Appendix H Climate Change Resilience Assessment: Upgrade of Cap-Brulé Wastewater Treatment Facility, Englobe, 2020

Englobe

Investing in Canada Infrastructure Program
Green Infrastructure: Environmental Quality

Climate Change Resilience Assessment: Upgrade of Cap-Brulé Wastwater Treatment Facility

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Property and Confidentiality

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Attestation of Completeness

I/we the undersigned attest that this Resilience Assessment was undertaken using recognized assessment tools and approaches (i.e., *ISO 31000:2009 Risk Management—Principles and Guidelines)* and complies with the General Guidance and any relevant sector-specific technical guidance issued by Infrastructure Canada for use under the Climate Lens.

Prepared by: _____ _____

Name Date

Validated by*: _____ _____

Name Date

*Resilience Assessments must be prepared, or at a minimum validated by, a licenced professional engineer, certified planner, or appropriately specialized biologist.

Executive Summary

The ***Greater Shediac Sewerage Commission (GSSC)*** is applying to Infrastructure Canada for funding toward the **Upgrade of Cap-Brulé Wastewater Treatment Facility (WWTF).** The project is being submitted under the **Investing in Canada Infrastructure Program (ICIP) – Green Infrastructure: Environmental quality** investment stream. Englobe Corp was hired to complete the Climate Lens for this funding application. This report includes the Climate Change Resilience Assessment, which is a requirement of the Climate Lens.

In 1971-1972 the GSSC constructed a wastewater treatment facility in Cap Brulé that included a two cell facultative lagoon with surface aerators. Today this facility is approaching its hydraulic and loading capacity, major work is required for the outfall, and the buildings and aeration systems are outdated. Furthermore, the current outfall location does not meet the required mixing levels at the end of its dispersion plume. As a result of these issues, the Shediac East Long-Term Wastewater Management Strategy report that was published in 2018 recommended that a new wastewater treatment facility (WWTF) be constructed.

The new WWTF will employ a Lagoon-type facility and Moving Bed Biofilm Reactor (MBBR) technology. Construction of the new facility is expected to begin in 2020 and will last for four years. The design life of the initial WWTF upgrades would be 25 years. Therefore, climate change hazards that could impact the facility over this timeframe were considered as part of this assessment.

The following climate change hazards were identified for the WWTF:

1. **Temperature Increases**: Mean annual temperatures in the Moncton/Shediac area are expected to rise approximately 0.3 °C – 1.0 °C between 2020 and 2050 [7][16].
2. **Freeze-Thaw Days**: The number of winter freeze-thaw days will increase by 3 days per year by 2050 and 5 days per year by 2080 [8].
3. **Sea Ice Coverage**: By the end of the century (2100) it is expected that there will be almost no sea ice coverage remaining in the Gulf of St. Lawrence. A reduction in sea ice will contribute to higher waves. It is expected that wave height will increase by 5 cm – 1 m between 2071 and 2100 [7].
4. **Sea Level Rise**: Sea levels along the coast of New Brunswick have risen approximately 30 cm over the past 100 years and they are expected to continue rising in the future. It has been estimated that sea levels will rise approximately 77 cm between 2010 and 2100 [9].
5. **Extreme Weather Events**: Extreme weather events such as hurricanes and tropical storms are expected to increase in the future, resulting in higher storm surges and increased coastal flooding and coastal erosion. It is estimated that in the Shediac area a current 1:40 year storm surge will represent a 1:5 year storm by 2100 [2].
6. **Precipitation**: The mean annual precipitation in the Moncton area is expected to rise from 1020 mm in 2020 to 1040 mm in 2050, and then 1060 mm by 2080 [8]. Data obtained from the Climatedata.ca website indicate that average total precipitation in the Shediac area would increase by approximately 4 mm per year from 2020 to 2100 [16] based on an RCP of 2.6.

7. **Shoreline Impacts**: Sea level rise combined with increased storm surges is expected to cause more coastal flooding and erosion. Dunes, cliffs, beaches, and marshlands along the Northumberland Strait are expected to continue to erode each year [10].

The above climate change hazards will all contribute to an increased risk of flooding along the coast of New Brunswick, where the new WWTF will be located. The primary risk identified for this project was "**flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**".

It was determined that due to the location of the new WWTF and without any mitigation measures in place , the likelihood of flooding leading to impaired operation of the existing WWTF was rated as "moderate" and the consequence was rated as "low". This resulted in an overall risk rating of "**low**".

Several mitigation measures have already been identified by the engineering design team, as outlined in the *Cap-Brule Wastewater Treatment Facility Preliminary Design Report*. The main mitigation measures include:

- **Adaptability:** The system must be able to handle an increase in capacity occasionally. To do so, bypasses can be added to the treatment process to help handle peak flow events. It is also possible to add an equalization capacity to the system. This will allow peak flows to be stored temporarily in an equalization basin until the flow returns to normal and the wastewater can be returned to the treatment process under lower and more uniform flow conditions. This equalization capacity is mainly to handle peaks from rain events as opposed to storm events. [12].
- **Wastewater runoff:** The lagoon berms must be high enough to avoid being overloaded from the surface and avoid any runoff of wastewater. They should be at least above the 1:100-year return period event in 2100.
- **Flooding:** Installation of a mechanized WWTF to minimize infiltration instead of the existing lagoon system. [12]. A pumped outfall instead of a gravity outfall would prevent water from infiltrating the sewer and increasing the flows. While a high-pumping head is not required, such a pumping facility must have a high capacity to deal with the variation in flow through the WWTF.
- **Damage to the outfall:** Forcemain (pressure pipe) installation is better able to accommodate the required diffusers that will be installed at the end of the outfall, with the ability to add "duckbill" check valves to minimize the potential for silt, sand, or other debris to enter the outfall.
- **Storm surges and freeze thaw cycles:** Install a pumped pipe instead of a gravity pipe. The gravity pipe would be shallow in order to sit on the sea floor at the discharge location and could become prone to movement during freeze thaw cycles within the wetland soil conditions. There is also risk with severe ice conditions and storms along the coast. The pumped pipe should be buried deep enough under the sand shoals in the intertidal area to avoid disturbing the pipeline.

With the above mitigation measures built into the new WWTF design, the residual risk of "**flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**" was rated. It was determined that the likelihood of this risk would be reduced to "vey low" while the consequences of this risk would remain "low". This resulted in an overall risk rating of "**negligible**".

The new WWTF will provide several benefits which were not quantified as part of this analysis. These benefits included:

- Benefits from avoiding water pollution;
- Benefits from avoiding loss in aquatic life and habitats;
- Benefits from avoiding loss in ecological services;
- Benefits from avoiding impact on tourism; and
- Benefits from avoiding wastewater runoff.

In addition to the above benefits, the construction phase of the project is also expected to produce approximately $19.25 Million in construction benefits over the four-year construction period (discounted back to $2020). The federal investment is also expected to create 255 direct jobs and 54 indirect/induced jobs, for a total of 309 jobs during the construction period.

The Climate Change Resilience Assessment has concluded that without any mitigation measures the new WWTF would be at a low risk of flooding, which could lead to impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment. However, with the mitigation measures that have been outlined by the engineering design team (as presented in **Section 6.1**) this risk would be reduced to 'negligible'.

1 Project overview

1.1 Introduction

The ***Greater Shediac Sewerage Commission (GSSC)*** is applying to Infrastructure Canada for funding toward the **Upgrade of Cap-Brulé Wastewater Treatment Facility (WWTF).** The project is being submitted under the **Investing in Canada Infrastructure Program (ICIP) – Green Infrastructure: Environmental quality** investment stream. Englobe Corp was hired to complete the Climate Lens for this funding application. This report presents the Climate Change Resilience Assessment that was required as per this agreement. Englobe has also completed the GHG Mitigation Assessment for this project.

1.2 Project/Community background

The Town of Shediac has a population of approximately 6 700 people and is located along the southeast coast of New-Brunswick. It is located close to other small communities including Shediac Cape, Cap Brulé, and Point-du-Chêne. The Town is known as the lobster capital of the world and hosts a festival every July that promotes its connection to lobster fishing. A large number of visitors are also attracted to the nearby beaches every summer. As a result of these attractions the Town is subject to large seasonal variation in population. [1]

In 1971-1972 the GSSC constructed a wastewater treatment facility in Cap Brulé that included a two cell facultative lagoon with surface aerators. The WWTF serves the Town of Shediac and surrounding areas including Cap Brulé and Pointe-du-Chêne. The Cap-Brulé wastewater treatment facility is located to the east of the Town of Shediac on Cap-Brulé Road, off of Route 133 as shown in **Figure 1**. The facility is bordered by Route 133 to the south, Chemin Cap-Brulé to the west, Lac des Boudreau Ouest to the north and an undeveloped rural residential area to the east.

Figure 1 – Exiting Cap Brulé WWTF

2 Project scope

The existing Cap-Brulé Wastewater Treatment Facility is an aerated lagoon with pre-treatment and disinfection providing Secondary Treatment levels for the Shediac East area (Town of Shediac, Pointe-du-Chêne, Shediac Cape & Cap Brulé). The influent to the treatment plant enters the site at the south-west corner through two separate connections; one connection from the trunk sewer that brings flows from the Town of Shediac, Shediac Cape, Cap Brulé & Pointe-du-Chêne and one connection from the east that collects flows from the east side of the lagoon. The outfall is presently at the northern most part of the WWTF boundary. During regular operation, the UV Disinfected effluent is discharged into a 280 m long narrow manmade channel located at the northern most part of the GSSC Facility as pictured in **Figure 2**. Where the narrow trench does not have significant flow from any other source, it is referred to as an "open pipe" in accordance with the Canadian Council of Ministers of the Environment (CCME) guidelines with no mixing until it is discharged by gravity into the 3.7 ha shallow basin referred to as Lac des Boudreau Ouest that is connected to the Northumberland Strait via a small shallow channel. Lac des Boudreau is a salt marsh which has high biodiversity [Communication 17-06-2020: Michel Belles-Isles. Michel.Belles-Isles@englobecorp.com]

Figure 2 – Existing Discharge and Outfall Trench

As mentioned previously, the population within the Town of Shediac increases significantly during the summer months and the flow of influent is expected to grow in the future. The facility is thus approaching its hydraulic and loading capacity.

In 2014, the GSSC completed its Environmental Risk Assessment (ERA) in accordance with CCME guidelines on its main wastewater treatment facility in Cap-Brulé, NB. The purpose of an ERA is to evaluate the current treatment objectives established by the regulatory authority and to confirm if they are adequately protecting the receiving environment. The assessment identified that the current outfall location does not meet the required mixing levels at the end of its dispersion plume. Furthermore, many of the existing assets and major components at the wastewater treatment plant have reached or are nearing the end of their expected useful life. Therefore, regardless of any required

upgrade to the WWTF to improve capacity, a major lifecycle renewal is anticipated in the short term (0-5 years).

Following the results of the ERA, in 2015 the GSSC commissioned a feasibility study for a new outfall that would meet the CCME mixing requirements. As part of the ERA, it was found that an acceptable mixing zone was available in the Northumberland Strait, approximately 350 m offshore. Due to the hydraulic losses through this outfall, the soft soils and environmental issues, the estimated cost to complete this upgrade is significant.

2.1 New/updated infrastructure description

Since the facility is approaching its hydraulic and loading capacity, and since other major work is required for the outfall, as well as the aging buildings and aeration systems, a new wastewater treatment plant was proposed as part of the recommendations of the Shediac East Long-Term Wastewater Management Strategy report that was published in 2018. It was recommended that the project team evaluate the merit of designing any facility components for the 50-year design flow projections. It was also proposed that due to the uncertainty of these projections, and their impact on the overall scale and cost of the required upgrades, that preliminary design proceed for the 25-year design flow projection.

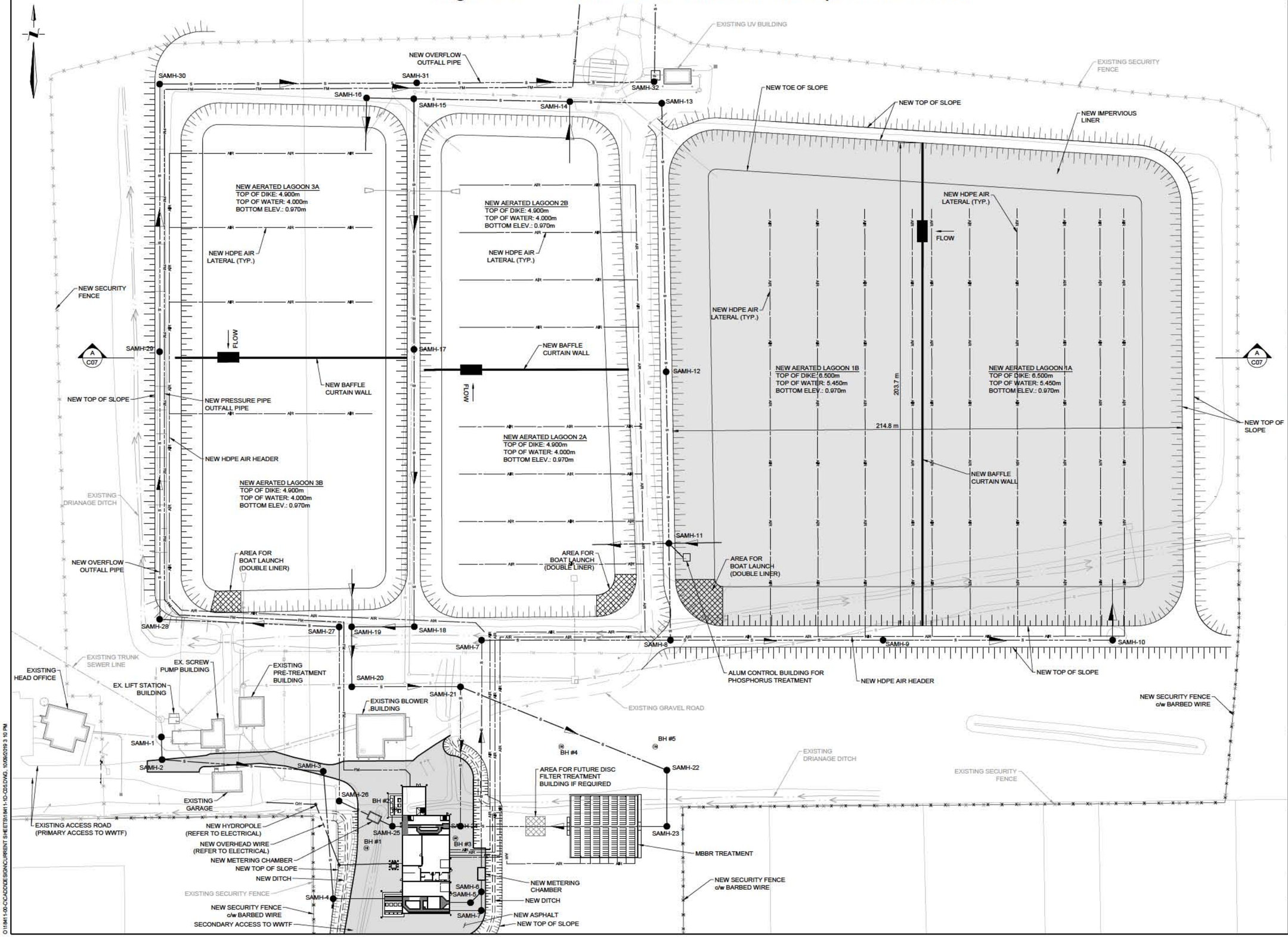
The new design will employ a lagoon-type facility and Moving Bed Biofilm Reactor (MBBR) technology. This option was recommended to the Commission due to the operational flexibility and reduced operation and maintenance requirements. Furthermore, this option reuses the existing lagoon cells at the WWTF. The outfall will also be moved to a new location. It will no longer pass through a channel discharged by gravity into the Lac des Boudreau Ouest. Instead, a pumped outfall will be installed that will discharge directly in the Northumberland Strait. A new Major Lift Station and a forcemain would be required at the outfall of the existing trunk sewer as the alternate location is geographically higher in elevation than the present WWTF location. The soil deposits on which the facility is located are sand, silt, some gravel and clay. The existing screwpump lift station, service and pretreatment buildings and lift station will be decommissioned. The UV and blower buildings will be used as storage. A new operations building will be constructed to replace all other infrastructure.

2.2 Scope of the assessment

The scope of this Climate Change Resilience Assessment includes the infrastructure and boundaries shown in **Figure 3** and **Figure 4**Figure 1 including the outfall, the effluent and influent pumping station, the forcemain, the operation building, the metering chamber, the UV channel and building, the lagoons, the top of berms, the pre-treatment building, the maintenance garage and the blower building.

The design life of the proposed new WWTF components would be 25 years, depending on the climactic impacts; therefore, anticipated risks associated with climate changes will be analyzed for this timeframe.

Figure 3 - Overall Site Plan of New Cap-Brulé WWTF



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NOTES

NO.	DATE	REVISIONS	BY	APPR.
A.0	SEPT 11/19	ISSUED FOR CLIENT REVIEW	SML	CG

GREATER SHEDIAC SEWERAGE COMMISSION
DES ÉGOUTS SHEDIAC ET BANLIEUES

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PROJECT TITLE

PRELIMINARY DESIGN - CAP-BRULE WASTE WATER TREATMENT FACILITY

SHEDIAC N.B.

DRAWING TITLE

OVERALL SITE PLAN

Scale	Drawn By	Design By
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	Sheet 5 of 25	

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Figure 4 - Overall Plan and Phasing of New Cap-Brulé WWTF

NORTHUMBERLAND STRAIT

PROPOSED FORCEMAIN DISCHARGE TO NORTHUMBERLAND STRAIT

PROPOSED NEW 600mm Ø FORCEMAIN

LAC DES BOUDREAU

EXISTING UV BUILDING

EXISTING WWTF DISCHARGE OUTLET

AERATED LAGOON NO.1

NEW AERATED CELL NO.1A

NEW AERATED CELL NO.1B

AERATED LAGOON NO.2

NEW AERATED CELL NO.2A

NEW AERATED CELL NO.2B

AERATED LAGOON NO.3

NEW AERATED CELL NO.3A

NEW AERATED CELL NO.3B

MBBR

WWTF

PROPOSED HEADWORKS, UV BUILDING

EXISTING BLOWER BUILDING

EXISTING PRE-TREATMENT BUILDING

HEAD OFFICE

WWTF ENTRANCE

CAP-BRULE ROAD

TOWARDS ROUTE NO. 133

NOTES

LEGEND

PHASE NO.1 - WWTP, LAGOON AND UNDERGROUND INFRASTRUCTURE

PHASE NO.2 - FORCEMAIN AND DISCHARGE

PHASE NO.3 - MBBR SYSTEM

NO.	DATE	REVISIONS	BY	APPR.
A.0	SEPT 11/19	ISSUED FOR CLIENT REVIEW	SML	CG

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PROJECT TITLE

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SHEDIAC N.B.

DRAWING TITLE

OVERALL PLAN AND PHASING

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3 Methodology

3.1 Identification and assessment of climate change risks

This Climate Change Resilience Assessment was completed using the methodology outlined in the Climate Lens – General Guidance (version 1.2 released September 6, 2019). The assessment is defined and described by the following three aspects:

a. Climate change hazard
b. Impact on asset
c. Consequence of impact

Climate change hazards are identified by a review of historical and recent Climate data, climate projections and other relevant research. The hazards are climate-related events that could occur in a short or long-term future. (i.e. increased storm intensity, heat waves, sea-level rise, etc.)

Impacts on the asset are determined for each of the identified hazards that may affect the project asset throughout the project analysis period. The impacts reflect the vulnerability of the asset. Direct and indirect impacts on the asset should be assessed.

Consequences of each of the impacts are assessed based on their effect on the project asset and the surrounding community.

The climate change risk encompasses the three previously defined aspects.

3.2 Risk evaluation

Risk identification is a process that can be described as partially subjective and qualitative. In order to evaluate and prioritize the risks to be mitigated, the consequence and likelihood of each risk is estimated though the risk evaluation process using the standardized tables and evaluation matrices provided in Infrastructure Canada's Climate Lens General Guidance.

The likelihood of each risk is estimated through a qualitative analysis that considers both past experiences (storms, floods, etc. that caused damage to the asset) as well as future climate projections. It is then rated on a 5-point scale and presented in a table similar to Table 1 shown below.

Table 1 - Example of Likelihood Assessment Table

Probability Range	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Significant Single Event	Not likely to occur in period	Likely to occur once between 30 and 50 years	Likely to occur once between 10 and 30 years	Likely to occur at least once a decade	Likely to occur once or more annually
Identified Risk					

Consequences of each risk are evaluated by their effect on people, the economy and the environment. Each evaluation may be separated into various sub-effects, using a 5-scale point rating system (very low risk = 1, very high risk = 5). For example, the consequence on the environment may be different in regard to the air, water, land and ecosystems. Results of this evaluation are presented in a table similar to Table 2 below.

Table 1 - Example of Consequences Assessment Table

Factor	People				Economic			Environment			
Degree	Health & Safety	Displacement	Loss of Livelihood	Reputation	Infrastructure Damage	Financial Impact on Proponent	Financial Impact on stakeholders	Air	Water	Land	Ecosystem
Very Low (1)											
Low (2)											
Moderate (3)											
High (4)											
Very High (5)											

The likelihood and consequence ratings are then combined to estimate an overall rating for each project risk using the evaluation matrix shown below.

Table 2 - Risk Evaluation Matrix

Consequences	Very High					
	High					
	Moderate					
	Low					
	Very Low					
		Very Low	Low	Moderate	High	Very High
	Likelihood					

Legend :

Extreme Risk	High Risk	Moderate Risk	Low Risk	Negligible Risk

3.3 Risk treatment or Adaptation measures

Once the risks are prioritized, it is determined which risks are acceptable for the organization and which have to be mitigated. Measures are then identified in order to decrease either the likelihood or the consequences of a particular risk so that the overall risk level can be reduced to an acceptable level. The feasibility of potential mitigation measures, including physical, logistical, or economic measures, can all be assessed within the project limitations.

Once mitigation measures are selected, their effectiveness is evaluated by repeating the consequence and likelihood risk rating with each mitigation measure in place.

3.4 Benefits evaluation

Once the adaptation measures are identified, a benefit evaluation is performed in order to identify the quantifiable and non-quantifiable benefits of the overall project, where possible.

Economic, environmental, and safety benefits were all considered, and these benefits were quantified, where possible. The benefits are used to complete a high-level analysis to determine the likelihood of the project resulting in a positive return on investment (ROI).

4 Results

In this section the climate change hazards are identified, the impact of these hazards on the WWTF is discussed, and the consequences of the impacts are summarized. The climate change hazards, impacts, and consequences are then used to define the project risk.

4.1 Climate change hazards

To assess the climate change hazards, information from six different sources were considered. The list below justifies the use of these sources in this analysis.

1. A report on the impacts of sea-level rise and climate change on the coastal zone of southeastern New Brunswick was prepared by the government of Canada in 2006 [6]. The objective of the multidisciplinary research was to quantify the impacts of climate change on the Gulf of St. Lawrence coastal zone of southeastern New Brunswick, including the impact in the Northumberland Strait.
2. In 2016 the government of Canada also prepared a report on the impacts of climate change on Canada's coasts [7]. The study was performed to identify the impacts of climate change on coastal regions and to recommend actions that mitigate these impacts.
3. Ouranos completed a report on future climate change scenarios for the Province of New Brunswick in 2016 [8]. The report identifies the main impacts of climate change in the Province.
4. Daigle (2020) completed a study regarding the sea-level rise and flooding estimates on New Brunswick coasts. This was an update to a previous study completed in 2017. [9]
5. Shediac expanded on a climate change action plan in 2019. The plan identified past events that are related to climate change, as well as possible climate change impacts that could affect the Town in the future. A vulnerability assessment has been done to determine which part of the town is at risk and mitigation measures have been developed. [10]
6. Ouranos completed another study in 2016 regarding erosion of the coasts due to climate change and physical constraints [11].

Temperature Changes

The 2016 Government of Canada report concluded that a significant increase in average air temperature is expected for the east coast of New Brunswick. The Ouranos report concluded that the mean annual temperature for Moncton with an RCP of 4.5 is expected to increase approximately 1 °C from 2020 to 2050 as shown in **Figure 5**. Data published on the cliamtedata.ca website [16] indicates that the mean temperature with an RCP of 2.6 is expected to rise approximately 0.3 °C from 2020 to 2048 (design life of the asset) as shown in **Figure 6**. In New Brunswick the accumulation of snow has already decreased by 25% in the north and 50% in the south [7].

Figure 5 – Mean Annual Temperature Increase (Ouranos Report)

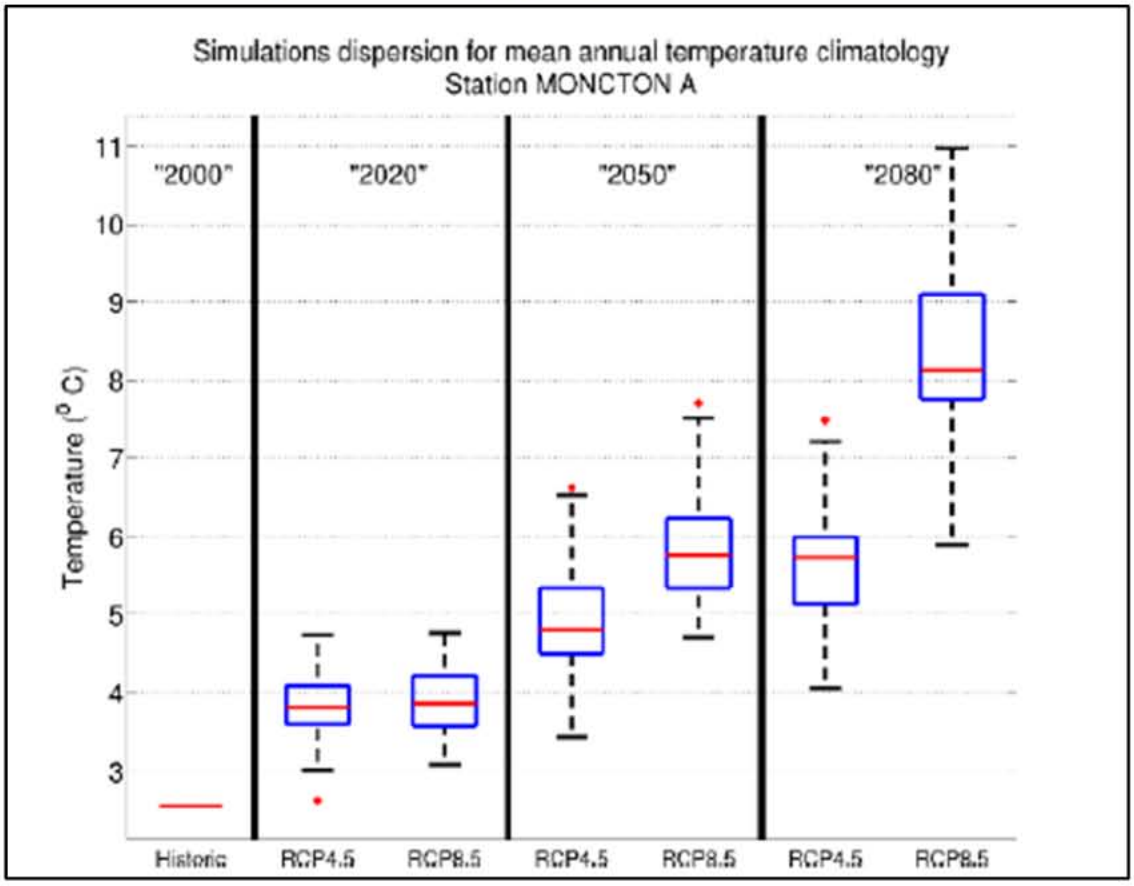
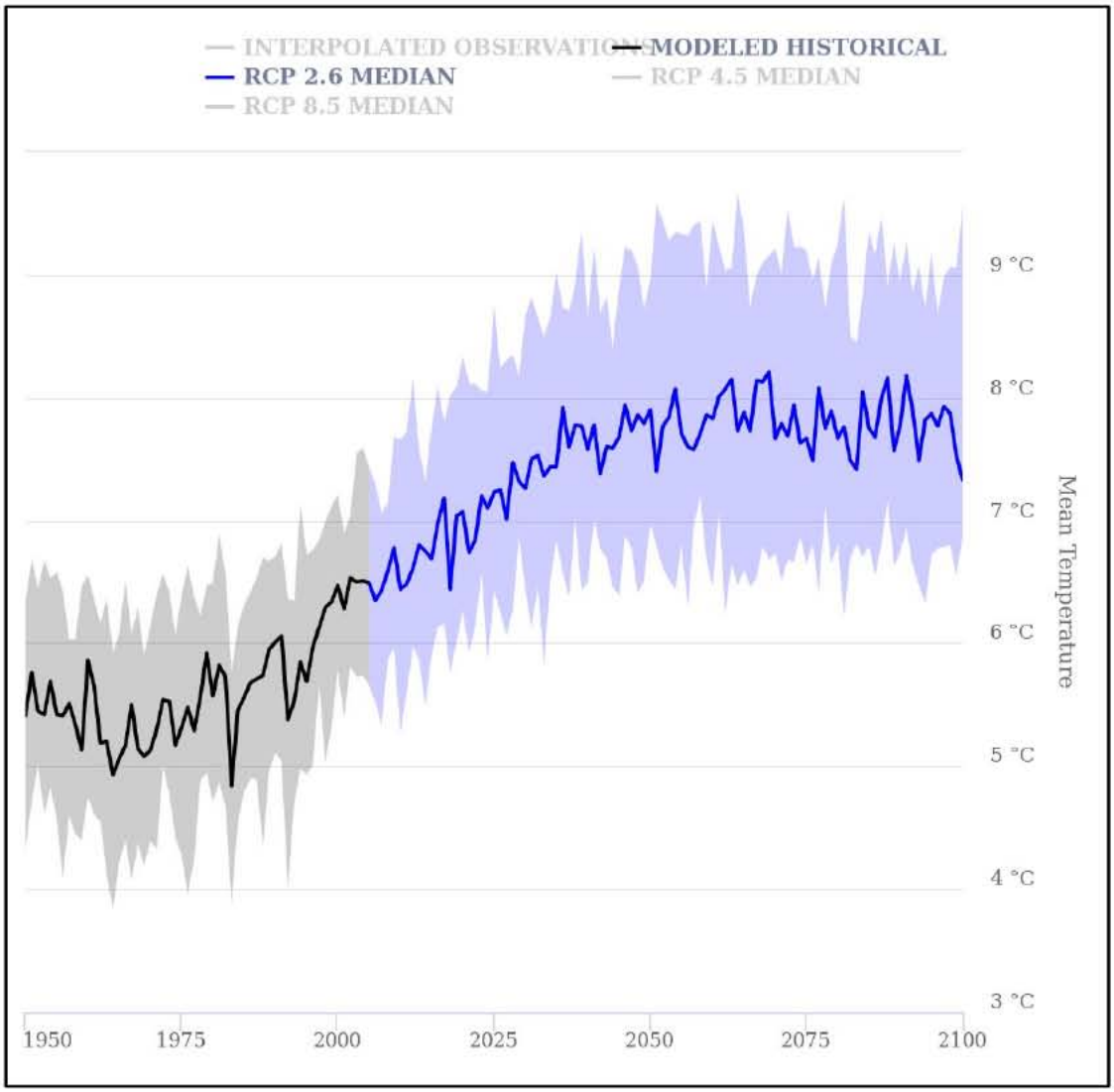


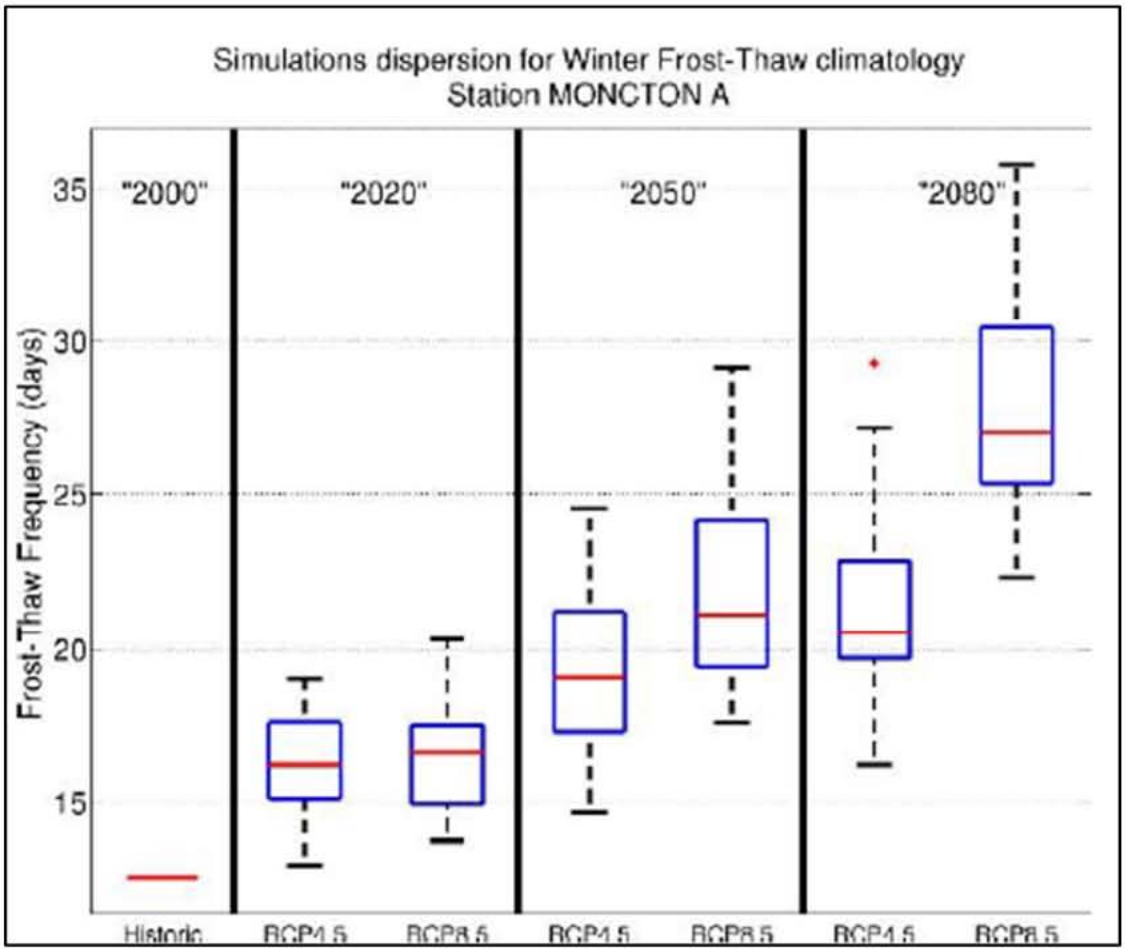
Figure 6 – Mean Annual Temperature Increase for Shediac NB (climatedata.ca)



Freeze-Thaw Days

The Ouranos report also concluded that the number of annual freeze-thaw days is expected to decrease in the future; however, the number of winter freeze-thaw days (freeze-thaw days occurring in the months of December, January, and February) will actually increase. The data in **Figure 7** shows that from 2020 to 2080, based on an RCP of 4.5, the number of winter frost-thaw days will rise by 5 days, going from 16 days to 21 days. The increased thawing of the waterway ice may, in extreme cases, contribute to increased water elevation and inland flooding. This impact also causes bank sediments to lose their cohesive strength causing detachment and collapse at the base of streambanks. In other words, the increase in freeze-thaw cycles can contribute to erosion.

Figure 7 – Winter Frost-Thaw Days



Sea Ice Coverage

As a result of rising air and sea-surface temperatures, winter temperatures will be warmer and, therefore, sea ice seasons are expected to be shortened by roughly 36 days between the period of 2041 to 2070. The NRCan report indicates that changes in the extent, thickness, and duration of sea ice cover will impact coasts and communities across the Province. It was estimated that by the end of the century, sea-ice coverage in most of the Gulf of St. Lawrence will be almost completely gone. The period of sea ice cover that completely covers the ocean surrounding the coast will decrease by an average of 33.4 days between 2041 and 2070. This will contribute to an increase in wave height of about 5 cm to 1 m between 2071 and 2100. Furthermore, shorter ice seasons lead to an increase in the total energy of storm waves since there's less ice cover to stop wave formation. Sediment balance will then be disrupted, causing increased erosion along the coast. [7]

Sea Level Rise

The 2006 Environment Canada Report [6] identified that sea-level has been rising for several years on the southeastern coast of New Brunswick and this has contributed to flooding of the Northumberland Strait. The sea level has risen by about 30 cm in the last 100 years in New Brunswick. The sea-level rise will continue. The east coast of

New Brunswick is moderately to highly sensitive to sea-level rise [3]. Climate warming causing melting of ice on the continents, glaciers and ice cap as well as thermal expansion of the surface layer of the ocean, will cause the sea level to rise at an accelerating rate. The median sea level change observed from 2010 to 2100 is a rise of 77 cm, going from 6.0 to 83 cm. It is also estimated that for a 50-year return period the level of the sea will go from 2.7 in 2010 to 3.5 in 2100. [9] Taking into account that storm-water levels and waves have already an effect on the mean sea level, rising of sea-level will likely cause flooding and wave attack, resulting in ecological and socio-economic impacts. In the future, even the weaker storm will cause coastal flooding and impacts related like the most extreme storms of the past.

Extreme Weather Events

Another impact identified in the NRCan report was the likelihood of increasing extreme weather events. These events can also result in extensive coastal erosion, as mentioned above, and increased frequency and height of storm surges. Hurricanes and tropical storms are already affecting New Brunswick, but they are expected to increase with climate change. According to the NRCan report, large storm surges combined with high tides will result in record-breaking water levels along the east coast of New Brunswick. In Shediac Bay, assuming a 60 cm sea-level rise scenario, the current 40-year return storm surge level is expected to be reduced to a 5-year return level by 2100. The east coast of New Brunswick is moderately to very highly sensitive to storm waves [2].

Precipitation

Warmer waters allow for stronger storms. The results from the Ouranos study also show that the average annual precipitation accumulation for Moncton will increase from 975 mm in 2000 to 1,100 mm in 2080 as shown in **Figure 8**. Data obtained from the climatedata.ca website [16] suggests that with an RCP of 2.6 the average total precipitation (rain and snow) would rise from around 1,132 mm in 2020 to 1,136 mm in 2100. The total precipitation will vary over the years with amounts lower than the 2020 levels expected during some years. However, the precipitation amounts are expected to trend upward during this timeframe, as shown in **Figure 9**. All these extreme events can lead to increased coastal flooding and increased risk of damage to coastal infrastructure. In the last decade, New Brunswick's infrastructure and buildings have been damaged or destroyed by storm waves and storm-driven sea ice. [6]

Figure 8 – Mean Annual Precipitation Increase (Ouranos)

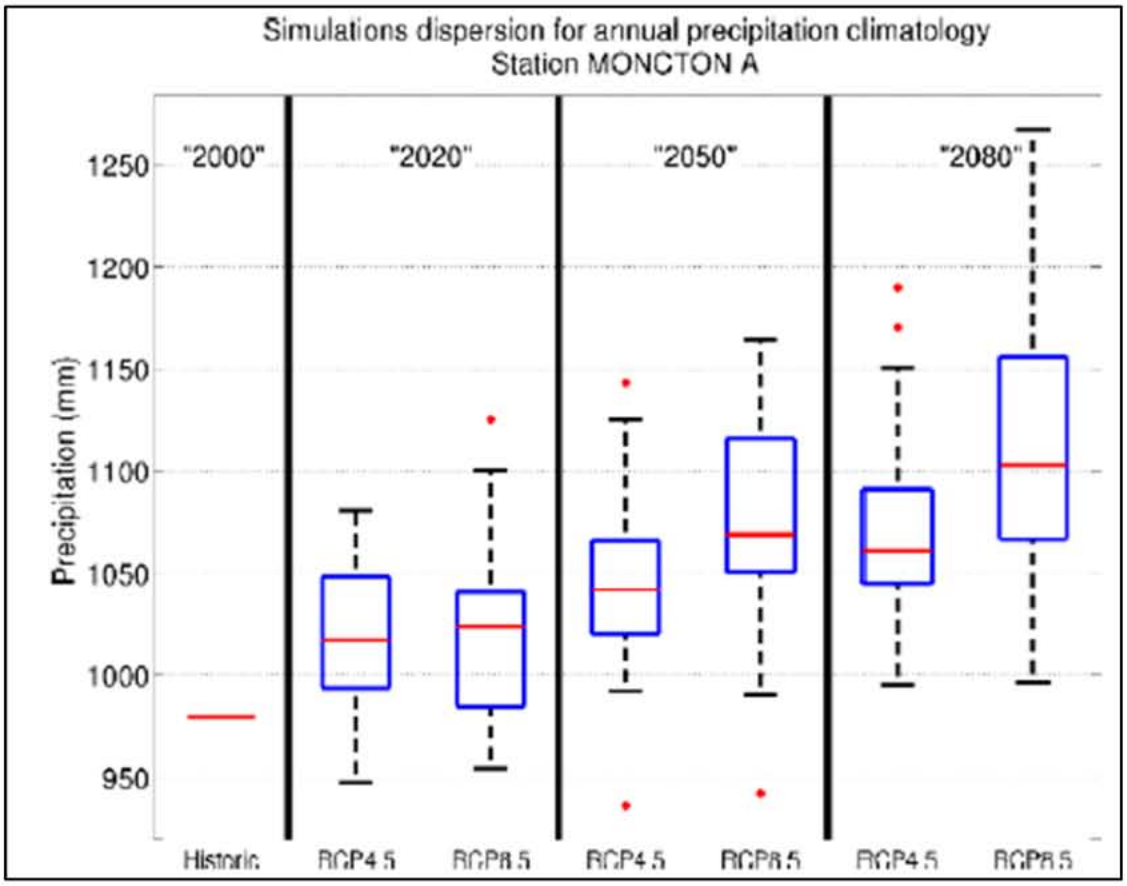
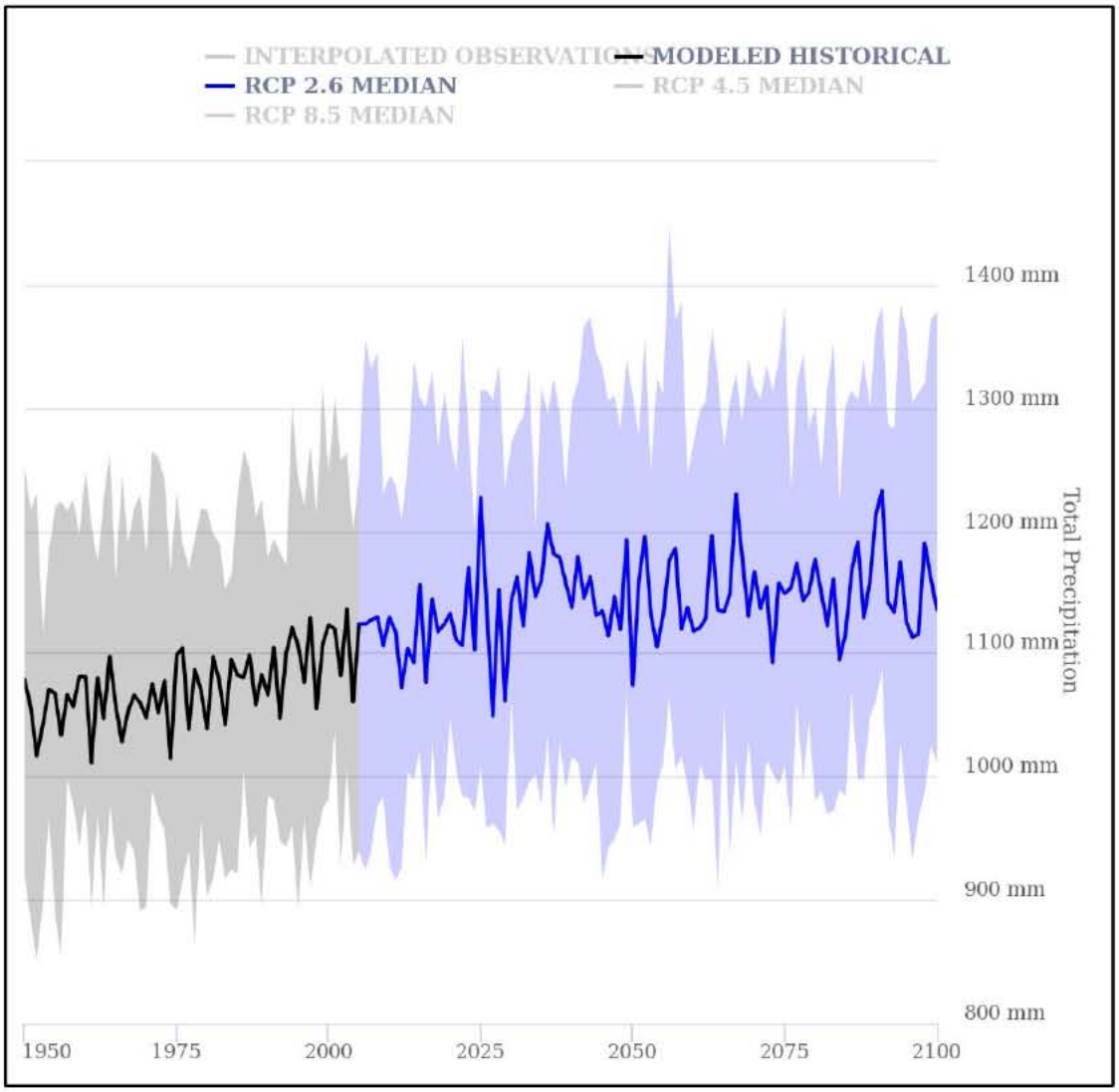


Figure 9 – Mean Annual Precipitation Increase for Shediac NB (Climatedata.ca)



Shoreline Impacts

In the Northumberland Strait, the sea-level has been rising and gradually pushing the shoreline back, causing long-term flooding and coastal erosion. This phenomenon has been going on for years, but rates of erosion are likely to increase. The impact on homes, buildings and infrastructure increases as the rate of waterfront development accelerates. [6] Salt marshes, coastal dunes and beaches act as natural buffers to reduce the impact of storm surges and flooding. By absorbing the force of storm surges, they help reduce the risk to public safety and damage to structures behind the coastline [10]. In the Northumberland Strait, there is 171 ha of beaches, 367 ha of coastal dunes and 2,169 ha of salt marshes. 44.44% of these beaches and 10.90% of its coastal dunes are inland rather than on spits and barrier islands. In terms of their gross area, the coastal beaches and dunes located inland, which are the most likely to be developed, appear to be particularly exposed. [11] The volume of barriers and dunes in the southeast of New Brunswick are the smallest in the province and thus more sensitive to coastal erosion. The level of erosion observed along the Northumberland

Strait is equivalent to a loss of roughly 85 cm of dunes per year, 26 cm of cliffs per year, 100 cm of beach per year and 30 cm of marshlands per year. [10]

These climate change hazards are interconnected and may affect the project area in many ways during its lifetime.

4.2 Climate related impacts on the assets

The Cap Brulé WWTF is located on the coast and therefore has the potential to be impacted by rising sea levels and/or storm waves. The following are some climate change impacts that have been identified for the existing WWTF [24]:

- Storm events can cause an overflow of the existing WWTF system.
- A rise in sea-levels could also impact the hydraulic capacity of the WWTF discharge.
- When sea-levels exceed the elevation where the metering chamber is located, there is a potential that flow metering accuracy could be impacted due to turbulence and backwater effects.
- Corrosion of key components may be accelerated due to salt-water intrusion.
- Sea-levels in excess of the elevation of the UV channel have the potential to impact the water levels in the remainder of the WWTF.
- During extreme events, UV bypass could occur due to the impacted water levels.

All of these sensitivities of the existing WWTF have been addressed in the new design in order to prevent these impacts from happening. However, these events can still occur and the list below summarizes the potential impacts on the assets. The climate change hazards described above are likely to cause flooding of the sanitary sewer system if no mitigation measures are implemented.

- It could then impact the hydraulic capacity of the WWTF, causing peak flows that are too high for the treatment facility to handle.
- Also, the lagoons could experience peak flows and then shorter hydraulic retention times [10]. This will cause wastewater discharge to go untreated or partially treated.
- The discharge will be highly charged with contaminants such as ammonia, E.coli, suspended solids and phosphorus that would go directly in the receiving environment. The Biochemical oxygen demand (BOD5) would be high.
- The discharge will also have a strong turbidity.
- In rare cases, higher flow rates can lead to a loss of biomass in biological processes that would reduce the efficiency of the treatment for several days [12].
- In the Town's climate change action plan, it was noted that the lagoons may be overloaded with water and discharged over the lagoon walls causing wastewater runoff charged with contaminants such as ammonia, E.coli, suspended solids and phosphorus that can affect the surrounding environment.
- Flooding may cause wear and tear of the assets, especially corrosion due to salt-water intrusion.
- Warm weather can promote the growth of algae within the lagoon [12].
- Heat waves can accentuate odours of the wastewater in the lagoons [12].

- In the long term, erosion could reach the lagoons and slowly erode them [25].

4.3 Consequence of Impact

As mentioned above, peak flow in the WWTF and lagoons can lead to a discharge of untreated or partially treated water. However, the CMME doesn't have criteria for an effluent discharged in salty or brackish water, such as the water in Lac des Boudreau, for the following parameters: E. Coli, ammonia, suspended solids, phosphorous, BOD5 and turbidity [17]. Even though there are no criteria and there is therefore no consequence expected on the receiving environment, it is possible that high tides could push the contaminants into Lac des Boudreau. Since it is a salt marsh with brackish water, the contaminants could impact the quality of the water and affect aquatic life and other beneficial uses. [Communication 17-06-2020: Michel Belles-Isles. Michel.Belles-Isles@englobecorp.com]

In rare cases, overloaded lagoons can overflow their walls and create runoff of wastewater. This runoff could flood surrounding buildings and infrastructure. It could also pollute the natural surrounding environment with the contaminants such as ammonia, E. coli, suspended solids or phosphorous. Based on an assessment of the topography surrounding the WWTF, impacts of any runoff on nearby water bodies would be limited to Lac des Boudreau [22].

If the runoff of wastewater or the contaminated effluent from the outfall were to reach Lac des Boudreau, the following impacts would occur:

According to the « Guideline for release of ammonia in wastewater effluents » published by the federal government, ammonia can impact aquatic life due to its acute and chronic toxicity. Ammonia at high levels can make it difficult for aquatic organisms to excrete the toxicant, resulting in toxic build up in internal tissues and blood, which can be lethal. It can also affect the reproductive system and can negatively impact growth in young organisms. Subsection 36(3) of the Fisheries Act also prohibits the deposit of deleterious substances of any kind in water which contains fish. This applies to the Northumberland Strait. [13] Furthermore, ammonia has a very pungent smell which can be a nuisance [14].

- Phosphorous is also problematic for aquatic life. When a significant amount is released in water, it can cause algae blooms which can affect the surrounding ecosystem. A significant increase in algae will reduce water quality, food resources and habitats and decrease the available oxygen for aquatic life to survive. This lack of oxygen will lead to illness or death of the aquatic life. This phenomenon is called eutrophication. Without completing an exhaustive analysis, it can be affirmed that with any unbalancing of an ecosystem, it is possible to assume that there will be a change in the biomass. Some algae blooms can also be "harmful to humans because they produce elevated toxins and bacterial growth that can make people sick if they come into contact with polluted water, consume tainted fish or shellfish, or drink contaminated water." [15].
- If the bacteria E. coli is found in recreational water in concentration higher than the permissible criteria, the water environment needs to be closed. Contact with

contaminated water can cause gastrointestinal illness, as well as ear, respiratory, wound, eye, skin and neurological infections [18]. It can also be harmful for aquatic life as it lowers the available oxygen levels. [19].

- Suspended solids reduce the penetration of light and affect photosynthesis through which organisms receive energy. These organisms are usually an essential source of food and producers of oxygen for the aquatic environment. [20] Suspended solids can cause gill abrasion and affect fish respiration. When the solids settle to the bottom, they can also clog stream beds and thus deprive fish eggs of oxygen. An increase in suspended solids is usually accompanied by an increase in turbidity. [21]
- Finally, all the contaminants present in the wastewater can increase the turbidity of the water. An increase in turbidity causes a decrease in light penetration and thus can affect the growth of organisms happening through photosynthesis. The water temperature can also increase because suspended particles absorb more heat. These aspects lead to a reduction in dissolved oxygen. [22] "Turbidity can also affect how well aquatic life can see or function underwater. Excessive turbidity is known to clog the gills of fish, interfere with their ability to find food, and bury bottom dwelling creatures and eggs." [22]

There are 2 beaches (Parlee and Belliveau beach) near Lac des Boudreau and the WWTF as well as a few cottages and restaurants. Anyone visiting these beaches, cottages, and restaurants, including both the local population and tourists, could be affected by the smell of ammonia. The recreational activities, such as fishing, in Lac des Boudreau can be affected by the water quality.

4.4 Risk definition

After identifying the applicable climate change hazards, determining the impacts that these hazards may have on the WWTF and identifying the consequences that these impacts would have on the community the following overall project risk has been identified and will be evaluated in the following section:

1. **Flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment.**

5 Risk Evaluation

5.1 Direct impacts

The first risk identified for this project – **Flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** – was analyzed in terms of its likelihood and its consequences without any mitigation measures, and the overall risk level was categorized. The results are presented below.

Likelihood:

As mentioned in **section 4.1.1**. precipitation, winter freeze-thaw days, and storm surges are expected to increase in the future, sea ice coverage is expected to decrease, and sea-level is expected to rise along the coast. Flooding of the Cap Brulé WWTF components is thus likely to occur during the project's 25-year service life. Shediac is already experiencing intense rainfall and storm surges and the intensity has been increasing in recent years [4]. The east coast is also very sensitive to storm waves and sea-level rise [2 and 3]. Based on all the information indicated in section 4, the risk of flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment has been rated as "Moderate" (likely to occur once between 10 to 30 years). The likelihood assessment is shown in Table 2.

Table 2 – Likelihood of Flooding causing impaired operation of the WWTF

Probability Range	Very Low	Low	Moderate	High	Very High
Significant Single Event	Not likely to occur in period	Likely to occur once between 30 and 50 years	Likely to occur once between 10 and 30 years	Likely to occur at least once a decade	Likely to occur once or more annually
Flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment			X		

Consequence:

The consequence of **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** was assessed in **section 4.1.3**. It is important to note that the consequence would only happen if the runoff of wastewater or the contaminated effluent from the outfall reaches Lac des Boudreau. The Town of Shediac is a major economic driver in the tourism and fishery industry in southeastern New Brunswick. Without Shediac and Cap-Pelé, New Brunswick would lose some of its main tourism attractions and a major processing sector of fishery products. There are 55 companies in the region in the accommodation and restoration services sector. Shediac and Cap-Pelé both have twice as many companies in the sector, proportionally to their respective population, than the whole

country, which underlines the importance of tourism to the local economy [1]. Untreated effluent from the WWTF could also negatively impact local businesses that are driven by cottage rentals, restaurants, and other recreational activity in the area. This would have additional negative impacts on the local economy.

The **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** can also impact the aquatic life in Lac Boudreau. The maintenance of coastal habitats, which characterize the landscapes of Shediac, is essential to the ecological functioning of marine life as it exists today [10]. Poor water quality can affect the habitat, impacting numerous types of species.

Using the point rating system, **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** in the project area would produce a total of 27 points across the 11 categories considered, resulting in an average of 2.45 points. This corresponds to a consequence rating of "low". The consequence rating of this risk is shown below in Table 3.

Table 3 – Consequence of flooding causing impaired operation of the WWTF

Factor	People				Economic				Environment		
Degree	Health & Safety	Displacement	Loss of Livelihood	Reputation	Infrastructure Damage	Financial Impact on Proponent	Financial Impact on stakeholders	Air	Water	Land	Ecosystem
Very Low (1)		X			X						
Low (2)	X		X					X		X	
Moderate (3)				X		X	X				
High (4)									X		X
Very High (5)											

Risk Evaluation:

The overall risk of **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** was evaluated based on its consequence and likelihood. With a consequence rating of "low" and a likelihood rating of "moderate", the overall risk was rated as "**low**", as shown in Table 4. A low rating indicates that some control measures are required to reduce the risk.

Table 4 – Flooding causing impaired operation of the WWTF Risk Evaluation Matrix

Consequences	Very High					
	High					
	Moderate					
	Low			X		
	Very Low					
		Very Low	Low	Moderate	High	Very High
	Likelihood					

Legend :

Extreme Risk	High Risk	Moderate Risk	Low Risk	Negligible Risk

6 Risk treatment

6.1 Mitigation measures

The existing WWTF needs to be replaced as it is not meeting the mixing levels required at the end of its dispersion plume and many of the existing assets and major components have reached or are nearing the end of their expected useful life. It is expected that the existing facility will be impacted by climate change hazards in the near future. The new facility could also be potentially impacted by these same climate change hazards as described in **section 4.1.2.** If the new design doesn't take into consideration most of the following mitigation measures, the risk (flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment) resulting from the climate change hazards would threaten the new facility.

- **Adaptability:** The system must be able to handle an increase in capacity occasionally. To do so, bypasses can be added to the treatment process to help handle peak flow events. It is also possible to add an equalization capacity to the system. This will allow peak flows to be stored temporarily in an equalization basin until the flow returns to normal and the wastewater can be returned to the treatment process under lower and more uniform flow conditions. This equalization capacity is mainly to handle peaks from rain events as opposed to storm events. [12].
- **Wastewater runoff:** The lagoon berms must be high enough to avoid being overloaded from the surface and avoid any runoff of wastewater. They should be at least above the 1:100-year return period event in 2100.
- **Flooding:** Installation of a mechanized WWTF to minimize infiltration instead of the existing lagoon system. [12]. A pumped outfall instead of a gravity outfall would prevent water from infiltrating the sewer and increasing the flows. While a high-pumping head is not required, such a pumping facility must have a high capacity to deal with the variation in flow through the WWTF.
- **Damage to the outfall:** Forcemain (pressure pipe) installation is better able to accommodate the required diffusers that will be installed at the end of the outfall, with the ability to add "duckbill" check valves to minimize the potential for silt, sand, or other debris to enter the outfall.
- **Storm surges and freeze thaw cycles:** Install a pumped pipe instead of a gravity pipe. The gravity pipe would be shallow in order to sit on the sea floor at the discharge location and could become prone to movement during freeze thaw cycles within the wetland soil conditions. There is also risk with severe ice conditions and storms along the coast. The pumped pipe should be buried deep enough under the sand shoals in the intertidal area to avoid disturbing the pipeline.

6.2 Preliminary feasibility analysis

Qualified engineers hired by the GSSC completed a preliminary design for the new WWTF that incorporates climate change hazards throughout all phases of the project. Climate data were researched, several studies were reviewed, the system capacity and

receiving environment were analyzed, and new durable wastewater treatment technologies were researched. All of the mitigation measures presented above in **Section 6.1** are integrated in the new Cap Brulé WWTF except for the equalization capacity.

6.3 Residual risk

6.3.1 Risk analysis with implemented measures

If designed as described in **section 6.2** and maintained correctly, the Cap Brulé WWTF will mitigate the impacts of climate change hazards that were identified in **Section 4**. By mitigating these climate change hazards, the mitigation measures will ultimately reduce the likelihood of flooding caused by storm surges, sea-level rise, intense precipitation, and increase in winter freeze-thaw cycles.

However, the consequence of the **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**, should it still occur, would remain unchanged.

Direct impacts

Since adaptation to climate change has been taken into account from the start of the project planning (see section 6.1), the risk analysis tables presented in **Section 5** were updated to reflect the risk of **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**, with the mitigation measures in place for the new WWTF. The likelihood of the **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** has been reduced from "moderate" to "very low" (Not likely to occur in period). The consequence of **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** should it still occur, has not changed and remains "low". The likelihood and consequences with the mitigation measures are shown in Table 5 and Table 6.

Table 5 – Likelihood of flooding causing impaired operation of the WWTF

Probability Range	Very Low	Low	Moderate	High	Very High
Significant Single Event	Not likely to occur in period	Likely to occur once between 30 and 50 years	Likely to occur once between 10 and 30 years	Likely to occur at least once in 5 years	Likely to occur once or more annually
Flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment	X				

Table 6 – Consequence of flooding causing impaired operation of the WWTF (unchanged from baseline)

Factor	People				Economic				Environment		
Degree	Health & Safety	Displacement	Loss of Livelihood	Reputation	Infrastructure Damage	Financial Impact on Proponent	Financial Impact on stakeholders	Air	Water	Land	Ecosystem
Very Low (1)		X			X						
Low (2)	X		X					X		X	
Moderate (3)				X		X	X				
High (4)									X		X
Very High (5)											

Reducing the likelihood rating from "moderate" to "very low" while the consequence rating remains at "low" would cause the overall risk to decrease from "low" to "negligible". The risk of the **flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment** rating with the mitigation measures in place is shown below in Table 7. A negligible risk rating indicates that additional controls are not required to reduce the risk.

Table 7 – Flooding causing impaired operation of the WWTF Risk Evaluation Matrix with Mitigation Measure

Consequences	Very High					
	High					
	Moderate					
	Low	X				
	Very Low					
		Very Low	Low	Moderate	High	Very High
	Likelihood					

Legend :

Extreme Risk	High Risk	Moderate Risk	Low Risk	Negligible Risk

6.3.2 Limitations and unmitigated risks

Following a review of the climate change hazards and the mitigation measures that are proposed, no additional unmitigated risks have been identified. All of the proposed mitigation measures will either help reduce the likelihood of flooding at the facility or they will allow the facility to continue operating in the event of a flood event.

7 Benefits

Several benefits have been identified for this project. The benefits include both quantifiable and non-quantifiable benefits. These benefits are discussed below.

7.1 Non-Quantifiable Benefits

The new ***Cap-Brulé Wastewater Treatment Facility*** project is expected to produce the following non-quantifiable benefits:

- Benefits from avoiding water pollution;
- Benefits from avoiding loss in aquatic life and habitats;
- Benefits from avoiding loss in ecological services;
- Benefits from avoiding impact on tourism; and
- Benefits from avoiding wastewater runoff.

The above benefits were not quantified as part of this analysis.

7.2 Quantifiable Benefits

In addition to the above non-quantifiable benefits the economic benefits generated by the project were quantified.

The new WWTF will generate economic benefits as a result of the construction expenditures. The construction benefits were estimated using the 2014 Statistics Canada Provincial Input-Output Multipliers for New Brunswick [26]. Multiplier # 25 (water, sewage and other systems) was used for the analysis.

The multiplier calculations indicated that the $13.76 Million federal portion of the investment is expected to produce approximately $21.3 Million ($2020) in construction phase benefits that would be realized throughout the construction period of the project. When discounted at an annual discount rate of 10% this amounts to approximately $19.25 Million in construction benefits over the four-year construction period (discounted back to $2020). The federal investment is also expected to create 255 direct jobs and 54 indirect/induced jobs, for a total of 309 jobs during the construction period. The construction phase benefits are summarized in **Table 8**.

Table 8 – Summary of Quantifiable Construction Phase Benefits

	Total Benefits of Analysis Period[1]		
	Benefits of Analysis Period		Benefits Discounted at 10%
Construction Phase Benefits	$ 21,328,000		$ 19,250,860
Construction Employment Benefits (FTE's)	Direct	Indirect & Induced	Total
	255 Jobs	54 Jobs	309 Jobs

[1] *Analysis period of Construction Benefits is 2020 - 2024.*

8 Consideration of resilience principles

Proportionate Assessment

The Cap Brulé WWTF is the only facility currently treating wastewater for the region of Shediac, Cap Brulé and Pointe-du-Chêne so it's effectiveness and durability is critical to the well-being of the surrounding environment. The commercial and recreational activities that take place along the coast near the WWTF and in Lac des Boudreau are essential to the economy of the Town and the Province. Should this project not move forward, the risk that the existing WWTF would eventually be unable to effectively treat wastewater would increase. If this were to happen the impacts on the surrounding ecosystems and tourist attractions would hurt the local and provincial economy. It is important that mitigation measures be put into place to reduce the likelihood of flooding of the WWTF that would impact the quality of water in Lac des Boudreau and therefore commercial and recreational activities. The new WWTF has been designed to mitigate against the climate change hazards that have been identified for the Shediac area.

Systemic Analysis of Risk

A holistic approach was used to complete this Climate Change Resilience assessment. Historical data and future climate change projections were obtained for the Province of New Brunswick, specific to the Town of Shediac area. The vulnerability of the asset was assessed, and the overall project risks were determined by considering the nearby infrastructure, population, environment and activities that rely on a properly functioning wastewater treatment facility. This includes the surrounding waterways, restaurants, hotels/cottages, beaches, fishing, etc. These dependencies were all considered as part of the risk analysis.

Pursuit of Multiple Benefits

The selected mitigation measures will produce multiple benefits. These benefits were discussed in more detail in **Section** Error! Reference source not found..

Avoidance of Unintended Consequences

The new WWTF will be constructed in a way that minimizes unintended consequences and environmental impacts. The existing lagoons will be used in the new design to avoid unintended consequences that could result from the construction of new lagoons. All other components of the facility will be new. The construction of a new structure has the potential to disturb existing ecosystems. This can be mitigated by having good knowledge of the existing shoreline environment and choosing an appropriate design to match that environment. Studies have been completed for this purpose.

9 Description of Evidence Base

The primary studies and research that were used as part of this Climate Change Resilience Assessment included the following:

- Savard, J.-P., van Proosdij, D. and O'Carroll, S. (2016). Perspectives on Canada's East Coast region; in Canada's Marine Coasts in a Changing Climate. Government of Canada;
- Daigle. (2020). Updated sea-level rise and flooding estimates for New Brunswick coastal sections 2020;
- Roy, P. and Huard D. (2016). Future Climate Scenarios - Province of New Brunswick. Montreal: Ouranos;
- Environment Canada. (2006). Impacts of sea-level rise and climate change on the coastal zone of southeastern New Brunswick;
- Bernatchez, P., Jolicoeur, S. and Savard, J-P. (2016). Impacts des changements climatiques et des contraintes physiques sur le réajustement des écosystèmes côtiers (coastal squeeze) du golfe et de l'estuaire du Saint-Laurent (GESL) et évaluation des mesures d'atténuation de ces impacts. Ouranos and Natural Resources Canada;
- Town of Shediac. (2019). Plan d'adaptation aux changements climatiques;
- Paris V.S. (2006). Expected impacts of climate change on water and wastewater treatment in the eastern Ontario region. University of Ottawa;
- Climate data. (2019). Annual values for Shediac.

The above studies, research, and guidelines have all contributed to the selection and design of the **Upgrade of Cap-Brulé Wastewater Treatment Facility**. The new facility will have more capacity to handle future wastewater demand and it will also be better equipped to mitigate against future climate change impacts, which have the potential to cause flooding of the WWTF and potentially impact the facility's ability to process wastewater.

10 Conclusion

The ***Greater Shediac Sewerage Commission (GSSC)*** is applying to Infrastructure Canada for funding toward the **Upgrade of Cap-Brulé Wastewater Treatment Facility (WWTF).** The project is being submitted under the **Investing in Canada Infrastructure Program (ICIP) – Green Infrastructure: Environmental quality** investment stream. Englobe Corp was hired to complete the Climate Lens for this funding application. This report includes the Climate Change Resilience Assessment, which is a requirement of the Climate Lens.

Seven climate change hazards were identified for this project, as presented in **Section 4.1**. These climate change hazards will all contribute to an increased risk of flooding along the coast of New Brunswick, where the new WWTF will be located. The primary risk identified for this project was "**flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**".

It was determined that due to the location of the new WWTF and without any mitigation measures in place, the likelihood of flooding leading to impaired operation of the new WWTF was rated as "moderate" and the consequence was rated as "low". This resulted in an overall risk rating of "**low**".

Several mitigation measures for the new WWTF have already been identified by the engineering design team, as outlined in the *Cap-Brule Wastewater Treatment Facility Preliminary Design Report*. These mitigation measures were listed in **Section 6.1**.

With the mitigation measures built into the new WWTF, the residual risk of "**flooding causing impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment**" was rated. It was determined that the likelihood of this risk would be reduced to "very low" while the consequences of this risk would remain "low". This resulted in an overall risk rating of "**negligible**".

The Climate Change Resilience Assessment has concluded that without any mitigation measures the new WWTF would be at a low risk of flooding, which could lead to impaired operation of the WWTF resulting in increased risk to public health and the surrounding environment. However, with the mitigation measures that have been outlined by the engineering design team (as presented in **Section 6.1**) this risk would be reduced to 'negligible'.

11 References

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