Appendix A – Summary of Work

The Windsor Street Exchange (WSE) Redevelopment Project began in June 2019, when Transport Canada announced funding for the project through the National Trade Corridors Fund (NTCF). The project was approved by HRM Council August 13, 2019, and was kicked off by HRM's project team in March 2020. Since the project kick-off, there has been a lot of work on project planning and design development completed by the project team, with support from external consultants. This report will outline the work that has led to the current proposed Functional Design.

This summary of work will describe:

- Interim Functional Planning, which resulted in two design options for consideration;
- Climate Change Resilience Assessment, which provided recommendations for design considerations;
- Technical Review, which included review and input from an external consultant to support the project team in selecting a design option; and
- Value Engineering Study, an in-depth review of work completed to date, and assessment of potential alternative options for the preferred configuration of the WSE.

Interim Functional Planning

The project team awarded a contract to WSP Canada in January 2021 to begin the design process on the WSE Redevelopment Project.

Existing Conditions Study

The initial stages of the design and planning process included gathering and reviewing all available data on the project from HRM. This included background information, existing planning framework and land use for the area, and evaluation of the existing conditions within the project area. Additionally, WSP collected topographical data for the project area and peak period traffic volume data.

Through analysis of the above information, and supported by Phase I of Public and Stakeholder Engagement, WSP developed a checklist of issues that are evident based on existing conditions. In addition to developing solutions that deal with congestion and general lack of capacity, it was recommended that any proposed solution should strive to address the following set of existing issues.

- Heavy weaving volumes on the inbound Bedford Highway lanes between the Joseph Howe Drive Ramp and the Windsor Street intersection create operational and safety concerns
- Trucks and buses travelling in mixed traffic experience significant delay during peak hours on Bedford Highway
- Transit buses must change lanes to the right into heavy traffic on the Bedford Highway in both the inbound and outbound directions just west of the WSE project area
- Active transportation connections are lacking through the WSE area
- Container trucks travelling towards the Fairview Cove Container Terminal (FCCT) must take a roundabout route with many turns causing additional transit time and conflicts with vehicle traffic
- Unmarked crosswalks on large channelized right turn lanes may create a hazard (location: Bedford Hwy to Windsor Street)
- Access to the cemetery from Bedford Highway is hazardous due to the high traffic volumes and number of lanes on Bedford Highway.

WSP also identified opportunities for areas of improvement, considering redirection of traffic through design, as well as supporting transportation mode-shift to reduce the volume of traffic using the intersection. The recommendations included:

- removing one or more of the intersection movements and grade-separate them from the intersection;
- adding new intersection approach lanes, which was not expected to provide significant benefits over the costs and impacts;
- using innovative approaches to consolidate signalization phases;
- separating bus traffic from long queues;
- separating active transportation and creating strong destination connections that avoid conflicts; and
- accommodating truck traffic as part of mixed traffic, though access to FCCT from Joseph Howe Drive – a high volume truck route – could be better connected.

The data and applicable results obtained from the existing conditions review was used to further develop design concepts and proceed to the functional design stages.

Phase 1 Public and Stakeholder Engagement
Phase 1 of public engagement for the project was held in April/May 2021, and gathered information on the existing conditions within the project area, how residents travel through the area, documented concerns from residents, businesses and property owners in the area, and identified what people want to see in the redesign of the Windsor Street Exchange. The project team also met with several stakeholders, including advocacy groups, utilities, and adjacent property owners.

In general, the feedback received through the engagement process could be summarized as follows:

- Concerns related to the safety of the current WSE area for all road users, especially those using active transportation modes of travel.
- Desire for improved connectivity between neighbourhoods, especially the Fairview/Clayton Park area to the Halifax Peninsula.
- Concerns about the impacts of construction and the final configuration on businesses in the area, as well as traffic flow.
- Importance of considering integration between projects and the impacts on the adjacent communities.

Concept Design Development
Information gathered through the Existing Conditions Study and Phase I Engagement was then used to develop several concepts for further consideration. The following items were considered when developing design options:

- Traffic Operations and Safety
    - Heavy weaving volumes are present on the inbound Bedford Highway lanes between the Joseph Howe Ramp and the Windsor Street intersection
    - An outbound lane on the Bedford Highway ends abruptly causing merge conflicts and intersection approach lane imbalance
    - The ramp from Lady Hammond Road towards the MacKay Bridge has poor sight distance and is a challenge for trucks to accelerate and merge into heavy traffic
- Transit
    - Inbound transit buses must change lanes to the right into heavy traffic entering the Bedford Highway from Joseph Howe Drive
    - Outbound transit buses must change lanes to the right into heavy traffic coming off the MacKay Bridge
    - There are no transit priority measures within the WSE
- Active Transportation
    - Three important active transportation facilities: the Bedford Highway (and the Chain of Lakes Trail via Joseph Howe), Windsor Street Bike Lanes and Africville Park (then onward to Barrington Street) are not well connected

- Truck Connections
    - The FCCT has an indirect connection to the MacKay Bridge resulting in additional transit time, noise, emissions, and vehicle conflicts
    - The FCCT has an indirect connection from Highway 102 (via Joseph Howe Drive) resulting in additional transit time, noise, emissions, and vehicle conflicts

Many different concept designs have been developed for this area, both through WSP's design work and as part of previous studies. Concepts have included changes to lane configurations approaching the intersections, multi-level interchanges, multiple roundabout configurations, displaced left turn lanes, and other options. Through traffic modeling and mapping of existing conditions, WSP developed two concept design options that meet the project objectives.

Both options included a grade-separated structure connecting the Bedford Highway and MacKay Bridge approach. This feature allows free traffic flow for highest volume vehicle movement separated from the rest of the road network. This would have a significant improvement on travel times between Fairview, Clayton Park and Bedford, and Dartmouth, Robie Street and Barrington Street. This feature also reduces lane changes required for vehicles traveling from Joseph Howe Drive towards the MacKay Bridge, which has been a long-standing safety and operational concern.

A multi-use path would be installed along the cemetery from the planned path along the Bedford Highway, connecting to Lady Hammond Road. Sidewalk connections would be installed to Bayne Street and Africville Road. Both options also include the installation of a multi-use path on Mackintosh Street. The project team has been investigating options for this connection to continue to Africville Road and ultimately connect with the Africville Active Transportation Connections Project, greatly improving access to Africville via active transportation.

<u>Option A</u>
The first option makes use of two roundabout intersections to move traffic to the road network. The main roundabout at the intersection of Bedford Highway and Windsor Street would be a multi-lane roundabout used by most vehicle traffic (other than the traffic on the grade-separated connection). The secondary roundabout at the intersection of Bayne Street and Africville Road would be a single-lane roundabout used primarily by those accessing the Port or traveling on Bayne Street, with higher volume connections to Bedford Highway and Windsor Street made using by-pass ramps.

Some of the benefits of Option A include:

- Continuous traffic flow through the area will allow for reduced travel times for Transit, vehicles, and goods movement to the Port.
- The frequency and severity of collisions is lower for roundabout configurations than with signalized intersections.

Some of the impacts of Option A include:

- There are limited options for Transit priority measures with a roundabout configuration.
- There are more crossings for pedestrians and cyclists on the legs of the main roundabout.

<u>Option B</u>
The second option makes use of five signalized intersections to connect to the local street network.

Bayne Street and Mackintosh Streets would be upgraded to major streets with a significant increase in traffic volumes. Bayne Street would connect to the current Robie Street exit from the MacKay Bridge. Bayne Street would be one-way between the exit and Mackintosh Street, and Lady Hammond Road would be one-way from Windsor Street to Kempt Road.

Traffic traveling from Bedford/Fairview would move through the Windsor Street intersection to connect directly with Bayne Street, Kempt Road, or Lady Hammond Road. Traffic traveling from Kempt Road or Lady Hammond Road could access a ramp to the MacKay Bridge approach, or use Mackintosh Street and Bayne Street to access Windsor Street or Bedford Highway. Traffic traveling from the MacKay Bridge would exit directly onto Bayne Street to use Mackintosh Street towards Lady Hammond Road, or continue on Bayne Street to access Windsor Street.

Some of the benefits of Option B include:

- Travel times for the highest volume movements are reduced.
- Transit priority measures could be included at intersections (such as queue jumps or dedicated Transit lanes), improving Transit travel times.
- Fewer crossings for pedestrians and cyclists in the area.
- Direct connections for trucks accessing the Port.

Some of the benefits of Option B include:

- Five intersection timings must be coordinated accounting for traffic flow patterns.
- Some movements through the area will have an increased travel time due to the road configuration. These are lower volume movements.

Phase 2 Public and Stakeholder Engagement
These two concepts, Option A and Option B, were then shared in Phase 2 of Public and Stakeholder Engagement in October/November 2021. External stakeholders during this round of engagement included local advocacy groups and property and/or business owners in and around the WSE study area.

Major takeaways from External Stakeholders:

- Some participants had concerns about the lack of information presented on future transit plans with either option.
- Some participants were concerned about spatial constraints and the space allowed for minimum widths for sidewalks and multi-use pathways.
- Some participants felt that a drawback for Option B were the right turn ‘slip lanes’ that would have active transportation users crossing with traffic possibly approaching from behind.
- Most participants felt that the active transportation options presented were an improvement on the current conditions.
- Most participants felt that while active transportation and transit were being accommodated, these modes were not being prioritized.
- Most participants preferred Option A, due to the perceived more direct pedestrian access with fewer crossings; however, some expressed concern with safety for AT users in a roundabout intersection.
- Concerns were raised in relation to any land required as well as potential impact to access and parking in sites.
- Concerns were raised in respect to impacts to traffic flow and access during construction.
- General agreement that improvements to the WSE are required.

An online survey was available on HRM's Shape Your City platform. A high-level summary of the responses is presented within this section.
Preferences for Options A or B:

- 36% felt that Option A would encourage them to walk or roll through the WSE, while only 13% said the same for Option B.
- 30% felt that Option A would encourage them to bike through the WSE, while only 12% said the same about
- Option B.
- 38% felt that Option A would encourage them to take transit through the WSE, while 31% said the same about Option B.
- 63% felt that Option A would improve their experience driving or as a passenger in a vehicle through the WSE, while only 23% said the same about Option B.

Feedback on Option A:

- Concern about roundabouts (pertaining to user understanding and navigation, snow removal, traffic volumes, wait times, and turning truck radius accommodation).
- Preference for roundabouts due to ability to accommodate traffic and positive experiences with other roundabouts.

Feedback on Option B:

- Preference for signalized intersection for better user familiarity.
- Concerns that vehicles are still required to merge and/or cross multiple lanes.
- Concerns with the number of intersections and navigational challenges for people driving.

General Project Feedback:

- Concern that both Options A and B are not ambitious or sustainable enough for the future.
- Concern that the study area does not include Joseph Howe Drive or the on-ramp between Joseph Howe Drive and the WSE.
- Appreciation that both options provide a more direct connection to and from the Bedford Highway and the Bridge.
- Concern about the active transportation options (not giving priority to AT, needing better connection to other AT facilities in the area)
- Concern about the inclusion of AT options in a high-traffic area.
- General perception that neither design would solve the existing issues at the WSE.
- Concern about lack of transit priority infrastructure presented in either option.
- Concern about the lack of overflow lanes and/or spaces for vehicles to pull over in the incidence of a collision or breakdown.

All feedback considered, more participants in the stakeholder engagement and the online survey preferred Option A than those who preferred Option B. On average, 42% of participants felt that it would improve their experience using all modes (driving, as a vehicle passenger, walking, rolling, biking, and transit), while only 20% on average felt that Option B would improve their experience using all modes.

However, many respondents whose preference was Option A noted the need for innovative wayfinding at the intersection to help unfamiliar users, and also for a robust educational program for how the roundabouts should be navigated by both people driving and people using active transportation modes. Additionally, many respondents whose preference was Option A felt that consideration should be given to transit priority measures.

Functional Design Options
Two concept designs were selected and refined to proceed to functional design. These are Option A (Roundabout) and Option B (Signalized Intersections).

For Option A, grade separated structures would be required to provide a direct connection from MacKay Bridge and Bedford Highway. A multi-use pathway is proposed on the south side of Bedford Highway connecting active transportation users to the roundabout. At the roundabout, multi-use pathways and sidewalk facilities would be used to access Windsor Street and Lady Hammond Road.

Option B includes a series of signalized intersections. As with Option A, a multi-use pathway would be proposed on the south side of Bedford Highway connecting active transportation users to the Windsor Street intersection. To mitigate potential capacity concerns, significant queue lengths and delay for vehicles and truck movements, adjustments were made to Option B from the concept design stage, including the conversion of the intersection of Bayne Street at Africville Road to a signalized intersection.

An intersection Level of Service (LOS) analysis was completed for both options to estimate how the two are expected to operate during future conditions with the reconfigured road network. For Option A, the proposed roundabout is expected to operate at acceptable performance criteria within the HRM critical limits during AM and PM peak hours based on the Sidra analysis. The roundabout and intersection of Lady Hammond Road and Kempt Road are expected to operate within the 85% capacity threshold during AM and PM peak hours, however the PM peak could be constrained by downstream capacity and queueing from Bedford Highway. For Option B, the network is shown to be operating within acceptable performance criteria except for periodic queue spillback between intersections during peak periods based on the Sidra Analysis.

The intersection Multi-Modal Level of Service (MMLOS) analysis was completed for the Functional Design of both options. Most of the results for Option A met the HRM's target LOS for the study intersection of Bedford Highway with Windsor Street roundabout layout, as well as the Lady Hammond at Kempt Road intersection. For pedestrians there is an overall LOS D due to the high number of approach lanes and the long crossing distances. Many of the results for this Option B Study intersections met the HRM's target LOS, but this option performed generally not as well as Option A. For pedestrians and cyclists there is an overall LOS D or E due to the long cycle lengths and crossing distances of the signalized intersections.

In terms of transit, there are currently no bus stops within the main WSE area. Option A results in a moderate reconfiguration of the ramp from the Bedford Highway to Windsor Street where there is currently an inbound bus stop. This stop would have to be rebuilt but could remain in the same general area. Little or no modification would be required for Option B. Other existing stops on Lady Hammond Road, Kempt Road and Windsor Street are set far enough back from areas that require street reconfiguration that little or no modification will be required. With greater delays projected at the signalized intersection, the transit times through the Option B are longer than Option A.

Connections into and out of the FCCT are much more direct with Options A and B than the current configuration. Entry points into the FCCT facilities are maintained to Africville Road, although there is encroachment into the current truck marshalling area. With the Option B signalized intersection, an improved connection to and from the FCCT would be achieved, particularly for trucks arriving from Joseph Howe Drive or Bedford Highway and those destined to the MacKay Bridge.

There are several impacted properties along the perimeter of the project area for both options. For Option A the majority of these have minor impact on the abutting property, except for along Bedford Highway. Option B has more significant impact to several properties due to the additional lanes required along Bayne Street. Utilities are also impacted by the proposed options. Utilities will be required to be realigned and reprofiled within the footprint of the project. There are requirements for reconfiguration of utilities due to proposed grade changes at the Bedford Highway / Windsor Street intersection.

Structurally, Option A would involve the construction of a raised bypass for the Bedford Highway. To permit access between the highway and the existing road network two overpass structures will be installed. To the west, a 32m overpass structure will be installed to span three traffic lanes. A second approximately 20m span overpass structure would be required for the westbound off ramp from Dartmouth. Option B would

involve the construction of a raised bypass for the Bedford Highway. To permit access between the highway and the existing road network, one overpass structure north of the Windsor Street intersection would be installed. The overpass would span the five lanes required for Windsor Street. Additionally, a sidewalk would be installed under the overpass to connect the proposed pedestrian network. To construct the raised Bedford Highway bypass lanes, retaining wall structures would be required at various locations across the site for both options. These retaining walls would vary in height from 1m to 8m.

Option A was anticipated to provide an overall construction timeframe of approximately 92 weeks and cost $40.8 million. Option B was anticipated to provide an overall construction timeframe of approximately 104 weeks and cost $43.9 million. Cost estimates include work and materials associated with each design option such as, earthwork, municipal services, and street construction.

WSP completed a comparison of Option A and Option B functional designs and considered the vehicular impacts, improvements to goods movement (trucks), transit and active transportation opportunities, physical constraints, structural and geotechnical reviews, and property impacts. After completing an evaluation comparison, Option A scored the highest compared to Option B. It is expected that Option A will cost less for property acquisition and have a smaller construction area and therefore, is expected to reduce the overall implementation timeframe versus Option B.

Climate Change Resilience Assessment

As part of the conceptual stages of the project design, HRM engaged WSP to conduct a Climate Lens Assessment (CLA) for the proposed redevelopment. The Climate Change Resilience Assessment (CCRA) was conducted for the project in accordance with the methods and requirements outlined by Infrastructure Canada's Climate Lens Guidance. The assessment reviewed historical and projected climate data for the region to determine potential vulnerabilities and climate change impacts to Windsor Street Exchange (WSE) operations and assets. Adaptation strategies were then recommended to improve the resilience of the project to future climate.

Projections indicate an increase in both average and extreme temperatures, and in intensity and frequency of precipitation across all seasons. Due to increasing temperatures, snowfall is expected to decrease, which indicates more precipitation falling as rain or freezing rain and increased frequency of freeze-thaw cycles during the winter months. Additionally, the region is expected to see an increase in wildfire activity and wildfire smoke. These changes to climate parameters are more pronounced towards the end of the century. Strong winds and storm activity are expected to decrease on average; however, hurricanes are expected to increase in the first half of this century, with a decrease shown towards the end of the century.

The assessment considers infrastructure elements of the proposed design summarized by road surfaces, deck and joints; structural members; granular materials; footings and piles; drainage infrastructure; and signage and lighting with additional consideration for landscape, maintenance, and road safety. A total of 34 climate impacts were evaluated as part of the CCRA. The results of the risk assessment identified 23 impacts with moderate and higher likelihoods.

Specific control measures were proposed for these impacts to decrease the level of risk through design considerations and operations and maintenance measures. If specific control measures are implemented, the residual risks are all rated as moderate, low, very low or provide an opportunity into the future. Overarching recommendations for HRM include:

- Consider future projections for increased temperatures and extreme heat in the design and selection of the surface course materials and structural construction materials. Current design specifications for asphalt and concrete mix designs may not be adequate, which may result in more frequent repairs throughout the lifecycle. Efforts may be focused in areas of high traffic volume and for heavy vehicle traffic. Considerations for installing structural vegetated walls to replace conventional concrete retaining walls, where appropriate, could provide co-benefits of lower embodied carbon, reduced urban heat island effects, and absorption of pollutants.

- Incorporate design guidelines from Design Specifications & Supplementary Standard Specifications for Water, Wastewater & Stormwater Systems, Halifax Water, 2020, which utilize future IDF curves for stormwater pipe sizing. Consider the downstream impacts of future for precipitation and peak flows in the design of drainage infrastructure including onsite retention.
- Continue regular inspection and maintenance of roadways and adapt procedures to changing weather conditions. As extreme weather increases in frequency and severity, HRM may need to adjust budgets to account for increasing inspections of roadway assets and to assess and repair potential damages.

Three primary potential opportunities have been identified, including longer growing seasons to support vegetation growth, fewer winter days resulting in less maintenance in the early spring and late fall, and reduced frost depths lowering the potential damage to roadways and drainage infrastructure. Additionally, fewer winter days may encourage the use of active transportation routes through the area. Opportunities to implement nature based solutions related to extreme heat events, such as tree planting to provide shade for the active transportation route and public transportation stops may also provide co-benefits in fulfilling the HRM Urban Forest Plan objectives.

Risk assessments should be considered as an ongoing process and it is therefore recommended that HRM periodically revisit the vulnerability and risk assessments and the control measures considered in the CCRA as new information becomes available (e.g., detailed design, updated climate projections, changes to operating parameters and/or local conditions) at a minimum every five years. It is recommended that control measures related to design are considered in all future road design work across the portfolio.

Technical Review

Due to the volume of traffic that currently moves through the Windsor Street Exchange, and accounting for future growth in Fairview, Clayton Park, and Bedford, the concept designs that have been developed to meet the project objectives are complex urban interchanges. The project team engaged a third-party consultant with the necessary expertise to provide a technical review of the design concept options and support the selection of a preferred configuration option; the Technical Review was completed by Exp Services.

Of the two options presented, Option B was viewed as the preferred option of the Exp review team for the following reasons:

- Less complex overall – easier for wayfinding;
- Fewer conflicts areas / longer weaving zones;
- Better accommodation of trucks;
- Similar to slightly better accommodation of AT users;
- Capital costs for both options are same order of magnitude; and
- Team not convinced Option A is feasible from an operational and geometric perspective within the given ROW constraints and apparent discrepancies in the LOS analysis.

The Exp Review Team also provided feedback on potential opportunities to further refine both options to address some of the comments presented by the review team. This feedback was considered in the development of Modified Option A and Modified Option B.

Modified Functional Design Options

WSP recommended further review of modification opportunities at the Joseph Howe Ramp intersection with Bedford Highway. HRM requested WSP investigate an enhancement recommendation to consist of “n extension of the project area to include Joseph Howe Drive for a direct connection to access the MacKay Bridge. Comments on the design options from HRM and the Technical Review were also provided to WSP for consideration. WSP then prepared Modified Option A and Modified Option B, which include proposed changes to the Joseph Howe ramp approach to the project area.

Modified Option A and Modified Option B allow more traffic to take advantage of the grade separated portion of the road network and provide a reduction in traffic volume approaching the primary intersection by modifying the use of the DV-K Ramp from Joseph Howe Drive toward the WSE. This reduction in traffic at the primary intersection in each option allows for lane reductions at the intersections.

For Modified Option A, the lane reductions that were possible with the reduction to eastbound approaching traffic simplifies the roundabout and removes three lane approaches that are shown in Option A. This provides operational benefit, as well as improvements to AT connectivity at the roundabout. Operational challenges are noted during the PM peak due to westbound downstream capacity and potential queuing of the westbound roundabout exit to Bedford Highway. With queueing at the roundabout exit, high volume of traffic from Windsor Street and Lady Hammond Road destined for Bedford Highway queue and have long delays.

The changes noted for Modified Option A versus Option A include:

- Reduction in traffic at primary intersection
- More traffic benefits from the grade separation portion of the network
- Simplified roundabout with improved AT crossings
- Continued operational challenges during the PM peak due to westbound downstream capacity and potential queueing at the roundabout exit

For Modified Option B, the lane reduction possible on the eastbound approach reduces the intersection area and provides opportunity to improve the angle of the ramp for traffic from Windsor Street to travel toward MacKay Bridge. These intersection reconfigurations are possible since traffic from the Joseph Howe ramp has the ability to bypass the signalized intersection.

The changes noted for Modified Option B versus Option B include:

- Reduction in traffic at primary intersection
- More traffic benefits from the grade separation portion of the network
- Reduced area with simplified eastbound and northbound approach at the Bedford Highway / Windsor Street intersection

Compared to Modified Option A, Modified Option B requires more property acquisition, includes a larger construction area, and has a higher expected cost for implementation. However, with the expected operational challenges resulting from known queueing on the Bedford Highway during the PM peak period and the potential to impact operations of the roundabout exit in Modified Option A, WSP recommended Modified Option B be carried forward in further stages of this project.

Value Engineering Study

In Spring 2022, the project team determined that a value engineering study of the revised Functional Plan Report submitted by WSP would be beneficial to evaluate the work that had been done so far and the design options that are under consideration, and provide recommendations to improve the efficiency, safety, impact, constructability, and cost of the project. The value engineering study was conducted by a team of experts, led by HDR and CBCL, and included pre-workshop review and preparation, a workshop which identified and evaluated potential alternatives, and review of which alternatives could be implemented on the project.

Value engineering is an approach that is used to analyze and improve projects, and has been used to evaluate design options for major infrastructure projects across North America. While value engineering has not been used on HRM transportation projects in the past, these studies have been successful in other jurisdictions to improve project outcomes, reduce construction costs, and deliver overall value for money. Given the complexity of the design options, the estimated construction costs, and the significant impact to the regional transportation network, it was expected that using value engineering on the WSE project would provide many benefits.

A value engineering study is conducted by a team of experts, and includes pre-workshop review and preparation, a workshop which identifies and evaluates potential alternatives, and review of which alternatives will be implemented on the project.

The value engineering study for the Windsor Street Exchange Redevelopment project:

- evaluated the work that has been done so far and the design options that were being considered;
- considered input received from the project stakeholders and the public;
- evaluated potential alternative design options; and
- provided recommendations to improve the efficiency, safety, impact, constructability and cost of the project.

Excerpts of the Value Engineering (VE) Study report are included in Appendix B of this report. Relevant information is summarized below.

Evaluation of Baseline Concept

Based on review of the Modified Design Options, it was determined that Modified Option B would be used as the 'Base Case' for the VE Study. The VE team evaluated the Base Case as the planned final design, and compared alternative options that were considered to the Base Case.

During the course of the VE study, a number of analytical tools and techniques were applied to develop a better understanding of the baseline concepts. A major component of this analysis was Value Metrics which seeks to assess the elements of cost, performance, time, and risk as they relate to project value. As part of the Value Metrics process, the project team representatives identified a number of Performance Requirements, defined as the essential, non-discretionary aspects of the project, and Performance Attributes, those aspects of a project's scope that may possess a range of potential values. These were used throughout the study to identify, evaluate, and document alternatives.

Performance requirements represent essential, non-discretionary aspects of project performance. Any concept that fails to meet the project's performance requirements, regardless of whether it was developed during the project's design process or during the course of the VE study, cannot be considered as a viable solution. Concepts that do not meet a performance requirement cannot be considered further unless such shortcomings are addressed through the VE study process in the form of VE alternatives.

- Highway Design Standards: must meet applicable design standards, or be approved by HRM's Variance Committee.
- Structural Design Standards: structures within the project area must comply with structural design standards.
- Environmental Review: must comply with regional, provincial and federal environmental law and be compatible with the environmental review process.
- Mainline Operation Requirements: must provide free flow operation between the Bedford Highway and MacKay Bridge.
- Maintain minimum operations during construction: maintain emergency access routes and ability to support Port operations, transit operations, and existing active transportation.
- Utility relocation requirements: maintain critical utility infrastructure and remove/relocate utilities as necessary.
- Maintain access to select facilities during construction: maintain truck access to the Port and equipment access to HRM Mackintosh Street Depot.
- Existing structures: cannot impact the structure of the existing Fairview and Mackintosh Street overpasses.
- Cemetery disturbances: prevent any excavation or permanent disturbance to St. John's Cemetery.

Performance attributes are defined as the elements of the project's scope that are pertinent to the project's need and purpose. Performance attributes were defined by the VE team based on the WSE project

objectives, and the Base Case was evaluated for each attribute to determine the baseline performance that alternatives would be compared against.

- Mainline Operations: The Mainline Operations performance attribute is defined as an assessment of traffic operations on the mainline facilities within the project limits above and beyond the minimum established in the project requirements. For this project, this is defined as the Bedford Highway to MacKay Bridge connection. Operational considerations include level of service relative to the 20-year traffic projections, as well as geometric considerations such as design speed, sight distance, lane widths, and shoulder widths. The attribute considers operational considerations for Trucks/Vehicles as tied together, and includes connectivity for trucks accessing the Port of Halifax. Transit improvements are also tied to mainline operations benefits, but also include potential for future dedicated transit facilities.
- Local Operations: Local Operations is defined as an assessment of traffic operations of the local roadway infrastructure, including the service roads, cross roads and other ancillary local roads. For this project, this includes Kempt Road, Lady Hammond Road, Bayne Street, Africville Road, Barrington Street, and Massachusetts Avenue, Joseph Howe. Operational considerations include level of service relative to future traffic projections; geometric considerations such as design speed, sight distance, and lane widths.
- Maintainability: The performance attribute Maintainability is defined as an assessment of the long-term maintainability of the transportation facility(s). Maintenance considerations include the following factors:
    - Overall Durability (M-1): Longevity (i.e. service life) and ability to maintain a good state of repair for pavements, structures, and other facility systems
    - Ease of Maintenance Efforts over the Service Life (M-2)
    - Accessibility and Safety Considerations for Maintenance Personnel (M-3)
- Temporary Construction Impacts: This performance attribute is defined by an assessment of the construction impacts of the facilities. These are temporary impacts only observed during the construction phase of the project. Construction impacts should consider the following components:
    - Temporary Public Impacts (C-1): A measure of the construction effects on the travelling public (staged construction and ease of traffic management)
    - Temporary Environmental Impacts (C-2): A measure of impacts to the surrounding community in terms of air, noise, vibrations, dust, and water quality
    - Constructability (C-3): The relative ease of constructing the proposed facility in term of availability of materials, availability of labor, and complexity of construction operations (such as stage construction complexity, lane restrictions and construction methods)
- Environmental Impacts: Defined as an approximation of the concept's overall effect on the natural environment. Since there is no habitat or other environmentally sensitive areas in the project limits, this attribute included the project's potential climate change resilience, such as through the installation of green infrastructure and/or the reduction of greenhouse gas emissions.
- Right of Way and Community Impacts: An assessment of the socio-economic impacts to private property, commercial properties, cultural, community impacts (including Africville), recreational, and historic resources. Attribute also considers the impacts to utilities and other resources within and adjacent to the project limits.
- Active Transportation: Assessment of the dedicated facilities to support active transportation, pedestrians, and non-motorized vehicles. Attribute considers safety of crossings, separation from vehicle traffic, and other amenities.

The performance attributes of a project are seldom of equal importance. Therefore, a systematic approach must be utilized to determine their relative importance in meeting the project's need and purpose. Once the performance attributes were defined and their scales developed, the VE team prioritized them based on their relative importance to the project. The performance attributes were systematically compared in pairs, asking the question: "An improvement to which attribute will provide the greatest benefit relative to the project's need and purpose?" Participants were then asked to indicate their priorities and the relative intensities of their preferences. The prioritization and relevant weighing of each performance attribute is

noted below; the weighing factors were used to provide a performance score for the Base Case and each alternative considered.

- Mainline Operations: 28.0%
- Active Transportation: 20.6%
- Right of Way and Community Impacts: 17.2%
- Local Operations: 13.7%
- Temporary Construction Impacts: 10.3%
- Maintainability 6.8%
- Environmental Impacts: 3.4%

Road Safety Review

The VE Team carried out a road safety review of the Base during the pre-workshop phase of the VE study. The safety review identified safety concerns associated with the Base Case and potential mitigation measures to address the safety concerns. The key safety concerns identified by the review are related to the following:

- Several segments of short weaving areas that may contribute to side swipe collisions.
- Closely spaced signalized intersections that may lead to aggressive driver behavior that may contribute to rear-end collisions.
- Confusing and unconventional lane layout and turning requirements, particularly at WB Lady Hammond Road and Windsor Street intersection that may contribute to right-angle collisions.

Vissim Traffic Modeling

The VE team was provided the Vissim Traffic Model for the Base Case. During the VE team's analysis of the model, an inbound bottleneck in the eastbound direction at the intersection of Joseph Howe Road and Bedford Highway was identified. This bottleneck was metering all inbound traffic from the southwest and west. This pinch point restricted the flow of traffic into the model and study area. The other modeling issue was a geometrically constrained single lane loop ramp from westbound Bedford Highway to Joseph Howe Drive. The small radius and the manner in which it splits from the Bedford Highway created a critically flawed weaving section between that ramp and any option in the Windsor Street Exchange area.

The VE Team developed a new traffic model with revised input volumes and new model geometry, speed controls, conflict management, and signalization. For the two locations identified above, the VE team incorporated the configurations of the VE Alternatives (VE Alternative BC-1 and BC-2) into the model in order accurately assess the traffic operations of the Base Case and the VE Alternatives. Travel time data collection corridors and nodes were placed into the model to collect output for a quantitative comparison of performance between the baseline and VE alternatives.

Cost Estimate Review and Parametric Cost Model

The Cost Estimate in the Functional Design Report for the Base Case is $44M (in 2020 Dollars). There has been an approximately 35% increase in construction costs over the last two years due to inflation and other factors. When accounting for this increase, the adjusted cost estimate from the Functional Design Report becomes $59.4M. The VE team prepared a Parametric Cost Model for the Base Case using unit rates for the major infrastructure components. The Parametric Cost Model then used quantity take-offs of the major infrastructure components for the distinct road segments in the project. Allowances and contingencies were applied to the Parametric Cost Model as follows:

- Traffic Control – 5%
- Utility Relocations – 17.9% (based on $6.45M in the Functional Design Cost Estimate)
- Minor Items – 30%

The total cost of the project as estimated by the Parametric Cost Model is $54.4M in 2022 dollars. Note additional escalation may need to be applied to this amount based upon an expected award date of 2025.

Value Opportunities and Focus Points
The primary opportunities for value improvement resulting from the VE team's analysis of the Base Case using the tools and techniques of the Value Methodology were as follows:

- Analysis of traffic outside of project limits and implications to project scope/design
- Base Case Modifications
    - Local road operations
    - ROW / Property / Utility Impacts
- Shift Bedford to At-Grade in lieu of Grade Separated
- Upgrade Africville Road
- Confirmed ability to prioritize transit and bypass queues
- Provide Active Transportation Connections & Improvements
- Possible phasing of improvements within funding and time constraints

Value Engineering Alternatives
The VE study identified 13 alternatives to the baseline concept that could potentially add value to the project through improved performance, cost savings, or a combination of both. The alternatives are organized by category based upon the project feature/project location or aspect of the project being addressed by them. Details of each alternative are included in Appendix B.

Summary of VE Alternatives			
Alt No.	**Alternative Title**	**Initial Cost Savings (Or Added Cost)**	**Performance Summary**
Base Case Modifications			
BC-1	Remove NB Joseph Howe to WB Bedford Highway access and convert WB Bedford to SB Joseph Howe Drive to dual lane loop ramp	($200,000)	Improved (MO)
BC-2	Create a direct taper slip ramp from MacKay Bridge to Massachusetts Avenue	($1,100,000)	Improved (MO)
BC-3	Remove traffic from Joseph Howe Drive ramp by providing signalized stop condition at Main Avenue with displaced left/DDI	($600,000)	Improved (MO, LO)
BC-4	Improve turning movement and signal phasing from the Port to MacKay Bridge at Windsor Street Exchange	$0	Improved (MO, LO)
BC-5	Modify Kempt Road operation and access	A. Comment B. $2,400,000 C. $2,800,000	Improved (ROW, AT) Reduced (LO, M)

Summary of VE Alternatives			
Alt No.	**Alternative Title**	**Initial Cost Savings (Or Added Cost)**	**Performance Summary**
Bedford At-Grade			
BAG-1	Eliminate grade separation of Bedford Highway at Windsor Intersection	$11,000,000	Improved (CI, ROW, Risk) Reduced (MO, LO, AT)
BAG-2	Relocate grade separation to the east with new local crossing	$10,100,000	Improved (MO, CI, M, ROW) Reduced (AT)
Africville Road Upgrades			
AR-1	Extend MacKintosh Street to Africville Road	$7,400,000	Improved (MO, LO, ROW, M)
Active Transportation			
AT-1	Provide basin-side AT connection to Africville Museum	($1,800,000)	Improved (AT) Reduced (ROW, M)
AT-2	Provide an AT connection to Bedford Highway on the south side	($32,000)	Improved (AT) Reduced (ROW, M)
AT-3	Provide AT connection to Devonshire Avenue along Lady Hammond Road and connect to Africville Museum	Comment	Improved (AT) Reduced (ROW, M)
AT-4	Convert sidewalks into multi-use pathways (MUPs)	($470,000)	Improved (AT) Reduced (ROW, M)
AT-5	Connect MacKintosh Street multi-use pathway to Africville Road over CN Railway	($340,000)	Improved (AT) Reduced (ROW, M)

Note: Because the cost data depicted above represent savings, a red value in parentheses represents a cost increase.

Performance Attribute Legend: MO – Mainline Operations, LO – Local Operations, AT – Active Transportation, ROW – Right of Way/Community Impacts, CI – Temporary Construction Impacts, M – Maintainability, EI – Environmental Impacts

VE Study Results

After developing the VE alternatives, the VE team reviewed and discussed each alternative and developed a consensus relative to its prioritization for implementation. The prioritization was based on

factors that include improved performance, likelihood of implementation, cost savings, or any combination thereof.

VE Strategies consisting of complimentary combinations of individual VE alternatives that were deemed the highest in priority were developed. The VE Strategies and the VE Alternatives included in them are summarized below:

- VE Strategy 1
  - BC-1, BC-2, BC-3, BC-5 (Option C), BAG-1, AR-1, AT-2, AT-3, AT-4, AT-5
  - Cumulative Savings: $18,490,000
- VE Strategy 2
  - BC-1, BC-2, BC-3, BC-5 (Option C), BAG-2, AT-2, AT-3, AT-4, AT-5
  - Cumulative Savings: $10,190,000
- VE Strategy 3
  - BC-1, BC-2, BC-3, BC-5 (Option C), AR-1, AT-2, AT-3, AT-4, AT-5
  - Cumulative Savings: $7,490,000

Although the different VE Strategies have varying impacts on overall project performance, they primarily benefit the project by reducing initial cost through base case modifications, reducing impacts to Bayne Street, and improving Active Transportation while improving maintainability and reducing ROW impacts. VE Strategy 1 eliminates the Windsor Street crossing/grade separation and extends Mackintosh Street to Africville Road. VE Strategy 2 shifts the grade separation to the east to avoid utility impacts and significantly improve mainline and local traffic operations. VE Strategy 3 improves the turning movement and signal phasing from the Port to MacKay Bridge at the Windsor Street Exchange and extends Mackintosh Street to Africville Road.

A summary of the cost, performance, and value change of the VE Strategies is provided in the following table. The performance scores for each VE Strategy were divided by the total cost scores for each VE Strategy to derive a value index. The value indices for the VE Strategies were then compared against the value index of the baseline concept and the difference is expressed as a percent (± %) deviation. Further details on how the study results were developed are available in Appendix B.

Summary of VE Alternatives				
Strategy Description	**Initial Cost Savings**	**Performance Change**	**Value Index**	**Value Change**
VE Strategy 1 – BC-1, BC-2, BC-3, BC-5 (Option C), BAG-1, AR-1, AT-2, AT-3, AT-4, AT-5	$18,490,000	-6.5%	2.375	+43%
VE Strategy 2 – BC-1, BC-2, BC-3, BC-5 (Option C), BAG-2, AT-2, AT-3, AT-4, AT-5	$10,190,000	+44.3%	2.961	+78%
VE Strategy 3 – BC-1, BC-2, BC-3, BC-5 (Option C), AR-1, AT-2, AT-3, AT-4, AT-5	$7,490,000	+28.0%	2.473	+49%

Implementation Action
Following the VE Study, the results were presented to the HRM project team, key stakeholders, and HRM management. Reviewers were asked to share their comments and recommended action for each alternative, and then that data was compiled for review in an Implementation Meeting. Final decisions on what action would be taken for each alternative are noted below, along with an update on the current status of the recommended action. Comments and approved actions are noted in the table in Appendix B.

- BC-1: Remove NB Joseph Howe to WB Bedford Highway access and convert WB Bedford Highway to SB Joseph Howe Drive to dual lane loop ramp.
    - Feedback was split between removing this alternative due to the potential impact on local traffic operations, or requiring further study. Ultimately this alternative was included for further study, and a revised version that addresses the concerns raised is part of the proposed final Functional Design.
- BC-2: Create a direct taper slip ramp from MacKay Bridge to Massachusetts Avenue.
    - While the value of this alternative was noted, given the potential changes to the ramps due to the MacKay Bridge project, it was decided that an interim measure should be considered. A modified version of the alternative is part of the proposed final Functional Design; while it does not provide the anticipated benefits of the alternative presented in the VE Study, it's expected that a better solution will be identified through the MacKay Bridge project.
- BC-3: Remove traffic from Joseph Howe Drive ramp by providing signalized stop condition at Main Avenue with displaced left/DDI.
    - Further study was required, and this alternative has been considered as part of the proposed final Functional Design.
- BC-4: Improve turning movement and signal phasing from the Port to MacKay Bridge at Windsor Street Exchange.
    - It was agreed that this alternative would be adopted; however, the final proposed Functional Design does not include this turning movement, and therefore this alternative has been dropped.
- BC-5: Modify Kempt Road operation and access.
    - Three alternative options to modify Kempt Road were considered as part of the VE Study, and ultimately it was decided that Option C, changing Kempt Road intersection to right-in-right-out, would be carried forward for further study. A modified version of this alternative is included in the proposed final Functional Design.
- BAG-1: Eliminate grade separation of Bedford Highway at Windsor Street Intersection.
    - While this option presented improvements to many aspects of the project, it was not expected to provide the Mainline Operations improvements that would be expected by our funding partners. This option was dropped from the project.
- BAG-2: Relocate grade separation to the east with new local crossing.
    - While this option showed promise as an improved alternative design, further study was needed for consideration. This option was evaluated and further refined, and now forms the basis of the proposed final Functional Design.
- AR-1: Extend Mackintosh Street to Africville Road.
    - This option was determined to be beneficial, but dependent on discussions with CN Rail on a new or relocated rail crossing. Ultimately, after further study and discussions with CN Rail, it was determined that the grades of a rail crossing would be significant for truck traffic and AT users, and CN Rail would not accept a crossing at this location. This alternative has been dropped from the project.
- AT-1: Provide basin-side AT connection to Africville Museum.
    - This option was determined to require further study, but also be outside the scope of the WSE project as an AT connection would be provided as part of the project. This alternative for an additional connection will be considered as part of other AT Planning efforts, though it is highly dependent on discussions with CN Rail and the Port Authority to ensure that it could be considered safely.
- AT-2: Provide an AT connection to Bedford Highway on the south side.
    - This alternative was accepted and has been included in the proposed final Functional Design.
- AT-3: Provide AT connection to Devonshire Avenue along Lady Hammond Road and connect to Africville Museum.

    - This option was determined to require further study, but also be outside the scope of the WSE project. This alternative for an additional connection will be considered as part of other AT Planning efforts, and the option for potential future additional connections will be considered in the WSE design.
- AT-4: Convert sidewalks into multi-use pathways (MUPs).
    - This option was deemed to have significant cost; however the active transportation routes through the project area have been considered, and sidewalks or MUPs are designated where the most optimal route has been determined in the final proposed Functional Design.
- AT-5: Connect MacKintosh Street multi-use pathway to Africville Road over CN Railway.
    - This option was considered along with AR-1, and given the grades of a connection at this location, and CN Rail not accepting a rail crossing, this alternative has been dropped from the project.