



Source: Montréal, Canada, 2020

MONTREAL

Canada

2021 Exploring Urban Resilience Pathways



About the report and the collection

Exploring Urban Resilience Pathways

This report is part of a collection wishing to provide a global overview about different cities' experience in resilience, and how this is evolving. The series is titled "Exploring Urban Resilience Pathways" and each report is prepared by one student of the Int. MSc. in City Resilience Design and Management (URNet-UIC Barcelona). During the first semester, students develop these reports as a learning outcome for their acquired analytical skills: to find, understand, organize and communicate critically different perspectives, approaches and models of urban resilience implementation, in a chosen city.

The aim of each report is thus to offer an easy-to-read overview about how adaptive capacities have been evolving in a selected city. The reports explore the past and current mechanisms through which each city responded to overlapping shocks and stresses. Nowadays current City Resilience Strategies – launched and supported by the Rockefeller 100RC program – are included within these analyses, representing the ultimate trend of understanding and implementing city resilience. Finally, current COVID19 pandemic responses are the final lens through which resilience mechanisms are discussed, to understand the alignment of resilience with other key urban goals, and ultimately respect to urban living.

What is interesting to learn from this series of reports, is that each of them critically discusses how cities managed adaptive responses to different threats, and how the concept of resilience evolved. Although the scope of these reports is ambitious and the analysis could result complex, the presentation has been designed to be easy to read and accessible to the general public. Each report of this collection maintains a standard structure, facilitating the reading and the reports (and cities) comparison.

Hope this initiative contributes to spread the understanding about how resilience has been framed and implemented in many cities across the globe.

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Montréal Canada

2021 Exploring Urban Resilience Pathways

SUMMARY

The Canadian city of Montréal is no stranger to urban adaptive strategies and resilience practices. As Québec's largest city and one with such a rich history, Montréal has had its fair share of struggles over the years. As an island with an advantageous geographic location, the city has long been placed in the public eye. In the 17th and 18th century, its location was strategic for Canadian trade and in the 19th century it exhibited a strong economic foothold for the British Empire in North America. In more recent years, the city has the second largest port in Canada and the only container port in the Québec-Ontario region. However, with these benefits came a flood of challenges which the city tried to overcome.

Montréal upheld its prominence in the 21st century as it became the first Canadian city to join the Rockefeller 100 Resilient Cities program, acknowledging the challenges it needs to face and willing to take action. Its location led to an abundance in immigrants to call it home, enriching the culture and community of the city. As such, many of the employed resilience strategies work towards ensuring this diverse community is protected and prosperous.

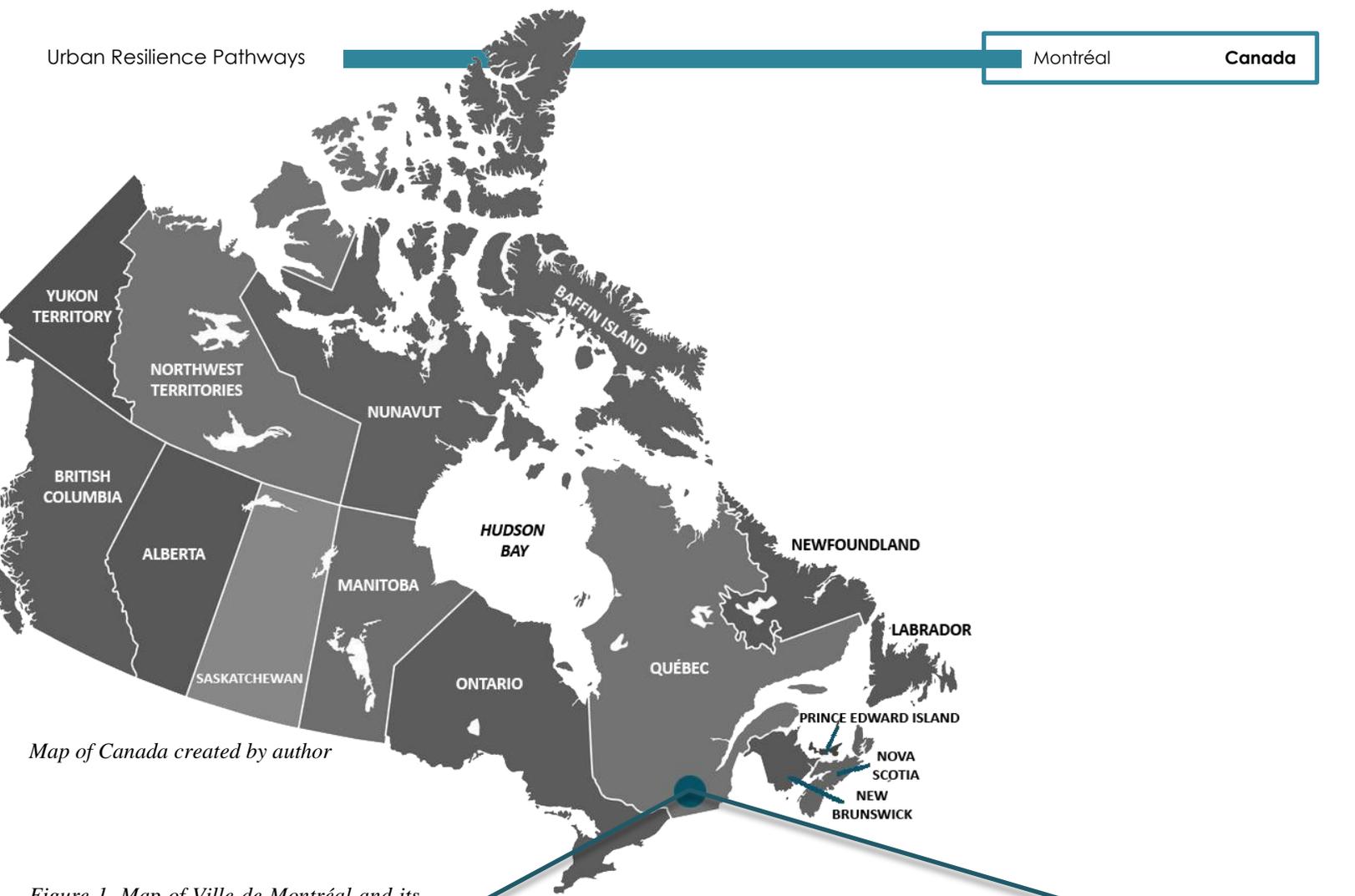
This report will delve into the shocks and stresses Montréal has faced over time and touches upon the strategies that have been devoted for the sake of the community. A city that has faced earthquakes, flooding, extreme storms, heatwaves, terrorist attacks and other severe devastations is conscious of its long road ahead in tackling disruptions. Through time it has taken actions not only through responsive efforts, but also preventive ones such as early warning systems and awareness raising practices. The approaches towards countering the threat of flooding will be analyzed within this report, in the hopes of re-evaluating the city's urban resilience pathway.

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LIST OF ABBREVIATIONS

100RC	100 Resilient Cities
PRA	Preliminary Resilience Assessment
SMWM	Sustainable Municipal Water Management
GLSLCI	Great Lakes and St. Lawrence Cities Initiative
CiTTs	Cities Transforming Towards Sustainability
INRS	Institut National de Recherche Scientifique
BMP	Best Management Practices
PIP	Particular Intervention Plan
SAC	Service D'avis À La Communauté
DSCR	Direction de la Sécurité Civile et de la Résilience
SIM	Service de Sécurité Incendie de Montréal
ARLUPD	Act Respecting Land Use Planning and Development
RCM	Regional County Municipalities
PPRLPI	Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains
MAMH	Ministère des Affaires Municipales et de l'Habitation
PMAD	Metropolitan Land Use and Development Plan
MMC	Montréal Metropolitan Community
BINAM	Bureau d'Intégration de Nouveaux Arrivants de Montréal



Map of Canada created by author

Figure 1. Map of Ville de Montréal and its different boroughs and reconstituted cities. Montréal Urban Agglomeration. Source: Montréal, 2017



- Ville de Montréal and its boroughs
- Reconstituted cities

INTRO MONTRÉAL

As Canada's second largest city, and the largest metropolis in the region of Québec, Montréal is home to 1.7 million people (Montréal Population 2021, 2021.). With 4,517 people per square kilometer (Montréal Population 2016, 2021) and 500 square kilometer of space being urbanized at a 90% rate (Preliminary Resilience Assessment - PRA, 2017), this vibrant and complex city has earned its status as the second most populated metropolitan area in Canada (Chevalier et al., 2020), right after the city of Toronto. The complexity of Montréal is attributed to the 19 boroughs that subdivide Ville de Montréal as well as 14 reconstituted cities, thus forming the agglomeration of Montréal (figure 1).

Montréal is the fourth largest francophone city in the world (PRA, 2017), whereby 54.3% of the population speaks French at home. However, due to its history as a center for immigrants from various backgrounds, Montréal's population is affluent with cultural diversity, as about 25.3% of the population speaks English and 20.4% speaks other languages such as Spanish, Arabic or Italian (Montréal, 2017). The large influx of immigrants from France, England, Scotland, Maghreb, Lebanon, Vietnam, and other countries from around the world have paved the way to diversifying and enriching the culture and community of this metropolis. This richness in culture has made the community of this city a valuable asset, one that it plans to protect, prepare, unify, and ensure its capability to recover, thus guaranteeing a collective resilience to vulnerabilities.

The island of Montréal is located at the meeting point of the St. Lawrence River and the Ottawa River (figure 2). It is surrounded by three bodies of water: Rivière des Prairies, the St. Lawrence River and Lac Saint-Louis and is considered the largest island in the Hochelaga Archipelago (Commission de Toponymie du Québec, 2012).

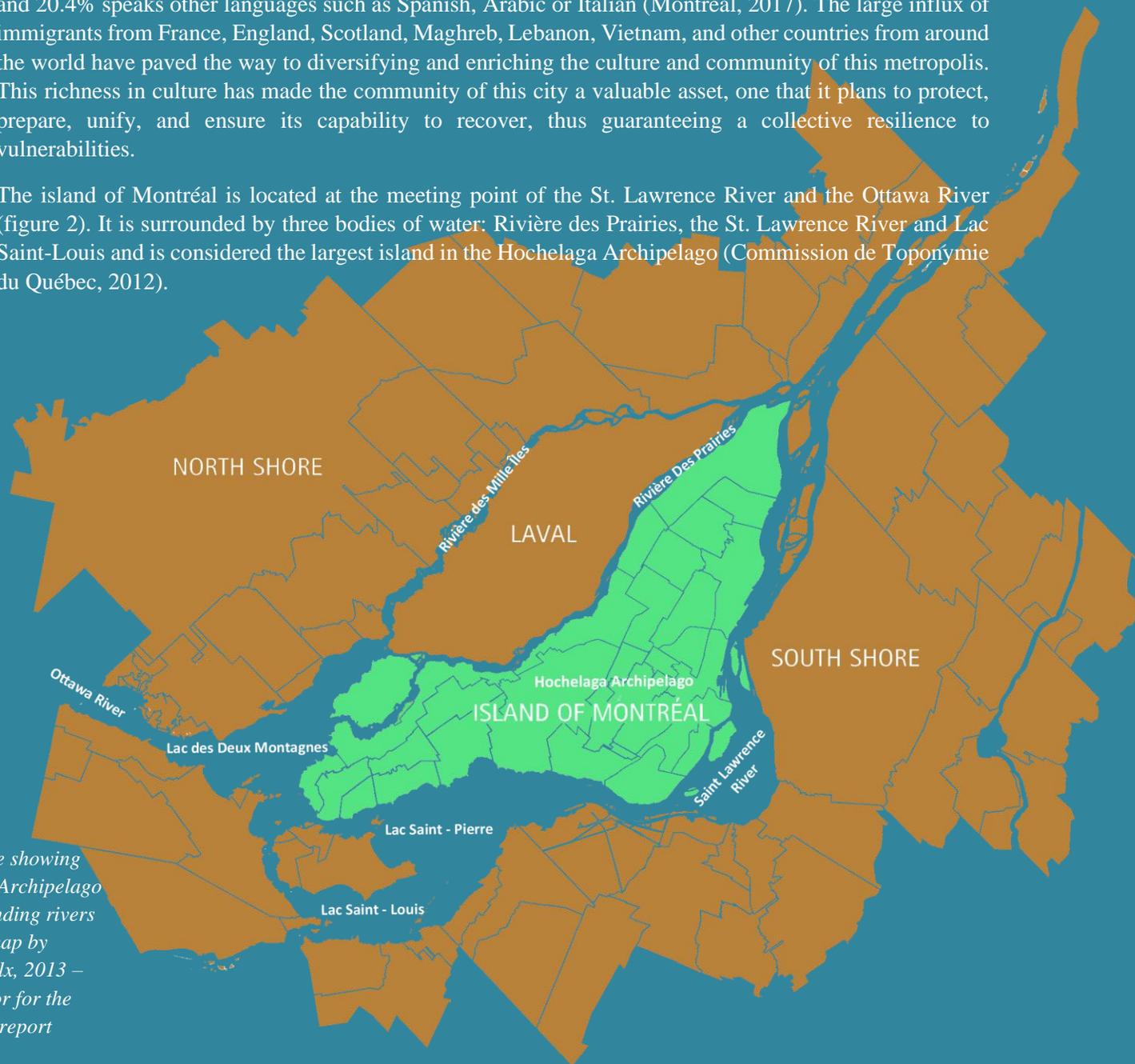


Figure 2. Image showing the Hochelaga Archipelago and the surrounding rivers
Source: Base map by Gilbert & Proulx, 2013 – Edited by author for the purpose of this report

With this topographical advantage came trade-offs as the city was vulnerable to extreme weather events that spurred a number of shocks and stresses over the years. Diagram 1 illustrates some of the hazards and risks that the city of Montréal is subjected to. With the threat of climate change becoming ubiquitous and given its location, the city has been and will continue to be under the threat of severe flooding caused by excessive runoff (examples: figures 3 and 4). However, Montréal has been developing strategies for countering floods and strengthening its resilience to these challenges. As Michael Berkowitz noted:

Montréal’s resilience was both tested and on full display in May 2017, when the city and surrounding communities experienced historic, powerful flooding that displaced thousands. The flood underpinned the importance of Montréal’s focus on urban resilience.

*Michael Berkowitz
President of 100 Resilient Cities
(Montréal, 2018, p.23)*

Diagram 1: Hazards and Risks Montréal Faces

Shocks

Stresses



Extreme Weather Events: Snow, Wind, Hail, Frost, Storms



Geophysical Shocks such as Earthquakes



Spring Flooding, Flash Floods and Runoff



Critical Infrastructure Breakdown or Malfunction, Major Industrial Accidents Involving Transportation of Dangerous or Hazardous Goods



Social Shocks such as Terrorism or Violent Demonstrations



Epidemics and Pandemics



Pollution, Ecosystem Collapse



Climatological Stresses such as Climate Change, Increased Rainfall, Increased Frequency of Destructive Storms, Heatwaves, Droughts etc.



Aging Infrastructure



Complex Governance, Lack of Trust etc.



High Unemployment, Flight of Human Capital, Congestion

*Information Sources: PRA, 2017; Ville de Montréal, 2018
Diagram created by author*



Figure 3. Flooding on Boulevard Decarie on July 14, 1987 caused by 101.2 mm of rainfall in just two hours. Source: Montréal, 2017



Figure 4. Sewer system overflowing after heavy rainfall in 2012. Source: Gilbert & Proulx, 2013

MONTRÉAL AND THE 100RC

Montréal joined the 100 Resilient City (100RC) program in December 2014 and was the first Canadian city to do so (Ville de Montréal, 2018). It released its Preliminary Resilience Assessment (PRA) in February 2017 which presented the main shocks and stresses the city faces and was used to pave the way for the second phase of the resilient strategy with action plans and targets. This report aims to delve into the issue of flooding that Montréal has been facing and examines how the city has adopted procedures to combat this risk before joining the 100RC. Section 2 of the report will explore these action plans and examine the presence of community resilience practices during that time as well. Sections 3 and 4 will then analyze the city's resilient strategy and approaches, then discuss tradeoffs and lessons learned through a link to the literature. The term resilience may have not been the essence of every policy or practice; however, Montréal has long been working towards urban resilience to flooding while placing the citizens at the forefront of all its action plans.

CITY PAST

ADAPTIVE PATHWAY

FLOODING AND WATER MANAGEMENT

Montréal is accustomed to the hardships of extreme weather as temperatures in this city can range from -40°C to 45°C (PRA, 2017). As such, there has risen a certain vulnerability to snowstorms, blizzards, heavy rainfalls, glazed frost, and heatwaves plaguing the city and causing dire consequences to the inhabitants and their land. The snowstorm of 1998 is a prime example of this, as Montréal faced one of its greatest environmental shocks (Ville de Montréal, 2018). On January 4, 1998 southern Québec and eastern Ontario faced an ice storm that lasted 5 days and pummeled their cities with 100 millimeters of icy rain and pellets (Martin & Pindera, 2018). The storm caused power outages, billions of dollars in damage, road closures and many deaths. The Montréal Gazette regarded it “among the worst natural disasters in Canadian history” (Montréal Gazette, 2019). Cascading effects of the storm caused additional issues. While the city witnessed an impressive surge in freezing precipitation, it also underwent flooding from burst piping and local drainage obstruction.

Urban flooding is “a temporary covering of land by water outside its normal confines” (Klijn, 2009, p. 13) and can be classified in two forms based on the origin of the water invading the urban and peri-urban areas. Fluvial flooding occurs when rivers or water bodies overflow and thus spill over their respective embankments. Pluvial flooding, on the other hand, happens when stormwater from extreme rainfall overwhelms the land and its drainage network (figure 5), hence causing an accumulation of runoff on surfaces or a dangerous and uncontrolled flow (Zurich, 2020). Figures 6 and 7 consider the territorial and social susceptibility to excessive rainfall, while figures 8 and 9 illustrate those same factors when considering river floods (Montréal, 2017). This shows the severity of flooding caused by excessive runoff and overflow in a lot of areas in the city, while neighborhoods along the periphery of Rivière des Prairies are susceptible to surges of river overspill, which is risk of increasing with the intensification of climate change. Since the year 1886 Montréal has suffered nine major fluvial floods causing millions in damages and countless evacuations (Capelle-Burny, 2019). The timeline of diagram 2 illustrates the different flooding events that have assaulted the city, some of their root causes and their socio-economic repercussions. Graphs 1 and 2 also portray the rainfall events through the years, displaying the increase in number of heavy rainfalls through the seasons from 1943 till 2014 (Montréal, 2017).



Figure 5. Flooding caused by severe storm in 2012
Source: Montréal, 2017

TERRITORIAL SUSCEPTIBILITY IN THE AREAS OF THE MONTRÉAL AGGLOMERATION EXPOSED TO FLOODING CAUSED BY EXCESSIVE RUNOFF WATER

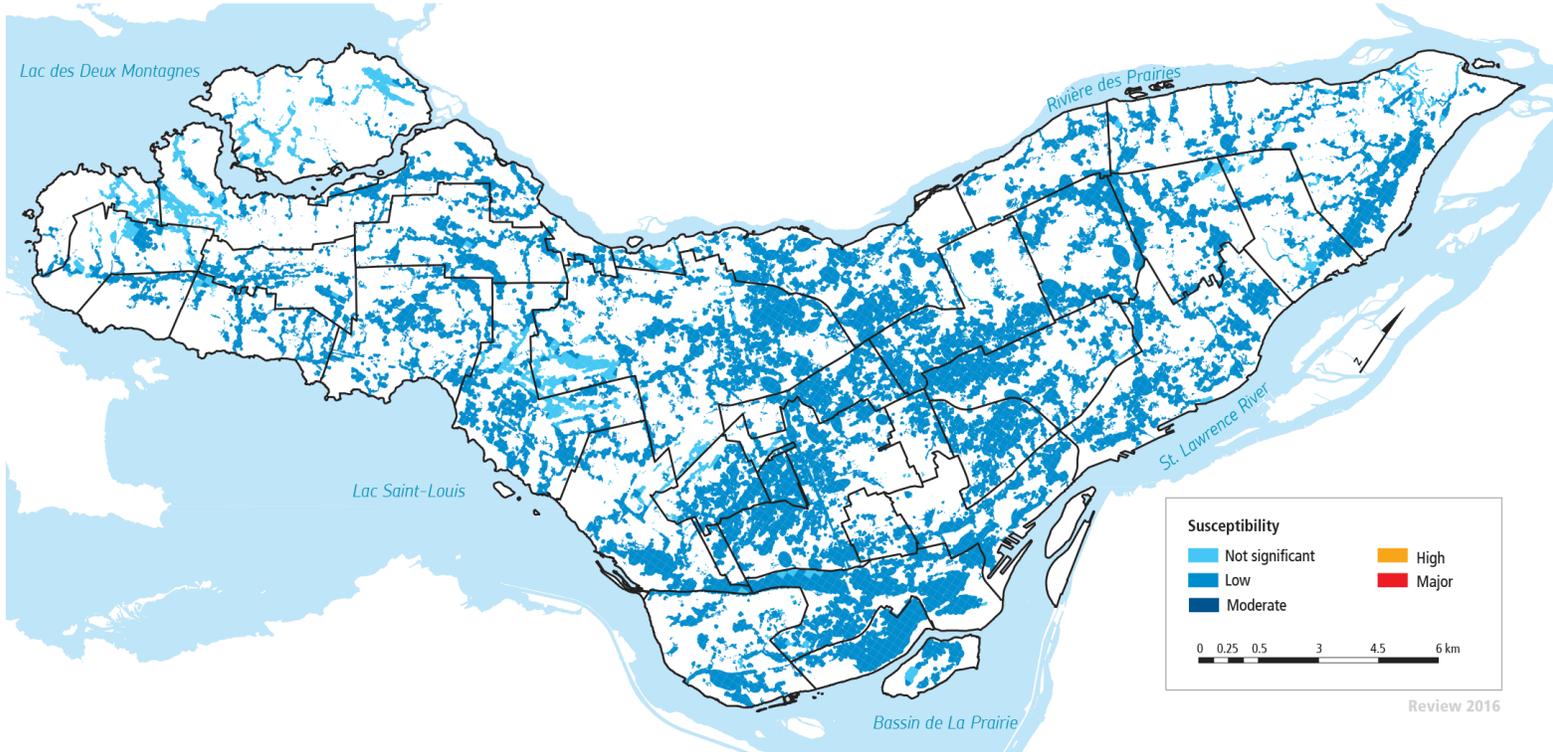


Figure 6. Source: Montréal, 2017

SOCIAL SUSCEPTIBILITY IN THE AREAS OF THE MONTRÉAL AGGLOMERATION EXPOSED TO FLOODING CAUSED BY EXCESSIVE RUNOFF WATER

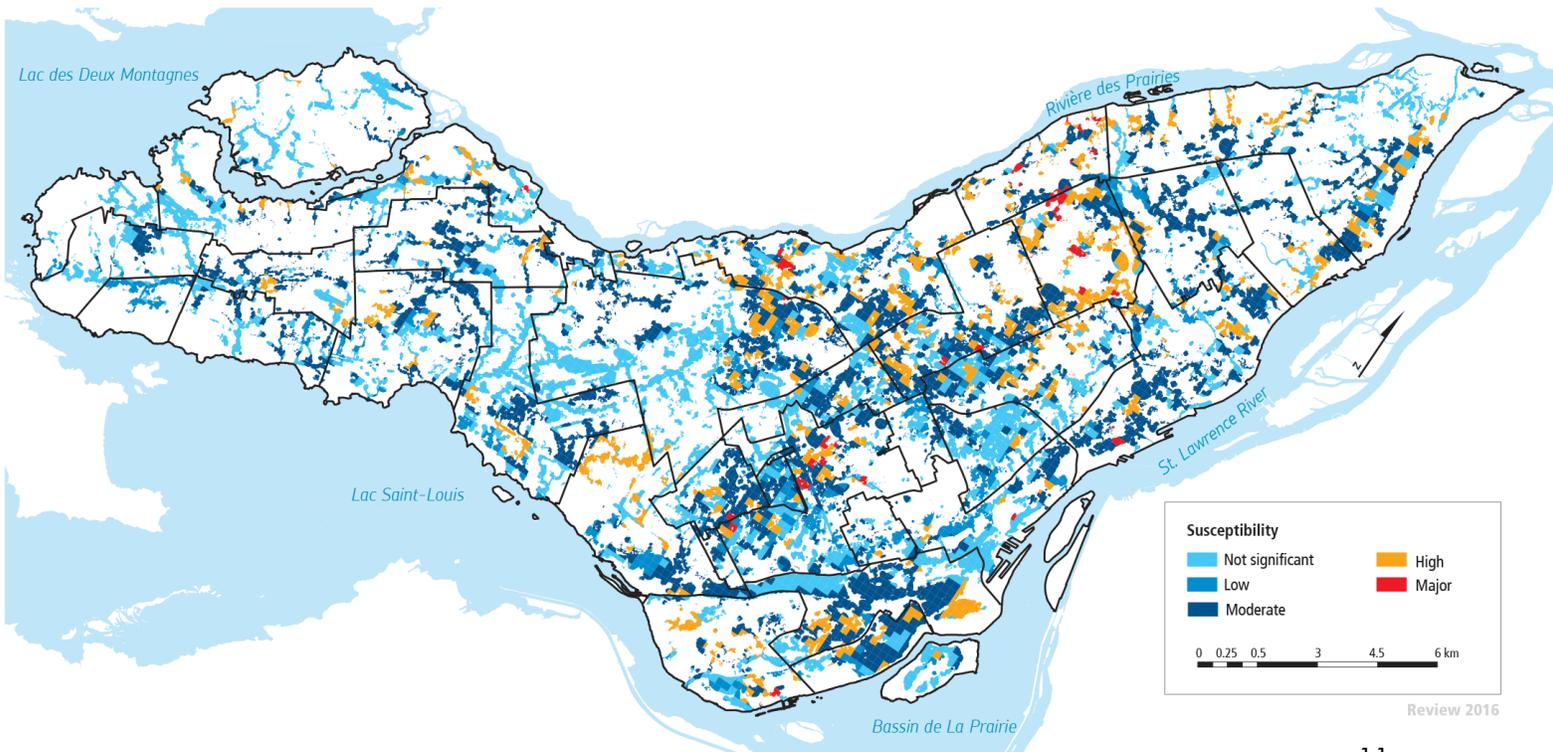


Figure 7. Source: Montréal, 2017

TERRITORIAL SUSCEPTIBILITY IN THE AREAS OF THE MONTRÉAL AGGLOMERATION EXPOSED TO RIVER FLOODS



Figure 8. Source: Montréal, 2017

SOCIAL SUSCEPTIBILITY IN THE AREAS OF THE MONTRÉAL AGGLOMERATION EXPOSED TO RIVER FLOODS



Figure 9. Source: Montréal, 2017

Diagram 2. Timeline of flooding events and the development of the different strategies to counter this risk over time – Created by author

Flooding Events in Montréal and Québec

Action Plans and Strategies

1960'S
Montréal's Ruelles Vertes projects

1886 FLOOD
Montréal. Saint-Lawrence River. Caused by ice jam, built up 8m high. 3 deaths. 'Millions' in damages.

1965 FLOOD
Saint-Lawrence River
Caused by ice jam
20 deaths

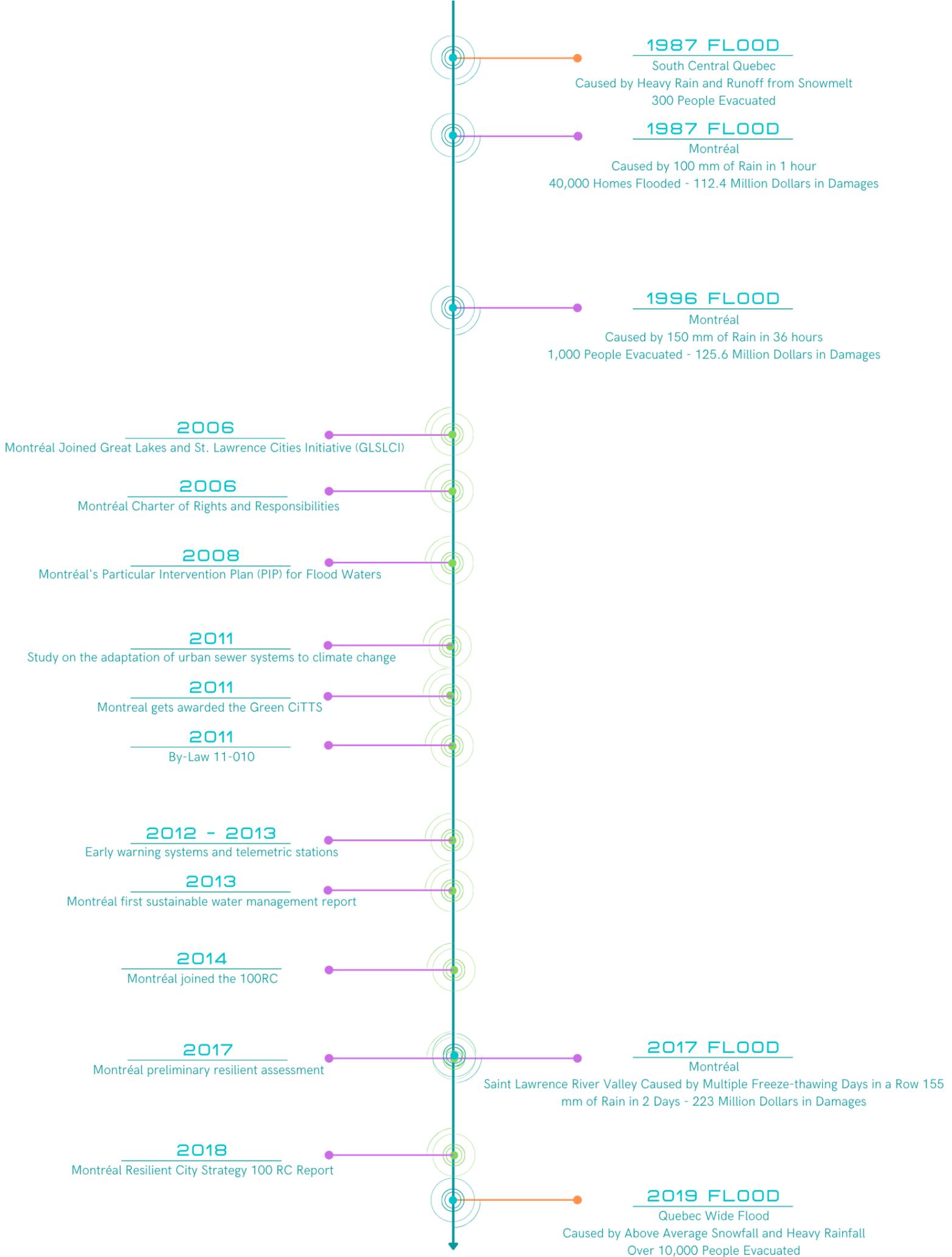
1971 FLOOD
Ottawa River Basin.
Flooded Lake of Two Mountains and West Montréal to Lac St. Pierre along St. Lawrence River

1974 FLOOD
Province Wide
Caused by Runoff from Spring Snow Melting
1600 Homes Flooded - 10,000 People Evacuated
99.6 Million Dollars in Damages

1976 FLOOD
Province Wide
Caused by Runoff from Spring Snowmelt
79 Million Dollars in Damages

LEGEND:

- Montréal related events
- Québec related events
- Flooding events
- Strategies and plans

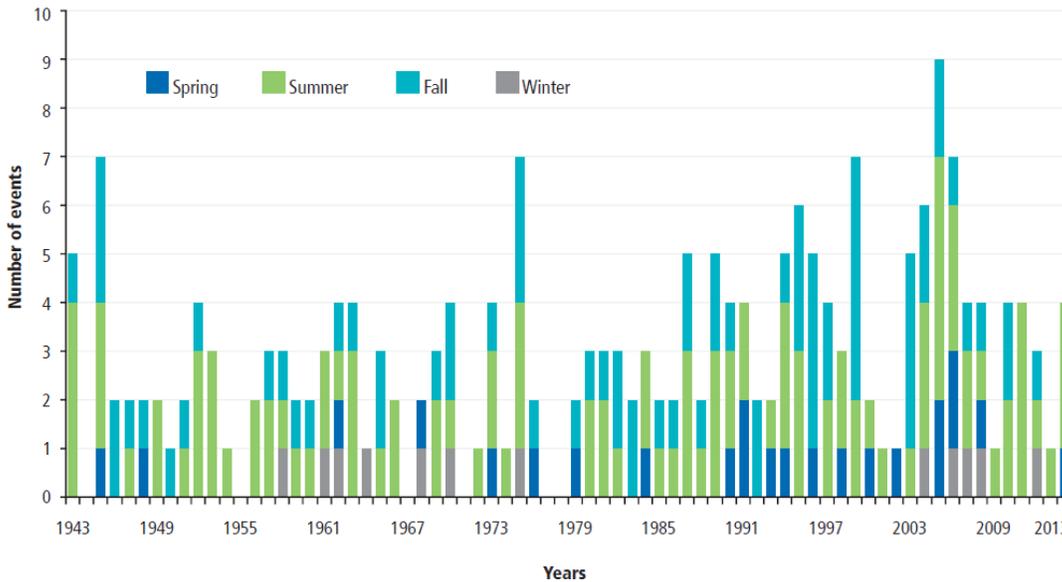


Ville de Montréal is well aware of the impacts of heavy rainstorms. In order to cut down on the number of sewer backups, it is constantly striving to improve the drainage system and reduce the flow of rainwater directed into this system.

(Service de L'Eau Montréal, 2011, p.2)

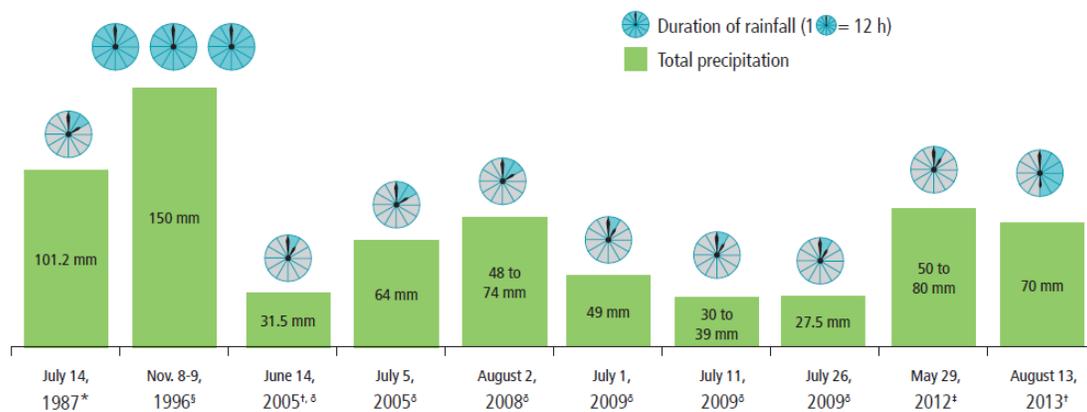
NUMBER OF DAYS DURING WHICH RAINFALL EXCEEDED 30 MM

Source: Data from the weather station at the Montréal-Trudeau International Airport.



Graph 1. Graph showing the amount of rainfall Montréal through the years and in different seasons. Source: Montréal, 2017

SOME NOTABLE RAINFALL EVENTS IN THE MONTRÉAL AGGLOMERATION, 1983-2013



Graph 2. Graph showing the rainfall experiences in Montréal through the years. Source: Montréal, 2017

Water management has long been a priority for this flood-prone city. It has launched many initiatives over the years to attain sustainable municipal water management (SMWM). Montréal has been a member of The Great Lakes and St. Lawrence Cities Initiative (GLSLCI) since 2006 and has participated in its initiative to promote SMWM (Gilbert & Proulx, 2013). GLSLCI is a binational association that involves 131 U.S and Canadian mayors and other local officials and representatives (Gilbert & Proulx, 2013). The coalition

embraces a collaboration with federal, state, and provincial government stakeholders to improve the infrastructure systems, programs, and services (GLSLCI, 2019) as well as promote the protection, preservation, and restoration of the Great Lakes and the St. Lawrence lake. The main aim of the GLSLCI is to sustain and enhance the well-being of the citizens of the region, be it economically or health-wise, and to ensure the vitality of these freshwater resources. The Green Cities Transforming Towards Sustainability (CiTTS) Program, which Montréal joined in 2012, is an example of one of the initiatives of the GLSLCI. The program aimed to ensure more sustainable management and investment in its water supply and sewage system to “reduce drinking water consumption, upgrade the drainage system, diminish overflows and cut pollution of aquatic environments” (Gilbert & Proulx, 2013, p. 7). Its progress in stormwater management, especially with the threat of climate change, granted Montréal the Green CiTTS award in June 2011 (Gilbert & Proulx, 2013). Montréal’s first SMWM report was published in 2012, comprising of principles and indicators, was also awarded the Green CiTTS award in June 2014. One of the milestones illustrated in the report exemplifies one of Montréal’s SMWM action plans, as it looks at the flood-prone areas in the city and highlights the studies and methodologies to assess the risk on vulnerable locations and people, in addition to adaptation plans for climate change impacts.

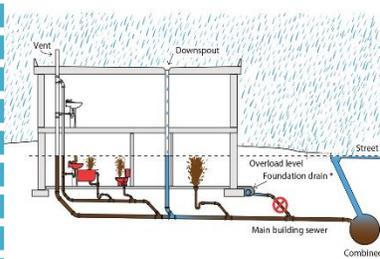
The 2011 study on the adaptation of urban sewer systems to climate change was carried out to “assess the impact of the potential intensification of precipitation on an actual urban drainage network” (Gouvernement du Québec, 2011, p. 12) over a 50 – year period. It was accomplished in conjunction with the OURANOS Consortium and Institut National de Recherche Scientifique (INRS) (Gouvernement du Québec, 2011). OURANOS is a non-profit organization that offers climate scenarios to Québec that are based on thorough scientific knowledge and research in an aim to “stimulate and support adaptation to anticipated climate changes” (OURANOS, 2021). The report concluded that the two most effective measures to runoff

reduction were stormwater retention structures and the decrease of impervious surfaces within a city. As such, laws and action plans were developed to help limit stormwater runoff. By-Law 11-010 Concerning the Protection of Buildings Against Sewer Backups was developed in 2011 and made public through its publication in The Gazette on June 27 of that year (Ville De Montréal, 2011). The by-law served as a preventive measure and guide for new construction, renovated buildings, and existing structures suffering from floods to ensure public safety and reduce the risks from heavy rainfall. Figure 10 illustrates the recommendations to prevent wastewater backup for flat roofs, taken from the by-law. Evidence of Montréal’s consideration to its community is demonstrated as an inspector was also supplied by the city to aid residents in proposing best management practices (BMP) fit for their buildings.

Backup of a sewer due to heavy rainstorms

ALL TYPES OF BUILDINGS WITH A FLAT ROOF

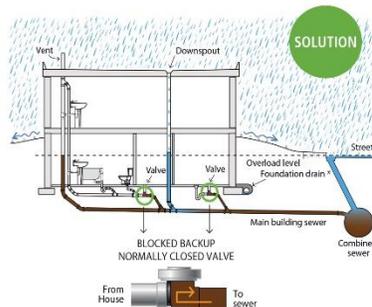
For all types of buildings with a flat roof, install a “normally closed” valve.



To guard against the risks of water seeping into your house, the foundation drain must not be directly connected to the sewer, as it is often overloaded during heavy rainstorms.

Smart precautions to take...

- In order to meet the requirements of the municipal bylaw, water from the foundation drain must first flow inside the building, into a sump, before being directed to the sewer. This sump will have to be equipped with a pump that automatically pushes the water back outside in case of a backup.
- In a heavy rainstorm, try to avoid using your washer, dishwasher, toilet flusher or shower or emptying your bathtub water. Wastewater draining from the building toward the sewer risks getting blocked by the valve, which has closed.



To prevent wastewater from backing up through plumbing fixtures, these fixtures must be protected by means of a “normally closed” valve.

Buildings with a flat roof have no outdoor gutters, but rather interior downspouts, which carry the water toward the sewer.

The “normally closed” backwater valve is a device designed to prevent wastewater from backing up into your building by opening only for the normal evacuation of wastewater. In case of a backup, the valve flap blocks the water that backs up in the opposite direction.

Figure 10. Source: Service de L'eau Montréal, 2011, p.1

A GREENER AWARENESS

“Plants prefer rainwater”

(Service de L'eau Montréal, 2011, p.2)

The concept of green infrastructure is familiar in this city as countless projects have been created in the past to promote stormwater retention and infiltration as well as curb the heat island effect. In the 1960s, the “Ruelles Vertes”, which translates to “Green Alleys”, was developed by residents as an urban revitalization initiative that transformed alleyways into urban gardens (Williams, 2017). The initiative was guided by the Eco-Quartiers, a program that promotes environmental citizenship and environmental awareness, and later gained endorsement by the government (World Wildlife Fund, 2020). By adding greenery, benches, art, vegetable gardens and green infrastructure, the alleyways were converted to accommodate rain gardens while the asphalt walkways were replaced with permeable pavements, thus decreasing the impact of heavy rainfall and the flooding caused by runoff (figures 11-12-13). The initiative continues to flourish to this day as around 40 new green alleys have been formed since 2010 (Lowrie, 2018). This initiative establishes Montréal’s effort to ensure public awareness in the issues that affect the community’s surrounding and wellbeing, as well as their engagement to achieve community resilience. Another example of Montréal’s efforts to safeguard awareness and public engagement is the Montréal Charter of Rights and Responsibilities adopted by City Council on January 1, 2006. The Charter establishes values of human dignity, justice, peace, equality, transparency, and democracy (Ville de Montréal, 2011). The aim of the Charter is to empower citizens and involve them in the growth and development of their city. Action plans include the support of preventive measures aimed at increasing citizen awareness and involvement in the challenges and issues that might hinder their safety and wellbeing.



Figure 11. Source: Haines, 2019



Figure 12. Source: Macrae, 2017



Figure 13. Source: This City Life, n.d.

EARLY WARNING PLANNING

In 2008, Montréal developed a Particular Intervention Plan (PIP) for Flood Waters as a response plan for potential floods (Gilbert & Proulx, 2013). The plan paved the way for the implementation of emergency warning or alert systems for inhabitants and vulnerable people within the city and boroughs (figure 14). As a result, telemetric stations were set-up to monitor the water levels of the Rivière des Prairies and the St. Lawrence River (figure 15). These stations are configured to the water levels of each river and define the specific “thresholds at which flood prevention and preparation measures must be deployed” (Gilbert & Proulx, 2013, p. 38).

Figure 14. Community Notice Service - Service D’avis À La Communauté (SAC)

The 2012 intervention for the early warning system

Measures the water levels and sends out an alert via siren and radio notification.

Vision:

“Foster resilience, with a view to sustainable development”

Source: Bradette & Thibault, 2012

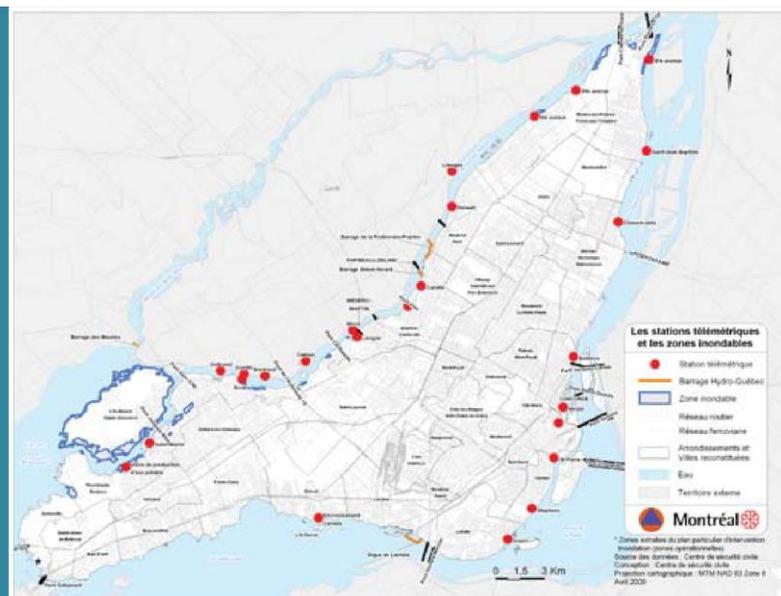
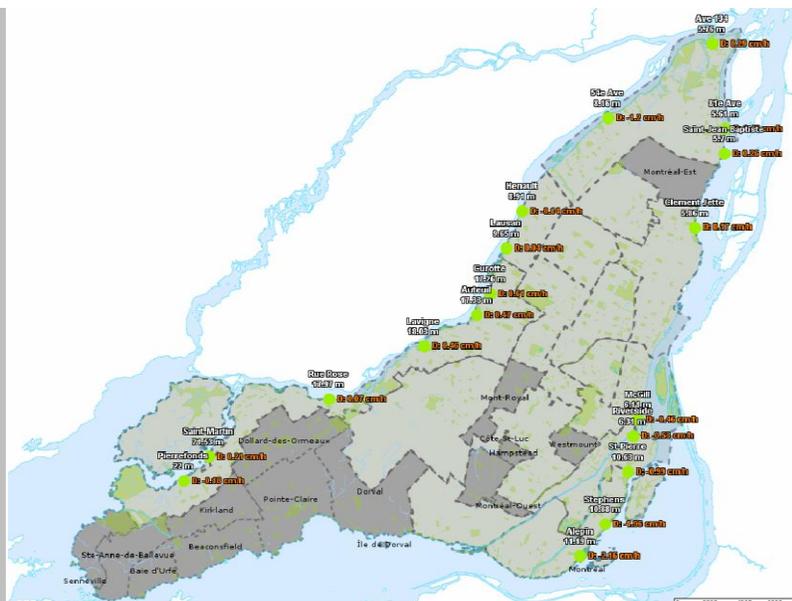


Figure 15. Montréal’s Centre de Sécurité Civile: Map identifying the telemetric stations and the areas that are most vulnerable to floods.

Source: Gilbert & Proulx, 2013

OBJECTIVES

ORIENTATIONS

1

Strengthen the community's capacity to adapt and react to natural and anthropogenic risks

2

Preserve an environment that meets Montrealers' essential needs

1

TAKE ACTION IN SUPPORT OF A UNIFIED AND SAFE COMMUNITY

3

Develop mutual aid and inclusion mechanisms to promote solidarity between citizens and reduce vulnerabilities

4

Ensure improved consideration of risks in land use and infrastructure planning

2

TAKE ACTION TO PROTECT OUR LIVING ENVIRONMENT

5

Carry out more exhaustive cost-benefit analyses on mitigation measures

6

Develop and sustain infrastructures to ensure the maintenance of services and essential systems

7

Promote a good state of preparedness among companies and business establishments in order to deal with disturbances

8

Ensure the effective and secure movement of people and goods

3

TAKE ACTION TO MAINTAIN A DIVERSIFIED AND INNOVATIVE ECONOMY

9

Anticipate socioeconomic challenges and capitalize on knowledge and creativity assets

10

Ensure the city's adequate state of preparedness in relation to natural and anthropogenic risks

4

TAKE ACTION TO PROMOTE INTEGRATED GOVERNANCE IN THE SERVICE OF THE COMMUNITY

11

Collaborate and share expertise in order to promote informed decision-making

12

Establish interactive communications between authorities and the public so as to disseminate information daily and alert citizens in the event of a disaster

Diagram 3. Resilient City Strategy Objectives and Orientations (100RC, 2018) – Diagram created by author

NOWADAYS

URBAN RESILIENCE

RESILIENCE IN MONTRÉAL

Two years after Montréal became a member of the 100RC program, the city founded its Bureau de la Résilience with an appointed chief resilience officer in charge of developing its resilient city strategy. (100RC, 2018). Aiming to improve the city's ability to anticipate, prevent, and adapt to any hazards or risks that may befall the community and their assets, Montréal's resilient city strategy upholds the vision of: "an alert, proactive and inclusive community acting on social, economic and environmental challenges" (100RC, 2018, p.23). The strategy sets a five year-action plan and constitutes of four major orientations and twelve objectives (illustrated in diagram 3). From these orientations, this report will focus on the second and fourth orientations due to their relevance to the previously declared themes.

The second orientation of the resilient city strategy dictates measures to protect Montréal's living environment, which includes action plans that mitigate the effects of climate change and lessen the consequences following extreme weather events. Through this strategy, urban planning takes into account the risks and vulnerabilities associated with hazards, such as flooding, and ensures new development projects are not leading to more liabilities and people are not exposed to threats. On December 12, 2017, the Direction de la Sécurité Civile et de la Résilience (DSCR) and the Service de Sécurité Incendie de Montréal (SIM) released the Incident and Feedback Report for the 2017 spring floods with the aim of making "Montréal a Flood-Resilient Community" (SIM, 2017). In addition, objectives in this section of the 100RC report also promote the resilience of critical infrastructure within the agglomeration in reaction to climate change. As such, the first Climate Change Adaptation Plan for Montréal was adopted in 2015 and then updated in 2017.

Orientation four of the 100RC report portrays Montréal's dedication to ensuring community resilience in the face of adversity and promotes the integration of governance in the service of this community. The resilient city strategy proposes objectives that work towards a proper state of preparedness, an adequate level of training, and sufficient awareness to natural and anthropogenic risks for all citizens. This includes modernizing communication resources and working towards a horizontal integration of coordination within and between departments in the municipality, as well as enhancing the vertical integration between borough, federal, provincial and regional administrations (100RC, 2018).

CURRENT WATER MANAGEMENT PRACTICES

In 2016, Montréal released an updated report for SMWM, as part of the CiTTS program and its commitment to monitor and express progress. The report displays an assessment score card that portrays the significant improvement and goals attained by the city between the years 2013 and 2016 (Haf et al., 2016). Examples of these initiatives include infrastructure renewal, promoting responsible water usage, and decreasing water production by 17% (Haf et al., 2016). In addition, the report portrays Montréal's achievement in assessing climate change impacts and proposing adaptation measures to counter them, explicated in the Climate Adaptation Plan that will be discussed further in this section. According to Global News, Montréal is working on a few upcoming projects to mitigate the risks of climate change and tackle flooding threats. These include the building of a retention system that maximizes overflow control in certain neighborhoods exposed to floods and in densely populated areas (Lau, 2019).

MAKING MONTRÉAL A FLOOD RESILIENT COMMUNITY

After the events of the 2017 spring flood, the city's DSCR compiled a report of the incident and summarized the key lessons learned. The report consisted of recommendations to make Montréal more resilient to flooding, ensure a state of preparedness, and improve the knowledge associated with this risk to guarantee better future response and mitigation measures. As such, the goals set out by these recommendations fall under the following titles: prevention, preparation, response, and recovery (illustrated in figure 16). The first step of any preventive measure is to understand the risk and the existing vulnerabilities. Accordingly, the report touches upon the existing flood zone maps with their respective technical reports used to map floodplains and calls attention to their shortcomings. To improve resilience to flooding, the DSCR urges the update of these maps, taking into consideration the information from the 2017 flood, the evolution of flood zones and their vulnerability to flooding. Also, the report states that updating these maps will not suffice if climate change-induced uncertainty is not factored in and the consequences of increased urbanization of catchment areas on local flow is not considered. As stated in the report "a better understanding of flood risk will enable us to improve our preventative measures by adapting our in land-use planning and implementing appropriate structural approaches and green infrastructure projects" (SIM, 2017, p.7).

Land-use planning plays an important factor when dealing with preventive measures for flooding. Building on the previously mentioned shortcoming, with no updated maps of vulnerable or flood-prone areas, land-use planning falls short in mitigating the threat of this phenomena. The report highlights that the region of Québec does indeed have a framework, titled Act Respecting Land Use Planning and Development (ARLUPD), which enforces regional county municipalities (RCMs) to incorporate the Protection Policy for Lakeshores, Riverbanks, Littoral Zones and Floodplains (PPRLPI) founded in 1987 (MAMH, 2017). However, this regulation provides only a baseline or minimal standards for these areas and expects municipalities to opt for more stringent criteria depending on their local situations. This top-down approach causes too much leeway in the implementation of these regulations, as municipalities can simply decide to cater to the bare minimum requirements. However, Montréal's 2017 flooding plan recognizes this drawback and recommends the formation of Metropolitan Land Use and Development Plan (PMAD) by the Montréal Metropolitan Community (MMC), a plan that incorporates the PPRLPI's instructions and develops land-use planning models that explicitly apply to Montréal's reality (SIM, 2017). This notion is emphasized in Montréal's resilient city strategy, orientation two objective (A) action plan 10, as requirements to establish "resilient construction and the integration of green infrastructures" (100RC, 2018, p. 35).

Among the other aims and objectives, the 2017 flooding report stresses on the improvement of a clear communication plan between responders, disaster victims, vulnerable people, and communication with the general population. During the 2017 flood it was evident that the communication channels were still not up to standards and were overwhelmed by the intensity of the event (SIM, 2017). As such, the report included specific measures to enhance the flood communication plan that was also mentioned in Montréal's resilience city strategy report (orientation 4).

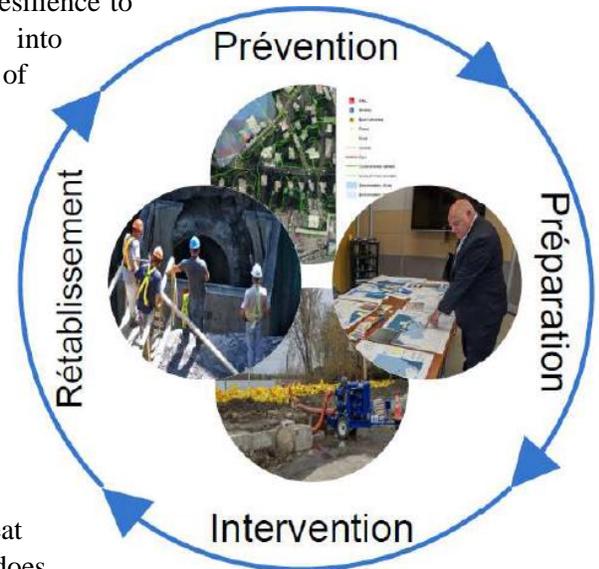


Figure 16. Source SIM, 2017

FLOODING IN 2019

As depicted in the timeline of diagram 2 presented earlier in this report, Montréal witnessed another severe flood in 2019. Based on the flooding report of that year, “the historic flood flow of the Ottawa River and the flows of some of its tributaries surpass those observed during the 2017 floods.” (Lachance, 2019, p. 13). As such, the 2019 floods were considered worse than those of 2017 in both range and time frame. It is reported that the preventive measures and mitigation interventions put in place after the previous flood incidents proved to be successful in lowering the damages incurred. “Only 110 residences were flooded in 2019 against 1,100 in 2017” (Lachance, 2019, p. 3). Based on the *Montréal Gazette*, the Mayoress of Montréal believes that the current 17-million-dollar cost of these preventive measures will continue to rise with the escalating climate crisis and urges for a more resilient plan of action to counter this risk (Scott, 2020). This news may well insinuate that Montréal’s resilient city strategy aims to merely reduce the vulnerability of the community with temporary costly measures rather than enhance the city’s ability to deal with shocks and stresses.

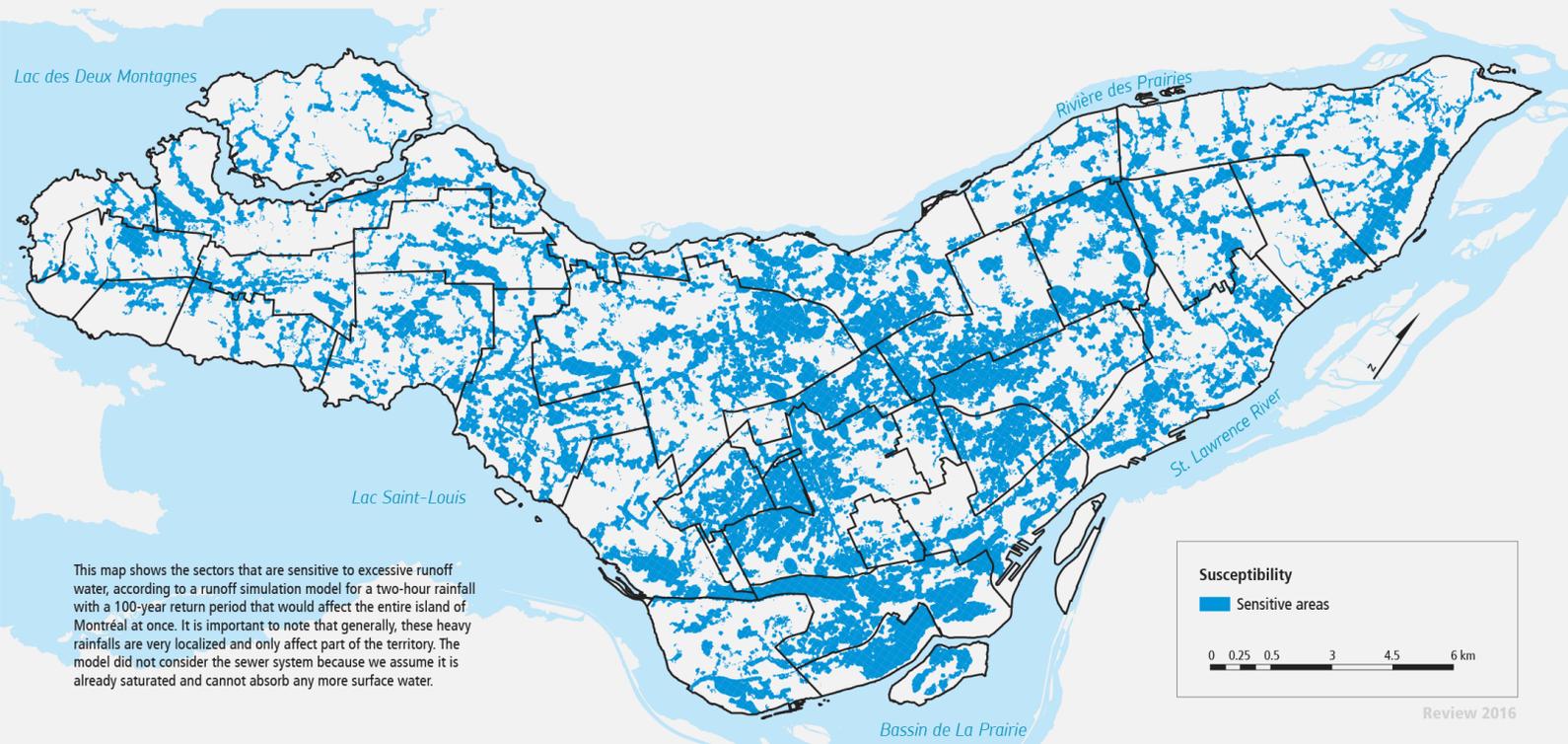
CLIMATE ADAPTATION PLAN

Montréal’s preliminary assessment report discusses the climate change adaptation plan created in 2015 by the Ville de Montréal’s Service de L’Environnement (PRA, 2017), which was the first climate report released for this urban agglomeration (Montréal, 2017). The report expands on the different climate hazards the city has faced over the years and analyzes the climate projections, supplied by the OURANOS Consortium, as well as their impacts on the built environment, the community, the economy and the natural environment (Montréal, 2017). The plan also delves into measures that the boroughs and the municipalities intend to implement to ensure these risks and challenges are managed.

The maps below from the climate adaptation report, illustrate the vulnerability of Montréal’s agglomeration to the different types of flooding (Montréal, 2017). Figures 17 and 18 display the territorial and social susceptibility to flooding from surrounding rivers, while figures 19 and 20 then illustrate the most exposed areas and those vulnerable to river floods, respectively. These images create a clear picture of the flooding, both pluvial and fluvial, with updated maps that can be used for plausible measures to counter this hazard, an issue that was missing in previous flooding reports.

AREAS OF THE MONTRÉAL AGGLOMERATION EXPOSED TO FLOODING CAUSED BY EXCESSIVE RUNOFF WATER

Figure 17. Source: Montréal, 2017



VULNERABILITY TO HEAVY RAINFALLS IN THE MONTRÉAL AGGLOMERATION

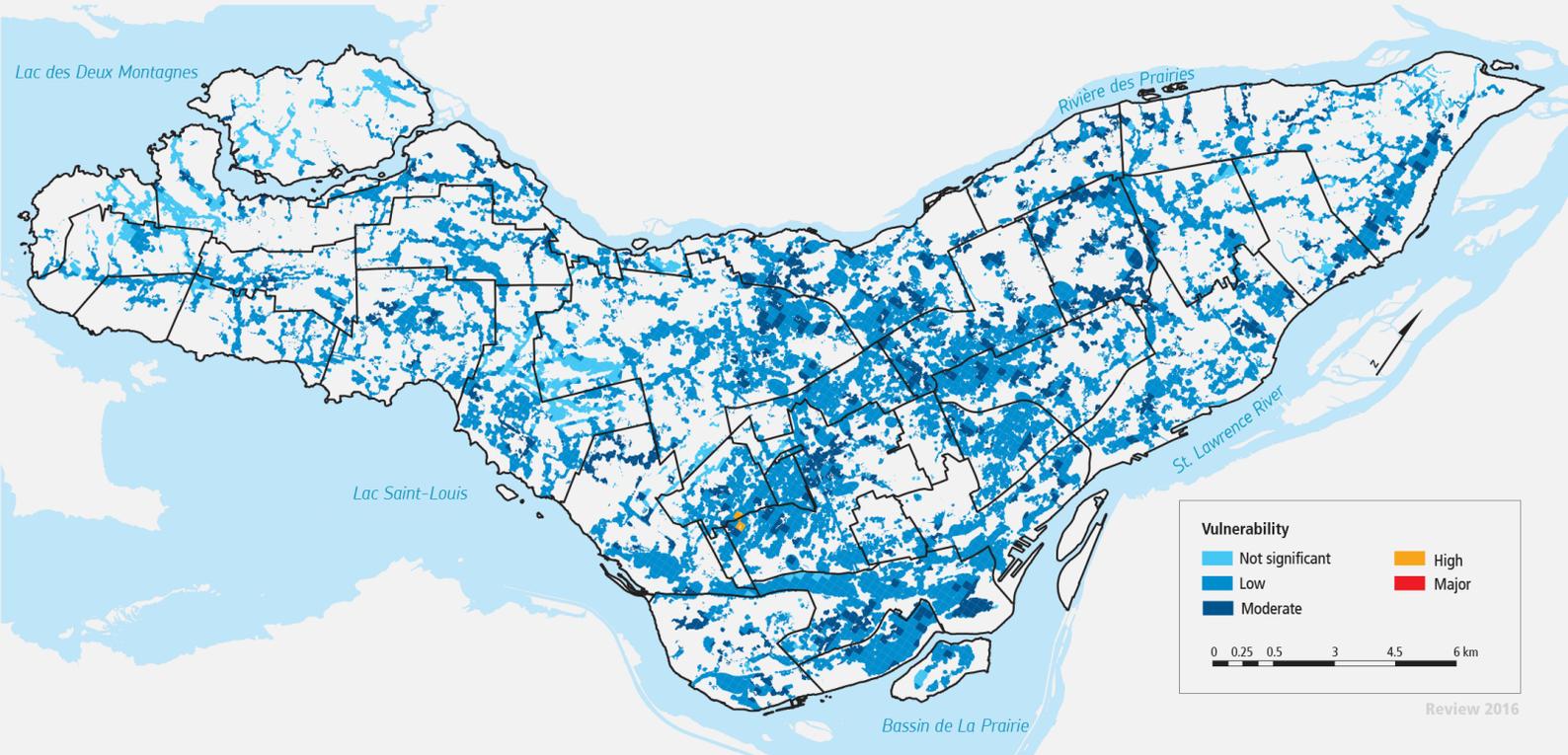


Figure 18. Source: Montréal, 2017

AREAS OF THE MONTRÉAL AGGLOMERATION SENSITIVE TO RIVER FLOODS (FLOOD-PRONE AREAS)



- 100-year return levels (sources: Révision des cotes de crues, Rivière des Prairies, CEHQ, 2006; Lac des Deux Montagnes, cartography by Ville de Montréal).
- The 100-year return levels increased by 30 cm to compensate for topographical data errors (they are at ± 30 cm).
- The areas' border is rounded up; it is adjusted to the higher-altitude isoline (0.5 m).

Figure 19. Source: Montréal, 2017

VULNERABILITY TO RIVER FLOODS IN THE MONTRÉAL AGGLOMERATION



Figure 20. Source: Montréal, 2017

A CONVOLUTED SYSTEM

As mentioned before, Montréal’s has an intricate division of municipal organization. The agglomeration council has jurisdiction over certain services and policies that concern the region as a whole, such as civil, penal and criminal matters (Ville de Montréal, n.d) as well as public transit and waste management (Chevalier et al., 2020). Each of the boroughs and the reconstituted cities have their own councils and they deal with services involving town planning, culture and leisure, parks and roads and other local matters (PRA, 2017). This complexity in governance structure and power dynamics might be a potential cause for instability in decision-making processes or a hinderance to the full disclosure of action plan implementation (PRA, 2017), both issues that will be discussed further in the next section.

DISCUSSION AND CONCLUSION

WHERE DOES MONTRÉAL STAND?

As the city releases report after report with titles and approaches that include the word ‘resilience’ or ‘adaptation’ (figure 21), this paper will try to better grasp the true resilience approach that Montréal seeks. The term resilience has become a go-to label that cities and municipalities leap at, especially in dealing with the challenges of climate change (Meerow et. al, 2016).



Figure 21. Reports released by Montréal over the years (PRI, 2017; Ville de Montréal, 2018; Montréal, 2017; SIM, 2017; Haf et al., 2016)

From the literature, the definition of resilience can be broken down to different concepts that are developed based on the different perspectives and understandings of the term. These concepts are: (1) resilience as rebound (2) resilience as robustness (3) resilience as “graceful extensibility” also known as the ability to adapt to the challenges and risk of unexpected failures and (4) resilience as “sustained adaptability” (Woods, 2015). It is evident from the 100RC report that the concept the city most familiarizes with is that of sustained adaptability, which takes into account the adaptive capabilities over a longer scale. It considers the challenges the system will face over its life cycles as well as their trade-offs. Montréal’s resilient city strategy is aware of the possibilities of trade-offs, especially when it concerns the city’s critical infrastructure.

...This major disaster provoked the realization, among authorities, that there were significant shortcomings in the coordination and organization of the emergency response, and that a failure in an essential network could set off a domino effect with a chain of adverse consequences.

(PRA, 2017, p. 21)

Approaches underlined in the 100RC report are indicative of the cities’ officials, policy and decision makers’ understanding of the value of catalyzing change at the community level through regenerative development (Resilience Earth, 2020). Diagram 4 illustrates the different stages of development that a city or community can experience.

Regenerative Spiral

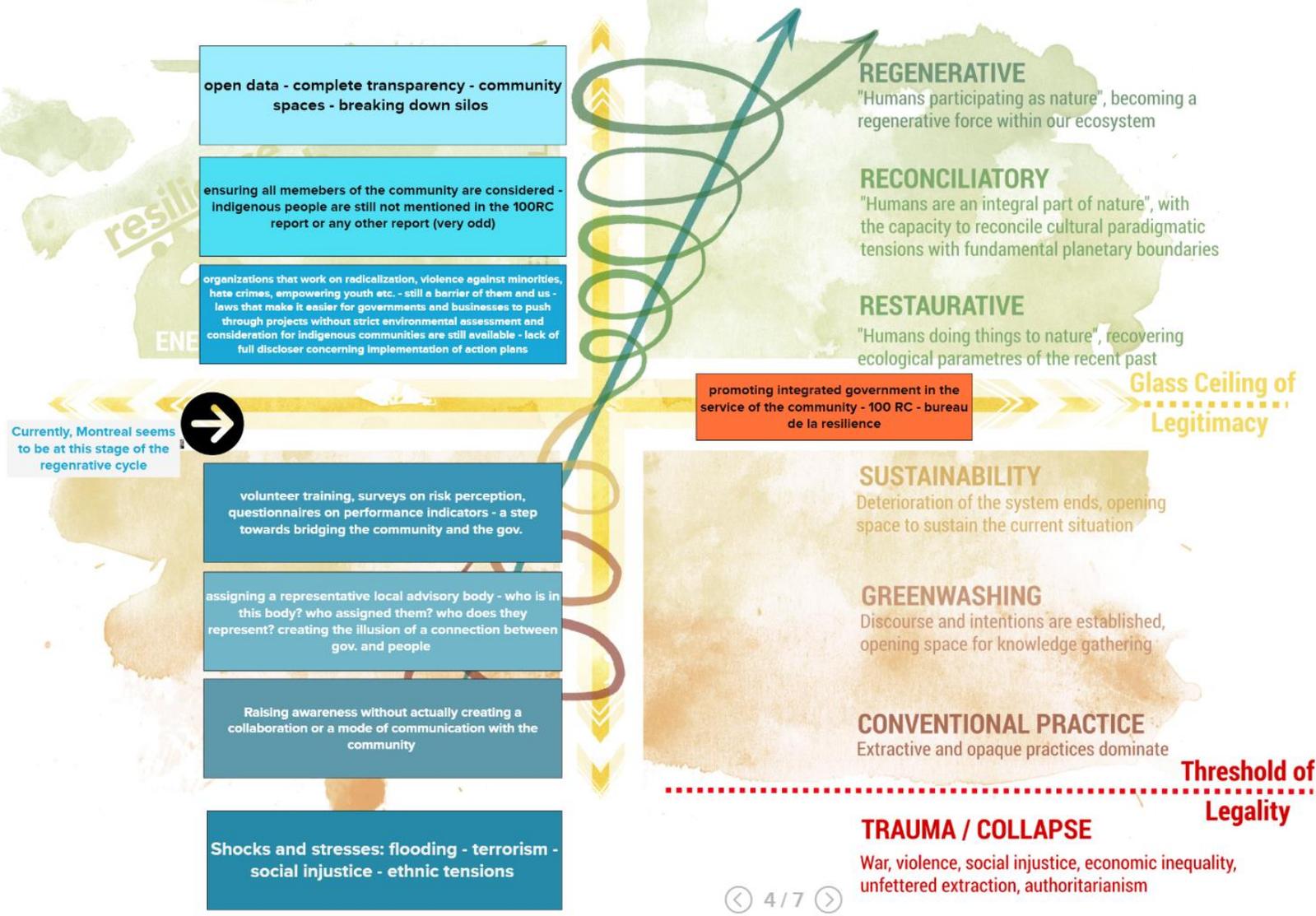


Diagram 4. Base diagram: Regenerative Cycle Analysis based on the Resilience Earth, 2020 framework – Modified by author for the purpose of this report (in blue and orange)- for larger version, refer to Appendix 3

The regenerative spiral recognizes the business-as-usual approach response to shocks and stresses, then categorizes the progressive steps within a Spiral Dynamic towards regenerative development (Mang & Reed, 2012). Currently Montréal’s resilience strategy can be allocated at the sustainability level, just before the glass ceiling of legitimacy. The creation of an integrated government in the service of the community acts as the leverage point (Meadows, 2016) that strengthens the city’s drive up this spiral. Leverage points in this case can be understood as components that bring about change. Diagram 5 illustrates these leverage points using the base diagram from Resilience Earth’s Iceberg model framework (Resilience Earth, 2020).

Iceberg of Leverage Points

LEGEND:

- Activation Forces (purple box)
- Restriction Forces (yellow box)
- Potential leverage points (star icon)

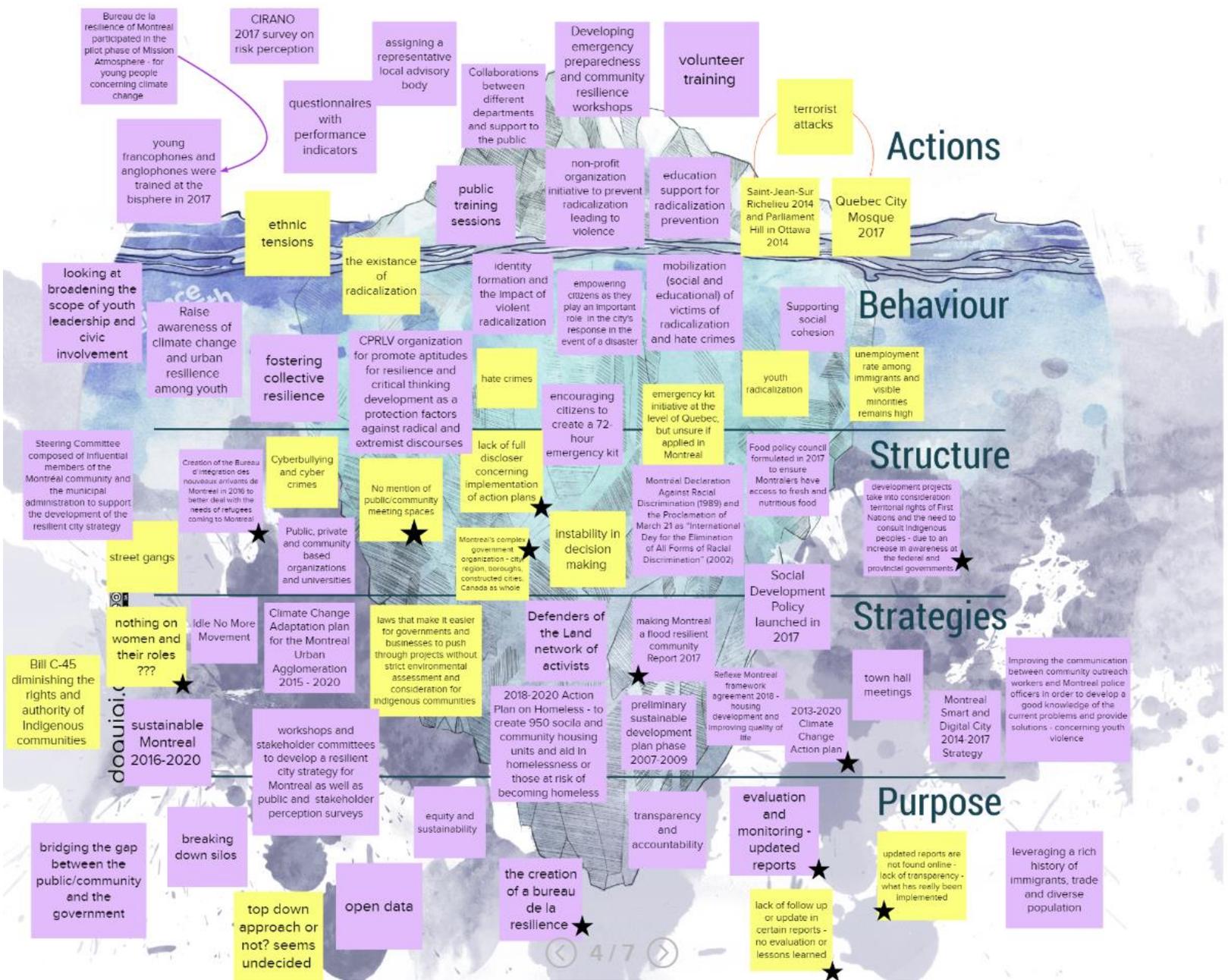


Diagram 5. Base diagram: Iceberg of Leverage points based on the Resilience Earth, 2020 framework – Modified by author to represent different observations made concerning Montréal and its resilience strategy (yellow and purple notes) – for larger version, refer to appendix 4

By situating the leverage points within the framework (the purple and yellow sticky notes), it is evident that a few shortcomings are found within Montréal’s resilient city strategy. First, there is a lack of disclosure of the implementation processes and outcomes. An interim report was scheduled to be released in 2020 to assess the execution of the actions as concrete strategies (100RC, 2018). However, no report was published at the time of this writing and a lack of transparent breakdown of finances and funding provoked a more in-depth analysis into the integrity of the implementation of this resilient strategy. Second, the 100RC report mentions the concept of bringing down silos (100RC, 2018) and building social cohesion. When examining

Montréal’s initiatives concerning members of its community, there remains traces of a top-down approach. The concept of empowering the youth and citizens as a whole, by organizing training and awareness campaigns and collaborations, still functions in “hub and spoke” kind of network. Figure 22 illustrates the development stages of networks (Mohr, 2016); whereby the first stage is where most network building begins and the fourth denotes the self-sustaining networks. With this in mind, Montréal’s community has yet to become an adaptive community capable of co-creation, co-operation and co-design, “with no one person [is] playing the central role” (Mohr, 2016). This also raises the issue of a lack of a decentralized system. Based on the literature, decentralization exists when “authority being spread out from a smaller to a larger number of actors” (Pollitt, 2005, p. 373) and from a “central authority to a less central authority” (Hermansson, 2018, p. 418). With no clear indication of the spread of decision making and policy formulation outside of the municipal organizations, and with the convoluted government as is, it would be easy to question the strength of the notion of resilience in Montréal. Re-centralizing backlash (Haase & Antoun, 2015; Ribot et al., 2006) for example is a possible trade-off, so is inequality brought on by an increase in marginalization and isolation (Hermansson, 2018), notions that the resilient city strategy report denounces as part of the future of this city.

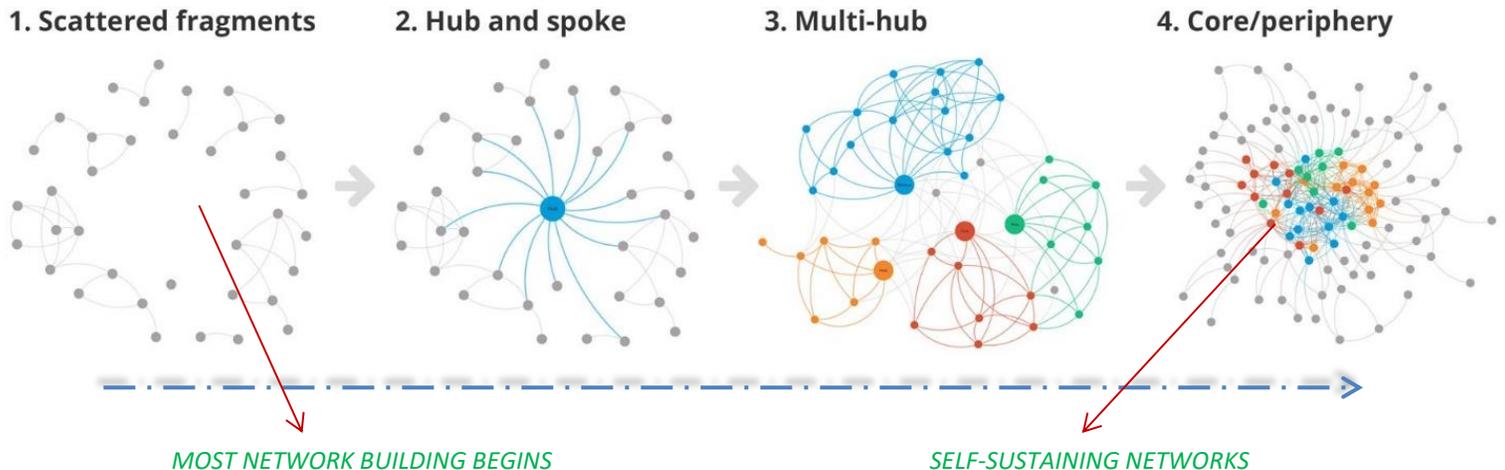


Figure 22. The development stages of networks (Mohr, 2016)

RESILIENCE FOR WHO?

“A community is considered to be resilient when members of the population are connected to one another and work together, so that they are able to function and sustain critical systems, even under stress; adapt to changes in the physical, social or economic environment; be self-reliant if external resources are limited or cut off; and learn from experience to improve itself over time”

(Arbon et al., 2016, p. 203)

When looking at community resilience, major factors to consider include diversity, equity and social justice. Montréal’s Centre for the Prevention of Radicalization Leading to Violence (100RC, 2018) is one mentioned implementation strategy that the city has incorporated to tackle the issue of hate crimes and violence brought on by extremist discourse. The Bureau d’Intégration des Nouveaux Arrivants de Montréal (BINAM), formulated in 2017, organized a support response plan for asylum seekers and to help immigrants integrate better into society (100RC, 2018). However, after further exploration, it has become evident that not all members of the community are considered within the resilience assessment and strategy

formation. Diagram 5 below illustrates the resilience cycle framework (Resilience Earth, 2020) while looking at the structural and environmental systems’ resilience within Montréal. On the other hand, when the resilience cycle framework is considered from the community perspective (diagram 6), we notice a certain discrepancy. Due to the aforementioned strategies to ensure that social justice and social acceptability are being prioritized, Montréal’s position seems promising. Yet, with the lack of consideration towards indigenous members of the society, or even to women, there seems to be a gap in the aspiration to seize overall community development and resilience.

Resilience Cycle

I have decided to work on this framework for two systems in an effort to see where these systems are and to study how their progress in the resilience cycle differs or converges.

Looking at the structural and environmental systems
 → Flooding

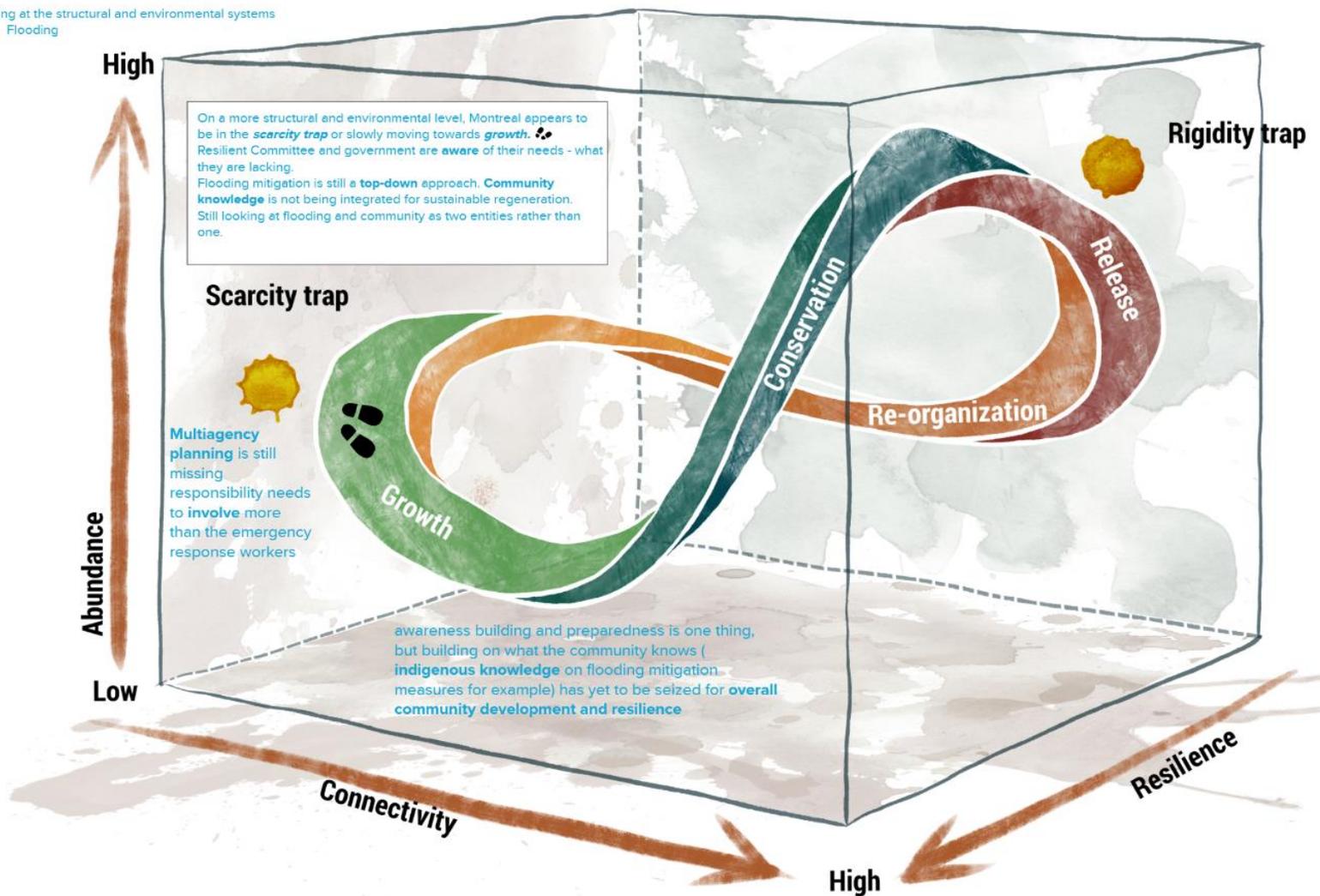


Diagram 6. Base diagram: Resilience Cycle Analysis based on the Resilience Earth, 2020 framework – Modified by author to display the analysis for the structural and environmental systems (in blue) – for larger version, refer to appendix 5

Looking at the social and cultural systems
 → Community relationships

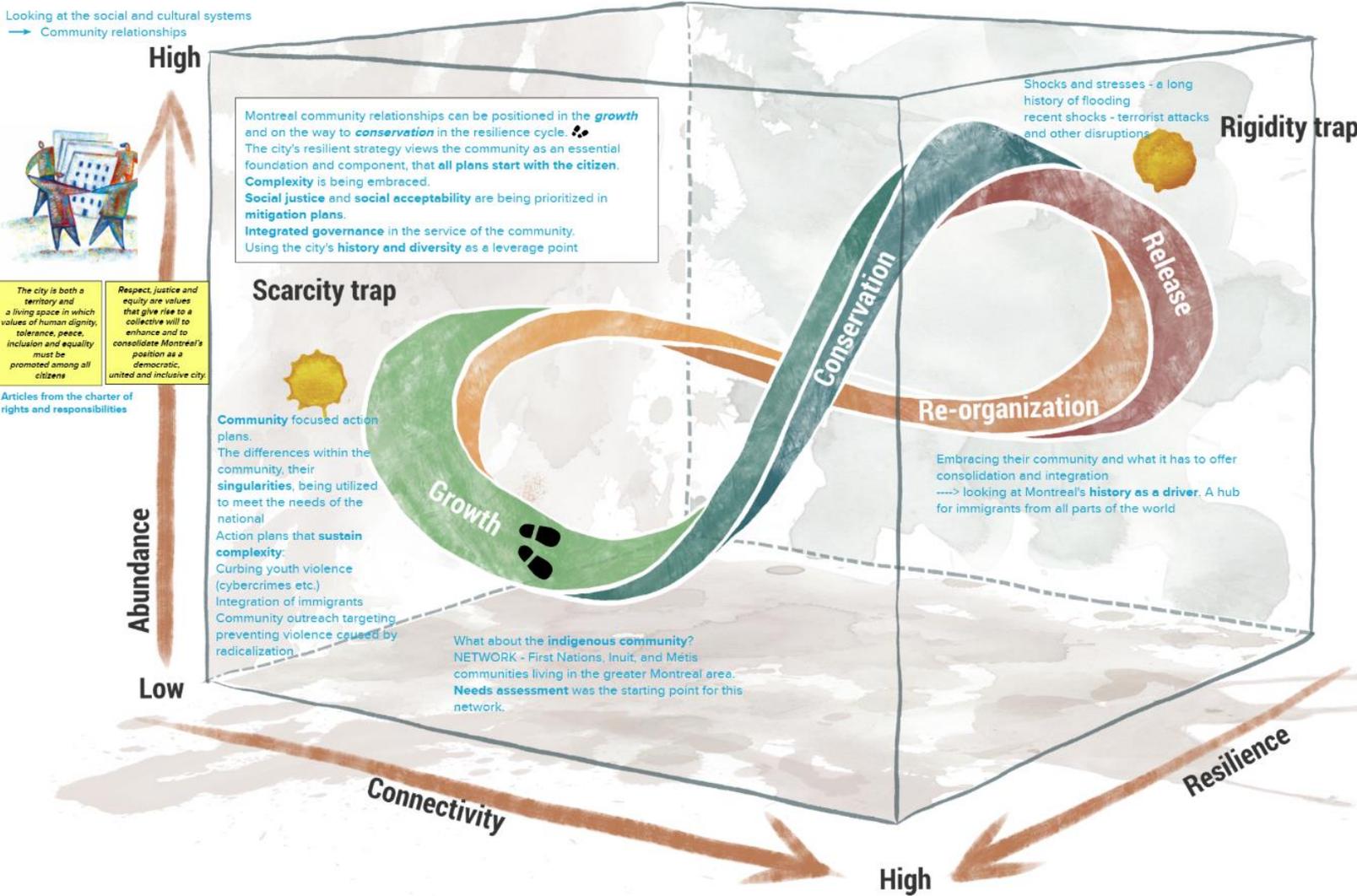


Diagram 7. Base diagram: Resilience Cycle Analysis based on the Resilience Earth, 2020 framework – Modified by author to display the analysis of the social and cultural systems (in blue) – for larger version, refer to appendix 6

RESILIENCE: BEFORE, NOW, AND GOING FORWARD

Resilience in Montréal is not a novel concept that has emerged just recently to participate with the hype and the publicity of the term. As evident in this paper, strategies along the years have been in the process of implementing a version of what resilience could be. However, with the impending threat of climate change can Montréal up its game in this field? When the Covid-19 pandemic hit the world in 2020, Montréal's resilience tactics and schemas seemed to have revealed more of its deficiencies rather than outline its progress. The report released by Canada's Chief Public Health Officer concerning the State of Public Health in 2020, indicated that "there were strong positive correlations between COVID-19 cases per 100,000 residents and the percentage of Black residents" (Canada, 2020). The correlation was also present in areas with a concentration of low- income members, healthcare workers and people living in unsuitable houses. Based on the *report*, and as of mid-May 2020, Covid-19 cases in disadvantaged areas or neighborhoods was 2.5 times more than those of the most affluent areas (Canada, 2020). This statistic shows the inconsistency in the city's claim to stress on cohesion and equity, while the heart of all its strategies allegedly caters to community above all else. The argument still stands then concerning the true implementation of resilience in this metropolitan region of Québec and begs for further examination into Montréal's future pathways in urban resilience.

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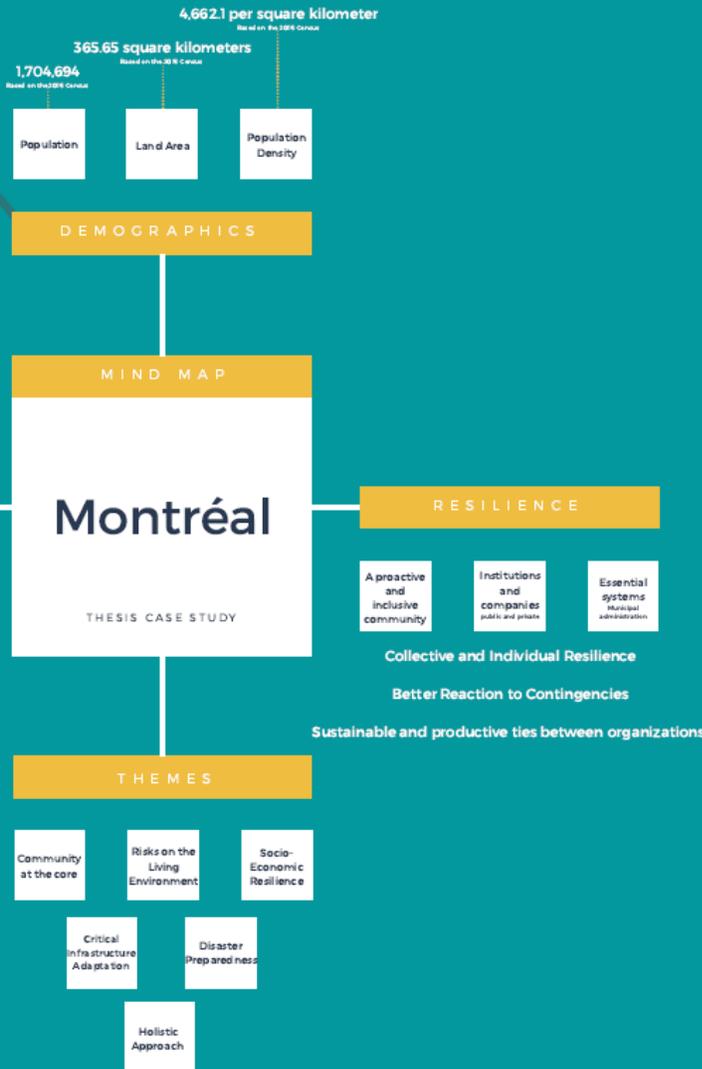
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- Figure 7:** Social susceptibility in the areas of the Montréal agglomeration exposed to flooding caused by excessive runoff water (Montréal, 2017)
- Figure 8:** Territorial susceptibility in the areas of the Montréal agglomeration exposed to river floods (Montréal, 2017)
- Figure 9:** Social susceptibility in the areas of the Montréal agglomeration exposed to river floods (Montréal, 2017)
- Figure 10:** Recommendations to prevent sewer backup due to heavy rainstorms for flat roof buildings (Service de L'eau Montréal, 2011)
- Figure 11:** Image of Montréal's Green Alley (Haines, 2019)
- Figure 12:** Image of Montréal's Green Alley (Macrae, 2017)
- Figure 13:** Image of Montréal's Green Alley (This City Life, n.d.)
- Figure 14:** The 2012 intervention for the early warning system (Bradette & Thibault, 2012)
- Figure 15:** Map identifying the telemetric stations and the areas that are most vulnerable to floods (Gilbert & Proulx, 2013)
- Figure 16:** Goals of Montréal's Incident and Feedback Report 2017 (SIM, 2017)
- Figure 17:** Areas of the Montréal agglomeration exposed to flooding caused by excessive runoff water (Montréal, 2017)
- Figure 18:** Vulnerability map of heavy rainfalls in the Montréal agglomeration (Montréal, 2017)
- Figure 19:** Areas of the Montréal agglomeration sensitive to river floods (Montréal, 2017)
- Figure 20:** Vulnerability map of river floods in the Montréal agglomeration (Montréal, 2017)
- Figure 21:** Reports released by Montréal over the years (PRI, 2017; Ville de Montréal, 2018; Montréal, 2017; SIM, 2017; Haf et al., 2016)
- Figure 22:** The development stages of networks (Mohr, 2016)
-
- Graph 1:** Number of days during which rainfall exceeded 30mm (Montréal, 2017)
- Graph 2:** Some notable rainfall events in the Montréal agglomeration from 1983 till 2013 (Montréal, 2017)

APPENDIX

APPENDIX 1

- Is a port city, whose port generates \$1.5 billion in direct economic benefits to the Canadian economy, including 140 million in Québec and 14 million in Montréal
- Montréal's energy system (hydroelectricity) stands out due to its use of renewable energy.
- Has third largest waste water treatment plant in the world
- Has 4,000 green laneways and 97 community gardens



Case Study City Resilience

Montréal is the largest City in Quebec and second largest city in Canada. It is also one of the most densely populated cities in Canada. Montréal has experienced a lot of environmental risks and man-made hazards ranging from floods and storms to explosions and terrorist attacks.

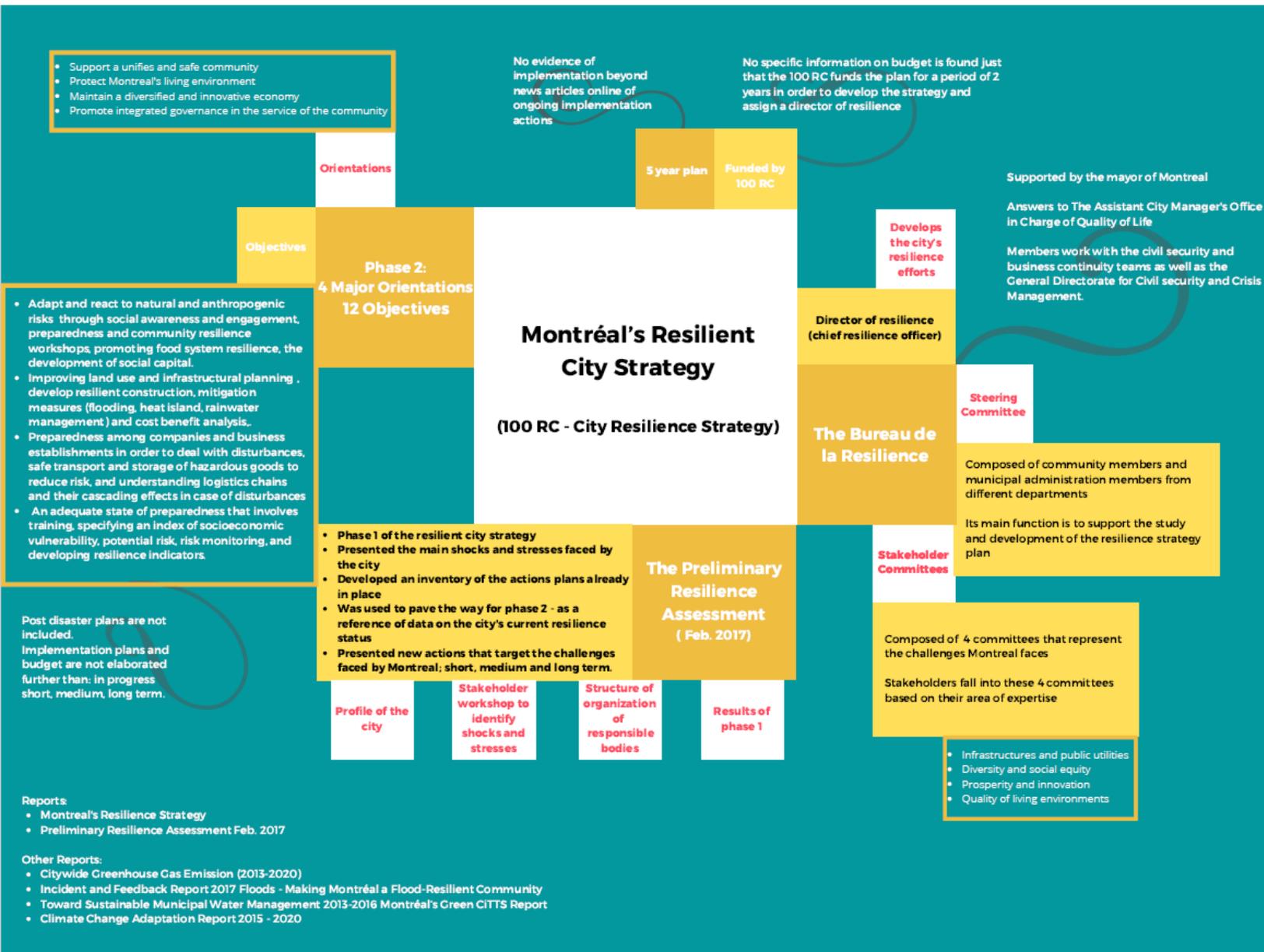
Montreal is the first city in Canada to join the 100 Resilient Cities in December 2014 and start the journey on fulfilling its vision of a resilient city. Montreal's resilient strategy places the citizen at its core. It recognizes that the city's resilience is a holistic and comprehensive approach that will only be achieved with all members of the municipal administration as well as the citizen's continuous involvement (through a local advisory body representing neighborhoods) and collaboration of public and private organizations.

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*Mind Map of Montréal's as a city in Canada: Demographic information of the city, shocks and stresses, themes and resilience focus areas within the city's resilient strategy.
Diagram created by author*

APPENDIX 2



Mind Map of Montréal's resilient city strategy: Breakdown of the preliminary resilience assessment and the 100RC report. Information on other relevant reports published concerning resilience pathways and adaptation approaches.

Diagram created by author

Regenerative Spiral

APPENDIX 3

Base diagram: Regenerative Cycle
Analysis based on the Resilience Earth,
2020 framework – Modified by author for
the purpose of this report (in blue and
orange)



Currently, Montreal seems to be at this stage of the regenerative cycle



promoting integrated government in the service of the community - 100 RC - bureau de la resilience

REGENERATIVE
"Humans participating as nature", becoming a regenerative force within our ecosystem

RECONCILIATORY
"Humans are an integral part of nature", with the capacity to reconcile cultural paradigmatic tensions with fundamental planetary boundaries

RESTAURATIVE
"Humans doing things to nature", "recovering ecological parameters of the recent past

Glass Ceiling of Legitimacy

SUSTAINABILITY
Deterioration of the system ends, opening space to sustain the current situation

GREENWASHING
Discourse and intentions are established, opening space for knowledge gathering

CONVENTIONAL PRACTICE
Extractive and opaque practices dominate

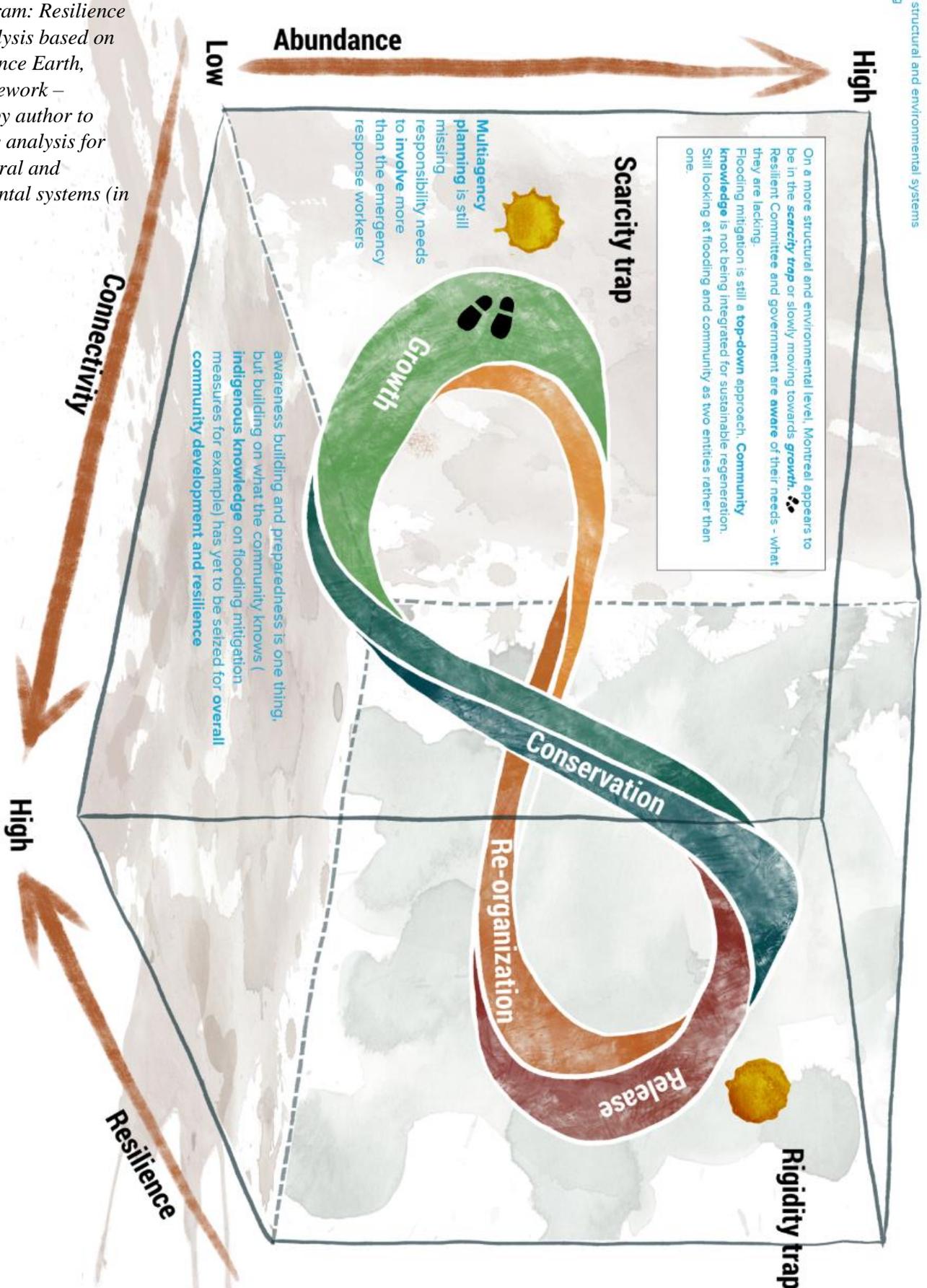
TRAUMA / COLLAPSE
War, violence, social injustice, economic inequality, unfettered extraction, authoritarianism

Threshold of Legality

Resilience Cycle

I have decided to work on this framework for two systems in an effort to see where these systems are and to study how their progress in the resilience cycle differs or converges.

Looking at the structural and environmental systems
→ Flooding



APPENDIX 5

Base diagram: Resilience Cycle Analysis based on the Resilience Earth, 2020 framework – Modified by author to display the analysis for the structural and environmental systems (in blue)

Resilience Cycle

Looking at the social and cultural systems
→ Community relationships



The city is both a territory and a living space in which values of human dignity, tolerance, peace, inclusion and equality promote and bring all citizens together.

Articles from the charter of rights and responsibilities

High

Abundance

LOW

Montreal community relationships can be positioned in the **growth** end on the way to **conservation** in the resilience cycle. The city's resilient strategy views the community as an essential foundation and component, that all plans start with the citizen. Complexity is being embraced. Social justice and social acceptability are being prioritized in mitigation plans. Integrated governance in the service of the community. Using the city's history and diversity as a leverage point.

Scarcity trap

Community focused action plans.
The differences within the community, their singularities, being utilized to meet the needs of the national

Action plans that sustain complexity:
Curbing youth violence (cybercrimes etc.)
Integration of immigrants
Community outreach targeting preventing violence caused by radicalization.

What about the **Indigenous community?**
NETWORK - First Nations, Inuit, and Metis communities living in the greater Montreal area.
Needs assessment was the starting point for this network.



Shocks and stresses - a long history of flooding recent shocks - terrorist attacks and other disruptions

Rigidity trap

Embracing their community and what it has to offer consolidation and integration
→ looking at Montreal's history as a driver. A hub for immigrants from all parts of the world

Connectivity

High

Resilience

APPENDIX 6

Base diagram: Resilience Cycle Analysis based on the Resilience Earth, 2020 framework – Modified by author to display the analysis of the social and cultural systems (in blue)

