VILLAGE OF HARRISON HOT SPRINGS
NOTICE OF MEETING AND AGENDA

REGULAR COUNCIL MEETING

Date: Monday, June 6, 2022
Time: 7:00 p.m.
Location: Council Chambers, (In Person and via Zoom video conference)
Memorial Hall, 290 Esplanade Avenue, Harrison Hot Springs, British Columbia

1. CALL TO ORDER

Meeting called to order by Mayor Facio.
Acknowledgment of Sts'ailes traditional territory.

2. INTRODUCTION OF LATE ITEMS

3. APPROVAL OF AGENDA

4. ADOPTION OF COUNCIL MINUTES

(a) THAT the Regular Council Meeting Minutes of May 16, 2022 be adopted. — **Item 4(a) Page 1**

5. BUSINESS ARISING FROM THE MINUTES

6. CONSENT AGENDA

i. Bylaws		
ii. Agreements		
iii. Committee/ Commission Minutes		
iv. Correspondence	(a) Fraser Health Re: Letter of Thanks for Success of COVID-19 Immunization Clinics	Item 6(iv)(a) Page 7

7. DELEGATIONS/PETITIONS

(a) Neville Berard and Veronique Bourgalt, Northwest Hydraulic Consultants Ltd.
Re: Harrison Hot Springs Village Waterfront Hydrotechnical Assessment — **Item 7(a) Page 9**

8. CORRESPONDENCE

9. BUSINESS ARISING FROM CORRESPONDENCE

10. REPORTS OF COUNCILLORS, COMMITTEES, COMMITTEE OF THE WHOLE AND COMMISSIONS

Councillor Hooper
Agassiz Harrison Historical Society
Fraser Health

Councillor Palmer
Fraser Valley Regional Library Board (Municipal Director)
Kent Harrison Joint Emergency Program Committee
Public Art Committee

Councillor Piper
Corrections Canada Citizen's Advisory Committee
Harrison Agassiz Chamber of Commerce
Kent Harrison Joint Emergency Program Committee
Tourism Harrison
Fraser Valley Regional Library Board (Alternate Municipal Director)

Councillor Vidal
Agassiz Harrison Healthy Communities
Fraser Valley Regional District Board (Alternate Municipal Director)
Fraser Valley Regional District Hospital Board (Alternate Municipal Director)

11. REPORTS FROM MAYOR

12. REPORTS FROM STAFF

(a) Report of Operations Manager – May 31, 2022 **Item 12(a) Page 59**
Re: Application for Funding to Complete Necessary Upgrades to the Harrison Lake Dike and WWTP Related Infrastructure – Canada Community-Building Fund (CCBF) in British Columbia – Strategic Priorities Fund

Recommendation:

THAT Northwest Hydraulic Consultants be engaged to apply to the Canada Community-Building Fund (CCBF) in British Columbia – Strategic Priorities Fund, on behalf of the Village, for a grant of up to $6,000,000.00 in order to undertake the recommended flood mitigation upgrades to the Harrison Lake Dike, the Waste Water Treatment Plant access road and the foreshore area around the Waste Water Treatment Plant; and

THAT the Harrison Hot Springs Village Waterfront Hydrotechnical Assessment, by NHC and dated May 30, 2022 be received for information.

(b) Report of Chief Administrative Officer – May 31, 2022 **Item 12(b) Page 61**
Re: Proposed Federal Electoral Boundary Adjustment

Recommendation:

THAT the Village write to the Federal Electoral Boundaries Commission for BC objecting to the Federal Electoral Boundary adjustment proposed for the ridings of Chilliwack and Mission-Maple Ridge.

(c) Report of Chief Administrative Officer – June 6, 2022
Re: 2021 Annual Report

Item 12(c) Distributed Separately

Recommendation:

THAT the 2021 Annual Report be approved.

13. BYLAWS

14. NEW BUSINESS

15. QUESTIONS FROM THE PUBLIC (pertaining to agenda items only)

16. ADJOURNMENT

4(a)

VILLAGE OF HARRISON HOT SPRINGS
MINUTES OF THE REGULAR MEETING OF COUNCIL

DATE: Monday, May 16, 2022
TIME: 7:00 p.m.
PLACE: Council Chambers, Memorial Hall
290 Esplanade Avenue, Harrison Hot Springs, BC

IN ATTENDANCE: Mayor Leo Facio
Councillor Ray Hooper
Councillor Gerry Palmer
Councillor Michie Vidal
Councillor Samantha Piper

Chief Administrative Officer, Madeline McDonald
Deputy Chief Administrative Officer/CO, Debra Key
Finance Manager, Scott Schultz
Community Services Manager, Rhonda Schell
Operations Manager, Tyson Koch
Planning Consultant, Ken Cossey

ABSENT:

Recording Secretary: T. Kafi

1. **CALL TO ORDER**

Mayor Facio called the meeting to order at 7:00 p.m.
Mayor Facio acknowledged the traditional territory of Sts'ailes

2. **INTRODUCTION OF LATE ITEMS**

None

3. **APPROVAL OF AGENDA**

Moved by Councillor Vidal
Seconded by Councillor Hooper

THAT the agenda be approved.

CARRIED
UNANIMOUSLY
RC-2022-05-06

4. **ADOPTION OF COUNCIL MINUTES**

Moved by Councillor Palmer
Seconded by Councillor Vidal

THAT the Regular Council Meeting Minutes of May 2, 2022 be adopted.

CARRIED
UNANIMOUSLY
RC-2022-05-07

5. BUSINESS ARISING FROM THE MINUTES

None

6. CONSENT AGENDA

None

7. DELEGATIONS/PETITIONS

None

8. CORRESPONDENCE

None

9. BUSINESS ARISING FROM CORRESPONDENCE

None

10. REPORTS OF COUNCILLORS, COMMITTEES, COMMITTEE OF THE WHOLE AND COMMISSIONS

Councillor Hooper

- Agassiz Harrison Historical Society – No report
- Fraser Health
  - Attended a webinar with the Tamarack Institute on Income Security, Climate Change and Community Resilience on May 4 and 11, 2022
  - Attended a Zoom meeting with members of Agassiz and Harrison BC CRN on May 9, 2022
  - Attended a Zoom meeting and webinar with the Alzheimer Society on How to Identify Early Sign of Dementia on May 4, 2022
  - Attended a Zoom meeting and training with the CNIB on May 6, 2022
  - Attended a Zoom meeting with members of the Autism BC on Behavioural Interventionist and Increase of Applied Behavioural Analysis on May 13, 2022
- Attended the District of Kent's Fill the Pool Fundraiser on May 14, 2022

Councillor Palmer

- Fraser Valley Regional Library Board (Municipal Director) – No report
- Kent Harrison Joint Emergency Program Committee – No report
- Public Art Committee – No report

Councillor Piper

- Corrections Canada Citizens Advisory Committee
  - Attended a meeting on May 4, 2022
- Harrison Agassiz Chamber of Commerce – No report
- Kent Harrison Joint Emergency Program Committee
  - Attended a meeting on May 11, 2022
- Tourism Harrison – No report
- Fraser Valley Regional Library Board (Alternate Municipal Director) – No report

Councillor Vidal
- Agassiz Harrison Healthy Communities – No report
- Fraser Valley Regional District Board (Alternate Municipal Director) – No report
- Fraser Valley Regional District Hospital Board (Alternate Municipal Director) – No report
- Attended the Lower Mainland Local Government Association Convention from May 4 to 6, 2022

MAYOR'S REPORT

- Reported that a new primary care centre is now open in Chilliwack at 7955 Evans Road, Chilliwack, BC V2R 5R7
- Reported on the Fraser Valley Regional District Regional and Corporate Services Committee meeting on May 12, 2022
- Reported on the Local Mainland Local Government Association Convention from May 4 to 6, 2022

11. REPORTS FROM STAFF

(a) Report of Deputy Chief Administrative Officer/Corporate Officer – May 2, 2022
Re: Approval for Permanent Outdoor Patio Expansion Application – LTK Investments Ltd. Dba Old Settler Pub, 220 Cedar Avenue, Harrison Hot Springs, BC

Moved by Councillor Vidal
Seconded by Councillor Piper

THAT the views and comments of the public were gathered and one (1) response was received; and

THAT LTK Investments Ltd.'s (dba Old Settler Pub) application to the Liquor and Cannabis Regulation Branch for permanent status of their outdoor patio expansion service area be approved.

DEFEATED
OPPOSED BY COUNCILLORS VIDAL, HOOPER, PIPER, PALMER

(b) Report of Community Services Manager – May 2, 2022
Re: Flag Policy

Moved by Councillor Piper
Seconded by Councillor Palmer

THAT the amendments to Flag Policy No. 1.36 be approved.

CARRIED
UNANIMOUSLY
RC-2022-05-08

(c) Report of Community Services Manager – May 10, 2022
Re: 2022 Grants to Groups

Councillor Hooper excused himself from Council Chambers at 7:53 pm due to a conflict of interest stating that he is a member of the Miami River Streamkeepers Society.

Moved by Councillor Piper
Seconded by Councillor Palmer

THAT the following community groups be provided with funding, under the Grants to Groups program:

Agassiz-Harrison Community Services	$2,000.00
Miami River Streamkeepers Society	$1,000.00
Agassiz-Harrison Aquanauts Swim Club	$1,350.00
Storytime in the Park	$1,000.00
Kent-Harrison Arts Council	$2,000.00

CARRIED
RC-2022-05-09

Councillor Hooper re-entered the Council Chambers at 7:55 pm.

(d) Report of Planning Consultant – May 11, 2022
Re: The Official Community Plan Review Update

Moved by Councillor Palmer
Seconded by Councillor Piper

THAT the Official Community Plan Review Update dated May 11, 2022 and attachments be received for information.

CARRIED UNANIMOUSLY
RC-2022-05-10

(e) Report of Operations Manager – May 11, 2022
Re: Water Reservoir Maintenance

Moved by Councillor Piper
Seconded by Councillor Vidal

THAT Greaterio Services be retained to undertake the purchase, installation and related works for the reservoir anode replacement and reservoir maintenance project for up to $88,000.00 to be funded from water utility reserves.

CARRIED UNANIMOUSLY
RC-2022-05-11

12. BYLAWS

None

13. NEW BUSINESS

None

14. QUESTIONS FROM THE PUBLIC (pertaining to agenda items only)

Questions from the public were entertained.

15. ADJOURNMENT

Moved by Councillor Piper
Seconded by Councillor Palmer

THAT the meeting be adjourned at 8:25 p.m.

CARRIED
UNANIMOUSLY
RC-2022-05-12

Leo Facio
Mayor

Debra Key
Corporate Officer

6(iv)(a)

fraserhealth

Fraser Health Authority
Suite 400, 13450 – 102nd Avenue
Surrey, BC V3T 0H1

May 19, 2022

Madeline McDonald
Chief Administrative Officer, Village of Harrison Hot Springs
495 Hot Springs Road
PO Box 160
Harrison Hot Springs, BC V0M 1K0

Dear Madeline,

On behalf of Fraser Health, we would like to thank all the staff from the Village of Harrison Hot Springs who have contributed to making our COVID-19 immunization clinics a success.

Your support has made our communities safer by making it easy for people to receive their COVID-19 vaccine. Thanks to your contributions and those of our other partners, we have delivered more than four million doses across the region, making our communities that much safer.

Thank you again for your on-going contributions and we look forward to continuing to collaborate with you in the future.

Sincerely,

Kathy Doull
Co-lead, Fraser Health COVID-19 Vaccine and Testing Coordination Centre
Executive Director, Clinical Operations, Pandemic Response

7(a)

Photo source: V. Bourgault

Harrison Hot Springs Village Waterfront Hydrotechnical Assessment

Prepared by:

Northwest Hydraulic Consultants Ltd.
30 Gostick Place
North Vancouver, BC V7M 3G3
Tel: (604) 980-6011
www.nhcweb.com

NHC Project Contact: Neville Berard
Neville Berard, P.Eng
Coastal Engineer

Prepared for:

The Village of Harrison Hot Springs
495 Hot Springs Road
P.O. Box 160
Harrison Hot Springs, BC
V0M 1K0

May 30, 2022
Draft Report, Rev. 0

NHC Reference 3006487

Document Tracking

Date	Revision No.	Reviewer	Issued for
May 30, 2021	0	Dale Muir	Client Review

Report prepared by:

Neville Berard, M.A.Sc., P.Eng.
Coastal Engineer

Veronique Bourgalt, M.Eng., EIT.
Coastal Engineer

Report reviewed by:

Dale Muir, M.Eng., P.Eng.
Principal

EGBC Permit to Practice # 1003221

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of The Village of Harrison Hot Springs for specific application to the hydrotechnical assessment and planning for flood protection from Harrison Lake at Harrison Hot Springs, British Columbia. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation, and was prepared in accordance with generally accepted engineering and geoscience practices.

Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by The Village of Harrison Hot Springs, its officers and employees. **Northwest Hydraulic Consultants Ltd.** denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents.

nhc

EXECUTIVE SUMMARY

The village of Harrison Hot Springs is exposed to natural hazards due to its location on Harrison Lake. Past high-water events have resulted in erosion of the road to the community's wastewater treatment plant (WWTP) and damage to the foreshore of the dike. In this work, design water levels for Harrison Lake have been updated to provide guidance on present day, year 2050 and year 2100 flood levels. These levels (shown in Table E.1) indicate that the community infrastructure is vulnerable to flooding during extreme events and that the risk is expected to grow as climate change progresses.

Table E1 – Approximate return period events for flood water levels on Harrison Lake

Elevation	Present Day	2050	2100
14 m	500 Yr	100 – 200 Yr	50 Yr
15 m	> 500 Yr	> 500 Yr	200 – 500 Yr
16 m	> 500 Yr	> 500 Yr	> 500 Yr

In addition to looking at the potential water levels for extreme events, the study considered wave effects at the dike (due to strong winds from the north) and recommendations for freeboard. A literature review of the risk due to a landslide generated tsunami was also undertaken.

Based on the results of the study, NHC recommends that the village of Harrison Hot Springs:

- **Increase the dike elevation to 15 m (from 13.9 m).** This new elevation would provide protection through mid-century against 500 yr return period high water levels. Consideration during the design of the upgrades should be given to reducing the wave run-up at the top of the dike to ensure that the structure is not damaged in the event waves occur during a high-water event.
- **Increase the elevation of the WWTP road to 14 m (from 12 m) and rebuild the riprap slope protection**. This would prevent the road from being inundated except in extreme circumstances and allow operations staff to access the critical infrastructure during extreme future water level events. If the roadway were to be submerged, the upgraded riprap protected would prevent the roadway from being damaged and preserve access.
- **Investigate monitoring of the Breckenridge slide.** Studies have shown that mitigating the impacts of the possible Breckenridge slide would be prohibitively obtrusive and expensive; however, there are solutions to monitoring, education of public and evacuation routes that should be pursued.

Climate change projections are regularly updated and should be reviewed periodically as part of the village planning to understand the evolving risk due to the changing climate.

Note that before applying any of the recommendations described herein, the contents of this detailed report, including sources of information and assumptions applied, should be fully read and understood.

TABLE OF CONTENTS

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1 INTRODUCTION

In support of the village of Harrison Hot Springs' (the village) broader objective of limiting the risk of natural hazards to their community, Northwest Hydraulic Consultants Ltd. (NHC) was retained to provide a hydrotechnical assessment of flood protection from Harrison Lake for the community considering current and future conditions due to climate change.

This work has been developed to meet the requirements of the Community Emergency Preparedness Fund (CEPF) Flood Risk Assessment, Flood Mapping & Flood Mitigation Planning 2021 grant administered by the Union of BC Municipalities (UBCM). This report includes relevant background information, findings from the site assessment, flood level assessment results, and recommendations for the elevation of the structural flood protection along Harrison Lake (i.e. dike elevation) which will be used to facilitate community planning.

1.1 Project Datum

All elevations referenced in this document are referenced to the Canadian Geodetic Vertical Datum of 2013 (CGVD2013). For data that is in Canadian Geodetic Vertical Datum of 1928 (CGVD28) the following local conversion formula has been applied:

$$CGVD2013 = CGVD28 + 0.148\,m$$ (Environment Canada, 2022)

2 BACKGROUND INFORMATION

2.1 Setting and Hazards

The village is located on the southern end of Harrison Lake. It is located within the Fraser Valley Regional District (FVRD), north of the village of Agassiz which is within the District of Kent (also a municipality within the FVRD). Harrison Lake can be a flood hazard to the village from high water levels, wind generated waves, or tsunami waves resulting from sudden water displacement by landslide at Mt. Breckenridge, located at the northern end of the lake.

Figure 2.1 shows the existing infrastructure at the village. The waterfront is protected by a 1.55 km long dike that protects the village against flood hazards from Harrison Lake. A lagoon fronts sections of the dike, providing protection to the dike from wind generated waves; however. the primary purpose of the lagoon is to provide recreational opportunities with a perimeter path and sheltered swimming. Critical community waterfront infrastructure, in addition to the dike, includes a pump station and a flood box at Miami Creek, the community's wastewater treatment plant (WWTP) at Whippoorwill Point and the WWTP access road.

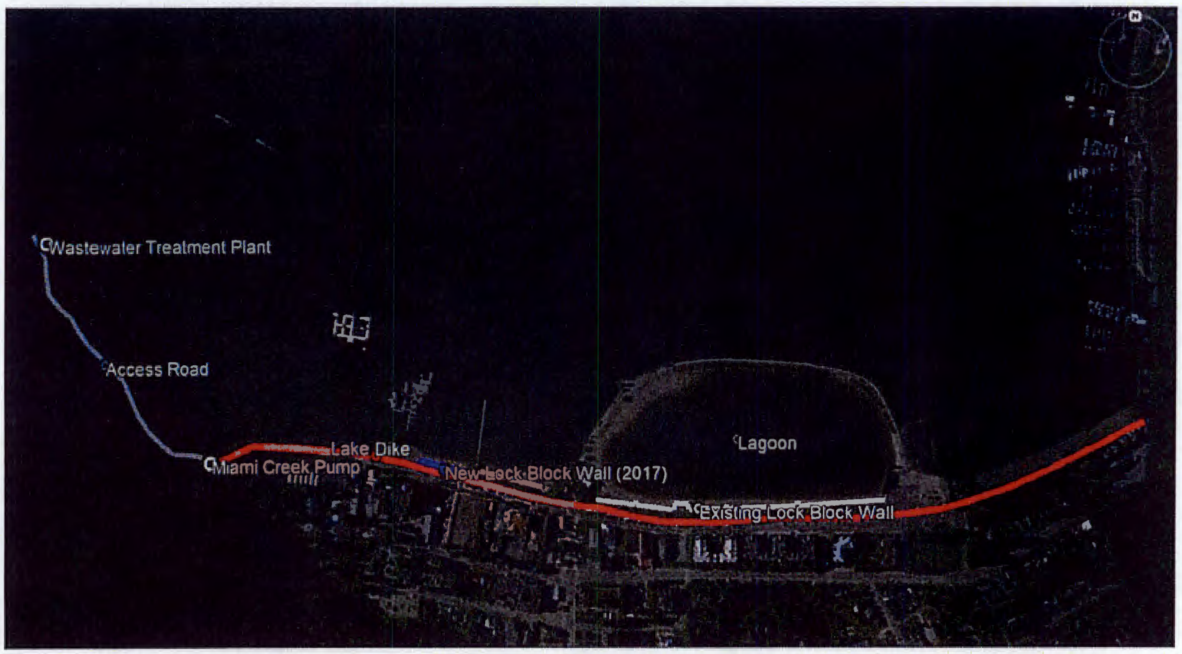

Figure 2.1 Existing infrastructure at the village waterfront (Satellite image from GoogleEarth dated February 9th, 2022)

2.2 Existing Flood Construction Levels

Currently, the village has designated floodplain areas in the Official Community Plan (OCP) which was set by the BC Ministry of Environment (The Village of Harrison Hot Springs, 2007). Within these areas, the flood construction level (FCL) is established as El. 14.55 m. This elevation was derived from the calculated Harrison Lake water level resulting from backwatering of Harrison River during the 1894 flood-of-record design flood on the Fraser River. The 1894 flood has previously been estimated to be flow of 17,000 m^3/s at the District of Hope (NHC, 2014).

2.3 Harrison Hot Springs Dike

The current dike was constructed in the middle of the last century following the 1948 flood: the second largest flood of record within the Fraser River valley and Harrison Lake. The dike is managed and maintained by the village of Harrison Hot Springs (i.e. the local diking authority). Figure 2.2 below shows the official location of the dike which effectively runs 1.55 km along the length of the village waterfront.

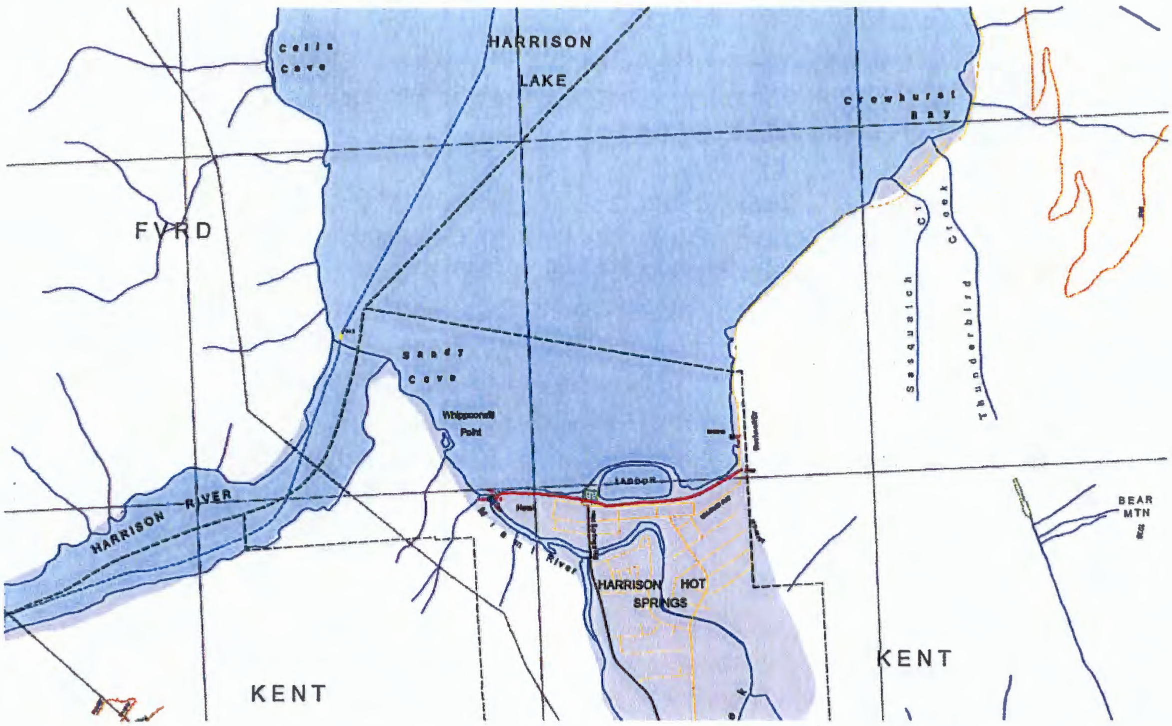

Figure 2.2 Diagram showing the Harrison Lake dike (in red) and the setting of the village in relation to other districts (Ministry of Environment, Lower Mainland Region, 2009).

Recent reports and extreme events have highlighted the need for the dike elevation to be increased. The Lower Mainland Dike Assessment (NHC, 2015) found that the current dike elevation of 13.9 m at Harrison Hot Springs met the 200 year flood profile but had almost no allowance for freeboard. The report noted that the main reasons that many of the dikes do not meet the guidelines are:

1. Updated models have produced higher flood levels. Previously dikes were designed to meet standards in the 1960's and 1970's that were based off of historic water levels and high watermarks from 1894 (flood of record) and 1948 (second largest flood on record)
2. Structural and geotechnical design guidelines have changed. Most dikes have not been assessed/designed for seismic stability.

Specific findings for the Harrison Lake dike from the report included:

- The dike did not meet the recommended crest elevation (of 14.5 m).
- Sections of riprap such as in front of the Harrison Hot Springs hotel were identified to have a slope of 1.5H:1V which does not meet standard. Closer to the Miami Creek outlet the riprap has a slope of 2H:1V which does meet standard.
- The boat launch (12 m) encroaches on the dike.
- No geotechnical data was available and seismic geotechnical conditions could not be inferred.
- There is some erosive action and erosion should be monitored.
- No right of way (ROW) access issues were identified.

The provincial consequence classification of the dike is major (from lowest to highest ratings are insignificant, minor, moderate, major, high) as reported in the BC Dike Consequence Classification Study (NHC, 2019a) (Government of British Columbia, 2022).

Lock-block walls are currently present at multiple locations on the waterside slope of the dike as shown in Figure 2.1. The original section was constructed prior to 2013 and spans the eastern section of the public beach, intermittently to the eastern end of the lagoon. A 2017 report stated that water levels have been reaching higher elevations in recent years compared to historical levels. This, along with high wind events generating waves, resulted in sections of the beach eroding between 2014 and 2017 along the toe of the embankment that were reported to be threatening to expose the dike. (CTQ Consultants Ltd., 2017). Additional lock-block walls were added as a beach-dike interface in attempt to protect the dike from erosion. The most recent section, constructed in 2018 (CTQ Consultants Ltd., 2017), extends along the western section of the public beach.

2.3.1 Miami Creek Pump Station

The Miami Creek pump station was initially constructed in the 1950s and underwent several upgrades and motor replacements before the system was fully replaced in 2016 (CTQ Consultants Ltd., 2016). During normal water levels, when the lake level is less than in Miami Creek, the two box culverts allow Miami Creek to freely discharge to lake. When the lake levels exceed the level in Miami Creek the culvert gates close, and the water is pumped over the dike to the lake. There is no historical record of flooding in the village from Miami Creek, but the creek may impose a hazard during extremely high flows. Flood hazard from Miami Creek is not evaluated in this project's scope.

As a part of the Miami Creek Pump Station upgrade, NHC performed a hydraulic assessment to provide design lake levels and creek flows. The study included a 10% increase in flows to account for potential climate change effects (NHC, 2014). The results of this analysis are shown below in Table 2.1.

Table 2.1 Results from 2014 hydrologic assessment of Harrison Lake (NHC, 2014)

Return Period (Years)	Summer (April 1 – September 30)		Winter (October 1 - March 31)	
	Lake Level (m)	Miami Creek Flow (m^3/s)	Lake Level (m)	Miami Creek Flow (m^3/s)
2	11.5		10.4	
5	12.0		10.9	
10	12.3	6.3	11.2	15.9
20	12.6	7.5	11.5	18.8
50	13.0	9.2	11.8	22.5
100	13.2	10.5	12.0	25.4
200	13.5	11.9	12.2	28.4

2.4 WWTP and Access Road

The WWTP for the village is accessed via an unpaved road which begins at the western end of the dike and leads northward to the plant, located at Whippoorwill Point (see Figure 2.1). The road elevation is approximately 13 m. In 2018, when the lake levels reached an elevation of approximately 12.5 m, the road experienced minor flooding, which eroded part of the road and the riprap slope protection. Improvement were recommended for the waste water treatment road in 2019 (CTQ Consultants Ltd., 2019); however, the grant application for project funding was not successful.

3 DATA COLLECTION AND SITE INVESTIGATION

Available historical data was provided by the village which was supplemented by information from the public domain, and updated topographic and bathymetric surveys. Additionally, a site inspection was conducted by NHC.

3.1 Data Collection

Terra Remote Sensing Inc. was retained to complete both topographical and bathymetric surveys of the village dike and waterfront area. All surveys were completed on August 19, 2021. In total three different surveys were performed (Figure 3.1):

1. Real Time Kinetic (RTK) survey grade GPS collection of spot elevations along the top of the dike.
2. Single beam bathymetric survey of near shore bed elevations a series of profiles.
3. Vessel mounted Lidar survey of high-density data of the front face of the dike from the water.

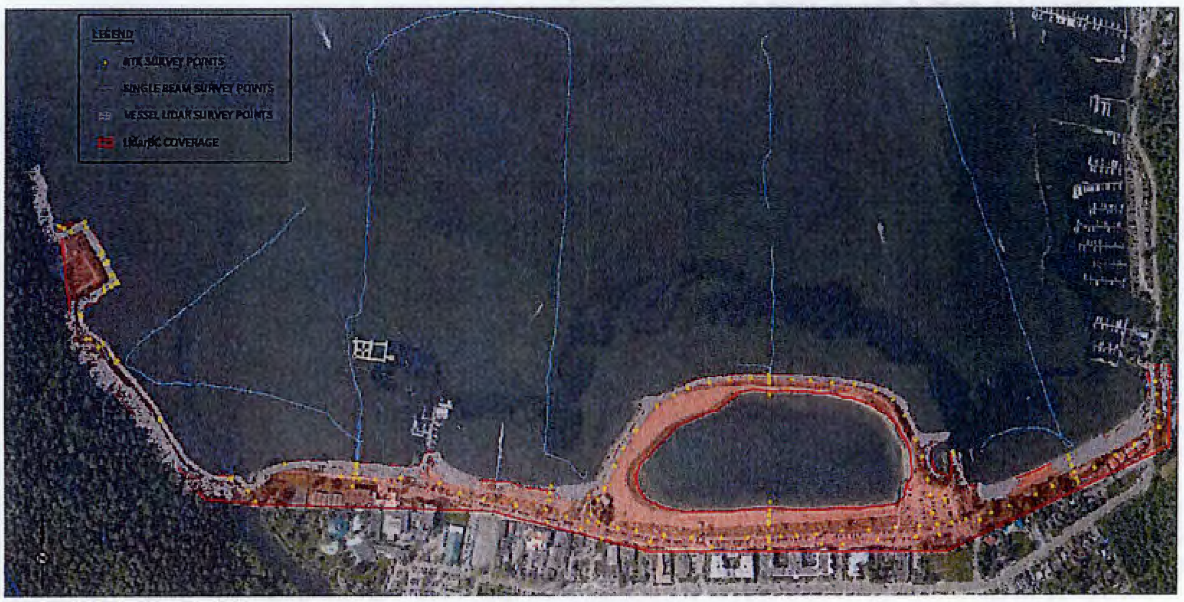

Figure 3.1 Data sources used in this work.

3.2 Site Investigation

NHC performed a site inspection January 26, 2022 to observe the waterfront, document any areas of concern and gain an understanding of upgrade feasibility. The waterfront inspection was discretized into 6 zones, based on their distinct features (Figure 3.2). Below is a brief description of each zone, along with photos and noted observations.

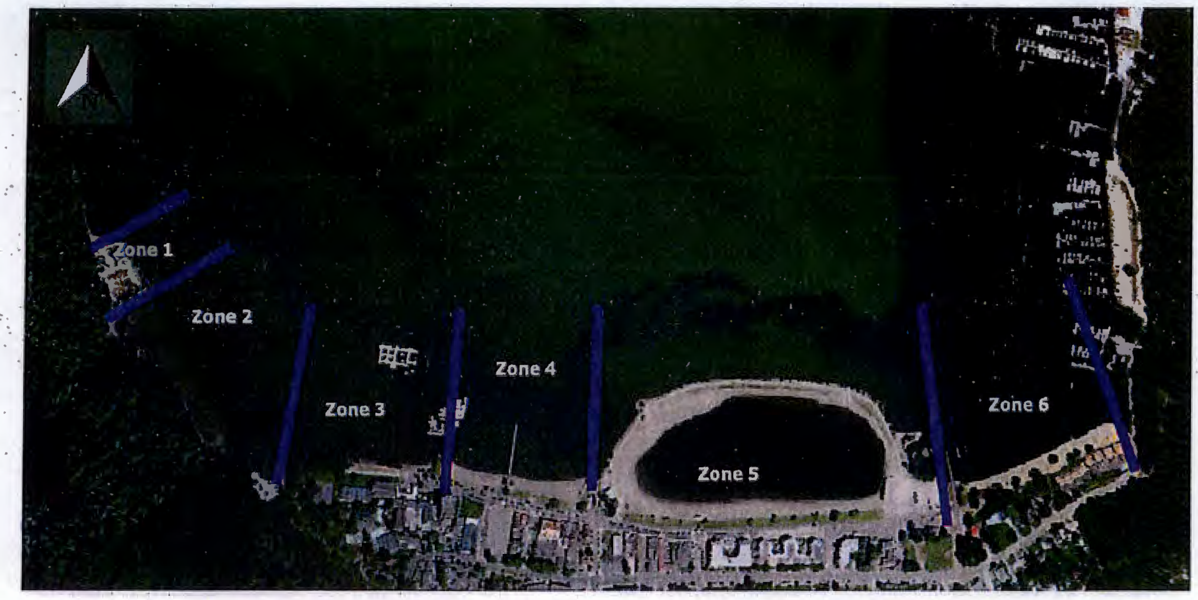

Figure 3.2 Shoreline zones set-up during project inspection.

3.2.1 Zone 1 and 2: WWTP and Access Road

Zone 1 is the smallest zone, limited to the WWTP. At the time of inspection the shoreline of the WWTP was not directly inspected. From afar, findings in this zone included large collection of driftwood on the riprap slopes and extensive vegetation at the top of the slopes (Figure 3.3). Note that an inspection of this zone is planned for a later date.

Figure 3.3 Zone 1 – View of the WWTP shoreline from the south.

Zone 2 is the WWTP access road, from the Miami Creek Pump Station to the WWTP. As discussed in Section 2.4, the road is subject to flooding and erosion during wind or high water events.

Finding in this zone include:

- Vegetation is present along the top of riprap that includes small diameter trees that could displace riprap as they grow and invasive blackberry which can be challenging to remove during construction (Figure 3.4)
- There is a notable loss of road fill at the top of the riprap slope at a number of locations. This is likely due to the lack of a filter layer (either rock or geotextile) which is prohibiting the riprap from functioning properly. (Figure 3.5). There are visible repairs at the top of the slope where fill that had previously washed out has been replaced. (Figure 3.6)
- Pockets of larger riprap (average diameter, D_{50}[1], of 500 mm – 700 mm) are interspersed with pockets of smaller rock (D_{50} of 100 mm – 300 mm). Some of the variability appears to be due to damage to the structure while in other locations it is due to different construction periods along the riprap.
- Additional damage to the structure was observed at a location where pieces of the riprap slope had been removed by the public in order to build a pool structure. (Figure 3.7)

Figure 3.4 Zone 2. Access road to the WWTP includes tree growing at the top of the armoured slope.

[1] D_{50} is commonly used to describe the average size of riprap material used for revetments and embankments. It can be defined as the size (typically in mm) that 50% of the rock by mass is larger than.

Figure 3.5 Zone 2 – Repaired erosion along the top of the riprap slope.

Figure 3.6 Zone 2 – Repairs to the top of the slope adjacent to the Miami Creek outlet.

Figure 3.7 Zone 2 – Rock from the riprap slope removed to create warm pools.

3.2.2 Zone 3: Western Dike

Zone 3 includes the area between the Miami Creek Pump Station and the marina access point. Like the WWTP access road, the shoreline in this zone has riprap as protection; some of this riprap was in good shape while other areas showed significant degradation. Significant findings in this zone are similar to zone 2 and include:

- The riprap was found to be in especially poor conditions in two locations: to the east of the Miami Creek outlet (Figure 3.8, Figure 3.9, Figure 3.15) and the very easternmost section of the zone (Figure 3.10) adjacent to the marina access peninsula. At both locations intermittent larger riprap (D_{50} of 400 mm to 700 mm) was scattered across the slope and smaller rocks and fines were visible.
- Vegetation, such as the invasive blackberry (Figure 3.8) and small diameter trees were observed along the top of the slope and could be responsible for displacing some of the rock material. The vegetation also makes it difficult to assess the condition of the slope.
- The riprap in front of the Harrison Hot Springs Resort was observed to be in reasonable condition; however, it appears that repairs have been made to the top of the slope. It is assumed that these repairs were to replace fines/ground soil that washed out through the structure due to the lack of a filter layer. (Figure 3.11)

Figure 3.8 Zone 3 – Invasive species covering the deteriorated riprap slope.

Figure 3.9 Zone 3 – Deteriorated riprap slope

Figure 3.10 Zone 3 – Riprap in poor condition at the eastern extent of zone 3 adjacent to the marina access peninsula.

Figure 3.11 Zone 3 – Assumed repairs to top of riprap in front of Harrison Hot Springs.

3.2.3 Zone 4: Public Sand Beach

Zone 4 includes the public beach from the marina access gangway to the western extent of the lagoon (at the public washroom facilities). This zone consists predominantly of a sandy beach backed by lock-blocks with sections of riprap at both the east and west ends. The Charlie Wilson Float Plane Dock is located between the two beaches. Findings in this zone include:

- Riprap protecting the marina gangway abutment appears to be relatively new and in good shape (Figure 3.12)
- Scour at the top of the beach is occurring in front of the lock-block wall. The lock-block walls were originally installed to protect the dike against scour; however, it appears they could now be exacerbating scour in front of the wall. It is not known whether this scour is wave driven when lake levels are high or due to surface was run-off from the upper dike (Figure 3.13)
- The beach has experienced deflation (lowering). It is assumed that this is predominantly due to aeolian (wind) sand transport from the wooden slat fencing that has been installed to retain sand. (Figure 3.13)
- The riprap at the eastern extent of the beach (where the beach connects to the Harrison Lagoon) is in moderate condition. Repairs have been made to the top of the slope where it appears fines have been washed out through the rock at the top of the slope. (Figure 3.15)

Figure 3.12 Zone 4 – Riprap protecting marina gangway abutment.

Figure 3.9 Zone 4 – Beach with lock-blocks (scour in front of lock-block is visible) and wooden slat fencing.

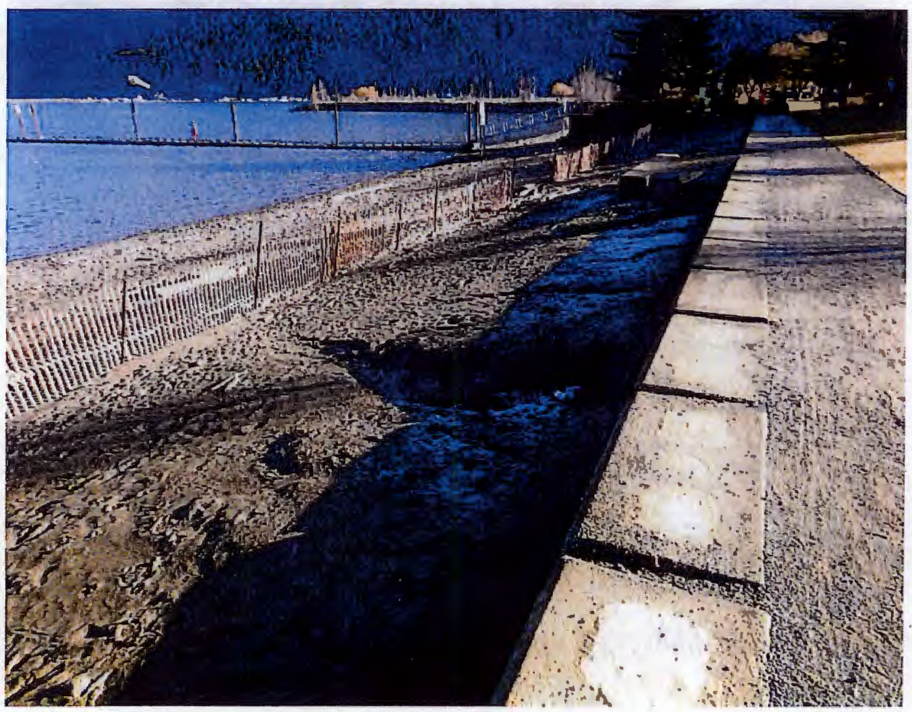

Figure 3.13 Zone 4 – Lock-block wall with scour occurring in front.

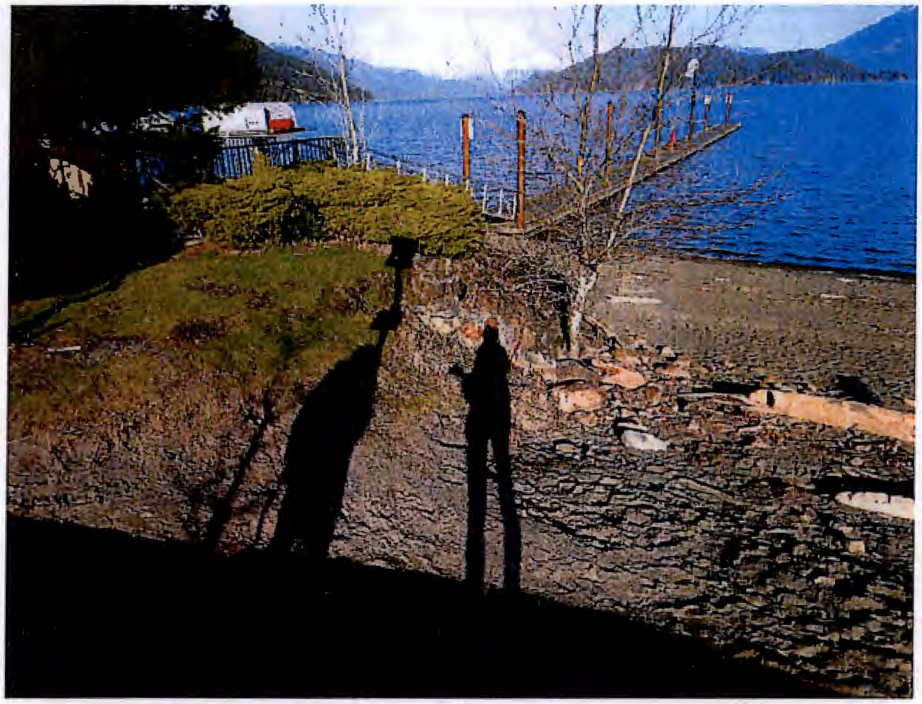

Figure 3.14 Zone 4 – Headland for the floatplane infrastructure.

Figure 3.15 Zone 4 – Riprap slope at the transition to the Harrison lagoon.

3.2.4 Zone 5: Harrison Lagoon

Zone 5 envelopes all waterfront infrastructure related to the lagoon. This includes both the pathway to the north of the lagoon on top of the armoured fill (referred to as the lagoon berm) and the beach that is directly in front of the dike to the south of the lagoon. The lagoon berm is not a part of the official Harrison dike; however, it does function to reduce wave run-up at the dike behind the berm. Key findings in this zone include:

- Observed locations of riprap movement and washout, such as fine material from the lagoon berm pathway being sucked out through gaps (due to no filter layer) in the riprap slope (Figure 3.16, Figure 3.18)
- Some variation in the sizing of riprap was observed here although less than what was seen in zone 3. Overall, the average rock size (D_{50}) varied from 200 mm to 700 mm (Figure 3.17). Large rocks have been added at the top of the slope where damage has occurred.
- Similar to in zone 4, scour was observed in front of the existing lock-block walls on the beach that backs the lagoon. At this location the scour is unlikely to be from wave action and is assumed to be due to surface water run-off. (Figure 3.19)

Note that a couple of changes are planned for this section in the short term including in front of the public washrooms where another lock-block wall will be installed to prevent further erosion (CTQ Consultants Ltd., 2022).

Figure 3.16 Zone 5 – Observed erosion at the top of the riprap slope on the lagoon berm.

Figure 3.17 Zone 5 – Variation in sizes of riprap on the offshore slope of the lagoon berm.

Figure 3.18 Zone 5 – Observed location of erosion in the lagoon berm.

Figure 3.19 Zone 5 - Existing lock-block wall and wooden slat fencing along the dike in front of the lagoon with severe erosion.

3.2.5 Zone 6: Eastern Dike

Zone 6 includes everything east of the lagoon, including the boat launch, stormwater outflow pipe, and the rest of the exposed shoreline to the eastern extent of the dike. The beach in this zone does not have a lock-block wall, and houses and buildings are much closer to the water than in the other zones. Findings include:

- A two lane boat launch intersects the dike. (Figure 3.20) This was identified in the dike assessment project (NHC, 2015) as encroaching and will need to be assessed for the impact on the dike.
- There is a stormwater outflow pipe on the beach which appears to act as a groyne; as a result sediment has collected on the west and eroded to the east. (Figure 3.21) This results in the homes to the east of the structure being more exposed to wave events.
- Residential properties are closer to the top of dike than in other zones. (Figure 3.22)
- Erosion is occurring at the top of the beach. (Figure 3.23) This appears similar to the surface run-off erosion witnessed in zone 4.
- Aeolian sediment transport is also a concern in this zone based on the wooden slate fencing. (Figure 3.23)

Figure 3.20 Zone 6 – Boat launch.

Figure 3.21 Zone 6 – Discrepancy in beach elevations due to water outfall pipe

Figure 3.22 Zone 6 - Residential properties directly behind the top of dike.

Figure 3.23 Zone 6 – Scour occurring at the top of the beach.

4 WATER LEVELS ON HARRISON LAKE

Inflow to Harrison Lake is predominantly from the Lillooet River at the north end of the lake. Runoff from the surrounding slopes and associated tributaries also contribute flow. Flow leaves the lake through the Harrison River, a relatively short channel (~18 km), to the Fraser River. High water levels on the Fraser River backwater Harrison River, restricting outflows from the lake.

4.1 Historical Water Levels at Harrison Lake

The water level in Harrison Lake has been monitored by the Water Survey of Canada (WSC 08MG0012) since 1933. The highest recorded water levels are:

- 1948: 13.4 m
- 1950: 13.3 m
- 1967: 13.0 m
- 1974: 12.8 m.

Recent high water spring freshet events include 2012 (12.6 m) and 2018 (12.5 m).

The following figure (Figure 4.1) illustrates the annual hydrograph of lake levels. Frequency analysis of historical annual maximum water levels was used to determine values that coincided with average annual exceedance probability (AEPs); results are shown in Table 4.1. The duration of flood levels near the peak varies from flood to flood. For example, during the 1948 flood Harrison Lake level stayed within 0.3 m of the maximum daily level for two weeks (14 days), but during the 1950 flood the lake stayed within 0.3 m of the maximum daily level for only 5 days.

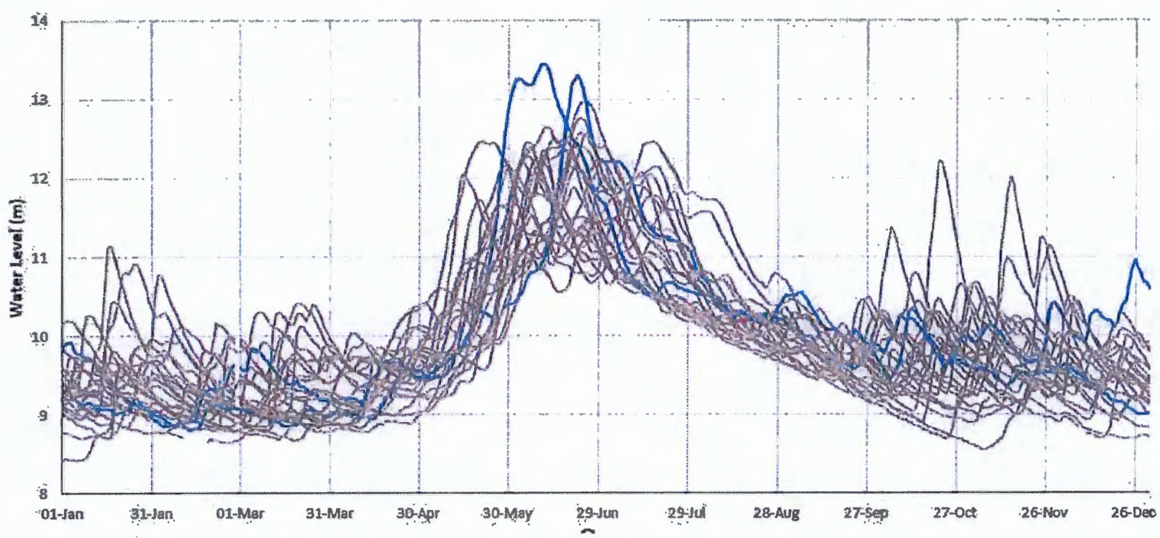

Figure 4.1 Historical lake levels on Harrison Lake 1933 – 2020 with years exceeding 13 m shown in blue. WSC gauge 08MG012.

Table 4.1 **Average annual exceedance probability (and corresponding return period) for high level events on Harrison Lake based on historical water levels (WSC 08MG012).**

AEP	Return Period (yrs)	Water Level (m)
0.2%	500	13.9
0.5%	200	13.6
1%	100	13.3
2%	50	13.1

4.2 Fraser River Quantile Flows and Harrison Lake Flood Levels

Over the period of record from this gauge the lake level has been typically lowest from late summer to late winter. Freshet inflow, particularly high Fraser River levels, increase the lake level from May through August. Within the data record, only 3 of the 30 years in which the lake level exceeded El. 12.0 m, occurred outside of the spring freshet. None of these years were within the highest 18 years of lake levels (i.e. lake level was El. 12.2 or lower). For the majority of years of data (80%) and particularly all of the highest lake levels, the annual maximum lake level coincides with the annual maximum Fraser River flow (as measured at Hope, WSC 08MF005).

When high lake levels occurred outside of the spring freshet, they are a result of intense fall rain, or rain-on-snow events. Despite being outside of the period of the Fraser River spring freshet, they still often occur coincidently with maximum or near maximum Fraser River flows; as seen during the 2021 November 15 event. Harrison Lake level data for 2021 are not yet included in the published record, but are provisionally presented as 12.1 m for November 16 by the WSC gauge 08MG012 (Government of Canada, 2022).

4.3 Project Future Lake Levels (Climate Change)

Following are elements of the average projection of future climate for the Coast and Mountains ecoprovince as presented by Pacific Climate Impact Consortium (PCIC) (*using RCP8.5 and CMIP5*):

- Annual temperature is to increase 3°C by mid-century and 4.9°C by 2070-2100.
- Summer precipitation is to decrease 6% by mid-century and by 9% by 2070-2100.
- Fall/winter precipitation is to increase 5% by mid-century and 11% by 2070-2100.
- Precipitation as snowfall is to decrease 45% by mid-century and by 55% by 2070-2100.
- Increases in high intensity precipitation.

Similar projections (but slightly different magnitude) are projected for other regions of BC. These projections suggest that the magnitude, frequency, and timing of high and low water levels are likely to change with time, but does not define a quantitative influence to flood levels or flood flows. Due to the historic correlation of maximum lake levels with Fraser River flood flows, previous studies conducted to quantify projected impact of climate change of Fraser River flood flows were reviewed to inform projected changes in Harrison Lake flood levels.

4.3.1 Simulation of Current and Future Fraser River Flood Flows

A 1D numerical, hydraulic model was developed at the start of this century of the Lower Fraser River from Hope to the Salish Sea. The model was used for real time forecasting of freshet flood levels and to provide an update of design flood profiles along this reach. In 2014, the model was used to simulate a range of scenarios representing both historic and future floods. The historic event scenarios were based on the historic flow record and included different AEPs (i.e. quantile flows) and the 1894 flood (roughly equivalent to 0.2% AEP). The simulated scenarios also included future flows as projected to occur with climate change (MFLNRORD and NHC, 2014). The flow data came from a 2012 study by PCIC (Werner, 2011), which were created with a *variable infiltration capacity* (VIC) hydrologic model. The VIC model initially utilized eight different *global climate models* (GCMs) with three *greenhouse gas emissions scenarios* (GGESs). The three GGESs, A2, A1B, and B1, are from the Intergovernmental Panel on Climate Change Assessment Report 4 (IPCC, 2007) released in 2000 (Nakićenović, N. et al., 2000). Two future climate simulations were then selected to represent moderate climate change (HadCM3 of B1 GGES) and intense climate change (HadGEM of A1B). These climate projections were simulated in the 1D hydraulic model along with 0, 0.5, and 1.0 m of sea level rise. The results have been used along the Fraser River to evaluate future flood profiles. However, the presented model results do not extend up the Harrison River to the Harrison Lake.

In 2019, NHC developed a 2D numerical, hydraulic model of the Lower Fraser River for the Fraser Basin Council (NHC, 2019c). The model again extends from Hope to the Salish Sea, but does include Harrison River, Harrison Lake, and Harrison Lake inflow. The model was based on more recent bathymetric survey and LiDAR data. Model simulations were developed using updated, projected flow time series produced by PCIC in 2018 (NHC, 2019c). For the 2018 dataset, the VIC hydrologic model (used in 2014) was replaced by VIC-GL (GL for glaciation) which incorporates glaciation and glacier mass and energy balance (Schnorbus, 2017). Both the 2014 and 2018 hydrologic models used the same GCM and GGEM scenarios from the IPCC AR4 report.

The model was used to simulate unsteady flow; that is, the simulated flow varies with time instead of simulation of a constant (*peak*) flow. The general shape of the 1948 freshet hydrograph was used to create flood hydrographs for AEPs from 2% to 0.2% for Fraser River at Hope. The 1948 flood hydrograph was selected as most representative of extreme events. During this event Harrison Lake did not peak until 11 days following the peak of the Fraser River. In comparison, during the next three highest floods on record (1950, 1967, 1974), Harrison Lake levels peaked within 2 days of the Fraser River. Despite the delay, this hydrograph was selected since it was from the highest lake level and largest Fraser River flow on record (20 to 40% greater peak flow than the next highest events). For hydraulic modeling purposes, Harrison Lake inflows were simulated as being concurrent with the Fraser River freshet hydrographs, patterned after back-calculated lake inflows from the 1972 flood and scaled to approximately match flow rates from a regression between Fraser River peak flows and coincident lake inflows over various durations. Freshet inflows from other Fraser River tributaries are small, and constant inflows were assumed for model simulations as initially reported in NHC (2014).

Simulated scenarios were run for current conditions (2011 to 2040), mid-century (2041 to 2070) and end-of-century (2071 to 2100). Future flood flows were derived using HadCM3 (NHC, 2019c). For all simulations, a 50 % AEP summer sea level was used. For simulation scenarios representing climate change to mid century, 0.5 m of sea level rise was added to the historic 2-year level. For end of century simulations, 1.0 m of sea level rise was applied (NHC, 2019c). Due to the distance of Harrison Lake from the ocean, lake water levels are not dependent on the downstream sea level for sea levels within the projected range of plausible values. Further details regarding the development of the 2D hydraulic model and simulated climate change scenarios are presented in (NHC, 2019d) and (MFLNRORD and NHC, 2014)

Although the simulations presented suggest peak flows increase with the progression of time, some of the simulations suggest the highest peak flows occur closer to mid-century. In addition, the timing of peak flows is projected to change over time. This is expected to include an earlier freshet (and subsequent earlier low summer lake level) and may also include increased occurrences of high flow and high lake level events associated intense fall/winter rain or rain-on-snow (NHC, 2019b). The 2021 November 15/16 event may be a harbinger of such a change. As greenhouse gas emissions and resulting climate change continue over time, the projected effects of the climate change will need to be updated and refined.

4.3.2 Lake Levels Corresponding to Current and Future River Flood Events

A total of 13 base scenarios were run, corresponding to a range of AEPs for present and future conditions. The maximum daily water surface levels have been extracted from the 2D numerical model at a point directly in front of the Harrison Lake lagoon for the range of flood scenarios, as presented in Table 4.2. The present day lake levels derived from the simulation of quantile Fraser River flows are equivalent to the results determined through frequency analysis of the historic lake level data, except for the most frequent event which is 0.1 m lower (Table 4.1).

Table 4.2 Simulated flood scenarios and Harrison Lake water levels

Flow Condition	AEP	Upstream Boundary Peak Flow (m³/s)		Max Lake Level (m)
		Fraser River at Hope	Harrison Lake Inflow	
Present Day	1894 Event	17,000	2,050	14.07
	0.2%	**16,500**	**2,010**	**13.94**
	0.5%	15,200	1,890	13.58
	1%	14,300	1,810	13.29
	2%	13,400	1,720	13.00
2050	**0.2%**	**19,140**	**2,171**	**14.57**
	0.5%	17,328	1,985	14.10
	1%	16,016	1,846	13.76
	2%	14,740	1,737	13.38

Flow Condition	AEP	Upstream Boundary Peak Flow (m³/s)		Max Lake Level (m)
		Fraser River at Hope	Harrison Lake Inflow	
2100	**0.2%**	**22, 935**	**2,452**	**15.55**
	0.5%	20, 216	2,211	14.88
	1%	18,590	2,045	14.37
	2%	16,750	1,892	13.95

5 WAVE EFFECT ASSESSMENT

Design information to describe the risk of waves to the village dike was collected, analysed and is summarised below.

5.1 Winds

No long-term record of local winds is available at the project site. Assessment of winds was therefore based on available nearby stations from a variety of operators which are shown in Table 5.1 and Figure 5.1.

Typically, stations operated and maintained by Environment and Climate Change Canada (ECCC) are installed with care given to ensure winds are measured in an unobstructed fashion. These wind measurements are post-processed and quality checked by ECCC. Other stations throughout BC, such as those operated by the British Columbia Ministry of the Environment (MoE), the Ministry formerly known as British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD)[2] or Metro Vancouver (MV) are installed for alternative purposes such as air quality monitoring or precipitation measurement. Often these stations are composed of instruments with many functions and while they come with the capability to monitor winds they may not be located or installed in a manner that facilitates collection of data suitable for design purposes. Quality control is often not performed on these wind measurements.

Measurements from each of these stations were analysed to determine which were the most representative of the conditions over the lake. Of these, only the two ECCC stations had records longer than five years that recorded consistent high magnitude (greater than 10 m/s) wind events. In comparison, the stations listed as 3 and 4 in Table 5.1 either had only a few events larger than 5 m/s (MLFNRORD Big Silver) or none (BC MoE Chilliwack). The ECCC station at Agassiz, located 7 km south of the village waterfront and to the northwest of the Fraser River was the closer to the project site and selected for further analysis.

[2] As of April 1, 2022 this Ministry has been divided into two ministries: Ministry of Land, Water and Resource Stewardship and Ministry of Forests.

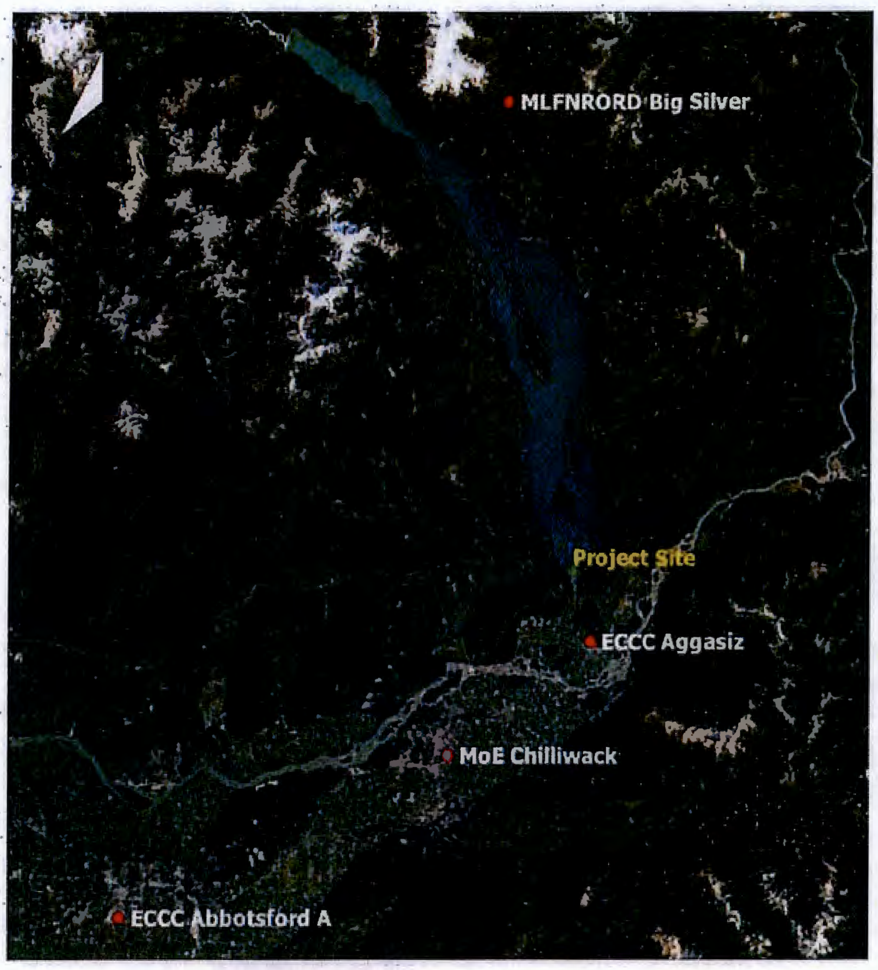

Figure 5.1 Location of available wind stations in relation to the project site.

Table 5.1 Wind stations analysed to determine Harrison Lake wind climate.

No.	Source	Station Name	Dates of Operation
1	ECCC	Agassiz	1994 – present
2	ECCC	Abbotsford International	1953 – present
3	BC MoE	Chilliwack	1989 -1990 & 1994 - 2000
4	BC MFLNRORD	Big Silver	1992 -2007 & 2009 -2021

A wind rose for the station is shown in Figure 5.2. A wind rose is a graphical representation of the historical distribution of wind speed and direction from which the wind blows from. The wind rose plot suggests winds most frequently come from the north through northeast, with the highest wind speeds limited to those from the northeast. Due to topographical sheltering from a hill directly to the north of the station, it is expected that ECCC Agassiz would not experience the full northerly winds expected and reported anecdotally at the village. From the wind rose, it is apparent that the station picks up the Fraser River outflow winds from the northeast but not the northern storms experienced in the village.

Extreme event analysis was conducted on the ECCC Agassiz dataset (Table 5.2). Because directional information at Agassiz is not expected to be consistent with Harrison Lake, winds have been assumed to be omnidirectional; that is the frequency analysis was conducted based on magnitude without consideration of direction. Due to the seasonality of the water levels on Harrison Lake, wind events for the freshet season (defined here as April to September) were looked at separately and were lower than the non-freshet wind season. However, due to uncertainty with the direction of the wind data and the likelihood that climate change will continue to make it harder to predict when high water levels and high wind events occur, the full year wind speeds were used for the analysis.

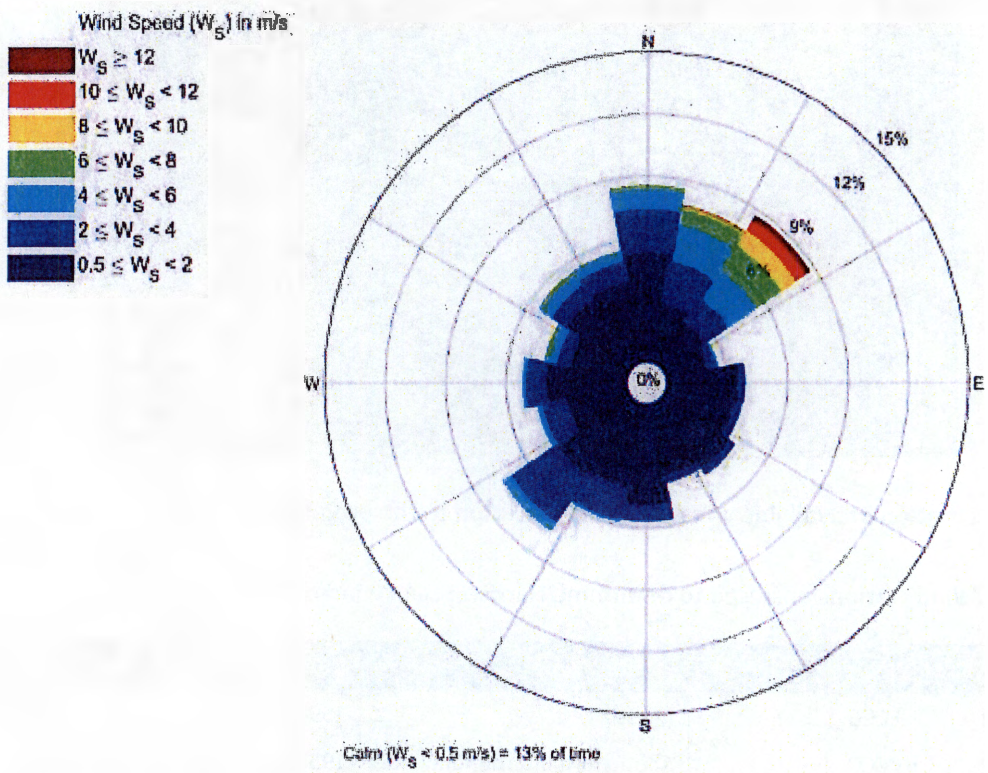

Figure 5.2 Wind rose for ECCC Agassiz (1994 – 2021).

Table 5.2 Extreme wind speed analysis for Harrison Lake (based on ECCC Agassiz)

AEP	Return Period (yrs)	Wind Speed (m/s)		
		Mean	Upper Bound 90%	Lower Bound 90%
50 %	2	15.4	15.9	14.9
10 %	10	17.5	18.4	16.5
5 %	20	18.3	19.5	17.0
2 %	50	19.3	21.0	17.6
1 %	100	20.1	22.2	18.0
0.5 %	200	20.9	23.4	18.4

5.2 Wave Climate

Waves at the dike are expected to be predominantly wind-generated during high water events. However, waves due to vessel traffic are also typical during the summer season and thus have been included below to be considered during shoreline stability calculations.

5.2.1 Wind Generated Waves

A numerical model (Simulating WAves Nearshore or SWAN (Booij, N. et al., 2004) was developed to simulate wave generation and transformation to the dike. The model was established using a coarse grid with 100 m grid spacing of the full lake (Figure 5.3) and a finer grid of 20 m spacing of the southern portion of the lake near the village (Figure 5.4).

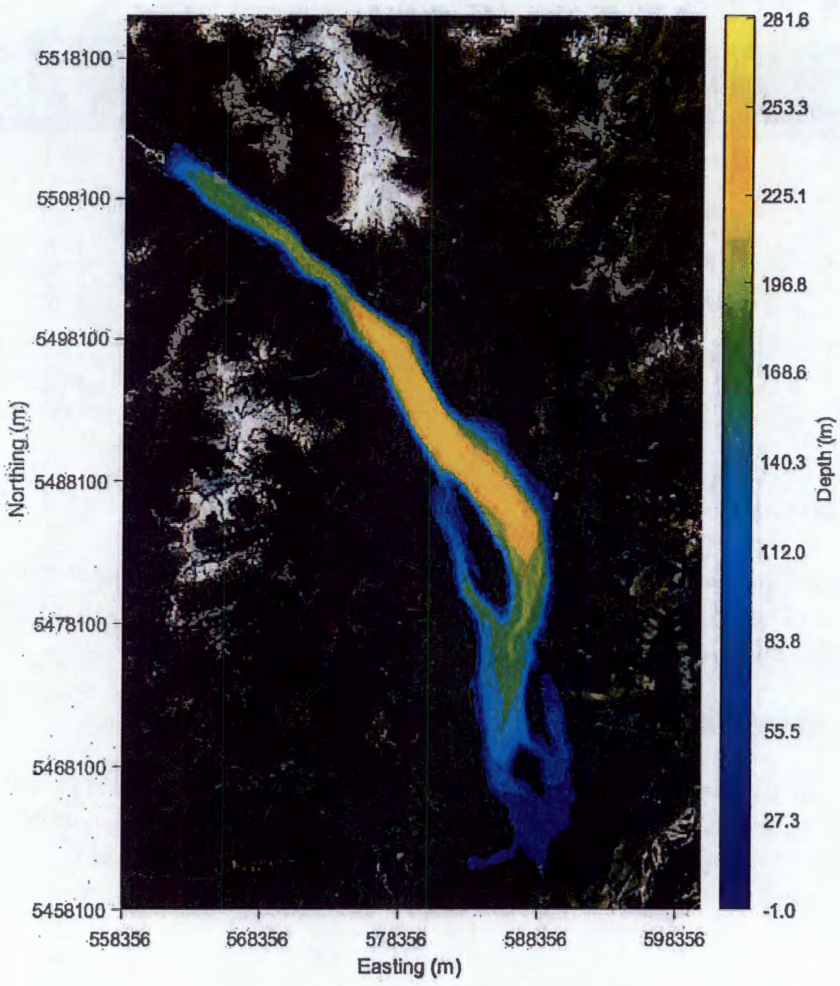

Figure 5.3 SWAN model domain illustrating the coarse grid extent and lake depth.

A number of scenarios were simulated to assess the impact of winds from different directions (NNE, N and NNW) for present day and future (2050 and 2100) water levels. Simulations used a 2 % AEP wind speed acting constantly across the model domain (over the full surface of the lake). The model simulations, the resulting significant wave height[3] (H_s) and peak wave period[4] (T_p) were extracted. An example of the fine grid model output of significant wave height for a water level of 13.9 m (present day 0.2 % AEP) with wind from the NNE is shown in Figure 5.4.

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[3] Significant Wave Height (H_s) is typically used to describe wave fields and is approximately equal to the average of the highest 1/3 of the waves.

[4] Peak Wave Period (T_p) is the wave period (time between successive wave crests) with the largest amount of energy in a wave spectrum.

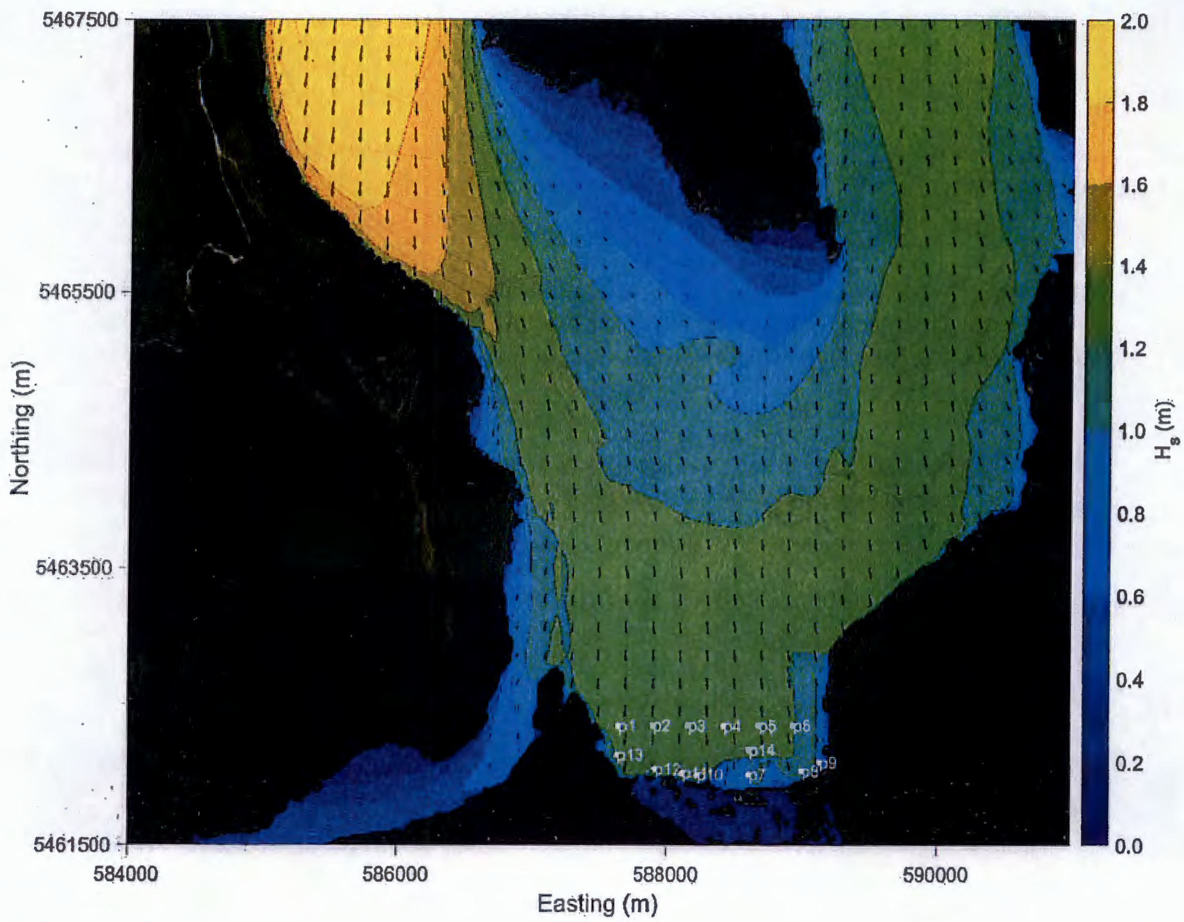

Figure 5.4 Example SWAN output showing significant wave height corresponding to a 2% AEP NNE wind during a present day 0.2% water level. Locations of data output points shown in white.

From the series of model simulations, the maximum wave height representative for each shoreline zone was extracted and is shown in Table 5.3.

Table 5.3 Design wind generated wave conditions for present day water levels.

	H_s	T_p	Dir
	(m)	(m)	(deg)
Zone 1	1.2	3.0	6
Zone 2	1.2	3.1	10
Zone 3	1.3	3.0	7
Zone 4	1.3	3.0	360
Zone 5	1.0	3.3	355
Zone 6	1.1	3.0	340

5.2.2 Vessel Generated Waves

Boat wake has been identified as a concern of the client due to the busy waterfront. Vessel induced waves of concern for this region are expected to occur primarily due to small recreational boats and not due to tugboats (which generally govern in other regions of the Lower Mainland).

Recreational vehicles typically operating in the region are expected to be between 15-25 ft most of the time. Research completed in Alaska which analysed new and previous measurements of vessel wake for a variety of vessels (Maynord, 2005) found no waves larger than 0.6 m for vessels less than 25 ft in length.

Harbour tugboats are larger vessels that could be transporting good for construction or industry on the lake. A large 30 m tug can create a wave of 0.8 m with a period of 3.2 seconds (Vancouver Fraser Port Authority, 2018).

These estimated maximum wave heights are less than the design wind-wave but they are expected to occur more regularly during summertime conditions.

Table 5.4 Design vessel generated wave conditions.

Return Period	Tugboats		Recreational Vessels	
	H_s (m)	T_p (s)	H_s (m)	T_p (s)
50-yr	0.8	3.2	0.6	3.2

5.2.3 Wave Effect

Wave effect at the dike is important to understand the risk of waves impacting the top of the dike during wind storm events that may take place during high water. The BC Provincial Sea Dike Guidelines (BC MoE, 2011) accept the use of two methods for calculating wave effect: run-up and overtopping. In this case, the wave effect considered is the run-up, the maximum vertical extent of wave uprush on a beach or structure above the still water level. The level of wave run-up depends greatly on the slope, orientation, and character (vegetation and roughness) of the shoreline. The level of wave run-up is generally characterized by the two percent exceedance value of wave run-up, $R_{2\%}$ (i.e. only two percent of the wave run-up values observed will reach or exceed $R_{2\%}$). Representative sections for each of the dike zones were generated and then calculations of $R_{2\%}$ were made using the Overtopping Manual (EurOtop, 2018) industry standard methodology. The results of the wave run-up for present day flood conditions (13.9 m) are shown below in Table 5.5.

These values are calculated assuming that the typical slope extends along the same slope up to the point of maximum run-up. Because the water levels considered is 13.9 m and the dike elevation is typically around 14.0 m, we know that this is not the case, and that the dike would in fact be inundated with its current profile. Instead these run-up values are calculated assuming the dike is in fact raised and help to determine what elevation run-up would reach on these typical slopes.

Table 5.5 Wave runup for each of the waterfront zones

	$R_{2\%}$ (m)
Zone 1	1.7
Zone 2	N/A - Inundated
Zone 3	1.5
Zone 4	2.5
Zone 5	2.0
Zone 6	2.5

Run-up should be revisited for any proposed upgrades to the dike structure.

6 LANDSLIDE TSUNAMI RISK

A 1990s investigation by Emergency Management BC found that there is a large mass of rock, called a sackung, moving slowly down the southwest side of Mt. Breakenridge (Figure 6.1) on the north end of Harrison Lake (Kennedy, 2021a). This sackung is identified as being on the steep, lake side of the mountain, in the summit ice fields showing fault-like ridges believed to be tension cracks due to instability (MtnPg.asp, n.d.). If the entire mass were to suddenly slide down the mountain, it is estimated it would trigger a displacement wave with wave heights of 20-25 m at Echo Island, 5 km off the coast of the village reaching the village and other exposed communities around the lake in under 20 minutes (FVRD, 2021). The village does have some natural protection, such as Echo Island and the natural shoal (created by Fraser River sediment depositing into the lake through Harrison River) (Kennedy, 2021a); however, it is still expected the dike would be overtopped by 2 meters, and that the wave would move through the village in under two minutes, with speeds of up to 5m/s (Kennedy, 2021a).

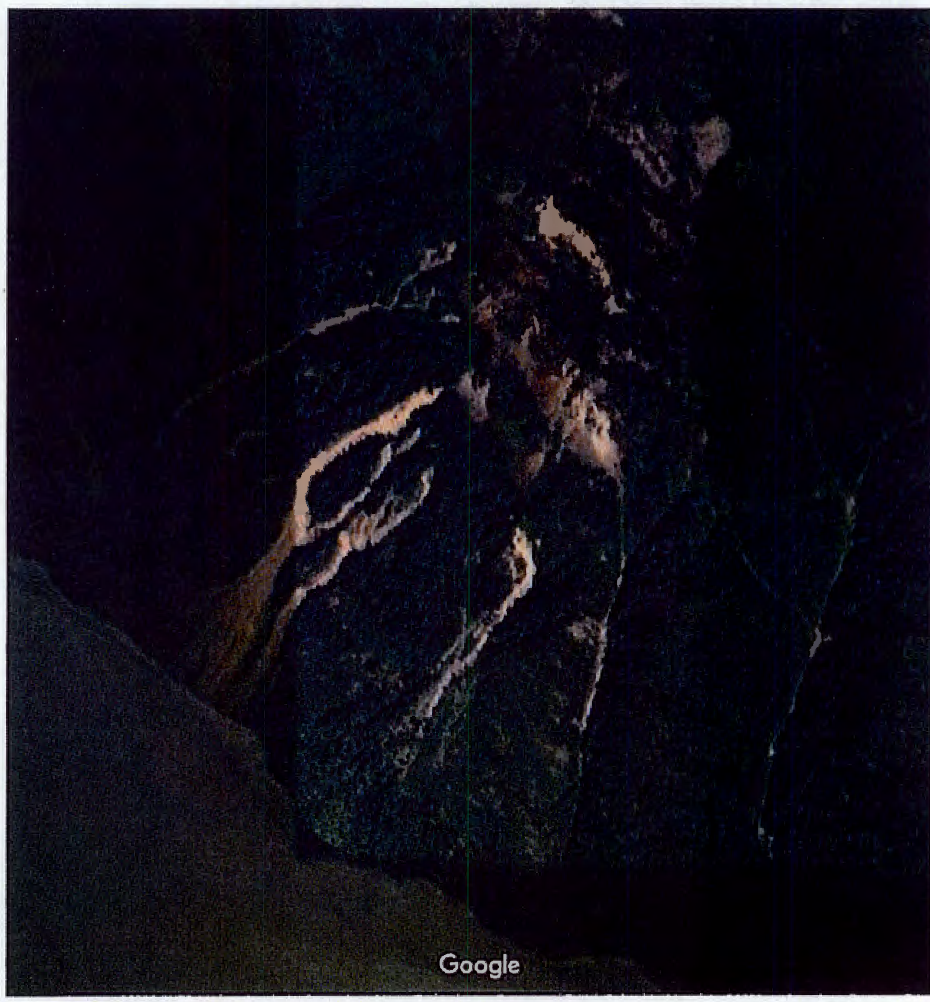

Figure 6.1 The Mt. Breakenridge hazard slope, showing past landslide scaring and possible tension cracks (GoogleEarth image from June 29, 2017).

Bathymetry surveys conducted in 2017 and 2018 (Hughes et al., 2020) discovered evidence of three historical slide events in the lake, two of which would likely have resulted in significant tsunamigenic waves (Figure 6.2). The subsequent investigation into whether there were deposits around the village of which would indicate large displacement wave found no obvious deposits (Kennedy, 2021b). This indicates that while there is historical evidence of large landslides into the lake, the tsunamis created by them may not have severe, or did not travel the extent of the lake (Kennedy, 2021b).

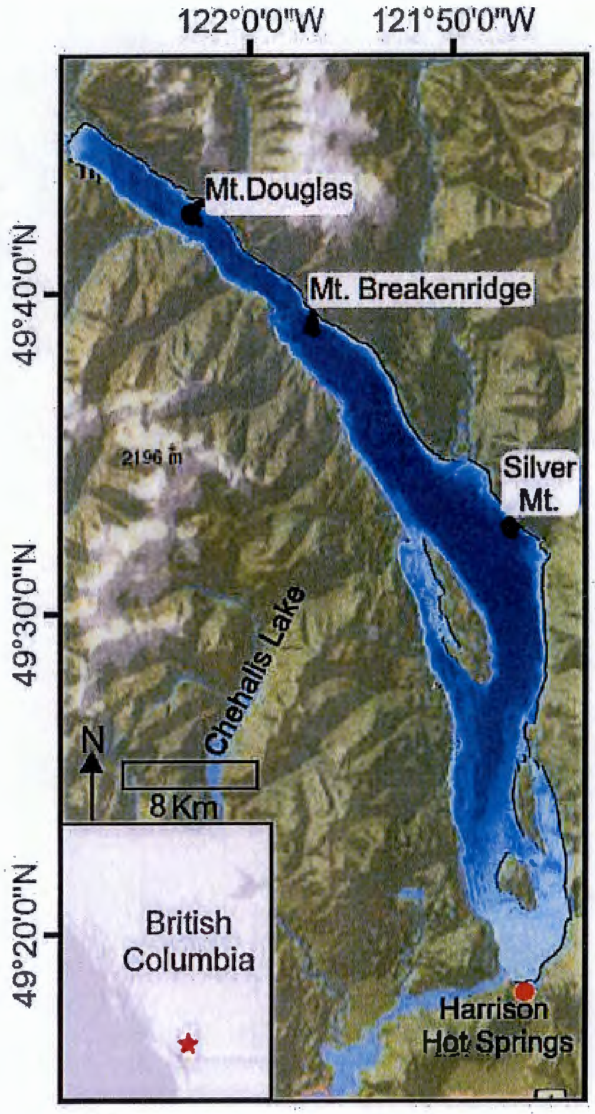

Figure 6.2 Map showing the three potential slides of concern in relation to the village (Hughes et al., 2020).

While there is not much information on the displacement waves which could be created in Harrison Lake, landslide-triggered waves have occurred in other areas where fjords and fjord lakes are prominent in the geography. A recent example is the 2007 tsunamigenic landslide which occurred in nearby Chehalis Lake (also shown on Figure 6.2). It triggered an initial wave as high as 38 m, with waves as high as 7.8 m affecting the far shore of the lake, 8 km away from the rock slide (Hughes et al., 2020). Similar events have been well documented in other areas where glacial fjords are present, such as Norway, and show that consequences to exposed communities can be severe (Hughes et al., 2020).

Landslide generated tsunamis are still considered rare and historically ocean based tsunamis triggered by earthquakes have result in more damage and deaths (Schiermeier, 2017) although there has been an increase in landslides in BC due to permafrost and glacial melting (Hughes et al., 2020). Climate change is increasing the risk in areas where glaciers, permafrost or precipitation falling as snow stabilizes mountain slopes, as melting increases and heat waves become more common (Fountain, 2020). During heat waves, high precipitation events, or progressively hotter summers, water can act as lubricant to loosen or enable large slides (Fountain, 2020). While not easily quantifiable, it provides further motivation to implement more warning and detection measures (Hughes et al., 2020).

It is thought that the likelihood of such an event occurring in Harrison Lake is 1 in 5000 years, with the greatest hazard to the village of Harrison Hot Springs coming from Mount Breakenridge (FVRD, 2021). Evacuations for Harrison Hot Springs and Rockwell Drive would be the responsibility of the village and the District of Kent, who share the Emergency Support Services team to provide essentials like food, clothing, and lodging to those displaced during emergencies (Kennedy, 2021a). The Fraser Valley Regional District would be responsible for evacuating other areas of the lake (Kennedy, 2021a).

7 RECOMMENDATIONS

Based on the work undertaken, a number of recommendations have been identified to improve the resilience of the village of Harrison Hot Springs to the hazards posed by the Harrison Lake.

7.1 Landslide Tsunami Risk

As discussed above, the risk of a tsunami caused by a landslide into the lake has been estimated at 5 m arriving at the village waterfront. Depending on the time of year that the event occurs, this could have significant implications for the village. The following recommendations are provided in order from simplest to most challenging to implement:

1. **Monitoring of the Slope**: In BC, the Downie Slide, which is the largest known unstable slope in the world, has 25 GPS run surface monuments which monitor the movement of different sections of the slide (Kalenchuk et al., 2012). Additionally, it has an extensive drainage system to increase slope stability, as it threatens two dams and a reservoir. Installing a few monuments on the unstable slope on Mt. Breakenridge, with yearly monitoring (to be increased if more movement or landslides occur), is recommended. FVRD could oversee the monitoring system, as the Port Douglas First Nations would also be impacted by such an event
2. **Seabed Pressure Sensors:** In Norway, seabed (or in this case, lakebed) pressure sensors are used to detect large changes indicative of a tsunami; however, it is noted that warning times for these systems are very short (Harbitz et al., 2014). These sensors would need to be paired with a communication method for warning the public.
3. **Escape Route Planning:** In 2020, the Harrison council approved the Rockwell Drive to Lougheed Highway evacuation route to provide a second way out of Harrison Hot Springs (Louis, 2020). However, this route runs along the eastern side of the lake, which would also be at risk from a tsunami if a Mount Breakenridge landslide did occur. The only other road out of Harrison Hot Springs is highway 9, which could become very condensed during an evacuation. Walking/hiking trails up the natural steep bluffs to the east and west of the village could also be considered as back up emergency routes. Both residents and tourists should be made aware of all routes out of the village.
4. **Warning System:** Multiple types of warning systems could be applicable for the village. These include sirens typically installed in coastal regions for tsunami warnings or text message style warning systems currently being implemented by the Government of British Columbia

NHC recommends that at a minimum, item 1 (slope stability monitoring) be put into place at Mount Breakenridge.

7.2 WWTP and Access Road

The current elevation of the roadway is approximately 12 m. Flooding during high water events is a nuisance; however, the more critical aspect is that the roadway is being eroded due to the poor conditions for riprap. NHC recommends that the roadway is increased to 14 m, which is expected to be inundated only during extreme events up to mid-century with current climate projections. Equally as important is that the riprap armour protecting the roadway (and the WWTP if needed) is inspected in a detailed fashion and upgraded so that it functions to protect the roadway. If this is completed, the extreme event floods would result in some water on the roadway allowing village operations staff to still access the facility via land. Additionally, once the water receded, it is expected that no major repairs would be required

7.3 Waterfront Dike Upgrades

It was well documented prior to this study that the Harrison dike was below recommended elevation. Increasing the elevation could be completed via permanent solutions (such as raising the earthworks dike), temporary solutions (such as tiger dams etc) or a hybrid of the two. It is understood that the village prefers the permanent solution and our recommendations reflect this.

Based on the design values calculated here NHC recommends that the dike elevation be raised to an elevation of 15 m across the full length. The reasons being:

- The Miami Creek pump station (completed in 2015) was designed for an FCL of 14.55 m. Based on a review of the drawings it is assumed that the pump station would function to a level of 15.0 m. This will need to be confirmed during a detailed design process.
- An elevation of 15.0 m will allow for the implementation of recommended crest width of 4.0 m and side slopes of 1V:3H as recommended in the Dike Design Manual (MECCS, 2003) without significant engineered structures such as vertical walls.
- The estimated cost of upgrades to this elevation are preliminarily estimated to be under % 5,000,000 which could be covered by the UBCM Strategic Priorities Fund Program.

In addition to the considerations for dike upgrades, the following items should also be considered:

- A review of surface water run-off on the present and proposed future dike. Erosion was observed at a number of dike locations and this is likely a result of poor surface water management.
- Evaluating the addition of sand to the public beaches. The natural sand beach on the south shore of Harrison Lake does not appear to be receiving new sediment and is deflating instead of accreting. The addition of sand would increase the space available to the public during high water events and also reduce the run-up at the top of the dike by inducing wave breaking closer to the dike toe.

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12(a)

HARRISON HOT SPRINGS
Naturally Refreshed

VILLAGE OF HARRISON HOT SPRINGS

REPORT TO COUNCIL

TO: Mayor and Council **DATE:** May 31, 2022

FROM: Tyson Koch, Operations Manager **FILE:** 1855-03-30

SUBJECT: Application for Funding to Complete Necessary Upgrades to the Harrison Lake Dike and WWTP Related Infrastructure – Canada Community-Building Fund (CCBF) in British Columbia – Strategic Priorities Fund

ISSUE: The Harrison Lake Dike, the Waste Water Treatment Plant (WWTP) Access Road and area around the Waste Water Treatment Plant require significant infrastructure upgrades.

BACKGROUND:

On February 10, 2021, Village Council directed staff to engage Northwest Hydraulic Consultants (NHC) to complete a flood risk assessment focusing on the Harrison Lake Dike and the road and infrastructure associated with the Harrison Hot Springs Waste Water Treatment Plant.

Based on the results of NHC's study, the recommended infrastructure upgrades are:

- The Harrison Lake Protective Dike elevation be raised to 15m (from 13.9m), including the installation of wave run-up mitigation works, in order to provide flood protection during extreme high-water levels.
- The WWTP road elevation be raised to 14m (from 12m) including rebuilding the existing rip-rap slope to prevent the road from being inundated by high lake waters. This will ensure Village staff can safely access the WWTP to complete daily environmental operating procedures.

The Strategic Priorities Fund (SPF) is one of three funding streams delivered through the Canada Community-Building Fund (CCBF) in British Columbia, formerly known as the Gas Tax Fund. The current CCBF Agreement provides a ten-year commitment of federal funding for investments in local government infrastructure.

The SPF-Capital Infrastructure stream provides grant funding specifically targeted for the capital costs of local government infrastructure projects that are large in scale, regional in impact, or innovative and support the national objectives of productivity and economic growth, a clean environment and strong cities and communities.

The SPF program can contribute a maximum of 100% of the cost of eligible activities – to a maximum of $6 million. The deadline for this application is June 30, 2022.

Staff recommends engaging NHC to complete the funding application through the Strategic Priorities Fund - Canada Community-Building Fund for up to $6,000,000.00.

RECOMMENDATIONS:

THAT Northwest Hydraulic Consultants be engaged to apply to the Canada Community-Building Fund (CCBF) in British Columbia – Strategic Priorities Fund, on behalf of the Village, for a grant of up to $6,000,000.00 in order to undertake the recommended flood mitigation upgrades to the Harrison Lake Dike, the Waste Water Treatment Plant access road and the foreshore area around the Waste Water Treatment Plant; and

THAT the Harrison Hot Springs Village Waterfront Hydrotechnical Assessment, by NHC and dated May 30, 2022 be received for information.

Respectfully submitted:

Tyson Koch
Tyson Koch AScT, RSIS
Operations Manager

REVIEWED BY:

Madeline McDonald
Madeline McDonald
Chief Administrative Officer

REVIEWED BY:

Scott Schultz
Scott Schultz
Financial Officer

12(b)

HARRISON HOT SPRINGS
Naturally Refreshed

VILLAGE OF HARRISON HOT SPRINGS

REPORT TO COUNCIL

TO:	**Mayor and Council**	**DATE: May 31, 2022**
FROM:	**Madeline McDonald** **Chief Administrative Officer**	**FILE: 0400-40**
SUBJECT:	**Proposed Federal Electoral Boundary Adjustment**	

ISSUE:

The Federal Electoral Boundaries Commission for BC has proposed Federal Electoral Boundary adjustments which would move the Village of Harrison Hot Springs from the Chilliwack Federal Riding into the Mission-Maple Ridge Federal Riding.

BACKGROUND:

The Federal Electoral Boundaries Commission for BC is a parliamentary body which reviews electoral boundaries following every 10-year census. The Commission recommends adjustments to Federal Electoral Boundaries to compensate for changes in population distribution as defined by the census. As a result of the 2021 census, the number of BC Federal Electoral Districts will be increased from 42 to 43 in accordance with a formula found within the Canadian Constitution of Canada. Along with this change comes a reorganizing of electoral boundaries to accommodate the new configuration. Currently, the Commission is proposing to move the Village of Harrison Hot Springs, along with the District of Kent, into the Federal Electoral riding of Mission-Maple Ridge, severing our communities from Chilliwack where our current MP presides.

The proposed move raises concerns about effective political representation at the federal level because many Village residents work in the greater Chilliwack area and most residents go to Chilliwack for shopping, school and professional services, including critical medical services. Mission and Maple Ridge are not the primary service areas for our residents or for our business operators and, at this point, there is no public transit link with those areas from either Harrison or Kent.

The Commission is seeking feedback on the proposed changes and it is recommended that the Village both write to the Commission and attend the upcoming consultation meeting in Chilliwack on September 19, 2022 at 7 pm at the Coast Hotel.

RECOMMENDATION:

THAT the Village write to the Federal Electoral Boundaries Commission for BC objecting to the Federal Electoral Boundary adjustment proposed for the ridings of Chilliwack and Mission-Maple Ridge.

Respectfully submitted:

Madeline McDonald

Madeline McDonald
Chief Administrative Officer

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HARRISON HOT SPRINGS
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VILLAGE OF HARRISON HOT SPRINGS

REPORT TO COUNCIL

TO:	**Mayor and Council**	**DATE: June 6, 2022**
FROM:	**Madeline McDonald** **Chief Administrative Officer**	**FILE: 1880**
SUBJECT:	**2021 Annual Report**	

ISSUE:

The 2021 Annual Report is presented for approval by Council.

BACKGROUND:

Section 98 of the *Community Charter* requires that an annual report be prepared by June 30th each year and made available to the public at least two weeks prior to the meeting. The annual report was made available for public inspection on May 17, 2022. Section 99 of the *Community Charter* requires that council must consider the report at a meeting held at least 14 days after the report is made available for public inspection.

RECOMMENDATION:

THAT the 2021 Annual Report be approved.

Respectfully submitted;

Madeline McDonald
Madeline McDonald
Chief Administrative Officer