



TOWN OF GRAND BAY-WESTFIELD

Community Climate Adaptation Plan

March 2021



This project was made possible with support from the New Brunswick Environmental Trust Fund



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March 16, 2021



Town of Grand Bay-Westfield
609 River Valley Drive
Grand Bay-Westfield, NB
E5K 4V3

Attention: John Enns-Wind, Chief Administrative Officer, Town of Grand Bay-Westfield

RE: Community Climate Change Adaptation Plan

Dillon Consulting Limited is pleased to present the final report for the Community Climate Change Adaptation Plan for the Town of Grand Bay-Westfield. This report summarizes the overall project context, methodology and results including the identification of anticipated climate-related infrastructure and service vulnerabilities as well as adaptive measures and recommendations to respond to the identified issues. We would like to thank the Town of Grand Bay-Westfield for the opportunity. It has been a pleasure working with you on this project.

Sincerely,

DILLON CONSULTING LIMITED

A handwritten signature in blue ink, appearing to read "Julie DiCicco".

Julie DiCicco, M.A.Sc., P.Eng.
Project Manager, Associate

JD:jmg

Attachment: Grand Bay-Westfield Community Climate Change Adaptation Plan

cc: David Taylor, Development & Planning Officer, Town of Grand Bay-Westfield
Bruce Gault, Works Commissioner, Town of Grand Bay-Westfield
Troy Gautreau, Fire Chief, Town of Grand Bay-Westfield

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EXECUTIVE SUMMARY

In 2020, Dillon Consulting Limited (Dillon) worked collaboratively with the Town of Grand Bay-Westfield (the Town or GBW) to submit a proposal to the Environmental Trust Fund (ETF) of New Brunswick to seek funding to develop a climate change vulnerability assessment and adaptation plan. Upon approval of this funding request, Dillon was engaged to help complete a community Climate Change Adaptation Plan (CCAP).

The main objectives of this CCAP are to identify the climate change vulnerabilities of Town infrastructure, assets, and components, and to develop strategic adaptation measures that will increase the Town's resilience to climate change.

VULNERABILITY ASSESSMENT

The project employed three methods for assessing Town infrastructure. (1) Infrastructure assessment in alignment with approaches defined within ISO 31000 - Risk Management Principles and Guidelines, (2) Spatial assessment to determine Town components impacted by flood events using expected high flood elevations, and (3) Planning review to discuss the potential climate change impacts on GBW's future development, growth, and general population.

INFRASTRUCTURE ASSESSMENT

The purpose of the infrastructure assessment was to identify climate change impacts to specific categories of within the Town's portfolio of public infrastructure. The asset categories and corresponding key components evaluated in this project are:

- **Transportation Assets:** Asphalt roadways and parking lots, asphalt and concrete sidewalks, gravel or natural pedestrian trails, the NB southern railway.
- **Waste, Wastewater, Storm Assets:** Underground (U/G) sanitary sewer lines, sewage lift stations, wastewater treatment building, wastewater lagoon, trickling filter building, U/G storm sewer lines, water supply pump houses, culverts and catch basins, private wells, private septic tanks.
- **Community Structures:** components include Foundation/ structure, roof (shingles), roof (flat), exterior finishes, and mechanical/electrical.
- **Parks and Recreational Elements:** components include Splash pad, washroom facility (by splash pad), gazebo (at Unity Park), and parks.
- **Community Elements:** Power/ utility services, and communications infrastructure.

Once the infrastructure components were identified, a four-step process was initiated to determine the vulnerability of each infrastructure component:

1. Identification of potential risk interactions between infrastructure components and climate hazards;

2. Calculation of the probability of occurrence for climate hazards using current climate data and future climate projections;
3. Assessment of the severity of the anticipated impact for each feasible interaction between a climate hazard and an infrastructure component; and
4. Calculation of the risk scores corresponding to defined risk levels (i.e. negligible, low, moderate, or high) by multiplying the probability of occurrence with the severity of the impact for each climate interaction under assessment.

The calculation of a risk score is based on the following fundamental equation:

$$\text{Risk Score} = \text{Probability} \times \text{Severity}$$

Ultimately, the infrastructure assessment resulted in the identification of one (1) high, sixteen (16) moderate, and twenty-five (25) low risk interactions. These are listed in Section 3.1 of the report and in Appendix A. High and moderate risks were prioritized in subsequent steps as they require more immediate actions and solutions compared to low risks.

The identified high and moderate risks related to the following assets: Asphalt Roadways and Parking Lots, Gravel or Natural Pedestrian Trails, Railway, Water Supply Pump Houses, Wells, Sewage Lift Stations (SLS), Grinder Pump Stations (GP), Underground Storm Sewer Lines, Culverts and Catch Basins, Roof (Shingles), Parks, Power/Utility, Communications/Utility.

SPATIAL ASSESSMENT

A spatial assessment was conducted using flood extent mapping to visually identify which Town assets were potentially vulnerable to flooding. Assets were located on a map and assigned a risk level of either high, moderate, or low depending on their proximity to the flood extents, where:

- Components inside the flood zone were deemed a high risk;
- Components close to the flood zone were deemed a moderate risk; and
- Components outside of the flood zone were deemed a low risk.

As the spatial assessment was more qualitative in nature, Town staff and public stakeholders were engaged to comment on vulnerable infrastructure or areas within the community. Engagement activities were completed as part of this project was conducted through a series of interviews, workshops and online activities, specifically these consisted of:

- Targeted interviews with Town staff;
- An online Vulnerability Mapping Exercise through the online engagement platform, Social Pinpoint (SPP); and
- An online Adaptations Survey through the SPP platform.

The spatial assessment identified fourteen (14) high risks and twenty-eight (28) moderate risks for consideration. The identified high risks resided within the following infrastructure categories: Roadways, Railway, Water Supply Pump House #2, Grinder Pumps #1, #7, #10, Sewage Lift Stations #7 and #10, Wastewater Treatment Plant, Brundage Point River Centre, and Storage Garage.

PLANNING REVIEW

Dillon also viewed the potential climate change impacts on land use planning and the general population, as the Town continues to welcome more residents and encourage ongoing residential development. As such, Dillon explored the impacts of flooding, high heat, and drought on future development with a focus on future land use intensification areas. These three climate hazards were selected by planners at Dillon due to the understanding that these hazards would have the most direct and observable impacts on land use planning and development. This approach was done qualitatively through desktop research informed by professional judgement and experts on land use planning.

This review found that:

- The aging population of the Town will face higher risks from climate change compared to the younger population. The aging population of the Town coupled with the increase in the number of heat waves and hot days will put the community at heightened risk of heat-related illnesses.
- The compounding effects of grey infrastructure expansion from continued development and increasing frequency and intensity of hot and dry weather is expected to place increasing strain on the Town water supply due to increased water demand and decreased groundwater recharge.
- Greater flooding is expected to continue to jeopardize the safety and livelihood of residents, and risks of destruction. Within the town limits, there are 61 vacant plots of land that are in flood risk areas with a total assessed value (2019) of \$804,100.00. These 61 vacant plots of land have a total tax levy of \$20,024.07. Proper measures need to be taken in order to safely and effectively optimize the available land for further development.

ADAPTATIONS AND RECOMMENDATIONS

At least one (1) adaptation measure or recommendation was identified for each climate interaction that achieved a moderate or high risk score in the assessment, where:

- Adaptation measures are actions concerned with upgrading infrastructure components, or creating new studies and plans. These actions are characterized by their need for funding and capital investment; and
- Recommendations are actions concerned with reviewing and/or modifying processes and systems that are currently in place to facilitate continuous improvement

The development of adaptations and recommendations included a review of climate change vulnerabilities in consideration of the climate hazard (i.e., flooding, high temperatures, etc.). The

assessment identified that the climate hazards that generated the highest number of vulnerabilities relate to flooding and heavy rainfall events. Over many years, Town staff have taken proactive steps in creating protocols and procedures to mitigate or respond to flooding or heavy rainfall-induced impacts. Some of the recommendations identified are already being conducted by the Town and are included in this report for reporting purposes only.

The purpose of these findings is to assist with the prioritization of adaptation measures and recommendations in order to inform future decision making on opportunities to build GBW's resilience and adaptive capacity to projected climate change impacts. The assessment's final adaptation and recommendation measures are provided in Appendix D.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The Town of Grand Bay-Westfield (“GBW” or “the Town”) is comprised of the former Town of Grand Bay and the former Village of Westfield. GBW is located in southwestern New Brunswick along the west bank of the Saint John River and is home to a community of approximately 4,900 residents. GBW is experiencing many of the climate change impacts documented elsewhere in southern New Brunswick, including rising temperatures, increased annual precipitation, less snowfall, more extreme rain events, and warmer winters. The Town is heavily affected by river flooding as caused by the spring freshet. Flooding continues to be an ongoing challenge for the community. GBW is planning for the future growth of the community and has undertaken this assessment as an important climate resilience initiative to examine how it can better manage its infrastructure, services and community elements, and improve its community’s resilience to climate change impacts.

To gain a deeper understanding of the potential impacts of climate change on Town infrastructure, Dillon Consulting Limited (Dillon) worked collaboratively with the Town to submit a proposal to the Environmental Trust Fund (ETF) of New Brunswick to seek funding to complete a Climate Change Vulnerability Assessment. The ETF provides assistance for action-oriented projects with tangible and measurable results, aimed at protecting, preserving and enhancing the natural environment. Representatives from Climate Change Secretariat (CCS), who represent the ETF for Climate Change related projects, requested that the Climate Change Vulnerability Assessment project be comprised of a full Climate Change Adaptation Plan (CCAP or Plan) for the community, with significant community engagement and input.

As a result of discussions with the CCS, this project consists of a climate change vulnerability assessment, community engagement, and development of a final Climate Change Adaptation Plan.

The overall objective of this plan is to strengthen GBW’s resilience to potential climate change impacts through the development of data-driven and community-informed measures.

1.2 PROJECT SCOPE

The CCAP consisted of two (2) phases:

1. A Vulnerability Assessment Phase; and
2. An Adaptation Planning Phase.

The Vulnerability Assessment Phase assessed the degrees of risk that specific local climate hazards can impose on Town infrastructure, core services, and operations through both qualitative and quantitative approaches to the assessments. The quantitative approach was applied during the infrastructure assessment and this effort included a risk scoring method aligned with ISO 31000 - Risk Management Principles and Guidelines. Accompanying this quantitative approach, a qualitative approach was then applied during the spatial assessment, involving a facilitated discussion between Town staff and the Dillon team to discuss, confirm and evaluate flooding related impacts and land use considerations. Moreover, potential climate change impacts on future development were also explored through desktop research during the planning review.

At the end of this process, the team developed a final compiled list of the identified high, moderate, and low risk interactions between Town assets, services, and operations, and the identified climate hazards for the region.

The Adaptation Planning Phase of the project identified strategic and feasible climate change adaptation measures and recommendations that are deemed feasible options to help in managing and mitigating the Town's high and moderate risk interactions that were identified during the vulnerability assessment phase. The key tasks associated with each phase of project scope for this CCAP are summarized below.

1. Vulnerability Assessment Phase

➤ Background Review

- Detailed review of infrastructure data and compiled a list of critical infrastructure, core services, and external service providers;
- Review and analysis of past reports conducted on Town infrastructure;
- Compilation of existing climate change data and projections for the region; and
- Review of flood levels and mapping available through the Province of New Brunswick.

➤ Targeted Interviews

- Conducted one-on-one, key person interviews with Town staff with knowledge of community infrastructure; and
- Compiled an initial list of climate change vulnerabilities within the community.

➤ Community Engagement Session #1

- Developed an online engagement platform using Social Pin Point (SPP) community engagement platform software for community participation in an online mapping exercise; and
- Finalized a list of interactions to be included in the vulnerability assessment.

➤ Vulnerability Assessment

- Facilitation and execution of a vulnerability assessment workshop and compiled vulnerability assessment results into a list of high, moderate or low risks stemming from identified climate change vulnerabilities;
- Completion of a qualitative spatial assessment to identify flooding-specific infrastructure risks through the use of flood elevations; and
- Evaluation of the potential impacts of flooding, heat risk, and drought on future development and growth of the Town through desktop research and existing knowledge of site development factors throughout the planning review.

2. Adaptation Planning Phase

➤ Internal Adaptation Planning Workshop

- Review and validation of the prioritized list of infrastructure and service vulnerabilities;
- Development of adaptation measures and other recommendations to address the high and moderate risk interactions identified from the vulnerability assessment; and

- Development of a finalized list of adaptation measures and recommendations for review and approval by the Town Project Team prior to final reporting for the Project.
- Community Engagement Session #2
 - Conducted an online survey on SPP that was open to all community members to provide input and guidance on specific focus areas within the adaptation measures and/or recommendations provided.
- Final Reporting
 - Preparation and submittal of draft and final CCAP reports to the Town Council.

1.3 STAKEHOLDER ENGAGEMENT

The approach taken towards the development of this CCAP was driven by historical and projected climate data and an engagement process that facilitated stakeholder collaboration and community participation. Recently, the formats for public exchange have changed in various ways to reduce risks to public health due to the COVID-19 pandemic. Under the health and safety restrictions set by governments, engagement sessions were conducted virtually to allow completion of the assessment in a safe manner. Virtual engagement sessions have proven to be effective in establishing and fostering communication with stakeholders and the public throughout the current pandemic environment. When effectively facilitated, virtual engagements can be a valuable tool for providing insightful anecdotal information without the need for travel and also provide the benefit of imposing a lower environmental footprint than what is incurred when travelling to attend in-person events.

1.3.1 TOWN PROJECT TEAM

The Town Project Team served as the main stakeholder group throughout the project, providing comment, feedback, and direction on the project from initiation to final approval. The engaged stakeholders are listed in below:

- Bruce Gault – Works Commissioner, Town of Grand Bay-Westfield
- Troy Gautreau – Fire Chief, Town of Grand Bay-Westfield
- Gary Clark – Recreation Director, Town of Grand Bay-Westfield
- John Enns-Wind – Chief Administrative Officer, Town of Grand Bay-Westfield
- David Taylor – Development & Planning Officer, Town of Grand Bay-Westfield

Table 1 below, summarizes the various engagement sessions and meetings that contributed to this project. The engagement sessions were facilitated in a format intended to generate meaningful feedback from key stakeholders, resulting in an engagement-driven CCAP development process.

Table 1: Engagement Sessions/ Meetings Summary

Phase	Engagement Session/ Meeting	Date	Engaged Group	Purpose
Project Initiation	Project Initiation Meeting	July 15, 2020	Town Project Team	During the Project Initiation Meeting between Dillon and the Town Project Team, all team members were introduced, the project approach was reviewed and discussed, project roles were confirmed, and key project milestones were established.
Phase 1: Vulnerability Assessment	Targeted Interviews	October 28, 2020 November 4 – 5, 2020	Town Project Team	Four (4) targeted interviews were conducted with Town staff to gather input to help identify potential climate change vulnerabilities to specific Town infrastructure that they provide. Interviews were tailored to the participants' respective areas of expertise to maximize the value of the input gathered. The interviews included questions directed towards the identification of past climate change impacts to specific Town assets that Dillon identified during the background review process. Participants were also asked about any adaptation measures that have been considered or implemented in the past to protect Town infrastructure. The targeted interviews identified fifteen (15) initial vulnerabilities.
	Community Engagement Session #1 - Online Vulnerability Mapping Exercise	October 5 – November 6, 2020	Town Community	The first Community Engagement Session entailed working together on an online vulnerability mapping exercise. The purpose of this session was to gather input regarding the Town's climate change vulnerabilities from the Town's community members ahead of Dillon's Internal Vulnerability Assessment Workshop. The information gathered in this engagement session was then integrated into the subsequent steps of the vulnerability assessment phase.
	Internal Vulnerability Assessment Workshop	November 10/16/17, 2020	Dillon Internal Staff	A multi-disciplinary team of Dillon staff assigned risk scores to the identified climate hazard/infrastructure interactions (vulnerabilities) and assigned high, moderate, or low risk level scores to each interaction based on the criteria outlined in Section 2.1.2 of this Plan.
Phase 2: Adaptation Planning	Adaptation Planning Workshop	December 8, 2020	Town Project Team	Dillon collaborated with Town Staff to develop potential viable adaptation measures and recommendations to address the moderate and high risks identified in the vulnerability assessment phase of this project.
	Community Engagement Session #2 - Online Adaptations Survey Exercise	March 1 – 22, 2021	Town Community	The GBW community was engaged again through the online platform Social Pinpoint to participate in an online survey. The objective of this survey was to obtain community feedback regarding which adaptation measures and recommendations should be prioritized.

1.3.2 SOCIAL PINPOINT ONLINE ENGAGEMENT

The GBW community was engaged in two (2) separate engagement sessions through the online community engagement platform, Social Pinpoint (SPP). SPP allows participants to review project information at their leisure to comment, ask questions, and contribute to the project through the online community engagement platform, Social Pinpoint (SPP). The community engagement sessions as part of this project are briefly summarized in the following sections.

1.3.2.1 COMMUNITY ENGAGEMENT SESSION #1 – ONLINE VULNERABILITY MAPPING

The mapping activity was open for comment from October 5, 2020 until November 6, 2020. A map of the Town was pre-populated with the 15 vulnerabilities identified in the targeted interviews. The vulnerabilities were displayed as markers with unique icons that people can click on for more information. The online engagement platform was shared on the Town's Website and social media platforms. The GBW community was invited to read and comment on the initially identified vulnerabilities, drop new markers to signify additional vulnerabilities, or learn about the project through the platform. Ultimately, only one (1) additional comment was received from the community. The gathered inputs were then compiled and integrated into subsequent steps of the assessment. Examples of these comments are shown in Figure 1, below.

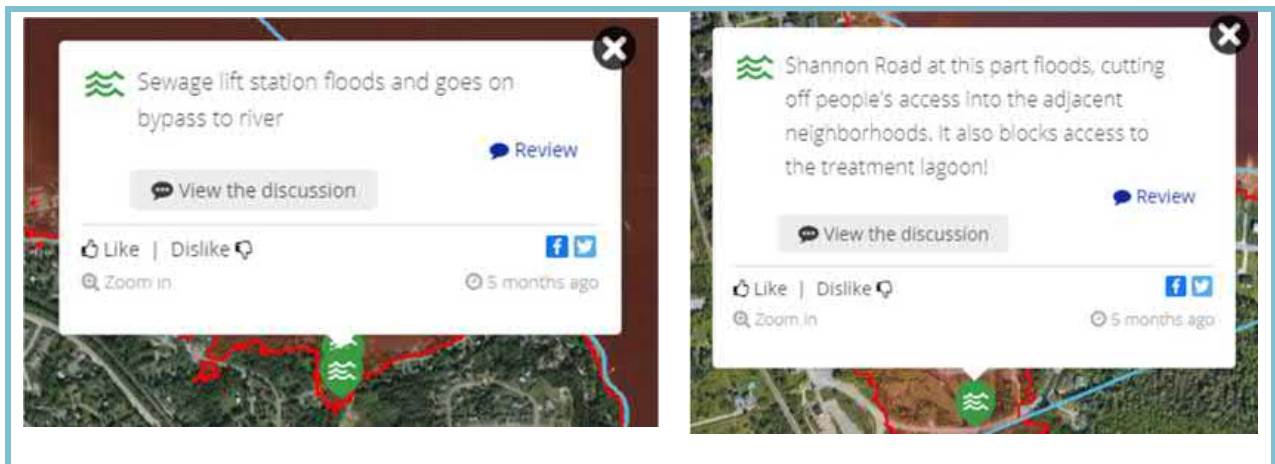


Figure 1. Vulnerabilities Identified on Social Pinpoint Mapping Activity

A brief summary of the engagement activity, as of March 3, 2021, is shown in Figure 2, below.

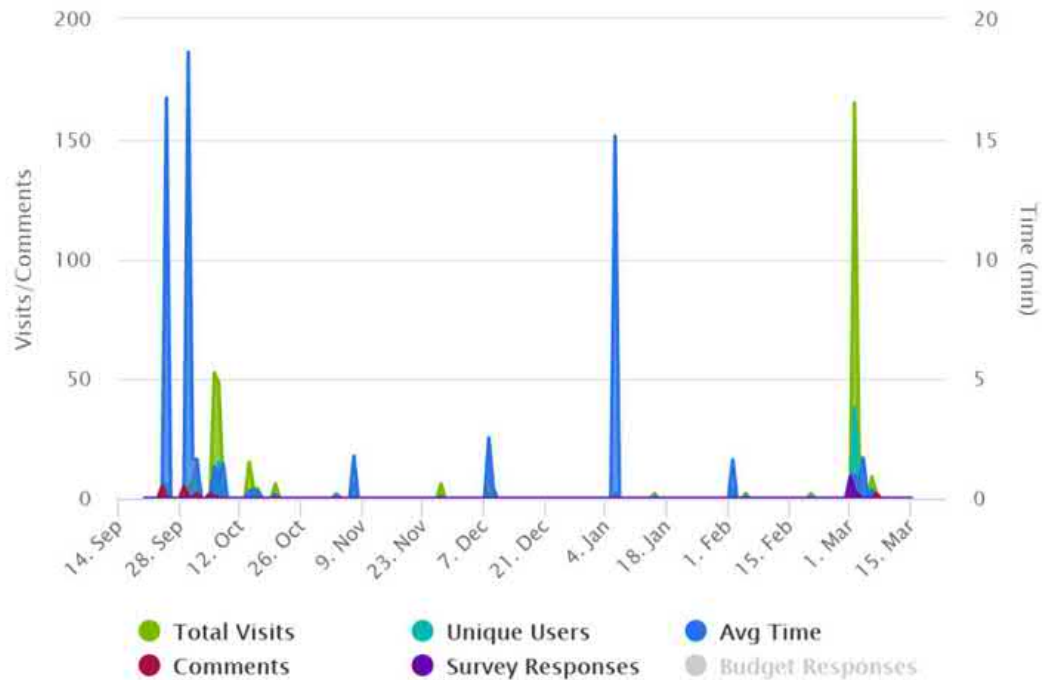


Figure 2. Engagement Summary

The results from the mapping exercise helped in gathering more anecdotal information than is typically available through desktop research. These first-hand accounts provided strong evidence that certain climate hazard-infrastructure interactions have already occurred in the past which in turn informed the vulnerability assessment phase.

1.3.2.2 COMMUNITY ENGAGEMENT SESSION #2 – ONLINE ADAPTATIONS SURVEY

The GBW community was engaged again through Social Pinpoint to participate in an online survey. The online engagement platform was shared again on the Town's Website and social media platforms, and was open to the general public. The online survey included questions to rank adaptation measures developed for stormwater management and runoff, and riverine flooding. The objective of this survey was to obtain community feedback regarding which adaptation measures and recommendations should be prioritized. This survey was maintained and kept active from March 1, 2021 until March 22, 2021.

As of March 15, 2021, thirteen (13) survey responses have been collected. As presented in Figure 3 and Figure 4 below, riverine flooding was flagged as the largest concern for GBW residents.

Q1. Of the following vulnerabilities, which of these should be considered priorities for the Town of Grand Bay-Westfield?

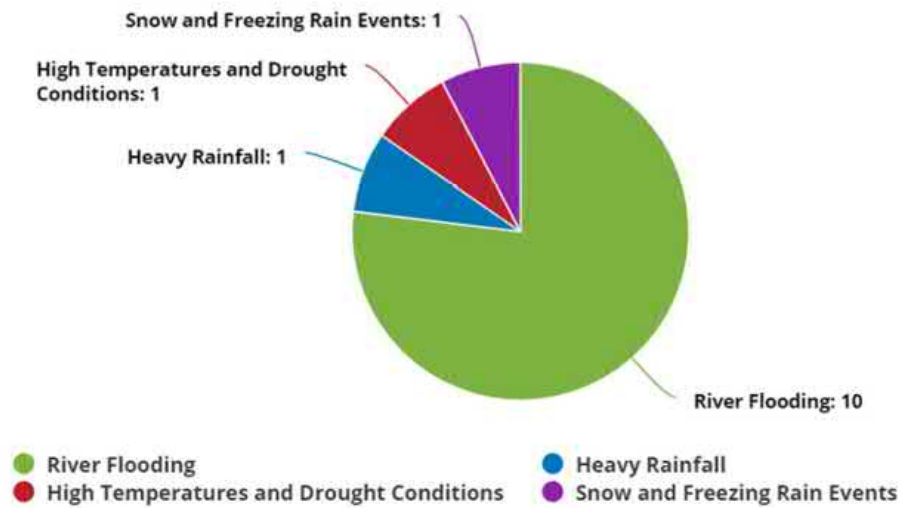


Figure 3. Screenshot of Survey Question 1

Q2. Please rank the following vulnerabilities in terms of relative importance.

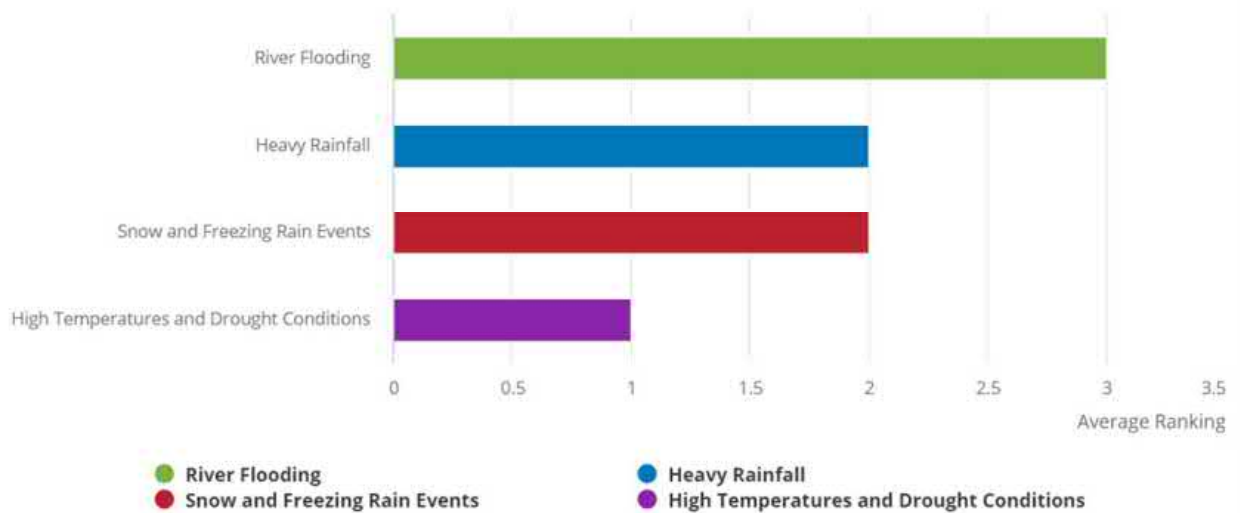


Figure 4. Screenshot of Survey Question 2

(The choice with largest average ranking is the most preferred choice)

2.0 VULNERABILITY ASSESSMENT

2.1 VULNERABILITY ASSESSMENT METHODOLOGY

As previously described, the approach to the vulnerability assessment phase involved a background review to develop an infrastructure component listing and compilation of relevant available climate data. This phase of the project was driven by consultation with subject matter experts and project stakeholders in order to assess the vulnerability of specific Town infrastructure.

The vulnerability assessment was conducted using results from three methods; an infrastructure assessment, a spatial assessment, and a planning review whereby:

- The infrastructure assessment focused on the interactions between specific Town infrastructure assets and the projected climate hazards excluding flooding impacts;
- The spatial assessment focused on the interactions between specific Town infrastructure assets and flood extents. The spatial risks were evaluated qualitatively with the use of flood maps.
- The planning review focused on the interactions between specific climate hazards (i.e. flooding, high heat, and drought conditions) on the Town's future development, growth, and general population.

The methodology employed for each assessment is expanded upon in Sections 2.2, 2.3, and 2.4.

2.1.1 BACKGROUND REVIEW

2.1.1.1 INFRASTRUCTURE LISTING

The component listing compiled for this project was developed and informed from two sources:

1. Town of Grand Bay-Westfield's Asset Management Plan (2018), which contains general information related to infrastructure type, infrastructure condition, and replacement value;
2. Stakeholder Interviews, which helped in developing a finalized list of Town infrastructure and services.

Specific infrastructure components were identified within broader infrastructure categories dictated by their asset classification (transportation, water/wastewater, etc.), which helped to guide the assessment. The infrastructure components considered as part of this assessment are shown in Table 2 and Table 3, below. Table 2 explores the general infrastructure and natural elements within the Town while Table 3 explores specific Town buildings and facilities. This separation was done to facilitate the more qualitative discussions during the spatial assessment, which is centred on the proximity of each building or facility to the identified flood extents. This contrasts with the more quantitative vulnerability assessment approach completed for the general infrastructure and natural elements.

Table 2: Infrastructure Assessment - Asset Listing

Infrastructure Category	Infrastructure Component
Transportation Assets	Asphalt Roadways and Parking Lots
	Asphalt and Concrete Sidewalks
	Gravel or Natural Pedestrian Trails
	Railway (NB Southern Railroad)
Waste, Wastewater, Stormwater Assets	U/G Sanitary Sewer Lines
	Sewage Lift Stations
	Grinder Pump Stations
	Wastewater Treatment Building
	Wastewater Lagoon
	Trickling Filter Building
	U/G Storm Sewer Lines
	Water Supply Pump Houses
	Culverts and Catch Basins
	Private Wells
Private Septic Tanks	
Community Structures	Foundation/ Structure
	Roof (shingles)
	Roof (flat)
	Exterior Finishes
	Mechanical/ Electrical
Parks and Recreational Elements	Splash Pad
	Washroom Facility (By Splash pad)
	Gazebo (at Unity Park)
	Parks
Community Elements	Power/Utility
	Communications/ Utility

Table 3: Spatial Assessment - Asset Listing

Infrastructure Category	Infrastructure Component
Transportation Assets	Roads: <ul style="list-style-type: none"> • Hazel St. • Spruce St. • Beach Rd. • Brandy Point Rd. • Riverside Park • Ferry Rd. • Nerepis Rd. • Hammond Rd. • Westfield Cr. • Station St. • Brittain Rd. • Ferry Rd.
	Bridges: <ul style="list-style-type: none"> • Nerepis Bridge Rd. • Shannon Rd.
	Railway (NB Southern Railroad)
Waste, Wastewater, Stormwater Assets	Water Supply Pump House #2
	Grinder Pumps #1, 7, and 10
	Sewage Lift Stations #7 and 10
	Wastewater Treatment Lagoon
	Trickling Filter Building
Community Structures	Community Centrum
	Brundage Point River Centre
	Salt Shed
	Storage Garage
	Fire Station #2
	Works Garage and Office
	Fire Training Facility
River Valley Lions Community Centre	

2.1.1.2 CLIMATE HAZARDS

Through a review of available climate data for the region, seven (7) climate hazards were identified as the most important for the assessment due to their potential impacts on the selected Town infrastructure. Through the use of multiple publicly available data sources, climate data was also assembled for the Town, shown in Table 4, below. Observed historical climate data for the region was compiled for the period 1981 to 2010. Climate change projections were then compiled for the time period between 2069 and 2099 using an ensemble of Global Climate Models with an emission scenario

of Representative Concentration Pathway (RCP) 8.5, aligning with a “business as usual” condition resulting from ongoing, continued growth in global GHG emissions.


RCP’s are scenarios that describe alternative trajectories for carbon dioxide emissions and the resulting atmospheric CO₂ concentrations from 2000 to 2100. RCP8.5 represents a global temperature increase of 3.2 to 5.4°C, as well as an increase in extreme rainfall and other weather events (Climate Nexus, 2021). The emission scenario of RCP 8.5 was selected to best inform the vulnerability assessment, which in turn informs risk management planning. Globally, GHG emissions in the 2020’s continue to grow. Selecting a lower emission RCP would assume global GHG reductions that have yet to occur, resulting in a vulnerability assessment that may underestimate impacts and associated climate risks. Selecting an RCP that aligns with recent and current global GHG emissions trends is preferable for applications intended to inform risk management planning.

Climate data projections for high temperatures, low temperatures, heavy rainfall, and freeze-thaw cycles were collected from readily available open sources, specifically:

- Ouranos, a Canadian non-profit organization specializing in climate scenarios and projections, and adaptation planning;
- ClimateData.ca, an online climate data portal produced collaboratively by Canada’s leading climate organizations and supported, in part, by the Government of Canada, and
- The Climate Atlas of Canada, an online database with downscaled climate data that integrates interactive web design with climatology, cartography, and storytelling to better support education and applied decision-making.

Data for freezing rain was obtained through published research on the Possible Impacts of Climate Change on Freezing Rain Using Downscaled Future Climate Scenarios (Cheng et al., 2011). Wind data was obtained through review of published research journals containing downscaled wind speed data for Canadian Provinces (Cheng et al., 2014). Projections for snowfall were obtained through an internal statistical analysis conducted by a certified meteorologist on the Dillon team. Drought conditions were assessed qualitatively based on data on dry days and longest spells of >30°C days obtained from ClimateData.ca and the Climate Atlas. Table 4 lists the climate hazards considered in the vulnerability assessment and the corresponding climate data source. As shown, high temperatures, heavy rainfall, freezing rain and high winds are expected to trend upwards.

Table 4: Climate Data Projections

Climate Hazard	Baseline Values (1981 – 2010)	Trend	Projected Value (2069 - 2099)	Source
High Temperatures Average number of days per year with a maximum temperature > 30°C.	0.1 Days/Year		17.1 Days/Year	ClimateData.ca
Low Temperatures Average number of days per year with a maximum temperature < -30°C	0.5 Days/Year		0 Days/Year	ClimateData.ca
Heavy Rainfall Average number of days per year with precipitation as rain ≥ 25 mm	16.0 Days/Year		19.8 Days/Year	ClimateData.ca
Freeze-Thaw Cycles Daily maximum temperature > 0°C and the daily minimum temperature is ≤ -1 °C	78.9 Occurrences		64.9 Occurrences	Climate Atlas
Freezing Rain Average number of days with rain or ice pellets lasting longer than 6 hours	0.9 Day/Year		1.1 Days/Year	Cheng et al. Study
Snowfall Average number of days per year with snow ≥ 10 cm	7.2 Days/Year		1.0 Days/Year	Internal Analysis
High Wind Gusts Average number of days per year with wind gusts ≥ 70 km/h	2.5 Days/Year		3.0 Days/Year	Cheng et al. Study
Drought Conditions Combined effect of dry days and longest spell of >30°C days Parameter shown: longest spell of >30°C days	0.2 Days		6.8 Days	Climate Atlas

2.2 INFRASTRUCTURE ASSESSMENT METHODOLOGY

The methodology used for this assessment is in alignment with ISO 31000 - Risk Management Principles and Guidelines and accordingly follows classical risk assessment best practices. The process required executing four (4) key steps to conduct the infrastructure vulnerability assessment of Town infrastructure. These are:

1. Identify potential risk interactions between infrastructure components and climate hazards;
2. Calculate the probability of occurrence for climate hazards using current climate data and future climate projections;
3. Determine the severity of an impact of each feasible interaction between a climate hazard and an infrastructure component; and
4. Calculate the risk score corresponding to defined risk levels (i.e. negligible, low, moderate, or high) by multiplying the probability of occurrence with the severity of the impact.

The calculation of a Risk Score is based on the following fundamental equation:

$$\text{Risk Score} = \text{Probability} \times \text{Severity}$$

Where;

- Probability is the statistical frequency/probability of specific climate hazard thresholds being reached historically, and in the future; and,
- Severity is a measurement of the climate hazard's impact on a particular asset.

2.2.1 STEP 1: RISK INTERACTIONS

A multidisciplinary team at Dillon identified the possible interactions between the studied climate hazards and Town infrastructure using an interaction matrix. The interaction matrix was then further expanded through the formation of vulnerability statements which provided general initial descriptions of the expected impacts. For example, one initially identified interaction was between asphalt roadways and high temperatures, and the corresponding vulnerability statement for this interaction identified a concern regarding the rutting from the softening and deterioration of asphalt surfaces due to heat stress. The matrix and vulnerability statements were then distilled during the Internal Vulnerability Assessment Workshop. The aforementioned interaction matrix is shown in Appendix A – Vulnerability Interaction Matrix and Scores.

2.2.2 STEP 2: PROBABILITY OF OCCURRENCE

For the purposes of this project, the scale factor values for probability were established on a scale from 1 to 7, with 1 considered to be of the lowest probability (Negligible; Improbable) and 7 being the highest probability (Often; Highly Probable).

The probability scoring criteria was tailored for the project by Dillon and was informed by criteria successfully applied on similar assessments and adapted from ISO 31000's Risk Management Guidance. To assign a probability score, the historical and future occurrence probability values were obtained from the climate data sources for each climate hazard (Section 2.1.1.2). Historical climate data was assigned a score from 1-7 based on professional judgement using the criteria outlined in Table 5, below. Historical climate data was assigned a score of "Occasional" (3) or "Moderate; Possible; Normal" (4).

Assigning a future probability score for each climate hazard required a simple calculation to relate the future projection back to the historical climate value. The calculation required taking the average future climate projection value (average occurrences per year), dividing it by the historical climate hazard value, and multiplying by 0.5, which is the median probability value for "Moderate; Possible; Normal" score.

Table 5: Probability of Climate Hazard Occurring

Score	Descriptor	Occurrence Range
1	Negligible; Improbable	>0 to 0.05
2	Remotely Possible	0.05 to 0.1
3	Occasional	0.1 to 0.25
4	Moderate; Possible; Normal	0.25 to 0.75
5	Likely; Frequent	0.75 to 1.25
6	Probable	1.25 to 2
7	Often; Highly Probable	>2

2.2.3 STEP 3: SEVERITY OF IMPACT

The consequences of the climate change impacts were assessed by a multidisciplinary team of Dillon specialists where severity scores were assigned by specialist participants during an internal Vulnerability Assessment Workshop. Here, severity scores were assigned to each risk and potential consequences of the events were discussed to develop details required to provide rationales for the assigned scores. The professional assessment and judgement informed the determination of which severity rating category applied for each consequence, and accordingly, its corresponding Severity Score.

Table 6 presents the scale used to rank the severity of climate interactions. Assigning a severity score was based on two criteria:

1. Asset impacts focused on the physical impacts to the infrastructure components; and
2. Service impacts focused on the impacts to each component's capacity to provide specific functions, services, and operations.

Table 6: Severity of Climate Hazard Impact

Score	Descriptor	Asset Impacts	Service Impacts
0	No effect	Negligible; Not applicable	Negligible; Not Applicable
1	Measurable	Very low; Superficial Damage	Very low; Some measurable change
2	Minor	Low, Minor repairs required, Increased Maintenance	Low; Slight loss of serviceability
3	Moderate	Moderate; Repairs required; No impact on budget; Increased Maintenance	Moderate loss of serviceability
4	Major	Some loss of function; Major repairs required; Some budget impacts	Major loss of serviceability; Some loss of capacity
5	Serious	Loss of function; Significant impact on budget but can be repaired	Loss of capacity; Some loss of function
6	Hazardous	Loss of asset; Conduct replacement required	Major; Loss of function
7	Catastrophic	Extreme; Loss of asset	Extreme; Loss of asset

2.2.4 STEP 4: INTERACTION RISK SCORE

After identifying the probability and severity scores for the climate hazard/infrastructure interactions, risk scores were calculated for each interaction vulnerability by multiplying the probability of the climate hazard occurring and the severity of the climate hazard's impact on the infrastructure component. The risk scores correspond to risk levels defined as high, moderate, low or negligible risk. Figure 5, below, presents the risk level definitions used in evaluating the risk score for this vulnerability assessment.

Risk Score	Definition								
High Risk	Immediate action required								
Moderate Risk	Action may be required; Managed by continuous improvement								
Low Risk	Manage with Existing Measures								
Negligible Risk	Neutral or Positive Impact								

Probability	7	0	7	14	21	28	35	42	49
	6	0	6	12	18	24	30	36	42
	5	0	5	10	15	20	25	30	35
	4	0	4	8	12	16	20	24	28
	3	0	3	6	9	12	15	18	21
	2	0	2	4	6	8	10	12	14
	1	0	1	2	3	4	5	6	7
		0	1	2	3	4	5	6	7
Severity									

Figure 5. Interaction Risk Scoring Criteria

A negligible score (i.e., green square) within the matrix signifies a negligible risk event that does not require further consideration. A low score (i.e., yellow square) signifies a low risk where existing measures are sufficient to manage the risks, but continuous monitoring should be a consideration. A moderate score (i.e., orange square) signifies a moderate risk where action may be required to control or lower risks and managed by continuous improvement. A high score (i.e., red square) signifies a high or unacceptable risk where high priority or immediate action is required. The results of the interaction risk scoring process are shown in Appendix A. The moderate risks identified were further explored in Section 3.0 – Vulnerability Assessment Results of this Plan.

2.3 SPATIAL ASSESSMENT METHODOLOGY

An important recurring risk to Town infrastructure is flooding, exacerbated by conditions such as the spring freshet. The spatial assessment was conducted qualitatively through the review of flood extents with the Town map to visually determine which components of the Town infrastructure or services are impacted by flooding now and in the future.

Assets from Table 3 – Spatial Assessment – Asset Listing were located on the map and assigned a risk rating of either high, moderate, or low depending on their proximity to the flood extents. An example of this is presented in Figure 6, below, where the flood extents are represented as the darker shaded areas. Therefore, if the infrastructure is located:

- Inside the flood zone, it is deemed a high risk – Action required;
- Close to the flood zone, it is deemed moderate risk – May be managed by existing measures; and
- Outside the flood zone, it is deemed low risk – No action required: advisory only.

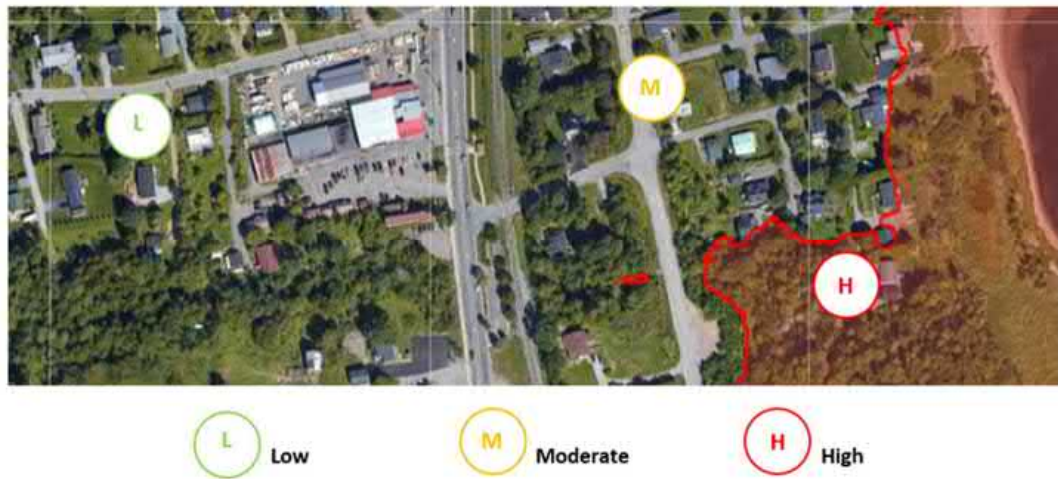


Figure 6. Spatial Assessment Methodology

2.4 PLANNING REVIEW

In addition to approaches mentioned above, Dillon also viewed the potential climate change impacts on considerations for land use planning and the general population as the Town continues to welcome more residents and encourage residential development. The sustainable development of the Town would require strong planning policies that consider anticipated climate change impacts. As such, Dillon explored the impacts of flooding, high heat, and drought on future development with a focus on future land use intensification areas. These three climate hazards were selected by planners at Dillon due to the understanding that these hazards would have the most direct and observable impacts on land use planning and development. This approach was done qualitatively through desktop research informed by professional judgement and led by Dillon Planners.

During the Vulnerability Assessment workshops and discussions with Town staff, a series of maps were developed to help guide a greater conversation around heavy rainfall or drainage risk, fire risk, and flooding risk. The maps used to inform these discussions are provided in Appendix B – Flooding and Risk Discussion Maps.

3.0 VULNERABILITY ASSESSMENT RESULTS

3.1 INFRASTRUCTURE ASSESSMENT RESULTS

Based on the results of the infrastructure assessment, a total of seventeen (17) moderate and high risk interactions were identified for Town infrastructure: one (1) high risk and sixteen (16) moderate risk interactions. These risks are presented in Table 7, below. Yellow shaded cells signify low risks, orange shaded cells signify moderate risks, and red shaded cells signify high risks.

Table 7. Moderate and High-Risk Assets

Infrastructure	Hazard	Vulnerability	Current Risk Score (2020s)	Projected Risk Score (2080s)
Transportation				
Asphalt Roadways/ Parking Lots	High Temperatures	Premature deterioration due to softening of asphalt surfaces leading to increased maintenance	6	14
Gravel or Natural Pedestrian Trails	Freezing Rain	Slippery Conditions - safety issues and strain on operations and maintenance staff	12	16
Railway (NB Southern Railroad)	Heavy Rainfall	Erosion of rail bed material resulting in uneven rails can potentially lead to increased maintenance and purchase of additional material, and increased risk of derailment	28	28
Railway (NB Southern Railroad)	Freeze-Thaw Cycles	Water intrusion and expansion can damage wood or concrete rail ties while frost heaving can degrade ballasts and lead to uneven rails, increased costs and risk of derailment	20	20
Water, Wastewater, Stormwater Assets				
Water Supply Pump Houses	Drought Conditions	Low water levels - Can't pump water to fill tanker trucks.	14	14
Private Wells	Heavy Rainfall	Infiltration and potential contamination based on increased water run off	16	16
Private Wells	Drought Conditions	Drought conditions can dry up wells and impede groundwater recharge causing water security concerns	18	42
Sewage Lift Stations (wet wells, no buildings)	Heavy Rainfall	Lift stations become overwhelmed potentially leading to sewage backup in homes or emergency overflow. Inflow and Infiltration (I&I) concerns at connection points	24	24

Infrastructure	Hazard	Vulnerability	Current Risk Score (2020s)	Projected Risk Score (2080s)
Grinder Pump Stations	Heavy Rainfall	Pump station pumps become overwhelmed potentially leading to sewage backup in homes or emergency overflow. I&I concerns.	24	24
U/G Storm Sewer Lines	Freeze-Thaw Cycles	Older/poorly insulated pipes and manholes experiencing frost heaves leading to water infiltration and increased maintenance needs	24	24
Culverts and Catch Basins	Heavy Rainfall	Heavy rainfall coupled with poor drainage can lead to potential overland flooding	16	16
Community Structures				
Roof (shingles)	High Temperatures	Sun (UV) exposure leading to premature deterioration of shingles	6	14
Recreational Elements				
Parks	Drought Conditions	Hot and dry weather can negatively impact the health of flora (grass, shrubs, etc.)	6	14
Community Elements				
Power/ Utility	Freezing Rain	Downed power lines/poles from ice accretion or debris blowing onto structure	18	24
Power/ Utility	High Wind Gusts	Downed power lines/poles from ice accretion or debris blowing onto structure	18	24
Communications/ Data	Freezing Rain	Downed communication lines/poles from ice accretion or debris blowing onto structure	18	24
Communications/ Data	High Wind Gusts	Downed communication lines/poles from ice accretion or debris blowing onto structure	18	24

3.1.2 WATER, WASTEWATER, AND STORMWATER ASSETS

This infrastructure category resulted in the highest count of risk interactions with impacts from heavy rainfall, freeze-thaw cycles, and drought conditions. The impacted assets were found to be the private wells, water supply pump houses, sewage lift stations, grinder pump stations, underground storm sewer lines, as well as culverts and catch basins.

Persistent drought conditions can impede groundwater recharge and facilitate the drying up of wells, threatening the availability of water in individual private wells. Water supply pump houses for the

purpose of fire safety could also be impacted as low water levels would obstruct the Town's ability to fill tanker trucks which reduces the community's preparedness for responding to fire emergencies.

For the community wastewater systems, the sewage lift stations and grinder pump stations were found to be heavily impacted by heavy rainfall. Existing Inflow and infiltration (I&I) issues for this system, coupled with the projected increase in heavy rainfall days can potentially overwhelm these systems and trigger an emergency overflow or a sewage backup.

For stormwater systems, heavy rainfall was found to overwhelm existing drainage systems in known areas of concern, and cause ponding and/or overland flooding. The Town, however, is aware of these known areas of concern and are actively monitoring them prior to and following heavy rainfall events. Moreover, freeze-thaw cycles can affect older or poorly insulated storm pipes closer to the surface through frost heaving which leads to increased maintenance needs.

3.1.1 TRANSPORTATION ASSETS

The identified transportation assets found to be at moderate risk under conditions of future climate were the asphalt roadways and parking lots, gravel or natural pedestrian trails, and the NB Southern Railway. Asphalt roadways and parking lots can deteriorate prematurely due to rutting under extended high temperatures. Impacts to the railway stem from heavy rainfall and freeze-thaw cycles affecting rail beds. This is a considerable concern as a washout of rail bed material or deterioration of wooden or concrete tracks can cause rail ties to sink unevenly under heavy loads as these loads are unable to be dissipated into supporting materials. This can compromise the integrity of the rail system, consequently increasing maintenance costs and risks to public safety.

Another concern was the impacts of freezing rain on gravel or natural pedestrian trails. Freezing rain can create unsafe travelling conditions and increase the risk of slips, trips, and falls and potential for injury resulting from these conditions. For these reasons, this impact generally poses a risk to public safety as a whole.

3.1.3 COMMUNITY STRUCTURES

For the purpose of the infrastructure assessment, community structures (i.e. buildings) were assessed by their individual components. This generalized approach was taken to help assess buildings without the need to specifically investigate each building within the Town limits. The selected categories were:

- Foundation/structure, which includes construction type, subbase structures, and building envelope and insulation;
- Roofs (shingles and flat);
- Exterior finishes, which includes siding, and windows; and
- Mechanical/electrical components, which includes HVAC (Heating, Ventilation, and Air Conditioning) systems.

Of the components assessed, roof (shingles) and high temperatures resulted in a moderate risk interaction due to increased UV exposure leading to premature deterioration of roof shingles.

3.1.4 RECREATIONAL ELEMENTS

In this category, it was found that high temperatures and drought conditions can negatively impact the health of trees and other flora within parks, leading to strain on operations staff to maintain the parks.

3.1.5 COMMUNITY ELEMENTS

Utility lines were found to be vulnerable to freezing rain and high wind gusts. The combination of these two climate hazards are known to take down utility poles and lines. This can result in extended power outages prompting the need for major repairs and remediation to restore power back to the Town.

3.2 SPATIAL ASSESSMENT RESULTS

One of the most significant climate change impacts for the Town is riverine flooding. For this assessment, a spatial assessment was conducted to visually determine which components of the Town-owned infrastructure or services are impacted by flooding. The spatial assessment conducted was qualitative in nature and impacted assets were discussed on a case-by-case basis throughout the targeted interviews and the internal vulnerability assessment workshop. Town-owned assets were assessed as high, moderate, or low risk based on their proximity to flood-prone areas. The spatial assessment results are presented in detail in Appendix C. For this project, moderate and high risks were prioritized for risk reduction action during the subsequent adaptation planning phase.

Many of the most frequently mentioned infrastructure categories subject to flooding risk were transportation assets, which play an important role in facilitating the connectivity and mobility in and around the Town, as well as their critical role in providing access for emergency services. Roadways were discussed on a case-by-case basis throughout the targeted interviews and the internal vulnerability assessment workshop. Roadways were also categorized into both partially or completely submerged in a flood, and whether or not they were still functional or rendered non-functional during a flood event. Brandy Point Road, Riverside Park, Nerepis Road, and Brittain Road were roadways at high risk of flooding. Other impacted transportation assets included sections of the railroad and the Shannon Road Bridge. The flooding of Shannon Road Bridge was a recurring point of discussion due to the fact that this event would isolate residents located east of the bridge. Additionally, roads that would require additional gravel/ material to build up during a flood event were also identified.

The impacts to Water Supply Pump House #2 stem from its electrical components and motors. Flooding and sudden-onset heavy rain events can strain these components. This prompted the need for Town staff to routinely remove the pumps from the building prior to a forecasted heavy rain event or pending river flooding events. Similarly, the electrical components on Grinder Pump Stations #1, #7, and #10, and Sewage Lift Stations #7 and #10 are also vulnerable to flooding. The wastewater treatment lagoon was also identified to be highly vulnerable to flooding risks.

Other identified community structures with flooding risks were the Brundage Point River Centre, and the storage garage. The Brundage Point River Centre is located on the banks of the Saint John River and is heavily impacted by floods on an annual basis. During flood events, the River Centre is sandbagged and water that infiltrates the sandbags is pumped out. The storage garage however, does not hold any critical equipment and is deemed a low priority by the Town staff.

3.3 PLANNING REVIEW RESULTS

Flooding, heat risk, and drought were the three (3) climate hazards considered in this section due to their direct and observable impacts to the growth of the Town.

3.3.1 FLOODING

Many properties in GBW are located in high flood risk areas according to the 100-year flood level predictions map (See Appendix B). As such, to understand the impact of flooding on future land uses, it is important to explore the impacts of flooding on undeveloped land. Demographic growth and economic development in flood-prone areas, accompanied by poor land-use planning, can lead to increased risk of destruction, and jeopardize the safety and livelihood of residents living in these areas.

Flooding drastically increases the vulnerability of people living in flood prone areas through rendering routes and neighborhoods inaccessible by emergency services. This is an important vulnerability consideration when planning for future development as roads need to be able to accommodate emergency vehicle access during floods.

Furthermore, understanding the value of undeveloped land beneath the predicted 100-year flood levels is crucial for future planning. Within the town limits, there are 61 vacant plots of land that are in flood risk areas with a total assessed value (2019) of \$804,100.00. These 61 vacant plots of land have a total tax levy of \$20,024.07. Proper measures need to be taken in order to safely and effectively optimize the available land.

3.3.2 HEAT RISK

It was found that older adults encounter higher risks from climate change impacts compared to other age groups. For example, through fragility, disability, and lack of mobility, older adults are vulnerable to being stuck in poor environments. They are at increased risk of dehydration and heat-related illnesses, which is further heightened due to other factors such as living alone, co-morbidities, medication (Harper, S. 2019). With a 4.5% increase in the median age of the population from 2011 – 2016, it is clear that GBW's population is aging (Statistics Canada. 2016). Extra precautions need to be taken by the municipality to improve safety and comfort of all residents throughout future climate events.

The Climate Atlas of Canada projects that the number of heat waves in the region will increase from an average of 0.4 (1976-2005) to 3.6 (2051-2080) per year. Alongside the increase in the average number of days per year with a maximum temperature > 30°C, this increase in hot weather frequency will pose risks to the Town population.

The health risks imposed on vulnerable populations add another dimension to this concern. New Brunswick Public Health highlights that people most vulnerable and at risk to health effects related to extreme heat are:

- Young children and older adults;
- The homeless and socially isolated;
- People with chronic health conditions; and
- People using certain medications.

New Brunswick's Heat Alert and Response System (HARS) has three alert levels (New Brunswick, 2021).

Level 1 - Heat Alert:

- Certain vulnerable persons may be affected (persons with pre-existing respiratory and cardiovascular diseases).

Level 2 - High Heat Alert:

- Everyone is at increased risk of heat stress and heat stroke under level 2 conditions.
- People living alone without air conditioning are at high risk especially if the heat wave lasts many days.
- Organizers of sport and recreational activities should build in regular water breaks and rest or consider rescheduling activities.

Level 3 - Extreme Heat Alert:

- People living alone without air conditioning are at extreme risk.
- Organizers of sport and recreational activities should reschedule activities.

The aging population of the Town coupled with the increase in the number of heat waves and hot days will put the community at increasing risk of heat-related illnesses.

3.3.3 DROUGHT

Future growth in GBW will be prioritized in the intensification areas identified on the Grand Bay-Westfield Future Land Use Map. The *Commercial Intensification Area* and the *Residential Intensification Area* are centred on the undeveloped land surrounding Colonel Nase Boulevard. Colonel Nase Boulevard is a Mixed Use Zone that has been groomed and prepared for new commercial and residential development. The area is located between the Provincial Route 7 Highway and River Valley Drive (Route 177).

As a future growth node, it can be expected that the area will see an increase in concentrated commercial and residential development in the coming years, which will have an impact on the Town's water demand and supply. The Town relies on groundwater for its water supply and therefore the replenishment of this source requires consideration as the community manages its continued growth. Large areas of impermeable surfaces will increase surface runoff and decrease natural infiltration. This can ultimately decrease groundwater recharge and place stress on the Town's private wells. Water is a

vital resource that is required for the growth and development of any community and as such, it is important to consider the compounding effects of grey infrastructure development and increasing frequency and intensity of hot and dry weather.

Another dimension of heat-related climate events not fully explored in this report is that of wildfire or forest fire risk. The Town has extensive forest cover, and so forest fires during hot and dry seasons may pose an increasing risk to manage for the community. However, an exploration into this impact would require data that is unavailable in public climate data portals, and would prompt a need to communicate with Natural Resources Canada (NRCan), which is the organization that currently managed fire risk in New Brunswick, for a fire risk assessment.

4.0 ADAPTATION PLANNING

4.1 ADAPTATION PLANNING METHODOLOGY

Following the vulnerability assessment phase, an adaptation planning workshop was held. The purpose of this workshop was to develop adaptation measures for the high and moderate risk interactions identified during both the infrastructure and spatial assessments. During this workshop, appropriate adaptation measures and recommendations that could be applied to each high and moderate risk were discussed. These included:

- Adaptation measures - actions concerned with updating and creating infrastructure components, studies, and plans. These actions are characterized by their need for funding and capital.
- Recommendations - actions concerned with reviewing and/or modifying processes and systems, such as SOPs (Standard Operating Procedures) or maintenance routines, which are currently in place and are seeing continuous improvement.

Where applicable, at least one (1) adaptation measure or recommendation was developed for each high and moderate risk interaction identified in the infrastructure and spatial vulnerability assessments.

4.2 ADAPTATION MEASURES AND RECOMMENDATIONS

4.2.1 ADAPTATION MEASURES

The developed adaptation measures are presented in Table 8, below. The identified adaptation measures are discussed in more detail in the sections that follow. A full summary of Adaptation Measures specific to relevant climate interactions is provided in Appendix D.

Table 8. Adaptations and Recommendations

Adaptation No.	Adaptation Measures	Motivation Factors
Heavy Rainfall Adaptations		
1	Improve stormwater conveyance through the use of green infrastructure to increase water infiltration and slow surface flow. These can include: Buffer strips & hedges; Rain gardens; Retention Ponds.	Heavy rainfall coupled with poor drainage can lead to potential overland flooding and increased erosion rates due to runoff.
Flooding Adaptations		
2	Heighten and strengthen berm around lagoon as required to prevent breach in high flood events.	Flood events can overwhelm the berm and compromise the wastewater treatment process
3	Lift Station #7 (Brandy Point Road) and #10 (Riverside Park Drive) - Permanently raise or reconfigure the Lift Stations	Possible damage to electrical components of pump stations can impact use and cause damage
4	Permanently raise the road as required;	Riverine flooding greatly impacts roadways, potentially blocking access to neighbourhood and critical infrastructure
5	Preventative Zoning and Permitting which can include: Revision of future land use plans with flood extents; Set minimum building elevation for new construction, in accordance with the latest recommended elevation levels set by the Université de Moncton.	River Centre is highly susceptible to flooding
6	Building up vacant land to meet the latest minimum building elevation recommendation would allow to capitalize on the number of vacant lots that are in the 100-year flood extents	Flooding will have a great impact on development and zoning as it is expected that the flood extents might continue to encroach inland with time

Adaptation No.	Adaptation Measures	Motivation Factors
7	Protect River Centre against high flood events (e.g. barricades, pumping out basement)	Structures are highly susceptible to flooding
High Temperatures & Drought Conditions Adaptations		
8	Explore alternative roofing materials or UV protective coating on a case by case basis where roofing change is needed while continuing to manage with existing measures	Sun (UV) exposure leading to premature deterioration of shingles
9	Acquire generators for the River Centre to function as a cooling/warming centre	River Centre currently services as an emergency centre
10	Install shading structures in strategic public locations (e.g. bus stops) to minimize the impact of heat exposure	High heat exposure can pose health and safety risks to vulnerable populations
11	Develop public water infrastructure for Colonel Nase Boulevard and other residential intensification areas	The increased domestic water usage from new developments and the decrease in groundwater recharge during dry seasons can strain the Town's water supply

4.2.1.1 HEAVY RAINFALL

The frequency and intensity of heavy rainfall is projected to increase in the future. This is expected to prompt a need for a corresponding increase in the Town's stormwater conveyance capacity. As mentioned above, Town Staff have established protocols for checking on stormwater assets before and after heavy rainfall events. Additionally, stormwater infrastructure upgrades are completed as part of road upgrades completed on a yearly basis. The Town is aware of potential problem areas and have proactively included these upgrades in future capital planning. Recommended adaptation action is proposed below, in addition to actions already in place for the Town.

IMPROVE STORMWATER CONVEYANCE THROUGH GREEN INFRASTRUCTURE

The projected increase in heavy rainfall will induce increasing loads on existing stormwater systems. It is anticipated that these loads will exceed the capacity of existing stormwater management systems. A sustainable and progressive strategy that is being deployed globally is the development of green infrastructure within communities. Green infrastructure is an approach to infrastructure that incorporates natural vegetative systems and engineered green technologies to emulate the natural hydrological cycle, and in turn provide communities with a diverse range of social, economic, and environmental benefits.

Green infrastructure systems such as rain gardens, and natural and engineered wetlands can provide benefits that include increased water infiltration and absorption, resulting in the reduction of peak runoff flows. Moreover, other methods such as constructing permeable pavements for parking lots, sidewalks, and low-traffic roads can also offer similar functions of increased water infiltration and decreased runoff volume. This mechanism also contributes to groundwater replenishment as green infrastructure systems encourage gradual infiltration versus flash runoff of peak flows to receiving streams. This is expected to become an increasingly important function as a changing climate can pose risks to water security.

Therefore, it is recommended that the Town invests in developing its inventory of green infrastructure. In doing so, the Town can increase its stormwater management capacity, resilience to heavy rainfall and flooding events, as well as overall sustainability.

4.2.1.2 FLOODING

Flooding was identified as a significant vulnerability for the Town as it was the most discussed climate event throughout the engagement sessions. Several measures are proposed to help prepare the Town for the impacts of flooding and are detailed in the sections that follow.

RAISE ELECTRICAL COMPONENTS OF LIFT STATIONS

Lift stations are critical components to every community's water and wastewater management efforts. The flooding of Sewage Lift Stations (SLS) #7 and #10 quickly render them inoperable as the flood can physically damage the electrical components. Lift station failure can result in overflow situations and

sewer backups of untreated wastewater into homes or surrounding environments. For this reason, it is recommended that the Town raises the electrical components of these lift stations to be above the future projected flood levels.

HEIGHTEN AND STRENGTHEN BERM AROUND LAGOON

Flooding can have a major impact on the Town's wastewater lagoon and the effluent loadings to receiving waters. As flood levels rise, the lagoon will be at higher risks of being overwhelmed. This interferes with the treatment process and causes untreated sewage to overflow to the immediate environment which can pose environmental and human health risks. Therefore, it is recommended that the Town heightens and strengthens the berm around the wastewater lagoon to reduce the risk of this impact.

PERMANENTLY RAISE ROADS (AS NEEDED)

The roads that were considered under this strategy were: Brandy Point Road (between 9 and 36 Brandy Point Road); Riverside Park Drive; Nerepis Road (between Westfield School and 159 Nerepis Road); Shannon Road-Bridge; and Brittain Road (between 9 Nerepis Road and the bridge). In order to maintain connectivity and mobility for Town residents as well as emergency services, it was discussed that the Town should consider the permanent raising of heavily flooded roads.

PROTECT RIVER CENTRE AGAINST HIGH FLOOD EVENTS

Brundage Point River Centre is located right next to the Saint John River and floods annually in the spring due to the freshet. It is recommended that the Town continues to protect the building through existing measures such as barricading and pumping out the basement when it floods. However, it is to be noted that an exploration of other proactive measures to mitigate this impact should be considered in the future. This can include relocation of the River Centre or raising the structure itself to be above the latest flood extents.

ESTABLISH PREVENTATIVE ZONING AND PERMITTING

As flood limits change through time, reviewing and revising land use policies to adapt to the changing environmental conditions can help the Town prepare for future flooding challenges. This can include the revision and update of the Town's future land use plan to consider diverting development away from flood-prone areas wherever possible, and the setting an updated minimum building elevation for new construction as per recommendations provided by Université de Moncton (results pending).

Additionally, this minimum building elevation can also be utilized in the context of building up vacant land to facilitate development of vacant lots within the flood extents if development cannot be diverted to outside of the flood extents. These measures seek to encourage the safe and practical development of the Town and mitigate the potential future costs associated with the repairs and remediation of flood impacted structures.

4.2.1.3 HIGH TEMPERATURES AND DROUGHT CONDITIONS

Considering the aging population and the drastic increase in the number of heat waves and hot days, the Town should establish precautionary measures for their residents at each heat alert level (outlined in **Section 3.0.3** above). This will work to reduce the risk of heat stress and heat-related illnesses for vulnerable members of the community. The identified vulnerability concerning the private wells was flagged as a concern since water is an essential service. The Town is limited in potential actions that can be taken to mitigate this vulnerability as residents are primarily on private drinking water wells. Additionally, the vulnerability identified with the water supply pump houses were considered to be minimal as the Town can manage with the existing pumps.

ACQUIRE GENERATORS FOR THE RIVER CENTRE TO FUNCTION AS A COOLING/WARMING CENTRE

One adaptation measure is to install generators at the River Centre to establish a dedicated cooling centre in the summer and warming centre in the winter. The River Centre currently serves as the Town's emergency centre, and this measure will help improve its capacity to temporarily address the negative impacts of intense heat or cold. This will serve the Town population especially those who do not have access to air conditioning in the summer and/or heating in the winter.

INSTALL SHADING STRUCTURES IN PUBLIC SPACES

To further alleviate the negative impacts of heat, it is also recommended that the Town explores the installation of shade structures at strategic public locations such as bus stops, open spaces, and ball fields. Shade structures can reduce high heat exposure, help cool outdoor spaces and provide pedestrians some level of protection against the elements.

DEVELOP PUBLIC WATER INFRASTRUCTURE FOR COLONEL NASE BOULEVARD

As growth of the Town continues, the water demand will grow accordingly as well. This increase in demand for water use coupled with the potential decrease in groundwater recharge due to dry and hot seasons, can place increasing strain on the Town water table. One adaptation measure to address this is to develop public water source, supply and treatment system for the Colonel Nase Boulevard and other residential intensification areas. This water system is not expected to replace existing private wells, but will allow the Town to continue to develop with a robust water supply that is less sensitive to hot and dry climate conditions.

4.3.1 RECOMMENDATIONS

The recommendations developed during the internal adaptation planning workshop address the moderate and high interactions identified in the vulnerability assessment and are discussed from a high-level as they relate to specific climate hazards. A detailed list of adaptation measures and recommendations are presented in Appendix D – Adaptation and Recommendations.

HEAVY RAINFALL

With its identified impact on the railway, it is important to note rail assets are outside of Town jurisdiction but concerns regarding the railway itself or culvert systems underneath the rail should be identified and communicated to NB Southern/DTI for remedial actions.

The stormwater and wastewater management systems were also found to be heavily impacted by projected increases in heavy rainfall. The following recommendations are proposed to help the Town prepare for the impacts of heavy rainfall events:

- Continue to conduct on-site inspections of culverts/ drainage ditches before and after heavy rainfall events.

HIGH TEMPERATURES/ DROUGHT CONDITIONS

High temperature events were also found to have a number of interactions with key Town infrastructure assets including private wells, asphalt roads, and roof shingles. However, private wells extend well beyond the Town's jurisdiction and so the following recommendations are proposed to help the Town prepare for the impacts of high temperatures and drought conditions:

- Continue to conduct yearly roadway inspections currently conducted by the Town's consulting engineers.
- Work with contractor/ consultant to establish QA/QC measures during asphalt installation to help reduce premature deterioration of asphalt surfaces.
- Explore alternative roofing materials or UV protective coating on a case-by-case basis where roofing change is needed while continuing to manage with existing measures.

FREEZING RAIN/ FREEZE-THAW CYCLES

Freezing rain and freeze-thaw cycles were also found to have a number of interactions with key Town infrastructure assets including asphalt roads, and power supply. The following recommendations are proposed to help the Town prepare for the impacts of freezing rain and freeze-thaw cycles:

- Continue to conduct yearly roadway inspections currently conducted by the Town's consulting engineers.
- Review building electricity needs and update EMO Plan to capture large scale power outage events as part of ongoing operational improvements
- Review expected snowfall and de-icing procedures ahead of issuing the yearly Snow Control tender. Changes to be considered may include modifying the type of de-icer used with less corrosive agents.

4.4 PLANNING ADAPTATIONS

FLOODING

Land Use Planning is critical for delivering economic, social and environmental benefits by creating more stable and predictable conditions for investment and development. A combination of structural and non-structural measures can be taken from a land-use planning perspective to most effectively reduce flood risk. These measures include:

- Separation of river and population (land-use control, flood-proofing, house-raising etc.);
- Redevelopment of land use policies (minimum building elevation standards); and
- Source control to reduce runoff (permeable pavement, afforestation, planting native species).

Separating the river and population prepares for the longevity of the town. Flood proofing homes and other buildings within the flood risk area will improve the durability of existing buildings. Alternatively, raising existing homes above the predicted future flood levels is an option for homeowners who may be at risk of property damage from flooding.

Redeveloping land use policies to adapt to the changing environmental conditions would be beneficial to prepare for future challenges. As such, implementing a minimum building elevation standard, as per as per recommendations provided by Université de Moncton (results pending), into the existing land use policies would better equip the town for resilient future development. This standard will encourage housing starts to be developed on a level that that accounts for the high risk of flooding. Access points for these properties should also meet the minimum building elevation to ensure secure access to and from the property in the event of a flood.

Building up vacant land to meet these minimum requirements would allow for residents to capitalize on the number of vacant lots that are in the 100-year flood extents, while adhering to the minimum building elevation standards. Given that there are 61 vacant plots of land within the flood risk areas of the town, development of residential units on these properties is likely. Regulating these developments with minimum building elevations will require property owners to build up their land prior to development, which will in turn prepare for the longevity of their development.

Additionally, integrating a minimum infrastructure development standard will increase the durability of infrastructure and safety of residents. Building up road infrastructure will help prepare for future flooding scenarios. This will increase reliability of emergency service vehicles and also improve the mobility for residents living in flood risk areas.

Furthermore, stormwater management strategies can also be considered to mitigate future flood risks. Preserving natural greenspace when planning for new development, developing green infrastructure with native plants with high absorption rates, constructing permeable surfaces where feasible, and implementing afforestation practices can improve the management of inland flood risks.

HEAT RISK

Based on the province's HARS, it is recommended that cooling centres be available to accommodate for residents who can be classified into Level 2 and above. Everyone is at increased risk of heat stress and heat stroke under Level 2 conditions, especially those without access to air conditioning and members of vulnerable groups. Considering the aging population in GBW, cooling centres should be an important consideration to reduce the risk of heat-related illnesses or deaths.

Additionally, considering the popularity of outdoor activity in the GBW community, it is recommended that shading structures be introduced in strategic locations to minimize the impact of heat exposure. With the exponential increase in the number of hot days in the coming years, it will be important to invest in shading structures at outdoor locations such as ball fields, bus stops and public open spaces. Shading structures play an important role in designing pedestrian friendly outdoor spaces.

DROUGHT

Sustainable development of towns like GBW requires robust water supply systems. Considering the implementation of public water infrastructure for Colonel Nase Boulevard and other residential intensification areas will help mitigate future impacts surrounding water insecurity.

To mitigate impacts and adapt to dry conditions, it is important to consider drought resistance planning. Implementing low impact design and landscaping elements can alleviate concerns of drought. There are various types of low impact design and landscaping elements. Planting native and drought tolerant species will help to minimize water usage and increase the Town's environmental vitality. Additionally, forgoing large areas of impermeable surfaces (surface parking) will help maintain natural infiltration and lessen the developmental impact on the natural water table. Furthermore, maintaining forest cover will offer watershed protection, prevent soil erosion and ultimately mitigate the other impacts of climate change.

Implementing drought resistance planning in GBW in ways that respond to climate change has benefits that go beyond coping with droughts, floods and high temperatures. If done sensitively, it can foster learning opportunities and contribute to community health and well-being.

5.0 CONCLUSION

The Climate Change Adaptation Plan aims to present a starting point as to how GBW can continue to proactively prepare for the projected changes in climate patterns. This Plan will require consistent monitoring and review of the adaptation measures and recommendations outlined in Section 4.0 of this report. The developed adaptation measures and recommendations present opportunities for GBW to improve climate resilience to chronic and emerging climate impacts.

In summary, the climate change vulnerability assessment conducted for the GBW identified sixteen (16) moderate risk and one (1) high risk interactions from the infrastructure assessment, and fourteen (14) high risk and twenty-eight (28) moderate risk interactions from the spatial assessment. Additionally, the planning review has also brought light onto the impacts of flooding and increasing heat on the Town population and growth. The adaptation measures developed heavily address the two climate hazards that have been found to have the most impact on the community, flooding and high temperatures/drought conditions. The adaptation measures are characterized by their need for funding and capital investment. These include the development of green infrastructure to improve the Town's overall stormwater management capacity, updating of physical infrastructure such as the strengthening of the lagoon berm or the flood-proofing of pump stations, and setting up a municipal cooling Centre.

A set of recommendations were developed in addition to the adaptation measures and were centred on the continuous improvement of existing actions. These include the review and/or modification of processes and systems that are currently in place.

The adaptation measures and recommendations outlined in Section 4.0 – Adaptation Planning of this CCAP as well as Appendix D – Adaptations and Recommendations, will require ongoing and scheduled review and update as additional datasets are collected, including data pertaining to ongoing monitoring of impacts and the effectiveness of the Town's responses to such impacts.

5.1 LIMITATIONS

The nature of completing a qualitative analysis inherently includes limitations and uncertainties, as they are informed by observed trends and expected impacts. The individuals present for the assessment of service and operational vulnerabilities are familiar with Hampton's infrastructure, services and past climatic impacts, therefore their contribution to the discussion was invaluable in identifying vulnerabilities. An additional limitation encountered in this project was the limited number of responses during the first online engagement activity, which is the online vulnerability mapping exercise. The map was pre-populated with 15 initially identified vulnerabilities and only 1 additional response was received throughout the session.

5.1.1 CLIMATE DATA LIMITATIONS

The climate change hazards used in this project were obtained from two sources, each using separate projection models with inherent limitations. Generally, the uncertainty found in climate projections can be divided into three main categories:

1. Natural climate variability (i.e., the natural fluctuations of the climate on timescales ranging from days to decades);
2. Models (i.e. different parameterizations in models can lead to somewhat different climate change signals or properties); and
3. Scenarios (i.e. future CO2 emissions, representative concentration pathways).

Uncertainty categories 1 and 2 relate to the use of large ensembles of models. Using a large ensemble will ultimately help develop a measure of the natural climate variability, which is related to the spread of the simulations estimated by looking at the 10th, 25th, 75th and 90th percentiles for each climate indicator.

Uncertainty category 3 is covered by using the most realistic RCP scenarios (namely RCP 8.5) to align with the current progress of global GHG emission reductions. RCP 8.5 aligns with the current “business as usual” trend of no significant reduction in global GHG emissions, and a possibility of continued growth in atmospheric loadings of global GHGs.

This report was prepared by Dillon Consulting Limited for the sole benefit of our Client for the purposes outlined in our approved scope of work. The material in it reflects Dillon’s best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties.

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Appendix A

Vulnerability Interaction Matrix and Scores

Current (2020) Climate Asset Impacts

Asset Listing	Climate Hazards																							
	High Temperatures Very Hot Days (>30 °C)			Low Temperatures Very Cold Days (<20 °C)			Heavy Precipitation Heavy Precipitation Days (20mm)			Freeze-Thaw Cycles Freeze-Thaw Counts			Freezing Rain Days with Rain or Ice Pellets lasting > 6 hrs			Snow Fall Days with Snowfall > 10cm			High Wind Gusts High Winds > 70km/hr			Drought Conditions Long Spell of Dry Days		
	Probability Score		3	Probability Score		3	Probability Score		4	Probability Score		4	Probability Score		3	Probability Score		4	Probability Score		3	Probability Score		3
Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	
Transportation																								
Asphalt Roadways/ Parking Lots	Premature deterioration of asphalt surfaces (softening) leading to increased maintenance	2	6	Premature deterioration of concrete surfaces (hardening) leading to increased maintenance	3	9		0	Frost heaving causing cracks and potholes leading to increased maintenance	3	12	Increase salt usage causing premature deterioration leading to increased maintenance	3	9		0				0				0
Asphalt and Concrete Sidewalks			0	Premature deterioration of concrete surfaces (hardening) leading to increased maintenance	1	3		0	Frost heaving causing cracks and potholes leading to increased maintenance	1	4	Increase salt usage causing premature deterioration leading to increased maintenance	2	6		0				0				0
Gravel or Natural Pedestrian Trails			0			0		2	8	Washout of material leading to increased maintenance and purchase of additional material		0				0			0		The municipal heritage trail typically experiences severe washouts and fallen trees. This can result in closure for repairs and maintenance	2	6	0
Railway (NB Southern Railroad)			0			0		7	28	Erosion of railbed material causing gaps or uneven rails due to lack of support leading to potential train derailment	5	20	Water intrusion in railbed material worsening cracks and causing gaps or uneven rails due to lack of support leading to potential train derailment		0				0					0
Water, Wastewater, Storm Assets	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
U/G Sanitary Sewer Lines			0			0		0			0			0		0			0					0
Sewage Lift Stations			0			0		6	24	Lift stations become overwhelmed/ fail, leading to sewage backup in homes or emergency overflow. There are known I&I concerns at connection points		0				0			0					0
Grinder Pump Stations			0			0		6	24	Pump stations become overwhelmed/ fail, leading to sewage backup in homes or emergency overflow.		0				0			0					0
Wastewater Treatment Building			0			0		0			0					0			0					0
Wastewater Lagoon			0			0		0			0					0			0					0
Trickling Filter Building			0			0		0			0					0			0					0
U/G Storm Sewer Lines			0	Older or poorly insulated pipes susceptible to cracking. Increased maintenance needs	6	18		0	Older/poorly insulated pipes susceptible to cracking. Increased maintenance needs	6	24					0			0					0
Water Supply Pump Houses			0			0		0			0					0			0		Low water levels - Can't pump water to fill tanker trucks. Depending on elevation of pond and elevations of inverts of culverts. Tanker truck can extend hose into the river	2	6	0
Culverts and Catch Basins			0			0		4	16	Heavy rainfall coupled with poor drainage can lead to potential overland flooding		0				0			0		High wind gusts can blow debris and block culverts leading to poor drainage and potential overland flooding	2	6	0
Private Wells						0		4	16	Infiltration and potential contamination based on increased water run off		0				0			0		Drought conditions can dry up wells and impede groundwater recharge causing water security concerns			0
Community Structures	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
Foundation/ Structure			0	Cracking of foundations leading to increased maintenance and repair	2	6	Water intrusion causing leaks and possible flooding due to existing cracks leading to increased maintenance and repairs	2	8	Water intrusion and freezing causing larger cracks leading to increased maintenance and repairs, exacerbated deterioration and lack of structural integrity	2	8				0			0					0
Roof (shingles)	Sun (UV) exposure leading to premature deterioration of shingles	2	6	Cold temperatures leading to premature deterioration of shingles	2	6		0	Water intrusion in cracks and raised shingles causing leaks and indoor damage	2	8					0			0		Loss of shingles	2	6	0
Roof (flat)			0			0		3	12	Drainage system overwhelmed causing ponding and potential leaks		0	Drainage system overwhelmed causing ponding and potential leaks	3	9				0					0
Exterior Finishes			0			0		0			0					0			0					0
Mechanical/ Electrical			0			0		0			0					0			0					0

Current (2020) Climate Asset Impacts

Asset Listing	Climate Hazards																							
	High Temperatures Very Hot Days (>30 °C)			Low Temperatures Very Cold Days (<20 °C)			Heavy Precipitation Heavy Precipitation Days (20mm)			Freeze-Thaw Cycles Freeze-Thaw Counts			Freezing Rain Days with Rain or Ice Pellets lasting > 6 hrs			Snow Fall Days with Snowfall > 10cm			High Wind Gusts High Winds > 70km/hr			Drought Conditions Long Spell of Dry Days		
	Probability Score		3	Probability Score		3	Probability Score		4	Probability Score		4	Probability Score		3	Probability Score		4	Probability Score		3	Probability Score		3
Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	
Recreational Elements																								
Splash Pad			0			If water is not drained from inside system, can freeze and cause major issues.	4	12			0												0	
Washroom facility			0			If water is not drained from inside system, can freeze and cause major issues.	4	12			0												0	
Gazebo at Unity Park - Metal Structure			0					0			0												0	
Parks			0					0			0											0		0
						Poor drainage and ponding, could damage grass and grounds	2	8			0											0		0
Community Elements																								
Power/ Utility			0					0			0											0		0
								0			0											0		0
Cellphone/ Data			0					0			0											0		0
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Future (2080) Climate Asset Impacts

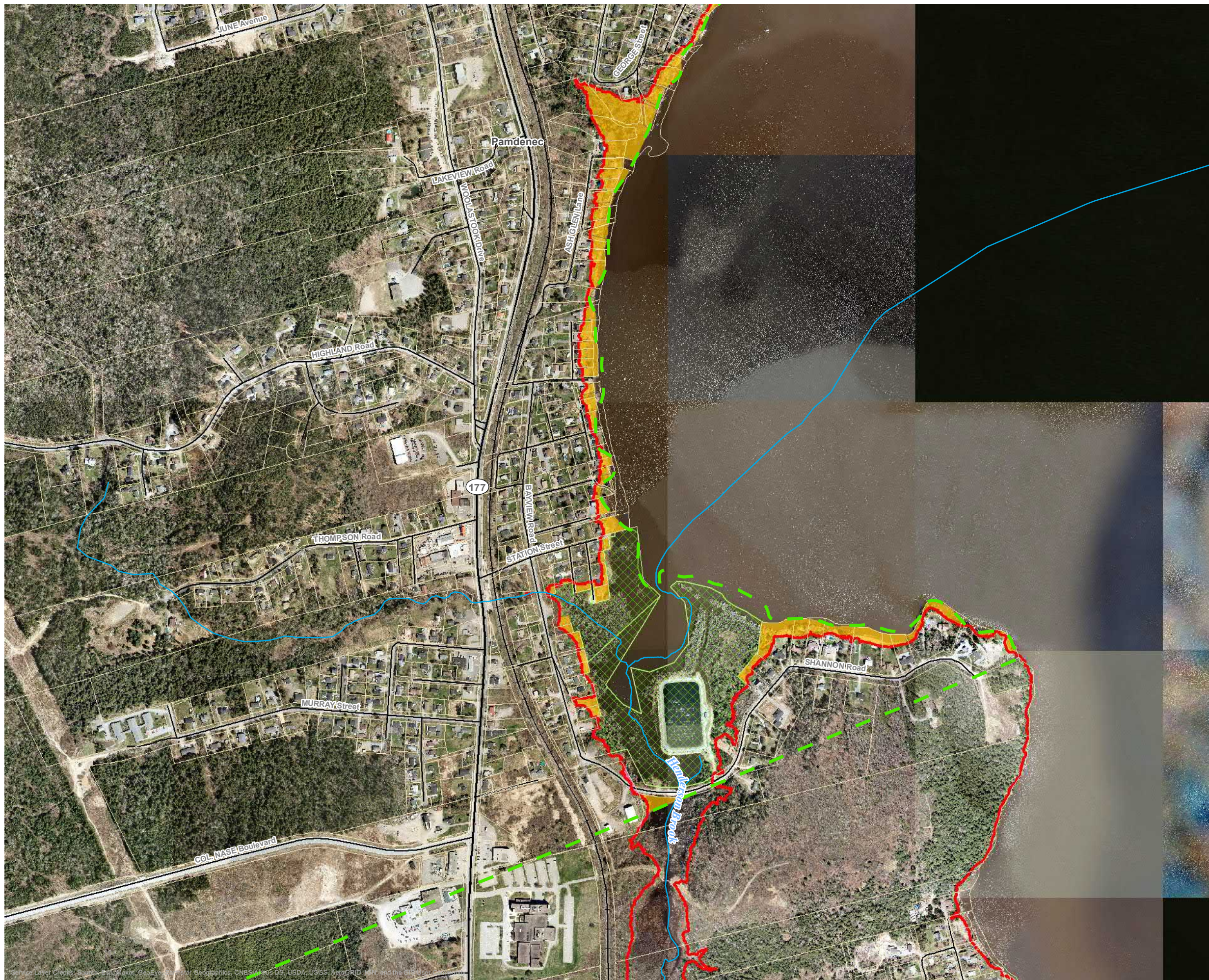
Asset Listing	Climate Hazards																										
	High Temperatures Very Hot Days (>30 °C)			Low Temperatures Very Cold Days (<20 °C)			Heavy Precipitation Heavy Precipitation Days (20mm)			Freeze-Thaw Cycles Freeze-Thaw Counts			Freezing Rain Days with Rain or Ice Pellets lasting > 6 hrs			Snow Fall Days with Snowfall > 10cm			High Wind Gusts High Winds > 70km/hr			Drought Conditions Long Spell of Dry Days					
	Probability Score		7	Probability Score		1	Probability Score		4	Probability Score		4	Probability Score		4	Probability Score		2	Probability Score		4	Probability Score		7			
Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R				
Recreational Elements																											
Splash Pad			0	If water is not drained from inside system, can freeze and cause major issues.	4	4			0	Frost heaving impacting - engineered base material should be resilient to these changes	1	4			0			0			0			0			
Washroom facility			0	If water is not drained from inside system, can freeze and cause major issues.	4	4			0			0			0			0			0			0			
Gazebo at Unity Park - Metal Structure			0			0			0			0			0			0			0			0			
Parks			0			0	Poor drainage and ponding, could damage grass and grounds	2	8			0			0			0			0	The trees could be damaged or completely lost	1	4	Damage to grass and flora	2	14
Community Elements																											
Power/ Utility			0			0			0			0	Downed power lines/poles from ice accretion or debris blowing onto structure	6	24			0			0	Downed power lines/poles from ice accretion or debris blowing onto structure	6	24			0
Cellphone/ Data			0			0			0			0	Downed communication lines/poles from ice accretion or debris blowing onto structure	6	24			0			0	Downed communication lines/poles from ice accretion or debris blowing onto structure	6	24			0

Projected Future (2080) Climate Service Impacts

Asset Listing	Climate Hazards																							
	High Temperatures Very Hot Days (+30 °C)			Low Temperatures Very Cold Days (-20 °C)			Heavy Precipitation Heavy Precipitation Days (20mm)			Freeze-Thaw Cycles Freeze-Thaw Counts			Freezing Rain Days with Rain or Ice Pellets lasting > 6 hrs			Snow Fall Days with Snowfall > 10cm			High Wind Gusts High Winds > 70km/hr			Drought Conditions Long Spell of Dry Days		
	Probability Score	7		Probability Score	1		Probability Score	4		Probability Score	4		Probability Score	4		Probability Score	2		Probability Score	4		Probability Score	7	
Transportation	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
Asphalt Roadways/ Parking Lots			0			0			0			0	Slippery Conditions - safety issues and strain on operations and maintenance staff - vehicular traffic	3	12			0	Snow days combined with Rain creates icy conditions - safety concerns	3	6			0
Asphalt and Concrete Sidewalks			0			0			0			0	Slippery Conditions - safety issues and strain on operations and maintenance staff. Could lead to increased legal fees due to increased slips/trips/falls claims	2	8			0	Snow days combined with Rain creates icy conditions increasing occurrence of slips/trips/falls	2	4			0
Gravel or Natural Pedestrian Trails			0			0			0			0	Slippery Conditions - safety issues and strain on operations and maintenance staff. Could lead to increased legal fees due to increased slips/trips/falls claims	4	16			0	Snow days combined with Rain creates icy conditions increasing occurrence of slips/trips/falls	4	8			0
Railway (NB Southern Railroad)			0			0			0			0						0						0
Water, Wastewater, Storm Assets	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
U/G Sanitary Sewer Lines			0			0			0			0						0						0
Water Supply Pump Houses			0			0			0			0						0						0
U/G Storm Sewer Lines			0			0			0			0						0						0
Culverts and Catch Basins			0			0			0			0						0						0
Sewage Lift Stations (wet wells, no buildings)			0			0			0			0						0						0
Grinder Pump Stations			0			0			0			0						0						0
Wastewater Treatment Building (blower building)			0			0			0			0						0						0
Wastewater Lagoon			0			0			0			0						0						0
Trickling Filter Building			0			0			0			0						0						0
Community Structures	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
Foundation/ Structure			0			0			0			0						0						0
Roof (shingles)			0			0			0			0						0						0
Roof (flat)			0			0			0			0						0						0
Exterior Finishes			0			0			0			0						0						0
Mechanical/ Electrical			0			0			0			0						0						0
Recreational Elements	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
Splash Pad			0			0			0			0						0						0
Parks and Trails			0			0			0			0	Increased maintenance operations due to washout of trail material/soil.	2	8			0	Increased maintenance operations due to downed trees/branches/debris	2	8			0
Community Elements	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R	Impact	S	R
Power/ Utility			0			0			0			0						0						0
Cellphone/ Data			0			0			0			0						0						0

Appendix B

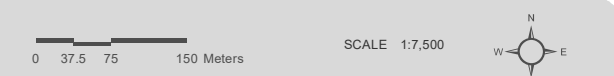
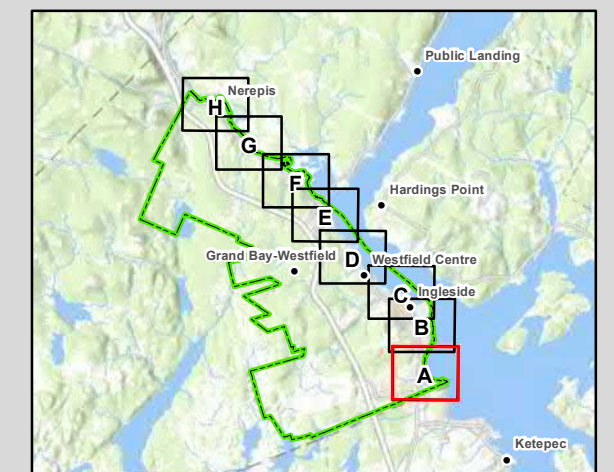
Flooding and Risk Discussion Maps



TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE A

- | | |
|--|--------------------------|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Institutional |
| Town Boundary | Stable Residential |
| GeoNB PAN Boundaries | Environmental Protection |
| Watercourse | |
| Street | |
| Highway | |
| Railway | |



MAP DRAWING INFORMATION: ESRI, DIGITALGLOBE, GEOEYE, EATHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGIRD, IGN, AND THE GIS USER COMMUNITY
DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
MAP CHECKED BY: JAB
MAP PROJECTION: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC



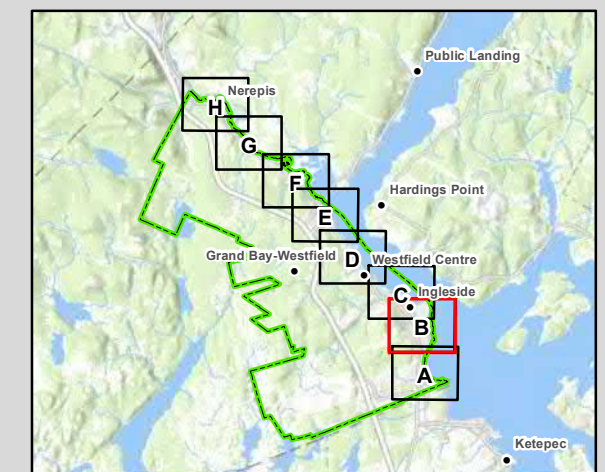
PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE B

- | | |
|--|---|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Future Land Use - Flood Affected Areas |
| Town Boundary | Stable Residential |
| GeoNB PAN Boundaries | Parks, Recreation and Open Space |
| Watercourse | |
| Street | |
| Highway | |
| Railway | |



MAP DRAWING INFORMATION: ESRI, DIGITALGLOBE, GEOEYE, EATHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AERGRID, IGN, AND THE GIS USER COMMUNITY
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MAP CHECKED BY: JAB
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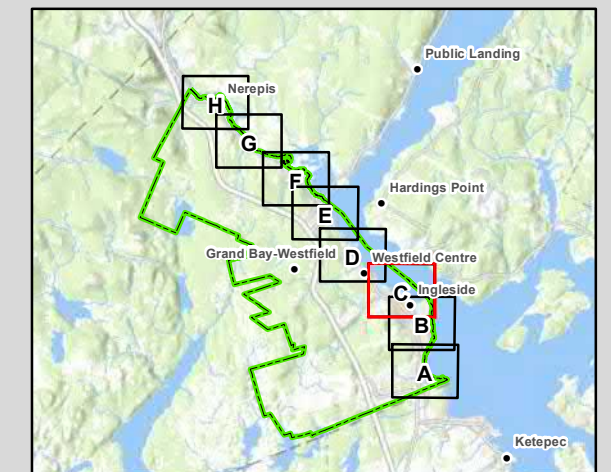
PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE C

- | | |
|--|---|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Future Land Use - Flood Affected Areas |
| Town Boundary | Commercial Corridor |
| GeoNB PAN Boundaries | Stable Residential |
| Watercourse | Rural Residential |
| Street | Parks, Recreation and Open Space |
| Highway | |
| Railway | |



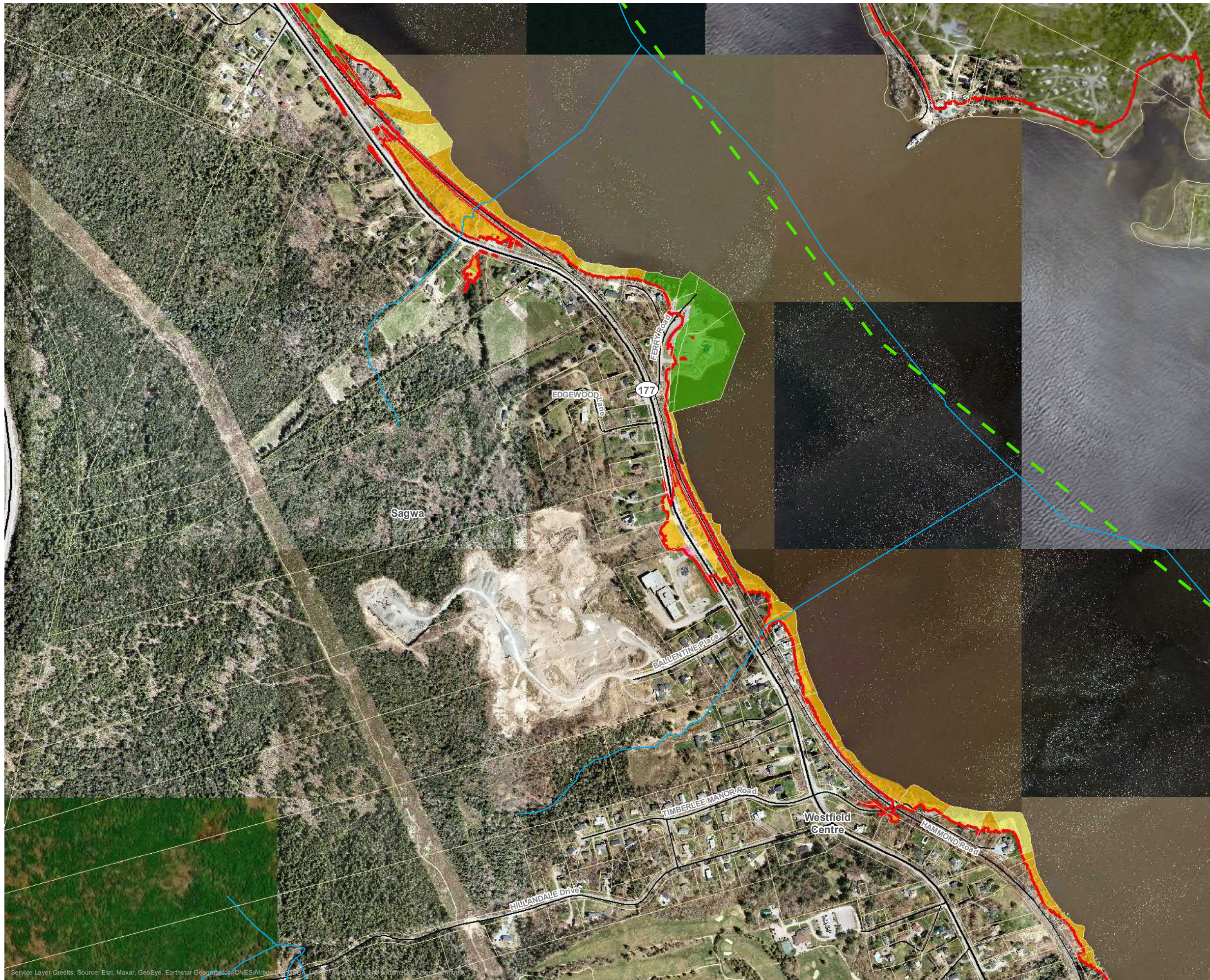
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DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
MAP CHECKED BY: JAB
MAP PROJECTION: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC



PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-27

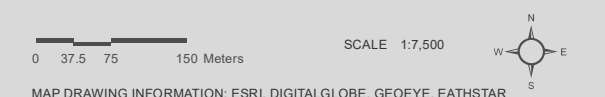
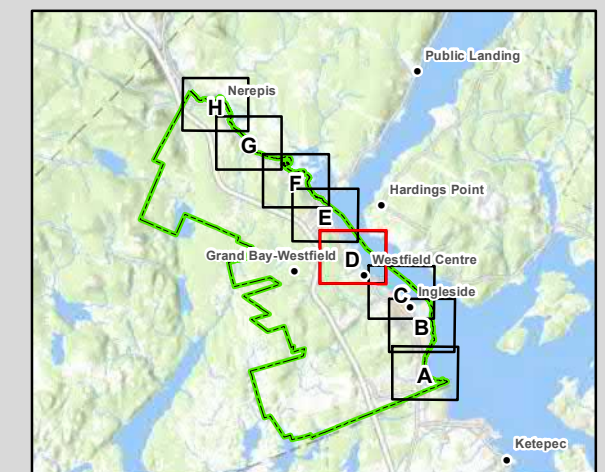




TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE D

- | | |
|--|---|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Future Land Use - Flood Affected Areas |
| Town Boundary | Institutional |
| GeoNB PAN Boundaries | Stable Residential |
| Watercourse | Rural Residential |
| Street | Parks, Recreation and Open Space |
| Highway | |
| Railway | |



MAP DRAWING INFORMATION: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AERGRID, IGN, AND THE GIS USER COMMUNITY
DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
MAP CHECKED BY: JAB
MAP PROJECTION: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC



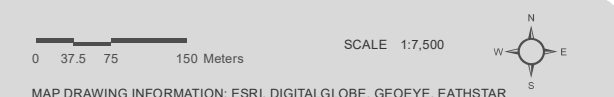
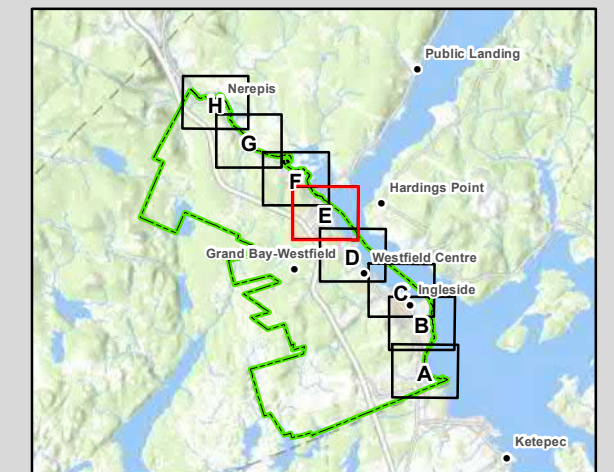
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STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE E

- | | |
|--|---|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Future Land Use - Flood Affected Areas |
| Town Boundary | Institutional |
| GeoNB PAN Boundaries | Stable Residential |
| Watercourse | Rural Residential |
| Street | Parks, Recreation and Open Space |
| Highway | |
| Railway | |

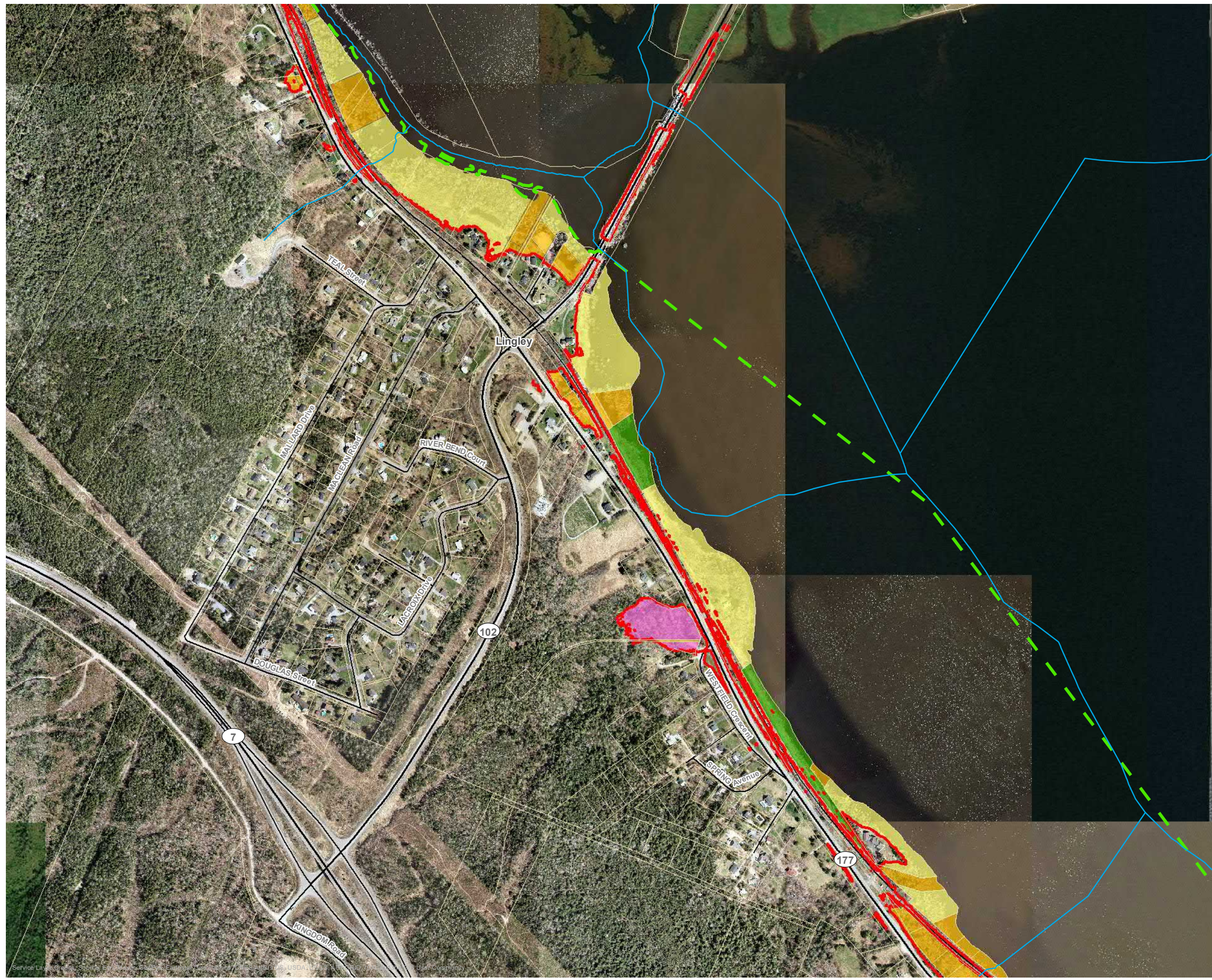


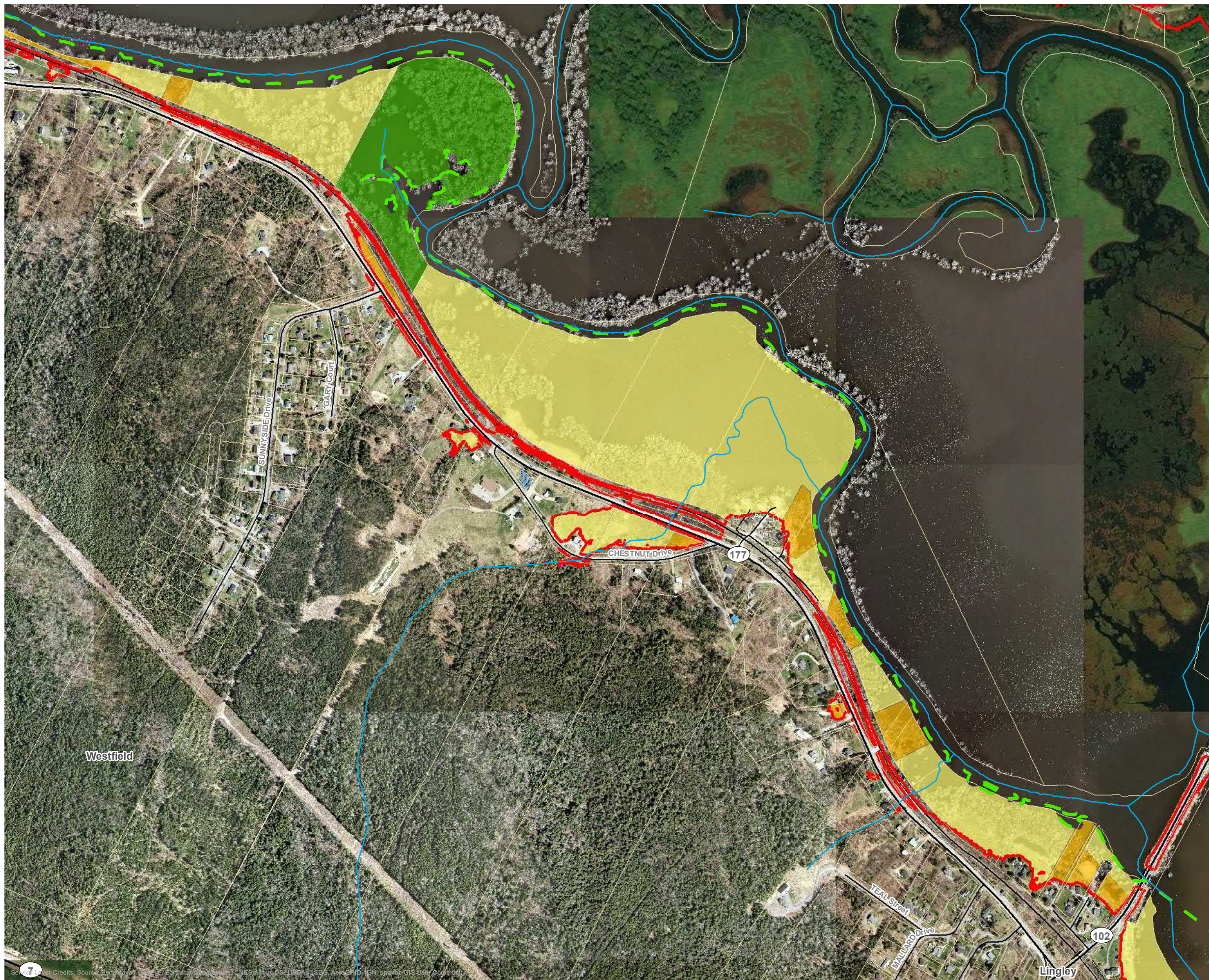
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 DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
 MAP CHECKED BY: JAB
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PROJECT: 20-3070
 STATUS: DRAFT
 DATE: 2020-11-27

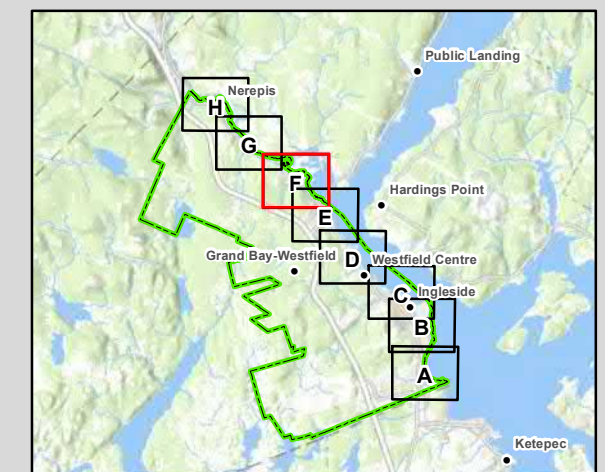




TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS
FIGURE F

- | | |
|--|----------------------------------|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Stable Residential |
| Town Boundary | Rural Residential |
| GeoNB PAN Boundaries | Parks, Recreation and Open Space |
| Watercourse | |
| Street | |
| Highway | |
| Railway | |

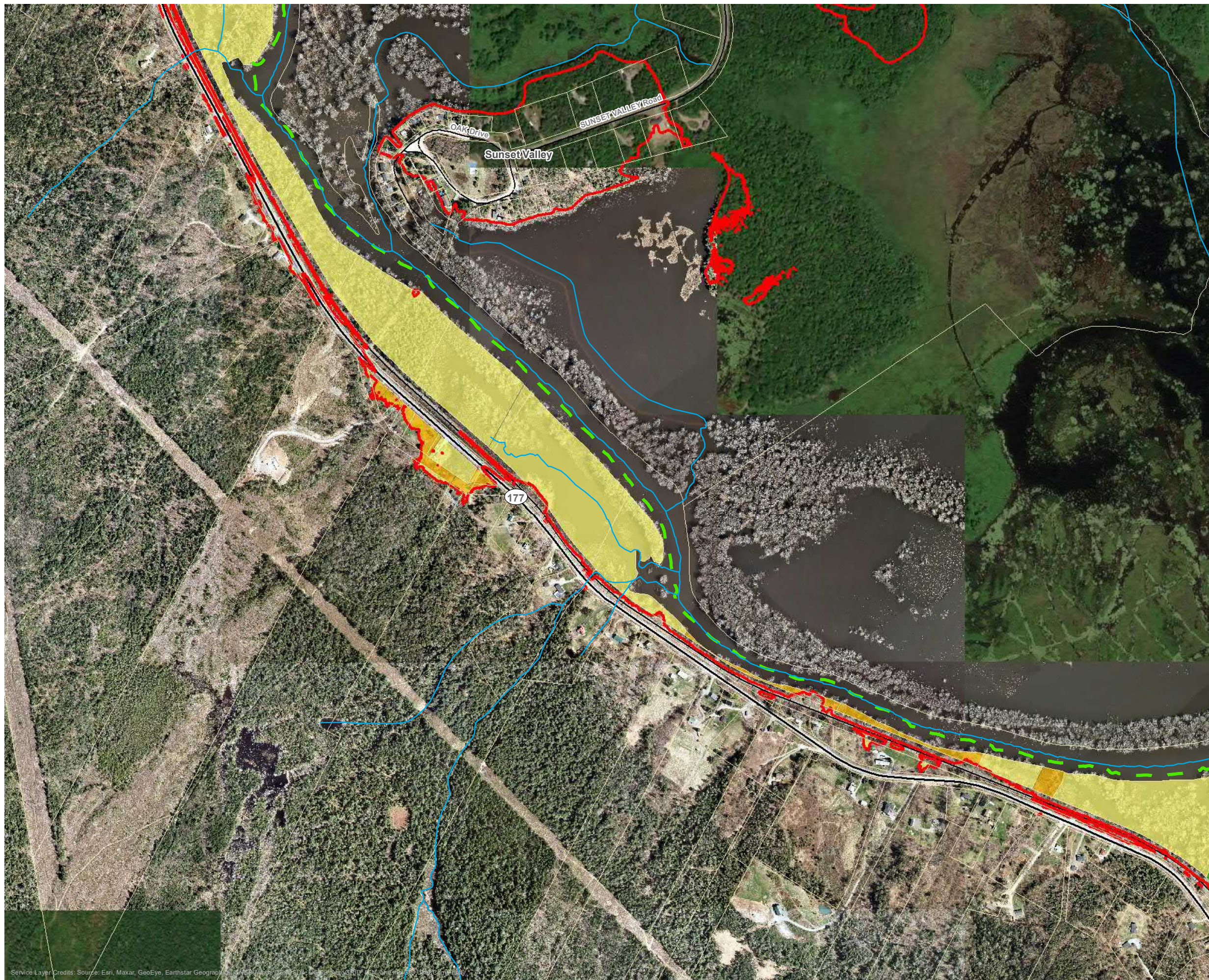


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DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
MAP CHECKED BY: JAB
MAP PROJECTION: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC



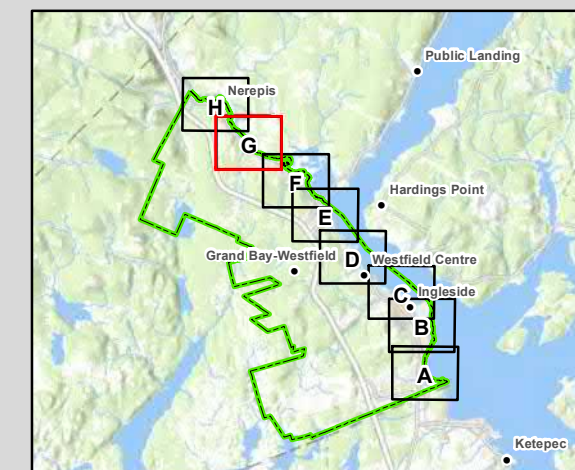
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STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FLOOD ELEVATION MAPS FIGURE G

- | | |
|--|---|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Future Land Use - Flood Affected Areas |
| Town Boundary | Stable Residential |
| GeoNB PAN Boundaries | Rural Residential |
| Watercourse | Parks, Recreation and Open Space |
| Street | |
| Highway | |
| Railway | |

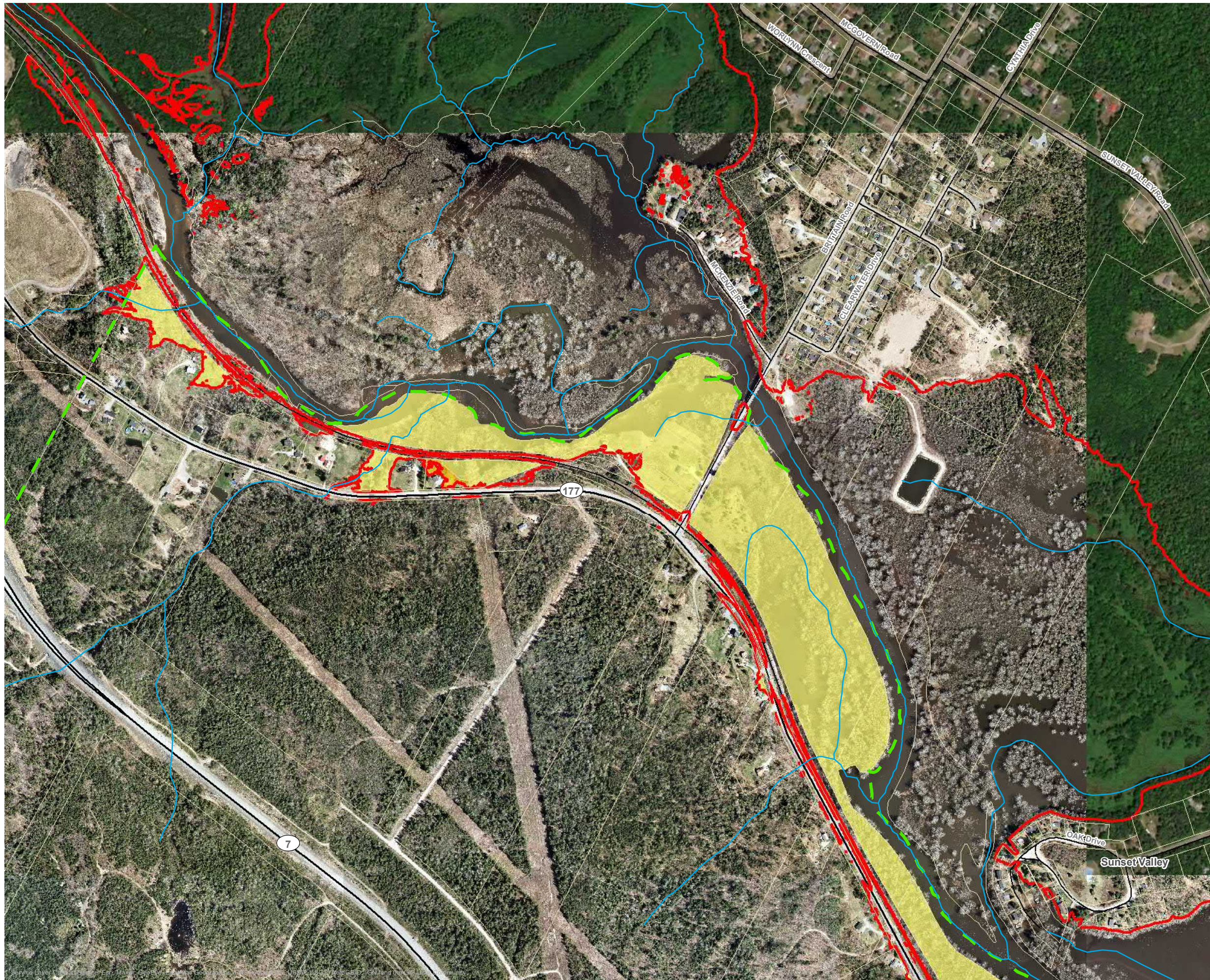


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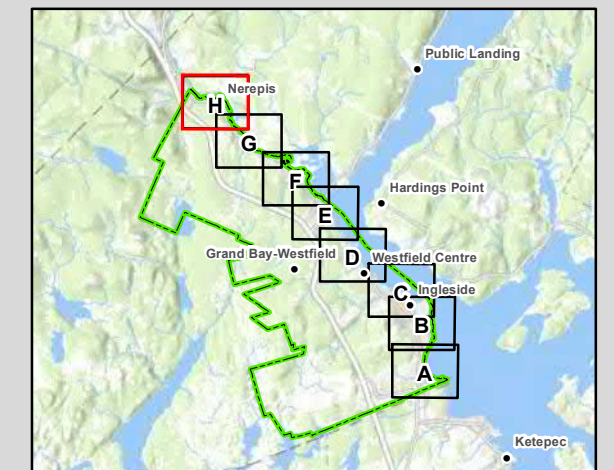
PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FUTURE LAND USE FLOOD EFFECTS FIGURE H

- | | |
|--|--------------------|
| Projected 100 year Flood Level (6.70 m - CGVD28) | Institutional |
| Town Boundary | Stable Residential |
| GeoNB PAN Boundaries | Rural Residential |
| Watercourse | |
| Street | |
| Highway | |
| Railway | |

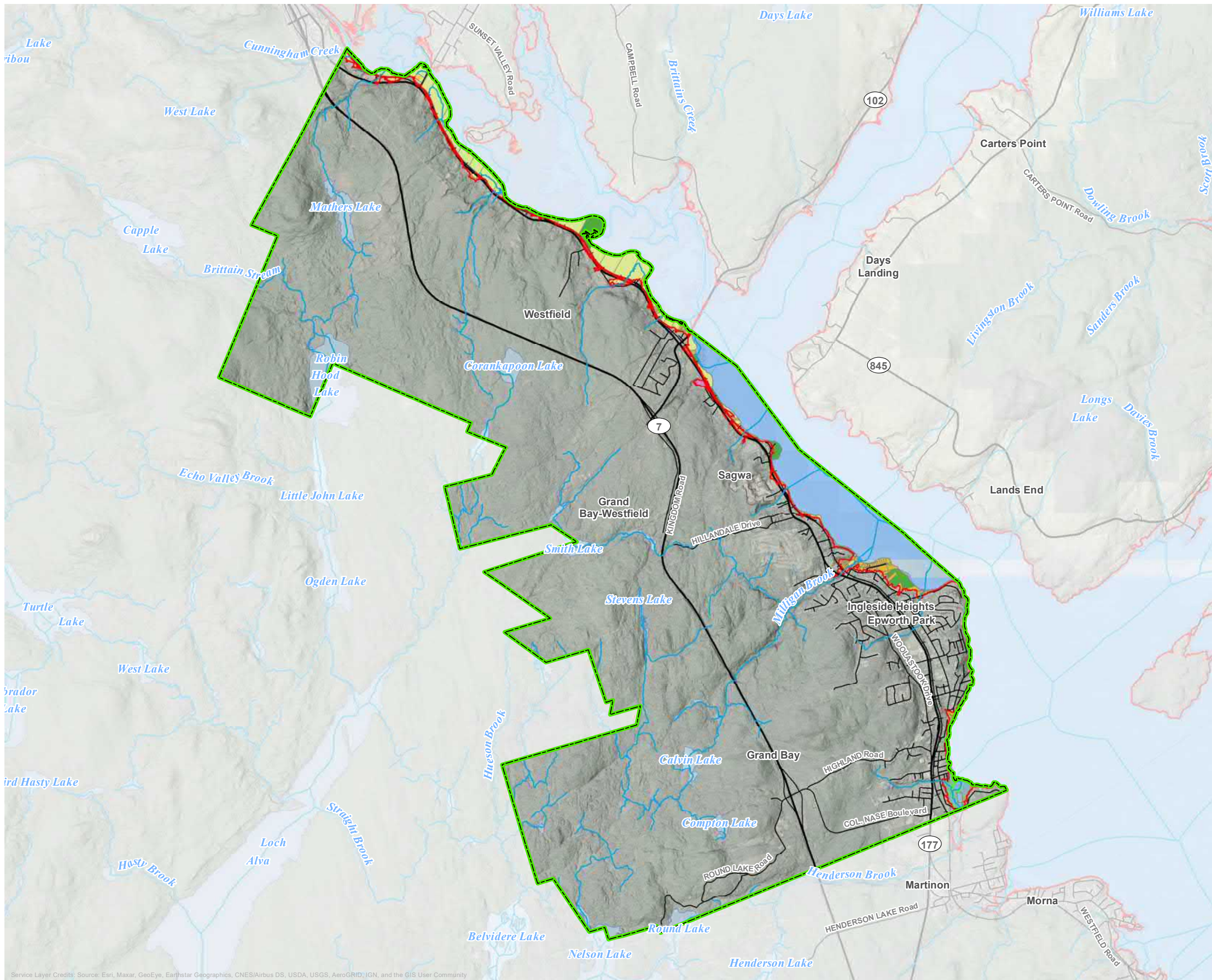


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DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

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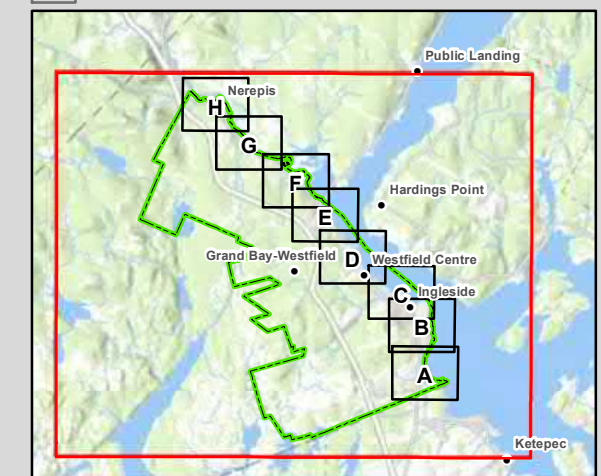
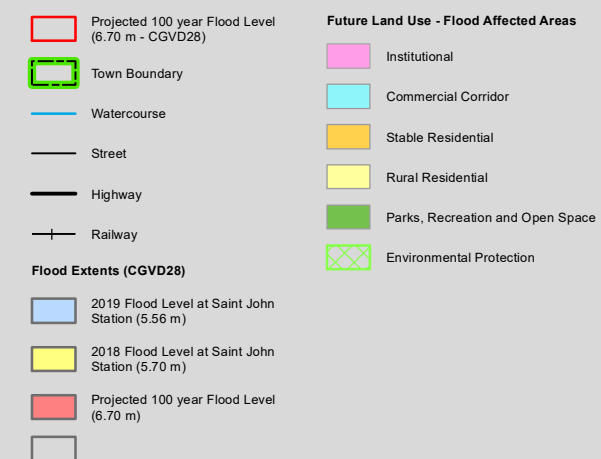


PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-27



TOWN OF GRAND BAY WESTFIELD

FUTURE LAND USE FLOOD EFFECTS



377550 Meters

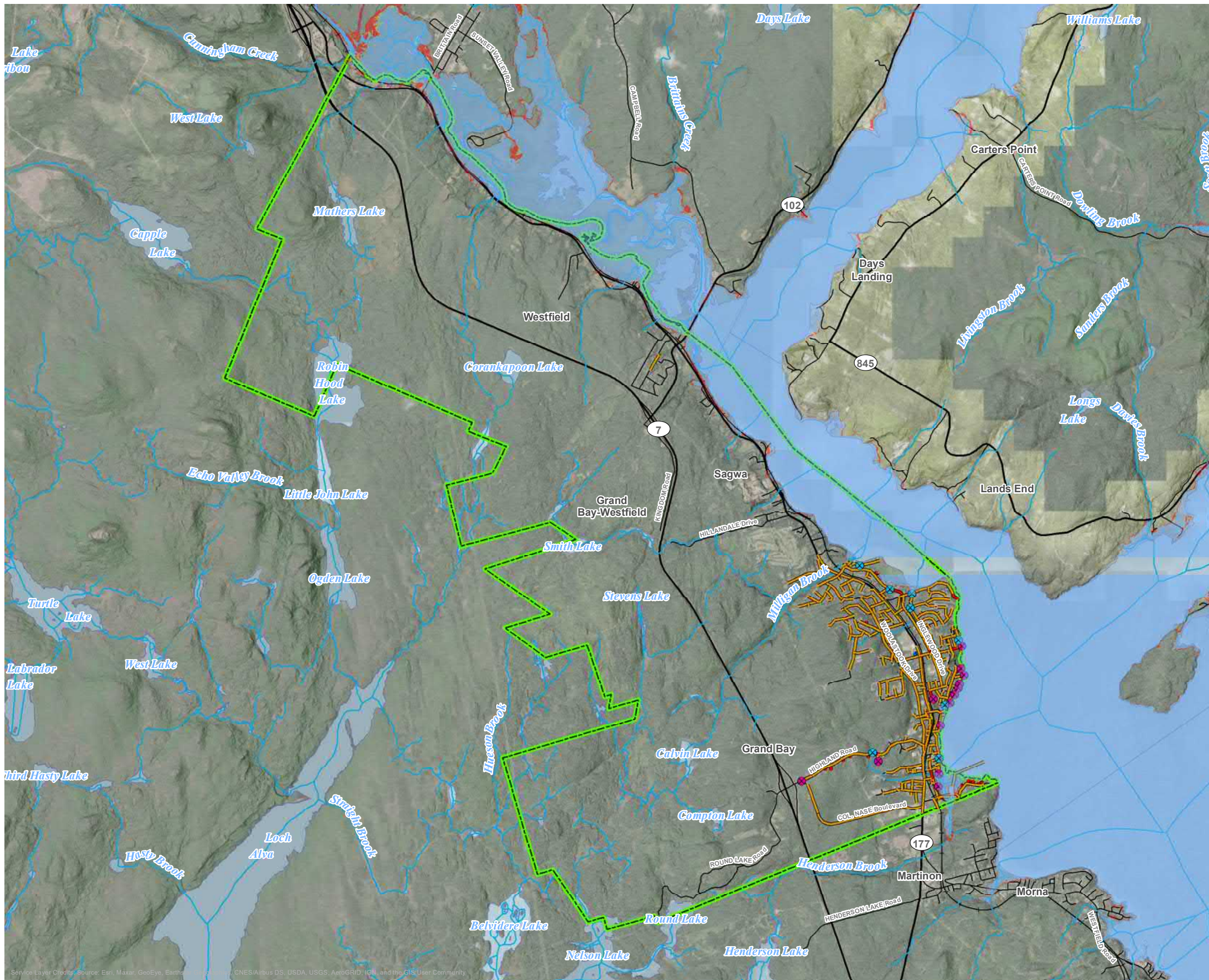
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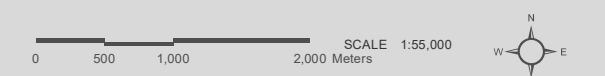
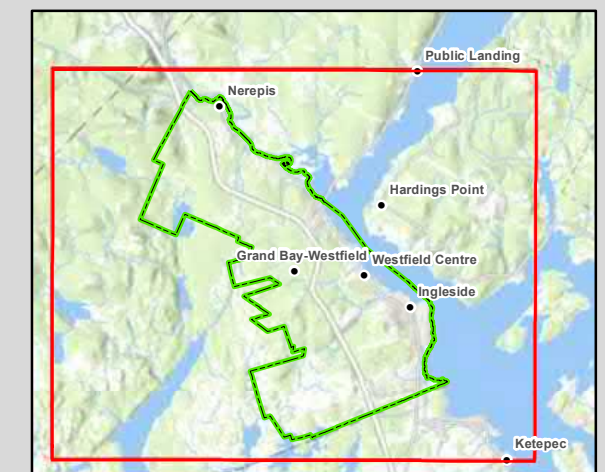
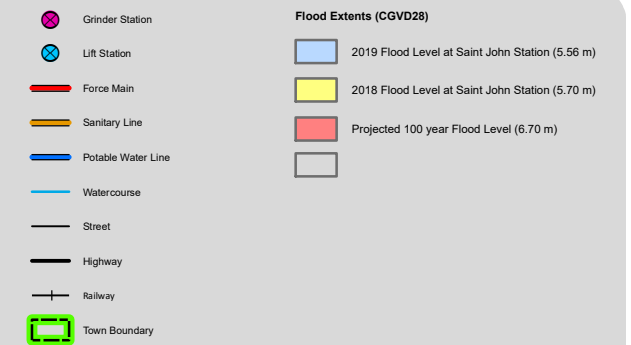


PROJECT: 20-3070
STATUS: DRAFT
DATE: 2020-11-30



TOWN OF GRAND BAY WESTFIELD

FLOOD RISK WATER/WASTE WATER ASSETS



MAP DRAWING INFORMATION: ESRI, DIGITALGLOBE, GEOEYE, EATHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGIRD, IGN, AND THE GIS USER COMMUNITY
 DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

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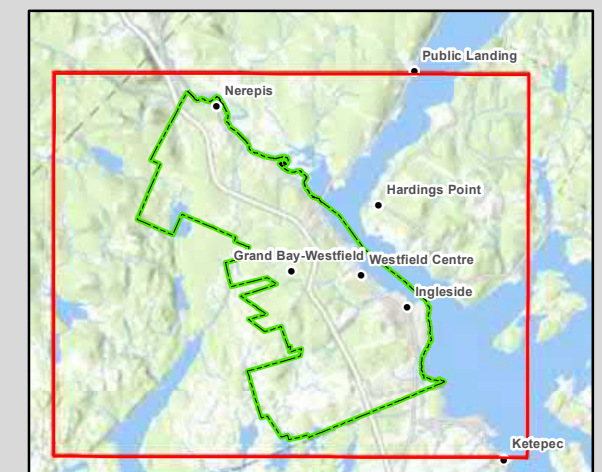
PROJECT: 20-3070
 STATUS: DRAFT
 DATE: 2020-11-30



TOWN OF GRAND BAY WESTFIELD

FOREST FIRE RISK

- Mature Forest Stands (Potential Forest Fire Hazard) - NBERD Survey
- Town Boundary
- Utility Corridor
- Watercourse
- Street
- Highway
- Railway
- Waterbodies

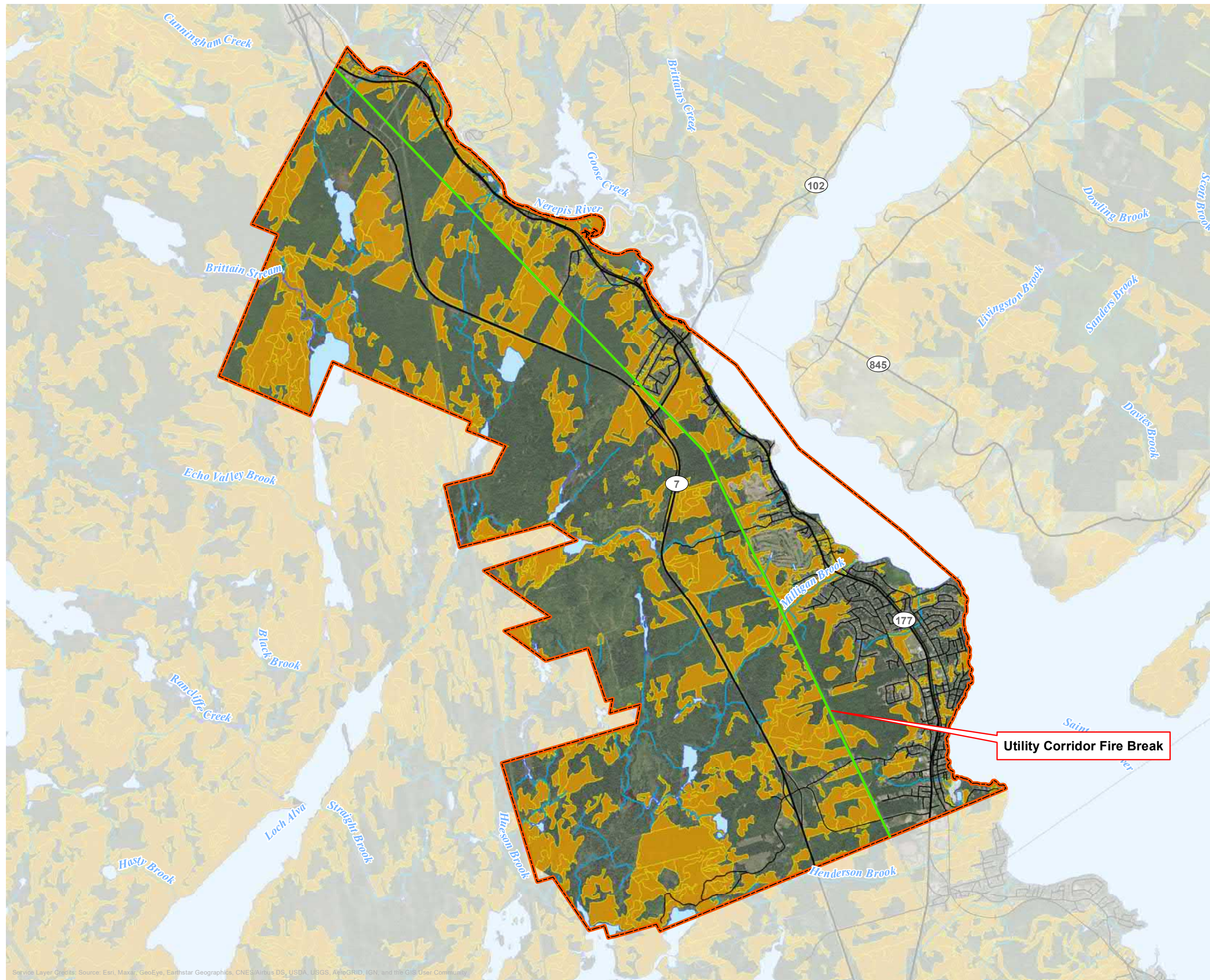


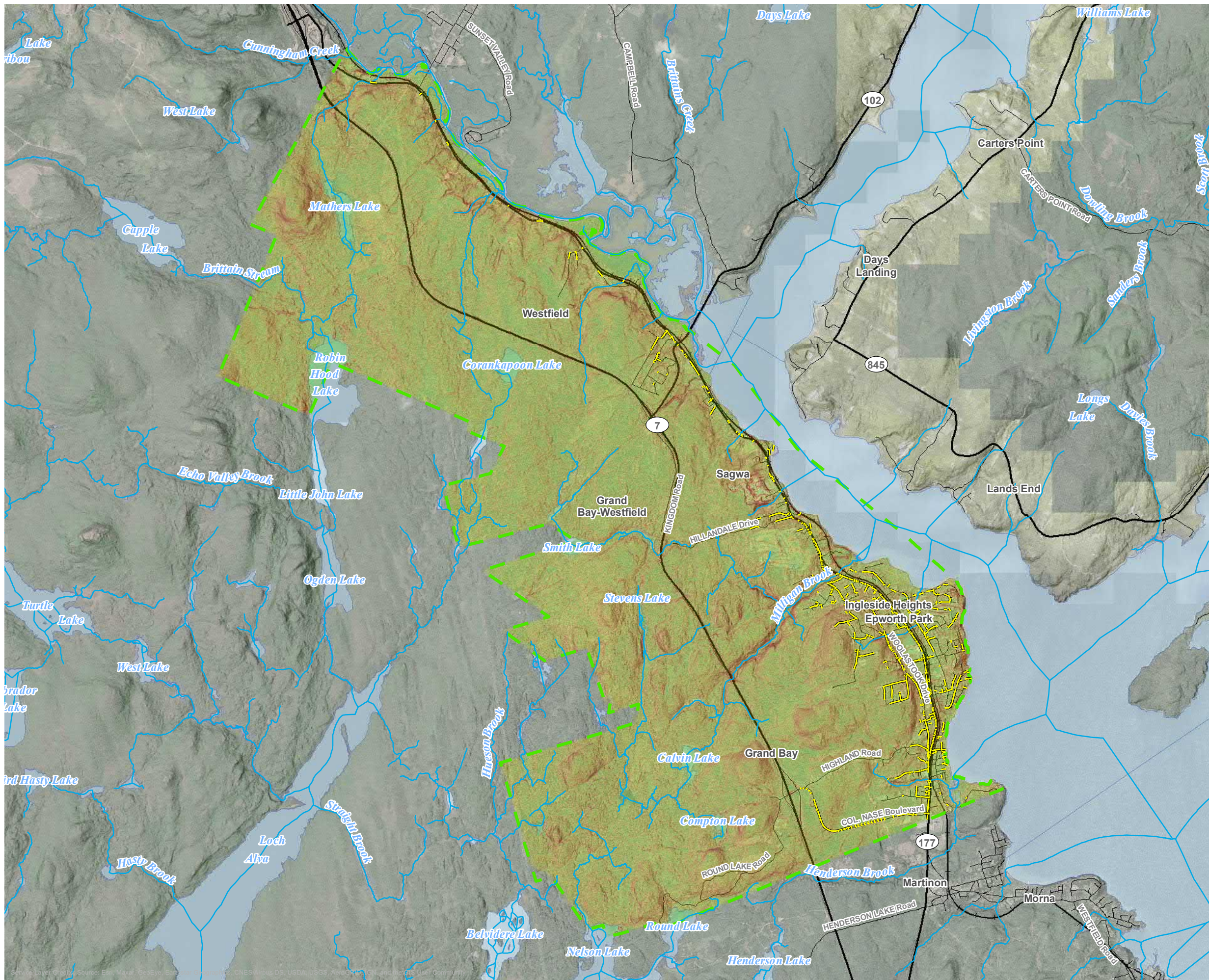
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 DATA PROVIDED BY: GEONB, GOVERNMENT OF CANADA

MAP CREATED BY: KCE
 MAP CHECKED BY: JAB
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PROJECT: 20-3070
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 DATE: 2020-11-30

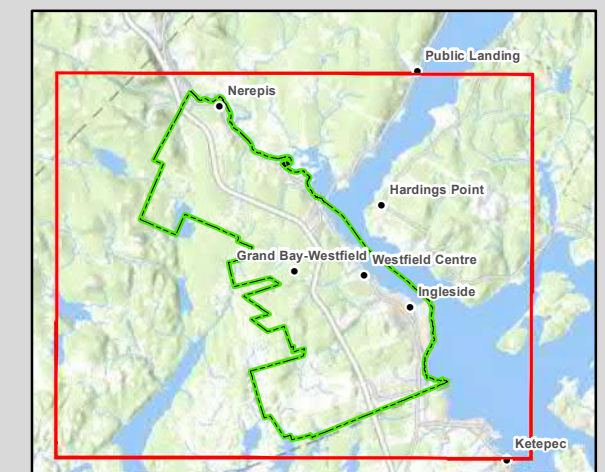




TOWN OF GRAND BAY WESTFIELD

TOPOGRAPHY

Storm Sewer	Percent Slope
Town Boundary	0 - 3
Watercourse	3 - 6
Street	6 - 9
Highway	9 - 12
Railway	12 - 15
Waterbodies	15 - 30
	30 - 50
	50 +



377550 Meters SCALE 1:54,112

MAP DRAWING INFORMATION: ESRI, DIGITALGLOBE, GEOEYE, EATHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRIID, IGN, AND THE GIS USER COMMUNITY
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MAP CREATED BY: KCE
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 MAP PROJECTION: NAD 1983 CSRS NEW BRUNSWICK STEREOGRAPHIC



PROJECT: 20-2437
 STATUS: DRAFT
 DATE: 2020-11-30

Appendix C

Spatial Assessment Results

Spatial Assessment Results

Infrastructure	Civic Address	Core Service	Spatial Assessment	Rating	Impact/ Rationale
Transportation Assets					
Roadways	Hazel Street	Transportation	Partial - functional	Moderate	
	Spruce Street	Transportation	Partial - functional	Moderate	
	Beach Road	Transportation	Partial - functional	Moderate	
	Brandy Point Road	Transportation	Partial - non functional	High	
	Riverside Park	Transportation	Complete - non functional	High	The street can be covered in water in almost any spring season. Deep ponding at a number of points.
	Ferry Road	Transportation	Partial - functional	Moderate	
	Nerepis Road	Transportation	Partial - non functional	High	Rock is placed every year to raise the road between Westfield School and 159 Nerepis Rd.
	Hammond Road	Transportation	Partial - functional	Moderate	
	Westfield Crescent	Transportation	Partial - functional	Moderate	
	Woolastook Dr	Transportation	Partial - functional	Moderate	Rock is placed durring high flood events.
	Station St	Transportation	Partial - functional	Moderate	This road and the on-ramp to the bridge was raised to the bridge's elevation after the 2018 flood event. Flood water can reach the guardrail, therefore road may be closed due to safety reasons.
Brittain Road	Transportation	Partial - non functional	High	Part of the road is completely flooded.	
Bridge	Nerepis Road Bridge	Transportation	Partial - functional	Moderate	Shoulder of the bridge and onramp has washed out.
	Shannon Road	Transportation	Partial - functional	Moderate	
Ferry		Transportation	Partial - functional	Moderate	Cable ferry is impacted by low/high water levels. In flood conditions they will import fill material to build up cable slab.
NB Southern Railroad	Along St. John River	Transportation	Partially Inside (case-by-case)	High	
Community Structures					
Brundage Point River Center (including VIC and storage)	4 Ferry Rd.	Recreation	Inside	High	The River Centre floods every year but the community is equipped to sandbag and pump water. Some repairs are completed every year in the crawl space.
Fire Station #2	293 Nerepis Rd.	Fire	Close to	Moderate	Access to the town from the fire station could be delayed due to road being flooded.
Storage Garage	150 Nerepis Rd.	Sewage	Inside / Close to	High	Floods every year but equipment is moved out of facility ahead of floods.
Water, Wastewater, Storm Assets					
Water Supply Pump House #1	27 Morning Side Cr.	Water	Close to	Moderate	Connected to well - could be impacted by drought conditions.
Water Supply Pump House #2	35 Westfield Cr.	Water	Inside	High	The building was not impacted in past flood levels but is deemed within projected flood elevations.
Grinder Pump No.1	Brooker Lane	Sewage	Inside / Close to	High	Impacts related to contaminant released into water stream if it becomes flooded
Grinder Pump No.3	Hazel Street	Sewage	Close to	Moderate	
Grinder Pump No.6	Ash Glen Lane	Sewage	Close to	Moderate	
Grinder Pump No.8	South Street	Sewage	Close to	Moderate	
Grinder Pump No.9	George Street and Ella Lane	Sewage	Close to	Moderate	
Grinder Pump No. 10	River Street	Sewage	Close to	Moderate	flooding events
Grinder Pump No. 11	River Street	Sewage	Close to	Moderate	flooding events
Grinder Pump No.12	River Street	Sewage	Close to	Moderate	flooding events
Grinder Pump No.13	Points Road	Sewage	Close to	Moderate	
Grinder Pump No.16	Young Street	Sewage	Close to	Moderate	
Grinder Pump No.17	Irvine Lane	Sewage	Close to	Moderate	
S.L.S No.2	Kenwood Drive	Sewage	Close to	Moderate	
S.L.S No.3	George Street and Ella Lane	Sewage	Close to	Moderate	
S.L.S No.6	Inglewood and Brandy	Sewage	Close to	Moderate	
S.L.S No.7	Brandy Point Road	Sewage	Close to	Moderate	
S.L.S No.8	Young Street	Sewage	Close to	Moderate	
S.L.S No.10	Riverside Park Drive	Sewage	Inside / Close to	High	flooding events
Wastewater Treatment Plant	33 Shannon Road	Sewage	Inside / Close to	High	elevations.

Appendix D

Adaptations and Recommendations

Adaptations and Recommendations

Infrastructure	Hazard	Vulnerability	Projected Risk Score (2080s)	Risk Rating	Adaptation Measures	Recommendations
Transportation Assets						
Asphalt Roadways and Parking Lots	High Temperatures/Drought Conditions	Premature deterioration due to rutting of asphalt surfaces under high heat and UV exposure	14	Moderate		Continue to complete yearly roadway inspections currently conducted by the Town's consulting engineers Establish QA/QC measures during asphalt installation to help reduce premature deterioration of asphalt surfaces
	Flooding	Riverine flooding greatly impacts roadways, potentially blocking access to neighbourhood and critical infrastructure	Spatial	High	Permanently raise the roads as required (i.e. Brandy Point Road, Riverside Park Drive, Nerepis Road, Shannon Road)	
Gravel or Natural Pedestrian Trails	Freezing Rain/Freeze-Thaw Cycles	Premature deterioration due to hardening of asphalt surfaces or frost heaving	16	Moderate		Continue to complete yearly roadway inspections currently conducted by the Town's consulting engineers Review expected snowfall and de-icing procedures ahead of issuing the yearly Snow Control tender. Changes to be considered may include modifying the type of de-icer used with less corrosive agents
Water, Wastewater, Stormwater Assets						
Culverts and Catch Basins	Heavy Precipitation	Heavy rainfall can cause the system to become overwhelmed leading to localized flooding	16	Moderate		Continue to complete on-site inspections of culverts/ drainage ditches before and after heavy rainfall events
Culverts and Catch Basins	Heavy Precipitation	Culverts can become overwhelmed potentially leading to backups or overflows	16	Moderate	Improve storm water conveyance through the use of green infrastructure to increase water infiltration and slow surface flow. These can include: Buffer strips & hedges; Rain gardens; Retention ponds	
Sewage Lift Stations	Heavy Precipitation	Lift stations become overwhelmed potentially leading to sewage backup in homes or emergency overflow. I&I concerns at connection points	24	Moderate	Improve storm water conveyance through the use of green infrastructure to increase water infiltration and slow surface flow. These can include: Buffer strips & hedges; Rain gardens; Retention ponds	
Sewage Lift Stations	Flooding	Riverine flooding greatly impacts lift stations near the river, potentially causing overflow issues and public and environmental health concerns	Spatial	High	Lift Stations #7 & #10 - Permanently raise (electrical components) or reconfigure the Lift Stations;	
Sewage Lift Stations	Flooding	Possible damage to electrical components of pump stations can impact use and cause damage	Spatial	High	Raise electrical components within lift stations as required above high flood extents	
Water Supply Pump House #2	Flooding	Possible damage to electrical components of pump stations can impact use and cause damage	Spatial	High	Raise electrical components as required above high flood extents	
Wastewater Lagoon	Flooding	Flood events can overwhelm the berm and compromise the wastewater treatment process	Spatial	High	Heighten and strengthen berm around lagoon as required to prevent breach in high flood events	
Community Structures						
Roof (Shingles)	High Temperatures/Drought Conditions	Sun (UV) exposure leading to premature deterioration of shingles	14	Moderate		Explore alternative roofing materials or UV protective coating on a case by case basis where roofing change is needed while continuing to manage with existing measures
Community Elements						
Storage Garage	Flooding	Structures are highly susceptible to flooding	Spatial	High	Low priority - Manage with existing measures	
Brundage Point River Center	Flooding	Structures are highly susceptible to flooding	Spatial	High	Protect River Center against high flood events (e.g. barricades, pumping out basement)	
Brundage Point River Center	Flooding	Riverine flooding greatly impacts roadways, potentially blocking access to neighbourhood and critical infrastructure	Spatial	High	Preventative Zoning and Permitting which can include: Revision of future land use plans with flood extents, and setting minimum building elevation for new construction	
Brundage Point River Center (Including VIC and Storage)	High Temperatures/ Drought Conditions	Town has yet to have a dedicated cooling/warming center	Qualitative	High	Acquire generators for the river centre to function as a cooling/warming center	

Adaptations and Recommendations

Infrastructure	Hazard	Vulnerability	Projected Risk Score (2080s)	Risk Rating	Adaptation Measures	Recommendations
Community Elements						
Power/Communication Lines	Freezing Rain (+ High Wind Gusts)	Downed lines/poles from ice accretion or debris blowing onto structure	24	Moderate		Review building electricity needs and update EMO Plan to capture large scale power outage events as part of ongoing operational improvements
General Community	Flooding	Flooding will have a great impact on development and zoning as it is expected that the flood extents might continue to encroach inland with time	Spatial	High	Building up vacant land to meet the latest minimum building elevation recommendation to capitalize on the number of vacant lots that are in the 100 year flood extents	
General Community	High Temperatures/ Drought Conditions	High heat exposure can pose health and safety risks to vulnerable populations	Qualitative	Moderate	Install shading structures in strategic public locations (e.g. bus stops) to minimize the impact of heat exposure	
General Community	High Temperatures/ Drought Conditions	The increased domestic water usage from new developments and the decrease in groundwater recharge during dry seasons can strain the Town's water supply	Qualitative	Moderate	Develop public water infrastructure for Colonel Nase Boulevard and other residential intensification areas	