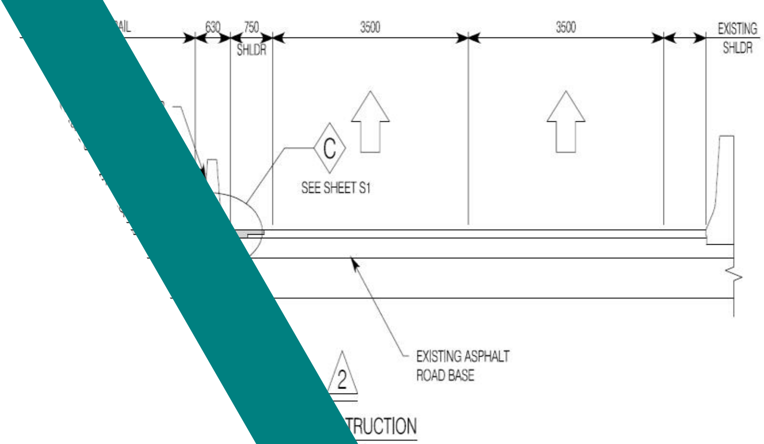
Road Safety Audit
(Detail Design Stage)
Final Report

Keddy Access Trail
Hamilton, Ontario, Canada



Prepared for:

Daryl Bender and Steve Molloy
City of Hamilton

[03.03.20] : Intus Road Safety Engineering Incorporated

Keddy Access Trail
Hamilton, Ontario, Canada

Road Safety Audit (Detail Design Stage)
Final Report

March 3, 2020

Prepared and Submitted by:

Gerald Forbes, M.Eng., P.Eng., PTOE
President & Chief Engineer

Intus Road Safety Engineering Incorporated
2606 Bluffs Way
Burlington, ON L7M 0T8
Phone: 905.332.9470
email: gerry@intus.ca

LICENSED PROFESSIONAL ENGINEER
MAR 3/20
G. J. FORBES
PROVINCE OF ONTARIO

1.0 INTRODUCTION

1.1 Project Scope

1.1.1 This report details the results of the 90% Design Stage Road Safety Audit for the Keddy Access Trail in the City of Hamilton, Ontario using drawings issued on December 20, 2019.

1.1.2 The audit was completed for the City of Hamilton by ***Intus Road Safety Engineering Incorporated***. No previous road safety audits have been completed for this project.

1.1.3 The project scope includes the detailed design and construction of a bicycle path and multi-use trail (MUT) along the north side of the Claremont Access from the intersection of West 5th Street and Brantdale Avenue to the intersection of Wellington Street and Hunter Street East, including trail connections and reconfiguration of the lanes for motor vehicle traffic. The scope of the audit does not include temporary work and detours required during the construction of the trail.

1.2 Road Safety Audit Objectives

1.2.1 A road safety audit is a process for systematically checking the safety of road transportation projects, based on sound road safety engineering principles and undertaken from the road users' perspectives. A road safety audit provides an independent assessment of the anticipated safety performance of a road transportation project at predetermined intervals by road safety specialists. It is duly noted that the project design team remains ultimately responsible for the design. A road safety audit is defined as:

> *a formal and independent safety performance review of a road transportation project by a qualified safety specialist, addressing the safety of all road users.*

1.2.2 The objectives of the road safety audit are to identify design elements which may have a negative impact on the safety performance of the facility and to suggest corrective measures for consideration by the design team at this stage. The corrective measures suggested in a road safety audit report are not prescriptive and should be regarded as indicative of the nature of a solution, which may or may not be adopted by the design team "as is". The responsibility for the final design and hence for the selection of specific solutions to identified safety issues, rests with the designer, and not with the road safety auditor.

1.3 Auditor

1.3.1 This Road Safety Audit was undertaken by *Gerry Forbes, M.Eng., P.Eng., PTOE,* who is President & Chief Engineer of Intus Road Safety Engineering Incorporated.

1.3.2 The road safety auditor was not involved with the design or the development of the project. The scope of a road safety audit does not cover structural safety.

1.4 Audit Process

1.4.1 The safety audit was carried out in general conformance with the procedures set out in the Transportation Association of Canada's (TAC) Canadian Road Safety Audits Guide, December 2001. Material that was reviewed for the audit is listed in Appendix A.

1.4.2 The designers are under no obligation to accept all the audit findings and/or its suggestions. Also, it is not the role of the auditor to agree to or approve of the designer's responses to the audit. Rather, the audit provides the opportunity to highlight potential safety issues and have them formally considered by the designer, in conjunction with all other project considerations.

1.4.3 The designers and/or owners are encouraged to prepare response reports that complete the road safety audit process. Identified safety issues should be accepted, conditionally accepted, or rejected (with detailed explanations). The mitigation measures suggested are based on the auditor's experience and are not intended to cover the full range of countermeasures.

2.0 ROAD SAFETY AUDIT FINDINGS

2.1 The project initiation meeting was held between the auditor and the owner on February 10, 2020. At that time the owner highlighted the following road safety concerns for this phase of the project.

- The type of barrier to be used to physically separate the MUT and the vehicular lanes of the Claremont Access (i.e., steel beam guard rail versus a concrete barrier);
- The need for a directional dividing line (i.e., a centreline) on the MUT; and
- The operating speed of downbound cyclists on the MUT.

Each of the above-captioned issues are addressed below, along with other identified safety issues to be considered by the designers/owners.

2.2 Type of Barrier

2.2.1 The prevailing design manuals and guidance offered to designers with respect to selecting barrier type do not overtly consider the safety of road users other than motorists. In other words, when a barrier is being used to physically separate motorized traffic from a MUT, the design advice only considers motorist safety. As a result, the type of barrier recommended for the project is based on the following risk assessment.

2.2.2 The following risks are present and must be considered to inform decisions concerning barrier type:

- ***Motorist impact with the barrier:*** The severity of the crash when impacted by a motorist on the Claremont Access;
- ***Cyclist impact with the barrier:*** The severity of the crash when impacted by a cyclist on the MUT;
- ***Secondary crashes:*** The likelihood of a MUT user being involved in a secondary crash, when the barrier is struck by an errant motorist;
- ***Ancillary risks:*** Drainage and winter maintenance of the trail surface.

2.2.3 Both the likelihood of the barrier being struck by a motorist or being struck by a cyclist is the same regardless of the barrier type selected[1]. As such, these aspects of safety, in and of themselves, are not relevant to a safety-based assessment of barrier type.

2.2.4 With respect to the severity of a crash when impacted by a motorist, the Roadside Design Manual (MTO, 2017) provides s*everity indices* for various roadside hardware and states that steel beam guard rail (SBGR) and concrete barrier systems have severity indices of 3.1 and 3.2, respectively. This means the probabilities of the different crash severities are as follows:

Barrier System	**Probability of Crash Severity (%)**		
	Property Damage Only	**Injury**	**Fatal**
SBGR	41.7	57.1	1.2
Concrete	40.4	58.2	1.4

[1] Assuming the steel beam guard rail and a concrete barrier are in the same general location within the road allowance.

2.2.5 The concrete barrier is expected to result in a slightly higher crash severity than the SBGR. However, the difference between the crash severities of the two barrier systems is nominal. In this respect, there is no preference between the two barrier systems.

2.2.6 When considering the severity of a crash when the barrier is impacted by a cyclist, the research is sparse and offers no definitive guidance. When a cyclist strikes a barrier there are two main scenarios: colliding with the barrier while upright; and sliding into the barrier (either with or separated from the bicycle). Crashes while upright can result in a cyclist being thrown off the bicycle due to snagging or entanglement with the barrier, making the horizontal members of the barrier the important factor in crash severity. In the sliding scenario, the barrier posts and the vertical members are the principle hazard.

2.2.7 The subject barrier will separate the Keddy Access Trail from the motorized vehicle lanes of the Claremont Access and offers a situation that will generally restrain impact angles (even within the horizontal curves). In the instance of a shallow impact angle crash, research for motorcycle crashes with roadside barriers reveals that concrete barriers are favoured over SBGR. The concrete barrier offers a smooth and continuous profile that better dissipates the kinetic energy of the crash during a sliding type crash. Moreover, there is less chance of snagging and entanglements. The SBGR posts are particularly hazardous as they can concentrate impact forces during a direct impact.

2.2.8 In fact, Daniello and Gabler (2011) in research concerning the impacts of barrier type on motorcyclist safety concluded that concrete barriers were less hazardous than SBGR. While this research pertains to motorcyclist, as opposed to bicyclists, the crash mechanisms and results are reasonably transferable. Therefore, the concrete barrier is the preferred option with respect to cyclist crash severity.

2.2.9 The likelihood of a trail user being involved in a secondary crash when the barrier is struck by an errant motorist is determined by the probability of a motorist striking the barrier, the probability of a trail user being at the same location at the same time as the barrier strike, and the deformation/deflection of the barrier towards to MUT. The probability of a barrier strike and the probability of a MUT being present are not dependent on the type of barrier. Hence, the choice of a barrier type is dependent on the deflection of the barrier once it is struck. In this regard, the Roadside Design Manual (MTO, 2017) recommends that there be no obstacles within 1.6 metres and 0.8 metres of the face of the barrier for SBGR and concrete barriers, respectively. The recommended setbacks are reflective of the different deflection characteristics of the two barrier systems. The concrete barrier offers lower deflections during impact and minimizes the chances of a secondary crash with a MUT user. Therefore, in this aspect of the risk analysis, a concrete barrier is the preferred barrier system.

2.2.10 The ancillary risks presented by the different drainage characteristics of the SBGR and the concrete barrier are mixed. The design drawings clearly show catchbasins installed at the base of a concrete barrier separating the MUT from the Claremont Access. If the concrete barrier is replaced by a SBGR with no other changes to drainage/grading, then there is no safety advantage with either option. However, if the SBGR is implemented without catchbasins at the interface between the Claremont Access and the MUT (because the comparatively unobstructed road surface of the SBGR would allow surface water from the Claremont Access to drain across the MUT to catchbasins on the north side of the MUT) then there are two impacts on safety:

- The SBGR would be considered advantageous during winter maintenance, where the brine created by the applied salt and motor vehicle traffic on the Claremont Access would assist with melting snow on the MUT; and

- The concrete barrier would be considered advantageous during wet weather when temperatures are above freezing, because the SBGR would allow the surface runoff from the Claremont Access to flow across the MUT, creating a marginally thicker layer of water.

It is not practical to quantify the risks of both safety impacts without knowing the volume of trail users, the relatively frequency of wet and snowy weather, and other sundry factors.

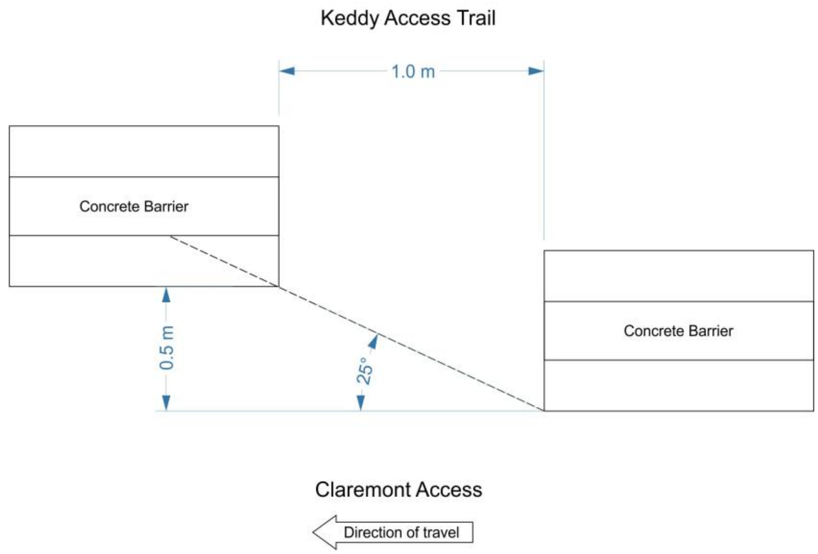
At any rate, it is my understanding that the design team has decided that regardless of the type of barrier to be used, catchbasins are to be implemented at the interface of the Claremont Access and the MUT.[2] If this is the case, then there is no preference among SBGR or concrete barrier.

2.2.11 The above risk analysis indicates that a concrete barrier is the preferred separator. The primary purpose of the barrier is to protect MUT users from errant vehicles, and this objective is best achieved with a concrete barrier.

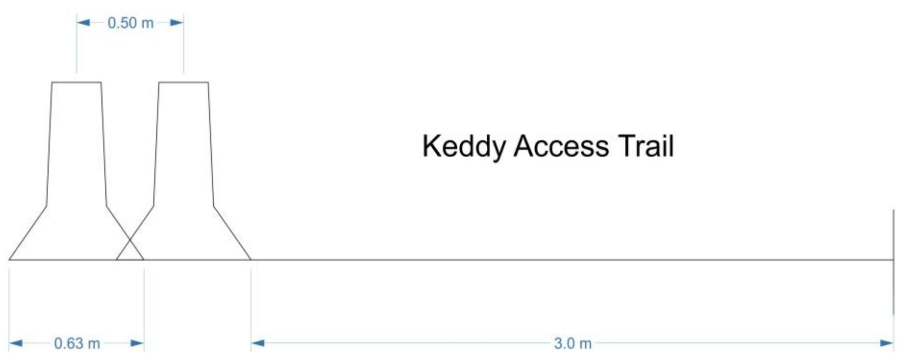
2.2.12 Having stated the above, it is noted that the pedestrian crossing located at or near Southam Park requires a short break/opening in the barrier system. Furthermore, it is planned to have other short breaks/openings in the barrier system to accommodate MUT access by emergency services. The breaks/openings will be approximately 1.0 metres wide.

2.2.13 The unprotected, blunt end of a concrete barrier is a significant safety hazard to errant road/trail users. If the ends of the barrier cannot be protected by an industry-approved end treatment it is recommended that barriers be offset as shown in Figure 1. Most vehicles will depart the roadway at an angle of 25 degrees or less. Offsetting the downstream barrier effectively shields the exposed end of the downstream barrier with the upstream barrier.

[2] Under a SBGR configuration a continuous concrete curb would be required to direct surface runoff to the catchbasins.



PLAN VIEW



CROSS SECTION

FIGURE 1: Emergency and Pedestrian Openings

2.2.14 While the offset addresses safety concerns for motorists on the Claremont Access and downbound MUT users, the offset does not address the exposed end hazard for upbound MUT users. However, given the grade of the Keddy Access Trail, operating speeds of upbound MUT users is not expected to be very high. As a result, the risk presented by the exposed end of the barrier is low. No action is required, however, a hazard marker or similar delineation may be placed in the exposed end to warn upbound MUT users of the existence of the hazard.

2.2.15 The barrier offset makes the opening slightly more obvious to upbound MUT users – leading to potential confusion about whether the opening is an allowable route. This is expected to be a minor concern, since the opening is relatively small and the offset still results in the base of the concrete barriers visually overlapping (see the Cross Section in Figure 1). If desired, measures may be taken to minimize the probability of upbound MUT users passing through the opening to the Claremont Access. For example, a directional dividing line and/or edge lines may be marked on the trail from 20 metres in advance of, and through the opening. Also, signing may be used to direct upbound trail users to keep to the right at these locations. Alternatively, if it is acceptable to the emergency services, a movable or breakable horizontal beam or member could be erected across the opening. The beam is intended to be a visual obstruction that discourages MUT users from entering the opening, but not a substantive structural measure that would inhibit emergency services from using the opening.

2.2.16 Based on the material made available for this audit, there is an emergency services opening at or near the St. Joseph’s Drive connection. Openings in the barrier to accommodate emergency services should not align with any of the side trails that intersect the Keddy Access Trail. The openings may be confused as pedestrian/cyclist crossings of the Claremont Access and inadvertently cause pedestrians/cyclists to enter the motor vehicle lanes of the Claremont Access. The emergency services opening should be offset a suitable distance from the St. Joseph’s Drive connecting trail.

2.3 Directional Dividing Line

2.3.1 The prevailing guideline concerning pavement markings on MUTs is *OTM Book 18 – Bicycle Facilities*. With respect to in-boulevard shared-use facilities, Book 18 states:

> *… segregation of cyclists and pedestrians should be avoided where possible. Instead, a directional dividing line may be marked on the pathway, thus allowing it to operate as a “miniature roadway”. This relies on users obeying the basic premise that slower moving pedestrians and cyclists should keep right, and faster moving path users should pass on the left.*

2.3.2 With respect to two-way, raised cycling tracks, the OTM states:

> *… a 100 millimetre yellow directional dividing line should be placed in the centre of the two-way raised cycle track to separate bidirectional travel. This directional dividing line should be solid along segments with reduced sightlines and visibility in order to discourage passing manoeuvres. A*

> *broken (dashed) directional dividing line should be provided along segments where passing is permitted.*

2.3.3 The OTM indicates that a DDL is *permitted* on an in-boulevard MUT, but a DDL is recommended for a two-way cycle track. This is more confusing than helpful as the two types of facilities are generally very similar.

2.3.4 The primary purpose of a DDL is to provide clear delineation of the trail into directions of travel. If there is no confusion among trail users concerning the side of the path on which they should be travelling, then a DDL is not required. Moreover, if good forward visibility is afforded to trail users, then there is no reason why reasonably prudent trail users should not be able to see any potentially conflicting users and avoid any conflicts. The Keddy Trail offers excellent forward visibility and as such, a DDL is not required.

2.3.5 In fact, a DDL, in most cases, is contraindicated on a MUT. The research concerning cyclist speed on MUTs indicates cyclists are more likely to travel above the average speed on paths with a DDL.[3] A DDL for the Keddy Trail is not recommended except in instances where the forward visibility is less than the stopping sight distance for the design speed.

2.4 Speed

2.4.1 The speed of downbound cyclists on the Keddy Access Trail has been identified as a potential safety issue by the owners.

2.4.2 The Geometric Design Guide for Canadian Roads (TAC, 2017) states:

- On a grade of 4.0%, downhill coasting speeds can reach 25 km/h;
- On grades of 4.0% to 6.0%, downhill coasting speeds can reach 40 km/h; and
- On grades between 6.0% and 8.0% downhill coasting speeds can reach 60 km/h.

2.4.3 The design speed of the horizontal alignment of the MUT, particularly near the bottom of the Claremont Access, appears to be suitable for 60 km/h operating speeds. It would be preferable to provide a wider path at this location to better accommodate the trajectory variations of fast-moving cyclists. However, the lower end of the trail is constructed on an existing structure, and there is no practical opportunity to widen the trail for this purpose.

[3] NSW Government, "Shared paths: Discussion of research findings and key safety issues", Centre for Road Safety, Australia, August 2015.

2.4.4 Nonetheless, faster-moving cyclists on a MUT can be a hazard to pedestrians (an themselves). When steep grades and higher cyclist speeds cannot be avoided (such as on the Keddy Access Trail), higher cyclist speeds should be mitigated through the use of regularly-spaced speed reducing measures. The following measures are available for use and should be considered by the designer/owner.

Device	Comment	Example
Speed hump and vertical deflections	These can destabilize riders and be a hazard if poorly sited or inadequately marked. Vertical deflections may also present a trip hazard for pedestrians. Use humps with care. These devices must be marked and provided with advance warning signs.	Port Mann Bridge, British Columbia (see Figure 2)
Chicanes and horizontal deflection	Very effective at reducing speeds. Must be sited properly, easily detectable, and provided with advance warning	Jacques Cartier Champlain Bridge, Quebec (see Figure 3)
Pavement Markings	These low-cost options place important messages directly within the cyclists line of sight. Large areas of paint may become slippery during wet surface conditions.	Brisbane, Australia (see Figure 4)
Tactile coloured surfaces and alternative paving materials	Minimal to no hazard to trail users, but the effectiveness of these measures is largely unknown. Also, the colour and texture of the pavement provides no specific guidance to road users concerning speed.	None available.

2.4.5 Since bicycles are not required to have a speed-measuring device (and most do not have one), speed limits are not a practical measure for the Keddy Access Trail (even if the speed limit could be effectively enforced).

2.4.6 In all cases, any physical speed-reducing device must provide a clear unambiguous direction to the user, and the device must not become an unexpected hazard for the trail user.

FIGURE 2: BUMP Warning Sign on the Port Mann Bridge[4]

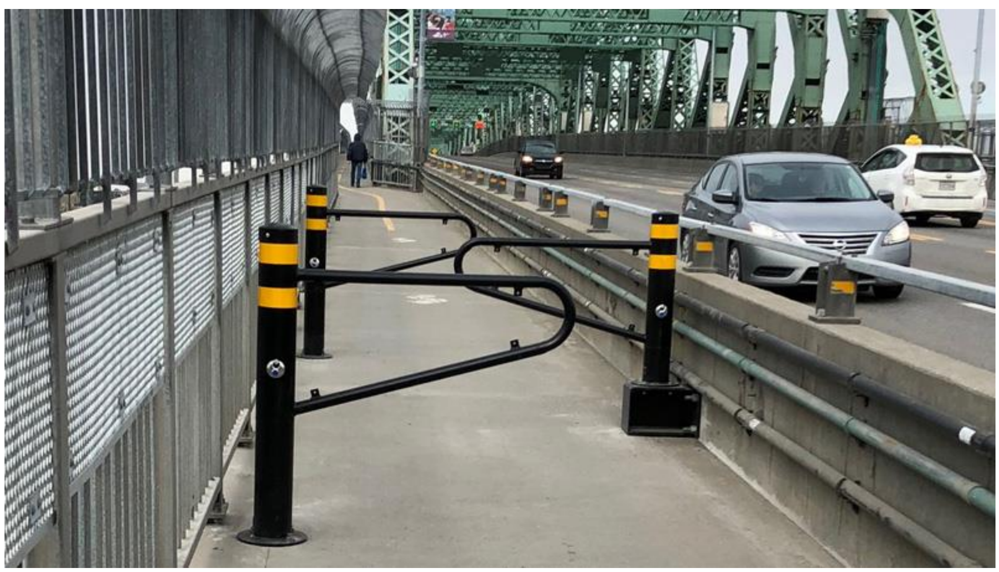


FIGURE 3: Chicane on the Jacques Cartier Champlain Bridge[5]

[4] The speed hump is not visible but is denoted by the warning sign shown at the side of the MUT.
[5] The chicanes have the ability to be swung "open" for emergencies and/or snow removal in winter. The distance between the barriers is sufficient for bicycles as well as bicycles with child trailers to pass through without dismounting. Signs and reflective materials assist path users in identifying the chicanes during times of low light.

FIGURE 4: SLOW Pavement Marking (Brisbane, Australia)[6]

2.4.7 Speed may also be a factor in the upbound direction, where steep grades limit speeds to the minimum speeds to maintain balance and/or cause some cyclists to dismount and walk. Any physical speed reducing measures that are implemented should not lower upbound speeds to less than about 10 km/h (i.e., the minimum speed required to maintain balance and forward momentum).

2.4.8 It is assumed that the MUT will be equipped with all other traffic control devices as required and recommended by *OTM Book 18 – Bicycle Facilities*.

2.4.9 It is necessary for the Keddy Trail to be signed with a STEEP GRADE sign

2.5 Other Safety Issues

2.5.1 The following road safety issues were identified by the auditor.

2.5.2 The concrete barrier separating the MUT from the Claremont Access allows errant cyclists who strike the barrier at a shallow angle to be thrown from their bicycle, over the barrier, and into the motorized lanes of the Claremont Access. A steel beam should be mounted along the top of the concrete barrier to minimize the chances of a cyclist vaulting over the barrier into the Claremont Access.

2.5.3 Signs are required to clearly communicate to trail users the transition from the bicycle path to the MUT (Sheet MC-2). A SHARED PATHWAY sign (Rb-71) should be posted

[6] Note that the KEEP LEFT message is used because Australian rules of the road require cyclists to operate on the left side of the road.

for northbound trail users, and a similar sign with an ENDS tab sign should be posted for southbound trail users.

2.5.4 Trail user conflicts are exacerbated on the MUT at the IPS, where the P-gates west of the IPS require cyclists on the MUT to attend to users entering the MUT from the Southam Park and select an appropriate speed and path to traverse the P-gates almost simultaneously (Sheet MC-5). Consideration should be given to relocating the P-gates further west.

2.5.5 It is unclear which trail user has the right-of-way at the intersection of the MUT with the Southam Park crossing (see the "Traffic Signal Installation (IPS) – 5th West Street" sheet). The IPS controls conflicts between motorists on the West 5th Street ramp and users of the pedestrian crosswalk, but the IPS does not control the conflict between the MUT and the crosswalk. The pedestrian signal heads may give crosswalk users the impression that they have the right-of-way to enter the MUT from Southam Park (and not simply to cross the ramp), while MUT users have no control and the apparent right-of-way.

2.5.6 Related to the above concern is some confusion about whether cyclists are permitted to ride across the West 5th Street ramp or whether they are required to dismount and walk across the ramp. The signal configuration and pavement markings displayed on the IPS drawing suggest that cyclists are required to dismount and walk across the ramp. If this is the case, then a DISMOUNT AND WALK sign (Rb-70) should be erected on both sides of the West 5th Street ramp crossing. If cyclists are permitted to ride across the ramp, then crossride markings and bicycle signal heads are required.

2.5.7 The pedestrian pushbutton on the north side of the West 5th Street ramp crossing, which is intended for southbound users, is located on the left side of the crossing, and may result in users waiting/standing in the path of northbound users (see "Typical Signal Installation (IPS) 5th West Street" sheet).

2.5.8 There is a drafting error where the STOP HERE ON RED SIGNAL (Rb-78) sign is not shown erected adjacent to the marked stop line (see "Typical Signal Installation (IPS) 5th West Street" sheet).

2.5.9 There are two side paths to Arkeldun Avenue (Sheet MC-9) and, therefore the potential for MUT users to use the wrong side path for their intended purpose resulting in cyclists crossing Arkeldun Avenue midblock or cycling in the wrong direction on Arkeldun Avenue. For example, a downbound cyclist on the MUT who wants to continue downbound on Arkeldun Avenue may turn left onto the first side path encountered. This action would result in the cyclist landing at the upbound lanes of Arkeldun Avenue. Directional signing for the Arkeldun Avenue, and other, side paths is recommended to minimize out-of-way travel and risky manoeuvres resulting from improper turns.

2.5.10 Westbound cyclists on the MUT are directed on to the south side of Hunter Street East (the left-side of the street) and placed in conflict with northbound right turns from Wellington Street (Sheet MC-14). Signs and markings should be used to define right-of-way and provide better positive guidance to road users in this area.

2.5.11 Ensure there is adequate forward visibility across the inside of the horizontal curves in the Southam Park path (Sheet SP-2). Also, consider widening the path at the horizontal curves to allow for cyclist lean and off-tracking during curve negotiation.

2.5.12 The grade of the MUT may be a surprise to unfamiliar trail users, especially cyclists. It is recommended that STEEP HILL signs (see Figure 5) be erected to warn trail users of this feature of the trail. This sign may be supplemented with a length of grade tab sign, and/or an indication of the severity of the grade (e.g., 6%).

FIGURE 5: STEEP HILL Sign

2.5.13 There is little information on the design drawings concerning the traffic signs to be implemented along the MUT and the various side trails. It is assumed that these facilities will be outfitted with these traffic control devices in accordance with the recommendations of *OTM Book 18 – Bicycle Facilities*.

3.0 CONCLUSION

3.1 This road safety audit has been carried out solely for the purpose of identifying any features of the design that could be added, removed or altered to improve the road safety performance associated with the project.

Gerry Forbes, M.Eng, P.Eng, PTOE
President & Chief Engineer
Intus Road Safety Engineering Incorporated

Statement of Limitations

The findings and opinions contained in this document are based on an examination of available and relevant plans and documents, as well as the specified road and its surroundings. The findings reflect the Road Safety Auditor's best professional judgment in light of the information available to him at the time of the preparation of the safety audit.

This safety audit was conducted using generally accepted road safety engineering principles, covers only physical features that may affect road users' safety, and has sought to identify potential road safety hazards. However, guarantees cannot be made or implied that all safety deficiencies or collision causes have been identified. Further, if all the issues raised in this report were to be rectified or amended, this would not confirm that the highway is 'safe'; rather, the consideration of the identified issues may result in changes to the design which could prove beneficial to the safety performance of the facility.

The document was prepared for the City of Hamilton and no third party should solely rely on the information therein in any particular circumstances without seeking professional advice. The road safety auditor and Intus Road Safety Engineering Incorporated accept no responsibility for damages, if any, incurred to any person or property acting or failing to act as a result of the material in this document.

APPENDIX A

The following material was reviewed in preparation of this road safety audit report:

- Bicycle Lane and Multi-Use Trail Construction drawings for West 5th Street at Brantdale Avenue to Claremont Access, Claremont Access to Hunter Street E, Contract No. C15-39-19 (TP), City of Hamilton, Public Works Department:

- Memo from Dillon Consulting Limited to Daryl Bender of the City of Hamilton, Subject: Design Brief – Claremont Cycling Access Multi-use Pathway Lighting, dated November 28, 2019, 2 pages.

- Claremont Multi-use Trail Key Plan showing Emergency Services Openings in the Barrier, delivered as *Claremont Access – Traffic Separation.PDF*, undated, 1 page.

- Sheet No. S12, Box Beam Railing on Sidewalk – PL2 (With Concrete End Wall), Project No. 11-4364, County of Essex, last updated January 2013, 1 page.

- Electronic mail message from Edward Soldo to Brian Hollingsworth, re: Claremont Separator, dated February 6, 2020.

- Word file titled “Claremont Access to Forbes.docx”, created by Daryl Bender, last edited February 7, 2020, 5 pages.

- Electronic mail message from Jody Yarmo to Daryl Bender, re: Claremont Keddy Trail (cyclists & peds), dated February 18, 2020.

END OF REPORT