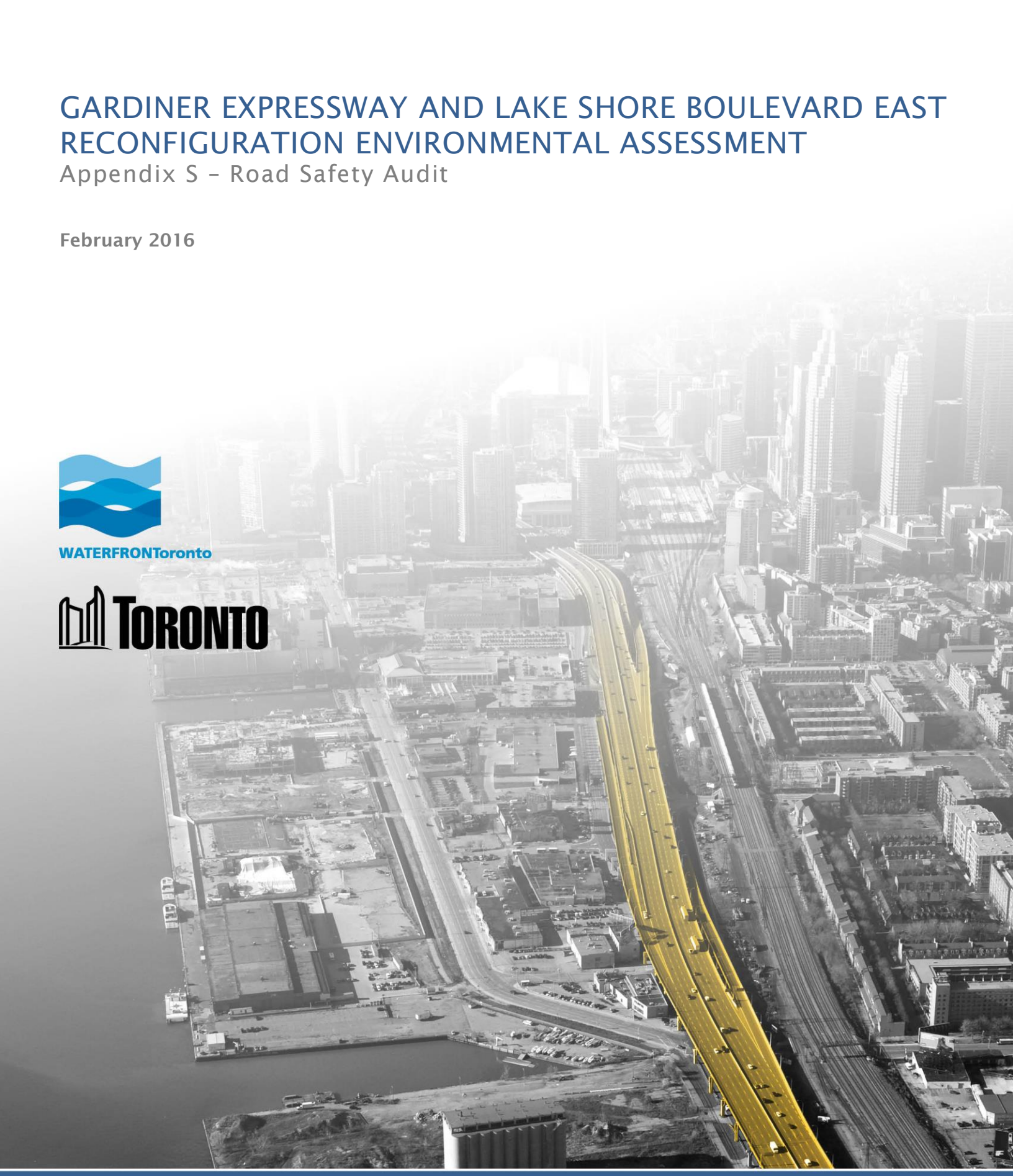
GARDINER EXPRESSWAY AND LAKE SHORE BOULEVARD EAST RECONFIGURATION ENVIRONMENTAL ASSESSMENT

Appendix S – Road Safety Audit

February 2016



WATERFRONToronto

TORONTO

DILLON CONSULTING

HARGREAVES ASSOCIATES

MORRISON HERSHFIELD

PERKINS + WILL

MEMO

DATE: February 16, 2016

SUBJECT: Gardiner-Lake Shore Boulevard East Reconfiguration EA – Safety Review Responses

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This memo presents the status of the conceptual design of the three current Hybrid alternatives (Options 1, 2A and 3) with respect to addressing safety review comments chiefly outlined in AECOM's January 5, 2015 memorandum and Dillon's own in-house reviews. These reviews were based on initial, preliminary plans and profiles of the three alternatives. These alternatives are continuing to go through revision as the designs evolve and undergo more detailed evaluation and scrutiny. Figure 1, taken from the AECOM memo, was used to divide the project into sections to assist in the organization of this summary.

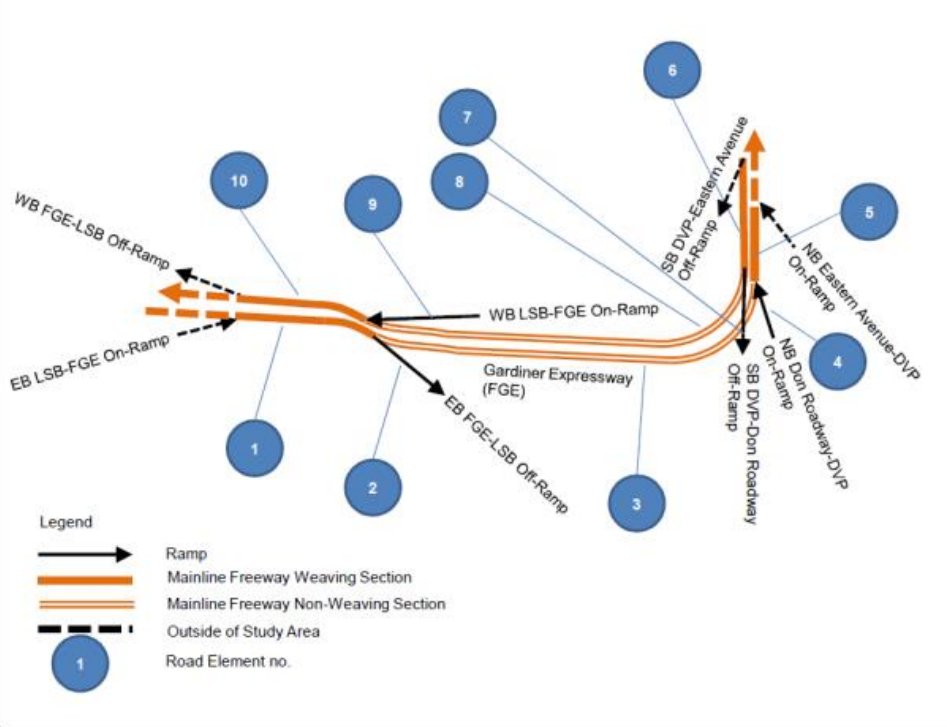

FIGURE 1: SAFETY ANALYSIS SECTIONS

The Comment/response table below is separated into two parts; Part A is a summary by road element (there are ten road elements) and Part B is a summary of potential mitigation comments/responses organized by Alternative. Part B reference numbers (i.e. ID #s) have been noted in the Part A table to aid in the review of recommended actions to be taken.

ID #	AECOM Comment	Dillon Response	Mitigation Reference
PART A: Comments & Responses By Road Element			
Road Element #1: Eastbound FGE between the Jarvis Street On-Ramp and the New LSB EB Off-ramp			
Alternative 1			
1.	Potential One-Sided Weaving / Speed Differential Issue with cars entering FGE at Jarvis exiting at the FGE-DVP W-N ramp. Potential Sightline Issue at the downstream bullnose	Agree that this is a potential issue with Alternative 1 that has the DVP exit on the median side. This condition is improved with Alternatives 2A and 3 where the DVP exit is on the right side.	23
Alternatives 2A and 3			
2.	Potential Sightline Issue at the downstream bullnose	The bull nose is located 40 m east of the road high spot and is 0.96 m below the high spot in elevation. Although there is a sightline issue (ability to see the road service at the bullnose from west of the high spot) a vehicle stopped at the bullnose, as well as any bullnose signage/hazard warning, will be visible. Shifting the bullnose location to the west and/or moving the vertical curve high spot further east should be reviewed during the design phase. Note that the desire, from an urban design/aesthetic standpoint, to minimize any Gardiner deck widening over the Cherry Street corridor, led to the positioning of the new exit bullnose to the east side and matching the vertical profile of the Gardiner to the west (with its highpoint).	27
3.	Potential for Violation of Drivers' Expectations (left side ramp exit to LSB)	Acknowledged	23
Road Element #2: FGE Eastbound Off-Ramp to LSB			
Alternative 1			
4.	Potential Sightline Issue: approach to Munition Street may have sightlines blocked due to FGE piers and parapet walls – potentially exacerbated by ramp's horizontal curve and step downgrade as well as lighting condition under FGE	Acknowledged. Pier locations will be adjusted, where required, to accommodate this ramp. This has been allowed for in the project costing. The relatively steep downgrade slope (6%) is to ensure adequate flat grade on west approach to Munition intersection. Also see explanation above (ID #2 for bullnose positioning. Lighting will not be an issue – adequate lighting will be provided.	24
Alternative 2A and 3			
5.	Potential Sightline Issue: Stopping sight distance appears not to be available at the western end due to presence of a crest vertical curve with K-value of 9 on top of	K value has been increased to 11.	28

ID #	AECOM Comment	Dillon Response	Mitigation Reference
	the ramp (at STA.0+300).		
Road Element #3: FGE-DVP W-N Ramp			
Alternative 1			
6.	On existing W-N ramp (which is utilized in this option) there is a narrower-than-standard shoulder width for emergency purposes along the curved eastern portion.	Acknowledged – this is an existing condition	25
Alternative 2A and 3			
7.	Potential for Violation of Drivers' Expectations: transition from high speed FGE section to the west to tight 60 km/h ramp)	Acknowledged – mitigation required in advance of this ramp to adjust drivers' approach speed.	29
8.	Potential Sightline / Increased Driver Workload / Vehicle Instability Issues: Along the curved eastern portion of the ramp, motorists sightline could be blocked by the inside parapet walls (exacerbated by presence of parapet walls and steep downgrades /horizontal curve)	Acknowledged – existing ramp downgrade is currently at 6% - same as proposed. Right shoulder increase to 2.5 m. Reduced posted speeds recommended.	30
Road Element #4: Don Roadway-DVP Northbound On-Ramp			
Alternatives 1, 2A and 3			
9.	No issues identified	n/a	n/a
Road Element #5: Northbound DVP			
Alternatives 1, 2A and 3			
10.	No issues identified	n/a	n/a
Road Element #6: Southbound DVP north of FGE Ramp			
Alternatives 1 and 2A			
11.	No issues identified	n/a	n/a
Alternative 3			
12.	Potential for Speed Differentials: Shorter than standard speed-change lane at exit terminal.	Acknowledged. Approach speeds into this section of the DVP recommended for reduction. Increase in length of speed change lane (south from the Richmond – Adelaide interchange) to be assessed further in design phase.	36
Road Element #7: DVP-Don Roadway Southbound Off-ramp			
Alternative #1			
13.	Not reviewed - Profile drawing is needed for further review	Profile not developed as this ramp is unchanged from existing conditions.	n/a
Alternative 2A			
14.	Potential Sightline Issue: Stopping sight	Very tight constraints exist in this area as	31

ID #	AECOM Comment	Dillon Response	Mitigation Reference
	distance appears not to be available for motorists exiting DVP from the ramp due to presence of a crest vertical curve with K-value equal to 4 at STA.0+300.	evidenced by the profile issues with existing southbound Don Roadway. New road profile improvements have been made: K value has been increased from 4 to 10 at STA. 0+287 and road slope after vertical curve has been modified from 6% down to 3.9%	
Alternative 3			
15.	Vertical Clearance Issue: Elevated westbound DVP-FGE ramp located above would create vertical clearance issue for motorists exiting DVP from Don Roadway off-ramp.	Target vertical clearance of 7.0 m has been achieved.	37
Road Element #8: DVP-FGE N-W Ramp			
Alternative 1			
16.	Based on field observations, there is a narrower than standard shoulder width for emergency purposes along the curved eastern portion. No further comment - Profile drawing and design speed are needed for further review, if available.	Acknowledged. Profile not developed as this ramp is unchanged from existing conditions.	26
Alternative 2A			
17.	Potential Sightline / Increased Driver Workload: Along the curved eastern portion of the ramp, motorists' sightlines could be blocked by the outside parapet walls in an environment creating heavy workload for drivers to adjust their vehicles' lane positioning. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering.	Acknowledged –Right shoulder width increase to 2.5 m will aid sightlines as will speed reduction recommendations.	32
Alternative 3			
18.	Potential Sightline Issue / Increased Driver Workload Issue: For a shorter distance in comparison to that of Alternative #2A, along the curved eastern portion of the ramp, motorists' sightlines could be blocked by the outside parapet walls in an environment with heavy workload for drivers to adjust their vehicles' lane positioning. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering.	Acknowledged –Right shoulder width increase to 2.5 m will aid sightlines as will speed reduction recommendations.	38

ID #	AECOM Comment	Dillon Response	Mitigation Reference
19.	Potential for Speed Differentials: Trucks may experience significant loss of speed (especially in icy road conditions) due to presence of a 6.9% upgrade along the curved portion of the ramp.	Grade reduced to 6.0%. This grade Is maintained for only approximately 120 m, truck speed differential not expected to be an issue.	38
Road Element #9: LSB Westbound On-Ramp to FGE			
Alternative #1			
20.	No issues identified.	n/a	n/a
Alternatives 2A and 3			
21.	Potential Sightline Issue: Stopping sight distance appears not to be available for entering motorists from the ramp to FGE due to presence of a crest vertical curve with K-value of 6 at the top of the ramp (STA.0+310).	Crest vertical curve increased form K=6 to K=13.	33
Road Element #10: FGE Westbound to Sherbourne Off-Ramp			
Alternatives 1, 2A and 3			
22.	Potential One-Sided Weaving Issue: between entering vehicles from the DVP N-W and the LSB-FGE on ramps and the Sherbourne exit ramp	Acknowledged. Expected low volume of motorists will be entering the Gardiner at this location from the LSB-FGE on ramp to exit at Sherbourne. Alternatives 2 and 3 place the heavier N-W ramp to Sherbourne exit ramp on the right side to minimize this weave.	34

ID #	AECOM Comment	Dillon Response
PART B: Potential Mitigation Comment/Responses by Alternative		
Alternative #1		
Road Element #1 - Mitigation		
23.	Weaving and speed differential issue: • Appropriate advance signage • Lower FGE speed limit on approach to weaving section (augmented with visual clues - e.g. narrower lanes) • Crash attenuators at the fork • Relocating the LSB off-ramp to left of FGE-DVP ramp (similar to Alternatives #2A and #3).	General agreement the proposed mitigation in the first three bullet points– to be assessed further in the design phase. Relocating the LSB off-ramp to the left would be inconsistent with the intent of this alternative which is to maintain the existing FGE-DVP ramps.
Road Element #2 - Mitigation		
24.	Potential sightline issue (many factors): • Installation of end-of-queue detection systems to warn of potential queues downstream. • Provision of illumination. • Provision of a wider shoulder on the left side of the off-ramp. • Provision of transverse rumble strips along the straight section of the off-ramp. • Removal / relocation of two to three bridge piers located along the north side of the off-ramp approximately between STA.0+300 and STA.0+400.	General agreement with proposed mitigation– to be assessed further in the design phase.
Road Element #3 - Mitigation		
25.	Narrower-than-standard shoulder: • Provision of wider structure for eastbound FGE-DVP ramp.	Widening of this ramp would be inconsistent with the intent of this alternative which is to maintain the existing FGE-DVP ramps.
Road Element #8 - Mitigation		
26.	Potential weaving / speed differential issue between uphill LSB on-ramp and Sherbourne off-ramp: • Relocating the proposed LSB on-ramp to the east such that the on-ramp starts being elevated from the first intersection along the realigned LSB to the west of the LSB / Don Roadway intersection.	Not recommended. Shifting this ramp to the east would conflict with the proposed Munition Street intersection.
Alternative #2		
Road Element #1 - Mitigation		
27.	Potential sightline issue, violation of drivers' expectations and speed differential: • Provision of appropriate signage	

ID #	AECOM Comment	Dillon Response
	• Lowering posted speed on approach mainline (with visual clues) • Implementation of crash attenuators • Relocating the exit fork to the west • Minimize ramp curvature east of bullnose • Provision of rumble strips	General agreement with proposed mitigation– to be assessed further in the design phase. Relocating exit fork to the left is at conflict with desire to minimize deck width over the Cherry Street corridor.
Road Element #2 - Mitigation		
28.	Potential sightline issues: • Provision of appropriate signage • Lowering posted speed on approach mainline (with visual clues) • Implementation of crash attenuators • Relocating the exit fork to the west • Minimize ramp curvature east of bullnose • Provision of rumble strips	General agreement with proposed mitigation– to be assessed further in the design phase. Relocating exit fork to the west is at conflict with desire to minimize deck width over the Cherry Street corridor.
Road Element #3 - Mitigation		
29.	Potential violation of drivers' expectations on eastbound FGE-DVP ramp: • Provision of appropriate signage • Lowering posted speed on approach mainline (with visual clues) • Implementation of crash attenuators • Relocating the exit fork to the west • Minimize ramp curvature east of bullnose • Provision of rumble strips	General agreement with proposed mitigation– to be assessed further in the design phase. Relocating exit fork to the west is at conflict with desire to minimize deck width over the Cherry Street corridor.
30.	Potential sightline issues: • provision of a flatter crest vertical curve • Installation of end-of-queue detection systems • Lowering posted speed limit even further through provision of "reduced speed zone" for motorists travelling eastbound on approach to the curved section	Flatter crest vertical curve achieved with design revision. General agreement with the remainder of the proposed mitigation– to be assessed further in the design phase.
Road Element #7 - Mitigation		
31.	Potential sightline issue for southbound Don Roadway off-ramp: • Provision of a flatter crest vertical curve (if possible, considering all other • Installation of end-of-queue detection systems	New road profile improvements have been made: K value has been increased from 4 to 10 at STA. 0+287 and road slope after vertical curve has been modified from 6% down to 3.9%. General agreement with proposed mitigation– to be assessed further in the design phase.
Road Element #8 - Mitigation		
32.	Potential sightline issue along the eastern portions of the westbound DVP-FGE ramp	

ID #	AECOM Comment	Dillon Response
	due to a combination of curved horizontal alignment and outside bridge parapets: • Installation of end-of-queue detection systems	General agreement with proposed mitigation– to be assessed further in the design phase.
Road Element #9 - Mitigation		
33.	Potential sightline issue for westbound motorists entering from LSB on-ramp due to presence of a crest vertical curve (with K-value equal to 6) at top of the on-ramp (STA.0+310): • Relocating the on-ramp and the associated bull nose at the entrance terminal to the west such that the crest vertical curve can be flattened.	Crest vertical curve increased form K=6 to K=13. . Relocating bull nose of the entrance terminal to the west is at conflict with desire to minimize deck width over the Cherry Street corridor.
Road Element #10 - Mitigation		
34.	Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp: • Insufficient weaving traffic volumes to address	Expected low volume of motorists will be entering the Gardiner at this location from the LSB-FGE on ramp to exit at Sherbourne.
Alternative #3		
All Road Elements - Mitigation		
35.	All items listed under Alternatives 2 also apply to Alternative 3 (with exception of sightline issues with Don Roadway SB off-ramp)	See above responses
Road Element #6 - Mitigation		
36.	Potential for speed differentials on southbound DVP mainline section between Eastern off-ramp and Don-Roadway off-ramp due to shorter-than-standard speed-change lane at Don Roadway off-ramp exit terminal: • Provision of a longer speed change lane	General agreement with proposed mitigation– to be assessed further in the design phase.
Road Element #7 - Mitigation		
37.	Vertical clearance issue for motorists exiting DVP from Don Roadway off-ramp: • Revisiting the proposed alignment of Don Roadway off-ramp.	Adjustments to vertical alignment have been recommended. Refer to revised Sheet No. P3-1.
Road Element #8 - Mitigation		
38.	Potential for speed differentials on westbound DVP-FGE ramp; trucks may experience significant loss of speed (especially in icy road conditions) due to presence of a 6.9% upgrade along the	Grade reduced to 6.0%. This grade Is maintained for only approximately 120 m, truck speed differential not expected to be an issue.

ID #	AECOM Comment	Dillon Response
	curved portion of the ramp: • Revisiting the proposed alignment of westbound DVP-FGE ramp.	

AECOM
105 Commerce Valley Drive West, Floor 7 905 886 7022 tel
Markham, ON, Canada L3T 7W3 905 886 9494 fax
www.aecom.com

Memorandum

Subject	Waterfront Toronto – Gardiner-DVP Ramps Road Safety Audit
Date	January 5, 2016

This memorandum is intended to provide a summary of findings from the review of the "preliminary" design drawings of the three "Hybrid" Alternative Design Concepts (namely, Alternative #1, Alternative #2A, and Alternative #3) of Gardiner Expressway (FGE)-Don Valley Parkway (DVP) ramps including on-ramps and off-ramps from / to Lakeshore (LSB) Boulevard to / from FGE and those from / to Don Roadway to / from DVP. This memorandum, where possible, also provides a list of potential treatments to mitigate the identified potential safety issues. The study area limits are Cherry Street to the west and Don Roadway to the east. Note that mid-block sections and intersections along LSB as well as non-elevated portions of FGE-DVP ramps are outside of study scope. The review process included a detailed review of the "preliminary" plan and profile drawings provided by Waterfront Toronto, and also considers the observations made during a site visit (on Thursday, November 19, 2015) of the study area, with a focus on the potential safety performance of various road elements within the study area. These road elements include mainline freeway weaving sections, mainline freeway non-weaving sections, and ramps locates within the above-noted study area boundaries. Figure 1 shows a schematic map of the study area and its study road elements.

Note that this memorandum is a revised copy of the memorandum under a similar name that was submitted to Waterfront Toronto project team on December 3, 2015. This revision to the previous memorandum was requested following development of a new version of Alternative #3 by the Gardiner Expressway East EA Consultant team and the Waterfront Toronto's subsequent request to update the road safety audit findings.

The following "preliminary" design drawings were reviewed:

- ALTERNATIVE DESIGN 1 HYBRID[1] – Sheet no. 1 - October 22, 2015;
- ALTERNATIVE DESIGN 1 HYBRID PROFILES[2] – Sheet no. P1-1 - October 9, 2015;
- ALTERNATIVE DESIGN 2A HYBRID[3] – MORE NORTHERN ALIGNMENT - Sheet no. 2A - October 23, 2015;
- ALTERNATIVE DESIGN 2A HYBRID[4] – MORE NORTHERN ALIGNMENT PROFILES (1 OF 2) – Sheet no. P2A-1 - October 9, 2015;
- ALTERNATIVE DESIGN 2A HYBRID[5] – MORE NORTHERN ALIGNMENT PROFILES (2 OF 2) – Sheet no. P2A-2 - October 9, 2015;
- ALTERNATIVE DESIGN 3 HYBRID[6] – NORTHERN ALIGNMENT WITH RAIL BRIDGE WIDENING - Sheet no. 3 - October 23, 2015;

[1] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\2015-09-21 HYBRID OPTION\OPTION 1 VERSION 10.DWG*

[2] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\DESIGN PROFILES\OPTION 1 VERSION 8_ALIGNMENT AND PROFILE.DWG*

[3] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\2015-09-21 HYBRID OPTION\HYBRID OPTION H60A VERSION 6 (OPTION 2A).DWG*

[4] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\DESIGN PROFILES\ HYBRID OPTION H60A VERSION 3_ALIGNMENT AND PROFILE.DWG*

[5] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\DESIGN PROFILES\ HYBRID OPTION H60A VERSION 3_ALIGNMENT AND PROFILE.DWG*

- ALTERNATIVE DESIGN 3 HYBRID[7] – NORTHERN ALIGNMENT WITH RAIL BRIDGE WIDENING PROFILES (1 OF 2) – Sheet no. P3-1 - October 9, 2015;
- ALTERNATIVE DESIGN 3 HYBRID[8] – NORTHERN ALIGNMENT WITH RAIL BRIDGE WIDENING PROFILES (2 OF 2) – Sheet no. P3-2 - October 9, 2015; and
- A marked-up version of ALTERNATIVE DESIGN # HYBRID – NORTHERN ALIGNMENT WITH RAIL BRIDGE WIDENING - Sheet no. 3 - October 23, 2015 with hand written notes to illustrate the proposed changes to the original design of Alternative #3.

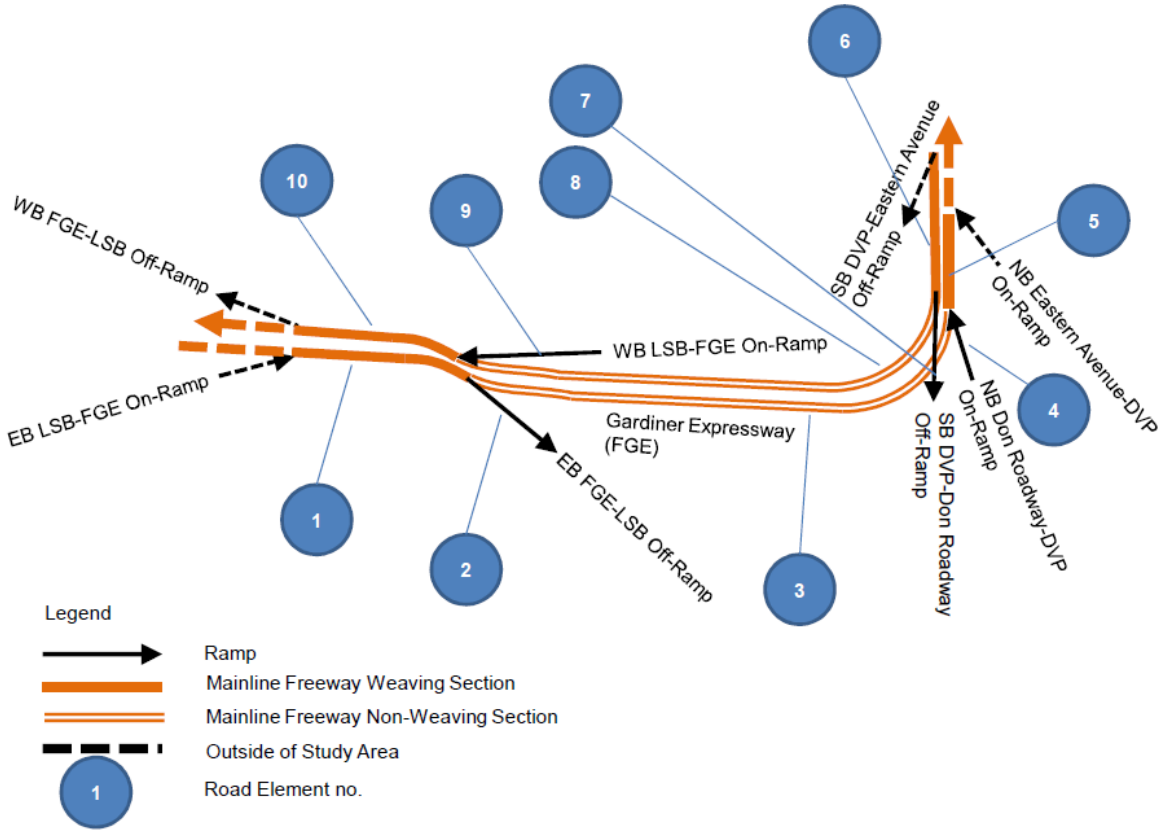

Figure 1 – Study Area Map

Potential Road Safety Issues

The review process included a detailed review of the physical aspects including mainline sections and ramps vertical and horizontal alignments, lane configuration / continuity, as well as relevant environmental considerations. Note that only a high-level review of cross-sectional elements was conducted as at the time of preparation of this memorandum, design drawings illustrating cross sections of road elements were not available. In addition, the safety review considers human factors

[6] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\2015-09-21 HYBRID OPTION\HYBRID NORTHERN OPTION H60 VERSION 6 (OPTION 3).DWG*

[7] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\DESIGN PROFILES\ HYBRID NORTHERN H60 OPTION 3 VERSION 5_ALIGNMENT AND PROFILE.DWG*

[8] *FILENAME: G:\CAD\091405\2015 PHASE\02-CIVIL\02-DESIGN\DESIGN PROFILES\ HYBRID OPTION H60A VERSION 3_ALIGNMENT AND PROFILE.DWG*

and road user safety in the context of the design. The identified potential safety issues for each study road element and "Hybrid" Alternative Design Concept are provided in Table 1.

Note that in conducting the road safety audits, the following assumptions were made:

- Design Speed for FGE for Section to the West of Study Area = 110 km/h;
- Design Speed for DVP for Section to the North of Study Area = 110 km/h;
- Minimum Ramp Design Speed within Study Area (as per information provided in Table F5-1 of the MTO's Geometric Design Standards for Ontario Highways) = 60 km/h;
- Super-elevation along Curved Portions of FGE-DVP ramps = 6%; and
- Design Speed for FGE-DVP Connecting Roadways = 60 km/h in Alternatives #2A, and #3.

Table 2 presents a summary of identified potential safety issues for each of the three "Hybrid" Alternative Design Concepts.

Table 1 – Road Safety Audit Findings

Road Element no.	Road Element Description	Alternative #1	Alternative #2A	Alternative #3
1	Eastbound FGE Mainline Section between Tip of Painted Gore Area of Eastbound LSB-FGE On-Ramp (i.e., Lower Jarvis On-Ramp) and Tip of Painted Gore Area of Eastbound FGE-LSB Off-Ramp (i.e., the "fork")	<u>Potential One-Sided Weaving / Speed Differential Issue</u>: Relatively high volume of motorists (estimated at maximum of 1'130 vehicles during the PM peak hour[9]) entering FGE from the uphill LSB-FGE on-ramp (i.e., Lower Jarvis on-Ramp) and destined to DVP northbound direction are to accelerate to the "assumed" speed and make two lane changes to the left through relatively high volume of motorists (estimated at maximum of 1'846 vehicles during the PM peak hour[10]) on FGE and heading to LSB off-ramp (as well as a portion of motorists on FGE and heading to DVP north) within a 450-m long weaving area. Even if proper signage is provided, for some drivers, the distance travelled during a summation of vehicle acceleration time, "reading time" (i.e., time to read, detect, and understand the to-be-provided overhead / side-mounted signs), "decision time", "manoeuvre time" could be longer than the available weaving distance. <u>Potential Sightline Issue</u>: Due to lane discontinuity at the "fork", some drivers may not initiate lane changing manoeuvres until they see the exit bull nose of the downstream off-ramp (i.e.,	<u>Potential Sightline Issue</u>: Due to lane discontinuity at the "fork", some drivers may not initiate lane changing manoeuvres until they see the physical bull nose of the "fork". **To lesser extent in comparison to that of Alternative #1**, sightline of some motorists on the two inside lanes to the exit bull nose could be blocked by the parapet walls and due to presence of a horizontal curve ahead of the "fork". <u>Potential for Violation of Drivers' Expectations</u>: Considering the existing lay-out with exit ramp to LSB on the right side, a left exit to LSB may violate drivers' expectations; locating the off-ramp on the left side may violate drivers' expectations in the short run (i.e., during initial period after opening to public). In addition, the expected speed differential between the accelerating traffic destined to DVP and decelerating traffic exiting FGE onto LSE off ramp on the inner lanes could create a potential for rear-end collisions.	<u>Potential Sightline Issue</u>: Due to lane discontinuity at the "fork", some drivers may not initiate lane changing manoeuvres until they see the physical bull nose of the "fork". **To lesser extent in comparison to that of Alternative #1**, sightline of some motorists on the two inside lanes to the exit bull nose could be blocked by the parapet walls and due to presence of a horizontal curve ahead of the "fork". <u>Potential for Violation of Drivers' Expectations</u>: Considering the existing lay-out with exit ramp to LSB on the right side, a left exit to LSB may violate drivers' expectations; locating the off-ramp on the left side may violate drivers' expectations in the short run (i.e., during initial period after opening to public). In addition, the expected speed differential between the accelerating traffic destined to DVP and decelerating traffic exiting FGE onto LSE off ramp on the inner lanes could create a potential for rear-end collisions.

[9] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015. It was assumed that entering eastbound traffic from Lower Jarvis on-ramp would be destined to DVP (and not LSB).*

[10] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015.*

Road Element no.	Road Element Description	Alternative #1	Alternative #2A	Alternative #3
		the "fork"). Sightline of some motorists on the outside lane and the adjacent lane to the exit bull nose could be blocked by the parapet walls and due to presence of a horizontal curve ahead of the "fork".		
2	Eastbound FGE-LSB Off-Ramp	Potential Sightline Issue: The to-be-retained existing bridge piers (of the elevated eastbound FGE mainline section) and inside parapet walls of the off-ramp may obstruct sightlines for exiting motorists on approach to the intersection of Munition Street; approaching motorists' sightlines to end of eastbound vehicles queue may be blocked by the bridge piers and inside parapet walls. This can be of a greater issue in the absence of appropriate lighting for the underpass section of the off-ramp. The proposed design of the ramp with a 5%-downgrade slope followed by a horizontal curve would likely not provide unobstructed sightlines for motorists to make necessary collision avoidance manoeuvers, if needed.	Potential Sightline Issue: Stopping sight distance appears not to be available at the western end due to presence of a crest vertical curve with K-value of 9 on top of the ramp (at STA.0+300). The proposed vertical arrangement would likely not provide unobstructed sightlines for motorists exiting FGE from the ramp to make necessary collision avoidance manoeuvres, if needed.	Potential Sightline Issue: Stopping sight distance appears not to be available at the western end due to presence of a crest vertical curve with K-value of 9 on top of the ramp (at STA.0+300). The proposed vertical arrangement would likely not provide unobstructed sightlines for motorists exiting FGE from the ramp to make necessary collision avoidance manoeuvres, if needed.
3	Eastbound FGE-DVP Ramp[11]	Based on field observations, there is a narrower-than-standard shoulder width for emergency purposes along the curved eastern portion. No further comment - Profile drawing and design speed are needed for further review, if available.	Potential for Violation of Drivers' Expectations: FGE's tangential (straight) and fairly level alignment on approach to the horizontally curved portion of the ramp (with design speed of 60 km/h) is perceived by some drivers as a notion that they can operate safely at speed of 90 km/h or even higher. Hence, drivers' expectations could be violated.	Potential for Violation of Drivers' Expectations: FGE's tangential (straight) and fairly level alignment on approach to the horizontally curved portion of the ramp (with design speed of 60 km/h) is perceived by some drivers as a notion that they can operate safely at speed of 90 km/h or even higher. Hence, drivers' expectations could be violated.

[11] *Eastbound FGE mainline section between tip of painted gore area of FGE-LSB off-ramp and tip of painted gore area of Don Roadway-DVP on-ramp*

Road Element no.	Road Element Description	Alternative #1	Alternative #2A	Alternative #3
			Potential Sightline / Increased Driver Workload / Vehicle Instability Issues: Along the curved eastern portion of the ramp, motorists sightline could be blocked by the inside parapet walls. This is coupled with presence of a crest vertical curve with K-value of 8 followed by a 6.5% downgrade along the curved portion of the ramp at STA.1+040; this creates a potential for sightline obstruction for motorists negotiating the curved portion of the ramp in an environment with heavy workload for drivers to adjust their vehicles' lane positioning and a potential for vehicle instability. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering.	Potential Sightline / Increased Driver Workload / Vehicle Instability Issues: **For a shorter distance in comparison to that of Alternative #2**, along the curved eastern portion of the ramp, motorists sightline could be blocked by the inside parapet walls. This is coupled with presence of a crest vertical curve with K-value of 6 followed by a 6.9% downgrade along the curved portion of the ramp at STA.1+000; this creates a potential for sightline obstruction for motorists negotiating the curved portion of the ramp in an environment with heavy workload for drivers to adjust their vehicles' lane positioning and a potential for vehicle instability. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering.
4	Northbound Don Roadway-DVP On-Ramp	No issues identified.	No issues identified.	No issues identified.
5	Northbound DVP Mainline Section between Tip of Painted Gore Area of Don Roadway-DVP On-Ramp and Tip of Painted Gore Area of Eastern Avenue-DVP On-Ramp	No issues identified.	No issues identified.	No issues identified.

Road Element no.	Road Element Description	Alternative #1	Alternative #2A	Alternative #3
6	Southbound DVP Mainline Section between Tip of Painted Gore Area of DVP-Eastern Avenue Off-Ramp and Tip of Painted Gore Area of DVP-LSB Off-Ramp	No issues identified.	No issues identified.	Potential for Speed Differentials: Shorter than standard speed-change lane at exit terminal.
7	Southbound DVP-Don Roadway Off-Ramp	Not reviewed - Profile drawing is needed for further review, if available.	Potential Sightline Issue: Stopping sight distance appears not to be available for motorists exiting DVP from the ramp due to presence of a crest vertical curve with K-value equal to 4 at STA.0+300.	Vertical Clearance Issue: Elevated westbound DVP-FGE ramp located above would create vertical clearance issue for motorists exiting DVP from Don Roadway off-ramp.
8	Westbound DVP-FGE Ramp[12]	Based on field observations, there is a narrower than standard shoulder width for emergency purposes along the curved eastern portion. No further comment - Profile drawing and design speed are needed for further review, if available.	Potential Sightline / Increased Driver Workload: Along the curved eastern portion of the ramp, motorists' sightlines could be blocked by the outside parapet walls in an environment creating heavy workload for drivers to adjust their vehicles' lane positioning. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering.	Potential Sightline Issue / Increased Driver Workload Issue: **For a shorter distance in comparison to that of Alternative #2A**, along the curved eastern portion of the ramp, motorists' sightlines could be blocked by the outside parapet walls in an environment with heavy workload for drivers to adjust their vehicles' lane positioning. Proposed geometry would likely not provide necessary unobstructed sight lines for collision avoidance manoeuvering. Potential for Speed Differentials: Trucks may experience significant loss of speed (especially in icy road conditions) due to presence of a 6.9% upgrade along the curved portion of the ramp.

[12] *Westbound FGE mainline section between tip of painted gore area of DVP-Don Roadway off-ramp and tip of painted gore area of LSB-FGE on-ramp*

Road Element no.	Road Element Description	Alternative #1	Alternative #2A	Alternative #3
9	Westbound LSB-FGE On-Ramp	No issues identified.	Potential Sightline Issue: Stopping sight distance appears not to be available for entering motorists from the ramp to FGE due to presence of a crest vertical curve with K-value of 6 at the top of the ramp (STA.0+310).	Potential Sightline Issue: Stopping sight distance appears not to be available for entering motorists from the ramp to FGE due to presence of a crest vertical curve with K-value of 6 at the top of the ramp (STA.0+310).
10	Westbound FGE Mainline Section between Tip of Painted Gore Area of Westbound LSB-FGE On-Ramp and Tip of Painted Gore Area of Westbound FGE-LSB Off-Ramp (i.e., Sherbourne Off-Ramp)	Potential One-Sided Weaving Issue: Relatively low volume (estimated at maximum of 389 vehicles during the AM peak hour[13]) of motorists entering FGE from the westbound DVP-FGE ramp and destined to Sherbourne Street off-ramp are to accelerate to the "assumed" speed and make two lane changes to the right through relatively high volume (estimated at maximum of 2,284 vehicles during the AM peak hour[14]) of motorists entering from LSB on-ramp and intended to continue travelling west along FGE within a 420-m long weaving area.	Potential Two-Sided Weaving Issue: Relatively low volume (estimated at maximum of 389 vehicles during the AM peak hour[15]) of motorists entering FGE from the westbound DVP-FGE ramp and destined to Sherbourne Street off-ramp are to accelerate to the "assumed" speed and make two lane changes to the right through relatively high volume (estimated at maximum of 2'587 vehicles during the AM peak hour[16]) of motorists entering from LSB on-ramp and intended to continue travelling west along FGE within a 420-m long weaving area.	Potential Two-Sided Weaving Issue: Relatively low volume (estimated at maximum of 389 vehicles during the AM peak hour[17]) of motorists entering FGE from the westbound DVP-FGE ramp and destined to Sherbourne Street off-ramp are to accelerate to the "assumed" speed and make two lane changes to the right through relatively high volume (estimated at maximum of 2'587 vehicles during the AM peak hour[18]) of motorists entering from LSB on-ramp and intended to continue travelling west along FGE within a 420-m long weaving area.

[13] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015. It was conservatively assumed that all traffic exiting FGE from Sherbourne off-ramp are originated from DVP SB.*

[14] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015.*

[15] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015. It was conservatively assumed that all traffic exiting FGE from Sherbourne off-ramp are originated from LSB.*

[16] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015.*

[17] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015. It was conservatively assumed that all traffic exiting FGE from Sherbourne off-ramp are originated from LSB.*

[18] *Estimated based on information provided by the EA Consultant team in an email on Friday, November 20, 2015.*

Table 2 – Summary of Road Safety Audit Findings

Alternative #1	Alternative #2A	Alternative #3
• Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 450-m long FGE eastbound mainline section between uphill Lower Jarvis on-ramp and LSB off-ramp (i.e., the "fork"). This is coupled with potential sightline issue for eastbound motorist on approach to the "fork" due to a combination of curved horizontal alignment, outside bridge parapets, and lane discontinuity at the "fork". • Potential sightline issue for motorists exiting from eastbound LSB off-ramp on approach to Munition Street intersection due to a combination of potential sightline obstructions by bridge piers, inside parapet walls, 5% steep downgrade, and curved horizontal alignment along the ramp. • Narrower than standard shoulder width for emergency purposes along the curved eastern portions of eastbound FGE-DVP ramp and westbound DVP-FGE ramp (i.e., N-W ramp). • Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp. • Note that the eastbound FGE-DVP ramp has not been fully reviewed yet as profile drawing was not available at the time of preparation of this memorandum. • Note that the westbound DVP-FGE ramp has not been fully reviewed yet as profile drawing was not available at the time of preparation of this memorandum. • Note that the southbound DVP-Don Roadway	• Potential sightline issue for eastbound motorist on approach to the "fork", **to lesser extent in comparison to that of Alternative #1**, due to a combination of curved horizontal alignment, outside bridge parapets, and lane discontinuity at the "fork". • Potential for violation of drivers' expectations for eastbound motorists on approach to the "fork"; considering the existing lay-out with eastbound LSB off-ramp on the right side, locating the off-ramp on the left side may violate drivers' expectations in the short run (i.e., during initial period after opening to public). In addition, the expected speed differential between the accelerating traffic destined to DVP and decelerating traffic exiting FGE onto LSE off ramp on the inner lanes could create a potential for rear-end collisions. • Potential sightline issue for eastbound motorists on approach to LSB off-ramp due to presence of a crest vertical curve (with K-value equal to 9) at top of the off-ramp (STA. 0+300). • Potential for violation of drivers' expectations on eastbound FGE-DVP ramp and vehicle instability; the ramp's straight and fairly level alignment on approach to a horizontally curved portion of the ramp (with design speed of 60 km/h and radius of 130 m) may be perceived by some drivers as a notion that they can operate safely at speed of 90 km/h or even higher. • Potential sightline / increased driver workload / vehicle instability issue on approach to eastern portion of eastbound FGE-DVP ramp due to a combination of curved horizontal alignment, inside bridge parapet walls, and presence of a	• Similar to Alternative #2A - Potential sightline issue for eastbound motorist on approach to the "fork", **to lesser extent in comparison to that of Alternative #1**, due to a combination of curved horizontal alignment, outside bridge parapets, and lane discontinuity at the "fork". • Similar to Alternative #2A - Potential for violation of drivers' expectations for eastbound motorists on approach to the "fork"; considering the existing lay-out with eastbound LSB off-ramp on the right side, locating the off-ramp on the left side may violate drivers' expectations in the short run (i.e., during initial period after opening to public). In addition, the expected speed differential between the accelerating traffic destined to DVP and decelerating traffic exiting FGE onto LSE off ramp on the inner lanes could create a potential for rear-end collisions. • Similar to Alternative #2A - Potential sightline issue for eastbound motorists on approach to LSB off-ramp due to presence of a crest vertical curve (with K-value equal to 9) at top of the off-ramp (STA. 0+300). • Similar to Alternative #2A - Potential for violation of drivers' expectations on eastbound FGE-DVP ramp and vehicle instability; the ramp's straight and fairly level alignment on approach to a horizontally curved portion of the ramp (with design speed of 60 km/h and radius of 130 m) may be perceived by some drivers as a notion that they can operate safely at speed of 90 km/h or even higher. • Potential sightline / increased driver workload / vehicle instability issue on approach to eastern portion of eastbound FGE-DVP ramp due to a combination of curved horizontal alignment, inside

Alternative #1	Alternative #2A	Alternative #3
off-ramp has not been reviewed yet as profile drawing was not available at the time of preparation of this memorandum.	crest vertical curve with K-value of 8 followed by a 6.5% downgrade along the horizontal curve at STA.1+040. • Potential sightline issue for southbound Don Roadway off-ramp due to presence of a crest vertical curve with K-value equal to 4. • Potential sightline / increased driver workload issue along the eastern portions of the westbound DVP-FGE ramp due to a combination of curved horizontal alignment and outside bridge parapets. • Potential sightline issue for westbound motorists entering from LSB on-ramp due to presence of a crest vertical curve (with K-value equal to 6) at top of the on-ramp (STA. 0+310). • Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp.	bridge parapets (**for a shorter distance in comparison to that of Alternative #2A**), and presence of a crest vertical curve with K-value of 6 followed by a 6.9% downgrade along the horizontal curve STA.1+000. • Potential for speed differentials on southbound DVP mainline section between Eastern off-ramp and Don-Roadway off-ramp due to shorter-than-standard speed-change lane at Don Roadway off-ramp exit terminal. • Vertical clearance issue for motorists exiting DVP from Don Roadway off-ramp. • Potential sightline / increased driver workload issue **for a shorter distance in comparison to that of Alternative #2A**, along the eastern portion of the westbound DVP-FGE ramp due to a combination of curved horizontal alignment, outside bridge parapets, and presence of a crest vertical curve with K-value of 13 along the horizontal curve. • Potential for speed differentials on westbound DVP-FGE ramp; trucks may experience significant loss of speed (especially in icy road conditions) due to presence of a 6.9% upgrade along the curved portion of the ramp. • Similar to Alternative #2A - Potential sightline issue for westbound motorists entering from LSB on-ramp due to presence of a crest vertical curve (with K-value equal to 6) at top of the on-ramp (STA. 0+310). • Similar to Alternative #2A - Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp.

Potential Treatments

Table 3 presents potential treatment options to address the identified road safety issues for the three "Hybrid" Alternative Design Concepts.

Note that this section is not intended to prescribe specific types of treatments to be implemented within the study area. It only provides potential "engineering" treatment options. However, the implementation of the listed potential treatments does not ensure that the subject road elements would be "safe". "Safety" is a relative term and a design can only be either more or less safe, and not "safe" or "unsafe". Including these potential treatments has a potential to improve the overall safety performance of the facility. Finally, it should be noted that the scope and focus of this memorandum is road safety. Other factors (cost, structural and geotechnical adequacy / considerations, aesthetics, and others) pertinent to planning and engineering decision-making for the evaluations of the three alternatives are out of the "road safety" scope of work.

Alternative no.	Identified Safety Issues	Potential Treatments
1	• Road Element no. 1 - Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 450-m long FGE eastbound mainline section between uphill Lower Jarvis on-ramp and LSB off-ramp (i.e., the "fork"). This is coupled with potential sightline issue for eastbound motorist on approach to the "fork" due to a combination of curved horizontal alignment, outside bridge parapets, and lane discontinuity at the "fork".	• Provision of appropriate overhead "advance" and "turn-off" guide signs for entering motorists from the Lower Jarvis on-ramp as well as those travelling on the eastbound FGE mainline section. • Lowering posted speed limits for motorists travelling eastbound on FGE mainline section on approach to the weaving section. This should be accompanied with provision of visual clues (e.g., narrower travel lanes) to motorists that road environment requires lower travel speed. • Provision of crash attenuators at the "fork". • Relocating the LSB off-ramp to left of FGE-DVP ramp (similar to Alternatives #2A and #3).
	• Road Element no. 2 - Potential sightline issue for motorists exiting from eastbound LSB off-ramp on approach to Munition Street intersection due to a combination of potential sightline obstructions by bridge piers, inside parapet walls, 5% steep downgrade, and curved horizontal alignment along the ramp.	• Installation of end-of-queue detection systems along the off-ramp to warn the exiting motorists from FGE on the straight section of the off-ramp about potential queues downstream. • Provision of illumination. • Provision of a wider shoulder on the left side of the off-ramp. • Provision of transverse rumble strips along the straight section of the off-ramp. • Removal / relocation of two to three bridge piers located along the north side of the off-ramp approximately between STA.0+300 and STA.0+400.

Alternative no.	Identified Safety Issues	Potential Treatments
1	• Road Element no. 3 – Narrower-than-standard shoulder width for emergency purposes along the curved eastern portions of eastbound FGE-DVP ramp and westbound DVP-FGE ramp (i.e., N-W ramp).	• Provision of wider structure for eastbound FGE-DVP ramp. Note that even in the existing design the shoulder widths along this curved section is narrower than standard.
	• Road Element no. 8 - Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp.	• Relocating the proposed LSB on-ramp to the east such that the on-ramp starts being elevated from the first intersection along the realigned LSB to the west of the LSB / Don Roadway intersection.
2	• Road Element no. 1 - Potential sightline issue for eastbound motorist on approach to the "fork" due to a combination of curved horizontal alignment, outside bridge parapets, and lane discontinuity at the "fork".	• Provision of appropriate overhead "advance" (e.g., diagrammatic) and "turn-off" guide signs for entering motorists from the Lower Jarvis on-ramp as well as those travelling on the eastbound FGE mainline section. • Lowering posted speed limits for motorists travelling eastbound on FGE mainline section on approach to the weaving section. This should be accompanied with provision of visual clues to motorists that road environment requires lower travel speed. • Provision of crash attenuators at the "fork". • Relocating the "fork" and the associated bull nose to the west such that the bull nose can be seen from longer distances (than decision sight distance) on eastbound mainline section ahead of the "fork". Moreover, this way the crest vertical curve on top of the off-ramp can be slightly flattened. In addition, with relocation of the bull nose to the west, the off-ramp could have a straight and flat alignment for some distance downstream of the bull nose before its downhill slope starts; there would be a
	• Road Element no. 1 - Potential for violation of drivers' expectations on approach to the "fork"; considering the existing lay-out with eastbound LSB off-ramp on the right side, locating the off-ramp on the left side may violate drivers' expectations in the short run (i.e., during initial period after opening to public). In addition, the expected speed differential between the accelerating traffic destined to DVP and decelerating traffic exiting FGE onto LSE off ramp on the inner lanes could create a potential for rear-end collisions.	
	• Road Element no. 2 - Potential sightline issue for eastbound motorists on approach to LSB off-ramp due to presence of a crest vertical curve (with K-value equal to 9) at top of the off-ramp (STA.0+300).	

Alternative no.	Identified Safety Issues	Potential Treatments
2	• Road Element no. 3 - Potential violation of drivers' expectations on eastbound FGE-DVP ramp; the ramp's straight and fairly level alignment on approach to a horizontally curved portion of the ramp (with design speed of 60 km/h and radius of 130 m) may be perceived by some drivers as a notion that they can operate safely at speed of 90 km/h or even higher.	lower number of motorists (as compared to how it is proposed in Alternative #2A with the downhill slope starts immediately downstream of the bull-nose location) given an impression that the eastbound FGE-DVP ramp is a mainline freeway with a left-side exit ramp. • Provision of transverse rumble strips along the straight section of the eastbound FGE-DVP ramp on approach to the horizontally curved portion on the east end.
	• Road Element no. 3 - Potential sightline / increased driver workload issue on approach to eastern portion of eastbound FGE-DVP ramp due to a combination of curved horizontal alignment, inside bridge parapets, and presence of a crest vertical curve with K-value of 8 along the horizontal curve at STA.1+040.	• In addition to the above, provision of a flatter crest vertical curve (if possible, considering all other constraints) • Installation of end-of-queue detection systems along the curved portion of the ramp to warn the eastbound motorists about potential queues downstream. • Lowering posted speed limit even further through provision of "reduced speed zone" for motorists travelling eastbound on approach to the curved section.
	• Road Element no. 7 - Potential sightline issue for southbound Don Roadway off-ramp due to presence of a crest vertical curve with K-value equal to 4.	• Provision of a flatter crest vertical curve (if possible, considering all other constraints). • Installation of end-of-queue detection systems along the off-ramp to warn the exiting motorists from DVP on the speed change lane of the off-ramp about potential queues downstream.
	• Road Element no. 8 - Potential sightline issue along the eastern portions of the westbound DVP-FGE ramp due to a combination of curved horizontal alignment and outside bridge parapets.	• Installation of end-of-queue detection systems along the curved portion of the ramp to warn the entering motorists from DVP about potential queues downstream.
	• Road Element no. 9 - Potential sightline issue for westbound motorists entering from LSB on-ramp due to presence of a crest vertical curve (with K-value equal to 6) at top of the on-ramp (STA.0+310).	• Relocating the on-ramp and the associated bull nose at the entrance terminal to the west such that the crest vertical curve can be flattened.

Alternative no.	Identified Safety Issues	Potential Treatments
2	• Road Element no. 10 - Potential weaving / speed differential issue due to relatively high volume of weaving traffic within 420-m long FGE westbound mainline section between uphill LSB on-ramp and Sherbourne off-ramp.	Note that development of potential treatments for this issue requires traffic volumes information within this weaving section (i.e., traffic volumes from DVP to FGE, from LSB on-ramp to FGE, from DVP to Sherbourne Street off-ramp, and from LSB to Sherbourne Street off-ramp) which were not available at the time of preparation of this memorandum.
3	Note that with the exception of the three below issues, all the issues identified for Alternative #3 is the same as those for Alternative #2A. In addition, the noted potential sightline issue for southbound Don Roadway off-ramp due to presence of a crest vertical curve with Alternative #2A would not be a concern with Alternative #3.	Note that the potential treatments are similar to those noted above for Alternative #2A.
	• Road Element no. 6 - Potential for speed differentials on southbound DVP mainline section between Eastern off-ramp and Don-Roadway off-ramp due to shorter-than-standard speed-change lane at Don Roadway off-ramp exit terminal.	• Provision of a longer speed change lane (if possible, considering all other constraints).
	• Road Element no. 7 - Vertical clearance issue for motorists exiting DVP from Don Roadway off-ramp.	• Revisiting the proposed alignment of Don Roadway off-ramp.
	• Road Element no. 8 - Potential for speed differentials on westbound DVP-FGE ramp; trucks may experience significant loss of speed (especially in icy road conditions) due to presence of a 6.9% upgrade along the curved portion of the ramp.	• Revisiting the proposed alignment of westbound DVP-FGE ramp.