TECHNICAL MEMORANDUM

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TO
Ministry of Transportation and Infrastructure

CC Michael Carreira (Binnie), Robert McMahon (Ausenco)

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SILVER-SKAGIT ROAD FLOOD MITIGATION – 10.9 KM SITE HYDROTECHNICAL ASSESSMENT(REV 1)

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 is divided into multiple sites depending on their location along the corridor. This memorandum describes the hydrotechnical considerations and assessment carried out to provide a mitigation design for the 10.9 km site.

The 10.9 km site requires road surface and culvert replacement, as well as restoration of the main drainage channel towards Silverhope Creek across the Silver-Skagit Rd. The culvert and road replacement are required due to a complete washout due to runoff and debris flow from the upper drainage across the Silver-Skagit Rd along approximately 100 m of the roadway. The proposed culvert replacement and channel restoration returns the main drainage path towards Silverhope Creek to its original path prior the November 2021 flood event. 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 km^2 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 Silverhope Creek at the 10.9 km site is approximately 4.14 km^2 and consists of steep mountain terrain draining towards Silverhope Creek across the Silver-Skagit road. Similar to other tributary catchments, the area draining to Silverhope Creek at the 10.9 km site is subject to debris floods. The 10.9 km watershed exhibits elevations ranging from approximately 1841 masl near Wells Peak, to 360 masl at the Silver-Skagit Road crossing.

WSPcarried out an analysis of nearby hydrometric stations within 30 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 (08MH056). For a contributing catchment of 4.14 km^2, the resulting 200-yr return period peak flow (Q200) is approximately 8.6 m^3/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.

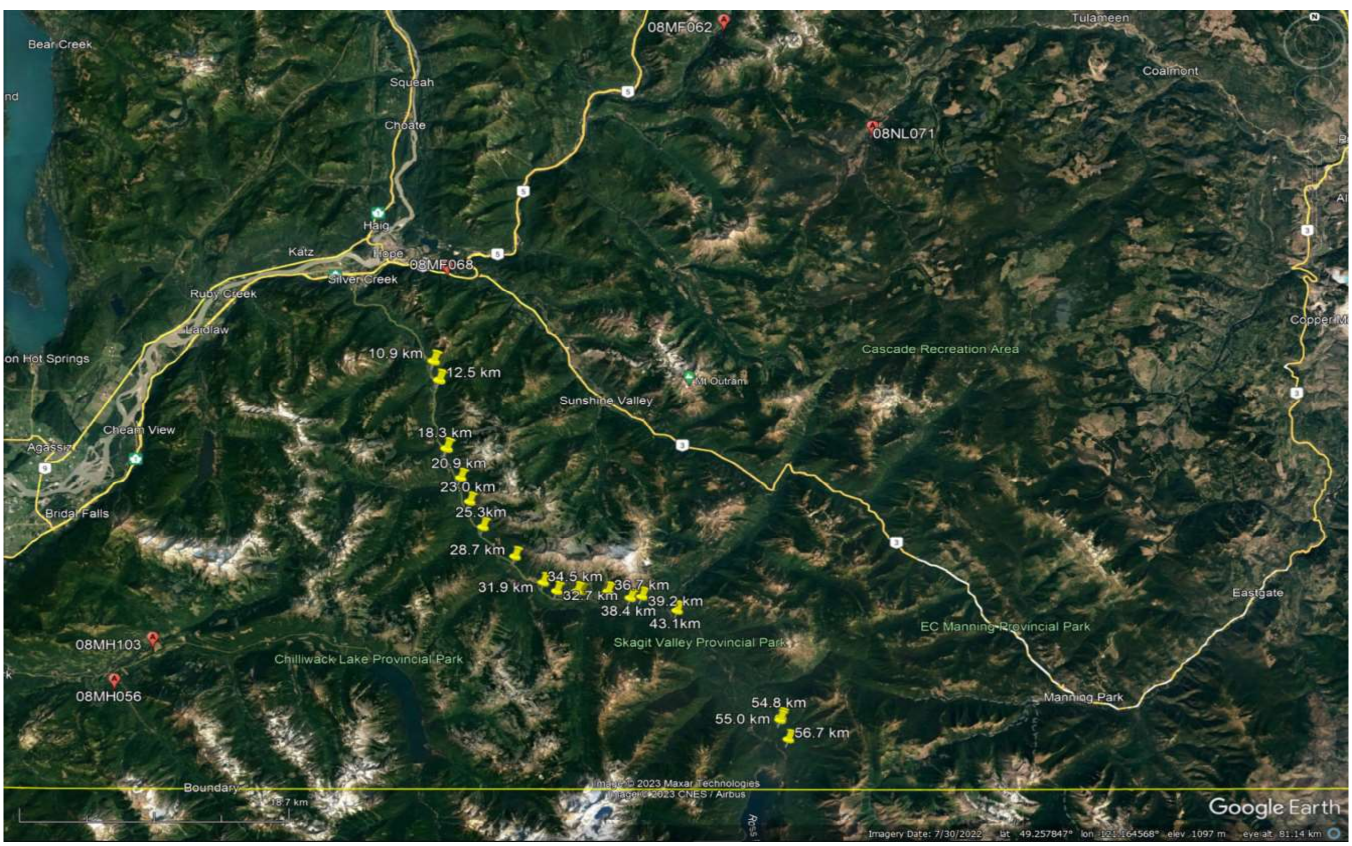

Figure 1 Hydrometric Stations near Hope, BC

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 conceptual mitigation design at the 10.9 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.As a check to the projected flow increases based on the PCIC hydrologic model results, the IDF-CC Tool, Version 6.5, created by Western University was used to estimate projected precipitation increases for the area to the end of the century under RCP 8.5. The results indicate that 100-year, 24-hour events could increase in intensity by 19%, which is reasonably close to the results obtained with the PCIC data.

The resulting Q200 considering climate change is 10.1 m³/s.

3.0 HYDRAULIC ANALYSIS

WSP carried out a hydraulic analysis for the 10.9 km site to evaluate the design flow for the proposed culvert and channel replacement during the Q200 event. The design peak flow was then used to size the proposed culvert, channel and provide erosion protection along the channel. Results of the analysis are summarized in the following sections.

3.1 Culvert and Channel Design

The resulting peak flow at the 10.9 km site during the Q200 including climate change, as described in Section 2, was adjusted to account for potential debris floods at the culvert location. Based on a Melton ratio of 0.5 for the watershed, which corresponds to potential for “debris floods”, the water-only peak flow for the location was adjusted by a debris flood bulking factor of 2.0. Once adjusted, the Q200 design flow for the culvert and channel is the 10.9 km site is 20.2 m³/s.

Several culvert options were considered for the replacement; the options included: a corrugated steel pipe (CSP), a CSP arch culvert and a pre-cast concrete box culvert. Based on the debris flood potential at the site and considering future maintenance requirements and durability, the selected culvert type is a pre-cast concrete box culvert.

WSP carried out a hydraulic analysis for the proposed culvert configuration, with a resulting culvert sizing of two (2) pre-cast concrete box culvert barrels of 2700 mm (span) x 2400 mm (rise). The culvert pipes are to be embedded by a minimum 480 mm to allow for fish passage across the culvert. For the proposed culvert configuration, and based on a trapezoidal open channel with a bottom width of 6 m and 12.5% longitudinal slope, 2H:1V side slopes and a Manning's n roughness coefficient of 0.05, the culvert outlet velocity has been estimated as 2.7 m/s.

In addition to the culvert design, WSP evaluated the required drainage channel size to convey the design flow into the proposed culvert. The resulting channel consists of a trapezoidal open channel with a minimum base width of 6.0 m and 2H:1V side slopes.

3.2 Erosion Protection

Erosion protection to the drainage channel has been provided via a riprap layer. Sizing for the riprap has been obtained following recommendations from the Transportation Association of Canada (TAC) guidelines using the US Army Corps of Engineers procedure (USACE 1991) for the Q200 design flow and channel configuration described above and shown in Figure 2. The resulting riprap consists of Class 250 kg riprap and extends along the drainage channel up to 10.0 m upstream from the culvert inlet, and 15.0 m downstream of the culvert outlet. Approximate rock particle weights and sizes for Class 250 kg riprap, based on spherical rock particles with a specific gravity of 2.50, are provided in Table 1. Riprap sizing for the roadside ditch leading to the main channel was estimated from the catchment area contributing to the ditch (2.79 ha) and a longitudinal ditch slope of 6.2%; for a trapezoidal channel with a bottom width of 0.75 m and 2H:1V side slopes, the resulting riprap is Class 10 kg riprap. Rock particle sizes and gradation for the Class 10 kg riprap is provided in Table 2. A typical cross section is shown in Figure 2.

Table 1 – Class 250 kg Riprap Weight and Gradation

Percent Smaller (by Weight)	Weight (kg)	Intermediate Dimension (mm)
100	1,250	1,000
85	750	830
50	250	575
15	25	270

Table 2 – Class 10 kg Riprap Mass and Gradation

Percent Smaller (by Mass)	Mass (kg)	Intermediate Dimension (mm)
100	50	350
85	30	285
50	10	200
15	1	90

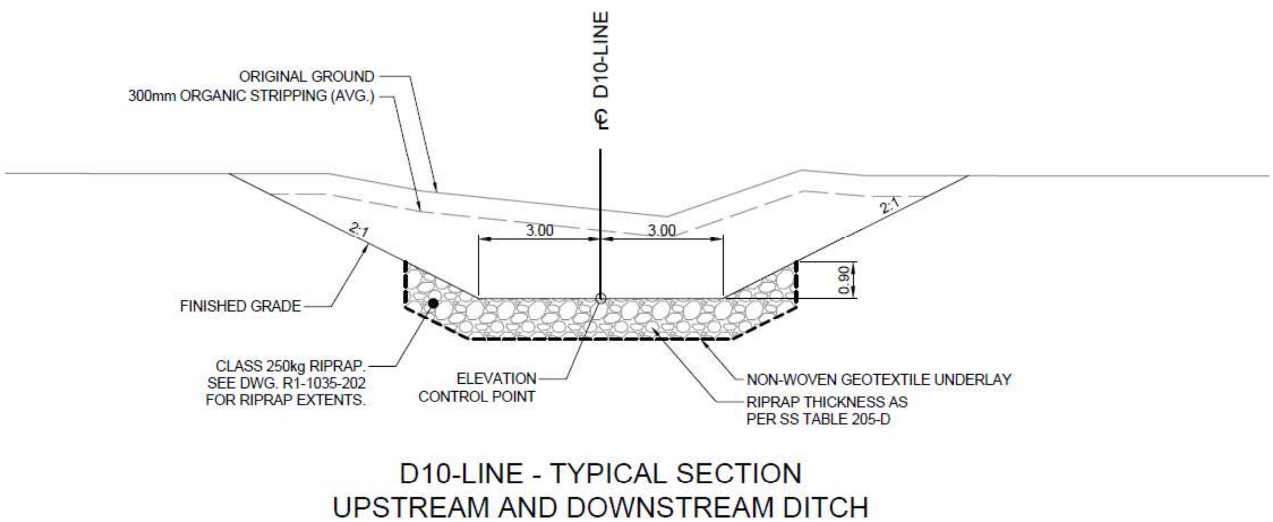

Figure 2 10.9 km Drainage Ditch Typical Cross Section

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.

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May. 12 2023

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