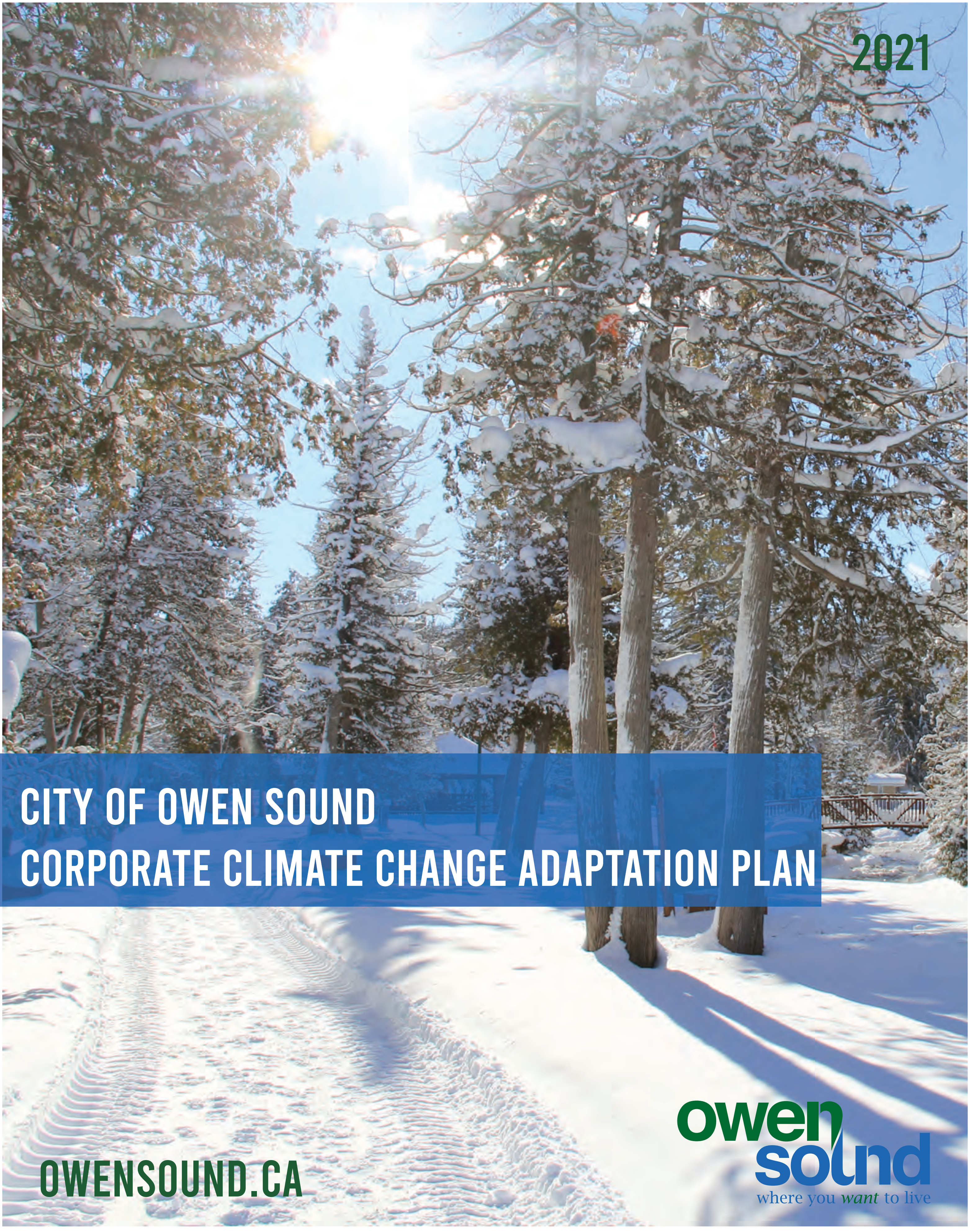

2021

CITY OF OWEN SOUND
CORPORATE CLIMATE CHANGE ADAPTATION PLAN

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CORPORATE CLIMATE CHANGE ADAPTATION PLAN
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EXECUTIVE SUMMARY

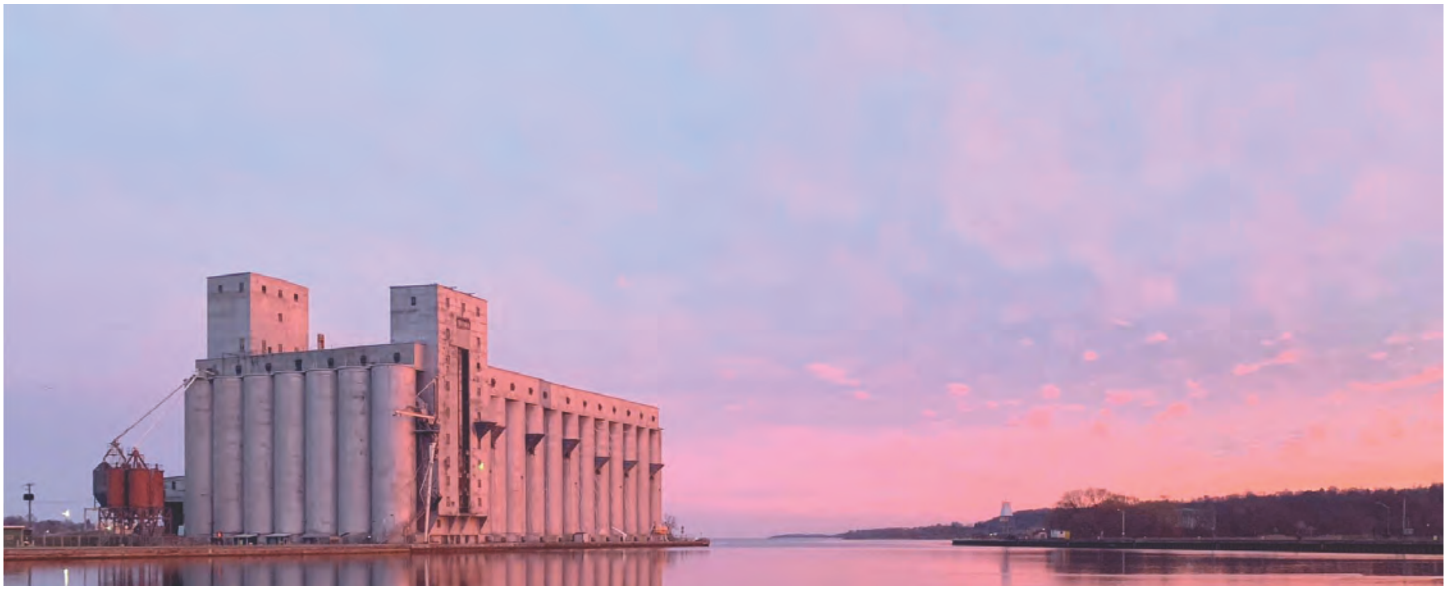
The City of Owen Sound has developed a Corporate Climate Change Adaptation Plan to understand the impact that climate change has on services and infrastructure (stormwater network, roads, and build-ings) which the City is responsible for. The purpose of the corporate climate change adaptation plan is to increase the resiliency of those City infrastructure and services. Increased resiliency will reduce service disruption and increase service reliability equating to a more liveable community.

The Corporate Climate Change Adaptation Plan identifies climatic threats and impacts to infrastructure and services and then evaluates and prioritizes efforts by assessing the vulnerability and the risks to Owen Sound's physical, economic, social, and ecological systems.

Based on the vulnerability and risk assessment, the plan prioritizes practical and effective actions to minimize impacts and build climate resilience across the corporation.

Adaptation is an essential response to climate change. It complements mitigation efforts and focuses on reducing the negative impacts of climate change. Adaptation and mitigation are not mutually exclusive and some actions will benefit both mitigation and adaptation. Even with mitigation efforts underway, the City needs to build resilience to ensure the adaptability of infrastructure and services to climate changes.

The Corporate Climate Change Adaptation Plan recommends specific measures to enhance the City's ability to cope with the impacts and risks associated with climate change.



ACKNOWLEDGEMENTS

Land Acknowledgement:
The City of Owen Sound wishes to acknowledge the Territory of the Anishinabek Nation: The People of the Three Fires known as Ojibway, Odawa, and Pottawatomie Nations. And further gives thanks to the Chippewas of Saugeen, and the Chippewas of Nawash, now known as the Saugeen Ojibway Nation, as the traditional keepers of this land.

The City of Owen Sound would like to thank everyone who contributed to the development of this adaptation plan. The development of this plan was a cooperative project with the Grey Sauble Conservation Authority (GSCA) and was supported by a cross-functional steering committee and technical committee as well as dedicated staff and external stakeholders that shared their knowledge and expertise.

We thank you for your efforts in increasing the City's resiliency to the impacts of climate change.

Steering Committee Members:
Kris Robinson – City of Owen Sound
Gloria Dangerfi eld – Grey Sauble Conservation Authority
Dennis Kefalas – City Public Works and Engineering
Chris Webb - City Engineering
Heidi Jennen – City Emergency Management
Cassandra Cesco – City Environmental Services
Amy Cann – City Planning
Mac Plewes – Grey Sauble Conservation Authority
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Dana Goetz – City Engineering

The preparation of this plan was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

Government of Canada Gouvernement du Canada
Canada

FCM FEDERATION OF CANADIAN MUNICIPALITIES FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

INTRODUCTION

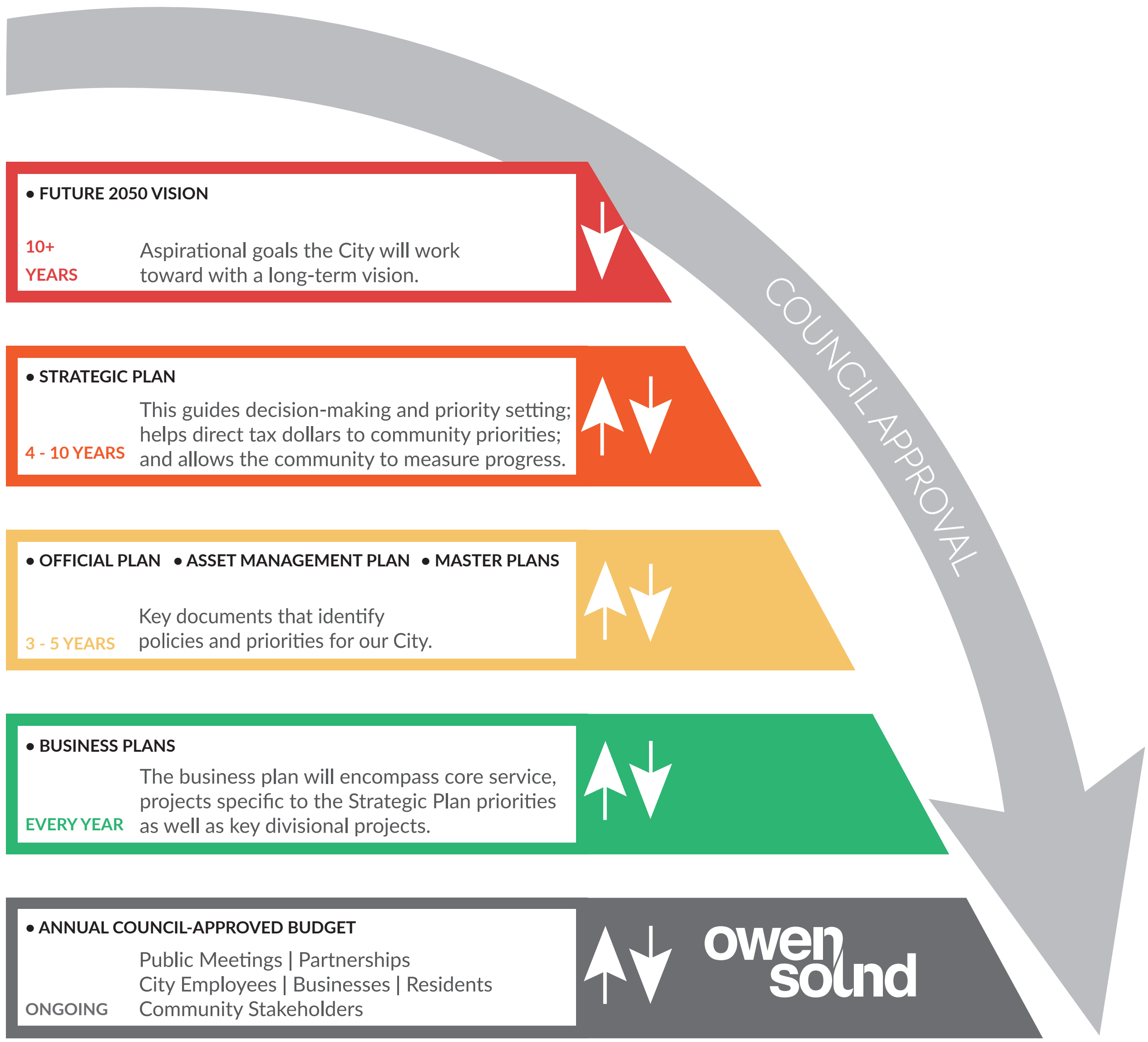
Throughout Canada, all tiers of government are feeling the effects climate change will have on their areas of governance. Some of these factors include rain fall, snow fall, average seasonal temperature, water levels, and flooding.

With the rising concern of climate change throughout the world, Canada, and Ontario, the City of Owen Sound identified the need to consider the effects that it may have on its services. Through its consideration, the City has determined that the first step in ensuring resiliency in light of a changing climate is a Corporate Climate Change Adaptation Plan (CCCAP).

In March 2018, the Government of Canada and the Federation of Canadian Municipalities (FCM) announced funding to help municipalities better prepare and adapt to the new realities of climate change. On February 4, 2019 the City of Owen Sound received notice of grant funding from FCM to develop a CCCAP to increase the City's capacity to not only cope with the impacts, but to thrive in the face of a changing climate. This is a cooperative project with Grey Sauble Conservation Authority (GSCA) as the increased asset knowledge related to stormwater management and the potential impacts from flood plain mapping will benefit both organizations.

While the CCCAP focuses on climate adaptation, it's important to note that the City is also participating in a number of corporate and community-oriented mitigation initiatives.

The City is a member of the Climate Change Working Group led by Grey County in the development of a County Climate Change Action Plan. This comprehensive strategy is focused on climate change mitigation in the six key areas of Buildings, Transportation, Waste, Agriculture, Land-Use and Energy.



Owen Sound's Commitment to Climate Change

Owen Sound's Refreshed Strategic Plan identifies being a 'Green City' as a priority of Council. Key Results have been developed to achieve the goal statement related to the environment which states: We will continue to ensure environmental integrity is maintained in Owen Sound and the surrounding area by protecting our environment and natural assets. We will protect, preserve, maintain and enhance Owen Sound's scenic and natural heritage, and we will do so by using resources wisely, cooperating with adjoining communities and agencies, and taking responsibility for City actions.

The federal and provincial governments provide strategic focus, standards, and potential funding streams for adaptation, it will be up to local governments to align policy and implement projects and initiatives to create sustainable resiliency. The combined efforts of the City, Grey County, provincial and federal ministries, the Grey Sauble Conservation Authority, and countless other organizations help to ensure environmental integrity is maintained in Owen Sound.

An Official Plan sets goals and policies to guide development and growth in the City over the next 20 years. The City's Official Plan (currently undergoing an update) is an important tool to support the City's vision of being a vibrant and thriving community. The City's updated Official Plan will include policy to enable climate change adaptation and mitigation which will align with the Grey County Official Plan on Climate Change to ensure that we have a collaborative and consistent approach to the policies related to development in our area.

From the County of Grey's Official Plan:

> Climate change is considered by many to be the world's biggest challenge in the coming century. Grey County's weather is already changing and will continue to change. We can expect that there will be more frequent snow squalls, more extreme rain and flooding events, and warmer summer temperatures. We must take action to adapt to and mitigate the effects of a changing climate. This will include making greater efforts to protect and to enhance the resiliency of our natural, built, and social environments. This Plan has been written with this objective in mind. Additionally, the County of Grey will work towards creating a Climate Change Action Plan that will coordinate the County's efforts to embrace and facilitate resilient, sustainable development to mitigate the effects of climate change within our communities. The County can become more resilient to climate change. Our efforts to adapt can also help Grey County remain affordable and economically competitive. The emerging green economy will provide significant opportunities for creative solutions, innovation, and job growth.

Maximizing Grant Funding:
Understanding Storm Water Systems and Potential Flooding within the City

As resources are constrained, City staff realized that grant funding could be used to create a CCCAP while also increasing the City's knowledge of assets related to storm water management and the potential impacts from flooding within the City. Through the funding provided by FCM, a Geospatial & Climate Adaptation Technician position was funded to create a spatial inventory of the municipal infrastructure (stormwater, culverts, bridges, slopes and rivers) on the west side of the City. The west side of the City was focused on as there was limited consolidated information on the existing infrastructure.

Urban and riverine flooding can damage built infrastructure and disrupt services as well as cause other issues such as erosion and the destabilization of slopes. Urban flooding is when the minor system (storm water pipes under the ground) and the major system (streets) are overwhelmed with water and areas that these systems are meant to protect become flooded. Riverine flooding is when a river's banks swell causing flooding to the surrounding area which many cause damages to buildings, roads and other infrastructure.

Once this spatial inventory was gathered, various rain models (commonly referred to as 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events) were applied to understand the impacts on the infrastructure.

This information is invaluable as the City assesses where to focus efforts on infrastructure improvements.

Adaptation is an essential response to climate change. It complements mitigation efforts and focuses on reducing the negative impacts of climate change. Adaptation and mitigation are not mutually exclusive and some actions will benefit both mitigation and adaptation. Even with mitigation efforts underway, the City needs to ensure adaptability of infrastructure and services as the climate changes.

Adaptation includes any actions that help us adjust to the impacts of climate change. Examples of adaptation actions include increasing the capacity of stormwater management systems, using different construction materials, updating operating procedures, and modifying outdoor work policies.

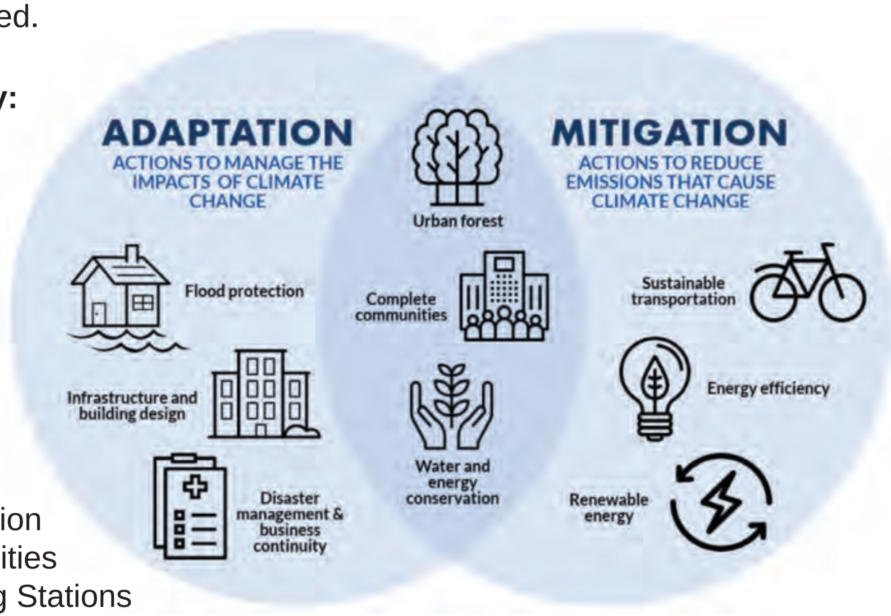
In contrast, mitigation includes any actions that reduce the amount of greenhouse gases released into our atmosphere that contribute to climate change. Examples include improving the energy efficiency of buildings and using low-emission vehicles.

Adaptation and mitigation are not mutually exclusive. Some actions have co-benefits, meaning they contribute to both objectives. For example, planting trees will assist in providing shade and adapting to extreme heat, while also mitigating greenhouse gas emissions by acting as a carbon sink and potentially lowering energy use in both summer and winter months.

Climate change adaptation involves making adjustments in our decisions, activities and thinking in response to observed and predicted changes in climate. The goal is limiting harm or reducing costs in the long term while taking advantage of new opportunities and maximizing benefits. Successful adaptation does not mean that impacts will not occur, only that they will be less severe than would be experienced had no adaptation occurred.

Mitigation Efforts Already Underway:

- LED Streetlight Conversion
- Industrial Park – Cycling Trail
- Solar Panels
- Tree Planting Program
- Energy Management Program
- Corporate Greening – 3rd Avenue
- Traffic Signal Control Coordination
- Salt Management Program
- Bottle Refill Stations
- Household Hazardous Waste Collection
- Energy Demand Management - Facilities
- Electric Vehicles and Public Charging Stations



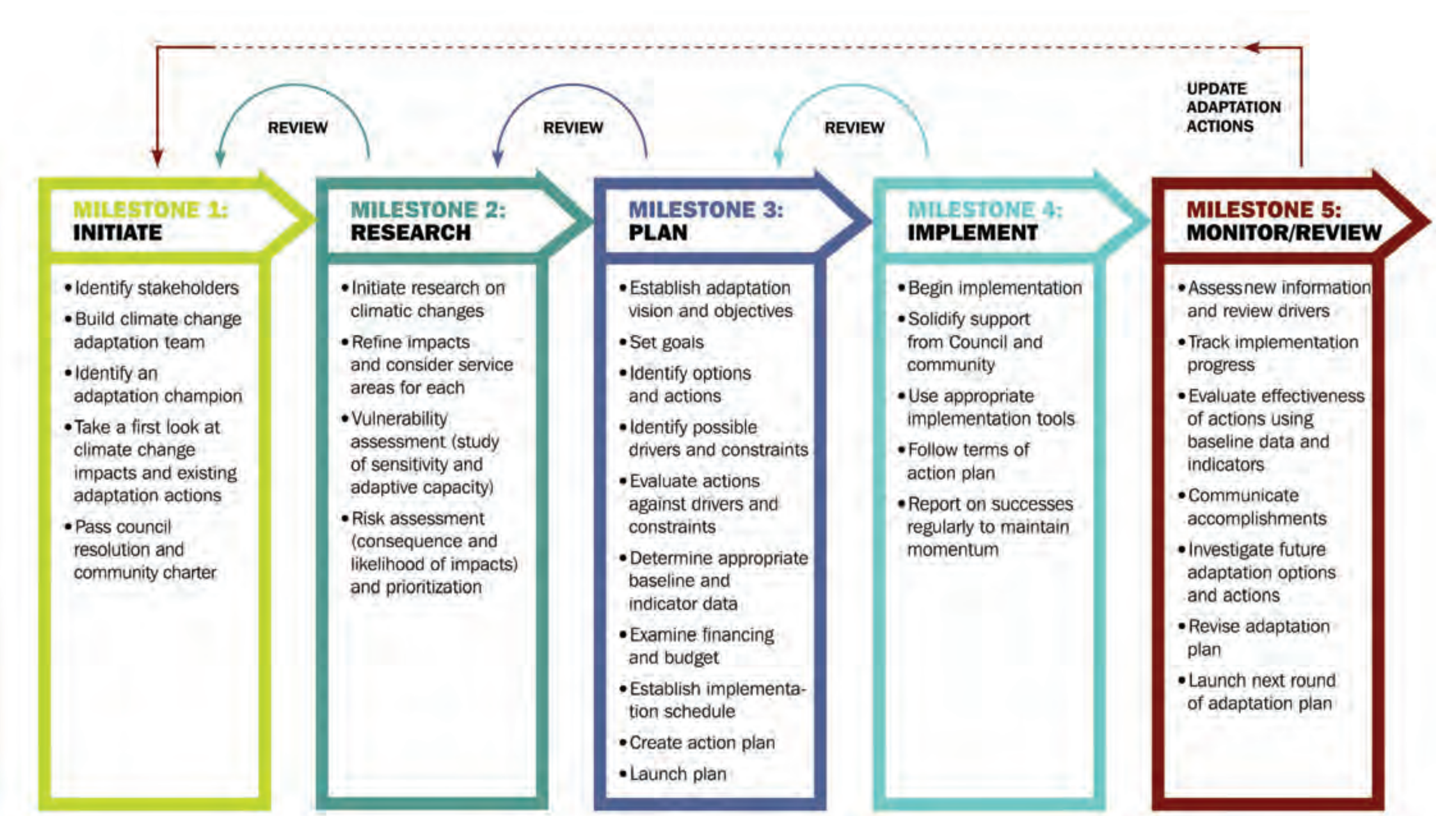
ADAPTATION = MANAGING THE UNAVOIDABLE **MITIGATION = AVOIDING THE UNMANAGEABLE**

OUR PROCESS

The Steering Committee identified the Building Adaptive and Resilient Communities (BARC) program, which was developed by ICLEI Canada, as the guiding framework in order to have a comprehensive, proven methodology for developing and implementing a CCCAP.

This framework has been applied by municipalities across the country including, Barrie (ON), Hamilton (ON), and Calgary (AB).

BARC Milestone Framework outlined below:



OUR PLAN

Vision and Objectives

As the Steering Committee worked to articulate the City's desired future state related to climate change adaptation, the following vision and objectives were developed:

Vision:

Owen Sound will have a sustainable, practical and innovative approach in building resiliency to the changing climate

Objectives:

- Integrate a climate change adaptation lens into the City's strategies, plans, and policies
- Strengthen resiliency in City infrastructure and services
- Create conditions to minimize health and safety risks to outdoor workers and community members.
- Strengthen the natural infrastructure including the urban forest
- Increase awareness and knowledge of corporate climate change adaptation

RESEARCH

Climate Change Projections for the City of Owen Sound

A review of the historic and projected weather information records was undertaken to provide scientific guidance for the City's CCCAP and to enable the plan to be developed based on the best known projections of today rather, than broad hypotheses of what could happen.

Historic weather information records for the City date from 1879 until 2006. The information provides approximately 127 years of data with some gaps during the First and Second World War. These records provided a solid understanding of the City's historic climate, as well as how it has changed over time until 2006.

Different projections were then applied to increase understanding of how the climate will continue to change over time within the City. One of the well known changes being experienced are changes in temperature, however other impacts include changes in seasonal rain fall, yearly snow fall, and extreme rainfall. All of these are projected to change throughout Canada; and the City of Owen Sound is no exception.

Based on the data, the climate of the City is changing and the City will need to adapt to ensure resiliency of services. The City's CCCAP will help inform future City services and infrastructure (stormwater network, roads, and buildings) and increase the City's capacity to not only cope with the impacts, but to thrive in face of a changing climate.

Detailed historical and projected climate information can be found in Appendix 1 – *Detailed Historical and Projected Climate Information*.

TEMPERATURE

Average annual temperature increases from 1879-2006:

Spring + 1.2 C

Summer + 0.5 C

Fall + 1.8 C

Winter + 2 C

PROJECTIONS

The number of hot days (+30 C or higher) as well as hot nights are projected to increase. Very cold days (-30 C or colder) are projected to decrease. Shoulder seasons (Spring & Fall) are projected to be longer; meaning summer and winter seasons are projected to become shorter than current seasons.

	By 2050	By 2080
RCP 4.5:	+ 1 C	+ 2.9 C
RCP 8.5:	+ 2.1 C	+ 4.2 C

Representative Concentration Pathways (RCPs) climate scenarios. These are scenarios that use amounts of greenhouse gases (GHGs) in the models to simulate a future based on the amount of GHGs produced in those simulated futures.

RCP 4.5 – global reduction and stabilization of GHGs by the end of the century – this number is optimistically low in conjunction with current GHG emissions and lack of reduction plans.

RCP 8.5 – high GHGs emissions, equivalent to what the world emits today.

PRECIPITATION

Average annual increase in total precipitation (rain, snow, sleet, hail, etc.) from 1879-2006:

Spring + 62 mm

Summer + 25 mm

Fall - 37 mm

Winter + 28 mm

The historical data in this report was collected beginning in 1879 until 2006.

PROJECTIONS

On average the City receives a total of 3 meters of snow during the winter season. That amount has not changed significantly since 1879, but the number of days that snowfall occurs has decreased. Meaning on the days it snows, the City receives more on those days.

	By 2050	By 2080
RCP 4.5:	+ 49 mm	+ 85 mm
RCP 8.5:	+ 42 mm	+ 86 mm

Climatic Threats & Impact Identification

The climatic threats which have been identified based on the projected climate changes could have the potential to impact the City's services and infrastructure significantly. From a people centric perspective, extreme heat, cold and weather events could be disruptive, and could limit access to City services impacting people's physical and mental health as well as creating health and safety concerns for staff. From a built environment perspective, more freezing rain events, extreme weather, and volatile temperatures could lead to increased maintenance and replacement costs.
A total of 10 climatic threats were identified.

- **Milder winter temperatures**
- **Increased intensity, duration and frequency of rainfall**
- **Increased extreme weather events**
- **Increased temperature variability in shoulder seasons**
- **Increased annual temperatures**
- **Increased frequency / severity of drought**
- **Increased extreme changes in winter temperatures**
- **Increased summer temperatures**
- **Extreme cold temperatures**
- **Increased frequency of freezing rain**

The priority impacts were assessed for vulnerability to understand how sensitive are the current infrastructure, assets and services and their current capacity to adapt.

🟢 Green dot - Low Vulnerability (not very or not at all vulnerable to harm from the impact)

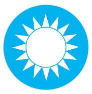
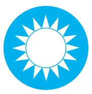
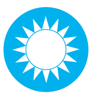
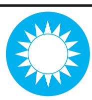
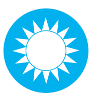
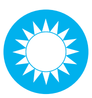
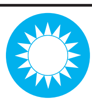
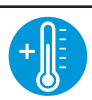
🟠 Orange dot - Medium Vulnerability (somewhat vulnerable to harm from the impact)

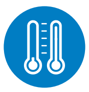
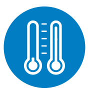
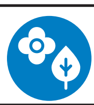
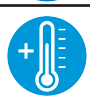
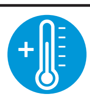
🔴 Red dot - High Vulnerability (very vulnerable to harm from the impact)

Impact Identification:

Climatic Threat	Impact	Vulnerability Assessment
	Cancellations of City delivered outdoor programming and outdoor rental space (eg. Public events, Bayshore Gazebo rentals, Harrison Park Picnic shelter rentals)	🟢
	Delays in maintenance and construction projects, resulting in issues with scheduling and completing projects on time	🟠
	Extreme seasonal conditions (eg February melt) resulting in disruption to outdoor events and programming and winter-based recreation, city transit and school / bus cancellations	🟠
	Increased damage and compaction of grass surfaces, leading to increased sports field closures	🟢
	Increased damage to City owned assets and infrastructure, leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes and decreased availability of contractors	🟠
	Warmer temperatures leading to increased stress on City vehicles and equipment and increased maintenance requirements	🟠
	Increased days with closures / cancellations eg. Roads, city transit, programming, schools	🟢
	Increased dry periods, leading to increased irrigation requirements and increased overall water demand or rationing of water	🟢
	Increased dust in public spaces, leading to greater maintenance requirements (eg street sweeping, ball diamond maintenance)	🟢
	Increased erosion, resulting in damage to natural infrastructure, built infrastructure, and potential slope failure	🟠
	Increased freeze-thaw cycles causing damage to, and decreased service life of City-owned buildings and infrastructure	🟠
	Increased freeze-thaw cycles causing damage to, and hazardous conditions on, transportation infrastructure, leading to increased liability and insurance claims	🟠
	Increased lake effect snow leading to increased winter control requirements	🟠

Impact Identification:

Climatic Threat	Impact	Vulnerability Assessment
	Increased frequency and duration of hot days (> 30 °C) leading to decreased survivability of trees, increased maintenance requirements, and increased need for shade trees and structures	
	Increased frequency and duration of hot days (> 30 °C) leading to increased energy usage to cool City owned facilities	
	Increased frequency and duration of hot days (> 30 °C) leading to increased health and safety risks to the public, specifically vulnerable populations (eg elderly, socially isolated)	
	Increased frequency and duration of hot days (> 30 °C) leading to increased tourism / demand for aquatic facilities, splash parks and programming (capacity)	
	Increased frequency and duration of hot days (> 30 °C) resulting in decreased use of outdoor recreation areas and facilities and increased demand for indoor facilities	
	Increased frequency and duration of hot days (> 30 °C) resulting in increased damage to roads, culverts, sidewalks, parking lots and outdoor recreation facilities	
	Increased frozen water services and water main breaks	
	Increased hazardous conditions on roads, parking lots, sidewalks and trails, and within urban forests resulting in increased demand on winter operations and increased safety risks to outdoor workers	
	Increased hazardous conditions on roads, parking lots, sidewalks and trails, resulting in increased public safety issues and insurance claims	
	Increased heat and poor air quality alerts, leading to health and safety risks to outdoor workers and increased project / task duration	
	Warmer temperatures, leading to increased incidences of vector-borne illness due to longer exposure periods	
	Increased inflow into sanitary sewers, causing sewer backups and flooding, bypass events, wwtp upsets	
	Increased insect/pest survival rates, leading to increased tree and vegetation maintenance and asset loss	

Climatic Threat	Impact	Vulnerability Assessment
	Increased mechanical failure of operational and maintenance equipment, leading to increased stress on operations and decreased service level	
	Increased rain events while ground is frozen or has significant snow depths, resulting in overland flooding	
	Increased salt use, resulting in accelerated deterioration of City fleet and infrastructure and increased maintenance requirements	
	Increased stress on trees and natural areas, resulting in higher disease susceptibility and decreased rates of establishments for new plants	
	Increased tree branches and debris blocking catch basins and culverts, leading to increased flooding potential and maintenance requirements	
	Increased water levels in great lakes accelerating shoreline erosion, reducing natural infrastructure and increasing maintenance requirements	
	Inundation of parks and sportsfield, leading to temporary loss of facilities, increased maintenance requirements and need to reconstruct	
	Longer growing season and winter season, leading to increased issues optimizing City Fleet (eg snow plow change over)	
	Longer growing season resulting in increased spread of invasive species (eg phragmites)	
	Longer shoulder seasons, leading to extended maintenance seasons and issues hiring students as seasonal staff	
	Overburdening of storm sewers and storm water management facilities, resulting in overland flooding	
	Reduced use of active transportation and increased demand on roadways	
	Riverine or overland flooding could result in public emergencies and / or evacuations	
	Riverine or overland flooding, resulting in disruption or damage to City owned assets (roads, underground infrastructure, natural infrastructure)	

Impact Identification:

As part of the impact identification, impacts were identified for infrastructure which the City is not responsible for, but which could impact City services provided. These have been captured below:

Climatic Threat	Impact	Vulnerability Assessment
	Increased damage to power lines, resulting in more outages and service disruptions	
	Increased electrical surges and power outages, resulting in service disruptions	
	Increased electricity demand, resulting in more power outages and service disruptions	
	Increased impact to local agriculture leading to decreased local food sources	
	Increased incidences of power outages, resulting in increased demand on fire and police services resources	
	Increased incidences of power outages, resulting in public health and safety risks associated with heating and cooling	

Vulnerability and risk assessments assist in determining which impacts from climate change are most critical to address.

Impacts that were assigned a Medium or High vulnerability ranking were assessed for risk, taking into consideration the likelihood of occurrence and consequence if it did occur.

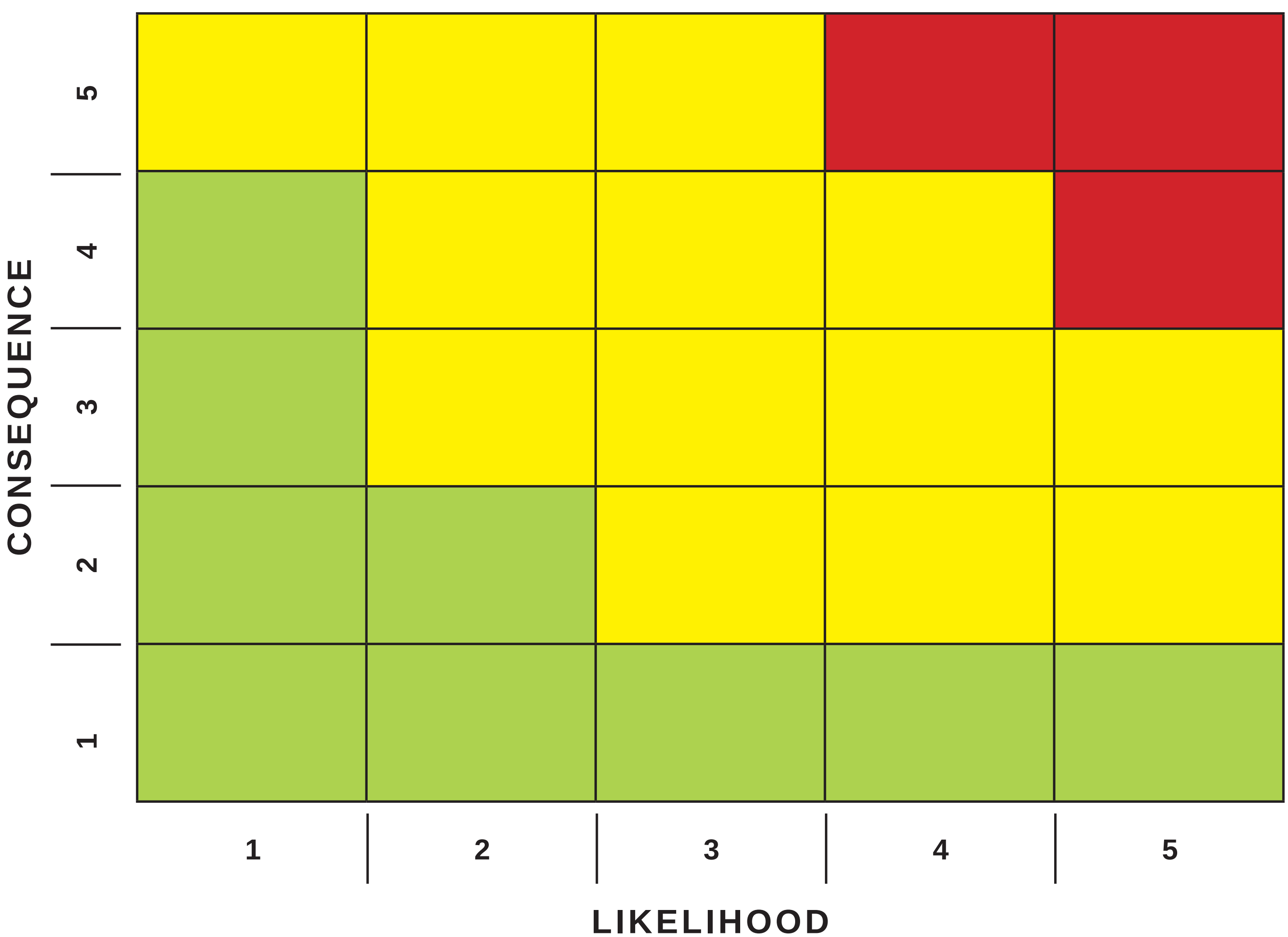
Consequence refers to the known or estimated outcomes of a particular impact (with a lens of environmental, economic and social). Within social, economic, and environmental, the consequence criteria was defined and a rating from 1 to 5 were assigned to each criteria, where 1 was ‘negligible’ and 5 was ‘catastrophic’.

Likelihood is based on how likely it is that an impact will occur and considers both the probability of the threat and the probability of the associated outcomes occurring.

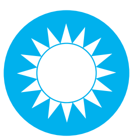
Risk Probability

Almost Certain (5)	May occur several times per year	More likely than not – probability greater than 50%
Likely (4)	May occur once per year	As likely as not – 50/50 chance
Possible (3)	May occur once in 5 years	Less likely – probability less than 50%, but still quite high
Unlikely (2)	May occur once in 10+ years	Unlikely, but not negligible – probability low (but higher than 0)
Rare (1)	May occur once in 50+ years	Negligible – probability very small

An overall risk score was calculated using the Likelihood and Consequence criteria.



The purpose of the risk assessment was to prioritize the impacts to determine which impacts should be addressed initially (those that pose the greatest risk). Based on the results of the vulnerability assessment, the Steering Committee identified the top 20 impacts and assessed their risk.

Climatic Threat	Impact	Actions
 **Risk Level:** **High**	Increased damage to City owned assets and infrastructure, leading to increased maintenance and repairs, increased health and safety risks to outdoor workers, increased call volumes and decreased availability of contractors	• Incorporate impact in risk assessment for non-core assets within Asset Management Plan by July 2023 • Review and update health and safety policies for staff by December 2022 • Develop a business case for business continuity planning integrated with emergency planning as part of 2022 budget process • Develop a business case for customer service strategy as part of 2022 budget process
 **Risk Level:** **High**	Increased frequency and duration of hot days (> 30 degrees Celsius) leading to increased health and safety risks to the public, specifically vulnerable populations (eg elderly, socially isolated)	• Review and update procedures related to emergency shelters/ cooling centers to include climate change impact by December 2022 • Utilize the City's tree planting program to create passive shade spaces • Identify partnerships to develop or enhance a check-in program for vulnerable populations by December 2021
 Risk Level: **High**	Increased hazardous conditions on roads, parking lots, sidewalks and trails, and within urban forests resulting in increased demand on winter operations and increased safety risks to outdoor workers	• Review and update health and safety policies for staff by December 2022 • Incorporate impact in risk assessment for non-core assets within Asset Management Plan by July 2024 • Utilize the winter control/salt management program to address hazardous conditions as required
 Risk Level: **High**	Increased hazardous conditions on roads, parking lots, sidewalks and trails, resulting in increased public safety issues and insurance claims	• Implement communications strategy to increase clarity to public about media notices related to storm events and impacts to reductions in service level during event by December 2021 • Develop a business case for the 2022 budget process to undertake a trails master plan as part of a broader active transportation master plan

Risk Level & Impacts:

Climatic Threat	Impact	Actions
Risk Level: **High**	Increased inflow into sanitary sewers, causing sewer backups and flooding, bypass events, wastewater treatment plant upsets	• Increase messaging to the public regarding the back flow prevention program and spend 95% of allocated budget each fiscal year by December 2021 • Utilize 95% of allocated funding each fiscal year to complete cured in place piping to reduce infiltration (ground water) in sanitary sewer system • Utilize 95% of allocated funding each fiscal year to implement storm water separation program to reduce inflow (surface water) in sanitary sewer system • Document optimization of operation of secondary plant during high flow events by December 2021 • Complete build of East Bayshore sewage pumping station in 2021 where historical bypass events have occurred • Identify sewage pumping stations where bypass events have occurred and include in long term financial plan by December 2022
Risk Level: **Moderate**	Increased heat and poor air quality alerts, leading to health and safety risks to outdoor workers and increased project / task duration	• Review and update health and safety policies for staff by December 2022
Risk Level: **Moderate**	Extreme seasonal conditions (eg February melt) resulting in disruption to outdoor events and programming and winter-based recreation, city transit and school / bus cancellations	• Implement communications strategy to increase clarity to public about media notices related to storm events and impacts to reductions in service level during event by December 2021
Risk Level: **Moderate**	Increased rain events while ground is frozen or has significant snow depths, resulting in overland flooding	• Incorporate impact in risk assessment for non-core assets within Asset Management Plan by July 2024 • Develop business case as part of the 2022 budget process to undertake a storm water master plan
Risk Level: **Moderate**	Delays in maintenance and construction projects, resulting in issues with scheduling and completing projects on time	• Update purchasing bylaw to implement strategic procurement to enable integrated project delivery and a formal supplier performance program by December 2022 • Develop a business case as part of the 2022 budget process for business continuity planning integrated with emergency planning

Risk Level & Impacts:

Climatic Threat	Impact	Actions
Risk Level: **Moderate**	Increased electrical surges and power outages, resulting in service disruptions	• Develop a business case as part of the 2022 budget process for business continuity planning integrated with emergency planning
Risk Level: **Moderate**	Increased erosion, resulting in damage to natural infrastructure, built infrastructure, and potential slope failure	• Develop a business case as part of the 2022 budget process to undertake a city wide slope stability review
Risk Level: **Moderate**	Increased freeze-thaw cycles causing damage to, and decreased service life of City-owned buildings and infrastructure	• Incorporate impact in risk assessment for non-core assets within Asset Management Plan by July 2024
Risk Level: **Moderate**	Increased freeze-thaw cycles causing damage to, and hazardous conditions on, transportation infrastructure, leading to increased liability and insurance claims	• Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022
Risk Level: **Moderate**	Increased frozen water services and water main breaks	• Review and update water main (degree tracker program) / run water program by December 2021 • Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022
Risk Level: **Moderate**	Increased lake effect snow leading to increased winter control requirements	• Implement communications strategy to increase clarity to public about media notices related to storm events and impacts to reductions in service level during event by December 2021
Risk Level: **Moderate**	Increased salt use, resulting in accelerated deterioration of City fleet and infrastructure and increased maintenance requirements	• Incorporate impact in risk assessment for non-core assets within Asset Management Plan by July 2024

Risk Level & Impacts:

Climatic Threat	Impact	Actions
Risk Level: Low	Riverine or overland flooding could result in public emergencies and / or evacuations	• Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022 • Develop business case as part of the 2022 budget process to undertake a storm water master plan
Risk Level: Low	Riverine or overland flooding, resulting in disruption or damage to City owned assets (roads, underground infrastructure, natural infrastructure)	• Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022 • Develop business case as part of the 2022 budget process to undertake a storm water master plan
Risk Level: Low	Overburdening of storm sewers and storm water management facilities, resulting in overland flooding	• Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022 • Develop business case as part of the 2022 budget process to undertake a storm water master plan
Risk Level: Low	Inundation of parks and sportsfield, leading to temporary loss of facilities, increased maintenance requirements and need to reconstruct	• Incorporate impact in risk assessment for core assets within Asset Management Plan by July 2022 • Develop business case as part of the 2022 budget process to undertake a storm water master plan

RECOMMENDATIONS

In addition to the actions identified to address specific impacts, additional recommendations have been identified in order to embed a culture of sustainability within the City and to help us achieve the goal statement within the City's Strategic Plan.

We will continue to ensure environmental integrity is maintained in Owen Sound and the surrounding area by protecting our environment and natural assets. We will protect, preserve, maintain and enhance Owen Sound's scenic and natural heritage, and we will do so by using resources wisely, cooperating with adjoining communities and agencies, and taking responsibility for City actions.

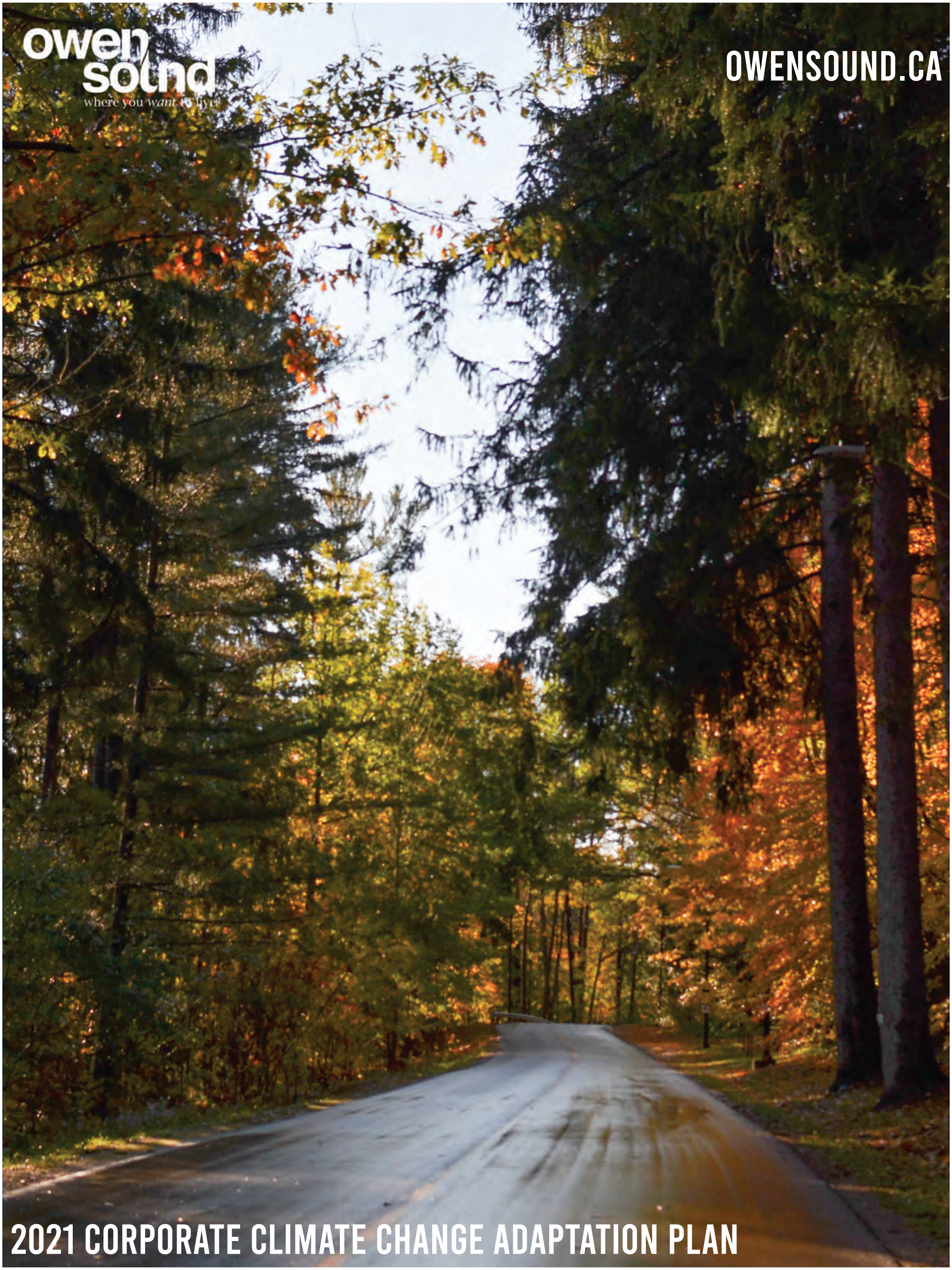
1. Implement a comprehensive business planning process as part of the 2022 budget to ensure financial and human resources are available to implement identified actions successfully.

2. Develop a climate change adaptation lens tool to utilize in a review of all administrative policies.

3. Utilize the Official Plan update, and other development-related policy initiatives, to create a framework for protecting and enhancing the City's natural infrastructure.

4. Utilize the Refreshed Strategic Plan to clearly establish key results measuring progress towards the environment and identify regular reporting intervals to Council on progress.

Through collaboration across all city divisions, staff will be able to develop achievable work plans to implement the identified actions and increase our resiliency to adapt city infrastructure and services to the changing climate.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2021 CORPORATE CLIMATE CHANGE ADAPTATION PLAN

CORPORATE CLIMATE CHANGE ADAPTATION PLAN

APPENDIX 1 –DETAILED HISTORICAL AND PROJECTED CLIMATE **INFORMATION**

Contents

1.0 Introduction

With the rising concern of climate change throughout the world, Canada, and Ontario, the City of Owen Sound (the City) has begun to consider the effects that it may have on its services. Through its consideration, the City has determined that the first step in ensuring resiliency in light of a changing climate is a Corporate Climate Change Adaptation Plan (CCCAP).

To achieve the creation and implementation of a CCCAP, the City applied for a grant from the Federation of Canadian Municipalities' (FCM) Municipalities for Climate Innovation Program. By completing this project, the City will have a CCCAP that evaluates and prioritizes risks to infrastructure and services due to changes in the local climate and identifies measures that can be implemented to minimize the impacts of these effects.

The following document creates a foundation for the work done to understand both the historic and projected change in climate for the City. This will provide scientific guidance for the City's CCCAP. This will allow the plan to be developed based on the best known projections of today rather, than broad hypotheses of what could happen.

2.0 Background

Throughout Canada, all tiers of government are feeling impacts from climate change on their areas of governance. Some of these indicators include changes in: rain fall, snow fall, and average seasonal temperature. The following document presents both historic and projected values for these factors. This document will provide the basis for the City to understand how climate change could affect the City.

3.0 Climate vs. Weather

There can sometimes be confusion when it comes to climate vs weather. Weather is the ever changing, short period situation of an area. Weather changes from day to day, and from season to season. Climate is the overall average conditions for a given geographic area. This average normally changes from season to season though not day to day. Therefore, you could be in a hot climate and have a day where temperatures are generally considered cool for that area, this cool day will not, however, change the overall climate of the area, and it is an outlier compared to the average. When it comes to climate change this means that the average climate is changing, not general weather. This means you could still have a cold day in the summer, though most days on average are warmer than they have been historically.

4.0 Historic Climate Information

The first historic weather information records date back to December of the year 1879 collected by the City. This information stretches to the year of 1961, when the weather station was moved and then re-established by the Ministry of Environment in the year of 1965, the station was eventually retried in the year of 2006.

The information provided by these two stations is around 127 years of data with some gaps during the Great War, and the Second World War. This provides a good understanding of the City's historic climate, as well as how it has changed over time until the year of 2006.

4.1 Temperature

The following section shows the historic temperatures based on a seasonal means. The reason that seasonal mean was chosen due to each season having different temperature variations, the four seasons provide a better representation of the climate over these time periods. The temperatures are presented as three types of mean temperatures, mean temperature, mean maximum temperature, and mean minimum temperature. This information is broken into three sections due to the movement of the weather station within the City, this is to provide both stand alone and combine information for the reader to make their own thoughts and theorises of the climate historic climate and to also present a continuous data set.

4.1.1 Temperatures 1879 to 1962

The following information presented is the seasonal means for the years 1879 to 1962 to provide a view of the City's climate over time for these periods.

Spring Temperatures 1879 to 1962

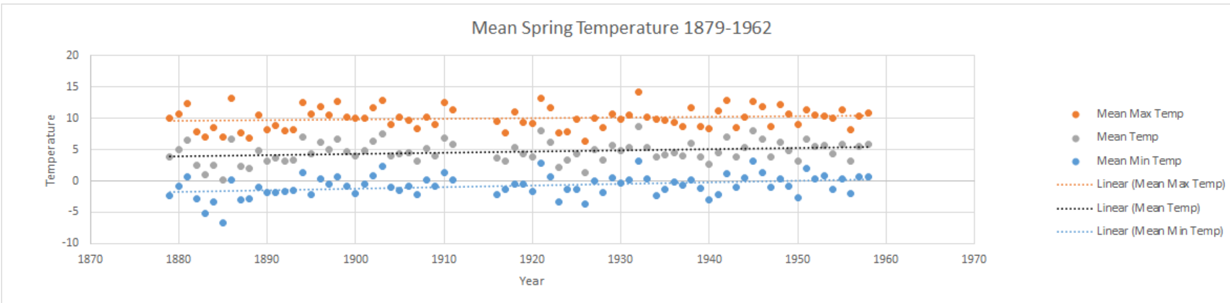

Figure 1: This figure shows the mean spring temperatures in degrees calculus for the time periods 1879 to 1962. All information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Spring 1879 - 1962			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	9.6°C	3.9°C	-1.7°C
1962	10.5°C	5.4°C	0.4°C
Difference	0.9°C	1.5°C	2.1°C

Table 1: This table shows the mean spring temperatures based on linear calculations for the years 1879 and 1962. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Summer Temperatures 1879 to 1962

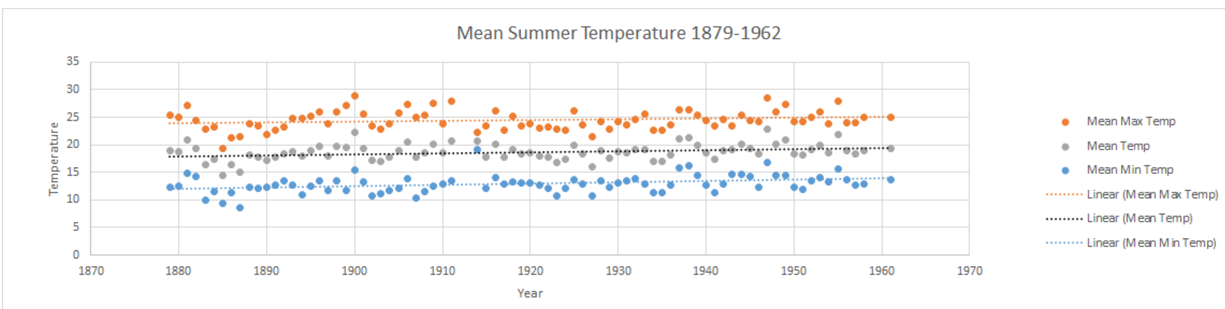

Figure 2: This figure shows the mean summer temperatures in degrees calculus for the time periods 1879 to 1962 all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Summer 1879 - 1962			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	24.0°C	18.0°C	12.0°C
1962	25.1°C	19.6°C	14.0°C
Difference	1.1°C	1.6°C	2.0°C

Table 2: This table shows the mean summer temperatures based on linear calculations for the years 1879 and 1962. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Fall Temperatures 1879 to 1962

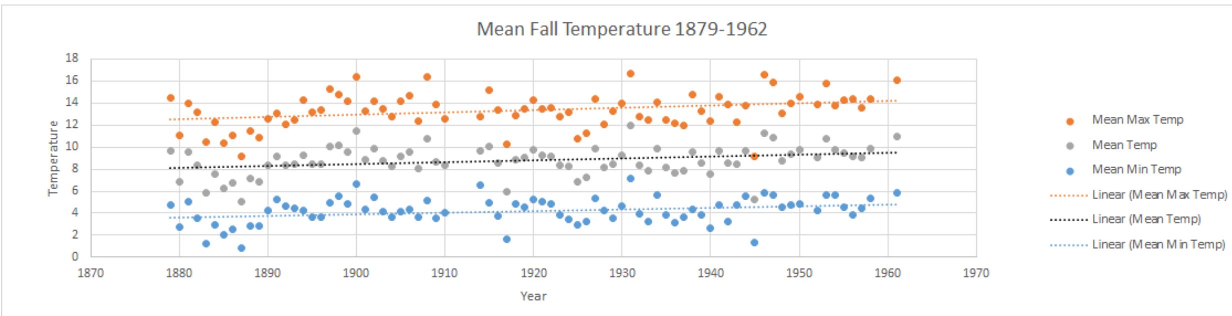

Figure 3: This figure shows the mean fall temperatures in degrees calculus for the time periods 1879 to 1962, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Fall 1879-1962			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	12.4°C	8.0°C	3.6°C
1962	14.2°C	9.5°C	4.8°C
Difference	1.7°C	1.5°C	1.2°C

Table 3: This table shows the mean fall temperatures based on linear calculations for the years 1879 and 1962. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Winter Temperatures 1879 to 1962

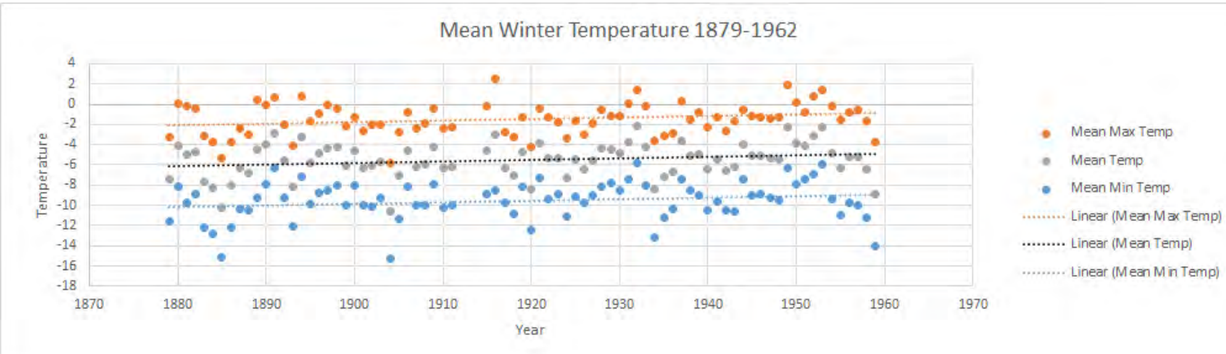

Figure 4: This figure shows the mean winter temperatures in degrees calculus for the time periods 1879 to 1962, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Winter 1879 - 1962			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	-2.0°C	-6.1°C	-10.2°C
1962	-0.7°C	-4.9°C	-9.0°C
Difference	1.2°C	1.2°C	1.3°C

Table 4: This table shows the mean fall temperatures based on linear calculations for the years 1879 and 1962. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

4.1.2 Temperatures 1965 to 2006

The information presented below is the seasonal means for the years 1965 to 2006 to provide a view of the City's climate over time for these periods.

Spring Temperatures 1965 to 2006

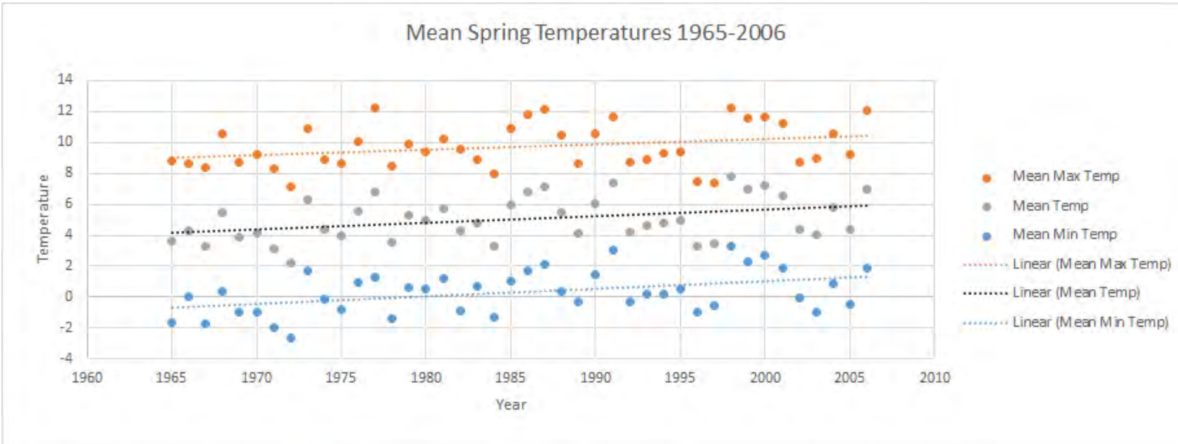

Figure 5: This figure shows the mean spring temperatures in degrees calculus for the time periods 1965 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Spring 1965 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1965	9.1°C	4.1°C	-0.8°C
2006	10.5°C	5.9°C	1.3°C
Difference	1.4°C	1.7°C	2.1°C

Table 5: This table shows the mean summer temperatures based on linear calculations for the years 1965 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Summer Temperatures 1965 to 2006

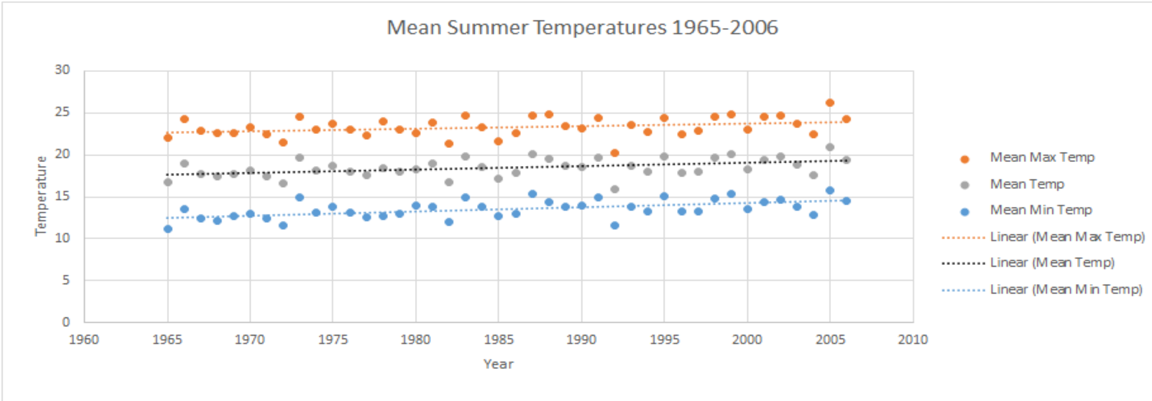

Figure 6: This figure shows the mean summer temperatures in degrees calculus for the time periods 1965 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Summer 1965 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1965	22.6°C	17.6°C	12.5°C
2006	23.9°C	19.3°C	14.5°C
Difference	1.3°C	1.6°C	2.0°C

Table 6: This table shows the mean summer temperatures based on linear calculations for the years 1965 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Fall 1965 Temperatures to 2006

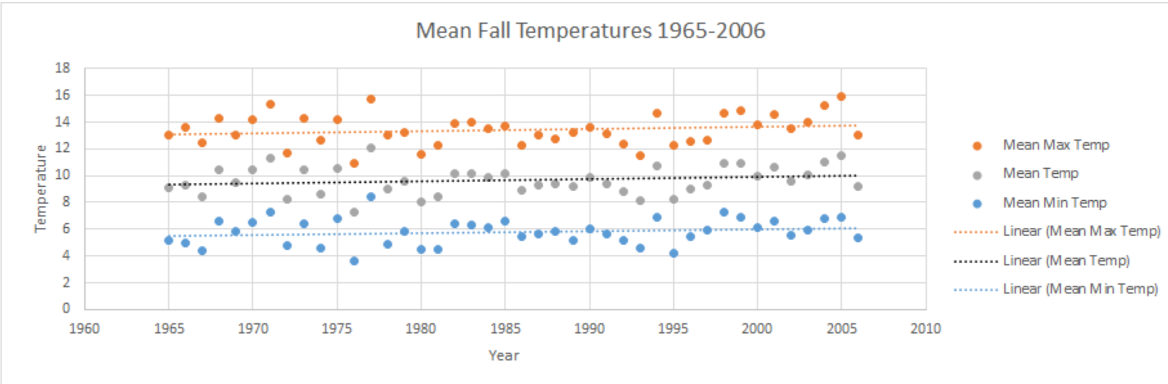

Figure 7: This figure shows the mean fall temperatures in degrees calculus for the time periods 1965 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Fall 1965 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1965	13.0°C	9.3°C	5.6°C
2006	13.7°C	9.9°C	6.2°C
Difference	0.7°C	0.6°C	0.6°C

Table 6: This table shows the mean summer temperatures based on linear calculations for the years 1965 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Winter Temperatures 1965 to 2006

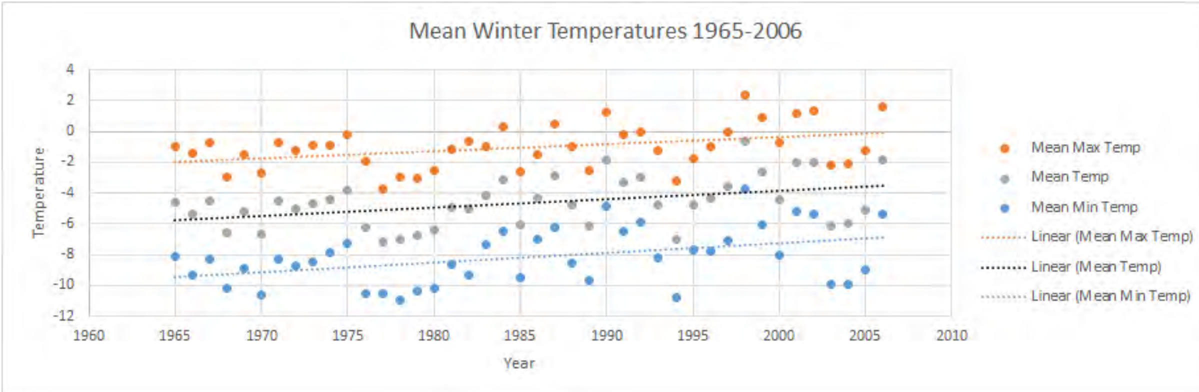

Figure 8: This figure shows the mean winter temperatures in degrees calculus for the time periods 1965 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Winter 1965 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1965	-1.9°C	-5.8°C	-9.5°C
2006	-0.1°C	-3.5°C	-6.9°C
Difference	1.8°C	2.3°C	2.6°C

Table 8: This table shows the mean winter temperatures based on linear calculations for the years 1965 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

4.1.3 Temperatures 1879 to 2006

The information presented below is the seasonal means for the years 1879 to 2006 presented as a combined data set to provide a view of The City of Owen Sound's climate over the full 127 years.

Spring Temperatures 1879 to 2006

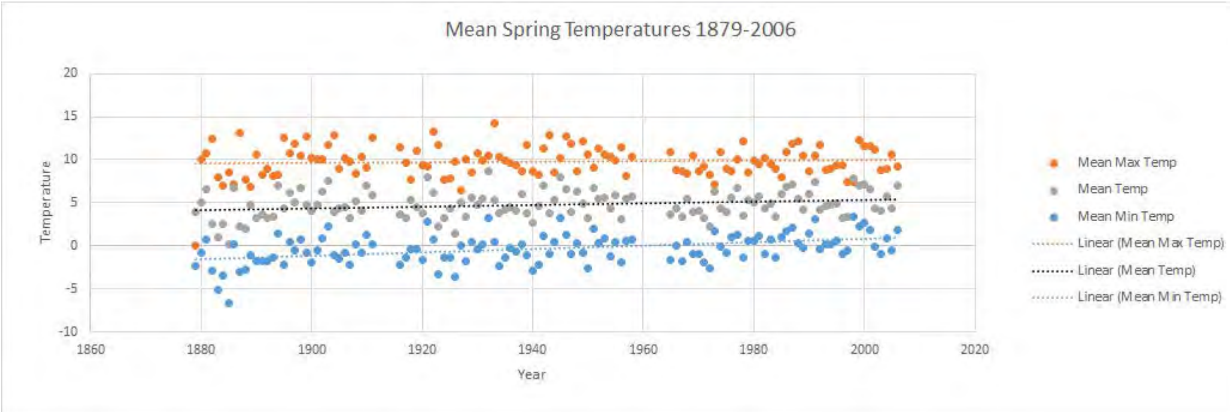

Figure 9: This figure shows the mean spring temperatures in degrees calculus for the time periods 1879 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Spring 1879 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	9.7°C	4.1°C	-1.7°C
2006	10.2°C	5.3°C	0.8°C
Difference	0.4°C	1.2°C	2.5°C

Table 9: This table shows the mean spring temperatures based on linear calculations for the years 1879 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Summer Temperatures 1879 to 2006

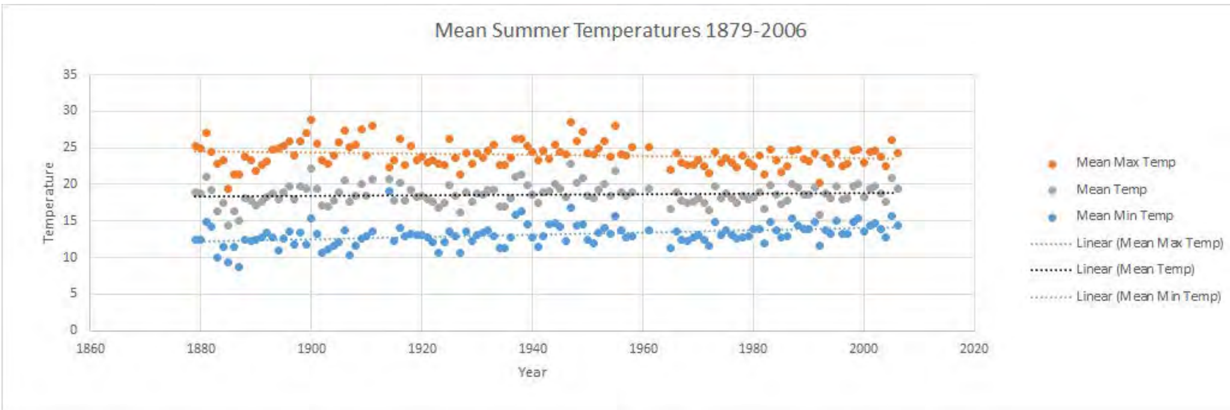

Figure 10: This figure shows the mean summer temperatures in degrees calculus for the time periods 1879 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Summer 1879 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	24.5°C	18.3°C	12.2°C
2006	23.5°C	18.8°C	14.1°C
Difference	-1.0°C	0.5°C	1.9°C

Table 10: This table shows the mean summer temperatures based on linear calculations for the years 1879 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Fall Temperatures 1879 to 2006

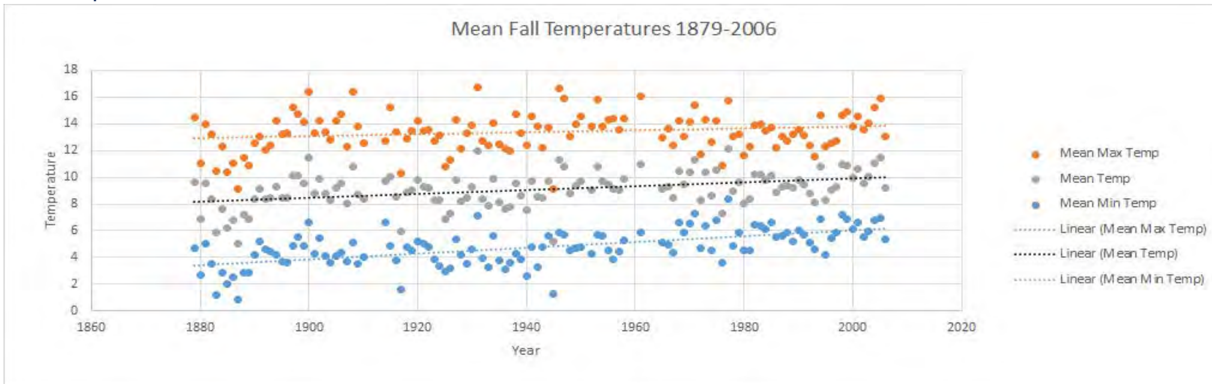

Figure 11: This figure shows the mean fall temperatures in degrees calculus for the time periods 1879 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Fall 1879 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	12.8°C	8.1°C	3.4°C
2006	13.7°C	10.0°C	6.1°C
Difference	0.9°C	1.8°C	2.7°C

Table 10: This table shows the mean fall temperatures based on linear calculations for the years 1879 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Winter Temperatures 1879 to 2006

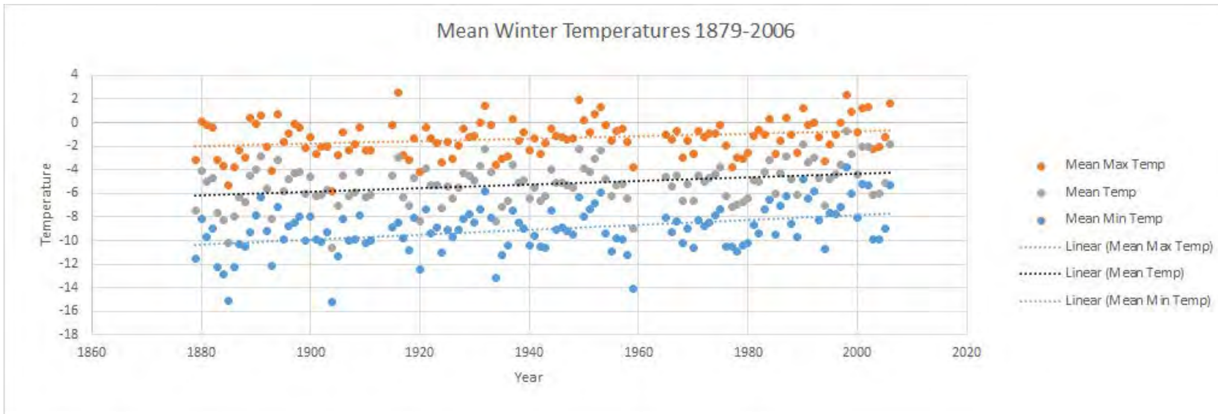

Figure 12: This figure shows the mean fall temperatures in degrees calculus for the time periods 1879 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Winter 1879 - 2006			
	Max Temperature	**Mean Temperature**	**Min Temperature**
1879	-1.9°C	-6.2°C	-10.3°C
2006	-0.6°C	-4.2°C	-7.7°C
Difference	1.3°C	2.0°C	2.6°C

Table 10: This table shows the mean fall temperatures based on linear calculations for the years 1879 to 2006. This provides an idea of how temperatures have changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

4.2 Precipitation

Precipitation is any form of water falling from the sky to the ground. This could be rain, snow, sleet, hail, etc. Precipitation is an important factor of climate, too little rain could have cause drought, and too much could cause flooding. This could be for snow as well, too much could disrupt transit or daily life, too little could disrupt animal habitat, winter tourism, and spring melts. Understanding how historic precipitation information and how it has changed over time could provide the City with an idea of what the future may have in store.

4.2.1 Rainfall

Rainfall is strictly limited to rain events. Observing the trends of rain fall over time can provide insight into historical changes and the trend associated with that posable change. Charts can be found of the rainfall information in Appendix (B)

Rainfall 1879 to 1962

Rainfall 1879 to 1962			
Season	**1879**	**1962**	**Change**
Spring	130 mm	127 mm	-3 mm
Summer	222 mm	187 mm	-35 mm
Fall	216 mm	192 mm	-24 mm
Winter	67 mm	42 mm	-25 mm

Table 11: This table shows the mean rainfall based on linier calculations for the years 1879 to 1962. This provides an idea of how rainfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Rainfall 1965 to 2006

Rainfall 1965 to 2006			
Season	**1965**	**2006**	**Change**
Spring	132 mm	207 mm	75 mm
Summer	270 mm	208 mm	-62 mm
Fall	241 mm	298 mm	57 mm
Winter	46 mm	105 mm	59 mm

Table 12: This table shows the mean rainfall based on linier calculations for the years 1965 to 2006. This provides an idea of how rainfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Rainfall 1879 to 2006

Rainfall 1879 to 2006			
Season	**1879**	**2006**	**Change**
Spring	111 mm	174 mm	62 mm
Summer	205 mm	230 mm	25 mm
Fall	216 mm	180 mm	-37 mm
Winter	49 mm	77 mm	28 mm

Table 13: This table shows the mean rainfall based on linier calculations for the years 1879 to 2006. This provides an idea of how rainfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

4.2.2 Snowfall

Snowfall is a well known factor of life in Canada. There is a significant cost to the City, when it comes to winter maintenance. Snowfall is a major factor in Canadian life it can slow down or stop transit, works and daily life with significant events. On average the City receives 3 metres (10 feet) of snow during the winter season. The following section shows the snow fall over the last 127 years for the weather stations as well as a combine data set.

Snowfall 1879 to 1962

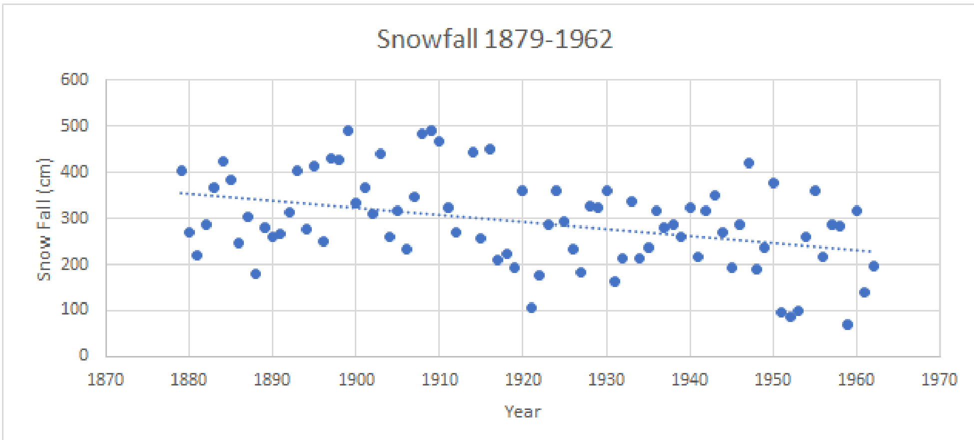

Figure 13: This figure shows the mean snowfall in degrees centimetres for the time periods 1879 to 1962, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Snowfall 1879 to 1962			
Year	**1879**	**1962**	**Difference**
Snowfall	356.7991 cm	228.3898 cm	-128.4093 cm

Table 14: This table shows mean snowfall based on linier calculations for the years 1879 to 1962. This provides an idea of how snowfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Snowfall 1965 to 2006

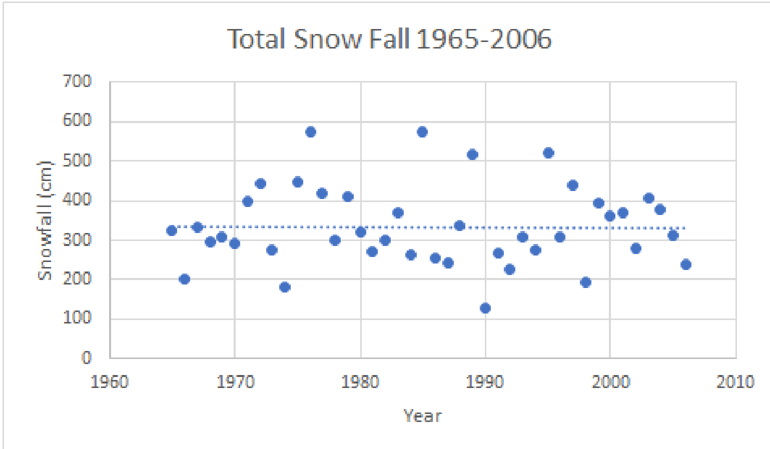

Figure 14: This figure shows the mean snowfall in degrees centimetres for the time periods 1879 to 1962, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Snowfall 1965-2006			
Year	**1965**	**2006**	**Difference**
Snowfall	335.69 cm	335.13 cm	-0.56 cm

Table 15: This table shows mean snowfall based on linier calculations for the years 1965 to 2006. This provides an idea of how snowfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

Snowfall 1978 to 2006

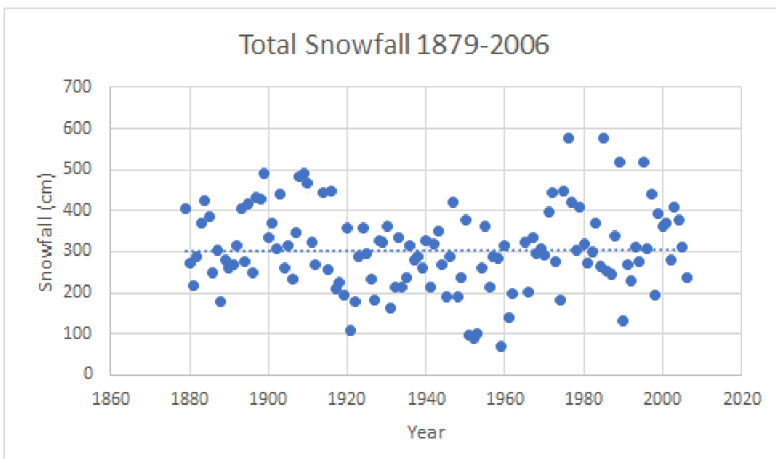

Figure 15: This figure shows the mean snowfall in degrees centimetres for the time periods 1879 to 2006, all information in this figure is based on historic data from the Ministry of Environment and Climate Change Canada

Snowfall 1879-2006			
Year	**1879**	**2006**	**Difference**
Snowfall	306.2968 cm	307.4652 cm	1.1684 cm

Table 16: This table shows mean snowfall based on linier calculations for the years 1879 to 2006. This provides an idea of how snowfall has changed over this time period through a liner method. All information in this table is based on historic data from the Ministry of Environment and Climate Change Canada

4.2.3 Extreme Rainfall

Rainfall by itself is not overly concerning, it is when there is a lot of rain that it becomes a problem for urban and non-urban systems. Extreme rainfall can cause both urban and riverine flooding, as well as other problems like erosion and destabilization of slopes. Within the City, urban flooding is one of the greater concerns when it some to extreme rainfall. Urban flooding is when the minor system (storm water pipes under the ground) and the major system (streets) are overwhelmed with water and areas that these systems are meant to protect, become flooded. This can also happen with rivers, when an extreme rainfall event occurs a river's banks can swell causing flooding to the surrounding area which many cause damages to buildings, roads and other infrastructure.

High intensity events that could be anywhere from 5 minutes to 24 hours. These events are classified based on the probability of the event to happen; this is called a return period. The most common referenced return periods today are the, 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events, these are design storms. These storms vary in their intensity and some are less intense than others, the 2-year being the least intense of the six storms and the 100- year being the most intense. Each of these events have a probability of happening, for example a 2-year storm means that the chance of that storm happening in once in two years or 0.5% chance of it happening in a year, this does not mean it happens every two years or that it could not happen more than once in a two-year period this is only the chance of it happening in any given year.

IFD Curves (Intensity Duration Frequency Curve) are charts created to understand how storm are classified based on local data. Each storm can be calculated or classed based on an IDF curve. The design storms changes based on the local area's historic information. This means that the City's 2-year IDF curve would be different from the City of Toronto's 2-year IDF curve. These curves are used when designing storm water infrastructure or when mapping a floodplain. They are used in the hydrologic calculations for overland water flow that would occur during these events. This is then calibrated against flow information captured for the system to better understand how the water flows across land, and through pipe systems. Below is a summary of values calculated from the IDF Curve from the City's Site Development Engineering Standards (Appendix D).

Owen Sound IDF Rainfall depth (mm)									
Duration	**5 minutes**	**10 minutes**	**15 minutes**	**30 minutes**	**60 minutes**	**2 Hours**	**6 Hours**	**12 Hours**	**24 Hours**
2-yr	10.96	13.36	15.00	18.29	22.30	27.19	37.23	45.39	55.34
5-yr	14.66	17.75	19.85	24.03	29.10	35.24	47.72	57.78	69.96
10-yr	17.13	20.68	23.08	27.85	33.60	40.54	54.60	65.89	79.50
25-yr	20.29	24.40	27.18	32.68	39.30	47.26	63.30	76.11	91.52
50-yr	22.57	27.11	30.17	36.23	43.50	52.23	69.81	83.83	100.66
100-yr	24.88	29.83	33.17	39.78	47.70	57.20	76.28	91.47	109.68

Table 17: The table above shows the depth in millimeters that would fall during a given time duration for each design storm. The information in this chart was taken from Owen Sound Site Development Engineering Standards found in Appendix D

Owen Sound IFD Rainfall intensity (mm/hr)									
Duration	**5 minutes**	**10 minutes**	**15 minutes**	**30 minutes**	**60 minutes**	**2 Hours**	**6 Hours**	**12 Hours**	**24 Hours**
2-yr	131.47	80.15	60.00	36.58	22.30	13.59	6.20	3.78	2.31
5-yr	175.88	106.48	79.39	48.07	29.10	17.62	7.95	4.81	2.91
10-yr	205.62	124.05	92.31	55.69	33.60	20.27	9.10	5.49	3.31
25-yr	243.51	146.40	108.72	65.37	39.30	23.63	10.55	6.34	3.81
50-yr	270.87	162.63	120.67	72.45	43.50	26.12	11.64	6.99	4.19
100-yr	298.51	178.98	132.69	79.56	47.70	28.60	12.71	7.62	4.57

Table 18: The table above shows the rate that rain would fall in millimeters per hour during a given time duration for each design storm. The information in this chart was taken from Owen Sound Site Development Engineering Standards found in Appendix D

5.0 Climate Projections

The following section shows the projected changes that could be experienced by the City based on the best known data. This information is projected and is not a prediction of the exact future of the City's climate.

Different projections must be performed to have a better understanding of how the climate will change over time within the jurisdiction of the City. One of the most well known changes is temperature, though there are many more points of interest. These are as follows: temperature, seasonal rain fall, yearly snow fall, and extreme rainfall. All of these are projected to change throughout Canada; and the City is no exception. This can be seen in the historic information in the previous section.

5.1 Emission Scenarios

The following sections will reference Representative Concentration Pathways (RCPs) climate scenarios. These are scenarios that use amounts of greenhouse gases (GHGs) in the models to simulate a future based on the amount of GHGs produced in those simulated futures. RCP-8.5 is the high GHGs scenarios projecting that the world continues to emit large amounts of GHGs. RCP-4.5 assumes a large reduction in production of GHGs over time and a stabilization of GHGs consternation by the end of the century. RCP-2.6 is a very low GHG future scenarios. (Prairie Climate Centre 2019)

5.2 Temperature

One of the most well known changes, when people talk about climate change, is that it is going to get globally warmer. The following section shows the projected change for the City over the next 60 years.

RCP 4.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	**Period**	**Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Mean Temperature	**Annual**	6.8°C	7.2°C	8.7°C	10.2°C	8.0°C	9.7°C	11.5°C
Mean Temperature	**Spring**	4.8°C	4.0°C	6.5°C	9.0°C	4.9°C	7.4°C	9.9°C
Mean Temperature	**Summer**	18.1°C	17.9°C	19.8°C	21.3°C	18.7°C	20.9°C	23.0°C
Mean Temperature	**Fall**	9.1°C	8.8°C	10.9°C	13.0°C	9.9°C	11.8°C	14.0°C
Mean Temperature	**Winter**	-5.1°C	-6.2°C	-2.7°C	0.4°C	-4.9°C	-1.5°C	1.5°C

Table 19: The table above shows projected mean temperatures based on the RCP 4.5; all projection is referenced from Prairie Climate Centre 2019.

RCP 8.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	**Period**	**Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Mean Temperature	**Annual**	6.8°C	7.4°C	8.9°C	10.5°C	9.1°C	11.0°C	13.0°C
Mean Temperature	**Spring**	4.8°C	4.1°C	6.6°C	8.9°C	5.9°C	8.4°C	10.8°C
Mean Temperature	**Summer**	18.1°C	18.4°C	20.2°C	22.2°C	19.7°C	22.3°C	24.7°C
Mean Temperature	**Fall**	9.1°C	9.2°C	11.2°C	13.3°C	10.9°C	13.1°C	15.7°C
Mean Temperature	**Winter**	-5.2°C	-5.3°C	-2.5°C	0.2°C	-3.6°C	0.0°C	3.4°C

Table 20: The table above shows projected mean temperatures based on the RCP 8.5; all projection is referenced from Prairie Climate Centre 2019.

5.3 Precipitation

Depending on the season, the projections for overall precipitation could increase or decrease. Overall, based on means, there is a projected increase. For the City, this could mean more rain events in all seasons.

RCP 4.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	Period	Mean	Low	Mean	High	Low	Mean	High
Precipitation	Annual	1004 mm	870 mm	1053 mm	1242 mm	867 mm	1089 mm	1343 mm
Precipitation	Spring	208 mm	147 mm	224 mm	319 mm	153 mm	239 mm	339 mm
Precipitation	Summer	217 mm	139 mm	218 mm	319 mm	126 mm	220 mm	334 mm
Precipitation	Fall	288 mm	201 mm	296 mm	420 mm	198 mm	304 mm	441 mm
Precipitation	Winter	287 mm	232 mm	316 mm	412 mm	232 mm	326 mm	430 mm

Table 21: The table above shows projected mean precipitation based on the RCP 4.5; all projection is referenced from Prairie Climate Centre 2019.

RCP 8.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	Period	Mean	Low	Mean	High	Low	Mean	High
Precipitation	Annual	1004 mm	856 mm	1046 mm	1244 mm	889 mm	1090 mm	1326 mm
Precipitation	Spring	208 mm	150 mm	225 mm	314 mm	159 mm	248 mm	358 mm
Precipitation	Summer	217 mm	130 mm	216 mm	312 mm	107 mm	212 mm	347 mm
Precipitation	Fall	288 mm	181 mm	286 mm	409 mm	198 mm	295 mm	423 mm
Precipitation	Winter	287 mm	228 mm	320 mm	423 mm	240 mm	335 mm	458 mm

Table 22: The table above shows projected mean precipitation based on the RCP 8.5; all projection is referenced from Prairie Climate Centre 2019.

5.4 Snow

Snowfall for the City has not changed significantly over the last 127 years. Based on a linear line from 1879 to 1962, snow seemed to be decreasing. However, when the data from 1965 to 2006 is added, the line evens out and there is not a significant change in snow fall over the winter season.

Based on the information provided by Environment Canada, there has been a change in number of days per season with snow cover. This change is around 5% to 10% less across Canada from 1981 to 2015. This is due to the shortening snow season (Climate Change Canada). This does not mean the City will get less snow. There is a chance there will be a similar amount of snow just over the shorter season, this is supported by the fact that the City has received a similar amount of snow fall for the last 127 years.

5.5 Extreme Rainfall

Extreme rain fall is one of the many factors projected to change. The City has chosen two sources of projected information for calculating this change, the IDF Curve Lookup is a web-based application provided by the Ontario Ministry of Transportation, and the Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – Version 4.0. These two tools will provide projections to better understand the possible change in these events.

The two sources of projections will provide the City with an idea of how the changing climate could affect these rainfall events. This information will be utilized in two ways.

First, by doing a comparison of probability based on each of the standard events: the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year and then by plotting the 12-hour events from the projected information on the current City IDF curve and finding the change in probability for each event.

Second, will be by developing 2D storm water models with the projected IDF information producing water surfaces that will then be compared to the current IDF curve water surfaces for each event.

All of this data, in combination with a risk assessment, will give the City a better understanding of the potential challenges based on the projected change in climate.

5.6 Other Variables

With a changing climate there are many different variables to consider. Some of these are very hot days, very cold days, and the dates of the last frost, the date of first frost and the overall frost season. These are some of the general variables that could change.

RCP 4.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	**Period**	**Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Tropical Nights	**Annual**	2	2	7	18	4	13	33
Very hot days (+30)	**Annual**	3	3	10	27	6	18	42
Very Cold days (-30)	**Annual**	0	0	0	0	0	0	0
Date of last Spring Frost	**Annual**	May 7	April 14	April 29	May 17	April 10	April 21	May 10
Date of First Fall Frost	**Annual**	Oct. 15	Oct. 6	Oct. 26	Nov. 10	Oct. 13	Nov. 3	Nov. 18
Frost Sean (Days)	**Annual**	161	147	180	206	160	196	219

Table 23: The table above shows other factors that climate change could affect under the RCP 4.5 scenario; all projection are referenced from Prairie Climate Centre 2019.

RCP 8.5								
		1976 - 2005	2021 - 2050			2051 - 2080		
Variable	**Period**	**Mean**	**Low**	**Mean**	**High**	**Low**	**Mean**	**High**
Tropical Nights	**Annual**	2	3	9	23	9	25	48
Very hot days (+30)	**Annual**	3	5	13	35	11	32	63
Very Cold days (-30)	**Annual**	0	0	0	0	0	0	0
Date of last Spring Frost	**Annual**	May 7	April 12	April 28	May 16	April 6	April 13	May 4
Date of First Fall Frost	**Annual**	Oct. 15	Oct. 11	Oct. 28	Nov. 11	Oct. 23	Nov. 11	Nov. 25
Frost Sean (Days)	**Annual**	161	154	184	210	177	212	231

Table 24: The table above shows other factors that climate change could affect under the RCP 4.5 scenario; all projections are referenced from Prairie Climate Centre 2019.

6.0 Conclusion

In conclusion, based on the data, the climate of the City is changing and the City will need to adapt to ensure resiliency of services. The City's CCCAP will help inform future City services and capital infrastructure (storm water network, roads, and buildings) and increase the City's capacity to not only cope with the impacts, but to thrive in face of a changing climate.

7.0 References

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Appendix

Appendix A: Historic Temperature Calculations

Equation

Equation of the Line was used to determine the mean for years of interest. This was done by plotting the historic information and then calculating the equation of the line for each of the different mean values, Max, mean, and min. Where x is equal to the year of interest.

$$y=mx+b$$

$$y=0.0103*x+(-9.733)$$

$$y=0.0103*1880+(-9.733)$$

$$y= 3.9$$

Equations used

The following equations were used to calculate the mean for the set time periods, and only within those time periods. This provided a steady mean throughout each time period. Where x is equal to the year of interest.

	Season Mean Temperature Calculations					
	Spring			**Summer**		
	1879-1962	**1965-2006**	**1879-2006**	**1879-1962**	**1965-2006**	**1879-2006**
Max	y = 0.0103x - 9.733	y = 0.0337x - 57.116	y = 0.0034x + 3.3308	y = 0.0131x - 0.65	y = 0.0316x - 39.49	y = -0.0075x + 38.554
Mean	y = 0.0176x - 29.142	y = 0.0417x - 77.799	y = 0.0098x - 14.32	y = 0.0188x - 17.278	y = 0.0399x - 60.755	y = 0.0037x + 11.493
Min	y = 0.025x - 48.697	y = 0.0503x - 99.599	y = 0.0194x - 38.116	y = 0.0252x - 33.501	y = 0.0482x - 82.188	y = 0.0147x - 15.425
	Fall			**Winter**		
	1879-1962	**1965-2006**	**1879-2006**	**1879-1962**	**1965-2006**	**1879-2006**
Max	y = 0.0208x - 26.637	y = 0.0177x - 21.799	y = 0.0072x - 0.7195	y = 0.0148x - 29.784	y = 0.0451x - 90.57	y = 0.0102x - 21.066
Mean	y = 0.0178x - 25.398	y = 0.0157x - 21.6	y = 0.0143x - 18.724	y = 0.015x - 34.291	y = 0.0549x - 113.65	y = 0.0155x - 35.315
Min	y = 0.0147x - 24.007	y = 0.0144x - 22.709	y = 0.0213x - 36.618	y = 0.0153x - 38.97	y = 0.0636x - 134.45	y = 0.0207x - 49.24

Table 25: The table above present the equations used to calculate various mean temperatures over several time periods. All calculation are based on data from Ministry of Environment and Climate Change Canada. (2019). Past weather and climate, Historical Data.

Appendix B: Historic Rainfall Calculations

Equation of the Line was used to determine the mean for years of interest. This was done by plotting the historic information and then calculating the equation of the line for each of the different mean seasonal rain fall on a yearly basis. Where x is equal to the year of interest.

$$y=mx+b$$

$$y=-0.0316 * x + 189.05$$

$$y=0.0103 * 1879 + 189.05$$

$$y= 130 \text{ mm}$$

Equations used

The following equations were used to calculate the mean for the set time periods, and only within those time periods. This provided a steady mean throughout each time period. Where x is equal to the year of interest.

	Season Mean Rainfall Calculations					
	Spring			**Summer**		
	1879-1962	**1965-2006**	**1879-2006**	**1879-1962**	**1965-2006**	**1879-2006**
Mean	y = -0.0316x + 189.05	y = 1.8277x - 3459.6	y = 0.49x - 809.3	y = -0.4204x + 1012.3	y = -1.5117x + 3240.9	y = 0.1985x - 167.96
	Fall			**Winter**		
	1879-1962	**1965-2006**	**1879-2006**	**1879-1962**	**1965-2006**	**1879-2006**
Mean	y = -0.288x + 757.4	y = 1.3913x - 2492.8	y = -0.288x + 757.4	y = -0.3004x + 631.2	y = 1.4445x - 2792.5	y = 0.22x - 364.81

Table 26: The table above present the equations used to calculate various mean rainfall over several time periods. All calculation are based on data from Ministry of Environment and Climate Change Canada. (2019). Past weather and climate, Historical Data.

Appendix C: Historic Snowfall Calculations

Equation of the Line was used to determine the mean for years of interest. This was done by plotting the historic information and then calculating the equation of the line for each of the different mean seasonal rain fall on a yearly basis. Where x is equal to the year of interest.

$$y=mx+b$$

$$y = -1.5471x + 3263.8$$

$$y= -1.547 * 1879 + 3263.8$$

$$y= 356.7991 \text{ cm}$$

Equations used

The following equations were used to calculate the mean for the set time periods, and only within those time periods. This provided a steady mean throughout each time period. Where x is equal to the year of interest.

	Mean Snowfall Calculations		
	1879-1962	**1965-2006**	**1879-2006**
Mean	y = -1.5471x + 3263.8	y = -0.0137x + 362.61	y = 0.0092x + 289.01

Table 27: The table above present the equations used to calculate various mean snowfall over several time periods. All calculation are based on data from Ministry of Environment and Climate Change Canada. (2019). Past weather and climate, Historical Data.

Appendix D: City of Owen Sound IDF-Curve

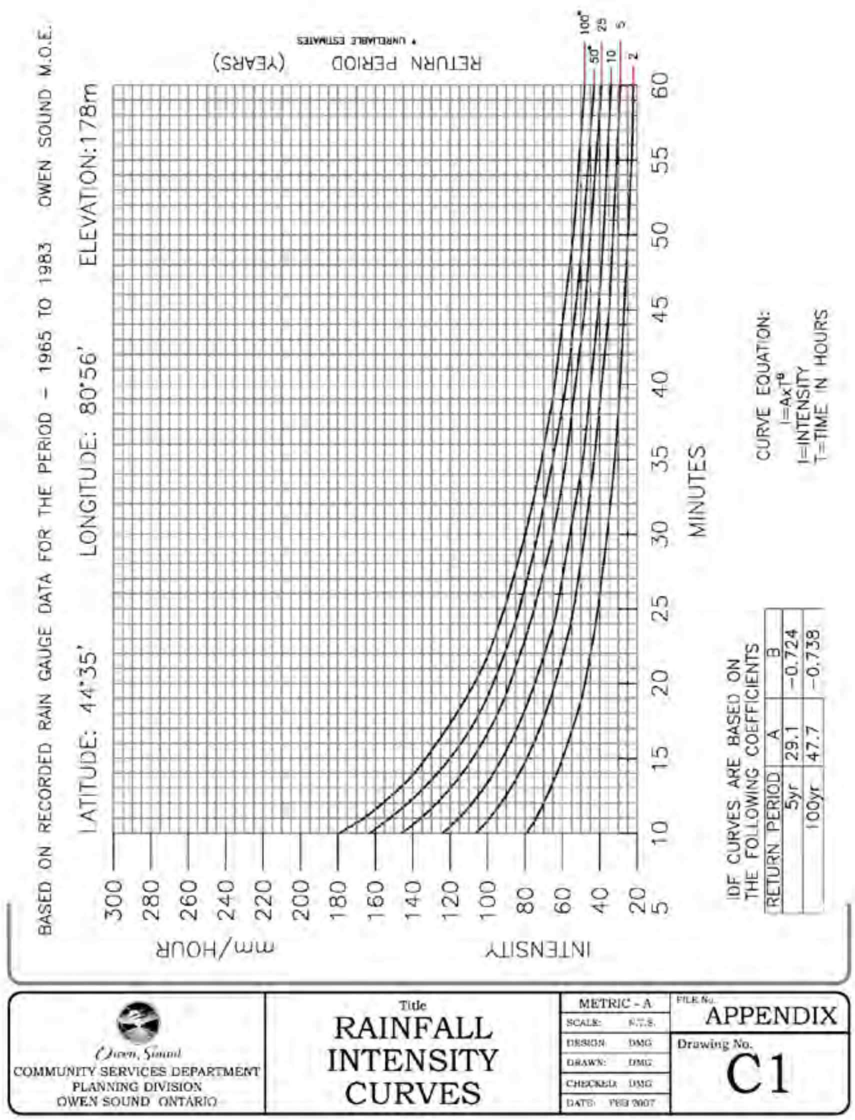

Figure 16: The figure above shows the IDF curve for the City of Owen Sound taken from Owen Sound Site Development Engineering Standards