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northwest hydraulic consultants

NHC Ref. No. 3002812

20 March 2017

Sproat Lake Community Association
9346 Bomber Base Road
Port Alberni, BC
V9Y 9Z3

Attention: **Greg Steel**
President

Copy to: **Bob Cole, SLCA Resident**

Via email: avra.gsteel@gmail.com; bobcole@shaw.ca

Re: **Sproat Lake Outlet**
Proposal for Engineering Hydrotechnical Study – Rev 1

Dear Mr. Steel:

1 INTRODUCTION

Sproat Lake Community Association (SLCA) member Bob Cole contacted Northwest Hydraulic Consultants Ltd. (NHC) in February 2017 to discuss flooding of lakeshore residences that occurred in the fall of 2016, as well as past major flood events. These floods have affected dozens of homes and properties with damages in the hundreds of thousands of dollars.

In 1992, a bedrock outcrop on the left bank (looking downstream) of the Sproat River immediately downstream of the lake outlet was identified as a hydraulic constriction during floods in the Sproat system, and this feature is believed to have contributed to high flood levels in Sproat Lake (Figure 1). It is NHC's understanding that the SLCA would like to investigate the hydrotechnical effects that this feature has on lake levels and downstream discharges. Furthermore, there is uncertainty about the effects that the outlet weir and the weir plates have on water levels in the lake, and SLCA would like to assess this component also.

The purpose of this proposal letter is to outline our recommended approach, estimated costs, and relative schedule for undertaking a hydrotechnical assessment of the lake outlet. The outcome of the study will specifically quantify the effects of the bedrock outcrop and outlet weir on the lake levels and downstream discharge to the Sproat River.

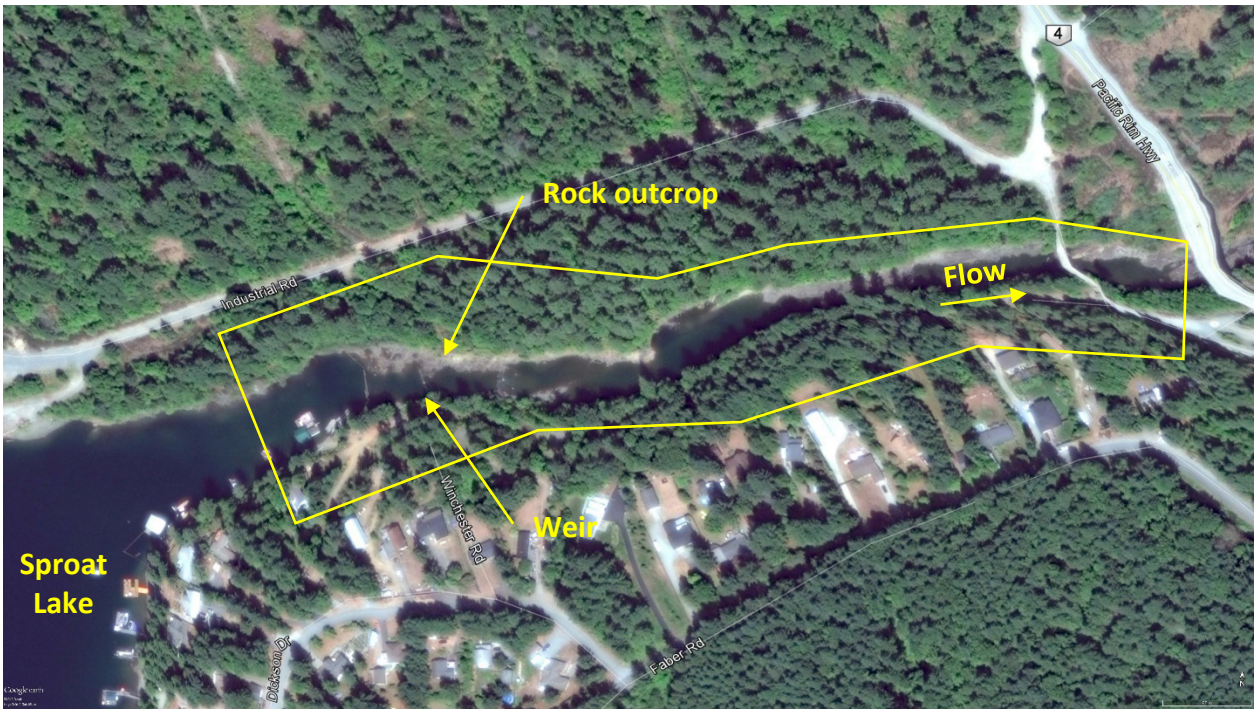

Figure 1. Project overview showing the area of interest for the study

2 APPROACH

Our approach for assessing the extreme lake flooding and the effects the bedrock outcrop and weir have on lake levels and downstream discharges is to develop a two-dimensional flow model. The model will be based on the actual geometries of the outlet. An inflow hydrograph will be developed using available hydrologic data, then the model results will be checked against the historical hydrologic data (discharge and water levels). The next step will be to run the model with modified geometry to simulate the scenarios of interest including:

1) Present conditions with the bedrock outcrop, and proposed conditions without the bedrock outcrop; and,

2) Weir plates in position and removed weir plates.

2.1 Geometry

The model geometry will be collected from various sources. The Provincial bathymetry survey and BC TRIM maps will be used to estimate the active storage volume of the lake. The active storage volume is the volume between the minimum lake level and the maximum lake level. The outlet of the lake will be surveyed using a combination of methods; these depend on the project timing and hydrologic conditions at the time of the survey. If water levels are very low then a digital photogrammetric method will be used to survey all exposed areas (i.e. areas not under water or under tree cover). Vegetated areas will be surveyed with a total station and underwater areas will be surveyed with an RTK GPS and/or a total station. If water levels are high or moderate at the time of the survey then an RTK GPS and total station

will be used. For deeper areas, NHC will survey the river and lake outlet downstream of the log boom with our RTK GPS and survey grade sounder from our small jet boat. The survey extents will be approximately as shown on Figure 1.

2.2 Model Overview

The flood model we will use for this study is the US Army Corps of Engineer's (USACE) Hydraulic Engineering Center River Analysis System (HEC-RAS). The model will be used to simulate existing geometry of the river and the proposed adjustments, as outlined above. The Water Survey of Canada data for Sproat Lake (date of data: 1913 to 1996; gauge # 08HB015) and the Sproat River (date of data 1913 to 1996; gauge # 08HB015) will be used in conjunction with the model and lake bathymetry/TRIM data to develop an inflow hydrograph to the lake that coincides with one of the significant floods, such as the 1968 or 1992 flood event. The model will then be run with the generated inflow hydrograph and the water level and discharge results will be compared to the historical flood data to verify the model's accuracy. Once the model is running well, the base geometry will be adjusted to remove the bedrock outcrop and re-run. The results for water levels and downstream discharge will be compared. A similar set of simulations will be performed for the weir plate removal.

2.3 Reporting

A report will be prepared to document the study. It will include a description of the methods and data that were used. Results will be shown in tables and charts. A draft report will be submitted to the SLCA for review, and a presentation of the study will be provided to SLCA and its partners in Port Alberni (venue to be provided by the SLCA). Comments on the draft report will be addressed and a final report will be produced. The report will be submitted in digital form on a thumb drive, as well as 2 hard copies.

3 SCHEDULE AND BUDGET

The project is expected to take 12 weeks to complete. Work can start after SLCA and NHC complete a contract for the work.

The cost estimate to complete the work is $40,000, plus GST. A summary of the estimated costs are shown in Table 1. Work will be invoiced on a lump sum basis, and invoiced monthly based on percent completion.

Table 1. Project cost estimate

Task No.	Task Name	Fees	Disbursements	Total
1	Site inspection and surveys	$15,000	$5,000	$20,000
2	Hydrology and modelling	$15,000	-	$15,000
3	Reporting	$4,750	$250	$5,000
	Total			**$40,000**

4 PROJECT TEAM

NHC will complete this project using its highly trained in-house staff. Our field staff and survey crew operate under a thorough WCB compliant health and safety program, and they are well versed in collecting high quality field data in challenging environments. Our engineering and modelling staff are leaders in surface water resources engineering. Key staff and their proposed roles for this project are listed in Table 2. Resumes for Graham Hill, P.Eng. and Dr. Dave McLean, P.Eng. are included in Appendix A. Other qualified NHC staff may work on the project as required.

Table 2. Key NHC staff

NHC Staff	Role
Dr. Dave McLean, P.Eng.	Senior Technical Review
Graham Hill, P.Eng.	Project Manager and Technical Lead
Ryan Rasmussen, EIT	Lead Modeller and Survey Assistant
Aaron Snyder	Lead Field Data Collector / Survey Lead

5 CORPORATE BACKGROUND

Northwest Hydraulic Consultants (NHC) is an internationally recognized engineering consulting company that specializes in water resources engineering for the development, management and protection of water resources. NHC's professionals are highly qualified in all areas of hydrotechnical engineering. We offer state-of-the-art expertise, in-depth experience, innovative thinking, and responsive service.

NHC supports the goals and well-being of our clients and the global community we serve by providing technically advanced, environmentally responsible, innovative, and specialized scientific and engineering solutions to water resource challenges. We base our insights and recommendations on focused and advanced research and applications conducted in the field, our laboratories, and our offices. We describe and analyze complex hydrologic and hydraulic conditions in the field, and model them in both sophisticated software programs and in physical laboratory models.

The company's areas of expertise include dam safety, hydraulic design, river engineering, hydrology, fisheries engineering, sedimentation, watershed restoration, construction management, coastal engineering and geomorphology, international development, and physical and numerical modelling. In support of the firm's consulting services, NHC offers services in the fields of geographic information systems (GIS), digital terrain modelling (DTM), and field data acquisition (bathymetric surveys, sediment sampling and analysis, velocity measurements, hydrometrics, etc.). NHC presently employs a staff of about 200 of which 70 percent are professionals. NHC personnel are highly qualified and come from a variety of backgrounds ranging from the sciences, technology, consulting, teaching, research, and government service. By employing recognized experts in the field of water resources, NHC can provide clients with specialist advice or services for a particular aspect of a project or organize and manage a project team to provide complete engineering services. Please visit our website (www.nhcweb.com) for additional details regarding our areas of specialization, and specific examples of our project experience.

6 CLOSURE

We hope this proposal thoroughly explains our approach and offered services. Please contact Graham Hill by phone at 250-754-6425 or by email at ghill@nhcweb.com if you have any questions or wish to proceed with the work.

Sincerely,

Northwest Hydraulic Consultants Ltd.

Graham Hill, P.Eng.
Associate

ENCLOSURES

Appendix A: Resumes for Key Staff

David McLean, Ph.D, P.Eng.

Hydrotechnical Engineering Specialist

Education

Ph.D, Interdisciplinary Hydrology Program, UBC,1990

M.A.Sc., Civil Engineering, UBC,1980

B.A.Sc., Geological Engineering, UBC, 1975

License/Affiliations

Professional Engineers Association and Geoscientists of BC

Canadian Water Resources Association

Awards

Hilgard Hydraulics Prize, American Society of Civil Engineers, 1983

Years Experience

35

Areas of Expertise

River Engineering

Coastal Engineering

Sedimentation Engineering

Fluvial Geomorphology

Flood Hazard Assessment

Hydrology

Dr. David McLean has over 35 years of experience in sedimentation, hydraulics, river and coastal engineering and fluvial geomorphology. He has participated in a wide range of water resource projects involving hydrological analysis, field data collection and surveys, hydraulic analysis and modelling in rivers, estuaries and coastal environments. He has conducted numerous studies to assess the physical impacts of major engineering works such as dams, port developments and training works for assessing environmental impacts and has participated in several CEAA reviews.

Selected Project Experience

Flood Management Seminar, Vancouver Island (for the Association of Professional Engineers and Geoscientists of British Columbia). Conducted a seminar on flood management, including a brief overview of flood management in BC and the present regulatory framework. Various case studies, comparing past and present methods for flood risk assessment, management and protection were described. In addition to flooding, other hazards such as erosion, debris flows and channel avulsion were discussed (2009).

Fraser River Flood Profile, Fraser River, British Columbia (for Fraser Basin Council). Project manager responsible for a hydraulic modelling investigation to assess the flood level along the Lower Fraser River from Chilliwack to the Strait of Georgia. The 18 month study assessed two different types of flood mechanisms-an extreme spring freshet causing high flows and water levels and an extreme high tide in the winter months due to storm surge. The flood levels were then compared and a final design flood profile was then adopted. The flood levels were computed using the MIKE11 hydrodynamic model which simulated the unsteady effects of tides and river flows through a complex branching networks of channels and islands, (2005-2008).

Main Rivers Flood and Bank Erosion Risk Management Program, Bangladesh (Asian Development Bank). Bangladesh is located on a vast floodplain. The lower reach of the river system carries the combined flow of the Ganges and Brahmaputra River, making it the third largest river in the world. In 2012-2013, Dr. McLean was the hydrotechnical specialist for a feasibility study to define flood and erosion mitigation projects along a 60 km reach of the main rivers. The work included hydrological investigations, reviewing climate change predictions and supervising MIKE11 hydraulic modelling studies to assess the effectiveness of various project concepts and alternatives. The value of the recommended projects amounted to approximately $400 million (2012-2013).

Container Capacity Improvement Program, Effects of Terminal 2 on Hydrodynamics and Sedimentation (Port Metro Vancouver). Technical reviewer and advisor on studies to assess the effects of port expansion on the physical processes on Roberts Bank and the Fraser River delta. The studies include assessing tide and wave-induced project effects on sedimentation and erosion along the tidal flats and delta. The assessment considers the effect of future sea level rise on ocean levels and erosion to the tidal flats and adjacent shoreline. (2011-2013).

Sediment Management on Lower Cowichan River, Vancouver Island (for Cowichan Valley Regional District). Project manager and senior river engineer responsible for planning and implementing a sediment and debris management program on the Cowichan River. The river is has an unstable gravel bed channel and is undergoing

rapid sedimentation and lateral instability. An assessment of sedimentation trends was carried out by comparing airphotos and past channel surveys. Four sediment removal sites were identified and plans and permits were prepared for removing gravel in 2012 and 2013. The work has been carried out and longterm monitoring is being carried out to assess the effectiveness of the works (2012-2013).

Technical Review of Hydrotechnical Investigations for Yakima River Levee Set-back Plan, Washington State (for Yakima County). Yakima County is undertaking an innovative program to reduce the risk of levee failures by setting back the structures from the Yakima River. Geomorphic and sediment modeling investigations are being undertaken to assess the long-term effect of setting back the levees. Dr. McLean was hired by Yakima County to provide expert review of these investigations. The work included a site inspection along the river, review of existing data and review of technical reports and publications. Advice was provided to strengthen the technical findings so that reliable estimates can be made of the project benefits and impacts. (2010 - Present).

Chemainus River Bank Protection Works, Vancouver Island (for Municipality of North Cowichan). The Chemainus River is an unstable gravel bed channel and actively aggrades as its gradient flattens out near the coast. The municipality's new water supply system required protection against river erosion and flooding. NHC was retained to design river bank stabilization measures to protect the new facilities, while at the same time not adversely affecting critical fish habitat in the reach. The work involved a site assessment, a review of past channel instability using historic air photos, updating a flood frequency analysis to determine an appropriate design flood, conducting river surveys and hydraulic modeling to determine channel hydraulic characteristics. The adopted bank protection measures included a buried riprap sill to prevent future shifting, channel excavation to re-direct flow spills and a bank revetment at critical sections. (2007).

Assessment of Scour Protection Requirements at GVRD River Pipeline Crossings (for Greater Vancouver Regional District) Project manager responsible for conducting river engineering studies to assess scour and to design scour protection counter-measures at seven river pipeline crossings sites in the Lower Mainland. The crossings included five crossings of the Lower Fraser River, a crossing on the Serpentine River and at the Iona Jetty outfall. The investigations included reviewing the history of operations and maintenance records, assessing historic surveys, conducted hydraulic and scour computations, preparing designs and plans of scour protection measures and estimating costs of the work. (2005-2006).

Padma Multipurpose Bridge Project-Detailed Design of River Training Structures, Bangladesh (for Bangladesh Bridge Authority and Maunsell Ltd.) The Padma River is the third largest river in the world and presents a significant challenge to bridge designers due to its unstable channel pattern, high velocities and deep scour. As senior river engineer, Dr. McLean worked with a team of river engineers, geotechnical specialists, numerical modellers and physical modellers to assess the scour at the bridge and to design river training structures to guide the flow through the bridge. The work includes (1) planning the field investigation program, (2) supervising hydraulic and morphologic modeling using MIKE-21 (3) assessing channel erosion hazards along the river using historic satellite imagery and maps (4) developing a test program for physical and numerical model studies and supervising the tests (5) identifying alternative river training works options and determining the preferred alternative (2009-2010).

Review of Sediment Transport Data, Lower Fraser River, British Columbia (for Water Survey of Canada). Reviewed and analyzed suspended-load and bed-load data collected on the lower Fraser River at Hope, Agassiz and Mission. Assessed the effectiveness of the sediment program and outlined potential modifications to the program. (1990).

Selected Publications and Presentations

McLean, D., Galay, V., Wright, B. and W. Fleenor (2013). Integrating flood management, sediment management and fisheries habitat enhancement on the coastal rivers of British Columbia. In River Basin Management VII, ed. C. Brebbia, WIT Press, Southhampton, United Kingdom, pg 301-312.

Vasquez, J., McLean, D., O'Connor, V. and A. Zimmermann (2012). "Hydraulic Modeling for the Padma River Bridge", International Conference on Fluvial Hydraulics, River-Flow.

Neill, C.R., Oberhagemann, K., McLean, D. and Q. Ferdous (2010) "River training works for Padma Multipurpose Bridge, Bangladesh", IABSE, JSCE - Advances in Bridge Engineering, Conference, Dhaka, Bangladesh.

Graham Hill, P.Eng.

Hydrotechnical Engineer

Education

B.A. Sc. Bio-Resource Engineering, University of British Columbia, 1998

License/Affiliations

Association of Professional Engineers of British Columbia

Years Experience

19

Areas of Expertise

Dams

Coastal Engineering

River Engineering

Environment

Hydrology

Hydrotechnical Design

Numerical Modeling

Fish Passage

Fish Habitat

Project Management

Field Services

Mr. Graham Hill has over 19 years of experience in project planning, analysis, design, construction and project management. Recent Vancouver Island projects include the Salmon River Diversion (BC Hydro), Tod Creek Dam (The Butchart Gardens), McLean Mill Dam (City of Port Alberni), Elk-Beaver Lake Dam (Capitol Regional District), Cameron Lake Weir (Fisheries and Oceans Canada) and Keogh Lake Weir (Fisheries and Oceans Canada). Graham's work on these projects included: conducting field reviews of existing structures; reviewing hydrology and inflow design floods; reviewing hydraulic structures including stoplogs, valves, spillways, fishways, riprap, and weirs; designing hydrotechnical components of the dams including valves, spillways, and erosion protection; preparing water licenses and amendments; managing construction of small dam improvements; designing and managing the installation of automated monitoring and automated valve equipment; and, preparing operating, monitoring and maintenance manuals.

Selected Project Experience

Elk-Beaver Lake Dam, Victoria, BC (for Capital Regional District) Surveyed the site, reviewed the existing high structure. Estimated IDF hydrology, routed flows through the reservoir, designed the outlet hydraulic works, prepared conceptual designs and report, prepared cost estimate, reviewed water license requirements including minimum and maximum bypass flows. Modeled potential dam breaks and inundation effects. Designed a new outlet structure and a fishway to provide adult and juvenile trout was incorporated. Prepared dam development documents to meet BC Dam Safety requirements.

BC Hydro Salmon River Diversion, Campbell River, BC (for BC Hydro, BC Conservation Foundation, and Campbell River Salmon Foundation). Worked in a team of project planners, biologists and engineers to assess existing dam structure elements and to develop designs for infrastructure upgrades. Reviewed historic data and drawings; conducted field surveys; prepared reports, drawings and presentations; estimate project construction costs. Upstream (adult) and downstream (juvenile) fish passage infrastructure upgrades played a key role in the project development.

Kitsuksis Creek Dam, Port Alberni, BC (for City of Port Alberni). Reviewed the existing structure including the hydraulic controls. Developed concepts and final designs for removing the dam from the main creek flow. Detailed designs were completed for upgrading the existing dam. Upstream adult fish passage was included. Sediment transport, dam safety, hydrotechnical design, and hydrology aspects were reviewed. Provided engineering support for the construction of the dam upgrades.

Little Qualicum River Dam, Parksville, BC (for Fisheries and Oceans Canada). Re-designed a water storage/flow control structure at the outlet of the lake. Modeled high flow and various flow conditions for the hydraulic structure, designed and supervised the aluminium fishway and flow control structure installation, graded the invert of the lake to access additional water storage. Installed remote sensing and automated operating controls. Managed the project construction budget and prepared as-built drawings and a detailed Operations and Maintenance Manual.

Graham Hill

Westwood Lake Siphon, Nanaimo, BC (for BC Conservation Foundation). Project Engineer for final design and construction inspections for a flow augmentation siphon at the Westwood Lake Dam. The siphon pipe was 150 m long with the inlet screen 7 m below the lake surface.

Keogh River Dam, Port Hardy, BC (for BC Conservation Foundation). Conducted a review of the current structure, and made recommendations for additional storage and other improvements. Prepared technical documents for a water license amendment, prepared a water budget and draft operating curves. Designed a low flow release structure that provides measured flows to downstream aquatic habitats and assists with attracting fish towards the existing combination fishway.

Susitna-Watana Hydroelectric Fish Passage (for US Fish and Wildlife Service and Alaska Fish and Game Department) Technical advisor for upstream and downstream fish passage options for a proposed 180 m high dam on the Susitna River in Alaska. Worked on a team with fish passage engineers and biologists to review large volumes of data, and to direct studies and plans. Input included biological studies, preliminary construction plans, topographic maps, hydrologic studies, ice studies, feasibility studies, and others.

Knarston Creek Bypass, Lantzville, BC (for District of Lantzville). Hydrotechnical engineer for the flood bypass project - determined design hydrology, coordinated a topographic survey, assembled a numerical model, estimated sediment transport rates, designed a flood flow diversion and sediment trap, conducted a wind-wave-tide level analysis, designed a coastal outfall and erosion protection, prepared environmental permitting documentation, and provided construction quality assurance.

Tsolum River Flood Hydrology Investigation, Courtenay, BC (for City of Courtenay, Comox Valley Regional District, and TimberWest Forest Corporation). Lead engineer for an investigation of recent flood events on the Tsolum River. Reviewed climate change, forest hydrology, and climate change literature. Analyzed numerous data sets including peak flow records, precipitation, temperature, and snow pack. Presented interim findings and summarized the investigation in a final report.

Cowichan River Flood Management, Duncan, BC (for District of North Cowichan, Cowichan Valley Regional District, Cowichan Tribes, and the City of Duncan). Project Engineer for the detailed design, permitting and construction of river training and flood management work on the Cowichan River near the sewage treatment and outfall plant. Removed 15,000 m^3 of substrate from the river, relocated a large (500+ logs) debris jam, relocated a 200 m long overflow channel away from the toe of the dikes, and installed 1000 m^3 of riprap to strengthen the outfall pipe.

Somass Estuary Culvert (BC Conservation Foundation). Senior project engineer to upgrade twin failing small diameter culverts under the Regional District's service road at Christie Slough. A topographic survey was conducted of the area and an unsteady-state numerical hydraulic model was developed to assess the replacement structure options. Design drawings and specification were prepared for the selected 2.4 m diameter HDPE pipe. Services included construction project management, design conformance and project documentation.

Courtenay River Estuary Dike Breach (for Comox Valley Project Watershed). Lead engineer for the analysis and design of a dike breach using a concrete box culvert. Reviewed and compiled available data including bathymetry, LiDAR and topographic data; directed water level data collection using remote sensors; oversaw TELEMAC 2D modeling of the project area; prepared and delivered summary presentations of the project; and, prepared detailed design drawings and construction cost estimates.

Point Reyes Geomorphological Assessment, San Francisco, California (for US National Park Service). Project engineer for a geomorphological investigation at Point Reyes National Seashore near San Francisco, California. Responsible for analyzing and predicting the natural response to removing a perched culvert and several dams in the intertidal zone. Assessed soil samples, topographical surveys, hydrology and hydraulic data, and historical photos.

Vancouver Island District Bridge Inspections (for BC Ministry of Transportation and Infrastructure). Project engineer on a team that inspected over 300 structures on the Central and South Vancouver Island regions to identify and assess existing and potential hydrotechnical issues. Developed remedial plans for multiple crossings to address stream alignment, rock armour, scour, erosion, hydraulic capacity, and/or other issues.