



Alberni Valley & Bamfield Services Committee Meeting

Wednesday, December 1, 2021

Zoom/Board Room (Hybrid) – 3008 Fifth Avenue, Port Alberni, BC

1:30 pm

Regular Agenda

Watch the meeting live at <https://www.acrd.bc.ca/events/1-12-2021/>

Register to participate via Zoom Webinar at:

https://portalberni.zoom.us/webinar/register/WN_X3p-D7sdRoe7xS-rMCE8tQ

PAGE #

1. **CALL TO ORDER**

Recognition of Territories.

Notice to attendees and delegates that this meeting is being recorded and livestreamed to YouTube on the Regional District Website.

Introductions of Committee Members and Staff present in the Boardroom.

2. **APPROVAL OF AGENDA**

(motion to approve, including late items requires 2/3 majority vote)

3. **MINUTES**

- a. **Alberni Valley & Bamfield Services Committee Meeting held
September 1, 2021**

3-5

THAT the minutes of the Alberni Valley & Bamfield Committee meeting held on September 1, 2021 be received.

4. **PETITIONS, DELEGATIONS & PRESENTATIONS (10-minute maximum)**

- a. **Duncan Booth, WildSafe BC Alberni Valley Community Coordinator,
End of Season Presentation on the WildSafe Program in the Alberni
Valley.**
- b. **Mandy Ross, WildSafe BC Bamfield Program Coordinator,
Presentation on Past Year's Activities in Bamfield and the WildSafe
Assessment.**

5. REQUEST FOR DECISIONS

a. REQUEST FOR DECISION

Short-term Lease on Lot #15, Alberni Valley Regional Airport **6-9**

THAT the Alberni Valley & Bamfield Services Committee recommend that the Alberni-Clayoquot Regional District Board of Directors approve entering into a (3) three-year lease agreement with Seth and Quinn Melmock for lot # 15 at the Alberni Valley Regional Airport (AVRA) effective January 1st, 2022 to December 31st, 2025 at a rate of \$1626.15 per year plus applicable taxes and yearly BC CPI increases.

b. REQUEST FOR DECISION

Somass Watershed Flood Management Plan (SWFMP) Peer Review **10-73**

THAT the Alberni Valley and Bamfield Services Committee:

- 1. Receive the Hatch Somass Flood Management Plan Peer Review and the Somass Flood Management Plan NHC Response to the Peer Review and further refer to the Board of Directors for review;*
- 2. Recommend to the Board of Directors that staff investigate mitigation options.*

6. INFORMATION REPORTS

a. Alberni Valley Electoral Areas – Roadside Three-Stream Waste Services Update – J. Frank **74-77**

b. Presentation – Alberni Valley Emergency Program Update – H. Zenner

THAT the Alberni Valley & Bamfield Services Committee receives reports a-b.

7. LATE BUSINESS

8. QUESTION PERIOD

Questions/Comments from the public:

- **Participating in Person in the Board Room**
- **Participating in the Zoom meeting**
- **Emailed to the ACRD at responses@acrd.bc.ca**

9. ADJOURN



Alberni-Clayoquot Regional District

MINUTES OF THE ALBERNI VALLEY & BAMFIELD SERVICES COMMITTEE MEETING HELD ON WEDNESDAY, SEPTEMBER 1, 2021, 10:00 AM

Due to COVID-19 pandemic, meeting conducted via Zoom video/phone conferencing

DIRECTORS PRESENT: John McNabb, Chairperson, Director, Electoral Area “E” (Beaver Creek)
Bob Beckett, Director, Electoral Area “A” (Bamfield)
Penny Cote, Director, Electoral Area “D” (Sproat Lake)
Tanya Shannon, Director, Electoral Area “B” (Beaufort)
Dianne Bodnar, Director, Electoral Area “F” (Cherry Creek)
Sharie Minions, Mayor, City of Port Alberni
Ron Paulson, Councillor, City of Port Alberni
John Jack, Councillor, Huu-ay-aht First Nation

REGRETS: Wilfred Cootes, Councillor, Uchucklesaht Tribe Government

STAFF PRESENT: Teri Fong, Acting Chief Administrative Officer
Tricia Bryant, Acting Chief Financial Officer
Wendy Thomson, General Manager of Administrative Services
Paulo Eichelberger, Solid Waste Manager
Jodie Frank, Organics Diversion Coordinator

The meeting can be viewed on the Alberni-Clayoquot Regional District website at <https://www.acrd.bc.ca/events/1-9-2021/>

1. **CALL TO ORDER**

The Chairperson called the meeting to order at 10:00 am.

The Chairperson recognized the meeting is being held throughout the Nuuchahnulth territories.

The Chairperson reported this meeting is being recorded and livestreamed to YouTube on the Regional District website.

2. **APPROVAL OF AGENDA**

MOVED: Director Beckett

SECONDED: Director Shannon

THAT the agenda be approved as circulated with the following amendment: replacement of agenda pages 7 & 8, Request for Decision – City Residential Solid Waste Collection Services Transition Agreement with a revised Request for Decision with updated financials.

CARRIED

3. MINUTES

a. Alberni Valley & Bamfield Services Committee Minutes – July 21, 2021

MOVED: Director Shannon

SECONDED: Director Bodnar

THAT the minutes of the Alberni Valley and Bamfield Services Committee meeting held on September 1, 2021 be received.

CARRIED

4. PETITIONS, DELEGATIONS & PRESENTATIONS

a. Jodie Frank, ACRD Organics Coordinator regarding the City of Port Alberni Organics Program Roll-out

Ms. Frank presented the Regional District's Organics Diversion Program and the City of Port Alberni Organics Program Roll-out.

5. REQUEST FOR DECISIONS

a. Request for Decision regarding City Residential Solid Waste Collection Services Transition Agreement

MOVED: Director Paulson

SECONDED: Director Cote

THAT the Alberni Valley and Bamfield Services Committee recommend that the ACRD Board of Directors authorize the CAO to enter into a 3-Stream Waste Collection Service Transition Agreement between the City of Port Alberni and the Alberni-Clayoquot Regional District, for a term commencing the 13th of September 2021 and ending on the 31st of December 2021.

CARRIED

Director Jack left the meeting at 10:56 am.

Director Jack re-entered the meeting at 11:40 am.

b. Request for Decision regarding Alberni Valley Aquatics Proposed Service – Apportionment & Governance

MOVED: Director Cote

SECONDED: Director Paulson

THAT this report be deferred until a feasibility consultant is retained by the Regional District.

CARRIED

6. REPORTS

a. Alberni Valley Custom Transit – Free Transit for Children 12 and Under

MOVED: Director Jack
SECONDED: Director Shannon

THAT the Alberni Valley & Bamfield Services Committee receives this report.

7. LATE BUSINESS

8. QUESTION PERIOD

Questions/Comments from the public. The Corporate Officer advised there were no questions or comments from the public respecting an agenda topic from Zoom webinar attendees or submissions received by email at responses@acrd.bc.ca.

9. ADJOURN

MOVED: Director Bodnar
SECONDED: Director Minions

THAT the meeting be adjourned at 11:56 am.

CARRIED

Certified Correct:



John McNabb,
Chairperson



Wendy Thomson,
General Manager of Administrative Services



REQUEST FOR DECISION

To: Alberni Valley & Bamfield Services Committee
From: Mark Fortune, Airport Manger
Meeting Date: December 01 2021
Subject: Public request to Lease Lot # 15 Alberni Valley Regional Airport

Recommendation:

THAT the Alberni Valley & Bamfield Services Committee recommend that the Alberni-Clayoquot Regional District Board of Directors approve entering into a (3) three-year lease agreement with Seth and Quinn Melmock for lot # 15 at the Alberni Valley Regional Airport (AVRA) effective January 1st, 2022 to December 31st, 2025 at a rate of \$1626.15 per year plus applicable taxes and yearly BC CPI increases.

Desired Outcome:

To lease lot # 15 at AVRA to build an aircraft hangar and an aircraft Welding and fabrication facility. The outcome will increase aviation services on the airfield.

Summary:

A letter of interest has been received by Seth and Quinn Melmock to lease and develop lot # 15 at the Alberni Valley Regional Airport (AVRA). The purpose of the lease is to build an aircraft welding and fabrication facility.

Background:

The applicant has reviewed the available lots at AVRA and has decided to pursue Lot # 15 to build a aircraft welding and fabrication facility. Permitted uses under the AVRA Airport One Zone (AP-1) list, 1.1(f) aircraft hangar 1.1 (h) Aircraft servicing and maintenance. The applicant has submitted a site plan and building layout for the proposed structure.

Time Requirements – Staff & Elected Officials:

Minimal staff time / monitoring once implemented

Financial:

The lessor will pay the ACRD an annual fee of \$1,626.15/per year plus applicable taxes and yearly BC CPI increases and the annual AMC fee of \$.25/m2 or a minimum charge of \$300/year.

Policy or Legislation:

The proposal meets the requirements of the AVRA AP-1 zoning. A notice of disposition will be placed in the Newspaper and on www.acrd.bc.ca. The Board of Directors must approve lease agreements in accordance with the ACRD Officers Delegation Bylaw.

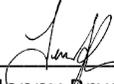
Options Considered:

1. Not enter into a lease.

This is the last airside lease lot available at AVRA. The following options were considered:

2. Defer the lease for future consideration.

Submitted by: 
Mark Fortune Airport Manager

Reviewed by: 
Jenny Brunn, Community Services Manager

Approved by: *Daniel Sailland*
Daniel Sailland, Chief Administrative Officer

CBS8/AVRA Lease Application

RE: Lot 15 Port Alberni Regional Airport

The following information is in regards to leasing the said lot 15 at the Port Alberni Regional Airport.

Name: Seth Melmock/ Quinn Melmock

Company nameTBA

Phone Number 250 895 0351/ 780-235 2050

Visualapproach@hotmail.com/ melmock4@gmail.com

Address: PO Box 1034 Port Alberni BC V9Y 7L9

:Proposal information : Block F of block 209 District lots

130,157,157,172,and 204..... lot 15 CBS8/AVRA Port Alberni Airport

:Location and size : Lot 15 measuring 30.0 metersx32.7 meters 980m²

:Proposed Land use: construction of a 60x60 Aircraft hangar/shop

:Site Plan for intended structures with access requirements.....attached

:Activities that will occur on site: Aircraft welding and fabrication shop

:All structures to be added to the site: 60x60 aircraft Hangar/shop

:The proposed use as a aircraft welding and fabrication shop falls into the guidelines of the current zoning and draft land use plan

:Servicing the lot: water – drilled well Sewer: Septic field Power: 200 amp service

Security issues will include locked Road access and building security

Camera including yard lighting

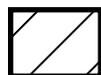
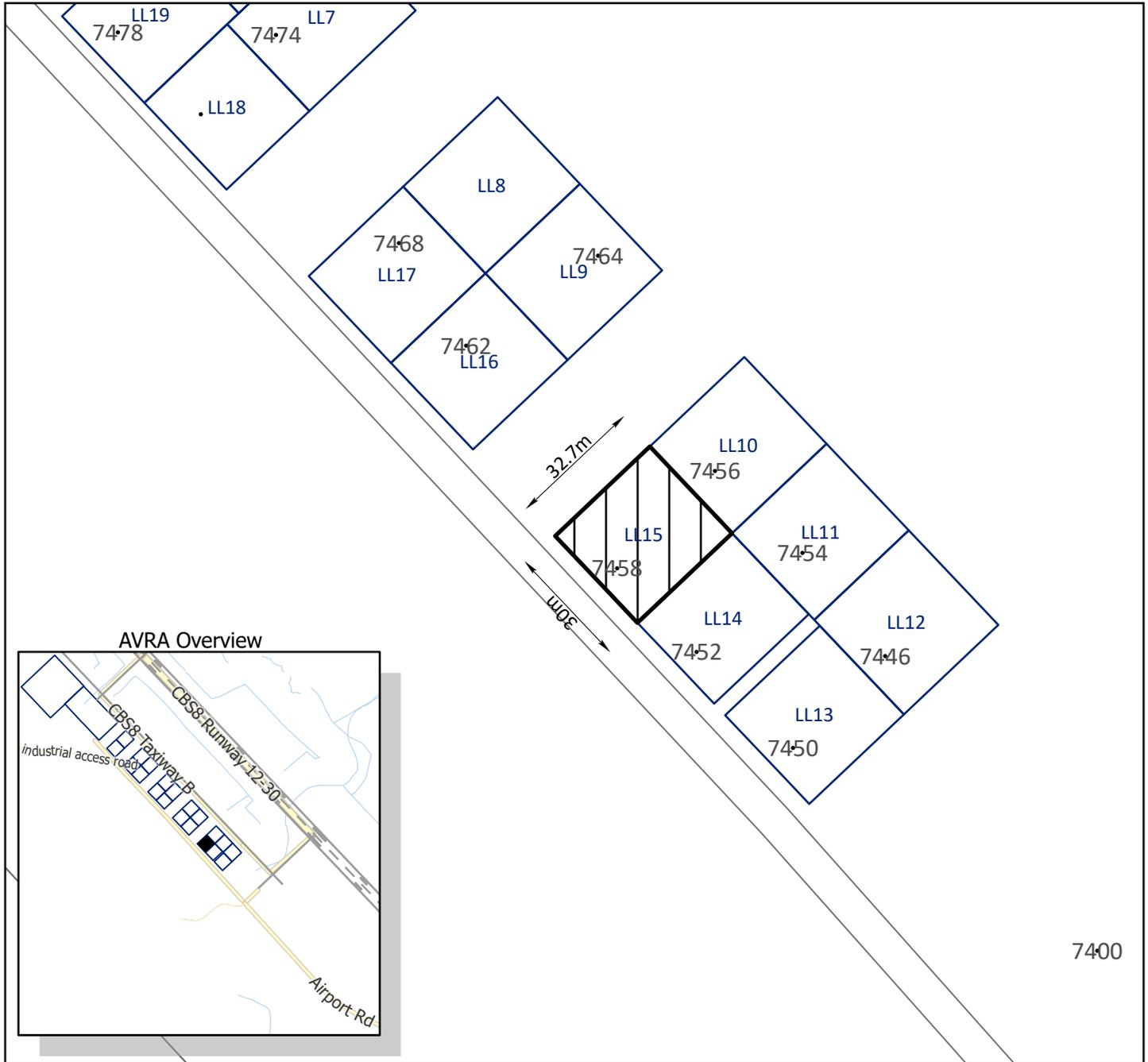
There will be impact on airport activities due to this proposal.

Thank you

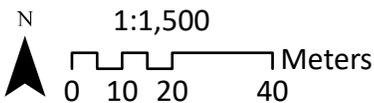
Seth Melmock/Quinn Melmock

Schedule 'A'

This schedule is attached to and forms part of CBS8 - Alberni Valley Regional Airport lease agreement for Lease Lot '15'



CBS8 Alberni Valley Regional Airport Lease Lot '15'
30.0 meters x 32.7 meters; 981 m²



Located at 7458 Airport Rd, Port Alberni,
over a portion of BLOCK F, OF BLOCK 209, DISTRICT LOTS 130, 157,
171, 172 AND 204, ALBERNI DISTRICT



Request for Decision

To: Alberni Valley and Bamfield Services Committee
From: Mike Irg, GM of Planning and Development
Meeting Date: December 1, 2021
Subject: Somass Watershed Flood Management Plan (SWFMP) Peer Review

Recommendation:

That the Alberni Valley and Bamfield Services Committee:

1. Receive the Hatch Somass Flood Management Plan Peer Review and the Somass Flood Management Plan NHC Response to the Peer Review and further refer to the Board of Directors for review;
2. Recommend to the Board of Directors that staff investigate mitigation options.

Desired Outcome:

To confirm the conclusions of the Somass Watershed Flood Management Plan (SWFMP) and then proceed with implementing the new flood maps for the applicable areas within the Electoral areas of the ACRD and explore mitigation options as directed by the Board.

To provide staff direction on next steps which involve separate ACRD services: the first, rural planning and building inspection for land use and flood construction mapping; the second, regional planning for multi-jurisdictional mitigation grant applications and/or studies.

The purpose of this report is to present the Plan to the Committee, make the Plan publicly available and to answer initial questions from Directors. If supported by the Committee, staff will present options to the Board of Directors for applying the new 200-year flood plain mapping to new development.

Summary:

The Somass Watershed Flood Management Plan was funded through a National Disaster Mitigation Program grant of \$500,000 with equal contributions from the Federal and Provincial Governments. The work and report was done by Northwest Hydraulic Consultants Ltd. (NHC) and completed in the spring of 2020. EMBC has reviewed the work and signed off on the report September 29, 2020.

The SWFMP included new flood maps which significantly increase the area covered by flood mapping within the Alberni Valley. These maps apply new flood construction levels for the portions of the Regional District covered by the mapping. The ACRD is responsible for land use planning and building inspection in the Electoral Areas of the ACRD. The City of Port Alberni, Tseshaht First Nation and Hupacasath First Nation would be responsible for applying the flood construction levels in their jurisdictions.

Another aspect of the SWFMP examined opportunities for flood mitigation, two examples of flood mitigation scenarios examined were modifications to the outlet of Sproat Lake and potential for improvements to impacted portions of Highway 4 and Tseshaht First Nation.

When the Board initially reviewed the SWFMP in 2020, there were questions about the new 200-year flood construction levels, which are significantly higher than the previous three-meters above the natural boundary from lakes and water courses as outlined in the Zoning Bylaw. The ACRD engaged Hatch Engineering to conduct a peer review of the SWFMP.

Summary from the Hatch Peer Review (pages 39 & 40):

“A flood management plan has been completed for the Somass watershed using a combination of empirical calculations and numerical modelling. The Somass Watershed Flood Management Plan has been reviewed, excluding Appendix A “Surveys” and Appendix H “Consultation”.

The study has generally followed appropriate industry guidelines and standards for inundation mapping, and includes some additional information that would typically be included in flood hazard maps such as flood depth. The study has generally adhered to standard guidelines and made use of the data available, and included appropriate methods when required data was not available including filling some of the gaps with the data collection program. Some non-conformances have been identified throughout the report, but for the most part these have been judged to be not critical to the results of the study and unlikely to impact the results, or they have been judged to produce conservative results. Some components of the study have been identified as areas that could benefit from additional detail to readily determine if results are accurate as some additional work was required to complete gaps in the documentation of the assessment. However, upon confirming when possible, the methodologies and results appear appropriate and reasonable overall. Many areas provide adequate detail and information from which to draw conclusions, and it is apparent that appropriate effort has been extended to develop an effective hydraulic modelling tool, fulfilling one of the main study objectives. The 200-Year Floodplain Maps are based on the work completed, and overall have been judged to provide an adequate representation of the design event, though they are likely conservative in some areas. The independent flood frequency assessment on the Sproat River near Alberni gauge produced similar results to those in the NHC study, which provides additional confidence in the study results.

Some non-conformances of note or items requiring clarification were identified. One item includes a lack of naturalization of the flows in the study area prior to completing the flood frequency analysis (in regards to the Stamp River Dam and the Ash River hydroelectric discharges). In addition, climate change impacted lake levels were calculated based on a backrouting of the river flows out of the lake, rather than by assessing the inflows to the lake and evaluating how much the level of the lake is expected to increase as a result of higher inflows to the lake. Considering the Great Central Lake’s interaction with the Stamp Lake Dam, the climate change increase should be applied to the inflows to the lake in order to consider the storage effects of the lake itself, determine the resulting lake level, and review how the dam passes this increased flow. This assessment appears to be conservative and results in higher levels on the lakes. One non-conformance that has a large impact on flood mapping includes the omission of the Tsunami assessment, but this was not part of NHC’s scope of work as it is understood that these assessments have been performed previously under a different scope. Some updates to the mapping labels and hatching should be completed for clarity and to showcase the final intended product.

The potential mitigation concept surrounding changes to the channel at the outlet of Sproat Lake was highlighted as a particular concern, and so particular attention was directed to review the details surrounding this concept. The analysis completed appears appropriate and uses an adequate amount of information. The conclusion reached for the mitigation option appears accurate and reasonable for higher return period floods. However, some observations have been noted and potential suggestions have been provided for review based on the available information, to ensure that they have been fully considered in this analysis, and to ensure that the effect of removing the weir or opening the fish windows are properly quantified under all levels of flood.”

Time Requirements – Staff & Elected Officials:

The SWFMP was a substantial project and required a significant amount of staff time to oversee. Staff time will be required to oversee the implementation of the flood maps and new flood construction levels. Within the ACRD, this will involve both planning and building inspection staff.

Staff recommends that the ACRD investigate mitigation options. If the Board supports this recommendation, resources and staff time will need to be included in the 2022 budget to investigate grant opportunities and research mitigation options recommended in the Plan.

Financial:

The grant to complete the Somass Watershed Flood Mapping Flood Management Plan was for \$500,000. Staff time was in addition to the grant. The peer review was approximately \$40,000 plus staff time to review the peer review and prepare reports for the Board.

Based on the Board's direction for implementation and mitigation, staff time and resources will be required. Staff will provide recommendations for the 2022-2026 ACRD Financial Plan. The Electoral Area Directors Committee is currently considering Community Works Funds to complete a flood plain bylaw for portions of the four Alberni Valley Electoral Areas in 2024.

Attachments:

Attached to the staff report is the Hatch Peer Review of the SWFMP and the NHC response to the Peer Review. The complete SWFMP is available on the ACRD web site [Flood Mapping Reports \(acrd.bc.ca\)](http://acrd.bc.ca).

Strategic Plan Implications:

Regional Planning is a core service and the Somass Watershed Flood Management Plan and Peer Review meets Strategic Plan objective 4.1 Identifying hazards and risks and objective 5.1 engaging with community partners.

SWFMP can be used inform updates to emergency planning, which meets Strategic Plan objective 4.3, Improved Coordination. In addition, the SWFMP has been shared with Island Health and the Provincial Approving Subdivision Officer to help inform their decision making.

Policy or Legislation:

The *Local Government Act*, the *Community Charter* and other Provincial statutes regulate how local governments manage flood hazard areas. Section 524 of the *Local Government Act (LGA)* sets out the requirements for regulating flood plain areas. The Flood Hazard Area Land Use Management Guidelines provides direction to local governments on establishing regulations in flood prone areas. This includes options for flood plain bylaws, development permit areas and setbacks in zoning bylaws. The area OCPs must include general policy statements regarding lands subject hazardous conditions.

Submitted by: Michael Irg
Mike Irg, MCIP, RPP, GM of Planning & Development

Approved by: Daniel Sailland
Daniel Sailland, MBA, Chief Administrative Officer

Report

Somass Watershed Flood Management Plan Peer Review

H365315-0000-200-066-0001

[p.p] Groeneveld, Joe [p.p] Groeneveld, Joe

Groeneveld, Joe Groeneveld, Joe

2021-08-12 2021-08-12

			Venturini, Victoria <i>Venturini, Victoria</i>	Zare, Soheil <i>[Signature]</i>	Groeneveld, Joe <i>Groeneveld, Joe</i>		
			2021-08-12	2021-08-12	2021-08-12		
2021-08-12	A	Client Review	S. Bohrn / S. Kenny / S. Murphy / V. Venturini / S. Zare		J. Groeneveld	S. Murphy	Not Required
DATE	REV.	STATUS	PREPARED BY		CHECKED BY	APPROVED BY	APPROVED BY
					Discipline Lead	Functional Manager	Client

H365315-0000-200-066-0001, Rev. A,

Important Notice to Reader

This report was prepared by Hatch Ltd. (“**Hatch**”) for the sole and exclusive use of Alberni-Clayoquot Regional District (the “**Client**”) for the purpose of providing a Peer Review in assisting the management of the Owner in making decisions with respect to the Somass Watershed Flood Management Plan (the “**Project**”). This report must not be used by the Client for any other purpose, or provided to, relied upon or used by any other person without Hatch’s prior written consent.

This report contains the expression of the opinion of Hatch using its professional judgment and reasonable care based on information available and conditions existing at the time of preparation.

The use of or reliance upon this report is subject to the following:

1. This report is to be read in the context of and subject to the terms of the relevant services agreement dated March 22, 2021 between Hatch and the Client (the “**Hatch Agreement**”), including any methodologies, procedures, techniques, assumptions and other relevant terms or conditions specified in the Hatch Agreement.
2. This report is meant to be read as a whole, and sections of the report must not be read or relied upon out of context.
3. Unless expressly stated otherwise in this report, Hatch has not verified the accuracy, completeness or validity of any information provided to Hatch by or on behalf of the Client and Hatch does not accept any liability in connection with such information.

Table of Contents

1. Introduction	1
2. Somass Watershed Flood Management Plan	2
2.1 Somass Watershed Flood Management Plan Report Overview	2
2.1.1 Study Design Basis.....	2
2.1.2 Review of Methodology	4
2.1.3 Discussion on Results	8
2.2 Appendix B - Hydrology Review	9
2.2.1 Study Design Basis.....	9
2.2.2 Review of Methodology	9
2.2.3 Discussion on Results	11
2.3 Appendix C - Coastal Assessment	12
2.3.1 Study Design Basis.....	12
2.3.2 Review of Methodology	14
2.3.3 Discussion on Results	16
2.4 Appendix D - Geomorphology	19
2.4.1 Study Design Basis.....	19
2.4.2 Review of Methodology	20
2.4.3 Discussion on Results	23
2.5 Appendix E - Hydraulic Modelling.....	24
2.5.1 Study Design Basis.....	24
2.5.2 Review of Methodology	25
2.5.3 Discussion on Results	27
2.6 Appendix F - Mapping Methodology	27
2.6.1 Study Design Basis.....	27
2.6.2 Review of Methodology	27
2.6.3 Discussion on Results	28
2.7 Appendix G - Flood Mitigation	28
2.7.1 Study Design Basis.....	28
2.7.2 Review of Methodology	29
2.7.3 Discussion on Results	34
2.8 Appendix I - Flood Depth Maps	35
2.8.1 Study Design Basis.....	35
2.8.2 Discussion on Results	35
2.9 Appendix J - Designated Flood Maps.....	35
2.9.1 Study Design Basis.....	35
2.9.2 Discussion on Results	35
2.10 Assessment of Dam Impact on Flood Mapping.....	37
2.10.1 Background Information	37
2.10.2 Review of Methodology and Discussion on Results.....	37
3. Summary	39
4. References	41

List of Tables

Table 2-1: Flood Mapping Conformance with Selected Guidelines [Flood Mapping in BC, APEGBC, 2017]	4
Table 2-2: Flood Frequency Analysis Conformance With Selected Guidelines [AT, 2001]	10
Table 2-3: Hydraulic Models Developed for the Study	25
Table 2-4: Sproat Weir Design Rating Curve.....	33

List of Figures

Figure 2-1: Schematization of the Components to Determine FCL Based on the Combined Method (Above) and Probabilistic Method (Below).....	13
Figure 2-2 : BC Tsunami Notification Zones	18
Figure 2-3: Sproat Lake Weir 1956 Design Drawing	31
Figure 2-4: Relationship between Sproat River flows and Sproat River lake levels for 1913-1996 (NHC, 2020)	32
Figure 2-5: Sproat Lake Outlet Channel Profile View (NHC) (shown for Mitigation Scenario 4 – widened constriction compared to baseline conditions).....	34

1. Introduction

The Alberni-Clayoquot Regional District (ACRD) commenced preparation of the first ever comprehensive Somass Watershed Flood Management Plan (SWFMP) in 2018 and the report was completed in 2020. The Plan provides flood risk information covering areas of Sproat Lake, Sproat River, Great Central Lake and the Ash River and additionally provides updated flood risk information for the Alberni Inlet, Somass Estuary, Somass River, and the Stamp River where previous floodplain mapping was completed over 20 years ago. The “Designated Floodplain Maps” produced as part of this project depict minimum flood construction levels based on a 200-year flood event, incorporating expected sea level rise and geomorphic uplift projected for the year 2100, as well as freeboard and wave effects at the shoreline. The Regional District requested Hatch provide a peer review of the Somass Watershed Flood Management Plan and the 200-Year Designated Floodplain Maps.

The peer review process documents the review of the Somass Watershed Management Plan as well as its relevant appendices and maps to identify whether the methodology applied to prepare the plan followed appropriate methodologies for the scope that NHC was given. The plan is assessed for use of industry standards and guidelines, the adequacy of data used, and reasonableness of the results. Independent calculations were not performed unless stated otherwise. It is acknowledged that Hatch is not privy to the internal discussions and collaboration that has occurred over the course of this important project, and so professional comment is included where applicable for consideration, but it is acknowledged that the reasoning for specific methodologies is likely available but not documented. This process will bring to light any of these small additions that can increase clarity for the external reader. Any comment that is judged to be important to the outcome of the study is specifically highlighted.

2. Somass Watershed Flood Management Plan

The peer review process has been broken down into individual sections dedicated to review of the main overview report as well as each Appendix included in the previous study, as follows.

2.1 Somass Watershed Flood Management Plan Report Overview

2.1.1 Study Design Basis

2.1.1.1 Scope of Work

The overall project scope of work requested by ACRD for the water management study includes:

1. Development of up to date flood mapping for the Somass River system.
2. Development of a comprehensive hydraulic modelling tool that can be used to evaluate flood mitigation measures.
3. Development of flood mitigation concepts that can be developed in conjunction with habitat restoration to provide integrated water management planning along the river system.

The project was to consist of five separate tasks:

- Consultation with the stakeholder group (*not included in peer review*)
- Hydrological studies
- Field surveys (*not included in peer review*)
- Model development and assessment of base case studies
- Flood mitigation scenarios.

The scope of work states that the mapping must meet APEG flood mapping guidelines.

NHC outlined the following scope within their report:

1. Development of an official 200-year Designated Floodplain Map for the Somass River system.
2. Development of a comprehensive hydraulic modelling tool that can be used to evaluate flood mitigation measures.
3. Development of flood mitigation concepts that can provide integrated water management planning along the river system.
4. Undertake consultation with stakeholder groups (*this objective is not included in the peer review*).

2.1.1.2 *Reference Documents*

The following documents were referenced in the main report:

- Legislated Flood Assessments in a Changing Climate in BC (EGBC, 2018) [Ref. 1]
- Flood Hazard Area Land Use Management Guidelines (Ministry of Water, Land and Air Protection: Province of BC, May 2004, amended January 2018). Referred to as “BC Flood Hazard Guidelines” in report. [Ref. 3]

The SWFMP study was funded by the National Disaster Mitigation Program (NDMP) and Emergency Management British Columbia, which references the APEGBC Guidelines for Flood Mapping in BC [Ref. 4]. This guideline is not specifically referenced in the main body of the NHC report, and is not found in the reference lists in the appendices. It is an industry standard guideline that should be applied to all flood mapping projects. The work is assessed against this guideline to measure its compliance with it regardless.

The category of use for the mapping produced for this assessment indicates “floodplain management”. As discussed in “Flood Mapping BC”, floodplain mapping references a designated flood based on the 1-in-200-year flood (Ministry of Water, Land and Air Protection [MWLAP], 2004). There are no provincial standards for freeboard. The maps are one aspect of floodplain management, as they provide information on the nature of the hazard and risk, but need to be complemented by measures for effective land use planning and regulation of development including floodplain bylaws to address issue such as the requirement for floodproofing and permitted floodproofing methods. It also includes emergency response and recovery, and structural flood protection.

The methodology presented for this study covers the production of 200-year Floodplain Maps for the Somass River system, the development of flood mitigation concepts and the evaluation of these mitigation measures. Effective land use planning, development regulation and emergency response and recovery are not covered within this scope.

Although the maps are not full flood hazard maps, it is noted that additional information is included that forms a portion of this type of study as well. Information on the hazards associated with defined flood events including flood depth is presented. This is included as it assists in the development of mitigation measures, but does not indicate that flood hazard mapping standards are to be followed for this study, which would include additional hazard information such as velocity of flow, duration of flooding, and the relative category (low, medium, or high, for example) of the hazard defined.

2.1.1.3 *Design Criteria*

Design criteria used throughout the study are specified in the individual sections.

2.1.2 **Review of Methodology**

2.1.2.1 *Design Approach*

This study assesses three of the four types of flood hazards evident within the Somass River system: riverine floods generated by extreme winter precipitation combined with snowmelt, coastal flooding generated by extreme high tides combined with storm surges, and flooding on Sproat Lake and Great Central Lake due to high tides combined with storm surges. Assessment of tsunami hazards is not included.

This project was broken down into the following phases:

- Phase 1: Data Collection
- Phase 2: Hydraulic Modelling
- Phase 3: Flood Mapping
- Phase 4: Mapping Review and Future Steps.

Phase 1 and Phase 3 demonstrate input from a “Technical Working Group” as part of Stakeholder Consultation (not included in this review).

Hatch reviewed the overall floodplain mapping analysis against the requirements of the Flood Mapping in BC APEGBC Professional Practice Guidelines (2017). The guidelines describe the standard of care APEGBC members should follow in providing professional services related to this professional activity of carrying out flood mapping in BC and specify the tasks APEGBC members should perform to fulfill their professional obligations. The information in these guidelines is helpful to not only determine if the analysis was conducted properly and in accordance with expected industry standards, but also as a check to determine if sufficient information was provided in order to review and update the analysis in the future. These guidelines form the basic guidance for the overall project, with additional engineering best practices commented on further within each specific report Appendix reviewed, as required.

**Table 2-1: Flood Mapping Conformance with Selected Guidelines
[Flood Mapping in BC, APEGBC, 2017]**

No.	Guidelines for Professional Practice	Guidelines Summary	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
3.1	Categories of Flood Mapping	Mapping types in BC are presented as: Inundation Maps, Flood Hazard Maps or Flood Risk Maps.	Adheres to “Inundation Maps” category. This will be used to assess conformance.
3.2	Climate Change Considerations	References Section 3.5.3 of the APEGBC Professional Practice Guidelines – Legislated Flood Assessments in a Changing Climate in BC.	Discussed in Appendix B Hydrology Review.
		References Ausenco Sandwell (2011) which recommends planning for a 1-m SLR by 2100 and 2-m by 2200. (Reference updated)	Conforms.

No.	Guidelines for Professional Practice	Guidelines Summary	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
3.3	Data requirements	Essential data components of flood mapping include: topographic and bathymetric elevation data, base map features (streams, waterbodies, roads, etc.), infrastructure, land cover, land tenure, geomorphology, climate data, aerial or satellite imagery, hydrometric data. Can be supplemented by historical data. All relevant provincial legislation and local government regulations and policies reviewed.	Conforms.
3.4.1	Topographic Mapping - Mapping Standards	Should adhere to certain standards. Examples include FEMA and EXCIMAP 2007a). No specific standards specified for BC. <i>Note that since publication of Flood Mapping in BC, the Federal Flood Mapping Guideline Series has been developed, including the Federal Airborne LiDAR Data Acquisition Guideline and the Federal Geomatics Guidelines for Flood Mapping. As these guidelines were published during and after the course of this study, they are not explicitly compared here. However, they should be referenced in future studies.</i>	Conforms (generally conforms to the Federal Flood Mapping Guideline series, though not explicitly compared due to release date of guidelines) Some reference to an adapted version of MLIT Flood Hazard Mapping Manual in Japan.
3.4.2	Topographic Mapping - Map Accuracy	No Canadian guidelines for flood mapping accuracy. Depends on flood risk. Highest specification level is for a consolidated vertical accuracy of 36.3 cm, which corresponds to an equivalent contour accuracy of 0.6 m. <i>See note in 3.4.1 on the Federal Flood Mapping Guideline Series above.</i>	N/A for this study.
		LiDAR data should be captured in "leaf-off" conditions.	Unclear if this conforms. Captured mid-September.
		Minimum requirements for DEMs are 10 m by 10 m horizontal resolution (5 m by 5 m preferred), with 0.5 m vertical resolution (0.3 m preferred).	Conforms (0.5 m horizontal resolution). Expected conformance to vertical resolution.
		Current convention: North American Datum of 1983 (NAD83) for horizontal control. Canadian Geodetic Vertical Datum of 1928 (CGVD28) for vertical control, in process of being replaced by CGVD2013.	Conforms. CGVD2013 applied.
		Flood maps are to reference datum and note the conversion correction to the other datum.	Partially conforms. Conversion correction not provided, but this information can be readily found and has no impact on study.
		Projection: UTM with coordinates in metres as northings and eastings within the UTM grid.	Conforms.

No.	Guidelines for Professional Practice	Guidelines Summary	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
3.4.3	Topographic Mapping - Mapping Technologies	To generate data required to construct DEMs required for flood mapping: Ground surveys, GPS surveys, photogrammetry, LiDAR combined with orthorectified digital imagery, synthetic aperture radar (SAR) and its variations (IFSAR, GeoSAR, AIRSAR).	<p>Conforms.</p> <p>Study uses terrestrial surveying of bridges and hydrometric benchmark surveys to shift water level data into CGVD2013 datum.</p> <p>Study uses sonar instruments for bathymetric survey.</p> <p>Study uses LiDAR (flown September 2018 and as available from July 2014).</p>
3.5.1	Inundation Mapping – River Floods	<p>Design Floods</p> <p>Design floods for traditional floodplain maps have been return periods of 200 years, used to establish design elevations for flood mitigation works and FCLs (Fraser River uses the Flood Of Record). For debris flood and debris flow hazards, higher return periods are typically selected. This is the standard-based approach.</p> <p>A risk-based approach is increasingly being used to align design return periods with risk. If geohazards exist, for example, (debris flow, landslide dam breach), design flood return periods should be increased.</p>	<p>Conforms to standards-based approach for traditional floodplain maps with a selected 200-year return period.</p> <p>EGBC 2018 outlines this expectation in a BC floodplain map.</p>
		<p>QP should recommend design flow, but the client should make the final decision.</p>	<p>Conforms.</p> <p>This scenario was confirmed with ACRD in a May 9, 2019 memo “Selection of Climate Change Adaptation Scenarios”.</p>
		<p>QP responsible to ensure that ice jam floods are considered as part of determining the appropriate design flood.</p>	N/A
		<p>If a design event is anticipated to contain a large amount of debris, it may be appropriate to apply a bulking factor to account for the increased volume of flow.</p>	N/A
3.5.1	Inundation Mapping – River Floods	<p>Hydraulic Modelling</p> <p>Should reflect local variation in topography caused by dikes, roads, buildings and potential impediments to flow; culverts and bridges.</p>	<p>Mostly conforms.</p> <p>Some discussion on inclusion of bridge deck for scenarios where it is affected.</p>

No.	Guidelines for Professional Practice	Guidelines Summary	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
		Calibration and validation exercises should be completed.	Conforms. Specific monitoring sites were established during the study to collect hydrometric data to calibrate the model. Historic records used to validate.
		Does not normally include representation of scour, erosion or deposition.	Conforms. The hydraulic model does not attempt to represent these processes.
3.5.1	Inundation Mapping – River Floods	Freeboard Typical values for “water” floods are 0.3 m above the maximum instantaneous design flood level or 0.6 m above the mean daily design flood level (whichever is higher).	Conforms. FCLs include a freeboard of 0.6 m.
		Larger freeboards applied where there is potential for debris floods, debris flows, ice jams, debris jams, sedimentation, etc.	Conforms. Additional notes on maps where there is potential for bank erosion or other bankline alterations.
		In coastal situations, it is applied on top of wave, surge and SLR allowances.	Conforms.
		Important to note if freeboard is incorporated onto an inundation map.	Conforms. The 200-Year Designated Floodplain Maps indicate where freeboard is included.
3.5.2	Inundation Mapping – Alluvial Fans	N/A	N/A
3.5.3	Inundation Mapping – Coastal Floods	FCL is the sum of SWL, local SLR, wave effects and freeboard. Two methods can be used to define SWL Combined Method, where the design still water level (SWL) parameters (tide, and storm surge) are summed independently of whether they are likely to occur simultaneously Probabilistic Method, which assesses the likelihood of each SWL component occurring simultaneously.	Conforms. NHC used the probability method to define SWL and addresses all other FCL parameters. However, the report lacks detail in some areas (see Section 2.3).
		Tsunami should be considered.	Does not conform. (see Section 2.3)

No.	Guidelines for Professional Practice	Guidelines Summary	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
3.5.4	Inundation Mapping – Dike Breach Flood Levels	More realistic flood elevations in floodplain areas can be calculated by simulating dike breaches and modelling the propagation of resulting flood waves over the floodplain. ... Various breach locations should be assessed to establish the worst case scenario, and combinations of breaches should be included in the analysis.	Does not conform. Conservative assumptions made to account for dike breach scenarios.
3.6	Flood Hazard Mapping	N/A	N/A for scope, but some hazards were mapped (depth of flow).
3.7	Flood Risk Mapping	N/A	N/A
3.9.1	Deliverables - Map Notations	Includes disclaimers as relevant (regarding boundaries, base information quality, etc.).	Partially conforms. Disclaimers are included. Base information acquisition dates included, but base information quality is not included. Does not affect outcome.
3.9.2	Deliverables - Specifications	Map sheet should include: base map/photo and flood information block, base map author and stamp block, flood risk author and stamp block, legend, north arrow, datum, scale, contour interval, map sheet index, client logo, title, sheet number. (National Guidelines, AECOM 2013).	Mostly conforms. Contours not included on map. Does not affect outcome.

In addition to the above components specifically outlined in the Flood Mapping guidelines, additional items were completed by NHC including a geomorphology assessment and the production of flood depth maps. The main report states that “channel stability and sediment deposition are important considerations in flood mapping as they influence the accuracy of mapping and the recommended freeboard requirements”. This is further explained in the Appendix D review section. The flood depth maps were produced for additional information purposes only, and are not part of the typical flood mapping package. They were produced to compare flood scenarios and assist with providing input for high level planning.

2.1.3 Discussion on Results

NHC has prepared flood mapping for the Somass River system using appropriate guidelines and standards. HEC-RAS 1D and 2D models were prepared using high quality data, and hydrologic inputs were prepared taking climate change into consideration, with climate change driven coastal effects.

In general, the overall analysis has adhered to the guidelines as presented in Table 2-1, with some minor non-conformances. In our opinion, most of these are not critical to the results of the study and are not likely to impact the results. The non-conformance identified from the

general overview that has the largest impact on flood mapping includes the omission of the Tsunami assessment, but this was not part of NHC's scope of work.

In accordance with *APEGBC Professional Practice Guidelines – Flood Mapping in BC*, a Flood Mapping Assurance Statement should be completed, signed, sealed and dated for this project. As described within the statement, this may follow this peer review once any significant comments are addressed, as applicable.

2.2 Appendix B - Hydrology Review

2.2.1 Study Design Basis

2.2.1.1 Scope of Work

ACRD requested that NHC carry out the hydrologic assessment necessary to complete the flood mapping exercise for the Somass watershed.

2.2.1.2 Reference Documents

The hydrologic analysis followed the guidelines that are laid out in the EGBC Legislated Flood Assessments as well as the APEGBC Professional Practice Guidelines for Flood Mapping in BC. The first document does not prescribe a methodology for hydrologic assessments, but speaks qualitatively about the kinds of assessments that can be undertaken. The NHC report also made reference to some publications that deal with the impacts of climate change and sea level rise on the flows and water levels in the area.

The documents that were used as references and guidance documents are generally accepted and appropriate industry guidelines.

2.2.1.3 Design Criteria

The Professional Practice Guidelines for Flood Mapping in BC state that flood frequency analysis should be conducted to determine the magnitude of the 20 year flood as well as the 200 year flood. The former is used to apply Health Act requirements for septic systems, while the latter is used to establish design elevations for mitigation measures and flood construction levels.

2.2.2 Review of Methodology

2.2.2.1 Design Approach

NHC reviewed the available hydrologic data and performed flood frequency analysis to determine the appropriate inflows to be used in the hydraulic models. Those in turn were used to produce the flood maps for the watershed.

2.2.2.2 Flood Frequency Analysis

Hatch reviewed the flood frequency analysis against the requirements of the Alberta Transportation Flood Frequency Guidelines (2001). The Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation (2019) were also used, however the guidance in these two documents is very similar. While the guidelines were written by Alberta Transportation, they are applicable in any jurisdiction and they provide an indication of what

to look for when reviewing a flood frequency assessment. The information in these guidelines is helpful to not only determine if the analysis was conducted properly and in accordance with accepted industry standards, but also as a check to see if sufficient information was provided in order to review and update the analysis in the future.

Table 2-2: Flood Frequency Analysis Conformance With Selected Guidelines [AT, 2001]

No.	Guideline	Somass Watershed Flood Management Plan Analysis (NHC, 2020)
5.1.3	Use a filled series of instantaneous peaks if there are only a few missing, otherwise analyze daily and apply a peaking factor to the analysis results.	Conforms. Analyzed instantaneous, but used a regression method (MOVE) to determine instantaneous peaks for missing years.
5.1.4	If flow regulation is significant, de-regulate the series if possible to extend the record to as long as possible.	Does not conform. No de-regulation was performed, and data from prior to the regulation were omitted from the study.
5.2.1 5.2.2 5.3	Fill short gaps in the record and extend records by correlation with a nearby station if the records are highly correlated and missing data are likely to affect the results.	Partially conforms. The records were not infilled or extended, but no discussion was provided on if the gaps in the record could impact the results of the analysis. Note: only one station was used that had a record past 2000 since many of the stations have been discontinued.
7.1	Test at least the Log-Normal, Gumbel, and Log-Pearson III distributions.	Partially conforms. The report uses the LP3 distribution and makes mention of tests on the Gumbel, GEV, and log-normal distributions, but does not show them in a plot to assess the goodness of fit.
7.6	Exclude low outliers when determining sample skew.	No mention of skew in the analysis, so does not conform.
9.1.3	List streamflow gauging stations and periods of record.	Conforms.
9.1.3	Include a map showing basin boundaries, stream network and gauging stations	Conforms. Figure 1 shows this basin overview very well.
9.1.4	Summarize previous studies for the same site.	Does not conform. No mention of the 1997 work done as part of the Floodplain Mapping Project in the Hydrology Appendix, and only a passing mention in the main body of the report. Comparing the current results to previous allows for a better understanding of what may have changed in the intervening years and is a good check on the magnitude of the current results.
9.2.3	Present sequential plots of the data series. Discuss peculiarities and anomalies.	Does not conform. These plots and discussion can help to identify trends over time or any possible shifts that may have occurred in the watershed.
9.2.4	Present the results of tests for stationarity and homogeneity.	Does not conform. These tests are not shown in the report. Many typical statistical software packages calculate these values.
9.2.6	Present frequency curves	Conforms. Frequency curves were provided for the LP3 distribution.
9.2.7	Report uncertainty in flood frequency estimates.	Conforms. The 95% confidence interval was provided for the LP3 Flood Frequency Estimates.

In general, the analysis has adhered to these guidelines, with some non-conformances. In our opinion, most of these are not critical to the results of the study and are not likely to impact the results.

One area that could be considered a shortcoming of the study was the lack of naturalization of the flows in the study area prior to completing the flood frequency analysis. Standard practice in regulated watersheds such as the Somass Watershed is to perform analysis on the annual peak flows and remove the impacts of regulation. Regulation serves to moderate extreme values in the data set, making the highest values lower by storing some of the runoff associated with high flows and increasing the lowest flows by releasing some of the stored water. More data and a thorough analysis of the impacts of the Stamp River Dam and the Ash River hydroelectric discharges on flood flows is required in order to determine the impact that this would have on the extreme flood flows in the study area.

In order to account for the impacts of climate change on flows in the areas, NHC reviewed a number of General Circulation Models (GCMs) to determine the impacts to temperature and precipitation. After reviewing the data from the available models, NHC adjusted the flows on the streams in the area by 10 and 20% on each of the rivers for the 2050 and 2080 200-year flood events, respectively. In order to determine the climate change impacted lake levels, they then modeled the system using a 1-D hydraulic model. The NHC findings were that precipitation values are projected to increase by 9 and 17% for 2050s and 2080s, respectively in the winter for the RCP8.5 scenario (the climate scenario with the greatest atmospheric carbon, a worst-case scenario). They then rounded up to adjust the flows (the assumption was that flow was more or less directly proportional to precipitation) by 10 and 20%.

While insufficient information is available to definitively determine how the assessment was conducted, it appears that the climate change impacted lake levels were calculated based on a backrouting of the river flows out of the lake, rather than by assessing the inflows to the lake and evaluating how much the level of the lake is expected to increase as a result of having the higher inflows. While this assessment is conservative and results in higher levels on the lakes, it may be overly so in this case as it appears to result in excessively high levels on both Great Central Lake and Sproat Lake as a result of climate change.

Spreadsheets were provided that contained the results of the flood frequency analysis that was completed by NHC. These spreadsheets were reviewed but were password protected and did not contain any formulas so they were of limited use to this review and did not change the above conclusion.

2.2.3 Discussion on Results

NHC produced a series of tables that provide the flood peak flows (or water levels for the lakes) for a series of return periods with varying degrees of climate change. Their results appear to be reasonable and derived using typical industry methods. While the climate change estimates of 10% and 20% are slightly arbitrary, they are justified in the report and provide a measure of conservatism into the future. In the absence of more detailed climate

change modelling (such as the PCIC station data that is available for mainland BC), the estimate made by NHC is appropriate.

An assessment on the impacts of regulation on the flows should be carried out to estimate the flood frequency using naturalized values. Depending on the available storage, dams will typically moderate extreme flows and by not removing the effects of regulation, the estimates of flood frequency may not be fully representative of the hydrology of the system. Further analysis of the structures and how they impact flood peak flows is required to fully assess the impacts on the study results.

Hatch performed an independent assessment of the flow record on the Sproat River near Alberni (08HB008), testing multiple distributions and examining the uncertainty associated with the estimate with the HYFRAN+ statistical package. This station had data from 1914 to 2017 (93 years of data because some years were incomplete or missing) that were used for the analysis. This is the same dataset that was used by NHC in their analysis as no additional data was available. The finding from this assessment was that the Log-Pearson Type III distribution (the one chosen by NHC) fits the data the best, especially at the high end of the distribution and is therefore the most appropriate distribution to use for determining the 200-year flood. The results for the peak flow associated with this event also matched closely with what NHC calculated, which gives confidence that their results are appropriate.

The findings of the climate change portion of the analysis made use of available data and used reasonable assumptions to determine the impacts to flows as a result of the changing climate. Estimates of water levels on the lakes use a backrouting technique rather than assessing the inflows to the lake and their impact on water levels, which may result in excessively high water levels on both lakes.

2.3 Appendix C - Coastal Assessment

2.3.1 Study Design Basis

2.3.1.1 Scope of Work

To define the Flood Construction Level (FCL) along the shorelines of the Alberni Inlet, Sproat Lake, and Great Central Lake, NHC performed a study of the water levels generated by astronomical (tides), meteorological (waves, storm surge), climate change (Sea Level Rise - SLR), and land characterization (wave run-up on different shoreline types).

2.3.1.2 Reference Documents

The NHC report states that the study followed the BC Ministry of Forests Natural Resources Flood Hazard Area Land Use Management Guidelines (BCMFLNRD, 2018), and the Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use Sea (2011). Both documents are also referenced within the Professional Practice Guidelines Legislated Flood Assessments in a Changing Climate in BC (2018); however, the report does not refer specifically to the latter.

Additional standard coastal documents and tools, such the numerical model SWAN and the EurOtop Manual (2016), were used in the assessment.

2.3.1.3 Design Criteria

As shown in Figure 2-1, FCL along coastal areas can be defined based on a:

- Combined Method, where the design still water level (SWL) parameters (tide, storm surge, and SLR) are summed independently of whether they are likely to occur simultaneously
- Probabilistic Method, which assesses the likelihood of each SWL component occurring simultaneously.

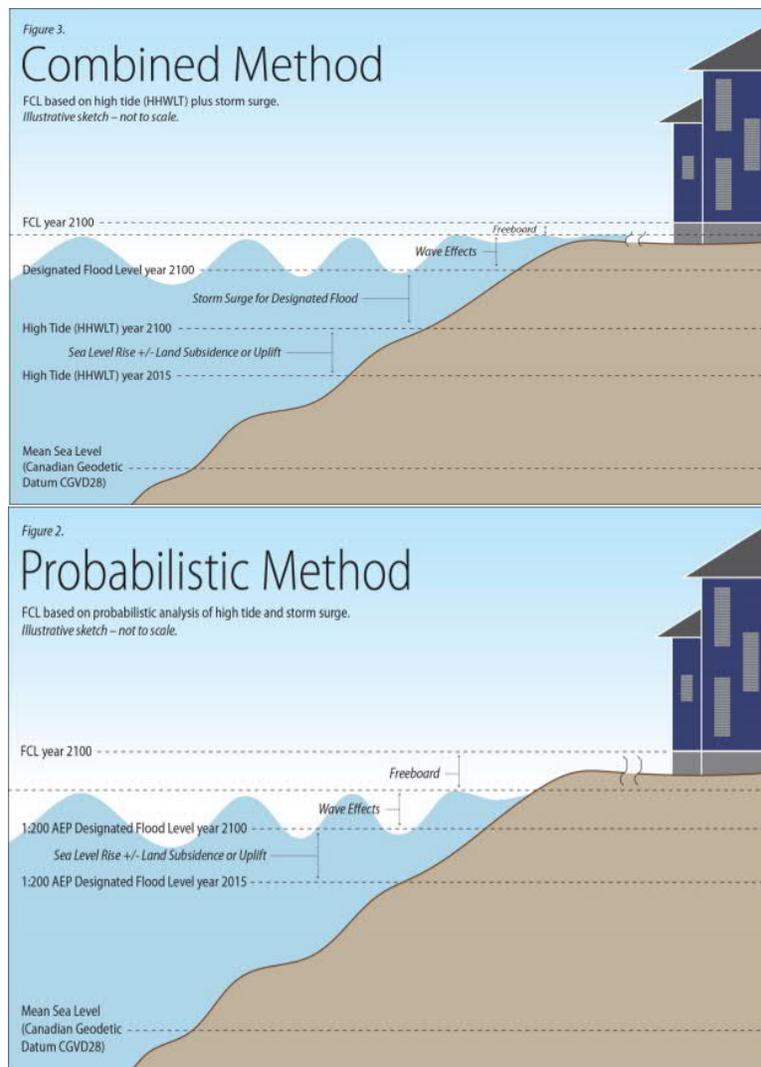


Figure 2-1: Schematization of the Components to Determine FCL Based on the Combined Method (Above) and Probabilistic Method (Below)

For this study, NHC adopted a probabilistic methodology and summed the following parameters to determine FCL:

- The 1 in 200 Annual Exceedance Probability (AEP) water level, including:
 - ◆ Allowance for future SLR to the year 2100
 - ◆ Allowance for regional uplift, or subsidence to the year 2100.
- Estimated wave effects associated with the Designated Storm with a 200-year AEP, including:
 - ◆ Wave run-up
 - ◆ Wind and wave setup.
- Seiches within the lakes
- A minimum freeboard of 0.6 m.

As noted in Section 2 of the NHC Final Report, tsunami hazard was not considered in this assessment.

2.3.2 Review of Methodology

2.3.2.1 Design Approach

2.3.2.1.1 Water Levels

The 1 in 200 AEP water levels for each section were defined based on the following methodology:

- For Port Alberni Inlet, an extreme event analysis was applied to the water levels recorded by the Port Alberni tide gauge (Station # 8575) using a Gumble and GEV distributions for an annual maxima methodology, as well as a Generalized Pareto Distribution (GPD) peak-over-threshold (POT) method. The report provides the table of results for the distribution with the best fit but does not specify which one it is.
- For Sproat Lake and Great Central Lake the 200-year AEP is defined in Appendix B of the NHC report and is addressed in more detail in Section 2.2 of this review document.

2.3.2.1.2 Climate Change - Sea Level Rise and Precipitation

The impact of climate change components was estimated based on the following approach, for each relevant coastal zone:

- For the Port Alberni Inlet, the SLR allowance follows the Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use Sea (2011) projection of 1.0 m by 2100 and 2.0 m by 2200. A regional uplift allowance of -0.17 m by the year 2100 was used, which results in a net regional SLR of 0.83 m
- For Sproat Lake and Great Central Lake, the impact of increased precipitation for different scenarios is defined in Appendix B of the NHC report and is addressed in

Section 2.2 of this review document. Table 16 of the Coastal Assessment report presents the FCL results but does not specify which climate change scenario was applied to the 1 in 200 AEP Total Water Level. Commentary on this is provided in Section 2.2.

2.3.2.1.3 Wave Effects

Wind

The results of an analysis of regional winds were used to characterize waves along the shorelines of Port Alberni, and Sproat Lake and Great Central Lake. The “Port Alberni A” meteorological station was deemed to provide the most representative winds for generating waves in the area of interest. An extreme event analysis of southerly winds, which have the largest frequency of occurrence as shown in the rose plot distribution presented by NHC in Section 1.3.1 of Appendix C of the Final Report, was carried out using Gumble and GEV distributions for annual maxima methodology, as well as a GPD distribution for the POT method. The best fit distribution was used to define wind speeds for different return periods, which yielded a speed of 22.4 m/s for the 200-year AEP. The report does not specify which distribution provided the best fit.

Wave Generation

For each area of interest, waves were developed based on the following methodology:

- For the Port Alberni Inlet, the numerical wave model SWAN was setup and used to determine significant wave height (H_s) along different reaches of the inlet, based on the 200-year wind event from the South. Since no measure waves are available for comparison/calibration, sensitivity tests of the different wave generation equations included in SWAN were carried out to determine which would yield the highest wave height. This results in selection of the ST6 equation.
- For Sproat Lake, the numerical model SWAN was also used. The 200-year AEP north-easterly, easterly, south-easterly, south-westerly, westerly, and north-westerly 200-year AEP wind events were used to generate waves along the lake shorelines, however the results on the wind extreme analysis for those wind directions is not presented in the report. In contrast to the method selected for Port Alberni, the selected wave equation was based on a literature review, which led to the use of the Komen equation. The wind event which yielded the largest significant wave height was used to characterize waves along different reaches of the lake.
- For the Great Central Lake, since no bathymetry data was available, the JONSWAP parametric wave hindcast, described in Kamphuis (2010) was used. It is unclear which wind events were used to determine significant wave heights along the different reaches. The report mentions that the longest fetch is 12 km for winds from the East.

Wave Run up

The report cites the use of three methodologies:

- EurOtop Manual (2016) used for shorelines protected by Rip-Rap revetment
- Stockdon (2006) used for gravel or sandy beaches
- Shoreline Protection Manual (1984) used for shorelines protected by vertical walls.

The tables provided in the report indicate that each shoreline can be classified as:

- The Port Alberni Inlet shorelines protected by rip-rap structures
- Sproat Lake has been subdivided into grassy slopes, retaining walls, and Rip-Rap slopes
- Great Central Lake has been subdivided into grassy slopes, and Rip-Rap slopes.

Wave and Wind Setup

The report states that wave and wind setup were calculated using Equations 2 and 3 from Moura et al (2013), and the Hydrotechnical Considerations for Dam Safety (2013).

No additional details are provided, besides the table of results.

Seiches

The identification of seiches and their period within Sproat Lake and Great Central Lake was based on a comparison between Merian's formula and measured data at 15- and 5-minute intervals for the period November 2018 and April 2019, as well as through a spectral analysis of the measured data. Graphical analysis results are provided only for Sproat Lake, but the same seiche elevation of 0.03 m is applied to both lakes.

2.3.3 Discussion on Results

In general, the methodology applied for determining each component of the FCL based on a probabilistic approach follows standard guidelines and the results appear to be reasonable.

However, the report does not provide a significant amount of detail, in some cases limiting itself to citing the references used and the results obtained, without providing all information required to verify whether the results are accurate. In addition, the assumptions appear to be inconsistent.

The following list describes items that could benefit from more detail, but that are not believed to significantly affect the end result:

- A regional uplift allowance of -0.17 m by the year 2100 was used, but does not appear to match the annual rate of 2.5 mm/yr identified by the 2011 BC guidelines. However, although not cited in the report references, it does match the rate of 2.06 mm/yr identified in the Relative Sea-level Projections in Canada and the Adjacent Mainland United States, issued by the Geological Survey of Canada in 2014.

- The selection of the SWAN model equation for the Port Alberni inlet was based on a sensitivity analysis of the available options, while for Sproat Lake the selection was based on a literature review.
- Wind speeds for different return periods have been provided only for South winds. While for Port Alberni the South wind speed for the 200-year AEP was used explicitly, winds from multiple directions, with unknown wind speeds, were used to establish the maximum significant wave height within Sproat Lake.

For the Great Central Lake it is not known what wind direction or speed was used. A check of the possible wave height and associated periods generated using the JONSWAP wave hindcast equation would suggest that a wind speed of 33 m/s has been used to obtain the wave height results presented in Table 8 of the NHC report. This assumption appears to be overly conservative based on the wind data presented in the report (i.e., 22 m/s wind speed from the South for the 200-year AEP).

- With regards to run-up:
 - ◆ It is unclear why the Stockdon (2006) reference was used, since the tables of results do not identify areas with sandy or gravel beaches.
 - ◆ The EurOtop (for which the latest edition is 2018, not the cited 2016) provides equations to address both Rip-Rap and vertical walls. Therefore, the reference to the use of the Shore Protection Manual (1984) is unclear.
 - ◆ No distinction appears to have been made on slope angles, which will have a significant impact on run-up.
- The report states that wave set up is based on Moura et al. 2013; however, this work does not provide equations and is not entirely applicable to this work since it addresses only tidal inlets. It is likely the equation 2 from Tinh et al. (2008, instead of the cited 2007 article below Figure 20 of the NHC report) has been used. However, this assumption and how the equation was applied cannot be verified, based on the available information.
- Seiche analysis is presented for Sproat Lake, but the same results are applied to both lakes.

Although the items above should be clarified, it is not believed that additional details would result in a significant impact on the final FCL results presented in Table 15, 16 and 17 of Appendix C of the NHC Final Report.

With regards to wave run-up, a more detailed classification of each section of shoreline and of its geometry would be required to provide more accurate results; however, as stated in the Report, this was outside of the NHC Scope of Work. If additional work on wave run-up is carried out, it is noted that the allowable overtopping for different shoreline uses should be considered, as recommended in the EurOtop manual (2018).

The main consideration that arose from the review of Appendix C of the NHC Flood Assessment Report, is that tsunami hazard was not considered. The Flood Hazard Area Land Use Management Guidelines (2018) states that areas subject to significant tsunami hazard, as defined in the by zones A, B, C, and D of the tsunami notification zone shown in Figure 2-2, should consider tsunami hazards. However, this was outside of the NHC Scope of Work.

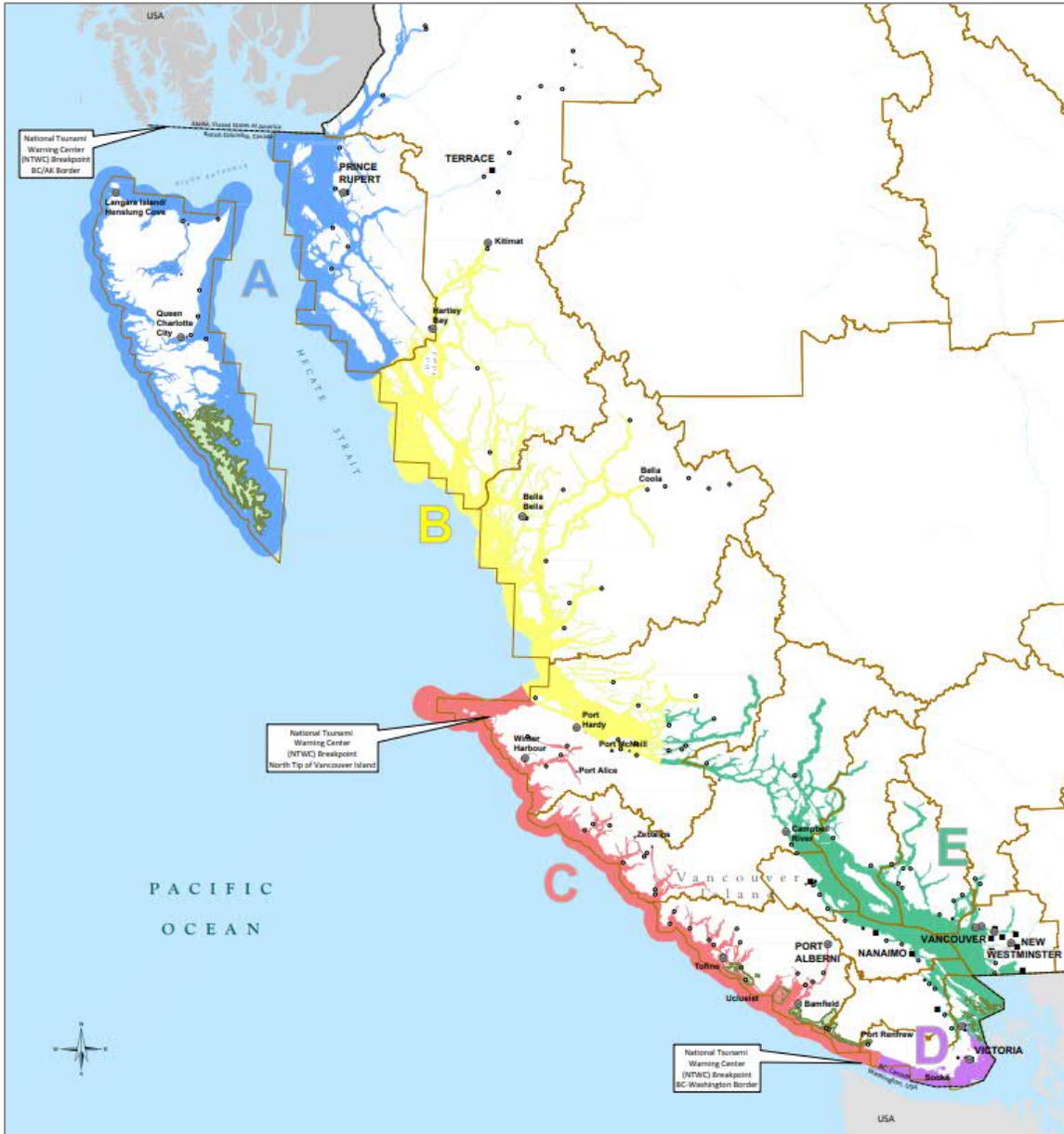


Figure 2-2 : BC Tsunami Notification Zones

The Climate Change Adaption Guidelines for Sea Dikes and Coastal Flood Hazard Land Use Sea (2011) state that the freeboard allowance should be the greater of:

- 0.6m, or
- For flood proofing fill – the crest elevation of an equivalent sea dike
- For exposed vertical building foundations – the wave-structure interaction
- For tsunami areas – the runup elevation of the appropriate tsunami hazard.

2.4 Appendix D - Geomorphology

2.4.1 Study Design Basis

2.4.1.1 Scope of Work

NHC carried out a geomorphology assessment of the Somass watershed to support the flood management plan, with a focus on the river's channel stability. While ACRD did not explicitly list a geomorphology assessment in the project's scope and objectives, the APEGBC Professional Practice Guidelines for Flood Mapping in BC [Ref. 4] states that bank erosion can be a significant flood hazard and should be considered to determine whether shoreline setbacks should be added to the flood hazard maps. However, a geomorphology assessment is not necessarily required for flood inundation mapping.

NHC states that the scope of the geomorphology assessment is to provide qualitative insight, while only providing limited quantitative assessments on the channel stability along the study reach. The summary of the report aims to assess the channel patterns over time, and to assess the effects of sediment on flood levels.

2.4.1.2 Reference Documents

The following key documents were referenced in the geomorphology assessment:

- BC MELP (1997). A Design Brief on the Floodplain Mapping Project for Somass River and Tributaries at Port Alberni, BC (35100-30/100-5229). Prepared by Ministry of Environment, Lands and Parks, Victoria, BC.
- Earle, S. (2003). The Geology and Geological History of Vancouver Island. [online]
- Kellerhals, R., Church, M., and Bray, D. (1976). Classification and Analysis of River Processes. Journal of the Hydraulic Division, American Society of Civil Engineering, 102(HY7).
- NHC (2016). Somass River Integrated Fish Habitat Restoration Overview – Final Report.
- Rosgen, D. L. (1994). A classification of natural rivers. Catena, 22, 169-199.
- Schumm, S. A. (1977). The Fluvial System. Wiley, New York.

Most of the references listed consist of existing data and background studies for the Somass River and watershed. However, the channel stability assessment carried out by NHC follows guidance and methods mainly from (Kellerhals et al., 1976), with reference to (Rosgen, 1994) as well.

There is no mention of the APEGBC Professional Practice Guidelines for Flood Mapping in BC. The intent of the study was not to use the information to establish setbacks, as this is typically completed for flood hazard mapping.

2.4.1.3 *Design Criteria*

There is no mention of the APEGBC Professional Practice Guidelines for Flood Mapping in BC. As a geomorphology assessment is not required for flood inundation mapping, it is reasonable that no particular design criteria is mentioned in this portion of the study.

NHC states that in this study, the main considerations are based on (Kellerhals et al., 1976), which include:

- Channel planform
- Relation of the channel valley walls
- Relation of the channel to the valley flat.

No specific criteria are listed in terms on how the main considerations are to be assessed to define whether the channel is deemed stable or active, and whether considerations (e.g. setbacks) should be included in the flood maps.

2.4.2 *Review of Methodology*

2.4.2.1 *Approach*

The approach included a detailed assessment of the overall Somass watershed setting, which consists of listing and describing the following:

- River basins
- Physiography
- Geology
- Geomorphology.

The Somass watershed was divided into nine (9) sub-reaches; The Somass and Stamp rivers were divided into seven (7) sub-reaches, and there is a reach for the Ash River and Sproat River. A detailed channel stability assessment was conducted for each of the nine (9) sub-reaches.

The channel stability assessment for each sub-reach consists of the following:

- Morphological characteristics
- Planform changes

- Cross-section changes
- Rating curve changes.

Not all of the nine (9) sub-reaches include both cross-section and rating curve changes, as it depends on available data, but each sub-reach includes at least one of the two (cross-section or rating curve).

A BC Ministry of Environment, Land and Parks (MELP) HEC-RAS model from a 1997 study was used for the assessment of reach R-7 (Downstream of Pacific Rim Highway Bridge).

2.4.2.2 *Setting*

The setting of the Somass Watershed is described in Appendix D by summarizing the characteristics of the river basins, as well as the watershed's physiography, geology and geomorphology.

River Basins

Appendix D provides a sufficient high-level description of three sub-basins which drain into the Alberni Inlet (Ash, Great Central Lake, Sproat), as well as of the Somass River and the Somass Estuary.

Physiography

Appendix D provides a brief description of the general setting of the Somass watershed, mostly in terms of its geographic extents, and some high-level information of the Alberni Basin (low lying area, width varying from 8 to 13 km). However, some additional information could be included regarding wind and flood levels. Wind conditions, such as dominant wind directions and wind speeds (typical and extreme), as well as the range of lake levels experienced (typical seasonal variation, flood conditions) can provide important information to help in understanding shoreline erosion at the lakes or any reach where wave action leads to erosion. Flood levels reaching typically unexposed areas of the banks, along with wave energy from high wind event, can be significant events leading to shoreline erosion.

Geology

Appendix D provided a figure illustrating the bedrock geology units and type of the Somass watershed extent and provides a detailed description of their time of formation.

Geomorphology

Appendix D provided a figure illustrating the surface materials throughout the Somass watershed extent and provides a detailed description of their geomorphological compositions, and also speaks to the historic continental (or post-glacial) rebound of the Alberni Basin and how it has been stable for approximately 6,000 years.

Some additional details regarding the general composition of the till layers (fines, sand, gravel) could be helpful with understanding the general composition of the surface material in the watershed. However, some information regarding the surface material of the rivers and lakes are provided in Section 5 of Appendix D, such as composition (fines, sand, gravel), presence of exposed bedrock and bed formations such as dunes.

2.4.2.3 Channel Stability

The channel stability assessment divided the watershed's river system into nine reaches; seven reaches for the Stamp and Somass rivers, which were divided into morphologically homogeneous reaches of varying length, as well as separate reaches for the Ash River and Sproat River. Hatch did not do a check to ensure that these reaches present morphologically homogeneous extents. However, the NHC report indicates that the main factors considered when distinguishing the reaches is based on (Kellerhals et al., 1976) consisted of:

- Channel platform
- Relation of the channel to the valley walls
- Relation of the channel to the valley flat (referring to the depositional surface built-up by river sedimentation and subject to occasional flooding, erosion and accretion).

The channel stability assessment of the nine reaches varied a bit for each reach depending on the available data, but overall, the assessments included morphological characteristics, planform changes, historic gauge rating curves and cross-section changes.

Below are general comments on each of the assessments performed for each of the nine reaches.

Morphological Characteristics

The morphological characteristics of each sub-reach are described in detail and include photos of the banks taken during the site visit, which show a wide range of riverbanks, where some appear stable (flat slope, coarse material or bedrock), while others are relatively tall eroding banks. Details also include the general bed material present in the reaches, characteristics such as bedrock controls, side bars, meandering pattern, as well as developments such as dikes, structures and erosion protection.

While Appendix D describes many observations of each sub-reach, some including eroding banks, it does not clearly describe how it leads to the summarizing conclusion of the main report that there are only minor inputs from bank erosion and tributaries. However, it does state that the presence of the large lakes (Great Central and Sproat Lake) effectively intercept and store the inflowing sediment.

Planform Changes

Planform changes were assessed by tracing bank lines from air photos collected in 1951 and 2018, and then comparing the traced bank lines to evaluate whether any lateral changes occurred between both years. While this methodology is a common method for assessing historical changes to river and lake banks, it seems as though the 1951 and 2018 air photos were not georeferenced, as the report states that future work will involve georeferencing air photos between 1951 and 2018. Georeferencing air photos, which is adding coordinates to digital data so that the data appears in the correct space in GIS or CAD software, is important to perform an accurate assessment of comparing traced bank lines.

While many areas within the reaches are reported to be laterally stable, Appendix D does highlight some areas within the reaches that have underwent significant changes, such as channel migrations in areas of eroding banks, and some substantial channel rearrangement that was observed at both the Ash-Stamp confluence and the Stamp-Sproat confluence. There is no discussion on whether these findings should be applied to the flood maps or to the hydraulic modelling.

There is no discussion on whether the observations made from the use of non-georeferenced photos pose any risks, or if they may need to be considered for the flood maps or hydraulic modelling. However, the Appendix D report mentions that future work will include georeferencing the 1951 and 2018 air photos for a better assessment of the historical lateral changes. Based on this review, it is surmised that this would only be required to complete a full hazard assessment, but is not necessarily needed for the inundation mapping series.

Rating Curves

Comparing time dependent, historical rating curves from WSC gauges provides good indications on whether the channel is stable, as a stable channel would be expected to maintain a similar stage/flow rating curve over time.

The process followed in comparing these curves is good. However, from a presentation standpoint, the clarity of some of the figures could perhaps be improved, as some of the data on the figures is not clearly visible. For example, Figure 8 from Appendix D only has the red line (2004 to 2009) visible up to a flow of approximately 200 m³/s (less than the 2-year return period).

Cross-Section Changes

Cross-sectional survey data was available in some reaches along the Stamp and Somass rivers from 1994 (MELP) and 2019 (NHC). Comparing historic cross-sections provides a good indication on how the river has evolved overtime, and whether it has been stable, or has experienced erosion or accretion over time.

Some changes have been observed from the surveys, in particular the substantial channel rearrangement that seems to have occurred at both the Stamp-Sproat confluences. Other observations have also been made, such as the ongoing scour hole formation at the Pacific Rim Highway bridge, where the bed continues to degrade and widen.

2.4.3 Discussion on Results

Appendix D concludes that both the lateral and vertical channel changes along the lower Ash River, Stamp River, Sproat River and Somass River have been very low over the last several decades, except for some substantial channel rearrangement that was documented between 1951 and 2018 at both the Ash-Stamp confluence and the Stamp-Sproat confluence. However, Appendix D and the main report do not conclude what this means regarding whether considerations should be given to the flood mapping, or if a setback should be considered to account for erosion. However, in the final mapping series, a comment is included at these locations stating that these areas are potentially subject to flooding in the

event of localized bank erosion or other bankline alterations, and recommends site specific investigations be conducted prior to development.

Appendix D and the geomorphology section of the main report do list that the sediment supply and inputs in the Somass river system are low, but it does not explicitly state that the river system's sedimentation have no effects on flood levels due to the low sediment supply and inputs.

Overall, the individual assessments of the site characteristics and available data for the geomorphology study are well detailed, and follow standard methodologies, such as comparing historic air photos and surveyed cross-sections. The study also overall meets its goal of providing qualitative insight, while only performing limited quantitative assessments on channel stability along the study reach.

The following list describes items that could benefit from more details, but that are not believed to significantly affect the end result for the flood mapping, especially considering it is not necessarily a required component of the SOW:

- Clearly describe how the summarizing conclusion of the main report that there are only minor inputs from bank erosion and tributaries was made, as there are several observations listed in Appendix D of eroding banks and areas of channel rearrangement.
- Include notes on wind condition and lake levels in the physiography section, as flood levels on lakes reaching typically unexposed areas of the banks, along with wave energy from high wind event, can be significant events leading to shoreline erosion.
- The air-photos from 1951 and 2018 were not georeferenced; georeferencing the air photos would provide a more accurate assessment of the historical lateral changes. NHC has noted this observation.
- Ensure all data from rating curve figures (such as Figure 8 of Appendix D) are visible.
- Appendix D refers to future geomorphology work (georeferencing of air photos) but does not list further information on the future geomorphology work in terms of what the purpose and scope would be for the flood management study.

2.5 Appendix E - Hydraulic Modelling

2.5.1 Study Design Basis

ACRD requested that NHC develop a comprehensive hydraulic modelling tool to produce up to date flood mapping for the Somass River system, which can also be used to evaluate flood mitigation measures. Many of the model inputs have been developed and detailed in previous sections of this report, and so are not replicated here. The overall design basis guidelines are described in Table 2-1, and additional modelling references are described as part of methodology, either as best practice or with reference to the Federal Geomatic Guidelines for Flood Mapping (2019), published during the course of this study.

2.5.2 Review of Methodology

2.5.2.1 Numerical Modelling

NHC divided the project study area into three independent HEC-RAS models. This was done to take advantage of the relatively shorter computational times of 1D models, while accurately representing more complex multidirectional hydraulics, where required. The three models developed are summarized in Table 2-3.

Table 2-3: Hydraulic Models Developed for the Study

Reach	Model Length (km)	Model Type
Somass River	15.2	2D
Upper Sproat River/Sproat Lake	1.4	1D
Upper Stamp River/Great Central Lake	3.5	1D

HEC-RAS is an industry standard modelling software, and is typically used for these types of study applications. This is an appropriate model selection (in regards to 1D/2D selection) and the set-up aligns well with the characteristics of each river reach.

NHC generated the base Digital Elevation Model (DEM) for the model setup using LiDAR information from external sources, as well as bathymetry point data, which they collected. The survey information including the bathymetric survey, instruments used and data acquisition patterns were excluded from the peer review.

NHC used four upstream inflow boundary conditions for the 2D Somass River model, two of which (Kitsuksis Creek and Rogers Creek), did not specify the data source used to develop the inflow boundary condition. Although these are two major tributaries on the Somass River, it is judged to be unlikely that the methodology to produce the flood inflow boundary condition, once documented, would have a noticeable impact on the overall study results.

Some components of the bridge crossing geometry, such as the abutment constriction and piers, are incorporated into the 2D model where applicable. However, bridge decks have not been included, and therefore the model will not simulate hydraulic losses that may occur due to pressurized flow should it occur through the bridge opening (i.e. if the flood level reaches the bridge deck(s)). Hydraulic grade lines (HGLs) for some of the crossings were not provided, so it was difficult to determine which crossings may experience some degree of impingement on the lower chord of the deck. This is a reasonable exclusion if the flood level does not reach the bridge deck lower chord, however there is one scenario that demonstrates overtopping. There is not enough information to determine if the lower bridge chord is impacted for the remaining scenarios. This is already acknowledged by NHC and judged to introduce minimal error compared to the climate change estimate. It would be useful to include a table of bridge characteristics (low and high deck elevations) and calculated water levels either within the report or as metadata records, as suggested in the Federal Geomatic Guidelines for Flood Mapping (2019). This would assist in the understanding of flood impacts. It would indicate if additional measures are required to ensure the hydraulic effects of the

bridges are captured, if it is indicated that the bridge is impacted. However, impacts to flood levels would only occur locally at the bridge crossing, and since it does not impact the main channel flows, this was considered to be reasonable.

The general model setup appropriately ensures that dikes, roads, railway embankments and topographic flood controlling features are incorporated into the model DEM using standard techniques. Additional model inputs such as Manning's roughness values are determined in an appropriate manner, through model calibration. Given the data collection program that was undertaken for this purpose, which included a water elevation profile of the reach, three water level loggers, and 7 flow measurement locations during the largest flow of the 2018/19 flood season, it is surmised that this analysis includes an appropriate amount of data to produce a good calibration.

Standard practice for hydraulic modelling includes calibration of a model to a known data set, and validation of a model by verifying that a calibrated model successfully simulates a second flood event. NHC performed calibration exercises for all models, which was supported by a data collection program to supplement the limited data available. This allowed for calibration to an approximate 2-year event for the 2D model, which will primarily focus on the bathymetric portion of the river. The series of calibration runs depicting observed vs. modeled flow demonstrate a good match. The analysis indicates that flows are being routed correctly and tributary inflows are reasonable, which are both reasonable conclusions. The analysis on the performance of the model to match water levels at specific flows for the calibration run is also considered to be sufficient. The 1D Upper Sproat River calibration/validation exercises follow standard engineering practice and conclusions appear valid and appropriate for the study. Similarly, for the Upper Stamp River 1D Model calibration/validation exercise, appropriate analyses were performed to determine relationships between the lake levels and downstream river flows.

NHC validated its calibrated 2D Somass River model using five different historic flood events. It was noted that the model overestimated water levels for flows between 300 m³/s to 600 m³/s, and underestimated water levels below 300 m³/s and above 600 m³/s. This was largely attributed to the formation of a mid-channel gravel bar near the WSC gauge stations where the flood events were recorded. This difference looks to be quite small, and may be the result of dynamic morphology during the flood. The gravel bar may change in elevation and extent over the course of large flood events. Alternatively, this could indicate a shift in channel control. Overall, the match looks reasonable.

Dike failure scenarios were not simulated, but rather the dikes were assumed to stay intact when overtopped. The BC guidelines recommend that the scenario consider possible breaching of the dike, especially if overtopping is expected. However, the 200-Year Designated Floodplain Map set includes overtopping of the River Road and Kitsuksis dikes via what is inferred to be projected river water levels into the areas behind the dikes, and also simulates the ponding of water behind the dikes. Additional analysis for this particular case does not appear to be required from the information given, so this is judged to be a fair

approach and will be somewhat conservative. In addition, these inundation areas are marked with an identifier attribute and mapped in a different hatching (to be updated), as recommended in the Federal Geomatic Guidelines for Flood Mapping (2019).

NHC used two different combinations of flow and tide conditions to simulate flooding on the Somass floodplain, which appropriately appear to target a combined probability of exceedance of 1/200 years. These combinations were modelled under future climate change scenarios for the 2050s, 2100s and 2200s as well. For each flow condition, the maximum inundation extents for each flow and tide combination were combined to showcase the maximum floodplain extents for a 200 year event.

Overall, the hydraulic models produced for this study demonstrate good detail and standard modelling practices.

2.5.3 **Discussion on Results**

A comprehensive set of hydraulic models have been produced using industry standard software. Standard engineering practices have been used to develop the models, so it is judged that they appropriately address the study objective of having the ability to be used to evaluate flood mitigation measures. In general, Hatch agrees with NHC's discussions on model limitations and uncertainties, which should be considered when evaluating flood mitigation measures and the study results. The modelling work has resulted in the production of up to date flood mapping for the Somass River system.

2.6 **Appendix F - Mapping Methodology**

2.6.1 **Study Design Basis**

2.6.1.1 *Scope of Work*

ACRD requested that NHC carry out the necessary analysis to develop up to date flood mapping for the Somass River system.

2.6.1.2 *Reference Documents*

The following documents were used specific to mapping:

- "Flood Hazard Mapping Manual in Japan". Flood Control Division, River Bureau, Ministry of Land, Infrastructure and Transportation (MLIT), 2005.

Although there are no particular mapping standards specified for BC, Flood Mapping in BC [Ref. 4] states that mapping should adhere to certain standards.

2.6.2 **Review of Methodology**

The mapping methodology has been reviewed against the requirements of the Flood Mapping in BC APEGBC Professional Practice Guidelines (2017), as demonstrated in the overall review requirements outlined in Table 2-1. The Federal Geomatic Guidelines for Flood Mapping (2019) were also used, however the guidance in these two documents is very similar.

Flood depth rasters for the flood depth maps were taken directly from HEC-RAS models and displayed. For the floodplain maps, these extents were smoothed. Manual edits were made to areas behind dikes, extending the floodplain beyond the modeled extents to the same elevation within the Somass River. This was a conservative measure, presumably taken in lieu of completing official dike breach analysis (though as previously stated, this seems to be a reasonable expected outcome and includes an identifier attribute with special hatching). Additional areas were smoothed and/or extended using engineering judgement. Notes were added to include possibility of flooding from bank erosion on sharp river bends. Calculated coastal FCLs use the exported still water elevations from HEC-RAS and apply the freeboard to attain the map results. HEC-RAS model results for the lakes include the appropriate horizontal and vertical considerations including wave effects, wind setup, seiche and freeboard.

The reviewed methodology is appropriate for the purpose of the scope of work. Adequate information is used to prepare the map sets.

2.6.3 **Discussion on Results**

Results are compared to the previous floodplain maps prepared in 1997. The 1997 inundation extents include an additional 0.6 m of freeboard within the final polygon, whereas the update floodplain map set does not include the freeboard within the inundation extents. The extents themselves are therefore comparable, though the FCL isolines from the updated map set demonstrate higher levels than the previous map set. This is reasonable, given the climate change projections and updated hydrological analyses completed in the updated study. The general similarity in the two studies lends confidence in the results. The results are judged to fulfill the scope of work.

2.7 **Appendix G - Flood Mitigation**

2.7.1 **Study Design Basis**

2.7.1.1 *Scope of Work*

ACRD requested two key components regarding mitigation measures. The first step included the development of a “comprehensive hydraulic modelling tool that can be used to evaluate flood mitigation measures”, followed by the development of “flood mitigation concepts that *can be developed in conjunction with habitat restoration* to provide integrated water management planning along the river system.”

The scope of work mirrored in the NHC report removed the portion “can be developed in conjunction with habitat restoration” from the scope.

2.7.1.2 *Reference Documents*

There are no guidelines or specific documents referenced for the development of flood mitigation concepts. Review of this section is measured against references found in the Federal Flood Mapping Guidelines Series: Bibliography of Best Practices and References for Flood Mitigation (NRCAN, 2018) and common engineering practices.

2.7.1.3 *Design Criteria*

The design criteria for the mitigation concepts includes the 200-year flood construction level extents determined in this study.

2.7.2 *Review of Methodology*

2.7.2.1 *Approach*

NHC presents an outline to the flood mitigation and adaptation planning process, and describes considerations to be made in future studies that analyze mitigation options. It describes the general road map to assist with the selection of mitigation options, including the recommendation that a risk assessment be completed to outline flood risk inventories and costs, which can help prioritize mitigation options. The study follows the guidance outlined in Ausenco Sandwell (2011) and EGBC (2018), as also referenced in the Federal Flood Mapping Guidelines Series: Bibliography of Best Practices and References for Flood Mitigation.

NHC consulted with stakeholders to come up with a list of nine preliminary mitigation concepts. From this list, two options were selected to test the effectiveness of their application within the hydraulic model. Although the model was applied to test these scenarios, they are still only preliminary in nature and would require further definition of public priorities, cost and environmental impact.

The concept designs are reasonable suggestions to explore. These generally include: modify a lake outlet, raise sections of the highway, flood-proof homes, modifying a dam for flood control, widen a segment of the river, raise a dike, add pump station, floodplain retreat of key facilities, infrastructure and land uses, and policy updates for development in floodplains. These are mitigation options commonly presented at identified locations, and are generally in line with the current flood management approach in BC (as specified in EGBC, 2018). Additional detail describing the concept “Breach Airport Road Dike” would assist with clarification on this concept, as it is not immediately clear how breaching the north dike will help mitigate flooding on the north side of the river. Clarity on whether this is a temporary, emergency measure or a long-term breach would be beneficial. A brief description of the problem would assist with understanding this solution, as the concept of breaching an intentional flood protection dike does not appear to be a natural solution, though it certainly has merit in specifically outlined situations.

The two selected options are reviewed further below.

1. *Potential Mitigation Concept: Raising Highway 4 at Tseshah First Nation*

The concept of raising the highway along its deficient sections is a fundamentally sound conclusion. Hatch has reviewed the analysis completed to assess this work, and notes that the methodology used in this assessment is appropriate for the scope of work, which is based on the 200-year flood mapping and the evaluation of flood mitigation concepts. The approach uses the study results for this portion of the Somass River, plotting the water surface profile on top of the road centerline to capture its deficiencies. The model

used has been previously evaluated in Appendix E Hydraulic Modelling. This approach is appropriate for a concept level design.

2. *Potential Mitigation Concept: Explore if changes to the channel at the outlet of Sproat Lake could reduce lake levels during floods.*

Significant flooding on Sproat Lake has caused concern with residents regarding the flow capacity at the outlet of Sproat Lake. NHC modeled the existing geometry of the lake and downstream channel, as well as four scenarios where modifications were made to the outlet channel to review if the suggested modifications would increase the outflow capacity. These scenarios include:

- i. Opening the fish windows on the Sproat Lake weir prior to a flood
- ii. Remove the weir from the channel
- iii. Remove “Bob’s Rock” (which would widen the channel immediately downstream of the weir)
- iv. Widen the long stretch of narrow channel from 260 to 430 m downstream of the weir.

The section of river between the outlet of Sproat Lake and the Highway 4 bridge is characterized by a mildly sloped channel with heavily vegetated banks. Immediately downstream of the Highway 4 bridge is a steep drop-off with a section including rapids. This section forces the water surface profile to pass through critical.

Hatch has reviewed this analysis, and notes that the methodology used in this assessment is appropriate for the scope of work, which is based on the 200-year flood mapping and the evaluation of flood mitigation concepts. Cross-sections in the 1-D Sproat Lake model appear to be spaced at an appropriate interval (less than 20 m spacing on average in this area) to capture the changes in channel geometry and resulting hydraulic effects and storage characteristics of the Sproat Lake Weir, Bob’s Rock, the constriction leading up to the Ash Main forestry road bridge (“the old logging bridge”), and the Highway 4 bridge. By capturing the variations in channel width and invert, it is expected that the location of hydraulic control would be identified within a 1D model. The analysis method is appropriate. Survey work was completed on the weir and upper Sproat River, and additional bathymetry was available around the weir. Paired with the LiDAR data, this provides adequate data to complete this assessment.

The model geometry used to delineate the 200-year floodplain was modified to assess the above scenario under a 30-year design flow. Cross-sections covering Sproat Lake (the outlet of Sproat Lake to the Sproat River) were replaced with a “Storage Area Element” to cover the attenuation effects of Sproat Lake. The HEC-RAS model files of this particular scenario were not available for review within the provided model package, however the files used for the main study were reviewed alongside the report details. It is unclear if the full attenuation effects were modeled with a “storage area element” in the 1D model. If using a “storage area”, the stage-storage characteristics of the lake are indeed used to make a direct

calculation of the resulting lake level vs inflow volume at each time step, and this is automatically applied upstream of the weir (in this case). However, the stage-storage characteristics or method of evaluating this are not defined within this section. This should be confirmed.

It is unclear if the full effect of the removal of the weir is considered, as it is not demonstrated if the initial water level at Sproat Lake is altered at the start of the simulations, for the various scenarios. If starting just above the crest of the weir for the base case, the case with the weir removed would likely have the starting lake level at an elevation just above natural ground at the outlet (approximately 0.6m lower), as this would become the new normal water level of the lake. Likewise for the scenario with the fish window open. This drop in lake level would represent a significant volume that could help to attenuate flows by providing additional flood storage.

Hatch reviewed the Sproat Lake weir. The design drawing from its construction in 1956 is shown in Figure 2-3. As stated in NHC's report, it is owned and operated by Catalyst for the purpose of maintaining lake levels for the mill water supply pipeline. NHC has noted an important observation that the lake level control has shifted over time, where higher lake levels have been measured post-1956, the year the weir was established. The relationship between Sproat River flows and Sproat River lake levels for 1913-1996 is demonstrated in a figure in their report and is copied in Figure 2-4 below for discussion.

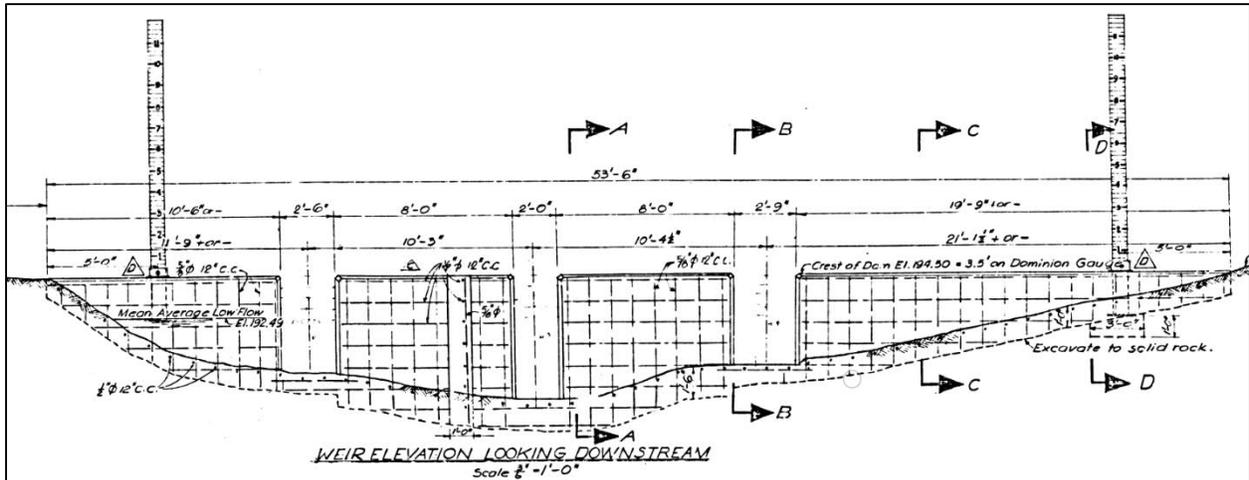


Figure 2-3: Sproat Lake Weir 1956 Design Drawing

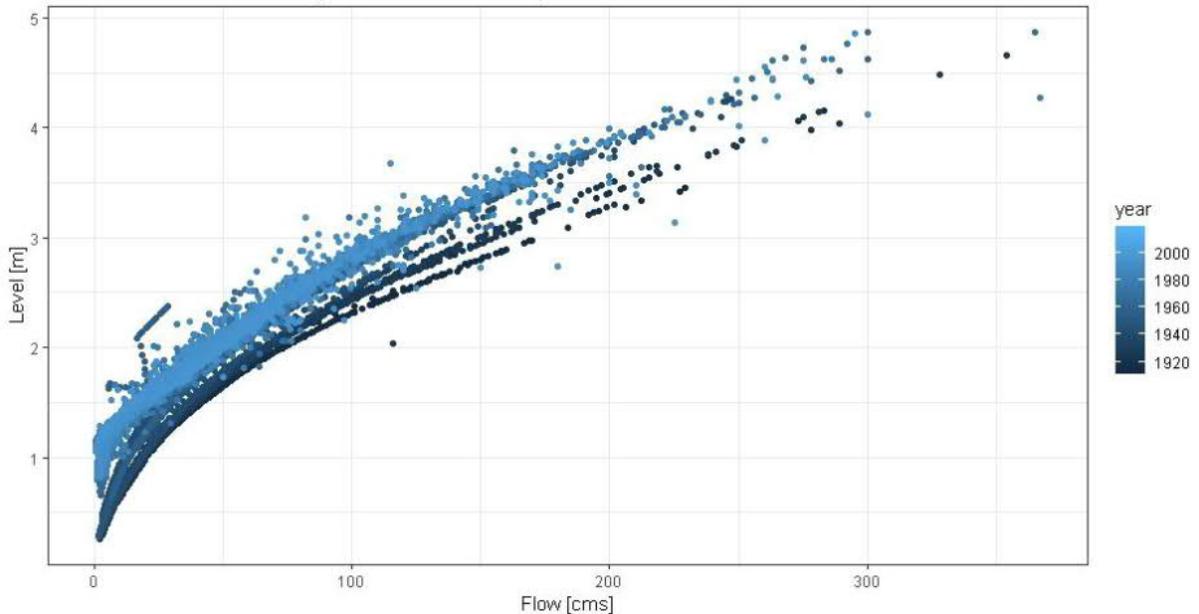


Figure 2-4: Relationship between Sproat River flows and Sproat River lake levels for 1913-1996 (NHC, 2020)

The NHC report and model demonstrate a weir crest elevation of 27.3 m in the Sproat Lake outlet channel with a thalweg of 26.74 m (i.e. a visible weir height of 0.56 m) on the upstream side of the weir. The weir is 19.35 m in length along the lake bed. The provided original 1956 design drawing “D51000_D 51004” includes a drawing with rating curve, which has been transcribed and converted to metric and to the same elevation datum as used in the NHC study (using the weir crest elevation of 27.3 m as the benchmark reference) to facilitate the peer review, and is presented below in Table 2-4. This drawing demonstrates a greater maximum weir height of 1.1 m at the deepest section. It is noted that the profile view of the lake to channel thalweg (extracted from the NHC report and shown in Figure 2-5) demonstrates what could be an accumulation of material behind the weir, as there is a distinct rise in the channel thalweg for approximately 25 m upstream of the weir, followed by a drop to elevation 25.63 m on the downstream side of the weir. This material could potentially be eroded with the removal of the weir, back to its presumptive natural state. Additional analysis would be required to confirm if this is a possibility. This does not appear to be covered in the geomorphology section. If this is the case, and it is only the weir that is removed in the model simulation but not the material, this could lead to artificially higher losses in the simulations.

In the scenarios that assess the removal of the weir, it does not appear that the initial level of the lake was altered at the start of the simulation. In order to assess the effect that the removal of the weir would have on lake levels and the system as a whole, the hydrologic record would need to be analyzed and altered to account for what the historic lake levels would have been if the weir was not in place. A flood frequency analysis would have to be

completed to determine the “new” flood frequency lake levels and corresponding flow, as the entire flow regime could change. The analysis presented in NHC’s report appears to assume that the flood conditions are unchanged, and the weir is simply removed from the system. The conclusion is that the weir is already backwatered from the downstream constriction, so its removal would not affect the presented flood levels. However, it appears that the control shifts at some point during the flood regime, so flood levels for the smaller, less frequent events would be reduced. This will influence the economics, as the flood damage curve will decrease at the lower end of the spectrum. This should be taken into account in any risk comparison studies. It is recommended that this analysis be completed to determine the system effects of removing the weir in order to quantify its impact.

Table 2-4: Sproat Weir Design Rating Curve

Key Elevations	Supplied Historic Rating Curve		Historic Rating Curve, metric		Elevation (current study datum)	
	Elevation (local)	Discharge	Elevation (local)	Discharge	Elevation	Discharge
	(ft)	(ft ³ /s)	(m)	(m ³ /s)	(m)	(m ³ /s)
	191	0	0.0	0	26.2	0
Low flow (Sept. 12, 1944)	191.94	55	0.5	2	26.5	2
	193	310	2.7	9	26.8	9
	194	600	5.2	17	27.1	17
Weir Crest	194.5	780	6.7	22	27.3	22
	195	960	8.3	27	27.5	27
	196	1480	12.8	42	27.8	42
	197	2150	18.6	61	28.1	61
	198	2840	24.5	80	28.4	80
	199	3900	33.7	110	28.7	110
	200	5000	43.2	142	29.0	142
	201	6220	53.7	176	29.3	176
	202	7650	66.0	217	29.6	217
	203	8670	74.8	246	29.9	246
	204	10620	91.7	301	30.2	301
Max high water elevation (Feb 9, 1918)	204.7	11100	95.8	314	30.4	314

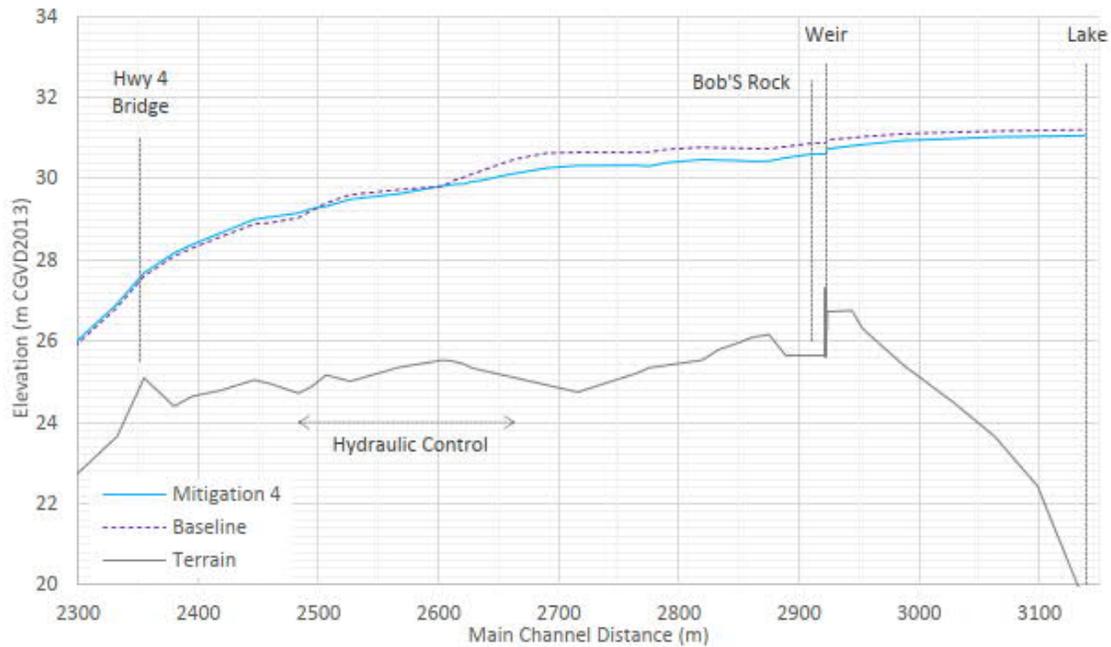


Figure 2-5: Sproat Lake Outlet Channel Profile View (NHC)
(shown for Mitigation Scenario 4 – widened constriction compared to baseline conditions)

The overall results of the geometry modification assessment indicate a constriction in the long narrow portion of the outlet channel that is the ultimate control of the water levels and discharge at Sproat Lake. In reviewing the available data and geometry, this conclusion appears to be accurate and reasonable for higher return period floods.

It is recommended that the details mentioned above be clarified to ensure that the effect of removing the weir or opening the fish windows are properly quantified under all levels of flood.

2.7.3 Discussion on Results

NHC produced a comprehensive hydraulic modelling tool of the river system, and demonstrated that it can be used to evaluate flood mitigation measures. A list of flood mitigation concepts was produced, and two concepts were further evaluated using the model. This portion of the study has addressed its objective. Although the mitigation concepts did not specifically include habitat restoration as in the original scope, this appears to have been agreed upon either prior to starting the study, or as a result of the types of mitigation concepts required based on the study outcomes.

The identified mitigation concepts appear to be reasonable as presented. Additional detail regarding the “Breach Airport Road Dike” option is suggested for improved understanding for the reader. The assessment of the two mitigation concepts uses an appropriate amount of data to evaluate the problem. However, it is not clear if the methodology used to assess the Sproat Lake weir concept is properly applied. The identification of the hydraulic control at the

outlet of Sproat Lake as being the narrow channel appears to be the correct conclusion. However, this applies to large flood events only, whereas smaller events would be controlled by the weir.

Clarification that the initial water level on Sproat Lake is appropriately adjusted depending on the mitigation scenario (weir, no weir, fish windows open or closed), if this is indeed a correct assumption, would assist in ensuring and documenting that these options are fully explored. Confirming if the channel elevation in front of the weir is an erodible material artificially raising the profile in front of the weir would add clarity to this analysis as well.

2.8 Appendix I - Flood Depth Maps

2.8.1 Study Design Basis

Production of the flood depth maps is not specifically requested in the scope of work, but these maps help to enhance project understanding of the results. Their development is a result of the work that was detailed and reviewed in previous sections of this report, and so is not replicated here.

2.8.2 Discussion on Results

The basic mapping methodology was reviewed and discussed in Section 2.6, and the review of the map details and results is presented below. The flood depth maps are informative and generally clear.

2.9 Appendix J - Designated Flood Maps

2.9.1 Study Design Basis

Production of the flood maps is one of the key outcomes of the project. Their development is a result of the work detailed and reviewed in previous sections of this report, and so is not replicated here.

2.9.2 Discussion on Results

NHC has produced a complete set of Floodplain Maps for the Somass Watershed Flood Management Plan delineating potential flooding caused by the highest water level associated with either of the following design scenarios:

- Riverine design flood based on a 200-year return period event with a 20% climate change allowance to the year 2100.
- Lake design flood based on a 200-year return period event with an allowance for climate change combined with wave effects, wind setup and seiche to the year 2100. The Lake FCL zone indicates the most landward extent of wave effects. The boundary is a smoothed representation of the combined (worse case) results for all directions of waves for a given flood scenario.
- A freeboard allowance (safety factor) of 0.6 m is included in the Flood Construction Level Isolines and Flood Construction Level values.

The Designated Floodplain Maps provided in Appendix J have been reviewed against the requirements of the Flood Mapping in BC APEGBC Professional Practice Guidelines (2017), as demonstrated in the overall review requirements outlined in Table 2-1.

Mapping methodology is discussed in Section 2.6, with the review of the map details and results presented here. The flood maps are informative and generally clear, but do contain a few details that are not clear and require additional information. These include the following.

- The notes on the Designated Floodplain Maps are not entirely clear.
 - ◆ Notes on map sheet 13 indicate: “Flood inundation boundaries represent modeled inundation extents only. Freeboard of 0.6 m is not applied to the inundation boundary. Freeboard is applied to FCL isolines only.” This is also supported in the legend which reads “Flood Extents Excluding Freeboard” to indicate the filled dark blue areas. As the black FCL isolines that include freeboard extend to the same location as the dark blue inundation area that does not include freeboard, it would be helpful to the reader to even more clearly indicate that the black FCL isolines are only demonstrating the elevation, in a comment such as “The flood inundation boundary should be extended to the elevation shown on the FCL isolines to arrive at the elevation including freeboard.” This could be paired with the inclusion of labeled contours to help the reader better approximate those extents.
 - ◆ Notes on the map sheets refer to a number of hatched areas, but hatched areas could not be located. It is presumed these will be added for the final version.
 - ◆ Notes on map sheet 2 indicate: “The dam has been excluded from the study”, which is indicated for both the Stamp River Dam and the Robertson Creek Dam. The meaning of this note is not immediately clear, knowing that the Robertson Creek Dam is not included in the model at all, but the Stamp River Dam and its reach is indeed included in the model (as well as it can with the available information).
- It is not clear how the Coastal FCL extents, ending between FCLs of 5.2 m and 5.1 m in the vicinity of the River Road PALB Dike, were established or why they are not shown in some areas.
- One additional note surrounds the naming convention for the floodplain maps. Flood Mapping in BC states that floodplains are no longer considered to be “designated” by the province. Rather, inundation maps are defined in this guideline as topographic maps showing the extent of floodwater in plan, under defined flood events. This alludes to the fact that the design flood selected may not always be the 200-year flood as demonstrated on historical “designated” flood plain maps. The provided examples in the guideline support the name “Floodplain Mapping”. This is simply a note for discussion, in the case that this discussion has not yet occurred.

In general, the production of the flood maps has adhered to the Flood Mapping in BC APEGBC Professional Practice Guidelines (2017), with some non-conformances. In our opinion, most of these are not critical to the results of the study and are not likely to have a significant impact on the results. Apparent accidental mapping omissions will of course need to be corrected for clarity and completeness. The floodplain maps fulfill one of the key components of the scope of work.

2.10 Assessment of Dam Impact on Flood Mapping

At the request of ACRD, Hatch has reviewed the above-noted report and appendices prepared by Northwest Hydraulic Consultants (NHC), with a particular review of the methodology surrounding the interaction of Great Central Lake and the Stamp River Dam and the Robertson Creek Saddle Dam, and how the dams impact the flood mapping. A summary of our findings is included below.

2.10.1 Background Information

Background information as outlined in the NHC report is summarized as follows, for information. The Stamp River Dam on Great Central Lake was originally constructed in 1925 to provide dilution waters to add to pulp mill effluent released into Alberni Harbour. The dam was raised in 1957, which required the construction of the Robertson Creek Saddle Dam at a low point in the reservoir. Since 2004, dilution waters have not been required, and the dam is used solely for fish conservation purposes. The dam was not designed or licensed for flood control purposes, but its operation affects downstream peak flows. The stoplog spillway arrangement includes 8 bays with crest elevations specified for each bay for each of 0, 1, 2, and 3 stoplogs available for each bay. An operational rule curve does not exist for the Stamp River Dam, but operations generally revolve around managing the lake level and fish flows. Great Central Lake levels are managed to lower levels by November 1 to provide a buffer in the event of large rain events. It is also stated that operating rules must be followed when the forecasted 24-hour precipitation exceeds 25 mm. When water levels exceed the set point, stoplogs should be removed. Two to three stop logs are kept in each bay from November onwards and are removed in response to precipitation forecasts in excess of 25 mm/day.

The Robertson Saddle Dam was reconstructed in 2011. It was designed to withstand all operational conditions and lake levels.

2.10.2 Review of Methodology and Discussion on Results

The 200-Year Designated Floodplain Map sheet 2 includes the notation “The dam has been excluded from the study” beside each of the Stamp River Dam and the Robertson Creek Saddle Dam. It is acknowledged that the Robertson Creek Saddle Dam is not included in the study, as its small capacity compared to the large volume of Great Central Lake would not have a significant impact on the study results. This appears to be a reasonable assumption. However, it is not immediately clear what this is meant to imply for the Stamp River Dam. Appendix E Hydraulic Modelling and review of the HEC-RAS model itself demonstrates that the Stamp River Dam geometry is included in the HEC-RAS model. Clarity on this would be helpful (or removal of this if it is there in error).

The Stamp River Dam is assumed to have 3 stoplogs in each bay for the final model scenario. This assumption appears to be adequate for the information available, noting that there is no specific record or fixed rules indicating when stoplogs are removed (and levels and stoplog counts are not consistent across all bays); but that it appears to indicate that 2 to 3 stoplogs are indeed left in place prior to winter. Changing the stoplog arrangement will not affect flood mapping downstream of the dam for the present day 200-year flood as these results are not dependent on the dam as the downstream river flows are based on flood frequency analysis of flows on the river. However, it would affect the lake level that corresponds to the downstream discharge, if additional flow capacity is available through removal of all stoplogs. Although outside of the scope for this project, it could be beneficial to confirm if this is indeed the expected condition in a flood scenario (and if operations will change as a result of the most recent Dam Safety Review) while passing the peak of the flow, as the presented operating conditions (and engineering best practice) would suggest that all stoplog bays would be opened prior to the expected arrival of a flood of this magnitude. Mis-operation and failure to remove the stoplogs prior to a significant event could indeed result in higher lake levels during a flood as presented.

The report notes that overtopping of the dam crest does not occur and therefore did not have to be modeled, but the presented levels (84.46 m for the 200-year event) are higher than the dam crest (84.26 m). A review of the model appears to demonstrate that overtopping flows are accounted for, therefore this the meaning of this statement should be clarified. Additional details surrounding the modelling of the dam would assist with understanding.

It is noted that historical water level records do not exist for Great Central Lake, therefore a flood frequency analysis cannot be conducted to determine the 200-year lake level. A flood frequency analysis was performed on the WSC gauge downstream of the dam to determine the 200 year flow in the downstream reach. This flow was used as the upstream inflow to a 1-D HEC-RAS model that includes the lower portion of Great Central Lake, the Stamp Lake Dam and the downstream river reach. The resulting lake level required to pass this discharge was selected as the associated 200-year lake level. This is an appropriate methodology to estimate the 200-year lake level in the absence of long term data. However, this same methodology is applied to estimate peak lake levels under climate change. It appears that it is the discharge from the dam that is multiplied by the 10% and 20% climate change factor, and the water level required to produce this discharge is taken as the lake level under climate change. However, the discharge from the dam is entirely dependent on the geometry of the spillway and the storage curve of the upstream reservoir, and does not consider the specific variables affected by climate change. It is expected that this increase would be applied to the inflows to the lake in order to consider the storage effects of the lake itself, determine the resulting lake level, and review how the dam passes this increased flow.

3. Summary

A flood management plan has been completed for the Somass watershed using a combination of empirical calculations and numerical modelling. The Somass Watershed Flood Management Plan has been reviewed, excluding Appendix A “Surveys” and Appendix H “Consultation”.

The study has generally followed appropriate industry guidelines and standards for inundation mapping, and includes some additional information that would typically be included in flood hazard maps such as flood depth. The study has generally adhered to standard guidelines and made use of the data available, and included appropriate methods when required data was not available including filling some of the gaps with the data collection program. Some non-conformances have been identified throughout the report, but for the most part these have been judged to be not critical to the results of the study and unlikely to impact the results, or they have been judged to produce conservative results. Some components of the study have been identified as areas that could benefit from additional detail to readily determine if results are accurate as some additional work was required to complete gaps in the documentation of the assessment. However, upon confirming when possible, the methodologies and results appear appropriate and reasonable overall. Many areas provide adequate detail and information from which to draw conclusions, and it is apparent that appropriate effort has been extended to develop an effective hydraulic modelling tool, fulfilling one of the main study objectives. The 200-Year Floodplain Maps are based on the work completed, and overall have been judged to provide an adequate representation of the design event, though they are likely conservative in some areas. The independent flood frequency assessment on the Sproat River near Alberni gauge produced similar results to those in the NHC study, which provides additional confidence in the study results.

Some non-conformances of note or items requiring clarification were identified. One item includes a lack of naturalization of the flows in the study area prior to completing the flood frequency analysis (in regards to the Stamp River Dam and the Ash River hydroelectric discharges). In addition, climate change impacted lake levels were calculated based on a backrouting of the river flows out of the lake, rather than by assessing the inflows to the lake and evaluating how much the level of the lake is expected to increase as a result of higher inflows to the lake. Considering the Great Central Lake’s interaction with the Stamp Lake Dam, the climate change increase should be applied to the inflows to the lake in order to consider the storage effects of the lake itself, determine the resulting lake level, and review how the dam passes this increased flow. This assessment appears to be conservative and results in higher levels on the lakes. One non-conformance that has a large impact on flood mapping includes the omission of the Tsunami assessment, but this was not part of NHC’s scope of work as it is understood that these assessments have been performed previously under a different scope. Some updates to the mapping labels and hatching should be completed for clarity and to showcase the final intended product.

The potential mitigation concept surrounding changes to the channel at the outlet of Sproat Lake was highlighted as a particular concern, and so particular attention was directed to review the details surrounding this concept. The analysis completed appears appropriate and uses an adequate amount of information. The conclusion reached for the mitigation option appears accurate and reasonable for higher return period floods. However, some observations have been noted and potential suggestions have been provided for review based on the available information, to ensure that they have been fully considered in this analysis, and to ensure that the effect of removing the weir or opening the fish windows are properly quantified under all levels of flood.

4. References

1. Engineers Geoscientists British Columbia (EGBC). "Professional Practice Guidelines: Legislated Flood Assessments in a Changing Climate in BC" Version 2.1. 28 August 2018.
2. Kerr Wood Leidal Associates (KWL), prepared for Ministry of Forests, Lands, Natural Resource Operations with federal funding support through Natural Resources Canada's Regional Adaptation Collaborative Program. "Coastal Floodplain Mapping – Guidelines and Specifications". June 2011.
3. Ministry of Water, Land and Air Protection: Province of BC. "Flood Hazard Area Land Use Management Guidelines". May 2004. Amended by Ministry of Forests, Lands, Natural Resource Operations and Rural Development, January 2018.
4. Professional Engineers and Geoscientists of BC (EGBC). "Flood Mapping in BC: APEGBC Professional Practice Guidelines V1.0". January 2017.
5. Natural Resources Canada, Federal Flood Mapping Guidelines Series: Federal Airborne LiDAR Data Acquisition Guideline (Version 3.0). General Information Product 117e. 2020.
6. Natural Resources Canada, Federal Flood Mapping Guidelines Series: Bibliography of Best Practices and References for Flood Mitigation (Version 2.0). General Information Product 115e. 2018.
7. Natural Resources Canada, Federal Flood Mapping Guidelines Series: Federal Hydrologic and Hydraulic Procedures for Flood Hazard Delineation. General Information Product 113e. 2019.
8. Natural Resources Canada, Federal Flood Mapping Guidelines Series: Federal Geomatics Guidelines for Flood Mapping (Version 1.0). General Information Product 114e. 2019.

3003140

November 1, 2021

Alberni-Clayoquot Regional District3008 5th Avenue
Port Alberni, BC
V9Y 2E3**Attention:** **Mike Irg**
Manager of Planning and Development**Via email:** mirg@acrd.bc.ca**Re:** **Somass Watershed Flood Management Plan
NHC's Response to the Peer Review**

Dear Mr. Irg:

Thank you for giving NHC an opportunity to respond to a peer review completed by Hatch Ltd. (Hatch) on our Somass flood mapping project.

- NHC prepared the *Somass Watershed Flood Management Plan, Final Report* for the Alberni-Clayoquot Regional District (ACRD); we submitted our report on May 1, 2020.
- The ACRD retained Hatch to conduct a peer review.
- NHC received Hatch's report via email from ACRD on November 19, 2021; NHC was asked by the ACRD to review Hatch's report and provide comments (M. Irg. pers comm.)
- Our response (this document) is based on Hatch's *Report, Somass Watershed Flood Management Plan Peer Review* (H365315-0000-200-066-0001) dated August 12, 2021.

We have extracted Hatch's comments and responded to each in tabular format, see **Table 1**. Four general responses are provided at the top of the table.

Table 1. NHC’s responses to the peer review

Comment # & Hatch’s page #	Hatch’s Comment	NHC’s Response
1 Page: n/a	n/a	Contacting an EGBC registrant whose work is to be reviewed is not a requirement, but it is a professional courtesy and it provides the opportunity for the exchange of pertinent information that would assist in the review. Engineers and Geoscientists BC encourages open communication when possible (EGBC, 2021). For this review, ACRD forwarded contact information from Hatch to NHC, but Hatch didn’t contact NHC directly to notify us that they were reviewing our work.
2 Page: n/a	n/a	For past reviews, NHC has received a scope of work and budget from our clients to actively participate in the review process. For this review, no scope of work or budget was arranged. We did receive a single inquiry through the ACRD about a hydrology file, for which we provided the information in an open spreadsheet format with the proprietary information (e.g. formulas) removed. No further inquiries or lines of communication were directed to us.
3 Page: n/a	n/a	The Somass flood study summary report is a high-level overview and should not be considered standalone from the technical appendices. This is stated on the first page of the summary report under section ‘This Report’. Several Hatch review comments indicate missing information, references, and methodology. There are several instances outlined below where NHC indicates the Appendices and page number/section in which the missing information is actually provided. The summary report and appendices are one document and continuously reference each other and should not be read as standalone segments.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
4 Page: n/a	n/a	Hatch used a series of 2019 references in assessing NHC's work. The Somass study was initiated in 2018, with a significant portion of the technical work completed in 2018 and 2019. Its unreasonable to review our work against guidelines that were not available at the time of undertaking the project, unless explicitly stated as such.
5 Page 3	NHC did not directly reference the EGBC Guidelines for Flood Mapping in BC (EGBC, 2017)	NHC did use EGBC guidelines for the work, although not extensively referenced in the report. The specific EGBC (2017) guidelines mentioned by Hatch are listed as a reference document in Appendix B Hydrologic Analysis (B2, Appendix A).
6 Page 9	Hatch used the Federal Hydrologic and Hydraulic Procedure for Flood Hazard Delineation (2019) and Alberta Transportation (2001) to guide the flood frequency analysis review	NHC is familiar and has reviewed the Federal Hydrologic and Hydraulic Procedures report. It is relatively general in nature and describes standard practice and methods developed by other agencies and organizations that NHC have used for many years. The document states it is not intended to supersede other technical guidance. It also states the information and perspective does not reflect that of any specific province or region. Therefore, the technical standards and guidelines NHC has followed are sufficient. The Alberta Transportation (2001) guideline is a not a typical guideline used by BC hydrologists for floodplain mapping work particularly since coastal watersheds and runoff characteristics are very different.
7 Pages 10 & 11	NHC did not deregulate the series of flows	Flows were not deregulated due to the specific design and operation of the structures on Sproat Lake and Great Central Lake. The weir on Sproat Lake controls low flows only. The channel control is located approximately 275 meters downstream of the weir (Appendix B, pg. 21 to 23). The Stamp River dam does not have a high-level spillway. The dam is configured for 11 stop logs, however winter operating conditions maintain a 2 to 3 stop log configuration (Appendix B, pg. 25).

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
8 Page 10	Exclude low outliers when determining sample skew, present the results of tests for stationarity, present the plots of the data series and discuss peculiarities and anomalies.	Skew and stationarity were not assessed. Limited statistical analysis was completed on the data prior to analysis due to budgetary constraints on the hydrology scope of work. Mann-Kendall trends in runoff were calculated (Appendix B, pg. 29). NHC welcomes the opportunity to complete further statistical analysis for the hydrological component of this project
9 Page 10	Summarize previous [hydrology] studies for the same site	The Province's 1997 study is referenced in Appendix A, Appendix B as well as Appendix F.
10 Pages 11 & 12	<p>While insufficient information is available to definitively determine how the assessment was conducted, it appears that the climate change impacted lake levels were calculated based on a backrouting of the river flows out of the lake, rather than by assessing the inflows to the lake and evaluating how much the level of the lake is expected to increase as a result of having the higher inflows. While this assessment is conservative and results in higher levels on the lakes, it may be overly so in this case as it appears to result in excessively high levels on both Great Central Lake and Sproat Lake as a result of climate change.</p> <p>Estimates of water levels on the lakes use a backrouting technique rather than assessing the inflows to the lake and their impact on water levels, which may result in excessively high water levels on both lakes.</p>	<p>In a similar setting on Vancouver Island, NHC recently used both a back routing method (similar methodology as for the Somass study) and a forward routing method to simulate inflows. For the forward routing approach on the other watershed, we used lake levels and outlet flows to generate a long time series of inflows, then completed a frequency analysis of inflows, estimate the 200 year inflow then forward routed the inflow through the lake to estimate the outflow. The accuracy of the inflows was very sensitive to the quality and length of the lake level data. In the end, the results from the 2 methods agreed closely. The water level records for Sproat Lake were not as good as the other watershed mentioned above, and even worse for Great Central Lake (GCL). Thus, the forward routing analysis in the Somass basin would not have greatly improved the results. We'd also like to note that NHC's scope and budget did not accommodate the forward routing methods (which require a high level of effort), and/or detailed hydrologic modelling. NHC would be pleased to continue working with the ACRD to monitor lake conditions (e.g. wind, waves, and water levels), and to conduct more in-depth desktop analyses on the hydrology of Sproat Lake.</p>

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
11 Page 11	Spreadsheets were provided that contained the results of the flood frequency analysis that was completed by NHC. These spreadsheets were reviewed but were password protected and did not contain any formulas so they were of limited use to this review and did not change the above conclusion.	We received a single inquiry via email from the ACRD on behalf of Hatch requesting a hydrology file. The request said "Would you be able to provide flood frequency and climate change data (spreadsheets?) to accompany the data deliverables package we received with the initial package delivery?" (A. Wilson, April 2, 2021. pers. comm.) NHC provided the requested information in a non-password protected spreadsheet with our proprietary information (e.g. formulas) removed. As noted in the spreadsheet, much of our flood frequency analysis work was completed in the statistical computing program R. No further inquiries or lines of communication were directed to us.
12 Pages 11 & 12	In the absence of more detailed climate change modelling (such as PCIC station data that is available for mainland BC), the climate change estimates made by NHC is appropriate.	Future precipitation and temperature data for the Port Alberni region were downloaded from PCIC and used to inform the climate change impacts to hydrology (Appendix B, pg. 33 to 37)
13 Page 15	NHC used four upstream inflow boundary conditions for the 2D Somass River model, two of which (Kitsuksis Creek and Rogers Creek), did not specify the data source used to develop the inflow boundary condition	Development of inflow boundary conditions for Kitsuksis and Rogers creek are summarized in Appendix B, pg. 38 to 41. Sections titled 'riverine boundary conditions' and 'inflow hydrographs'
14 Page 16	A regional uplift allowance of -0.17 m by the year 2100 was used, but does not appear to match the annual rate of 2.5 mm/yr identified by the 2011 BC guidelines. However, although not cited in the report references, it does match the rate of 2.06 mm/yr identified in the Relative Sea-level Projections in Canada and the Adjacent Mainland United States, issued by the Geological Survey of Canada in 2014.	There are various guidelines and a range of the average predicted rate of uplift in the Alberni area. The Geologic Survey of Canada (2014) <i>Relative Sea-Level Projections in Canada and the Adjacent Mainland United States</i> was used.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
15 Page 17	Wind speeds for different return periods have been provided only for South winds. While for Port Alberni the South wind speed for the 200-year AEP was used explicitly, winds from multiple directions, with unknown wind speeds, were used to establish the maximum significant wave height within Sproat Lake.	There is a lack of wind speeds and wave climate data for the study area. NHC applied the 200-year AEP for south winds to multiple wind directions for Sproat Lake (Appendix C, pg. 18). Additional data gathering and desktop analysis could increase the accuracy and certainty of the results. NHC recommends gathering additional physical data (e.g. wave characteristics, wind, and water levels) followed by detailed desktop analysis. NHC welcomes the opportunity to continue working with the ACRD on managing flood risk and adapting to climate change.
16 Page 17	For the Great Central Lake it is not known what wind direction or speed was used. A check of the possible wave height and associated periods generated using the JONSWAP wave hindcast equation would suggest that a wind speed of 33 m/s has been used to obtain the wave height results presented in Table 8 of the NHC report. This assumption appears to be overly conservative based on the wind data presented in the report (i.e., 22 m/s wind speed from the South for the 200-year AEP).	There is very limited data available for GCL. If the ACRD wants to refine the Flood Construction Levels (FCLs) in this area, NHC recommends gathering additional physical data (e.g. wave characteristics, wind, and water levels) followed by detailed desktop analysis. NHC welcomes the opportunity to continue working with the ACRD on managing flood risk and adapting to climate change.
17 Page 17	<p>With regards to run-up:</p> <ul style="list-style-type: none"> ▪ It is unclear why the Stockdon (2006) reference was used, since the tables of results do not identify areas with sandy or gravel beaches. ▪ The EurOtop (for which the latest edition is 2018, not the cited 2016) provides equations to address both riprap and vertical walls. Therefore, the reference to the ▪ use of the Shore Protection Manual (1984) is unclear. ▪ No distinction appears to have been made on slope angles, which will have a significant impact on run-up. 	The study provides a generalized classification of the shorelines and their geometries. The NHC work provides conservative estimates of the wave effects at the mapped areas. Site specific investigations can be carried out to further refine the wave characteristics, run-up, and flood construction levels on the lakes and inlet.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
18 Page 17	The report states that wave set up is based on Moura et al. 2013; however, this work does not provide equations and is not entirely applicable to this work since it addresses only tidal inlets. It is likely the equation 2 from Tinh et al. (2008, instead of the cited 2007 article below Figure 20 of the NHC report) has been used. However, this assumption and how the equation was applied cannot be verified, based on the available information.	The study provides a generalized classification of the shorelines and their geometries. The NHC work provides conservative estimates of the wave effects at the mapped areas. Site specific investigations can be carried out to further refine the wave characteristics, run-up, and flood construction levels on the lakes and inlet.
19 Page 17	Seiche analysis is presented for Sproat Lake, but the same results are applied to both lakes.	There is no available data on which to conduct a seiche analysis for GCL. Thus the Sproat Lake estimate was applied. Note that the seiche effect is relatively small relative to other factors (e.g. flood still-water level, waves, freeboard)
20 Page 18	The main consideration that arose from the review of Appendix C of the NHC Flood Assessment Report, is that tsunami hazard was not considered. The Flood Hazard Area Land Use Management Guidelines (2018) states that areas subject to significant tsunami hazard, as defined in the by zones A, B, C, and D of the tsunami notification zone shown in Figure 2-2, should consider tsunami hazards.	As noted by Hatch, assessing and/or mapping tsunami hazards was outside NHC's scope of work.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
<p>21</p> <p>Page 23</p>	<p>The following list describes items that could benefit from more details, but that are not believed to significantly affect the end result for the flood mapping, especially considering it is not necessarily a required component of the SOW:</p> <ul style="list-style-type: none"> ▪ Clearly describe how the summarizing conclusion of the main report that there are only minor inputs from bank erosion and tributaries was made, as there are several observations listed in Appendix D of eroding banks and areas of channel rearrangement. ▪ Include notes on wind condition and lake levels in the physiography section, as flood levels on lakes reaching typically unexposed areas of the banks, along with wave energy from high wind event, can be significant events leading to shoreline erosion. ▪ The air-photos from 1951 and 2018 were not georeferenced; georeferencing the air photos would provide a more accurate assessment of the historical lateral changes. NHC has noted this observation. ▪ Ensure all data from rating curve figures (such as Figure 8 of Appendix D) are visible. ▪ Appendix D refers to future geomorphology work (georeferencing of air photos) but does not list further information on the future geomorphology work in terms of what the purpose and scope would be for the flood management study. 	<p>NHC appreciates the comments suggesting additional detail and future work would benefit flood planning in the Somass Basin. NHC welcomes the opportunity to continue working with the ACRD on managing flood risk and adapting to climate change.</p>

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
22 Page 28	For the floodplain maps, these extents were smoothed. Manual edits were made to areas behind dikes, extending the floodplain beyond the modeled extents to the same elevation within the Somass River. This was a conservative measure, presumably taken in lieu of completing official dike breach analysis (though as previously stated, this seems to be a reasonable expected outcome and includes an identifier attribute with special hatching).	The area behind River Road (dike) has a small storage component. As such, overtopping or a dike breach would lead to the area filling with flood water relatively quickly, then flowing back over the dike near the confluence with Kitsuksis. The actual flow dynamics behind River Road are incredibly complicated. For example, the hydraulics would be affected by elements such as topography, ditches, fences, houses, outbuildings, and parked vehicles. We feel our approach of extending the flood profile isolines across the area behind River Road was not a conservative measure, but rather a reasonable one.
23 Page 29	Additional detail describing the concept "Breach Airport Road Dike" would assist with clarification on this concept, as it is not immediately clear how breaching the north dike will help mitigate flooding on the north side of the river.	Concept 4 (Appendix G, page 12) is to breach the Airport Road dike. This structure is on the south side of the river, across from River Road. By breaching the Airport Road dike, flood levels in the river may be lowered, which would take pressure off the populated area on the north side of the river. Note that the Airport Road dike does afford some protection to the water line and effluent treatment ponds; however, the area is primarily undeveloped or agricultural.
24 Page 30	It is unclear if the full effect of the removal of the weir is considered, as it is not demonstrated if the initial water level at Sproat Lake is altered at the start of the simulations, for the various scenarios. If starting just above the crest of the weir for the base case, the case with the weir removed would likely have the starting lake level at an elevation just above natural ground at the outlet (approximately 0.6m lower), as this would become the new normal water level of the lake. Likewise for the scenario with the fish window open. This drop in lake level would represent a significant volume that could help to attenuate flows by providing additional flood storage.	The HEC-RAS 1D backwater model was used for all simulation, as stated in Appendix G, page 18. For this model, a boundary condition was established downstream of Hwy 4 where there was no hydraulic influence on the lake level. The same inflow hydrograph was routed for each of the scenarios that were assessed. The model computed the starting water levels based on the inflow hydrograph and the backwater calculations. Thus, the starting lake level for the various scenarios was accounted for.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
25 Page 31	It is unclear if the full attenuation effects were modeled with a "storage area element" in the 1D model. If using a "storage area", the stage-storage characteristics of the lake are indeed used to make a direct calculation of the resulting lake level vs inflow volume at each time step, and this is automatically applied upstream of the weir (in this case). However, the stage-storage characteristics or method of evaluating this are not defined within this section. This should be confirmed.	Yes, the storage element represented the entire lake's volume at various stages. From Appendix G, page 18: A storage element was added in the model to represent Sproat Lake. The storage element was required to study attenuation effects of the different scenarios. The input hydrograph was scaled such that the 2016 lake outlet discharge matched the WSC gauged flow of 300 m ³ /s. All scenarios were forced with the same input hydrograph.
26 Page 32	It is noted that the profile view of the lake to channel thalweg (extracted from the NHC report and shown in Figure 2-5) demonstrates what could be an accumulation of material behind the weir, as there is a distinct rise in the channel thalweg for approximately 25 m upstream of the weir, followed by a drop to elevation 25.63 m on the downstream side of the weir. This material could potentially be eroded with the removal of the weir, back to its presumptive natural state. Additional analysis would be required to confirm if this is a possibility. This does not appear to be covered in the geomorphology section. If this is the case, and it is only the weir that is removed in the model simulation but not the material, this could lead to artificially higher losses in the simulations.	A large rock excavation was completed at the time of construction of the weir to help mitigate potential flood impacts of the structure. The lake outlet was widened from pre-weir conditions. The hydraulic control for the lake outlet during flood conditions of more than about 200 m ³ /s is farther downstream (about 260 to 430 m downstream of the weir for an outflow of 300 m ³ /s). Additional analysis is possible to assess the effects of the weir on lower discharges, but once flows get to about 200 m ³ /s the weir is essentially drowned out (NHC App B Fig 6; BC Provincial letter and engineer's report from 1968). In other words, the weir and any bed forms upstream of it do not have any effect during flood events such as the 2016 flood when lake outflow was 300 m ³ /s.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
27 Pages 32 & 33	The provided original 1956 design drawing "D51000_D 51004" includes a drawing with rating curve, which has been transcribed and converted to metric and to the same elevation datum as used in the NHC study (using the weir crest elevation of 27.3 m as the benchmark reference) to facilitate the peer review, and is presented below in Table 2-4. And Table 2-4 on page 33.	The conversion from the 1956 local datum to NGVD28 is [local datum – 105.84 ft] / 3.28 ft/m. Then the conversion to the study datum of CGVD2013 is approx. +0.175 m. The datum shift on Hatch's Table 2-4, 3 rd column is incorrect. For the Feb 9, 1918 event, the original rating curve and NHC's model results are within 0.08 m.
28 Pages 32 & 33	In order to assess the effect that the removal of the weir would have on lake levels and the system as a whole, the hydrologic record would need to be analyzed and altered to account for what the historic lake levels would have been if the weir was not in place. A flood frequency analysis would have to be completed to determine the "new" flood frequency lake levels and corresponding flow, as the entire flow regime could change. The analysis presented in NHC's report appears to assume that the flood conditions are unchanged, and the weir is simply removed from the system. The conclusion is that the weir is already backwatered from the downstream constriction, so it's removal would not affect the presented flood levels. However, it appears that the control shifts at some point during the flood regime, so flood levels for the smaller, less frequent events would be reduced. This will influence the economics, as the flood damage curve will decrease at the lower end of the spectrum. This should be taken into account in any risk comparison studies. It is recommended that this analysis be completed to determine the system effects of removing the weir in order to quantify its impact.	NHC agrees with Hatch that additional detailed analysis is required to assess the full hydrologic implications of the weir; that detailed analysis was outside of our work assignment. NHC welcomes the opportunity to continue working with the ACRD on managing flood risk at the outlet of Sproat Lake.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
29 Page 33	<p>The analysis presented in NHC's report appears to assume that the flood conditions are unchanged, and the weir is simply removed from the system. The conclusion is that the weir is already backwatered from the downstream constriction, so its removal would not affect the presented flood levels. However, it appears that the control shifts at some point during the flood regime, so flood levels for the smaller, less frequent events would be reduced. This will influence the economics, as the flood damage curve will decrease at the lower end of the spectrum. This should be taken into account in any risk comparison studies. It is recommended that this analysis be completed to determine the system effects of removing the weir in order to quantify its impact.</p>	<p>NHC agrees with Hatch that additional detailed analysis is required to assess the full hydrologic implications of the weir; that detailed analysis was outside of our work assignment. NHC welcomes the opportunity to continue working with the ACRD on managing flood risk at the outlet of Sproat Lake.</p>
30 Page 36	<p>Notes on map sheet 13 indicate: "Flood inundation boundaries represent modeled inundation extents only. Freeboard of 0.6 m is not applied to the inundation boundary. Freeboard is applied to FCL isolines only." This is also supported in the legend which reads "Flood Extents Excluding Freeboard" to indicate the filled dark blue areas. As the black FCL isolines that include freeboard extend to the same location as the dark blue inundation area that does not include freeboard, it would be helpful to the reader to even more clearly indicate that the black FCL isolines are only demonstrating the elevation, in a comment such as "The flood inundation boundary should be extended to the elevation shown on the FCL isolines to arrive at the elevation including freeboard." This could be paired with the inclusion of labeled contours to help the reader better approximate those extents.</p>	<p>The maps indicate that the report should be consulted and used in concert with the flood maps to understand the assumptions and methodology used to prepare the maps. In our opinion additional commentary on the maps will only add confusion to the information that is presented.</p>

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
31 Page 36	Notes on the map sheets refer to a number of hatched areas, but hatched areas could not be located. It is presumed these will be added for the final version.	<p>The purpose and use of hatched areas is described in Appendix F, pg. 4 to 5. Hatched areas are located on mapsheet 3, 6, 10, 13, 14, and 15.</p> <p>These hatched areas were on the maps NHC submitted to ACRD. Was there a specific sheet that Hatch is referring to?</p>
32 Page 36	Notes on map sheet 2 indicate: "The dam has been excluded from the study", which is indicated for both the Stamp River Dam and the Robertson Creek Dam. The meaning of this note is not immediately clear, knowing that the Robertson Creek Dam is not included in the model at all, but the Stamp River Dam and its reach is indeed included in the model (as well as it can with the available information).	The mapped FCLs did not extend over the footprints of the dams.
33 Page 36	It is not clear how the Coastal FCL extents, ending between FCLs of 5.2 m and 5.1 m in the vicinity of the River Road PALB Dike, were established or why they are not shown in some areas.	The coastal FCL extents in the river are a function of where coastal processes, primarily waves, are factored.
34 Page 36	One additional note surrounds the naming convention for the floodplain maps. Flood Mapping in BC states that floodplains are no longer considered to be "designated" by the province. Rather, inundation maps are defined in this guideline as topographic maps showing the extent of floodwater in plan, under defined flood events. This alludes to the fact that the design flood selected may not always be the 200-year flood as demonstrated on historical "designated" flood plain maps. The provided examples in the guideline support the name "Floodplain Mapping". This is simply a note for discussion, in the case that this discussion has not yet occurred.	Floodplain Mapping in BC states that the province's historic (30 year old) floodplain maps listed on the Provincial website "are no longer considered to be designated by the Province". These old Provincial maps are obsolete and were not prepared using presently available methods. The usage in the report was restricted to meaning the specific flood events that were used to prepare the floodplain maps.

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
35 Page 37	The stoplog spillway arrangement includes 8 bays with crest elevations specified for each bay for each of 0, 1, 2, and 3 stoplogs available for each bay.	There are up to 11 stoplogs available for each bay. NHC considered modelling the dam outlet, which affects levels in GCL, using 0, 1, 2, or 3 logs. There is a possibility that there could be more than 3 logs when a flood occurs; however, the historic records indicate there are usually 3 or less logs in place. If the flows are high, stoplog removal can be impeded.
36 Page 37	The 200-Year Designated Floodplain Map sheet 2 includes the notation "The dam has been excluded from the study" beside each of the Stamp River Dam and the Robertson Creek Saddle Dam. It is acknowledged that the Robertson Creek Saddle Dam is not included in the study, as its small capacity compared to the large volume of Great Central Lake would not have a significant impact on the study results	The mapped FCLs did not extend over the footprints of the dams on GCL.
37 Page 38	The report notes that overtopping of the dam crest does not occur and therefore did not have to be modeled, but the presented levels (84.46 m for the 200-year event) are higher than the dam crest (84.26 m). A review of the model appears to demonstrate that overtopping flows are accounted for, therefore this the meaning of this statement should be clarified. Additional details surrounding the modelling of the dam would assist with understanding.	<p>The GCL dam crest (Stamp River Dam) is 84.26 m. It may overtop as it is a concrete overtopping-style structure, compared to a ported-style structure. Appendix E, p15 states "There was no need to model pressurized flow through the bay openings or overtopping of the dam crest at elevation 84.26 m because these conditions did not occur." This sentence refers to the pressurized flow condition not occurring as opposed to the dam not overtopping.</p> <p>The maps in Appendix J, Sheet 2 have annotations at the dams that say "The dam has been excluded from the study". To clarify, modelling accounted for the geometry of the dams, but the flood maps do not show the FCLs at the dams.</p>

Comment # & Hatch's page #	Hatch's Comment	NHC's Response
38 Page 38	<p>A flood frequency analysis was performed on the WSC gauge downstream of the dam to determine the 200 year flow in the downstream reach. This flow was used as the upstream inflow to a 1-D HEC-RAS model that includes the lower portion of Great Central Lake, the Stamp Lake Dam and the downstream river reach. The resulting lake level required to pass this discharge was selected as the associated 200-year lake level. This is an appropriate methodology to estimate the 200-year lake level in the absence of long term data. However, this same methodology is applied to estimate peak lake levels under climate change. It appears that it is the discharge from the dam that is multiplied by the 10% and 20% climate change factor, and the water level required to produce this discharge is taken as the lake level under climate change. However, the discharge from the dam is entirely dependent on the geometry of the spillway and the storage curve of the upstream reservoir, and does not consider the specific variables affected by climate change. It is expected that this increase would be applied to the inflows to the lake in order to consider the storage effects of the lake itself, determine the resulting lake level, and review how the dam passes this increased flow.</p>	<p>In a similar setting on Vancouver Island, NHC recently used both a back routing method (similar methodology as for the Somass study) and a forward routing method to simulate inflows. For the forward routing approach on the other watershed, we used lake levels and outlet flows to generate a long time series of inflows, then completed a frequency analysis of inflows, estimate the 200 year inflow then forward routed the inflow through the lake to estimate the outflow. The accuracy of the computed inflows was found to be sensitive to the quality of the lake level data. In the end, the results from the 2 methods agreed very closely. The available water level records for GCL are even more limited than on Sproat Lake. We'd also like to note that NHC's scope and budget did not accommodate the forward routing methods (which require a high level of effort), and/or detailed hydrologic modelling. NHC would be pleased to continue working with the ACRD to monitor lake conditions (e.g. wind, waves, and water levels), and to conduct more in-depth desktop analyses on the hydrology of GCL.</p>

Closure

Thank you for the opportunity to respond to the peer review completed on our Somass Watershed Flood Management Plan. Please contact me if you have any questions or require additional support.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Prepared by:

Graham Hill, P.Eng
Principal

Disclaimer

This report has been prepared by Northwest Hydraulic Consultants Ltd. for the benefit of for specific application to the Somass Watershed Flood Management Plan. 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 practices.

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REPORT FOR INFORMATION

To: Alberni Valley and Bamfield Committee

From: Jodie Frank, Organics Coordinator

Meeting Date: December 1, 2021

Subject: Alberni Valley Electoral Areas - Roadside Three-Stream Waste Services Update

Desired Outcome:

The purpose of this report is to provide the Alberni Valley (AV) and Bamfield Committee's with an overview of the engagement and consultation process in the Alberni Valley (Areas B, D, E and F) to determine if there is an interest for a roadside three-stream collection service.

Summary:

In September 2021, the Alberni Clayoquot Regional District (ACRD) and the City of Port Alberni (CPA) implemented the first phase of the Regional Organics Diversion project that included moving to a curbside three-stream (recycling, organics and garbage) collection system to all single-family households within the city limit boundaries of Port Alberni.

The ACRD is now exploring options for a similar service for the Alberni Valley electoral areas and in order to move forward with future program development, the ACRD is looking to collect feedback and support from residents to help inform directors regarding introducing a roadside waste service in electoral areas.

The recent implementation of the Sortn'Go three-stream has demonstrated a successful program to date and achieved an increase of waste diverted from the landfill. The previous waste diversion rate of 20% has increased to 65% over the first 10 weeks of the program and has diverted over 465 tonnes of organic waste from the landfill. On average residents, residing within the City of Port Alberni city limits, are diverting 14% recyclables and 51% organics at the curbside.

Background:

The ACRD is looking to engage with the AV communities prior to developing the scope of the project to determine the degree of interest in each of electoral area and First Nations communities. The overview of a three-stream waste service would include providing three stream-curbside collection (recycling, organics and garbage) and could service up to approximately 3000 single family households. It is also important to note that the ACRD is considering implementation of an organics ban at the landfill in 2023 and curbside collection would offer a management option for restricting those materials from entering the landfill and or potential financial penalties.

There are significant environmental benefits from collecting organics and recycling at the curb including:

- further increase waste diversion;
- extending the life of the landfill;
- a reduction of landfill gas production by diverting these materials from landfilling;
- achieve the per capita disposal rate target of 400kg/year;
- reduction of illegal dumping on streets and in trails, improving neighbourhood esthetics by keeping materials contained;
- a reduction of fire hazards associated with the build-up of yard waste in forested areas;
- reduced human-wildlife interactions;

- reduce open air burning of waste material;
- a reduction of individual trips to the landfill to drop off yard waste, in turn reducing GHGs and improving air quality; and
- production of a useful compost amendment from previous waste materials.

Funding to support upgrades to the new waste services, including the ACRD's Regional Organics Implementation Project, is eligible through the Strategic Priorities fund. In 2020, the ACRD received a \$6-million grant that will fund the introduction of organics collection in the regional district. The program phases are the following:

- Phase 1: City of Port Alberni (completed phase)
- Phase 2: Tofino & Ucluelet (current)
- Phase 3: **Alberni Valley Electoral Areas**, Bamfield, First Nations and surrounding communities (consultation with community 2022)

Carts

With the implementation of a fully automated collection system, residents will be provided with a set of easy-to-roll carts with attached lids for convenient and efficient disposal of recyclables, food waste and garbage. Organics would be collected weekly with garbage and recycling alternating bi-weekly. Cart sizes being considered for three-stream collection are 120 L for Garbage, 240 L for Recycling and 120L or 240L for organics with wildlife proof mechanisms included as a specification requirement (for both garbage and organic containers).

Public Support

A recent survey was conducted on letsconnectacrd.ca specific to AV residents. Out of the survey participants the following information was determined:

- 57% have roadside collection and 36% self-haul for garbage and recycling
- 72% expressed a level of interest 10% were impartial and 17% are not interested
- In a report submitted to the AVB Board Aug 11th 2020 it was determined that Phase 1- (City Port Alberni) will act as a pilot for Phases 2 (West Coast communities) and Phase 3 (Alberni Valley electoral areas, first nations and Bamfield) implementation using success and data measures to support the implementation of the similar waste services for the AV electoral areas.

Next Steps:

Engagement

In order to achieve success with implementation of a potential new waste service, it is important for the ACRD to develop a strong engagement strategy that will allow the ACRD to collaborate with the community and gauge the level of interest for a new standardized waste service, and to determine barriers and rational for opposition. The engagement process will also help determine if a new service could be established in all electoral areas, or in selected electoral areas and first nation communities.

Engagement and outreach planning are currently underway with a focus of achieving two main goals:

1. **INFORM** Alberni Valley residents about the ACRD goals to increase waste diversion and opportunities presented via roadside collection services.
2. **CONSULT** with Alberni Valley residents about implementation of a three-stream waste diversion program.

To achieve the two outreach goals, the objectives and activities below are proposed and a survey for each area will be undertaken and combined with required information about the proposed service and promotional materials for it to succeed.

GOAL 1: INFORM ABOUT WASTE DIVERSION GOALS + ROADSIDE COLLECTION OPPORTUNITIES	
Objectives	1. Provide update about ACRD waste diversion goals and current statistics
	2. Inform about potential service options and estimated cost

Main Communications Activities	Create and promote online information hub
	Develop and deliver direct-mail infosheet (or for insert in other mailer if available)
	Create and share FAQ/infosheet
	Social media posts for ACRD accounts
	Identify opportunities to support directors in sharing information

GOAL 2: CONSULT AND GENERATE DATA ON THE INTEREST OF IMPEMENTATION OF A THREE-STREAM PROGRAM	
Objectives	1. Create opportunity, area-by-area, for residents to indicate interest in service
	2. Promote opportunity using a range of tools to achieve strong response rate
Main Communications Activities	Develop and post survey for each area on LetsConnect with contest
	Draft and distribute press release to launch engagement
	Create and provide hard-copy surveys for those who don't wish to submit online
	Host informational sessions (Location/# TBC) with opportunity for on-site survey
	Create handbill for landfill operators to distribute promoting survey
	Develop and publish traditional media advertising (print, radio)
	Social media posts for ACRD accounts
	Monitor for, and assist with replies to questions or comments about the project

Timeline

The below timeline is based on these key factors:

- A two-to-three-week focused survey period that is supported by strongly coordinated, simultaneous promotion will be designed to generate high response rates.
- No less than 10-days' notice should be provided for community informational events
- The month of December is not recommended for engagement unless absolutely mandatory – especially if the issue has the potential to generate negative feedback.

The engagement window is recommended for Jan. 10-31. This allows the project team adequate time to generate materials and promote the engagement, after the December holiday season.

Conclusion/Recommendation

The proposed engagement for Alberni Valley electoral areas will provide education and purpose for the proposed curbside three-stream service, primarily contributing to the Alberni Valleys diversion targets. This engagement process will also allow residents to be involved the decision making and will allow directors to hear from the community about each electoral area's level of interest and provide input to be considered as decisions about the proposed service are made.

The engagement timeline allows for sufficient time to consult and determine if a roadside collection program is of interest for residents in the area and is necessary in order for the ACRD to achieve its grant funding requirements which will expire spring of 2023.

Submitted by: *Jodie Frank*
 Jodie Frank, Organics Coordinator

Reviewed by: *Jenny Brunn*
 Jenny Brunn, General Manager of Community Services

Approved by: *Daniel Sailland*

Daniel Sailland, Chief Administrative Officer