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NHC Reference 3006917

Cowichan Valley Regional District
175 Ingram Street
Duncan, BC, V

Attention: **Jeff Moore, Senior Environmental Analyst**
Copy to: **Kate Miller, Manager, Environmental Services Division**
Via email: Jeff.Moore@cvrd.bc.ca; Kate.Miller@cvrd.bc.ca

Re: **Cowichan-Koksilah Floodplain Maps**
Estimating FCL Values from Flood Maps Rev. 0

Dear Jeff:

1 Introduction

1.1 Purpose

Northwest Hydraulic Consultants Ltd. (NHC) were requested by the CVRD to provide guidance on using and interpreting the updated floodplain maps of the Cowichan-Koksilah River for the purposes of estimating Flood Construction Levels (FCL's). The FCL values represent the minimum elevations for floodproofing buildings on the floodplain. This information can be incorporated into building bylaws, subdivision approvals, and local government planning and regulations.

1.2 FCLs and Flood Extents

1.2.1 Designated Flood Conditions and Assumptions

The FCL was calculated using a designated flood having a return period of 200 years, incorporating potential future sea level rise and increased runoff due to climate change. Based on guidance from EGBC and provincial regulatory agencies as well as information from previous climate change studies conducted by the CVRD, the following climate change scenario was adopted for preparing the maps:

- 200 year flood discharges on all rivers increased by 20% above historic (present) values.
- 200 year ocean level increased by 1 m above historic (present) levels.

The adopted climate change scenario is intended to represent conditions in the year 2100. However, predicting future climate change is highly uncertain so the actual time frame associated with the scenario could be longer or shorter. The adopted designated flood conditions are consistent with EGBC guidelines (APEGBC, 2017; EGBC, 2018) and present flood mapping practice in BC.

Based on regulatory guidelines, it was further assumed that the existing dikes in the region would not function during the designated flood due to breaching or overtopping. This assumption allows water to

spill from the main channels across broad areas of the floodplain, including much of downtown Duncan. The assumption is conservative and represents a plausible "worst-case" condition if the dikes are not maintained and upgraded in the future. It should be the goal of all communities in the region to monitor, maintain and upgrade the dikes (if necessary) to ensure they will function during an extreme flood in the future.

A freeboard was added to the computed 200 year flood elevation to determine the FCLs. The freeboard accounts for uncertainty associated to the hydrologic and hydraulic modelling (e.g., inaccuracies in input data, inherent model simplifications) as well as limitations and inaccuracies associated with the map preparation. APEGBC (2017) suggests that a minimum freeboard of 0.3 m should be applied to the annual peak instantaneous (QPI) flows and 0.6 m to the annual max daily (QPD) flows. For the Cowichan and Koksilah floodplains a 0.6 m freeboard was applied to the instantaneous flows, which is more conservative than the minimum value in the guideline. Adopting a higher freeboard level for the Cowichan-Koksilah River floodplain is appropriate, given the past occurrences of log jams and sedimentation problems.

The FCL values are referenced to geodetic (CGVD 2013) datum (Canadian Geodetic Vertical Datum of 2013). This vertical datum has been specified by the federal (NRCan, 2018) and BC government for all floodplain mapping products (including Lidar). Previous flood maps as well as older topo surveys in the region were prepared to a different geodetic datum (CGVD28) and should not be directly compared without adjusting the values to the current datum.

The spatial extent of the flooding depicted in the maps is based on the computed FCL values and therefore includes the allowance for freeboard. The difference between the modelled flood extents and the final flood extents with freeboard, is represented by a lighter shade of blue in the flood maps. This area is expected to be subjected to shallower flooding than the darker blue areas on the maps.

The floodplain maps represent only flooding from overland flow by the main rivers in the region and not other types of flooding such as local stormwater runoff, groundwater, ponding of rainwater or more extreme events. Specific limitations are indicated in the "notes" section of the map sheets.

2 Estimating FCL Values from Flood Maps

2.1.1 Update to Map Sheets

The FCL values are displayed on the flood maps as smoothed isolines (contours) and some manual interpretation of the raw model output has been necessary to simplify interpretation of the information. For example, small localized "islands" only marginally dry and surrounded by inundated areas have been eliminated and shown as falling within the floodplain.

The 2021 flood maps were issued using 0.5 m contour interval FCL isolines, which was appropriate for interpolating FCL values for most areas on the floodplain. However, CVRD indicated that some users found it difficult to interpolate levels in areas where the isolines were widely separated. NHC were requested to revise the maps by increasing the resolution of the isolines in these areas. Consequently, NHC prepared updated maps using a contour interval of 0.2 m in some regions to improve interpretation and usability of the maps. A contour interval of 0.5 m was maintained in the remaining areas where the

isolines were well defined and interpolation of values between contours was straight forward. These updated maps are submitted with this memo and supersede all previous map sheets.

2.2 Estimating FCL Values from Flood Maps

The following section provides guidance on how to use the flood maps to determine the appropriate FCL at a proposed building or development. The hypothetical flood map shown in Figure 2.1 is for illustrative purposes only and does not represent any portion of the floodplain in the CVRD region.

The FCL for a specific building or space is to be taken as the highest FCL applicable for that location, which is considered the FCL at the upstream end of the building or space. Where the upstream end of the building or space is located between isolines, two methods can be used for determining the applicable FCL:

- Approach 1: the FCL is taken as the value represented by the next upstream isoline (higher of the two FCL isolines bounding the building or space).
- Approach 2: the FCL is calculated through linear interpolation between the two isolines in which the upstream face of the building or space is located. Results should be rounded up to the nearest 0.1 m.

Two examples are represented below, based on the buildings and mapped isolines shown in Figure 2.1:

- The first step is to identify the upstream end of the buildings. This will be the point along the perimeter that is closest to the upstream (highest value) FCL. Building 1 represents a hypothetical future development and is located between two isolines. The northeast corner represents the upstream end as it Is closest to the upstream FCL. Building 2 is between three isolines, two of which have a value of 441 m. The third FCL has a value of 440.5 m. In this case, the north 441 m FCL has been selected to do the interpolation since it's closer to the building.
- Once the upstream end is identified for each building, the shortest distance from this location to the upstream and downstream FCLs is measured. The upstream and downstream FCLs for both buildings have an elevation of 441 m and 440.5 m, respectively. The distances are shown in Figure 2.1 (purple dashed lines).
- The FCL for Building 1 can be calculated as follows:
  - Approach 1: 441 m
  - Approach 2: $440.5 + (441 - 440.5)\left(\frac{37}{37+25}\right) = 440.8\ m$
- The FCL for Building 2 can be calculated as follows:
  - Approach 1: 441 m
  - Approach 2: $440.5 + (441 - 440.5)\left(\frac{52}{52+106}\right) = 440.7\ m$

Approach 2 should be more accurate than Approach 1 but requires some interpretation of the FCL isolines. Approach 1 is simpler and produces a more conservative value than Approach 2. Either method is acceptable.

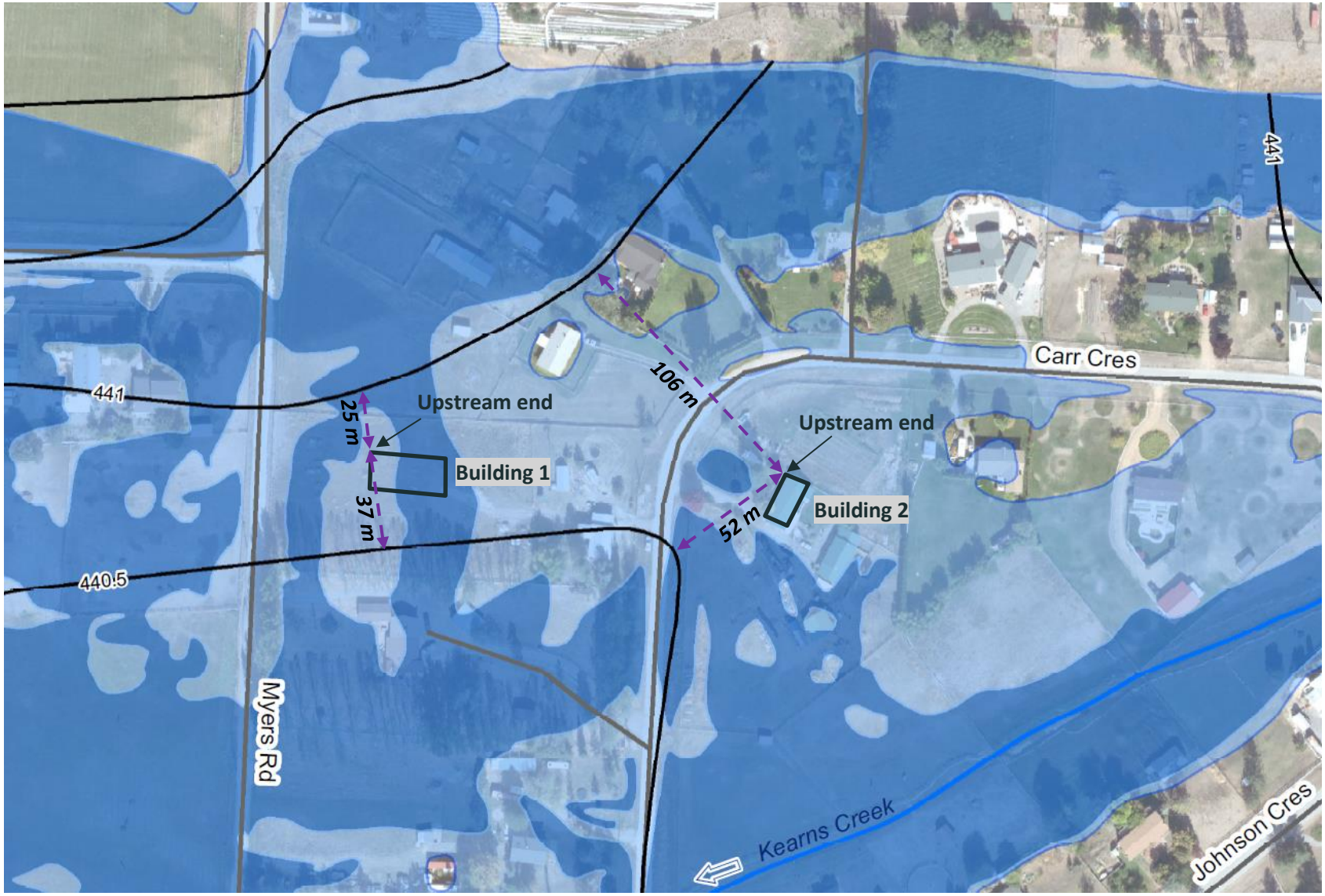

Figure 2.1 Example of FCL calculation for two buildings

Thank you for providing NHC the opportunity to participate in in this study. If you have any questions, or would like to discuss the information further, please contact the undersigned.

DISCLAIMER

This report has been prepared by **Northwest Hydraulic Consultants Ltd.** for the benefit of **Cowichan Valley Regional District** for specific application to the **Cowichan-Koksilah Floodplain Maps**. The information and data contained herein represent **Northwest Hydraulic Consultants Ltd.** best professional judgment in light of the knowledge and information available to **Northwest Hydraulic Consultants Ltd.** at the time of preparation and was prepared in accordance with generally accepted engineering and geoscience practices.

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Report prepared by:

UNSIGNED DRAFT BY

Natalia Leon-Barrios, M.Sc., P. Eng.
Flood Modelling Specialist

Report reviewed by:

UNSIGNED DRAFT BY

Dave McLean, PhD, P.Eng.
Principal

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