District Municipality of Muskoka
Structural Flood Mitigation Options

Report

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Appendix B Site Visit Report

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1. Introduction

Water management within the Muskoka River Watershed (MRW) is complex and has evolved over many years to balance conflicting water demands. Starting in the 1800s, major changes were made to lake storage and connecting channels to facilitate navigation and, in turn, stimulate industry growth. These changes, however, were not meant to address flood mitigation. Within the last 12 years, the watershed has experienced major flooding (specifically in 2008, 2013, 2016 and 2019) that caused significant damage to municipal infrastructure and private property.

District Municipality of Muskoka (DMM) sought to reduce flood risk and address watershed health and has seized the Province of Ontario's support to do so. In turn, DMM has scoped 12 projects designed to describe the existing conditions within the watershed, and to inform a future integrated watershed management (IWM) approach to flood risk reduction. This integrated watershed management approach seeks to balance conservation and development while managing human activities and natural resources at a watershed scale. This report serves to identify potential structural options within the watershed that will specifically mitigate flood risk and describes the work executed to derive these options. This work was subdivided into the following main tasks:

- Background information collection/review
- Site reconnaissance/visit
- Hydraulic system review
- Option identification
- Initial concept design development
- Estimation of scope and costs associated with the preliminary design of the flood mitigation options.

These tasks are summarized in the following sections. As an important note, throughout this report are the terms *Baseline Case* and *Mitigation Case*. *Baseline Case* refers to status-quo flood-impacted conditions based on the current state of the watershed, while *Mitigation Case* refers to flood impacted-conditions that occur after the implementation of specific flood mitigation options. The definitions of these terms are revisited throughout the report where needed for clarify.

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2. Background Information Collection and Review

The following is a brief description of the key information sources collected and reviewed as part of this study.

2.1 Guidelines, Reports and Studies

- **Dam Operations Manual for Muskoka River Dams** (Ontario Ministry of Natural Resources, 1997 with 2007 updates) – The Dam Operations Manual (DOM) for Muskoka River Dams was provided by Ministry of Natural Resources and Forestry (MNRF) and includes the physical dimensions and operational details for the various control structures throughout the MRW. This document is referred to throughout this report as *the DOM (OMNR, 1997, updated in 2007).*
- **Muskoka River Water Management Plan** (Ontario Ministry of Natural Resources, et al, 2006 with amendments) – The Muskoka River Water Management Plan (MRWMP) provides information on the seasonal operating conditions and the storage characteristics of major lakes in the watershed.
- **Report of the Muskoka Watershed Advisory Group: Interim Advice and Recommendations to Address Priority Environmental Issues in the Muskoka River Watershed** (Muskoka Watershed Advisory Group, 2020) – This report provides background information on an array of issues in the MRW, including flooding. A need to pursue flood mitigation studies is discussed in Recommendation 8.
- **An Independent Review of the 2019 Flood Events in Ontario** (MacNeil 2016) – This report was authored by Douglas McNeil, Ontario's Special Advisor on Flooding (2019).
- **Matthias Generating Station Dam Safety Review** (RJ Burnside, 2007) – This dam safety review document provided rating curves that relate spillway capacity to head pond levels for Matthias Generating Station (GS), which were considered during options development.
- **Technical Report for Muskoka River Flood Plain Mapping Study** (**H356689-00000-200-230-0002)** (Hatch, 2020) – This report details the hydrologic and hydraulic analyses that produced estimates of flood-impacted water levels for the application as part of the Flood Plain Mapping Study (FPMS) in the MRW. Select hydraulic models described in this report were adopted for this study (see Section 2.3).
- **Interim Progress Report (H366496-0000-200-230-0001)** (Hatch, 2022a) – Interim progress report dated June 3, 2022, issued to DMM by Hatch as part of the FPMS. This report includes detailed information on the structure, set-up and calibration of the hydrologic model adopted for this study (see Section 2.3).
- **South Muskoka – Fraserburg Reach Floodplain Mapping Memo (H366496-0000-200-030-0001)** (Hatch, 2022b) – Memo dated June 10, 2022, issued to DMM by Hatch as part

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of the FPMS. This memo includes detailed information on the structure, set-up and calibration of the Fraserburg hydraulic model adopted for this study (see Section 2.3).

- **Musquash River Floodplain Mapping Memo (H366496-0000-200-030-0005 – in progress)** (Hatch, 2022c) – In-progress memo to be issued to the DMM by Hatch documenting the structure, set-up and calibration of the Musquash River hydraulic model adopted for this study (see Section 2.3).

2.2 Other Datasets

- ***300-5-A-21 MR14 - Issued for Tender Drawings*** – These drawings provided by DMM outlines engineering works that are approved for completion on Fraserburg Road. The work completed is related to infrastructure protection from flood conditions.
- ***'High Falls Operator Spreadsheet' tool*** – This Microsoft® Excel® workbook was provided by Bracebridge Generation and facilitates calculation of head pond levels and total flow under different operating conditions at High Falls GS.
- ***'SLUICE-Flow-Matthias GS – adjusted Cd'* tool** – This Microsoft® Excel® workbook was provided by Orillia Power Generation Corporation and facilitates calculation of head pond levels and flow under different operating conditions at Matthias GS.
- ***LiDAR Survey Data*** – These topographic mapping data cover 1508.4 km^2 of the MRW and were collected as part of DMM's FPMS. Further information on collection and processing of these LiDAR data is provided in the *Technical Report for Muskoka River Flood Plain Mapping Study* (Hatch, 2020). The 1-m grid datasets of *Bare Earth* and *Hydroflattened* digital elevation models (DEM) created from LiDAR data were employed for analyses.
- ***Zoning GIS Datasets (various)*** – These geospatial data included zoning classification layers for the six municipalities in Muskoka (Town of Huntsville, Town of Bracebridge, Town of Gravenhurst, Township of Muskoka Lakes, Township of Lake of Bays, and Township of Georgian Bay). These data were used to characterize the land use of flood impacted areas.
- ***'Building_Footprint_2018' GIS Dataset*** – These geospatial data include the footprints of structures throughout the MRW. DMM provided descriptive classifications (e.g., residential, boathouse, etc) for select structures (based on areal size and other factors), however these classifications are considered preliminary and may be subject to refinement.

2.3 Flood Plain Mapping Study (FPMS) Models

As part of the 2020 FPMS in the MRW (Hatch 2020), several hydraulic models were created using HEC-RAS (Version 5.0.7). HEC-RAS is a modelling software developed by the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center and can facilitate development of both one-dimensional (1D) or two-dimensional models (2D).

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The models developed for the 2020 FPMS and adopted for this study included *Big East*, *Huntsville Narrows*, *Baysville*, *Purbrook*, *Springdale* and *Bala Reach*. A thorough description of these models is provided in the 2020 FPMS report (Hatch 2020). Since the 2020 FPMS, additional hydraulic models have been developed for flood plain mapping in different areas of the MRW. Two of these additional models were adopted for this study, specifically Fraserburg (Hatch 2022b) and Musquash River (Hatch 2022c).

As part of FPMS in the MRW, a hydrologic watershed model was developed using the USACE's Hydrologic Engineering Center Hydrologic Modelling System (HEC-HMS) software (Version 4.8). HEC-HMS is a standard tool for hydrologic modelling that is widely used in Canada. The model is able to represent snow accumulation and melt, snowmelt- and rainfall-runoff transformation, overland flow routing, groundwater outflow, and reservoir routing using a range of user-selected model processes. These features make the model suitable for simulating hydrologic conditions during the design events of the MRW. Further information on this model is provided in an interim report issued to DMM (Hatch 2022a).

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3. Study Priority Areas

DMM is comprised of 13 lower tier municipalities and 2 upper tier municipalities, which include the Towns of Gravenhurst, Bracebridge and Huntsville. These municipalities are located within the MRW, a basin which encompasses an area of approximately 5100 km^2 (including 78,000 ha of lakes). The watershed extends from headwaters along the western side of Algonquin Provincial Park and outlets to Georgian Bay via two rivers. The watershed features three distinct regions, specifically, North Branch Muskoka River, South Branch Muskoka River, and Lower Watershed ('Muskoka Lakes').

The North Branch and South Branch regions account for approximately two-thirds of the total MRW's drainage area. The South Branch and North Branch of the Muskoka River confluence near Bracebridge, and outlet as a single river into Lake Muskoka. The Lower Watershed region features several large lakes – Lake Joseph, Lake Rosseau, and Lake Muskoka – where Lake Muskoka is the largest among them. Outflows from Lake Muskoka bifurcate into the Moon and Musquash Rivers, both of which flow to Georgian Bay. A number of monitoring sites are located throughout the MRW (see Figure 3-1), which assist in characterizing hydrologic conditions throughout the year.

In recent historical years, the MRW has experienced several large flood events that have led to extensive damages. Flood management in MRW is a challenging endeavor, owed in part to diverse water demands throughout the area. These water demands come from a variety of stakeholders, including Indigenous communities, hydropower operators, cottagers, and tourists/recreationalists. High densities of structures (e.g., homes, commercial buildings, etc) in floodplain areas present further challenges in the pursuit of flood mitigation. While comprehensive elimination of flooding is not possible for the MRW, targeted mitigations can be implemented to lessen the severity of flooding in local areas.

The focus of this study was to identify and analyze structural mitigations to address flooding in the MRW. This report is focused on identification of flood mitigation options and describing the local flood mitigation potential of 10 selected options within specific geographic areas. Watershed-scale impacts of these mitigations will be assessed in *Flood Modifications Review*.

Hatch, DMM and the IWM Technical Working Group (TWG) collaborated together to identify five areas within the watershed for option identification and assessment. The selection of these locations was based on observational data collected during the 2013 and 2019 flood events and historical knowledge of the watershed. The general boundaries of these areas are identified in Figure 3-2 as *Priority Areas of Concern* and are referred to as follows—*Big East River* (North Branch Muskoka River), *Huntsville Narrows* (North Branch Muskoka River), *Springdale* (North Branch Muskoka River), *Baysville/Fraserburg/Purbrook* (South Branch Muskoka River), *Muskoka/Bala* (Lower Watershed).

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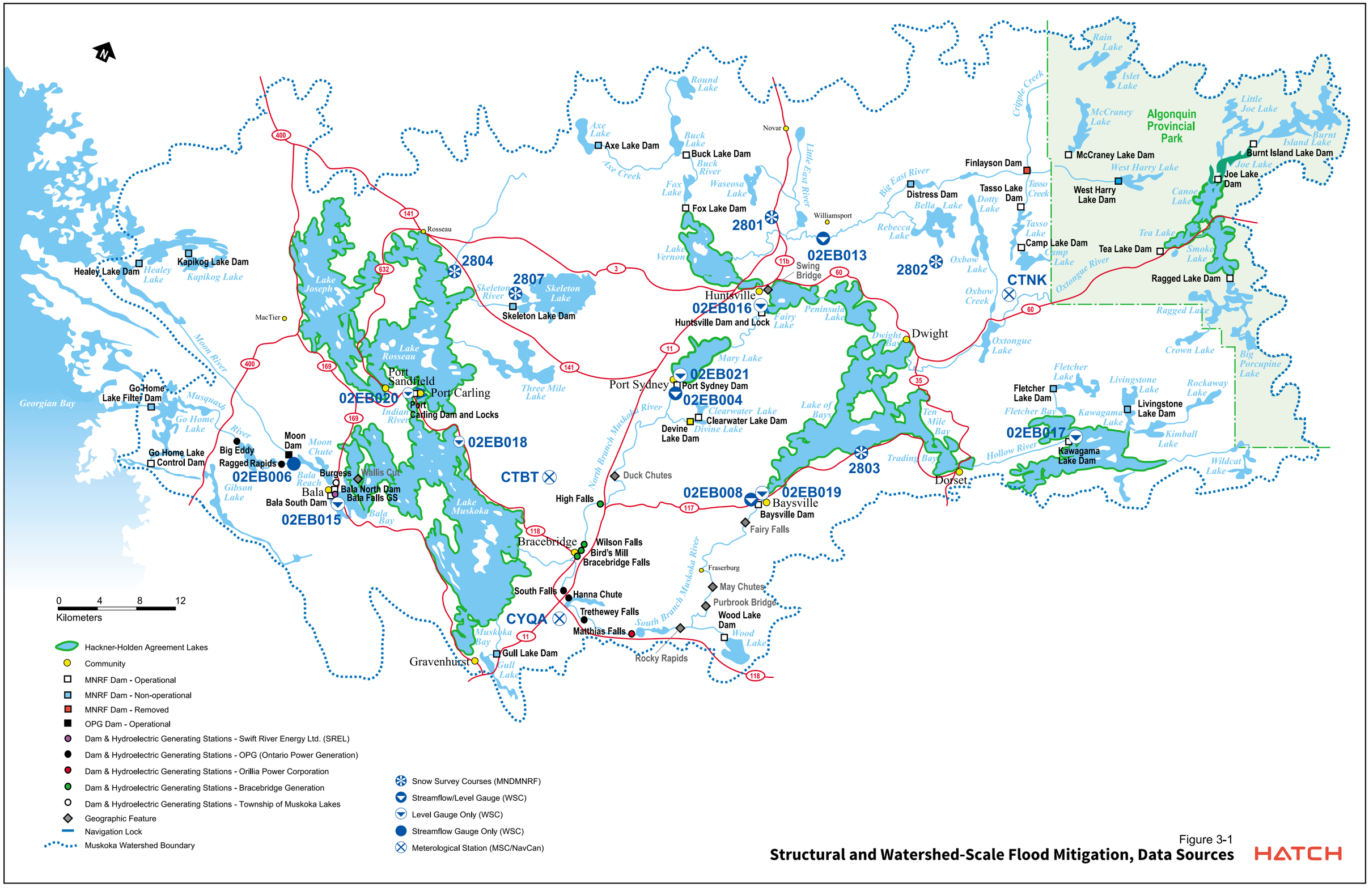

Figure 3-1

Structural and Watershed-Scale Flood Mitigation, Data Sources

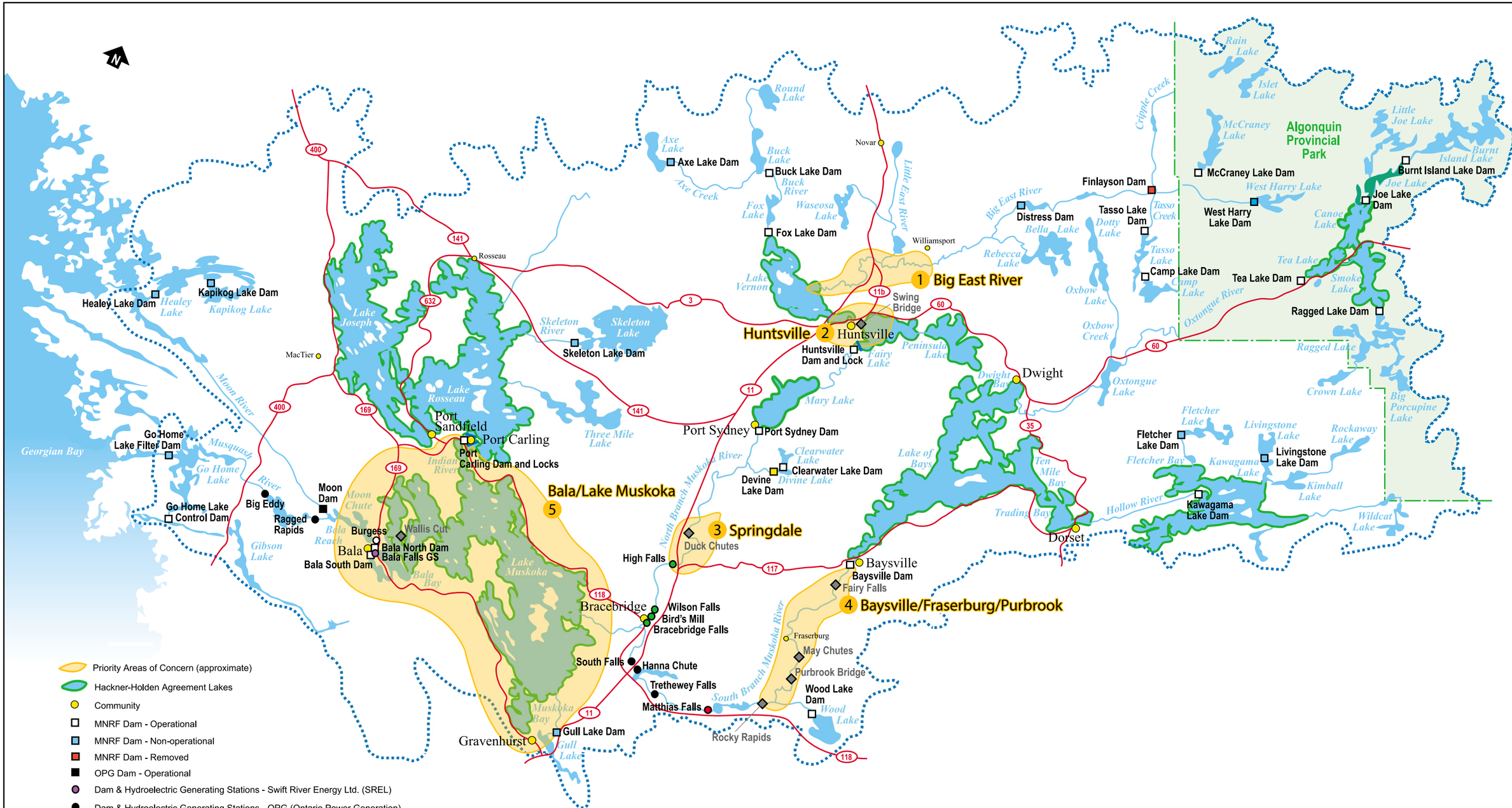

Figure 3-2

Structural and Watershed-Scale Flood Mitigation, Areas of Concern (approximate)

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4. Flood Event Hydrology

The two design flood events adopted as the basis for examining flood impacts in the MRW are those that occurred in 2019 and 2013. In April and May of those years, rain-on-snow events produced significant flooding and the highest flow rates ever recorded at the four main Water Survey of Canada (WSC) stations in the watershed. A forensic analysis of these events is provided in numerous reports, including the *Technical Report for Muskoka River Flood Plain Mapping Study* (Hatch 2020).

Trends relevant to this study include that the 2019 event is the governing design flood for the South Branch (downstream from Lake of Bays), North Branch (downstream from Fairy Lake) and Lower Watershed regions. Additionally, the 2013 event is the governing design flood for the North Branch (upstream from Fairy Lake). Baseline Case conditions in each priority area were established using either of these two design flood events to inform the development of flood mitigation options. These design flood events were also applied to evaluate the potential effectiveness of flood mitigations as part of the Mitigation Case.

The main hydrologic inputs required for both Baseline Case and Mitigation Case assessments were flow (Q) and water level (i.e., water surface elevation; WSE), as these datasets are necessary for hydraulic model simulations. Flow data for design flood events were sourced from WSC records and were supplemented by simulated flows using the FPMS hydrologic model to quantify the flow contributions of ungauged sub-basins in the MRW. Water level data were mainly adopted from assumptions made as part of the FPMS.

Design flood hydrographs[1] and cumulative flow volumes for each of the priority areas (and their respective reaches) are provided in Figure 4-1 through Figure 4-7. Applications of these hydrographs during hydraulic modelling are discussed further in Section 5.

[1] Flow is designated by the letter “Q” in these figures.

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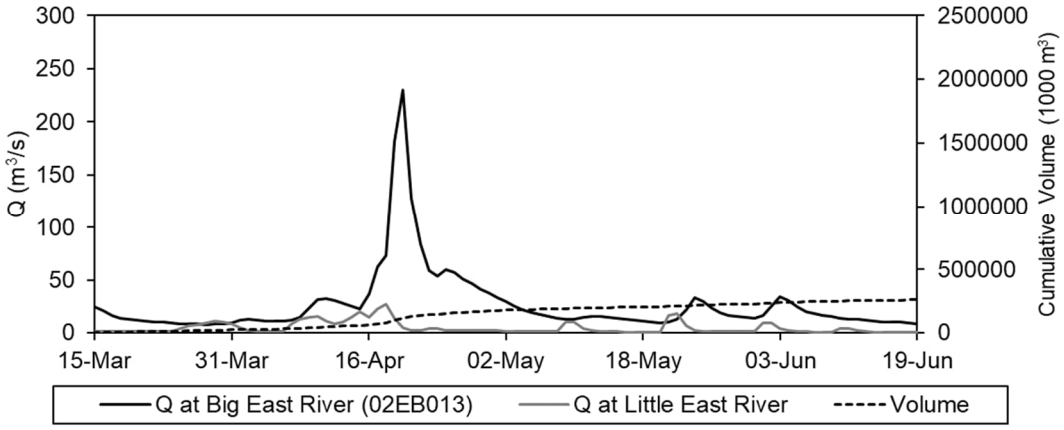

Figure 4-1: Design flood hydrographs to the *Upper Big East River* reach (Year 2013)

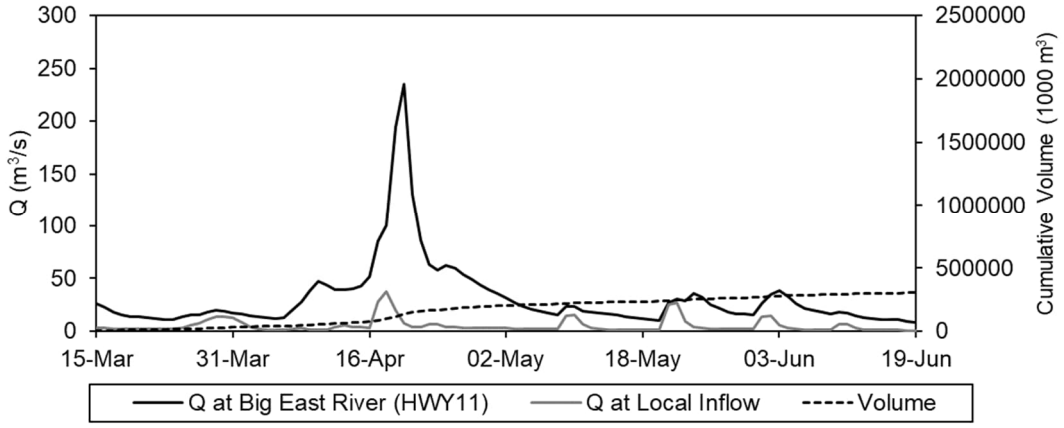

Figure 4-2: Design flood hydrographs to the *Lower Big East River* reach (Year 2013)

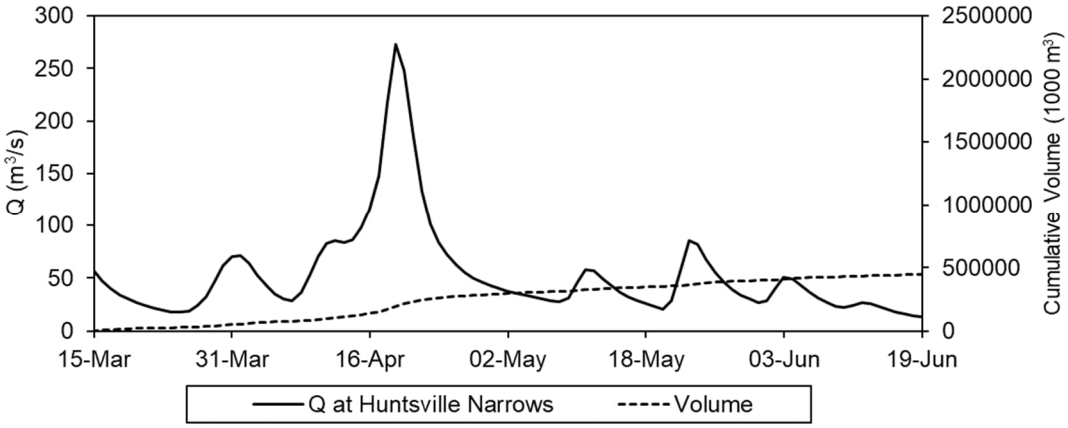

Figure 4-3: Design flood hydrograph to the *Huntsville Narrows* reach (Year 2013)

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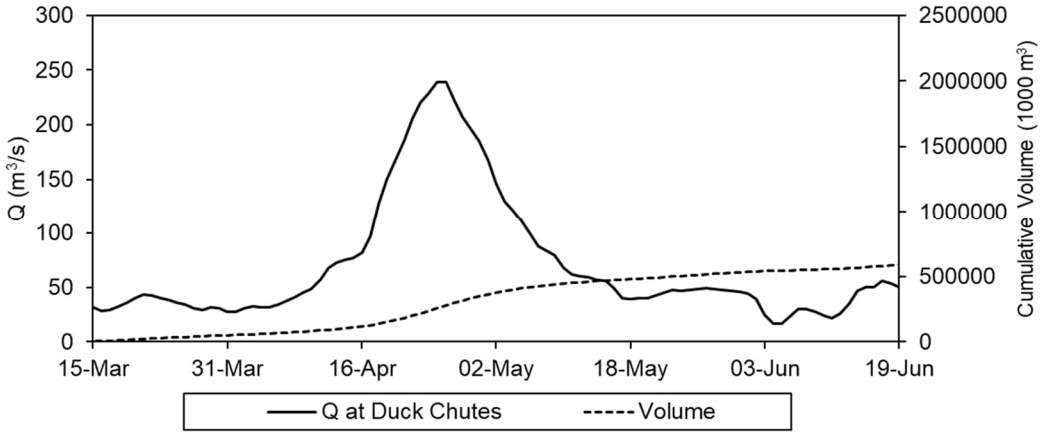

Figure 4-4: Design flood hydrograph to the *Springdale* reach (Year 2019)

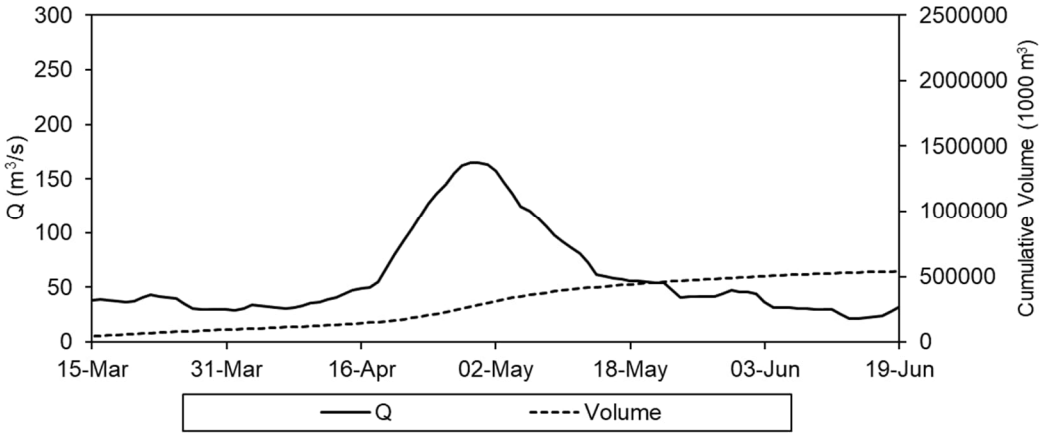

Figure 4-5: Design flood hydrograph to the *Baysville* and *Fraserburg* reaches (Year 2019)

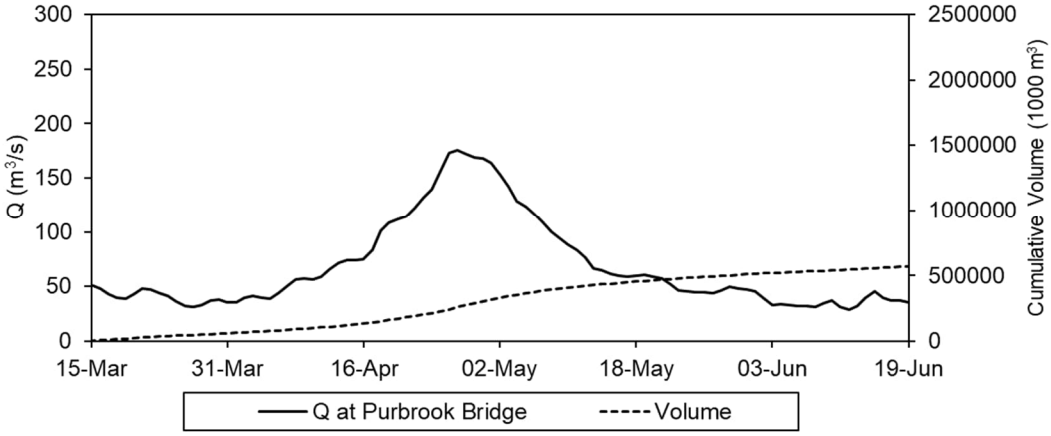

Figure 4-6: Design flood hydrograph to the *Purbrook* reach (Year 2019)

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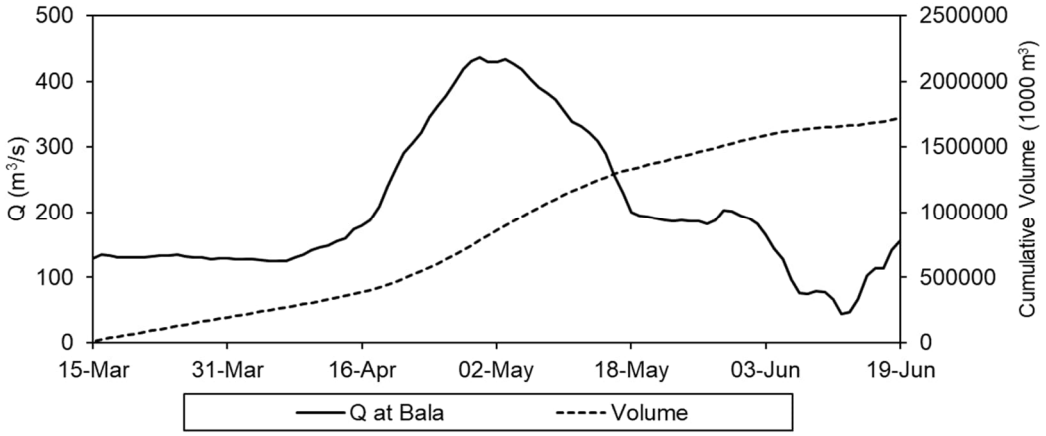

Figure 4-7: Design flood hydrograph to the *Muskoka/Bala* reaches (Year 2019)

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5. Hydraulic Systems and Environmental Review Methodology

5.1 Hydraulic Systems

As discussed in the Section 2.3, all hydraulic models used to facilitate this study associated were adopted from the FPMS. A summary of these models is presented in Table 5-1. As indicated in Table 5-1, the following changes to select FPMS models were pursued to satisfy the objectives of this study:

- **Extension of the Muskoka/Bala model upstream from Bala Park Island**: The Muskoka/Bala model adopted from the FPMS had an upstream boundary at the tailrace of Bala Dam. To simulate the Bala Park Island constrictions (Section 6.5), three additional reaches were added to extend the model boundary upstream from the island. The use of junctions was included to estimate the proportion of total Lake Muskoka outflow through each of the three island constrictions. Bala Dams were represented by a rating curve relating Bala Bay water level and Bala Bay outflow, which was sourced from the DOM (OMNR, 1997 with 2007 updates). Further details on the model expansion are as follows:
  - Bathymetry of the three constriction channels was based on sonar data collected using a HydroLite-TM (Transom Mount) survey kit combined with a Trimble® R10 GNSS system. The geometry of train bridges was incorporated into the hydraulic model and based on survey points collected by field surveyors of main features, including pier widths/locations and soffit elevations.
  - Channel bed roughness (0.035) and floodplain roughness (0.06) values for the Bala Reach Section were assigned in the FPMS model were adopted herein. Contraction and expansion coefficients for each constriction channel were set to 0.6 and 0.8, respectively, which are higher than typical values. These values are justified as they properly represent the hydraulic losses associated with lake-river flow transitions. Cross-sections representing Bala Bay and Lake Muskoka were given a very low assumed bed elevation (as no bathymetry was available for lake sections), under the assumption of negligible hydraulic losses between lake cross-sections.
  - Small adjustments to the location of the downstream boundary at Moon Chutes were required. Following these adjustments, the model yielded an adequate simulation of Lake Muskoka water levels during both the 2013 design flood event (0.03 m error, observed greater than simulated) and the 2019 design flood event (0.05 m error, simulated less than observed). The model set-up is shown in Figure 5-1.

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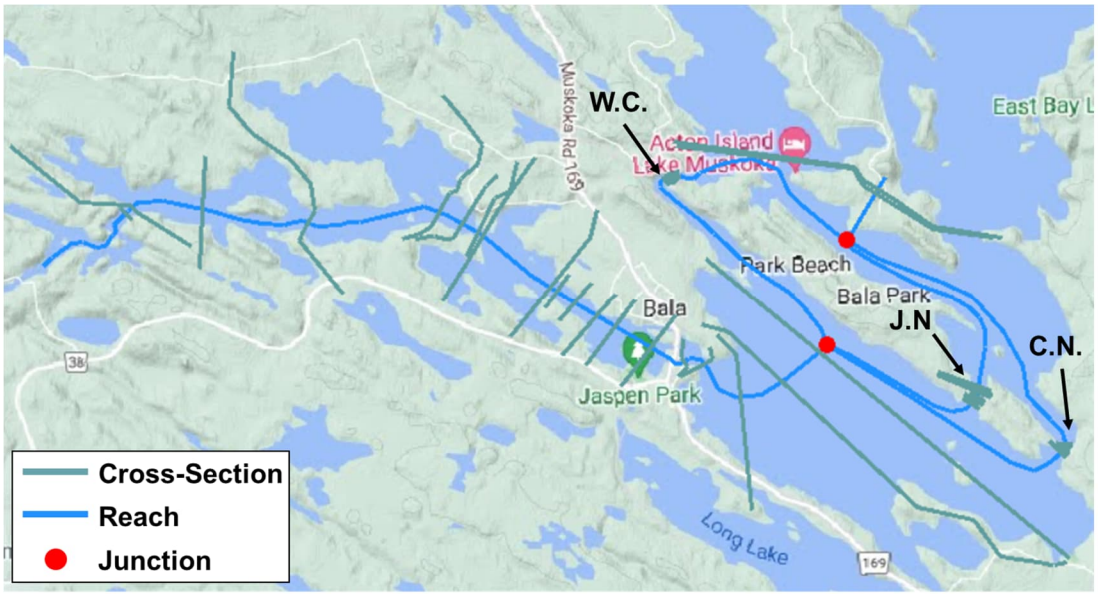

Figure 5-1: Extension of Muskoka/Bala model through Wallis Cut (W.C.), Jannacks Narrows (J.N.) and Coultier Narrows (C.N.); General flow direction from right to left

- **Application of unsteady flow settings**: Previous studies were conducted using steady state hydraulic models. However, the availability of design flood hydrographs for each model provides opportunity to conduct unsteady simulations. Unsteady simulations include application of time-varying flows and/or water levels at model boundaries, while steady simulations consider a single time-invariant value at each boundary. In general, it is expected that steady simulations may yield slightly higher water levels relative to unsteady simulations, and that unsteady simulations yield higher accuracy results.
- While unsteady simulations were applied for most models, only steady simulations were performed for Fraserburg and Muskoka/Bala models. This approach is due to the presence of multiple hydraulic controls within these reaches, which presents a challenging condition for achieving model stability in an unsteady model simulation. The implication of this decision is that water levels in Fraserburg and Muskoka/Bala should be considered to be slightly conservatively high for the design flood event.
- **Q-WSE critical depth rating curve**: Application of unsteady flow simulations at Baysville required development of a critical depth rating curve. This pursuit included simulating downstream critical depth over a range of steady flow conditions to develop a curve and applying this curve as a downstream boundary condition during the unsteady flow simulation.

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Table 5-1: Summary of Priority Area Hydraulic Models (red bolded entries indicate required FPMS model changes)

Priority Area	Type of Model	Design Flood Event Year	Reach	Upstream Model Boundary	Downstream Model Boundary	Downstream Water Level Boundary for *Baseline Case*	Steady or Unsteady Simulation Settings	Original Model Source
Big East River	2D	2013	Upper Big East River	Williams Port Little East River	Big East at HWY 11	Q-WSE Rating Curve	**Unsteady[1]**	(Hatch 2020)
			Lower Big East River	Big East at HWY 11 Local inflow	Lake Vernon	Constant Water Level (286.68 m)	**Unsteady[1]**	(Hatch 2020)
Huntsville Narrows	1D	2013	Huntsville Narrows	Lake Vernon	Fairy Lake	Constant Water Level (285.3 m)	**Unsteady[1]**	(Hatch 2020)
Springdale	1D	2019	Springdale	Duke Chutes	High Falls GS Head Pond	Constant Water Level (270.8 m)	**Unsteady[1]**	(Hatch 2020)
Baysville/ Fraserburg/ Purbrook	1D	2019	Baysville	Baysville Dam	Fairy Falls	**Q-WSE Critical Depth Rating Curve[1]**	**Unsteady[1]**	(Hatch 2020)
			Fraserburg	Fairy Falls	Purbrook Bridge	Normal Depth	Steady[2]	(Hatch 2022b)
	1D & 2D		Purbrook	Purbrook Bridge	Matthias GS Head Pond	Constant Water Level 293.5 m	**Unsteady[1]**	(Hatch 2020)
Muskoka/Bala	1D	2019	Lake Muskoka Bala Bay Bala Reach (U/S of Moon Chutes)	**U/S of Bala Park Island[1]**	Moon Chutes	Critical Depth	Steady[2]	(Hatch 2020)
			Bala Reach (D/S of Moon Chutes)	Moon Chutes	D/S of Ragged Rapids and Moon Chutes	Normal Depth		(Hatch 2022c)

[1]Model changes from FPMS for application are described in Section 5.
[2]The presence of numerous hydraulic controls within Fraserburg and Muskoka/Bala models posed constraints for applying unsteady simulation settings.

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5.1.1 Flood Impact Assessment

The degree of flood impacts in the Baseline Case and Mitigation Case was quantified through the combination of two specific metrics:

- *Flood Inundation Area*: defined as the horizontal extent of impacted land and water regions during peak water levels.
- *The Number of Impacted Structures*: determined by comparing a structure's footprint with the flood inundation area. Intersection between these two datasets triggers identification of an impacted structure.

Supplemental datasets of zoning and structure classification were incorporated into the assessment as well. These supplemental datasets are as follows:

1) Zoning classes: Generalized zoning classes were derived from zoning geospatial data obtained for the municipalities of *Town of Huntsville, Town of Bracebridge, Town of Gravenhurst, Township of Muskoka Lakes, Township of Lake of Bays,* and *Township of Georgian Bay*. These generalized zoning classes (e.g., Residential, Commercial, Environmental Protection, etc) were inferred from more detailed classification data in the zoning datasets. Zoning classes were applied to characterize land area percentages within each 'flood inundation area'.
2) Classified building footprints: Classified building footprint geospatial data was provided by DMM, and these data were applied to categorize 'impacted structures' as part of the study. Accordingly, these classification data were considered preliminary and may require future review/refinement by DMM.

Note that classified building footprint data were not available for all areas of the study, and in these cases, non-classified impacted structures are counted with a classification of 'no data'.

5.2 Environmental

The environmental review provided a summary of existing natural heritage conditions to inform the evaluation of the alternative flood mitigation measures, as well as to identify recommended studies to be completed to inform environmental permitting and approvals requirements to proceed.

Available background information related to the natural environment within each priority area was collected and reviewed in order to document natural features such as woodlands, wetlands (including unevaluated and evaluated Provincially Significant Wetlands [PSWs]), fish and fish habitat, general wildlife habitat, and Species at Risk (SAR) occurrences. The SAR identified were defined as species listed as Special Concern (SC), Threatened (THR), or Endangered (END) under Schedule 1 of the federal *Species at Risk Act (2002)* (SARA) and/or under the *Endangered Species Act (2007)* (ESA) *Ontario Regulation 230/08: Species at Risk in Ontario List.*

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A number of sources were consulted in this desktop review, including the following:

- Applicable Ministry of Natural Resources and Forestry (MNRF) databases and mapping layers including
  - Land Information Ontario (LIO) database (MNRF 2020)
    - Fish Activity Area
    - Aquatic Resource Area
    - Wildlife Value Areas
  - Natural Heritage Information Centre (NHIC) database (2022); and
  - Fish ON-Line
- Ontario Breeding Bird Atlas (OBBA) (Bird Studies Canada (BSC), et al. 2006)
- Fisheries and Oceans Canada (DFO) Species at Risk Mapping Tool (DFO 2022)
- 'Herps of Ontario' database in iNaturalist (iNaturalist 2020). Previously known as the Ontario Reptile and Amphibian Atlas
- Atlas of the Mammals of Ontario (Dobbyn 1994)
- Lower and upper tier Official Plans including
  - District of Muskoka Official Plan (The District of Muskoka Community and Planning Services Department, 2019)
  - Town of Huntsville Official Plan (2019)
- Muskoka Watershed Report Card (2018)
- Aerial photography.

Baseline Case Conditions

Various environmental features identified during the desktop review noted above were reviewed. The results of the review are presented in a 'Baseline Case Environmental Review Table' (Table 7-2) and are intended to provide an overview of potential impacts to both natural features and agricultural/residential properties during baseline flood conditions.

Mitigation Case Conditions

The environmental features documented during the desktop review were then reviewed against the mitigation case scenarios to determine the impacts of altered inundation zones, as well as high-level potential impacts from preliminary potential construction methodologies associated with each preferred solution. These findings have been presented in a 'Mitigation Case Environmental Review Table' (Table 10-1) along with supporting text in Section 10.1.

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Alterations to the flow regime within the watershed may result in changes to habitats or ecosystem functions. These potential impacts should be considered in parallel to designing the mitigation measure so that impacts can be minimized through planning of subsequent design phases. For each option, potential environmental impacts were identified at a desktop level through the following steps:

1. Previously published Geographic Information System (GIS) database layers were applied to a base map of the Muskoka River watershed. Features include sensitive ecosystems such as unevaluated and evaluated wetlands including PSWs, Areas of Natural and Scientific Interest (ANSI), and specialized habitats such as significant bird areas, critical fish habitat (as defined by a species' recovery strategy and available on DFO mapping), spawning areas, etc.
2. During selection of flood mitigation options, highly sensitive areas (i.e., presence of potential SAR habitat, habitats highly sensitive to alteration, etc) were reviewed to identify areas where flood mitigation measures may have elevated risks of significant impacts.
3. Once options for flood mitigation were selected, measures that require permanent alteration to environment such as deepening channels, increasing flood flow capacity, and placement of flood control structures were reviewed to identify permanent alterations to the landscape that could alter the surrounding natural environment.
4. Predicted flood water levels following implementation of the mitigation measures were reviewed to assess if temporary flood impacts would impact sensitive ecosystems under flood conditions. This assessment was based upon previously mapped features and focused on areas that may have significant negative impacts if the area is temporarily flooded.
5. Mitigation measures were reviewed to determine if they will alter flow patterns upstream and downstream from the mitigation measure area. For example, increasing flow through a structure by lowering water levels that may impact wetland storage or if water level changes would impact potential fish spawning habitat. These impacts were identified based upon mapped features contained in existing databases.
6. Natural areas that suggest there is potential for sensitive habitats to be present where permanent alteration may affect these habitats were identified using the existing databases. These areas have been identified for field surveys during the design phases (Table 10-3) should the flood mitigation measure be selected for implementation.
7. Based on the work required for each mitigation measure, a preliminary list of permits that may be triggered was developed (Section 10.3.2). Additional studies that may be required for each permit were also identified.

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8. For each option, additional potential field surveys have been identified to refine potential impacts and to assist with refining the design that can also be included with permit applications (Table 10-3).

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6. Baseline Case Hydraulic Systems Review

This section presents findings of a review of select hydraulic systems within the MRW. These findings are in the context of each priority area individually, thus establishing the Baseline Case conditions required to inform development of flood mitigation options. With a sub-section for each priority area, references are made to full-page tables located in Section 6.6, including

- Table 6-1: Baseline Case Flood Inundation Area, Number of Impacted Structures, and Impacted Structure Density
- Table 6-2: Baseline Case Number of Impacted Structures (Including Classification)
- Table 6-3: Baseline Case Flood Inundation Area (Including Zoning Classification).

Plan and profile view of Baseline Case flood conditions within each priority area are included as full-page maps at the end of Section 6.

6.1 Big East River

Big East River functions as a major tributary within the North Branch of the MRW. The river originates at East End Lake in Algonquin Provincial Park and terminates at Lake Vernon. The sub-watershed of the Big East River includes numerous large lakes such as Bella Lake and Rebecca Lake, and at the mouth of the Big East River (i.e., Lake Vernon) its drainage area is approximately 650 km^2. The *Big East River* priority area extends from 1 km downstream from Williamsport Road to the mouth at Lake Vernon. As shown in Figure 6-1, this reach features evidence of dynamic channel activity, through the presence of both channel meandering and oxbow features.

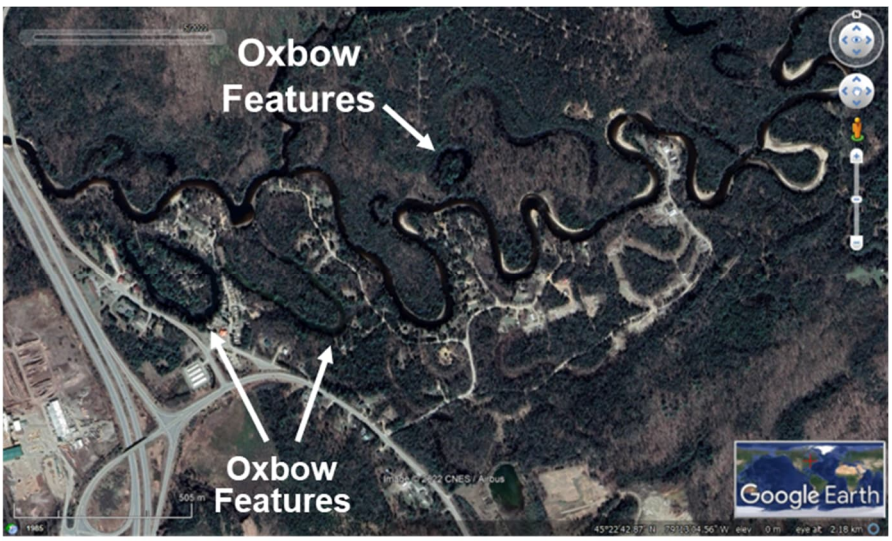

Figure 6-1: Oxbow features of the Big East River upstream from HWY11 (flow from right to left). (Source: Google Earth™ Imagery)

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The sinuosity (i.e., degree of curvature and bending) of the Big East River was calculated to be approximately 2.6 within the priority area. A sinuosity of 2.6 corresponds with a meandering channel (Mueller, 1968), and further reinforces the dynamic nature of the channel. Satellite imagery and geospatial data of structure footprints show significant development within the river's meander belt, which is defined as the space that the meandering watercourse occupies on its floodplain (Parish Geomorphic, 2004).

The flood inundation area for the Baseline Case is the largest of any priority area (9.64 km^2; Table 6-1), which is attributed to the Big East River's expansive floodplain. The majority of the flood inundation area (97%) is classified as Natural Resources (Table 6-3). The expansive extent of overland flooding in the Baseline Case (Figure 6-10) is consistent with Natural Resources zoning, as floodway and flood fringe areas are included in this zone. Within the flood inundation area, 620 structures are impacted, most of which are classified as either commercial or residential (see Figure 6-2).

The impacted structure density is 64.3/km^2 of flood inundation area, which is moderate relative to other priority areas. As shown in Figure 6-10, high density clusters of impacted structures are observed in the Big East Delta up to upstream from Ravencliffe Bridge (river stations 0 to 4000 m), near Highway 11 South Bound (approximately river station of 8000 m), and near River Cove Dr. and Robert RD W (approx. river station of 16,000 m). One notable area of high head loss is across the Highway 11 and Railway bridges between river stations 13,000 and 15,000 m.

The water surface profile of the Big East River is influenced both by Lake Vernon water level and the incoming flows from the sub-watershed. Flows from the Big East River sub-watershed are regulated by several upstream dams. The most downstream from these dams, Distress Dam (location shown in Figure 3-2), has a drainage area of 464 km^2. In 2000, Distress Dam was converted to a spill structure (as described in the DOM (OMNR, 1997 with 2007 updates)) and, in essence, functions as a weir to control flow and water levels. The DOM (OMNR, 1997 with 2007 updates) lists the purpose of the dam as being for recreation, and the current state of the structure is shown in Figure 6-2.

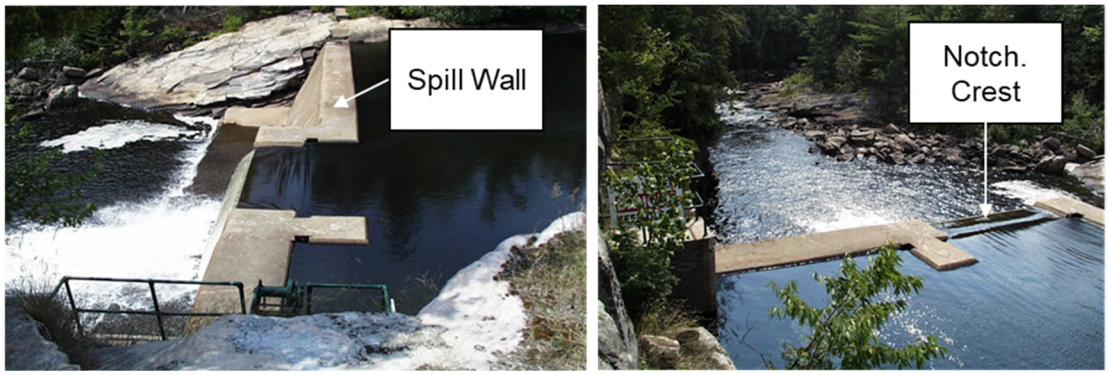

Figure 6-2: Existing control structure at Distress Dam upstream from the *Big East River* priority area. (Source: the DOM [OMNR, 1997 with 2007 updates])

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6.2 Huntsville Narrows

The Huntsville Narrows is a section of the Muskoka River North Branch that flows through the Town of Huntsville in an easternly direction. This reach is highly urbanized and features two bridges – the Centre Street bridge and the Main Street East swing bridge. The swing bridge (Figure 6-3) is not currently operated for navigation passage but remains accessible for crossing by vehicle and pedestrian traffic.



Figure 6-3: Huntsville swing bridge (flow from left to right). (Source: Site Visit May 2022)

Immediately upstream from the swing bridge in the north-side floodplain is a commercial area that is particularly low-lying relative its adjacent shoreline along the Muskoka River (Figure 6-4).

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Figure 6-4: Low-lying shoreline (foreground) and adjacent commercial area (background). (Source: Site Visit May 2022)

The Huntsville Narrows priority area includes the Muskoka River North Branch from Lake Vernon (upstream) to Fairy Lake (downstream). The flood inundation area for the Baseline Case (1.19 km^2) of Huntsville Narrows is comparatively small amongst the priority areas. The zoning classifications for the Baseline Case flood inundation area are diverse due to the urban setting (Table 6-3), although predominant classes include residential (35%) and commercial (22%).

Within the Baseline Case flood inundation area, there are 77 impacted structures. Included in this structure count is 27 boat houses, which are represented by a horizontal track of low-lying points within the inset graph at an elevation of 283.35 m (Figure 6-11). A significant number of the remaining impacted structures are located in the adjacent commercial area north of the Muskoka River North Branch between river stations 3000 and 4000 m. The impacted structure density in the Huntsville Narrows reach is 64.7/km^2 of flood inundation area, which is moderate relative to other priority areas.

Much of the flooding in Huntsville Narrows is attributed to backwater caused by the swing bridge, which is consistent with the previous identification of this structure as a possible

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hydraulic ‘choke point’ (Cragg 2020). Another primary cause is high water levels both upstream (Lake Vernon) and downstream (Fairy Lake) of Huntsville Narrows.

Water levels through the Huntsville Narrows are a function of water level in the Huntsville Lakes, specifically Lake Vernon (upstream) and Fairy Lake (downstream). Along with Peninsula Lake, Lake Vernon and Fairy Lake comprise the ‘Huntsville Lake’, and all three of these interconnected lakes are regulated by the Huntsville Dam. This dam is located 5 km downstream from the swing bridge and 0.7 km downstream from the Fairy Lake outlet.

6.3 Springdale

Springdale is an area of the Muskoka River North Branch downstream from Mary Lake, which is downstream from the Huntsville Lakes. As shown in Figure 6-12, the Springdale reach is flanked by many residential shoreline properties (e.g., between river station 1000 and 2000 m), including a high density of properties along Shoreline Road (approx. river station of 3000 m). Satellite imagery and site visit observations indicate extensive forest cover along most of the shoreline for this reach. The Springdale priority area includes the Muskoka River North Branch from Duck Chutes (upstream) to the High Falls GS head pond (downstream; Figure 6-5).



Figure 6-5: Aerial footage High Falls GS and head pond during the 2019 design flood (flow in the upwards direction) (Source: Muskoka Flood 2019 video footage)

The flood inundation area of the Baseline Case (0.57 km^2) is small relative to the other priority areas. Residential zoning comprises the majority of zoning within the flood inundation area (74%; Table 6-2). Within the flood inundation area, there are 109 structures, almost all of which are residences or associated outbuildings and sheds (Table 6-2). Despite its relatively

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small flood inundation area, this reach features the highest impacted structure density (191.2/km^2 of flood inundation area).

Water levels in this reach are highly influenced by regulation at High Falls GS via its upstream head pond, which is operated by Bracebridge Power. An increase in head pond elevation results in an increase in upstream water levels through the Springdale reach resulting from natural head loss in the river. This backwater effect terminates at Duck Chutes, as the chutes function as a hydraulic control ('choke point'), and as a result Muskoka River North Branch water levels upstream from Duck Chutes are insensitive to the backwater influence of regulation at High Falls GS.

6.4 Baysville/Fraserburg/Purbrook

The Baysville/Fraserburg/Purbrook priority area is part of the Muskoka River South Branch. At its upstream end is Lake of Bays, which features a drainage area of 601 km^2 and receives inflows from major rivers including the Oxtongue River, Hollow River and the Boyne River. Lake of Bays has the second-largest surface area of all lakes in the Muskoka River Watershed (68 km^2), and water levels in the lake are regulated by the Baysville Dam at its outlet. The Baysville/Fraserburg/Purbrook priority area spans from the Baysville Dam to the Matthias GS head pond. This priority area is divided into three reaches—*Baysville* (Baysville Dam to Fairy Falls), *Fraserburg* (downstream from Fairy Falls to Purbrook Bridge), and *Purbrook* (downstream from Purbrook Bridge to the Matthias GS head pond).

The hydraulic characteristics of these reaches can be evaluated in isolation from each other due to the presence of hydraulic controls ('choke points') that separate the reaches. These choke points inhibit influence of downstream features (e.g., bridges, dams, constrictions, etc) on upstream water levels. Hydraulic controls that separate these reaches include Fairy Falls (between Baysville and Fraserburg) and Purbrook Rapids (between Fraserburg and Purbrook).

The following sections describe the Baseline Case conditions for each reach of the Baysville/ Fraserburg/Purbrook priority area.

6.4.1 Baysville

The Baysville reach is located between Baysville Dam and Fairy Falls. The flood inundation area for the Baseline Case (0.51 km^2) is the smallest of all priority area reaches. Residential zoning comprises the majority of the flood inundation area (88%; Table 6-3). Within the flood inundation area, there are 12 structures, almost all of which are residences or associated outbuildings and sheds (Table 6-2).

This reach features the lowest impacted structure density of all priority area reaches (23.5/km^2 of flood inundation area). Closer inspection of the location of impacted structures in Figure 6-13 shows that impacted structures are well-distributed throughout the flood inundation area. The implication of this being that a significant reduction in flood inundation area is likely required to reduce flood impacts to a small number of structures. This situation

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creates a challenging constraint to overcome in the development of feasible flood mitigation options.

6.4.2 Fraserburg

The Fraserburg reach is located between downstream from Fairy Falls and Purbrook Bridge. The reach features a highly meandering channel section near the Fraserburg Road bridge. Aerial footage from the 2019 design flood event shows that the channel capacity was exceeded in this reach resulting in overtopping of the bridge (Figure 6-6).



Figure 6-6: Aerial footage of the Fraserburg Road Bridge overtopping during 2019 design flood event (flow from right). (Source: Muskoka Flood 2019 video footage)

The flood inundation area for the Baseline Case (2.01 km^2) is comparatively moderate amongst the priority areas. Zoning classifications within the flood inundation area are closely divided between residential (50%) and combination of environmental protection (33%) and open space (11%) (Table 6-3). Within the inundation area there are 49 structures, most of which are located between Fraserburg Road bridge and May Chutes (Figure 6-14). While no data were available to categorize these structures, a cursory review of zoning classifications suggests that most of these structures are likely either residential or sheds/outbuildings. Further ground-truthing would be required to verify this assessment.

The impacted structure density of the Fraserburg reach (24.4/km^2 of flood inundation area) is comparable to the Baysville reach (23.5 km^2). However, a more detailed assessment of conditions in Figure 6-14 indicates that impacted structures are closer together in the Fraserburg reach as compared to the Baysville reach. This means that at a sub-reach scale, impacted structure density is higher in the Fraserburg Reach. The presence of several hydraulic controls within the Fraserburg reach (e.g., May Chutes) present opportunities to

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implement mitigations that target specific clusters of impacted structures. Similar sub-reach flood mitigation approaches are not as easily identified for the Baysville to Fairy Falls reach.

6.4.3 *Purbrook*

The Purbrook reach is located between Purbrook Bridge and Matthias GS head pond. The flood inundation area for the Baseline Case (4.36 km^2) is largest amongst all priority area reaches. Unlike other reaches, the majority of zoning within the flood inundation area is Environmental Protection (79%; Table 6-3). This is due to the presence of several large wetlands that are flood impacted under design flood conditions (Figure 6-15).

Within the flood inundation area, there are 145 structures, almost all of which are residences or associated outbuildings and sheds (see Table 6-2). Despite the large number of impacted structures, this reach features a low impacted structure density (33.3/km^2 of flood inundation area). Despite a low impacted structure density, there is high sub-reach impacted structure density in the Island Way region around river station 6000 m (Figure 6-15). Similar to the Fraserburg reach, the presence of hydraulic controls within the reach (i.e., Rocky Rapids) may present opportunities for sub-reach mitigation.

6.5 Muskoka/Bala

The Muskoka/Bala priority area is distinct from all other priority areas, due to the large size of the area. This priority area includes a network of lake and river reaches (*Lake Muskoka*, *Bala Bay*, and *Bala Reach*), which are separated by several hydraulic controls (Figure 6-7).

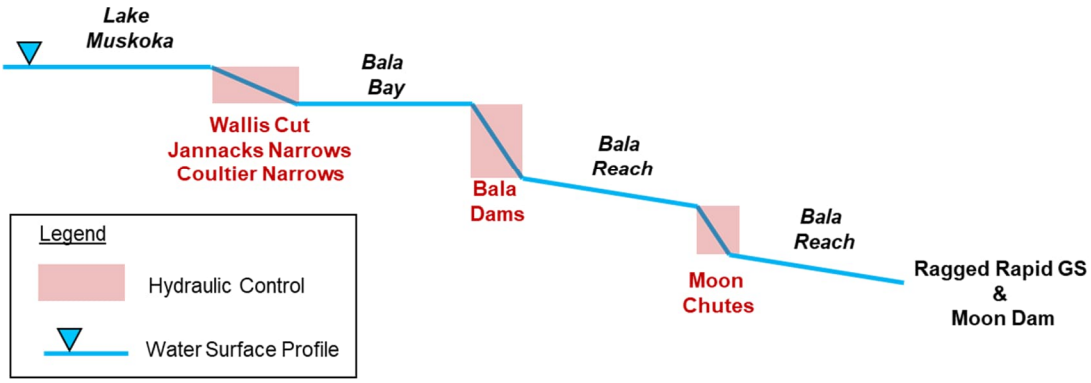

Figure 6-7: Schematic of the Muskoka/Bala priority area sub-reaches (*Lake Muskoka*, *Bala Bay*, and *Bala Reach (upstream from Moon Chutes* and *downstream from Moon Chutes*)

The following sections describe the reaches shown in Figure 6-7 that comprise the Muskoka/Bala priority area.

6.5.1 *Lake Muskoka*

Lake Muskoka is the largest lake in the Muskoka River watershed with a cumulative drainage area of 4683 km^2 (outlet at Bala Dams). Water levels in Lake Muskoka are a function of

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inflows from three sub-watersheds (North Branch, South Branch, and Lower Muskoka), as well as regulation at Bala Dams. Lake Muskoka water levels are also influenced by three constrictions at Bala Park Island, through which outflow is conveyed from Lake Muskoka to Bala Bay. Historical flow and water level observations indicate that the culmination of hydraulic losses across these three constrictions (Wallis Cut, Jannacks Narrows, and Coultier Narrows) can result in backwater leading to high Lake Muskoka water levels during flood events. For instance, during the 2019 design flood, a 0.45 m water level differential was observed in late-April between Lake Muskoka and Bala Bay (Figure 6-8).

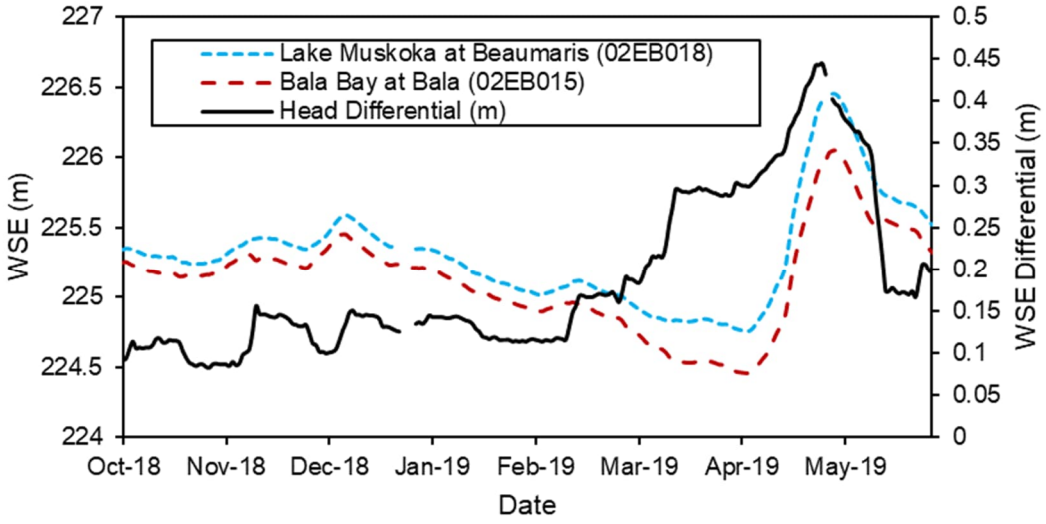

Figure 6-8: Observed hydrometric conditions during the 2018-2019 season at Lake Muskoka and Bala Bay

Hydraulic simulations of the 2019 design flood using the Muskoka/Bala model (see Table 5-1) indicate that less than 10% of total Lake Muskoka outflow (Q_T) is conveyed through Wallis Cut. The remainder of the flow is almost evenly conveyed through Jannacks Narrows and Coultier Narrows (Figure 6-9). A summary of flow conditions, along with photos of the Bala Park Island constrictions and their associated train bridge crossings, is shown in Figure 6-9.

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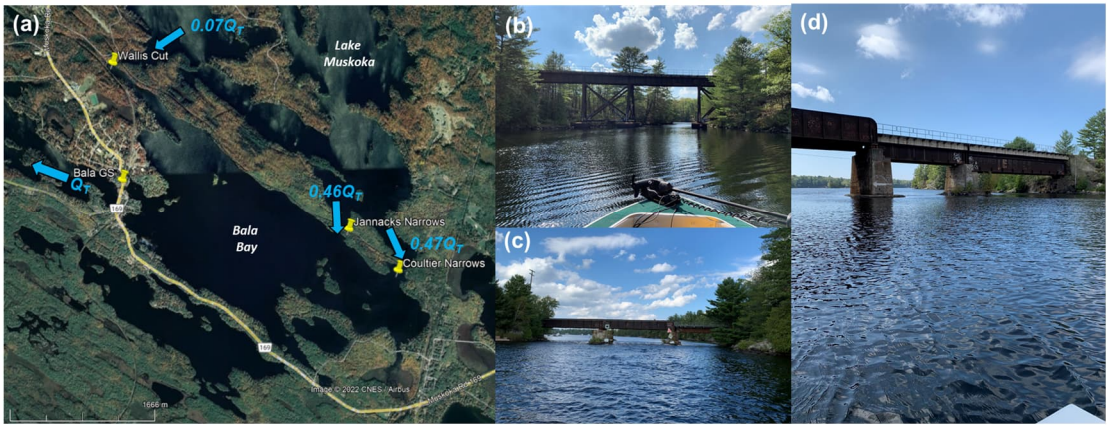

Figure 6-9: (a) 2019 design flood event flow distribution simulated at Bala Park Island constrictions; site photos of constrictions and bridge crossings at (b) Wallis Cut, (c) Jannacks Narrows, and (d) Coultier Narrows

It is notable that during the 2019 design flood, the flow capacity of the North Bala Dam and the South Dam exceeded the inflow capacity of the three constrictions combined, meaning that hydraulic control shifted to Bala Park Island.

The flood inundation area for the Baseline Case is approximately 122.5 km^2, however, this includes the surface area of Lake Muskoka (excluding Bala Bay). Of the 3339 impacted structures in the 122.5 km^2 flood inundation area, over two-thirds of these structures are boat houses, while most of the remaining are residences or associated outbuildings and sheds (see Table 6-2). The low impacted structure density (27.3/km^2 of flood inundation area) is diluted by the inclusion of Lake Muskoka water area within the flood inundation area.

The DOM (OMNR, 1997 with 2007 updates) indicates that the cumulative *surface* area of Lake Muskoka (including Bala Bay) is 120 km^2. Using geospatial data from the National Hydrographic Network (2019) the surface area of Lake Muskoka (without Bala Bay) was estimated to be approximately 116 km^2, meaning the flood inundation area (land-only) is approximately 6.5 km^2. Of the flooded inundated land area surrounding Lake Muskoka, residential zoning comprises the majority (63%), with the next largest portion designated as environmental protection area (16%; Table 6-3).

Exclusion of the Lake Muskoka water body from calculation of impacted structure density properly reflects the extent of flooding along the Lake Muskoka shoreline under the design flood. By applying the land-only flood inundation area (6.5 km^2), this reach has an impacted structure density of 514/km^2 of flood inundation area. Even when boathouses are excluded (as some flood impacts to these structures may be expected), the impacted structure density is 158/km^2 of flood inundation area, which is comparable to the highest impacted area at Springdale (Table 6-1).

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6.5.2 *Bala Bay*

Bala Bay is a section of Lake Muskoka downstream from the Bala Park Island constrictions (Figure 6-9). Water levels in Bala Bay are primarily a function of flows from Lake Muskoka upstream from Bala Park Island, as well as regulation at Bala Dams. The flood inundation area for the Baseline Case is approximately 4.79 km^2, however this includes surface area of the Bala Bay (approximately 4 km^2). Zoning classes of flood impacted lands surrounding Bala Bay are similar to those of the Lake Muskoka.

Of the 246 impacted structures along the shoreline of Bala Bay, approximately 70% are boat houses (see Table 6-2). Impacted structure density calculated by applying flood inundation land area only (0.79 km^2) yields an impact density of 311.3/km^2 of flood inundation area, although that number is reduced to 88.6/km^2 of flood inundation area if boat houses are excluded. A comparison of impacted structure densities suggests that flood impacts along Lake Muskoka are more severe than they are along Bala Bay, which is largely a reflection of backwater effect resulting from the Bala Park Island constrictions.

6.5.3 *Bala Reach*

For the purposes of this study, Bala Reach is defined as the river section spanning from the tailrace of Bala Dams to both Ragged Rapids GS and Moon Dam. This reach features numerous back bays with highly developed shorelines. The flood inundation of Bala Reach upstream from Moon Chutes is 4.79 km^2, where almost all land-affected areas (84%) are residential. Of the 237 impacted structures in the area, over 90% are residences or associated outbuildings and sheds (Table 6-2). The proportion of impacted structures that are boathouses is comparatively less for Bala Reach relative to either Lake Muskoka or Bala Bay.

Upstream from Moon Dam and Ragged Rapids GS is the Moon Chutes rapids, which functions as a choke point within the Bala Reach. The reach from Moon Chutes to the Moon Dam/ Ragged Rapids GS includes several locations of bifurcating or converging flow, which contributes to the hydraulic complexity of this area. As reported in the DOM (OMNR, 1997 with 2007 updates), a 2.06 m drop in water level across the chutes was measured in April 1980 during a flow event of 355 m^3/s. The DOM (OMNR, 1997 with 2007 updates) also reports that during high flows (>85 m^3/s), flow control shifts from Moon Dam and Ragged Rapids GS to Moon Chutes, meaning that this natural hydraulic constriction is a primary cause of high-water levels observed in Bala Reach upstream from Moon Chutes.

6.6 Summary of Flood Impacts

A summary of Baseline Case flood impacts are provided in Table 6-1, Table 6-2, and Table 6-3. These tables are cited throughout Section 9 where mitigation options are summarized. Following these tables are plan and profile views of Baseline Case flood conditions within each priority area (Figure 6-10 through Figure 6-16).

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Table 6-1: Baseline Case Flood Inundation Area, Number of Impacted Structures, and Impacted Structure Density

Priority Area	Reach	Flood Inundation Area[1] (km^2)	# of Local Impacted Structures (-)	# Impacted Structures per km^2 of Inundation Area (-)
Big East River	Big East River	9.64	620	64.3
Huntsville Narrows	Huntsville	1.19	77	64.7
Springdale	Springdale	0.57	109	191.2
Baysville/Fraserburg/Purbrook	Baysville	0.51	12	23.5
Baysville/Fraserburg/Purbrook	Fraserburg	2.01	49	24.4
Baysville/Fraserburg/Purbrook	Purbrook	4.36	145	33.3
Muskoka/Bala	Lake Muskoka	122.48	3339	See Section 6.5
Muskoka/Bala	Bala Bay	4.79	246	See Section 6.5
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	3.53	237	67.1
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	TBA	TBA	TBA

Notes:
[1]Inundation area includes both the area of the water body (i.e., river channel or lake), as well as adjacent floodplain areas surrounding the water body.
TBA – this information will be provided as part of the *Flood Modifications Review Report*

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Table 6-2: Baseline Case Number of Impacted Structures (Including Classification)

Priority Area	Reach	# of Impacted Structures	Classification[1,2]						
			B	C	I\I\SP	O	R	S	N/D
Big East River	Big East River	620	8	344	7	35	136	88	2
Huntsville Narrows	Huntsville	77	27	17	7	3	14	8	-
Springdale	Springdale	109	1	2	0	22	66	18	-
Baysville/Fraserburg/ Purbrook	Baysville	12	0	1	0	1	7	3	-
Baysville/Fraserburg/ Purbrook	Fraserburg[3]	49	0	0	0	0	0	0	49
Baysville/Fraserburg/ Purbrook	Purbrook	145	8	0	0	33	47	57	-
Muskoka/Bala	Lake Muskoka	3339	2307	84	2	152	564	228	2
Muskoka/Bala	Bala Bay	246	176	6	2	9	43	10	-
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	237	19	1	0	22	156	26	13
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

Notes:
[1]Definitions: B = boathouse; C = commercial; I\I\SP = industrial/institutional/special purpose; O = outbuilding; R = residential; S = shed; N/D = no data
[2]Structure classifications are based on data provided by DMM and are considered preliminary.
TBA – this information will be provided as part of the *Flood Modifications Review* report
[3]No structure classifications were available for the Fraserburg reach.

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Table 6-3: Baseline Case Flood Inundation Area (Including Zoning Classification)

Priority Area	Reach	Flood Inundation Area[2] (km^2)	Zoning Classification[1] (expressed as % of Inundation Area)										
			Commercial	Extractive	Industrial	Institutional	Natural Resources[3]	Environmental Protection	Open Space	Residential	Rural	Transportation[4]	Undefined
Big East River	Big East River	9.64	1%	<1%	<1%	<1%	96%	-	1%	<1%	1%	-	-
Huntsville Narrows	Huntsville	1.19	22%	-	13%	10%	3%	-	17%	35%	-	<1%	-
Springdale	Springdale	0.57	-	-	-	-	-	9%	6%	74%	11%	-	<1%
Baysville/Fraserburg/Purbrook	Baysville	0.51	1%	-	-	<1%	-	8%	3%	88%	-	-	-
Baysville/Fraserburg/Purbrook	Fraserburg	2.01	-	-	<1%	1%	-	33%	11%	50%	5%	-	-
Baysville/Fraserburg/Purbrook	Purbrook	4.36	-	-	<1%	-	-	78%	<1%	12%	10%	-	-
Muskoka/Bala	Lake Muskoka	122.48	4%	-	<1%	1%	-	16%	8%	63%	9%	<1%	-
Muskoka/Bala	Bala Bay	4.79	5%	-	1%	<1%	-	-	6%	87%	-	-	-
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	3.53	3%	-	-	-	-	3%	8%	84%	2%	<1%	-
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

Notes:
[1]Percentages may not add to exactly 100% due to rounding.
[2]Percentages exclude water bodies, which do not have a zoning classification.
[3]Includes floodway and flood fringe areas.
[4]Includes waterfront landings.
TBA – this information will be provided as part of the *Flood Modifications Review* report

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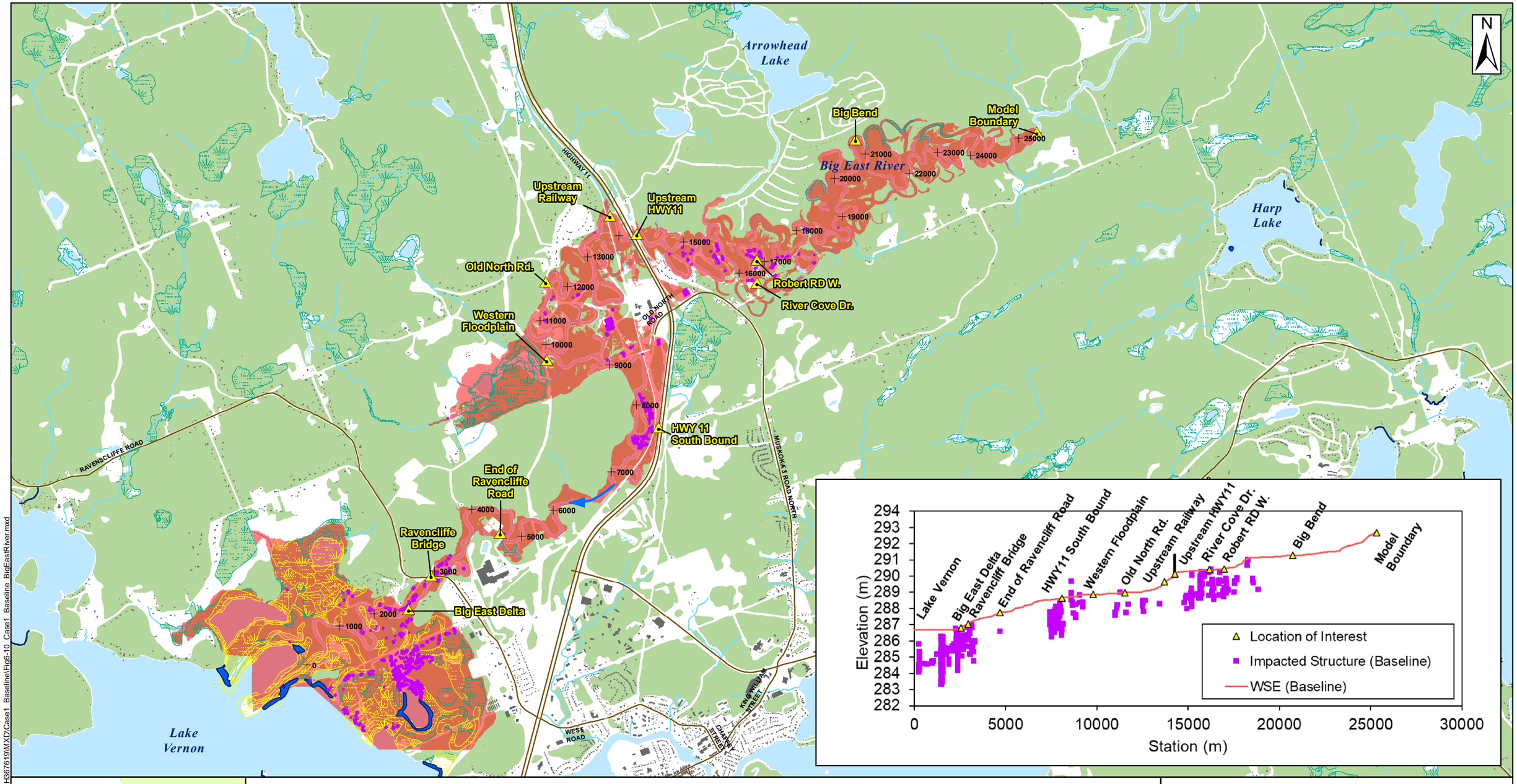

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LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- River Station (1000 m Intervals)
- Location of Interest
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

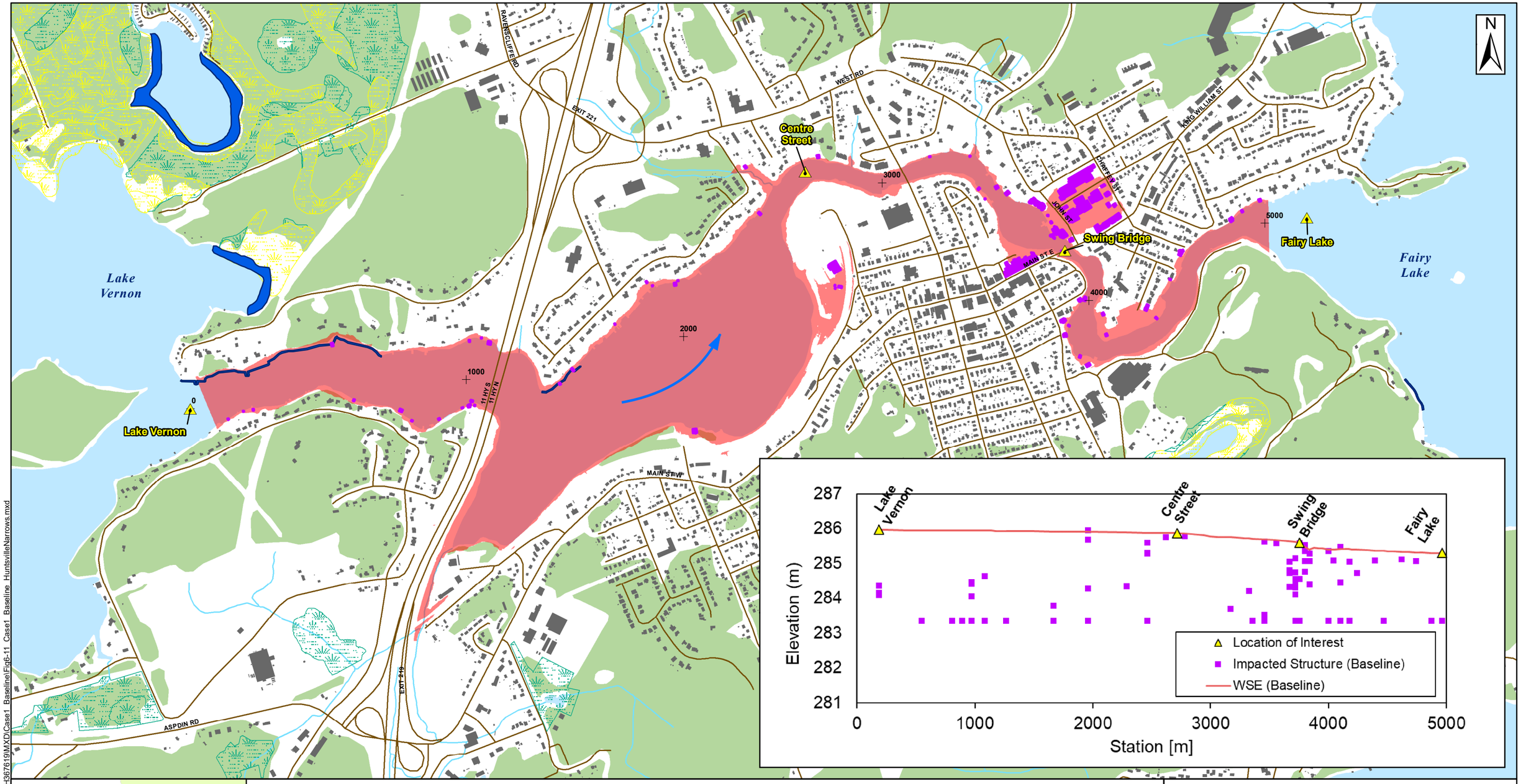
DATA SOURCES
1. Produced by Hatch, contains information used under the Open Government License - Ontario
2. Great Lakes, Political Boundaries - US Census Bureau
3. Spatial Referencing NAD83 UTM Zone 17N

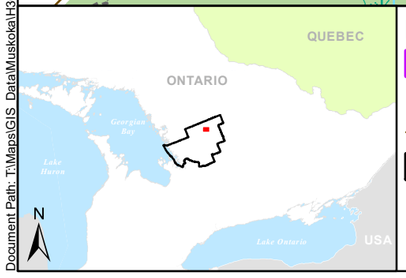
0 0.5 1 2 km

1:40,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Big East River
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:	HATCH
J. SNELGROVE	K. LEES	6-10	0	
DATE: 2022/09/12	PAGE: 1 of 1			





LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000m Intervals)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.125 0.25 0.5 km

1:13,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Hunstville Narrows
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	6-11	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

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Duck Chutes

5000

4000

3000

Springdale Shores

2000

1000

0

High Falls Head Pond

HIGHWAY 11

BONNIE LAKE ROAD

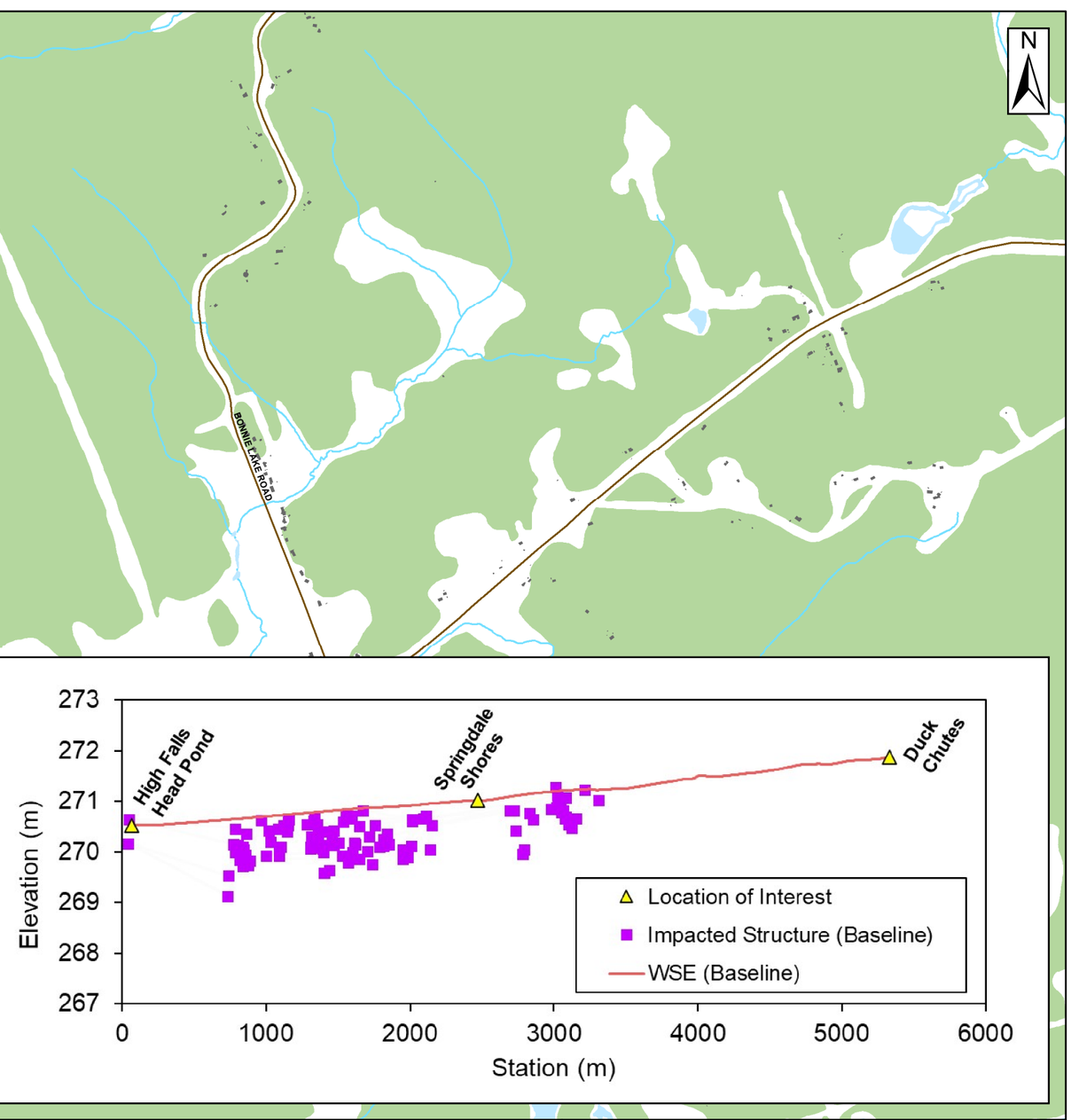
MUSKOKA ROAD 117

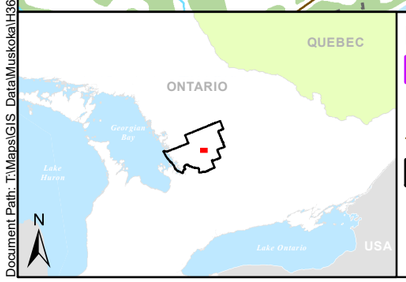
HOLIDAY PARK ROAD

HIGH FALLS ROAD

Muskoka River

N





LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Station (1000 m Intervals)
- Flood Inundation Boundary (Baseline)
- Wooded Area

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.25 0.5 1 km

1:18,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Springdale
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	6-12	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

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MUSKOKA ROAD 117

BRUNEL ROAD

ECHO LAKE ROAD

Baysville Dam

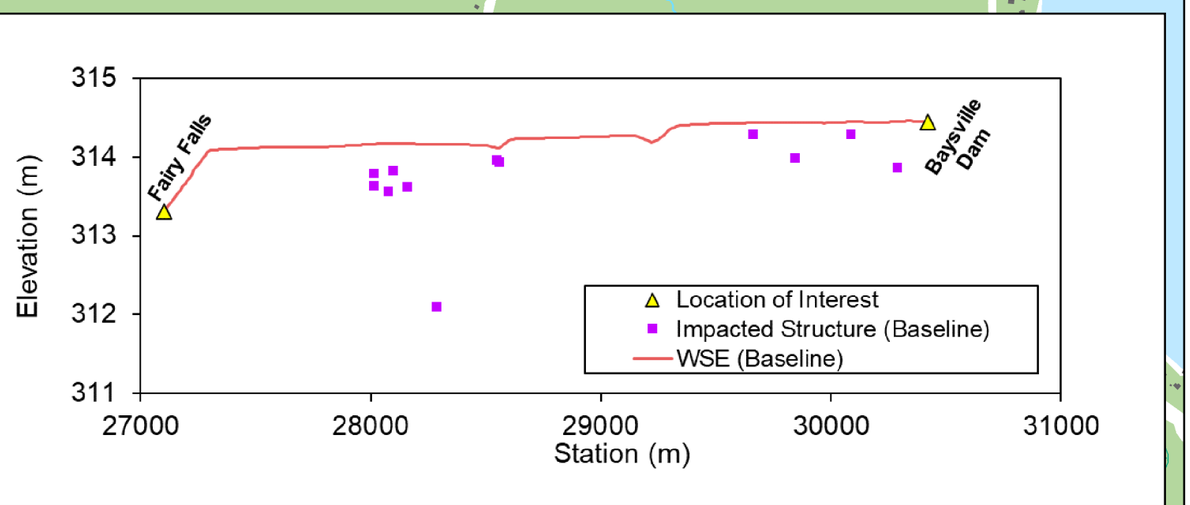
30000

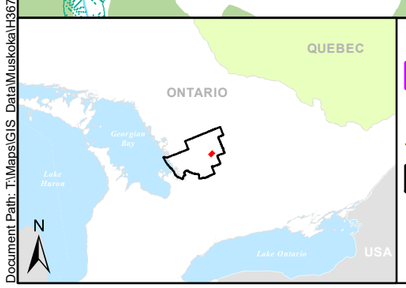
29000

28000

Fairy Falls

27000





LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Station (1000 m Intervals)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.125 0.25 0.5 km

1:12,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Baysville to Fairy Falls
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:	
J. SNELGROVE	K. LEES	6-13	0	HATCH
DATE: 2022/09/12	PAGE: 1 of 1			

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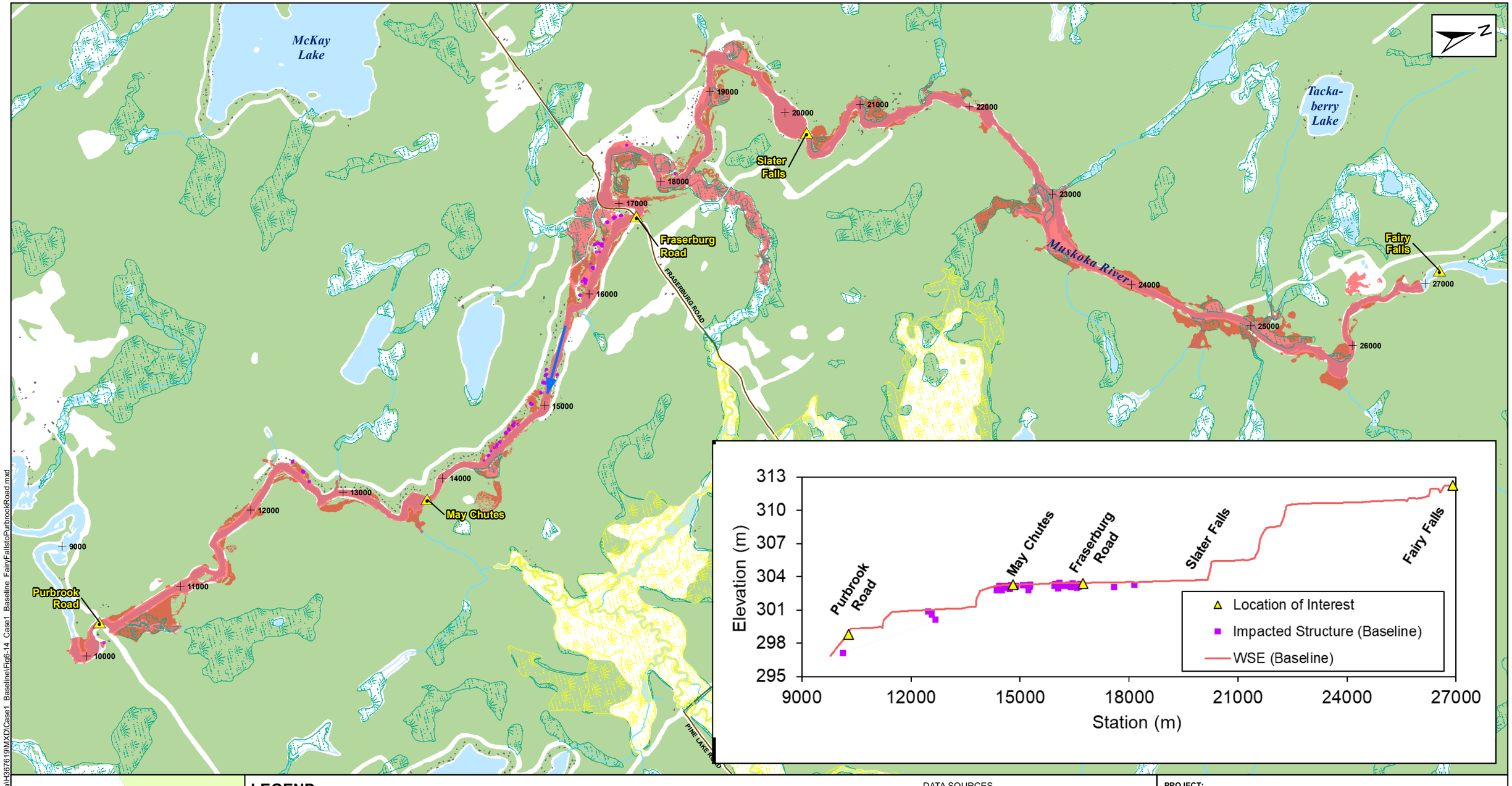

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QUEBEC
ONTARIO
USA
N

LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000 m Intervals)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland
- Flow Direction

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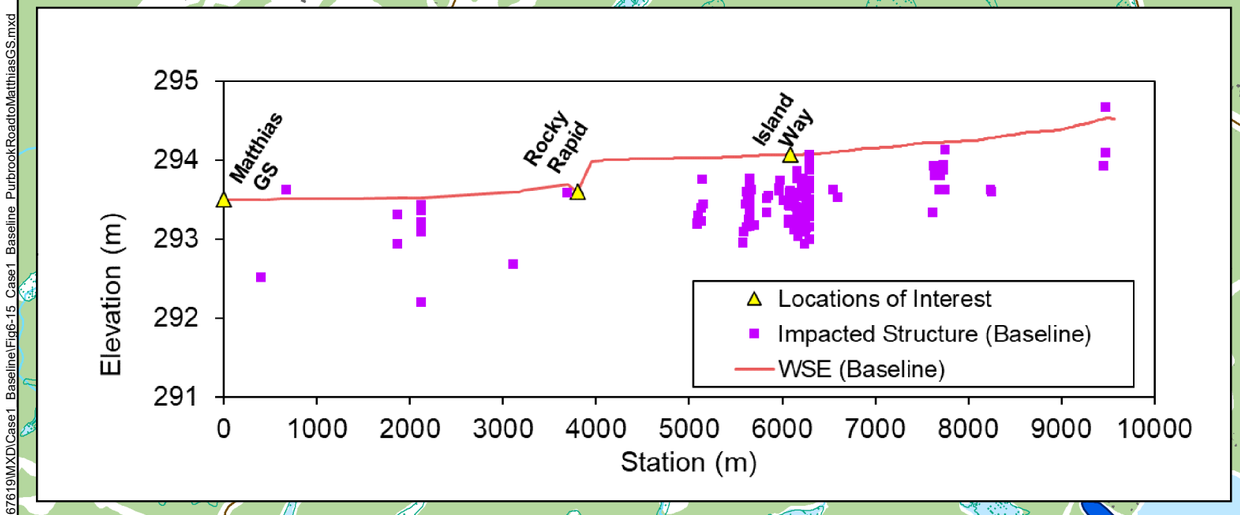
0 0.25 0.5 1 km
1:27,000

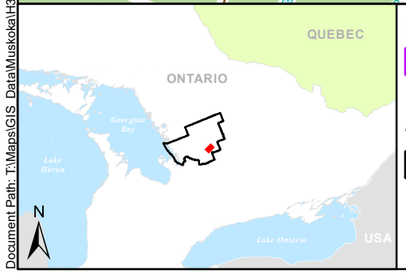
PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Fairy Falls to Purbrook Road
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	6-14	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

Matthias GS
0
1000
Rocky Rapids
3000
4000
5000
6000
7000
8000
9000
10000
11000
12000
Purbrook Road
Island Way
Muskoka River
Spring Lake
HIGHWAY 118





LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000 m Intervals)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.25 0.5 1 km

1:23,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Purbrook Road to Matthias GS
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	6-15	0
DATE: 2022/09/12	PAGE: 1 of 1		

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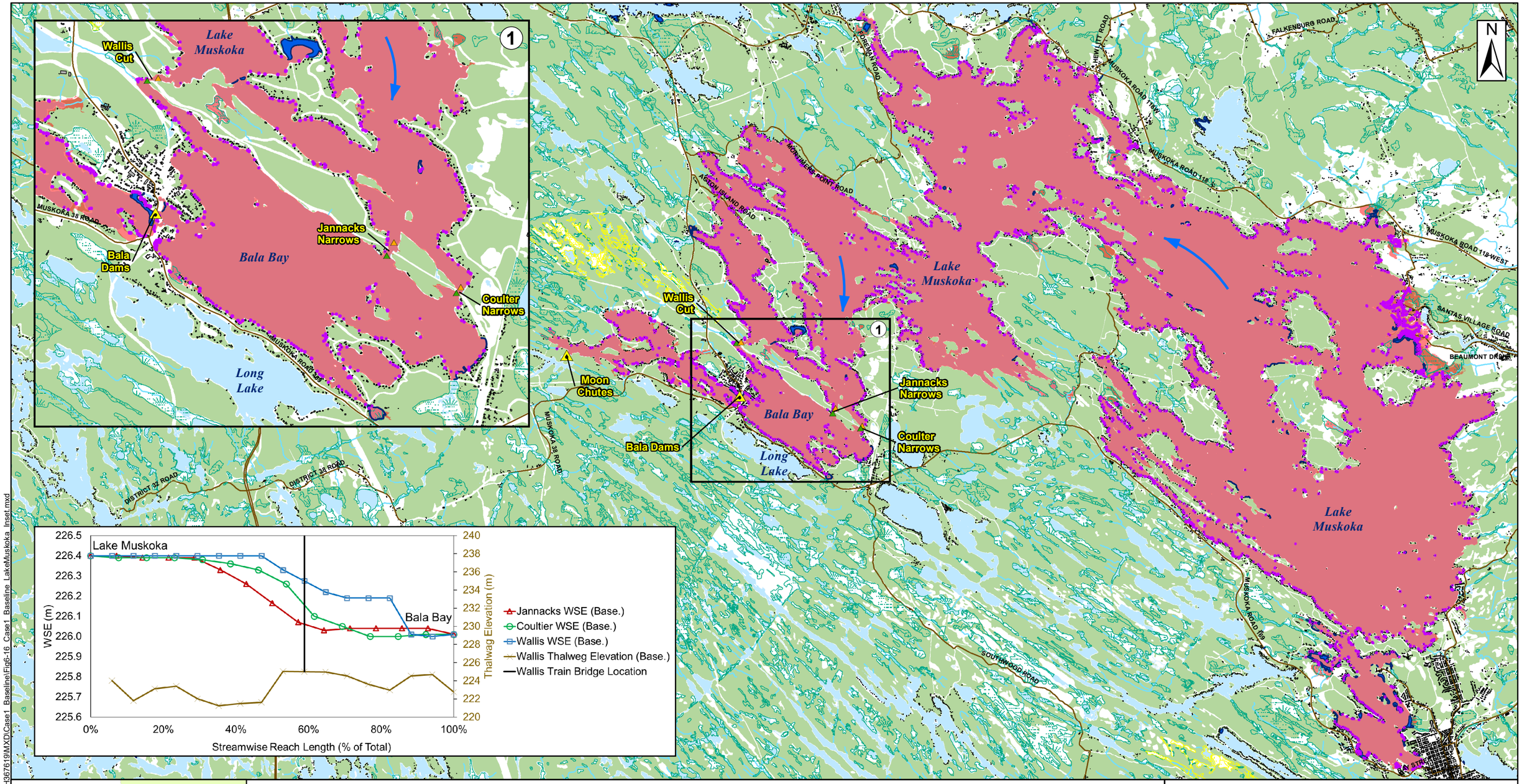

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LEGEND

- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Streamwise Reach Length (0% of Total)
- Streamwise Reach Length (100% of Total)
- Location of Interest
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 1.25 2.5 5 km

1:100,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Baseline Case Conditions - Lake Muskoka
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	6-16	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

7. Baseline Case Environmental Review

As noted in Section 5.2, a desktop review of existing natural heritage conditions, including occurrences of SAR, were reviewed and documented. Table 7-1 presents the results of the SAR desktop review for each of priority area with checkmarks indicating the potential presence of a SAR. Both the listings of the provincial ESA and federal SARA were reviewed. The review resulted in the identification of 37 provincially listed SAR. Records for four SAR bats (including Little Brown Bat (*Myotis lucifugus*), Northern Myotis (*Myotis septentrionalis*), Tri-colored Bat (*Pipistrellus subflavus*), Eastern Small-footed Myotis (*Myotis leibii*)) were not identified during a desktop screening, however, were added to the list of potential SAR due to the high likelihood of suitable habitat to be present within woodlands in the Study Area.

For the specific priority areas, varying numbers of these 37 provincially listed SAR were recorded as having the potential to occur within the area and included

- **Big East River:** 19 SAR recorded
- **Big East River – Distress Dam:** 14 SAR recorded
- **Huntsville Narrows / Brunel Locks**: 23 SAR recorded
- **Springdale:** 15 SAR recorded
- **Baysville:** 16 SAR recorded
- **Fraserburg:** 17 SAR recorded
- **Purbrook:** 15 SAR recorded
- **Muskoka/Bala:** 27 SAR recorded**.**

To gain an understanding of the baseline natural environment prior to the implementation of any mitigation measures and to document the remaining features identified within the desktop review, Table 7-2 has been prepared to outline potential impacts to natural heritage features like woodlands, wetlands, fish and fish spawning habitat, potential SAR habitat, general wildlife impacts and residential/agricultural impacts for each of the priority areas during current flood conditions.

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Table 7-1: Species at Risk Desktop Review for Priority Areas

Common Name	Scientific Name	ESA	SARA	Habitat Description (sourced from ontario.ca and species-registry.canada.ca)	Big East River	Big East River – Distress Dam	Huntsville Narrows / Brunel Locks	Springdale	Baysville	Fraserburg	Purbrook	Muskoka/Bala
Birds												
Bank Swallow	*Riparia*	THR	THR	Nests in a wide variety of naturally and anthropogenically created vertical banks, which often erode and change over time including aggregate pits and the shores of large lakes and rivers.	✓		✓					
Barn Swallow	*Hirundo rustica*	THR	THR	Commonly associated with human structures such as buildings, open barns, bridges and culverts where their mud nest-cups can be built.	✓	✓	✓	✓	✓	✓	✓	✓
Bobolink	*Dolichonyx oryzivorus*	THR	THR	Commonly found in areas with medium to tall grass - meadows or tall grass prairies.			✓		✓	✓	✓	✓
Canada Warbler	*Cardellina canadensis*	SC	THR	Found in various forests with well-developed shrubbery, including wet mixed forests, riparian shrub forests, and old-growth forests with open canopies.	✓	✓	✓	✓	✓	✓	✓	✓
Chimney Swift	*Chaetura pelagica*	THR	THR	Historically found in deciduous and coniferous, usually wet forest types, all with a well-developed, dense shrub layer; now most are found in urban areas in large, uncapped chimneys.	✓		✓		✓	✓	✓	✓
Common Nighthawk	*Chordeiles minor*	SC	THR	Traditionally associated with open areas with little to no ground vegetation but have been known to be found along gravel roads and railways, in urban parks, nesting in cultivated fields, orchards and mine tailings.	✓		✓		✓	✓		✓
Eastern Meadowlark	*Sturnella magna*	THR	THR	Primarily found in moderately tall grasslands, such as pastures and hayfields - can also be found in alfalfa fields, weedy borders of croplands, roadsides, orchards, overgrown fields, and other open areas.	✓		✓	✓				✓
Eastern Whip-poor-will	*Antrostomus vociferus*	THR	THR	Usually found in areas with a mix of open and forested areas, such as savannahs, open woodlands, or where there are openings in mature deciduous, coniferous, and mixed forests.								✓
Eastern Wood-pewee	*Contopus virens*	SC	SC	Commonly found in the mid-canopy layer of forest clearings and edges of deciduous and mixed forests. Mostly found within intermediate-age mature forest stands with very little understory.	✓	✓	✓	✓	✓	✓	✓	✓
Evening Grosbeak	*Coccothraustes vespertinus*	SC	SC	Generally found in open and mature mixed-woods forests dominated by White Spruce, Trembling Aspen, and fir species where Spruce Budworm is abundant. Outside of the breeding season, this species is largely dependent on seed crops and fruit-bearing trees.	✓	✓	✓	✓	✓	✓	✓	
Golden-winged Warbler	*Vermivora chrysoptera*	SC	THR	Tends to nest in shrubby areas that are surrounded by mature forests – typically in locations of recent disturbance which include, fields, hydro and utility corridors and logged areas.				✓	✓	✓	✓	✓
Least Bittern	*Ixobrychus exilis*	THR	THR	Strongly prefers cattail marshes near or with access to open water. Nests are built above marsh water in dense, emergent vegetation.								✓
Olive-sided Flycatcher	*Contopus cooperi*	SC	THR	Commonly found along the edges or openings of coniferous or mixed forests, adjacent to watercourses or wetlands, that have been logged or burned and provide access to tall snags and trees that can be used as foraging perches.	✓	✓	✓		✓	✓	✓	✓
Peregrine Falcon	*Falco peregrinus*	SC	SC	Nests are usually on tall, steep cliff edges in close proximity to large water bodies. This species can also be found in urban environments, and often raise their young on ledges of tall buildings.		✓	✓					
Red-headed Woodpecker	*Melanerpes erythrocephalus*	END	END	Commonly found in open woodland and woodland edges and is often found in parks, golf courses and cemeteries.								✓
Wood Thrush	*Hylocichla mustelina*	SC	THR	Found in mature mixed and deciduous forests with well-developed understory and tall trees. These birds can be found in small stands of trees but prefer large forest mosaics.	✓	✓	✓	✓	✓	✓	✓	✓

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Common Name	Scientific Name	ESA	SARA	Habitat Description (sourced from ontario.ca and species-registry.canada.ca)	Big East River	Big East River – Distress Dam	Huntsville Narrows / Brunel Locks	Springdale	Baysville	Fraserburg	Purbrook	Muskoka/Bala
Herpetofauna												
Blanding's Turtle	*Emydoidea blandingii*	THR	END	Typically inhabit shallow lakes, ponds, and wetlands with clean water and mucky bottoms. Prefer large bodies of water and areas with fallen trees and other debris for basking.				✓			✓	✓
Common Five-lined Skink	*Plestiodon fasciatus*	SC	SC	Maintains a body temperature between 28 and 36 degrees Celsius by basking on sunny rocks and logs. Preferred hibernacula are in the crevices among rocks. This species is commonly found underneath rocks on open bedrock in forested habitats.								✓
Eastern Hog-nosed Snake	*Heterdon platirhinos*	THR	THR	Commonly associated with habitats with an abundance of toads. Nests and hibernates in well-drained, sandy habitats including beaches and dry forests.				✓				✓
Eastern Milksnake	*Lampropeltis Triangulum*	-	SC	Grasslands / pastures, rocky outcrops, forests (all types) with extensive forest cover; natural corridors (e.g., shorelines) are important; may be found near wetlands.								✓
Eastern Musk Turtle	*Sternotherus odoratus*	SC	SC	Found in slow-moving ponds, lakes, marshes, and rivers with abundant vegetation and muddy bottoms that are used for hibernacula. Nests are found in direct sunlight in close proximity to water in soil, decaying vegetation, rotting wood, on open ground, in rock crevices, or in muskrat lodges.								✓
Eastern Ribbonsnake	*Thamnophis sauritus*	SC	SC	Semi-aquatic species associated with marshes or other shallow water. Hibernacula often consists of underground burrows or rock crevices.								✓
Massasauga	*Sistrurus catenatus pop. 1*	THR	THR	Prefers to dry, open habitats with opportunities to warm themselves in the sun and maintain the body temperature required for gestation. Hibernacula often consists of underground crevices above the water table and below the frost line.								✓
Midland Painted Turtle	*Chrysemys picta marginata*	-	SC	These turtles occupy slow-moving, shallow, vegetated wetlands and watercourses during their active season and as adults when overwintering, while juveniles may overwinter in aquatic or terrestrial habitats. Nesting habitat is commonly associated with the shorelines of lakes and wetlands.	✓	✓	✓	✓	✓	✓	✓	✓
Northern Map Turtle	*Graptemys geographica*	SC	SC	Commonly associated with emergent, unobstructed rocks and fallen trees found on watercourses and lakeshores with high-quality water and mollusc prey. Hibernates at the bottom of deep, slow-moving watercourses.								✓
Snapping Turtle	*Chelydra serpentina*	SC	SC	Often found hidden in shallow waters with soft mud and leaf litter with only their noses exposed. In early to mid-summer, during nesting season, females travel along shorelines or utilize artificial structures to search for suitable nesting sites.	✓	✓	✓	✓	✓	✓	✓	✓
Insects												
Gypsy Cuckoo Bumble Bee	*Bombus bohemicus*	END	END	Occurs in a variety of habitats including agricultural areas, open meadows, urban areas, and boreal forests.			✓					
Riverine Clubtail	*Chelydra serpentina*	SC	SC	Larvae can often be found burrowing in at the bottom of riverine habitats, while adults disperse to feed on forest canopies after emerging.	✓							
Rusty-patched Bumble Bee	*Bombus affinis*	END	END	Often found in open habitats including urban settings, savannahs, open woods, and mixed farmlands.			✓					✓
Transverse Lady Beetle	*Coccinella transversoguttata*	END	SC	Habitat generalist found in a variety of land cover types, including agricultural areas, coniferous forests, deciduous forests, and suburban gardens. Distribution is driven primarily by prey availability across various vegetation types.						✓		
Yellow-banded Bumble Bee	*Bombus terricola*	SC	SC	Forage and habitat generalist able to utilize a variety of land cover types, nectaring plants, and environmental conditions. However, nests are often underground in abandoned or old rodent burrows.	✓		✓					✓

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Common Name	Scientific Name	ESA	SARA	Habitat Description (sourced from ontario.ca and species-registry.canada.ca)	Big East River	Big East River – Distress Dam	Huntsville Narrows / Brunel Locks	Springdale	Baysville	Fraserburg	Purbrook	Muskoka/Bala
Vegetation												
Black Ash	*Fraxinus nigra*	END	-	Black Ash is a wetland species that can be found in fens, floodplains, and swamps.	✓	✓	✓					
Butternut	*Juglans cinerea*	END	END	Commonly associated with riparian habitat with rich, moist, and well-drained soils. They are intolerant of shade.			✓					
Spotted Wintergreen	*Chimaphila maculata*	THR	THR	Woodland species associated with dry, oak or oak-pine mixed woodlands with sandy soils. Does best in semi-open habitats.					✓	✓		
Mammals												
Little Brown Bat	*Myotis lucifugus*	END	END	During the day they roost in trees and buildings. They often select attics, abandoned buildings and barns for summer colonies where they can raise their young. Bats can squeeze through very tiny spaces (as small as six millimetres across) and this is how they access many roosting areas. Little Brown Bats hibernate from October or November to March or April, most often in caves or abandoned mines that are humid and remain above freezing.	✓	✓	✓	✓	✓	✓	✓	✓
Northern Myotis	*Myotis septentrionalis*	END	END	Northern Myotis are associated with boreal forests, choosing to roost under loose bark and in the cavities of trees. These bats hibernate from October or November to March or April, most often in caves or abandoned mines.	✓	✓	✓	✓	✓	✓	✓	✓
Tri-colored Bat	*Pipistrellus subflavus*	END	END	During the summer, the Tri-colored Bat is found in a variety of forested habitats. It forms day roosts and maternity colonies in older forest and occasionally in barns or other structures. They overwinter in caves where they typically roost by themselves rather than part of a group.	✓	✓	✓	✓	✓	✓	✓	✓
Eastern Small-footed Myotis	*Myotis leibii*	END	-	In the spring and summer, Eastern Small-footed Myotis will roost in a variety of habitats, including in or under rocks, in rock outcrops, in buildings, under bridges, or in caves, mines, or hollow trees. In the winter, these bats hibernate, most often in caves and abandoned mines. They seem to choose colder and drier sites than similar bats and will return to the same spot each year.	✓	✓	✓	✓	✓	✓	✓	✓
Fish												
No SAR fish identified during the records review.												

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Table 7-2: Baseline Case Environmental Review

Location	Impacts						
	Woodland Inundation	Wetland Inundation	Fish / Fish Spawning Habitat (only known records for spawning habitat included in assessment)	Potential Species at Risk Habitat		General Wildlife Impacts	Residential / Agricultural Inundation
Big East River	Baseline flood conditions are likely to see the inundation of woodland areas.	Baseline flood conditions are likely to see the inundation of wetland areas. An evaluated PSW (Big Delta River East Wetland) to the southwest is expected to be affected.	Baseline flood conditions potentially result in • Impacts to fish habitat from higher water levels (including several spawning areas along the Lake Vernon shoreline including Northern Pike and Lake Trout spawning areas. • Impacts to water quality (sedimentation deleterious substances) from flood drawdowns	Bank Swallow Barn Swallow Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher	Wood Thrush Midland Painted Turtle Snapping Turtle Riverine Clubtail Yellow-banded Bumble Bee Black Ash Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions would likely see impacts to Stratum 1 and Stratum 2 deer overwintering habitat, in addition to a Mixed Wader Nesting Colony and a Colonial Waterbird Nesting Area.	Baseline overland flooding is impacting approximately 620 structures, most of which are classified as residential or commercial.
Big East River – Distress Dam	Baseline flood conditions are unlikely to result in the flooding of woodland areas.	Baseline flood conditions are unlikely to result in the inundation of wetland areas.	Baseline flood conditions potentially result in • Impacts to fish habitat from higher water levels (including potentially sensitive brook trout habitat) • Impacts to water quality (sedimentation, deleterious substances and potential thermal degradation to cold water regimes) from flood drawdowns	Barn Swallow Canada Warbler Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Midland Painted Turtle Snapping Turtle Black Ash Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact a late wintering area for Moose.	
Huntsville Narrows / Brunel Locks	Baseline flood conditions are unlikely to result in the flooding of woodland areas.	Baseline flood conditions are unlikely to result in the inundation of wetland areas.	Baseline flood conditions potentially result in • Impacts to fish habitat from higher water levels (including several spawning areas including Northern Pike and Lake Trout spawning areas along channel shorelines between Lake Vernon and Fairy Lake • Impacts to water quality (sedimentation deleterious substances) from flood drawdowns, particularly from runoff from the commercial properties between John St and Chaffey St	Bank Swallow Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Midland Painted Turtle Snapping Turtle Gypsy Cuckoo Bumble Bee Rusty-patched Bumble Bee Yellow-banded Bumble Bee Black Ash Butternut Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact Stratum 2 deer overwintering conditions.	In baseline flood conditions, water is rising over banks and flooding infrastructure in the Town of Huntsville, including commercial parking lots.
Springdale	Baseline flood conditions are likely to see the inundation of woodland areas.	Baseline flood conditions are likely to see the inundation of various unevaluated wetland areas. No PSW is expected to be directly affected.	Baseline flood conditions potentially result in • Impacts to water quality (sedimentation deleterious substances) from flood drawdowns	Barn Swallow Canada Warbler Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Wood Thrush Blanding's Turtle	Eastern Hog-nosed Snake Midland Painted Turtle Snapping Turtle Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact Stratum 2 deer overwintering habitat.	In baseline flood conditions, increased High Falls head pond elevations can cause flooding in residential shoreline development areas.
Baysville	Baseline flood conditions are likely to see the inundation of woodland areas.	Baseline flood conditions are likely to see the inundation of various unevaluated wetland areas. No PSW is expected to be directly affected.	Baseline flood conditions potentially result in • Impacts to fish habitat from higher water levels (particularly several spawning areas including Smallmouth	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee	Wood Thrush Midland Painted Turtle Snapping Turtle Spotted Wintergreen Little Brown Bat Northern Myotis	No impacts to Stratum 2 deer overwintering habitat are expected during baseline flood conditions; however, baseline flood conditions have the potential to impact a Mixed Wader Nesting Colony.	In baseline flood conditions, the flood inundation area impacts approximately 8 well-distributed residential structures, 3 sheds and 1 outbuilding.

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Location	Impacts						
	Woodland Inundation	Wetland Inundation	Fish / Fish Spawning Habitat (only known records for spawning habitat included in assessment)	Potential Species at Risk Habitat		General Wildlife Impacts	Residential / Agricultural Inundation
			Bass spawning areas surrounding the Baysville Dam • Impacts to water quality (sedimentation deleterious substances) from flood drawdowns	Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Tri-colored Bat Eastern Small-footed Myotis		
Fraserburg	Baseline flood conditions are likely to see the inundation of woodland areas.	Baseline flood conditions are likely to see the inundation of various unevaluated wetland areas. No PSW is expected to be directly affected.	Baseline flood conditions potentially result in • Impacts to fish movement from increased velocities through narrows such as May Chutes • Impacts to water quality (sedimentation, deleterious substances) from flood drawdowns	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Wood Thrush Midland Painted Turtle Snapping Turtle Transverse Lady Beetle Spotted Wintergreen Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact Stratum 2 deer overwintering habitat, as well as a Mixed Wader Nesting Colony.	In baseline flood conditions, the presence of high-water levels during the design flood impacts 49 structures.
Purbrook	Baseline flood conditions are likely to see the inundation of woodland areas.	Baseline flood conditions are likely to see the inundation of various unevaluated wetland areas. No PSW is expected to be directly affected.	Baseline flood conditions potentially result in • Impacts to fish movement from increased velocities through narrows such as Rocky Rapids • Impacts to water quality (sedimentation, deleterious substances) from flood drawdowns	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Wood Thrush Blanding's Turtle Midland Painted Turtle Snapping Turtle Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact Stratum 2 deer overwintering habitat, as well as on a Mixed Wader Nesting Colony.	In baseline flood conditions, this is the largest flood inundation area, impacting approximately 145 structures.
Muskoka/Bala	Baseline flood conditions are unlikely to result in the flooding of woodland areas.	Baseline flood conditions are likely to see the inundation of various unevaluated wetland areas. No PSW is expected to be directly affected.	Baseline flood conditions potentially result in: • Impacts to fish habitat from higher water levels (particularly several spawning areas including Smallmouth Bass, Northern Pike, Lake Trout, Largemouth Bass and Walleye spawning areas surrounding the shorelines and shoals of Bala Bay and Lake Muskoka • Impacts to water quality (sedimentation deleterious substances) from flood drawdowns • Impacts to fish movement from increased velocities through narrows such as Wallis Cut, Jannacks Narrows, Coultier Narrows	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Meadowlark Eastern Whip-poor-will Eastern Wood-pewee Golden-winged Warbler Least Bittern Olive-sided Flycatcher Red-headed Woodpecker Wood Thrush Blanding's Turtle Common Five-lined Skink	Eastern Hog-nosed Snake Eastern Milksnake Eastern Musk Turtle Eastern Ribbonsnake Massasauga Midland Painted Turtle Northern Map Turtle Snapping Turtle Rusty-patched Bumble Bee Yellow-banded Bumble Bee Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis	Baseline flood conditions have the potential to impact Stratum 2 deer overwintering habitat, as well as a Mixed Wader Nesting Colony.	In baseline flood conditions, the culmination of hydraulic losses is resulting in backwater, which is leading to higher water levels in Lake Muskoka.

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8. Site Visit

A site visit was conducted by Hatch staff (who were accompanied by DMM representatives) from May 16 to 18, 2022 (inclusive). The purpose of the site visit was to gain first-hand knowledge of priority area conditions and to better understand the limitations and opportunities associated with development of potential flood mitigation options.

During the visit, Hatch conducted reconnaissance of key locations throughout the watershed that were accessible by public land. These visits included locations along both the North Branch and South Branch of the Muskoka River, as well as in the Lower Watershed region. Several important locations were excluded from the site visit due to either access issues or time constraints. In the absence of first-hand observations of these sites, project objectives were addressed through accessing other resources (e.g., historical documentation, geospatial data, etc) to address project objectives. Any remaining data gaps were identified for future studies. Full details of the site visit are outlined in a comprehensive trip report delivered to DMM on May 30, 2022, and included in Appendix B.

Focus areas at each location were features that could influence flood mitigation design. These included features categorized as geotechnical (e.g., local and general topography), structural (e.g., bedrock conditions), hydrotechnical (e.g., floodplain characteristics and hydraulic constrictions), and environmental (e.g., habitat conditions and recreational sites). The following is a high-level overview of the main findings from the site visit, which helped complement the information gathered during background information collection and review.

Big East River

- High water marks noted on bridge piers at Highway 11 and Arrowhead park road, showing evidence of conditions from recent floods.
- Remnants of bridge piers identified near Ravenscliffe Road bridge, however no evidence of hydraulic constriction due to these remnants was observed.

Huntsville

- Low points along the shoreline on the north-side of the river upstream from the Main St. E swing bridge were photographed.
- Most structures close to the shoreline were visually confirmed to be boathouses rather than dwellings (i.e., residences).

Springdale

- High topographic elevations in the Bracebridge Resource Management Area were identified, posing a significant constraint for implementing temporary storage for flood mitigation.
- The presence of a private road along much of the area of interest was noted.

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- Presence of a cold-water creek important for brook trout spawning was documented as one of the tributaries flowing into the Muskoka River in the Springdale priority area.

Baysville/Fraserburg/Purbrook

- While significant residential development was observed along the Baysville reach, field observations note that most structures were set back from the immediate shoreline. This observation is consistent with low structure impact density calculated for this reach.
- Two bridge locations (Fraserburg Road and Purbrook Road) were visited and photographed. The Fraserburg road was noted to have a history of being overtopped during flood conditions in the Muskoka River.

Muskoka/Bala

- Residences in the upper Bala Reach area between Moon Chutes and the Bala Dams were observed to be located close to the waterfront. Many of these residences were also noted to have docks.
- The section of shoreline downstream from Moon Chutes was noted to have steep side slopes with visible bedrock outcrops.

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9. Mitigation Case Option Identification, Selection and Design

A primary objective of this study was to identify 10 structural mitigation options amongst five priority areas that will promote flood risk reduction. Structural flood mitigations can be broadly categorized as either *flood protection/diversion* or *flood attenuation* options. Flood protection/diversion options (e.g., embankments and bypass channels) reduce flood risk by physically re-directing flow. Alternatively, flood attenuation options (e.g., temporary flood storage areas) can reduce peak flow rates by changing the temporal patterns of flow transfer between connected water bodies. The intended impact of both categories of options is the lowering of water levels in flood-prone areas.

The process of option identification, selection and design involved the following stages.

- **Stage 1: Review of Baseline Hydraulic and Environmental Conditions**

  Baseline Case conditions in each priority area were reviewed by a team of hydraulic engineering and aquatic ecology subject-matter experts. Materials examined included plan and profile views of flood conditions within each priority. The locations and elevations of impacted structures were also reviewed to characterize density of impacted structures, and elevation of impacted structures relative to flood water levels. Environmental factors were reviewed to identify criteria and constraints relevant to development of flood mitigation options. These materials were supplemented by other findings from the background information review.

- **Stage 2: Multi-Disciplinary Identification of Preliminary Mitigation Options**

  Expanding on findings from review of hydraulic and environmental conditions, a broad list of potential mitigations was identified by a multi-disciplinary team. These findings were supplemented by input from subject-matter experts in geotechnical engineering and structural engineering. Selection of mitigation options for each reach was guided by consideration of several factors, which included

  - effectiveness of mitigation (i.e., reducing local flood impacts to land and structures)
  - local environmental impacts
  - local social impacts
  - constructability and timely implementation
  - cost
  - flood risk outside of each priority area (particularly in the downstream areas of the MRW)
  - regulatory limits and bylaws
  - land ownership.

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- **Stage 3: Options Presentation and Review by DMM and TWG**

  Hatch delivered a workshop to DMM and the Technical Working Group (TWG) on June 24, 2022, where the full list of preliminary mitigation options was presented. The presentation included a description of each option, and a ranking of the options using the factors outlined above. These presentation slides are included in Appendix A. However, the content in these slides may not be completely consistent with the content in this report based on the advancement of each flood mitigation options since the workshop. Examples include changes to options (e.g., additional outflow through the Brunel Locks) and refinement of hydrologic and hydraulic modelling assumptions.

- **Stage 4: Options Selection and Design**

  A subset of 10 options were selected from the full list of preliminary mitigation options. Descriptions of these 10 options are provided in Sections 9.1 through 9.5, which include a demonstration of local flood mitigation impacts through hydraulic or hydrologic modelling (where possible). Flood mitigation options identified, but not pursued for advancement, are briefly discussed in Section 9.7.

9.1 Big East River

As discussed in Section 6.1, the Big East River priority area features a highly sinuous channel with a wide meander belt. Given the large flood inundation extent of the Big East River, flood mitigation through attenuation will be the most effective approach. As such, the first selected option was temporary flood storage upstream from the Distress Dam site by means of a retrofitted control structure.

9.1.1 Option 1: Retrofit of Control Structure at Distress Dam

Water levels and flows on the Big East River near Distress Dam are currently controlled by a relatively low-level weir structure (shown in Figure 6-2). Using both LiDAR data (supplemented by digital elevation model data from Ontario GeoHub) and hydraulic calculations, the existing weir crest elevation at the structure was estimated to be 340 m (based on vertical datum CGVD28). However, this elevation requires confirmation by field survey. In its current state, the site has limited flood mitigation potential due to the limited storage volume that can be impounded upstream from the structure. By retrofitting the spill structure to a larger dam, the resulting increase in upstream storage volume could be employed during a flood to reduce peak flow rates to, and therefore lower water levels at, the Big East River priority area.

The retrofitted control structure at Distress Dam should be designed such that it can maintain the normal flow regime during non-flood conditions but can be used to temporarily impound water during a major flood event. Upstream impoundment during flood conditions can be achieved by implementing some form of hydraulic control at the site, such as a mechanized gate, an Obermeyer weir, or a combination of both. The operational timing of this hydraulic

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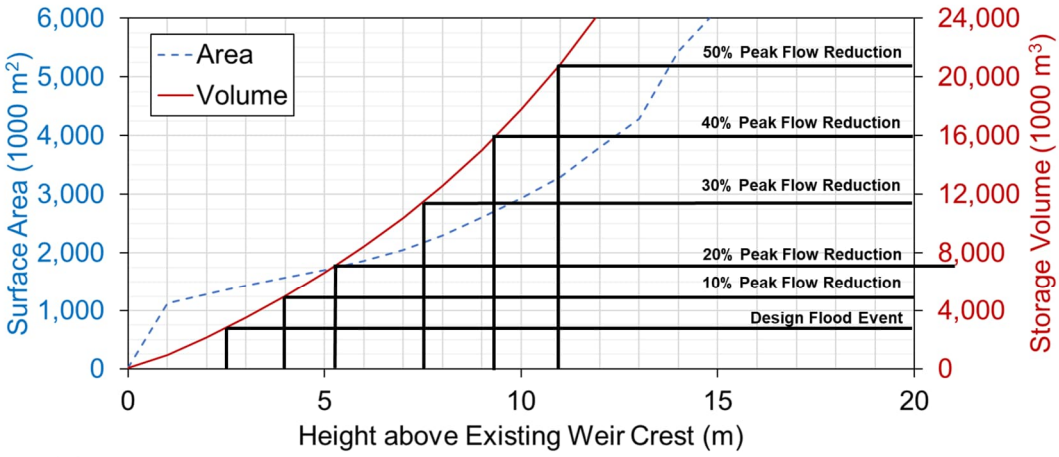
control could be informed by a flood forecasting system, which can help to lower the flood risk further by using flood storage to attenuate the forecasted flood peak.

Using LiDAR data, stage-area and stage-storage curves were estimated for the watershed area upstream from the Distress Dam site. The developed stage-area and stage-volume curves are shown on Figure 9-1, where stage is shown as elevation above the existing weir crest.



Notes:
1) Curves exclude storage below existing weir crest.
2) LiDAR indicates existing weir crest is at approximately 340 masl

Figure 9-1: Stage-storage and stage-area relationships for the watershed area upstream from Distress Dam

The inundation surface area and storage volume required to reduce peak flows were estimated using design flood hydrographs to the Big East River priority area. This analysis assumes that maximum benefit in peak flow reduction can be achieved through well-timed deployment of the hydraulic control to impound water upstream. This assumption will need to be refined as part of future studies.

As shown on Figure 9-1, the analysis indicates that achieving a 50% reduction in peak flow in the Big East River priority area, requires an approximately 11 m high structure to impound the associated flow volume. The structure must be sufficiently wide to cover the cross-section of the Distress Dam watershed outlet. A comparison of this 11 m elevation (above the existing weir crest) to the existing terrain at the site is shown in Figure 9-2.

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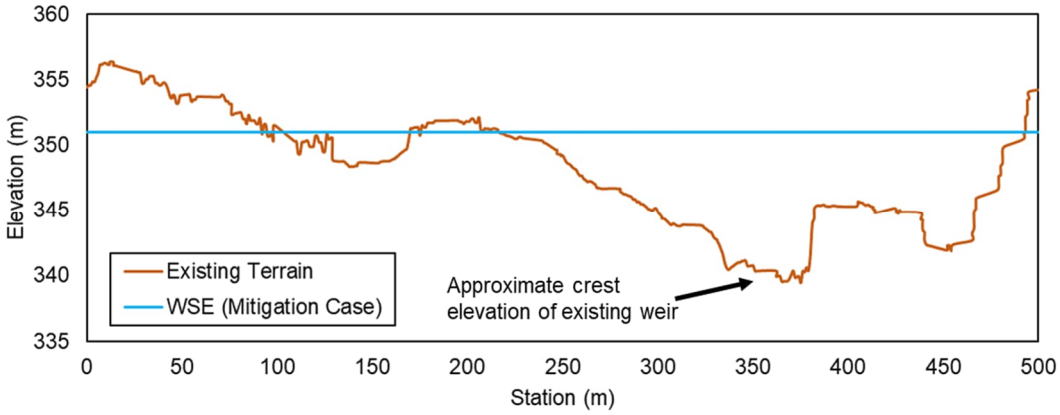

Figure 9-2: Cross-section view of the Distress watershed outlet with an inundation water level in the mitigation case

As shown in Figure 9-2, the overall size of the structure (in terms of length and height) required to reduce peak flow by an estimated 50% is approximately the area shown between the *Existing Terrain* and *WSE (Mitigation Case)* lines. The areal extent of the inundation associated with an impoundment of 11 m of water is quantified in Figure 9-1 and illustrated in Figure 9-13. Figure 9-1 includes the varying inundation surface areas and storage volume requirement estimates to achieve varying levels of peak flow reduction (10% through 50%). The presentation in Figure 9-1 demonstrates a non-linear relationship, showing that incremental benefit in storage volume increases at higher elevations (e.g., storage volume increase from an elevation 10 m to 11 m is greater than that from 5 m to 6 m).

The flood mitigation impact of the raised Distress Dam on the Big East River priority area was assessed using both a hydraulic and hydrologic model. A hydrologic model was required to estimate the reduction in Lake Vernon peak water level resulting from flood impoundment upstream from Distress Dam, as lower Lake Vernon water levels help to reduce flooding along the Big East Area. The results of this analysis are summarized in Table 9-1.

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Table 9-1: Estimated flood mitigation benefits for different peak flow reduction cases

Scenario	Estimated Inundation Elevation above Crest at Existing Distress Dam (m)	Peak Flow of Big East River @ Lake Vernon (m^3/s)	Estimated Drop in Lake Vernon Peak Water Level[1,2] (m)	Flood Inundation Area in Big Eas9t River Priority Area (km^2)	# of Impacted Structures in Big East River Priority Area (-)	# of Impacted Structures in Distress Dam Inundation Area (-)
Design Flood Event	2.56[3]	242	N/A	9.64	620	5 (estimated)
10% Peak Flow Reduction	4.0	218	-0.05	9.49	600 (-20)	6 (+1)
20% Peak Flow Reduction	5.2	194	-0.13	9.36	594 (-26)	8 (+3)
30% Peak Flow Reduction	7.6	169	-0.26	9.00	572 (-48)	11 (+6)
40% Peak Flow Reduction	9.2	145	-0.39	8.68	559 (-61)	17 (+12)
50% Peak Flow Reduction	11.0	121	-0.54	8.36	523 (-97)	21 (+16)

[1]Design water level assumed as 286.68 m (see Table 5-1)
[2]Drop in Lake Vernon peak water level was estimated using the hydrologic model.
[3]Calculated based on characteristics of the existing structure and peak discharge at Distress Dam.

Table 9-1 reveals that potential flood mitigation benefits that can be achieved under different peak flow reduction cases. For brevity, the following discussion focuses on the most impactful flood mitigation scenario presented in Table 9-1, which is the 50% peak flow reduction case.

A 50% reduction in peak flow to the Big East Priority area is estimated to reduce peak water levels in Lake Vernon by 0.54 m. A lower Lake Vernon water level combined with a reduced peak flow reduces the flood inundation area of the Big East River from 9.64 km^2 to 8.36 km^2. This change results in a reduction in flood impacted structures from 620 to 523 (16% decrease). A plan and profile view of the reduction in flood inundation area and impacted structures due to mitigation is shown in Figure 9-14.

The 97 flood mitigated structures due to mitigation are classified mainly as either commercial (27) or residential (32) (Table 9.5). After accounting for the estimated 16 structures that will be flood impacted upstream within the Distress Dam inundation area, the net number of structures not flood-impacted due to mitigation is 81. The structures in the Distress Dam inundation area are not currently classified. The inundation area that becomes flood mitigated structures is almost exclusively classified as Natural Resources (Table 9-5).

9.2 Huntsville Narrows

As discussed in Section 6.2, Huntsville Narrows is an urbanized reach of the Muskoka River North Branch. A dense cluster of structures, at high risk of flooding, is located in a commercial lot immediately upstream from the Centre Street swing bridge. Flood reduction in

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this priority area focused on targeting this commercial lot and its surrounding area through flood protection/diversion options.

9.2.1 *Options 2* and 3*: Berm Protection near Swing Bridge* and *Increase Fairy Lake Outflow via the Brunel Lift Locks*

The first of two options for the Huntsville Narrows are the construction of a berm along the Muskoka River shoreline near John St (Figure 9-3).



Figure 9-3: Approximate shoreline berm location (Huntsville Narrows)

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This berm functions as a barrier between the commercial lot and the Muskoka River North Branch, thus containing flow in the main channel during flood events. Drainage will be incorporated as part of stormwater management at the site. Preliminary assessments show that the berm would vary in height but may need to be approximately two metres tall at some locations along the shoreline.

The volume of water stored in the commercial lot during the design flood event is estimated to be less than 1% of the total water volume in the reach. A reduction in flood storage of this small amount during the design flood, would not have a measurable impact on water levels in the Huntsville Narrows channel or in either Lake Vernon or Fairy Lake.

As shown in Figure 9-15, the construction of a shoreline berm has the potential to effectively eliminate flooding for most structures in the adjacent commercial area upstream from the swing bridge. The berm should be designed and constructed to minimize impacts to shoreline accessibility and nearby businesses. The berm could also incorporate architectural features to enhance the aesthetic value of the structure.

The second option selected to mitigate flood impacts in the Huntsville Narrows reach is to increase outflows from Fairy Lake during the design flood at the Huntsville Dam. The Huntsville Dam features six gates, as well as an additional entrance leading to the Brunel Lift locks (Figure 9-4).

Boat passage through the locks channel is facilitated through the Brunel Lift Locks via an upstream gate/door (which does not completely seal). According to the DOM (OMNR, 1997 with 2007 updates), the lock has a length of 27.2 m and a width of 6.25 m, with a normal water level difference of 3.1 m between the upper and lower sides of the lock. The locks channel entrance is closed from winter through late-May (weather dependent), and thus is not active during the spring season or during passage of the spring freshet. Therefore, the outlet capacity of the dam could be increased by opening the upstream and downstream lock gates and allowing additional overflow to bypass the main spillway through the lock structure.

The increase in outflow capacity from Fairy Lake via the locks channel entrance was estimated using hydraulic structure information provided within the DOM (OMNR, 1997 with 2007 updates). The lock channel entrance has a width of 4.1 m, and while the sill elevation of the lock entrance channel is not reported in the DOM (OMNR, 1997 with 2007 updates), it was assumed to have an elevation of 281.6 m. This elevation is the same as the sill elevation of the upper gate of the Brunel Lift Lock. Confirmation of the lock entrance sill will be required to confirm the findings summarized herein, as this information was not available for this study.

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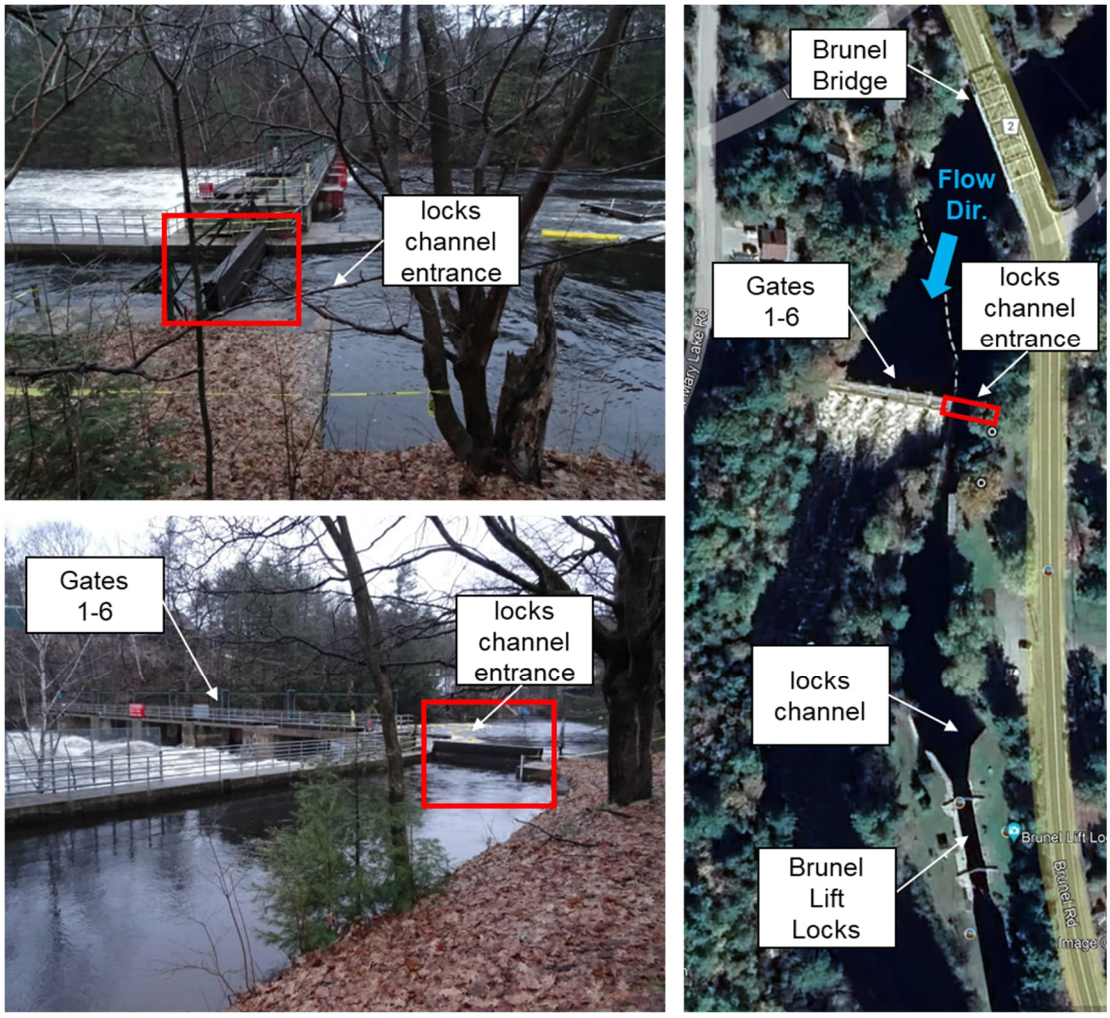

Figure 9-4: Huntsville Dam site, including Gates 1 to 6, the Brunel Lift Locks, and the locks channel

Using the dimensions of the lock, a stage-discharge relationship was developed for the lock channel entrance, assuming critical flow would be established at the entrance. This relationship was used to adjust the existing stage-storage-discharge relationship defined in the hydrologic model (shown as black and dashed in Figure 9-5), to reflect the increased outflow capacity provided by the lock channel entrance (shown as grey and solid in Figure 9-5).

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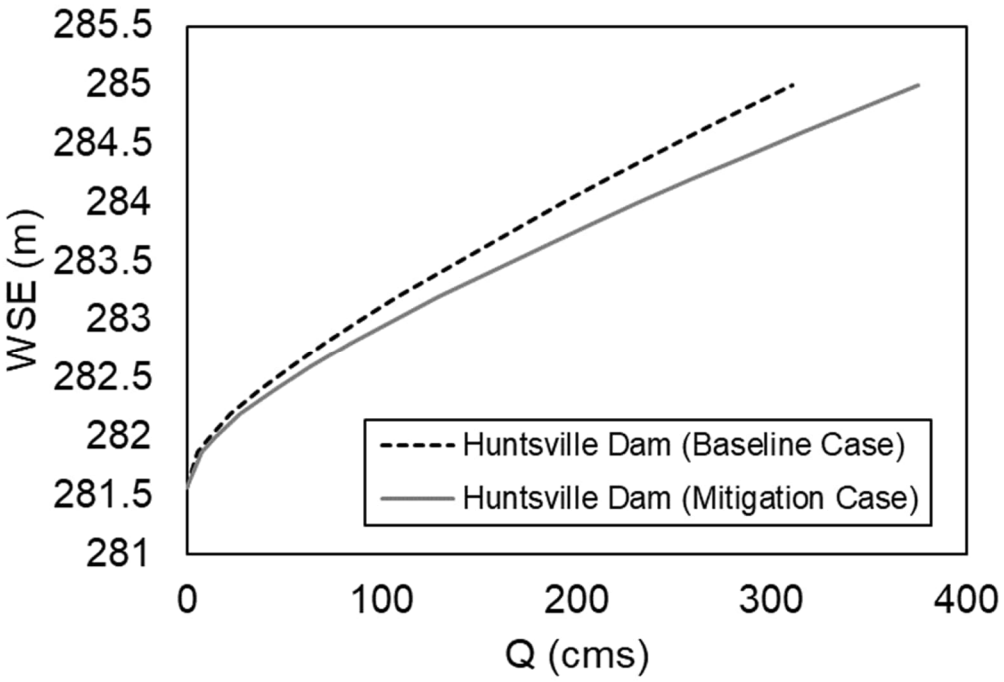

Figure 9-5: Huntsville Dam outflow rating curves for Baseline Case (flow through Gate 1 to 6 only) and Mitigation Case (flow through Gate 1 to 6 and locks channel entrance)

Simulation of the Fairy Lake peak water level using Baseline Case and Mitigation discharge rating curves for Huntsville Dam using the hydrologic model (Figure 9-5) showed that increased outflow through the locks channel entrance would result in a 0.27 m reduction in Fairy Lake's peak water level. One potential impact resulting from increased outflows from Fairy Lake is an increased flood risk to downstream lakes and rivers (e.g., Mary Lake). Further assessment on cumulative watershed impacts associated with increasing Fairy Lake outflows will be evaluated in *Flood Modifications Review Project*.

The cumulative flood mitigation impact of Options 2 and 3 are reflected in Figure 9-15. Of the 22 flood mitigated structures (a 29% decrease in impacted structures compared to the Baseline Case), the majority are commercial structures. The 0.05 km^2 net reduction in flood inundation area is comprised mainly of commercial area (98%).

9.3 Springdale

As discussed in Section 6.3, Springdale is a reach of the Muskoka River where water levels are influenced by operation of the High Falls GS head pond. The reach features primarily residential developments, with several high-density clusters of structures. The flood reduction option for this area involves targeting increased capacity of High Falls GS head pond levels during spring to limit flooding along the Springdale reach.

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9.3.1 *Option 4: Retrofit of Control Structure at High Falls*

Head pond levels in the High Falls GS are primarily controlled by a vertical lift gate and free overflow spillway (Figure 9-6), and an intake structure to the powerhouse.



Figure 9-6: High Falls GS hydraulic structures and sill elevations (Sources: photo from Hatch site visit September 2018, sill elevations from Bracebridge Power)

Under normal operating conditions flow is passed through the powerhouse and the vertical lift gate when spill is required. There is an approximate 3.6 m difference between the sill elevation of the free overflow spillway (265.44 m) and the top of the vertical lift gate (269.07 m). During high flow events, water levels rise when the capacity of the powerhouse and vertical lift gate is exceeded, and water begins to flow over the sill elevation of the free overflow spillway, as is the case for the design flood event conditions (Figure 9-6).

The flood mitigation option selected for the Springdale reach includes replacement of part or all of the free overflow spillway with an Obermeyer spillway gate (Obermeyer). An Obermeyer is a pneumatically controlled, bottom hinged spillway gate that uses an inflatable airbladder to change the elevation of the sill. This allows the sill elevation to be lowered during flood conditions (thus increasing its capacity and lowering the elevation of the High Falls GS head

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pond), followed by a raising of the sill to maintain normal water level conditions for the remainder of the year.



Figure 9-7: Example of an Obermeyer weir control. (Source: Obermeyer Hydro Inc.)

Several assumptions were made to evaluate the flood mitigation benefit that could be achieved with replacement of the free overflow spillway with an Obermeyer spillway gate. For instance, it was assumed that the entire length of the free overflow spillway (approximately 50 m) could be replaced with an Obermeyer spillway gate. Also, calculations of water levels and flows were based on an operator spreadsheet provided by Bracebridge Generation. However, it was acknowledged that there was uncertainty in the accuracy of the hydraulic calculations in this spreadsheet under high flow conditions. A summary of this analysis is provided in Table 9-2.

Table 9-2: Summary of Option 4 Analysis Parameters

Parameter	Units	Value
Invert Elevation of Existing Vertical Lift Gate	m	265.44
Invert Elevation of Existing Free Overflow Spillway	m	269.07
Assumed Invert of Proposed Obermeyer Weir	m	266.07
Assumed Sill Length of Obermeyer Weir	m	50.8
Design Peak Flow Rate	m^3/s	239.3

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Parameter	Units	Value
Observed Head Pond Peak Water Level (spring 2019)	m	270.53
Maximum Allowed Head Pond Elevation	m	270.80
Head Pond Peak Water Level with Obermeyer Weir	m	267.90

As summarized in Table 9-2, replacement of the free overflow spillway with an Obermeyer weir of the same length would result in a significantly lower head pond elevation during passage of the design flood event (267.90 m). A comparison of flood conditions for the head pond at 270.8 m (maximum allowed head pond elevation) and 267.90 m (peak head pond level with Obermeyer weir) is shown in Figure 9-16. This change in water level is estimated to reduce the flood inundation area from 0.57 km^2 to 0.30 km^2, resulting in 103 more flood mitigated structures (a 94% decrease in impacted structures compared to the Baseline Case). Most of these 103 floods mitigated structures are classified as residences.

9.4 Baysville/Fraserburg/Purbrook

9.4.1 Option 5: Channel Enlargement at May Chutes

May Chutes is one of several cascades that exist along the South Muskoka River, located near Sherwood Forest Road upstream from Crozier Falls. Water levels for the Baseline Case (Figure 9-17) show that backwater from May Chutes is a partial cause of flooding upstream to Slater Falls. This flooding directly impacts a high-density cluster of structures near Fraserburg Road.

The option selected for Fraserburg is channel enlargement at May Chutes to mitigate flooding from May Chutes to Slater Falls. The proposed enlargement would either lower, widen or use a combination of lowering and widening to increase its flow capacity. To demonstrate this potential, a preliminary excavation depth of approximately 5 m was tested at May Chutes and extended for several hundred meters upstream. Further refinement of excavation depths and extents will occur in *Flood Modifications Review*.

As shown in Figure 9-17, channel excavation at May Chutes lowers water levels from May Chutes to Slater Falls, effectively eliminating flood impacts to structures. Depending on the improvement scheme adopted, it may also result in permanent changes to water levels throughout the reach. Further study is required to identify any changes to the hydrologic regime of this watercourse resulting from this flood mitigation option.

The drop in water levels resulting from May Chutes excavation equates to a reduction in flood inundation area from 2.01 km^2 to 1.45 km^2. The zoning classification of this flood alleviated area is mainly either residential or environmental protection (Table 9-5). The reduction in water level also results in the flooding of fewer wetland areas, which may require further investigation of associated environmental impacts. No classification information was

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available to characterize the 44 flood mitigated structures, however they are likely residential structure based on aerial imagery.

9.4.2 *Option 6* and *Option 7: Channel Enlargement at Rocky Rapids* and *Lower Head Pond Flood Levels at Matthias GS*

Two options were identified for flood mitigation in the Purbrook reach. While each option alone represents a flood mitigation benefit, there is a synergistic benefit achieved by implementing both options together.

The first option relates to adjustment of head pond levels at Matthias GS during flood conditions. Matthias GS is operated by Orillia Power, and features three spillways and a large head differential from head pond to tailrace. Two of the three spillways have mechanized, bottom drawn, steel gates, while the third has non-mechanized, panel gates. The third spillway is noted to only be used in the case of severe flows. The Matthias GS head pond has a maximum allowable elevation of 293.5 m, and during the 2019 design flood the head pond reached an elevation of 293.16 m, very close to the maximum allowable elevation.

The following analysis was conducted to determine required changes to gate openings at the two main spillways to pass the design flood event under a lower head pond elevation. For this analysis, no flood passage through the third spillway is assumed, and the gate opening heights of the main two main spillways are assumed to be equal. Using stage-discharge rating curves provided by Orillia Power and a head pond elevation of 293.16 m, the gate opening height required to pass the design flood under these assumptions was calculated.

Using the calculated gate opening height estimated for the design flood event, the increase in gate height required to pass the design flood at a head pond elevation of 292 m was calculated to be 0.4 m for each gate. A head pond elevation of 292 m corresponds with the lower limit of the ‘normal operating zone’ for the Matthias head pond as outlined in the *MRWMP*. That is, if the gates were opened by an additional 0.4 m during this event, the upstream level can be lowered to 292 m. The capacity already exists at the station to do this.

Hydraulic simulations of the design flood with the head pond at 292 m showed significant reductions in upstream water levels, however, these reductions diminish upstream from Rocky Rapids due to the hydraulic control established at this location by the high bed levels. While lower head pond levels reduce flood impacts to several structures from river station 0 m to 3500 m (see Figure 9-18), this mitigation does not significantly reduce flood impacts upstream from Rocky Rapids. The full flood mitigation benefit of lowering Matthias GS head pond levels is only realized if the hydraulic control at Rocky Rapids is reduced.

The second option for flood mitigation in the Purbrook reach is therefore channel enlargement at Rocky Rapids. Similar to channel enlargement at May Chutes, the proposed mitigation primarily involves either widening or lowering the channel invert. To demonstrate the effect of this, a preliminary excavation depth of approximately 5 m was tested at Rocky Rapids and

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extended along a reach of several hundred meters. Further refinement of excavation depths and extents will be explored in the *Flood Modifications Review*.

The cumulative flood mitigation benefit achieved by Options 6 and 7 implemented in tandem is shown in Figure 9-18. A reduction in flood inundation area from 4.36 km^2 to 1.68 km^2 results in 137 additional flood mitigated structures. These flood mitigated structures include a dense cluster of structures near Island Way near river station 6000 m (Figure 9-18), most of which are residences or associated outbuildings and sheds (Table 9-3). Significant reductions in flood inundation area are observed in several wetland areas.

Depending on the excavation scheme adopted, the excavation may result in some permanent changes to water levels throughout the reach. Further study is required to identify any changes the hydrologic regime of this watercourse resulting from this flood mitigation option.

9.5 Muskoka/Bala

As discussed in Section 6.5, the Muskoka/Bala priority area features both lake and river settings separated by several hydraulic controls. Flood mitigation in this area is unique such that any mitigations implemented in the different reaches (Lake Muskoka, Bala Bay, and Bala Reach), could have a direct impact on the other three areas. The mitigations described below describe these potential inter-connection impacts.

9.5.1 Option 8 and *9: Channel Enlargement at Wallis Cut* and *Retrofit of Control Structure at Bala South Dam*

During the 2019 flood event, a nearly 0.5 m water level differential was observed between Lake Muskoka and Bala Bay (i.e., between Bala Park Island). This differential was the result of hydraulic losses through three constriction channels at the outlet of Lake Muskoka, with hydraulic modelling indicating that losses are highest through the Wallis Cut constriction.

Options 8 and 9 are presented together, as they are closely related. This first option for the Muskoka/Bala priority area is channel enlargement at the Wallis Cut. Wallis Cut was selected for channel enlargement from the three outlet channels because of its high hydraulic losses. Further, the low normal flows in this channel (<10% total Lake Muskoka outflow during the design flood) present an advantage for water management during construction. Preliminary simulations show that an excavation of approximately 1 to 2 m along most of the Wallis Cut channel would increase the flow through Wallis Cut from 7% of the total to 15% of the total during the design flood. As a result, peak Lake Muskoka water levels would be 0.14 m lower than they were during the Baseline Case. Further refinement of excavation depths and extent will be pursued in the *Flood Modifications Review*.

One constraint to channel enlargement at Wallis Cut is the presence of a CN train bridge (i.e., Mile 115.30 of the Bala Subdivision). Hydraulic simulations show a choke point is present and coincident with the horizontal position of the bridge. As such, channel enlargement via bedrock excavation in the vicinity of the bridge and its foundation may be required.

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Alternatively, relocation of the bridge to a different location in Wallis Cut may be a more desirable option. Further consultation with regulators and transportation authorities will be required to advance enlargement of the Wallis Cut option.

Outflows from Lake Muskoka are routed through the Bala Park Island Constrictions to Bala Bay. Water released from Bala Bay primarily flows out of Bala Dams (North Bala Dam and South Bala Dams). As of 2020, North Bala Dam not only functions as an outflow control structure but also as a run-of-river hydropower facility. A small fraction of flow (no more than 4 m^3/s) flows out of Bala Bay through the Burgess Dam. However, given this small flowrate, Burgess Dam does not significantly influence water levels in Lake Muskoka or the downstream Moon River.

A potential issue with implementing channel enlargement at Wallis Cut (i.e., Option 8) is an increase in peak outflow rate through the Bala Park Island constrictions during the design flood, thus increasing flood risk at Bala Bay. The second option selected for the Muskoka/Bala priority area explores and addresses increased flood risk at Bala Bay by way of retrofitting the control structure at Bala South Dam. Using the Muskoka/Bala hydraulic model, rating curves relating Lake Muskoka outflow and water level were generated for both Baseline Case and Mitigation Case (i.e., post-implementation of Option 8). These rating curves were programmed into the hydrologic model to simulate the change in peak outflow from Lake Muskoka during the design flood event, with results showing an approximately 2% increase. Based on rating curves published in the DOM (OMNR, 1997 with 2007 updates), this 2% increase in peak flow translates to a 3 cm increase in Bala Bay peak water level (Figure 9-8).

The increase in Bala Bay peak water level can be mitigated by increasing outflow capacity through the Bala Dams by approximately 2%. The sill elevations and widths of all eight bays of the South Bala Dam are 223.11 m and 4.3 m, respectively. According to the DOM (OMNR, 1997 with 2007 updates), a channel restriction upstream from the South Bala Dam in the form of an elevated smooth bedrock ledge is located approximately 30 m upstream of the dam near the log boom (Figure 9-9).

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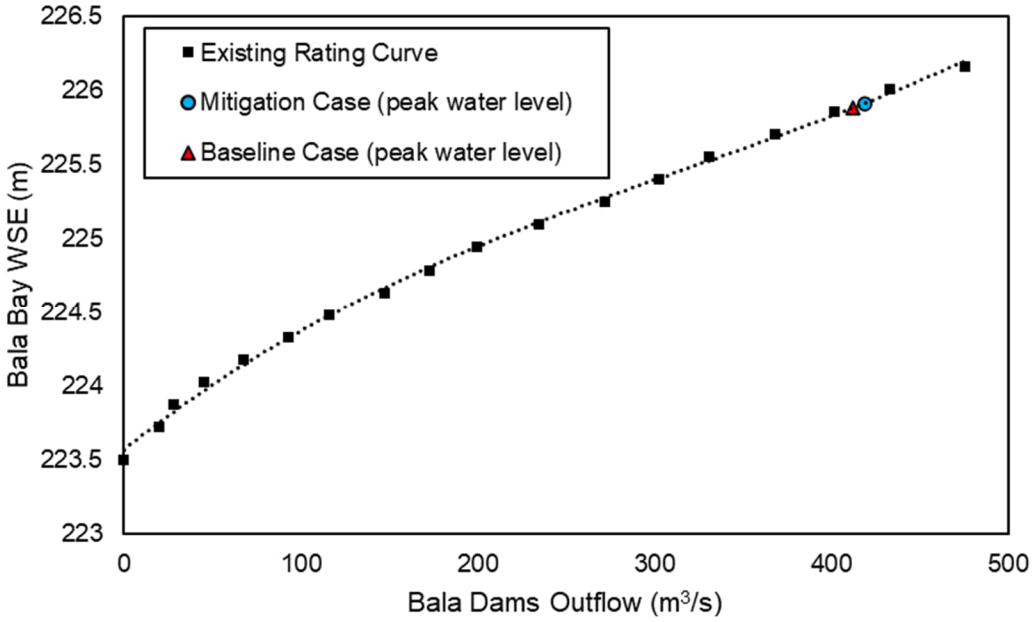

Figure 9-8: Bala Bay peak water level before (Baseline Case) and after (Mitigation Case) channel enlargement at Wallis Cut

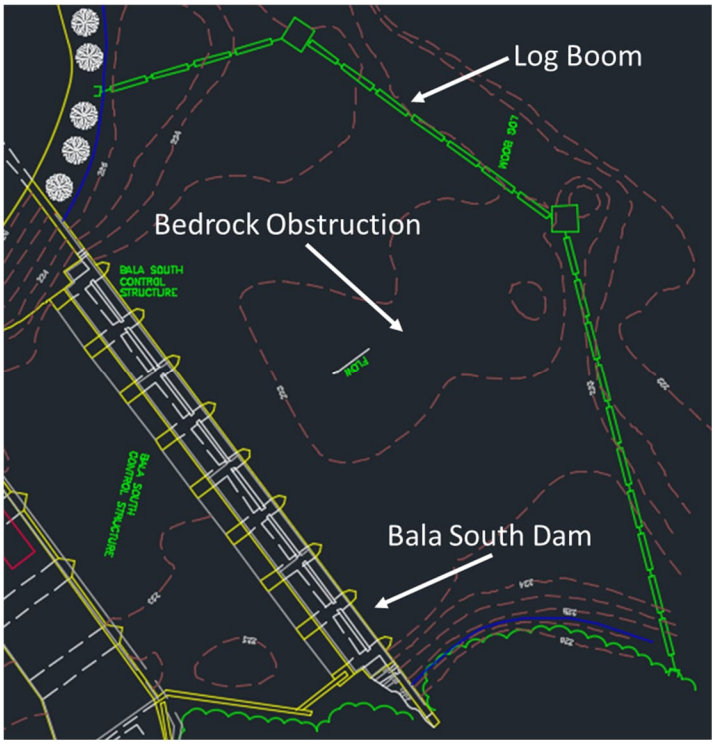

Figure 9-9: Bedrock obstruction upstream from Bala South Dam (image capture from survey data as part of the *North Bala Dam* project – Hatch project number 327078)

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The top of bedrock elevation is, on average, 0.3 m above the sills of the Bala South Dam bays. The DOM (OMNR, 1997 with 2007 updates) reports that due to this obstruction no significant outflow from Bala Bay occurs when the water level of Bala Bay is below 223.41 m. A full open-gate condition includes placement of one stoplog that is 0.3 m tall into each bay, where the top of each stop log is at 223.41 m.

Using rating curves relating Bala South Dam gates/log-settings and Bala Bay water level, as well as the assumption that the 'effective' sill elevation of each bay is 223.41 m, it is estimated that to increase outflow capacity by 2% the 'effective' sill elevation of each bay will need to be reduced to 223.36 m. This means that if the 'effective' sill elevation of each bay was at 223.36 m, the peak water level in Bala Bay during the design flood event would be unchanged from the Baseline Case, even if peak flow rate from Lake Muskoka to Bala Bay was 2% higher.

For this to be achieved, excavation of the bedrock area upstream from the south dam will need to occur.

9.5.1.1 Commentary: Fourth Channel Excavation through Bala Park Island

A prospective option considered was the excavation of a fourth location through Bala Park Island. A specific area of interest was an approximately 20 m wide by 500 m long parcel of land approximately 1 km south-east of Wallis Cut (Figure 9-10) that corresponds with an unopened municipal road allowance.

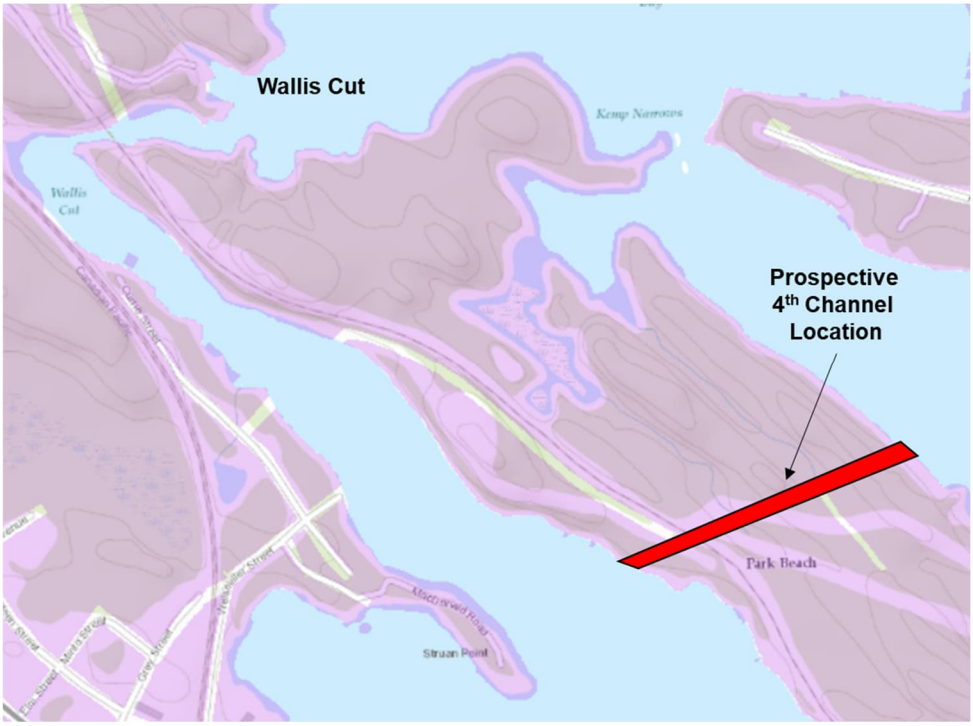

Figure 9-10: Location for prospective channel through Bala Park Island

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The estimated volume of excavation required for this channel was based on the following assumptions:

- Uniform flow through the channel (i.e., slope of water surface and channel bed are equal).
- Water surface profile elevations were based on maximum 2019 water levels observed in Lake Muskoka and Bala Bay.
- Channel had a constant depth of 4 m, and a uniform width of 20 m.

Based on these assumptions, to lower the existing terrain of the prospective channel area to the elevation of the prospective channel bed (Figure 9-11), an excavation of approximately 106,000 m^3 would be required.

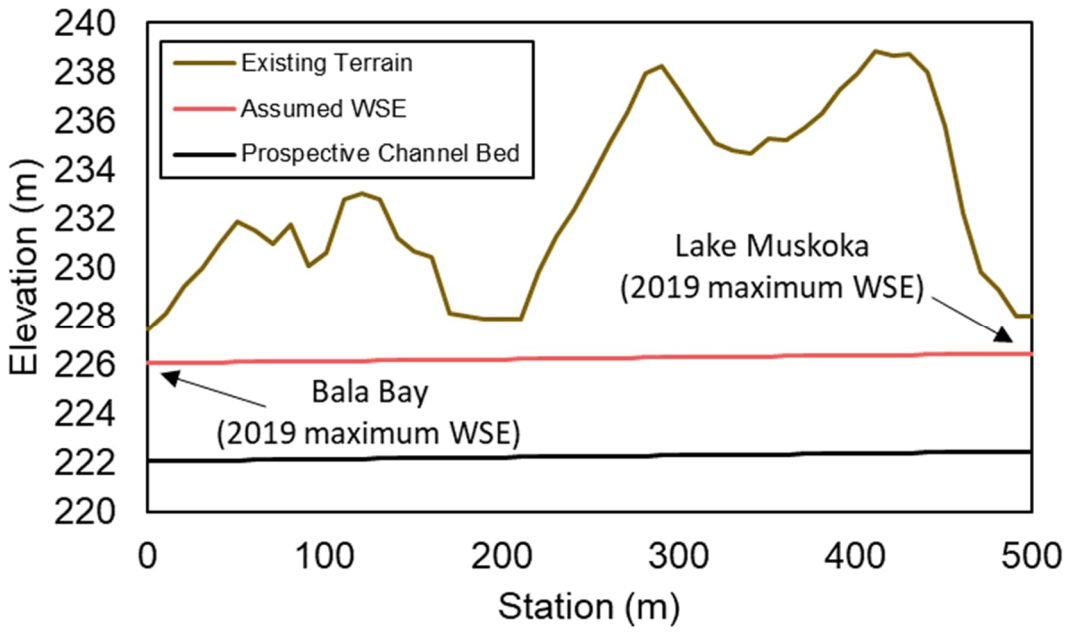

Figure 9-11: Existing and prospective conditions for the fourth Bala Park Island channel

This volume is approximately 10 times the excavation volume required for Wallis cut. In addition to this large excavation requirement, there is need to design and build at least one bridge to facilitate rail transportation. Comparing implementation costs of excavation of a fourth channel to enlargement of Wallis Cut, enlargement of Wallis Cut presents a more feasible option.

A preliminary hydraulic model simulation of the added channel in Figure 9-11 was performed. This simulation showed that excavation of this channel would lower Baseline Case Lake

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Muskoka peak water levels by 0.16 m, a slight advantage over the 0.14 m lowering of peak water levels by Wallis Cut channel enlargement. However, a comparison of excavation volumes suggests that costs of constructing a fourth channel will be significantly greater than channel enlargement at Wallis Cut. Further study would be required to advance development of a fourth channel excavation.

9.5.2 Option 10: Channel Enlargement at Moon Chutes

Downstream from Bala Dams is the Bala Reach of the Muskoka River. For the purpose of this report, the term Bala Reach is meant to describe river sections between the Bala Dam's tailrace and both Ragged Rapids GS and Moon River Dam. Located 6.6 km downstream from Bala Dams is Moon Chute, which is a narrow river section that was previously enlarged by rock excavation to provide flow to downstream facilities Figure 9-12.

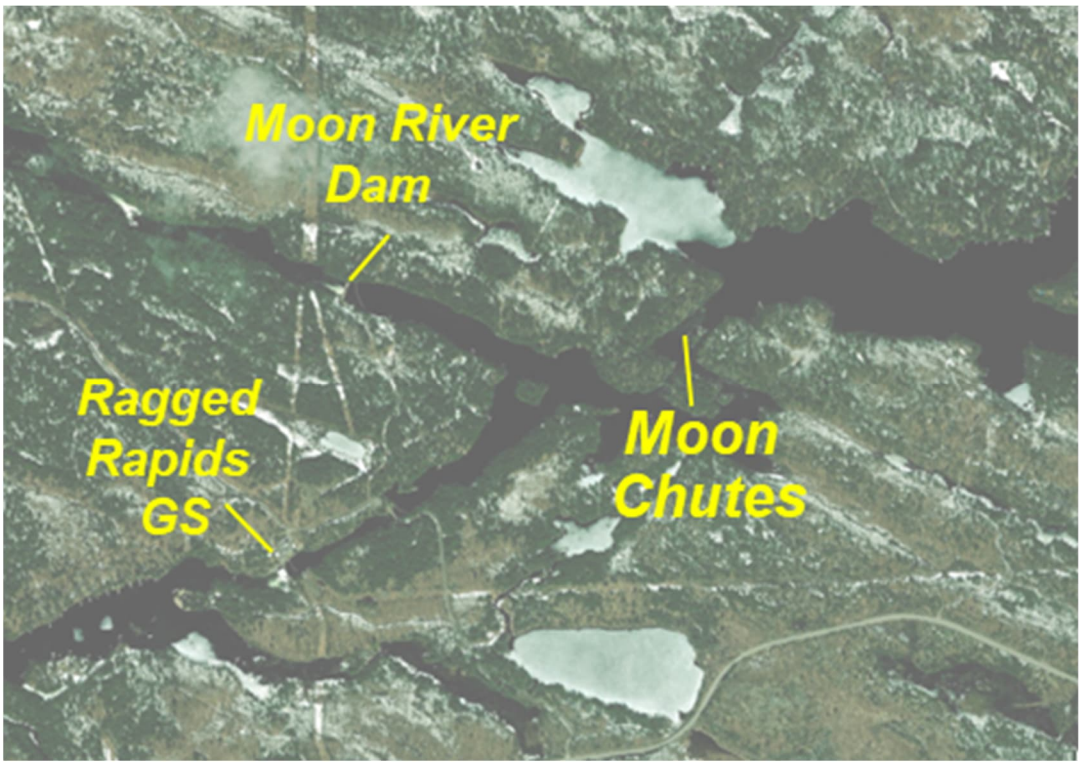

Figure 9-12: Location of Moon Chutes, Moon River Dam and Ragged Rapids GS

Under normal conditions, Moon Chutes remains submerged as control of water levels in Bala Reach is provided by regulation at Moon River Dam and Ragged Rapids GS. Under high flow conditions, hydraulic control shifts from these two downstream locations to Moon Chutes. A reported 2.5 m water level drop occurs between Moon Chutes and Ragged Rapids GS under fully open conditions at high flows.

The last flood mitigation option identified is further channel enlargement at Moon Chutes. Channel enlargement will serve to reduce the influence of Moon Chutes on water levels,

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particularly during high flows. This change could mean that hydraulic control is maintained at Moon River Dam and Ragged Rapids GS during high flows, resulting in lower water levels between Bala Dam and Moon Chutes. Quantitative assessments of flood mitigation benefits achieved by Moon Chutes channel enlargement will be provided in as part of the *Flood Modifications Review*.

9.6 Summary of Flood Mitigation Benefits

A summary of flood mitigation benefits is provided in Table 9-3, Table 9-4, and Table 9-5. These tables are discussed through Section 9 above. Following these tables are plan and profile view of Mitigation Case flood conditions within each priority area (Figure 9-14 through Figure 9-19).

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Table 9-3: Comparison of Baseline Case and Mitigation Case Flood Conditions

Priority Area	Reach	Flood Mitigation Options Assessed[1]	Flood Inundation Area[2] (km^2)		# of Local Impacted Structures (-)	
			Baseline Case	Mitigation Case	Baseline Case	Mitigation Case
Big East River	Big East River	1	9.64	8.36	620	523
Huntsville Narrows	Huntsville	2, 3	1.19	1.14	77	55
Springdale	Springdale	4	0.57	0.30	109	6
Baysville/Fraserburg/Purbrook	Baysville	-[2]	0.51	N/A[3]	12	N/A[3]
Baysville/Fraserburg/Purbrook	Fraserburg	5	2.01	1.45	49	5
Baysville/Fraserburg/Purbrook	Purbrook	6,7	4.36	1.68	145	8
Muskoka/Bala	Lake Muskoka	8,9,10	122.48	121.64	3339	3183
Muskoka/Bala	Bala Bay	8,9,10	4.79	4.79	246	250[4]
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	8,9,10	TBA	TBA	TBA	TBA
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	8,9,10	TBA	TBA	TBA	TBA

Notes:
[1]Mitigation options assessed at each reach only considered local effects to the priority area, and in exceptional circumstances, water bodies in close proximity to the priority area.
[2]Inundation area includes both the area of the water body (i.e., river channel or lake), as well as adjacent floodplain areas surrounding the water body.
[3]None of the selected mitigation options will have a significant flood mitigation impact on the Baysville reach.
[4]An increase in impacted structures from Baseline Case to Mitigation Case reflects higher peak water levels in Bala Bay due to Option 8 (see Section 9.5.1). This effect is mitigated by Option 9 (see Section 9.5.1).
TBA – this information will be provided as part of the *Flood Modifications Review* report.

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Table 9-4: Flood Mitigated Structures (including Category)

Priority Area	Reach	Change in Number of Impacted Structures from Baseline Case to Mitigation Case (including % change)	Classification[1,2]						
			B	C	I\I\SP	O	R	S	N/D
Big East River	Big East River	-97 (16% decrease)	7	27	6	3	32	21	1
Huntsville Narrows	Huntsville	-22 (29% decrease)	1	14	1	1	5	0	0
Springdale	Springdale	-103 (94% decrease)	0	2	0	21	63	17	0
Baysville/Fraserburg/Purbrook	Baysville	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Baysville/Fraserburg/Purbrook	Fraserburg	-44 (90% decrease)	0	0	0	0	0	0	44
Baysville/Fraserburg/Purbrook	Purbrook	-137 (94% decrease)	6	0	0	32	44	56	0
Muskoka/Bala	Lake Muskoka	-156 (4.7% decrease)	4	5	0	10	106	30	1
Muskoka/Bala	Bala Bay	+4[3] (1.6% increase)	0	0	0	0	3	1	0
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

Notes:
[1]Definitions: B = boathouse; C = commercial; I\I\SP = industrial/institutional/special purpose; O = outbuilding; R = residential; S = shed; N/D = no data
[2]Structure classifications are based on data provided by DMM and are considered preliminary.
[3]An increase in impacted structures from Baseline Case to Mitigation Case reflects higher peak water levels in Bala Bay due to Option 8 (see Section 9.5.1). This effect is mitigated by Option 9 (see Section 9.5.1).
TBA – this information will be provided as part of the *Flood Modifications Review* report.

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Table 9-5: Comparison of Baseline Case and Mitigation Case Flood Conditions (including Zoning Classification)

Priority Area	Reach	Flood Inundation Area[2] (km²)			Zoning Classification[1] (expressed as % of Inundation Area Net Change)										
		Baseline Base	Mitigation Case	Net Change	Commercial	Extractive	Industrial	Institutional	Natural Resources[3]	Environmental Protection	Open-Space	Residential	Rural	Transportation[4]	Undefined
Big East River	Big East River	9.64	8.36	-1.28	<1%	<1%	2%	<1%	90%	-	2%	1%	4%	-	-
Huntsville Narrows	Huntsville	1.19	1.14	-0.05	98%	-	<1%	<1%	<1%	-	<1%	2%	-	<1%	-
Springdale	Springdale	0.57	0.30	-0.27	-	-	-	-	-	2%	6%	80%	11%	-	<1%
Baysville/Fraserburg/Purbrook	Baysville	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Baysville/Fraserburg/Purbrook	Fraserburg	2.01	1.45	-0.56	-	-	<1%	<1%	-	47%	<1%	45%	8%	-	-
Baysville/Fraserburg/Purbrook	Purbrook	4.36	1.68	-2.68	-	-	0%	-	-	79%	0%	11%	10%	-	-
Muskoka/Bala	Lake Muskoka	122.48	121.64	-0.84	3%	-	<1%	1%	-	14%	6%	48%	27%	-	-
Muskoka/Bala	Bala Bay	4.79	4.79	+<0.01	5%	-	2%	<1%	-	-	5%	88%	-	-	-
Muskoka/Bala	Bala Reach (Bala Dam to Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA
Muskoka/Bala	Bala Reach (Downstream from Moon Chutes)	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA	TBA

Notes:
N/A – No material flood mitigation in the Baysville reach for this study.
[1]Percentages may not add to exactly 100% due to rounding.
[2]Percentages exclude water bodies, which do not have a zoning classification.
[3]Includes floodway and flood fringe areas.
[4]Includes waterfront landings.
TBA – this information will be provided as part of the *Flood Modifications Review* report.

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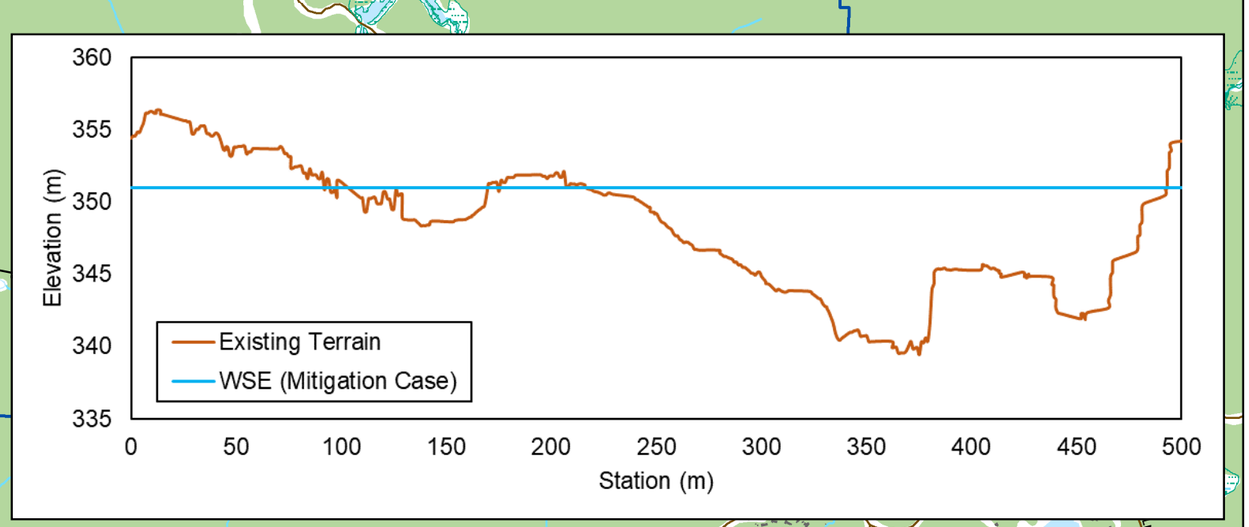
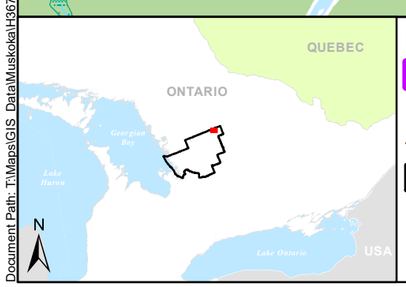
BILLIE BEAR RD

DISTRESS DAM RD

N





LEGEND

- Impacted Structure (Mitigation)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Outlet Cross Section
- Approximate Inundation Area at Elevation 351m
- Watershed Boundary
- Wooded Area
- Flow Direction

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

DATA SOURCES
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3. Spatial Referencing NAD83 UTM Zone 17N

0 0.25 0.5 1 km

1:19,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Modified Distress Dam Site
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	9-13	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

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Arrowhead Lake

Big Bend

Model Boundary

Big East River

Harp Lake

Upstream of Railway

Upstream HWY11

Old North Rd.

Robert RD W.

River Cove Drive

Western Floodplain

HWY 11 South Bound

End of Ravencliffe Road

Lake Vernon/ Big East Delta

Ravencliffe Bridge

Lake Vernon

HIGHWAY 11

OLD NORTH ROAD

RAVENSCLIFFE ROAD

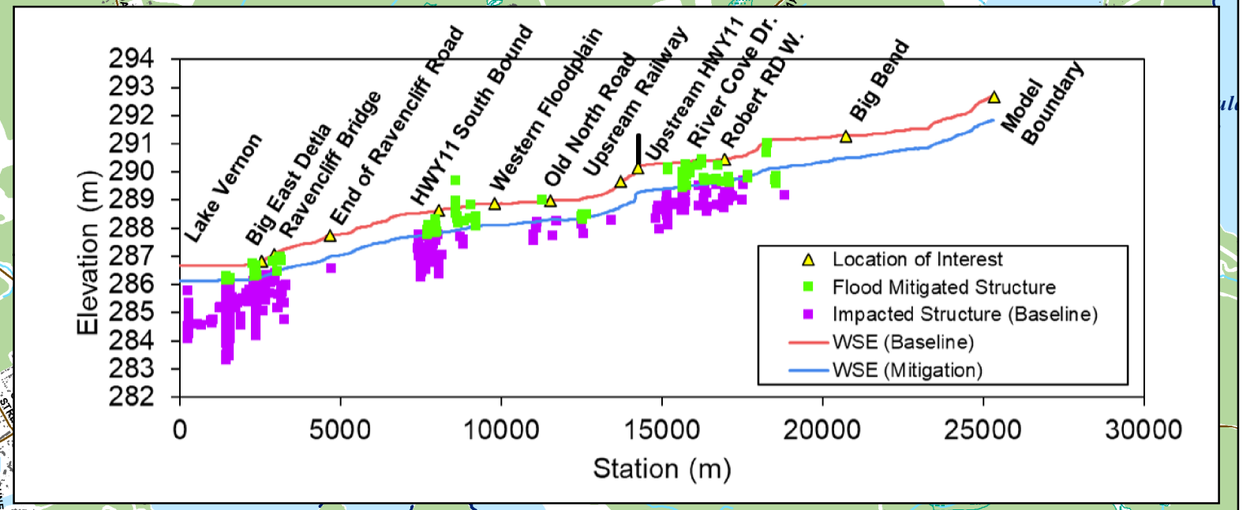
MUSKOKA 3 ROAD

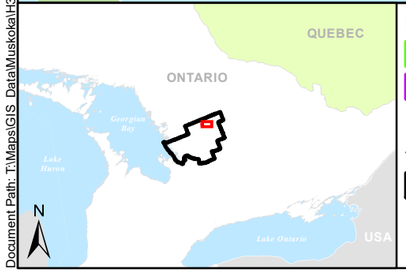
WEST ROAD

MAIN STREET WEST

BRUNEL ROAD

N





LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000 m Intervals)
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity

- Spawning Area
- Flow Direction

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0 0.5 1 2 km

1:40,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Big East River
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	9-14	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

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Lake Vernon

Fairy Lake

RAVENSCLIFFE RD

EXIT 221

WEST RD

Centre Street

KING WILLIAM ST

CLIFFE ST

JOHN ST

Swing Bridge

MAIN ST E

Fairy Lake

0

Lake Vernon

1000

11 HWY S
11 HWY N

2000

3000

4000

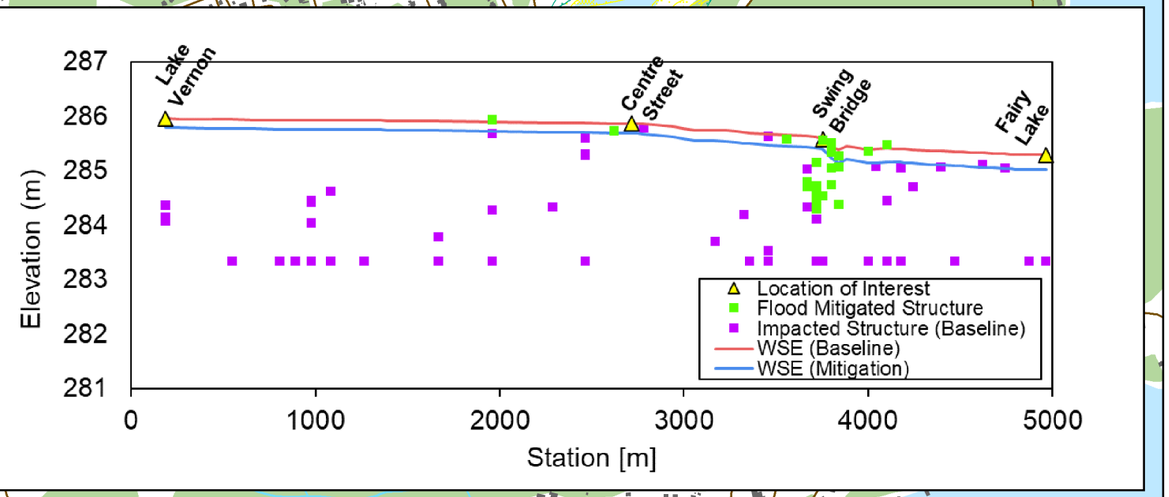
5000

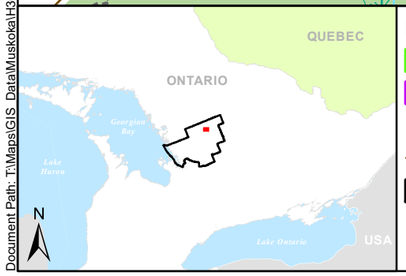
MAIN ST W

EXIT 219

ASPDIN RD

N





LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000m Intervals)
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.125 0.25 0.5 km

1:13,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Hunstville Narrows
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	9-15	0
DATE: 2022/09/12	PAGE: 1 of 1		

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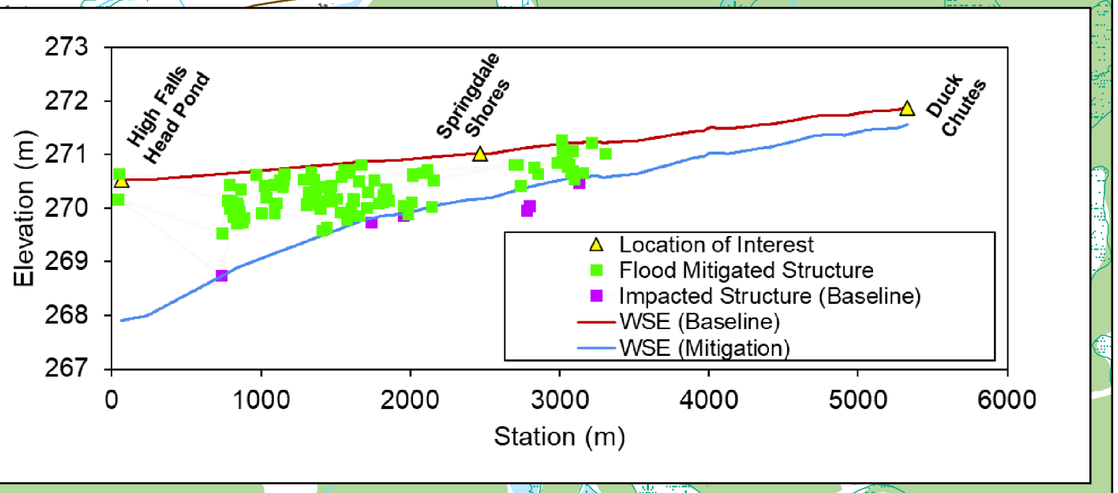
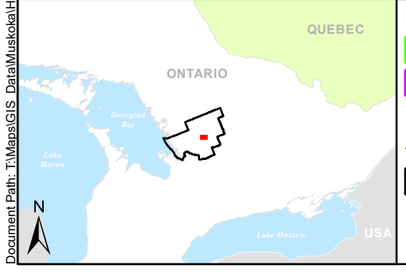
Duck Chutes
5000
4000
3000
2000
1000
0
Springdale Shores
High Falls Head Pond
Muskoka River
HIGHWAY 11
BONNIE LAKE ROAD
MUSKOKA ROAD 117
HOLIDAY PARK ROAD
HIGH FALLS ROAD
N





LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- River Station (1000 m Intervals)
- Location of Interest
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland

Fish Activity

- Spawning Area
- Flow Direction

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0 0.25 0.5 1 km

1:18,000

PROJECT: Structural Flood Mitigation Options				
FIGURE TITLE: Flood Mitigation at Springdale				
CLIENT: District of Muskoka				
DWG BY: J. SNELGROVE	CHK BY: K. LEES	FIGURE NO.: 9-16	REV NO.: 0	HATCH
DATE: 2022/09/12	PAGE: 1 of 1			

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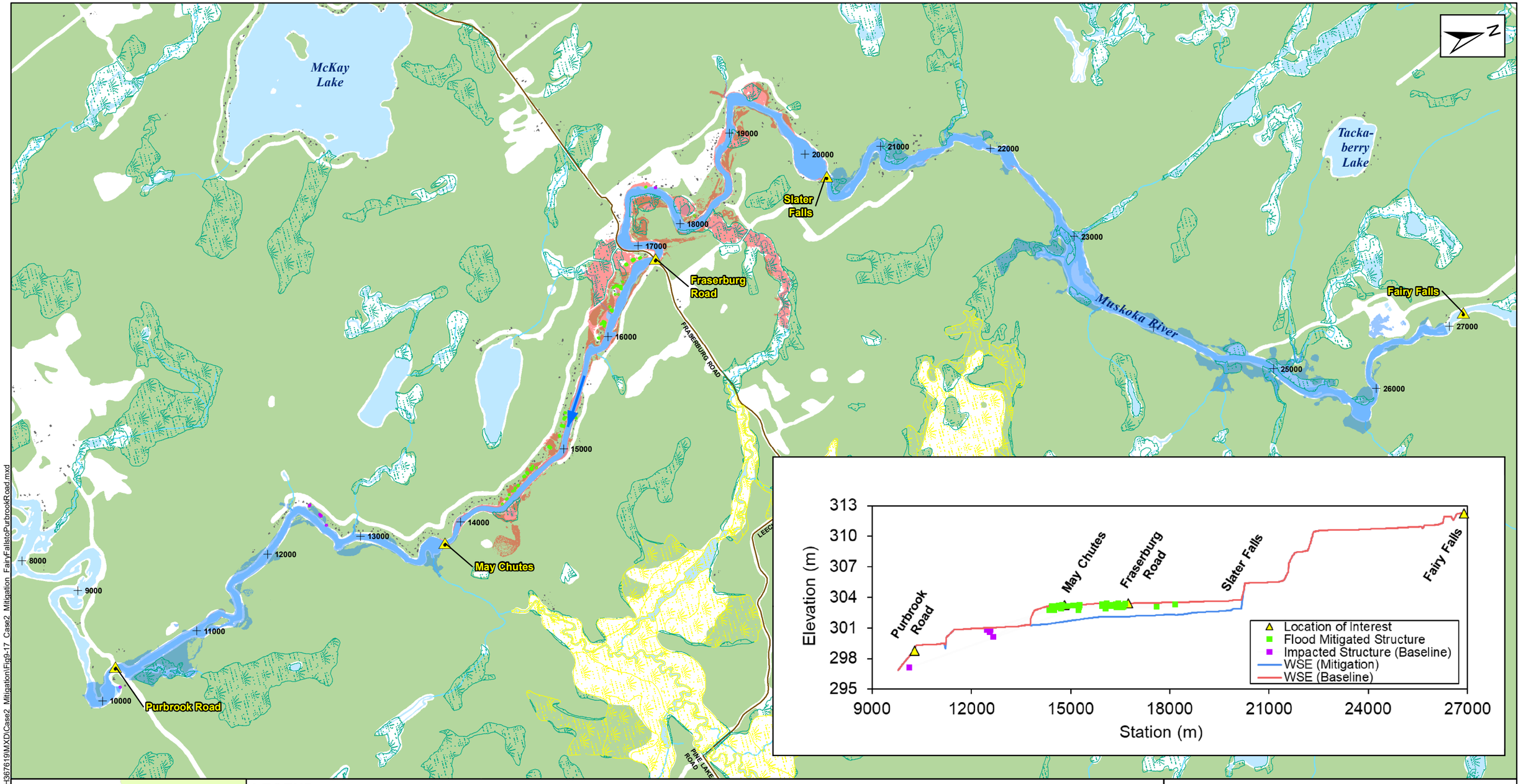



LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000 m Intervals)
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Flow Direction

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3. Spatial Referencing NAD83 UTM Zone 17N

0 0.25 0.5 1 km

1:27,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Fairy Falls to Purbrook Road
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	9-17	0
DATE: 2022/09/12	PAGE: 1 of 1		

HATCH

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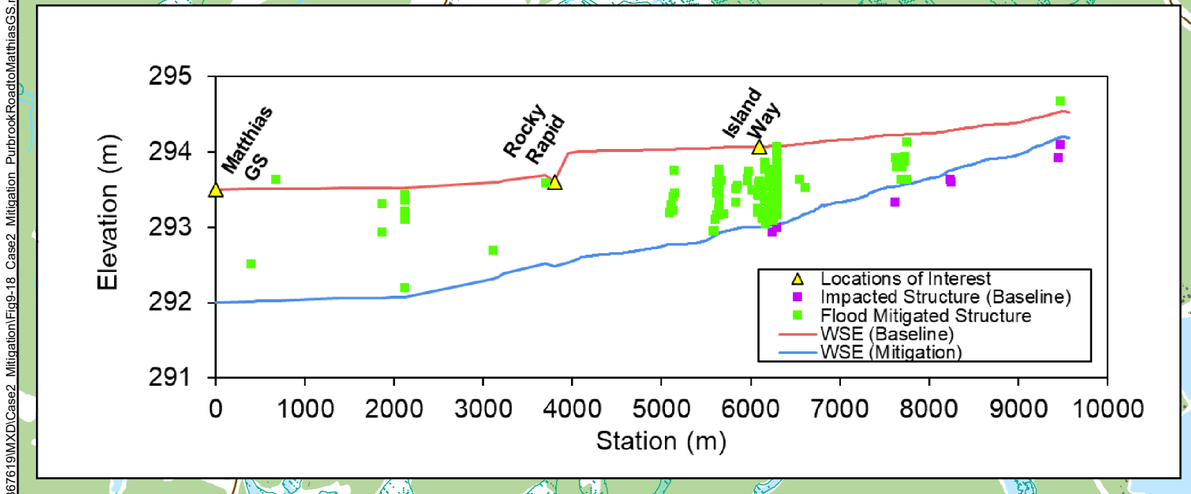
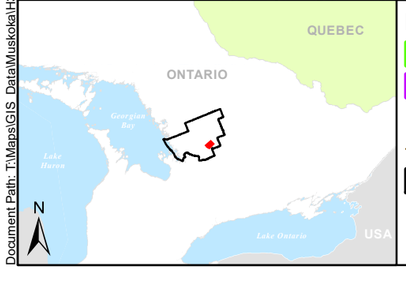
Matthias GS
0
1000
2000
3000
Rocky Rapids
4000
5000
6000
Island Way
7000
8000
9000
Muskoka River
Purbrook Road
10000
11000
12000
HIGHWAY 118
Spring Lake





LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Location of Interest
- River Stations (1000 m Intervals)
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 0.25 0.5 1 km

1:23,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Purbrook Road to Matthias GS
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:	
J. SNELGROVE	K. LEES	9-18	0	HATCH
DATE: 2022/09/12	PAGE: 1 of 1			

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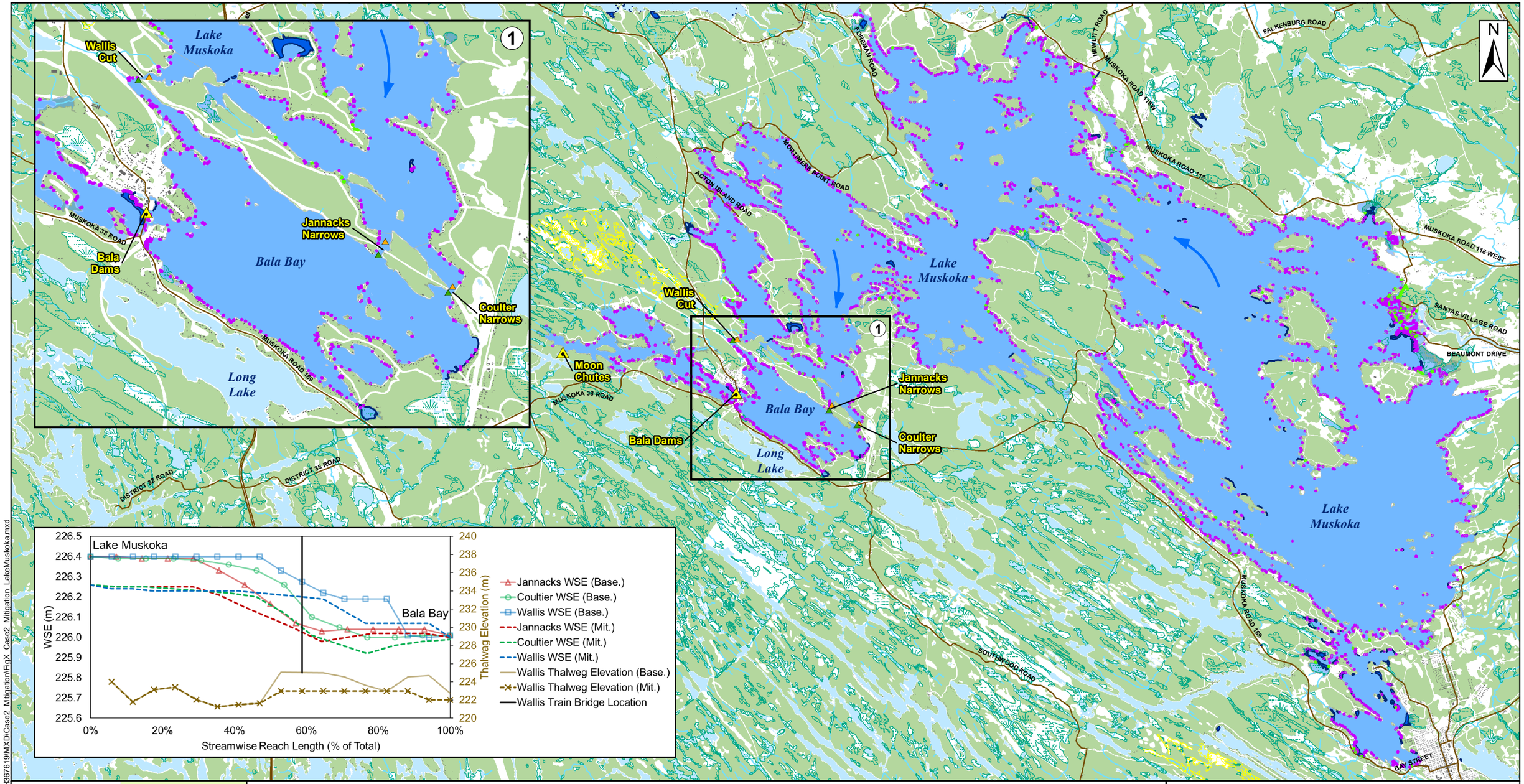

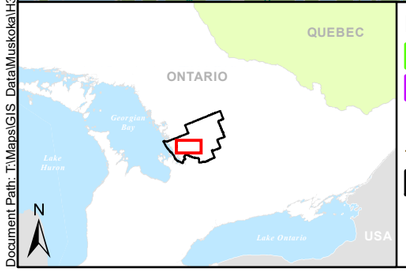

LEGEND

- Flood Mitigated Structure
- Impacted Structure (Baseline)
- Structure
- Road
- District of Muskoka Boundary
- Watercourse
- Waterbody
- Streamwise Reach Length (0% of Total)
- Streamwise Reach Length (100% of Total)
- Location of Interest
- Flood Inundation Area (Mitigation)
- Flood Inundation Area (Baseline)
- Wooded Area

Wetland

- Not Provincially Significant Wetland
- Provincially Significant Wetland

Fish Activity Area

- Spawning Area
- Flow Direction

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0 1.25 2.5 5 km

1:100,000

PROJECT:	Structural Flood Mitigation Options
FIGURE TITLE:	Flood Mitigation at Lake Muskoka
CLIENT:	District of Muskoka

DWG BY:	CHK BY:	FIGURE NO.:	REV NO.:
J. SNELGROVE	K. LEES	9-19	0
DATE: 2022/09/12	PAGE: 1 of 1		

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9.7 Supplemental Options Considered

As mentioned in Section 9, a preliminary set of options was identified. A set of preferred options was then selected based on a qualitative ranking assessment and discussion with DMM and the TWG – these ten options are presented in the sections above. The following options were also evaluated but were not pursued. A short description of these options as well as identified constraints which precluded advancement are as follows:

9.7.1 Big East River

1) **Flood containment structure at the former site of Finlayson Dam**: This flood attenuation option is similar in concept to the proposed retrofit of the control structure at Distress Dam (Section 9.1.1). One drawback of this option is that the stage-volume ratio for the upstream inundation area at Finlayson is greater relative to Distress, meaning that a higher control structure would be required at Finlayson to achieve the same flood mitigation benefit. Further, Finlayson is also more geographically remote than Distress and would, therefore, could present greater construction and operational challenges.

2) **Dyking and channel straightening via bypasses**: The highly dynamic morphology of the Big East River presents challenges for implementing dyking and channel bypasses. Long and meandering shorelines mean that large quantities of material are required to build appropriately sized levees to protect structures within the Big East River's meander belt. As the channel continues to evolve and meander, these levees may become structurally unstable leading to repair and rehabilitation requirements. Construction of bypass channels could reduce energy dissipation in the river, meaning that the river flows could become more erosive in other areas of the channel. Instead of mitigating flooding, these bypass channels could simply move flooding issues elsewhere along the Big East River.

9.7.2 Huntsville

3) **Channel Excavation at Huntsville:** Excavation of the Muskoka River North Branch upstream from the Centre Street swing bridge was considered. However, hydraulic analyses showed that only small water level reductions were achieved for large quantities of excavation. These results indicate that water levels in the Huntsville Narrows are controlled primarily by other factors, including the Huntsville Lakes' water levels and the hydraulic control of the swing bridge.

4) **Raised Road at John Street:** Raising the road at John Street (located near the Swing Bridge) was considered as an alternative to the shoreline berm option reflected as Option 6. This option would involve recontouring John St in the lowest sections of the road to provide sufficient freeboard to prevent water ingress during a flood. This would entail a raise of over 2 m in the center and a recontouring extending over 200 m. Entrances to properties on both sides of John St would need to be regraded. The height of the raise may require retaining walls at entrances and along the road to avoid infringing on private property. In addition to cost and logistical considerations of raising John Street, the

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shoreline berm option (i.e., Option 6) is advantageous from a flood protection perspective as it protects a greater number of structures.

9.7.3 Springdale

5) **Raised Road at Springdale Shores:** Springdale Shores features a cluster of flood-impacted structures that were targeted for protection by a levee, in the form of raising the road at Springdale Shores. Further investigation of this option uncovered that this road is privately owned, and for this reason the option could not be pursued.

6) **Temporary Wetland Storage at Springdale:** Several land parcels surrounding the Springdale reach of the Muskoka River's North Branch were examined as potential sites for wetland storage. Upon review of LiDAR data for the area, the topography features high elevations and steep slopes that are comprised of underlying bedrock. This precludes the feasibility of significant peak flow reductions through use of a 'green' flood attenuation option such as a constructed wetland. Even if this option were pursued, significant excavation depths would be required to provide the substantial volume required for material changes in peak water levels at Springdale.

9.7.4 Baysville/Fraserburg/Purbrook

7) **Increase Lake of Bays storage:** The feasibility of reducing peak water levels along the Muskoka River South Branch via increasing peak water levels in Lake of Bays was investigated. This approach would require structural modifications to the Baysville Dam to increase outflow control during flood conditions. An analysis of impacted structures under different peak flow reduction scenarios (e.g., 10%, 20%, etc) was completed using a hydrologic model, LiDAR based topography data, and a geospatial layer of structure footprints. The ratio of impacted structures surrounding Lake of Bays relative to Muskoka River South Branch (Baysville/Fraserburg/Purbrook specifically) was at least 2:1 for the scenarios tested, with some cases showing ratios as high as 5:1. These findings suggest that such a practice would result in a net increase in the number of flood-impacted structures in the South Branch of the MRW, which would be counterproductive for reducing flood risk.

9.7.5 Muskoka/Bala

8) **Channel Excavation at Coultier Narrows and Jannacks Narrows:** Bathymetric surveys indicate that similar to Wallis Cut (see Option 8), Coultier Narrows and Jannacks Narrows also have high bed elevations that are obstructing flows. Simulated flow distributions between these three constrictions suggest that Wallis Cut has relatively low flow rate amongst the three channels, which presents an advantage for water management during construction. For this main reason, only Wallis Cut was advanced for flood mitigation via channel enlargement.

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10. Mitigation Case Environmental Review

Table 10-1 below provides an overview of mitigation case impacts to natural heritage features like woodlands, wetlands, fish and fish spawning habitat, potential SAR habitat, general wildlife impacts and residential/agricultural impacts for each of the priority areas. Commentary is provided in the following subsections.

10.1 General Impacts

General impacts that may apply to woodlands, wetlands, fish and fish habitat, and general wildlife habitat within the priority areas have been reviewed and are described below.

10.1.1 Woodlands

Inundation Increase

- In areas where adjacent banks and floodplain areas are wooded and become inundated, this may result in degraded tree health or the eventual failure of the tree depending on the tree species affected, duration of the inundation event and seasonal timing.
  - Species: Some tree species are more resilient and tolerant to inundation events and will fare better than others.
  - Duration: A brief period of inundation is less likely to cause undue harm to the tree, however, flooding of a tree's roots for greater than a week will result in injury (Tree Canada, 2020).
  - Season: The timing of the inundation to the woodland areas is important as if the event takes place during the dormant during the winter months, trees can forgo oxygen for longer periods.
- Regardless of the depth of inundation, shortages or loss of oxygen in flooded soils can result in negative impacts to the tree. When soil pores, which are typically filled with oxygen, are flooded with water oxygen is unable to passively reach the tree roots.
- Tree symptoms of flood stress include chlorosis (yellowing of normally green leaves due to a lack of chlorophyll), wilting, undersized/curling leaves, sparse crown, early fall colouring, branch-tip dieback and eventual failure of the tree (The Morton Arboretum, 2022).
- When trees are in a state of stress, they are more susceptible to disease and less resilient against defoliating insects (Canadian Council of Forest Ministers, 2009).
- Depending on the contents of the flood waters, the contents transported and deposited can either degrade or improve soil conditions. Pollutants and excess nutrients may degrade soil health and cause stress to trees, whereas important nutrients and mineral deposits may result in improved plant growth.

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Table 10-1: Mitigation Case Environmental Review

Location	Impacts						
	Woodland Inundation	Wetland Inundation	Fish/Fish Spawning Habitat	Species At Risk with Records in Priority Area		General Wildlife Impacts	Residential / Agricultural Inundation
Big East River	Mitigation efforts are likely to reduce, but not eliminate, inundation of woodland areas.	Mitigation efforts are likely to reduce, but not eliminate, inundation of wetland areas.	Mitigation Efforts could potentially result in: • Increased impacts to fish habitat from higher water levels (including several spawning areas along the Lake Vernon shoreline including Northern Pike and Lake Trout spawning areas. • Reduced impacts to water quality (sedimentation, deleterious substances) from flood drawdowns due to the reduction of urban environments that would experience flood conditions	Bank Swallow Barn Swallow Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher	Bank Swallow Barn Swallow Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher	Impacts to Stratum 2 deer overwintering habitat, the Mixed Wader Nesting Colony, and the Colonial Waterbird Nesting Area would likely be reduced with reduced inundation impacts but continue to persist. Mitigation efforts have the potential to reduce or eliminate impacts to Stratum 1 deer overwintering habitat.	Mitigation efforts are expected to reduce inundation impacts within designated 'Environmental Protection' zoning, where there are flood mitigated structures. Structures in this area include boathouses, commercial, I/I/SP, outbuildings, residential and sheds.
Big East River – Distress Dam	Mitigation efforts would likely see new inundation of previously un-inundated woodland areas.	Mitigation efforts would likely see new inundation of previously un-inundated wetland areas.	Mitigation efforts could potentially result in: • Increased impacts to fish habitat from higher water levels (including potentially sensitive brook trout habitat in Tonawand Creek, particularly if the Distress Dam head pond water levels become higher than current flood conditions • Impacts to water quality (sedimentation, deleterious substances and potential thermal degradation to cold water regimes) from flood drawdowns in large terrestrial areas adjacent to the River that would become inundated	Barn Swallow Canada Warbler Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Barn Swallow Canada Warbler Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Mitigation efforts have the potential to inadvertently impact late wintering area for Moose.	
Huntsville Narrows / Brunel Locks	Mitigation efforts are unlikely to alter baseline impacts (i.e., no inundation) to woodland areas.	Mitigation efforts are unlikely to alter baseline impacts (i.e., no inundation) to wetland areas.	Mitigation efforts will potentially result in: • Impacts to fish habitat from higher water levels similar to that of the baseline flood scenarios (including several spawning areas including Northern Pike and Lake Trout spawning areas along channel shorelines between Lake Vernon and Fairy Lake • Impacts to fish movement through channel at Brunel Locks from increased velocities through the channel potentially resulting in disruptions to fish migration and access to habitat. • Some impacts to water quality (sedimentation, deleterious substances) from flood drawdowns, albeit likely to a lesser degree than baseline flood scenarios due to flood prevention within the commercial properties between John St and Chaffey St • Potential impacts to riparian/shoreline habitats within area of proposed berm/retaining wall	Bank Swallow Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Bank Swallow Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Mitigation efforts would be unlikely to alter baseline impacts (i.e., no impact) to Stratum 2 deer overwintering habitat.	Mitigation efforts are expected to reduce inundation impacts to the Town of Huntsville. Structures in this area include boathouses, commercial, I/I/SP, outbuildings and residential.
Springdale	Mitigation efforts have the potential to eliminate inundation effects of woodland areas.	Mitigation efforts are unlikely to reduce or eliminate inundation impacts to wetland areas.	Mitigation efforts may potentially result in: • Reduced impacts to water quality (sedimentation deleterious substances) from flood drawdowns as flooded terrestrial areas have been reduced	Barn Swallow Canada Warbler Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Wood Thrush Blanding's Turtle	Barn Swallow Canada Warbler Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Wood Thrush Blanding's Turtle	Mitigation efforts have the potential to reduce or eliminate impacts to Stratum 2 deer overwintering habitat.	Mitigation efforts are expected to reduce inundation impacts to shoreline areas. Structures in this area include commercial, outbuildings, residential and sheds.
Baysville	There are no mitigation options for this sub-reach, and thus any impacts on affected woodland areas will continue.	There are no mitigation options for this sub-reach, and thus any impacts on affected wetland areas will continue.	There are no mitigation options for this sub-reach, therefore any impacts to Smallmouth Bass spawning within the South Branch of the Muskoka River will continue	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	There are no mitigation options for this sub-reach, and thus any effects on deer overwintering habitat, the Mixed Wader Nesting Colony, and the Colonial Waterbird Nesting Area would continue.	There are no mitigation options for this sub-reach, and thus any effects to residential or agricultural would continue.

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Location	Impacts						
	Woodland Inundation	Wetland Inundation	Fish/Fish Spawning Habitat	Species At Risk with Records in Priority Area		General Wildlife Impacts	Residential / Agricultural Inundation
Fraserburg	Mitigation efforts have the potential to eliminate inundation effects of woodland areas.	Mitigation efforts are likely to reduce, but not eliminate, inundation of wetland areas. Mitigation efforts are expected to bring down water surface profile.	Mitigation efforts could potentially result in: • Permanent impacts to fish movement (migration, spawning, general usage) from increased velocities through narrows such as May Chutes, particularly from excavation efforts resulting in increased depths • Temporary restriction of fish movement through May Chutes during channel excavation works • Temporary impacts to fish behaviour from bedrock blasting noise and vibration levels • Reduced impacts to water quality (deleterious substances) from flood drawdowns due to reduction of flooding in urbanized areas (Fraserburg Road), however potential increase in sedimentation from increased overland flow from terrestrial vegetation communities	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Mitigation efforts have the potential to reduce impacts to Stratum 2 deer overwintering habitat the Mixed Wader Nesting Colony, and the Colonial Waterbird Nesting Area, but would likely not eliminate the impacts entirely.	Mitigation efforts are expected to reduce inundation impacts on structures in this area.
Purbrook	Mitigation efforts are likely to reduce, but not eliminate, inundation of woodland areas.	Mitigation efforts are likely to reduce, but not eliminate, inundation of wetland areas. Due to lower head pond levels, water availability in impacted wetlands in this priority area is likely to decrease.	Mitigation efforts could potentially result in: • Permanent impacts to fish movement (migration, spawning, general usage) from increased velocities through narrows such as Rocky Rapids, particularly from excavation efforts resulting in increased depths. This area may be particularly sensitive to increased depths as fish likely use the shallow rapids for life processes. • Temporary restriction of fish movement through Rocky Rapids during channel excavation works • Reduced impacts to water quality (deleterious substances and sedimentation) from flood drawdowns due to reduction of flooding in wetland environments	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Mitigation efforts have the potential to reduce impacts to Stratum 2 deer overwintering habitat, the Mixed Wader Nesting Colony, and the Colonial Waterbird Nesting Area, but would likely not eliminate the impacts entirely.	Mitigation efforts are expected to reduce impacts on structures in this area. Structures include boathouses, outbuildings, residential and sheds.
Muskoka/Bala	Mitigation efforts are unlikely to impact any inundation effects on woodland areas.	Mitigation efforts are unlikely to reduce or eliminate overall inundation impacts to wetland areas. Mitigation efforts may decrease water levels for wetlands adjacent to Lake Muskoka, and increase / saturate for wetlands adjacent to Bala Bay.	Mitigation efforts could potentially result in: • Further impacts to fish habitat from higher water levels in Bala Bay during flood scenarios (particularly several spawning areas including Smallmouth Bass, Northern Pike, Lake Trout, Largemouth Bass and Walleye spawning areas surrounding the shorelines and shoals of Bala Bay) • Permanent lowering of water levels within Lake Muskoka has the potential to expose shallow areas used for Smallmouth Bass, Northern Pike, Lake Trout, Largemouth Bass and Walleye spawning, potentially resulting in a loss of spawning habitat • Impacts to water quality (sedimentation deleterious substances) from flood drawdown along areas of Bala Bay where water levels are anticipated to increase during flood events • Further impacts to fish movement from increased velocities through narrows such as Wallis Cut, Jannacks Narrows, Coultier Narrows due to channel excavations and widenings	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Meadowlark Eastern Whip-poor-will Eastern Wood-pewee Golden-winged Warbler Least Bittern Olive-sided Flycatcher Red-headed Woodpecker Wood Thrush Blanding's Turtle Common Five-lined Skink	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Meadowlark Eastern Whip-poor-will Eastern Wood-pewee Golden-winged Warbler Least Bittern Olive-sided Flycatcher Red-headed Woodpecker Wood Thrush Blanding's Turtle Common Five-lined Skink	Mitigation efforts are unlikely to have any significant effect on baseline impacts to Stratum 2 deer overwintering habitat, the Mixed Wader Nesting Colony, and the Colonial Waterbird Nesting Area.	Mitigation efforts are expected to reduce backwater in Lake Muskoka. A preliminary list of structures in this area include boathouses, commercial, outbuildings, residential and sheds.

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- Depending on the depth of inundation, flood waters have the ability to carry debris resulting in the harm to a tree's roots/trunk.

Inundation Decrease

- Decreasing the frequency of inundation, depending on the seasonal requirements of the trees in the area, can benefit woodland communities that only require periodical inundation.

10.1.2 Wetlands

- Changes in water levels and inundation events can place stress on wetland ecosystems.
  - When wetlands are in a state of stress, they and the species they host (e.g., Blanding's Turtle) are more susceptible to disease and less resilient against the spread of invasives such as the European Common Reed (*Phragmites australis ssp. australis*) and the Emerald Ash Borer (*Agrilus planipennis fairmaire*) (COSEWIC, 2016).
- Changes in water levels and inundation events can either decrease or increase habitat connectivity for wetland species depending on the species affected, the duration of the inundation event, the depth of inundation, and seasonal timing.

Inundation Increase

- Wetland inundation may result in degraded vegetation health or failure depending on the species affected, the duration of the inundation event, and seasonal timing.
  - When soils become saturated, they become completely anaerobic apart from a thin oxygenated layer at the surface (Van Diggelen, 1991). Thus, regardless of the depth of inundation, shortages or loss of oxygen in flooded soils can result in negative impacts to wetland vegetation.
  - Increased inundation events decrease the recovery rate and capability of wetland vegetation, which may suggest an increased risk of ecosystem collapse (van Belzen et al, 2017).
- Increased flood events can place stress on a wetland ecosystem by creating wetter and higher-salinity conditions.
- Prolonged inundation can decrease the functional capacity of a wetland due to altered abundances of forest floor litter and tree debris (Price & Berkowitz, 2020).
- Inundation events can contribute to increased sedimentation or alteration of turbidity levels, which may jeopardize water quality and wetland health due to growth of algae and/or phytoplankton blooms.
- Changes to water flow can alter shorelines and shoreline habitat, which can reduce the availability of suitable habitat for wildlife species.

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- For example, increasing water levels have been negatively correlated with nest numbers and availability of nesting substrate for wading and aquatic birds (Chastant, et al, 2017).

Inundation Decrease

- Water control measures must not hydrologically disconnect wetlands from the Muskoka River, as this may have impacts on both the watershed and the unique chemical composition of the wetlands in this area; watershed and chemical changes can alter the distribution of beavers and other wetland biota.
- Decreases in inundation and water flow resulting in decreased soil water content can make soils hydrophobic, which can cause soil compaction and promote increased nutrient run-off (Wright, 2009).

10.1.3 Fish and Fish Habitat

Flood mitigation measures such as channel excavation and dredging may result in the following general impacts:

- Deepening watercourses or changing watercourse structure will modify water flow and volume through a given area. Water depth and flow alterations have the potential to influence watercourse characteristics such as in water structure, substrate types, temperature, oxygenation, shoreline morphology and in water vegetation. All of these factors influence the type of habitat present and whether fish with utilize it for spawning purposes. To better understand the extent of these changes hydrotechnical modelling may be required to understand the habitats that may be altered or created.
- Changes in water levels and flow can alter water temperatures and therefore the life cycle of some fish species. Generally deeper waters are less prone to high temperature fluctuation. Several fish species rely on water temperature as an environmental trigger to begin spawning activities (i.e., Walleye).
- Changes in water levels can alter light availability throughout the water column. Deeper waters may not allow light to penetrate to the bottom and cause decomposition of the existing submerged vegetation, changing sediment composition and the aquatic vegetation community. Different fish species prefer different vegetation communities and density of vegetation.
- Changes in water levels have the potential to expose spawning habitat (i.e., shoreline shoals used by Lake Trout, shallow vegetated areas used by bass and sunfish species) making it unusable for spawning. Loss of spawning habitat has the potential to limit population sustainability if the habitat is not available in other areas near the lost habitat.
- This activity may temporarily impact water quality and appropriate mitigation measures and best management practices will need to be put in place to minimize local and downstream impacts from increased turbidity, anthropogenic materials and

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sedimentation. In water work will also require some mitigation measures to minimize impacts to the locally present fish community and habitat.

Flood mitigation measures requiring the temporary increase in water volume and inundation lands adjacent to lakes or head ponds may result in the following general impacts.

- Changes in head pond releases may impact downstream flow levels. Certain species have specific flow requirements for spawning activities (i.e., Walleye rely on fast-flowing rivers or rocky lake shoals with sufficient flow or wave action to keep eggs well oxygenated). Stagnant waters within lakes and head ponds are more likely to have lower oxygen levels than riffles (faster running water that is mixed with the air).
- Temporary inundation of normally terrestrial landscapes may lead to sedimentation and bank destruction from the overland areas to the waterbody. Increases in sedimentation can impact fish and fish habitat in multiple different ways. Sediment can cover the gills of fish and other aquatic organisms interfering with life processes (i.e., decreased growth/reproduction capabilities). Species have varying tolerances to turbidity levels, with some being more sensitive than others. Large amounts of sediments can cover coarser substrates making it unsuitable spawning habitat for some species. For instance, Lake Trout require clean gravel substrates to spawn. Sedimentation can decrease the quality of spawning habitat available. It can also cover fish eggs decreasing oxygen levels and their chance of survival. Turbidity increases as a result of sedimentation can reduce light penetration deep into watercourses which can cause submerged aquatic vegetation to die off and reduce dissolved oxygen levels. Sediment runoff in agricultural areas can lead to heavy algae growth which can lead to eutrophication and reduced oxygen levels in waterbodies.
- Temporary inundation of upland areas during high water periods can lead to temporary pooling in areas outside of the normal high watermark once water levels return to lower. This can lead to the stranding of fish and ultimately the death of fish.
- If scenarios exist where water levels may be lowered to increase flood capacity in lakes, foraging habitat available for the fish community may be reduced. Where these areas overlap with known spawning habitat, this may impact the total amount of spawning habitat available. It is expected that some tolerance exists for changing water levels in these areas and that similar/suitable habitat would be established elsewhere in the system/lake.

10.1.4 General Wildlife Habitat

- Development activities, fluctuations in water levels, and inundation events occurring during breeding season may result in damage to nests and nestling mortality (COSEWIC, 2013).

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- Development activities may include excavation, construction activity during river erosion and flood control projects, as well as the implementation of flood or erosion control measures such as armoring or hardening shorelines (COSEWIC, 2013).
- Inundation events and fluctuations in water level associated with flood control and hydropower projects can also result in nest and colony inundation, leading to increased risks of nest damage and nestling mortality (COSEWIC, 2013).

- According to the District of Muskoka's Official Plan (2019), activities such as development and site alterations must consider impacts on wintering habitat for White Tailed Deer (*Odocoileus virginianus*). This habitat can be separated into two areas: Stratum 1 and Stratum 2.
  - Stratum 1 overwintering habitat is considered "core" habitat and can be described as the area where deer concentrate mid-winter when the depth of snow cover restricts movement (>50cm). It is generally surrounded by Stratum 2 overwintering habitat.
  - Site alteration or development activity in Stratum 1 habitat areas is generally not permitted as it would impact food supply and thermal cover required by deer.
  - Site alteration or development activity in Stratum 2 habitat areas may be permitted on the condition it conserves valuable thermal cover, movement corridors, and feeding areas.
  - If habitat is identified, activity in that location must be avoided, or mitigation measures must be proposed.

10.1.5 Species at Risk

As identified in Section 7, records for 37 provincially listed SAR have been identified in the Study Area as potentially occurring within the priority areas. Table 10-2 below lists the records for the SAR were identified in the desktop review.

To better understand the potential presence/absence of individuals and suitable habitat for the listed SAR, it is recommended that appropriate habitat and vegetation surveys are undertaken to refine where the habitats or species may occur. These surveys can be targeted to the areas directly or indirectly impacted during flood conditions or if the mitigation measures permanently alter water levels within the priority area.

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Table 10-2: Summary of SAR Records for Each Priority Area

Location	Total SAR Records	Recorded SAR in Area	
Big East River	Records for 19 SAR	Bank Swallow Barn Swallow Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher	Wood Thrush Midland Painted Turtle Snapping Turtle Riverine Clubtail Yellow-banded Bumble Bee Black Ash Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Big East River – Distress Dam	Records for 14 SAR	Barn Swallow Canada Warbler Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon Wood Thrush	Midland Painted Turtle Snapping Turtle Black Ash Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Huntsville Narrows / Brunel Locks	Records for 23 SAR	Bank Swallow Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Olive-sided Flycatcher Peregrine Falcon	Wood Thrush Midland Painted Turtle Snapping Turtle Gypsy Cuckoo Bumble Bee Rusty-patched Bumble Bee Yellow-banded Bumble Bee Black Ash Butternut Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Springdale	Records for 15 SAR	Barn Swallow Canada Warbler Eastern Meadowlark Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Wood Thrush	Blanding's Turtle Eastern Hog-nosed Snake Midland Painted Turtle Snapping Turtle Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Baysville	Records for 16 SAR	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler	Olive-sided Flycatcher Wood Thrush Midland Painted Turtle Snapping Turtle Spotted Wintergreen Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis

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Location	Total SAR Records	Recorded SAR in Area	
Fraserburg	Records for 17 SAR	Barn Swallow Bobolink Canada Warbler Chimney Swift Common Nighthawk Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Wood Thrush Midland Painted Turtle Snapping Turtle Transverse Lady Beetle Spotted Wintergreen Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Purbrook	Records for 15 SAR	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Wood-pewee Evening Grosbeak Golden-winged Warbler Olive-sided Flycatcher	Wood Thrush Blanding's Turtle Midland Painted Turtle Snapping Turtle Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis
Muskoka/Bala	Records for 27 SAR	Barn Swallow Bobolink Canada Warbler Chimney Swift Eastern Meadowlark Eastern Whip-poor-will Eastern Wood-pewee Golden-winged Warbler Least Bittern Olive-sided Flycatcher Red-headed Woodpecker Wood Thrush Blanding's Turtle	Common Five-lined Skink Eastern Hog-nosed Snake Eastern Milksnake Eastern Musk Turtle Eastern Ribbonsnake Massasauga Midland Painted Turtle Northern Map Turtle Snapping Turtle Rusty-patched Bumble Bee Yellow-banded Bumble Bee Little Brown Bat Northern Myotis Tri-colored Bat Eastern Small-footed Myotis

10.2 Species at Risk Impacts

Where design options are being explored, potential impacts to SAR that may occur from the mitigation case measures within the priority areas are described below. It is anticipated that many of the potential impacts described in Section 10.2 for other species will also be applicable to SAR.

- Species-at-risk birds (e.g., Bank Swallow, Eastern Wood-pewee) may be threatened by loss or degradation of breeding and foraging habitat resulting from erosion and flood control activities, land clearing, or land conversion.

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- Variations in water levels may further affect food availability, plant cover, and/or the distribution of predators and competitors for bird species (e.g., Bobolink).
- Degradation of wetland habitats and movement corridors, changes in water levels, and/or water level manipulation will likely exacerbate existing population-level threats for at-risk herpetofauna (e.g., Midland Painted Turtle, Blanding's Turtle).
- Wetland vegetation species (e.g., Black Ash, Butternut) are sensitive to the spread of problematic or invasive species, such as Emerald Ash Borer or Butternut Canker, which are promoted by changes in moisture regimes or habitat degradation.
- Insects and other arthropods (e.g., Riverine Clubtail, Yellow-banded Bumble Bee) are sensitive to loss of habitat, water pollution, and the spread of invasive species. They may also be impacted by increased drought or inundation events, but the extent of this threat is unclear (COSEWIC, 2015).
- Bat species (e.g., Little Brown Bat) are sensitive to changes in forest structure; if bat hibernation areas are present at any site locations, bats in that area may further be adversely impacted by disturbances while hibernating and or loss of suitable roost trees.

10.3 Environmental Recommendations

10.3.1 Recommended Field Investigations/Surveys

The following Table 10-3 identifies a list of surveys that may be required in order to inform environmental permitting and approval requirements to proceed with the proposed flood mitigation options as described above in Section 9. The table identifies the recommended studies in two stages:

1) Baseline Studies: As presented in Table 10-3, surveys including Rapid Ecological Land Classification (ELC), Suitable Habitat Classification, high level fish habitat assessments and OBBA Point Count Surveys are recommended to be completed first to gain a better understanding of the vegetation communities, confirming and characterizing habitat types and presence/absence of most SAR birds. These surveys can be effectively completed in parallel to one another over large study areas to inform any potential required follow-up studies more specifically related to SAR. The initial surveys inform one another as the inventory of the vegetation communities, by way of ELC, allows for the characterization of habitat types for SAR. This information is crucial in informing additional SAR specific surveys that may be required to inform environmental approvals and permitting.

2) **Potential Detailed Studies**: Once the recommended baseline studies are completed, the results will be assessed to determine the need for further detailed surveys. Based on the desktop review presented in Section 7, a preliminary list of Detailed Studies has been provided in Table 10-3. However, in the event incidental SAR or SAR habitat is seen onsite during the completion of baseline studies or is requested/recommended by a

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permitting agency, such as MNRF or Ministry of Environment, Conservation and Parks (MECP), through consultation, this list is subject to change.

Table 10-3: Recommended Environmental Surveys

Recommended Baseline Surveys	Potential Detailed Surveys
Big East River	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Crepuscular Bird Survey (2013 Ontario Survey Protocol for Eastern Whip-poor-will (Caprimulgus vociferus) • Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment
Big East River – Distress Dam	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment
Huntsville Narrows / Brunel Locks	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Crepuscular Bird Survey (2013 Ontario Survey Protocol for Eastern Whip-poor-will (Caprimulgus vociferus) • Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment
Springdale	
• Rapid Ecological Land Classification / Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Turtle Visual Encounter Surveys (VES) (Survey protocol for Blanding's Turtle in Ontario, 2015) • Bat Roost Surveys • Habitat Suitability Assessment (Eastern Hog-nosed Snake) • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment • Snake emergence and cover board surveys

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Recommended Baseline Surveys	Potential Detailed Surveys
Fraserburg	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Crepuscular Bird Survey (2013 Ontario Survey Protocol for Eastern Whip-poor-will (Caprimulgus vociferus) • Turtle Visual Encounter Surveys (VES) (Survey protocol for Blanding's Turtle in Ontario, 2015) • Snake emergence and cover board surveys • Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys including spawning surveys in Rocky Rapids • Fluvial Geomorphology Assessment
Purbrook	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Turtle VES Surveys (Survey protocol for Blanding's Turtle in Ontario, 2015) • Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment
Muskoka/Bala	
• Rapid Ecological Land Classification/ Suitable Habitat Identification • OBBA Point Count Survey • High Level Fish Habitat Survey	• Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario • Crepuscular Bird Survey (2013 Ontario Survey Protocol for Eastern Whip-poor-will (Caprimulgus vociferus) • Turtle VES Surveys (Survey protocol for Blanding's Turtle in Ontario, 2015 • Snake VES Survey (Survey protocol for Ontario's species at risk snakes, 2016) • Bat Roost Surveys • Detailed Fish Habitat / Fish Community Surveys • Fluvial Geomorphology Assessment

The following Targeted Surveys may be required confirm the presence/absence of SAR, sensitive habitats, and sensitive fish habitat within the priority areas. Surveys required for each priority area would be identified during the baseline surveys to assist with refining permitting requirements for the area. Table 10-4 lists the Survey Protocol as well as the targeted species and/or sensitive features it that would be identified during each survey.

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Table 10-4: Targeted Surveys For Confirming Presence of Sensitive Features

Survey Protocol	Targeted Species / Features
Survey Protocol for Eastern Meadowlark (*Sturnella magna*) in Ontario (MNR, 2013)	Bobolink, Eastern Meadowlark
Crepuscular Bird Survey (Ontario Survey Protocol for Eastern Whip-poor-will (*Caprimulgus vociferus*), (MNRF, 2013)	Common Nighthawk, Eastern Whip-poor-will
Turtle VES Surveys (Survey Protocol for Blanding's Turtle in Ontario, MNRF, 2015)	Northern Map Turtle, Snapping Turtle, Blanding's Turtle, Musk Turtle,
Snake VES Survey (Survey Protocol for Ontario's SAR Snakes, MNRF, 2016)	Massasauga, Eastern Hog-nosed Snake
Bat Snag Surveys (Survey Protocol for Species at Risk Bats within Treed Habitats, Guelph District MNRF, 2017)	Little Brown Myotis, Eastern-small Footed Myotis, Northern Myotis, Tri-colored Bat
Detailed Fish Habitat / Fish Community Surveys (i.e., Ontario Stream Assessment Protocol)	All Fish/Critical Habitat Features
Fluvial Geomorphology Assessment:	Channel Form and Function

10.3.2 Permitting Summary

Based on the environmental records review and desktop level assessment of the natural heritage features in each priority area, the following is a list of environmental permits and approvals that may be required to support the development of this study. This list will be refined in the *Flood Modifications Review* and the baseline and targeted environmental investigations/surveys are completed, and the relevant agencies consulted.

10.3.2.1 Federal

***Species at Risk Act*, 2002:** This Act provides a framework to ensure the survival of wildlife species and the protection of natural heritage in Canada (Species at Risk Act, S.C. 2002, c. 29 2002). Under SARA, the Federal government has responsibility for wildlife as follows: Wildlife on Federal lands, aquatic species; and Migratory birds protected by the *Migratory Birds Convention Act* (MBCA) (Migratory Birds Convention Act, S.C. 1994, c. 22 1994). Species listed under SARA are defined as Species At Risk (SAR) of disappearing from Canada. Specifically, SARA contains prohibitions against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling or trading of individuals of Endangered, Threatened and Extirpated Species listed in Schedule 1 of the Act. The Act also contains a prohibition against the damage or destruction of their residence (e.g., nest or den).

Applicability: The appropriate authority for consideration of a permit application under SARA depends on the species affected by the proposed activity and its location. A desktop screening was completed in order to compile a list of provincially listed SAR and was cross

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referenced with SARA Schedule 1 to determine the potential presence of SARA species within the Study Area. Federal lands or aquatic species listed on Schedule 1 were not identified during the desktop screening, however the individuals and nests of birds listed on Schedule 1 of SARA and listed on the *Migratory Birds Convention Act* (1994) are protected.

Fisheries Act, 1985: The Federal *Fisheries Act* was established in 1985 with amendments that came into effect on August 28, 2019. This Act provides protection to fish and fish habitat such that:

"No person shall carry on any work, undertaking or activity other than fishing that results in the death of fish" (Section 34.4 (1))."

"No person shall carry on any work, undertaking or activity that results in harmful alteration, disruption or destruction of fish habitat." (Section 35(1))."

Fish habitat is defined by the Act as "water frequented by fish and any other areas on which fish depend directly or indirectly to carry out their life processes, including spawning grounds and nursery, rearing, food supply and migration areas". The *Fisheries Act* requires that any development project avoid causing the death of fish, or a Harmful Alteration, Disruption or Destruction (HADD) of fish habitat unless authorized by the Minister of Fisheries and Oceans. This applies to any works being undertaken in or near waterbodies that supports fish habitat as defined in the act. If mitigation measures cannot be applied, and residual effects will cause death to fish, or result in a HADD, then a Request for Review must be submitted to DFO. If DFO identifies that the project is likely to result in the death of fish or a HADD of fish habitat, an Authorization (i.e., approval) for the Project will be required and as a result, an Offsetting Plan may be required.

Applicability: Any waterbody or watercourse that contains fish, or indirectly supports fish, as described in the *Fisheries Act*, is provided protection under the Act. All Priority Areas contain watercourses/waterbodies that are known to contain fish and several critical habitat features including spawning shoals, and as such the Project must comply with the *Fisheries Act*. Should mitigation case flood control scenarios be anticipated to result in a significant impact to the resident fish population, a Request for Project Review should be submitted to DFO to determine if the project may result in a HADD. If DFO determines that the work would result in a HADD, typically an Offsetting Plan would be developed in consultation with the District of Muskoka and DFO, or in cases where DFO determines that HADD is significant, a more onerous Fisheries Act Authorization may be required.

10.3.2.2 Provincial

Endangered Species Act, 2007: The Ontario Endangered Species Act, 2007 (ESA) was passed into law in 2007 and came into effect on June 30, 2008. Under the ESA, there are more than 200 species in Ontario that are identified as Extirpated (EXP), Endangered (END), Threatened (THR), or of Special Concern (SC). Section 9 of the ESA generally prohibits the killing or harming of a Threatened or Endangered species, as well as the destruction of its

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habitat. Section 10 of the ESA prohibits the damage or destruction of the habitat of species listed as Endangered and Threatened. Habitat is broadly characterized within the ESA as the area prescribed by a regulation (O. Reg. 242/08) as the habitat of the species or an area on which the species depends directly or indirectly, to carry on its life processes, including reproduction, rearing of young, hibernation, migration or feeding.

Applicability: To better understand the absence/presence of the SAR and their habitats in the priority area Study Areas, baseline surveys are recommended. Should potential SAR habitat be identified, then targeted surveys should be conducted to further confirm habitat presence and use by SAR. The results of these surveys will inform the need for the Project to obtain permits under the ESA 2007 and/or its regulatory exemptions under the Act for Threatened/Endangered species. Should any impacts to SAR habitat be identified during future stages of the project, the results of the surveys should be submitted to the MECP in an Information Gathering Form (IGF) to confirm permitting requirements. If impacts to confirmed SAR and SAR habitat cannot be avoided, a permit under the ESA will be required, or regulatory exemptions under the ESA may apply.

Ontario Water Resources Act, 1990 and Environmental Protection Act, 1990: If in-water work is required during construction activities, dewatering may be required to create an isolated dry work area. If dewatering is over 50,000 L/day but under 400,000 L/day a registration on the Environmental Activity and Sector Registry (EASR) system would be required. If dewatering exceeds 400,000 L/day, a Permit to Take Water (PTTW) would be required.

Any water pumped during dewatering activities will need be discharged to the appropriate area and would require an approval of one or a combination of the following:

- MECP Environmental Compliance Approval (OWRA, Section 53); and/or
- Municipal Discharge Permits.

The need for these permits will be determined during future phases of the project.

Conservation Authorities Act, 1990: The priority areas of the Project do not fall within a regulated area of a conservation authority. Therefore, no permit under Ontario Regulation 166/06 is anticipated.

Lake and Rivers Improvement Act, 1990: The Lake and Rivers Improvement Act (LRIA), originally passed into law in 1927, was revised in 1990 to reflect changes in management philosophies (Stork & Chang, 1990). Under the LRIA, the Minister of Natural Resources and Forestry is given the legislative authority to govern dam design, construction, operation, maintenance, and safety in Ontario (OMNRF, 2017). It is also applicable to channel modifications, including modifications that alter flows and/or water levels (OMNRF, 2017).

Applicability: LRIA approval is required for various works, including works on dams, river channels, and water crossings. Specifically, approval must be obtained to modify a dam to

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raise water levels, control flooding via the creation of reservoirs, or divert the flow of water (OMNRF, 2017). Channelization also requires LRIA approval when the work takes place outside of a conservation authority and has the potential to adversely impact fish habitat or movement (OMNRF, 2017). To best understand LRIA applicability, the OMNRF recommends submitting an application for review and requesting a scoping meeting so that they are able to review and provide feedback (OMNRF, 2017).

10.3.2.3 Municipal

Upper and Lower-Tier Municipal Tree By-Laws: In the event the project requires the removal or injury of trees, the local municipal tree by-laws should be reviewed to confirm tree permitting requirements.

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11. Preliminary Design Scope and Cost Requirements

For each of the flood mitigation options selected (Section 9), an initial estimate of the cost and scope requirements to advance the option to a preliminary engineering design was derived. These estimates are presented as high-level ranges which were approximated. These estimates will be further refined and based on the further development of options in the *Flood Modifications Review*.

The general scope requirements are similar for all options to advance them to preliminary design and include the following activities and tasks:

- Project Management (Project governance, coordination, meetings, and reporting)
- Background Review and Site Visit (Collection and review of pertinent data, followed by a site visit by select team members, where necessary)
- Field Investigation (Collection of site topographic surveys, bathymetric surveys, and/or geotechnical investigations)
- Preliminary Design (Engineering design of each component, including hydrotechnical, structural, geotechnical, and mechanical input)
- Environmental Review (Environmental review, including constraints mapping, species at risk reviews, and permitting input)
- Cost Estimate (Class 3[2]) to support full project funding requests. Based on material quantities and earthworks requirements.
- Stakeholder Engagement (Support to the District in soliciting and managing stakeholder input e.g., public consultation)
- Deliverable Preparation (Preparation of all drawings and a final summary report).

While these major activities will be common to all options, within these general scope requirements are unique features for each option that require particular consideration and will influence the cost estimates for individual options. For example, the excavation of Wallis Cut will require a rail study to evaluate potential options for relocation or modification of the existing railway bridge. These unique requirements (summarized in Table 11-1) were factored into the initial estimate of costs for preliminary engineering design to the extent possible at this early phase of study. Additionally, these costs (Table 11-1) were estimated based on perceived design effort; environmental constraints and construction requirements (among other factors).

[2] As per the AACE International Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction.

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Table 11-1: Costs for Preliminary Design Engineering Services

Flood Mitigation Option	Examples of Unique Project Scope Requirements	Approximated Range of Costs for Preliminary Engineering Services (2022 $CAD)
Option 1: Retrofit of Control Structure at Distress Dam	Dam Classification Study Dam Design	300,000 – 500,000
Option 2: Berm Protection near Swing Bridge	Public Impacts Study Architectural Services	200,000 – 300,000
Option 3: Increase Fairy Lake Outflow via the Brunel Lift Locks	Public Impacts Study Architectural Services 3D Flow Assessment	100,000 – 300,000
Option 4: Retrofit of Control Structure at High Falls	Obermeyer Gate Design Hydropower Impacts Study	100,000 – 300,000
Option 5: Channel Enlargement at May Chutes	Public Safety Evaluation Detailed Bathymetric Surveys	100,000 – 300,000
Option 6: Channel Enlargement at Rocky Rapids	Public Safety Evaluation Detailed Bathymetric Surveys	100,000 – 300,000
Option 7: Lower Head pond Flood Levels at Matthias GS	Hydropower Impacts Study	50,000 – 100,000
Option 8: Channel Enlargement at Wallis Cut	Public Safety Evaluation Detailed Bathymetric Surveys Rail Impact Study	200,000 – 300,000
Option 9: Retrofit of Control Structure at Bala South Dam	Hydropower Impacts Study Detailed Bathymetric Surveys	100,000 – 300,000
Option 10: Channel Enlargement at Moon Chutes	Public Safety Evaluation Hydropower Impacts Study Detailed Bathymetric Surveys	200,000 – 300,000

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12. Summary and Future Work

This study aimed to identify structural options to mitigate flood risk as part of an integrated water management approach to the MRW. Options were identified and selected with the specific purpose of reducing flood risk in five priority areas (*Big East*, *Huntsville Narrows, Springdale*, *Baysville/Fraserburg/Purbrook*, and *Bala*). This report documents the findings including descriptions of the design process adopted to identify preliminary ideas, assess constraints and criteria, and select 10 structural options to advance forward in *Flood Modifications Review*.

The specific focus of the *Structural Flood Mitigation Options* Project was the selection and evaluation of impacts of the 10 selected options within their respective priority area. The *Flood Modifications Review* will further refine these options and will include an evaluation of the net watershed impacts (in terms of flood risk) of concurrent implementation of the 10 options. The following is a summary of the findings within the main areas of this report (study area and hydrology; hydraulic systems; environmental review; site visit; option selection and development; and preliminary design scope and cost requirements).

12.1 Study Area and Hydrology

- The MRW basin encompasses a drainage area of 5,100 km^2, which includes sections that overlap with DMM municipalities. The MRW features three regions – South Branch, North Branch and Lower Watershed – and at least one of the five priority areas is located within each region.
- The two design flood events adopted for evaluating flood impacts in MRW priority areas were those that occurred in 2019 and 2013. Flood impacts between these events differed, where 2013 resulted in more severe upstream flooding (e.g., Big East River), and 2019 resulted in more severe downstream flooding (e.g., Bala).
- Flow and water level records to characterize flood conditions were obtained from WSC records, background reports and studies, as well as a hydrologic model adopted from the DMM FPMS. The hydrologic model was also adopted herein to facilitate identification and evaluation of flood mitigation options.

12.2 Hydraulic Systems

- Hydraulic conditions of the water bodies in each priority area were assessed using hydraulic models adopted from the DMM FPMS. These models were adapted as described in this report to achieve study objectives, including expansion of the Muskoka/Bala model from Bala Dam to upstream from Bala Park Island.
- The water surface profiles of the water bodies within each priority area were reviewed, with a specific focus on ‘choke points’ both natural (e.g., constrictions and rock outcrops) and anthropogenic (e.g., bridges and dams). Reviews also included mapping of flood inundation areas during design flood events to visualize the extent and severity of local

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flooding. These reviews assisted identification of specific river features could be targeted for mitigation, and also the type of mitigation that may be most effective for a particular reach (i.e., flood attenuation, or flood diversion/bypass).

- The magnitude of local flood impacts was quantified using two key metrics:
  - flood inundation area
  - number of flood-impacted structures.

  These metrics were enhanced by incorporating proportions of different land zones impacted by flooding (e.g., residential, commercial), and a preliminary description of impacted structures (e.g., boathouse, residence).

12.3 Environmental Review

- A preliminary desktop review of the environmental features for both the baseline and mitigation case conditions identified potential impacts to woodlands, wetlands, fish and fish habitat, general wildlife habitat, and SAR in the priority areas. Results of the desktop review indicate there are several environmental features/SAR habitats within each of the priority areas that have the potential to be impacted from the mitigation case scenarios.
- As mitigative design options continue to be explored and further developed for the priority areas, more specific impacts associated with the construction and operation of these structures may be identified and should be taken into consideration for future environmental surveys and permitting/approvals.
- Surveys including ELC, Suitable Habitat Classification, high level fish habitat assessments, and OBBA Point Count Surveys are recommended to be completed to gain a better understanding of the vegetation communities as well as to confirm and characterize habitat types and the presence / absence of SAR and SAR habitat in the priority areas. Future targeted SAR specific surveys may be required depending on the results from preliminary investigations.

12.4 Site Visit

- The team accompanied by DMM representatives conducted a site visit from May 16, to 18, 2022. This visit included various locations throughout the watershed accessible by land, including locations in all three regions of the MRW (South Branch, North Branch, Lower Watershed).
- A comprehensive trip report was delivered to the DMM on May 30, 2022. This report outlines the observed of these visits, which are categorized as geotechnical (e.g., local and general topography), structural (e.g., bedrock conditions), hydrotechnical (e.g., floodplain characteristics and hydraulic constrictions), and environmental (e.g., habitat conditions and recreational sites).

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- The focus of reconnaissance at each location visited was on features that would influence flood mitigation design. The findings from this study were informative for the options identification and selection component of this study.

12.5 Options Selection and Development

- The findings of the hydraulic and environmental reviews were supplemented by input on priority area conditions from subject-matter experts in geotechnical engineering and structural engineering. The combined insight from this multidisciplinary team resulted in identification of a broad list of design alternatives covering each of the five priority areas.
- Each design alternative was ranked using qualitative parameters. The team delivered a workshop to DMM and TWG on June 24, 2022, where the full list of preliminary mitigation options and their rankings was presented.
- The team selected a subset of 10 options from the list of preliminary mitigation options. Descriptions of these 10 options are provided in Sections 9.1 through 9.5, which include a demonstration of local flood mitigation impacts through hydraulic or hydrologic modelling (where possible). Flood mitigation options identified in this study but not pursued for advancement are briefly discussed in Section 9.7.

12.6 Preliminary Design Scope and Cost Requirements

- For each of the flood mitigation options selected (Section 9), an initial estimate of costs and scope requirements for preliminary engineering design was derived. These cost and scope requirements considered unique features of all 10 options and will be refined as part of the *Flood Modifications Review*.

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Appendix A
Workshop Presentation Slides

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Overview



1. Introduction
2. Project Scope / Overview of Flood Mitigation (0.25 hours)
3. Operational Management (0.5 hours)
4. Preliminary Structural Mitigation Options (1 hour)
   a. Introduce options decision matrix (10 min)
   b. Big East River (10 min)
   c. Huntsville (10 min)
   d. Springdale (North Branch) (10 min)
   e. Baysville/Fraserburg/Purbrook (10 min)
   f. Bala (10 min)
5. Closing + Meeting Actions

Introductions and Objectives

- Introduction
  - TWG/DMM
  - Hatch
- Objectives
  - Project 2
    - Present and discuss operational adjustments that may reduce flood risk.
  - Project 3
    - Present and discuss structural options conceived.
    - Refine/develop ranking matrix attributes.
    - Collectively determine options to carry forward to Phase 2.

Project Scope

Project 2 – Operational Adjustments and Scoping Study for the Muskoka River Water Management Plan

- Phase 1 - Determining operational adjustments that may reduce flood risk and enhance ecological resiliency in the Watershed
- Phase 2 – Provide a comprehensive work scope necessary to initiate an amendment of the MRWMP

Project 3 – Structural and Watershed-Scale Flood Mitigation

- Phase 1 - Identify structural options within the five high priority areas that will promote flood risk reduction. The characteristics and constraints associated with these options will be defined within a localized context. i.e., within the priority area.
- Phase 2 – Analyze the flood mitigation options conceived in Phase 1 from a holistic or system-based perspective to determine cumulative change (within the watershed) associated with adopting one or more of these options. Recommend flood risk reduction scheme based on decision matrix that includes cost, engineering effort, and perceived environmental impacts.

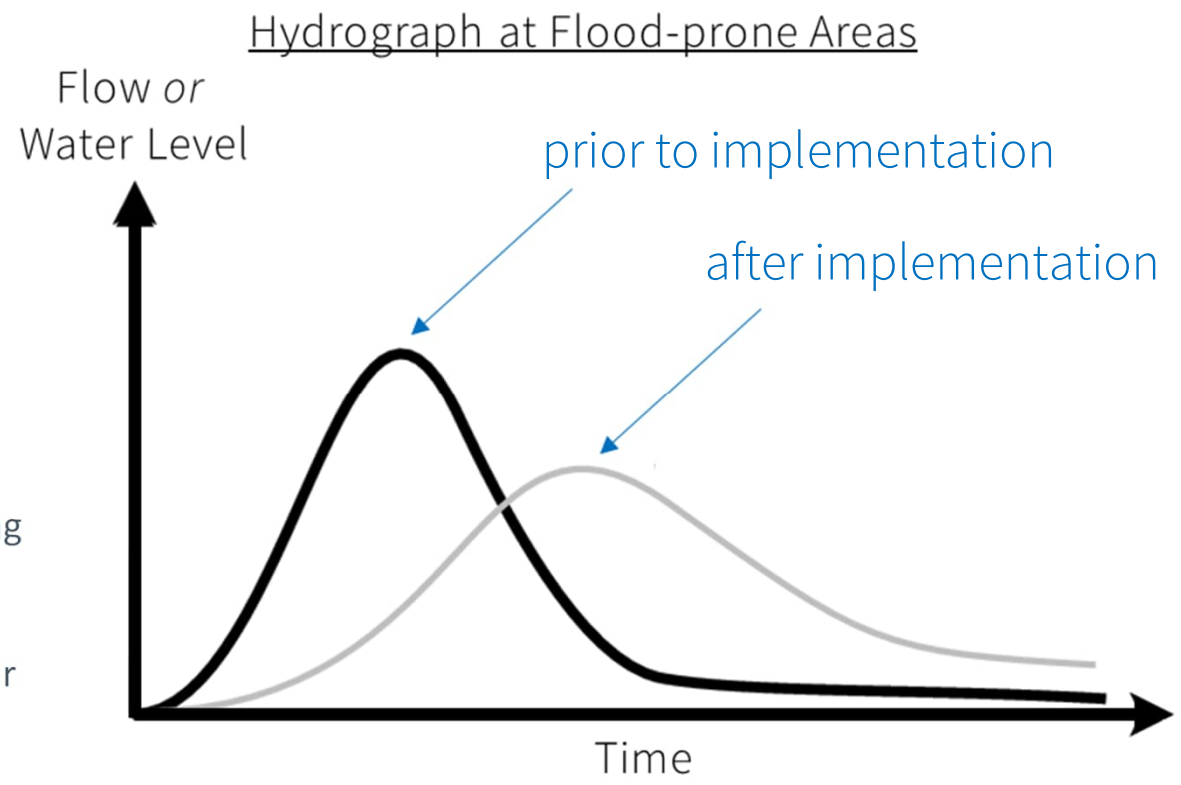
Flood Mitigation Strategies

Strategy 1: Flood Protection or Diversion

- embankments
- bypass channel
- channel modification

Strategy 2: Flood Attenuation

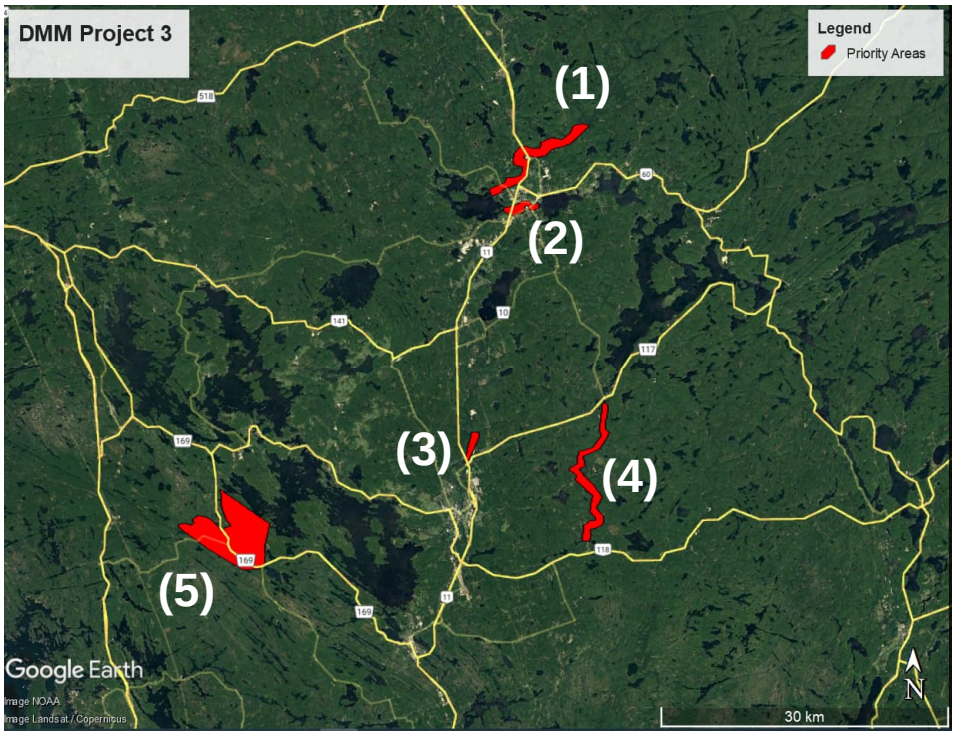
- adapting hydraulic controls
- create temporary storage
- greater/earlier lake drawdown before spring
- phased approach to managing water levels
- increase maximum permitted existing water levels
- staggered arrival of peak inflows



Project 3: Structural Mitigation

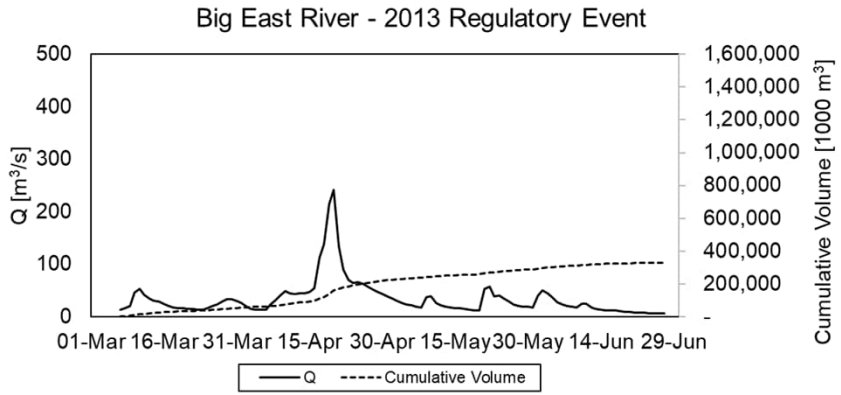
Study Priority Areas

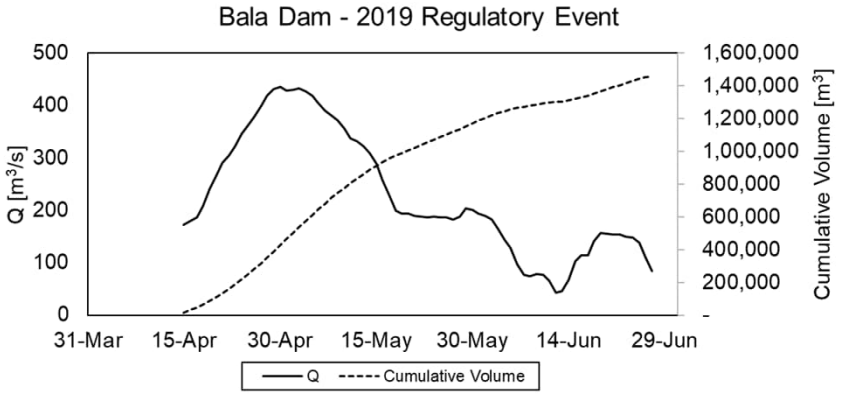
1) Big East River
2) Huntsville
3) Springdale
4) Baysville/ Fraserburg/ Purbrook
5) Bala



Hydrologic Datasets

Governing Regulatory Event	Priority Area	Design Peak Flow (m^3/s)
2013	Big East River	242 m^3/s
2013	Huntsville	273 m^3/s
2019	Springdale	239 m^3/s
2019	Baysville	165 m^3/s
2019	Fraserburg	165 m^3/s
2019	Purbrook	176 m^3/s
2019	Bala	436 m^3/s

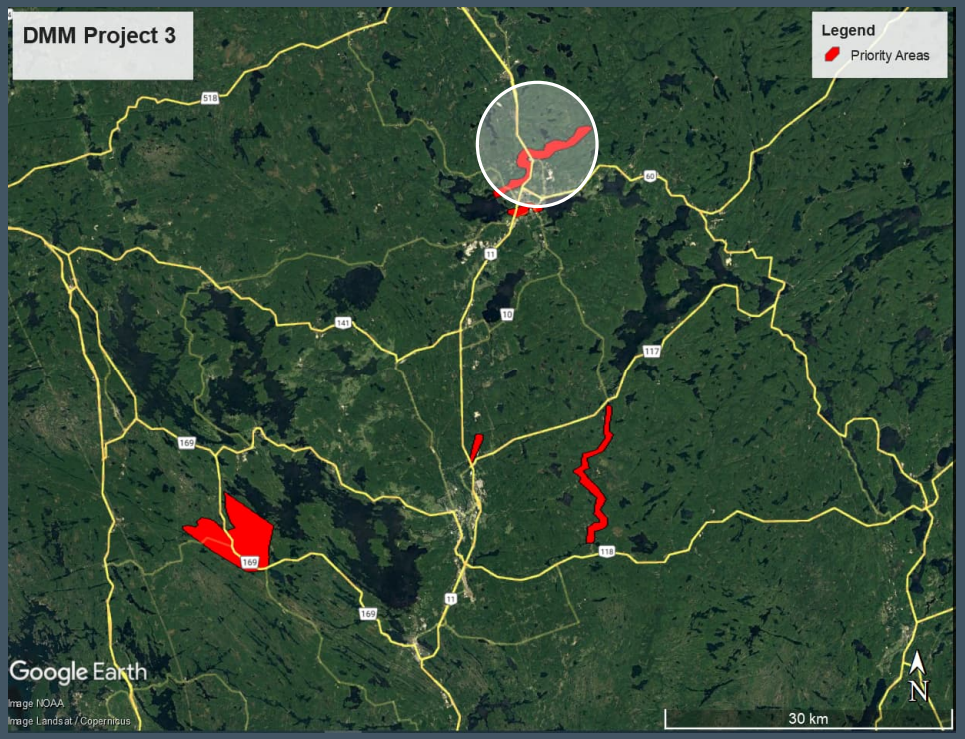




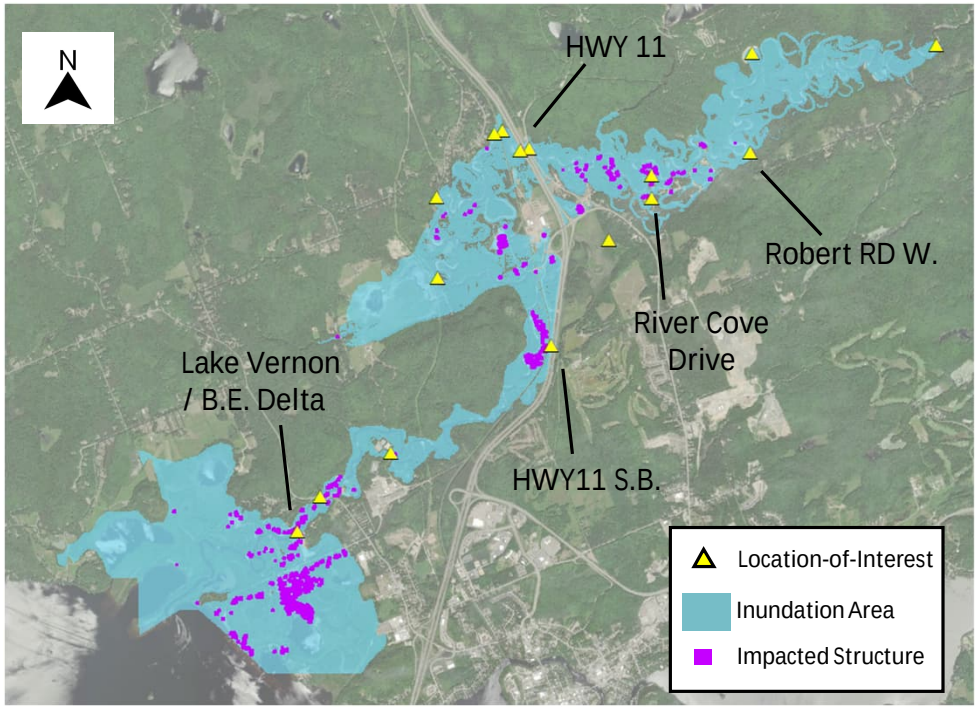
Evaluation Criteria for Options

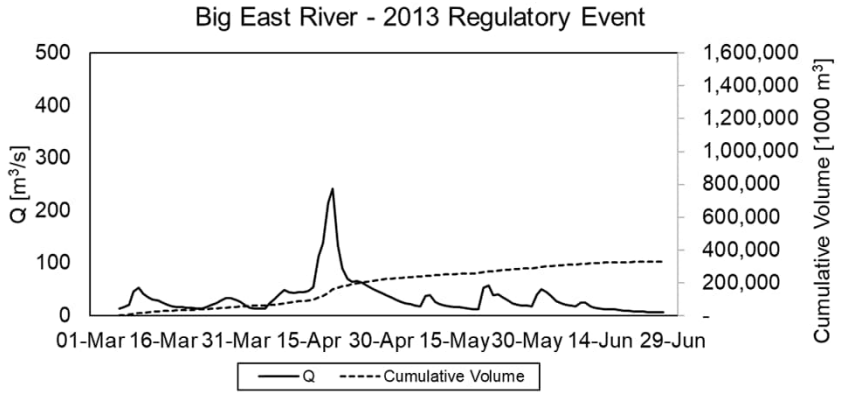
Raking (0-3)	Description of Ranking				
	Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Local Impacts to Flooded Structures	Potential for Adverse Local Environmental Impacts	Potential for Adverse Local Impacts to Residents
0	High Cost	High Potential	Minimal Effectiveness	High Potential	High Potential
1	Moderate Cost	Moderate Potential	Low Effectiveness	Moderate Potential	Moderate Potential
2	Low Cost	Low Potential	Moderate Effectiveness	Low Potential	Low Potential
3	Minimal Cost	Minimal Potential	High Effectiveness	Minimal Potential	Minimal Potential

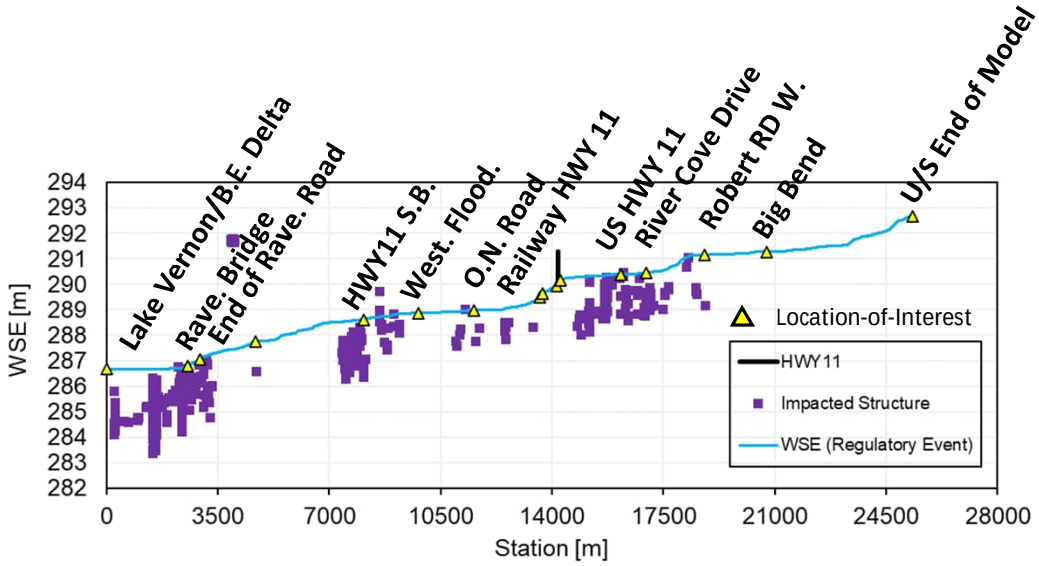
Big East


DMM Project 3
Legend
Priority Areas
Google Earth
Image NOAA
Image Landsat / Copernicus
30 km
N

Big East River
Regulatory Event

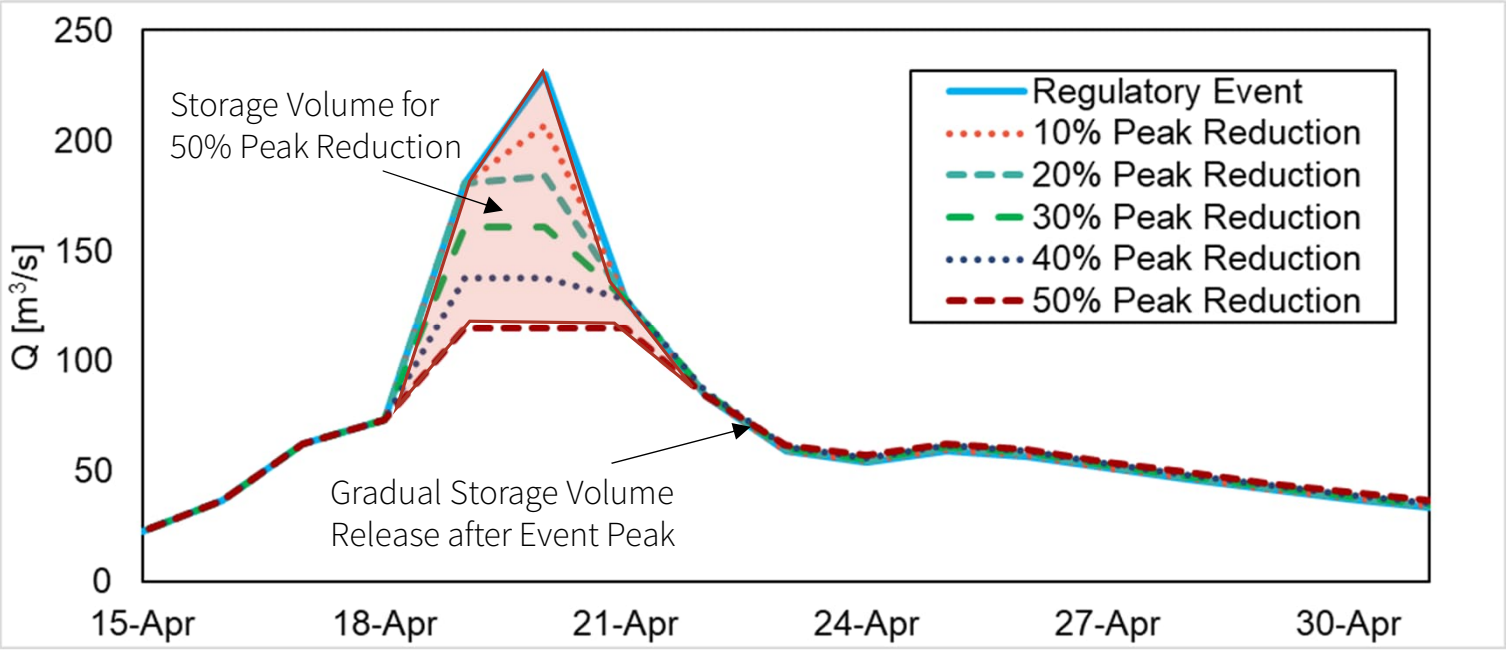






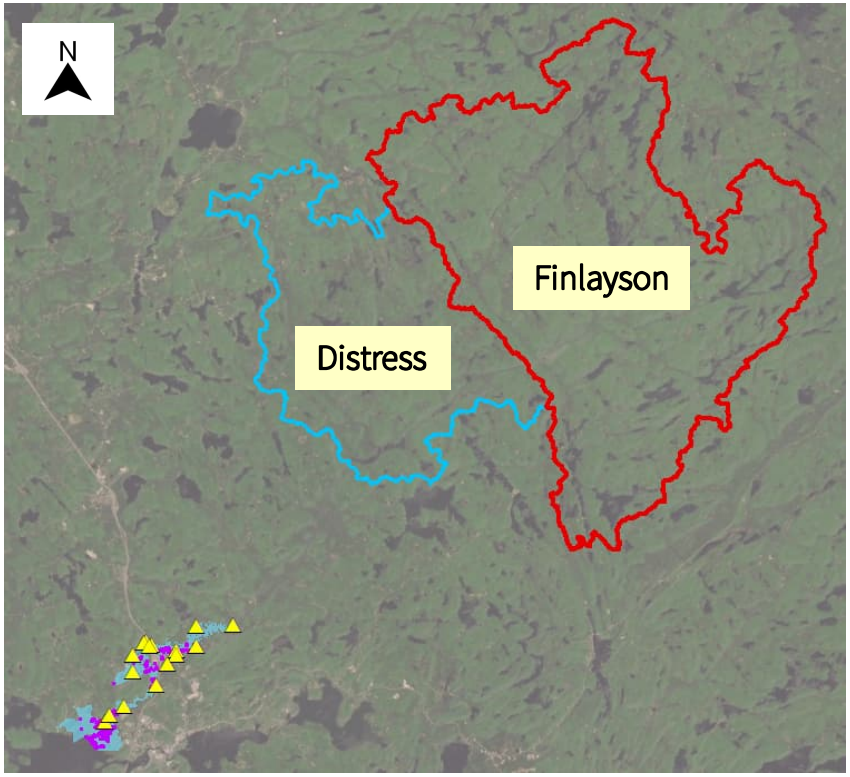
Big East River

Flood Control by Peak Flow Reduction



Big East River

Distress & Finlayson Site Catchment Areas



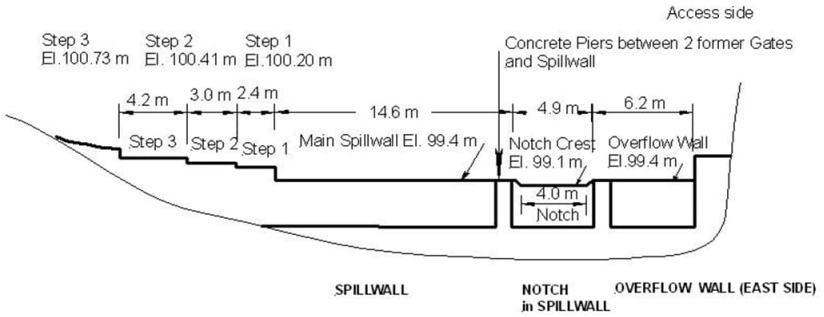
Big East River

Distress Dam – Existing Condition



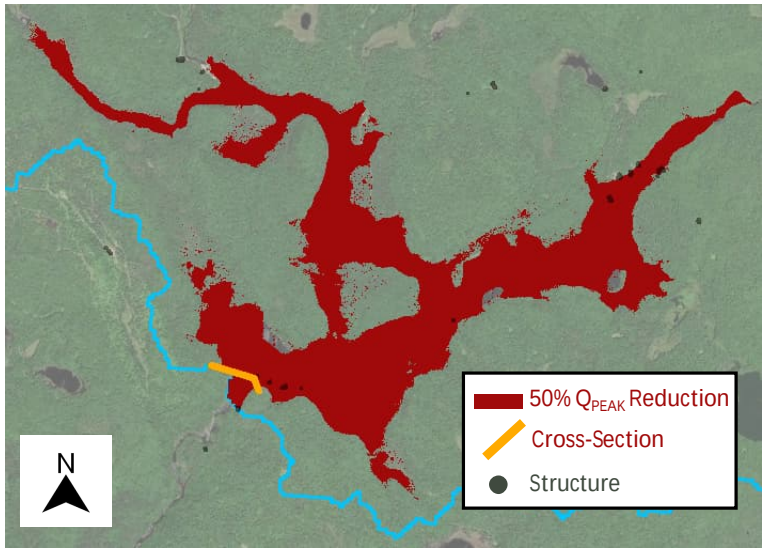


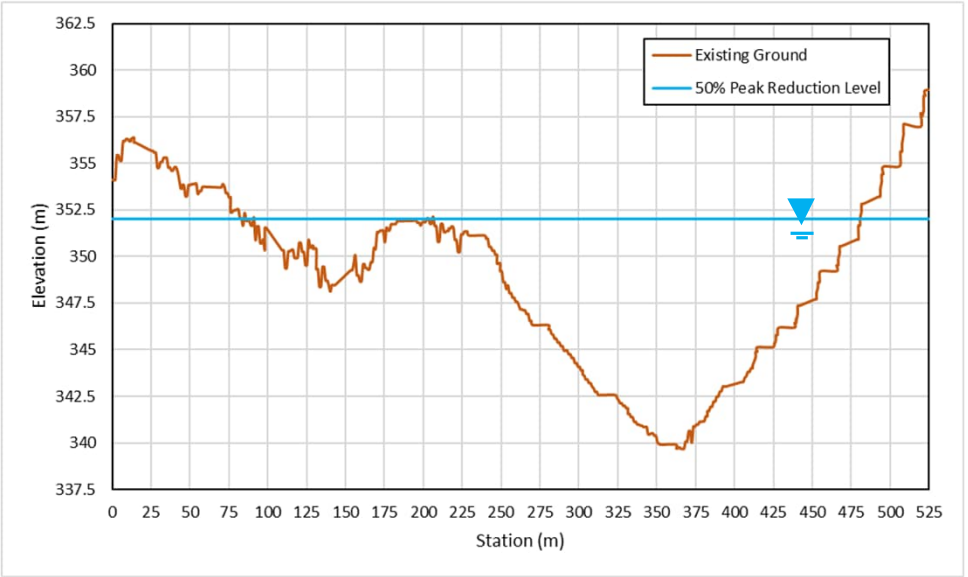




Big East River

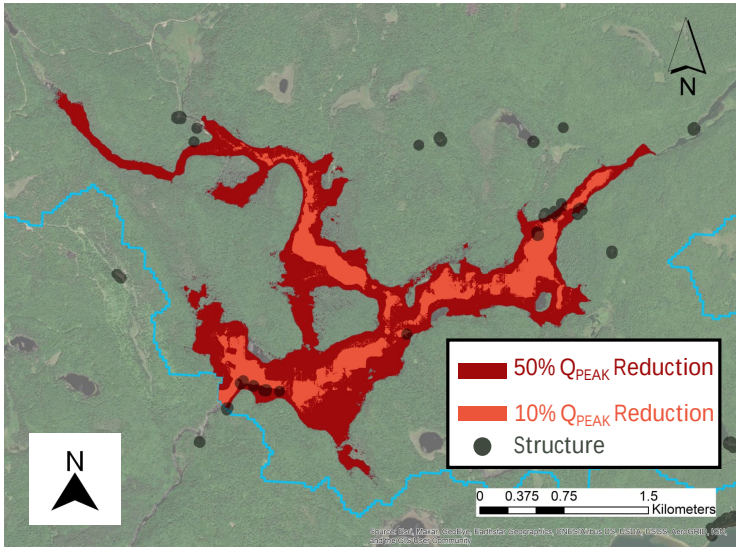
Option 1: Existing Ground at Distress Site

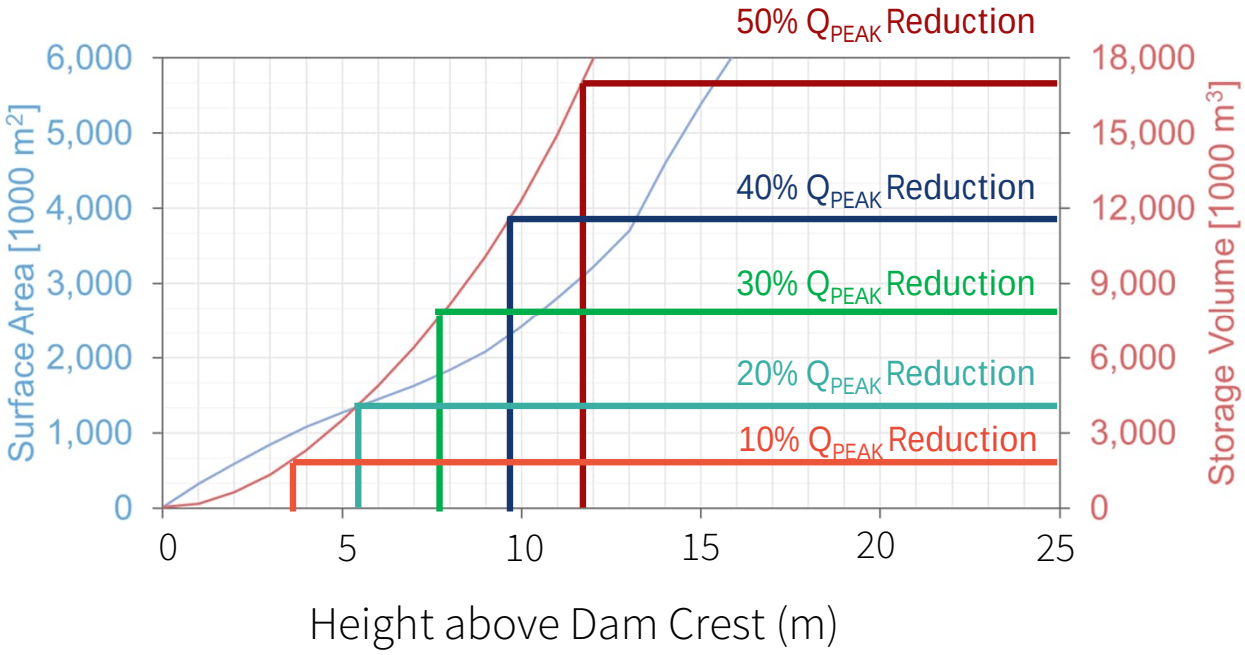




Big East River

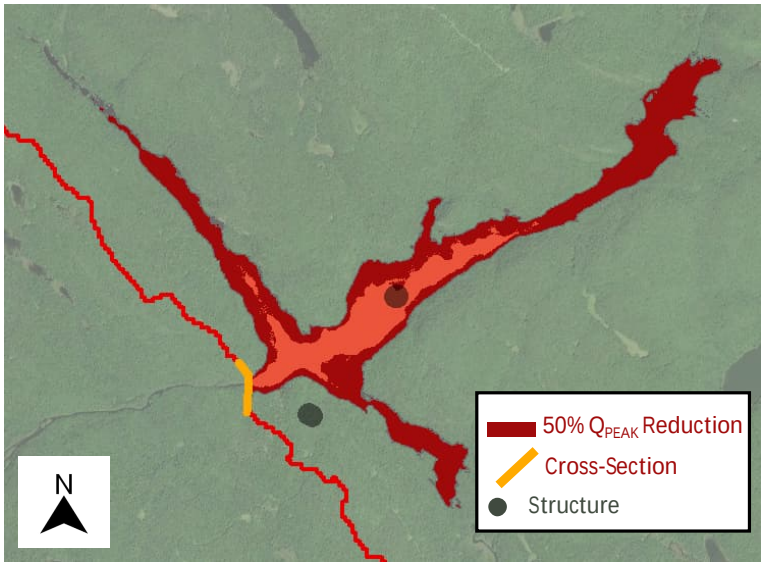
Option 1: Control Structure and Upstream Storage at Distress

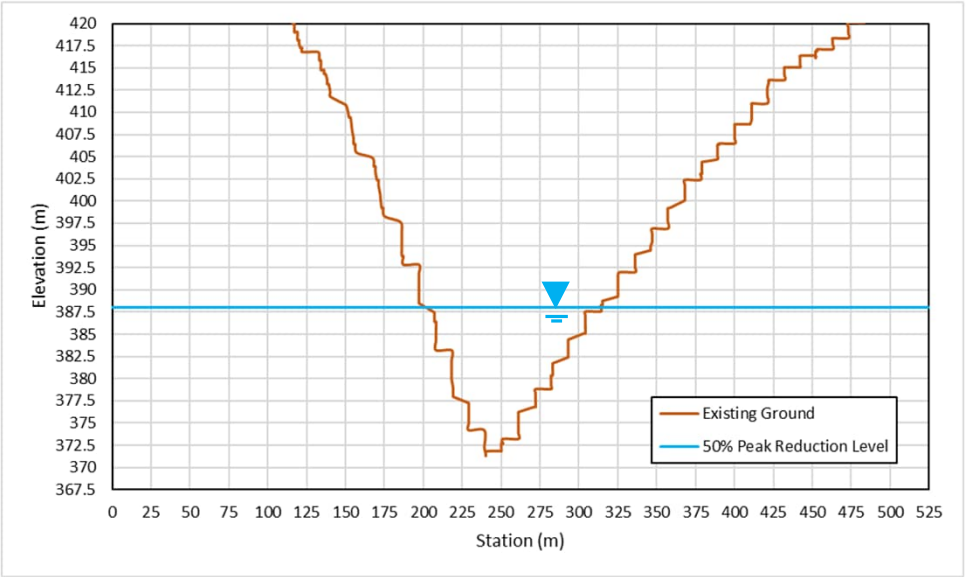




Big East River

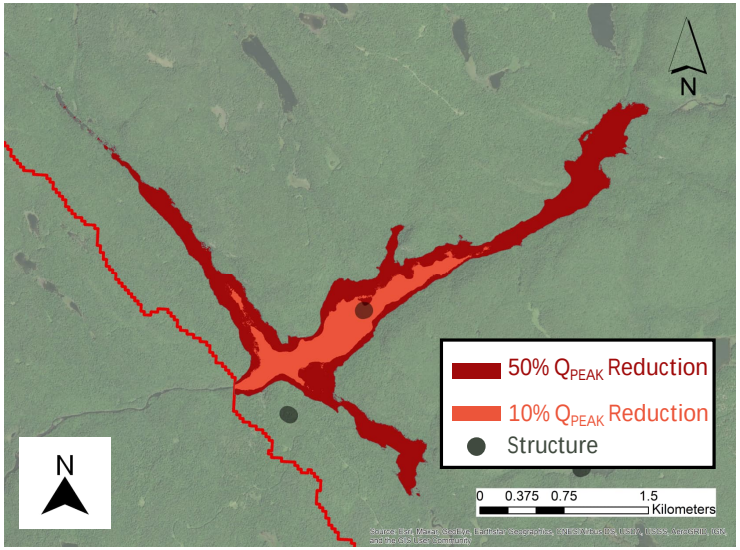
Option 2: Existing Ground at Finlayson Site

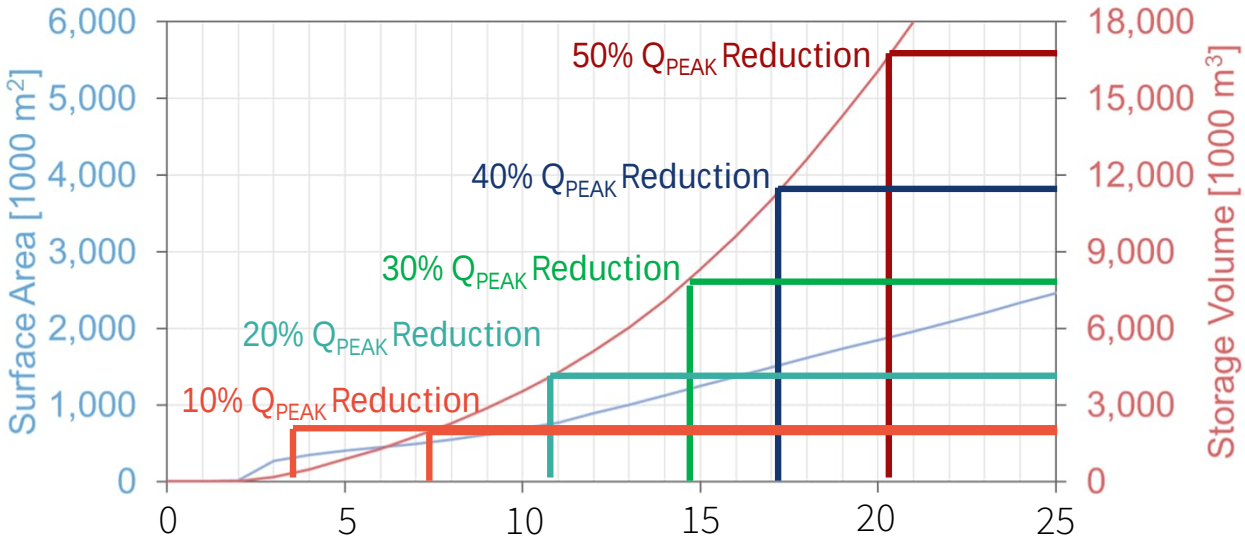




Big East River

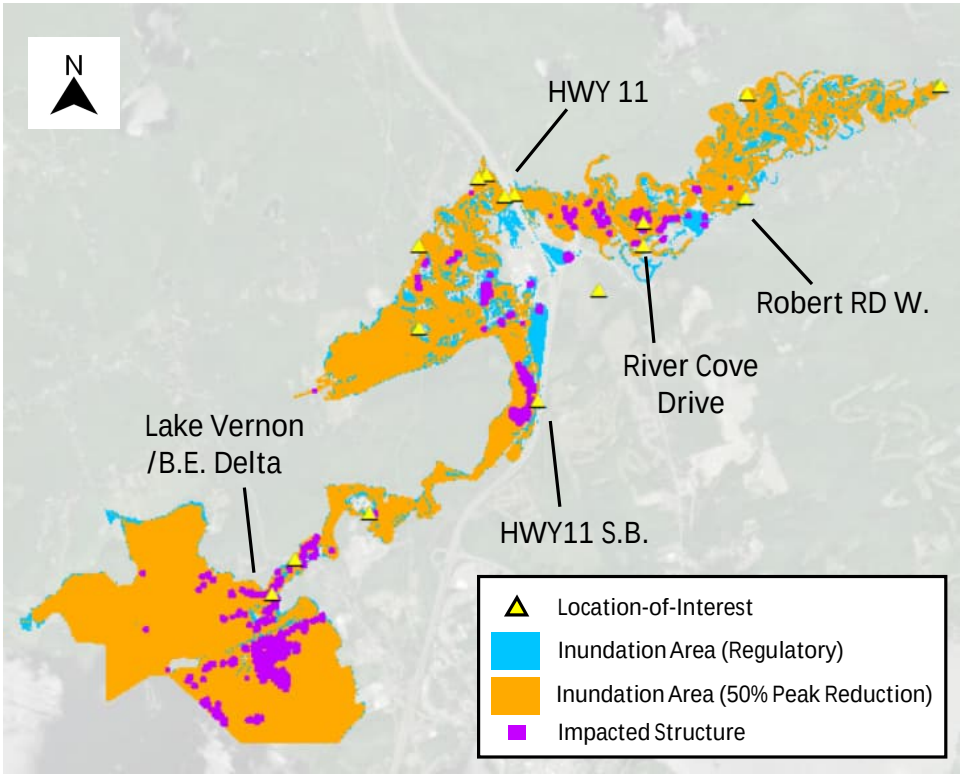
Option 2: Control Structure and Upstream Storage at Finlayson

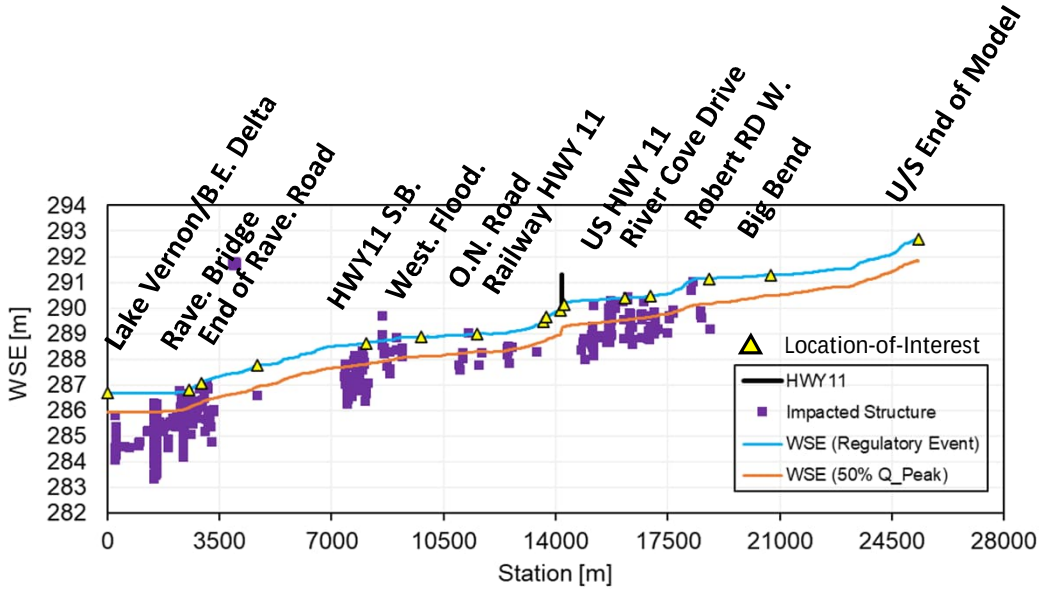


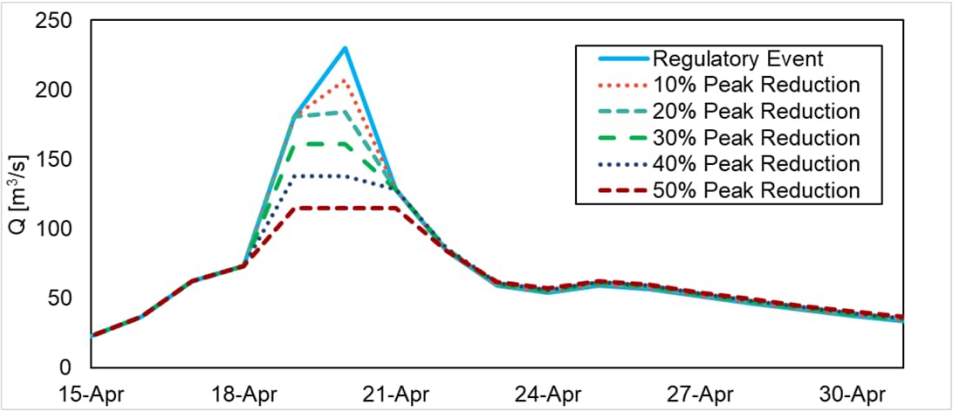


Big East River

Potential Effectiveness of Mitigation







Big East River

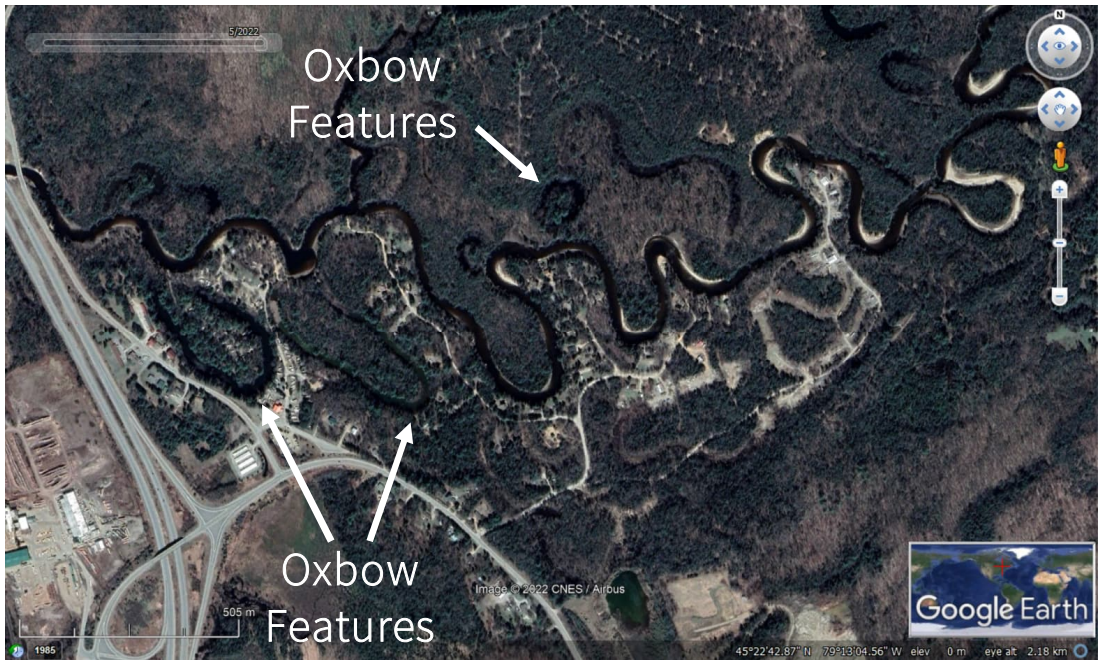
Simulated Effectiveness of Mitigation

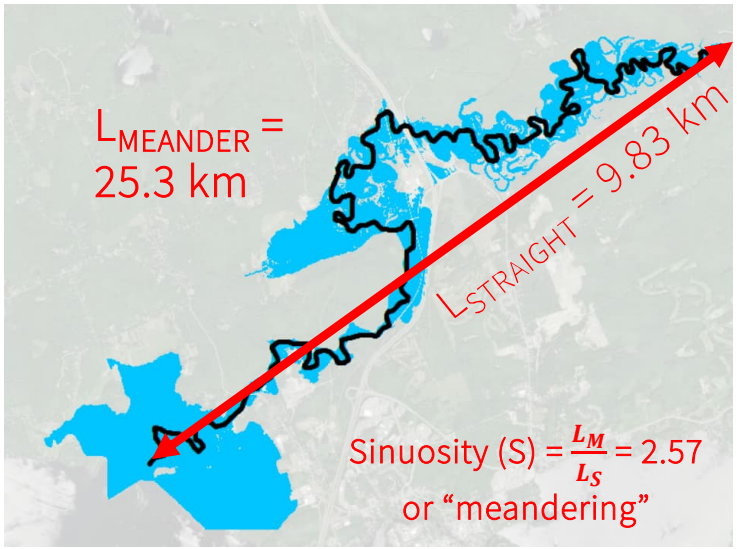
Scenario	Peak Flow of Big East @ Lake Vernon (m^3/s)	Estimated Drop in Lake Vernon Peak Water Level[1] (m)	Big East Flood Inundation Extent Area (km^2)	# of Impacted Structures (-)	# of Impacted Structures in Storage Area Upstream of Distress (-)	# of Impacted Structures in Storage Area Upstream of Finlayson (-)
Regulatory Event	242	N/A[2]	9.6	620	4 (estimate)	0
10% Peak Reduction	218	-0.09 m	9.5	600 (-20)	5 (+1)	0
20% Peak Reduction	194	-0.21 m	9.3	593 (-27)	8 (+4)	3 (+3)
30% Peak Reduction	169	-0.36 m	9.0	570 (-50)	12 (+8)	3 (+3)
40% Peak Reduction	145	-0.52 m	8.8	555 (-65)	19 (+15)	3 (+3)
50% Peak Reduction	121	-0.73 m	8.3	514 (-106)	23 (+19)	3 (+3)

[1]2019 Muskoka River Flood Plain Mapping Study (FPMS)
[2]Regulatory event water level of 286.68 m (2019, FPMS)

Big East River

Channel Excavation and Local Dyking



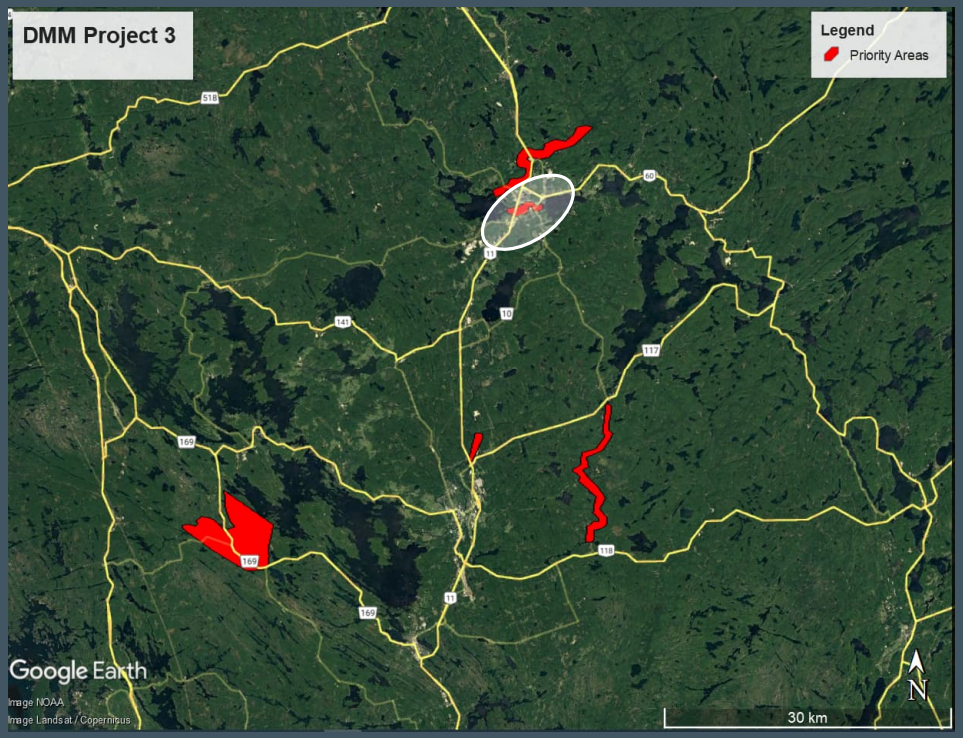


- Meandering and oxbow features evidence of highly active channel
- Structures located within river's meander belt
- Channel excavation/bypass may worsen flooding and exacerbate channel migration
- Long & active meandering shoreline presents challenges for dyking

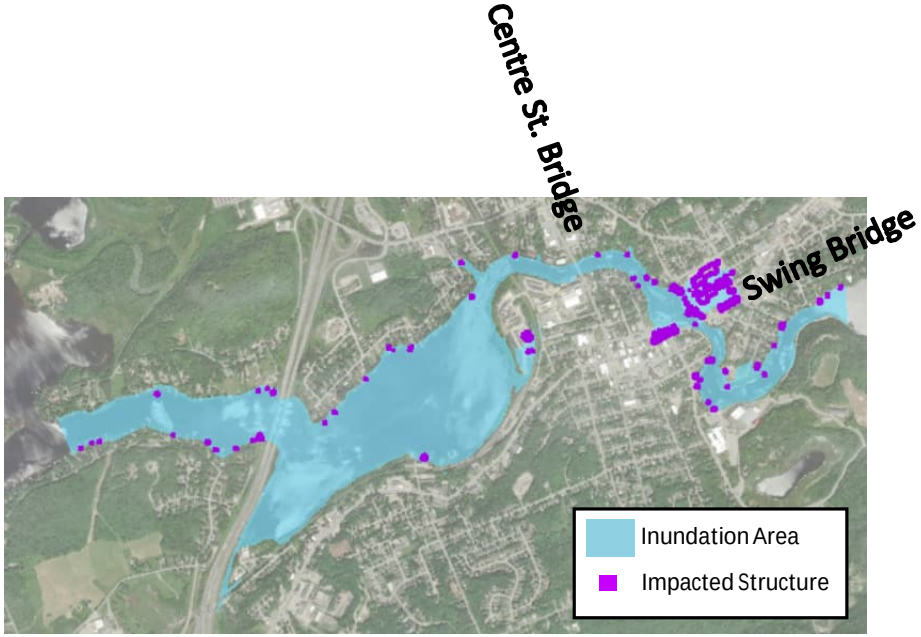
Big East River
Preliminary Options Ranking

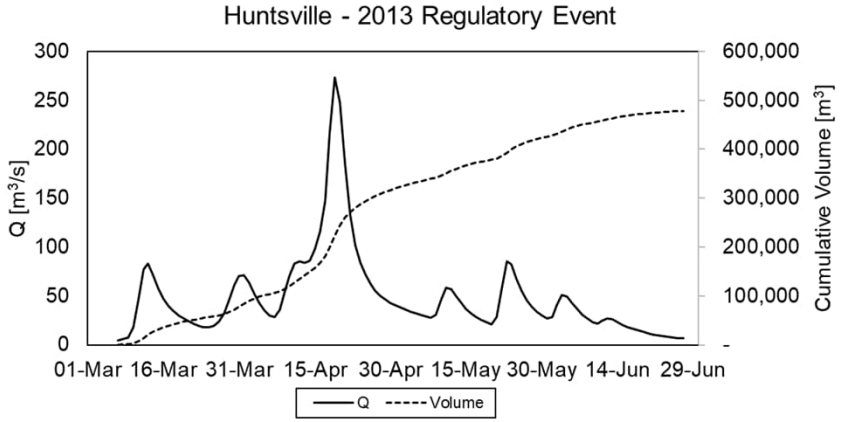
Priority Area	Option Description	Mitigation Strategy	Ranking (0 - 3; where 3 is best ranking)					Total
			Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Local Impacts to Flooded Structures	Potential for Adverse Local Environmental Impacts	Potential for Adverse Local Impacts to Residents	
Big East	Temporary Storage Upstream of Distress	Flood Attenuation	1	1	3	2	3	10
Big East	Temporary Storage Upstream of Finlayson	Flood Attenuation	1	1	3	1	3	9
Big East	Channel Excavation	Flood Bypass	1	2	0	2	1	6
Big East	Local Dyking	Flood Bypass	2	2	0	2	1	7

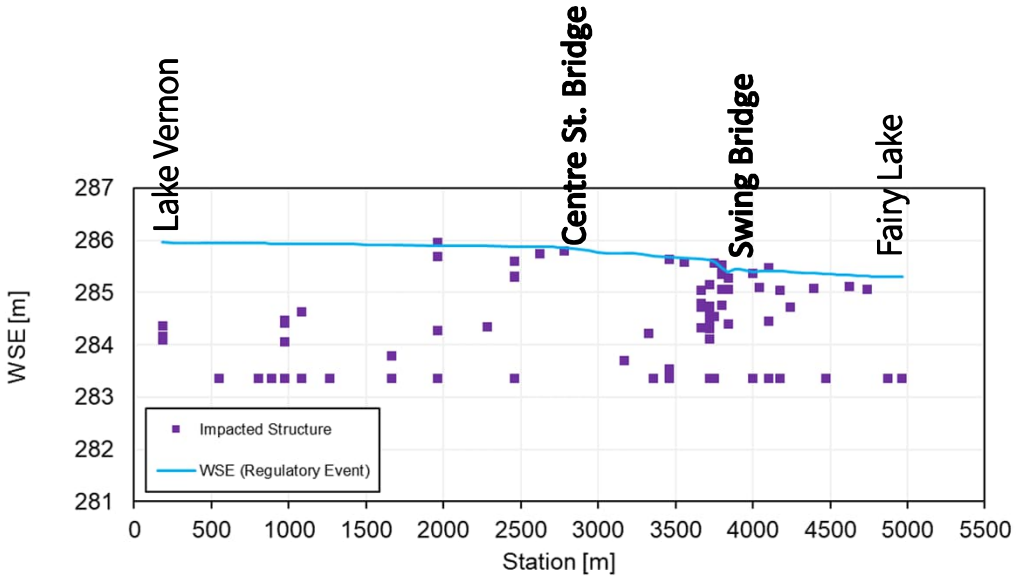
Huntsville


DMM Project 3
Legend
Priority Areas
Google Earth
Image NOAA
Image Landsat / Copernicus
30 km
N

Huntsville
Regulatory Event

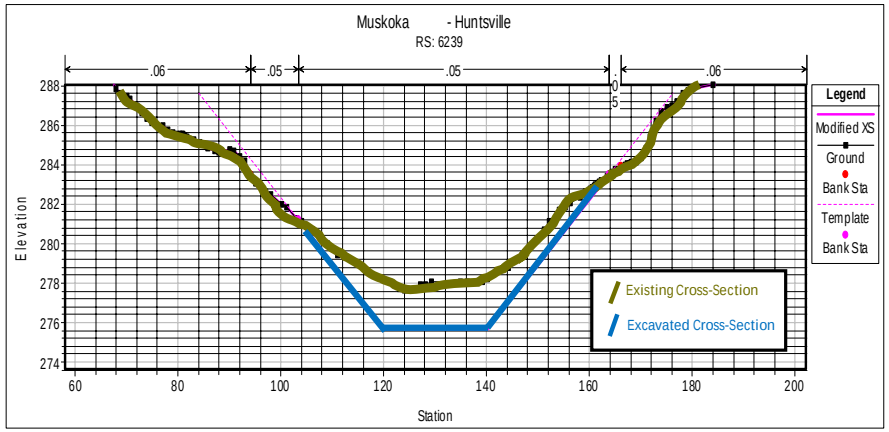




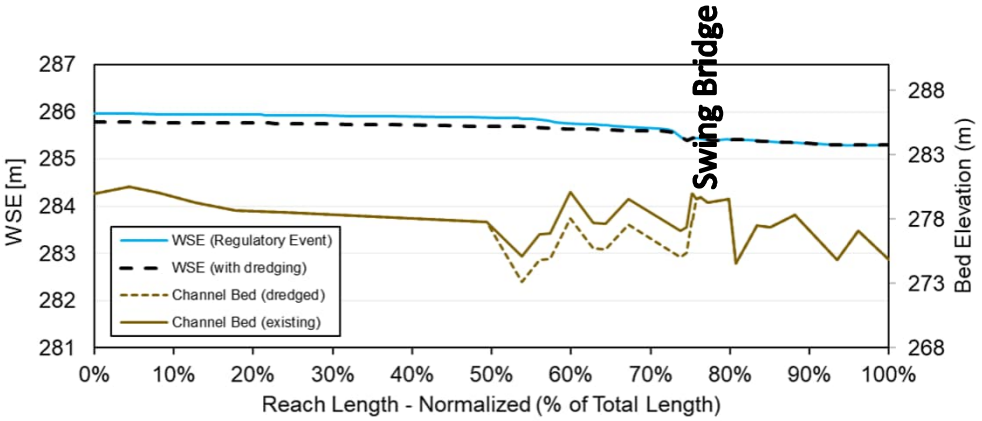


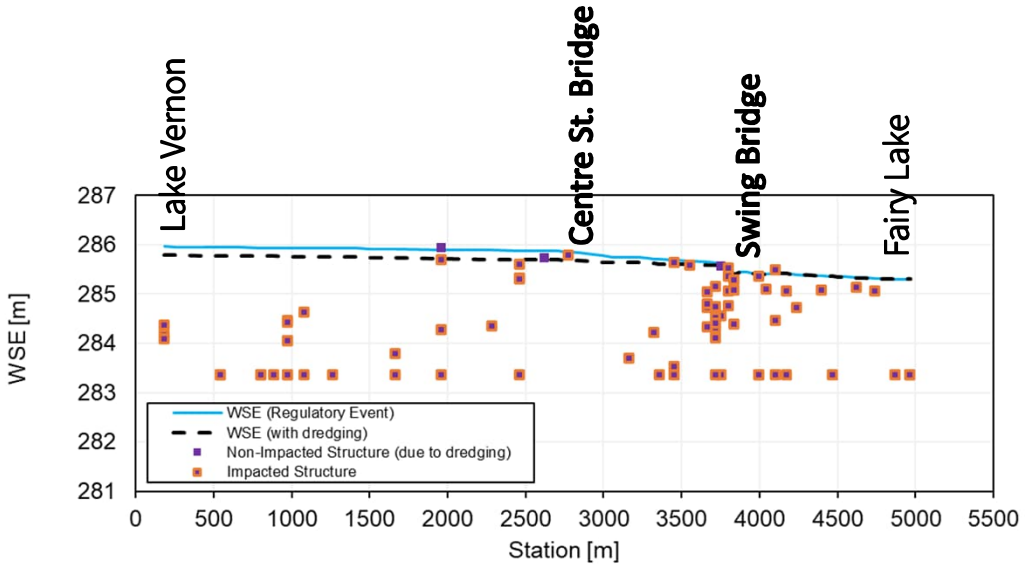
Huntsville

Option 1: Channel Dredging





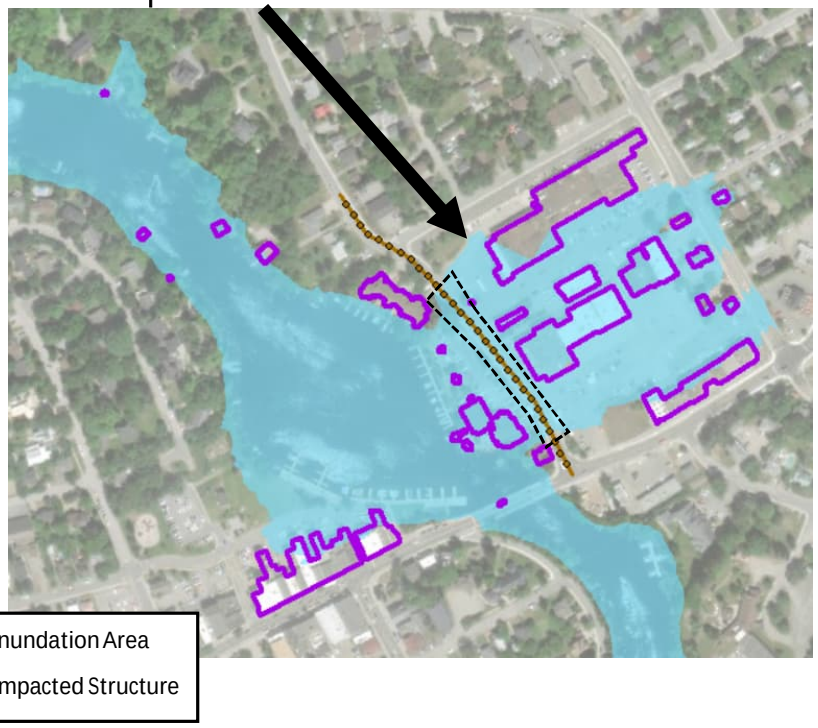


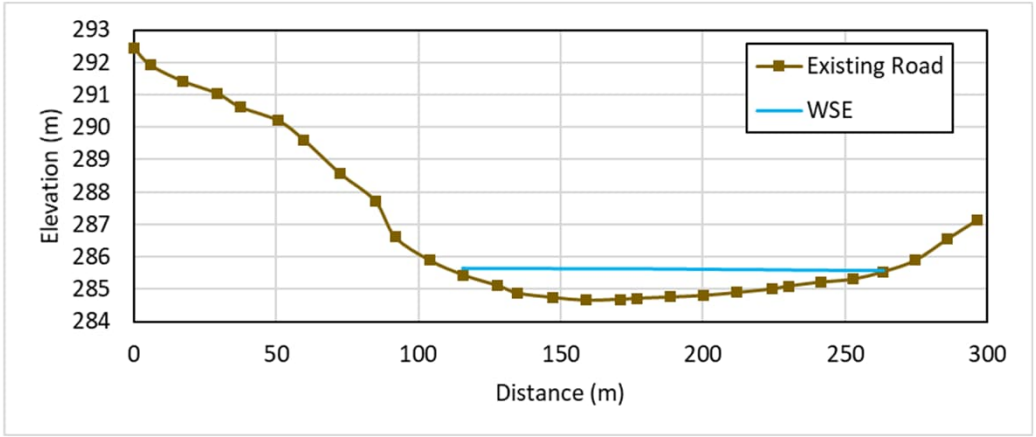


Huntsville

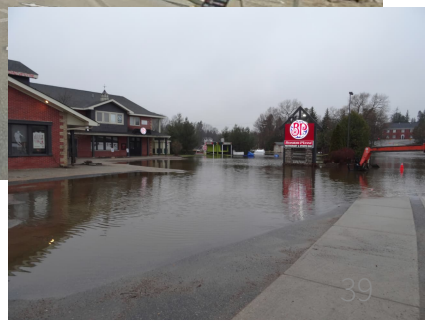
Option 2a: Raise Road @ John St.

Flooding in commercial/parking area comprises <1% total flow volume



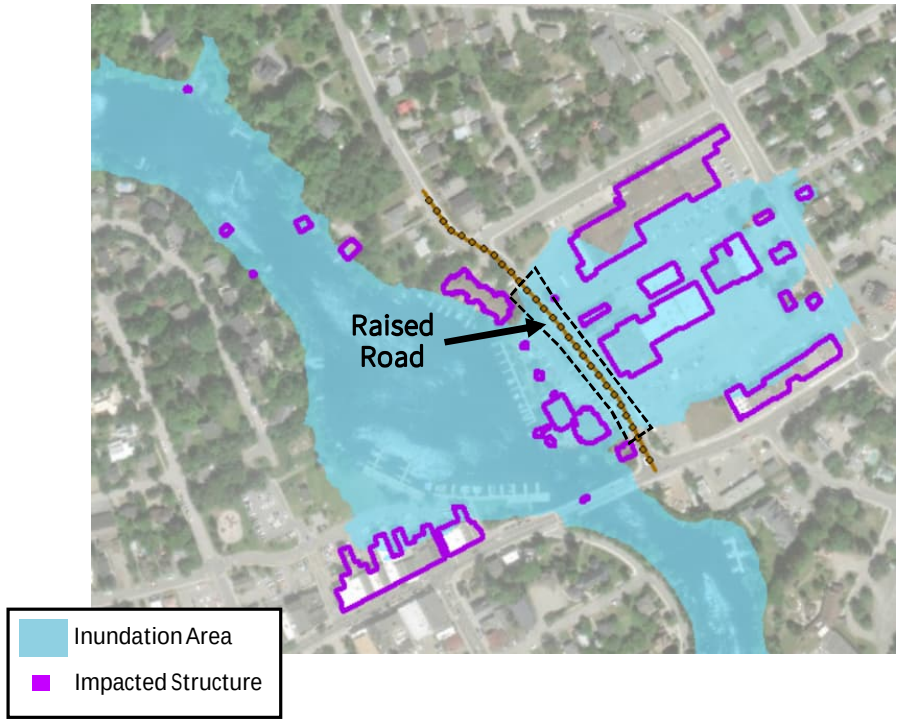


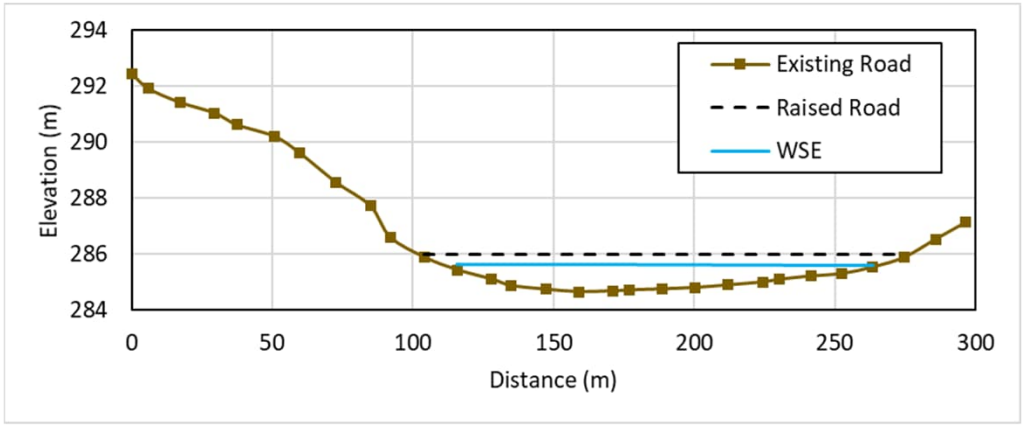


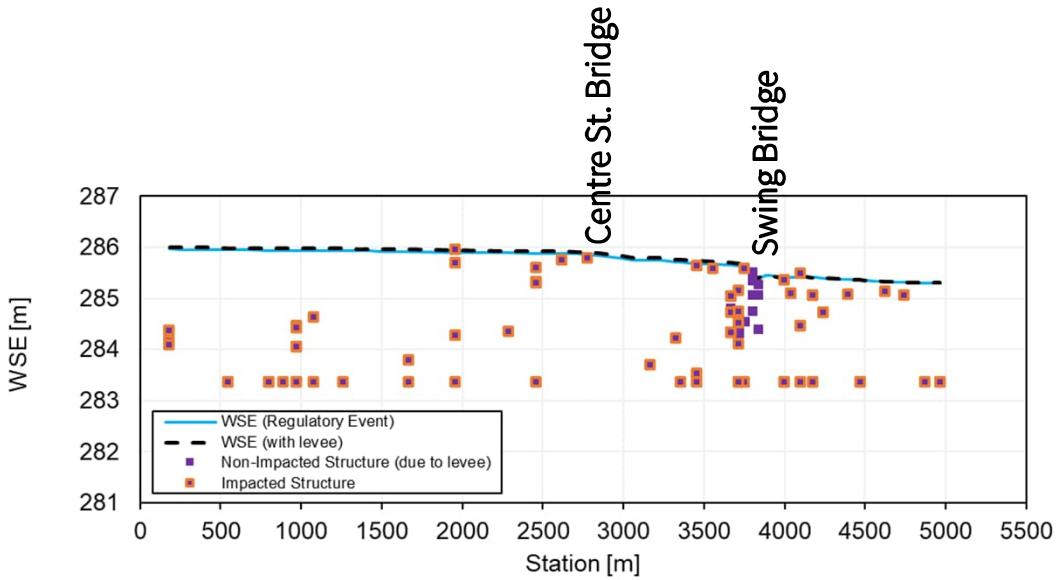


Huntsville

Option 2a: Raise Road @ John St.

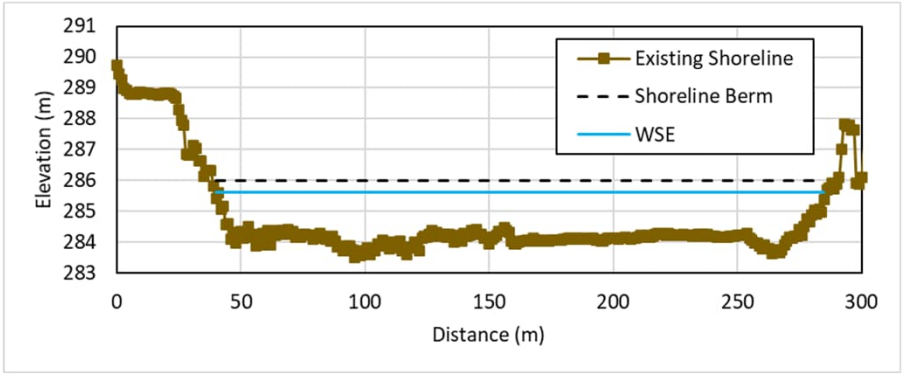


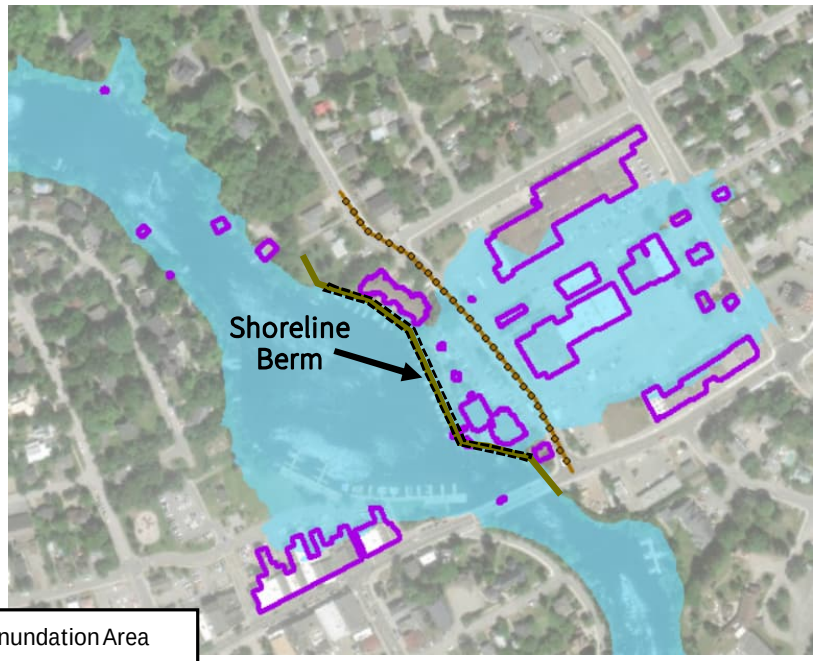




Huntsville

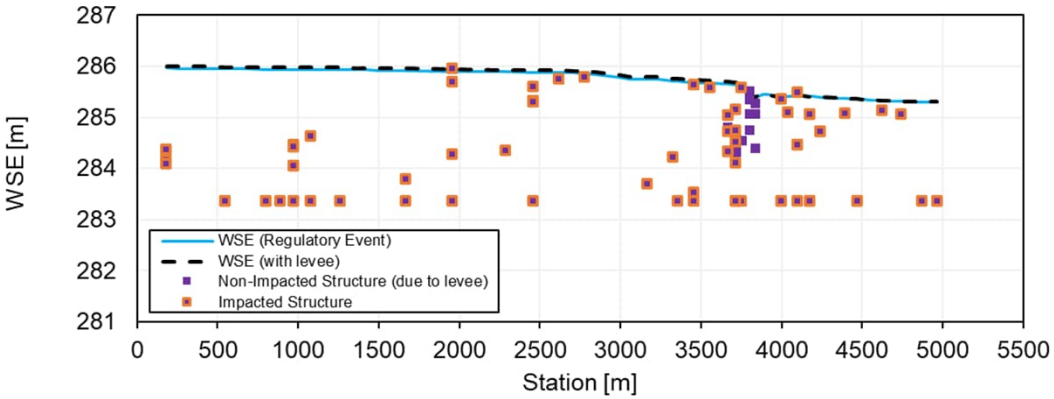
Option 2b: Shoreline Berm









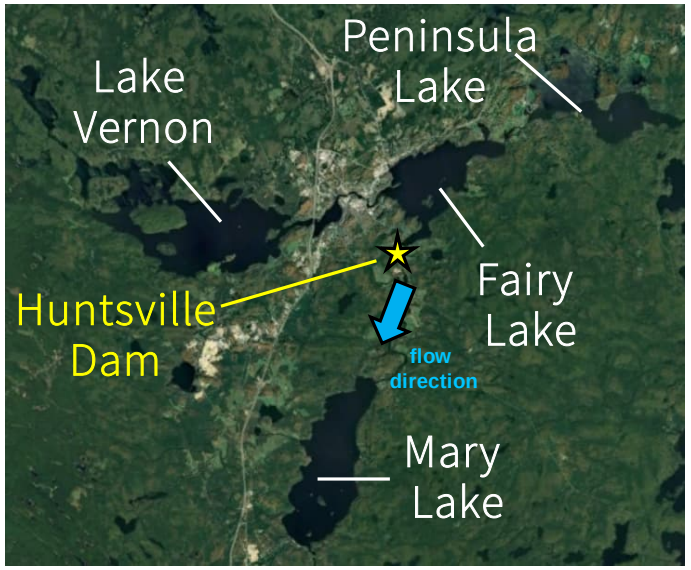


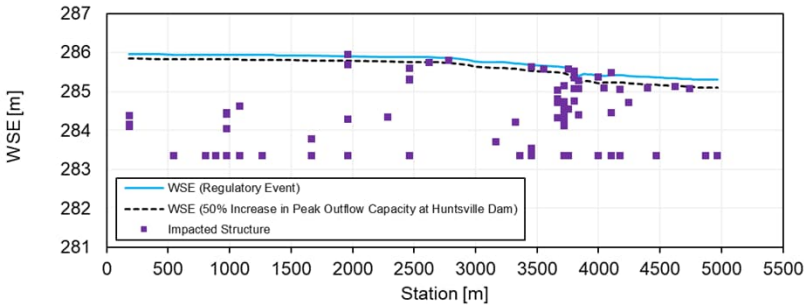
Huntsville

Option 3: Increase Peak Outflow Capacity at Huntsville Dam

Scenario	Increased Storage in Mary Lake / Decreased Storage in Fairy-Peninsula Lakes (m)	# of Impacted Structures on Fairy-Peninsula Lakes (-)	# of Impacted Structures on Mary Lake (-)
Current Peak Outflow Capacity	NA	392	89
25% Increase in Peak Outflow Capacity at Huntsville Dam	1,339,007 m^3	383 (-9)	94 (+5)
50% Increase in Peak Outflow Capacity at Huntsville Dam	4,651,932 m^3	359 (-33)	121 (+32)

*Analysis assumes all three lakes have the same water surface elevation.
*Lake Vernon excluded from this analysis, as it is located upstream of Huntsville Narrows.
*Assume increase storage increase with stage is 3x in Fairy-Peninsula relative to Mary Lake.





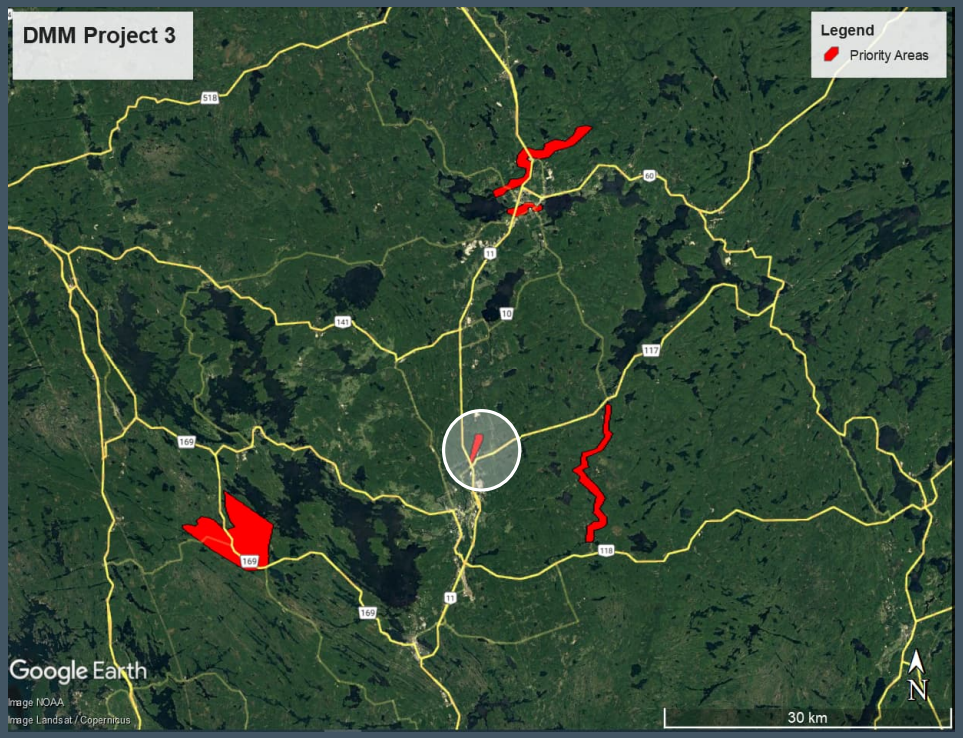
Marginal net benefit achieved through increasing Huntsville Dam outflow. Flooding reduction in Huntsville Narrows and Fairy/Peninsula transferred to Mary Lake (and other lower lakes).

Huntsville

Preliminary Options Ranking

Priority Area	Option Description	Mitigation Strategy	Ranking (0 - 3; where 3 is best ranking)					Total
			Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Impacts to Flooded Structures	Potential for Adverse Impacts to Local Environment	Potential for Adverse Impacts to Local Residents	
Huntsville	Channel Enlargement Upstream of Swing Bridge	Flood Bypass	1	1	1	1	2	6
Huntsville	Raised Road @ John St. or Shoreline Berm	Flood Bypass	2	3	3	3	2	13
Huntsville	Increase in Fairy Lake Outflow Capacity	Flood Attenuation	2	2	3	1	0	8

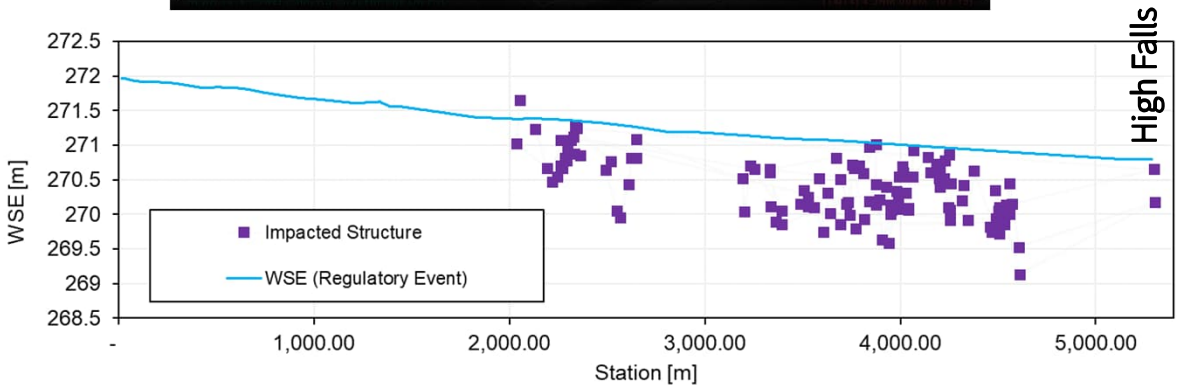
North Branch

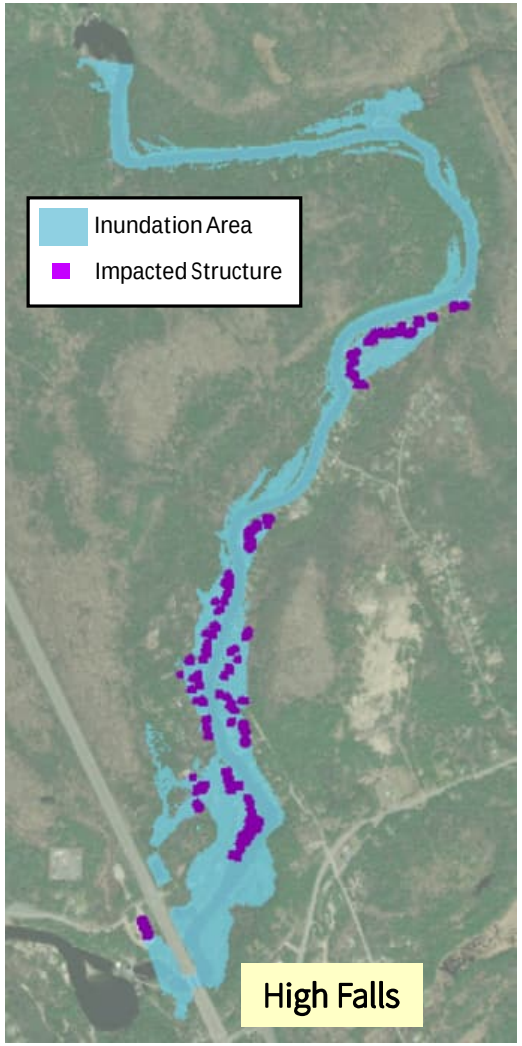


North Branch

Regulatory Event



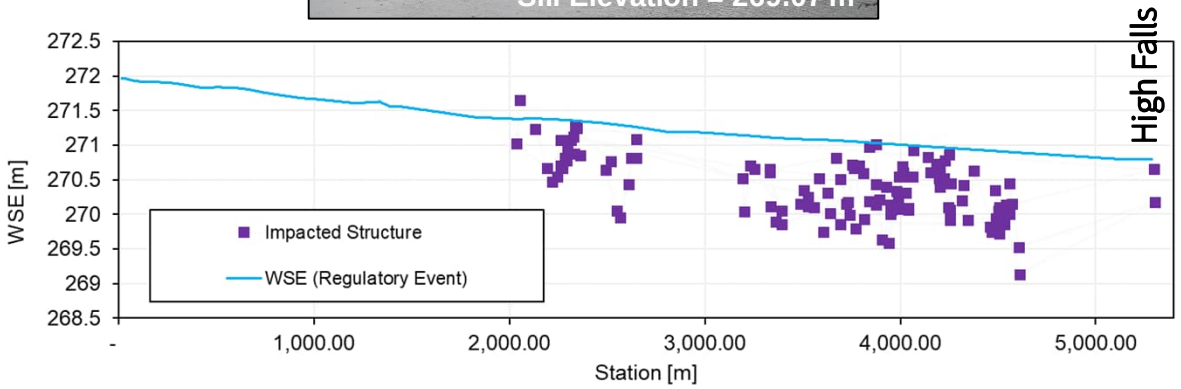


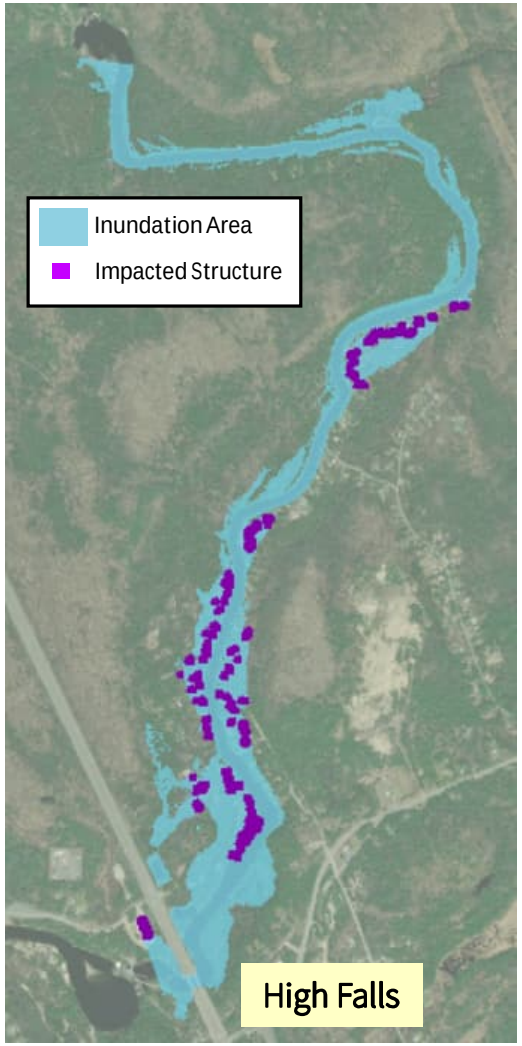


North Branch

Hydraulic Control at High Falls





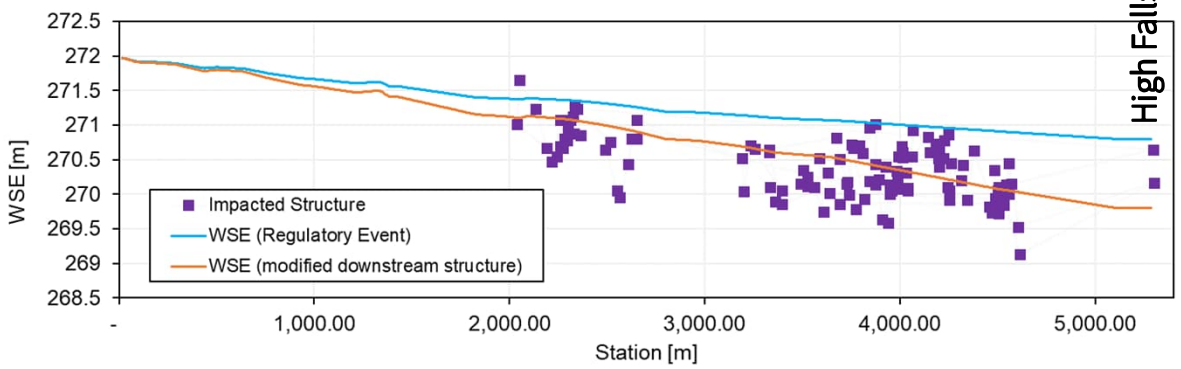


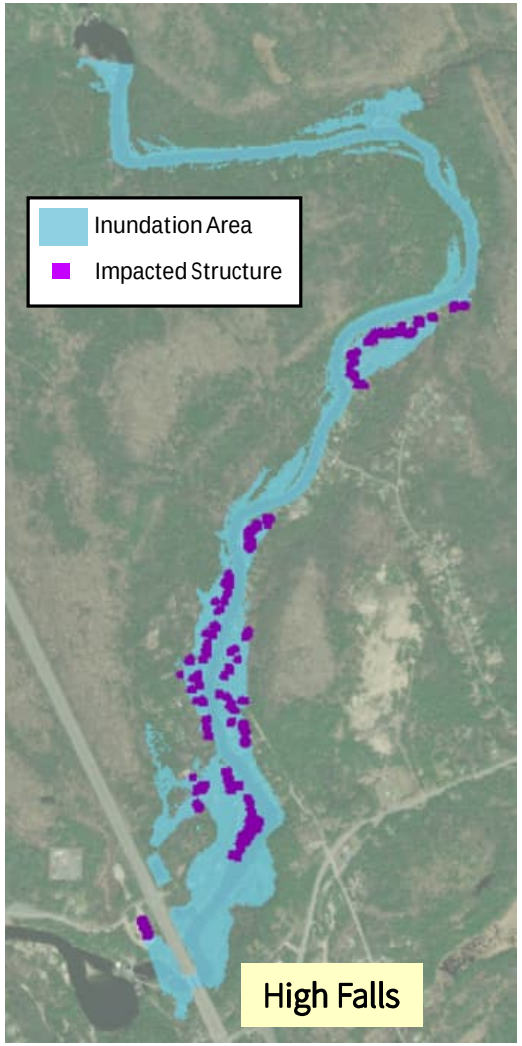
North Branch

Option 1: Obermeyer Control @ High Falls



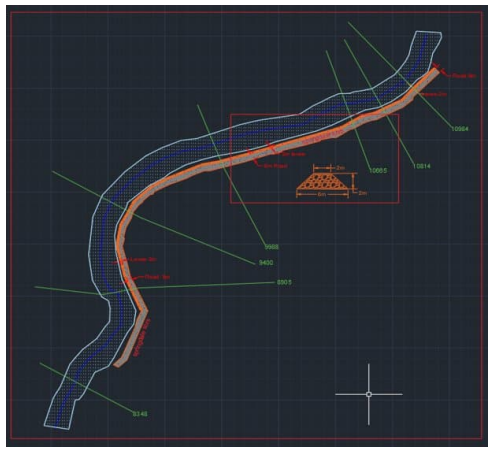


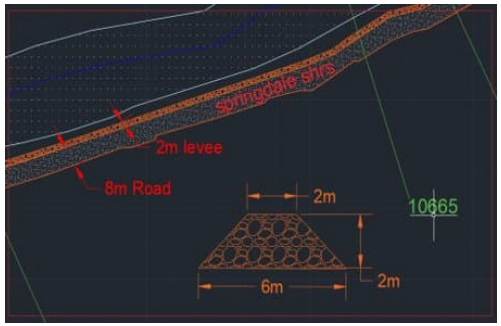


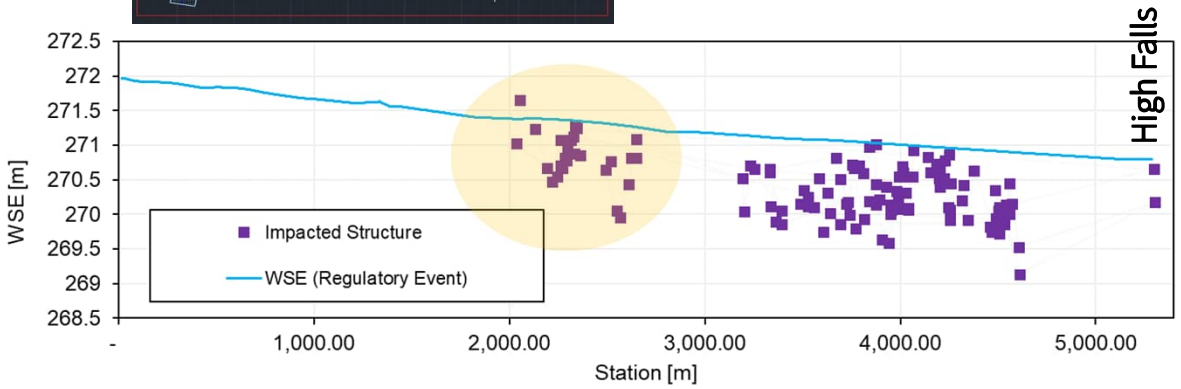


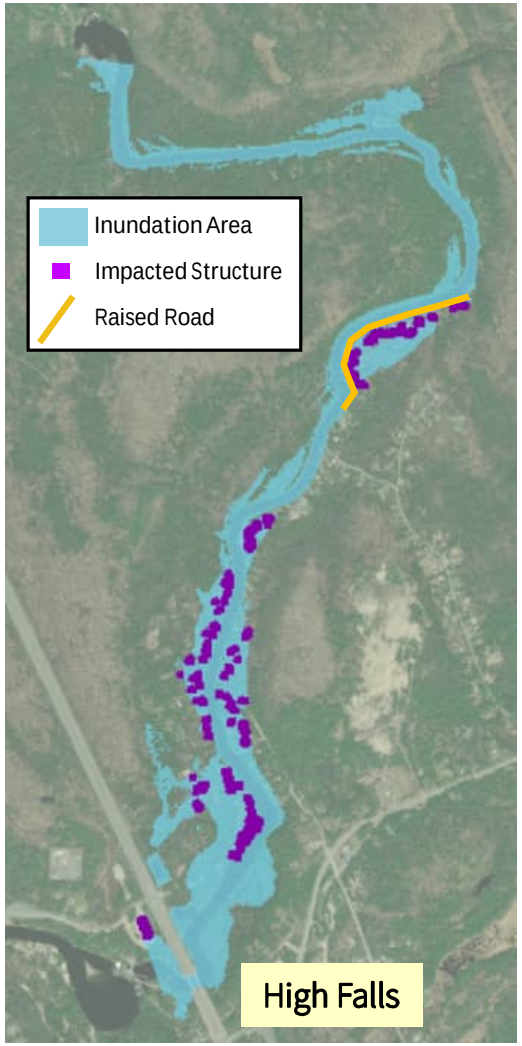
North Branch

Option 2: Raise Road @ Springdale Shores









North Branch

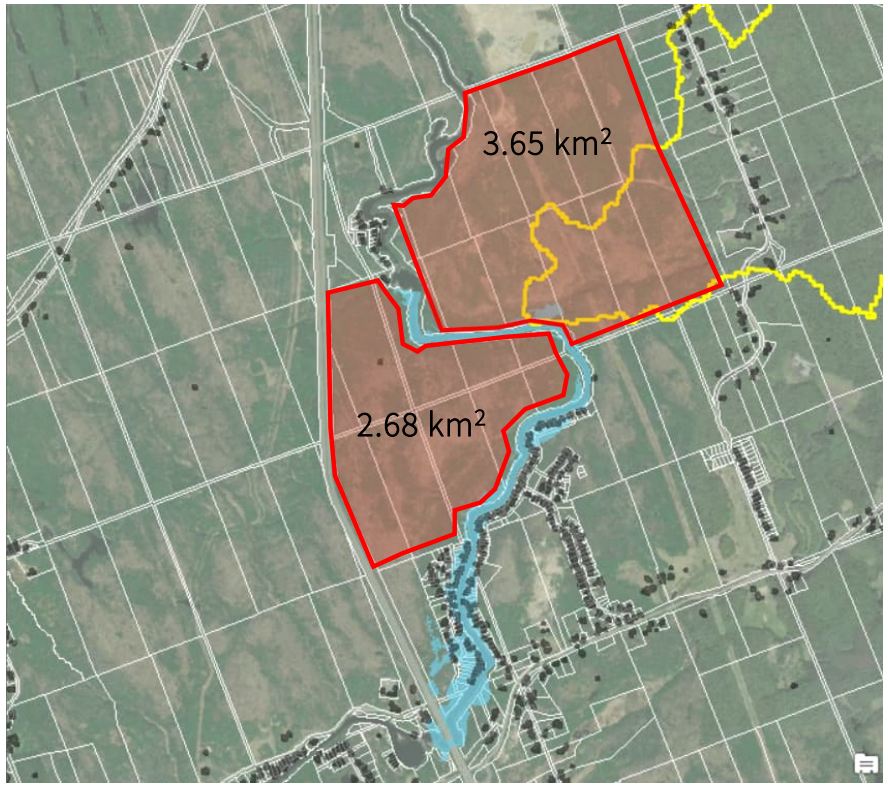
Potential Effectiveness of Mitigation

Scenario	Peak High Falls Water level (m)	Modelled Inundation Extent Area (km^2)	# of Impacted Structures (-)
Regulatory Event	270.8	0.65	121
0.5 m reduction in High Falls WSE due to Obermeyer control	270.3 (-0.5 m)	0.56	103 (-18) *or* 81 (-40) with raised road
1.0 m reduction in High Falls WSE due to Obermeyer control	269.8 (-1.0 m)	0.49	71 (-50) *or* 53 (-68) with raised road

North Branch

Considered Option – Temporary Storage via Constructed Wetland

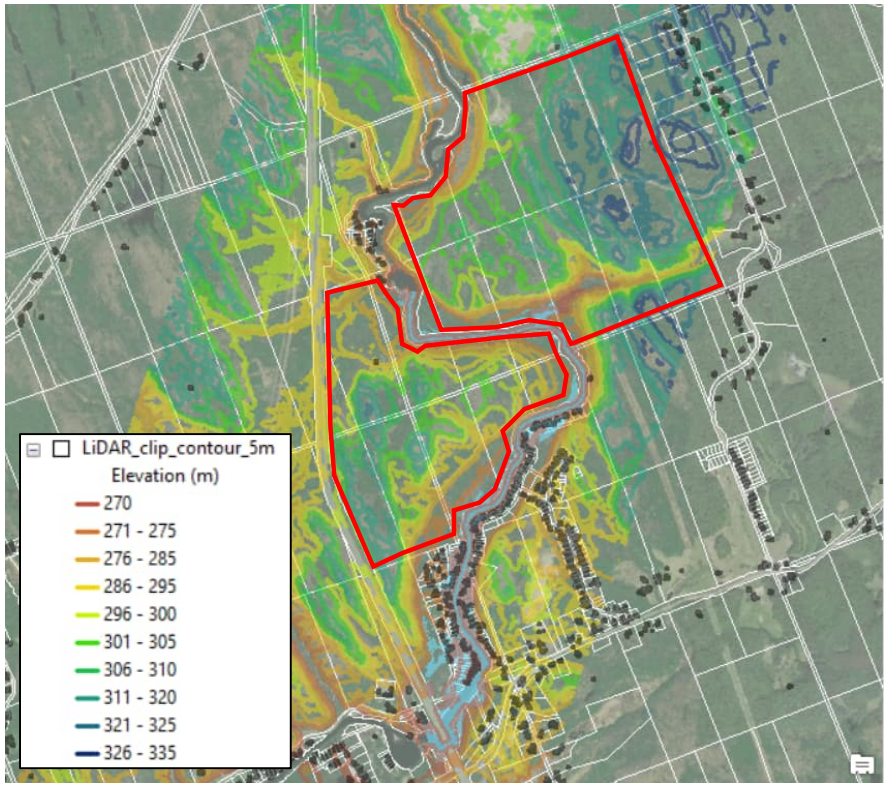
Scenario	Volume (m^3)	Storage Depth Requirement for Total 6.33 km^2 Area (m)
10% Peak Reduction	2,552,812	0.4
30% Peak Reduction	14,183,826	2.2
50% Peak Reduction	33,468,748	5.3



North Branch

Considered Option – Temporary Storage via Constructed Wetland

Constraint: existing grading in prospective storage areas

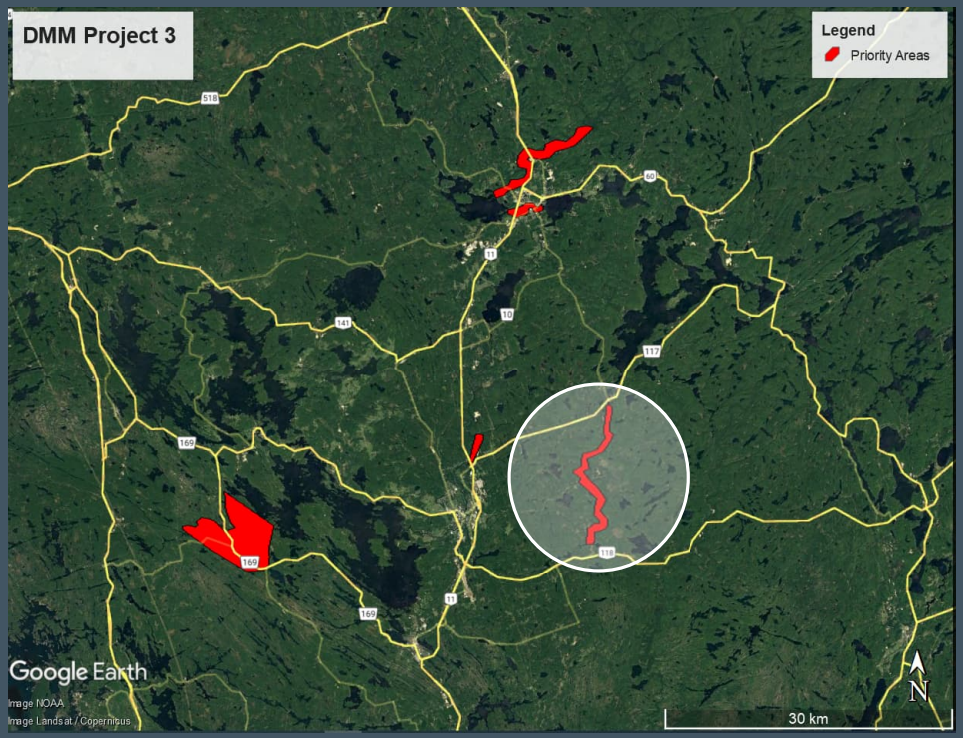


North Branch

Preliminary Options Ranking

Priority Area	Option Description	Mitigation Strategy	Ranking (0 - 3; where 3 is best ranking)					Total
			Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Local Impacts to Flooded Structures	Potential for Adverse Local Environmental Impacts	Potential for Adverse Local Impacts to Residents	
Springdale (North Branch)	Obermeyer Control @ High Falls	Flood Bypass	2	2	3	2	3	12
Springdale (North Branch)	Raised Road @ Springdale Shores	Flood Bypass	1	2	3	2	0	8
Springdale (North Branch)	Constructed Wetland	Flood Bypass	0	0	1	0	0	1

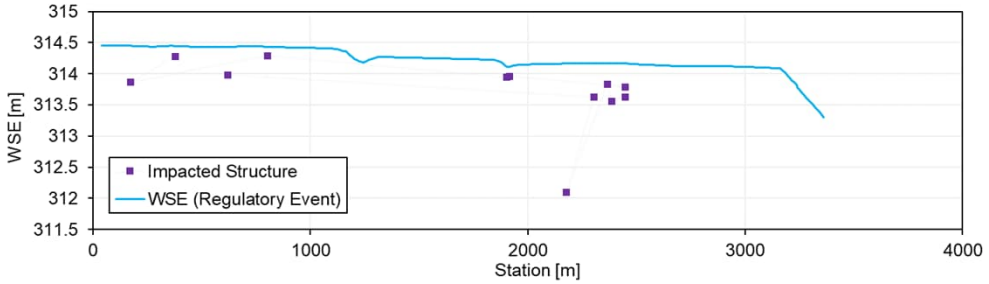
Baysville/Fraserburg/Purbrook



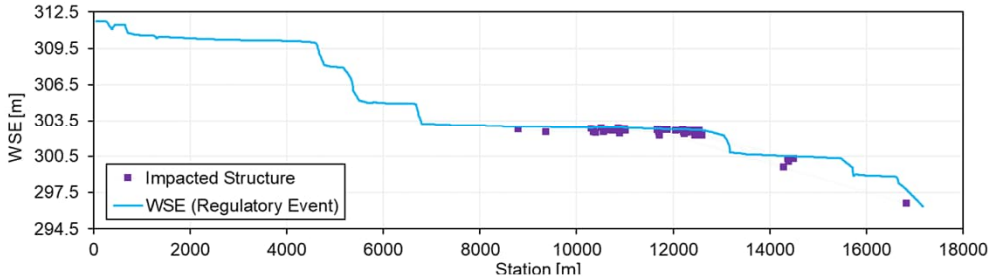
Baysville/Fraserburg/Purbrook

Regulatory Event

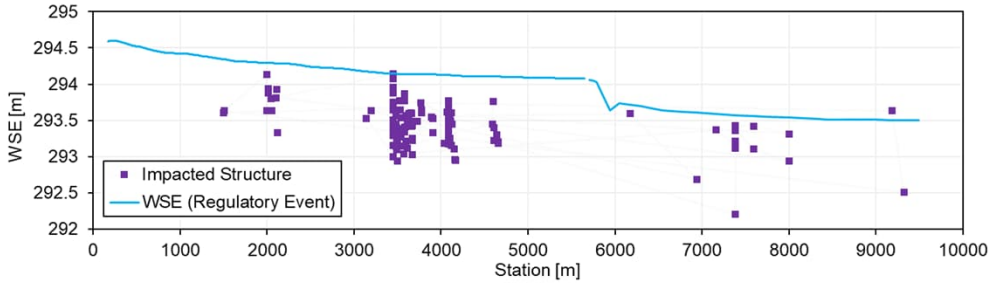
Baysville



Fraserburg



Purbrook



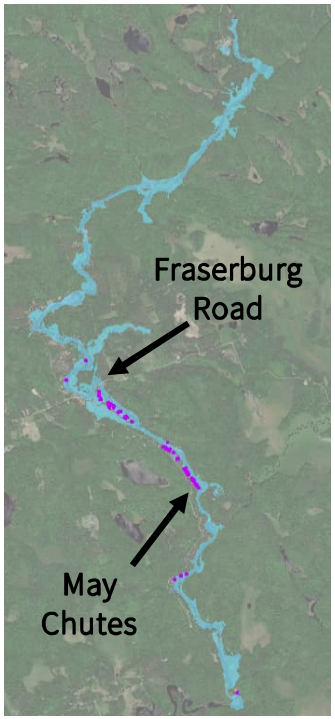
Baysville/Fraserburg/Purbrook

Regulatory Event

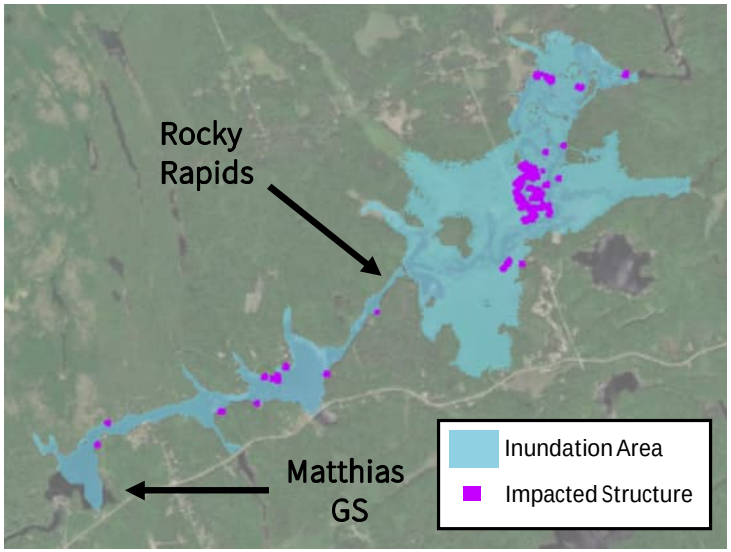
Baysville



Fraserburg

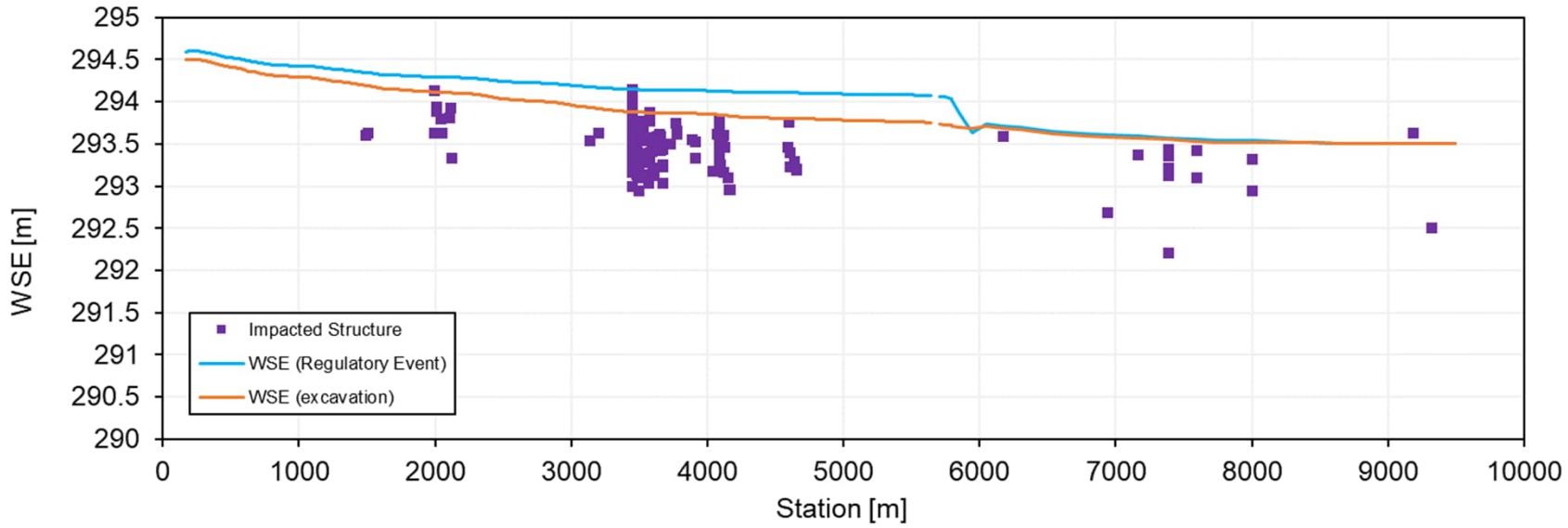


Purbrook



Baysville/Fraserburg/Purbrook

Option 1: Excavation at Rocky Rapids (Purbrook)



Baysville/Fraserburg/Purbrook

Option 2: Operational Adjustment at Matthias GS

Matthias GS
Stage-Discharge Relationship

528 m^3/s 963.0 feet

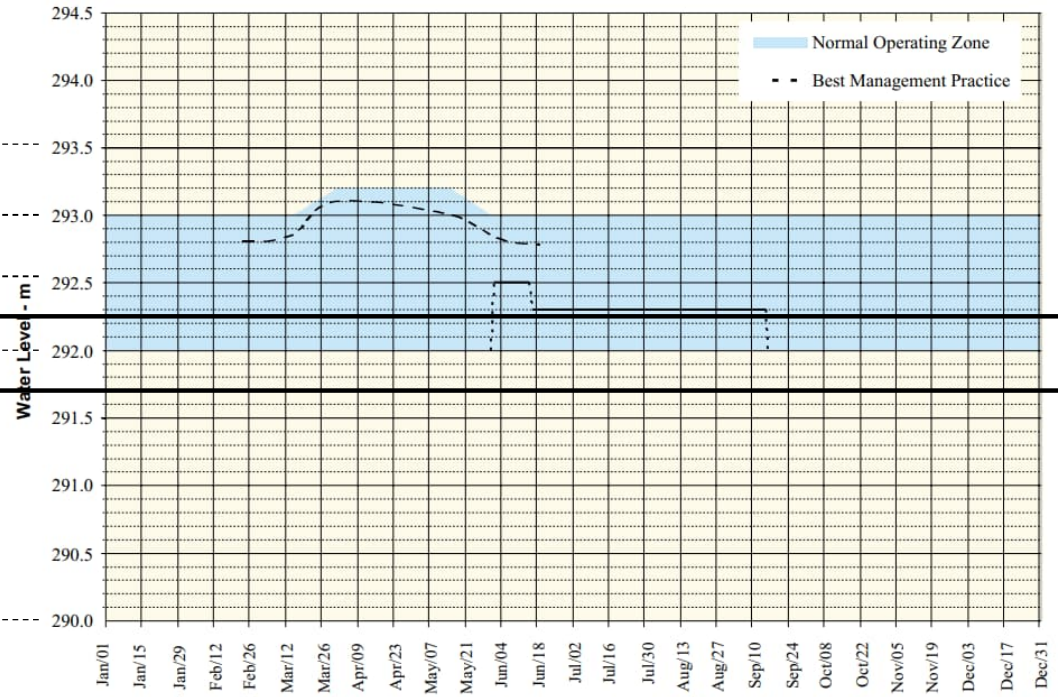
480 m^3/s 961.3 feet

432 m^3/s 959.6 feet

385 m^3/s 958.0 feet

176 m^3/s 950.0 feet

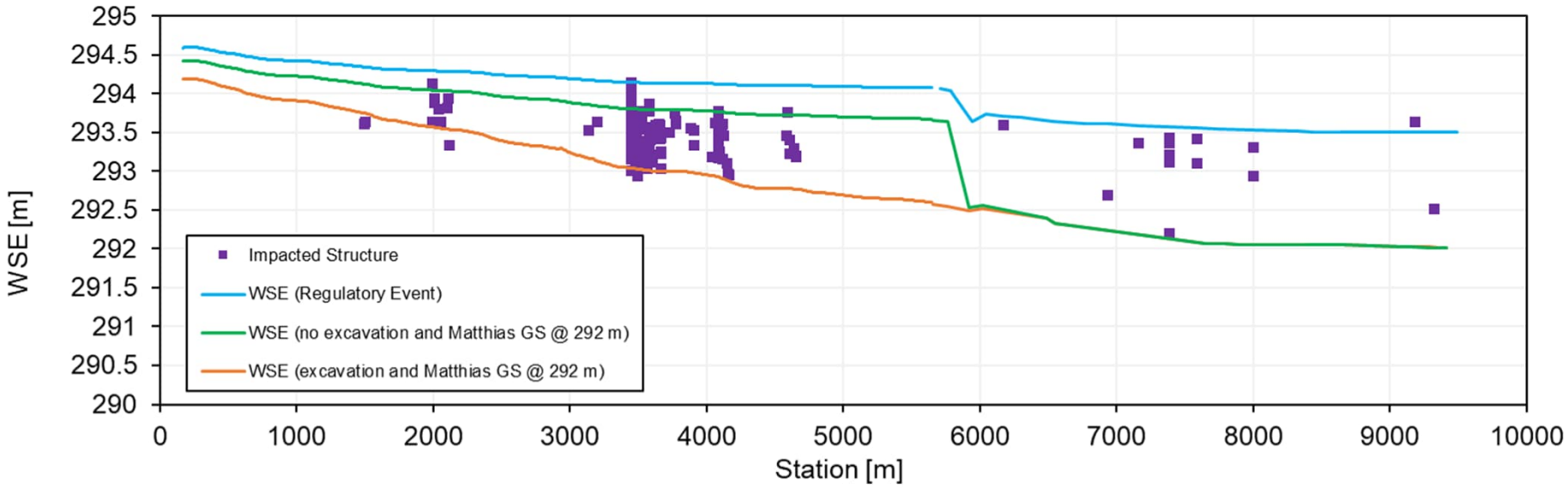
Matthias GS (Water Management Plan)



(Regulatory Event Peak Flow With Gates Fully Open)

Baysville/Fraserburg/Purbrook

Option 2: Operational Adjustment at Matthias GS



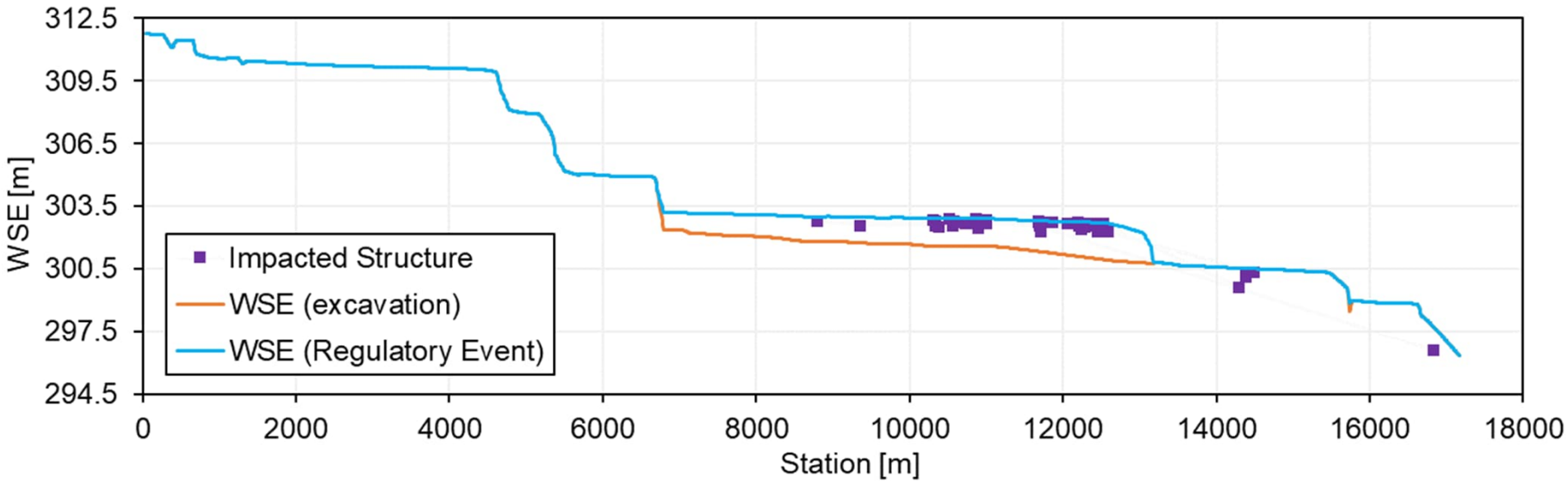
Baysville/Fraserburg/Purbrook

Option 3 – Flood Control via Lake of Bays

Scenario	Peak Flow at Baysville (m^3/s)	Estimated Peak Water Level Lake of Bays (m)	# of Impacted Structures at Lake of Bays (-)	# of Impacted Structures (-)			
				Total	Baysville	Fraserburg	Purbrook
Regulatory Event	165	315.51	1925	206	12	49	145
10% Peak Reduction	149	315.67	1977 (+52)	183 (-23)	10	30	143
20% Peak Reduction	132	315.79	2017 (+92)	163 (-43)	8	14	141
30% Peak Reduction	116	315.92	2059 (+134)	145 (-61)	4	5	136
40% Peak Reduction	99	316.29	2180 (+255)	129 (-77)	1	2	126
50% Peak Reduction	83	316.72	2321 (+396)	126 (-80)	1	2	123

Baysville/Fraserburg/Purbrook

Option 4: Excavation at May Chutes (Fraserburg)

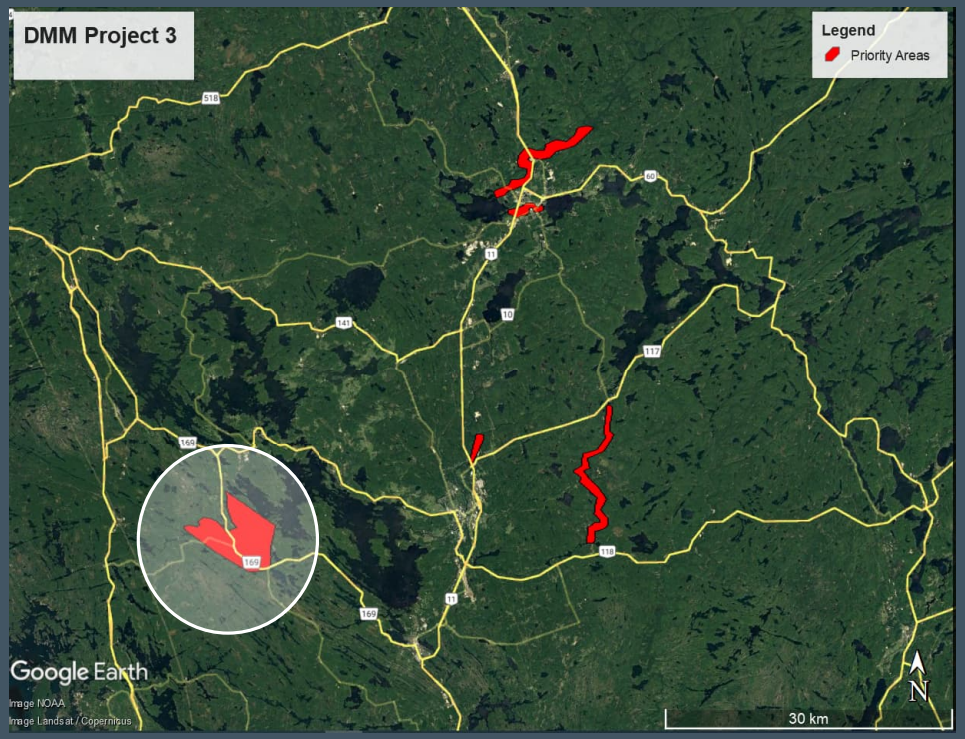


Baysville/Fraserburg/Purbrook

Preliminary Options Ranking

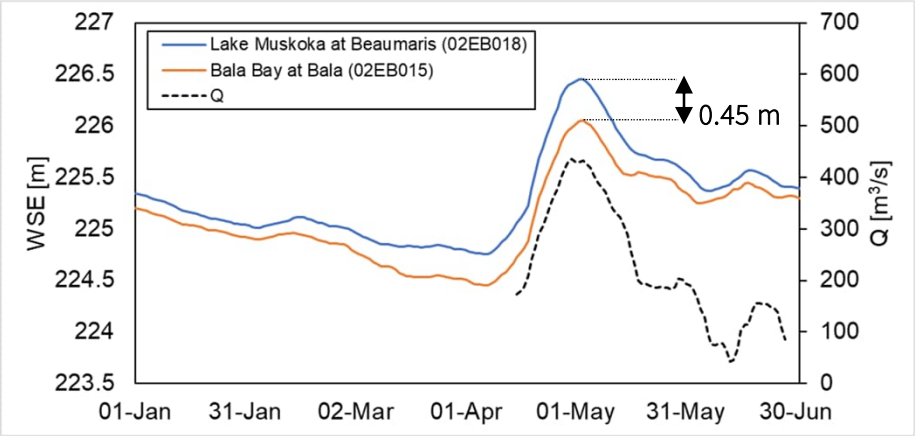
Priority Area	Option Description	Mitigation Strategy	Ranking (0 - 3; where 3 is best ranking)					Total
			Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Local Impacts to Flooded Structures	Potential for Adverse Local Environmental Impacts	Potential for Adverse Local Impacts to Residents	
Baysville/ Fraserburg/ Purbrook	Channel Enlargement at Rocky Rapids	Flood Bypass	2	2	3	1	2	10
Baysville/Fraserburg/ Purbrook	Reduced Matthias GS Head Pond Elevation	Flood Bypass	3	3	3	2	1	12
Baysville/Fraserburg/ Purbrook	Flood Attenuation in Lake of Bays	Flood Attentuation	3	3	0	0	0	6
Baysville/ Fraserburg/ Purbrook	Channel Enlargement at May Chutes	Flood Bypass	2	2	3	1	2	10

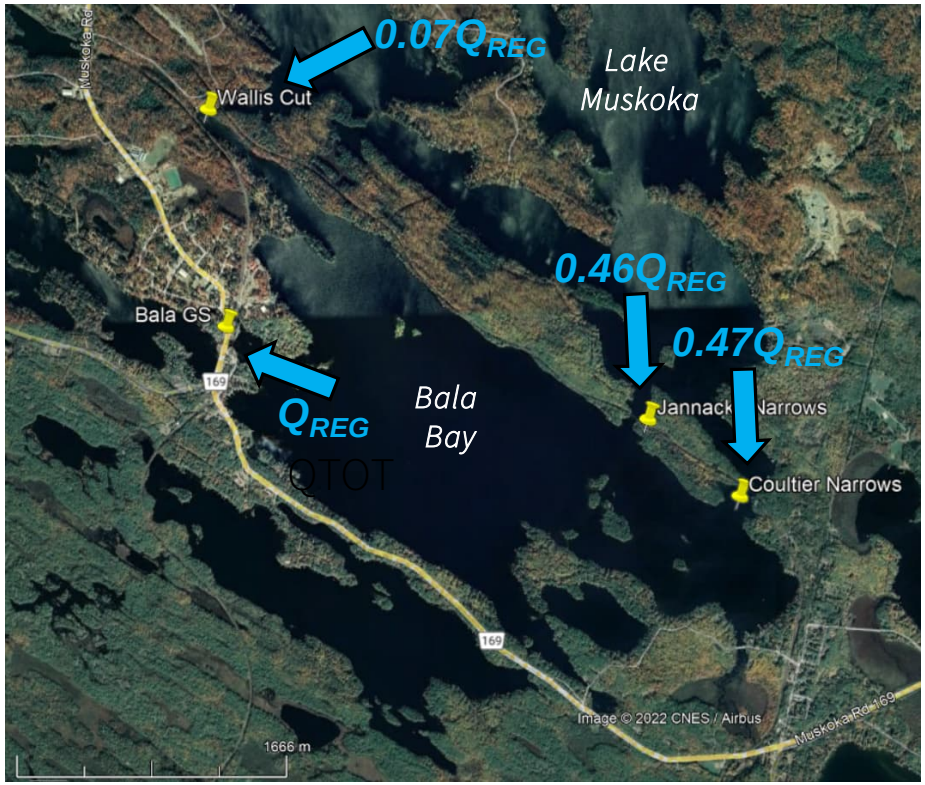
Bala


DMM Project 3
Legend
Priority Areas
518
60
11
10
141
117
169
118
11
169
Google Earth
Image NOAA
Image Landsat / Copernicus
30 km
N

Bala

Flow Distribution: Regulatory Event

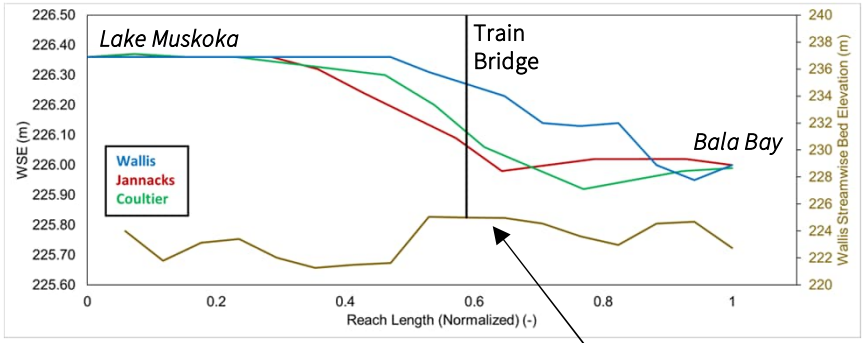


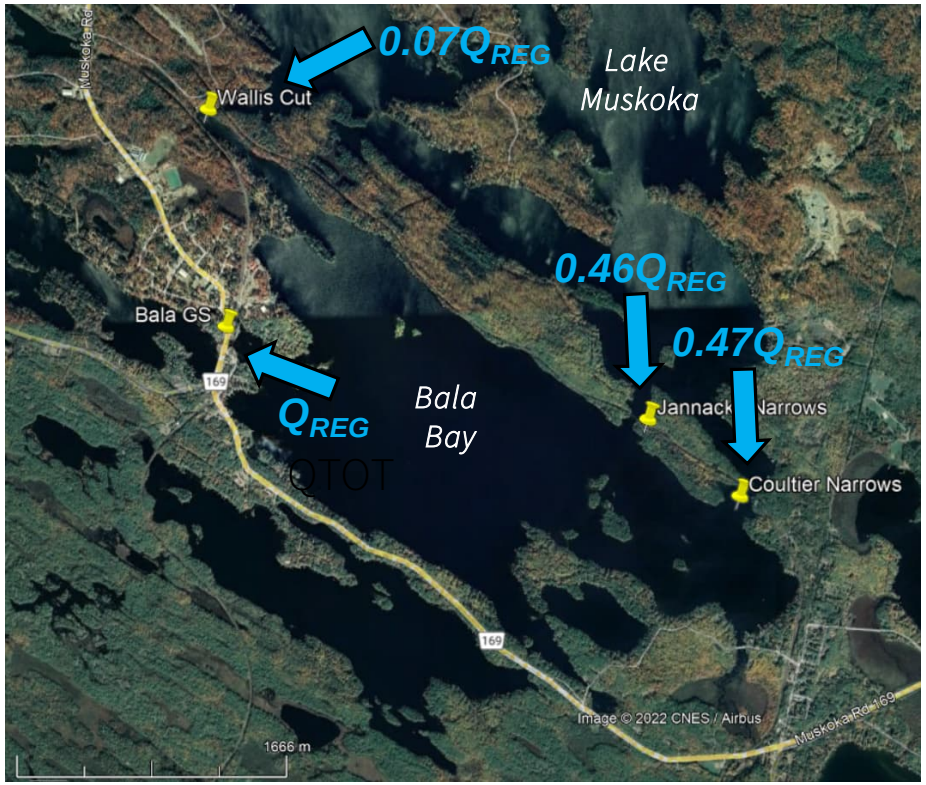


Bala

Option 1: Channel Excavation at Wallis Cut



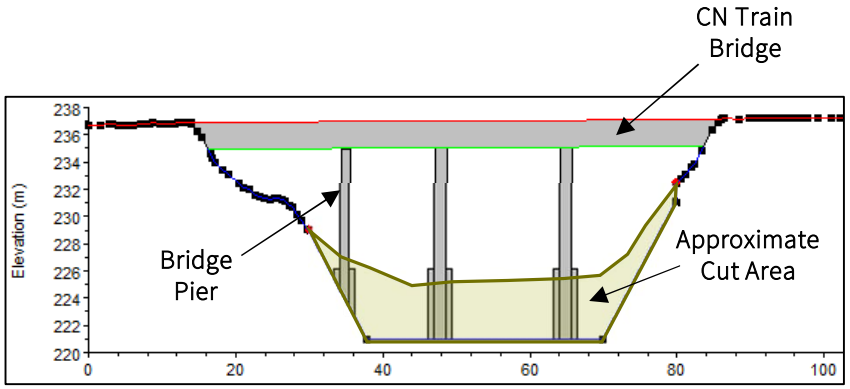


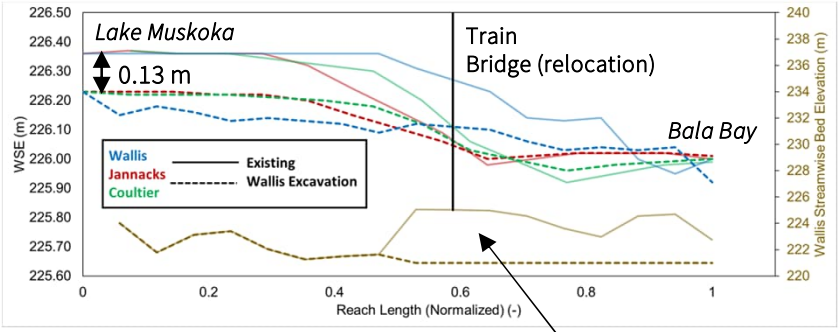


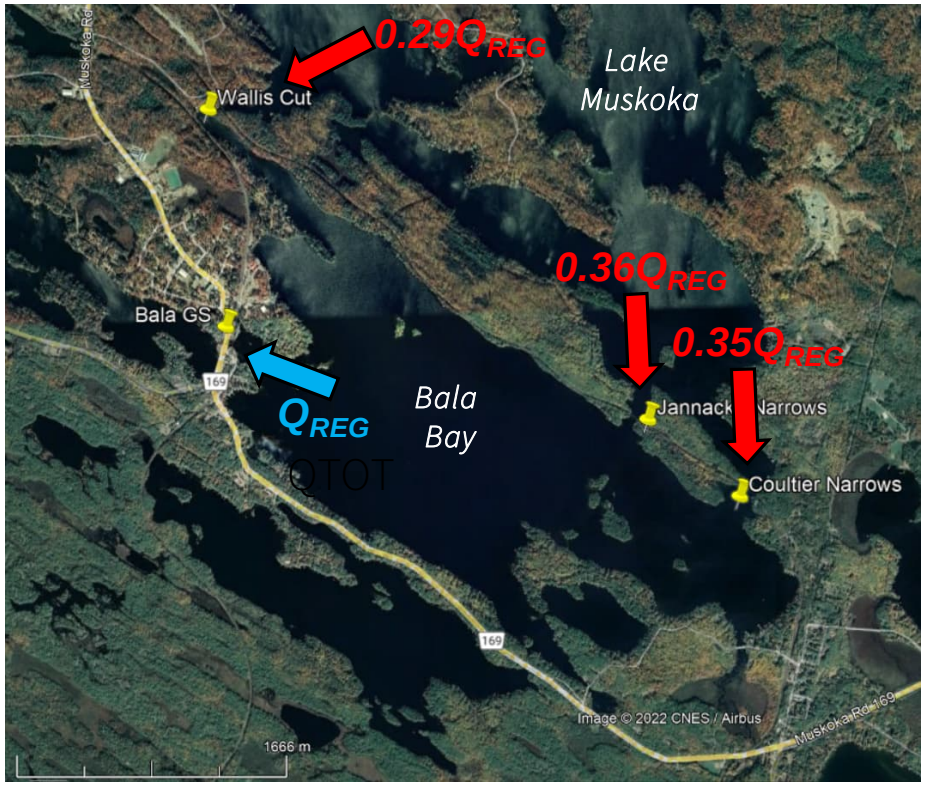
Flow restricted by high bed elevation

Bala

Option 1: Channel Excavation at Wallis Cut







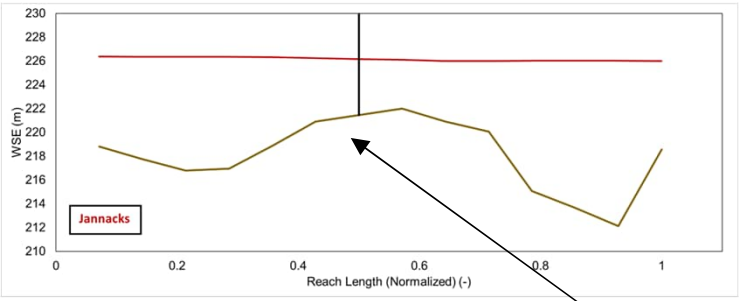
Preliminary Cut Volume = 9,594 m^3
(channel area approximately 70 m long, 30 m wide)
will likely require relocation of train bridge

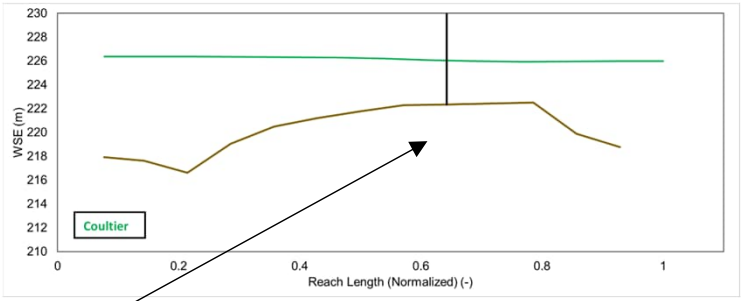
Bala

Considered Option – Jannacks Narrows and Coultier Narrows









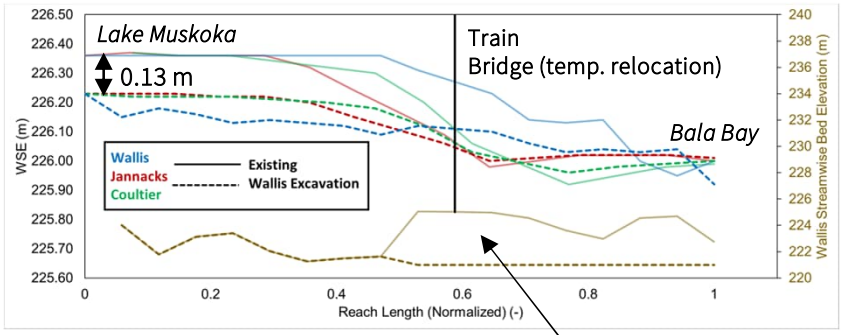
Flow also restricted
by high bed elevation
(also near train bridges)

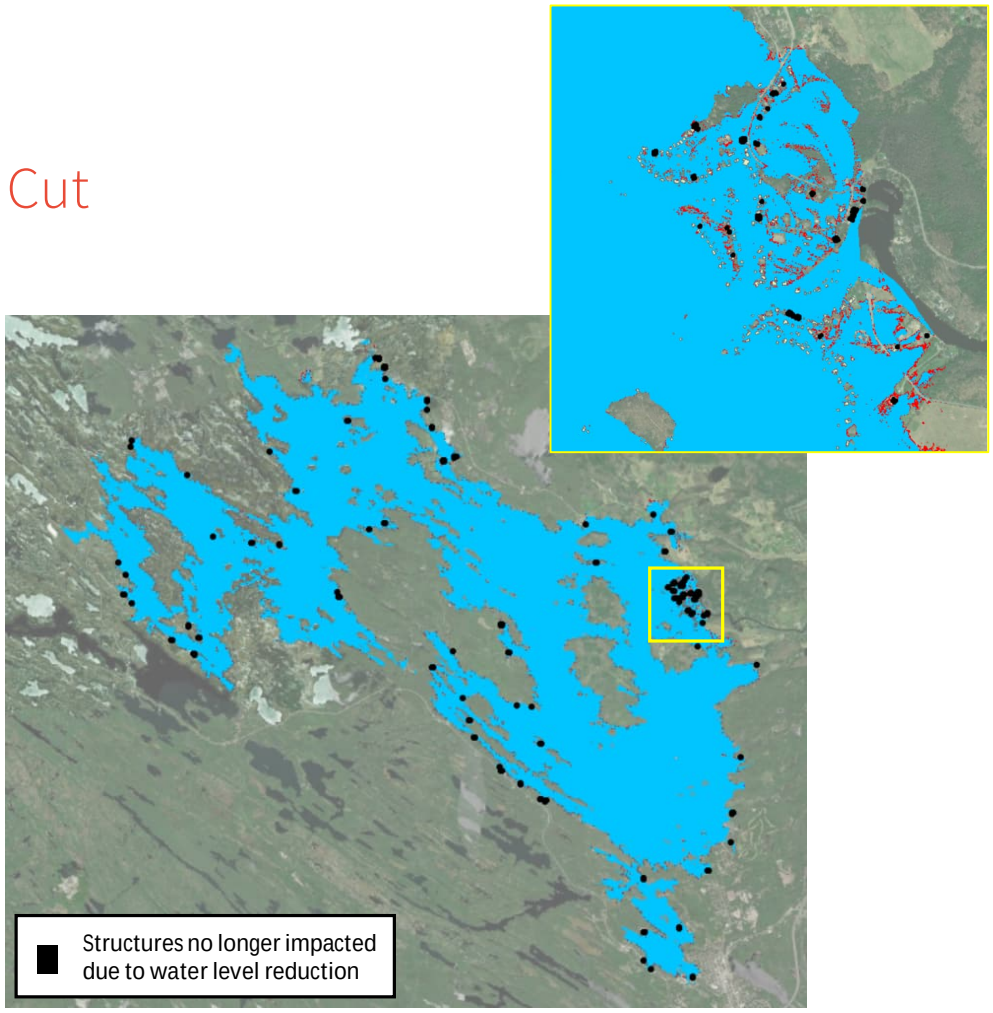
Bala

Option 1: Channel Excavation at Wallis Cut

Lake Muskoka Water Level (m)	# of Impacted Structures[1] on Lake Muskoka (-)
226.45 (2019 Event)	3389
226.35	3301 (-88)

[1]May include docks and boat houses, emphasis on relative reduction.





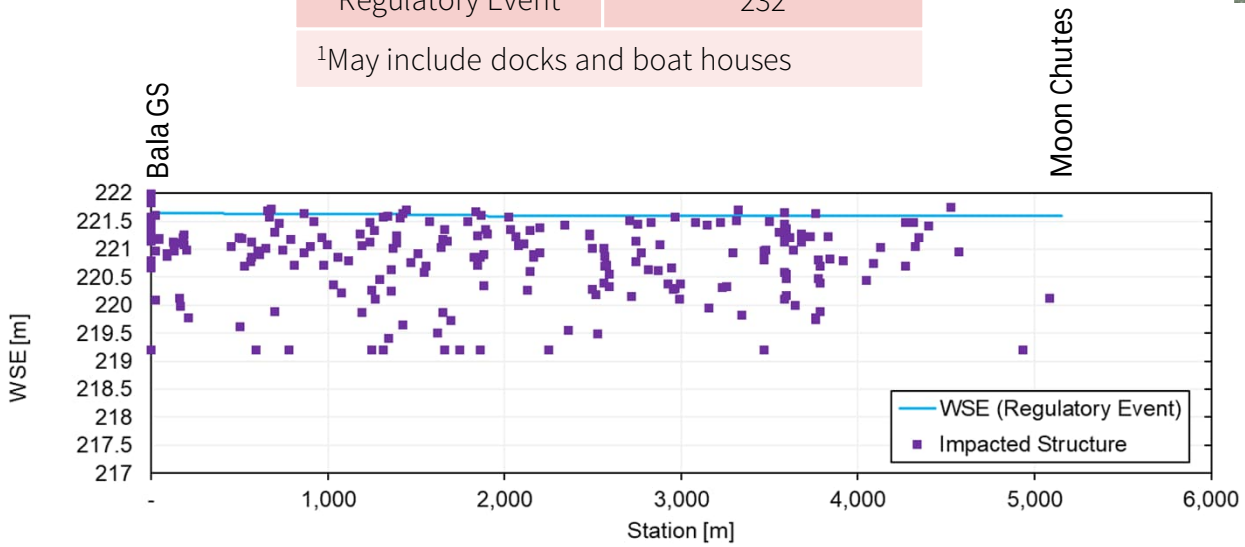
Preliminary Cut Volume = 9,594 m^3
(channel area approximately 70 m long, 30 m wide)
*will require temporary relocation of train bridge

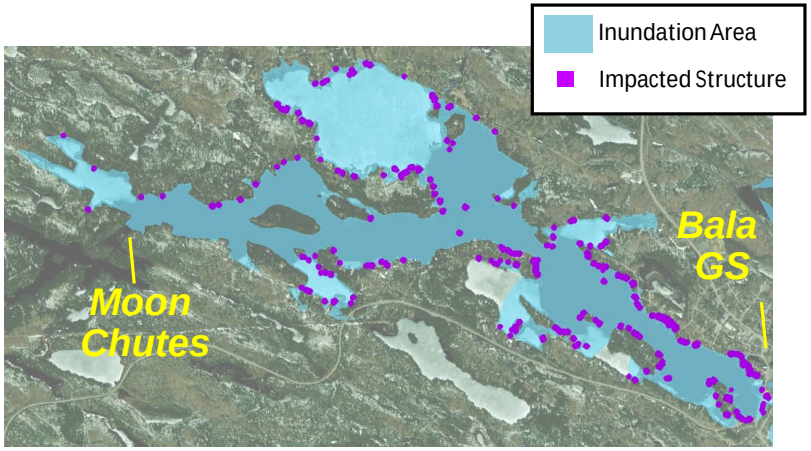
Bala

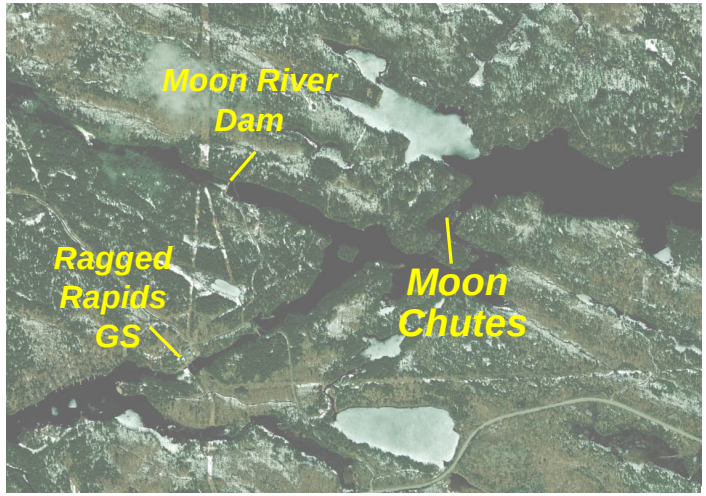
Option 2: Channel Excavation at Moon Chutes

Scenario	# of Impacted Structures[1] between Bala GS and Moon Chutes (-)
Regulatory Event	232

[1]May include docks and boat houses







Bala

Option 2: Channel Excavation at Moon Chutes

Downstream

- Lake Muskoka is the outlet of the Muskoka River; the outflow from the Bala dams enters the Bala Reach of the Moon River immediately downstream (Bala North dam is at the top of Bala Falls);

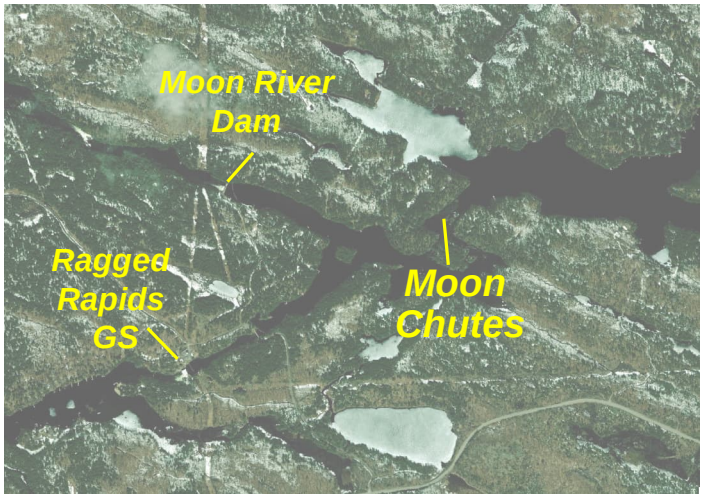
- for flows up to 3000 cfs (85 cms), the Bala Reach is controlled by the Ragged Rapids power dam on the Musquash River and the Moon control dam on the Moon River located 6.6 km downstream of Bala; both dams are operated by OPG a narrow section of the river channel above the Moon Chute was enlarged with rock excavation to pass 3000 cfs (plant capacity) when the power plants were developed:

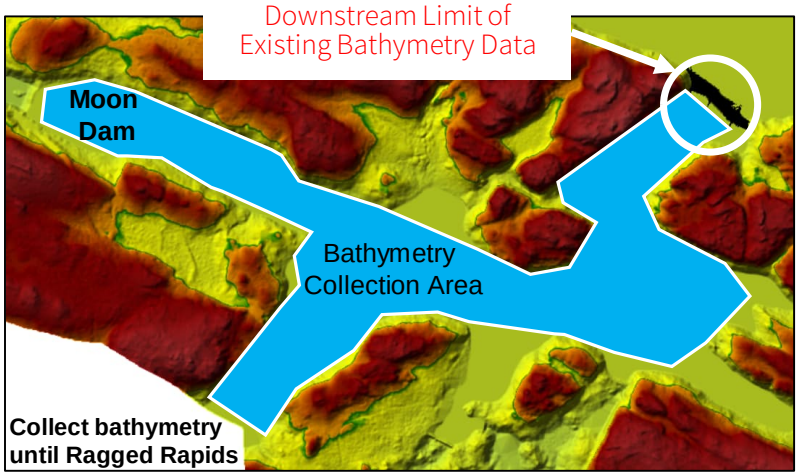
- the Moon Chute is located approximately 5.3 km downstream from the Bala dams in the Bala Reach and is normally submerged except at higher flows; as flows increase above 3000 cfs, the Moon dam is progressively opened resulting in a water level drop from above the chute to the dams; flow control then shifts to the natural chute;

- the forks of the Moon River are located approximately 6 km downstream from the Bala Dams below the Moon Chute within the Bala Reach with the Musquash River branching to the south-west and flowing to Go-Home Lake and the Moon River flowing north-west; both rivers empty into Georgian Bay;

- Partially opening the Moon Dam downstream has the effect of lowering the water level in the area of the forks of the river between the Ragged Rapids dam, the Moon Dam and the Moon Chutes and indirectly lowers the Bala reach levels to alleviate flooding which can occur there;

- In high flow periods, control of the flow shifts upstream from the dams to the Chutes; up to a 2.5 metre drop in water level across the Moon Chutes occurs when the Moon dam and the Ragged Rapids dam are fully open.

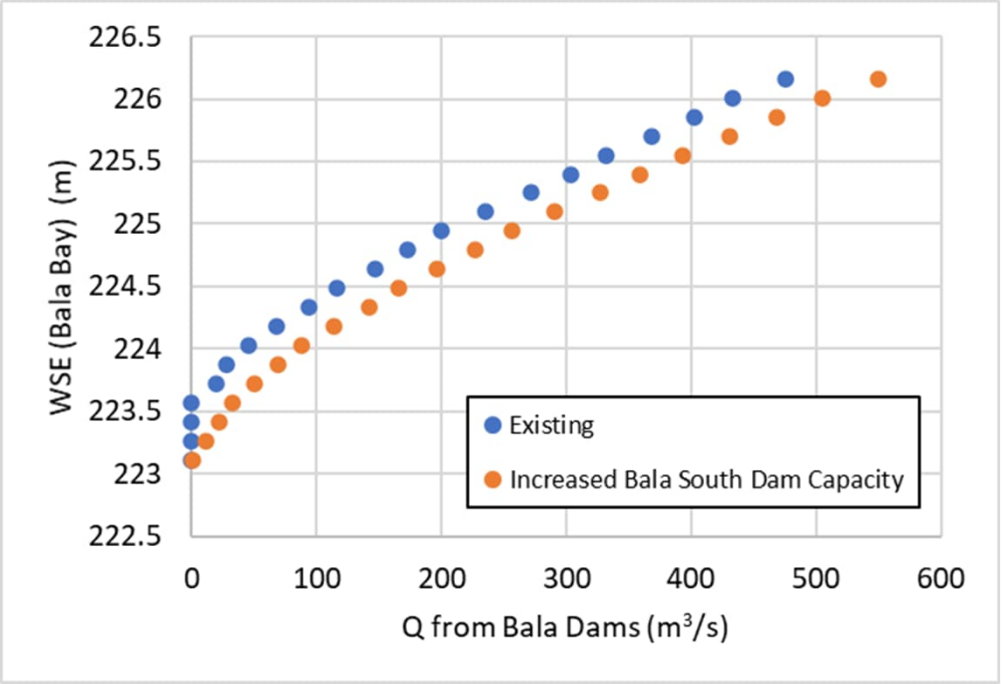




Bala

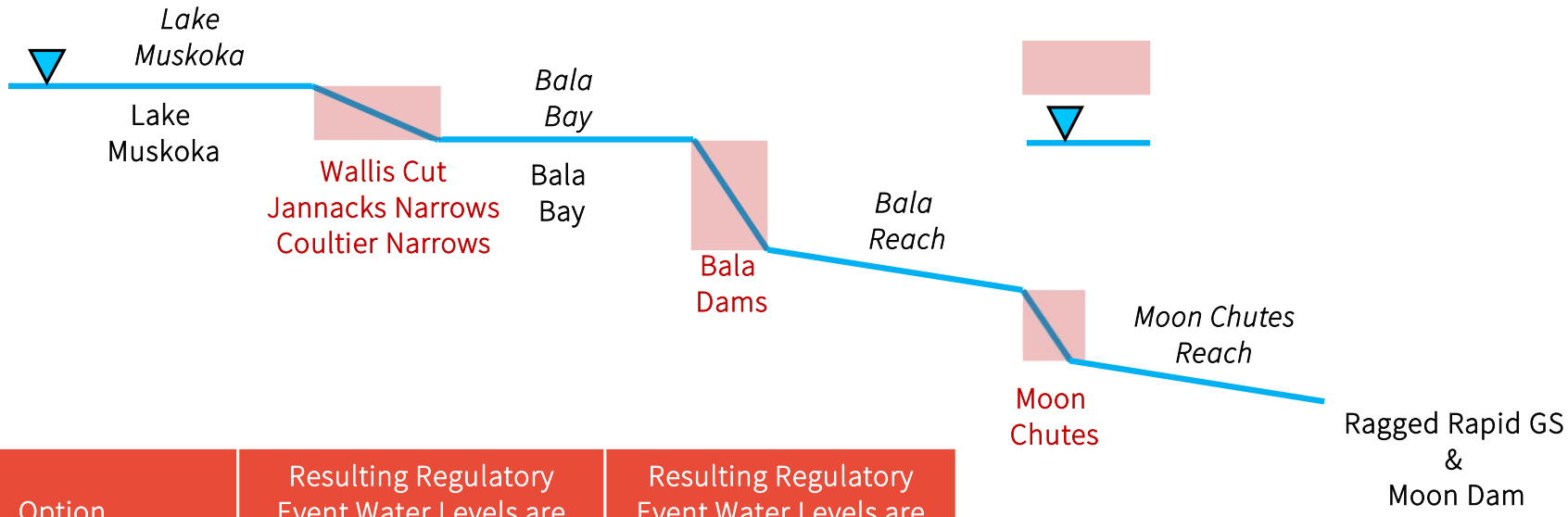
Option 3: Modification of Bala Bay South Dam

Scenario	Estimated Drop in Lake Muskoka Peak Water Level (m)	Estimated # of Impacted Structures on Lake Muskoka (-)
Existing	-	3389
Wallis Cut Excavation	-0.13 m	3301 (-88)
Lower Bala Bay WSE by 0.5 m via increasing Bala South dam capacity	-0.14 m	3301 (-88)
Wallis Cut Excavation *with* increasing Bala South dam capacity	-0.34 m	3042 (-259)



Bala

Trade-off of Flood Mitigation in Bala Reaches



Option	Resulting Regulatory Event Water Levels are Lower	Resulting Regulatory Event Water Levels are Higher
Wallis Cut Excavation	Reach 1	Reach 2/3/4
Bala Dam Modification	Reach 1/2	Reach 3/4
Moon Chutes Excavation[1]	Reach 3	Reach 4

[1]Reach 1 and 2 are not significantly affected as they are upstream of Bala dams

Flood mitigation achieved in one Bala reach (1-4), will be at the expense of one or more other reaches. Effective options result in net mitigation benefit considering all reaches.

Bala

Preliminary Options Ranking

Priority Area	Option Description	Mitigation Strategy	Ranking (0 - 3; where 3 is best ranking)					Total
			Cost	Potential for Barriers to Constructability and Timely Implementation	Effectiveness of Reducing Local Impacts to Flooded Structures	Potential for Adverse Local Environmental Impacts	Potential for Adverse Local Impacts to Residents	
Bala	Excavate at Wallis Cut	Flood Bypass	1	1	3	3	3	11
Bala	Excavate at Moon Chutes	Flood Bypass	2	2	3	3	3	13
Bala	Modification of South Bay Dam	Flood Bypass	2	2	2	3	3	12

Discussion

Appendix B
Site Visit Report

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Trip Report

May 30, 2022

The District Municipality Muskoka
Muskoka River Watershed IWM - Release 1, Project 3 Structural and Watershed-Scale Flood Mitigation

Distribution
Those present + J. Shaw,
J. Groeneveld, J. Frain, K. Lees

Trip Report

Date:	May 16 to 18, 2022	
Location:	Muskoka River Muskoka	
Present:	Chris Hannon Surendra Thapa	Glenn Cunnington Alana Perez Kevin Boyle (May 16 only)
Purpose:	Aid Development of Flood Mitigation Options	

1. Introduction

The District Municipality of Muskoka (DMM) seeks to reduce flood risk and address watershed health. In turn, DMM has scoped five projects designed to facilitate a holistic approach to managing water within the watershed. This integrated watershed management approach seeks to balance conservation and development while managing human activities and natural resources at a watershed scale. Hatch was commissioned by DMM to execute Project 3, which served to identify structural options within the watershed that will specifically mitigate flood risk.

Project 3 included a site visit to aid in the development of flood mitigation options at five areas designated at high priority by DMM.

1. **Lower Muskoka Watershed** – The Moon Chutes upstream to the perimeter of Lake Muskoka. Specific focus will be on the presumed “choke point” between Moon Chutes and the Bala Park Island narrows where water flow conveyance capacity is restricted thus resulting in high water levels on Lake Muskoka.

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2. **North Branch Muskoka River** – Flooding upstream from Bracebridge Generating Station (GS) and beyond HWY11 to Springdale Shores.
3. **North Branch Muskoka River** – Downtown Huntsville, specifically the vicinity of the Main Street Bridge in Huntsville where potential flow restriction results in downtown property flooding.
4. **North Branch Muskoka River** – The Big East River upstream from Lake Vernon.
5. **South Branch Muskoka River** – South Muskoka River between Purbrook and Lake of Bays Dam. Purbrook – hydraulic control (rapids and falls) serves as potential "choke point".

The purpose of the site visit was to gain first-hand knowledge of these sites to better understand limitations and opportunities associated with potential flood mitigation options already under development. In general, the reconnaissance focused on the following:

- Local and general topography
- Evidence of high-water marks from typical spring events or the 2013 and 2019 floods
- Local soil and bedrock conditions
- Identify socially and environmentally important properties and features along the watershed
- Identify constrictions and conveyance limitations (e.g., hydraulic control points) along the watershed
- Identify/review potential bypass channel routes or storage options
- Visually confirm floodplain characteristics.

In total, 538 photographs were taken during the site reconnaissance. Most photos were geotagged and assimilated into a Keyhole Markup Language (KMZ) file suitable for use with Google Earth™.

2. Inspection Program

The site inspections were undertaken between May 16 and 18 (inclusive). Sites were accessed by road or by foot using publicly accessible routes. The inspections were carried out by Chris Hannon and Surendra Thapa of Hatch and accompanied by Glenn Cunnington and Alana Perez on May 16 and 17, and by Kevin Boyle on May 16, representing DMM. In general, the inspections progressed from the north to the south as detailed in the Section 3. Key areas visited are presented in Figure 1. The weather was overcast for most of the inspection with some light rain particularly on May 16 and fair on May 18.

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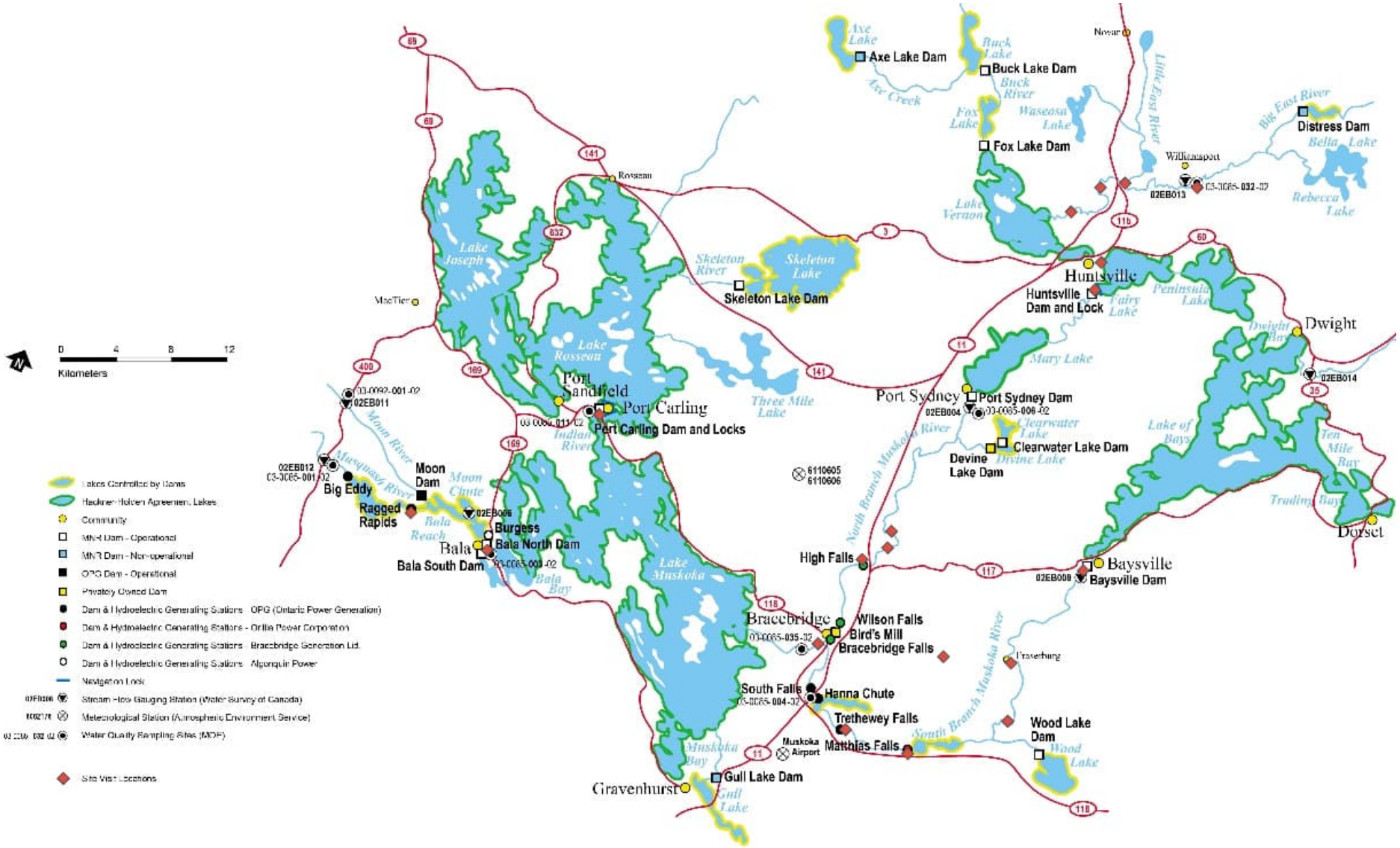

Figure 1 Areas Visited During the Site Visit

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3. Observations and Commentary

The following is an observational summary of the site reconnaissance. The site visit was organized by the direction of flow and broken up into the following segments:

- **Big East to Brunel Locks** – Big East, Vernon Lake, Fairy Lake and the Town of Huntsville.
- **Muskoka North Branch** – Brunel Locks through Mary Lake, Springdale Shores and to Bracebridge.
- **Muskoka South Branch** – Outflow of Lake of Bays at Baysville, Purbrook and South Branch to Bracebridge.
- **Lake Muskoka** – Outlet of Lake Rosseau at Port Carling, Outlet of Muskoka at Bala and Ragged Rapids.

Some of the observations relate to photographs which have been included with this report.

Several sites that may be important to the overall project could not be visited due to access and time limitations. These locations are summarized below for completeness.

- **Big East River to Brunel Locks** – Distressed Dam, Finlayson Dam Site
- **Muskoka North Branch** – Port Sydney Dam, Duck Chutes and upstream area
- **Muskoka South Branch** – Rocky Rapids
- **Lake Muskoka** Outlet– Bala Narrows (Wallis Cut, Jannacks Narrows and Coultier Narrows), Moon Chutes

3.1 Big East River to Brunel Locks

3.1.1 Big East River

Several crossings over the Big East River were visited. In general, it was found the terrain consists of both relatively flat areas with old oxbows and areas of higher rocky ground. Several crossings were visited which were suspected to act as constrictions during high flow events. In particular, the three-bridge crossing - two at Highway 11 and one at Arrowhead Park Road, located in a flat area within 100 m, was noted to have high water marks in the bridge piers. The sand banks at this location, Photograph 1, is typical of the flat areas along the river. All three bridges do not appear (visually) as a constriction but should be verified with hydraulic modeling.

The crossing near Bridgeview Lane, where Ravenscliffe Road crosses the Big East River, is an example of where the river is constrained by high ground (both natural and manmade). Immediately upstream of the Ravenscliffe Road bridge were remnants of old bridge pier(s). However they did not appear to restrict the flow. Photograph 2 looks from the relatively high bridge abutment toward the houses in the plain immediately upstream from the bridge.

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3.1.2 *Town of Huntsville*

At Huntsville, the narrows between Hunters Bay and Fairy Lake were visited at several locations with the main focus being the known constriction at the Swing Bridge, Photograph 3, and the area upstream along John St. known as “Beer Lake” which was flooded during the 2019 flood. The lowest area between the Narrows and the Beer Lake area is shown in Photograph 4 and was considered to be a portion of the area needing a berm along the shoreline to mitigate flooding. Any such design would need to consider and facilitate stormwater drainage from this area.

Other than the commercial properties in the “Beer Lake” area, most of the structures close to the shoreline upstream from the swing bridge, which are expected to be impacted in a flood, were noted to be boathouses rather than dwellings. One exception was a pumping station at the end of Hodges Lane which is located in a draw and is anticipated to be inundated.

3.1.3 *Huntsville Dam and Brunel Locks*

The outlet of Fairy Lake is controlled by the Huntsville Dam and Brunel Locks facility, Photograph 5. The Brunel Road bridge did not appear to be constriction to flow.

3.2 Muskoka North Branch

3.2.1 *Bracebridge Resource Management Area*

The Bracebridge Resource Management Area is a conservation area with hiking, biking and skiing trails upstream from the Springdale Shores section of the Muskoka North Branch and downstream from Duck Chutes. Prior to the site visit, this area was considered to be a potential site to create flood storage. However, the site visit found the banks in this area to be relatively steep with plateaus estimated to be approximately 2.5 to 4 m above the river, Photograph 6, implying offline storage in this area would be impractical. The ground adjacent to the river rose away from the banks on both sides and, based on topography and outcroppings, the bedrock was believed to be generally shallow in this area. A cold-water creek, understood to be a spawning creek for brook trout flows into the North Branch in this area, Photograph 7.

3.2.2 *Springdale Shores*

The Springdale Shores area is a residential area along the Muskoka North Branch which was impacted by flooding during the 2019 flood. Along the riverfront, the density of houses is similar to a suburban street. The bank here varies in elevation but, in the area visited, is typically 2 to 3 m above the river, Photograph 8. In the area visited, the private road running along the river is often higher than the residences, Photograph 9, and would act as a barrier to flood water until it is overtopped.

3.2.3 *High Falls Generating Station*

Located upstream from the Town of Bracebridge is the High Falls GS, owned and operated by Ontario Power Generation Ltd. The head pond of the generating station has limited capacity, Photograph 10. One option under consideration is the possibility of rehabilitating or replacing the unused flashboard gates or the overflow gravity section, Photograph 11, to increase the conveyance capacity through the dam. The area immediately downstream from the High Falls GS has a resort/campground along the shore facing the falls.

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3.3 Muskoka South Branch

3.3.1 Baysville

The dam at Baysville controls flow from the Lake of Bays. The road bridge upstream of the dam did not visually appear as a constriction. There is limited opportunity to increase capacity at this dam due to nearby residences and would require raising the overflow spillway section of the dam, Photograph 12. It was noted that the shorelines on both sides of the waterway were lined with residences, both upstream and downstream; most were noted to be set back from and sufficiently above the water level to avoid impacts during the flood. The road bridge upstream from the Baysville dam was noted to be wider than the dam and therefore not the constriction in this reach, Photograph 13.

3.3.2 Fraserburg

There were a number of residences in the Fraserburg area which were impacted by the 2019 flood. It was understood that there are plans to provide overflow relief at the bend upstream from the bridge during flood events in order to protect the bridge. Photograph 14 illustrates the section of roadway, which was overtopped during 2019 flood, where a floodway is being proposed. The area with residences impacted by flooding is downstream from the bridge.

3.3.3 Purbook

The Purbook area is vulnerable to flooding during high water events as there is very little freeboard above the river and the topography is very flat, Photograph 15. There are a number of cottage and camp type properties at Purbrook. A viable structural option to mitigate flood risk in this area was perceived to be a challenge.

3.3.4 Purbrook Road Crossing

The road to the Purbrook development from Bracebridge crosses a wetland. The road embankment forms a causeway with a small bridge which together act as a constriction to flow through the wetland, which is understood to drain into the South Branch upstream of Rocky Rapids. District staff indicated this crossing typically floods before Purbrook during a high-water event. The view from the crossing looking upstream is shown in Photograph 16.

3.3.5 Muskoka South Branch Generating Stations

Between Purbrook and the confluence with the North Muskoka Branch, there are four hydroelectric generating stations. It is understood that the Matthias GS has some limited capacity to retain water in the head pond. The remaining generating stations, Trethewey Falls (Photograph 17), Hannah Chutes and South Falls, all have little to no storage capacity and are effectively run-of-river.

3.4 Lake Muskoka

3.4.1 Bala

The Town of Bala is located at the outlet of Lake Muskoka. The actual constriction at the outlet of Lake Muskoka is the Bala Narrows, which consists of three outlets from Lake Muskoka to Bala Bay. Unfortunately, these locations were not accessible from public property during the site visit. At the Town of Bala, there are three control structures, two generating stations and the Bala Falls spillway, Photograph 18. The properties along the lake upstream from the control structures are understood to not be greatly impacted by flooding

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due to the presence of the Bala Narrows upstream and the control structures immediately downstream. In the Bala Reach area downstream from the control structures, the shoreline was noted to be lined with residences, many of which are located relatively close to the waterfront. Virtually all of the properties were noted to have docks.

Bala Narrows upstream from the Town of Bala could not be reached during the site visit. The narrows and Wallis Cut, in particular, are being considered to increase the conveyance out of Lake Muskoka.

3.4.2 Ragged Rapids Generating Station

Downstream from the Moon Chutes is the Ragged Rapids GS, Photograph 19. Shoreline in this section of the watershed was observed to be relatively steep with visible outcroppings of bedrock.

Chris Hannon

CH:maw

Appendix A – Site Photographs
Appendix B – Select Output from KMZ Files
Attachment – KMZ Files

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Appendix A:
Site Photographs

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Photograph 1 – Hwy 11 Crossing of Big East River (interface between green and grey colour on the piers indicate high flood marks)

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Photograph 2 – Old Pier Remnant upstream of Ravenscliffe Rd (No. 2) Bridge Crossing the Big East River

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Photograph 3 Huntsville Swing Bridge, Looking Downstream. River Bed under the bridge appears very shallow, approx. 1 m or so.

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Photograph 4 Low Spot Along Shore adjacent to "Beer Lake"

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Photograph 5 – Huntsville Dam (right) and Brunel Locks (left) viewed from Brunel Rd Bridge Upstream

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Photograph 6 Looking upstream along the Resource Management Area

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Photograph 7 Outlet of Creek Upstream from Springdale Shores

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Photograph 8 - Shoreline in the Springdale Area

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Photograph 9 Springdale Shore Access Road Between the River and Homes

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Photograph 10 Head Pond of the High Falls Generating Station

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Photograph 11 High Falls Stoplog Bay and Adjacent Gravity Weir, Looking Upstream

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Photograph 12 Baysville Dam at the Outlet of Lake of Bays

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Photograph 13 Baysville Rd Bridge Upstream from Baysville Dam Does Not Appear as a Constriction, Looking Downstream

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Photograph 14 Bend in the River Upstream from the Bridge at Fraserburg

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Photograph 15 Purbrook Looking up the Oxbow Inlet

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Photograph 16 Purbrook Road Section Upstream from Rocky Rapids, the District Staff noted that this Section of the Purbrook Road Gets Flooded Before Flooding Occurs in Purbrook Area

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Photograph 17 Head Pond at Trethewey Falls Generating Station

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Photograph 18 Control Structure at Bala Falls

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Photograph 19 View Looking Upstream Above the Ragged Rapids Generating Station

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Appendix B
Select Output from KMZ Files

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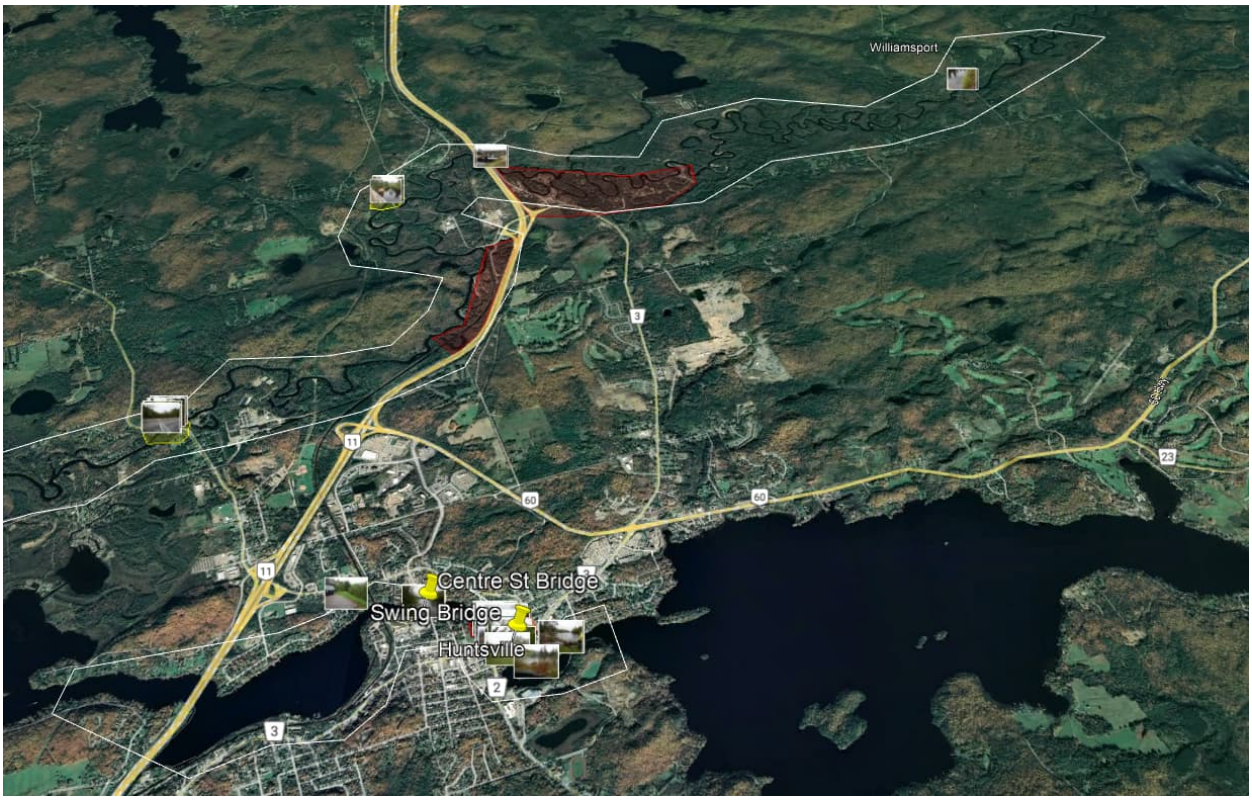

Figure 2 Area Visited on May 16 (Huntsville)

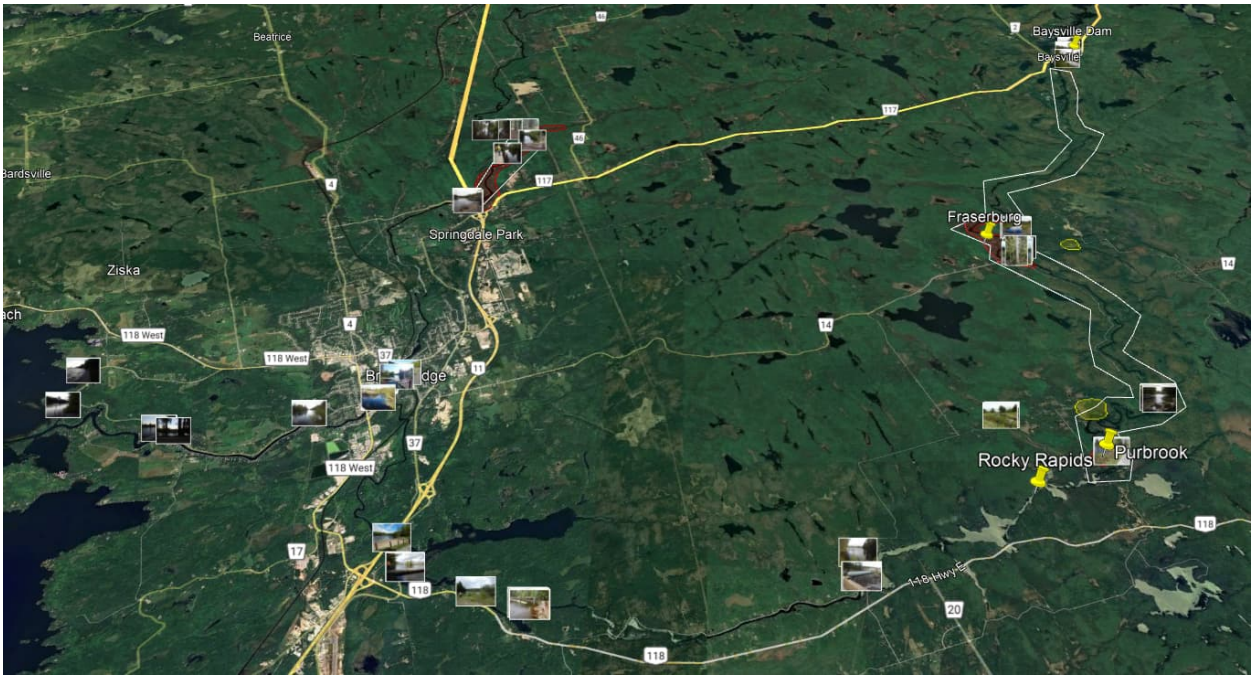

Figure 3 Area Visited on May 17 (Springdale, Baysville, Fraserburg, Purbrook, Bracebridge)

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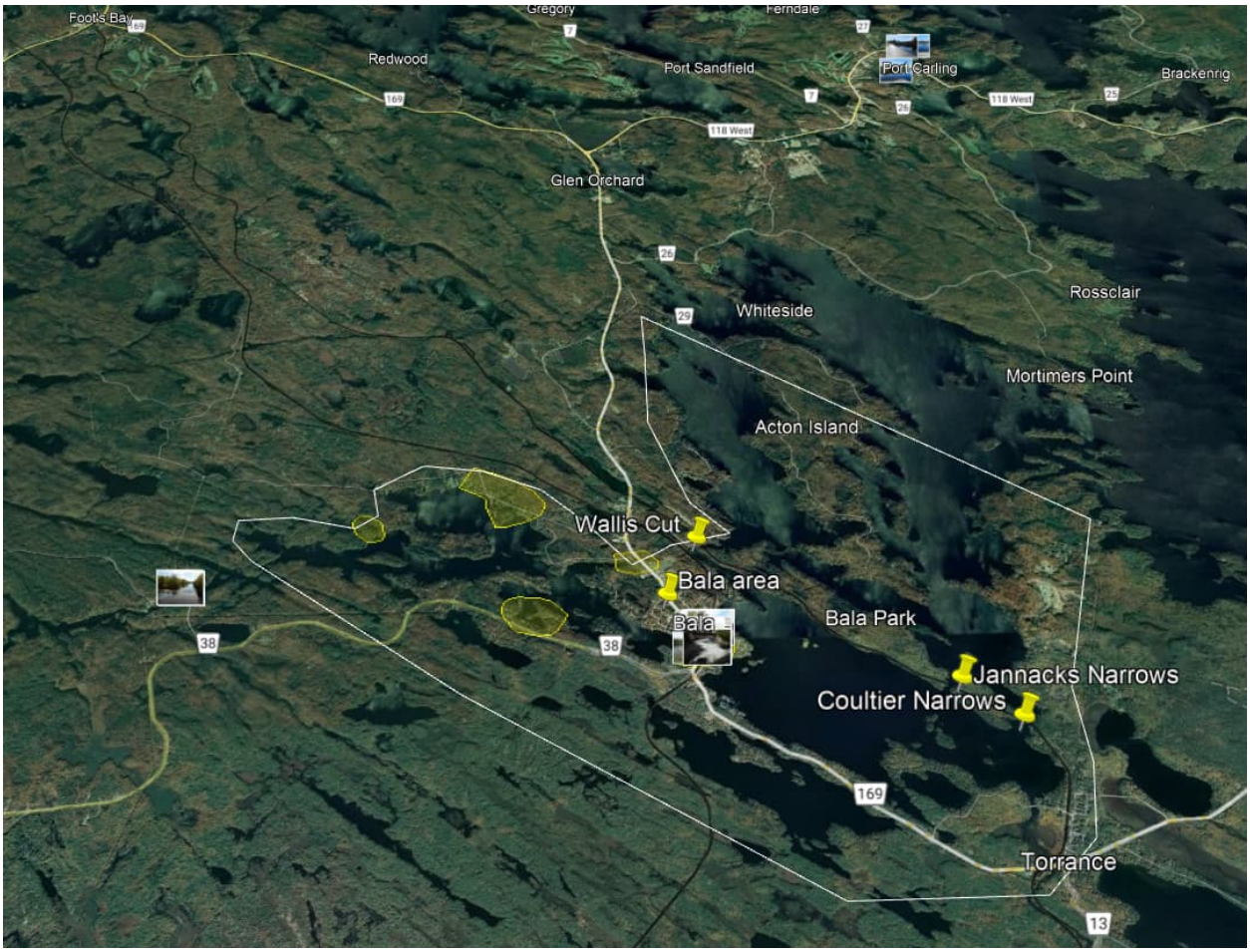

Figure 4 Area Visited on May 18 (Port Carling, Bala Generating Station Dam, Ragged Rapid)

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