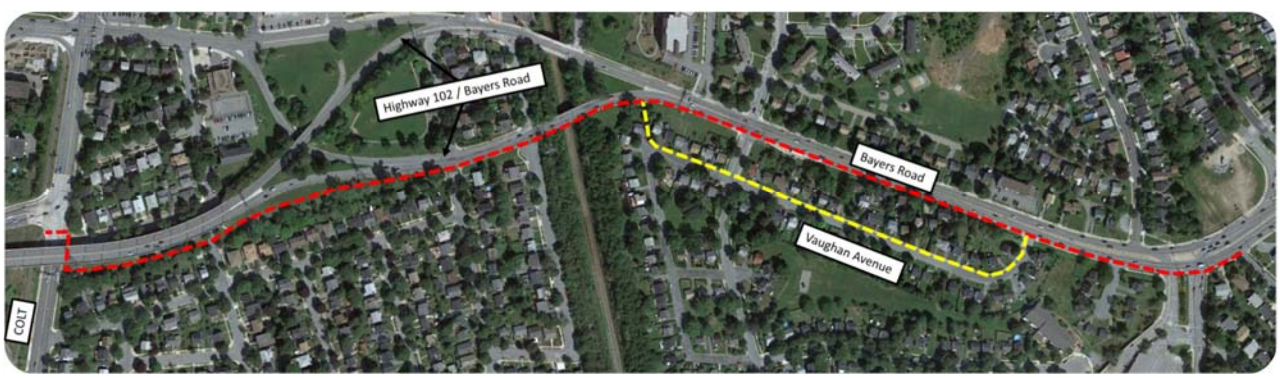
ACTIVE TRANSPORTATION CONNECTION STUDY:
Chain of Lakes Trail to Halifax Peninsula

HALIFAX REGIONAL MUNICIPALITY

BICYCLE NOVA SCOTIA



FINAL REPORT

September 2016

–

WSP
1 Spectacle Lake Drive
Dartmouth, NS B3B 1X7

Phone 902-835-9955
Fax 902-835-1645
www.wspgroup.com

Table of Contents

Chapter **Contents** **Page**

1.0 Introduction

1.1 Background

The Chain of Lakes Trail (COLT) is an extensive multi-purpose active transportation (AT) facility that serves as a key spine in Halifax Regional Municipality (HRM)'s regional greenway network. Developed on a former railway corridor, its exceptional design standard and connectivity to other AT facilities and adjacent neighbourhoods have quickly made it one of HRM's most heavily used and valuable AT assets.

In an effort to further leverage the key benefits of the COLT, HRM's *2014-2019 Active Transportation Priorities Plan* (2014) identifies the need to develop improved connections between it and key destinations, most prominently to the Halifax Peninsula. Mobility between Mainland Halifax and the Peninsula is an important constraint for all transportation modes due to the limited number of opportunities to the cross CN rail cut. A lack of dedicated AT facilities across the isthmus requires that pedestrians and cyclists navigate congested roadways and intersections such as Bayers Road / Highway 102, the Windsor Street Exchange, and the Armdale Roundabout.

The *AT Priorities Plan* has envisioned a formal AT connection, suitable for all ages and abilities, between the COLT (in the vicinity of the Joseph Howe Drive – Highway 102 intersection) and George Dauphinee Avenue. This connection, running in the vicinity of the Bayers Road / Highway 102 corridor, would provide a centrally located alignment that links to existing and proposed AT facilities. Providing a safer, more comfortable, and direct AT connection in this area helps residents of Fairview, Fairmount, Clayton Park (and points beyond on the Western Mainland) to access the peninsula. Though the connection has many potential advantages, there are also significant challenges that must be considered, among them the need to cross major streets, intersections, and the CN Rail Cut. In addition, there is uncertainty associated with the Bayers Road / Highway 102 corridor, for which HRM and the Province are planning significant expansion that could include extensive reconfiguration of existing road infrastructure.

To aid in the next steps toward implementation, HRM – in conjunction with Bicycle Nova Scotia (BNS) – has retained WSP Canada Inc. (WSP) to complete a Study that includes planning and functional design for an AT connection between the COLT (at Joseph Howe Drive) and George Dauphinee Avenue.

1.2 Study Objectives

The primary objectives of the Study include the following:

- Identify alternatives for a multi-use AT facility that provides a formal connection between the COLT (at Joseph Howe Drive) and George Dauphinee Avenue;

- Investigate and develop potential solutions to challenges along the proposed route, including:
    - Crossing of Joseph Howe Drive;
    - Crossing of the CN Rail Cut;
    - Right-of-way (ROW) limitations on Bayers Road and uncertainty with regard to future Bayers Road widening plans by Nova Scotia Transportation and Infrastructure Renewal (NSTIR) and HRM
    - Crossing the Halifax Shopping Centre's Bayers Road driveway;

- Determine the preferred connection option through an evaluation process that considers key criteria including connectivity, directness, user comfort, safety, constructability, costs, and consistency with HRM AT planning objectives, and;

- Develop functional designs and preliminary cost estimates for the preferred connection option.

1.3 Study Area

The major components of the proposed AT connection include the following (See Figure 1-1):

1. Improved crossing of Joseph Howe Drive;
2. Short connection along Joseph Howe Drive between the Highway 102 ramp intersection and the area beneath Highway 102;
3. AT Greenway between Joseph Howe Drive and Vaughan Avenue (including crossing of the CN Rail Cut);
4. Local Street Bikeway on Vaughan Avenue. Alternatively, an AT Greenway along Bayers Road east of the rail cut is desired, but is expected to have significant challenges that will limit feasibility;
5. AT Greenway between Vaughan Avenue and George Dauphinee Avenue (including crossing of the Halifax Shopping Centre Driveway).

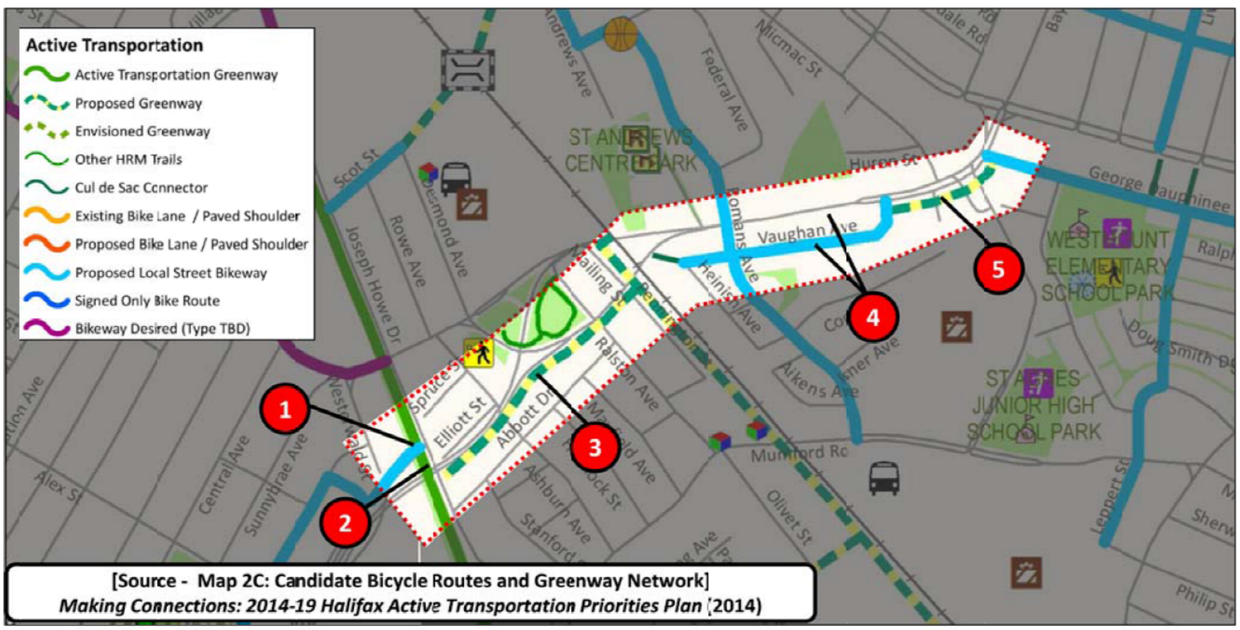


Figure 1-1: Recommended AT Connection – *Making Connections: 2014-19 Halifax AT Priorities Plan* (2014)

2.0 Background Review and Stakeholder Consultation

2.1 Existing Conditions Review

2.1.1 Site Investigations

WSP completed initial site investigations on Friday, February 26, 2016, along with representatives from HRM and Bicycle Nova Scotia. Subsequent site investigations were completed by WSP throughout the project.

2.1.2 Mapping Data

Digital mapping including property boundary information, Lidar topographical data, GIS layers, and aerial photography were obtained from HRM Business Intelligence & Data Services. Digital mapping was compiled to establish base drawings of the Study Area.

2.1.3 Land Ownership

The majority of the lands along the proposed alignment are owned by either HRM or NSTIR. HRM owns the Bayers Road right-of-way from George Dauphinee Avenue to the CN Rail Cut, along with Joseph Howe Drive. NSTIR owns the land from the CN Rail Cut to Joseph Howe Drive and the Highway 102 ramps at the intersection with Joseph Howe Drive.

2.1.4 Traffic Data

Intersection turning movement counts, machine counts, and signal timing information was obtained from HRM Traffic Management for use in the review of existing traffic characteristics and analysis of intersection performance.

2.2 Stakeholder Consultation

A consultation session was held on May 31st, 2016 with several key stakeholders. The intent of the meeting was to introduce the project and identify opportunities and constraints related to each option. The following sections summarize the information that was obtained from each stakeholder group.

2.2.1 Nova Scotia Transportation and Infrastructure Renewal (NSTIR)

Nova Scotia Transportation and Infrastructure Renewal (NSTIR) owns and maintains provincial highways in the province, including Highway 102 and a portion of Bayers Road in the Study Area. WSP's discussions with NSTIR Staff focused on the following issues:

- Trail Development within Bayers Road ROW: Trail development along the NSTIR-owned section of the Bayers Road / Highway 102 corridor will require approval by the NSTIR Area Manager. This will require that the proposed facility cross section is acceptable based on NSTIR standards. Use of NSTIR right-of-way for trail uses is subject to the Department's *Trail Policy*[1]. Any trail development within NSTIR right-of-way requires a 'Work Within Highway Right-of-Way Permit', which is a type of agreement between NSTIR and a trail proponent (i.e. municipality, trails organization) that establishes the framework for trail operation including assignment of responsibility for key items such as maintenance, insurance, and liability. Trails developed within NSTIR right-of-way are not granted any ownership of the land (e.g. easement, lease) but rather are issued a permit or license to use the space.

- Overpass structure at CN Rail Cut: NSTIR owns and maintains the Bayers Road bridge structure at the CN Rail Cut. Modifying the roadway configuration on the bridge – including narrowing travel lanes, adding and modifying barriers, and providing right-of-way width for a trail – would require approval from NSTIR.

- Intersection Modifications: Any modifications to the intersection of the Highway 102 ramps with Joseph Howe Drive would require input and approval from NSTIR.

2.2.2 *Halifax Regional Municipality (HRM)*

HRM includes multiple departments that will be important to consider as part of this project. Specific issues that will require coordination with HRM include the following:

- HRM's Project Planning and Design Services department, which includes HRM's Active Transportation group, are responsible for the implementation of the region-wide AT Plan[2].

- HRM's Traffic Management department will be involved in reviewing any proposed changes to HRM-owned streets including Joseph Howe Drive, sections of Bayers Road, Vaughan Avenue, and George Dauphinee Avenue. This will include modifications to intersections including the Highway 102 - Joseph Howe Drive intersection and the Bayers Road – Halifax Shopping Centre driveway.

2.2.3 *Bicycle Nova Scotia (BNS)*

Bicycle Nova Scotia (BNS) is an organization that aims to encourage and expand cycling in the province through promotion, advocacy, and the development of bicycle infrastructure. BNS are currently playing a key role in the development of the 'Nova Scotia Blue Route', an interconnected network of bikeways across Nova Scotia that will include strategically designated on- and off-road cycling routes. In this role, BNS has provided co-funding for this Study with HRM, and will review the proposed configuration to ensure consistency with its vision for the Blue Route.

BLUE ROUTE

[1] NSTIR Policy PO1033: *Trail Policy*
[2] *Making Connections: 2014-19 Halifax Active Transportation Priorities Plan* (Halifax Regional Municipality, 2014)

2.3 Future Roadway Planning

Regional transportation planning in HRM has included consideration for the need to provide significant capacity expansion to the Bayers Road / Highway 102 corridor. Though plans are presently very uncertain, both HRM and NSTIR have completed conceptual planning and design for expansion for the corridor, including potentially significant changes within the Study Area for this assignment.

HRM provided conceptual design drawings from the *Bayers Road / Highway 102 Corridor Study* (Stantec, 2009) for review as part of this project. The drawings indicate proposed upgrades to the corridor that, in general, expand the primarily 4-lane cross section of the corridor (within the Study Area for this assignment) to include six traffic lanes. Key changes that may impact future AT facilities in the Study Area include:

- A new twin highway elevated structure running between Joseph Howe Drive and Ashburn Drive to replace the existing overpass structure. The structure would include widening.
- Abandonment or repurposing of the existing inbound Bayers Road lanes and removal of the CN rail cut bridge, as well as re-establishment of previously severed street connections on Ralston Avenue and Pennington Street
- Widening of Bayers Road, including on the south side, between the CN rail cut and Windsor Street. Widening will require acquisition of several properties on both sides of the street.

While these plans are noted as conceptual only and have not been formally endorsed by HRM, they do provide a useful guide in understanding the extent to which future highway upgrades could impact development of other infrastructure (including AT facilities) in the area. It should also be noted that if roadway upgrades of this scale are eventually pursued, there is likely potential for the incorporation of dedicated AT facilities. For the purposes of this Study, the conceptual highway plans have been considered only minimally, primarily as a means of identifying key constraints that could influence route selection.

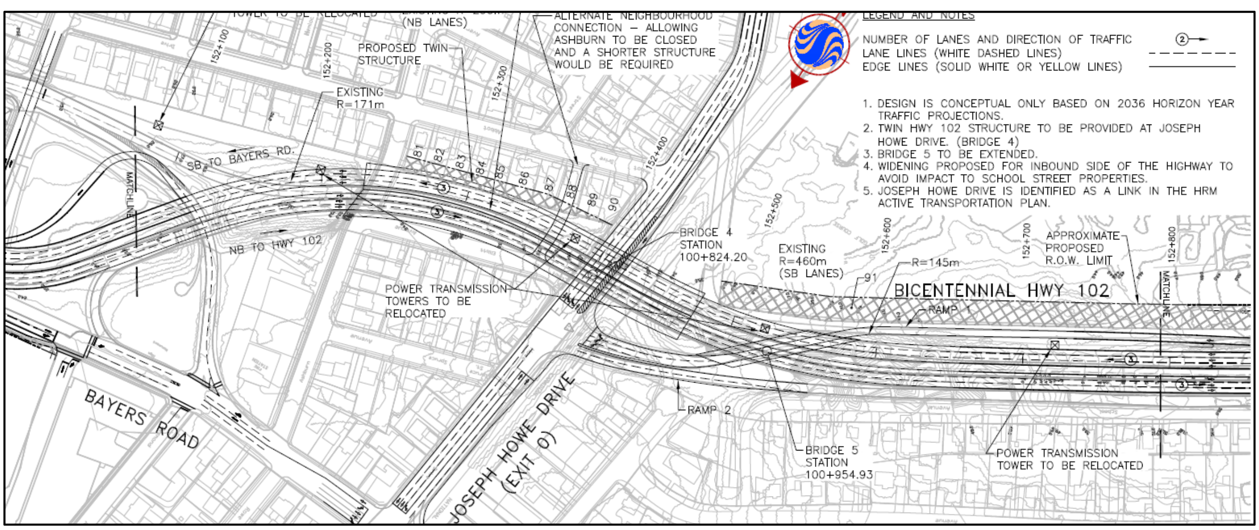


Figure 2-1: Conceptual design of potential roadway expansions
[Source: *Bayers Road / Highway 102 Corridor Study* (Stantec, 2009)]

3.0 Facility Types

The AT facility types envisioned for the proposed connection and associated design standards are discussed in the following sections.

3.1 Active Transportation (AT) Greenway

The proposed connection will consist primarily of AT greenway. AT greenways, also commonly referred to as multi-use trails, are dedicated AT facilities that permit 2-way travel for non-motorized AT uses. AT greenways are typically 3.0 to 4.0m wide, and include a crusher dust or asphalt pavement surface.

3.1.1 HRM Design Standards

Cross sections for the proposed alignment will generally follow one of two forms: (i) directly adjacent to the roadway, or (ii) separated from the roadway. HRM's *Municipal Design Guidelines* (2013) includes two facility types that may be considered applicable for this project:

i. **Adjacent to Roadway:** There are some locations where the facility will run directly adjacent to the roadway. HRM's *Municipal Design Guidelines* (2013) includes this type of facility – denoted as "Boulevard Pathway" **–** in standard cross section details for roadways prefaced as "Active Transportation" Collectors and Arterials. In these instances, it is ideal to introduce a buffer area between the facility and the edge of the vehicle lanes. The preferred minimum cross section width is 4.0m, and there is a recommended sodded buffer that ranges between 1.5m and 2.85m.

ii. **Separated from Roadway:** Where space is available, the facility will ideally be separated from the roadway to increase user safety and comfort. This type of facility is included in HRM's *Municipal Design Guidelines* (2013) as an "Active Transportation Off Road Trail". The preferred minimum cross section width is 4.0m, with a 0.5m shoulders on either side, 2:1 side slopes that blend with the existing grade, and ditching as required.

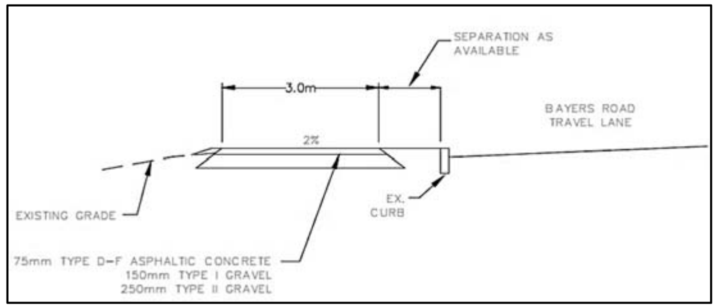
In both facility types described above, the preferred minimum width is 4.0m. However, this is based on an ideal situation; in many cases, a minimum width of 3.0m is considered acceptable.

3.1.2 Proposed Design Standards

HRM's *Municipal Design Guidelines* (2013) can often be very challenging to accommodate in the case of urban retrofit projects, where right-of-way constraints limit available width. In these cases, a context sensitive approach should consider local factors (e.g. available width, expected user demand, urban / rural application, etc.) and engineering judgement should be exercised in determining a suitable design standard.

Existing conditions in the Study Area includes limited right-of-way, particularly along sections of Bayers Road. Consequently, a context sensitive approach will be required that will require the use of revised design standards. Proposed design standards for AT greenways along the proposed alignment are generally discussed below:

i. **Adjacent to Roadway:** The most constrained sections are those that run adjacent to Bayers Road, where there is minimal separation between the existing sidewalk and both the traveled way and adjacent properties. The existing sidewalk is typically 1.5-1.8m wide, with a sodded buffer (including light poles) typically 0.9-1.1m wide. There is variable separation (and grades) between the sidewalk and adjacent properties. Based on existing conditions, it is proposed that a typical 3.0m wide cross section be established as the preferred design standard while retaining an approximately 1.0m sod buffer. An asphalt pavement surface is also recommended.



Proposed greenway cross section adjacent to roadway

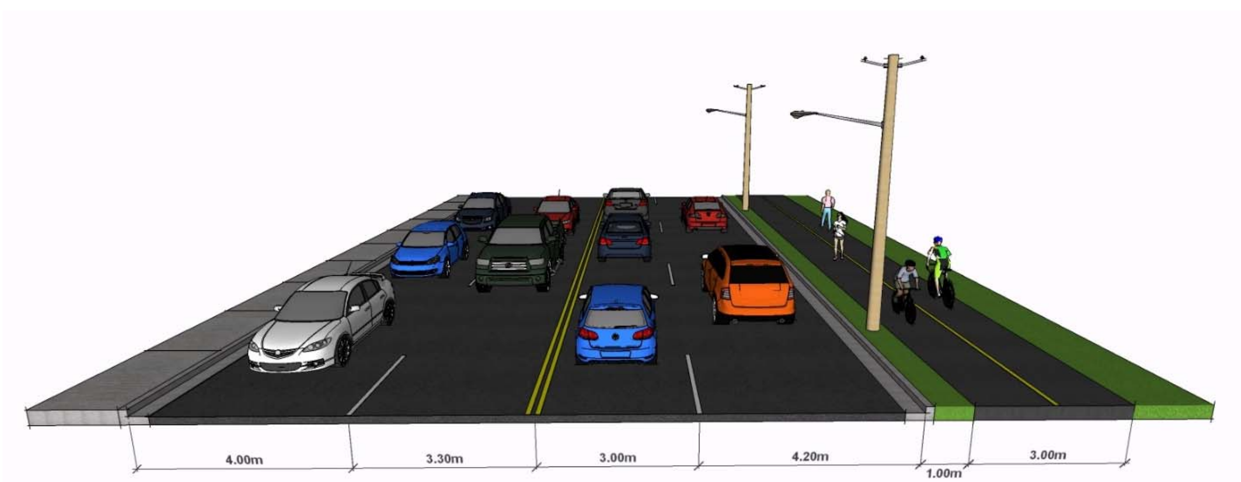
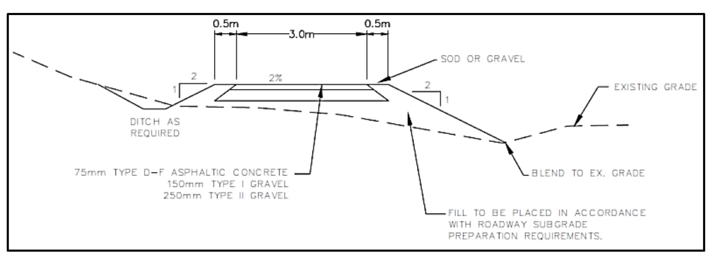


Figure 3-1: Proposed design standard: Greenway adjacent to roadway

ii. **Separated from Roadway:** In locations where available space permits separation from the roadway, width constraints are less of a concern. It is proposed that sections of greenway that are separated from the roadway will also be paved and 3.0m wide (increased to 4.0m where there is available width), but built with other standard features including 0.5m shoulders and ditching as required. The space available for these sections will likely allow the typical cross section to be used throughout, with variation only in ditching, as required.



Proposed greenway cross section separated from roadway

Given that a significant portion of the facility is expected to have a maximum width of 3.0m, and that anticipated usage of the facility will be high, there is potential that the mixing of cyclists and pedestrians could be a safety concern. The route could attract high volumes of commuting cyclists, who tend to desire higher travel speeds. Considering these concerns, as well as the fact that there are alternate options for pedestrians to navigate through the corridor, an option that could be considered is to prohibit pedestrians from the facility and make it a “cycling only” facility.

3.1.3 *Street Crossings*

The TAC *Bikeway Traffic Control Guidelines for Canada* (2012) includes designated trail crossing warning signage as well as pavement markings (crosswalk lines supplemented with “Elephant’s Feet” markings that signify that bicycles may cross) that may installed on trail crossings (See Figure 3-2). Depending on a jurisdiction’s Motor Vehicle Act (MVA), these trail crossings may provide right-of-way to the trail users and permit cyclists to cross without dismounting. Though these types of trail crossings have been installed in other parts of Canada, Nova Scotia’s MVA does not currently permit their installation. The advance trail crossing warning signage may be installed; however, does not assign priority to pedestrians and cyclists unless a designated crosswalk is in place.

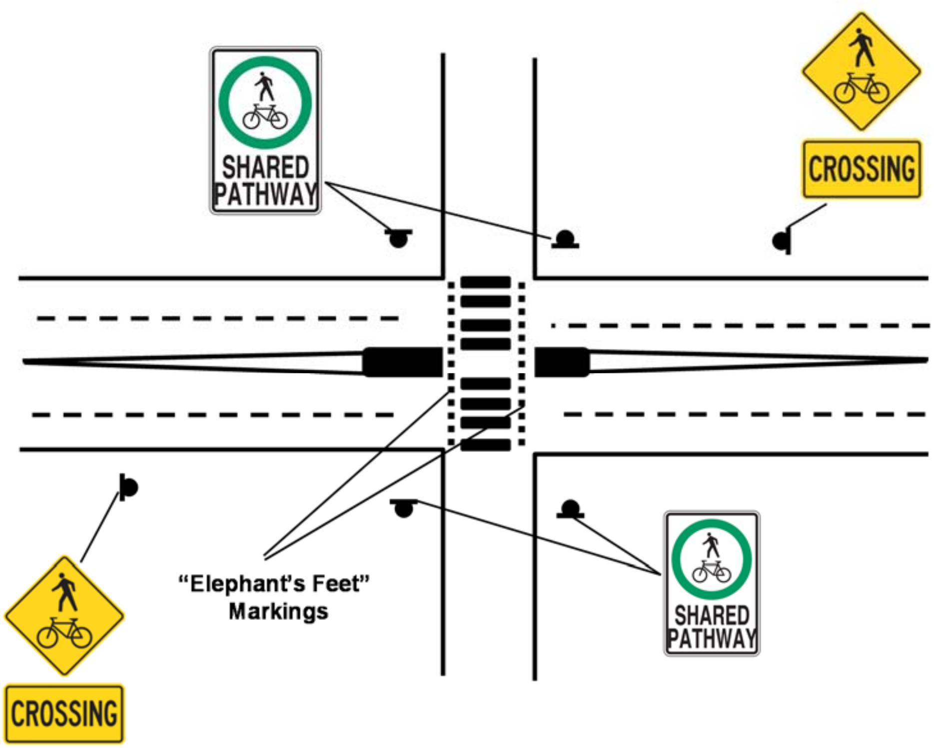


Figure 3-2: Trail Crossing Configuration
Source: *TAC Bikeway Traffic Control Guidelines* (2012) – Figure 40

Pedestrian and Bicycle Crossing Ahead’ sign (WC-47) and ‘Crossing’ tab (WC-7S)

Shared Pathway’ sign (RB-93)

3.2 Local Street Bikeway

Local street bikeways, also commonly referred to as ‘Bicycle Boulevards’, are low speed, low volume streets that have been optimized for bicycle through traffic. Local street bikeways typically include a mixture of traffic calming and bicycle priority measures to minimize traffic volumes and speeds and create a comfortable cycling environment suited to a wide range of users. Although the local street bikeway concept is new to HRM, it is a facility that is becoming increasingly popular in other jurisdictions in Canada and the US.

3.2.1 *Traffic Calming / Bicycle Priority Measures*

There are a variety of traffic calming and bicycle priority measures that are commonly used on local street bikeways. The intent of these measures is to provide guidance and awareness of the bicycle route, improve safety for bicyclists, and manage conflicts with motor vehicles by considering speed, volume, and intersection movements.

Directional diverter allows bicycles only to make through movements [Source: *NACTO Bikeway Design Guide* (2012)

Mini roundabout slows traffic and discourages shortcutting

Street closure restricts all movements except for cyclists and pedestrians

Speed humps slow traffic and sharrows / signage promote cycling

3.2.2 *Pavement Markings and Signage*

Local street bikeways use pavement markings and signage to clearly communicate to all road users the nature of the facility. Some typical examples of pavement markings and signage that are used in local street bikeways are summarized below.

Bike Route Signage	Placement of bike route signage at the beginning of each block and at regular intervals identifies the street as a component of a designated cycling route. Directional arrows can also be considered in locations where the route alignment changes.	 **TAC IB-23 / IS6-L**

Pavement Markings	Sharrow markings are used primarily to provide guidance on cyclist positioning and typically accompany the 'Share the Road' warning sign. They can also be used on local street bikeways to complement bike route signage and raise awareness to the priority of cycling to the street.	 **Sharrow Marking**

4.0 Overview of Proposed Alignment

The connection under consideration as part of this Study runs east-west approximately 1.1km between the COLT (in the vicinity of the Joseph Howe Drive – Highway 102 Exit 0 ramp intersection) and George Dauphinee Avenue. The proposed alignment is expected to include variable elements ranging from separated off-street greenway sections to on-street bicycle facilities. There are multiple 'pinch points' and other challenges that require consideration.

For the purposes of this Study, the alignment has been divided into five distinctive sections, each with their own design characteristics and challenges. This chapter provides a detailed summary of each of the five sections illustrated in Figure 4-1.

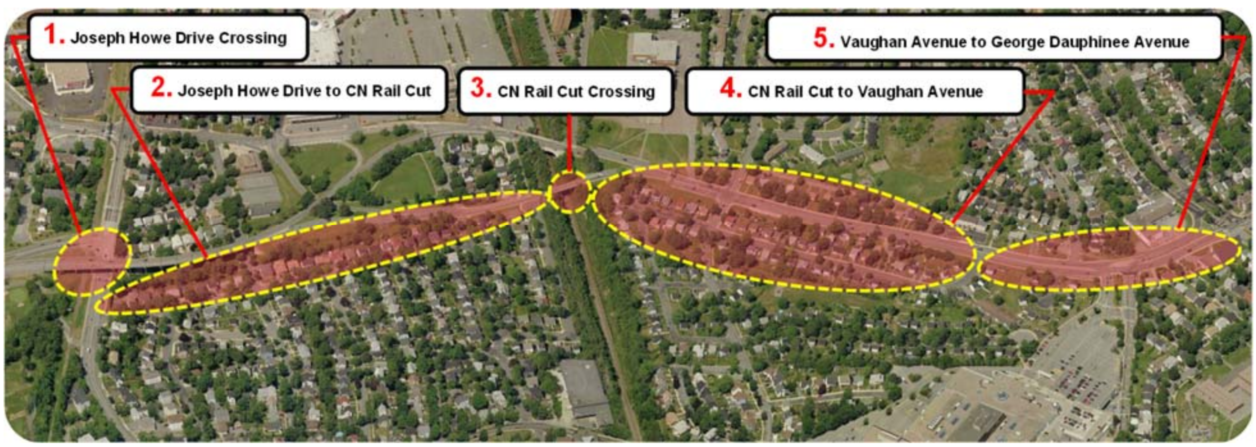


Figure 4-1: Proposed Alignment by Section

4.1 Section 1: Joseph Howe Drive Crossing

4.1.1 *Overview*

The western terminus of the proposed alignment is at the Joseph Howe Drive – Highway 102 Exit 0 ramp intersection. The COLT runs north-south through the west side of the intersection. The objective for this assignment was to review the available options for making an AT connection across Joseph Howe Drive at or near the intersection. This crossing is challenging due to several factors (Figure 4-2):

- Heavy Traffic Volumes: The intersection is subject to heavy traffic volumes, particularly during peak weekday AM and PM peak periods. Annual average daily traffic (AADT) on Joseph Howe Drive exceeds 25,000 vehicles per day (vpd). With heavy conflicting traffic volumes, the intersection is relatively large and includes lengthy cycle lengths that exceed 110 seconds.
- Intersection Configuration: The existing intersection configuration is not ideal for COLT users, and presents challenges for convenient crossing of Joseph Howe Drive.
  - o Pedestrian crossing distances are long, and the Highway 102 ramp's eastbound right turn channel island is very small, providing minimal refuge area for crossing pedestrians and cyclists.
  - o The most direct crossing between the COLT and the proposed alignment is located at the existing trail curb cut on the southeast corner, approximately 15m south of the Joseph Howe Drive northbound stop bar.

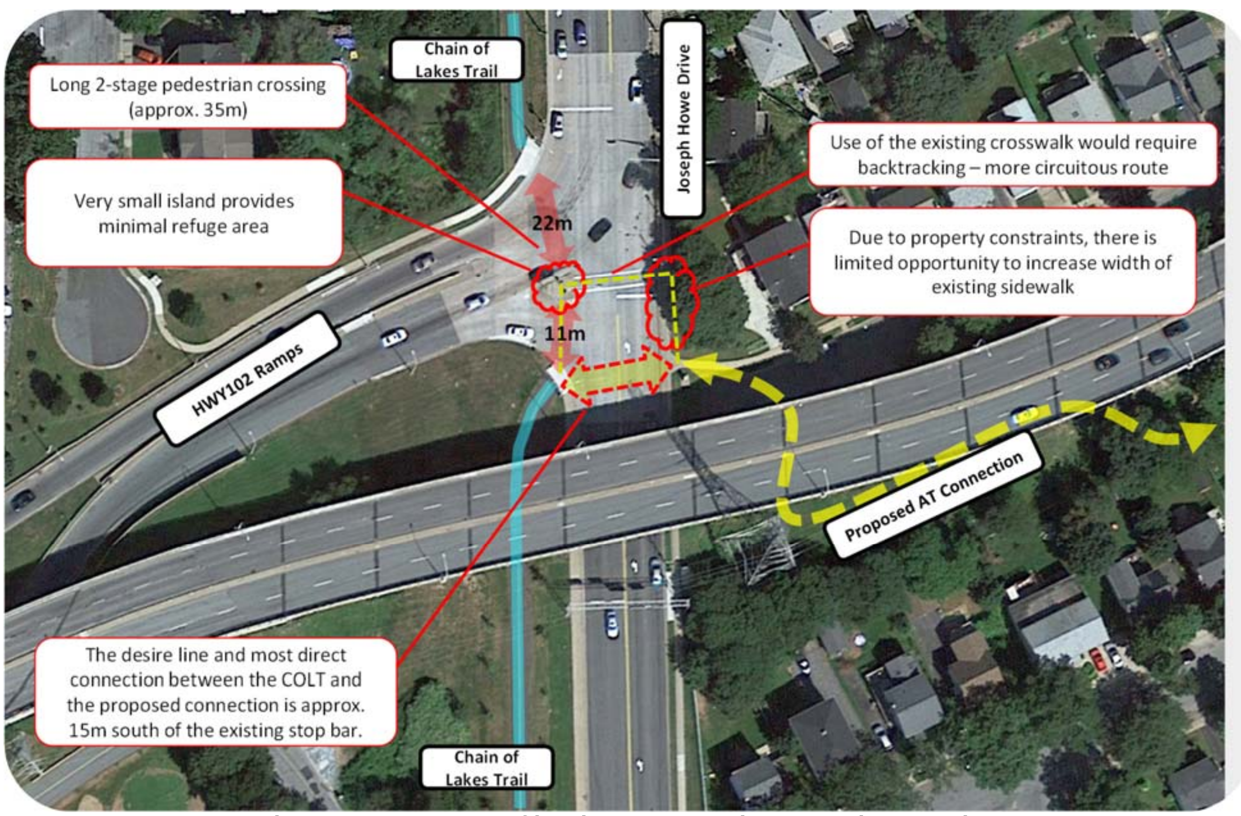
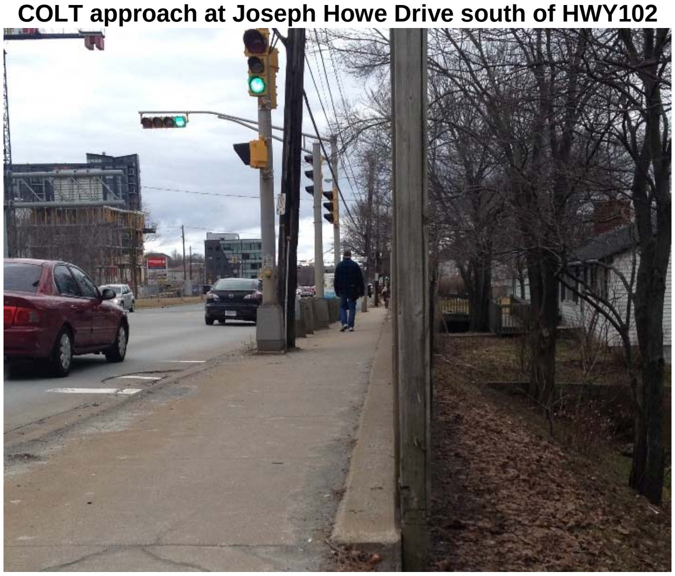


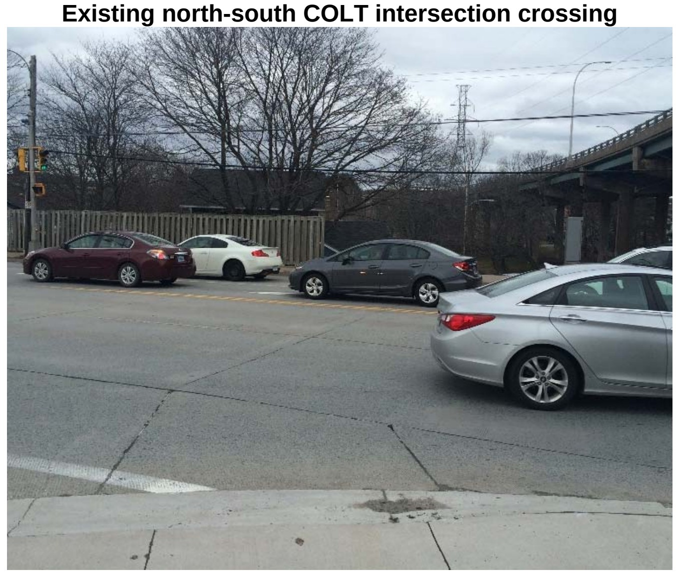
Figure 4-2: Summary of key issues: Joseph Howe Drive crossing

COLT approach at Joseph Howe Drive south of HWY102

Existing north-south COLT intersection crossing



ROW limitations on the east side of Joseph Howe Drive constrain ability to widen the existing sidewalk

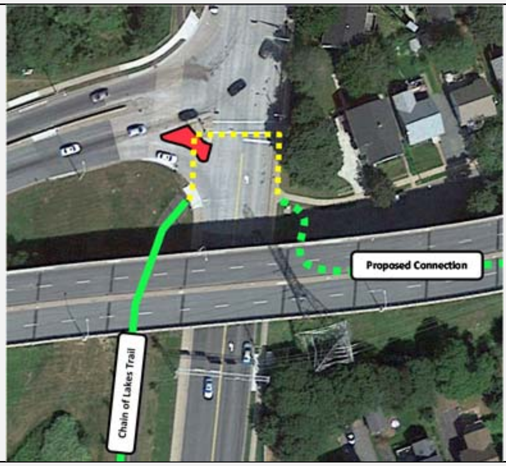
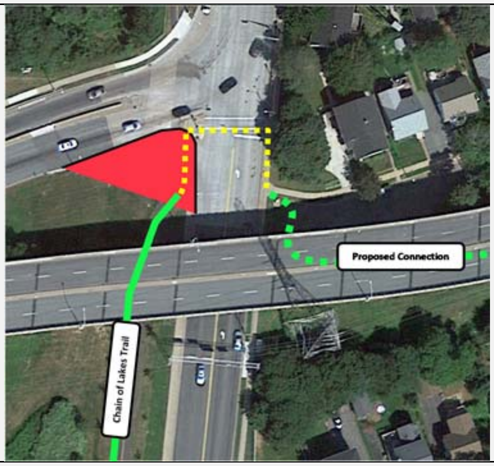


Looking across Joseph Howe Drive at the most direct crossing location

4.1.2 *Review of Design Options*

Several options were considered for the modification of the existing intersection to provide a safer, more comfortable and convenient crossing of Joseph Howe Drive between the COLT and the proposed connection to the peninsula. The various intersection modification options that were considered focused on one of two crossing options: (1) via the existing crosswalks, or (2) via a new, more direct crossing further south from the existing south crosswalk. Table 4-1 summarizes the advantages and disadvantages associated with each.

Table 4-1: Summary of Options -- Crossing Joseph Howe Drive

	1. Crossing via Existing Crosswalks		**2. Direct Crossing via New Crosswalk**
	(a) Increase size of Refuge Island	**(b)** Remove Channel Island	Move Crosswalk South
			
Description	Cross Joseph Howe Drive via the existing crosswalks, but increase the size of the existing pedestrian refuge island.	Cross Joseph Howe Drive via the existing south crosswalk, but remove the existing right turn channel.	Shift the existing south crosswalk approximately 15m to the south to provide a direct crossing of Joseph Howe Drive between the COLT and the proposed connection.
Pros	• Provides additional refuge area for pedestrians and cyclists • May reduce the crossing distance to the refuge island • May require relatively minimal modifications	• Eliminates the need for a refuge island • May reduce the pedestrian and cyclist crossing distance • Removes heavy volume, high-speed crossing at the right turn channel.	• Much more direct crossing for pedestrians and cyclists to the proposed COLT connection. • Removes the channelization crossing conflict for users of the proposed COLT connection
Cons	• Maintains a heavy volume, high-speed crossing at the right turn channel. • Vehicles' approach angle to the crossing would not be improved • Impacts geometry for right turn truck movements; may require modification to inside curb to accommodate design vehicle • Less direct alignment to the proposed COLT connection to the peninsula that has ROW limitations along the east side of Joseph Howe Drive	• Impacts performance of the EB right turn movement • Impacts geometry for EB right turn truck movements. • Less direct alignment to the proposed COLT connection to the peninsula • Less direct alignment to the proposed COLT connection to the peninsula that has ROW limitations along the east side of Joseph Howe Drive	• Impacts performance of the EB right turn and NB left turn and through movements • Does not improve crossing experience for COLT users on the west intersection approach. • Requires modifications to pavement markings and traffic signal infrastructure. • Distance between the proposed south crossing and the EB right turn channel is longer; could enable high speed right turns and less safe conflict points.

4.1.3 *Preferred Crossing Option*

The preferred crossing option is a hybrid of Options 1(a) and 2, including a new direct crossing of Joseph Howe Drive south of the existing crosswalk. Proposed intersection modifications, illustrated in Figure 4-3, include the following:

- Shift the existing south crossing approximately 15m to the south to provide the direct east-west connection.
- Eliminate the eastbound right turn channel to remove the two-stage crossing for pedestrians and cyclists heading to/from the east. Requires realignment of the eastbound approach and addition of an eastbound right turn lane;
- Add a southbound right turn channel island to provide pedestrian / cyclist refuge and significantly improve operation of the southbound right turn movement.

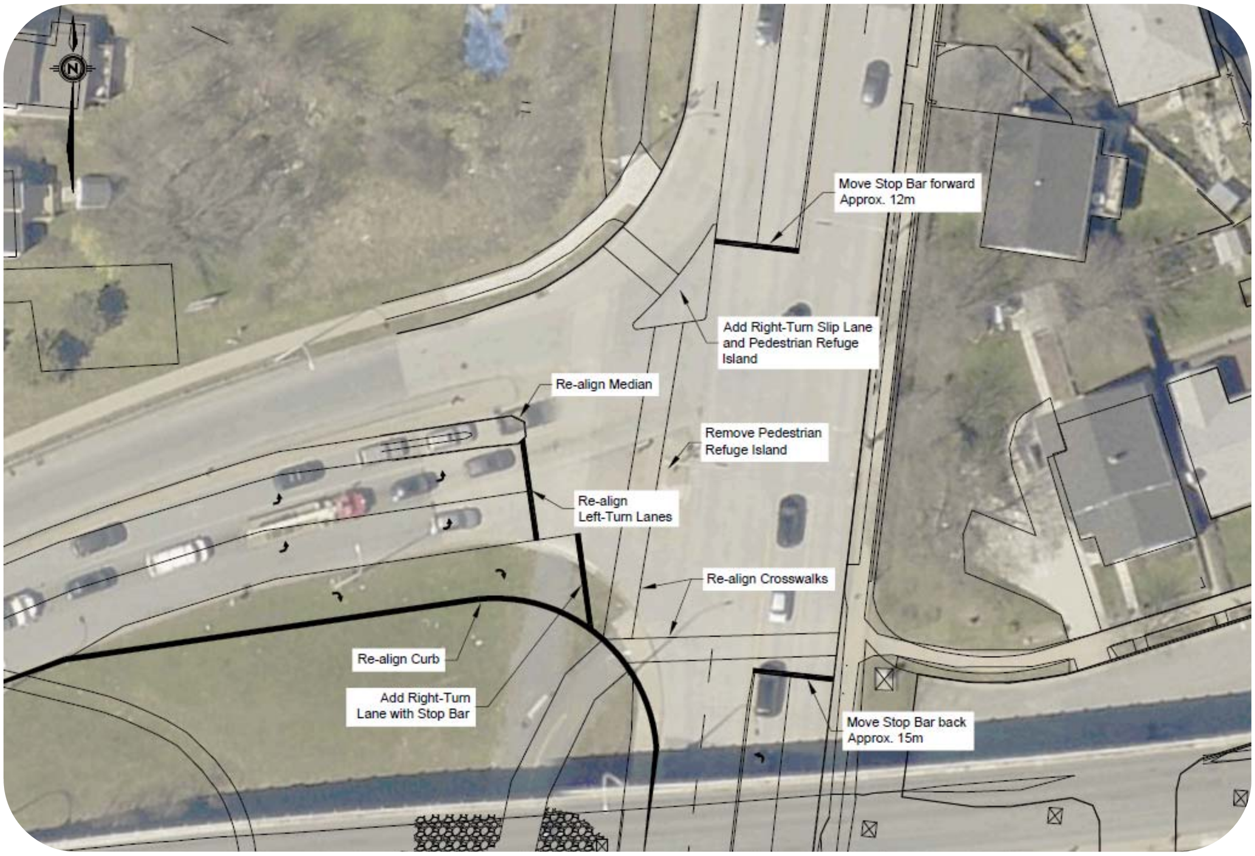


Figure 4-3: Preferred Intersection Concept -- Joseph Howe Drive – Highway 102 Exit 0 ramp intersection

With these geometric changes at the intersection, modification to the signal phasing is suggested in order to mitigate the effects of removing the eastbound right-turn channel and reduce the conflict between right-turning vehicles and pedestrians crossing Joseph Howe Drive. The modifications to the signal phasing are illustrated in Figure 4-4 and summarized below:

- Add a southbound right-turn channel for traffic turning right onto the Highway 102 ramps and move the stop bar on the Southbound approach forward approximately 12 m;
- Overlap the northbound left-turn phase with a signalized eastbound right-turn phase; and,
- Restrict eastbound right turns during the eastbound left turn phase.

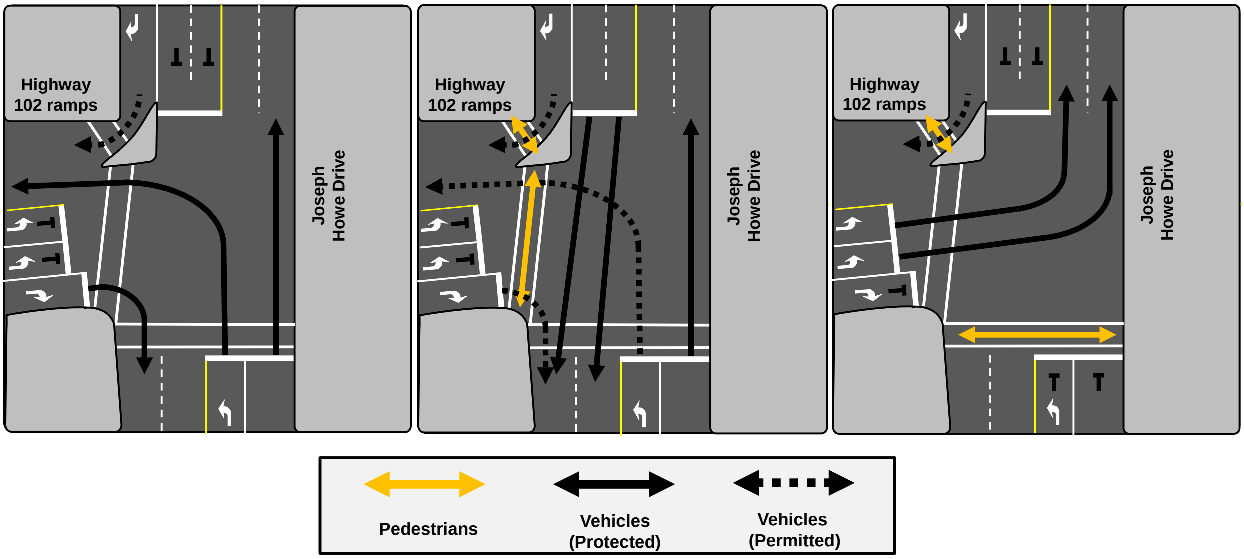


Figure 4-4: Signal phasing for proposed modified Joseph Howe Intersection

Intersection level of performance was completed using Synchro 9.0 software in order to assess the implications of these intersection changes on traffic operation; modeling results provided in Appendix C and are summarized in Table 4-2. The intersection was modeled for AM and PM peak periods based on both existing signal timings and the adjusted signal timings as described above. Results indicate that with proposed configuration changes and signal phase modifications the intersection is expected to operate with similar levels of performance to existing conditions, and shows some improvement to key movements including the Joseph Howe Drive northbound left turn.

Table 4-2: Intersection analysis for modified Joseph Howe Drive intersection

LOS Criteria	Control Delay (sec/veh), v/c Ratio, and 95% Queue (m) by Intersection Movement						Overall Intersection	
	EB-L	EB-R	NB-L	NB-T	SB-T	SB-R	Delay	LOS
Weekday AM Peak Hour - Existing Conditions (Page C-1)								
Delay	19.4	48.7	91.0	24.3	72.8	5.4	47.8	D
LOS	B	D	F	C	E	A		
v/c	0.33	0.98	1.01	0.40	1.03	0.49		
Queue	47.7	270.5	75.1	69.6	178.9	20.2		
Weekday AM Peak Hour - Reconfigured Intersection with Adjusted Signal Timings (Page C-3)								
Delay	21.4	48.4	71.0	22.0	57.5	1.9	41.3	D
LOS	C	D	E	C	E	A		
v/c	0.35	0.98	0.94	0.38	0.97	0.27		
Queue	50.5	270.1	71.5	66.0	171.2	13.5		
Weekday PM Peak Hour - Existing Conditions (Page C-2)								
Delay	37.9	3.9	11.7	12.0	19.7	10.3	14.8	B
LOS	D	A	B	B	B	B		
v/c	0.59	0.32	0.72	0.68	0.35	0.76		
Queue	54.4	17.5	63.8	132.7	49.6	67.4		
Weekday PM Peak Hour - Reconfigured Intersection with Adjusted Signal Timings (Page C-4)								
Delay	39.2	4.1	13.5	13.2	20.2	9.2	15.4	B
LOS	D	A	B	B	C	A		
v/c	0.54	0.32	0.74	0.67	0.31	0.65		
Queue	54.0	17.9	73.4	149.9	52.8	101.1		

4.2 Section 2: Joseph Howe Drive to CN Rail Cut

4.2.1 *Overview*

The proposed alignment section between Joseph Howe Drive and the CN Rail Cut runs east-west approximately 500m, primarily along the south side of Highway 102 and Bayers Road. Overall, this section provides good options for development of a greenway connection. The majority of lands are owned by NSTIR, and in general there is available ROW to install a greenway with good separation from traffic. Key elements of this alignment section, illustrated in Figure 4-5, are summarized in the following subsections.

Figure 4-5: Proposed alignment from the CN Rail Cut to Joseph Howe Drive

4.2.2 *Joseph Howe Drive to Ashburn Drive*

The section between Joseph Howe Drive and Ashburn Drive is approximately 150m in length, running beneath the existing Highway 102 overpass structure on NSTIR lands. The three alignment options illustrated in Figure 4-6 are described in Table 4-3.

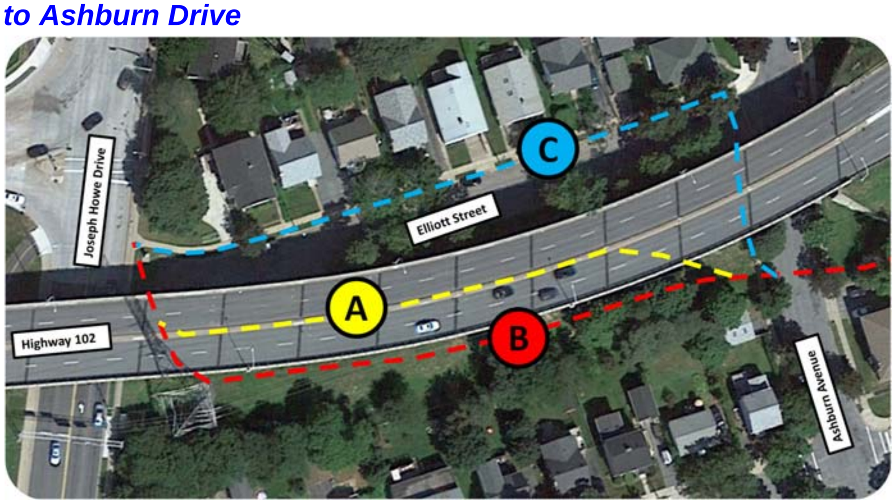


Figure 4-6: Alignment options between Ashburn Avenue and Joseph Howe Drive

Table 4-3: Summary of Options -- Joseph Howe Drive to Ashburn Drive

	a. Beneath Highway Structure	**b. South of Highway Structure**	**c. Elliott Street**
			
	Greenway section running along the lands directly beneath the Highway 102 structure.	Greenway section running just south of the Highway 102 structure.	Local street bikeway section on Elliott Street
Pros	• Direct alignment • Adequate width and well prepared base material • Adequate grades • Provides shelter from direct precipitation.	• Direct alignment • Adequate width and well prepared base material • Adequate grades	• Inexpensive due to use of existing street connection • Street has very minimal traffic volume • Adequate grades
Cons	• Relatively steep grades connecting to Joseph Howe Drive • Roadway surface drain pipes discharge below the structure, which could expose users to spray and potentially cause icy conditions during winter. • Bridge piers could limit visibility and pose a collision risk • The existing turning tee would need to be modified or avoided.	• Relatively steep grades connecting to Joseph Howe Drive • Space may be constrained by NS Power transmission tower.	• Relatively steep grades connecting to Joseph Howe Drive • Does not maintain continuity of greenway facility type • Jog in alignment at Ashburn Drive would have awkward transitions

Based on consultation with stakeholders and consideration of the advantages and disadvantages of each option, Option B was selected for further consideration as part of this study. However, it is expected that all three are viable options that could be considered if necessary.

4.2.3 *Ashburn Drive Crossing*

A greenway crossing of Ashburn Drive would be required just south of the Highway 102 overpass structure. Ashburn Drive is a local street that runs north-south approximately 500m between Bayers Road and Mumford Road. Though traffic data were not available from HRM Traffic Managament, it is anticipated that volumes and speeds are relatively low. Visibility on both approaches to the proposed crossing location appear adequate.

It is not anticipated that this location would meet HRM minimum requirements for a marked / signed crosswalk at this time. In the interim, it is expected that a basic trail crossing will be adequate, including installation of new curb cuts and stop signs on both greenway approaches to the street and "Pedestrian / Bicycle Crossing Ahead" (WC47/WC-7S) warning signs on both street approaches to the greenway crossing. A detailed review of the appropriate crossing that includes a data-based analysis should be considered during the detailed design process.

Pedestrian and Bicycle Crossing Ahead' sign (WC-47) and 'Crossing' tab (WC-7S)

Ashburn Drive approaches to the proposed greenway crossing location

4.2.4 *Ashburn Drive to CN Rail Cut*

The section running between Ashburn Drive and the CN rail cut includes a relatively generous amount of property along the south side of Bayers Road and the rear edge of private properties on the north side of Abbott Drive, Ralston Avenue, and Pennington Street. The green space and many mature trees provide a natural envronment that is a reprieve from the nearby heavy traffic on Highway 102.

Based on the available space through the majority of this section, it is expected that a 4.0m greenway section can relatively easily be accommodated with very good separation from the Bayers Road traveled way. Grades are gentle, and the grassy terrain appears ideal for greenway construction.

Lands through this section are owned by NSTIR, from whom approval would be required in order to develop the a greenway. There are also two large NS Power towers adjacent to Bayers Road that should be avoided.

Just west of the CN rail cut, the ROW narrows and crosses two cul-de-sacs: Ralston Avenue and Pennington Street. Both cul-de-sacs restrict vehicle access to Bayers Road with steel guiderail, and have sidewalk and a sod buffer running between them and the Highway 102 inbound lanes. Construction of the greeway connection through these cul-de-sacs would require relocation of existing guiderail and removal of the existing sidewalk. It appears that there is sufficient space within the each cul-de-sac to reduce size as necessary while maintaining manoeuvrability turning vehicles.

Looking west from just east of Ashburn Drive

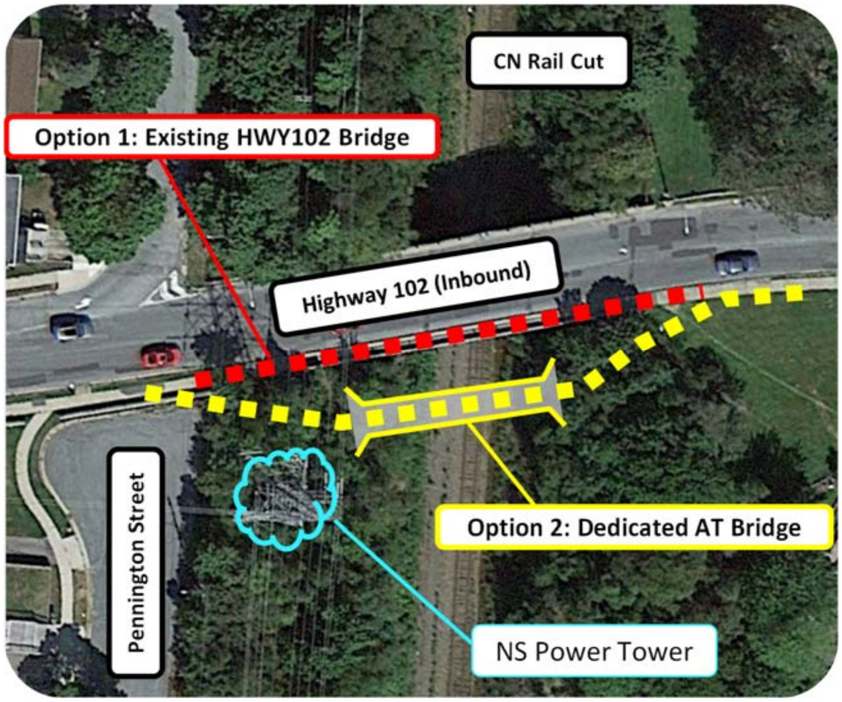
Looking west from just east of Ralston Avenue

Looking west toward Ralston Avenue from Pennington Street

4.3 Section 3: CN Rail Cut Crossing

4.3.1 *Overview*

Located at the approximately midway point of the Study Area, the CN rail cut presents a key challenge for continuity of the greenway connection. In order to continue the proposed greenway east across the rail cut, a structured crossing will be required to bridge the approximately 32m span. Two separate options were considered as part of this assignment, including (1) integration of an AT crossing on the existing Highway 102 inbound lanes bridge structure, and (2) construction of a dedicated AT bridge south of Highway 102. Both rail cut crossing options are discussed in the following sections.



4.3.2 *Option 1: Existing Highway 102 / Bayers Road Bridge*

The existing Highway 102 / Bayers Road bridge was considered as a potential greenway crossing option due to its potential to provide a direct and cost effective crossing. The 11.2m wide bridge presently includes two eastbound traffic lanes (each approximately 4.8m wide), with a 1.5m sidewalk running along its south side. The bridge is owned and maintained by NSTIR, and is approximately 50 years old. NSTIR has indicated that the bridge will require major rehabilitation or replacement in the foreseeable future.

A key regional transportation route, Highway 102 / Bayers Road transitions between a Freeway and Arterial in the vicinity of the bridge, and has an AADT of approximately 19,000 vpd. The posted speed limit on the bridge is 50km/h; however, it is located in a transition zone where eastbound vehicles traveling at high speeds on Highway 102 slow as they approach the more urban character of Bayers Road. As a result, it is expected that vehicle speeds during free flow operation tend to exceed the 50km/h speed limit, in some cases by a considerable margin. Due to the heavy traffic volumes and presumed high operating speeds, physical separation – both horizontal and vertical – is assumed to be an essential component of a crossing on the existing bridge.

Looking east on the Bayers Road CN Rail Cut bridge

Proposed Cross Section

Review of the existing Bayers Road bridge cross section has indicated a width of 11.2m. A proposed cross section for the bridge, illustrated in Figure 4-7, includes the following:

- A 2.5m wide asphalt greenway section on the south side of the bridge, which requires removal of the existing 1.5m concrete sidewalk. Though the 2.5m is narrower than the preferred 3.0m greenway width, it represents a reasonable compromise given the short section and prevailing width constraints;
- A concrete jersey barrier separating the greenway from the adjacent traffic lanes;
- Reduction of the existing travel lane widths from 4.85m to 4.0m. This width exceeds NSTIR's minimum 3.7m minimum standard for this highway classification; however, does not provide the minimum 1.0m separation between travel lanes and adjacent bridge rails / concrete barriers required by NSTIR standards. Designation of minimum 3.7m travel lanes would provide a 0.3m separation on the outside of each lane. Though NSTIR standards are not met, it is noted that the 50km/h speed limit is considerably less than typical for a highway classification. Also, there is potential that narrowed widths could prove beneficial in reducing operating speeds to a level more suited to the current posted speed limit.
- It is noted that the structural capacity of the existing bridge to accommodate these changes has not been explicitly considered. Further consideration of this option would require a detailed structural investigation and capacity analysis.
- The existing railing on the south side of the structure would need to be upgraded to meet standard heights for pedestrian / cyclist facilities.

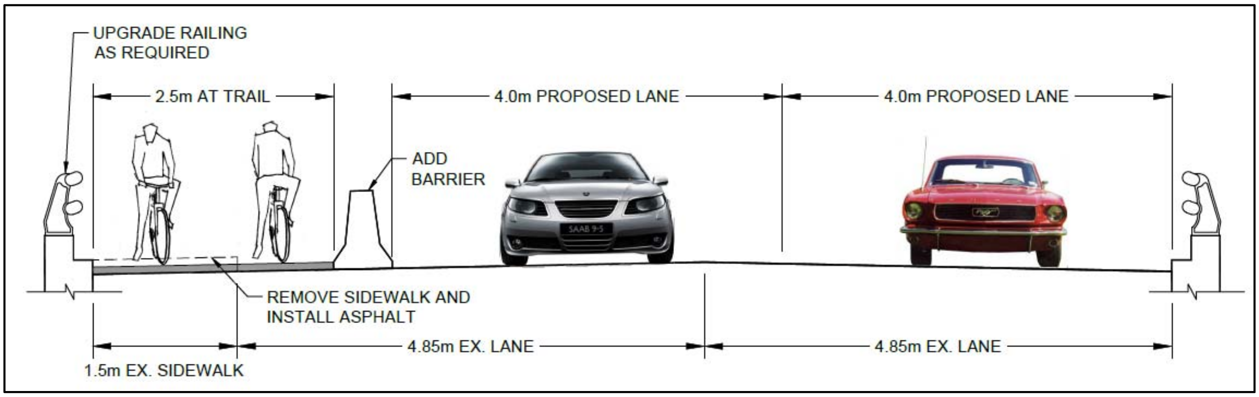


Figure 4-7: Preliminary Cross Section Option at the Bayers Road Rail Cut Bridge

Preliminary feedback from NSTIR related to the proposed cross section has indicated that the department does not currently support the Bayers Road bridge option as shown due to the following[3]:

- Sub-standard separation between travel lanes and adjacent bridge rails / concrete barriers;
- The proposed 2.5m greenway is less than the 3.0 - 4.0m width facility preferred by the Department;

NSTIR indicated its preference for the separate AT bridge option if the project is pursued. The Department also indicated that if a new bridge is constructed, that the proposed alignment should consider future initiatives including the potential future widening of the Highway 102 / Bayers Road Corridor and the expected future rehabilitation / reconstruction of the Bayers Road rail cut bridge, which will be expected to require construction of a temporary bridge for use during construction. It is noted that based on the *Bayers Road / Highway 102 Corridor Study* (Stantec, 2009), the existing bridge has been identified for removal.

4.3.3 *Option 2: Dedicated AT Bridge*

A dedicated AT bridge crossing the rail cut is the alternative to crossing via the existing Bayers Road bridge. Following the proposed alignment on the south side of Bayers Road, a dedicated AT bridge would cross the rail cut parallel to the Bayers Road bridge. Though undoubtedly a more expensive and resource intensive option, it would avoid direct interaction with Bayers Road traffic and provide a more comfortable facility for users.

Looking south on the CN Rail Cut from the Bayers Road bridge

CN Rail Requirements

CN Rail is both a landowner and a regulatory body that would need to be considered in order to pursue a bridge across the rail cut. CN Rail owns lands both within and abutting the rail cut, and consequently would need to be consulted to facilitate any necessary land acquisitions. The following is a summary of key requirements that should be considered related to CN Rail and any proposed rail cut crossing:

[3] Correspondence with NSTIR Development Engineer Greg Chisholm (July 22, 2016 letter – *RE: Highway 102 CN Rail Bridge near Bayers Road (Inbound) AT Cross-Section Concept*)

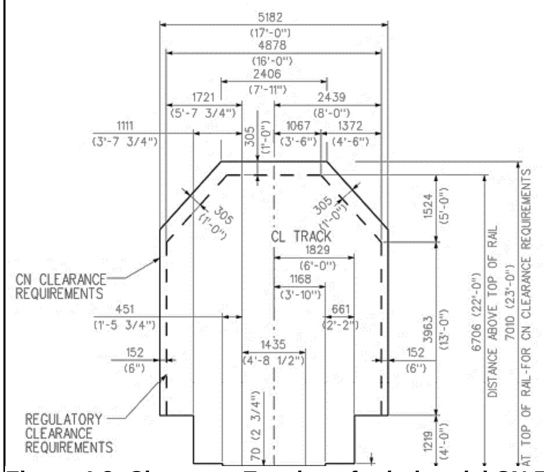


Figure 4-8: Clearance Envelope for industrial CN Rail tracks in Canada [Engineering Specifications for Industrial Tracks] (CN Rail, 2011)

- Clearance: The proposed crossing must meet CN rail cut requirements for structures overpassing railway tracks. The 'clearance envelope' (see Figure 4-8), which defines the horizontal and vertical clearances required around industrial tracks in Canada, indicates a minimum vertical clearance requirement of 7.01m if any structure crosses the rail cut through the proposed alignment.

- Agreements: In order for a new bridge to cross CN's corridor, a '*Standard New Grade Separation Agreement*' would be required. Typically, CN Rail requires an annual payment or license fee for each railway crossing.

- Corridor Access: Permission from CN would be required in order to gain access to the corridor for any required topographical or geotechnical investigations. Prior to the construction phase it would be necessary to obtain approval to construct the bridge abutments and span, and detailed design drawings must be approved by CN prior to construction.

Proposed Bridge Configuration

The proposed bridge would include a 3.0m travelled way cross section and permit AT uses only. The proposed bridge configuration includes the following:

- Reinforced concrete abutments (with retaining walls as required);
- Pre-fabricated steel truss superstructure with concrete or steel deck;
- 50 to 75mm thick asphalt paving over deck;
- 1.5m high railings;
- 5m long paved approach slab on each side;
- Area lighting added on each end and at center span;
- Approximate approach grades: A preferred maximum slope of 5% should be achieved. Based on the grade of the existing overpass and the elevations on either side of the rail cut, it is expected that the pedestrian bridge will have minimal slope (<2%).

It is noted that there may be opportunity to utilize bridge panels recently salvaged from the Macdonald Bridge bikeway. In 2013, WSP completed preliminary design for an AT bridge over the CN rail cut connecting Scot Street and Chisholm Avenue (approximately 450m north of the Bayers Road bridge)[4]. The preliminary design of the proposed 40m Scot Street / Chisholm Avenue bridge, illustrated in Figure 4-9, includes a steel truss structure with concrete abutments and deck panels salvaged from the Macdonald Bridge, providing a total bridge width of 6.2m including a 5.3m-wide travelled way. A design for the dedicated AT bridge at Bayers Road would likely be very similar, though the crossing width is narrower, requiring a shorter span length.

[4] *Engineering Design: Five Active Transportation Bridges Preliminary Design Report* (GENIVAR, 2013)

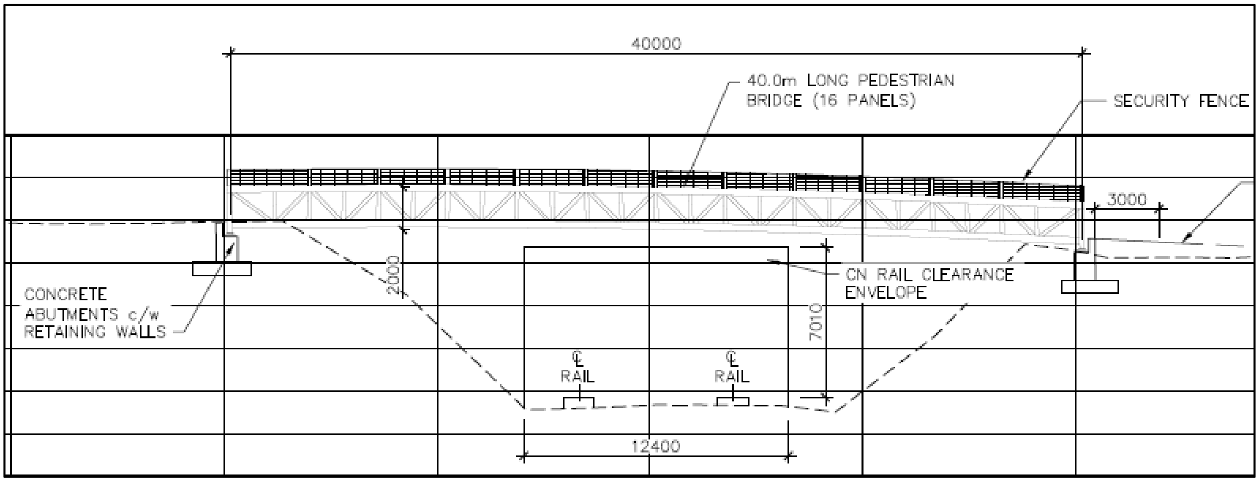


Figure 4-9: Side view of proposed Scot Street / Chisolm Avenue AT bridge crossing the CN Rail Cut

4.4 Section 4: CN Rail Cut to Vaughan Avenue

4.4.1 *Overview*

The approximately 450m section of the proposed connection between the CN Rail Cut and the Vaughan Avenue – Bayers Road intersection represents the most challenging portion of the route. Limited available ROW on Bayers Road, along with uncertainty associated with future roadway widening, make the completion of a continuous greenway a very challenging task. Due to the significant constraints associated with construction of a greenway along the south side of Bayers Road, an alternate option – a parallel local street bikeway connection on Vaughan Avenue – was also considered. Key elements of this alignment section, illustrated in Figure 4-10, are summarized in the following subsections.

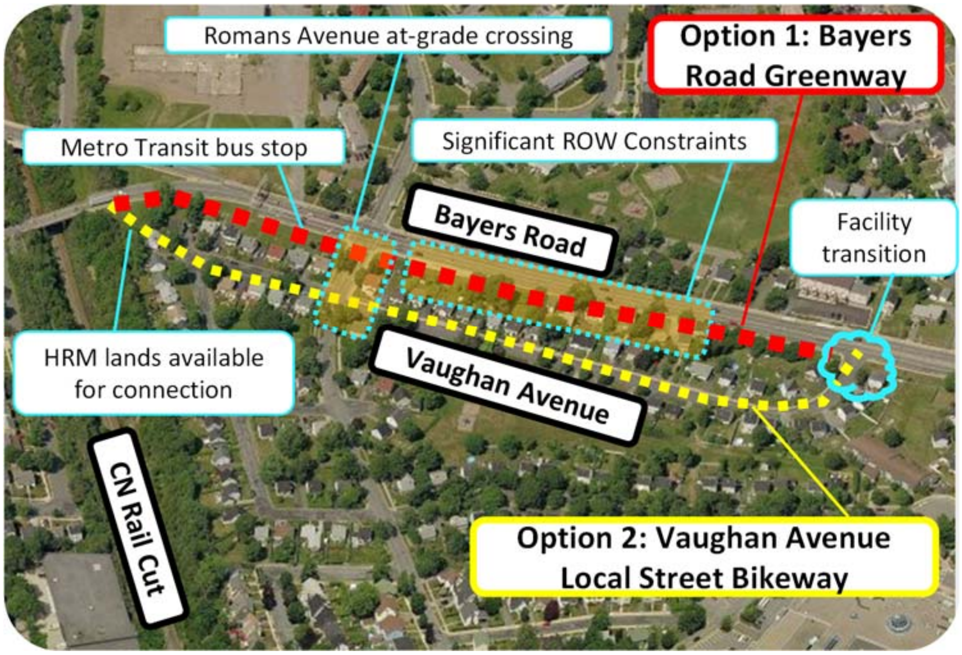


Figure 4-10: Alignment Options: CN rail cut to Vaughan Avenue

4.4.2 *Option 1: Bayers Road Greenway*

Option 1, a greenway connection along the south side of Bayers Road, represents the ideal connection option given its directness and consistency with the preferred facility type for the COLT connection. However, there are significant property constraints that limit its potential, not only in the short-term, but also due to significant widening associated with the future potential Highway 102 / Bayers Road corridor expansion project.

This section of Bayers Road is owned and operated by HRM. A 4-lane undivided arterial roadway with an AADT of approximately 19,000 vpd, it has a posted speed limit of 50km/h. Due to heavy traffic volumes, horizontal separation is assumed to be an essential component of a greenway facility along this section.

Cross Section Considerations

An ideal cross section for the greenway on this section of Bayers Road, illustrated in Figure 4-11, includes a 3.0 wide asphalt greenway section on the south side of the road, separated from the south traffic lane by a 1.0m sod buffer. Construction of this option would require, at a minimum, removal of the existing concrete sidewalk and widening to the south.

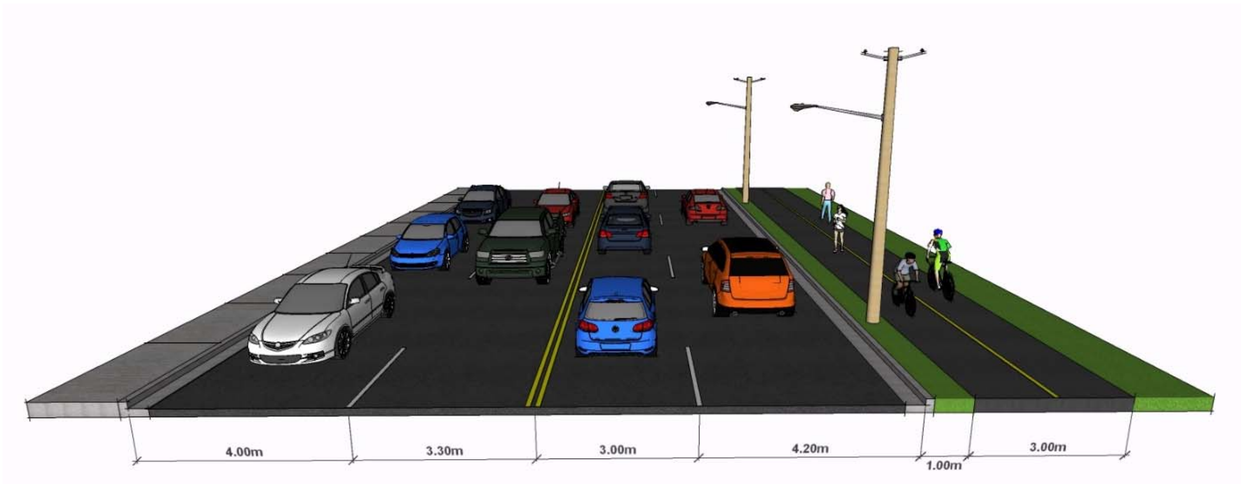


Figure 4-11: Ideal Cross Section (Looking to the east)
Bayers Road Greenway (CN Rail Cut to Vaughan Avenue)

Available ROW varies considerably along this section. In many cases, impacts on private property and/or construction of extensive retaining walls would be required to achieve the desired greenway width. Figure 4-12 indicates four distinct sub-sections and Table 4-4 provides a description of the available ROW and the primary constraints to greenway development.

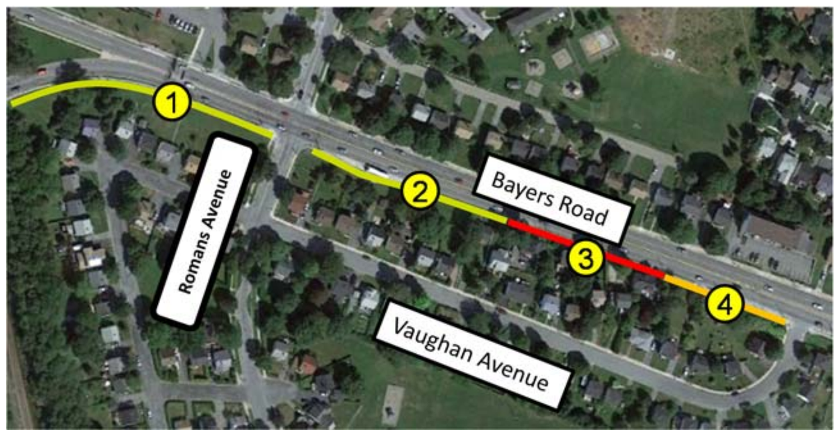


Figure 4-12: Typical Sections – Bayers Road (CN Rail Cut to Vaughan Avenue)

Table 4-4: Summary of Existing Constraints - Bayers Road (CN Rail Cut to Vaughan Avenue)

1. CN Rail Cut to Romans Avenue: Length: 170m Available ROW: 9.5 – 20.5m Sod Buffer Width: 0.7 – 0.9m Sidewalk Width: 1.4 – 1.7m There appears to be adequate ROW to construct a greenway through this section with minimal impacts.	

<table>
<tr><td>2. Romans Avenue to Civic 6850:
Length: 90m
Available ROW: 13.5 – 14.2m
Sod Buffer Width: 0 – 0.8m
Sidewalk Width: 1.6 – 2.5m

There appears to be adequate ROW to construct a greenway through this section without significant impacts. It is expected that a traffic signal pole at Romans Avenue as well as road signage and/or bus stop features would require relocation.
Moderate cross slopes in the vicinity of the bus stop may require fills and retaining walls.</td><td>
</td></tr>
<tr><td>3. Civic 6850 to Civic 6810:
Length: 120m
Available ROW: 3.0 – 4.4m
Sod Buffer Width: 0.9m
Sidewalk Width: 1.6m

There is very minimal available ROW through this section. Widening to the south would encroach on multiple properties, including existing houses that are built up to the property line. It is expected that considerable property acquisition required to achieve desired width.

Steep cross slopes on the south side require cuts and retaining walls.</td><td></td></tr>
<tr><td>4. Civic 6810 to Vaughan Avenue:
Length: 70m
Available ROW: 5.6 – 8.5m
Sod Buffer Width: 0.9m
Sidewalk Width: 1.6m

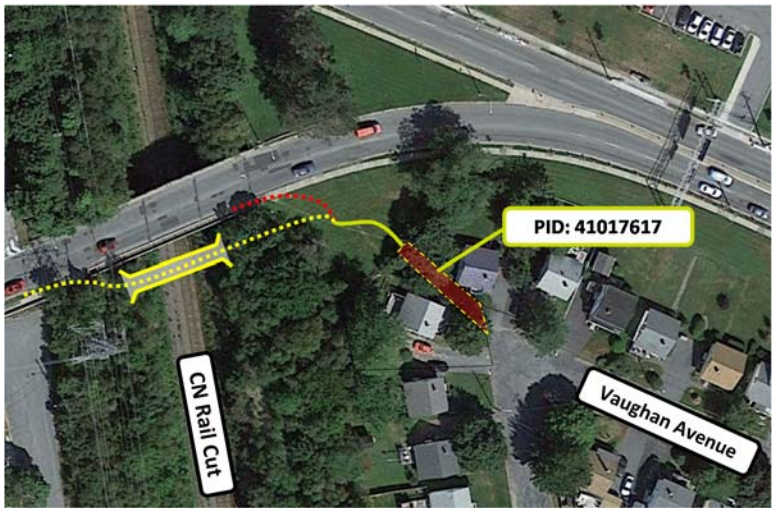
Adequate available ROW; however, steep banks on the south side require fills and retaining walls.</td><td></td></tr>
</table>

Potential Impacts of Bayers Road Widening

This section of Bayers Road could be particularly important in terms of potential future capacity upgrades on the Highway 102 / Bayers Road corridor. Conceptual plans in the *Bayers Road / Highway 102 Corridor Study* (Stantec, 2009) indicate widening from four through lanes to six between Connaught Avenue and Highway 102, in addition to turning lanes and configuration changes at several intersections. Given the minimal available ROW through parts of this section of Bayers Road, it is expected that a considerable amount of property acquisition would be required, including that of several existing houses.

4.4.3 *Option 2: Vaughan Avenue Local Street Bikeway*

Recognizing the constraints associated with Option A, a secondary option has been considered for this section. Option 2 consists of a local street bikeway on Vaughan Avenue, a local street that runs parallel to Bayers Road from just east of the CN rail cut to just west of Coleman Court over a distance of approximately 400m. Though not as ideal as a continuous greenway on Bayers Road, it has fewer challenges and provides an opportunity to maintain continuity of the facility.



An HRM-owned parcel (PID: 41017617) connects to Vaughan Avenue from the east side of the CN Rail Cut

A low volume residential local street (AADT 175 vpd), Vaughan Avenue is well suited for use as a local street bikeway. The existing curb-to-curb width is approximately 9m, accommodating 2-way traffic with unrestricted on-street parking on both sides of the street. There is an approximately 1.6m sidewalk running along the north side of the street (east of Romans Avenue), though the sidewalk width is often pinched by power poles.

The Vaughan Avenue – Romans Avenue intersection, located near the west end of the street, is 2-way stop-controlled, with free flow traffic on Romans Avenue. Romans Avenue has been known as a shortcutting route in the area, and HRM has targeted this through traffic calming measures (chicanes) just south of Vaughan Avenue. Though machine count data were not available for Romans Avenue, a September 2014 turning movement for the nearby Bayers Road – Romans Avenue intersection indicates a peak hour 2-way volume of 337, which translates into a rough AADT estimate of approximately 3,370 vpd.

Looking east on Vaughan Avenue towards the Romans Avenue intersection

Looking north on Vaughan Avenue towards the Bayers Road intersection

Narrow Sidewalk

Design Options

The intent of a local street bikeway is to optimize cycling on a street, which is typically done through the introduction of traffic calming measures that aim to reduce through traffic volumes and vehicle speeds, as well as incorporation of visual cues (i.e. signage, pavement markings) that indicate to both motorists and cyclists that cycling is a priority mode. HRM does not currently have any designated local street bikeways and has yet to established design standards or endorse a design guide for use in the Municipality. As a result, the concepts considered as part of this assignment would be subject to further consideration during more detailed design.

In the case of Vaughan Avenue, since traffic volumes are already very low and there is limited incentive for motorists to use it as a shortcutting route, it is not expected that significant traffic calming features will be required. The key elements of the Vaughan Avenue local street bikeway would rather be focused on signage and pavement markings to

Figure 4-13: Proposed Cross Section (Looking to the east) – Vaughan Avenue Local Street Bikeway

effectively identify the route as a designated AT facility and promote wayfinding. As illustrated in the cross section concept in Figure 4-13, the Vaughan Avenue bikeway could incorporate the following features:

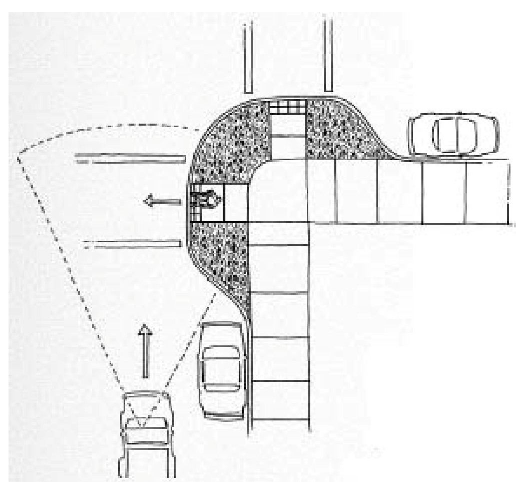
Bike Route Signage: Bike route signage should be considered at the beginning of each block and at regular intervals as a facility identifier. Directional arrows should also be considered in locations where the alignment changes (i.e. at the Bayers Road intersection).

Sharrow Markings: Sharrow markings are used primarily to provide guidance on cyclist positioning and typically accompany the 'Share the Road' warning sign. They can also be used on local street bikeways to complement bike route signage and raise awareness to the priority of cycling to the street. Sharrow placement is an important consideration – since Vaughan Avenue has on-street parking, consideration may be given to locating sharrow makings closer to the centre of the street, outside of the 'door zone'.

Intersection Treatments: The Romans Avenue intersection is the most challenging location to consider. Ideally, cyclists should be given increased opportunity for a safe and convenient crossing. However, given the significant imbalance in traffic volumes between Vaughan Avenue and Romans Avenue, it may be difficult to assign priority to Vaughan Avenue. Given that Romans Avenue has been identified as a route in need of traffic calming, there may be opportunity to further enhance existing traffic calming on the street through installation of features at the Vaughan Avenue – Romans Avenue intersection.

Intersection treatment options that could be considered include modification of the stop control configuration (convert to all-way stop or make Vaughan Avenue free flow). Alternatively, intersection geometry could be modified to reduce the crossing distance and improve visibility of cyclists. This could be achieved through addition of curb extensions.

4-way Stop



Corner Curb Extension (FHWA)

4.5 Section 5: Vaughan Avenue to George Dauphinee Avenue

At the eastern end of the Study Area, the proposed facility would include a greenway section along the south side of Bayers Road. Similar to the the Bayers Road portion of Section 4, this section is challenging due to limited available ROW, terrain, and uncertainty associated with future roadway widening. The Halifax Shopping Centre also presents a key challenge. Key elements of this alignment section, illustrated in Figure 4-14, are summarized in the following subsections.

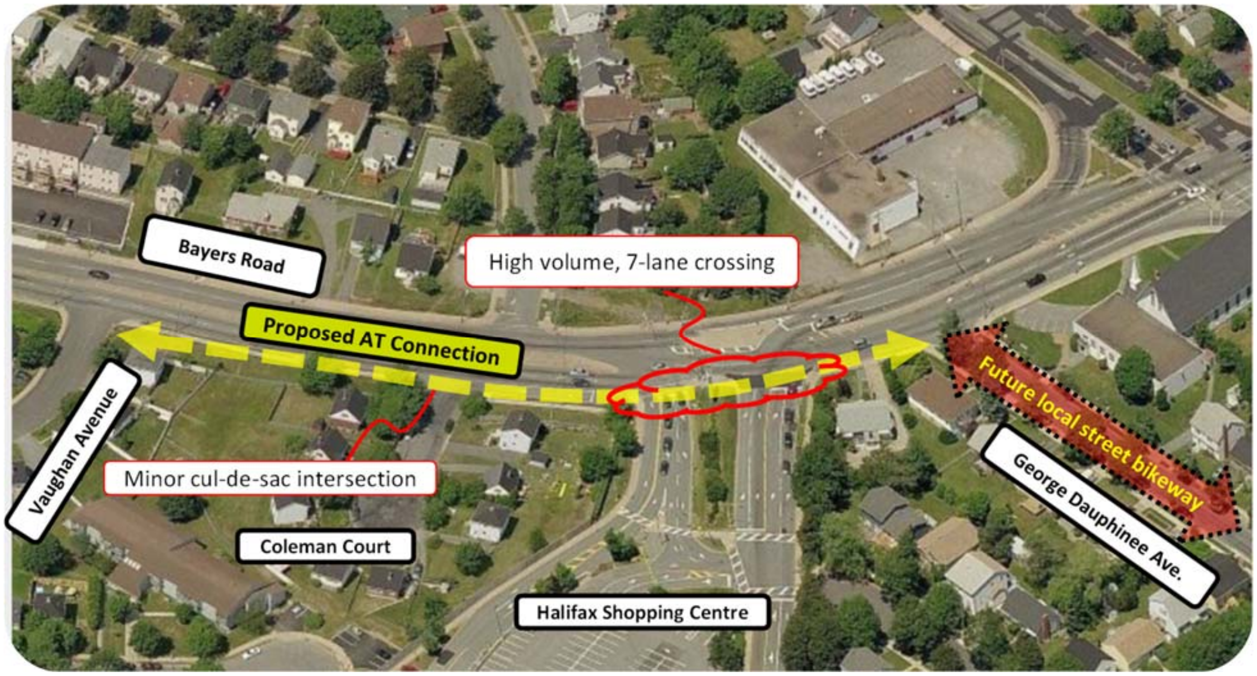


Figure 4-14: Vaughan Avenue to George Dauphinee Avenue

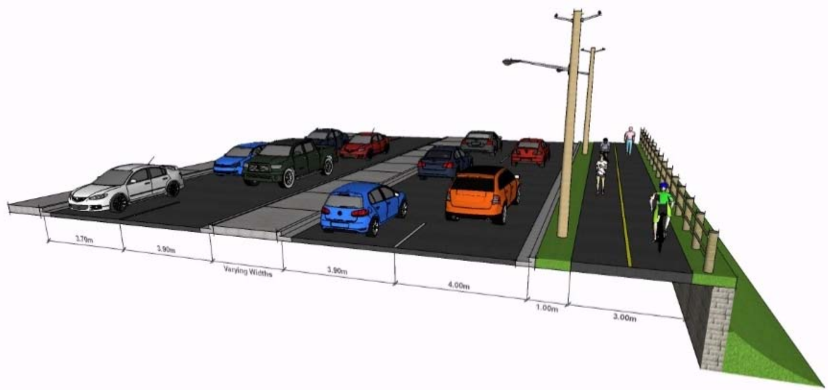
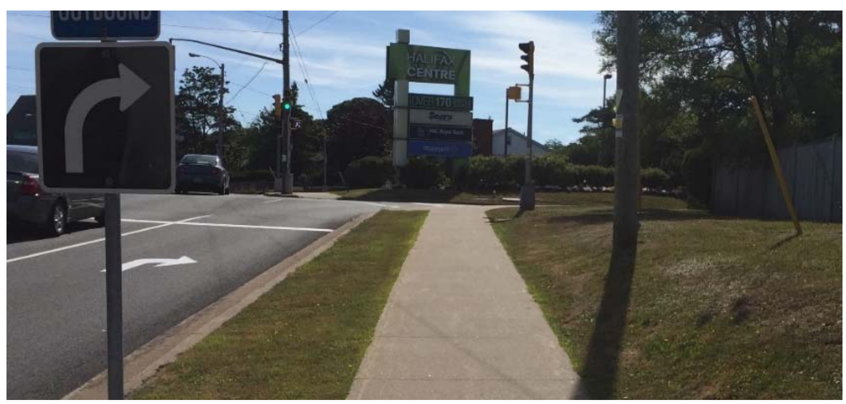
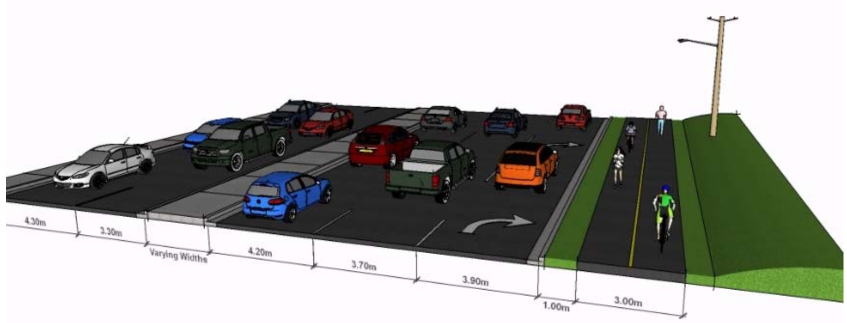
4.5.1 *Bayers Road Sections*

This section of Bayers Road is owned and operated by HRM. It primarily consists of a 4-lane divided cross section (with additional turn lanes), and is an arterial roadway with an AADT of approximately 19,000 vpd. Due to heavy traffic volumes, horizontal separation is assumed to be an essential component of a greenway facility along this section.

Cross Section Considerations

The preferred facility type on Bayers Road includes a 3.0m asphalt pavement greenway along the south side of the street, separated by a 1.0m sod buffer area. This will require removal of the existing concrete sidewalk and widening of the facility to the south. Generally, property constraints are less of a concern along this section than on other sections of Bayers Road; however, varying terrain along the south side of the road is a key consideration. Steep banks in some areas will require the some relatively large fill sections and retaining walls in order to provide the desired 3.0m greenway width.

Table 4-5: Summary of Existing Constraints and Proposed Cross Sections
Bayers Road (Vaughan Avenue to George Dauphinee Avenue)

Vaughan Avenue to Coleman Court: Length: 80m Available ROW: 9.2 – 10.5m Sod Buffer Width: 0.9m Sidewalk Width: 1.6m There appears to be adequate ROW to construct a greenway through this section. However, steep banks on the south side require fills and retaining walls to achieve the desired width. Generally, the distance between the edge of sidewalk and top of slope is approximately 1.0m, and distance between top of slope and the property boundary is approximately 6.0m. Railing will be required along the edge of the retaining wall.	 
Coleman Court to Halifax Shopping Centre Driveway: Length: 40m Available ROW: 9.9 – 10.5m Sod Buffer Width: 1.3 – 1.6m Sidewalk Width: 1.6m There appears to be adequate ROW to construct a greenway through this section with minimal impacts. The terrain slopes toward the south side of Bayers Road; as a result, cuts will be required to achieve the desired width.	 

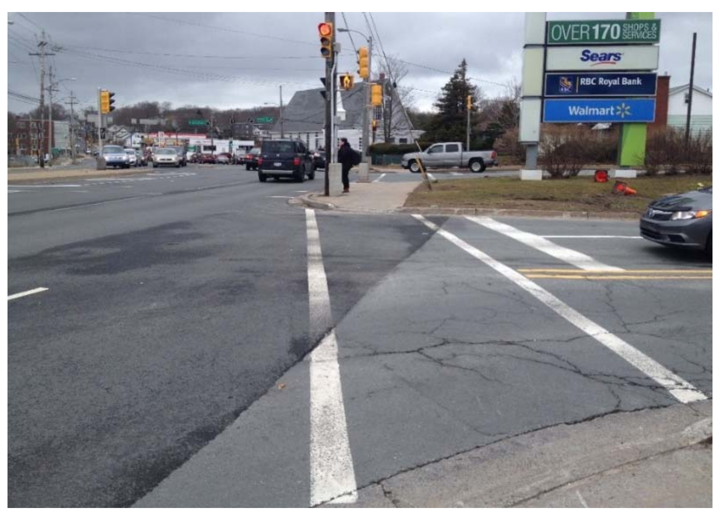
Halifax Shopping Centre to George Dauphinee Avenue:
Length: 30m
Available ROW: 3.5m
Sod Buffer Width: 0.9m
Sidewalk Width: 1.5m – 1.9m

There is inadequate width between the curb and property line to add the preferred 1.0m sod buffer and 3.0m greenway. For this short section, the following options could be considered:

i. Reduce greenway width from 3.0m to 2.5m.
ii. Retain 3.0m greenway width, but encroach on property line.
iii. Retain 3.0m greenway width, but remove 1.0m sod buffer. Note that there is one pole located within the existing sod buffer.
iv. Reclaim a portion of the traveled way in order to widen to preferred greenway width.

4.5.2 *Halifax Shopping Centre Driveways*

The Halifax Shopping Centre Driveway intersection presents a challenge for the proposed connection. It is a signalized intersection with multiple approach lanes and two separate two-way driveways to / from the mall. Traffic volumes are heavy during peak periods – particularly through traffic on Bayers Road – and the intersection is in close proximity (approximately 110 metres) to the Bayers Road intersection at Connaught Avenue. Incorporation of an enhanced crossing of the driveway for greenway users requires consideration of heavy turning volumes in and out of the Shopping Centre, and proposed solutions should aim to limit any impacts to operation of the signalized intersection.



Looking east across the Halifax Shopping Centre Driveways

For the purposes of this Study, two separate options have been considered: (i) Do nothing (dismount and use existing crosswalks) and (ii) Modified operation to improve crossing for greenway users.

Option 1: Do Nothing (Dismount and Use Existing Crosswalks)

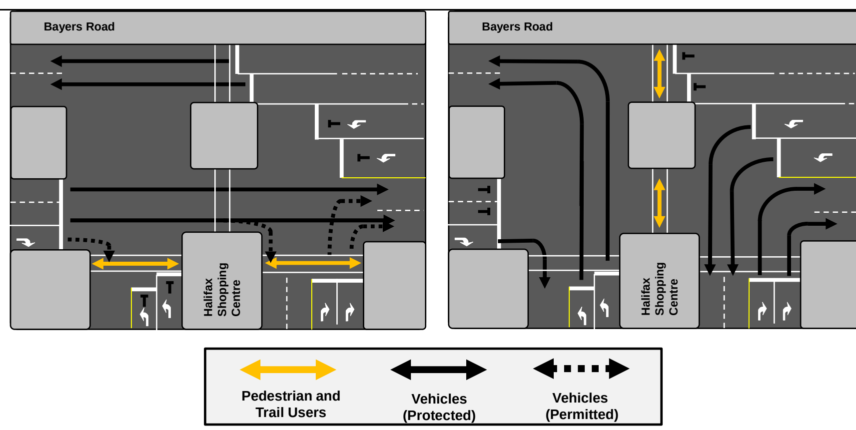
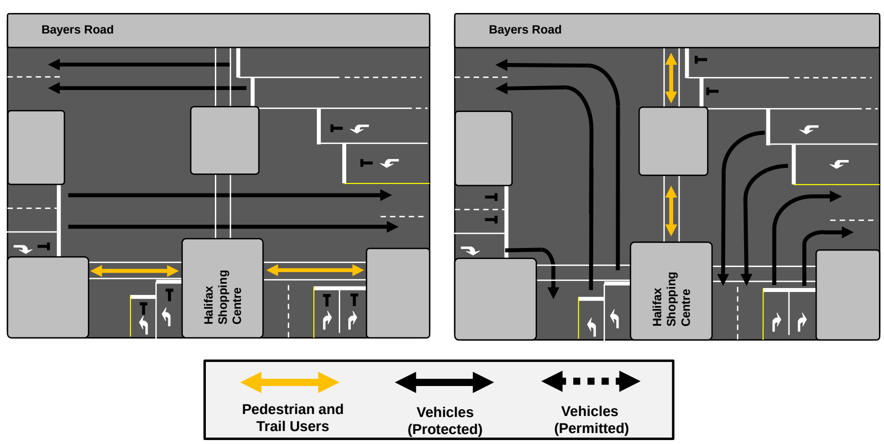
The simplest and least impactful option for this crossing is to leave it in its current configuration, requiring cyclists to dismount and walk their bicycle across the existing crosswalks. Although dismounting is not ideal for cyclists, this requires minimal to no impact on or modifications to the intersection while maintaining a safe crossing.

RB-79: Dismount and Walk Sign

Option 2: Modified operation to improve crossing for greenway users

An alternate option that could be considered to improve the crossing experience for greenway uses would be to modify intersection operation – specifically signal phasing and turn restrictions – to separate vehicle movements and greenway users.

The shopping centre driveways currently operate as a two-phase signalized intersection (See Figure 4-15). As illustrated in the modified signal phasing diagram shown in Figure 4-16, changes could be made to the signal phasing and turn permissions to remove the conflicts between the right turning vehicles into and out of the Halifax Shopping Centre driveways and the greenway crossings of the Shopping Centre driveways. The removal of the ‘permitted’ right turns would improve safety and comfort for users of the facility.

Existing Signal Phasing	 **Figure 4-15**
Optional Modified Signal Phasing • Restrict northbound right turns on red; • Restrict eastbound right turns on red (separate right turn signal displays are required); • Prohibit eastbound right turns at the east driveway.	 **Figure 4-16**

To evaluate the anticipated impact on intersection operation resulting from these changes, intersection level of performance analysis was completed using Synchro 9.0 software with traffic volumes and existing signal timings provided by HRM and with modified signal phasing.

Results of this analysis, summarized in Table 4-6, indicate the following:

- Right turn movements including the Bayers Road eastbound right turn (west driveway) and Halifax Shopping Centre northbound right turn experience decreases in level of performance for all time periods, most notably during the PM peak hour. However, the movements still operate within HRM acceptable limits.

- The Bayers Road eastbound through movement experiences modest improvements in level of performance.

Given the considerable increase in queue lengths for the Bayers Road eastbound right turn movement, it is expected that an extension of the existing right turn storage lane would be beneficial.

Table 4-6: Intersection Performance Analysis: Existing and modified Halifax Shopping Centre Intersection

LOS Criteria	Control Delay (sec/veh), LOS, v/c Ratio, and 95%ile Queue (m) by Intersection Movement							Overall Intersection	
	EB-T	EB-R (west dw)	EB-R (east dw)	WB-L	WB-T	NB-L	NB-R	Delay	LOS
Weekday AM Peak Hour - Existing Conditions (Pages C-5, C-6)									
Delay	36.2	6.4	6.0	33.0	12.9	30.5	28.1	15.7	B
LOS	C	A	A	C	B	C	C		
v/c	0.93	0.03	0.03	0.26	0.40	0.04	0.21		
Queue	239.7	5.4	1.0	31.2	59.2	7.6	22.8		
Weekday AM Peak Hour - with Phasing Modifications (Pages C-9, C-10)									
Delay	32.4	32.1	0.0	33.0	12.9	30.5	32.6	14.8	B
LOS	C	C	A	C	B	C	C		
v/c	0.91	0.14	0.00	0.26	0.40	0.04	0.22		
Queue	227.2	20.2	0.0	31.2	59.2	7.6	25.2		
Weekday PM Peak Hour - Existing Conditions (Pages C-7, C-8)									
Delay	13.3	4.0	1.3	42.2	20.2	45.9	12.8	12.0	B
LOS	B	A	A	D	B	D	B		
v/c	0.50	0.09	0.09	0.28	0.76	0.49	0.34		
Queue	89.9	9.1	0.0	35.9	182.2	61.2	20.9		
Weekday PM Peak Hour - with Phasing Modifications (Pages C-11, C-12)									
Delay	12.8	47.3	0.0	42.2	20.2	45.9	45.1	14.3	B
LOS	B	D	A	D	B	D	D		
v/c	0.47	0.44	0.00	0.28	0.76	0.49	0.43		
Queue	82.6	58.0	0.0	35.9	182.2	61.2	49.5		

5.0 Functional Design and Cost Estimates

5.1 Summary and Recommendations

5.1.1 Section 1: Joseph Howe Drive Crossing

Establishing an improved crossing of Joseph Howe Drive in a critical component of the proposed COLT extension. Multiple options for improving the crossing were investigated, ranging from use of the existing crosswalk to intersection modifications that enable a more direct crossing between the COLT and the east side of Joseph Howe Drive.

- The preferred option for this crossing, as detailed in Section 4.1.3, includes a new direct crossing of Joseph Howe Drive south of the existing crosswalk. Proposed intersection modifications include shifting the existing south crossing approximately 15m to the south (to provide the direct east-west connection), elimination of the eastbound right turn channel (to remove the two-stage crossing for pedestrians and cyclists heading to/from the east) and addition of a southbound right turn channel island (to provide pedestrian / cyclist refuge and significantly improve operation of the southbound right turn movement). This crossing may be considered a candidate for a "CrossRide" treatment if permitted in the future under the MVA.

5.1.2 Section 2: Joseph Howe Drive to CN Rail Cut

The section between Joseph Howe Drive and the CN Rail Cut runs east-west approximately 500m, primarily along the south side of Highway 102 and Bayers Road. Overall, this section provides good options for development of a greenway connection. The majority of lands are owned by NSTIR, and in general there is available ROW to install a greenway with good separation from traffic.

- The recommended alignment through this section includes a greenway connection south of the Highway 102 overpass structure, an at-grade crossing of Ashburn Drive, and a separated 4.0m wide greenway section running south of Bayers Road.

5.1.3 Section 3: CN Rail Cut Crossing

The CN rail cut represents a key challenge along the proposed connection, as a structured crossing will be required. Two separate options were considered for the crossing, including:

1. AT Crossing on the existing Highway 102 inbound bridge structure: Preliminary investigation indicates that width constraints on the bridge structure would limit the greenway width to 2.5m, while providing substandard separation distance between the travel lanes and the adjacent railings / barriers. NSTIR has indicated that it does not support the concept as presented.

2. Dedicated AT bridge: Consideration was given to the potential for a new AT bridge south of the existing Highway 102 bridge. A new structure would provide a more comfortable and convenient crossing for cyclists without the need to disturb the existing structure. However, the new bridge would require increased construction costs as well as extensive coordination with CN, along with ongoing leasing costs.

- It is recommended that HRM consider both of these options moving forward. Further consultation with NSTIR should be completed in order to determine if an agreement for Option 1 can be established. Given that minimum standards are only marginally exceeded, and that the highway facility is located in a transition zone (freeway to arterial road), there may be opportunity to identify a context sensitive design that is to the satisfaction of both parties. With regard to the dedicated AT bridge, initial planning and discussions with CN should be considered.

5.1.4 *Section 4: CN Rail Cut to Vaughan Avenue*

The section between the CN Rail Cut and the Vaughan Avenue – Bayers Road intersection is the most challenging portion of the route. Two options were considered:

1. Bayers Road Greenway: The ideal option in terms of route connectivity, this concept is signficantly constrained by limited available ROW on Bayers Road, along with uncertainty associated with future roadway widening.

2. Vaughan Avenue Greenway: A local street bikeway running parallel to Bayers Road on Vaughan Avenue. Though not as ideal as a continuous greenway on Bayers Road, it has fewer challenges and provides an opportunity to maintain continuity of the facility.

   - It is recommended that the local street bikeway be considered in the short-term, with ongoing consideration of the potential for the Bayers Road Greenway as HRM determines its approach to any capacity upgrades to the Highway 102 / Bayers Road corridor. It is recognized that although there are significant property constraints, they are limited to a small number of individual parcels, and that ongoing corridor preservation efforts by HRM may introduce opportunities that make this option more feasible.

5.1.5 *Section 5: Vaughan Avenue to George Dauphinee Avenue*

The proposed facility would include a greenway section along the south side of Bayers Road. Though constraints related to property / terrain and the potential for future road widening are present along this section, they are not as significant as on other sections of Bayers Road. The alignment crosses a major intersection at the Halifax Shopping Centre – though there are limited options available to improve the crossing for AT users, a concept for revised signal phasing was considered that reduces some key conflicts with turning vehicles.

- It is recommended that the proposed greenway alignment be further considered, and that consideration be given to the proposed signal phasing modifications.

5.2 Functional Design

Functional design drawings have been prepared for concept options representing the recommended alignment. The concept sketches that have been prepared for this assignment are intended to illustrate functional interpretations of the recommended upgrades and provide a basis for preliminary cost estimates. The design used a combination of HRM GIS information (property, contour, infrastructure, aerial photography layers), topographical survey (provided by Bicycle Nova Scotia), and field measurements to establish existing conditions. Functional design drawings are provided in Appendix A.

5.3 Cost Estimates

Preliminary cost estimates, developed based on the concept sketches, are provided in Appendix B. These cost estimates are limited by the lack of available topographical and geotechnical information, but are provided as a reference for planning purposes. The estimates include a contingency of 20% to reflect the uncertain nature of the prices, and include construction costs only (no allowance has been made for engineering, administration, inspection or environmental costs).

A summary breakdown by section is provided in Table 5-1.

Table 5-1: Summary of preliminary cost estimate by section

Section	Preliminary Cost Estimate (HST excl.)[1]
1. **Joseph Howe Drive Crossing**	$140,000
2. **Joseph Howe Drive to CN Rail Cut**	$290,000
3. **CN Rail Cut Crossing**[2]	$110,000
4. **CN Rail Cut to Vaughan Avenue**[3]	$90,000
5. **Vaughan Avenue to George Dauphinee Avenue**[4]	$250,000
TOTAL	**$880,000**

Notes:
1. Itemized breakdown of estimated costs are provided in Appendix B. Costs include a 20% contingency to represent the level of uncertainty.
2. Cost estimate is based on the modification of the existing Highway 102 rail cut bridge to include a greenway. The estimated cost to construct the 40m dedicated AT bridge is $500,000.
3. Cost estimate is based on the construction of the local street bikeway option, including connection to the CN rail cut. Costs have not been estimated for the Bayers Road Greenway option.
4. Cost estimate includes modification of the Halifax Shopping Centre driveway to include revised signal phasing and an extended eastbound right turn storage lane.

Appendix A
Conceptual Alignment and Profile Sketches

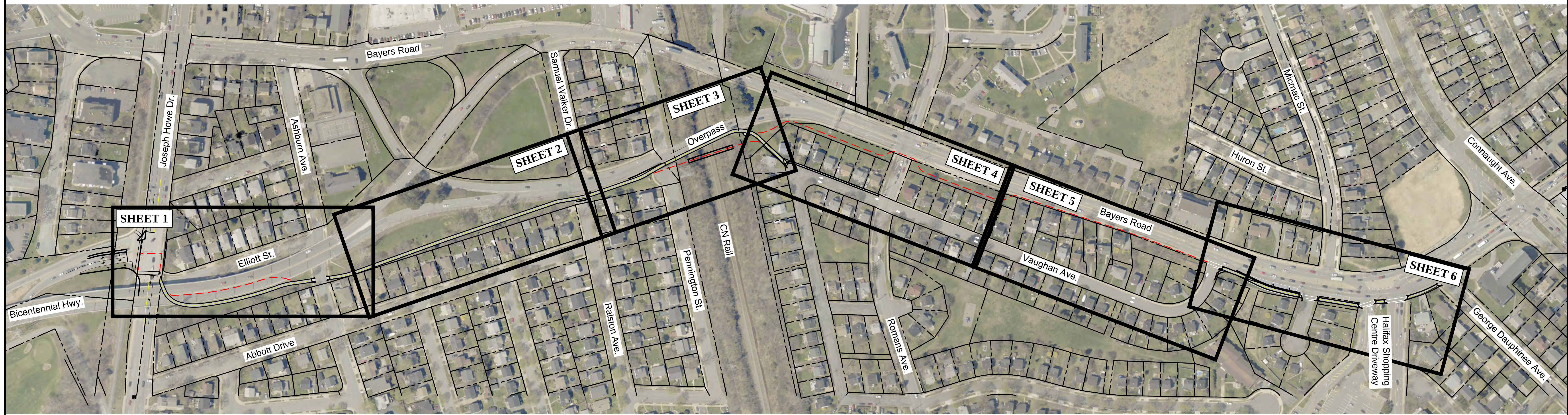
ACTIVE TRANSPORTATION CONNECTION STUDY:
CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

FUNCTIONAL DESIGN

HALIFAX, NOVA SCOTIA

REVISION 0
ISSUED FOR REVIEW - SEPTEMBER.01, 2016

DRAWING LIST:



NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

PRELIMINARY

SHEET 0

COVER SHEET

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:3000 METRIC

60 40 20 0 60 120 180

Drawn: P. NICKERSON

Checked: M. CONNORS

Date: SEPT. 1, 2016

CLIENT

HALIFAX

BICYCLE NOVA SCOTIA

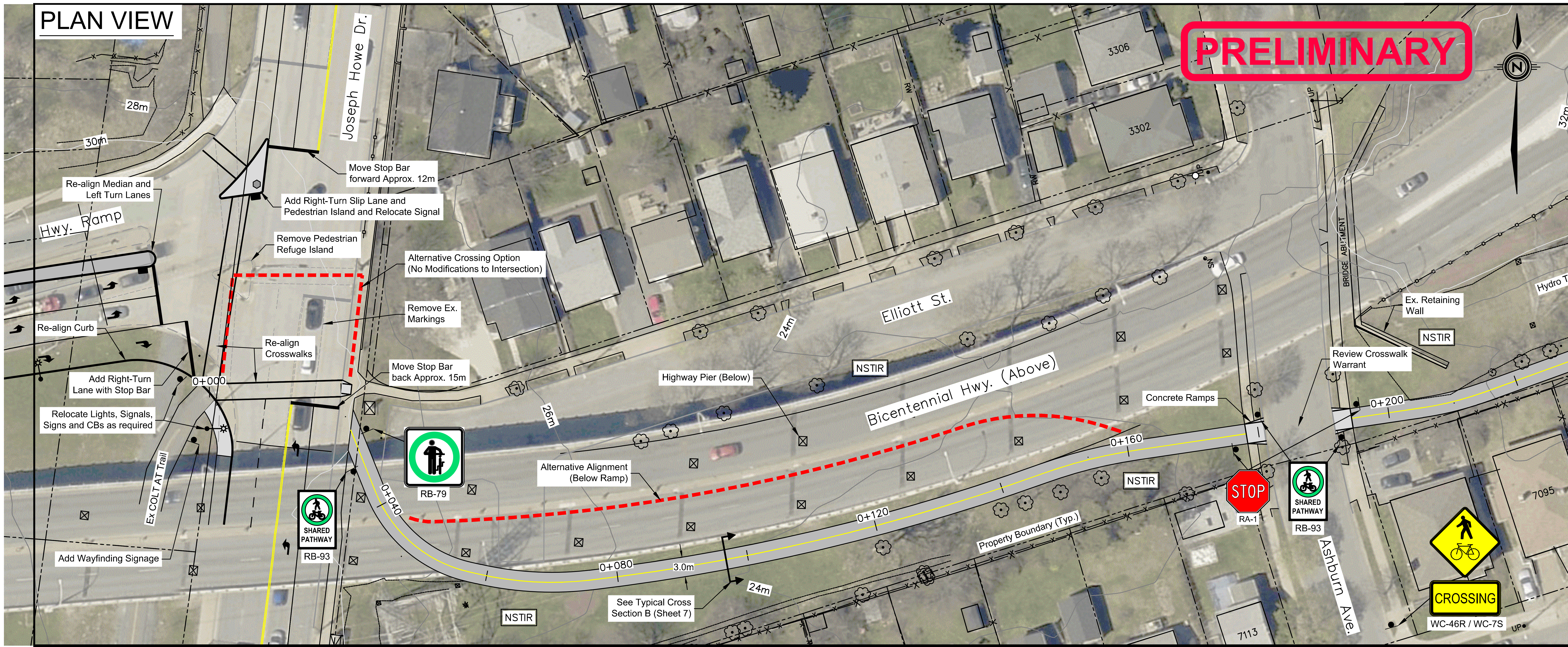
WSP

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

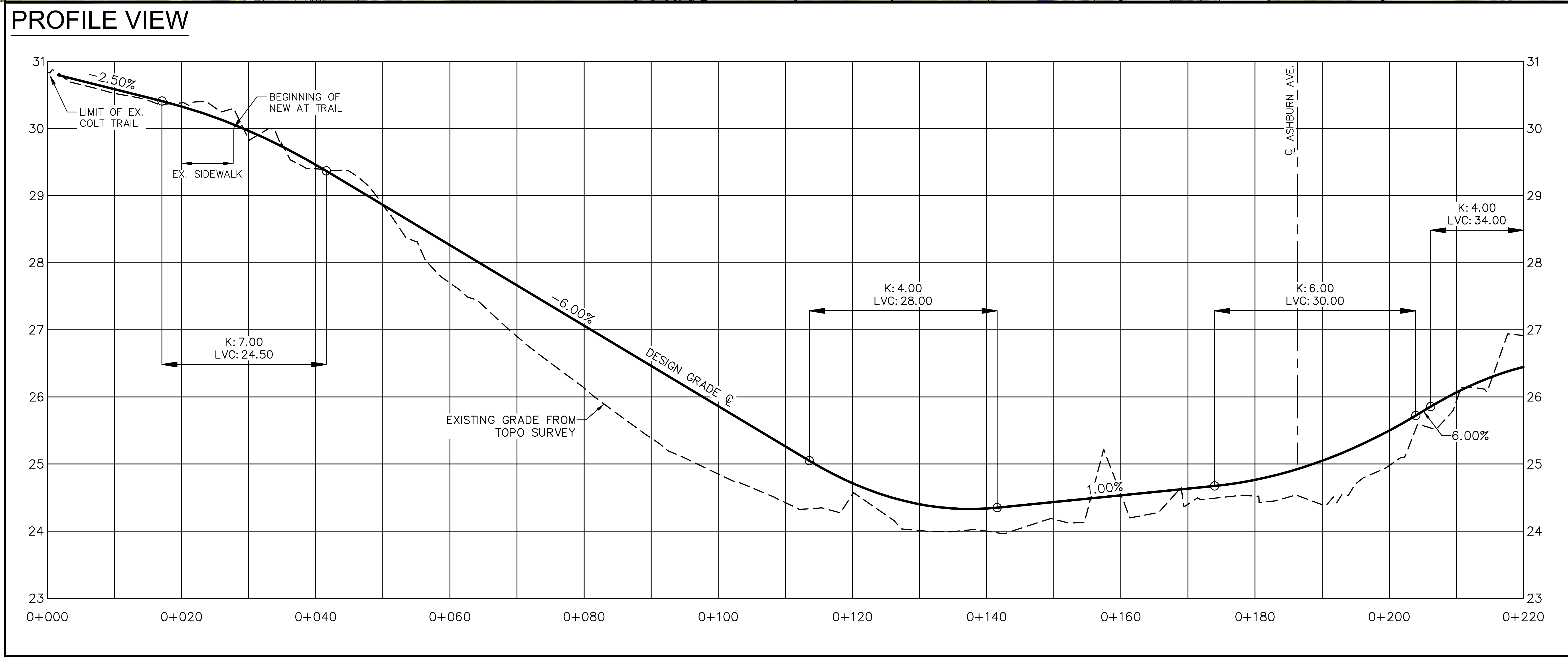
Sheet:0

FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PLAN VIEW



PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- REMOVED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 1

PLAN & PROFILE
STA. 0+000 TO 0+220

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC

10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

WSP

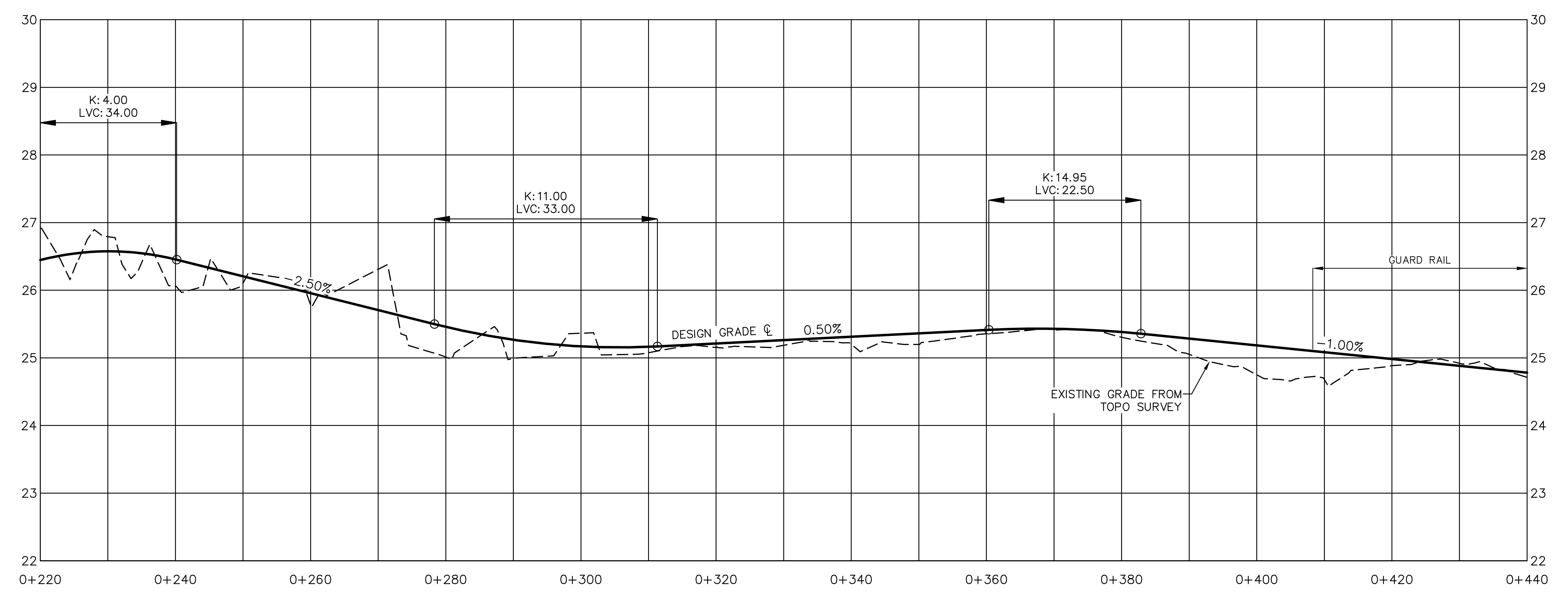
1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

Sheet:1

FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PLAN VIEW

PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- PROPOSED TOP OF SLOPE
- GUARD RAIL / SAFETY FENCE
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 2

PLAN & PROFILE
STA. 0+220 TO 0+440

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC

10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

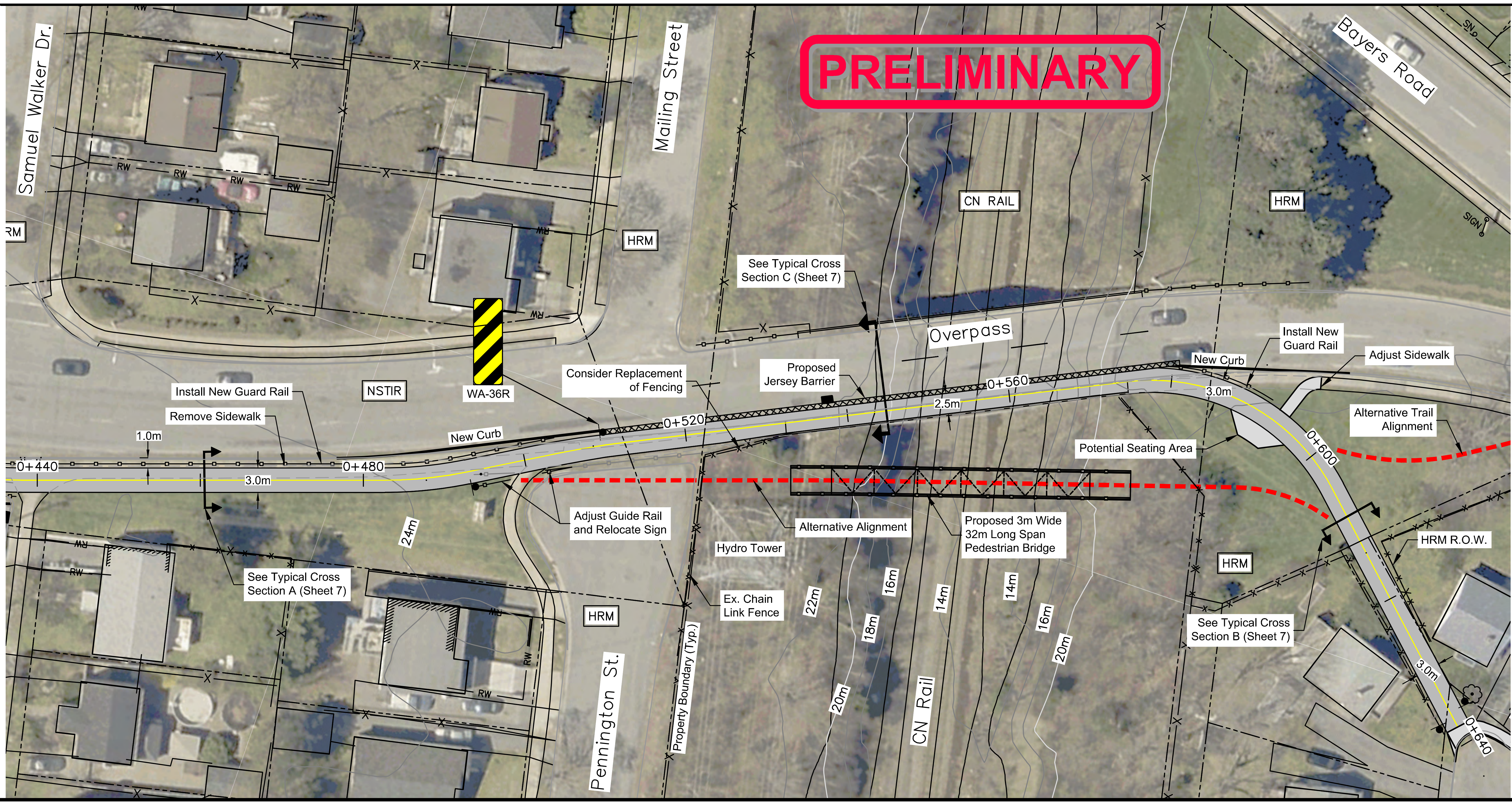
WSP

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

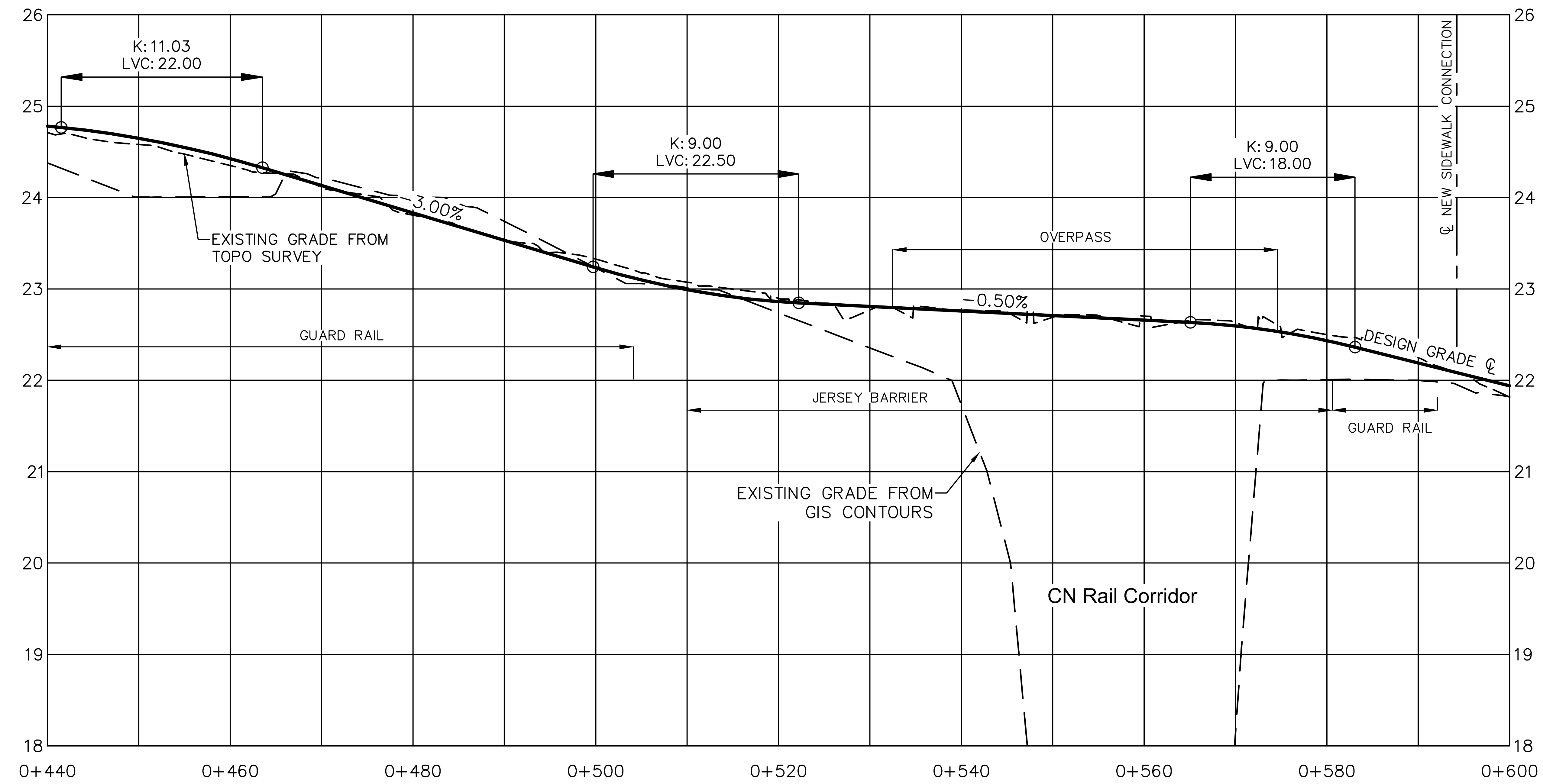
Sheet:2

FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PLAN VIEW



PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- PROPOSED TOP OF SLOPE
- GUARD RAIL / SAFETY FENCE
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 3

PLAN & PROFILE
STA. 0+440 TO 0+600

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC

10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

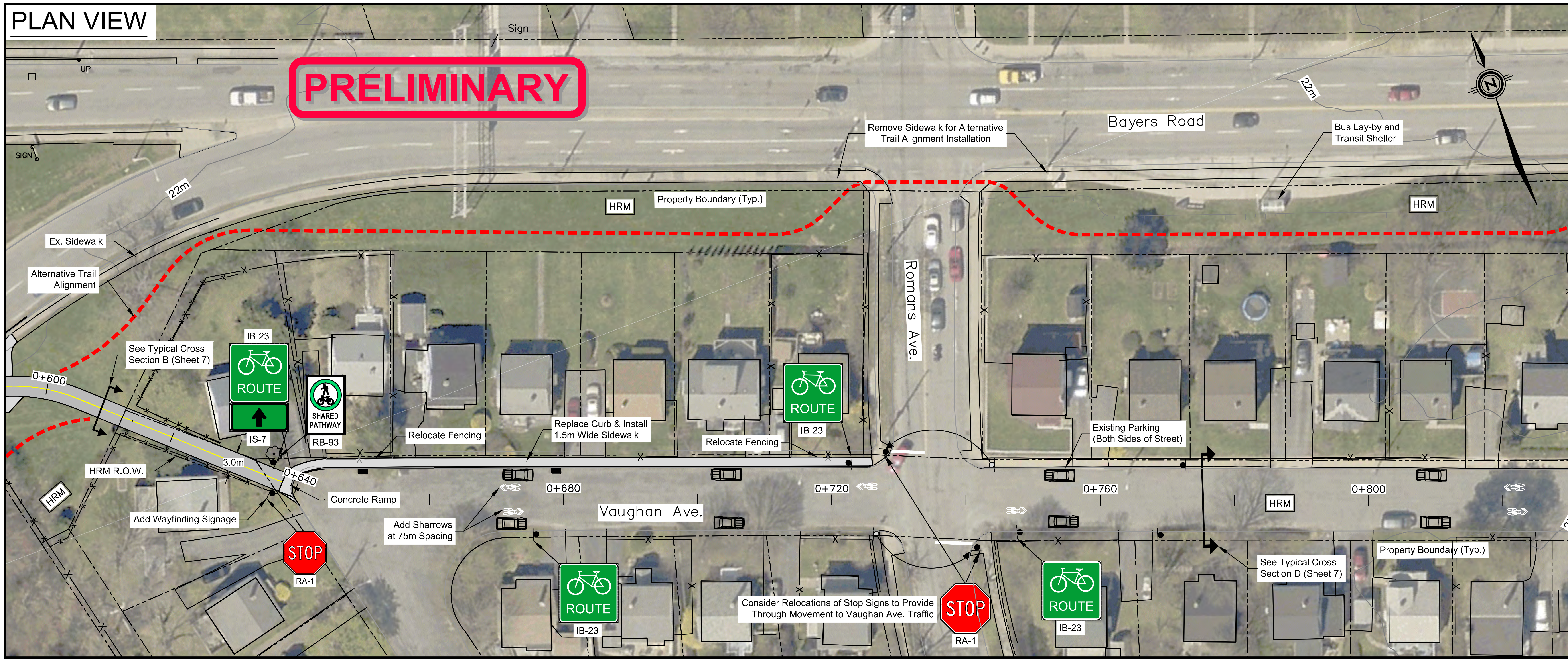
WSP

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

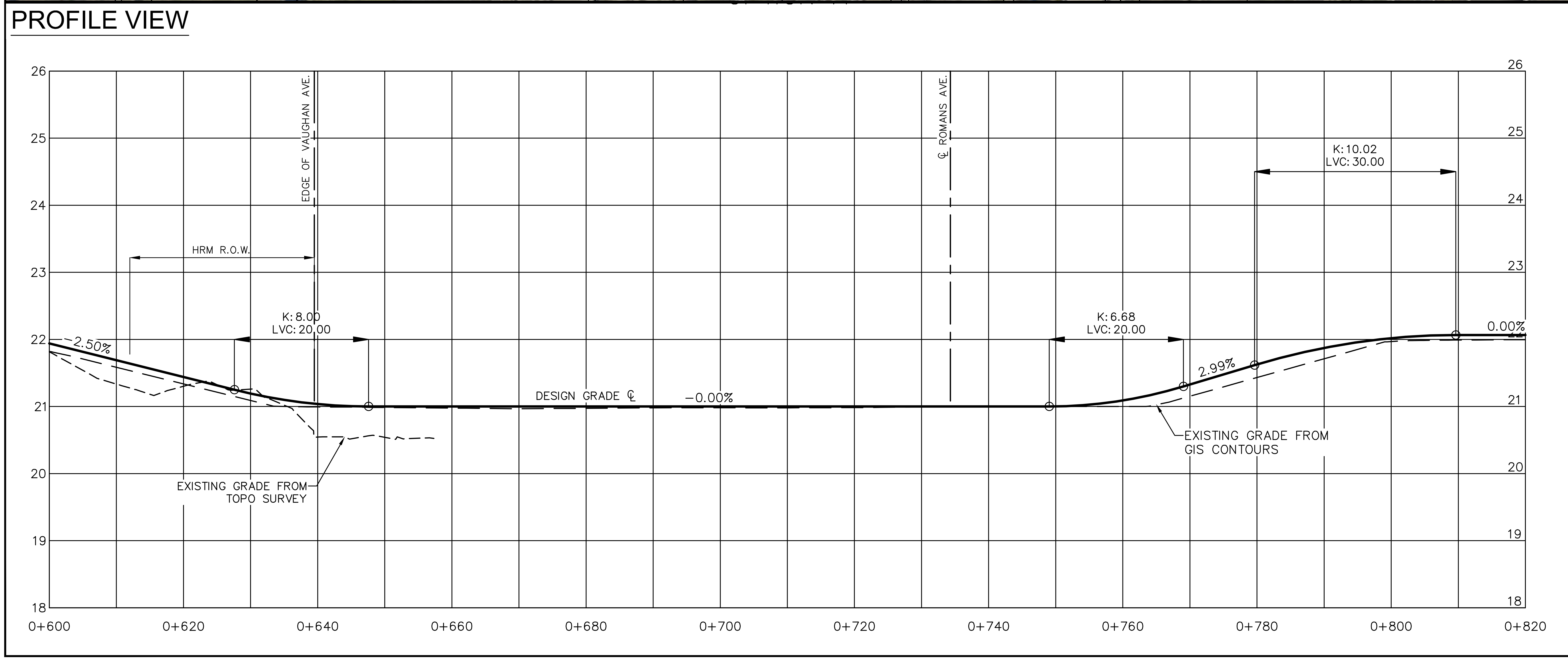
Sheet:3

FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PLAN VIEW



PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- PROPOSED TOP OF SLOPE
- GUARD RAIL / SAFETY FENCE
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 4

PLAN & PROFILE
STA. 0+600 TO 0+820

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC
10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

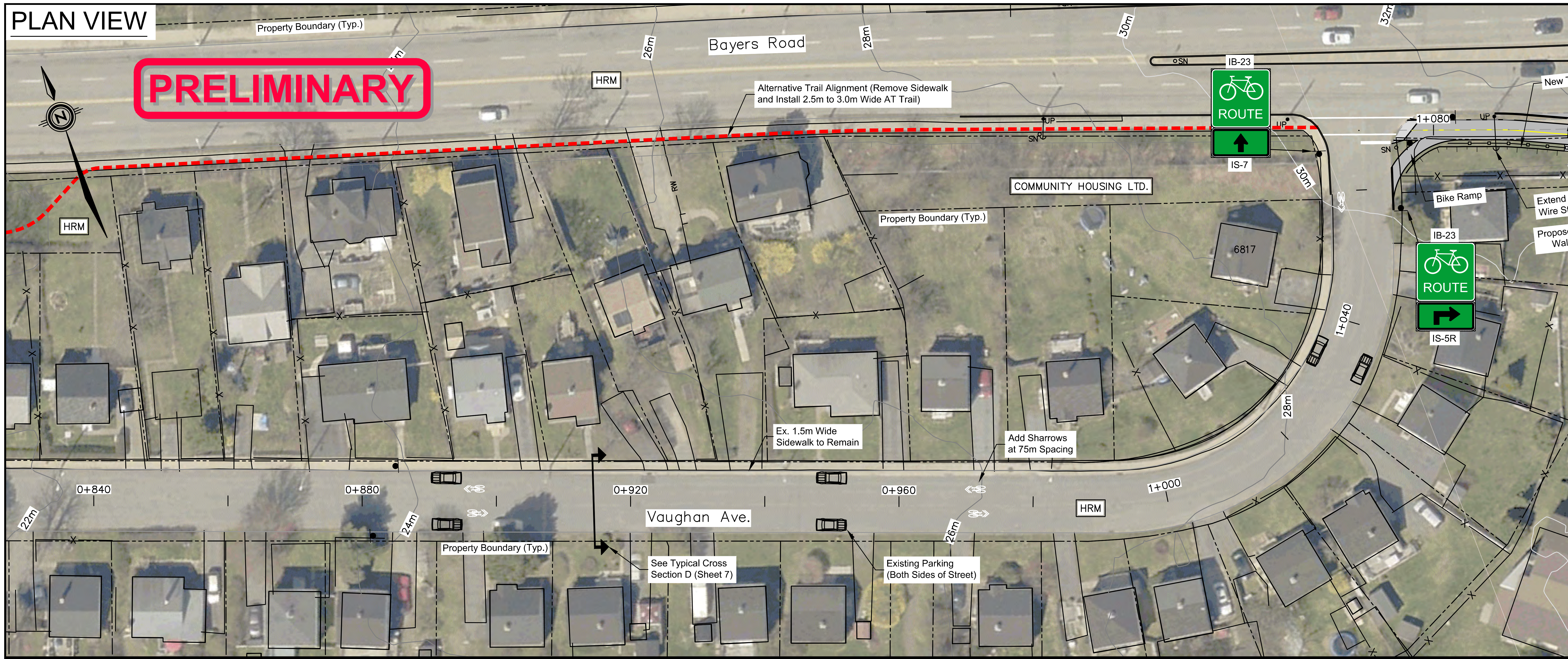
HALIFAX
BICYCLE NOVA SCOTIA

WSP

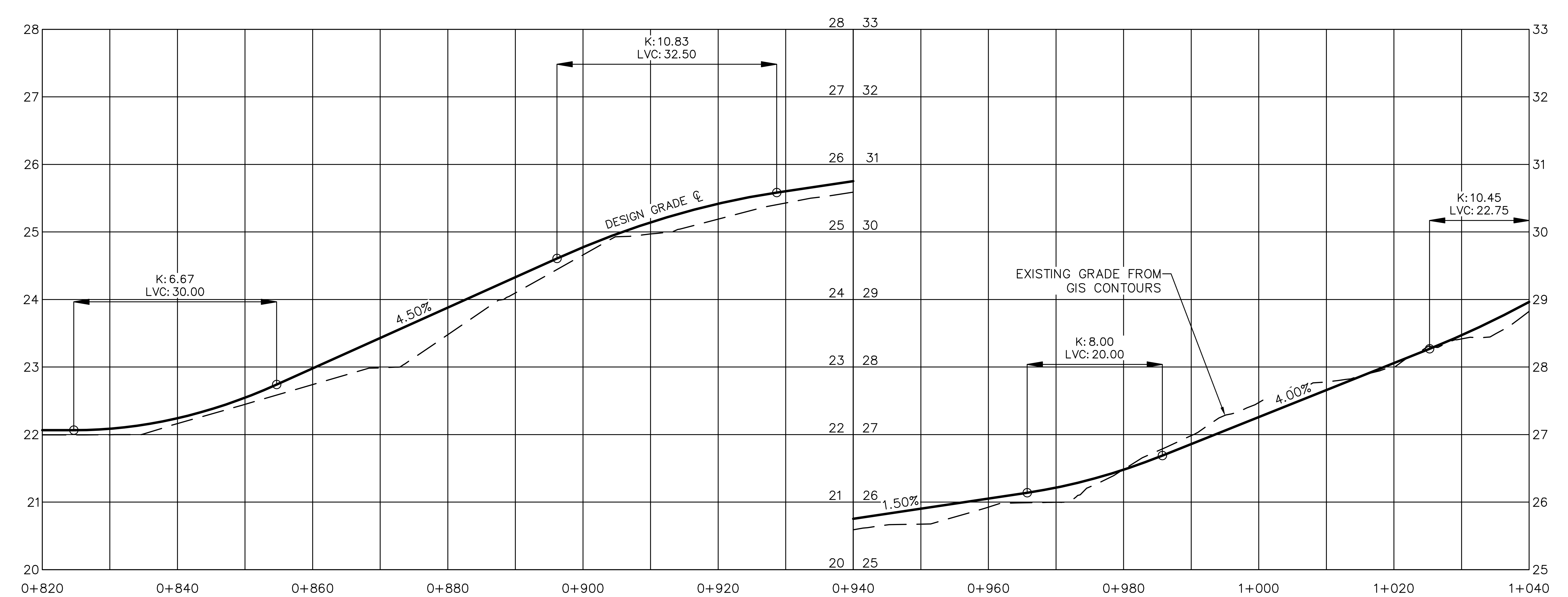
1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

Sheet:4

PLAN VIEW



PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- PROPOSED TOP OF SLOPE
- GUARD RAIL / SAFETY FENCE
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 5

PLAN & PROFILE
STA. 0+820 TO 1+040

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC

10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

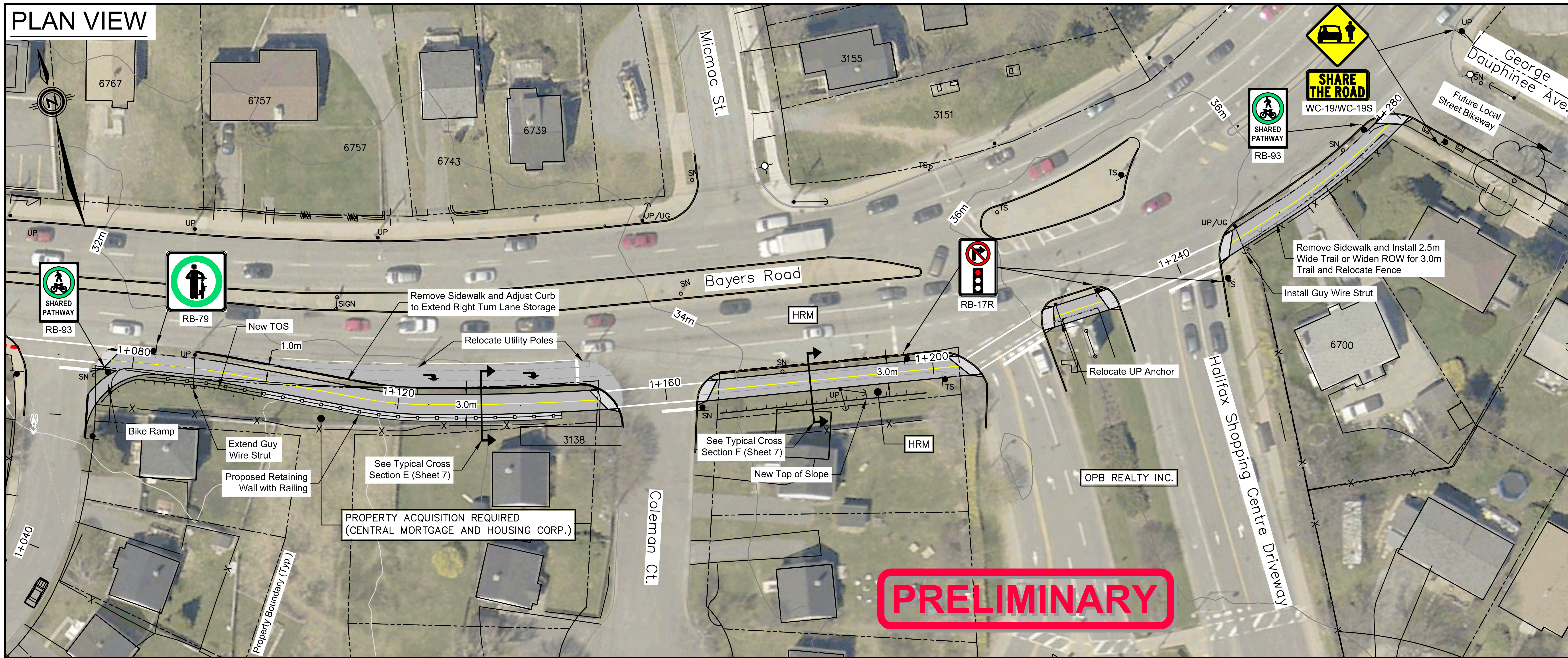
WSP

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

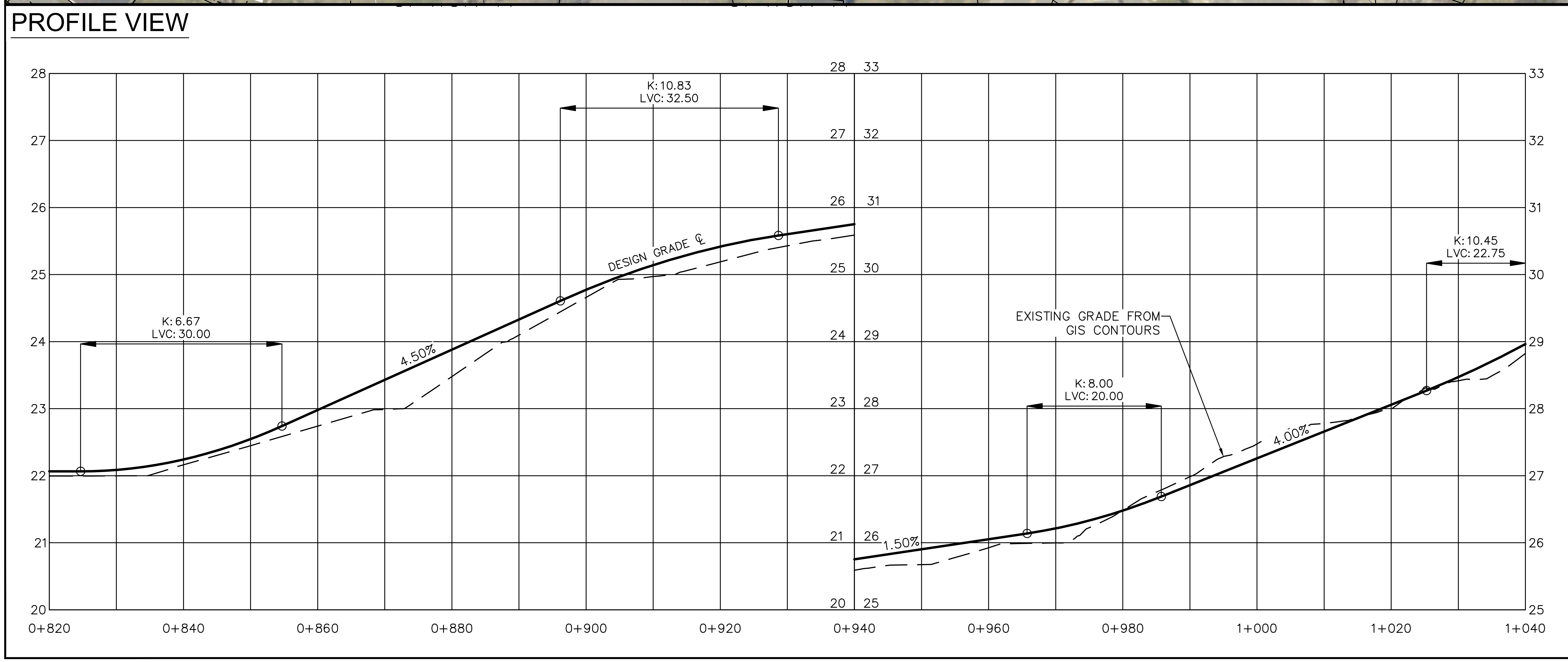
Sheet:5

FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PLAN VIEW



PROFILE VIEW



LEGEND

- PROPERTY BOUNDARY
- NSTIR/HRM — PROPERTY OWNER
- PROPOSED AT TRAIL
- ALTERNATIVE TRAIL ALIGNMENT
- PROPOSED CONCRETE SIDEWALK
- PROPOSED CURB
- REMOVED CURB
- PROPOSED PAVEMENT MARKING
- RELOCATED CATCHBASIN
- RELOCATED TRAFFIC SIGNAL
- RELOCATED LIGHT POLE
- PROPOSED SIGN
- PROPOSED TOP OF SLOPE
- GUARD RAIL / SAFETY FENCE
- CHAIN LINK / BOUNDARY FENCE
- 24m — CONTOUR

NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 6

PLAN & PROFILE
STA. 1+040 TO 1+280

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC

10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

WSP

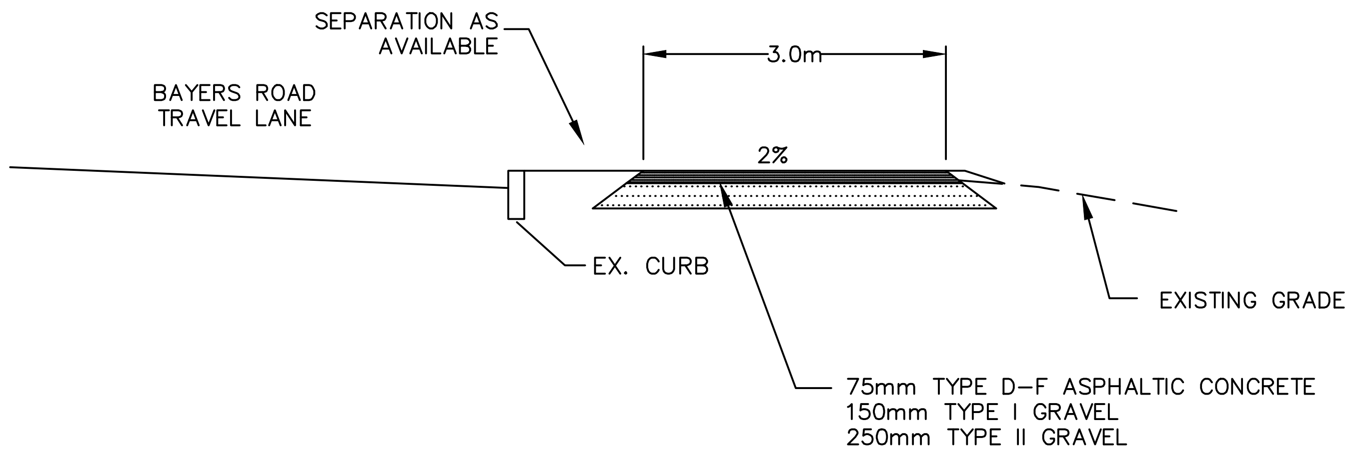
1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

Sheet:6

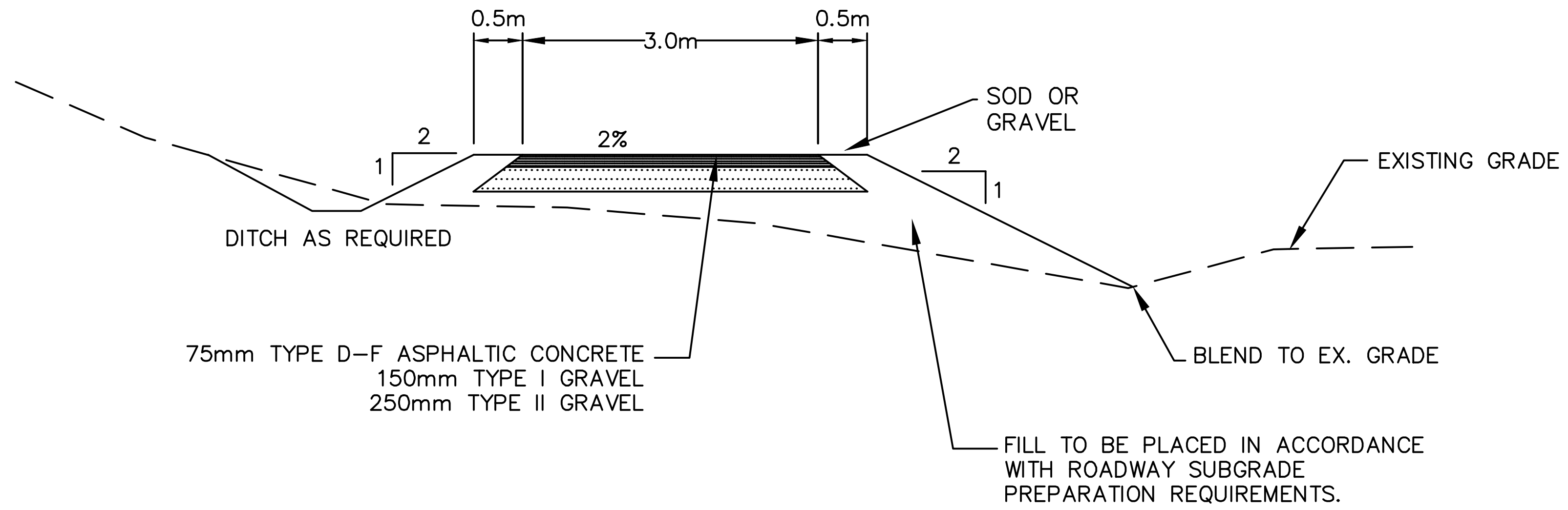
FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

PRELIMINARY

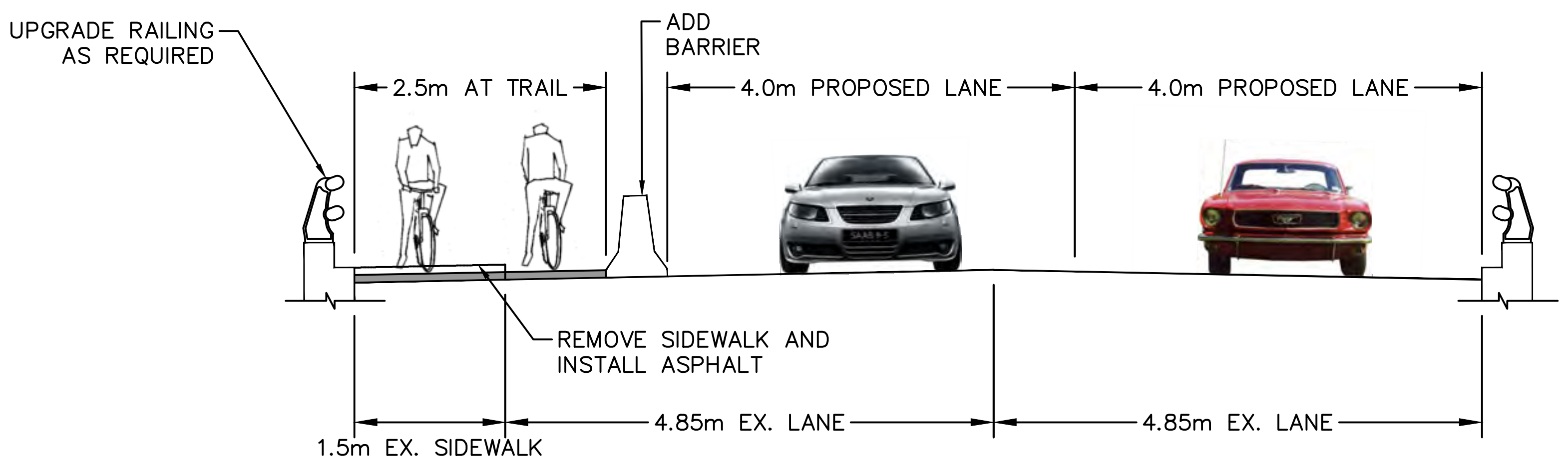
TYPICAL GREENWAY CROSS SECTION A
(ADJACENT TO ROADWAY)
A
1:75



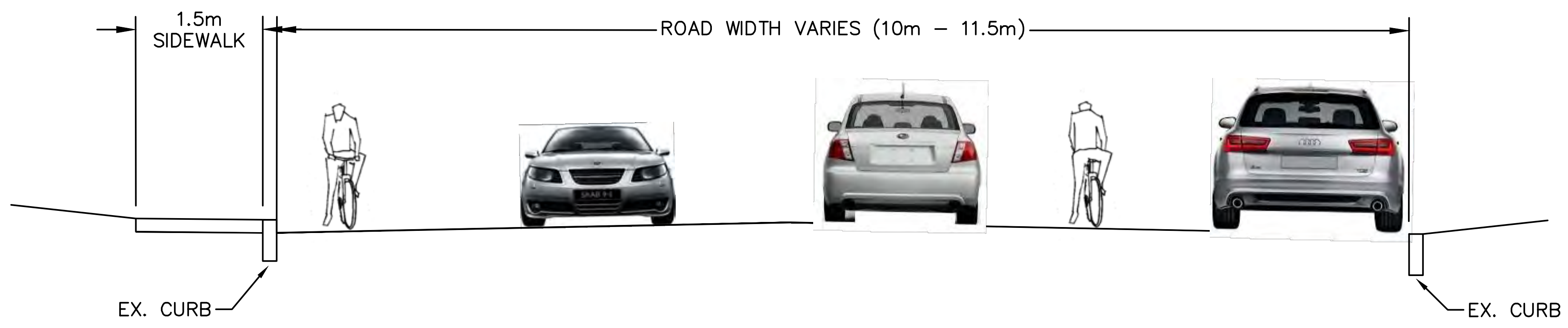
TYPICAL GREENWAY CROSS SECTION B
(SEPARATED FROM ROADWAY)
B
1:75



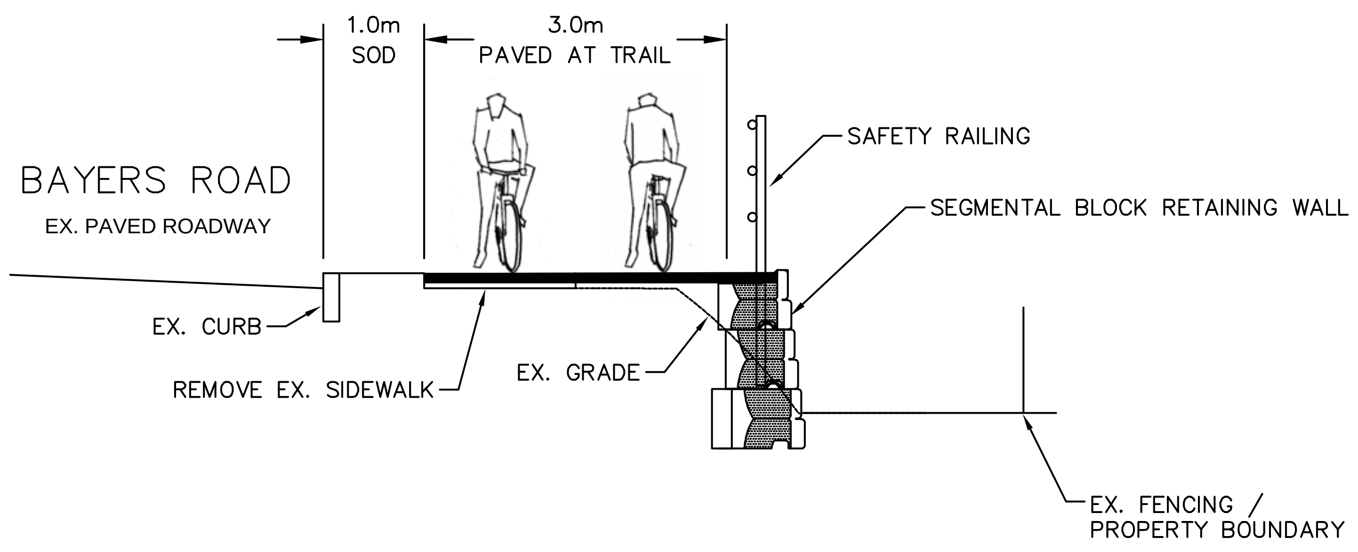
TYPICAL GREENWAY CROSS SECTION C
(EXISTING OVERPASS)
C
1:75



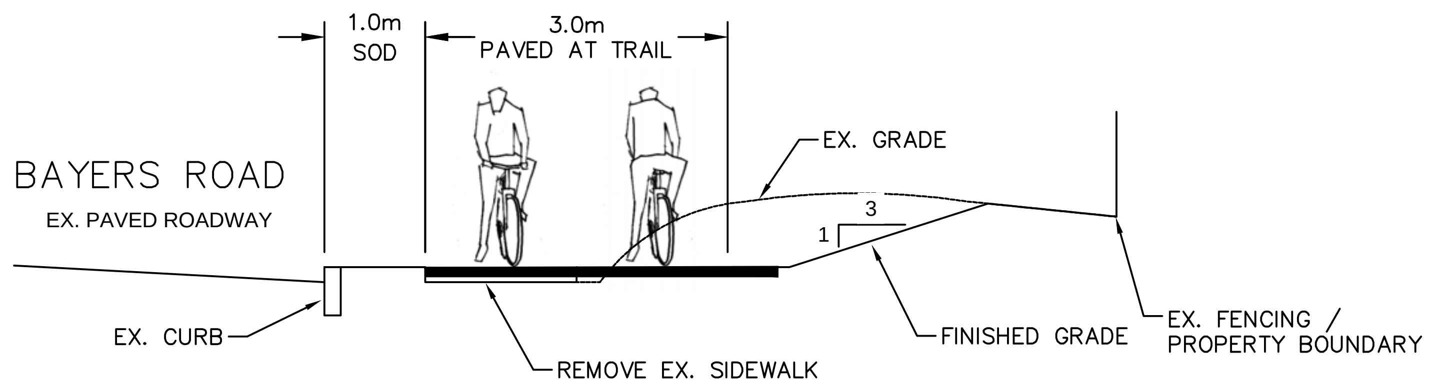
TYPICAL GREENWAY CROSS SECTION D
(VAUGHAN AVENUE)
D
1:75



TYPICAL GREENWAY CROSS SECTION E
(BAYERS ROAD, VAUGHAN AVE. TO COLEMAN CT.)
E
1:75



TYPICAL GREENWAY CROSS SECTION F
(BAYERS ROAD, COLEMAN CT. TO SHOPPING CENTRE)
F
1:75



NOTES

1. ALL EXISTING FEATURES SHOWN ARE APPROXIMATE ONLY.
2. ALL PROPOSED TRAIL LAYOUTS ARE PRELIMINARY AND CONCEPTUAL ONLY. TOPOGRAPHIC SURVEY INFORMATION AND DETAILED DESIGN ARE REQUIRED TO CONFIRM EXACT ALIGNMENT.

SHEET 7

TYPICAL CROSS SECTIONS

PROJECT

ACTIVE TRANSPORTATION CONNECTION STUDY: CHAIN OF LAKES GREENWAY TO GEORGE DAUPHINEE AVENUE

SCALE

SCALE: 1:500 METRIC
10 8 6 4 2 0 10 20 30

Drawn: P. NICKERSON
Checked: M. CONNORS
Date: SEPT. 1, 2016

CLIENT

HALIFAX
BICYCLE NOVA SCOTIA

WSP

1 SPECTACLE LAKE DRIVE
DARTMOUTH, NOVA SCOTIA CANADA, B3B 1X7
PHONE: 902 835-9955 - FAX: 902 835-1645 - WWW.WSPGROUP.COM

Sheet:7
FILE: K:\DARTMOUTH\2016\161-02775 BICYCLE NS_CHAIN OF LAKES GREENWAY\11_DWG\11.7_TRAFFIC\161-02775 - FUNCTIONAL PLANS.DWG

Appendix B
Preliminary Cost Estimates

COLT CONNECTION STUDY
CLASS C ESTIMATE OF PROBABLE COSTS

PROJECT NO. 161-02775
DATE: September 1, 2016
CLIENT: HRM
CONSULTANT: WSP
UNIT PRICE SOURCE: WSP
NOTE: HST NOT INCLUDED IN INDICATED UNIT PRICES AND TOTALS.
* BASED ON USING THE EXISTING OVERPASS. THE INSTALLATION OF A NEW 40m LONG PEDESTRAIN BRIDGE AT THE CN RAIL CROSSING IS ESTIMATED AT $500,000.

This estimate of probable construction cost is approximate only. Actual cost may vary significantly from this estimate due to market conditions such as material and labour costs, time of year, industry workload, competition, etc. This estimate has been prepared based on our experience with similar projects. This estimate has not been prepared by obtaining any estimates or quotes from contractors. Due to the uncertainties of what contractors bid, WSP cannot make any assurances that this estimate will be within a reasonable range of the tendered low bid. When assessing this project for business feasibility purposes this estimate should not be relied upon without considering these factors.

				SECTION 1		SECTION 2		SECTION 3*		SECTION 4		SECTION 5	
ITEM	DESCRIPTION	UNITS	UNIT PRICE	QNTY.	COST	QNTY.	COST	QNTY.	COST	QNTY.	COST	QNTY.	COST
1	Land Acquisition Anticipated?	-	-	No		No		No		No		Yes	
2	Tree Clearing / Grubbing	LS	-			1	$2,000						
3	Mass Excavation & Embankment - Common	m3	$30		$0	100	$3,000		$0		$0	450	$13,500
4	3.0m Wide Paved AT Trail (including gravels, asphalt and sod reinstatement)	m	$285		$0	85	$24,225	30	$8,550	60	$17,100	150	$42,750
5	4.0m Wide Paved AT Trail (including gravels, asphalt and sod reinstatement)	m	$380			400	$152,000						
6	Road Widening	m2	$110	240	$26,400		$0		$0		$0	150	$16,500
7	Ashalt Removal	m2	$15	80	$1,200	50	$750	140	$2,100	20	$300		$0
8	Curb Installation	m	$105	180	$18,900	50	$5,250		$0	100	$10,500	70	$7,350
9	Curb Removal	m	$25	180	$4,500	50	$1,250	60	$1,500	100	$2,500	70	$1,750
10	Install Curb Cut and Ramp	each	$1,000	1	$1,000	2	$2,000		$0	1	$1,000	8	$8,000
11	Sidewalk Installation	m2	$100	110	$11,000		$0		$0	140	$14,000		$0
12	Sidewalk Removal	m2	$20	120	$2,400	150	$3,000	420	$8,400	25	$500	275	$5,500
13	Remove Pavement Markings	LS	-	1	$1,000			1	$200				
14	New Pavement Markings	LS	-	1	$2,500			1	$500	1	$1,250	1	$1,000
15	Retaining Wall	m2	$700		$0		$0		$0		$0	100	$70,000
16	Fencing / Railing	m	$105		$0		$0	10	$1,050		$0	100	$10,500
17	Guide Rail Installation	m	$140		$0	85	$11,900		$0	15	$2,100		$0
18	Guide Rail Removal	m	$20		$0	20	$400		$0		$0		$0
19	Upgrade Bridge Guard Rail	m	$730		$0		$0	40	$29,200		$0		$0
20	Jersey Barrier	m	$150		$0		$0	70	$10,500		$0		$0
21	Install Asphalt over Bridge (75mm thick)	m2	$50		$0		$0	120	$6,000		$0		$0
22	New Sign / Sign Relocation	each	$500	3	$1,500	8	$4,000	1	$500	10	$5,000	8	$4,000
23	Utility Pole Relocation	each	$5,000		$0		$0		$0		$0	2	$10,000
24	Utility Pole Anchor / Strut Adjustment	each	$1,500		$0		$0		$0		$0	3	$4,500
25	Street Light / Traffic Signal Relocation	each	$7,500	3	$22,500		$0		$0		$0		$0
26	Catchbasin Relocation / Installation	each	$8,000	2	$16,000	1	$8,000	1	$8,000	2	$16,000		$0
27	Trees	each	$550		$0	20	$11,000		$0		$0		$0
28	Topsoil & Sod	m2	$15		$0		$0		$0		$0	150	$2,250
29	Silt Fence	m	$7		$0	400	$2,800		$0	100	$700		$0
30	Seating Area	each	$2,500		$0		$0		$0	1	$2,500		$0
31	Traffic Control	LS	-	1	$5,000	1	$1,500	1	$7,500	1	$1,500	1	$2,500

	Section 1	Section 2	Section 3*	Section 4	Section 5
Sub-Total	**$113,900**	**$233,075**	**$84,000**	**$74,950**	**$200,100**
Contingency (25%)	**$28,475**	**$58,269**	**$21,000**	**$18,738**	**$50,025**
ESTIMATED COST (excl. HST)	**$140,000**	**$290,000**	**$110,000**	**$90,000**	**$250,000**

TOTAL COST (Excl. HST) **$880,000**

Section Descriptions

Section 1: Joseph Howe Dr. Crossing
Section 2: Joseph Howe Dr. to CN Rail Cut
Section 3: CN Rail Cut Crossing
Section 4: CN Rail Cut to Vaughan Ave.
Section 5: Vaughan Ave. to George Dauphinee Ave.

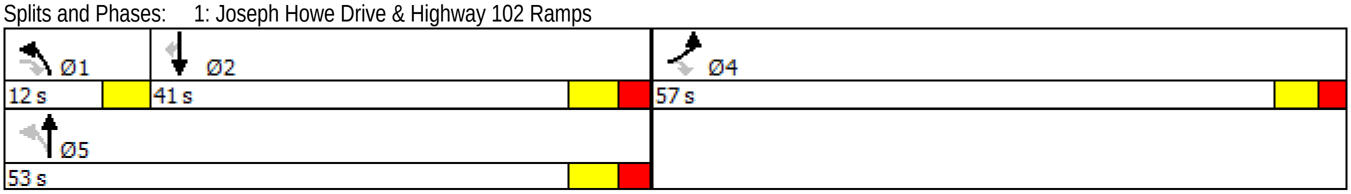
Appendix C
Intersection Performance Analysis

Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	485	827	189	293	1051	339
Future Volume (vph)	485	827	189	293	1051	339
Satd. Flow (prot)	3471	1601	1789	1883	3579	1601
Flt Permitted	0.950		0.105			
Satd. Flow (perm)	3471	1601	198	1883	3579	1601
Satd. Flow (RTOR)		7				368
Lane Group Flow (vph)	527	899	205	318	1142	368
Turn Type	Prot	Perm	pm+pt	NA	NA	Perm
Protected Phases	4		1	5	2	
Permitted Phases		4 1	5			2
Total Split (s)	57.0		12.0	53.0	41.0	41.0
Total Lost Time (s)	6.0		4.0	6.9	6.9	6.9
Act Effct Green (s)	51.0	63.0	49.0	46.1	34.1	34.1
Actuated g/C Ratio	0.46	0.57	0.45	0.42	0.31	0.31
v/c Ratio	0.33	0.98	1.01	0.40	1.03	0.49
Control Delay	19.4	48.7	91.0	24.3	72.8	5.4
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	19.4	48.7	91.0	24.3	72.8	5.4
LOS	B	D	F	C	E	A
Approach Delay	37.9			50.4	56.4	
Approach LOS	D			D	E	
Queue Length 50th (m)	35.8	176.1	~27.9	46.8	~138.4	0.0
Queue Length 95th (m)	47.7	#270.5	#75.1	69.6	#178.9	20.2
Internal Link Dist (m)	87.6			141.6	97.6	
Turn Bay Length (m)		30.0				100.0
Base Capacity (vph)	1609	919	203	789	1109	750
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.33	0.98	1.01	0.40	1.03	0.49

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 1.03
Intersection Signal Delay: 47.8 Intersection LOS: D
Intersection Capacity Utilization 91.0% ICU Level of Service F
Analysis Period (min) 15
~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Joseph Howe Drive & Highway 102 Ramps

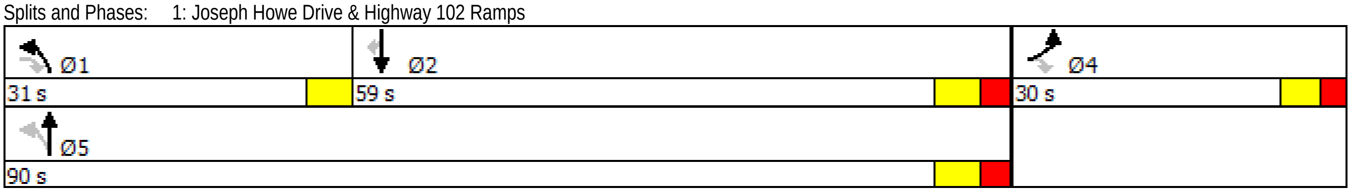


Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	331	257	511	776	442	701
Future Volume (vph)	331	257	511	776	442	701
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0	30.0	0.0			100.0
Storage Lanes	2	1	1			1
Taper Length (m)	2.5		2.5			
Satd. Flow (prot)	3471	1601	1789	1883	3579	1601
Flt Permitted	0.950		0.408			
Satd. Flow (perm)	3471	1601	768	1883	3579	1601
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)		258				623
Link Speed (k/h)	48			48	48	
Link Distance (m)	111.6			165.6	121.6	
Travel Time (s)	8.4			12.4	9.1	
Lane Group Flow (vph)	360	279	555	843	480	762
Turn Type	Prot	Perm	pm+pt	NA	NA	Perm
Protected Phases	4		1	5	2	
Permitted Phases		4 1	5			2
Total Split (s)	30.0		31.0	90.0	59.0	59.0
Total Lost Time (s)	6.0		4.0	6.9	6.9	6.9
Act Effct Green (s)	14.7	37.8	58.5	55.5	32.4	32.4
Actuated g/C Ratio	0.18	0.45	0.70	0.66	0.39	0.39
v/c Ratio	0.59	0.32	0.72	0.68	0.35	0.76
Control Delay	37.9	3.9	11.7	12.0	19.7	10.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	37.9	3.9	11.7	12.0	19.7	10.3
LOS	D	A	B	B	B	B
Approach Delay	23.1			11.9	13.9	
Approach LOS	C			B	B	
Queue Length 50th (m)	24.2	1.5	29.2	64.9	26.2	13.7
Queue Length 95th (m)	54.4	17.5	63.8	132.7	49.6	67.4
Internal Link Dist (m)	87.6			141.6	97.6	
Turn Bay Length (m)		30.0				100.0
Base Capacity (vph)	1043	1004	882	1739	2335	1261
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.35	0.28	0.63	0.48	0.21	0.60

Intersection Summary

Area Type: Other
Cycle Length: 120
Actuated Cycle Length: 83.7
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 14.8 Intersection LOS: B
Intersection Capacity Utilization 80.8% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Joseph Howe Drive & Highway 102 Ramps

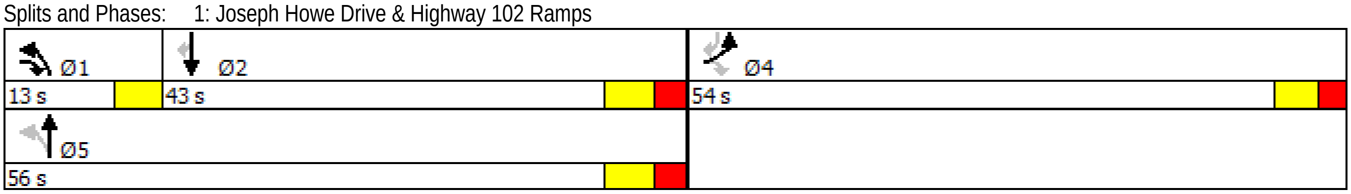


Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	485	827	189	293	1051	339
Future Volume (vph)	485	827	189	293	1051	339
Satd. Flow (prot)	3471	1601	1789	1883	3579	1601
Flt Permitted	0.950		0.100			
Satd. Flow (perm)	3471	1601	188	1883	3579	1601
Satd. Flow (RTOR)		9				119
Lane Group Flow (vph)	527	899	205	318	1142	368
Turn Type	Prot	pm+ov	pm+pt	NA	NA	custom
Protected Phases	4	1	1	5	2	
Permitted Phases		4	5			4 2
Total Split (s)	54.0	13.0	13.0	56.0	43.0	
Total Lost Time (s)	6.0	4.0	4.0	6.9	6.9	
Act Effct Green (s)	48.0	63.0	52.0	49.1	36.1	91.0
Actuated g/C Ratio	0.44	0.57	0.47	0.45	0.33	0.83
v/c Ratio	0.35	0.98	0.94	0.38	0.97	0.27
Control Delay	21.4	48.4	71.0	22.0	57.5	1.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	21.4	48.4	71.0	22.0	57.5	1.9
LOS	C	D	E	C	E	A
Approach Delay	38.4			41.2	44.0	
Approach LOS	D			D	D	
Queue Length 50th (m)	37.8	175.5	27.1	44.3	126.5	8.1
Queue Length 95th (m)	50.5	#270.1	#71.5	66.0	#171.2	13.5
Internal Link Dist (m)	87.6			141.6	97.6	
Turn Bay Length (m)		30.0				100.0
Base Capacity (vph)	1514	920	219	840	1174	1345
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.35	0.98	0.94	0.38	0.97	0.27

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.98
Intersection Signal Delay: 41.3 Intersection LOS: D
Intersection Capacity Utilization 89.3% ICU Level of Service E
Analysis Period (min) 15
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Joseph Howe Drive & Highway 102 Ramps

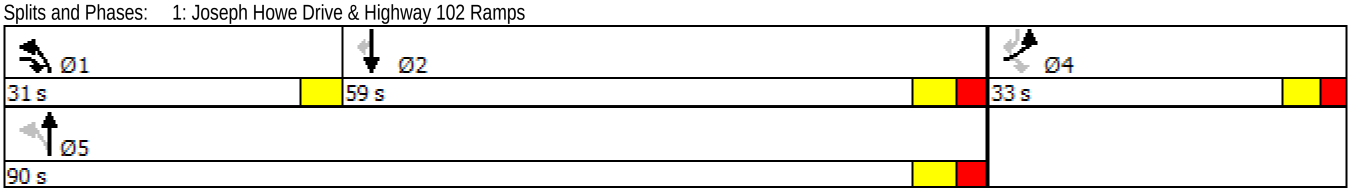


Lane Group	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations						
Traffic Volume (vph)	331	257	511	776	442	701
Future Volume (vph)	331	257	511	776	442	701
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Storage Length (m)	0.0	50.0	0.0			100.0
Storage Lanes	2	1	1			1
Taper Length (m)	2.5		2.5			
Satd. Flow (prot)	3471	1601	1789	1883	3579	1601
Flt Permitted	0.950		0.414			
Satd. Flow (perm)	3471	1601	780	1883	3579	1601
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)		249				200
Link Speed (k/h)	48			48	48	
Link Distance (m)	111.6			165.6	121.6	
Travel Time (s)	8.4			12.4	9.1	
Lane Group Flow (vph)	360	279	555	843	480	762
Turn Type	Prot	pm+ov	pm+pt	NA	NA	custom
Protected Phases	4	1	1	5	2	
Permitted Phases		4	5			4 2
Total Split (s)	33.0	31.0	31.0	90.0	59.0	
Total Lost Time (s)	6.0	4.0	4.0	6.9	6.9	
Act Effct Green (s)	18.5	43.8	67.2	64.2	41.0	66.6
Actuated g/C Ratio	0.19	0.46	0.70	0.67	0.43	0.69
v/c Ratio	0.54	0.32	0.74	0.67	0.31	0.65
Control Delay	39.2	4.1	13.5	13.2	20.2	9.2
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	39.2	4.1	13.5	13.2	20.2	9.2
LOS	D	A	B	B	C	A
Approach Delay	23.9			13.3	13.4	
Approach LOS	C			B	B	
Queue Length 50th (m)	28.7	2.7	36.4	78.4	29.1	47.1
Queue Length 95th (m)	54.0	17.9	73.4	149.9	52.8	101.1
Internal Link Dist (m)	87.6			141.6	97.6	
Turn Bay Length (m)		50.0				100.0
Base Capacity (vph)	1004	866	838	1645	1999	1307
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.36	0.32	0.66	0.51	0.24	0.58

Intersection Summary

Area Type: Other
Cycle Length: 123
Actuated Cycle Length: 96
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.74
Intersection Signal Delay: 15.4 Intersection LOS: B
Intersection Capacity Utilization 80.0% ICU Level of Service D
Analysis Period (min) 15

Splits and Phases: 1: Joseph Howe Drive & Highway 102 Ramps

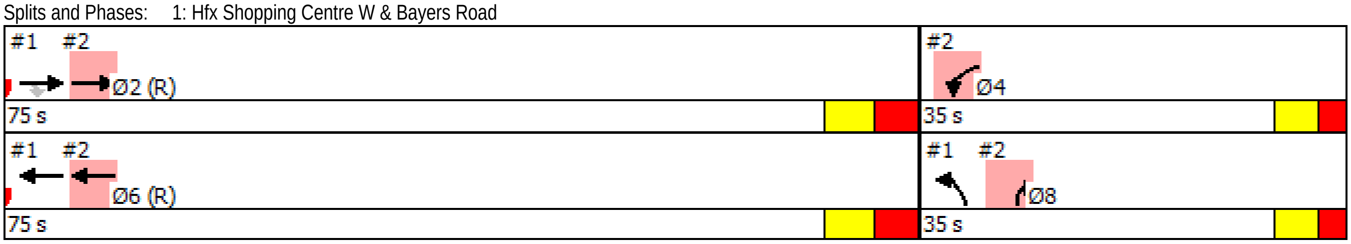


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø4
Lane Configurations							
Traffic Volume (vph)	1860	29	0	797	38	0	
Future Volume (vph)	1860	29	0	797	38	0	
Satd. Flow (prot)	3579	1601	0	3579	3471	0	
Flt Permitted					0.950		
Satd. Flow (perm)	3579	1601	0	3579	3471	0	
Satd. Flow (RTOR)		11					
Lane Group Flow (vph)	2022	32	0	866	41	0	
Turn Type	NA	Perm		NA	Prot		
Protected Phases	2			6	8		4
Permitted Phases		2					
Total Split (s)	75.0	75.0		75.0	35.0		35.0
Total Lost Time (s)	7.9	7.9		7.9	6.0		
Act Effct Green (s)	67.1	67.1		67.1	29.0		
Actuated g/C Ratio	0.61	0.61		0.61	0.26		
v/c Ratio	0.93	0.03		0.40	0.04		
Control Delay	28.2	6.4		1.2	30.5		
Queue Delay	2.0	0.0		0.0	0.0		
Total Delay	30.2	6.4		1.2	30.5		
LOS	C	A		A	C		
Approach Delay	29.9			1.2	30.5		
Approach LOS	C			A	C		
Queue Length 50th (m)	190.6	1.7		1.7	3.4		
Queue Length 95th (m)	#239.7	5.4		2.0	7.6		
Internal Link Dist (m)	358.4			1.1	77.8		
Turn Bay Length (m)		25.0					
Base Capacity (vph)	2183	980		2183	915		
Starvation Cap Reductn	0	0		0	0		
Spillback Cap Reductn	78	0		0	0		
Storage Cap Reductn	0	0		0	0		
Reduced v/c Ratio	0.96	0.03		0.40	0.04		

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.93
Intersection Signal Delay: 21.5 — Intersection LOS: C
Intersection Capacity Utilization 68.8% — ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 1: Hfx Shopping Centre W & Bayers Road

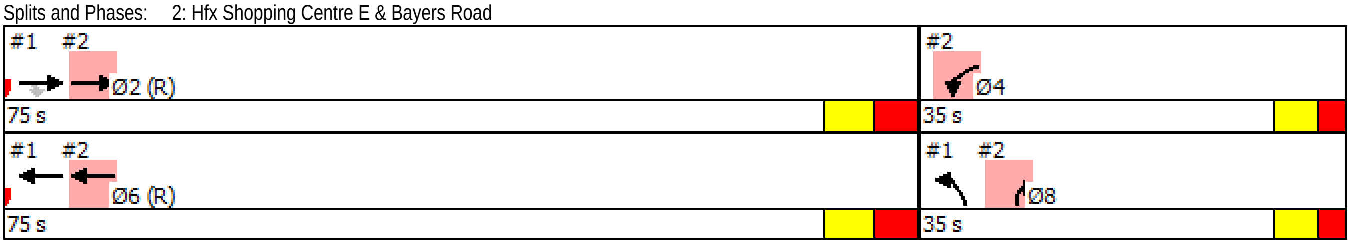


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1835	25	219	797	0	150
Future Volume (vph)	1835	25	219	797	0	150
Satd. Flow (prot)	3571	0	3471	3579	0	2818
Flt Permitted			0.950			
Satd. Flow (perm)	3571	0	3471	3579	0	2818
Satd. Flow (RTOR)	2					22
Lane Group Flow (vph)	2022	0	238	866	0	163
Turn Type	NA		Prot	NA		Prot
Protected Phases	2		4	6		8
Permitted Phases						
Total Split (s)	75.0		35.0	75.0		35.0
Total Lost Time (s)	7.9		6.0	7.9		6.0
Act Effct Green (s)	67.1		29.0	67.1		29.0
Actuated g/C Ratio	0.61		0.26	0.61		0.26
v/c Ratio	0.93		0.26	0.40		0.21
Control Delay	6.0		33.0	11.7		28.1
Queue Delay	0.0		0.0	0.0		0.0
Total Delay	6.0		33.0	11.7		28.1
LOS	A		C	B		C
Approach Delay	6.0			16.3	28.1	
Approach LOS	A			B	C	
Queue Length 50th (m)	0.5		20.8	46.8		13.3
Queue Length 95th (m)	m#1.0		31.2	59.2		22.8
Internal Link Dist (m)	1.1			45.6	91.5	
Turn Bay Length (m)			30.0			
Base Capacity (vph)	2179		915	2183		759
Starvation Cap Reductn	0		0	0		0
Spillback Cap Reductn	0		0	0		0
Storage Cap Reductn	0		0	0		0
Reduced v/c Ratio	0.93		0.26	0.40		0.21

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.93
Intersection Signal Delay: 10.5 — Intersection LOS: B
Intersection Capacity Utilization 69.4% — ICU Level of Service C
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

Splits and Phases: 2: Hfx Shopping Centre E & Bayers Road

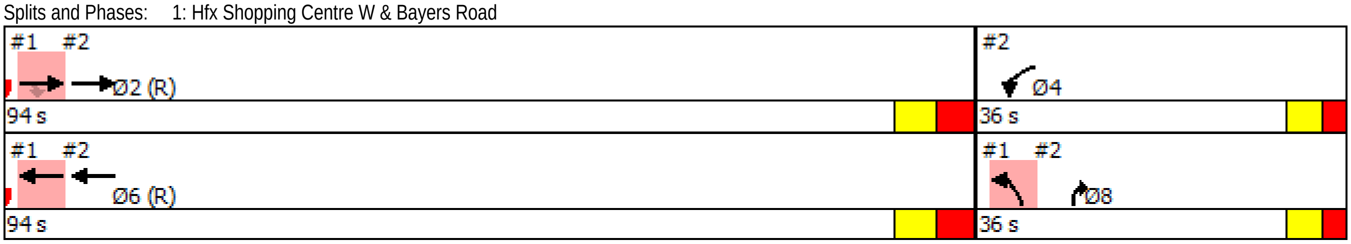


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø4
Lane Configurations							
Traffic Volume (vph)	1093	86	0	1662	364	0	
Future Volume (vph)	1093	86	0	1662	364	0	
Satd. Flow (prot)	3579	1601	0	3579	3471	0	
Flt Permitted					0.950		
Satd. Flow (perm)	3579	1601	0	3579	3471	0	
Satd. Flow (RTOR)		52					
Lane Group Flow (vph)	1188	93	0	1807	396	0	
Turn Type	NA	Perm		NA	Prot		
Protected Phases	2			6	8		4
Permitted Phases		2					
Total Split (s)	94.0	94.0		94.0	36.0		36.0
Total Lost Time (s)	7.9	7.9		7.9	6.0		
Act Effct Green (s)	86.1	86.1		86.1	30.0		
Actuated g/C Ratio	0.66	0.66		0.66	0.23		
v/c Ratio	0.50	0.09		0.76	0.49		
Control Delay	12.0	4.0		2.5	45.9		
Queue Delay	0.0	0.0		0.0	0.0		
Total Delay	12.0	4.0		2.5	45.9		
LOS	B	A		A	D		
Approach Delay	11.4			2.5	45.9		
Approach LOS	B			A	D		
Queue Length 50th (m)	74.8	3.4		6.0	45.7		
Queue Length 95th (m)	89.9	9.1		6.5	61.2		
Internal Link Dist (m)	270.4			1.1	77.8		
Turn Bay Length (m)		25.0					
Base Capacity (vph)	2370	1077		2370	801		
Starvation Cap Reductn	0	0		0	0		
Spillback Cap Reductn	0	0		0	0		
Storage Cap Reductn	0	0		0	0		
Reduced v/c Ratio	0.50	0.09		0.76	0.49		

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 10.7 Intersection LOS: B
Intersection Capacity Utilization 67.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Hfx Shopping Centre W & Bayers Road

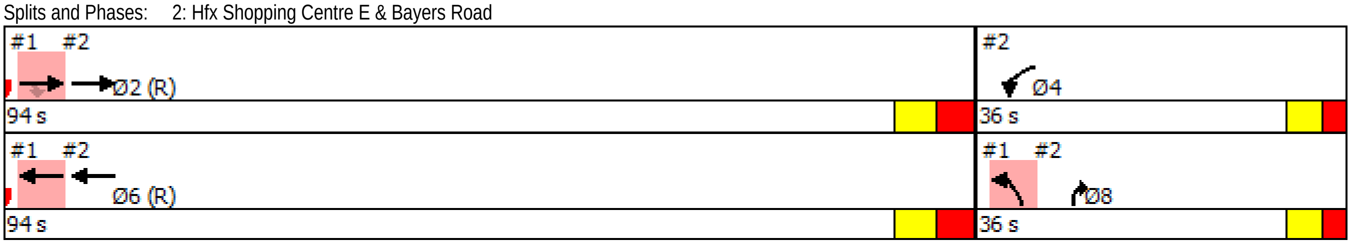


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1029	64	206	1662	0	256
Future Volume (vph)	1029	64	206	1662	0	256
Satd. Flow (prot)	3546	0	3471	3579	0	2818
Flt Permitted			0.950			
Satd. Flow (perm)	3546	0	3471	3579	0	2818
Satd. Flow (RTOR)	10					206
Lane Group Flow (vph)	1188	0	224	1807	0	278
Turn Type	NA		Prot	NA		Prot
Protected Phases	2		4	6		8
Permitted Phases						
Total Split (s)	94.0		36.0	94.0		36.0
Total Lost Time (s)	7.9		6.0	7.9		6.0
Act Effct Green (s)	86.1		30.0	86.1		30.0
Actuated g/C Ratio	0.66		0.23	0.66		0.23
v/c Ratio	0.51		0.28	0.76		0.34
Control Delay	1.3		42.2	17.7		12.8
Queue Delay	0.0		0.0	0.0		0.0
Total Delay	1.3		42.2	17.7		12.8
LOS	A		D	B		B
Approach Delay	1.3			20.4	12.8	
Approach LOS	A			C	B	
Queue Length 50th (m)	0.6		24.4	153.8		8.3
Queue Length 95th (m)	0.0		35.9	182.2		20.9
Internal Link Dist (m)	1.1			47.8	91.5	
Turn Bay Length (m)			30.0			
Base Capacity (vph)	2351		801	2370		808
Starvation Cap Reductn	0		0	0		0
Spillback Cap Reductn	0		0	0		0
Storage Cap Reductn	0		0	0		0
Reduced v/c Ratio	0.51		0.28	0.76		0.34

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 13.3 — Intersection LOS: B
Intersection Capacity Utilization 52.5% — ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 2: Hfx Shopping Centre E & Bayers Road

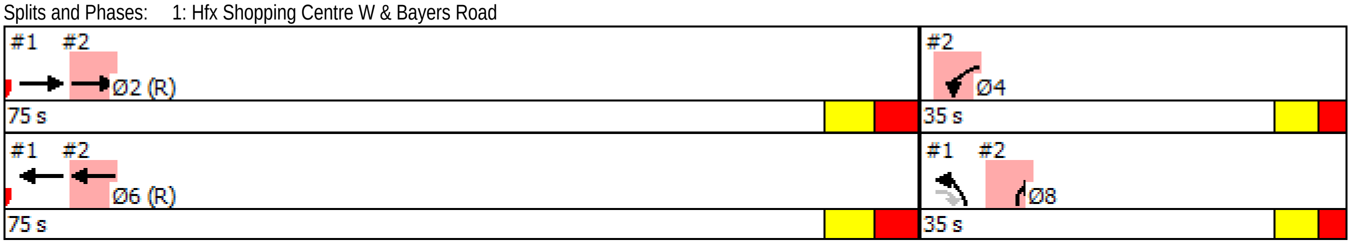


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø4
Lane Configurations							
Traffic Volume (vph)	1835	54	0	797	38	0	
Future Volume (vph)	1835	54	0	797	38	0	
Satd. Flow (prot)	3579	1601	0	3579	3471	0	
Flt Permitted					0.950		
Satd. Flow (perm)	3579	1601	0	3579	3471	0	
Satd. Flow (RTOR)							
Lane Group Flow (vph)	1995	59	0	866	41	0	
Turn Type	NA	custom		NA	Prot		
Protected Phases	2			6	8		4
Permitted Phases		8					
Total Split (s)	75.0	35.0		75.0	35.0		35.0
Total Lost Time (s)	7.9	6.0		7.9	6.0		
Act Effct Green (s)	67.1	29.0		67.1	29.0		
Actuated g/C Ratio	0.61	0.26		0.61	0.26		
v/c Ratio	0.91	0.14		0.40	0.04		
Control Delay	26.9	32.1		1.2	30.5		
Queue Delay	0.1	0.0		0.0	0.0		
Total Delay	27.1	32.1		1.2	30.5		
LOS	C	C		A	C		
Approach Delay	27.2			1.2	30.5		
Approach LOS	C			A	C		
Queue Length 50th (m)	185.0	9.7		1.7	3.4		
Queue Length 95th (m)	227.2	20.2		2.0	7.6		
Internal Link Dist (m)	358.4			1.1	77.8		
Turn Bay Length (m)		25.0					
Base Capacity (vph)	2183	422		2183	915		
Starvation Cap Reductn	0	0		0	0		
Spillback Cap Reductn	11	0		0	0		
Storage Cap Reductn	0	0		0	0		
Reduced v/c Ratio	0.92	0.14		0.40	0.04		

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 19.7 — Intersection LOS: B
Intersection Capacity Utilization 68.1% — ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Hfx Shopping Centre W & Bayers Road

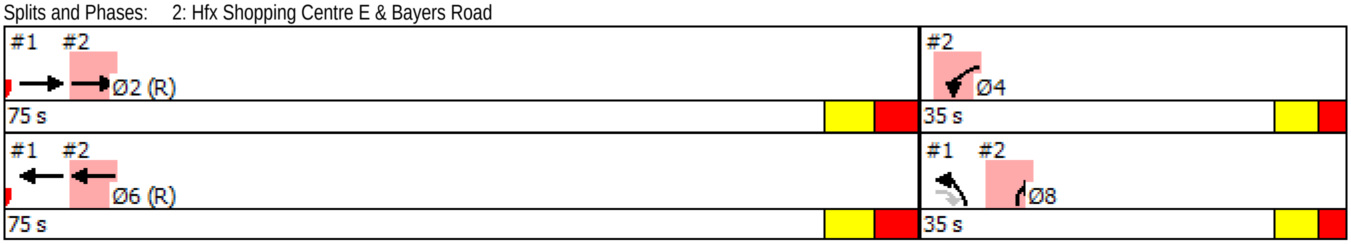


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1835	0	219	797	0	150
Future Volume (vph)	1835	0	219	797	0	150
Satd. Flow (prot)	3579	0	3471	3579	0	2818
Flt Permitted			0.950			
Satd. Flow (perm)	3579	0	3471	3579	0	2818
Satd. Flow (RTOR)						
Lane Group Flow (vph)	1995	0	238	866	0	163
Turn Type	NA		Prot	NA		Prot
Protected Phases	2		4	6		8
Permitted Phases						
Total Split (s)	75.0		35.0	75.0		35.0
Total Lost Time (s)	7.9		6.0	7.9		6.0
Act Effct Green (s)	67.1		29.0	67.1		29.0
Actuated g/C Ratio	0.61		0.26	0.61		0.26
v/c Ratio	0.91		0.26	0.40		0.22
Control Delay	5.3		33.0	11.7		32.6
Queue Delay	0.0		0.0	0.0		0.0
Total Delay	5.3		33.0	11.7		32.6
LOS	A		C	B		C
Approach Delay	5.3			16.3	32.6	
Approach LOS	A			B	C	
Queue Length 50th (m)	6.6		20.8	46.8		15.5
Queue Length 95th (m)	11.7		31.2	59.2		25.2
Internal Link Dist (m)	1.1			45.6	91.5	
Turn Bay Length (m)			30.0			
Base Capacity (vph)	2183		915	2183		742
Starvation Cap Reductn	0		0	0		0
Spillback Cap Reductn	0		0	0		0
Storage Cap Reductn	0		0	0		0
Reduced v/c Ratio	0.91		0.26	0.40		0.22

Intersection Summary

Cycle Length: 110
Actuated Cycle Length: 110
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.91
Intersection Signal Delay: 10.4 Intersection LOS: B
Intersection Capacity Utilization 68.6% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 2: Hfx Shopping Centre E & Bayers Road

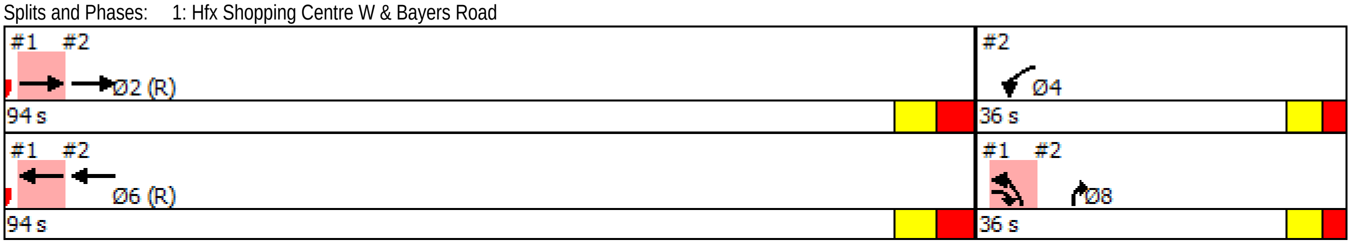


Lane Group	EBT	EBR	WBL	WBT	NBL	NBR	Ø4
Lane Configurations							
Traffic Volume (vph)	1029	150	0	1662	364	0	
Future Volume (vph)	1029	150	0	1662	364	0	
Satd. Flow (prot)	3579	1601	0	3579	3471	0	
Flt Permitted					0.950		
Satd. Flow (perm)	3579	1601	0	3579	3471	0	
Satd. Flow (RTOR)							
Lane Group Flow (vph)	1118	163	0	1807	396	0	
Turn Type	NA	Over		NA	Prot		
Protected Phases	2	8		6	8		4
Permitted Phases							
Total Split (s)	94.0	36.0		94.0	36.0		36.0
Total Lost Time (s)	7.9	6.0		7.9	6.0		
Act Effct Green (s)	86.1	30.0		86.1	30.0		
Actuated g/C Ratio	0.66	0.23		0.66	0.23		
v/c Ratio	0.47	0.44		0.76	0.49		
Control Delay	11.6	47.3		2.5	45.9		
Queue Delay	0.0	0.0		0.0	0.0		
Total Delay	11.6	47.3		2.5	45.9		
LOS	B	D		A	D		
Approach Delay	16.1			2.5	45.9		
Approach LOS	B			A	D		
Queue Length 50th (m)	68.5	36.0		6.0	45.7		
Queue Length 95th (m)	82.6	58.0		6.5	61.2		
Internal Link Dist (m)	270.4			1.1	77.8		
Turn Bay Length (m)		25.0					
Base Capacity (vph)	2370	369		2370	801		
Starvation Cap Reductn	0	0		0	0		
Spillback Cap Reductn	0	0		0	0		
Storage Cap Reductn	0	0		0	0		
Reduced v/c Ratio	0.47	0.44		0.76	0.49		

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 12.4 Intersection LOS: B
Intersection Capacity Utilization 67.9% ICU Level of Service C
Analysis Period (min) 15

Splits and Phases: 1: Hfx Shopping Centre W & Bayers Road



Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	1029	0	206	1662	0	256
Future Volume (vph)	1029	0	206	1662	0	256
Satd. Flow (prot)	3579	0	3471	3579	0	2818
Flt Permitted			0.950			
Satd. Flow (perm)	3579	0	3471	3579	0	2818
Satd. Flow (RTOR)						
Lane Group Flow (vph)	1118	0	224	1807	0	278
Turn Type	NA		Prot	NA		Prot
Protected Phases	2		4	6		8
Permitted Phases						
Total Split (s)	94.0		36.0	94.0		36.0
Total Lost Time (s)	7.9		6.0	7.9		6.0
Act Effct Green (s)	86.1		30.0	86.1		30.0
Actuated g/C Ratio	0.66		0.23	0.66		0.23
v/c Ratio	0.47		0.28	0.76		0.43
Control Delay	1.2		42.2	17.7		45.1
Queue Delay	0.0		0.0	0.0		0.0
Total Delay	1.2		42.2	17.7		45.1
LOS	A		D	B		D
Approach Delay	1.2			20.4	45.1	
Approach LOS	A			C	D	
Queue Length 50th (m)	2.2		24.4	153.8		34.7
Queue Length 95th (m)	2.5		35.9	182.2		49.5
Internal Link Dist (m)	1.1			47.8	91.5	
Turn Bay Length (m)			30.0			
Base Capacity (vph)	2370		801	2370		650
Starvation Cap Reductn	0		0	0		0
Spillback Cap Reductn	0		0	0		0
Storage Cap Reductn	0		0	0		0
Reduced v/c Ratio	0.47		0.28	0.76		0.43

Intersection Summary

Cycle Length: 130
Actuated Cycle Length: 130
Offset: 0 (0%), Referenced to phase 2:EBT and 6:WBT, Start of Green
Control Type: Actuated-Coordinated
Maximum v/c Ratio: 0.76
Intersection Signal Delay: 16.2 — Intersection LOS: B
Intersection Capacity Utilization 52.5% — ICU Level of Service A
Analysis Period (min) 15

Splits and Phases: 2: Hfx Shopping Centre E & Bayers Road