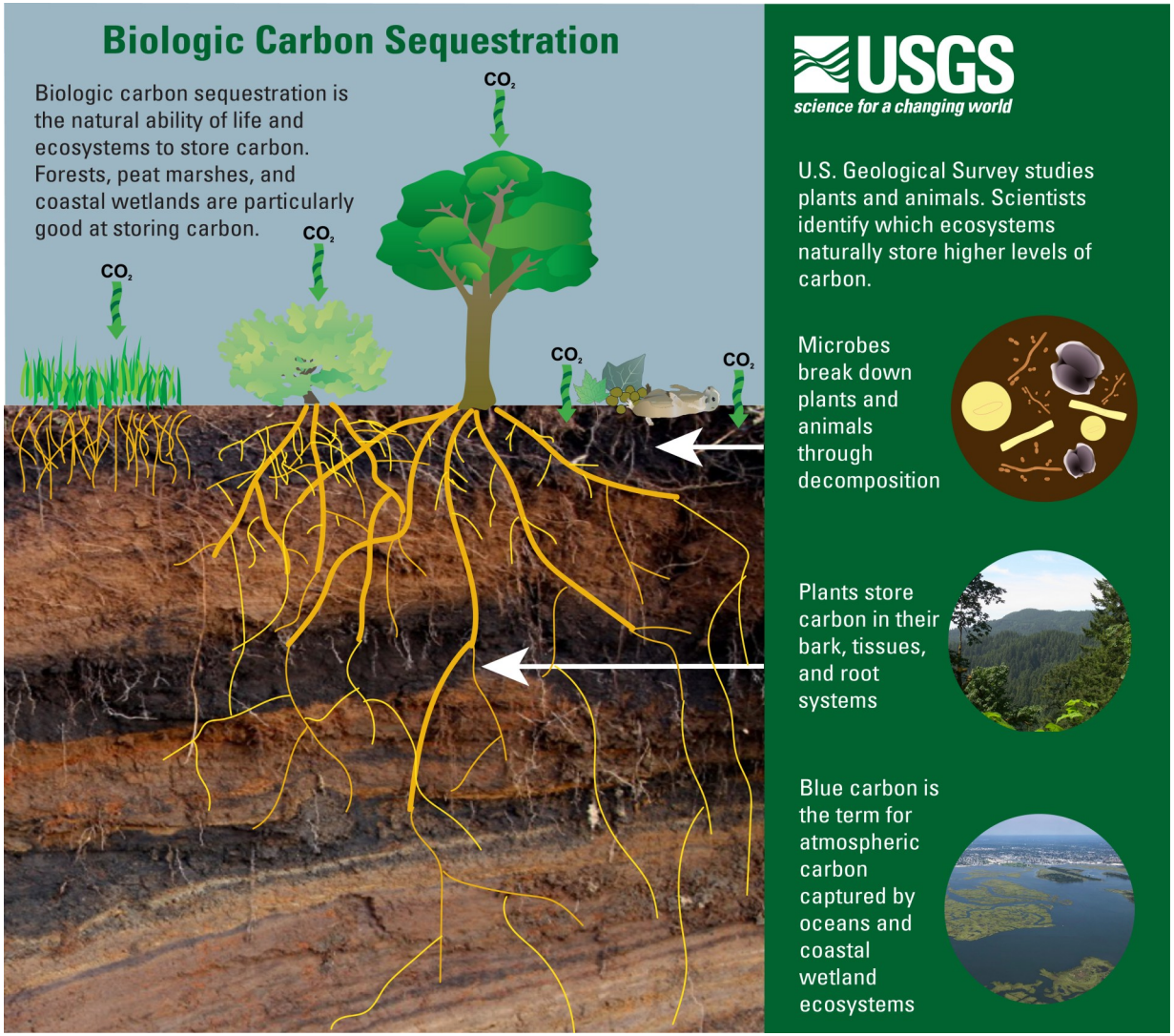
Trees primarily absorb gaseous air pollution through leaf stomata, with some gases captured by the plant surface. Inside the leaf, gases spread to intercellular spaces and can form acids or interact with inner surfaces. Trees also trap airborne particles. [1]

Heat Island and Micro Heat Island Mitigation

Tree transpiration and canopies influence factors like air temperature, wind speed, and surface roughness, impacting the mixing-layer height. This can change pollution levels in cities. For each percent increase in canopy cover, trees can reduce mid-day temperatures by 0.07 to 0.36 degrees F.[2]

Carbon Sequestration

Trees absorb carbon dioxide (CO2) and emit oxygen (O2) during photosynthesis. As they grow, the carbon integrates into their trunks, limbs, roots, and leaves. When tree parts decay or trees perish, the stored carbon returns to the atmosphere through respiration or combustion or moves into the soil.[3]



1: David Nowak, Air pollution removal by urban forests in Canada and its effect on air quality and human health; https://doi.org/10.1016/j.ufug.2017.10.019

2: Sevgi Yılmaz, et al., Determination of climatic differences in three different land uses in the city of Erzurum, Turkey; https://doi.org/10.1016/j.buildenv.2006.01.017

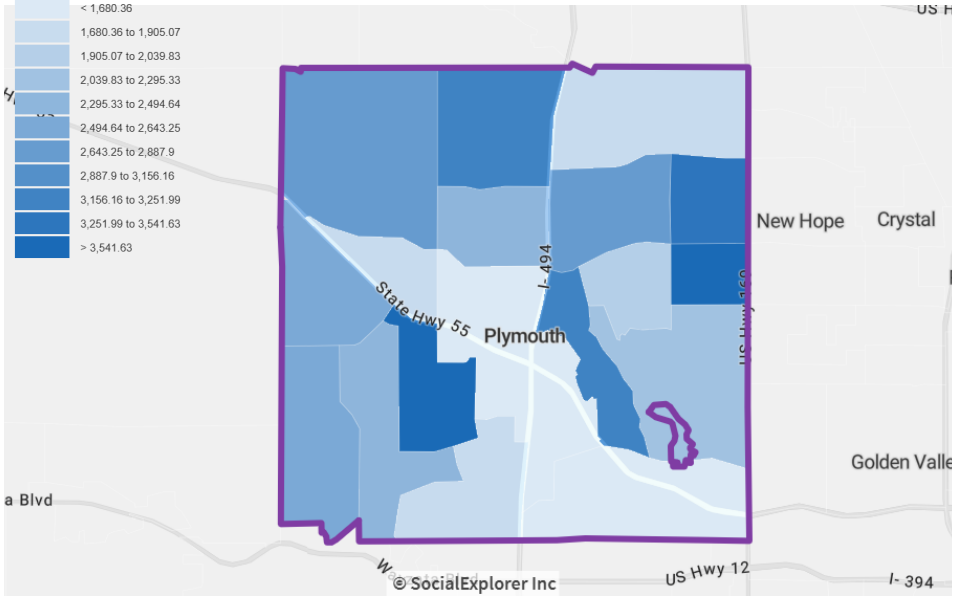
3: USDA Forest Service, Forests and Carbon Storage; https://www.fs.usda.gov/ccrc/topics/forests-and-carbon-storage-2012

Graphic Source:
USGS Climate Adaptation Science Centers

Land Coverage Categories Measured

Cover Class	Description
Agriculture / Crops	Cultivated crops, community garden, permaculture site
Dark Impervious - Buildings	Buildings with Dark Impervious Roof Surfaces
Dark Impervious - Pavement	Pavement with Dark Impervious Surfaces
Lawn	Maintained Grass Cover
Light Impervious - Buildings	Buildings with Light Impervious Roof Surfaces
Light Impervious - Pavement	Pavement with Light Impervious Surfaces
Prairie Grass / Wildflower	Wild, Native, Wetlands, and non-manicured grass cover
Tree/Shrub	Trees, large shrubs
Water	Open Water, Lake, Pond, River

Population Density of City of Plymouth Per Square Mile by Census Tract



Methodology

This study establishes recommended goals by analyzing tree canopy, grass/shrub, and impervious surface coverage through aerial imagery and the i-Tree Canopy Software. Aerial imagery is provided by either Google or Bing and is typically between 1 and 3 years old. This tool provides statistically valid estimates using random points. It was applied to interpret 9,836 points across Plymouth's 18 census tracts, maintaining a standard error of typically 0.2% to 2%.

Coverage categories include Trees/Shrubs, Lawn, Prairie Grass, Bare Ground, Water, Impervious Surface Light (buildings), Impervious Surface Light (pavement), Impervious Surface Dark (buildings), and Impervious Surface Dark (pavement). Calculations for Tree Canopy Benefits, Tree Canopy Values, Heat Island Contribution, Stormwater Runoff, and Carbon Sequestration were made by census tract, leading to recommendations for enhancing the city's tree canopy and green infrastructure in the report's Recommendations Section. More technical details are in Appendix 1.

Mapping in This Report

This assessment contains maps generated at the Census Tract level. They aim to convey, or relate to, relevant US Census Bureau data. Census boundaries, set by the Bureau, may not always match community boundaries. We choose boundaries that support the study without skewing aggregated community data. All areas within community boundaries are included in the plan this Baseline Document supports, even if not shown on a map.

Section 02

Land Coverage Characteristics

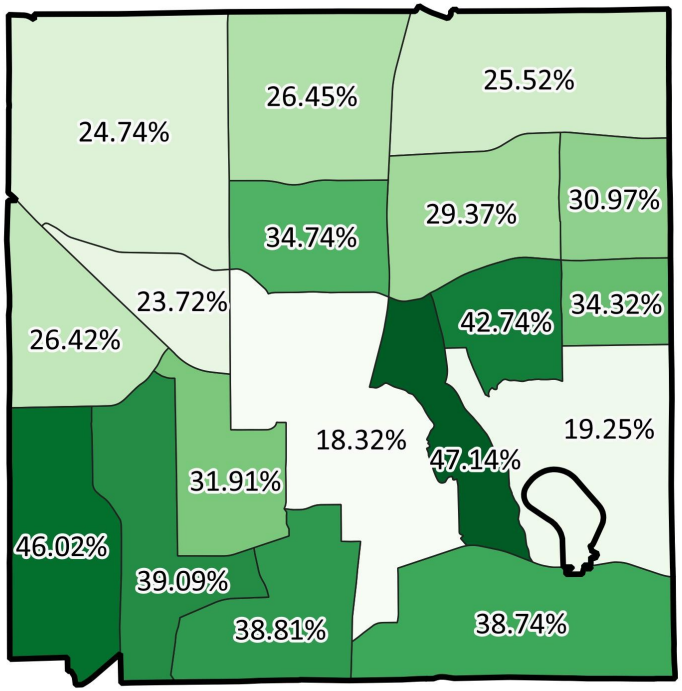
Classification of coverage categories included Tree Canopy, Grass, Water, Impervious Surface Light, and Impervious Surface Dark.

Tree Canopy Coverage*

City Average: **30.6%**

City High: **47.1%**
Tract 026505

City Low: **18.3%**
Tract 026514



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.

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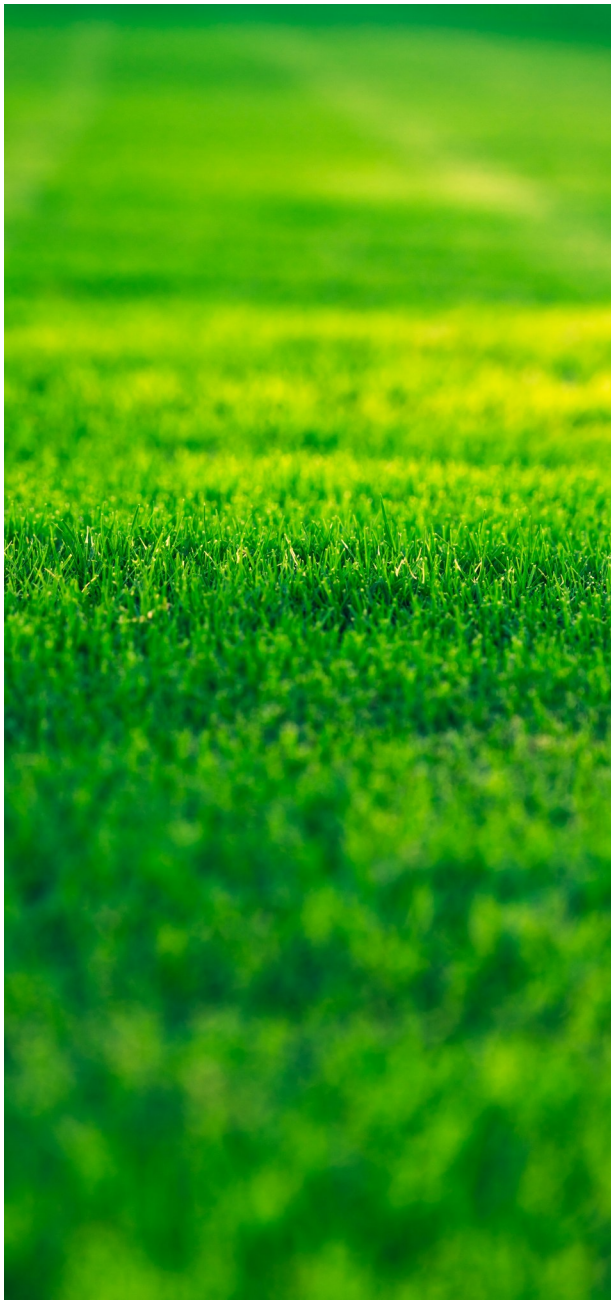
Land Coverage Characteristics

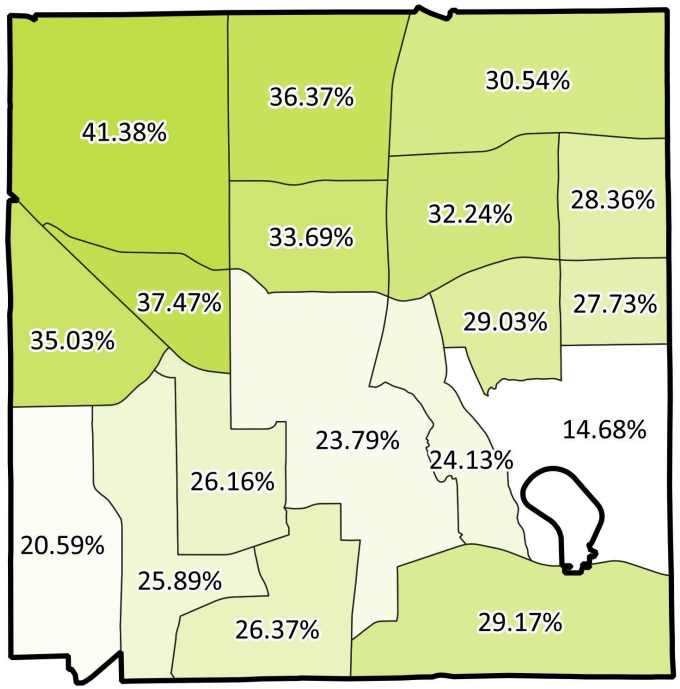


Lawn and Grass Coverage*

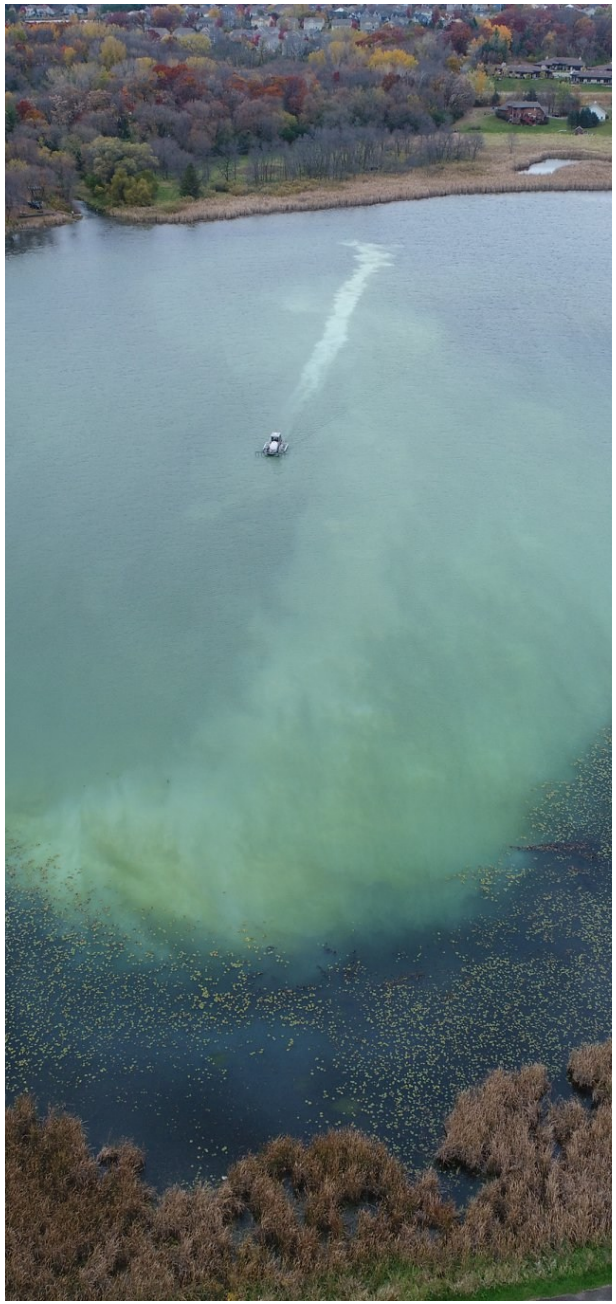
City Average: **29.7%**

City High: **41.4%**
Tract 026616

City Low: **14.7%**
Tract 026516



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.



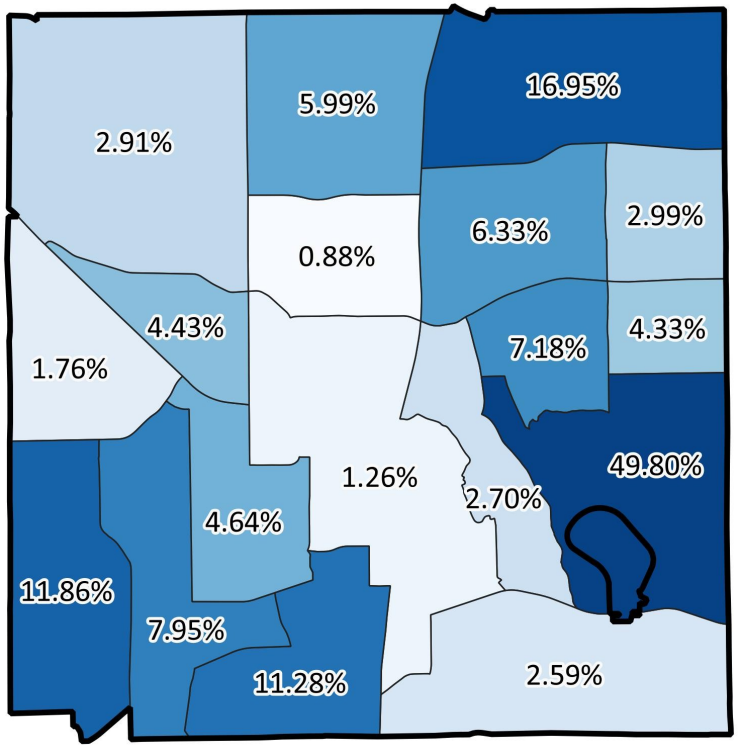
Land Coverage Characteristics

Open Water Coverage*
(does not include wetlands)

City Average: **7.7%**

City High: **49.8%**
Tract 026516

City Low: **0.9%**
Tract 026614



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.

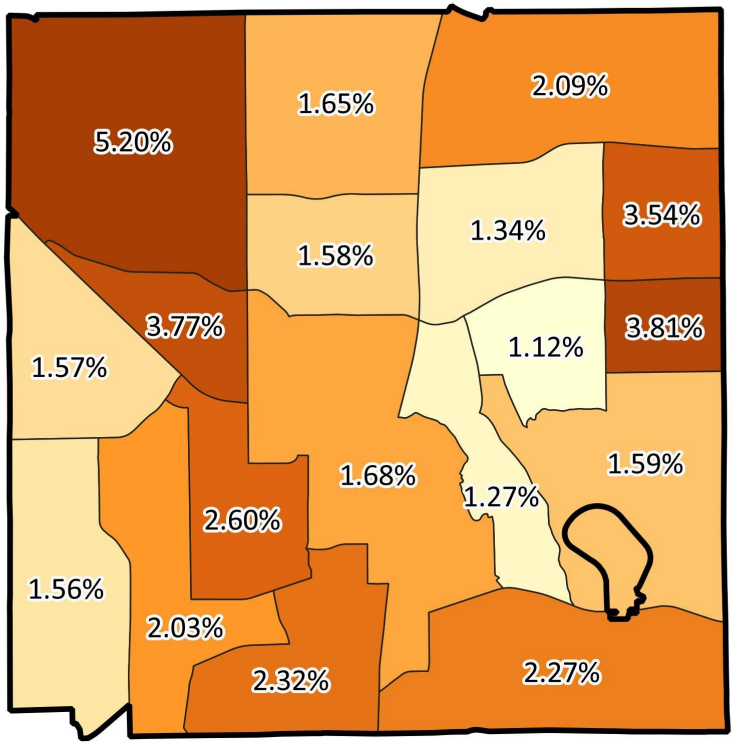
Land Coverage Characteristics

Bare Ground Coverage*
(may vary annually due to construction activities)

City Average: **2.4%**

City High: **5.2%**
Tract 026616

City Low: **1.1%**
Tract 026515



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.

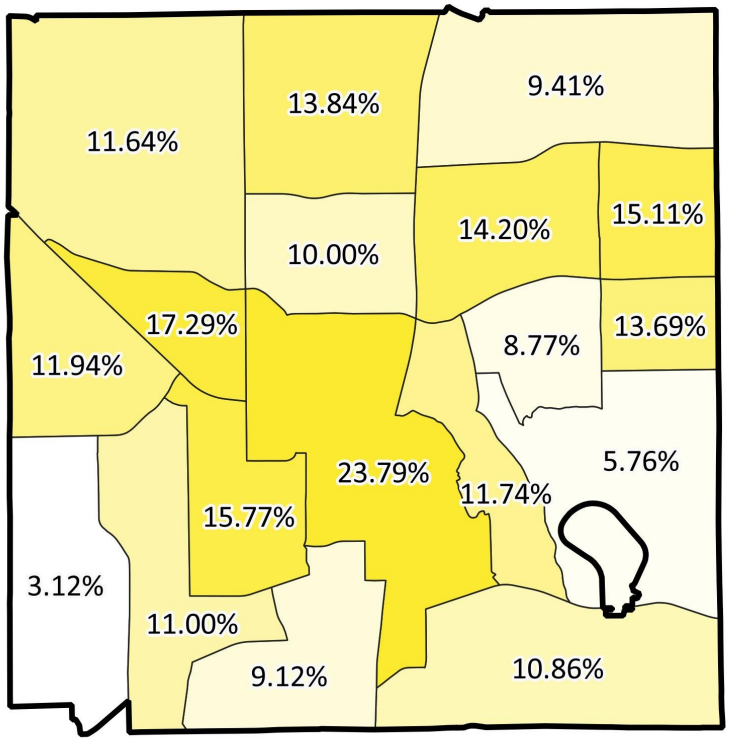
Land Coverage Characteristics

Light Impervious Surface Coverage* (buildings + pavement)

City Average: **12.4%**

City High: **23.8%**
Tract 026514

City Low: **3.1%**
Tract 026606



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.

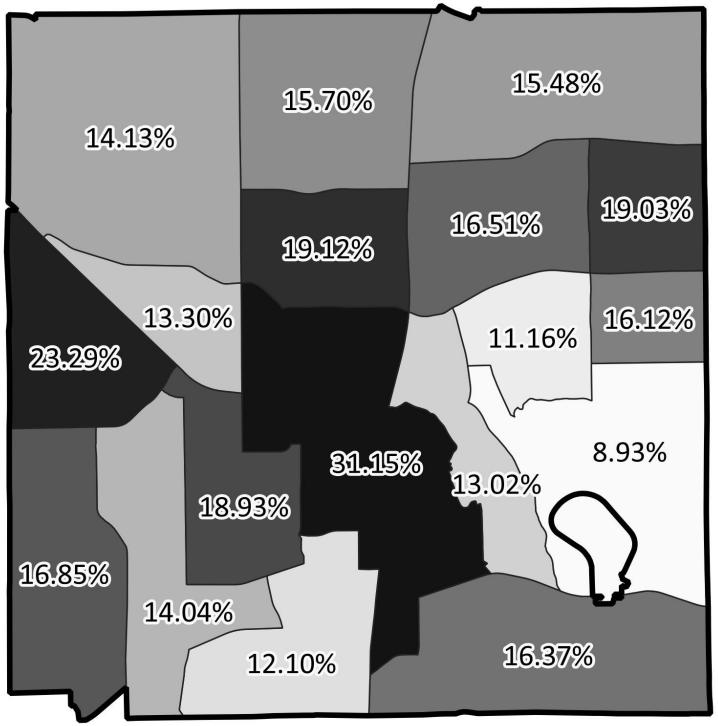
Land Coverage Characteristics

Dark Impervious Surface Coverage* (buildings + pavement)

City Average: **17.2%**

City High: **31.2%**
Tract 026514

City Low: **8.9%**
Tract 026516



* Data points taken on iTree using aerial images provided by either Google or Bing and is typically between 1 and 3 years old.

Section 03

Land Cover Impacts and Benefits

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The condition and health of a community's Tree Canopy and green infrastructure and the magnitude and nature of impervious surfaces have meaningful consequences on the area's environment. Estimating the baseline land cover contributions to the community's environment enables the City to project the impact of potential strategies and to track improvements over time. The following maps in this section diagram the impacts and benefits of the City's Tree Canopy, grass, and impervious surface coverage.

Pollution Absorption by Trees

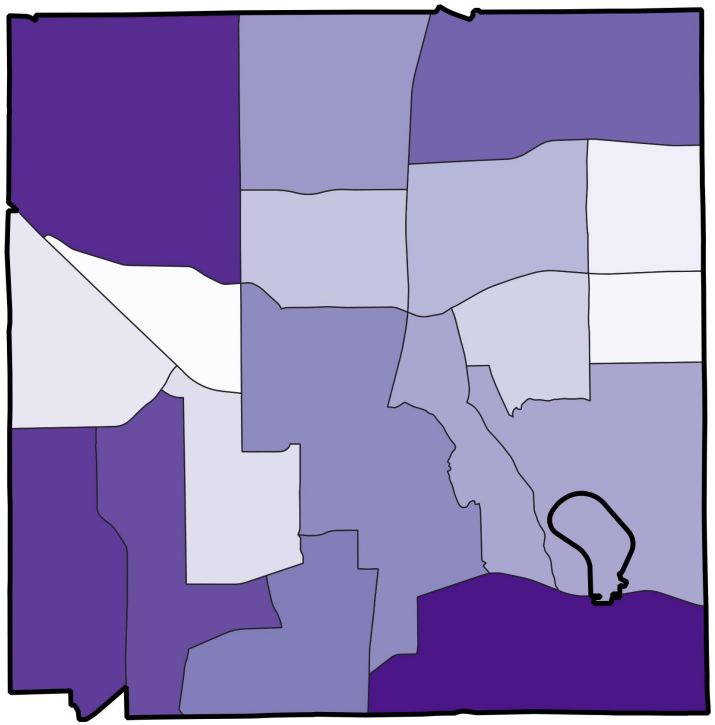
Air pollution is a major environmental concern in most major metropolitan areas globally. Air pollutants are known to increase incidents of heart disease, asthma, emphysema, and cancer. Meanwhile, global warming projections for Minnesota anticipate an increase in air quality impacts. Healthy tree canopies offer the ability to remove significant amounts of air pollutants and consequently improve environmental quality and human health.

Pollution Absorption by Trees - Particulates

Particulate matter pollution is divided into two categories: Fine Particulate (PM2.5) and Course Particulate (PM10). Numerous studies have linked fine particulate pollution with a number of health risks including respiratory disease, asthma, bronchitis, and increased heart disease and heart attacks. Course particulate matter has been shown to aggravate heart and lung diseases and to cause lung damage.

Land Cover Impacts and Benefits

Pollution Absorbed Annually by City's Tree Canopy[1]



Carbon Monoxide
1,491 lbs

31
36
47
60
61
63
66
72
79
84
89
93
102
103
134
140
150

Nitrogen Dioxide
30,569 lbs

640
740
964
1,232
1,257
1,292
1,358
1,486
1,618
1,619
1,719
1,833
1,915
2,098
2,107
2,739
2,871
3,081

Ozone
224,172 lbs

4,693
5,429
7,069
9,034
9,214
9,473
9,962
10,898
11,867
11,872
12,607
13,440
14,046
15,382
15,449
20,086
21,054
22,596

Sulfur Dioxide
3,341 lbs

105
135
137
141
148
162
177
188
200
209
229
230
299
314
337
70
81

Fine Particulate (PM2.5)
9,637 lbs

202
233
304
388
396
407
428
468
510
542
578
604
661
664
864
905
971

Course Particulate (PM10)
81,800 lbs

1,713
1,981
2,579
3,297
3,362
3,457
3,635
3,977
4,330
4,332
4,600
4,904
5,125
5,613
5,637
7,330
7,683
8,245

1: USDA Forest Service iTree Canopy; https://www.itreetools.org/

Land Cover Impacts and Benefits

Pollution Absorption - Carbon

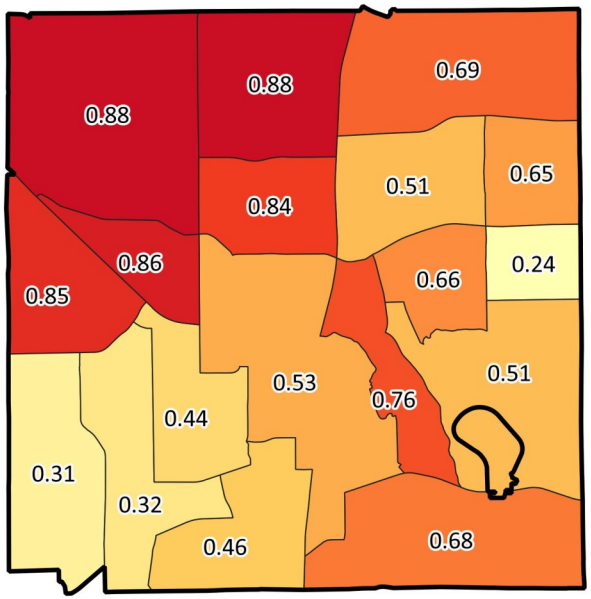
Carbon Dioxide pollution is the largest human-made emission contributing to Global Warming. Carbon sequestration helps reduce atmospheric greenhouse gases by capturing CO2. This can be natural or technology-driven, like in carbon capture projects. The two main methods are geologic and biologic, with trees and grasses being key for biological sequestration.

During growth, plants capture carbon and store it in their structure and soil. For every 3.663 pounds of CO2 sequestered, 1 pound of carbon is stored. The following diagrams estimate carbon sequestration in Plymouth's census tracts using trees and grasses. (Note: These are rule-of-thumb values; actual rates can vary widely based on factors including land management practices, soil types, and topography)

Annual Carbon Sequestration by Grasses per Acre

4,191 Metric Tons

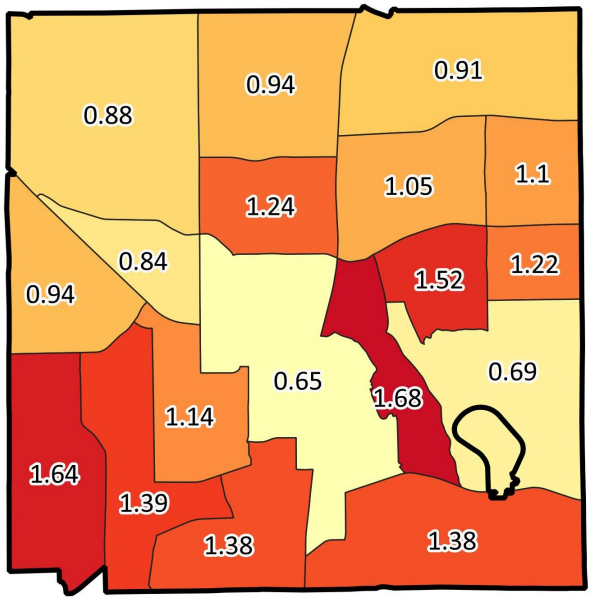
Values in Metric Tons / Acre



Annual Carbon Sequestration by Trees per Acre

22,911 Metric Tons

Values in Metric Tons / Acre



Pollution Absorption - Carbon

The combined carbon sequestration services of grasses and trees throughout the community can be seen as a measure of equity of green infrastructure when viewed on a per-acre basis. Higher per-acre carbon sequestration rates reflect combined higher rates of per-acre green infrastructure (trees and grasses). In addition, these per-acre values can help guide future tree canopy increase goals by focusing on portions of the community with lower per-acre baselines.

See Sections 05, 06 and 07 for a framework for prioritizing, calculating, and projecting example tree canopy goals. Note, the proposed framework does not include land in use as agriculture in calculations of potential tree canopy increases.

Total Annual Carbon Sequestration of Green Infrastructure per Acre
(excluding agriculture)

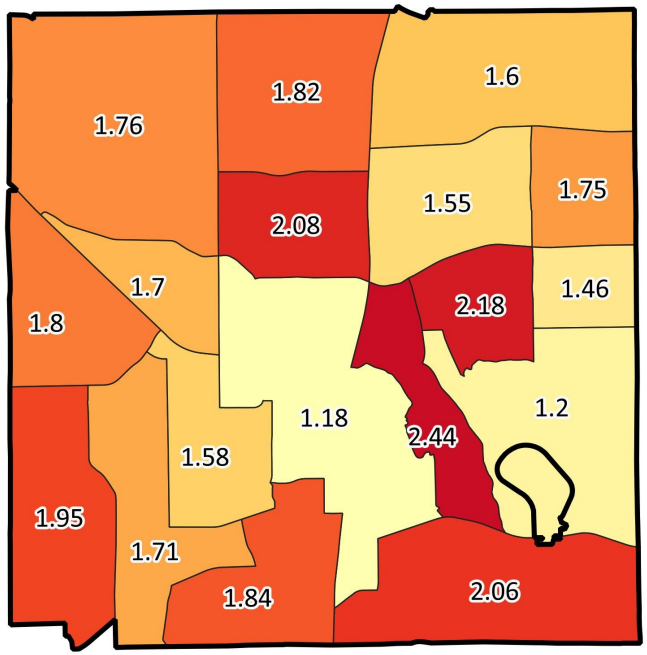
27,102 Metric Tons

Values in Metric Tons

City Average: **1.76**

City High: **2.44**
Tract 026505

City Low: **1.18**
Tract 026514



Land Cover Impacts and Benefits

Energy Savings

Trees in urban areas modify climates by providing shade, blocking winds, and cooling through leaf evaporation. For precise energy savings, tree positions relative to buildings must be closely examined. Trees that influence building energy use, like those shading a building from summer sun, are termed energy-affecting trees.

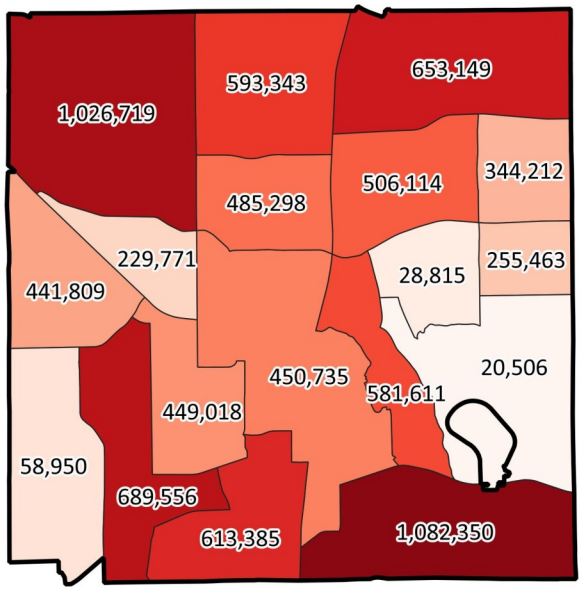
On a broader scale, we can estimate energy savings using average energy-affecting trees per acre from the study on US residential building energy conservation.[2] With these figures, we can gauge the electrical and gas savings of Plymouth's tree canopy.

2: David J. Nowak, et al "Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States", https://doi.org/10.1016/j.ufug.2016.12.004

Estimated Electricity Savings From City's Tree Canopy[2]

8,510,804 kWh (annually)

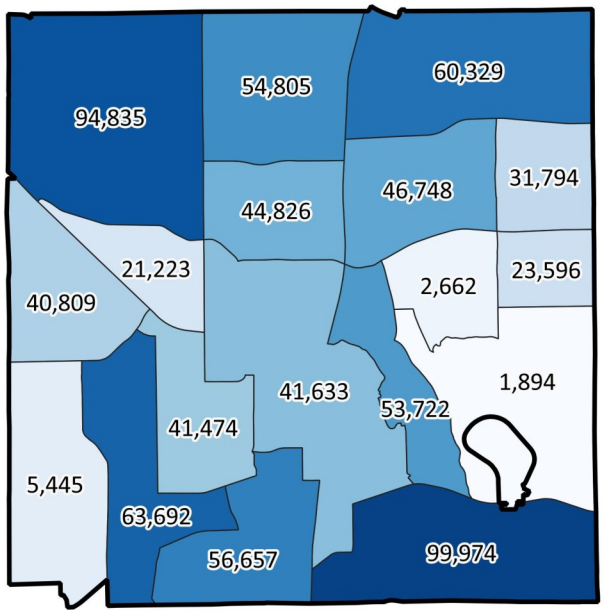
Values in kWh



Estimated Heating Savings From City's Tree Canopy[2]

786,118 Therms (annually)

Values in Therms



Heat Island Contribution

Heat islands result from higher temperatures in developed areas compared to rural ones, due to human activities and infrastructure. This phenomenon increases discomfort and health risks during hot periods.

NOAA predicts that, if greenhouse gas emissions continue unchecked, Plymouth will see more days above 95° F (refer to Plymouth's Climate Vulnerability Assessment). Depending on various factors like humidity and access to air-conditioning, such temperatures can cause discomfort, heat stress, illness, or even death. Therefore, addressing Heat Island effects is crucial for Plymouth.

A 2006 study by Minnesota State University and the University of Minnesota[3] links a city's impervious surface percentage to its heat island temperature rise, with variations by season. For our analysis, we've focused on the summer ratio since heat-related risks intensify during heat waves. The provided numbers for regions indicate potential temperature increases if a city had uniform impervious characteristics like that region. These numbers do not necessarily represent the actual summer time temperature difference from tract to tract, but instead are a representation of the comparative level of overall heat island impacts for the overall community.

3: Fi Yuan and Marvin Bauer, "Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery"; https://www.sciencedirect.com/science/article/abs/pii/S0034425706003191

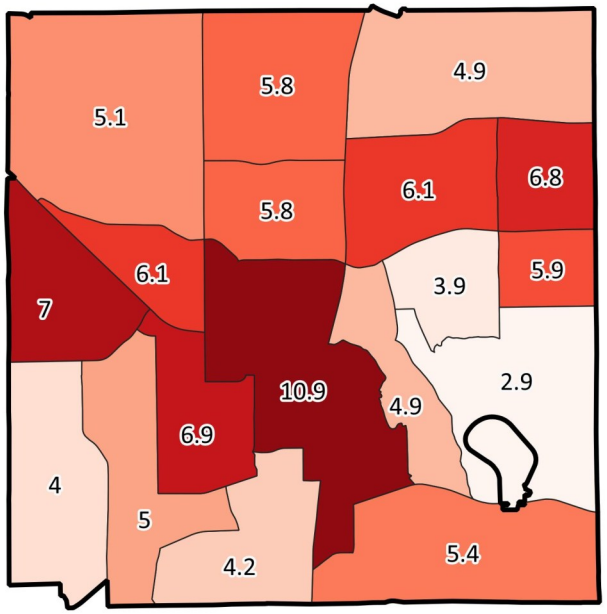
Estimated Micro Heat Island Contribution of City of Plymouth Impervious Surfaces[3]
(summer values)

Values in ° F

City Average: **5.9°F**

City High: **10.9°F**
Tract 026514

City Low: **2.9°F**
Tract 026516



Land Cover Impacts and Benefits

Stormwater Runoff From Impervious Surfaces

Increases in impervious cover can dramatically increase the impact of so-called 100-year flood events. Typically, floods in areas of high impervious surfaces are short-lived, however, they do carry risks to infrastructure and vulnerable populations. Extended flooding can stress trees, leading to leaf yellowing, defoliation, and crown dieback. If damage is severe, tree mortality can occur. In addition, flooding can lead to secondary attacks by insect pests and diseases. Some species are more tolerant of flooding than others.

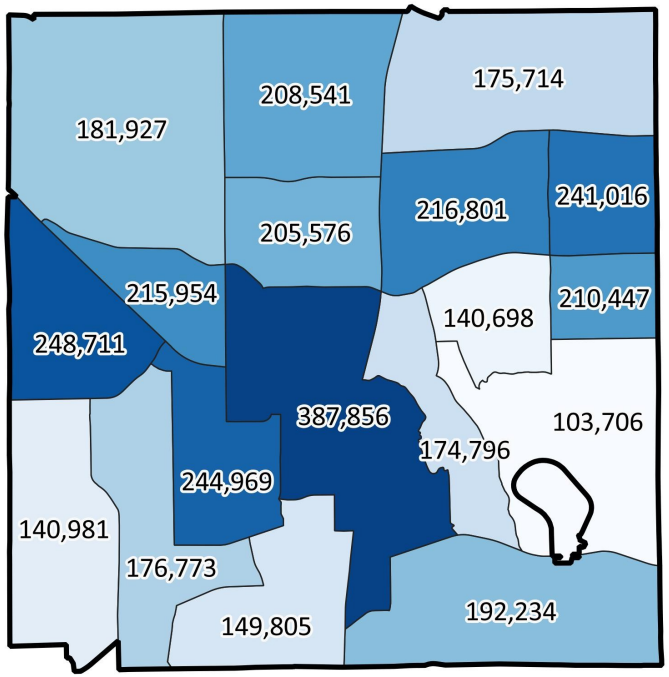
According to data from National Climatic Data Center and NOAA, the City receives 26" of precipitation annually. That total precipitation level and the impervious surface coverages can then be used to estimate the total potential stormwater runoff values by census tract (rainfall x area) as indicated below.

NOAA predicts that, if greenhouse gas emissions continue unchecked, Plymouth will see more annual precipitation as well as an increase in heavy precipitation events (refer to Plymouth's Climate Vulnerability Assessment). The increase in heavy precipitation events, in particular, increases the sensitivity to stormwater runoff in certain areas of the city.

Estimated Potential Stormwater Runoff Generated City of Plymouth's Impervious Surfaces Annually

City Total:	**4.4** Billion Gallons
City Average:	**209,122** Gallons / Acre
City High:	**387,856** Gallons / Acre (Tract 026514)
City Low:	**103,706** Gallons / Acre (Tract 026516)

Values in 1,000 Gallons / Acre



Stormwater Uptake by Green Infrastructure

Green Infrastructure like native grasses, wetlands, and trees play a vital role in stormwater management. They help maintain and mimic the natural water cycle, often disrupted by urban development.

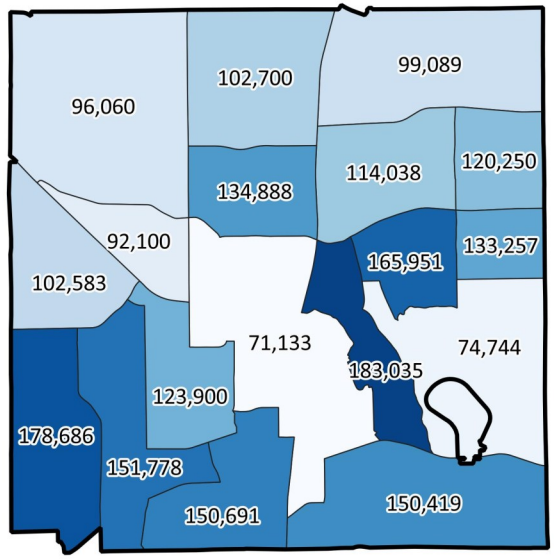
To gauge stormwater uptake by census tract, we used data from studies on urban tree canopy and grass water uptake.[4, 5, 6, 7, 8] Accurate values require detailed soil hydrology and runoff curve numbers. This study serves as a comparative tool between census tracts.

Estimated Stormwater Uptake by Trees Per Acre

City Total: **2.5** Billion Gallons

City Avg: **118,729** Gallons / Acre

Values in 1,000 Gallons / Acre

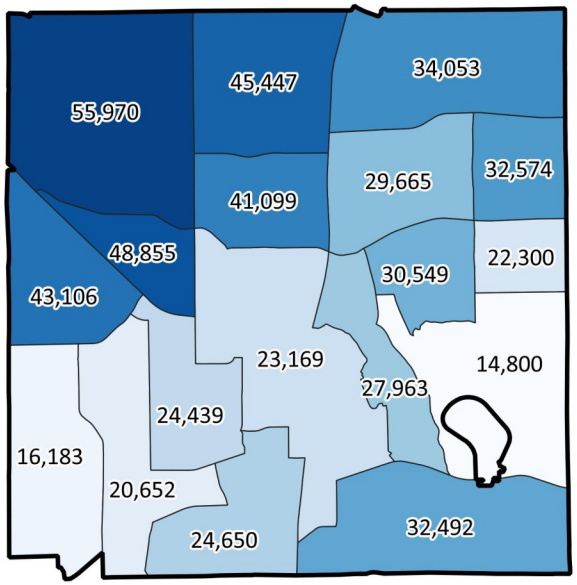


Estimated Stormwater Uptake by Grasses Per Acre

City Total: **694.8** Million Gallons

City Avg: **33,027** Gallons / Acre

Values in 1,000 Gallons / Acre



Land Cover Impacts and Benefits

Stormwater Runoff Uptake Need Potentially Unmet

To determine the possible gap in stormwater management, we take the estimated total stormwater runoff from the City's impervious surface and subtract the estimated amount the city's green infrastructure can handle. This difference shows the potential for stormwater management shortfall for each census tract. While this doesn't indicate daily risks, it could highlight vulnerabilities during heavy rainfall or extreme weather events.

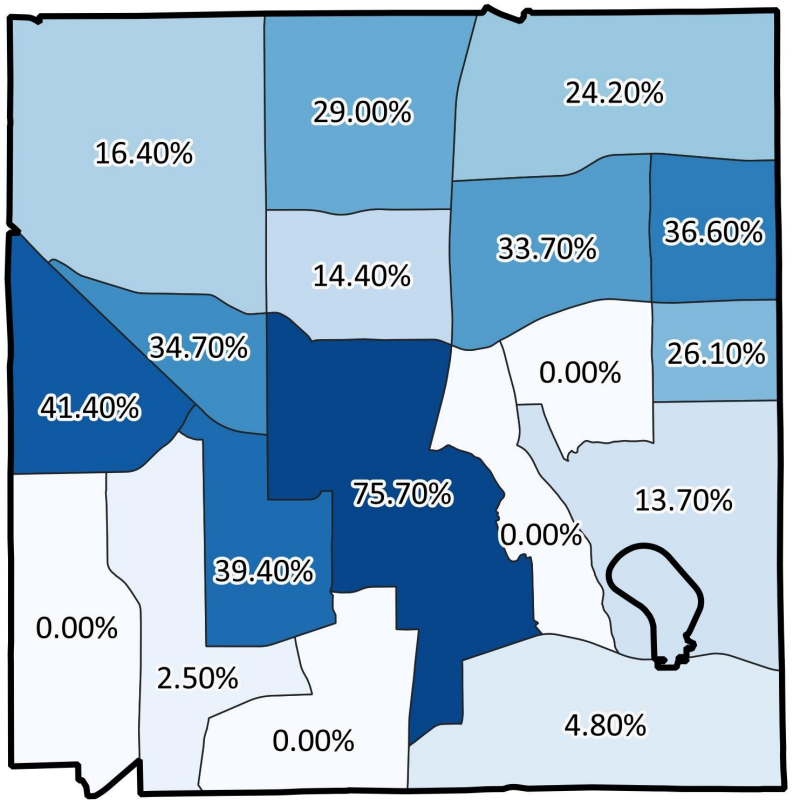
For precise values and to identify specific flood risks, a comprehensive hydrology study is essential. However, this estimation helps gauge the relative risk of flash floods or other stormwater impacts associated with heavy precipitation in each tract. It offers a starting point to decide where detailed research should be done and where green infrastructure or surface reduction strategies might be most needed.

Estimated Stormwater Runoff Uptake Need Potentially Unmet by Green Infrastructure

City Average: **27.4%** of estimated potential runoff

City High: **75.7%** of estimated potential runoff
Tract 026514

City Low: **0%** of estimated potential runoff
Multiple Tracts



Section 04

Tree Canopy Economic Value

Click here to return to TOC

Recently, the USDA Forest Service developed models with partners to help cities evaluate their tree resources' economic and environmental worth. Benefits in Section 3 have both economic and environmental value.

Air Pollution Removal Values

Section 3 mentions six pollutants as defined by the U.S. EPA: carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), sulfur dioxide (SO2), particulate matter (PM), PM less than 2.5 microns (PM2.5), and PM between 2.5 and 10 microns (PM10).

Estimates for pollution removal come from the USDA iTree Canopy tool and are based on EPA's BenMAP.[1] Using various data, it gauges pollution removal and values in urban/rural areas. Values per ton removed are: CO at $0.44 | NO2 at $0.20, O3 at $0.96, SO2 at $0.07, PM2.5 at $33.56, PM10 at $1.97, and CO2 at $118.02.

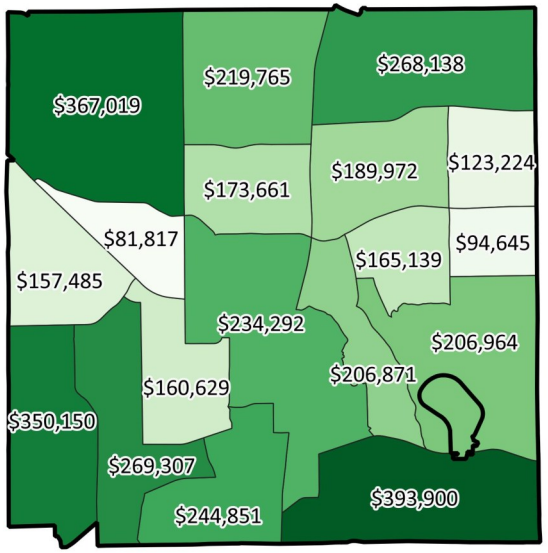
Building Energy Savings Values

Section 3 explains how to estimate energy savings using tree counts per acre based on a study. With these averages, we can calculate the electrical and gas savings from the City's tree canopy using average costs for electricity and natural gas.

1: USDA iTree Methods: https://www.itreetools.org/support/resources-overview/i-tree-methods-and-files

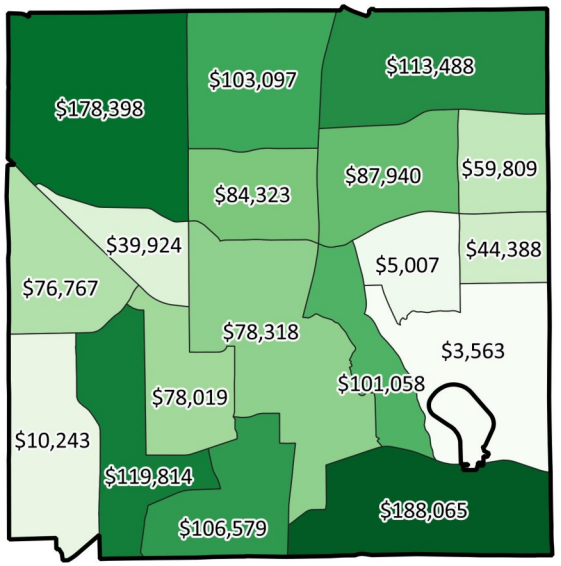
Annual Pollution Absorption and Carbon Sequestration Value of Trees

$3,907,829



Annual Energy Savings Value of Trees

$1,478,800



Tree Canopy Economic Value

Tree Value

The economic benefits outlined on the previous page can be viewed on the basis of value-per-acre and value-per-household to establish an understanding of tree benefit equity throughout the City.

Tree Canopy Benefit Per Acre

City Average:

$256

City High:

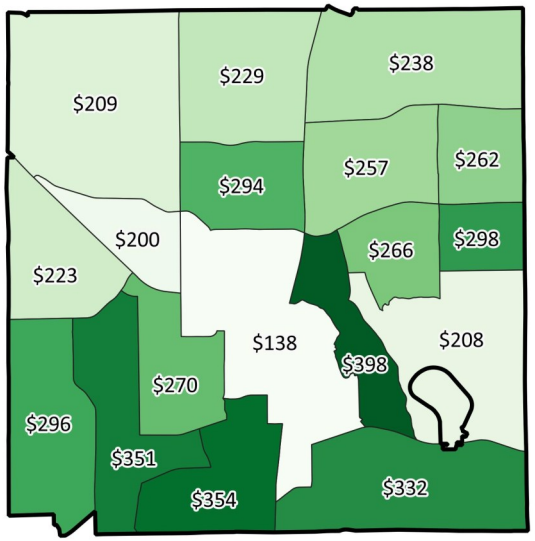
$398

Tract 026505

City Low:

$138

Tract 026514



Tree Canopy Benefit Per Household

City Average:

$165

City High:

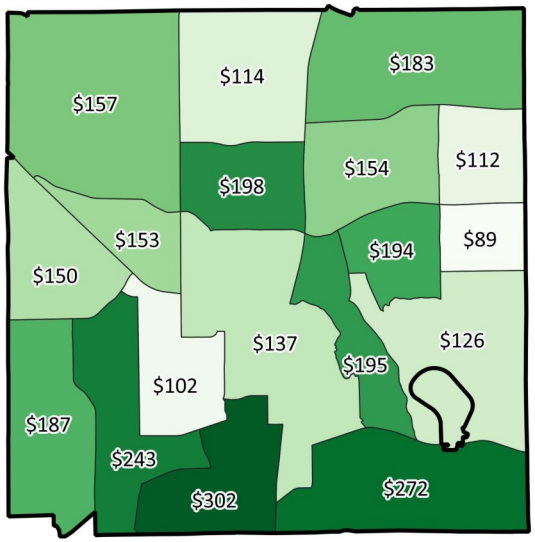
$302

Tract 026609

City Low:

$89

Tract 026511

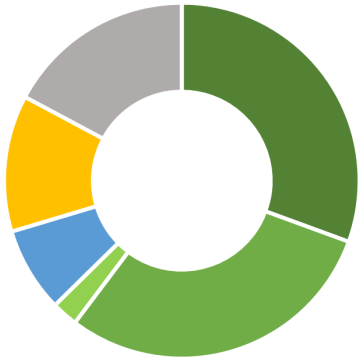


Section 05 Findings

The health of the city's green infrastructure and the impacts of impervious land cover affect everyone in the community and city policies and actions should consider needs of the entire community. As with all planning efforts landcover planning benefits from analysis in order to assist in establishing priorities for efforts. An effort to structure a prioritization should not be seen as an attempt to discard the need to address or improve land cover impacts for any neighborhood of the city - whether or not it is defined as one of the "priority" neighborhoods. Prioritization, however, is necessary to ensure the greatest impact and effectiveness of limited city resources.

To assist in prioritization, in the following pages, this report reviews the community green infrastructure and impervious surface data through "filters" in order to arrive at a recommended prioritization of neighborhoods for policy action. These "filters" are based on the land coverage information detailed in Section 2 of this report.

Ground Cover Breakdown by Type



30.6%	Trees/Shrubs
29.7%	Grass Cover
2.4%	Bare Ground
7.7%	Water
12.4%	Light Impervious
17.2%	Dark Impervious

Water category does not include wetlands.

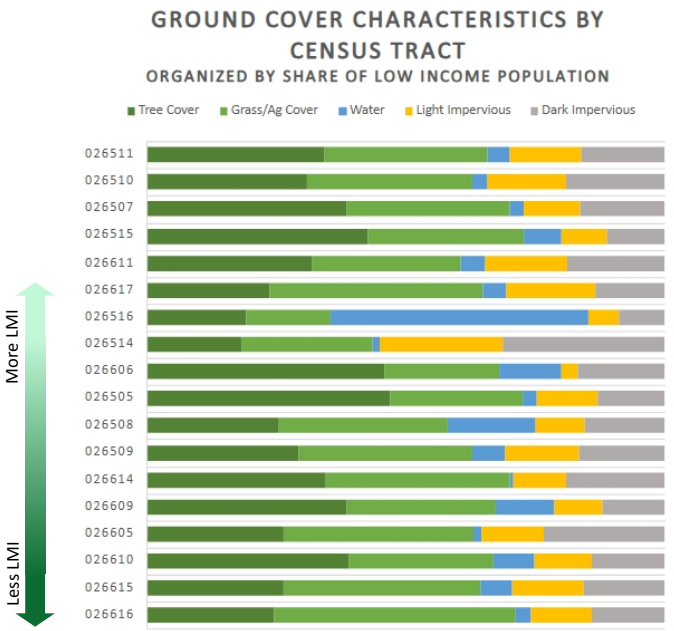
Click here to return to TOC

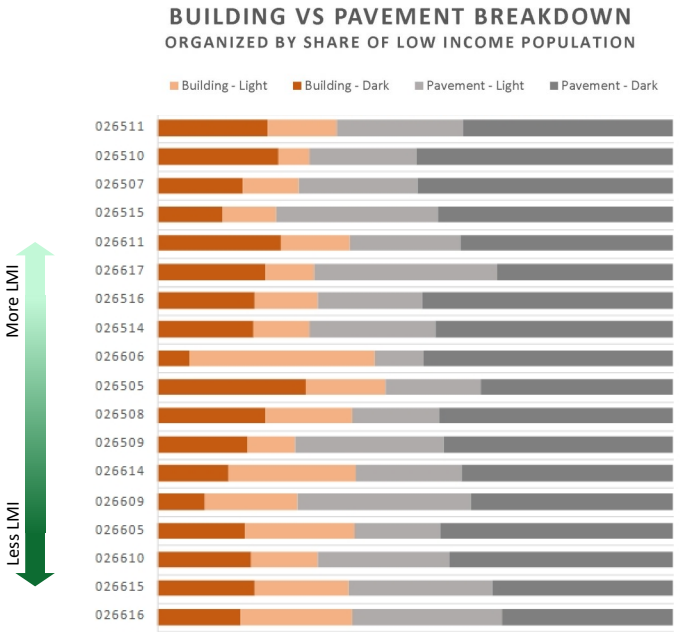
Ground Cover Characteristics by Census Tract

Organized by Share of Low Income Population (LMI)

The bar chart to the upper right compares land cover data from Section 2 by Census Tract while the bar chart to the lower right compares types of impervious surface coverage by Census Tract. In each chart, tracts with the most low-income households (LMI) are at the top and the least at the bottom.

The charts do not show a consistent link between LMI populations and total tree canopy or impervious surface coverage. However, there is a slight trend towards higher dark impervious coverage share within census tracts with higher LMI communities.





Review Criteria - Increased Tree Canopy

Prioritization of locations for increased tree canopy included in this report is based on existing land-use, demographics, and increased ecosystem and public health benefits of increased tree plantings.

To determine the best locations to plant trees, tree canopy and impervious cover maps developed for this report's Section 2 were used in conjunction with U.S. Census data to produce an index of priority planting areas by neighborhood. Index values were produced for each neighborhood with higher index values relating to higher priority of the area for tree planting. This index is a type of "environmental equity" index with areas with higher human population density, higher economic stress, lower existing tree cover, and higher total tree canopy potential receiving the higher index value. The criteria used to make the index were:

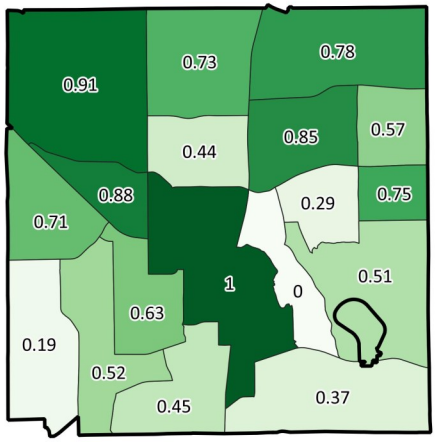
- Potential for New Trees
- Low Income Density
- Population Density
- Heat Island Reduction Need

These criteria are then combined to establish a "Weighted Priority Tree Canopy Increase."

Prioritization based on

Potential for New Trees

Higher values represent increased potential for tree planting based on physical capacity (available open space, open lawn areas, etc). Available open space does not include land in use as agriculture.

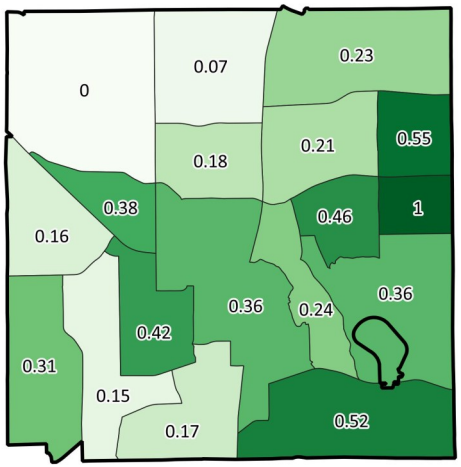


Prioritization Index
(higher # = higher priority)

Prioritization based on

Low Income Density (equity adjustment)

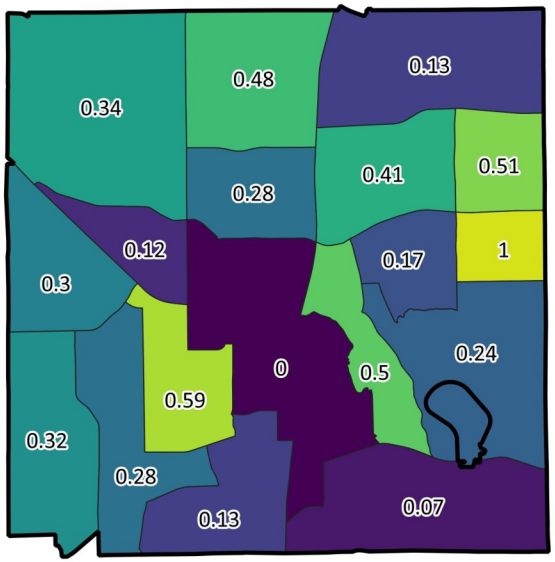
Higher low income density values represent higher potential for increasing environmental equity of tree canopy cover and benefits.



Prioritization Index
(higher # = higher priority)

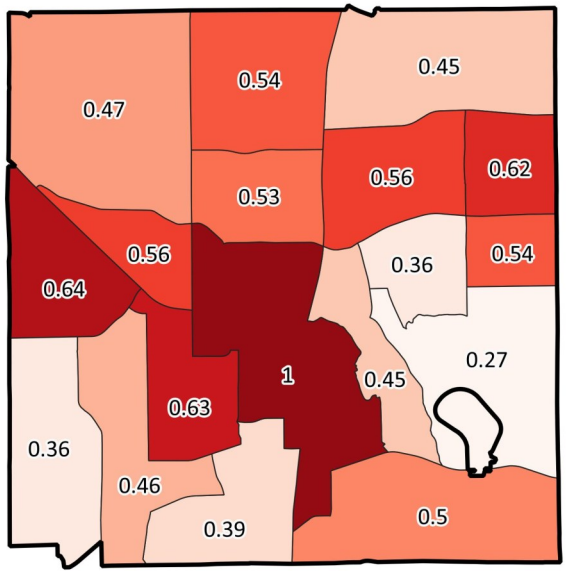
Findings

Prioritization based on
Population Density
The greater the population density, the greater the opportunity for tree planting to impact community members. Population densities shown are estimates based on US Census data by tract. Higher numbers represent higher prioritization based on this category.



Prioritization Index
(higher # = higher priority)

Prioritization based on
Heat Island Reduction Need
Higher heat island reduction need values represent increased potential for reducing current and future heat island impacts through tree planting.



Prioritization Index
(higher # = higher priority)

Importance of Ground Cover and Heat Island Mitigation
A study by the University of Wisconsin-Madison found that the warming effect of impervious surfaces within developed areas was effectively countered by the cooling effect of trees, especially when tree canopy coverage was 40% or greater.[1] The same study found that reducing overall coverage of impervious surfaces is critical for the reduction of night-time summer temperatures.

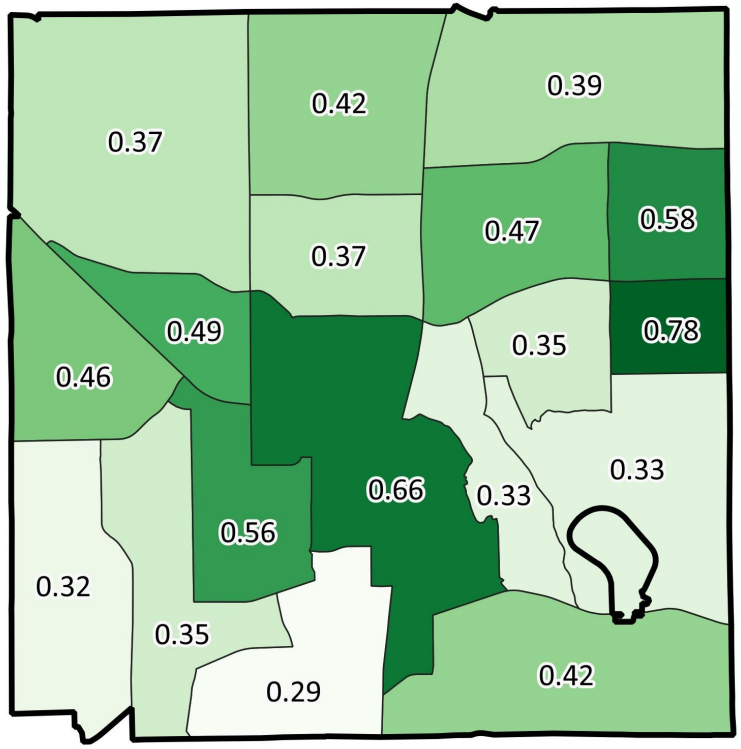
1:Carly D. Ziter, et al, "Scale-dependent interactions between tree canopy cover and impervious surfaces reduce daytime urban heat during summer," University of Wisconsin-Madison, 2019; https://doi.org/10.1073/pnas.1817561116

Weighted Priority Tree Canopy Increase

The weighted prioritization for tree canopy increase looks to balance the potential for increased tree canopy with the opportunity to improve tree canopy benefit equity, potential to positively impact as many households as possible, and the need for mitigation of heat island impacts. Higher numbers represent higher prioritization, however, this prioritization does not imply tree canopy increase should not be encouraged in all census tracts.

The priorities above are weighted as follows:
Potential for New Trees: 15%
Low Income Density (equity adjustment): 30%
Population Density: 15%
Heat Island Reduction Need: 40%

Prioritization Index
(higher # = higher priority)



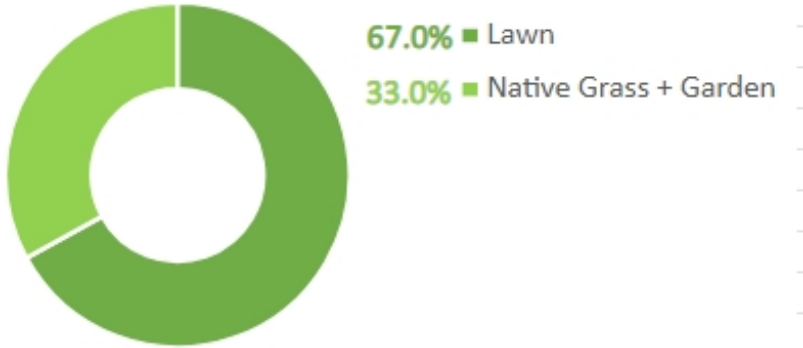
Findings

In addition to opportunities to expand and improve the City's tree canopy, the findings of the ground cover study as outlined in Section 2 may be used to identify additional opportunities for increased heat island mitigation and increased native grass installations.

Turf Reduction Potential

As illustrated in the chart to the right, an estimated 33.0% of all grass ground cover in the City of Plymouth are native and wildflower grasses. The remaining 67.0% are manicured lawns - representing a great opportunity for turf reduction. Turf reduction can increase stormwater uptake, reduce potable water use, and increase soil carbon.
Note, these ground cover calculations do not include agricultural / crop lands.

Comparing Lawn and Native Grass Coverage

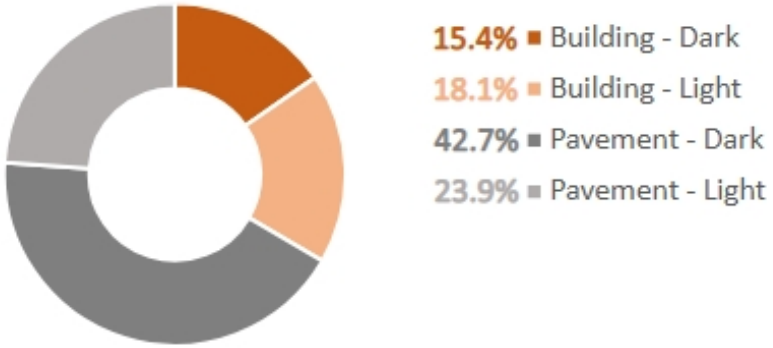


Impervious Surface Characteristic

Overall, imperious surfaces cover 29.6% of all land area in the City of Plymouth. Implementing strategies to reduce both light and dark impervious surfaces, particularly in high density areas and areas with limited green infrastructure, can decrease the potential for stormwater management challenges, flash flood risk, and heat island impacts.

As outlined in Section 3, the City's experiences of heat island are directly impacted by the level of impervious surface coverage, particularly dark roofs and pavement. As the diagram to the right illustrates, dark pavements make up 42.7% while dark roof structures make up 15.4%, totaling 58.1% of all impervious surfaces being classified as "dark." These represent significant opportunities for decreasing heat island impacts in the community through "cool" and "green" roof and pavement strategies.

Comparing Dark Impervious Surface Coverage



ATTENTION

Section

06

Calculating Potential Goals

Click here to return to TOC

Calculating Tree Canopy Coverage Goal for 2040

This report provides a sample tree canopy goal to assist the City's CARP planning process. The goals here are initial benchmarks for planning and help grasp the connection between tree canopy objectives, potential effects, and the extent of effort needed to achieve them.

The CARP plan is anticipated to have 2035 interim goals and 2050 long-range goals. Given the uncertainties and variables in setting multi-decade objectives, this report a 2040 goal for tree canopy coverage, with longer term goals to be determined after implementing the CARP plan.

An "Environmental Equity" approach from Section 05 shapes the 2040 goal. This method evaluates census tracts based on potential for new trees, low income density, population density, and heat island reduction need. The proposed framework does not include land in use as agriculture in calculations of potential tree canopy increases.

The recommended, or example, tree canopy increase goals are:

For neighborhoods in the top 1/3rd Neighborhood Priority Ranking: **10%**

For neighborhoods in middle 1/3rd Neighborhood Priority Ranking: **6.25%**

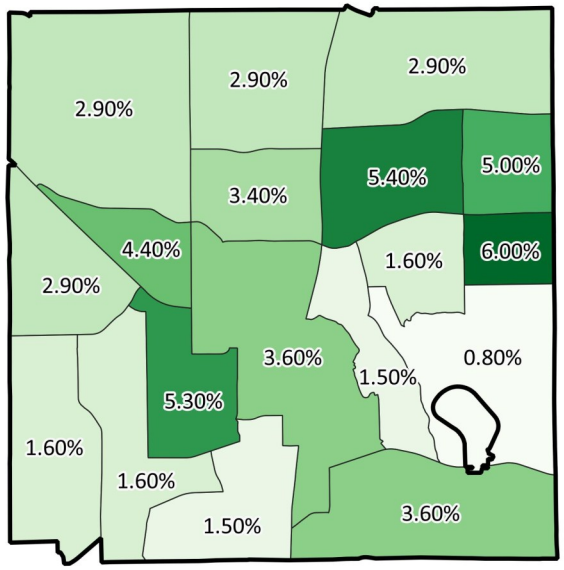
For neighborhoods in bottom 1/3rd Neighborhood Priority Ranking: **2.5%**

Tree Canopy Goal as Increase in Absolute Ground Cover Percentage

City Average: **3%**

City High: **11%**
Tract 59.01

City Low: **0.7%**
Tract 73.17

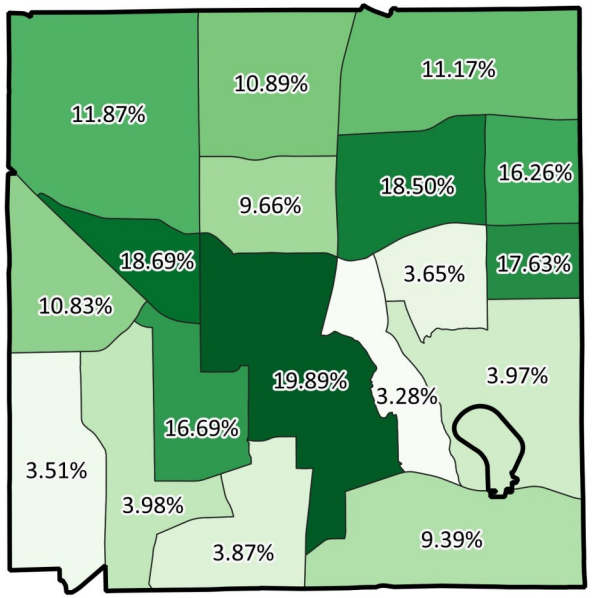


Tree Canopy Goal as Percentage Increase Over Existing Tree Canopy Area

City Average: **10%**

City High: **19.9%**
Tract 265.14

City Low: **3.3%**
Tract 265.05



Calculating Potential Goals

New Tree Plantings Needed to Achieve Tree Canopy Coverage Goal for 2040

While it is easy to think of the long range tree canopy coverage goals for each neighborhood in terms of planting trees, it is critical that tree canopy enhancement goals include a combination of tree protection, tree maintenance, and tree planting in order to be fully realized and efficiently implemented.

A common calculation used to determine the new tree planting requirements is based on a report by the USDA Forest Service.[1] That report offers the following conceptual analysis for increasing UTC:

CB + CG - CM + CN = CT

Where:
CB= the existing Tree Canopy;
CG= the growth of existing Tree Canopy (protection and maintenance);
CM= Tree Canopy mortality or loss due to natural and human-induced causes (including removal of invasive species).
CN= Tree Canopy increase from new trees (planting); and
CT= total Tree Canopy Result (or goal)

The maps on the following pages illustrate these calculations for the example 2040 goal for the City of Plymouth.

1: J. Morgan Grove, et al, A Report on New York City's Present and Possible Urban Tree Canopy; https://www.fs.usda.gov/nrs/utc/reports/UTC_NYC_Report_2006.pdf

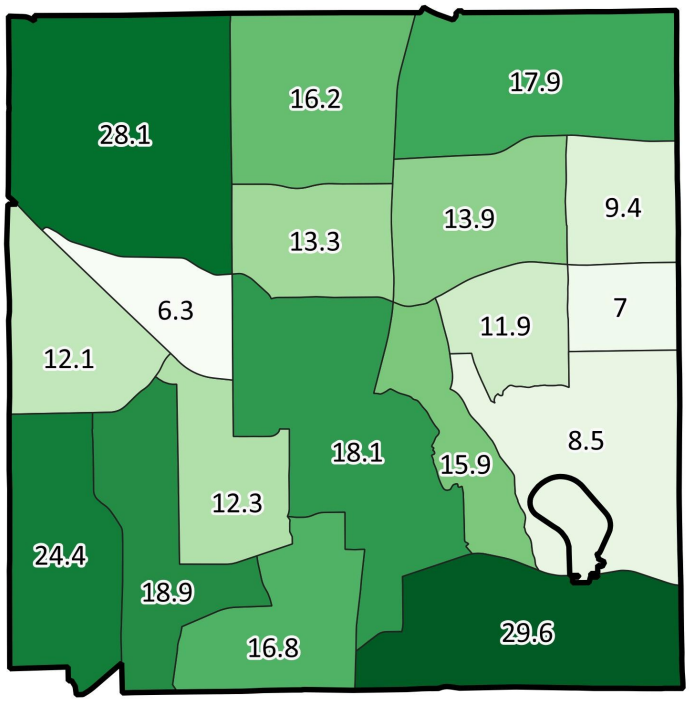
2: E. Gregory McPherson and Paula J. Peper, Urban Tree Growth Modeling; https://www.fs.usda.gov/psw/publications/mcpherson/psw_2012_mcpherson001.pdf

3: Jason S. Lyle, How Fast Do Trees Grow; http://qualityforest.com/forester-notes/how-fast-do-trees-grow.pdf

Translating Tree Canopy Coverage Goal To New Tree Planting - Growth Rates (CG)

Consideration of tree canopy growth rate is important in anticipating long-range tree canopy goals and annual new planting needs. Though there are studies on urban tree canopy growth rates, the methodologies, studied species, and results vary. Due to the high variability of information and results, this report uses the blended annual growth rate of 4.36% found in the most prevalent studies.[2, 3]

Growth Rates (CG) - Acres of Potential Annual Canopy Growth



Values in acres

Translating Tree Canopy Coverage Goal To New Tree Planting - Mortality Rates (CM)

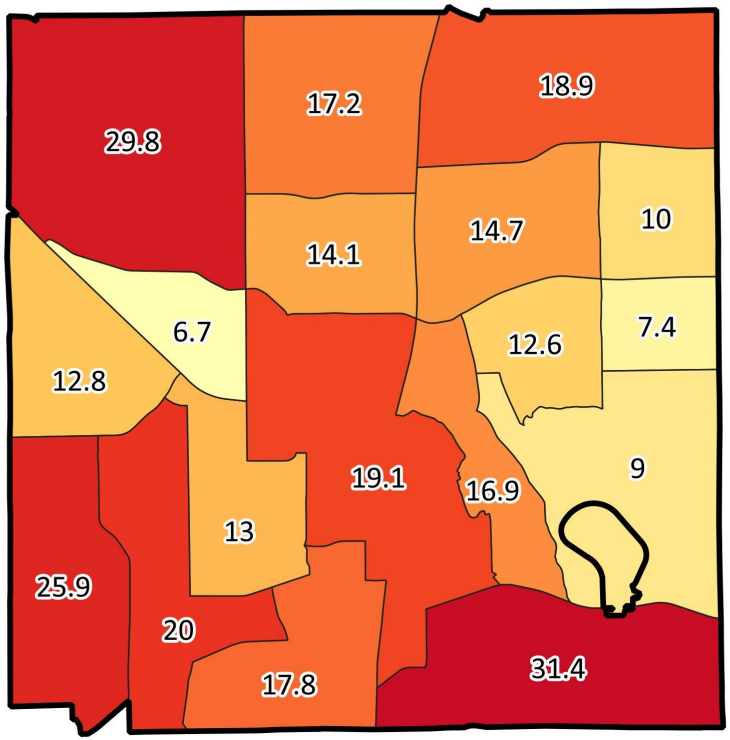
Consideration of tree canopy growth rate is important in anticipating long-range tree canopy goals and annual new planting needs. As with urban tree growth rates, existing studies and results vary. Due to the high variability of information and results, this report uses the mixed urban tree mean mortality of 4.3% from "Urban Tree Mortality: A Literature Review."[4]

Ash Tree Mortality and Invasive Species Removal

The USDA Forest Service approximates that Ash trees make up about 7% of forest trees in the Eastern U.S. and might constitute up to 50% of urban street trees.[5] Unfortunately, the Emerald Ash Borer insect poses a significant threat to Ash trees. City's long-term tree canopy strategies should expect major Ash tree losses in the upcoming 10-15 years (all non -treated trees included). Besides unwanted tree deaths, invasive species removal could be a necessary management strategy.

This study uses 9% as the assumed Ash tree share of the existing urban tree canopy, with an assumed 50% loss occurring over the next 15 years. These losses are included in the total tree mortality rates (TM) illustrated.

Mortality Rates (CM) - Acres of Potential Annual Canopy Loss



Values in acres

4: Deborah R. Hilbert, et al, Urban Tree Mortality: A Literature Review; https://www.fs.usda.gov/nrs/pubs/jrnl/2019/nrs_2019_hilbert_001.pdf

5: Devin J. Wanner, Virgina Tech Demonstrates New Method To Treat Ash Firewood; https://www.fs.usda.gov/features/virginia-tech-demonstrates-new-method-treat-ash-firewood

Calculating Potential Goals

Translating Tree Canopy Coverage Goal To New Tree Planting - New Tree Planting Annual Target (CN)

Using the new planting requirement calculation method (CB + CG - CM + CN = CT) with the previously defined values for existing tree canopy (CB), growth rates (CG), mortality rates (CM), and the 2040 Tree Canopy (CT) goals by neighborhood the required number of new trees to be planted to meet that goal can be identified.[1] The map below shows the annual new tree count required to meet the 2040 tree canopy goals for each census tract.

As mentioned before, the example tree canopy goal provided is preliminary and aims to support the city's CARP planning team. These targets serve as foundational markers for planning, enabling the team to understand the link between tree canopy aims, potential impacts, and the effort required to meet them. The framework which established this goal presumes current agricultural land stays operational.

New Tree Planting Annual Target to Meet 2040 Tree Canopy Goal (CN)

Community-Wide Total (Note, Acreage represents the canopy coverage at year of planting, with an assumed new tree crown radius of 5’ planted no more than 22’ apart):

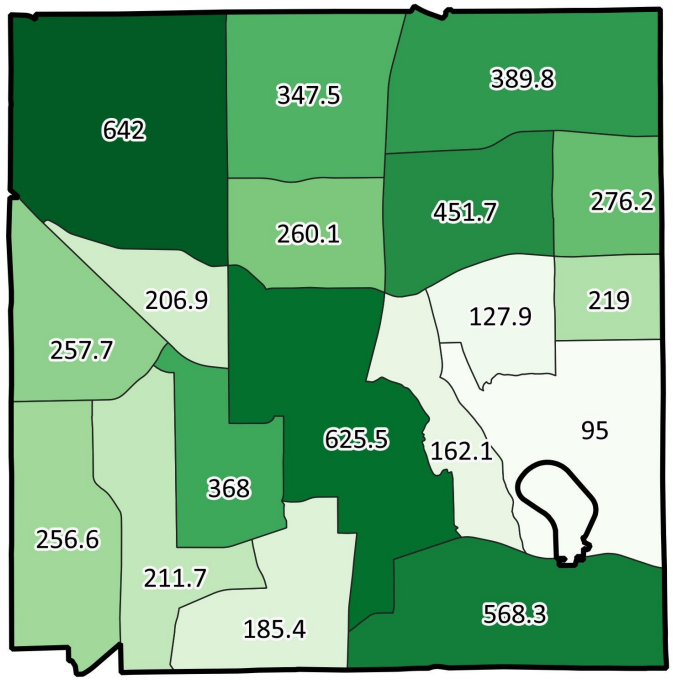
City Total Annual New Planting Target Required for Goal:

63 Acres **5,652** New Trees

City High: **7.1** Acres **642** New Trees
Tract 026616

City Low: **1.0** Acres **95** New Trees

Citywide Planting Target - New Trees Per Year by Census Tract



New trees planted annually

Calculating Potential Goals

Annual Path to 2040 Tree Canopy Cover Goal

The chart below shows the community wide average values for year beginning canopy cover (CB), annual growth rate (CG), mortality rate (CM), the new tree planting targets (CN) and the year end tree canopy goal (CT) for each year through the 2040 goal.

	CB (existing)		CG (growth)		CM (loss)		CN (new)		CT (year goal)	UTC (year end coverage %)
2026	6433	+	281	-	-297	+	63	=	6479	30.8%
2027	6479	+	283	-	-299	+	63	=	6525	31.0%
2028	6525	+	285	-	-302	+	63	=	6571	31.2%
2029	6571	+	287	-	-304	+	63	=	6617	31.5%
2030	6617	+	289	-	-306	+	63	=	6663	31.7%
2031	6663	+	291	-	-308	+	63	=	6710	31.9%
2032	6710	+	293	-	-310	+	64	=	6756	32.1%
2033	6756	+	295	-	-312	+	64	=	6802	32.3%
2034	6802	+	297	-	-314	+	64	=	6848	32.6%
2035	6848	+	299	-	-316	+	64	=	6894	32.8%
2036	6894	+	301	-	-319	+	64	=	6940	33.0%
2037	6940	+	303	-	-321	+	64	=	6986	33.2%
2038	6986	+	305	-	-323	+	64	=	7032	33.4%
2039	7032	+	307	-	-325	+	64	=	7079	33.6%
2040	7079	+	309	-	-327	+	64	=	7125	33.9%

Section 07 Recommendations

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Recommendations

Even with a strong existing green infrastructure, the City has the potential for more. As this report outlines, tree canopy cover in the City provides a number of benefits including pollution absorption, energy consumption savings, carbon sequestration, micro heat island mitigation, and economic benefit. Consequently, increases in green infrastructure offer significant reward potential for the City.

Primary Strategic Goal Recommendations

Section 6 provided a recommended example goal for tree canopy increase while Section 5 noted the opportunities related to the City's impervious surfaces. The following are overarching example goals to support the CARP Planning Team:

1. Increase the tree canopy coverage throughout the City an average of 12% over the existing tree canopy coverage by 2040 (equal to an increase of 3% of city-wide land area), particularly in census tracts with increased vulnerable population shares (see the City's Climate Vulnerability Assessment for more information).

2. Decrease the quantity of "dark" impervious surfaces throughout the City 3% by 2035, particularly in neighborhoods identified with higher heat island contributions in Section 3, (approximately 12 acres annually). Strategies include "cool pavement", "cool roof", and "green roof" replacements.

3. Increase pollinator supportiveness of lawns and non-agricultural grasslands in City of Plymouth and achieve a 3% turf replacement with native grasses and wildflowers by 2035 (approximately 14 acres annually).

Section

A

i-Tree Technical Notes

From USDA iTree Tools, Canopy Technical Notes; https://www.itreetools.org/support/resources-overview/i-tree-methods-and-files

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i-Tree Canopy Technical Notes

This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon. The user can define any cover classes that they like and the program will show estimation results throughout the interpretation process. Point data and results can be exported for use in other programs if desired.

There are three steps to this analysis:

1) Import a file that delimits the boundary of your area of analysis (e.g., city boundary). Some standard boundary files for the US can be located on the US Census website. Data from these sites will require some minor processing in GIS software to select and export a specific boundary area polygon.
2) Name the cover classes you want to classify (e.g., tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed.
3) Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from step 2 that the point falls upon.

The more points that are interpreted, the more accurate the estimate.

Credits

The concept and prototype of this program were developed by David J. Nowak, Jeffrey T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company).

Limitations

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Information on calculating standard errors can be found below. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

Calculating Standard Error and Confidence Intervals from Photo-Interpreted Estimates of Tree Cover

In photo-interpretation, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree, building, water).

From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). To illustrate how this is done, let us assume 1,000 points have been interpreted and classified within a city as either "tree" or "non-tree" as a means to ascertain the tree cover within that city, and 330 points were classified as "tree".

To calculate the percent tree cover and SE, let:

N = total number of sampled points (i.e, 1,000)
n = total number of points classified as tree (i.e., 330), and
p = n/N (i.e., 330/1,000 = 0.33)
q = 1 – p (i.e., 1 - 0.33 = 0.67)
SE = √ (pq/N) (i.e., √ (0.33 x 0.67 / 1,000) = 0.0149)

Thus in this example, tree cover in the city is estimated at 33% with a SE of 1.5%. Based on the SE formula, SE is greatest when p=0.5 and least when p is very small or very large (Table 1).

Table 1. Estimate of SE (N = 1000) with varying p.

p	SE
0.01	0.0031
0.1	0.0095
0.3	0.0145
0.5	0.0158
0.7	0.0145
0.9	0.0095
0.99	0.0031

Confidence Interval

In the case above, a 95% confidence interval can be calculated. "Under simple random sampling, a 95% confidence interval procedure has the interpretation that for 95% of the possible samples of size *n*, the interval covers the true value of the population mean" (Thompson 2002). The 95% confidence interval for the above example is between 30.1% and 35.9%. To calculate a 95% confidence interval (if N>=30) the SE x 1.96 (i.e., 0.0149 x 1.96 = 0.029) is added to and subtracted from the estimate (i.e., 0.33) to obtain the confidence interval.

SE if n < 10

If the number of points classified in a category (n) is less than 10, a different SE formula (Poisson) should be used as the normal approximation cannot be relied upon with a small sample size (<10) (Hodges and Lehmann, 1964). In this case:

$SE = (\sqrt{n}) / N$

For example, if n = 5 and N = 1000, p = n/N (i.e., 5/1,000 = 0.005) and $SE = \sqrt{5} / 1000 = 0.0022$. Thus the tree cover estimate would be 0.5% with a SE of 0.22%.

References

Lindgren, BW and GW McElrath. 1969. Introduction to Probability and Statistics. Macmillan Co. London

Hodges, JL and EL Lehmann. 1964. Basic Concepts of Probability and Statistics. Holden-Day, Inc. San Francisco.

Thompson, S. K. 2002. Sampling, second edition. John Wiley and Sons, Inc., New York, New York.

Section B

Climate Adaptive Tree Species

USDA Forest Service Urban Area Summaries:
https://www.fs.usda.gov/nrs/atlas/combined/resources/summaries/urban/

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ua 57628

U.S. Census Bureau Urban Areas
Climate Change Atlas Tree Species
Current and Potential Future Habitat, Capability, and Migration

USDA Forest Service
Northern Research Station
Landscape Change Research Group
Iverson, Peters, Prasad, Matthews

	sq. km	sq. mi	FIA Plots
Area of Region	8,900.0	3,436.3	132

Species Information

The columns below provide breif summaries of the species associated with the region and described in the table on the next pages. Definitions are provided in the Excel file for this region.

Genus	Species
Ash	3
Hickory	1
Maple	4
Oak	5
Pine	4
Other	26
	43

Abundance	
Abundant	1
Common	20
Rare	22
Absent	15
	58

	Model Reliability	Adaptability
High	12	19
Medium	20	28
Low	22	10
FIA	5	
	59	**57**

Potential Change in Habitat Suitability	Scenario RCP45	Scenario RCP85
Increase	17	15
No Change	12	13
Decrease	9	10
New	13	13
Unknown	8	8
	59	**59**

Capability to Cope or Persist	Scenario RCP45	Scenario RCP85
Very Good	4	4
Good	11	10
Fair	11	12
Poor	6	5
Very Poor	5	6
FIA Only	3	3
Unknown	3	3
	43	**43**

Migration Potential	SHIFT RCP45	SHIFT RCP85
Likely	2	2
Infill	30	29
Migrate	3	6
	35	**37**

Potential Changes in Climate Variables

Temperature (°F)

	Scenario	2009	2039	2069	2099
Annual Average	CCSM45	45.1	46.9	50.0	50.4
	CCSM85	45.1	47.9	51.1	54.6
	GFDL45	45.1	50.1	50.6	52.0
	GFDL85	45.1	48.3	51.7	56.6
	HAD45	45.1	48.1	51.9	53.8
	HAD85	45.1	48.7	53.2	58.6
Growing Season May—Sep	CCSM45	65.8	67.8	70.5	71.0
	CCSM85	65.8	68.7	71.8	76.0
	GFDL45	65.8	71.8	72.2	74.2
	GFDL85	65.8	69.7	73.4	79.1
	HAD45	65.8	68.8	71.9	74.1
	HAD85	65.8	69.1	73.6	78.9
Coldest Month Average	CCSM45	11.9	13.7	16.1	16.7
	CCSM85	11.9	14.1	16.4	18.7
	GFDL45	11.9	15.6	17.1	17.5
	GFDL85	11.9	15.8	17.6	20.5
	HAD45	11.9	13.4	17.8	17.7
	HAD85	11.9	17.3	21.0	24.4
Warmest Month Average	CCSM45	72.3	74.8	76.3	76.9
	CCSM85	72.3	76.1	78.0	80.7
	GFDL45	72.3	75.5	77.0	78.5
	GFDL85	72.3	76.4	78.3	81.9
	HAD45	72.3	75.5	77.2	78.7
	HAD85	72.3	76.6	78.9	82.6

Precipitation (in)

	Scenario	2009	2039	2069	2099
Annual Total	CCSM45	31.4	32.5	32.0	31.3
	CCSM85	31.4	31.0	30.8	31.4
	GFDL45	31.4	34.7	36.7	33.6
	GFDL85	31.4	34.7	37.5	35.9
	HAD45	31.4	33.7	33.1	33.2
	HAD85	31.4	32.7	33.5	35.6
Growing Season May—Sep	CCSM45	19.9	20.1	19.3	18.9
	CCSM85	19.9	19.1	17.9	17.5
	GFDL45	19.9	21.9	22.6	19.9
	GFDL85	19.9	22.0	22.3	20.3
	HAD45	19.9	20.3	18.9	18.9
	HAD85	19.9	19.3	17.9	18.2

NOTE: For the six climate variables, four 30-year periods are used to indicate six potential future trajectories. The period ending in 2009 is based on modeled observations from the PRISM Climate Group and the three future periods were obtained from the NASA NEX-DCP30 dataset. Future climate projections from three models under two emission scenarios show estimates of each climate variable within the region. The three models are CCSM4, GFDL CM3, and HadGEM2-ES and the emission scenarios are the 4.5 and 8.5 RCP. The average value for the region is reported, even though locations within the region may vary substantially based on latitude, elevation, land-use, or other factors.

Cite as: Iverson, L.R.; Prasad, A.M.; Peters, M.P.; Matthews, S.N. 2019. Facilitating Adaptive Forest Management under Climate Change: A Spatially Specific Synthesis of 125 Species for Habitat Changes and Assisted Migration over the Eastern United States. Forests. 10(11): 989. https://doi.org/10.3390/f10110989.

ua 57628

U.S. Census Bureau Urban Areas
Climate Change Atlas Tree Species
Current and Potential Future Habitat, Capability, and Migration

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Common Name	Scientific Name	Range	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
quaking aspen	Populus tremuloides	WDH	High	39.3	582.1	23.7	Sm. dec.	Sm. dec.	Medium	Abundant	Fair	Fair	Infill +	Infill +	0	1
northern red oak	Quercus rubra	WDH	Medium	48.3	429.5	15.2	Sm. dec.	Lg. dec.	High	Common	Fair	Fair	Infill +	Infill +	1	2
American elm	Ulmus americana	WDH	Medium	70.8	376.3	10.0	No change	No change	Medium	Common	Fair	Fair	Infill +	Infill +	1	3
boxelder	Acer negundo	WSH	Low	67.4	359.6	13.6	No change	Sm. dec.	High	Common	Good	Fair	Infill ++	Infill +	1	4
northern pin oak	Quercus ellipsoidalis	NSH	Medium	46.1	324.4	13.1	Sm. dec.	Sm. dec.	High	Common	Fair	Fair	Infill +	Infill +	1	5
American basswood	Tilia americana	WSL	Medium	38.2	315.8	16.8	Sm. dec.	Sm. dec.	Medium	Common	Poor	Poor	Infill +	Infill +	0	6
green ash	Fraxinus pennsylvanica	WSH	Low	59.6	283.0	10.3	Sm. inc.	Sm. inc.	Medium	Common	Good	Good	Infill ++	Infill ++	1	7
white oak	Quercus alba	WDH	Medium	20.2	188.4	13.1	Sm. inc.	No change	High	Common	Very Good	Good	Infill ++	Infill ++	1	8
red pine	Pinus resinosa	NSH	Medium	15.7	186.3	21.0	No change	No change	Low	Common	Poor	Poor	Infill +	Infill +	0	9
bur oak	Quercus macrocarpa	NDH	Medium	52.8	186.3	10.0	Lg. inc.	Sm. inc.	High	Common	Very Good	Very Good	Infill ++	Infill ++	1	10
black cherry	Prunus serotina	WDL	Medium	51.7	149.9	7.6	Sm. inc.	Sm. inc.	Low	Common	Fair	Fair	Infill +	Infill +	1	11
eastern cottonwood	Populus deltoides	NSH	Low	15.7	130.5	19.9	Sm. inc.	Lg. inc.	Medium	Common	Good	Very Good	Infill ++	Infill ++	1	12
paper birch	Betula papyrifera	WDH	High	33.7	128.4	6.1	No change	No change	Medium	Common	Fair	Fair	Infill +	Infill +	1	13
red maple	Acer rubrum	WDH	High	16.9	117.3	7.9	Sm. inc.	Sm. inc.	High	Common	Very Good	Very Good	Infill ++	Infill ++	1	14
eastern hophornbeam; ironw	Ostrya virginiana	WSL	Low	36	91.2	6.4	No change	No change	High	Common	Good	Good	Infill ++	Infill ++	1	15
black willow	Salix nigra	NSH	Low	15.7	80.1	15.0	Lg. dec.	No change	Low	Common	Very Poor	Poor		Infill +	2	16
black ash	Fraxinus nigra	WSH	Medium	16.9	72.0	8.3	Sm. inc.	No change	Low	Common	Fair	Poor	Infill +	Infill +	1	17
balsam fir	Abies balsamea	NDH	High	1.1	62.5	50.0	No change	No change	Low	Common	Poor	Poor	Infill +	Infill +	2	18
northern white-cedar	Thuja occidentalis	WSH	High	1.1	55.9	44.7	No change	No change	Medium	Common	Fair	Fair	Infill +	Infill +	2	19
silver maple	Acer saccharinum	NSH	Low	20.2	50.9	10.0	Lg. inc.	Lg. inc.	High	Common	Very Good	Very Good	Infill ++	Infill ++	1	20
slippery elm	Ulmus rubra	WSL	Low	32.6	50.5	4.4	No change	No change	Medium	Common	Fair	Fair	Infill +	Infill +	1	21
eastern redcedar	Juniperus virginiana	WDH	Medium	31.5	41.8	3.9	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	1	22
eastern white pine	Pinus strobus	WDH	High	12.4	41.8	4.7	Sm. inc.	No change	Low	Rare	Poor	Very Poor	Infill +		2	23
sugar maple	Acer saccharum	WDH	High	16.9	40.0	9.8	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	24
white spruce	Picea glauca	NSL	Medium	9	35.3	8.2	No change	Sm. dec.	Medium	Rare	Poor	Very Poor	Infill +		1	25
tamarack (native)	Larix laricina	NSH	High	3.4	33.9	9.0	No change	No change	Low	Rare	Very Poor	Very Poor			2	26
black locust	Robinia pseudoacacia	NDH	Low	5.6	29.7	14.2	No change	Sm. inc.	Medium	Rare	Poor	Fair	Infill +	Infill +	2	27
hackberry	Celtis occidentalis	WDH	Medium	32.6	29.2	3.0	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	28
black oak	Quercus velutina	WDH	High	1.1	23.3	18.6	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			2	29
butternut	Juglans cinerea	NSLX	FIA	21.3	21.6	3.5	Unknown	Unknown	Low	Rare	FIA Only	FIA Only			0	30
black walnut	Juglans nigra	WDH	Low	10.1	20.1	6.6	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good	Infill ++	Infill ++	2	31
jack pine	Pinus banksiana	NSH	Medium	6.7	13.2	5.3	No change	No change	High	Rare	Fair	Fair	Infill +	Infill +	2	32
Siberian elm	Ulmus pumila	NDH	FIA	10.1	13.0	8.4	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	33
serviceberry	Amelanchier spp.	NSL	Low	2.2	11.0	4.4	Lg. dec.	Lg. dec.	Medium	Rare	Very Poor	Very Poor			0	34
bitternut hickory	Carya cordiformis	WSL	Low	19.1	10.0	4.1	Lg. inc.	Lg. inc.	High	Rare	Good	Good	Infill ++	Infill ++	2	35
chokecherry	Prunus virginiana	NSLX	FIA	10.1	9.2	1.3	Unknown	Unknown	Medium	Rare	FIA Only	FIA Only			0	36
yellow birch	Betula alleghaniensis	NDL	High	3.4	5.8	1.6	Sm. dec.	Sm. dec.	Medium	Rare	Very Poor	Very Poor			2	37
Scots pine	Pinus sylvestris	NSH	FIA	2.2	5.4	2.2	Unknown	Unknown	NA	Rare	NNIS	NNIS			0	38
white ash	Fraxinus americana	WDL	Medium	6.7	4.3	2.0	Lg. inc.	Lg. inc.	Low	Rare	Fair	Fair	Infill +	Infill +	2	39
American mountain-ash	Sorbus americana	NSL	Low	1.1	2.3	1.9	Sm. dec.	Sm. dec.	Low	Rare	Very Poor	Very Poor			0	40
peachleaf willow	Salix amygdaloides	NSLX	FIA	9	2.2	3.5	Unknown	Unknown	Medium	Rare	FIA Only	FIA Only			0	41
river birch	Betula nigra	NSL	Low	1.1	1.2	0.9	Very Lg. dec.	Very Lg. dec.	Medium	Rare	Lost	Lost			0	42
red mulberry	Morus rubra	NSL	Low	4.5	0.4	1.4	Lg. inc.	Lg. inc.	Medium	Rare	Good	Good			2	43
striped maple	Acer pensylvanicum	NSL	Medium	0	0	0	Unknown	Unknown	Medium	Absent	Unknown	Unknown			0	44
mountain maple	Acer spicatum	NSL	Low	0	0	0	Unknown	Unknown	High	Absent	Unknown	Unknown			0	45
American hornbeam; muscle	Carpinus caroliniana	WSL	Low	0	0	0	Unknown	Unknown	Medium	Modeled	Unknown	Unknown			0	46
shagbark hickory	Carya ovata	WSL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Likely +	Likely +	3	47

U.S. Census Bureau Urban Areas

Climate Change Atlas Tree Species

Current and Potential Future Habitat, Capability, and Migration

USDA Forest Service
Northern Research Station
Landscape Change Research Group
Iverson, Peters, Prasad, Matthews

Common Name	Scientific Name	Range	MR	%Cell	FIAsum	FIAiv	ChngCl45	ChngCl85	Adap	Abund	Capabil45	Capabil85	SHIFT45	SHIFT85	SSO	N
black hickory	Carya texana	NDL	High	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			0	48
mockernut hickory	Carya alba	WDL	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate +	3	49
eastern redbud	Cercis canadensis	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat		Migrate +	3	50
honeylocust	Gleditsia triacanthos	NSH	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	51
Osage-orange	Maclura pomifera	NDH	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat		Migrate +	3	52
sycamore	Platanus occidentalis	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	53
bigtooth aspen	Populus grandidentata	NSL	Medium	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Likely +	Likely +	3	54
swamp white oak	Quercus bicolor	NSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat	Migrate +	Migrate +	3	55
blackjack oak	Quercus marilandica	NSL	Medium	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	56
Shumard oak	Quercus shumardii	NSL	Low	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			0	57
post oak	Quercus stellata	WDH	High	0	0	0	New Habitat	New Habitat	High	Absent	New Habitat	New Habitat			3	58
sassafras	Sassafras albidum	WSL	Low	0	0	0	New Habitat	New Habitat	Medium	Absent	New Habitat	New Habitat			3	59

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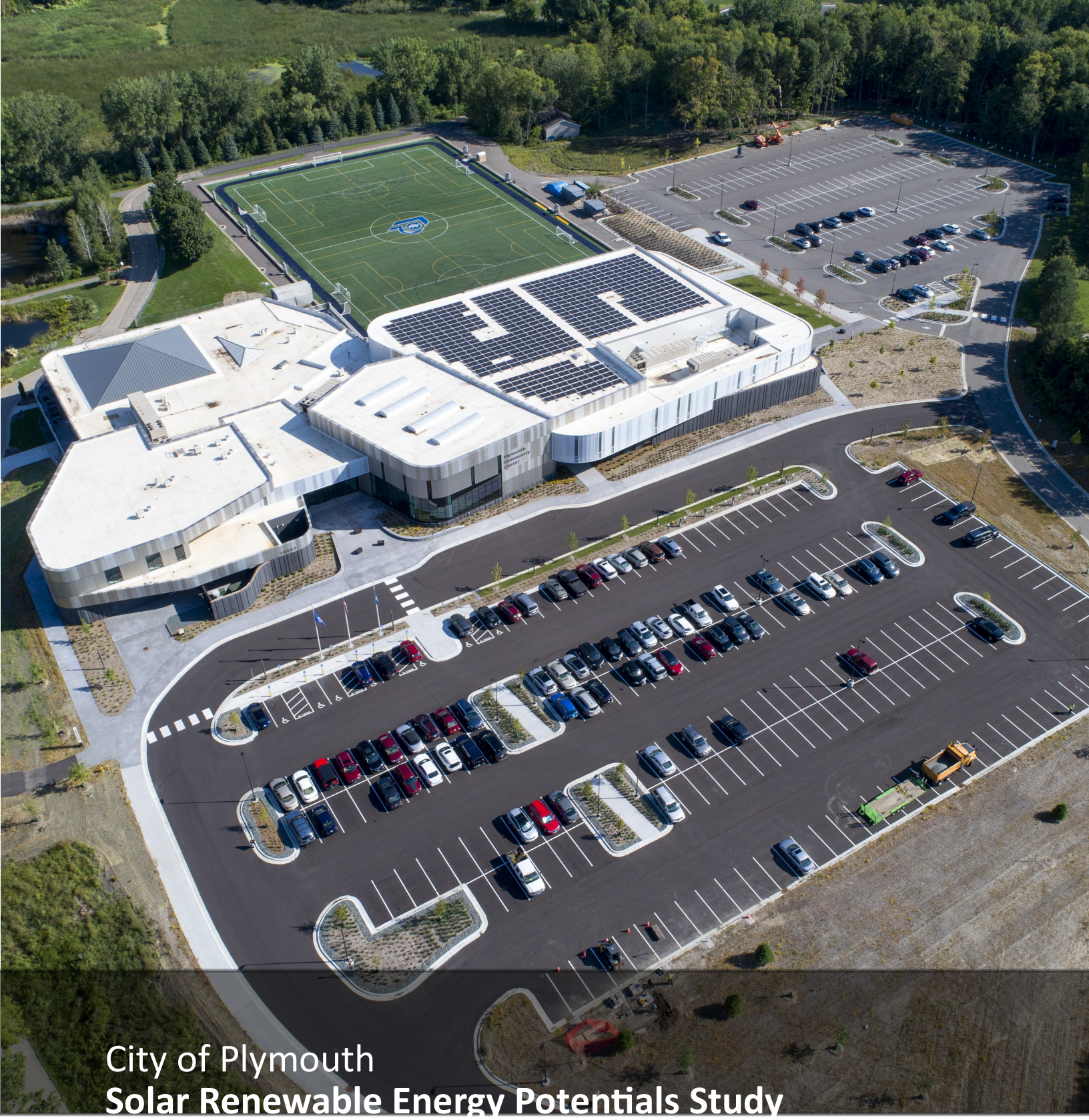

City of Plymouth
Solar Renewable Energy Potentials Study

November, 2025
Revised: February 2026

Prepared by:

making change personal
paleBLUEdot LLC

Photo: Ideal Energies, LLC

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Section 01

Introduction

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Introduction

Intent of This Study

The intent of this study is to support the City in appropriate and effective renewable energy goalsetting within the City's Climate Action and Resilience Planning process. This study seeks also to help the City establish strategies addressing renewable energy development. The primary focus of this study is to establish the Community-Wide rooftop solar PV potential throughout the City, including economic and environmental benefits.

How Solar PV Works

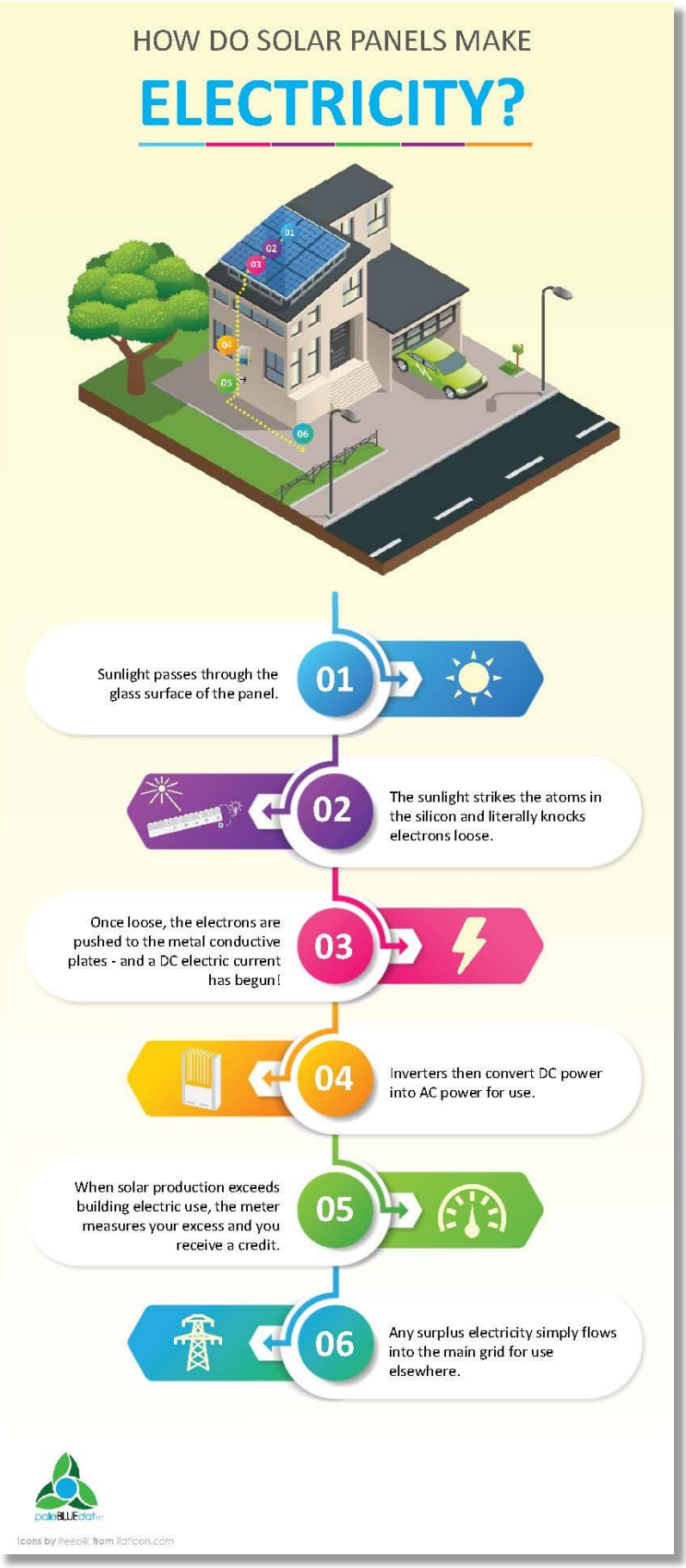
Solar electricity is created using Solar Photovoltaic panels, or Solar PV for short. The word photovoltaic, or PV, comes from the process of converting light (photons) to electricity (voltage), which is called the PV effect. The key to a solar PV panel is the semiconductor material.

Solar PV semiconductors combine properties of some metals and properties of insulators - making them uniquely capable of converting light into electricity. The simple explanation of how solar panels create electricity is that as sunlight (specifically UV light) strikes the semiconductor materials in the PV cell, the energy knocks loose electrons. Those electrons then move back and forth between semiconductor plates producing an electric current.

Structural Capacity for Rooftop Arrays

The assessments included in this report do not include assessments of rooftop structures to accept the additional loading of a solar PV array. Projects which anticipate rooftop arrays should have a preliminary structural assessment to confirm solar PV loading can be adequately handled by the existing structure. The weight of a PV system varies based on the panel and racking systems selected.

For rooftop arrays, two racking system configurations are common: flush or tilted mechanically fastened racking types (which require roof penetrations, or clamp on standing seams); and ballasted racking types (which use weighted components to make the array stationary through gravity and typically do not require roof penetrations). A reasonable "rule of thumb" for solar PV array assembly structural loading is 2-4lbs per square foot for typical flush or tilted racking systems, or 5-9lbs for ballasted racking systems.



Introduction

Net Metering

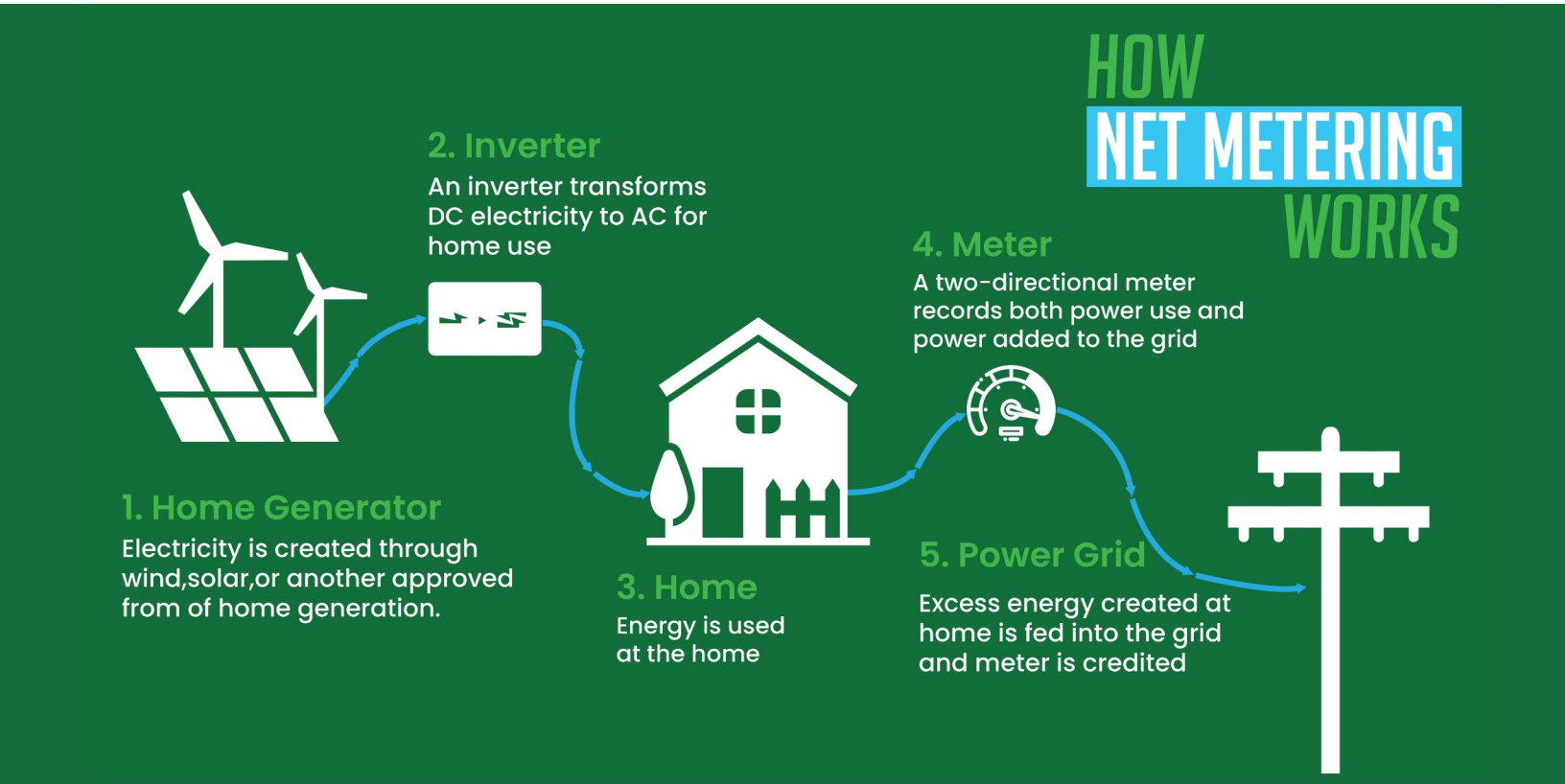
The site concepts in this report are based on grid-connected systems with net metering. Net metering tracks the amount of energy generated on site, as well as the amount of energy consumed from the grid. Net metering allows customers to get credit on their energy bill from excess energy generation, when the amount of energy a solar panel system generates is greater than the amount of energy consumed from the electric utility. Such interconnection is considered non-incentivized, meaning that the site/solar array owner will retain the renewable energy credit that the PV system produces and will offset the cost of energy needed when the solar panels are not producing energy (nighttime, short and cloudy days).

Net Metering in Plymouth

According to the State of Minnesota Public Utilities Commission:

> *Generally, if a customer produces more electricity than it uses, a utility will compensate or credit the customer for their excess generation depending on the option the customer elects to receive in the contract they signed with the utility. Utilities keep the rates updated in a rate book.*
>
> *The amount a customer is paid for the electricity they do not use is found in their utility's tariff (often called the compensation rate). The compensation rate depends on several factors:*
>
> *The size of the customer's system; The specific costs and retail rates of their utility (updated annually); and, Whether the customer is served by a cooperative, municipal, or public utility.*

Learn more about Net Metering in the State of Minnesota here: https://mn.gov/puc/activities/economic-analysis/distributed-energy/net-metering/

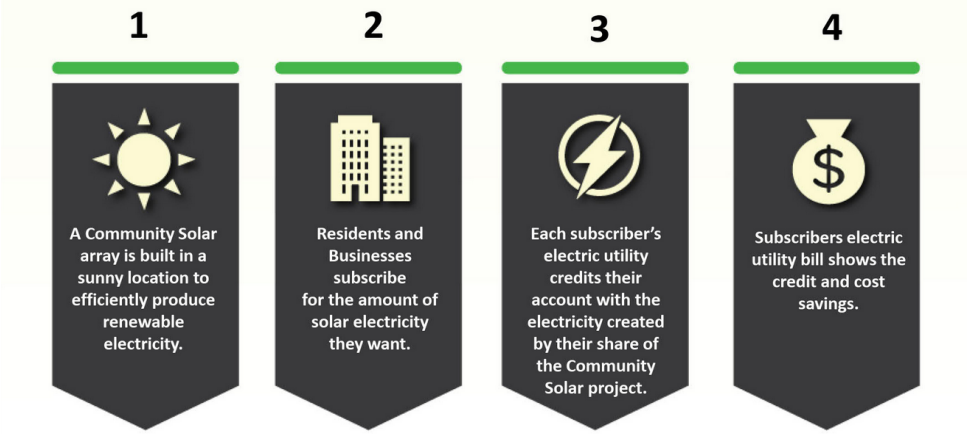


Introduction

Community Solar

Community solar is a distributed solar energy deployment model enabling customers to purchase or rent a portion of a larger solar photovoltaic (PV) system located offsite and shared with others. Members of the community who sign up for a solar facility get compensation for the energy their share generates, either through reduced electricity bills or energy credits. In Minnesota, only licensed utilities and cooperatives are authorized to offer community solar energy to consumers. While some utility companies, such as Xcel Energy's Community Solar Program, do offer a communal solar subscription service, other utilities in Minnesota currently lack a similar program for their customer base.

How Does Community Solar Work



Renewable Energy Credits

Renewable Energy Credits (RECs) are tradable, non-tangible energy commodities that represent proof that a quantity of electricity was generated from an eligible renewable energy resource. RECs represent all of the "green" or clean energy attributes of electricity produced from renewable resources like solar PV. A REC includes everything that differentiates the effects of generating electricity with renewable resources instead of using other types of resources. It's crucial to note that a Renewable Energy Certificate (REC) also represents the environmental benefits of generating electricity from renewable sources. Only the final holder of the REC has the exclusive right to make this claim. Once a producer or owner of a REC has sold it, rather than consuming it themselves, they have sold the claim and cannot truthfully state that they are using renewable electricity.

Many building owners interested in pursuing the installation of a solar pv system on their property are motivated from an interest in using (and claiming) renewable energy for operations. Very careful understanding of a project's Renewable Energy Credits and the status of their ownership is critical. Failure to carefully define ownership of REC may cause the inability of a building owner to claim the renewable benefits they wish to obtain. Building owners should assume that RECs will not be available for any projects which are delivered through a "third party" project delivery method, community solar subscription, or any project which utilizes a utility subsidized approach. It may be possible for building owners to retain REC credits, however, and paleBLUEdot recommends that any building owner looking into "third party" solar arrays explore the retention of all REC credits produced by the recommended projects if financially feasible.

From a Greenhouse Gas accounting perspective, this means that facilities served through community solar subscriptions or third party ownership structures will not be able to account for emissions reductions due to renewable energy use unless REC credits are purchased. In this situation, without the purchase of REC credits, the City's GHG Inventory will need to use the regional electric grid emissions factors for calculation of emissions.

The Role of

Renewable Energy Credits

3 Because the electricity from all sources is blended in the grid, it is unclear which customer receives the actual electrons produced from the renewable energy source.

4 Consumers can purchase RECs to legitimately claim the use of renewable energy.

2 In the mixed-source grid, electrons from different sources are indistinguishable.

1 A REC is generated for each megawatt-hour of renewable electricity added to the grid, representing its environmental benefits.

Introduction

Peak Shaving and Demand Charges

Customers pay for electricity based on either consumption (in kWh) or demand (in kW); residential users typically pay for consumption, while commercial users often face combined tariffs. Demand charges, tied to peak power usage during 15-minute intervals per billing cycle, cover power plant and utility costs.

For high-energy users, demand charges may constitute 30% to 70% of their bill. To mitigate these costs, many employ "peak shaving" strategies to manage demand and integrate solar arrays with battery systems. These smart batteries, controlled for charging and discharging, adapt to usage patterns, optimizing grid-battery switches for cost savings.

Peak Shaving and Local Utilities

Many local electric utilities and co-ops purchase electricity from larger generators and distribute it to customers under long-term agreements, which may include higher prices during peak demand. By introducing solar arrays and storage systems, these utilities can diminish peak demand on the grid, mitigating high costs.

Project Delivery Options

There are many options for pursuing solar projects for business or residential property including:

Purchasing a System:
Acquiring a solar array directly simplifies ownership but can be costly upfront, akin to buying a car or house.

Solar Lease:
A "third party ownership" option, where a leasing company owns and installs the solar array with no upfront fees; customers pay a fixed monthly rate offset by free electricity from the panels, allowed in many states, including Minnesota.

Power Purchasing Agreement (PPA):
A contract where a developer installs a solar system on a customer's property; the customer buys generated power at a rate typically cheaper than the local utility, with monthly payments based on system energy production; benefits include reduced grid electricity costs, while customers should discuss retaining Renewable Energy Credits for environmental benefits.

Introduction

Solar Financing and Incentives

Solar energy delivers positive environmental impacts, and contributes to our nation's energy independence. The 2019 U.S. Energy & Employment Report states that in 2018, clean energy generation and energy efficiency sectors provided 2.4 million jobs.[1] This is double the number of jobs in the fossil energy production sector. To encourage the continued expansion of solar, governments and utilities offer tax breaks and financial incentives to make solar more accessible for today's businesses and homeowners. The following are some of the incentives available in Minnesota.

State of Minnesota Incentives

Minnesota Municipal Property Tax Exemptions

A system up to 50 kW that is net-metered OR is not connected to the grid and only provides power to the property on which it is located is also exempt from municipal property taxes. A system up to 50 kW that is not net-metered and is connected to the grid OR is not connected to the grid but provides power to multiple properties is subject to municipal property taxes, unless the municipality has created a local exemption. Systems 50 kW and greater that are net-metered may reduce their capacity by 50 kW for valuation purposes if they are subject to municipal property taxes.

Minnesota Solar Sales Tax Exemptions

When you install solar panels on your home or business in Minnesota, you don't have to pay any sales tax on your solar purchase. This translates into a 7% savings on every solar PV installation in the State.

Xcel Energy's Solar Rewards Program

Funded by the Minnesota Renewable Development Fund, this incentive program rewards solar homeowners in Xcel Energy's service territory with an annual payment, calculated based on their solar system's energy output. For up to a decade, Xcel compensates participating property owners at a fixed rate for every kilowatt-hour (kWh) their solar installations produce. However, it's important to note that this program transfers the green credits (RECs) to the utility for the 10-year duration. Consequently, property owners aiming to reduce their greenhouse gas emissions should be aware of the related accounting effects.

Federal Incentives

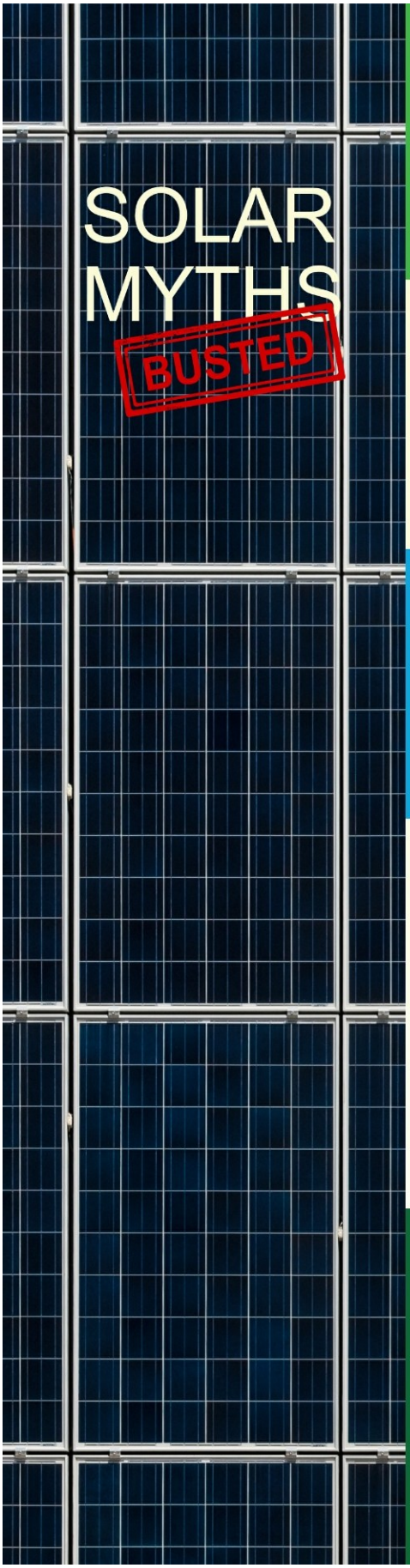
Federal Modified Accelerated Cost Recovery System (MACRS)

The Modified Accelerated Cost Recovery System (MACRS), established in 1986, enables businesses to depreciate tangible property investments over varying periods (three to 50 years); solar equipment qualifies for a five-year recovery period.

If an Investment Tax Credit (ITC) grant is claimed (e.g., 30% ITC), the depreciable basis must be reduced by half of the ITC value (15%), resulting in a tax deduction basis of 85% of equipment cost. While MACRS depreciation benefits can be intricate, they provide substantial incentives for renewable energy investments, warranting advice from a solar tax-savvy accountant.

Resources:
https://www.seia.org/initiatives/depreciation-solar-energy-property-macrs
https://www.irs.gov/credits-deductions/cost-recovery-for-qualified-clean-energy-facilities-property-and-technology

1: 2019 U.S. Energy & Employment Report https://cutt.ly/hwcOXTIT



1 SOLAR PANELS WILL DAMAGE MY ROOF. MYTH

Fact: The solar PV cells attached to rooftops use modern materials perfected in labs. Holes need to be drilled into a roof to attach solar panels, but your roof can still be protected. Reputable solar panel installation companies follow industry best practices, like using quality flashed mounts to waterproof roof penetrations

2 SOLAR PANELS DON'T WORK IN COLD CLIMATES MYTH

Fact: If there are any daylight hours in your area, solar panels can still be effective. This is why Germany—which receives about the same amount of sunshine as Alaska—is currently a solar superpower. In fact, even though Utah is known for a long winter season, the state has enough solar power potential to provide all the electricity the U.S. needs. Solar panels are built to withstand varying temperatures, and they can produce electricity from indirect light.

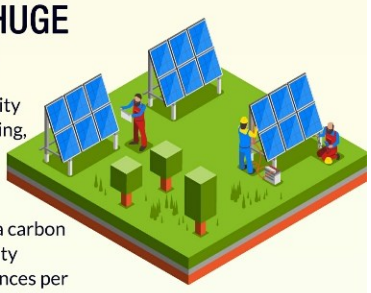
3 SOLAR PANELS ARE TOXIC. MYTH

Fact: Detailed analysis indicates that the large-scale implementation of solar has the potential to reduce pollution-related environmental impacts of electricity production, such as GHG emissions, freshwater ecotoxicity, eutrophication, and particulate-matter exposure. The pollution caused by higher material requirements of these technologies is small compared with the direct emissions of fossil fuel-fired power plants

4 SOLAR ELECTRICITY HAS A HUGE CARBON FOOTPRINT MYTH

Fact: The operation of solar pv modules generating electricity do not produce greenhouse gas emissions. The manufacturing, installation, and on-going maintenance of solar PV does produce a carbon footprint – what is known as "Lifecycle emissions".

The lifecycle emissions of electricity generated by coal has a carbon footprint of 35.3 ounces per KWh generated, while electricity generated by natural gas has a carbon footprint of 17.65 ounces per KWh generated. Meanwhile, the lifecycle emissions for Solar PV equates to an average of 1.4 ounces of greenhouse gas for every kWh the panel will produce over its lifetime – a 92% reduction of emissions over natural gas and a 98% reduction of emissions over coal.



5 SOLAR ELECTRICITY DOES NOT REALLY HAVE ENVIRONMENTAL AND HEALTH BENEFITS MYTH

Fact: In the United States, the actual environmental and health benefits for every solar module (individual panel) installed is:

- 10,600 lbs of greenhouse gases eliminated
- Equivalent to 94,000 Cubic Feet of Manmade Atmosphere avoided
- 69,650 gallons of freshwater saved
- Equivalent to the annual water use of 232 households saved
- Creates more jobs: nationally, solar employs 350,000 people – twice that of the coal industry.
- Elimination of over 5 pounds of particulate air pollution for every solar panel installed.

Section 02

Solar in Minnesota

Solar in Minnesota

As of September 2025, Minnesota has a total of 2,924 megawatts (2,924,000,000 watts) of solar capacity installed statewide. The State of Minnesota ranks 20th nationally for total solar energy production capacity. The State's solar installation total is enough to power 418,302 homes. The share of the State's total electricity use that comes from solar power is 5.37%. Current solar growth projections for the State equal an additional 2,843MW over the next 5 years - a growth rate that ranks 24th nationally.

Costs for Solar PV installation in the state have declined 43% since 2013. Price declines have been accompanied by an overall increase in investment in solar energy. A total of $4.5 billion has been invested in Solar PV installations in the state.

The industry currently employs approximately 4,795 people in 164 companies Statewide. The solar industry jobs market has increased 8.2% over the last 5 years.

Sources:
https://www.seia.org/state-solar-policy/Minnesota-solar
https://irecusa.org/Minnesota-solar-and-clean-energy-jobs/

Minnesota Solar Job Trends

Solar Jobs, 2022	4,643
Jobs Added, 2022	73
% Growth, 2022	1.6%
State Ranking for Solar Jobs	17
State Ranking for Solar Jobs Per Capita	14
Projected Growth, 2023	0.5%
5-Year Growth, 2017-2022	9.1%

IREC https://irecusa.org/Minnesota-solar-and-clean-energy-jobs/

MN SOLAR State Spotlight

RANKINGS

20th
for total installed solar capacity

CAPACITY		
28th Residential	21st Utility	6th Non-Residential DG
PER CAPITA		
36th Residential	28th Utility	7th Non-Residential DG

Total Solar Installed (MW)
2924.2
544.9 MW in 2024

4,795
Solar Jobs
Ranks 18th

MN Solar Market Value
$4.5B
$713M Invested in 2024

Enough to Power
418,302
MN Homes

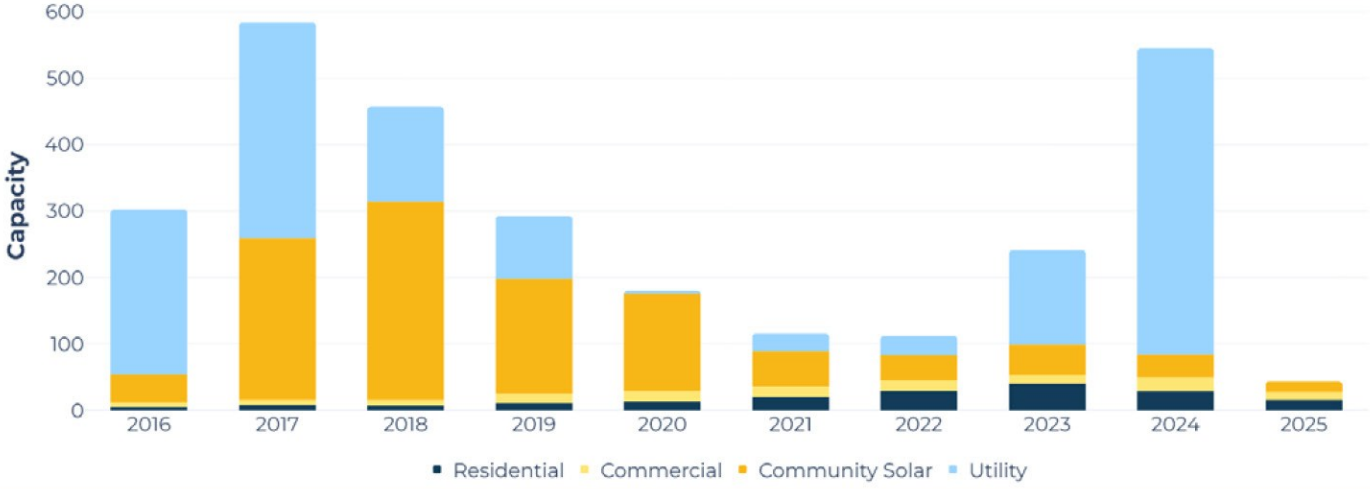
Powered by
164
Solar Companies

Growth Projection Over the Next 5 Years (MW)
2843
Ranks 24th

5.37% of MN electricity is from solar

1.23% of MN homes have solar

Minnesota Annual Solar Installations



SEIA Solar Energy Industries Association®

SEIA.org/Minnesota
September 2025

Minnesota Jobs in Other Clean Energy Industries

Solar Jobs, 2022 (Majority-Time)	4,643
Solar Jobs, 2022 (All)	5,120
Clean Storage Jobs	1,985
Wind Energy Jobs	2,759
Traditional Hydropower Jobs	982
Low-Impact Hydropower Jobs	200
Geothermal Jobs	140
Micro Grid Jobs	336
Smart Grid Jobs	261
Energy Efficiency Jobs	43,133

Created with Datawrapper

IREC https://irecusa.org/Minnesota-solar-and-clean-energy-jobs/

Section 03

Solar in Plymouth

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Solar in Plymouth

Based on information available from Xcel Energy, it is estimated that Plymouth has 215 solar installations with a capacity of 5,830 KW. This is equal to 2.41% of the total solar generating Capacity in the State, compared to the City's 1.39% share of State population, making the City's share of installed capacity approximately 173% of the state average. Plymouth has an average of 6.57 solar PV installations per 1,000 homes. This is approximately 70.9% of the State average.

The total solar installation Capacity in Plymouth is estimated to generate 7,180,000 kWh annually - enough to power 676 homes. As noted in Section 2, costs for Solar PV installation in the State have declined significantly since 2015. According to Solar Energy Industries Association (SEIA) the City currently has 4 solar company, or approximately 2.4% of the State's total solar business entities.

City of Plymouth's Solar Share

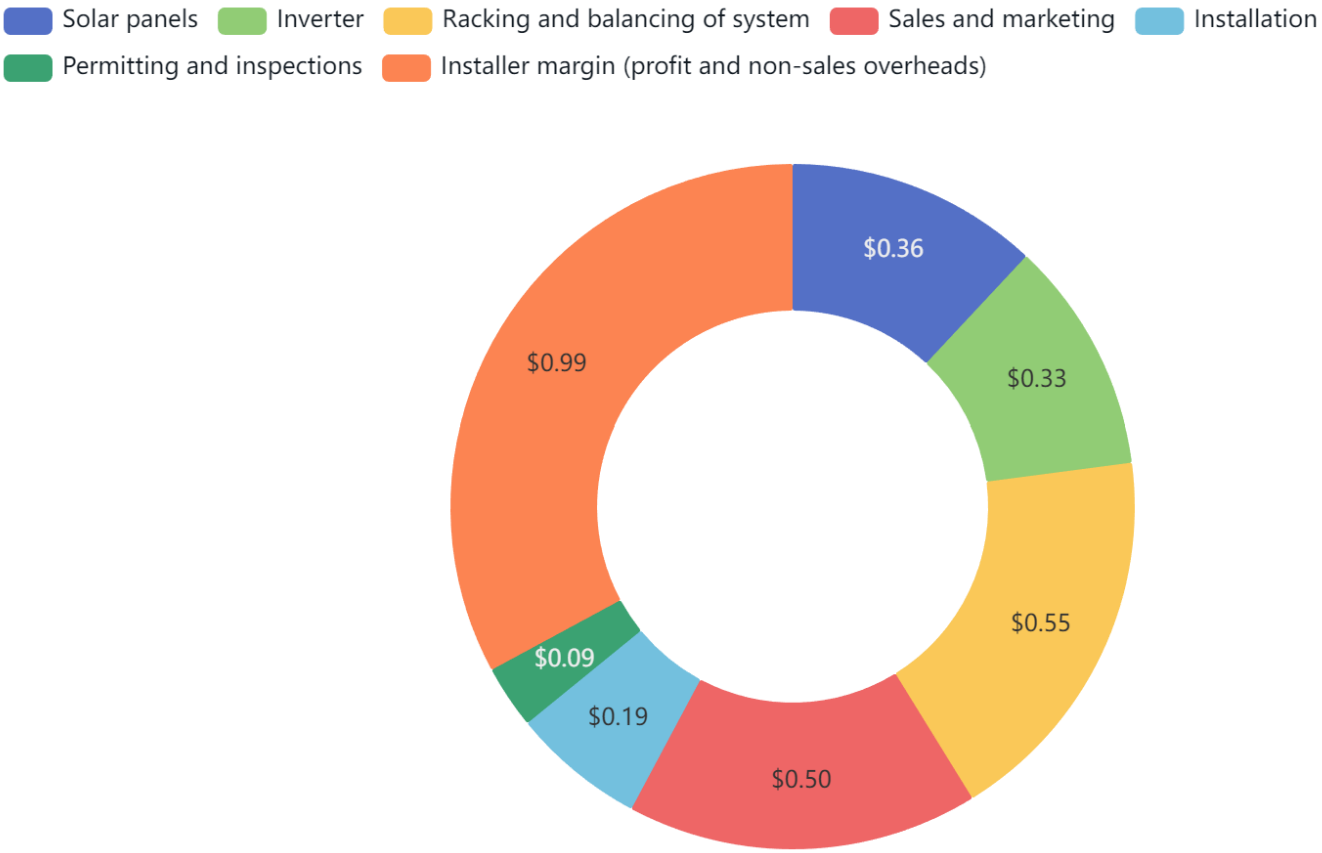
	State	Community	Community Share
Population	5,737,915	79,526	**1.39%**
Number of Solar Installations	20,899	215	**1.03%**
Average Solar Installations / 1,000 households	9.26	6.57	**70.92%**
Estimated Solar Capacity (MW)	241.97	5.83	**2.41%**
Estimated Electricity Generated Annually (GWH)	297.91	7.18	**2.41%**
Average Array Size (KW)	11.58	27.13	**234%**
Solar Industry Businesses	164	4	**2.44%**

Solar in Plymouth

Estimated Solar PV Installation Cost by Component in Plymouth

Average Estimated Cost (before incentives):

For 6kW Solar Array: **$3.16 per watt** For 10kW Solar Array: **$2.77 per watt**



Section 04

City Wide Solar Potential

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City Wide Solar Potentials

Methodology and Data

This section calculates the total technical Capacity and total generation potential for rooftop solar in the City. Total solar PV potential is custom calculated for the City of Plymouth using methodology based on the National Renewable Energy Laboratory (NREL).[1] The community specific calculations in this study use raw data from NREL provided dataset(s) as outlined in "Input Data" below.

Input Data

The National Renewable Energy Laboratory (NREL) provides roof plane data based on lidar readings from the U.S. Department of Homeland Security between 2006-2014. We used the "Small Building Suitability" dataset to estimate suitable building rooftops, by zip code, for solar installations up to 54,000 square feet.[2] For zip codes which extend significantly beyond the boundary of the community, capacities are calculated as a pro-rata share of the zip code in based on the estimated share of the zip code's population living in the city.

Tilt and Orientation

Roof plane's tilt and orientation are crucial for evaluating PV suitability. The "Small Building Suitability" data obtained from NREL noted above includes roof tilts in 5 categories:

- Flat (0° - 9.5°)
- Low (9.5°- 21.5°)
- Mid-Low (21.5° – 34.5°)
- Mid-High (34.5° – 47.5°)
- High (47.5° – 60°)

Orientations in the data are West, Southwest, South, Southeast, East, and flat. Roofs tilted over 60° and certain orientations are excluded.

Generation Potential

Using NREL's data, we calculate the "Nameplate Capacity" based on the panel assumptions below. Tilted rooftops assume 85% solar panel coverage, reserving 15% for setbacks and obstructions. Flat roofs assume spacing to avoid self-shading based on the tilt described in the panel assumptions below. We use this to estimate potential installed capacity (KW dc) for each roof class.

Panel Assumptions:

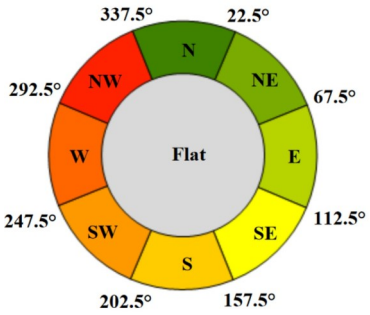
Rated Capacity:	**410 watt**
Dimensions:	**68" x 45"**
Tilt used on flat roofs:	**15°**

Solar Energy Estimates

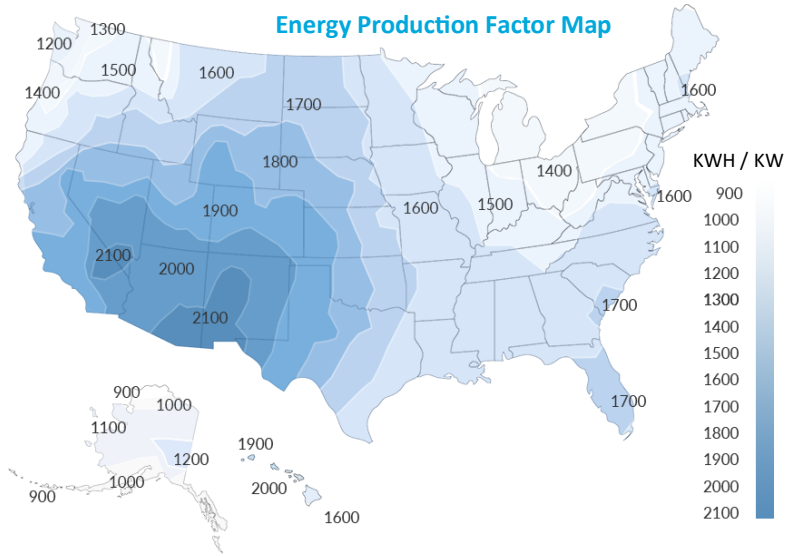
To estimate the energy generation for each roof tilt and orientation class, the above calculated total potential installed capacity (KW dc) is multiplied by the specific yield factor or "energy production factor" (kWh produced to KW capacity installed) for the region. Adjustments account for system and shading losses: 15% for flat roofs and 30% for angled roofs.

Capacity & Market Scenarios

We outline the Technical Rooftop Capacity, representing total potential. To set a solar goal, we pinpoint the "optimized" capacity for better financial returns and gauge potential market demand in the community. Further details on these capacities and market scenarios are provided later.



Azimuth Classifications
Graphic source: NREL



Data Source: NREL; Graphic Source: LetsGoSolar.com

1: Rooftop Solar Photovoltaic Technical Potential in The United States: A Detailed Assessment, NREL, https://www.nrel.gov/docs/fy16osti/65298.pdf

2: Small Building Suitability dataset, NREL, https://data.nrel.gov/submissions/47

City Wide Solar Potentials

Rooftop Technical Capacity In Plymouth

Technical Capacity represents the total rooftop solar PV potential assuming no economic or grid constraints. Based on the methodology described above, Plymouth has an estimated 22,905 buildings, of which approximately 18,286 are considered solar suitable.

These buildings include roughly 15,000 roof planes that are flat or oriented east, southeast, south, southwest, or west, totaling an estimated 8.9 million square feet. As shown in the chart below, roof planes are further categorized by tilt. The total **technical installed capacity** for all qualifying rooftops is estimated at **129.1 MWDC**.

Rooftop Generation Capacity In Plymouth

Generation Capacity represents the City's total annual rooftop solar PV energy potential derived from its technical capacity. It is calculated using a city-specific annual energy production factor (kWh per kW of nameplate capacity) based on local weather and solar insolation, adjusted for estimated system losses by roof azimuth and tilt. As shown in the chart below, total rooftop solar PV generation potential is estimated at **153,104,000 kWh annually**, equivalent to approximately **20.9% of the City's current total electricity consumption**.

Technical Rooftop Capacity In Plymouth

			Flat	Low Tilt	Mid-Low Tilt	Mid-High Tilt	High Tilt
Subtotal Flat							
Suitable Buildings	782	2.3%	**782**	-	-	-	-
Suitable Roof Planes	642	2.3%	**642**	-	-	-	-
Square Footage	362,284	4.1%	**362,284**	-	-	-	-
Capacity (KW dc)	3,790	2.9%	**3,790**	-	-	-	-
Generation (KWH)	5,154,878	3.4%	**5,154,878**	-	-	-	-
Subtotal South Facing							
Suitable Buildings	10,746	31.3%	-	**1,604**	**6,615**	**2,524**	**4**
Suitable Roof Planes	8,819	31.3%	-	**1,316**	**5,429**	**2,071**	**3**
Square Footage	3,025,127	34.0%	-	**503,568**	**1,933,758**	**587,318**	**483**
Capacity (KW dc)	31,653	24.5%	-	**5,269**	**20,232**	**6,145**	**8**
Generation (KWH)	43,046,320	28.1%	-	**7,165,178**	**27,515,117**	**8,356,854**	**9,171**
West + Southwest							
Suitable Buildings	11,205	32.6%	-	**1,434**	**6,765**	**3,000**	**6**
Suitable Roof Planes	9,196	32.6%	-	**1,177**	**5,552**	**2,462**	**5**
Square Footage	2,693,804	30.2%	-	**391,989**	**1,667,548**	**633,454**	**814**
Capacity (KW dc)	45,691	35.4%	-	**6,649**	**28,284**	**10,744**	**14**
Generation (KWH)	51,174,468	33.4%	-	**7,446,647**	**31,678,567**	**12,033,789**	**15,465**
East + Southeast							
Suitable Buildings	11,588	33.8%	-	**1,309**	**7,006**	**3,266**	**7**
Suitable Roof Planes	9,510	33.8%	-	**1,074**	**5,750**	**2,680**	**6**
Square Footage	2,828,245	31.7%	-	**360,039**	**1,765,548**	**701,842**	**817**
Capacity (KW dc)	47,972	37.2%	-	**6,107**	**29,947**	**11,904**	**14**
Generation (KWH)	53,728,453	35.1%	-	**6,839,693**	**33,540,286**	**13,332,954**	**15,520**

Grand Total		**Subtotals: Flat Roof**		**Low Tilt**		**Mid-Low Tilt**		**Mid-High Tilt**		**High Tilt**	
Suitable Buildings	34,321	782	2.3%	4,346	12.7%	20,387	59.4%	8,789	25.6%	17	0.0%
Suitable Roof Planes	28,167	642	2.3%	3,567	12.7%	16,731	59.4%	7,213	25.6%	14	0.0%
Square Footage	8,909,461	362,284	4.1%	1,255,595	14.1%	5,366,854	60.2%	1,922,614	21.6%	2,114	0.0%
Capacity (KW dc)	129,107	3,790	2.9%	18,024	14.0%	78,463	60.8%	28,794	22.3%	36	0.0%
Generation (KWH)	153,104,118	5,154,878	3.4%	21,451,517	14.0%	92,733,970	60.6%	33,723,597	22.0%	40,156	0.0%

Share of Community Electricity Use Met Through Total Potential Technical Generation **20.9%**

City Wide Solar Potentials

Optimized Generation Capacity In Plymouth

While the total solar generation potential described above is technically feasible, citywide potential estimates should reflect the most cost-effective installations based on current technology and costs. Solar PV systems with poor orientation generate less energy per dollar, so an **optimized capacity** is used to represent cost-effective solar potential.

Although precise cost-effectiveness depends on site-specific conditions, typical performance assumptions can be used to estimate citywide potential. For Plymouth's latitude and climate, flat and south-facing roof planes are generally cost-effective. West and southwest-facing roofs with low or moderate tilt are also likely cost-effective, while steeper tilts may cause self-shading and require case-by-case evaluation. East and southeast-facing roofs with low tilt are typically cost-effective, while steeper tilts may have limited optimal exposure and should also be evaluated individually.

On the chart below, all solar suitable roof planes with roof tilt and azimuth orientation combinations likely to be consistently cost effective are shown and are considered to be the City's Optimized Generation Capacity. **It should be noted that installations outside of these selections may still be cost effective but require individual feasibility assessment**. The total Optimized Rooftop Solar Generation Capacity in Plymouth is estimated to be 94,166,000 KWH annually, approximately 12.9% of the City's current total electric consumption.

Optimized Rooftop Capacity In Plymouth

			Flat	Low Tilt	Mid-Low Tilt	Mid-High Tilt	High Tilt
Subtotal Flat							
Suitable Buildings	782	3.7%	**782**				
Suitable Roof Planes	642	3.7%	**642**				
Square Footage	362,284	6.2%	**362,284**				
Capacity (KW dc)	3,790	5.0%	**3,790**				
Generation (KWH)	5,154,878	5.5%	**5,154,878**				
Subtotal South Facing							
Suitable Buildings	10,746	51.1%		**1,604**	**6,615**	**2,524**	**4**
Suitable Roof Planes	8,819	51.1%		**1,316**	**5,429**	**2,071**	**3**
Square Footage	3,025,127	52.1%		**503,568**	**1,933,758**	**587,318**	**483**
Capacity (KW dc)	31,653	41.4%		**5,269**	**20,232**	**6,145**	**8**
Generation (KWH)	43,046,320	45.7%		**7,165,178**	**27,515,117**	**8,356,854**	**9,171**
West + Southwest							
Suitable Buildings	8,199	39.0%		**1,434**	**6,765**		
Suitable Roof Planes	6,729	39.0%		**1,177**	**5,552**		
Square Footage	2,059,536	35.5%		**391,989**	**1,667,548**		
Capacity (KW dc)	34,933	45.7%		**6,649**	**28,284**		
Generation (KWH)	39,125,214	41.5%		**7,446,647**	**31,678,567**		
East + Southeast							
Suitable Buildings	1,309	6.2%		**1,309**			
Suitable Roof Planes	1,074	6.2%		**1,074**			
Square Footage	360,039	6.2%		**360,039**			
Capacity (KW dc)	6,107	8.0%		**6,107**			
Generation (KWH)	6,839,693	7.3%		**6,839,693**			

Grand Total		**Subtotals: Flat Roof**		**Low Tilt**		**Mid-Low Tilt**		**Mid-High Tilt**		**High Tilt**	
Suitable Buildings	21,036	782	3.7%	4,346	20.7%	13,380	63.6%	2,524	12.0%	4	0.0%
Suitable Roof Planes	17,264	642	3.7%	3,567	20.7%	10,981	63.6%	2,071	12.0%	3	0.0%
Square Footage	5,806,986	362,284	6.2%	1,255,595	21.6%	3,601,306	62.0%	587,318	10.1%	483	0.0%
Capacity (KW dc)	76,484	3,790	5.0%	18,024	23.6%	48,516	63.4%	6,145	8.0%	8	0.0%
Generation (KWH)	94,166,104	5,154,878	5.5%	21,451,517	22.8%	59,193,684	62.9%	8,356,854	8.9%	9,171	0.0%

Share of Community Electricity Use Met Through Total Potential Technical Generation **12.9%**

City Wide Solar Potentials

Market Capacity

Adequately anticipating the potential for new solar PV installations must consider not only the potential technical and generation capacities, but also the likely market capacity. As an emerging energy sector, there is little data upon which to base projections for likely installation of rooftop solar PV in the private sector. Additionally, the solar PV market is rapidly changing in both sophistication as well as in pricing and cost effectiveness. As noted in the Solar in Minnesota section of this report, the installed cost of solar PV in the state has dropped 11% since 2017 and is expected to continue to decline in the coming years. Projections of solar PV installations should anticipate a continued increase in the number of solar pv installations year over year.

Market History

According to the Department of Energy, since 2005 the residential solar PV market has grown at an annual rate of 51%. A growth rate that has resulted in a residential solar PV capacity 95 times larger in just 12 years. In the State of Minnesota, the new installed capacity that went on line in 2020 was nearly 231 MW; equal to 37% of the cumulative total of all solar PV installations in the state for **all previous years**.

Based on information available from Project Sunroof, it is estimated that the City of La Crosse has 200 solar installations with a generating capacity of 1.5 MW. This is equal to 2.21% of the total number of arrays or 0.24% of the total solar generating capacity installed in the State. These can be compared against the City's share of the total State population of 0.89% - meaning that when reviewed by the number of arrays installed, the City is almost 2.5 times the State average on a per capita basis, but when reviewed by the total generating capacity, it is estimated that the city may be closer to 30% of the State per capita average.

State Market Projections

The Solar Energy Industries Association (SEIA) projects solar PV installation capacity in the State to increase 4,630 MW by 2028. This is equal to a sustained compound increase of installed capacity of 36% annually.

City Wide Solar Potentials

Plymouth Market Absorption Projections

Growth Scenario: Share of Projected Statewide Annual Increase Based on Population Share Adjusted for Median Household Income

This scenario anticipates the City's rate of increase in solar PV installed capacity adjusts the projected 5 year Statewide annual rate of increase by the community's median household income compared to the state median household income. The City's median household income of $133,865 is 163% of the statewide median income of $82,109. Adjusting the projected statewide growth rate by 163%, then, adjusts the community's projected solar adoption in alignment with potential financial considerations of the community compared to the statewide average. This scenario would mean an increase of approximately 34,482 KW of installed capacity resulting in a total of 40,315 KW, equivalent to 52% of the optimized capacity potential within the City by 2035.

As the market continues to mature through the 2030's it may be reasonable to assume a reduction in the growth rate of new installed Capacity. For purposes of this study, we use an annual growth rate of 20% reduction of the scenario growth rate years 2031 through 2035, and another 75% reduction for years 2036 through 2040. The chart below shows projections through 2040 using the assumptions outlined above.

NOTE: This projection does not include distributed ground-mounted solar PV potentials nor utility scale solar PV installation potential.

Share of Projected Statewide Annual Increase Based on Population Share, Adjusted for Community Median Household Income Compared to State Median Household Income

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of Community Electric Consumption	This is Equivalent to adding (x) 9KW Residential Arrays Annually:	Or Equivalent to adding (x) 40KW Commercial Arrays Annually:
2030	16,910	20,819,899	**2.85%**	**246**	**55.4**
2035	40,315	49,635,803	**6.79%**	**520**	**117**
2040	64,087	78,903,767	**10.79%**	**264**	**59**

City Wide Solar Potentials

Plymouth Market Absorption Projections

Share of Projected Statewide Annual Increase Based on Community's Share of Statewide Installed Capacity

This scenario anticipates the City's rate of increase in solar PV installed capacity maintains the same relationship to the projected 5 year statewide installed capacity as the community's existing installed capacity compared to the state's existing installed capacity (see "City of Plymouth's Solar Share" Section 3). This scenario would mean an increase of approximately 39,478 KW of installed capacity within the City by 2035. Based on the City's current higher-than-average share of existing installed solar PV capacity, this would result in a continued higher-than-average per capita share of total statewide solar in 2035 (174% of average). This scenario would result in around 45,312 KW of installed capacity, equivalent to 59% of the optimized rooftop capacity potential within the City by 2035.

The chart below shows projections through 2040 using the assumptions outlined above.

NOTE: This projection does not include distributed ground-mounted solar PV potentials nor utility scale solar PV installation potential.

Share of Projected Statewide Annual Increase
Based on Community's Share of Total Existing State-Wide Installed Capacity (net metered)

Year	Cumulative Installed (KW)	Annual Generation (KWH)	% of Community Electric Consumption	This is Equivalent to adding (x) 9KW Residential Arrays Annually:	Or Equivalent to adding (x) 40KW Commercial Arrays Annually:
2030	18,023	22,190,335	**3.04%**	**271**	**60.9**
2035	45,312	55,787,417	**7.63%**	**606**	**136**
2040	74,243	91,407,790	**12.51%**	**321**	**72**

City Wide Solar Potentials

Suggested Rooftop Targeted Scenario

Based on the City's current lower-than-average per capita installed solar capacity (when measured by KW), we recommend striving to keep pace with the projected growth for the state. We believe using the growth scenario "**Share of Projected Statewide Annual Increase Based on Community's Share of Statewide Installed Capacity** " should be an achievable, though possibly a "stretch," goal.

Estimating Additional Capacity

In addition to roof mounted solar PV potential, the City of Plymouth has significant solar PV potential associated with ground mounted arrays as well as arrays mounted over parking—known as "Carport" arrays. Compiling a detailed estimate of the reasonable Capacity for ground mounted or carport arrays requires a much higher level of understanding of each potential subject site in order to determine the feasibility of a ground mounted or carport array at that site than what is feasible within the scope of this project effort. Some of the site use considerations on the feasibility of ground mounted arrays for specific sites include:

- Land status and planned future use
- Land quality and alternative use options
- Distance to electric grid interconnection
- Accessibility and security
- Slop and configuration
- Flooding and wetland considerations
- Proximity to primary air traffic lanes and air traffic control jurisdictions relative to glare concerns

For this report, however, we have estimated the percentage of "bare ground" and share of parking pavement which may potentially be anticipated to receive solar PV installations. The total acreage of ground and parking pavement is estimated from ground cover survey readings conducted for the Plymouth Ground Cover, Heat Island, and Carbon Sequestration Study.

For both Carport and Ground Mounted arrays, the "Nameplate Capacity" potential per square foot of covered ground or parking plane area was calculated. This calculation assumed a typical 400 watt Capacity panel with a footprint of 79" x 40" with an assumed panel tilt angle of 22 degrees and 35.6" spacing between panel rows to avoid shading at winter solstice conditions. Next, this nameplate Capacity was adjusted for assumed system losses including shading, heat loss, mismatch, snow, dirt, etc. Additionally, losses were calculated for tilt classifications based on the System Advisor Model. Lastly, generation potential was calculated using the base Energy Production Factor for the region (annual KWH production/KW nameplate Capacity), modified by the loss factors outlined earlier.

Carport Potential

The total paved area within the City of Plymouth is estimated to be 4,148 acres—approximately 19.7% of all land in the City. We estimate parking takes up 10% of this number. From a technical standpoint, much of this area is likely to be reasonably suitable for carport solar arrays, however, many locations may not perform well financially based on use and utility rate cases. Using a modest 0.5% assumed near-term availability and suitability rate, this still represents up to 2.2 acres of near-term carport solar array coverage potential. Based on the above calculation factors, this would result in a total of 959 KW of installed capacity producing 1,303,000 KWH annually by 2035, approximately 0.2% of the City's total electric consumption.

Ground Mounted Potential

The total lawn and "bare ground" area within the City of Plymouth, excluding tree canopy coverage areas, is estimated to be 4,187 acres—approximately 19.9% of all land in the City. From a technical standpoint, much of this area is likely to be reasonably suitable for ground mounted solar arrays, however, many locations may not be appropriate for ground mounted arrays due to one or more of the site use considerations outlined above. Using a moderate 0.5% assumed near-term availability and suitability rate, this still represents up to 21 acres of near-term ground mounted array coverage potential. Based on the above calculation factors, this would result in a total of 4,836 KW of installed capacity producing 6,577,000 KWH annually, approximately 0.9% of the City's total electric consumption.

Section 05

Low To Medium Income Solar PV Potential

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Low to Medium Income Solar PV Potential

The Need to Focus on Low and Moderate Income Solar Potential

Solar PV systems offer numerous benefits, including cost savings, energy resilience, and reduced air pollution and GHG emissions, benefiting the environment and human health. Currently, the majority of U.S. solar customers are middle to upper class, middle-aged, and predominantly male. A recent NREL study found that solar panel installation households had median incomes roughly $32,000 higher than state medians.[1]

Solar's growth presents a significant opportunity to address challenges faced by lower-income communities, such as high housing costs, unemployment, and pollution. It can provide financial relief, create jobs, and offer clean, local energy to communities disproportionately affected by traditional power generation. However, many low- and moderate-income (LMI) households, defined as those with incomes at or below 80% of the area's median, still lack access to distributed solar power in the U.S.

While solar PV costs have decreased, upfront installation expenses remain a barrier for low- and moderate-income (LMI) communities due to limited disposable income. Additionally, LMI populations encounter various hurdles in adopting distributed solar systems, including:

- frequently lower credit scores, making it difficult to attain a loan for solar investments;
- insufficient tax burden to benefit from tax incentives; and
- lower rates of homeownership and higher likelihood of living in multifamily housing units—making for limited control over decisions about utilities, especially rooftop solar.

Expanding solar access for low- and moderate-income (LMI) communities is vital for advancing renewable energy, energy resilience, and Climate Action objectives. Addressing the challenges outlined and achieving community-wide renewable energy goals necessitate this expansion. Nationally, LMI households hold half of all residential solar potential, totaling 320 GW—over thirty times the 2017 new solar capacity.[1]

Energy Burden vs Energy Poverty

Energy burden levels in targeted LMI communities matter. However, energy burden doesn't always indicate household need. Some low-income households might not be low wealth. For instance, a retired couple might have major investments but minimal annual withdrawals. Energy burden doesn't necessarily show households in energy poverty—those who sacrifice energy needs or choose between energy and other essentials. Current datasets reviewed in this report lack metrics to determine energy poverty. LMI solar program could address this through strategies like defining eligibility through programs like LIHEAP or WAP.

Energy Burden In Plymouth

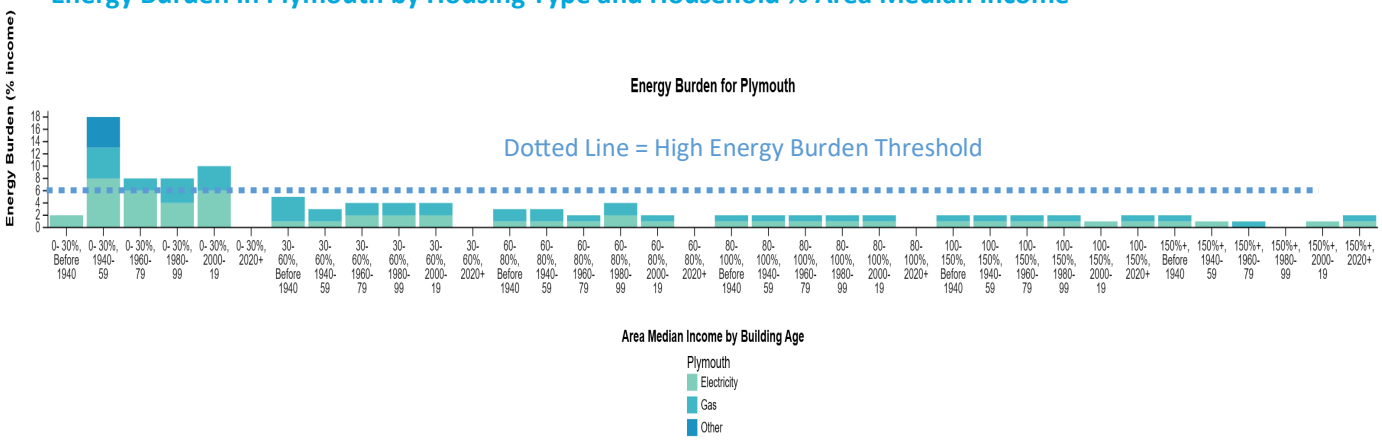
A household's energy burden—the percentage of household income spent on energy bills—provides an indication of energy affordability. Researchers define households with a 6% energy burden or higher to experience a high burden.[2] Factors that may increase energy burdens include the physical condition of a home, a household's ability to invest in energy-efficient upgrades, and the availability of energy efficiency programs and incentives.

See the charts on the following page for a breakdown of households with high energy burden.

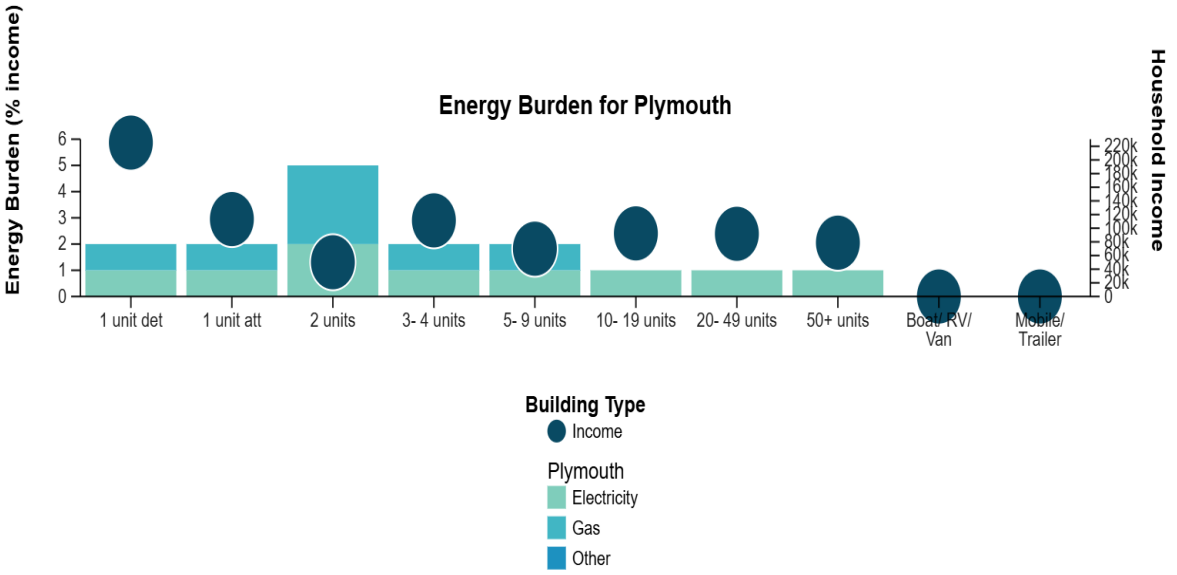
1: National Renewable Energy Laboratory, "Rooftop Solar Technical Potential for Low-to-Moderate Income Households in the United States"; https://www.nrel.gov/docs/fy18osti/70901.pdf
2: ACEEE, "National and Regional Energy Burdens"; https://www.aceee.org/sites/default/files/pdfs/ACEEE-01%20Energy%20Burden%20-%20National.pdf

Low to Medium Income Solar PV Potential

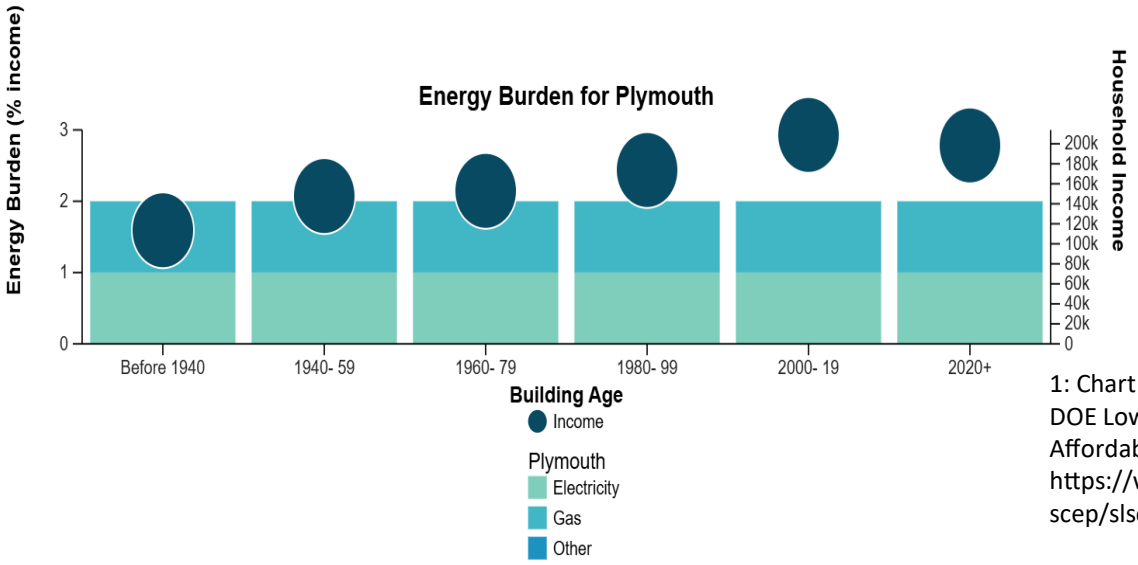
Energy Burden In Plymouth by Housing Type and Household % Area Median Income[1]



Energy Burden by Building Type and Household Income[1]



Energy Burden by Building Age and Household Income[1]



1: Chart produced by US DOE Low-income Energy Affordability Data Tool https://www.energy.gov/scep/slsc/lead-tool

Low to Medium Income Solar PV Potential

Energy Burden In Plymouth (continued)

The LMI households, by income as a percentage of Area Median Income (AMI) and housing type, which are effected by high (over 6%) energy burden are:

Share of Total LMI Households with High Energy Burden

Housing Type By Income Level	Total Households with High Energy Burden	Share of High Energy Burden in Income Category	Share of Total LMI Households with High Energy Burden
Income 0-30% AMI:	**1,130**		**100%**
Single Family Household detached	516	46%	46%
Single Family Household Attached	470	42%	42%
2 Unit Buildings	-		
3-4 Unit Buildings	43	4%	4%
5-9 Unit Buildings	65	6%	6%
10-19 Unit Buildings	32	3%	3%
20-49 Unit Buildings	-		
50+ Unit Buildings	-		
Mobile Home/Trailer	4	0%	0%
Income 30-60% AMI:	**0**		**0%**
Single Family Household detached	-		
Single Family Household Attached	-		
2 Unit Buildings	-		
3-4 Unit Buildings	-		
5-9 Unit Buildings	-		
10-19 Unit Buildings	-		
20-49 Unit Buildings	-		
50+ Unit Buildings	-		
Mobile Home/Trailer	0		0%
Income 60-80% AMI:	**0**		**0%**
Single Family Household detached	-		
Single Family Household Attached	-		
2 Unit Buildings	-		
3-4 Unit Buildings	-		
5-9 Unit Buildings	-		
10-19 Unit Buildings	-		
20-49 Unit Buildings	-		
50+ Unit Buildings	-		
Mobile Home/Trailer	0		0
Total LMI Households With High Energy Burden:	**1,130**		

Low to Medium Income Solar PV Potential

Energy Burden Program and Policy Focus Suggestions for Plymouth

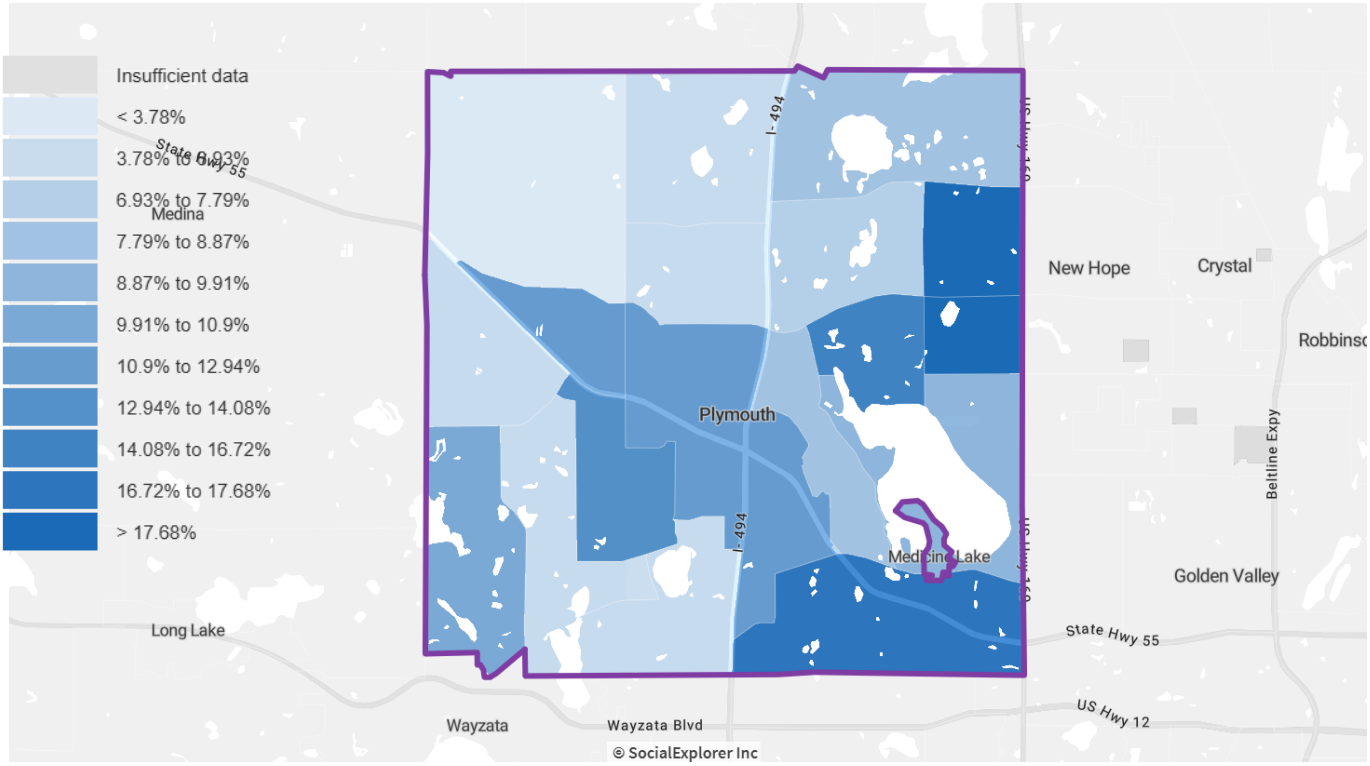
Based on the data represented in the charts on page 5-3 by the US Department of Energy, it appears that most households in the <30% AMI income range are likely to have high energy burden, regardless of the age of their home, while households within the 30%-60% AMI income range are more likely to have high energy burden if their home was built prior to 1940. The data shown in the "by Building Type" and "by Building Age" charts also suggests that households living in buildings with 2, 3-4 or 5-9 units are likely to have larger disparities between household income and overall energy burden.

Combining these observations with the information on the Share of Total LMI Households with High Energy Burden chart on page 5-4 indicate that the Village of Plymouth can likely impact energy burden within the community by ensuring programs and policies include a focus on the following households:

- All households in the 0-30% AMI income range, especially those in single family homes
- LMI households living in buildings built before 1980, with a particular focus on buildings built before 1940.
- Qualifying households based on existing program qualifications such as Low Income Home Energy Assistance Program (LIHEAP)

Low Income Share of Population by Census Tract

Below is an estimation of the "struggling to poor" share of the total population by census tract. "Struggling to poor" is defined as under 2 times poverty rate.



Section 06

City-Wide Solar Benefits

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City Wide Solar Benefits

Economic Potential for Plymouth

According to the National Renewable Energy Laboratory (NREL) JEDI model, the additional solar PV capacity which could be installed in the City by 2035 (Suggested Rooftop Targeted Scenario as well as the estimated ground mounted and carport array potentials outlined on page 4-8) has a total construction value of over $140 million (2025 dollars). Below is a breakout of the economic development potential of suggested scenarios new installed solar PV capacity:

Local Economic Impacts Through 2035
Summary Results Based on Potential Distributed Solar Goal*

	Jobs	Earnings	Output	Value Added
During construction and installation period		$000 (2025)	$000 (2025)	$000 (2025)
Project Development and Onsite Labor Impacts				
Construction and Installation Labor	195.1	$13,992.9		
Construction and Installation Related Services	273.6	$20,824.9		
Subtotal	**468.7**	**$34,817.7**	**$62,035.1**	**$46,426.3**
Module and Supply Chain Impacts				
Manufacturing Impacts	0.0	$0.0	$0.0	$0.0
Trade (Wholesale and Retail)	73.6	$5,992.9	$19,753.9	$11,564.1
Finance, Insurance and Real Estate	0.0	$0.0	$0.0	$0.0
Professional Services	89.7	$5,897.8	$17,231.5	$9,850.1
Other Services	145.7	$14,111.3	$36,410.0	$21,214.7
Other Sectors	202.5	$6,366.7	$18,177.9	$10,241.9
Subtotal	511.5	$32,368.8	$91,573.3	$52,870.8
Induced Impacts	373.8	$21,184.0	$69,498.1	$38,366.1
Total Impacts	**1,354.1**	**$88,370.5**	**$223,106.4**	**$137,663.2**
During operating years	Annual Jobs	Annual Earnings $000 (2025)	Annual Output $000 (2025)	Annual Output $000 (2025)
Onsite Labor Impacts				
PV Project Labor Only	11.3	$754.0	$754.0	$754.0
Local Revenue and Supply Chain Impacts	3.9	$297.5	$1,014.6	$573.4
Induced Impacts	3.2	$182.1	$597.4	$329.8
Total Impacts	**18.4**	**$1,233.6**	**$2,365.9**	**$1,657.1**

*Includes estimated Ground Mounted and Carport array potential outlined in Section 4.

Additional Economic Benefit

In addition to the local re-investment share of the construction and maintenance costs, Plymouth residents and business owners who invest in solar PV will have direct economic benefit in the form of savings. These savings represent increased economic potential within the City. For example, many owners who install solar PV see a decrease in their annual energy costs (including solar PV project finance costs). Though savings vary, a reasonable estimate of the out-of-pocket savings for residents and businesses in Plymouth is $500,000 to $700,000 annually by 2035 (based on a third party ownership structure, long-term savings for direct ownership can be significantly higher).

City Wide Solar Benefits

Environmental Benefits for Plymouth

The core environmental benefits of Solar PV electric energy generation relate to improved air quality, reduced greenhouse gas emissions, and reduced water consumption.

Greenhouse Gas and Electricity

Greenhouse gas emissions form, primarily, from the burning of fossil fuels. The carbon footprint of electricity is the total greenhouse gas emissions throughout the life-cycle from source fuel extraction through to end user electricity. According to the Intergovernmental Panel on Climate Change (IPCC), the median greenhouse gas emission, measured in metric tonnes, for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Metric Tonnes GHG/GWh
Hydroelectric	4
Wind	12
Nuclear	16
Biomass	18
Geothermal	45
Solar PV	46
Natural gas	469
Coal	1001

The Water/Energy Nexus

Water and energy are inextricably linked in our current modern infrastructure. Water is used in all phases of energy production. Energy is required to extract, pump and deliver water for use, and to treat waste-water so it can be safely returned to the environment. The cumulative impact of electricity generation on our water sources can be significant, and varies by fuel source. "Water use of electricity technologies: A global meta-analysis" from *Renewable and Sustainable Energy Reviews*, Volume 115, 2019, the average fresh water use for 1 Gwh of electricity by fuel type is as follows:

Electricity Source	Gallons/GWh
Hydroelectric	1,311,000
Wind	11,000
Nuclear	605,000
Biomass	22,481,000
Geothermal	270,000
Solar PV	87,000
Natural gas	158,000
Coal	586,000

Current Electric Grid Profile

According to utility data, the total GHG emissions per MWH equal approximately 0.224 metric tons (2024 reporting). Using the above average fresh water use by fuel type, the average water use per 1 Gwh of electricity in the community is likely 400,000 to 500,000 gallons.

Based on these numbers, by 2035 the additional solar PV installed in the City of Plymouth can reduce its annual Greenhouse Gas emissions and its annual water footprint as follows*:

Scenario Carbon and Water Footprint Reduction Potential

Year	**Annual Generation** (GWH)	**GHG Emission Reduction** (mTons)	**GHG Emission Reduction** (Million Cubic Feet of Atmosphere)	**Water Footprint Reduction** (Mgallons)
2030	30.07	6,736	132	160
2035	63.67	14,262	280	338
2040	99.29	22,241	436	527

*Note, as a measure of energy consumption, water footprint is a measure of a community's full energy supply chain impacts on water consumption and is not reflected directly on a community's local water consumption.

Section 07

Other Renewable Energy Strategy Potentials

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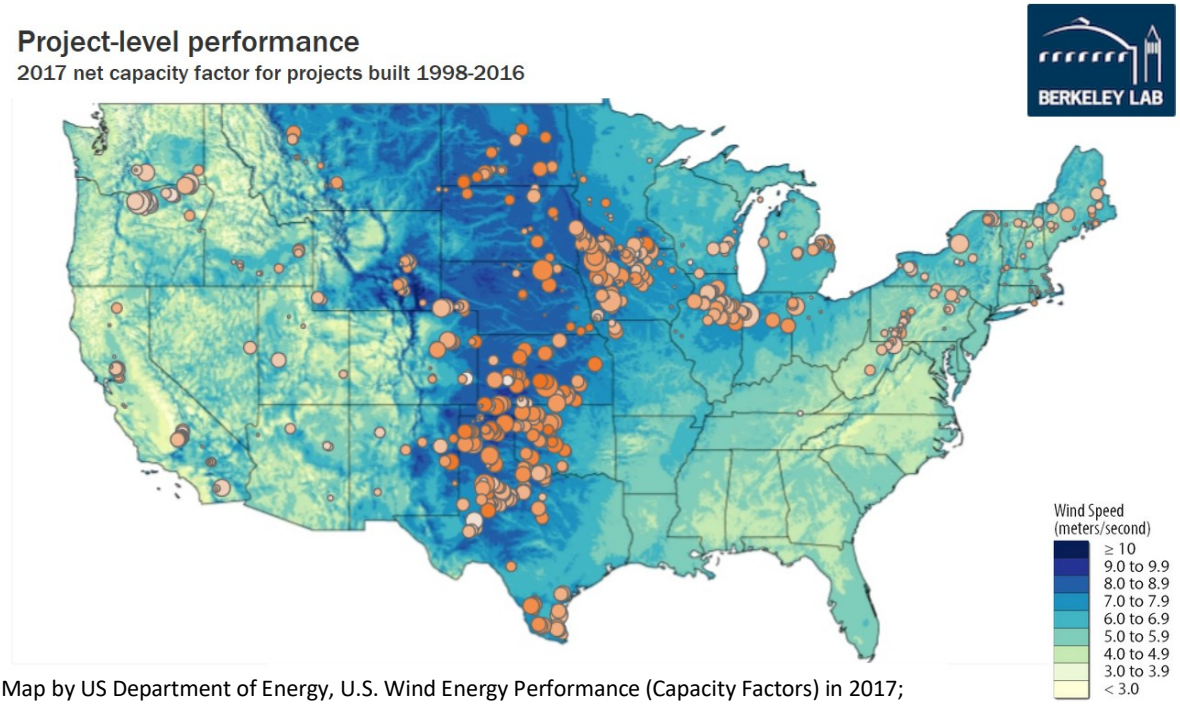
Other Renewable Energy Strategy Potentials - Customer-Owned Wind Energy

How Do Wind Turbines Work

Wind turbines convert wind into electricity. Wind spins turbine blades, which then drives a generator to produce electricity. The aerodynamic force on the blades, similar to airplane wings, causes a pressure difference. This creates lift, making the rotor spin, which in turn powers the generator to produce electricity.

Wind Power Performance

Wind speeds and patterns vary across the U.S. due to factors like terrain and geography. These elements define a region's "capacity factor" for wind turbines, which compares actual to potential energy output. The US DOE notes Minnesota has one of the highest capacity factors. Thus, Plymouth might be prime for wind power.



Map by US Department of Energy, U.S. Wind Energy Performance (Capacity Factors) in 2017; https://windexchange.energy.gov/maps-data/332

Calculating Wind Turbine Generating Capacity

Using a wind turbine's nameplate capacity and the site's anticipated capacity factor, we can estimate its annual electricity generation. The capacity factor, derived from regional performance data, represents the average power output divided by the turbine's maximum capability. The US DOE states Minnesota's average capacity factor is 35.9%. Consequently, to calculate a turbine's potential annual generation in Plymouth, use:

Nameplate capacity

x

total hours in year (8,760)

x

site's capacity factor (35.9%)

=

Total Anticipated Electricity Generation

Small Scale Wind as a Renewable Energy Pathway for Plymouth

The US Department of Energy noted a $5,120/kW average cost for small wind projects in 2021 from 16 projects totaling 396 kW. Typically at 14 kW, these can help entities offset energy costs. They need open, obstruction-free areas, with turbines 30 feet above obstacles within 500 feet.

Plymouth's larger open spaces or less populated areas may be suitable for increased customer-owned wind turbine installations.

Other Renewable Energy Strategy Potentials - No Emission Biomass to Power

No Emission Biomass to Power - Gasification

What is Plasma Gasification

Plasma gasification uses electricity and high heat to turn city waste into useful materials without burning it. Some people think this method is just like burning trash, but it's not. Instead of burning the trash, plasma gasification changes organic materials into a gas rich in energy and turns other materials into a glass-like substance called slag. This process reduces landfill waste while providing an energy source that can be used for electricity or liquid fuel.

How does Plasma Gasification Work

In plasma gasification, a strong electric current creates an arc between two points. A non-reactive gas is then sent through this arc into a closed container with waste. This electric arc gets hotter than the Sun's surface, breaking down most of the waste into basic gas elements and simplifying complex molecules to single atoms.

What Is Produced By Plasma Gasification

The plasma gasification process results in makes three things:

1. Syngas is a gas made of hydrogen and carbon monoxide. A large portion of the waste, like plastics, turns into syngas. Before you can use this gas for power, harmful chemicals have to filtered. After that, Syngas can burn like natural gas, or converted into a human-made diesel fuel or hydrogen. Typically some of the syngas produced is used to power the gasification plant, but the rest can replace use of these other fuels or sold to utilities or companies to generate electricity.

2. Slag is like a black, glassy rock. It can be cleaned to remove bad metals like mercury. After that, it can be turned it into bricks or gravel.

3. Extra heat comes from the process, this heat can be used to make steam, which can also help to generate more electricity.

Is Plasma Gasification Carbon Neutral

Plasma gasification happens in a sealed environment, so it doesn't release any emissions directly. While burning its produced syngas does emit CO2, this is considered carbon-neutral because the fuel comes from biomass. Even counting these emissions, plasma gasification is a lower-emission option for managing waste. A 2010 study by SCS found that it produced significantly fewer greenhouse gases compared to other methods like landfills and incineration.[1] Specifically, it emitted 31 million tons less CO2 per megawatt-hour than landfills that capture energy and 50,000 tons less than burning natural gas, making it a more eco-friendly choice.

Environmental Considerations of Plasma Gasification

Research indicates that two-stage plasma gasification is a greener alternative to incineration for managing trash.[2] Not only is it more environmentally friendly, but it also generates more electricity and can readily produce liquid fuels like hydrogen. This method excels at reducing harmful emissions and waste, positioning it as a top contender for future waste management practices. Unique benefits, like converting waste into reusable materials, further differentiate it from other waste disposal methods. By breaking waste down to its core components, plasma gasification bypasses the environmental issues tied to landfills and incineration.

The Economics of Plasma Gasification

Running a plasma gasification plant does cost money, which could make small-scale operations financially unfeasible. However, research indicates that these plants start turning a profit when they process around 100 tons of waste per day, thanks to the energy they produce and sell.[3] This suggests that a community, or a group of communities, generating between 26,000 and 36,000 tons of landfill waste each year could likely support a cost-effective plasma gasification plant.

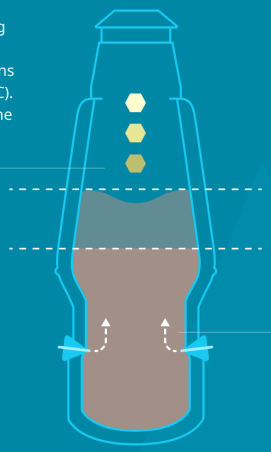
1: Plasma Gasification—The Waste-to-Energy Solution For The Future, http://large.stanford.edu/courses/2021/ph240/jibodu2/docs/birsan-2014.pdf

2: Environmental Assessment of Municipal Solid Waste by Two-Stage Plasma Gasification, https://www.mdpi.com/1997-1073/12/1/137

SIERRA ENERGY

Polisher zone

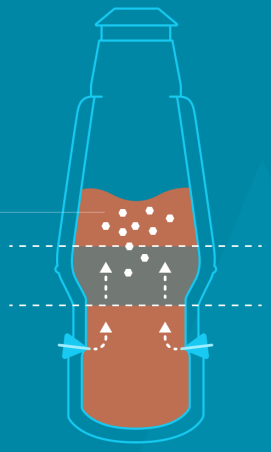
Condensable tars in the raw syngas exiting the top of the bed are fully converted to additional syngas using controlled reactions with oxygen and steam at 2,000°F (1,100°C). The tar-free syngas then exits the top of the gasifier ready for downstream processing.



Oxygen and steam are injected into the bottom of the gasifier producing hot syngas that rises and exchanges heat with the bed of waste material. This supports additional gasification reactions, devolatilization, and drying.

Drying and devolatilization zone

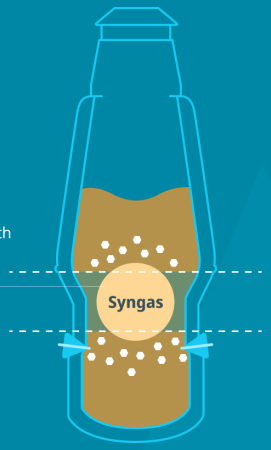
Waste enters the side of gasifier and is dried by rising hot syngas. The waste then descends into the devolatilization zone where a mix of light gases, hydrocarbons, and condensable tars are released at 1,300°F (704°C).



Solids that escape with the gas are cleaned out of the syngas and recycled back into the gasifier during gas cleaning.

Gasification zone

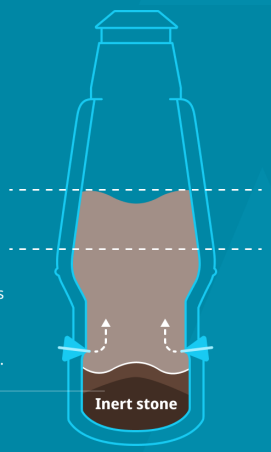
Gasification occurs in the lower section of the vessel where the remaining carbon-containing materials in the waste react with the steam and oxygen.



The exothermic gasification reaction raises the temperature of the lower zone from about 2,500°F (1,371°C) to 4,000°F (2,204°C) allowing for the thorough conversion of remaining carbon into syngas; the large amount of energy produced at this stage allows the FastOx® system to be self-sustaining.

Melting zone

At 4,000°F (2,204°C), inorganic compounds and metals melt and collect at the bottom in a molten state. This is removed as non-leaching inert stone and recovered metals.



The ultra high temperatures of FastOx® gasification allow the system to completely convert mixed waste without producing toxic by-products.

Graphic Source: Sierra Energy

Other Renewable Energy Strategy Potentials - No Emission Biomass to Power

Plasma Gasification Potential in City of Plymouth

According to Sierra Energy, based on the City of Plymouth's total landfilled municipal solid waste, the current waste stream within Plymouth could support the following gasification derived energy potential:

	Hennepin County Total Landfill Waste		City of Plymouth Total Landfill Waste	
	303,509,885	**kWh Electricity** annually	**19,175,878**	
		or		
	67,181,121	**Pounds Hydrogen Fuel** annually Usable as a fuel alternative for fuel cells or engine generator sets	**4,244,531**	
		or		
163% of Community Diesel Consumption	**16,760,084**	**Gallons of Renewable Diesel** annually Usable as a fuel alternative for vehicles	**1,058,909**	**664%** of Municipal Diesel Consumption
		or		
	377,863,712	**Pounds of Ammonia** annually Usable as a fuel alternative for fuel cells or engine generator sets	**23,873,583**	

Source: Sierra Energy

Section 08

Example Renewable Energy Scenario

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Example Renewable Energy Potential Scenario

This Renewable Energy Potential study is among the "Baseline Documents" supporting the planning team. It aims to offer data for developing renewable energy goals, primarily focusing on Citywide rooftop solar PV and its benefits. A Renewable Energy Potential Scenario is presented to illustrate a renewable energy pathway, highlighting the scale of installations required for potential objectives. While renewable energy goals will evolve through the planning process, this preliminary information will help the team gauge necessary adjustments in installations, costs, and savings related to the final customer-owned renewable energy goal.

Example Renewable Energy Pathway by 2035 (excluding utility scale measures)

Summarizing the calculations for the Suggested Rooftop Targeted Scenario as well as the estimated ground mounted and carport array potentials (outlined in section 4), as well as up to 1 MW of wind turbine installations, or approximately 318 installations of 30KW micro turbines, based on localized estimated generating capacity (outlined in section 6)

Optimized Rooftop Solar Potential, Carport Potential, and Ground Mounted Potential outlined previously illustrates a potential pathway for the City of Plymouth to increase its distributed solar Capacity by 2035. Combining the Recommended Rooftop Targeted Scenario with the Carport Potential and Ground Mounted Potential indicates a potential 2035 goal as follows:

Source Potential	Cumulative Installed (KW)	Annual Generation (KWH)	Share of Demand
Estimated Existing	5,834	7,182,167	0.98%
New Rooftop	45,312	55,787,417	7.63%
New Carport	959	1,303,877	0.18%
New Ground Mounted	4,836	6,577,492	0.90%
New Wind Energy	953	3,654,723	0.50%
Total Potential	**57,893**	**74,505,676**	**10.19%**

To achieve this goal, the community would need to achieve the following solar PV installation coverage:

Rooftop Coverage	2,997,363	Square Feet
Parking Lot Coverage	2.1	Acres
Lawn / Bare Ground Coverage	20.9	Acres
New Micro Wind Generators	318	0.003MW ave size turbine

Appendix A

Example LMI Energy Programs

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Appendix A - LMI Program Examples

As outlined in Section 5, there are many ways increasing renewable energy and energy efficiency programs focused on low and moderate income (LMI) households can have community-wide benefits. There are a number of energy efficiency and solar assistance programs which have been established by communities to do just that. Example programs include efforts by municipalities, States, non-profit entities, and utilities. Reviewing examples from each of these types of groups is helpful in identifying the range of potential - even though each of these types of groups may have different capacities, funding streams, and perhaps even motivations.

Example LMI Programs—Energy Efficiency

LLBO Energy Assistance Program

The Energy Assistance Program (EAP) helps pay home heating costs. Households with the lowest incomes and highest energy costs receive the greatest benefit. Under this program, rather than energy assistance dollars flowing to community action agencies to be re-distributed to utilities on behalf of low-income families, the community action agency generates its own electricity on behalf of its low-income clients. The community solar array sells power to tribal government buildings and utilities and uses the revenue generated to fund energy payments for low-income community members. Monetary savings from community owned solar arrays are then integrated into the local energy assistance program which is then distributed through the Energy Assistance Program recipients. Recipients are not directly subscribed to the Community Solar project but instead are enrolled through local energy assistance program, with participating varying annually based on the following criteria:

Size of grant is based on household size, income, fuel type and energy usage
Households with the lowest income and highest fuel costs receive the highest grants
Federally funded through US Department of Human Services
Funds are available for renters or homeowners
Educate consumers to use home heating energy efficiently and safely
Advocate with energy suppliers and human service providers on behalf of consumers
Crisis help for utility disconnections or necessary fuel deliveries
Emergency heating system repair or replacement

The installation provides a unique capacity-building occasion to support training and renewable employment opportunities for Leech Lake Band members. Select construction trades trainees obtain their Registered Unlicensed Electrician license and receive hands-on training in solar installations, positioning them for a growing number of clean energy job opportunities across the state and beyond.
https://www.llojibwe.org/tribalassistance/energyassist.html

Edina Energy Efficiency Cost Share and Coon Rapids Energy Efficiency Rebates

These municipal programs partner with the Xcel Energy Home Energy Squad program. The Home Energy Squad may determine that a larger project could improve the energy efficiency of a home. These municipalities offer cost sharing for a range projects. This cost sharing helps to bring down the cost of big ticket projects that have a positive impact on the efficiency of a participant's home. Residents who've had a Home Energy Squad visit in the past 36 months can apply for a cost share for eligible energy efficiency upgrades. For the City of Edina, the cost share is up to $1,000. For the City of Coon Rapids, maximum rebates are $250 for an appliance upgrade and $550 for an air sealing and insulation project. Projects covered include:

- Buying an energy efficient air conditioner or air source heat pump.
- Buying an energy efficient water heater.
- Air sealing your house.
- Insulating your house.

Appendix A - LMI Program Examples

Longmont, Colorado—Community Housing Program.
Longmont's Community Housing Program offers a fee reduction for projects that incorporate certain building features, including energy efficiency and energy conservation measures. Approved projects that provide more than the minimum requirement are eligible for additional incentives, subject to available funding, including:

- Fee Waivers: A percentage of certain development fees may be waived for qualifying projects. Reductions can range from 50% to 75% for for-sale units and from 20% to 50% for rental units.
- Fee Deferral: As part of the Impact Fee Deferral Program, new residential developments in the City of Longmont are eligible to defer payment for several City-relate fees.
- Subsidy for Water/Sewer System Developments Fees: Projects that provide more than the minimum required affordability may qualify for a percentage of the fees to be subsidized.
- Offsets for Cash-in-Lieu of Raw Water Deficits: A project that provides a minimum of 25% of total units in a development as affordable may be eligible to receive an offset for a percentage of the raw water deficit cash-in-lieu owed to the City. This incentive is only available to projects that are being platted; redevelopment projects are ineligible.

https://www.longmontcolorado.gov/departments/departments-e-m/housing-and-community-investment/housing-programs/affordable-housing-incentives

Bridgeport, Connecticut - Energy Improvement District
The City of Bridgeport has established an Energy Improvement District to promote the planning, development, and funding of energy-related activities. The Board seeks to promote the BGreen 2020 plan to increase the efficiency of energy use in the City of Bridgeport, and attract commerce and industry.

The EID Board has begun examining the following projects on behalf of City. The Energy Improvement District allows Bridgeport to generate and sell local renewable power and buy power in bulk to reduce costs. The Board has solicited proposals from Energy Suppliers licensed in the State of Connecticut to provide a service contract package for City residents and businesses to help reduce energy costs on their monthly utility bills https://www.bridgeportct.gov/content/341307/347097/347109.aspx

City of Chicago, Illinois —Retrofit Chicago Residential Partnership
Led by the Mayor's Office, the Retrofit Chicago Residential Partnership brings together organizations seeking to advance residential energy efficiency for Chicago residents. Partners include ComEd, Peoples Gas, Community Investment Corporation, Elevate Energy, and the Chicago Bungalow Association. As of 2014, the Partnership members have saved Chicago residents over $4 million annually with over 100,000 installations of energy saving products in residences and over 20,000 deeper retrofit improvements.

Customer benefits include:

- Free energy assessments with free energy-saving products and installation
- Rebates for energy efficient appliances and other products
- Financing tools such as income qualifying grants for bungalow & vintage homeowners, energy savers loans, and on-bill financing
- Connect to qualified contractors
- Learn more about how you can manage your energy use through online tools and leverage a smart meter to save more on electricity bills (https://www.chicago.gov/city/en/progs/env/smart-grid-for-a-smart-chicago.html)
- Visit the FAQ page to learn more about available offerings residents can take advantage of as a Chicago resident (https://www.chicago.gov/city/en/progs/env/retrofit-chicago-faqs.html)

Appendix A - LMI Program Examples

City of Chicago, Illinois - Bungalow Association Energy Savers Grant
The Historic Chicago Bungalow Association (HCBA) offers grants for certified Chicago Bungalow owners to make their homes more energy-efficient, which benefits families and neighborhoods alike. Each grant, valued at $3,600, goes towards weatherization services such as attic insulation and wind sealing along walls, windows, foundations, and other weak spots that typically lend themselves to heat loss in older brick homes. Applicants must live in an HCBA-certifiable Historic Chicago Bungalow and be a member of HCBA. Household income must be at or below 80% Area Median.

City of Portland, Oregon – Green Investment Fund
Portland, Oregon established its Green Investment Fund (GIF) in 2005 to provide financial incentives for the adoption of innovative technologies in energy efficiency, renewable energy, water conservation, stormwater management, and green building materials. The GIF was intended to demonstrate green building in an array of project types; to highlight the most innovative, regionally appropriate practices and technologies; and to support publicly valuable green building projects. The $2.5 million Green Investment Fund provide grants for demonstration of affordable housing units that incorporated energy efficiency and environmental features.

Multiple Municipalities, Long Island, New York - Long Island Green Homes
Long Island Green Homes is a non-profit collaborative partnership of Long Island Towns, community-based organizations and Molloy College funded primarily with a community outreach grant awarded by the New York State Energy Research and Development Authority (NYSERDA) in order to help Long Islanders improve their homes and use energy more wisely in their everyday lives.

Via one-on-one support from the program's Energy Navigators, Long Island homeowners are connected with government funds and local, certified contractors to receive a free home energy audit, and money saving and energy efficient improvements to their homes. In addition to reducing participant home's carbon footprint and saving residents money, the Long Island Green Homes Initiative stimulates job growth and business opportunities in the community.

County Government Examples

Montgomery County, Maryland— Greenbank
Green banks are financial institutions that can leverage public funding to attract private capital for clean energy projects (including energy efficiency, renewable energy, and other distributed energy resources), as well as other "green" investments. They can assist states and communities in partnering with private lenders and investors to mobilize capital, alleviate perceived risks, and design attractive financial instruments to support these investments.

The Montgomery County Green Bank has partnered with lender to offer community members preferred terms and interest rates not generally offered to the public. These reduced terms can help low-income community members afford energy efficiency upgrades.

Note, the 2022 Inflation Reduction Act (IRA) authorized the Greenhouse Gas Reduction Fund (GGRF), a $27 billion clean energy deployment bank housed at the Environmental Protection Agency (EPA). The legislation for this fund includes moneys for supporting the development of local and state green banks.

Appendix A - LMI Program Examples

Example LMI Programs—Solar

City of St Louis Park Solar Sundown Rebate
The City's Solar Sundown rebate program is a cost share to support reducing the solar installation expenses. The program provides a 4% cost share for city residents and increases the total cost share to 6% for income qualified residents.

Brian Hoffman, City of St. Louis Park Director of Building and Energy, said, "This program clearly demonstrates that city incentives are a powerful tool to help achieve Climate Action Plan goals. The $115,000 for funding the program successfully leveraged $2.7 million in private investment in renewable energy in St. Louis Park, which will result in thousands of dollars of savings for those property owners over the life of those panels."

Edina Solar Cost Share
The City of Edina offers a solar installation cost share program. The total available funding is 4% of the total solar PV cost with property owner participation in the Federal Investment Tax Credit

Edina Community Solar
The City of Edina partnered with a non-profit community solar developer to install a rooftop solar array on one of the municipality's largest buildings. The city offered the rooftop at no cost, leveraging a reduced project cost. The resulting development is then offered to community members for solar subscriptions at rates well below the standard residential retail rate. Preference is given to LMI households.

City of Chaska Solar Panel Rebate
The Chaska Solar Rebate Program offers a rebate of $250 per kW AC installed. The total rebate is capped at $2,500. Rebate requests are processed on a "first-come first-served" basis. Annual rebate funds are limited and payouts could be paid over several years.

City of Houston - Sunnyside Landfill Solar Farm
The City of Houston competitively bid the opportunity to develop a solar installation on their Sunnyside Landfill. In the final proposal, the City retains ownership of property and liability of the subsurface landfill material. The tenant (solar developer) will complete permitting for and restoration of the landfill cover, be responsible for maintaining the restored cover within the leased space, including all landscaping, mowing, reseeding, etc. The project will develop a 50 MW utility solar array which will produce enough electricity to power 5,000 homes annually (power sold to electric utility) as well as a community owned 2MW solar array which will produce enough electricity to power 200 homes and which will provide power discounts for low-income residents in the neighborhood. The project is expected to include opportunities to train and employ local labor.
https://www.houstontx.gov/mayor/press/sunnyside-solar-farm.html

City of San Antonio—SolarHost
In 2015, San Antonio's municipally owned utility, CPS Energy, launched a pilot program called SolarHost in San Antonio, TX. SolarHost provides participating homeowners with a 3-cents per kilowatt/hour utility bill credit for hosting a solar PV project on their rooftop for 20 years. The solar installations are designed not to hinder the property and if any roof repairs are required, CPS pays the cost for removal and reinstallation. SolarHost has been a success, reaching its goal of 5 MW installed by February 2017. To date, 8,000 applications were received with over 600 systems installed across San Antonio. Without income or credit score requirements, SolarHost can be categorized as an Inclusive Solar Finance product by increasing access to solar for low income and/or low credit score customers by establishing a long-term arrangement that creates economic value derived from the installation of solar PV.
https://www.solarhostsa.com/

City of Charlottesville—Solar Property Tax Credit
The City of Charlottesville offers a tax credit for certified solar energy equipment, facilities or devices that are attached to real estate within the City of Charlottesville. The tax credit applies a portion of the total cost of the solar equipment, facilities, or devices as a credit on the real estate tax bill for 5 years. A successful application must be made to receive this tax credit.

Appendix A - LMI Program Examples

City of Austin—Solar Rebate Program
Residents in Austin can earn a $2,500 rebate by completing the City's solar education course and installing a qualifying solar photovoltaic (PV) system on their home. https://austinenergy.com/green-power/solar-solutions/for-your-home/solar-photovoltaic-rebates-incentives

City of Denver— Climate Action Rebate
The City of Denver Climate Action Rebate program provides up to $4,000 cost sharing for solar PV installations on residential properties.

City of Denver—CARE
The Housing Authority of the City and County of Denver's (DHA's) Clean Affordable Renewable Energy (CARE) project provides solar benefits to affordable housing properties in the Denver Metro area through a 2 MW ground-mounted shared solar array. DHA manages the project and apportions the credits for the electricity produced by the array across several multifamily affordable housing facilities as well as and individual LMI households. The project is reported to generate a 15-20% electricity bill savings for the 500-plus households participating. DHA partnered with GRID Alternatives to develop and provide work force training and job opportunities. The project provided over 50 Denver residents from under-served communities with hands-on solar job training. https://www.usgbc.org/sites/default/files/2020-02/DHA%20Case%20Study%20October2019_1.pdf

State Examples

State of Colorado
The Colorado Energy Office (CEO) has implemented two cost-effective low-income solar energy offerings as part of an effort to comprehensively address household energy burden - community solar (as a demonstration project) and rooftop solar. Both demonstrate the feasibility of combining energy efficiency and solar offerings to help reduce utility bills for residents most in need - those paying more than four percent of household income on energy costs.

Community Solar:
In 2015, the Colorado Energy Office (CEO) launched a low-income community solar demonstration project. The purpose of the project is to demonstrate the feasibility of building 100 percent low-income community solar models and to reduce household energy burden. GRID Alternatives was awarded a $1.2 million grant from CEO to implement the project. In this capacity, GRID is responsible for securing utility partners, developing program terms, building each project, and leveraging CEO dollars with a 2:1 partner match. Multiple utility partners have been engaged and six community solar models have been built. All utility providers have agreed to offer solar credits to low-income subscribers to ensure that the solar energy provided is affordable. Subscribers are connected to each system for a set period of time and must reapply at the end of the contract term. Targeted subscribers are eligible for weatherization.

Community solar projects in this program offset either a pre-determined KW cap, or up to 100% of a subscriber's usage, resulting in a cost savings of approximately 50%. Subscribers were solicited through traditional outreach and marketing methods. These methods included flyers, brochures, direct calls, and in-person workshops. Households that had previously received weatherization services were targeted for outreach to ensure those subscribed maximized energy cost savings.
https://energyoffice.colorado.gov/community-solar-0

Appendix A - LMI Program Examples

Colorado Rooftop Solar

The CEO Weatherization Assistance Program (WAP) offers rooftop solar photovoltaics (rooftop PV) to its clients on a limited basis. Colorado is the first state in the nation to receive approval from the U.S. Department of Energy (DOE) to integrate rooftop PV into WAP. The CEO WAP includes rooftop PV as a measure to specifically target expensive residential electricity expenditures. WAP anticipates being able to save each of its rooftop PV clients more than $400 annually by reducing electricity costs. Rooftop PV will be installed on a limited number of homes that meet certain criteria to ensure they will provide a high return on investment.
https://energyoffice.colorado.gov/rooftop-solar-pv

Non-Profit Examples

RE-volv Revolving Fund

RE-volv, a small nonprofit organization headquartered in San Francisco, provides solar financing assistance for small and medium sized nonprofits, which often do not have the funds to cover the upfront cost of a PV system. The RE-volv model uses crowdfunding to help raise the upfront solar array costs and RE-volv leverages student volunteers who assist with its crowdfunding and solar education campaigns.

The nonprofit beneficiary pays RE-volv for its solar installation over time through a lease or power purchase agreement (PPA) financing arrangement. As the nonprofit makes its financing payments, RE-volv reinvests money into a fund that helps offset the cost of additional solar projects for other nonprofits. This revolving fund, called the Solar Feed Fund, is a pay-it-forward model for solar energy that is designed to continually perpetuate itself to help pay for new solar projects.

Crowdfunding is the practice of raising money from many people, typically in small amounts, through online donations. RE-volv offers a nonprofit beneficiary a crowdfunding platform for raising funds to cover the cost of adopting solar. The crowdfunding platform gives prospective donors a two-fold basis for contributing to a campaign: to support the nonprofit beneficiary organization and to support the clean energy economy through a solar investment. Since solar can provide electricity bill savings, it can enable more of a nonprofit's funds to be directed toward its mission-related work. By contributing to a solar crowdfunding campaign, donors committed to an organization can help advance the nonprofit's core mission.

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Regular Environmental Quality Committee
March 11, 2026
Agenda Number: 6.2

To:	Environmental Quality Committee
Prepared by:	Talori Dunsworth, Senior Water Resources Technician
Reviewed by:	Michael Payne, City Engineer/Deputy Public Works Director
Item:	**Water Resources Education and Outreach Plan**

1. Action Requested:

Review and provide feedback on the Water Resources Education and Outreach Plan.

2. Background:

Education and outreach is one of the key requirements of the city's MS4 (Municipal Separate Storm Sewer System) permit, specifically under Minimum Control Measure 1, which focuses on Public Education and Outreach. In the 2026 pre-public draft permit, the Minnesota Pollution Control Agency added a new requirement that cities develop and implement a formal, written Education and Outreach Plan.

Even though the permit has not yet been formally reissued, staff saw this as a good opportunity to step back and evaluate our current program. Staff used this time to better organize documentation, strengthen messaging, and ensure the city is meeting both current expectations and anticipated upcoming regulatory changes.

Each summer, especially after heavy rain events, the Water Resources Division receives a number of questions and concerns from residents related to high water levels, drainage issues, soil erosion, and other surface and groundwater impacts. Historically, much of the city's response has been reactive. The education and outreach plan shifts focus to a proactive model to help the public understand why these issues occur, how the stormwater system functions, and what steps can be taken to reduce impacts.

By shifting toward more proactive education, the city aims to reduce confusion, improve transparency, and equip the community with the knowledge needed to better understand and support the city's water resource management efforts.

3. Budget Impact:
N/A

4. Attachments:
1. Draft Water Resources Education and Outreach Plan

City of Plymouth

Water Resources
Education and Outreach Plan

March 2026

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Introduction & Purpose

The City of Plymouth has historically met and exceeded Municipal Separate Storm Sewer System (MS4) public education requirements. However, this plan represents an opportunity to organize existing efforts, strengthen documentation, and expand strategic messaging. Rather than responding reactively to seasonal concerns, this plan shifts the city's efforts toward a proactive, prevention focused model that empowers members of the Plymouth community to stay informed and have an active role in protecting water quality.

Public Education & Outreach is a core requirement of the MS4 permit under Minimum Control Measure (MCM) 1, Sections 16.1 – 16.9. With the release of the 2026 pre-public draft permit, the Minnesota Pollution Control Agency (MPCA) requires all MS4 communities to develop and implement a formal, written Education and Outreach (E&O) Plan.

The purpose of the E&O plan is to:

- Increase public understanding of how water moves through Plymouth's landscape and infrastructure
- Clearly communicate the city's policies, programs, and best management practices
- Equip residents, property owners, contractors and internal staff with practical tools to prevent pollution and manage stormwater in a responsible way
- Reduce preventable complaints, violations, and environmental impacts

This plan aligns the outreach efforts with measurable outcomes, seasonal timing, regulatory requirements, and cross-departmental coordination. The MS4 Permit requires an annual evaluation of the education and outreach program to ensure it addresses evolving community needs and regulatory priorities.

Goals and Measurable Outcomes

The City of Plymouth's Education and Outreach Program is designed to produce measurable improvement in awareness, behavior, and regulatory compliance. Success will be evaluated using quantitative metrics, participation tracking, and trend analysis over time.

1. Expand and Formalize Outreach Efforts

   Goal: Increase consistent, documented engagement with priority audiences
   Measurable Outcomes:

   - Attend 10 outreach events in a calendar year

- Publish content in at least four editions of Plymouth News annually
- Implement a seasonally targeted social media campaign that highlights water resources topics
- Track website engagement metrics such as page visits, downloads, and views on videos

2. Shift from Reactive to Proactive Communication

Goal: Reduce preventable complaints and service requests through anticipatory education

Measurable Outcomes:

- Reduce weather-related drainage and erosion requests year-over-year through targeted seasonal messaging
- Develop and distribute topic specific checklists and educational materials prior to high impact seasons
    - Examples include spring thaw, summer irrigation, and winter salt application
- Track trends in recurring complaint categories to assess the effectiveness of outreach activities

3. Increase Public Awareness of Water Resource Programs and Practices

Goal: Improve resident understanding of city initiatives, regulatory requirements, and available assistance programs

Measurable Outcomes:

- Increase participation in voluntary programs such as Adopt-A-Storm Drain, Adopt-A-Parks, and Water Efficiency Rebates
- Increase attendance at workshops, open houses, and educational events hosted by the city and its partners
- Promote at least one targeted mailing or digital campaign for high-priority initiatives; **Determined annually by staff*
- Collect feedback periodically in the form of event surveys or informal polling to assess comprehension and impact

4. Improve Compliance and Internal Operational Awareness

Goal: Reduce preventable violations and strengthen internal best management practices

Measurable Outcomes:

- Provide annual illicit discharge and pollution prevention training for all city staff
- Distribute erosion and sediment control educational materials to contractors at pre-construction meetings
- Distribute educational materials on routine erosion and sediment control at the start and end of each construction season to all construction contacts
- Track and evaluate trends in MS4 permit related violations or corrective actions

5. Strengthen Regional and Interdepartmental Collaboration

Goal: Coordinate outreach efforts to maximize impact and reduce duplication of efforts

Measurable Outcomes:

- Coordinate with internal departments and external agencies such as local watershed organizations/districts, adjacent cities, and regional stormwater groups
- Collaborate on at least five joint outreach initiatives per year
- Document shared campaigns and co-branded educational materials for MS4 reporting purposes

This framework allows the city to measure success not solely by the number of materials distributed, but by long-term behavioral shifts, improved compliance, and increased community participation in water resource protection.

Outreach Methods

The City of Plymouth will use multiple strategies to effectively reach residents, contractors, students, internal staff, and local/regional partners. Each method is selected based on audience, seasonal timing, regulatory requirements, and the complexity of the topic being communicated.

Outreach methods are categorized as:

- Direct Engagement (Events)
- Print & Newsletter Communications
- City Website
- Social Media

- Mass Visibility Messaging (billboard)
- Partner Led Education & Regional Collaboration

Each method includes defined objectives and tracking mechanisms to support annual MS4 reporting.

1. Direct Engagement (In-Person Outreach)

Purpose:

Provide high-impact communication opportunities that allow staff to answer questions, demonstrate concepts, and distribute materials directly to the public.

Target Audience:

Residents, property owners, contractors, students, families, lake associations, and internal staff

Delivery Methods:

- City hosted events (open houses, earth day/arbor day, winter maintenance open house)
- Community events (Discover Plymouth, Bark in the Park, Drop off Days)
- Pre-Construction Meetings
- Workshops and demonstrations (rain garden, native vegetation, soil health)

Tools Used:

- Educational handouts and postcards
- Demonstration models (soil profiles, soil testing, Enviroscape)
- Interactive activities
- Sign-up sheets for voluntary programs

Performance Tracking:

- Number of events attended annually
- Estimated attendance
- Materials distributed
- Program sign-ups that are generated from events

2. Print and Newsletter Communication

Purpose:

Provide structured, seasonal education that is aligned with high-risk periods (spring thaw, summer irrigation, winter salt application).

Target Audience:

Residents, property owners, students, families, lake associations, and internal staff

Delivery Method:

- Bi-monthly Plymouth News newsletter

Content Focus Area:

- Seasonal drainage guidance
- Program promotions (Adopt-A-Storm Drain, Water Efficiency Rebate Program, native plant conversion program (TBD), other workshops
- Irrigation best practices
- Chloride reduction
- Winter construction expectations (new and redevelopment)

Performance Tracking:

- Number of articles included annually
- Alignment with seasonal calendar goals
- Website traffic on newsletter specific pages and associated topic pages

3. City Website

Purpose:

Serve as the primary location for regulatory, technical, and other pertinent information to be accessible and transparent with residents.

Target Audience:

Residents, property owners, students, families, lake associations, and internal staff

Delivery Method:

- plymouthmn.gov/environment

Content Focus Area:

- Surface Water Management Plan (SWMP)
- Stormwater Pollution Prevention Program (SWPPP) Document
- Illicit Discharge Detection and Elimination (IDDE) Program information
- Rebate Program information (WERP and possible new programs)
- Water Quality Best Management Practices (BMP) Information
- Wetland and wetland buffer information and regulations

- Smart Salting

Performance Tracking:

- Number of articles included annually
- Applications for rebate programs
- MyPlymouth requests
- Website traffic on specific pages as they relate to the topics above

4. Social Media

Purpose:

Deliver short-form, timely messaging to reinforce seasonal topics and increase awareness among a broader audience

Target Audience:

Residents, property owners, students, families, lake associations, and members of the general public

Delivery Method:

- City managed social media channels as coordinated by Communications Division
  - Facebook
  - X (Twitter)
  - Instagram

Content Areas:

- Seasonal reminders (Adopt-A-Storm Drain, Aquatic Invasive Species (AIS), fertilizer information, salt application)
- Educational reels
- Event promotion
- Quick "Did you Know" facts
- Visual before/ after project highlights or drone footage

Performance Tracking:

- Post frequency
- Engagement metrics (reach, impressions, shares, etc.)
- Click-through rates from post to city website

5. Mass Visibility Messaging (Billboards)

Purpose:

To provide high visibility awareness messaging during appropriate seasons

Target Audience:

Members of the general public

Delivery Method:

- Electronic billboards along Interstate 494 and State Highway 169

Content Areas:

- Winter Salt Awareness
- Adopt-A-Storm Drain Promotion
- Water Conservation messaging during peak irrigation season or during drought
- Clean, Drain, Dry Aquatic Invasive Species Awareness

Performance Tracking:

- Billboard post frequency
- Engagement metrics (reach, impressions, shares, etc.)
- Click-through rates to city website

6. Partner-Led Education & Regional Collaboration

Purpose:

Leverage regional expertise and funding partnerships to expand staff capacity and streamline messaging in the water resources industry

Target Audience:

Residents, property owners, students, families, lake associations and internal staff

Primary Partners:

- West Metro Water Alliance (WMWA)
- Watershed Management Organizations (WMOs) and Watershed District (WD)
- Metro Blooms
- Three Rivers Park District
- Neighboring Municipalities
- Lake Associations
- American Public Works Association – Minnesota Chapter
- Minnesota Cities Stormwater Coalition (MCSC)
- Minnesota Pollution Control Agency (MPCA)

Delivery Method:

- 3rd Grade Earth Day/Arbor Day presentations

- 4th Grade watershed work and water cycle lesson (WMWA)
- Co-hosted workshops (resilient yards and planting for pollinators)
- Shared educational media kits
- Joint campaigns (local, regional, statewide)

Content Focus Area:

- TBD

Performance Tracking:

- Number of initiatives annually
- Workshop attendance
- School classroom participation

Implementation Strategy

Each outreach method will be aligned with:

- Seasonal calendar timing
- Target audience selection
- Regulatory requirements under the MS4 Permit – MCM 1
- Annual documentation for permit reporting

By organizing outreach methods in this structured format, the city ensures communication efforts are intentional, measurable, and strategically aligned with the long-term water resource protection goals outlined in the various above-mentioned documents.

Appendix & Seasonal Calendar Distribution

Appendices for each topic will include prepared social media posts, newsletters, postcard mailings, billboard signage, SOPs, plans, guides, and other resources as attachments once they are created/compiled

- ADA Compliance review with communications for all documents distributed

Education & Outreach Topics Summary

The city's education and outreach efforts will focus on increasing the public's understanding of stormwater management, water quality protection, regulatory compliance, and individual stewardship responsibilities. For each topic, outreach materials will follow a consistent framework:

1. **Overview of the issue**

2. **Why does it matter (environmental, infrastructure and/or community impact)**
3. **What the city is doing (policies, programs and capital improvements)**
4. **What can members of the public do**
5. **Method of implementation or delivery**

The following priority topic areas guide implementation of the program:

Stormwater Pollution Prevention & Water Quality Protection

Adopt-a-Storm Drain

- Adopt-A-Storm Drain is a component of the city's umbrella program "Adopt-A-Spot". Adopt-A-Storm Drain is a volunteer opportunity for residents and community groups to get involved by improving water quality locally. The program entails "adopting" a stormwater drain in Plymouth and committing to cleaning out leaves, yard waste, tree debris, sand, salt, and trash from entering the city's storm sewer system and preventing stormwater pollution. All storm drains in the city drain to surface waters, so any pollutants that enter the curb or roadway will eventually make their way to downstream waterbodies and have a negative impact on water quality.
- This program is advertised in the city's March/April newsletter and again in the September/October newsletter. Residents can volunteer to "adopt" a storm drain, which entails regularly cleaning and clearing the catch basin itself and debris in the surrounding area. This helps reduce flood risk and pollutants entering local waterways. The city provides materials to mark the storm drain and staff are available for technical assistance if requested.

Erosion & Sediment Control

- In accordance with the MS4 permit, city staff conduct erosion & sediment control inspections bi-weekly on active construction sites. Further educating contractors on Construction Stormwater Permit requirements could help prevent common violations, rather than violations being repeatedly reflected on inspection reports.
- Residents live next to and occasionally within active construction sites in subdivisions. They commonly see products like bio-logs, silt fence, sediment retention basins, and more. These items can become unsightly and a nuisance to residents. Additionally, residents completing work on their property that requires moving more than 50 cubic yards of soil triggers the

need for a city grading permit – therefore requiring sediment and erosion controls. Educating the public about erosion control products will provide a better understanding of how they work and why they are required. Educated community members also act as informants when a site is noticeably out of compliance and notify city staff that a field visit is necessary.

- An educational flyer will be distributed at pre-construction meetings.

Illicit Discharge

- Illicit discharge is a term defined as any release to a storm sewer system that is not composed entirely of stormwater. Examples of this include:
  - Paints
  - Motor oil
  - Antifreeze
  - Cleaning products
  - Failing septic system drainage
  - Illegal sanitary sewer connections
  - Concrete washout
  - Industrial wastewater
  - Car wash wastewater
  - Yard waste (leaves, grass clippings)
  - Chemicals
  - Swimming pool water that is not de-chlorinated
  - Pet waste
  - Litter and trash
- The City of Plymouth has a robust Illicit Discharge Detection and Elimination (IDDE) program. This program and procedures are available on the city's website under "Surface Water Resources > Pollution Prevention Plan".
- All staff receive annual training to refresh illicit discharge identification, prevention, reporting, and procedures.
- Residents can report to city staff if they see anything that appears to have been dumped into a waterbody or storm sewer that does not look like stormwater. If the person reporting the illicit discharge is responsible for its cause, they should report it to the Minnesota Duty Officer at 800-422-0798. Remediation and additional reporting will be coordinated by city staff.

Pet Waste

- Pet waste left on the landscape washes into surface waters and increases coliform bacteria levels causing algal blooms and dangerous swimming conditions.
- Pet waste education is required by section 16.6 of the MS4 permit – "For cities and townships, at least once each calendar year, the permittee must distribute educational materials or equivalent outreach focused on pet waste".
- Throughout the City of Plymouth Parks system, visitors can find pet waste stations with free waste disposal bags and information about how it can harmfully impact the environment. These signs include a reference to City Code Section 915 and fulfill a requirement of the MS4 requirement.
- The city plans to expand on pet waste outreach through direct engagement at the city's Bark in the Park event in May.

Street Sweeping & Solid Waste

- Street Sweeping helps prevent debris from entering the storm sewer by removing excess yard waste from curb and gutter lines. The city currently sweeps twice a year, in the spring and fall.
- Street sweeping education can be featured in the city newsletter in advance of the season that the sweepers will be in use on city roads.
- Each year, the city hosts two events for residents to properly dispose of household solid waste, spent batteries, and textiles. In the spring, the city hosts drop off days, which are two consecutive days for residents to dispose of difficult items from their residences. In the fall, the city hosts an additional drop off event which prioritizes free and confidential shredding of documents, along with other standard drop off day items like batteries and textiles.
- The city manages a drop-off site that is free to Plymouth residents for used motor oil, antifreeze, oil filters, organics, and recycling year-round to promote proper disposal of hazardous materials.

Capital Improvement Projects (CIP)

- The City of Plymouth's strategy for improving water quality focuses on pollution preventing first and stormwater treatment second. The plan goes beyond reacting to problems after they occur by implementing proactive

programs and policies to protect surface water. This strategy utilizes environmental and water resource inventories, monitoring data, citizen input, ordinances, and other available information to work towards achieving the goals. The surface water management plan is the framework for implementation of best management practices, programs, and policies to manage surface water and to meet goals established for water resources in the future.

- CIP projects include but are not limited to pond dredging, streambank stabilization, and wetland restoration projects. These projects reduce the amount of sediment and other pollutants from entering Plymouth lakes and improve water quality.
- Residents near CIP construction sites will receive targeted mailing about the on-going construction activity, including the environmental benefits of the work being done.

Nutrient Management & Algae Prevention

Algae

- Algae blooms in surface waters are primarily caused by excess nutrients, most commonly phosphorus and nitrogen. These nutrients come from a variety of sources that include lawn fertilizers, poorly maintained septic systems, and phosphorus-rich soils. Stormwater runoff transports sediment, grass clippings, pet waste residue, plants, and leaves that cause additional phosphorus loading in surface water resources that capture runoff. The surrounding environment can also affect algal growth, especially during prolonged periods of warm, calm weather as experienced in Minnesota mid-summer. Sunlight is a key factor in photosynthesis, and high temperatures combined with minimal wind cause water bodies to remain stagnant and provide ideal conditions for algae production. Uncharacteristically wet springs can also result in heavier runoff and deliver extra nutrients to lakes and ponds. Many algae blooms are not harmful, but some cyanobacteria can produce cyanotoxins that can make people and animals very sick if exposed to them. One toxic cyanobacteria bloom that occurs in Minnesota lakes is commonly referred to as “blue-green algae”, which is very bright green, brown, or blue. In some severe cases, it can be identified by its resemblance to pea soup or spilled paint. It produces significant discoloration and emits

pungent odors like that of rotten eggs, sewage, and decaying fish. It is harmful to humans and animals, and it is a threat to wildlife that live or rely on the water body.

- The City of Plymouth has BMPs in place to filter out nutrients and other pollutants in stormwater runoff from entering surface waters.
- Residents can reduce the risk of harmful algae blooms by keeping yard waste, leaves, and grass clippings out of the curbline and storm drains. Additionally, residents can refrain from over-applying fertilizer or not using it at all, especially if they live on or near surface waters. If fertilizer is necessary, ensure it is a phosphorus-free blend.

Native Plantings & Natural Shorelines

- Native plants have roots up to 12 ft deep, much deeper than the average residential turf grass mix. Deeply rooted plants increase groundwater infiltration and reduce the need for summer irrigation. When planted as a natural shoreline, native plants help filter excess nutrients from lawn fertilizers before entering surface waters, which cause unsightly algal blooms.
- The city is partnering with Metro Blooms to host Resilient Yards and Planting for Pollinators workshops over the growing season to educate homeowners interested in environmentally friendly landscaping. Workshop content includes, but is not limited to, what plants to use, how to establish the plot, and the ecosystem benefits of native gardening.

Stormwater Pond Maintenance

- Stormwater ponds are one type of best management practice for water quality and volume storage that are widely present in developing and urbanized municipalities. They are often constructed to meet stormwater requirements on a development and capture localized runoff. Maintenance is necessary for stormwater ponds to function as designed long-term. Examples of maintenance include removal of debris at inlet or outlet structures, repair or replacement of stormwater pipes and infrastructure, slope and buffer stabilization, and basin dredging. Routine maintenance on stormwater ponds removes sediment, reduces downstream pollutant loading, and restores flood control capabilities.
- All ponds in the city have been inventoried, and maintenance projects are prioritized based on current condition and downstream impacts. These

projects are conducted annually in the winter and they are promoted on the city's website and included in November/December newsletter articles. Further outreach and education could be done via mailing to homeowners with property on or near a stormwater pond that includes best management practices before and after project completion.

Public Best Management Practices (BMPs)

- Structural best management practices are engineered, physical features that are designed to control the quantity of and improve the quality of stormwater runoff before it reaches lakes, ponds, rivers, wetlands, streams, and groundwater. BMPs are often used to meet requirements of the Minnesota Pollution Control Agency for the MS4 Permit. Structural BMPs differ from other best management practices being that they are built infrastructure, rather than implemented procedures such as street-sweeping. Structural BMPs reduce flooding by slowing stormwater runoff, removing pollutants such as phosphorus and sediment, promoting infiltration, and generally protecting water resources. There are many types of structural BMPs:
  - Stormwater Ponds – Effective for flood control and phosphorus reduction as sediment capture systems. They require regular maintenance such as sediment removal and vegetation management. Examples:
    - Wet (permanent pool of water)
    - Dry ponds (temporarily store runoff after large precipitation events)
  - Infiltration Practices – Capture runoff and allow it to soak into the ground, reduce stormwater runoff volume and pollutant loading; They require sandy or loamy soils to meet infiltration rate requirements. Examples:
    - Infiltration basins
    - Infiltration trenches
    - Dry wells
  - Bioretention systems (rain gardens) - Shallow, planted basins that collect runoff; highly engineered to treat stormwater through filtration, infiltration, and native plant uptake. They can be designed for cold climates and function well in urban and suburban areas. Rain gardens provide additional habitat and pollinator access.

- Vegetated swales – shallow, grassy or planted channels that slow runoff and promote sediment settling and infiltration. Best for roads, parking lots, and other low-slope areas that collect significant runoff.
- Permeable pavement – allows water to pass through pavement and other typically impermeable (water cannot infiltrate) surfaces into underlying stone and soil media for drainage; reduces runoff volume and peak flow. Requires regular maintenance, caution with plowing and salt/sand application; designed to prevent clogging but needs routine vacuum sweeping. Examples:
  - Pervious concrete
  - Porous asphalt
  - Permeable pavers
- Filtration practices – runoff passes through a filter media that binds to or remove pollutants, great alternative where infiltration practices aren't feasible. Examples:
  - Sand filters
  - Media filters
  - Underground filtration systems

Wildlife; Muskrats, Beavers, etc.

- Wildlife like muskrats and beavers can cause damage to public and private stormwater infrastructure. In certain cases, these animals may be protected through the Minnesota Department of Natural Resources, and any interested party is required to obtain a Take Permit to alter or remove wildlife and/or their habitat(s) causing nuisance.

Chloride Reduction & Winter Practices

Chloride

- Chloride from de-icing salt and water softeners gets into lakes, streams, and other surface waters following winter maintenance operations. One teaspoon of salt permanently pollutes five gallons of water, and once chloride is in the water, there is no feasible way to remove it. Approximately 78% of salt applied in the Twin Cities for winter maintenance remains in lakes, wetlands, groundwater, and other surface waters. Chloride can have detrimental effects on aquatic ecosystems by harming vegetation and

changing the plant community structure and composition. Terrestrial plants and wildlife are also at risk of chloride pollution, with the severity ranging from plant root damage to death for avian and other sensitive species. Salt can also irritate pet paws and cause illness if consumed. De-icing salt corrodes infrastructure including bridges, roads, trails, and parking lots leading to increased operation and maintenance costs.

- Winter salt week is nationally recognized as the last week of January, with the goal of increased awareness and education on salt application for winter maintenance and the effects of chloride pollution on the natural environment. Several virtual seminars are put on by winter maintenance and water resources professionals on a variety of up-and-coming topics.
- The city hosts a Winter Maintenance Open House as an outreach event for residents, kids and families, contractors, and staff from neighboring municipalities to learn about Plymouth's winter maintenance operations and the impact of chloride on water resources and infrastructure.

Construction Stormwater Winterization

- The city will conduct timely outreach to educate relevant parties of construction stormwater permit requirements during the winter.
- An informational email will be sent to communicate necessary controls and changes to remain in compliance with the CSW permit.

Ice Fishing Waste

- Educate winter recreationists about the "Keep it Clean" organizational agenda, addressing the problem of garbage and waste left behind on the ice.
- Consider joining as a member city and gain access to branded outreach materials to distribute brightly colored trash bags so ice fishermen and other recreationists can easily see them to promote responsible waste disposal.

Drainage, Flooding & Soil Education

Drainage & Flooding

- Drainage and stormwater management are governed at the federal level and further administered by the state of Minnesota and other local government units. Urban stormwater management is dictated by the regulations set in the MS4 Permit. Drainage in Minnesota is unique because the state's topography was shaped by glaciers that left high water tables and a vast

network of lakes, wetlands, and other surface waters. Minnesota has lost over 50% of its original wetlands due to agriculture and development, resulting in severe drainage issues, increased flood risk, and decreased water quality with the loss of natural buffers and excessive nutrient loading. Stormwater can accumulate in undesirable places following a rain event due to the significant loss of wetlands. Water drains to historically low areas of land.

- Drainage tips are featured in the March/April newsletter. In the future the city will create a "What Can You Do" checklist for homeowners to investigate what may be causing drainage issues and provide city contact information for additional assistance.
- Mitigation techniques:
  - Sump pumps
    - Sump pumps are a stormwater pump designed to collect surface water and divert it away from the foundation of a house or saturated low spots of a yard. They can be directed towards front or back yards and drain to the storm sewer system.
  - Drain tile & French drains
    - Drain tile pipes and French drains are both commonly used to drain water from wet spots in yards. These are two practices used to move water away from a particular area. Drain tile is a perforated pipe that runs underground, and French drains are rock-filled trenches that may have a drain tile pipe in them.
    - It is important to make sure that any drain tile pipes used have a positive slope, so they adequately drain water. Installing drain tiles in a trench that is backfilled with pea gravel or sand will provide the best drainage capabilities. This method requires a trench to be dug, which can damage roots and harm trees. The city publishes Engineering Guidelines and Standard Specifications that provide information on drain-tile materials and installation.
  - Rain gardens and native plantings
    - Installing a rain garden can help to capture water and allow it to soak into the ground.
    - Rain gardens can vary in size, shape, and location. There are many factors that need to be considered during design. A

professional can aid in the design of a raingarden, but in general they should:
    - Be located at least 10 feet away from a home or structure.
    - Be designed to allow water to drain within 48 hours.
    - Compost and sand can be added to soil to increase infiltration rates.
- Plants best suited for rain gardens are deep-rooted plants that help break up the soil and allow water to soak into the ground more easily.
- The University of Minnesota Extension or Metro Blooms are great resources for more information about rain gardens.

- Redirecting downspouts
    - Changing the direction of downspout extenders can also have a significant impact on solving drainage problems. Extending downspouts and pointing them toward the road or toward a raingarden may help reduce pooling water in backyards.
- Impacts on Buffers
    - Buffers are vegetated strips around surface waters that protect water quality by filtering pollutants and stabilizing soils. They are typically native plants, grasses, or shrubs that help prevent erosion, balance pH, and can increase groundwater infiltration.
- Improved soil health
    - There are a lot of heavy, poorly draining clay subsoils in Plymouth. Clay soil is comprised of fine particles packed tightly together, slowing the rate at which water moves into the ground. When water is applied faster than the soil can absorb it, particularly after heavy rain, it can lead to runoff, standing water, soggy lawns, stressed plants, and increased landscape maintenance. One way to improve drainage in heavy clay or compacted soils is to add organic material or compost to loosen up soils and increase aeration, which allows for more effective water storage and absorption.
- Adjust irrigation practices
    - Clay soil absorbs water slowly but holds moisture for longer periods. Watering less frequently and applying water at a

slower rate can reduce runoff and allow moisture to soak in more effectively.

- Residents are encouraged to check soil moisture 4 to 6 inches below the surface before irrigating again. Avoid calendar-based watering schedules and instead use soil probes, moisture sensors, or manual checks to help prevent overwatering.
- Drip irrigation systems and soaker hoses deliver water more slowly than traditional sprinklers and may be better suited for clay soils.

Soils

- The city receives drainage requests from residents who are concerned that their yards are staying wet for longer than 48 hours after a precipitation event. Plymouth is built on multiple wetland complexes and is dominated by clay soils that hold onto water particles rather than infiltrating water quickly. City staffs' goal is to educate residents on clay soil so they can have a better understanding of why they are experiencing saturated lawns during spring snow melt and precipitation events. Through hands on activities like soil ribboning, residents can interact with soil in a new way and leave with a better understanding of how its physical and chemical characteristics affect their property.
- A city event like Discover Plymouth would be a great environment for an interactive activity like soil ribboning to educate on soil health and characteristics.

Aquatic Invasive Species (AIS)

- AIS are non-native species that dominate freshwater ecosystems due to the lack of natural predators to keep populations in balance. The presence of invasive species can be distressing for residents and recreators when they notice the waterbody is increasingly weedy.
- Once invasive species are detected in public waterbodies, population management largely falls under the jurisdiction of agencies like the DNR, watershed districts, and soil and water conservation districts.
- The City of Plymouth's outreach focus will be on promoting "Clean, Drain, Dry" messaging, encouraging boaters and anglers to properly transport their boat without further spreading AIS populations.

- Clean, Drain, Dry messaging can be displayed on signs at public boat launches. Additionally, Billboard space can be utilized in summer during peak outdoor recreation weekends like Memorial Day, Fourth of July, and Labor Day.

Wetlands & Buffer Protection

Wetland Buffers & Terrestrial Invasive Species Management

- City ordinance requires wetland buffers of 20-50 feet depending on the classification of the water body. Residents are not permitted to mow, prune, or remove native vegetation within the buffer; however, residents are allowed to remove invasive species if present. Educational materials will be tailored to which activities are permitted in native buffers, as well as invasive species identification, removal methods, and disposal methods.

Wetlands & Delineations

- Wetlands are diverse, abundant ecosystems present in Minnesota. Today, there are about 10.6 million acres of wetlands in the state, which is only about 50% of the original area pre-development. They provide countless benefits to the surrounding environment, including:
  - Erosion control: Wetland vegetation reduces wave damage along lakes and stream banks.
  - Flood control: Wetlands can slow and retain runoff water, reducing the frequency of flooding along streams and rivers.
  - Groundwater recharge and discharge: Some wetlands recharge groundwater by holding surface water and allowing it to slowly filter into the groundwater reserves. Some wetlands are discharge areas; they receive groundwater even during dry periods and help maintain flows in nearby rivers and streams.
  - Water quality: Wetlands protect the water quality of downstream lakes, streams, and rivers by removing pollutants.
  - Rare species habitat: 43 percent of threatened or endangered species in the U.S. live in or depend on wetlands.
  - Recreation: Wetlands are a great place to canoe, hunt, fish, and observe wildlife.
  - Economic value: Wetlands provide economic commodities such as wild rice and bait fish
- There are many different types of wetlands in Minnesota with varying characteristics. Some are dry for most of the year while others hold several feet of water. Plant communities in each wetland type are also widely varied and can include shrubs, sedges, and trees.

    - Wetlands are highly regulated because of the ecological value they provide. The Clean Water Act Section 404 regulates impacts to wetlands that are under federal jurisdiction, administered by the U.S. Army Corps of Engineers.
    - The Public Waters Permit Program is administered by the Minnesota DNR and regulates activities in public waters, including shoreline impacts on or below the ordinary high-water level (OHWL).
    - The Wetland Conservation Act (WCA) regulates wetlands in Minnesota that are not public waters. It is administered by local government units and overseen by the Minnesota Board of Water and Soil Resources (BWSR). BWSR is a statewide soil and water conservation agency that does work to protect fish and wildlife habitat, improve water quality, and provide guidance on wetland regulation in Minnesota.
- Wetland delineations are the process of identifying and mapping the precise boundaries of wetlands based on soil, vegetation, and hydrology indicators. Wetland delineations are required when a nearby development project, roadway, or agricultural fieldwork could impact a wetland. It is a long, intensive process that requires a team of professionals from various local government organizations to conduct an assessment, determine all possible impacts, and make decisions based on technical ruling. There is a lot of work on or around wetlands that is prohibited under the protection of the Wetland Conservation Act.
- In spring, the city will send out a pamphlet or mailing with all the wetlands in Plymouth highlighted and facts about wetlands, identification, and buffer conservation.

Capital Improvements & Ecological Restorations

Stream Restorations

- Stream restorations re-establish a stream's general structure, function, and behavior before disturbance of development and land use over time. Stream restorations are water quality improvement projects that stabilize bank slopes and reduce erosion and nutrient loading, reconnect floodplains for flood mitigation, and improve aquatic habitats by installing rip rap and other features to create deeper, more oxygenated water. It is also an opportunity to replace existing stormwater infrastructure to increase storage and promote fish and aquatic species passage throughout the waterway.
- The Nov/Dec Newsletter will be highlighting winter water resources projects, including stream restorations that are a water quality improvement project.

Photos of previously completed projects will be included with photos and a list of environmental benefits.

Water Conservation & Efficiency

Summer Irrigation & Residential Water Use

- Newsletter article distributed in May/June on municipal water use in Plymouth and ways residents can reduce their consumption, either by home improvements or changing behaviors. There will also be promotion for the city's Water Efficiency Rebate Grant Program, incentivizing residents to replace old water-consuming appliances with new, efficient models to save water and cut costs. This article will also include information on irrigation and lawn watering, which should be done approximately 2-3 times a week for 15 minutes. Turf grass cannot handle oversaturation due to extremely shallow root systems, so it is recommended to not trim grass as short and to adjust irrigation times in accordance with weather events. This information and more are available on the city's website under the "Conserve Water" tab.

Water Efficiency Rebate program (WERP)

- The Water Efficiency Rebate program is a grant program that offers rebates to property owners or renters who are customers of the municipal water supply system and who replace specified water using devices with devices that are certified to be more water-efficient and reduce overall municipal water use. The program is funded, in part, by a grant from the Metropolitan Council, to encourage reduction of municipal water use for both residential and commercial properties in the city. Rebates are granted to residential and commercial property owners who complete water efficiency improvement projects. The grant program is on a two-year cycle that renews bi-annually in July, and the city website updates information as necessary, including available remaining funds. The program is featured in the March/April newsletter and throughout the year to promote reduced municipal water use.

Youth & Community Environmental Education

Earth Week

- Earth Week is celebrated in mid-April to demonstrate support and raise awareness for environmental protection. Earth Day is April 22nd, and Arbor

Day is nationally regarded as the last Friday in April but varies based on geographical region and growing season. Water Resources, Forestry, and Environmental staff give presentations alongside city volunteers in local 3rd grade classrooms. Topics educated include recycling and solid waste, energy efficiency, water resources protection, native plants, and trees. Staff will post a reel on social media, as well as a variety of resources to educate on current topics related to Earth Week, and what residents can do to make a difference.

Water Cycle

- The city's education and outreach program is bolstered by the ongoing efforts of the West Metro Watershed Alliance (WMWA). WMWA is funded through Watershed Management Organizations and employs two part-time employees who create outreach, education media kits, and classroom lessons for the greater west metro region. Area 4th grade students receive hands on learning about the water cycle and watersheds and have recently been expanded into lessons about how erosion can impact water quality.

Conclusion

This education and outreach plan is intended to be more than a set of scheduled events; it is the city's commitment to protecting and improving water quality through proactive education and measurable actions by leveraging increased outreach efforts and providing greater access to educational materials and resources.

The success of this initiative will not only be measured by the number of participants reached, but by the long-term shifts in best management practices and behaviors. The city remains dedicated to inclusiveness, transparency, and continuous improvement as these strategies are implemented. This plan is subject to change and intended to be a living document that evolves as we continually adapt to changing research and knowledge in the field and meet the goals for the city. City staff hope this helps to provide some tools, knowledge, and support necessary for everyone to play a role in ensuring our water resources continue to thrive.

Glossary

Acronyms

AIS – Aquatic Invasive Species
Non-native plants, animals, or organisms that spread quickly and harm lakes, rivers, wetlands, and native species.

BMP – Best Management Practice
A method, practice, or structure used to reduce stormwater runoff and prevent pollution.

BWSR – Board of Water and Soil Resources
A Minnesota state agency that oversees wetland protection and conservation programs.

CIP – Capital Improvement Project
A city project that builds, repairs, or improves public infrastructure such as stormwater ponds, streams, or wetlands.

CSW – Construction Stormwater (Permit)
A state permit that regulates erosion and sediment control on construction sites.

IDDE – Illicit Discharge Detection and Elimination
A program that identifies and stops illegal or improper discharges into the storm sewer system.

MCM – Minimum Control Measure
A required category of activities under the MS4 Permit. Public Education and Outreach is MCM 1.

MPCA – Minnesota Pollution Control Agency
The state agency that issues and enforces the MS4 Permit.

MS4 – Municipal Separate Storm Sewer System
A publicly owned stormwater drainage system that collects and conveys stormwater runoff. Cities like Plymouth operate under an MS4 permit.

MCSC – Minnesota Cities Stormwater Coalition
A coalition of Minnesota cities that collaborate on stormwater policy and permit issues.

OHWL – Ordinary High Water Level
The boundary of a lake, river, or wetland that shows the highest-level water normally reaches.

SWMP – Surface Water Management Plan
The city's long-term plan for managing stormwater, protecting water quality, and reducing flooding.

SWPPP – Stormwater Pollution Prevention Program
A document required under the MS4 Permit that describes how the city prevents stormwater pollution.

WCA – Wetland Conservation Act
A Minnesota law that regulates impacts to wetlands and requires replacement if wetlands are filled or drained.

WERP – Water Efficiency Rebate Program
A city rebate program that encourages residents and businesses to install water-efficient fixtures and appliances.

WD – Watershed District
A local government entity that manages water resources within a specific watershed boundary.

WMO – Watershed Management Organization
A joint powers organization of cities that manages water resources within a watershed.

WMWA – West Metro Water Alliance
A regional partnership that provides water education programs and outreach materials.

Definitions

Algae
Simple aquatic plants that grow in water. Excess nutrients like phosphorus can cause algae blooms.

Bioretention System (Rain Garden)
A shallow, planted area designed to collect and treat stormwater runoff through filtration and infiltration.

Buffer
A vegetated strip of land next to a lake, wetland, or stream that protects water quality by filtering pollutants and preventing erosion.

Chloride
A chemical component of salt. Chloride from winter de-icing salt can permanently pollute lakes, streams, and groundwater.

Clean, Drain, Dry
A public education message that encourages boaters and anglers to clean equipment, drain water, and dry boats to prevent the spread of aquatic invasive species.

Drain Tile
A perforated pipe installed underground to move excess water away from a yard or foundation.

Erosion
The movement of soil by water, wind, or other natural forces.

Filtration Practice
A stormwater treatment method that passes runoff through filter media to remove pollutants.

French Drain
A gravel-filled trench, sometimes with a perforated pipe, that redirects water away from wet areas.

Groundwater
Water located below the ground surface in soil and rock.

Illicit Discharge
Any release to the storm sewer system that is not stormwater. Examples include paint, oil, chemicals, or wastewater.

Infiltration
The process of water soaking into the ground.

Infiltration Basin or Trench
A stormwater practice that captures runoff and allows it to soak into the soil.

Native Plants
Plants that naturally occur in Minnesota and are adapted to local climate and soils.

Nutrients
Substances such as phosphorus and nitrogen that help plants grow. Excess nutrients can harm water quality.

Permeable Pavement
Pavement that allows water to pass through it into the ground below.

Phosphorus
A nutrient found in fertilizer, soil, and organic material. Too much phosphorus in water can cause algae blooms.

Runoff
Water from rain or snowmelt that flows over land instead of soaking into the ground.

Sediment
Soil particles that are carried by water and deposited elsewhere.

Stormwater
Rainwater or snowmelt that flows over streets, rooftops, and lawns.

Stormwater Pond
A constructed basin that stores and treats stormwater runoff before it enters downstream water bodies.

Watershed
An area of land where all water drains to a common lake, river, or wetland.

Wetland
Land that is saturated with water long enough to support water-tolerant plants and soils.

Regular Environmental Quality Committee
March 11, 2026
Agenda Number: 6.3

To:	Environmental Quality Committee
Prepared by:	MK Anderson, Environmental Stewardship Coordinator
Reviewed by:	Michael Payne, City Engineer/Deputy Public Works Director
Item:	**Plymouth Environmental Academy**

1. Action Requested:
2026 Plymouth Environmental Academy Update.

2. Background:
The Environmental Quality Committee 2026 Work Plan includes a continuation of the Plymouth Environmental Academy (PEA) set to begin in the second quarter of 2026. At the January & February 2026 meetings, Committee members had lengthy discussions on the future of the Academy. The discussion included, but was not limited to, the potential options for the restructuring and rebranding of the Academy.

At the March 2026 meeting, the Committee will continue discussing the rebranding of the Academy, program leadership and implementation. In 2026, staff proposes a format that includes two educational workshops and two tours that relate to the topic.

- Potential Topics
  - Native Plants & Native Shorelines
  - Solid Waste Overview (Organics, Recycling and Trash)
  - Energy Conservation / Energy Action Plan
  - Water Conservation
  - Winter Maintenance

3. Budget Impact:
N/A

4. Attachments:

Regular Environmental Quality Committee
March 11, 2026
Agenda Number: 8.1

To: Environmental Quality Committee

Prepared by: Ben Scharenbroich, Water Resources Supervisor

Reviewed by: Ben Scharenbroich, Water Resources Supervisor

Item: **Upcoming Events**

1. Action Requested:
Review upcoming City events.

2. Background:
Discover Plymouth – March 21, 2026 – 9:00am - 1:00pm – Plymouth Community Center (14800 34th Avenue North)
Resilient Yards Workshop – March 24, 2026 – 6:00pm - 8:00pm – Plymouth Community Center (14800 34th Avenue North)
Regular Environmental Quality Committee Meeting – April 8, 2026 – 7:00pm – Plymouth City Hall (3400 Plymouth Boulevard)
Drop Off Days – May 1 & 2, 2026 – Plymouth Maintenance Facility (14900 23rd Avenue North)
Climate Action and Resiliency Plan Listening Sessions:
- May 5, 2026 – 6:00pm - 8:30pm – Plymouth Community Center (14800 34th Avenue North)
- May 7, 2026 – 6:00pm - 8:30pm – Parkers Lake Building (15205 County Road 6)
- May 12, 2026 – 6:00pm - 8:30pm – Fire Station 2 (13205 County Road 6)
- May 14, 2026 – 6:00pm - 8:30pm – Bass Lake Park Building (5450 Northwest Blvd)

Rain Barrel / Compost Bin Pick Up & Plate To Garden Event – May 9, 2026 – 8:00am - 12:00pm - Plymouth Maintenance Facility (14900 23rd Avenue North)
Regular Environmental Quality Committee Meeting – May 13, 2026 – 7:00pm – Plymouth City Hall (3400 Plymouth Boulevard)

3. Budget Impact:
N/A

4. Attachments: