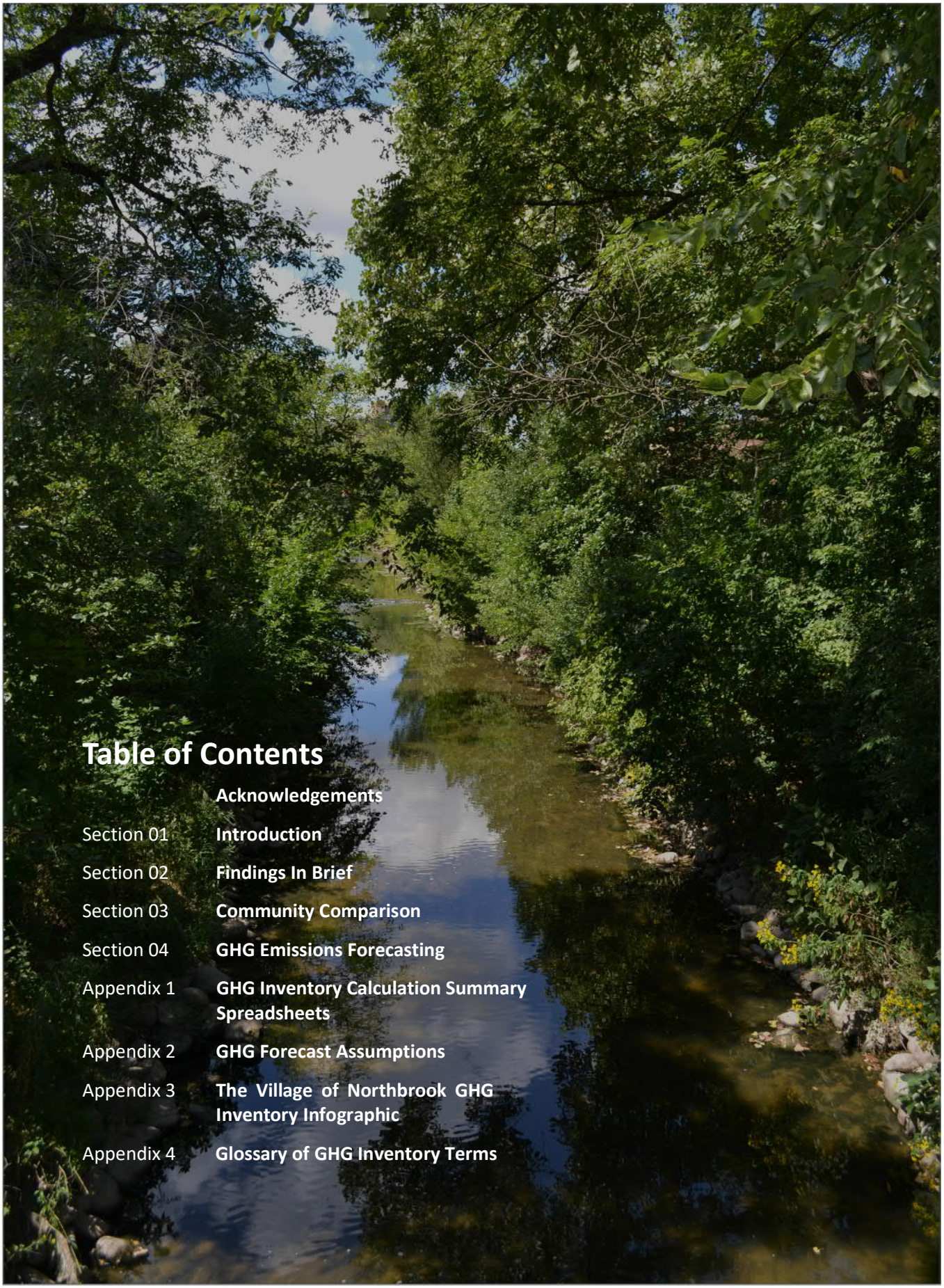
Village of Northbrook
Community Greenhouse Gas Inventory

September 2020
REVISED

Prepared By:

making change personal
paleBLUEdot LLC



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Acknowledgements

Thank you to the following organizations and individuals for their contributions:

Village of Northbrook

Thomas Poupard, Director of Development and Planning Services
Michaela Kohlstedt, Deputy Director of Development and Planning Services
Charmaine John, Greenest Region Corps Sustainability Fellow
Jeff Rowitz, Chief Financial Officer
Matt Morrison, Deputy Public Works Director
Michaela Kohlstedt, Deputy Director of Development and Planning Services

Chicago Metropolitan Agency for Planning

Jose Rodriguez, Senior Transportation Planner

Consumption Data Collection Support

ComEd:	Edith Ruiz, External Affairs Manager
Nicor Gas:	Pat Eaves-Heard, Regional Manager Community Affairs

Consultant Team

paleBLUEdot LLC

Ted Redmond, Principal
Colleen Redmond, Co-Founder

Section 01

Introduction

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Crêpes
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Introduction

Background

The Village of Northbrook has a deep and rich history promoting Environmental Sustainability alongside its partners in suburban Cook County. To this end, Northbrook's local governments have each undertaken initiatives and created programs to help residents and businesses develop green practices while promoting the environment.

Over the course of the past decade, the Village has been refining its local policies to address environmental issues. The Village now wishes to take more directed steps in addressing the climate crisis on a local level. The Board of Trustees has requested that the Department of Development & Planning Services work in conjunction with paleBLUEdoot in preparing an assessment of local environmental conditions and the identification of steps that can be taken to ensure Northbrook is not only resilient to climate changes, but takes positive steps in reducing greenhouse gas emissions locally. This greenhouse gas inventory is a foundational study supporting that planning effort.

> Without data, you're just another person with an opinion.
> W. Edwards Deming, Engineer, Professor, and Management Consultant

The Value of The Village of Northbrook Community Greenhouse Gas Inventories

The goal of the Village of Northbrook community wide inventory is to estimate the GHG emissions associated with the activities of the people who live, work, learn, travel, visit, and recreate within the Village's geographical boundaries during three study years, 2010, 2014, and 2018. These inventories must be transparent and able to be replicated, updated, and compared with future assessments for Northbrook and assessments for peer cities.

Measuring the energy aspects of human activities and the associated GHG emissions offers a unique way to compare the effectiveness of various energy and sustainability best management practices. Greenhouse gas emissions and energy[1] 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, tons of waste processed, and gallons of potable water distributed.

Every community prepares annual operating and capital improvement budgets. These assessments can be thought of as an assessment of the environmental budget for municipal operations. Recording these performance metrics is essential to promoting efficiency and sustainable change. Along with providing statewide benefits, these GHG assessments will:

- Support identification of opportunities to save resources and money.
- Provide a baseline for estimating the effectiveness of many sustainability measures.
- Inform subsequent analyses, plans, and policy decisions.
- Improve the Village's competitiveness for federal and state funding opportunities that are targeted to communities that have taken steps to measure and improve their energy efficiency and reduce their carbon footprints.
- Assist in promoting public understanding of the Village's effects on climate change.
- Serve as a model for other communities.
-

[1] Energy is expressed as kBtu (a thousand British thermal units) or MMBtu (a million Btus).

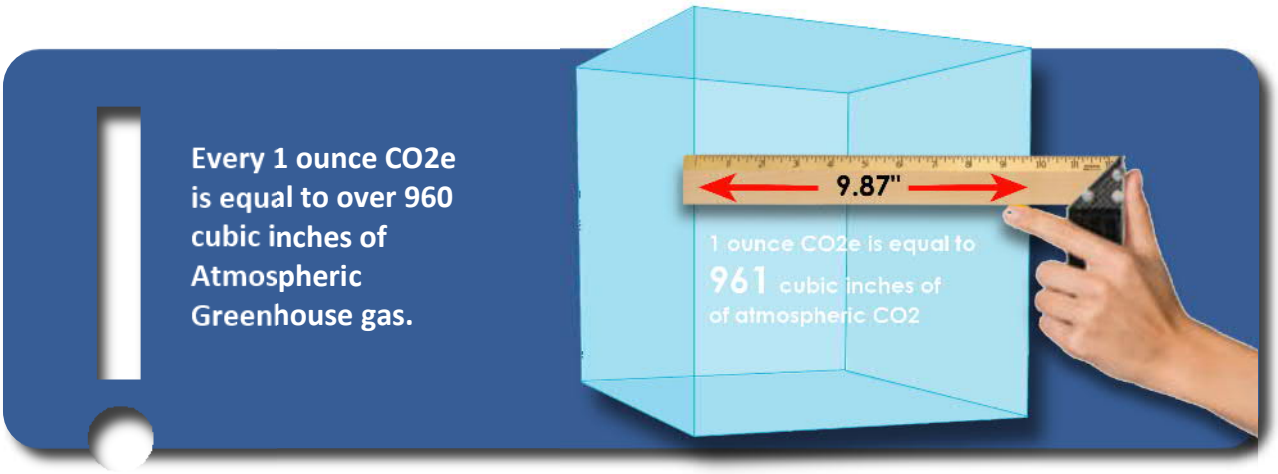
Introduction

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.

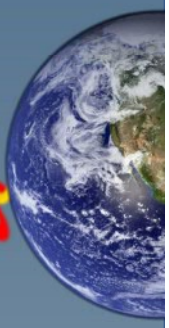
Graphic Representations

Greenhouse Gas Inventories quantify gas emissions in terms of weight - typically Metric Tons. It is important to understand that these references 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.



GHG's Impact on Our Climate

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**.

Non-Greenhouse Gases do not react to visible or infrared light, allowing both sunlight and infrared energy to pass unaffected. This mean's Earth's heat can radiate out into space.

Greenhouse Gases also do not react to visible light, however, they **DO** react to infrared energy, trapping Earth's heat energy and reflecting it back, warming the Earth.

Greenhouse Gases trap Earth's heat energy and reflect it back, warming the Earth.

Global Levels of **Greenhouse Gas:** in Parts Per Million (ppm)

1850 **285.2** ppm

1930 **307.5** ppm

1975 **331.4** ppm

2019 **415.7** ppm

Non-Greenhouse Gases

- Nitrogen N_2
- Oxygen O_2
- Argon Ar

Greenhouse Gases

- CO^2 Carbon Dioxide
- CH^4 Methane
- N_2O Nitrous Oxide
- H_2O Water Vapor

Non-Greenhouse Gases allow Earth's heat energy to radiate into space

The more **Greenhouse Gases** in our atmosphere, the more global warming we experience.

Introduction

What is a Community Greenhouse Gas Inventory?

A community Greenhouse Gas (GHG) Inventory follows a standard protocol to quantify a city's greenhouse gas (GHG) 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.

Greenhouse Gas Sectors

Where do GHGs come from?

Energy

Emissions are produced from the combustion of natural gas, coal, and other fossil fuels primarily for heating, cooling, and electricity generation.

Transportation

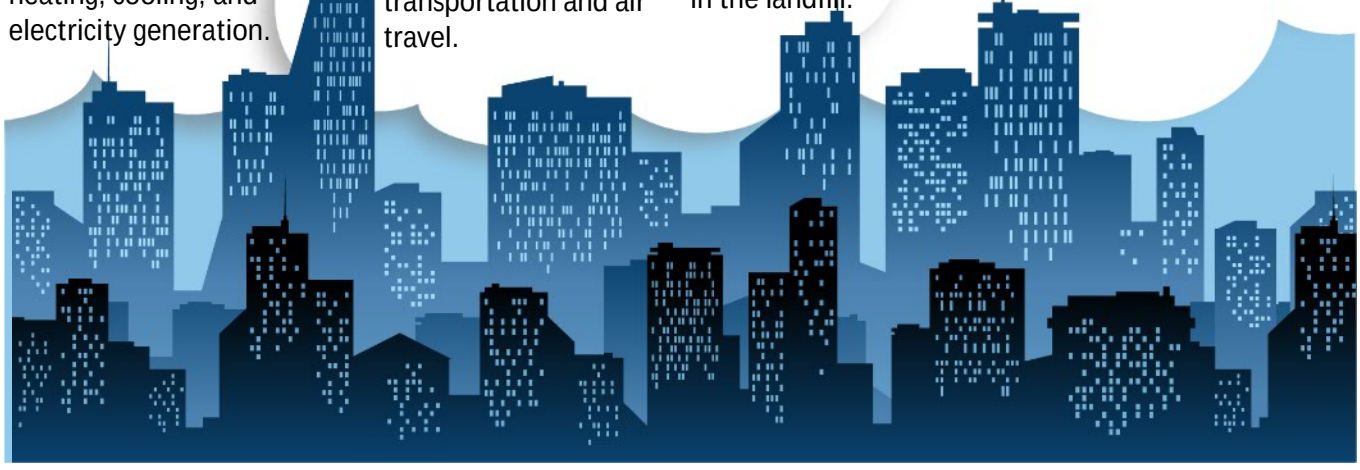
Emissions come from the combustion of fossil fuels for ground transportation and air travel.

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.



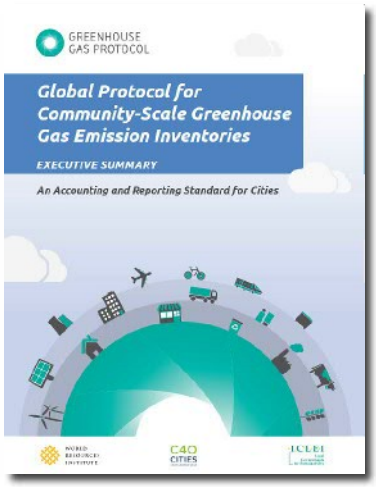
Introduction

Methodology, Sources, and Terminology

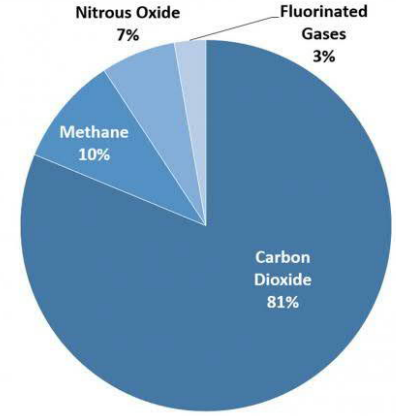
This GHG inventory is assembled based on the Greenhouse Gas Protocol for businesses and communities established by GHG Protocol (www.ghgprotocol.org/) and is consistent with the protocol established by ICLEI Local Governments for Sustainability. The terminology used in this report is consistent with international Carbon Footprinting protocols. Unless noted otherwise, the Greenhouse Gas (GHG) emissions shown in this report are in CO2e: Carbon Dioxide Equivalent. CO2e is a standard for expressing the impact of all greenhouse gas including those from other pollutants including methane (CH4), nitrous oxide (N2O), and florinated gasses like CFCs in terms of the equivalent amount of CO2 that would have the same impact. GHG emissions are represented in Metric Tonnes (2,204.62 pounds) to be consistent with international standard reporting.

GHG inventories, generally, arrive at an estimated emission in each emissions sector by multiplying raw consumption data - total electricity consumed as an example - by an emissions factor which define the greenhouse gasses emitted per unit of raw consumption. The chart below illustrates the sources used for all raw consumption and emission factor data used in the GHG inventory calculations.

The GHG emissions included in this inventory are those associated with sources and uses within the Village of Northbrook limits.



Overview of U.S. GHG Emissions by Greenhouse Gas Type



Source: U.S. EPA

Data Sources Used in the Greenhouse Gas Inventory

GHG Emission Sector	Project Resource
Residential Energy Consumption - Electricity	Data Source: Commonwealth Edison
	Emissions Factors: Same as above
Residential Energy Consumption - Natural Gas	Data Source: Nicor Gas
	Emissions Factors: US Community Protocol default fuel emission factors
Commercial/Institutional Energy Consumption - Electricity	Data Source: Commonwealth Edison
	Emissions Factors: Same as above
Commercial/Institutional Energy Consumption - Natural Gas	Data Source: Nicor Gas
	Emissions Factors: US Community Protocol default fuel emission factors
Transportation - On Road	Data Source: Illinois Department of Transportation VMT Estimates
	Emissions Factors: US EPA MOVES model
Transportation - Public Transit	Data Source: ??
	Emissions Factors: EPA Climate Leadership Emissions Factors
Transportation - Air Travel	Data Source: City of Chicago, Citywide GHG Inventory Aviation Activity Sector
	Emissions Factors: IPCC and US EPA Inventory of US GHG Emissions and Sinks
Waste - Solid Waste	Data Source: Village of Northbrook, Advanced Disposal
	Emissions Factors: Illinois Commodity/Waste Generation and Characterization Study Update / US Community Protocol Default Landfill Assumptions.
Waste - Wastewater	Data Source: Village of Northbrook Water and Wastewater Services, Metropolitan Water Reclamation District
	Emissions Factors: US Community Protocol population based emissions models / Fuel Mix Disclosure Report / US EPA eGRID
Water	Data Source: Village of Northbrook Water and Wastewater Services
	Emissions Factors: Above emission factors for electricity and natural gas consumption.

Section 02

Findings In Brief

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Forest acres needed to sequester Northbrook's community wide GHG emissions:
675,226 Acres
Total land within village:
8,448 Acres
Forest area required to sequester Northbrook's community wide emissions:
79.9x
Land area within Village of Northbrook.

Findings In Brief

2010 By The Numbers

GHG Emissions
661,748
19.91 MT Per-Capita
17.94 MT / Job
0.3205 MT / $1,000 GDP

Population
33,240

GDP
$2,064,691,936
$62,115 GDP Per-Capita

Employment
36,882

2018 By The Numbers

GHG Emissions
519,924
15.68 MT Per-Capita
13.64 MT / Job
0.2220 MT / $1,000 GDP

Population
33,167

GDP
$2,342,220,088
$70,619 GDP Per-Capita

Employment
38,120

8 Year Trend Dashboard

GHG Emissions
-141,824 -21.43%
-4.23 MT Per-Capita
-4.30 MT / Job
-0.10 MT / $1,000 GDP

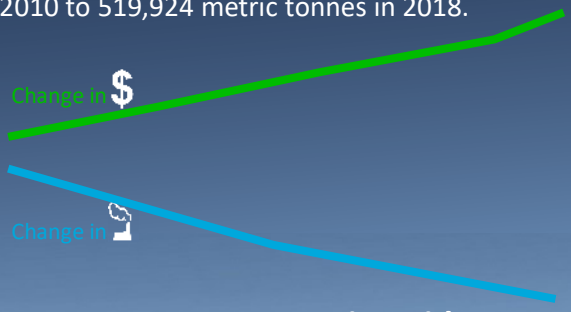
Population
-73 -0.22%

GDP
+$277,528,153 +13.44%
+$8,504 GDP Per-Capita

Employment
+1,238 +3.36%

Northbrook Community Wide GHG Emissions Overview

Community wide total emissions for the Village of Northbrook dropped 21.43% from 661,748 metric tonnes in 2010 to 519,924 metric tonnes in 2018.

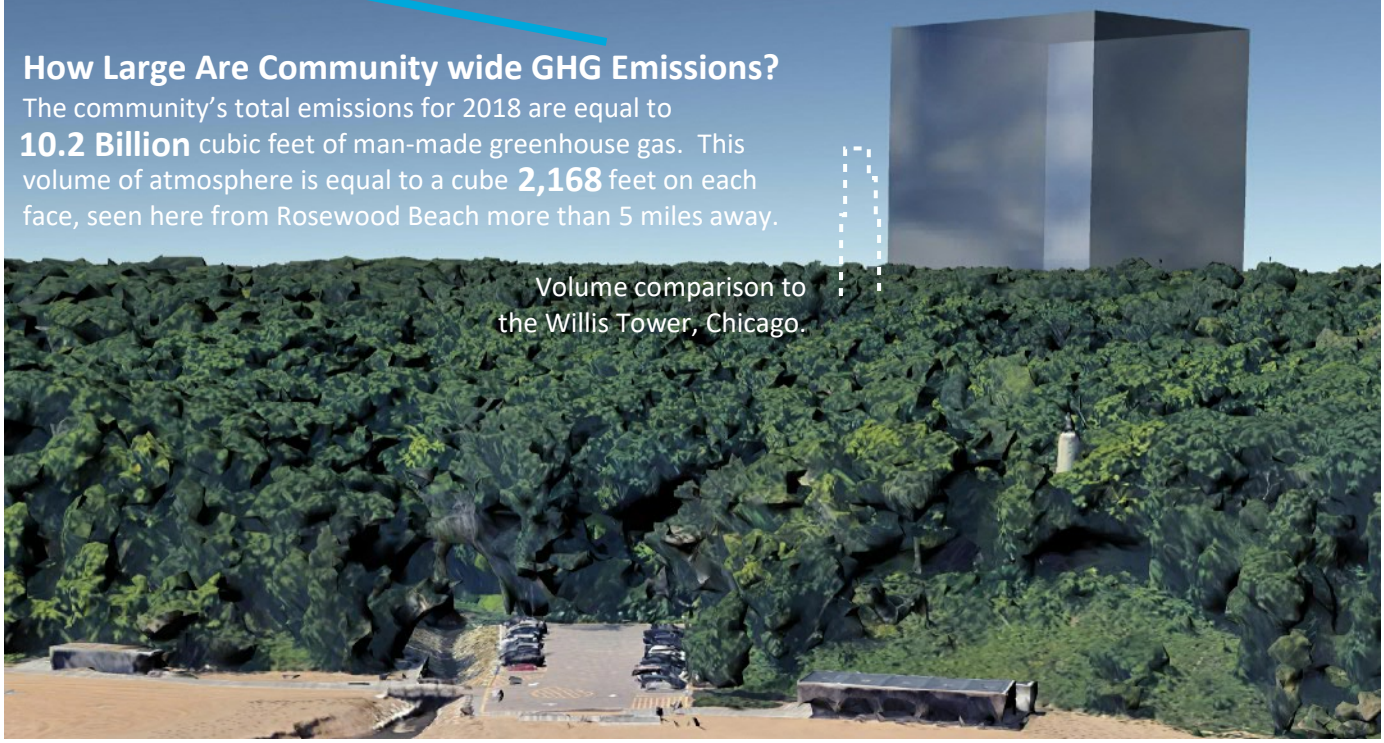


Think Economic Development is Tied To Increased Emissions?

Think again! Between 2010 and 2018 the Village was able to decrease it's GHG emissions by 21.43% while growing it's economy by 13.44% (pro rata share of County reporting) and adding 3.36% more jobs!

How Large Are Community wide GHG Emissions?

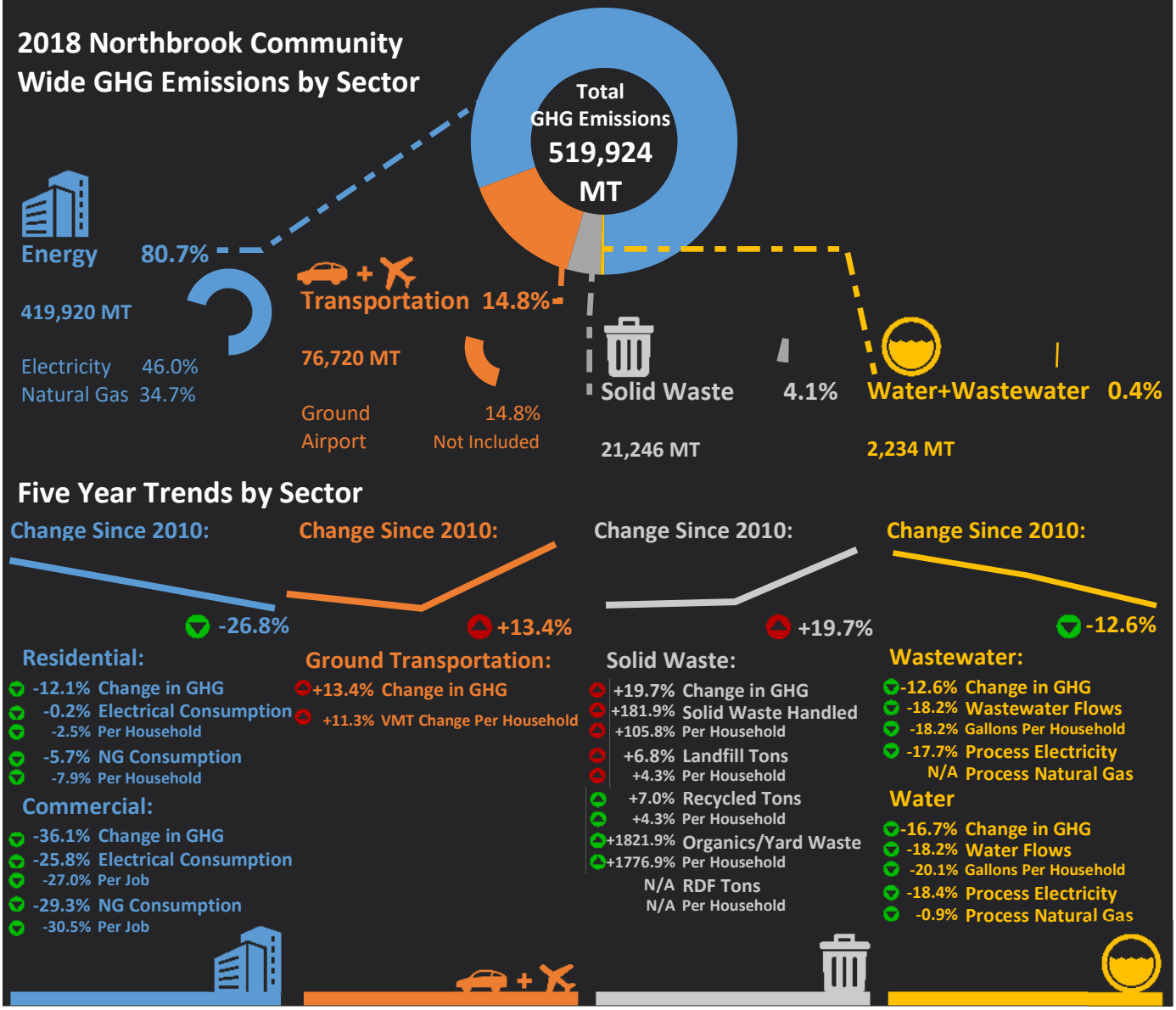
The community's total emissions for 2018 are equal to **10.2 Billion** cubic feet of man-made greenhouse gas. This volume of atmosphere is equal to a cube **2,168** feet on each face, seen here from Rosewood Beach more than 5 miles away.



Volume comparison to the Willis Tower, Chicago.

Findings In Brief

2018 Northbrook Community Wide GHG Emissions by Sector



Five Year Trends by Sector

Per-capita emissions for electrical consumption have declined 32.7% in since 2010. Electricity consumption by household in 2018, however, is 160% of the regional average. Per-capita emissions for natural gas consumption decreased 17.2%, due to significant reduced consumption in the non-residential sector. Natural gas consumption by household in 2018, however, is 158% of the regional average. *

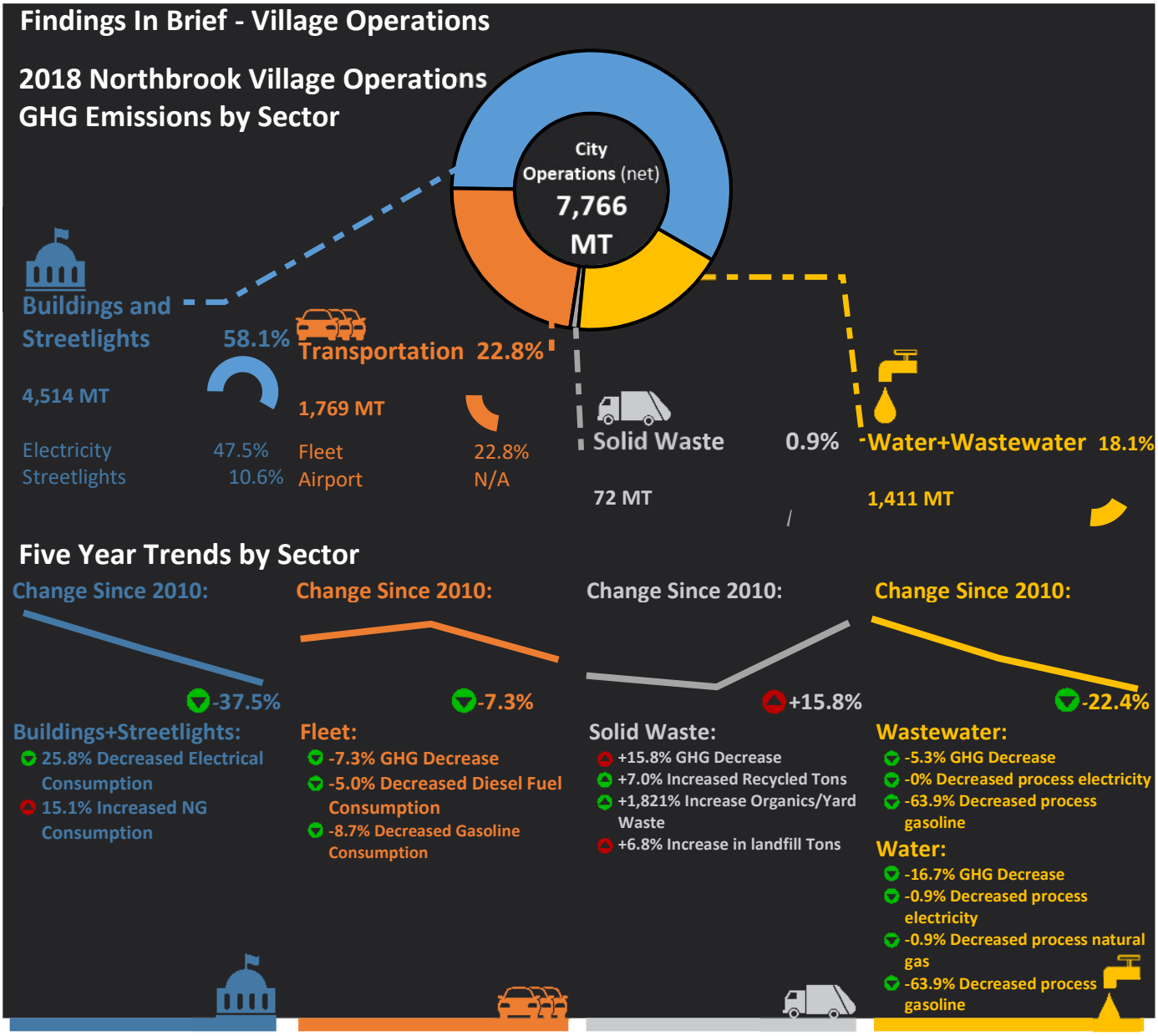
Since 2010, vehicle miles traveled (VMT) increased by 14%, but the associated GHG emissions increased by only 13.4% due to more efficient vehicles and cleaner fuels. VMT per household in 2018 is 64% of the regional household average**.

Air transportation emissions are not included in this inventory due to lack of data.

Per-capita emissions from solid waste management have increased 19.7% since 2010. The increase in emissions are due in part to an increase in reported organics/yard waste collection and a landfill tonnage handled from 9,091 tons in 2010 to 9,708 tons annually in 2018.

Per-household wastewater flows have decreased approximately 18.2% since 2010. Over the same time, emissions associated with wastewater treatment have decreased 12.6% due to a reduction in process electrical energy consumption and a significant reduction in reported process gasoline use.

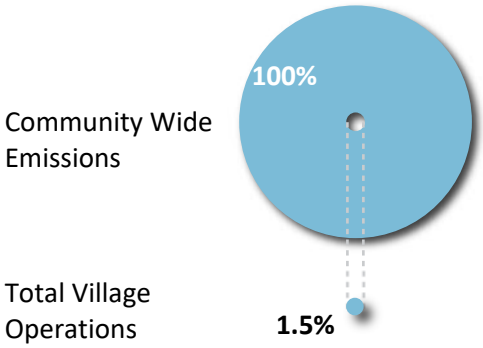
*Regional average calculations are based on the Chicago Regional Greenhouse Gas Emissions Inventory published by CMAP.
**VMT does not include trips which pass through the Village with neither trip origin nor trip destination within Village.



Estimated Buildings and Streetlights emissions have decreased approximately 37% since 2010. Transportation emissions for Village Operations have decreased over 7% due to decreases in transportation fuels, particularly diesel consumption which was reduced 8.7%. Solid waste emissions are estimated to have increased over 15% due in part to an increase in reported organics/yard waste collection and a landfill tonnage. Wastewater associated emissions have decreased 5.3% while Water associated emissions have decreased 16.7% both due largely to a significant decrease in process gasoline fuel consumption reported.

As illustrated in the chart to the right, the total Village Operations emissions account for approximately 1.5% of Community Wide emissions for 2018. This could be compared to the share of Village operations staff to total commercial/institutional jobs within the community of 0.9%

Relationship of Village Operations Emissions to Community Wide Emissions




Northbrook
From Chicago

Section 03

Community Comparison

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Community Comparison

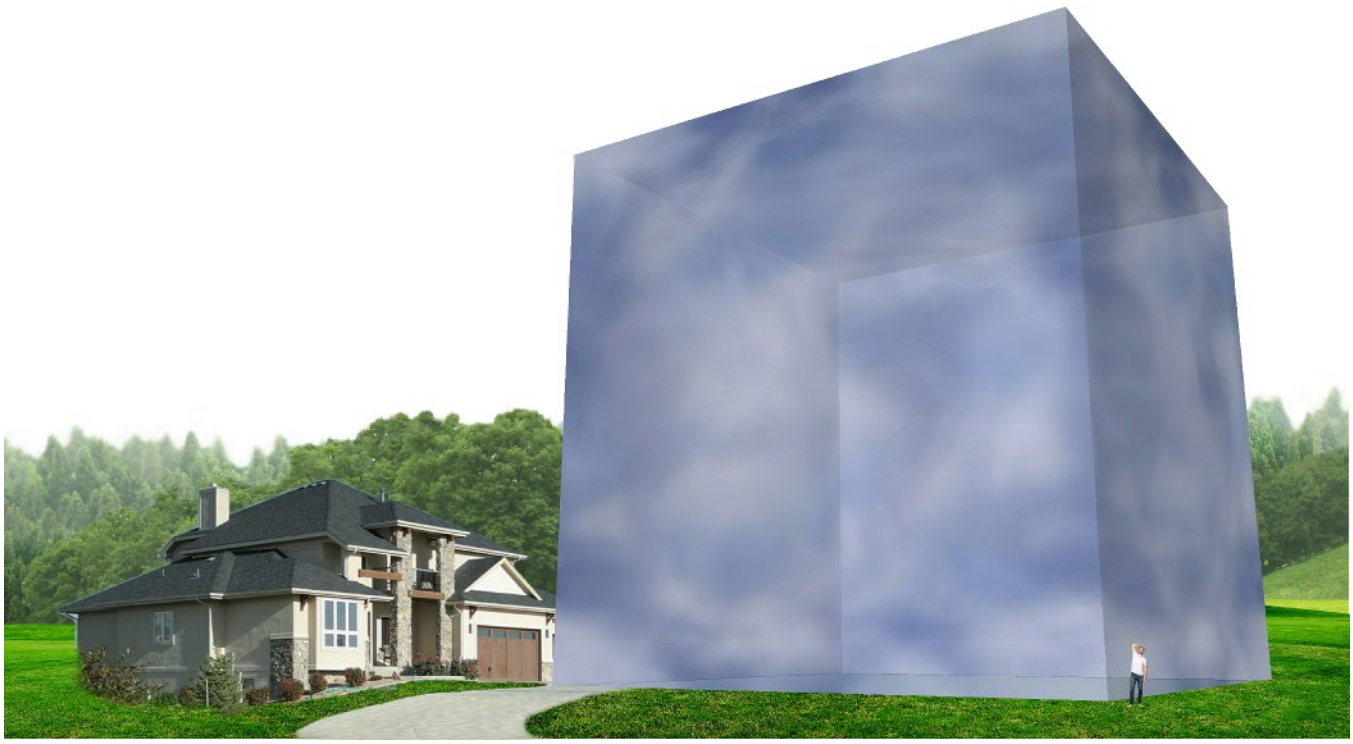
The results of community GHG inventories vary somewhat due to the information collected, variations in inventory methodology, community demographics, climate, economic factors, and regional considerations. Consequently, a direct community-to-community comparison should not be viewed as a comprehensive comparison of Greenhouse Gas emission efficiencies. 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 only be effectively done by adjusting for differences in overall community population. To make this adjustment, community GHG emissions are regularly compared based on a per-capita basis.

Understanding Northbrook's Per-Capita Community Wide Emissions

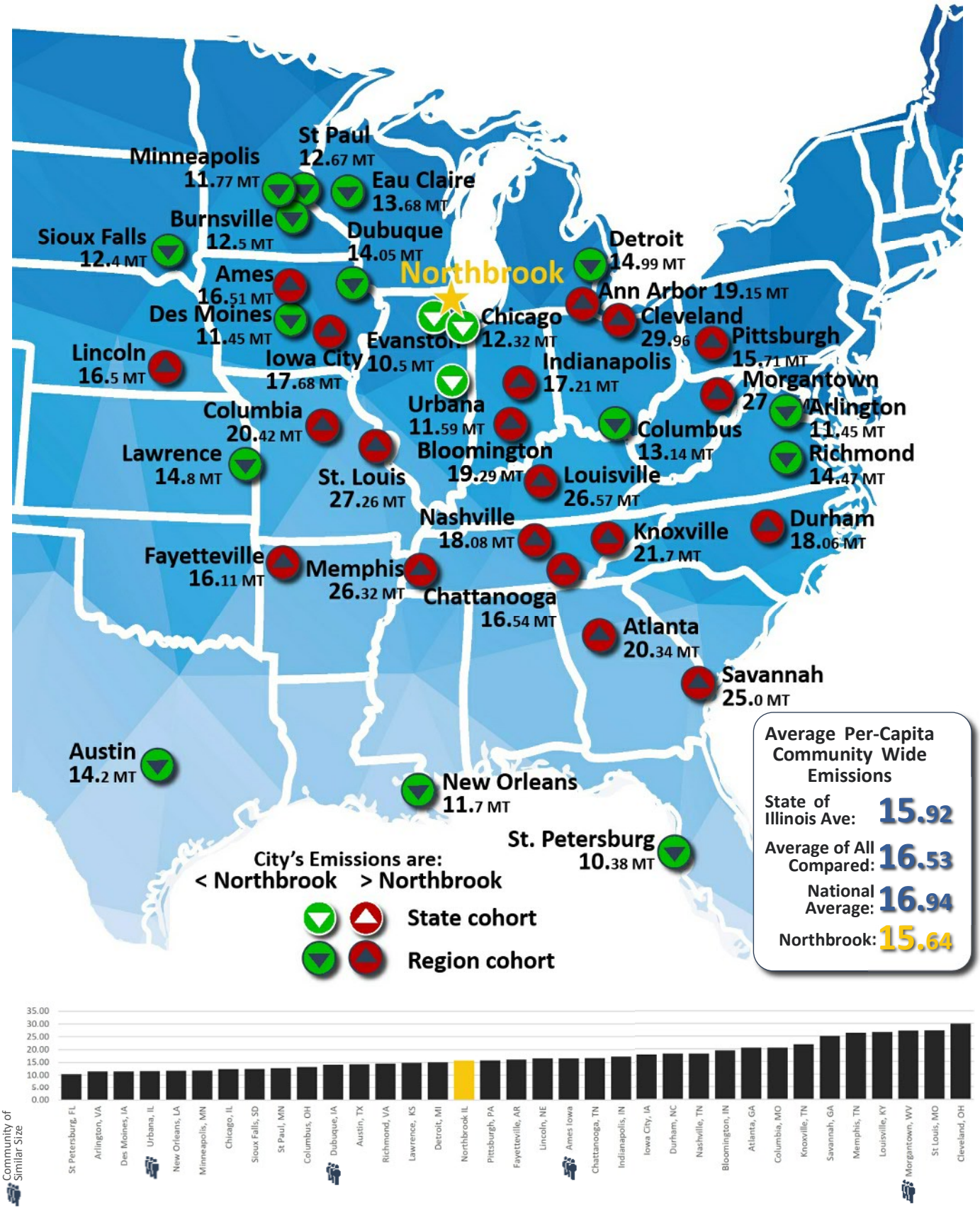
As outlined in Section 2, the Village of Northbrook's 2018 community wide emissions totaled 594,336 metric tons. By simply dividing this community wide emissions total by the total Village population we arrive at an average of 15.64 metric tons (MT) per person. Of course, this number represents only an average. The actual emissions each individual resident may be responsible for generating can vary significantly based on a range of personal choices in energy and resource consumption and waste.

How Large Are Community Wide Per-Capita GHG Emissions?

The Village of Northbrook's community wide emissions per-captia for 2018 are equal to **306,932** cubic feet of man-made greenhouse gas. This volume of atmosphere is equal to a cube **$67^{.5}$** feet on each face.



Community Cohorts Map

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Section 04

GHG Emissions Forecasting

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GHG Emissions Forecasting

Why Create a GHG Emission Forecast?

Increasing greenhouse gas emissions, and consequently, atmospheric concentrations, will have many effects on our global, regional, and local climate conditions. Future changes are expected to include a warmer atmosphere, a warmer and more acidic ocean, more powerful storms, broader swings in weather variability, and changes in precipitation patterns. The extent of future climate change depends our on-going GHG emissions. The more we emit, the broader our future climate changes will be. Put another way, the extent of climate change we experience in the future depends on the policies our communities put into place and the actions we as individuals take to reduce 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 planning efforts.

Business-As-Usual Forecast

Emissions are typically forecast under a business-as-usual (BAU) scenario. The Intergovernmental Panel on Climate Change (IPCC) defines a "business-as-usual" baseline case as the level of emissions that would result if future development trends follow those of the past and no changes in policies take place. A BAU forecast assumes that no emission-reduction actions will be undertaken beyond those already in place, or committed to, in the base year. The BAU forecast bases future projections on anticipated demographic changes, such as population changes and projected jobs within a community.

This approach allows for analysis of a community's full emissions growth potential before identifying emissions reduction strategies. As noted above, BAU emission forecasts are critical in providing insight into the scale of reductions necessary to achieve an emissions target before considering reductions likely to result from federal and statewide actions (e.g., vehicle efficiency standards), inherent technological advancements (e.g., energy-efficient appliances, lighting technology), or new local voluntary or mandatory conservation efforts (e.g., green building requirements).

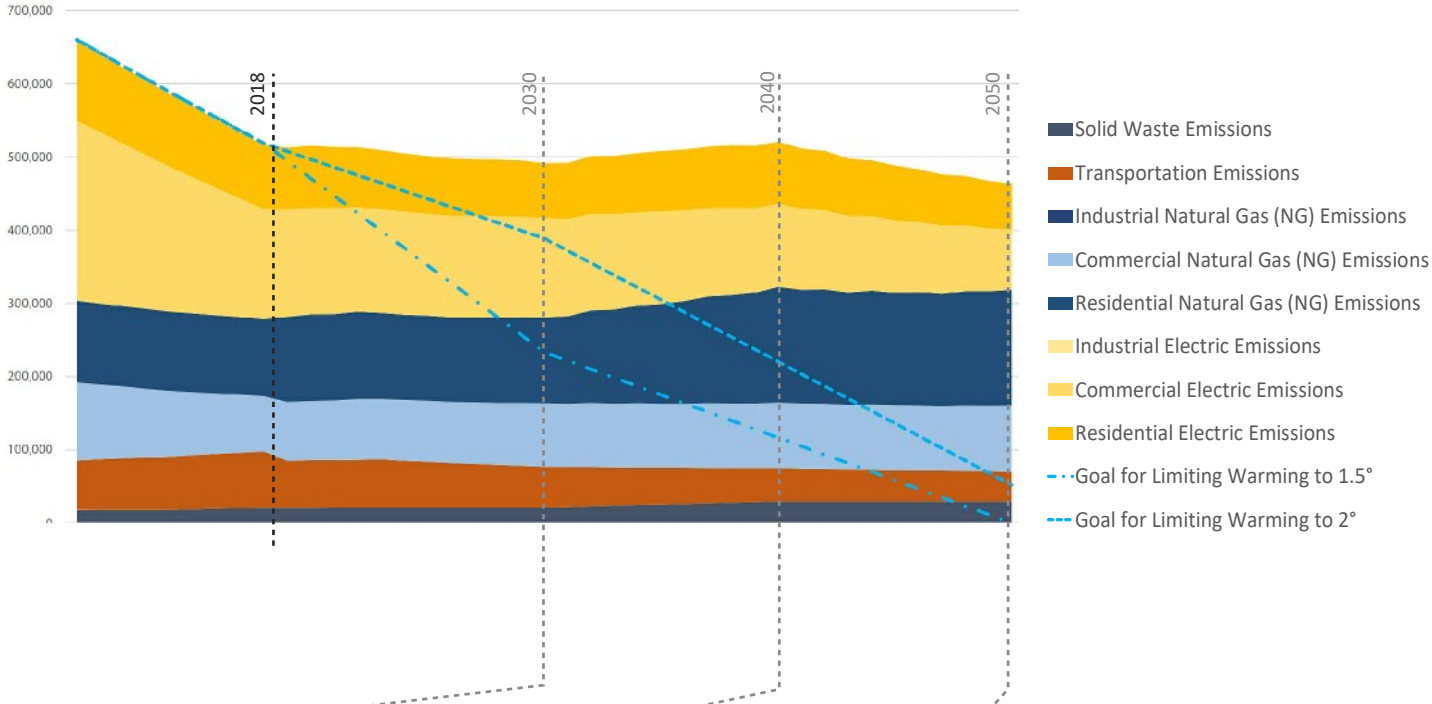
The Village of Northbrook community wide GHG forecasts included here were based on population and employment growth estimates projected based on community's share of the Chicago Metro projected growth as indicated in CMAP's ON TO 2050. In addition to these data, information from the State of Illinois, the US Environmental Protection Agency, US Department of Transportation, and US Energy Information Agency. The full assumptions used for the Business-as-usual GHG Emissions Forecast model are outlined in detail in the appendix of this report.

Uncertainty

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, as articulated in the forecast assumptions provided. The results of the forecast should be understood to contain uncertainty. Changes in industry structure over time, the particular impacts of policies, changing weather and economic conditions all add variability to how future emissions will develop.

GHG Emissions Forecasting

Northbrook Community Wide GHG Emissions Business as Usual Forecast



Change from 2010

2030 GHG Emissions **-4.8%**
Total Annual GHG 493,673

Energy

Electricity Use Emissions: **-40.5%**

Residential	75,178
Commercial	135,627
Industrial	0

Natural Gas Use Emissions: **-6.5%**

Residential	117,427
Commercial	86,598
Industrial	0

Transportation

Transportation Emissions: **-17.9%**
VMT (Thousands) 167,719

Solid Waste

Solid Waste Emissions: **21.3%**
LFG Emissions 21,528

Wastewater+Water

Wastewater+Water : **1.2%**

Wastewater Emissions	955
Water Emissions	1,309

Change from 2010

2040 GHG Emissions **0.8%**
Total Annual GHG 523,217

Energy

Electricity Use Emissions: **-44.0%**

Residential	85,003
Commercial	113,461
Industrial	0

Natural Gas Use Emissions: **13.5%**

Residential	158,361
Commercial	89,331
Industrial	0

Transportation

Transportation Emissions: **-32.4%**
VMT (Thousands) 168,404

Solid Waste

Solid Waste Emissions: **65.5%**
LFG Emissions 29,370

Wastewater+Water

Wastewater+Water : **33.4%**

Wastewater Emissions	1,303
Water Emissions	1,786

Change from 2010

2050 GHG Emissions **-10.3%**
Total Annual GHG 465,481

Energy

Electricity Use Emissions: **-59.1%**

Residential	62,283
Commercial	82,559
Industrial	0

Natural Gas Use Emissions: **14.0%**

Residential	158,054
Commercial	90,682
Industrial	0

Transportation

Transportation Emissions: **-39.9%**
VMT (Thousands) 171,835

Solid Waste

Solid Waste Emissions: **66.2%**
LFG Emissions 29,495

Wastewater+Water

Wastewater+Water : **21.4%**

Wastewater Emissions	1,308
Water Emissions	1,793

GHG Emissions Forecasting

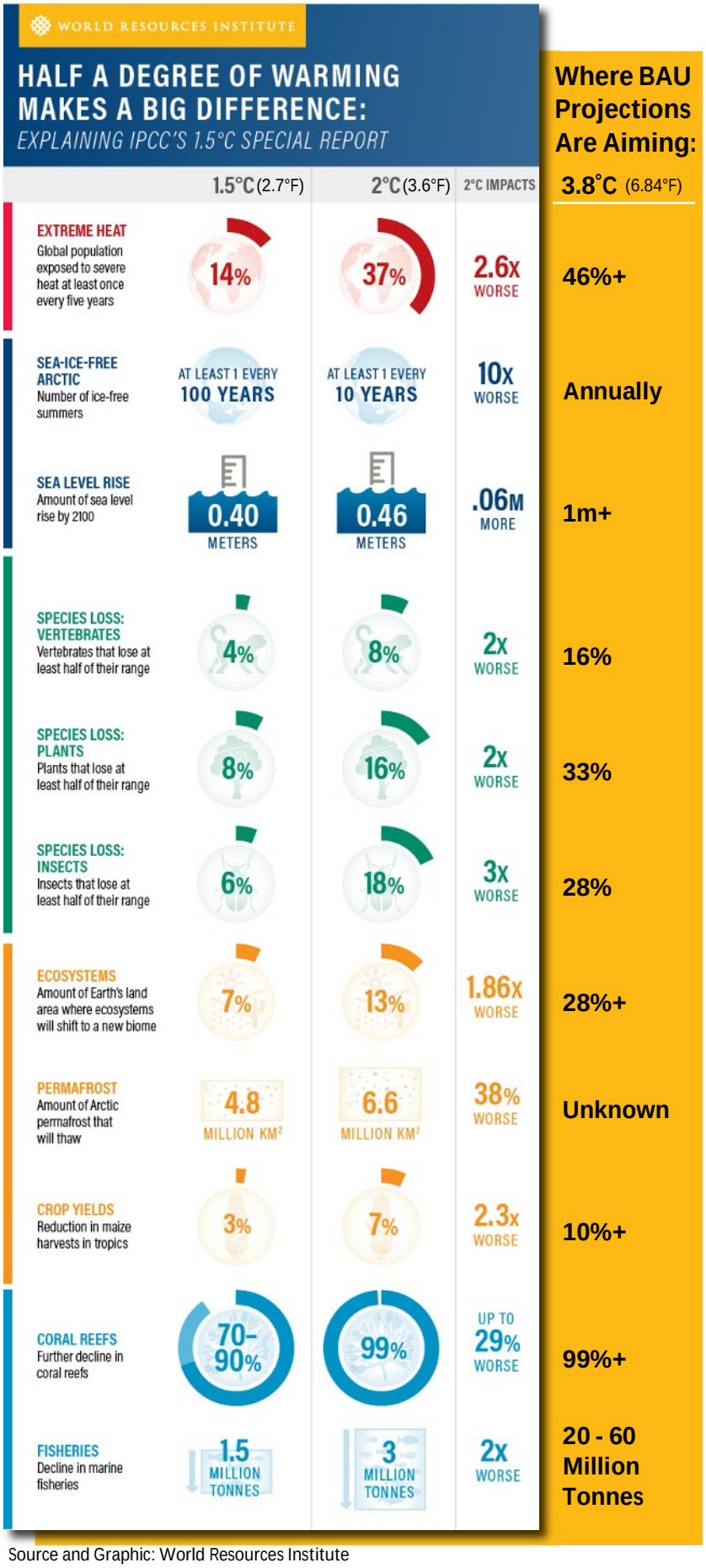
Understanding Impacts of BAU Forecast

Understanding what the BAU forecast means for Northbrook may be best achieved by placing emissions forecasts within a global perspective of climate change impacts. Global impacts can be viewed through understanding difference between 1.5˚C, 2˚C, and 4.6˚C degree global warming.

The International Panel on Climate Change (IPCC) is the United Nation Environment Porgramme (UNEP) body for assessing the science related to climate change and providing support in climate action policy making. 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 calculates that by 2030, global emissions will need to be 25% lower than 2018, and the reaching 80% reductions 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 and then achieving 90% or greater reductions by 2050.

The infographic to the right, created by the World Resources Institute summarizes some of the global climate change impact differences between reducing global emissions to cap global warming at 1.5˚C vs capping global warming to 2˚C. We've added an illustration of the impacts related to a 3.8˚C warming - which is where current Northbrook Business-as-Usual projections point.



Source and Graphic: World Resources Institute

Section A1

GHG Inventory Calculation Summary Spreadsheet

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Community Wide Integrated Inventory Tool

Updated 8/31/20

Village of Northbrook

Climate Action Plan

9/22/2020

Village Wide Emissions Inventory Data Calculations

Emissions Sectors	2010			2014			Change from Prior Study Year	2018			Change from Prior Study Year	MMBtu Change Since	GHG Change Since
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			
Electricity (Scope 2, MWh):													
Notes: **Gross Consumption**							Consumption				Consumption		
3 Residential	157,992	539,068	108,224	157,992	539,068	99,693	0.0%	156,067	532,501	88,022	-1.2%	-1.2%	-18.7%
3 Small and Large Commercial	361,665	1,234,001	247,740	315,569	1,076,721	199,124	-12.7%	268,523	916,202	151,447	-14.9%	-25.8%	-38.9%
3 Industrial	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
3 Streetlights	1,821	6,212	-	1,821	6,212	1,149	0.0%	1,821	6,212	1,027	0.0%	0.0%	N/A
Subtractions							Subtractions				Subtractions		
Residential - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Residential - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Commercial - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Commercial - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Industrial - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Industrial - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Waste, Water, Wastewater Process	(2,145)	(7,320)	-	(2,136)	(7,287)	-	-0.4%	(2,127)	(7,257)	-	-0.4%	-0.9%	
Streetlights - Wind Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Streetlights - Solar Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Residential	157,992	539,068	108,224	157,992	539,068	99,693	-7.9%	156,067	532,501	88,022	-11.7%		-18.7%
Commercial	359,520	1,226,681	246,271	313,433	1,069,434	197,776	19.7%	266,396	908,945	150,248	24.0%		-39.0%
Industrial	-	-	-	-	-	-	N/A	-	-	-	N/A		N/A
Streetlights	1,821	6,212	1,247	1,821	6,212	1,149	-7.9%	1,821	6,212	1,027	-10.6%		-17.7%
Subtotals	**521,477**	**1,779,280**	**355,742**	**475,381**	**1,622,001**	**298,618**	**-16.1%**	**426,411**	**1,454,914**	**239,296**	**-19.9%**		**-32.7%**
Blended emission factor (tonnes per MWh)	0.685			0.631				0.564			-10.6%		N/A
Electricity as a % of total citywide amounts		25.4%	53.8%		25.2%	50.6%			24.5%	46.0%			
Natural gas (Scope 1, therms):													
Notes: **Gross Consumption**							Consumption				Consumption		
3 Residential	21,060,007	2,105,497	111,591	20,392,738	2,038,786	108,056	-3.2%	19,863,450	1,985,870	105,251	-2.6%	-5.7%	-5.7%
3 Small and Large Commercial	20,123,805	2,011,900	106,631	16,920,502	1,691,646	89,657	-15.9%	14,224,706	1,422,131	75,373	-15.9%	-29.3%	29.3%
3 Industrial	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Subtractions							Subtractions				Subtractions		
Residential - Renewable Natural Gas Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Commercial - Renewable Natural Gas Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Industrial - Renewable Natural Gas Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Waste, Water, Wastewater Process	(37,561)	(3,755)	-	(46,319)	(4,631)	-	23.3%	(37,207)	(3,720)	-	-19.7%	-0.9%	
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Residential	21,060,007	2,105,497	111,591	20,392,738	2,038,786	108,056	3.2%	19,863,450	1,985,870	105,251	2.6%		-5.7%
Commercial	20,086,244	2,011,900	106,631	16,874,183	1,691,646	89,657	-15.9%	14,187,499	1,422,131	75,373	-15.9%		-29.3%
Industrial	-	(3,755)	(199)	-	(4,631)	(245)	23.3%	-	(3,720)	(197)	-19.7%		-0.9%
Subtotals	**41,146,251**	**4,113,642**	**218,023**	**37,266,921**	**3,725,801**	**197,467**	**-9.4%**	**34,050,949**	**3,404,281**	**180,427**	**-8.6%**		**-17.2%**
Emission factor (tonnes per MMBtu)	0.053			0.053				0.053					
Natural gas as a % of total citywide amounts		58.7%	32.9%		58.0%	33.5%			57.3%	34.7%			
Transportation (Scope 1):													
Notes: **Grand Transportation**							Consumption				Consumption		
6 Vehicle miles traveled (thousands of miles)	128,762	903,497	67,682	139,773	978,424	73,767	8.6%	146,768	1,002,456	76,720	5.0%	14.0%	13.4%
Estimated Fuel Consumed	7,322,200			7,935,213			8.4%	8,130,371			2.5%		N/A
Emission factor (tonnes per thousand VMT)	0.526			0.524			-0.3%	0.523			-0.3%		N/A
Transportation as a % of total citywide amounts		12.9%	10.2%		15.2%	12.4%			16.9%	14.8%			
Solid Waste (Scope 1):													
Notes: **Gross Consumption**							Consumption				Consumption		
Electricity (MWh)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Natural gas (therms)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Solid Waste Handled	13,881			13,854			-0.2%	29,245			111.1%	110.7%	N/A
5 Recycled (tons)	3,996		-	3,954		-	-1.0%	4,276		-	8.1%	7.0%	N/A
5 Organics / Yard Waste / Trees	794		126	780		124	-1.7%	15,260		2,431	1856.0%	1821.9%	1821.9%
5 MSW managed as RDF (tons)	-		-	-		-	N/A	-		-	N/A	N/A	N/A
5 Landfill (tons)	9,091		17,620	9,120		17,675	0.3%	9,708		18,815	6.4%	6.8%	6.8%
Subtotals		-	**17,746**		-	**17,800**	**0.3%**		-	**21,246**	**19.4%**	N/A	19.7%
Emission factor - RDF (tonnes per ton)	1.27			1.27				1.27					
6 Emission factor - Landfill (tonnes per ton)	1.94			1.94				1.94					
Solid waste as a % of total citywide amounts		0.0%	2.7%		0.0%	3.0%			0.0%	4.1%			
Water (Scope 1):													
Notes: **Gross Consumption**							Consumption				Consumption		
7 Water Flows (gallons in millions)	1,549			1,498			-3.3%	1,267			-15.4%	-18.2%	
8 Electricity (MWh)	1,948	6,648	1,335	1,939	6,615	1,223	-0.5%	1,930	6,585	1,089	0.5%	0.9%	-18.4%
Natural gas (therms)	37,561	3,755	199	46,319	4,631	245	23.3%	37,207	3,720	197	-19.7%	-0.9%	-0.9%
Gasoline (gal.)	1,855	207,456	16	912	101,994	8	-50.8%	669	74,818	6	-26.6%	-63.9%	-63.9%
Diesel (gal.)	-	0	0	-	0	0	N/A	-	0	0	N/A	N/A	N/A
Emissions from combustion of digestor gas (tonnes)			0			0	N/A			0	N/A		N/A
Subtotals		**217,859**	**1,550**		**113,240**	**1,477**	**-4.7%**		**85,123**	**1,292**	**-12.5%**		16.7%
Emission factor -Water (tonnes per million	1.00			0.99				1.02					
Wastewater as a % of total citywide amounts		3.1%	0.2%		1.8%	0.3%			1.4%	0.2%			
Wastewater (Scope 1):													
Notes: **Gross Consumption**							Consumption				Consumption		
9 Wastewater Flows (gallons in millions)	1,470			1,422			-3.3%	1,203			-15.4%	-18.2%	
Biologic Emissions			853			825				825			
8 Electricity (MWh)	197	672	135	197	672	124	0.0%	197	672	111	0.0%	0.0%	17.7%
Natural gas (therms)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Gasoline (gal.)	1,855	207,456	16	912	101,994	8	-50.8%	669	74,818	6	-26.6%	-63.9%	-63.9%
Diesel (gal.)	-	0	0	-	0	0	N/A	-	0	0	N/A	N/A	N/A
Emissions from combustion of digester gas (tonnes)			0			0	N/A			0	N/A		N/A
Subtotals		**208,128**	**1,005**		**102,666**	**958**	**-4.7%**		**75,490**	**942**	**-1.6%**		-6.2%
Emission factor -Wastewater (tonnes per	0.68			0.67				0.78					
Wastewater as a % of total citywide amounts		3.0%	0.2%		1.6%	0.2%			1.3%	0.2%			
Citywide Totals (Scope 1 & 2):		**7,004,546**	**661,748**		**6,428,892**	**589,586**	**-10.9%**		**5,937,142**	**519,924**	**-11.8%**	**-15.2%**	**-21.4%**
		Per-Capita:	19.91		**Per-Capita:**	17.48	-12.2%		**Per-Capita:**	15.68			-21.3%

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. To avoid double-counting, energy consumption and emissions associated with process electricity and process natural gas for wastewater treatment and solid waste management are subtracted Electricity and Natural Gas sectors
3. Community wide consumption for years 2010 and 2014 are not available from Utility. Numbers shown are estimated using a "back-casting" methodology based on community populations, employment numbers, and recorded variations in Cooling Degree Days and Heating Degree Days.
4. Community wide annual VMT is based on "backcasting" and interpolation of 2015 and 2020 VMT data provided by CMAP. Trip data includes trips with origin and destination within Village and trips with origin OR destination within Village. Trips with neither origin nor destination within Village (pass through only) are not included.
5. 2010 MSW Gross Consumption data is unavailable, inventory uses 2012 data.
6. Emission Factors are based on CMAP 2015 Chicago Regional Greenhouse Gas Emissions Inventory
7. Water flows relate to reported distributuion within Village of Northbrook only.
8. Annual electric consumption for 2010 and 2014 are estimated based on detailed 2019 records
9. Wastewater flows for 2018 is based on detailed data provided by Village. 2010 and 2014 flows are estimated based on calculated community wastewater to water ratios applied to known water distributuion quantities for years.

Citywide Integrated Inventory Tool

Updated 8/31/20

Village of Northbrook

Climate Action Plan

9/17/2020

Village Operations Emissions Inventory Data Calculations

Emissions Sectors	2010			2014			Change from Prior Study Year	2018			Change from Prior Study Year	MMBtu Change Since	GHG Change Since
	FTE 287 Est Daytime Pop 55,593			FTE 287 Est Daytime Pop 55,643				FTE 287 Est Daytime Pop 55,057					
	Consumption	MMBtu	GHG	Consumption	MMBtu	GHG		Consumption	MMBtu	GHG			
Electricity (Scope 2, MWh):													
Notes: **Gross Consumption**							Consumption				Consumption		
3 Buildings, Grounds, Streetlights	11,676	39,838	7,998	10,188	34,760	6,428	-12.7%	8,669	29,578	4,889	-14.9%	-25.8%	-38.9%
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	
Waste, Water, Wastewater Process	(2,145)	(7,320)	-	(2,136)	(7,287)	-	-0.4%	(2,127)	(7,257)	-	-0.4%	-0.9%	
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Buildings, Grounds, Streetlights	9,531	32,518	6,528	8,052	27,473	5,081	-22.2%	6,542	22,321	3,690	-27.4%		-43.5%
Subtotals	**11,676**	**39,838**	**6,528**	**10,188**	**34,760**	**5,081**	**-22.2%**	**8,669**	**29,578**	**3,690**	**-27.4%**		-43.5%
Blended emission factor (tonnes per MWh)	0.685			0.631				0.564			-10.6%		N/A
Electricity as a % of total citywide amounts		0.2%	59.9%		0.1%	53.4%			0.1%	47.5%			
Natural gas (Scope 1, therms):													
Notes: **Gross Consumption**							Consumption				Consumption		
Buildings and Grounds	167,402	16,736	887	187,568	18,752	994	12.0%	192,741	19,269	1,021	2.8%	15.1%	15.1%
(other)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Subtractions							Subtractions				Subtractions		
Buildings - Renewable Natural Gas Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
(other) - Renewable Natural Gas Sourced	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	
Waste, Water, Wastewater Process	(37,561)	(3,755)	-	(46,319)	(4,631)	-	23.3%	(37,207)	(3,720)	-	-19.7%	-0.9%	
Net Consumption With Emissions							GHG Emissions				GHG Emissions		
Buildings and Grounds	129,841	12,981	688	141,249	14,122	748	8.8%	155,534	15,550	824	10.1%		19.8%
(other)	-	-	-	-	-	-	N/A	-	-	-	N/A		N/A
Subtotals	**129,841**	**12,981**	**688**	**141,249**	**14,122**	**748**	**8.8%**	**155,534**	**15,550**	**824**	**10.1%**		19.8%
Emission factor (tonnes per MMBtu)	0.053			0.053				0.053					
Natural gas as a % of total citywide amounts		0.0%	6.3%		0.1%	7.9%			0.1%	10.6%			
Transportation:													
Notes: **Grand Transportation Fuel**			**1,909**			**2,019**	Consumption			**1,769**	Consumption		
Diesel (gal.)	70,200	9,090,900	713	82,133	10,636,224	835	17.0%	66,720	8,640,240	678	-18.8%	-5.0%	-5.0%
BioDiesel B20 (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Gasoline (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
e10 Gasoline (gal.)	149,070	16,671,393	1,195	147,733	16,521,868	1,185	-0.9%	136,092	15,219,985	1,091	-7.9%	-8.7%	-8.7%
e85 (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Airport			**0**			**0**	**N/A**			**0**			**N/A**
Av Fuel	0	0	0	0	0	0	N/A	0	0	0	N/A	-	N/A
Jet Fuel	0	0	0	0	0	0	N/A	0	0	0	N/A	N/A	N/A
Subtotals	-	**25,762,293**	**1,909**	-	**27,158,091**	**2,019**	**5.8%**	-	**23,860,225**	**1,769**	**-12.4%**		-7.3%
Transportation as a % of total citywide amounts		99.0%	17.5%		99.4%	21.2%			99.5%	22.8%			
Solid Waste:													
Notes: **Solid Waste Share**	Community Wide	City Ops Share		Community Wide	City Ops Share			Community Wide	City Ops Share				
Estimated Commercial Share of MSW	45.0%			45.0%				45.0%					
4 Community Wide Solid Waste Handled	13,881	49		13,854	47			29,245	99				
Recycled (tons)	3,996	14	0	3,954	13	0		4,275	14	0		7.0%	
Organics / Yard Waste / Trees	794	3	0	780	3	0		15,260	52	8		1821.9%	
MSW managed as RDF (tons)	0	-	N/A	0	-	N/A		0	-	N/A		N/A	
Landfill (tons)	9,091	32	62	9,120	31	60		9,708	33	64		6.8%	
Subtotals		**65**	**62**		**63**	**60**	**-3.0%**		**165**	**72**	**19.4%**		15.8%
Solid waste as a % of total citywide amounts		0.0%	0.6%		0.0%	0.0%			0.0%	0.0%			
Water (Scope 1):													
Notes: **Gross Consumption Share**							Consumption				Consumption		
7 Water Flows (gallons in millions)	1,549			1,498			-3.3%	1,267			-15.4%		N/A
8 Electricity (MWh)	1,948	6,648	1,335	1,939	6,615	1,223	-0.5%	1,930	6,585	1,089	-0.5%	-0.9%	-18.4%
Natural gas (therms)	37,561	3,755	199	46,319	4,631	245	23.3%	37,207	3,720	197	-19.7%	-0.9%	0.9%
Gasoline (gal.)	1,855	207,456	16	912	101,994	8	-50.8%	669	74,818	6	-26.6%	-63.9%	-63.9%
Diesel (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Emissions from combustion of digester gas (tonnes)			-			-	N/A			-	N/A		N/A
Subtotals		**217,859**	**1,550**		**113,240**	**1,477**	**-4.7%**		**85,123**	**1,292**	**-12.5%**		-16.7%
Emission factor -Water (tonnes per million G	1.00			0.99				1.02					
Wastewater as a % of total citywide amounts		0.8%	14.2%		0.4%	15.5%			0.4%	16.6%			
Wastewater (Scope 1):													
Notes: **Operations Gross Consumption**							Consumption				Consumption		
9 Wastewater Flows (gallons in millions)	1,470			1,422			-3.3%	1,203			-15.4%		N/A
8 Electricity (MWh)	197	672	135	197	672	124	0.0%	197	672	111	0.0%	0.0%	-17.7%
Natural gas (therms)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Gasoline (gal.)	1,855	207,456	16	912	101,994	8	50.8%	669	74,818	6	-26.6%	-63.9%	-63.9%
Diesel (gal.)	-	-	-	-	-	-	N/A	-	-	-	N/A	N/A	N/A
Subtotals		**208,128**	**151**		**102,666**	**132**	**-12.6%**		**75,490**	**117**	**-11.6%**		-22.7%
Gross Consumption Share	Flow (MMGal)		GHG	Flow (MMGal)		GHG		Flow (MMGal)		GHG			
Wastewater Flows (gallons in millions)	1470.32		1,005	1422.26		958		1202.95		942			
Estimated Daytime Share of Consumption	45.0%			45.0%				45.0%					
Estimated Gallons Per Daytime Capita	0.012			0.012				0.010					
5 Estimated City Operations Share	3		2	3		2		3		2			
Subtotals		**0**	**2**		**0**	**2**	**-4.8%**		**0**	**2**	**-0.6%**		-5.3%
Wastewater as a % of total citywide amounts		0.8%	1.4%		0.4%	1.4%			0.3%	1.5%			
Citywide Totals (Scope 1 & 2):		**26,023,239**	**10,891**		**27,309,639**	**9,520**	**-12.6%**		**23,980,843**	**7,766**	**-18.4%**	**-7.8%**	**-28.7%**
		Per-Capita:	0.33		**Per-Capita:**	0.28	-13.9%		**Per-Capita:**	0.23			-28.5%
		Share of Citywide	1.5%		**Share of Citywide**	1.5%			**Share of Citywide**	1.3%			

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 To avoid double-counting, energy consumption and emissions associated with process electricity and process natural gas for wastewater treatment and solid waste management are subtracted Electricity and Natural Gas sectors
3 Village Operations electrical consumption for years 2010 and 2014 are not consistantly available. Numbers shown are estimated using a "back-casting" methodology similar to Community Wide electrical consumption modeling based on community populations, employment numbers, and recorded variations in Cooling Degree Days and Heating Degree Days.
4 Village Operations share of Solid Waste is estimated ProRata share of commercial portion of MSW based on FTE share of community-wide employment.
5 Village Operations share of wastewater is estimated ProRata share of commercial portion of wastewater generation based on FTE share of community-wide employment.
7 Water flows relate to reported distributuion within Village of Northbrook only.
8 Annual electric consumption for 2010 and 2014 are estimated based on detailed 2019 records
9 Wastewater flows for 2018 is based on detailed data provided by Village. 2010 and 2014 flows are estimated based on calculated community wastewater to water ratios applied to known water distributuion quantities for years.

Section A2

GHG Forecast Assumptions

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Village of Northbrook
GHG Forecast Assumptions:

Demographics:

- **Population:** Total Population projections through 2050 are projected based on Village's share of projected growth of the Local Area Allocation (LAA) developed in support of CMAP's ON TO 2050 forecast of population.
- **Households:** Total household counts through 2050 are projected based on Village's share of projected growth of the Local Area Allocation (LAA) developed in support of CMAP's ON TO 2050 forecast of households.
- **Jobs:** Total commercial and industrial jobs through 2050 are projected based on Village's share of projected growth of the Local Area Allocation (LAA) developed in support of CMAP's ON TO 2050 forecast of employment (note, share of commercial jobs and industrial jobs are projected using current percentages of total employment).

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 15% of electricity is used for cooling (RCP 8.5 model). 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 15% of commercial and 7.5% of industrial electricity is 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. 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). 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).

- Commercial and Industrial: Demand is based on a per job basis and modified based on projected heating degree days for each year, assuming that 40% of commercial and 20% of industrial natural gas is used for heating (RCP 8.5 model).
- Natural Gas emissions factors are projected to be unchanged.

Transportation:

- Vehicle Miles Traveled is based on *Chicago* Metropolitan Agency for Planning (*CMAP*) projections. Trip data projections include trips with origin and destination within Village and trips with origin OR destination within Village. Trips with neither origin nor destination within Village (pass through only) are not included.
- 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 75% 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 2030 (2.556) and then reducing the average vehicle per household 10% through 2050 (2.3).
- Electric Vehicle Adoption: Transportation emissions assume a reduction in fossil fuel based VMT emissions based on estimated adoption rates. Adoption rates for 2030 are based on based on Village's share of state projected total EV's from "A Roadmap for Electric Vehicles in Tennessee" by Drive Electric Tennessee. Adoption rates for 2040 and 2050 are based on a 1% annual increase from 2030 projections. Existing vehicle stock is assumed to be replaced based on an average replacement lifespan of 15 years.
  (https://www.edisonfoundation.net/iei/publications/Documents/IEI_EEI%20EV%20Forecast%20Report_Nov2018.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.

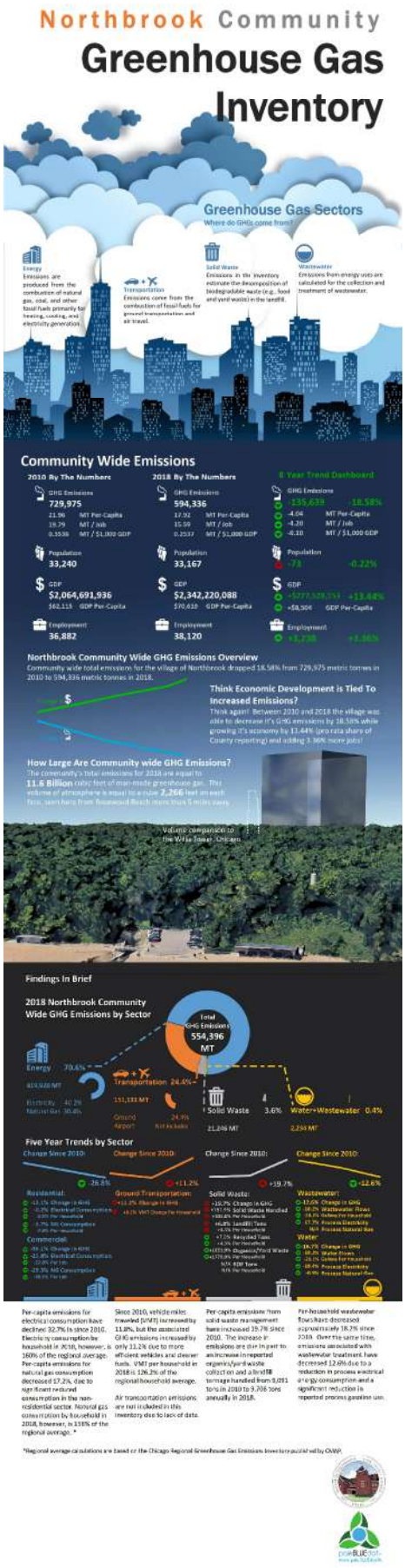
Note:

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.

Section A3

Community Wide GHG Inventory - Infographic

Click to Return to TOC



Community Wide GHG Inventory - Infographic

To the left is an image of the Community Wide Greenhouse Gas Inventory infographic created to summarize the findings of the inventory. Click on the image or scan the QR code to access the infographic.

https://cutt.ly/FfmQjvv

Section A4

GHG Inventory Glossary of Terms

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Biomass
Either (1) the total mass of living organisms in a given area or of a given species usually expressed as dry weight; or (2) Organic matter consisting of or recently derived from living organisms (especially regarded as fuel) excluding peat. Includes products, by-products and waste derived from such material. (IPCC1)

Biomass Waste
Organic non-fossil material of biological origin that is a byproduct or a discarded product. "Biomass waste" includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural crop byproducts, straw, and other biomass solids, liquids, and gases; but excludes wood and wood-derived fuels (including black liquor), biofuels feedstock, biodiesel, and fuel ethanol. Note: EIA "biomass waste" data also include energy crops grown specifically for energy production, which would not normally constitute waste. (EIA)

Black Carbon
Operationally defined aerosol species based on measurement of light absorption and chemical reactivity and/or thermal stability; consists of soot, charcoal and/or possible light absorbing refractory organic matter (Charlson and Heintzenberg, 1995, p. 401). (IPCC2)

C
Carbon Cycle
All parts (reservoirs) and fluxes of carbon. The cycle is usually thought of as four main reservoirs of carbon interconnected by pathways of exchange. The reservoirs are the atmosphere, terrestrial biosphere (usually includes freshwater systems), oceans, and sediments (includes fossil fuels). The annual movements of carbon, the carbon exchanges between reservoirs, occur because of various chemical, physical, geological, and biological processes. The ocean contains the largest pool of carbon near the surface of the Earth, but most of that pool is not involved with rapid exchange with the atmosphere. (NASA)

Carbon Dioxide (CO_2)
A naturally occurring gas, and also a by-product of burning fossil fuels and biomass, as well as land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth's radiative balance. It is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. (IPCC2)\

Carbon Dioxide Equivalent (CO_2e)
A metric used to compare emissions of various greenhouse gases. It is the mass of carbon dioxide that would produce the same estimated radiative forcing as a given mass of another greenhouse gas. Carbon dioxide equivalents are computed by multiplying the mass of the gas emitted by its global warming potential.

Carbon Equivalent (CE)
A metric measure used to compare the emissions of the different greenhouse gases based upon their global warming potential. Carbon equivalents can be calculated from to carbon dioxide equivalents by multiplying the carbon dioxide equivalents by 12/44 (the ratio of the molecular weight of carbon to that of carbon dioxide). The use of carbon equivalent is declining in GHG inventories.

Carbon Intensity
The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per British thermal unit (Btu) of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. (EIA)

Carbon Sequestration
This refers to the capture of CO_2 from the atmosphere and its long term storage in oceans (oceanic carbon sequestration), in biomass and soils (terrestrial carbon sequestration) or in underground reservoirs (geologic carbon sequestration).

Chlorofluorocarbons (CFCs)
Greenhouse gases covered under the 1987 Montreal Protocol and used for refrigeration, air conditioning, packaging, insulation, solvents, or aerosol propellants. Because they are not destroyed in the lower atmosphere, CFCs drift into the upper atmosphere where, given suitable conditions, they break down ozone. These gases are being replaced by other compounds, including hydrochlorofluorocarbons and hydrofluorocarbons, which are greenhouse gases covered under the Kyoto Protocol. (IPCC3)

Climate
Climate in a narrow sense is usually defined as the "average weather" or more rigorously as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. (IPCC2)

Climate Change
Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period (typically decades or longer). Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. (IPCC2)

Cogeneration
Cogeneration is an industrial structure, installation, plant, building, or self-generating facility that has sequential or simultaneous generation of multiple forms of useful energy (usually mechanical and thermal) in a single, integrated system. (CARB)

Combined Heat and Power (CHP)
Combined heat and power is the simultaneous production of both electricity and useful heat for application by the producer or to be sold to other users with the aim of better utilisation of the energy used. Public utilities may utilise part of the heat produced in power plants and sell it for public heating purposes. Industries as auto-producers may sell part of the excess electricity produced to other industries or to electric utilities. (IPCC)

Consistency
Consistency means that an inventory should be internally consistent in all its elements over a period of years. An inventory is consistent if the same methodologies are used for the base and all subsequent years and if consistent data sets are used to estimate emissions or removals from sources or sinks. (IPCC)

Continuous Emission Monitor (CEM)
A type of air emission monitoring system installed to operate continuously inside of a smokestack or other emission source. (CARB)

Criteria Air Pollutant
An air pollutant for which acceptable levels of exposure can be determined and for which an ambient air quality standard has been set. Examples include: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM10 and PM2.5. The term "criteria air pollutants" derives from the requirement that the U.S. EPA must describe the

characteristics and potential health and welfare effects of these pollutants. The U.S. EPA and CARB periodically review new scientific data and may propose revisions to the standards as a result. (CARB)

D

Deforestation

Those practices or processes that result in the change of forested lands to non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present and contributing to carbon storage. (UNFCC)

Distillate Fuel Oil

A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation. (EIA)

E

Emissions

The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere. (USEPA1)

Emission Factor

A coefficient that quantifies the emissions or removals of a gas per unit activity. Emission factors are often based on a sample of measurement data, averaged to develop a representative rate of emission for a given activity level under a given set of operating conditions. (IPCC)

Emission Inventory

An estimate of the amount of pollutants emitted into the atmosphere from major mobile, stationary, area-wide, and natural source categories over a specific period of time such as a day or a year. (CARB)

Emission Rate

The weight of a pollutant emitted per unit of time (e.g., tons / year). (CARB)

Estimation

Estimation is the assessment of the value of an unmeasurable quantity using available data and knowledge within stated computational formulas or mathematical models.

F

Fluorocarbons

Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine, or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs). (UNFCC)

Flux

Either (1) Raw materials, such as limestone, dolomite, lime, and silica sand, which are used to reduce the heat or other energy requirements of thermal processing of minerals (such as the smelting of metals). Fluxes also may serve a dual function as a slagging agent. (2) The rate of flow of any liquid or gas, across a given area; the amount of this crossing a given area in a given time. (e.g., "Flux of CO2 absorbed by forests"). (IPCC)

Fossil Fuel
Geologic deposits of hydrocarbons from ancient biological origin, such as coal, petroleum and natural gas.

Fuel Combustion
Fuel combustion is the intentional oxidation of materials within an apparatus that is designed to provide heat or mechanical work to a process, or for use away from the apparatus. (IPCC)

Fugitive Emissions
Emissions that are not emitted through an intentional release through stack or vent. This can include leaks from industrial plant and pipelines. (IPCC)

G
Geologic Farbon Sequestration
It is the process of injecting CO_2 from a source, such as coal-fired electric generating power plant, through a well into the deep subsurface. With proper site selection and management, geologic sequestration could play a major role in reducing emissions of CO_2. Research efforts to evaluate the technical aspects of CO_2 geologic sequestration are underway. (USEPA4)

Global Warming
Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases from human activities. Also see Climate Change (USEPA1)

Global Warming Potential (GWP)
An index, based upon radiative properties of well-mixed greenhouse gases, measuring the radiative forcing of a unit mass of a given well-mixed greenhouse gas in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in absorbing outgoing thermal infrared radiation. The Kyoto Protocol is based on GWPs from pulse emissions over a 100-year time frame. (IPCC2)

GCOM Global Covenant of Mayors:
GCoM is the largest global alliance for city climate leadership, built upon the commitment of over 10,000 cities and local governments. The alliance's mission is to mobilize and support climate and energy action in communities across the world.

Greenhouse Effect
Trapping and build-up of heat in the atmosphere (troposphere) near the earth's surface. Some of the heat flowing back toward space from the earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase. (UNFCC)

Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories:
A robust, transparent and globally-accepted framework that cities and local governments can use to consistently identify, calculate and report on city greenhouse gas emissions.

Greenhouse Gas
Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). (UNFCC)

Gross Domestic Product (GDP)
The sum of gross value added, at purchasers' prices, by all resident and non-resident producers in the economy, plus any taxes and minus any subsidies not included in the value of the products in a country or a geographic region for a given period, normally one year. It is calculated without deducting for depreciation of fabricated assets or depletion and degradation of natural resources. (IPCC3)

H
Halocarbons
A collective term for the group of partially halogenated organic species, including the chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), halons, methyl chloride, methyl bromide, etc. Many of the halocarbons have large Global Warming Potentials. The chlorine and bromine-containing halocarbons are also involved in the depletion of the ozone layer. (IPCC2)

Hydrocarbons
Strictly defined as molecules containing only hydrogen and carbon. The term is often used more broadly to include any molecules in petroleum which also contains molecules with S, N, or O An unsaturated hydrocarbon is any hydrocarbon containing olefinic or aromatic structures. (IPCC)

Hydrofluorocarbons (HFCs)
Compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23). (USEPA1)

I
ICLEI Local Governments for Sustainability:
A membership organization for local governments to pursue reductions in carbon pollution and improvements in advancing sustainable urban development. ICLEI's members and team of experts work together through peer exchange, partnerships and capacity building to create systemic change for urban sustainability.

Intergovernmental Panel on Climate Change
The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories. (USEPA1)

K
Kilowatt Hour (kWh):
A measure of electrical energy equivalent to a power consumption of 1,000 watts for one hour.

Kyoto Protocol
The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally

binding commitments, in addition to those included in the UNFCCC. Countries included in Annex B of the Protocol (most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005. (IPCC2)

L

Land Use and Land Use Change
Land use refers to the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions). The term land use is also used in the sense of the social and economic purposes for which land is managed (e.g., grazing, timber extraction and conservation). Land use change refers to a change in the use or management of land by humans, which may lead to a change in land cover. Land cover and land use change may have an impact on the surface albedo, evapotranspiration, sources and sinks of greenhouse gases, or other properties of the climate system and may thus have a radiative forcing and/or other impacts on climate, locally or globally. (IPCC2)

LULUCF
Acronym for "Land Use, Land Use Change and Forestry", a category of activities in GHG inventories.

M

Megawatt Hour (MWH):
A measure of electrical energy equivalent to a power consumption of 1,000,000 watts for one hour.

Methane (CH_4)
A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 25 times that of carbon dioxide (CO_2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, flooded rice fields, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Metric Ton
The tonne (t) or metric ton, sometimes referred to as a metric tonne, is an international unit of mass. A metric ton is equal to a Megagram (Mg), 1000 kilograms, 2204.6 pounds, or 1.1023 short tons.

Million Metric Tons (MMT)
Common measurement used in GHG inventories. It is equal to a Teragram (Tg).

Mitigation:
Actions taken to limit the magnitude or rate of long-term global warming and its related effects. Climate change mitigation generally involves reductions in human emissions of greenhouse gases.

Mobile Sources
Sources of air pollution such as automobiles, motorcycles, trucks, off-road vehicles, boats, and airplanes. (CARB)

Model
A model is a quantitatively-based abstraction of a real-world situation which may simplify or neglect certain features to better focus on its more important elements. (IPCC)

Municipal Solid Waste (MSW)
Residential solid waste and some non-hazardous commercial, institutional, and industrial wastes. This material is generally sent to municipal landfills for disposal. (USEPA1)

N

Natural Sources
Non-manmade emission sources, including biological and geological sources, wildfires, and windblown dust. (CARB)

Nitrogen Fixation
Conversion of atmospheric nitrogen gas into forms useful to plants and other organisms by lightning, bacteria, and blue-green algae; it is part of the nitrogen cycle. (UNFCC)

Nitrogen Oxides (NO_x)
Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced in the emissions of vehicle exhausts and from power stations. In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), can impair visibility, and have health consequences; they are thus considered pollutants. (NASA)

Nitrous Oxide (N_2O)
A powerful greenhouse gas with a global warming potential of 298 times that of carbon dioxide (CO_2). Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, manure management, fossil fuel combustion, nitric acid production, and biomass burning. The GWP is from the IPCC's Fourth Assessment Report (AR4).

O

Ozone (O_3)
Ozone, the triatomic form of oxygen (O_3), is a gaseous atmospheric constituent. In the troposphere, it is created both naturally and by photochemical reactions involving gases resulting from human activities (smog). Tropospheric ozone acts as a greenhouse gas. In the stratosphere, it is created by the interaction between solar ultraviolet radiation and molecular oxygen (O_2). Stratospheric ozone plays a dominant role in the stratospheric radiative balance. Its concentration is highest in the ozone layer. (IPCC2)

Ozone Depleting Substances (ODS)
A compound that contributes to stratospheric ozone depletion. Ozone-depleting substances (ODS) include CFCs, HCFCs, halons, methyl bromide, carbon tetrachloride, and methyl chloroform. ODS are generally very stable in the troposphere and only degrade under intense ultraviolet light in the stratosphere. When they break down, they release chlorine or bromine atoms, which then deplete ozone. (IPCC)

P

Perfluorocarbons (PFCs)
A group of human-made chemicals composed of carbon and fluorine only. These chemicals (predominantly CF_4 and C_2F_6) were introduced as alternatives, along with hydrofluorocarbons, to the ozone depleting substances. In addition, PFCs are emitted as by-products of industrial processes and are also used in manufacturing. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases: CF_4 has a global warming potential (GWP) of 7,390 and C_2F_6 has a GWP of 12,200. The GWP is from the IPCC's Fourth Assessment Report (AR4).

Photosynthesis
The process by which plants take carbon dioxide from the air (or bicarbonate in water) to build carbohydrates, releasing oxygen in the process. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations. (IPCC2)

Point Sources
Specific points of origin where pollutants are emitted into the atmosphere such as factory smokestacks. (CARB)

Process Emissions
Emissions from industrial processes involving chemical transformations other than combustion. (IPCC)

R
Radiative Forcing
A change in the balance between incoming solar radiation and outgoing infrared (i.e., thermal) radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases to the atmosphere traps an increased fraction of the infrared radiation, reradiating it back toward the surface of the Earth and thereby creates a warming influence. (UNFCC)

Reforestation
Planting of forests on lands that have previously contained forests but that have been converted to some other use. (IPCC2)

Regeneration
The act of renewing tree cover by establishing young trees, naturally or artificially - note regeneration usually maintains the same forest type and is done promptly after the previous stand or forest was removed. (CSU)

Residence Time
Average time spent in a reservoir by an individual atom or molecule. Also, this term is used to define the age of a molecule when it leaves the reservoir. With respect to greenhouse gases, residence time usually refers to how long a particular molecule remains in the atmosphere. (UNFCC)

Reservoir
Either (1) a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored; or (2) Water bodies regulated for human activities (energy production, irrigation, navigation, recreation etc.) where substantial changes in water area due to water level regulation may occur. (IPCC)

Respiration
The process whereby living organisms convert organic matter to carbon dioxide, releasing energy and consuming molecular oxygen. (IPCC2)

S
Scope 1:
Scope 1 includes emissions being released within the city limits resulting from combustion of fossil fuels and from waste decomposition in the landfill and wastewater treatment plant.

Scope 2:
Scope 2 includes emissions produced outside the city that are induced by consumption of electrical energy within the city limits.

Scope 3:
Scope 3 includes emissions of potential policy relevance to local government operations that can be measured and reported but do not qualify as Scope 1 or 2. This includes, but is not limited to, outsourced operations and employee commute.

Short Ton
Common measurement for a ton in the United States. A short ton is equal to 2,000 lbs or 0.907 metric tons. (USEPA1)

Sink
Any process, activity or mechanism that removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol from the atmosphere. (IPCC2)

Solar Radiation
Electromagnetic radiation emitted by the Sun. It is also referred to as shortwave radiation. Solar radiation has a distinctive range of wavelengths (spectrum) determined by the temperature of the Sun, peaking in visible wavelengths. (IPCC2)

Source
Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor of a greenhouse gas or aerosol into the atmosphere. (IPCC2)

Stationary Sources
Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit air pollutants. (CARB)

Sulfur Dioxide (SO_2)
A compound composed of one sulfur and two oxygen molecules. Sulfur dioxide emitted into the atmosphere through natural and anthropogenic processes is changed in a complex series of chemical reactions in the atmosphere to sulfate aerosols. These aerosols are believed to result in negative radiative forcing (i.e., tending to cool the Earth's surface) and do result in acid deposition (e.g., acid rain). (UNFCC)

Sulfur Hexafluoride (SF_6)
A colorless gas soluble in alcohol and ether, slightly soluble in water. A very powerful greenhouse gas with a global warming potential most recently estimated at 22,800 times that of carbon dioxide (CO_2). SF_6 is used primarily in electrical transmission and distribution systems and as a dielectric in electronics. This GWP is from the IPCC's Fourth Assessment Report (AR4).

T
Terrestrial Carbon Sequestration
It is the process through which carbon dioxide (CO_2) from the atmosphere is absorbed by trees, plants and crops through photosynthesis, and stored as carbon in biomass (tree trunks, branches, foliage and roots) and soils. The term "sinks" is also used to refer to forests, croplands, and grazing lands, and their ability to sequester carbon. Agriculture and forestry activities can also release CO_2 to the atmosphere. Therefore, a carbon sink occurs when carbon sequestration is greater than carbon releases over some time period. (USEPA3)

Therm:
A unit of measure for energy that is equivalent to 100,000 British Thermal units, or roughly the energy in 100 cubic feet of natural gas. Often used for measuring natural gas usage for billing purposes.

Total Organic Gases (TOG)
Gaseous organic compounds, including reactive organic gases and the relatively unreactive organic gases such as methane. (CARB)

Transparency
Transparency means that the assumptions and methodologies used for an inventory should be clearly explained to facilitate replication and assessment of the inventory by users of the reported information. The transparency of

inventories is fundamental to the success of the process for the communication and consideration of information. (IPCC)

Trend
The trend of a quantity measures its change over a time period, with a positive trend value indicating growth in the quantity, and a negative value indicating a decrease. It is defined as the ratio of the change in the quantity over the time period, divided by the initial value of the quantity, and is usually expressed either as a percentage or a fraction. (IPCC)

V
VMT Vehicle Miles Traveled:
A unit used to measure vehicle travel made by private vehicles, including passenger vehicles, truck, vans and motorcycles. Each mile traveled is counted as one vehicle mile regardless of the number of persons in the vehicle.

W
Water Vapor
The most abundant greenhouse gas; it is the water present in the atmosphere in gaseous form. Water vapor is an important part of the natural greenhouse effect. While humans are not significantly increasing its concentration, it contributes to the enhanced greenhouse effect because the warming influence of greenhouse gases leads to a positive water vapor feedback. In addition to its role as a natural greenhouse gas, water vapor plays an important role in regulating the temperature of the planet because clouds form when excess water vapor in the atmosphere condenses to form ice and water droplets and precipitation. (UNFCC)

Weather
Atmospheric condition at any given time or place. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate in a narrow sense is usually defined as the "average weather", or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period is 30 years, as defined by the World Meteorological Organization (WMO). These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard). (USEPA1)

Prepared by:

making change personal
paleBLUEdot LLC

2515 White Bear Ave, A8
Suite 177
Maplewood, MN 55109

Contact:
Ted Redmond
tredmond@palebluedot..llc