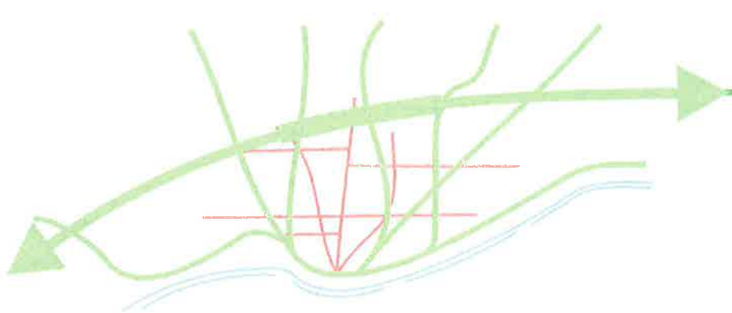
Ontario

407 TRANSITWAY

From East of Highway 400 to Kennedy Road

Environmental Project Report



Section 5: Identification of Alternatives and Evaluation Process

Delcan IBI GROUP

in association with

LGL

5. IDENTIFICATION OF ALTERNATIVES AND EVALUATION PROCESS

The Transit Project Assessment study was undertaken to develop the technically preferred alignment, stations and operation and maintenance facility, for a BRT system with the ability to convert to a LRT system. Through the Planning and Preliminary Design Stage of the study, the development of alternatives to the technology implemented, the station locations and layouts, and the route alignment have been completed. **Figure 5-1** illustrates the process from study initiation to the completion of the Preliminary Design Stage of the 407 Transitway study.

Figure 5-1: 407 Transitway, Central Section, Planning and Preliminary Development Stage

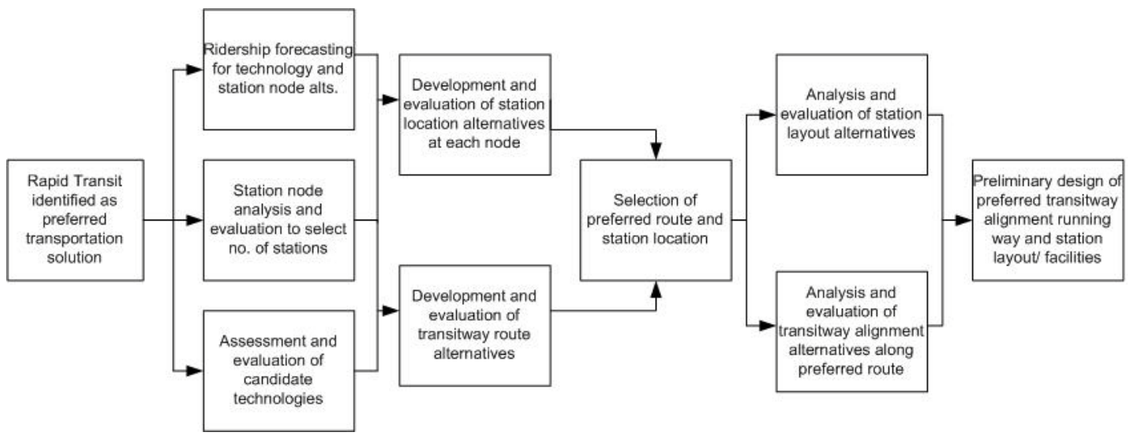
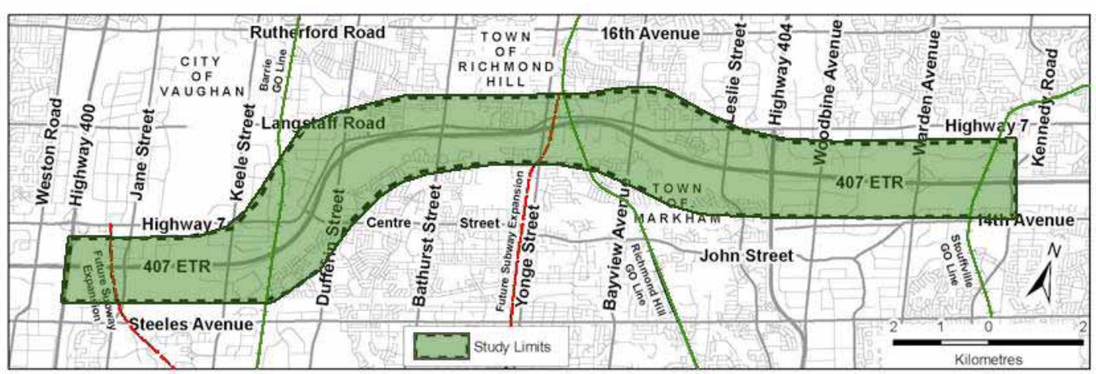


Figure 5-2: Key Plan of the Study Area



This project involves constructing a 23km separately dedicated running way for transit vehicles, an operation and maintenance facility, and seven stations within the project limits: Jane Station, GO Barrie (Concord) Station, Bathurst Station, Yonge Station, Leslie Station, Woodbine/Rodick Station, and Kennedy Station. The project limits are illustrated in **Figure 5-2**.

Study Purpose & Objectives:

The primary objective of the 407 Transitway is to foster and support sustainable travel behaviour and a more compact urban structure in the GTA. In this regard, the 407 Transitway is an integral element of the Growth Plan and has the following attributes:

- In its final form, the 407 Transitway would transform the existing predominantly radial system of high order regional transit facilities into a network configuration, thereby expanding travel choices as well as reinforcing the utilization of the existing system.
- It reinforces the emergence and development of mixed use UGCs in the vicinity of the Highway 407 Corridor, mostly comprised of office, retail and institutional elements.

A primary focus is to enable gateway opportunities through the provision of modal interchange facilities.

More specific objectives of this study are to design the 407 Transitway, maintenance facilities and stations to accommodate an initial bus service with provision for future conversion to LRT, including local bus access to and egress from the stations, platforms, access to/from the adjacent arterial road, parking, PPUDO, buildings, shelters and other miscellaneous amenities. To support these objectives, the scope requires that the following activities be undertaken:

- develop detailed ridership forecasts for 2011, 2021, 2031 and 2051 horizon years;
- develop a set of design standards for the defined section of the transitway for both bus operation and LRT operation (including the associated maintenance and storage yard, stations and transit equipment) that will also be applied in the future to the remaining sections of the 407 Transitway;
- develop a cost-effective, safe and innovative preliminary design and construction staging for the 407 Transitway, both for bus services and LRT service, involving minimum throwaway for conversion to LRT;
- present a recommended phased implementation strategy for this first section of the bus transitway;
- incorporate design features of the 407 Transitway to provide for integration with existing and proposed municipal transit services; and,
- develop a Marketing Plan to provide a framework for advocating the benefits and value of the project and to encourage funding for the project.

5.1 Study Assessment

For the evaluation of alternatives and the evaluation process, several varying workshops were undertaken throughout the Planning and Preliminary Design. These workshops facilitated the assessment of the study and led towards the development of the Transitway's Design Standards as well as the generation of the transitway's route and station alternatives. The following section describes the Functional Performance Specification (FPS), Risk Based Cost and Schedule Analysis (RBCSA), and Valued Engineering (VE) workshops that were conducted in the study assessment.

5.1.1 Functional Performance Specification and Design Criteria

A major component of this study was to develop Transitway Design Standards for the 407 Transitway alignment, stations, and operations, maintenance and storage facilities. The design standards were to be developed through a review of standards and practices used by other transportation and transit authorities and through a series of functional performance specification workshops. Participants to the workshops included the study team, representatives from Metrolinx, Human Factors North, York Region Transit, and OC Transpo and MTO.

The first Functional Performance Specifications Workshop was held in September 12-14, 2007. To discuss the principles for the Functional Performance Specification Process, project background, needs and opportunities, jurisdictional review of other transit systems and the project's study area.

As part of the first workshop, the Study Team visited Ottawa to inspect the OC Transpo operating system and identified factors for success and lessons learned. The workshop included brainstorming session for functional performance requirements which resulted in "high-level" visions for the 407 Transitway. The functional analysis produced a general functional tree to identify and organize all functional objectives to be met by the project.

Following the first workshop, all reasonable "Alternatives To" the undertaking were identified based on the results of the workshop. The "Alternatives To" was selected and a set of Alternative Methods for the transit technology was then developed and analyzed, resulting a recommendation of the preferred transit technology.

A second workshop held in October 31, 2007 to November 2, 2007 developed a more detailed, functional performance specification for runningway, stations and maintenance and storage facilities.

Based on the two workshops, MTO developed the Transitway Design Standards Manual to achieve safe, high speed (90-100 km/hr), initial BRT operation while not precluding future conversion to LRT.

5.1.2 Risk Based Cost and Schedule Analysis Workshops

Two risk-based cost and schedule analysis workshops for the 407 Transitway were held in the Fall of 2008 and in the Spring of 2010. Participants to these workshops included members for the study team, experts in transit, traffic and highway engineering, urban design/landscape architect expert, structural and drainage engineering, elicitors, project management and representatives of Metrolinx, OC Transpo and MTO. The intent for these workshops is to consult with technical experts in the review of the project schedule and cost estimate, which would form part of the overall decision making. The purpose of these workshops was to:

- analyze and document the potential range in both total project cost and schedule due to risks or opportunities; and,
- identify and prioritize risks and opportunities.

The workshops identified significant opportunities and risks to the overall project cost and project schedule. It also identified a list of considerations to minimize critical risks and to exploit critical opportunities.

The intent of the results was to form the basis for overall decision making as well as provide input into both VE and Risk Management (RM) strategies that may be undertaken by the project team to optimize delivery and value of this project.

5.1.3 Value Engineering Study

Two Value Engineering Study workshops were planned for this project. Participants to these workshops included members of the study team, experts in transit, traffic and highway engineering, urban design/landscape architect expert, structural and drainage engineering, human factors and representatives of Metrolinx and MTO. The first 5-day VE Study was conducted in the Fall of 2008 to analyze/evaluate the Technically Preferred Alternative for the 407 Transitway from Highway 400 to Kennedy Road. VE proposals were developed to address overall capital cost savings; life cycle cost savings and/or improved project performance while still achieving the functional requirements of the project (i.e. best value for the money spent). VE proposals were combined into the overall project scenarios and evaluation of these scenarios against the base case concept design was done to determine the overall preferred alternative to take forward into preliminary design. New perspective and ideas were received and identification of project risks and their mitigation were determined. Lastly, identification of unnecessary costs from the base case concept for 407 Transitway were made.

The most significant VE proposals discussed at the VE Study were:

- dedicated lanes adjacent to existing Highway 407 lanes;
- reduce runningway width to have a single operational shoulders;
- six stations by eliminating Bathurst Street Station;
- build transit station on top of Highway 407 at Leslie;
- relocate GO Barrie (Concord) Station and transitway south of Highway 407;
- locate stations over parking lot where appropriate;
- span stations across arterial roads;
- reduce skew of structures (e.g. west of GO Barrie Line);
- reduce length of spans; and,
- use of B5 Alignment (407 Transitway alignment south of Highway 407) and B1 Alignment (407 Transitway north of Highway 407) between Keele Street and Bathurst Street.

The VE Team determined which VE proposals best fit together into VE Scenarios that make sense and could be presented as cohesive, complete conceptual design solutions for the 407 Transitway. Two VE scenarios were developed, removing any cost overlaps between the proposals composing each of the scenarios.

Due to the conceptual stage of the project, the results of the evaluation were considered as guidance for the 407 Transitway preferred planning alternative being carried forward into preliminary design.

The second VE Study workshop was conducted in the Spring of 2010 to analyze the preliminary design of the Technically Preferred Alternative for the 407 Transitway. The Base Case and four VE scenarios based on inputs received from the VE Team were developed.

The first scenario consisted of a series of minor modifications to the Base Case designed such as relocation of bus loops at Bathurst Street Station and GO Barrie (Concord) Station, changes to the width of the runningway shoulder, etc.

The second scenario consisted of major modification to the Base Case design such as raising the grade of the south end of the parking facility at Bathurst Street Station to eliminate stairs/elevator to the elevated pedestrian

bridge over Highway 7, move the YRT/Viva stop closer to the GO Highway 7 bridge, changes to the runningway horizontal alignment and provision of an underground tunnel connection from the transitway stop platform to the intermodal station at Jane Street.

The third scenario consisted of a combination of modifications to the Base Case directed at enhancing the customer experience of using the 407 Transitway.

The fourth scenario was a combination of modifications to the Base Case directed at developing an elevated alignment for the 407 Transitway (skytrain) at both the Kennedy Station area and the Yonge Station area.

The Base Case and four scenarios were evaluated. Due to the 70% design stage of the project, the evaluation analysis did not result in a single firm recommendation by the overall VE Team. However, the conclusions provided insights that were considered throughout the remaining design process.

5.2 The Technology

Rapid Transit Technology Alternatives:

Five candidate technology alternatives were considered in developing a response to the need for inter-regional rapid transit in the ultimate 160 kilometres Highway 407 Corridor. These technologies encompassed the full range of system capacities and vehicle/infrastructure configurations that could be considered compatible with the transportation service and implementation needs of the corridor. Very high-speed inter-city rail technology (over 200km/hour) is not applicable to serve the distribution of ridership in the corridor and incompatible with the physical constraints of the Parkway Belt corridor. A description of the characteristics of each candidate technology listed below is presented in **Table 5-1** which discusses the general definition, vehicles, runningway and station requirements, control and information systems, fare collection, system capacity and capital costs.

1. BRT;
2. LRT;
3. Automated Guideway Transit (AGT);
4. Heavy Rail Transit (e.g. subway); and,
5. Commuter Rail.

Each of the above candidate technologies was evaluated against four major criteria reflecting the near- and long-term needs and objectives for the Highway 407 Corridor. These included:

- transit service quality encompassing capacity required, user convenience and comfort, service speed and reliability and network connectivity/interlining;
- planning considerations addressing infrastructure integration and the system's support of Provincial growth and planning policies;
- environmental compatibility covering effects on the natural and socio-economic environment and energy consumption; and,
- implementation considerations including ROW property needs, cost-effectiveness and implementation staging.

The findings of the evaluation of the five candidate technology alternatives are presented below in **Table 5-2** and the following section provides a discussion on the rationale for the selection of the preferred technology.

From the evaluation, it is evident that initially, BRT would be the preferred technology for the 407 Transitway but that conversion to LRT technology in the future should be protected to respond to the anticipated growth in ridership volumes beyond the 2031 planning horizon. In addition to significant implementation staging flexibility to transition from operation in mixed traffic on the 407 ETR to higher speed service on a fully exclusive runningway, BRT provides capacity for the projected demand at the desired level of convenience and comfort.

Like the other line-haul operating technologies, it offers the same benefits of network connectivity with three GO Rail lines and two subway line extensions to the corridor; and as well, being bus-based, it does not need feeder services at all stations as the vehicles are able to interline by operating on city streets or highways to reach key off-line destinations such as Pearson Airport or the 400-series highways. Also, the planned service quality has significant potential to increase transit use, encourage transit-oriented land use by directly linking the 407 ROW to the three regional centres (Vaughan Metropolitan Center, Richmond Hill Centre and Markham Centre).

Other technologies that only indirectly link to the regional centres will only partially reinforce urban form and development objectives, as would be the case at Vaughan regional centre which would require an additional transfer if rail-based technologies were adopted. Similar to the other technologies, BRT is a low emission vehicle technology that is becoming more available, energy efficient and with improved emission control. Other important advantage of the BRT system is the implementation staging flexibility, allowing the opportunity to build specific segments of runningway at a time, maintaining the transitway operation on the 407 ETR Highway along un-built or under construction segments. Being Lastly, BRT's capital and operating costs are compatible with the size of the market for rapid transit service in the corridor compared to the other high capital investment technologies and the runningway and station infrastructure can be shared by other transit operators providing compatible services.

LRT technology is recommended as the best candidate technology for later implementation in the 407 Transitway to meet the potential future increase in service demand. Unlike the Diesel Multiple Units (DMU) and Heavy Rail, the alignment geometric standards do not limit alignment planning options and it can be implemented with adequate measures to mitigate most natural and socio-economic impacts. Further, it allows flexibility to stage implementation across the study area with convenient transfers along the ROW; however, it is only viable if the segments exceed 10 to 12 kilometres in length. Conversion to automatic train operation is also feasible if east-west trip volumes in the corridor ever justified higher capacity (over 15,000 passengers per hour per direction) in the distant future.

Figure 5-3 Typical Passenger Capacity – Capital Cost for Rapid Transit Technology Options following the tables, illustrates the typical capacity ranges of higher order transit technologies relative to the implementation capital costs which vary with the degree of exclusivity of the system ROW. Experience around the world indicates that both BRT and LRT technologies can provide the capacities likely to be required in the Highway 407 Corridor both in the medium and long-term provided investment is made in a fully exclusive, grade separated ROW with overtaking capability at stations in the case of BRT.

Table 5-1: TECHNOLOGY CHARACTERISTICS

	Bus Rapid Transit (BRT)	Light Rail Transit (LRT)	Automated Guideway Transit (AGT)	Heavy Rail Transit (e.g. Subway)	Commuter Rail
General	 BRT technology is defined as the operation of conventional transit vehicles, or purpose built rubber-tired vehicles, or both, on an exclusive or partially exclusive right-of-way to provide a higher capacity and higher quality rapid transit service than conventional bus service, nearer to that of higher speed rail-based systems. Being bus-based, a significant feature of BRT technology is the ability to serve off-line key destinations without requiring an additional passenger transfer.	 Light Rail Transit (LRT) technology, in its current form, usually comprises electrically-propelled rail vehicles operating singly or coupled to form short trains operating on a partially or fully segregated right-of-way. This intermediate-capacity rapid transit technology can be based on a range of vehicle and infrastructure characteristics	 Automated Guideway Transit systems such as those in Vancouver, Scarborough and Lille, France with automated, mostly driverless operation require a rail right-of-way totally separated from other traffic over its entire length. These systems are typically electrically-powered providing intermediate to high capacity on elevated or underground guideways	 Heavy rail rapid transit or Subway technology is traditionally adopted for congested, densely-developed urban corridors or to carry large volumes of passengers to major CBDs. Establishing a fully segregated right-of-way allows the use of longer trains at close headways giving a high capacity, high-speed, typically underground system	 Locomotive-hauled cars or diesel multiple unit (DMU)-based commuter rail technology is generally used to carry large volumes of passengers to a central work zone on a limited stop fixed schedule Typically, the operating characteristics require a dedicated right-of-way with standards similar to existing inter-city rail corridors. This limits route opportunities and generally results in wider station spacing to maintain reasonable service speeds.
Vehicle technology	Available propulsion options for vehicles range from low-sulphur diesel and CNG to various electric hybrids and all-electric trolleys. Low-floor, multiple wide-door designs and optional guidance into stations speeds boarding and alighting thus reducing station dwell time. Vehicle lengths range from 12.2 metres (single unit) to 18 metres 25.5 metre(s) bi-articulated units are also used in some systems. Typical passenger capacities are 60 (single unit) to over 100 (bi-articulated unit) standing and seated passengers per vehicle.	LRT vehicles range from all-electric to diesel propelled, high and low-floor car designs. Lengths vary from 14 metres (single unit) to 45 metres (bi-articulated unit). Typical passenger capacities are approximately 75 (single unit) to as high as 200 (bi-articulated unit) standing and seated passengers per car. Vehicles can be coupled to form up to 3 or 4 car trains depending on vehicle length and demand. Normally, LRT vehicles do not meet railway collision absorption requirements. Where LRT shares existing rail lines, freight operation is restricted to hours when no LRT service is provided.	Generally, automated guideway transit vehicles also use electric propulsion, however the fully segregated secure right-of-way necessary allows the power to be distributed to the vehicles by a third rail at track level. Typically, trains comprise two to four cars in length with level boarding and passenger capacity between 75 and 130. The addition of communications and computer systems to control and regulate operations reduces the size of driver cabs, but requires a larger central control facility for the system.	Vehicles always feature level, no-step station platform to vehicle boarding/alighting through multiple wide doors. Lengths vary from 15 metres to 22.8 metres (mostly single unit) coupled in trains of 4-8 cars. Passenger capacities are up to 185 standing and seated passengers per car. Power is usually collected from a third rail; although an overhead contact system (catenary wire) may be used in some cases (e.g., Boston MBTA Blue Line).	Generally operated on freight or mixed freight/passenger rail corridors, the vehicles are typically loco-hauled or self-propelled, full-sized heavy rail cars. Many systems now use bi-level cars in the order of 26 metres (85 feet) long of the type currently in service on GO Transit's GTHA network. Many commuter rail vehicles require raised sections on platforms to permit accessibility by disabled passengers. In Quebec and Europe, self-propelled, diesel or electric multiple unit trains provide intermediate capacity service. Ottawa is using an example of DMU regional rail vehicles that has a capacity of 285 passengers and a length of 48 m.
Runningway	BRT can operate in general traffic, and/or exclusive bus lanes, and/or segregated transitways. The operating speed, capacity and reliability increases with the degree of segregation from general traffic and grade separation. The key objective in applying BRT technology is to provide a separate roadway for the transit vehicles to improve average operating speed and increase service reliability. Typically, a width of 10-12 metres is required to develop a segregated bi-directional running way if grading is not major. At stations or stops a larger right-of-way is needed to accommodate platforms (approx. 3-4 m wide) and passenger accessways. If the operation assumes that express service will overtake local service at stations, a much larger local right-of-way, up to 16 m, may be needed for stopping lanes each side of the through lanes.	LRT can operate mixed with general traffic (i.e. streetcar systems), and/or on exclusive lanes, and/or on segregated transitways. The operating speed, capacity and reliability increase with the degree of segregation from general traffic and grade separation. LRT requires an 8-10 metre wide right-of-way. Generally, it is separated from parallel traffic by a physical barrier such as a curb or curb and railing treatment. In many cases perpendicular roadways are crossed at-grade with signalized intersections through which the LRT is often given signal priority when headways permit. The overhead electric catenary system must be supported by new poles or suspended from lighting poles. In some key locations, the LRT may be grade separated from the road traffic to improve intersection function or provide access to a multi-modal station. Right-of-way along rail lines requires additional space for safety clearances.	AGT requires a 7.5-9 metre wide secure right-of-way. Generally it is elevated or, if at-grade, separated from parallel traffic by a physical barrier. Underground guideway can also be used when necessary. In all cases the right-of-way is grade-separated from perpendicular roadways. Computerized control systems can react to intrusions into the track area, and in driverless operation can handle the passenger interface issues, but are not sufficiently advanced to handle interaction with other vehicular traffic.	These high capacity systems require fully segregated and totally grade separated running ways. As subways are generally underground, the right-of-way width required is dependent on the method of tunnel construction. Cut-and-cover tunnels usually require a width of 12-14 m on the surface while twin bored tunnels occupy 18-20 m at the mid-height of the tunnel. Tunnels must allow a minimum cover of about 3 m to permit the crossing of utilities. The alignment required for high-speed subway operation generally consists of curve radii exceeding 300 m and profile grades of less than 3.5%.	Commuter rail technology requires an exclusive right-of-way with limited level crossings. Signalized gates control all crossings where rail traffic takes priority over road traffic. Rights-of-way are generally a minimum of 20 m wide to accommodate side slopes from the track grading. There are also geometric limitations to commuter rail facilities. Railways require a relatively flat track profile and space for large radius curves. These limitations are especially challenging in built-up urban corridors.

Table 5-1: TECHNOLOGY CHARACTERISTICS (Cont'd.)

	Bus Rapid Transit (BRT)	Light Rail Transit (LRT)	Automated Guideway Transit (AGT)	Heavy Rail Transit (e.g. Subway)	Commuter Rail
Stations or Stops	Formal stations at key locations along the route are focused at major cross street intersections and at major trip origins and destinations. These generally comprise platforms varying in length from 15-55 m. The stations can range from shelters on simple curb-height platforms, to large inter-modal transfer stations at key locations with park-and-ride lots and passenger pick-up/drop-off facilities. They are generally designed to be accessible by the disabled. Station spacing is approximately 1 km in built-up portions of corridors increasing to 2 km in lower density areas. Facilities at stations are aimed at a high level of convenience and comfort with enclosures providing more protection from the elements. Another rail-like feature sometimes incorporated is the ability to load and unload at platforms with a small clearance using a guidance system allowing more precise docking. Transitions for vehicles to enter or leave the transitway are included at strategic locations. 	Stations generally comprise platforms varying in length from 15m (streetcars) to 90m (multi-car trains) with shelters and passenger amenities. They are designed to be accessible by the disabled and may also include support facilities such as park and ride lots or passenger pick-up and drop-off areas. Station spacing is approximately 0.75 -1 km in built-up portions of corridors increasing to 2 km in lower density areas. Platforms at the stations are generally matched to the height of the vehicle floor. The current generation of LRT vehicles is being designed with low floors, which allow for easy passenger movements and low platform station stops. Where high floor vehicles are used, high platforms are desirable or steps on the vehicle can be used to board and alight. Stops can comprise simple curb-height platforms and shelters or more elaborate enclosed, intermodal stations with facilities for transfer from feeder buses and park-and-ride. 	Station stops are generally spaced more widely than for transitway or conventional LRT systems. In the CBD, or commercial centre, stations can be 500-800 metres apart, with the distance increasing towards the ends of a line. Typical suburban spacing can be in the 1-1.5 km range, wider if necessary. Platforms at the stations are generally matched to the height of the vehicle floor. The current generation of AGT vehicles is being designed with high floors, requiring high platform station stops. Stations tend to be more elaborate, often elevated to accommodate the fully grade separated right-of-way and with circulation facilities for the larger ultimate system passenger capacity. 	Generally underground or elevated with combinations of stairs, elevators and escalators to access platforms varying in length from 100-200m. Spacing is approximately 1 km in built-up portions of corridors to 3 km in less built-up areas. The fully segregated underground or depressed right-of way results in complex, costly stations with long platforms and access elements for large volumes of passengers. In the past platforms have been high-level to provide access at vehicle floor level. Passenger circulation usually requires a concourse with fare-paid zone and often, an extensive stair/escalator system depending on station depth. Feeder bus platforms and park-and-ride facilities are also needed at many stops. 	Station stops are generally spaced at 3-4 km in built-up portions of corridors increasing to 5 km in less built-up areas. The stops are often multi-modal with parking and bus access to collect passengers from local neighbourhoods. The larger vehicles and longer trains imply larger passenger loads which in turn require larger stations to accommodate passenger movement.
Systems	BRT systems are generally controlled by conventional traffic signals where the vehicles interface with other road vehicles. Voice and data communication is also more commonly provided to increase safety and security.	LRT systems have a signal system to control train operations, provide data and voice communications and enhance safety and security.	A GT systems have additional equipment on the vehicles and along the tracks to achieve computerized automatic train control. In some automated systems all functions are controlled by the remote system including door operation.	Heavy rail must have a signal system to control train operation. Additional systems provide data and voice communications, and enhance safety and security. Some systems (e.g., Vancouver Sky Train) are fully automated.	Commuter rail systems usually have a signal system to control train operation from a control centre, while additional systems provide data and voice communications, and enhance safety and security.
Intelligent Transportation Systems	Contemporary BRT systems usually incorporate an Intelligent Transportation System (ITS) with an automatic vehicle location module that supports transit signal priority at intersections when required and real-time passenger information at stations, on-board and at home through websites.	Contemporary LRT systems also have ITS capabilities to provide transit signal priority at intersections when required and real-time passenger information at stations, on-board and at home.	Contemporary Automated Guideway Transit systems also provide real-time passenger information in stations, on-board and from home.	Contemporary heavy rail systems also provide real-time passenger information in stations, on-board and from home.	Commuter rail systems often provide passenger information in stations, sometimes in real-time and on-board.

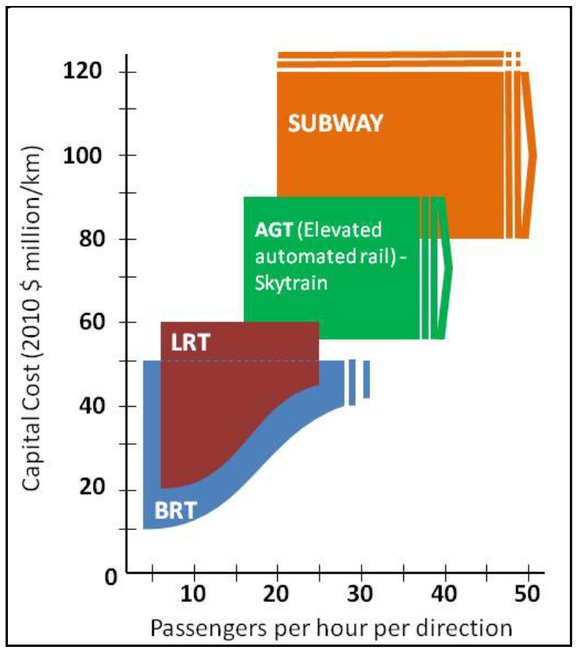
Table 5-1: TECHNOLOGY CHARACTERISTICS (Cont'd.)

	Bus Rapid Transit (BRT)	Light Rail Transit (LRT)	Automated Guideway Transit (AGT)	Heavy Rail Transit (e.g. Subway)	Commuter Rail
Fare Collection	Prepaid fares are required to reduce dwell times at stations and for passenger convenience. Options include fare gates and fare-paid, segregated platforms in stations and proof of payment systems using passes, smart cards or tickets.	Pre-payment of fares is required to reduce dwell times at stations, take advantage of efficiencies of train operation and for passenger convenience. Options include fare gates and fare-paid, segregated platforms in stations and proof of payment systems using passes, smart cards or date and time-validated tickets.	Pre-payment of fares is required to reduce dwell times at stations, take advantage of efficiencies of train operation and for passenger convenience. Options include fare gates and fare-paid, segregated platforms in stations and proof of payment systems using passes, smart cards or date and time-validated tickets.	Fare pre-payment is required to reduce dwell times at stations, take advantage of efficiencies of train operation and for passenger convenience. Options include fare gates and fare-paid, segregated platforms in stations and proof of payment systems using passes, magnetic strip card, smart cards or date and time-validated tickets.	Prepaid fares are beneficial to reduce dwell times at stations, avoid adding conductors to train crew and for passenger convenience. Options can include fare gates and fare-paid, segregated platforms in stations but are mostly proof of payment systems using passes, smart cards or tickets.
System Capacity	Segregated BRT service with station bypass lanes is capable of handling over 12,000 persons per peak hour per direction, depending on the degree of segregation from other traffic and grade separation. The busiest BRT segment in North America, in downtown Ottawa, carries approximately 10,000 passengers per hour in the peak direction during the single peak hour. The practical capacity without overtaking capability at stations is in the 8,000 passenger per hour range.	LRT systems are capable of carrying up to 18,000 persons per peak hour per direction, depending on the degree of segregation from other traffic and grade separation. Approximately, 10,000 people per hour (peak hour, peak direction) use the busiest light rail segments in North America in downtown Calgary and on the Green Line in downtown Boston.	A major benefit of the larger initial investment is the ability to expand the capacity of these systems to subway capacity levels by increasing the frequency of the trains under automatic control without major unit operating cost increases. Vancouver's new vehicles comprise a permanently coupled two-car vehicle with an overall length of 34.7 m and a capacity of 250 passengers. With trains consisting of two vehicles operated at 1.5 minutes headways, system capacities around 20,000 passengers per hour per direction are possible. AGT offers significant benefits if the high initial investment can be recovered by carrying large passenger volume growth in the mid to long-term periods of the system life.	Up to 60,000 per peak hour per direction for a double track line. During the early nineties, the TTC carried over 30,000 passengers per hour on the Yonge line, south of Bloor Street in the peak direction during the peak hour. New York's Lexington Avenue Line carries over 63,000 passengers per hour per direction on a four track running way, two local, two express, with trains comprised of eight 23 metre cars	As noted above commuter rail technology is usually adopted for long haul inter-regional services primarily to move large volumes of passengers commuting to major employment centres in CBDs. Its use in the Highway 407 corridor is partially compatible with the objectives for rapid transit in the corridor in the role of an east-west feeder line to existing north-south commuter rail corridors.
Capital Cost	Total costs, including transitways, stations, ITS, vehicles, fare collection system, etc. range from $15m - $30m for a partially segregated transitway with mostly at-grade intersections. Costs can increase to $60m+ per km for fully segregated, grade- separated segments. Implementation costs depend on the volumes to be carried, system complexity, the degree of segregation from general traffic and the type and degree of grade separation (e.g., at grade, below grade or elevated).	Total costs including stations, ITS, vehicles, fare collection system, etc. range from $5m per km for single track diesel lines using former rail rights-of-way to $40m per double track km for partially segregated at-grade, electrified lines with mostly at-grade intersections. Fully segregated, grade separated electrified transitways can cost up to $100m per double track km. Implementation costs depend on volumes to be carried, system complexity, degree of segregation from general traffic and the degree and type of grade separation (e.g., at grade, underground or elevated).	Usually entails significant investment in initial infrastructure and systems but offers an operating cost advantage if passenger demand levels optimize the technologies capacity Implementation costs depend on volumes to be carried, system complexity, and the type of grade separation (e.g., underground or elevated). Typical infrastructure and system costs range from $80 – 120M per double track km.	Total costs, including cost of vehicles, ITS, fare collection system range from $100-$200M+ per double-track km depending on station spacing and opportunity for surface running way. Implementation costs depend on volumes to be carried, system complexity, and the type of grade separation (e.g., subway or elevated).	Total costs including stations, ITS, vehicles, fare collection system, etc. range from $10m per km for single track diesel lines using former rail rights-of-way to $40m per double track km for partially segregated at-grade lines with mostly at-grade intersections. Fully segregated, grade separated systems can cost up to $70m per double track km.

Table 5-2: EVALUATION OF RAPID TRANSIT TECHNOLOGY ALTERNATIVES

RAPID TRANSIT TECHNOLOGY ALTERNATIVES	Bus Rapid Transit (BRT)	Light Rail Transit (LRT)	Automated Guideway Transit (AGT)	Heavy Rail Transit (e.g. Subway technology at-grade)	Commuter Rail
Evaluation Criteria	BRT technology is defined as the operation of conventional transit vehicles, or purpose built rubber-tired vehicles, or both, on an exclusive or partially exclusive right-of-way to provide a higher capacity and higher quality rapid transit service than conventional bus service, nearer to that of higher speed rail-based systems.	Light Rail Transit (LRT) technology, in its current form, usually comprises electrically-propelled rail vehicles operating singly or coupled to form short trains operating on a partially or fully segregated right-of-way. This intermediate-capacity rapid transit technology can be based on a range of vehicle and infrastructure characteristics.	Automated Guideway Transit (AGT) systems such as those in Vancouver, Scarborough and Lille, France with automated, mostly driverless operation require a rail right-of-way totally separated from other traffic over its entire length. Typically electrically-powered, these systems provide intermediate to high capacity on elevated or underground guideways.	Heavy rail rapid transit or Subway technology is traditionally adopted for congested, densely-developed urban corridors or to carry large volumes of passengers to major CBDs. Establishing a fully segregated right-of-way allows the use of longer trains at close headways giving a high capacity, high-speed, typically underground system.	Loco-hauled or DMU-based commuter rail technology is generally used to carry large volumes of passengers to a central work zone on a limited stop fixed schedule. Typically, the operating characteristics require a dedicated right-of-way with standards similar to existing inter-city rail corridors. This limits route opportunities and often wider station spacing.
Transit Service Quality • demand-capacity relationship • user convenience and comfort, • service reliability • operating speed • network connectivity/ transfer issues	BRT is compatible with the projected demand in the corridor (4000 -6,000 pass/hour per direction) and can provide the desired level of user convenience, comfort, speed and reliability. In the 407 transit ROW it offers the benefits of network connectivity with three GO Rail lines and a planned northward extension of the both the Yonge and Spadina subway lines. Being bus-based, a significant feature is the opportunity to link major trip-generating nodes off-line such as the Vaughan regional Centre and Pearson Airport without a passenger transfer.	Typically, LRT technology offers greater capacity (up to 15,000 pass/hour) than the projected demand and can provide the desired level of user convenience, comfort, speed and reliability. In the 407 transit ROW it also allows network connectivity with the three GO Rail lines and a planned northward extension of the both the Yonge and Spadina subway lines. However, the necessary line-haul operation requires transfers from feeder services at all stations.	In corridors where peak demand is unlikely to ever exceed 10,000 passengers per hour, the investment for AGT technology (capacity 10,000 – 25,000) cannot be justified despite reduced operating costs achieved by using centralized control for driverless train operation. AGT technology allows the required network connectivity and can provide the desired level of user convenience, comfort, speed and reliability but the necessary line-haul operation requires transfers from feeder services at all stations.	In corridors where peak demand is unlikely to ever exceed 10,000 passengers per hour, the capital investment, even for largely surface heavy rail, cannot be justified. Operating cost savings of large capacity train service (20,000-30,000 pass/hour) are not achieved with low ridership levels. Heavy Rail technology can provide the desired level of user convenience, comfort, speed and reliability but the necessary line-haul operation requires transfers from feeder services at all stations.	Commuter rail technology capacity is compatible with projected demand in the corridor (4000 -6,000 pass/hour per direction) and can provide the desired level of user convenience, comfort, speed and reliability. In the 407 right-of-way it also allows network connectivity with the three GO Rail lines and a planned northward extension of the both the Yonge and Spadina subway lines. However, the necessary line-haul operation requires transfers from feeder services at all stations.
Planning Considerations • support of Provincial objectives • infrastructure integration issues	BRT technology has good potential to increase transit use, encourage transit-oriented land use and link the 407 right-of-way to the proposed Regional Centres thus reinforcing urban form and development objectives. Also, it can provide inter-regional longer distance express trips. Opportunities for TOD generating walk-in ridership are limited but park-and-ride infrastructure can be developed.	In other jurisdictions, LRT technology has been shown to increase transit use and encourage transit-oriented land use. Opportunities for TOD generating walk-in ridership are limited but good park-and-ride infrastructure can be developed. Indirect links to proposed Regional Centres in Vaughan and Markham, partially reinforce urban form and development objectives. The protected ROW to the east and west has geometry that would allow inter-regional longer distance LRT service.	AGT technology, in other jurisdictions has been shown to increase transit use and encourage transit-oriented land use. Opportunities for TOD generating walk-in ridership are limited but good park-and-ride infrastructure can be developed. Indirect links to the proposed Regional Centres in Vaughan and Markham, partially reinforce urban form and development objectives. The protected ROW to the east and west has geometry that would allow inter-regional longer distance LRT service.	In most jurisdictions, Heavy Rail technology is known to increase transit use and encourage transit-oriented land use. Opportunities for TOD generating walk-in ridership are limited but good park-and-ride can be provided. Alignment geometric standards limit planning options and would increase costs. Indirect links to the proposed Regional Centres in Vaughan and Markham, only partially reinforce urban form and development objectives.	In most jurisdictions, commuter rail technology increases transit use for medium to long distance trips to major high density CBD-type destinations. Opportunities for TOD generating walk-in ridership are limited but good park-and-ride can be provided. Alignment geometric standards limit planning options and can increase costs. Indirect links to the proposed Regional Centres in Vaughan and Markham, only partially reinforce urban form and development objectives.
Environmental Compatibility • socio-economic environment • natural environment • reduction of emissions and energy consumption	Since the alignment can be largely at-grade alongside the 407 ETR, BRT technology could be implemented with adequate measures to mitigate most natural and social environmental impacts. These could include measures such as avoidance of sensitive natural features and watercourses, bridge widenings minimizing aquatic habitat effects, urban design treatment of new station areas, traffic infiltration prevention, noise attenuation devices etc. Low emission vehicle technology is becoming more available and proven.	The largely at-grade LRT alignment alongside the 407 ETR, could be implemented with adequate measures to mitigate most natural and social environmental impacts. These could include measures such as avoidance of sensitive natural features and watercourses, bridge widenings minimizing aquatic habitat effects, urban design treatment of new station areas, neighbourhood traffic infiltration prevention, noise attenuation devices etc. Electric propulsion eliminates emissions in the corridor, but requires low or zero emission generating methods.	As the alignment can be largely at-grade alongside the 407 ETR, AGT technology, with a ground level power rail, would require a totally secure ROW. It could be implemented with adequate measures to mitigate most natural and social environmental impacts. These would include measures such as avoiding sensitive natural features and water-courses, bridge widenings minimizing aquatic habitat effects, urban design treatment of new station areas, neighbourhood traffic infiltration prevention, noise attenuation and ROW intrusion detection devices etc. Electric propulsion eliminates emissions in the corridor, but requires low or zero emission generating methods.	Since the alignment can be largely at-grade alongside the 407 ETR, Heavy Rail technology, with a ground level power rail, would require a totally secure ROW. Geometric standards may make implementation mitigating most natural and social environmental impacts difficult. This would require measures such as avoiding, wherever practical, sensitive natural features and water-courses, bridge widenings minimizing aquatic habitat effects, urban design treatment of new station areas, neighbourhood traffic infiltration prevention, noise attenuation and ROW intrusion detection devices etc. Electric propulsion eliminates emissions in the corridor, but requires low or zero emission generating methods.	If geometric standards permit, the largely at-grade alignment alongside the 407 ETR, could be implemented with adequate measures to mitigate most natural and social environmental impacts These would include measures such as avoiding, wherever practical, sensitive natural features and water-courses, bridge widenings minimizing aquatic habitat effects, urban design treatment of new station areas, neighbourhood traffic infiltration prevention, noise attenuation devices etc.. Diesel propelled units will require state-of-the- art low emission engines to be environmentally acceptable
Implementation Considerations • property requirements • capital and operating costs • staging flexibility	BRT options have good planning and staging flexibility and their capital and operating costs are more in line with the size of the potential market for rapid transit service in this corridor. Right-of-way property requirements are marginally greater than those for rail-based systems due to need for runningway shoulders and bypass lanes at stations.	The capital investment and operating cost benefits are more in line with larger initial ridership levels than are projected for rapid transit service in this corridor. Conversion to LRT technology may be justified for longer term demand levels. LRT technology has fairly good planning flexibility and allows a reduced right-of-way width but viable initial operating segments usually exceed 10-12 km.	The proposed development density along the right-of-way does not support east-west trip volumes that would justify the higher capital investment needed for intermediate-high capacity AGT. Although fully grade-separated AGT technology minimizes surface property requirements, the technology does not allow flexibility to stage implementation across the study area without inconvenient transfers along the route..	The high capital investment needed for high capacity, heavy rail technology is not justified by the east-west trip volumes that would be generated by the proposed development density along the ROW. Although the fully grade separated Heavy Rail technology minimizes surface property needs, it does not allow the flexibility to stage implementation across the study area without inconvenient transfers along the route	The moderate capital investment and operating cost benefits are more in line with larger, initial ridership levels than are projected for service in this corridor. Conversion to commuter rail technology may be justified for longer term demand levels. Commuter rail right-of-way property needs are larger than the other rail systems. Also, it has less planning flexibility and does not have the flexibility to stage implementation across the study area without inconvenient transfers along the route.
	PREFERRED TECHNOLOGY	**Protect for LRT**			

Figure 5-3: Typical Passenger Capacity – Capital Cost for Rapid Transit Technology Options



Notwithstanding the BRT technology's greater flexibility and high capacities achieved elsewhere in the world, protection for eventual conversion to LRT is recommended for the corridor to accommodate ridership capacity needs beyond 2031 at lower operating cost. In addition to providing higher capacity, it is noted that conversion to LRT would bring additional benefits to the corridor such as, the currently assumed, greater potential for transit oriented development, and improved public perception of the technology, which could further increase ridership and provide additional environmental benefits.

5.3 Station Location Assessment

Following the assessment of potential technologies for the desired service on the transitway project, the next step during the Planning Study was determination of trip-generating zones that the transitway could potentially serve. A key factor in this determination was fulfilling the primary objective of the 407 Transitway project namely changing and improving transportation patterns in the 905-area through the introduction of a high-speed transit facility through the Highway 407 corridor.

Selection of station sites that effectively capture the projected travel patterns in the study area while at the same time achieving a spacing that optimizes the travel speed was the focus in ensuring achievement of the transitway project objectives.

Following the Planning Stage, the Preliminary Design Stage sought to carry forward the technically preferred station sites for further assessment and evaluation. The undertaking allowed for the filtering out of alternatives and the creation of the short-listed station locations.

The following section outlines the process adopted in determining the potential station sites, and the evaluation methodology involved in optimizing the number of stations along the 407 Transitway.

Definition of Station Nodes:

Initially, primary trip-generating zones were identified as the geographical areas where consideration of a station node was warranted. Within these geographical areas, the station node had to meet one or more of the following criteria:

- Be located within 500 metres of an UGC;
- Have the potential to interconnect with existing and future inter-regional transit networks such as GO Rail Lines and Toronto Subway expansion;
- Have the potential to connect with major north-south arterial roads; and
- Be able to serve as a park-and-ride destination from significant future population growth areas.

Also, with reference to the *Transitway Corridor Protection Study, Highway 407/Parkway Belt West Corridor from Highway 403 to Markham Road (1998),* the station nodes and sites identified in that study were considered as one station distribution alternative for the transitway project.

Secondly, station facility sites were identified and assessed for feasibility within the station nodes considered suitable for establishment of a transitway station. The development of station site layouts is described later in **Section 5** within each segment of the project route.

Initial Screening of Station Node and Site Alternatives:

Having developed a comprehensive list of potential station nodes, a short list of nodes worthy of further consideration was developed through further analysis and evaluation. The methods used to create a short list of station nodes involved consideration of projected ridership forecasts, and proximity to major urban growth centers and transportation corridors.

In the long list some of these station nodes fell outside the Highway 407 Corridor study area (e.g. York University). Through a preliminary screening of these nodes, their compatibility with the 407 Transitway objectives was assessed. Elimination of station nodes that did not fully meet the objectives of the 407 Transitway was based on the following considerations:

- A considerable amount of additional travel time would be required to serve these station nodes;
- There would be an excessively high cost associated with developing a grade separated transitway route to these nodes in a non-exclusive ROW situation; and
- There would be associated detrimental environmental and socio-economic effects from developing the transitway route to reach station nodes located outside of the primary Highway 407 Corridor Central Section.

Through the application of the above screening process, the following 11 potential station nodes were identified:

1. Vaughan Metropolitan Centre - Jane Street/Spadina Subway Extension route
2. Keele Street
3. GO Barrie Line corridor
4. Dufferin Street/Centre Street
5. Bathurst Street
6. Richmond Hill Centre/Yonge Street Subway Line extension route/GO Richmond Hill Line
7. Bayview Avenue
8. Leslie Street/Beaver Creek Business Park
9. Woodbine Avenue/Rodick Road/Highway 404/7 Business Park
10. Warden Avenue/Birchmount Road/Markham Centre West
11. Markham Centre/Kennedy Road/GO Stouffville Line

With the development of the 11 potential station nodes listed above, further analysis was undertaken to keep the transitway's primary objective at the forefront of the study approach, along with the use of demand modelling analysis. **Table 5-3** presents the comparison of the above potential station nodes against the project's transportation service and land use objectives.

A fundamental objective of the 407 Transitway is to "offer a faster, safer, reliable and efficient way of moving people". Meeting this objective requires:

- a facility with an alignment that will permit a high operating speed between stations, and
- an optimum number of stops (stations) located to serve all major transit trip generators, such as regional centres and achieve efficient access to the transitway from all modes of transportation in the corridor, encompassing inter-regional and local transit (rail and bus) and private automobiles through park-and-ride facilities. The resulting station spacing should allow transitway vehicles to achieve the optimum average operating speed (65-70 km/h) including station stops.

Demand modelling analysis of various station location scenarios conducted during the study indicated that a seven station scenario within the central segment of the 407 Transitway would achieve the above objectives. This table further illustrates the justification for the selection of the seven station nodes adopted for the remainder of the Preliminary Design study and used and used as the basis for evaluation of route options and ultimately, selection of the technically preferred alignment.

Selection of Preferred Station Nodes

Through this comparative evaluation process, the 11 potential station nodes were further reduced as described below.

Each node was assessed in terms of its ability to meet the key transportation and land use objectives for the transitway. **Table 5-3** summarizes the assessment of the eleven potential station nodes. Station nodes that ranked highest in the assessment were short-listed for further development of station facility sites along the alternative transitway routes. The seven short-listed station node locations were:

1. Vaughan Metropolitan Centre and TTC Spadina Line
2. GO Barrie (Concord) (crossing of a major radial transit line)
3. Bathurst Street (to serve Vaughan residential growth area and provide 'park and ride' capacity near the Yonge Station)
4. Richmond Hill-Langstaff Gateway, TTC Yonge Street Subway Station and GO Richmond Hill Line
5. Leslie Street (Beaver Creek Business Park)
6. Woodbine Avenue (to serve Markham Centre West, provide 'park and ride' capacity south of Markham residential growth area and support uniform service distribution along transitway corridor)
7. Markham Centre and GO Stouffville Line.

These preferred station nodes and facility site options within them were then connected with potential route links. As described later in **Section 5**, the development of alternative station site and transitway route combinations.

Table 5-3: Assessment Of Potential Station Nodes

● Very Good at Meeting the Objective ◕ Good at Meeting the Objective ◑ Fair at Meeting the Objective ◔ Poor at Meeting the Objective ○ Very Poor at Meeting the Objective

OBJECTIVE / CRITERIA / INDICATOR	GENERAL STATION LOCATION AREAS										
	VAUGHAN METROPOLITAN CENTRE (JANE)	KEELE	GO BARRIE (CONCORD)	DUFFERIN / CENTRE	BATHURST	RICHMOND HILL CENTRE (YONGE)	BAYVIEW	LESLIE	WOODBINE / RODICK	WARDEN / BIRCHMOUNT	MARKHAM CENTRE (KENNEDY)
TRANSPORTATION: Objective: Improve Integration with Regional Transportation Network											
POTENTIAL TRANSFER / INTERLINING OPPORTUNITIES	●	◑	◕	◔	◑	●	◑	◕	◑	◔	●
A) Subway / LRT Connections											
Proximity to Future TTC Lines	Spadina Subway					Yonge Subway		Don Mills LRT			
B) GO Transit Rail Connections											
Proximity to Existing GO Train Station						Langstaff Station on GO Richmond Hill Line					GO Unionville Station on GO Stouffville Line
Proximity to Future GO Train Station			Potential Connection to GO Barrie Line								
C) Inter-regional Transit Connections											
GO Transit, TTC, Brampton, Durham Region	Existing GO Bus Routes (45, 46, 47, 48 serve Keele (York U) from the west); Existing TTC Routes (35D); GO BRT (Future); Brampton Züm; Highway 400 HOV	Existing GO Bus Routes (45, 46, 47, 48, 51, 52, 54, 64); Existing TTC Routes (107)		Existing TTC Routes (105)		Existing GO Bus Routes (40, 51, 52, 54, 61, 91B)		Highway 404 HOV	Existing TTC Routes (24D, 224D)	TTC Route 68B	Existing GO Bus Routes (71, 52, 54); Durham BRT (Future); TTC Routes (TTC 17A - Future)
D) Local Transit Connections											
YRT/Viva (Note: 300 Routes are Express Service)	Viva Orange; Existing YRT Routes (20)	Viva Purple	Viva Purple; Viva BRT (Future); Existing YRT Routes (77)	Future YRT Feeder Services	Viva Purple; Viva BRT (Future); Existing YRT Routes (23, 87, 88); Future YRT Community Shuttles	Viva Blue; Viva Purple; Viva Pink; Viva BRT (Future); Existing YRT Routes (1, 83 / 83A, 91B, 99)	Viva Purple; Viva Pink; Viva BRT (Future); Existing YRT Routes (1, 91 / 91A)	Existing YRT Routes (82, 90)	Future Business Park Shuttles (Markham Centre)	Viva Yellow, Viva Green (Future); Existing YRT Routes (68B)	Viva Purple; Viva Pink; Viva Green; Existing YRT Routes (8, 301, 302)

Table 5-3: Assessment Of Potential Station Nodes

● Very Good at Meeting the Objective ◕ Good at Meeting the Objective ◑ Fair at Meeting the Objective ◔ Poor at Meeting the Objective ○ Very Poor at Meeting the Objective

OBJECTIVE / CRITERIA / INDICATOR	GENERAL STATION LOCATION AREAS																					
	VAUGHAN METROPOLITAN CENTRE (JANE)		KEELE		GO BARRIE (CONCORD)		DUFFERIN / CENTRE		BATHURST		RICHMOND HILL CENTRE (YONGE)		BAYVIEW		LESLIE		WOODBINE / RODICK		WARDEN / BIRCHMOUNT		MARKHAM CENTRE (KENNEDY)	
LAND USE: **Objective: Improve Accessibility to Existing / Planned Major Urban Centres; Foster and Support a more Compact Urban Structure**																						
POTENTIAL TO MEET LAND USE OBJECTIVES	●		◑		◑		◑		◑		●		◑		●		◑		●		●	
A) Ridership Accessibility																						
Adjacent Development (Within 3.0 km)	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*	*2001*	*2031*
(i) Population (Residential)	56,100	95,600	41,300	73,300	31,700	63,000	31,000	60,300	40,000	80,500	56,600	110,200	60,500	109,300	49,300	93,700	70,900	132,200	73,300	141,000	60,500	121,000
(ii) Employment (Office, Industrial)	31,500	50,800	33,300	49,000	16,400	31,900	21,600	35,700	34,400	53,200	39,500	63,700	49,100	76,800	34,900	62,400	27,100	63,000	25,000	56,000	22,100	50,000
(iii) Commercial (Retail)	Medium	High	Low	Low	Low	Low	Low	Low	Low	Low	High	High	Low	Low	Medium	Medium	Low	Low	Low	High	Low	High
B) Urban Growth Centres																						
Supports Urban Growth / Employment Centres	Vaughan Metropolitan Centre, Steeles West Industrial Area		Steeles West Industrial Area, Steeles West Mixed-Use Development		Keele Industrial Area (Vaughan Metropolitan Centre E)		Langstaff Business Park				Richmond Hill Centre, Rodick Road Industrial / Business Park				Beaver Creek Business Park, Commerce Valley Business Park		Rodick Road Industrial/ Browns Corner/ Allstate Business Park, Markham Centre W. 404/7 Business Park		Markham Centre, IBM		Markham Centre	
Supports Transit Oriented Development					Rockview Gardens Avenue Neighbourhood (East)		Beverly Glen Blvd. Neighbourhood (South)		P & R from NW Corner Bathurst / Highway 7		South Richvale Neighbourhood (West)		P & R from South Park Road Development (East) and Valleymede Residential		South of Highway 7 Along Leslie Street		Markham Centre W. 404/7 Business Park		Markham Centre		Markham Centre, Helen Avenue Neighbourhood (East)	
C) Urban Form																						
Support More Compact Urban Form	Yes		No		No		No		No		Yes		Potentially		Potentially		No		Yes		Yes	
OVERALL STATION NODE ASSESSMENT	●		◑		◕		◔		◑		●		◑		◕		◑		◑		●	
Approximate Distance Between Potential Station Nodes (Km)		2.5		1.3		2.7		2.3		2.6		1.6		2.2		2.6		1.6		1.8		
Distance Between Station Nodes That Are Good At Meeting The Objectives (Km)		3.8				7.6						3.8				6.0						
Distance between Station Nodes Recommended (Km)		3.8				5.0				2.6		3.8				2.6		3.4				

Assessment of Station Site Locations within Nodes

Station sites were initially considered in all four quadrants of each station node. They were then analyzed in terms of the station site generation criteria presented below in **Table 5-4** and, as a result, quadrants that did not meet those criteria were eliminated from further consideration.

Table 5-4: Station Site Assessment Criteria

Ability to connect with major north-south transportation corridors (i.e. major arterials, GO Transit, TTC Subway lines, 400 series highways, etc.) station location within 200 metres from the major intersections
Accessibility to existing and planned urban centres (i.e. UGC's) station location within 500 metres of an urban centre
Meet minimum facility/functional requirements: – minimum 40 metres width outside of the proposed running way route – minimum 150 metres length – minimum 25,000 m^2 area – delineate area beyond the minimum 25,000 m^2 area that avoids environmental constraints
Avoid environmental constraints, where possible (developed land, hazard land, watercourses, designated natural areas, contaminated sites, etc.)

5.4 Alternative Routes, Alignments & Station Layouts

The purpose of this section is to initially outline the evaluation criteria and process used to arrive at the technically preferred alignment and station alternatives for the 407 Transitway Central Section and describe the alternatives considered through the process. The process comprised several evaluation steps, each progressing to greater levels of analysis and design. Specifically, this section presents the following:

- Evaluation Criteria and Process
  - Routes, Station Sites and Alignment Alternatives
  - Station Layouts
- Evaluation of Alternatives
  - Segment A – From East of Highway 400 to East of Keele Street
  - Segment B – From East of Keele Street to West of Yonge Street
  - Segment C – From West of Yonge Street to West of Bayview Avenue
  - Segment D – From West of Bayview Avenue to East of Leslie Street
  - Segment E – From East of Leslie Street to East of Rodick Road
  - Segment F – From East of Rodick to East of Kennedy

5.4.1 Evaluation Criteria and Process

5.4.1.1 Routes, Station Sites and Alignment Alternatives

As a first step, transitway route alternatives linking the seven short-listed station nodes were developed along the Highway 407 Corridor using the Route Generation Criteria tabulated below:

- Route Generation Criteria (Runningways)
- Ability to connect with a station site;
- Exclusive, grade separated ROW within Highway 407 Corridor
- North side of Highway 407, south side of Highway 407 or one crossing of 407 ETR between station sites;
- Meet minimum geometric design standards:
  - minimum 560 metres radius on running way main lanes
  - minimum 420 metres radius entering and exiting station
  - minimum 300 metres tangent length in the vicinity of stations
  - minimum 100 metres tangent between reverse curves
  - maximum 5% gradient

The routes consisted of 50 metres wide swaths that met the route generation objectives and standards. Station sites were then identified for each station location defined in **Section 5.2**. Typically, routes and station sites were identified on both sides of Highway 407, where feasible. In the second step of the process, alignment alternatives, applying the geometric design standards, were developed for the selected routes within each segment.

a) Evaluation of Routes and Station Sites

The station sites available and alternative transitway routes to link them were evaluated separately in order to determine the technically preferred planning route(s) within each segment. Each route alternative and its associated station site were then assessed against the transitway objectives. The applicable criteria and indicators are presented below in **Table 5-5.**

Table 5-5: Evaluation Criteria and Indicators for Station Sites and Routes

Objectives	Criteria	Indicators
A) Enhance east-west cross-regional mobility (> 10 km)	Not applicable for evaluation of alternative methods.	N/A
B) Offer a faster, safer and more efficient way of moving people.	B1) Attractiveness of transit service to passengers.	B1.1) Travel time between station sites.
	B2) Ride comfort.	B2.1) Number of curves <560 m radius or 420 m radius at stations
		B2.2) Number of reverse curves.
C) Maximize utilization of protected 407 Transitway ROW.	C1) Minimize property acquisition.	C1.1) Length of transitway route located in protected 407 Transitway ROW
		C1.2) Area of transitway station located in protected station footprint.
D) Improve integration with the existing and planned regional transportation network.	D1) Convenience for transfers from other transit systems.	D1.1) Transfer distance between transitway route and other transit systems (YRT/Viva, GO Transit, TTC, Brampton Transit, etc.).
	D2) Convenience for access from other travel modes.	D2.1) Transfer distance between transitway route and other travel modes (private automobile, taxi, bicycle, pedestrians, ambulatory/ non-ambulatory disabled persons).

Objectives	Criteria	Indicators
E) Ability to increase capacity to meet additional travel demand.	E1) Infrastructure flexibility for responding to changes in expected markets and beyond.	E1.1) Number of station sites with potential surface expansion capability (serviceable land over the minimum 25,000 m^2)
F) Improve accessibility to existing/planned major urban centres/ nodes.	Not applicable for evaluation of alternative methods.	N/A
G) Increase support for a more compact urban structure.	G1) Opportunities to influence development pattern and urban design.	G1.1) Conformity with the goals, objectives and policies of provincial policy and municipal official plans.
		G1.2) Potential to stimulate transit supportive development in proximity to station site.
H) Minimize adverse effects on the natural environment.	H1) Potential effects on natural heritage features.	H1.1) Number, type and significance of terrestrial and aquatic natural heritage features affected.
	H2) Potential effects on geology and hydrogeology.	H2.1) Area of groundwater discharge affected.
		H2.2) Number of sites with issues of potential subsurface environmental concern (i.e. contaminated soils, etc) affected.
	H3) Potential effects on hydrology.	H3.1) Area of floodplain affected.
I) Minimize adverse effects on the social environment.	I1) Potential effects on socio-economic features.	I1.1) Length of transitway route located adjacent to residential neighbourhoods and other sensitive land uses.
		I1.2) Length of the transitway station located adjacent to residential neighbourhoods and other sensitive land uses.
	I2) Potential effects on cultural heritage resources.	I2.1) Number, type, and significance of archaeological sites, built heritage features and cultural landscapes affected.
J) Reduce reliance on energy resources and reduce harmful air emissions.	J1) Potential effects on resource depletion and global climate change.	J1.1) Length of transitway route between segment limits.
K) Offer a cost-effective way of moving people.	K1) Minimize the capital and operating costs.	K1.1) Length of transitway route between segment limits.
		K1.2) Number of structures required
	K2) Minimize the costs of property acquisition.	K2.1) Length of transitway route located on the Highway 407 ROW, government of Ontario lands, utility lands, municipal lands and private property.
		K2.5) Area of station sites located on the Highway 407 ROW, government of Ontario lands, utility lands, municipal private property and private lands.

Quantitative data was used, where available, otherwise, a qualitative scale was used (i.e. low, moderate, high).

The study adopted the Analytical Hierarchy Process, a decision making approach which consists of structuring multiple choice criteria into a hierarchy, comparing alternatives for each criterion, and determining an overall ranking of the alternatives. For this analysis the weights of the criteria were the same.

The data for each route segment alternative were converted into numerical values. For each criterion, the most preferable alternative was selected and given a value of one within the route segment. Then, the remaining alternative routes within the same route segment were calculated in relation to the most preferable. As a result, the maximum value would result in one and the lowest value would result in zero. Then, the converted numerical values were added for each alternative route. The alternative route with the highest result was chosen as the most preferable route alternative within the route segment.

A qualitative evaluation method (Reasoned Argument Method) was also used to compare alternatives. Whenever available or needed, a quantitative value was assigned to each criterion to determine the best option.

The qualitative and quantitative evaluations were conducted independently of one another to avoid bias. Once each evaluation had been completed separately, the results of the evaluation were compared to determine if the qualitative and the quantitative evaluation came to similar conclusions, and if not, why. A consensus approach was used to reconcile discrepancies where a particular alternative was not selected as the preferred alternative using both methods. This approach served to highlight the trade-offs made and the justification for selecting one alternative over another.

A composite plan of all technically preferred route segments and associated station sites was assembled to create the technically preferred route alternative, which was carried into preliminary design for further refinement. In cases where significant issues had not been resolved due mainly to third party uncertainties and/or on-going projects that would affect the transitway alignment, more than one route alternative within a segment was selected to be developed in further detail and be carried into the alignment evaluation stage.

b) <u>Alignment Alternatives Assessment</u>

Horizontal and vertical alignment alternatives within each selected route were then identified and assessed in order to define, for each segment, the optimum planning alignment to be developed further in preliminary design.

The alignment alternative assessment considered, in further detail, environmental issues such as water course and flood plain crossings, impacts to stakeholders and residents such as property, noise and visual effects; physical constrains such as at existing and planned road and rail infrastructure crossings; capital and maintenance costs and passenger ride comfort, among others.

Design options for crossing 407 ETR core lanes without affecting traffic flow on the Highway 407 were also assessed. Due to significant cost and construction complexity issues with underpasses, it was determined that overpasses should be adopted to cross the core lanes of the ETR.

Once selected as a technically preferred alternative, the alignment was then optimized to achieve the best feasible geometric design quality. These refinements resulted in some minor adjustments to portions of the alignment. None of the adjustments done at the refinement stage of the alignment design were significant enough to be considered a change of the preferred alignment requiring further comparative analysis.

5.4.1.2 Station Layouts

At each station site, platform and facilities layout alternatives were developed where practical and evaluated in terms of their operational efficiency, user convenience, effect on surrounding natural and socio-economic environment and cost-effectiveness.

5.4.2 Evaluation of Alternatives

The transitway was divided into segments for analysis purposes with segment limits generally at points where all route alternatives met at a common point along the route. The segment limits are summarized in **Table 5-6**.

Table 5-6: Segment Limits in Central Section

Segment	From	To
A	East of Highway 400	East of Keele Street
B	East of Keele Street	West of Yonge Street
C	West of Yonge Street	West of Bayview Avenue
D	West of Bayview Avenue	East of Leslie Street
E	East of Leslie Street	East of Rodick Road
F	East Rodick Road	East of Kennedy Road

5.4.2.1 Segment A – From East of Highway 400 to East of Keele Street

a) Alternative Routes

In this segment, assuming the 407 Transitway/Spadina Subway interface is immediately south of the 407 ETR at Jane Street, the only candidate route alternative is A1, located south of the Highway 407 and generally following the ROW identified in the Corridor Protection Study. It commences at the Highway 400 crossing proposed in the MTO's Corridor Protection Study which was the earlier phase of this EA, passes through the planned maintenance facility site and the 407/Jane Station site established in the Spadina Subway Extension EA and then continues east north of Beechwood Cemetery and immediately south of the 407 ETR to the segment limit.

Consequently, A1, as illustrated in **Figure 5-4** Segment A Route Alternatives becomes the recommended route carried forward into the Alternative Alignment evaluation stage, as it:

- Has a length and geometry which offers a fast, safe and efficient way of moving people, notwithstanding one curve less than the minimum desirable radius;
- Maximizes utilization of the protected 407 Transitway ROW and minimizes the effect of the necessary crossing of the Hydro ROW east of Highway 400;
- Provides good integration with the existing and planned regional transportation network at the 407 ETR station on the Spadina Subway Extension currently under design;
- Has some ability to increase capacity at the station to meet additional travel demand and protects the optimum site configuration for both bus-based and rail-based maintenance and storage facilities east of Jane Street;
- Improves accessibility to the planned Vaughan Metropolitan Centre by the proposed convenient connection to the Spadina Subway Extension and good access to Jane Street from the station site;
- Increases support for a more compact urban structure by encouraging more intense development in the Metropolitan Centre and surroundings;
- Minimizes adverse effects on the natural and social environment by built-in mitigation such as alignment geometry avoiding conflict with cemetery expansion plans and aquatic habitat preservation measures at the Black Creek crossing;
- Is a direct route which reduces reliance on energy resources and reduces harmful air emissions; and,
- Is an at-grade alignment with low grade-separation costs offering a cost-effective way of moving people.

Figure 5-4: Segment A - Route Alternatives

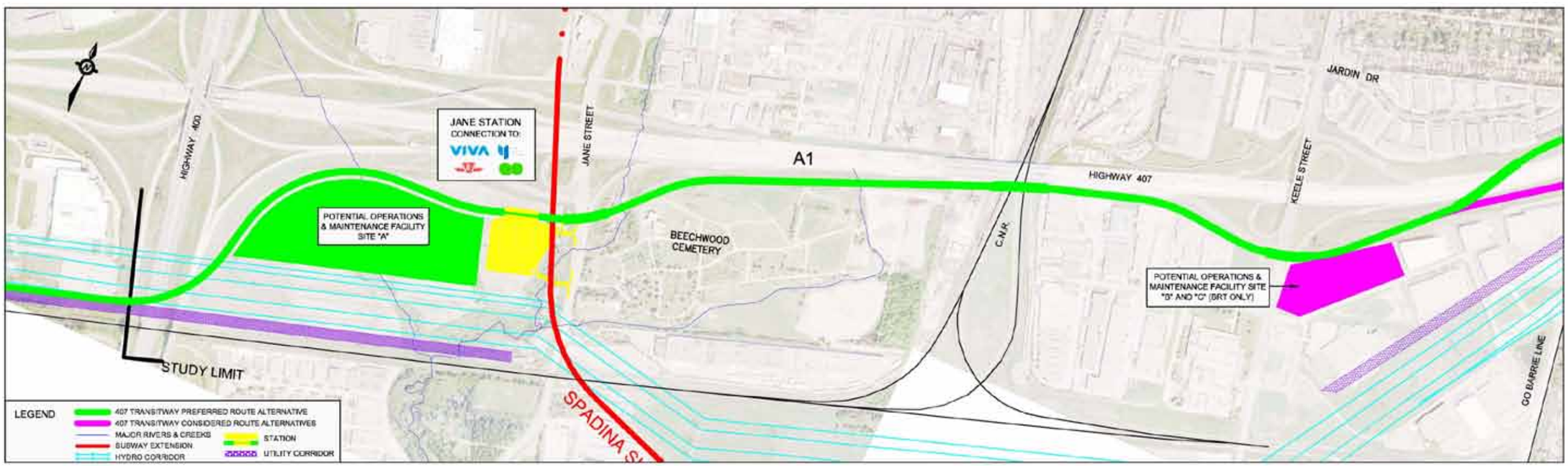


Figure 5-5, illustrates the selected preferred route from east of Highway 400 to west of Yonge Street.

b) Alternative Alignments

In the area between Highway 400 and Jane Street, two horizontal alignment options were studied as illustrated in **Figure 5-6**. These alignment options consider the Spadina Subway Station design, locations for the Transitway Operation and Maintenance Facility, flood plain issues as well as the desire to optimize feasible space for potential transit oriented development.

Between Jane Street and Keele Street, the only feasible horizontal alignment to meet the geometric standards without any significant effect on adjacent property was established.

Vertical alignment options analysed for the required grade separations; Jane Street, the McMillan Yard tracks and Keele Street, are discussed below.

Jane Street
Crossing Jane Street with an underpass was considered the only viable option for several reasons; crossing over Jane Street would imply an elevated Jane Station with inefficient integration with the Subway Station and bus facilities; Jane Street is already on an embankment crossing over 407 ETR Highway; costs for an elevated solution would be higher; the underground solution has virtually no visual impact.

CN Macmillan Yard
An underpass option was eliminated out due mainly to constructability complications, costs, operational impact to CN, as well as vertical alignment constraints west and east of the crossing.

Keele Street
Similarly to the Jane Street crossing, an overpass option was not favoured mainly due to geometric considerations and the visual impact on the business park properties located just south of the transitway.

c) Alternative Station Layouts

Jane Station
This is a multimodal station. As part of their design stage, York Region/TTC developed an evaluation of station layouts considering the integral functionality of all services. The 407 Transitway design team participated in various workshops organized by the TTC to evaluate several ground facility layout alternatives at the subway station. Jointly, the project undertook an evaluation of layout alternatives. Recognizing the TTC's bus terminal and parking configuration, the 407 Transitway team developed a conceptual plan of connections between the runningway and the station ground facilities as described in **Section 6**.

5.4.2.2 Segment B – From East of Keele Street to West of Yonge Street

a) Alternative Routes

In this segment, **Figure 5-7**, five route alternatives were identified following an initial screening. The findings of the evaluation of the candidate route alternatives are summarized below:

- There is no significant difference in length of all route alternatives resulting travel is an insignificant factor of evaluation;
- At the GO Barrie Line Station location, placing a transitway station facility on the south side of Highway 407 is not feasible due to the limited available and accessible space within and north of the hydro corridor. Consequently, for all route alternatives the preferred site for station ancillary facilities (park-and-ride, PPUDO, bus interface etc.) is on the north side of Highway 407, as close as possible to the GO ROW to achieve better connectivity with the existing and planned regional transportation network (a future GO Rail Station, Viva rapid transit, YRT local transit);
- B4 and B5 require a pedestrian bridge across Highway 407 to access the south side transitway station platforms from the northern facilities site at the GO line;
- All alternatives offer reasonable capacity to meet additional travel demand and, in the case of the north GO Line site, to stimulate transit supportive redevelopment of the surrounding land use;
- While the number of watercourse crossings required is similar in all alternatives, B5 is the alternative route with less complex infrastructure to mitigate intrusion on the flood plains of the West or East Don Rivers. B1, B2 and B4 intrude on one flood plain while B3 intrudes on both;
- The capital cost of alternatives B2 and B3 is significantly higher due to the need for three Highway 407 crossings; and,
- Alternatives B1, B4 and B5 minimize capital cost by crossing the Highway 407 at one location only.

From the above summary of findings, it is evident that overall, Alternatives B1 and B5 are the most responsive to the evaluation objectives. Key differences between these alternatives are:

- B5 has a major disadvantage in that a 150 metres long pedestrian bridge to cross the 407 ETR Highway, and a total walking distance from the 407 Transitway platforms to the potential future GO Barrie Line platforms of approx. 300 metres is required;
- B1 requires more complex infrastructure to mitigate intrusion across the West Don River floodplain;
- B5 intrudes significantly (700 metres.) into the Utility Corridor.

Alternative B1 was carried forward into the alternative alignment evaluation stage due to the significant adverse effects of Alternative B5 and also considering that potential adverse effects of Alternative B1 on the West Don River floodplain can be mitigated.

Figure 5-5: Segment A - Preferred Route

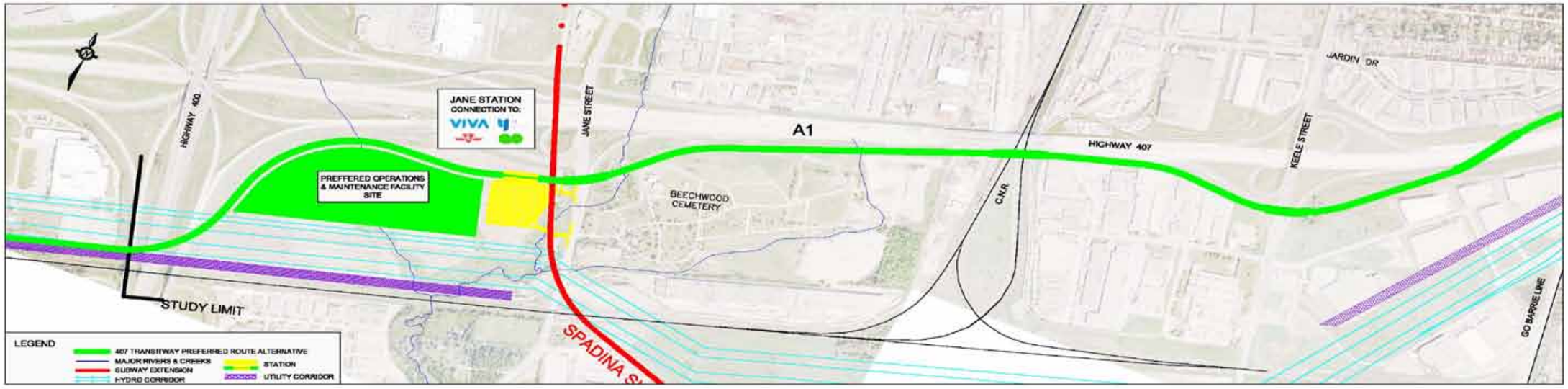


Figure 5-6: Segment A - Horizontal Alignment Options

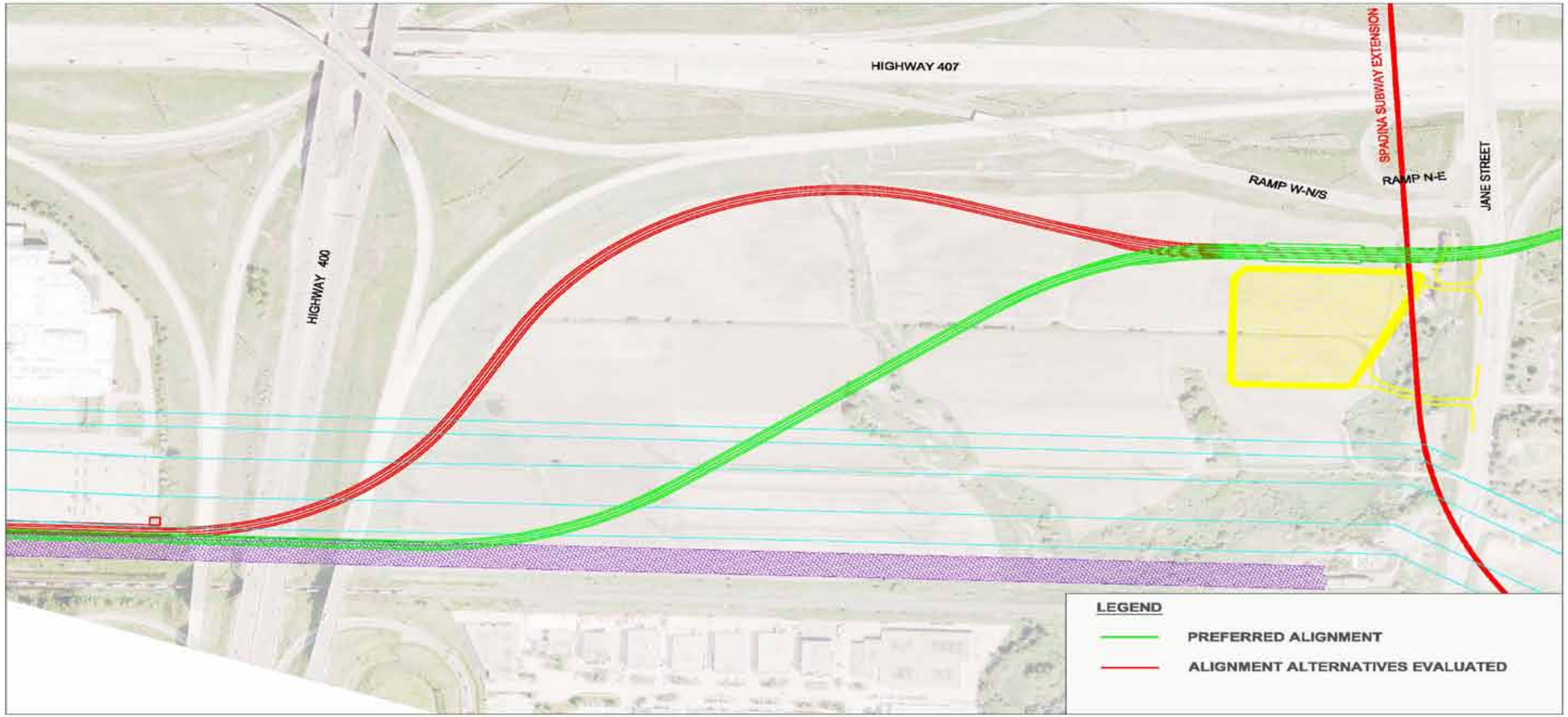


Figure 5-7: Segment B – Route Alternatives

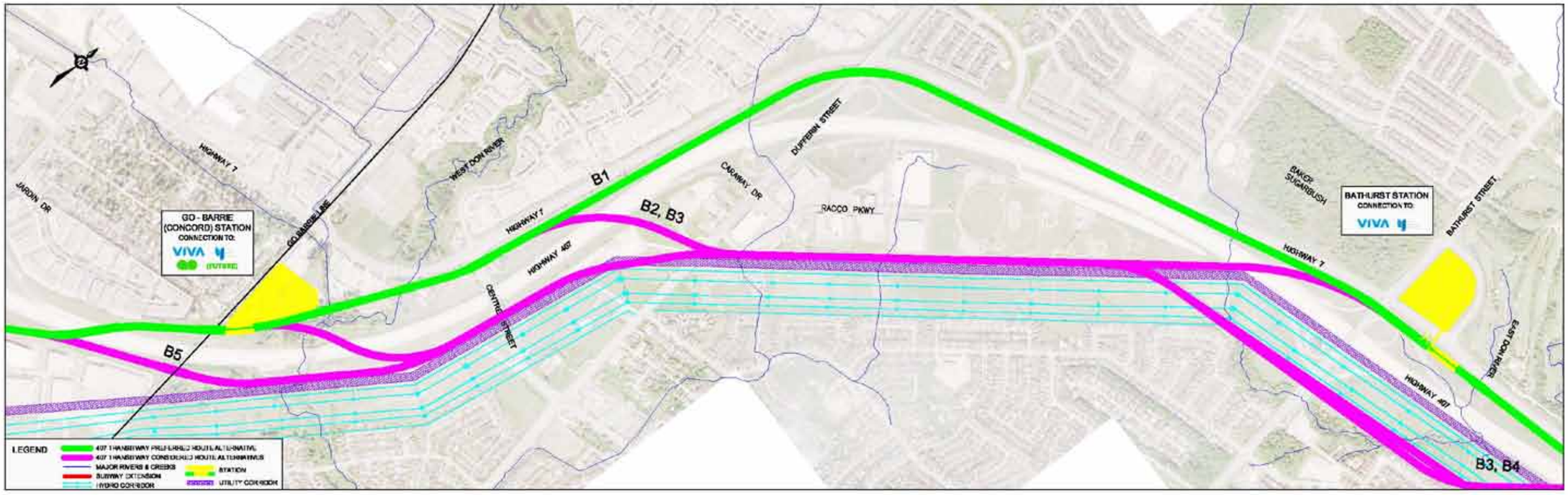


Figure 5-8 illustrates the selected preferred route from Highway 400 to Kennedy road.

b) Alternative Alignments

Horizontal alignment options were studied in the area between the GO Barrie grade separation and the crossing of Centre Street, as well as in the Bathurst Street area. In the GO Barrie (Concord) station area alignment variations considered aimed to minimize impacts to the West Don River water course and flood plain**. Figure 5-9**, as seen below, illustrates the alignment alternatives through the West Don Lands. In the Bathurst Street area, various alignment options were analyzed with a view to reducing impact to the 407 ETR-Bathurst Street Interchange operation, as well as cost and construction complexity.

Vertical options were analyzed for the required grade separations, in this segment. These comprised the GO Barrie Line, Centre Street, Dufferin Street and Bathurst Street, and are summarized.

GO Barrie Line crossing

Crossing either over or under the GO Barrie line was evaluated. Crossing over would represent less complexity during construction; however, the existing track is on an embankment which would imply elevated station platforms and consequently more inconvenient pedestrian connection to the station ground level facilities, future GO platforms and street level. Also crossing over would have a negative visual impact on the residents west of the GO Line and would require the runningway to be on a costly viaduct east of the station. As a result of this evaluation, an underpass of the GO Barrie Line was selected.

Centre Street crossing

The option of crossing under Centre Street was not adopted due to West Don River flood plain issues west of the crossing. Consequently an alignment crossing over Centre Street was selected.

Dufferin Avenue crossing

Crossing either over or under Dufferin was considered. As with most arterial road crossings of Highway 407, an overpass would imply being two levels (about 11 metres) over existing ground, requiring a long section of costly, elevated runningway, west and east of Dufferin Street. Consequently, an underpass across Dufferin Street was selected.

Bathurst Street crossing

Both overpass and underpass options were evaluated for the Bathurst Street crossing. The key findings of the evaluation in **Table 5-7** below were the following:

- An overpass option would require an elevated station with a climb equivalent to two storeys from the station ground facilities to reach the platforms. An underpass option results in less than half the vertical difference with the station ground facility.
- Passing over Bathurst would also require steeper runningway approach grades on both sides of the station.
- An underpass would necessitate more complex construction staging to cross the 407 ETR ramps and Bathurst Street.
- The visual intrusion and adverse noise impacts are minimized with the underpass option.

Table 5-7 Evaluation of Alternatives for Bathurst Street Grade Separation and Station

OBJECTIVE	GOALS	INDICATORS	ALT. 1 – Transitway under Bathurst Street/Ramps	ALT. 2 – Transitway over Bathurst Street/Ramps
Maximize service quality	Attractiveness of system access for passengers	Length/Height of vertical circulation elements to reach platforms	125m horiz. 6m up + 6m down	125m horiz. 6m up + 7m up
	Effect on transit operations	Transitway grading through grade separation and station	One Grade 3 to 4% Good station approach grades	Three grades 4 to 5% Undesirable, steep station approach grade
Minimize adverse effects on social environment	Minimize traffic disruption during construction	Nature, complexity and duration of temporary traffic accommodation measures required	Underpass construction requires lengthy, temporary diversions of ramps and several lane shifts on Bathurst. Traffic delays will be significant.	Elevated transitway construction will require limited diversion and lane closures. Short-term disruption mainly during girder erection.
	Avoid visual intrusion in sensitive areas	Extent of vistas affected by completed transitway works	At or below grade transitway works will not affect any vistas.	Elevated transitway intrudes on views of Baker Woods from south
	Minimize increase in ambient noise levels	Potential for noise intrusion in adjacent sensitive areas	Increase in ambient noise levels will be minimal and not discernable	Engine noise on climbing grades may intrude during quieter evening periods
Minimize adverse effects on natural environment	Avoid intrusion into ESAs	Extent of intrusion and proximity to ESAs	No intrusion as all works are between highways	No intrusion as all works are between highways
	Minimize effects on watercourse valley lands	Potential for adverse effects and nature of works in valley lands	Approaches and structure for E. Don River crossing are normal height with typical built-in mitigation.	Approaches and structure for E. Don River crossing are above normal height requiring major abutments and embankments with greater potential for adverse effects.
Offer a cost-effective way of moving people	Functional performance at least capital cost	Estimated order-of-magnitude construction and property costs	$xx million	$xx million
	Long term durability and hence least maintenance costs	Nature of infrastructure maintenance and effect on annual maintenance cost	Underpasses will increase runningway maintenance cost moderately; Station maintenance will be at normal levels.	Overpasses, retained fill and elevated station will increase maintenance costs significantly.
	Efficient, affordable transit operations	Effect of infrastructure configuration on transit operating costs	Transitway profile and station configuration will allow operations at normal cost levels	Minor increase in energy consumption due to steeper transitway profile grades.

Figure 5-8: Segment B - Preferred Route

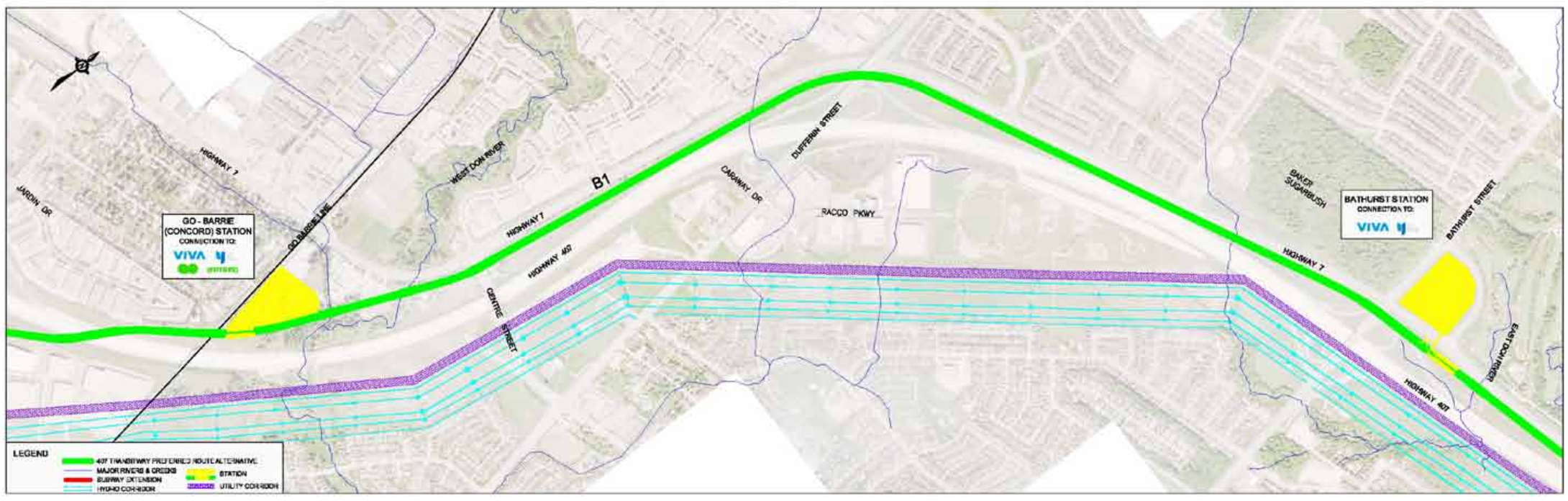
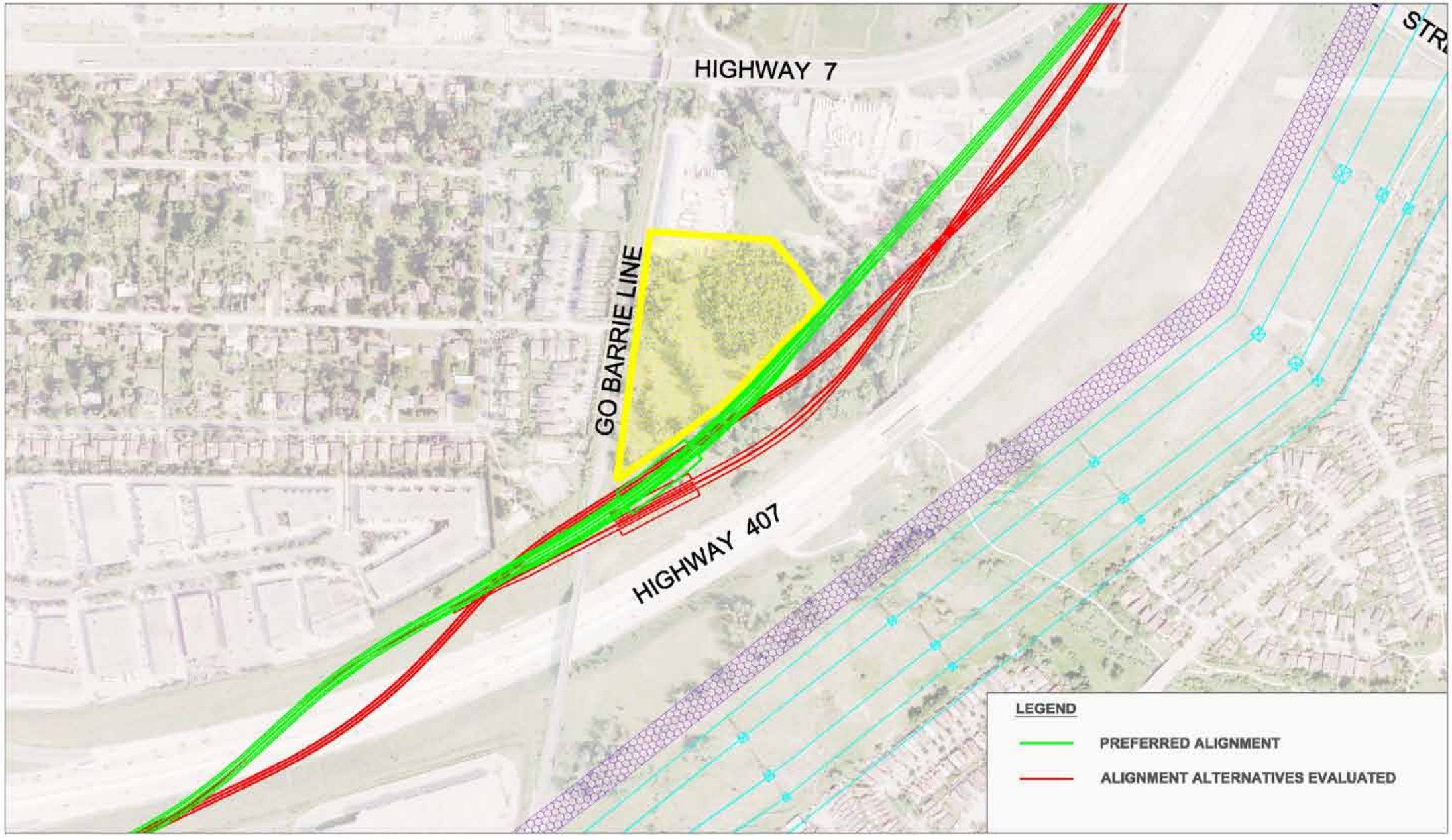


Figure 5-9: Alignment Alternatives through West Don River Valley



c) Alternative Station Layouts

Concord (GO Barrie) Station

Based on the preferred more northern alignment described above, three primary **transitway station locations** were considered. These comprised use of either the vacant provincial land protected by MTO between the GO ROW and the West Don River floodplain or a site east of the river and remote from the GO Barrie Line. These locations were combined with four potential locations for a future GO Rail platform if GO Transit builds a station platform at this location, to generate the four site layout alternatives shown in **Figure 5-10** and evaluated in terms of the project objectives in the matrix in **Table 5-8**. It should be noted that a potential GO Rail platform at this location would be further assessed by GO Transit once timelines for the transitway construction has been established.

For the remote locations, the only possible transitway station locations were opposite privately-owned land south and on the curve, of Highway 7 and further east between Highways 7 and 407 south of the Centre Street crossing. Both of these remote locations can only be served by parking and PPUDO access that is constrained in size and they would require a minimum 380-500 metre (450-560 m average) walk by all transit users transferring between the 407 Transitway Station and any of the GO Barrie rail service station locations (north or south of Highway 7).

In addition to this unacceptable, inconvenient transfer at a major network connection, the area between the flood plain and Highway 7 is not large enough for station ancillary facility needs (PPUDO, park-and-ride, bus transfer). Additional parking capacity can only be achieved by adding a lot on private land west of the river with a new river crossing to provide access. Walk-in distances from these parking facilities to northern GO Rail platform locations remain excessive. While all alternatives generally preserve flood plain and valley lands, an additional crossing is required to make parking either side of the tributary feasible.

Considering all factors assessed in the evaluation, the preferred transitway/GO Rail platform (if constructed) configuration is the Black Alternative, with station support facilities on the protected provincial land immediately adjacent to the existing rail ROW. Development of this site configuration:

- Minimizes the walking distances for passengers transferring between the transitway and the potential GO Rail platform, the seamless north-south to east-west connectivity essential at this node;
- Places PPUDO and park-and-ride facilities conveniently close to platform access for both transit systems;
- Provides a reasonable parking capacity without intruding into the West Don River flood plains;
- Allows most of the natural riverbank vegetation and the adjacent woodlot to be preserved;
- Requires a support facility layout that minimizes effects on natural vegetation;
- Permits mitigation of noise and visual effects on the residential community west of the GO Line as discussed in **Section 7**;
- Preserves access from the residential areas to the valley lands by means of defined walkways through the station support facilities;
- Provides improved access to the Marita Paine Park Trail via the new river crossing.

Table 5-8: Evaluation of Station Location Alternatives

OBJECTIVE	INDICATORS	Black Alternative GO platform South of Highway 7 Transitway Station adjacent to GO Rail ROW	Red Alternative GO platform North of Highway 7 Transitway Station south of Centre Street Overpass	Brown Alternative GO platform straddling Highway 7 Transitway Station between West Don River bridges	Blue Alternative GO platform immediately N of Highway 407; Transitway Station adjacent to GO Rail ROW
Improve Mobility	**Transfer Walking Distances (m)**				
	Transitway platform to GO platform: Centre-Centre Minimum	275 130	560 505	445 380	75 30
	Park & Ride to GO platform: Centre-Centre Minimum	55 25	460 300	360 25/160	320/520 110/330
	Park & Ride to transitway platform: Centre lot-Centre platform Minimum	275 130	465 320	155 30	320/520 275/480
	YRT/Viva stops on Highway 7 to end of GO platform	250	215	220	465
	YRT/Viva Highway 7 stops to transitway platform (YRT/Viva platforms at proposed intersection)	100	75	20	340
	Number of park-and-ride spaces available	650-700	350-400	550-600	600
	Access to Park & Ride	35 metre long bridge over West Don River tributary is required.	Not technically feasible from Centre St. due to traffic signal proximity. Lot SW of transitway station on Highway 7.	Least access time to and technically feasible but internal queuing may be problematic	Second P&R lot requires bridge over West Don River tributary
	Convenience of PPUDO	Location very convenient	Not feasible due to intersection proximity	Feasible for transitway; not feasible for GO	Location very convenient for transitway but more remote for GO
	Convenience of local community shuttle bus access	Transfer platform adjacent to stations	Walk-in from on-street stops on Highway 7	Walk-in from on-street stops on Highway 7	Pick-up/drop-off in south parking lot remote from both stations
Minimize adverse effects on social environment	Area of publicly-owned vacant table land property occupied	55%	24%	24%	24%
	Proximity of GO platform to publicly-owned table land property	260 metres alongside	280 metres north	70 metres north	180 metres alongside

OBJECTIVE	INDICATORS	Black Alternative GO platform South of Highway 7 Transitway Station adjacent to GO Rail ROW	Red Alternative GO platform North of Highway 7 Transitway Station south of Centre Street Overpass	Brown Alternative GO platform straddling Highway 7 Transitway Station between West Don River bridges	Blue Alternative GO platform immediately N of Highway 407; Transitway Station adjacent to GO Rail ROW
	Proximity of GO platform to residential land use south of Highway 7	Full length adjacent to residential community. Mitigation of visual and sound effects required.	Full length within new northern development remote from residential community	Southern half of platform fairly close to residential community	Northern half of platform opposite residential community
	Effect of GO Station on planned mixed-use development north of Highway 7	No effects as station is south of Highway 7	Requires walkway through park and internal street and mitigation of the interface along platform	Minor effect at south end of development	No effects as station is south of Highway 7
	Effect on access to valley lands/trails	Walkway through station site to valley and existing trail will be provided in site layout	Access only possible if table lands remain vacant or easement is provided in future uses	Access only possible if table lands remain vacant or easement is provided in future uses	Access only possible if table lands remain vacant or easement is provided in future uses
Minimize adverse effects on natural environment	Effect on West Don River and tributary flood plain/valley lands	Flood plain generally preserved. Single new crossing combining transitway and access road.	Flood plain generally preserved. Single new crossing for transitway	Flood plain generally preserved. Two new tributary crossings serving parking and for transitway	Flood plain generally preserved. Two new tributary crossings serving parking and for transitway
Offer a cost-effective way of moving people	Effect of transitway station location on transitway profile	Current profile; depressed station with some retaining wall	Profile raised on high retaining walls to accommodate elevated station	Current profile; Station at grade.	Current profile; depressed station with some retaining wall
	Highway 7 pedestrian bridge requirements	Bridge over highway for YRT/Viva to GO platform transfer requested by York Region	Long protected walkway and bridge over Highway 7 required between GO and transitway platforms	None	None
	Effect on area infrastructure costs	Assumed as baseline infrastructure cost	Moderately higher than baseline cost due to park & ride property acquisition, raised transitway profile and walkway/bridge requirement.	Moderately higher than baseline cost due to park & ride property acquisition and a GO platform location requiring a new Highway 7 rail bridge	Marginally higher than baseline cost due to park & ride property acquisition

A number of potential **station access alternatives** were developed for this station site. Each alternative has the same main access intersection on Highway 7 approximately 370 meters east of Baldwin Avenue, but different transit access locations as described below:

a) Option 1 – A shared access (Highway 7 and 407 Transitway Access intersection) for general traffic as well as transit vehicles;
b) Option 2 – A right-in only transit access combined with shared signalized main access for general traffic and other movements of transit vehicles;
c) Option 3 – Separate signalized accesses for transit and general traffic; and
d) Option 4 – Multi-Transit access.

The major challenge for transit operation at this location is the perceived delays for buses that enter or exit the station resulting from high background traffic volumes on Highway 7. As a result, Options 1), 3) and 4), which aim to reduce transit operational delays were developed in consultation with MTO, York Region, Metrolinx, YRT/ Viva staff. Although these three options would save travel times for buses accessing the station compared to Option a), a few concerns have been expressed by stakeholders regarding geometric configurations proposed for the other three options.

- Compared with Option 1), those three options with transit priority measures, such as dedicated transit-only lane and transit priority phase, would degrade traffic operations for through movements on Highway 7 during the peak periods in 2031.
- The rail overpass structure also imposes a sight distance issue. It was found that the maximum sight distance (160 meters) for the eastbound traffic approaching the signalized transit access does not meet the minimum require decision sight distance (over 250 meters).
- The eastbound double left and westbound double left at the main access intersection as illustrated in Option 3) would cause safety issues.
- Flood plain data shows there could be a flooding potential for the transit-only access under a condition of major Regional storm.

During consultation with local agencies, YRT staff indicated that future Viva Purple and YRT #77 routes would maintain service on Highway 7 with on-street stops close to the rail overpass to minimize bus running times and walking distance from on-street stops to future GO Barrie Line Station platforms.

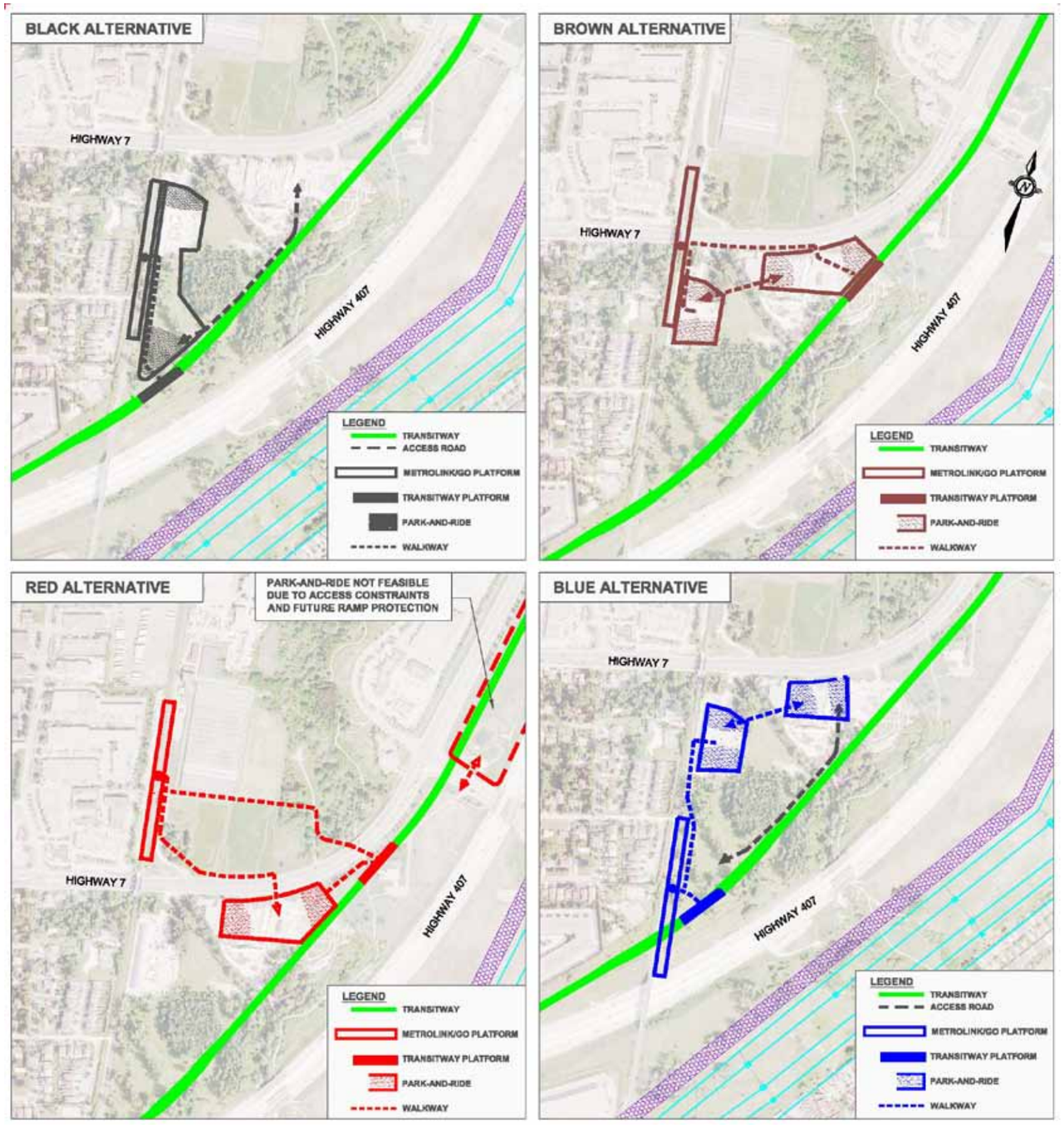
The above findings and discussions resulted in Option 1) being carried forward as the preferred option.

Bathurst Station

For Bathurst Station, one station layout concept of shared transit and general traffic access was considered. It was found that the provision of second access on Bathurst ramp for local transit services was not feasible. First of all, the spacing between two proposed intersections does not meet the minimum requirement documented in typical geometric design guidelines. In addition, additional signalized intersection would result in significant signal delays and increase travel times.

According to York Region's Highway 7 and Vaughan North-South Link EA, future YRT/Viva stops will be located on street near the intersection of Bathurst Ramp and Highway 7. It is anticipated that some infrequent community bus services will access Bathurst Station. Given all above considerations, a separate transit-only access is not warranted.

Figure 5-10: GO Barrie (Concord) Station Site Layout Alternatives



5.4.2.3 Segment C – From West of Yonge Street to West of Bayview Avenue

a) Alternative Routes

This segment includes the Yonge Station, which is the station with the highest boarding and alighting volumes on the entire route. Most of the users of this station will be transferring passengers to and from the future York Region/TTC Yonge Subway Extension, which according to the approved TPAP EPR, will have a station (named Richmond Hill Centre – RHC Station) west of the GO Richmond Hill Line under High Tech Road, at the core of the Richmond Hill portion of the future Richmond Hill-Langstaff gateway

In this segment, five primary route alternatives, as illustrated in **Figure 5-11,** were developed and assessed.

These comprised:

- three options (C1-C3) serving the proposed Yonge Subway Extension's RHC Station north of Highway 7,
- one (C4) remaining between Highways 7 and 407 remote (500m) from both the northern RHC subway station and the proposed Langstaff/Longbridge Station to the south of Highway 407 on the subway extension, and
- option (C5) south of Highway 407.

Initial Route Screening

In terms of intermodal connectivity, Alternative C5 could provide some opportunity to transfer to the future Yonge Subway extension at the proposed Langstaff/Longbridge Station; however, a station reasonably close to the subway would be remote (over 400m) from the GO Richmond Hill Rail Line and much further from the YRT/Viva RHC Bus Terminal. Other disadvantages of Route C5 include the environmental implications of the routes proximity to the surrounding existing and future residential developments and the unattractiveness of the station location in serving the planned regional centre since surrounding land use with potential for TOD is limited to approximately one quarter of the 500 metre radius catchment area.

Similarly, a station on Alternative C4, although reasonably well-connected to the GO Langstaff Station, would not provide an opportunity for a convenient connection to any planned Yonge Subway Station. Also, the station location would not attract walk-in ridership being remote from and not integrated with, TOD in the Regional Centre on both sides of Highway 407. In addition, good transfer connections from both auto and local transit are problematic with a station between highways and the major Hydro ROW. Although Alternative C4 would provide the shortest through travel time this benefit is marginal given that most, if not all services would be accelerating or decelerating from a stop at the Yonge Station.

Consequently, on the basis of the current, approved TPA Environmental Project Report for the Yonge Subway extension and the land use plans for the RHC UGC, both Alternatives C4 and C5 were screened out in the initial evaluation as they would not meet the fundamental objectives and functional requirements of the transitway integration at the Richmond Hill-Langstaff Gateway.

The remaining three route alternatives, short-listed from the five considered and shown in **Figure 5-12,** were assessed in terms of the primary transitway objectives and the key findings are summarized below:

- All alternatives require lower than desirable curve radii but still provide acceptable alignment geometry and on-board ride comfort at station area speeds. C3 has the least extent of sharp curvature;
- Alternative C2 requires a U-turn move behind the station resulting in a longer stop time in the station area for through passengers;
- Although all alternatives require sharp curvature, the resulting speed constraint is on station approaches where vehicle speed is governed by acceleration and deceleration rates as, it is assumed, all vehicles will have a scheduled stop at the Yonge Subway Station;
- All alternatives provide a high level of integration and connectivity with all other transit systems by minimizing the transfer distance between platforms;
- While all alternatives divert from the protected transitway corridor parallel to Highway 407, the diversion is mostly across or under publically-owned land, (Hydro ROW, Highway 7 and future Richmond Hill Centre streets);
- Alternatives C1 and C3, by being partially under proposed public open space in the Richmond Hill Centre planning concept, have moderately less impact on transit oriented development at the Regional Centre as they maximize transit accessibility without significant intrusion onto developable property;
- Effects on the natural environment are minimal for all alternatives and the minor intrusion into the existing storm water pond area can be mitigated;
- Alternative C2 has no effect on residential land uses in the segment while Alternatives C1 and C3 require a raised portion of transitway alongside the existing raised Highway 7 alignment adjacent to the NW quadrant residential area;
- Alternatives C1 and C3 require one crossing of the Hydro ROW while Alternative C2 crosses the ROW twice;
- Alternatives C1 and C3 capital cost will be moderately lower and implementation will cause less disruption of traffic in the Yonge/407 interchange.

Notwithstanding the above findings, all three route alternatives illustrated required further analysis of alignment and station location constraints and opportunities to identify the preferred routing and consequently were carried forward into the alignment alternative evaluation stage discussed below.

Figure 5-11: Segment C - Route Alternatives

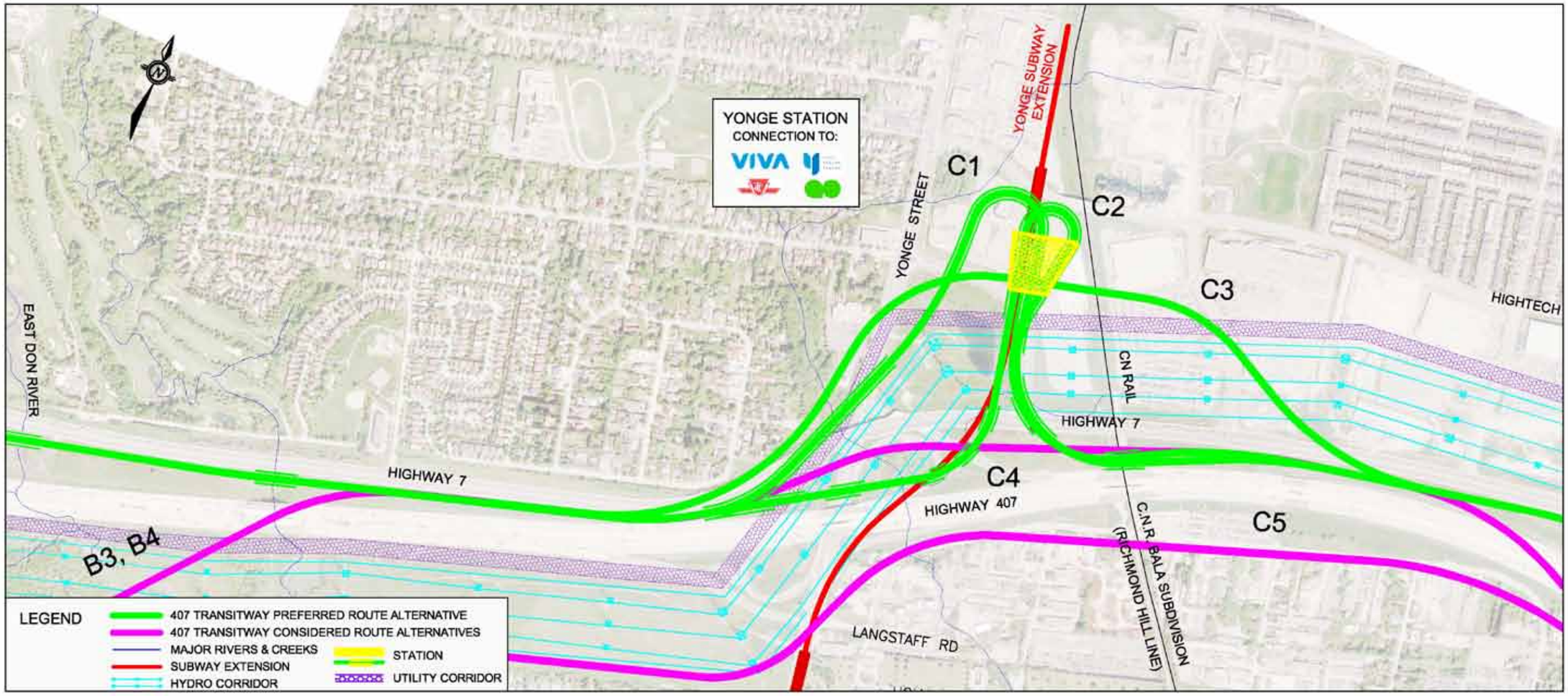
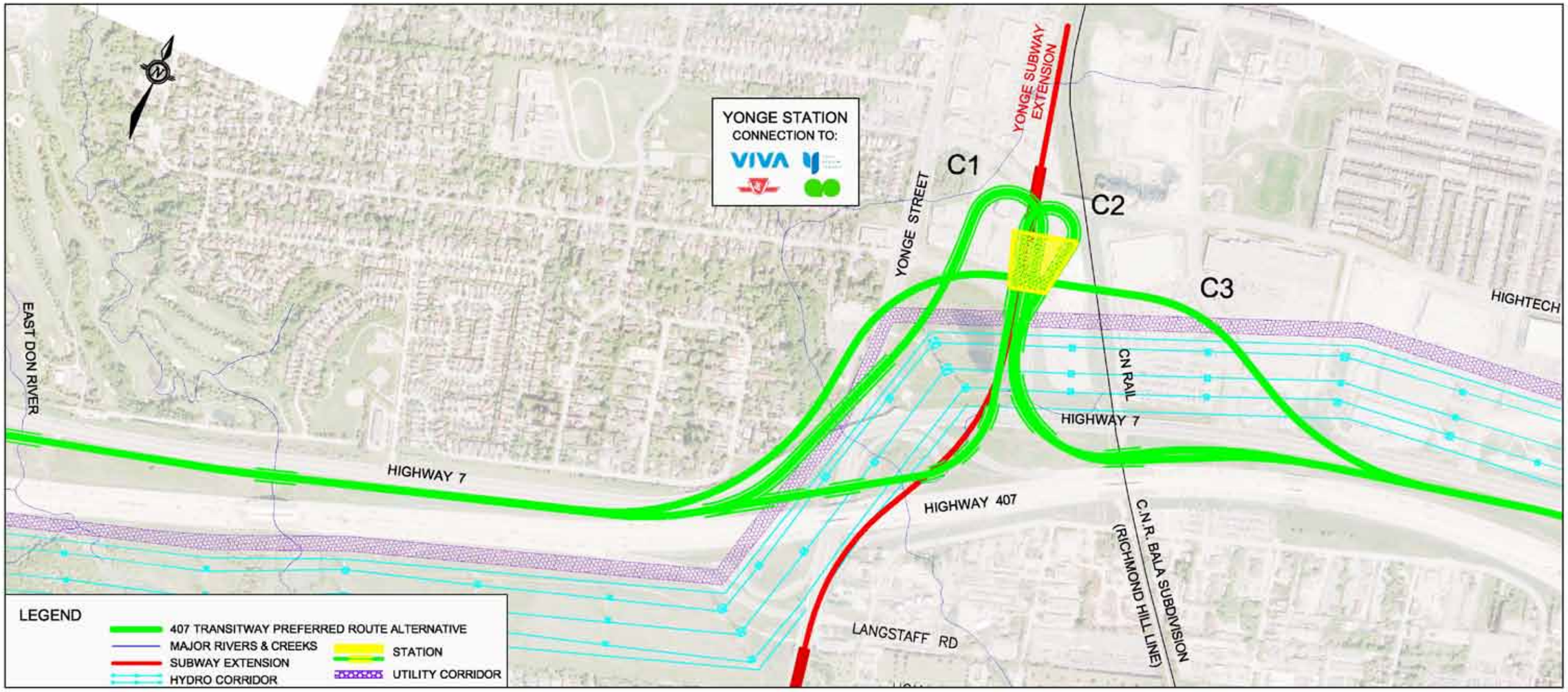


Figure 5-12: Segment C - Shortlisted Route Alternatives



b) Alternative Alignments

Numerous alignments and variations (**Figure 5-13**) were tested for the three alternative routes (C1, C2 and C3) for evaluation in the Richmond Hill Centre area responding to the following considerations:

- Location of station platforms in relation to future Yonge Subway Station, YRT/Viva Bus Terminal, future development;
- feasibility of accommodating short turn operation for buses and potential future light rail (crossovers);
- accessibility of buses to future road network under study by York Region;
- location of major utilities (including the Hydro corridor) and municipal service facilities (including the SWM pond);
- location of sub-structure elements of the Highway 407/Highway 7/Yonge Street Interchange;
- crossing of the various existing and planned road and rail facilities.

Through a screening process, a preferred alignment was selected for each of the three. **Figure 5-14** illustrates these preferred horizontal alignments, identified as C1A, C2A, and C3A.

The three selected horizontal alignments have multiple grade separated crossings, the CN GO Richmond Hill track, the Yonge Subway Extension runningway, two crossings of Highway 7, Yonge Street, and the 407 ETR-Yonge Street ramps. For the three refined alignment alternatives, profile options were identified and assessed considering geometric design standards, physical constrains and utility crossings, costs, construction complexity including impacts to the 407 ETR operation during construction and visual effects.

Having screened the preferred profile options for the three alignments carried forward, and following discussions with MTO and key stakeholders as well consulting with the public, the three alignment alternatives were evaluated against each other as described in the evaluation **Table 5-9** on the following page. As a result of the evaluation, Alignment C3A was selected as the preferred alternative.

Alternative Station Layouts

The investigation of station layout alternatives revealed that two basic layout alternatives were feasible at the preferred location established above. These are either the typical side-platform configuration described for most other transitway stations or a centre-platform arrangement, typical of most Toronto subway stations. If a centre-platform layout is used to simplify the vertical circulation requirements, BRT vehicles with right-hand doors only will have to cross over to left-hand running through the station. When the system is converted to LRT, vehicles will have doors both sides allowing right-hand running through the station. These operational features can be accommodated within the planned footprint of the station works at the Richmond Hill Centre.

Given that the runningway and platform elevation on the preferred transitway vertical alignment is approximately one metre above the tentative mezzanine floor level of the Yonge Subway Station, passengers transferring to/from the transitway to the subway will have both a horizontal (approx. 100m) and vertical circulation path between the two stations. This transfer path will be developed during preliminary and detailed design in collaboration with the design of the subway station south entrance and York Region multi-level bus terminal to be located south and east of the subway entrance.

In the event a side-platform configuration is adopted, the westbound platform will have a minor elevation difference to the subway station mezzanine while users of the eastbound platform will pass under the transitway and up a gradual ramp in the walkway to the mezzanine floor level. Similarly, if a centre-platform arrangement is adopted, all passengers would again pass under the westbound transitway lanes and rise in the walkway to reach the mezzanine level of the subway station.

The preferred station and platform layout will be determined after integrated preliminary design of the combined transitway and subway station facilities and the YRT bus terminal.

Figure 5-13: Segment C - All Alignment Alternatives Considered

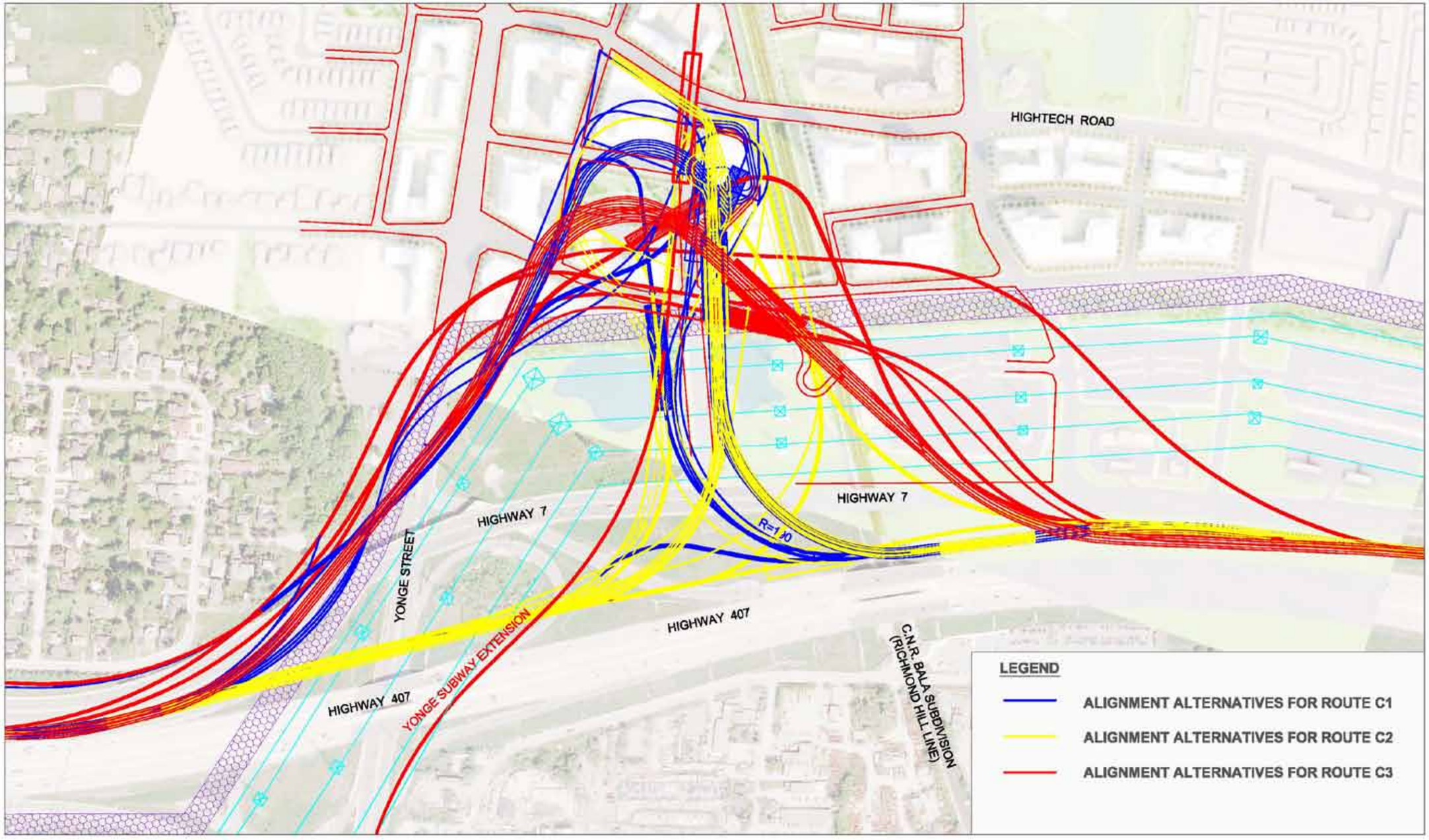


Figure 5-14: Segment C - Alignment Alternatives Evaluated

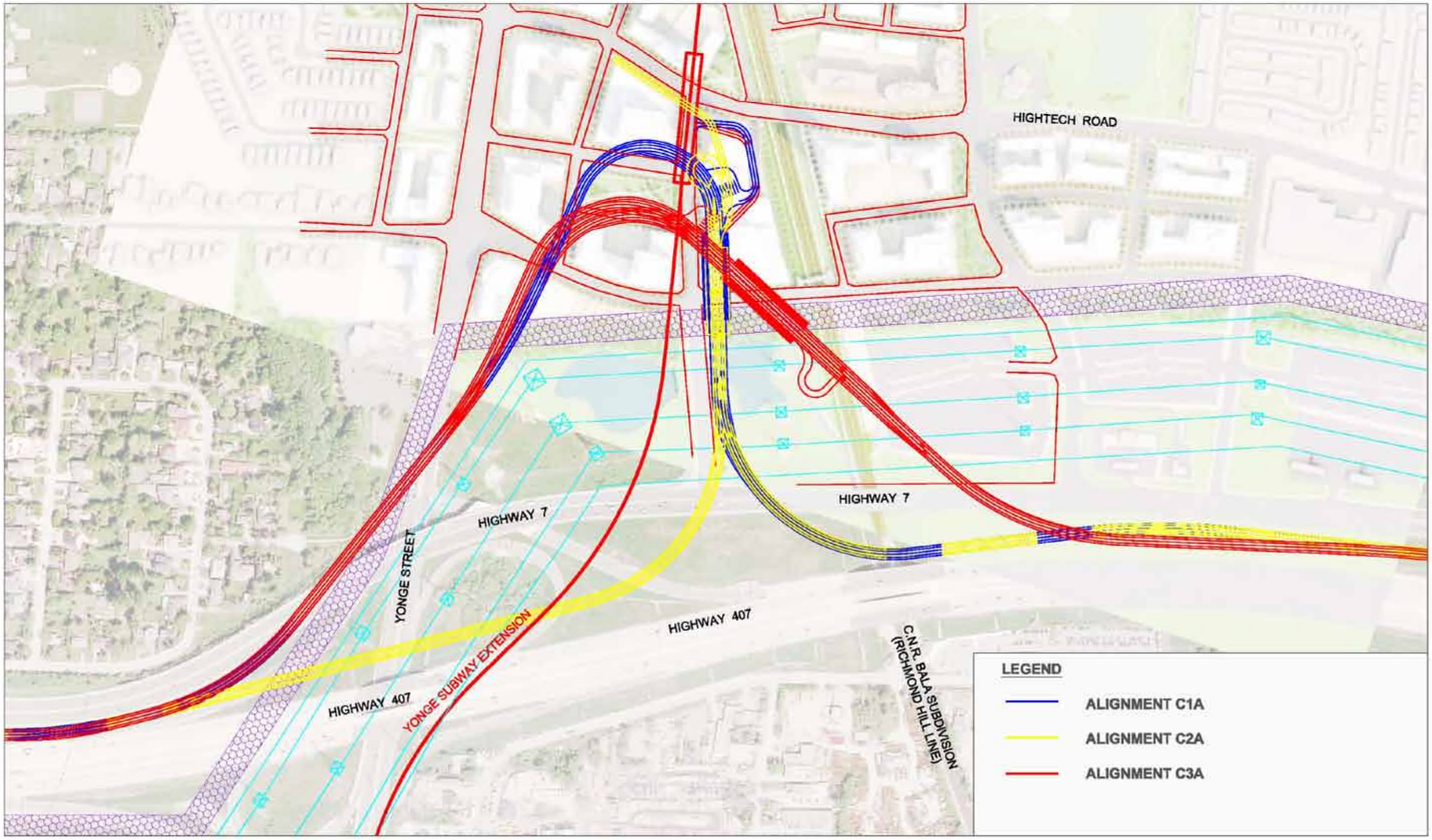


Table 5-9: Evaluation of Alignment Alternatives for Yonge Street Grade Separation and Yonge Station

OBJECTIVE (and relative weighting)	GOALS	INDICATORS	ALIGNMENT ALTERNATIVES		
			C2A – Stub-ended Transitway under Highway 7 and 407/Yonge Str. Interchange Ramps; over CN in NE quadrant RED	C1A – Through Transitway over Highway 7 and Yonge Street in NW quadrant: under Highway 7 & over CN in NE quadrant ORANGE	C3A – Through Transitway over Highway 7 and Yonge Street in NW quadrant: under CN and Highway 7 in NE quadrant BLUE
Improve Mobility	Attractive, convenient system access for passengers	Length/Height of vertical circulation elements to reach connecting system platforms. Interface with Subway primary entrance.	To Yonge Subway: 75m horiz.; 6m vert. To YRT/Viva: 75m average horiz.; 8m average vert. To GO Rail: 200m horiz.; 6m vert. Transitway turn-back loop transitway facilities could limit subway primary entrance configuration and design options.	To Yonge Subway: 120m horiz.; 6m vert. To YRT/Viva: 75m average horiz.; 8m average vert. To GO Rail: 150m horiz.; 6m vert. Transitway facilities could limit subway primary entrance configuration and design options.	To Yonge Subway: 150m horiz.; 6m vert. To YRT/Viva: 60m average horiz.; 8m average vert. To GO Rail: 80m horiz.; 6m vert. More remote transitway facilities allow greater flexibility in entrance configuration and design
	Maximize ride quality and passenger comfort	Transitway geometry and grading through grade separation and station	Station approach geometry contains one 200m and one 250m radius curve. 2 grades 4 and 5.75% - total length 200m	Station approach geometry contains one 80m and one 200m radius curve 2 grades 5 to 6% - total length 250m	Station approach geometry contains one 105m and one 300m radius curve 2 grades 4 to 5% - total length 560m
	Minimize travel time to access RHC Station	Estimated run time through RHC alignment off of 407 ROW	Westbound (LRT): 3.1 minutes (incl. 30 sec dwell with operator change) Min. BRT turnaround time of 75secs adds 45secs to runtime.	Westbound (LRT): 3.0 minutes (incl. 30 sec dwell)	Westbound (LRT): 2.5 minutes (incl. 30 sec dwell)
	Effect of infrastructure configuration on transit reliability	Potential for delays and incidents affecting adherence to service schedule and overall reliability	Stub-ended station configuration with at-grade crossing of EB and WB service increases potential for delays and loss of reliability.	Through station configuration permits reliable through operations and incorporates efficient turn-back features for both BRT and LRT.	Through station configuration permits reliable through operations and incorporates efficient turn-back features for both BRT and LRT.
40%			◐	◐	◕
Minimize adverse effects on social environment and RHC growth potential	Minimize road traffic disruption during construction	Nature and complexity of short term, temporary traffic accommodation measures required	Construction of 4 underpasses requires lengthy, temporary diversions of ramps and lane shifts on Highway 7. Traffic delays will be significant.	Construction of 2 underpasses requires temporary lane shifts on Highway 7. Elevated transitway construction will require limited diversion and lane modifications on Highway 7.	Construction of 1 underpass requires temporary lane shifts on Highway 7. Elevated transitway construction will require limited diversion and lane modifications on Highway 7.
	Minimize rail traffic disruption during construction	Nature, complexity and duration of temporary rail traffic accommodation measures required	Erection of transitway bridge over CN/GO mainlines will require one track occupancy and compliance with CN regulations	Erection of transitway bridge over CN/GO mainlines will require one track occupancy and compliance with CN regulations	Construction of CN underpass requires temporary diversion of CN/GO mainlines or construction techniques to maintain rail traffic on existing tracks..
	Avoid physical and visual intrusion in sensitive areas	Extent of visual intrusion by completed transitway works	At or below grade transitway works will not affect any views. Elevated segment of transitway over Yonge Street is within existing interchange.	Elevated transitway over Yonge Street increases views of interchange structures from NW quadrant residential neighbourhood.	Elevated transitway over Yonge Street increases views of interchange structures from NW quadrant residential neighbourhood.
	Minimize increase in ambient noise levels	Potential for noise intrusion in adjacent sensitive areas	Increase in ambient noise levels will be minimal and not discernable from sensitive receptors (residential neighbourhoods)	Attenuation of vehicle noise on climbing grades may be required to make increase in ambient levels during quieter evening periods not discernable	Attenuation of vehicle noise on climbing grades may be required to reduce increase in ambient levels during quieter evening periods not discernable
	Avoid physical intrusion into developable areas	Length of transitway ROW under or over land available for TOD west of subway	Approx. 50 metres (turn-back behind station) - remainder under roads, designated open space and mobility hub parcel	Approx. 80 metres – remainder under roads, designated open space and mobility hub parcel	Approx. 60 metres – remainder under roads, designated open space and mobility hub parcel
30%			◐	◐	◐
Minimize adverse effects on natural environment	Avoid intrusion into terrestrial habitat	Extent of intrusion and proximity to sensitive terrestrial habitat	500m of works within highway ROW across potential low quality terrestrial habitat	460m of works within highway ROW across potential low quality terrestrial habitat	280m of works within highway ROW across potential low quality terrestrial habitat
	Minimize effects on watercourses	Potential for adverse effects on aquatic habitat	Minor effects - design can include typical mitigation where alignment crosses surface or sub-surface watercourses	Minor effects - design can include typical mitigation where alignment crosses surface or sub-surface watercourses	Minor effects - design can include typical mitigation where alignment crosses surface or sub-surface watercourses
10%			◕	◕	◕
Offer a cost-effective way of moving people	High quality functionality at least capital cost	Estimated order-of-magnitude construction costs	$155-165 million	$140-150 million	$140-150 million
	Long term durability and hence least maintenance costs	Nature of infrastructure maintenance and effect on annual maintenance cost	2.1km segment length with 550 m underpass length with potential to increase runningway maintenance cost moderately; More complex underground station will increase maintenance costs	2.0km segment length with345m underpass length with potential to increase runningway maintenance cost moderately; Underground station will increase maintenance costs	1.7km segment length with 500m underpass length with potential to increase runningway maintenance cost moderately; Underground station will increase maintenance costs
	Efficient, affordable transit operations	Effect of infrastructure configuration on transit operating costs	Stub-ended station would require additional train operators when converted to LRT ($0.25million per annum). transitway profile and station configuration will allow operations at normal cost levels	Minor increase in energy consumption due to steeper transitway profile grades.	Moderate increase in energy consumption due to steeper transitway profile grades.
20%			◐	◕	◕
OVERALL RESPONSIVENESS (after weighting)					**MOST RESPONSIVE ALTERNATIVE**

LEGEND: **Overall Achievement of Objectives: Poor ◔ ◐ ◕ ● Very Good**

Goals & Indicators: Poor response **Very Good Response**

5.4.2.4 Segment D – From West of Bayview Avenue to East of Leslie Street

Alternative Routes

In Segment D, four route alternatives, D1 – D4, shown in **Figure 5-15**, were developed and evaluated. Initially, in this process, D3, south of Highway 407, was screened out because the southern route coming from the west in Segment C had already been eliminated.

Alternative D2 was also screened out due to significant disadvantages such as:

- the geometry not allowing transitway operation meeting the desirable design speed standard resulting in travel time penalties;
- a complicated crossing of Highway 407 west of Bayview Avenue crossing;
- proximity to the residential development immediately east of Bayview Avenue;
- the need for removal of a portion of sensitive deciduous forest resulting in a greater adverse affect on the natural environment;
- greater intrusion into the Hydro Corridor.

Alternatives D1 and D4, were carried forward for further detailed analysis and evaluation, in particular, for the determination of the Leslie Station location. This evaluation's key findings are summarized below:

- Both candidate alternatives could incorporate reasonably convenient vehicular access facilities (PPUDO, Park-and-ride, feeder bus transfers) however, in Alternative D4, an access ROW would have to be purchased from an adjacent commercial parking lot remote from a main street to reach a north-side Leslie Station parking area.. Avoiding this access complexity by placing the park-and-ride lot south of Highway 407 with a station on the north (D4) increases the walk distance to transitway platforms for park-and-ride users by 250-300m.
- Although the north-side station location, in Alternative D4, is closer to the centroid of the business park, it remains on the perimeter of the developed mixed-use lands beyond walk-in distance thus still requiring community shuttle bus access from the expanding residential areas to the west. It would also become 300m further from residential areas south of Highway 407 and park-and ride access is more difficult with limited capacity and no ability for expansion due to Highway 407 constraints. Also, significantly more of the northern D4 route is immediately adjacent to existing and future residential areas.
- Over half of the ROW in Alternative D1 is within the previously protected corridor while the D4 alternative would require a new ROW, albeit from ORC land along the north edge of Highway 407.
- Construction costs for Alternative D4 will be almost 50% higher due to the constrained D4 ROW, requiring the transitway to pass over Leslie Street and the station facilities on structure along with a higher cost crossing of the Highway 407/404 interchange further east. Some of this cost premium may be offset by the opportunity cost of D1 station land on the south side.

As a result of the above route evaluation conclusions, Alternative D1 with a south-side station was carried forward. Walk-in access from the business park across the Highway 407 bridge could be enhanced by providing weather protection along the additional 100 metre walking distance over the highway. **Figure 5-16** illustrates the selected preferred route through Segment D.

Alternative Alignments

Between Bayview Avenue and the Highway 407 crossing, two local alignment variations, D1A and D1B were considered, as illustrated in **Figure 5-17**. Alignment D1A has better geometry and a smaller skew angle in the crossing of Highway 407. However, it would have a more significant impact on the future development lands north of Highway 407, mainly due to the need to provide an underpass of the transitway immediately north of the Highway 407 crossing to allow access to the western portion of the lands severed by the transitway. While Alignment D1B avoids severing the lands into two parcels, it will require a more costly, new crossing of German Mills Creek instead of the Highway 7 culvert extension possible with Alignment D1A. Since this higher watercourse crossing cost is offset by avoiding the need for an access bridge under the transitway required in D1A, alignment D1B was carried forward to the vertical alignment analysis.

Vertical alignment alternatives were analysed for the required grade separations at Bayview Avenue, Highway 407 and Leslie Street. The results of this analysis are summarized below:

Bayview Avenue Crossing

In the examination of Bayview Avenue, it was concluded the preferred vertical alignment was an underpass for the following reasons: Bayview Avenue is already elevated as it crosses above both Highway 7 and Highway 407 creating an elevation difference that is more favourable to an underpass;

The hydro corridor also passes over the Bayview-Highway 7 and Bayview-Highway 407 intersection restricting the maximum height of a possible structure due to clearance requirements. The hydro clearance requirements do not allow for sufficient clearance of a structure over Bayview Avenue.

Leslie Street Crossing

Alternatives crossing over and under Leslie Street were evaluated. Crossing over Leslie Street represented less complexity during construction. However this would incur a much higher cost for earth works due to the existing elevation difference between Leslie Street and the surrounding ground. Crossing over Leslie would require that the adjacent station be elevated and would consequently be more inconvenient for passenger connection to the station facilities located at ground level; an underpass would result in a slightly depressed station. An overpass alignment results in no conflicts with the tributary located just west of the station; and underpass required extra design and mitigation considerations. Consequently an underpass alignment was considered preferable.

Figure 5-15: Segment D - Route Alternatives

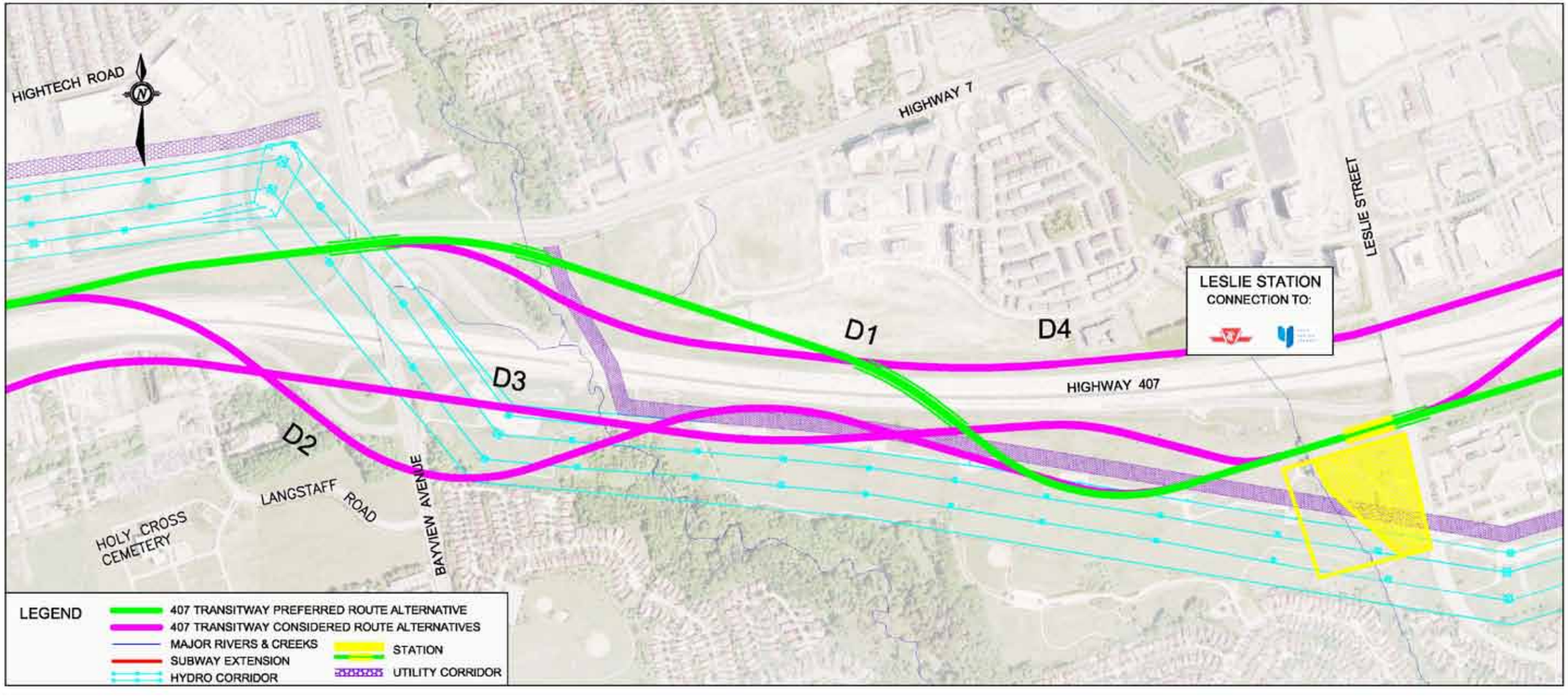


Figure 5-16: Preferred Route Segment D

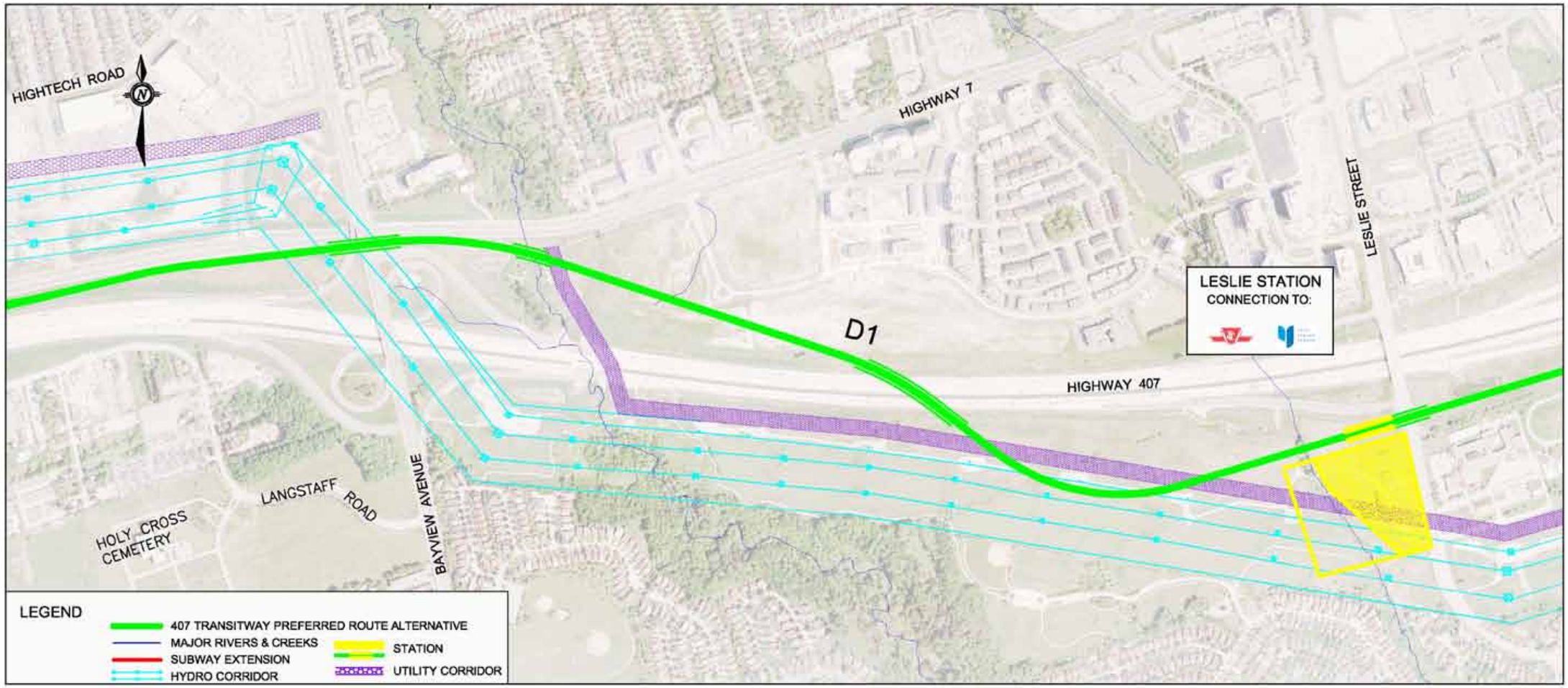
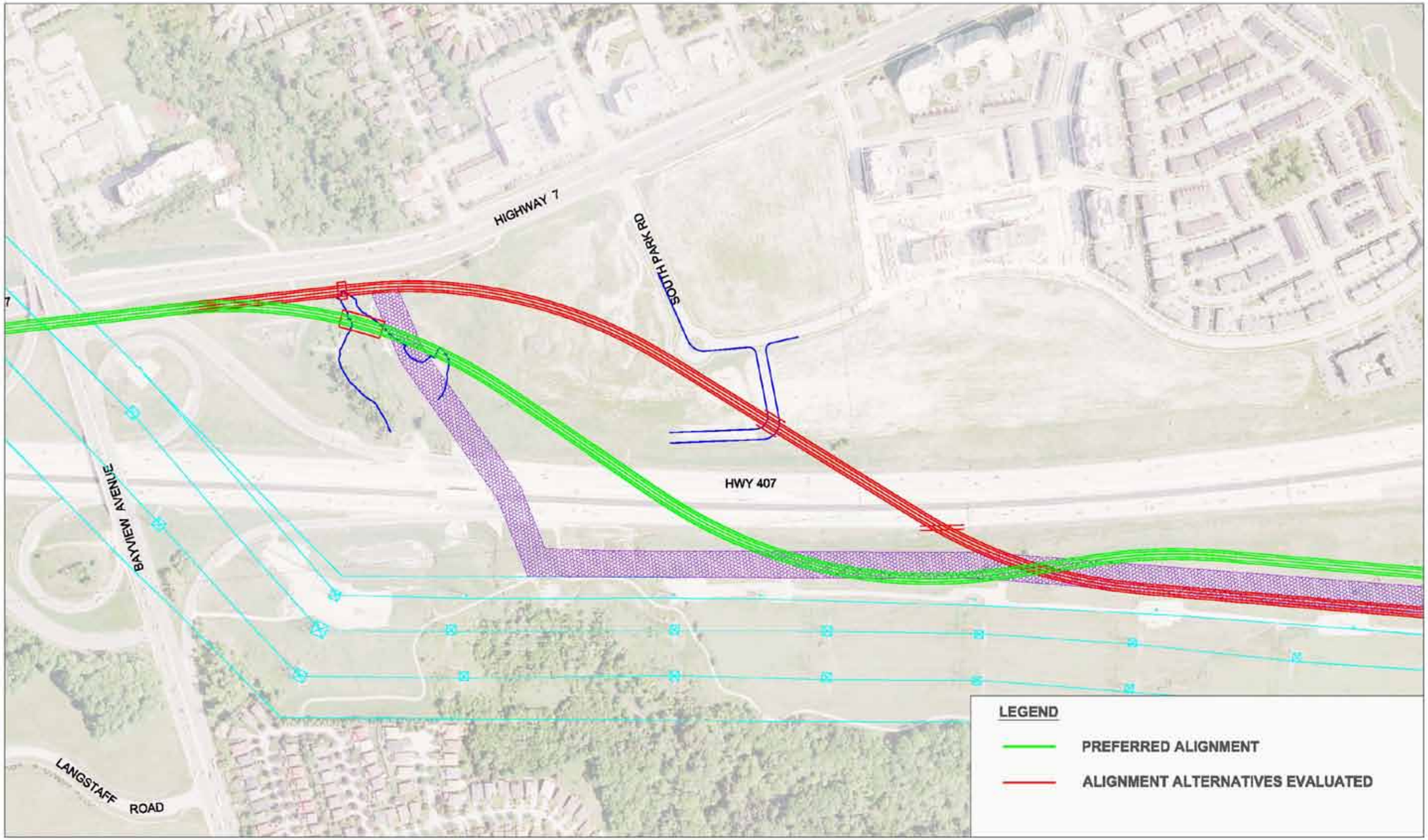


Figure 5-17: Bayview Avenue Underpass and Hydro Corridor Crossing



c) Alternative Station Layouts

Leslie Station includes a park-and-ride facility to serve surrounding and northern residential communities as well as convenient access to the commercial and business park areas north of Highway 407. Three layout concepts were assessed for the station considering the effects of each on transit operations, traffic circulation, economic benefits and environmental impacts. The alternatives comprised:

- Alternative 1 – An internal local transit loop with full signalized transit access;
- Alternative 2 – An internal local transit loop right-in-right-out transit access; and,
- Alternative 3 – On-street transit stops located on Leslie St. with a turn-back loop for local shuttle service only near the park-and-ride entrance.

Preliminary traffic analysis indicates that both Alternatives 1and 2 would result in extra delays to transit service at the park-and-ride access on Leslie Street. Segregating bus and parking access for these options is not feasible as the distance between two signalized controls south of Highway 407 eastbound off-ramp as proposed in Alternative 1 is not in compliance with "TAC and MTO Geometric Design Guidelines." The running time penalty on through service having to leave Leslie St. to transfer passengers within the station area is considered a significant disadvantage.

Compared to Alternatives 1 and 2, Alternative 3 offers the lowest capital, operating and maintenance costs due to the removal of an internal bus loop and platforms. Under Alternative 3, the bus platform/loop area could be converted into additional parking spaces. As a result, the requirement of land west of the creek for future parking spaces will be minimized, increasing the potential for a compact TOD west of the station. In addition, Alternative 3 will be the least disruptive to any future Leslie St. LRT operations and provides the shortest bus access running times among all three options.

For the above reasons, Alternative 3 is recommended as the preferred layout and feeder bus transfer arrangement for Leslie Station.

5.4.2.5 Segment E – From East of Leslie Street to East of Rodick Road

a) Alternative Routes

Three candidate route alternatives, shown in **Figure 5-18** were analyzed and evaluated in this segment. Alternatives E1 and E2 were located north of Highway 407 and E3 south of the highway, with all serving a station in between Woodbine Avenue and Rodick Road.

The evaluation findings can be summarized as follows:

- Route length is only slightly different between alternatives. Alternative E2 includes two curve radii of less than 560 metres and a reverse curve, hence the negative effect of alignment length and geometry on average speed, resulting travel time and ride comfort is marginally greater for Alternative E2. Nevertheless, all alternatives offer a fast, safe and efficient way of moving people;
- Alternative E3 utilizes most of the protected transitway ROW and station site while a totally new ROW and station site is required for E1 and for 80% of E2;
- Alternatives E1 and E2 require complex infrastructure to mitigate intrusion on the flood plain of the Rouge River tributary alongside Highway 407;
- Alternative E3 has a higher likelihood of conflict with potentially contaminated sites along the alignment, however this can be remedied; contaminated sites are likely to be encountered along Alternatives E1 and E2 routes as well;
- Capital costs for Alternative E1 will be highest since more complex infrastructure is required to cross Highway 404 and the Rouge River tributary north of Highway 407 along with higher property acquisition cost to obtain a new northern ROW.
- The complexity of grade separating E1 and E2 at Highway 404 and Woodbine Avenue will also increase their capital cost over the cost of E3; and,
- While Alternative E3 does not carry the capital cost of a Highway 407 crossing in this segment, it is likely that this southern route will have to cross the Highway 407 corridor further east in Segment F if a northern station site at the GO Stouffville Line is preferred.

From the above findings, Alternative E3 was considered the most responsive to the overall evaluation objectives and was carried forward into the alternative alignment evaluation stage. **Figure 5-19** illustrates this alternative carried forward.

b) Alternative Alignments

Various horizontal alignments along Route E3 were considered to optimize the solution to several issues and physical constraints in this segment including:

- The crossing of the Highway 404/407 Interchange;
- the existing 2200 mm. diameter York-Durham trunk sanitary sewer west of Woodbine Avenue;
- the proximity of the adjacent Hydro and Utility Corridors;
- the future widening of Miller Avenue
- the proposed plan of the road network expansion south of Miller Avenue, between Woodbine Avenue and Rodick Road, mainly the intersections of future streets with Miller Avenue;
- the requirement for a grade separated access to the Magna lands north of Miller Road and the transitway ROW, between Woodbine Avenue and Rodick Road; and,
- convenient access to the Woodbine/Rodick Station facilities.

Figure 5-18: Route Alternatives Segment E

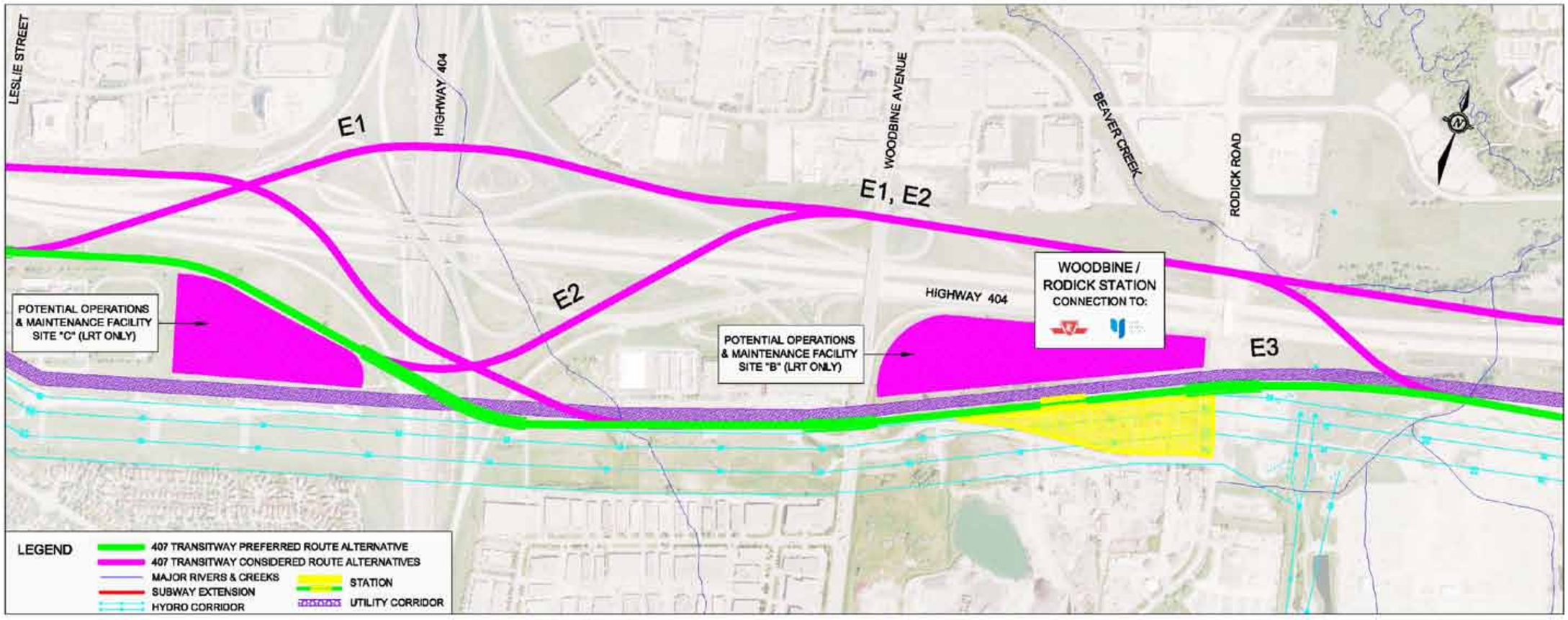
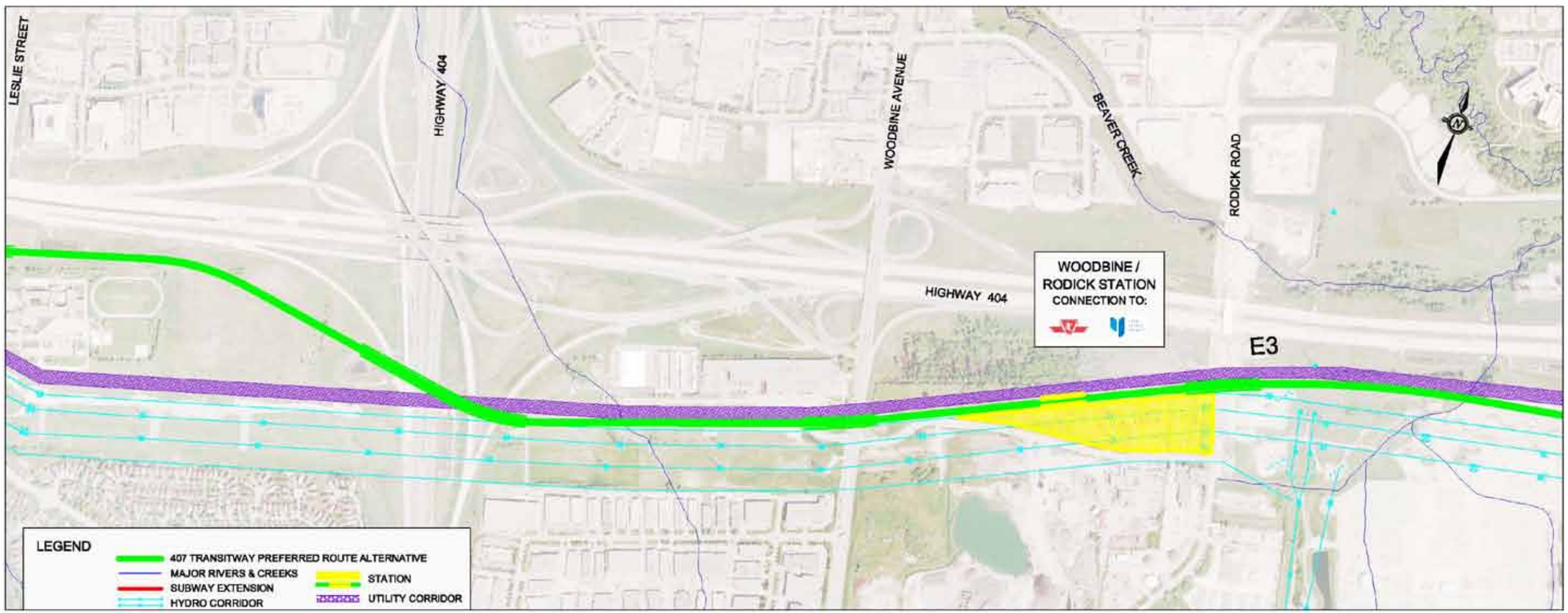


Figure 5-19: Preferred Route Segment E



The alignment alternative that best responds to these constraints is illustrated in **Figure 5-20**.

Vertical alignment alternatives assessed for the required grade separations of the Highway 404, Woodbine Avenue, and Rodick Road crossings are described below:

Highway 404 Interchange Crossing

Three alternatives considered for the Highway 404 Interchange crossing comprised an overpass above all lanes and ramps, an underpass below all lanes and ramps and a combination crossing over the two western ramps and the core lanes and under the two eastern ramps. The first alternative, requiring a long viaduct structure to ensure adequate clearance of all ramps, would carry excessively high capital costs. The alternative crossing under the entire interchange would have significant impacts to traffic during construction as well as high cost and complexity. The combined overpass – underpass alternative, although necessitating profile grade changes, resulted in the most constructible and cost-effective option. Measures to mitigate the traffic impact for this alternative are described in **Section 8**.

Woodbine Avenue Crossing

Again, at Woodbine Avenue, alternatives crossing over and under were assessed and evaluated. An underpass would conflict with the existing 2200 mm. diameter trunk sewer and require pumping to drain to the storm sewer system, hence an overpass was selected as the preferred alternative for this crossing. The overpass would include structures to grade separate Burncrest Road west of Woodbine Avenue and a future access road to the Magna property immediately east of the avenue.

Rodick Road Crossing

Both over and under grade separation profiles were also evaluated for the Rodick Road crossing. An underpass at Rodick Road was selected as the preferred alternative for this crossing for the following reasons:

- the desirability of placing the nearby Woodbine/Rodick Station slightly below grade to facilitate access to platforms from the surface parking and avoid intrusion into hydro clearance envelopes,
- more reasonable construction costs given that Rodick Road is already on an embankment resulting in the need for a very high overpass.

c) Alternative Station Layouts

The station site does not lend itself to more than one basic layout alternative. Variations assessed included the compatibility of the entrances with the planned local road network, separation of bus and PPUDO/park-and-ride entrances and optimization of the space allocated to parking and bus facilities for transferring passengers from the Highway 404 Business Park and Markham Centre West.

5.4.2.6 Segment F – From East of Rodick to East of Kennedy

a) Alternative Routes

In this segment alternatives F1 to F4 (illustrated in **Figure 5-21**) were assessed and evaluated. These encompassed routes serving two station sites north of Highway 407 and one site south, all immediately east of the GO Stouffville Line as it passes through Unionville Station west of Kennedy Road. The route alternatives were developed to optimize inter-connectivity between the YRT/Viva facilities located in accordance with York Region's approved EA and to maximize walk-in ridership attractiveness from TOD distributed uniformly across the Markham Centre East Precinct. The evaluation findings can be summarized as follows:

- Although route length is only slightly different between alternatives, Alternative F3 includes two curve radii of less than 560 metres and a reverse curve, hence the negative effect of the alignment length and geometry on average speed, resulting travel time and ride comfort is marginally greater for Alternative F3. Nevertheless, all alternatives offer a fast, safe and efficient way of moving people;
- Alternative F1 requires complex infrastructure to mitigate intrusion on the flood plain of the Rouge River tributary alongside Highway 407 east of Rodick Road;
- For alternatives F2 to F4, impacts on the natural environment are limited to conventional watercourse crossings where mitigation can be built into the design;
- The southern station site for Alternative F4 adds 400 metres to the minimum transfer distance for connection to YRT/Viva, TTC (future)and GO Rail services while the most northerly station (Alternative F3) minimizes the connection distance between all systems;
- Alternative F3 with the northernmost station location maximizes the walk-in ridership potential from transit-oriented development and best supports consolidation of transit facilities in the urban form of Markham Centre East;
- All route alternatives are remote from existing residential neighbourhoods and none require a crossing of the Hydro ROW;
- Alternative F1 capital costs to cross Warden Avenue will be higher due to the more complex grade separation needed to avoid conflict with existing commercial developments.

As a result of the findings on the previous page, Alternative F3 was considered the most responsive to the overall evaluation objectives and was carried forward into alignment alternative evaluation. Selection of Alternative F3 which transitions from south of Highway 407 at the end of Segment E to the north in segment F confirms compatibility with Alternative E3, the preferred alternative in Segment E.

Figure 5-20: Preferred Alignment Illustrating Magna Access and Miller Avenue Widening (Undertaken by Others)

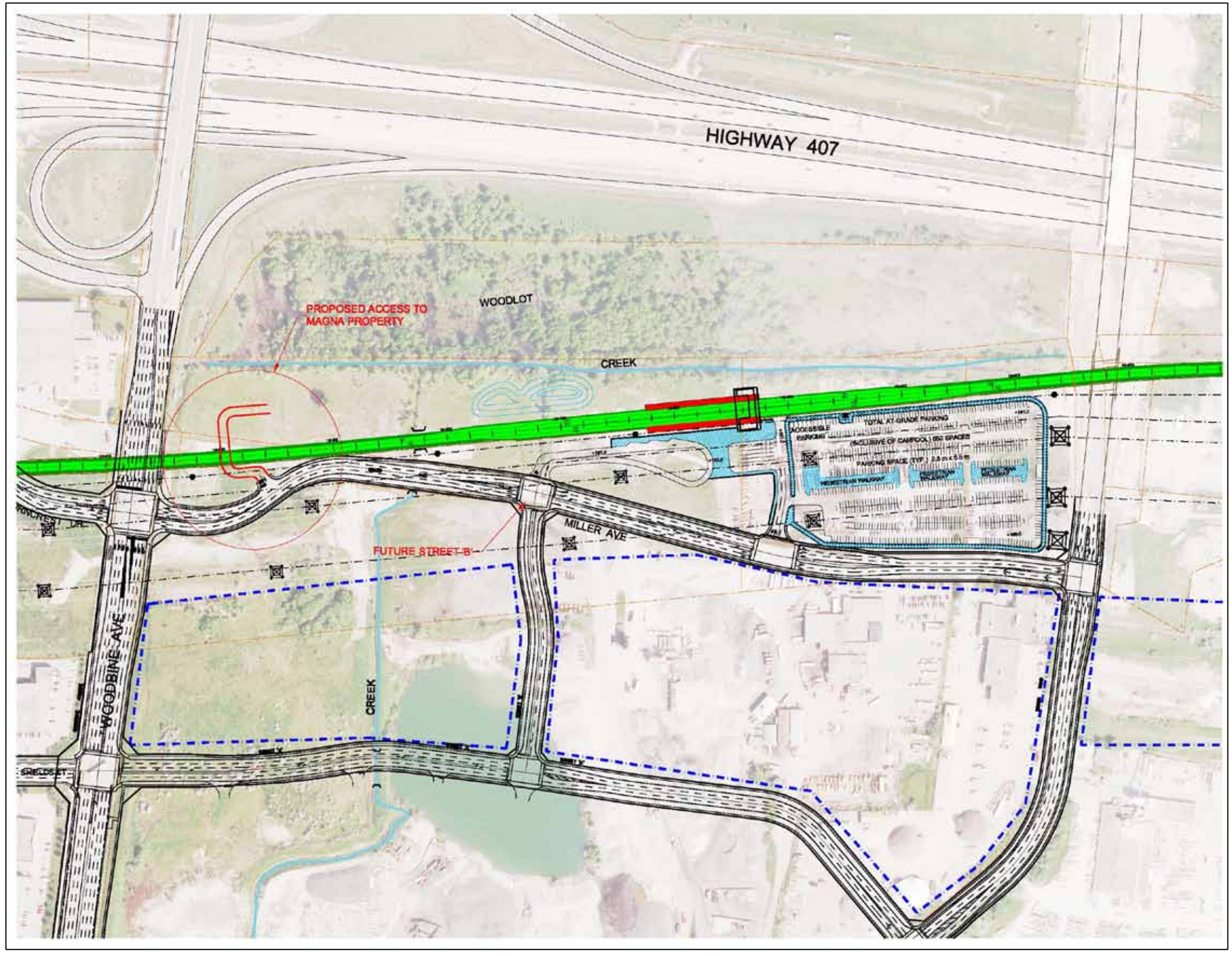


Figure 5-21: Segment F - Route Alternatives

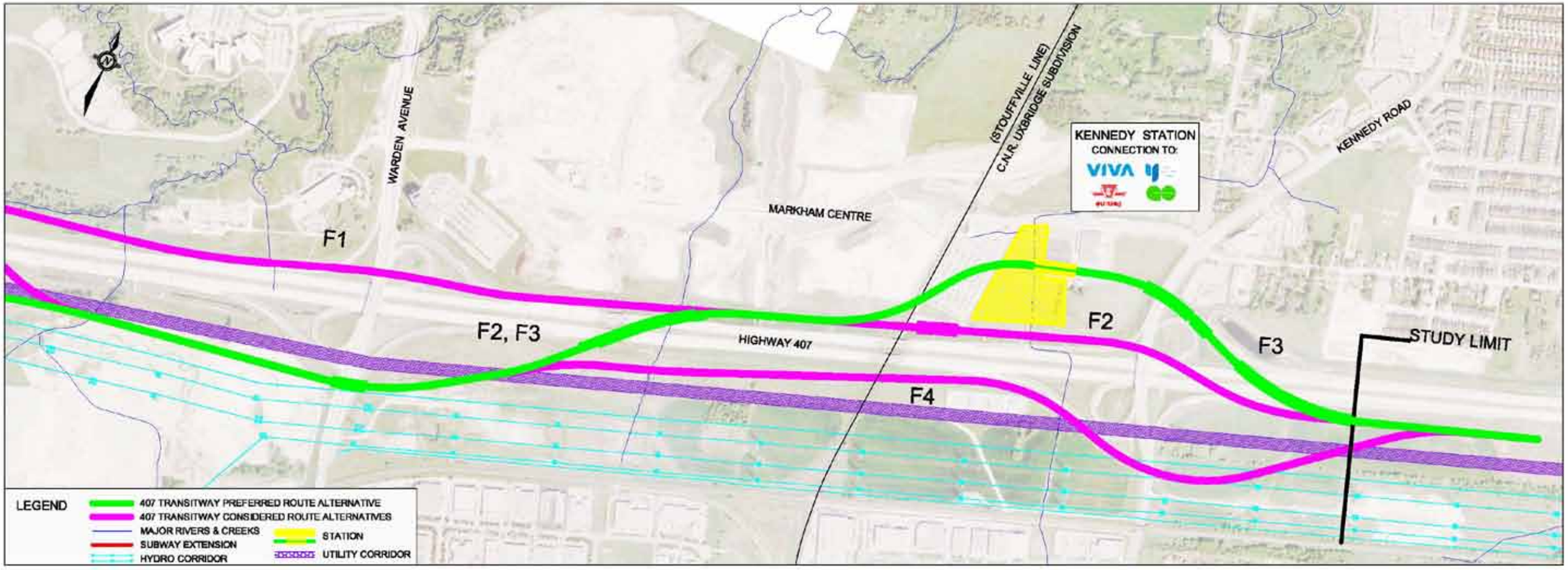


Figure 5-22 illustrates the selected preferred route from Highway 400 to Kennedy road.

b) Alternative Alignments

Between Rodick Road and the future Birchmount Road Extension, Route F3 horizontal alignment was analyzed with the goals of:

- Providing opportunity for the Town of Markham to accommodate a future extension of Miller Avenue;
- minimizing intrusion onto Hydro facilities, the Utility Corridor, and Markham District Energy Plant property;
- providing a feasible and cost effective crossing of the Warden Avenue interchange and the future Birchmount Road extension.

In the Kennedy Station area, several horizontal alignment alternatives were tested to assess their response to the following planning objectives:

- A 407 Transitway Station and mobility hub in the optimum location to serve both residential and commercial land uses in the eastern half of Markham Centre including proposed community amenities;
- Good connectivity to the other transit services using the hub, i.e., GO Stouffville Line Station and the YRT/Viva bus terminal;
- A 407 Transitway Station location that maximizes the benefits of the investment in capital works to cross Highway 407 twice and penetrate Markham Centre lands;
- Adequate access to/from the surface road network for transitway BRT vehicles;
- Alignment geometry compatible with future road network options between the point where the transitway enters Markham Centre lands and the Kennedy Road crossing;
- Sufficient tangent adjacent to the station to accommodate a potential rail crossover if facility is converted to LRT;
- Avoiding, if practical, impact on existing YMCA property and minimizing constraints on future development both east and west of the GO Line.;
- Provision of a feasible and cost effective crossing of the Kennedy Road Interchange.

Responding to the above objectives, alignment alternatives considered for Route Alternative F3 are illustrated in **Figure 5-23** and **Figure 5-24**. Following consultations with York Region Transit, York Region Rapid Transit Corporation and an initial evaluation in terms of criteria reflecting the objectives, Alignment F3A shown in green was selected.

Land use planning and development of an internal road network in the eastern half of Markham Centre has not yet been finalized and approved by the Town and other transportation jurisdictions involved. Conceptual development frameworks for the distribution and location of a range of land uses (commercial, residential, community amenities, open space etc.) and the associated road system within the area surrounding the GO Unionville rail station are currently under consideration.

Recently, the Town of Markham provided a concept for the land use framework in the eastern Markham Centre including proposed *Markham Live (2010)* facilities and a mobility hub on the southern boundary. This additional planning background led to the comparison discussed below. Alignment F3A, modified to integrate with the Town's proposed land uses and street network, is compared with F3B as proposed in the Town's concept and highlighted in **Figures 5-23** and **5-24**.

Alignment F3A, passing under Sciberras Road and the GO Stouffville Rail Line, aims to maximize the penetration into the Centre in order to place as much of the residential, commercial and "Markham Live" community amenity land uses within a 500 metre radius of the transit hub. This alignment creates a hub station opportunity and connectivity with the current YRT/Viva routing at the west end of YMCA Blvd.

Alternative F3B, although crossing Highway 407 from south to north and back, does not enter the Centre but passes over the GO Rail Line and through a station node at the southern boundary of the Centre.

This alternative requires a re-routing of the YRT/Viva rapidway from the Simcoe Promenade at Market Drive Ext. to enable YRT/Viva service to connect with the proposed 407 Transitway service at the station on the south side of the proposed commercial development and community amenities. While this station node does include most "Markham Live" community amenities and associated high-rise residential and commercial uses within a 500 metre radius of the hub, it does not capture the residential and commercial development further north in the Centre given that half of the catchment area is occupied by Highway 407 and the Hydro ROW.

The optimum location of the mobility hub within the Regional Centre and its success in achieving good, integrated, multi-modal connectivity, a strong sense of place and economic vitality will dictate the choice of the preferred alignment locally within the Centre. Given that the southern limit of the Centre's development is Highway 407 and the Hydro ROW, it is essential that the transitway alignment cross the highway to allow a hub within the Centre's boundaries. While this is achieved with both F3A and F3B, there are significant benefits in penetrating beyond the Centre boundary to maximize the hub's accessibility to the largest possible ridership base and a range of activities, services and amenities.

Alignment F3A aims to place the mobility hub as far north into the eastern centre as practical, recognizing the constraint of the recently completed Enterprise Boulevard grade separation with the GO Stouffville Line. This alignment can be integrated with the Town of Markham's conceptual development and street network framework without significant intrusion of the below-grade ROW into development parcels, permitting, where necessary, air-rights development. Implicit in pursuing this optimum hub location is acceptance of a higher capital cost for below-grade transitway infrastructure within the Markham Centre boundaries. This cost premium is estimated to be in the range of 2% of the overall Central Section infrastructure cost.

Foregoing the opportunity to penetrate into the Centre at all, by developing the mobility hub on the southern boundary as in Alignment F3B, does allow lower cost infrastructure works, largely on retained fill or elevated, along the southern Centre boundary. Notwithstanding the need for an elevated station, these works would not add a premium to the overall Central Section cost. While this cost advantage is significant, locating the hub alongside Highway 407 behind the potential convention centre and associated hotel, compromises the walk-in attractiveness of the hub for a large area of the Centre's transit users. The remoteness, without transit supporting land uses to the south, could also jeopardize the long term viability of the hub as a vibrant and vital place within the Centre to support the transportation experience.

Figure 5-22: Segment F – Preferred Route Alternative

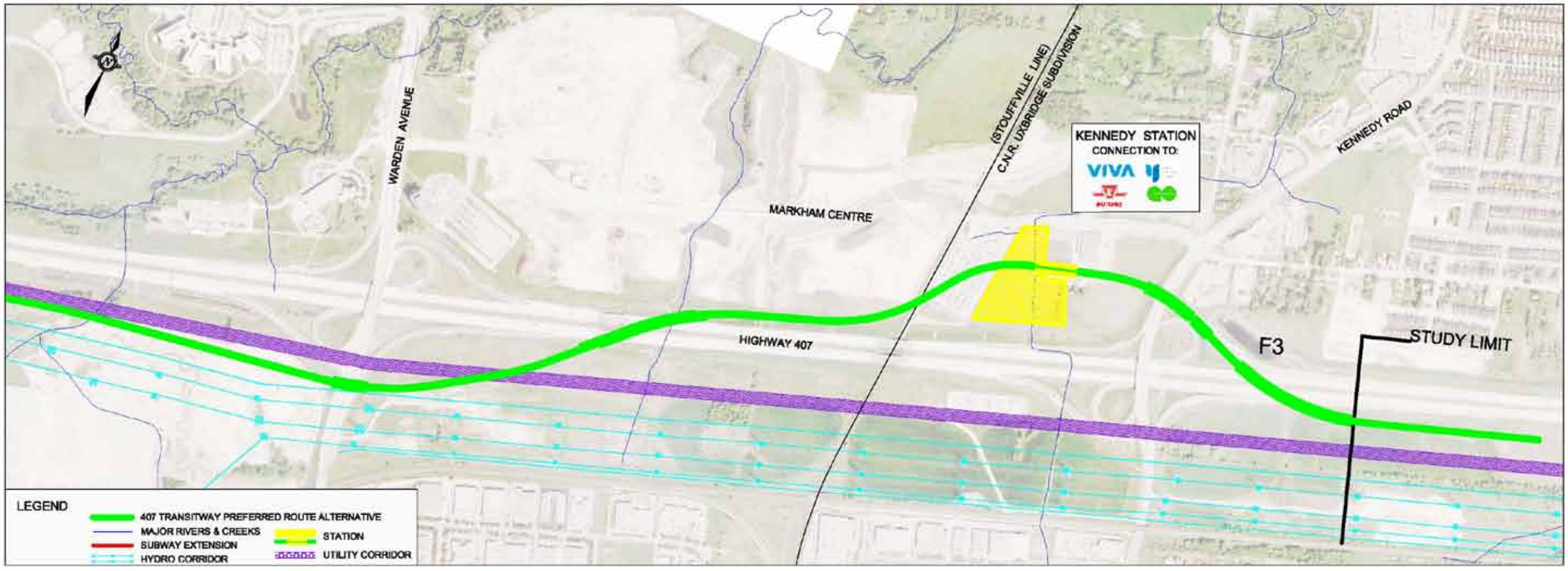


Figure 5-23: Integrated Alignment Alternative F3A

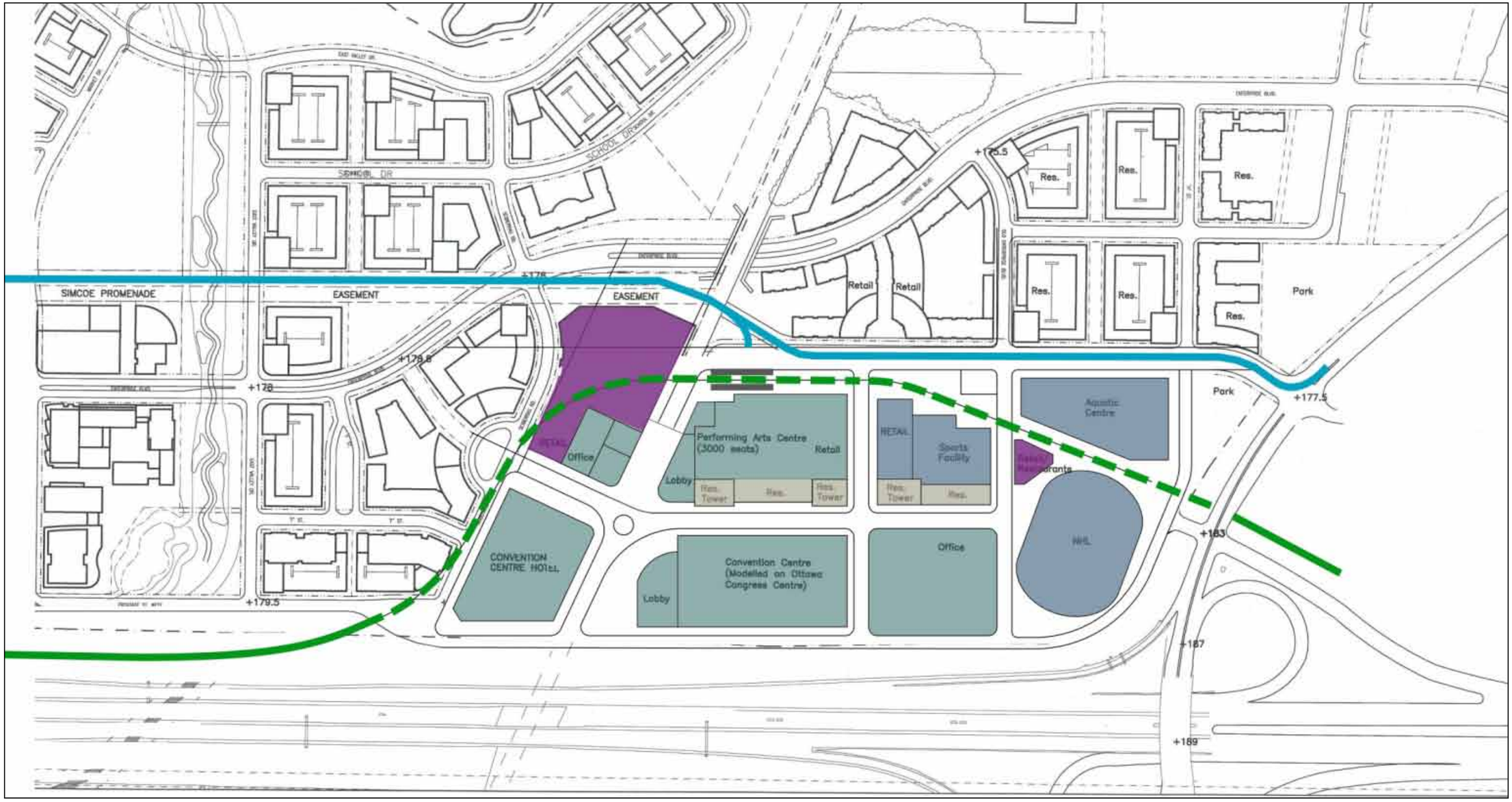


Figure 5-24: Integrated Alignment Alternative F3B

The preferred alignment F3A, shown in green in **Figure 5-25**, meets most of the planning objectives listed above given that the proposed underpass of the GO Line and below-grade station can be integrated with the Markham Centre East road network, including planned new road crossings over the GO Line and area land use plans.

Vertical Alignment alternatives analysis entailed an assessment of the options for the transitway to cross the north-south arterial roads in the segment as well as Highway 407 in transitioning from the south into Markham Centre. The findings of this analysis are outlined below.

Warden Avenue Crossing

Crossing over and under Warden Avenue were considered. As in most road arterial crossings, an overpass would imply being two levels (about 11 metres) over existing ground, representing a long section of costly elevated runningway; additionally impact to Hydro and Markham District Energy would be greater. Consequently it was selected to cross under Warden Avenue.

Birchmount Road Crossing

Crossing over the future Birchmount Road Extension would allow an integrated structure to cross over both, Highway 407 and Birchmount Road, crossing under Birchmount was consequently screened out.

CN Stouffville Line Crossing

The two options discussed above were considered. Although crossing over the track would be less costly and would have less impact during construction, the effects to the developments on either side of the GO track and the much less convenient inter-transit user connection, vertical grade challenges due to the proximity of the station platforms and effects to YMCA, were factors to screened out the option of crossing the CN GO Stouffville Line with an overpass.

Kennedy Avenue Crossing

Crossing over and under Kennedy Road were assessed. Kennedy Road as most north- south arterials cross Highway 407 on an overpass, consequently a transitway overpass like in the case of the other arterials would be very high and would imply a lengthy and costly viaduct on either side of the crossing with a significant visual effect. Crossing Kennedy Road with an underpass minimizes the surface effects to the lands east of Kennedy Road and is allows a favourable vertical alignment on the approach to the station.

5.5 Operation and Maintenance Facility Alternatives

An analysis of the potential operations and maintenance facility requirements was conducted for BRT and LRT operations on the 407 Transitway from Hamilton to Highway 35/115 for the year 2031. The purpose was to establish a demand-response operating scenario(s), the resulting vehicle fleet requirements and the property to be protected for the distribution, capacity and desirable location and size of facilities required to maintain the fleet.

5.5.1 BRT Operations

The analysis for BRT operations and maintenance facility requirement was based on the ridership demand forecasts (Planning Stage), assumed route network concepts, and service level projections along the 407 Transitway (from Hamilton to Highway 35/115). The projections of vehicle requirements were based on the route network, estimated route lengths, average operating speeds, running times and service frequencies. The 407 Transitway in this analysis was divided into three sections:

- West – Hamilton to Square One
- Central – Square One to Scarborough Centre
- East – Scarborough Centre to Oshawa Centre and beyond to Highways 35/115

Operations and Maintenance Facility Needs

The results of the analysis indicated that a transit fleet size of 158 buses including spares would be required to operate the planned service by 2031. The fleet of 158 buses consists of a distribution of 48 articulated buses (seating of 62 people), 63 double-deck buses (seating of 78 people) and 47 standard buses (seating of 39 people). A fleet of 158 buses would require a facility size of approximately 17,400 m^2 based on the general facility design guideline of 110 m^2/bus including vehicle storage, maintenance, administration and operations areas, and an overall site size of approximately 7 hectares (17 acres) including provision for employee parking, drive lanes and landscaping.

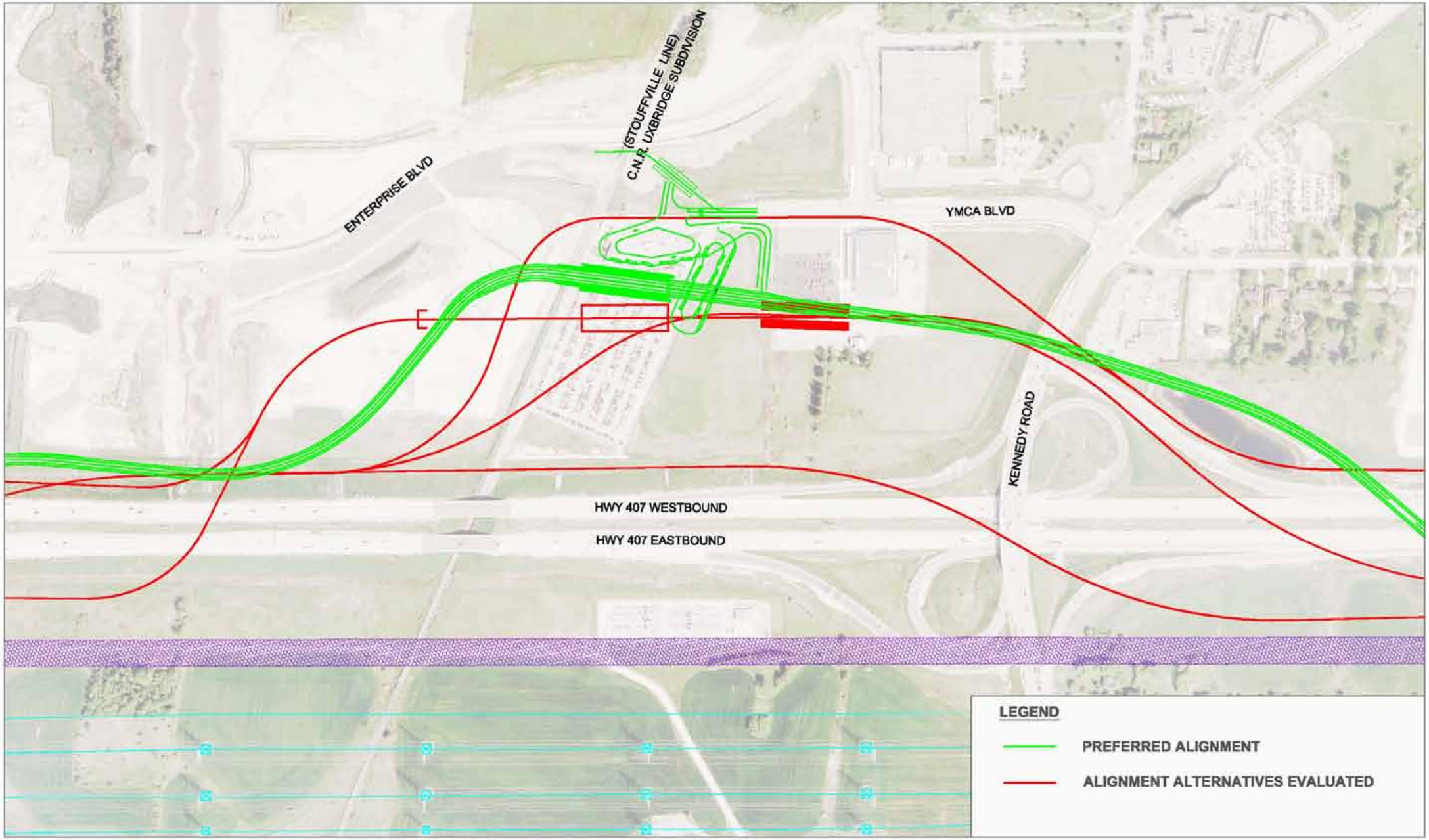
Three facilities or one facility per 407 Transitway section were suggested considering the total length of the 407 Transitway (160 kilometres from Hamilton to Highway 35/115) and the associated travel time from end to end (120 minutes one way). A single central facility would result in lengthy bus travel times and great distances of some 80 kilometres and 60 minutes each way, which would be significant, unacceptable and uneconomical. Dead-head times, to minimize non-productive driver time and to facilitate prompt response times to service needs or interruptions and vehicle maintenance issues, should preferably be limited to 20 minutes (25 to 30 kilometres).

The 2031 fleet needs associated with the three sections of the transitway have projected bus requirements including spares:

- West – 44 buses
- Central – 82 buses
- East – 34 buses

Beyond 2031, ridership and corresponding fleet needs will continue to grow as discussed in **Section 2** and a 50% increase in the above vehicle levels can be expected (i.e. 66 in west, 123 in Central, 51 in east). Alternatively, in the event of conversion of the Central Section to LRT, part of the overall central maintenance facility property protected would have to be assigned to rail vehicle storage and servicing.

Figure 5-25: Alignment Alternatives through Markham Centre



The facility for the west section, with up to 66 bus-capacity assuming an expansion allowance, would require approximately 7,700 m^2 and a site of approximately 2.5 hectares (6 acres) , potentially on a site protected in the north-west corner of Mississauga near the intersection of Highway 407 and 401 or in the Bronte Road area. The facility in the east section, for the storage and servicing of a fleet in the 50 vehicle range, would require justification for a stand-alone facility. Hence, consideration should be given to accommodating vehicles required for other inter-regional services and potentially collaborating with the local transit operator to store and service their fleet expansion needs. This would increase the facility fleet to the range justifying the construction of a second 50-bus capacity facility, logically on the site protected by MTO in Durham near the boundary between Ajax and Whitby

The facility for the central section would be the primary major maintenance and storage facility for the transitway. It should be designed for servicing 100 buses to accommodate future fleet expansion. The logical location for the facility is MTO's protected site at the junction of Highway 407 and Highway 400. This location is the only remaining site with adequate land area in the Central Section and it also benefits from the absence of sensitive land uses such as residential areas in the surrounding environment which consists mainly of compatible light industrial uses and road/rail transportation corridors. The analysis recommended that the site be planned with protection to maintain and store an equal number of vehicles that would be required for 400-series highway services currently operating or planned for the future expanded inter-regional bus transit network such as GO Transit operations. This approach of sharing the facility and site by more than one corridor fleet would result in the development of a more optimum facility nearer the typical more common industry capacity of about 150-200 vehicles.

Operations and Maintenance Strategy

The analysis of the potential operations and maintenance facility needs indicates that the facility in the central section would be the headquarters of the 407 Transitway incorporating all corporate, administrative, planning, operations, vehicle maintenance and facility maintenance functions. It would handle all major bus repairs as well as regular vehicle servicing and inspections functions. The buses stationed at the facilities in the west and east section would be serviced at those facilities nightly and receive minor running repairs. Drivers and local operations Supervisor and Inspectors would be assigned to these facilities as well.

The central facility at 2008 construction costs of \$2,200/m^2 would cost approximately \$24.2 million excluding land cost while the 52-bus capacity facility in the west section would cost \$12.8 million excluding land cost.

5.5.2 LRT Operations

The analysis divided the 407 Transitway into two sections for future LRT operations. The two sections correspond to potential operating segments at either side of the Highway 400 site, which is on MTO's protected land. The LRT service will be provided by 28-30 metres long articulated vehicles (seating 72 people) coupled in up to three vehicle train sets.

Based on ridership forecasts and the potential for growth of the three Regional Centres, it - was assumed that an initial phase of LRT operation would operate between Jane Street (Spadina Subway Extension Station) and Markham Centre, west of Kennedy Road. A second phase could extend the operation westward from Jane Street to the Tomken Road resulting in the major maintenance centre at the Highway 400 site being approximately central along the line. Ultimately, beyond the present 2031 planning horizon, a rail-based transitway service would extend further into the east and west sections of the Highway 407 corridor.

Operations and Maintenance Facility Needs

The ridership forecasts indicated that in 2031 an LRT service on the transitway between Richmond Hill Centre and Markham Centre should have a capacity of 5,200 passengers per hour per direction during the peak hour. This is covered by the assumed initial phase of LRT operation. Based on the ridership forecast, three scenarios for LRT Car Loading were presented: density for 4 passengers per square metre (could include some standing passengers), 2 passengers per square metre and all passengers being seated. The number of LRT vehicles/cars required were 45, 59 and 86 respectively. For the last phase of the LRT operation, the study concluded that 53, 69, and 101 vehicles/cars were required for each scenario.

MTO's protected land near Highway 400 was considered to be a reasonable location to accommodate a Central Operations and Maintenance Centre for the first phases of LRT operation, which would be over a 47 kilometres line. Although heavy repair and scheduled maintenance will be carried out at this facility, it is suggested that some end-of-line layover tracks for overnight storage and light inspection could be warranted to reduce dead-head distances for service start-up and provide off-peak storage during the day. Any significant extension of LRT operation beyond the initial 47 kilometres will require additional satellite storage capability east and west of the Central facility. For an extension to the west, the land protected in the Mississauga Road or Bronte area could fulfil this satellite function, initially at the end of an extension while in the east, the land protected by MTO at the Ajax/Whitby boundary in Durham is similarly positioned to serve both an initial eastward extension from Markham Centre to Whitby and, potentially, an ultimate eastward extension of rail service to the Highway 35/115 corridor.

A conceptual layout of a typical maintenance and storage complex was developed to assess the capacity of MTO's protected land by recognizing the site limits imposed by the Highway 407 ROW and existing Black Creek tributary flood plains. **Figure 5-26(b)** presents the conceptual layout of a typical maintenance and storage complex.

5.5.3 Description of Site Alternatives

In the 1998 Corridor Protection Study, the MTO identified suitable sites for Operations and Maintenance Facilities along the 407 Transitway Corridor. The largest of these sites, envisioned as the location for a Central Maintenance Facility, is located within this Central Section Study Area in the southeast quadrant of the Highway 400/Highway 407 interchange **(Site 'A')**. This site, approximately 20ha in area, was deemed to be adequate to accommodate both BRT and LRT fleet maintenance and storage requirements simultaneously, a situation that would arise if the Central Section had been converted to LRT while BRT was still operating on the western and eastern sections as well as the 400-Series highways.

The scope of this Preliminary Design Study required an assessment of the suitability of the Highway 400 protected site and any alternative locations for a major, Central Maintenance Facility along the Central Section or near the section limits. This investigation of alternatives has confirmed that the protected site would be able to accommodate both facilities in a reasonable configuration to store and service the anticipated BRT and LRT fleet sizes described above.

In terms of alternative sites, a single site, accommodating the fleets of both technologies, is not available on publicly-owned lands within the Central Section. The only other option considered was separate sites for each

technology. This approach yielded a second alternative **(Site 'B')** comprising the Keele Street Station site protected in the Corridor Protection Study and no longer required, combined with purchase of an undeveloped privately-owned site in Markham, east of Woodbine Avenue. The Keele Street site would accommodate a BRT maintenance and storage facility of similar size and configuration as that developed for the protected Highway 400 site. However, the privately-owned land between Woodbine Avenue and Rodick Road south of Highway 407 is a constrained, long and narrow site which would require a light rail vehicle building and storage yard configured specifically to match the site limits. Access from the transitway ROW to the site is also constrained by the Woodbine/Rodick Station location and the alignment vertical curvature.

A third alternative, **Site 'C'** comprises the Keele Street protected land developed as a BRT facility combined with the publicly-owned land in the southwest quadrant of the Highway 407 and Highway 404 interchange. This latter site could be configured as a LRT maintenance and storage facility to fit the shape of the lands on the south side of the transitway ROW as it crosses the protected lands.

The location and extent of the above sites are shown in the exhibits of the runningway alternatives in each of the three segments in which they occur (Segments A.B and E).

5.5.4 Evaluation of Site Alternatives

Table 5-10 summaries the evaluation of the three site alternatives in terms of nine criteria which reflect the key considerations in site selection and highlight important differences as well as the advantages and disadvantages of each alternative. Site 'B' requires acquisition of privately-owned land south of Highway 407 between Woodbine Avenues and Rodick Road, the only surplus Parkway Belt land in the Central Section suitable for a functional LRT facility. Key conclusions which can be drawn from the evaluation are summarized below:

Site 'A' performs well in terms of all site selection criteria offering the benefits of consolidating facilities for both technologies at a single, central location along the corridor and reasonable layout flexibility with capacity for expansion. Being publicly-owned, this site minimizes out-of-pocket land costs for both modes by avoiding the need to acquire and protect private land for future LRT vehicle maintenance and storage. However, the adoption of Site 'A' as the preferred site reduces the opportunity for other, earlier uses on land newly served by the 407 Subway Station on the Spadina Line extension.

Removing the protection of Site 'A' for both facilities will require acceptance of separate BRT and LRT facilities in the future as neither Site 'B' nor 'C' will accommodate both technologies which are likely to be required simultaneously to serve different sectors of the overall corridor. Adopting this approach will allow a reasonably good BRT configuration on the protected Keele Street Station lands but will require some compromises in layout, operational flexibility and long term capacity for LRT on the Woodbine/Rodick private lands of Site 'B'. Also, immediate or future purchase of these privately-owned lands will add to the ultimate project cost.

While Site 'C', with LRT facilities at Highway 404, removes some of these disadvantages, this location is incompatible with existing surrounding land uses and will remove any opportunity for future redevelopment of the prime lands immediately south of Highway 407 opposite the Commerce Valley Business Park to the north. This site is also being protected for a future Highway 404/407 transitway interface.

Considering the criteria overall, Site 'A' is the preferred alternative given the absence of either an alternative single site or combination of separate BRT and LRT sites that meets all criteria.

Table 5-10 Evaluation of Operation and Maintenance Site Alternatives

Selection Criteria	Site 'A' Protected land between Highway 400 and Jane Street for both BRT and LRT Operation and Maintenance Facilities	Site 'B' Protected land for Keele Street Station E. of Keele Street for BRT and private land between Woodbine and Rodick for LRT	Site 'C' Protected land for Keele St. Station E. of Keele Street for BRT and publicly-owned land S. of Highway 407 & W. of Highway 404 in Markham for LRT
Proximity to transitway ROW and 407 Central Section/400 series highway operations centroid	Site is immediately adjacent to transit-way with good access and reasonable proximity to network centroid (close to 400 and 407 highways).	Both sites are immediately adjacent to transitway with good BRT access but constrained LRT access. Site proximity to network centroid is good for BRT and reasonable for future LRT	Both sites are immediately adjacent to transitway with good BRT access and reasonable LRT access. Site proximity to network centroid is good for BRT (close to 404) and reasonable for future LRT
Site size and configuration – (parcel up to 18 hectares required)	Site size and shape offers good flexibility to optimize layout and configuration of facilities	BRT site size/shape allows reasonable flexibility to optimize configuration but long narrow LRT site limits layout flexibility.	Size/shape of both BRT and LRT sites allows reasonable flexibility to optimize configuration but narrow east side of LRT site limits layout flexibility.
Site ownership and acquisition cost	Entire site is publicly-owned and protected by MTO hence project land cost will be minimal. Placing O&M facilities on site A reduces opportunities for other uses	BRT site publicly-owned but LRT site with a single private owner would cost project an estimated $25million. BRT facilities on site B reduce opportunity for other uses.	Both BRT and LRT sites are publicly-owned and protected by MTO hence project land cost will be minimal. O&M facilities on site remove opportunities for other uses being protected at this node.
Site topography (grading and drainage requirements)	Moderate grading and drainage works required.	Moderate grading and drainage works required	Grading and drainage works required on BRT site are moderate but more significant on LRT site.
Compatibility with surrounding neighbourhood, (zoning, land uses & security)	Good – highway, transitway and hydro buffers to neighbouring uses including future commercial TOD integrated with planned Spadina Subway Station	Good at both sites which are surrounded by light industrial uses.	Light industrial uses around BRT site are compatible but existing education/future TOD uses are less compatible. Hydro ROW buffers adjacent residential.
Site access from transitway and road network and surrounding traffic conditions	Good connections possible for both road and rail vehicles. High traffic volume likely on Jane Street in future.	Good connections possible for road vehicles at BRT site and road and rail vehicles at LRT site. High Keele Street and Woodbine Ave. traffic volume in future.	Good connections possible for road vehicles at BRT site and road and rail vehicles at LRT site. Single access to LRT site from Leslie Street could be congested.
Site servicing and utility relocation/ interface requirements	Potentially no difficulty servicing site and no major utility conflicts.	Potentially no difficulty servicing BRT site. LRT storage parallel to Hydro lines may be problematic.	Potentially no difficulty servicing BRT site. LRT storage parallel to Hydro lines may be problematic.
Flexibility for expansion and protection of LRV maintenance and storage capability	Site size is adequate for facilities to serve both technologies simultaneously.	BRT site size is adequate for long term needs but LRT site has limited capacity for expansion to meet long term needs which would be reasonable if satellite storage sites E and W are protected.	BRT site size is adequate for long term needs but limited capacity for expansion on LRT site for long term needs would be reasonable if satellite storage sites E and W are protected.

Selection Criteria	Site 'A' Protected land between Highway 400 and Jane Street for both BRT and LRT Operation and Maintenance Facilities	Site 'B' Protected land for Keele Street Station E. of Keele Street for BRT and private land between Woodbine and Rodick for LRT	Site 'C' Protected land for Keele St. Station E. of Keele Street for BRT and publicly-owned land S. of Highway 407 & W. of Highway 404 in Markham for LRT
Environmental conditions and constraints	Black Creek tributary constrains layout flexibility. Stormwater management facilities required. No noise sensitivity	BRT site has no environmental constraints but LRT site requires removal of vegetation and possibly remediation of soil contamination.	Both BRT and LRT sites have no environmental constraints. Minor noise and visual sensitivity.

5.5.5 Preferred Site Layout Alternatives

Selection of the protected site at Highway 400 requires an assessment of layout alternatives to optimize the distribution of the site between BRT and LRT facilities and maximize the opportunity for transit oriented development on remaining land. Constraints influencing the location of the individual facilities and their configuration include the Black Creek tributary splitting the site in a north-south direction, the transitway alignment crossing east to west and the space required for Spadina Subway Station facilities on the east side along Jane Street.

Two alternatives, shown in **Figures 5-26(a) and (b)** were developed and compared to establish the optimum layout and most efficient use of the overall site. Alternative 1, **Figure 5-26(a)**, retains the transitway alignment in the protected ROW around the northern and western perimeter of the site and locates the BRT and LRT facilities to the south on either side of the Black Creek tributary. In the second alternative, **Figure 5-26(b)**, the transitway alignment is re-aligned southward, improving the geometry and Highway 400 crossing length, and at the same time allowing space to accommodate the BRT facility north of the transitway alignment. Placing the future LRT facility in the extreme northwest corner, west of the tributary, frees up lands adjacent to, and over the subway parking for TOD on the portion of the site closest to the subway station entrance.

The conclusion from the comparison of the alternatives is that the southern alignment, alternative 2 with BRT & LRT facilities to the north is preferred in that it:

- consolidates both BRT and LRT facilities on the north side of the transitway alignment more remote from the subway station;
- leaves approximately 2 hectares of surplus land adjacent to and west of, the subway parking to allow TOD with the opportunity for future integration of the subway parking and surface terminal facilities into the development;
- reduces the length of transitway across the Highway 400 ROW and improves the geometry and average speed through the site;
- preserves the flood plain and space for SWM ponds along the Black Creek tributary.

Figure 5-26(a): Conceptual Layout of Typical Maintenance and Storage Complex Alternative A

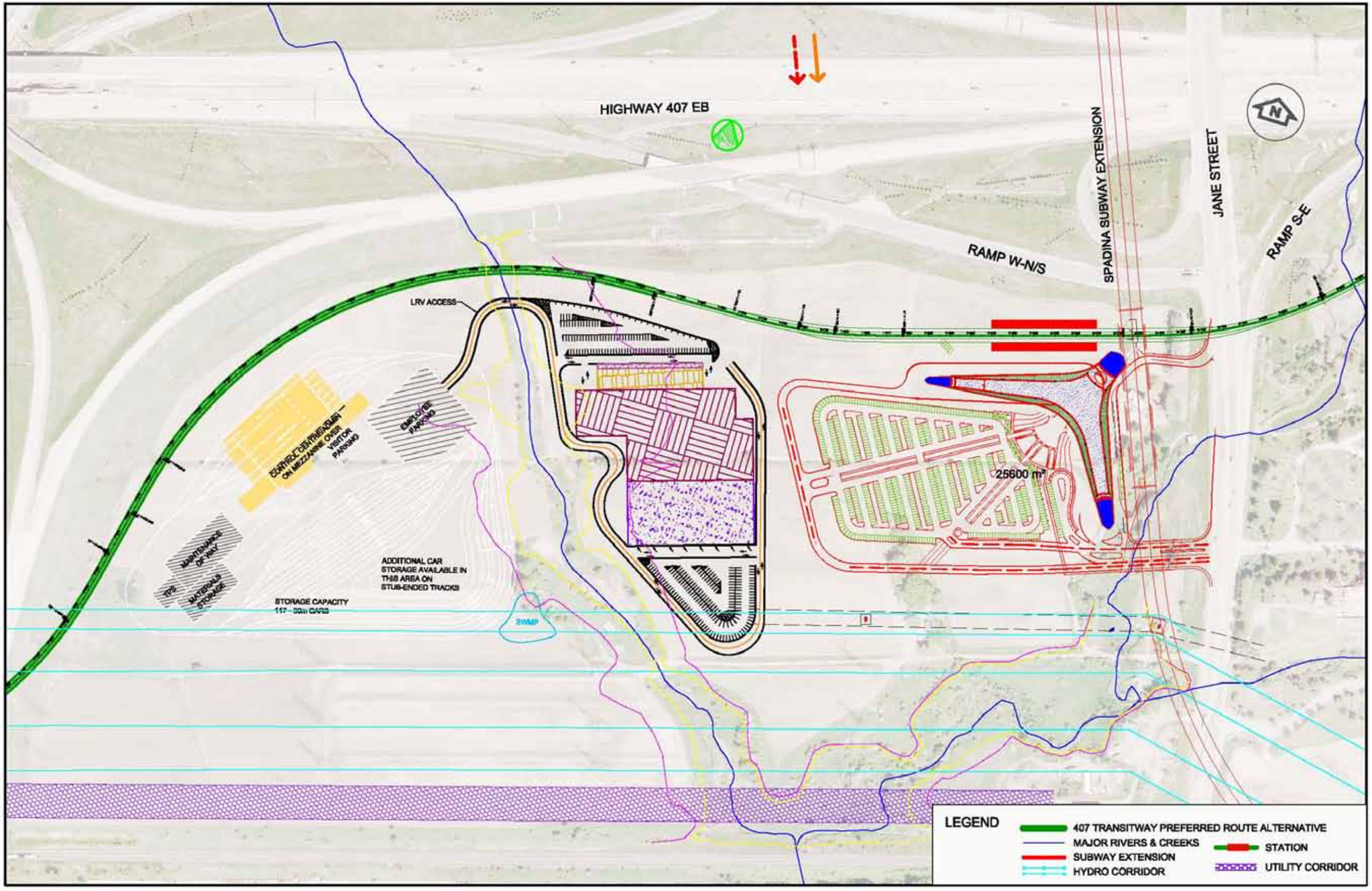
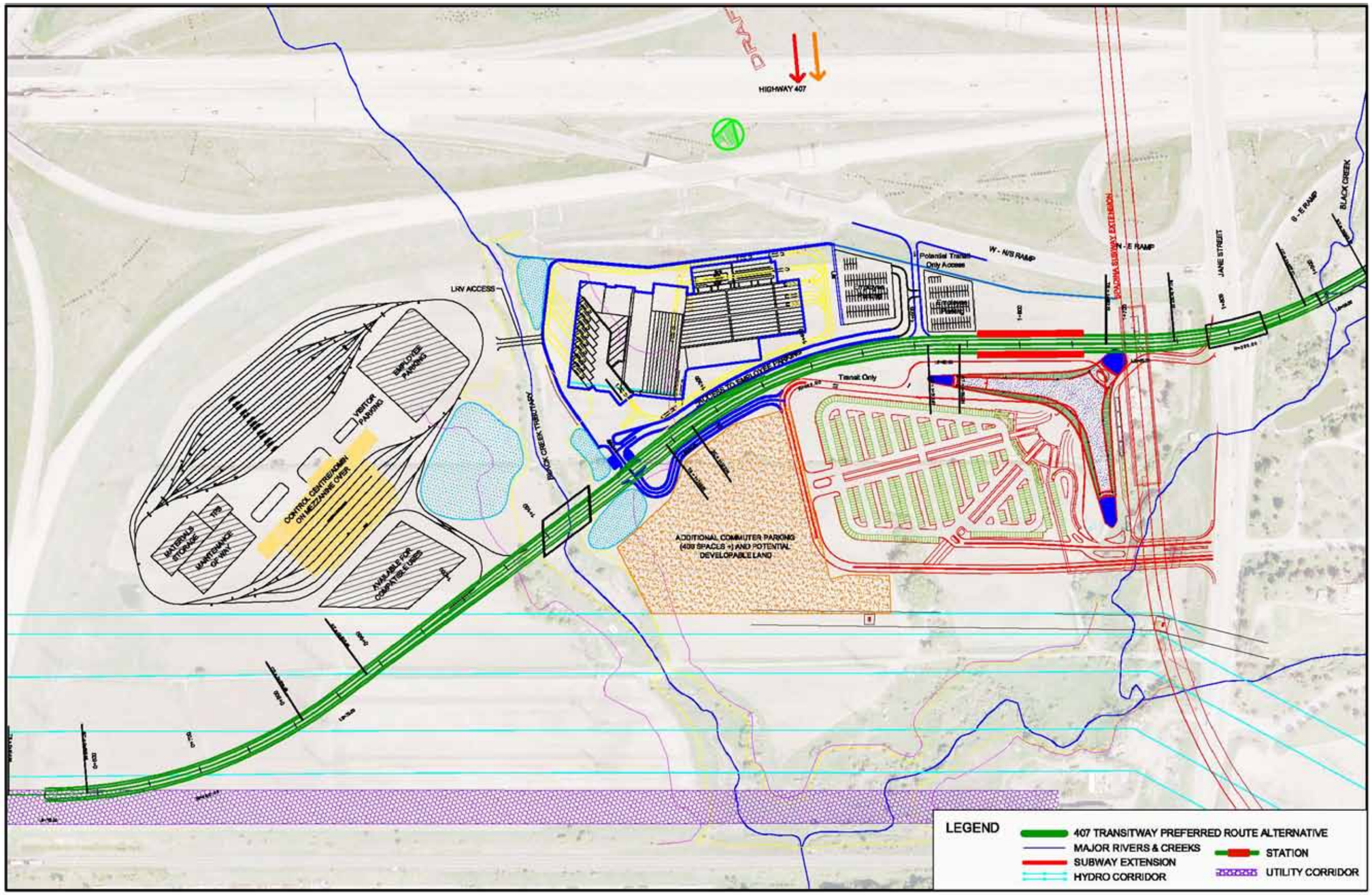



Figure 5-26(b): Conceptual Layout of Typical Maintenance and Storage Complex Alternative B