MEMO

TO : Mayor Fred Eisenberger and Hamilton City Council

FROM : Brian Malone, CIMA+

DATE : February 4, 2019

SUBJECT : Red Hill Valley Parkway - Pavement Friction Testing Results Review (CIMA+ File: B000920 / 200)

1. INTRODUCTION

The purpose of this memorandum is to detail our review of a report on the performance of roadway pavement done for the RHVP that was completed by Golder Associates in January 2014[1]. That report included friction testing of the pavement surfaces of the Lincoln Alexander Parkway (LINC) and the RHVP which were completed for Golder by their subcontractor, Tradewind Scientific Ltd.

CIMA has previously completed reports delivered to the City of Hamilton for the Red Hill Valley Parkway, including a report dated November 2015 entitled Red Hill Valley Parkway Detailed Safety Analysis[2], a memo that CIMA completed in 2019 for Lincoln Alexander Parkway / Red Hill Valley Parkway which updated the collision data and provided summaries of collision rates on the roads[3], and a review of speed limits on the LINC and RHVP completed in 2018. The 2014 Golder report was not part of materials available to CIMA when completing the above-mentioned reports.

CIMA was asked to respond to three questions following our review of the Golder report.

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[1] Red Hill Valley Parkway Performance Review After Six Years in Service, Golder Associates, Report Number 13-1184-0026, January 2014.
[2] Red Hill Valley Parkway Detailed Safety Analysis (Final), CIMA Canada Inc., Project Number B000558, November 2015
[3] Lincoln Alexander Parkway / Red Hill Valley Parkway Collision Rates, CIMA Canada Inc., Project Number B000558B, January 2019
(CIMA+ File: B000558B)

2. RESPONSE TO QUESTIONS

You requested that I respond to three questions, in the context of receiving and reviewing the Golder report and contemplating it's finding as they may relate to the findings and conclusions in the 2015 CIMA report.

The three questions and our responses are below and the summary of our review of the Golder report follows.

Question 1)

In light of the information in the 2014 Golder report, are any changes needed to the recommendations in the previous CIMA reports to the City regarding safety on the RHVP?

Answer 1)

CIMA had made a number of recommendations regarding safety on the RHVP. Having reviewed the 2015 Golder report, including the details of measurements of road pavement friction, we have not identified any information that would substantively change our recommendations.

CIMA had identified that there was a high proportion of collisions on the RHVP occurring in wet road conditions. We indicated that the issue may be related to the pavement surface skid resistance (surface friction) and high vehicle operating speeds. Our recommendations included multiple actions directed to these two elements. Remedial actions recommended included; increased speed enforcement, installation of larger speed signs, undertaking of pavement friction testing, and installation of 'slippery when wet' signs.

Had the Golder report been provided to CIMA and reviewed prior to completing our report, we would appropriately have adjusted the friction testing recommendation to one that urged further investigation of the friction findings in the Golder report, relating to road design and operations. It is apparent that this action was, in fact, undertaken as CIMA has been informed that additional evaluations of the pavement were undertaken by Golder for the City in 2017.

Question 2)

In light of the information in the 2014 Golder report, are any additional safety measures recommended to the City, recognizing that the RHVP is scheduled to be resurfaced in the late Spring of 2019;

Answer 2)

It is our understanding that the City has initiated action to undertake replacement of the pavement surface on the RHVP. With an expectation that the new surface will continue to have friction levels that meet or exceed the friction parameters used in the geometric design of the road and that the new surface will have friction levels consistent with the LINC, the recommendations in our earlier reports regarding surface friction will have been addressed.

The CIMA 2015 report included ten options that were recommended for consideration to improve safety on the RHVP. A number of those recommendations have been implemented and others are in progress or being further evaluated. Recognizing that repaving of the road is expected to occur in the late spring of 2019, we do not have any additional recommendations to add at this time.

One recommendation that may warrant a slight modification in the interim relates to speed enforcement. We had recommended 'regular' speed enforcement. Modified wording, to one of 'increased' or 'enhanced' speed enforcement in an effort to ensure closer compliance with the posted speed, could be used.

Question 3) *In light of the information in the 2014 Golder report, should the RHVP be closed to vehicular traffic in whole or in part, until the completion of the resurfacing work.*

Answer 3)

We do not recommend that the road should be closed until the completion of the resurfacing work.

An assessment of the road indicates that it operates within the design domain for which it was originally intended. The road surface friction is above the design parameters that support a design speed of 100 km/h and a posted speed of 90 km/h, albeit lower than the LINC and in a range that calls for further 'investigation'. Resurfacing that increases road surface friction will improve safety.

Any consideration of closure of the RHVP must also contemplate the possible safety drawbacks that would be associated with such action. Diverted traffic would use alternate routes, including the LINC, Centennial Parkway and other mountain access routes. Traffic increases on alternate routes would decrease safety, in some cases significantly. The RHVP is a controlled access facility with no pedestrian interaction and limited vehicle conflict points. Traffic diverted to alternate routes would be expected to increase congestion and result in more traffic interacting with crossing vehicle and pedestrians, likely resulting in less safe operations.

3. REVIEW OF GOLDER REPORT 13-1184-0026

Our response to the above questions is based on our review of the 2014 Golder report, including the Tradewinds Scientific section relating friction testing. The Golder report, in Section 5.0, states;

> "*Although the Friction Number (FN) values are higher than when measured in 2007 immediately after construction (between 30 and 34), they are considered to be relatively low. Typically, the FN values should be at least equal to or higher than 40 to be considered adequate.*"

This wording is referencing the results of road friction testing done by Tradewind Scientific. The Tradewind document refers to friction testing results using a device called a GripTester. Values are reported as Grip Numbers (GN), a measurement of friction. The Golder report has expressed the Tradewind GN numbers as Friction Numbers (FN).

For clarity, friction numbers can be referred to by two different formats. In road design the common format for friction is (f) with a range from 0.0 to 1.0. Zero indicates no friction and 1.0 indicates maximum friction. Alternately, friction is also referred to in the pavement industry as a Friction Number (FN) with a reference scale of 0 to 100. The two formats are interchangeable, with the appropriate adjustment. For example, an FN of 30 is equivalent to an (f) of 0.30.

The Tradewinds report references a table that shows Investigatory Skidding Resistance Levels (Risk Rating). It concludes that measured GN values, which average between 30 and 40 on the RHVP, are below a United Kingdom Investigatory Skidding Resistance Levels (Risk Rating) reference threshold for friction, stating;

> "*…friction averages as measured by the GripTester on the designated lanes and sections of the Red Hill Valley Parkway were below or well below the same UK Investigatory Level 2.*"

The Tradewind report included a reference table showing investigatory 'threshold' levels. However, the table they used is different from the reference table typically applied. The reference more broadly used for determination of investigatory levels is the table from the United Kingdom Pavement Management (UKPMS) publication for interpretation of Grip Tester data[4], shown in Figure 1. We note that it is this table which is also referenced in the United States in the Guide to Pavement Friction[5]. We have assessed reported friction values using the UKPMS table.

Tradewinds reported that the friction testing results were 'below or well below' the investigatory levels. When assessed against the UKPMS table we found that the results were closer to the threshold levels than indicated by Tradewind.

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[4] United Kingdom Pavement Management System, Volume 3, Chapter 11, Machine Data Collection for UKPMS – GripTester, Table 1, August 2005.

[5] Guide to Pavement Friction, NCHRP, 2009, page 79.

Figure 1 – UKPMA: Table 1- Site Categories and Investigatory Levels

Site Category and Definition			Investigatory Level at 50 km/h							
		SFC	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65
		GN	0.35	0.41	0.47	0.53	0.59	0.65	0.71	0.76
A	Motorway									
B	Dual carriageway – non event									
C	Single carriageway – non event									
Q	Approaches to and across minor and major junctions, approaches to roundabouts									
K	Approaches to pedestrian crossings and other high risk situations									
R	Roundabout									
G1	Gradient 5 – 10 % longer than 50m									
G2	Gradient > 10% longer than 50m									
S1	Bend radius < 500m – dual carriageway									
S2	Bend radius < 500m single carriageway									

Sources:

- *HD 28/04 (DMRB. Volume 7. Section 3. Part 1. Table 4.1)*
- *"Report on Correlation of SCRIM with Mark 2 GripTester Trial at TRL" Jacobs Babtie. Glasgow (2004).*

Notes:

Reference should be made to Chapter 4 of HD 28/04 and, in particular, the notes to Table 4.1 (of HD 28/04) for guidance on interpretation.

Key:

(dark grey)	*Investigatory Levels that will generally be used for trunk roads carrying significant traffic levels.*
(light grey)	*Investigatory Levels that will be appropriate in low risk situations, such as low traffic levels or where the risks present are well mitigated and a low incidence of accidents has been observed.*

The table in Figure 1 assists in determining when results from friction tests indicate the need for further investigation. It is important to know that, while research does confirm a correlation between lower pavement friction levels and collisions, this correlation is not automatically confirmation of collision causation. Interpretation of the GripTester pavement friction data as they relate to safety requires greater consideration.

Road sections that have lower friction measurements indicate a need to undertake review of the location because of the *potential* that collision risk may be elevated. But friction measurements that are at investigatory levels are in no way a definitive indication that a location is 'unsafe'.

The research for the development of the investigatory level thresholds states that for some sites, where FN values are below 35, collision risk *may* increase, but it also notes that for many sites with the same readings, collision risk will not exist. Thus, further investigation of conditions is needed.[6]

Our conclusion of the review of the Golder report is that the friction values measured are in the range that the UKPMS would identify as 'investigatory' and would need additional review of the roadway as a whole. The Golder / Tradewinds report made a similar overall conclusion from the data, albeit using a different reference table.

4. FRICTION VALUES FOR RED HILL VALLEY PARKWAY

This section provides an interpretation of the Golder findings as they relate to the geometric design and the operation of the RHVP as well as road safety.

4.1. Friction Levels in Design

Friction plays an important role in road design and operation. In Canada friction levels (f) are considered in two ways. One is the determination of the distance required for a vehicle to stop on a road and the other is the determination of the speed at which a vehicle can travel through a horizontal curve.

For a vehicle to stop, road friction must exist between vehicle tires and the road surface. The values assumed for the coefficient of friction (f) when designing a road ranges depending on the design speed of the road. Values are defined in the Transportation Association of Canada Geometric Design Guide for Canadian Roads (TAC-GDGCR).

The RHVP has a design speed of 100km/h and the (f) values used for road design would be f = 0.29, as shown in Table 1.2.5.2 from TAC-GDGCR.

TAC ATC Geometric Design Guide for Canadian Roads

Table 1.2.5.2 Coefficient of Friction for Wet Pavements[4]

Design Speed (km/h)	Operating Speed * (km/h)	Coefficient of Friction (f)
30	30	0.40
40	40	0.38
50	47-50	0.35
60	55-60	0.33
70	63-70	0.31
80	70-80	0.30
90	77-90	0.30
100	85-100	0.29
110	91-110	0.28
120	98-120	0.28
130	105-130	0.28

Note: * The range of operating speeds recognises that some drivers slow down in wet conditions: others do not.

[6] Accidents and the Skidding Resistance Standards for Strategic Roads in England, TRL Report TRL622, H. Viner, A Parry, 2005, Page 6.

For a vehicle to travel around a horizontal curve, friction must be sufficient such that centripetal force does not force a vehicle off a road. The TAC-GDGCR assigns an additional (f) value for the design of horizontal curves. The (f) used in curve design are considerably lower than for stopping requirements, providing a significant degree of safety. The friction values for horizontal curves are based on a threshold of comfort felt by the driver as they move through the curve, not the physics limits of the curve itself.

TAC table 2.1.2.1 indicates that the (f) value used in horizontal curve design, f = 0.12, for design speeds of 100km/h. The value considers a reasonable level of safety under a range of driving conditions, including drivers exceeding the posted speed limit and driving on wet roads. Road design must meet both (f) criteria through a horizontal curve.

Table 2.1.2.1 Maximum Lateral Friction for Rural and High Speed Urban Design[1]

Design Speed (km/h)	Maximum Lateral Friction for Rural and High Speed Urban Design
40	0.17
50	0.16
60	0.15
70	0.15
80	0.14
90	0.13
100	0.12
110	0.10
120	0.09
130	0.08

4.2. Friction Levels in Operation

Once a road is in operation the pavement friction values can be measured in the field. If measured values exceed the design values, the road will have conditions that allow operation in conjunction with the design speed.

The average friction levels measured on the RHVP, as reported by Golder, were indicated to range from FN values of 34 to 39, corresponding to (f) values of 0.34 to 0.39. These numbers are above the design parameters that were used in the road design for stopping distance, f=0.29, and horizontal curve design, f=0.12.

The Golder report indicated that some FN numbers are below the Investigatory Levels identified in the guidance, a finding we confirm. This indicates that further investigation of some sections of the road sections should be undertaken.

4.3. Discussion

Measurements of friction can be used in a number of ways.

Levels can be compared to the assumed design levels to ensure that the fundamental design parameters have been provided. The findings from the Golder report confirm that is the case on the RHVP.

Monitoring friction values during the operating life of a roadway can also be used to assess deterioration of the roadway infrastructure and assist in the overall determination of when then the infrastructure may approach the end of its lifecycle or require rehabilitation.

Friction measurements may also be useful in the comparison of the service being provided on different roads. The Golder / Tradewinds study completed comprehensive assessment of friction levels on both the LINC and the RHVP. The results show a significant difference in friction values between the two facilities.

While RHVP friction values are within the design domain expected for the road, they are significantly below those measured for the LINC. This difference can present a concern from a safety perspective. Road design principles allow for a wide range of operations by motorists. When pavement conditions are such that frictions values are significantly higher that those used in design, drivers are able to comfortably travel the road at higher speeds.

The difference in friction values for the LINC and the RHVP means that there is a different margin of safety available to drivers between the two roads. That variance between the facilities is something that drivers may not be readily aware of and can result in varying safety outcomes.

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FEB 04 2019
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