TECHNICAL MEMORANDUM

DATE 12 May 2023 **Reference No.** 22520011-TM

TO Ministry of Transportation and Infrastructure

CC Michael Carreira (R.F. Binnie & Associates), Robert McMahon (Ausenco)

FROM Emilio Martinez, MSc, PEng **EMAIL emilio.martinez@wsp.com**

SILVER-SKAGIT ROAD FLOOD MITIGATION – 23.0 KM SITE HYDROTECHNICAL ASSESSMENT

1.0 INTRODUCTION

WSP has been retained by the Ministry of Transportation and Infrastructure (MOTI) to provide hydrotechnical engineering and design services for flood response mitigation and recovery works on the Silver-Skagit Road near Hope, BC. The project has been divided into multiple sites depending on their location along the corridor. This memorandum describes the hydrotechnical considerations and assessment carried out to inform the design for the 23.0 km site mitigation.

The 23.0 km site requires restoration and potential realignment of the roadway due to approximately 100 m of erosion of the west shoulder caused by river flows against the road embankment. The proposed restoration includes repairs and riprap placement along the roadway, replacement of the drainage culvert, and temporary diversion works. Road alignment, geotechnical design, fill materials and geometry for road repairs were provided by the Highway Design Engineer (R.F. Binnie & Associates Ltd.) and geotechnical consultant (Wood PLC), and are outside of the hydrotechnical scope of work.

2.0 SITE CLIMATE AND HYDROLOGY

2.1 General Climate and Precipitation

Based on the Köppen climate classification, Hope has an oceanic climate with warm summers and moderately cold winters. Temperatures in Hope over the course of the year typically range from -2 ºC to 25 ºC and are rarely below -10 ºC or above 31 ºC with a distinct warm season between June and September, and a cold season between November and February. The hottest month of the year is typically August with an average high temperature of 24 ºC, and the coldest month is typically December with an average low of -2 ºC.

The chance of wet days in Hope varies significantly throughout the year. The wetter season is typically between October and April with the wettest month generally being November with an average rainfall of 199 mm; the driest month is generally August with an average rainfall of 34 mm. Wet days are comprised of rain only, snow only and rain and snow events. The month with the most snow is January, with an average snowfall of 276 mm.

2.2 Watershed Hydrology and Peak Flows

The Silverhope Creek drains approximately 350 km² of the Cascade Range entering the Fraser River in Hope, BC; the creek is approximately 40 km long from the upper reaches in the Cascade Range to Hope. The portion of the watershed draining to the 23.0 km site is approximately 83.7 km² and consists of forested steep mountain terrain with many of the tributaries being subject to debris floods. Elevations range from approximately 30 masl at the Fraser River in Hope, to over 2,200 masl along the southeastern boundary of the watershed.

WSP carried out an analysis of nearby hydrometric stations within 50 km of the site for unregulated streams to establish a relationship between catchment area and peak flows based on historical flow measurements. The stations included in the analysis are Chilliwack River above Slesse Creek (08MH103), Coquihalla River above Alexander Creek (08MF068), Coquihalla River below Needle Creek (08MF062), Slesse Creek near Vedder crossing (08MH056), and Tulameen River below Vuich Creek (08NL071). For a contributing catchment of 83.7 km², the resulting 200-yr return period peak flow (Q200) is approximately 120.6 m³/s, not accounting for climate change.

The location of the stations included in this analysis are shown in Figure 1. Although these gauges are for larger drainage areas, they have been selected to best represent potential runoff at this site and is considered to be adequate for the purposes of this report.

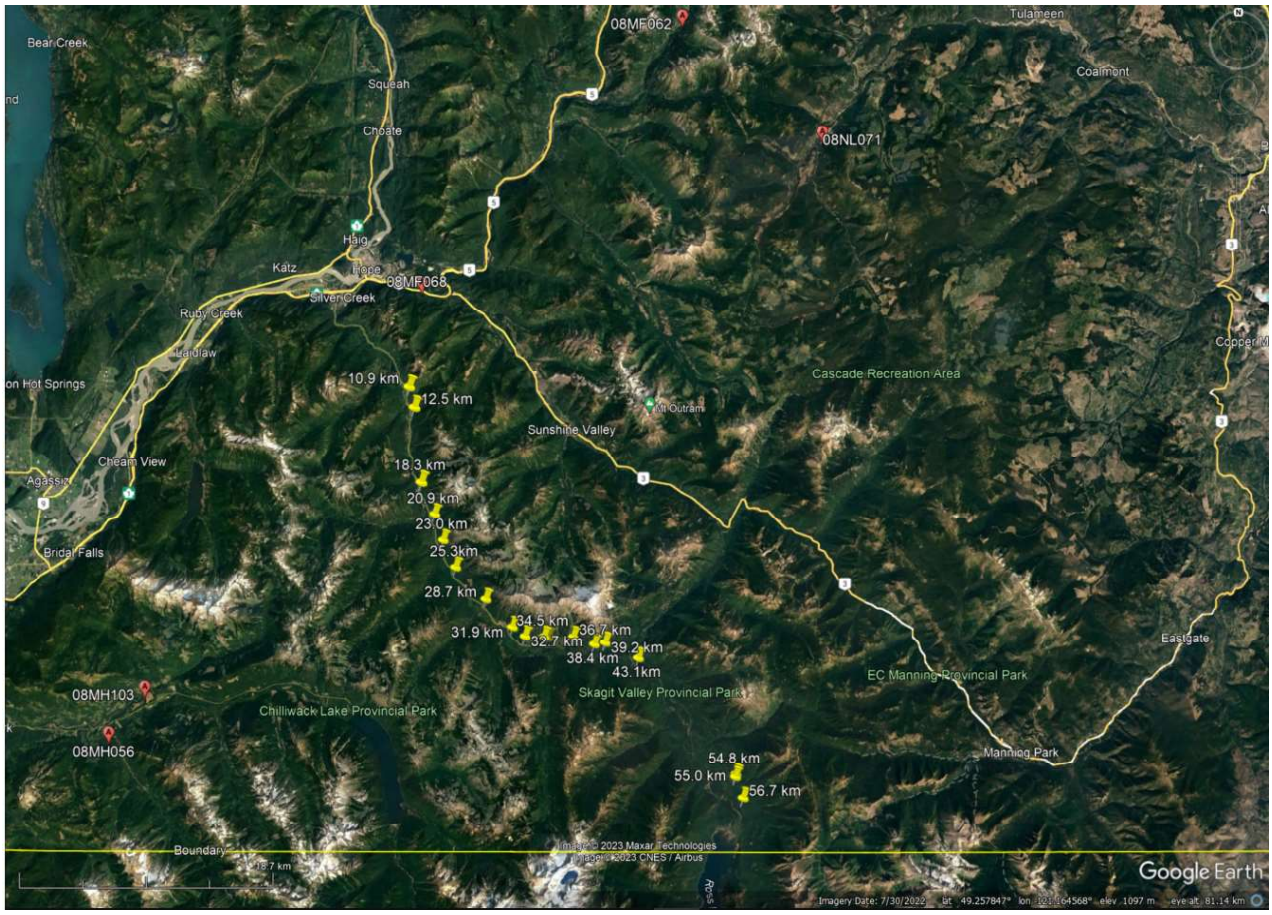

Figure 1 Hydrometric Stations near Hope, BC

2.3 Climate Change Considerations

Climate Change considerations within the preliminary design scope are applicable to small surface water drainage culvert sizing, water levels, erosion protection to the road embankment and estimates for the 200-yr return period peak flow (Q200). This section provides a summary of the climate change assessment carried out for the mitigation design at the 23.0 km site, which follows the professional practice guidance from EGBC on climate change-resilient highway infrastructure (2020).

The Pacific Climate Impacts Consortium (PCIC) station hydrologic model outputs for historic (1981-2010), mid-century (2040-2069), and end-of-century (2070-2099) periods under RCP 4.5 and RCP 8.5 scenarios were used to estimate projected increases to streamflow for the 200-year return period event at four hydrometric stations: Fraser River at Hope, Coquihalla River above Alexander Creek, Harrison River near Harrison Hot Springs, and Chilliwack River at Vedder Crossing. It was assumed that the increase in streamflow for these larger rivers was applicable to the site catchment. The projected peak flows during a 200-yr return period event were estimated by applying the average median percent increase in streamflow for the RCP 8.5 end-of-century scenario between the four stations (18%) to the 200-yr flow rate under current conditions. The resulting Q200 considering climate change is 142 m³/s.

3.0 HYDRAULIC ANALYSIS

WSP carried out a hydraulic analysis for the 23.0 km site to evaluate flood depths and flow velocities along Silverhope Creek and towards the drainage culvert at 23.0 km, during the Q200 event. The analysis consisted of a 1D hydrodynamic model using HEC-RAS to simulate steady-state conditions at cross sections along the 23.0 km site and approximately 1600 m upstream and downstream from the site. Topographic data for the cross sections was derived from LiDAR survey carried out in May 2022 and provided to WSP by MOTI. Bathymetric data for the creek was not available for inclusion in the model. Flow depths at the time of the LiDAR survey data acquisition were relatively shallow and the model results do not take into account the missing flow area in the surfaces captured by the survey, which results in slightly conservative flow depth and velocities. Results of the analysis are summarized in the following sections.

3.1 Flood Water Level

Water levels at the 23.0 km site during the Q200 including climate change, as described in Section 2, were obtained from the 1D HEC-RAS model. The resulting Q200 water level at the 23.0 km site is approximately 1.6 m above the creek thalweg. A minimum of 0.3 m freeboard was provided between the Q200 water levels and the top of riprap along the section of riprap-lined road embankment.

3.2 Erosion Protection

Erosion protection to the road embankment has been provided via a riprap revetment layer. Riprap sizing has been estimated following recommendations from Section 1000 of the MoTI Bridge Design Specifications (MoTI, 2019, Section 1000), the Transportation Association of Canada (TAC) design guidelines and the US Army Corps of Engineers procedure (USACE 1991), for the Q200 design flow and channel configuration described above. For a maximum flow velocity against the bank of 3.1 m/s assuming a straight segment, the recommended riprap is

Class 100 kg. Approximate rock particle weights and sizes for Class 100 kg riprap, based on spherical rock particles with a specific gravity of 2.50, are provided in Table 1. A typical cross section is shown in Figure 2.

Table 1 – Class 100 kg Riprap Weight and Gradation

Percent Smaller (by Weight)	Weight (kg)	Intermediate Dimension (mm)
100	500	750
85	300	610
50	100	425
15	10	200

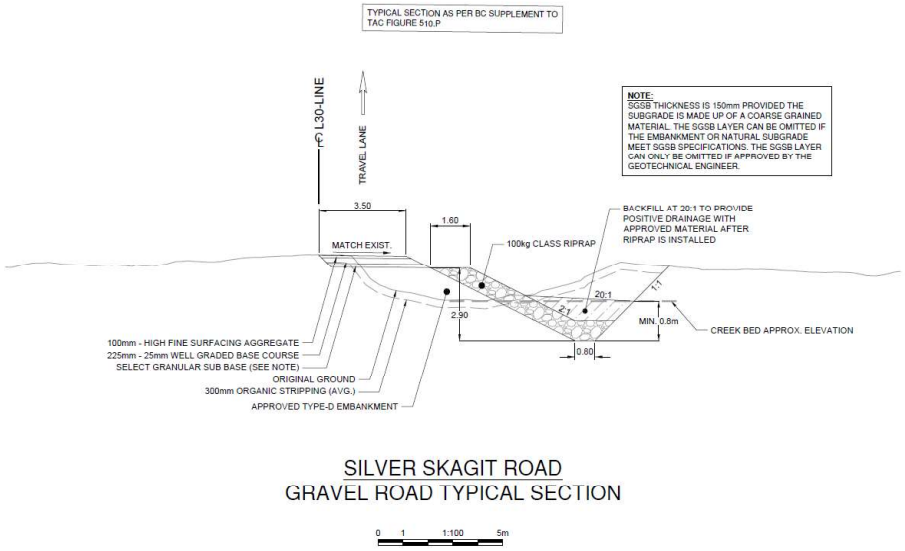

Figure 2 – 23.0 km Typical Cross Section

4.0 CLOSURE

We trust that this information is sufficient for your requirements. Should you have any questions regarding the above, or if you require further information, please do not hesitate to contact our office.

WSP Canada Inc.

Engineers & Geoscientist
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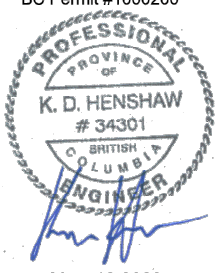

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Emilio Martinez, MSc, PEng
Hydrotechnical Engineer

Kevin Henshaw, PEng
Lead Hydrotechnical Engineer

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