Design Criteria Sheet for Climate Change Resilience

Highway Infrastructure Engineering Design and Climate Change Adaptation
BC Ministry of Transportation and Infrastructure
(Separate Criteria Sheet per Discipline)
(Submit all sheets to the Chief Engineers Office at:
BCMoTI-ChiefEngineersOffice@gov.bc.ca)

Project:	*BC Hwy 11 Flood Repairs: Road Surface Drainage Adequacy, CA-WSP-201-11400-05*
Type of work:	*Highway Rehab/ Drainage for Chainage 9+960 to 10+520*
Location:	*Highway 11 between near Valley Road, Abbotsford, BC*
Discipline:	*Hydrotechnical*

Design Component	Design Life or Return Period	Design Criteria + (Units)	Design Value Without Climate Change	Change in Design Value from Future Climate	Design Value Including Climate Change	Adaptation Cost Estimate ($)	Comments / Notes / Deviations / Variances
Spacing of Roadside Concrete Barrier with Drainage Slot (CRB-H) and Location of Catch Basin	5 yr RP	5-min Rainfall Intensity (mm/h)	60.20	+23%	74.25	$0	Increases in rainfall intensity results in increased surface runoff. The result is closer drainage barrier or catch basin spacing. See work including climate projections.

Explanatory Notes / Discussion:

Design Criteria
The drainage design criteria for the project are based on the principles outlined in the British Columbia Ministry of Transportation and Infrastructure (MoTI) Supplement to TAC Geometrics Design Guide – 1000 Hydraulics Chapter (BCTAC). This Design Criteria Sheet is limited to road surface drainage design, only applying to pavement drainage, and not including considerations for road flooding due to Willband Creek or other drainage crossings. The climate change study incorporates information laid out in the Engineers and Geoscientists of British Columbia (EGBC) 2020 professional practice guidelines for climate change-resilient designs for highway infrastructure.

Highway Surface Runoff Model:
The Environment and Climate Change Canada (ECCC) meteorological station at Abbotsford A (ID: 1100030) was used as the baseline data to characterize the design rainfall intensity. The Abbotsford A IDF curves draw from 24 years of data (1977-2001). A model for drainage barrier spacing was developed in Excel using the BCTAC guideline.

The model calculates highway runoff using 5-minute, 5-year return period rainfall intensity, and inputs of highway geometry such as crossfall and longitudinal slope, paved shoulder width, effective area contributing to runoff, and a manning's roughness coefficient. The model output is an approximate minimum spacing of drainage openings in a barrier.

Climate Change Projections:
In accordance with BCMoTI Climate Change Technical Circular T-04/19, the potential impacts of future climate change need to be considered on all Ministry projects. For the drainage design components of this Project, future climate change is anticipated to increase the frequency and intensity of rainfall events, especially in the late-fall and winter months. For all studies, the Shared Socio-economic Pathway (SSP) 5-8.5 was chosen. This climate scenario is one of the SSPs in the latest Synthesis Report from the Intergovernmental Panel on Climate Change, and it tracks closest to Relative Concentration Pathway (RCP) 8.5 with very high greenhouse gas emissions, also called the "status-quo" projection scenario. Projections were targeted for the 2080's (2070-2100).

The BCMoTI Coquihalla Climate Change Vulnerability Assessment (2010) in collaboration with the Pacific Climate Impacts Consortium (PCIC) identified that atmospheric river events like the "Pineapple Express" events have increased in intensity and frequency, and are projected to moderately increase, with medium level of confidence.

IDF_CC, a tool developed by Western University (https://www.idf-cc-uwo.ca/idfstation) generates historical and projected rainfall IDF summaries from ECCC meteorological stations. The resulting values below correspond to median values, and not extremes, as the IDF curves already present extreme rainfall. Using the Abbotsford A IDF station, the IDF_CC tool projected an increase of approximately 23% for 5-year return period short-duration rainfall (5 minutes).

T (years)	2	5	10	20	25	50	100
5 min	45.21	60.20	70.13	79.64	82.66	91.97	101.20
10 min	32.11	46.85	56.60	65.96	68.93	78.08	87.16
15 min	26.30	37.85	45.50	52.84	55.16	62.33	69.45
30 min	19.15	26.55	31.44	36.14	37.63	42.21	46.77
1 h	13.39	17.74	20.62	23.38	24.25	26.95	29.63
2 h	9.08	11.88	13.74	15.52	16.08	17.82	19.55
6 h	5.70	6.71	7.38	8.02	8.23	8.85	9.47
12 h	4.04	4.82	5.34	5.83	5.99	6.48	6.96
24 h	2.68	3.27	3.66	4.03	4.15	4.52	4.88

Figure 4: Historical IDF for Abbotsford A (IDF_CC)

T (years)	2	5	10	20	25	50	100
5 min	54.51	74.25	87.74	100.34	104.31	116.57	128.73
10 min	38.79	57.93	70.81	82.98	86.76	98.57	110.30
15 min	31.71	46.79	56.91	66.46	69.45	78.73	87.95
30 min	23.08	32.78	39.33	45.48	47.42	53.41	59.35
1 h	16.15	21.87	25.79	29.45	30.61	34.17	37.70
2 h	10.95	14.65	17.19	19.56	20.31	22.61	24.90
6 h	6.87	8.25	9.24	10.15	10.43	11.31	12.16
12 h	4.87	5.93	6.68	7.38	7.59	8.26	8.92
24 h	3.24	4.02	4.58	5.09	5.26	5.75	6.25

Figure 5: Projected IDF for Abbotsford A, 2070-2099, CMIP 6, SSP5.85 (IDF_CC)

Precipitation as snowfall is anticipated to decrease according to PCIC, however there is the potential for less frequent snow events to be larger in magnitude. Maintenance with respect to snow buildup is likely to be the more economical and effective approach, and it was therefore given a low-risk rating in terms of design.

Risk and Recommendations:

The existing outside barrier extents between chainages 9+960 and 10+520 were provided in Project drawings titles "Highway 11 Willband Creek Flood Repairs", dated January 16, 2024. The existing barrier, as shown on Google Earth Pro (March 2023) lacks consistent drainage barrier spacing on the outsides, with a median consisting mainly of drainage slot barriers. The existing risk is therefore considered to be Medium, since shoulder ponding is possible, and could result in a loss in highway capacity or loss of vehicle control.

This assessment applied the best available climate data and projections and historical weather data to assess the vulnerabilities of the project to changes in climate and extreme weather for the life of the asset, however, projections come with a level of uncertainty. The minimum required spacing of concrete drainage barriers was determined to be approximately 8.5 m, which translates to alternating one slotted and one barrier and one unslotted barrier, order to accommodate increased short-duration precipitation intensity up to the 2080's. CRB-H barriers were confirmed to be adequate for use at this spacing. The mitigated risk can be considered low if the above drainage barrier spacing is implemented. It is assumed that regular concrete barrier is the same cost as concrete drainage barrier, therefore adding drainage barriers to accommodate increased runoff would not impact the overall cost.

Additionally, this analysis identified the need for an additional catch basin in the northbound acceleration lane from Valley Road, at the end of the new median curb near station 10+125.

It should also be noted that the performance of the highway drainage barrier will only be assured with proper and regular inspection and maintenance during its service life. Regular inspection and maintenance will detect any natural or unnatural leaf litter and debris, grass, snow, and ice that may block or partially block the conveyance of water, thus not allowing it to perform as designed.

Maintenance and Future Considerations:

The Ministry should revisit the vulnerability, risks and control measures considered in this assessment as new information becomes available, including long-term climate projections, changes to operational or maintenance parameters and local conditions. This process can be aligned to infrastructure investment cycles, planned updates of the climate projections or other business continuity processes.

To account for uncertainties in climate change projections and to ensure performance of drainage slots, it is recommended to also utilize the Observational Method, as described in EGBC's professional practice guidelines for climate-resilient highway infrastructure (2020). This involves monitoring the drainage performance of the highway, and implementation of a plan to modify the design in response to observed climate changes in the future, as necessary. The overall objective of this approach is to achieve greater economy without compromising safety.

Recommended by: Engineer of Record: ____Justin Murray, P.Eng.____
(Print Name / Provide Seal & Signature)

DRAFT

Date: __February 13, 2024____

Engineering Firm: __WSP CANADA INC.____

Accepted by BCMoTI Consultant Liaison: ____
(For External Design)

Deviations and Variances Approved by the Chief Engineer: ____
Program Contact: Chief Engineer BCMoTI