TECHNICAL MEMORANDUM

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TO
Ministry of Transportation and Infrastructure

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SILVER-SKAGIT ROAD FLOOD MITIGATION – 55 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 and level of urgency along the corridor. This memorandum describes the hydrotechnical considerations and assessment carried out related to the proposed mitigation design for the 55 km site.

The 55 km site requires road surface repairs and culvert replacement, as well as restoration of the main drainage channel towards Klesilkwa River across the Silver-Skagit Rd. The culvert replacement and road repairs are required due to washout from runoff and debris flows from the upper drainage across the Silver-Skagit Rd. The proposed culvert replacement and channel restoration returns the main drainage path towards Klesilkwa River to its original path prior to the November 2021 flood event. Road alignment, geotechnical design, fill materials, and geometry for the temporary 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

Klesilkwa River is the main branch of the Skagit River, which flows south and drains to Ross Lake at the US-Canada border approximately 48 km south of Hope, BC; the river is approximately 26 km long from the upper reaches in the Cascade Range to Ross Lake and originates at around km 28 of Silver-Skagit Rd. The portion of the watershed draining to Klesilkwa River at the 55 km site is approximately 11.2 km² and consists of steep mountain terrain draining towards Klesilkwa River across the Silver-Skagit Road. Similar to other tributary catchments, the area draining to Klesilkwa River at the 55 km site is subject to debris floods. The 55 km watershed exhibits elevations ranging from approximately 1995 masl to 502 masl at the Silver-Skagit Road crossing.

WSP carried out an analysis of nearby hydrometric stations within 30 km of Silver-Skagit Road for unregulated streams to establish a relationship between the 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 1.858 km², the resulting 10-yr and 200-yr return period peak flows (Q10 and Q200) are approximately 1.1 and 3.5 m³/s, respectively, not accounting for climate change.

The location of the stations included in this analysis is 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 are considered adequate for the purposes of this report.

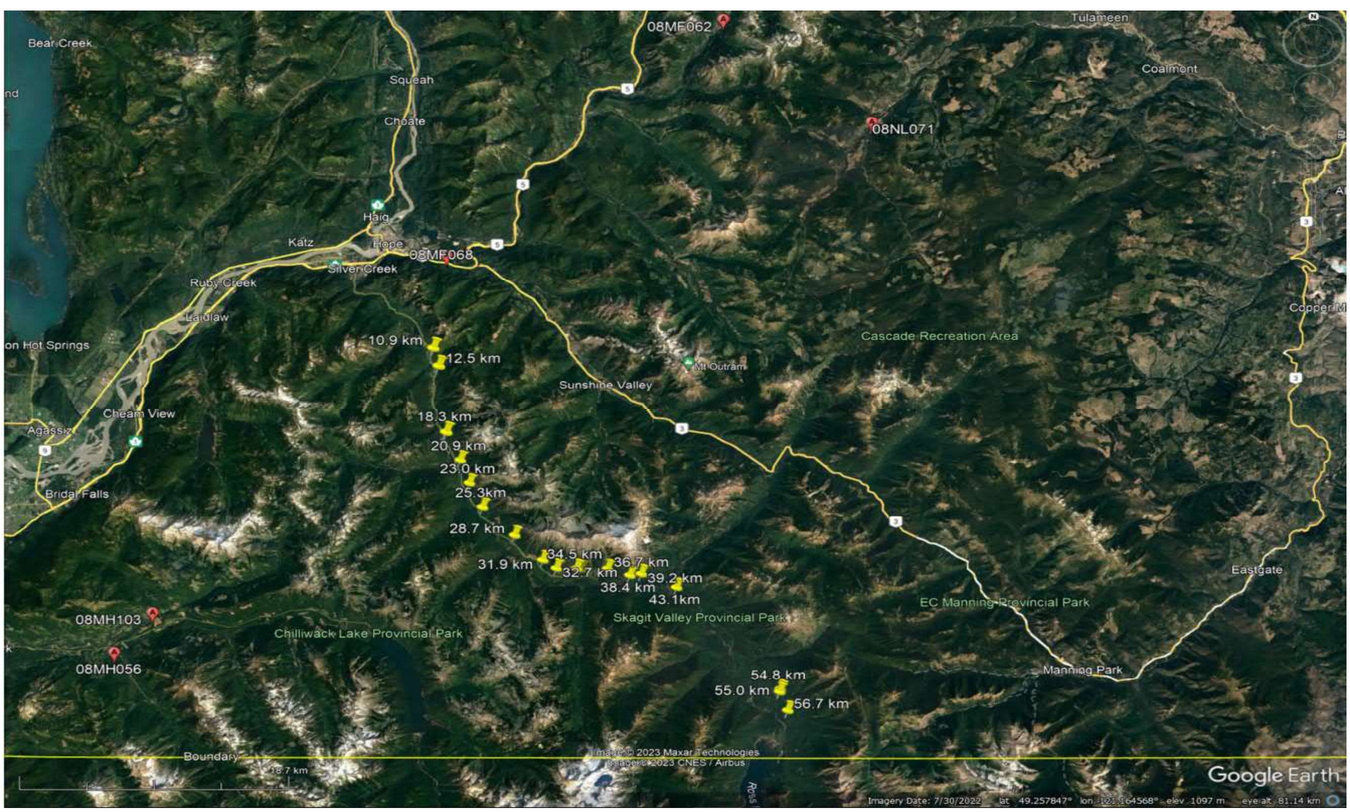

Figure 1 Hydrometric Stations near Hope, BC

2.3 Climate Change Considerations

This section provides of the climate change assessment caried out for the 55 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.

Applying the 18% climate change adjustment to the 200-year peak flows results in a Q200 of 4.1 m^3/s.

The estimated increase in flow rate associated with climate change is a high-level estimate only, for conceptual mitigation design. While this estimate is considered adequate for the emergency recovery phase, a more detailed and comprehensive climate change analysis should be considered along the corridor for future design phases.

3.0 HYDRAULIC ANALYSIS

WSP carried out a hydraulic analysis for the 55 km site to evaluate the design flow for the proposed culvert and channel replacement during the Q10 and Q200 events. The water-only peak flow for the location was adjusted by a debris flood bulking factor of 2.0. Once adjusted, the Q200 flows for the culvert and channel at the 55 km site is 8.2 m^3/s.

The design associated with conveying the full, debris- and climate change-adjusted design flow was found to be unjustifiable by the project team considering the mild degree of damage at this site. As such, a restorative design was selected to fit within the approximate footprint of the existing crossing. Several culvert sizes and type options were considered for the replacement; the options included corrugated steel pipe (CSP) and pre-cast concrete box culverts. A pre-cast design was selected to optimize capacity within the existing site footprint and decrease future maintenance requirements.

Detailed site topography was not available during the design phase.

3.1 Culvert Capacity

The proposed mitigation design includes two (2) 2700mm (span) x 900 mm (rise) pre-cast box-culverts of approximately 15 m in length and tailwater channel slope of 5%, while maintaining the 900 mm existing CSP culvert. Assuming a maximum headwater-to-depth ratio (HW/D) of 0.7, appropriate for systems with potential for floating debris. The capacity of the design is of 3.9 m^3/s which is sufficient to convey more than 1:10-year flow (Q10). For a channel roughness based on a Manning's n of 0.035, the tailwater velocity for the Q200 design flow has been estimated as 2.7 m/s.

In addition to the box culverts described above, the existing 900 mm CSP culvert is proposed to be replaced as part of the mitigation works. The peak flow for the 900 mm CSP during the Q10 design event is approximately 0.8 m^3/s not accounting for climate change with a culvert outlet velocity of 2.1 m/s.

Erosion protection should be provided at the culverts as described in Section 3.3. No provisions for fish passage across the culvert have been accounted for, as no fish populations have been identified at the site.

3.2 Channel Design

In addition to the culvert design, WSP evaluated the required drainage channel size to convey the design flows into the proposed culvert. The resulting channel consists of a trapezoidal open channel with 2H:1V side slopes and a minimum base width of 8 m.

3.3 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 for the culvert capacity and channel configurations described above. The resulting riprap for the main channel culverts consists of Class 100 kg riprap and extends along the drainage channel up to 1.8 m upstream from the culvert inlet, and 3.6 m downstream of the culvert outlet. Approximate rock particle mass and sizes for Class 100 kg riprap, based on spherical rock particles with a specific gravity of 2.50, are provided in Table 1.

Table 1 – Class 100 kg Riprap Mass and Gradation

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

2 – Class 10 kg Riprap Mass and Gradation

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

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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