RAPID TRANSIT FEASIBILITY STUDY

- Assessment of Rapid Transit Technologies
- Description of Representative Alignments
  - Estimated Capital Costs
- Transit Supportive Development Policies
  - Ontario Environmental Act

May 23, 2008
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1.0 INTRODUCTION

The objective of the assignment is to quantify the implications of introducing exclusive transit operation within the corridors established in the *Transportation Master Plan (TMP)* with a focus on the two corridors identified in the *Move Ontario 2020* submission for the City of Hamilton. The analysis will identify the physical implications together with the costs and construction impacts of implementation.

**Consultant’s Scope of Work**

The suggested scope of work for this assignment has been divided into 7 major work packages as follows:

- prepare a corridor constraints and opportunities analysis.
- prepare a forecast of the transit passenger demand applying the TMP modal share targets. Transit trip tables will be developed for the selected time horizons of 2001 and 2031. The model will provide the basis to assess the performance of the alternative rapid transit operating strategies and staging options.
- undertake a review of rapid transit technologies including system characteristics, vehicle technology and costs both capital and operating;
- prepare functional plans for each of the corridor options to provide a basis for identifying the implications of implementation in terms of property requirements, parking supply, traffic operations, support facilities (stations and vehicle servicing), pedestrian movements, staging and costs;
- outline an appropriate mix of transit supportive development policies to enhance the investment in rapid transit facilities; and
- develop a recommended approach to meeting the requirements of the EAA and public consultation.

This Interim Report outlines the basis for the geometric and performance characteristics of Light Rail Transit (LRT) and Bus Rapid Transit (BRT) to be applied in the development of alternative alignments within the selected east-west and north-south rapid transit (RT) corridors for each technology type. A description of the various LRT and BRT systems, vehicle types, representative cross sections and station arrangements is provided.

Based on the constraints and opportunities analysis, the representative RT systems within each of the corridors are outlined highlighting the more significant considerations. Preliminary unit capital costs are applied to provide a preliminary “order-of-magnitude” cost for the alternatives.
2.0 SELECTION OF REPRESENTATIVE RT TECHNOLOGIES

2.1 LRT

What Is Light Rail Transit?

Light Rail Transit (LRT) is a system of passenger transit that typically operates in urban settings. LRT usually runs at street-level in mixed vehicular and pedestrian traffic. Although grade separations are possible, it is assumed that the Hamilton system will be at-grade. LRT is typically propelled by overhead electrical wires although there are some systems that use diesel or electricity from a third rail as a power source. Some familiar terms that are commonly used to describe LRT are streetcar, tramway, and trolley.

LRT systems consist of relatively lightweight, steel-wheeled Light Rail Vehicles (LRVs) that run on steel rails. Train consists can be made up of single LRVs, or multiple LRVs coupled into short trains. The length of a train is affected by alignment constraints, street block lengths, and passenger demand.

There are several right-of-way (ROW) possibilities for LRT systems:

- An exclusive ROW is isolated from other traffic by either a grade separation or an at-grade exclusive lane separate from vehicular traffic with signalized crossings giving priority to public transit.
- A shared ROW separates LRT from other traffic with street-level transit lanes (such as on a median) that are designated solely for LRT use by a curb-type barrier or paint. Crossings may be handled with priority transit signals, or regular traffic signals.
- A common ROW allows LRT systems to operate in mixed vehicular and pedestrian traffic, and they are subject to street-level speeds and congestion. Crossings are usually handled by regular traffic signals.

The use of steel rails in LRT systems frees the driver from having to steer through traffic. LRVs are usually boarded at street-level with the aid of steps, ramps, or raised platforms depending on the floor height of the vehicle.

Types of LRT Systems

The most common type of Light Rail Transit is the Electric LRT which runs primarily on street-level tracks in shared ROW. The vehicles draw electric power from an overhead contact system called a catenary. Historic streetcars operate using this trolley technology, which has been modernized over the years.

Electric LRV are designed to function in urban environments, and are capable of providing suburban service on shared, exclusive, or semi-exclusive ROW. Most are articulated which allows them to turn tight corners on city streets. The lightweight vehicles allow the trains to climb steeper grades than systems...
designed to be shared with traditional heavy rail traffic. Most are double-ended with doors on both sides which provide quicker boarding and exiting times, and negates the need for a loop at the end of a line. The current trend in modern electric LRVs is to provide low floors (typically 350-400 mm) for easier access and less obtrusive platforms.

**Examples of Recent LRT Systems**

This section is intended to provide only a few examples of where Light Rail systems have been implemented in recent years.

**Houston, Texas**

The Houston Metropolitan Transit Authority opened Houston’s first light rail line in January 2004. This “starter” line runs 12.1 km from the University of Houston downtown campus linking downtown, midtown, the Museum District and the sprawling mile long complex of the Texas Medical Centre. The service is operated 19 hours a day using 18 Siemens S70 LRVs. The vehicle has a 70% low floor configuration. Trains currently operate on 6-minute headways from 4:30 a.m. to 7:30 p.m. Normal service is with single-car trains, but light rail vehicles can be coupled in 2-car sets.

**Minneapolis, MN**

This 19-km Light Rail System, which opened in 2004, connects downtown Minneapolis to the Minneapolis/St. Paul Airport and the Mall of America in Bloomington. It runs on an exclusive ROW with two tunnels and two bridges. The system includes 17 stations and two park-and-ride lots. The projected 2005 ridership was 19,300 weekday passengers rising to 24,600 passengers per weekday by 2020. Twenty-four LRVs costing $3 million each are used in the system. The total cost for this project was $715.3 million.
Tacoma, WA

Sound Transit opened the 2.6 km Tacoma Link Light Rail in August, 2003. This is a single-track service running on a shared ROW in mixed traffic with transit priority signals. It takes only eight minutes to ride the length of the corridor from the Theatre District to the Tacoma Dome Station. There are five stations along the corridor and one park-and-ride lot. Three low-floor Model 10-T LRV’s were ordered from Skoda in the Czech Republic for a total cost of $9 million including spare parts, taxes, and shipping.

Charlotte, NC

North Carolina’s first Light Rail, the South Corridor Light Rail Project in Charlotte, began service in the fall of 2006. Groundbreaking for construction took place in September 2004. The project is approximately 16 km in length from uptown Charlotte to Interstate 485. It runs on an exclusive ROW on the Norfolk Southern ROW with the northernmost 3 km on shared tracks with the Charlotte Trolley. The system will include 15 stations, with park-and-ride lots at seven of them.

Projected ridership is 17,000 passengers per day. Capital costs for the project are estimated at US$398.7 million. This includes US$52.5 million for 16 low-floor Siemens S70 LRV’s (including spare parts and system support). There is an option for ordering an additional 25 vehicles in the future. Houston and San Diego have also recently purchased Siemens S70 vehicles for their Light Rail Systems.
San Jose, CA

The Santa Clara Valley Transportation Authority (VTA) has three light rail projects underway. Kinkisharyo Inc. supplied 70 new low-floor LRVs to serve the entire VTA Light Rail system. Delivery was complete in early 2004 for a total cost of $200 million.

The Tasman East Light Rail and the Capitol Light Rail projects are extensions of the existing VTA Light Rail into Milpitas and Eastern San Jose. They will connect with bus service and the future San Francisco Bay Area Rapid Transit (BART) extension. The extension is 13 km in length. The system will include 11 new stations. The first 3 km of the Tasman East corridor was completed in May of 2001. The second 4.5 km phase of Tasman East includes a 7,200 ft elevated bridge and was completed in the summer of 2004. The Tasman portion of the project is expected to cost $275.1 million ($US).

The Capitol Light Rail portion of the project is a 5.3 km extension of the Tasman line that runs along the median of Capitol Avenue in a shared ROW. Construction was completed in the summer of 2004. The project cost for the Capitol extension is $159.8 million ($US).

The third extension to the existing VTA Light Rail system is the Vasona Light Rail Extension. This is a 10.9 km extension between Woz Way in downtown San Jose to Los Gatos. The line operates mainly on the Union Pacific Railroad right-of-way (exclusive), with a portion in a tunnel alignment. Phase 1 construction began in March 2001 and the entire system was operational by January 2006 with 11 new stations. The capital cost for the Vasona project is $375.8 million ($US).

Midland Metro (Birmingham), Alabama

The Midland Metro route is 21 km long, with 2 km of street running track and a shared alignment for the rest of the length. The system is fully electrified with 750 volt DC power supplied through overhead cables along the entire length of the route. There are 23 stations along the route. Each of the 16 LRVs has seats and can carry up to 208 passengers (56 seated, 152 standing).
Nottingham Express Transit (NET), England

NET Line 1 began operation in March of 2004 with a 14 km line running north from the city centre. The line includes 23 stations that are designed to accommodate the development of bus and minibus feeder services. Ridership for Line 1 is forecast at 11 million per year. Trams are electrically powered via a conventional 750-volt overhead contact system. There are 15 Bombardier Incentro trams (also used in Nantes, France) that are 32 m long and can operate at up to 80 km per hour. Two extensions to the NET are already in development, one of 7.6 km to the south and another of 9.8 km to the west.

Manchester Metrolink, England

The Metrolink network covers 38 km around Greater Manchester from the north, through the city centre to the south and the west. It has a fleet of 32 LRVs and serves 36 station stops, including 18 former British Rail stations, 15 new open plan stops and three shared mainline stations. The use of the former British Rail stations and the shared mainline stations requires that the trams use high platforms, with the floors 915 mm above ground.
Barcelona, Spain

In 2004 Barcelona opened two technically similar, LRT tramway systems mostly utilizing existing major arterial road right-of-way. With a total line mileage of 29.3 km, Barcelona’s two LRT startup projects cost a combined total of Eur 451 – amounting to approximately $19 million/km.

Trambaix – Opened on 3 April 2004. This system is located in the southwestern part of Barcelona, linking the university area with the Baix Llobregat suburbs on the southern edge of the city. Total line length is 15.8 km (9.8 mi), with 28 station-stops. Capital cost was Eur 246M, or about US$320 million. With 3 route permutations, this system is expected to carry about 7.6 million rider-trips annually (24,500 trips per day). Schedule speeds for the three route services average about 19 kph.

Trambesos – Opened on 8 May 2004, this system is located in the northeastern part of Barcelona, in the Badalona and Sant Adria de Besos districts of the urban area, serving the environs near the 1992 Olympic Village. Total line length is 13.5 km, with 27 station-stops. Capital cost was Eur 205M, or about US$266 million. There are two route permutations on this line, with schedule speeds averaging about 20-21 kph.

Nantes, France

In 2000, Nantes opened the extensions to two LRT lines (10 km at a cost of $325M). Nantes, which has the longest light rail network in France, has a fleet of pre-Citadis Alstom vehicles, but in April 2006 purchased 23 of the Adtranz modular LRVs under the name Incentro. These five-section articulated vehicles are 36.4 m long and 2.4 m wide and run on three bogies. At 33 tonnes, it lays claim to being the lightest LRV in the world for its length. The vehicles, type AT6/5L, can carry 259 passengers, 76 of them seated.

In order to achieve the lowest possible floor level, electrical equipment was switched to the roof area. Narrower seats and the removal of interior steps have created more circulation and boarding room in order to reduce station dwell time.
Strasbourg, France

The first section of line opened in November 1994, and has since grown to 47 stations along a 25 km network. Various versions of the Eurotram LRV are used throughout the system. Some of the fleet (36 units) is 33 m long with a capacity of 285 passengers of which 66 are seated, while the remaining 17 units are 43 m long with a capacity of 370 passengers, of which 92 are seated. All of the vehicles include the latest automated train protection equipment, and the driver has full control of all equipment from the cab. A fully automated interlocking signaling system allows for the operation of short headways, especially on the slower-speed sections through the city centre.

Light Rail Vehicle Characteristics

Most vehicle manufacturers offer a base model of each of their vehicles with basic specifications to give an example of what can be produced. In reality, their vehicles are rarely manufactured as stated in the specifications. Each transit authority has different needs and constraints, and most manufacturers will tailor their vehicles to suit the demands of a particular system. Dimensions, power, and seating configuration are examples of things that can be modified if needed to meet various design parameters.

A description follows of the various physical and performance characteristics that should be considered when selecting the appropriate vehicle for a system. Each attribute is an important component of the vehicle’s overall suitability for a system.

Power Supply

Light Rail Vehicles can be propelled by an overhead electrical catenary wire or a diesel engine. The advantage of an overhead contact system is that it causes less air pollution, is quieter, and there is less bulky propulsion equipment to fit within the car body allowing more flexibility for low floors and articulation. The advantage of a diesel-powered vehicle is that there is no need to construct an expensive and obtrusive overhead wiring system. Without the overhead wires, the vehicles can transfer to commuter or freight rail lines.
**Speed and Acceleration**

The speed at which an LRV can travel is a function of its power, the type of ROW, and the spacing between stops. A street-level system in mixed traffic will have varying speeds depending on the speed of the other vehicular traffic. A system on an exclusive or separate ROW will be able to travel faster since it will encounter fewer crossings, and have fewer obstacles to slow it down.

Given a typical acceleration, the spacing of station stops dictates the maximum speed that an LRV will obtain, which in turn dictates the maximum speed required when selecting a vehicle. Closely spaced stops in urban settings will require the vehicles to accelerate quickly for efficient service, but the maximum speed reached will be low since it will have to stop again quickly.

**SIEMENS S70 – Houston, TX**

![Image of Siemens S70](image)

**Performance and Technical Data**

- **Catenary Supply Voltage**: 750 Vdc (1500 Vdc optional)
- **Maximum Operational Speed**: 106 km/h
- **Maximum Operational Grade**: 7%
- **Minimum Turning Radius**: 25 m
- **Minimum Vertical Radius**: 250 m crest, 350 m sag
- **Service Acceleration**: 1.34 m/s²
- **Service Deceleration**: 1.34 m/s²
- **Emergency Deceleration**: 2.20 m/s²
- **Visibility**: Good
**Physical Data**

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<th>Category</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
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<td>Up to 4 vehicles</td>
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<tr>
<td>Passenger Capacity</td>
<td>64 seated, 148 standing, 4 wheelchair</td>
</tr>
<tr>
<td>Length Over Coupler Faces</td>
<td>29.37 m</td>
</tr>
<tr>
<td>Width</td>
<td>2.65 m</td>
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<tr>
<td>Height</td>
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<tr>
<td>Floor Height Above Top of Rail</td>
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<tr>
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</tr>
<tr>
<td>Track Gauge</td>
<td>1.435 m</td>
</tr>
<tr>
<td>Empty Weight</td>
<td>44 t</td>
</tr>
</tbody>
</table>

When there are longer runs between stations, the vehicles will have time to achieve higher speeds. Vehicles that require high speeds tend to have lower acceleration rates, and vice versa. The maximum speed and acceleration values are the vehicle's maximum safe operational values. The speed values range from 65 km/h to 105 km/h, and acceleration ranges from 0.8 m/s\(^2\) to 1.41 m/s\(^2\).

**Grade**

LRV operating on city streets must be able to handle the steep grades in an urban landscape. Vehicles with limited grade capabilities restrict the alignments that can be selected.

**Turning Radius**

Further to the grade requirements, LRT in urban settings must be able to navigate around tight corners by having a small turning radius. Most new electric LRT vehicles can navigate at 25 m radius curve turning from one downtown street to another. However, as far as possible, tight corners should be avoided because it can cause noise issues.

**Floor Height**

Floor height is one of the most important considerations when choosing an LRV. In order to provide accessible vehicles for people who are unable to use stairs, modern systems have been designed to match the platform boarding level with the level of the vehicle floor. Most vehicles require some type of platform for accessibility reasons.

When a low-floor vehicle is used, the platform level can be close to curb height, or the car may have a retractable ramp to street level. This is desirable when the public does not want a large platform obstructing views, or when the existing street right-of-way does not allow space for a large platform. Low-floor vehicles have roof-mounted equipment instead of in the undercarriage.
High-floor vehicles must have either a high platform for level boarding, or interior steps to access the seating area. The current trend is to avoid the need for steps in order to increase accessibility. High floors are mostly found in older vehicles such as the Toronto streetcars. Some vehicles have a combined low- and high-floor configuration. A 70% low-floor vehicle means that 70% of the floor area is at the low-floor level, while the remaining floor is raised. Most vehicles have a raised floor over the wheels at both the front and rear of the car. Seating in these high-floor areas is usually accessible by interior steps.

**Dimensions**

The length, width, and height of an LRV must be considered in relation to the available ROW, overhead and side clearances, and different platform options. Vehicles with roof-mounted equipment will be taller. The length of a train consist must fit within the constraints of the LRT network to avoid blocking intersections, exceeding platform lengths, etc.

**Passenger Capacity**

The required passenger capacity of a vehicle depends on the demand along the corridor as well as the projected population growth. Larger LRVs that can hold more passengers are best for main corridors that have the highest demand. In city centres, smaller LRV with less capacity are considered better for aesthetic reasons. Most vehicles can be coupled into short trains to increase capacity should the need arise. Changing the seating configuration of a vehicle can also increase capacity, as fewer seats will allow more standing room and a higher capacity.

**Visibility**

A low cab and good peripheral vision are necessary for LRT operators to see other traffic when operating on a shared ROW. The visibility rankings are subjective and are chosen based on height of cab and peripheral vision. A “good” ranking means the driver seat is low to the ground and has large side windows. A “fair” ranking means only one of these conditions exists, while a “poor” ranking indicates a high driver seat with limited side vision.

**Power Supply**

Electric LRV are powered by an overhead catenary wire that supplies a particular voltage. The typical range is from 600 Vdc to 1500 Vdc, given as either 600, 650, 750, or 1500 Vdc. 750 Vdc is the most common voltage in both North America and Europe, with 1500 Vdc being the least common in North America. However, the higher the voltage, the thinner and less obtrusive the wires, and the fewer sub-stations are required, for which reasons the 1500 V option is becoming more popular.
**Speed and Acceleration**

The range of maximum operational speed for electric LRT vehicles ranges from 65 km/h to 105 km/h. The Siemens S70 in Houston and Charlotte, Siemens SD-160 in Salt Lake City, and Siemens SD-460 in St. Louis are all capable of speeds up to 105 km/h.

Rates of acceleration range from 0.8 m/s$^2$ to 1.41 m/s$^2$. The typical value in North America is 1.34 m/s$^2$, which is found in all of the Kinki Sharyo vehicles and most Siemens vehicles. The LRV with the best acceleration rate is the Ansaldo Breda LRV in San Francisco, although this vehicle’s maximum speed is only 80 km/h.

**Grade**

The maximum grade on which an electric LRV can operate is approximately between 4% and 9%. Vehicles manufactured for North America are typically capable of handling a 6% or 7% grade over short distances. The Ansaldo Breda vehicles in Boston and San Francisco have the highest grade capacity at 9%.

**Turning Radius**

Minimum turning radii typically range from 13 m to 30 m. Articulation helps the vehicles turn around tight corners. North American values are usually 25 m with the Ansaldo Breda vehicles in Boston and San Francisco as low as 13 m and 14 m.

**Floor Height**

Low-floor heights are usually between 0.3 m and 0.4 m, with high floors anywhere between 0.6 m and 1.15 m. The most common low-floor height is 0.35 m (14 inches). As stated earlier, most low-floor vehicles have a high-floor portion at either end, meaning there are numerous floor height combinations.

**Dimensions**

In North America most modern LRVs are 2.65 m wide and 28-32 m long. In Europe LRVs are as long as 42 m and many are 2.4 m, rather than 2.65 m wide. Typical ranges in height are 3.19 m to 3.89 m with minimum clearance standards of 5m.

**Passenger Capacity**

The number of seats in an LRV depends on the size of the vehicle, how the seats are configured, the number of wheelchair spaces, and how much standing room
is to be left available. Smaller vehicles tend to have a lower number of seats, but this can be changed by adjusting some of the above-mentioned factors.

The amount of standing room also varies, and depends on how crush-load is measured and what the safety standards are. Most vehicles can be custom-made to suit the capacity needs of a system, as long as they are within their dimension limits. The seating capacity for LRTs ranges from 30 to 96 seats. Most North American vehicles are in the range of 55 to 75 seated passengers per vehicle, with the CAF Sacramento LRV having the highest number at 88. LRTs can hold a total of up to 300 passengers, with typical North American capacities between 150 and 200.

**Visibility**

LRVs tend to have good visibility since they are designed to operate at street-level in mixed traffic. The driver must be able to see other vehicles and pedestrians. Accordingly, the operator’s seat is low to the ground and has side windows for peripheral vision. The Siemens S70 is an example of an LRV with excellent visibility.

### 2.2 Bus Rapid Transit (BRT)

Some of the material in this section is drawn from the report “Bus Rapid Transit – A Canadian Industry Perspective”, published by the Canadian Urban Transit Association in February 2004.

**What is Bus Rapid Transit?**

A unique, overall definition of BRT that encompasses all of the necessary elements, and is fully applicable in the Canadian context is:

- **Bus Rapid Transit** is a rubber-tired rapid transit service that combines stations, vehicles, running ways, a flexible operating plan, and technology into a high quality, customer focused service that is frequent, fast, reliable, comfortable and cost efficient.

The key characteristics that are different from LRT systems are running ways and operating plans. These are described below.
**Guideways**

Guideways is the general term used to describe the travel lanes that BRT services operate on. There are three general types of BRT running ways, each of which has various configurations:

**Exclusive Busways:** This category describes limited access running ways that are generally not used by any other traffic or mode of transportation. The busways will typically be located in separate rights-of-way such as railway corridors (existing or abandoned), utility corridors (such as hydro corridors), and in the medians or boulevards of existing roadways. Types of facilities in this category can include grade-separated busways (intersections with general traffic streets are avoided by using bridges over or under the crossing street), and at-grade busways that cross streets at signalized intersections.

Some transit malls in urban or suburban business districts could be considered as at-grade busways. Some or all traffic signals may provide priority to BRT vehicles in order to minimize delay at cross streets.

**Dedicated Lanes.** These are exclusive transit or high occupancy vehicle (HOV) lanes that are located on existing roadways, but are separated from the regular road lanes in some way. Use of the dedicated lanes is restricted to buses and BRT vehicles in the case of transit lanes, and to buses, BRT vehicles, vanpools and carpools in the case of HOV lanes. Traffic signal priority for BRT vehicles and other buses can be used to maintain schedules and service intervals.

**Mixed Traffic.** It is possible for BRT services to operate in mixed traffic in cases where dedicated facilities are not required to guarantee reliable operation. Any occasional delay points for the BRT services can be addressed through site specific transit priority measures such as queue jump lanes and/or some form of traffic signal priority.
It is possible for BRT services to combine use of different types of running ways. For example, a service may operate on a bus lane in a suburban area before joining an exclusive busway to travel further into town. The busway may lead to a lightly used roadway where the BRT service continues without delay in mixed traffic before rejoining an exclusive busway to complete the journey to the central area.

**Operating Plan**

An operating plan for a BRT facility can take advantage of a variety of service alternatives:

*All Stops Route(s)* – Like Ottawa’s route 95, this route operates just like a rail service, running over the full length of a Busway and stopping at each station where it services passengers arriving and departing the station. The route may be extended beyond the Busway in order to serve key travel demand generators. The all stops route service frequency will be high during most time periods (at least every 5 minutes during peak periods and 10 minutes during the midday). This type of route typically requires even higher frequency service along busier sections close to the city centre, and the use of high capacity vehicles such as articulated buses.
Peak Direction Express/Limited Stop Service – A key busway feature is the ability to offer a high frequency no-transfer service to a high proportion of trips. This is achieved through the operation of a network of one-way, high frequency express/limited stop services. In the morning peak period, for example, buses pick up passengers in residential areas away from the busway, travel on the local street system to the busway, and then operate on the busway in an express or limited-stop mode, depending upon the demand levels and trip patterns. The intermediate busway stations allow customers to directly access developments next to the stations and to transfer to the all stops and counter peak direction express/limited stop services for travel to other locations in the corridor. In the afternoon peak period, the one-way service is provided in reverse.

Counter Peak Direction Express/Limited Stop Service – The all stops service serves corridor destinations, but to reduce the need to transfer to major destinations away from a busway, a network of counter peak direction express/limited stop routes can be operated. These routes operate during the peak period, typically starting a busway station close to the city centre in the morning, travel along the busway, then operate on the local street system in order to access a commercial area, business park, hospital, educational centre, or a series of the facilities located near each other. Because these routes operate in the counter peak direction, they can be provided at a low marginal cost by using bus trips that would otherwise be the dead head (out of service) links for the one-way peak direction express services.

Local Arterial/Feeder Services – Arterial bus services will always be operated in conjunction with BRT services. To take maximum advantage of BRT, their routes may need to be modified to reflect the presence of a facility. These modifications could include:
• Route diversions to ensure that each route intersects the busway in at least one location where passengers can transfer conveniently at a station;

• The elimination of the route sections where arterial bus service can be replaced by walk-in access to the busway;

• Route diversions where the arterial route may actually use a section of busway; and,

• Timing changes to provide a ‘pulse’ operation at major transfer locations (particularly late at night when service frequencies may be low).

**Examples of BRT Systems**

**Ottawa, ON**

The Transitway opened in 1983 and consists of a 60-km system that includes 26 km of bus-only roadway, with most of the remaining distance on reserved freeway or arterial lanes. The system feeds into downtown Ottawa and transitions to surface street operations in the downtown in transit only bus lanes. The “outside-in” approach to building the Transitway has meant that in the central city, operations are still accommodated on city streets, which, because of exclusive bus lanes, provide capacities of 10,000 passengers and approximately 200 buses per hour in each direction.

**Boston, MA**

The Silver Line connects downtown Boston to Logan Airport with dedicated bus lanes and bus only underground tunnels. Upon completion in 2010, the facility is expected to carry 60,000 passengers a day. The Silver Line service is being introduced in stages as construction on its three major sections is completed.
The section of the Silver Line route between Dudley Square and Downtown became operational 2002. The leg between South Station and Logan Airport via the South Boston Waterfront began service in Spring 2004. The final section -- linking Downtown and South Station -- is slated for completion by 2010.

Service is provided by 60-foot Neoplan low floor, climate-controlled, dual-mode buses. Each Silver Line station will have real-time passenger information and will be designed with rider comfort, convenience and safety in mind.

*Boston Silver Line - System Map*

*Brisbane, Australia*

The South East Busway in Brisbane, opened in 2000 – 2001, is one of the most technologically advanced Bus Rapid Transit systems in the world. It represents the “state-of-the-art” in Busway design, infrastructure and operations management. The South East Busway and various other Brisbane busway initiatives are modeled on the Ottawa Transitway system. The facility places significant emphasis on passenger amenities both in the stations, on the vehicle and in the level of information services. The operation uses modern low floor, air-conditioned conventional bus transit vehicles operating at high frequency within a completely separate right-of-way.
**Brisbane South East Busway**

![](image)

**BRT Vehicles**

Conventional transit vehicles are used, and will continue to be used on BRT systems throughout the world. However, a new breed of transit vehicle is emerging that combines vehicle characteristics that respond to the specific demands of the BRT service concept. The vehicle dimensions, material and performance specifications and geometric operating criteria are generally similar to conventional bus technology and governed by federal and provincial vehicle safety standards, applicable design codes, public vehicle and highway traffic act regulations. However, there is a perception that the BRT vehicles must incorporate advanced aesthetics and styling to clearly distinguish the system from the conventional bus system and to provide greater emphasis on passenger comfort. This direction is evident in the vehicle concepts being put forward by the various manufacturers. The vehicle designs feature distinctive styling with sleek exteriors, wrap treatments to cover the structural body components, and large windows. The vehicles combine performance and operational efficiency with a greater emphasis on passenger comfort. BRT vehicles combine many of the desirable features of light rail technology with a generally lower overall cost and greater flexibility in operations compared with that offered by rubber-tired vehicles.

Features of BRT focused vehicles include the following:

*Low floors*: Contribute to fast and convenient boarding by eliminating steps, providing greater accessibility for people with disabilities, and when combined with raised platforms, can provide for level boarding. Low floor vehicles can be more difficult to navigate in the vicinity of platforms and guidance systems can be used for precision docking.
Multiple Wide Doors: Allow for fast boarding of vehicles and can significantly reduce dwell time. Increasing the number of doors from two to three can potentially increase the passenger handling capability at stops by 50 percent and can improve distribution of passengers within the vehicle. Multiple door configurations are best used in conjunction with automated or off-vehicle fare collection or pay-on-exit type fare schemes. Two-sided BRT vehicle designs can support loading on both sides and provide greater flexibility in terms of stop arrangements.

Internal Circulation: BRT vehicles are characterized by wide aisles and efficient interior design that allow greater passenger comfort through reduced crowding, facilitate fast boardings and alighting, and allow for optimized vehicle loads by improving the distribution of passengers in the vehicle.

Reduced Environmental Impact: Alternative fuels and reductions in noise and air pollution contribute to a progressive image of the service, and hence passenger comfort. Newer propulsion system options include compressed natural gas (CNG), hybrid electric-diesel buses, and next generation diesel.

Distinctive Vehicle Design combined with branding and unique vehicle livery serve as a significant marketing element and can be a visual reminder to the public that the quality of service is beyond regular bus service. In addition to incorporating vehicle features from light rail vehicles, such as multiple door configurations, design cues are also taken from light rail vehicles to visually communicate the higher quality of service that these vehicles are typically associated with.

Bus manufacturers offering low-floor bus designs for the North American market include Gillig, Neoplan USA, New Flyer Industries, North American Bus Industries, Nova Bus, and Orion Bus Industries. Of the three Canadian vehicle manufacturers, New Flyer is the first to offer a vehicle that incorporates BRT vehicle design characteristics. Nova Bus and Orion are evaluating market interest and contemplating BRT type vehicle design features.
3.0 REPRESENTATIVE RT SYSTEM DEVELOPMENT

The assessment of RT technology is a function of the corridor characteristics, the ridership, costs and the local community preferences and perceptions. In order to provide a balanced comparison, LRT and BRT systems were developed to serve the east-west and north-south corridors.

The ridership estimates focus on the AM peak hour operating conditions, a period which reflects maximum fleet requirements, based on both current and future ridership peaking characteristics. The results of the ridership projections provide a basis for fleet requirements for each system alternative.

The corridors include:

- King Street / Main Street / Queenston Road between Eastgate Square and McMaster University; and
- James Street South / West 5th Street / Fennell Avenue / Upper James Street between the Waterfront and Hamilton International Airport with connections to Lime Ridge Mall.

In the course of developing the concepts, the implications of the constraints and opportunities review have come sharply into focus. Some of these implications are set out below and others are explored more thoroughly in subsequent route reviews by section.

1. Notwithstanding the enhanced transit concepts set out in the TMP, the Roads Network analysis did not assume any reduction in available lanes for the purposes of reserved lanes for transit. Accordingly, the suggestion that excess capacity exists in the arterial road network with RT in place is unlikely.
2. If “higher order” transit is to be implemented in the lower city east-west corridor, conversions of sections of King or Main from one-way to two-way do not appear to be feasible.
3. If enhanced transit is implemented on any of the roadway sections under consideration, separate bicycle lanes will be precluded because of safety and space considerations.
4. Existing legacy lane widths on major roads in the lower city are often narrow and, in some cases, are less than 3m. These widths affect operations, reduce capacity, and result in lower usage in curb lanes. Standard lane widths of approximately 3.5m would result in improved lane distribution and reduced friction between lanes.
5. Terminals or off-road platforms and shelters would be required at Eastgate Square (potential enhancement or expansion), in the Downtown (likely an enhanced and expanded MacNab Street Terminal), at the McMaster University entrance on Main Street West (with pedestrian and potentially transit vehicle grade separation from regular traffic), at the University Plaza, at Mohawk College or the Hamilton Health Sciences site at West 5th/ Fennell Avenue, at Lime Ridge Mall (potential enhancement or expansion), and Hamilton Airport. Consideration should be given to providing park and ride facilities at the outlying commercial and institutional activity centres.
6. There is insufficient clearance at two overhead structures for the minimum desirable 4.8m vertical clearance required for LRVs and their pantographs or the absolute minimum vertical clearance required of 4.6m between the top of rail and an overhead structure (4.2m for clearance to contact wire plus 0.4m minimum support structure for contact wire). The TH&B bridge on James Street South has a vertical clearance of 3.9m, and the pedestrian bridge over King Street West at Summers Lane has a vertical clearance of 4.2m. To overcome these constraints would require either reconstruction of these structures or the application of “purpose-built” vehicle technology.

7. The introduction of exclusive transit operations could affect the parking and loading operations either through physical restrictions or limitations by time of day.
• The James Mountain Road escarpment crossing, with grades up to 10.7%, will affect the operating speeds of rubber tired BRT vehicles but will not preclude their use, whereas the grades will preclude the use of LRT. Twin 6.5m dia. tunnels at 5% would be required for an LRT escarpment crossing. Conversely, an alternative route/corridor could be considered.

• Because of the legacy 20m road allowances on main roads in the lower city, and development that depends in part on on-street parking and loading activity, flexibility of rapid transit vehicles in getting around obstacles will be both necessary and important. LRVs do not have that flexibility.
• The analysis indicates that reserved transit lanes can be added to some of the identified corridors with moderate impacts on traffic capacity and moderate impacts on abutting development. However, for King and Main Streets between The Delta and Highway 403, implementation of reserved transit will result in a reduction in general purpose lanes (GPL) for several reasons:

- complete elimination of all on-street parking and loading is not reasonable, in that operations of reserved transit curb lanes would likely be affected or blocked quite frequently (as was the experience in Ottawa). So if a parking / loading / turning lane is provided on the right side, with a reserved transit lane in the second lane out, one GPL would be removed;

- in the four-lane sections, although existing lane widths are most often substandard, providing a suitably wide transit lane can be accommodated with minor widenings, while reducing the number of GPL by one; and

- in the five-lane sections, existing lane widths are substandard, and providing a suitably wide transit lane results in a reduction in total lanes by one, and in GPL by two.

8. A review of traffic volumes during peak and off-peak hours was undertaken. Data sources included traffic volumes from the City’s 1999 traffic volume summary, recent intersection counts from 2004 to 2007, and a screenline analysis undertaken in 2003 for the Hamilton Perimeter Road Needs Assessment.

Firstly, because lane widths are substandard, the curb lanes are less well used than interior lanes. This is compounded by the risk of vehicles stopping, parking, and loading even when technically prohibited by the curbside regulations. The evidence of this fact is illustrated by the traffic volumes vs. the number of available lanes in some road sections during the peak and off-peak periods. For example, King Street between Spadina Avenue (east of Sherman) and Victoria Streets has four, three, and two available lanes in the AMPK (7-9 a.m.), PMPK (4-6 p.m.), and off-peak hours respectively. However, the hourly traffic volumes on King Street are approximately 1730, 1700 and 1330 vehicles per hour respectively. Based on the volumes on the two lane section of King Street west of Wellington Street, two lanes can carry approximately 1500 vehicles per hour, or 750 vehicles per lane.

The current curbside regulations along the King/Main Corridor between the Delta and Highway 403 are illustrated in the following exhibit.
Each of the major sections of the corridor was examined to select a representative LRT/BRT configuration essentially within the existing road allowance. The possible joint use of existing rail corridors was rejected based on the experience in Ottawa in the introduction of the O-Train operation (see Appendix A). A range of possible roadway cross sections were developed to fit within the current road allowances along the corridor. These are illustrated in Appendix B. Plans for each segment of the east – west and north – south corridors were prepared to illustrate the assumed configuration of the “higher order” transit system. These plans are provided in Appendix C and are illustrated by photographs.

3.1 East-West Corridor: Eastgate Plaza to McMaster University

For each section the existing situation is described, a concept is proposed and the possible implications are highlighted. The length of each section is given in Appendix E.

Queenston Road / Main Street: Eastgate Square to the Delta

Existing Conditions

- two lanes of reasonable width in each direction, with an additional centre turn lane between Eastgate Square and the Traffic Circle
- parking and loading occurs in curb lane in off-peak periods

Proposed Concept

- operation in mixed traffic
- operational improvements to include reduction or removal of parking and loading (depending on the area), traffic signal priority, queue jump lanes

Implications

- transit will be limited to speed of regular traffic, so travel time benefits relative to the existing operation will not be realized
- impact on abutting land uses will be modest.

King Street: The Delta to Wellington Street/Main Street – Catherine Street to the Delta

Existing Conditions

- four or five physical lanes within a 20m ROW, but lane widths very marginal in many areas, resulting in lower usage of curb lanes and friction between lanes
- parking and loading occurs in curb lanes in off-peak periods, and on one side in some sections in the peak hours
Proposed Concept

- right lane reserved 24/7 for right turns, transit platform areas, loading, and parking, with reinforcement by sidewalk extensions
- second lane reserved for transit vehicles
- third and fourth lanes as general purpose lanes, with loading in the curb lane restricted to overnight periods
- section on King Street between Sherman and Stirton would have narrower lanes and potentially lower speed limit because of restricted road allowance
- spot improvements may be required to provide additional capacity at major intersections

Implications

- lane widths improved to reduce friction
- number of GPL would be reduced from four or five (some marginal) lanes to two lanes, but they would be unencumbered by transit vehicles or parking / loading
- relatively minor widening or narrowing required, so impact on abutting properties would be modest or beneficial
- parking and loading available full time on one side even in peak periods, but businesses on the opposite (left) side may not consider this a sufficient replacement for the loss of parking and loading on their side
- mid-block capacities should be sufficient, despite reduction in lanes
- intersection capacities are likely to be sufficient, but additional analysis may be required
- spot improvements at major intersections, if required to provide additional capacity for turning movements, would impact existing development in virtually every case

King Street – Wellington Street to Bay Street/Main Street – Bay Street to Catherine Street

Existing Conditions

- four or five physical lanes through the Downtown area except for King Street East between Wellington Street and Mary Street, but lane widths are marginal in some areas on Main Street, resulting in lower usage of curb lanes and friction between lanes
- parking and loading occurs in curb lanes in off-peak periods, and on one or both sides in some sections in the peak hours
- King Street East between Wellington Street and Mary Street is two through lanes with full time parking and loading in bays both sides
**Proposed Concept**

- establish reserved transit lane within the existing road platform, with markings to ensure sufficient flexibility for weaving and wayfinding
- consider re-striping and/or reconstruction of Main Street to provide four 3.5m lanes within a 20m ROW.

**Implications**

- effect on King Street from Wellington Street to Mary Street would be very similar to a conversion to two-way traffic, i.e. diversion of one westbound lane would be required

**King Street – Bay Street to Dundurn Street/Main Street – Dundurn Street to Bay Street**

**Existing Conditions**

- four or five physical lanes, but lane widths very marginal in many areas, resulting in lower usage of curb lanes and friction between lanes
- parking and loading occurs in curb lanes in off-peak periods, and on one side in some sections in the peak hours
- King Street operates as three lanes to Queen Street, but additional lanes/capacity need builds through Locke Street to Dundurn Street
- Main Street utilizes four lanes at Dundurn, but demand is variable for three to four lanes closer to the Downtown
- only Aberdeen and York Boulevard offer other east-west alternatives for connections to Hwy 403 or Main Street West

**Proposed Concept**

- between Queen Street and Bay Street - right lane reserved 24/7 for right turns, transit platform areas, loading, and parking, with reinforcement by sidewalk extensions; second lane reserved for transit vehicles; third and four lanes as general purpose lanes, with loading in the curb lane restricted to overnight
- between Dundurn Street and Queen Street, transition to reserved curb lanes near Dundurn Street, with three general purpose lanes.
- spot improvements may be required to provide additional capacity for turns at major intersections
Implications

- lane widths improved to reduce friction
- number of GPL would be reduced from four or five (some marginal) lanes to two or three lanes closer to Dundurn Street
- relatively minor widening or narrowing required and accordingly the impact on abutting properties would be modest or beneficial
- parking and loading available on one side even in peak periods on King Street between Bay and Queen Streets
- mid-block capacities should be sufficient, despite reduction in lanes
- spot improvements at major intersections would impact existing development

Main Street: Paradise Road to McMaster University

Existing Conditions

- three lanes eastbound, two lanes westbound, and centre turn lanes or medians between Paradise Road and Haddon Avenue
- three lanes in each direction plus median and turn lanes between Haddon Avenue and McMaster University
- no parking restrictions with very little stopping observed

Proposed Concept

- median transit lanes with left turn lanes and station platforms at major intersections
- two GPL in each direction between Paradise Road and Haddon Avenue, and three GPL in each direction between Haddon Avenue and McMaster University
- grade-separated station concept at McMaster University entrance to separate some vehicle and pedestrian movements

Implications

- property is restricted between Paradise Road and Haddon Avenue, so the provision of left turn lanes and station platforms will require widening
- centre median adjacent to McMaster would be removed, but there are opportunities for other median treatments

Main Street: McMaster University to University Plaza

Existing Conditions

- three lanes in each direction plus median and turn lanes between the McMaster University entrance and Cootes / Leyland
- two lanes in each direction plus centre turn lane between Cootes / Leyland and Rifle Range Road
• two lanes in each direction plus turn lanes at major streets between Rifle Range Road and Osler Drive
• two lanes in each direction to the University Plaza
• no parking restrictions with very little stopping observed

Proposed Concept

• median transit lanes with left turn lanes and station platforms at major intersections
• three GPL in each direction between McMaster University and Cootes / Leyland
• two GPL in each direction between Cootes / Leyland and the University Plaza
• grade-separated station concept at McMaster University entrance to separate some vehicle and pedestrian movements

Implications

• property is restricted, so the provision of left turn lanes and station platforms will require widening
• centre turn lanes would be removed but there are opportunities for providing U-turns wherever there are left turn opportunities

3.2 North – South Corridor: Waterfront to Hamilton International Airport

James Street North: Waterfront to Main Street

Existing Conditions

• numerous sidewalk extensions implemented as part of the James Street Downtown Action Plan reconstruction projects, resulting in one through lane in each direction for most of the section from Murray Street to the Downtown
• one lane in each direction plus parking and loading on each side between the Waterfront and Murray Street

Proposed Concept

• operation in mixed traffic
• operational improvements to include reduction or removal of parking and loading (depending on the area), traffic signal priority, queue jump lanes

Implications

• transit will be limited to speed of regular traffic, accordingly no improvement in travel time relative to the existing operation
• impact on abutting land uses will be modest
James Street South – Main Street to James Mountain Road

Existing Conditions

- four narrow physical lanes, with two being one general purpose lane in each direction and two for turn lanes and some parking and sidewalk extensions

Proposed Concept

- widen to four lanes with suitable boulevard and sidewalk
- may require narrower section at and approaching the TH&B bridge
- reserved transit lanes either at the curbs or in the centre lanes
- reconstruction of the THB structures could be required in both alternatives but certainly if LRT vehicles with overhead pantographs are chosen for this route

Implications

- removal of on-street parking and loading and replacement off-street or on side streets
- some turn restrictions may be required
- general purpose lanes would be primarily for local access and circulation
- local access and access to the hospital would be maintained, and emergency vehicles could use reserved bus lanes

James Mountain Road

Existing Conditions

- one lane in each direction for all traffic with maximum 10.7% grade

Proposed Concept

- for BRT alternative, limit the mountain access to bus rapid transit vehicles and emergency vehicles, including ambulances
- for LRT, construct 1.5 km tunnel, James Mountain Road would remain available to general traffic

Implications

- for BRT alternative, existing general traffic would be diverted to the Jolley Cut and the Claremont Access. Most buses would be removed from the Jolley Cut and relocated to James Mountain Road
- for LRT alternative, there is limited impact on traffic circulation

West 5th Street – James Mountain Road to Fennell Avenue/Fennell Avenue-West 5th Street to Upper James Street

Existing

- Four lane roadways with turn lanes at major intersections
Proposed Concept

- reserved 3.5m median transit lanes with 0.3m rumble strips adjacent to one general purpose lane on each side, plus turn lanes approaching major intersections
- terminal at Mohawk College
- no station on Fennell Avenue
- station on Upper James near Fennell Avenue

Implications

- ample opportunity for partnerships and redevelopment opportunities with Mohawk College and Hamilton Health Sciences
- assumes that Fennell Avenue could function with one GPL in each direction
- if additional east-west capacity is required on Fennell Avenue, the existing 23m ROW is likely insufficient and property may be required
- As Auchmar is a major constraint, it is likely that additional property would be preferred on the south side

Upper James Street – Fennell to Hamilton International Airport

Existing Conditions

- two lanes in each direction plus medians or centre turn lanes
- generally no parking with limited loading actually occurring, e.g. car dealerships
- Official Plan requirement of 36m ROW, which would be sufficient, but not all property has been acquired, and there are two cemetery/church constraints south of the LINC

Proposed Concept

- median transitway
- near-side stations with left turn lane provided for opposing traffic
- urban cross-section to south of Rymal Road, and rural cross-section south to HI Airport

Implications

- Left turns in and out of abutting commercial developments would be prohibited, but U-turn opportunities would be provided where possible, wherever left turn lanes are provided
- Property required at Stone Church Road to avoid the Barton Stone Church site

Mohawk Road – Upper James Street to Upper Wentworth Street/Upper Wentworth Street – Mohawk Road southerly

Existing Conditions

- two lanes in each direction plus medians or centre turn lanes
• generally no parking with very limited loading actually occurring
• Official Plan requirements of 30m ROW on Mohawk Road and 36m ROW on Upper Wentworth Street, which would be sufficient

Proposed Concept
• median transitway
• near-side stations with left turn lane provided for opposing traffic
• widening would be primarily to the south side on Mohawk Road because of existing offset roadway
• sufficient property is available on Upper Wentworth Street if additional lanes are required.

Implications
• left turns in and out of abutting commercial developments would be prohibited, but U-turn opportunities would be provided where possible

3.3 Description of RT Operating Plan

The forecast 2031 magnitude and distribution of transit trips within the City of Hamilton was based on the transit mode share targets established in the Transportation Master Plan (TMP). The forecast suggests transit trips will increase by approximately 100% between 2006 and 2031 given the assumed significant increase in the level of transit services, the introduction of “higher order” operations within the designated corridors together with the influence of population and employment growth. The largest increases in ridership will be on the east-west corridor through the City Centre. Greater detail regarding the assumptions and results is provided in Appendix D.

In general, it was assumed that the service frequency throughout the system will be increased by 50% which would be expected to increase transit ridership by approximately 25-30% assuming an elasticity of demand with respect to level of service of 0.5-0.6. The impact of the higher-order transit on modal share was applied depending on the origin and destination of trips. For those trips both originating from and destined to places within a short walk of rapid transit, a modal share enhancement of 30% was assumed (based on experience in Brisbane, Australia). For trips destined to locations near the rapid transit service but originating elsewhere, a modal share enhancement of 20% was assumed and for trips from areas close to the rapid transit lines but destined elsewhere, an enhancement of 10% was assumed. These assumptions were made based on experience that having rapid transit nearer the workplace is more important than near the residence.

The rapid transit network was developed based on the two corridors identified in the Move Ontario 2020 submission for the City of Hamilton, which are based on the recommendations for High Order Transit for the HTMP:

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- north-south between the Waterfront and Hamilton International Airport (A-Line); and
- east-west between Eastgate Square and McMaster University (B-Line)

Preliminary analysis indicated that the A-Line shall include a connection to Lime Ridge Mall based on the forecast of passenger demand. Further refinement of the service plan led to the addition of another pattern, from Downtown to Rymal Road to improve the balance between the capacity of the service and the passenger demand. The rapid transit network included in the final model assignment is shown below.
The passenger volumes on the network in the AM peak period (from 7-9 AM), as calculated by the VISUM model, are shown below.

Under the assumption of BRT technology, the projected demand would call for:

- **A-Line** - a headway of 4 minutes (15 articulated bus trips per hour) on the common section from downtown to Mohawk Road with 8 minute service from Mohawk to Rymal Road and 16 minute service between Waterfront and downtown and Rymal Road and the Airport;
- **B-Line** - a headway of 2.5 minutes (a service frequency of 24 articulated buses per hour) from Eastgate to McMaster.
This service would call for the operation of 9 articulated buses on the A-Line and 25 on the B-Line for a total of 34. Assuming a spares ratio of 20%, the fleet requirements to support this service would be 41 articulated buses.

Light Rail Vehicles (LRVs) typically have a design capacity of twice that of articulated buses (145 compared to 70-75). If LRT were to be implemented, the service frequencies would be halved and the number of vehicles required reduced to 18 as follows:

- the B-Line would run every 5 minutes and require 13 LRVs; and
- the A-Line would operate every 10 minutes on the common section from downtown to Mohawk Road, and 30 minutes from the Waterfront to downtown and to the Airport, requiring 5 LRVs.

Light rail services typically have a spares ratio of about 10% and so a fleet of 20 LRVs would be needed to support this service.

In summary, the total vehicle requirements for the A-Line and B-Line would be:

- for BRT 41 articulated buses;
- for LRT 20 LRVs

It should be noted that for comparison purposes, neither of these estimates takes account of the articulated buses already owned by HSR. It was assumed that, were the LRT option to be selected, the articulated buses would be redeployed on other routes and reduce the requirements for general fleet expansion.

The 2031 network analysis also indicated the following:

- The proposed rapid transit service A-Line and B-Line would significantly reduce the travel time on the Lower Hamilton City East-West Corridor and Central Mountain North-South Corridor and expand the 30 minute catchment areas of HSR services.

- The B-Line with faster, more frequent service would attract a large portion of east-west demand along the King Street/ Main Street corridor.

- The A-Line with increased speed would provide a well used link between the Mohawk College area and Downtown Hamilton, as a result of the creation of a transit terminal for Upper Hamilton which the A-Line would connect to Downtown and Lime Ridge Mall.

- The limited demand of the airport would result in a low ridership from Rymal Road to the airport along the A-line airport route.

- The future (2031) conditions network would increase the HSR system operating costs by service in the order of 70% although this estimate is not based on a route by route analysis of service capacity and demand.
4.0 ORDER OF MAGNITUDE CAPITAL COST ESTIMATES

Order of magnitude capital costs of the two representative systems have been developed to illustrate the potential costs. The costs have been based on the estimates prepared for recent RT projects undertaken by the Consultant. Infrastructure capital costs for LRT and BRT systems worldwide range widely depending on the location and nature of the installations. On average LRT installation costs are higher than BRT costs.

For the purposes of the estimate, the BRT estimate was based on the current Yonge Street Surface Transit Improvement project and the York Region VIVA BRT project. The detailed breakdown of the estimated BRT construction costs is given in Appendix E. Unit costs were applied to typical cross-sections assuming that the existing road base could be salvaged, but complete re-paving and roadway widening would be required. No significant excavation was assumed necessary in the corridor given the existing vertical alignment would not have to be changed. This is considered consistent with the situation within the north-south and east-west corridors in Hamilton. The resulting estimate is summarized below. No allowance for property acquisition is included. The estimate has incorporated an allowance to enhance the stop/station areas in the mixed traffic section of Main Street/Queenston Road and James Street North.

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Capital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>east-west BRT</strong></td>
<td>$ 141,570,000</td>
</tr>
<tr>
<td><strong>north-south BRT</strong></td>
<td></td>
</tr>
<tr>
<td>o Limeridge Mall segment</td>
<td>$ 124,100,000</td>
</tr>
<tr>
<td>o Hamilton Airport extension</td>
<td>$ 143,000,000</td>
</tr>
<tr>
<td>o TH&amp;B structure</td>
<td>$ 30,000,000</td>
</tr>
<tr>
<td>o Mohawk Terminal</td>
<td>$ 10,000,000</td>
</tr>
<tr>
<td><strong>maintenance, servicing and storage</strong></td>
<td>$ 5,000,000</td>
</tr>
<tr>
<td><strong>vehicles (articulated buses) 41 @ 900,000</strong></td>
<td>$ 36,900,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$490,570,000</td>
</tr>
</tbody>
</table>

For LRT, cost analysis applied in the recent Ottawa LRT EA Investigation was used as a basis for the estimate. This investigation estimated the average cost for an at-grade LRT to be $25M/km for the median section and $15M/km for the one-way section. In addition, costs for the tunnel section were estimated and an allowance was made for the replacement of the TH&B structure. The results are summarized below. No allowance for property acquisition is included in the estimate.
Corridor                          Capital Cost

- east-west LRT
  - median                          $202,500,000
  - one-way section                $202,500,000

- north-south LRT
  - BayFront - Limeridge Mall      $157,500,000
  - Hamilton Airport               $247,500,000
  - tunnel section                 $175,000,000
  - TH&B structures                $30,000,000
  - Mohawk Terminal                $10,000,000

- maintenance, servicing
  and storage yard                 $75,000,000

- vehicles (LRVs)                 20@ $4,000,000  $80,000,000

  Total                            $1,180,000,000

Based on the above, the preliminary budget allowance for the two options is given below.

- BRT: $490 M
- LRT: $1,180 M

The above costs should be considered “order-of-magnitude” estimates. Once the investigation proceeds to the next stages, refinements in the route and vehicle technology to address the constraints identified in this preliminary feasibility analysis could result in substantial changes in costs.
5.0 TRANSIT SUPPORTIVE DEVELOPMENT POLICIES

The success of a transit system depends not just on the provision of high-quality transit service but on the policies that support it to ensure that appropriate development occurs in areas with good accessibility to transit and to discourage development in areas that cannot be cost-effectively served by transit. Much has been written about how development can be formed and policies applied to support transit. The term that is generally used to describe this is ‘Transit Oriented Design’ (TOD).

Policy areas that support rapid transit ridership fall into four categories:

Land Use

- Locate high-density development hubs at rapid transit stations.
- Encourage mixed use developments at rapid transit stations.
- Locate all new development so that it is within a 400m (a 5-minute) walk of transit.
- Ensure that overall walking distance to transit is minimized by locating denser development closer to transit.
- Ensure that convenient and direct access to transit is provided or maintained; rapid transit stations and where possible transit stops are integrated into the development.
- Ensure that direct pedestrian access is provided to transit stations and stops through the provision of footpaths and sidewalks to minimize walking distance to transit.

System Integration

- Provide adequate Park-and-Ride lots at strategic locations on the periphery of the system.
- Ensure convenient transfer facilities between the rapid transit service, local feeder services and other connecting routes.
- Provide Bike-and Ride facilities at all transit stations.
- Provide access for taxis and passenger drop off areas (Kiss-and Ride) at key transit stations.

Quality of Service

- Expand the rapid transit system into developing areas to serve users with faster service, thereby establishing transit ridership patterns early.
- Secure sustained funding for the ongoing maintenance of the existing system and delivery of additional extensions.
- Give transit priority over general traffic in transit priority corridors.

2 See, for example TCRP Report 102, Transit-Oriented Development in the United States: Experiences, Challenges and Prospects.
- Rapid transit stations and vehicles should provide a high degree of comfort and have an up-market image. Real-time passenger information should be provided, as well as high-quality printed information, maps and directional signage.

**Demand Management**

- Emphasize reduced travel demand instead of increasing road capacity.
- Develop a parking strategy consistent with transit objectives (e.g. maximum, rather than minimum, parking requirements, parking pricing to discourage commuter parking).
- Innovative transit fares (e.g. U-Pass programs), marketing and education.

These policies are interdependent and their synergies achieve the desired change in travel behaviour. The overall success of the policies can be measured in increased ridership on a per capita basis and on the increased share of transit usage relative to auto use.

The possible tools available to municipal planners are Official Plan policies, subdivision and site plan controls, zoning, design guidelines, parking policies and policies governing the use of the road system. These tools can be used in the interests of promoting Transit Oriented Development which supports the transit system and reduces the amount of travel by car. They can be used to provide transit with priority over general traffic on the road network.

Hamilton is designated as an Urban Growth Centre in the Province of Ontario’s “Places to Grow” report. The report outlines a growth management strategy for the Greater Golden Horseshoe designed to accommodate the substantial growth and development envisaged in the area while containing the amount of urban sprawl. This will be implemented through the Official Plans.

In particular, the framework to guide future development calls for:

- the allocation of 40% of future development to 2031 within existing built-up areas;
- achieving densities of residents + jobs of 200 per hectare within urban growth centres;
- restricting commercial development in excess of 20,000\(^3\) square feet to “higher order” transit corridors; and
- complementing investment in enhanced transit through the introduction of Transportation Demand Management policies, including parking price and supply policies, exclusive right-of-way transit operation, transit priority measures and “transit travelling” urban design policies.

\(^3\) While this limit was specified in Ontario’s ‘Places to Grow’ report, there are examples of restrictions on new developments to be located at transit stations elsewhere. In Ottawa, for instance, all new major urban facilities such as hospitals, universities and community colleges, major sports centres as well as major shopping centres and employment centres are restricted to locations on the Transitway.
Hamilton’s own Transportation Master Plan includes ambitious modal share targets, to increase transit use by more than 100% by 2031. It also includes some high-level policies to support this target: in particular the development of transit-supportive densities, allowing for more compact mixed-use development around transit nodes. This will only be achieved in a meaningful way through the implementation and consistent application of specific policies. The following examples illustrate the way in which two cities, Portland and Vancouver, are going about ensuring success.

To be successful, Transit Oriented Design (TOD) needs to become part of a City’s underlying policy framework. In the case of Portland, Oregon, TOD has become one of the primary policy and implementation tools that the state, the region and local governments regularly call on to help maintain a compact urban form, reduce dependence on the automobile and support reinvestment in centres and corridors. Over time, sophisticated developers have learned that sites adjacent to transit are more likely to come with incentives for development than sites that are not.

Examples of these are programs available at the regional level in Portland:

- A TOD Implementation Program uses a combination of local and federal transportation funds to spur the construction of TOD. The level of support from this program for individual incentives has ranged from $50,000 to $2M in recent years.
- Metropolitan Transportation Improvement Program – regionally controlled transportation funds targeted to implement the 2040 Growth Concept. Since 1996 this has provided an average of $46M per year to support TOD.

In addition, there are other proactive approaches available to local governments that can be used to encourage the transit-friendly development in locations served by high-quality transit. These include the purchase of land at key locations and the oversight of its development in partnership with the private sector. This approach is being taken in Vancouver, where TransLink has recently launched a real estate division, modelled on an agency that has reshaped Hong Kong, that could produce up to $1.5 billion in revenue over the next 10 years while increasing transit ridership and managing travel demand.

Under the plan, enabled by recent provincial legislation, TransLink will purchase land along new rapid transit routes and around stations and ramp up the value of the land through denser zoning and partnerships with land developers to create high-density commercial and residential developments. Prior to this year, TransLink was legally empowered only to buy the land necessary for Sky Train operation.
6.0 ONTARIO ENVIRONMENTAL ASSESSMENT ACT

The Municipal Class EA (MCEA) was amended in October 2007 to include municipal transit projects. Should the preferred alternative for the Hamilton RT meet the definition of “Municipal Transit” as provided in Section D.1.2 of the MCEA, then the scope of the preferred undertaking will likely be that of a Schedule C project. If so, it would have to fulfill the requirements of Phases 1 through 4 of the Municipal Class EA process including mandatory minimum consultation requirements in Phases 2, 3 and 4 including the filing of an Environmental Study Report in Phase 4 for a minimum 30 day review period.

It should be noted, however, that on March 28, 2008, the Minister of the Environment introduced a draft regulation under the Ontario EA Act that will exempt public transit projects from the full requirements of the Act, provided specific conditions are met (e.g. requiring that a process prescribed in the regulation be followed). The process is focused so that consultation on the specific project and a MOE decision can be completed in 6 months. A transit project, which meets the definition of “transit project in the draft regulation and which is described in Schedule 1 to the draft regulation, is exempt from Part II of the Ontario EA Act as long as the proponent complies with the transit project assessment process outlined in the regulation. Project 10 under municipal projects includes “Construction of new transit system i.e. involving construction of new infrastructure”. Comments regarding the draft regulation have been requested by May 12, 2008. It is expected that the draft regulation would be approved shortly thereafter.

Therefore, based on the scope of the Hamilton RT, the approved MCEA and the Draft Transit Regulation, it would appear that the process for the Hamilton RT study can either follow the Municipal Class EA process for Schedule C projects or utilize the Transit Regulation once approved.
Appendix A – Shared Use of Rail Lines by LRT and Heavy Rail

Background

There are two railway lines that go through Hamilton that could be considered for Light Rail Transit (LRT):

- the CN line that carried freight traffic and VIA service and that travels on the north side of the city centre, serving the VIA station and Hamilton’s industrial area to the north and east of downtown; and
- the CP line that is used by GO and is CP main freight line to upstate New York.

Regulatory Issues

Both of these lines fall under the Canadian Railway Safety Act, which is administered by Transport Canada. An application to run in either of these corridors would be scrutinized by Transport Canada’s Rail Safety Branch.

Use of Same Tracks

Currently, all joint running of heavy rail and LRT on rails that fall under Transport Canada’s jurisdiction occurs with time separation. For instance, the O-Train in Ottawa, which was implemented in 2001 on a CPR freight track, was allowed to operate on condition that any freight movements in the corridor were restricted to the period between 1 AM and 5 AM (the LRT service operated between 6:30 AM and midnight). There would have been no question of concurrent operations, a fact that was reconfirmed with Transport Canada’s Rail Safety Branch for the preparation of this Memorandum.

In addition, the LRT engineering standards for construction, the vehicles themselves (particularly the crash worthiness), the operator training plan and the operating plan would all be subject to Transport Canada’s approval.

Beyond these considerations, additional conditions would apply if one-person-operation were requested. In the case of the O-Train in Ottawa, a positive train control system was required which had to meet Transport Canada’s requirements. The O-Train in Ottawa was the first one-person-operation passenger railway operating on a federal railway in Canada and it is believed that it is still unique in this respect.

Use of Additional Track(s) in Rail Corridor

If there is sufficient room in the corridor to provide separate tracks for the LRT service, the chances of meeting Transport Canada’s rail safety requirements and being able to provide a frequent, reliable LRT service are much greater.
Physical Issues

Sharing the Same Track

The width of heavy rail vehicles is greater than LRT vehicles which are usually 2.65m and this creates challenges in station areas unless there is sufficient room to allow a passing track through the middle for the heavy rail vehicles. LRT vehicles are generally low-floor (350mm) which is not compatible with GO Transit heavy rail vehicles and so platform height would be an issue. In the case of the O-Train in Ottawa, platform extenders were provided at the locations where the LRT vehicles’ doors would stop to allow for level boarding. These were designed so that they could be raised by maintenance staff at night to permit the passage of freight trains. While this arrangement works, it is not ideal since it leaves gaps between the train and the platform in the areas where there are no doors.

The quality of track required for LRT operation is significantly higher than that required for heavy rail. Continuous welded rail is required for LRT and it must be maintained in very good condition, otherwise it can cause serious damage to the light rail vehicles. If there are any crossings of rail lines (diamonds), serious problems can arise because of the small size of the LRT vehicles wheels which can suffer distortion from the impact. This problem was encountered for the O-Train in Ottawa, where the NRC engineers developed templates which were used to grind the rails at the crossing points to minimize the pressure on the LRT vehicles wheels.

Adding New Track for LRT in Existing Corridor

If the LRT can be provided with its own tracks many of the above issues disappear.

Operating a High Frequency Schedule

Notwithstanding the requirement of Transport Canada for time separation, to run a frequent, reliable LRT service the rail line must be free from other traffic in key time periods. This would certainly mean the peak periods and midday.

Experience Elsewhere

There is experience in Europe of joint use of heavy rail and LRT services. An example is in Saarbrucken which is on the border between France and Germany. This system operates on both French and German railways in mixed rail traffic, as well as on the downtown streets of Saarbrucken. This system calls for use of Automated Train Protection by both the LRT system and the heavy rail using the tracks.

In the United States of America, there is shared use in some locations but always with some degree of time separation between heavy rail and LRT. An example of this is New Jersey Transit.
Future Directions

Trends in Canada are likely to follow those in the USA. There was a full review done by the TRB of ‘Joint Operation of Light Rail Transit or Diesel Multiple Unit Vehicles with Railroads’ (TCRP Report 52, 1999) which was updated in September 2001 as a ‘Research Results Digest’. These reviews looked at global experience of joint operations and proposed a risk assessment methodology for screening proposals for joint running. In this report it is noted that it took Karlsruhe (the most famous example of joint running) twenty-five years to overcome the obstacles to joint use. The way forward in North America is likely to be slow.

Conclusion

The most serious impediment to shared use of heavy rail track by LRT vehicles is Transport Canada’s firm requirement for time separation. Given the current use of the lines in Hamilton by freight and passenger heavy rail services, it does not appear to be feasible to use the lines for a frequent, reliable LRT service. Even with a significant shift in Transport Canada’s position on this issue, to operate a frequent, reliable LRT service, would require the dedicated use of the line at least in peak periods.
Appendix B – Selected Representative Cross Sections

**Typical Cross-Section A**
14.3m Platform
One-Way Traffic

**Typical Cross-Section B**
13.8m Platform
One-Way Traffic

**Typical Cross-Section C**
12.2m Platform
One-Way Traffic
Typical Cross-Section D
16.0m Platform
One-Way Traffic

Typical Cross-Section E
14.6m Platform

Typical Cross-Section F1
14.0m Platform
Appendix C – Higher Order Transit Plans

- In some sections, rapid transit can be provided in dedicated lanes:
  - King Street – The Delta to Catharine Street and Bay Street to Dundurn Street
  - Main Street – Dundurn Street to Bay Street and Catharine Street to the Delta
  - James Street South – Main Street to James Mountain Road
- In other sections, rapid transit can be provided in a median transitway:
  - West 5th Street – James Mountain Road to Fennell Avenue – Fennell Avenue / West 5th Street to Upper James Street
  - Upper James Street from Fennell to Hamilton International Airport
  - Mohawk Road and Upper Wentworth Street between Upper James Street and Lime Ridge Mall
  - Main Street – Paradise Road to McMaster University
  - Main Street – McMaster University to University Plaza
- James Mountain Road can become reserved for transit and emergency services
Appendix D – Demand Forecasts and Representative Operating Plan

Background

The objective of this task was to develop a service plan and determine operating requirements for rapid transit in the two corridors established through the earlier part of the study: the ‘A-Line’ between the Waterfront and the Hamilton International Airport, and the ‘B-Line’ between Eastgate Square and the McMaster University GO Bus Terminal.

The 2006 Transportation Tomorrow Survey (TTS) data was used for this study. It was initially hoped that the EMME/2 trip tables developed for the previous Transportation Master Plan would be available for this work. However, there was insufficient detail available for these trip tables to generate transit trip tables. For this reason, it was decided to move ahead using the TTS data. The TTS data was collected in the fall of 2006 from a sample of 5% of residents of the GTA and Hamilton. The survey collects data on people’s travel patterns for a particular weekday, recording information about the origins, destinations, travel times and modes used.

The analysis was carried out using the VISUM macroscopic demand modelling software. Initially an existing conditions model was validated by comparing the results of an assignment of the 2006 TTS transit trip table to the 2006 transit network, developed as part of the TMP study, with screen-line counts from HSR staff. The model results were also compared with some on-off data that had been collected on route 27, which operates on a similar alignment to the future ‘A-Line’. Having validated the model for 2006:

- transit trip tables were developed for 2031, based on population and employment projections from GRIDS;
- a future transit network was developed for 2031 that included the two rapid transit lines as well as improvements to other services;
- the 2031 transit trip table was assigned to the 2031 transit network; and
- adjustments were made to match the service frequencies (supply) with the passenger volumes at peak load points (demand).

This process, which is described in more detail in this report, enabled estimates to be made of the BRT or LRT vehicles that would be required to operate the A- and B-Lines in 2031.

It should be noted that this work was done in the context of Hamilton’s Transportation Master Plan and so the transit ridership targets, an increase of 100% over 2001 ridership by 2031, are assumed to have been met.
Travel Patterns in 2006

2006 Base A.M. Peak Period Trip Tables

The 2006 a.m. peak period total person trip table was extracted from the 2006 Transportation Tomorrow Survey (TTS) database. It represents all trips made between 7:00 a.m. and 9:00 a.m., the period for which HSR count data was available. The 2006 TTS data indicate that a total of 3,160,200 trips were made in the Greater Golden Horseshoe area between 7:00 a.m. and 9:00 a.m., of which 150,400 trips were made within the City of Hamilton.

A 2006 transit trip table was developed for the same two-hour peak period based on 2006 TTS data. This was adjusted through the validation process using VISUM’s fuzzy logic algorithm so that, when assigned to the HSR transit network, the results were consistent with actual observations\(^4\). The final 2006 a.m. peak period transit trip table contained 10,400 trips within the City of Hamilton. Table D1 provides a summary of the 2006 a.m. peak period total person trip table and Table D2 provides a summary of the 2006 a.m. peak period transit trip table.

Table D1: Summary of the 2006 7:00-9:00 a.m. Total Person Trip Table

<table>
<thead>
<tr>
<th></th>
<th>Flambor.</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>5,294</td>
<td>935</td>
<td>339</td>
<td>34</td>
<td>201</td>
<td>1,595</td>
<td>670</td>
<td>9,068</td>
</tr>
<tr>
<td>Dundas</td>
<td>665</td>
<td>3,265</td>
<td>435</td>
<td>81</td>
<td>68</td>
<td>2,971</td>
<td>724</td>
<td>8,209</td>
</tr>
<tr>
<td>Ancaster</td>
<td>232</td>
<td>312</td>
<td>4,928</td>
<td>86</td>
<td>224</td>
<td>3,066</td>
<td>2,400</td>
<td>11,248</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>16</td>
<td>34</td>
<td>565</td>
<td>701</td>
<td>831</td>
<td>1,386</td>
<td></td>
<td>3,856</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>92</td>
<td>70</td>
<td>270</td>
<td>143</td>
<td>9,488</td>
<td>6,321</td>
<td>1,713</td>
<td>18,097</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>460</td>
<td>484</td>
<td>1,028</td>
<td>262</td>
<td>2,832</td>
<td>40,976</td>
<td>6,059</td>
<td>52,101</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>409</td>
<td>390</td>
<td>1,892</td>
<td>384</td>
<td>1,607</td>
<td>11,926</td>
<td>31,228</td>
<td>47,836</td>
</tr>
<tr>
<td>Total Trips within Hamilton</td>
<td>7,168</td>
<td>5,490</td>
<td>9,215</td>
<td>1,555</td>
<td>15,121</td>
<td>67,686</td>
<td>44,180</td>
<td>150,415</td>
</tr>
</tbody>
</table>

\(^4\) HSR provided observed screenline counts as well as some detailed on-off information for Route 27.
Table D2: Summary of the 2006 7:00-9:00 a.m. Transit Trip Table

<table>
<thead>
<tr>
<th></th>
<th>Flambor.</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dundas</td>
<td>0</td>
<td>14</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>202</td>
<td>76</td>
<td>306</td>
</tr>
<tr>
<td>Ancaster</td>
<td>0</td>
<td>16</td>
<td>60</td>
<td>0</td>
<td>16</td>
<td>115</td>
<td>16</td>
<td>222</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>37</td>
<td>66</td>
<td>103</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>194</td>
<td>62</td>
<td>288</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>0</td>
<td>74</td>
<td>53</td>
<td>21</td>
<td>143</td>
<td>4,870</td>
<td>1,146</td>
<td>6,307</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>0</td>
<td>13</td>
<td>35</td>
<td>0</td>
<td>43</td>
<td>1,139</td>
<td>1,942</td>
<td>3,171</td>
</tr>
<tr>
<td>Total Trips</td>
<td>0</td>
<td>116</td>
<td>176</td>
<td>21</td>
<td>233</td>
<td>6,556</td>
<td>3,309</td>
<td>10,412</td>
</tr>
</tbody>
</table>

The existing transit mode share for the City of Hamilton is approximately 7%. A breakdown of the transit mode share for the various areas of Hamilton is provided in Table D3.

Table D3: Summary of the 2006 7:00-9:00 a.m. Transit Mode Share

<table>
<thead>
<tr>
<th></th>
<th>Flambor.</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Dundas</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>10%</td>
<td>4%</td>
</tr>
<tr>
<td>Ancaster</td>
<td>0%</td>
<td>5%</td>
<td>1%</td>
<td>0%</td>
<td>0%</td>
<td>7%</td>
<td>4%</td>
<td>1%</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>5%</td>
<td>3%</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>0%</td>
<td>15%</td>
<td>5%</td>
<td>8%</td>
<td>5%</td>
<td>12%</td>
<td>19%</td>
<td>12%</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>0%</td>
<td>3%</td>
<td>2%</td>
<td>0%</td>
<td>3%</td>
<td>10%</td>
<td>6%</td>
<td>7%</td>
</tr>
<tr>
<td>Total Trips</td>
<td>0%</td>
<td>2%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
<td>10%</td>
<td>7%</td>
<td>7%</td>
</tr>
</tbody>
</table>

The transit trips shown in Table D2 indicate that the majority of transit trips (87%) are made within the Former Hamilton City, i.e., the Upper Hamilton and Lower Hamilton areas, with the rest of transit trips being distributed among Dundas, Ancaster, Glanbrook and Stoney Creek. It is noted that minimal transit trips are currently made to and from Flamborough and Glanbrook due to the fact that very limited transit service is currently provided to these areas.

The transit mode share summary shown in Table D3 indicates that the former City of Hamilton (Upper and Lower Hamilton) has the highest transit mode share among the City of Hamilton boroughs as HSR provides most of its transit...
service in the urban area of the city. In general, the transit mode share of the trips to and from the Lower Hamilton area is higher than it of the trips to and from the Upper Hamilton area.

Development of 2031 Transit Trip Table

A 2031 a.m. peak period (7:00 a.m. to 9:00 a.m.) total person trip table was developed based on the 2006 total person trip table and forecast population and employment changes in the GTA-Hamilton Area. Land use data for the City of Hamilton was taken from data produced as part of the Hamilton GRIDS Study. For the Greater Toronto Area as well as Niagara Region, land use data was taken from Greater Golden Horseshoe (GGH) Growth Forecasts produced by Hemson Consulting in 2005.

It should be noted that both GRIDS and the GGH Growth Forecasts were generated for years 2001 and 2011. The 2006 base year figures were established by interpolating between 2001 and 2011. A further adjustment was made to the population figures for the City of Hamilton and the population forecast as part of GRIDS was adjusted to match the 2006 Census findings. A summary of the population and employment forecasts used to develop the future 2031 a.m. peak period (7:00 a.m. to 9:00 a.m.) total person trip table is provided in Table D4.
### Table D4: Population and Employment Forecasts for the GTA + Hamilton

<table>
<thead>
<tr>
<th>Area</th>
<th>POPULATION 2006</th>
<th>2031</th>
<th>Growth</th>
<th>EMPLOYMENT 2006</th>
<th>2031</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamilton</td>
<td>504,000</td>
<td>670,000</td>
<td>33%</td>
<td>217,000</td>
<td>309,000</td>
<td>42%</td>
</tr>
<tr>
<td>Flamborough</td>
<td>39,000</td>
<td>54,000</td>
<td>38%</td>
<td>9,000</td>
<td>14,000</td>
<td>56%</td>
</tr>
<tr>
<td>Dundas</td>
<td>25,000</td>
<td>26,000</td>
<td>4%</td>
<td>7,000</td>
<td>8,000</td>
<td>14%</td>
</tr>
<tr>
<td>Ancaster</td>
<td>33,000</td>
<td>41,000</td>
<td>24%</td>
<td>9,000</td>
<td>26,000</td>
<td>189%</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>15,000</td>
<td>63,000</td>
<td>320%</td>
<td>8,000</td>
<td>21,000</td>
<td>163%</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>62,000</td>
<td>102,000</td>
<td>65%</td>
<td>30,000</td>
<td>42,000</td>
<td>40%</td>
</tr>
<tr>
<td>Hamilton</td>
<td>330,000</td>
<td>384,000</td>
<td>16%</td>
<td>154,000</td>
<td>198,000</td>
<td>29%</td>
</tr>
<tr>
<td>Halton</td>
<td>439,000</td>
<td>780,000</td>
<td>78%</td>
<td>235,000</td>
<td>390,000</td>
<td>66%</td>
</tr>
<tr>
<td>Niagara</td>
<td>427,000</td>
<td>511,000</td>
<td>20%</td>
<td>194,000</td>
<td>218,000</td>
<td>12%</td>
</tr>
<tr>
<td>Peel</td>
<td>1,175,000</td>
<td>1,640,00</td>
<td>40%</td>
<td>630,000</td>
<td>870,000</td>
<td>38%</td>
</tr>
<tr>
<td>Toronto</td>
<td>2,675,000</td>
<td>3,080,00</td>
<td>15%</td>
<td>1,490,000</td>
<td>1,640,00</td>
<td>10%</td>
</tr>
<tr>
<td>Durham</td>
<td>595,000</td>
<td>960,000</td>
<td>61%</td>
<td>225,000</td>
<td>350,000</td>
<td>56%</td>
</tr>
<tr>
<td>York</td>
<td>910,000</td>
<td>1,500,00</td>
<td>65%</td>
<td>490,000</td>
<td>780,000</td>
<td>59%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,725,000</td>
<td>9,141,00</td>
<td>36%</td>
<td>3,481,000</td>
<td>4,557,00</td>
<td>31%</td>
</tr>
</tbody>
</table>

The forecast population and employment growth rates for each zone were then applied to the existing zonal trip productions and attractions, respectively, in order to establish the 2031 a.m. peak period trip ends for each zone. In cases where green-field development will occur, the appropriate municipal trip attraction and production rates were applied. Also, if the existing trip production rate or attraction rate was more than twice the municipal average, municipal production and attraction rates were applied to the zonal population and employment growth, respectively. The total forecast 2031 attraction was then adjusted to match the total forecast 2031 production.

Once the forecasts 2031 a.m. peak period (7:00 a.m. to 9:00 a.m.) total person trip productions and attractions were established for each zone, the 2006 a.m.
peak period (7:00 a.m. to 9:00 a.m.) total person trip was fratared, or bi-
proportionally balanced, to the 2031 trip ends. This resulted in the 2031 a.m.
peak period (7:00 a.m. to 9:00 a.m.) total person trip table summarized in Table
D5.
Table D5: Summary of the 2031 7:00-9:00 a.m. Total Person Trip Table

<table>
<thead>
<tr>
<th>Flan.</th>
<th>Dun</th>
<th>Anc</th>
<th>Glan</th>
<th>SC</th>
<th>Lower Ham</th>
<th>Upper Ham</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flam.</td>
<td>7,187</td>
<td>1,106</td>
<td>1,901</td>
<td>37</td>
<td>242</td>
<td>2,577</td>
<td>1,041</td>
</tr>
<tr>
<td>Dundas</td>
<td>571</td>
<td>3,636</td>
<td>625</td>
<td>135</td>
<td>63</td>
<td>3,400</td>
<td>856</td>
</tr>
<tr>
<td>Ancaster</td>
<td>236</td>
<td>336</td>
<td>6,948</td>
<td>123</td>
<td>243</td>
<td>3,960</td>
<td>2,900</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>14</td>
<td>129</td>
<td>472</td>
<td>2,566</td>
<td>3,310</td>
<td>3,734</td>
<td>6,377</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>113</td>
<td>51</td>
<td>491</td>
<td>296</td>
<td>15,44</td>
<td></td>
<td>11,660</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>416</td>
<td>535</td>
<td>1,396</td>
<td>479</td>
<td>5,831</td>
<td>47,364</td>
<td>7,007</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>392</td>
<td>392</td>
<td>2,948</td>
<td>692</td>
<td>3,439</td>
<td>14,899</td>
<td>37,117</td>
</tr>
<tr>
<td>Total Trips within Hamilton</td>
<td>8,930</td>
<td>6,184</td>
<td>14,781</td>
<td>4,328</td>
<td>28,56</td>
<td>87,595</td>
<td>58,111</td>
</tr>
</tbody>
</table>

2031 Transit Trip Table Development

*Transit trip table based on existing levels of transit use*

The first step in this process was to develop a transit trip table based on the existing mode split. This was done based on the 2031 total trip table and using the transit mode shares shown in Table D3, but with adjustments to account for areas of development that currently do not have transit service, or very little.

Zones that are slated for major development in southern Hamilton – including the airport area along Upper James Street to Mount Hope, and south of the Red Hill Valley Parkway in the Elfrida area – were seeded. As these areas will house thousands of new residents and jobs, a general transit mode share was applied from and to these zones.

It was assumed that:

- 2% of trips to growth zones in Glanbrook would be made on transit (consistent with existing TMS to Dundas);
- 5% of trips from growth zones in Glanbrook would be made on transit (consistent with existing TMS from Glanbrook to former City of Hamilton);
- 4% of trips to growth zones in the former City of Hamilton would be made on transit (consistent with trips from outlying areas to the former City of Hamilton); and,
- 4% of trips from growth zones in the former City of Hamilton would be made on transit (consistent with existing TMS to Stoney Creek from Hamilton);
The resulting trend transit mode share peak period transit trip table is summarized below in Table D6. Table D7 provides the percentage of trips on transit between each area within the City of Hamilton.

### Table D6: Summary of the 2031 7:00-9:00 a.m. Trend TMS Transit Trip Table

<table>
<thead>
<tr>
<th>Area</th>
<th>Flamborough</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Dundas</td>
<td>0</td>
<td>12</td>
<td>17</td>
<td>3</td>
<td>0</td>
<td>244</td>
<td>80</td>
<td>355</td>
</tr>
<tr>
<td>Ancaster</td>
<td>0</td>
<td>19</td>
<td>229</td>
<td>1</td>
<td>8</td>
<td>133</td>
<td>20</td>
<td>411</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>1</td>
<td>0</td>
<td>11</td>
<td>91</td>
<td>129</td>
<td>137</td>
<td>265</td>
<td>634</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>62</td>
<td>347</td>
<td>96</td>
<td>510</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>0</td>
<td>69</td>
<td>47</td>
<td>55</td>
<td>139</td>
<td>5,939</td>
<td>1,309</td>
<td>7,558</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>1</td>
<td>19</td>
<td>27</td>
<td>10</td>
<td>63</td>
<td>1,462</td>
<td>2,162</td>
<td>3,744</td>
</tr>
<tr>
<td>Total Trips within Hamilton</td>
<td>1</td>
<td>119</td>
<td>354</td>
<td>164</td>
<td>402</td>
<td>8,262</td>
<td>3,933</td>
<td>13,235</td>
</tr>
</tbody>
</table>

### Table D7: Summary of the 2031 7:00-9:00 a.m. Trend Transit Mode Share

To increase the mode share from its current level, it will be necessary for HSR to provide service that is more attractive to users. It is beyond the scope of the study to develop a long range strategic plan for transit, and so it was assumed that by 2031 the TMP mode share for transit would have increased to close to double its value today.
In consultation with HSR staff, it was assumed that the frequency of most routes would have increased by 50% by 2031 – i.e. a service operating at 4 trips/hour would have increased to 6 trips/hour. This overall improvement of 50% in service, based on normal values of elasticity of demand with respect to service level of 0.6 to 0.7, would be expected to increase demand by 30-35%. It was therefore assumed that there would be a general 30% increase in transit demand by 2031. Further to this, it was also assumed that the introduction of rapid transit would increase demand for those trips benefiting from the new facilities. The attractiveness of the rapid transit services was assumed to increase transit demand as follows:

- trips originating from and destined to points along the rapid transit corridor would increase by an additional 30%;
- trips destined to points along the rapid transit corridors from elsewhere would increase by an additional 20%; and,
- trips originating from points along the rapid transit corridor to elsewhere would increase by an additional 10%.5

These proportions were applied to the trend TMS 2031 a.m. peak transit trip table to arrive at the adjusted TMS a.m. peak transit trip table. This final trip table is summarized in Table D8.

Table D8: Summary of the 2031 7:00-9:00 a.m. Adjusted TMS Transit Trips

<table>
<thead>
<tr>
<th></th>
<th>Flambor.</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>0</td>
<td>0</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>32</td>
</tr>
<tr>
<td>Dundas</td>
<td>0</td>
<td>16</td>
<td>23</td>
<td>4</td>
<td>0</td>
<td>380</td>
<td>122</td>
<td>546</td>
</tr>
<tr>
<td>Ancaster</td>
<td>0</td>
<td>27</td>
<td>315</td>
<td>2</td>
<td>11</td>
<td>210</td>
<td>31</td>
<td>596</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>1</td>
<td>0</td>
<td>16</td>
<td>133</td>
<td>178</td>
<td>215</td>
<td>391</td>
<td>933</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>86</td>
<td>530</td>
<td>141</td>
<td>762</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>0</td>
<td>98</td>
<td>68</td>
<td>92</td>
<td>199</td>
<td>9,599</td>
<td>2,078</td>
<td>12,134</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>1</td>
<td>27</td>
<td>37</td>
<td>17</td>
<td>87</td>
<td>2,351</td>
<td>3,245</td>
<td>5,763</td>
</tr>
<tr>
<td>Total Trips within Hamilton</td>
<td>1</td>
<td>168</td>
<td>490</td>
<td>253</td>
<td>560</td>
<td>13,285</td>
<td>6,007</td>
<td>20,765</td>
</tr>
</tbody>
</table>

The resulting a.m. peak period (7:00 a.m. to 9:00 a.m.) transit trip table is approximately 67% larger than the trend TMS transit trip table for the same period. This would suggest an increase in mode share of approximately 4% (from 6% to 10%). Table D9 provides a summary of the adjusted transit mode share between each area within the City of Hamilton. While this does not fully reflect the ambitious modal share targets of the Hamilton TMP, it was taken as a reasonable starting point for the development of the service requirements for 2031.

---

5 This reflects the experience that it is more tolerance for feeder service or a longer walk at the home end of a commuter trip than at the work end.
Table D9: 2031 7:00-9:00 a.m. Adjusted Transit Mode Share

<table>
<thead>
<tr>
<th></th>
<th>Flamborough</th>
<th>Dundas</th>
<th>Ancaster</th>
<th>Glanbrook</th>
<th>Stoney Creek</th>
<th>Lower Hamilton</th>
<th>Upper Hamilton</th>
<th>Total Trips within Hamilton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flamborough</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Dundas</td>
<td>0%</td>
<td>0%</td>
<td>4%</td>
<td>3%</td>
<td>0%</td>
<td>11%</td>
<td>14%</td>
<td>6%</td>
</tr>
<tr>
<td>Ancaster</td>
<td>0%</td>
<td>8%</td>
<td>5%</td>
<td>2%</td>
<td>5%</td>
<td>5%</td>
<td>1%</td>
<td>4%</td>
</tr>
<tr>
<td>Glanbrook</td>
<td>7%</td>
<td>0%</td>
<td>3%</td>
<td>5%</td>
<td>5%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
</tr>
<tr>
<td>Stoney Creek</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>2%</td>
<td>1%</td>
<td>5%</td>
<td>5%</td>
<td>2%</td>
</tr>
<tr>
<td>Lower Hamilton</td>
<td>0%</td>
<td>18%</td>
<td>5%</td>
<td>19%</td>
<td>3%</td>
<td>20%</td>
<td>30%</td>
<td>19%</td>
</tr>
<tr>
<td>Upper Hamilton</td>
<td>0%</td>
<td>7%</td>
<td>1%</td>
<td>2%</td>
<td>3%</td>
<td>16%</td>
<td>9%</td>
<td>10%</td>
</tr>
<tr>
<td>Total Trips within Hamilton</td>
<td>0%</td>
<td>3%</td>
<td>3%</td>
<td>6%</td>
<td>2%</td>
<td>15%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Development of 2031 Transit Network

The work being done on the feasibility of developing rapid transit in Hamilton provided direction for the service plan. It was assumed that by 2031 rapid transit would be implemented in two corridors: Waterfront to the Airport (A-Line) and Eastgate to McMaster (B-Line). Further, the A-Line would be routed via James Mountain Road and would probably have a staging option from Downtown to Lime Ridge Mall. The B-Line would be routed via Main Street West, west of Paradise Road, and terminate at the existing GO terminal at the University. These routes are shown in Figure 1.

A preliminary 2031 transit route network was developed in discussion with HSR staff. This included the A-Line and B-Line rapid transit routes and adjustments to routes in the vicinity, expansion of the route network to serve developing areas and increase service frequencies.

As described in Table D10, along with the new B-Line service, three A-Line patterns are included in the 2031 network. These rapid transit services will operate north-south along James Street and Upper James Street with a combined headway of 4 minutes between the Downtown Terminal and Mohawk College. The B-Line rapid transit service will replace the current Route 10 (Bee-line) with a faster, more frequent service between Eastgate Square and the McMaster GO Bus Terminal via King Street and Main Street.
Table D10: Representative Operating Plan for the Rapid Transit Service (2031) Conditions: BRT Technology

<table>
<thead>
<tr>
<th>Line</th>
<th>Route No.</th>
<th>Routing</th>
<th>Headway (mins)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Lines along James St./Upper James St.</td>
<td>A1</td>
<td>From Waterfront to Airport</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>From Downtown Terminal to Lime Ridge Mall</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>From Downtown Terminal to Rymal Rd.</td>
<td>16</td>
</tr>
<tr>
<td>B-Line along King St./Main St.</td>
<td>B</td>
<td>Dedicated rights-of-way from Delta to the McMaster GO Bus Terminal</td>
<td>2.5*</td>
</tr>
</tbody>
</table>

Figure 1 – A-Line and B-Line Rapid Transit Services
New transit services along Rymal Road and Highway 20 will be provided to serve the future growth areas, e.g. Elfrida, and to supplement the current limited services in these areas. Several north-south routes that now connect the upper and lower Hamilton will be truncated at Mohawk College and provide service on the mountain only.

The frequencies of the services in 2031 network were generally increased by 50% over the existing HSR services. However, Route 1 and 1-A which operate on King Street/Main Street were adjusted from 15 minute headway to 30 minute headway as the anticipated demand through this corridor will be accommodated on the B-Line.

Table D11 summarizes the travel times for the proposed rapid transit services. Given the higher operating speeds and new routing up the mountain, the travel time of A-line routes from Downtown to Mohawk Rd. will be decreased by approximately 13 minutes compared to the current Route 27 operations.

**Table D11: Summary the A-Line Travel Time: BRT Technology**

<table>
<thead>
<tr>
<th>Route Segment</th>
<th>Rapid Transit A-Line Routes</th>
<th>Regular Bus (Route 4 or 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A1-Waterfront to Airport</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Travel Time (min)</td>
<td>Travel Time (min)</td>
</tr>
<tr>
<td>from Burlington St. to King St.</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>from King St. to Fennell Ave.</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>from Fennell Ave. to Mohawk Rd.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>from Mohawk Rd. to Lime Ridge Mall</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>from Mohawk Rd. to Rymal Rd. via Upper James St.</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>from Rymal Rd. to Mountain Transit Centre</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>from Mountain Transit Centre to Airport</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>28</td>
</tr>
<tr>
<td>from King St. to Rymal Rd.</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>
The comparison of travel times between the B-Line and Route 10 is provided in Table D12. The table indicates that the B-Line westbound will save 6 minutes of travel time as a result of the dedicated rights-of-way from Delta (King Street at Main Street) to the McMaster GO Bus Terminal.

**Table D12: Representative B-Line Travel Time: BRT/LRT Technology**

<table>
<thead>
<tr>
<th>Route Segment</th>
<th>B-Line Travel Time (min)</th>
<th>Route 10 Travel Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>from Eastgate Square to Ottawa St.</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>from Ottawa St. to Hugson St.</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>from Hugson St. to McMaster Medical Centre</td>
<td>-</td>
<td>13</td>
</tr>
<tr>
<td>from Hugson St. to McMaster GO Bus Terminal</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>36</strong></td>
</tr>
</tbody>
</table>

**Assignment of 2031 Transit Trip Table to Future Network**

The future 2031 adjusted TMS trip table was assigned to the 2031 transit network to produce the future ridership forecast and network requirements for year 2031. A comparison of the assigned transit volumes across selected screenlines, streets and intersections is shown in Table D13 for 2006 and 2031.
Table D13: Comparison of assigned transit volumes for the 7-9 a.m. peak period

<table>
<thead>
<tr>
<th>Street</th>
<th>Existing (2006) Conditions Model</th>
<th>Future (2031) Conditions Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>King St. WB</td>
<td>1506</td>
<td>3121</td>
</tr>
<tr>
<td>(Route 1,5,10/B Line,34,51,52)</td>
<td>at Caroline St.</td>
<td></td>
</tr>
<tr>
<td>Main St. EB</td>
<td>559</td>
<td>1279</td>
</tr>
<tr>
<td>(Route 1,5,7,10/B-Line,51)</td>
<td>at Caroline St.</td>
<td></td>
</tr>
<tr>
<td>Barton St. EB</td>
<td>194</td>
<td>449</td>
</tr>
<tr>
<td>Barton St. WB</td>
<td>374</td>
<td>737</td>
</tr>
<tr>
<td>(Route 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Wellington St. NB</td>
<td>785</td>
<td>1050</td>
</tr>
<tr>
<td>Upper Wellington St. SB</td>
<td>424</td>
<td>456</td>
</tr>
<tr>
<td>(Route 22~27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen Line</td>
<td>559</td>
<td>1279</td>
</tr>
<tr>
<td>Caroline St.</td>
<td>at Main St. EB</td>
<td></td>
</tr>
<tr>
<td>(Route 1,5,7,10/B-Line,51,52)</td>
<td>at King St. WB</td>
<td>1506</td>
</tr>
<tr>
<td>Wellington St.</td>
<td>11</td>
<td>25</td>
</tr>
<tr>
<td>(Route 1,3,5,10/B-Line,52)</td>
<td>at Wilson St. EB</td>
<td></td>
</tr>
<tr>
<td>at Hunter St. EB</td>
<td>42</td>
<td>59</td>
</tr>
<tr>
<td>at King St. WB</td>
<td>951</td>
<td>2855</td>
</tr>
<tr>
<td>at Hunter St. WB</td>
<td>230</td>
<td>171</td>
</tr>
<tr>
<td>at Wilson St. WB</td>
<td>128</td>
<td>187</td>
</tr>
<tr>
<td>Intersection</td>
<td>54</td>
<td>84</td>
</tr>
<tr>
<td>(Route 2,4)</td>
<td>James St at Murray St. EB</td>
<td></td>
</tr>
<tr>
<td>James St at Murray St. WB</td>
<td>185</td>
<td>407</td>
</tr>
<tr>
<td>(Route 21,33,35)</td>
<td>334</td>
<td>1155</td>
</tr>
<tr>
<td>Fennell Ave. at West 5th St. NB</td>
<td>478</td>
<td>1232</td>
</tr>
</tbody>
</table>
As Table D13 illustrates, the ridership will increase significantly across the HSR network owing to the improved transit services (reflected by increased transit mode share in the trip table) and population and employment growth. The largest increases in ridership are east-west through the city centre. For instance, the ridership across the Caroline street screenline has increased by 129% eastbound and 107% westbound.

More detailed reviews of the A-Line and B-Line services are presented in Table D14 and Table D15 respectively. Table 14 indicates that significant ridership increases will occur along Upper James Street between Fennel Avenue and Stone Church Road, which suggests that the A-Line, with three patterns, is very attractive to the transit users.
Table D14: Comparison of the assigned ridership of the A-line and Route 27 for the 7:00-9:00 a.m. peak period

<table>
<thead>
<tr>
<th>Stop Location</th>
<th>Existing (2006) conditions model</th>
<th>Future (2031) conditions model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Route 27</td>
<td>A-Line</td>
</tr>
<tr>
<td><strong>Northbound</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Airport</td>
<td>-</td>
<td>53</td>
</tr>
<tr>
<td>Mountain Transit Center</td>
<td>0</td>
<td>55</td>
</tr>
<tr>
<td>Upper James Rd. at Rymal Rd.</td>
<td>19</td>
<td>90</td>
</tr>
<tr>
<td>Upper James Rd. at Stone Church Rd.</td>
<td>50</td>
<td>607</td>
</tr>
<tr>
<td>Upper James Rd. at Mohawk Rd.</td>
<td>92</td>
<td>1088</td>
</tr>
<tr>
<td>Upper James Rd. at Fennel Ave.</td>
<td>91</td>
<td>1219</td>
</tr>
<tr>
<td>Upper Wellington Rd. At Concession St.</td>
<td>93</td>
<td>-</td>
</tr>
<tr>
<td>King St. at Hughson St.</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td><strong>Southbound</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>King St. at Hughson St.</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td>Upper Wellington Rd. at Concession St.</td>
<td>84</td>
<td>-</td>
</tr>
<tr>
<td>Upper James Rd. at Fennel Ave.</td>
<td>109</td>
<td>796</td>
</tr>
<tr>
<td>Upper James Rd. at Mohawk Rd.</td>
<td>132</td>
<td>665</td>
</tr>
<tr>
<td>Upper James Rd. at Stone Church Rd.</td>
<td>70</td>
<td>301</td>
</tr>
<tr>
<td>Upper James Rd. at Rymal Rd.</td>
<td>21</td>
<td>108</td>
</tr>
<tr>
<td>Mountain Transit Center</td>
<td>0</td>
<td>28</td>
</tr>
<tr>
<td>Airport</td>
<td>-</td>
<td>27</td>
</tr>
</tbody>
</table>

Table D15 compares the ridership of the B-Line route as well as other parallel routes along King Street through the downtown area under both 2006 and 2031 conditions. The comparison indicates that the B-Line will attract a larger portion of the transit volumes in 2031 as compared to Route 10 in 2006. This suggests that the B-line will be more attractive than the other routes in 2031 given its faster and frequent service.
Table D15: Comparison of the assigned ridership of the B-line and other routes for the 7:00-9:00 a.m. peak period

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>King St. @ Caroline St. WB</td>
<td>1</td>
<td>827</td>
</tr>
<tr>
<td></td>
<td>10/B-Line</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>365</td>
</tr>
<tr>
<td>New Route on Garth St.</td>
<td>-</td>
<td>189</td>
</tr>
<tr>
<td>Total</td>
<td>1506</td>
<td>3121</td>
</tr>
</tbody>
</table>

| King St. @ Wellington St. WB | 1                               | 534 | 400 |
|                             | 10/B-Line                        | 201 | 2447 |
|                             | 52                               | 216 | 8   |
| Total                      | 951                             | 2855 |

2031 A.M. Peak Period Operating Statistics

In addition to the ridership forecast, the VISUM model also provided operating statistics for the existing (2006) network and the future (2031) network. A summary of the operating statistics for both networks is provided in Table D16.
Table D16: Peak Hour Statistics Comparison

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Linked Trips</td>
<td>6,872</td>
<td>13,705</td>
</tr>
<tr>
<td>Total Boardings</td>
<td>10,623</td>
<td>22,062</td>
</tr>
<tr>
<td>Passenger-Kilometres</td>
<td>42,192</td>
<td>82,851</td>
</tr>
<tr>
<td>Bus-Kilometres</td>
<td>2,436</td>
<td>4296</td>
</tr>
<tr>
<td>Revenue Bus Hour</td>
<td>142</td>
<td>215</td>
</tr>
<tr>
<td>Number of Buses²</td>
<td>142</td>
<td>215</td>
</tr>
<tr>
<td>Average Boardings per Trip</td>
<td>1.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Passenger Kilometres per Bus Kilometre</td>
<td>17.3</td>
<td>19.2</td>
</tr>
<tr>
<td>Boardings per Revenue Bus Hour</td>
<td>75</td>
<td>103</td>
</tr>
</tbody>
</table>

¹ A peak hour factor of 0.66 was used.
² the number of buses was adjusted assuming the addition of 8% to account for lay-up.

It should be noted that supply-demand balancing was not carried out on a network-wide basis; only for the two rapid transit corridors. The number of bus-kilometres shown in Table D16 indicates that the future (2031) conditions network increase the entire amount of HSR service by 67%. Total boardings per hour in 2031 will be doubled, which corresponds to an approximate 100% increase in transit trips within the City of Hamilton. The simulated average boardings per trip from the future (2031) conditions model are slightly larger than that from the existing (2006) conditions model. The likely explanation for this appears to be the fact that Route 21, 33, 34 and 35 will be truncated at Mohawk College in future 2031 network and passengers will therefore need to transfer to the A-Line to get to the downtown area. The number of vehicles required in future 2031 network will be roughly 50% more than that required today.

The time profile summary for rapid transit services shown in Table D17 indicates that approximately 34 vehicles will be required to operate the rapid transit services in 2031. Currently, approximately 13 vehicles are required to provide the services offered along the same routes.
Table D17: Time Profile Summary: 2031 Rapid Transit: BRT Technology

<table>
<thead>
<tr>
<th>Route No.</th>
<th>Routing</th>
<th>Round Trip Travel Time (excluding Lay-up period) (min)</th>
<th>Headway (min)</th>
<th>Vehicle #</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Waterfront-Airport</td>
<td>52</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td>A2</td>
<td>Downtown-Lime Ridge Mall</td>
<td>21</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>A3</td>
<td>Downtown-Rymal St.</td>
<td>23</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Eastgate Square-McMaster GO Bus Terminal</td>
<td>56</td>
<td>2.5</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>34</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A review of peak hour loads for the rapid transit routes is provided in Table D18. The service frequencies were adjusted to approximately correspond with the typical service design average maximum load for articulated buses of 70-75. In terms of A-line routes, the average maximum bus load of the Lime Ridge Mall route would be lower than anticipated since the mall is not open during the 7:00-9:00 a.m. peak period.

Light Rail Vehicles (LRVs) typically have a design capacity of twice that of articulated buses (145) and so, were LRT to be implemented, the service frequencies would be halved and the number of vehicles required reduced to 18: the B-Line would run every 5 minutes and require 13 LRVs; and the A-Line would operate every 10 minutes on the common section from downtown to Mohawk Road, and 30 minutes from the Waterfront to downtown and to the Airport, requiring 5 LRVs.

Table D18: Peak Load on the rapid transit routes simulated by the future (2031) conditions model

<table>
<thead>
<tr>
<th>Line</th>
<th>Line Pattern</th>
<th>Max. Line Route Load [7-9 a.m.]</th>
<th>Headway (min)</th>
<th>Average Max. Bus Load*</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-Line</td>
<td>A1-Waterfront to Airport</td>
<td>529</td>
<td>16</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>A2-Downtown to Lime ridge Mall</td>
<td>538</td>
<td>8</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>A3-Downtown to Rymal Rd.</td>
<td>321</td>
<td>16</td>
<td>56</td>
</tr>
<tr>
<td>B-Line</td>
<td>Eastgate Square to McMaster University</td>
<td>2,677</td>
<td>2.5</td>
<td>74</td>
</tr>
</tbody>
</table>

- A peak hour factor of 0.66 was applied to the maximum line route load for peak period to calculate the average maximum bus load.
Conclusions

It is assumed that by 2031 transit trips within the City of Hamilton will increase by approximately 100% as a result of the improved transit services and population and employment growth. The largest increases in ridership will be on east-west corridor through the city centre.

Rapid Transit service is planned in two corridors: a north-south alignment from the Waterfront to the Airport (A-Line); and an east-west alignment from Eastgate to McMaster (B-Line). In the case of the north-south alignment, three coordinated ‘patterns’ will be run: from the Waterfront to the Airport; from Downtown to Lime Ridge Mall; and from Downtown to Rymal Street.

The projected demand would call for:

- A-Line - a headway of 4 minutes (15 articulated bus trips per hour) on the common section from downtown to Mohawk Road with 8 minute service from Mohawk to Rymal Road and 16 minute service between Waterfront and downtown and Rymal Road and the Airport;
- B-Line - a headway of 2.5 minutes (a service frequency of 24 articulated buses per hour) from Eastgate to McMaster.

This service would call for the operation of 9 articulated buses on the A-Line and 25 on the B-Line for a total of 34.

Light Rail Vehicles (LRVs) typically have a design capacity of twice that of articulated buses (145 compared to 70-75) and so, were LRT to be implemented, the service frequencies would be halved and the number of vehicles required reduced to 18: the B-Line would run every 5 minutes and require 13 LRVs; and the A-Line would operate every 10 minutes on the common section from downtown to Mohawk Road, and 30 minutes from the Waterfront to downtown and to the Airport, requiring 5 LRVs.

Assuming a spares ratio of 20% for articulated buses and 10% for LRVs the total requirements would be:

- For BRT 41 articulated buses;
- For LRT 20 LRVs

The future (2031) conditions network analysis also suggested that:

- The proposed rapid transit service A-Line and B-Line will significantly reduce the travel time on the Lower Hamilton City Central Mountain North-South Corridor and East-West Corridor, and greatly increase the 30 - minute catchment area of HSR services.
- The B-Line with faster, more frequent service will attract a large portion of east-west demand along King Street/Main Street.
- The A-Line with increased speed will provide a well used link between the Mohawk College area and Downtown Hamilton, as a result of the creation of a transit terminal for Upper Hamilton which the A-Line will connect to Downtown and Lime Ridge Mall.

- Demand for service to and from the Airport is relatively low.
## Bus Rapid Transit Cost Estimates

<table>
<thead>
<tr>
<th>Section</th>
<th>From</th>
<th>To</th>
<th>Length (m)</th>
<th>Cross-section (see Appendix)</th>
<th>Construction Type (see Note 1)</th>
<th>Cost per metre (see Sheet 2)</th>
<th>No. of Platform/Shelters (see Note 2)</th>
<th>Estimated Cost ($1000s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Queenston / Main</td>
<td>Eastgate Square</td>
<td>The Delta</td>
<td>5,189</td>
<td>Unchanged</td>
<td>Add stations only</td>
<td>$0</td>
<td>6</td>
<td>$1,680</td>
</tr>
<tr>
<td>B King E</td>
<td>The Delta</td>
<td>Wellington</td>
<td>3,210</td>
<td>B &amp; C</td>
<td>1</td>
<td>$6,800</td>
<td>4</td>
<td>$22,945</td>
</tr>
<tr>
<td>B King E / W</td>
<td>Wellington</td>
<td>Bay</td>
<td>1,280</td>
<td>Reserved Lane</td>
<td>Add stations only</td>
<td>$0</td>
<td>2</td>
<td>$960</td>
</tr>
<tr>
<td>B King W</td>
<td>Bay</td>
<td>Queen</td>
<td>410</td>
<td></td>
<td>1</td>
<td>$6,800</td>
<td>1</td>
<td>$3,965</td>
</tr>
<tr>
<td>B King W</td>
<td>Dundurn</td>
<td>Queen</td>
<td>790</td>
<td>A</td>
<td>1</td>
<td>$6,800</td>
<td>1</td>
<td>$5,652</td>
</tr>
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<td>E of Macklin</td>
<td>Paradise / Main W</td>
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<td>Reserved Lane</td>
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<td>$0</td>
<td>0</td>
<td>$0</td>
</tr>
<tr>
<td>B Main W</td>
<td>Paradise</td>
<td>Hamilton</td>
<td>900</td>
<td>I &amp; J</td>
<td>2</td>
<td>$17,050</td>
<td>4</td>
<td>$68,200</td>
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<tr>
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<td>Dundurn</td>
<td>Haddon</td>
<td>820</td>
<td>K</td>
<td>3</td>
<td>$960</td>
<td>2 at Mac Ent. Station</td>
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</tr>
<tr>
<td>B Main W</td>
<td>Cootees / Leyland</td>
<td>University Plaza</td>
<td>1,800</td>
<td>I &amp; J</td>
<td>2</td>
<td>$17,050</td>
<td>4</td>
<td>$32,960</td>
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<tr>
<td>B Main W</td>
<td>Paradise</td>
<td>Dundurn</td>
<td>940</td>
<td>Reserved Lane</td>
<td>Add stations only</td>
<td>$0</td>
<td>1</td>
<td>$280</td>
</tr>
<tr>
<td>B Main W</td>
<td>Dundurn</td>
<td>Queen</td>
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<td>A</td>
<td>1</td>
<td>$6,800</td>
<td>1</td>
<td>$5,652</td>
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<tr>
<td>B Main W</td>
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<td>Catharine</td>
<td>750</td>
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<td>$560</td>
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<tr>
<td>B Main W</td>
<td>Catharine</td>
<td>Wellington</td>
<td>530</td>
<td>B</td>
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<td>0</td>
<td>$3,664</td>
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<td>The Delta</td>
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<td></td>
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<td>$6,800</td>
<td>4</td>
<td>$21,928</td>
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<tr>
<td>C James N</td>
<td>Guise</td>
<td>King</td>
<td>2,000</td>
<td>Unchanged</td>
<td>Add stations only</td>
<td>$0</td>
<td>6</td>
<td>$1,680</td>
</tr>
<tr>
<td>D James S</td>
<td>King</td>
<td>TH&amp;B Bridge (Note 3)</td>
<td>400</td>
<td>E</td>
<td>1</td>
<td>$9,960</td>
<td>0</td>
<td>$33,960</td>
</tr>
<tr>
<td>D James S</td>
<td>TH&amp;B Bridge</td>
<td>James Mountain Road</td>
<td>900</td>
<td>F &amp; G</td>
<td>1</td>
<td>$9,960</td>
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<td>$19,920</td>
</tr>
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<td>James S</td>
<td>Gateview</td>
<td>630</td>
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<td>0</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>E W 5th</td>
<td>Gateview</td>
<td>Fennell</td>
<td>500</td>
<td>E or I</td>
<td>2</td>
<td>$12,400</td>
<td>2 at Mohawk College</td>
<td>$6,200</td>
</tr>
<tr>
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<td>440</td>
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</tr>
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<td>Fennell</td>
<td>Mohawk</td>
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<td>I &amp; J</td>
<td>2</td>
<td>$17,050</td>
<td>4</td>
<td>$19,960</td>
</tr>
<tr>
<td>F Upper James</td>
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<td>3,060</td>
<td>I &amp; J</td>
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<td>$17,050</td>
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<td>$55,173</td>
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<tr>
<td>F Upper James</td>
<td>Rymal</td>
<td>Hi Airport</td>
<td>5,450</td>
<td>I &amp; J Forest</td>
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<td>Upper James</td>
<td>Upper Wentworth</td>
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<td>I &amp; J</td>
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<td>$17,050</td>
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<td>$31,497</td>
</tr>
<tr>
<td>G Upper Wentworth</td>
<td>Mohawk</td>
<td>Lime Ridge Mall</td>
<td>800</td>
<td>I</td>
<td>2</td>
<td>$15,960</td>
<td>2 at Lime Ridge Mall</td>
<td>$14,720</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td>30,180</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$410,241</td>
</tr>
</tbody>
</table>

**Note 1:**
- minor widenings or narowings, sub-base salvaged, complete mill and pave, new curbs, sidewalks, boulevards, landscaping, and public art
- minor widenings with all elements as in 1, but with addition of median rapidway
- significant widenings or realignment with full reconstruction, including all elements as in 1

**Note 2:**
- Curbside Stations, assume $290K each. Median Stations on two way sections, assume $600K each. Stations at McMaster University Entrance, Mohawk College, and Lime Ridge Mall assumed to cost $4m, $2m, and $2m respectively.

**Note 3:**
- Relocation of the TH&B Bridge assumed, at a cost of $30M