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Integrating Climate Change into Asset Management, a Framework for Municipalities – Part I

March 22, 2021

BluePlan ENGINEERING

GEI Consultants
Savanta Division

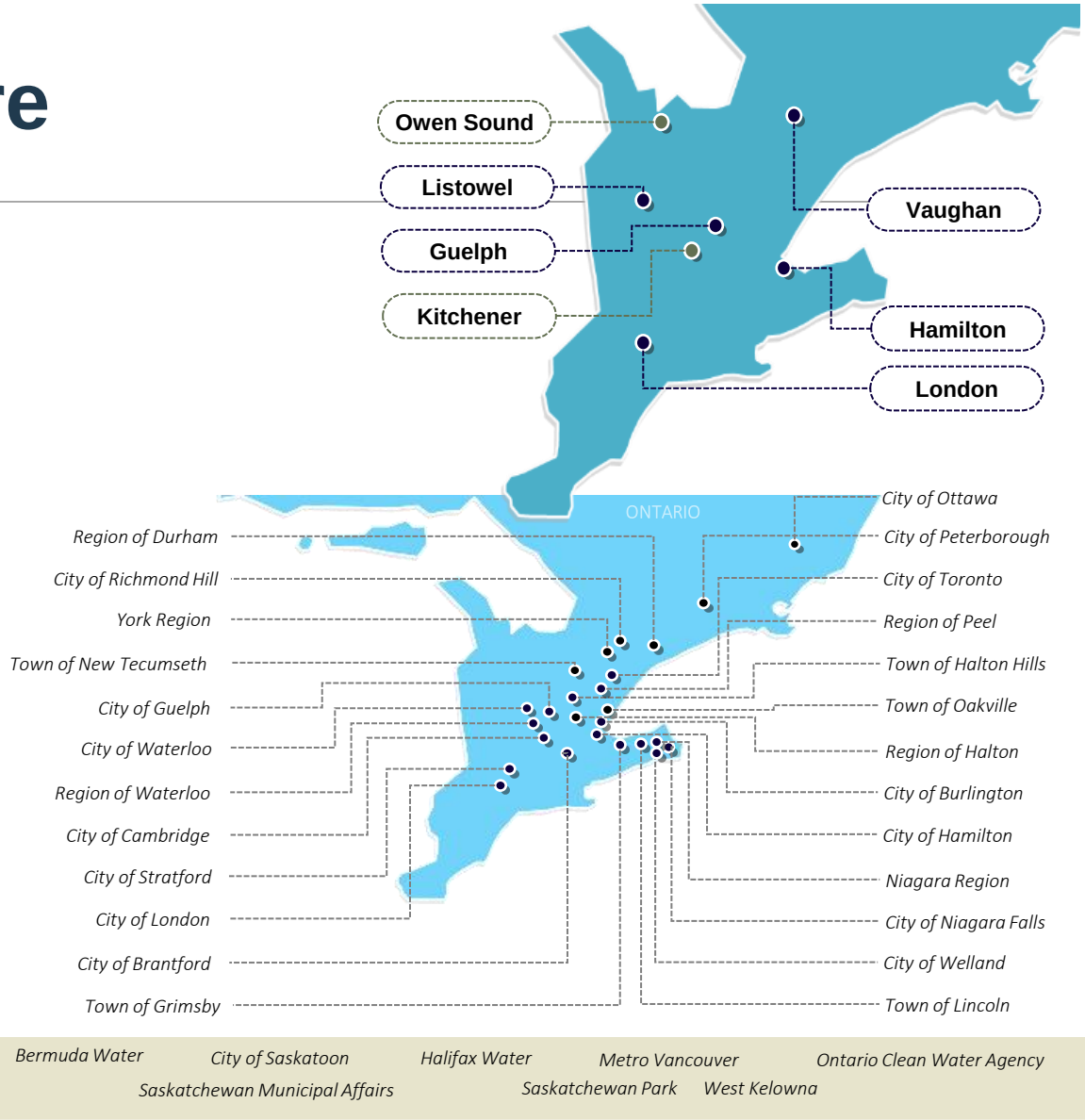
Who We Are

Terry Martins - GM BluePlan Engineering

- GMBP is privately owned with 7 offices across ON & 240+ staff
- Full-lifecycle Engineering firm

Strategy → Concept → Plan → Implement → Maintain

- AM team of over 70 staff focused on Asset Management & Infrastructure Planning:
- Over 500 IP/AM/EAM projects since 2014
- Terry has over 30 years of EAM experience



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Who We Are

GEI Consultants – Savanta Division

- Employee-owned environmental consulting and engineering firm.
- Over 900 staff in 45 offices across North America
- Clients: public and private sector, Indigenous communities and organizations, and all levels of government across Canada and the U.S.

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Project Overview

*The climate change asset management pilot project is testing a **framework** and adaptation **approach** for identifying **climate events and impacts of concern** for all municipal assets and LOS, identifying **response strategies/adaptation approaches**, and **quantifying** the financial implications of climate change **adaptation**.*

Our clients were asking us for a solution to Climate Change Adaptation!!!

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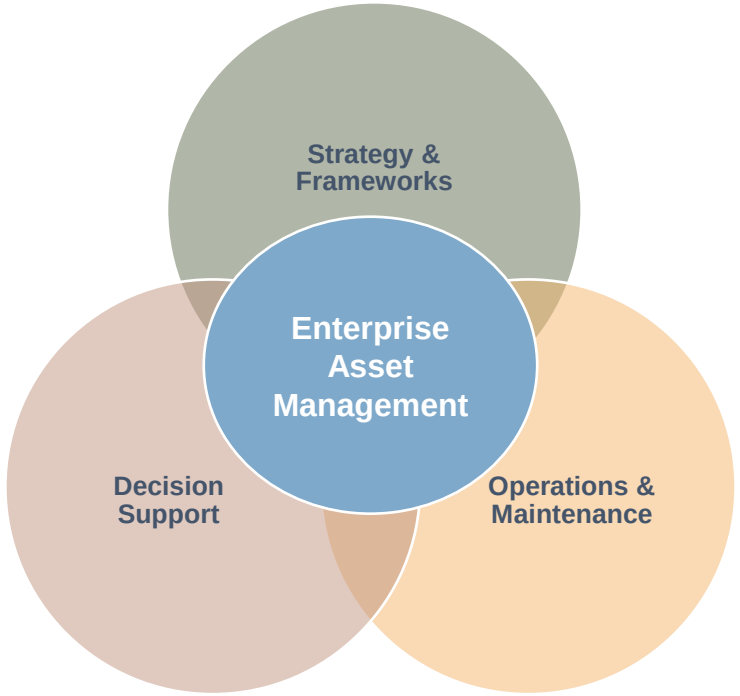
Project Framework



Phase 1: Climate Change Event Probability Analysis

Phase 2: Climate Change Risk Analysis

Phase 3: Climate Change Adaptation Strategies

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Project Objectives

- Build a connection between asset management and climate change
- Better inform decision making on the LOS implications & costs associated with climate change adaptation
- Test & calibrate a replicable framework that can be applied to all municipal asset classes
- To test the pilot project on 2 assets – water and wastewater

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Project Participants






TORONTO

Hamilton

DURHAM REGION

Halton REGION

Region of Peel
working with you

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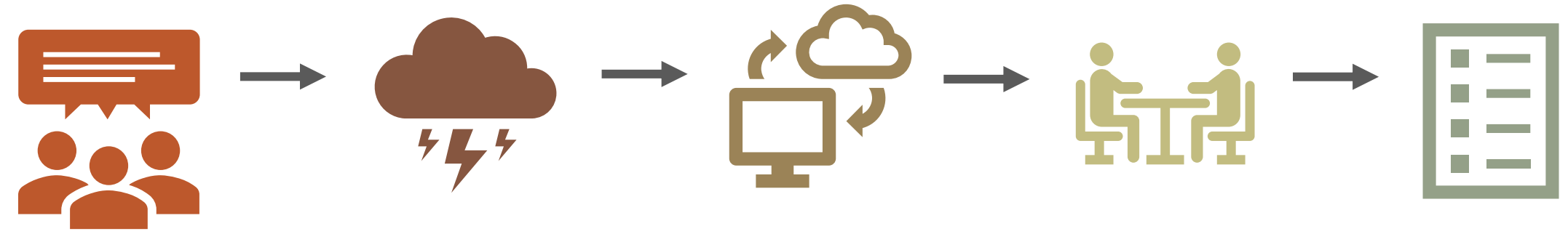
Phase 1 Approach



- Review of all climate events that impact W&WW assets and services
- Climate Change Event Probability Matrix (30s, 50s & 80s)
- Technical memo detailing Methodology & Results

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Phase 2 Approach

Review the impacts of events on LOS & assets

- Consider impact to LOS versus the probability of occurring
- Considered all Water & Wastewater assets/services

Assign adaptation approach to events:

1. **AM Strategies** to accommodate or minimize event impacts
2. **Design Modifications** to mitigate an event
3. **Emergency Response Procedures** to be carried out in an event

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Frozen Lateral Example

1. **AM Strategies:** 5-year Capital Plan to replace laterals <6 feet deep
2. **Design Modifications:** As watermains are replaced, ensure all laterals are >6 feet deep
3. **Emergency Response Procedures:** O&M respond to frozen lateral complaints

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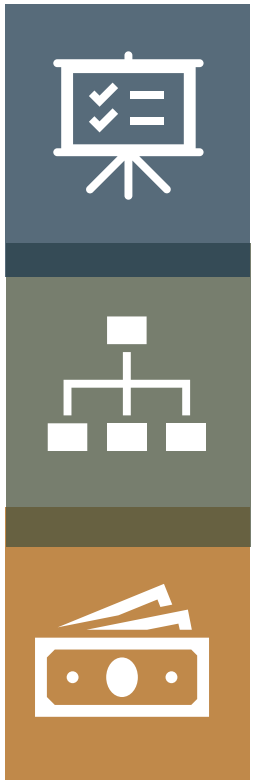
Phase 2 Worksheet

AM Strategy - 1 Design / Operating Modification - 2 Emergency Response Procedure - 3 Other/ Not applicable - 4		Extreme Precipitation							
		Impact	Days where precipitation >20mm	Days where precipitation >50mm	100mm of precipitation or more in 3 days	Multi day extreme precipitation event consistent with: - The July 8, 2013 Toronto Storm - The August 2014 Halton Storm - The July 2020 Toronto Storm - The Hurricane Hazel Storm	Current response	Desired Response	Additional Notes (Hamilton Specific)
Probability of Occurrence in One Year (**Range for all municipalities**)		2030s	100%	25 - 31%	11 - 49%	1.1% or less			
		2050s	100%	29 - 39%	11 - 89%	1.2% or less			
		2080s	100%	42 - 51%	14 - 100%	2% or less			
Water Assets	**Water Treatment Plant (process)**	**Water use restrictions or lower pressure:** Reduced water production capacity due to restrictions on ability to backwash filters (capacity in WW side)		x	x	x	3	3	Plant Ops-Standby Power. We have upgrades at the Woodward WWTP to provide backup power and we have backup power generators at Dundas WWTP
		Increased processing costs: Due to higher turbidity in intake water (coincides with high winds paired with high rain)		x	x	x	2	2	
		Water use restrictions or lower pressure: Flooding in low pipe galleries, pumps can't run.				x	4	3	Treatment plants in floodplain, back end of plant flooded - July 2008. Water level was near switch, had potential to shut plant down. Hasn't experienced this.
		Water use restrictions or lower pressure: Reduced water production capacity due to utility power failure.				x	4	1	Standby power requirement at all vertical water sites - no standby power at lowlift.
	Site Works	**Water use restrictions or lower pressure**: Flooding of site restricts access for operators to get to site, which could shut down the plant.				x	4	3	Same 2008 event - sections of plant underwater.
	Booster Stations	**Water use restrictions or lower pressure**: Flooding in low pipe galleries, pumps can't run.				x	4	3	
		Water use restrictions or lower pressure: Reduced water production capacity due to utility power failure.				x	2	1	Standby power at all critical locations.
		Water use restrictions or lower pressure: Flooding of site restricts access for operators to get to site, which could shut down the station.				x	4	3	
	Reservoirs/Tanks	**Water use restrictions or lower pressure**: Flooding in low pipe galleries if not gravity fed, pumps can't run.				x	4	3	Reservoirs are typically gravity - low impact
		Water use restrictions or lower pressure: Reduced water production capacity due to utility power failure if pumps required.				x	2	1	
	Laterals / Services	**Water use restrictions or lower pressure:** Service distribution due to washout/erosion.				x	3	3	
	Hydrants	**Water use restrictions or lower pressure:** Service distribution due to washout/erosion.				x	3	3	
		Loss of fire protection: Lack of access to hydrant in low lying/flooded areas				x	3	3	Not many hydrants in low-lying areas. Not a concern for Hamilton.
	Valves	**Water use restrictions or lower pressure:** Loss of maintenance access. Can aggravate a watermain break situation.				x	3	3	
	Transmission Mains	**Water use restrictions or lower pressure**: Service disruption due to washout/erosion at crossings and bridges etc.				x	3	1	Several critical mains are looked after proactively, rehabed earlier if vulnerable.
	Distribution Mains	**Water use restrictions or lower pressure**: Service disruption due to washout/erosion at crossings and bridges etc.				x	3	3	

Phase 3 Approach

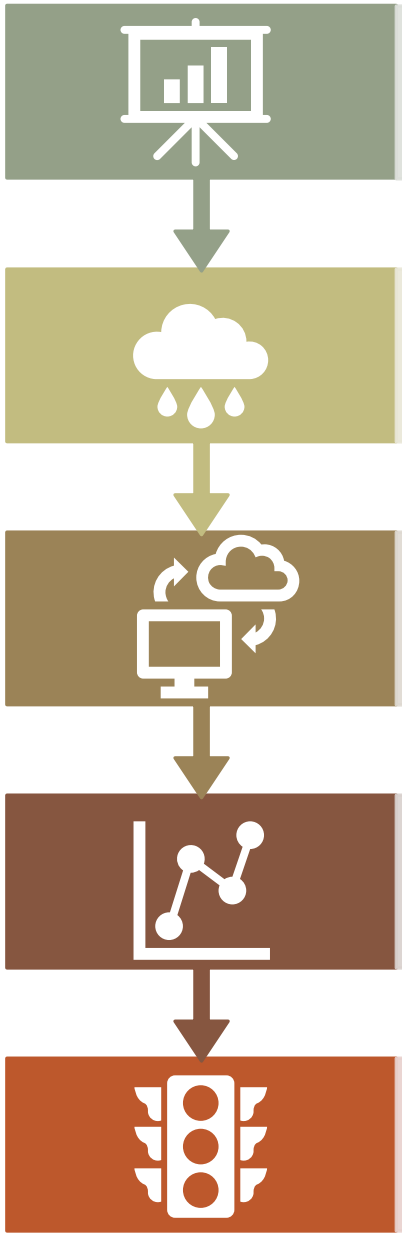


- Review of asset level AM strategies and data
- Preliminary analysis of asset LOS impacts
- Additional data gathering and revision of asset LOS impacts (based on stakeholder feedback)
- Preliminary development of AM strategies
- DSS analysis on financial impacts

Run DSS for 2 Asset Classes

- Before CCA lens is included (Capital $, impacted customers, Operator response time/costs)
- After CCA lens is included (see impacts on costs & customers)

DETAILED PHASE 1 METHODOLOGY



Obtain previously completed climate trends studies and reports

Identify appropriate climate events & combination events to be used in the study

Obtain climate variables from Gov. of Canada & Ontario portals. Cross-reference, compare & develop a suite of available variables

Estimate historical & future probabilities of occurrence

Apply red-yellow-green confidence levels (qualitatively) & produce final memo

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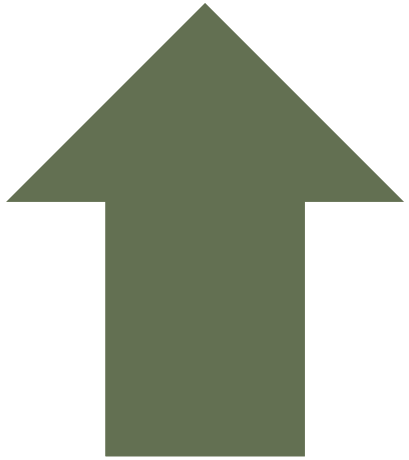
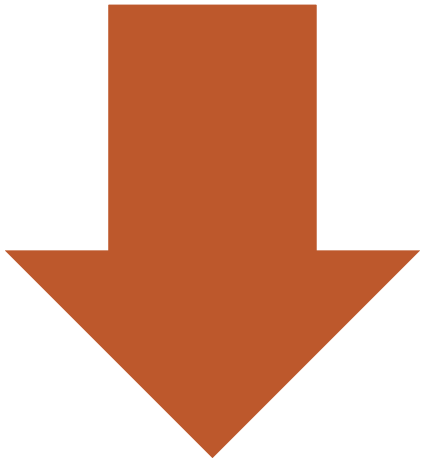
Tailoring our Approach Based on Customized Events



Typically Available Climate Data

- Air temperature
- Total precipitation
- Some pre-set climatological parameters (e.g., “days >10mm of rainfall)
- Extreme cold and extreme heat days
- Growing conditions and dry days



Typically Not Available Climate Data

- Customized threshold-based events (e.g., rainfall of 85mm)
- Back-to-back events (e.g., flooding during freezing winter months)
- Sub-daily data conditions

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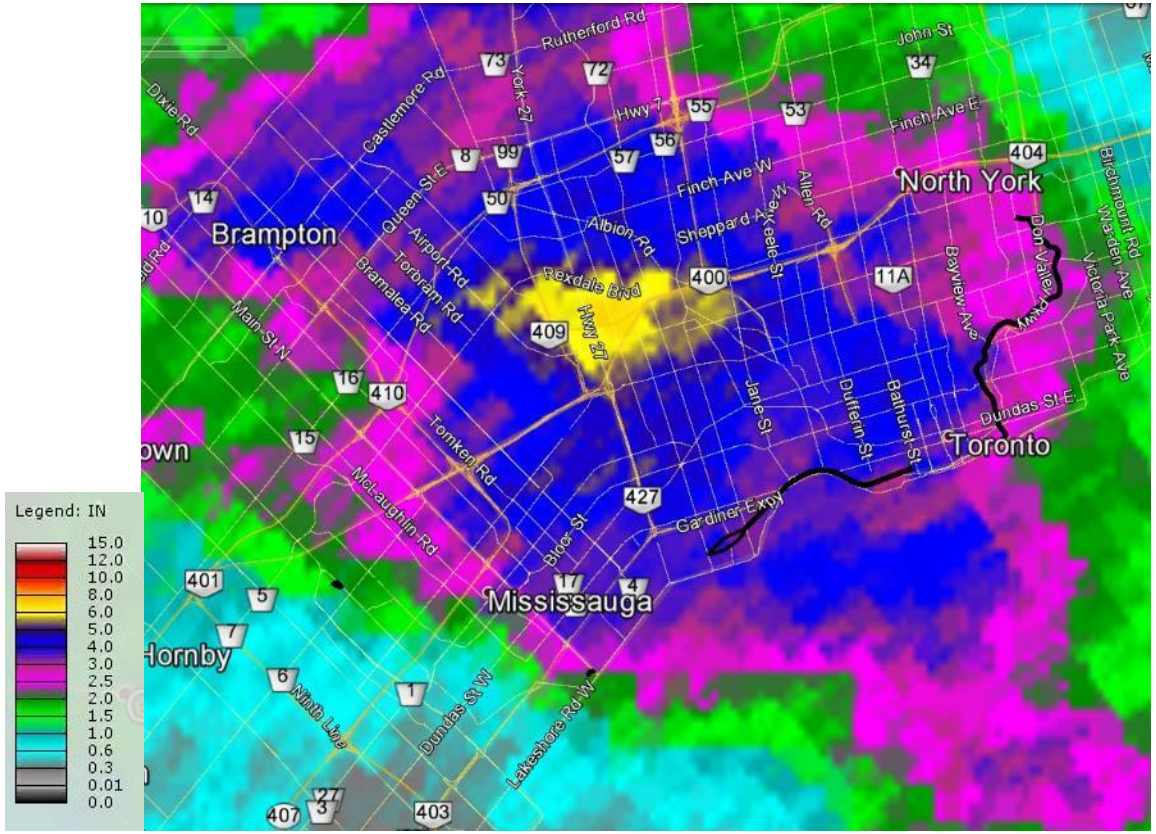
Climate Models and Surgical Storms

- **They cannot** predict with certainty whether an extreme “surgical” rainfall event will happen, where and on what date.
- They **can provide** an understanding of how extreme rainfall events may change over time, the probability of their occurrence and what impacts may occur that we need to prepare for.



July 8, 2013, Total Accumulated Precipitation, radar-derived, NOAA

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Climate Data Grid Cell Locations

- Northern and southern grid cell for each municipality
- Each grid cell covers an area of ~10km^2

Location	Northern Grid Cell		Southern Grid Cell	
	Latitude	Longitude	Latitude	Longitude
Durham Region	44.4583332	-79.12500248	43.87499989	-78.8750025
Halton Region	43.6249999	-80.04166911	43.37499991	-79.79166912
City of Hamilton	43.20833325	-79.87500245	43.20833325	-79.79166912
Peel Region	43.87499989	-80.04166911	43.54166657	-79.62500246
City of Toronto	43.79166656	-79.4583358	43.6249999	-79.37500247

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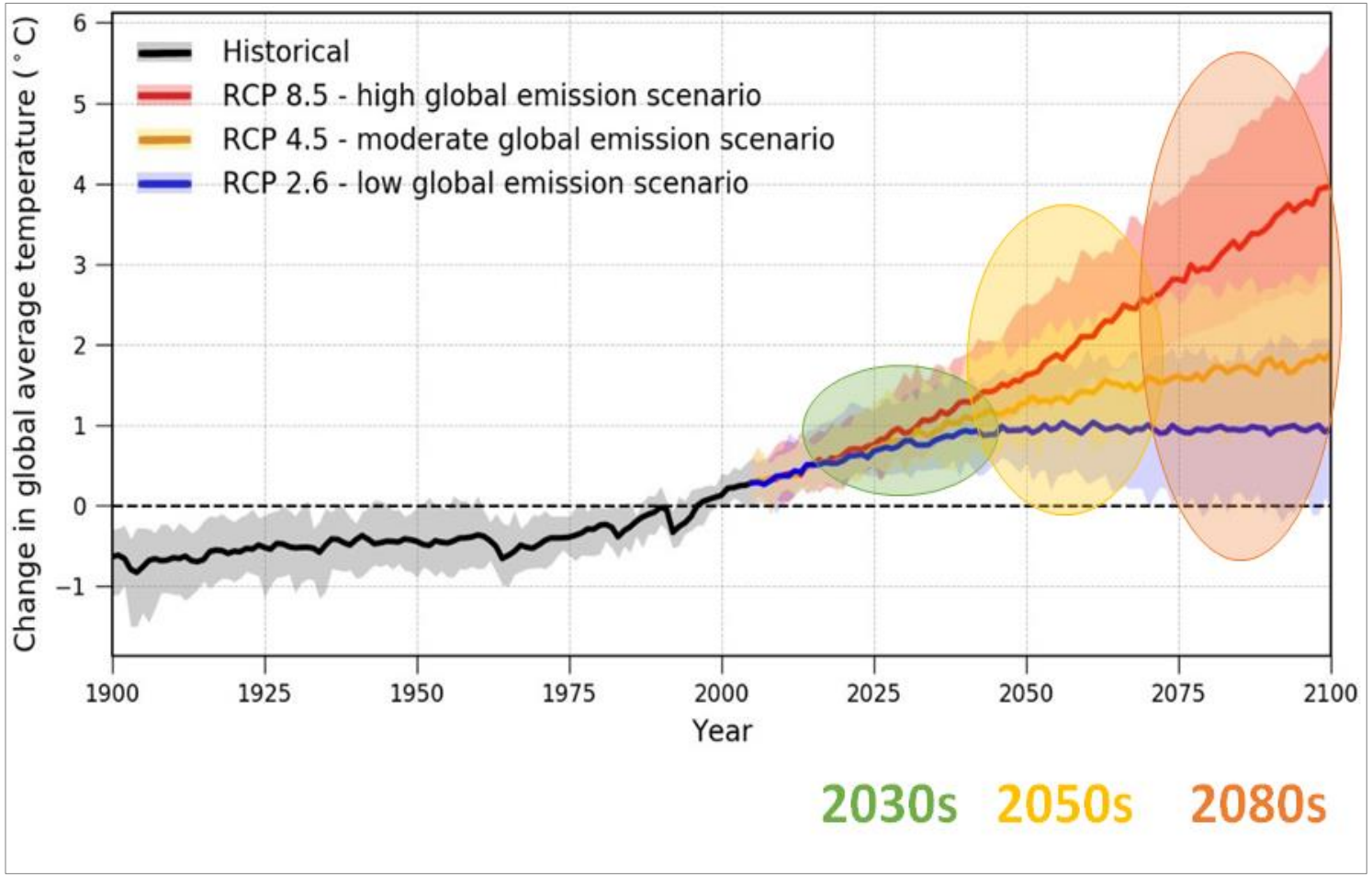
Qualitative Ranking for Data Uncertainty



Ranking Scale

- **High** – Robust
- **Medium** – Some Limitations
- **Low** – Use with Caution

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Event Probability Matrix

No.	Climate Event[1]	Occurring...	Climate Parameter(s) and Threshold(s)	Trend		Historical (1981-2010)					Short Term (2030s)						Mid Century (2050s)						Long Term (2080s)					
						Historical Condition[2]	Annual Occurrence (events/yr)[3]	Probability of Occurrence in One Year	Return Period (Historically)[4]	Confidence Rating[5]	Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2030s)	Confidence Rating	Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2050s)	Confidence Rating	Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2080s)	Confidence Rating
Water-Related Events																												
1	Extreme precipitation event (less extreme)	Annual	Days where precipitation >20mm	↑		○	6.1 - 6.4 events/yr	100%	0.17 year event	High	○	6.7 - 7 events/yr	± 1.4	100%	0.15 year event	Medium	○	7.5 - 7.9 events/yr	± 2.1	100%	0.13 year event	Medium	○	8.4 - 8.6 events/yr	± 3	100%	0.12 year event	Medium
2	Extreme precipitation event (more extreme)	Annual	Days where precipitation >50mm	↑		○	0.26 - 0.28 events/yr	27%	3.7 year event	High	○	0.29 - 0.32 events/yr	± 0.2	31%	3.3 year event	Medium	○	0.34 - 0.37 events/yr	± 0.2	34%	2.8 year event	Medium	○	0.43 - 0.46 events/yr	± 0.38	45%	2.3 year event	Medium
3	Multi-day extreme precipitation (over a few days)	Annual	100mm of precipitation or more in 3 days	↑		○	0.07 - 0.14 events/yr	11%	10.8 year event	High	○	0.13 - 0.14 events/year	± 0.2	14%	7.5 year event	Medium	○	0.12 - 0.23 events/yr	± 0.3	18%	6.3 year event	Medium	○	0.22 - 0.27 events/yr	± 0.26	25%	4.2 year event	Medium
4	The "July 8, 2013" Toronto storm	Annual	140mm precipitation or more in 2 hours	↑		○	0 - 0.01 events/yr	<1%	>100 year event	Low	○	0 - 0.011 events/yr	N/A	1.1%	90 year event	Low	○	0 - 0.012 events/yr	N/A	1.2%	83 year event	Low	○	0 - 0.016 events/yr	N/A	1.6%	62 year event	Low
5	The "August 2014" Halton storm	Annual	200mm of precipitation or more in 8 hours	↑		○	0 - 0.01 events/yr	<1%	>100 year event	Low	○	0 - 0.011 events/yr	N/A	1.1%	90 year event	Low	○	0 - 0.012 events/yr	N/A	1.2%	83 year event	Low	○	0 - 0.016 events/yr	N/A	1.6%	62 year event	Low
6	The "July 2020" Toronto storm	Annual	68mm of precipitation or more in 1hr	↑		○	0 - 0.01 events/yr	<1%	>100 year event	Low	○	0 - 0.011 events/yr	N/A	1.1%	90 year event	Low	○	0 - 0.012 events/yr	N/A	1.2%	83 year event	Low	○	0 - 0.016 events/yr	N/A	1.6%	62 year event	Low
7	The "Hurricane Hazel" storm	Annual	280mm of precipitation or more in 2 days	→		○	0.002 events/yr	0.2%	480 year event	Medium	○	0 events/yr	± 0	<1%	>100 year event	Low	○	0 events/yr	± 0	<1%	>100 year event	Low	○	0 events/yr	± 0	<1%	>100 year event	Low
8	Multi-day extreme precipitation (over a few days)	Annual	150mm of precipitation or more in 2 days	→		○	0.01 - 0.02 events/yr	1.5%	67 year event	Medium	○	0.004 - 0.01 events/yr	± 0.04	0.7%	143 year event	Low	○	0.006 - 0.01 events/yr	± 0.04	0.80%	125 year event	Low	○	0.008 - 0.04 events/yr	± 0.05	2.40%	42 year event	Low
9	Multi-day dry conditions	Annual	7 consecutive days where precipitation is 0mm	↑		○	14.1 - 17.4 events/yr	100%	0.06 year event	High	○	14.4 - 17.1 events/yr	± 5.6	100%	0.06 year event	Medium	○	14.7 - 18 events/yr	± 4.3	100%	0.06 year event	Medium	○	15.2 - 18 events/yr	± 7.2	100%	0.06 year event	Medium
10	Multi-day dry conditions	Annual	14 consecutive days where precipitation is 0mm	↑		○	1 - 1.5 events/yr	100%	0.84 year event	High	○	1 - 1.3 events/yr	± 1.3	100%	0.87 year event	Medium	○	1.2 - 1.6 events/yr	± 1.5	100%	0.74 year event	Medium	○	1.5 - 1.7 events/yr	± 2.4	100%	0.65 year event	Medium
11	Extreme rainfall with freezing conditions	Dec. to March	Days where precipitation >50mm and maximum temperature <0°C	→		○	0.002 events/yr	0.2%	480 year event	Medium	○	0.002 events/yr	± 0	0.2%	480 year event	Low	○	0.002 events/yr	± 0	0.2%	480 year event	Low	○	0.004 events/yr	± 0.008	0.40%	240 year event	Low
12	Saturated ground conditions over a week (high antecedent moisture) followed by an extreme rainfall event	May to September	50mm of precipitation or more in 5 days, followed by 30mm of precipitation in 1 day	↑		○	0.05 - 0.06 events/yr	5.5%	19.1 year event	High	○	0.04 -0.06 events/yr	± 0.1	5%	19.7 year event	Medium	○	0.08 - 0.09 events/yr	± 0.1	9%	12 year event	Medium	○	0.12 - 0.13 events/yr	± 0.19	13%	7.8 year event	Medium

- **Time horizons:** 2030s, 2050s, 2080s
- **Historical condition:** annual occurrence (events/yr), probability of occurrence in one year, return period (historically)
- **Projected conditions:** annual occurrence (events/yr), 10th to 90th percentile range, probability of occurrence in one year, return period
- **Trend identified**: ↑ ↓ →
- **Confidence ratings** applied to all time frames

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Climate Events

Water Related Events

Extreme precipitation event (less extreme)

Extreme precipitation event (more extreme)

Multi-day extreme precipitation (over a few days)

The "July 8, 2013" Toronto storm

The "August 2014" Halton storm

The "July 2020" Toronto storm

The "Hurricane Hazel" storm

Multi-day extreme precipitation (over a few days)

Multi-day dry conditions

Multi-day dry conditions

Extreme rainfall with freezing conditions

Saturated ground conditions over a week (high antecedent moisture) followed by an extreme rainfall event

Temperature Related Events

Extreme cold in a single day

Multi-day extreme cold event over a week

Multi-day extreme cold event over a week - less extreme

Multi-day extreme cold event over a week with no precipitation

Extreme heat in a single day

Extreme heat coupled with dry conditions

A freeze-thaw event

Two consecutive freeze-thaw events

Freeze-thaw event coupled with extreme rainfall

Extended extreme cold followed by a warm up - less extreme

Extended extreme cold followed by a warm up - more extreme

Other Customized Events

High lake levels exceeding Durham's outfall

High lake levels exceeding Hamilton's outfall

High lake levels exceeding Peel's outfall

High water temperatures (Proxy for the potential of algae growth) – Durham intakes

High water temperatures (Proxy for the potential of algae growth) – Peel intakes

High winds - less extreme scenario

High winds - more extreme scenario

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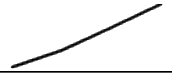
Example – Extreme Precipitation Event in Peel

Trend		Historical (1981-2010)				
		Historical Condition[2]	Annual Occurrence (events/yr)[3]	Probability of Occurrence in One Year	Return Period (Historically)[4]	Confidence Rating[5]
↑		◯	6.1 - 6.4 events/yr	100%	0.17 year event	High

Short Term (2030s)					
Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2030s)	Confidence Rating
◯	6.7 - 7 events/yr	± 1.4	100%	0.15 year event	Medium

Mid Century (2050s)					
Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2050s)	Confidence Rating
◯	7.5 - 7.9 events/yr	± 2.1	100%	0.13 year event	Medium

Long Term (2080s)					
Projected Condition	Annual Occurrence (events/yr)	10th to 90th Percentile Range	Probability of Occurrence in One Year	Return Period (2080s)	Confidence Rating
◯	8.4 - 8.6 events/yr	± 3	100%	0.12 year event	Medium

Less extreme event – days where precipitation >20mm

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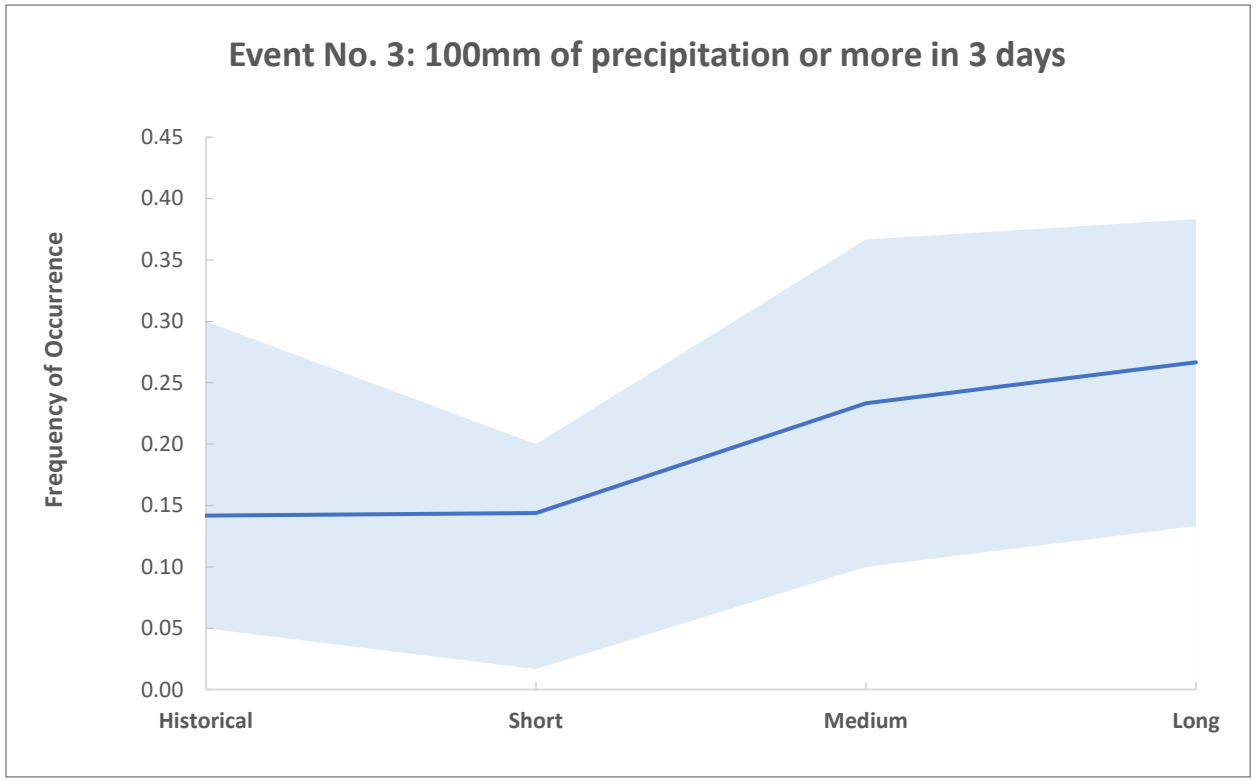
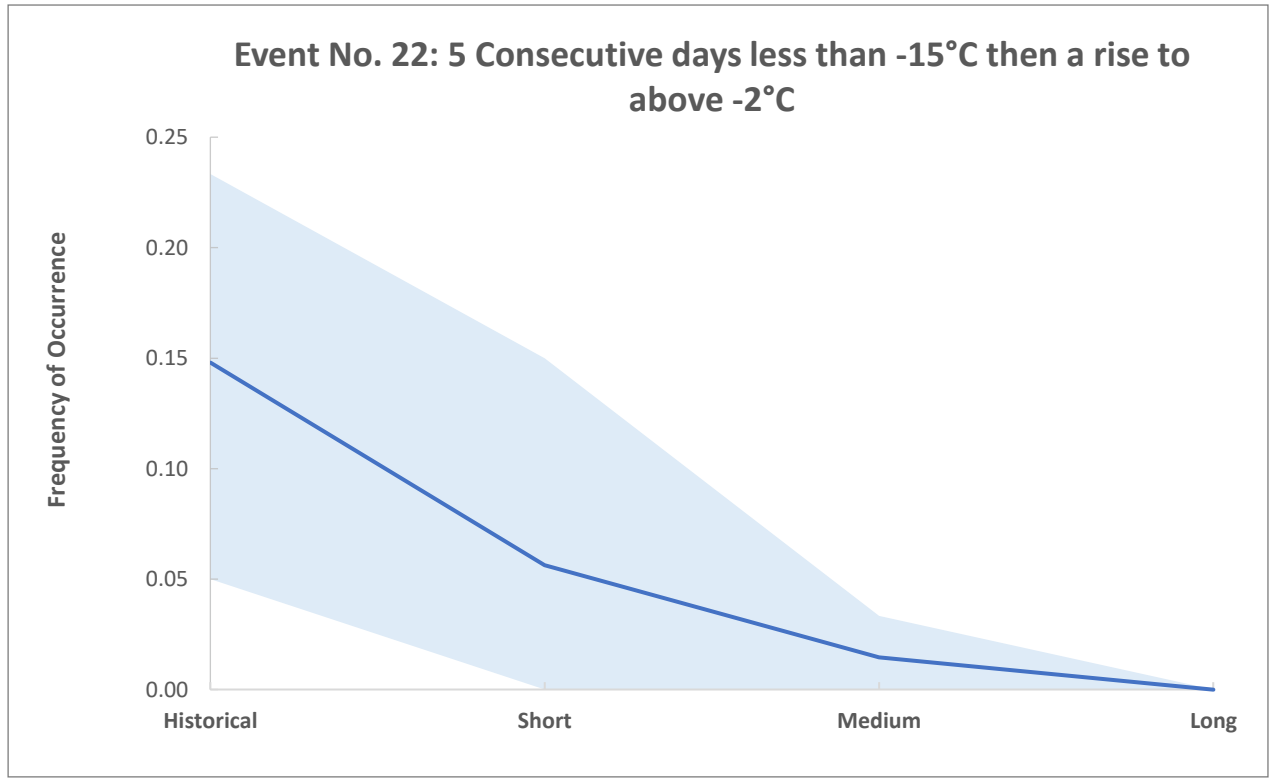
Results – Region of Peel





Next Steps

Phase 2 - being finalized and reviewed by participants

Phase 3 – Selecting 2 asset classes for DSS analysis

Present Phase 2 & 3 results in April

Refine framework to be applied to all asset classes for any municipality

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Thank You

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