BRITISH COLUMBIA MINISTRY OF TRANSPORTATION AND INFRASTRUCTURE

George Massey Crossing Technical Services

TRAFFIC AND GEOMETRICS TECHNICAL REPORT DRAFT

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APPENDIX Q. HIGHWAY 99 RAMP ANALYSIS

Stantec

Memo

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File:	115819043	Date:	November 28, 2019

Reference: George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-Lane Concept – REVISED DRAFT

This memo describes the expected traffic performance along Highway 99 from south of Highway 17A interchange to north of Steveston Interchange. The purpose of this analysis is to validate from the traffic perspective the different freeway elements such as ramps and freeway segments, for the proposed Immersed Tube Tunnel (ITT) of the George Massey Crossing. Of note, traffic operations for the long span bridge options are expected to be similar to the ITT as the laning and ramp configuration within the study area are similar under both concepts. This traffic analysis was conducted assuming a shoulder bus only lane on both directions of Highway 99 and the remaining six lanes dedicated to general purpose (GP) traffic. Planning horizons for this analysis included years 2035 and 2050.

1. PROJECT DESCRIPTION (8-LANE ITT CONCEPT)

The traffic analysis conducted herein was based on the ITT concept prepared by the design team as of November 1st 2019. Key design features are described below:

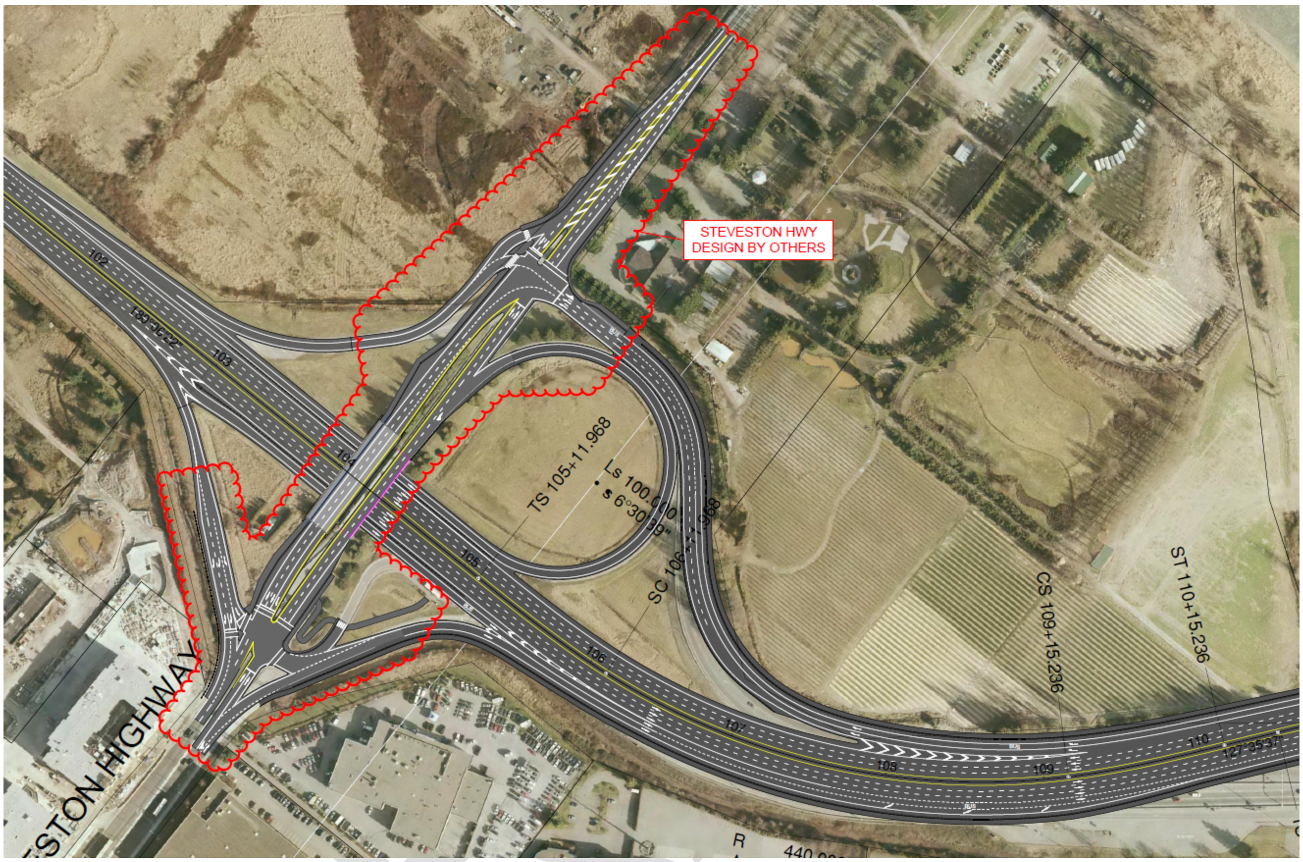
1.1. North Project Limit

The horizontal alignment for the immersed tube tunnel is located east (upstream) of the existing tunnel. The conceptual vertical alignment has a maximum grade of 5% and a minimum K value of 60 at the sag. At the northern project limit this alignment ties back to existing Highway 99 several hundred meters south of Steveston Highway, thereby maintaining the existing vertical clearance on Highway 99 under the bridge.

The existing Steveston Highway bridge will accommodate 6 through lanes on Highway 99 (3 lanes in each direction) plus the existing WB to NB on-ramp and the existing SB bus-only lane. Therefore, the existing two-lane Steveston Highway bridge can be maintained, although shoulder widths may need to be locally narrowed under the existing bridge. At the NB exit ramp to Steveston Highway, the existing two-lane exit is widened to two GP lanes plus a bus-only lane. In the SB direction, the existing bus stop and queue-jumper lane is maintained, as is the single lane, signal controlled entrance ramp from Steveston Highway. The GP traffic from the entrance ramp briefly shares the outside lane on Highway 99 with buses before merging with the 3rd SB lane on the new Crossing and the outside lane becomes bus-only.

The proposed design at the Steveston Interchange include the twinning the existing two-lane bridge over Highway 99 with a new three-lane structure immediately north of the existing bridge. As shown on Figure 1 below, it is assumed the new bridge will accommodate two WB lanes and one WBL lane and the existing bridge will carry two EB lanes with the development of the EB exit lane for the EB to NB loop ramp after crossing the bridge. The design of the proposed Steveston interchange was prepared by others.

Figure 1 – Proposed Steveston Interchange Tie-in with 8-lane Immersed Tube Tunnel



1.2. South Project Limit

The horizontal and vertical alignments of the immersed tube tunnel concept match to existing Highway 99 several hundred meters north of the Highway 17A interchange. However, highway reconstruction is proposed to extend to Highway 17A in order to reconfigure the laning to properly develop the 8-lane cross-section on the new Crossing.

Based on the proposed concept illustrated in Figure 2, the available horizontal clearance under the existing Highway 17A bridge will accommodate 5 through lanes on Highway 99 (3 lanes southbound and 2 lanes northbound) plus 4 lanes on C-D road/ramps (2 lanes per direction). Therefore, the existing Highway 17A bridges can be maintained.

In the NB direction the new lanes will match into the existing mainline lanes on Highway 99 between Highway 17 and Highway 17A. Northbound bus and HOV traffic traveling on the existing bus/HOV lane will continue to leave Highway 99 at the NB exit ramp to Highway 17A, cross Highway 17A at the signalized intersection, and re-enter Highway 99 via the NB entrance ramp. The concept shown in Figure 2 below incorporates a widening of the NB exit ramp. This ramp maintains the dedicated bus lane down the NB entrance ramps and along Highway 99 to match the dedicated bus lane on the 8-lane ITT. The two CD lanes will merge into a single lane and that lane will develop into the third lane for the GP traffic approximately 500 m north of the Highway 17A overpass. Approximately 300 m downstream in the northbound direction, HOV and GP traffic coming from the on-ramp that originated from the signalized intersection at Highway 17A, will merge on the Highway 99 mainline.

In the SB direction the new lanes will also match into the existing mainline lanes on Highway 99 between Highway 17 and Highway 17A. The three SB GP lanes from the new Crossing will continue under the existing Highway 17A bridges and match into the existing mainline lanes on Highway 99 between Highway 17 and Highway 17A. Buses travel in the dedicated outside bus lane from the new Crossing and will briefly leave Highway 99 at the SB exit ramp to avoid having to weave through exiting traffic and merge with the three GP lanes crossing under the Highway 17A bridges. As shown in Figure 2 below, a new dedicated bus slip ramp off the SB exit ramp will allow buses to cross under the bridges on the WB to SB entrance ramp, before eventually merging with the existing SB GB lanes on Highway 99 between Highway 17A and Highway 17.

Figure 2 – Proposed Highway 17A Interchange Tie-in with Immersed Tube Tunnel Concept

1.3. River Road Off-Ramp

The project includes a Highway 99 crossing via a flyover along River Road. This overpass will provide a direct connection between southbound traffic and River Road east of Highway 99, thus reducing traffic demand at the Highway 17A interchange.

The River Road off ramp will feature an approximately 120 m deceleration lane on the right side of the bus lane and a total diverging area of approximately 220 m along the bus lane. The off-ramp / River Road intersection will consist of a single lane roundabout. The layout of the River Road off-ramp and the roundabout are illustrated in Figure 3.

Reference: **George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-Lane Concept – REVISED DRAFT**

Figure 3 – River Road Off-Ramp with Immersed Tube Tunnel Concept

2. TRAFFIC ANALYSIS

The objective of the traffic analysis conducted herein is to validate from the traffic perspective the off-ramps, on-ramps and freeway segments of Highway 99 between south of Highway 17A interchange and north of Steveston interchange. For this analysis, traffic operations were measured in terms of level of service (LOS). The analysis focused on the critical directional peak hours. Based on this rationale, AM analysis was done for the northbound traffic and PM analysis was done for the southbound direction. Forecast 2035 and 2050 peak hour volumes were used for this analysis. Forecast traffic volumes were calculated from the EMME Regional Transportation Model (RTM) by McElhanney. A sketch of the forecast AM and PM peak hour volumes is attached to this memorandum.

The following parameters were used on the HCS analysis:

- Speeds: 100 km/h on mainline; 80 km/h on ramps
- Peak hour factor: default 0.90
- Vehicle classification: as illustrated on traffic volumes on attachments
- Grades: assumed level terrain
- Deceleration / Acceleration lengths: as per conceptual design version of November 1st, 2019
- Number of lanes: as per conceptual design version of November 1st, 2019

2.1. LOS Criteria

The freeway capacity analysis was based on the HCM, 6th Edition methodologies for freeway and multilane highway segments. This module is incorporated into the Highway Capacity Software (HCS) version 7.7. According to these methodologies the LOS is measured in terms of density, as this parameter describes a driver's proximity to other vehicles and is related to a driver's freedom to maneuver within the traffic stream. Similarly, for the on and off-ramps, vehicle density is related to the vehicle "turbulence" that is created at the acceleration and deceleration lanes and the impact on the adjacent through lanes on the highway.

Table 1 below summarizes the LOS criteria for freeway analysis based on the HCM methodologies.

LOS	Density (pc/km/ln)	Description
A	< 7	Free-flow operations. Free flow speed (FFS) prevails on the freeway and vehicles are almost completely unimpeded in the ability to maneuver within the traffic stream.
B	7 to 11	Reasonably free-flow operations and FFS on the freeway is maintained. Ability to maneuver is slightly restricted.
C	11 to 16	Provides for flow with speeds near the FSS of the freeway. Freedom to maneuver within the traffic stream is noticeably restricted, and the lane changes require more care.
D	16 to 22	This is the level at which speeds begin to decline with increasing flows, with density increasing more quickly. Freedom to maneuver within the traffic stream is seriously limited. Minor incidents can be expected to create queuing as traffic stream has limited space to absorb disruptions.
E	22 to 28	Describe operation at or near capacity. Operations on the freeway at this level are highly volatile because there are virtually no usable gaps within the traffic stream. Any disruption to the traffic stream can establish a disruption wave that propagates throughout the traffic stream.
F	>28	Unstable flow with queues forming behind bottlenecks

Table 1 – Level of Service Criteria for Freeway Analysis

Based on the above criteria, LOS E or worse is not considered acceptable for the freeway operation. Please note that HCS analysis is limited to isolated conditions. This means that if a LOS E or F is experienced along a highway segment, this may impact a significant portion of the operation upstream along the freeway and HCS does not have the capability to capture this impact.

It is understood that a more comprehensive traffic analysis using microsimulation tools may be undertaken in the future to confirm or refine laning and geometrics at the tie-ins. This will include consideration of how the auxiliary Bus, or possibly HOV, lanes are included in the design.

2.2. Capacity Analysis

Highway 99 segments as well as on-ramps and off-ramps were analyzed using HCS for AM and PM peak hour conditions for 2035 and 2050 planning horizons. As previously mentioned, the analysis was limited only to the critical peak hour direction.

Tables 2 and 3 summarize the LOS results for southbound and northbound direction, respectively during the 2035 planning horizon, whereas Table 4 and 5 summarize the results for the 2050 planning horizon.

Interchange / Freeway Segment	Movement	LOS	Remarks
Steveston Interchange	Freeway North of I/C	D	
	Southbound Off-Ramp	D	
	Freeway Under Bridge	D	
	Southbound On-Ramp	D	
	Freeway South of I/C	**E**	Freeway approaching capacity due to high demand of traffic south of Steveston Interchange
Immersed Tunnel	Freeway Segment	**E**	high demand of traffic south of Steveston Interchange
River Road Off-Ramp	Off-Ramp	D	
Highway 17A Interchange	Freeway North of I/C	D	
	Southbound Off-Ramp	C	
	Freeway Under Bridge	C	
	Southbound On-Ramp	C	
	Freeway South of I/C	C	

Table 2 – 2035 Capacity Analysis Southbound Direction (PM Peak Hour)

Reference: **George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-Lane Concept – REVISED DRAFT**

Interchange / Freeway Segment	Movement	LOS	Remarks
Highway 17 A Interchange	Freeway South of I/C	D	
	CD Road South of I/C	A	
	Northbound Off-Ramp	B	
	NB On-Ramp from Hwy 17A WB to Freeway	D	
	Freeway North of I/C	E	Freeway Approaching Capacity with more than 1,700 vphpl in the GP lanes
Immersed Tunnel	Freeway Segment	E	Freeway Approaching Capacity with more than 1,700 vphpl in the GP lanes
Steveston Interchange	Freeway South of I/C	E	Freeway Approaching Capacity with more than 1,700 vphpl in the GP lanes
	Northbound Off-Ramp	D	
	Freeway Under Bridge	C	
	Northbound On-Ramp	D	
	Freeway North of I/C	D	

Table 3 – 2035 Capacity Analysis Northbound Direction (AM Peak Hour)

Interchange / Freeway Segment	Movement	LOS	Remarks
Steveston Interchange	Freeway North of I/C	E	All traffic can barely be accomodated within 3 southbound lanes before Interchange
	Southbound Off-Ramp	D	
	Freeway Under Bridge	D	
	Southbound On-Ramp	F	Merging traffic and freeway traffic exceeds capacity (over 2,000 vplph)
	Freeway South of I/C	F	Capacity issues in accomodating over 6,000 vehicles per hour in three lanes
Immersed Tunnel	Freeway Segment	F	Capacity issues in accomodating over 6,000 vehicles per hour in three lanes
River Road Off-Ramp	Off-Ramp	F	Capacity issues due to upstream traffic demand
Highway 17A Interchange	Freeway North of I/C	E	Freeway approaching capacity due to high traffic demand from upstream conditions
	Southbound Off-Ramp	C	
	Freeway Under Bridge	C	
	Southbound On-Ramp	C	
	Freeway South of I/C	C	

Table 4 – 2050 Capacity Analysis Southbound Direction (PM Peak Hour)

Reference: George Massey Crossing: Traffic Review, Highway 99 Ramp Analysis Immersed Tube Tunnel 8-Lane Concept – REVISED DRAFT

Interchange / Freeway Segment	Movement	LOS	Remarks
Highway 17 A Interchange	Freeway South of I/C	**E**	Freeway Approaching Capacity. Spare capacity on the CD system
	CD Road South of I/C	A	
	Northbound Off-Ramp	B	
	NB On-Ramp from Hwy 17A WB to Freeway	D	
	Freeway North of I/C	**E**	Freeway Approaching Capacity with more than 1,800 vphpl in the GP lanes
Immersed Tunnel	Freeway Segment	**E**	Freeway Approaching Capacity with more than 1,800 vphpl in the GP lanes
Steveston Interchange	Freeway South of I/C	**E**	Freeway Approaching Capacity with more than 1,800 vphpl in the GP lanes
	Northbound Off-Ramp	D	
	Freeway Under Bridge	D	
	Northbound On-Ramp	D	
	Freeway North of I/C	D	

Table 5 – 2050 Capacity Analysis Northbound Direction (AM Peak Hour)

Southbound Analysis

Based on the above traffic analysis, in the southbound direction during the weekday PM peak hour by 2035, Highway 99 is expected at approaching capacity with LOS E between south of Steveston interchange to the River Road off-ramp. These conditions are attributed to the high demand of vehicles merging from Steveston interchange which are in the order of 1,200 vehicles per hour. These LOS E conditions are expected at the immersed tunnel and acceptable conditions will be expected south of the River Road off-ramp. The rest of the highway is expected to operate at acceptable conditions along the rest of the Highway 99 and the different ramps.

By 2050 traffic conditions are expected to deteriorate with LOS E expected along Highway 99 north of Steveston interchange; LOS F expected between the southbound off-ramp at Steveston to south of the River Road off-ramp; and LOS E expected before the Highway 17A interchange. Since the HCS software is limited to isolated conditions analysis, the LOS F conditions from Steveston to River Road may likely impact operations upstream along Highway 99.

Northbound Analysis

By 2035 during the AM peak hour Highway 99 is expected to be at approaching capacity with LOS E between north of Highway 17A interchange and south of Steveston interchange, this includes the immersed tunnel.

By 2050 LOS conditions are expected to remain at LOS E between Highway 17A and Steveston interchange. In addition, by this year the two GP northbound lanes under the Highway 17A bridge are expected at approaching capacity. However, the CD lanes are expected to operate at acceptable levels with spare capacity and some of the GP traffic approaching from Highway 17 may be reassigned to the CD system if traffic operations issues are being experienced on the GP lanes.

3. CONCLUSIONS

The traffic analysis conducted herein was prepared to validate the proposed ramps and freeway segments along Highway 99 between Highway 17A interchange and Steveston Interchange. The proposed design includes the 8-lane ITT with the shoulder lanes dedicated to buses only and the remaining six lanes for GP traffic. This analysis was conducted using the freeway module of the Highway Capacity Software and included the critical peak hour directions for the 2035 and 2050 planning horizons.

The analysis has indicated that the immersed tunnel is expected to operate at LOS E by 2035 in both directions and by 2050 conditions in the southbound direction are expected to deteriorate to LOS F between Steveston interchange and Highway 17A.

Ramps analysis has indicated operational issues at the River Road off-ramp and the southbound off-ramp at Steveston Interchange. These conditions are due to the high vehicle demand at both the proposed crossing and the Steveston Interchange southbound off-ramp during the AM peak hour.

Due to the limitations of HCS, the impact of the poor performance of a ramp or a Highway 99 segment on the upstream traffic could not be measured. However, it is understood that a more comprehensive traffic analysis using microsimulation tools may be undertaken in the future to confirm or refine laning and geometrics at the tie-ins. This will include consideration of how the auxiliary Bus, or possibly HOV, lanes are included in the design.

Attachments: 2035 and 2050 AM and PM peak hour volumes.

PRELIMINARY FOR INFORMATION ONLY

LEGEND

1800/30/100/30 = ALL VEHICLES / 2+HOV / HEAVY TRUCK / BUS

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GEORGE MASSEY CROSSING - 8 LANE

INTERIM PEAK HOUR TRAFFIC VOLUME FORECASTS 2035 AM (VEH/HR)

19BC-0090

REV B

PRELIMINARY FOR INFORMATION ONLY

LEGEND

1800/30/100/30 = ALL VEHICLES / 2+HOV / HEAVY TRUCK / BUS

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GEORGE MASSEY CROSSING - 8 LANE

INTERIM PEAK HOUR TRAFFIC VOLUME FORECASTS 2035 PM (VEH/HR)

19BC-0090

REV B

PRELIMINARY FOR INFORMATION ONLY

LEGEND

1800/30/100/30 = ALL VEHICLES / 2+HOV / HEAVY TRUCK / BUS

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GEORGE MASSEY CROSSING - 8 LANE

INTERIM PEAK HOUR TRAFFIC VOLUME FORECASTS 2050 AM (VEH/HR)

19BC-0090

REV B

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1800/30/100/30 = ALL VEHICLES / 2+HOV / HEAVY TRUCK / BUS

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GEORGE MASSEY CROSSING - 8 LANE

INTERIM PEAK HOUR TRAFFIC VOLUME FORECASTS 2050 PM (VEH/HR)

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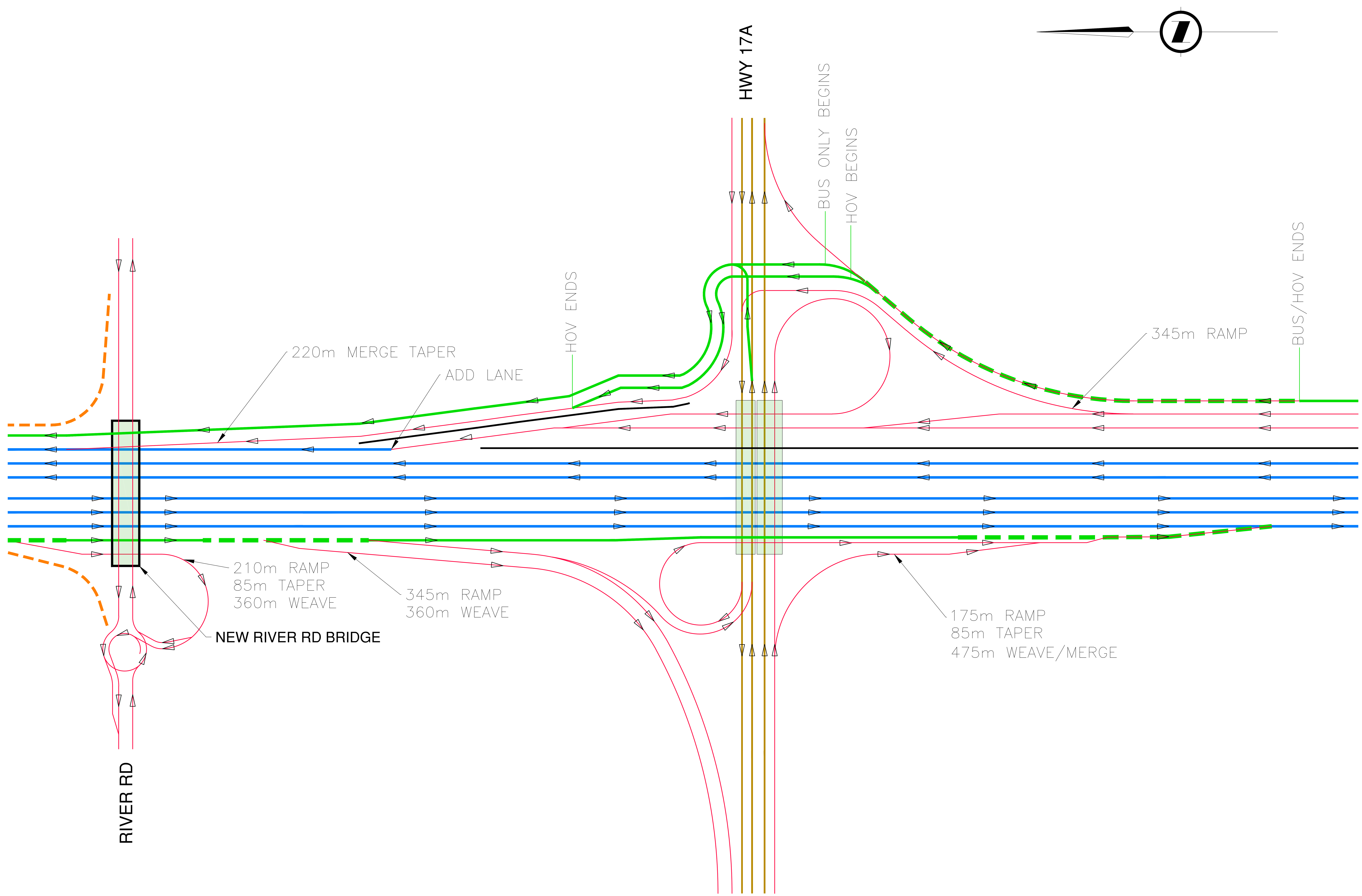
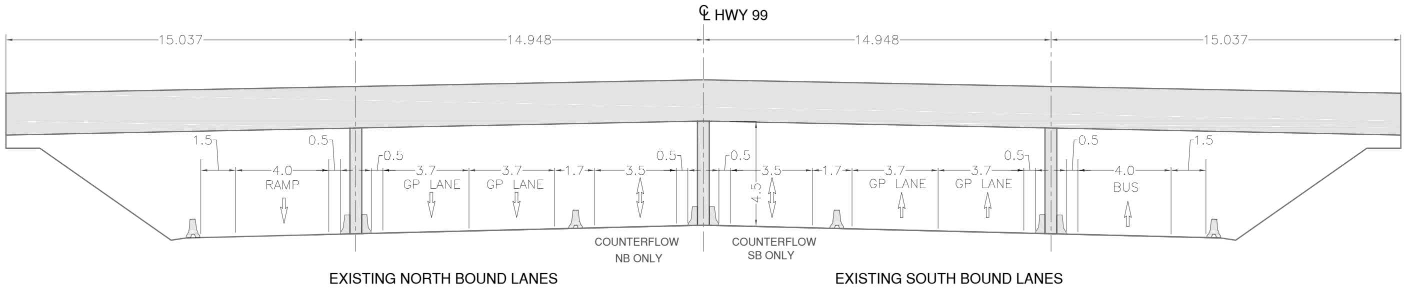
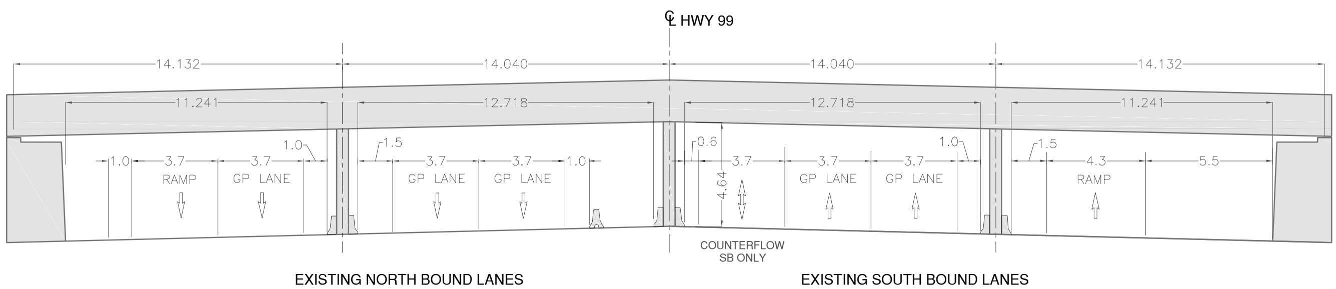
APPENDIX R. PROPOSED HIGHWAY 17A INTERCHANGE LANING SCHEMATIC



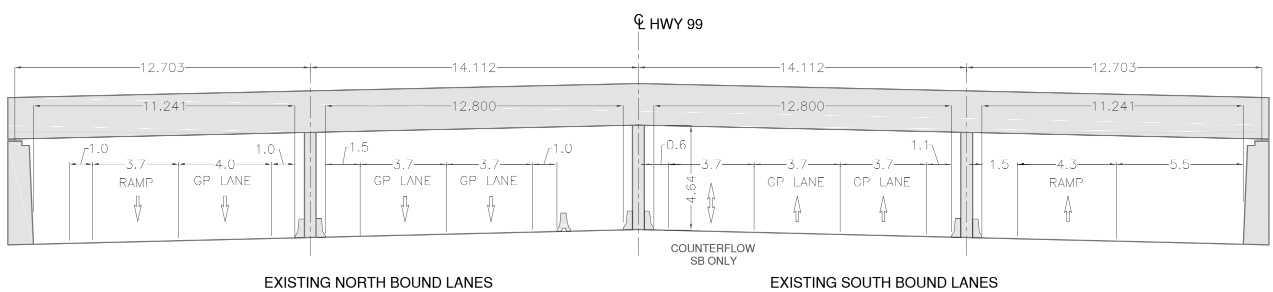
APPENDIX S. CROSS-SECTIONS AT EXISTING BRIDGES



HWY 99 SB / STEVESTON EXISTING BRIDGE

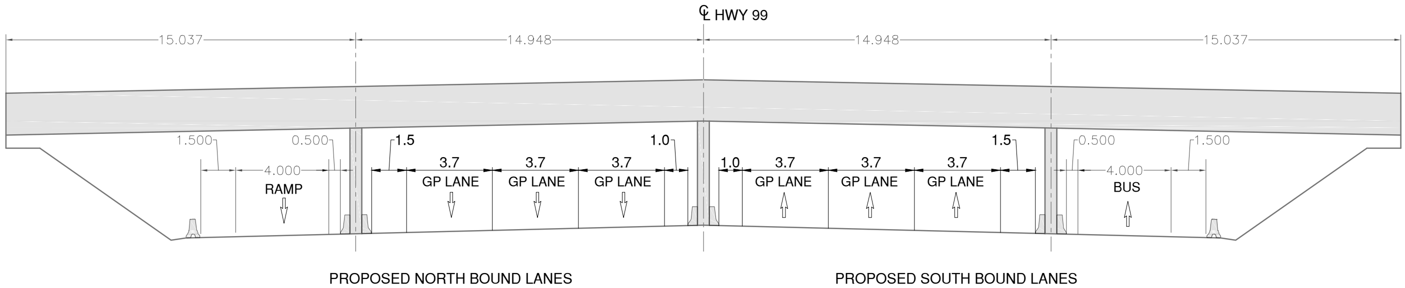


HWY 99 SB / HWY 17A EXISTING NORTH BRIDGE

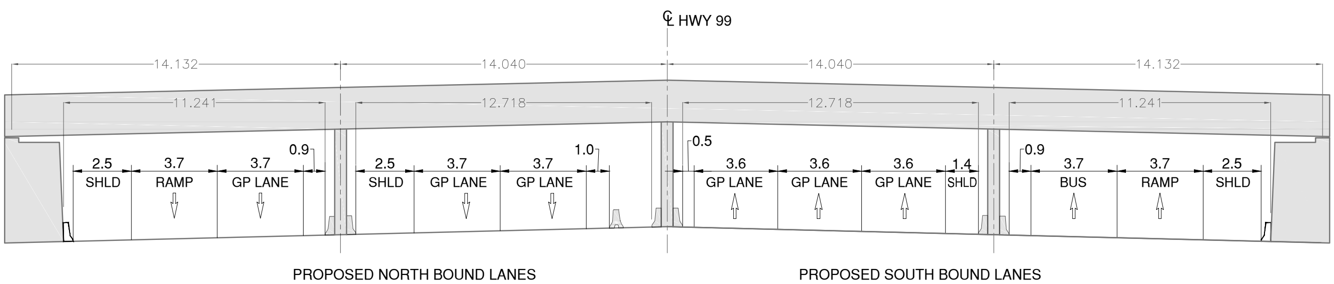


HWY 99 SB / HWY 17A EXISTING SOUTH BRIDGE

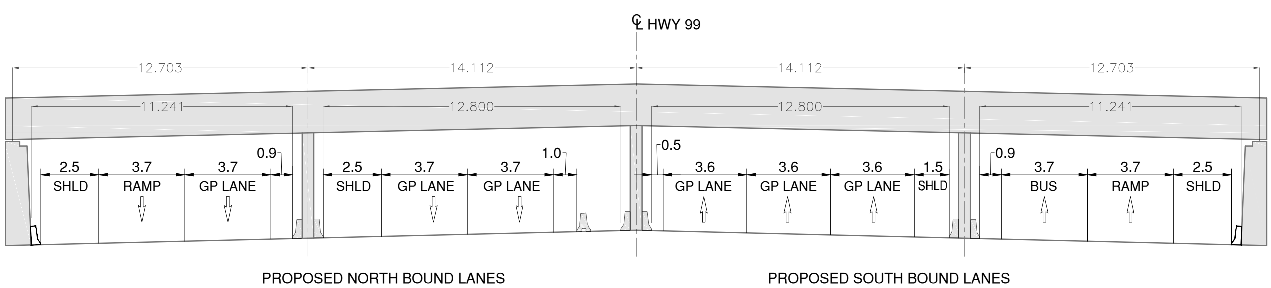
HWY 99 - EXISTING LANE CONFIGURATION



HWY 99 SB / STEVESTON EXISTING BRIDGE



HWY 99 SB / HWY 17A EXISTING NORTH BRIDGE



HWY 99 SB / HWY 17A EXISTING SOUTH BRIDGE

HWY 99 - PROPOSED LANE CONFIGURATION