CLIMATE CHANGE ADAPTATION PLAN FOR THE AGGLOMERATION OF MONTRÉAL 2015-2020

EXECUTIVE SUMMARY

Montréal

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A MESSAGE FROM OUR ELECTED OFFICIALS

The undeniable role of cities in the fight and adaptation to climate change is recognized throughout the world. Densely populated urban centres are on the first lines of the adverse consequences that may result from climate change. But cities are also environments that are conducive to innovation and action. That is why we are taking our responsibilities and are planning for a better quality of living for present and future generations of Montrealers.

The Agglomeration of Montréal committed to reducing its greenhouse gas (GHG) emissions by adopting, in 2013, its *Plan de réduction des émissions de GES de la collectivité montréalaise 2013-2020*. Despite our mitigation efforts, some of the apprehended climate disruptions are already observed: heat waves, heavy rainfalls, ice storms, etc. A strategy aiming to curtail the negative impacts of climate change is essential for our administration and citizens. That is why I am proud to present this first *Climate Change Adaptation Plan for the Agglomeration of Montréal 2015-2020*.

With this adaptation plan, many ambitious commitments have been undertaken by central departments, boroughs and municipalities. The measures announced aim to reduce heat islands, enhance biodiversity protection, manage runoffs, increase the resilience of infrastructures and adopt new practices with respect to the offering of recreational activities, to name but a few.

This plan is just a first step in a very concrete approach that not only consolidates our strengths and reinforces our ability to address all of these disruptions, but also demonstrates our resoluteness to maintain and enhance the quality of the living environments of our citizens.

Denis Coderre
Mayor of Montreal and President of the Montreal Metropolitan Community

Heat waves, heavy rainfalls, freezing rain… the extreme climate events of the past few years demonstrate that the effects of climate change are already being felt. These new conditions represent a challenge, but also opportunities that may be seized to position Montréal in the vanguard of cities in terms of sustainable development.

This first adaptation plan highlights our territory's vulnerabilities to climate change. The impacts observed and anticipated on the population, infrastructures, the natural environment and all of the activities that take place on the island are undeniable. The sum of the data consolidated in this plan provides solid arguments on the importance of moving from a strategizing mode to an action mode, and that is what we are committed to doing.

This adaptation plan presents concrete measures to address climate hazards that already affect us and whose impacts will likely be heightened in the coming years. Climate projections confirm that heat waves, heavy rainfalls and destructive storms will occur more frequently. This adaptation process is the ideal opportunity for us to modify and improve our measures to mitigate the impacts of climate change.

This plan is the result of a successful collaboration between the various actors in the Montréal agglomeration. Specialists in the fields of the environment, water management, infrastructures, buildings, green spaces and land use as well as representatives from all the boroughs and cities within the agglomeration have contributed to the development of this tool which will prove instrumental in increasing our agglomeration's resilience in the next five years.

Réal Ménard
Executive Committee member in charge of sustainable development, the environment, large parks and green spaces

MONTRÉAL ADAPTS TO CLIMATE CHANGE

The last decades have been crucial in terms of the climate. There have been countless extreme meteorological events throughout the world and their impacts have been extremely varied. Climate change and their amplification have been confirmed by the scientific community, including the Intergovernmental Panel on Climate Change (IPCC).

This changing climate is already being felt by the agglomeration of Montréal. The heat waves, floods and freezing rains recorded in recent years, which have resulted in many material and financial damages, and had a disruptive effect on the population's activities, are all manifestations of these climate change.

The agglomeration of Montréal is already dealing with changes that impact both the natural and built environments, the population and socioeconomic activities. Many non-climate factors, such as the age of infrastructures, land-use or socio-demographic characteristics will either amplify or, on the contrary, mitigate their apprehended repercussions.

Two types of joint actions are feasible regarding climate change: mitigation (also called reduction) and adaptation. **Mitigation** consists in reducing the intensity of these changes by diminishing anthropogenic (man-made) greenhouse gases. Montréal, toward this aim, has developed a greenhouse gas emissions reduction plan (*Plan de réduction des émissions de gaz à effet de serre de la collectivité montréalaise 2013-2020*). **Adaptation** consists in assessing the impacts of climate change on the agglomeration and implementing the necessary measures to minimize them. Adaptation measures make the agglomeration more **resilient** to climate change, allowing it to better react and reorganize itself while securing its essential functions and its identity.

This first climate change adaptation plan, a collaborative effort between municipal departments, local administrations and the Service de l'environnement, is only the starting point of an iterative process that will be enhanced in the coming years, to reflect the accumulation of changing data on the climate and the inherent risks as well as the effectiveness of the measures that will have been implemented.

Credit: © Denis Labine, Ville de Montréal

ADAPTATION AND RESILIENCE

Adaptation to climate change is a process whereby communities and ecosystems make adjustments to restrict the negative impacts of climate change and take advantage of their potential benefits.

Resilience refers to the capacity of a community's economic, social, political and physical infrastructure systems to absorb shocks and stresses and still retain their basic function and structure.*

* Source : Craig Applegath, www.resilientcity.org

PLAN OBJECTIVES

The adaptation plan has been designed with three specific objectives in mind, namely:

1. ***Consolidate all of the adaptation measures already in place which, while not specifically referring to an adaptation to climate change, truly serve that purpose***
   Many of the climate impacts on health issues and issues dealing with the protection of both natural and built environments are already built into many of the plans and strategies of the agglomeration of Montréal. More than 30 strategies, policies, plans and regulations associated, directly or indirectly, with climate change can be identified. This adaptation plan supports initiatives that have already been announced and provides solid arguments regarding the importance of implementing and acting on strategies.

2. ***Provide the relevant information on the vulnerabilities associated with climate change for all of the agglomeration's municipalities***
   Although climate projections are consistent throughout the agglomeration, vulnerability factors vary according to one's geographic location on the Island of Montréal. Consequently, it is essential to appreciate the local variations in vulnerability levels to best orient one's actions according to local circumstances and focus one's efforts where a greater vulnerability is observed.

3. ***Plan for the development of the agglomeration and its maintenance and repair operations in light of the constraints associated with climate change***
   This objective speaks to the very essence of a climate change adaptation plan, by encouraging new ways of thinking and doing things among stakeholders within the agglomeration, to reduce the inherent risks of climate change.

PLAN CONTENTS

This plan presents, in a first volume, a diagnosis of the adaptation challenges faced by the agglomeration of Montréal. It presents the vulnerability analysis of the agglomeration regarding six climatic hazards:

- increase in average temperatures,
- heavy rainfalls,
- heat waves,
- destructive storms,
- droughts and
- floods.

For each of these hazards, a description of the meteorological observations and climate projections is presented. Then follows an impact review of the hazard on the built and natural environments, the population and the municipal activities. Finally, a vulnerability analysis of the agglomeration of Montreal is presented, in the form of a map when possible.

The second volume is entirely dedicated to adaptation measures. It focuses on actions that need to be consolidated or developed and on the commitments of the various entities that make up the agglomeration of Montréal.

Credit: © Denis Labine, Ville de Montréal

TERRITORY COVERED BY THE PLAN

Located at the confluence of the St. Lawrence and Ottawa Rivers, the Island of Montréal measures approximately 50 km in length and 16 km at its widest point. Ringed by Des Prairies River, the St. Lawrence River and Lake Saint-Louis, it has 266.6 km of riverbanks and covers an area of 483 km^2 (499 km^2 counting the neighboring islands).

This territory regroups 16 municipalities that form the agglomeration of Montréal, which is comprised of 15 related municipalities and Ville de Montréal (subdivided into 19 boroughs). It is inhabited by almost 2 million people, i.e. 24% of the population of Québec[2].

The agglomeration of Montréal has several large parks, ecoterritories and protected areas that cover 21.3% of its territory[1]. These green spaces are mainly located at the extremities of the island, except for Mount Royal Park, which acts as a true lung in the centre of downtown Montréal, and Jean-Drapeau Park, also located near the city's business district. There are nearly 1.2 million trees in the public spaces[3].

THE AGGLOMERATION OF MONTRÉAL IN A FEW FIGURES

90%	of the territory is urbanized
1.9 million	persons lived on the Island of Montréal in 2011
3,780	persons per square kilometre (2011)[4, 5]
45%	of the population is concentrated in the centre of the island
10%	of the population lives in the island's extremities
15%	of the population is aged from 0 to 14
16%	of the total population is 65 years of age or older
33%	of the population is immigrant, i.e. 1 of every 3 residents[4]
3%	of the population speaks neither French nor English
39%	of households are comprised of a single person[2]
42%	of the housing stock was built before 1961
6,200 km	of roadways and arteries
18	bridges to access the island
68	metro stations on 4 lines extending 71 km
5	lines of commuter trains

AGGLOMERATION OF MONTRÉAL

CLIMATE PROJECTIONS

The Climate change adaptation plan of the agglomeration of Montréal builds on climate projections provided by Ouranos. These projections were produced for the Southern Québec region, including Montréal. A historical analysis was also conducted on Montréal's meteorological and hydrological observations made in the past few decades. These historical trends for Montréal are consistent with those for Southern Québec, which validates the relevance of using these projections.

__Ouranos__ is a research and development consortium that relies on more than 450 scientists and professionals working on regional climatology and adaptation to climate change.

In terms of **temperatures**, the projections indicate an increase of approximately 2 to 4 °C for the 2041-2070 period and of 4 to 7 °C for the 2071-2100 period. Also, the length of the plant growing season, which has already increased in recent decades, should increase from 10 to 30 days by 2050, depending on the emission scenario that is chosen. The length of the freeze-up period should continue to decline. It is expected to decrease from 2 to 4 weeks compared to today. It is estimated that, for the 2041-2070 horizon, the snow-cover period should be shortened from 45 to 65 days compared to the historical period of 1970-1999. The most extreme projections suggest the possibility of having a snow-cover period of less than 20 days. Finally, the climate projections point to an increase in the number of freeze-thaw cycles in the wintertime, but to a decline in their number in the fall and spring by 2050.

The trend observed, with respect to an increase in **precipitations**, particularly in heavy rainfalls, is confirmed by the climate projections. By 2050, annual precipitations should increase by 3 to 14% with a greater emphasis on rainfalls in the winter (+2 to +27%) and in the spring (+3 to +18%). A significant increase in the frequency and intensity of heavy rain episodes is also expected. The intensity of heavy rain episodes should increase by 10 to 25% by 2100. Furthermore, a rainfall of a given intensity, with a return period of 20 years in the 1986-2005 timeframe, should occur more frequently near 2046-2065 with a return period of about 7 to 10 years.

Credit : © Yves Provencher, Journal Métro

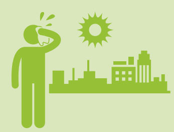
Similarly to the rest of the world, climate models forecast strong increases in the duration of **heat waves** as well as in the frequency of hot nights (minimum temperature > 20 °C). According to these same projections, the maximum extreme temperatures in the summer will increase more than the summers' average temperatures. This suggests longer and more intense heat waves in the coming decades.

As far as **destructive storms** are concerned (freezing rain, heavy rainfalls, hail and strong winds), the climate projections present great uncertainties. Despite the uncertainties in forecasting future destructive storms in Montréal, the trends that have already been observed and the considerable impacts that are associated with these destructive storms require a reflection and adapted measures for the agglomeration to better prepare itself to face these events in the future.

By 2081-2100, the majority of climate projections agree on shorter periods of meteorological **droughts** on an annual basis and in the winter (from December to February), but on longer periods during the summer season (June to August). By 2081-2100, the projections for abnormalities in soil moisture indicate annual drier conditions. This trend should be even more pronounced for summer seasons.

For Des Prairies River, a recent study simulated the average daily flow in 2042-2070. The results of this simulation suggest that spring **river floods** should occur earlier in the year than in the past (1972-2000). According to a study done by Ouranos, the levels of the St. Lawrence River should be lower in the vicinity of Montréal (from 20 cm to 120 cm) by 2050. In summary, it is expected that the spring floods of the Des Prairies River are trending to occur always earlier in the year. However, it is not yet clear whether these spring floods will intensify in the future. Hydrological models are still unable to take into account the frazil ice, which presently limits their predictive ability for this type of flood.

CLIMATE EVOLUTION ACCORDING TO VARIOUS HAZARDS*

 **INCREASE IN AVERAGE TEMPERATURES**	Extension of the summer season ↘ periods of freeze and snowfall ↗ number of freeze-thaw episodes
 **HEAVY RAINFALLS**	↗ frequency and intensity
 **HEAT WAVES**	↗ frequency and duration
 **DESTRUCTIVE STORMS**	↗ frequency of heavy snowfall episodes ↗ frequency of freezing rains
 **DROUGHTS**	↗ duration during the summer season
 **RIVER FLOODS**	↗ occurrence of spring floods earlier in the year

* The results of this table are based both on meteorological and hydrological observations in Montréal, and on projections for Southern Québec. The sole exception in terms of hazards is "Destructive storms" which only presents an analysis of meteorological observations in Montréal.

INCREASE IN AVERAGE TEMPERATURES

On the territory of the agglomeration of Montréal, one can observe a definite upward trend in temperatures (about 1 °C) between the 1970-1980 and 2000-2010 decades, similar to what is observed in the rest of Québec.

The increase in average temperatures has an impact on all seasons. For instance, the summer season is extended and the winter season is shortened, which has repercussions on climate related parameters. For example, in the 1955-1984 and 1985-2014 periods, we observed:

- an increase of nine days in the duration of the plant growth period;
- a five-day reduction of the freeze-up period;
- a marked reduction in the duration of the snowfall period, whose average of 103 days drops to 73 days on average.

Finally, a 29% increase in occurrences of freeze-thaw has been observed in the wintertime from 1942 to 2015.

Pothole on St. Lawrence Blvd., near Sherbrooke St. (25.02.2013)
Credit: © Dario Ayala, Montreal Gazette

IMPACTS

On the Montréal agglomeration territory, the impacts of the increase in average temperatures on the built environment are mainly observed in the wintertime. The increased number of freeze-thaw cycles entails an accelerated deterioration of the arteries of the Montréal roadway system and a greater presence of potholes. It also contributes to an accelerated deterioration of some bridges, tunnels and overpasses.

The increase in average temperatures also impacts the environment. Insects, whose metabolism depends directly on climate conditions, are extremely influenced by the temperature. These changes can generate an increase in the growth rate of some pests (harmful insects) and multiply the number of generations in a season. The changing climate may also modify the geographic distribution area of insects. It may also result in an increase in the frequency of infestations and in the seriousness of the damages caused to plants by pests.

Moreover, an increase of a few degrees can be sufficient to generate drastic changes in the biology of plants. Recently, the plant hardiness zone of Montréal has changed. The territory has gone from a 5B zone to a 6 zone, which implies changes in the distribution area of species and could stimulate the appearance of undesirable plant species.

Québec's plant hardiness zones are determined on the basis of Canadian data which include the minimum winter temperatures, the duration of the thaw-free period, summer precipitations, maximum temperatures, the snow-cover period, January rains and the maximum wind speeds. [6]

Tar spot on a maple leaf
Credit: © Équipe de lutte intégrée, Ville de Montréal

Pathogens (fungi, bacteria, viruses and nematodes), which are liable to cause infections in plants, are also impacted by an increase in temperatures. The increase in average winter temperatures could allow for the survival of a greater number of pathogen agents and, as a result, an expansion of their distribution area. Pathogen species that cannot survive in the present conditions could eventually attack plants in our region.

The increase in average summer temperatures could lead to an extension of the pollen production season. This situation is particularly preoccupying for allergenic plant species. For example, in Montréal, the pollen emission period of the common ragweed (*Ambrosia artemisiifolia* L.) has increased by three weeks between 1994 and 2002.[7, 8]

This lengthening of the pollen season can result in greater health problems for persons who are sensitive to allergens.

There are growing concerns regarding an increase in the prevalence of vector-borne and zoonotic diseases caused, among other factors, by the northward migration of vector-borne pathogen animal populations. Certain vector diseases such as Lyme's disease and the Nile fever, caused by the West Nile virus (WNV), have increased in the Province of Québec in recent years.

The increase in the winter average temperatures and the frequency of freeze-thaw episodes result in significant impacts on the operations of the agglomeration's municipalities. They entail an increase in costs owing to a greater reliance on the workforce and the consumption of resources (for ex. the need for abrasives during abrasive spreading operations).

The increase in average temperatures, resulting in an extension of the summer season, also has some positive impacts such as an increase in the number of days offering good conditions for outdoor work or an extension of the bicycle season.

NUMBER OF RECORDED CASES IN QUÉBEC OF LYME'S DISEASE AND NILE FEVER CAUSED BY THE WEST NILE VIRUS (WNV) SINCE 2002

PERIOD	NUMBER OF CASES RECORDED	
	Lyme's disease *	Nile fever **
2002 – 2003	Info not available	About 20 per year
2004 – 2010	< 15 per year	< 5 per year
2011	32	42
2012	43	132
2013	141	32

* MINISTÈRE DE LA SANTÉ ET DES SERVICES SOCIAUX. *Maladie de Lyme - Évolution de la maladie au Québec*, [Online]. [www.msss.gouv.qc.ca/professionnels/maladie-lyme.php#evolution-de-la-maladie-au-quebec] (Consulted May 25, 2015).

** MINISTÈRE DE LA SANTÉ ET DES SERVICES SOCIAUX. *Virus du Nil occidental (VNO) - Surveillance de cas humains de VNO au Québec*, [Online]. [www.msss.gouv.qc.ca/sujets/santepub/environnement/index.php?virus_du_nil#quebec] (Consulted May 25, 2015).

VULNERABILITY TO THE INCREASE IN AVERAGE TEMPERATURES

The agglomeration of Montréal's vulnerability to increases in average temperatures can difficultly be mapped. Indeed, there are no particular sectors that are more affected than others by this hazard. Therefore, we need to consider that it is the whole territory that needs to be covered and that will be impacted by these changes.

Nevertheless, certain elements have been identified as being sensitive to the impacts of an increase in average temperatures. For example, this is the case for concrete infrastructures which are sensitive to freeze-thaw cycles. Consequently, the road network and its associated structures such as bridges and tunnels are considered vulnerable.

The interactions between plants and insects are very complex. Both will be affected in many ways, but a more detailed analysis of all factors would require a finer understanding of their environment. Therefore, within the context of this first plan, it was agreed to draw a summary portrait of the issues without focusing on any particular sector. The implementation of projects on a local scale will require that certain aspects be analysed in more detail.

Finally, some groups of people were identified as being particularly sensitive to the extension of the pollen production season (children, young adults, persons suffering from asthma, etc.), but no analysis has been performed relative to their distribution on the territory.

MAJOR IMPACTS ON THE OPERATIONS OF THE MUNICIPALITIES IDENTIFIED WITHIN THE AGGLOMERATION OF MONTRÉAL ASSOCIATED WITH THE INCREASE IN AVERAGE WINTER AND SUMMER TEMPERATURES

WINTER
↑ of the average temperature
↑ of the frequency of freeze-thaw episodes

Salt spreading operations intended to make road surfaces and sidewalks safer will be multiplied since temperatures will more often approach the freezing point.

In periods of freeze-thaw, inspections of bridges, overpasses, tunnels, retaining walls and other road related structures are performed to prevent the fall of fragments. The likely increase in the number of freeze-thaw episodes risks entailing an increase in the number of these operations to check and secure these structures.

The maintenance of outdoor skating rinks has already become more difficult owing to the variations around the freezing point. The number of days during which it will be possible to practice this winter activity will decrease in the future.

SUMMER
Extension of the summer season
↑ of the average summer temperature

The demand for an access to water games, swimming pools and outdoor sports facilities will increase. An opening or access period beginning sooner in the spring and ending later in the fall will be expected by citizens. An adjustment will be required to meet the greater need for personnel responsible for the maintenance and surveillance of these facilities.

The lengthening of the summer season will bring about an increased demand for the resources dedicated to managing parks and green spaces, and caring for plants.

HEAVY RAINFALLS

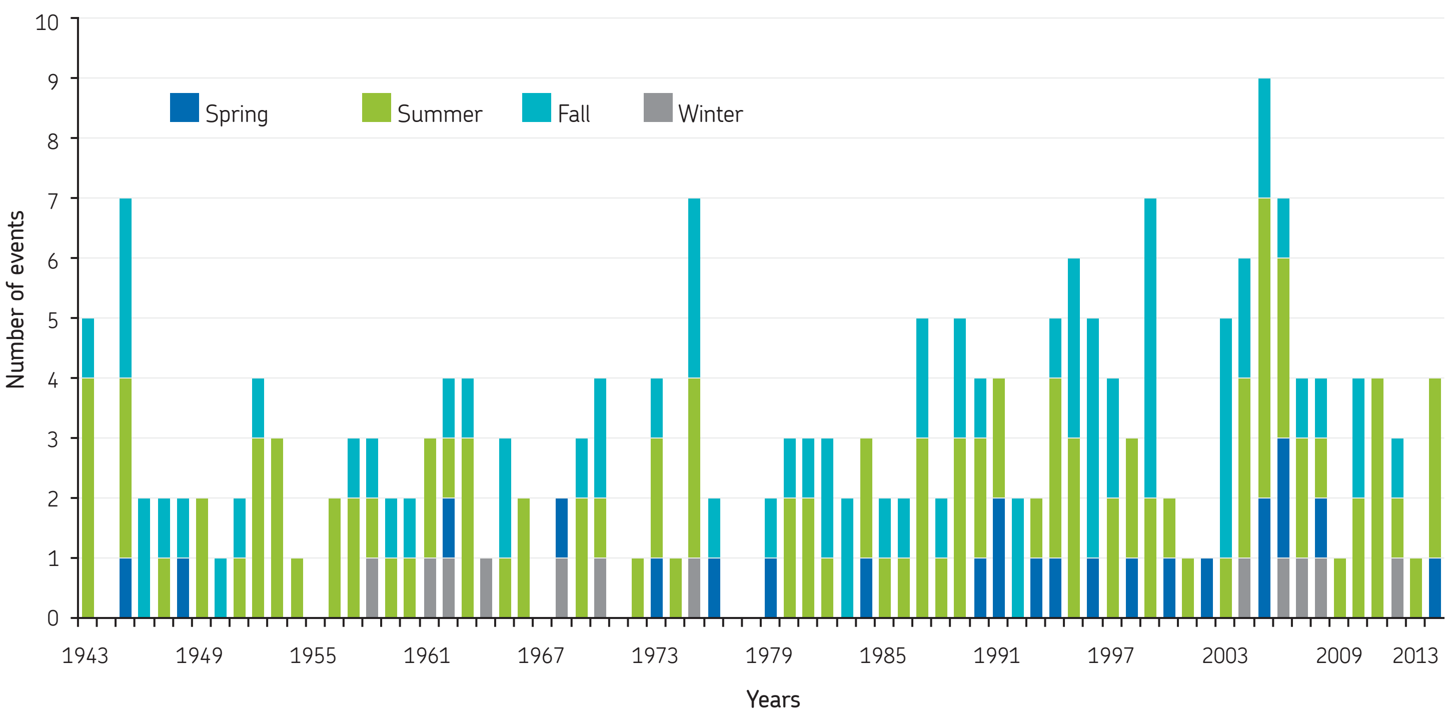
As a result of climate change, the air contained in the atmosphere warms up. This warmer air may hold more moisture. Consequently, the movement of water from the tropics to the boreal regions increases. Subpolar regions, like Québec, become more humid. Another impact consists in an increase in the frequency and intensity of heavy rainfall occurrences. This trend was observed in Southern Québec in the 1950-2010 period.

The figure below shows an increase in the number of heavy rainfall occurrences over the years on the territory of the agglomeration of Montréal, for the 1943-2014 interval.

Flooded street during the violent storm of May 29, 2012
Credit: © Olivier Pontbriand, La Presse

NUMBER OF DAYS DURING WHICH RAIN PRECIPITATIONS EXCEEDED 30 MM

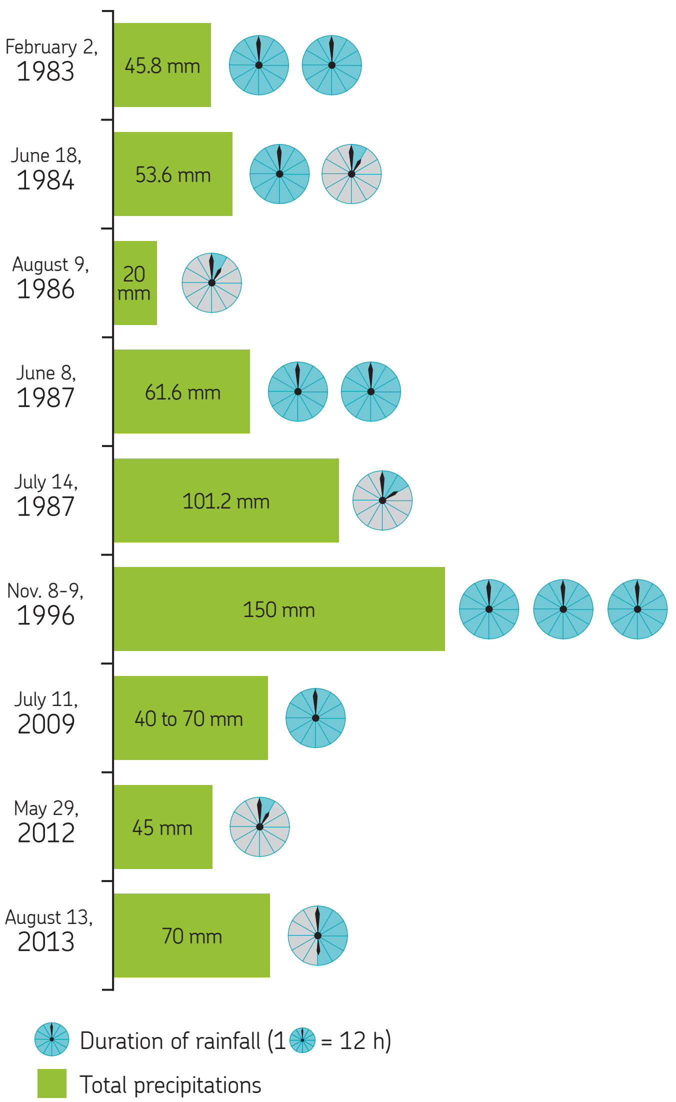
Data compiled by the meteorological station at Montréal-Trudeau International Airport.



LANDMARK EVENTS

In the past three decades, the Island of Montréal has witnessed many heavy rainfalls. Numerous negative impacts have been associated with these events. For example, on May 29, 2012, 45 mm of rain fell on Montréal in less than an hour, resulting in flash floods, and the closing of many streets and tunnels. Furthermore, many underground shopping centres in Montréal had to be evacuated, along with the metro stations of the orange line between the Berri-UQAM and Lionel-Groulx stations. Finally, about 15,300 homes were deprived of electricity.

HEAVY RAINFALL LANDMARK EVENTS ON THE AGGLOMERATION OF MONTRÉAL (1983-2013 PERIOD)



IMPACTS

During a heavy rainfall episode, the flow of wastewaters in sewers may increase drastically and the risks of an overflow can also rise rapidly in a short timespan. Once the network is saturated, runoff waters can no longer enter and they accumulate in lower points, which can cause flooding.

Basements are particularly at risk of being flooded. Factors such as the inadequate levelling of the ground and the presence of a garage entrance with a slope toward the house can result in the flooding of homes. Also, non protected buildings can suffer from a sewer backup, i.e. a return of water from the sewers in a building's plumbing that is not equipped with a check valve.

The flooding of buildings is responsible for considerable economic losses. First, they result in costs related to the destruction and damages to properties. Secondly, the increase in flood damages to buildings results in increased insurance premiums and can even sometimes reduce insurers' coverage of this risk.

Floods result, not only in health problems and economic losses, but also increased insurance premiums.
Credit: © Olivier Pontbriand, La Presse

Significant emotional or material losses can bring about psychological disorders among victims. Also, flooded buildings have a greater risk of developing mould issues. When these mould issues are significant, they can cause serious health problems, such as asthma and allergic reactions.

The strong flows of rainwater runoffs and floods in urban environments also damage the road network (particularly culverts), sewer systems (particularly retention basins, rainwater and combined sewers, and pumping stations) and underground facilities, which can result in service outages depending on the service (for ex. electricity, telephone, Internet, etc.).

In addition to reducing mobility in the territory, floods are an important cause of accidents, injuries and deaths. For example, two deaths were reported during the heavy rainfall that occurred in Montréal on July 14, 1987. An elderly man drowned when his car was submerged in the Décarie Expressway, while another man was electrocuted.

Finally, intense rains have few impacts on the environment. In fact, the vegetation and ecosystems of temperate areas are quite resilient to heavy rainfalls in the summertime. However, the overflow of wastewaters in waterways increases the quantity of pathogenic organisms and pollutants.

The operational impacts identified in Montréal in relation to the increased frequency and intensity of heavy rainfalls are related to public works, drinking water production activities and the treatment of wastewaters. For instance, paving works and the rehabilitation and replacement of water mains can be delayed during periods of heavy rainfalls, which can cause delays in the subsequent phases of the project.

On July 14, 1987, Décarie Expressway looked like some rapids after a rainfall of 101.2 mm in just two hours.
Credit: © La Presse

VULNERABILITY TO HEAVY RAINS

The agglomeration of Montréal's vulnerability to heavy rainfalls is determined through a geographic analysis of the areas having a water accumulation potential, as well as infrastructures and groups of persons sensitive to the impacts of this hazard.

Topography is the factor that influences water accumulation the most. The other significant parameter is urbanization. The older neighbourhoods, located in the centre of the island and having a high density of population, buildings and roads (Ahuntsic-Cartierville, Côte-des-Neiges–Notre-Dame-de-Grâce, Côte-Saint-Luc, Hampstead, Le Plateau-Mont-Royal, Rosemont–La Petite-Patrie, Saint-Laurent, Le Sud-Ouest, Verdun, Villeray–Saint-Michel–Parc-Extension) all have areas with a water accumulation potential on a major portion of their territory. The western and part of the eastern sectors of the island are less mineralized areas, which allows rainwaters to be partly absorbed by the ground, thus diminishing the potential for water to accumulate.

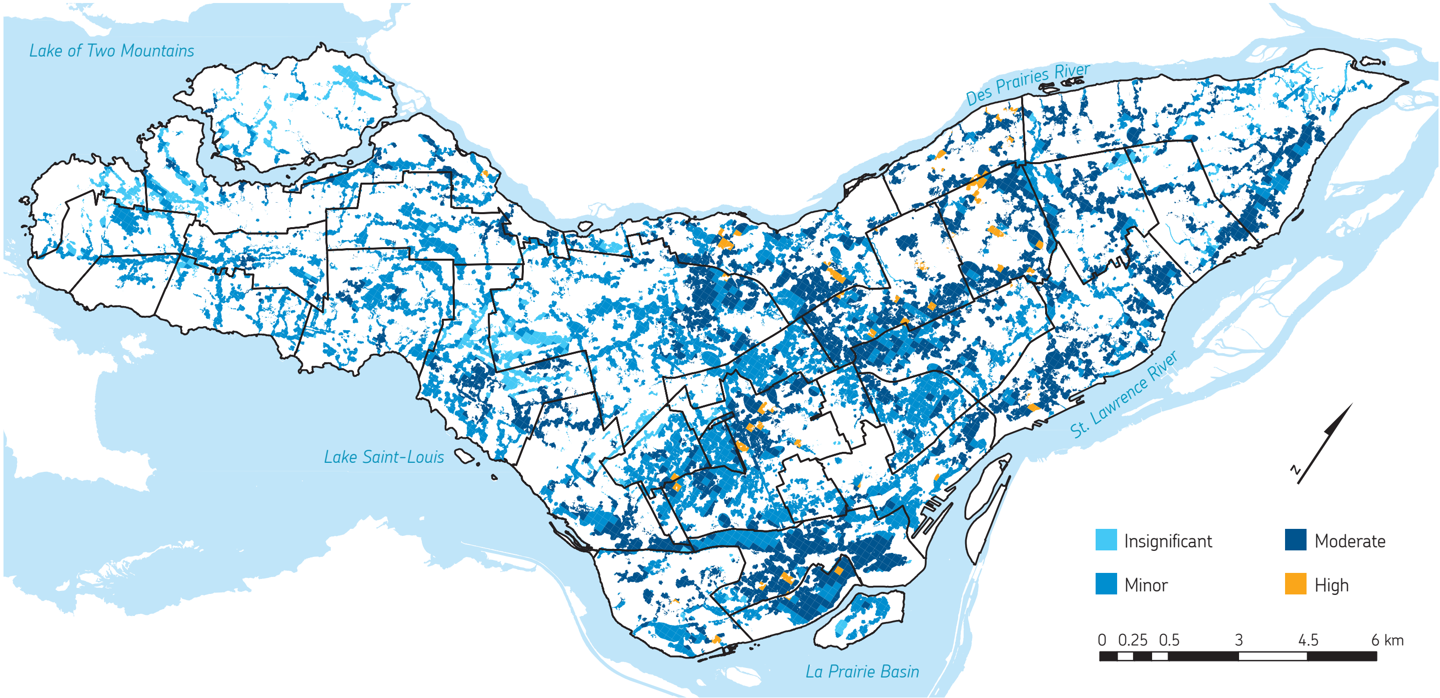
Finally, other factors such as the vegetation, type of soil and soil occupation influence the speed of runoffs, absorption and the accumulation of rainwaters.

Many infrastructures are sensitive to heavy rainfalls, of which the sewer network, buildings, in particular critical sites (hospitals, police stations, drinking water plants, etc.) or sites of interest (for ex. schools, metro stations, bridge entrances and exits, etc.), underground facilities and the road network.

Many groups of persons are sensitive to the impacts of heavy rainfalls, particularly children, persons aged 65 and more, and the materially disadvantaged.

The map below shows that an important part of the agglomeration features a minor or moderate vulnerability to heavy rainfalls and that the most vulnerable areas are found in the centre and eastern sectors of the island. Only a few areas are highly vulnerable, because they are located in areas with a risk of accumulation of runoff rainwaters along with the presence of sensitive infrastructures and groups of persons.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO HEAVY RAINFALLS



HEAT WAVES

Extreme heat, oppressive heat or heat waves are all expressions that explain the meteorological phenomenon that refers to abnormally high temperatures both in the daytime and nighttime. This heat, that accumulates faster than it can be evacuated, can last a few days and be accompanied by high humidity levels that are very uncomfortable.

Several aspects have to be considered when studying heat waves: duration, rate of humidity and contrast day/night. A heat wave that last for a long period of time or whose humidity is high (high humidex) will be particularly uncomfortable for people. It is the same when nights do not cool enough (night temperature remains above 20 ° C).

In Montréal, heat waves are on the rise, notably with an increase of 58% of nights with a high humidex value over the 1953-2012 period.

LANDMARK EVENTS

The agglomeration of Montréal has witnessed many heat waves in the last 70 years, some of which were particularly memorable and even resulted in fatalities.

LANDMARK HEAT WAVE EVENTS
ON THE AGGLOMERATION OF MONTRÉAL

DATE	AVERAGE TEMPERATURES	NUMBER OF FATALITIES
July 9-13, 1987	32.6 °C	169
June 16-18, 1994	33.1 °C	103
July 1-3, 2002	33.2 °C	30
August 14-18, 2009	30.7 °C	N. A.
July 5-10, 2010	33 °C	106
July 20-23, 2011	32.9 °C	13
July 14-19, 2013	32 °C	2

IMPACTS

In a densely populated urban environment, heat waves are an important public health issue. Indeed, periods of extreme heat provoke thermal stresses in persons, causing cramps, fainting and heat strokes. Extreme heat is also responsible for many discomforts, resulting in many hospitalizations, and may even aggravate the frail condition of persons suffering from certain diseases and cause premature deaths. In the past 30 years, heat waves have been responsible for over 400 deaths on the territory of the agglomeration of Montréal.

A crowded swimming pool in Laurier Park, Le Plateau-Mont-Royal
Credit: © Marco Campanozzi, La Presse

Heat waves can also produce and exacerbate the impacts of atmospheric pollution. The resulting poor air quality is a factor that can aggravate the symptoms of many health problems and restrict the practice of outdoor activities and sports.

Vegetation, which is so important in an urban environment, is also vulnerable to heat waves. Although trees and other plants can rely on defense mechanisms, a heat wave can induce shocks, among which hydric stresses that can greatly fragilize them and lead to illnesses. The vegetation that is impacted then requires more care or must be replaced. All of these happenings have impacts on the resources required for their upkeep and their maintenance costs.

Heat waves, even for a short duration, can diminish the populations of many insects. This impact may be positive in the case of harmful species, but the opposite will be true in the case of species such as pollinators.

The aquatic environment may also suffer from heat waves since they give rise to a rapid and massive increase in blooms of cyanobacteria. The proliferation of these blue algae can have numerous repercussions, among which the eutrophization of waterways which compromises their equilibrium and reduces their biodiversity, in addition to reducing the access to water for swimming.

Extreme temperatures can affect or weaken the agglomeration's infrastructures by impacting roads and arteries. Roadways that are heavily travelled and used by heavy vehicles may soften, deform themselves and produce ruts under the weight of these vehicles. Extreme temperatures can also cause premature damages to the expansion joints of structures.

Finally, heat waves can impact municipal operations and services. They also often give rise to an increased demand for certain services, such as the use of swimming pools, paddling pools and water games or an extension of the 'business' hours of air conditioned public buildings such as libraries and community centres. These demands will result in an increase in interventions and an increased need for personnel to provide services to the population, maintain the infrastructures and deploy emergency measures, when necessary.

Appearance of a bloom of cyanobacteria in the summer of 2012 at the last lock of the Lachine Canal, just before the mouth of the Old Port of Montréal
Credit: © Réseau de suivi du milieu aquatique, Ville de Montréal

VULNERABILITIES TO HEAT WAVES

Heat islands cover 28% of the Island of Montréal. They are mainly found in the northern and eastern sectors of the agglomeration. The boroughs of Ville-Marie, Plateau-Mont-Royal, Sud-Ouest, Mercier–Hochelaga-Maisonneuve, Villeray–Saint-Michel–Parc-Extension, Montréal-Nord and Saint-Léonard present the greatest area of heat islands.

From all of the factors described that contribute to the vulnerability of certain sectors of the territory (see the table on the following page), one needs to add the presence of populations that are particularly sensitive to this hazard, namely young children and the elderly, especially those who live by themselves or suffer from chronic diseases. Also, certain immigrants may be more vulnerable to heat waves because of their inability to speak and understand French and English. This is because, in addition to not being reached by the heat wave advisories and recommended response measures, they are less inclined to ask for assistance. The same is true for people who live in social isolation. Finally, the level of revenue influences citizens' vulnerability, since the most disadvantaged have a lesser access to air conditioning.

Vegetation is also sensitive to heat waves, particularly when it is found in urban heat islands. In fact, although there are generally few trees in urban heat islands (UHI), those that are present are particularly vulnerable to heat waves, since the temperatures therein are greater than those elsewhere on the territory.

Finally, since roads and arteries are likely to be affected by heat waves, they are identified as being infrastructures sensitive to this hazard.

A map of the vulnerability relative to heat waves has been prepared using all of these factors in order to identify the sectors that are the most sensitive to heat waves. This map is an extremely useful tool to target vulnerable sectors and then decide on the most appropriate adaptation strategies.

FACTORS CONTRIBUTING TO THE FORMATION OF URBAN HEAT ISLANDS

Type of materials - Certain materials absorb a lot of heat in the daytime and release this heat at night, which explains why temperatures remain high at night in urban heat islands.

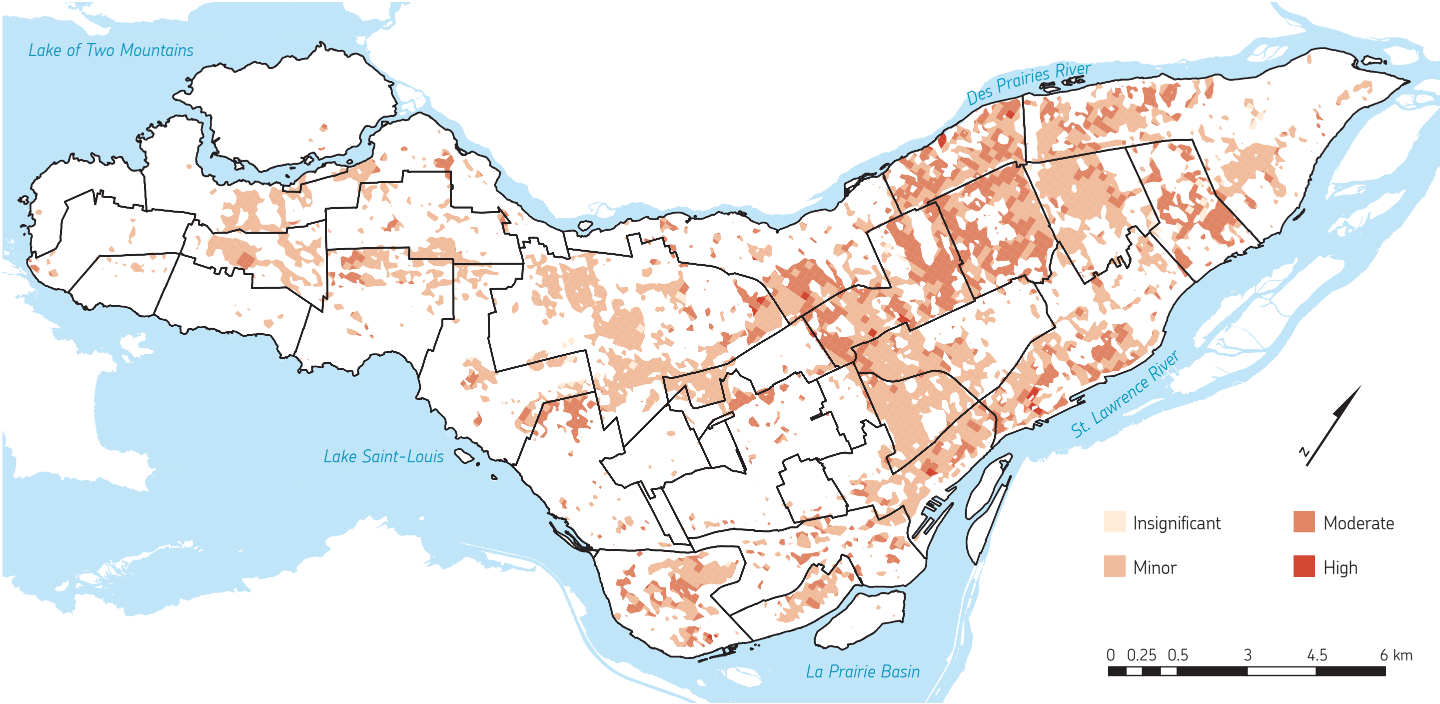
Lack of vegetation – In addition to absorbing part of the heat that would otherwise be stored by materials, vegetation refreshes the ambient air through the transpiration process.

Soil sealing – Permeable soils allow for a partial evaporation of the water they contain in periods of extreme heat. This evaporation is produced through the absorption of the energy of ambient air, which then refreshes the air.

Human (anthropic) activities – Many human activities release heat, among which air conditioning, the motors of vehicles and certain industrial activities.

Urban morphology – An urban geometry that combines narrow streets and tall buildings contributes to the formation of urban heat islands.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO HEAT WAVES



DESTRUCTIVE STORMS

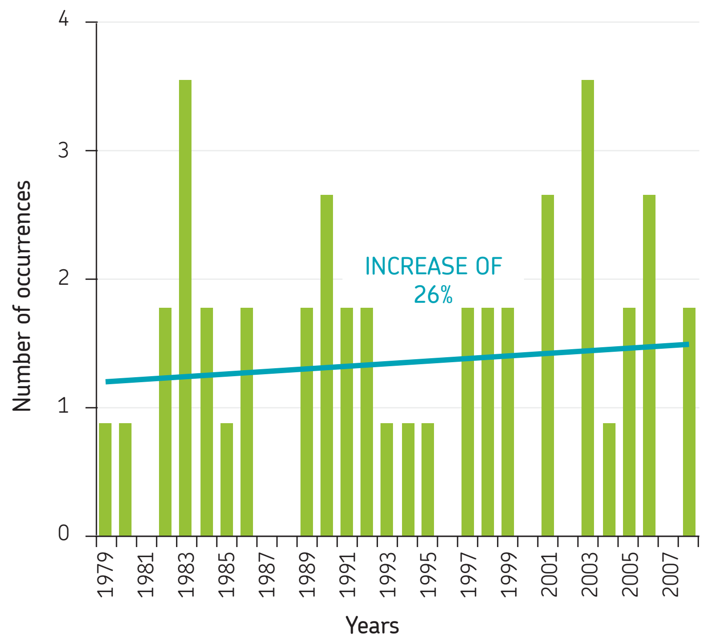
The destructive storm hazard regroups many types of storms: wind storms, hail storms, heavy snowfalls and freezing rain. This grouping was made mainly on the basis of the devastating impacts these events can entail.

The meteorological data that are presently available for Montréal do not allow for an assessment of the evolution of wind or hail storm occurrences in the past decades.

With respect to freezing rain events, a team of researchers from McGill University recently collected data from 1979 to 2008 [9], that show an increase of about 26% in the number of events that occurred on the agglomeration of Montréal. As far as heavy snowfalls are concerned, their number increased in the past 70 years. Indeed, the Island of Montréal witnessed 13 days during which there fell more than 30 centimetres of snow during the 1994-2014 period, whereas this phenomenon only occurred 9 times during the 1942-1993 period.

EVOLUTION OF FREEZING RAIN EPISODES ON THE AGGLOMERATION OF MONTRÉAL

Data derived from RESSLER et al. [9]



Strong winds knock down a huge tree branch on a vehicle in the Hochelaga-Maisonneuve district. (01.11.2013)
Credit: © Patrick Sansfaçon, La Presse

LANDMARK EVENTS

In the past 30 years, many destructive storms have hit the Island of Montréal. These events resulted in numerous negative impacts. For instance, on January 5, 1998, from 5 to 80 mm of freezing rain fell from the Maritimes up to the Ottawa and St. Lawrence River Valleys. This was the second costliest disaster in Canadian history with 28 deaths, 945 injuries and 600,000 evacuees.[10, 11]

LANDMARK EVENTS ON THE AGGLOMERATION OF MONTRÉAL

DATE	TYPE OF STORM	PRECISIONS
November 16, 1983	Snow and freezing rain	20 cm of snow
December 13, 1983	Freezing rain	N.A.
December 3, 1984	Snow	21 cm of snow
May 29, 1986	Hail	Hailstones up to 8 cm in diameter
June 29, 1986	Hail	Hailstones of 0.5 to 1.5 cm in diameter
November 20-22, 1986	Snow	30 cm of snow
January 22-23, 1987	Snow	30 cm of snow
May 29, 1987	Hail	Hailstones of 1 to 1.2 cm in diameter
July 18, 1987	Hail	N.A.
February 12-13, 1988	Snow	20 cm of snow
January 5, 1994	Snow	25 cm of snow
January 5, 1998	Freezing rain	According to sources, 5 to 80 mm of freezing rain
January 18, 2012	Wind	N.A.
December 27, 2012	Snow	45 cm of snow in less than 24 hrs
July 19, 2013	Wind	Winds exceeding 100 km/h

1998 ice storm crisis
Credit: © Denis Labine, Ville de Montréal

December 27, 2012 snowstorm
Credit: © Matias Garabedian, Flickr (CC BY-SA 2.0)

IMPACTS

Strong winds, the accumulation of freezing rain, hail and heavy snowfalls can all result in distortions, damages and an accelerated wear of infrastructures and vegetation. The severity of the damages depends on the force of the storm (wind speed, the thickness of the accumulation of freezing rain or snow, the size of the hailstones). Destructive storms have a direct impact on the population through their consequences on the life, health and on activities in the city.

In the Montréal agglomeration, the damages inflicted by destructive storms mainly consist of falling trees and branches, damages to roofs or other components of the building envelope. On the one hand, strong wind bursts can tear up or raise certain elements of a house, for example its roof. Not only can they compromise the integrity of buildings, they can also cause serious damages in the vicinity. For example, flying debris may hit and damage windows, window displays and façades, in addition to being a hazard for pedestrians. On the other hand, heavy snowfalls and freezing rain can overload a roof structure and inflict damages.

The damages caused to homes can entail costs related to material damages, but also result in increased insurance premiums and reduced coverage for some homeowners. Disaster victims may also suffer from psychological trauma.

Destructive storms may also cause power outages. Electrical cables may be broken, either by strong winds or the accumulation of ice for instance. When power outages occur in the wintertime, citizens may have to leave their home in search of warmth. It can also cause carbon monoxide intoxications due to the indoor use of heating or cooking devices designed for an outdoor use. Moreover, the stoppage of residential medical equipment and the increase in food poisoning due to the interruption of refrigerators and freezers are also a direct consequence of power outages, and this in all seasons.

Aerial commodities other than electricity may also be damaged. The damages inflicted on lights or traffic signs, as well as the snow, freezing rain or debris on the ground, can disrupt road traffic. Also, health issues may be aggravated when those suffering are limited in their movements.

The environmental impacts of destructive storms in an urban milieu mainly affect the vegetation, particularly trees. Whenever snow and freezing rain accumulate and are accompanied by very strong winds, trees may be uprooted or their trunks broken. In addition to affecting the normal growth and shape of trees, the damages inflicted to trees by freezing rain can render them more vulnerable to insects and illnesses.

The operational impacts that have been identified in relation to destructive storms in Montréal are related to an increase in the cost of operations, among these those pertaining to snow removal and tree pruning, an increased deployment of first responders and of personnel to clear snow or spread melters and abrasives to make roadways and sidewalks safer.

Snow clearing in Montréal
Credit: © Martin Chamberland, La Presse

VULNERABILITY TO DESTRUCTIVE STORMS

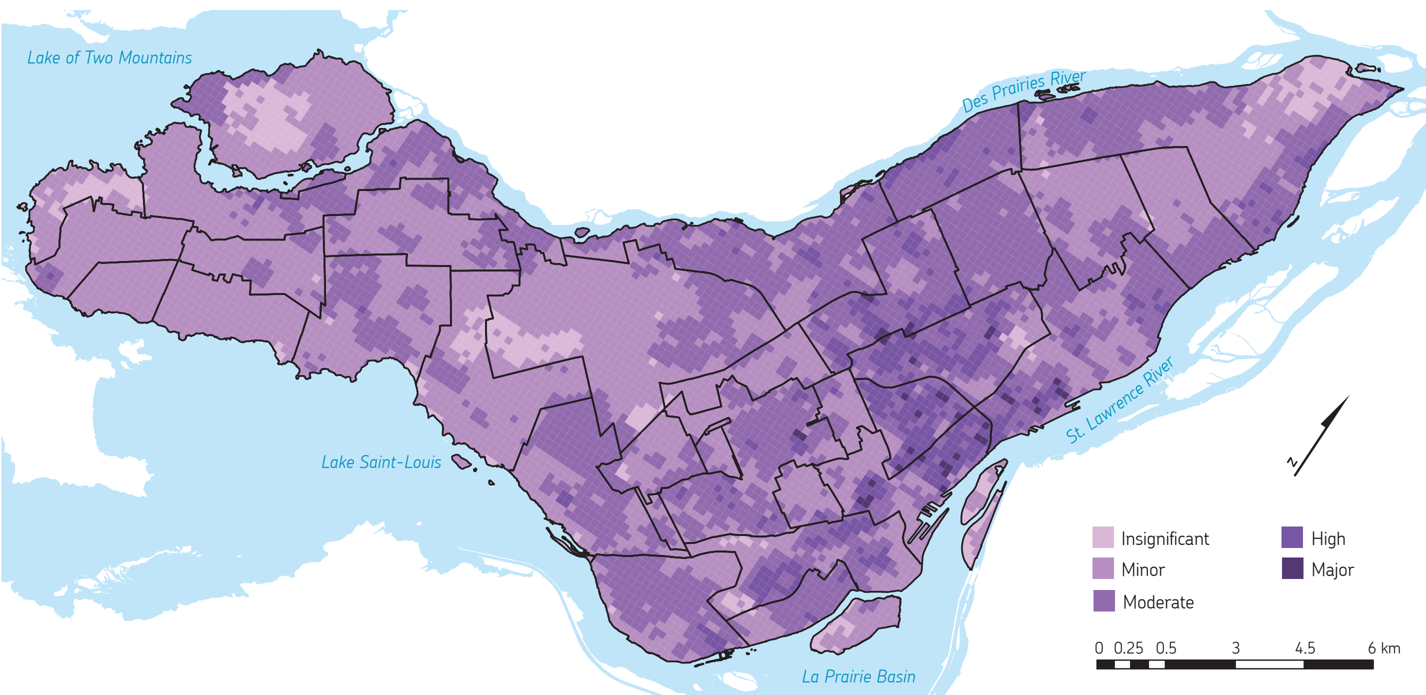
The vulnerability of the agglomeration of Montréal to destructive storms is obtained by geographically identifying the infrastructures and groups of persons sensitive to the impacts of this hazard and by assuming that all sectors within the agglomeration of Montréal are liable to be hit by a storm.

Buildings as well as critical sites and places of interest (for ex. hospitals, police stations, subway stations) are considered vulnerability factors when present in an area hit by a destructive storm. Indeed, significant impacts are associated with the presence of these elements on the territory either because of direct damage to buildings or impacts resulting from the limited access to places of interest.

Regarding social sensitivity factors, the three groups of persons identified as the most vulnerable to storms are the materially disadvantaged, those living alone and the elderly. Consequently, the sectors that are home to people possessing many of these characteristics present a high vulnerability.

The map below shows that more vulnerable sectors can be found just about everywhere on the Island of Montréal with a slight concentration in more densely populated neighbourhoods, owing to the concentration of sensitive persons and infrastructures in those sectors.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO DESTRUCTIVE STORMS



DROUGHTS

Different definitions of droughts can be found in the literature. Each describes a different reality and their use depends on the issue that is considered. If one focuses on the number of consecutive days without any precipitations, then one is referring to a meteorological drought. If the focus is on a water deficit in the ground, the reference is to ground or soil dryness (also called an agricultural drought). As far as a hydrological drought is concerned, this type of drought refers to particularly low levels of surface and groundwaters. Finally, a socioeconomic drought integrates the actions of humans on water resources. Obviously, these types of droughts are all interrelated. Within the context of this adaptation plan, ground dryness is the one that is most often mentioned due to its potential considerable impacts on the territory of the agglomeration.

LANDMARK EVENTS

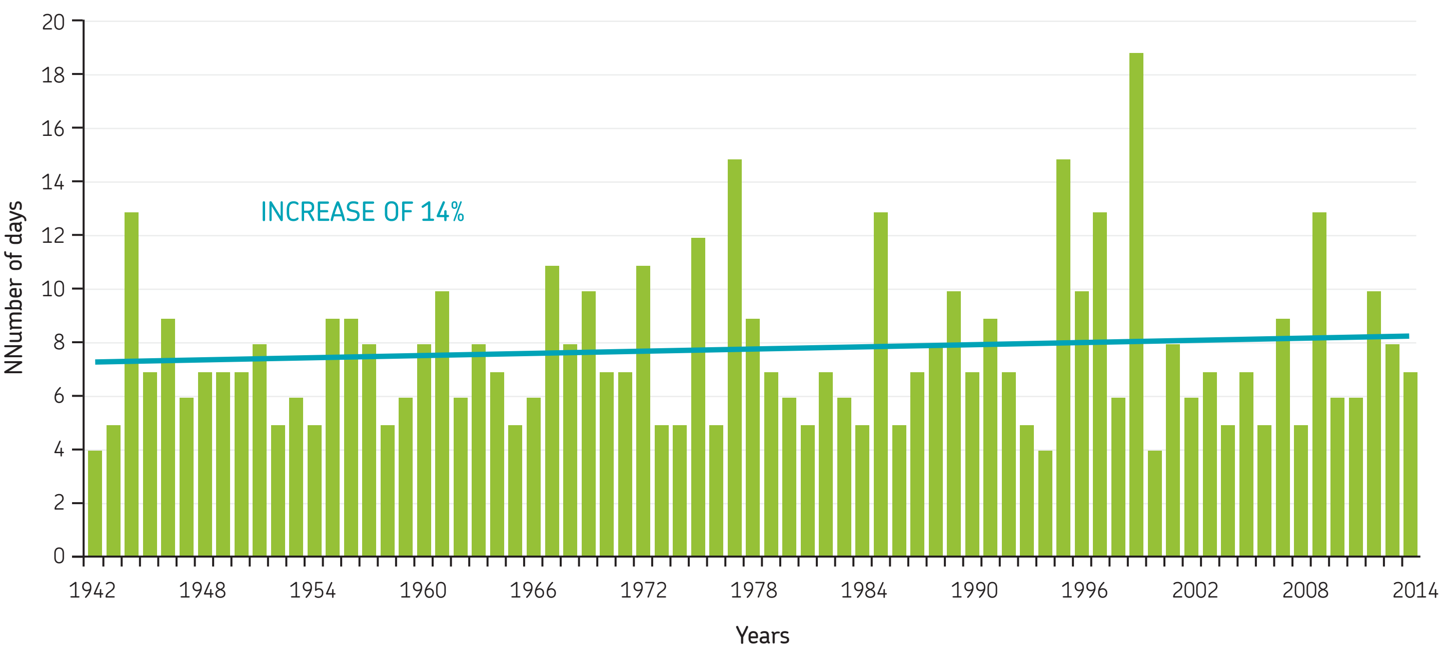
No drought of significant importance has been recorded for the agglomeration of Montréal in the past 30 years. The last major drought occurred in 1957, when some 2.1 millimetres of rain were recorded in Dorval and 0.6 millimetres in the McGill University station in August. August 1957 is considered the driest month on record in the Greater Montréal Region.

One can assess whether meteorological droughts have increased in Montréal by calculating the number of consecutive days without any precipitations in a given time interval, as illustrated in the figure below. On this basis, one can observe a very slight upward trend in drought occurrences. However, it is not significant and it is still too early to attribute it to climate change. Furthermore, on average, for the whole of Southern Québec, the recorded data show a slight downward trend of the indices of meteorological drought.

With respect to agricultural, hydrological and socioeconomic droughts, historical observations to date do not allow us to conclude that they have significantly increased in Montréal owing to climate change. Despite these observations' uncertainties, the indications for a long-term change seem clearer. Indeed, the projected increase in the number of droughts only becomes reliable starting in the 2081-2100 period. However, there should be no alarming situation from now until 2020.

EVOLUTION OF THE NUMBER OF CONSECUTIVE DAYS WITHOUT PRECIPITATIONS FROM MAY TO SEPTEMBER BETWEEN 1942 AND 2014

Data compiled by the meteorological station at Montréal-Trudeau International Airport.



IMPACTS

The impacts of droughts on the territory of the agglomeration of Montréal are mainly related to dry soils. These result in damages to buildings and infrastructures built on clay soils when the necessary mitigating measures were not applied to these constructions. Settling of foundations may occur when clay soils dry up, thus causing a retraction of the soil. These damages consist in the appearance of tears in the foundations which may progress to the walls.

Economically speaking, these damages may have serious consequences. Since home insurance generally does not cover the damages caused by the settling of clay soils, their owners must assume the total repair costs, often very expensive, of the required work on the foundations.

Similarly, dry soils may also damage sidewalks, road surfaces and sewer lines built on clay soils.

The environmental impacts of droughts in urban settings mainly affect the vegetation and waterways. In periods of droughts, the quality of water is generally impaired due to various factors: a rise in water temperatures, a decline in dissolved oxygen concentrations, conditions favouring the development of the efflorescence of cyanobacteria, eutrophization and an increased concentration of certain pollutants.

Droughts are a source of hydric stress for plants that may even kill them should the drought be protracted. This stress can reduce the vigor of trees and increase their vulnerability to pests and pathogens. By impacting the vegetation, droughts reduce the many ecological services that it provides.

Periods of droughts are often accompanied by extreme heats that affect the levels of atmospheric pollutants. Under dry conditions, dust and particles, as well as pollens, are more easily airborne and contribute to poor air quality. This greater presence of airborne pollutants and pollens is believed to exacerbate the symptoms of respiratory and cardiovascular illnesses, and contribute to degrading the health of persons who are already frail.

In the agglomeration of Montréal, the operational impacts of droughts particularly affect drinking water production activities and the maintenance of green spaces and streets.

Cracks in wall likely due to shifting foundations
Credit: © Ville de Montréal

On the one hand, the increased demand for water, because of the drought, could result in too much pressure being brought upon water treatment and purification equipment. This increased demand could entail a shorter network interval, enfeeble the system in the event of a problem and cause an increase in production costs. The adduction ability could be impaired if water levels were very low, thus restricting the capacity of water production plants.

On the other hand, greater coordination and more resources are necessary to ensure the durability of amenities, green spaces and street trees.

Finally, more street cleaning operations are required for streets to remain clean, as under dry conditions they tend to degrade.

VULNERABILITY TO DROUGHTS

The agglomeration of Montréal's vulnerability to droughts is determined by considering the buildings constructed in areas where soils are likely to shrink when dry and there are groups of persons sensitive to the impacts caused by droughts, especially due to impaired air quality.

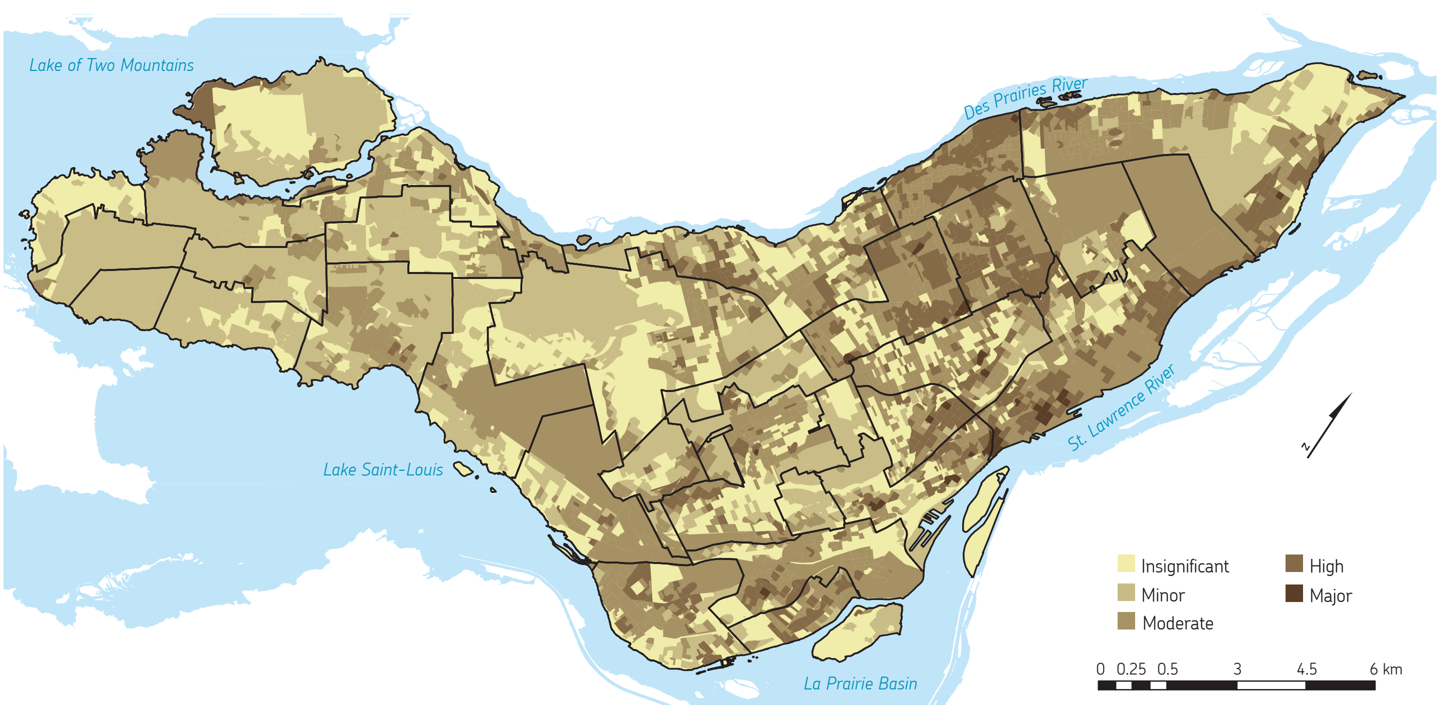
The type of soil was the only factor used to determine the sectors sensitive to soil contraction in the agglomeration of Montréal. As was mentioned previously, the soils that contract when dry are clay soils. However, factors such as the soil's water retention potential and the soil's occupation also influence its degree of dryness. For example, roads, parking lots and buildings are all impermeable infrastructures that prevent the absorption of rainwaters by the soil.

As described previously, buildings, roadways and sidewalks are sensitive to soil contraction when they dry up. The agglomeration of Montréal is particularly sensitive to this phenomenon, as a large portion of its soils is clayey. Consequently, the density of buildings is a critical factor in a vulnerability analysis.

In terms of the social aspect, the groups of persons who are the most sensitive to droughts are the disadvantaged and persons living alone.

To summarize, vulnerability to droughts varies greatly from one sector to another in the agglomeration, mainly depending on the density of buildings and the concentration of persons sensitive to the impacts associated with poor air quality.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO DROUGHTS



RIVER FLOODS

Climate change alter the hydrological cycle owing to more occurrences of heavy rainfalls and droughts. This modification of the water cycle has an impact on floods. A flood refers to a situation whereby the flow rate or level of a river exceeds a critical threshold.

The risk of flooding for the agglomeration of Montréal mainly concerns the boroughs and related municipalities along the Des Prairies River. Those whose territory touches the banks of the St. Lawrence River are less subject to be affected by this hazard.

LANDMARK EVENTS

The last significant river floods on the Island of Montréal occurred in April 2004 and 2008, and both concerned the Des Prairies River.

HIGHLIGHTS OF THE LAST SIGNIFICANT FLOODS OF 2004 AND 2008

DATE	PRECISIONS
April 2004	Accumulation of frazil in the Des Prairies River in the sector of Pierrefonds, which resulted in an increase in water levels. An ice jam* upstream of the river aggravated the flood phenomenon. A few homes were flooded.
April 2008	The heavy snowfalls of the winter of 2007-2008 and the regular snow melt in all of the Ottawa River watershed resulted in an important water intake in the Des Prairies River in the spring of 2008. Many sectors were impacted, of which Ahuntsic-Cartierville, Pierrefonds, L'Île-Bizard, Sainte-Anne-de-Bellevue and Senneville.

*According to Environment Canada's definition, an ice jam is an "An accumulation of broken river ice or sea ice not moving due to some physical restriction and resisting to pressure."

The ices of the Des Prairies River tore down the fence of the Berthiaume-du-Tremblay Residence in the borough of Ahuntsic-Cartierville. (18.04.2014)
Credit: © Philippe Rachiele – journaldesvoisins.com

Based on the data since 1942, one notices that spring floods recur earlier in the year. Not only do these floods seem to happen earlier in the year, but the maximum levels recorded reached unprecedented levels between 1972 and 2000. Flow rates exceeding 3,550 m^3/s were recorded, well in excess of the critical threshold (of 2,550 m^3/s) set by the Centre de sécurité civile.

The shortening of the winter season has resulted in an earlier spring thaw, which explains the occurrence of spring floods earlier in the year. The multiplication of thaw periods that entail an increased number of freeze-thaw cycles fosters the formation of ice jams, disrupting the normal flow of the waterway and provoking floods. The agglomeration of Montréal was accustomed to ice jams from the beginning of April to the end of May, but in recent years, these ice jams have been observed even in January and February.

IMPACTS

Whenever the flow rate or level of a river exceeds a critical threshold, the river overflows causing a flood. In an urban setting, floods result in damages to the built environment and especially to buildings located in flood plains. They also impact sewer networks and underground commodities.

In flood periods, the sewer systems may be saturated more quickly, resulting in backed up sewers in some buildings. The heavy floods may weaken the infrastructures that are too solicited and damage them. Spring floods may also cause damage to underground commodities (for ex. electricity, telephone, Internet, etc.) which can lead to service outages.

Also, floods provoke the premature erosion and destabilization of riverbanks. Eroded riverbanks drag sediments into the water, which may impair its quality.

Spring floods also impact the health of the populations affected. Not only can they bring about gastrointestinal illnesses through a direct contact with the flood waters, they can result in psychological trauma to those persons incurring major material losses. Moreover, flooded basements are subject to the proliferation of mould, which can result in serious health issues such as asthma and allergic reactions.

Floods in an urban environment can make it more difficult to move around, close sections of roadways and slow down traffic. Tunnels and viaducts may sometimes be submerged, causing traffic problems and even endangering the life of people trapped in their vehicle.

Finally, river floods require an important mobilization of the resources responsible for the implementation of emergency response measures.

The froglike amphibious backhoe at work in the Des Prairies River. (27.01.2009)
Credit: © Ivanoh Demers, La Presse

VULNERABILITY TO RIVER FLOODS

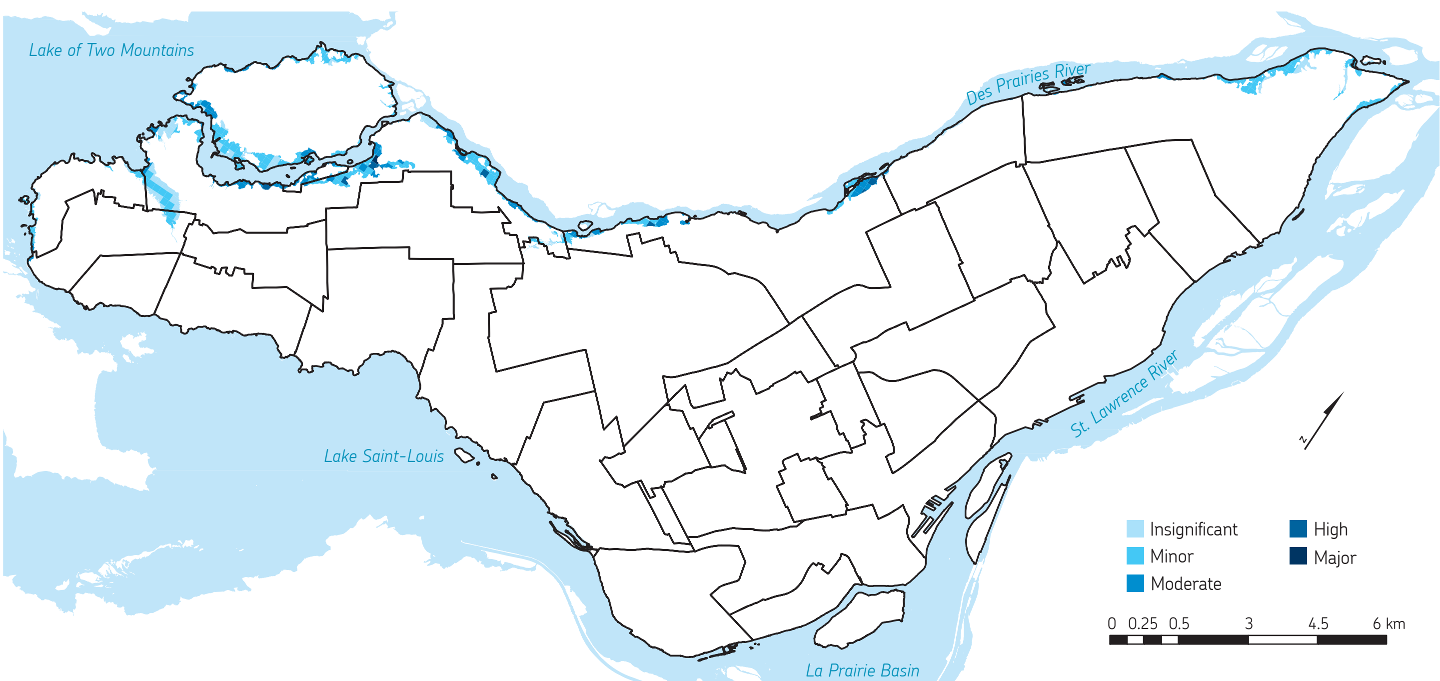
The sectors that are vulnerable to floods are identified on the following map. These sectors are located on the territory of the following municipalities and boroughs: Pierrefonds-Roxboro, Ahuntsic-Cartierville, Montréal-Nord, Rivière-des-Prairies–Pointe-aux-Trembles and Senneville.

Any infrastructure and/or population located within a flood-prone area is considered vulnerable. The extent of this vulnerability depends on a host of factors: the density of buildings, the presence of critical sites such as hospitals, police stations, a drinking water treatment plant and the presence of sites of interest such as schools and bridge entrances and exits.

The presence of roads is also a factor that can make a sector more vulnerable to floods. Water that accumulates under a street's foundation contributes to its premature wear and to damages to these infrastructures.

Finally, the sectors that feature a high population density are obviously more vulnerable to the impacts of floods.

AGGLOMERATION OF MONTRÉAL VULNERABILITY TO RIVER FLOODS

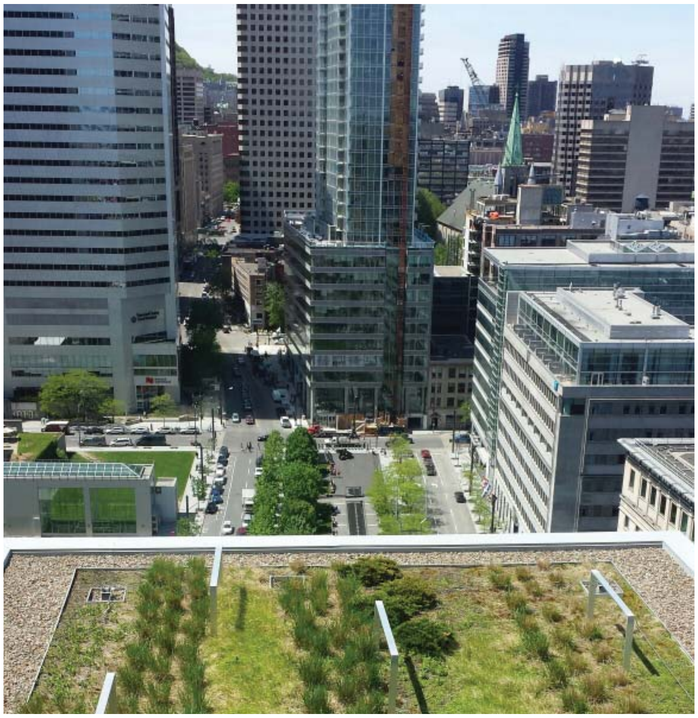


ADAPTATION MEASURES

Adaptation measures are the core of this first climate change adaptation plan for the agglomeration of Montréal. These measures aim to reduce the territory's vulnerabilities and translate how the municipal actors are adjusting or will adjust to a changing climate.

The measures announced in this first plan consolidate the experiences acquired and reinforce our capacity to integrate climate issues into all of the city's activity spheres.

For each hazard, three to six key measures were identified through a collaboration between central departments, municipalities and boroughs, as well as specialists in the field of planning, green spaces, buildings, water management, sports, etc. These key measures then translate into many actions that will be implemented by central departments, municipalities and boroughs (see table on the following page).



Green roof on one of the towers of Québecor Média's headquarters
Credit: © Philippe Aubry

The choice of actions of this first climate change adaptation plan was made on the basis of the following criteria:

- **Implementation has already started or been planned**
  Some plans, strategies and regulations already incorporate measures contributing to the climate change adaptation. The adaptation plan is an opportunity to consolidate its actions.
- **Feasibility in the short term, i.e. by 2020**
  Their implementation requires a brief period of time and can be implemented by the end of the period covered by this plan.
- **Adaptation potential to more than one climate hazard**
  Certain actions have co-benefits, allowing them to increase their resilience to more than one hazard.

To conclude, another criteria was added for the adaptation measures that will be implemented at the local level by the boroughs and municipalities. Indeed, they must be **consistent with the diagnosis of local vulnerability** that was presented to them.

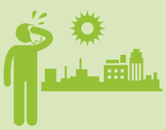
FOLLOW-UP MECHANISMS

A mid-term report on the climate change adaptation plan will be prepared in 2017-2018. This assessment will also present an opportunity to amend or enhance the plan.

A final report on this first adaptation plan will be published at the end of the period covered by the plan, i.e. 2015-2020.

In order to perform a follow-up that is as precise as possible, the commitments included in the plan are accompanied, in most cases, by a specific objective and an indicator for monitoring progress. Each department, municipality and borough shall be responsible for providing the City's Service de l'environnement the data relative to the progress recorded in the implementation of their measures for the purpose of preparing mid-term and final reports.

CATEGORIES OF ADAPTATION MEASURES FOR EACH CLIMATE HAZARD

	INCREASE IN AVERAGE TEMPERATURES	– Protect biodiversity – Increase the resilience of infrastructures to freeze-thaw phenomena – Adapt the offering of winter recreational activities and maintenance activities – Increase the offering of summer recreational activities and maintenance activities – Control undesirable plant species
	HEAVY RAINFALLS	– Control or collect rainwaters – Increase the resilience of infrastructures and buildings to rainwaters – Minimize impermeable surfaces – Ensure the capacity of storm sewer and combined sewer systems – Increase and preserve the vegetation cover – Develop emergency response measures for heavy rainfalls
	HEAT WAVES	– Counter heat islands – Design spaces allowing people to refresh themselves and avoid exposure to extreme heat (cool areas) – Protect biodiversity against heat waves – Develop emergency response measures for heat waves
	DESTRUCTIVE STORMS	– Increase the resilience of infrastructures and buildings to strong winds and freezing rain – Develop emergency response measures for extended power failures (in winter conditions) – Increase the resilience of vegetation to strong winds and freezing rain
	DROUGHTS	– Ensure both the quality and quantity of drinking water – Increase the resilience of infrastructures and buildings to the drying out of soils – Increase the resilience of vegetation to droughts
	RIVER FLOODS	– Increase the resilience of infrastructures and buildings to flooding of river banks – Develop emergency response measures for flood-prone areas – Increase the stability of river banks against erosion

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