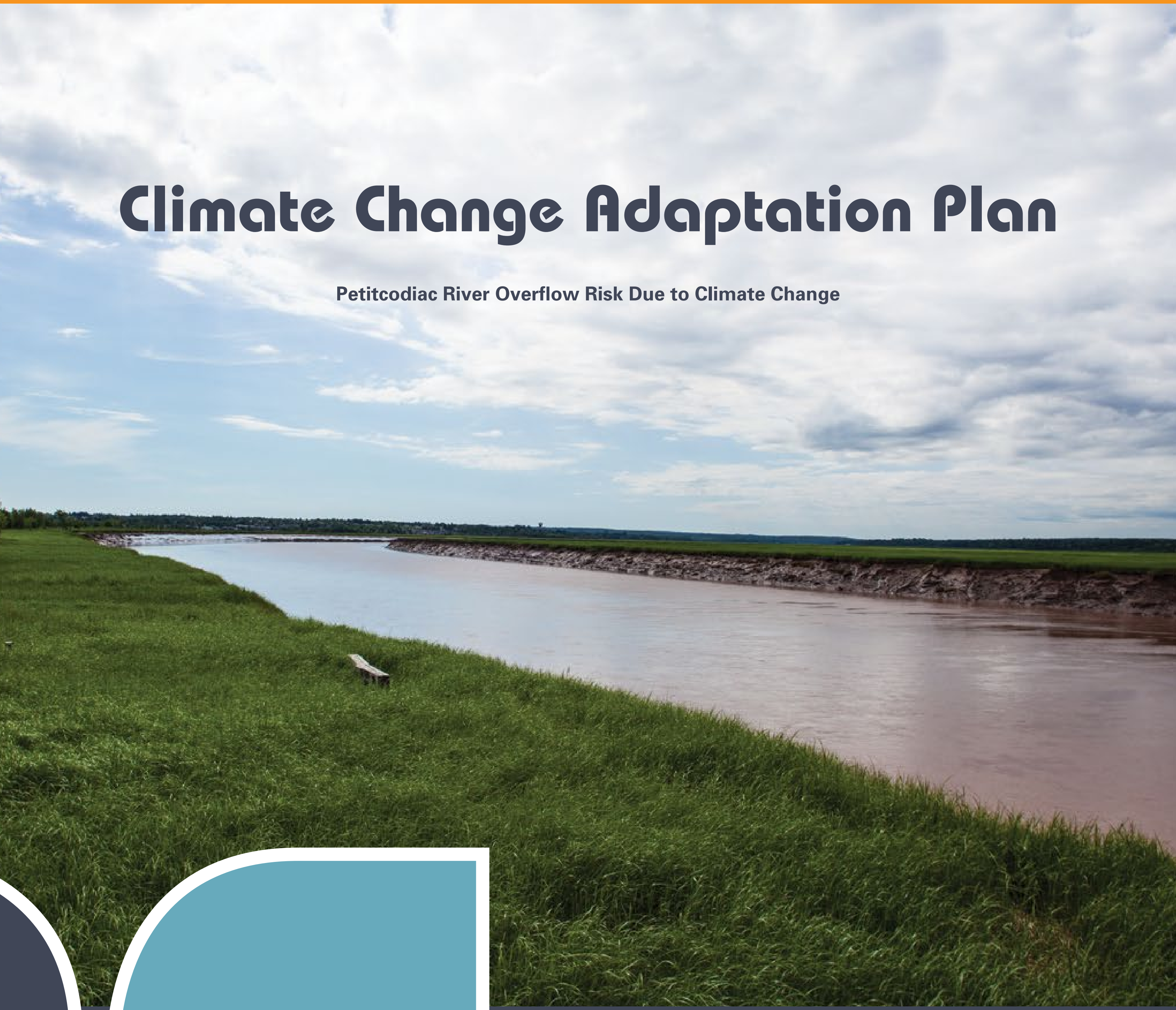
# Climate Change Adaptation Plan

**Petitcodiac River Overflow Risk Due to Climate Change**



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# Foreword

In recent years, the Government of Canada has invested in programs to help Canadians adapt to climate change. Among these investments is the Regional Adaptation Collaborative (RAC) Program regarding climate change. In April 2010, the cities of Dieppe, Moncton and Riverview participated in this jointly funded program to assess the flood risk of the Petitcodiac River as a result of climate change, for which a technical study was prepared by AMEC Earth and Environmental in December 2011.

The City of Dieppe Climate Change Adaptation (CCA) committee was created in February 2014 to identify risks associated with climate change, develop adaptation strategies and ensure continuous monitoring of climate change adaptation issues. The CCA committee reports to the Chief Administrative Officer and is comprised of various municipal service employees. The CCA committee prepared this document to provide information on the causes and effects of climate change. Flood risks from the Petitcodiac River associated with global warming have been designated a priority. This document was prepared as a result. Historically, freshwater runoff, compounded by melting snow, has caused floods in the Chartersville Marsh. However, the flooding of the Marsh is not discussed in this document; the focus is on the flooding risk of the Petitcodiac River. This document includes general recommendations in order to provide possible solutions for developing an action plan.

With a view to maintaining the City of Dieppe's prosperity and the well-being of its residents, the CCA committee is committed to continuing its efforts and working with all stakeholders to meet the municipality's current and future needs.

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# City of Dieppe Climate Change Adaptation (CCA) committee

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# 1 Introduction

## 1.1. What is climate change?

Climate change can de defined as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.[1]

Although climate change is caused by natural processes such as variations in the Earth's orbit and volcanic eruptions, the advent of the industrial age by human beings rapidly accelerated climate change, particularly global warming. Global warming in recent years has primarily been caused by the additional billions of tonnes in greenhouse gases in the atmosphere, carbon dioxide ($CO_2$) in particular, as seen in Figure 1.1.

**How global warming happens:**

- Life on Earth is possible because of the warmth of the sun. While some of this incoming solar radiation bounces back into space, a small portion of it is trapped by the delicate balance of gases that make up our atmosphere. This is the greenhouse effect phenomenon. Without this layer of insulation, Earth would simply be another frozen rock hurtling through space. Carbon dioxide ($CO_2$) is the most important gas in this layer of insulation.
- $CO_2$ is stored all over the planet — in plants, rocks, and even us. We are disrupting the protective balance of our planet when we release $CO_2$ in vast quantities so rapidly, be it through burning fossil fuels (coal, oil and gas), cutting down trees, exploiting land and the oceans, and by breathing (over six billion human beings breathe, along with the billions of animals we raise to feed ourselves).
- By disrupting the atmospheric balance that keeps the climate stable, we are now seeing extreme effects around the globe. It's like a thermostat that's gone haywire — it just doesn't work the way it should. Our thin yet comfortable layer of insulation is now like a thick, heat-trapping blanket. The result: global warming.[2]

[1] United Nations Framework Convention on Climate Change. (2014). http://unfccc.int/resource/docs/convkp/conveng.pdf

[2] What is climate change? (2014). David Suzuki Foundation. http://www.davidsuzuki.org/issues/climate-change/science/climate-change-basics/climate-change-101-1/

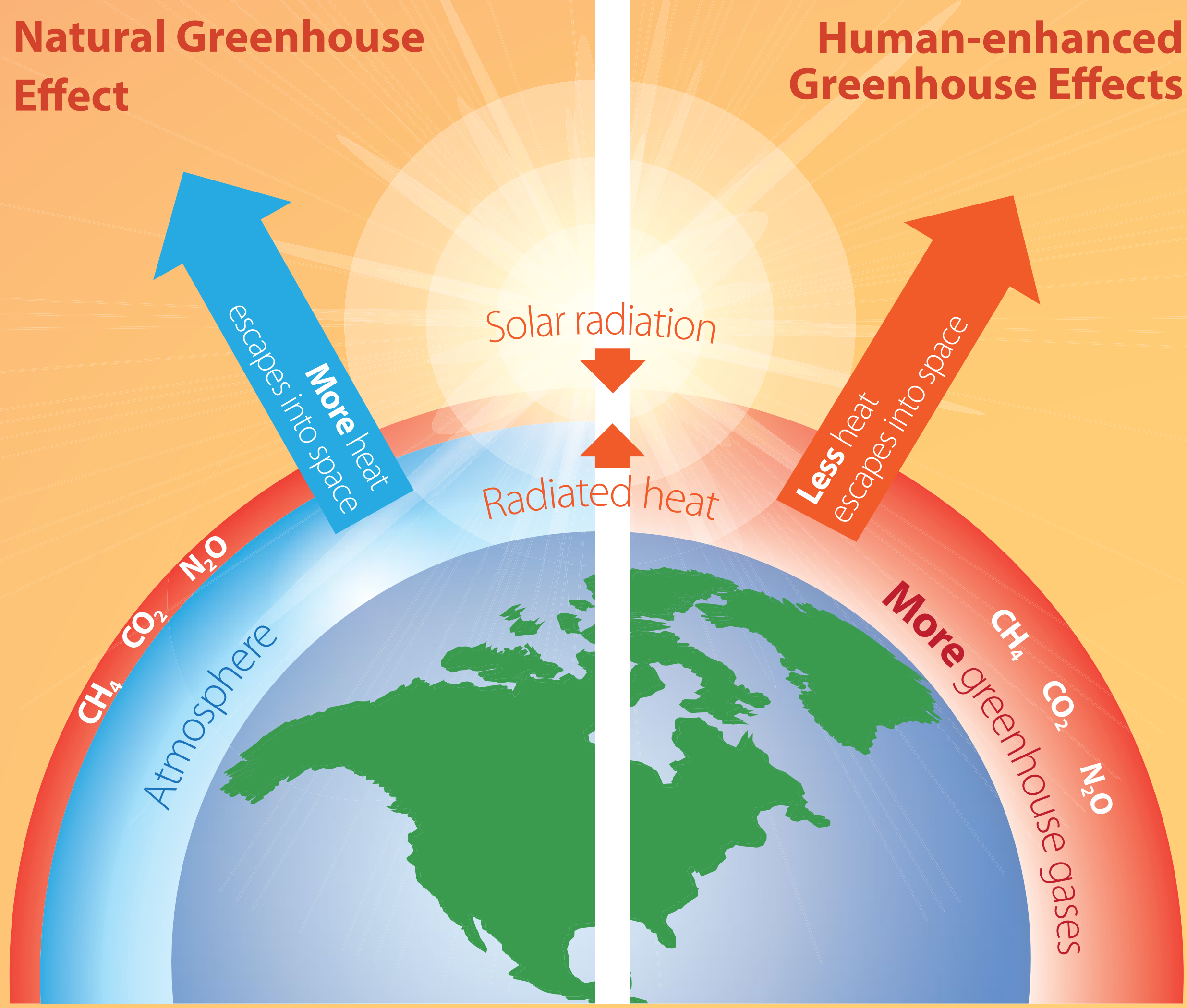


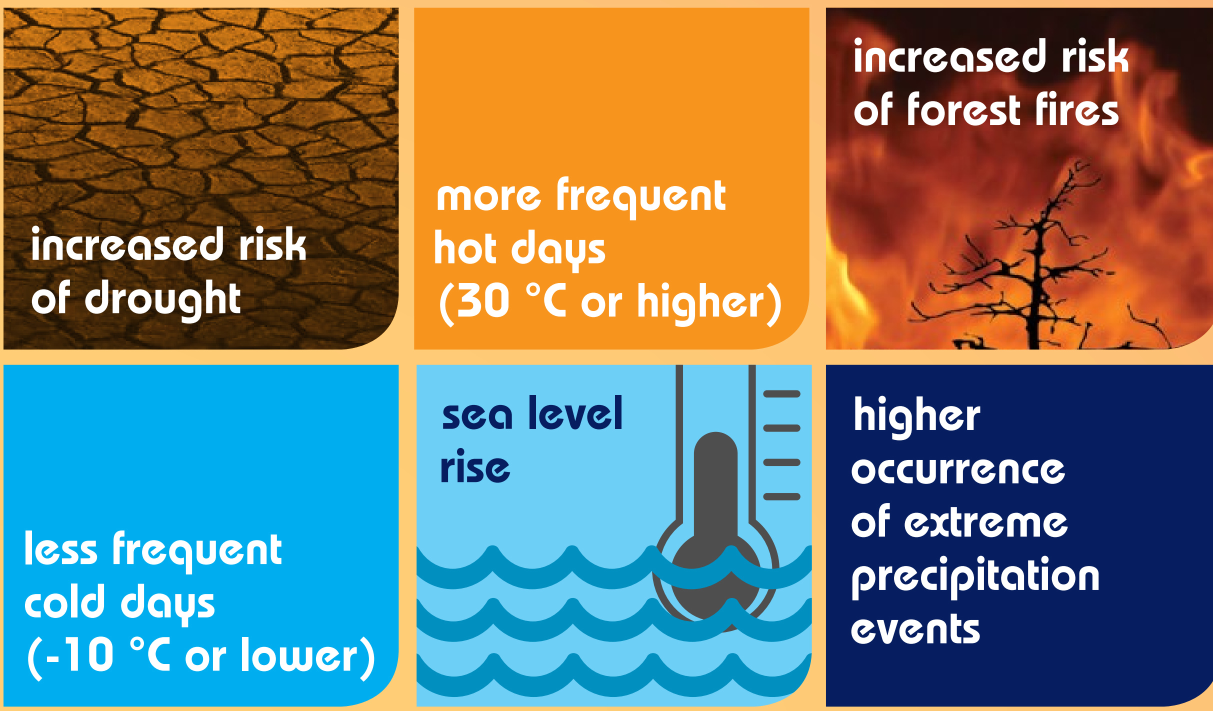

**Figure 1.1**

## Greenhouse effect[3]

**Left** – Naturally occurring greenhouse gases—carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide (N2O)—normally trap some of the sun's heat, keeping the planet from freezing.

**Right** – Human activities are increasing greenhouse gas levels, leading to an enhanced greenhouse effect.

**Global warming has several global and regional consequences such as:**



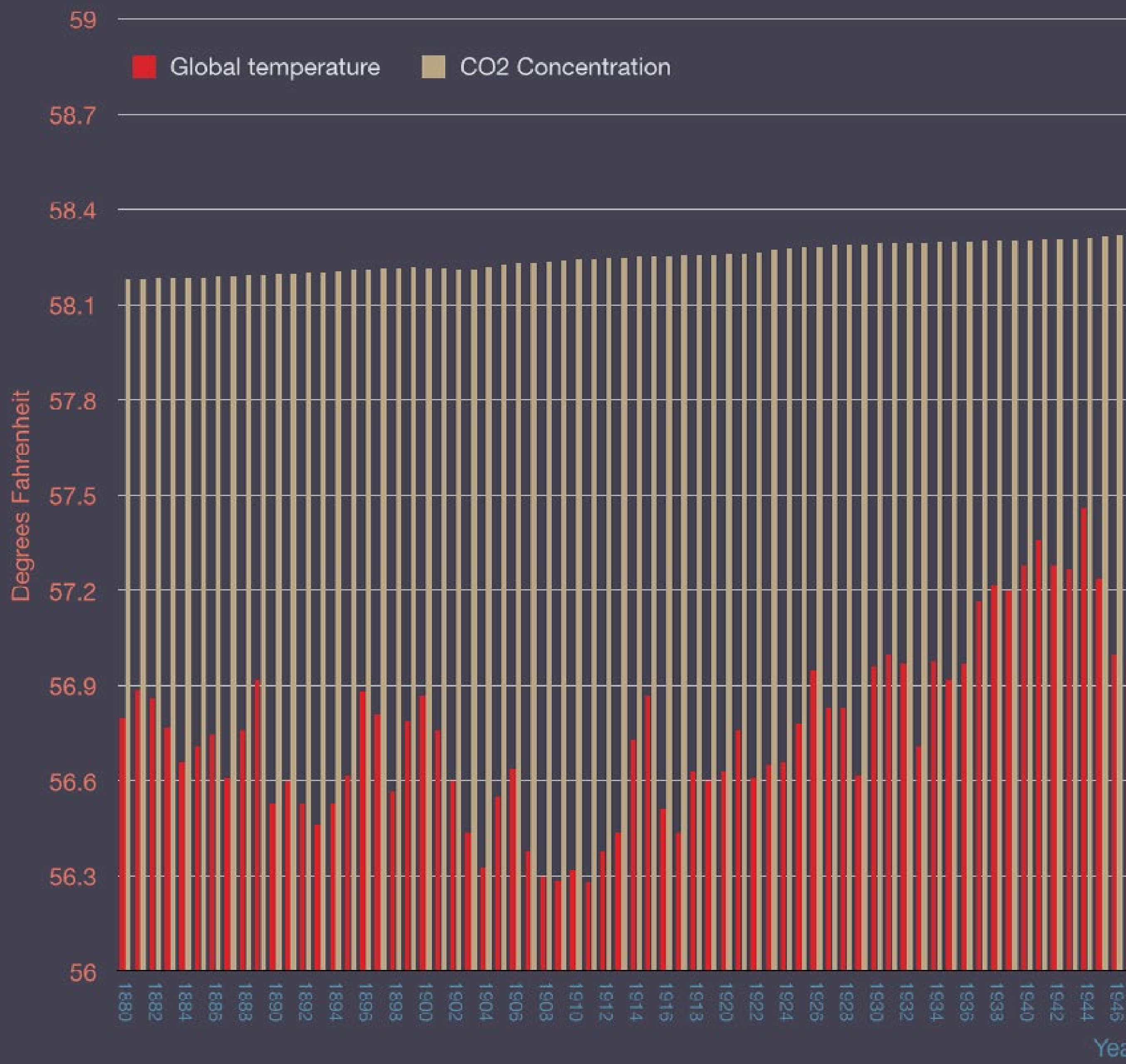

The spatial (where) and temporal (when) distribution of the consequences is difficult to predict regionally due to limitations on the accuracy of the climate models used, and particularly due to the uncertainty of current and future government and individual behaviour. In spite of these uncertainties, there is widespread scientific consensus that the climate change effect constitutes the single greatest environmental challenge of our time and has long-since ceased to be a scientific anomaly. It is no longer just one of many environmental and regulatory concerns.[4]

3 What is Climate Change? (2014). National Park Service. http://www.nps.gov/goga/naturescience/climate-change-causes.htm

4 Climate Change: Introduction. (2014). United Nations Environment Programme. http://www.unep.org/climatechange/Introduction.aspx

# GLOBAL TEMPERATURE AND $CO_2$

## ILLUSTRATION 1.2 ANNUAL GLOBAL TEMPERATURE MESURED ON THE SURFACE OF CONTINENTS AND OCEANS[5]



The red bars indicate temperatures above and below the 1901-2000 average temperature. The beige bars indicate atmospheric CO2 concentration for this period.

[5] Global climate change indicators. (2014). National Oceanic and Atmospheric Administration – National Climatic Data Center. www.ncdc.noaa.gov/indicators/

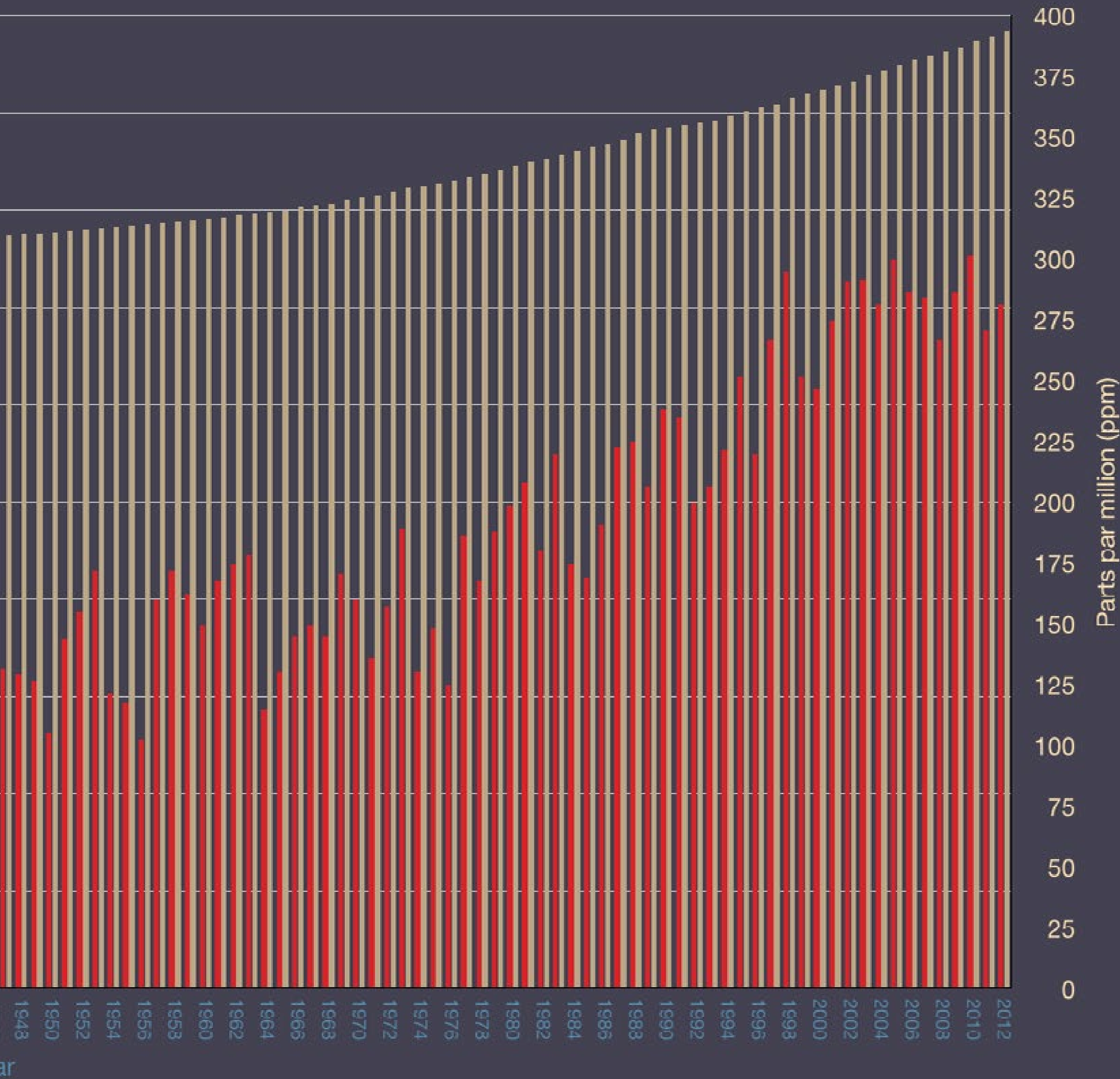
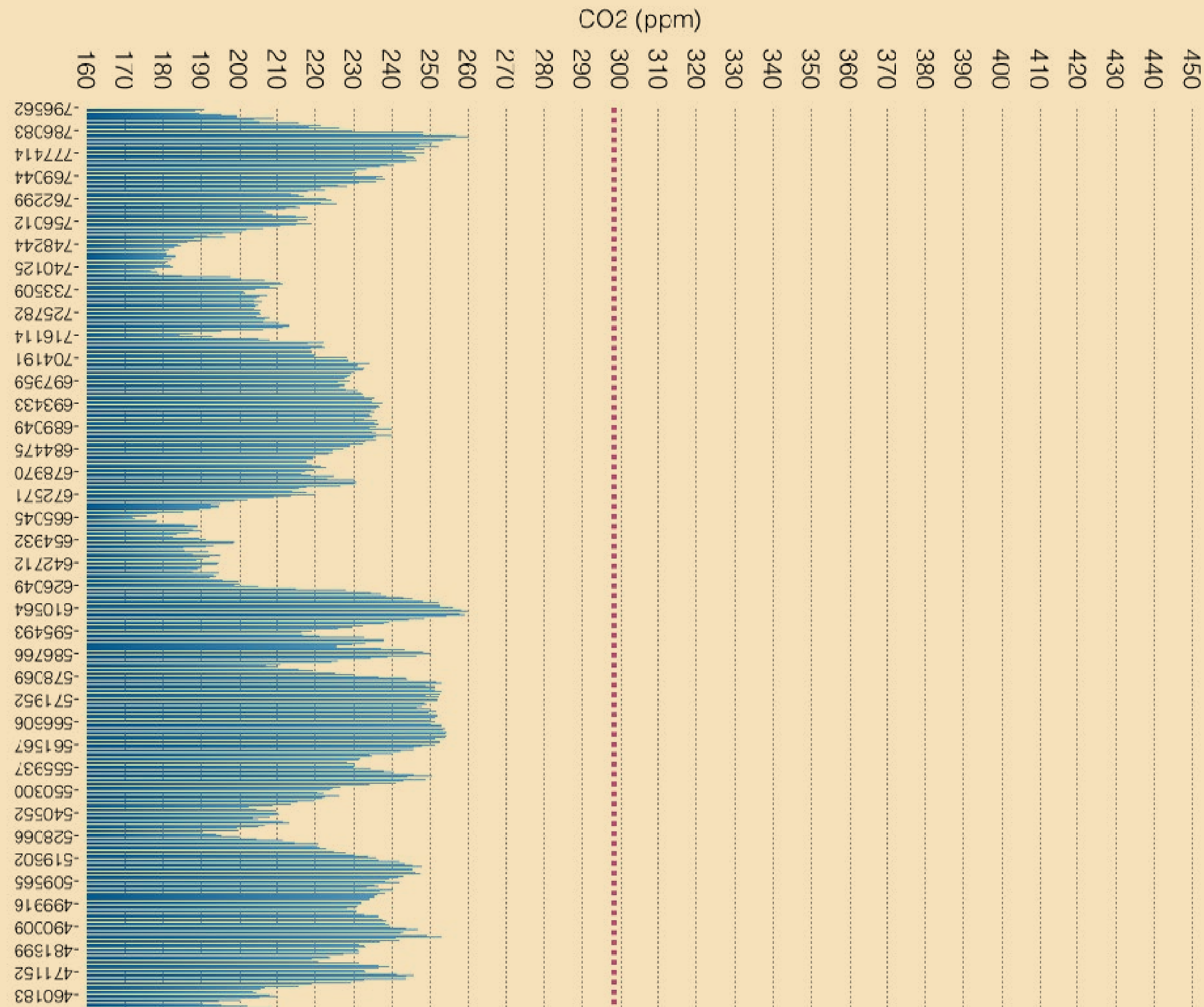
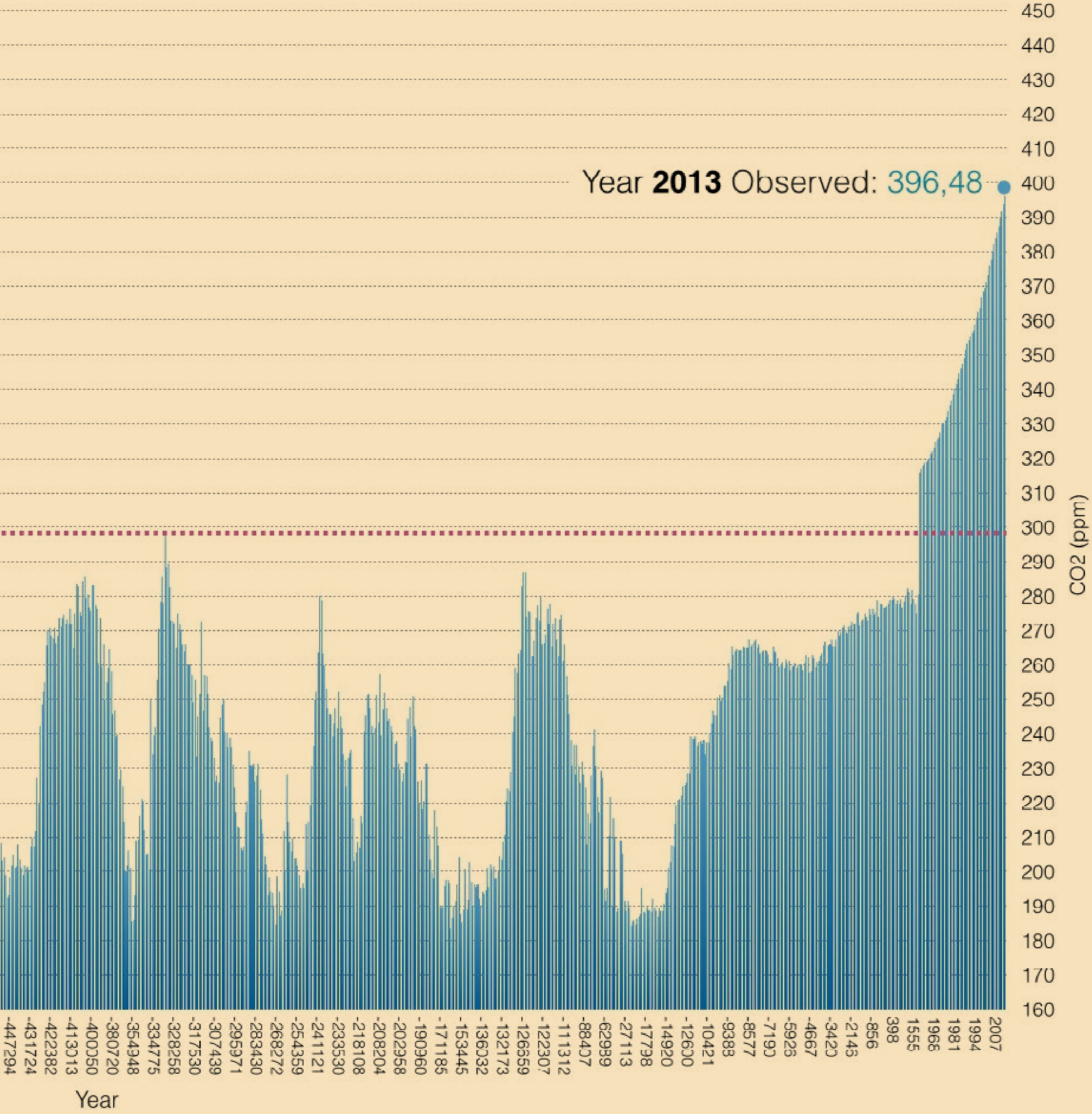


Figure 1.3

## Carbon dioxide ($CO_2$) concentrations in parts per million (ppm) over the past 800,000 years.[6]

The $CO_2$ concentration was measured from bubbles of air trapped in an Antarctic ice core. The projections are based on future greenhouse gas emission scenarios.






[6] Karl, T., Melillo, J., Peterson, T., (eds.). (2009). Global Climate Change Impacts in the United States.

## 1.2. How is climate change predicted?

Predictions on future climate changes are carried out using several complex numerical models entitled global climate models. These models are comprised of fundamental scientific concepts of physical, chemical and biological processes governing the Earth's climate system. Several variables, such as estimating future greenhouse gas emission rates, are entered into the models to assess future climate changes.

Using the analogy of a lava lamp, heat from a bulb causes blobs of goo to move about inside the lamp. The Earth's climate is similar, in that heat from the sun causes fluids (air and water) to move around the planet. The equivalent of a global climate model would be changing the bulb from 30 to 50 watts. Would the blobs move faster? Would there be more blobs, but smaller?[7]

[7] Climate Concepts: Analogies and Useful Descriptions. (2014). National Environmental Education Foundation. www.earthgauge.net/2011/analogies-for-models

# 2 What does climate change mean to residents?

## 2.1. Trends for Greater Moncton

| Climate change indices | Historical data | Projections | | |
|---|---|---|---|---|
| | | Short-term | Medium-term | Long-term |
| | 1971 – 2000 | 2011 – 2040 | 2041 – 2070 | 2071 – 2100 |
| Mean annual temperature | 5.1 | 6.4 | 7.6 | 9.0 |
| Mean spring temperature | 3.4 | 4.5 | 5.7 | 7.0 |
| Mean summer temperature | 17.2 | 18.1 | 19.3 | 20.5 |
| Mean autumn temperature | 7.1 | 8.6 | 9.8 | 11.1 |
| Mean winter temperature | -7.5 | -5.8 | -4.2 | -2.3 |
| Annual number of hot days (T > 30 °C) | 4.0 | 7.4 | 14.8 | 23.8 |
| Annual number of very hot days (T > 35 °C) | 0.0 | 0.0 | 0.4 | 1.7 |
| Annual number of cold days (T < -10 °C) | 13.0 | 8.7 | 5.8 | 3.6 |
| Annual freeze-thaw cycles | 102.2 | 92.1 | 85.1 | 77.3 |
| Annual consecutive freeze-free days | 187.0 | 212.0 | 230.8 | 249.8 |
| Annual days with rain | 132.0 | 120.6 | 130.8 | 135.9 |
| Annual days with snow | 34.0 | 27.1 | 21.9 | 18.1 |

Figure 1.4

### Climate change indices for the Greater Moncton Area.[9]

The average of the results of ten climate models and two greenhouse gas emissions scenarios were used to determine the above projections. The effects of the projections shown could be positive (growth in tourism industry during the summer) and negative (higher flood risk), which will affect all residents of Dieppe to varying degrees and at different times in the future.

9 Daigle, R., Dalton, S., Richards, W., Riley, M. (2009). Climate change scenarios: New Brunswick Municipalities.

# What are the potential risks of climate change?

## 3.1. Risks

The Climate Change Adaptation (CCA) committee conducted a general risk analysis of extreme weather events using the Sentinel software.

**The following extreme events were evaluated:**

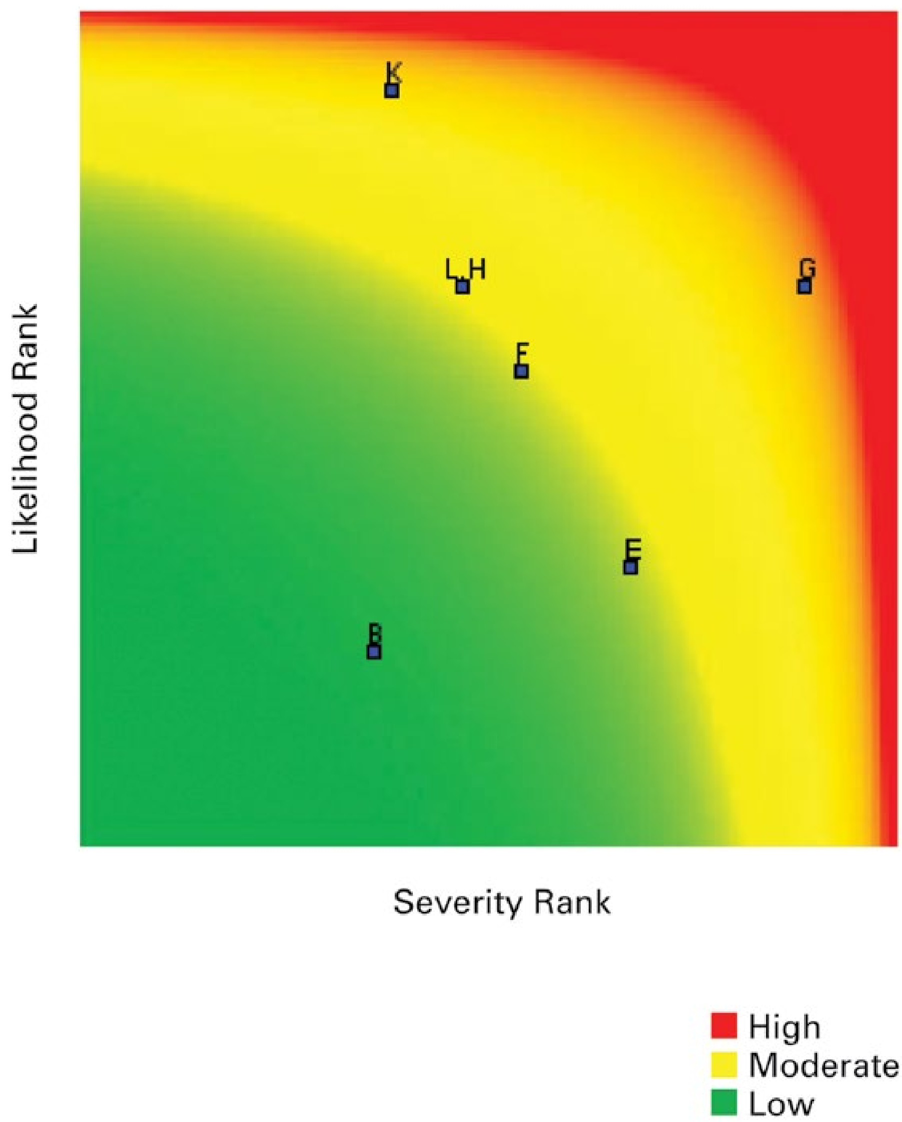
- floods (K)
- hurricanes (G)
- forest fires (E)
- heat waves (F)
- cold waves (B)
- severe winter storms (L)
- ice storms (H)

## **3.2.** Comparative risk analysis

Figure 1.5, created using Sentinel, shows that floods and storm surges caused by hurricanes and tropical storms currently pose the greatest risk to the municipality. This software serves as a preliminary risk assessment tool based on the likelihood of an event occurring and its potential consequences for the municipality. Other risks besides the Petitcodiac River flooding will be discussed in the future, as required.

**Figure 1.5**

### Results of the climate change risk assessment using Sentinel



# 4 What factors affect the Petitcodiac River water levels?

The Petitcodiac River estuary is located in the Bay of Fundy, which has what are considered the highest tides in the world. The effects of these tides are felt in the Petitcodiac River in Dieppe. Before the causeway was built between Moncton and Riverview, the effects of the tides were felt as far as Salisbury. After 1968, the effects of the tides upstream of the newly constructed causeway ceased and the volume of tides greatly subsided, causing siltation in the river and lower hydraulic capacity. The permanent opening of the gates in 2010 resulted in a widening and partial deepening of the river in relation to pre-causeway conditions.

In December 2011, a technical study entitled Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick was published by AMEC Earth & Environmental to assess the existing and future flood risks of the Petitcodiac River. It should be noted that floods may be caused by many factors but that the study and this document focus specifically on the Petitcodiac River flood risks, namely, risks arising from five sources that impact on the water level of the Petitcodiac River and its tributaries:

- **4.1.** sea level rise
- **4.2.** land subsidence
- **4.3.** tides
- **4.4.** storm surges
- **4.5.** freshwater contribution

In order to understand the flood risk in the Petitcodiac River, it is essential to understand each of the five components.

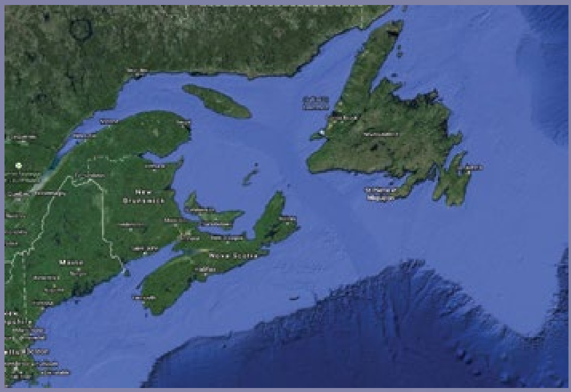
## 4.1. Sea level rise

Sea level rise is not a new occurrence; Figure 1.6 shows the approximate sea level 8,000 years ago. We can see that the Northumberland Strait did not exist at that time and Prince Edward Island was not an island but rather an adjoining landmass with New Brunswick and Nova Scotia. This shows that sea levels fluctuate naturally over time.

## 8000 years ago

*Shaw, J., Gareau, P., Courtney, R.C. (2002)*

## Today



*google.ca*

**Figure 1.6**

# Approximate sea level 8,000 years ago compared to current sea level[10]

This rise is attributed to the thermal expansion of oceans and the melting of polar ice caps on landmasses such as Antarctica and Greenland.[11]

[10] Shaw, J., Gareau, P., Courtney, R.C. (2002). *Paleogeography of Atlantic Canada 13–0 kyr: Quaternary Science Reviews*, v. 21, p. 1861-1878.

[11] AMEC Earth and Environmental. (2011). *Climate change adaptation measures for Greater Moncton Area, New Brunswick : Final Report.*

## 4.2. Land subsidence

Land subsidence occurs as a result of crustal movement of the Earth and is not affected by climate change. The Earth's crust is subsiding in some parts of the continent and rising in others. The subsidence rate in the Greater Moncton Area is estimated at 0.15 metres per century.[12]

Over the past century, a sea level rise of over 0.25 metres has been observed in the Bay of Fundy in St. John, as shown in Figure 1.7. This rise is attributed to land subsidence as well as sea level rise.

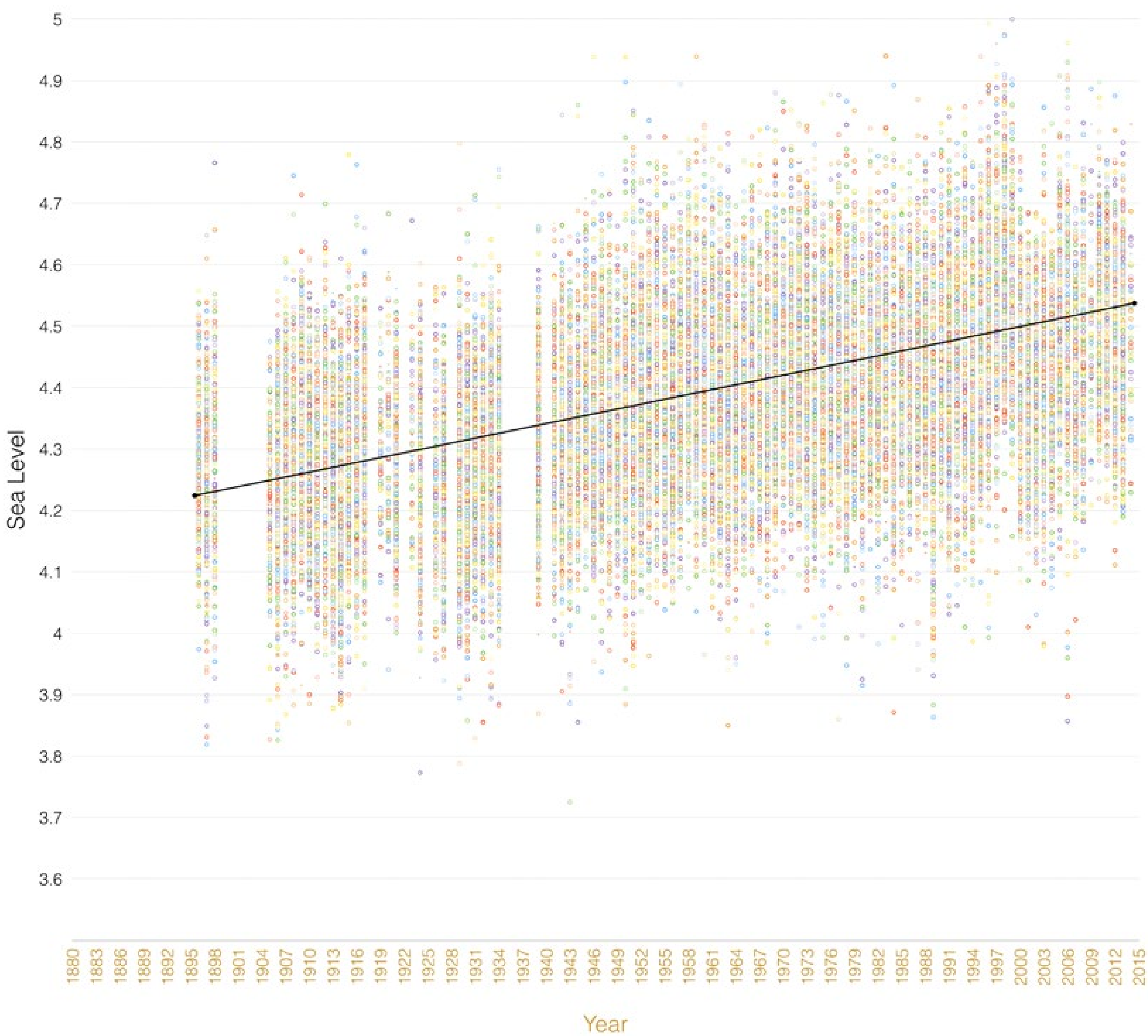
[12] AMEC Earth and Environmental. (2011). Climate Change Adaptation Measures for Greater Moncton Area, New Brunswick: Final Report.

[13] Canadian Tides and Water Levels Data Archive. (2014). Fisheries and Oceans Canada. http://www.isdm-gdsi.gc.ca/isdm-gdsi/twl-mne/index-eng.htm

Figure 1.7

## Daily average tides in the Bay of Fundy in Saint John

Daily average sea elevations have been calculated since 1896 and are represented by dots on the graph. A linear trend curve was adjusted to the data and a sea level rise trend is evident. (Prepared based on data obtained from the Fisheries and Oceans Canada Integrated Science Data Management website.)[13]



# 4.3. Tides

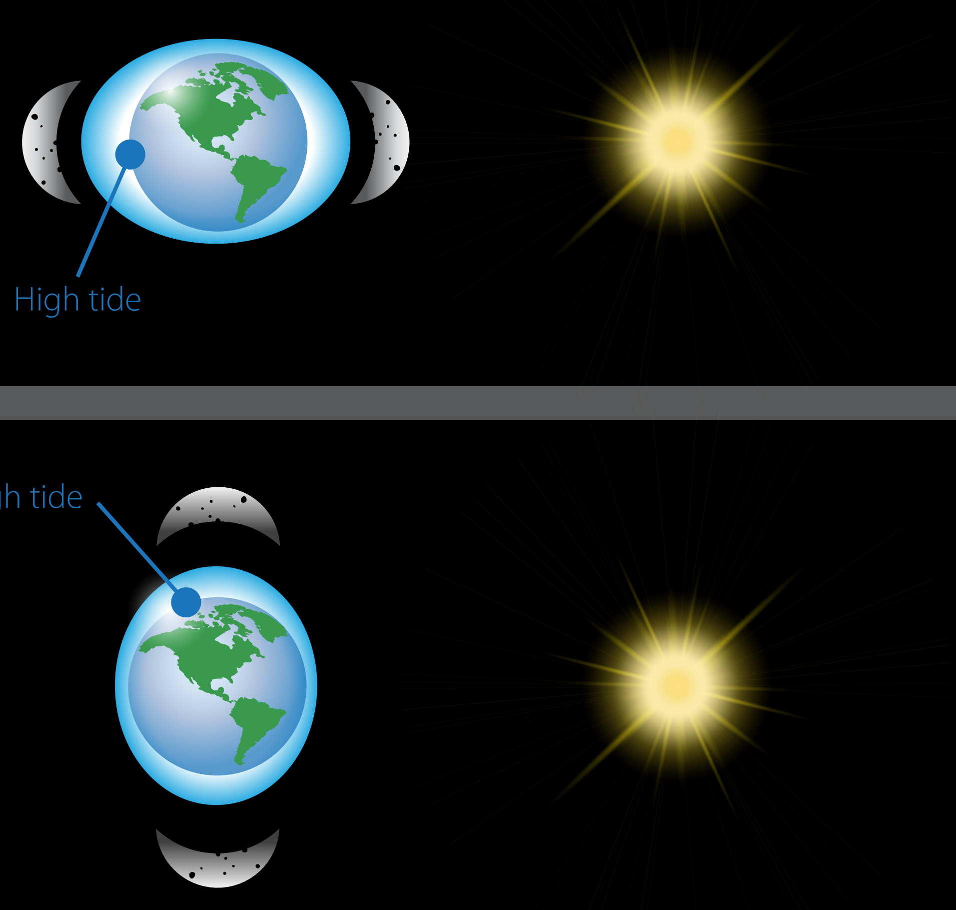
Tides are caused by the gravitational pull of the moon and the sun. The magnitude of the tides is governed by the cyclical positions of the moon and the sun in relation to Earth, as shown in Figure 1.8.

The Bay of Fundy has a unique bathymetry (depth and width) which produces the highest tides in the world. The effects of these tides are seen on the Petitcodiac River in the form of tidal waves.

Construction of the causeway between Moncton and Riverview in 1968 and the opening of its gates in 2010 vastly altered tidal heights in the Petitcodiac River. Studies have shown that widening the opening in the causeway will raise tidal heights to pre-causeway conditions.[14]

**Figure 1.8**

**Influence of the moon and sun on tides**



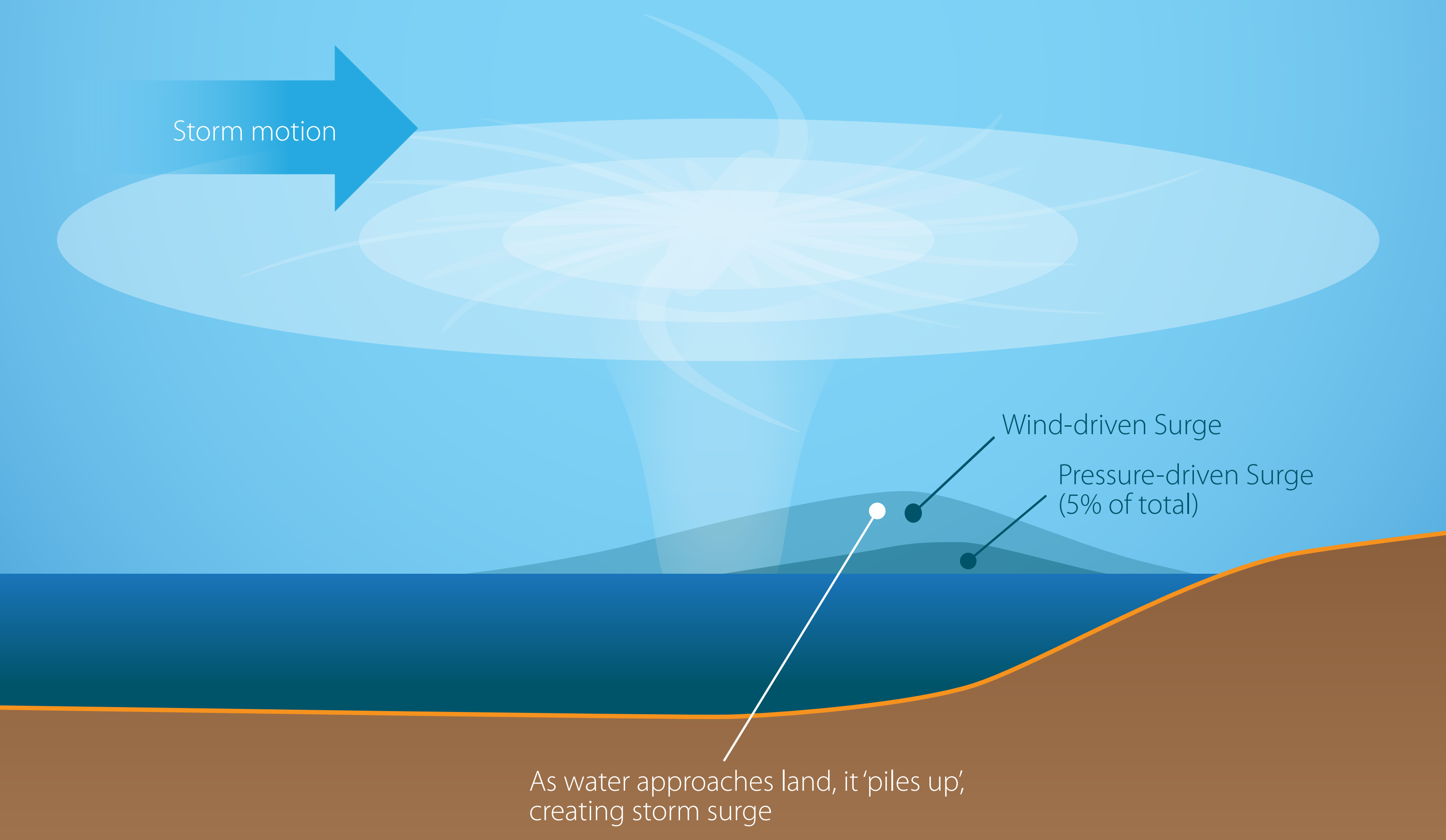

The top scenario creates larger tides with the combined gravitational forces of the moon and sun, while the bottom scenario creates smaller tides due to partial cancellation of gravitational forces.

# 4.4. Storm surges

Storm surges are caused by strong winds and low atmospheric pressure accompanying a storm system. The force of the wind creates a wave that moves in the direction of the wind and the storm's low atmospheric pressure causes a suction effect on the water surface which raises the water level even more, as shown in Figure 1.9.

**Figure 1.9**

**Storm surge[15]**




14 AMEC Earth and Environmental. (2011). Climate change adaptation measures for Greater Moncton Area, New Brunswick: Final Report.

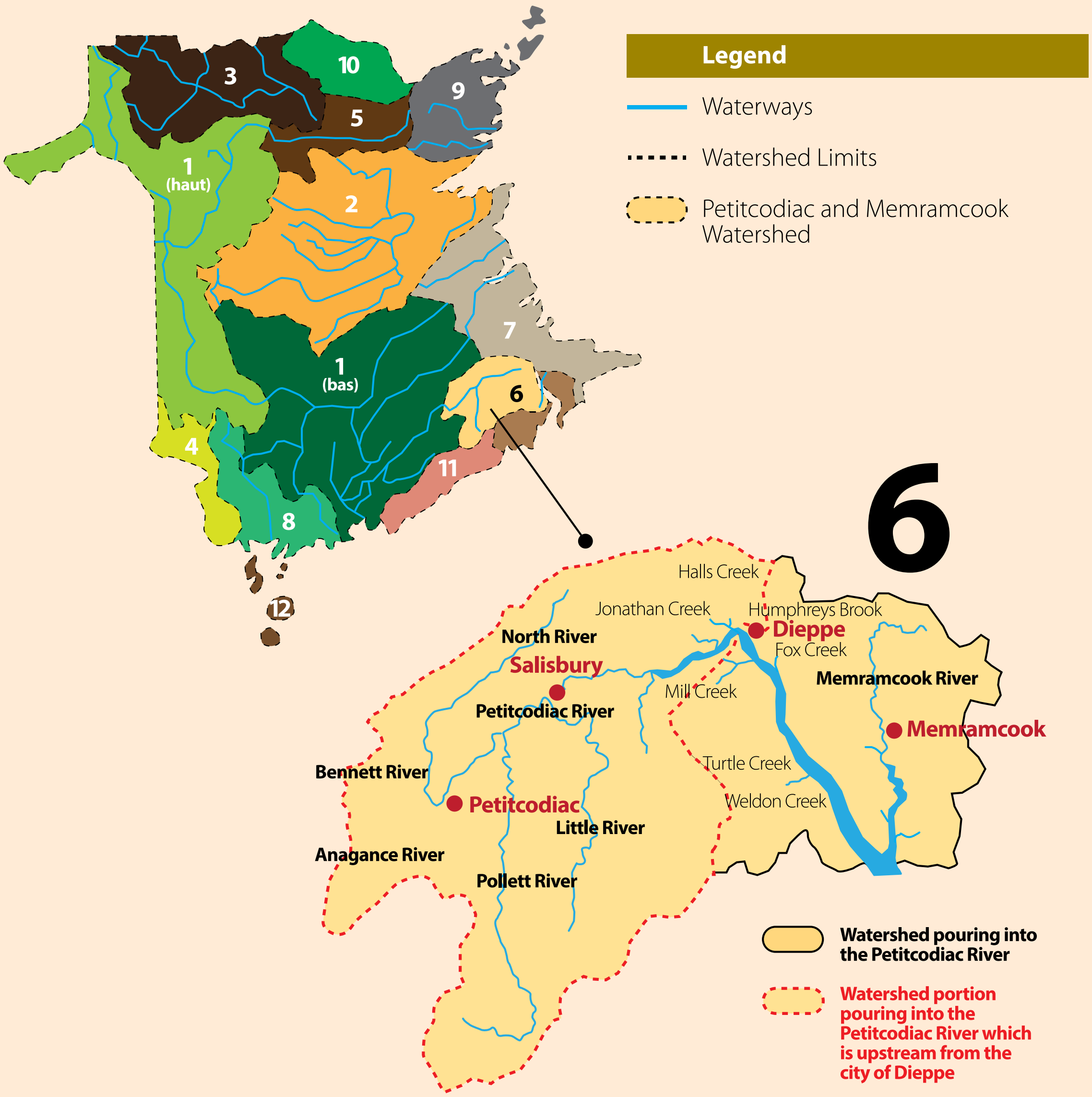
15 Storm surge overview. (2013). National Atmospheric and Oceanic Administration – National Hurricane Center. www.nhc.noaa.gov/surge/

# 4.5. Freshwater contribution

During a precipitation event, some rain penetrates the soil, while the rest drains away on the land surface. This flow is referred to as runoff. As shown in Figure 1.10, the watershed of the Petitcodiac River acts as a funnel that directs the runoff toward the Petitcodiac River, causing its water level to rise. The rise in water level in the Petitcodiac River caused by freshwater contribution varies partly depending on the storm's intensity and duration, and on the soil saturation level in the watershed before the storm.

**Figure 1.10**

## Petitcodiac River Watershed[16]




[16] Rivers and streams: Our watershed. (2014). Petitcodiac Watershed Alliance. www.petitcodiacwatershed.org/rivers_and_streams


# 5 Current and future flood risks

## 5.1. Anticipated water levels in the Petitcodiac River

Several projected water levels were identified in the AMEC technical study based on a few planning horizons and are presented in Figure 1.11.

Figure 1.11

## Water levels for selected planning horizons[17]

| | Return period (probability) | | | |
|---|---|---|---|---|
| Horizon | 1:25 (4%) | 1:50 (2%) | 1:100 (1%) | Saxby Gale |
| | Water level (m) | | | |
| Present | 8.85 | 9.05 | 9.25 | 10.54 |
| Year 2025 | 8.98 | 9.18 | 9.38 | 10.67 |
| Year 2055 | 9.27 | 9.47 | 9.67 | 10.96 |
| Year 2085 | 9.65 | 9.85 | 10.05 | 11.34 |
| Year 2100 | 9.85 | 10.05 | 10.25 | 11.54 |

The return period concept characterizes the projected occurrence frequency of a phenomenon (example: once every 100 years gives a 1:100 return period). This does not imply that an event with a 1:100 return period, i.e., a 1/100 (1%) probability, will only occur every 100 years, because these events can occur two years in a row.

An analogy can be made with flipping a coin: landing tails on a toss does not influence the result of the next toss since each toss produces independent results, but landing tails once between two tosses is likely, the probability for each toss being 50%.

The Saxby Gale is a tropical storm that hit Eastern Canada in 1869. The storm surge generated by this depression was over 2 m and raised the water level in the Petitcodiac River to 10.08 m based on the elevation marker plaque in Bore Park, which is the highest storm surge ever recorded in Greater Moncton. No return periods are available for the Saxby Gale since there is only data for a single occurrence of this magnitude and a statistical analysis is not possible.

[17] AMEC Earth and Environmental. (2011). Climate change adaptation measures for Greater Moncton Area, New Brunswick : Final Report.

# 5.2. Flood scenarios

The CCA committee assessed four flood scenarios to determine current and future flood risks, as presented in Figure 1.12.

Figure 1.12

## Flood scenarios

These scenarios show immediate and future flood risks according to AMEC.

| | Flood elevation (m) | Year | Approximate return period | Approximate probability | Comments |
|---|---|---|---|---|---|
| **Scenario 1** | 8 | Current | 1:1 | 100% | This event currently occurs annually. |
| **Scenario 2** | 9.25 | Current | 1:100 | 1% | This event currently has a 1% probability of occurring. |
| | | 2055 | 1:25 | 4% | This event will have a 4% probability of occurring in 2055. |
| | | 2100 | 1:1 | 100% | This event will occur annually in 2100. |
| **Scenario 3** | 10.50 | Current | Saxby Gale | < 1% | This event currently has a less than 1% probability of occurring. |
| | | 2100 | 1:100 | 1% | This event will have a 1% probability of occurring in 2100. |
| **Scenario 4** | 11.50 | 2100 | Saxby Gale | < 1% | This event will have a less than 1% probability of occurring in 2100. |

## 5.2.1. Scenario 1 – 8 metres

This scenario represents high tides in 2014.

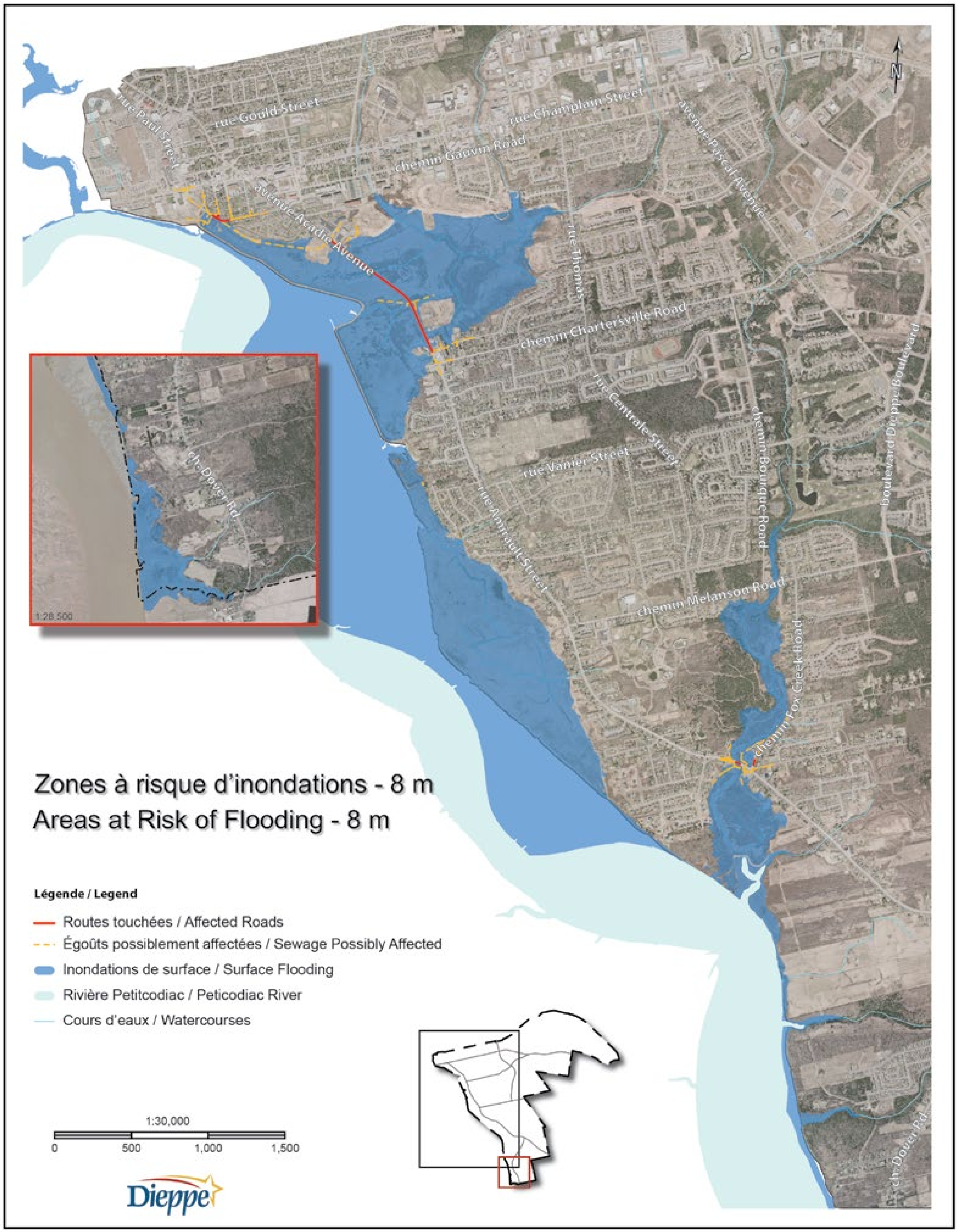
As illustrated in Figure 1.13, this scenario presents very little risk for Dieppe.

The duration of floods in the Chartersville Marsh is partially attributed to high tides in the Petitcodiac River. An elevated water level in the river can temporarily prevent water from being discharged into the marsh.

A break in the Chartersville Marsh dyke could have severe consequences on a small proportion of the built environment around the marsh.

**Figure 1.13**

# Flood scenario – 8 metres



## 5.2.2. Scenario 2 – 9.25 metres

This scenario represents the projected flood level for a storm with a 1:100 return period in 2014. In addition, this water level is anticipated annually in 2100 due to global warming and the sea level rise.

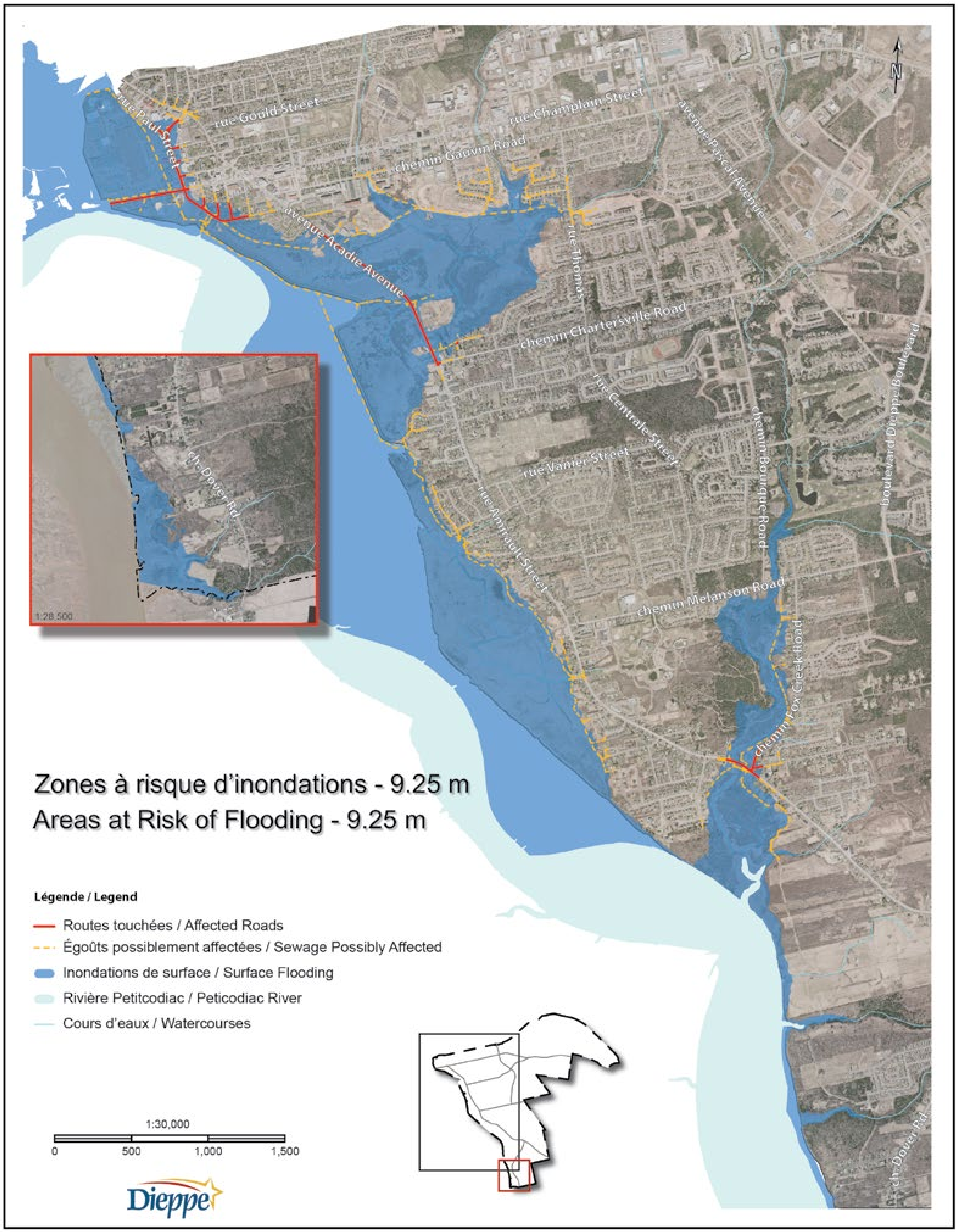
Figure 1.14 shows that water has spilled over the Chartersville Marsh dyke and flooded part of Champlain, Paul and Amirault streets and a few local streets, including residences and businesses in that area. Moreover, residences, businesses and vacant land neighbouring the Chartersville Marsh, Fox Creek and Petitcodiac River are at risk of flooding.

A number of residences and businesses are at risk of sewer back-ups.

There is a risk that the duration of the flooding in the Chartersville Marsh may increase in the future due to the elevated water level in the Petitcodiac River that has persisted for an extended period, which prevents water from draining from the marsh.

**Figure 1.14**

# Flood scenario – 9.25 metres



### 5.2.3. Scenario 3 – 10.50 metres

This scenario presents the projected flooding level for a storm with a 1:100 return period in 2100.

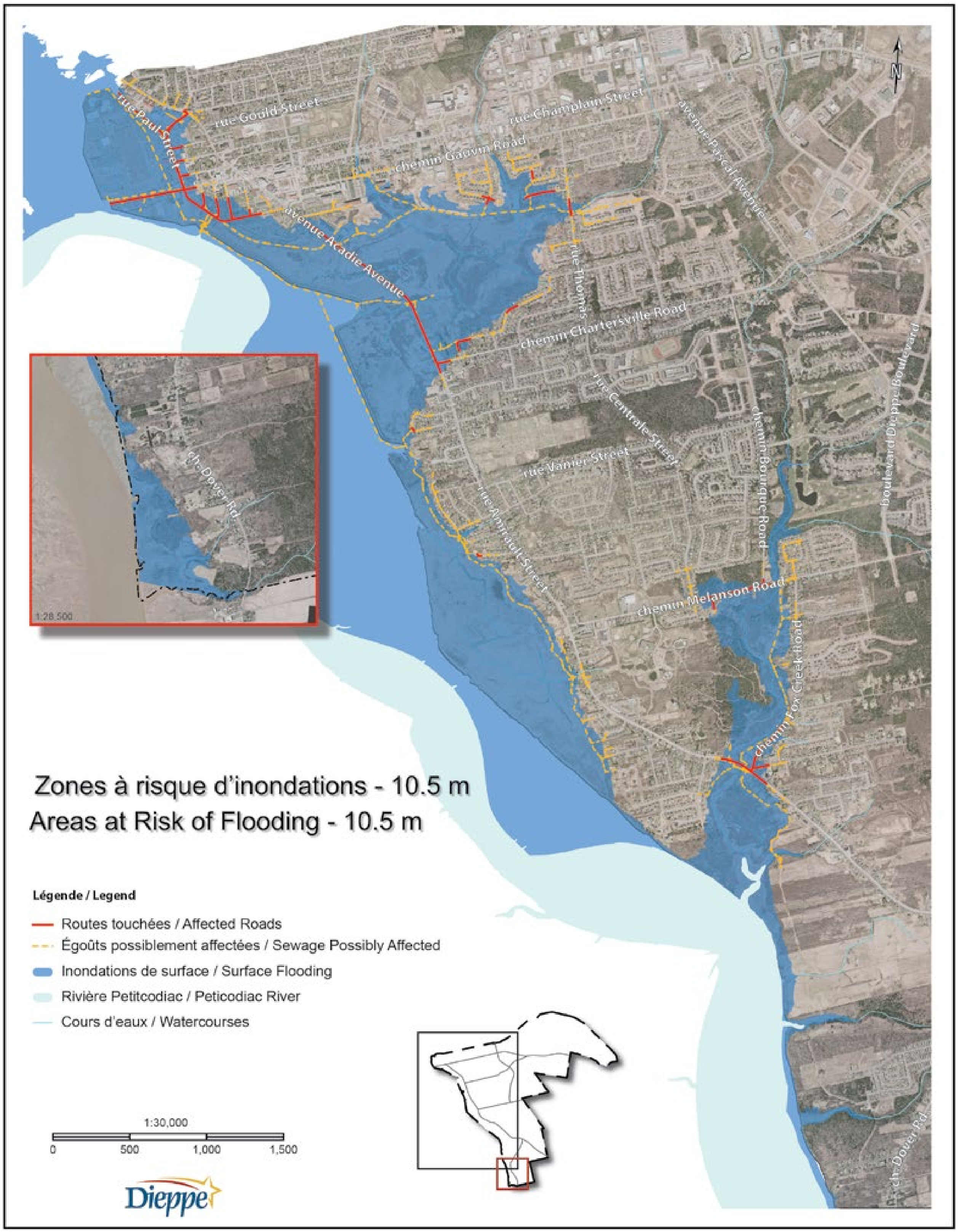
As shown in Figure 1.15, this scenario shows a flood risk in the same locations as scenario 2, but on a broader scale. Melanson Road and Thomas Street are also affected.

There is a substantial sewer back-up risk.

Vehicular traffic becomes difficult and several detours must be set up.

**Figure 1.15**

# Flood scenario – 10.50 metres



### 5.2.4. Scenario 4 – 11.50 metres

This scenario represents the projected flood risk associated with a Saxby Gale in 2100.

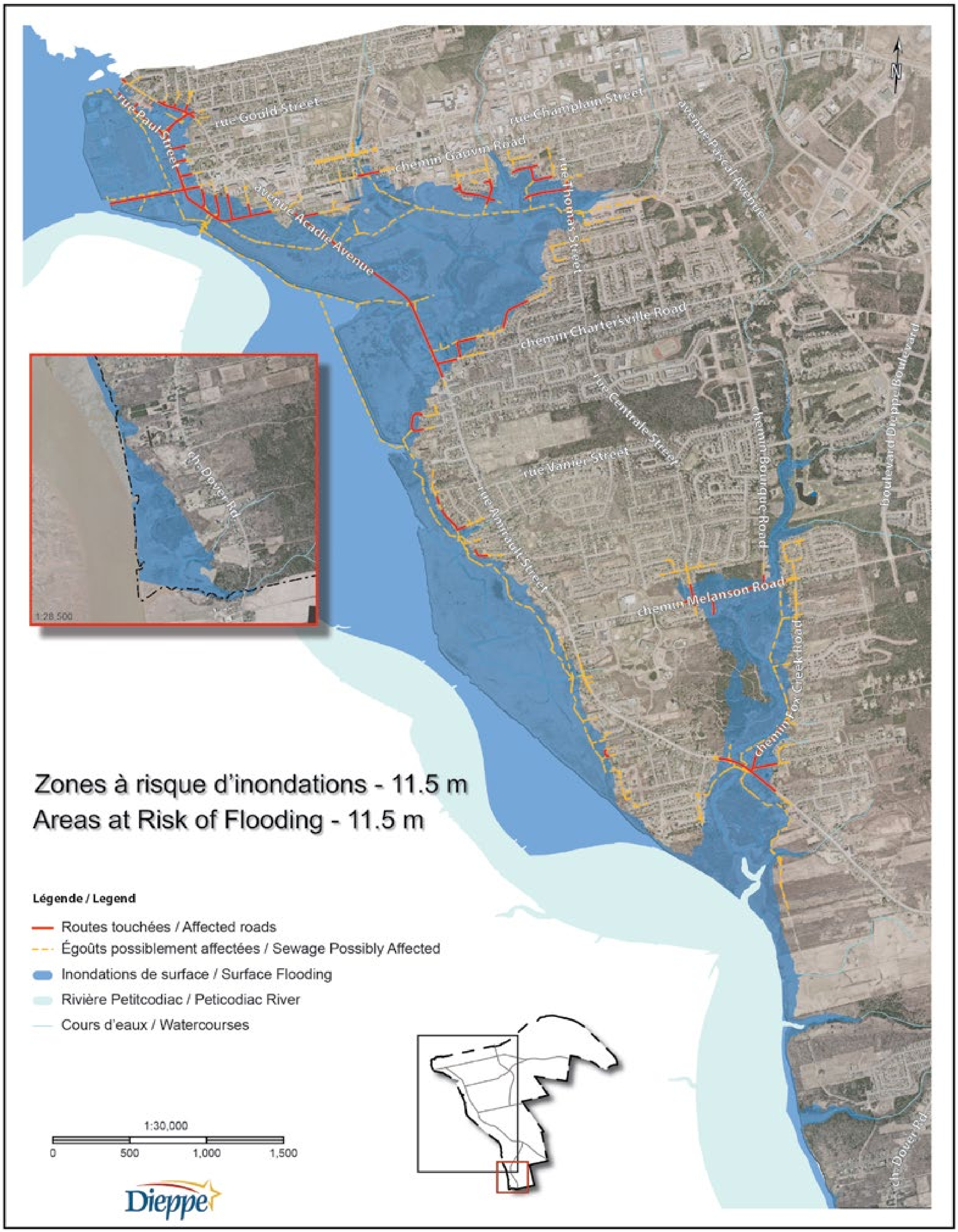
It is associated with a low-probability catastrophic event. Although considered rare, such an event could still occur by 2100.

As shown in Figure 1.16, this scenario shows a flood risk that spans the length of Hall's Creek, Chartersville Marsh, the Petitcodiac River and Fox Creek.

The risk of sewer back-ups is widespread on all low-lying lands.

**Figure 1.16**

# Flood scenario – 11.50 metres



# 6 What are the potential impacts of flooding?

The CCA committee conducted a preliminary analysis of the municipality's infrastructures, buildings and facilities on public and private property, and the potential impacts of flooding from the Petitcodiac River include the following:

## i. water damage to at-risk residences and businesses;

- Surface water in buildings may result in rot, mould, mildew, rust, disbonding of materials and loss of personal effects

## ii. relocation of part of the population over the short, medium or long term;

- Residences may become inhabitable due to water damage and loss of access to homes

## iii. impact on health and public safety;

- Mould and mildew problems as well as contact with viruses or bacteria due to biological contamination may pose health risks
- Refusing to evacuate a home at risk of flooding and returning to a flooded building may result in electrical and structural safety risks

## iv. sanitary and storm sewer back-ups;

- Flooding in sewer systems can cause back-ups inside buildings

## v. pollution and contamination;

- Flooding of gas stations, sewer systems and industrial sites can cause hazardous substance spills in the environment

## vi. erosion of roads, trails and culverts;

- Receding flood waters can erode certain infrastructures

## vii. closing of arterial and collector roadways, local roads, sidewalks and trails;

- Several road and pedestrian detours would need to be set up over the short, medium or long term, depending on the extent of damage to infrastructure
- Could render certain properties inaccessible, increasing emergency services response time

## viii. malfunction of traffic signals;

- May cause traffic delays
- Increases risk of collisions

## ix. public transit service interruption;

- Some routes would be altered or suspended

## x. interruption of essential services (hydro, sewers, telecommunications);

- These services include underground components that would be at risk of flooding

## xi. cost of repairing damage caused by flooding;

- Costs to residents, businesses, the municipality, insurance companies, etc.

## xii. losses to the local economy;

- Temporary or permanent closure of businesses
- Lost workdays over the short, medium and long term for part of the population

## xiii. deaths directly or indirectly caused by flooding;

- Refusal to evacuate

## xiv. overall perception of the municipality.

- Perception of municipality's flood risk
- Perception of incident management

# 7 How can we mitigate flood risks?

There are four general approaches for managing flood risks from the Petitcodiac River:

## 1

**Avoidance:** avoiding building in at-risk areas, for example, by creating setback limits for development in flood-risk areas.

| Benefits | Drawbacks |
|---|---|
| • Most certain, long-term protection.<br>• No protective work against floods required. | • Requires a deeper change in approach to development in at-risk areas. |

## 2

**Retreat:** moving away from at-risk areas.

| Benefits | Drawbacks |
|---|---|
| • Certain, long-term protection. | • Costly to move existing buildings.<br>• Owners must be willing to move their building.<br>• Difficulty finding available land to relocate buildings to. |

## 3

**Accommodation:** continuing to use land but in a modified way to accommodate increased flood risks, for example, raising homes on pilings.

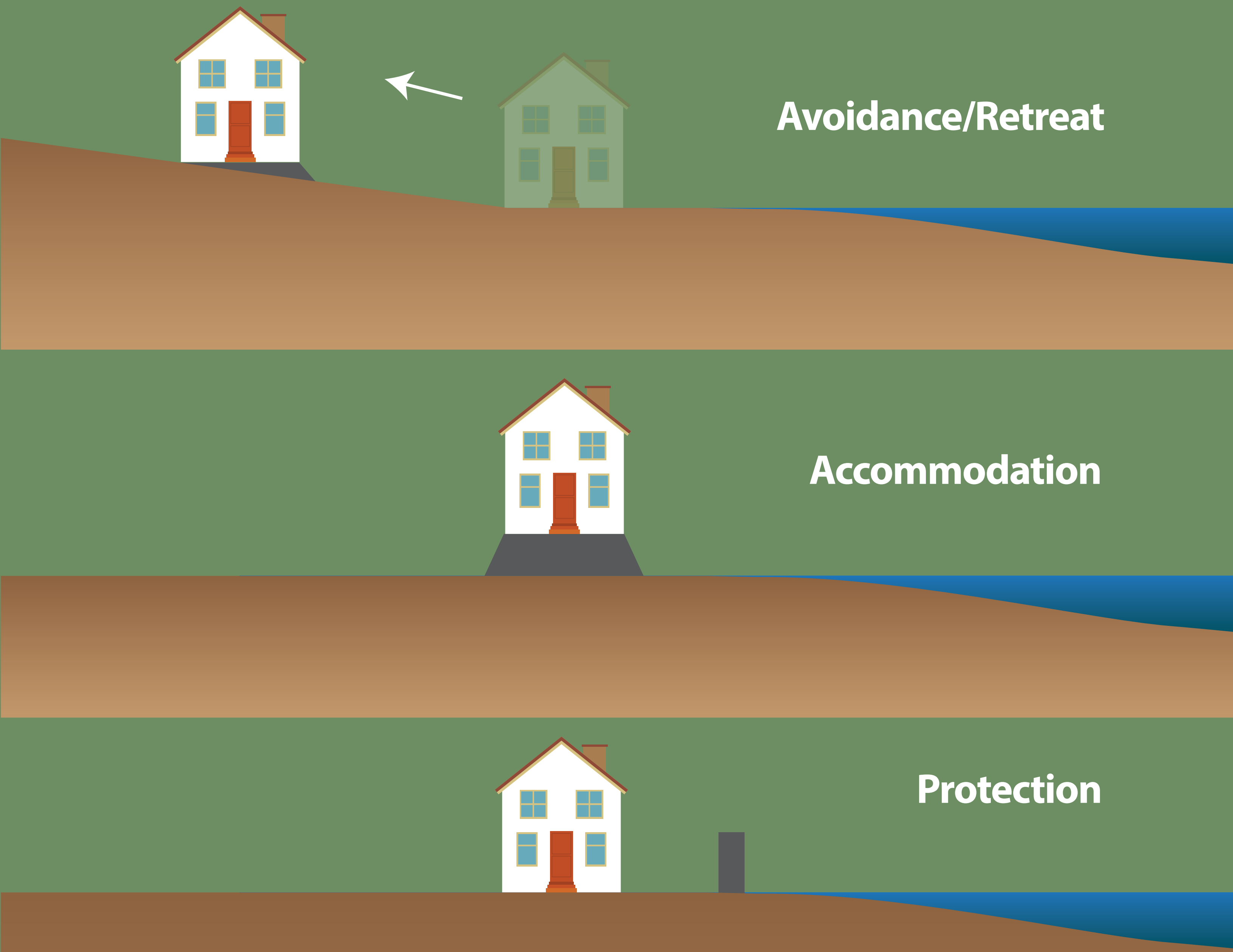
| Benefits | Drawbacks |
|---|---|
| • May result in lower costs than moving infrastructure.<br>• Allows land to continue to be used. | • Requires maintenance and may result in higher long-term costs.<br>• Exposure to unanticipated risks. |

## 4

**Protection:** undertaking protective measures to continue using the land, for example, measures for hard protection, such as building dykes.

| Benefits | Drawbacks |
|---|---|
| • Allows land to continue to be used. | • May worsen impacts elsewhere; for example, the dykes may cause flooding in neighbouring areas.<br>• Requires maintenance and close monitoring.<br>• Exposure to unanticipated risks. |

In many situations, a good adaptation strategy for flood-risk areas is not restricted to a single type of action, and resorts to a mix of actions that may change over time. It is also important to keep in mind that the proposed measures will not be appropriate for all communities.[18]




[18] Daigle, R. (2012). Sea Level Rise and Flooding - What They Mean for New Brunswick's Coastal Communities.

# 8 Actions carried out by the City of Dieppe due to climate change

## 8.1. Regulations and practices introduced

The following regulations and policies have been established by the City of Dieppe to mitigate flood and climate change risks:

i. 2008 adoption of a design criterion restricting post-construction runoff flow from a development site to pre-construction runoff flow (zero net).

ii. Revised design criteria for stormwater infrastructures in 2008 to accommodate an increase in rainfall intensity due to climate change.

iii. Establishment of an 8.5 metre minimum construction elevation around the Chartersville Marsh in 1996 in the zoning bylaw.

iv. Flood risk notice to owners for projects below 10.5 metre elevation that are at risk of flooding, since January 2014.

v. Limitation of developments inside "Conservation" and "Floodplain" zones.

vi. Adaptation of the Emergency Measures Plan.

# 8.2. Creation of the CCA committee

The CCA committee was created with the following objectives:

- identifying and understanding the effects and risks of climate change;
- sharing climate change information and encouraging public participation;
- identifying recommendations and developing strategies to reduce climate change risks;
- implementing strategies;
- continuously monitoring the strategies adopted and new scientific studies to meet the municipality's future needs.

# 8.3. Public participation

The CCA committee organized information sessions with the Planning Advisory Committee and developers/builders/consulting engineers. The purpose of these sessions was to draw attention to flood risks associated with climate change.

Informal consultations were also held with developers/builders/consulting engineers to obtain relevant feedback.

# 8.4. Discussions with utility companies, public utilities and government agencies

The CCA committee contacted the following governement agencies, utility companies, public utilities to determine the risk to the municipality, residents and businesses:

- City of Moncton
- Greater Moncton Sewerage Commission
- NB Power
- Bell Aliant
- Enbridge Gas
- Maritimes and Northeast Pipeline
- Rogers

Although discussions are currently at the preliminary stage, Enbridge Gas and Maritimes and Northeast Pipeline confirmed that no components in their distribution system would be affected by the flood scenarios in this document. However, Enbridge Gas indicated that the supply of natural gas to residences affected by flooding would be turned off, and that any equipment that came in contact with the water would require inspection by a licensed gas technician.[19]

[19] Flooding: Be Prepared! (2014). Enbridge Gas New Brunswick. http://naturalgasnb.com/CMS/en/home/safety/flooding.aspx

# 9 What else can we do?

The results of the AMEC study provide information that the municipality can use to develop analysis and regulation tools to mitigate or eliminate flood risks. Following an assessment of this report and the infrastructures, buildings and facilities on public and private property in the municipality, the CCA committee identified the following general recommendations, not listed in any order of priority:

The CCA committee should develop and present an action plan in September 2015 in order to reduce or eliminate the risk of the Petitcodiac River flooding in the municipality. This action plan would be based on the following components, in no particular order:

## 9.1. public participation

## 9.2. emergency measures

## 9.3. regulations

## 9.4. physical improvements

## 9.5. research and planning

## 9.6. partnership

## 9.7. continuous monitoring

## 9.1. Public participation

Public participation should be an integral part of developing solutions to flood risks in the Petitcodiac River. The CCA committee would determine the level of participation as required.

## 9.2. Emergency measures

A simulation exercise should be carried out based on the flood scenarios identified in the AMEC report and the emergency plan should be revised as required.

## 9.3. Regulations

The municipal plan and zoning bylaw should be reviewed to develop policies and regulations which specifically address adapting for Petitcodiac River floods and their mitigation measures by generally following the recommendations mentioned in the AMEC report as well as any CCA committee recommendations. The mitigation measures may include the following:

- revising the minimum structure elevation;
- revising the setback distances from waterways;
- revising conservation and wetland zones to reflect new trends;
- adopting protection measures for new and existing structures.

## 9.4. Physical improvements

New infrastructure should be designed based on the flood risks identified in the AMEC report and its significance and expected service life, and existing infrastructure at risk should be assessed to determine appropriate solutions.

Improvements could be made to the following infrastructures:

- roads
- culverts
- sanitary sewers
- storm sewers
- trails

## 9.5. Research and planning

In-depth studies should be conducted to assess the capacity of and risks to infrastructures, buildings and existing facilities on public and private property in the municipality and to assess the cost of adaptation measures resulting from these studies to develop a related financing plan.The studies may include:

- modelling sanitary sewers in collaboration with the Greater Moncton Sewerage Commission;
- assessing traffic during a flood;
- conducting a feasibility assessment and technical analysis for raising certain dykes;
- researching financing options.

## 9.6. Partnership

The CCA committee should coordinate its efforts with other government agencies, public utilities and utility companies, such as:

- City of Moncton
- Greater Moncton Sewerage Commission
- Government of New Brunswick
- Government of Canada
- RCMP
- Ambulance NB
- NB Power
- Bell Aliant
- Enbridge Gas
- Maritimes and Northeast Pipeline
- Rogers

## 9.7. Continuous monitoring

The CCA committee should remain in place to ensure the following:

- implementation of the Petitcodiac River flood risk recommendations;
- assessment of other climate change risks;
- continuous monitoring of the most recent scientific studies to guide adaptation measures appropriately.

# 10 Conclusion

The sea level rise — caused by climate change and land subsidence — poses an increasing flood risk in Dieppe. The 8-metre high tide in the Petitcodiac River in 2014 is expected to rise to approximately 9.25 metres in 2100. This sea level rise in the river, combined with a storm surge, could potentially flood low-lying lands in the municipality where a built environment and vacant lots currently exist.

The City of Dieppe is committed to assessing the Petitcodiac River flood risks and engaging in discussions with stakeholders in an effective, pragmatic manner. It is crucial that the municipality adopt mitigation measures to protect current and future investments. In the future, climate change will play an increasingly serious role and structured planning and implementation of adaptation measures is essential to meet the municipality's needs and minimize risks to its population in the future.

# Other Resources

Climate Change Adaptation Plan and Flood Management Strategy. (2013). City of Moncton. http://www.moncton.ca/Assets/Residents+English/Environment/Climate+Change+Adaptation+Plan.pdf

Local Government, Sustainability and Climate Change: A Resource for Elected Municipal Officials in New Brunswick. (2012). Margaret Tusz-King. http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/Municiple_Guidebook_English_Sept_2012.pdf

Municipal Climate Change Action Plan. (2011). Canada - Nova Scotia Infrastructure Secretariat. http://www.nsinfrastructure.ca/uploads/MCCAP%20Guidebook-final%20draft%202011.pdf

Adapting to Climate Change: An Introduction for Canadian Municipalities. (2010). Natural Resources Canada. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/earthsciences/pdf/mun/pdf/mun_e.pdf

Land Investments at Risk: Flooding and Storm Surges. (2013). Association of New Brunswick Land Surveyors, New Brunswick Real Estate Association, and New Brunswick Law Society. http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/120061%20-%20Land%20Investments%20at%20Risk%20-%20Flooding%20and%20Storm%20Surges%20-%20Association%20of%20NB%20Land%20Surveyors[1].pdf

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