GREATER TORONTO AND HAMILTON AREA

REGIONAL RAPID RAIL

A VISION FOR THE FUTURE

PREPARED FOR

TRANSPORT ACTION ONTARIO

(FORMERLY TRANSPORT 2000 ONTARIO)

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JULY 2013

Abstract

The Greater Toronto and Hamilton Area (GTHA) is facing worsening congestion, verging on gridlock on various key corridors. After decades of little investment in new transit infrastructure, the provincial government's regional transit agency, Metrolinx, has started to plan and build more transit. The Metrolinx plan, known as *The Big Move*, includes plans to expand and enhance the GO rail system.

This Regional Rapid Rail report builds on *The Big Move*, specifically looking at achieving maximum value from the GO rail network. This would involve the prompt conversion of the vast majority of the GO rail network into an electrified regional rail system operated with Electric Multiple-Units (EMUs – like a subway train, but as a bi-level model), with frequent (headways of four to ten minutes during peak periods), all-day (every 15 minutes or better), two-way service to form a regional backbone, integrated with various local transit systems to maximize trip options. This would effectively transform the GO rail system into a "surface subway" network over 450km in extent, which could meet the very high demands projected for various GO corridors. This "surface subway" concept is common in Europe, such as the Overground in London, UK, the RER in Paris, France, and the Stadtschnellbahn (S-Bahn) in Berlin, Germany, among many other cities.

Bi-level EMUs serve the Swiss S-Bahn of Zürich. Photo credit: Peter Elektro, 2011. Link: commons.wikimedia.org/wiki/File:Testfahrt_SBB_S-bahnzug_RABe-511-001_Re-450-s.jpg

Achieving 450km of electrified, regional, all-day GO rail service is equivalent to the cost of achieving 65-70km of underground transit. Annual operating cost savings from an EMU-operated GO rail service over a diesel-operated service is estimated at over $465-million by 2031. Therefore, electrification with EMUs could serve as a means to avoid sharp increases in operating budgets for GO rail service over the long-term. The conceptual network, focused on the existing GO system with the exception of a new corridor in Scarborough, is illustrated in Figure 1 on page iv.

Crucial among the many proposals this report puts forward for consideration are:

- Commence electrification immediately. This would save approximately $1.5-billion by avoiding investment in expansion of a diesel fleet that

would encounter serious and expensive obstacles to meeting projected 2031 demands. Obstacles include additional tracks for which space may not always be available, Union Station constraints, and issues regarding maintenance facilities. Therefore, consider a fleet plan using electric vehicles to accommodate ridership growth in lieu of expansion of the diesel fleet, including the expansion of maintenance facilities.

- Introduce EMUs on the GO rail system. This would provide improved operational flexibility, greater cost-efficiency, and faster average operating speeds over locomotive-hauled trains using either diesel or electric technologies. A simulation found that with EMUs, the number of stations could be almost doubled without a travel time penalty. While capital and operating cost differences were found to be modest by 2021, EMUs were found to be far more cost-effective in terms of both capital and operating costs by 2031. Therefore, adoption of EMUs as the preferred electric vehicle technology option would be the most sustainable option to serve GO Transit's long-term needs.
- Revise the contract for the Whitby maintenance and storage facility to be a dedicated EMU facility instead of a diesel locomotive facility.
- Progressively introduce 56 new stations to the existing network, as proposed in this report. This would greatly strengthen connectivity with local transit systems, resulting in increased rider convenience and access. The use of EMUs combined with selected 3-track segments offering local and express services would result in competitive travel times while serving a broader array of origin-destination pairs, resulting in increased ridership.
- Transition Pearson Airport rail service to a Kitchener GO rail operation through-routed via the airport. This would link the airport to Brampton and points further west in addition to various points within Toronto. It would also avoid complicated operational challenges in the Union Station Rail Corridor in the future. The Diesel Multiple-Units (DMUs) that would originally serve the airport could serve an operation between Hamilton and St Catharines following the completion of the electrified Kitchener GO rail service through-routing via Pearson. The 3.3km airport rail spur currently under construction for exclusive use with DMUs could be re-purposed for LRT service into the airport as part of an extension from Humber College
- Replace the current Scarborough RT line with a new Scarborough GO rail corridor. This could save an estimated $500-million in conversion costs compared with the LRT design, that in turn might allow an immediate extension to Malvern within the current budget envelope. This approach could offer a direct "one-seat" link between downtown Toronto and various locations across Scarborough, with increased capacity, while also better protecting alternative network options that could become necessary for future corridors in the northeast as envisioned in *The Big Move*. This could also provide some alleviation for both the Bloor-Danforth and Yonge subway lines.
- Enhanced Richmond Hill GO service could be key interceptor of a significant portion of traffic that would otherwise be attracted to the Yonge subway, particularly from York Region, where travel-time savings would be greatest. A modified alignment utilizing the ex-CP Don Branch

route between Lawrence Ave E and Gerrard St E could improve average speed.

- Future capacity shortfalls at Union Station cannot be solved without major investment, including four new underground tracks and shoulder stations to the east and west. Since this cannot be accomplished without the busiest GO corridors (particularly Lakeshore) being electrified, electrification would therefore be a critical component of a viable solution to providing projected capacity requirements at Union Station.
- Equip all trains and almost all tracks along affected corridors with Positive Train Control to safely allow closer spacing of trains. Positive Train Control could be considered as a means to avoid investment in additional track (plus bridges) while maintaining the same service level.

The estimated $55-million average cost per kilometre for converting the GO rail system to EMU operation is much less than the cost of building underground transit, and is even cheaper than many on-street LRT projects proposed around the GTHA, with up to four times the capacity. On a basis of passenger capacity per dollar of capital investment, the GO EMU approach is highly cost-effective. Going forward, given the demands projected for 2031, the analyses within this report demonstrate that EMUs would clearly be the soundest option, if not the only practical option, for the future fleet of the GO rail system.

Table 1: Summary of Costs, Route Lengths, and Hourly Passenger Capacities:

Corridor	Lakeshore	Stouffville	Scarborough	Kitchener	Milton	Richmond Hill	Barrie	USRC	NETWORK TOTAL
Capital $ to 2021 ($B)	$4.6	$0.7	$1.7	$2.7	$0.9	$0.5	$1.2	$1.0	**$13.2**
Capital $ 2021-2031 ($B)	$1.3	$0.0	$0.6	$1.4	$1.1	$1.3	$1.1	$4.7	**$11.6**
Length (km)	131.5	26.1	33.3	98.6	48.0	43.1	65.3	5.2	**451.1**
Capital $M/km	$44.6	$27.9	$68.6	$41.6	$41.8	$41.8	$35.9	$1,094.1	**$55.0**
Pphpd* (2031)	23,000	3,100	11,700	23,500	24,500	19,300	8,700	133,525	-

*Passengers per hour per direction (figures are from modeling data prepared for *The Big Move*)

(Note: USRC ridership includes Lakeshore East peak hour demand of 19,725pphpd in addition to other listed values; 23,000pphpd represents Lakeshore West demand)

Another clear advantage of this approach is that almost all of the rights-of-way are in place, reducing time for construction, road network disruptions during construction, and conflicts with other modes.

In conclusion, an electrified, EMU-based GO rail system as scoped in this report offers great benefits and value-for-money, including substantial annual savings over the long-term for the GO rail operating budget. This would potentially be of great interest to both Metrolinx and the municipalities served by such a network.

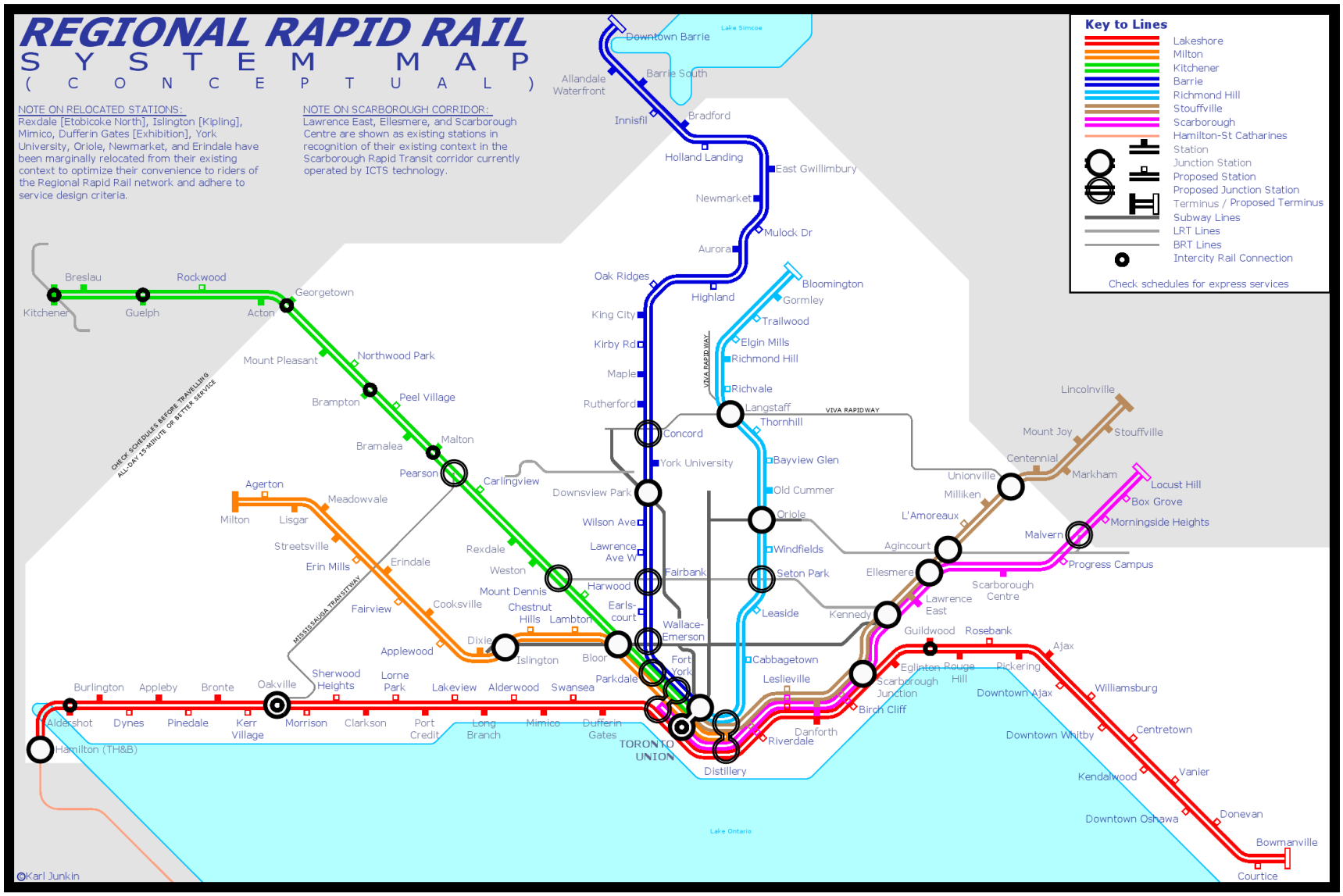

Figure 1

This diagram mimics the style of the original design of the London, UK system map conceived in 1931 by Harry Beck
This is a conceptual map representing a proposal for a network in the year 2031 and does not represent current service(s) or facilities

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Preface

This Regional Rapid Rail report has its origins in a complex series of events that unfolded during the electrification study commissioned by Metrolinx in 2009 and undertaken from late 2009 and through 2010. This author participated in many of the stakeholder workshops Metrolinx organized through a third-party for that study. At the initial workshop, indications that discussions would include bold concepts relating to the future form of GO Transit rail service in the Greater Toronto and Hamilton Area (GTHA) and even the land uses near such service were encouraging. Unfortunately, later workshops did not include such concepts. During the final workshop, strong disagreements between the invited stakeholders and the consultants hired by Metrolinx for the 2010 electrification study emerged. These disagreements were recorded in the 2010 electrification study's Appendix 2I-2, pages 18-19.

Metrolinx released the 2010 electrification study in January, 2011. In February-March, 2011, this author prepared a presentation that was delivered at the Annual General Meeting of Transport Action Ontario in April, 2011. That presentation provided a very "broad strokes" overview of cost differences between electrification options, accompanied by a holistic set of inputs for comparison that included different schedules for the implementation of each technology. This served as a "dry run" of sorts for the subject matter that was explored in much more detail in preparing this Regional Rapid Rail report.

Preparations for a detailed analysis of Electric Multiple-Units (EMUs) compared to locomotive options for a future GO rail network commenced in May, 2011, shortly before the release of "No Little Plan: Electrifying GO Transit" by Greg Gormick. While serving as a follow-up to "No Little Plan," (as it, too, raised concerns about the conclusions regarding EMUs published in the 2010 electrification study), the original intent of this report was to inform and influence political dialogue and campaigns in the run-up to the October, 2011 Ontario election. However, it was still early in the project when some unexpected discoveries started a chain of events that made that target date for completion unrealistic.

The 2010 electrification study provided a detailed comparison of electric locomotives with diesel locomotives, but the same was not done with EMUs. The objective of this Regional Rapid Rail report is to provide a detailed comparison of options relating to EMUs as a technology, as well as to conceptualize the network EMUs have the potential to enable. An EMU operation can provide a service comparable to a subway designed for longer distances, without the cost of tunnels (with very limited exceptions), and without reallocation of road space.

It is hoped that this Regional Rapid Rail report will be useful in informing policy and planning for electrification going forward. The

numbers that emerged as the research progressed surprised even this author. In addition, this report's scope was expanded while in progress to include putting forward other additional opportunities that appear to be strongly in the public interest for long-term sustainable electrified GO Transit rail service in the growing GTHA. It is also an intent of this Regional Rapid Rail report to be generally compatible with and supportive of the long-term goals and broader principles outlined in "*The Big Move*," the Regional Transportation Plan prepared by Metrolinx and approved by the Metrolinx Board in December, 2008.

While this Regional Rapid Rail report was initially intended to be limited to the "Express Rail" corridors (Lakeshore, Kitchener, Milton, and Richmond Hill) identified in *The Big Move*, the numbers prepared for the "Express Rail" corridors led to an increasing interest in considering the entire GO rail system. In addition, a refined comparison between the 2021 and 2031 outlooks also became a key feature. The substantial difference between the two resulting from this analysis may be of significant interest.

Events that unfolded in the spring of 2012, but predating the "One City" concept that emerged from City Hall, led to the addition of a conceptual "semi-new" corridor to the GO rail system through Scarborough. This was influenced by a complex combination of challenges facing some of the proposed services in *The Big Move*. New lines were originally intended to be off-limits for this Regional Rapid Rail report, but the arguments for an exception in this unique case were extraordinarily compelling.

Much of the source data for the research in this Regional Rapid Rail report was obtained from GO/Metrolinx-published documents. However, the methodology applied using the numbers from these source data was different from the 2010 electrification study, for reasons explained clearly in the body of the report. While the variables and their associated values were in most cases the same, the mathematical operations they were used with differed. Various values were modified on the basis of time horizons to provide a reflection of price escalation, but excluding inflation. Most importantly, the 2031 time horizon was added in addition to the 2021 horizon that was used in the 2010 electrification study. The two time horizons allowed for two lenses for comparison, which was important because of the assumed unlikelihood that the entire GO rail system would be electrified by 2021. Various digital cross-referencing layers were applied as a safeguard to catch human errors, and this project entailed the largest spreadsheet file this author has created to date. A lot of work went into the spreadsheet, as well as into certain drawings, for the sake of transparency of this work. Transparency of the process for which numbers were derived in this Regional Rapid Rail report was something this author considers to be of great importance on. If a reader wishes to know where a number came from, they should be able to find out, and the appendices (largely consisting of spreadsheet data, plus some drawings) were structured

to meet this objective.

It has been difficult to keep this Regional Rapid Rail report current as changes to the GO system would occur every few months – an extension to Kitchener, a new fleet order expanding the number of locomotive-hauled rail coaches, a new grade separation funded and moving forward, etc. Eventually, it was decided to disregard further revised inputs, effectively putting a “time-lock” on the report contents for any quantitative analyses. This “time-lock” would have an approximate date of April, 2012. For example, the latest order for new GO rail coaches placed in the spring of 2012 has not been included.

The findings of this report imply substantial ramifications arising from the technology selection for GO Transit's future. GO is at a critical juncture given the projected pressures anticipated, and the absence of a decision on future electric fleet at the time of writing. However, this in turn provides an opportunity to convey information that may be valuable in the discussion of how future pressures might be met, and how the GTHA might be equipped to absorb the growth expected over the next two decades and beyond. GO rail service is going to be playing a critical role – that is a foregone conclusion: It is a question of “How,” not “If.” This applies to both peak and off-peak (and even to reverse-peak) travel choices in the region.

This Regional Rapid Rail report is directed at political bodies, policy analysts, economists, planners, engineers, and local transit operators that either rely on or have a stake or interest in any part(s) of the GO rail system. The decisions that will be made over the next few years will have impacts extending over several decades. There appears to be a significant opportunity for decision-makers to take bold and visionary action on regional GTHA rail service while also improving the sustainability of the province's finances over the medium- and especially long-term.

This has at times felt like a never-ending project, but the end result has been very satisfying from the perspective of the social responsibility of a private citizen, and it is sincerely hoped that this Regional Rapid Rail report can serve others well and become a positive contribution to the GTHA.

About the Author

Karl Junkin has been observing transit developments in and around Toronto for several years. Educated in Architectural Technology from Sheridan College in the GTA, most of his work experience in that field has been in Tokyo, Japan. His final assignment in Tokyo before returning to Toronto was for a competition submission for a construction management job involving two towers that were to go up near downtown Tokyo on a site that had one of the oldest subway lines in Tokyo cutting across it on an angle.

After returning to Toronto, Karl worked for about a year at Toronto City Hall as a councillor's assistant, where a lot of his time was spent on transit-related matters. Since leaving City Hall, Karl has completed a diploma program for Civil Engineering Design and Technology at Metro College, and will soon be eligible to apply for certification with the Ontario Association of Civil Engineering Technicians and Technologists. Karl is currently employed by an engineering consulting firm in the GTA.

Acknowledgements

Aiding this author through the development of this report were a few second sets of eyes: Sincere and deep appreciation from the author goes to:
Peter Miasek, Ph.D., President of Transport Action Ontario;
Edward J. Levy, P. Eng., Transport Action Ontario Board member; and
Bruce Budd, Secretary of Transport Action Ontario,
Their efforts, feedback, and involvement in this project were invaluable, and a sizable contribution given the large size this report ultimately became. Thank you very much!

Although not involved specifically with this project, but heavily involved in a previous undertaking that laid a lot of groundwork for the methodology applied in this report, Philippe Bernier, P. Eng., M. Phil, has also made an important contribution to this report, even if in an indirect manner. Thank you!

There were other, smaller pieces of input contributed by other members of the Board of Transport Action Ontario. The 2011 roster (over and above those already mentioned) included:
Tony Turrittin, Ph.D., Vice-President;
Natalie Litwin, Past President;
Avrum Reigenstreif, Ph.D., Treasurer;
Dan Hammond;
Richard Crawford, P. Eng.;
Elizabeth Hill;
and David Scott.

Thank you!

There are others that have been party to discussions about this report, and while not all can be named, their input and interest is appreciated!

Legal

This report was undertaken as a private citizen. The views, opinions, and conclusions expressed in this report are those of the author and do not reflect those of the author's employer. While Transport Action Ontario supports electrification of the GO rail system, frequent rail service on most of the GO rail system, and the use of EMUs for a significant portion of GO rail service, the details of how those are achieved as expressed in this report are the opinion of the author, and may or may not be shared by Transport Action Ontario.

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Executive Summary

The Greater Toronto and Hamilton Area (GTHA) faces a major transportation crisis. Commuting times are among the highest in North America. The cost of congestion is estimated at $6-billion annually, and projected to increase to $15-billion annually unless major investment in transportation infrastructure is made. As gridlock worsens, significant action is needed on a regional scale. This Regional Rapid Rail report puts forward a cost-effective option and vision for a substantial increase in service to transit users across the GTHA.

1. Background and Precursors

In 2006, Metrolinx was established by the Ontario Government to develop and implement a regional transportation plan for the Greater Toronto and Hamilton Area (GTHA). This was released in 2008 and was entitled "*The Big Move*." At the time, it was estimated to cost $50-billion over 25 years. Also released in 2008 was a modeling backgrounder that provides projected 2031 demands for various projects in *The Big Move*, including demands for the GO corridors. That model included fare integration defined as follows:

> *Transit fares for the model were kept at the same current level, in real terms, with fare integration between local transit operators assumed, such that double fares for short cross-boundary trips would be eliminated.*

The figures from the modeling backgrounder were used to determine 2031 service levels for this Regional Rapid Rail report.

GO Transit (GO), a division of Metrolinx since 2009, operates seven commuter rail corridors – all currently diesel powered – totaling 450km and serving 62 stations. The corridors connect Toronto Union Station with Hamilton, Milton, Kitchener, Barrie, Richmond Hill, Stouffville (Lincolnville), and Oshawa, and all are envisioned to play major roles in achieving the goals in *The Big Move*, particularly those identified for "Express Rail" service.

The map at the end of this section depicts the current network.

In January, 2011, Metrolinx released the 2010 electrification study on the electrification of the GO rail network. The study identified the fixed infrastructure requirements such as bridges, track, grade separations, etcetera, needed to improve service to meet 2021 demand levels in the "Reference Case," but an estimate of the cost for that infrastructure was not published. It also identified fixed infrastructure needs for electrification, such as overhead catenary, substations, and autotransformers, for which their estimated costs were published. Trainsets were assumed to be locomotives pulling

10 bi-level coaches. This separation of fixed infrastructure types resulted in electrification-specific costs being isolated, thereby avoiding any overstating of the "cost of electrification."

The Metrolinx Board ultimately approved an option to electrify the Lakeshore East, Lakeshore West and Kitchener corridors over a 22-year period. The Ontario Government initiated an environmental assessment for electrifying only the Air Rail Link and access from Union Station to Willowbrook Yards, although the 2010 electrification study warned such action would be inadvisable due to the low benefit relative to its cost. Preliminary engineering is currently underway, but no funding is committed for implementation at time of writing.

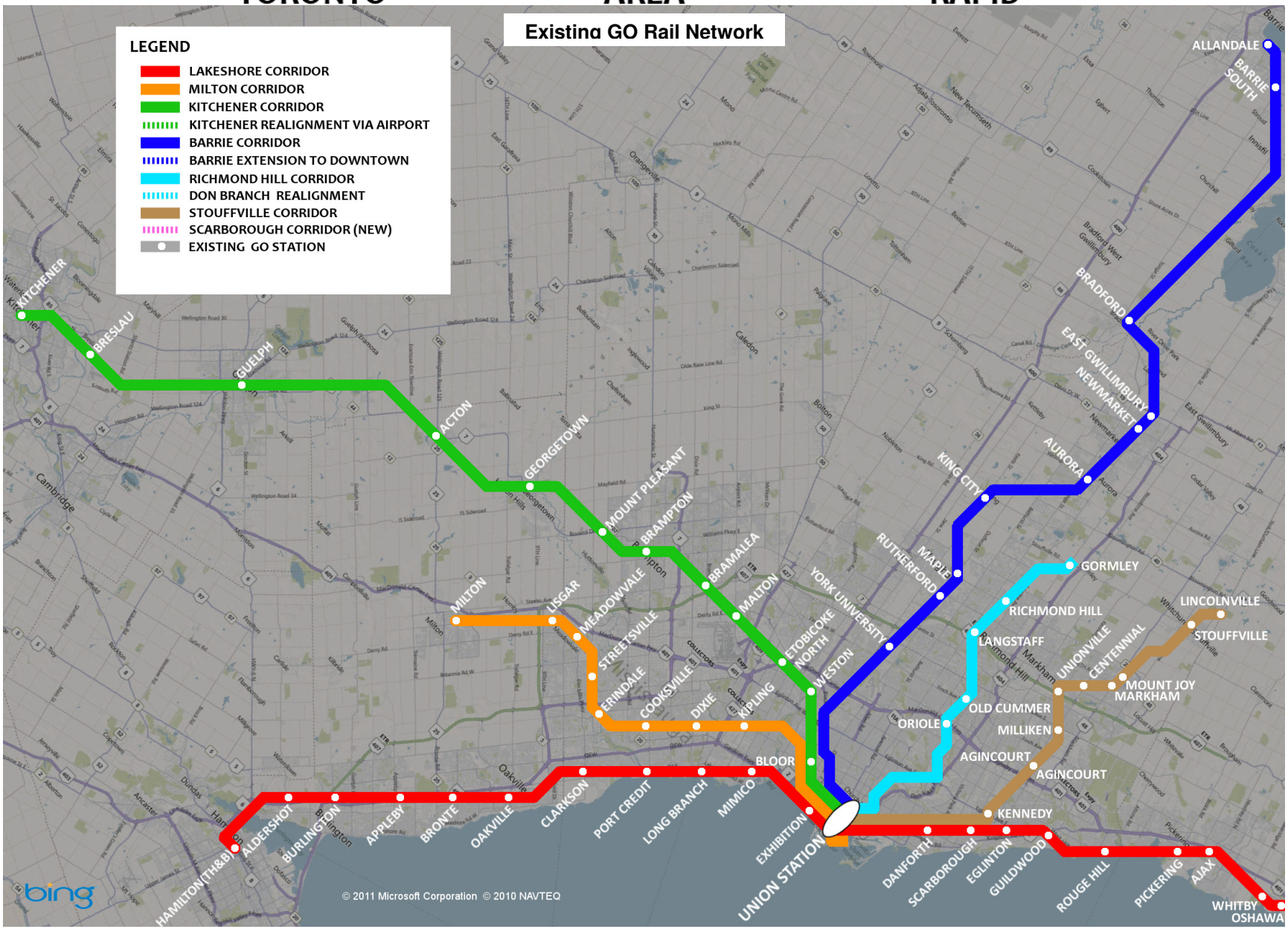
In May, 2011, Transport Action Ontario, the Clean Train Coalition, and the Canadian Auto Workers released a report titled "No Little Plan: Electrifying GO Transit," by Greg Gormick, noted transportation policy advisor and writer. It discussed the benefits of electrification across the world and for GO, especially using Electric Multiple-Units (EMU). It recommended an accelerated pace and expanded scope of electrification, as well as implementation of an urban rail concept similar to those of various "Stadtschnellbahn" [S-Bahn] systems in cities such as Berlin (Germany), Zurich (Switzerland), Copenhagen (Denmark), and Vienna (Austria).

This Regional Rapid Rail report is both an investigative analysis and a visioning piece on the potential future of GO Transit as influenced by technology choices that must be made soon, as well as a follow-up to "No Little Plan." The report presents a corridor-by-corridor detailed analysis of the infrastructure needs, costs and challenges of providing an electrified rail network with service levels comparable to a "surface subway" utilizing the existing mainline railway network in the GTHA, suitably enhanced. The objective is to make this information available and digestible for anyone that is affected by or interested in the challenges that face the GO rail network. This Regional Rapid Rail report envisions a plan that is achievable in about 15 years, covering two phases, plus a comparatively modest third phase beyond the 15-year horizon.

This report focuses on the existing GO corridors, with the exception of the Scarborough corridor (proposed herein), which largely replaces and extends the service offered by the existing SRT line while also accommodating an alternative arrangement to the Locust Hill service proposed in *The Big Move*.

Finally, it is recognized that other new corridors could be developed in the future and added to the GO rail network. As one example, *The Big Move* envisions a new corridor to Bolton. However, it is unlikely that such new corridors, if implemented, would be converted to electric operation in the short-term.

GREATER TORONTO HAMILTON AREA REGIONAL RAPID RAIL



2. The Regional Rapid Rail Vision for the GTHA

This Regional Rapid Rail report envisions an efficient, longer-distance, two-way, all-day frequent transit service covering most population centres within the GTHA. It is comparable to S-Bahn systems in Berlin, Germany and Vienna, Austria. This would involve:

1. Electrification with EMUs to provide improved operational flexibility and greater cost-efficiency
2. Expanded connections with local transit along electrified lines to increase the number and distribution of convenient interchanges and origin-destination pairs, by adding 56 stations to the existing network, as well as six more new stations along a new line through Scarborough
3. Improved service frequency to substantially reduce the impact of just missing a train, as summarized in the table below (in minutes):

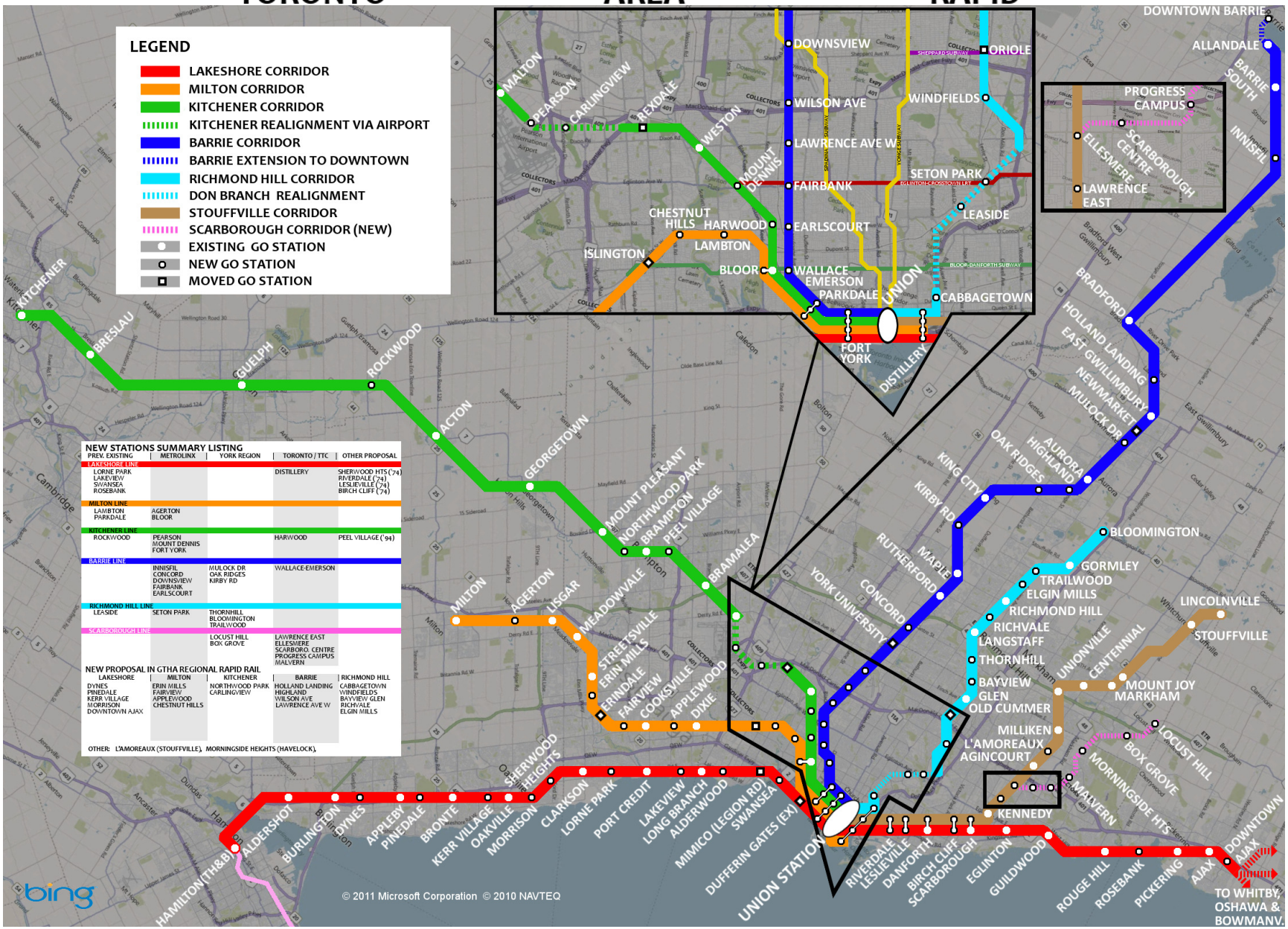
2021-2031 Service Outlook

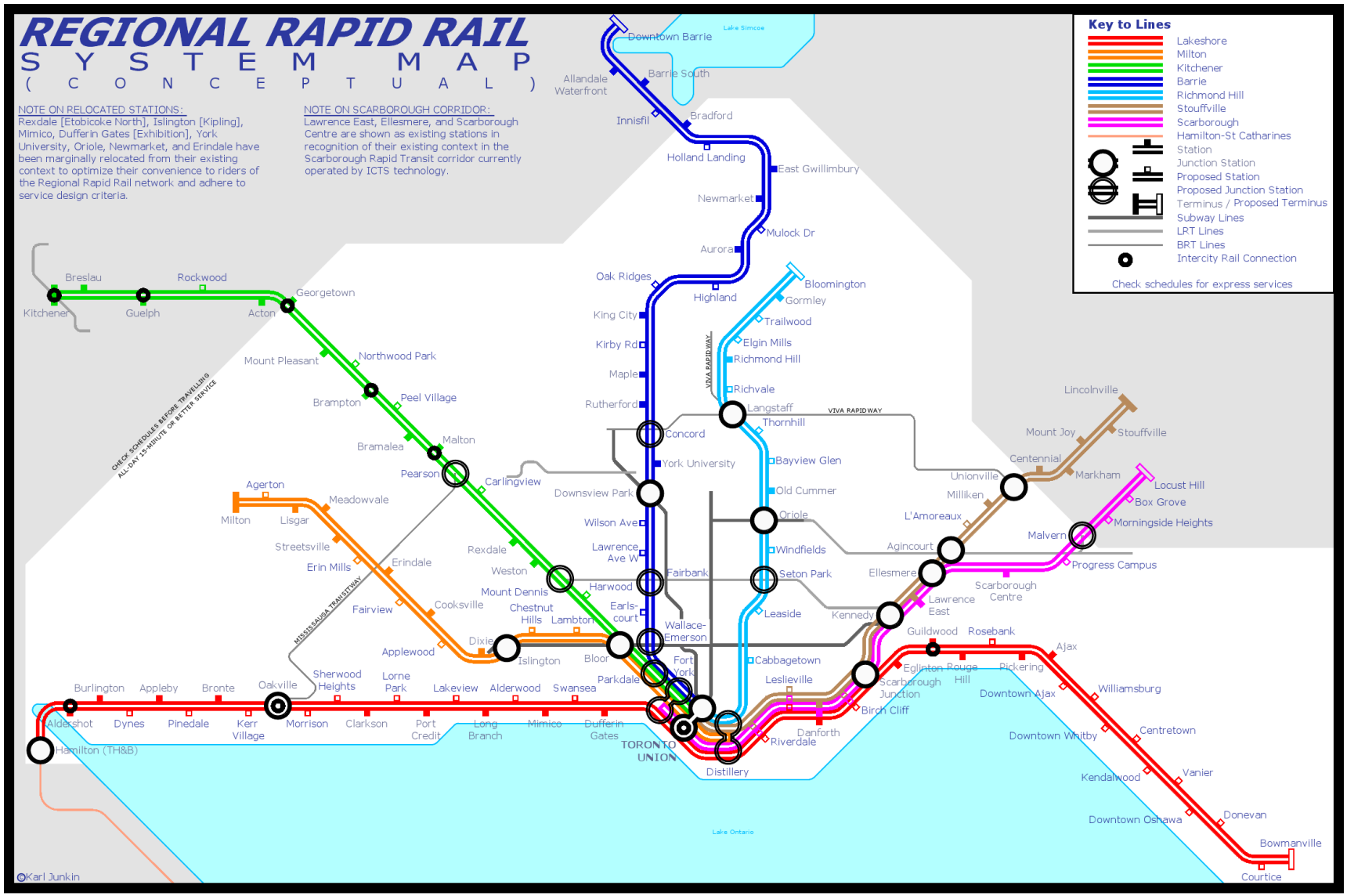
Service Level by Period	Peak Hour Frequencies in minutes (Average)			Off-Peak Frequencies in minutes (Scheduled)		
Corridor	**Current**	**2021**	**2031**	**Current**	**2021**	**2031**
Lakeshore West	10	6	4	30 to 60	30	15
Lakeshore East	8.5	6.5	5	30 to 60	30	15
Kitchener (via Pearson)	25	8.5	4	Bus only	60	15
Milton	15	10	3.5	Bus only	60	15
Richmond Hill	30	20	5	Bus only	60	15
Barrie	30	15	10	Bus only	60	15
Stouffville	31	15	10	Bus only	60	15
Scarborough (NEW)	Not built	n/a	6	Not built	n/a	±7.5

The two maps on the following pages depict the proposed network, including all new stations.

Most lines would have an express service available. Lakeshore would be four tracks over a substantial length of the route and other corridors would have 3-track stretches or occasional overtake tracks to accommodate express service. Only Milton would not have any overtake tracks in the vision outlined in this Regional Rapid Rail report, due to the complexities associated with right-of-way constraints combined with CP's requirement of 2-track freight service availability at all times. Overtake tracks on the Milton corridor are not impossible, but right-of-way constraints are complicated and would involve property acquisition, a subject that this report will not delve into.

GREATER HAMILTON REGIONAL RAIL TORONTO AREA RAPID





This diagram mimics the style of the original design of the London, UK system map conceived in 1931 by Harry Beck
This is a conceptual map representing a proposal for a network in the year 2031 and does not represent current service(s) or facilities

3. Use of an EMU Fleet

The 2010 electrification study dealt only briefly with EMUs. Nevertheless, its results indicated that EMUs would be 2.5 times more costly to operate than electric locomotive-hauled trains over a 25-year period. This Regional Rapid Rail report identified concerns with some of the assumptions used in the 2010 electrification study that contributed to that conclusion. Three important assumptions outlined in the 2010 electrification study that caused concern were: (a) trains being all-EMU rather than half EMU's and half unpowered coaches; (b) having the same service model applied to all technologies; and (c) all trains required to be the same length at all times. The methodology applied in this Regional Rapid Rail report did not include those three assumptions, and resulted in the finding that EMUs would be the cheapest option for the medium-term and beyond. Results for the short-term/2021 outlook were mixed and inconsistent among corridors, but EMUs became progressively more efficient on all corridors as service levels increased over time.

EMUs have the potential to revolutionize GO's operations. They are faster due to more powerful acceleration and deceleration ability, opening up the ability to use a smaller fleet for the same service level. This would provide numerous benefits, including reduced maintenance and smaller storage yards for the same service level.

EMUs can also be easily split into shorter trains, providing energy savings and opening up operational flexibility. The more powerful regenerative braking of EMUs offers potential reduction in electrical power demand draw. This is a result of the opportunity for greater sharing of energy within the network between EMU-operated trains, even between trains on different lines, for which opportunities would be plentiful within Toronto especially. As some vehicles brake while others accelerate, the electrical power is both generated and used within the network, reducing stress on the electrical grid.

EMU trains criss-cross The Netherlands, with most routes 40-130km long, and a 160km/h (100mph) top speed. A 12-car "VIRM" bi-level EMU train is shown above. Photo credit: Maurits Vink, 2007 Link: en.wikipedia.org/wiki/File:VIRM6.jpg

EMUs can also serve more stations without adding to passenger total travel time, which is a key attribute of the Regional Rapid Rail vision.

A simulated service model using the Milton corridor was prepared to evaluate the impact of additional stations, and the finding was that the number of stations could almost double without a penalty to the trip time from terminus to terminus using EMUs compared with diesel locomotives. Adding stations to lines with electrification is not a new concept; it is taking place right now in the San Francisco and San Jose area. Given the existing built form around most new stations proposed in this Regional Rapid Rail report, it is assumed new stations would have little (if any) parking, unless local transit was absent or minimal.

The "Reference Case" from the 2010 electrification study assumed a near-doubling of the size of the diesel fleet between 2010 and 2020 before any work on electrification begins. While current diesel equipment can continue to service non-electrified corridors (existing or new), for the Government of Ontario to consider investing $1.5-billion on a much larger diesel fleet instead of using electrification as a means to accommodate system growth could have unforeseen, expensive consequences. This concern is based on future operating expense calculations found in the appendices of this Regional Rapid Rail report. Also of concern is the risk (with a larger diesel fleet) relating to the cost-prohibitive option of converting locomotive-hauled coaches to EMU-operation, which even applies to the non-powered coaches in an EMU trainset.

EMUs are not new to the region, as the TTC subway system is run with EMUs, and the new LRT lines will also be EMUs. Decades ago, EMU-operation appeared on TTC streetcar lines as well. EMUs have been serving a wide variety of railways worldwide for over a century, and remain common today. The analyses in this report demonstrate without a doubt that the selection of EMUs as the preferred electric vehicle technology for the future of the GO rail network would clearly be the soundest policy going forward, if not the only practical option going forward, given the projected demands.

4. Whitby: An EMU Maintenance Facility

GO needs a new maintenance yard if it is to grow. Its sole existing yard, Willowbrook, located in Mimico, is at capacity. Electrification with EMUs as envisioned in this Regional Rapid Rail report would enable Willowbrook to continue undisturbed as the diesel maintenance facility, with storage-only functions for electric trains, and a new maintenance facility for EMUs would be built east of the Whitby GO station.

However, because the plan assumed in the 2010 electrification study does not envisage electrification commencing until 2020, after billions will have been spent on nearly doubling the size of the diesel fleet, that plan would be more expensive to deliver and less efficient to operate than the proposal described herein. Under the assumptions outlined in the 2010 electrification study Reference Case, the Whitby yard would be designed for diesel operations, with provision for electrification only for electric locomotives (i.e. it would not be EMU-compatible), and the Willowbrook yard would be electrified first. Commencing GO rail electrification immediately, as envisioned in this Regional Rapid Rail report, would allow all growth to be taken on by electric vehicles that could be serviced initially only at a new Whitby EMU maintenance facility. When Willowbrook's diesel capacity needs ultimately decline, some EMU functionality could then be provided there.

5. Union Station: Underground Component Needed

Union Station has long been known to require expanded capacity for meeting projected 2021 demands, and there is now work underway to provide solutions to those short-term pressures. These include a new west concourse to improve crowd movement on and off platforms, and an improved signal system with modernized trackwork to increase train speeds between Cherry St and Strachan Ave. No project currently underway will add any tracks to the station.

The capacity problems at Union Station projected for 2031 exist whether the GO operations remain dieselized or are electrified. Electrification of the busiest lines, however, would create new possibilities that would not be achievable with diesel operation. Specifically, electrification would offer the opportunity to construct up to six or possibly seven tracks on an underground level beneath Union, as there would be no diesel exhaust fumes to deal with. While this is the only feasible way to add new through-tracks to Union Station, it is admittedly a costly project. Further details are provided in Chapter 12, and are summarized in section 7.8 of this Executive Summary.

6. Network Cost Summary ($ Billion)

Network costs, including both fixed infrastructure and fleet capital costs and operating costs were estimated from the 2010 electrification study and from other comparable reports, reflecting professional judgment. Fleet costs are based on the assumption that diesel equipment made surplus on lines electrified in the first phase can be either reused to the end of its useful life on other diesel-operated lines in the network or resold to others. The costing methodology is described more fully in Chapter 4 and the numbers can be found in appendices A through T. These appendices are part of a large Excel spreadsheet (with some cells unlocked) that can be made available to interested readers.

Capital Costs Between Now and 2021 (2021) and Between 2021 and 2031 (2031)

Corridor	2021($B)	2031($B)
Lakeshore (West & East)	$4.56	$1.30
Stouffville	$0.73	$0.00
Scarborough	$1.72	$0.56
Kitchener	$2.67	$1.43
Milton	$0.87	$1.14
Richmond Hill	$0.49	$1.31
Barrie	$1.20	$1.15
USRC	$1.00	$4.68
NETWORK TOTAL	**$13.24**	**$11.57**

Per the above table, total capital costs, in 2010-dollars, for an EMU-based GO rail system as envisioned in this Regional Rapid Rail report for meeting 2031 service levels are estimated to be $24.81-billion. It is of interest to compare the 2031 EMU capital costs to the 2031 diesel locomotive case. This can readily be done for the existing corridors (Lakeshore, Kitchener, Stouffville, Milton, Richmond Hill, Barrie) from information in this Regional Rapid Rail report. Total capital costs for the EMU option are $17-billion versus $12.6-billion for the diesel locomotive option, a difference of $4.4-billion. Excluded from this breakdown are implications for the Union Station Rail Corridor (USRC). Indications from other studies suggest that USRC track capacity expansion will be critical, but expansion of track capacity with operations based entirely on diesel locomotives renders underground operations infeasible. Therefore, track expansion in the USRC is only considered possible with electric operations. With no diesel option for new tracks in the USRC, there cannot be any comparison of costs between diesel and electric USRC options.

The difference of $4.4-billion would pay for itself in a few years from the substantial operating cost savings the investment would yield, which are summarized below:

Annual Incremental Operating Cost Comparison by Technology by Corridor in 2031

Corridor	Diesel Ann. Op. Cost ($M)	EMU Ann. Op. Cost ($M)	Annual Difference
Lakeshore	$383.64	$147.64	$236.00
Stouffville	n/a	n/a	n/a
Scarborough	n/a	n/a	n/a
Kitchener	$146.88	$82.75	$64.13
Milton	$150.88	$84.10	$66.78
Richmond Hill	$101.66	$61.24	$40.42
Barrie (Off-Peak Fuel $ Only)	$67.91	$8.47	$59.44
TOTAL	**$850.97**	**$384.19**	**$466.78**

Estimated operating cost savings in 2031 would exceed $465-million/year, ensuring the additional initial investment in EMU technology would be quickly recouped by system efficiencies, and would yield substantial ongoing savings after the investment has paid itself off.

7. Corridor-by-Corridor analysis

The next sections provide summaries of the opportunities, challenges and costs for each corridor.

7.1. Lakeshore Corridor

- Electrification between Aldershot and Hamilton requires a commitment to one of the two routes through Hamilton. The ideal long-term solution from both transit planning and sustainable development perspectives for providing Hamilton with all-day GO rail service would be the continuation of operation along the CP line to connect to the current Hamilton TH&B station. The TH&B station is located in Hamilton's downtown core along Hunter St E, immediately east of James St S. It is accessed by trains to/from Toronto through the single-tracked Hunter St tunnel. An expanded Hunter St tunnel would be necessary to accommodate reliable, frequent GO rail service in co-existence with CP freight rail operations. Admittedly, this would be a costly undertaking. Consideration could be given to a comprehensive benefits:cost analysis that includes the long-term 2031 outlook – or beyond – for both freight rail activity and GO rail activity, as well as local and intercity bus activity, to determine the implications of the CN and CP routes. Publications on this subject to date do not look beyond the year 2021.
- A future rail connection from the TH&B station to St Catharines would be possible with the addition of a short turning track to connect the CP line to the CN line west of the Ottawa St N and Beach Rd intersection. DMUs could provide service between St Catharines and Hamilton, with transfers to the electrified GO line to/from Toronto made via a shared platform at the Hamilton TH&B station, with special design features providing accessible boarding for both vehicle types.
- Regarding the route from Ajax to Oshawa, in the context of an extension to Bowmanville in which the CP line is preferred from and through Oshawa, further Metrolinx evaluation would be justified in the context of a substantial GO rail service improvement through Whitby by connecting from the existing line to the CP corridor near Lakeridge Rd.
- This Regional Rapid Rail report proposes ten new stations for the Lakeshore West section of the corridor, plus the relocation of the Mimico station, and six new stations for the Lakeshore East section of the corridor west of Whitby. Nine more stations along the realignment and extension from Whitby to Bowmanville are also proposed.
- To accommodate local freight movements, this Regional Rapid Rail report proposes a section of fifth track accompanied by additional main line switches through each of the Willowbrook and Oakville yards.
- A rail-to-rail grade separation over the Hamilton junction for exclusive GO use warrants consideration as a means for providing frequent GO rail service between the Aldershot station and Hamilton. This would permanently avoid frequent conflicts with CN freight trains operating

to/from the Grimsby subdivision and/or the CN Hamilton yard. This is expected to be required even for half-hourly all-day service to Hamilton, whether Hamilton is served by the CN or CP line – as per above, the CP line is preferred.

- Eighteen new road-rail grade separations, 24 road bridge widenings, and 13 river bridge widenings would be necessary to accommodate future service levels, irrespective of vehicle technology.
- The Lakeshore corridor would yield the highest savings from EMU operations of any single corridor. Electric locomotives were found to have higher operating costs in 2021 than EMUs, and an electric locomotive-based fleet would incur higher capital cost than an EMU-based fleet.
- Fleet costs are substantial, regardless of whether diesel locomotives or EMU's are used, and are estimated to cost about $1.8-billion by 2031.
- Fleet maintenance costs were found to be higher using EMUs than locomotive options, but were more than offset by significant energy savings, debt servicing savings and reduced labour costs.
- Costs not captured in the calculations prepared for this report include regular track wear, differences in yard and layover facility sizes/capacities, etc., but it is clear that such costs would be reduced by adopting the lighter, smaller EMU fleet.
- In the long term, EMUs will be invaluable to the Lakeshore corridor as well as to other corridors thereafter by cost-effectively and safely meeting the high demand projections of 2031 and beyond. The estimates indicate that a conversion from diesel locomotives to electric locomotives first would be a more expensive two-step transition. An electrification process that uses an EMU fleet from the outset would save money by eliminating repetitive fleet replacement long before the end of the replaced fleet's useful service life.

7.2. Stouffville Corridor

- Electrification from the Scarborough junction [the Scarborough GO station] to the Unionville GO station would facilitate off-peak and counter-peak EMU service south of the Unionville GO station, providing operating savings from reduced energy costs.
- Peak diesel rail service to/from Union Station and bus services between Unionville and Lincolnville/Uxbridge were assumed to continue. Co-existence of EMU and diesel locomotive-hauled trains on the same track would be very minimal
- Consider providing off-peak service to the Unionville GO station with 4-car EMU trains split from Scarborough and/or Lakeshore East trains at Lawrence East and Birch Cliff stations, respectively, as detailed in Chapter 7 and summarized in section 7.3 in this executive summary.
- Seven arterial road grade separations and two river bridge widenings would be necessary to accommodate future service levels.
- A single-track fly-under at the Scarborough junction warrants consideration to accommodate northbound Stouffville corridor (and Scarborough corridor) trains. This would permanently avoid likely frequent conflicts with westbound Lakeshore East operations.
- This Regional Rapid Rail report proposes three new stations at Finch Ave E, Ellesmere Rd, and Lawrence Ave E. The latter two are also related to the Scarborough corridor summarized in the following section.

7.3. Scarborough Corridor

- Conversion of the current SRT line (currently planned for conversion to LRT) from Ellesmere to Scarborough Centre to GO EMU service warrants consideration. This would avoid having two transit corridors with different technologies immediately next to one another for the 4km between the Kennedy and Ellesmere stations.
- The estimated $500-million savings of the GO EMU option versus the LRT option could allow extension of service to Malvern with EMUs in the short-term.
- The option of operating one-seat service between Union Station and Scarborough Centre could be made available with the Scarborough corridor GO EMU service. Such an operation would lead to some alleviation of stress on the Yonge subway, as well as on transfer traffic at the Bloor-Yonge station, significantly improving the quality of transit options between downtown Toronto and various locations throughout Scarborough. This could be especially significant given the unlikelihood of new subway capacity into downtown Toronto being operational within the next 12 to 15 years.
- The ability to join together and break apart trains at the next station southwest of the Scarborough GO station – presumably the new Birch Cliff station proposed in the Lakeshore chapter of this Regional Rapid Rail report – also could alleviate stress on Union Station.
- An extension from Malvern to the north to connect with the Havelock subdivision south of Passmore Ave could serve parts of northeast Scarborough and southeast Markham. This would require approximately 3.2 km of new track, including 1.2 km underground. This would facilitate GO service to Locust Hill without operating along CP's main line. Locust Hill GO service was envisioned in *The Big Move* utilizing CP's Belleville subdivision. However, due to CP's abandonment of its Ottawa Valley line, all CP freight traffic now runs through Toronto, complicating access for GO operations along the Belleville subdivision.
- The connection from the Havelock subdivision to Malvern and Scarborough Centre could also substantially reduce conflicting traffic movements at Union Station resutling from the proposed Peterborough passenger rail service, if the Peterborough (Shining Waters Railway) service were to serve Union Station.
- In total, five new stations beyond Scarborough Centre are proposed in this Regional Rapid Rail report – Progress Campus, Malvern, Morningside Heights, Box Grove and Locust Hill (all variations of proposals by others).
- Capacity differences between the LRT and GO EMU options would be of particular concern if major redevelopment initiatives do materialize at some point in the future, especially if within 500m, or possibly 800m, walking distance of an access to the Scarborough Centre station.

7.4. Kitchener Corridor

- The Air-Rail Link [Union-Pearson Express] will serve Pearson Airport by rail in the short-term, but to provide an optimum long-term solution for rail service between the airport and downtown Toronto, a service through the airport that utilizes the same GO EMUs that would be used for the Kitchener GO corridor would be the most efficient. This would render unnecessary the fourth Weston subdivision track, as well as an additional underground Union Station track and platform to facilitate the proposed Air-Rail Link there, among other avoidable costs. A comparison of these costs is presented in the table to the right, and indicates that both options are virtually equal at $1.2-billion.
- Relocation of the Etobicoke North station to Islington Ave in Rexdale would provide improved access and connectivity with bus services.
- While the Air-Rail Link is in operation, construction of an airport rail access that is compatible with GO rail from the 401 crossing with the Weston subdivision could take place. This new rail access could potentially include a station at the Carlingview Dr and Dixon Rd intersection. During peak periods, an interim service model that could be considered at this point in the transition would involve splitting an EMU GO train from Toronto into an airport-bound train and a Brampton/Kitchener train at the Rexdale station. Trains would combine in the opposite direction. During off-peak periods, when demand would be lower and trains shorter, branch operations could also be considered.

Infrastructure	2-Car DMU Plan ($M)	16-Car EMU Plan ($M)	Comment
+1 Underground Track/Platform at Union Station	$250	n/a	Full-length track required; DMUs on surface track
+1 Rail-to-rail grade separation along Weston subdivision	$125	n/a	Required for DMUs to get north of GO Kitchener ops in 2031
Bloor GO station 6-track layout (platforms for all tracks)	$150	n/a	Serves Milton & Kitchener/ARL; only 5 tracks with airport through-routed ops
Parkdale GO station 8-track layout (platforms serving all tracks)	$250	n/a	Opportunity cost - serves Barrie, Milton, Kitchener/ARL; 7 tracks if thru-routed
Weston subdivision 4th track (20km)	$400	n/a	Not required with through-route
Electrification Incremental $	$15	$0	Difference in single-track-kilometres
Additional DMUs for St Catharines	$55	$0	Hamilton to St Catharines fleet
Savings on Finch W. LRT Extension	$0	($100)	2+km of re-purposed infrastructure
New EMU link from east of Pearson	n/a	$1,000	First component for through-routed design
New EMU link from north of Pearson	n/a	$350	Second component for through-routed design
OPTION TOTALS	**$1,245**	**$1,250**	

Note: Except 4th track, all costs in above chart are rough guestimates

- Upon completion of the new GO rail airport access, the Air-Rail Link spur now under construction could be re-purposed for LRT service into the airport as part of an extension of the Etobicoke-Finch West LRT from the Humber College North Campus, while the new GO rail access is extended north of the airport to reconnect with the existing line, providing Kitchener GO rail operations through-routed via the airport.

- The Georgetown South Project (expansion to a 3-track corridor and elimination of all level crossings through Toronto) essentially makes the corridor east of Highway 427 ready for expanded Kitchener GO rail service if consolidation with rail service to the airport could be realized.
- In addition to the Pearson Airport through-routed service alternative, this Regional Rapid Rail report suggests six additional stations – three in Toronto, two in Brampton, and one in Rockwood.
- The station proposed at St Clair Ave W (Harwood) in Toronto is admittedly a challenge, due to the legacy of the existing narrow grade separation at this crossing. There is an opportunity, albeit expensive, to lower the GO and CP lines and have St Clair Ave W pass over the tracks. This would allow for a wider street and improved connections with local streetcar and bus services.
- Estimated infrastructure west of Highway 427 included triple tracking, eight river bridge expansions and 18 new road-rail grade separations.
- Electrification from Union to Kitchener would achieve an estimated annual operating savings of $5- to $10-million by 2021, and an estimated $55- to $65-million by 2031. EMUs achieve higher savings in the 2031 estimate and savings are anticipated further over the electric locomotive option's savings compared with the diesel option as prices escalate over time in combination with further service level increases.
- A fourth track was included in the Halwest Junction area (immediately east of Bramalea GO station) estimate to accommodate freight traffic.

7.5. Milton Corridor

- The implied benefit:cost ratio for electrification of the Milton corridor is 0.94:1 based on the 2010 electrification study, a very strong score.
- This service operates on one of the most heavily used CP freight corridors. Therefore, accommodating heavy volumes of both freight and passenger services would be a key factor in corridor design. CP requires two-track freight service at all times on this corridor. Therefore, a 4-track corridor would be necessary to run frequent all-day GO service with high peak period demands, regardless of the technology selected for GO trains.
- A 4-track corridor would involve expansion of ten river crossings and six existing road bridges.
- Consider alternative solutions for two at-grade road-rail crossings where conventional grade separation would appear to be unreasonable. These two crossings are at Ontario St W and Loreland Ave.
- Consider relocation of the Kipling GO station to Islington for improved convenience and efficiency of connections between the GO system and local transit, and better integration with the urban fabric of Etobicoke Centre, an Urban Growth Centre.
- One new station proposed as part of the Reference Case (at Trafalgar Rd [Agerton]) and five more are proposed in this Regional Rapid Rail report – two in Toronto and three in Mississauga.
- Corridor property constraints combined with the demands imposed by freight and passenger services would complicate the implementation of overtake tracks, although such provisions are not impossible.

7.6. Richmond Hill Corridor

- This corridor presents significant potential for intercepting passenger demand that currently favours the Yonge subway. There is political pressure to extend the Yonge subway north to Richmond Hill in order to serve the growing demand north of Finch, but this would risk exacerbating capacity problems downstream. At $4.2-billion for a 6.8km line (7.4km with satellite yard), it is an extremely expensive project.
- As cited in the recent Downtown Rapid Transit Expansion Study (DRTES) released in October, 2012, the Yonge subway faces significant capacity challenges in the future, even without an extension northward. The DRTES assumed "enhanced GO services", but the service frequency for the Richmond Hill corridor was not modeled at a frequency better than every 20 minutes. EMUs on the Richmond Hill GO line would have the potential to provide significant Yonge corridor relief, at reasonable cost. To provide alleviation on the Yonge subway, capacity above projected demand would be necessary to absorb the diverted demand. Consider a 2031 EMU service frequency of 4.25 minutes along the Richmond Hill corridor and extending all peak hour trains and platforms from 12 to 16 cars in length. This would represent an increase from a frequency of every 5 minutes with 12-car trains for a 2031 EMU base service calculated from the 2008 modeling backgrounder published with *The Big Move*. The extra capacity could be provided at an extra cost of around $300-million. This capacity in the system would provide the time needed for implementation of new subway capacity between Flemingdon Park and Toronto's downtown, but it must be noted that both the Richmond Hill GO corridor and the new subway will ultimately be heavily used.
- Consider switching from the current ex-CN Bala subdivision routing to the ex-CP Don Branch routing between Lawrence Ave E and Gerrard St E for improved speed south of Lawrence Ave E. Access to the Don Branch would be provided via new, dedicated GO tracks along the CP main line using lands mostly occupied by former freight yards. Utilizing the Don Branch would shorten the route by approximately 1km. If the tracks were rehabilitated and upgraded, the Don Branch speeds between Gerrard St E and Lawrence Ave E should be at least 50% higher than what is possible on the existing Bala subdivision between those same streets.
- Utilizing the Don Branch could also allow service to be provided to Leaside, at a station located close to the high density Thorncliffe Park community, and make a possible connection with the Eglinton-Crosstown LRT near Leslie St and Eglinton Ave E, dramatically changing the ridership projection for the Leslie station along the Eglinton-Crosstown.
- Twelve new or altered stations are envisioned in this Regional Rapid Rail report, including one at Thornhill that, although more expensive than a typical GO rail station, would meet an important need and may not be possible to add at a future date due to potential complications relating to the Doncaster diamond grade separation project. No connection from the Richmond Hill corridor to the Bloor subway is proposed in this report, due to such a connection's great complexity and probable high cost.

7.7. Barrie Corridor

- Significant untapped potential for growth in this corridor is known to exist, with numerous additional stations already proposed by Metrolinx (Earlscourt, Fairbank, Downsview, Concord, and Innisfil), York Region (Kirby, Oak Ridges, and Mulock), and the City of Toronto (Wallace-Emerson). With the exception of Innisfil, all existing proposals are located on the Toronto-Bradford section of the corridor.
- This Regional Rapid Rail report generally agrees with the 2010 electrification study's conclusion that corridors should be electrified in their entirety before starting electric service in a corridor. However, the Barrie corridor could be a potential exception, with the limitation that only off-peak service be provided by electric vehicles. A surplus of fleet would be available at off-peak times since most other lines would be electric by the time the Barrie corridor is electrified, and therefore no additional electric fleet investment would be required.
- Estimated off-peak energy savings support consideration of electrification of the Barrie corridor between Parkdale and Bradford. The section between Parkdale and Union would presumably have already been electrified by this time. Peak period diesel service to/from Barrie is assumed in this Regional Rapid Rail report to continue until end-of-life of diesel equipment, unless economic or operating considerations force early retirement of diesel equipment on the Barrie corridor.
- The fuel savings estimated in this Regional Rapid Rail report for off-peak EMU service to Bradford are significant due to the 67km one-way length of trip from Toronto and quantity of fuel involved for each trip. Not estimated, but also worth consideration is that fuel consumption would rise with the substantial number of additional stations along the corridor.
- The new infrastructure to be constructed involves double-tracking Union-Bradford, new grade separations, all but one of which are in York Region, and twinning some river bridges, particularly the Holland River bridge near Bradford.
- At the Davenport diamond, where the Barrie corridor crosses the CP North Toronto subdivision, a rail-rail grade separation solution is necessary, and is one of the most expensive line items in the capital cost estimate for this corridor. This Regional Rapid Rail report suggests integrating a new GO station between Bloor St W and Wallace Ave, as has been proposed in past City of Toronto planning documents to provide an interchange with the Lansdowne station on the Bloor-Danforth subway. This would be a component of the Davenport diamond grade separation project.
- Consider approximately 5km of overtake tracks for running express services at locations to be determined.
- Consider potential road configuration adjustments in King City as an alternative solution to peak period traffic volumes around the King City GO station due to significant complications associated with a grade separation at Station Rd.
- Consider elevating the existing Aurora GO station in its current location to achieve a grade separation with Wellington St E in Aurora.

- Consider relocation of the existing Newmarket GO station to the opposite side of Davis Dr in order to enhance safety at the station by not locating the station along a curve with a large building obstructing sight lines and sound paths.
- Four additional stations beyond existing proposals are proposed in this Regional Rapid Rail report – two in Toronto and two in York Region.
- Consider relocation of the York University GO station to abut Steeles Ave W to connect with bus services.
- Consider a short reinstatement of tracks to a downtown station in Barrie, to connect with the Downtown Barrie Bus Terminal.
- There may be freight traffic management concerns between Finch Ave W and Steeles Ave W requiring scheduling agreements in coordination with CN and CN customers.

7.8. Union Station Rail Corridor (USRC)

- The USRC is a special part of the network where every train ultimately operates. This creates significant challenges as a consequence. Modeling a design in this corridor capable of meeting 2031 service levels that match *The Big Move* projected demands was the most complex part of this Regional Rapid Rail report.
- Work currently underway on track layout and platforms is expected to provide the capacity required for projected demands at Union Station until 2021.
- Metrolinx recently published two studies on the USRC: The *Union Station and Union Station Rail Corridor Capacity Study* and the *Union Station Demands and Opportunities Study*. Results of these studies indicated that four new underground tracks would be needed at Union Station by 2031 in order to accommodate approximately 90 trains through the station during the AM peak hour. An alternative proposal presented in the aforementioned studies that involved a satellite terminus between Spadina and Bathurst serving the Georgetown and Barrie corridors would appear to encounter operating complications in the medium- to long-term.
- In addition to extra tracks, future improvements to platforms and pedestrian management will still be needed to meet 2031 demands; i.e. meeting the need to safely empty a train of 1,500-2,000 passengers in less than 2 minutes.
- The analysis in this Regional Rapid Rail report agrees with the aforementioned reports that a total of 18-19 tracks will be needed at Union Station by 2031. That suggests that 3-4 new underground tracks at Union Station would be essential if unreliable peak period service on GO rail corridors is to be avoided. VIA Rail Canada may also be affected in the absence of new underground tracks. A conceptual track assignment model that would maximize corridor capacity for 2031 demands was developed in this Regional Rapid Rail report. This included providing track and platforms for VIA Rail Canada in addition to GO Transit. The analysis indicated that the Lakeshore corridor was best to move underground, and included the provision for future additional underground tracks at Union Station to be added when necessary.
- To avoid conflicting train movements between busy GO operations and VIA Rail Canada's "The Canadian" train through the Union Station Rail Corridor, consider having "The Canadian" use the Stouffville corridor with a connection to the existing transcontinental alignment near Beaverton. This would involve the restoration of about 50km of abandoned rail corridors between Beaverton and Uxbridge, comprising sections of three different railway subdivisions. This approach would be less costly than very complex alternatives confined to the rail network that is currently operational.

- Consider shoulder stations at the east and west ends of the USRC to increase route choice for riders and reduce the number of alighting passengers in the morning peak period at Union Station. Trains scheduled to terminate in the downtown core would pass through Union and terminate at a shoulder station beyond Union, with possible exceptions for a small number of trains to/from the Willowbrook yard. To the west, a station could be located at Fort York (Bathurst St and Front St W). The current Exhibition station may require relocation to Dufferin Gates as a result of its close proximity to the Fort York station. To the east, a new station could be located at the Distillery District (between Parliament St and Cherry St). Lakeshore train service at both shoulders would be at an underground level due to a lack of space to ascend sooner in the western section of the USRC and to frequent, closely spaced road-under-rail crossings in the eastern section of the USRC. At Fort York, westbound Kitchener trains and some eastbound trains would be a few meters below grade – but still open-air – to allow a platform to be installed beneath adjacent tracks.
- Interchange opportunities with a new east-west subway across the downtown core would enhance the GO rail network's versatility and conveniently serve a greater number of origin-destination pairs. An interchange would be especially opportune at Fort York, where a comparable proposal appeared in the *Union Station 2031 Demands and Opportunities Study*, except that no terminating operations eastbound at Fort York are envisioned in this Regional Rapid Rail report and all lines would serve the Fort York station. Similar opportunities for a connection east of Union Station would also be worth considering, but the alignment of a new east-west subway has far more potential alternatives east of Yonge St than west of Yonge St.
- In order to divert large numbers of GO rail passengers away from Union Station by means of shoulder stations, it would be very beneficial for employment concentrations to expand on an east-west axis within the precincts adjacent to or otherwise within walking distance of the USRC. Currently, employment concentrations have been oriented along the north-south axis that follows the Yonge and University subway lines.
- At the Bloor GO station, only Kitchener trains currently provide service while Milton trains pass the station without stopping. Metrolinx has expressed a desire for both trains to serve the Bloor GO station, but the limited available space precludes six tracks through the station. Were the airport to be served by regular GO trains instead of a separate service with a different fleet, five tracks at the Bloor GO station would be sufficient for both Kitchener and Milton corridors to serve the station.
- Consider additional stations at Parkdale, Riverdale and Cabbagetown if it can be confirmed that TTC services connecting with these stations could handle the projected AM peak surge loads. Both the Parkdale and Cabbagetown stations could be positioned to serve northern areas of the downtown core by means of enhanced streetcar infrastructure, if they would not be overwhelmed by the demand. The Riverdale station might serve a connection with a new east-west subway line, depending on its alignment.

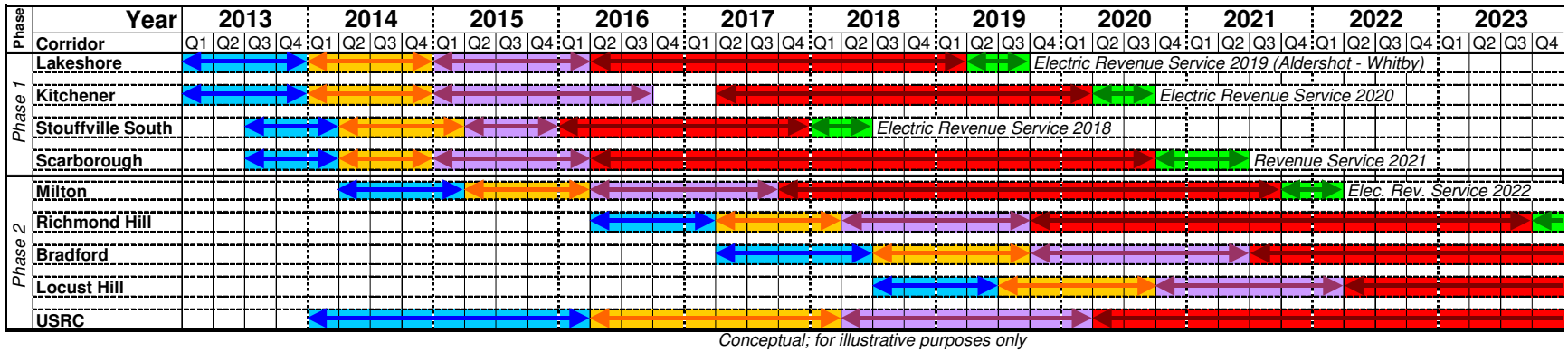
7.9. Network and Implementation Issues

- The service frequencies that would be needed to meet the demands projected in *The Big Move* would require a Positive Train Control signaling system in order to facilitate the closer spacing of trains. This would be applicable for all GO trains, as well as VIA Rail Canada trains serving the Greater Toronto and Hamilton Area.
- As trains enter stations, train bells must be sounded to meet the requirement of the Canadian Rail Operating Rules. To protect smart growth development opportunities around stations and avoid complaints from neighbours about the frequent noise of the bells when service becomes much more frequent, most GO stations should be upgraded to include an arched ceiling with a suitable acoustic lining and speakers pointing into this arch. Rural stations such as Gormley and stations near freight yards such as Aldershot would not need such upgrading.
- Consider two additional layover yards, one each west and east of Union Station, to accommodate the large number of trains that will require a layover location between the morning and afternoon peak periods by 2031. In the west, the most favourable location may be CP's Obico intermodal terminal (southwest of Kipling GO station), which has recently ceased operating. In the east, the most favourable location would likely be somewhere on the Havelock subdivision – where land may be found – on the conceptual Scarborough corridor.
- To support an all-day GO rail service model, expansion of local transit services would play an essential role given the inherent constraints associated with park-and-ride facilities for a rail network that is radial with respect to the downtown core. All issues associated with coordinating the various transit services would be determined in negotiations with local transit agencies.
- It is recognized that new stations would not be opened simultaneously on any given corridor. Some new stations would be implemented sooner to meet latent demand as service frequencies improve to provide more capacity, while other new stations would be part of broader planning opportunities relating to sustainable development and smart growth. This would also represent a good opportunity to build public and political acceptance of regional rapid rail.
- Based on a 2008 study of the Lakeshore corridor, the timeline to electrify each corridor is expected to be 7-8 years, including environmental assessment, design, construction, and commissioning. If would be feasible, and conceivably more efficient, to stagger multiple corridors' workflows. This would facilitate dramatically more expedient electrification of the network as a whole. The most efficient means of electrifying an existing rail corridor is to use what is known as a multi-function "factory train," which is like a rail-mounted assembly line that typically operates during overnight periods, electrifying approximately 1.6 single-track-kilometres per night.
- The timeline envisioned in this Regional Rapid Rail report for electrified revenue service to be phased in is roughly as illustrated in the table on the following page. While this sequence has been used for estimating purposes, policymakers could change the prioritization sequence.

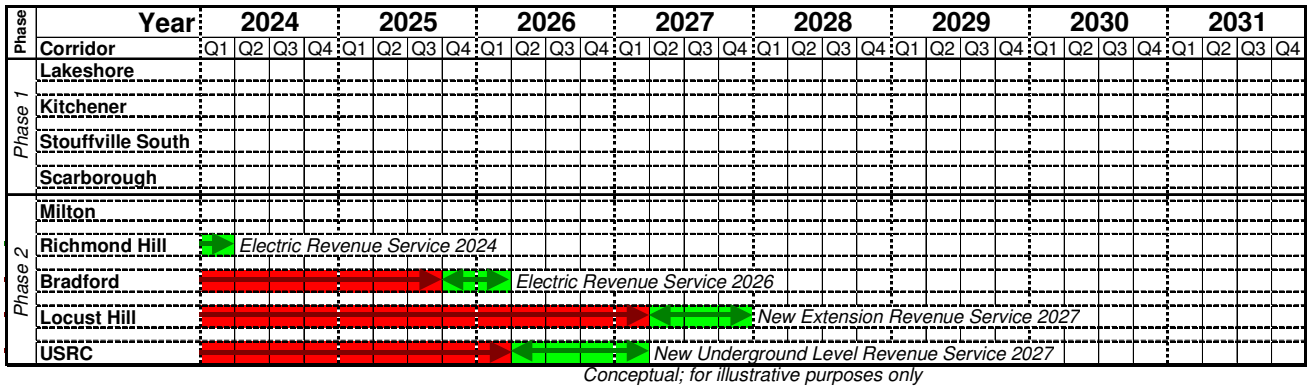
Conceptual Roll Out of GO Electrification

Phase 1			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Stouffville South	Kennedy to Ellesmere	2017	Necessary EA approvals already in place from SRT
	Ellesmere to Unionville	2019	Also includes Scarborough Junction to Kennedy
Lakeshore	Hamilton to Bowmanville	2019	Hamilton (TH&B) may require more construction time
Kitchener	Kitchener to Toronto	2020	Excludes through-routed Pearson service
Scarborough	Ellesmere to Malvern	2021	No factory train – new rapid transit construction
Phase 2			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Milton	Milton to Toronto	2022	Runs to Distillery District east of Union Station
Richmond Hill	Toronto to Richmond Hill	2024	Can alleviate Yonge Subway with additional fleet
Barrie	Bradford to Toronto	2026	Consider reinstatement of line into downtown Barrie
Underground USRC	Parkdale to Riverdale	2027	Surveying, design work, etc. should start as soon as possible
Kitchener	Rexdale to Pearson	2028	Corridor through-routed via Pearson Airport
Phase 3			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Scarborough	Malvern to Locust Hill	2029	New construction connects with Havelock subdivision
Stouffville North	Unionville to Lincolnville	2036	Approximate end of life of current locomotives
Barrie	Barrie to Bradford	2036	Approximate end of life of current locomotives

A hypothetical implementation plan may look comparable to the following project schedule:



Conceptual; for illustrative purposes only



Conceptual; for illustrative purposes only

LEGEND

- Preliminary Design (10%)
- Environmental Assessment (30%)
- Detailed Design and Procurement (100%)
- Execution/Construction
- Commissioning

8. Conclusions

The Big Move projections for the future of the GO rail lines are ambitious, with some lines being called upon to carry more than 20,000 passengers per hour per direction (i.e. a train every 3½ to 5 minutes). The key conclusion of this Regional Rapid Rail report is that these projections prepared for *The Big Move* can be met if the capital required for the prerequisite infrastructure enhancements can be made available - electrified rail lines using EMUs, numerous new stations for better local transit integration, Positive Train Control, and all-day service every 15 minutes (or better). Indeed, on the basis of passenger capacity per dollar of capital expenditure, a GO EMU approach would be substantially more cost-effective than other rapid transit technologies, such as subway, LRT, or BRT.

Corridor	2021($B)	2031($B)
Lakeshore (West & East)	$4.56	$1.30
Stouffville	$0.73	$0.00
Scarborough	$1.72	$0.56
Kitchener	$2.67	$1.43
Milton	$0.87	$1.14
Richmond Hill	$0.49	$1.31
Barrie	$1.20	$1.15
USRC	$1.00	$4.68
NETWORK TOTAL	**$13.24**	**$11.57**

The cost analysis shows that, by 2031, annual network operating costs for EMUs are estimated to be $467-million less than diesel locomotive-hauled consists, which should spur a greater urgency to electrify as quickly as possible. Furthermore, of the $17-billion capital cost for the 7 existing rail corridors (not including the USRC), the cost analysis also shows that about 74% of the total would comprise costs associated with accommodating the required service levels, as well as new stations that have been included in existing plans. Including the purchase of the EMU fleet, the electrification costs ($2.7B) represents only 18% of the $17-billion total and could be readily recouped by the aforementioned operating cost savings. The remaining 8% includes the cost of Positive Train Control, and new stations that were not part of existing plans at time of writing.

The vision outlined in this Regional Rapid Rail report, which corresponds with much of what The Big Move envisions for the GO rail system as a whole, cannot be achieved without the Union Station Rail Corridor being expanded by means of a new underground track level. Running DMUs every 15 minutes in both directions would consume disproportionate Union Station Rail Corridor resources at its most constrained point. A transition strategy that re-purposes the DMU infrastructure as LRT infrastructure could be worth considering in an effort to avoid difficult operating complications developing in the Union Station Rail Corridor at some point between 2021 and 2031.

It is proposed in this Regional Rapid Rail report that the DMUs already purchased for the Air-Rail Link be reassigned to operate between the Hamilton TH&B station and St Catharines (or elsewhere

in the Niagara region), as the ridership projections and patterns published in the EA for expansion into the Niagara region would not support full-length GO trains.

In large part, this Regional Rapid Rail report reflects the conclusions of the report "No Little Plan" written by Greg Gormick in 2011. It is also remarkably consistent with a little-seen "Super GO" report from 1974 prepared for the Ontario Government's then-Ministry of Transportation and Communications that analyzed electrification of the Lakeshore corridor.

The most influential factor relating to operating costs resulting from electrification was energy cost. Notable was the very wide increase in the gap between fuel options between the 2021 and 2031 horizons.

It is essential to highlight the sensitivity to the price of diesel fuel, as the price of oil is known to be volatile and therefore difficult to predict. The price of a barrel of oil went up by 550% between early 2002 and early 2012, and gasoline prices in Toronto have doubled over the last 10 years, which is equivalent to a 7.5% annual average increase. This is indicative of the enormous risk inherent in choosing to maintain dependence upon diesel motive power. Such a decision could lead to particularly serious consequences if there is a sharp increase in the costs of oil production as new sources become increasingly difficult to extract in a safe and environmentally responsible manner. Potential instability of certain major oil producing regions is another factor to consider seriously.

Energy Cost Sensitivity Analysis for 2021 & 2031

Average Annual Price Increase		Annual Network Operating Savings ($M)	
Diesel	Electric	2021	2031
6%	6%	$43.00	$305.58
6%	7.5%	$37.24	$268.57
6%	9%	$30.61	$219.64
6%	10.5%	$23.00	$155.21
6%	12%	$14.29	$70.69
7.5%	**6%**	**$62.66**	**$466.78**
7.5%	7.5%	$56.89	$429.76
7.5%	9%	$50.26	$380.83
7.5%	10.5%	$42.66	$316.40
7.5%	12%	$33.94	$231.88
9%	6%	$85.57	$682.84
9%	7.5%	$79.80	$645.82
9%	9%	$73.17	$596.89
9%	10.5%	$65.57	$532.46
9%	12%	$56.86	$447.94
10.5%	6%	$112.23	$971.26
10.5%	7.5%	$106.46	$934.25
10.5%	9%	$99.83	$885.32
10.5%	10.5%	$92.23	$820.89
10.5%	12%	$83.51	$736.37
12%	6%	$143.17	$1,354.80
12%	7.5%	$137.41	$1,317.78
12%	9%	$130.78	$1,268.85
12%	10.5%	$123.18	$1,204.42
12%	12%	$114.46	$1,119.90

Debt interest rate and average labour cost increase changes had negligibly small impacts.

The sensitivity analysis relating to energy costs set out in the table on this page supports the assertion that the methodology applied in this Regional Rapid Rail report is reasonably conservative, in that it is based upon recent and established trends. This has very serious ramifications for future provincial budgets in the form of subsidies, or for sharp increases in transit fares on the GO rail system. Electrification would offer a safeguard against such volatility.

Regarding capital cost estimates between now and 2021, there is a great deal of common ground between this Regional Rapid Rail report and the requirements associated with the "Next Wave" of *The Big Move* that was being promoted at time of writing. One element of the comparison that would be necessary to consider is the issue of subway network capacity constraints. The Scarborough GO corridor is particularly relevant to this, as proposals such as the SRT (LRT) that would feed more riders onto the Bloor-Danforth subway would push demand above what it can carry while the Scarborough GO rail corridor proposed in this report would alleviate the Bloor-Danforth subway. As was discussed in Chapter 7, capacity expansion on the Bloor-Danforth subway would be complicated. A value of $1-billion was assigned as a representation of this cost, although this may be understated, and includes a new yard and its connecting tracks, new fleet, and new pocket tracks to enable trippers similar to what is done on the Yonge subway during the morning peak period. Therefore, most of the costs between now and 2021 would not be "new money."

While there is a lack of information publicly available for constructing a comparison over the 2021-2031 period, the costs of proposals in this Regional Rapid Rail report between now and 2021 can be reconciled with the "Next Wave" and the SRT. While the capital cost estimate from not 2021 is $13.2-billion, existing plans and network requirements are worth $11.5-billion, a $1.7-billion difference, as detailed in the following table:

Reconciliation up to Year 2021

GTHA Regional Rapid Rail		The Big Move [Next Wave]			
Item	**Cost ($B)**	**Cost ($B)**	**Item**	**Funding Status**	**Funding Description**
Diesel Case (7 Corridors)	$6.0	$4.9	All-Day 2-Way Service (5 Corridors)	Requested	Funding requested
Lakeshore Electrification	$0.9	$1.7	Lakeshore Electrification	Requested	
Kitchener Electrification	$0.6	$0.9	Kitchener Electrifcation	Requested	
Subtotal	**$7.5**	**$7.5**		Requested	Total funding requested
Scarborough Corridor	$1.7	$1.8	SRT	Committed	Total funding in hand
Subtotal	**$1.7**	**$1.8**			
USRC Expansion	$1.0	$0.0	N/A (1)	None	Need identified in USRC study, but no estimate
Stouffville Electrification	$0.1	$0.0	N/A	None	No corresponding project or plan
Additional Stations, PTC, Misc	$1.7	$0.0	N/A	None	
Pearson Thru-Route	$1.2	$1.2	Air-Rail Link Accommodation (2)	Unidentified Need	Weston S/D 4th trk, fly-over, USRC req.ts, etc. for shuttle
N/A	$0.0	$1.0	Subway Capacity Expansion (3)	Unidentified Need	Various essential projects with no funding identified
Subtotal	**$4.0**	**$2.2**		Unfunded	No funding
Total	**$13.2**	**$11.5**	Total Funding Needs		

Notes:
1. USRC expansion with four underground tracks was recommended in the US & USRC Track Capacity Study
2. Air-Rail Link accommodation is estimated to be expensive to allow co-existence between expanded GO service and ARL service
3. More subway capacity required in the absence of the Scarborough Corridor and existing GO rail corridor capacity-boosting improvements.

This Regional Rapid Rail report draws attention to 17 items that would have significant impacts in relation to a more sustainable GO rail system being achieved within a reasonable period of time. Although all are important, the following, which have network-wide impacts, are especially critical:

- Replacement of the diesel fleet expansion plans and with a fleet plan based on EMUs.
- Revision of the parameters of the contract being prepared for the Whitby maintenance facility.
- Initiation of planning and design work for a new underground level through the USRC at the earliest opportunity.
- Development of a strategy to transition the Air-Rail Link service as it is currently envisaged into an operating model in which Kitchener GO rail EMU service would through-route via Pearson Airport. The current Air-Rail Link model would consume USRC resources that are disproportionate to its potential ridership and could be a significant contributor to operational complications over the long-term.

Queen's Park frequently reiterates its existing commitments to GTHA transit totaling $16-billion as the largest in Ontario history. However, in the context of three decades' worth of required catch-up (not to mention inflation), $16-billion does not go as far as one might wish, particularly when underground infrastructure projects are involved. To ensure the GTHA stays competitive, additional investment by Queen's Park will be required. This would most likely be achieved by means of new revenue mechanisms. The GO rail system is the most valuable regional transportation resource the GTHA has, but it can be much better. The system clearly has enormous potential, especially with EMUs (the most cost-effective option), if Queen's Park decides to invest in that system. There has to be dedicated, visionary leadership at Queen's Park, similar to that demonstrated by Premier John Robarts in the 1960s that resulted in the debut of GO Transit service between Pickering and Oakville, and also resulted in the guaranteed loan for then-Metropolitan Toronto to assist with the construction of the Bloor-Danforth subway, which was instrumental in bringing forward the opening date of the Keele to Woodbine section from 1969 to early 1966.

It is physically feasible to make this transformation in GO service happen if the leadership at Queen's Park is seriously committed to keeping the GTHA the envy of most other regions across North America – as Premier Robarts demonstrated a generation ago. Will Queen's Park lead, and help secure the requisite funding and legislative support? The region's future depends on it.

1. Introduction

1.1 Background and Precursors

In 2006, Metrolinx was established by the Ontario Government to develop and implement a regional transportation plan for the Greater Toronto and Hamilton Area (GTHA), released in 2008 and entitled *The Big Move*. At the time, it was estimated to cost $50-billion over 25 years.

GO Transit (GO), a division of Metrolinx since 2009, operates seven commuter rail corridors (all currently diesel powered) totaling 450km and serving 62 stations. They connect Toronto Union Station with Hamilton, Milton, Kitchener, Barrie, Richmond Hill, Stouffville, and Oshawa, and are envisioned to play major roles in achieving the goals in *The Big Move*, particularly those identified for "Express Rail."

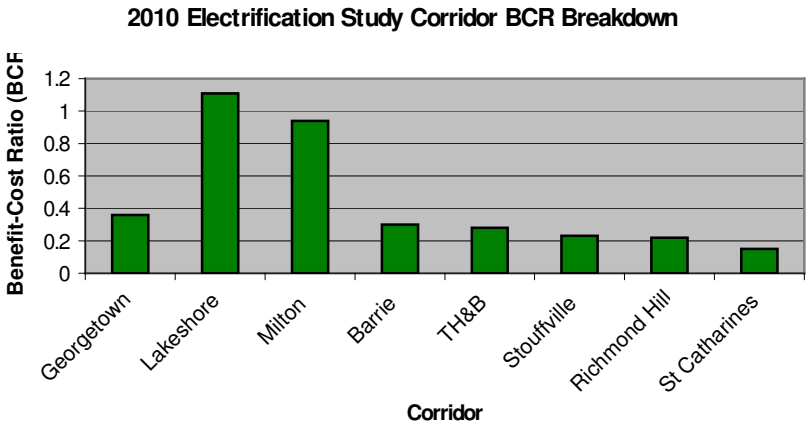
In January 2011, Metrolinx released a study on electrification of the entire GO rail network (hereafter referred to as the "2010 electrification study"), undertaken as a result of public opposition to projected rail traffic volumes in the Georgetown South Service Expansion and Union-Pearson Rail Link environmental assessment. The Metrolinx Board approved the 2010 electrification study on January 26, 2011, along with that study's recommendation of "Option 3," which consisted of electrification of the Lakeshore and Kitchener corridors. The Ontario Government announced the initiation of an environmental assessment for electrification of the Air-Rail Link alone within an hour thereafter, yet it was stated clearly on pages 56-57 of the 2010 electrification study's main document the following:

> *Option 1 ([Kitchener]) performs poorly with a [Benefit-Cost Ratio] of 0.4:1 because electrifying the [Kitchener] line alone does not have the critical mass in transportation benefits to offset the initial capital expenditure of electrifying large sections of the Union Station Rail Corridor. To electrify the Airport Rail Link alone would have a lower [Benefit-Cost Ratio] because it would incur most of the infrastructure costs but have limited journey time savings compared to Option 1 in its entirety.*

The above conclusion was sound, given the similar operating speeds of Multiple-Unit operation with either electric or diesel technologies for the Air-Rail Link. The Ontario Government spent $4-million to have the 2010 electrification study produced, and subsequently began down a path to electrify the Air-Rail Link alone, ignoring the warnings against such action contained within the 2010 electrification study.

Various combinations of corridors to be electrified were evaluated in the 2010 electrification study with a Benefits Case Analysis (BCA), wherein the benefits and costs were compared for each combination short-listed. The results were expressed as Benefit-Cost Ratios (BCRs), although the ratios were expressed as numbers rather than ratios since the underside of the ratios were always equal to one as a value of benefit per dollar of investment.

Breaking these results down per corridor is not truly reflective of the BCR for each corridor, since there are economies of scale and other factors involved that influence different combinations. That said, a rough idea of how the lines scored in the BCAs undertaken for the 2010 electrification study break down as per the graph below:



Note: TH&B, Stouffville, Richmond Hill, and St Catharines services are assumed, based on a derived combined average BCR of 0.22 for those four (Option 18 BCR of 0.5 x 8 lines less Option 15 BCR of 0.78 ÷ 4 lines = 0.22).

Transport Action Ontario has long been promoting a frequent, all-day, regional rail network for the GTHA. On June 1, 2007, the organization (under its previous name of Transport 2000 Ontario) released a high-level regional rail proposal. That proposal also endorsed a Toronto Board of Trade report from July of 2001, "A Strategy for Rail-Based Passenger Transit in the Greater Toronto Area," that recommended an off-peak GO service initiative as one part of a broader, regional, rail-based transit strategy. A lot has happened in the past five years, with a lot of information publicly released over that time, and the most recent data now available may warrant a renewed look at the "how" associated with providing a target service level that would be sustainable in the GTHA region.

In May, 2011, Transport Action Canada, Transport Action Ontario, the Clean Train Coalition, and the Canadian Auto Workers released a commissioned report by Greg Gormick titled "No Little Plan: Electrifying GO Transit." That report, which had its differences of opinion with the 2010 electrification study (with detailed reasons explaining why), chronicled GO's decades of experience in studying electrification. It provided a general history of electrified railways worldwide, illustrating how and why the technology is proven, powerful, and popular. "No Little Plan" also pointed out what has resulted from applying the technology in other jurisdictions, but it did not explore details of the opportunities and challenges a GTHA context entails for electrifying the railways used for GO.

"No Little Plan" asserted that electrified GO rail service would strategically position the GTHA for meeting future travel demands in a sustainable fashion, and Metrolinx publications seem to point to the same thing. However, the challenging political environment for funding such an undertaking complicates decision-making on this important choice, and remains a key issue that has not yet been addressed. Complicating matters further, the 2010 electrification study's focus on 2021 has resulted in an absence of the longer-term operating costs of a diesel service at the service levels envisioned by 2031 in *The Big Move*. A key related question, which urgently needs an answer: "Does the GTHA need Electric Multiple-Unit (EMU) equipment to replace today's Locomotive-Hauled Consists[1] (LHCs) over the long-term?" This requires a model of 2031 service levels.

[1] "Consist" is industry jargon for "train"

1.2 The Vision for Regional Rapid Rail in the GTHA

This Regional Rapid Rail report envisions an efficient, longer-distance, all-day frequent transit service covering most population centres within the GTHA. This could see the GO rail system evolve into a service comparable to StadtschnellBahn (S-Bahn) systems in Berlin, Germany, and Vienna, Austria, and similar such systems in many other major urban areas. This would involve:

1. Electrification with EMUs to provide improved operational flexibility and greater cost-efficiency
2. Expanded connections with local transit along electrified lines to increase the quantity of convenient interchanges and origin-destination pairs, by adding 56 stations to the existing network, as well as another six new stations along a new line through Scarborough
3. Improved service frequency to substantially reduce the impact of just missing a train, as summarized in the table below

2021-2031 Service Outlook

Service Level by Period	Peak Hour Frequencies in minutes (Average)			Off-Peak Frequencies in minutes (Scheduled)		
Corridor	**Current**	**2021**	**2031**	**Current**	**2021**	**2031**
Lakeshore West	10	6	4	30 to 60	30	15
Lakeshore East	8.5	6.5	5	30 to 60	30	15
Kitchener (via Pearson)	25	8.5	4	Bus only	60	15
Milton	15	10	3.5	Bus only	60	15
Richmond Hill	30	20	5	Bus only	60	15
Barrie	30	15	10	Bus only	60	15
Stouffville* **	31	15	10	Bus only	60	15
Scarborough (NEW)	Not built	n/a	6	Not built	n/a	±7.5

****Stouffville Corridor: Based on June 29, 2010 Metrolinx report, not the 2008 Modeling Backgrounder which had a far lower implied frequency.*

NOTE (Peak Hour): Peak Hour frequency is an average based on the AM peak hour, and not representative of a conceptual schedule.

NOTE (Off-Peak): Metrolinx has previously suggested network-wide 15-minute service; e.g. in the 2008 Lakeshore Corridor electrification study. Off-peak service does not necessarily mean rail service over the entire corridor end to end (varies by corridor).

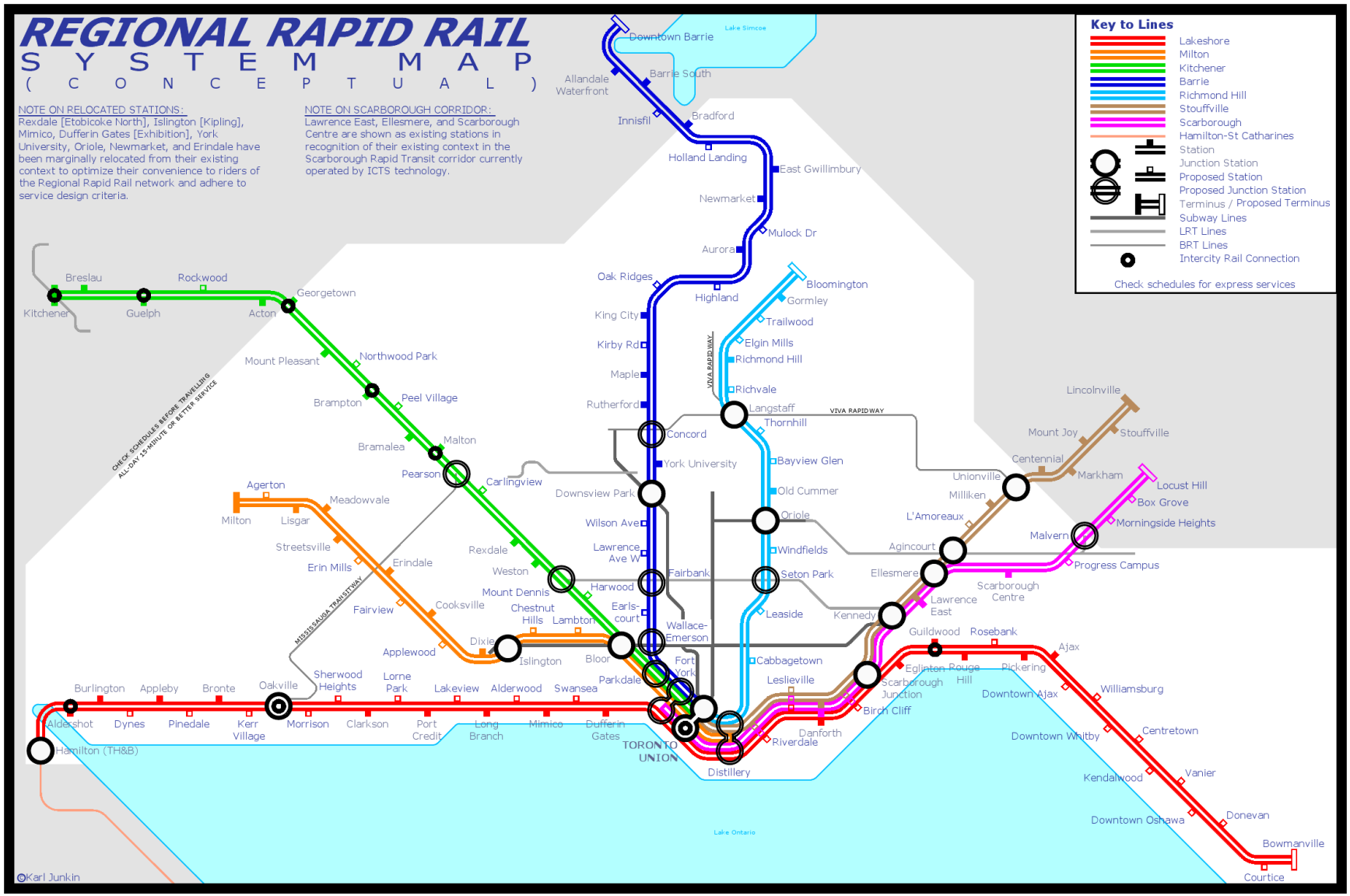
1.3 The Goal of this Report

With a detailed outline of what the GO rail system could be capable of providing, with many elements made practical only through electrification, policymakers and elected governments would have the information needed for ambitious service expansion in a credible and achievable manner. There are many aspects involved, and this Regional Rapid Rail report attempts to present these in a coherent manner.

By making the needed information available and digestible, all in one place, it is hoped that the government will have the confidence to take these ideas forward – ideas which by North American cultural standards would be considered “bold” yet by Eurasian standards could be considered “conventional.”

Transformative change does not happen overnight, but it can pass the point of no return in two full-length terms of government if action is swift from the start of the first term. If this is going to be successful politically, politicians have to get on the train before it leaves the station – which is shortly after the day of the vote.

As time passes, costs can escalate for a variety of reasons, and each year the busier lines remain diesel-powered operations represents annual operating expenses that are higher than necessary.



This diagram mimics the style of the original design of the London, UK system map conceived in 1931 by Harry Beck
This is a conceptual map representing a proposal for a network in the year 2031 and does not represent current service(s) or facilities

2. Network Needs and Opportunities

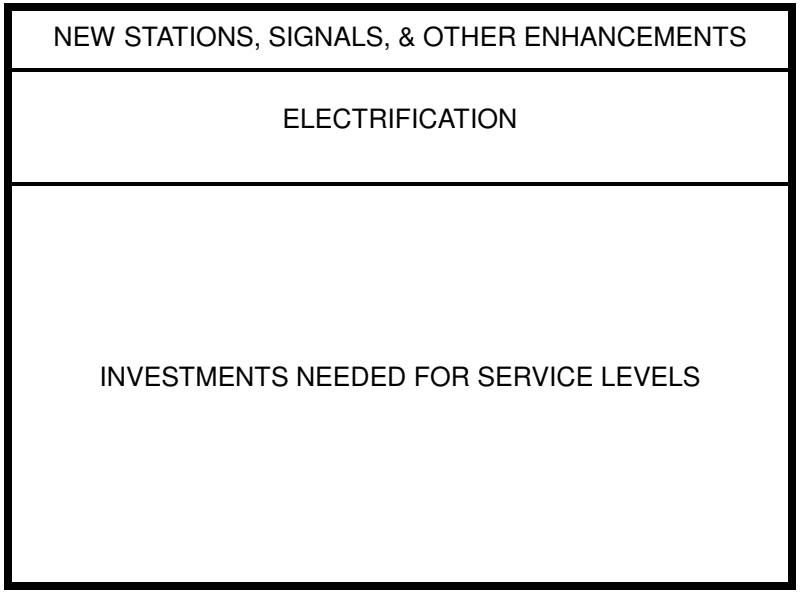
2.1 Fixed Infrastructure

In the 2010 electrification study, two types of fixed infrastructure were considered: Fixed infrastructure for service levels and fixed infrastructure for electrification.

Fixed infrastructure for service levels refers to tracks, widening of existing bridges over roads and rivers, rail-to-rail grade separations, train yards, and, while not identified in the 2010 electrification study (but can reasonably be assumed), road-to-rail grade separations. Fixed infrastructure for electrification includes the overhead catenary system, traction power substations, autotransformer stations, and underpass clearance adjustments where existing vertical clearance is inadequate. The 2010 electrification study's Reference Case, a conceptual 2021 network, identified the fixed infrastructure required for running enough service to meet 2021 demand. This report refers to Reference Case infrastructure as the "Diesel Case," as conceptual 2021 service model prepared for the 2010 electrification study was based on the travel times of current diesel trains. The separation of fixed infrastructure types resulted in electrification-specific costs being isolated, thereby avoiding any overstating of "the cost of electrification," a sensitive concern in that study. However, no cost estimates for the Reference Case were published.

The requirements for each corridor, both for service levels and for electrification, are identified in chapters 5 through 11, and issues with the Union Station Rail Corridor are discussed in Chapter 12. Other enhancements for improved service that are rendered practical by the adoption of EMUs as the vehicle for electric operation are also discussed, including estimated costs.

Rough Proportional Breakdown of Capital Costs (Visual):



2.2 Why an EMU Fleet?

The 2010 electrification study dealt only briefly with EMUs, wherein it concluded EMUs cost "40% more in capital cost, while over the 30-year lifecycle they were around 2.5 times more expensive." The 2010 electrification study provided a detailed analysis only for the locomotive technologies (electric and diesel). Chapter 4.3 of "No Little Plan" considered the EMU costs in the 2010 electrification study overstated, citing senior railroaders with extensive North American commuter rail experience.

These costs were analyzed through the work done in preparing this Regional Rapid Rail report's appendices. The only way the 2010 electrification study's numbers could be reasonably reproduced through reverse engineering was for them to have assumed: (A) 12-car all-EMU trains[2], rather than a composition of half EMUs and half unpowered coaches as was presented and published in the electrification study's stakeholder workshop sessions; and (B) the replacement of 10-car locomotive-hauled trains on a 1:1 basis, rather than adjusting the service schedule/model to take advantage of the faster average operating speeds EMUs provide. The 2010 electrification study requirement that all trains be the same length at all times, presented in the study as part of the Reference Case, further diminished the potential of EMUs, particularly as it related to off-peak opportunities.

RABe 511 bi-level EMUs service the S-Bahn system of Zürich, Switzerland.
Top speed: 160km/h (100mph). Photo credit: Peter Elektro, 2011
Link: commons.wikimedia.org/wiki/File:Testfahrt_SBB_S-bahnzug_RABe-511-001_Re-450-s.jpg

[2] Simulated EMU travel times based on half-EMU, half-trailer consist, but cost calculations appear to have assumed an all-EMU consist with no trailers.

EMUs have the potential to revolutionize GO operations, and this appears to be recognized as a possibility in the last few pages of the 2010 electrification study. Even though the 2010 electrification study did state the electric locomotive was the preferred technology, staff told the Metrolinx Board they were not voting on an electric vehicle technology when that very question came from a board member just before approving the electrification study on January 26, 2011 (while there was no audio recording of this meeting, this author was in attendance and heard this exchange first-hand).

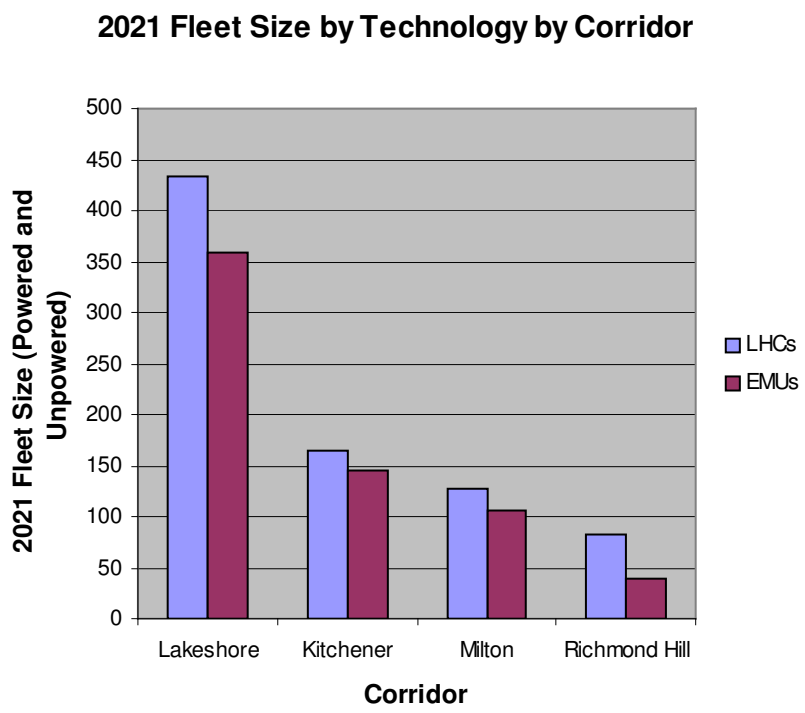
"VIRM" bi-level EMU trains criss-cross The Netherlands on various routes, many centred on Utrecht, with most route lengths in the 40-130km range. A 12-car "VIRM" bi-level EMU train is shown above. Operating since the mid-1990s, with a top speed of 160km/h (100mph). Photo credit: Maurits Vink, 2007
Link: en.wikipedia.org/wiki/File:VIRM6.jpg

EMUs are faster than LHCs of either technology, and are therefore able to provide the same service with fewer trains. Using the Lakeshore line from Hamilton to Bowmanville as an example, the 2010 electrification study stated this service would require 37 trains. The 2010 study did not actually state how many EMUs would be needed since it assumed 1:1 replacements, but it did provide enough information within its supporting background data to calculate that only 31 EMU trains would be required (Note: Four of those trains may best be DMUs – details are found in Chapter 5). Admittedly, the price per train would be higher with EMUs, but EMUs can serve their corridor(s) with a smaller fleet, making them cheaper to operate than the electric locomotive option in most cases, particularly by 2031. Extensive details of the capital and operating costs are included in the appendices of this Regional Rapid Rail report.

Providing the same level of service with a smaller fleet comes with other advantages:

1. Lower crew to passenger ratio
2. Smaller and cheaper maintenance facilities for the network, and possibly fewer maintenance personnel
3. Not as many spaces needed to park trains (a big benefit between rush hours, where downtown storage is increasingly harder to come by).
4. While each EMU train consumes a little more power per run than an electric LHC, a reduction in the number of trains by operating EMUs would lower overall power consumption on a line. Peak demand draw is also reduced with EMUs, and their higher regenerative braking potential creates more opportunities to share power within the network instead of drawing from the grid.
5. EMU cars are lighter, resulting in reduced track wear and, therefore, reduced track maintenance costs.

Human resources needed to provide GO rail service will still rise from today's levels since demand currently exceeds supply. However, as with mechanical resources, human resources will increase at a slower rate with EMUs than they would with expansion using LHCs, leading to further cost efficiencies for GO rail services. No jobs would be eliminated through electrification, but fewer new positions would be created per unit of ridership increase.



EMUs also reduce energy consumption for off-peak service, as longer EMU trains can be split easily into shorter trains. This was done by the Toronto Transit Commission (TTC) in the earliest years of the Yonge subway, when the original "Red Rockets" ran on the line. Some of those trains came with deliberately non-functional cabs that were used to make trains where half the cars had functional cabs and half had non-functional cabs, allowing them to split from an 8-car train into two independent 4-car trains. Technological advances now make such splitting much easier than when the TTC operated alternate-length trains.

Maintenance costs of EMU vehicles may be a little higher than those of LHCs, despite less trains being required with EMUs, but EMUs yield savings in other ways, including energy, labour, and debt servicing. As a result of EMUs' ability to provide more attractive service, GO ridership would be expected to increase by a wider margin, resulting in higher fare revenues with EMUs.

A 4-car "Red Rocket" heads south to Bloor as an 8-car set further down heads north. Original photo from the Toronto Archives, Series 385, File 305, taken April 23, 1954

Diesel trains running initially on the lines to be electrified could be shifted to other lines to expand service on lines that are still diesel-operated, or possibly used to provide trains for initial service on new lines. This means that there would be little or no loss from replacing diesel trains with electric trains in the context of the network. In fact, a spin-off benefit from electrifying the busiest line(s) would be the fiscally efficient expansion of non-electrified lines; the principal issue outstanding is the management of spaces to park trains at the ends of the lines – known as layover sites.

At time of writing, current fleet expansion plans see a near doubling in the size of the diesel train fleet between 2010 and 2020 before any work on electrification begins. While existing diesel equipment can continue to service non-electrified corridors (existing or new), investing $1.5-billion on a larger diesel fleet when electrification is under active consideration could risk becoming a poor allocation of a substantial sum of limited funds. Assuming a near-doubling in the size of the diesel fleet makes an enormous difference to the cost of bringing EMUs into the network, because the EMU coaches, whether powered or non-powered models, would differ fundamentally from the coaches currently pulled by locomotives. Although technically feasible, it would be cost-prohibitive to convert the locomotive-hauled coaches to EMU-operation, even for the non-powered coaches, according to LTK Consulting, the leading North American experts in electrified railways.

REFERENCE CASE GROWTH TO 2020			
Fleet	**Coaches**	**Cabs**	**D-Locos**
Unit Cost	$2.74	$3.06	$7.82
Existing*	459	53	57
On Order*	47	3	0
Projected**	828	92	92
Spares	42	10	16
Required	364	46	51
Subtotal ($M)	$997.4	$140.8	$398.8
TOTAL ($M)	**$1,536.9**		

** Existing and On Order fleet based on Canadian Public Transit Database. Details in Appendix F.*

*** Projected for 2021 revenue-service only (before spares)*

2.3 Whitby: An EMU Maintenance Facility

GO needs a new maintenance yard if it is to grow. Its sole existing such yard located in Mimico, Willowbrook, is at capacity. Ideally, under an electrification rollout, Willowbrook would continue undisturbed as the diesel facility, while a new facility for EMU trains is built east of the Whitby GO station.

However, the 2010 electrification study recommended an approach that would be more expensive and less efficient over the long-term. One factor involved was the assumption of electrification work not commencing until 2021, by which time billions in cost for the near-doubling of the diesel fleet would have been incurred. Therefore, the 2010 electrification study proposed that the new Whitby maintenance yard be designed as a diesel facility, with provision for electrification. However, said provisions would be for electric locomotive maintenance needs, raising the prospect of complex and costly conversion of the facility to maintain EMUs.

The 2010 electrification study also proposed that the Willowbrook yard be electrified first, but this approach would overall incur higher operating costs from fuel/electricity prices, due to the longer distance from Union Station to Whitby, at 51km, compared with Union Station to Willowbrook, at 11km. The 2010 electrification study assumed nine trains in 2021 would make out-of-service round trips between Union Station and the Whitby yard on a daily basis, representing a total 720 daily vehicle-kilometres more than would be required for utilizing the existing Willowbrook facility, a value that would rise in subsequent years with service growth. This would incur millions in additional annual operating expenses in addition to the capital cost of constructing the Whitby yard as a diesel facility initially rather than an electric facility.

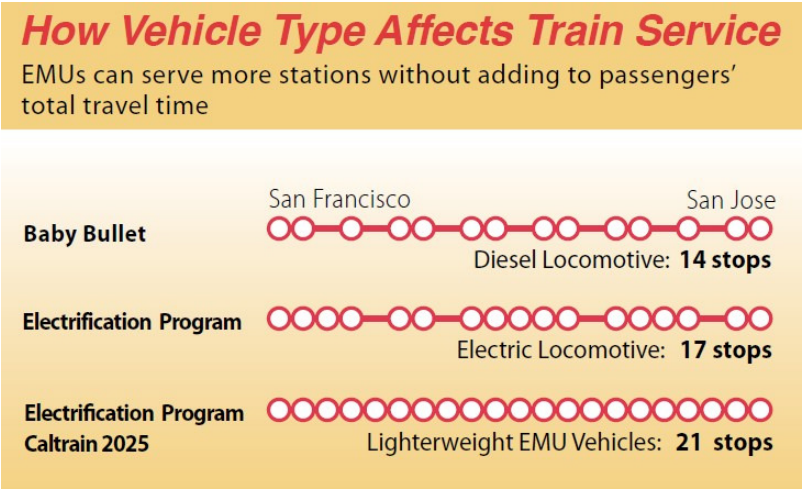
Electrifying immediately would allow all growth to be taken on by electric vehicles being added to the GO rail system. As mentioned in section 2.2, service increases on non-electrified lines can be achieved by reassigning the existing diesel trains from newly electrified lines, and these diesel trains can continue to be looked after at Willowbrook alone since there would be no new diesel vehicles added to the fleet in such a scenario. When the diesel train fleet requirements become less than what is currently operating, such equipment could be sold for estimated values outlined in Appendix A.

At time of writing, plans to move ahead with a diesel Whitby yard to expand the diesel fleet were recently funded. The adoption of a more cost-effective and sustainable GO expansion plan could be considered by utilizing the Whitby maintenance facility as the initial main facility for the electric fleet.

2.4 A More Comprehensive Network

GO Transit has historically focused on extending lines as far away from Toronto Union Station as possible instead of maximizing geographic coverage through additional stations along established GO rail corridors where there are residents to serve and local transit connections to feed the GO service. Examples exist along every GO line.

Electrification offers an opportunity to strengthen the network through enhanced coverage – without extending the lines. Adding stations to lines with electrification as the enabler is not a new concept; it is taking place right now in California where a line between San Francisco and San Jose (with many similarities to GO's Lakeshore lines) is being electrified with additional stations as part of the project. GO/Metrolinx had recorded a high level of interest among stakeholders in this topic at the start of its January 2011 electrification study, but the topic was not included in the final study publication, although three new stations (Agerton, Mount Dennis, Innisfil) were already in GO/Metrolinx's plans before the electrification study began.



Above from part of a January 2009 public handout in San Francisco, CA, "Caltrain 2025 – Rapid Rail Revolution"

http://www.caltrain.com/projectsplans/Projects/Caltrain_Capital_Program.html

Because early GO rail services were in many cases implemented before local transit services in many parts of what is now called the 905 area, GO was built to be very dependent on commuter parking at stations. Even though local transit exists in almost every jurisdiction now served by GO trains, GO is still quite dependent on commuter parking. This can create problems for electrification, as lots are often full by 7:30 a.m. and stay that way until 5:30 p.m., discouraging ridership between rush hours. Commuter parking has a role to play, as auto travel is an important mode in the broader transportation network. Recognition of the limits to auto travel to GO rail stations is growing increasingly vital as uneconomical parking expansion continues. Lately, this has included very expensive multi-storied parking structures at Burlington, Oakville, Aurora, Centennial, Ajax, and Whitby, with more under construction at time of writing.

Additional stations that do not depend on commuter parking can be the first to showcase more sustainable strategies for getting GO riders to stations at all times of day by means of a more integrated network with a greater quantity of high-quality links to local systems. Coordination and cooperation among GO and local transit systems would be very important to making such stations work. The more connections that can be reasonably and conveniently made between local transit systems and electrified GO rail, the more people can be expected to ride.

3. Introduction to Issues at Union Station

3.1 The Core Problem

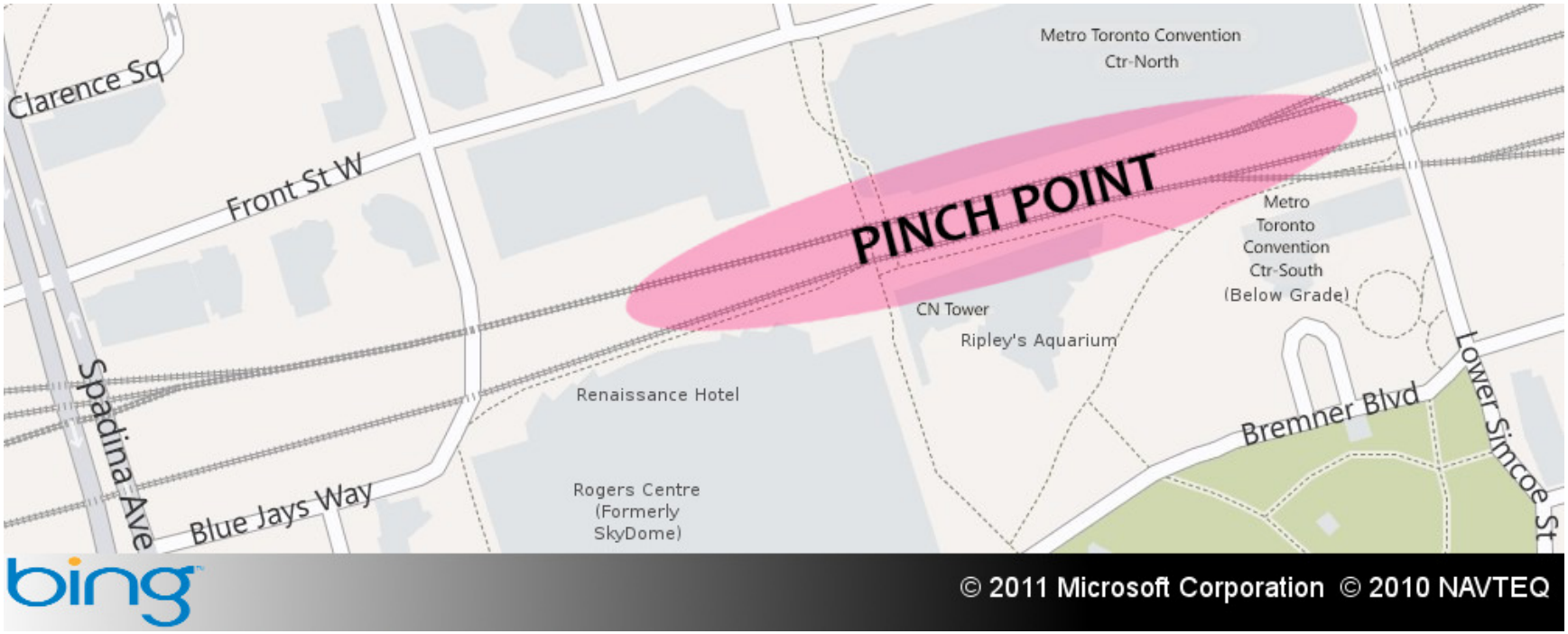
In 2008, Metrolinx commissioned consultants Hatch Mott MacDonald to prepare a Lakeshore Corridor Electrification Study, in which a major congestion problem at Union Station based on Metrolinx 2031 expansion plans was identified. Concurrently with the 2010 electrification study, Metrolinx commissioned a study to evaluate the capacity of Union Station. That study has been completed, and has spurred some spin-off works to provide short-term solutions to meeting projected 2021 demands. Near the end of the electrification study, the Union Station study served to confirm that Union Station does not have the capacity needed to accommodate 2031 demands for GO service. This is a very big, very expensive problem.

Every rail service now operated by GO connects to Union Station; by extension, constraints at Union Station affect all GO rail services. **This is <u>not</u> "just a Toronto problem,"** this problem affects Hamilton, Barrie, Simcoe County, and the regions of Halton, Peel, York, Durham and Waterloo, plus all locations en route.

In an effort to prepare the station for a much larger role in the future, large projects are already underway at Union Station and in the Union Station Rail Corridor (USRC).

The historical station headhouse, the train-shed, and the area beneath the tracks are getting a long-overdue rehabilitation and expansion. The expansion, which will include a new west concourse to allow new stairway access to GO train platforms to be added between the Great Hall and York Street, is especially significant as it is expected to improve platform safety by getting crowds on and off platforms more quickly, at more locations. In turn, this should allow trains to service the platforms in a more timely and safe manner.

In the USRC, improvements have been underway to modernize the 1920s-era track layout that has not been upgraded in over 80 years. The improvements will increase train speeds between Cherry St and Strachan Ave, by up to 100 percent in some sections (doubling permitted speeds). If that can be achieved, it would be a big improvement, but there is a key pinch point west of Union Station that makes things very complicated for increasing the number of trains that can run through Union Station in a given period of real time. The "pinch point" is between the CN Tower and the Metro Toronto Convention Centre North Building, and is compounded by the Rogers Centre (originally known as SkyDome) and the Renaissance Hotel.



No project currently underway will add any tracks to the station. In fact, one of the short-term solutions being designed will actually take away one of the highline tracks at the southern edge of the corridor (which currently has no platform to serve it). That track will be replaced with a platform to give all tracks at the south end platforms to handle passengers. Beyond this, expanding the existing platform level is physically impossible as there is a heritage building to its immediate north (the station's beaux-arts headhouse) and several recent high-rise structures to the south, as well as the abutting Air Canada Centre. Other challenges around Union Station are detailed in Chapter 12.

Electrification of the busiest lines, however, would create new possibilities that would be unthinkable with diesel trains, as explained in the following section.

3.2 An Underground Union Station

EMU trains, like the TTC's subways and streetcars, can operate underground in a cost-effective way, unlike diesel trains, and open an opportunity to add significant track capacity at Union Station.

If one looks at how Union Station is built, with structural columns located directly beneath the tracks, it quickly becomes clear that building a new track level above the existing train-shed would be physically impossible. For the same reason, any meaningful rearrangement of tracks at the existing track level is also physically impossible. Any new level has to be beneath the existing structure. The estimated depth needed to dodge all underground obstacles is around 23.5m beneath the existing track level, or almost two storeys beneath the TTC subway/streetcar platforms at Union. This depth estimate is based on drawings from the Digital Map Owners Group, a common source of utility mapping in the pre-amalgamated City of Toronto, and has also been confirmed in the *Union Station and USRC Capacity Study*.

Getting the trains to such depths is possible, but neither simple nor inexpensive. It involves a long approach to the new below-grade station on a gentle descent. The length of the covered part of the tunnel would probably be around 5km, from the west side of the Don River to Strachan Ave.

The highest number of tracks that could be added beneath Union Station with generous platform space (in stark contrast to the existing platforms in the train-shed) is seven tracks. The Union Station Capacity Study indicated that four new tracks would be required by 2031, but it would be reasonable to be prepared for future tracks beyond 2031 to be added as they become necessary.

An underground level at Union Station would take a long time to construct, and electric trains should be running years before an underground level would be ready for service. The underground level should be expected to have a multi-billion-dollar price tag. As detailed in Chapter 12, this Regional Rapid Rail report arrived at an estimate of $5.7-billion. The transportation demands projected for 2031 suggest that expansion of USRC track capacity would be essential to provide enough GO rail service.

4. Methodology and Validation

Great efforts have been made to be as transparent as possible in supporting the assertions of this report. All the background behind these findings can be found in the appendices that provide the detailed methodology used in this report.

The discussion of the individual corridors in chapters 5 through 11 had the costs grouped, with select exceptions, under 3 common categories. These categories were “Diesel Case,” “Electrification,” and “EMU Case,” all estimated for both 2021 and 2031 time horizons. The “Diesel Case” included the costs of fixed infrastructure required for providing service levels that would match the projected demand, as well as the fleet requirement to meet that service level with diesel locomotive-hauled consists (which in some cases was conceivably impractical). “Electrification” included the costs of electrification fixed infrastructure and electric vehicles. Fixed infrastructure costs were as provided by the 2010 electrification study where provided, and estimated by average cost per single-track-kilometre where necessary, while vehicle calculations were done by a reproduction of the 2010 electrification methodology and applied with EMUs using customized schedules that created an operations model that took advantage of EMU characteristics. The “EMU Case” includes the costs of additional enhancements to service quality, including Positive Train Control, and some additional stations for improved relationships and synergies with local transit connections.

4.1. Tools Used

Most of the appendices are generated from Excel worksheets that are combined into a fairly large (half-megabyte) workbook [spreadsheet] file and reliant on formulas wherever possible to minimize instances of human error and maximize data accuracy. To avoid errors in formulae, some cross-referencing checks were put in place to act as flags for spotting such errors easily and fixing them prior to publication. While the appendices are part of the publication, the Excel (.xls – 2000 version) file is being put online so that anyone can see how the numbers were generated, with a few cells left unlocked in Appendix A so that anyone can see how changing these limited unlocked variables can influence other values further down the chain.

During the process of data generation, there were some disagreements with the methodology applied in the 2010 electrification study. For completeness and transparency, this Regional Rapid Rail report documented these disagreements.

4.2. Foundation Data

Appendices A through F represent the foundations for the other calculations. Sources for appendices A and B are explicitly stated; an overwhelming majority of the figures are from the 2010 electrification study. Some new variables that were not included in that study have been added, for example, relating to labour. Appendices C and D are recreations of the 2010 electrification study data, for the purpose of clarifying the methodology applied therein and to cross-reference with this Regional Rapid Rail report's methodology. Appendix E identified some disagreements with certain Reference Case assumptions from the 2010 electrification study, in that the figures for the existing 2010 fleet did not appear to reflect the actual size of GO Transit's rail fleet in 2010.

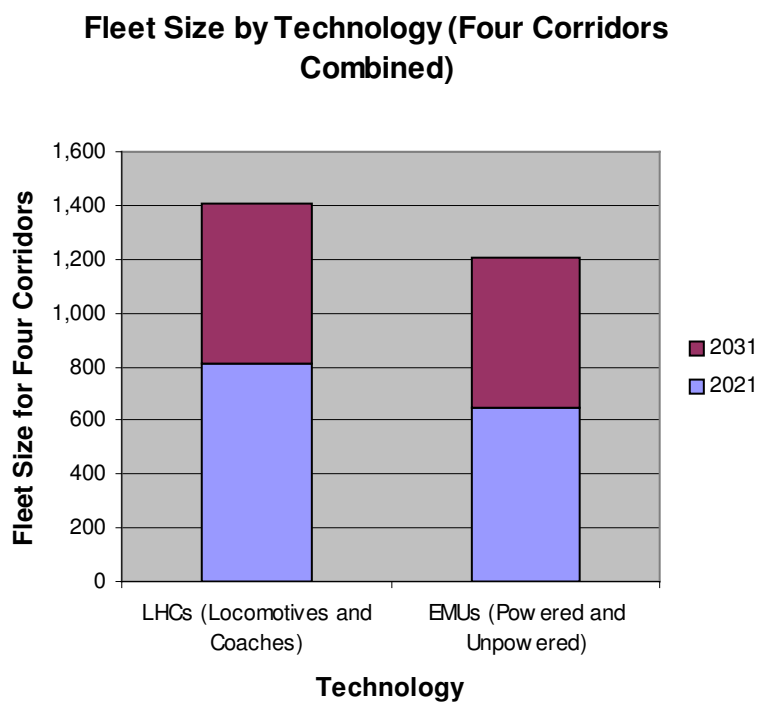
The full details of the existing unpowered fleet were assembled from the Canadian Public Transit Discussion Board and put into the table that forms the bulk of Appendix F. Rebuild and retirement dates that have not yet occurred are assumed, but are supported by the 2008 Hatch Mott MacDonald electrification report on the Lakeshore corridor, as well as more recent Metrolinx correspondence.

4.3. Appropriate Adjustments to Data for Operation with EMUs

Appendices G and H detail extensively the assumptions behind an optimized EMU operating model for the year 2021 developed as a substitute for the Reference Case. The EMU operating model is based on the capacity and travel speeds provided by the 2010 electrification study and reproduced in this Regional Rapid Rail report in Appendix C.

EMUs with an average operating speed that is faster than that of locomotives by a fair margin must have an operating model tailored to their higher performance, but the 2010 electrification study did not reflect this due to Reference Case assumptions. An approach that optimized the Reference Case operating model to each technology's performance characteristics should have shown EMUs requiring fewer vehicles than any locomotive technology to meet a target service level, and by extension, would have significantly impacted the cost of the EMU option. An EMU-tailored operating model for 2021 based on the Reference Case was developed in detail in Appendices G and H, the latter being a comprehensive breakdown of what is known as "equipment cycling" (simply described as how and when trains move from one part of the network to another throughout the day).

EMU turn-around time was based on O-Train operations in Ottawa, ON, where 3-car DMUs turn around in three minutes. With 12-car EMU trains, it was assumed that each of the two crew members on the train would have to move down five or seven cars, depending on which end of the train each crew member was assigned for a given terminus. In this turn-around operation, the driver becomes the



"customer service ambassador" and vice-versa. At a walking distance for each crew member of just over double the length of an O-Train, just over double the turn-around time was allotted, at seven minutes; the 2010 electrification study's Reference Case used a turnaround time for locomotive-hauled trains of ten minutes.

For Union Station dwells, Hatch Mott MacDonald identified in 2008 a minimum dwell time of four minutes at peak times, and that figure has been used in this Regional Rapid Rail report. The Union Station dwell time used in the 2010 electrification study was five minutes, but there was no published reason for the increase over the 2008 value.

For the evaluation of 2031 service levels, Appendix I was prepared with the peak point projections published for *The Big Move* and used to project a rough estimate of the magnitude of equipment needed to meet demand in the peak hour. The 2008 backgrounder published on the modeling for *The Big Move* stated that the model assumed fare integration described in the backgrounder as follows:

> *Transit fares for the model were kept at the same current level, in real terms, with fare integration between local transit operators assumed, such that double fares for short cross-boundary trips would be eliminated. As discussed earlier in this backgrounder, model limitations preclude the ability to predict the beneficial impact on ridership of more widespread use of transit passes in the future. Discretionary use of transit would be expected to increase as the number of pass-holders increases, particularly in non-peak periods. As a result, the model may under-estimate future ridership.*

Linear extrapolation from the Reference Case was applied to the shoulder hours of the morning peak period to determine the impacts from the early morning build up of service. As the afternoon peak period demand is more spread out and thus exerts less pressure on the system than the morning peak period, the latter governed projected equipment needs. Cycling assumptions were very rough as insufficient data were available for 2031 equipment cycling needs (the detailed inputs for the 2031 modeling methodology (GGH model) have not been publicly released.

4.4. Comparative Data

For Appendices J through M, detailed cost comparisons were prepared through the combined interpretations of all the preceding appendices' contents. The costs were broken down into capital and operating costs, for the years 2021 and 2031.

Appendix J was dedicated to a comparison of capital costs by corridor, for both 2021 and 2031. It should be highlighted that spare pools are calculated cumulatively, meaning that the sequence of electrification impacts the size of the spare pool, and this factor is noted at the top of each corridor's table. That also applies to the diesel locomotive calculations, where the existing diesel fleet factors into the spare calculation. This Regional Rapid Rail report deviates from the methodology used in the 2010 electrification study in that the cost of vehicle rebuilds required between now and 2031 were applied to the existing equipment that would be needed for continued service in the locomotive model, detailed assumptions for which were provided in Appendix F. EMU equipment is not compatible with existing equipment and so does not have any rebuild costs associated with it in this time span. Because EMUs would eventually render some existing unpowered fleet as surplus, a resale value was assigned for these, as well as an adjusted diesel locomotive resale value based on the 2008 Hatch Mott MacDonald Lakeshore electrification report that used a sliding scale depreciation factor, as explained in Appendix A.

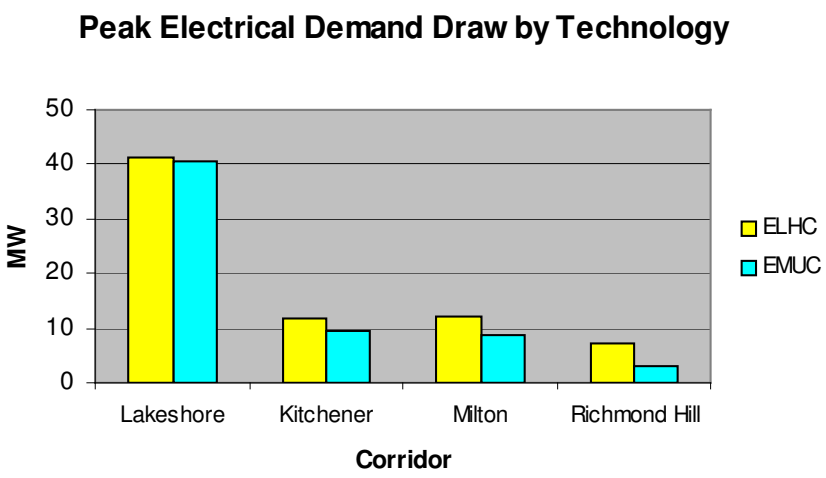
Electricity consumption for 2021 is broken down in extensive detail in Appendices K and L. In order to properly understand the basis of the electricity cost for each technology, it is necessary to estimate the demand charge separately from the consumption charge, since different technologies with different fleet sizes and weights will exert different demand loads and thus incur different demand charges in addition to different consumption charges. The 2010 electrification study combined these two charges into an average charge per ton-mile, but also included the unit costs for each of the consumption charge the demand charge from the Independent Electricity Systems Operator.

The 2010 electrification study provided detailed peak power demand results at each traction power substation in their network design in their Appendix 7; this information was read off of a graph and so may not be perfectly accurate, but should be very close. This information was compiled into a chart in Appendix K, and a second chart beside it assigned a peak demand electrical power draw to each corridor. In order to determine the accuracy of the power draw assigned, the kWh consumed per ton-mile was used for cross-referencing. This required reproducing the power draw of every corridor as modeled in

the Reference Case. The power in kWh required to move one ton of equipment across one mile of corridor was assumed to be consistent. This was compared against the reproduced 2010 electrification study calculations for electricity costs for checking accuracy, and then applied to other technologies. Technically speaking, each mile along a corridor would not require the same kWh to move one ton due to varying gradients, but the variance should be negligible for the purposes of this Regional Rapid Rail report.

This Regional Rapid Rail report was using the electricity cost for electric locomotive options provided by the 2010 electrification study, but it was discovered during reproduction of those calculations that the 2010 electrification study calculations applied locomotive weights in error: The ton-mileage incurred for electric locomotive operations was calculated using the weight of a Tier 4 diesel locomotive in the 2010 electrification study. As electric locomotives were only half the weight of a Tier 4 diesel locomotive, Appendix L included the "D-Loco" technology label for the reproduced 2010 electrification study figure, but the figure that accounted for the lower electric locomotive weight used the "E-Loco" technology label.

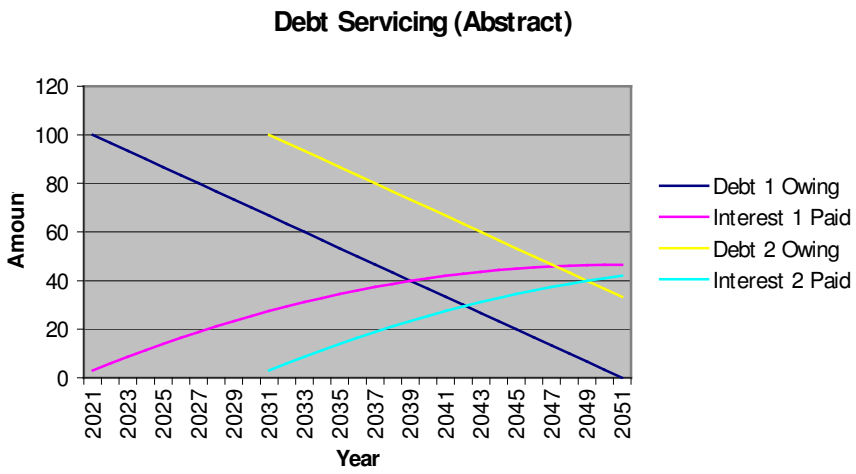
For EMUs, two separate calculations were prepared in the interest of transparency. The "EMU(1:1)" technology ran the 2010 electrification study's Reference Case with all assumptions unaltered, including all trains being the same length at all times and no consideration of schedule optimization. Given the Reference Case's restrictive assumptions, which do not capture the efficiencies of EMUs, the 2010 electrification study analysis resulted in EMUs having a higher electricity cost. Under a subsequent calculation label, "EMU(Best)" technology applied the optimized operating model constructed in Appendices G and H, where a smaller fleet was providing the same capacity and off-peak service was provided by shorter trains. When taking full advantage of what EMUs have to offer, the EMUs offered lower electricity costs, as well as a lower peak demand draw of 13-17MW, depending on whether or the Air-Rail Link was factored in. Not captured, however, is the potential reduction in demand draw from the greater regenerative braking offered by EMUs and the opportunity for greater sharing of energy within the network



between lines as some vehicles brake while others accelerate, for which opportunities would be plentiful within Toronto especially. The impacts of this potential demand draw reduction were not quantified, as the means to calculate such were not available for this Regional Rapid Rail report.

Appendix M assembled the train crew labour cost differences, as well as bus fuel and bus operator cost differences, and combined them with maintenance costs and other applicable data from other appendices for a total operating cost comparison.

Incremental debt servicing was also applied as an operating cost, even though that would not appear on the books of GO/Metrolinx if the capital expenses of electrification were government-funded (which would likely be the case). Incremental debt-servicing calculations were based on a 30-year bond, with 3% interest. In 2021, it was assumed the principal payment would be 1/30th of the incremental debt, with 3% interest applied on the total incremental debt amount; although technically unrealistic as capital expenses would have been spread over a number of years, this was done for simplicity. In 2031, there were two components to the debt calculation: Remaining debt and new debt. Two-thirds of the debt were assumed to remain from the 2021 calculation, with 1/20th of the remaining debt in principal plus 3% interest on the remaining debt (2/3rds of the 2021 calculation) being paid in 2031. New debt incurred between 2021 and 2031 was calculated separately with incremental principal and interest costs added to the 2031 value using the same method as 2021 calculations. This is visualized in the graph below, showing two separate debts outstanding and declining over time, shown together with cumulative interest paid on each of the two debts undertaken.



Note: Interest shown is cumulative over the life of the debt, taken at 3% for each year based on outstanding principal still owing. Debts displayed as net outstanding principal at each year, and declines over time as debt is repaid.

4.5. Fixed Infrastruture

Appendices N-T detail the capital cost assumptions for fixed infrastructure for each corridor, except for the cost to electrify the corridor. Many of the fixed infrastructure requirements were in the Reference Case, and are discussed in some detail in each corridor's dedicated chapter. The cost to electrify is as provided for each corridor by the 2010 electrification study, except for the cost of vehicles, which are discussed separately in detail.

4.6. Validation Summary

In order to assess the validity of the methodology for this Regional Rapid Rail report, reproductions of calculations from the 2010 electrification study were integrated into the spreadsheet structure as a screen to catch errors in calculation methodology. The results are presented below:

Parameter	Appendix	Deviation from 2010 elec. study
2021 Fuel Costs	D	0.02% to 1.22%
LS, KT ELHC Cost	J	0.17% to 0.5%
2021 Demand Draw	K	Matches 2010 study Appendix 7E
2021 kWh Cost	L	Match to 1.2%

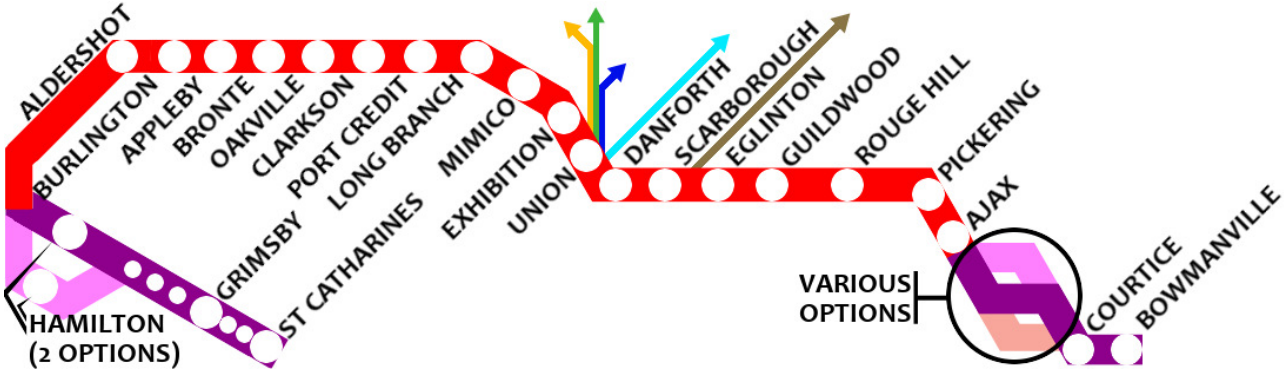
The deviations above are within acceptable tolerances and demonstrate that the costing methodology used in this report is sound.

5. Lakeshore Corridor

The Lakeshore East and West lines from Oakville to Pickering, via Union Station, are the oldest parts of the GO rail network (service inaugurated in 1967), and today represent the busiest section of the network – particularly Lakeshore West, which now also operates four weekday trains to/from Hamilton. The Lakeshore East service currently extends as far east as Oshawa. GO struggles to get enough trains into service for meeting the demand on the Lakeshore East and West lines, and has been adding new tracks to the corridor in recent years to make more room for running additional service.

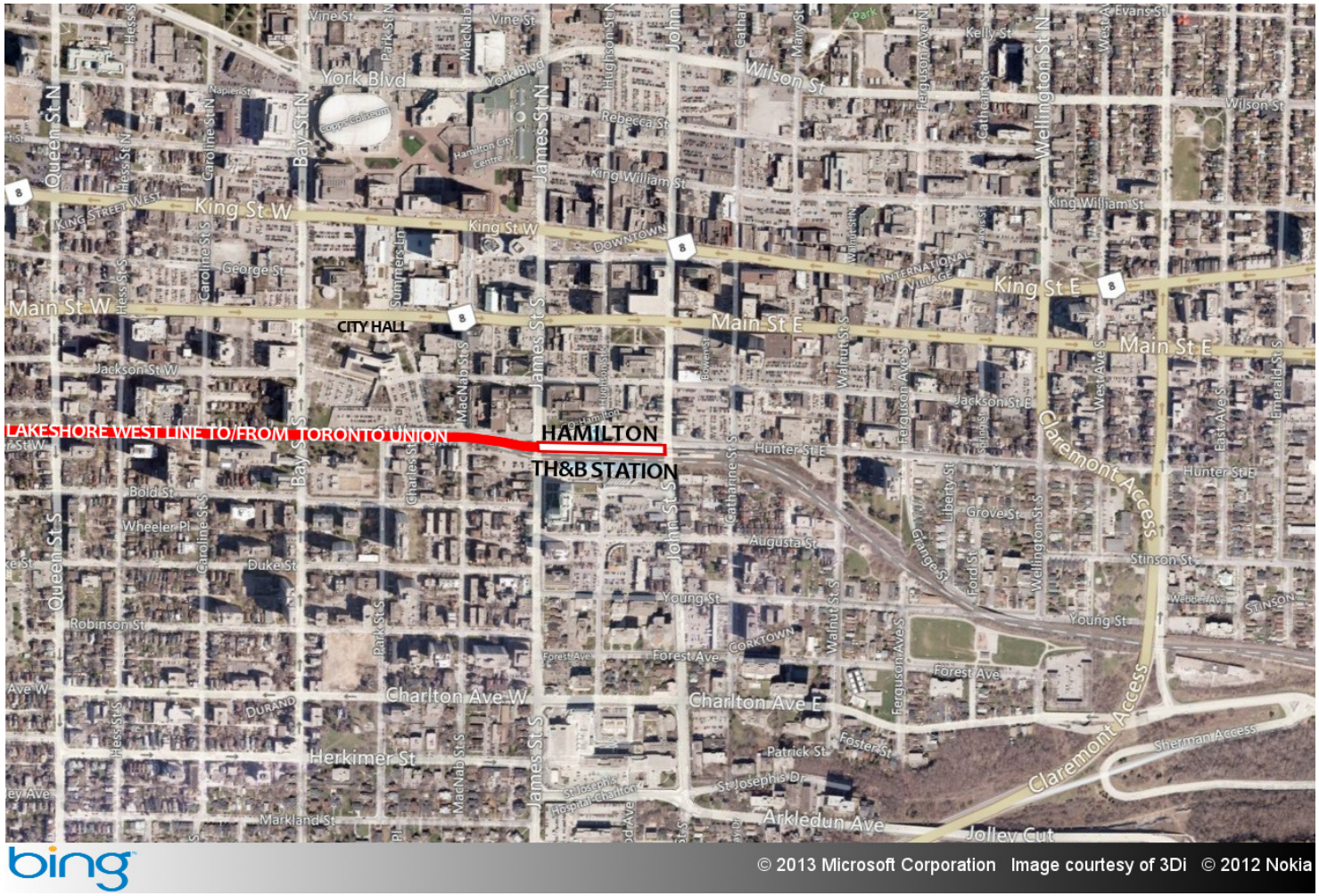
5.1. From Aldershot to Ajax

GO/Metrolinx is currently looking at extensions to both ends of the Lakeshore Corridor, but these extensions are not yet funded. These extensions may re-route parts of the existing line, west of Aldershot and east of Ajax, and so could result in losing an existing station or two at each end, to be replaced nearby along the rerouted section. The best routing for these extensions remain unclear, casting uncertainty on the route beyond Aldershot and Ajax. The estimates for the Lakeshore corridor in this Regional Rapid Rail report therefore analyze the section between Aldershot and Ajax separately from the extensions for fixed infrastructure. The exception to this is for the cost of electrification, as the 2010 electrification study published its estimate from Hamilton to Bowmanville, and is used as provided.



5.1.1. Extension beyond Aldershot

In the west, an extension to St Catharines, or possibly Niagara Falls, is being studied. The line to St Catharines is not the same rail line that goes to the existing Hamilton GO station. There is a connecting line between the two, notwithstanding its narrow width as a connecting corridor that is less than ideal. The high cost of reconstructing the Hunter St tunnel is



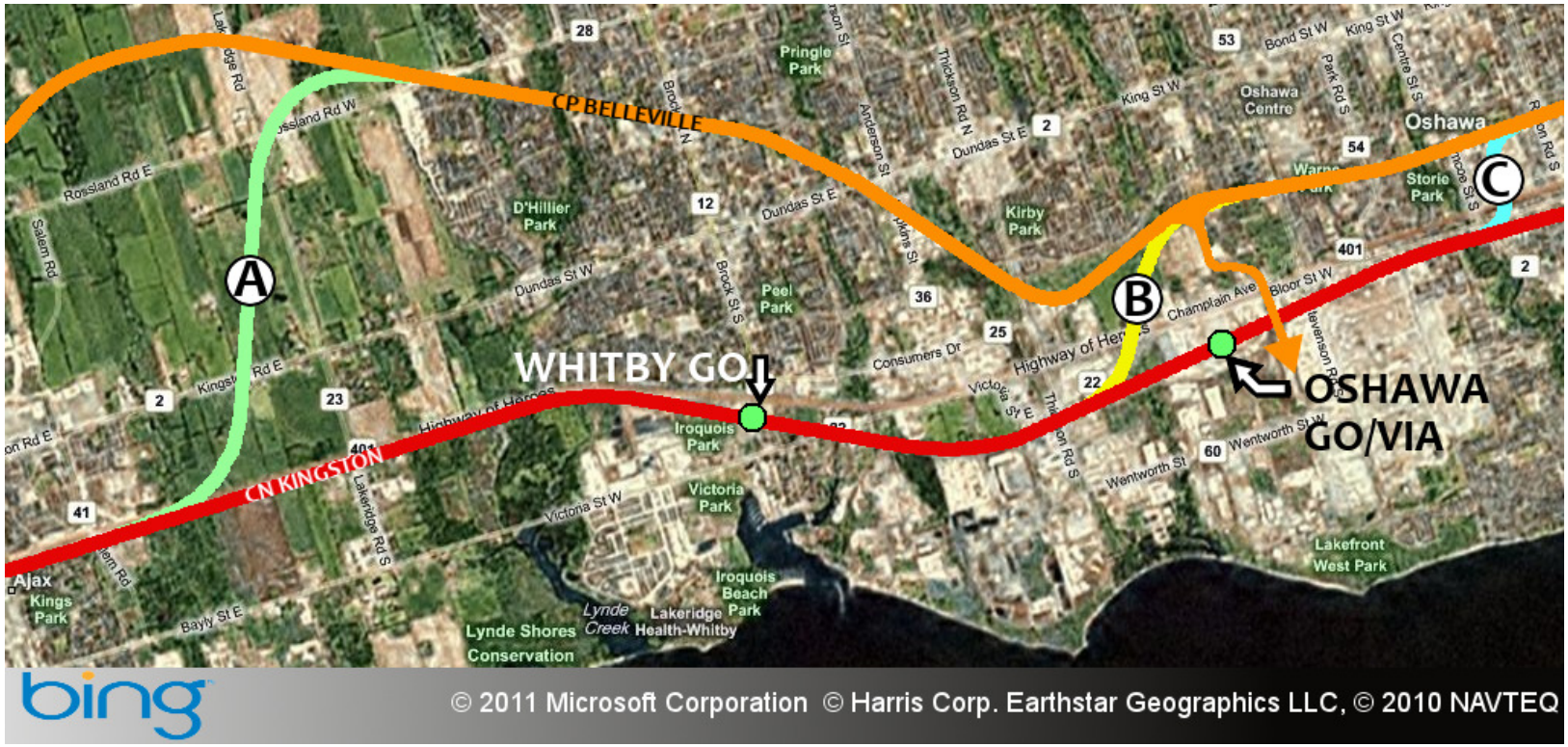
very likely to be a major influence on the decision to use the CN rail corridor through Hamilton and serving the former CN Hamilton station located off Murray St at James St N on the way to St Catharines. The Hunter St tunnel, a busy mainline for Canadian Pacific (CP) freight trains crossing to/from the U.S. at Fort Erie, is 600m long, single-tracked, and is surrounded by apartment buildings. Moreover, the ventilation in the tunnel likely does not meet modern standards, and therefore would require updating as part of its reconstruction as a wider tunnel.

Known as the TH&B station, after the railway that originally built the line before eventually coming under CP ownership, the existing Hamilton GO station appears to have its significance acknowledged in the 2010 electrification study's Reference Case. The Hamilton TH&B station is situated in an ideal location in downtown Hamilton, and the Reference Case includes peak period, peak direction trains serving the station in its 2021 service model. However, the tunnel cannot be electrified without being rebuilt. Running diesel locomotive-hauled GO trains and EMU GO trains simultaneously on the same line for about 60km would likely be susceptible to frequent complications, as they could not operate on the same schedules since EMUs are faster. Therefore, operations that blend the two technologies should be avoided along significant lengths. It should be noted, however, that this problem does not apply to VIA Rail Canada operations that serve the Oakville and Aldershot stations, as its trains stop infrequently, and thus would not suffer the same speed penalties that diesel locomotive-hauled GO trains would experience.

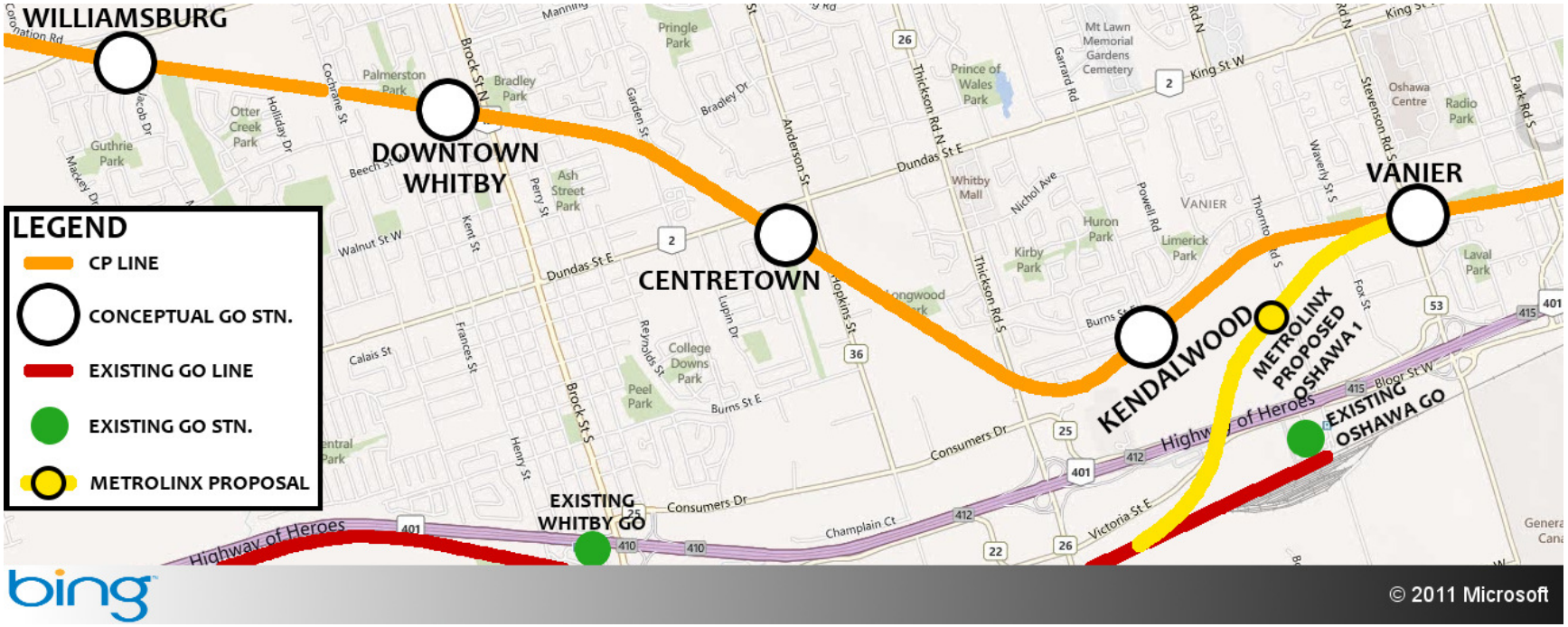
While expensive, there are significant advantages to investing in the rebuilding of the Hunter St tunnel, both to add tracks and to have it electrified (there is insufficient information available to estimate the cost of reconstruction of the Hunter tunnel). Given that this issue is unresolved, this Regional Rapid Rail report will look at the Hamilton connection separately from the rest of the corridor.

5.1.2. Extension Beyond Ajax

In the east, an extension to Bowmanville is being studied. This extension would see GO trains in Durham Region rerouted from the CN corridor [Kingston subdivision], alongside which GO currently runs in its own immediately adjacent corridor, to the nearby CP corridor [Belleville subdivision]. There are alternatives to the location of a connection between the two rail corridors worth consideration that have not been evaluated to date. The existing Oshawa GO station and possibly also the existing Whitby GO station could end up being closed and replaced by new stations along the CP corridor. Since the consideration of this extension renders the future of the two existing easternmost GO stations uncertain, a definitive decision on alignment through Durham Region should be made prior to proceeding with electrification of the corridor.



The map on the previous page shows 3 different options (A, B, & C) for diverging from the existing GO corridor (shown in red) to the CP corridor further north (shown in orange). Option "B" is the preferred option from the environmental assessment, but option "A" is worth serious consideration as it could offer very significant ridership benefits through Whitby, with reduced car dependency to access GO rail services. Option "C," beyond the end of the existing line, would result in no stations being closed, and maintains the existing connection with VIA Rail Canada at the current Oshawa station, but it should be noted that the current Oshawa GO/VIA station is not well located. The map below identifies potential stations through Whitby and western Oshawa for consideration with option "A." For reference, it also shows the Metrolinx proposal, shown as option "B" on the map on the previous page.



5.2. Improving Connections – Lakeshore West

Connections between GO and local transit are critical, but at the same time, a balance needs to be struck between the service types. That balance has been elusive due to the competing priorities of different target markets, and the resulting status quo typically involves radial local transit systems operating as many bus routes as possible to/from the one or two GO stations in town. This dose not serve either GO or the local systems in an optimal way, as route choices become limited for the local system as well as the sustainability of ridership growth for the GO system through a higher reliance on parking. With EMUs replacing locomotive-hauled trains, serving stations in less time, the possibilities for both GO and the locals systems could expand dramatically.

The Lakeshore West line connects with Burlington Transit, Oakville Transit, Mississauga Transit, and the TTC. There are also many Hamilton Street Railway connections at the Hamilton GO [TH&B] station.

New stations could be located at:

- Cumberland Ave in Burlington (Dynes GO Station),
- Burloak Dr, Burlington-Oakville border (Pinedale GO Station),
- Dorval Dr in Oakville (Kerr Village GO Station),
- Morrison Rd in Oakville (Morrison GO Station),
- Ford Dr* in Oakville (Sherwood Heights GO Station),
- Lorne Park Rd* in Mississauga (Lorne Park GO Station),
- Ogden Ave* in Mississauga (Lakeview GO Station),
- Kipling Ave* in Etobicoke (Alderwood GO Station), and
- Windemere Ave* in Toronto (Swansea GO Station).

**Similar or identical to proposed stations in the 1974 report, "The Case for 'Super GO'," attached to this Regional Rapid Rail report as Appendix Z.*

5.3. Improving Connections – Lakeshore East

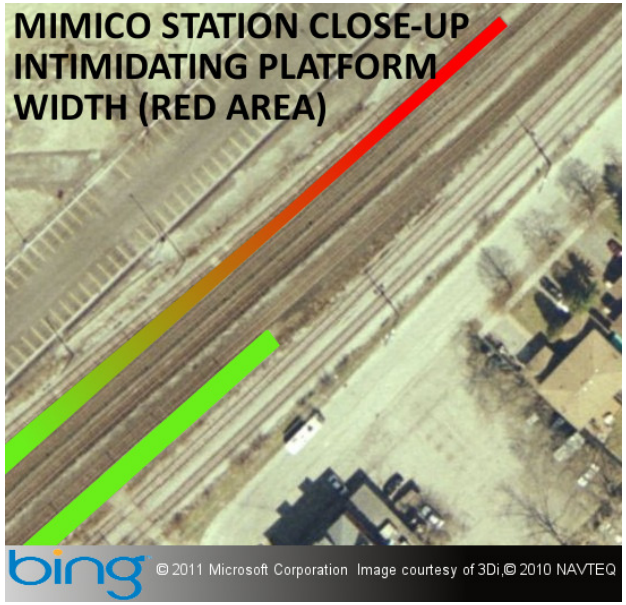
While fewer people use the Lakeshore East corridor than its western counterpart, it is expected to grow and be comparably busy in the peak period. As mentioned previously, due to uncertainty regarding extensions, this section will consider the corridor only as far east as Ajax, including a new station in Ajax east of the existing Ajax GO station.

New stations could be added at:

- Harwood Ave in Ajax (Downtown Ajax GO Station),
- Granite Ct [Oklahoma Dr] in Pickering (Rosebank GO Station),
- Birchmount Rd* in Scarborough (Birch Cliff GO Station),
- Coxwell Ave* in Toronto (Leslieville GO Station), and
- Carlaw Ave & Gerrard St E* in Toronto (Riverdale GO Station).

**Similar or identical to proposed stations in the 1974 report, "The Case for 'Super GO'," attached to this Regional Rapid Rail report as Appendix Z.*

5.4. The Future of Mimico



Mimico is a GO station that attempts to do more than it is capable of. The exsiting westbound platform is inherently intimidating and incompatible with accessibility standards because of its unacceptably narrow width for a significant section at its east end. This cannot be rectified without expropriation and demolition, and even then space is very tight given planned track additions for trains using Willowbrook Yard to/from Union Station (Willowbrook Yard is immediately across Royal York Rd from the Mimico station). Although a station has been here for over 150 years, the combination of new pressures and changing surroundings has made things complicated for this site. Mimico's current patronage is very low – only the Exhibition station draws lower peak period ridership on the Lakeshore West line, and that is changing with the recent intensification adjacent to the Exhibition station.

One solution worth seriously considering is moving the station. A location that could be a strong candidate is just west of Park Lawn Rd, about a kilometre east of the existing station. This location has the space necessary to provide for platforms and additional tracks. The density found along both north and south sides of the rail corridor along Legion Rd, which would be at the west end of the station platforms), greatly exceeds that found at the existing Mimico station by Royal York Rd. Similar to Royal York Rd, a TTC bus route serves Park Lawn Rd, but a far better transit connection than that which exists at the station by Royal York Rd could be provided at Park Lawn Rd by a relocated station. The existing Mimico station lacks accommodation for a proper connection with southbound Royal York Rd buses. With such close proximity to the Gardiner Expressway ramps, a station by Park Lawn Rd would be an improvement for those driving to the station; whereas road access to the existing Mimico GO station has always been awkward in that it involves following local streets characterized by older, low density residential development. In short, the existing Mimico station predates the automobile age, and the nature of the station's surrounding neighbourhood reflects this. The Unionville GO station, which was situated between Eureka St and Main St until it was moved to its current location between Enterprise Dr and Highway 407, provides a precedent for relocating a GO rail station. Very similar to the existing Mimico station site, the original Unionville station site has a history dating back to the 1800s.

Left: Existing Mimico station platform and parking off Royal York Rd.

Right: A new Mimico station and parking area by Park Lawn Rd.

The Royal York Rd area is generally stable as a neighbourhood, and travel patterns are unlikely to change beyond the influences of factors such as gas prices, but the Legion Rd area has been growing and has space to continue to grow. Moving the station would also put GO access very close to a beautiful stretch of Toronto's western waterfront, a stretch that is also publicly owned and therefore available for open public use in contrast with the privately-owned waterfront around the foot of Royal York Rd.

5.5. Freight Co-Existence

GO does not own all parts of its network, and is therefore often a tenant which rents track time. As a tenant, the needs of corridor owners must be recognized and respected. Freight rail is important to many sectors of the economy, and alleviates congestion on Ontario highways.

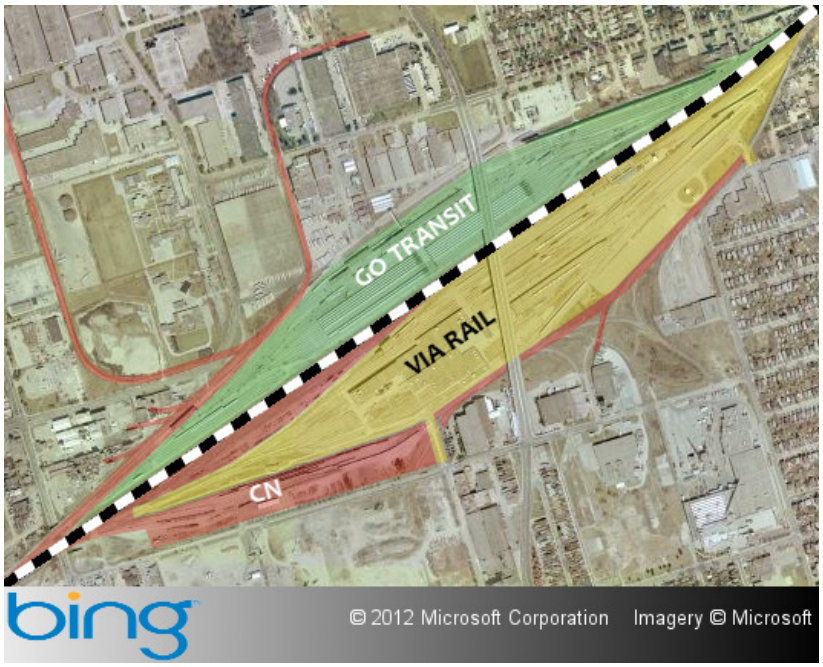
5.5.1. Lakeshore Corridor Ownership and Traffic

GO owns the Lakeshore corridor east of the Burlington GO station [the Burlington junction], and has control over traffic in this part of its network. There are a few small clusters of freight traffic sources remaining along the now-GO-owned corridor, including: A Petro Canada facility in western Oakville, a Procor faciliy, the Oakville yard and the Ford plant, the St Lawrence lead plus the nearby Clarkson yard along with the Petro Canada spur in Mississauga, the Flintcote and Jockey leads in Toronto's Alderwood neighbourhood near Willowbrook, the Toronto Harbour Commission spur to the Port Lands, the Geco spur near The Golden Mile area of Scarborough, and the Compton spur in southeastern Scarborough's Beechgrove area.

CN owns the line between the Burlington and Hamilton junctions, but typically avoids operating its trains on this line east of the Burlington junction during weekday peak periods. Freight traffic is light east of the Mimico GO station, with a little more than a dozen sources of freight activity between there and Pickering, mostly in Scarborough. From the Clarkson GO station to the Burlington junction remains a measurable source of local traffic for CN service, with freight traffic concentrated predominantly on the south side of the corridor, apart from three single-property spurs plus the Ford plant (including Oakville Yard) on the north side. Additional mainline track near the CN yards at Willowbrook and Oakville could be considered for accommodating freight traffic without disruptions to GO service.

The CN-owned line between the Burlington and Hamilton junctions is a multi-mainline link to one of CN's largest yards: MacMillan Yard, in Vaughan, northwest of Keele St and Hwy 7. There are also two smaller CN yards in the Hamilton Junction area: Hamilton Yard (northwest of Bay and Barton Sts in Hamilton), and Aldershot Yard (by the Aldershot GO/VIA station). CN operates its mainlines with long stretches that are left single-track, so a single track available for freight traffic between the Burlington and Hamilton junctions may meet the needs of CN. However, while CN may need only a single track, this junction is effectively a four-way intersection in CN's network. In combination with CN's nearby yard activities at Aldershot and Hamilton, there exists a high potential for conflicting movements between CN and frequent GO service operations, particularly with CN trains to/from Hamilton or Fort Erie.

5.5.2. CN Operations at Willowbrook



CN has a small presence at Willowbrook (shown in red on the above map), but it does still have activity in the area. A challenge emerges in that the yard is on the south side of the mainline while about 3/4 of its customers are on the north side of the mainline. Unless all local freight activity is to be confined to overnight periods, which may not be realistic (this information is not known), local freight trains traveling from the yard to the nearby customers need to be accommodated in addition to busy Lakeshore GO services. This could be achieved with a fifth mainline track through Willowbrook combined with a large

series of switches arranged to allow trains to weave around one another at speed. Consideration could be given to the use of higher-speed turnouts to achieve this, such as the AREMA #26.5 that has been used in the Amtrak Northeast corridor that allows trains to operate through the diverging route at 97km/h. This would facilitate a short freight train to navigate from the yard to the north track, albeit slowly at busier periods, while GO operating speeds would be negligibly affected, if affected at all.

The service track on the north side of the corridor that accesses the Flintcote Lead near Browns Line is envisioned in this Regional Rapid Rail report to be extended to Canpa, where the corridor connects with the CP Canpa subdivision. This track would serve all customers not

reachable directly from CN's yard, except for the Castrol facility. With a short spur to the Castrol facility from the east, it should be serviceable while avoiding disruption to the passenger services outside of peak periods. The off-peak 15-minute gaps between local passenger trains on the south track would allow enough time for a freight train from the CN yard to reach the Castrol facility's spur (a distance of about 1.5km).

5.5.3. CN Operations at Oakville

The situation at CN's Oakville yard is very similar to that of Willowbrook, except mirrored; i.e. the yard is on the north side of the mainline, while all but three customers (formerly four; General Electric shut down its Oakville operation in 2009) are on the south side east of Burlington. A fifth track between the Oakville station and the Royal Windsor Dr underpass, plus a suitable arrangement of switches, could allow the same operation here as described for Willowbrook. Even excluding the Ford Plant, which is connected to the Oakville yard directly, the customers served from the Oakville yard are generally larger compared to those served from the Willowbrook yard. Some of these customers are actually substantially larger (like Petro Canada), and receive more rail cars at a time, so the fifth track would be longer at Oakville than at Willowbrook.

In order to accommodate the passage of daytime freight traffic past the Oakville GO station to reach freight customers west of the Oakville yard by 2031, a fifth track across the south side of the station could be necessary. Existing bridges across Trafalgar Rd are already wide enough to accommodate this, and such a track would not interfere with existing station platforms, including recent changes at the station that included the addition of a fourth track. Whether or not the fifth track needs to continue west of the station would depend on future GO schedules, mainly on how much service is to be turned back at Oakville versus how much is to continue further west.

Of the three customers on the north side between Oakville and Burlington stations, one of them (a packaging company) could reasonably be served from the Aldershot yard since it is very close to the Burlington GO station, which would simplify traffic management east of there. The other two would likely be served by very short trains, only about half-a-dozen cars. This should not be problematic for passenger operations even without additional infrastructure beyond short additional service tracks, if the freight locals run during less busy passenger service periods. Strategic placement of switches could mitigate potential conflicting traffic movements with the least amount of infrastructure.

5.5.4. Access to Hamilton

CN and CP both have corridors that run through Hamilton, and both of them carry international freight traffic via Fort Erie. Metrolinx has been exploring options to accommodate off-peak service to Hamilton, as well as expanded rush hour service. At time of writing, the most recent publication on this topic appeared in May of 2011, in a report by Hatch Mott MacDonald on Hamilton Junction that was an appendix to the Niagara Peninsula GO Rail Expansion environmental assessment. That Hamilton Junction report was prepared after the 2010 electrification study's Reference Case was developed. Its conclusions indicate significant potential freight traffic conflicts with the GO operations defined in the Reference Case.

Hamilton Junction requires expanded infrastructure in order for future freight and passenger rail operations to co-exist, and Hatch Mott MacDonald provided cost estimates to Metrolinx for two infrastructure options at Hamilton Junction, using a traffic projection reflecting the 2015-2021 horizon. The first option was for a rail-to-rail grade-separation for exclusive GO use to enable trains to reach the TH&B station on the CP line from the Aldershot station. This would be a complex undertaking, estimated to cost at least $143-million. The second option involved serving the former Hamilton (James) station via the CN line, which was estimated to cost $70-million, but would be highly susceptible to major delays if freight (or even VIA) traffic increases. Fifteen-minute frequencies were never simulated; such service is not expected to run until after 2021; i.e. beyond the scope of the Hamilton Junction report. This is a critical concern in weighing the value of such a long-term investment.

There are other major concerns arising from the Hamilton Junction report:

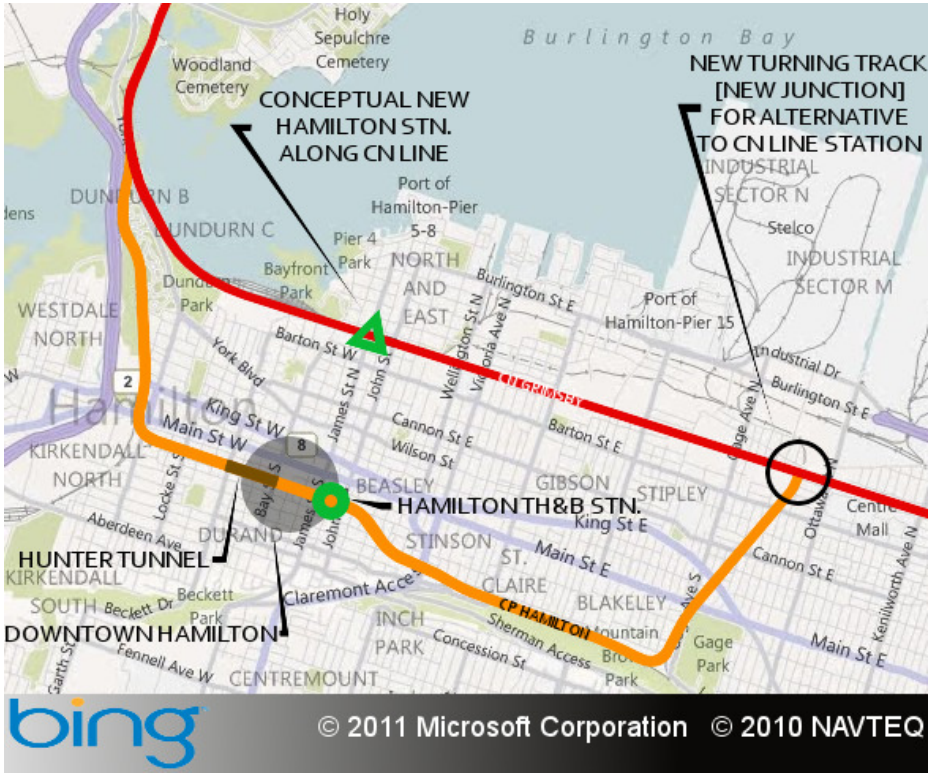
1. Its simulations gave GO/VIA priority, but CN owns the line and would realistically give its trains priority over those of GO or VIA. No reasons were given for this simulated priority assumption.
2. No scenarios were simulated where CN trains had priority. By a huge margin, CN would suffer the brunt of delays in the report simulations – delays that in reality would more likely hit GO/VIA.
3. Hatch Mott MacDonald wrote that they did not consult CN during the preparation of the report, but warned CN likely would not accept the kind of delays simulated.
4. Potentially, CN's Hamilton Yard could be extremely problematic for frequent GO service, as it is located on the opposite side of the corridor from CN network connections on the other side of Hamilton Junction. This significantly amplifies the likelihood of conflicts between frequent all-day GO service and freight traffic, an observation supported by the Hatch Mott MacDonald simulation results. Redesigning the yard is not a viable option.

The $70-million estimated cost for the Hamilton (James) station is conditional on CN, and no feasibility study of this operation for the 2021-2031 horizon has been done based upon 15-minute all-day GO service. Based on the 30-minute all-day GO service simulation and the conflicts it encounters, however, the viability of 15-minute all-day service to the Hamilton (James) station co-existing with CN activity would be doubtful.

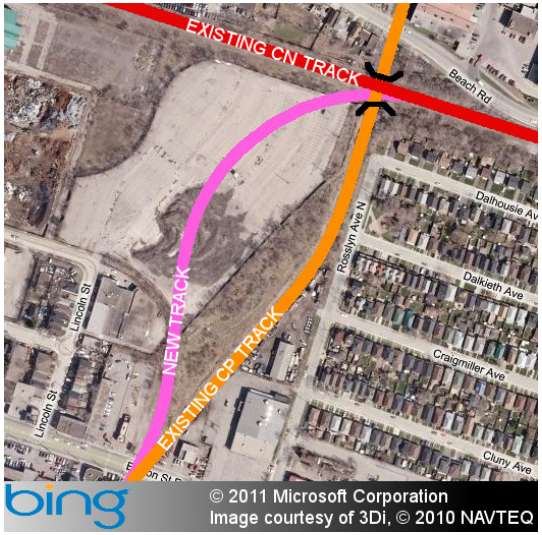
The potential for conflicts with CP are substantially lower than with CN. The TH&B station is located on the north side of the CP corridor, and CP has no activity on the north side of its corridor between the TH&B station and Hamilton Junction. The main source of local freight activity along this section – Aberdeen Yard – is on the south side. The $143-million estimated by Hatch Mott MacDonald for providing a rail-to-rail grade separation would result in a permanent solution to a variety of challenges inherent in providing all-day service through the Hamilton junction, at a station much closer to Hamilton's city centre than could be provided along the CN line. However, the expansion of the Hunter St tunnel, which would be the only existing location with conflicting train movements, would be a prerequisite for enabling frequent service to the TH&B station.

5.6. Hamilton TH&B Station

This station is a major transit focal point for GO Transit. In addition to weekday peak period rail service, a notable amount of express GO bus traffic also operates to Union Station from the TH&B station. Considering the investment that has already been made in the station itself to date, and the strong historical relationship it has with downtown Hamilton, there is an argument to be made for maximizing the value of this major asset. Hamilton TH&B's infrastructure is not only rail-based, but includes some significant bus-based infrastructure as part of the same complex, serving as Hamilton's hub for intercity bus traffic. Also, almost 20 local bus routes (over half of the Hamilton Street Railway network) pass the TH&B Station on James and John Sts, although most local buses do not actually enter the TH&B station bus terminal proper. Both James and John Sts have existing direct access to the TH&B Station – although these could be improved to provide better service in inclement weather.



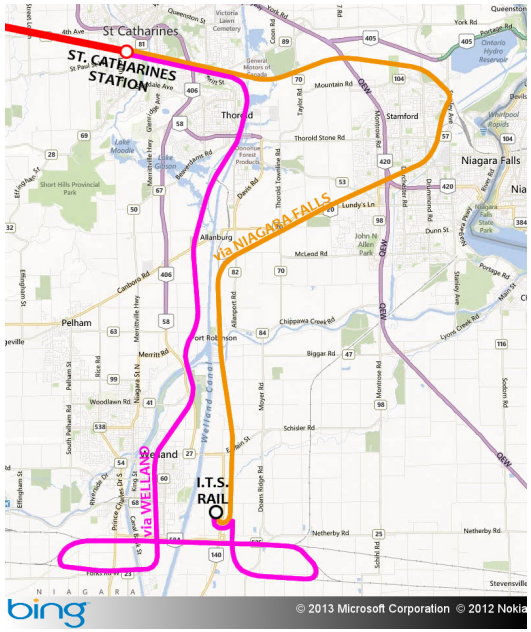
The TH&B station, located in the downtown core of Hamilton, is an ideal location for a major rail station providing all-day frequent GO rail service. Moreover, the relatively short and relatively level distance between the TH&B station and the waterfront also gives the station a very wide, very effective area of coverage for the entire central area and beyond. The Hamilton (James) station along the CN Grimsby subdivision to the north does not possess such desirable qualities. The TH&B station has great potential to serve as an ideal meeting point between St Catharines-bound Diesel Multiple-Unit (DMU) trains and Toronto-bound EMU trains. However, fixed infrastructure costs between the Aldershot and TH&B stations cannot be isolated from the 2010 electrification study, and therefore no estimate is provided.



It could be unnecessary for trains operating to/from St Catharines along the CN Grimsby subdivision to bypass downtown Hamilton. The existing CP tracks east of the TH&B station intersect the CN corridor, and a new connecting track could link the two corridors, as illustrated in the figure to the left. A very high-level analysis using GIS suggests that this could likely be accomplished with a turning radius of about 200m (very similar to conditions at the Kinnear junction by Gage Ave S at Cumberland Ave), with a gradient of 1.5% (possibly less) over a distance of 300m.

While the probability for conflicting train movements with CP traffic west of the TH&B station is extremely low if the Hunter St tunnel were expanded, there may be some concern with the far less frequent St Catharines service between the CP Kinnear yard (east of the TH&B station) and the CN line, but no study of that has been undertaken to date.

Bypassing downtown Hamilton to save the capital costs of retrofitting the Hunter St tunnel could prove to be an unfortunate decision from the perspective of achieving long-term network efficiency, network connectivity, and how many people a strategically located central station might serve. The costs of *missing* the opportunity to make all-day rail service to the Hamilton TH&B station feasible could be quite high.



The ridership projection published for the St Catharines extension represents very low demand, and half of the ridership has Hamilton as its final destination. Regular GO trains serving this extension as in the electrification study's Reference Case would not be cost-efficient, based on the Niagara Peninsula GO Rail Expansion environmental assessment's ridership projections published after the Reference Case was developed. DMUs running between only Hamilton and St Catharines would be a more sustainable service model, and may even draw higher ridership induced by more attractive schedules resulting from smaller trains operating more frequently with superior travel times.

To have the EMU and DMU operations connect at the TH&B station would make it an ideal hub. Willowbrook might not be an economical maintenance site for DMUs serving only the south shores of Lake Ontario, but ITS Rail has a facility that maintains locomotives in nearby Welland, which could maintain such a small fleet of DMUs through a public-private partnership. Two options for reaching this facility from St Catharines are illustrated in the lower-right on the previous page.

Given these opportunities, the TH&B station would be worth strong consideration for both all-day service to/from Toronto as well as for a terminus for service to/from St Catherines, serving as a connecting station with transfers made via a shared platform with special ramp designs. It is acknowledged that this would entail the associated infrastructure costs of the Hunter St tunnel reconstruction and four bridges requiring rebuilds just west of that tunnel, as well as the new turning track east of the TH&B station. However, this consideration is especially important in the context of avoiding potentially major long-term conflicts with freight traffic beyond the 2021 horizon's service levels.

5.7. Diesel Case, Electrification, and EMU Case Costs

There are three broad categories of cost relating to transforming the GO system used in this Regional Rapid Rail report. These are the "Diesel Case;" "Electrification," and the "EMU Case." Each of the three is estimated for two different years: 2021 and 2031.

The fixed infrastructure costs of the Reference Case, a conceptual 2021 network used in the 2010 electrification study, were not published. While not published, a number of reasonable assumptions can be made to obtain a credible estimate of what the costs could conceivably be for building the Reference Case. These assumptions, among others, are detailed in Appendix N, and form most of the 2021 "Diesel Case" costs, except those relating specifically to the fleet. Estimates contained in Appendix N also encompass infrastructure requirements between 2021 and 2031, including additional track and grade-separations for providing the 2031 service levels envisioned in *The Big Move*. Estimated costs of accommodating service levels for meeting the 2031 projections from *The Big Move* were assigned to the 2031 Diesel Case.

The cost of electrification was published in the 2010 electrification study. The electrification cost for the Lakeshore corridor applies to the section between the Hamilton (James) and Bowmanville stations, rather than the Hamilton TH&B and Bowmanville stations. There are additional costs for using the TH&B station instead of the alternative Hamilton (James) station, as well as for resolving conflicting traffic movements between freight and passenger trains between the Hamilton and Aldershot stations. These have been estimated separately and are factored into the estimates for the Diesel Case or the EMU Case, as appropriate.

The electrification cost for vehicles has been modified from the published estimate in the 2010 electrification study to represent EMUs. The EMUs have a lower capital cost than locomotive options as fewer vehicles would be required. The cost represents an incremental amount compared with the cost of increasing the diesel fleet size from current levels to 92 revenue service trains plus spares. All Lakeshore Diesel Case costs are therefore new diesel purchases, including new locomotives, new coaches, and new cab cars. In early 2012, the GO Transit website stated that the GO fleet consisted of 44 trains in revenue service during rush hours. Coach and cab car fleet details as of early 2012 are found in Appendix F.

The cost of the "EMU Case" is for infrastructure that the Reference Case does not include. This is primarily the cost of a new signal system to allow more aggressive service per track, but also includes some conceptual additional stations that EMUs render practical.

The breakdown, explained in more detail in the following sections, is summarized below:

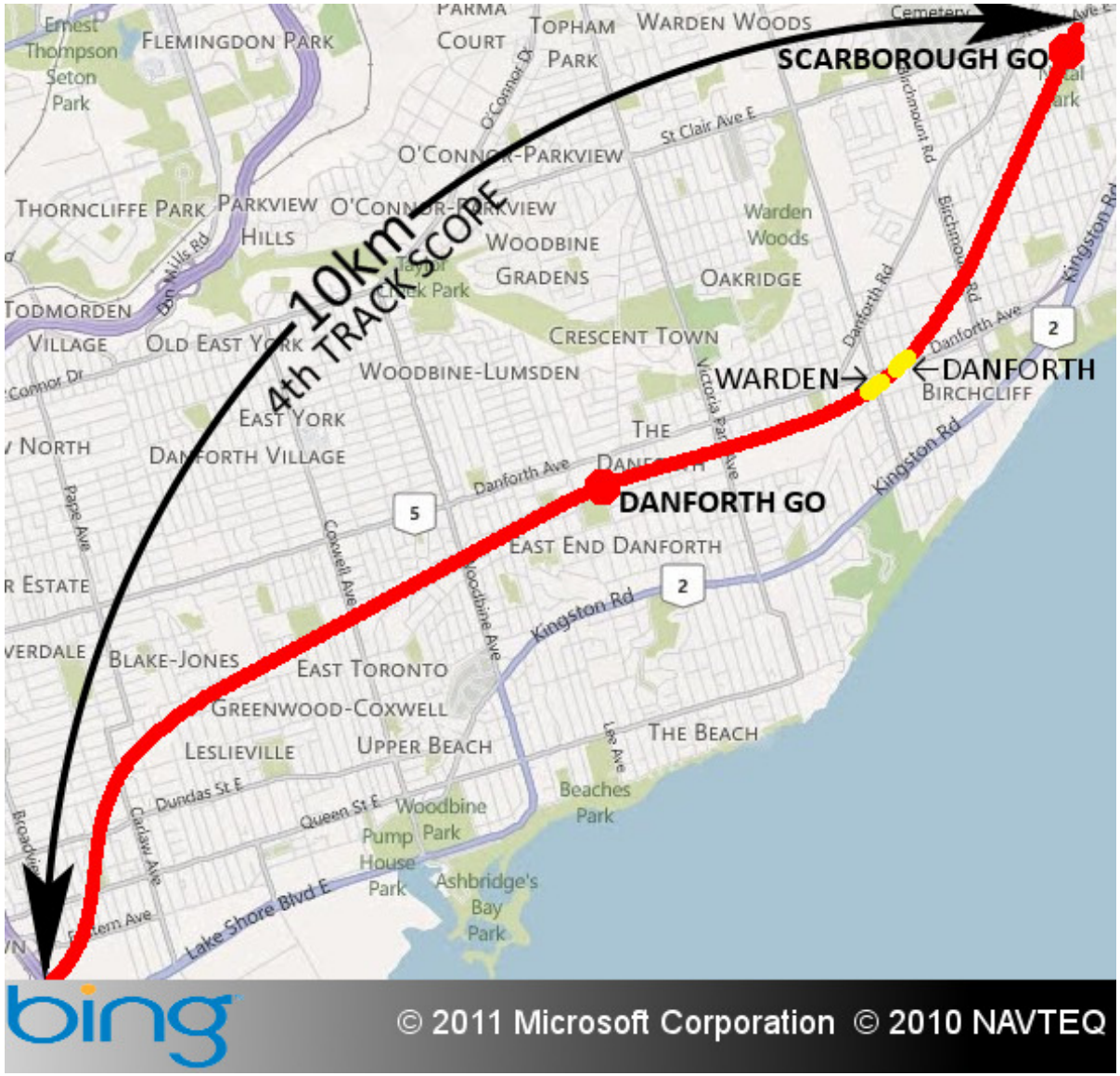
Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$62.00	$254.66
	Whitby Yard (Electric)*	$213.00	$0.00
	Bowmanville Extension	$248.74	$0.00
	Grade Separations (Road-Rail)	$533.25	$0.00
	Bridge Widenings (Road)	$0.00	$145.80
	Bridge Widenings (River)	$0.00	$176.18
	Fleet (Capital)	$1,420.72	$451.22
	Expanding Existing Stations	$0.00	$39.15
	Subtotal	**$2,477.71**	**$1,067.01**
Electrification	Infrastructure (incremental)	$1,020.00	$241.93
	EMU Fleet (incremental)	($120.98)	($80.48)
	Subtotal (incremental)	**$899.02**	**$161.45**
EMU Case	Positive Train Control Centre*	$135.00	$0.00
	USRC Positive Train Control*	$13.73	$0.00
	Wayside PTC	$56.32	$17.83
	PTC for LHCs	$4.30	$1.20
	PTC for EMUs (incremental)	$14.40	$4.40
	New Stations	$151.20	$49.95
	Whitby Realignment Along CP Belleville	$312.19	$0.00
	Hamilton Hunter Tunnel	$440.00	$0.00
	Subtotal	**$1,127.15**	**$73.38**
Hamilton-St Cats	**DMU Fleet**	$55.00	$0.00
CORRIDOR TOTAL		**$4,558.87**	**$1,301.83**

**Network-wide cost*

5.7.1. Diesel Case

The Diesel Case is an estimate of what it would take to meet 2021 and 2031 service levels, including both fixed infrastructure such as tracks and bridges, and fleet expansion using diesel LHCs. Most new track for the Lakeshore corridor in the Reference Case has already been built, except for the installation of a third track between the Guildwood and Pickering stations, and a fourth track for 10km between the Don River and Scarborough Junction (by the Scarborough GO station; pictured). These two stretches of corridor expansion are estimated to cost around $62-million, including modifications to 2 bridges (Warden and Danforth Aves).

Aggressive levels of express train services would be expected to operate between at least Oakville and Pickering (both of which are designated Urban Growth Centres), and more track expansion would be



needed for that kind of service beyond the 2021 infrastructure outlined in the Reference Case. This is especially important in the context of a network with several additional stations that were not in the Reference Case added along the existing line to boost ridership through improved network connectivity. These conceptual additional stations could be particularly beneficial for stimulating demand outside peak periods. A service model where both local and express trains run all day long becomes important, considering the length of the corridor combined with the higher number of stations. In most areas, one more additional track will be warranted, while a few short sections should not require this. In all, about 90 new single-track-kilometres are considered in this Regional Rapid Rail report as necessary for such services, at an estimated cost of $255-million. This should not create a need for property acquisition.

The corridor between the Scarborough GO station and Union Station could be an area of concern. Without EMUs, this part of the network could exhibit peak period capacity shortfalls due to the presence of Stouffville service combined with aggressive Lakeshore East service, including non-revenue movements between Union Station and the Whiby yard. Moreover, this is also a busy section of the VIA Rail Canada network, a part of the Toronto-Ottawa-Montreal “triangle.” Part of the corridor through the Warden/Danforth area is also narrower than standard width and cannot accommodate 6 tracks without expropriation. This may make service levels for meeting the projected demand practically impossible to operate without the flexibility that EMUs can offer to optimize efficiency of available tracks on limited land.

The yet-to-be-built Whitby yard is needed regardless of what technology is used for future service expansion, and is therefore also part of the Diesel Case. An estimate for this facility, as an electric site, exists in the October 2008 Lakeshore electrification study by Hatch Mott MacDonald, at $150-million. That should be $158-million after three years of inflation, and $213-million with a 35% contingency added.

Because no estimate was available at time of writing for a diesel Whitby yard, the full cost of the electrified yard was included in the Diesel Case, even though this was not ideal. However, it would be most cost-effective to meet future growth by moving immediately towards electrification of the busiest existing corridors with Whitby as the main base for EMU needs, built for that function from the outset. This approach would avoid costly conversions of the Whitby yard in the future, while also minimizing disruptions at the existing Willowbrook facility over the medium-term.

The 2010 electrification study assumed a peak period operation to Bowmanville as part of the Reference Case. This has been estimated to cost $249-million as outlined in Appendix N.

It was assumed in this Regional Rapid Rail report that 18 level crossings would require replacement with grade separations in order to safely and reliably accommodate Reference Case service levels:

Lakeshore West	**Lakeshore East** (Scarborough)
Burloak Dr (Burlington/Oakville)	Scarborough Golf Club Rd
Fourth Line (Oakville)	Galloway Rd
Chartwell Rd (Oakville)	Poplar Rd
Clarkson Rd (Mississauga)	Morningside Ave
Lorne Park Rd (Mississauga)	Manse Rd
Stavebank Rd (Mississauga)	Beechgrove Dr
Revus Ave (Mississauga)	Chesterton Shores
Alexandra Ave (Mississauga)	Rodd Ave (Pickering)
Ogden Ave (Mississauga)	
Haig Blvd (Mississauga)	

The above are estimated to cost $533-million. Alexandra, Ogden, and Haig would be accomplished by raising the rail corridor as a viaduct.

While a significant proportion of the Reference Case for Lakeshore has already been built, it is extimated that $1.06-billion in Reference Case fixed infrastructure costs ($2.48-billion - $1.42-billion = $1,057-million) remain to be funded. Among this infrastructure is the challenging Lakeview area, where this Regional Rapid Rail report proposes a viaduct. This is due to multiple creek crossings, multiple closely-spaced at-grade crossings, and numerous properties near the railway crossings, in addition to other existing grade separations nearby. While expensive, this represents a significant opportunity by using such a new structure to create a new station. Moreover, this is the same area where Mississauga is trying to significantly improve its public waterfront lands. These fixed infrastructure improvements need to be funded in order to enable the service levels of the future that would otherwise see level crossings effectively closed during at least weekday peak periods. Among the affected crossings is Ogden Ave, along which MiWay's Dixie route operates.

In many locations, additional tracks would require widened bridges across roads and rivers. There are 27 road crossings and 13 river crossings that are not wide enough at time of writing.

The cost for widening road bridges at the following locations is estimated at $146-million.

Lakeshore West

- Plains Rd (Burlington)
- Brant St (Burlington)
- Walkers Line (Burlington)
- Dorval Dr (Oakville)
- Ford Dr (Oakville)
- Winston Churchill Blvd (Mississauga)
- Mississauga Rd (Mississauga)
- Dixie Rd (Mississauga)
- Thirtieth St (Etobicoke)
- Park Lawn Rd (Etobicoke)
- South Kingsway (Toronto)
- Ellis Ave (Toronto)
- Colborne Lodge Dr (Toronto)
- Parkside Dr (Toronto)
- Dowling Ave (Toronto)
- Jameson Ave (Toronto)
- Dunn Ave (Toronto)

Lakeshore East

- Logan Ave (Toronto)
- Carlaw Ave (Toronto)
- Gerrard St E (Toronto)
- Jones Ave (Toronto)
- Coxwell Ave (Toronto)
- Woodbine Ave (Toronto)
- Warden Ave (Scarborough)
- Danforth Ave (Scarborough)
- St Clair Ave W (Scarborough)
- Eglinton Ave E (Scarborough)

The cost for expanded river crossings at the following locations is estimated at $176-million.

- Sheldon Creek (Burlington)
- Sheldon Creek East (Oakville)
- Bronte Creek (Oakville)
- Fourteen Mile Creek (Oakville)
- McCraney Creek (Oakville)
- Sixteen Mile Creek (Oakville)
- Joshua Creek (Oakville)
- Credit River (Mississauga)
- Etobicoke Creek (Etobicoke/Mississauga)
- Mimico Creek (Etobicoke)
- Humber River (Etobicoke/Toronto)
- Highland Creek (Scarborough)
- Rouge River (Scarborough)

As mentioned previously, the Reference Case projected that the fleet must grow to 92 revenue service trains, which is close to double the size of what the GO system operated with at time of writing. While the first phase of electrification would roll out no sooner than 2019, this Regional Rapid Rail report accounts for the cost of accommodating the fleet growth projected to be met by 2021 in the Reference Case by assigning that fleet growth to the Diesel Case, based on diesel trainsets. This serves as a frame of reference to compare with electric vehicles, and avoids this fleet investment being treated as a sunk cost. The $1.42-billion new fleet cost for the service levels on the Lakeshore corridor represents the combined cost of 43 diesel locomotives, 350 coaches, and 41 cab cars that are considered in this Regional Rapid Rail report to be part of the Diesel Case. The methodology for fleet calculations in this report diverges from those applied in the 2010 electrification study, as the methodology of the latter only calculated locomotive costs, due to the assumption of the latter that coach quantities are common to all options. The methodology of this Regional Rapid Rail report accommodates holistic and comprehensive considerations of fleet costs by allowing for varying coach quantities with each vehicle technology option. The costs for vehicles of EMU and electric locomotive technologies were compared against the Diesel Case cost using the same comprehensive methodology.

In order to calculate the fleet resources required, demand must be measured using two key metrics: The peak hour peak point demand, and the shoulder hours in the peak period. The peak hour peak point demand is the busiest 60-minute window in the peak direction, just before arriving at Union Station in the morning. The shoulder hours are the 60-minute time spans on either side of the peak hour. As in the Reference Case, the capacity per LHC is assumed to be consistent at 1,600 regardless of locomotive technology.

Lakeshore West and Lakeshore East had different demand projections in both the Reference Case and in *The Big Move*. The capacity provided in the Reference Case at the peak point for Lakeshore West was 19,200 passengers per hour in 2021, and was projected in *The Big Move* to grow to 23,000 passengers per hour in 2031. For Lakeshore East, the peak point capacity provided was 12,800 passengers per hour in 2021, and while *The Big Move* projected a demand of 26,300 in 2031, the Union Station Demands and Opportunities Study indicates that a 25% downward revision is more realistic, which translates to a peak hour demand of 19,725 in 2031.

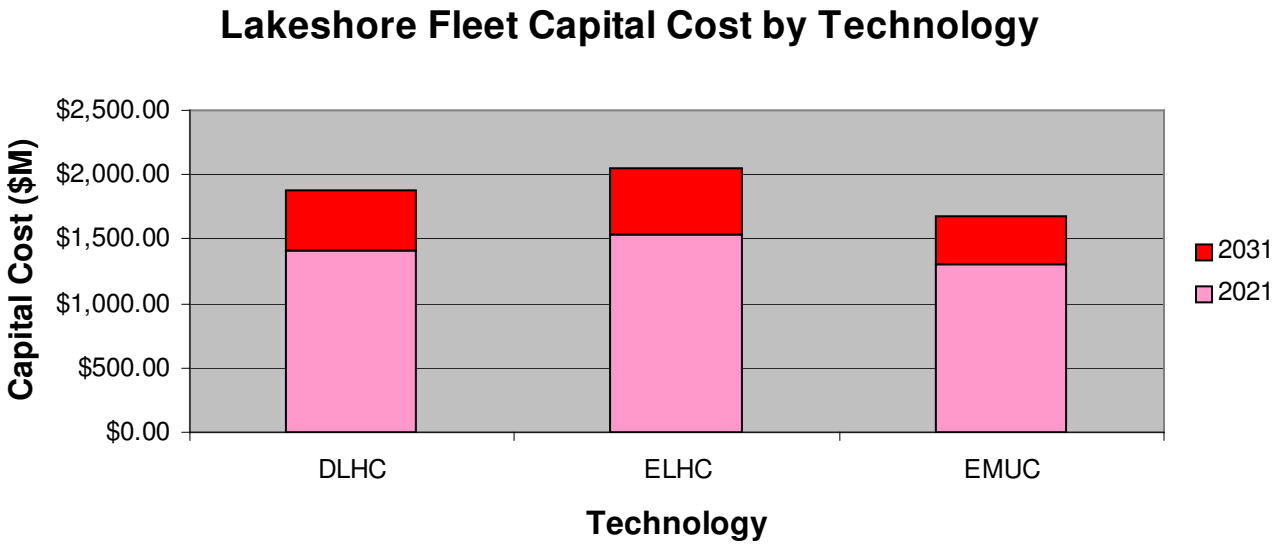
The changes in shoulder hours between 2021 and 2031 were based on a ratio relative to the peak hour. Within the Reference Case, this ratio was 3:1 for Lakeshore West, and 2:1 for Lakeshore East, meaning that there are 3 times as many trains in the peak hour than in either of the shoulder hours for Lakeshore West, and twice as many peak hour trains than in either of the shoulder hours for Lakeshore East. These 2021 ratios were extrapolated proportionately for determining 2031 service levels during the shoulder hours.

For Lakeshore West, 4 additional trains were required between 2021 and 2031 morning rush hours; this quantity of fleet did not vary with change in technology. For Lakeshore East, 6 new LHCs were added to the fleet between 2021 and 2031, or 4 faster EMU trains. The Lakeshore East and West corridors combined totaled 94 coaches with 11 cab cars and 11 (diesel) or 12 (electric) locomotives, or, for the EMU alternative, 51 coaches with 56 EMUs.

The estimated capital cost of fleet growth between 2021 and 2031, based on the information above, is $451-million for an expanded fleet with diesel LHCs. With electric LHCs, the estimate is $500-million, whereas with EMUs the estimate is $371-million. The $371-million estimate for EMUs minus the $451-million estimate for diesel LHCs results in the $80-million incremental savings with EMUs (and $129-million incremental savings over electric locomotives). These fleet expansion estimates for 2031 are imperfect due to a lack of refined demand data, and so opportunities for equipment cycling cannot be explored in detail here. It may ultimately be possible to meet the 2031 demand with fewer trains than estimated, which

applies to any of the technologies. The details of this simplified approach for determining 2031 fleet requirements can be found in Appendix I.

Expansion of most of the existing stations along the Lakeshore corridor would be required when an additional track is added beyond 2021. This is estimated to cost $39-million.



5.7.2. Electrification

The 2010 electrification study estimated the cost of electrifying the Lakeshore Corridor from Hamilton (James) to Bowmanville to be $1.02-billion for fixed infrastructure, using a 35% contingency. An estimated $242-million in additional overhead catenary infrastructure is estimated in this Regional Rapid Rail report to be required between 2021 and 2031 for the 90 single-track-kilometres discussed in the Diesel Case. In addition, $123-million was estimated in the 2010 electrification study as the incremental cost for electric vehicles, but that was based on the use of electric locomotives.

The Reference Case assumed the same vehicles running between Hamilton and Toronto would also extend to St Catharines. As discussed in section 5.6, this Regional Rapid Rail report concluded that the Hamilton-oriented, fairly low ridership patterns now known rendered such a model uneconomical. A DMU operation between St Catharines and Hamilton meeting an EMU operation between Hamilton and Toronto would be a more economical alternative. The DMUs alone are $55-million in capital cost as per an existing contract – the right quantity of DMUs for such are already on order, but for the Air-Rail Link; this will be discussed in Chapter 8.

The line from the TH&B station to Bowmanville can be operated with a smaller fleet of EMUs. The estimated capital cost for rail vehicles drops sharply with this arrangement, DMUs included (although it could be argued they should not be since they are already on order), bringing the total electrification cost down to $954-million by 2021. In terms of net capital fleet investment, using EMUs (and a small number of DMUs) reduces the fleet investment cost by $121-million compared to expansion with diesel locomotive option, and by almost $244-million compared to expansion with electric locomotives.

It also should be highlighted that the 2010 electrification study estimate is an ***incremental*** cost for an electric fleet over the cost for an expanded diesel fleet. The incremental cost represents the difference between technologies for meeting the same service level target. Section 2.2 discussed conflicts with implementation timelines as they relate to fleet investment, and in particular an investment of $1.5-billion in a non-EMU fleet by 2021.

The differences in costs between technologies widens further over the 2021-2031 horizon, with EMUs still the lowest-cost and most cost-effective option, saving $80-million more in capital cost than diesel locomotives, and saving $129-million more than the electric locomotive option. In total from now until 2031, this would mean that EMUs are $373-million cheaper than electric locomotives, and $201-million cheaper than expansion with diesel locomotives.

5.7.3. EMU Case

The EMU Case involves a new signal system and conceptual new stations in the corridor, to both meet increased peak demand levels and expand travel options and local connections. Some of these new stations are along a realignment of the corridor through Whtiby, which is also a part of the EMU Case.

A new signal system would enable trains to run at shorter headways safely. Positive Train Control (PTC) is a signal system that could be considered an "add-on" that would be overlaid on the existing Centralized Traffic Control (CTC) signal system that GO corridors are currently equipped with, except for the Barrie corridor, which is still "dark territory." PTC and the existing signal system can co-exist, meaning that trains equipped with PTC can still operate in territory that is not equipped with PTC.

In determining the necessity of PTC, a simplified schedule check suggested that Lakeshore West would require razor-sharp adherence to schedules with a very high risk of cascading domino effects on other trains from even minor delays if not equipped with PTC. One train delayed by even one minute during the peak hour could impact many other trains, even with four dedicated tracks provided in the corridor east of Oakville – and six tracks east of Willowbrook. The Union Station Rail Corridor would be especially sensitive to such effects, with the potential to impact trains across the network.

Although 12-car trains could allow slightly more breathing space in schedules, 12-car trains are slower than 10-car trains. The increase in weight that the locomotive has to pull has a negative impact on the rate of acceleration, increasing travel times for trips with a large number of station stops in particular. Slower trains can mean more trains are required since equipment cycling[3] becomes compromised with 12-car trains. They may also attract lower levels of ridership growth due to the longer trip times. Therefore, longer trains at wider headways would be counterproductive as an alternative to PTC.

PTC involves a network-wide nerve centre, wayside elements that are built into the corridor alongside the tracks, and on-board equipment that travels with the trains. The capital cost of the network-wide Positive Train Control Centre is estimated at $135-million, and an estimated $14-million is also required for wayside PTC equipment in the Union Station Rail Corridor as a network-wide cost. The wayside elements for the Lakeshore corridor, excluding the Union Station Rail Corridor, are estimated to

[3] Equipment cycling can be thought of as "Train A" going to the end of another line after arriving at Union to become "Train H"

cost $56-million in 2021, plus another estimated $18-million for new track laid between 2021 and 2031 ($74-million total). The cost of on-board PTC equipment varies with the fleet technology, starting at an estimated $4-million for locomotive-hauled trains of either technology by 2021, while EMUs would have an incremental cost estimated at $14.5-million over and above what locomotives would require by 2021. For 2031, another $1-million for on-board PTC is estimated for an expanded locomotive fleet while EMUs would be an estimated $4.5-million more expensive. In total, the locomotive-hauled options involve $79-million in PTC capital costs while the EMU option involves $98-million in PTC capital costs.

While EMUs would be around $19-million more expensive in terms of PTC capital costs than locomotives, the adoption of EMU technology would lead to savings of either $201-million (compared with diesel LHCs) or $373-million (compared with electric LHCs) in capital costs for the vehicle purchases themselves. Additionally, while the total PTC investment[4] with EMUs is estimated to cost $98-million, the alternative to PTC would be to lay additional track across much of the corridor, which would easily be well over double the cost of the PTC option, and closer to quadruple if the additional track were electrified in order to handle electric locomotives.

Conceptual new stations discussed earlier in this chapter are estimated to cost $151-million.

The realignment through Whitby is envisioned as starting near Ajax's eastern border, where a new corridor will cross Highway 401 as it curves to the northeast. It is would cross the new Highway 407 connector while on a northeasterly bearing, before connecting into the CP Belleville subdivison on a southeasterly bearing. The new tracks for the GO service would need to be north of the CP freight tracks to avoid conflicts with local freight customers. This realignment, about 15km in length, is estimated to cost $312-million, including five stations along the realignment.

Expansion of the Hunter St tunnel through downtown Hamilton, discussed extensively in previous sections of this chapter, is estimated to cost $440-million, including four nearby bridge reconstructions.

[4] PTC investment for components exclusive to the Lakeshore corridor, excluding network costs of $149-million

5.8. Operating Costs

Detailed operating costs were provided by the 2010 electrification study for evaluating the different locomotive technologies in the Reference Case's 2021 service model. Detailed evaluations of EMUs were not provided in the same manner in the 2010 electrification study, although EMU operating data were published without the discussion that was provided for locomotive options. The same methodology used for comparing electric locomotives with diesel locomotives in the 2010 electrification study can be applied for determining the cost of EMUs, with a few cautious, defensible assumptions required to represent information not published in the 2010 electrification study. This allows both EMUs and electric LHCs to be compared with diesel LHCs in terms of operating costs.

A similar exercise can also be done for the 2031 service model, with the cost of energy during the weekday peak periods being the main element to be accounted for. Calculating peak period energy consumption requires knowing how many trains would originate from a given distance away from Union Station; i.e. how many from Oakville vs. Aldershot vs. Hamilton, and how many from Pickering vs. Whitby vs. Oshawa vs. Bowmanville. Where the trains will park between peak periods also has a significant impact, as many will no doubt be forced to use Whitby, because the 3 sites in Toronto (Willowbrook, Bathurst, and Don) will undoubtedly be overwhelmed by 2031. This kind of detailed scheduling data for the peak period in 2031 is not available. The only exception to this would be for the section between Hamilton and St Catharines, because of the low demand projection would imply that 2031 service levels could be unchanged from 2021 service levels.

There are 4 main cost categories which impact either the GO rail operating budget or the Provincial budget; Fleet Maintenance, Energy, Labour, and Debt Servicing. See Appendix M for details. Plant maintenance is omitted due to a lack of publicly available information.

Fleet Maintenance Costs

Based on the 2010 electrification study, electric locomotives would reduce locomotive maintenance costs by $1.07-million compared with diesel locomotives in 2021. While the EMUs would generate savings over electric locomotives in terms of maintaining fewer coaches ($25-million), elimination of locomotive maintenance ($11-million), and elimination of cab car maintenance ($7-million). However, the total $43-million in savings are more than consumed by the $57-million annual upkeep of the EMU cars themselves, as well as another $3-million for maintaining the DMUs operating between Hamilton and St Catharines. Electric locomotive operations were assumed to serve to Hamilton (James), while EMU operations would

serve the Hamilton TH&B station. Fleet maintenance costs include equipment for diesel operation to St Catharines.

The fleet maintenance costs for EMUs do increase faster than the costs of other technologies over the 2021 to 2031 time period, but it is very significant that this is the only line item that presents EMUs being more expensive than both of the other alternatives.

Energy Costs

Even with the assumption of 11 more route-km of off-peak service on the Lakeshore corridor by operating all-day EMU service to Bowmanville instead of Oshawa, EMUs were found to generate lower energy costs than electric locomotives. This would be achieved by a combination of the EMUs' ability to split into shorter trains during periods of reduced demand, their higher regenerative braking rate, and a smaller fleet with EMUs resulting in a lower demand charge.

The energy costs in the 2010 electrification study were based on 2010 electricity rates, expressed as a cost per ton-mile of $0.00752 representing the combined price of both the electricity consumption charge and the electricity demand charge. When comparing EMUs to electric locomotives, demand charges should be calculated separately, and the information needed to calculate these charges were included in the 2010 electrification study. The 2010 electrification study also used 2009 diesel fuel prices of $0.75/L for the Reference Case's 2021 service model.

In comparing 2021 to 2031 energy consumption, escalated prices relative to the 2009 and 2010 prices would be required in order to obtain a reasonable estimate of future energy expenses. As the price of electricity rises each year, adjusted rates were used in this Regional Rapid Rail report as outlined in Appendix A. Only the consumption charge was increased; the demand charge rate was left consistent, i.e., assumed to rise with inflation (all costs are presented in 2010-dollars in this Regional Rapid Rail report).

Running shorter trains off-peak (8-car trains on weekdays and 4-car trains on weekends) dramatically reduces off-peak energy consumption, by almost 40% compared to electric LHCs for a fixed length at all times. In 2021, the estimated savings were almost $6-million a year, and in 2031, the estimated savings were over $28-million a year. Estimated off-peak diesel energy costs were about 2.5 times the costs of electricity for LHCs in 2021, or over 3 times as much as EMUs in 2021, and widening in 2031 to 3.5 times the cost of electricity for LHCs, or 5.5 times as much as EMUs.

Labour Costs

The significantly faster average speed of EMUs has big implications for the labour requirements to provide GO train service, but this was assumed to be constant in the 2010 electrification study because

there is a negligible difference between diesel locomotive and electric locomotive crewing needs. Only with EMUs does that change, and even in 2021, estimated crewing costs would be $4-million cheaper than locomotives of either technology. By 2031, the estimated labour savings could be almost $9-million annually.

Even at the less aggressive 2021 service levels, EMUs can provide the same service frequency over a wider service area with fewer trains, which reduces labour requirements. Running train service over a greater distance with the same staff in turn reduces the quantity of "train bus" services needed, reducing labour requirements even further at least during off-peak periods.

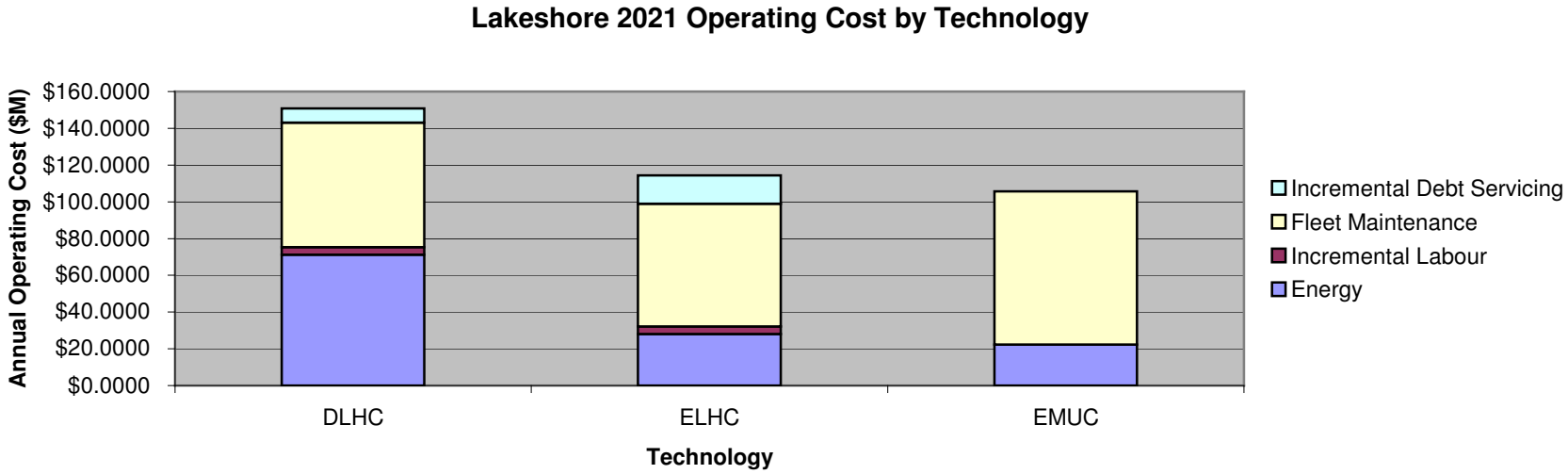
Debt Servicing Costs

The difference in debt servicing is a factor, except it would appear in the Provincial budget rather than in GO/Metrolinx's operating budget. This is a real cost of transit that gets paid for by the Province, even if it may seem like an "invisible" cost. GO/Metrolinx does not turn a profit; capital projects will be funded by the Province through debt, plus interest (and ultimately paid for by taxes). This Regional Rapid Rail report looks at the ***incremental*** debt servicing obligations, which is the difference in debt and interest incurred from different technology options, listed in amounts due in the given years.

Electric locomotives require almost $244-million more than EMUs in capital cost at 2021 service levels. As more service needs to be provided at peak times, the capital cost requirements between electric technologies widens by another $129-million by 2031.

In 2031, a new capital cost for both LHC options appears in the form of retirement of existing coaches. The oldest 64 coaches in today's fleet will be at the end of their life in 2031 and will need to be replaced. Of these, 27 are attributed to Lakeshore based on its percentage of fleet makeup in 2031 relative to the priority lines (Lakeshore, Kitchener, Milton, and Richmond Hill), with a capital cost value of $74-million ($2.74-million per coach) that is translated into a debt-servicing expense in the annual operating budget in 2031.

Despite its low visibility, debt servicing represents a notable proportion of the total cost of providing transit infrastructure capable of reliable service, and that cost tips the overall balance of operating expenses in EMUs' favour on the Lakeshore corridor in 2021. EMUs would be very likely to also generate higher ridership through their higher performance, thereby having a greater impact on curbing increases in GTHA congestion while also reducing the subsidy needed from the Province.



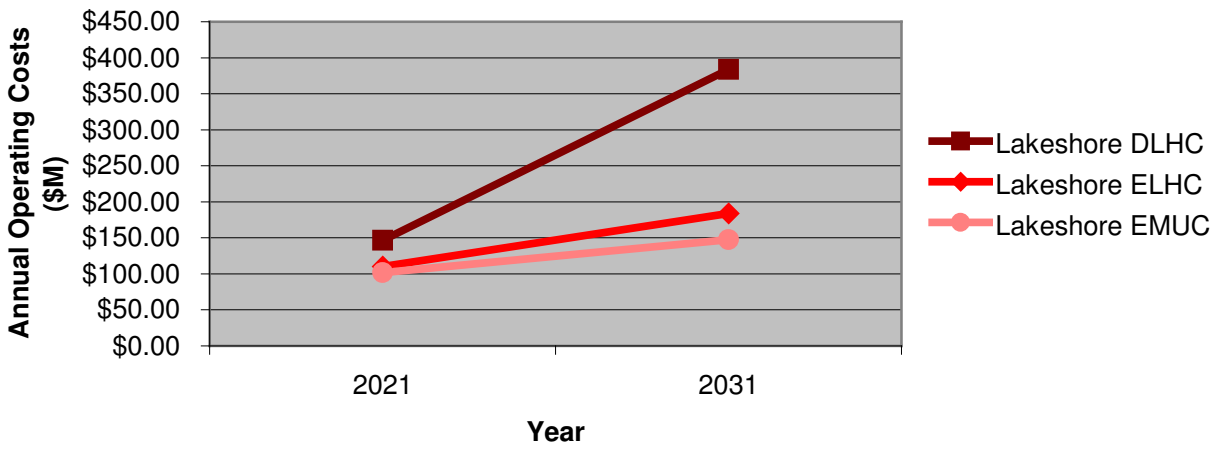
Uncaptured Costs (Plant Maintenance)

There are other savings with EMUs that would ideally have been captured in the comparison, but were not available. These include savings resulting from reduced track wear from running lighter weight vehicles, reduced maintenance of an additional and/or larger yard and layover facilities for a larger staff and fleet than needed with EMUs, different track quantities for 2031 service levels that would otherwise be impossible to maintain with LHCs of either technology, etcetera. The longer-term risk exists that it may not even be possible to sustain the demand on the Lakeshore corridor without the flexibility offered by EMUs to squeeze more capacity out of each track.

The graph above illustrates the proportional breakdown of annual operating cost differences for 2021, while the chart and graph on the following page summarizes the annual operating costs for 2021 and 2031. Detailed unit costs relating to the figures are found in Appendix A.

	Lakeshore Annual Operating Cost ($M)					
	2021			2031		
	DLHC	ELHC	EMUC	DLHC	ELHC	EMUC
Diesel Equipment Maintenance	$12.1991	$2.8370	$2.8300	$15.6035	$2.8370	$2.8300
Electric Equipment Maintenance	n/a	$8.2892	$56.8480	n/a	$11.2148	$73.8720
Unpowered Coach Maintenance	$55.6304	$55.6304	$23.7861	$70.7083	$70.7083	$30.8802
Energy	$71.2466	$28.1399	$22.2699	$285.7759	$78.0437	$49.7909
Incremental Labour	n/a	n/a	($4.0098)	n/a	n/a	($8.8586)
Incremental Debt Servicing	$7.6621	$15.4356	$0.0000	$11.5493	$21.1595	$0.0000
Total	**$146.7382**	**$110.3321**	**$101.7242**	**$383.6370**	**$183.9633**	**$148.5146**

Lakeshore Annual Operating Costs Comparison 2021-2031



5.9. EMUs for a Longer-Term Outlook

While the 2010 electrification study was in favour of electrifying the Lakeshore line, electrification remains an unfunded project that is not part of Ontario's current capital budget plans. The 2010 electrification study carried forward electric locomotives as the preferred electric technology for detailed evaluation, but there is a lot of risk in deciding to run with electric locomotives given that the Reference Case and the year during which electric service could be expected to commence are extremely close to one another. As such, its Reference Case captures none of the growth that electrification would be expected to accommodate over the first decade or so of electrified operations (roughly from 2020 to 2030), and that diesel technology is likely to struggle greatly with.

There are corridors, Lakeshore among them, that eventually will absolutely require EMUs to meet the demand projections prepared for *The Big Move*. This makes the long-term outlook of significant concern, considering that:

1. Switching electric technologies later would result in additional plant costs and other drawbacks from a mixed fleet of electric locomotives and EMUs.
2. As mentioned previously, it might not even be possible to operate Lakeshore East without EMUs by 2031 due to corridor constraints west of Scarborough Junction.
3. Conversion costs arising from different electric technologies at Whitby and/or Willowbrook yards could be avoided.
4. When optimized service models are applied for 2031 service levels (based on *The Big Move* projections) in comparing EMUs, the electric locomotives require more capital while providing fewer benefits in terms of system performance.
5. Electric locomotives would incur higher annual subsidies, as they would not attract as high a ridership as EMUs while simultaneously incurring higher debt and operating costs.

It is conceivable that Lakeshore would require EMUs only a decade or so after the commencement of electric locomotive operation. Considering that the lifespan of electric vehicles can be in excess of a half-century, if well maintained, this should be a major concern in weighing which technological investment to make. Examples of electric rail vehicles providing over a half-century of service are provided in "No Little Plan."

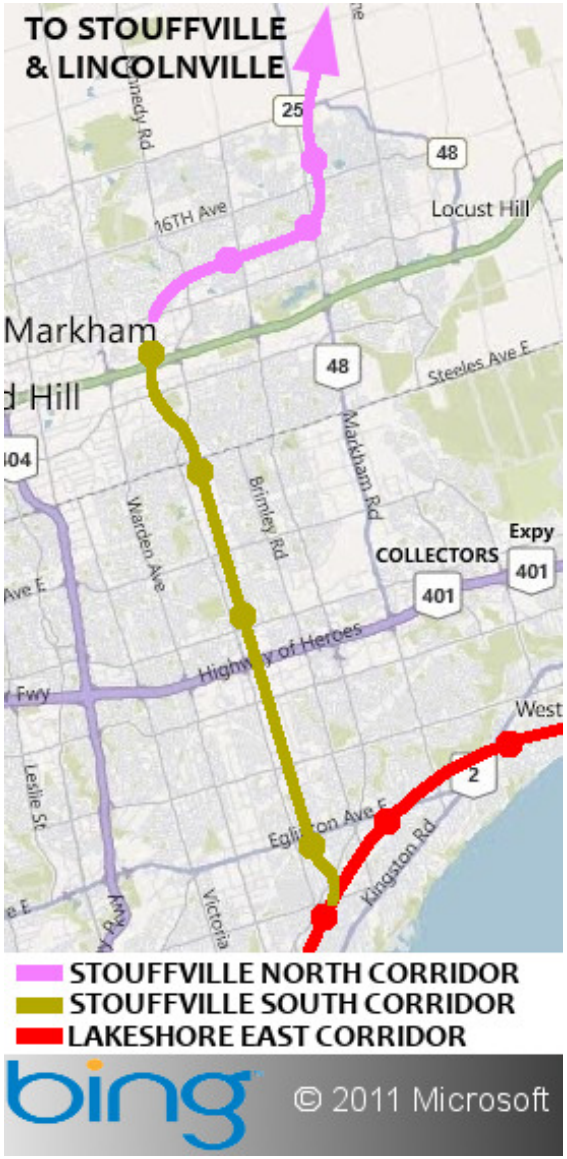
6. Stouffville Corridor

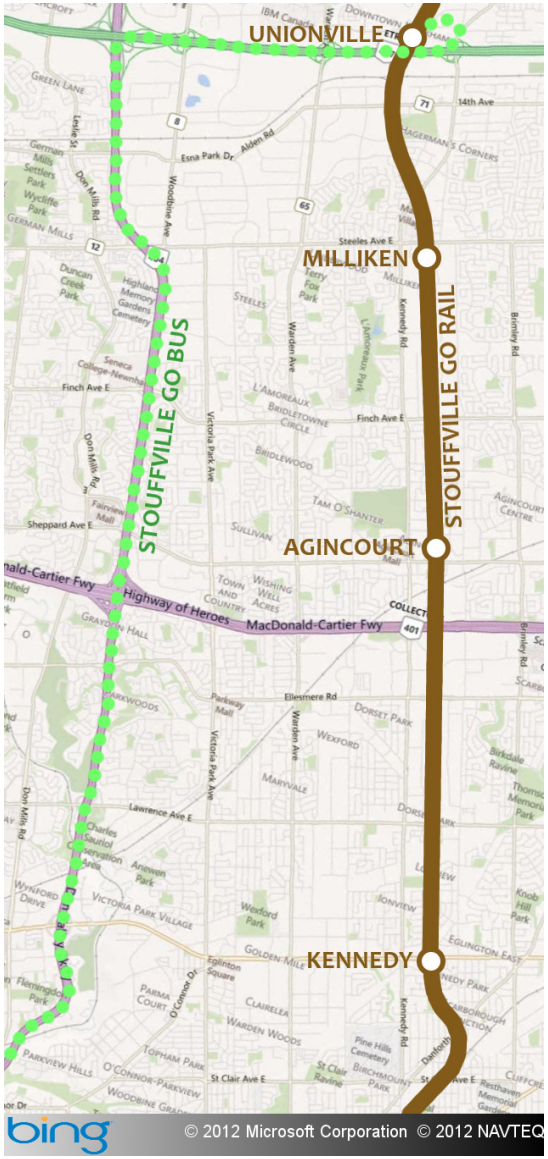
Like the Lakeshore East corridor, the Stouffville corridor is entirely GO-owned. Utilizing what is known to the railways as the Uxbridge subdivision, the line extends through Markham, including both its new and historic central areas, and also through Scarborough about midway between Kennedy Rd and Midland Ave.

6.1. Stouffville South vs. Stouffville North

The existing Stouffville corridor can be split into north and south portions. The divide between the two is the Unionville GO station, which is located immediately north of Highway 407 and west of Kennedy Rd. The Unionville GO station is close to the new downtown of Markham, an identified Urban Growth Centre, and will also feature a very well-designed connection to the Highway 7 East VIVA Rapidway now under construction, a key higher-order local transit service. The Unionville GO station would also connect with 407-based services when the 407 Transitway is built and in operation. GO Transit currently operates mixed traffic bus services on Highway 407.

Taken as a whole, the Stouffville GO line has a weak benefit:cost ratio for providing all-day rail service, which suggests a weak case for electrification until the details are examined more closely. Of note is that the Stouffville corridor stations in Scarborough (Milliken, Agincourt, and Kennedy) receive no GO bus service at any time due to the corresponding GO bus route using the Don Valley Parkway and Highway 404 through Toronto, leaving the Scarborough stations serviced only in rush hours by trains in the peak direction. For demand management reasons, Stouffville trains





have been operated without stopping at the Danforth and Scarborough GO stations, even though they share tracks with the Lakeshore East line. As it would be optimal from the perspective of an integrated transit network to provide service to these stations with Stouffville trains, future operating models could allow consideration towards changing this operation, especially if operated with EMUs.

A strong case exists for considering electrification of the southern part of the Stouffville corridor in the near-term when the above is considered in combination with:

a) The Metrolinx preference as per a Benefits Case Analysis for running all-day service on the Stouffville corridor to Unionville, and
b) The supposition that any electrification scenario would see the Lakeshore East corridor electrified between Union Station and Scarborough Junction, where the Stouffville corridor merges with the Lakeshore East line.
c) The proposal discussed in the following chapter for a new GO corridor through Scarborough.

South of the Unionville GO station, two-way off-peak service at stations in Scarborough and Toronto could be provided with 4-car EMU trains. GO bus services, which do stop at all GO stations through Markham in addition to Stouffville and Lincolnville, could continue to provide off-peak and counter-peak direction service northeast from Unionville until demand warrants all-day rail service. Peak period, peak direction service to/from the Lincolnville GO station could continue to be provided by diesel trains in at least the medium-term, while counter-peak service to Unionville could be provided by Lakeshore West and select rush-hour Kitchener EMU trains that would otherwise be moved to midday storage. These trains would be expected to be four cars long upon arrival at Unionville (discussed later). Once three of the 4-car trains have arrived at Unionville and combined into a single 12-car train, a peak direction trip into Union Station could be provided by the lengthened EMU train.

6.2. Diesel Case, Electrification, and EMU Case Costs

Please see section 5.7 for an overview of the methodology regarding cost categories.

The breakdown works out to:

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$39.85	$0.00
	Grade Separations (Road-Rail)	$205.61	$0.00
	Grade Separations (Rail-Rail)	$141.75	$0.00
	Bridge Widenings (River)	$12.56	$0.00
	Fleet (Capital)	$113.04	$0.00*
	Expanding Existing Stations	$62.10	$0.00
	Subtotal	**$574.90**	**$0.00**
Electrification	Infrastructure (incremental)	$90.00	$0.00
	Subtotal (incremental)	**$90.00**	**$0.00**
EMU Case	Wayside PTC	$6.08	$0.00
	PTC for LHCs	$1.89	$0.00
	New Stations	$54.00	$0.00
	Subtotal	**$61.97**	**$0.00**
CORRIDOR TOTAL		**$726.87**	**$0.00**

** The Big Move projects 2031 ridership as lower than in the 2021 Reference Case*

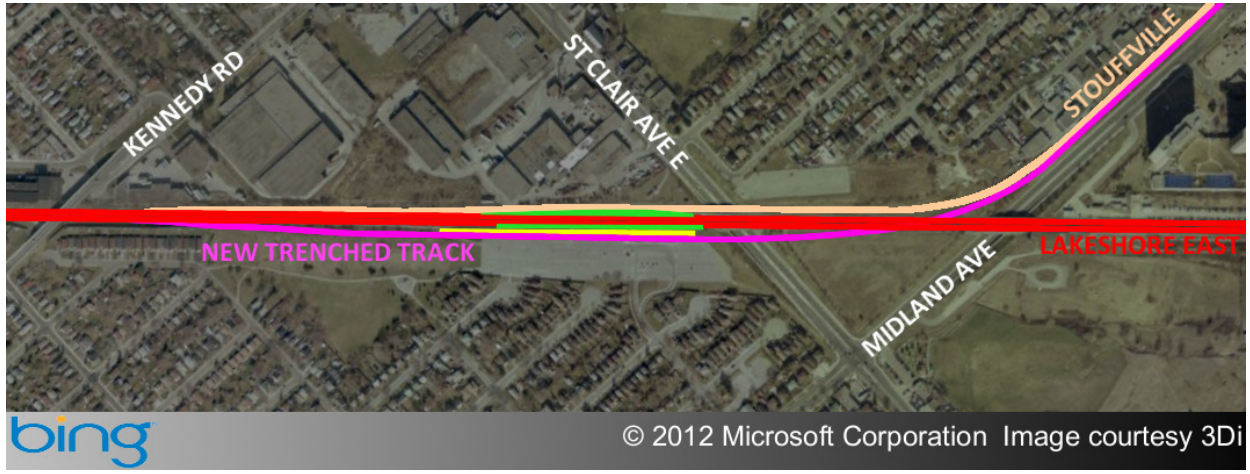
6.2.1. Diesel Case

The 2010 electrification study's Reference Case included double-tracking south from the Mount Joy GO station with all-day GO rail service to that station, but a subsequent Metrolinx analysis recommended that all-day service should be cut back to the Unionville GO station. This differed from the Reference Case, but the benefit:cost scores for running service was 1.0 to Unionville, and 0.6 to Lincolnville. By linear interpolation, the benefit:cost ratio for all-day service to Mount Joy would presumably be approximately 0.8. Double-tracking was estimated in this Regional Rapid Rail report to cost $40-million over the corridor between Unionville and the Scarborough junction, just west of the existing Scarborough GO station where the Uxbridge subdivision joins the Kingston subdivision used by the Lakeshore East corridor.

There are ten level crossings with roads along the southern part of the Stouffville corridor, of which three are minor roads that would not warrant grade separation given the lower frequency of peak period Stouffville corridor services. These are: Progress Ave, Havendale Rd, and Passmore Ave. For Progress Ave, a grade separation may be considered at a time when redevelopment plans around its crossing with the Uxbridge subdivision are prepared. The other seven are arterial roads, with a combined estimated cost of $206-million to grade-separate. The seven arterial road grade separations, from north to south, are:

1. Denison St
2. Kennedy Rd
3. Steeles Ave E
4. McNicoll Ave
5. Finch Ave E
6. Huntingwood Dr
7. Danforth Rd (at Midland Ave north of St Clair Ave E, not shown in image)

Frequent rush hour services along the Lakeshore East line in combination with Whitby-related non-revenue movements create the need for additional infrastructure in the form of a fly-under at the Scarborough GO station, including an additional platform at the Scarborough GO station in a deep trench (deep enough to accommodate a train beneath St Clair Ave E). Given the existing average track gradient of 0.82% uphill in the eastbound direction through this area, this is the most practical approach given the challenging topographical conditions with existing infrastructure in place (especially when factoring in effects at nearby Danforth Rd). This would facilitate the operation of northbound Stouffville corridor trains without impacting Lakeshore East services – southbound Stouffville corridor trains can serve this station with existing infrastructure. This would be usable by either technology (gradients would be ~1%) and are not a technology-specific cost, but rather, a cost associated with service levels to meet projected demand (particularly for Lakeshore East), and would be required whether diesel or electric vehicles are used for either line. As such, this rail-rail grade separation is assigned to the Diesel Case, and is estimated to cost $142-million (including new platform).



The line crosses West Highland Creek twice in quick succession just south of Highway 401. Bridgeworks for twinning those crossings were estimated to cost $13-million.

Rebuilding of the diesel fleet was estimated to cost $113-million, while expanding the existing station platforms through Scarborough plus Unionville to serve a second track was estimated to cost $62-million, most of which is to lower the Kennedy GO station by 3m in order to achieve much-improved connectivity with the subway and community improvement opportunities around the Eglinton Ave E crossing.

6.2.2. Electrification

There would be 16km of double-tracked corridor between the Unionville and Scarborough GO stations to electrify. This was estimated to cost $90-million, although this figure was difficult to estimate, as the 2010 electrification study did not isolate the costs for this corridor in their electrification study.

Assuming rush hour service to/from Lincolnville would still be operated with diesel trains, and with counter-peak electric trains running between Toronto and Unionville being provided by Lakeshore and select rush-hour Kitchener runs through strategic use of equipment cycling during peak periods, no new vehicles should be required for providing such service in the Stouffville South corridor. There would be no lack of EMUs available for off-peak operations.

6.2.3. EMU Case

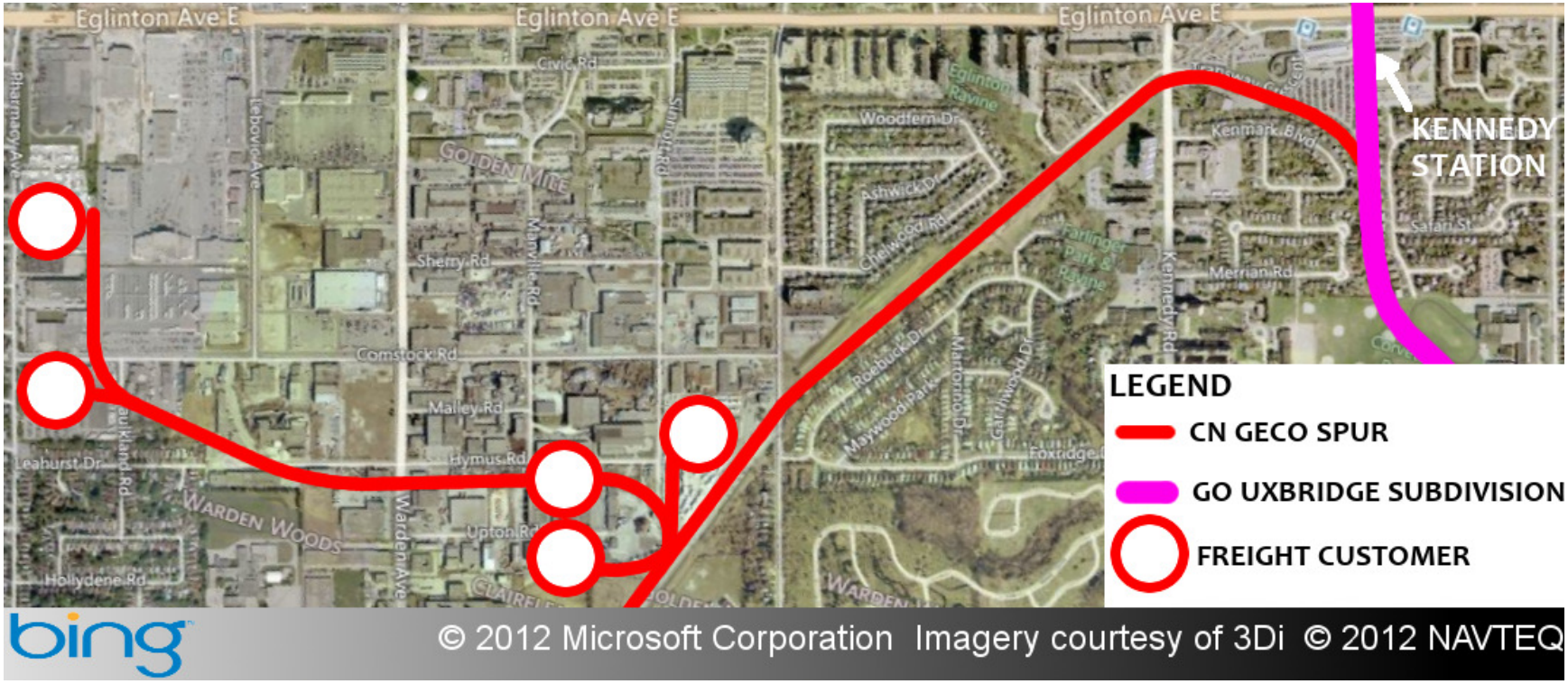
Wayside Positive Train Control (PTC) for Unionville to Scarborough Juction is estimated to cost $6-million. On-board PTC is estimated to cost $1.9-million for 14 diesel locomotives. New stations at Finch Ave E, Ellesmere Rd, and Lawrence Ave E (the latter two are explained more fully in the following chapter), are estimated at $54-million.

6.3. Freight Operations on the Stouffville Corridor

There is very limited freight activity on the Stouffville corridor, with only half-a-dozen freight customers. All but one of those customers are located along the Geco spur, which diverges west off of the Stouffville corridor just south of Eglinton Ave E and the Kennedy GO/TTC station, with the remaining customer at Lawrence Ave E. The Geco spur is illustrated on the following page. There are only two to three freight trains per week utilizing the Stouffville corridor.

6.4. Operating Costs

Operating costs for the Stouffville corridor are not available due to the absence of a compatible Reference Case comparison; the Reference Case modeled all-day service to Mount Joy for the Stouffville corridor, whereas the Metrolinx preference for an all-day service terminus was later concluded to be Unionville. This Regional Rapid Rail report agrees with the Unionville option. However, fuel consumption data is only available for the Mount Joy option, and fuel consumption is not a linear equation as it is influenced by track gradient, for which detailed data are publicly unavailable. However, the diesel:EMU energy consumption cost patterns of the other corridors were at least 2.5:1 in 2021, and at least 4:1 in 2031; these are significant operating cost savings from electrification, even if only for off-peak periods.



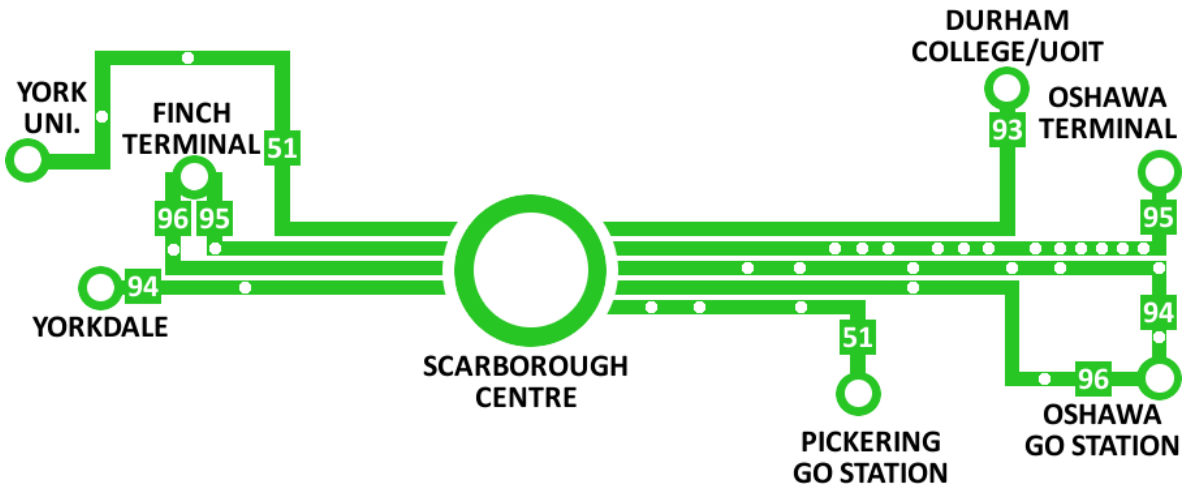
Above: CN Geco spur and local CN freight customers west of the Kennedy GO station, accessed via the Stouffville corridor [Uxbridge subdivision].

7. Scarborough Corridor

The Scarborough Rapid Transit (SRT) line is currently a 6.4km TTC corridor that has about 2/3rds of its route running alongside the Stouffville GO corridor. The SRT was built in the 1980s with a technology that became orphaned within the TTC system and is now obsolete. This technology is technically known as an Intermediate Capacity Transit System (ICTS), Mark-I model. Now at the end of its life and financially unreasonable to replace as-is, the SRT must change technology if the corridor is to continue seeing rail service in the future.

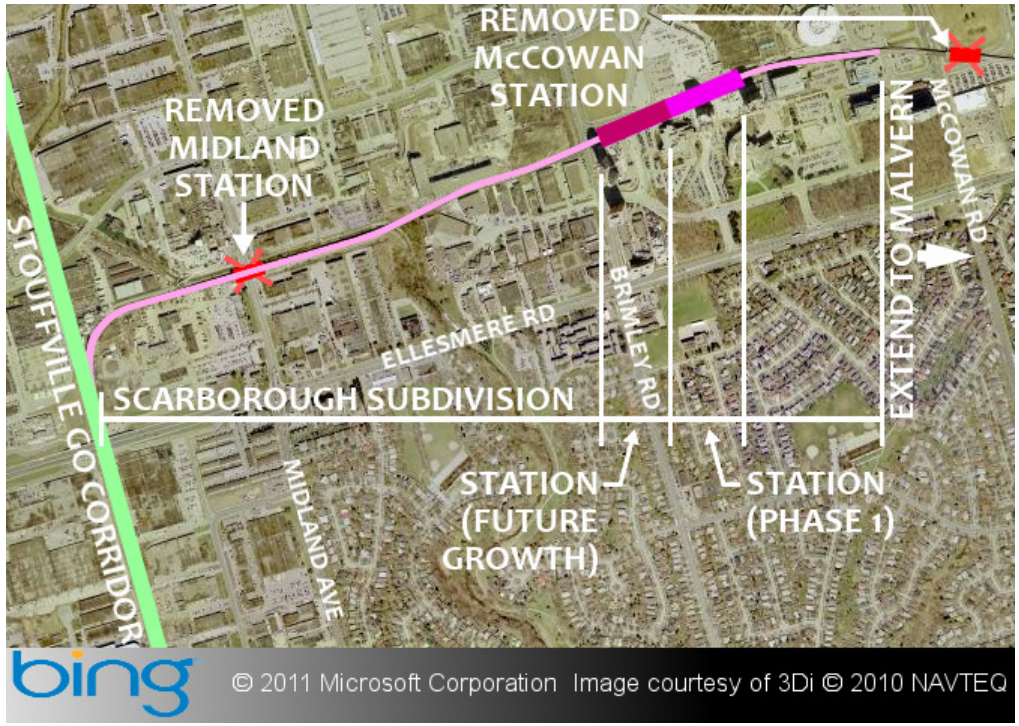
7.1. The Regional Network and the Scarborough Corridor

The TTC owns the SRT line at time of writing, but Metrolinx is about to acquire ownership of it. However, duplication of 4km of infrastructure within a single corridor and belonging to a single transit agency could be unnecessary. Consolidating resources would be the most efficient approach, and in this situation would include the added benefit of bringing GO rail through Scarborough Centre – where various GO and TTC bus services converge. Especially given that plans to through-route SRT vehicles along Eglinton Ave have been abandoned, this question is especially relevant.



Schematic diagram of GO bus routes that serve Scarborough Centre

The estimated cost of the currently planned replacement of the SRT with LRT technology is $1.3-billion dollars for a fairly short line, representing a per-kilometre cost in excess of $200-million on average. In a scenario where Lakeshore GO electrification goes ahead, including provision of a heavy maintenance yard for looking after its vehicles in Whitby, using GO EMUs to serve Scarborough Centre could be an alternative worth considering, as it may be as much as $500-million less in capital cost. This is due largely to replacement of the north-south 4km of the SRT being avoided, requiring only an expanded GO line with two additional stations that would not require complex modification. This is in contrast with the existing SRT stations that would require conversion for the LRT option. The east-west 2km of the SRT would be replaced, but without Midland and McCowan stations, both of which are relatively little used.



GO trains serving Scarborough Centre would also allow trains from there to continue south of Kennedy Station to at least the Scarborough GO station. With appropriately managed relationships between the Lakeshore and Stouffville GO services, particularly as it impacts Union Station, trains serving Scarborough Centre could run directly to Union Station. Such a service would have the potential to provide modest alleviation to the southern Yonge subway for comparatively very low cost. The Bloor-Danforth line, which is also under high stress west from at least Broadview station, would also see alleviation by default.

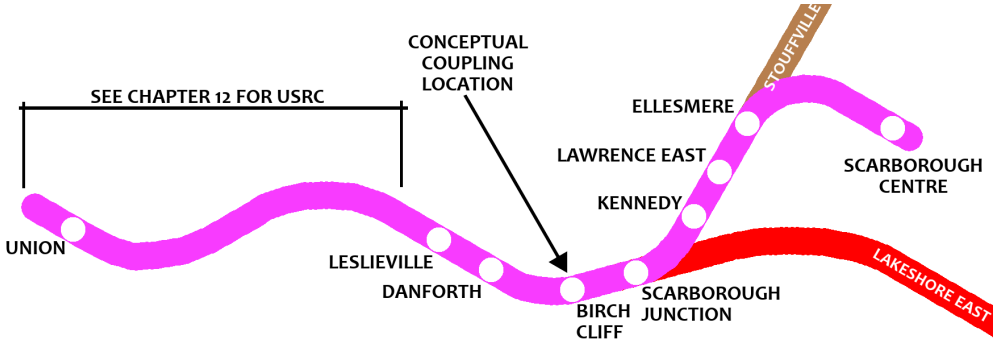
As this is a new corridor that starts and ends in Scarborough, this report refers to it simply as the Scarborough corridor [subdivision].

7.2. Accommodating a Direct Link from Scarborough Centre to Downtown

Union Station capacity is constrained in the long-term projections. This is an important factor when thinking about connecting more train lines to Union. One alternative to address that challenge could be to take advantage of the ability of EMU trains to join together [couple] and break apart [decouple] easily. This could happen at the next station southwest of the Scarborough GO station.

EMU GO trains are expected to be 12 cars long, as suggested in the 2010 electrification study. GO station platforms can be extended to 16-car-long train lengths if necessary. The Georgetown South Project environmental assessment has design plates suggesting that 16-car-long trains have been considered by showing 400m-long platforms (each GO rail car is 25m long). Most of Union's platforms are already long enough, but 16-car trains would require additional stairs and elevators not in the Union Station renovation design now under construction. However, another additional concourse (beyond the new west concourse) is something that GO staff have mulled over previously, but is not part of any current plan.

How many trains need to run through Scarborough Centre depends on the projected corridor demand. Metrolinx and the TTC had different projections for the SRT corridor, due to a difference between the networks modeled. That difference was the inclusion of CP corridors through Scarborough being used for GO service. The SRT corridor demand therefore depends on activity (or any lack thereof) on a combination of corridors in Scarborough north of Highway 401, and this should be outlined in some detail to get a clear picture of the projected ridership.



7.2.1. Extension Northeast from Scarborough Centre

There is an existing and funded proposal for extending the SRT as LRT to the Chinese Canadian Cultural Centre at Sheppard Ave E just east of Progress Ave, as well as a proposal for a subsequent extension from there to Malvern that does not yet have funding. The funding available for the SRT extension to Sheppard Ave E combined with the conversion of the existing line to LRT is $1.8-billion.

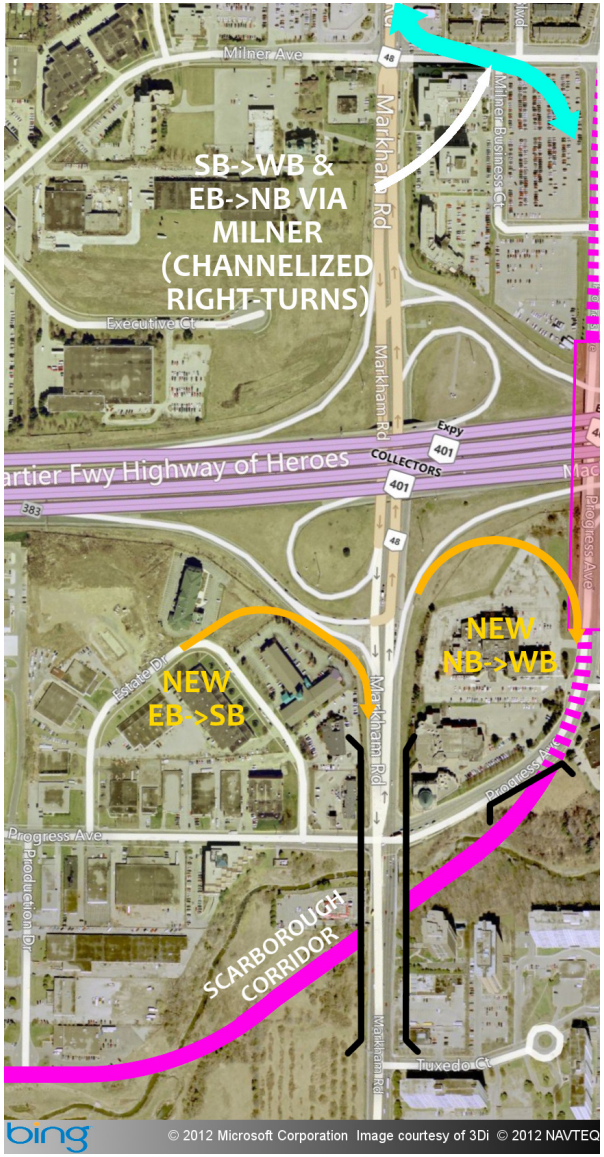
The funded LRT extension is to be fully grade separated even though the demand is only 3,000 passengers per hour per direction (pphpd). Due to a demand of 10,000pphpd along the existing line between Scarborough Centre and Kennedy based on the TTC's ridership projection, the expectation is that all trains on the line would each be 3 cars in length. With each train having a loading standard of 390 passengers, the frequency required for the line between Scarborough Centre and Malvern need only be one train every 7 minutes and 45 seconds, which can be handled comfortably at grade with shared traffic signals. Grade-separation for LRT infrastructure between Scarborough Centre and Malvern would therefore be overbuilding for the demand projected, and might not be the best value for money, especially considering the exclusively non-revenue-service underground junction at Sheppard Ave E. However, this LRT design originated from an earlier proposed extension using a newer version of the existing ICTS technology (Mark II, for which full grade separation would be required). Even with the relatively low projected demand level northeast of Scarborough Centre compared with west of Scarborough Centre, suggestions of an at-grade LRT operation northeast of Scarborough Centre never gained acceptance.

If the investment is going to be made in a fully grade-separated extension, the line could be considered for use by GO EMUs to achieve higher value from the infrastructure. The "line on a map" would look

the same with GO EMUs, but the corridor would differ from a light rail corridor, in particular the reduced extent of elevated structure, as well as less undergrounding, which would reduce cost. The $1.8-billion spent on an EMU-equipped line could take the service to Malvern immediately instead of only to Sheppard Ave E. This is made possible by the significant savings in the conversion of the existing SRT corridor, as most of it is immediately adjacent to the existing Stouffville GO corridor. The direct link from both Mavlern and Scarborough Centre to downtown also has a greater potential to entice higher ridership, which would not be problematic, as GO EMUs can provide much higher capacity than LRT.

Limited adjustments to the road network would be required with the GO EMU alternative due to differences in vertical alignments. Changes to Markham Rd, quite close to its 401 ramps, would enhance road safety by eliminating the steep slopes descending into the Highland Creek valley, with Markham Rd reconstructed as a new bridge above the new GO tracks. These changes, illustrated to the right, include short new roads for east (EB) to south (SB) and north (NB) to west (WB) turns. Changes to Sheppard Ave E would be for accommodating the Sheppard East LRT, which cannot cross heavy rail tracks without grade separation.

Almost identical to the LRT proposal, GO EMU service would have stations at Centennial College's Progress Campus and by Malvern Town Centre. The GO EMU service concept differs from the LRT proposal with respect to a station at Sheppard Ave E, because the distance from Sheppard to either the Malvern station or the Progress Campus station is only a little over 1km, which would be too close by GO rail standards. However, nothing prevents consideration of a Sheppard East LRT branch line into Malvern, likely via Neilson Rd. A Malvern LRT branch would connect with the EMU GO station in Malvern, providing a network configuration in Malvern that would serve both local and regional trips.



The transfer traffic between the Scarborough corridor between the Scarborough Centre station and the Sheppard East LRT to/from North York can be reasonably expected to be very low, as the McCowan bus link to Scarborough Centre (which has frequent bus service provided by various converging routes, with the 129 McCowan North being by far the most frequent) would be more attractive than double-backing via Sheppard Ave E and Progress Ave. Transfers between Malvern and the Sheppard corridor to/from North York are more likely, as they are direct trips, and the conceptual Neilson Rd LRT branch could accommodate that trip pattern.

The Progress Campus and Malvern stations are roughly in the same spots as proposed in the SRT EA, but adjusted to accommodate larger trains since EMU GO trains are much longer than the LRT trains. While mostly in the same spot, a major difference with the Progress Campus station is that it would no longer be elevated, but underground (possibly tunneled with a 3-face tunnel boring machine – as Kajima Construction did for an Osaka subway station in 1995), and would serve both sides of Highway 401.

Bellamy station, proposed in the SRT EA, has no funding, and would not be built as part of the currently-proposed LRT project, but as with the proposed station at Sheppard Ave E, a station at Bellamy Rd would have been too close to other stations to meet GO rail standards. Given the history of the Brimley station; i.e. it has been long-proposed just west of Scarborough Centre, but was deferred in the 1980s; it can reasonably be expected that the Bellamy station would be unlikely to ever get built.

The proposed LRT yard at Conlins Rd and Sheppard Ave E is supposed to be funded in part by the $1.8-billion estimate for the TTC's SRT proposal, although the breakdown for this is not provided. However, worth noting in the context of this proposal is that the SRT would have ~95 LRVs out of a total of ~149 LRVs for the SRT, Sheppard East, and Morningside LRT lines looked after at Conlins, meaning that the SRT would consume almost 2/3rds (64%) of the expected capacity. Conlins yard would be substantially reduced in size, and cost, if the SRT were served by GO EMUs instead of LRVs. The LRVs on order for the SRT could be redirected to projects in Peel Region, City of Hamilton, and the City of Toronto waterfront.

Conlins Yard Storage Capacity Calculations

Line	Rte-km	Directions	Demand/hour/dir	LRVs/hour	Headway (sec)	LRVs per Train	Average Speed	Round Trip(hr	Round Trip(sec)	Terminal Time(sec)	Total Round Trip(sec)	LRV Quantity	Spares	Total LRVs
Sheppard	14	2	3,000	11.5	312	2	23	1.2	4,382.6	600	4,982.6	32	3	35
SRT	18	2	10,000	25.6	140.4	3	34	1.1	3,811.8	180	3,991.8	86	9	95
Morningside	15	2	1,500	11.5	312	1	23	1.3	4,695.7	600	5,295.7	17	2	19

Total Conlins Storage: 149
Conlins allocation to SRT: 63.76%

As summarized in the table below, the transit ridership observed in today's system indicates that SRT demand is concentrated around Malvern and the Progress Campus area. Malvern-oriented routes to the SRT make up about one-third of the Scarborough Centre-bound bus service capacity currently operated, excluding those bus services that operate only between the Bloor-Danforth subway and the Scarborough Centre station.

Rte No.	Rte Name	Schedule Frequency (AM Peak)	Buses per Hour	Capacity per Hour	Serves Malvern	Serves Scarborough Centre
129	McCowan N.	4.5	13.3	680	No	Yes
130	Middlefield	15.0	4.0	204	No	Yes
131	Nugget	7.5	8.0	408	Yes	Yes
132	Milner	12.0	5.0	255	Yes	Yes
133	Neilson	9.0	6.7	340	Yes	Yes
134B	Progress	20.0	3.0	153	Yes	Yes
134C	Progress	6.0	10.0	510	Campus	Yes
38	Highland Creek	7.5	8.0	408	No	Yes
21B	Brimley	6.7	9.0	457	No	Yes
169	Huntingwood	20.0	3.0	153	No	Yes
Total Serving Scarborough Centre				3568		
Total Serving Malvern				1156		
Total Serving Malvern as % of Scarborough Ctr Service						32.4%
Total Serving Malvern and Campus				1666		
Total Serving Malvern & Campus as % of Scarb. Ctr Service						46.7%

When the bus routes that serve Progress Campus are also included in addition to Malvern for the target catchment area, the ratio is close to half of the bus service capacity at Scarborough Centre, at 47%. While there will clearly be some local riding to consider when interpreting these figures, the highest frequencies are always nearest Scarborough Centre. The most common criticism of transit in northeastern Scarborough is the quantity and quality of transfers, or the length of the bus ride to avoid said transfers. This suggests that there is potential latent demand in the corridor. The mode share of transit in Scarborough could therefore increase if better transit options from the northeast were provided, particularly if transfers at both the Kennedy and Bloor-Yonge stations can be avoided.

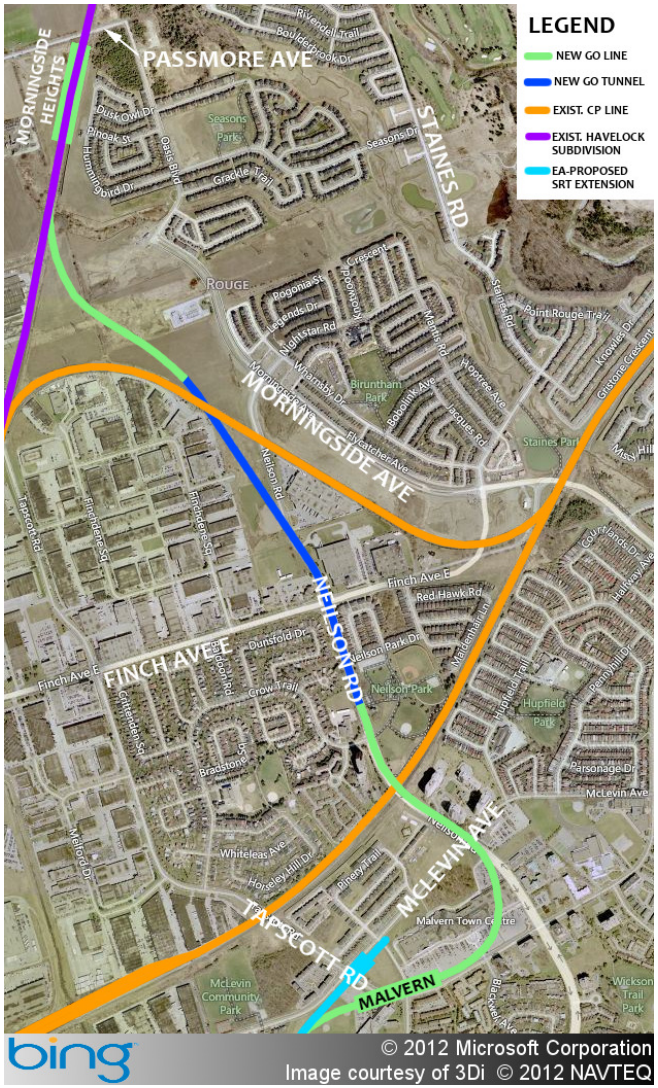
7.2.2. Locust Hill and Peterborough Connection

The Scarborough corridor proposed in this Regional Rapid Rail report provides a design solution that in part responds to changes that have occurred since 2008 that have a significant impact on the original regional transportation plan put forward in *The Big Move*. Among the impacts of these changes are questions about whether sufficient track time agreements to operate GO rail services on the Belleville subdivision could be secured. The Belleville subdivision is a part of the Canadian Pacific Railway's busy mainline between Montreal and Toronto. The Scarborough corridor offers not only an alternate route, but also additional and important benefits for traffic management through the Union Station Rail Corridor.

Admittedly, the Malvern community happens to have a rail line running through it already – the Belleville subdivision. However, that is a sensitive part of the freight rail network; the Canadian Pacific Railway runs all of its traffic coming from east of Toronto through Malvern, and significant traffic from various locations utilizes its Toronto Yard located just northwest of the intersection of McLevin Ave and Markham Rd (virtually across the street from Malvern).

In 2011, Canadian Pacific (CP) removed tracks between Pembroke and Renfrew in the western part of Greater Ottawa, which is significant to the Toronto area since that was the only alternate route for CP traffic that connects Quebec with Northern Ontario and Western Canada without being routed through Toronto. In the context of potential future expansion for GO, this situation makes the plans outlined in 2008 in *The Big Move* for running two services through Toronto Yard, one to Locust Hill and one to Seaton, potentially cost-prohibitive (it was already going to be difficult even when there still was a bypass near Ottawa). Given that significant unforeseen changes beyond the control of Metrolinx have taken place in the national rail network in the four short years since *The Big Move* was published, it would be worthwhile to discuss alternatives to services proposed on the CP network through Scarborough.

The proposal in *The Big Move* to run trains to Locust Hill in the eastern part of the Town of Markham was to use the Havelock subdivision (owned until recently by CP). However, given the recent changes in the CP rail network, this Regional Rapid Rail report puts forward the concept of running service to Locust Hill by extending the Scarborough GO corridor from Malvern to connect with the Havelock subdivision just south of its crossing with Passmore Ave. This alternative could be considered for avoiding the challenges of operating GO services through the CP Toronto yard and avoiding the costs of difficult expansion of the Belleville subdivision through Scarborough.



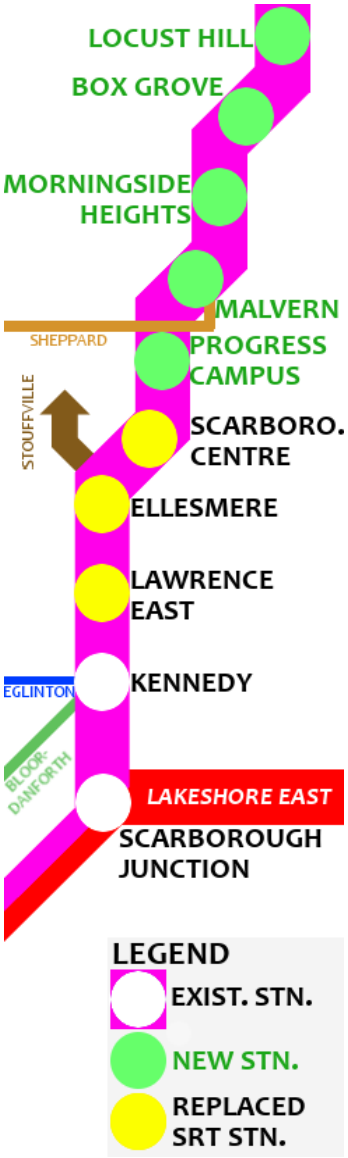
Once reaching the existing Havelock line, the Scarborough corridor can extend GO EMU service to the Morningside Heights and Box Grove communities before reaching Locust Hill. For Morningside Heights, Passmore Ave would be a preferable station location over nearby Steeles Ave E when details of the local geography, built form, and local area transit network layouts are considered. The Box Grove station could be on the north side of 14th Ave. Having the Locust Hill line routed through Malvern and Scarborough Centre would certainly boost its ridership projection, which was very low in *The Big Move*'s 2031 projection. Given data that are available from the Transportation Tomorrow Survey (2006), such a corridor may even have reverse-peak potential, as 10% of peak period trips from Scarborough are bound for Markham.

The Havelock line is the existing rail line that links CP's Toronto Yard to Peterborough. Rail service between Toronto and Peterborough could also potentially be affected by the CP Belleville subdivision challenges, but is further complicated by other factors that will be discussed in chapters 10 and 12. Routing via Scarborough Centre would avoid these issues, or at least substantially simplify the operational challenges.

The link between the intersection of Tapscott and Neilson Rds and the Havelock subdivision, about half-a-kilometre south of its crossing with Passmore Ave, would be approximately 3.2km in length. Of this, about 1.2km would have to be underground due to built environment constraints around the intersection of Finch Ave E and Neilson Rd. Considering that the Peterborough service would use diesel multiple units initially, and that the tunnel would have to be much longer than 300m, heavy ventilation equipment would be a concern. A partially open, grated top of the tunnel in the median of Neilson Road (except where there are intersecting streets) could mitigate that concern.

While the Scarborough corridor should have two tracks southwest from Malvern, north from Malvern would not necessarily require a second track – however, the tunnel should be built to a size that could comfortably accommodate a gauntlet track[5] operation, should service levels increase to a point where that would become warranted. This would happen if the Havelock line were to need a second track extending over part of or all of the length between Morningside Heights and Locust Hill. The provision for a gauntlet track avoids the cost of a second or larger tunnel structure across Finch Ave E. This would not recreate problems similar to those with the Hunter St tunnel in Hamilton as there would not be any freight traffic with which this tunnel would need to be shared.

Assuming the Peterborough rail service would be operating in future, this would allow the Peterborough service to run through Scarborough Centre. This would result in Scarborough Centre being served by TTC bus services, GO rail and bus services, and an intercity rail service, increasing potential ridership for all services through network connections and offering strong potential for stimulating meaningful employment growth in Scarborough Centre. That would transform Scarborough Centre into a strong network hub of local, regional, and intercity services in a designated Urban Growth Centre under the Places to Grow Act.

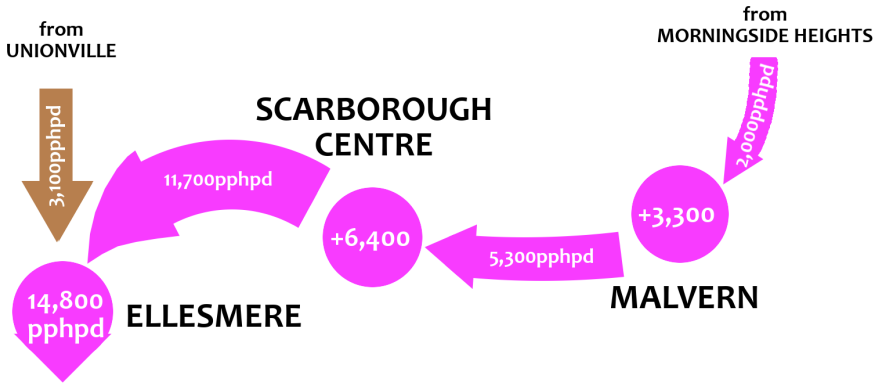


While GO EMU technology differs significantly from LRT, the Scarborough corridor proposal in this Regional Rapid Rail report does not go against the will of Toronto City Council with regard to its reaffirmation of the SRT as a priority project – in fact, because the cost would be less per kilometre, it should allow rapid transit service to reach Malvern sooner than the LRT proposal. It would also provide a subway-like service linking Malvern and Scarborough Centre not only to each other, but also directly to Union Station, and the GO EMU option would have a maximum capacity far higher than the 12,000-14,000pphpd upper limit of 3-car LRT option. The higher capacity is particularly relevant to the discussion of the Scarborough corridor proposal when all the pieces from *The Big Move* discussed earlier get put together.

[5] A "gauntlet track" is a railway term that can be thought of as one track with four rails instead of two

There were three corridors through northern Scarborough In *The Big Move*, four if the Stouffville corridor is included. Ridership projections for these three, in addition to the Stouffville corridor at 3,100pphpd, were the Locust Hill service along the Havelock line via CP's Belleville line (2,000pphpd), the Seaton service along CP's Belleville line (6,600pphpd), and the SRT service to Malvern (6,400pphpd – *The Big Move* figure). The TTC projected the SRT's 2031 demand at 10,000pphpd, the difference being attributable to the two new GO lines in *The Big Move* not included in the TTC model.

Given that Malvern is a known source of very high bus traffic for the SRT, the difference between the two SRT projections can be reasonably expected to equate to the volume intercepted by the Seaton service using the CP Belleville subdivision. This results in a roughly 50/50 split in trip origin between Scarborough and Durham for the Seaton service peak hour demand. If half of the Seaton service projection were used (3,300pphpd), then the combined total of these three corridors west of Scarborough Centre would be almost 12,000pphpd, before accounting for any demand stimulated by the direct link to Union Station from Scarborough Centre (the means for determining how much of a ridership increase this would yield were not available for this Regional Rapid Rail report). Add the Stouffville corridor to the total and the demand would be approximately 15,000pphpd south of the Ellesmere station, which exceeds what LRT can be expected to handle using 3-car trains. 12,000pphpd would be equal to an 8-car GO EMU train every 5 minutes, or a 3-car TTC LRT train every 1 minute and 57 seconds. Frequencies tighter than 1 minute and 45 seconds are unrealistic to sustain for a full hour, even with automated/driverless train operation, and particularly when certain stations have extremely high demand causing long station dwells at such locations, thereby limiting the practical frequency.



7.2.3. Seaton Connection

There is potential for the Seaton area to be served via the Scarborough corridor, but there is a lack of information available on what shape such a corridor may take. It would be prudent, however, to be cautious about what requirements may be associated with the existing CP Belleville subdivision across the southern edge of Seaton, which has previously been the favoured route. If the Scarborough corridor were to branch onto the CN York subdivision from the Havelock subdivision just north of Steeles Ave E in order to reach the CP Belleville subdivision, this would result in about 14km of freight rail corridor expansion in order to reach Brock Rd. Both CN York and CP Belleville have only a single track through these areas, and there are a few single-track bridges along this corridor as well. By contrast, a new branch line would avoid infrastructure conflicts with the freight railways. Such a branch might be significantly shorter in length than utilizing the existing freight lines, with a length of around 8km if it were to originate either at Locust Hill or just north of the Box Grove station. Two stations in Seaton placed about 2km apart could conceivably be conveniently reached by almost half of the Seaton population if the branch line were routed along an alignment similar to the Whitevale Bypass. This approach could open up various opportunities that would be supportive of the growth planning objectives in Seaton, but more information is required and would be for a separate undertaking by others.

Regardless of what form of rail service reaches Seaton, there would be strong connections from Durham Region to the Scarborough corridor possible via the Highway 2/Ellesmere and Taunton/Steeles corridors included in *The Big Move* (BRT technology assumed), which have been proposed to connect to the Scarborough Centre and Milliken stations, respectively. The Milliken station is along the Stouffville corridor, but the Taunton/Steeles corridor could also serve the Scarborough corridor's Morningside Heights station at Passmore Ave, either in addition to or as an alternative to Milliken, depending on the ridership patterns being served. Depending on the competitiveness of service frequencies and route layouts, the ridership generated by these Durham Region BRT corridors could be quite strong.

7.2.4. Co-existence with Lakeshore East Service from Scarborough Junction to Union Station

The 2010 electrification study shows that the busiest GO stations during the peak period on the Lakeshore East line would be Whitby, Ajax, Rouge Hill, and Pickering (listed in descending order), all of which receive at least some express services today. The Oshawa station, which also receives express service, fares comparatively poorly. This should allow local trains that originate in Pickering to serve a lower demand than the express trains, and consequently, to be 8 cars long instead of 12. These could be combined with Scarborough Centre trains of the same length west of the Scarborough GO station to form 16-car trains bound for Union Station. The same operation would work in reverse. A potential meeting/splitting point could be the conceptual Birch Cliff station mentioned in the Lakeshore corridor chapter, as it would minimize additional infrastructure requirements, and still take place east of the pinch point at Danforth Ave.

This kind of operation is not new, although it would be new to GO/Metrolinx. The 2010 electrification study alludes to this very concept on page 80 of the main report. This is a common practice on some Japanese railways that have branch line trains join into combined trains along the trunk mainline into Tokyo, operations witnessed first-hand by this author. There are lessons to be learned from the examples of Odakyū Electric Railway (小田急電鉄), or Keikyū Electric Railway (京急電鉄), both operating in Greater Tokyo. Video examples of this from Keikyū's operations can be found on YouTube (www.youtube.com) at the following URLs:

Video 1 – Keikyu Shinagawa Coupling;
http://www.youtube.com/watch?v=XxZqvH8ZQWU
Video 2 – Keikyu train's decoupling at Keikyu Kawasaki station;
http://www.youtube.com/watch?v=2XPiTumGzzk

As the above videos illustrate, the operation to either combine (couple) or split (decouple) trains is a one-minute procedure.

Outside peak periods, pressure on the Lakeshore East line is expected to be quite low compared to Lakeshore West. The pressure at Scarborough Centre outside of rush hour would also be lower. Assuming 15-minute off-peak frequencies, all trains bound for Oshawa/Bowmanville can split into a 4-car train through Scarborough, and an 8-car train to Oshawa/Bowmanville, and 8-car off-peak Stouffville corridor trains can split in half at the Lawrence or Ellesmere stations, with one 4-car train bound for Unionville and the other 4-car train for Scarborough Centre. Properly scheduled, trains through Scarborough would run roughly every 7.5 minutes.

A viable option worth considering for operations on the Scarborough corridor would be for trains to serve all stations served by the Lakeshore East line west of and including the Scarborough GO station. Operations on the Scarborough corridor would also have the current SRT stations served, except for the Midland and McCowan stations, as they would cease to existing in this concept due to a combination of low ridership and minimum station spacing standards for GO rail.

Many trains serving the Scarborough corridor from a split Lakeshore train would typically be original in Halton or Hamilton. Similar applies for the westbound operations where two trains combine into a single train that will become a Lakeshore West train at Union Station. This is a significant connectivity enhancement in line with the objectives of *The Big Move* to connect Urban Growth Centres to one another.

The distance between stations in this model for the Scarborough corridor is in line with the 2km minimum for GO rail standards, including the distance between the Kenendy and Scarborough GO stations. The only minor exception would be the distance between the Scarborough Centre and Ellesmere stations at 1.9km, but this applies only with 16-car trains; shorter trains would make this distance 2km or higher.

7.3. EMU Case Costs

Please see section 5.7 for an overview of the methodology regarding cost categories.

The breakdown, which as new infrastructure has only an EMU Case, works out to:

Category	Element	2021($M)	2031($M)
EMU Case	Wayside PTC	$18.99	$5.69
	EMU Fleet (incremental)	$126.38	$94.42
	PTC for EMUs (incremental)	$2.57	$1.89
	Track & Running Structures	$1,199.73	$385.73
	Grade Separations (Road-Rail)	$189.00	$0.00
	Electrification along Havelock Line	$0.00	$15.21
	New Stations	$162.00	$56.70
	Temporary Bus Terminals	$25.00	$0.00
CORRIDOR TOTAL		**$1,723.66**	**$559.64**

7.3.1. EMU Case

The Scarborough corridor in this Regional Rapid Rail report would be a new line in the GO rail system, and as such was not part of the 2010 electrification study. As a new line starting as an electrified service, there is no diesel case, nor an electrification cost, as the infrastructure would be electrified when first built.

Wayside Positive Train Control (PTC) for the Scarborough corridor to Mavlern is estimated to cost $19-million. Connecting the Scarborough subdivision with the Havelock line between 2021 and 2031 would cost another estimated $6-million in wayside PTC.

The Scarborough corridor is projected to require an EMU fleet estimated to cost $126-million by 2021. This cost is still incremental, since equipment cycling and coupling operations would optimize the fleet size. By 2031, additional EMU fleet estimated to cost $94-million would be needed to meet projected demand.

On-board PTC is estimated to cost $2.6-million for 19 EMU cars for the Scarborough corridor. As demand and fleet grows along the corridor, a further estimated $1.9-million would be needed for equipping the expanded EMU fleet with on-board PTC.

The new corridor's fixed infrastructure is estimated to cost $1.39-billion (including $189-million in grade separations) from Ellesmere Rd at the Stouffville corridor [Uxbridge subdivision] to Malvern, to be completed by 2021. Another estimated $386-million to be invested after 2021 would extend the line from Malvern to Morningside Heights, where it could link with the existing Havelock subdivision. Electrifying the nearly 7km along the Havelock subdivision between Morningside Heights and Locust Hill is estimated to cost $15-million.

Excluding the Havelock subdivision, new stations for the Scarborough corridor are estimated to cost $162-million by 2021. The three Havelock subdivision stations are estimated to cost $57-million, and would be built between 2021 and 2031.

When demand reaches the point that requires 12-car GO trains along the Scarborough corridor, the time will have arrived for the full Stouffville corridor to be electrified, as EMU co-existence with LHCs could conceivably become impractical west of Scarborough Junction. EMU operation of the entire Stouffville corridor will free the dedicated Stouffville track along the Lakeshore East corridor to be used by peak period Scarborough corridor trains that have become too long to couple with Lakeshore trains, while shorter Stouffville trains, possibly at better frequencies, would couple with Lakeshore East trains

instead. This would make sense in the long-term given the mix of demands projected to be at play in this part of the network.

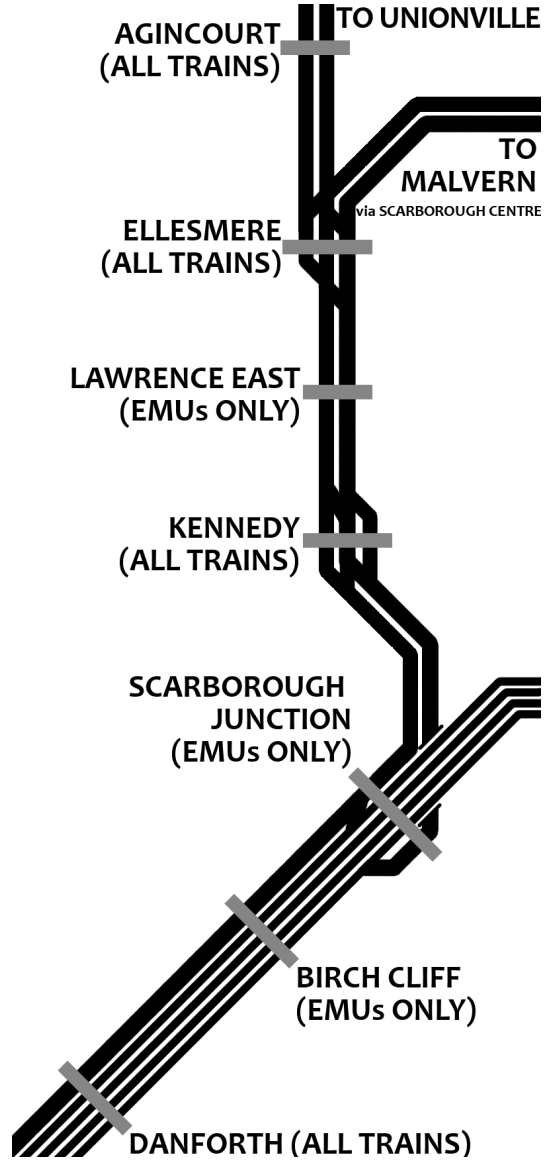
Temporary bus facilities would be required during construction of the Scarborough corridor infrastructure north of Ellesmere Rd, south of which electrified GO service would ideally already be running by the time the TTC's existing SRT service is shut down. Being closer to the Whitby yard than any line other than Lakeshore East, this short stretch could serve as a first section for GO/Metrolinx to develop a familiarity with electrified service. Initial operation of just the SRT service area would not have to contend with Union Station electrification and Union Station capacity issues. Given the existing EAs for the SRT and for the Whitby yard, this could be done before the existing SRT reaches the end of its operating life. Interim non-revenue movements would require a diesel locomotive to get EMUs to/from Whitby for heavy maintenance until electrification EAs allow electrification between Scarborough Junction and Whitby, and between Scarborough Junction and Kennedy stations. Given the relatively short distance between the Kennedy and Ellesmere stations, coupled EMU trains could likely be accommodated at station locations in an on-line storage arrangement until electrification expands along the Lakeshore East corridor.

Temporary bus terminals could be located at the Ellesmere station for TTC buses only, and at Scarborough Centre for both GO and TTC buses. These terminals are estimated to cost $25-million.

7.4. Mixing Diesel and EMUs

The peak period diesel operations along the Stouffville corridor would have minimal conflict with EMUs, as they would be on shared tracks for only a few kilometres between Ellesmere Rd and Birchmount Rd. Diesel Stouffville trains' impact on EMU traffic would be the equivalent of what VIA Rail would experience on Lakeshore express service, but if Stouffville diesel trains skip the "new" [replaced] Lawrence East GO station and the existing Scarborough GO station, that would ensure effects on EMU operations resulting from shared diesel operations are minimized. This partly limits the attractiveness of the existing Scarborough GO station as a strategic transit interchange point between peak direction Stouffville corridor diesel trains and the Lakeshore East corridor. However, the network would still be very functional given the overlapping connectivity offered by the Scarborough corridor as an EMU operation, in addition to the occasional peak direction EMU serving Unionville blended with the diesel operation.

Stouffville diesel trains can make additional stops without conflicting scheduling impacts at Finch Ave E and at the "new" Ellesmere station if it has a 3-track layout (recommended for junction functionality), and the same should apply to the Danforth GO station – where it could have a dedicated track. The Kennedy GO station would be the only station served by both technologies on the same tracks; this would likely be manageable. A simplified track diagram of this operation is shown to the right. Thick black lines represent tracks dedicated to service along the Stouffville and Scarborough corridors usable by diesel locomotive-hauled trains as well as EMUs. The thin black lines represent tracks for serving the Lakeshore corridor that can be shared with EMUs bound for or originating from the Stouffville and Scarborough corridors by coupling to Lakeshore trains.



7.5. Operating Costs

For the Scarborough corridor EMU service, the existing TTC operation (and its currently proposed LRT replacement) should be used as a starting point. However, these kinds of data are not available, especially as the impacts go beyond the SRT alone. Because GO service to/from Scarborough Centre and Malvern would enable direct service to downtown Toronto, modest alleviation could be expected for the Yonge subway south of Bloor St, in addition to alleviation for the Bloor-Danforth subway. It is not known what the all-in value is for an additional four or more southbound Yonge line trains in the AM peak hour (providing 4,300pphpd of capacity, or more), assuming those additional trains could even be accommodated in an operation already running at capacity.

What is known in terms of benefits and system efficiencies versus today's ICTS (and tomorrow's LRT) service is that less labour is involved in running higher capacity trains at wider headways to Scarborough Centre and Malvern. These headways would be about two minutes wider than today's off-peak frequency, and three minutes wider than today at peak, with higher reliability and better odds of passengers being seated during peak periods. The consolidation of operations between Eglinton Ave E and Ellesmere Rd results in a reduction in the overall volume of track infrastructure that needs to be maintained in the this part of Stouffville corridor (with the current SRT immediately adjacent). Additionally, and of particular significance, the GO EMU option has a vastly larger growth cushion beyond 2031 than LRT. If the LRT option were to carry 10,000+ passengers per hour in 2031, it would be nearing its practical limit of 12,000pphpd to 14,000pphpd based on the train length restriction of 96m that various infrastructure elements are designed for. On the other hand, if GO EMU trains were extended to 16-car lengths, the EMU option could accommodate almost 25,000 per hour at 5-minute headways – all seated. That level of capacity would not be required, but it demonstrates that this is a cost-effective long-term (even very-long-term) solution, while the LRT could conceivably experience a capacity shortfall. This would be of particular concern if major redevelopment initiatives do materialize at some point in the future, especially if within 500m, or possibly 800m, walking distance of an access to the Scarborough Centre station.

LRT is a viable, appropriate, and sustainable transit option for corridors like Sheppard East, Finch West, and others where demand is unlikely to exceed LRT's at-grade/in-street capacity limits. However, the information available when preparing this Regional Rapid Rail report suggests that LRT would not be suitable for the unique network dynamics as they relate to the GO rail system in the Scarborough corridor.

7.6. A Bold Solution for a Complex Set of Challenges

The concept discussed in this chapter regarding the Scarborough corridor is bold and off the beaten path. However, the proposal to run LRT on the SRT corridor carries risk that is similar to what ultimately befell the ICTS in terms of the capacity provided for the demand projected. While capacity will clearly go up with LRT compared against the existing ICTS, it is unclear if it will increase by a sufficient margin, and that could be a cause for concern and pause. Designs for the LRT infrastructure are not intended for anything longer than 3-car trains, 96m long, resulting in a fixed capacity limit in the 12,000-14,000pphpd range, assuming a ***sustained*** headway of 105 seconds as the lowest practical headway. Projections for 2031 are 10,000pphpd with a terminus at Kennedy. The projection is certain to be higher if direct, "one-seat" service to downtown Toronto is provided, and that would thereby increase the transit share of the modal split in Scarborough. Bi-level EMU GO service through Scarborough Centre and Malvern is bold in that it possesses the versatility to adapt to future demand in a wide variety of growth scenarios. In that same sense, the LRT is not bold, while carrying higher risk due to its capacity limit being rather close to its 2031 demand projection. While demand projections are valuable tools, it must be borne in mind that projections are not exact sciences, and are based on assumptions that may or may not play out as projected. What if the actual demand becomes modestly higher than projected?

This concept also keeps options open for future transportation expansion in northeastern Scarborough and southeastern Markham. The infrastructure requirements along the CP main line corridor since the removal of tracks west of Ottawa could result in serious obstacles for future service expansion of the GO rail system to Locust Hill. Replacement of the SRT with bi-level EMU GO service provides an alternative that would bypass one of the busiest areas along the CP main line. This could prove to be a very cost-effective alternative.

Somewhat absent from the discussion of growth in the SRT corridor is the capacity constraint on the Bloor-Danforth line. This is a line that has started facing serious peak period crowding, and this is likely to get worse as the line is already operating at a tight headway. The infrastructure design and demand spread of the Bloor-Danforth line leave it poorly equipped to provide "trippers" for tightening headways beyond what terminal operations typically allow. This creates an imperative for improving capacity that serves not only the SRT corridor, but also bypasses the Bloor-Danforth subway, not to mention the Yonge subway. This is a daunting challenge that requires a bold solution. Bi-level EMU GO service can provide the resources to deal with this network challenge cost-effectively, and provide some much-needed travel alternatives to an area many consider neglected.

8. Kitchener Corridor and the Air-Rail Link

The Kitchener corridor (known until recently as the Georgetown corridor) currently schedules two round trips to Kitchener per day, with more round trips planned when a larger layover site is built in Baden, 17km west of Kitchener. Most of the remaining runs originate or terminate at Georgetown, while a small number operate only as far as the Brampton or Bramalea stations.

The 2010 electrification study Reference Case suggested that rail service would be provided to Kitchener only during peak periods – even after the Baden layover site was in operation. *The Big Move* originally did not propose any service west of the Georgetown station, as the Kitchener extension from Georgetown was not in *The Big Move* when it was published in 2008.

For two decades, the Kitchener corridor has had its infrastructure expansion affected by the Air-Rail Link project, which has had multiple previous aliases, including “Blue 22” as well as the “Union-Pearson Rail Link,” and was recently re-branded as the “Union-Pearson Express.” It has been a controversial project. Perhaps the most significant event in the 20-year history of Air-Rail Link studies and proposals has been the recent change in ownership of the Weston subdivision between the Bramalea GO station (the Halwest junction) and Union Station from CN to GO/Metrolinx.

8.1. Urban Corridor: From Toronto to Mount Pleasant

The urbanized section of the corridor extends from downtown Toronto to a station on the western outskirts of Brampton: the Mount Pleasant GO station at Creditview Rd and Bovaird Dr. With one exception, this is the section where stations could be added, as much of the corridor west of Mount Pleasant passes through largely undeveloped agricultural land, except for the cities of Guelph and Kitchener, and the communities of Georgetown, Acton, and Rockwood. Of these, only Rockwood does not have a rail station (although Rockwood is currently served by GO buses).

The full Kitchener line is about 100km in length, while it is about 39km from Union Station to the Mount Pleasant station. There are currently 6 other stations along the urbanized section, and the point nearest to Pearson International Airport on the entire GO rail system.

8.2. Pearson International Airport

The Air-Rail Link project currently under construction involves the operation of 2-car diesel multiple-unit (DMU) trains every 15 minutes between Union Station and Pearson Airport. The service would follow the GO/Metrolinx-owned Weston subdivision on which Kitchener corridor services also operate. From Union Station, the Air-Rail Link operation would serve the Bloor and Weston GO stations before leaving the Weston subdivision and utilizing a new 3.3km airport spur that starts at the Mississauga border, where the Kitchener corridor crosses Highway 427 just north of Highway 409. While the fare remains undetermined at time of writing, some expect a ticket price of $25 for the 25km, 25-minute one-way trip. It is unclear if the original plan for the Air-Rail Link involving service at Union Station on the northern-most track, track number 1 serving platform 3, would still work in light of recent concerns about how that arrangement would negatively impact overall corridor capacity approaching Union Station; plans might be changing in favour of track number 3, serving platforms 5 and/or 6. Environmental assessment approvals to construct a 4-track corridor from Bathurst St to Highway 427 are in place for the Kitchener corridor. The 4th track does not have funding in the current construction project, which will result in a 3-track corridor by 2015.

Pearson Airport generates air traveler traffic to/from all directions across the GTHA. Past studies have suggested 17% of air traveler traffic would originate/terminate in the broader downtown Toronto area. However, demand generated by air travelers is different from demand generated by airport workers. The Air-Rail Link proposal, repeatedly advanced over the past two decades, seems to focus on business-class air travelers as the principal market, while premium fares would be unaffordable for airport workers to use the service. It is worth emphasizing that the broader Airport Corporate District is the GTHA's next largest employment precinct after downtown Toronto, with 40,000 jobs. Like airport travelers, these employees come from all directions across the GTHA.

Moreover, the 17% of Pearson Airport traffic originating in downtown Toronto does not mean that all of that traffic would be using the Air-Rail Link. For many, Union Station would be out of the way for their trip to/from the airport, and therefore many will not opt for the Air-Rail Link. Many others would not be willing or able to pay the premium fare. Metrolinx is estimating the ridership at 5,000 passengers per day for both directions combined, which would be less than 5.8% of current Pearson Airport traffic (86,000 travelers a day according to Pearson's website at time of writing, excluding "meeters and greeters"). The Sheppard subway line carries 5,000 passengers in one hour in one direction, and this level of ridership a common point of criticism directed at that line. With 100,820 daily rides, the ratio of capital cost per daily ride on the $1-billion Sheppard subway is $9,919/ride. For a total of $183-million based on $128-million for the airport spur and $55-million for the DMU vehicles, the capital cost per daily ride on the Air-Rail Link will be $36,600.

The fare structure proposed for the Air-Rail Link service is marketed to business-class travelers, and the service currently proposed has a carrying capacity to match the size of this market. The capacity of the Air-Rail Link is within the range of what a mixed-traffic bus route could provide. As per numbers published by Metrolinx:

- 63 seats per Air-Rail Link car (no standees permitted)
- 2 cars per Air-Rail Link train (126 seats maximum per train)
- 4 Air-Rail Link trains per direction per hour (15-minute frequency)
- Air-Rail Link carrying capacity of 504 passengers per hour (126x4)

The numbers for a TTC bus service:

- TTC buses have around 37 seats per bus (varies by model, some have 36, some 38)
- There are many TTC bus routes run with rush hour frequencies of 5 minutes or better
- A bus running every 4 minutes and 25 seconds would provide the same seating capacity as the Air-Rail Link
- A bus every 171 seconds – just under every 3 minutes (a handful of TTC bus routes run with 2-3 minute frequencies) – with standees (48 per bus seated and standing) would have a capacity of 1,008 passengers per hour – double that of the Air-Rail Link

An approach whereby airport employees could take a GO train to the airport instead of driving would funnel high capacities through Pearson, offering the potential for a greater reduction in reliance on GTHA roadways, thereby reducing congestion. An added benefit of this model would be that GO train capacity may be more efficiently used by workers from Brampton getting off at Pearson and in turn freeing up room for others at GO stations within Toronto, which nets better economic performance by having a higher quantity of shorter trips spread over the line.

Brampton is the fastest-growing municipality in the GTA, especially along its north and west flanks, the latter being the location of the

Mount Pleasant GO station which serves a recently built part of the still-growing city. Like Toronto, Brampton is also among the origins of traffic bound for Pearson Airport. As a growing market, especially a market that would be traveling in the peak direction in peak periods (the opposite of the situation in the City of Toronto), enticing airport employees to use GO rail to get to work has the potential for alleviating airport area congestion. This potential is enhanced further if the train is making many stops along the way, allowing for many connections with other transit services for workers originating from a wide array of locations (also known as “linked trips” in the transit industry). The infrastructure resources from the Weston subdivision being allocated to a limited-stop, frequent, express service between Union Station and Pearson Airport are not proportional with the projected demand for that service: In each hour, the airport would be served by only 4 trains with 2 cars each. Rail-based, integrated and regionally connected rapid transit serving Pearson Airport that provides links with many origins and destinations along the way, both east and west of the airport, would yield higher transportation network benefits and efficiency. By comparison, a single 4-car EMU GO train would provide the same capacity to the airport as the hourly capacity of the Air-Rail Link, as each GO Bi-Level EMU would have the same capacity as a 2-car Air-Rail Link train. If that GO EMU service to the airport were to operate every 15 minutes, it would provide 4 times the capacity of the Air-Rail Link. Longer trains through the airport would further increase this multiplier.

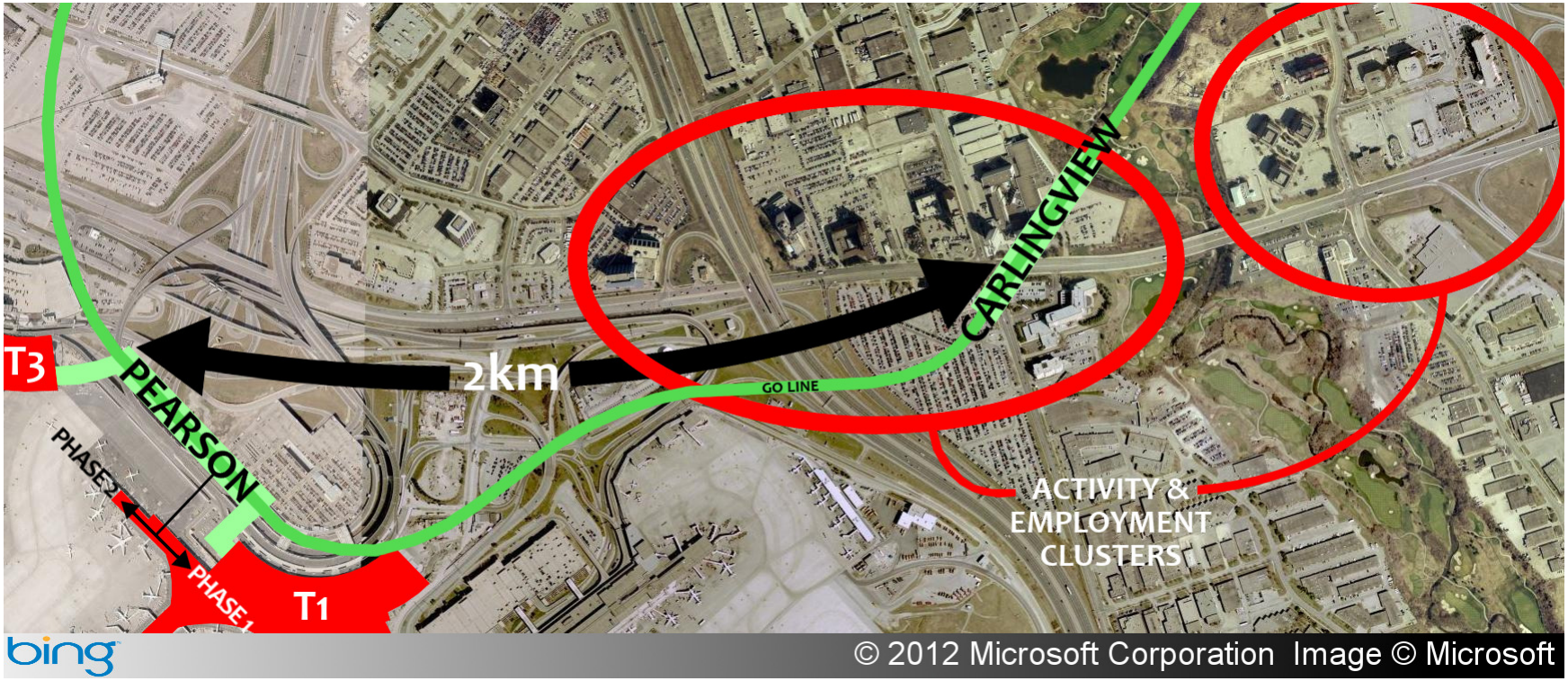
Without question, the Air-Rail Link currently under construction will provide service to Pearson Airport for the short-term. However, providing service both to the airport and on the Weston subdivision in a sustainable and efficient manner for the medium- and long-term would involve both an ultimate vision, and a strategy for achieving that vision.

An ultimate vision might feature:

- Minimization of abandonment of infrastructure already constructed.
- Airport terminals served by the same GO EMUs that would be operated elsewhere on the electrified network.
- An airport station as a line station along the Kitchener corridor to provide service to/from both Toronto and Brampton (and points further west).
- An airport station with a platform that straddles the space between airport terminals, so both terminals are served by a single GO station.
- Airport (district) employees using regular GO fares for their commute to work using the airport station.
  - Air travelers who are not airport/airline staff could still be charged premium fares to use the airport station if policymakers so choose.
- Trains serving the airport operating as local services to achieve the widest possible catchment area and thereby attract the largest ridership.
- An additional stop in the Airport Corporate District (Note: The former Regal Constellation hotel is being razed even though there is no replacement building proposed at time of writing; this is a very unusual and very advantageous circumstance that is taken advantage of in this Regional Rapid Rail report – the additional stop is shown as occupying this site and could be integrated into a future development)

A strategy to achieve such a vision might involve the following stages:

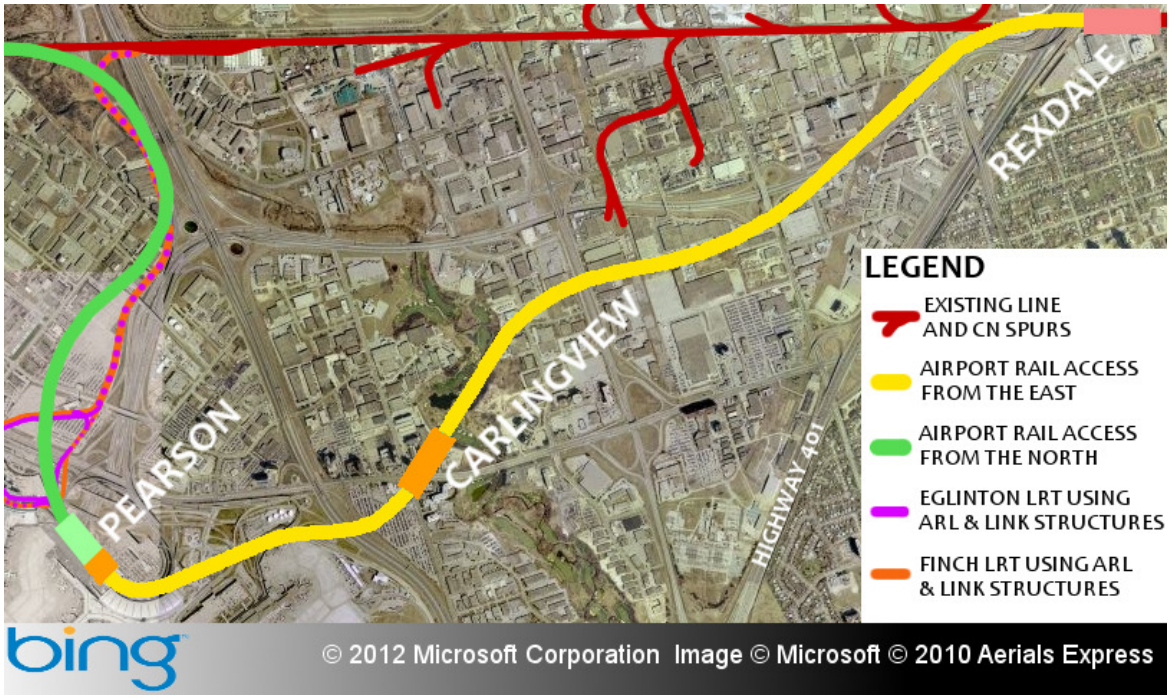
- 2015: Air-Rail Link service as currently proposed.
- 2021: Service to airport operates to new airport station along new spur to/from the Weston subdivision at Highway 401 with GO EMUs.
  - Kitchener GO rail service expands with change to operating model for serving the airport..
  - DMUs originally serving airport reallocated to Hamilton-St Catharines service.
- 2024: Original airport spur re-purposed for part of the Etobicoke-Finch LRT extension from Humber College North Campus to the airport.
  - Incorporates most of the infrastructure currently used for the LINK service between the two terminals and the Viscount parking area.
- 2025: Through-routed Kitchener GO rail service to the new airport station integrated with LRT lines serving Eglinton Ave and Finch Ave W.



The design of the Air-Rail Link spur incorporates geometry that does not meet GO rail standards. This includes insufficient vertical clearance, gradients that are too steep, horizontal curves that are too sharp, and a station that is too short with extension of the station precluded by vertical alignment geometry. However, much of the spur geometry would be viable for a design intended for LRT service.

While not a part of funded plans, there have been proposals from the City of Toronto and the TTC for the Etobicoke-Finch West LRT to be extended from Humber College North Campus to Pearson Airport via the Woodbine Lands southwest of Rexdale Blvd and Highway 27, and was included in *The Big Move*. Feasibility studies on such an extension have taken place, but have not been published in the absence of an environmental assessment for such a project. None of the options evaluated would have included utilization of the Air-Rail

Link spur as it would have been beyond the jurisdiction of the City of Toronto or the TTC, but the Air-Rail Link spur is conveniently located for being re-purposed as an extension of the Etobicoke-Finch West LRT. Furthermore, a re-purposed Air-Rail Link spur would also be capable of doubling as an extension of the Eglinton-Crosstown LRT, especially if the Pearson extension of the Eglinton-Crosstown LRT replaces the existing LINK people mover operation, as it could be overwhelmed at Terminal 1 due to its inherent capacity limitations. This could increase the Eglinton-Crosstown LRT ridership as Humber College would then become a trip generator for the Eglinton-Crosstown LRT without a transfer, and beneficial to the Etobicoke-Finch West LRT in that it would have a connection with Mississauga Transitway services, either at Pearson or at another point along the Eglinton-Crosstown LRT. With adjustments to support column heights, part of the re-purposed Air-Rail Link spur could be used for providing a loop track function at Pearson. Through this design option, 85% of the Air-Rail Link spur infrastructure would be re-purposed for LRT service.



Before the airport spur can be re-purposed, a replacement must enter service. This could be provided from the east. Immediately west of the Weston subdivision crossing with Highway 401, a new alignment into Pearson Airport could begin with design criteria that are compliant with GO rail standards. Initially, this new alignment could serve a shorter station at the airport accommodating a 4-car GO EMU. This station could be expanded to accommodate longer trains at the time that through-routed operations commence, when a direct link is provided to Pearson Airport for the Malton-Kitchener portion of Kitchener GO service.

The airport rail access from the east would be over 5km long, and could feature a station at Carlingview Dr to serve a broader portion of the Airport Corporate District market and further alleviate airport area congestion by serving more workers spread over a larger area. While the cost of such a project would likely exceed $1-billion, there are investments in other expansion measures were such an undertaking to not occur that would be avoided. Of particular importance, this would lessen the strain on Union Station by creating a more efficient network that serves more riders connecting more locations with fewer trains along the Kitchener corridor, both during and outside of peak periods.

The airport rail access from the east could conceivably enter service by 2021, and would initially be served by splitting an EMU GO train from Toronto into an airport-bound train and a Brampton/Kitchener-bound train, as well as combining trains in the opposite direction. This would function as an interim service model between the discontinuation of DMU operations on the Weston subdivision and the through-routing of Kitchener GO rail service via Pearson Airport. Through-routing may be achievable by 2025, while airport LRT service might commence a year earlier, in 2024.

8.3. Georgetown South Project

The Georgetown South Project is a corridor expansion from largely single-track to fully triple-tracked with all level crossings eliminated between Bathurst St and Highway 427. It was originally estimated to cost $1-billion, excluding the Air-Rail Link vehicles and airport spur.

This project has been controversial in communities along the corridor, and in Weston especially. Between the Jane St and Weston Rd railway crossings, construction of a 300m tunnel beneath King St and Church St in Weston Village and its associated impacts, including the new Denison Rd E grade separation, have been difficult. The public consultations left something to be desired, which has resulted in some loss of public trust in the project proponents among the affected communities. The public perception in these communities is that the project design was “final” before consultations began, without an adequate understanding of the local community fabric. Issues of concern to the community included increased traffic in school zones, public safety concerns at certain new rail crossings, and an exacerbated divide/barrier effect imposed by the expanded transit corridor. Addressing these issues would have increased the cost of construction, but could have generated higher long-term benefits.

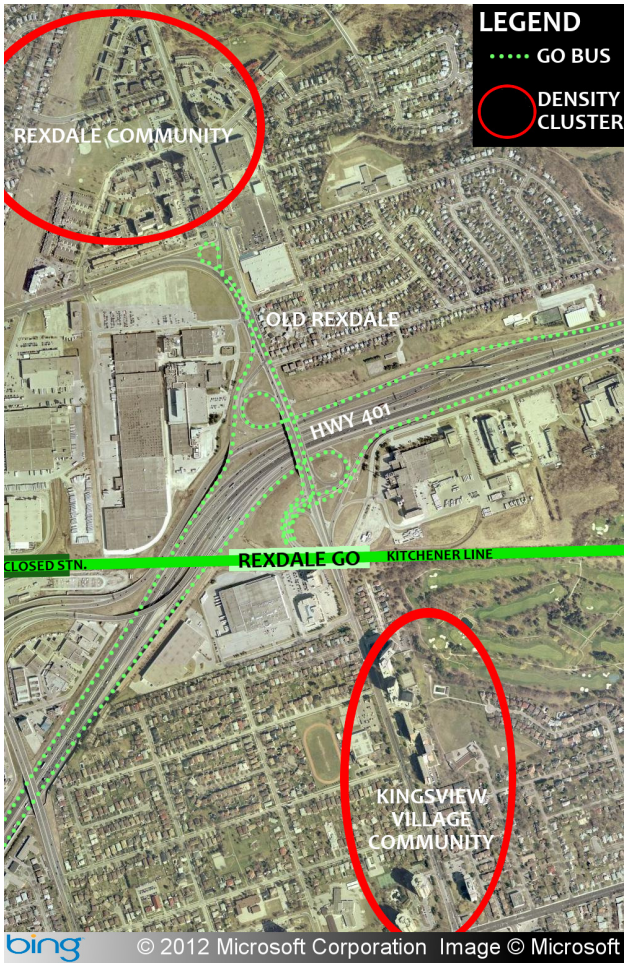
The public will understandably be opposed to public money being spent on projects that they perceive as damaging to their communities. Projects are easier to implement with local support.

The controversy is also in part attributable to the expanded service in the corridor not being usable by many communities due to a lack of stations. It would make good planning sense for these communities to have access to the expanded service by means of more stations provided along the corridor, as it would be feasible to do this.

Average station spacing along the existing corridor exceeds 6km between the Weston GO station and Union Station (a 13.4km run). For an urban, developed corridor that is mostly dense, there is an underserved market with stations this far apart. With some modest changes to some TTC bus routes, this corridor happens to be geographically placed where it could take a lot of pressure off of the western portion of the existing subway network. The west end of the Bloor subway line, and to a lesser extent the University-Spadina subway line as well, would benefit in this regard.

The work being undertaken for the Georgetown South Project is a useful infrastructure expansion for the GO system as a whole. However, while the environmental assessment stated the project was for expanded GO service, the infrastructure will be for the Air-Rail Link. Kitchener GO rail service will not expand in 2015 as a result.

8.4. Etobicoke North Versus Rexdale



The Etobicoke North GO station was not part of the original Kitchener (then Georgetown) corridor when service was initiated, although it was added within about six months following the start of service. The station appears to have been selected primarily for its location at an intersecting hydro corridor, as hydro corridors were attractive for use as parking lots. The station vicinity is not pedestrian-friendly. However, Etobicoke North only has 530 spaces, which is small in comparison to supply at many other GO rail stations.

The station's current location at Kipling Ave is in an industrial area and the road network is only convenient for connecting with the Kipling Ave TTC bus service. The station is not near the homes of any riders, and lacks connections with multiple local transit routes, and for those who drive to the station, the only direct 400-series highway access available from this station is to and from the east, the opposite direction most would likely be arriving to and from.

If the Etobicoke North station were to be moved from its current location, immediately west of Highway 401 at Kipling Ave, to immediately east of Highway 401 at Islington Ave in Rexdale, many advantages would materialize:

- There are some population clusters close enough for residents to walk to the station.
- The road layout in this area would accommodate many local bus connections.
- The Islington highway ramps allow access to/from both directions on Highway 401.
- The superior Highway 401 connection would allow various GO buses to/from Yorkdale/York Mills to connect with the Kitchener GO rail service.

Each of the foregoing is likely to encourage increased ridership on the electrified line both during and outside of peak periods.

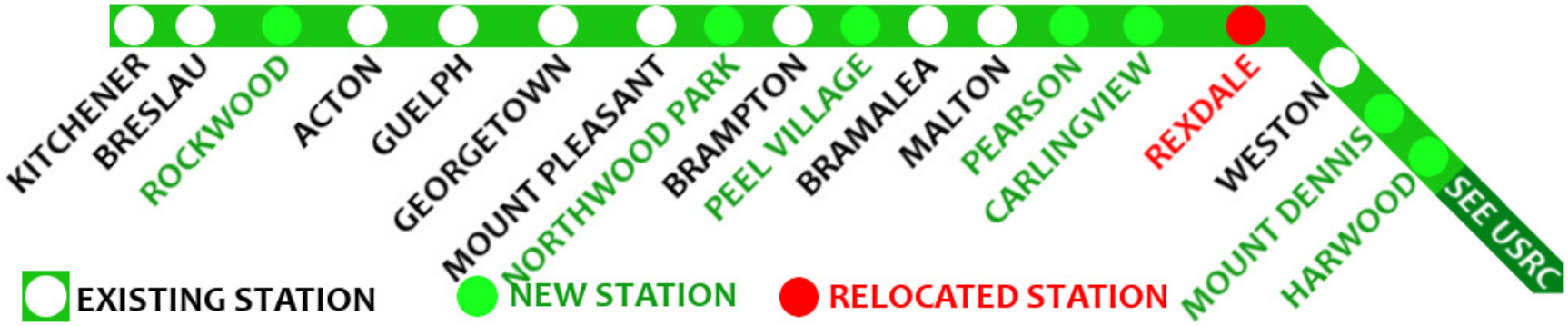
The Etobicoke North GO station, if relocated to the west side of Kipling Ave as proposed in the environmental assessment for the Georgetown South Project, would no longer be served in a GO rail operation that is through-routed via Pearson Airport. This is due to the diverging point of a through-routed alignment occurring between Highway 401 and Kipling Ave. A Rexdale station at Islington Ave would avoid this complication and minimize abandonment of infrastructure in transitioning to the ultimate vision for rail service to the airport.

No construction work has started on the Etobicoke North station relocation at time of writing.

8.5. Improving Connectivity

There are a number of opportunities for additional stations, split almost evenly between Toronto and Brampton. The Breslau station is assumed existing in this Regional Rapid Rail report based on November, 2012 planning policies and development initiatives undertaken by the Region of Waterloo implying it will not be long until it proceeds at time of writing. Excluding a new routing through the airport district, these new stations are:

- Queen St W in Toronto (Parkdale GO Station) – *see Chapter 12*
- St Clair Ave W in York (Harwood GO Station)
- Eglinton Ave W in York (Mount Dennis GO Station)
- Kennedy Rd in Brampton (Peel Village GO Station)
- Chinguacousy Rd in Brampton (Northwood Park GO Station)
- Main St N in Rockwood (Rockwood GO Station)



The station additions listed on the preceding page meet Toronto City Council halfway with regard to its Member Motion 22.12 on April 11, 2012 that passed by a vote of 40-2:

- Harwood [St Clair Ave W] and Mount Dennis [Eglinton Ave W] were part of City Council's motion, and the previously discussed Carlingview station presumably would be equivalent to City Council's suggested station at Woodbine.

- Parkdale [Queen St W] is substituted for Liberty Village [King St W] due to the physical infeasibility of a station at King St due to corridor geometry changes now under construction for the Strachan Ave grade separation with the Newmarket, Weston, and Lower Galt subdivisions. Parkdale, at Queen St, is also a historic station site.

- City Council's request for a station at Carlton Village would most likely be infeasible due to the West Toronto Diamond grade separation structure and geometry, and would have been too close to the Harwood station at St Clair Ave W.

- A station serving the Junction would be too close to the existing station at Bloor St W, and were it feasible, would have been too close to the Carlton Village station as well.

- The Council-proposed station at Jane St would only be 1.0km from both the existing Weston station and the proposed Mount Dennis [Eglinton Ave W] station, which is still too close for GO rail services, which are not local TTC subway services. It should be noted that even without a GO station at Jane St, the TTC's 35 Jane bus route could still connect with the Kitchener corridor if the route were split into two routes operating north and south of Eglinton Ave W, especially if the yet-to-be-funded Jane LRT is only built north from Eglinton Ave W, which is a conceivable outcome given that Jane St becomes challengingly narrow south of Lambton Ave (just south of Eglinton Ave W). Extending the Jane LRT south of Eglinton Ave W would very likely require an expensive tunnel that would be difficult to justify based upon demand projections currently available.

8.5.1. Harwood Station

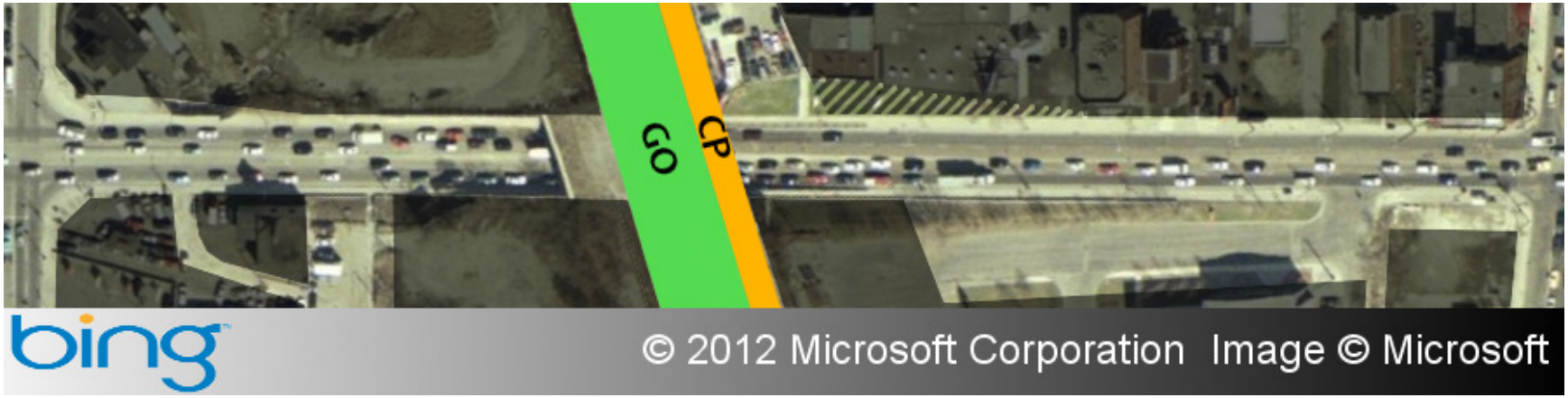
Admittedly, a station at St Clair Ave W is complicated. Achieving a successful connection between the station and the street to connect the GO service to the TTC's 512 St Clair streetcar and the heavily used 41 Keele bus services has challenges that would have to be overcome. With minor adjustments, other bus routes operating near the railway crossing at St Clair Ave W, such as those currently using the Townsley loop, could also connect with a Harwood GO station.

The current infrastructure arrangement does not lend itself well to a station due to the legacy of the existing grade separation shared by two railways, GO and CP, as both corridors narrow to share the same crossing over St Clair Ave W. Not only are the rail corridors narrow, but the St Clair Ave W roadway allowance also narrows, to only 20m beneath the railways. A roadway allowance only 20m wide should have been a major issue during the St Clair Ave W streetcar right-of-way project. Neither the Georgetown South Project nor the St Clair Ave W reconstruction project made modifications to this bridge. The existing bridge structure was erected eight decades ago, in 1932.

The current configuration provides insufficient space for platforms for either the GO service or the streetcar service. Traffic flow along St Clair Ave W in this area has been a major local issue as well.

The problems arising from this 20m-wide section of St Clair Ave W have been a topic that the local councillor, Cesar Palacio, has been trying to get dealt with at time of writing.

There are interesting geometric factors involved in the immediate area of this grade separation. Before the grade separation existed, both Union St and Mulock Ave intersected with St Clair Ave W. The railways, meanwhile, peak in height at St Clair Ave W. This strongly suggests that the grade separation may be "upside-down;" i.e. the optimal arrangement may be for the tracks to go under the road. At the underpass across Rogers Rd, the GO line is at 119.8m above sea level, while at St Clair Ave W it is at 123.8m above sea level only to dive down abruptly to 114.3m above sea level by its crossing at Old Weston Rd. The CP line presumably follows a similar vertical alignment north of St Clair Ave W, but south of St Clair Ave W it drops to only 121.9m above sea level. The CP line is more complicated due to the higher sensitivity to track gradients of the heavier and longer trains used for its freight operations, but it is clear that the opportunity exists to lower the GO line and raise the road. Accommodating the CP line at a gradient acceptable to the railway will result in additional height by which St Clair Ave W will have to be raised if the CP line is to reach its existing elevation by its crossing with Old Weston Rd.



There is no lack of City of Toronto property on the east side of the railways, shown as the non-shaded areas in the above image. The right of way for St Clair Ave W is actually 45m wide at its widest point, or wider if the embanked property is included, shown in a hatched shade in the above image. The west side is narrower, and it could be difficult to get wider than 23m, although this may be all that is required if the streetcar stop spans east from the railway crossing. This would allow 2 lanes for road traffic and 1 lane for exclusive streetcar use in each direction, plus sidewalks that would be slightly narrower than preferred on the west side of the railways, but still meeting minimum standards, unless additional property is acquired. On the east side, there would also be enough space for streetcar platforms in both directions to connect with the GO service below. Passing beneath the road, the CP track can be shifted a little to the east to avoid conflicts with the GO platform for westbound trains by passing beneath Union Street as that street is reconnected to St Clair Ave W. The new height of St Clair Ave W would be about 3.5m higher than the current rail bridge's level. The new height should only require slopes of about 3% on the west side, and up to 4% on the east side with a 2% gradient along the streetcar platform area. These gradients would provide good comfort and accessibility for all users. It should be possible to have the CP line run at a gradient of 0.60%. The GO line along the station platform should be at a gradient of 0.4% to 0.5%.

This would be a major engineering job that would close St Clair Ave W while under construction, but would provide excellent end results.

8.6. Diesel Case, Electrification, and EMU Case Costs

The future ridership projections for the Kitchener line are extremely high – this is the corridor with the highest growth projection relative to that carried by the existing service. With the constraints known to exist at Union Station, corridor resource management will be a key concern, particularly as it relates to current plans for the Air-Rail Link. The service model planned may be expected to encounter severe operational challenges in the medium- and long-term. While the existing service plan may be sustainable in the short-term from a corridor resource perspective, proactive planning for an airport service model that would be compatible with medium- and long-term GO rail expansion plans would avoid prolonged conflicts between services that will be time-consuming to address.

There is broad agreement that the Kitchener line has a significant amount of latent demand. That makes corridor expansion important, but the high service level expected in the future makes electrification now equally important. To proceed with electrification later would risk exacerbated political resistance to electrification in the future due to the combination of further investments made in diesel resources and the cost of electrification that increases with the size of the diesel fleet – among other sources of cost escalation. Delays to electrification carry significant risks socially, economically, and environmentally. Expansion of service on this corridor in the absence of electrification and EMUs would be likely to encounter either constraints on the levels of service that can be provided, or substantial costs to achieve the desired levels of service. EMUs in combination with a superior signaling system such as Positive Train Control can allow more service to be provided on each track. However, an optimum arrangement of resources in the corridor would see the highest levels of service being efficiently delivered with the lowest quantity of single-track-kilometres, and achieving that would involve the Kitchener GO rail service passing through Pearson Airport. A staging strategy for enabling increased traffic operations in the corridor incrementally would be able to accommodate a sustainable ultimate infrastructure configuration. Following the Pan-Am Games, this Regional Rapid Rail report outlines a three-step incremental reconfiguration of service to the airport for a solution that would be sustainable in the long-term.

On the following page are the breakdowns for the estimate of the Kitchener corridor. The money for the Georgetown South Project (east of Highway 427) is considered spent, and is assumed to fund all requirements of the Reference Case as a 3-track corridor. The fourth track would be unnecessary if rail service to the airport were not provided by a separate service, and the airport were instead served by the GO rail vehicles used for Kitchener corridor service.

Please see section 5.7 for an overview of the methodology regarding cost categories.

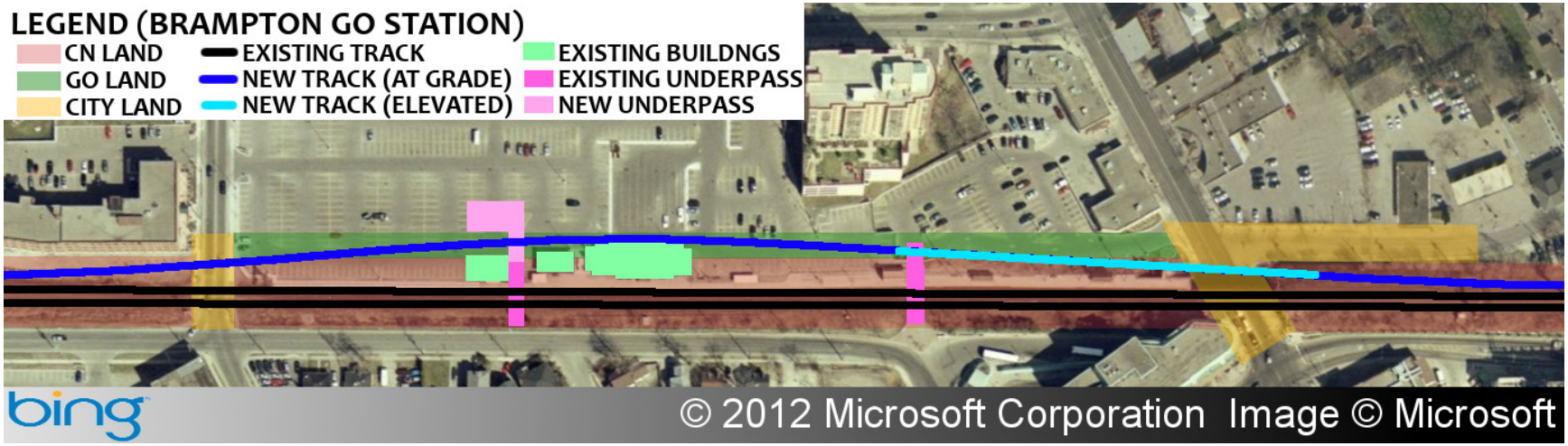
The breakdown works out to:

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$202.28	$50.00
	Bridge Widenings (River)	$185.63	$0.00
	Grade Separations (Road-Rail)	$297.81	$541.35
	Fleet (Capital)	$219.80	$497.56
	Expanding Existing Stations	$2.70	$0.00
	New Stations	$20.25	$0.00
	Subtotal	**$928.46**	**$1,088.91**
Through-Route Airport GO Rail Service	Airport GO Rail Access East of Airport	$1,000.00	$0.00
	Airport GO Rail Access North of Airport	$0.00	$350.00
	Subtotal	**$1,000.00**	**$350.00**
Electrification	Infrastructure (incremental)	$412.00	$3.00
	EMU Fleet (incremental)	$216.38	($35.14)
	Subtotal (incremental)	**$628.38**	**($32.14)**
EMU Case	New Stations	$117.45	$16.20
	Wayside PTC	$47.57	$0.00
	PTC for LHCs	$1.70	$1.40
	PTC for EMUs (incremental)	$5.90	$5.50
	Credit for Air-Rail Link DMUs	($55.00)	$0.00
	Subtotal	**$117.62**	**$23.10**
CORRIDOR TOTAL		**$2,674.46**	**$1,429.87**

8.6.1. Diesel Case

The Diesel Case in this analysis looks west of Highway 427 only, as the investment has already been made east of Highway 427 and is assumed to be at least triple-tracked. Rail service to the airport is discussed separately. The 2010 electrification study's Reference Case west of Highway 427 provides for three tracks on both the Weston and Halton subdivisions where GO will be operating, except for 1 mile (1.6km) around the Brampton GO station. Apart from the Brampton GO station challenge, this is a sustainable arrangement, as both local and express trains would serve all stops west of the Bramalea GO station. The Bramalea station is virtually across the street from the Halwest junction between the Weston and Halton subdivisions, east of which GO becomes owner and most freight rail traffic diverges from the GO corridor, leaving the third track on the Weston subdivision available for VIA Rail Canada and express GO Transit rail operations.

Seventy-five new single-track-kilometres are added for the Diesel Case between Highway 427 and Kitchener. This is estimated to cost $202-million, including a 35% contingency. Another estimated $50-million would be involved to add a third track in the Brampton GO station area. This is expensive for its relatively short length of 1.6km, as part of it would be elevated and it also involves some significant changes to the north side of the Brampton GO station. Without this track, the Brampton GO station would be a choke point as this part of



the corridor is a busy CN mainline, and a key component of CN's Toronto bypass route that keeps freight trains away from the Lakeshore corridor east of the Burlington junction. Brampton is the busiest station on the line, and is also an Urban Growth Centre. Frequent disruptions at this location in the network from CN freight traffic, which will have priority, would negatively impact GO rail service reliability.

There are a number of river bridges that require expansion to accommodate the 75 new single-track-kilometres, almost doubling the new track cost. Including the bridge works would increase the estimate to $186-million, including a 35% contingency. The crossings include:

- Etobicoke Creek
- Credit River
- Eramosa River
- Speed River
- Grand River
- 3 other streams (names unknown)

Grade-separating all level crossings between Highway 427 and Mount Pleasant are assumed to be part of the Diesel Case given the service level expected by 2021. These grade separations, including 4 bridge widenings and expansion for additional tracks at level crossings where grade separations are not required, are estimated to cost $298-million, including a 35% contingency.

Certain level crossings are assumed to be grade-separated beyond 2021 between Kitchener and Mississauga Rd where the roads are arterials in order to accommodate increased peak period services in 2031. Local low-traffic roads were not considered for grade-separation. This section of the corridor is almost 60km long, and passes through the cities of Kitchener and Guelph. The grade separation estimate is $541-million for 18 new grade separations and a dozen bridge widenings, including a 35% contingency.

Expansion of the locomotive-hauled diesel fleet for the Kitchener corridor is estimated to cost $220-million, mostly involving rebuilds of existing vehicles, although some would be new purchases expanding the overall fleet size. There would be substantial new purchases required for the Diesel Case to meet 2031 demand projections, estimated to cost $498-million.

An estimated $3-million is also assigned to the Diesel Case for a new platform at the Georgetown GO/VIA station. A new station in Mount Dennis at Eglinton Ave W (part of the 2010 electrification study Reference Case) is estimated to cost $20-million. While the Mount Dennis station is part of the Reference Case, it is not part of the Georgetown South Project now under construction.

8.6.2. Airport Rail Service

The 3.3km airport spur, under construction at time of writing, is a $128-million project. Service along it is planned to be provided with a fleet of DMUs that have already been purchased for $55-million. The contract for purchasing those DMUs has a contract option for $33-million to provide 3-car trains instead of 2-car trains, which has not yet been exercised. It is assumed that this contract option would be exercised in the 2021-2031 period if DMUs were to still be running to the airport during that time.

The 2010 electrification study Reference Case assumed a 4-track corridor between Highway 427 and Union Station, but this was based on having two separate operations on a shared corridor. It is not a requirement for the airport to be served by trains of a design that is different from what GO uses for its operations in other corridors, although the infrastructure design requirements would become more onerous. This is due to GO trains being longer as well as heavier than the proposed DMU operation, and require different clearance heights and gentler gradients for the vertical alignment than the Air-Rail Link spur under construction currently. One of the horizontal curves also does not meet standards for regular GO operations, although this is due to the speed restriction from such curves rather than the feasibility of trains safely operating through such curves. To have GO service to the airport, designated as an anchor hub in planning documents, restricted to bus operations and a premium fare express train of limited capacity leaves something to be desired. It would be ideal if the long-term solution for bringing rail-based rapid transit service to the airport were provided by a regular GO rail operation such as the Kitchener corridor. This would provide a variety of benefits that would deliver greater value for money:

- Reduced operating costs by requiring less infrastructure to maintain on the Weston subdivision.
- Fewer train crews assigned to operations in the Kitchener corridor than would be required for two separate operations sharing the corridor.
- Higher ridership by making rail service to the airport an affordable option to airport workers and those working in the airport corporate district, not only from Toronto, but also from west of Toronto (Brampton, Georgetown, Guelph, Kitchener, etc.).
- Reduction of capacity consumption in the Union Station Rail Corridor from operations providing service on the Weston subdivision.

The 4th track between Highway 427 and Union is complicated due to some space constraints and is estimated to cost $400-million. Its construction is believed to be unlikely before 2021.

8.6.3. Electrification

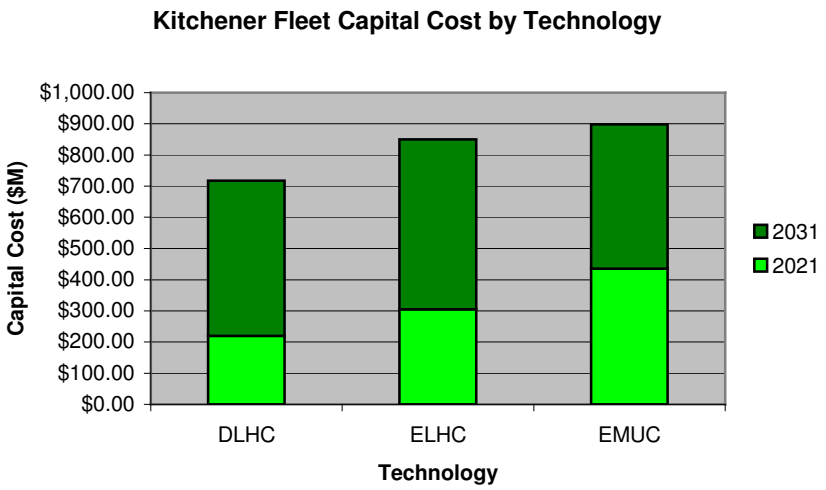
The 2010 electrification study estimated $412-million in infrastructure upgrades to electrify the Kitchener corridor, including a 35% contingency. That estimate also includes the 3.3km Air-Rail Link spur. While the fourth track on the Weston subdivision would not be necessary if the Air-Rail Link is no longer a separate operation with different vehicles by having regular Kitchener GO operations run through the airport between Malton and Rexdale, the capital cost of electrification would only be cheaper by approximately four percent. This is due to the interim configuration when rail service to the airport switches from diesel operations to electric operations and airport rail service access switches from north of the airport to east of the airport. The alternative to this arrangement would be to maintain diesel operations in the Kitchener corridor for another five years, which would likely be more expensive, depending on the combination of service levels and fuel prices. More importantly, the alternative would further postpone expanded Kitchener GO rail service without the addition of an expensive fourth track that ultimately would not be warranted for 2031 demand projections if the Kitchener GO rail service were routed through Pearson Airport.

An additional $3-million would be spent later to electrify the third track around the Brampton GO station area, which was not part of the Reference Case and so not part of the above electrification estimate.

The incremental cost for running EMU vehicles on the Kitchener service is estimated at $216-million by 2021, and would incur an estimated savings of $35-million in the 2021-2031 period, for a total incremental electric vehicle investment of $181-million. This is in stark constrast with the Lakeshore corridor where a substantial savings was yielded from EMUs, but what makes Kitchener more expensive in terms of EMU capital cost is that the locomotive-hauled coach fleet will have already become almost large enough after Lakeshore's expansion to allow for predominantly vehicle rebuilds rather than the need for new vehicle purchases to meet 2021 service levels. This would also apply to the diesel locomotives.

While the estimate for EMUs is $131-million higher than the 2010 electrification study's incremental capital cost estimate for electric locomotives at $85-million for 2021, it is worth considering the savings that would come from Lakeshore, which was $121-million less than the diesel base case, or $244-million less than electrifying with electric locomotives. The Lakeshore and Kitchener lines combined still leave EMUs $113-million cheaper than electric locomotives by 2021.

Between 2021 and 2031 service levels, the EMUs clearly begin to narrow the difference in cost compared with electric locomotives, being $49-million more expensive than electric locomotives in 2031. Assuming a relatively consistent rate of growth beyond 2031, EMUs would match or overtake electric locomotives in cost-efficiency somewhere around 2036. It is worthwhile to reinforce that these vehicles, properly maintained, can last for half-a-century, so the long-term outlook in cases like these are very relevant. The option of "just switching vehicles later" has negative consequences in terms of economics, fleet harmonization, interlining opportunities, resource consolidation, etc., that would be substantial for a fleet as large as that of GO Transit. The incremental cost is worth the value for the significant benefits the EMUs provide, not only in the corridor, but also for future system-wide considerations, including lower operating costs.



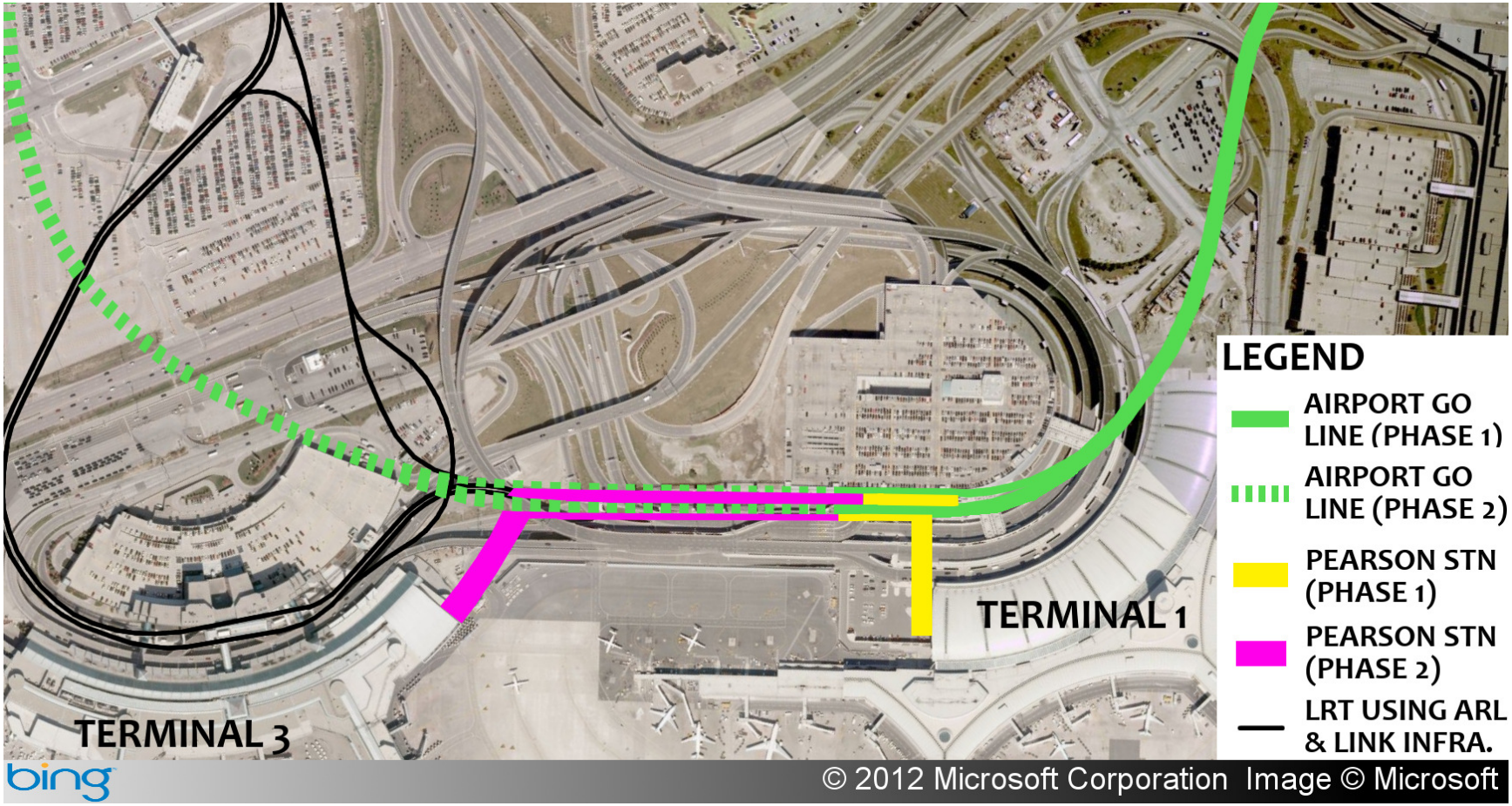
8.6.4. EMU Case

The new stations described in an earlier section are estimated to cost $134-million, 70% of which is attributed to the Harwood station due to complex issues around the St Clair Ave W crossing. Changes at St Clair Ave W would be expensive, but would also bring significant benefits beyond the addition of an integrated multi-modal transit station, including strong potential for a reduction in undeveloped street frontage along an otherwise developed and vibrant urban strip. The $134-million excludes the Parkdale station, as this Regional Rapid Rail report considers it part of the Union Station Rail Corridor (although technically it is beyond the Union Station Rail Corridor proper) and is discussed in Chapter 12. The cost of the Rexdale station is also not included, as it is an alternative to the relocation of the Etobicoke North station to the west side of Kipling Ave that is part of the funded Georgetown South Project. Work on the Etobicoke North station relocation hadn't started at time of writing, but it is a part of the Diesel Case estimate, and that work would be avoided by building the Rexdale station instead.

A Positive Train Control signaling system would be added to the corridor in the same manner as for other corridors described previously, with the wayside component estimated to cost $48-million, while the in-vehicle component is estimated to cost approximately $2-million for LHCs and another $6-million incrementally for EMUs by 2021. As the fleet grows to the 2031 level, another $1-million would be spent on the LHCs for Positive Train Control, while the EMUs would cost another $6-million incrementally.

Electrified Kitchener GO rail operations through the airport using EMUs would render the fourth track between Highway 427 and Bathurst St unnecessary. More importantly, the restrictions of track space in the west half of the Union Station Rail Corridor become far easier to manage in peak periods if Kitchener GO rail services were routed through the airport. For infrastructure running north from the airport to reconnect with the Weston subdivision, allowing trains operating to/from the Malton GO station to reach the airport, the vertical alignment would feature a far gentler gradient than in the Air-Rail Link spur design in order to meet GO rail standards. It is possible to keep the gradient between Mimico Creek and Pearson to a maximum of 1.0%. However, this involves more elevated track than what the Air-Rail Link spur required. The airport rail access from the north is guestimated at $350-million, but this is offset by the cost of the $400-million fourth track that would no longer be necessary in an operation where Kitchener corridor trains are routed through the airport.

The ultimate vision for serving the airport anchor hub would involve the 400m gap between airport terminals bridged by the new airport GO station accommodating full-length GO trains that would be the same length during peak periods. The platform would access Terminal 1 at its east end and Terminal 3 at its west end. There would be a GO-LRT connection at the Terminal 1 end. Whether Finch LRT operations serve only Terminal 3 or both terminals is not determined in this vision, and either option appears to be feasible to pursue. The main difference would be that if the Finch LRT serves Terminal 1, a 3-track elevated LRT station could be required.



The highest capacity in a 3-track corridor providing service to both Brampton-Kitchener and Pearson would undoubtedly be delivered by a single through-routed operation, as this would eliminate most conflicting train movements on the Weston subdivision, as well as reducing the number of trains on the Weston subdivision in any given hour. There would need to be an interim solution for when access to/from the east is constructed and access to/from the north is being re-purposed for LRT along with the airport rail access from the east extended north. The interim arrangement could have the airport rail access from the east utilized by 4-car-long trains that have split from a full-length train westbound at the Rexdale station, while in the eastbound direction a 4-car train at the Rexdale station can combine with a train consisting of eight or twelve cars to form a full-length train operating to Union Station. As an interim solution, however, this would not be viable in the medium- to long-term, as 2031 frequencies would complicate westbound Pearson trains crossing the eastbound tracks, when the frequencies of the Kitchener service would make such a crossover a delicate maneuver in peak periods. As such, completion of the through-routed infrastructure would be necessary prior to service levels reaching a frequency that complicates the westbound train-splitting operations – this applies particularly to frequent peak period express operations.

There are a large number of complex factors at play when analyzing the comparative costs of airport rail service options. The full capital costs associated with a separate Air-Rail Link DMU service versus those of through-routing GO EMUs are not immediately evident as other projects are also impacted, including one project that is not part of the GO rail system. In particular, with Pearson trains and Kitchener GO trains being one and the same service, it is a certainty that the stress exerted on Union Station would be reduced relative to two separate services operating on the Weston subdivision. It is conceivable that such an effect would put off the cost of at least one of the new underground tracks through a new Union Station lower level, savings that are estimated to exceed $200-million. More significantly, the dedication of one of the tracks to the Air-Rail Link at Union Station over the long term would see one of the tracks serving only 500 passengers an hour while many other tracks are carrying in excess of 20,000 passengers an hour. This represents a very substantial capacity reduction at the station for as long as the Air-Rail Link operates as a separate service from the Kitchener GO line.

If the Air-Rail Link were not a separate service, it would avoid the need to construct a fourth track on the Weston subdivision, calculated by others to cost $400-million. Other rail-rail grade separations that are not yet identified, but could be expected to become necessary in future, also would be avoided with the through-routing ultimate vision. These further offset the cost of the through-routing infrastructure.

Service between St Catharines and Hamilton could be financially impacted by the decision on airport rail service options as well. The DMUs for the Air-Rail Link could be used for the Hamilton-St Catharines service when EMUs begin serving the airport.

With the re-purposing of infrastructure discussed earlier, the absence of using the Air-Rail Link infrastructure for Finch LRT access into the airport would be another potential financial impact. As the distance from Viscount Rd to the Weston subdivision is a distance of 2km, a value of $100-million could be assumed to represent the value of that opportunity.

Further details will be outlined in Chapter 12, but to the left is what a very rough comparative breakdown might look like.

The DMUs purchased for the Air-Rail Link are being counted as a credit for the Kitchener corridor in this Regional Rapid Rail report because this report already expensed them to the Lakeshore corridor in Chapter 5 for service between St. Catharines and Hamilton, even though they've already been bought and the money should be considered spent. Treating this cost as a credit avoids double counting. The $33-million cost for expanding the DMU fleet is cancelled out for the through-routed option, as this unexercised contract option will no longer be necessary in an EMU model.

Infrastructure	2-Car DMU Plan ($M)	16-Car EMU Plan ($M)	Comment
+1 Underground Track/Platform at Union Station	$250	n/a	Full-length track required; DMUs on surface track
+1 Rail-to-rail grade separation along Weston subdivision	$125	n/a	Required for DMUs to get north of GO Kitchener ops in 2031
Bloor GO station 6-track layout (platforms for all tracks)	$150	n/a	Serves Milton & Kitchener/ARL; only 5 tracks with airport through-routed ops
Parkdale GO station 8-track layout (platforms serving all tracks)	$250	n/a	Opportunity cost - serves Barrie, Milton, Kitchener/ARL; 7 tracks if thru-routed
Weston subdivision 4th track (20km)	$400	n/a	Not required with through-route
Electrification Incremental $	$15	$0	Difference in single-track-kilometres
Additional DMUs for St Catharines	$55	$0	Hamilton to St Catharines fleet
Savings on Finch W. LRT Extension	$0	($100)	2+km of re-purposed infrastructure
New EMU link from east of Pearson	n/a	$1,000	First component for through-routed design
New EMU link from north of Pearson	n/a	$350	Second component for through-routed design
OPTION TOTALS	**$1,245**	**$1,250**	

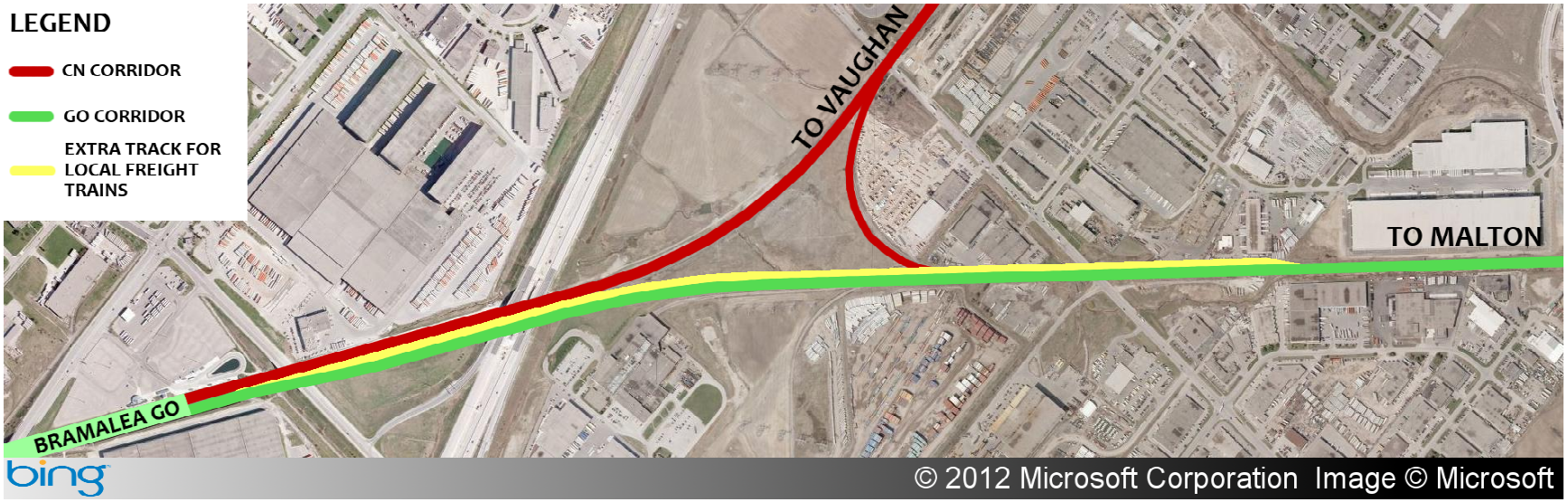
Note: Except 4th track, all costs in above chart are rough guestimates

8.7. Freight Traffic through Halton

Between the Georgetown and Bramalea GO stations, the Kitchener corridor follows the Halton subdivision and is sharing space with a major CN freight line that is the main link to MacMillan Yard in Vaughan from all of southern Ontario (Niagara, Windsor, Sarnia). It also connects with the large CN Brampton Intermodal Terminal, southeast of the Queen St E and Airport Rd intersection. In addition to the need to accommodate passing freight trains, sources of local freight activity in the Bramalea and Etobicoke areas on both sides of the GO corridor would also need to be accommodated.

A 4th mainline track in the Halwest junction area (a short distance east of the Bramalea GO station) plus an array of switches would allow short local freight trains to get across the corridor safely while frequent GO service is running between Toronto and Brampton. This is similar to the approach described for Willowbrook and Oakville yards in Chapter 5.

The $3-million cost for this extra track for freight operations has been included in the New Track category under the Diesel Case.



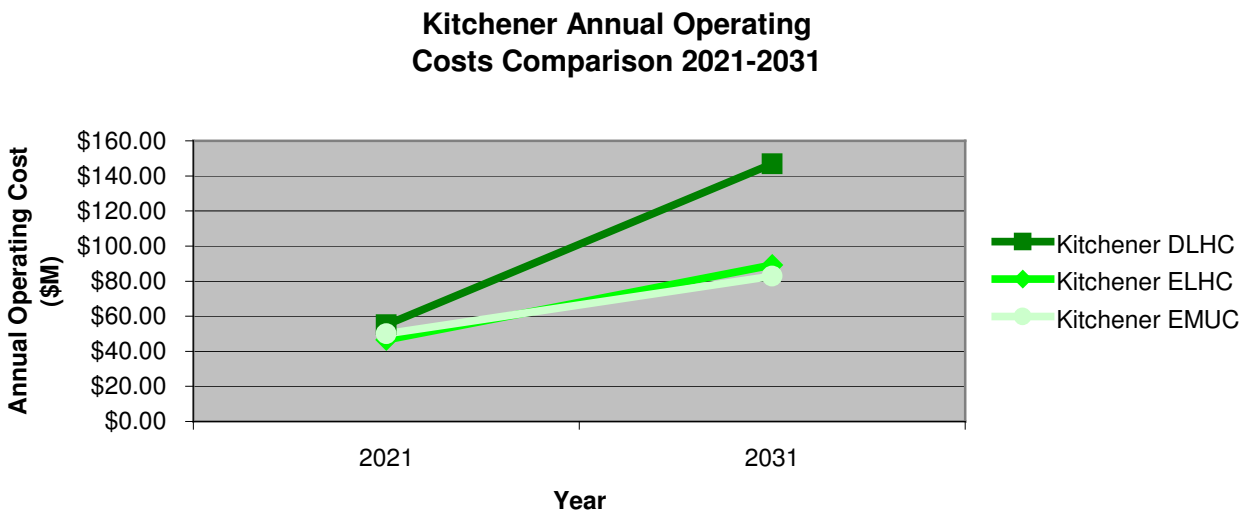
The freight trains serving properties in Etobicoke would effectively have no need to cross tracks used by GO if GO trains are diverted through Pearson Airport. Few, if any, freight trains are expected to cross Islington Ave along the Kitchener corridor.

Through-movements for long-haul freight trains of substantial length are assumed to operate with only one track available to CN between the Halwest and Silver junctions (the latter a short distance west of the Georgetown GO/VIA station). Long-haul freight trains would be expected to use the north track during normal operating conditions. During peak periods, scheduling at the Silver junction would be sensitive, but should be manageable if appropriate scheduling agreements and priority assignments can be arranged between GO/Metrolinx and CN. This corridor is very important to both railways, and by extension to the GTHA in general as both GO and CN reduce congestion of Ontario 400-series highways by diverting cars and trucks, respectively, from GTHA arterial roads and expressways. A rail-rail grade separation at the Silver junction should not be necessary given GO trains would be far less frequent at this point along the corridor, so long as GO/Metrolinx and CN can agree on peak period operations when scheduling is most sensitive for trains operating west of the Georgetown GO/VIA station.

8.8. Operating Costs

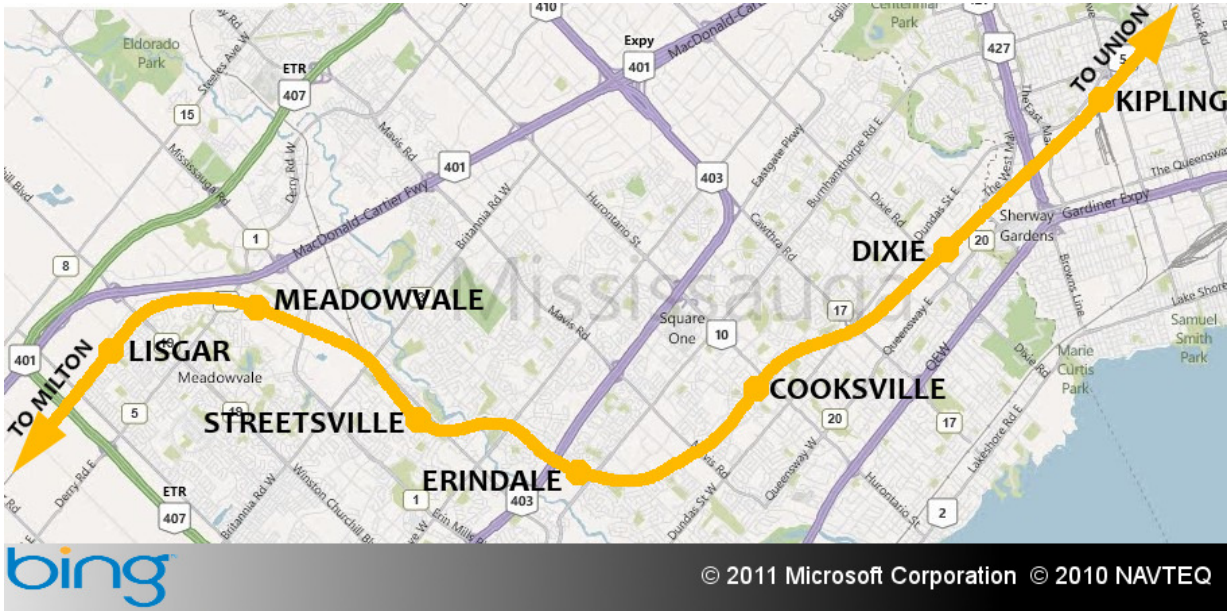
While the Lakeshore corridor's savings amount to almost $8-million a year compared to electrification with electric locomotives, the Kitchener corridor is more expensive using EMUs rather than electric locomotives in 2021. However, almost $5-million would still be saved annually in comparison with a diesel operation. Although electric locomotive operation would be almost $4-million cheaper than the EMU operation in 2021, service quality with EMUs would be enhanced, with rail service able to operate all-day to Georgetown without increasing resources. What is both interesting and very much worth noting, is that by 2031 the tables would be turned, with EMU operations becoming cheaper than electric locomotives by about $5.5-million.

	Kitchener Annual Operating Cost ($M)					
	2021			2031		
	DLHC	ELHC	EMUC	DLHC	ELHC	EMUC
Diesel Equipment Maintenance	$8.2189	n/a	n/a	$12.1907	n/a	n/a
Electric Equipment Maintenance	n/a	$6.9284	$23.1040	n/a	$10.3416	$44.0800
Unpowered Coach Maintenance	$21.0716	$21.0716	$9.5979	$39.3006	$39.3006	$18.3612
Energy	$21.1151	$8.4150	$5.1676	$87.9842	$24.6056	$14.4628
Incremental Labour	$4.6881	$4.6881	($1.6642)	$5.1785	$5.1785	($5.6981)
Incremental Debt Servicing	$0.0000	$5.3884	$13.7041	$2.2255	$9.7601	$11.5403
Total	**$55.0937**	**$46.4914**	**$49.9094**	**$146.8795**	**$89.1864**	**$82.7461**


Kitchener Annual Operating Costs Comparison 2021-2031
Annual Operating Cost ($M)
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
2021
2031
Year
Kitchener DLHC
Kitchener ELHC
Kitchener EMUC

9. Milton Corridor

The Milton corridor covers the northwest area of Mississauga as well as its broader city centre area. For years the service has struggled to keep up with peak period demands, with some trains running just 10 minutes apart – and the 12-car trains are always "standing room only." It operates the most frequent rush hour service after Lakeshore, and has long had by far the most aggressive train-bus services during the shoulder period after the last morning train inbound and during both shoulder periods of the afternoon peak period train service outbound.

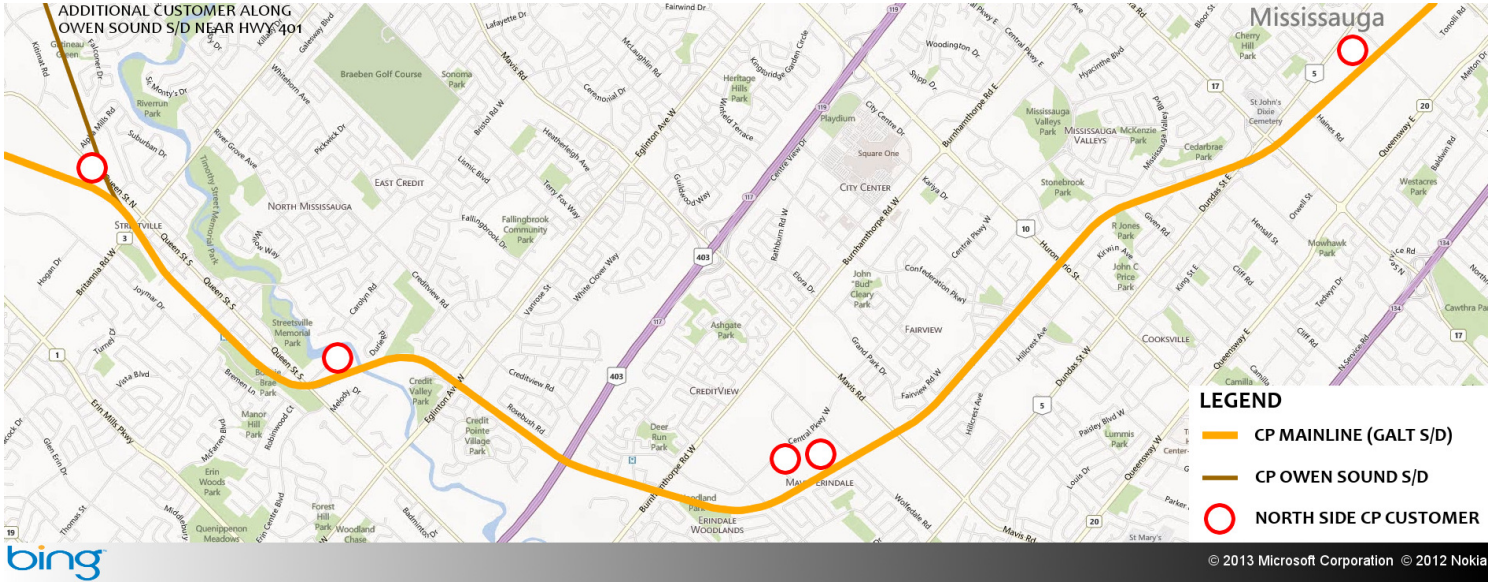


A conclusion of the 2010 electrification study that was not emphasized was the high benefit:cost score of the Milton corridor for electrification. The fact that Option 3 (Kitchener and Lakeshore) scored the same benefit:cost ratio (0.94) as Option 11 (Kitchener, Lakeshore & Milton) is quite telling in terms of how strongly the Milton corridor performs, as it implies its benefit:cost ratio must be 0.94:1, which is higher than any corridor except for Lakeshore. The Milton corridor certainly scores markedly higher than the Kitchener corridor, although there are other valid reasons for the Kitchener corridor to be made a higher priority.

9.1. GO Operations' Co-existence with CP Operations

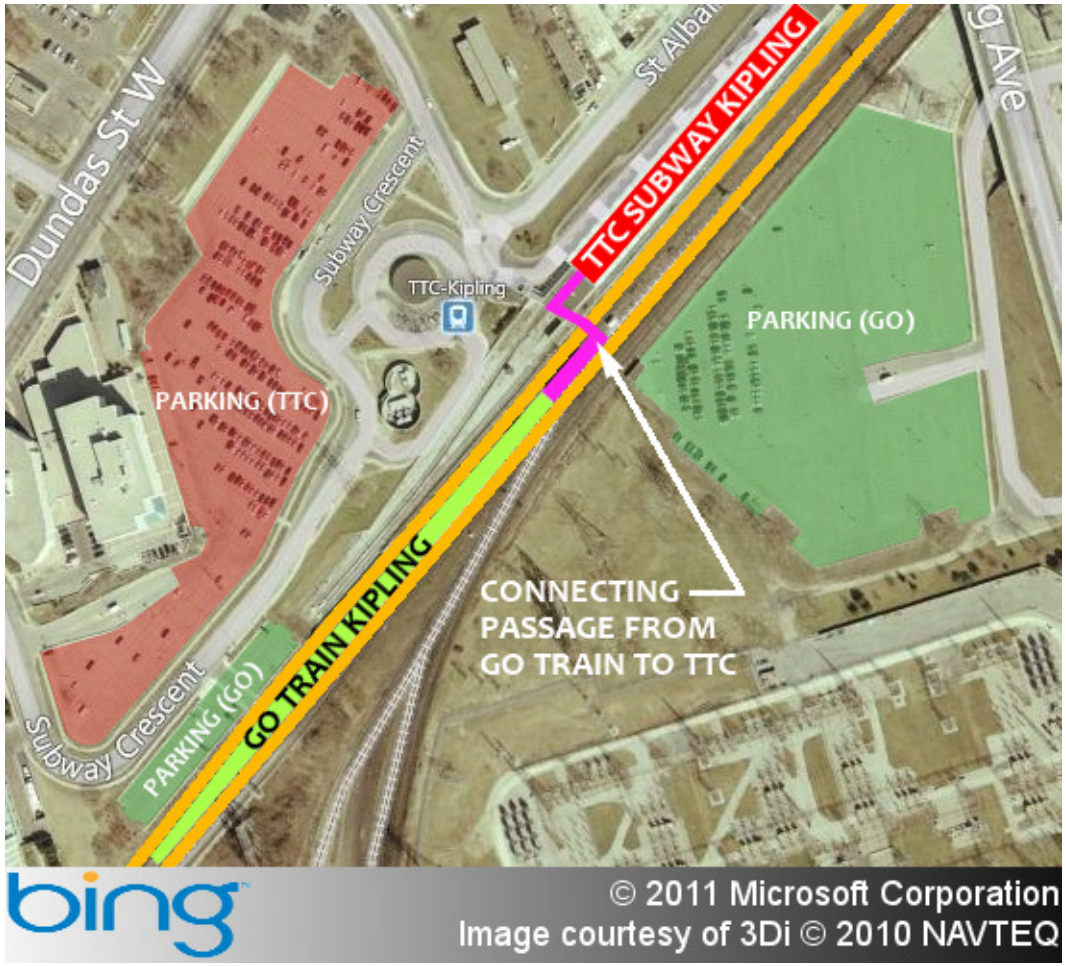
The Milton corridor is the only existing GO rail service that is operated on an exclusively Canadian Pacific Railway (CP) corridor, using crews provided by CP. All other GO rail services are currently run with Bombardier-contracted crews.

While the relationships between GO train movements and CP train movements are generally manageable as far as avoiding conflicts between operators is concerned, all-day GO train frequencies beyond a certain point might conceivably create complications. Although most freight customers between the Milton GO station and West Toronto Diamond are on the south side of the corridor, about half-a-dozen CP freight customers are on the north side. GO operations are confined to the north side of the corridor as well (except through the former City of York). Unless served in the middle of the night when GO trains are not running, all-day frequent GO service could conflict with CP access to its north-side customers. It would be advantageous to have a plan developed for dealing with a situation in which Milton GO service exceeds a certain frequency. This is an important issue, as every business served by rail along the GO network translates to many fewer trucks on Ontario highways.

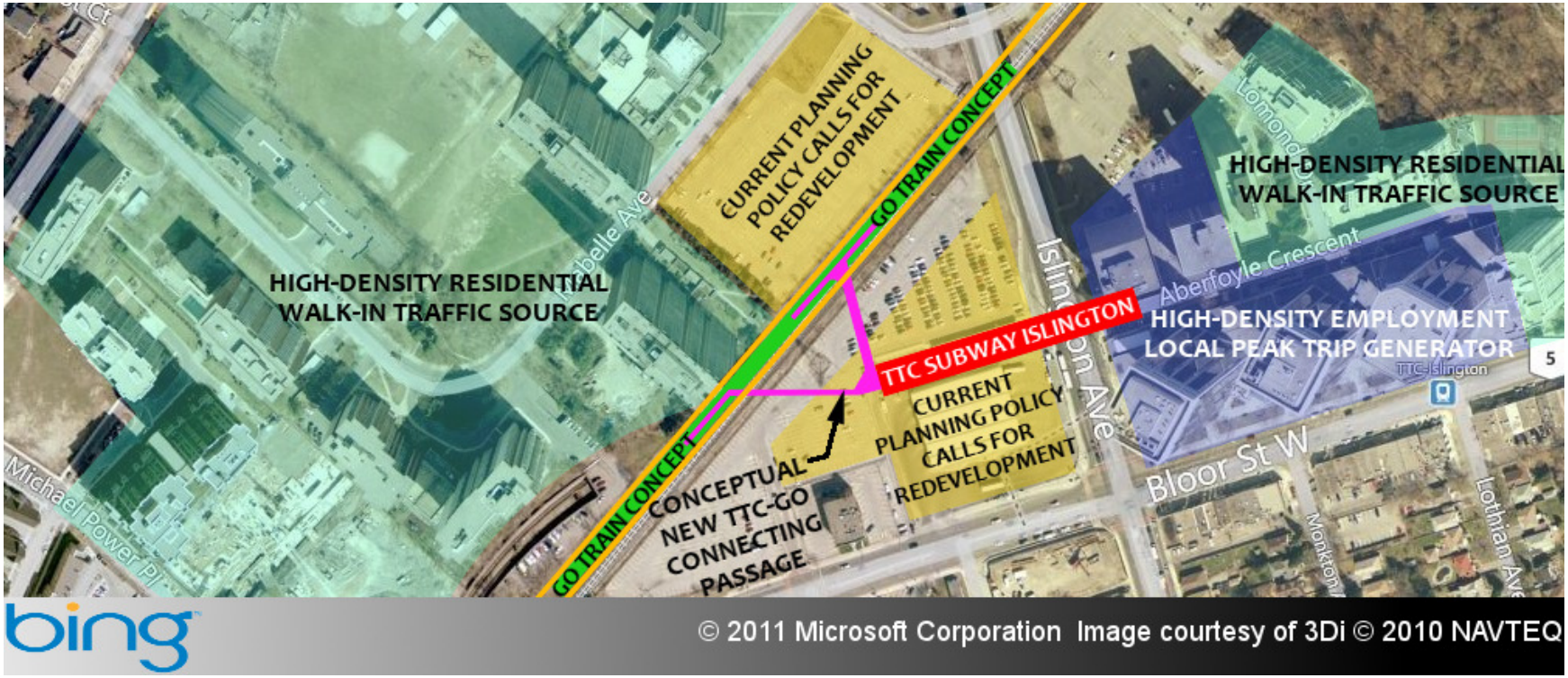


9.2. Future of Kipling Station

When the Kipling station complex was built in 1980-1981, design goals were not coordinated. While less than a year separated the introduction of TTC's and GO's respective rail services, the TTC wasn't thinking about the not-yet-existing Milton GO service when planning the Kipling extension. The subway extension from Islington to Kipling in Etobicoke had a few purposes, including expanded parking capacity on the subway system, positioning for a future connection to a new yard (for which lands were already acquired at the time), and integration with a planned rapid transit line from the Kipling station through a hydro corridor to Pearson Airport that ultimately was never built. Mississauga Transit has long favoured the Islington station terminal due to its superior ease of access for a number of its busier routes, and has resisted moving its operations from Islington. GO, meanwhile, was interested in a subway connection. Kipling would have been cheaper to build a connection into compared to Islington, and in the days of 6-car GO trains, there may not have been an appreciable difference in passenger convenience. GO trains are now twice as long, which changes the perspective.

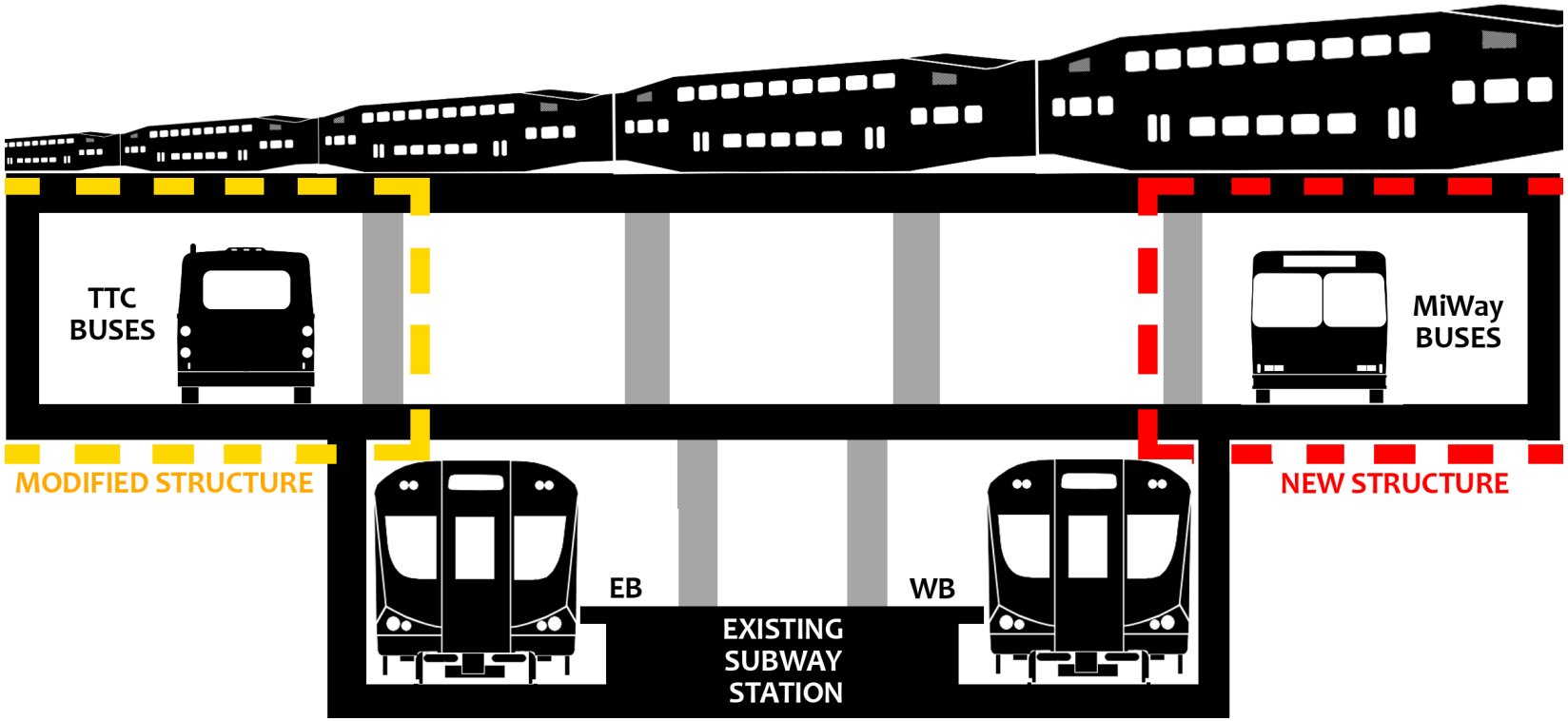


Islington offers great opportunities for superior connectivity between GO, TTC, and Mississauga Transit. A new exit at the west end of the Islington TTC platform would be involved, but the walk for potential GO riders would be less crowded and shorter on average from any car of a 12-car GO train,. It also has the potential to reduce dwell times, as GO passengers getting off at Islington would have several cars that would be convenient for them, instead of only the easternmost car, as at Kipling today. These benefits would be further enhanced if an electrified Milton corridor were to ever operate 16-car trains, for which an argument may in future materialize as the corridor already operates with frequent 12-car trains at peak times. A 16-car-long conceptual platform is shown in the image below.



The latest attempt to redevelop the Islington station lands fell through, but a new redevelopment effort involving enhanced relationships among the three different transit agencies represents an exciting opportunity – particularly if buses could serve the mezzanine level directly as in the conceptual cross-section below.

The site would also be capable of attracting a much higher potential walk-in trade for GO, offering more opportunities for diverting ridership bound for downtown from the Bloor subway (and also from the Yonge and University subways). Walk-ins versus bus connections make a significant difference for GO at TTC connections because there is no relationship between GO and TTC fares. TTC bus passengers at stations served by both GO train and TTC subway have the choice of a subway ride for free, or a GO train ride at an additional fare at least 50% higher than the fare already paid to ride the bus to the station.



9.3. Diesel Case, Electrification, and EMU Case Costs

Please see section 5.7 for an overview of the methodology regarding cost categories.

The breakdown works out to:

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$187.24	$0.00
	Grade Separations (Rail-Rail)	$101.25	$0.00
	Grade Separations (Road-Rail)	$270.00	$108.00
	Bridge Widenings (River)	$172.13	$0.00
	Bridge Widenings (Road)	$18.90	$0.00
	Fleet (Capital)	$101.04	$530.04
	Expanding Existing Stations	$8.10	$0.00
	New Stations	$6.75	$0.00
	Subtotal	**$865.40**	**$638.04**
Electrification	Infrastructure (incremental)	$0.00	$202.00
	EMU Fleet (incremental)	$0.00	$174.38
	Subtotal (incremental)	**$0.00**	**$376.38**
EMU Case	Wayside PTC	$0.00	$35.34
	PTC for LHCs	$0.00	$2.80
	PTC for EMUs (incremental)	$0.00	$10.30
	New Stations	$0.00	$76.95
	Subtotal	**$0.00**	**$125.39**
CORRIDOR TOTAL		**$865.40**	**$1,139.81**

9.3.1. Diesel Case

The Reference Case includes four tracks in the Milton corridor, as this is a requirement from CP. Currently, 69% of the corridor has two tracks, and typically three tracks elsewhere (four near Kipling station), full details of which can be found in Appendix Q. The Galt subdivision, on which Milton service operates, is an important corridor for CP, as it makes up part of its mainline that connects its international tunnel crossing under the Detroit River with the Port of Montreal. CP trains operating between northern Ontario and either the Detroit River crossing or the Fort Erie International Railway Bridge crossing would also follow the Milton corridor. Attaining four continuous tracks in the corridor is estimated to cost $188-million for almost 69 new single-track-kilometres, plus another $101-million for a new rail-rail grade separation just east of the Humber River exclusively for GO service.

There are seven new grade separations assumed to be components of the Reference Case, incurring total costs estimated at $270-million. These grade separations, all located in the City of Mississauga would be required at:

- Stanfield Rd,
- Haines Rd,
- Wolfedale Rd,
- Erindale Station Rd,
- Mississauga Rd,
- Thomas St, and
- Tannery St.

These grade-separations would almost fully grade-separate the line as far as the Meadowvale GO station. There would be two exceptions: Loreland Ave, and Ontario St.

Loreland Ave is a curious crossing where the street abruptly terminates immediately after crossing the rail corridor. The road serves only one property, sandwiched between the rail corridor on the north side, and two creeks, Pallet's Creek and Etobicoke Creek, converging on the south side of the property. The property appears to be used for managing inter-modal freight containers. This suggests it serves freight purposes, although there are insufficient tracks beside the property for any trains to have inter-modal containers removed from their flatbed cars at this site. A cost comparison between a grade separation with the rail corridor versus a new creek crossing by road from The Queensway could identify which option would be more cost-effective, should the crossing become practically closed due to GO rail service frequency.

The Ontario St crossing serves only 23 households, meaning traffic is extremely light and the cost of a grade separation here could be very difficult to justify. A grade separation would also have significant property impacts on many of those households. There are two potential alternative solutions in the event the rail crossing becomes practically closed due to GO rail service frequency:

1. A new easterly extension of Siberry Rd, from Pioneer Dr, connecting with the northern tip of Rutledge Rd, a route where a pedestrian trail already exists – however, this trail is on the south flank of a school property.
2. Extend Rutledge Rd south alongside the rail corridor to Tannery St.

Four more grade separations required beyond 2021, at Tenth Line, Ninth Line, Sixth Line, and Fifth Line, are estimated to cost $108-million.

There are ten river crossings requiring widening for the Reference Case, estimated to cost $172-million. These include:

- Humber River (Toronto/Etobicoke),
- Mimico Creek (Etobicoke),
- Etobicoke Creek (Toronto/Mississauga),
- Pallet's Creek (Mississauga),
- Cooksville Creek (Mississauga),
- Credit River (Mississauga),
- Mullet Creek (Mississauga),
- East Oakville Creek (Milton),
- Middle Oakville Creek (Milton), and
- West Oakville Creek (Milton)

There are six bridge widenings included in the Diesel Case, estimated to cost $19-mililon. These include:

- Thompson Rd,
- James Snow Pkwy,
- Winston Churchill Blvd,
- Mavis Rd,
- Hurontario St, and
- Dixie Rd

Other bridges are wide enough to accommodate the Diesel Case.

The Diesel Case is based entirely on rebuilds of the required fleet for running Milton service in 2021, estimated to cost $101-million. By 2031, diesel fleet costs are estimated to be $530-million.

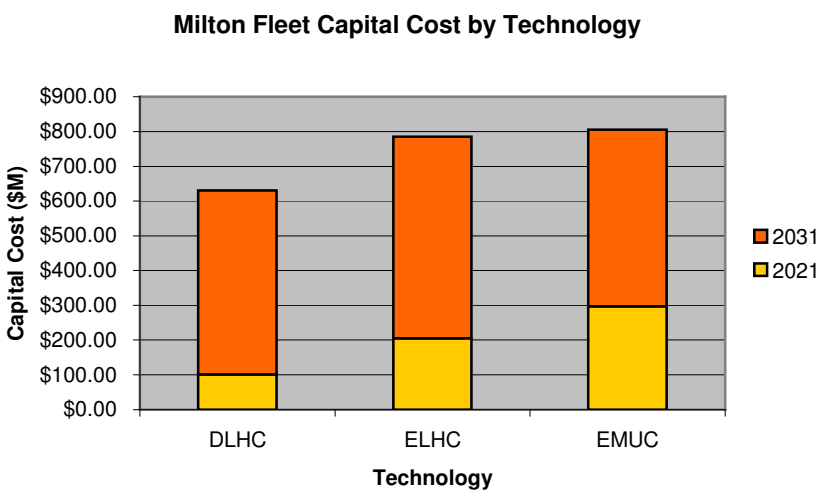
Expansion of existing stations to serve more than one track where only one is currently serviced is estimated to cost $8-million, while the new Agerton station at Trafalgar Rd, included in the 2010 electrification study's Reference Case, is estimated to cost $7-million.

9.3.2. Electrification

The 2010 electrification study estimated a cost of $202-million for the electrification infrastructure along the Milton corridor.

Electric locomotives were estimated in the 2010 electrification study to have an incremental cost of $100-million by 2021, although this is believed to be $134-million due to an error in the quantity of existing locomotives in the current fleet (an error that affected fleet estimates for Option 11, Option 15, and Option 18 in the 2010 electrification study; details in Appendix E). This report, using different methodology, estimates the 2021 cost at $104-million when rebuilds are a part of the equation, as well as using a different method of determining the sale value of existing locomotives as described in Chapter 4. From today to 2031, the incremental cost of electric locomotives is estimated to grow to $154-million.

With EMUs, the 2031 incremental investment value from today would be a total of $174-million (the 2021 figure is higher, reaching $196-million); i.e. $20-million more than electric locomotives. Similar to Kitchener, the vehicle costs are influenced significantly by the 2021 Diesel Case fleet being all rebuilds in the Milton corridor calculations. Assuming the Lakeshore and Kitchener corridors would be electrified before the Milton corridor, the fleet of diesel locomotives, coaches, and cab cars remaining for use on other non-electrified lines would be sufficient to meet 2021 Reference Case service levels.



9.3.3. EMU Case

Wayside Positive Train Control along the Milton corridor is estimated to cost $36-million. On-board Positive Train Control is estimated at $3-million for LHCs, and an additional $10-million for EMUs (or $13-million total).

Relocation of the Erindale GO station platform (existing station building, east access tunnel, and parking to remain)

The additional stations in the EMU Case (excluding Agerton, which was part of the Diesel Case) are estimated to cost $77-million. These include:

- Jane St in York (Lambton GO Station),
- Royal York Rd in Etobicoke (Chestnut Hills GO Station),
- Cawthra Rd in Mississauga (Applewood GO Station),
- Mavis Rd in Mississauga (Fairview GO Station),
- Eglinton Ave W in Mississauga (Erin Mills GO Station),
  - The geometrically constrained location of the new Erin Mills GO station at Eglinton Ave W would push the Erindale GO station to the opposite side of Burnhamthorpe Rd W in order to maintain station spacing standards.

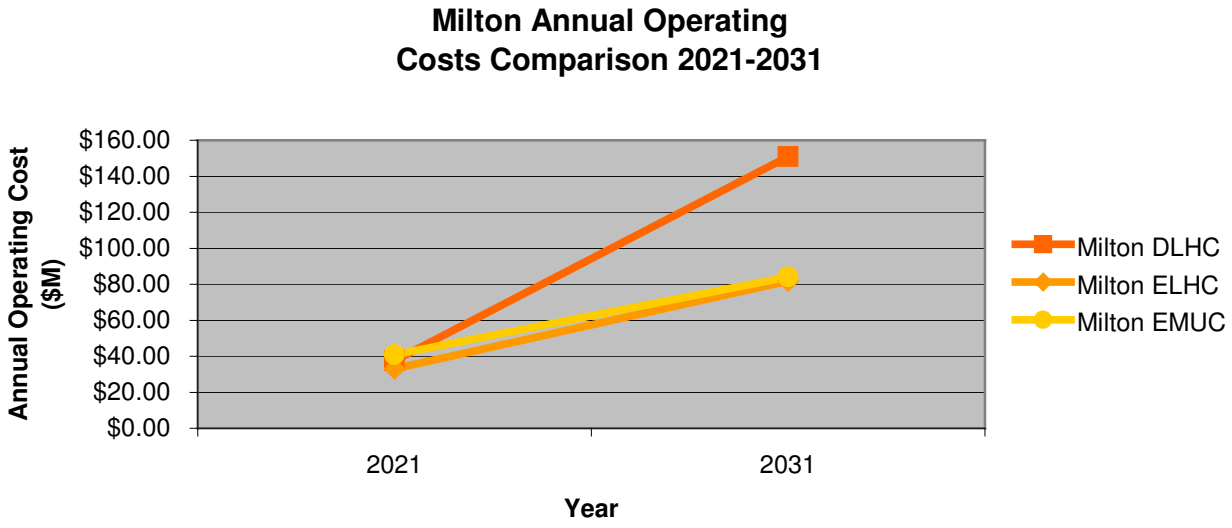
9.4. Operating Costs

The operating savings comparing diesel with EMUs are not as high as with electric locomotives, and at the lower Reference Case service levels, are actually more expensive to operate than diesel locomotives, although that changes very drastically with higher service levels and fuel prices in 2031. The difference is influenced largely by the relatively small fleet size required for the Milton corridor in 2021, and therefore largely catches up to electric locomotive costs in 2031.

As with other lines discussed in earlier chapters, the EMU case would provide more off-peak rail service than the electric locomotive case it is being compared with. This represents 13km of corridor in Milton's case that gets more service with EMUs than with LHCs. Also worth noting is that the Milton corridor has a 2031 peak hour peak point demand projection that exceeds that projected for Lakeshore West.

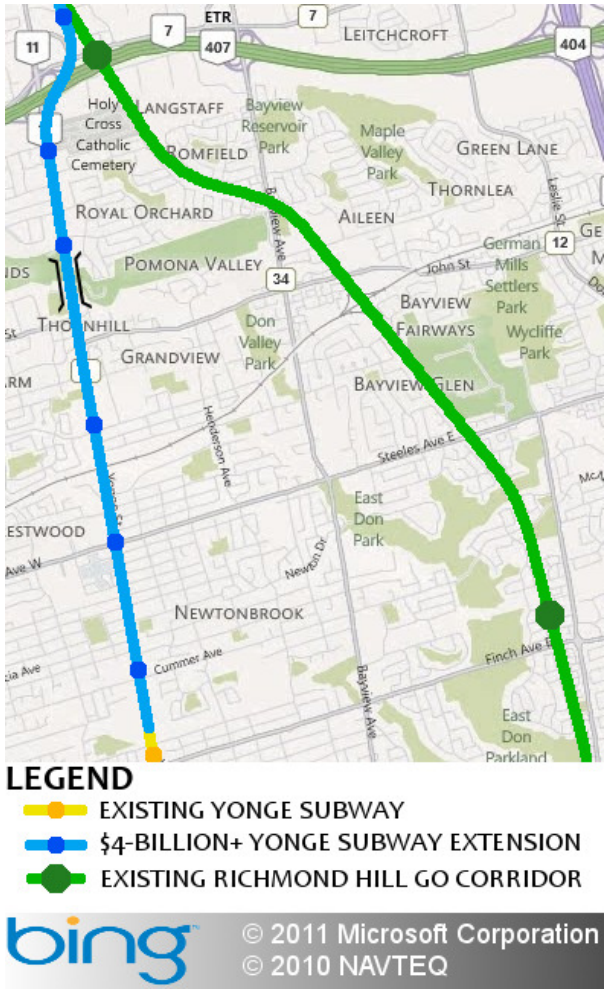
Service demand imposed upon the Milton corridor is extraordinarily high for a two-track corridor, and property constraints restrict the ability to provide overtake [bypass] tracks. There will be three or four tracks for each of the Lakeshore West and Georgetown corridors, both of which exhibit lower peak hour peak point demand projections. Meeting future service requirements for the Milton corridor with only two tracks would be very difficult with electric LHCs, and conceivably impossible with diesel LHCs. When the costs of EMUs are compared with the costs of infrastructure expansion required for LHCs, particularly additional tracks (estimates for tracks that would only be required in LHC scenarios were not prepared), it is clear that EMUs make more sense in economic terms.

	Milton Annual Operating Cost ($M)					
	2021			2031		
	DLHC	ELHC	EMUC	DLHC	ELHC	EMUC
Diesel Equipment Maintenance	$3.4044	n/a	n/a	$7.9436	n/a	n/a
Electric Equipment Maintenance	n/a	$3.1694	$16.7200	n/a	$7.0702	$37.3920
Unpowered Coach Maintenance	$16.4992	$16.4992	$6.9550	$36.1495	$36.1495	$16.6920
Energy	$17.6188	$6.7542	$6.1216	$105.4089	$28.4114	$23.7473
Incremental Labour	n/a	n/a	($1.3235)	n/a	n/a	($4.1928)
Incremental Debt Servicing	$0.0000	$6.5651	$12.4235	$1.3794	$10.1189	$10.4619
Total	**$37.5224**	**$32.9879**	**$40.8965**	**$150.8814**	**$81.7500**	**$84.1004**


Milton Annual Operating
Costs Comparison 2021-2031
Annual Operating Cost ($M)
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
$0.00
2021
2031
Year
Milton DLHC
Milton ELHC
Milton EMUC

10. Richmond Hill Corridor

Much of the Richmond Hill corridor follows the Don Valley as it extends north-south through Toronto. It uses the Bala subdivision, which is a major CN freight corridor north of the Doncaster diamond in the John St/Bayview Ave area of Thornhill, York Region, connecting CN's southern Ontario rail network to Western Canada. South of the Doncaster diamond, the corridor is under GO/Metrolinx ownership.



10.1. The Yonge Street Corridor and Relationships with GO

After entering southern York Region, the Richmond Hill corridor follows the Yonge St corridor closely. Even through North York, between Eglinton Ave E and Steeles Ave E, the Richmond Hill corridor offers significant potential to intercept traffic that currently feeds into the Yonge subway from the east. However, with the exception of Union Station, the Richmond Hill corridor has only two existing stations south of Steeles Ave E, both sub-optimally located. This severely undercuts the significant potential of the Richmond Hill corridor.

There is political pressure to extend the Yonge subway to Highway 7, a situation that has arguably become a "false start" of sorts given the challenges it faces following the completion of its environmental assessment. This extension is estimated by the TTC to cost $4.2-billion for 7.4km, including a small satellite yard added immediately north of the new terminus, increasing the preliminary design length from 6.8km. This is 75% higher than the earlier, more preliminary estimate of $2.4-billion originally published in the project's environmental assessment. A 7.4km project costing $4.2-billion is a cost of $567.6-million per kilometre.

The extension of the Yonge subway is financially unsustainable given the available alternatives in this part of the region. Moreover, the downstream impacts of the Yonge subway extension could conceivably result in a crisis, as capacity problems already exist today. Compounding existing capacity shortfalls on the country's busiest transit corridor with a subway extension is extraordinarily high risk.

Not proceeding with the Yonge subway extension was the recommendation put forward in the recent Downtown Rapid Transit Expansion Study (DRTES), released in 2012, by Dawson et al, a joint study by the TTC and the City of Toronto supported by consultant services from HDR. DRTES made for sobering reading on the severity of the challenges facing rising transportation demand into downtown as most options serving that demand are near or over capacity currently. Furthermore, this situation was projected to remain in a similarly precarious state 20 years from now, even with improvements that had no funding at time of writing as well as at the time the DRTES was done.

There was a clear interest expressed in the DRTES to look at what options might be possible through the GO rail corridors, but this was not done as it was deemed "beyond the scope" of the DRTES; this was unfortunate, particularly in light of their charts that showed consistently a surplus of capacity on the Richmond Hill GO corridor.

Table A-2: 2031 Inbound Rapid Transit Capacity Deficiencies

	Capacity (2031 Reference)	Inbound Demand (2031 Reference)	V/C (2031 Reference)	Inbound Deficiency (2031 Reference)
AM from NORTH				
University Subway	38,000	25,100	0.66	0
Yonge Subway	38,000	35,800	0.94	0
Barrie-Bradford GO	6,400	7,500	1.17	1,100
Richmond Hill GO	4,800	2,500	0.54	0
Stouffville GO	6,400	8,500	1.34	2,100
AM from WEST				
B-D Subway (west of Bathurst)	33,000	20,100	0.61	0
Georgetown GO	9,600	11,000	1.15	1,400
Milton GO	11,500	12,000	1.04	500
Lakeshore West GO	19,200	13,900	0.72	0
AM from EAST				
B-D Subway (east of Sherbourne)	33,000	31,400	0.95	0
Lakeshore East GO	14,400	21,200	1.47	6,800
TOTALS				
TOTAL from NORTH	93,600	79,500	0.85	3,200
TOTAL from WEST (Excluding BD)	40,300	36,900	0.92	1,900
TOTAL from EAST (Excluding BD)	14,400	21,200	1.47	6,800
TOTAL Inbound (Excl. BD)	**148,300**	**137,600**	**0.93**	**11,900**

Source: 2031 City of Toronto and TTC GTA/Maditic Model
PHF of 0.55 applied to TTC routes and 2031 GO routes

One of a variety of different simulated 2031 transportation models (MADITUC) in the DRTES showing low Richmond Hill line ridership.

In 2031, the Richmond Hill GO corridor was projected to have a Volume:Capacity (V/C) ratio of 0.54 in the MADITUC model used by the DRTES. That was presumably based on the existing context of the line, wherein only two stations exist south of the Langstaff GO station, both in Toronto, and both of these are inconvenient to reach by TTC bus or subway services. In that context, the low V/C ratio was a reasonable result, but it was also in the same context that a more detailed look at opportunities for GO corridor options as part of

the DRTES could have been invaluable. The unusually low V/C ratio for Richmond Hill GO service was not commented on in the DRTES.

The main transportation hub that is the focus of the justification for extending the Yonge subway is "Richmond Hill Centre" (a confusing name given that the Richmond Hill GO station is located 4km further north). "Richmond Hill Centre" is located northeast of the Yonge St and Highway 7 interchange, and is an identified Urban Growth Centre in current growth plans agreed to by York Region and the Province.

This Urban Growth Centre is already served by rail; i.e. the Langstaff GO station is located on the east flank of "Richmond Hill Centre." However, the GO station platform is some distance from the bridge over the tracks to the YRT terminal there, resulting in a transfer node that could benefit from an enhanced design. The connection can be greatly improved with a shift in GO platform location by about 100m to the north after extension to 12-car train-lengths. Other substantial improvements are possible at the point in time when the demand at the current terminal exceeds its capacity, when rebuilding the terminal becomes necessary. At that time, there would be an excellent opportunity for a stronger integration with the existing bridge structure, ideally in conjunction with a mixed-use complex featuring a 2nd-level bus terminal (or dual-level depending on capacity requirements).

Combined with the discounted fare York Region Transit (YRT) riders are entitled to when they hold a GO train ticket, high-frequency GO service along the Richmond Hill line between the Langstaff GO station and downtown Toronto could be very attractive and quite competitive with the subway, particularly if stations are added along the GO line to serve more origin-destination pairs. This is critical in light of the capacity limits of the Yonge subway, which have become an increasing concern lately as ridership is projected to exceed the capacity of the existing Yonge subway line. This is the case even when the high capacity new trains, upgraded signal system, and automated train operation are included. This is projected to be the case even if there were no Yonge subway extension to "Richmond Hill Centre." Richmond Hill GO service, on the other hand, has substantial room for growth, and its upgrading as described above would be *billions* of dollars cheaper than the subway extension.

With an additional station by Thornhill Square (John St), the Richmond Hill GO service could intercept all existing east-west YRT bus routes running east of Yonge and south of Highway 7. The only YRT routes currently bound for the Yonge Subway that would not be intercepted by Richmond Hill GO service would be the Clark Ave, Bathurst St, Centre St, and Thornhill Woods Dr routes, although two of those could be reoriented towards a new Thornhill station.

York Region has repeatedly claimed through its published reports that subway is the only transit technology option that can meet its demand projections between Steeles and Highway 7, but these publications did not seem to acknowledge the potential capacity of the GO corridor and the impact additional stations to the GO corridor south of "Richmond Hill Centre" would have, as no mention of either was present. There would also be demand originating north of Richmond Hill Centre that could be intercepted by the GO corridor, but not by the subway. The capacity projected by York Region to be required south of "Richmond Hill Centre" is over 14,000 passengers in the peak hour. This represents a startling 60% jump over the 2031 demand projection published in *The Big Move* modeling backgrounder of 8,800 passengers per hour for the Yonge subway extension. However, 14,000 passengers per hour would be well within the potential capacity of EMU GO service along the Richmond Hill corridor if equipped with a modern signal system; therefore, subway is not the only technology capable of meeting this demand. The high ridership projection of 14,000pphpd for the Yonge subway raises the question of how many bus routes were modeled to run to the "Richmond Hill Centre" node and how many of those routes could conveniently integrate with the Richmond Hill GO corridor.

Development plans at "Richmond Hill Centre" are ambitious, and they will stimulate some increase in demand for transit. This also applies to development plans at some other locations along Yonge St between Steeles Ave and Highway 7. However, it is known that dense development patterns alone will not necessarily generate subway-level demands. This has been clearly demonstrated and verified along Sheppard Ave E from Yonge to Don Mills. Like the Sheppard subway, "Richmond Hill Centre" is adjacent to a 400-series highway, and therefore has the potential to attract a residential occupancy that is not necessarily transit-oriented unless parking was not provided in these developments, a highly unlikely outcome as the units would be virtually unmarketable in that part of the region without parking. Therefore, feeder bus routes would be the main driver of subway ridership at "Richmond Hill Centre," some of which could be intercepted by the GO system before reaching Richmond Hill Centre via new GO stations.

10.2. Improving Richmond Hill GO Connectivity with TTC

Currently, the Richmond Hill GO rail service only stops twice within Toronto's borders, and in both cases, connections with TTC services leave much to be desired. When the line was built, the practice was to favour parking over good transit connections. Initiatives geared towards moving away from a parking-reliant philosophy in favour of a more sustainable, transit-integrated philosophy would increase the potential of the line.

10.2.1. New Potential TTC Connections

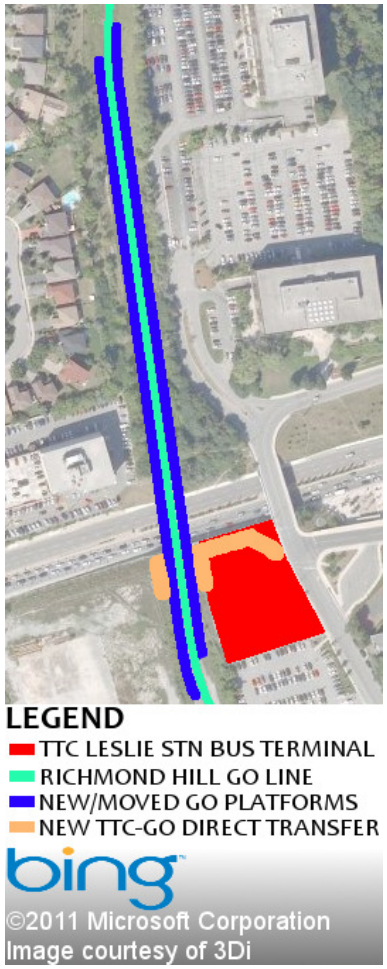
Connections between TTC and Richmond Hill GO services could be expanded by means of new GO stations at Steeles Ave E, and at York Mills Rd. The latter also happens to serve an employment area, a feature that is highly consistent with current planning policies and would encourage trips to spread out more across the line.

10.2.2. Old Cummer GO Station

The Old Cummer GO station is quite close to Finch Ave E, but the connecting bus stop in either direction on Finch Ave E is at least 250m away from the nearest (southern-most) point on the existing platform. Even with the extension of the platform to accommodate 12-car trains, which was being implemented at time of writing, there would still be a 200m walk between TTC bus and GO train, plus a staircase that would see the walk exceed 200m for the eastbound Finch East TTC bus in particular. A transfer that requires a walk in excess of 200m does not qualify as a viable transfer by TTC standards. The TTC connection would be significantly improved if the GO platform were shifted approximately 150m to the south relative to the southernmost point of the platform's 12-car length. Ideally, the connection should be both sheltered and accessible by means of a ramp. The Old Cummer GO station parking lot is small (437 spaces), while the Finch East TTC service is the busiest peak period bus route operated by the TTC, operating at an average of a bus every 70 seconds (which is extremely challenging).

10.2.3. Oriole GO Station

Relocating the Oriole GO station has been talked about periodically for some time, but to date has never been carried out. The station long predates the construction of the Sheppard subway, but prioritizing a highway over a subway for a railway station location, regardless of which came first, runs counter to contemporary planning philosophy. The walk between the Oriole GO station and the TTC Leslie subway station – platform to platform – is over half-a-kilometre, over 400m of which is completely open and exposed to the elements. Extraordinarily few, if any, riders consider this a practical transfer, and any initiatives to try and encourage transfer traffic here without relocating the station would be unlikely to have a meaningful impact. It is not the ease of the walk, but rather, its length that is the key factor.



Incidentally, the TTC Leslie station bus terminal abuts the GO corridor. However, the geometry of the corridor is somewhat unfortunate, as there happens to be a curve along the GO corridor immediately south of the abutting TTC bus terminal, which is undesirable for a station. While not ideal for those who get off at the north end of the train, it would still be a vast improvement to move the station to straddle Sheppard Ave E and provide a direct, predominantly sheltered connection from the GO platform to the TTC station.

10.3. Straighter, Faster, Shorter – The Don Branch Route

As a diesel service, there are arguments in favour of keeping the existing Richmond Hill corridor routing. The alternative route along the ex-CP Don Branch has a steep gradient of up to 1.75%, which would cause some stress northbound for a 12-car diesel GO train. However, the Don Branch is close to 1km shorter than the existing Richmond Hill line along the winding Bala subdivision. The re-routing would only apply between Lawrence Ave E and Gerrard St E, a span where there are currently no stations. The Don Branch has fallen into disrepair, and has been in a mothballed state since 2009, but remains in place and is currently under GO/Metrolinx ownership. The connecting switch at CP's Belleville subdivision has been removed, but it could be easily reinstalled if warranted by the establishment of regular GO service. Reinstallation of said switch would be dependant on CP mainline corridor track expansion designs. In Chapter 5 of "No Little Plan: Electrifying GO Transit," page 53, it is stated that there is a case for electrification of the Richmond Hill corridor "as part of a long overdue realignment and expansion of the route." While it was not specified, this was in relation to the utilization of the Don Branch for the rerouted Richmond Hill GO service.

Richmond Hill GO service using the Don Branch is not a new concept. The idea has been recommended in the past, but never funded. GO Transit, when governed by the Greater Toronto Services Board, recommended such a project be undertaken in a report released in August, 2000, *Route Map to the Future*, which outlined a then-$4.1-billion network expansion plan, in which it stated:

"The next step would be improvements to the single-track corridor between Union Station and Oriole station (at Highway 401). Diverting the service to the CP corridor would make it possible to establish stations in the Don Mills and Leaside areas. Double-tracking would be required to support additional service up to the all-day level."

York Region's 2002 Transportation Master Plan also recommended the Richmond Hill GO service be diverted to the CP line.

The Leaside Spur, just east of and roughly parallel with Leslie St, which used to connect the CN Bala subdivision south of Oriole with the CP line to/from Leaside and still in existence when the above referenced plans were developed, is now gone and unlikely to be restored (it has since become an off-road bike trail). However, the City of Toronto released a design prepared by Cansult/LEA Consulting for a new connection between the two railways as part of the Don Valley Corridor Transportation Master Plan study in 2005. The new connection was not recommended at the time, which predated Metrolinx, but many of the factors that led to that conclusion no longer apply in light of *The Big Move*. The Cansult/LEA Consulting report stated:

"…should circumstances change in the longer term, the 'east of the DVP' connection option is still possible since the work to be done would be entirely on public lands and the recent residential development would not be directly affected…"

At the time, the cost of the new connection was estimated at $22-million (2005-$), which would be about $25-million in 2010-$. The concept was for a single-track connection, but a double-tracked connection would be necessary to handle the frequent service required to provide attractive service relative to the Yonge subway line; i.e. to successfully divert ridership from it.

If the tracks were rehabilitated and upgraded, the Don Branch speeds should be at least 50% higher than what is possible on the existing Bala subdivision alignment on the Gerrard-Lawrence section of the route.

While no stations are practical between Lawrence Ave E and Gerrard St E along the Bala subdivision due to the effects of the Don Valley terrain, using the Don Branch would change that situation, as the *Route Map to the Future* report indicated. The Don Branch option has a significantly superior relationship to Eglinton Ave E for designing a TTC connection by having much less vertical distance between the two services. There have been past indications that Metrolinx was interested in a connection between the Eglinton-Crosstown LRT and the Richmond Hill GO corridor, although those efforts appeared to focus on the existing Bala subdivision routing. That effort was understandably abandoned, but an Eglinton LRT connection along the CP line would hold much more promise. There is also the site of the former CPR Leaside station that could become an active station once more, this time for GO/Metrolinx use. Like the Bala subdivision, however, a connection between the Danforth Subway and the Don Branch would be very expensive and extremely complex, and is therefore not considered in this Regional Rapid Rail report.

Consequently, while Yonge subway ridership from Eglinton and north thereof could be diverted, Richmond Hill GO service would not divert significant ridership from south of Eglinton, including most Bloor-Yonge transfer traffic, but the ridership diverted from the Yonge line by the Richmond Hill GO service would still be substantial, and as such would represent very high value for money. That catchment zone south of Eglinton, however, is not without significant demand, as the projected ridership figures for 2031 prepared for *The Big Move* make very clear. Those figures indicate that both the Richmond Hill GO corridor and new subway capacity into the downtown core from Eglinton Ave E would be heavily used, with each corridor playing its own important and distinct role in the reliability of the regional network. Electrification of the Richmond Hill GO corridor would be capable of providing more time for new subway capacity into downtown to be implemented, but it would be unrealistic to expect it to create an environment that renders said new subway capacity as permanently unnecessary.

10.4. Diesel Case, Electrification, and EMU Case Costs

Please see section 5.7 for an overview of the methodology regarding cost categories, excluding the Don Branch as discussed in section 10.4.2..

The breakdown works out to:

Category	Element	2021($M)	2031($M)
Diesel Case (North of Lawrence)	Bridge Widenings (River)	$35.44	$0.00
	Grade Separations (Road-Rail)	$116.78	$0.00
	Grade Separations (Rail-Rail)	$100.00	$0.00
	New Track	$72.00	$8.10
	Fleet (Capital)	$67.12	$647.22
	Expanding Existing Stations	$9.45	$0.00
	Subtotal	**$400.78**	**$655.32**
Don Branch	Bridge Widenings (River)	$0.00	$216.00
	Grade Separations (Road-Rail)	$0.00	$37.80
	New Track	$0.00	$94.75
	Subtotal	**$0.00**	**$348.55**
Electrification	Infrastructure (incremental)	$0.00	$250.00
	EMU Fleet (incremental)	$0.00	($22.77)
	Subtotal (incremental)	**$0.00**	**$227.23**
EMU Case	Wayside PTC	$0.00	$20.60
	PTC for LHCs	$0.00	$2.80
	PTC for EMUs (incremental)	$0.00	$8.30
	New Stations	$87.75	$48.60
	Subtotal	**$87.75**	**$80.30**
CORRIDOR TOTAL		**$488.53**	**$1,311.40**

10.4.1. Diesel Case (North of Lawrence Ave E)

The Diesel Case costs include new track, including bridge works and grade separations, and also includes the diesel fleet cost.

The 2010 electrification study's Reference Case adhered to the current corridor routing, but it would be in the best interests of the transit system, in light of the pressure on the Yonge subway, and from a performance and service attractiveness perspective, to not maintain the current corridor between Lawrence Ave E and Gerrard St E, if the creation of an attractive and cost-effective alternative compared with the subway is available. To deal with this alternative, the Diesel Case was broken into two parts, split at Lawrence Ave E in Toronto. This section covers the section north of Lawrence Ave E.

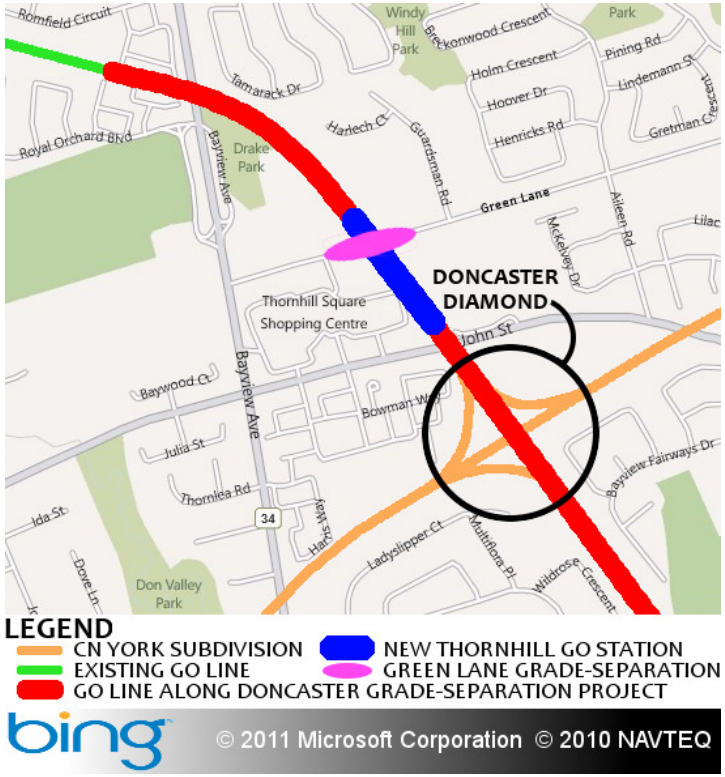
There are two river bridges requiring twinning by 2021, both located between Sheppard and Steeles, estimated to cost $35-million.

Regarding grade separations (road-rail) along the proposed extension of the Richmond Hill corridor, an engineering contract for a grade separation is already in progress for 19th Ave, and therefore is considered funded. The Weldrick Rd grade separation is planned to take place in 2018, estimated in a consultant report to cost $9.5M, but is not yet funded. Bethesda Sideroad is proposed to be grade-separated due to a new Highway 404 interchange, but no cost is assigned since it would not be prompted by future GO rail service levels. Weldrick and other as-yet unfunded grade separations are estimated to cost a total of $117-million, by 2021.

The Langstaff Rd grade separation was not included in the above estimate because a developer with ambitious and much-anticipated plans for what are known as the "Langstaff Lands" south of the Langstaff GO station is expected to cover that cost. The Green Lane grade-separation is tied to the complicated Doncaster Diamond Grade Separation project, because of the very close proximity between the two projects in the John St/Bayvew Ave area of Thornhill, and so was also excluded from the above estimate. The Doncaster diamond is a rail-rail crossing between the Bala subdivision and CN's busy York subdivision (part of the Toronto bypass between the Burlington and Pickering GO stations), estimated to cost $100-million.

The Doncaster diamond is a site with overlapping projects that would best be considered together and coordinated at the outset for the optimal transit result to be achieved. As the Reference Case has correctly noted, the Doncaster diamond needs to be grade-separated, and design work for this project is already underway. Green Lane is very near Doncaster, and it would be logical for the road-rail grade-separation to be implemented concurrently with the diamond.

What has not been included, despite public pressure having been exerted by the local community in the past, is the inclusion of a new Thornhill GO station. The relationship such a GO station would have with the rail-rail grade-separation at Doncaster is admittedly complex, and makes a GO station at this location far more expensive than the typical average, but this location has the necessary foundations for a smart-growth location for a GO station, and is home to a community clamouring for more transit service in their area where, ironically, infrastructure already partially exists – the tracks are there, but a station platform is not. Integrating these three elements (station, rail-rail crossing, and road-rail crossing) into a single, coordinated design solution would avoid the creation of physical or operational conflicts in future, which in turn would result in the most cost-effective approach. It is worth stressing that adding the station after the grade separation has been put in place is not necessarily realistic.



Only Leslie St at Stouffville Rd would remain as an at-grade crossing, which is in a rural area with lower service frequency and lower volumes of road traffic.

The cost of new track for the Reference Case north of Lawrence Ave E is estimated to be $72-million. An estimated additional $8-million would provide overtake/bypass tracks where appropriate for express services beyond 2021.

The cost of the rebuilt diesel fleet needed for the Richmond Hill service is estimated at $67-million. The Richmond Hill corridor is expecting aggressive growth in *The Big Move*. The projected demand for 2031 would require an expanded diesel fleet estimated to cost $647-million.

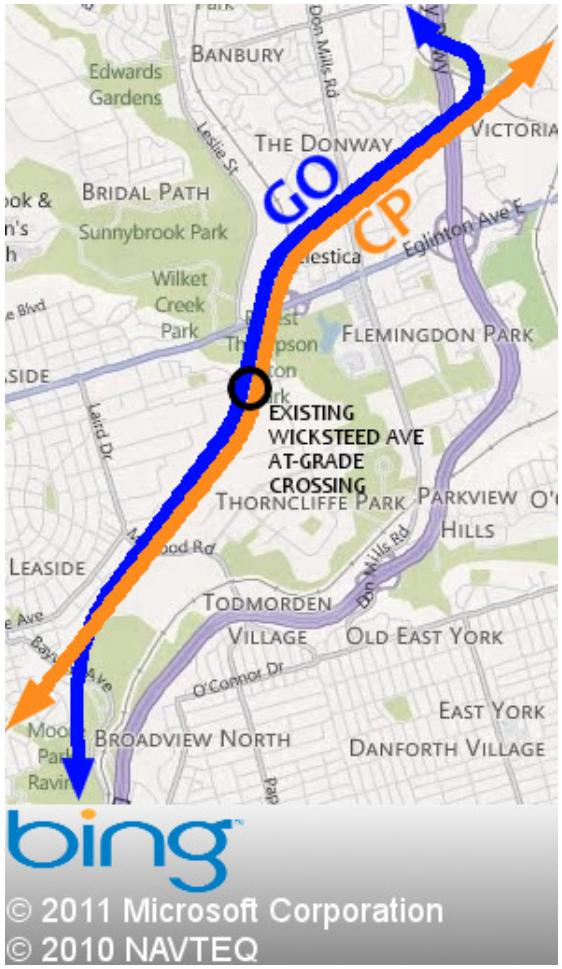
An additional $9-million is estimated to be needed for expansion of existing stations.

10.4.2. Don Branch

South from Lawrence Ave E, this Regional Rapid Rail report proposes an alternate routing down the Don Branch, which would have a different cost than using the current alignment. Admittedly, the Don Branch would be a more expensive option, but the substantial benefits are worth considering.

The biggest single cost would be the river bridges. While there are three bridges to deal with along the Don Branch routing compared with seven along the existing Bala subdivision, one of the bridges on the Don Branch proper and another on the CP mainline are large bridge projects with high cost. The total cost of river bridgeworks is estimated at $216-million. The cost of the seven Bala subdivision bridges mentioned above was estimated at $65-million.

The grade separations are estimated to cost $38-million for three crossings along this section, only one of which is currently a level crossing. It should be noted that this is about the same as what the existing routing would have cost, which had two crossings estimated at $41-million (one of which was built like a river bridge that would have needed twinning).



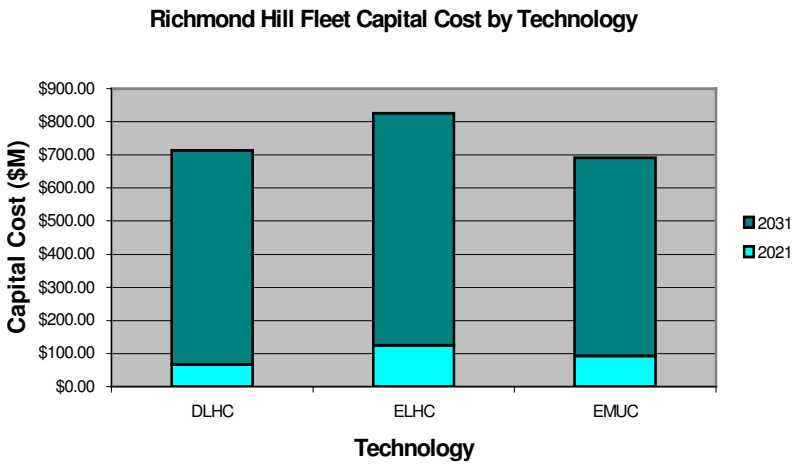
For track work, the section through Leaside following the CP mainline would require four-tracking to allow frequent GO service to co-exist with one of the busiest sections of CP's network, as on the Milton line. In addition, the Don Branch requires a second track, as well as rehabilitation of the existing mothballed track. Finally, the new Wynford area connection between CP and GO requires two tracks. Taken together, this is estimated to cost $95-million, while track work along the existing corridor would have cost $25-million. The difference is due largely to the new track connection north of Wynford, although the four-tracking along the CP mainline and track rehabilitation along the Don Branch are also factors. A detailed breakdown is available in Appendix R.

10.4.3. Electrification

The 2010 electrification study estimate for electrification of the fixed infrastructure on the Richmond Hill corridor was bundled together with estimates for the Stouffville and remaining Lakeshore West (the Hamilton TH&B station and CN Grimsby subdivision) parts of the network. This meant the cost had to be estimated based on the cost per single-track-km relating to the other lines. This was a little over $2-million per single-track-km, and the Richmond Hill Corridor to Bloomington Rd, southeast of Aurora in York Region, accounts for 109 single-track-kilometres. If $2.25-million is assumed per single-track-km, the estimate for electrification would be $245-million.

The cost estimated for electrification is assumed to be the same regardless of which route is selected (Bala vs Don Branch). The difference in length between the two is just under 1km, which would be a difference of less than $5-million between the two route options.

Potentially, Richmond Hill represents significant opportunities for optimizing resource management, in that corridors would be sharing vehicles after passing through Union Station. With their faster travel speeds, the EMUs could reach an appropriate station near the north end of the line in time to make a second or third trip into Toronto in the morning. Through this strategy of sending Georgetown and selected Lakeshore West trains onto the Richmond Hill line, the use of EMUs would only require the purchase of three new trains for 2021 service levels, plus spares. The incremental cost relative to the diesel case is only $26-million based on 2021 service levels, even if all the diesel trains in question were rebuilds of existing trains in the fleet (i.e. not new train purchases). By 2031, that $26-million incremental cost would be paid back by realizing $49-million in savings from EMUs over diesel locomotives when fleet growth between 2021 and 2031 is taken into account, resulting in a net capital cost savings of $23-million between the present and 2031 from EMUs. Compared with the use of electric locomotives in 2031, EMUs would be less costly by $160-million.



Details behind these calculations are found in Appendices G and H.

10.4.4. EMU Case

Wayside Positive Train Control (PTC) equipment in the corridor is estimated to cost $21-million, while on-board PTC is expected to cost about $3-million for a LHC fleet, and $8-million more (or $11-million total) for an EMU fleet.

Additional stations along the line include:

- 16th Ave, near Yonge St (Richvale GO Station),
- John St/Green Lane, near Bayview Ave (Thornhill GO Station),
- Steeles Ave E, near Leslie St (Bayview Glen GO Station),
- York Mills Rd, near Leslie St (Windfields GO Station),
- Eglinton Ave E, near Leslie St (Seton Park GO Station) ***(along CP Belleville)***, and
- Millwood Rd, near Laird Dr (Leaside GO Station) ***(along CP Belleville)***.

Adding these stations is estimated to cost $136-million. Of that, $88-million would be spent by 2021 for the Thornhill, Bayview Glen, Elgin Mills, and relocated Oriole stations. The remaining stations are estimated to cost $49-million, to be spent after 2021. Details for these stations can be found in Appendix R.

A Trailwood station, at Bayview and 19th Aves, could be added to the line in future. This station was not included in the estimate, but would be worth considering for further improved connections between systems within York Region. This station appears in York Region's Transportation Master Plan.

Although refined projection data were not available, the peak period frequencies were presumed to vary on three different sections of an extended line, given the built form and network connections: South from Langstaff; between Langstaff and Elgin Mills (or Trailwood), and north of Elgin Mills (or Trailwood). For this reason, the cost of an additional 1.5km of electrified single-track was added to the Regional Rapid Rail cost, estimated at $8-million. Minor design adjustments at the new layover site to avoid further additional track for all-day 15-minute service on the entire line might be necessary.

10.4.5. Alleviating Pressure on the Yonge Subway

Unlike other GO lines, the Richmond Hill corridor has great potential to provide meaningful alleviation to the TTC's overstressed Yonge subway. There are two prerequisites to attracting riders to use the GO service instead of the subway:

1. Aggressive service levels to make wait times for trains competitive with the subway, which interpretations of *The Big Move*'s demand projections suggest would already be every 5 minutes at Union Station from about 6:50am to 9:20am in 2031.
2. Providing the requisite capacity needed to accommodate those diverted riders

The additional capacity would require additional vehicle purchases. Providing a diverted peak hour capacity of, say, 10,000 passengers per hour per direction, over and above *The Big Move*'s projected requirement, would require two strategies:

1. Moving from a five-minute frequency to a four-minute-15-second frequency (14 trains per hour, or two more per hour than for a five-minute frequency)
2. Extending all southbound platforms and morning peak hour southbound EMU trains from 12 cars to 16 cars in length, and same for northbound if afternoon peak load spread warrants

Assuming trains outside the peak hour (i.e. those trains making their peak direction run(s) during the shoulder hours) would remain 12 cars long, this would require a purchase of 40 EMU cars plus 6 spares, and 40 coach cars plus 2 spares, for costs estimated at $193.2-million and $115.1-million, respectively, or a combined $308.3-million. There would be another $4.6-million required for equipping these additional EMUs with Positive Train Control. This is just one hypothetical model of a substantial capacity expansion. Further additional vehicles could be purchased to either lengthen more trains for shoulder hour service or further increase frequency if Union Station can accommodate it.

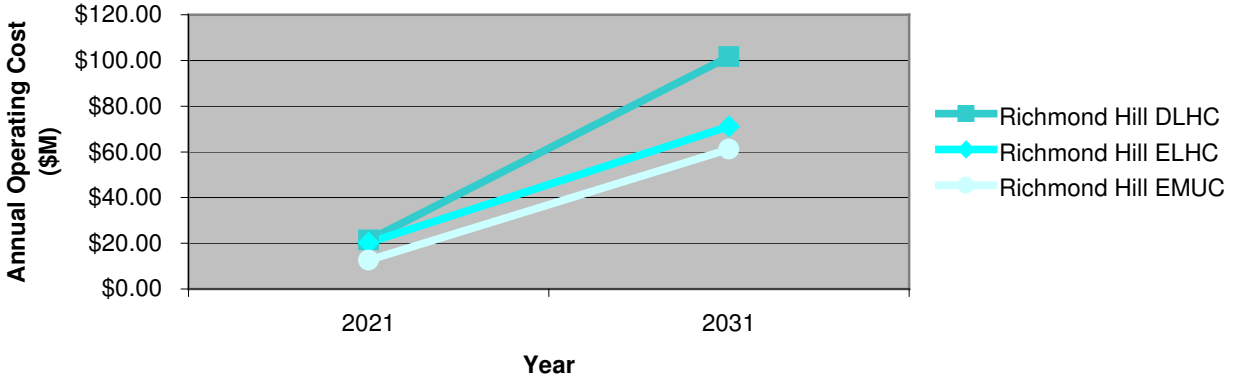
These service levels could be achieved well before 2031 in order to improve regional transit sooner rather than later. It is important that the political will to reconsider the Yonge subway extension, for which funding remains unavailable at time of writing, materialize in favour of the much more cost-effective Richmond Hill GO rail expansion. Again, this is proposed in recognition of the potential unintended negative consequences south of Eglinton Ave and in downtown Toronto from an extension of the Yonge subway that would likely reverberate across the whole Yonge-University-Spadina subway line. Serious problems on the Bloor-Danforth subway line could also result, especially at Yonge and St George stations, risking the creation of more regional transit problems instead of solving existing problems.

10.5. Operating Costs

Compared to the Reference Case, the savings would be very high with EMUs because such a small incremental increase in the network fleet size is required to make the Richmond Hill corridor function adequately with EMUs rather than electric locomotives, as shown in the chart below. By 2021, the savings are estimated to be $8.7-million annually with EMUs over the Diesel Case. By comparison, electric locomotives would generate only $1.1-million in savings. These figures include operating the EMUs all-day to Bloomington instead of Richmond Hill. By 2031, while electric locomotives would save just over $30-million, EMUs would save almost $40-million.

	Richmond Hill Annual Operating Cost ($M)					
	2021			2031		
	DLHC	ELHC	EMUC	DLHC	ELHC	EMUC
Diesel Equipment Maintenance	$2.5533	n/a	n/a	$7.9436	n/a	n/a
Electric Equipment Maintenance	n/a	$1.9504	$6.3840	n/a	$6.5826	$33.7440
Unpowered Coach Maintenance	$10.5055	$10.5055	$2.6429	$34.6979	$34.6979	$14.0491
Energy	$8.3122	$4.1238	$3.1206	$55.9306	$20.3237	$15.2182
Incremental Labour	n/a	n/a	($1.1969)	n/a	n/a	($3.1605)
Incremental Debt Servicing	$0.0000	$3.6806	$1.6448	$3.0869	$9.5443	$1.3851
Total	**$21.3710**	**$20.2603**	**$12.5954**	**$101.6589**	**$71.1485**	**$61.2358**

Richmond Hill Annual Operating Costs Comparison 2021-2031



Providing alleviation to the Yonge subway through substantially increased Richmond Hill capacity combined with 2031 service levels would obviously incur increased operating costs. However, it would not be logical to compare those costs with GO operations at lower service levels. The comparison would logically be made with the costs of extending TTC subway service along Yonge St through York Region, an unnecessary undertaking if GO service were transformed to a competitively attractive service with more frequent stops to intercept more riders. How the numbers would compare is unclear, as the detailed TTC figures were not available to generate a comparison and no model has included Richmond Hill GO service with a peak hour frequency better than 3 trains per hour (a train every 20 minutes), but a few factors can be highlighted. Using transformed GO service instead of a TTC subway extension to serve the Yonge St corridor through York Region would avoid:

1. Very significant capital costs of tunneling and stations,
2. Tunnel maintenance and associated ventilation and fire suppression systems' upkeep through York Region,
3. Much higher lighting requirements in York Region tunnels and stations than would be required for GO,
4. The need for more escalators and elevators in York Region subway stations than GO stations would need in order to maintain mandated full accessibility,
5. Complicated security infrastructure at York Region underground, multi-level subway stations compared to typical GO stations.

Also worth highlighting is the fact that the capital cost of the 7.4km Yonge subway extension is in the same ballpark as the 2010 electrification study estimated for electrifying the entire 508.9km GO rail network. That estimate included the cost of retrofits to the Hunter St tunnel in downtown Hamilton. By a very wide margin, the most cost-effective and financially sustainable approach is the option of transforming Richmond Hill GO to subway-like service levels and capacity.

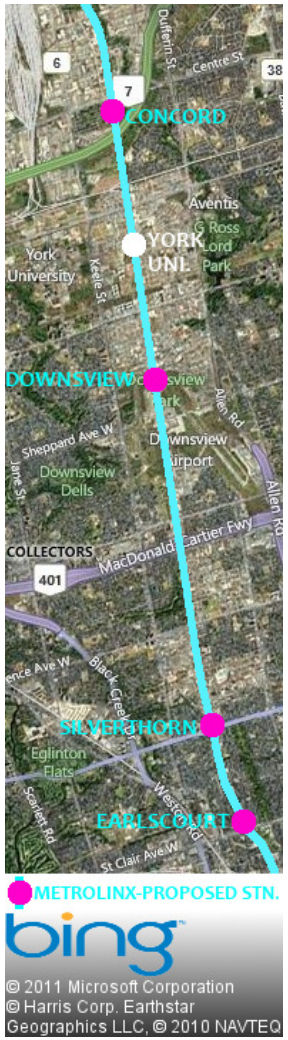
11. Barrie Corridor

The Barrie corridor has some similarities with the Stouffville corridor in that its ridership projections are not as strong as most other GO corridors. While Barrie has stronger projections than Stouffville, the corridor is much longer at 101km, from Toronto's waterfront on Lake Ontario, to Barrie's waterfront on the south shore of Kempenfelt Bay off Lake Simcoe. Also like Stouffville, Barrie is one of three corridors entirely owned by GO from end to end (the third is Lakeshore East).

11.1. Bradford Versus Barrie

The Barrie Corridor used to be the Bradford Corridor before the extension from Bradford to Barrie was reinstated in 2007 – GO service previously ran to Barrie for a short few years in the early 1990s. The extension from Bradford to Barrie made the line 50% longer. The extended portion of the corridor, however, has very little along it to warrant stations. Innisfil is the only sizable community between the two points, unless the Lefroy and Gilford communities were to see some significant growth.

The original Toronto-Bradford section of the line is known to have a lot of untapped potential. GO has started to tap that potential with three stations – Rutherford (2001), York University (2002), and East Gwillimbury (2004) – added over the past twelve years between Bradford and Toronto. Four more are being considered for St Clair Ave W (Earlscourt), Eglinton Ave W (Fairbank), Sheppard Ave W (Downsview), and Highway 7 (Concord), all connecting to higher order transit services. York Region is also interested in harnessing the Barrie line's potential through three additional GO stations in its territory at Mulock Dr near Bayview Ave, at Bloomington Rd/Bathurst St, and at Kirby Rd/Keele St.



The Toronto-Bradford section could be an exception to the finding in the 2010 electrification study that it is more cost effective to electrify the whole line than only part of the line. If the electrified portion is to be for only off-peak service, provided by a fleet of electric vehicles leftover from peak operations on another corridor, there are opportunities available at lower cost than would otherwise be the case for partial electrification. In this Regional Rapid Rail report, most of the network is assumed to be electrified before Barrie since it is not an “Express Rail” corridor. However, the 2010 electrification study gave preference to Barrie over Richmond Hill despite the latter’s “Express Rail” designation.

Off-peak-only electric service would not require the purchase of new electric vehicles. A key difference is that, as a longer line for off-peak service (67km), more fuel is consumed for off-peak service than on other lines in the network. This would be particularly pronounced if additional stations were provided, because additional stations give rise to increased fuel consumption. See section 11.6 for details on this consideration.

Three of the four new stations south of Highway 7 proposed by Metrolinx were not present in the Reference Case model published in the 2010 electrification study, with the one exception being Downsview. In addition, none of the York Region-proposed stations were included in the Reference Case. This means that the energy savings for off-peak service between Bradford and Toronto could be markedly higher than would be expected for other lines if those stations were added.

A station at Bloor St W, near the Lansdowne TTC subway station, already appears in the City of Toronto’s planning documents, but GO/Metrolinx have yet to pursue this station. While it is workable and worthwhile to have a connection between TTC and GO at this location, it will never be ideal no matter how well it is designed due to legacies of infrastructure built almost half-a-century ago. There will always be about 200m between the GO and TTC platforms, which makes an efficient, convenient design that much more important for this connection.

11.2. Further Service Enhancements

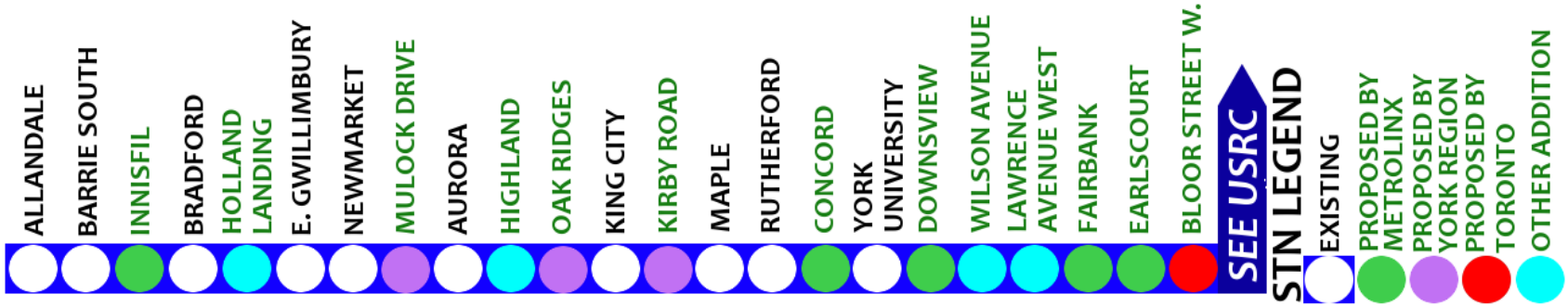
Over and above those stations already proposed by Metrolinx, York Region, and the City of Toronto, the potential of the Barrie corridor could be further unlocked by a few more additional stations, particularly as it relates to Yonge St through York Region. Worth emphasizing is that the higher the number of stations, the greater the advantage of EMU operation, especially in the case of a line as long as Toronto to Bradford and Barrie.

In York Region, additional stations could be considered at:

- Yonge St, in Holland Landing (Holland Landing GO Station), and
- Yonge St, in Aurora (Highland GO Station).

In Toronto, additional stations could be considered at:

- Wilson Ave, in North York, and
- Lawrence Ave W, in North York.



A 100km-long GO rail service with frequent stations along most of it, operating within a corridor wide enough for additional tracks (if needed), naturally raises the prospect of introducing regular express service. This would be a longer-term issue rather than a medium-term concern, but it is worth considering for the future evolution of service in the Barrie corridor, depending on how other investments along the corridor unfold. In any event, evaluation of such an approach has already partially begun with a Benefits Case Analysis by Metrolinx of GO rail off-peak service expansion, which included Barrie express services during peak periods.

However, instead of the current Lakeshore model, where trains skip a series of consecutive stations, an express model where stations are not skipped in one consecutive band may be more appropriate given the diversity of existing conditions along this line; i.e. rural and urban landscapes, as well as widely spaced areas of settlement. This may be a model comparable to the so-called "Rapid" (快速) service category found on various Japanese railways. This Regional Rapid Rail report proposes such a structure, illustrated below in comparison with the model from the Benefits Case Analysis that proposed express operation to/from the King City GO station.

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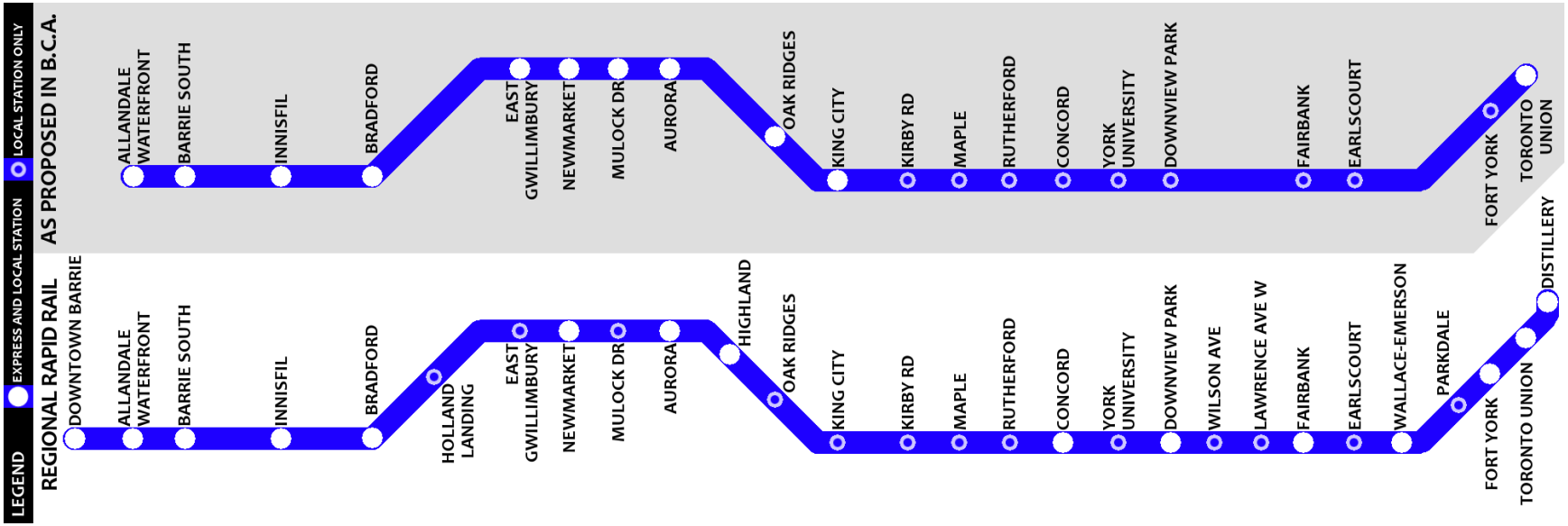


11.3. Diesel Case, Electrification, and EMU Case Costs

Please see section 5.7 for an overview of the methodology regarding cost categories. However, only the Diesel Case applies to the whole line.

The breakdown works out to:

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$188.10	$14.00
	Bridge Widenings (River)	$28.55	$0.00
	Grade Separations (Road-Rail)	$244.38	$357.75
	Grade Separations (Road-Rail)	$270.00	$0.00
	Fleet (Capital)	$103.04	$40.38
	Expanding Existing Stations	$18.90	$0.00
	New Stations	$40.50	$128.25
	Subtotal	**$893.48**	**$540.38**
Electrification	Infrastructure (incremental)	$0.00	$331.00
	EMU Fleet (incremental)	$0.00	$0.00
	Subtotal (incremental)	**$0.00**	**$331.00**
EMU Case	PTC for LHCs	$0.00	$1.80
	Wayside PTC	$0.00	$32.00
	Grade Separations (Road-Rail)	$270.00	$0.00
	New Stations	$0.00	$105.30
	Rebuilt Stations	$33.75	$135.00
	Subtotal	**$303.75**	**$274.10**
CORRIDOR TOTAL		**$1,197.23**	**$1,145.48**

11.3.1. Diesel Case

The 2010 electrification study's Reference Case illustrated plans for double-tracking the entire Toronto-Bradford section of the corridor, almost all of which is currently single-track. From Union Station to about 100m east of Lansdowne Ave, the Barrie corridor currently has no tracks at all, but rather, shares tracks with the Kitchener corridor. The proposed new tracks are estimated to cost $188-million with a 35% contingency.

As indicated in the Benefits Case Analysis that Metrolinx undertook for GO expansion (all lines except Lakeshore [West and East] and Kitchener), Metrolinx plans to run some express services at least during peak periods on the Barrie corridor. While this author is not convinced that non-stop runs between Union and King City followed by all stops being served between King City and Barrie results in the optimal express model, there is agreement that the presence of express services will require occasional passing tracks around some stations where the express service would pass without stopping. Such tracks were not in the Reference Case. The assumed quantity of electrified track for express trains to overtake local trains is 5km, at an estimated cost of $14-million; the locations of these tracks are not specified in this Regional Rapid Rail report.

The double-tracking of the corridor south from Bradford also involves bridge widening at rivers, estimated at $29-million, a majority of which is for the Holland River bridge just south of the Bradford GO station. It may be concluded that the Holland River bridge is so close to the Bradford GO station that twinning it is unnecessary.

Many road-rail grade separations are expected to be necessary with all-day service to Bradford. All are in York Region, save for two in Toronto (and of those two, one is tied to the Davenport Diamond, discussed below).

Not all roads require grade separation, as many parts of the corridor are rural and are not expected to generate enough road traffic to warrant grade separation with the railway. In addition, some very limited exceptions would also arise in industrial areas where the benefits of grade separation might not be worthwhile relative to their costs and local property impacts. In those locations where no grade separation is proposed but additional track is, a small cost was applied to each such crossing. Altogether, work at road crossings (grade separations and expanded at-grade crossings) is estimated to cost $244-million by 2021 and another $358-million by 2031, (a total of $602-million). Those grade separation estimates exclude the area around the Aurora GO station, which will be discussed separately as part of the EMU Case.

Davenport Diamond is a very complicated challenge. It is where the CP mainline crosses the Barrie corridor near Lansdowne Ave and Dupont St in Toronto. Both corridors are narrower than the average railway, with the Barrie corridor only 20m wide and the CP mainline 26m wide, which adds complexity to an already difficult construction project. The project involves reconstructing the Dupont St crossing no matter what solution goes forward, and also involves the at-grade crossing at Wallace Ave, an important street to the local community.

Metrolinx attempted to undertake this project a few years ago, but encountered severe pushback from the community as the designs put forward did not sufficiently consider the needs of and impacts to the local community. This community, known as the Junction Triangle, has had a difficult history that has bred strong distrust among the local residents toward both elected representatives and the railways. Metrolinx was in the unfavourable position of embodying both, leaving the agency at a disadvantage in dealing with the local residents since some level of distrust was present from the outset. The effort was ultimately abandoned; this was the best course of action, as the design options put forward could be improved.

Significant opportunities exist for the Davenport Diamond area, in the Junction Triangle in particular. It would be a worthwhile effort to put the necessary financial resources into getting an optimal design constructed for this project. Considerable revitalization potential is emerging locally, and the area is zoned for both employment and residential developments. The local community is open to increased density if done well. There is also a great opportunity to achieve the most favourable connection in a difficult location between the Barrie corridor and the TTC's Lansdowne station (which is approximately 200m east of the corridor). The Barrie corridor has for a long time functioned as a barrier in the community by disconnecting some streets, with a particularly unpleasant history relating to the failure of the Paton Rd pedestrian underpass, sealed off for years due to health concerns and the ease with which illicit and violent activity could (and

did) occur within it. Three new connections across the tracks could be created, allowing enhanced connectivity and cross-pollination across the tracks, achieving better use of public spaces and more support for local businesses by providing easier access from parts of the community that are impeded by the railway and currently must depend upon a circuitous route. This in turn would make the area more attractive to invest in for future revitalization proposals, benefitting the local community, the development industry, and the city in general. At the same time, this kind of approach would confer the added benefit of doing some much-needed fence-mending with a local community that has long felt slighted by other interests winning preferential treatment over their local needs.

The estimated cost of the approach envisioned for this Regional Rapid Rail report is expensive at $540-million, but would result in valuable finished infrastructure that would draw local investment for the foreseeable future. This would make the return on investment worthwhile, and would greatly enhance the efficiency and capacity of a challenging intersecting point in the transit network.

It is not known what option Metrolinx had favoured in its earlier effort. Consequently, there is no information available on what the previous proposal for Davenport Diamond would have cost. The cost for this diamond envisioned in this Regional Rapid Rail report has been split in half, with $270-million being attributed to the Diesel Case (as this is a needed rail-rail grade separation for future service levels), and another $270-million attributed to the EMU Case.

The cost of rebuilt diesel equipment required for running service at Reference Case service levels in 2021 is estimated at $103-million. Estimated 2031 service levels would require an additional $40-million expenditure for rebuilt equipment if other parts of the GO rail network are electrified with EMUs. **However**, if electrification of other lines in the GO rail network were to not materialize, $160-million would be needed for the purchase of new diesel equipment because existing equipment that could have been rebuilt would be spoken for by meeting the needs of other lines. **This represents a $120-million savings for the Barrie corridor resulting from running EMUs on the GO rail network's other lines.** Arguably, this could be deducted from the $331-million estimated for electrifying the corridor between Toronto and Bradford (see following page for electrification estimate), suggesting that the net cost of electrification would be $211-million. However, because this is a savings resulting from electrification of other corridors, this is not necessarily an appropriate way of estimating the net cost of improving the Barrie corridor. However, it could be considered a legitimate saving in relation to the entire network.

South of Bradford, expansion of the existing stations along the line that would require an additional track is estimated to cost $19-million.

The Downsview and Innisfil stations, which did appear in the 2021 model for the Reference Case in the 2010 electrification study, are expected to be implemented by 2021 and are estimated to cost $40-million. As mentioned previously, Metrolinx has been pursuing stations in Earlscourt (a standalone initiative by Metrolinx), Fairbank (in coordination with the Eglinton-Crosstown LRT), and Concord (in coordination with the 407 Transitway). In addition, York Region is interested in establishing stations at Kirby Rd, Bloomington Rd W [Oak Ridges], and Mulock Dr. As such, these are being attributed to the Diesel Case cost for implementation between 2021 and 2031, estimated at $128-million.

11.3.2. Electrification

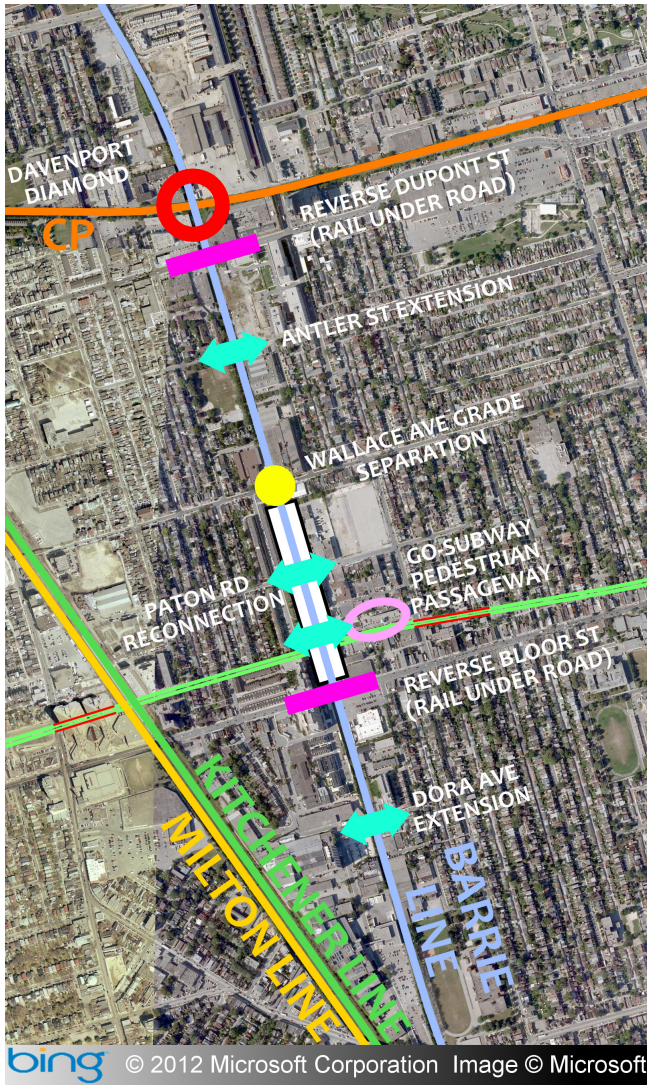
The 2010 electrification study estimated $414-million as the cost of electrifying the entire Barrie corridor including 35% contingency. However, this Regional Rapid Rail report proposes initially electrifying only as far north as Bradford, comprising about 80% of the track-kilometres, estimated at a cost of 80% of $414-million, or $331-million.

Because only off-peak electric service is being put forward in this Regional Rapid Rail report, there would be no capital cost for electric vehicles.

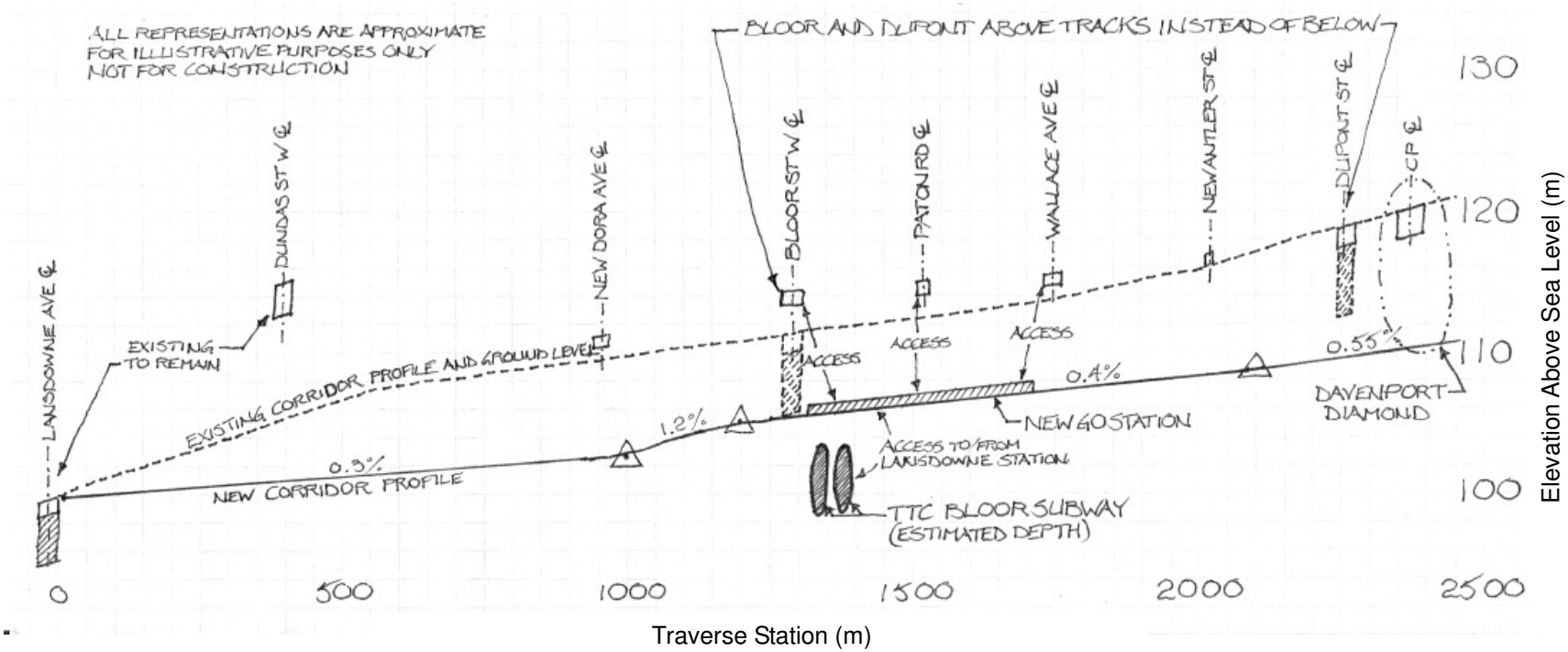
11.3.3. EMU Case

Positive Train Control for all locomotives on the Barrie corridor in 2031 would cost approximately $2-million. There would not be a cost associated with Positive Train Control for the off-peak EMUs since they would have already been equipped in connection with electrification of other corridors. The cost of the wayside components for Positive Train Control along the full 101km Barrie corridor is estimated at $32-million.

The estimated cost of rebuilding the Davenport Diamond, as mentioned in the foregoing discussion of the Diesel Case (Section 11.3.1), would be evenly split between the Diesel Case and the EMU Case; i.e. assigning $270-million to each. While Wallace Ave and Dupont St were expected to be dealt with in the previous-but-aborted Davenport Diamond project, this Regional Rapid Rail report has included the addition of a station between Bloor St W and Wallace Ave to connect with both the local area (which is experiencing



revitalization) and the TTC's Bloor subway at its Lansdowne station a block away. The closing down of the Ontario Redi-Mix concrete facility at 57 Wade Ave in 2010 creates an ideal property for ancillary GO station infrastructure. The concept proposed in this report also seizes the opportunity for significant "place-making" and community improvement by sinking the corridor over an extended length south of Davenport Diamond proper, which includes opening up Bloor St W to the sky at the Barrie corridor's crossing and greatly mitigating the "dead-zone" created along the section of Bloor St W between two railway underpasses when Bloor streetcar service was replaced by the Bloor-Danforth subway (Note: No subway exits provide any direct access to the section between the rail corridors). If the corridor were lowered, several improvements in the local street network would be possible; e.g. reconnected streets or connections for active transportation options only. Details should be determined by the local community.

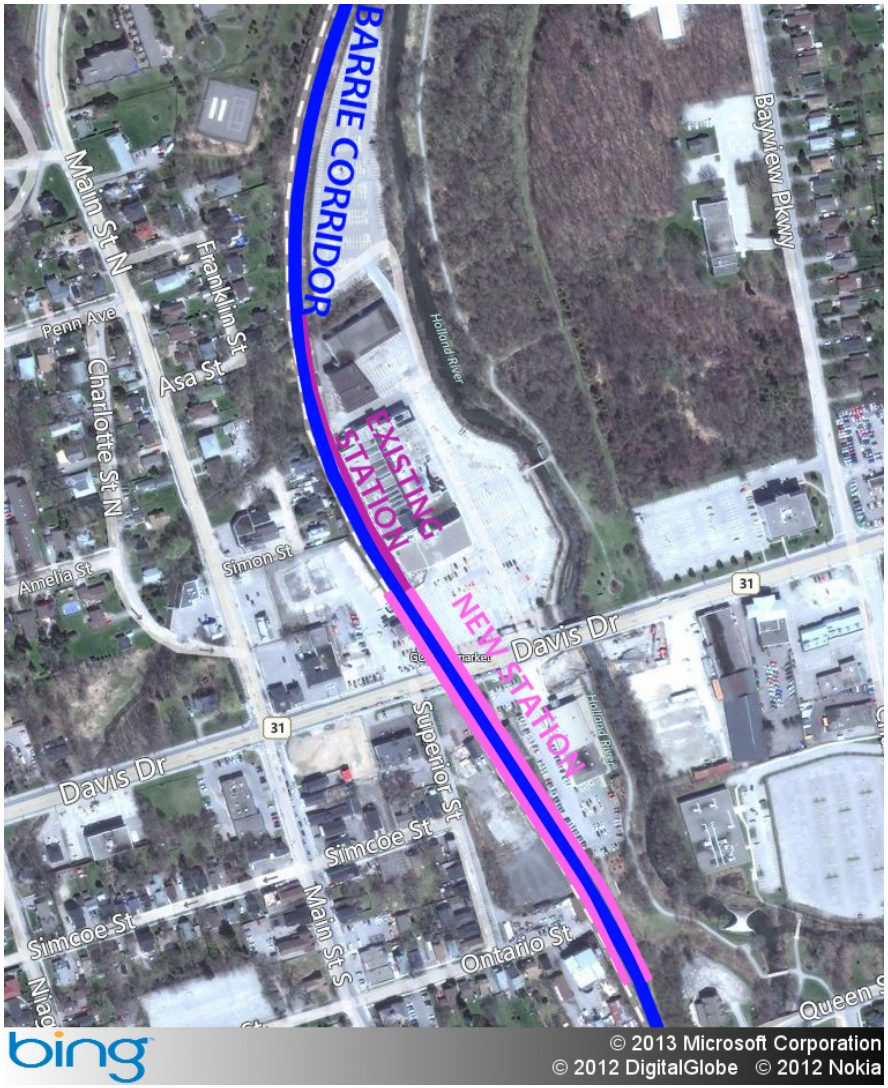


(Does not reflect actual stationing along the Newmarket subdivision)

Opportunities in the Bloor-Lansdowne area are significant, in terms of "reconnecting" the neighbourhood, as it has been an area in decline until recently, and its fortunes are now shifting in a more positive direction. The long-term impacts for the local area have the potential to yield great benefits if appropriate design solutions are applied. In any event, the details will be important. The City of Toronto has anticipated a station on the GO Barrie line at Bloor in the past, which would provide for a Bloor-Danforth subway connection at the Lansdowne station. According to a November, 2002 community council report, GO Transit had confirmed to the City that a future station at Bloor along the Barrie (then-Bradford) corridor was feasible.

As mentioned earlier, most of the additional stations along the Barrie corridor are already proposed by various jurisdictions: one by the City of Toronto, three by York Region, five by Metrolinx (six if a new station is included in the Union Station Rail Corridor, discussed in the following chapter), for a total of nine (or ten) stations, roughly doubling the existing count along the corridor. A further four are proposed in this Regional Rapid Rail report, which would connect with intersecting transit corridors in Toronto and improve coverage in York Region (two each in Toronto and York Region).

Further to adding stations to the corridor, a special case exists in Aurora where the grade separation at Wellington St would likely require the reconstruction of the current Aurora GO station as an elevated station due to existing topographic and built form constraints. Centre St would also be grade separated by default. Any attempt to lower these streets under the existing railway would result in substantial property impacts and/or acquisition. The corridor in this area is downhill northbound at a grade which railways consider steep, except at the current station where it levels off briefly. This represents an advantage for the redesigning of the station while creating construction staging challenges at the same time. The Engelhard Dr grade separation, south of the station, would probably be the first component to go forward, which involves putting the road under the railway. However, the Engelhard Dr grade separation would be affected by the new station at Yonge St near Henderson Dr, where re-grading would also be required because the existing gradient is unsuitably steep for a GO station. Therefore, the railway would be partially raised at Engelhard Dr relative to its existing elevation, reducing the extent to which the road requires lowering. However, as part of a construction management strategy, the new station at Yonge St should be built and put into service before the reconstruction of the Aurora GO station begins. The re-grading north of the reconstructed Aurora GO station would extend to a point close to St John's Sideroad, a significant distance, but necessary to keep what is known as the ruling grade along the corridor unchanged in recognition of the fact that some freight activity (for which retention of ruling grade would be important) still operates to Bradford, as CN maintains running rights along the corridor south of Bradford.



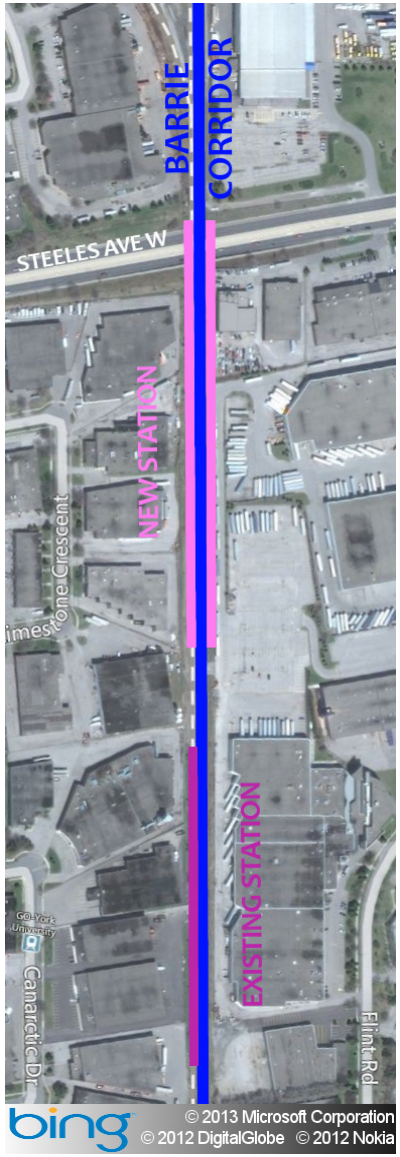
The grade separation at Davis Dr, where the Newmarket GO station is located, wouldl likely require a combination of lowering the railway and raising the roadway to mitigate negative impacts in the immediate area. Lowering the railway this close to the existing station would cause problems in terms of platform height. However, stations are ideally not located on curves for safey reasons, and in the case of existing Newmarket GO station that is almost entirely curved, the sight lines and sound paths are particularly poor. While reconstruction of the station could be likely as a result of the grade separation, relocation of the Newmarket GO station would be desirable as a safety improvement initiative. A southerly relocation situating most of the station to the south of Davis Dr would accommodate platforms that would be predominantly straight. A small part of the platform would remain on the north side of Davis Dr. The Davis Dr grade separation would be above average in terms of cost, since the bridge that takes Davis Dr across the nearby Holland River also requires reconstruction in order to achieve the necessary clearance over the railway. Moreover, access to the properties between the river and the railway need to be maintained in a safe manner in the grade separated configuration, unless these properties are redeveloped in coordination with the design constraints inherent in the grade separation.

While the Bradford GO station is also located entirely on a curve, no obstructions to sight and sound lines exist at that station, in contrast to the situation at the Newmarket GO station in the form of the Davis

Tannery building. Consequently, it would not be absolutely necessary from a safety perspective to relocate the station to a straight section of track. If development occurs on the east side of the corridor in Bradford, that situation may change.

Relocation of the York University GO station a very short distance north from its current, isolated location would provide a relationship between the platform and Steeles Ave W. Strong connections with TTC and YRT bus services could be created at Steeles Ave W to connect the GO station with a large number of bus passengers.

Regarding the King City GO station; the Station Rd crossing would be difficult to grade separate due to the short distance between the railway and Keele St. The size of the community on the west of the railway is small, rendering a grade separation difficult to justify. However, there may be concerns during peak periods due to the presence of GO station parking lots on both sides of the railway at this location. Other measures, such as expansion of the road network on the west side of the rail corridor to connect with other arterials without crossing the railway, would be cheaper and much simpler than a grade separation at Station Rd if safety becomes a concern. As a small community, King City could not generate a need for significant local transit service that would be cost-effective. Private automobiles would likely constitute the main access mode for the King City GO station, especially during the winter months.



The four new conceptual stations in the EMU Case in this Regional Rapid Rail report are envisioned as being added between 2021 and 2031, at an estimated cost of $105-million. The station reconstructions are estimated to cost $33-million for Newmarket, assumed to be implemented by 2021, and $135-million for Aurora, assumed to be implemented after 2021, both including a 35% contingency.

Cost breakdowns for all fixed infrastructure are found in Appendix S.

11.4. Freight Activity and the Barrie Corridor

While CN has recently sold the entire corridor to GO/Metrolinx, CN maintains running rights and limited clusters of freight activity are present along the line. Most of this activity is not far from Snider, the location where the Barrie corridor crosses CN's York subdivision that serves as CN's Toronto by-pass (and today is CN's main corridor through the GTA since it has sold its other routes through Toronto). Snider is also very close to CN's MacMillan Yard.

North of Downsview Park in North York, there exists some local freight activity, much of it associated with the tank farms facilitated by the major pipeline network connections in this part of the region. With the exception of Bombardier (on the Downsview airfield), plus one spur near the York University GO station serving Alpine Electronics, the freight activity is all on the west side of the corridor, which is ideal given the track layout at Snider, with tracks turning only west of the Barrie corridor (towards MacMillan Yard). This freight activity would reasonably be expected to not conflict with GO service.

In Vaughan, there is one spur serving a few industries in the Langstaff Rd area and some additional activity just north of the Maple GO station, all of which is also on the west side of the corridor, except for Anco Chemicals Inc. near the Teston Rd crossing. In the Maple area, increased GO operations would not be materially affected by local freight operations serving industry, regardless of where industry is located relative to the railway right-of-way. This is mainly because of the area's greater distance from Snider. Freight activity is so light that it would not be a cause for concern. In addition, freight trains along this line would be relatively short in length, which would also reduce their impact on GO services.

There are a small handful of industries in the immediate area of the Bradford GO station receiving local freight traffic, all on the west side. This is similar to the situation in the Maple area described above. Bradford is the northern-most site of freight activity along the Barrie corridor, excluding services of the Barrie-Collingwood Railway. Despite coming into close physical proximity with the GO Transit layover site in Barrie and the Allandale Waterfront GO station, traffic from the Barrie-Collingwood Railway would not interfere with GO operations in any event – the track between Barrie and Bradford was almost torn up at one point in the late 1990s.

11.5. One Last Reinstatement

The tracks between Allandale and downtown Barrie were torn up in the mid 1990s by the then-newly privatized CN. The right-of-way has not yet been built on, and passes close to only a small handful of properties. Only five road crossings would be involved in restoring this part of the line. The old railway passes a point literally across the street from the current downtown Barrie bus terminal, and runs through the waterfront area of Barrie's historic downtown core. This presents an opportunity for integrating transit, possibly generating some reverse-commute trips that would otherwise be done by car, and giving Barrie's downtown a big boost towards a more sustainable urban fabric, attracting more traffic for its downtown attractions and businesses. If sensitively designed and integrated with other modes, such a change could have potentially significant impacts upon demand patterns in the corridor.

While only 2km in length, such an extension would make the Barrie corridor a downtown to downtown line, via the Urban Growth Centres in Newmarket and Vaughan, making the corridor a potentially strong spine in the regional rail system, providing similarities with the lines to downtown Kitchener and downtown Hamilton.

11.6. Triggers for Electrification

Considering the Lakeshore West corridor's express service in which five stops were skipped compared to the local service, there was a fuel savings of around 16 gallons per one-way trip. If it were assumed that five stations were added to the line for Bradford service, fuel consumption would be increased by a similar amount. If those assumptions were applied to an energy consumption calculation, as in the chart on the right of this page, it shows EMUs would save close to $3-million annually from off-peak operations alone at Reference Case service levels and energy prices – which corresponds with hourly service based upon 2009 (diesel) and 2010 (hydro) energy prices.

Lakeshore West Local/Express Fuel Comparison

From	To	Direction	Service	Fuel (g)	Δ Fuel
Toronto	St Catharines	Inbound	Local	153.8	16
			Express	137.8	
		Outbound	Local	158.5	16.7
			Express	141.8	
	TH&B	Inbound	Local	105.8	16
			Express	89.8	
		Outbound	Local	108	14.4
			Express	93.6	

Barrie With/Without Additional Stations Fuel Comparison

From	To	Direction	Service	Fuel (g)	L (g x 4.546)
Toronto	Bradford	Inbound	Existing	85.39	388.18
		Outbound	Existing	100.06	454.87
		Inbound	Add Stns	101.39	460.92
		Outbound	Add Stns	116.76	530.79

2021 Off-peak Trips/Day for Toronto-Bradford

Day Type	Round Trips	Fuel (L)	Fuel $	EMUC ton-mi.	EMUC Elec. $
Weekday	14	3,470,985	$6,200,340	75,782,773	$889,789
Weekend	10	1,140,466	$2,037,255	24,900,054	$292,359
Annual	4,650	4,611,451	**$8,237,595**	100,682,827	**$1,182,148**

2031 Off-peak Trips/Day for Toronto-Bradford

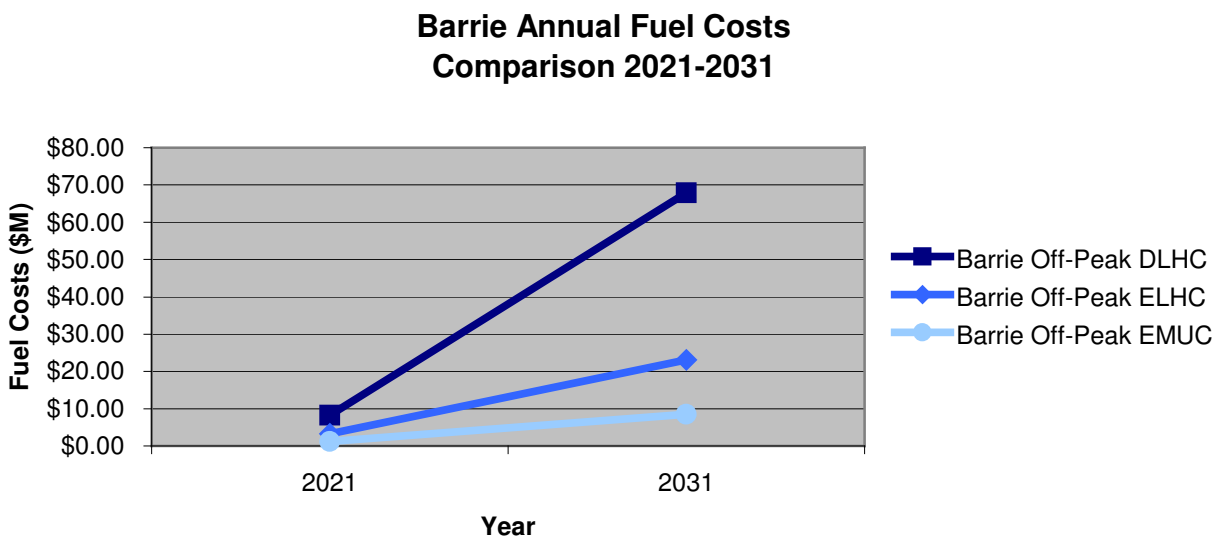
Day Type	Round Trips	Fuel (L)	Fuel $	EMUC ton-mi.	EMUC Elec. $
Weekday	56	13,883,939	$51,116,388	303,131,091	$6,373,906
Weekend	40	4,561,866	$16,795,385	99,600,216	$2,094,284
Annual	18,600	18,445,804	**$67,911,773**	402,731,306	**$8,468,190**

There are three major factors that can affect electrification decisions on this line. The first is service frequency, the second is cost of energy, and the third is equipment lifespan.

If a move were made to roll out a standard of 15-minute off-peak service frequencies across the GO network, as Metrolinx has suggested in the past and as this Regional Rapid Rail report envisions, then energy consumption with EMUs compared with diesel locomotives would save over $28-million annually using a 2021 price of $1.79/L for diesel fuel and $0.162/kWh for electricity. As is shown in the table above, electricity costs for off-peak hourly EMU service are estimated to cost $1.19-million per year, while diesel fuel costs for the same off-peak service operated with diesel locomotive-hauled trains are estimated to cost $8.24-million per year. Therefore, EMU operation for hourly off-peak service provides an estimated annual saving of $7.05-million. For 15-minute off-peak frequencies instead of hourly, the $7.05-million annual saving is multiplied by four to arrive

at an estimated annual saving of $28.2-million. There would be no additional maintenance costs for EMUs in an off-peak-only application, as EMUs need not be added to the fleet to run this operation.

The cost of energy is expected to rise rapidly over the coming years, for both fuel and electricity. In 2031, with the price of fuel at $3.68/L and



electricity at just over $0.29/kWh, the annual energy savings (electrification versus diesel) are estimated to skyrocket to almost $60-million a year. Such savings would pay off the investment in fixed electrification infrastructure in a relatively short period of time, even with interest; strongly suggesting that electrification would essentially pay for itself.

In the event that service frequency on the line does not rise and the price of diesel fuel does not sharply rise, then the case for electrification might not materialize until the existing diesel equipment reaches the end of its life, in the late 2030s. In the view of this author, however, this scenario is unlikely, and betting on no substantial rise in fuel price could be a very costly gamble.

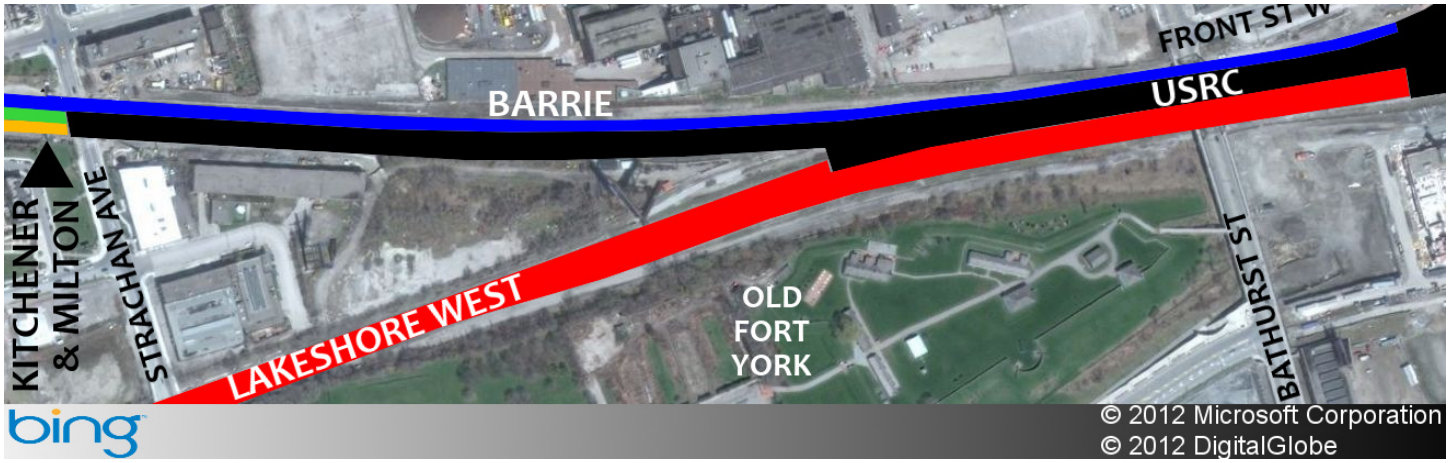
In the end, the only question is when, not if, to electrify the Barrie corridor.

12. Union Station Rail Corridor

The Union Station Rail Corridor (USRC) is a special part of the network where every train ultimately runs to, from, or through, and thus needs to be looked at as a corridor on its own given the extraordinary demands exerted on this roughly 4km section of infrastructure.

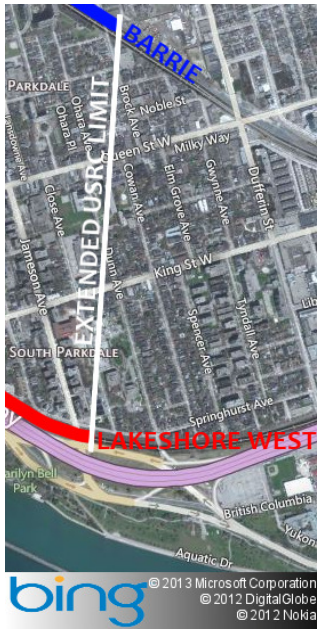
The limits of the USRC, as defined by the railways, vary by corridor (and in the case of the Lakeshore West corridor, by track as well). These are:

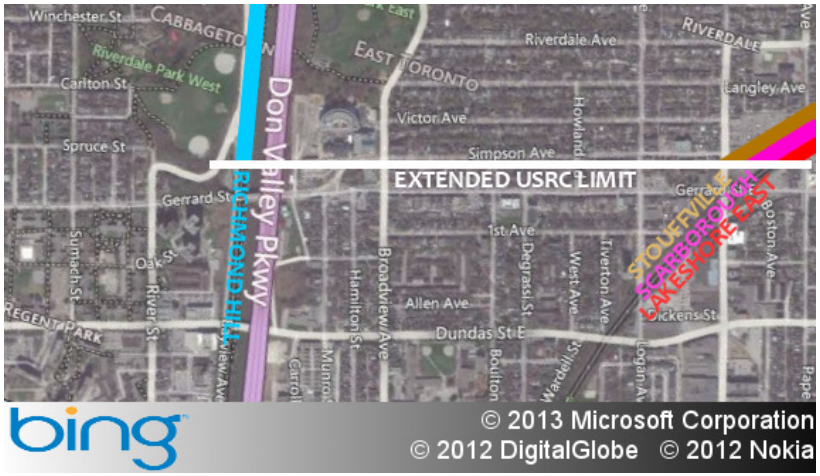
Distance	Direction	Rel. to Road	Corridor		Corridor	Rel. to Road	Direction	Distance
~145m	East of	Bathurst St	Barrie	TORONTO UNION STATION (Milepost 0.0 for all subdivisions except Kingston (Lakeshore E.))	Richmond H.	Queen St E	South by	~145m
~15m	West of	Strachan Ave	Kitchener		Lakeshore E.	Cherry St	East by	~320m
~15m	West of	Strachan Ave	Milton		*(Stouffville trains enter the USRC via Lakeshore East)*			
~175m	West of	Bathurst St	Lakeshore W. (westbound)					
~145m	East of	Bathurst St	Lakeshore W. (eastbound)					



Although the technical limits are as outlined in the above table, in order to capture the scope of infrastructure needs coherently, this chapter will look:

- Approximately 3km further west along the Lakeshore and Barrie lines, roughly to their respective crossings with Jameson and Brock Aves.
- Approximately 5km further west along the Milton and Kitchener lines, to just south of West Toronto Diamond, just north of Dupont St.
- Approximately 1.5km further north along the Richmond Hill line, to just north of Gerrard St.
- Approximately 3km further east along the Lakeshore and Stouffville lines, to Pape Ave.





12.1. Work Currently Under Way

There are a number of projects currently in progress in the Union Station Rail Corridor, including the Union Station platform area and the space beneath the tracks and platforms between York and Bay Sts.

Across the Union Station Rail Corridor, the switching system is being modernized. There are 268 switches in the corridor, and the design had never been modernized since its initial construction over 80 years ago prior to the recent undertaking. This work is expected to double train speeds between Jarvis St and the Don River, and increase speeds by 50% between Blue Jays Way [Peter St] and Bathurst St. The speed limits through the broader train shed area will not change given the combination of sharp reverse curves, density of switches nearest the train shed, and crowded, narrow platforms.

In the western part of the corridor, modest infrastructure expansion is in progress with the addition of a 3rd track through the fly-under (between Spadina Ave and Bathurst St) and is nearing completion at time of writing. There are also plans in place for an additional track in the "pinch point" area on the north side of the corridor, alongside the Metro Toronto Convention Centre North Building, referred to as "New B Track" by the consultants. While there is an existing plan with detailed design either already produced or currently in production, the construction schedule of this additional track is not yet determined and is not expected to be in operation until after 2015 (according to chapter 4.1 of the *US and USRC Track Capacity Study*).

In the platform area, there are major improvements currently under construction. The platforms will have substantially expanded vertical connections (stairs, elevators) with new, expanded, or renovated areas below, including the new West GO Concourse along the east side of York St, plus substantial renovation and expansion of the existing East GO Concourse along the west side of Bay St. The plan also includes the much anticipated "dig down" to the station's foundation footings, creating new retail/circulation space beneath the VIA Concourse between the East and West GO concourses. A new south platform for the TTC Union subway station is also under construction at time of writing.

Proposed plans for dramatic expansion of Union Loop to accommodate the future waterfront streetcars serving the Union Station complex had no funding at time of writing.

12.2. Metrolinx Studies of Union Station

Over the course of the electrification study and continuing for several months following, two additional studies were prepared for Metrolinx on the challenges facing Union Station in the medium- to long-term. These were the *US & USRC Track Capacity Study* (the Capacity Study) and the *Union Station 2031 Demands and Opportunities Study* (the Opportunities Study), done concurrently and in collaboration with one another.

In the Capacity Study, corridor operation simulation results were published. The simulations assumed the presence of additional VIA Rail Canada services in the Toronto-Ottawa/Montreal corridor, and no change to Ontario Northland Railway service that was subsequently discontinued. Those two assumptions were held consistent for this Regional Rapid Rail report's analysis as well (details on Ontario Northland Railway in section 12.5.4.). The Capacity Study assumed the Air Rail Link was operating, and that there were no rail services to/from Bolton or Peterborough. This Regional Rapid Rail report diverges from these particular assumptions. Bolton rail service was assumed in the Opportunities Study.

Infrastructure changes in the Capacity Study included track/switch reconfigurations southwest of the train shed, plus one new switch to the northwest.

The Capacity Study found major conflicts with non-revenue movements that this author had already been giving attention to in the drafting of this Regional Rapid Rail report prior to the completion of the Union Station studies. The Capacity Study found that the 2021 Reference Case model used in the electrification study was difficult to accommodate with the existing infrastructure, but that conflicting train movements could be avoided by means of schedule adjustments. However, worth noting was that schedules for non-Lakeshore rail services in the peak hour were assumed to be based on only 10-20 minute frequencies in 2021. Milton, Kitchener, and Richmond Hill would be far more frequent when accommodating *The Big Move*'s projections expected by 2031. The Lakeshore services were assumed to be operating with average frequencies of 5.5 to 7.5 minutes in the Capacity Study simulations for 2021.

In terms of performance impacts of electrification, the Capacity Study looked only at electric locomotives, but found that when schedules become tighter, the difference electrification makes rises sharply as they recover from unscheduled stops more quickly. That finding would certainly be magnified further with operations utilizing EMUs.

The Capacity Study consistently assumed VIA Rail traffic would be moved to the southernmost tracks at Union Station, from track 12 or

13 through to track 15, with the exception of the Kitchener-Sarnia service, which was sometimes assumed to run from track 4. *The Canadian* service did not appear to be part of the Capacity Study's model. Complications could be likely to result with VIA Rail using the southern tracks due to a couple of issues.

One issue would be that Union Station's VIA Rail concourse baggage carrousels only serve tracks 7 through 10 – these are not proposed to change in the current renovations of Union Station. Another issue is the conflicting movements between VIA Rail operations and Lakeshore GO rail services through the USRC, which would be minimized if VIA Rail trains do not use the southernmost tracks. This is particularly relevant to departing eastbound Lakeshore trains and arriving westbound VIA Rail trains through the eastern USRC.

The Capacity Study compared the benefits of through-routing versus double berthing GO trains, and concluded that double berthing would not increase capacity due to the "pinch point" at John St. It found the double berthing model would further constrain capacity on the approach tracks, as more conflicting train movements would result from it. In recognition of the frequent headways required for the 2031 projections in *The Big Move*, double berthing would be impractical, as conflicting train movements would undoubtedly become unmanageable with such aggressive schedules. Even if the approach tracks were not compromised, most platforms at Union Station are too short for accommodating double berthing. The platform length constraints for double berthing are exacerbated when 16-car EMU trains are considered. Most platforms cannot be materially lengthened within the complex constraints of the surrounding environs, with many new high-rise projects immediately adjacent to the tracks, in combination with the switch-dense track layout of the corridor.

The long-term capacity identified for the station was about 90 train movements per hour, but achieving that capacity requires an additional four tracks being added for serving passengers, **which would only be practical if underground**. In the Opportunities Study, this was evaluated as Option 6B.

The Capacity Study analyses confirm, without actually stating so, that the Air-Rail Link would consume disproportionate resources in the USRC, and is unnecessarily increasing the number of underground tracks involved relative to the number of passengers each Air-Rail Link train is expected to carry. Therefore, the Air-Rail Link service as envisioned creates serious complications for the USRC, and suggests that three underground tracks might be sufficient if Pearson Airport were served by a through-routed model with regular (electrified) GO trains. As was mentioned in Chapter 8, a 400m track beneath Union Station is estimated to cost more than $200-million.

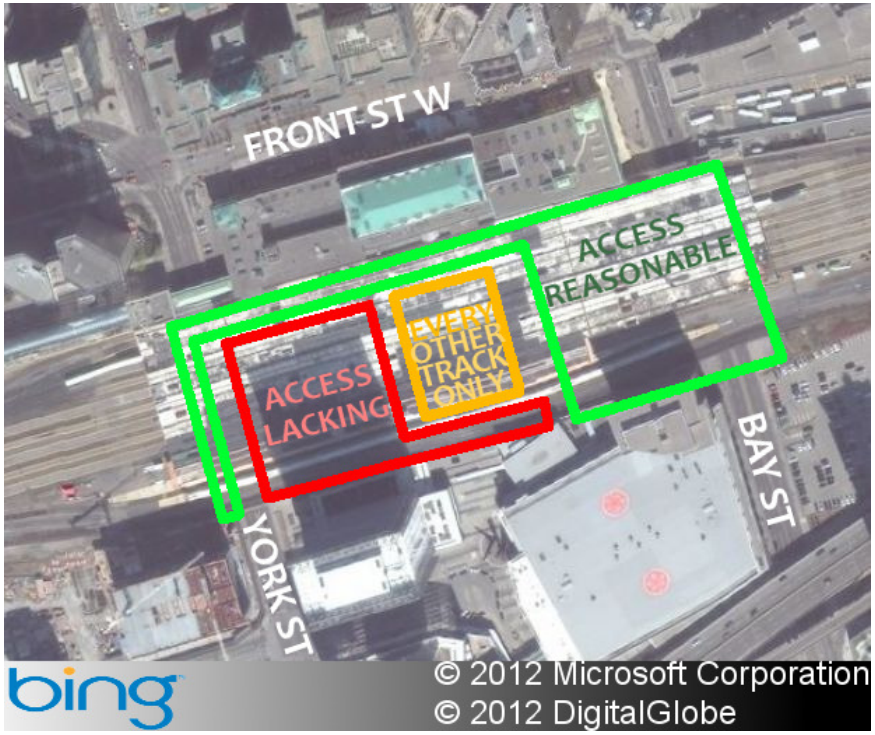
As an alternative to the tunnel under Union, the Capacity Study proposed a satellite terminus between Spadina Ave and Bathurst St for Barrie and local Kitchener trains. This alternative required a new subway – often referred to as the "Downtown Relief Line (DRL)" – to connect with this satellite terminus for trips to complete into downtown, except for those with final destinations within walking distance of the satellite terminus. The alternative also envisioned a connection for Lakeshore West trains with such a new subway, at the Exhibition station. However, the surge loads that may be expected at such a satellite terminus, surge loads that could conceivably overwhelm the connecting subway, could require an unusually wide platform to accommodate passengers unable to board the first train or two. If a Kitchener train and a Barrie train arrive roughly simultaneously at the station, the surge load would be around 2500 passengers, even if about 20% of GO passengers walk to their final destination from the satellite terminus. That situation would be potentially exacerbated if Bolton service were to be added to the equation. If there were ever a subway disruption in the peak hour at such a station, it would be a concerning situation that would be very challenging to design around.

The Opportunities Study, which referred to this satellite terminus alternative as Option 4B, assigned Bolton trains to this satellite terminus as well, but it is unclear if that service could be accommodated as no service plan or operations simulation has been done with Bolton service included in the Capacity Study's models. Regardless of the operating models simulated, this satellite terminus would result in a disjointed network lacking integration between GO train lines, and therefore would be unlikely to provide a viable long-term solution. Considering the inability of Option 4B to accommodate continued growth beyond 2031, it may not yield the desired value for money. As such, this author would be concerned about the long-term sustainability of the Opportunities Study's Option 4B, including the limited-stop DRL. This author strongly supports a DRL, but is of the view that it must be a local service with stations around every 500m through downtown in order to serve the widest array of origin-destination pairs. Distances between stations of 500m or less are common within the existing downtown subway network (south of College St). The 2031 ridership projections prepared for *The Big Move* strongly imply that both the DRL and a substantially expanded Richmond Hill GO service would be essential infrastructure to meet the projected demand.

Given the above, the Capacity Study's Option 6B, with adjustments, offers the means to meet long-term and very-long-term needs in an integrated fashion. The network performance achievable with Option 6B would appear to offer the highest value for money.

12.3. Dwell Times and Demand Management

A major challenge for the future stress expected at Union Station would be the long dwell times of emptying trains that are at least 10 cars long (Note: Most of the trains at time of writing are 12 cars long). These trains each discharge 1,500 to 2,000 passengers, supposedly in less than two minutes. Union Station's platforms are actually too narrow for this level of use, as the station was never intended to meet this demand when designed over 80 years ago. This gives rise to safety challenges relating to getting trains out of the station quickly after passengers have detrained, thereby indirectly extending dwell times and lowering the train throughput capacity of the station; i.e. if trains travel slower through the station, fewer trains will flow through the station in any given peak hour. Admittedly, planned expansions at Union currently under construction will help greatly with this, allowing more exit points from many platforms, spread out across the length of the trains. Currently, most exits are concentrated at the east end of the train shed, as illustrated to the right.



Modest platform extensions appear to be practical to the west for all tracks except track 1, which could be extended to the east if major changes were considered for the bus terminal access to/from track 1. For tracks 12 and 13, platform extensions would require some modifications to the track layout between York and Simcoe Sts – a measure similar to that recommended by the Capacity Study.

Westerly extensions of platforms would support an initiative for another new concourse beneath the rail corridor on the west side of York St, allowing new platform-to-concourse stairs/escalators to be added as far west as approximately halfway between York and Simcoe Sts. With 16-car EMU train operation, a new west concourse could allow heady adjustments that could in theory

marginally reduce needed track quantities at Union. In this scenario, EMUs would provide options that change the capacity of Union Station, a prospect that has not been publicly explored to date.

The expanded pedestrian capacity being created by current renovations at Union is still projected to be overwhelmed in 2031, according to the Opportunities Study and City of Toronto models prepared for the Union Station Revitalization project. However, this is conditional on actually getting enough trains in and out of the station to cause said overloading. As such, the mindset of “every second counts” with regard to impacts on dwell times is valid in this case, as an average dwell time reduction of, say, 30 seconds, can translate to two additional trains per hour (a capacity of over 4,000 passengers an hour with 16-car trains) per track through the station. Put another way to illustrate the same principle; a 15-second reduction across 12 tracks would yield capacity for another 24,000 passengers an hour to roll through on Union Station’s existing tracks (whether those passengers get off the train or stay on the train). The effects of this extend beyond Union Station itself, as the constraints of train throughput at Union Station can reverberate through the network and affect various GO rail services across the region.

12.4. Measuring the Constraints

By a very wide margin, this was the most challenging and complex part of this Regional Rapid Rail report and significant design analysis was undertaken to ensure a solid understanding was obtained in relation to the challenges facing the Union Station Rail Corridor and its environs. This involved assembling detailed information defining the constraints and investigating what would physically fit within the corridor, including three-dimensional relationships. Incidentally, the Capacity Study and Opportunities Study came out while this work was in progress.

12.4.1. Modeling Union Station

Property line information was gathered from Toronto Maps (http://map.toronto.ca) and approximate coordinates with approximate elevations above sea level collected through a Google Maps interface developed by Daft Logic (http://www.daftlogic.com). These data were used to create a collection of survey points, which created a three-dimensional digital replication of the Union Station Rail Corridor terrain in software called Bentley Rail Track, a powerful software package used in the industry. Accuracy of these data is believed to be sufficient for a very high level analysis, as is the intent, but clearly much more refined data than was available to this author would be required for detailed design/pre-construction work.

Approximate alignments of the existing tracks in the corridor were recreated and then possible realignments that would improve operations were overlaid to see if they would physically fit in the corridor. Three-dimensional investigations of underground tracks were also modeled to see where related supporting structures would begin and end, conditional on the feasibility of relationships with underground utilities. Due to geotechnical issues, conventional tunnel boring machines are likely not an option in as confined a space as the USRC, especially around John St, and consideration of other tunneling methods would very likely be necessary. Virtually all of the land south of Front St is reclaimed from the harbour, and consists of unsorted fill.

The drawings generated with this USRC model are found in Appendix X.

The following design guidelines were assumed in relation to the concept set out on the preceding page:

1. GO lines cannot interfere with one another, with limited exceptions for non-revenue movements and use of overflow tracks.
2. Designs shall be capable of accommodating 400m-long GO trains (16-car EMUs).
3. Two additional shared stations through the USRC shall be served by all GO lines to spread demand loads across downtown.
4. Capacity of the Bathurst North yard shall be a minimum seven trains, and capacity of the Don yard shall be a minimum of ten trains.
5. VIA Rail & ONR shall use Union Station tracks 8 through 10, which are served by baggage carrousel infrastructure at the platform.
6. Maximum gradient shall be two percent; minimum of one route across the USRC to be maintained at a maximum gradient of one percent.
7. To the greatest extent possible, corridor improvements shall remain within existing corridor property lines and publicly owned lands.
8. New underground tracks shall allow full-speed operation to maximize train throughput per track per hour.
9. Electrified tunnel height shall be at least 6.9m, although 5.5m could conceivably be sufficient.
10. Underground tracks shall avoid identifiable structural obstructions.

12.4.2. Track Assignments

The GO train track assignment practices in the USRC require adjustment to meet future demand, as confirmed in the Capacity Study. It was also confirmed that track assignments have a large impact on capacity in the Union Station Rail Corridor because the current practice is to accommodate various lines crossing one another's paths, reducing reliability of service as train frequencies improve. For high-frequency services required in the future, trains would require paths through the USRC that are free of interference from other lines. The key challenge inherent in this functional requirement is that there are not enough tracks around John St to accommodate the combined service levels projected without frequent conflicts.

The projected frequencies for 2031 do make it clear that a lower level at Union Station is essential, which the Capacity Study and the Opportunities Study confirm. The table below gives a reasonable idea of how this likely came to be given the data presented in Appendix I of this report.

Corridor	Lakeshore West	Lakeshore East	Kitchener	Milton	Barrie	Richmond Hill	Stouffville	Overflow	VIA Rail / ONR	TOTAL
Tracks	2-3	2	3	2	1	2	1	2	2 (3 in PM peak)	18-19
Notes								At peak	Baggage tracks	

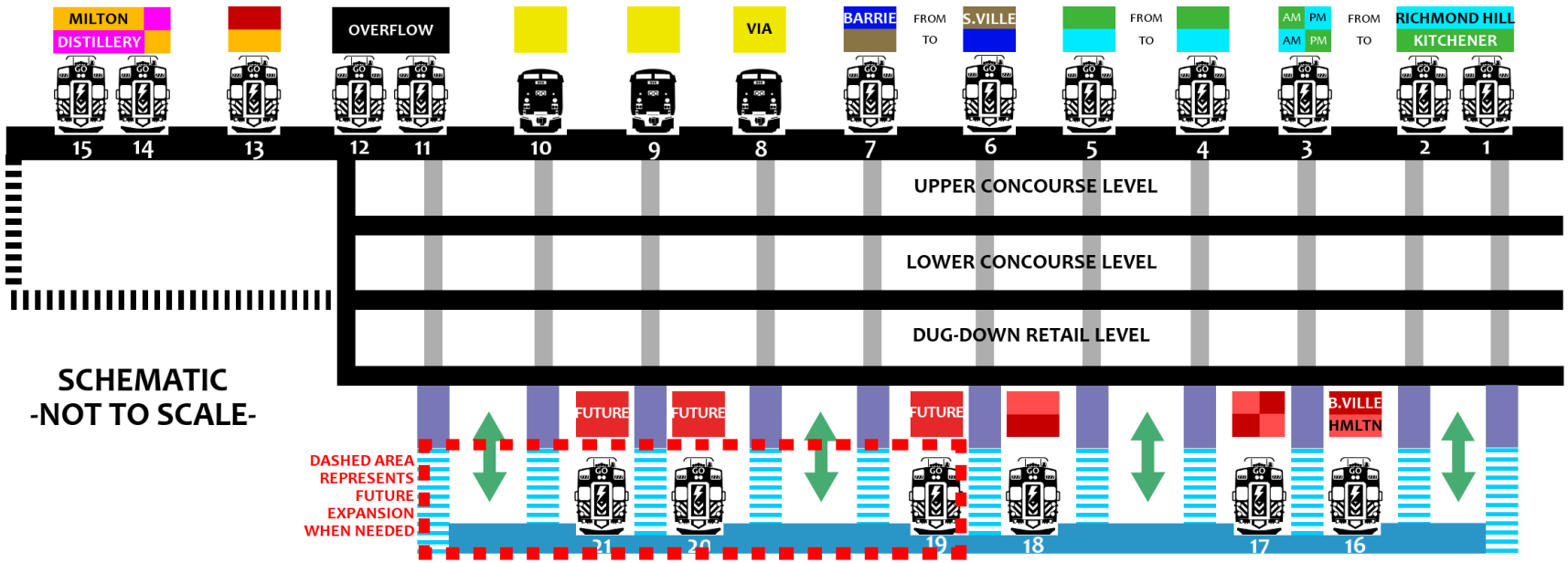
The total number of tracks needed by 2031 according to the chart on the previous page is 18 to 19. Union Station currently has 14 tracks served by platforms, which will be increased to 15 tracks in the near-term. That leaves at least three tracks that need to be underground, based on a lower Lakeshore East figure as the high 2031 projection in the Greater Golden Horseshoe model for Lakeshore East has been challenged by other professionals, as outlined in the Opportunities Study. If other services not yet operating, such as the ARL, such as the Bolton corridor, or – as proposed in this Regional Rapid Rail report – the Scarborough corridor service, further tracks might need to be added to the total shown in the table on the preceding page. Up to 21 (conceivably 22) tracks could potentially be made available at Union Station, although that quantity would not be required in 2031, and leaves the option available to add more tracks later when further expansion at Union Station is eventually required.

A conceptual track assignment model that would maximize corridor capacity for 2031 demands is outlined in the table below:

Corridor (Inbound)	**Tracks**	**Outbound For**
Richmond Hill	1-2	Through-service on Kitchener or to Willowbrook (after 9:00am only) (uses fly-under)
Kitchener	3-5	Through-service on Richmond Hill (uses fly-under)
Stouffville & Barrie	6-7	Through-service to Bradford/Barrie & Unionville/Lincolnville, respectively, some to yards
VIA Rail Canada	8-10	Toronto Maintenance Centre, Windsor, Sarnia, Niagara Falls, Ottawa, Montreal, and Vancouver
ONR Northlander	10	Cochrane, Toronto Maintenance Centre
Overflow	11-12	Includes Peterborough and peak-only Scarborough trains (if any aren't coupled to Lakeshore trains)
Lakeshore East / Milton	13	Fort York (to/from non-revenue movement for midday storage) or Milton
Milton	14-15	Distillery only at AM peak
Lakeshore East (all-day trains)	16	New underground tracks, for Willowbrook Yard, Oakville, Aldershot, and Hamilton TH&B
Lakeshore (peak-only trains)	17	Various along Lakeshore corridor
Lakeshore West (all-day trains)	18	New underground tracks for Whitby, Bowmanville (including Scarborough corridor trains)
Future Lakeshore	19-21	Expand incrementally as growth warrants

Note 1: Recent studies have lowered Lakeshore East 2031 projections from those published in 2008 (25% reduction).

Note 2: In future, Stouffville trains instead of Scarborough trains may couple to Lakeshore trains; Scarborough trains then through-route to Bradford and utilize Track 6 and Track 7.


MILTON
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KITCHENER
15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
UPPER CONCOURSE LEVEL
LOWER CONCOURSE LEVEL
DUG-DOWN RETAIL LEVEL
SCHEMATIC
-NOT TO SCALE-
FUTURE
FUTURE
FUTURE
B.VILLE
HMLTN
DASHED AREA
REPRESENTS
FUTURE
EXPANSION
WHEN NEEDED
21 20 19 18 17 16

12.5. VIA Rail Accommodation

VIA Rail service was analyzed on the basis of two different schedules, one based on currently published schedules and another based on expanded service between Toronto and both Ottawa and Montreal. These were conceptual schedules published in the Capacity Study, provided to the consultants by VIA Rail Canada. Services to Windsor via Brantford, Sarnia via Kitchener, and Niagara Falls via Grimsby were assumed to remain at current service levels.

The number of tracks required for VIA Rail services was the same for both current and expanded schedules. In the morning, two tracks were required for VIA Rail services, while three tracks were needed in the much more complex afternoon peak period. More VIA Rail trains were scheduled to arrive at Union in the afternoon than in the morning rush hour, an expected outcome given the distances VIA routes travel. All VIA Rail revenue service arrivals at Union occur after the morning peak period, except for the Niagara Falls service. During various periods, tracks are shared by two trains where it is operationally compatible to do so, as platforms are long enough to accommodate this kind of operation, and the design of the VIA Concourse also lends itself well to this model. Indeed, this practice is followed at certain times currently by VIA Rail at Union Station. As might be expected, the practice would be necessary more often in the expanded schedule.

The charts on the following page illustrate conceptual streamlining of track resource management for VIA Rail operations at Union Station in peak periods. While based on existing schedules, it is not reflective of existing practices, including through-routed operations that may not currently be in effect. However, they are being actively contemplated according to the Capacity Study. Tracks 8 to 10 are 550-600m long and therefore should be able to accommodate two VIA trains in the same direction, unless one of the trains being accommodated is *The Canadian*. *The Canadian* operates with a much longer train than those on other routes. *The Canadian* has a scheduled early-morning arrival and a late-evening departure, up to three days per week, and as such should not cause platform conflicts.

Far more complex than accommodating VIA Rail trains on a limited number of tracks was determining how VIA Rail trains would enter and exit Union Station while avoiding conflicts with aggressive GO service levels. Most VIA Rail services follow the Lakeshore corridor, which would have the easiest access to tracks 8 through 10 after being diverted from the Lakeshore tunnel serving a new underground level at Union Station. There are two exceptions: *The Canadian* service from Vancouver, and the Sarnia via Kitchener service.

GREATER TORONTO HAMILTON AREA REGIONAL RAPID RAIL

Conceptual VIA Rail track occupancy based on current schedules:

AM VIA Rail Track Usage		0600												0700												0800												0900						
		00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30
Track 8	Train 1	*to* **MONTREAL/OTTAWA**																				*to* **NIAGARA FALLS**																							
Track 9	Train 1													*to* **WINDSOR**																	*from* **NIAGARA FALLS** *to* **MONTREAL/OTTAWA**													
		k 8 left empty, although some days would be served by an arrival of The Canadian for a brief period (about 15 minutes), ideally around 6:15 to avoid Richmond Hill GO service con																																										
PM VIA Rail Track Usage		1600												1700												1800												1900						
		00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30
Track 8	Train 1		*from* **MONTREAL** *to* **SARNIA**																												*to* **WINDSOR**													
	Train 2										*from* **MONTREAL** *to* **WINDSOR**																																
Track 9	Train 1	*from* **NIAGARA FALLS** *to* **MONTREAL/OTTAWA**															*fr.* **OTTAWA** *to* **NF**							*fr.* **WINDSOR** *to* **MTL/OTW**																			
Track 10	Train 1														*to* **OTTAWA**																													

Conceptual VIA Rail track occupancy based on expanded schedules:

AM VIA Rail Track Usage		0600												0700												0800												0900						
		00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30
Track 8	Train 1	*t* **M**				*to* **OTTAWA**													*to* **OTTAWA**																						*fr* **OTTAWA**			
	Train 2																					*to* **NIAGARA FALLS**																							
Track 9	Train 1											*to* **MONTREAL**																			*from* **NF** *to* **OTTAWA**													
	Train 2												*to* **WINDSOR**																														*to* **MONTREAL**			
PM VIA Rail Track Usage		1600												1700												1800												1900						
		00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30	35	40	45	50	55	00	05	10	15	20	25	30
Track 8	Train 1					*from* **MONTREAL** *to* **SARNIA**																			*fr.* **WINDSOR** *to* **MTL/OT'WA**																			
	Train 2						*from* **OTTAWA** *to* **WINDSOR**																																					
Track 9	Train 1	*to* **OTTAWA**											*to* **OTTAWA**												*fr.* **OT'WA**				*fr.* **MONTREAL** *to* **WINDSOR**												*fr.* **MTL**			
	Train 2														*to* **NIAGARA FALLS**																													
Track 10	Train 1						*to* **MONTREAL**												*to* **MONTREAL**												*to* **MONTREAL**													

12.5.1. VIA Rail Access Routes into Union Station (Montreal/Ottawa – Windsor/Niagara Falls)

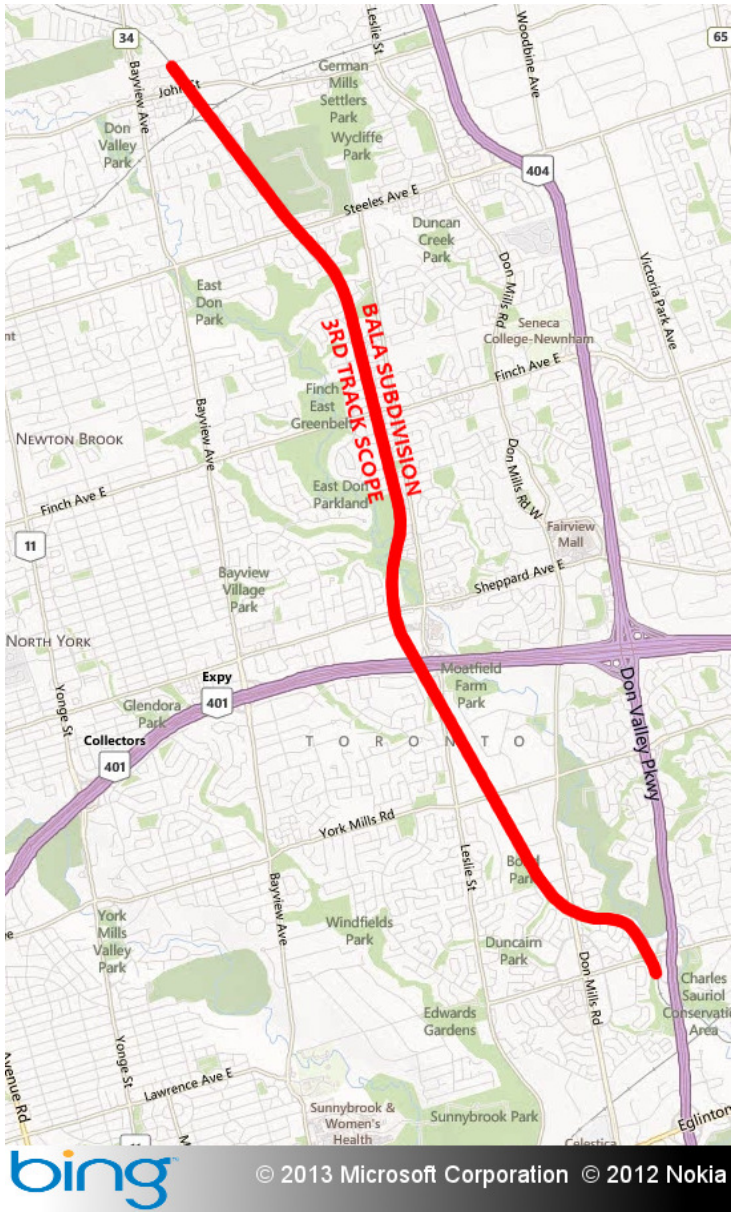
VIA Rail trips that operate to/from Union station via Oakville (both Windsor and Niagara Falls services) would use the same tracks that would be used by the Lakeshore West corridor express GO trains west of the Exhibition Place area. East of Exhibition Place, VIA Rail trains could divert to a new track primarily dedicated to VIA Rail's Union Station access and provide its trains access to its platforms at Union Station through a new fly-under. This track would also be available for Lakeshore overflow if/as necessary, and for some non-revenue GO trains moving between Willowbrook and Union Station's existing track level. This would allow VIA Rail trains to reach a point north of the Milton corridor's tracks, so that Milton service would not result in an impassable "wall of trains" blocking VIA Rail trains from Union Station tracks 8 through 10 (Note: Milton trains are assumed to use tracks 14 and 15). This short VIA track linking its Union Station tracks to Oakville would be used for both directions of VIA service, including non-revenue movements between Union Station and VIA Rail's Toronto Maintenance Centre. Drawings describing this new track, identified as a realigned "Track 4" of the Oakville subdivision, are found in Appendix X.

VIA trips to/from Montreal and/or Ottawa would be operating on the Lakeshore East corridor's express tracks until a point near Queen St E, where they would be switched onto tracks that would connect with Union Station tracks 8 through 10. These two tracks would also be shared with some overflow functions for revenue and non-revenue peak period GO rail operations, possibly including limited Don Yard movements.

There would be a challenging balance to be struck with VIA Rail operations in the Lakeshore East corridor because of the proposed Whitby Yard. Such a yard would create scenarios where there would be high volumes of GO traffic in both directions during peak periods. Trains would be either entering or leaving the yard in one direction, while frequent peak period express services would be operating in the other direction. The problem would occur over a significant distance, between the Eastern Ave crossing and the Pickering GO station. Yard movements would require coordination by having the trains use the Whitby and Don yards, and any other yards to the east, scheduled in a fashion that would create sufficient "slots" for VIA in the Lakeshore East corridor over this distance. Revenue service movements would require coordination of schedules between GO Transit and VIA Rail Canada to accommodate coexistence of operations on one of the most congested subdivisions, including agreed protocols for delays. An absence of effectively coordinated schedules could damage reliability for both services given the high volume of movements involved.

12.5.2. Conflicts for *The Canadian*

The Canadian departs Union later in the evening, at 22:00, by which point Richmond Hill service could be winding down for the day and may not be problematic. The arrival of *The Canadian* is much more problematic. However, if it were possible for the three-hour layover in Winnipeg to be substantially cut, with some other schedule tightening at other stations through northern Ontario, the train would arrive at Union at around 6:15AM. That would be just before peak period frequencies of an aggressively scheduled Richmond Hill GO service would consume all of the track time in the corridor. If the schedule is not adjusted for the inbound trip of *The Canadian*, an additional track would need to be laid in the corridor for 10.5km between Doncaster (John St in Thornhill) and Lawrence Ave E in Toronto, plus about 2km from about Gerrard St to Cherry St, estimated to cost around $85-million for the new track and additional bridgeworks over roads and rivers. However, the additional track would not solve the problem created by some very difficult maneuvering through the Union Station Rail Corridor to get from what would be the northern-most track at Cherry St to tracks 8 through 10 at Union Station. This would be virtually guaranteed to disrupt Richmond Hill services, with carryover effects on its through-routed counterpart (assumed to be Kitchener in this Regional Rapid Rail report). Other services such as Stouffville and/or Barrie may also be disrupted depending on Union Station Rail Corridor congestion. An alternative is discussed for *Northlander* access in section 11.5.4 that could also work for *The Canadian*.



12.5.3. Sarnia via Kitchener VIA Rail Access

Trains **from** Sarnia (eastbound) would presumably use the Kitchener express track until a point close to Queen St W, then switch to the local track until Bathurst St, at which point VIA Rail trains could divert to a track alongside the one used by VIA Rail trains coming from Oakville. For trips **to** Sarnia, trains would use the same track, but, depending on time of day, a local Kitchener train may need to be shifted to the express track for a short distance west of the existing fly-under to make way for a VIA trip leaving Union Station. This would be a delicate operation, as VIA Rail trains westbound to Kitchener and Sarnia would briefly occupy a track that would otherwise always be assigned to eastbound GO service. This would not be a serious issue outside of peak periods. During peak periods, there may be a need to do a runaround using the less-congested Barrie corridor tracks as far as Brock St, and then move across to the Kitchener corridor near Lansdowne Ave, a point north of which the Barrie and Kitchener corridors diverge.

12.5.4. Ontario Northland Railway

In April 2012, the Ontario Government announced an intention to divest itself of the Ontario Northland Transportation Commission, which included the Ontario Northland Railway. At time of writing, Ontario Northland Railway passenger services south of Cochrane had ceased operation, but it was recognized that this was a political issue that would be ongoing, and included an environment involving a minority governing party in the Ontario Legislative Assembly. As a result, the future of the Ontario Northland Railway was unknown at time of writing. In the absence of any certainty regarding its future, this report assumed the service provided by the Ontario Northland Railway to Union Station (the *Northlander*) had to be accommodated.

The *Northlander*, a daily (except Saturday) service operated by Ontario Northland Railway between Toronto Union Station and Cochrane in northern Ontario, operates on the same path as *The Canadian* service of VIA Rail south of Washago, Ontario. The schedules for the *Northlander* are more problematic than for *The Canadian*, and it is unclear if some schedule adjustments are reasonable in this case because the last-operated schedules have trains at Union Station in the shoulder hours of both the AM and PM peak periods. The *Northlander* would presumably use the same tracks at Union Station as VIA Rail trains, since other tracks would be in use by GO in the AM especially. As would be the case for *The Canadian* VIA Rail service, operating between Union tracks 8 through 10 and the northernmost track east of Cherry St during peak periods would be problematic for the *Northlander* in the future.

Alternative routes to operate the service over were considered, and no reasonable alternate routings were found to be readily available. Routes that are available are fairly circuitous and would also be prone to conflicts with freight activity if using the CN Halton/York lines running north of Steeles Ave west/east (respectively) of MacMillan Yard near Keele St and Highway 7.

With no reasonable existing alternate routes available, historical lines were looked at. One option found would provide a reasonably direct route diverting trains along the Stouffville corridor, which would involve restoring select parts of some old corridors that were abandoned in the 1990s or earlier. Starting from Beaverton, south of Washago along the existing *Northlander* route on the CN mainline (Bala subdivision), restorations of the Midland subdivision for about 12.5km east to a former junction near Lorneville, the Coboconk subdivision for about 22.5km from Lorneville south to Blackwater, and the Uxbridge subdivision for about 15km further south of Blackwater to Uxbridge (where it would meet existing GO-owned tracks), would enable a bypass avoiding Richmond Hill GO service conflicts. 50km of single-track restoration would be estimated to cost around $135M plus any costs associated with land acquisition and upgrading track

quality between Stouffville and Uxbridge, or $50M more than an additional track in the existing corridor shared with Richmond Hill GO trains, but fixes the Union Station Rail Corridor maneuvering issue.

This route would also presumably be usable by *The Canadian* if VIA Rail schedules cannot be adjusted around rush hour Richmond Hill GO service.

Restoration of the Newmarket subdivision (the original route for the *Northlander* and *The Canadian* routes before it was torn up through Orillia) was looked at, but was not believed to be feasible, as the land has been built on in a small part of the eastern fringes of Barrie on the north shore of Kempenfelt Bay, as well as in various pockets in Orillia. There's also a casino in the way a short distance northeast of Orillia. The cost would have been very similar as the quantity of track restoration is roughly equivalent, but the property issues with the Newmarket subdivision option are believed to be major hurdles.

This is infrastructure that would not be used for GO rail services, and the estimates in this report do not include this infrastructure. However, this would be an issue affecting other railways of the Crown.

12.6. Shoulder Stations

Additional GO stations in downtown Toronto, specifically at the periphery of the USRC, could increase route choices for riders and reduce the number of passengers that have no choice but to go through the Union Station complex. Fewer people getting off per train at Union Station would offer real potential to shorten dwell times at Union in combination with other measures such as vertical transportation improvements and targeting employment growth around shoulder stations. The shorter dwell times would increase the number of trains per hour that could operate on each track.

GO/Metrolinx has established 2km as the minimum distance between stations. However, downtown Toronto's employment density warrants flexibility. Given the unusually high demand, and the built form of downtown Toronto, the distance between shoulder stations should be relaxed marginally from the minimum standard to 1.8km. In general, there needs to be a larger role filled by GO rail services in the "416" transportation network going forward.

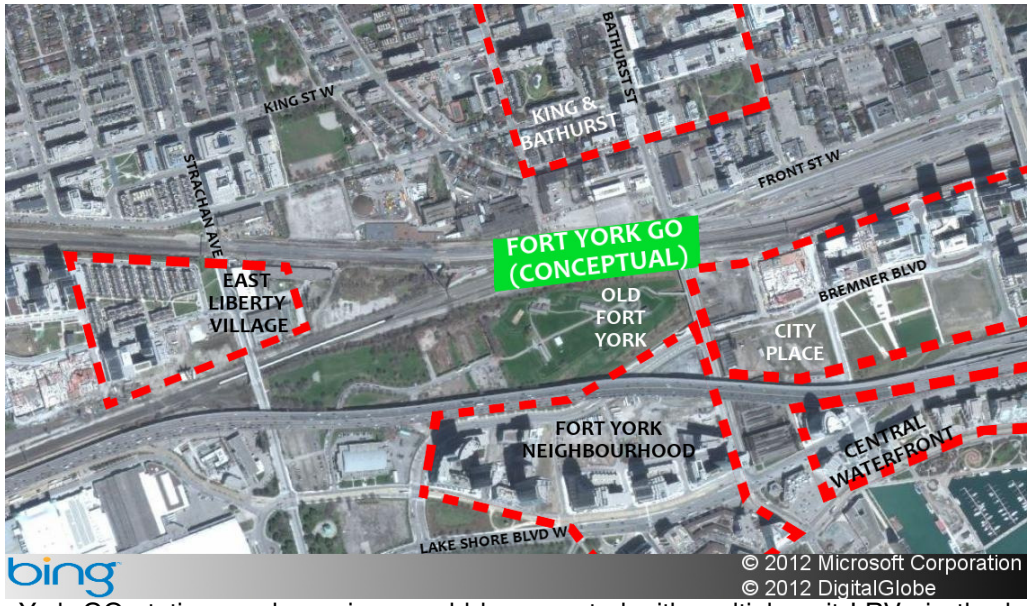
The traditional pattern of growth in downtown Toronto has mostly been to follow the University and southern Yonge subway lines, along a north-south axis in the core. Since Toronto has no control over GO, but does over the TTC, Toronto's growth plans have been oriented towards TTC infrastructure instead of GO infrastructure, and from the perspective of a civic government looking to be in control of their own destiny, this was a logical strategy to adopt under the circumstances – but TTC capacity for this growth pattern has started to fall short.

There are limits to this strategy of letting the Toronto-owned TTC be the key enabler for Toronto's continued downtown employment growth, and City policies envisioning GO being a bigger player in meeting growing downtown demands would be of strategic significance. The USRC runs through downtown on an east-west axis, so if some demand at Union is to be diverted to shoulder stations, planning by the City to support such objectives would have to branch out from the current north-south focus. The implementation of such planning initiatives would take at least a decade to show meaningful results, and so will not happen overnight. This requires commitment and cooperation, across successive Toronto city councils and successive Ontario legislative assemblies.

Over the past decade especially, there has been peripheral growth to the west of the downtown core, although this has to some degree also been a longer historical trend. Many brownfield sites in the western part of downtown have been transformed into dense urban communities, a pattern that continues to unfold. This could be harnessed to a certain degree and unified with future growth planning for westerly shoulder stations.

While the east side of downtown has had a less-thriving recent history than its western counterpart, there are ambitious plans currently under way, with significant construction in progress. If these projects go according to plan, they will be the start of a grand transformation, with the East Bayfront and Distillery District already showing early promise, and the West Don Lands are expected to be a great legacy of the Pan-Am Games. The City has previously been in talks with GO about a possible station in this area, but this was not considered in the Capacity Study.

12.6.1. Fort York GO Station (and the Future of Exhibition GO Station)



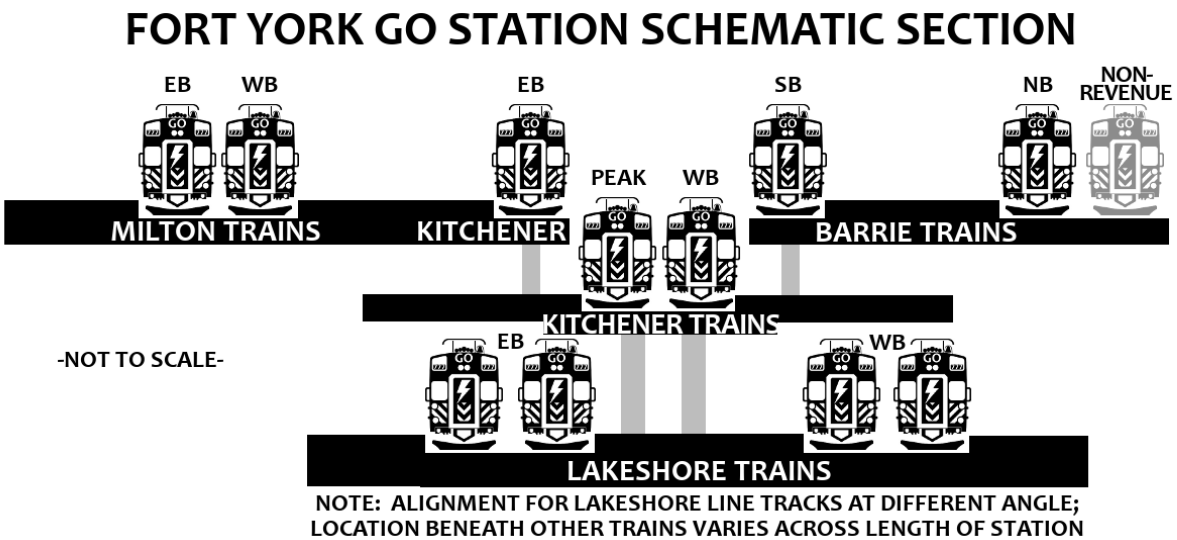
Located by the intersection of Bathurst St and Front St W, the station would be on the north flank of Old Fort York, and provide good relationships with the western part of the central waterfront and expanded downtown core. The King and Bathurst area would also be nearby, as would the western end of the City Place development (still under construction at time of writing). Such a station could connect to an expanded network of dedicated transit rights-of-way depending on design solutions, involving among other elements the Bathurst St Bridge reconstruction, as well as the (unfunded) Bremner Blvd streetcar line. Theoretically, should the added capacity become necessary due to future surge loads from the Fort York GO station, such services could be operated with multiple-unit LRVs in the longer-term. Such LRVs would involve a vehicle model with couplers, which differs from the current model on order – this should not be an issue given the timeline horizon in question.

While the location is quite similar to the satellite terminus of the Opportunities Study's Option 4B, no turn-around operations would take place at a platform in the concept proposed in this Regional Rapid Rail report. That feature would address the concern regarding surge loads with Option 4B from the Opportunities Study, and make this location an ideal connection with a future east-west downtown subway.

The Fort York station would be located right at the point where all rail lines from the west converge. It would allow transfers between GO lines to be possible without having to do so at Union Station.

By extension, passengers coming from the east, or north in the case of the Richmond Hill corridor, would have the option of continuing further west of Union. Trains would not have to empty out entirely at Union for passengers with a final destination further west, although diesel trains being taken out of service bound for Willowbrook might not be able to access a platform at Fort York as there isn't enough space to fit everything in; this might not be an issue if the CP Obico lands (discussed in Chapter 13) are re-purposed as a GO facility, depending on the size of the remaining diesel fleet.

A non-revenue benefit to GO would materialize with a station at Fort York as well, in that it would enhance the flexibility of crews by having the yard and the GO station at locations across the street from one another. It is of particular value in the management of consist lengths between peak and off peak periods, as the result would be that fewer non-revenue train movements would be necessary. The ability of crews to drop a non-revenue train in the yard and then board a revenue train to elsewhere in the network may also increase the flexibility of swing-shift crews in a system with frequent all-day service.



FRONT ST W

Physical constraints, particularly those at Bathurst St itself, in combination with the way existing infrastructure is laid out east of Bathurst St, force undergrounding of Lakeshore tracks at Fort York. Two of the tracks in the Kitchener corridor would also be lowered by a few metres to allow a platform to be installed beneath the adjacent tracks, thereby making the most efficient use of scarce space.

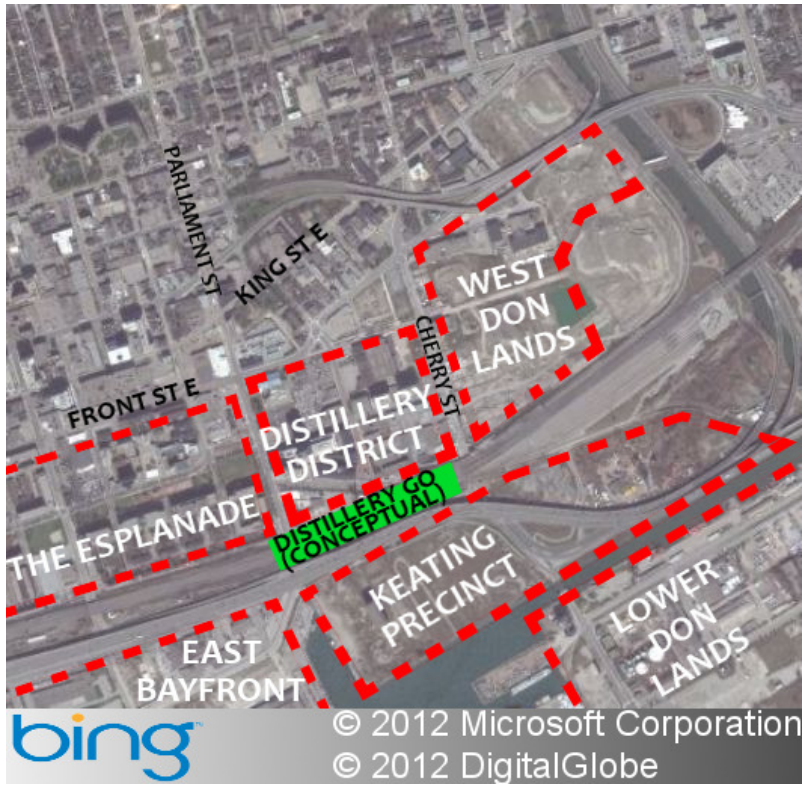
The station would allow local and express Lakeshore and Kitchener trains to stop at Fort York, in addition to the Milton and Barrie services that would operate on only two tracks each. The conceptual track layout, using lands that were formerly part of the long-gone Bathurst South yard, would create eight additional midday storage slots on the southwest flank of the Fort York station. The total midday storage capacity at the west edge of the Union Station Rail Corridor would become 16 trains when combined with the Bathurst North yard's eight tracks (Note: This represents an increase over the current seven tracks at Bathurst North). All 16 storage slots would be able to accommodate 400m-long trains. Drawings representing this conceptual track layout are found in Appendix X.

In addition to access from Bathurst St itself, the station could provide direct access to Fort York proper and to Liberty Village via Ordnance St. Tecumseh St would also be a potential access point and there is even potential to tie in the new bridge spanning the corridor near Portland St. These would all help to maximize the catchment area of the station to optimize its potential to draw traffic from any direction at any time of day.

The Fort York station would be too close to the Exhibition GO station for Lakeshore trains; when the Fort York station enters service, the Exhibition station could be moved west, to Dufferin St, a location also known as Dufferin Gates. This would be 1.8km from the Fort York station, the same as the distance would be between the Fork York station and Union Station. A southern portion of the old VIA Rail Exhibition station, whose platform still exists, mothballed on the west side of Dufferin St, might potentially be restored as part of the relocated GO station. The Dufferin Gates location would provide excellent connections with the busy Dufferin St TTC service, and the area already has a streetcar loop by the site, for either an extension from Fleet St or other streetcar services. The convenience of access to Exhibition Place or Ontario Place would not be meaningfully impacted by the relocation of the existing Exhibition station to Dufferin. The reconstruction of the Dufferin St Bridge should allow for the relocated station, however, as consultations for such a project are currently underway.

12.6.2. Distillery GO Station

Located at Trinity St, 1.8km from Union Station, with access to both Cherry St and Parliament St, this station would be generally centred upon the southern edge of the Distillery District. On the south side of the rail corridor, this station would be located between two areas that are on the verge of transformative change: The East Bayfront to the southwest, and the Lower Don Lands to the southeast, including the Keating Precinct. To the west, the station would also connect with The Esplanade community across Parliament St, and to the northeast are the aforementioned West Don Lands currently under construction.



Preparations for construction of a Cherry St streetcar service are already underway. Its relatively short length notwithstanding, the Cherry St streetcar project is one of the more visionary and community-driven transportation corridor plans Toronto has developed and could set a new standard. Other plans for streetcars operating in dedicated rights-of-way exist for Queens Quay East and through the Lower Don Lands communities, but these have run into budget challenges that have yet to be resolved.

Like its western counterpart at Fort York, all GO lines approaching from the east side of Union could serve the Distillery GO station. The Milton corridor, which would not have a through-routed counterpart east of Union, would be able to terminate at this station as well, allowing those coming from the west who have a destination further east to continue past Union, and/or avoid having to transfer trains at Union. Those from the east who would not be bound for a destination as deep into downtown as Union Station would be able to get off closer to their final destinations.

Just as at the Fort York station, Lakeshore trains would be serving this area at an underground level, and would be back at the surface

before reaching the Don River, but only if substantial adjustments can be made to the existing corridor. Space was very constrained just west of the Don River, where the Kingston subdivision utilized for Lakeshore corridor services is squeezed between the Richmond Hill corridor [the Bala subdivision] to the north and the Don yard to the south. This would be very complicated to resolve, with the existing four tracks being raised several metres and creating a double-decked bridge crossing the Don River and Don Valley Parkway while the four tracks emerging from the underground level would cross the Don at the existing bridge level. There are hydro lines crossing the rail corridor along the west edge of the Don River, but there are hydro-related properties to the almost immediate north and south of the rail corridor that should be convenient for a short undergrounding of this stretch of hydro corridor. As a domino effect from double-decking the bridge over the Don River, substantial bridge reconstruction would also become necessary at the crossing over Eastern Ave. The northern tracks at Eastern Ave would be at much higher elevations than the southern tracks, but no tracks would be lower than the existing bridge. The bridge at Queen St E should not require reconstruction, even if very minor re-grading of tracks is required.

The construction of the Distillery station would create an opportunity to hollow out the underside of the rail corridor in a way that would not increase disruption beyond what the construction of the station itself would entail. The role that Trinity St and the Distillery could play make this a potentially rich opportunity and could enhance the pedestrian-friendly and transit-friendly characteristics of the revitalization effort that has been underway in this area already for years. Plans already exist for extending Trinity St across the rail corridor. Although more complicated and disruptive, there could even be a potential opportunity to erect a structure or multiple structures above a part or multiple parts of the station to recoup some of the value from the station investment.

Minor adjustments to the elevation of Cherry St may be necessary at the rail crossing due to the new underground level, although this is unclear. What is clear, however, is that this point will narrowly achieve the required vertical clearances, unless the required clearance is less than the 6.9m assumed in the aforementioned design guidelines. Cherry St would be torn up at this location regardless during station and portal construction. Most of the existing Cherry St rail bridge would have to be reconstructed, with different tracks at different elevations, as part of the new double-decked Don River bridge approach.

12.6.3. Cost of Expanding the Union Station Rail Corridor

Below is a very rough estimate based on extrapolation of TTC subway construction figures. The figures include the different costs of tunneling based on the square of the cross-sectional area, and of station construction based on $3,000 per cubic metre. The results, while high, are not surprising considering the larger size of the tunnels compared to TTC subway tunnels, and especially the much longer station box lengths required in addition to the number of underground tracks. The whole Union Station Rail Corridor is estimated to cost $5.7-billion, as broken down in the chart below. A more detailed breakdown can be found in Appendix U, a breakdown based in turn on drawings found in Appendix X.

USRC Simplified Capital $ Summary

Fort York Station	$1,034.1
Lower Union Station	$791.4
Distillery Station	$824.6
New Tunnels	$2,485.0
Tracks and Structures	$543.5
TOTAL	**$5,678.5**

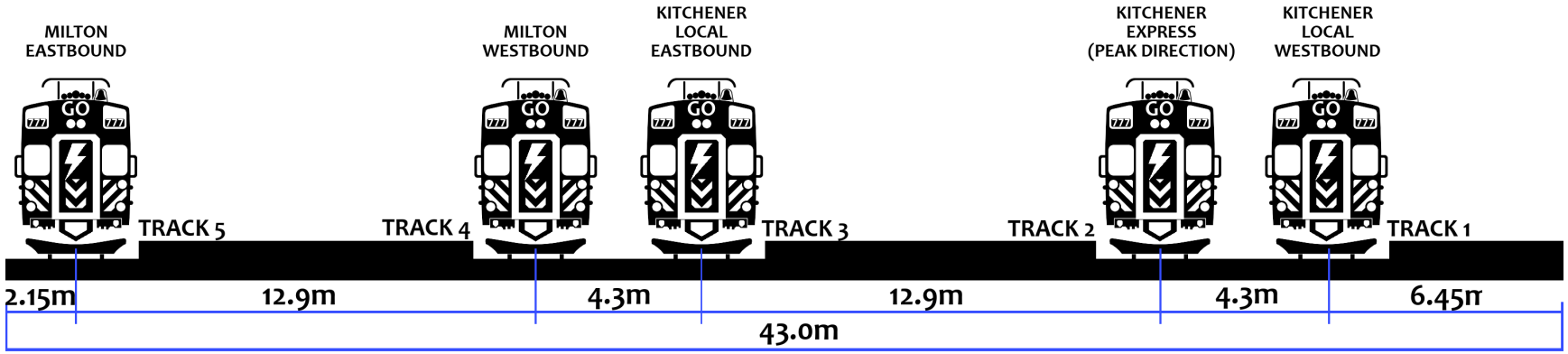
12.6.4. Bloor GO Station

What happens to the Bloor GO station going forward is a complicated affair because of competition for limited resources between projects.

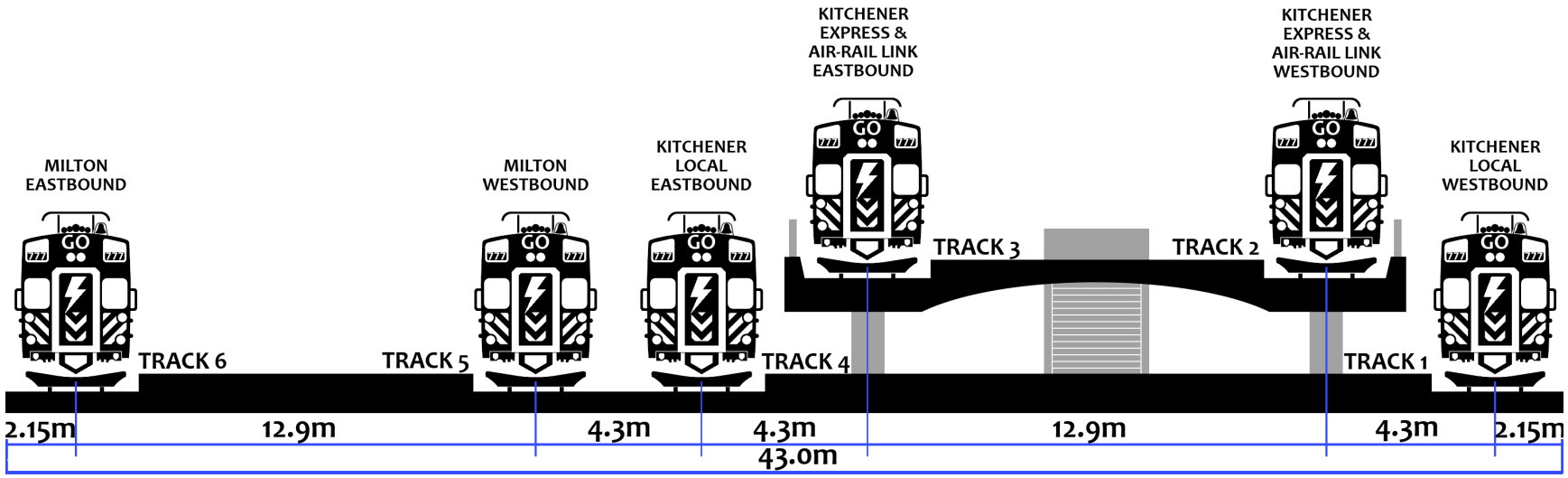
Today, Kitchener trains serve the Bloor GO station while Milton trains pass without stopping to serve it. The Milton corridor tracks at this station do not have platforms currently. Metrolinx has expressed a desire for both Milton and Kitchener trains to serve the Bloor GO station, but the limited available space in the corridor has posed challenges without infringing on the West Toronto Rail Path, a unique and attractive piece of pedestrian and cycling infrastructure that should be maintained and extended.

The Air-Rail Link shuttle creates a conflict with the Milton line in the allocation of limited space for platforms at Bloor. In terms of the number of passengers served, the Milton line would logically have the higher priority over the Air-Rail Link, but this has not happened. This can be resolved at relatively reasonable cost in the future.

The environmental assessment for the Air-Rail Link was completed and approved about six months before Metrolinx concluded that Milton trains should stop at Bloor. There is enough space for five tracks to be served by platforms at the Bloor GO station without getting into expensive configurations. It is only the sixth track required by the Air-Rail Link as currently proposed that results in serious space constraints. If a through-routed airport operation, as part of the regular GO line, were to replace the Air-Rail Link in future, five tracks would suffice at the Bloor GO station, with only tracks 4 and 5 requiring a new stairwell to Bloor (Track 1 can use the rail path's stairwell). A schematic of this arrangement is shown at the top of the following page.



Two island platforms for only the Kitchener corridor are currently proposed as part of the Air-Rail Link project, but if the platform configuration at the Bloor GO station provided one island platform for the Milton corridor and one island platform plus a side platform for the Kitchener corridor, this would accommodate a five-track configuration within the existing 43m-width available. The above diagram's platform serving tracks 2 and 3 is an expansion of the existing eastbound platform, and the above diagram's Track 2 is the existing station's westbound track.



If both directions for each of Kitchener Express/Air-Rail Link and Kitchener Local trains were to stop at the Bloor GO station, in addition to Milton corridor trains, then the middle two tracks, along with its island platform, could be raised and an additional island platform built beneath. The height involved for such, including consideration of the accessible platform, should be about five metres from top-of-rail to top-of-rail. If a through-routed Pearson GO service could replace the currently proposed Air-Rail Link scheme, this magnitude of infrastructure can be avoided. Such infrastructure and its costs should therefore be considered as exclusively associated with the Air-Rail Link shuttle service.

12.7. Additional Shoulder Stations Dependent on TTC Infrastructure Improvement

The potential for further shoulder stations for GO in the old City of Toronto exist, but their value is questionable without significant improvement to TTC infrastructure. For at least one out of the three possible further station additions, such could take the form of a new subway line that could reasonably be expected to intersect with such a GO station – past proposals for the "Downtown Relief Line" have shown a subway running through such a location, which is potentially significant given that it may be quite difficult to run a subway alignment through the Distillery District.

The costs of the following stations are not included in the Union Station Rail Corridor estimate, as they are conditional elements that require other criteria beyond the GO network to be met before they can be responsibly proposed and constructed. The combined costs of these stations is roughly estimated to be $70-million.

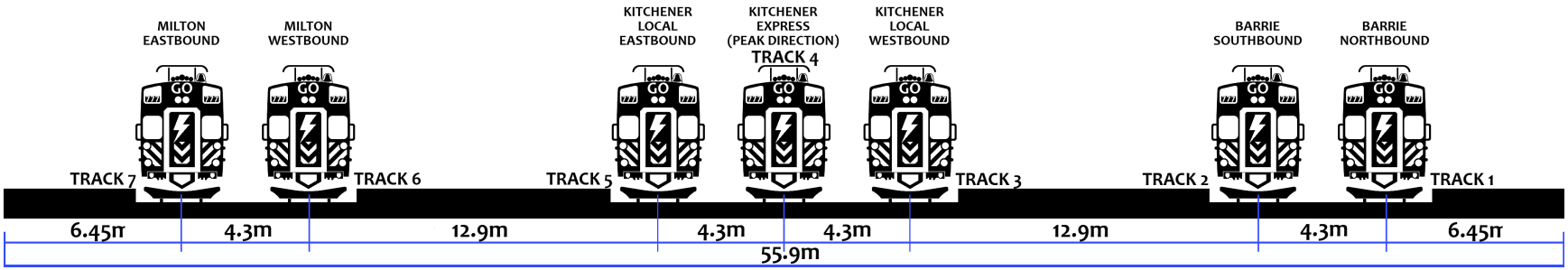
12.7.1. Parkdale GO Station

The concept of a station in the vicinity of Parkdale/Liberty Village has been intermittently under consideration since the early 1990s when the City of Toronto and the development industry first started to redevelop the massive cluster of brownfield properties south of King St W and east of Dufferin St. Those plans envisioned a GO station immediately south of King St W in 1992. This was taken off the table suddenly in the 2009 environmental assessment for the Air-Rail Link.

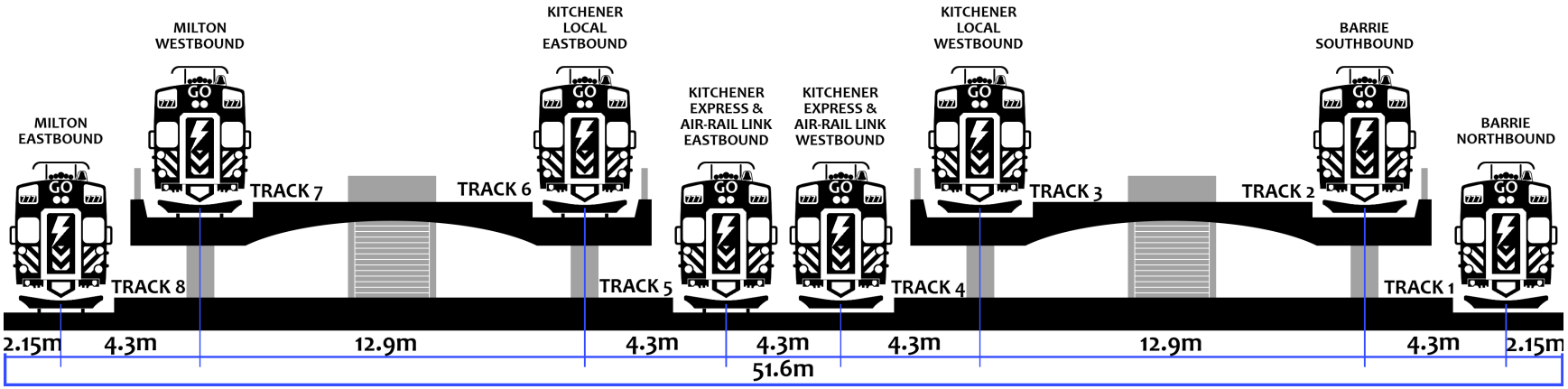
There were two key factors in the 2009 proposal that rendered the King St station unfeasible. One was the expropriation required to accommodate platforms and as many as eight tracks at the station site, a requirement that would have applied equally to King St or Queen St. This was especially problematic with regard to the large properties adjacent to this part of the corridor that were recently redeveloped. The other was the urgent need for a grade separation at Strachan Ave, which would have made a station there physically impossible because of resulting grades.

The expropriation issue, however, applies only to an eight-track model with all tracks served by platforms. There are two solutions to this, although a conceptual Parkdale GO station adjacent to the intersection of Queen St W and Dufferin St would encounter similar circumstances to those at the Bloor GO station discussed in the preceding section. In both cases, the Air-Rail Link shuttle service is what creates the need for the eighth track.

The corridor northwest of the Dufferin/Queen intersection is approximately 56m in width. If it is assumed that Kitchener express trains would not stop at this station, and that the airport would be served by a through-routed GO service, this would provide enough width for a station with seven tracks, including requisite platforms..



However, if the Air-Rail Link were to be operated as a separate service sharing tracks with Kitchener Express trains, then accommodating this station within the confined space available would become substantially more expensive because of the need for elevated tracks and platforms. This cost is expected to be in excess of $150-million.



Even if tracks 4 and 5 were to not have platforms, at least one of the eight tracks would still have to be elevated to fit within 56m.

The eighth track requirement is created by the operating frequency of the Air-Rail Link. The inability to implement holistic stations at important locations such as Bloor St W or Queen St W within the corridor's existing constraints result in missed opportunities in these rapidly redeveloping precincts. These missed opportunities have costs, although such costs are difficult to quantify.

A Parkdale GO station would be 2.4km from the GO stations at Bloor (for either of the Milton, Kitchener, and Barrie lines), and 2.1km from the Fort York GO station if both stations were built. Together with neighbouring Liberty Village, the southern end of Parkdale has seen significant revitalization occur recently, and this pattern is repeating between King St W and Queen St W, creating an urban environment that is well-suited for a station site. Long ago, it was the site of a former passenger rail station. While the urban fabric of Parkdale makes it a good location for a station, substantial TTC infrastructure enhancements could be needed prior. These improvements could either be in the form of a new subway line, or substantial enhancements to the King (Dufferin to Church), Queen (Dufferin to Victoria), and Dufferin St (Queen to King) streetcar infrastructure. Otherwise, there could be a risk of overloading the TTC services in the local area due to surge loads created in the AM peak period by multiple GO trains arriving at approximately the same time with a significant volume of alighting passengers. Detailed demand modeling would be important in assessing these impacts from a Parkdale GO station and determining the necessary mitigation.

12.7.2. Riverdale GO Station

Such a station, located at Carlaw Ave and Gerrard St E, would provide direct GO rail service to both Riverdale and (western) Leslieville. The station would be served by the Lakeshore and Stouffville corridors, as well as by the Scarborough corridor proposed in this Regional Rapid Rail report. There are already some denser residential properties in the area, such as along Blake Ave, adjacent to the rail corridor at Pape Ave, and some redevelopment activity around Logan Ave near the rail corridor. South of the rail corridor in this area exists one of the few precincts in the east end of the old City of Toronto to still have an industrial quality to its built form.

Like Parkdale, a GO station at this location without improved TTC infrastructure to connect with might risk overloading local TTC services. This could be in the form of either a new subway, or substantial enhancements to streetcar infrastructure along multiple corridors west of Carlaw Ave or Broadview Ave.

Express trains would not stop at this station, as the width of the corridor is insufficient to provide a platform for those tracks. The Riverdale station would be 2.5km from the Distillery station if both were built, and 2.2km from the Leslieville station at Coxwell if both were built (the Leslieville GO station, if built, would be 2.1km from the existing Danforth GO station).

12.7.3. Cabbagetown GO Station

Such a station, located at Gerrard St E near River St on the Richmond Hill corridor, would allow for connections with streetcar services that serve areas considerably north of the financial heart of the downtown core; i.e. beyond the distance most people are willing to walk from Union Station. The distance between the south sidewalk of Gerrard St E and the north sidewalk of Dundas St E at its crossings with the Richmond Hill corridor is 300m – the same length as a 12-car train.

This is a high-density part of the eastern central area, with a rough history. Ambitious gentrification projects are underway west of the rail corridor. East of the rail corridor, brownfield redevelopment has been occurring just across the Don River south of Dundas St E, along with the Bridgepoint project north of Gerrard St E. The station would be 2.0km from the Distillery GO station if both stations were built.

The dynamics between such a station and the precincts served by it is worth closer study. The presence of two streetcar lines which serve the northern fringe of the core connecting with a single GO station makes it difficult to predict the degree of interconnectivity that might emerge, especially since one streetcar line terminates nearby whereas the other does not. Further adding to the potential opportunity is the existing local streetcar track layout that could provide an on-street loop at this station, which could increase the level of service to/from this station if needed. Such a loop would have a similar configuration for both streetcar lines.

- 505 Dundas: Eastbound on Dundas -> Northbound on Parliament -> Eastbound on Gerrard -> Southbound on Broadview
- 506 Carlton: Eastbound on Gerrard -> Southbound on Broadview -> Westbound on Dundas -> Northbound on Parliament

The potential concentration of streetcar services resulting from this would create a need for signal priority on the loop to be seriously considered in order to avoid operating problems. This is based upon the assumption that there would be enough streetcars available from TTC and that TTC has enough carhouse space to look after the required fleet size. Evaluation of safety issues with regard to passenger volumes transferring from GO train to TTC streetcars would be an important consideration. Transfers from TTC streetcars to GO train would be much less of a concern, as surge loads would not create safety issues for that direction of transfer under normal operating conditions.

The benefit to be derived from such a station would be that the Richmond Hill corridor would connect conveniently with a wider north-south section of the downtown core. This in turn would boost GO Transit's potential to divert ridership from the Yonge subway for certain trips, depending on where the trip is intercepted further north.

12.8. Peterborough Rail Service

Similar to VIA Rail's *The Canadian* and ONR's *Northlander* services, the Peterborough service would encounter great difficulty entering Union Station during peak periods, although it would be possible to make room for it at Cherry St as an alternate downtown area terminus, which would connect with all GO lines. However, the shortcoming of Cherry St is that no connection with VIA Rail services would be possible, nor with the existing subway system. Another shortcoming is that getting from Leaside to Cherry St along the Don Branch would require a third track along the Don Branch, which would be very expensive due to the long bridge near the Don Valley Brickworks.

In Chapter 7 of this Regional Rapid Rail report, the SRT corridor was analyzed for use as a GO service, including a potential extension from Malvern to Morningside Heights where it would link with the Havelock subdivision to be utilized by Peterborough service. This would allow the Peterborough service to bypass the Richmond Hill corridor and follow a much less conflict-prone route to Union Station's tracks 8 through 10.

12.9. Accommodating Bolton GO Rail Service

Admittedly, ridership projections for a potential GO rail service to Bolton are modest at best. In any event, it would be very likely that it would be a peak period-only service, with trains running at most twice per hour. In the Environmental Assessment for the Georgetown South Project, the corridor design plates showed Bolton trains entering the Kitchener corridor between Eglinton Ave W and Black Creek Dr, and this is a location that should work for both AM and PM operations so long as Kitchener express schedules and counter-peak Kitchener local schedules can all be efficiently coordinated with Bolton train services. This would be the case even if Bolton and Kitchener services were not operating with a common technology (Bolton service would certainly begin as diesel), and could be expected to work well in an operation that has Bolton service serving few stations south of Eglinton. However, the efficiency of this operation could be compromised if the Air-Rail Link shuttle service is in operation.

Bolton trains would be able to use either Union Station track 10 in the AM peak if available, or one of the overflow tracks. Bolton trains would ideally utilize tracks not shared with Kitchener trains at Union Station due to sensitivity of dwell times, as diesel train dwells are longer due to lower performance compared with EMUs. Bolton trains could use the track proposed for Sarnia VIA Rail trains to get into Union Station in the morning. In the afternoon, the Bolton service could use a Barrie corridor track to enter the Kitchener corridor, again like some Sarnia VIA Rail trains might do.

12.10. Growth Planning and GO Transit Infrastructure Coordination

If significant numbers of GO rail passengers are going to be disembarking at central area locations other than Union Station, the creation of employment concentrations in parts of the central area other than the immediate Union Station area will be important. This does not require major changes to current planning intentions, but the idea of spreading employment growth out on the east-west axis would warrant serious consideration as new plans are formed and existing plans revisited on their regular cycles, typically every 5 years. This would diverge from the pattern of focusing primarily on the north-south axis served by the existing downtown subway lines. Employment growth near the rail corridor at Cherry St and around Strachan Ave as well as the broader Lower Spadina Ave precinct is already projected to be fairly high, creating potential for significant peak period destinations these areas that could attract some GO rail passengers away from Union Station.

While weekday peak period pressures are unlikely to moderate significantly, the operating budget for GO rail service would benefit from more off-peak, non-work trip generators. The shoulder stations described facilitate opportunities for that to some degree, not only by locating GO service closer to more diversified activities, but also by expanding the number of local transit routes the network can conveniently connect with, increasing trip options and origin-destination pairs. This in turn would allow riders to be distributed among several locations. Service frequencies convenient to riders will be an important influence on the success of off-peak GO rail service. In such a scenario of closer, more frequent stations, EMUs would help greatly to curb energy costs.

It must always be remembered that road space in the former City of Toronto is essentially fixed, and nowhere is this more evident than in the downtown core. Buildings typically extend to the sidewalk edge, and on most streets there is neither a boulevard nor a median that could be taken away for an extra lane or two. Subways, as demonstrated by the proposed Yonge extension as well as Sheppard East, are becoming increasingly expensive and difficult to justify, and alternatives must be explored and maximized. Getting the most out of the GO rail network through infrastructure enhancements is by far the more practical alternative from a cost-efficiency perspective. This applies to both local [intra-municipal] and longer-haul [intra-regional] trips focused upon downtown Toronto. While a downtown GO rail tunnel is certainly an expensive undertaking, estimated earlier in this chapter at $5.7-billion, it would be less costly than a network of new subways or freeways. It would also be far less disruptive to communities, although railway operations might be affected in selected locations in the USRC. While the GO rail system can serve the larger regional network, it cannot replace the need for the DRL – ridership projections indicate both are necessary.

What has been observed for a very long time is that infrastructure can attract investment. The shoulder stations in the USRC are capable of maintaining that time-tested truth if the political will is there to a) build it, and b) plan for growth around them, including necessary zoning changes.

13. Network and Implementation Issues

Certain issues are common to most areas of the network rather than being specific to one corridor, and therefore affect the GO rail system as a whole. This includes other operators that may share corridors or parts of corridors with GO, especially as it relates to Positive Train Control. However, most important in achieving the network envisioned in this Regional Rapid Rail report are positive public attitudes towards such an initiative. Revolutionizing GO rail service by electrification with EMUs offers huge benefits to the public at large, but public support cannot be taken for granted.

13.1. Canadian Rail Operating Rules (CROR) and Positive Train Control (PTC)

With the exception of rail-based rapid transit with exclusive infrastructure, the CROR govern all railway operations on the heavy railway corridors in Canada. Put another way in relation to GO Transit, all railway corridors that are or were owned by CN or CP railways are governed by CROR. It is important to note that GO Transit ownership of such corridors does not exempt GO trains from CROR adherence, as running rights for freight operations are still in place on all lines despite the change of ownership.

The CROR cover a variety of signal systems, including those used by GO to manage their own rail operations. Most of these are under Centralized Traffic Control, except for the Barrie corridor, which uses the older Occupancy Control System, also known as “dark territory.” Both of these systems, especially the Occupancy Control System, have limitations, influencing how frequently trains can run (headway).

Among all the rules for the various control systems included in the CROR, there are as yet no rules defined for PTC environments, as PTC has not yet been applied anywhere in Canada. In 2008, United States lawmakers passed the Rail Safety Improvement Act in response to a deadly rail collision in California. That law requires PTC to be installed by 2015 in all U.S. rail corridors carrying passenger trains as well as all corridors carrying hazardous materials. With those changes happening south of the Canada-U.S. border, the CROR will have to be expanded to recognize PTC at some point since CN and CP own and operate cross-border networks. In addition, there are limited border crossings into Canada by CSX Transportation and Burlington Northern-Santa Fe (BNSF). The Montreal, Maine and Atlantic Railway may also be a factor as a cross-border short-line railway carrying petroleum and other chemicals that would be considered hazardous.

The National Transportation Safety Board has been interested in PTC for over two decades (http://www.tsb.gc.ca/eng/rapports-reports/rail/2009/r09w0118/r09w0118.asp):

"*Since 1990, the National Transportation Safety Board has had positive train control (PTC) on its 'most wanted list' of safety improvements. PTC refers to automated technology that can prevent train collisions, overspeed derailments, overlaps of authority, and other human factors–related occurrences. Most PTC systems are based on global positioning system technology and can either operate in dark territory or be linked into existing signal systems. The train reports its position to the control centre over a wireless data link. The control centre's safety interlocking logic uses data from all trains to issue limits-of-movement authority and speed limits to each train, keeping safe separation between trains.*

The train's onboard computer monitors the data against actual train location and speed to determine potential and actual unsafe conditions. If one train is approaching another, is nearing the end of its limits, or is exceeding its speed limit, the onboard computer warns the locomotive engineer, who is expected to take appropriate action. If action is not taken, the onboard computer automatically initiates a safety brake application to either slow or stop the train.

PTC technology is currently in limited use on at least two Class 1 railways in the United States. In the U.S., it has been mandated that by 2015, railways must install PTC on all rail lines used by passenger trains and lines used by freight trains that move toxic inhalation hazardous materials. In Canada, PTC systems have not been implemented on any Class 1 railway, except on a limited trial basis. However, the Quebec North Shore and Labrador Railway has conducted a pilot project using a proximity detection device that initiates a train brake application if a locomotive engineer fails to respond to an alert."

13.2. Quieter Surroundings at GO Stations in a PTC Environment

The Canadian Rail Operating Rules (CROR) govern the use of the bell on trains that create a sound commonly associated with GO trains by people who see them regularly, even if they don't use them. The bell is a safety feature required by CROR Rule 13, but is an issue for smart growth in the GTHA as the noise is an undesirable feature of the ambient environment for people who live close to GO rail stations. This would be accentuated with the replacement of diesel locomotives, which currently drown out the sound of the bell to some degree, particularly when the locomotive is at the front of the train. There are potentially strong opportunities to address the issue of the bell arising from an expanded CROR that include a new set of rules for PTC. This would be an important consideration towards steering regional growth in a direction that will minimize increases in road travel by maximizing the attractiveness of the immediate vicinity of GO stations for concentrating population and employment.

Rule 13 of the CROR reads as follows:

"*Engine Bell*

(a) The engine bell must be rung when:

1. an engine is about to move, except when switching requires frequent stopping and starting after the initial move;

2. passing any movement standing on an adjacent track;

3. approaching, passing or moving about station facilities or shop track areas; and

4. one-quarter of a mile from every public crossing at grade (except within limits as may be prescribed in special instructions) until the crossing is fully occupied by the engine or cars. When engine whistle signal 14(l) is sounded, the engine bell need not be rung. "

The issue, as it relates to safety, is primarily to ensure the crews are made aware of risks and hazards created by moving vehicles in their immediate vicinities in order to avoid injury or death. While freight operations crews still have members who frequently walk near moving cars and at times even hang onto the outside corner of moving cars for short intervals, this does not happen with passenger trains outside of yards. In a

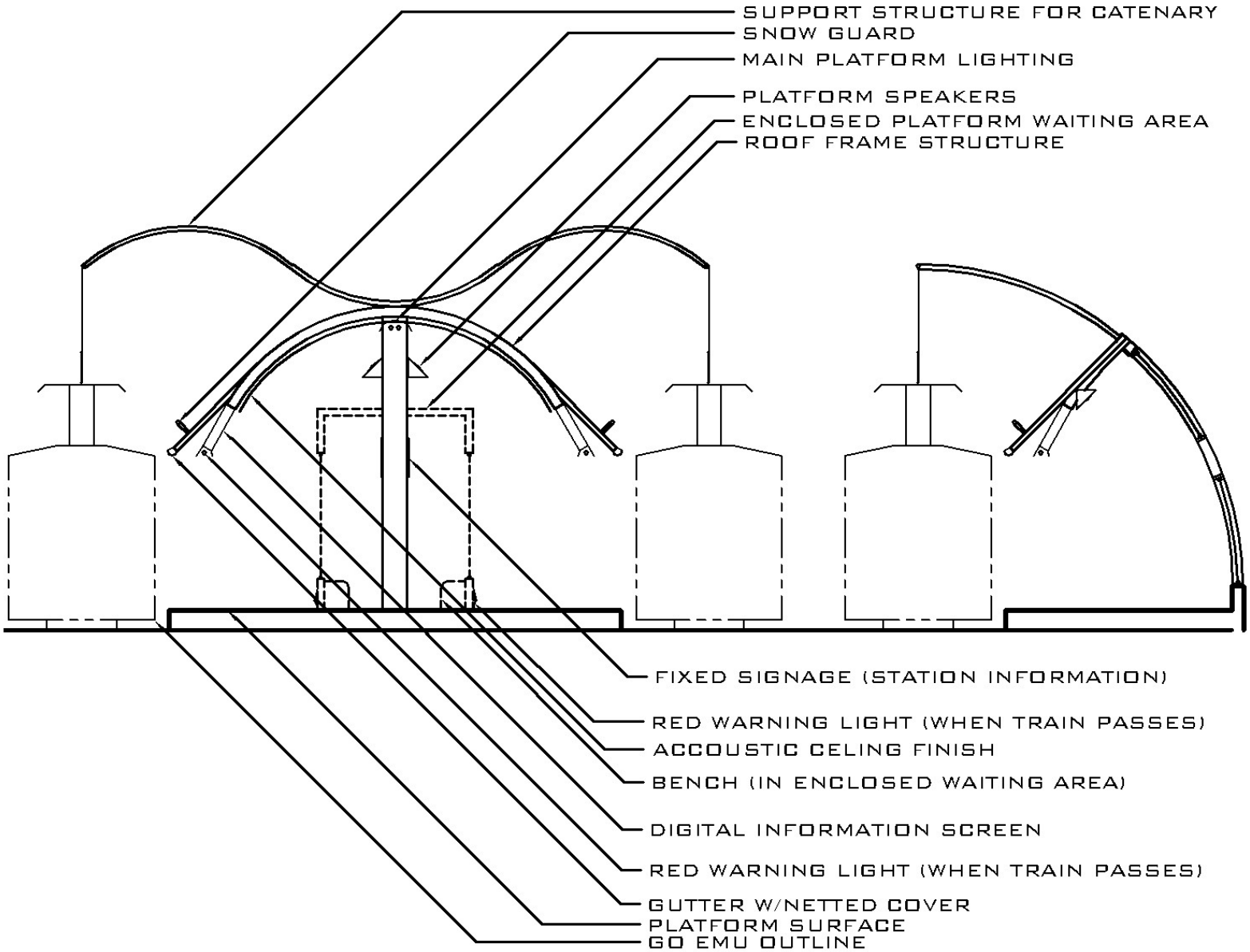
PTC environment in particular, where a number of communications options are available to alert both in-vehicle crew and workers on the tracks or vehicle exterior, there are opportunities to remove some of the bell requirements while still maintaining safety for crew.

For Rule 13.(a).1., PTC can verify the presence of other trains within a certain distance and also identify what types of trains, if any, are operating within that distance. If there are no non-passenger trains in the vicinity and there is no yard or shop nearby, this rule could conceivably be amended to specify an exception for PTC environments with no negative impact to safety, although it would not apply when near yards, shops, etc, without a physical barrier to provide safe separation. This would apply to stations such as Bronte and Clarkson, as well as to potential future layover areas such as Mount Pleasant, where workers may be on the yard tracks but would not be in any danger with a physical separation preventing them from coming into contact with a passenger train on the mainline. This would allow safe operations without using the engine bell.

A similar exception outside of yards and shops for passenger trains could also be made with respect to Rule 13.(a).2., subject to PTC confirming that no freight activity without physical separation from the mainline is present within a quarter-mile (or other determined safe distance).

In the case of rule 13.(a).3., the safety concern is for passengers as much as for the notification of workers. This is where station design can play a significant role by incorporating audio systems and visual displays into a suitable built form. Those systems and displays can notify affected passengers and station workers of an approaching train more efficiently than the moving train's devices, and can include more information such as indicating whether the approaching train will be stopping at the station or not. The built form of the station can improve the typical state of affairs by careful consideration of the form of shelter from the elements, acoustics, and lighting in creative ways that will convey information to both passengers and staff more clearly than under current arrangements while minimizing the dispersion of such information beyond the platform's immediate area. This can substantially mitigate sources of railway station noise to allow smart growth to take place very close to GO rail stations.

By having an arched ceiling with a suitable acoustic lining, with speakers pointing into this arch, the sound from the speakers would bounce off the arch within a confined yet open space, so that only passengers on the affected platform will be able to hear the announcements relevant to them. Similarly, appropriately designed warning lighting can be synchronized with the announcement speakers and digital information displays to provide visual warning of approaching trains, leading to a universal design, which would enhance safety features for persons with either a visual or aural challenge, and could even be largely (although not entirely) independent of the spoken or written languages used by various riders.


SUPPORT STRUCTURE FOR CATENARY
SNOW GUARD
MAIN PLATFORM LIGHTING
PLATFORM SPEAKERS
ENCLOSED PLATFORM WAITING AREA
ROOF FRAME STRUCTURE
FIXED SIGNAGE (STATION INFORMATION)
RED WARNING LIGHT (WHEN TRAIN PASSES)
ACCOUSTIC CELING FINISH
BENCH (IN ENCLOSED WAITING AREA)
DIGITAL INFORMATION SCREEN
RED WARNING LIGHT (WHEN TRAIN PASSES)
GUTTER W/NETTED COVER
PLATFORM SURFACE
GO EMU OUTLINE

If the station's safety features are not working, the system needs to be able to pass vital information to approaching trains. Supervisory Control And Data Acquisition (SCADA) can provide this. In such cases, engineers would have to ring the bell until the station's features are working again.

Rule 13.(a).4. is not a serious concern given that the overwhelming majority of urban area crossings would be grade-separated by the late stages of the build-out described in this Regional Rapid Rail report. The small minority of at-grade crossings to remain would be in rural areas or, in limited cases, in industrial areas within urban landscapes, as well as the residential areas along the Stouffville line at the Havendale Rd crossing in Scarborough, and through most of Markham. More significant is the reference to Rule 14.(l), which requires the train horn to be sounded when approaching at-grade crossings. While not spelled out in the CROR, exemption from this rule can be achieved by providing crossing protection in a manner that does not allow use of the oncoming lane to go around crossing arms in the lowered position. Other parts of the GO rail network do not require the use of the train horn at at-grade crossings; e.g. at various locations along the Lakeshore, Kitchener, and Richmond Hill lines. The City of Markham is working towards improvements to permit operation without the train horn/whistle along the Stouffville line.

Rule 14.(f). also requires the horn to be sounded, but only in instances at stations where the driver of the train feels that extra warning is needed for passengers. GO stations currently provide no dynamic or real-time active warning signals for oncoming trains, but if this changes as described in relation to rule 13.(a).3, the horn should be unnecessary altogether at stations. Rule 14 explicitly prohibits the unnecessary use of train horns.

13.2.1. GO Stations Without Upgrade

The following is a list of stations where the conceptual design described above would be either not warranted or not sensible because of nearby freight railway operations or the local built form; i.e. urban or rural.

Corridor	Station	Status	Proposed by	Reason(s)
Lakeshore West	Aldershot	Existing	N/A (Existing)	Heavy CN traffic; CN Aldershot Yard; Semi-rural area
Milton	Agerton	Proposed	GO/Metrolinx	Rural area
Kitchener	Acton	Existing	N/A (Existing)	Semi-rural area
	Breslau	Committed	Approved EA	Semi-rural area
Barrie	Kirby	Proposed	GO/Metrolinx/York Region	Rural area - may change in future (revise when warranted)
	King City	Existing	N/A (Existing)	Semi-rural area
	Temperanceville	Proposed	York Region	Semi-rural area
	Holland Landing	Concept	Proposed in this report	Rural area
	Innisfil	Proposed	GO/Metrolinx	Rural area
	Barrie South	Existing	N/A (Existing)	Semi-rural area – may change (revise when warranted)
Richmond Hill	Trailwood	Concept	Proposed in this report	Rural area
	Gormley	Existing	N/A (Existing)	Rural area
	Bloomington	Proposed	GO/Metrolinx	Rural area
Stouffville	Lincolnville	Existing	N/A (Existing)	Rural area, layover site combined with station
Lakeshore East	Courtice	Proposed	GO/Metrolinx	Rural area, layover site proposed in immediate vicinity

13.3. VIA Rail Canada and PTC

VIA Rail Canada operates many medium- and long-distance intercity rail services through Toronto Union Station using rights-of-way owned by GO Transit. This would require VIA Rail locomotives to be equipped with on-board PTC so that its trains can operate safely on rights-of-way owned by GO Transit, and specifically, allow VIA Rail operations to be blended with GO operations on shared trackage.

VIA Rail has 74 locomotives in its nation-wide fleet – 21 of the newer P42DC model that run on its higher demand and higher-speed lines such as Toronto-Montreal (among others), and 53 of the older F40PH model used for the rest of its services.

While it is arguably viable to have some locomotives remain unequipped with PTC if they are essentially kept out of the Toronto area permanently (unless coupled to another locomotive such as is done with The Canadian service), this would give rise to managerial complexity that may be undesirable. It is unclear what the impact of this would be on operating cost, particularly whether or not it would be a positive net impact.

A P42DC pulls a VIA Rail train westbound out of the Union Station Rail Corridor at Strachan Ave.

If all 74 locomotives were to be equipped with on-board PTC equipment, it would require an investment of $10-million including a 35% contingency ($0.1M x 74 x (1 + 0.35)). This should be considered a VIA Rail Canada expense, separate from (despite being related to) the GO rail system, and as such this cost should not be applied to the cost of the vision for the GTHA in this Regional Rapid Rail report. Nonetheless, it is acknowledged that there would be some expense applied to VIA Rail Canada for co-existence with GO operations in a PTC environment for any trains expected to run through Toronto.

13.4. Service Models and Travel Times

An alternative service model known as “Skip Stop” was suggested to this author as an alternative to longer trains. As a response to this suggestion, a service model of the Milton corridor was constructed for evaluating the capacity that could be achieved with this alternative.

“Skip Stop” operations have no trains that serve every station. Instead, there are at least two semi-local trains that serve every other station with some common stations served by both for passengers to switch between the two services at. This increases the average speed of service, thereby increasing the capacity per track. This has been successfully applied in other jurisdictions, but it has not been used in the GO rail system before, and this model was critical in determining Union Station impacts from such an operation. The Milton corridor was selected for this model because Milton is the most constrained corridor in terms of property. The model’s construction was cross-referenced with the existing schedule of the Milton corridor and the EMU schedule that the 2010 electrification study provided in its Appendix 5. Actual corridor speed limits were applied in the model, obtained from Appendix 3 of the 2010 electrification study. Subsequent to confirmation of appropriate acceleration and braking rates along the existing service and an EMU version of the existing service, the model was expanded with additional stations and a “Skip Stop” schedule.

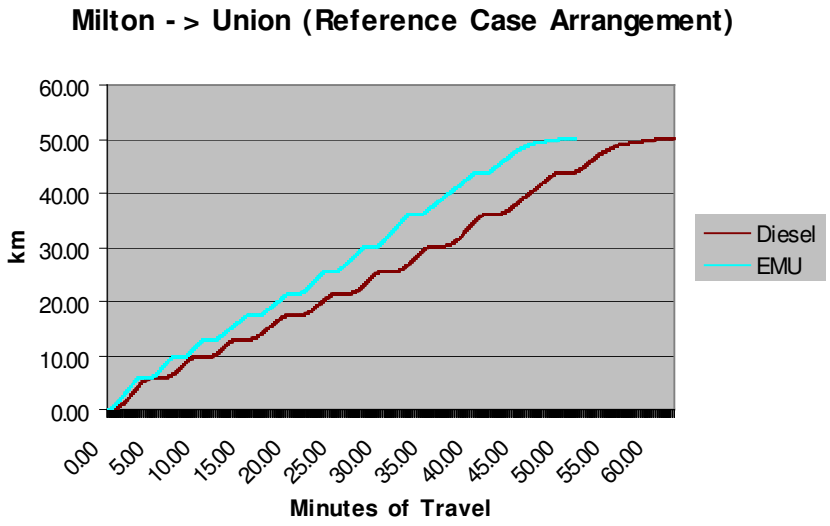
The model, included as Appendix Y, generated various results of interest. The most impressive of these was the finding that the diesel locomotive-hauled option with the two Reference Case stations added had a travel time of 62 minutes, while the EMU option with all stations added as described in Chapter 9 of this Regional Rapid Rail report had a travel time of 61 minutes. The model with all stations from Chapter 9 has 70% more stations than the Reference Case. The Caltrain model that was shown in Chapter 2 (section 2.4) only had a 50% increase in the

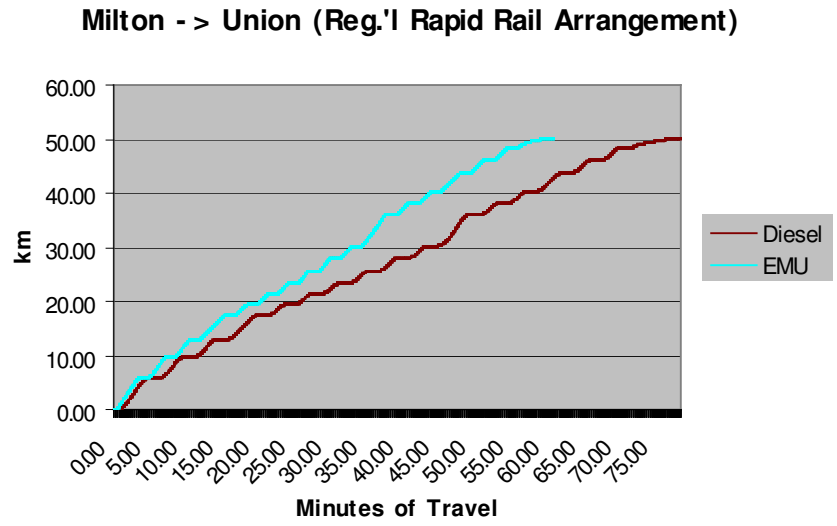
Summary of Travel Times in Minutes by Arrangement and Technology from Milton to Union Station

Station	Diesel (EX)	Diesel (RC)	Diesel (RRR)	EMU (EX)	EMU (RC)	EMU (RRR)	EMU (SSA)	EMU (SSB)
Milton	0	0	0	0	0	0	0	0
Agerton	X	5	5	X	4	4	4	X
Lisgar	7	10	10	6	8	8	X	6
Meadowvale	12	15	15	9	11	11	10	9
Streetsville	17	20	20	14	16	16	14	X
Erin Mills	X	X	24	X	X	19	X	16
Erindale	23	26	28	19	21	22	19	X
Fairview	X	X	32	X	X	25	X	20
Cooksville	28	31	36	23	25	28	23	23
Applewood	X	X	40	X	X	31	26	X
Dixie	33	36	44	27	29	34	X	27
Islington*	39	42	50	32	34	38	32	32
Chestnut Hills	X	X	54	X	X	41	35	X
Lambton	X	X	58	X	X	45	X	37
Bloor	X	50	63	X	41	49	41	41
Parkdale	X	X	67	X	X	52	44	X
Fort York	X	X	71	X	X	55	X	46
Union Station	57	62	78	48	51	61	52	52

* *Islington is a relocation of the existing Kipling station*
(EX): *Existing arrangement of service as operated at time of writing, current as of 2013.*
(RC): *Reference Case arrangement as outlined in Appendix 3 of the 2010 electrification study.*
(RRR): *Arrangement as outlined in Chapter 9 of this Regional Rapid Rail report.*
(SSA): *Skip Stop 'A' arrangement - not viable with 12-car trains, cannot meet projected demand.*
(SSB): *Skip Stop 'B' arrangement - not viable with 12-car trains, cannot meet projected demand.*

number of stations without speed penalty for EMU-operation, but Caltrain operates locomotive-hauled trains that are only half the length of what GO Transit operates, and the travel time penalty per stop is higher with longer trains. Therefore, this is a valid outcome.





Consider the existing diesel locomotive-hauled service compared with the EMU service with all stations described in Chapter 9 added, which is a 112.5% increase in the number of stations with a travel time increase of only four minutes. With each EMU stop adding two minutes to travel time, an increase of 87.5% in the number of stations would result in the EMUs achieving the same travel time as the current service operating today.

The additional station quantities as percentages relative to existing stations on other lines appear as follows:

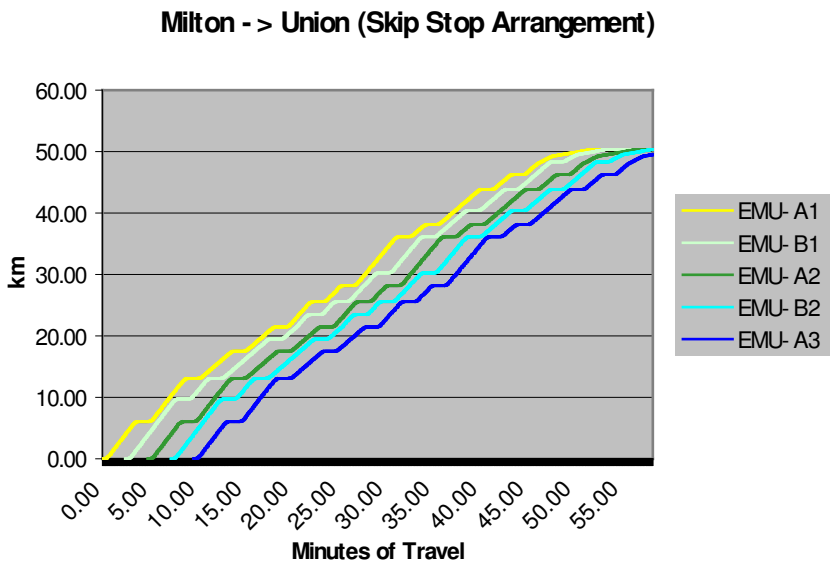
Line	Lakeshore West	Kitchener	Barrie	Richmond Hill	Stouffville	Lakeshore East
New Stations	10	9	15	10 (to Gormley)	8	5 (to Ajax)
Exist. Stations	11	12	10	5 (to Gormley)	11	7 (to Ajax)
Increase (%)	91%	75%	150%	200%	73%	71%

The Barrie and Richmond Hill corridors have a proportionally large increase in their number of stations. In the case of the Barrie corridor, 11 out of the 15 new stations are proposals by others. In the future, it is expected that there will be an express service along the Barrie corridor, one possible example of which has been described in Chapter 11.

For the Richmond Hill corridor, the large increase in the number of stations is partly due to the unusually low number of existing stations – Lakeshore West, for example, has the same number of new stations. The new stations are a mixture of proposals by York Region and stations designed to intercept Yonge subway ridership. Even with the additional stations, the Richmond Hill corridor would still offer a significant travel time saving to passengers connecting to the station by bus from east of the Richmond Hill corridor. In the case of traffic that originates in York Region, passengers coming from west of the Richmond Hill corridor could also see a notable travel time saving by diverting to the Richmond Hill corridor instead of the Yonge subway. The higher speed that would be attained along the Don Branch alignment compared with the existing route between Lawrence Ave E and Gerrard St E would offset some of the travel time increase from additional stations.

The other remaining lines are seeing increases in the number of stations in the 71% to 91% range, which should result in no increase in travel time, except possibly for the Lakeshore West corridor, although any increase that may result would be minor. Express services would continue to be provided in any event. Many of the new stations envisioned along the Lakeshore West corridor east of Oakville have previously been proposed as far back as 1974, or, in the example of Lorne Park, has been a station that was part of the GO rail system in the past.

The analysis of "Skip Stop" operation found that headways as short as 2'25" could be safely operated per track. However, the model found that constraints in the Union Station Rail Corridor would only be able to accommodate 8-car trains. The model worked with 8-car trains due to the ability of two trains to occupy the same platform at Union Station, couple at the platform, and then pull away as a single



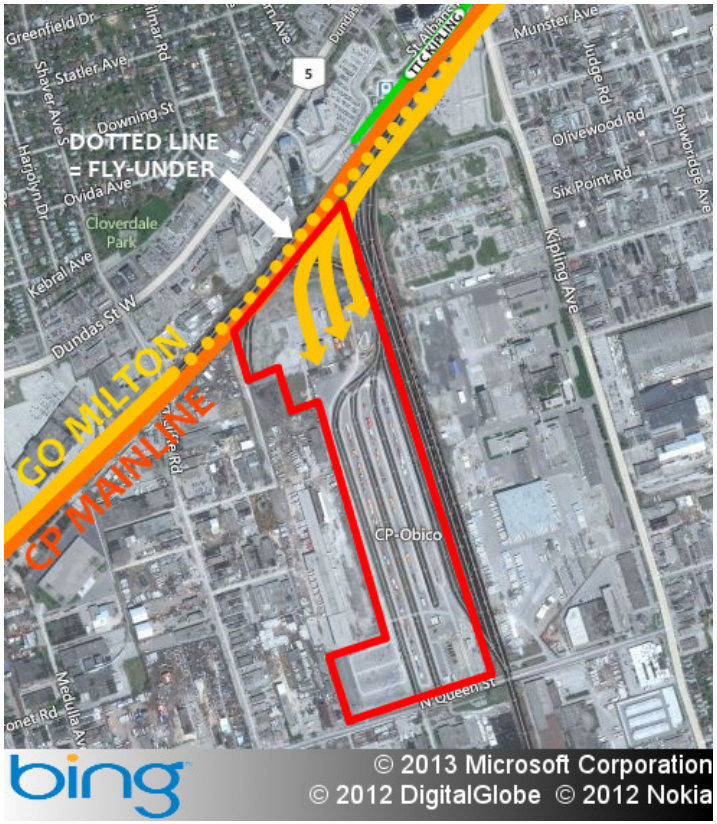
16-car train. The Union Station platforms are in most cases not long enough for two trains per track with 12-car trains, and the track switch layout precludes platform extensions to such lengths. The alternative, except for greatly reduced dwell times, would be to allocate more tracks at Union Station to the Milton corridor, but all the tracks would already be in use by other corridors. Furthermore, if the "Skip Stop" operation were to be applied to more than one corridor, Union Station would quickly become unmanageable. This is unfortunate as the capacity achievable with 12-car trains in a "Skip Stop" operation was equivalent to a local operation with a 16-car train with a 3'30" headway, while providing a travel time saving of nine minutes. This capacity was 36,000pphpd for the former and 34,000pphpd for the latter. However, in the 8-car train operation of "Skip Stop," the capacity drops to 24,000pphpd, which happens to be about the same as the projected 2031 demand. This would make "Skip Stop" an inadvisable option for GO service given the severe constraints of the Union Station Rail Corridor.

This model was also used to calculate the travel time of a diesel locomotive-hauled train serving all the additional stations described in Chapter 9. This would not be a practical operation. However, modeling this operation creates a compelling snapshot that highlights how powerful EMUs can be. The EMUs complete the trip from Milton to Union Station in 61 minutes, while the diesel locomotive-hauled train had a travel time of 78 minutes. This was 14 minutes longer than the Reference Case diesel train schedule, which had only two more stations than today's operation. For a one-way trip, the EMU (61 minutes) was 17 minutes faster than the diesel train (78 minutes).

The model, which was constructed as a spreadsheet, will be available for download.

13.5. Network Yard Management

While GO is expanding its facilities currently, predominantly through the addition of new layover sites at the outer ends of the network, much more will be required beyond what is currently planned, as the fleet growth between 2021 and 2031 is expected to be substantial. Hidden within this challenge is an opportunity to promote a more effective result of decentralized development of certain urban growth centres as supplementary employment nodes, even though these would not provide any meaningful alleviation at Union Station in terms of actual train throughput per hour.



Recently, CP indicated its intent to close its Obico intermodal facility immediately south of the Kipling GO/TTC station. This is a significant opportunity for GO to acquire a large quantity of land with existing high-capacity rail connections within a reasonable distance of Union Station. This would allow many trains coming from the east that are peak period operations to be taken out of service during the midday period by using the Etobicoke Centre area as its last stop. However, this would entail reconsideration of where GO and CP build their rail-to-rail grade separation (i.e. instead of close to Scarlett Rd, a location near Kipling Ave would be optimal), and would affect the design of the Islington station layout discussed in Chapter 9.

While it would be a logical outcome for the Obico lands to be acquired by GO/Metrolinx when CP puts it up for sale, the network distribution of midday layover facilities with Obico would become lopsided to the west as a result. Ideally, such would be avoided. Additional land for midday storage would be required on the east side of the network to avoid awkward vehicle management – a situation that could result in inefficient use of scarce peak hour track capacity through downtown Toronto. This challenge may best be met on the Havelock subdivision, where there's land, via the conceptual Scarborough corridor. This would serve two purposes: First, it would provide east-side storage for a large number of trains

during midday periods, although the distance is greater from Union than Mimico or Obico – however, it would still be closer than Whitby. Second, the same facility would serve as the overnight layover for Scarborough trains.

Network yard management opportunities such as the above could dovetail with growth management opportunities in Toronto. Both Scarborough Centre and Etobicoke Centre have been targets for decentralized intensification in the past. The benefit coming from the success of such an initiative, from the perspective of transportation economics, is that it would put to productive use surplus reverse-peak capacity in the system that has to be provided as a byproduct of peak direction supply. This outcome was expected in the past to materialize on the subway system. However, this did not happen, and this is not surprising since the TTC's rapid transit system terminates at both of these centres. The GO model does not suffer from this to the same extent, as neither Scarborough Centre nor Etobicoke Centre would be the end of the line for most trains. All-day rapid transit service would be provided in two directions, and would extend beyond Toronto's borders. For Etobicoke Centre, it could be receiving trains from Durham Region, Markham, Scarborough, and Mississauga/Milton, while Scarborough Centre could be receiving trains from Kitchener, Halton, Peel, Hamilton, and Markham, plus very limited Peterborough service. While a number of through-routed operations would be limited to peak periods, riders would still have the same travel options available to them at other times with a transfer in downtown Toronto. Such service would therefore provide a much wider potential catchment area that would encourage more employers to locate in these areas. This would be especially attractive after commercial property tax rates have been rebalanced in Toronto, a multi-year process currently in progress.

If successful, GO rail services operating between Union Station and each of these layover sites will yield higher ridership that will in turn lower the net cost of moving trains to and from their midday layover sites at Obico and along the Havelock subdivision. Although these two facilities could provide a significant proportion of the total space needed to store trains, there is no guarantee that these will make up the entire shortfall, given that details are generally not available even though the potential is obviously high. There are also scheduling limitations, which would need to be taken into account for both of the proposed facilities, assuming that new track is not added beyond what was estimated in this Regional Rapid Rail report.

13.6. Local Transit Expansion

Particularly in the 905 areas, there will be a pressing need for significant expansion of local transit services in order to support an all-day GO rail service model that does not rely on parking. While kiss'n'rides and taxi stands will be integral features offered at selected stations, most stations will need to be designed to allow most riders to access the station without parking their private vehicle at the station during both peak and off-peak periods. Otherwise, the cost of providing typical parking supplies, as well as the development opportunities such parking would eliminate, could threaten the viability of the strategy just described, at least from a financial perspective. Even if funding was no issue, a functional constraint exists in that there would be serious congestion problems around GO rail stations that provide excessive parking, as is already evident today at a number of busier stations.

Local transit expansion is an important issue, but an issue that has a large number of possible permutations, and introduces jurisdictional issues. For some of these to be addressed, there is already enabling legislation in the Metrolinx Act. For certain routes, particularly shorter ones, the question of which operator should have responsibility for local transit routes serving GO rail stations may well arise; i.e. should local transit service be the local authority's responsibility, or should GO Transit itself operate them based upon integration with the GO fare regime? The need for schedule coordination between connecting services would also be a factor to consider, although this will be much less of an issue than it is today should all services operate with at least 15 minute frequencies all day across the system. In any event, avoiding “just-missed” connections to the greatest degree practical in scheduling would yield best results.

Local transit issues cannot be addressed in this Regional Rapid Rail report, but it will certainly be important for policymakers to be cognisant of local transit needs when they go forward with expansion of GO rail services. This will have a cost, a cost that is currently borne by the municipalities in most cases. In the 905 area, the subsidies are substantial (in percentage terms), in many cases comprising more than half of operating budgets. Expansion of these services in step with GO rail expansion will require coordination or other agreement with the municipalities that are currently subsidizing these local operations (of note is that trips to GO stations at highly subsidized fares are paid for by GO to the municipalities).

Among other needs, this will involve additional vehicles and additional facilities, mainly garages (but in some cases will likely involve the introduction of some LRT systems, such as in the case of the Hurontario-Main corridor along the main north-south spine through the Regional Municipality of Peel), to provide the higher service levels needed to keep up with GO rail effectively and reliably.

These two parts of the system, GO rail services and connecting local transit services, must work together effectively in order to achieve a successful and sustainable outcome. This will apply to most areas of the GO rail network, except for rural and thinly developed areas, where parking and kiss'n'ride facilities at stations will be the principal means of access and intermodal transfer. At rural stations, active transportation options should also be encouraged where viable, although this will likely have very limited impact, particularly in colder months.

13.7. Electrification Milestones

While the cost per kilometre of electrifying GO rail is quite low when compared with BRT, LRT, or especially subways, the GO corridors are longer than LRT or subway lines. The length of GO corridors, which in some cases exceed 100km (Barrie and Kitchener lines), still means that hundreds of millions of dollars per corridor will be required for electrification. Each corridor should take around seven years to electrify, but multiple corridors' workflows can be staggered to dramatically speed up electrification of the network as a whole.

With significant public funding required to electrify a corridor, there is an understandable concern that both the public and their political representatives will need to see steady, measurable progress. To this end, there are milestones that can showcase the progress achieved, and these would ideally be made publicly visible in some manner, even though much of the work will take place during overnight hours when GO trains are not running.

The most efficient means of electrifying an existing rail corridor is to use what is known as a "factory train." Factory trains are capable of making fast progress during the night on installation of electrification infrastructure. While a few years of design work, procurement orders, assessments, and miscellaneous bureaucratic formalities that need to precede the actual

A factory train Metrolinx has employed for track tie replacement along the Lakeshore corridor parked for the weekend at Dufferin St. – a similar style of equipment exists for factory trains that install/maintain overhead wiring.

construction work are unavoidable, the arrival of the factory train can be an event representing a solid, tangible symbol of "passing the point of no return," an embodiment of progress on the electrification project that can make very clear what the money has been spent on; i.e. a rail-mounted assembly line for building electrified infrastructure (overhead catenary supports, catenary and contact wires, etc.). When the work is visibly underway, it would solidify public and political acceptance.

What these factory trains look like can be seen in images on the website of an Italian manufacturer of this kind of equipment: http://www.bonciani.com/en/services/equipment/train-wiring-installation-contact-line.html

Another example similar to the above is the recent order for a factory train placed by Network Rail in the U.K. for their Great Western mail ine electrification project, and being manufactured by a German company known as Windhoff. Their website features a variety of images for these vehicles, including a Flash interface that demonstrates the versatility of these vehicles. From their English homepage, select "Railway Vehicles" from their top menu, and when the submenu to the left appears, select "Modular Concept" and/or "Types of Vehicles" to view depictions of factory trains: http://www.windhoff.de/e/index_ft.htm

After the factory train is activated, the first phase of the roll-out to be carried out by the factory train (over 240km of corridor) could be completed in about two years. It is around this time that new electric passenger rail vehicles would start to arrive for extended periods of testing to confirm performance and safety, known as commissioning. A year after commissioning commences, the first corridor could enter electric service. Another year later, the electrified operation of the second corridor could commence, and so on. At the same time, additional service expansion could be scheduled on non-electric lines since there would then be a large inventory of diesel-powered equipment suddenly available. Once the public experiences EMU service, they will yearn for more, which in itself will support continuation and acceleration of the program.

13.8. Other Details for a Regional Rapid Rail System

Electrification would be a key "enabler" in revolutionizing GO rail, but electrification would not be the sole component. The smaller projects, particularly additional stations that were not necessarily practical to serve with locomotive-hauled trains, are where a lot of transformative potential can be realized. While typical outlying GO stations are inexpensive to build and operate, local conditions are sometimes unusually complicated.

Clearly, proposed new stations do not need to be opened simultaneously. They can be phased in, although establishing priorities would be important. The sequence of station openings would also depend on aforementioned relationships with municipal governments and the need for agreements with local transit agencies in order to ensure that optimal functional relationships can be established between new GO stations and local transit services when new GO stations open for public use.

There are select stations that would ideally be ready for use when electrified service begins. After that, other stations could be added periodically to consistently build public and political acceptance of and support for transit investments in the electrified GO rail network.

Electrifying GO rail service and transforming it into a *Regional Rapid Rail* system would result in substantially increased geographic coverage, providing service for many communities per corridor at a low per-kilometre capital investment.

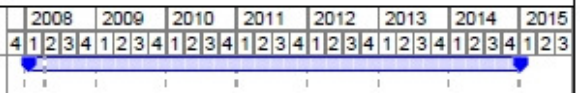
13.9. Time Lines

This Regional Rapid Rail report envisions an aggressive but realistic roll-out of electrification; the sooner the system is implemented, the higher the savings to the GO Transit operating budget – and the sooner higher capacity can be provided. This time line is based on available data from the 2008 Lakeshore electrification study (project schedule excerpt below) and is also based in large part on the ranking of electrification priorities in the 2010 electrification study. The main deviation from the 2010 electrification study was the Richmond Hill corridor being considered a higher priority than the Barrie corridor, for reasons articulated in chapters 10 and 11. The Stouffville South and Scarborough corridors also deviated from the 2010 electrification study, to a lesser degree, as reasoned in chapters 6 and 7. While this sequence has been used for estimating purposes, policymakers could change the prioritization sequence.

As concluded in the 2010 electrification study, the Lakeshore and Kitchener corridors have been considered as "Phase 1" in this Regional Rapid Rail report, along with the Scarborough corridor since the SRT is a funded project. Because of the inclusion of the Scarborough corridor in "Phase 1," the Stouffville South corridor was also included, given the very short remaining distance to complete that part of the network. "Phase 2" electrification in this Regional Rapid Rail report consists of the balance of the network with the exception of the Stouffville North corridor, and the Barrie corridor north of Bradford, which are considered to be "Phase 3" electrification, and triggered by the existing diesel fleet reaching the end of its economic service life (unless other factors force electrification to be undertaken earlier).

Lakeshore Corridor Electrification - Detailed Implementation Schedule

ID	Task	Dur.	Start	Finish	Pred.
1	Lakeshore Electrification Project	90.75 mo	1/25/2008	1/8/2015	

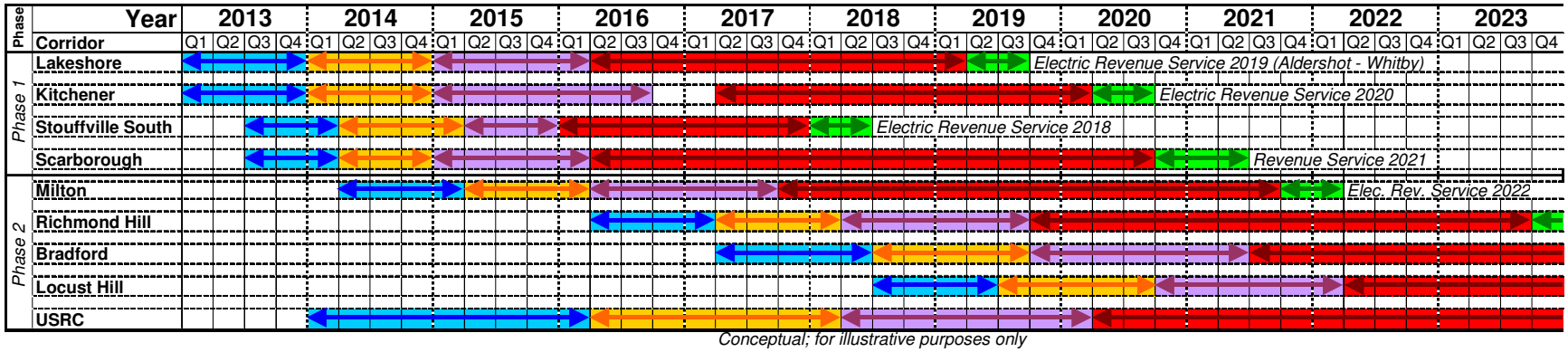


Excerpt from 2008 Lakeshore electrification study – estimated project duration of seven years to electrify the Lakeshore corridor

The time line envisioned in this Regional Rapid Rail report for electric revenue service to be phased in is roughly as illustrated in the following table:

Phase 1			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Stouffville South	Kennedy to Ellesmere	2017	Necessary EA approvals already in place from SRT
	Ellesmere to Unionville	2019	Also includes Scarborough Junction to Kennedy
Lakeshore	Hamilton to Bowmanville	2019	Hamilton (TH&B) may require more construction time
Kitchener	Kitchener to Toronto	2020	Excludes through-routed Pearson service
Scarborough	Ellesmere to Malvern	2021	No factory train – new rapid transit construction
Phase 2			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Milton	Milton to Toronto	2022	Runs to Distillery District east of Union Station
Richmond Hill	Toronto to Richmond Hill	2024	Can alleviate Yonge Subway with additional fleet
Barrie	Bradford to Toronto	2026	Consider reinstatement of line into downtown Barrie
Underground USRC	Parkdale to Riverdale	2027	Surveying, design work, etc. should start as soon as possible
Kitchener	Rexdale to Pearson	2028	Corridor through-routed via Pearson Airport
Phase 3			
Corridor	**Segment**	**Elec. Ops. Start**	**Notes**
Scarborough	Malvern to Locust Hill	2029	New construction connects with Havelock subdivision
Stouffville North	Unionville to Lincolnville	2036	Approximate end of life of current locomotives
Barrie	Barrie to Bradford	2036	Approximate end of life of current locomotives

A project schedule based on the table on the preceding page is illustrated below.



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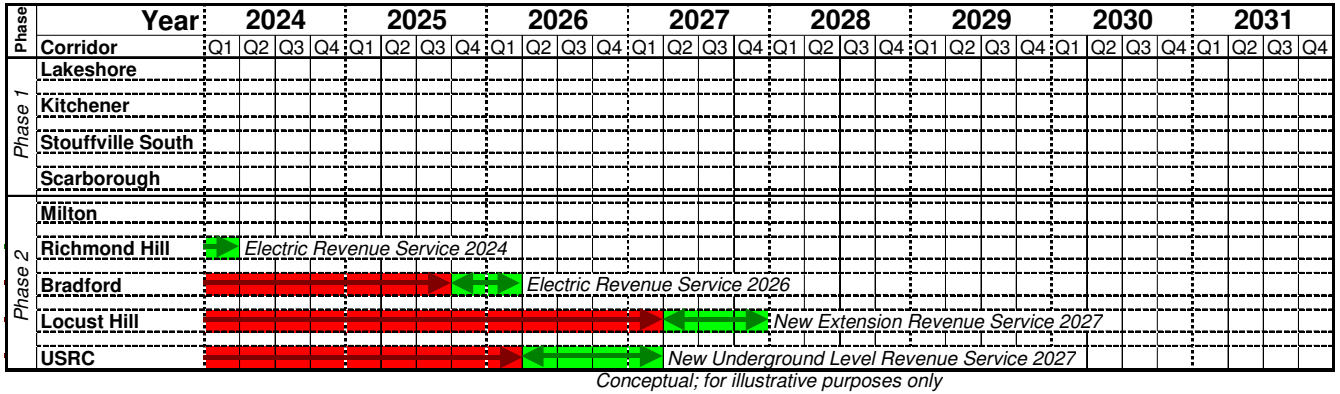


Conceptual; for illustrative purposes only

LEGEND

- Preliminary Design (10%)
- Environmental Assessment (30%)
- Detailed Design and Procurement (100%)
- Execution/Construction
- Commissioning

14. Conclusions

> *Whether through economic losses or infrastructure investment, tens of billions of dollars will be involved in GTHA transportation; the cheaper option is to invest in a timely enhancement of the GTHA's rail network infrastructure – starting now.*

It is widely acknowledged, and supported by numerous opinion polls by sources such as the Pembina Institute, that a major transportation crisis has unfolded in the GTHA. Concerted action on a significant scale is urgently required to stave off enormous annual economic losses in the region, projected to be $15-billion/year by 2031. Effective implementation of *The Big Move* would go a long way towards the significant action needed, particularly with the potential offered by the GO rail corridors and the demand projections that *The Big Move* anticipates for these corridors. *The Big Move* projections for the future of the GO rail lines are ambitious, with some lines being called upon to carry more than 20,000 passengers per hour per direction (i.e. a train every 3½ to 5 minutes).

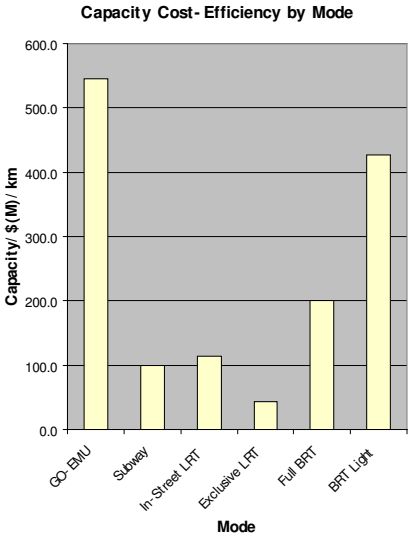
The key conclusion of this Regional Rapid Rail report is that these projections prepared for *The Big Move* can be met if the money required for the prerequisite infrastructure enhancements can be made available, while EMUs would provide the most cost-effective operations. It is worth highlighting that the cost of the GTHA's transportation challenges can either be most economically incurred through an immediate start on infrastructure investment, or incurred later at far greater costs, further burdened with higher operating costs and lower transit ridership resulting from lower service quality. Whether through economic losses or infrastructure investment, tens of billions of dollars will be involved in GTHA transportation. The cheaper option is to invest in a timely, urgent enhancement of the GTHA's rail network infrastructure.

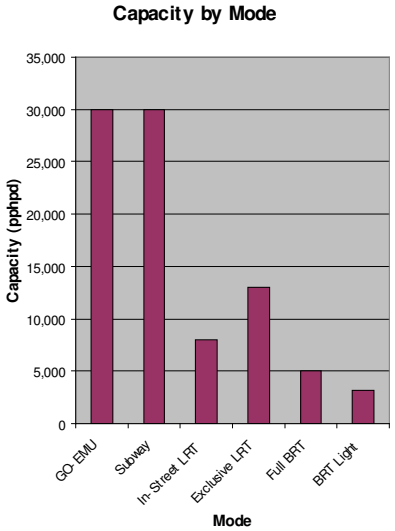
In this Regional Rapid Rail report, the capital cost to provide around 450 route-km of EMU-based GO rail service, offering a peak period capacity of up to 30,000 passengers per hour per direction (pphpd) per track is estimated to be $25-billion, for an average cost of $55-million/km. On a per-passenger basis, this equates to 545 passengers per $M/km. This is extremely cost-effective versus other rapid transit modes of any carrying capacity.

Bus Rapid Transit with continuous dedicated lanes (Full BRT) would incur capital costs of about $25-million/km. Examples vary in cost. The design under construction currently is costing approximately $34-million/km while the Mississauga Transitway project, also under

construction at time of writing, is approximately $14-million/km. Proposals for the Durham-Scarborough BRT and Dundas BRT corridors, both of which did not have funding at time of writing, are also estimated at approximately $14-million/km. BRT can typically carry a maximum of only 5,000-6,000pphpd, unless a more infrastructure-intensive and expensive design such as that of the system in Ottawa is applied. BRT Light, a much cheaper option, provides non-continuous road space for buses, and has a practical capacity of around 3,200pphpd.

Mode	GO-EMU	Subway	In-Street LRT	Exclusive LRT	Full BRT	BRT Light
Capital-$(M)/km	$55.0	$300	$70	$300	$25	$7.5





At-grade Light Rail Transit (LRT) capital costs range from approximately $55 -million to $90-million/km, with a capacity of up to around 7,500-9,500pphpd. If grade-separated at much higher cost, capacity can rise to approximately 11,000-14,000pphpd with 3-car trains. Values vary with the loading standard of the light rail vehicle. Subways with six cars/train (137m-long trains) can carry more than 30,000pphpd, but typically incur capital costs exceeding $300m/km.

Paul Bedford, a former Metrolinx board member and also a former Chief Planner for the City of Toronto, has recently been trying to draw attention to the fact that *The Big Move* will cost much more than the $50-billion originally stated when it was published in 2008. He has suggested that $75-billion would be more realistic. The numbers generated by this Regional Rapid Rail report strongly support Mr. Bedford's warning if the many projects listed in the 25-year plan of *The Big Move* are to be carried through to implementation.

The GO rail system upgrades alone are capable of consuming almost half[6] of the $50-billion that *The Big Move* originally estimated. With other *The Big Move* projects including the *5-in-10* plan, the Downtown Relief Line, and LRT projects in the City of Hamilton and the Region of Peel, very little of the $50-billion capital cost originally estimated would be left for the balance of envisioned projects, consisting predominantly of an array of BRT proposals.

[6] Estimate includes the cost of new underground USRC tracks.

14.1. Inclusion of 2031 in Electric Operations Evaluation a Dramatic Game-Changer

However, a substantial difference in capital and operating cost was found between 2021 and 2031, with nearly system-wide electrified operation costing hundreds of million of dollars less per year than diesel to operate in 2031.

The 2010 electrification study provided significant background material with which to conduct analysis, although its use of 2021 as the reference year in analyzing all technology options resulted in a snapshot of the impacts at the approximate commencement of electrified service. As such, no analysis of the impacts of each technology option over the long-term was included in the 2010 electrification study. This Regional Rapid Rail report has extended this analysis through the 2021-2031 period, and adjusted the methodology to more realistically reflect changing prices over time, particularly energy, which had the most impact. This Regional Rapid Rail report also evaluated an EMU operation with a service model using an optimized schedule, taking advantage of the faster round-trip times of EMUs that would therefore require a smaller fleet.

This Regional Rapid Rail report partly agreed with the 2010 electrification study about the cost savings in 2021, which would be relatively small if the costs of diesel and electric options are compared. However, a substantial difference in capital and operating cost savings was found between 2021 and 2031, with nearly system-wide electrified operation costing **hundreds of millions of dollars less per year** than diesel to operate in 2031. This should raise considerable alarm and spur a greater urgency to electrify immediately, with EMUs being the cheapest option when taking full advantage of their unique versatility when compared with locomotive-hauled options. The estimated annual operating savings over diesel in 2021 for the electric locomotive-hauled option was calculated in this Regional Rapid Rail report to be $56-million in 2010-dollars, which would be about $70-million in 2021-dollars. That estimate excluded the northern portions of the Barrie and Stouffville corridors from the electrified portion of the network. The 2010 electrification study estimated $53-million in annual operating savings over diesel with electric locomotives with the entire network electrified, in 2021-dollars. The two reports were expected to have different figures for reasons outlined in Chapter 4 regarding differences in opinion on methodology.

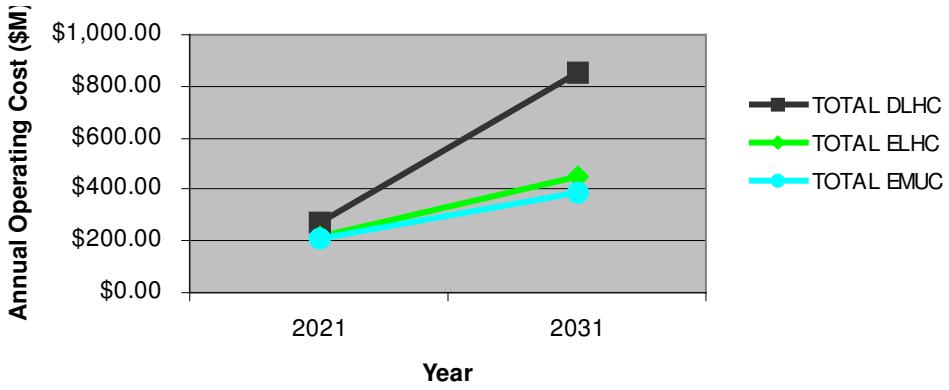
Year	Network Savings ($M/yr)
2021	$50.20
2022	$78.83
2023	$110.84
2024	$161.12
2025	$196.29
2026	$264.72
2027	$305.13
2028	$345.54
2029	$385.95
2030	$426.37
2031	$466.78
2032	$507.19
2033	$547.60
2034	$588.02
2035	$628.43
2036	$668.84

	Network Annual Operating Costs ($M)					
	2021			2031		
Corridor	**DLHC**	**ELHC**	**EMUC**	**DLHC**	**ELHC**	**EMUC**
Lakeshore	$146.74	$110.33	$101.72	$383.64	$183.96	$147.64
Kitchener	$55.09	$46.49	$49.91	$146.88	$89.19	$82.75
Milton	$37.52	$32.99	$40.90	$150.88	$81.75	$84.10
Richmond Hill	$21.37	$20.26	$12.60	$101.66	$71.15	$61.24
Barrie (Off-Peak Fuel $ Only)	$8.24	$3.22	$1.18	$67.91	$23.08	$8.47
TOTAL	$268.96	$213.29	$206.31	$850.97	$449.13	$384.19
Incremental Op-$	$62.66*	$6.99	$0.00	$466.78	$64.94	$0.00

**2021 incremental cost for diesel over EMUs of $62.66-million includes Milton, Richmond Hill, and Barrie, which would not yet be electrified.*

(Note: The 2021 incremental cost for diesel over EMUs would be $50.2-million with only Lakeshore and Kitchener corridors operating with EMUs.)

Total Annual Operating Costs
Comparison 2021-2031



Legend - DLHC: Diesel Locomotive-Hauled Consist; ELHC: Electric Locomotive-Hauled Consist; EMUC: Electric Multiple-Unit Consist

14.2. Sensitivity Analysis

…the enormous risk inherent in choosing to maintain dependence upon diesel motive power.

The analysis in this Regional Rapid Rail report includes some assumptions of future average price trends for operating cost factors such as labour, debt servicing, and energy. These would be affected by non-inflationary factors such as regulatory bodies, geo-political issues as they relate to supply for meeting demand, collective bargaining, among others.

It is known from Government of Ontario statements that electricity rates are expected to rise by an average of eight percent per year over the next 10 to 15 years. If inflation were excluded, the six percent figure used in this Regional Rapid Rail report can be considered reasonable for a projection in 2010-dollars. The 2010 electrification study stated that diesel fuel costs were expected to escalate faster than the cost of electricity, and therefore an average rate of increase of 7.5% per year was considered reasonable, and was duly applied.

A three percent interest rate on public debt was assumed, based on the relatively favourable rates senior levels of government can typically obtain.

Labour wages were assumed to rise one percent above inflation.

Changes to labour and debt servicing costs had very small impacts on the operating costs, particularly in 2031. The impact of energy prices on operating costs, however, had a significant influence, and operating costs were particularly volatile in relation to changes in the price of diesel fuel.

Average Annual Price Increase		Annual Network Operating Savings ($M)	
Diesel	Electric	2021	2031
6%	6%	$43.00	$305.58
6%	7.5%	$37.24	$268.57
6%	9%	$30.61	$219.64
6%	10.5%	$23.00	$155.21
6%	12%	$14.29	$70.69
7.5%	**6%**	**$62.66**	**$466.78**
7.5%	7.5%	$56.89	$429.76
7.5%	9%	$50.26	$380.83
7.5%	10.5%	$42.66	$316.40
7.5%	12%	$33.94	$231.88
9%	6%	$85.57	$682.84
9%	7.5%	$79.80	$645.82
9%	9%	$73.17	$596.89
9%	10.5%	$65.57	$532.46
9%	12%	$56.86	$447.94
10.5%	6%	$112.23	$971.26
10.5%	7.5%	$106.46	$934.25
10.5%	9%	$99.83	$885.32
10.5%	10.5%	$92.23	$820.89
10.5%	12%	$83.51	$736.37
12%	6%	$143.17	$1,354.80
12%	7.5%	$137.41	$1,317.78
12%	9%	$130.78	$1,268.85
12%	10.5%	$123.18	$1,204.42
12%	12%	$114.46	$1,119.90

Debt interest rate and average labour cost increase changes had negligibly small impacts.

It is essential to highlight the sensitivity to the price of diesel fuel, as the price of oil is known to be volatile and therefore difficult to predict. The price of a barrel of oil went up by 550% between early 2002 and early 2012, and gasoline prices in Toronto have doubled over the last ten years, which is equivalent to a 7.5% annual average increase. This is indicative of the enormous risk inherent in choosing to maintain dependence upon diesel motive power. Such a decision could lead to particularly serious consequences if there is a sharp increase in the costs of oil production as new sources becoming increasingly difficult and complex to extract in a safe and environmentally responsible manner. Potential instability of certain major oil producing regions is another factor to consider seriously.

The sensitivity analysis relating to energy costs set out on the previous page supports the contention that the methodology applied in this Regional Rapid Rail report is reasonably conservative, in that it is based upon recent and established trends. This has very serious ramifications for future provincial budgets in the form of subsidies, or for sharp increases in transit fares on the GO rail system. Electrification would offer a safeguard against such volatility.

14.3. How Much Would Electrification Cost in the Grand Scheme of Things?

> *…the capital cost of the "Electrification" category had already been recouped through operating cost savings by 2031, assuming… the GO system predominantly EMU-operated by that time.*

The abridged network-wide capital cost breakdown (in $-millions) for the seven existing GO rail corridors, excluding the Union Station Rail Corridor (discussed separately), is as follows:

Year	to 2021($M)	2021-2031($M)	Total to 2031($M)
Diesel Case	$7,195.73	$4,688.21	$11,883.94
Electrification	$1,617.40	$1,063.92	$2,681.32
EMU Case	$1,698.24	$576.26	$2,274.50
TOTAL	$10,511.37	$6,328.38	$16,839.75

The capital cost calculations for this report were broken down into three common categories. These were the "Diesel Case," "Electrification," and the "EMU Case." The "Diesel Case" covered all fixed infrastructure and fleet costs needed to achieve the projected service levels with diesel locomotive-hauled consists. The "Electrification" costs covered incremental fixed infrastructure costs, as well as the capital cost of the electric vehicles, consistent with the 2010 electrification study. The "EMU case" covered the extra network features that take advantage of what EMUs could offer, such as additional stations, and other needs for meeting service levels that are not part of current plans, including Positive Train Control.

Year	Cumulative Savings ($M)
2021	$50.20
2022	$129.03
2023	$239.87
2024	$400.99
2025	$597.29
2026	$862.00
2027	$1,167.13
2028	$1,512.68
2029	$1,898.63
2030	$2,325.00
2031	$2,791.78
2032	$3,298.97
2033	$3,846.57
2034	$4,434.59
2035	$5,063.02
2036	$5,731.86

By a very wide margin, most of the costs required for the GO system are those associated with accommodating service levels, not for accommodating electric operations. The total cost of "Electrification" is only 18% ($2.7-billion) of the combined "Diesel Case" and "Electrification" categories.

Equally important was the finding that the capital cost of the "Electrification" category had already been recouped through operating cost savings by 2031, assuming the electrification schedule outlined in this report were implemented and the GO system predominantly EMU-operated by that time. Only the Unionville-Lincolnville and Bradford-Barrie segments would still be awaiting electrification. The Hamilton-St Catharines service is assumed to not be electrified due to its low ridership and commensurate service levels. However, a case could certainly be

made for its electrification when the DMUs reach their end-of-life.

The cumulative savings figures in the table on the preceding page were derived by linear interpolation without operating models developed for each year. Consequently, real-world costs would vary with the actual service provided in each year during the 2021-2031 period. In order to provide greater detail, corridor-by-corridor breakdowns for each year have been included in Appendix M.

The capital cost calculations on the preceding page exclude the cost of expanding the Union Station Rail Corridor because that is needed to accommodate forecast service levels in any event. However, such expansion would only be feasible with electrification of at least the Lakeshore corridor. The Scarborough corridor is also excluded from the above calculations as it is not an existing GO corridor, and therefore generates no content under the "Diesel Case" or "Electrification" categories. Also absent due to a lack of information for analysis are the costs of alignment alternatives for the following:

- A new turning track off of the CN mainline just west of Ottawa St N in Hamilton to allow St Catharines rail service to reach the TH&B station, and
- An extension through Barrie north of Tiffin St to the downtown bus terminal.

While the foregoing reflect sound planning principles, evaluations of their costs and benefits would be necessary for their further consideration.

It is important to highlight that fleet requirements will differ with different station combinations throughout the network. Because of the complicated array of possible combinations of stations involved, these calculations have not been undertaken for the purposes of this Regional Rapid Rail report. All fleet costs were based on the simulations run in the 2010 electrification study, and partly on the 2008 Lakeshore electrification study.

Bi-level [Gallery] EMUs provide commuter service on the METRA Electric corridor in Chicago, IL. Photo Credit: Zol87, 2009

Link: http://en.wikipedia.org/wiki/File:93rd_StreetSouth_Chicago_Metra_Station.jpg

Regarding capital cost estimates between now and 2021, there is a great deal of common ground between this Regional Rapid Rail report and the requirements associated with the "Next Wave" of *The Big Move* that was being promoted at time of writing. One element of the comparison that would be necessary to consider is the issue of subway network capacity constraints. The Scarborough GO corridor is particularly relevant to this, as proposals such as the SRT (LRT) that would feed more riders onto the Bloor-Danforth subway would push demand above what it can carry while the Scarborough GO rail corridor proposed in this report would alleviate the Bloor-Danforth subway. As was discussed in Chapter 7, capacity expansion on the Bloor-Danforth subway would be complicated. A value of $1-billion was assigned as a representation of this cost, although this may be understated, and includes a new yard and its connecting tracks, new fleet, and new pocket tracks to enable trippers similar to what is done on the Yonge subway during the morning peak period. Therefore, most of the costs between now and 2021 would not be "new money."

While there is a lack of information publicly available for constructing a comparison over the 2021-2031 period, the costs of proposals in this Regional Rapid Rail report between now and 2021 can be reconciled with the "Next Wave" and the SRT. While the capital cost estimate from not 2021 is $13.2-billion, existing plans and network requirements are worth $11.5-billion, a $1.7-billion difference, as detailed in the following table:

Reconciliation up to Year 2021

GTHA Regional Rapid Rail		The Big Move [Next Wave]			
Item	**Cost ($B)**	**Cost ($B)**	**Item**	**Funding Status**	**Funding Description**
Diesel Case (7 Corridors)	$6.0	$4.9	All-Day 2-Way Service (5 Corridors)	Requested	Funding requested
Lakeshore Electrification	$0.9	$1.7	Lakeshore Electrification	Requested	
Kitchener Electrification	$0.6	$0.9	Kitchener Electrifcation	Requested	
Subtotal	**$7.5**	**$7.5**		Requested	Total funding requested
Scarborough Corridor	$1.7	$1.8	SRT	Committed	Total funding in hand
Subtotal	**$1.7**	**$1.8**			
USRC Expansion	$1.0	$0.0	N/A (1)	None	Need identified in USRC study, but no estimate
Stouffville Electrification	$0.1	$0.0	N/A	None	No corresponding project or plan
Additional Stations, PTC, Misc	$1.7	$0.0	N/A	None	
Pearson Thru-Route	$1.2	$1.2	Air-Rail Link Accommodation (2)	Unidentified Need	Weston S/D 4th trk, fly-over, USRC req.ts, etc. for shuttle
N/A	$0.0	$1.0	Subway Capacity Expansion (3)	Unidentified Need	Various essential projects with no funding identified
Subtotal	**$4.0**	**$2.2**		Unfunded	No funding
Total	**$13.2**	**$11.5**	Total Funding Needs		

Notes:
1. USRC expansion with four underground tracks was recommended in the US & USRC Track Capacity Study
2. Air-Rail Link accommodation is estimated to be expensive to allow co-existence between expanded GO service and ARL service
3. More subway capacity required in the absence of the Scarborough Corridor and existing GO rail corridor capacity-boosting improvements.

14.4. Everything Rides on Union Station

> *…much of what The Big Move envisions… cannot happen without the Union Station Rail Corridor being expanded with a new underground track level across it.*

The vision outlined in this Regional Rapid Rail report, which corresponds with much of what *The Big Move* envisions for the GO rail system as a whole, cannot be achieved without the Union Station Rail Corridor being expanded with a new underground track level across it – that would be exclusive to electric vehicles. Moreover, strategies to disperse demand east-west across the central area in order to avoid overwhelming not only the pedestrian circulation within Union Station itself, but also both the PATH network underground and the downtown sidewalks that encounter frequent signalized crossings that reduce its pedestrian capacity. These facilities will be increasingly important in ensuring a sustainable, growing, and economically vibrant downtown that will continue to be the economic powerhouse of not only the GTHA, but of Ontario as a whole.

14.5. Frequent, Bi-Directional DMU Operations Unacceptable in the Union Station Rail Corridor at Peak Periods

Running DMUs every 15 minutes in both directions would consume disproportionate Union Station Rail Corridor resources at its most constrained point…

The Government of Ontario initiated an environmental assessment (EA) for the electrification of only the Air-Rail Link within an hour of the Metrolinx Board's approval of the 2010 electrification study's Option 3 in January, 2011. While it is agreed that service to the airport should be electrified, this action by the Government of Ontario appears to go against the professional advice it spent $4-million to obtain, as the Air-Rail Link electrified in isolation would offer relatively little benefit for the cost of electrifying it. This is a reasonable assertion in that both the diesel and electric versions of the Air-Rail Link would be Multiple-Unit (MU) operations, offering comparable speed and performance using very short trains on headways of 15 minutes.

The real issue that has not yet been considered relates to the complications that the Air-Rail Link would impose on the Union Station Rail Corridor. Running DMUs every 15 minutes in both directions would consume disproportionate Union Station Rail Corridor resources at its most constrained point (between the Renaissance Hotel and the Metro Toronto Convention Centre North Building), which may compromise the ability of the GO rail system to provide enough service for the people who ride the GO trains to work every day. For this reason, among others that could incur additional costs over time, a transition strategy could be worth considering in an effort to avoid difficult operating complications developing at some point between 2021 and 2031.

Following the aforementioned transition of rail service to the airport away from DMUs, the DMUs purchased for the Air-Rail Link are proposed by this Regional Rapid Rail report to be reassigned to operate between the Hamilton TH&B station and St Catharines (or elsewhere in the Niagara region), as the ridership projections and patterns published in the EA for expansion into the Niagara region would not support full-length GO trains. This would allow the DMU equipment to be re-purposed within the GO system while also being kept away from the Union Station Rail Corridor.

14.6. Reinforcing the Conclusions of Others

The report "No Little Plan"… recommended EMUs for the GO system… This Regional Rapid Rail report strongly agrees…

The report "No Little Plan" by Greg Gormick recommended EMUs for the GO rail system, at an accelerated pace and in concert with an expanded scope of electrification. This Regional Rapid Rail report strongly agrees and provides supporting cost calculations. Both reports come to the same conclusion.

"No Little Plan" used empirical evidence in other jurisdictions to support its position. This was sensible, but was vulnerable to deflection by assertions that the GO rail system is somehow unique. This Regional Rapid Rail report confidently concludes that the GO system is not particularly unique in this respect. For most of the GO rail network, EMUs would be the most efficient and economical choice for the future of GO rail service in the GTHA, and the time to start the transition is now. This will yield enormous savings when 15-minute all-day service is operating on nearly all GO lines in 2031, while recognizing that diesel operation could continue on outlying sections of lower-demand routes until equipment end-of-life. The annual operating cost savings resulting from the use of EMUs instead of diesel locomotives is estimated to be over $465-million dollars (2010-dollars) in 2031. In inflated dollars, a single year of operating cost savings would be over $700-million (2031-dollars) in 2031. Clearly, savings would be very significant, with great implications over the long-term for the financial health of GO/Metrolinx, and for the Queen's Park treasury that subsidizes GO Transit operations. Municipalities in the region would be affected as they also contribute to the GO Transit budget.

This report was released in 2013. While 2031 is 18 years away, it is expected to take at least 15 years to implement an undertaking of this scale. The sooner work begins on transforming the GO rail system to be prepared for projected future demands, the lower the economic losses that could result from either delay or inaction to meet the projections prepared for *The Big Move*.

14.7. Consistent with Analysis Dating Back 40 Years

The similarities between the conclusions in this Regional Rapid Rail report and those in The Case for 'Super GO' were astounding… The Case for 'Super GO' puts EMUs in a very positive light.

The findings of this Regional Rapid Rail report's analysis are not new.

As this report was receiving its final edits, a report from 1974 titled "The Case for 'Super GO'" happened to come by this author through a media source. In 1974, GO rail service on the then-Georgetown corridor had just commenced, and Lakeshore was the only other corridor in the GO rail system then. Even at that time, electrification was being seriously considered at Queen's Park, and the similarities between the conclusions of this Regional Rapid Rail report and those in *The Case for 'Super GO'* are instructive. *The Case for 'Super GO'* was not found online prior to the release of this Regional Rapid Rail report, and has been attached to it as Appendix Z, as it is important material that needs to be part of the debate and would best be in the public realm.

The Case for 'Super GO' put EMUs in a very positive light. On page 47, *The Case for 'Super GO'* stated the following regarding EMUs:

> *If self-propelled, electrified gallery cars are selected, a number of further advantages can be cited, viz, lower crew complement required for GO self-propelled car operation; improved flexibility since quantity of trains is not limited to the number of available locomotives, consists may be enlarged or reduced easily; even greater on-the-road reliability since with many cabs and traction motors, a localized failure will not disable the train; consistency of performance since each car (or pair of cars) has its own complement of traction motors.*

The above was in addition to comments much earlier in the document, on page seven, that framed electrification in general as a key opportunity as it relates to expansion of the system and increasing capacity:

> *In the assessment of equipment for GO operations, the prospect of electrified operation should not be overlooked. With the capital cost of electric rolling stock equivalent to that powered by internal combustion power, the capital cost of erecting catenary and other lineside equipment would appear to return significant benefit in the area of reliability, operating cost and environmental impact.*

The principal thrust of this Regional Rapid Rail report is the same as the above quotes from 1974, the key difference being that the importance of EMUs today has grown significantly since, as there is now a more pronounced capital cost differential between technologies for a very large fleet like GO Transit requires.

The finding of this Regional Rapid Rail report regarding cost relative to subway is also very similar to *The Case for 'Super GO.'* On page seven, *The Case for 'Super GO'* identified the cost of subway as $35- to $50-million per mile ($22- to $31-million per kilometre), while ambitious expansion of GO capacity was estimated to cost $4.7-million per mile ($2.9-million per kilometre). That placed the cost of GO expansion in the range of 9.5% to 13.5% of the cost of subway construction. With today's cost of subway ranging from $325-million per kilometre to $560-million per kilometre, the $55-million per kilometre cost for GO expansion estimated in this Regional Rapid Rail report placed GO expansion in the range of 10% to 17% of the cost of subway. This cross-reference further reinforces the methodology applied in this Regional Rapid Rail report as sound, with the marginally higher percentage range attributed to the underground level required for the Union Station Rail Corridor.

Interestingly, *The Case for 'Super GO'* was also concerned about the stress exerted upon the subway system. Page four states:

> *Improved Lakeshore GO service may provide relief for the Yonge subway congestion south of Bloor. It should be considered as an alternative for improving access to the downtown core from the eastern suburbs.*

The above is applicable not only to the Lakeshore East corridor today, as the Richmond Hill corridor is especially well positioned to provide relief to the Yonge subway if changes and enhancements to its infrastructure were implemented. The Stouffville and Scarborough corridors would be capable of providing relief to both the Bloor-Danforth and Yonge subways.

Positive Train Control, a key feature proposed in this Regional Rapid Rail report for making shorter headways possible, was also loosely discussed in *The Case for 'Super GO'* on page 25, although not by that name. It referred to headways as tight as every two minutes as being feasible on a single GO-exclusive track for Lakeshore GO service. This was apparently based on consultation with the then-Crown corporation CNR. This Regional Rapid Rail report proposed headways only as short as every 3.5 minutes. The proposals for additional stations along the Lakeshore line were also very similar in the two reports. Also on page 25, *The Case for 'Super GO'* expressed a similar planning approach for additional stations in terms of how they relate to feeder bus services:

> *The function of these additional stations would be to improve accessibility of the rail system to the surrounding feeder networks, and stations would be arranged so as to facilitate intermodal transfers.*

A comparison of proposed stations between this Regional Rapid Rail report and *The Case for 'Super GO'* is outlined in the table below:

"Super GO" Station	**Regional Rapid Rail Report Station**	**Location Similarity**
Ford	Sheridan Heights	Identical
Lorne Park	Lorne Park	Identical
Cawthra	Lakeview	Difference within ~800m
Kipling	Alderwood	Identical
Humber	Swansea	Difference within ~1000m
Sunnyside (at Roncesvalles)	*[Concluded not feasible]*	*Not Applicable*
Queen	Riverdale	Difference within ~700m
Coxwell	Leslieville	Identical
Warden	Birchcliff	Difference within ~1000m

The scope of the above table comprises the section of the line through Mississauga and Toronto (Etobicoke and Scarborough inclusive) only.

There are additional stations along the Lakeshore corridor in Halton and Durham regions proposed in this Regional Rapid Rail report that are not listed in the table above, see Chapter 5 for details.

14.8. Actionable Items for an Alternative Course

Certain items in this Regional Rapid Rail report would have a significant impact as it relates to a more sustainable GO rail system being achieved within a reasonable period of time. These are outlined corridor by corridor in the following subsections.

14.8.1. Items of Concern with Network-Wide Implications

Item	Urgency	Alternative	Concern
Existing Diesel Fleet Plan	Currently underway (GO2020 Plan).	Replacement with an EMU-based fleet plan.	Substantial cost increase for transitioning to the most cost-effective EMU-operation if the diesel fleet grows significantly prior to electrification.
EMU Fleet Plan	Long lead time requires ~3 years, including design and development.	Growth accommodated by EMU fleet introduction while diesel fleet maintained and reassigned until sold or retired.	The capital cost of fleet expansion required with diesel expansion could instead be used to absorb the introduction of electric vehicles into the system. This would offer an electrification strategy with the lowest capital cost. It would also offer the greatest overall operational cost-efficiency by electrified operation commencing at the earliest possible date. The current system is at/near capacity on some lines, with large rates of growth projected. As EMUs are introduced to the busiest lines, remaining lines could see expanded service through redeployment of existing diesel equipment displaced by the introduction of electric service.
Whitby Maintenance Facility	Contract being prepared.	Revision of contract parameters.	Substantial cost increase would result for subsequently transitioning to EMU-operation if this facility is initially built for locomotive operations.
USRC Expansion for Underground Track Level	Very complex project with an implementation schedule of over a decade.	Initiation of preliminary planning and design work at the earliest opportunity.	Ridership projections for 2031 prepared for *The Big Move* cannot be accommodated without additional tracks through the Union Station Rail Corridor. Stations at Bathurst St and Cherry St would divert some ridership to ease pedestrian congestion in and around the Union Station complex, including the PATH and Union Station Precinct sidewalk network. Projections prepared for *The Big Move* indicate that both the new lower track level and a new subway through the downtown core of Toronto would be required. An underground track level is estimated in this Regional Rapid Rail report to cost $5.7-billion for the initial 3-track configuration that would be expandable to six tracks as needed with growth over time.

14.8.2. Lakeshore Corridor Items of Concern

Item	Urgency	Alternative	Concern
Hamilton Service	Planning for new Hamilton (James) station underway.	Expansion of the Hunter St tunnel for increased GO rail service to/from the TH&B station.	The Hamilton TH&B station is the ideal location for a Hamilton train station, and the use of Hamilton (James) will not avoid the cost of a rail-to-rail grade separation at Hamilton Junction. Hamilton (James) will be prone to freight train conflicts due to the location and layouts of the nearby Aldershot and Hamilton CN yards. There would not be CP freight traffic conflicts with GO service between the TH&B station and Hamilton Junction if the Hunter St tunnel were expanded.
CN-CP Connection in Durham Region	Environmental Assessment completed.	Re-evaluation of alignment to compare an alternative not previously considered.	The option of reaching the CP line west of Whitby would vastly improve service quality through Whitby and reach a broader cross-section of the intra-regional travel market, with dramatically improved relationships with Durham Region Transit in Whitby.
Scarborough Junction	Service levels matching projected 2031 demand would compromise reliability of northbound at-grade rail-rail crossing movements.	Fly-under for east-to-north train movements through the junction, including a new trenched station platform added to the existing station at this junction.	Northbound Stouffville and future Scarborough trains could see delays due to the combination of revenue Lakeshore trains and non-revenue movements to/from the Whitby yard, as well as VIA Rail Canada traffic that also operates in the corridor. Disruptions to Stouffville and future Scarborough services during peak periods could be severe in the absence of a new grade-separated rail-rail crossing [fly-under] for northbound trains.

14.8.3. Kitchener Corridor (including Airport Service) Items of Concern

Item	Urgency	Alternative	Concern
Airport Rail Service	With a separate rail shuttle service to the airport, medium- to long-term demands would be costly and operationally complex to sustain given the interrelationships between the airport spur, the Weston subdivision, and the Union Station Rail Corridor.	A transition plan that would allow the existing spur to be 85% re-purposed for LRT access to the airport, with a new alignment for GO EMUs through-routed via the airport built to provide a higher level of service to the airport anchor hub.	As designed, the Air-Rail Link service will eventually cause disproportionate resource consumption in the Union Station Rail Corridor, which poses sustainability challenges at that critical and chronically congested point. Other infrastructure investments that could be avoided, including, but not limited to, the fourth track in the Weston subdivision and an additional underground track at Union Station than would otherwise be required, creates many additional but not yet identified costs for the Air-Rail Link service as currently proposed. Among these is an extension of the Etobicoke-Finch West LRT to the airport from Humber College, which could be reduced by re-purposing 85% of the Air-Rail Link spur for LRT. A through-routed GO rail airport option would be roughly equivalent in cost to the current Air-Rail Link proposal over the long-term. Consolidating Kitchener corridor and airport corridor services into a single GO rail service could significantly mitigate Union Station Rail Corridor issues in particular.
St Clair Ave W	Evaluation of options to widen St Clair Ave W at railway corridor by City of Toronto in progress.	Rearrange road/rail configuration with a raised St Clair Ave W between Keele St and Old Weston Rd passing above lowered GO Weston and CP MacTier subdivisions.	Grades for the streetcar service, road vehicles, and GO services would improve with this layout. CP freight operations, to a lesser degree, should also benefit. The new layout would enable an integrated station for GO and 512 streetcar service at a location where a streetcar stop is not possible by rail corridor in the existing road/rail configuration. The new road/rail configuration would also provide reconnections within the local street grid in the immediate rail corridor vicinity to improve urban form.
Etobicoke North / Rexdale	Detailed design underway.	Relocation of the existing Etobicoke North station to Islington Ave [Rexdale] in lieu of relocation to the west side of Kipling Ave.	Superior GO station location at Islington Ave given possible connections with both GO and non-GO bus services, and sources of local walk-in traffic not far from this location. The Islington Ave location is also more convenient to access for park'n'ride users.
Continuous Third Track through Brampton	Busy CN mainline at the busiest GO station on the Kitchener corridor.	Initiating design and environmental assessment work for the Brampton GO/VIA station to receive a third track.	Reliability of GO service would be compromised without a dedicated, continuous CN track through Brampton as CN is owner of the right-of-way and CN trains will therefore have priority over GO trains. The Brampton GO/VIA station is on CN's Halton subdivision that by-passes Toronto to the north. The third track is achievable using mostly GO parking lot lands.

14.8.4. Scarborough Corridor Items of Concern

Item	Urgency	Alternative	Concern
SRT Environmental Assessment (EA)	Approved and funded project.	Amendment to the EA for the use of GO EMUs in lieu of LRVs.	The LRT option would be at high risk of facing a capacity shortfall, with a projected demand of 10,000ppdph in 2031 while the practical capacity of the LRT is 12,000-14,000ppdph. The maximum capacity with GO EMUs greatly exceeds that of the proposed LRT. GO EMUs offer significantly greater efficiency of resources, improved network dynamics, and more attractive trip patterns that will yield benefits to other lines currently nearing capacity, notably the Danforth subway line. It would also provide some alleviation of the overcrowded southern section of the Yonge subway line.
Proposed Locust Hill Service in *The Big Move*	Original proposal would face major obstacles with Ottawa area CP trackage now removed.	Extension of the new Scarborough subdivision north from Malvern to connect with the Havelock subdivision between McNicoll and Passmore Aves.	The disappearance of the CP line west of Ottawa through Pembroke and Renfrew complicates the proposal for operating GO rail on the busy CP main line corridor and through the CP Toronto yard. Peak period rail traffic congestion at Union Station would also be complicated via the Don Branch. The Scarborough GO rail corridor option avoids the busy CP line in favour of a dedicated and GO-owned corridor, providing an alternative to a plan that may no longer be viable, and aligns with known transportation patterns. It would also lower the operating costs of serving Locust Hill, as it would be an extension of the higher-demand Scarborough line rather than a net new line. Congestion from Locust Hill trains in the Union Station Rail Corridor would be mitigated by approaching Union from the Lakeshore East corridor.

14.8.5. Milton Corridor Items of Concern

Item	Urgency	Alternative	Concern
Rail-to-rail grade separation	The CP Obico yard is expected to be sold soon.	A rail-rail grade separation location that allows easy access to the Obico site on the south side of the Galt subdivision.	Non-revenue passenger trains moving in or out of the yard would conflict with CP freight traffic if the grade separation is located by Scarlett Rd as the Reference Case proposed. A location further west would also allow a GO station at Islington (relocated from Kipling) to be located on the south side of the corridor, which has design advantages for a multi-modal hub with GO rail, the Bloor-Danforth subway, and bus services.

14.8.6. Richmond Hill Corridor Items of Concern

Item	Urgency	Alternative	Concern
Doncaster Diamond	Design under development.	Incorporation of a new Thornhill GO station in the design of the new rail-to-rail grade separation.	There will not be an opportunity to add a Thornhill GO station later. Such a station in the John St/Bayview Ave area would have to be incorporated into the design of the rail-to-rail grade separation in order to be viable. It is not feasible to grade-separate and provide the new station as separate initiatives without incurring a prolonged period of severe service disruption.
Don Branch	Initiative is long overdue.	Utilization of the Don Branch alignment between Gerrard St E and Lawrence Ave E via a new connection between the Belleville and Bala subdivisions north of Wynford as per the LEA/Cansult 2005 proposal.	The route via the Don Branch is almost 1km shorter, and straighter. The latter would allow for higher speed along the line compared to the current line that has many curves. The Don Branch would create the opportunity for two new station locations to improve attractiveness of service, potentially including a viable connection to the Eglinton-Crosstown LRT at Leslie/Eglinton.

14.8.7. Barrie Corridor Items of Concern

Item	Urgency	Alternative	Concern
Davenport Diamond	The CP mainline at-grade rail-rail crossing would create conflicts with GO rail service, negatively impacting GO rail service reliability.	A comprehensive corridor design to incorporate a subway connection at the Bloor/Lansdowne station and create/improve links between the east and west sides of the rail corridor in the local area.	This neighbourhood has a complex history, and while fortunes are starting to change, investment in the local community is needed. The potential for urban form enhancements in this area is unusually significant, including the opportunity to partially “repair” the “isolated” stretch of Bloor St W around the intersection with Symington Ave, which is sandwiched between two railway underpasses. A holistic design would enhance community synergies, improve quality of place, stimulate “smart growth” opportunities around heavy transit infrastructure, and expand multi-modal travel options.

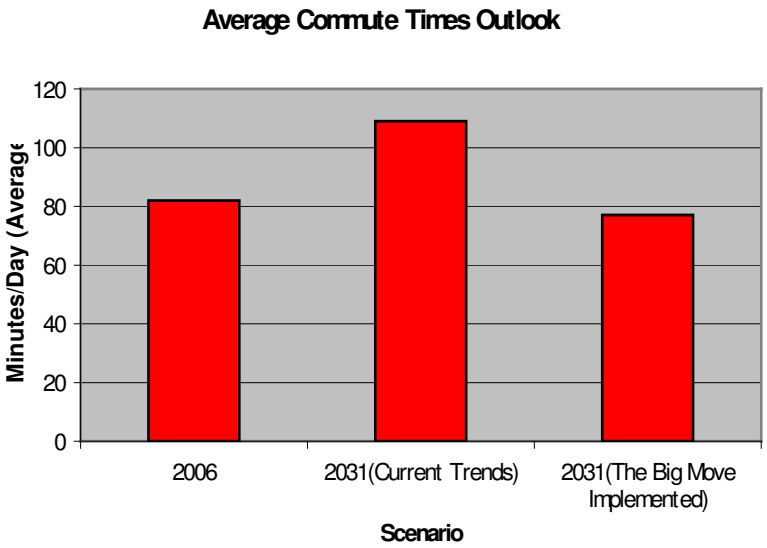
14.9. Serious Consequences for Inaction

If there is prolonged inaction on meaningful investment in the GTHA's rail infrastructure, it will negatively impact its competitiveness with other regions in Ontario, Canada, and internationally.

There has not been much discussion in terms of the risks of failing to bring the GTHA's transportation infrastructure up to a standard that would keep up with the demands resulting from forecast population and employment growth in the region. While *The Big Move* presented an estimate of the projected increase in average commute times if "Business as Usual" prevailed, the number was somewhat abstract in the way it has been presented, as it grouped all trip lengths and all modes into a single average. As such, the meaning of this average value is not well understood by the general public.

The fundamental question is "Will businesses and residents put up with such long commutes?" The answer to that question cannot be given with any certainty, but what happens if "No" is the answer? This is what must be avoided. Average commute times are already harming the region's economic competitiveness.

The Mayor of Mississauga, once appearing as a guest at a Metrolinx Board meeting and invited to speak at that meeting, spoke of her observations that traffic in Mississauga was already so congested that employers were starting to decamp to regions like Waterloo, and urged Metrolinx to take action on the implementation of alternative revenue tools so that more projects could be undertaken expeditiously. The prolonged absence of predictable, sustainable funding from senior levels of government for transportation infrastructure has left planners across the region unable to effectively do their jobs over a period of several decades, because they have not had any assurance that the money would be available for what they knew to be the best course of action.



Graph created by numbers published on p.59 of The Big Move.

Now the consequences of that absence of funding, compounded over the decades, are unsurprisingly coming to a head. If there is prolonged inaction on meaningful investment in the GTHA's rail infrastructure, it will negatively impact its competitiveness with other regions in Ontario, Canada, and internationally. Queen's Park frequently reiterates the existing commitments in GTHA transit totaling $16-billion as the largest in Ontario history. However, in the context of three decades' worth of required catch-up (not to mention inflation), $16-billion does not go as far as one might wish, particularly when underground infrastructure projects are involved. To ensure the GTHA stays competitive, additional investment by Queen's Park will be required, most likely achieved by means of new revenue mechanisms. If Queen's Park is unable to make further investment, businesses might prefer locations such as London, Kitchener, Ottawa, or out of province, and if they do, they will take population and income growth with them. Such a pattern could be expensive, as it will inherently favour a low-density growth model that is known to incur high service costs per citizen.

It is vital that the GTHA continue to be a choice location for population and employment growth so that its concentration can continue to support more sustainable development patterns and curb urban sprawl. There is a need for the benefits from economies of scale to be captured by cash-strapped municipal governments, which generally do not have many taxation powers beyond the property tax. The GO rail system will be key to making that happen, and EMUs will allow the GO rail system to do more with less.

14.10. In Closing

…the selection of EMUs as the preferred electric vehicle technology would clearly be the soundest policy going forward, if not the only practical option going forward…

The GO rail system is the best transportation resource the GTHA has, but it can be much better. The system clearly has enormous potential, especially with EMUs (the most cost-effective option), if Queen's Park decides to invest in that system. There has to be dedicated, visionary leadership at Queen's Park that is prepared to invest in the foundations needed for the GTHA region's economy to thrive. An EMU-operated GO rail network, with new underground tracks added through the Union Station Rail Corridor, will provide the means to absorb the projected growth to 2031 and beyond. It will provide enough flexibility to last for generations.

Revolutionizing the GO rail system by enhancing its infrastructure for improved service levels combined with a transition to EMUs would be the most significant transit undertaking since the 1960s, when Premier John Robarts's leadership (1961-1971) resulted in the debut of GO train service between Pickering and Oakville (and envisioned GO service to reach Burlington, even when first announced in 1965).

It was also the Robarts era that significant expansion of the TTC subway system occurred. In late 1962, Queen's Park guaranteed a loan for then-Metropolitan Toronto to assist with the construction of the Bloor-Danforth subway from Keele to Woodbine, which was instrumental in bringing forward the opening date of that section from 1969 to early 1966.

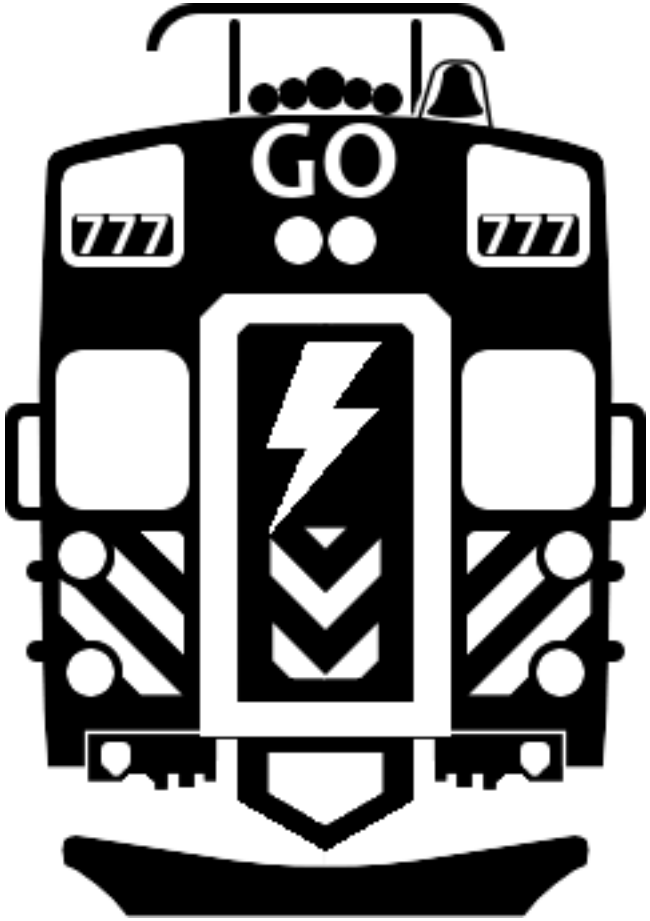
That support for public transit infrastructure generations ago enabled this region to prosper for over four decades, and sets a very important precedent that demonstrates that it is possible for the Ontario Legislature to enact and enable transformative change that will last generations. The infrastructure that resulted is now operating close to capacity and urgently requires new investment for the next generation and beyond. Who will provide that needed leadership?

To varying degrees, the Kitchener, Milton, and Lakeshore lines are all positioned to contribute to alleviation of the Bloor section of the Bloor-Danforth subway. The Milton line is particularly noteworthy in this respect. In addition, the Richmond Hill line, and to a lesser extent the Stouffville line, could contribute towards alleviation of the overstressed Yonge subway. The new Scarborough corridor proposed in this Regional Rapid Rail report, and to a lesser extent improvements to the Lakeshore line, could modestly but meaningfully alleviate the Danforth section of the Bloor-Danforth subway.

The GO rail system needs to function as a network not only in terms of its own lines, but through greatly enhanced coordination with the transit lines operated by other agencies, as it is critical to reduce the reliance the GO rail system has on increasingly scarce and costly parking, particularly at stations in the “905 belt.” The problems facing the subway network in Toronto should matter to the operators of the GO rail system, as the two have a common interest, and can offer benefits to one another that gets more value out of each unit of resource supplied by either or both systems. The same applies to the bus systems. In short, a greater degree of integration and coordination of services between GO rail and other public transit services throughout the GTHA region is important to the success of the regional transit system as a whole.

It is physically feasible to make this transformation in GO service happen if the leadership at Queen's Park is seriously committed to keeping the GTHA the envy of most other regions across North America – as Premier Robarts demonstrated a generation ago. Transportation has been clearly identified as the current “Achilles heel” of the region, and it will be up to Queen's Park to restore the once exemplary success of our regional transportation system. EMU operation will be critical to making that happen for the GO rail system. The analyses in this report demonstrate without a doubt that the selection of EMUs as the preferred electric vehicle technology would clearly be the soundest policy going forward, if not the only practical option going forward, given the projected demands.

If that transformation takes place, there could be a redux wherein transit experts will once again come to Ontario to see how transit should be done, like they did decades ago. Will Queen's Park lead, and help secure the requisite funding and legislative support? The region's future depends on it.



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APPENDICES OVERVIEW

APPENDIX ID	Title	Description
APPENDIX A	Vehicle Unit Costs & Standard Metrics	Lists the various unit costs (capital and operating), some of which vary by year, and typical metrics used for various calculations in many of the other appendices
APPENDIX B	Vehicle Weights Summary	Provides a detailed breakdown of weight components for passenger rail vehicles, serving as an important basis for calculating ton-mileage between technologies.
APPENDIX C	Reference Case Schedules	Provides distances, travel times, and fuel consumption for all trips by each technology, as provided in Metrolinx's Reference Case (except for the Stouffville corridor).
APPENDIX D	Reference Case Fuel Consumption	Reproduces the fuel calculations provided in the Reference Case, and lists deviation. This appendix verifies the reproduction of the Reference Case Schedules' data.
APPENDIX E	2010 Electrification Study Fleet Figure Adjustments	Corrects the difference between the actual existing GO fleet and the Reference Case fleet Metrolinx used in its electrification study, which did not match (but should have).
APPENDIX F	Current GO Fleet Composition	Detailed breakdown of the existing GO coach fleet. This data has been assembled to understand when rebuilds and retirements will occur and their impacts on costs.
APPENDIX G	EMU Detailed Scheduling Data	Details differences along Lakeshore, Georgetown, Milton, and Richmond Hill corridors between an EMU operating case optimized for that technology from the Reference Case that was designed for diesel LHCs.
APPENDIX H	2021 EMU Equipment Cycling	Demonstrates the equipment cycling of EMU operation on a network with Lakeshore, Georgetown, Milton, and Richmond Hill lines.
APPENDIX I	2031 Peak Demand	Projects the required fleet expansion between the Metrolinx electrification study's Reference Case and the 2031 projections in *The Big Move*.
APPENDIX J	Capital Costs of Rolling Stock	Determines the costs of Rolling Stock for 3 technology options on the Lakeshore, Georgetown, Milton, and Richmond Hill lines, including the relationship to existing fleet. The calculations are done for both 2021 and 2031 fleet requirements.
APPENDIX K	Electricity Demand Charges	Calculates the peak power draw and electricity demand charges per corridor by technology.
APPENDIX L	Annual Electricity Cost Calculations	Calculates electricity consumption costs per corridor by technology and operating model, broken down by ton-miles; includes regenerative braking and annual kWh calculations.
APPENDIX M	Annual Operating Costs	Calculations for total operating costs by technology, including labour, energy, vehicle upkeep, and debt servicing costs, for both 2021 and 2031, along Lakeshore, Georgetown, Milton, and Richmond Hill lines..
APPENDIX N	Lakeshore Fixed Infrastructure Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the Lakeshore corridor.
APPENDIX O	Stouffville Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the southern Stouffville corridor.
APPENDIX P	Scarborough Costs	Detailed breakdown of costs for new Scarborough corridor (& vehicles)
APPENDIX Q	Kitchener Fixed Infrastructure Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the Georgetown corridor.
APPENDIX R	Milton Fixed Infrastructure Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the Milton corridor.
APPENDIX S	Richmond Hill Fixed Infrastructure Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the Richmond Hill corridor.
APPENDIX T	Barrie Fixed Infrastructure Costs	Detailed breakdown of costs for fixed [immobile] infrastructure elements along the Richmond Hill corridor
APPENDIX U	USRC Fixed Infrastructure Costs	Breakdown of estimated costs for conceptual Union Station Rail Corridor underground level complete with shoulder stations, etc.
APPENDIX V	Network Cost Summary	Summary of all lines' overall costs for 2021 and 2031 horizons
APPENDIX W	Station Index	Complete index of all existing and proposed new stations, with details
APPENDIX X	Drawings	Drawings for the Lakeview GO station, the Scarborough corridor west of Malvern, and the USRC.
APPENDIX Y	Milton Service Simulation	Simulation of different technologies and station combinations for trip times along the Milton corridor.
APPENDIX Z	The Case for 'Super GO' (1974)	1974 analysis of electrification options for the Ontario Ministry of Transportation and Communications.

Appendix A: Vehicle Unit Costs & Standard Metrics

APPENDIX A

Vehicle Unit Costs & Standard Metrics

Vehicle Unit Costs

Vehicle (Model/Manufacturer)	Capital $	Annual Maintenance $	Spare Ratio	Source	Notes
Diesel Locomotive (MP40)	$7.82	$0.2837	16%	Metrolinx	
Electric Locomotive (ALP-46A)	$11.20	$0.2438	16%	Metrolinx	2
Single-Level DMU (Sumitomo)	$4.58	$0.2830	20%	Metrolinx	3
Bi-Level EMU (Bombardier?)*	$4.20	$0.3040	15%	Estimated	2
Bi-Level Coach (Bombardier)	$2.74	$0.1391	5%	Metrolinx	1
Bi-Level Cab Car (Bombardier)	$3.06	$0.1694	10%	Metrolinx	1
Cab Car Conversion for Elec. Loco.	$0.015	n/a	n/a	Metrolinx	

Note 1: Spare Ratio from 2008 Hatch Mott MacDonald report on Lakeshore electrification prepared for GO, inflated by 25%

1a: As per Section 8.4 of Appendix 8B in the electrification study, Metrolinx did not assign a spare ratio to coaches, and the cab car spare ratio assigned was excessive;
25%-inflated Hatch Mott MacDonald ratios from 2008 used for cabs and coaches instead.

Note 2: Capital and maintenance cost derived from Metrolinx statements on EMUs in electrification report:

2a: Capital cost 40% higher - Believed to represent cost of an all-EMU 12-car train.
2a(i): $11.20 * 1.16 (spare ratio) + $2.74 * 9 + $3.06 * 1.16 (spare ratio) = $41.2 for a 10-car electric locomotive train.
2a(ii): $4.2 * 1.15 (spare ratio) * 12 = $57.96 for a 12-car all-EMU train.
2a(iii): $54.36 / $38.92 = 1.39; 12-car all-EMU train has ~40% higher capital cost than 10-car electric locomotive train.

2b: 2.5 more expensive to maintain over the 30-year lifecycle - Believed to represent cost of an all-EMU 12-car train.
2b(I): $0.2438 * 1.16 (spare ratio) + $0.1391 * 9 + $0.1694 * 1.16 (spare ratio) = $1.7312/yr on average for 30 years.
2b(ii): $0.3040 * 1.15 (spare ratio) * 12 = $4.1952/yr on average for 30 years.
2b(iii): $4.1952 / $1.7041 = 2.4618; EMUs almost 2.5 times as expensive on average for 30 years.
2b(iv): On a 1:1 replacement ratio, EMUs' annual energy costs are 0.036 times higher than electric locomotives

2c: Metrolinx workshop#4 stated 50/50 composition between powered/unpowered cars in a 12-car EMU train, or 6 of each, yet statements on EMU costs published in the electrification study only seem to make sense with all 12 cars powered. Additionally, the comparison between EMU and electric locomotive technologies appears to have taken place on a 1:1 basis, which fails to take advantage of the faster speeds EMUs provide as it relates to equipment cycling and fleet size.

2d: Spare ratio for electric locomotives should be less (~12.5%?), but is left as published for consistency and comparability.

Note 3: Capital cost based on DMU contract signed after electrification study. Electrification study figure was $4.03-million. Contract was for 12 DMUs at a value of $55-million, or $4.58-million each.

APPENDIX A

Vehicle Unit Costs & Standard Metrics

Composition of Trains

Vehicle Type	DMU	DLHC/ELHC	EMU	Notes
Total Cars in Consist	2	11	12	As per Metrolinx
Powered Cars in Consist	2	1	6	As per Metrolinx
Trailers in Consist (no cabs)	0	9	6	As per Metrolinx
Trailers in Consist with Cabs	0	1	0	As per Metrolinx
Electric Propulsion (hp)	n/a	6,340	6,438	As per Metrolinx
Regenerative Braking*	n/a	15%	20%	See note below

**Applies to electric vehicles only, before demand charge*

Note: 15% for ELHC as per Metrolinx, 20% for EMU based on following from www.railway-energy.org:

> *Generally, EMUs have a better regenerative braking performance than loco-hauled trains, since more axles are powered. The higher the motor power and the more axles are powered, the more energy may be recovered.*

Rebuild Cost and Vehicle Sale Values

Vehicle	Rebuild	Sale in 2021	Source
Diesel Locomotive	$2.00	($1.51)	HMM 2008 Lakeshore EStudy
Bi-Level Coach Trailer	$0.66	*($0.45)*	Rebuild: 2009 ONR contract
Bi-Level Cab Car	$0.70	*($0.49)*	Rebuild: 2009 ONR contract

Sale values of coaches and cab cars were assumed at 20% of their Metrolinx-published base cost.
Diesel locomotive 2021 sale value based on HMM's 5%/year straight-line depreciation assumption.
(the MP40s would be approaching 15 years of age in 2021, value based on a base cost of $6.02-million; new MP40s are purchased with an extended cost of $7.82-million, but extended costs cannot be resold)
Metrolinx's 2010 electrification study assumed $1-million sale value for MP40s, but used longer timelines.

Positive Train Control (PTC) - On-Board Equipment

Cost per Powered Vehicle: $0.1 million

PTC requires, in the case of LHCs, all locomotives (including spares) to have on-board PTC equipment.
For EMUs, all powered cars, or all cars with a driver's cab, must have on-board PTC equipment.

Vehicle Unit Costs & Standard Metrics

Standard Metrics

Metric	Value	Unit	Notes
Annual Weekdays	250	Days/Year	As published by Metrolinx
Annual Weekend Days & Holidays	115	Days/Year	As published by Metrolinx
Assumed Weekday Peak Hours	7	Hours/Day	3hrs in AM, 4hrs in PM
Assumed Weekday Off-Peak Hours	14	Hours/Day	Operate 5AM-2AM, less peak
Assumed Weekend Off-Peak Hours	18	Hours/Day	Operate 7AM-1AM
Crew per Train	2	Staff/Consist	Assumed future standard
2011 Wage (Train Operator)	$42.78	$/hr	As in TCRC-Bombardier CBA
2011 Wage (Cust. Serv. Ambass.)	$22.36	$/hr	As in TCRC-Bombardier CBA
Average 2011 Crew Wage	$32.57	$/hr	Assume same for bus drivers
Assumed Value of Benefits	70%	of and added to wage	*Assumption*
All-in Assumed 2011 Wage	$55.37	$/hr	Base and benefits total
Annual Wage Hike	1%	After inflation	*Assumption*, inflation negated
All-in Assumed 2021 Wage	$61.16	$/hr	Base and benefits total
All-in Assumed 2031 Wage	$67.56	$/hr	Base and benefits total
2009 Cost of Fuel	$0.75	/L	As published by Metrolinx
Assumed 2021 Cost of Fuel	$1.79	/L	*Assumed annual rise of 7.50%*
Assumed 2031 Cost of Fuel	$3.68	/L	*Assumed annual rise of 7.50%*
Gallons per Litre	4.546	g/L	As published by Metrolinx
Hotel Power	20%	Additional diesel use	As published by Metrolinx
Power Factor	98%	of power draw (W)	As published by Metrolinx
Watts per hp	746	W	Physics
Demand Charge	$5.41	/kVA @ Peak 1-hour avg.	As published by Metrolinx
Transformer Discount	$0.60	/kW	IESO, used in Demand Charge
Net 2010 Cost of Electricity	$0.00756	/Ton-Mile	Metrolinx; Includes Demand $
2010 Electricity Consumption $	$0.0855	/kWh	As published by Metrolinx
2021 Electrictiy Consumption $	$0.162	/kWh	*Assumed annual rise of 6.00%*
2031 Electrictiy Consumption $	$0.291	/kWh	*Assumed annual rise of 6.00%*
Assumed Bond for Capital Debt	30	-year bond	Principal repaid over 30 years
Interest Charge on Capital Debt	3%	/Year	Bank of Canada 2011 prime rate
Contingency	35%	of infrastructure capital $	1 of 2 values used by Metrolinx

Appendix B: Vehicle Weights Summary

APPENDIX B

Vehicle Weights Summary

Model or Element	Weight	Unit	Source	Notes
Locomotive Weights				
Diesel Tier 2	129	tons	2010 Electrification Study	As published in the 2010 electrification study
Diesel Tier 4 (w/Fuel)	186.5	tons	Trinity Railway Express (Austin, TX)	Coach weight in calculation from Trinity Railway Express
No. 2 Diesel Fuel	0.85	kg/L	Various	
Fuel Load (8410L)	7.1	tons	Derived	Fuel capacity of 8410L published in the 2010 elec. study
Tier 4 Add-on Equip.	50.4	tons	Derived from 2010 e-study figures	
Electric Locomotive	90.2	tons	2010 Electrification Study	2010 electrification study Appendix 7 states 198,400lbs
Passenger Weights				
Average Passenger	77.9	kg	Derived from 2010 e-study figures	
Capacity/Train	1540	/train	2010 Electrification Study	
Loaded Difference	120	tons	Derived from 2010 e-study figures	
Coach Weights				
Empty	49.5	tons	2010 Electrification Study	As published in the 2010 electrification study
Capacity	156	riders	Derived from 2010 e-study figures	154 stated as an average, but included cab car
Loaded	61.7	tons	Derived from 2010 e-study figures	(Series IV model coaches have 156 seats)
Cab Car Weights				
Empty	55.5	tons	Trinity Railway Express (Austin, TX)	122,000lbs, GO Transit source not found
Capacity	136	riders	Various cite 136 as lowest capacity	Believed to be Series III model
Loaded	66.1	tons	Derived from preceding 2 figures	Trinity Rail Express cars bought used from GO in late 1990s
EMU Weights				
Empty	60.9	tons	Metra Highliner (Chicago, IL)	134,000lbs (assumed nearest match for comparison)
Capacity	101	riders	Assumed	Based on 12-car train capacity of 1,540, as per Metrolinx
Loaded	68.8	tons	Derived from preceding 2 figures	2010 study's 121,254lbs was lighter than cab car; not used
Diesel Locomotive-Hauled Consist Weights				
Empty	687.5	tons	2010 Electrification Study	As published in the 2010 electrification study
Loaded	807.5	tons	2010 Electrification Study	As published in the 2010 electrification study
Electric Locomotive-Hauled Consist Weights				
Empty	591.1	tons	Derived (see Note)	Replaced diesel locomotive with electric locomotive
Loaded	711.1	tons	Derived (see Note)	Replaced diesel locomotive with electric locomotive
EMU Consist Weights				
Empty	662.5	tons	Derived (see Note)	Composed of 6 EMUs and 6 Coaches
Loaded	782.6	tons	Derived	12-car train capacity of 1,542

Appendix C: Reference Case Schedules

APPENDIX C

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

LAKESHORE TRIP QUANTITIES (REFERENCE CASE)

Lakeshore West - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
St Cats	Union	Yes	2	71.2	142.4	153.8	307.6	1:59	1:51	0:08	1:39	0:20
St Cats	Union	Yes (Exp.)	2	71.2	142.4	137.8	275.6	1:42	1:35	0:07	1:28	0:14
Hamilton (James)	Union	Yes	38	39.3	1493.4	106.46	4045.518	1:15	1:09	0:06	0:58	0:17
Hamilton (TH&B)	Union	Yes	2	39.9	79.8	105.8	211.6	1:16	1:09	0:07	0:59	0:17
Hamilton (TH&B)	Union	Yes (Exp.)	2	39.9	79.8	89.8	179.6	0:58	0:54	0:04	0:48	0:10
Aldershot	Union	Yes (Exp.)	2	34.6	69.2	79.4	158.8	0:45	0:41	0:04	0:36	0:09
Oakville	Union	Yes	4	21.4	85.6	58	232	0:41	0:38	0:03	0:32	0:09
Union	Oakville	Yes	4	21.4	85.6	59	236	0:37	0:34	0:03	0:29	0:08
Union	Aldershot	Yes (Exp.)	2	34.6	69.2	83	166	0:46	0:42	0:04	0:37	0:09
Union	Hamilton (TH&B)	Yes (Exp.)	1	39.9	39.9	93.6	93.6	0:59	0:54	0:05	0:48	0:11
Union	Hamilton (TH&B)	Yes	3	39.9	119.7	108	324	1:15	1:09	0:06	0:59	0:16
Union	Hamilton (James)	Yes	38	39.3	1493.4	105.31	4001.78	1:11	1:05	0:06	0:55	0:16
Union	St Cats	Yes (Exp.)	2	71.2	142.4	141.8	283.6	1:42	1:35	0:07	1:28	0:14
Union	St Cats	Yes	2	71.2	142.4	158.5	317	1:59	1:51	0:08	1:39	0:20
AM DEPLOYMENT		**REVENUE TOTAL**	**104**	**n/a**	**4185.2**	**n/a**	**10832.698**	n/a				
Stoney Creek	Hamilton (James)	No	6	3.7	22.2	2	12					
Stoney Creek	Aldershot	No	2	8.4	16.8	13	26					
Hamilton THB	Hamilton THB	No	4	0	0	0	0					
St Cats	St Cats	No	4	0	0	0	0					
Willowbrook	Oakville	No	4	14.7	58.8	41.4	165.6					
MIDDAY STORAGE		**DEPLOY TOTAL**	**20**	**n/a**	**97.8**	**n/a**	**203.6**					
Union	Don	No	7	1.5	10.5	1.6	11.2					
Union	Whitby	No	4	28.83	115.32	77	308					
Whitby	Union	No	4	28.83	115.32	77.5	310					
Don	Union	No	7	1.5	10.5	2.1	14.7					
PM RETURN TO YARD		**STORAGE TOTAL**	**11**	**n/a**	**251.64**	**n/a**	**643.9**					
Oakville	Willowbrook	No	4	14.7	58.8	40.7	162.8					
Hamilton (James)	Stoney Creek	No	6	3.7	22.2	4.45	26.7					
St Cats	St Cats	No	4	0	0	0	0					
Hamilton THB	Hamilton THB	No	4	0	0	0	0					
Aldershot	Stoney Creek	No	2	8.4	16.8	12.4	24.8					
		RETURN TOTAL	**20**	**n/a**	**97.8**	**n/a**	**214.3**					

Orange-shaded trips have their non-Union terminus in unelectrified territory in the Reference Case and as such remian deisel in the Reference Case model

APPENDIX C

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

Lakeshore East - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
Bowmanville	Union	Yes	2	42.98	85.96	110	220	1:21	1:15	0:06	1:05	0:16
Bowmanville	Union	Yes (Exp.)	4	42.98	171.92	94.7	378.8	1:05	0:59	0:06	0:54	0:11
Oshawa	Union	Yes	39	36.28	1414.92	95.35	3718.65	1:08	1:03	0:05	0:55	0:13
Whitby	Union	Yes	1	28.83	28.83	77.6	77.6	0:55	0:51	0:04	0:44	0:11
Pickering	Union	Yes	3	20.93	62.79	56	168	0:42	0:39	0:03	0:34	0:08
Union	Pickering	Yes	2	20.93	41.86	55.2	110.4	0:40	0:37	0:03	0:32	0:08
Union	Whitby	Yes	3	28.83	86.49	77	231	0:53	0:49	0:04	0:42	0:11
Union	Oshawa	Yes	38	36.28	1378.64	96.32	3660.16	1:07	1:01	0:06	0:53	0:14
Union	Bowmanville	Yes (Exp.)	3	42.98	128.94	102.2	306.6	1:06	0:59	0:07	0:54	0:12
Union	Bowmanville	Yes	3	42.98	128.94	116.4	349.2	1:23	1:15	0:08	1:05	0:18
AM DEPLOYMENT		**REVENUE TOTAL**	**98**	**n/a**	**3529.29**	**n/a**	**9220.41**	n/a				
Whitby	Oshawa	No	7	7.5	52.5	19.4	135.8					
Whitby	Whitby	No	1	0	0	0	0					
Whitby	Pickering	No	3	7.9	23.7	21.6	64.8					
Bowmanville	Bowmanville	No	6	0	0	0	0					
MIDDAY STORAGE		**DEPLOY TOTAL**	**17**	**n/a**	**76.2**	**n/a**	**200.6**					
Union	Bathurst	No	1	1.3	1.3	3	3					
Union	Willowbrook	No	13	6.7	87.1	17.6	228.8					
Willowbrook	Union	No	13	6.7	87.1	17.3	224.9					
Bathurst	Union	No	1	1.3	1.3	2	2					
PM RETURN TO YARD		**STORAGE TOTAL**	**14**	**n/a**	**176.8**	**n/a**	**458.7**					
Oshawa	Whitby	No	6	7.5	45	17.6	105.6					
Whitby	Whitby	No	3	0	0	0	0					
Pickering	Whitby	No	2	7.9	15.8	21.6	43.2					
Bowmanville	Bowmanville	No	6	0	0	0	0					
		RETURN TOTAL	**17**	**n/a**	**60.8**	**n/a**	**148.8**					

Yellow -shaded values represent inconsistencies in the 2010 electrification study appendices 5B and 5E; 5B is more detailed and considered to override the 5E value

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

REFERENCE CASE LAKESHORE PEAK PERIOD THROUGH-UNION TRIPS

Ar | Eastbound Thru-Union	Dp	Ar | Westbound Thru-Union	Dp
6:28	6:33	6:30	6:35
6:58	7:03	7:00	7:05
7:28	7:33	7:30	7:35
7:58	8:03	8:00	8:05
8:28	8:33	8:30	8:35
8:58	9:03	9:00	9:05
9:28	9:33	9:30	9:35
ev 1/2hr	ev 1/2hr	ev 1/2hr	ev 1/2hr
15:30	15:35	15:28	15:33
16:00	16:05	15:58	16:03
16:30	16:35	16:28	16:33
17:00	17:05	16:58	17:03
17:30	17:35	17:28	17:33
18:00	18:05	17:58	18:03
18:30	18:35	18:28	18:33
19:00	19:05	18:58	19:03
19:30	19:35	19:28	19:30
ev. 1/2hr	ev. 1/2hr	ev 1/2hr	ev 1/2hr

LAKESHORE E. MIDDAY STORAGE

Don Yard (7) + Whitby Yard (4)		
Union Ar	Yard	Union Dp
6:45	DH	15:18
7:15		15:48
7:36		16:40
7:42		16:48
7:50		16:55
8:00		17:18
8:09		17:24
8:09		17:48
8:19		18:18
8:45		18:48
9:15		19:18

The Reference Case appears to assume double berthing on the Lakeshore Corridor. As such, midday storage values are reversed between the two Lakeshore lines

LAKESHORE W. MIDDAY STORAGE

Willowbrook (7) + Bathurst Yard (1)			
Union Ar	Yard	Union Dp	Diesel To
6:43	DH	16:15	TH&B
7:13		15:45	St.Cat's
7:35		16:36	TH&B
7:47		17:00	St.Cat's
8:05		17:44	TH&B
8:18		18:07	St.Cat's
8:43		18:45	TH&B
9:13		19:15	St.Cat's

Willowbrook (6)		
Union Ar	Yard	Union Dp
7:38	DH	16:42
7:48		16:55
7:55		17:10
8:08		17:18
8:18		17:25
8:20		18:15

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

GEORGETOWN TRIP QUANTITIES (REFERENCE CASE)

Georgetown - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
Kitchener	Union	Yes	8	62.6	500.8	122.5	980	1:49	1:42	0:07	1:35	0:14
Kitchener	Union	Yes (Exp.)	2	62.6	125.2	115	230	1:38	1:34	0:04	1:29	0:09
Mount Pleasant	Union	Yes	19	24.1	457.9	48.3	918	0:53	0:47	0:06	0:43	0:10
Bramalea	Union	Yes	1	17.4	17.4	35	35	0:40	0:36	0:04	0:32	0:08
Union	Bramalea	Yes	2	17.4	34.8	48	96	0:36	0:34	0:02	0:30	0:06
Union	Mount Pleasant	Yes	19	24.1	457.9	69.25	1,316	0:49	0:45	0:04	0:41	0:08
Union	Kitchener	Yes	10	62.6	626	154	1,540	1:54	1:43	0:11	1:36	0:18
AM DEPLOYMENT		**REVENUE TOTAL**	**61**	**n/a**	**2220**	**n/a**	**5114.45**					
Mount Pleasant	Bramalea	No	1	6.7	6.7	14	14					
MIDDAY STORAGE		**DEPLOY TOTAL**	**1**	**n/a**	**6.7**	**n/a**	**14**					
Union	Don	No	10	1.5	15	1.6	16					
Union	Bathurst	No	1	1.3	1.3	3	3					
Bathurst	Union	No	1	1.3	1.3	2	2					
Don	Union	No	10	1.5	15	2.1	21					
DEADHEAD EQUIP. MOVES		**STORAGE TOTAL**	**11**	**n/a**	**29.7**	**n/a**	**47**					
Bramalea	Union	No	1	17.4	17.4	35	35					
PM RETURN TO YARD		**DEADHEAD TOTAL**	**1**	**n/a**	**17.4**	**n/a**	**35**					
Bramalea	Mount Pleasant	No	1	6.7	6.7	21	21					
		RETURN TOTAL	**1**	**n/a**	**6.7**	**n/a**	**21**					

Note: Baden-Kitchener deadheading not calculated in 2010 electrification study

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

MILTON TRIP QUANTITIES (REFERENCE CASE)

Milton - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
Milton	Union	Yes	11	31.2	343.2	66.2	728.2	0:57	0:54	0:03	0:48	0:09
Meadowvale	Union	Yes	19	23.1	438.9	45.4	862.6	0:44	0:41	0:03	0:37	0:07
Union	Meadowvale	Yes	19	23.1	438.9	63.6	1,208	0:42	0:39	0:03	0:36	0:06
Union	Milton	Yes	13	31.2	405.6	85.7	1,114	0:57	0:53	0:04	0:48	0:09
AM DEPLOYMENT		**REVENUE TOTAL**	**62**	**n/a**	**1626.6**	**n/a**	**3913.3**					
Willowbrook	Union	No	1	6.7	6.7	17.3	17					
Milton	Meadowvale	No	1	8.1	8.1	21	21					
MIDDAY STORAGE		**DEPLOY TOTAL**	**2**	**n/a**	**14.8**	**n/a**	**38**					
Union	Milton	No	9	31.2	280.8	85.7	771					
Milton	Union	No	8	31.2	249.6	66.15	529					
DEADHEAD EQUIP. MOVES		**STORAGE TOTAL**	**9**	**n/a**	**530.4**	**n/a**	**1,301**					
Union	Milton	No	2	31.2	62.4	85.7	171					
Milton	Union	No	5	31.2	156	66.15	331					
PM RETURN TO YARD		**DEADHEAD TOTAL**	**n/a**	**n/a**	**218.4**	**n/a**	**502**					
Meadowvale	Milton	No	1	8.1	8.1	22	22					
Union	Willowbrook	No	1	6.7	6.7	17.6	18					
		RETURN TOTAL	**2**	**n/a**	**14.8**	**n/a**	**40**					
			43		43							

RICHMOND HILL TRIP QUANTITIES (REFERENCE CASE)

Richmond Hill - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
Bloomington	Union	Yes	6	28.5	171	35.45	212.7	0:55	0:55	0:00	0:51	0:04
Richmond Hill	Union	Yes	19	21.0	399	26.3	499.7	0:42	0:42	0:00	0:38	0:04
Union	Richmond Hill	Yes	19	21.0	399	50.2	954	0:40	0:40	0:00	0:37	0:03
Union	Bloomington	Yes	8	28.5	228	74.1	593	0:56	0:55	0:01	0:51	0:05
AM DEPLOYMENT		**REVENUE TOTAL**	**52**	**n/a**	**1197**	**n/a**	**2259**					
Bloomington	Richmond Hill	No	1	7.5	7.5	9	9					
Willowbrook	Richmond Hill	No	1	27.7	27.7	67	67					
MIDDAY STORAGE		**DEPLOY TOTAL**	**2**	**n/a**	**35.2**	**n/a**	**76**					
Union	Bathurst	No	5	1.3	6.5	2.2	11					
Bathurst	Union	No	5	1.3	6.5	3.4	17					
DEADHEAD EQUIP. MOVES		**STORAGE TOTAL**	**5**	**n/a**	**13**	**n/a**	**28**					
Union	Bloomington	No	1	28.5	28.5	74	74					
Bloomington	Union	No	3	28.5	85.5	35.4	106					
PM RETURN TO YARD		**DEADHEAD TOTAL**	**n/a**	**n/a**	**114**	**n/a**	**180**					
Richmond Hill	Willowbrook	No	1	27.7	27.7	44	44					
Richmond Hill	Bloomington	No	1	7.5	7.5	24	24					
		RETURN TOTAL	**2**	**n/a**	**35.2**	**n/a**	**68**					

Reference Case Schedules *(figures as published in the 2010 electrification study or derived directly from figures therein unless otherwise noted)*

BARRIE TRIP QUANTITIES (REFERENCE CASE)

Barrie - Revenue		Revenue	Ref. Case	Distance (miles)		Fuel Gallons		Travel Times (hr:mm)				
From	To	Service?	No. Trips	/Trip	/Day	/Trip	/Day	DLHC	ELHC	Savings	EMUC	Savings
Allandale	Union	Yes	7	63.0	441	130.15	911.05	1:42	1:38	0:04	1:30	0:12
Bradford	Union	Yes	19	41.5	788.5	85.39	1622.41	1:10	1:07	0:03	1:00	0:07
Union	Bradford	Yes	19	41.5	788.5	100.06	1,901.1	1:07	1:04	0:03	0:57	0:10
Union	Allandale	Yes	8	63.0	504	146.67	1,173.4	1:44	1:38	0:06	1:30	0:14
AM DEPLOYMENT		**REVENUE TOTAL**	**53**	**n/a**	**2522**	**n/a**	**5607.96**					
Bradford	Allandale	No	1	21.5	21.5	47	47					
Willowbrook	Union	No	1	6.7	6.7	17	17					
MIDDAY STORAGE		**DEPLOY TOTAL**	**2**	**n/a**	**28.2**	**n/a**	**64**					
Union	Whitby	No	5	28.83	144.15	77	385					
Union	Don	No	2	2.0	4	1.6	3.2					
Don	Union	No	2	2.0	4	2.1	4					
Whitby	Union	No	5	28.83	144.15	77.6	388					
Bradford	Union	No	1	41.5	41.5	85	85					
PM RETURN TO YARD		**STORAGE TOTAL**	**8**	**n/a**	**337.8**	**n/a**	**865.4**					
Allandale	Bradford	No	2	21.5	43	45	90					
Union	Willowbrook	No	1	6.7	6.7	18	18					
		RETURN TOTAL	**3**	**n/a**	**49.7**	**n/a**	**108**					

Appendix D: Reference Case Fuel Consumption

APPENDIX D

Reference Case Fuel Consumption

	TH&B/Grimsby*	Lakeshore W.	Lakeshore E.	Georgetown	Milton	Richmond Hill
Revenue Fuel (g)	635.858	10196.84	9220.41	5114.45	3,913	2,259
Non-Revenue Fuel (g)	0	876.6	993.3	117.0	1,880.6	352.2
Annual (Weekdays)	158,964.5	2,768,360.0	2,553,427.5	1,307,862.5	1,448,462.5	652,800.0
Weekend%	0%	32.82101%	36.10358%	19.01308%	24.82361%	30.66662%
Annual Weekend	0	908,603.7	921,878.7	248,664.9	359,560.7	200,191.7
Annual Total (g)	158,964.5	3,676,963.7	3,475,306.2	1,556,527.4	1,808,023.2	852,991.7
Convert to Litres	722,652.6	16,715,477.0	15,798,742.2	7,075,973.8	8,219,273.4	3,877,700.2
Hotel Power (+20%)	144,530.52	3,343,095.41	3,159,748.43	1,415,194.75	1,643,854.68	775,540.05
TOTAL FUEL (L)	**867,183.1**	**20,058,572.4**	**18,958,490.6**	**8,491,168.5**	**9,863,128.1**	**4,653,240.3**
Cost of Fuel (2009)	**$650,387**	**$15,043,929**	**$14,218,868**	**$6,368,376**	**$7,397,346**	**$3,489,930**
Published by Metrolinx	*$649,510*	*$15,227,979*	*$14,166,371*	*$6,364,175*	*$7,398,814*	*$3,491,001*
Deviation Between Totals	*0.14%*	*1.22%*	*0.37%*	*0.07%*	*0.02%*	*0.03%*

Total Fuel (L) from All Lines Above: **62,024,599.9 L**
Total Fuel ($) from All Lines Above: **$46,518,450**

ARL Fuel $ (Ref. Case Figure)
$2,496,900

	Weekday (g)	Weekend (%)	Weekend (g)	Annual (L)	Hotel Power (L)	Fuel Cost (2009)
Barrie (Benchmark)	1,661,340.0	29.10324%	483,503.7	9,750,459.4	1,950,091.9	$8,775,413.5

**TH&B/Grimsby refers to rush hour fuel consumption for 2 segments: TH&B to Aldershot, and; Stoney Creek Yard to St Catharines. The Reference Case appears to have assumed that if these runs do not reach their termini, TH&B trains would run to/from Aldershot, and St Catharines trains would run to/from Hamilton (James). These costs are excluded in the Lakeshore West fuel cost calculation. Reference Case fuel cost for TH&B/Grimsby was $595,384, but this was with 10% Hotel Power instead of 20%, corrected above.*

Lakeshore East deviation is higher due to an inconsistency in Reference Case data that has been corrected for above.

General Notes

Above is a recreation of the 2010 electrification study fuel calculations - Stouffville is omitted due to the Mt. Joy/Unionville conflict.
Detailed breakdowns of fuel consumption as provided by the 2010 electrification study are shown in Appendix C.
Standard 4.546 litres (L) per gallon (g), with 2009 cost of fuel at $0.75/L, as listed in Appendix A.
The 2010 electrification study uses a 2009 fuel price for 2021 consumption calculations, which is unrealistic
(Fuel costs in this report are adjusted to higher levels to reflect future years' prices in Appendix A).

Appendix E: 2010 Electrification Study Fleet Figure Adjustments

APPENDIX E

2010 Electrification Study Fleet Figure Adjustments

All dollar values are in millions

Reference Case Fleet Assumptions Published in the 2010 Electrification Study

For 2021	Existing Locomotives:	52	Required Loco.'s*:	92	Existing Cabs:	52

*Represents revenue locomotives only (spares added in calculations)

Option	Affected Loco.'s	Loco. Costs	# of Loco.'s left to Buy or Sell	Loco. Buy or Sell $	ARL Fleet	ARL Fleet $	Affected Cabs**	Cost of Retrofit	Difference
Opt 1	17	$132.94	38	$297.16	12	$48.36	0	$0.000	
	17	$190.40	39	$304.98	12	$66.96	17	$0.255	
		$57.46		$7.82		$18.60		$0.255	*$84.14*
Opt 2	43	$336.26	12	$93.84	0	$0.00	0	$0.000	
	34	$380.80	22	$172.04	0	$0.00	34	$0.510	
		$44.54		$78.20		$0.00		$0.510	*$123.25*
Opt 3	60	$430.10	-5	$0.00	12	$48.36	0	$0.000	
	50	$560.00	5	$39.10	12	$66.96	50	$0.750	
		$129.90		$39.10		$18.60		$0.750	*$188.35*
Opt 11	72	$430.10	-17	$0.00	12	$48.36	0	$0.000	
	63	$705.60	-7	($7.00)	12	$66.96	55	$0.825	
		$275.50		($7.00)		$18.60		$0.825	*$287.93*
Opt 15	84	$430.10	-29	$0.00	12	$48.36	0	$0.000	
	75	$840.00	-19	($19.00)	12	$66.96	55	$0.825	
		$409.90		($19.00)		$18.60		$0.825	*$410.33*
Opt 18	107	$430.10	-52	$0.00	12	$48.36	0	$0.000	
	107	$1,198.40	-52	($52.00)	12	$66.96	55	$0.825	
		$768.30		($52.00)		$18.60		$0.825	*$735.73*

**2010 electrification study methodology erroneously used a new cab car purchasing chronology that applied the calculation backwards.

Electrification Options not Costed by the 2010 Electrification Study Outside Full Network Total

Richmond Hill	Stouffville	TH&B/Grimsby
$91.80	$153.00	$102.00

Cost for vehicles only, assuming electric locomotives

2010 Electrification Study Fleet Figure Adjustments

All dollar values are in millions

Corrected Reference Case Fleet Assumptions

For 2021	Existing Locomotives:	57	Required Loco.'s*:	92	Existing Cabs:	56

*Represents revenue locomotives only (spares added in calculations)

Blue-shaded figures represent changes from 2010 electrification study figures

Corrected Option	Affected Loco.'s	Loco. Costs	# of Loco.'s left to Buy or Sell	Loco. Buy or Sell $	ARL Fleet	ARL Fleet $	Affected Cabs**	Cost of Retrofit	Difference
Opt 1	17	$132.94	33	$258.06	12	$48.36	0	$0.000	
	17	$190.40	34	$265.88	12	$66.96	0	$0.000	
		$57.46		$7.82		$18.60		$0.000	$83.88
Opt 2	43	$336.26	7	$54.74	0	$0.00	0	$0.000	
	34	$380.80	17	$132.94	0	$0.00	0	$0.000	
		$44.54		$78.20		$0.00		$0.000	$122.74
Opt 3	60	$391.00	-10	$0.00	12	$48.36	0	$0.000	
	50	$560.00	0	$0.00	12	$66.96	2	$0.030	
		$169.00		$0.00		$18.60		$0.030	$187.63
Opt 11	72	$391.00	-22	$0.00	12	$48.36	0	$0.000	
Corrected by	63	$705.60	-12	($12.00)	12	$66.96	14	$0.210	
$33.49		$314.60		($12.00)		$18.60		$0.210	$321.41
Opt 15	84	$391.00	-34	$0.00	12	$48.36	0	$0.000	
Corrected by	75	$840.00	-24	($24.00)	12	$66.96	25	$0.375	
$33.65		$449.00		($24.00)		$18.60		$0.375	$443.98
Opt 18	107	$391.00	-57	$0.00	12	$48.36	0	$0.000	
Corrected by	107	$1,198.40	-57	($57.00)	12	$66.96	56	$0.840	
$34.12		$807.40		($57.00)		$18.60		$0.840	$769.84

**Methodology changed from 2010 electrification study so that new cab cars purchased first (already converted), then existing ones converted. Spare ratio for the cab cars adjusted to 10% (the 2010 electrification study used the same ratio as for locomotives).

Appendix F: Current GO Fleet Composition

APPENDIX F

Current GO Fleet Composition

(GO fleet data compiled from Canadian Public Transit Discussion Board detailed records, www.cptdb.ca)

Delivered	Coach	Cab	Rebuilt	Midlife	Rebuild2	Retire	Series	Fleet IDs
1976-78	80		1998-2000	Past	2019	2031	I	2000-2079
1983-84	56		2002-2004	Past	2024	2036	II	2100-2155
1983-84		15	2002-2004	Past	2024	2036	II	200-214
1987-1989	54		2007-2011	Past	2030	2042	III	2200-2253
1987-1989		9	2007-2011	Past	2030	2042	III	215-223
1989-90	42		2007-2011	Past	2030	2042	IV	2300-2341
1989-90		18	2007-2011	Past	2030	2042	IV	224-241
1990-91	57		Due Now	2011	2031	2043	V	2400-2455, 2499
1998	-16		n/a				I	2000, 2001, 2010-2017, 2019-2024
1999	5		1999-2001	Past	2021	2033	I	2010-2012, 2015, 2019
1999		-2	n/a				III/IV	223, 224
2002	22		Still New	2022	2042	2054	VI	2500-2521
2003-04	30		Still New	2023	2043	2055	VII	2522-2541, 2600-2609
2004		4	Still New	2023	2043	2055	VII	242-245
2005	11		Still New	2025	2045	2057	VII	2610-2620
2006-07		5	Still New	2026	2046	2058	VII	246-250
2006-08	44		Still New	2027	2047	2059	VII	2542-2544, 2621-2661
2008-09	32		Brand New	2028	2048	2060	VIII	2545-2546, 2700-2729
2008-09		3	Brand New	2028	2048	2060	VIII	251-253
2010-11	42		Brand New	2030	2050	2062	VIII	2547-2549, 2730-2768
2010-11		1	On Order	2030	2050	2062	VIII	Awaiting Delivery (254?)
2011-12	47		On Order	2032	2052	2064	?	Awaiting Delivery
2011-12		3	On Order	2032	2052	2064	?	Awaiting Delivery (255-257?)

With the exception of the most recently ordered 50 cars, all cars will require at least 1 rebuild before 2031

Current Locomotive-Hauled Coach Equipment

Fleet	Coach	Cab
Total	506	56

Coach Fleet Size for 2021 Reference Case

Fleet	Coach	Cab
Total	870	102

Note: Spare ratios adjusted from 2010 electrification study to 2008 Lakeshore electrification study +25%

Coach Rebuilds and Retirements by 2031

	1st Rebuild	2nd Rebuild	Retire 2031
Coaches	181	278	64
Cabs	13	40	0

Appendix G: EMU Detailed Scheduling Data

APPENDIX G

EMU Detailed Scheduling Data

Assumed 12-car EMU trains can turn around in 7 minutes, based on O-Train's 3-minute turnaround operation for 3-car DMUs. Hatch Mott MacDonald in their 2008 GO electrification study identified 4 minutes dwell at Union Station, not 5.

LAKESHORE EMU ALL-DAY ROUND TRIP OPTIONS

OPTION 1:	One-way Travel Time		**OPTION 2:**	One-way Travel Time	
Oshawa - TH&B	Optimized	Ref. Case	**Bowmanvile - TH&B**	Optimized	Ref. Case
Oshawa - Union	55	55	Bowmanville - Union	65	65
Union Layover WB	5	5	Union Layover WB	4	5
Union - TH&B	59	59	Union - TH&B	59	59
TH&B Layover	17	10	TH&B Layover	7	10
TH&B - Union	59	59	TH&B - Union	59	59
Union Layover EB	5	5	Union Layover EB	4	5
Union - Oshawa	53	53	Union - Bowmanville	65	65
Oshawa Layover	17	10	Bowmanville Layover	7	10
Total Round Trip Time	**270**	**256**	**Total Round Trip Time**	**270**	**278**
Trains for 30min. service	9		Trains for 30min. service	9	**10**

OPTION 2 provides more service with the same staff and equipment, and is therefore preferred.

GEORGETOWN EMU ALL-DAY ROUND TRIP OPTIONS

UNION-GEORGETOWN TRIP DETAILS			**Travel Times**		
From	To	Miles	DLHC	ELHC	EMUC
Union	Georgetown	29.34	0:57	0:52	0:48
Georgetown	Union	29.34	1:01	0:55	0:50

OPTION 1:	One-way Travel Time		**OPTION 2:**	One-way Travel Time	
Mt Pleasant - Union	Optimized	Ref. Case	**Georgetown - Union**	Optimized	Ref. Case
Mt Pleasant - Union	43	43	Georgetown - Union	50	50
Union Layover	18	10	Union Layover	11	10
Union - Mt Pleasant	41	41	Union - Georgetown	48	48
Mt Pleasant Layover	18	10	Georgetown Layover	11	10
Total Round Trip Time:	**120**	**104**	**Total Round Trip Time**	**120**	**118**
Trains for hourly service:	2		Trains for hourly service:	2	

OPTION 2 provides more service with the same staff and equipment, and is therefore preferred.

Travel time figures (excluding layover periods) are 2010 electrification study figures or figures directly derived from therein

EMU Detailed Scheduling Data

MILTON EMU ALL-DAY ROUND TRIP CALCULATIONS

OPTION 1:	One-way Travel Time		**OPTION 2:**	One-way Travel Time	
Meadowvale - Union	Optimized	Ref. Case	**Milton - Union**	Optimized	Ref. Case
Meadowvale - Union	37	48	Milton - Union	48	48
Union Layover	23	10	Union Layover	12	10
Union - Meadowvale	36	48	Union - Milton	48	48
Meadowvale Layover	24	10	Milton Layover	12	10
Total Round Trip Time:	**120**	**116**	**Total Round Trip Time**	**120**	**116**
Trains for hourly service:	2		Trains for hourly service:	2	

OPTION 2 provides more service with the same staff and equipment, and is therefore preferred.

RICHMOND HILL EMU ALL-DAY ROUND TRIP CALCULATIONS

OPTION 1:	One-way Travel Time		OPTION 2:	One-way Travel Time	
Richmond Hill - Union	Optimized	Ref. Case	Bloomington - Union	Optimized	Ref. Case
Richmond Hill - Union	38	38	Bloomington - Union	51	51
Union Layover	22	10	Union Layover	9	10
Union - Richmond Hill	37	37	Union - Bloomington	51	51
Richmond Hill Layover	23	10	Bloomington Layover	9	10
Total Round Trip Time:	**120**	**95**	**Total Round Trip Time**	**120**	**122**
Trains for hourly service:	2		Trains for hourly service:	2	**3**

OPTION 2 provides more service with the same staff and equipment, and is therefore preferred.

RICHMOND HILL CAN THROUGH-ROUTE WITH GEORGETOWN

Travel time figures (excluding layover periods) are 2010 electrification study figures or figures directly derived from therein

EMU Detailed Scheduling Data

LAKESHORE WEEKDAY EMU TRIP QUANTITIES

Trips	Trip Dist	From	Daily Distance	To	Cars
5	82.88	Bowmanville	414.4	TH&B	12
6	82.88	TH&B	497.28	Bowmanville	12
7	21.4	Oakville	149.8	Union	12
8	21.4	Union	171.2	Oakville	12
13	34.6	Aldershot	449.8	Union	12
11	34.6	Union	380.6	Aldershot	12
5	20.9	Pickering	104.65	Union	12
4	20.9	Union	83.72	Pickering	12
7	43.0	Bowmanville	300.86	Union	12
7	43.0	Union	300.86	Bowmanville	12
17	28.8	Whitby	490.11	Union	12
19	28.8	Union	547.77	Whitby	12
3	14.2	Whitby	42.45	Bowmanville	8
3	14.2	Bowmanville	42.45	Whitby	8
5	33.2	TH&B	166	Mimico	8
5	33.2	Mimico	166	TH&B	8
5	6.7	Union	33.5	Mimico	12
5	6.7	Mimico	33.5	Union	12
4	39.9	Union	159.6	TH&B	12
4	39.9	TH&B	159.6	Union	12
24	82.88	Bowmanville	1989.12	TH&B	8
23	82.88	TH&B	1906.24	Bowmanville	8

Lakeshore West

12 -car train daily miles: 1976.5

8 -car train daily miles: 2207.3

Lakeshore East

12 -car train daily miles: 2300.75

8 -car train daily miles: 2104.96

Includes rush hour services

Detailed rush-hour schedule can bs found on page 5 of Appendix G

All distance figures are from the 2010 electrification study

EMU Detailed Scheduling Data

GEORGETOWN-RICHMOND HILL THRU-ROUTE EMU WEEKDAY REVENUE TRIPS

UNION-LANGSTAFF TRIP DETAILS				
From	To	**No. Trips**	/Trip	/Day
Langstaff	Union	1	18.3	18.3
Union	Langstaff	1	18.3	18.3

Trips	Trip Dist	From	Daily Distance	To	Cars
1	24.1	Mount Pleasant	24.1	Union	12
5	29.34	Georgetown	146.7	Union	12
19	28.5	Bloomington	541.5	Union	12
16	28.5	Union	456	Bloomington	12
5	29.34	Union	146.7	Georgetown	12
12	29.34	Georgetown	352.08	Union	4
10	28.5	Bloomington	285	Union	4
12	28.5	Union	342	Bloomington	4
12	29.34	Union	352.08	Georgetown	4
2	24.1	Union	48.2	Mount Pleasant	4

All Langstaff, Kitchener, and Bramalea trains are run with 12-car consists

Richmond Hill		**Georgetown**	
997.5	12-car train miles	317.5	12-car train miles
627	4-car train miles	752.36	4-car train miles
36.6	to/from Langstaff	1356.4	for Kitchener, Bramalea
1661.1		2426.26	

Almost all Mount Pleasant trips are extended to Georgetown (see Appendix H for details)
One less trip from Mt. Pleasant to Union due to physically impossible spacing between trains in Reference Case
Changes to Richmond Hill schedule extends all trains to/from Bloomington except one run to/from Langstaff.
One additional run from Bloomington to Union added for optimizing equipment cycling, operated in service.

All distance figures are from the 2010 electrification study

EMU Detailed Scheduling Data

MILTON WEEKDAY EMU TRIP QUANTITIES

Chart shows all-day cycling of two trains only, with differing lengths.
Trains are named after their original trip ID in the AM rush hour, MLL21 and MLL29.

MLL29: 9:33 Ar @ Union Station
MLL21: 8:28 Ar @ Union Station

All-day trains depart Union and Milton 40 after the hour, 48 minutes one-way travel time in both directions

Dp	Ar	Train to Milton	Train to Union	Change Length	4-car	12-car
7:40	8:28	n/a	MLL21	>Shorten MLL21		1
8:45	9:33	MLL21	MLL29	>Shorten MLL29	1	1
9:40	10:28	MLL29	MLL21		2	
10:40	11:28	MLL21	MLL29		2	
11:40	12:28	MLL29	MLL21		2	
12:40	13:28	MLL21	MLL29		2	
13:40	14:28	MLL29	MLL21		2	
14:40	15:28	MLL21	MLL29	>Extend MLL29	2	
15:40	16:28	MLL29	MLL21	>Extend MLL21	1	1
16:40	17:28	MLL21	MLL29			2
17:40	18:28	MLL29	MLL21			2
18:40	19:28	MLL21	MLL29	>Shorten MLL21		2
19:40	20:28	MLL29	MLL21	>Shorten MLL29	1	1
20:40	21:28	MLL21	MLL29		2	
21:40	22:28	MLL29	MLL21		2	
22:40	23:28	MLL21	MLL29		2	
23:40	0:28	MLL29	MLL21		2	
0:35	1:23	n/a	MLL29		1	
0:40	1:28	MLL21	n/a		1	
1:30	2:18	MLL29	n/a		1	
				TOTAL	26	10
				Daily train miles for MLL21 & MLL29 only:	811.2	312
				Daily train miles for all trains other than MLL21 & MLL29:	0	1481
				Total line train miles (all lengths):	2604.6	

One less round-trip due to changes in deadheading from Reference Case

All distance figures are from the 2010 electrification study

EMU Detailed Scheduling Data

LAKESHORE EMU LENGTH CHANGES

1st Length Shortening		Train Length Elongating		2nd Train Length Shortening	
Time	Site	Time	Site	Time	Site
8:13	(WB) Mimico	15:25	(EB) Mimico	18:46	Bowmanville
8:43	(WB) Mimico	15:44	(WB) Whitby	19:01	TH&B
8:53	(EB) Whitby	15:55	(EB) Mimico	19:16	Bowmanville
9:13	(WB) Mimico	15:58	Union Station	19:31	TH&B
9:23	(EB) Whitby	16:25	(EB) Mimico	19:46	Bowmanville
9:41	Union Station	16:14	(WB) Whitby	20:01	TH&B
9:43	(WB) Mimico	16:55	(EB) Mimico	20:16	Bowmanville
9:53	(EB) Whitby	16:44	(WB) Whitby	20:31	TH&B
10:13	(WB) Mimico	17:25	(EB) Mimico	20:46	Bowmanville

ASSUMED EMU WEEKEND TRIP QUANTITIES

All weekend EMU service assumed to be provided with 4-car trains
No non-revenue movements on weekends assumed

LAKESHORE		Round Trips/Day	Distance/Round Trip	Daily Distance
Bowmanville-TH&B	Round Trips	36	165.76	5967.36
GEORGETOWN		Round Trips/Day	Distance/Round Trip	Daily Distance
Mt Pleasant - Union	Round Trips	2	48.2	96.4
Georgetown Union	Round Trips	7	58.68	410.76
MILTON		Round Trips/Day	Distance/Round Trip	Daily Distance
Milton - Union	Round Trips	12	62.4	748.8
RICHMOND HILL		Round Trips/Day	Distance/Round Trip	Daily Distance
Bloomington - Union	Round Trips	10	57.0	570

Quantity of trips based on approximation of Reference Case weekend % figure from Metrolinx

All distance figures are from the 2010 electrification study

EMU Detailed Scheduling Data

LAKESHORE EMU ALL-DAY EQUIPMENT CYCLING CHECK

Check Deployment Scheduling for 9 All-Day Cycling Trains

Bow ->	Union ->	TH&B	TH&B ->	Union ->	Bow
5:23	6:28	**7:31**	5:38	6:37	**7:46**
5:53	6:58	8:01	6:08	7:07	8:16
6:23	7:28	8:31	6:38	7:37	8:46
6:53	7:58	9:01	7:08	8:07	9:16
7:23	8:28	9:31	**7:38**	Cycle first train from Bowmanville	
7:53	Cycle first train from TH&B				

5 trains need to be deployed from Bowmanville
(1 less than proposed in the Reference Case)

4 trains need to be deployed from Hamilton
(existing layover site has 4 slots)

MILTON EQUIPMENT CYCLING CHANGES MADE POSSIBLE BY EMUs

AM Equipment Cycling Adjustments				
Trip ID	Chng. Term.	Ar Term. w/EMUs	Becomes	Dp
MLL02	*Redundant and unnecessary, eliminate*			
MLL07	Ext to Milton	7:03	MLL17	8:00
DH59A	In Service	7:33	MLL21	7:40
DH60A	In Service	7:48	MLL23	7:55
DH61A	In Service	8:08	MLL25	8:15
DH62A	In Service	8:23	MLL27	8:30
DH63A	In Service	8:38	MLL29	8:45

NOTE: MLL21 & MLL29 become all-day cycling runs to/from Milton

PM Equipment Cycling Adjustments				
Trip ID	Chng. Term.	Ar Term. w/EMUs	Becomes	Dp
MLL20	n/a	16:18	DH66B (but in service)	16:27
MLL26	n/a	16:38	DH59D (but in service)	16:52
MLL28	n/a	16:58	DH60D (but in service)	17:12
MLL30	n/a	17:18	DH61C (but in service)	17:32
MLL34	n/a	17:33	MLL47 (extended to Milton)	17:40
MLL36	n/a	17:48	DH62C (but in service)	17:55
MLL38	n/a	18:03	DH63C (but in service)	18:12

EMU Detailed Scheduling Data

GEORGETOWN EQUIPMENT CYCLING CHANGES MADE POSSIBLE BY EMUs

AM	Equipment Cycling Adjustments			
Trip ID	Ar Term. w/EMUs	Throught to/as	Becomes	Dp
GTL02	6:30	Bramalea Exp. (24min travel time)	GTL12	7:10
GTL08	7:13	Pickering Express	LKEL18	7:45
PM	**Equipment Cycling Adjustments**			
Trip ID	Ar Term. w/EMUs	Throught to/as	Becomes	Dp
GTL45	19:15	Union Exp. & Whitby Local	New Whitby Local trip	19:56

RICHMOND HILL EQUIPMENT CYCLING CHANGES MADE POSSIBLE BY EMUs

AM	Equipment Cycling Adjustments			
Trip ID	Ar Term. w/EMUs	Throught to/as	Becomes	Dp
RI01	6:52	Oakville Express	LKWL14	7:25
RI03	7:09	Oakville Local	LKWL20	7:55
RI05	7:22	Adjusted GTL01	GTL22	8:35
GTL04	6:51	Langstaff Local	RI09	7:35
GTL06	6:59	Bloomington Local	RI13	8:01
GTL10	7:28	Bloomington Local	RI17	8:31

RI07, RI11, & RI15 are the only AM trips that need new EMU train purchases. Detailed PM equipment cycling in Appendix H.

PM	Equipment Cycling Adjustments			
Trip ID	Ar Term. w/EMUs	Throught to/as	Becomes	Dp
RI20	16:55	Union Local from Bloomington	GTL37	17:55
RI22	17:04	Union Local from Bloomington	GTL41	18:15
LKWL47	17:07	Union Local from Oakville	RI32	18:04
RI24	17:25	Union Local from Bloomington	RI36	18:34
RI26	17:55	Union Local from Bloomington	RI38	19:04
LKWL61	18:46	Union Local from Oakville	RI42	19:34

Trip RI30 returns to Whitby (new trip in service)

EMU DETAILED SCHEDULING DATA: CONCEPTUAL LAKESHORE PEAK PERIODS (BASED ON REFERENCE CASE CAPACITY)

APPENDIX G

LAKESHORE EAST - AM Peak

Departure		Arrival			Through to		
Time	Location	Time	Loc.	DH?	Location	Ar @	Notes
5:23	Bowmanville	6:28	Union	No	TH&B	7:31	All-day
5:59	Whitby	6:43	Union	Exp	Oakville	7:05	2nd in-bound trip
5:53	Bowmanville	6:58	Union	No	TH&B	8:01	All-day
6:29	Whitby	7:13	Union	Exp	Oakville	7:35	2nd in-bound trip
6:23	Bowmanville	7:28	Union	No	TH&B	8:31	All-day
6:38	Bowmanville	7:32	Union	No	Aldershot	8:20	Express (PNorth), 2nd in-bound trip
7:15	Pickering	7:49	Union	Yes	Willowbrook	8:08	
7:20	Whitby	7:54	Union	Yes	Willowbrook	8:13	Express (RoHill)
6:53	Bowmanville	7:58	Union	No	TH&B	9:01	All-day
7:25	Whitby	7:59	Union	Yes	Willowbrook		Express (RoHill)
7:35	Pickering	8:09	Union	Yes	Willowbrook		Not newly deployed
7:35	Whitby	8:09	Union	Yes	Willowbrook		Express (RoHill)
7:45	Pickering	8:19	Union	Yes	Willowbrook		
7:23	Bowmanville	8:28	Union	No	TH&B	9:31	All-day
7:59	Whitby	8:43	Union	Yes	Willowbrook	9:03	Not newly deployed
7:53	Bowmanville	8:58	Union	No	TH&B	10:01	All-day
8:29	Whitby	9:13	Union	Yes	Willowbrook	9:33	Not newly deployed
8:23	Bowmanville	9:28	Union	No	TH&B	10:31	All-day
Ev 1/2hr	Bowmanville	Ev 1/2hr	Union	No	TH&B	Ev 1/2hr	All-day

Shaded area represents peak hour

LAKESHORE WEST - AM Peak

Departure		Arrival			Through to		
Time	Location	Time	Loc.	DH?	Location	Ar @	Notes
5:38	TH&B	6:37	Union	No	Bowmanville	7:46	All-day
6:05	Aldershot	6:52	Union	No	Pickering	7:28	2nd in-bound trip
6:08	TH&B	7:07	Union	No	Bowmanville	8:16	All-day
6:35	Aldershot	7:22	Union	Yes	Whitby	7:47	2nd in-bound trip
6:38	TH&B	7:37	Union	No	Bowmanville	8:46	All-day
7:00	Aldershot	7:36	Union	Exp	Whitby	8:11	Express, 2nd in-bound trip
7:15	Oakville	7:47	Union	Yes	Don	7:53	Not newly deployed
7:15	Aldershot	7:51	Union	No	Whitby	8:37	Express
7:25	Oakville	7:57	Union	Yes	Don	8:03	
7:25	Aldershot	8:01	Union	Yes	Don	8:07	Express
7:08	TH&B	8:07	Union	No	Bowmanville	9:16	All-day
7:45	Oakville	8:17	Union	No	Whitby	9:03	Not newly deployed
7:43	Aldershot	8:19	Union	Yes	Don	8:25	Express
7:55	Oakville	8:27	Union	No	Whitby	9:13	
7:55	Aldershot	8:31	Union	Yes	Don	8:37	Express
7:38	TH&B	8:37	Union	No	Bowmanville	9:46	All-day
8:05	Aldershot	8:52	Union	Yes	Don	8:53	
8:08	TH&B	9:07	Union	No	Bowmanville	10:16	All-day
8:35	Aldershot	9:22	Union	No	Whitby	10:08	Not newly deployed
8:38	TH&B	9:37	Union	No	Bowmanville	10:46	All-day
Ev 1/2hr	TH&B	Ev 1/2hr	Union	No	Bowmanville	Ev 1/2hr	All-day

LAKESHORE WEST - PM Peak

Through from			Departure		Destination		
Time	Location	DH?	Time	Loc.	Location	Ar @	Notes
14:23	Bowmanville	No	15:32	Union	TH&B	16:31	All-day
15:41	Don	Yes	15:47	Union	Aldershot	16:33	2nd out-bound trip
14:53	Bowmanville	No	16:02	Union	TH&B	17:01	All-day
15:27	Whitby	No	16:17	Union	Aldershot	17:03	2nd out-bound trip
15:23	Bowmanville	No	16:32	Union	TH&B	17:31	All-day
16:29	Don	Yes	16:35	Union	Aldershot	17:12	Express
16:32	Don	Yes	16:38	Union	Oakville	17:07	
16:39	Don	Yes	16:45	Union	Aldershot	17:20	Express
16:20	Whitby	Yes	16:52	Union	Aldershot	17:27	Express (NFMS*)
15:53	Bowmanville	No	17:02	Union	TH&B	18:01	All-day
17:01	Don	Yes	17:08	Union	Oakville	17:37	2nd out-bound trip
16:27	Whitby	No	17:15	Union	Oakville	17:44	
16:50	Whitby	Yes	17:22	Union	Aldershot	17:58	Express; 3rd out-bound trip (NFMS*)
16:23	Bowmanville	No	17:32	Union	TH&B	18:31	All-day
17:02	Whitby	Exp	17:40	Union	Aldershot	18:26	2nd out-bound trip
16:53	Bowmanville	No	18:02	Union	TH&B	19:01	All-day
17:30	Pickering	No	18:08	Union	Aldershot	18:44	Express; Not from midday storage
17:27	Whitby	No	18:17	Union	Oakville	18:46	3rd out-bound trip (NFMS*) - 19:56@Unic
17:23	Bowmanville	No	18:32	Union	TH&B	19:31	All-day
18:09	Pickering	No	18:47	Union	Aldershot	19:33	Not from midday storage
17:53	Bowmanville	No	19:02	Union	TH&B	20:01	All-day
18:27	Whitby	No	19:17	Union	Aldershot	20:03	Not from midday storage
18:23	Bowmanville	No	19:32	Union	TH&B	20:31	All-day
Ev 1/2hr	Bowmanville	No	Ev 1/2hr	Union	TH&B	Ev 1/2hr	All-day
23:53	Bowmanville	No	1:02	Union	TH&B	2:01	**Last Train**

LAKESHORE EAST - PM Peak

Through from			Departure		Destination		
Time	Location	DH?	Time	Loc.	Location	Ar @	Notes
14:08	TH&B	No	15:11	Union	Bowmanville	16:16	All-day
15:07	Willowbrook	Yes	15:26	Union	Whitby	16:08	2nd out-bound trip
14:38	TH&B	No	15:41	Union	Bowmanville	16:46	All-day
15:37	Willowbrook	Yes	15:56	Union	Whitby	16:38	2nd out-bound trip
15:08	TH&B	No	16:11	Union	Bowmanville	17:16	All-day
16:21	Willowbrook	Yes	16:40	Union	Whitby	17:11	Express, 2nd out-bound trip
15:38	TH&B	No	16:41	Union	Bowmanville	17:46	All-day
16:32	Willowbrook	Yes	16:51	Union	Pickering	17:23	2nd out-bound trip
16:37	Willowbrook	Yes	16:56	Union	Bowmanville	17:52	Express (PNorth)
16:42	Willowbrook	Yes	17:01	Union	Whitby	17:43	
16:08	TH&B	No	17:11	Union	Bowmanville	18:16	All-day
17:02	Willowbrook	Yes	17:21	Union	Pickering	17:53	2nd out-bound trip
16:51	Aldershot	Exp	17:31	Union	Whitby	18:02	Express (RoHill) (NFMS*), 3rd
16:38	TH&B	No	17:41	Union	Bowmanville	18:46	All-day
17:16	Aldershot	Exp	17:56	Union	Whitby	18:38	Not from midday storage
17:08	TH&B	No	18:11	Union	Bowmanville	19:16	All-day
17:50	Oakville	No	18:26	Union	Whitby	19:08	Not from midday storage
17:38	TH&B	No	18:41	Union	Bowmanville	19:46	All-day
18:05	Aldershot	No	18:56	Union	Whitby	19:38	Not from midday storage
18:08	TH&B	No	19:11	Union	Bowmanville	20:16	All-day
18:36	Aldershot	No	19:26	Union	Whitby	20:08	Not from midday storage
18:38	TH&B	No	19:41	Union	Bowmanville	20:46	All-day
Ev 1/2hr	TH&B	No	Ev 1/2hr	Union	Bowmanville	Ev 1/2hr	All-day
0:08	TH&B	No	1:11	Union	Bowmanville	2:16	**Last train**

*NFMS = Not from midday storage

Deployment Summary	
Trains	Site
4	TH&B
6	Bowmanville
2	Willowbrook - Oakville
7	Whitby
8	Willowbrook - Aldershot
27	**Total (Electric)**
4	St Cats - TH&B
31	Total (Diesel & Electric)

Midday Storage AM in	
Trains	Site
8	Willowbrook
4	Whitby
6	Don
18	**Total**

Midday Storage PM Out	
Trains	Site
7	Willowbrook
2	Whitby
6	Don
15	**Total**

Return Summary	
Trains	Site
4	TH&B
6	Bowmanville
3	Willowbrook - Oakville
5	Whitby
6	Willowbrook - Aldershot
24	**Total (Electric)**
4	St Cats - TH&B
28	Total (Diesel & Electric)

Appendix H: 2021 EMU Equipment Cycling

2021 EMU Equipment Cycling

Train	Early-AM Equipment Cycling											Late-AM Equipment Cycling							
ID	Deploy From	Dp	1st Run To	Ar	Dp	2nd Run To	Ar	Dp	3rd Run To	Ar	Dp	4th Run To	Ar	Dp	5th Run To	Ar	Dp	6th Run To	Ar
1	Kitchener	4:59	Union	6:34	6:41	Bramalea Exp	7:03	7:10	Union	**7:42**	**8:15**	Georgetown	9:03	9:18	Bloomington	11:04	11:19	Georgetown	13:03
2	Kitchener	5:16	Union	6:51	6:55	Langstaff	7:28	7:35	Union	8:09	8:19	Bloomington	9:10	9:19	Union	**10:10**	10:15	Georgetown	11:03
3	Bowmanville	5:23	Hamilton	7:31	7:38	Bowmanville	9:46	9:53	Hamilton	12:01	12:08	Bowmanville	14:16	14:23	Hamilton	16:31	16:38	Bowmanville	18:46
4	Willowbrook	5:35	Aldershot	5:55	6:05	Union	6:52	6:56	Pickering	7:28	7:35	Union	8:09	8:13	Willowbrook	8:29	**YARD**		
5	Hamilton	5:38	Bowmanville	7:46	7:53	Hamilton	10:01	10:08	Bowmanville	12:16	12:23	Hamilton	14:31	14:38	Bowmanville	16:46	16:53	Hamilton	19:01
6	Kitchener	5:38	Union	7:13	7:17	Pickering Exp	7:38	7:45	Union	8:19	8:23	Willowbrook	8:39	**YARD**					
7	Milton	5:50	Union	6:38	6:45	Milton	7:33	7:40	Union-Milton	**9:28**	9:40	Union-Milton	11:28	11:40	Union-Milton	13:28	13:40	Union-Milton	**15:28**
8	Bowmanville	5:53	Hamilton	8:01	8:08	Bowmanville	10:16	10:23	Hamilton	12:31	12:38	Bowmanville	14:46	14:53	Hamilton	17:01	17:08	Bowmanville	19:16
9	Kitchener	5:54	Union	7:29	7:33	Bloomington	8:24	8:31	Union	9:22	9:26	Bathurst	9:28	**YARD**					
10	Whitby	5:59	Union	6:43	6:47	Oakville Exp	7:05	7:15	Union	7:47	7:51	Don	7:53	**YARD**					
11	Bloomington	6:01	Union	6:52	6:56	Oakville Exp	7:15	7:25	Union	7:57	8:01	Don	8:03	**YARD**					
12	Kitchener	6:04	Union Exp	7:33	7:37	Don	**7:39**	**YARD**											
13	Willowbrook	6:05	Aldershot	6:25	6:35	Union	7:22	7:26	Whitby DH	7:47	7:59	Union	8:43	8:47	Willowbrook	9:03	**YARD**		
14	Milton	6:05	Union	6:53	7:00	Milton	7:48	7:55	Union	8:43	8:55	Milton	9:43	**YARD**					
15	Hamilton	6:08	Bowmanville	8:16	8:23	Hamilton	10:31	10:38	Bowmanville	12:46	12:53	Hamilton	15:01	15:08	Bowmanville	17:16	17:23	Hamilton	19:31
16	Milton	6:15	Union	7:03	7:10	Meadowvale	7:46	8:00	Union	8:37	8:50	Milton	9:38	**YARD**					
17	Mount Pleasant	6:16	Union	6:59	7:03	Bloomington	7:54	8:01	Union	**8:52**	**9:15**	Georgetown	10:03	10:18	Bloomington	12:04	12:19	Georgetown	14:03
18	Bloomington	6:18	Union	7:09	7:13	Oakville	7:44	7:55	Union	8:27	8:31	Whitby	9:13	**YARD**					
19	Bowmanville	6:23	Hamilton	8:31	8:38	Bowmanville	10:46	10:53	Hamilton	13:01	13:08	Bowmanville	15:16	15:23	Hamilton	17:31	17:38	Bowmanville	19:46
20	Milton	6:25	Union	7:13	7:20	Milton	8:08	8:15	Union	9:03	9:10	Milton	9:58	**YARD**					
21	Whitby	6:29	Union	7:13	7:17	Oakville Exp	7:36	7:45	Union	8:17	8:21	Whitby	9:03	**YARD**					
22	Kitchener	6:29	Union	8:04	8:08	Don	8:10	**YARD**											
23	Willowbrook	6:30	Aldershot	6:50	7:00	Union Exp	7:36	7:40	Whitby Exp	8:11	8:29	Union	9:13	9:17	Willowbrook	9:33	**YARD**		
24	Bloomington	6:31	Union	7:22	7:26	Georgetown	8:14	8:35	Union	9:25	9:29	Don	9:31	**YARD**					
25	Kitchener	6:34	Union Exp	8:03	8:07	Don	8:09	**YARD**											
26	Hamilton	6:38	Bowmanville	8:46	8:53	Hamilton	11:01	11:08	Bowmanville	13:16	13:23	Hamilton	15:31	15:38	Bowmanville	17:46	17:53	Hamilton	20:01
27	Bowmanville	6:38	Union Exp	7:32	7:36	Aldershot	8:22	8:35	Union	9:22	9:26	Whitby	10:08	**YARD**					
28	Milton	6:40	Union	7:28	7:35	Milton	8:23	8:30	Union	9:18	9:25	Milton	10:13	**YARD**					
29	Willowbrook	6:45	Aldershot	7:05	7:15	Union Exp	7:51	7:55	Whitby	8:37	**YARD**								
30	Kitchener	6:51	Union	8:26	8:30	Don	8:32	9:02	Bathurst	9:07	**YARD**								
31	Bowmanville	6:53	Hamilton	9:01	9:08	Bowmanville	11:16	11:23	Hamilton	13:31	13:38	Bowmanville	15:46	15:53	Hamilton	18:01	18:08	Bowmanville	20:16
32	Willowbrook	6:55	Aldershot	7:15	7:25	Union Exp	8:01	8:05	Don	8:07	**YARD**								
33	Milton	6:55	Union	7:43	7:50	Milton	8:38	8:45	Union	9:33	9:40	Milton	**10:28**	10:40	Union-Milton	12:28	12:40	Union-Milton	**14:28**
34	Bloomington	7:01	Union	7:52	7:56	Bathurst	7:58	**YARD**											
35	Whitby	7:02	Pickering	7:12	7:15	Union	7:49	7:53	Willowbrook	8:09	**YARD**								
36	Hamilton	7:08	Bowmanville	9:16	9:23	Hamilton	11:31	11:38	Bowmanville	13:46	13:53	Hamilton	16:01	16:08	Bowmanville	18:16	18:23	Hamilton	20:31
37	Milton	7:10	Union	7:58	8:10	Milton	8:58	**YARD**											
38	Kitchener	7:11	Union	8:46	8:50	Don	8:52	**YARD**											
39	Willowbrook	7:13	Aldershot	7:33	7:43	Union Exp	8:19	8:23	Don	8:25	**YARD**								
40	Whitby	7:20	Union Exp	7:54	7:58	Willowbrook	8:14	**YARD**											
41	Bowmanville	7:23	Hamilton	9:31	9:38	Bowmanville	11:46	11:53	Hamilton	14:01	14:08	Bowmanville	16:16	16:23	Hamilton	18:31	18:38	Bowmanville	20:46
42	Whitby	7:25	Union Exp	7:59	8:03	Willowbrook	8:19	**YARD**											
43	Willowbrook	7:25	Aldershot	7:45	7:55	Union Exp	8:31	8:35	Don	8:37	**YARD**								
44	Milton	7:25	Union	8:13	8:20	Milton	9:08	**YARD**											
45	Kitchener	7:29	Union	9:04	9:08	Don	9:10	**YARD**											
46	Bloomington	7:31	Union	8:22	8:26	Bathurst	8:28	**YARD**											
47	Whitby	7:35	Union Exp	8:09	8:13	Willowbrook	8:29	**YARD**											
48	Willowbrook	7:35	Aldershot	7:55	8:05	Union	8:52	8:56	Don	8:58	**YARD**								
49	Bloomington	8:18	Union	**9:09**	9:19	Bloomington	10:10	10:19	Georgetown	12:03	12:18	Bloomington	14:04	14:19	Union	**15:10**	15:15	Georgetown	16:03

See Appendix G for summary data

2021 EMU Equipment Cycling

Train	Afternoon PM Equipment Cycling										Evening PM Equipment Cycling								
ID	Dp	7th Run To	Ar	Dp	8th Run To	Ar	Dp	9th Run To	Ar	Dp	10th Run To	Ar	Dp	11th Run To	Ar	Dp	12th Run To	Ar	Dp
1	13:18	Bloomington	15:04	15:29	Union	**16:20**	16:25	Kitchener	18:00		**RETURN**								
2	11:18	Bloomington	13:04	13:19	Georgetown	15:03	15:18	Union	**16:08**	16:13	Bloomington	17:04	17:19	Union	18:10	18:15	Kitchener	19:50	
3	18:53	Hamilton	21:01	21:08	Bowmanville	23:16	23:23	Hamilton	1:31		**RETURN**								
4	17:02	Union	17:17	17:21	Pickering	17:53	18:09	Union	18:43	18:47	Aldershot	19:33	19:43	Willowbrook	20:03		**RETURN**		
5	19:08	Bowmanville	21:16	21:23	Hamilton	23:31	23:38	Bowmanville	1:46		**RETURN**								
6	15:13	Union	15:15	15:25	Kitchener	17:00		**RETURN**											
7	15:40	Union-Milton	17:28	17:40	Union-Milton	**19:28**	19:40	Union-Milton	21:28	21:40	Union-Milton	23:28	23:40	Union-Milton	1:28		**RETURN**		
8	19:23	Hamilton	21:31	21:38	Bowmanville	23:46	23:53	Hamilton	2:01		**RETURN**								
9	15:30	Union	15:45	15:55	Kitchener	17:30		**RETURN**											
10	17:01	Union	17:03	17:08	Oakville	17:37	17:50	Union	18:22	18:26	Whitby	19:08		**RETURN**					
11	16:32	Union	16:34	16:38	Oakville	17:07	17:27	Union	17:59	18:04	Bloomington	18:54		**RETURN**					
12	17:17	Union	17:19	17:23	Georgetown	18:11	18:18	Bloomington	**20:04**	20:19	Georgetown	22:03	22:18	Bloomington	0:04	0:19	Union	**1:10**	1:15
13	16:32	Union	16:47	16:51	Pickering	17:23	17:30	Union	18:04	18:08	Aldershot Exp	18:44	18:54	Willowbrook	19:14		**RETURN**		
14	14:32	Union	15:20	15:30	Milton	16:18	16:30	Unon	17:18	17:30	Milton	18:08		**RETURN**					
15	19:38	Bowmanville	21:46	21:53	Hamilton	0:01	0:08	Bowmanville	2:16		**RETURN**								
16	14:52	Union	15:40	15:50	Milton	16:38	16:52	Union	17:40	17:50	Milton	18:38		**RETURN**					
17	14:18	Bloomington	16:04	16:19	Union	**17:10**	17:15	Kitchener	18:50		**RETURN**								
18	15:42	Union	16:26	16:34	Bloomington	17:25	17:34	Union	18:25	18:34	Bloomington	19:25		**RETURN**					
19	19:53	Hamilton	22:01	22:08	Bowmanville	0:16		**RETURN**											
20	16:12	Union	16:00	16:10	Milton	16:58	17:12	Union	18:00	18:10	Milton	18:58		**RETURN**					
21	15:27	Union	16:13	16:17	Aldershot	17:03	17:16	Union Exp	17:52	17:56	Whitby	18:38		**RETURN**					
22	16:51	Union	16:53	16:55	Kitchener	18:30		**RETURN**											
23	15:07	Union	15:22	15:26	Whitby	16:08	16:20	Union DH	16:48	16:52	Aldershot Exp	17:27	17:37	Willowbrook	17:57		**RETURN**		
24	18:09	Union	18:11	18:15	Georgetown	19:03	19:18	Bloomington	**21:04**	21:19	Georgetown	23:03	23:18	Bloomington	1:04		**RETURN**		
25	17:31	Union	17:33	17:35	Kitchener	19:10		**RETURN**											
26	20:08	Bowmanville	22:16	22:23	Hamilton	0:31		**RETURN**											
27	17:02	Union Exp	17:36	17:40	Aldershot	18:26	18:36	Union	19:22	19:26	Whitby	20:08		**RETURN**					
28	16:33	Union	16:20	16:30	Milton	17:18	17:30	Union	18:18	18:30	Milton	19:18		**RETURN**					
29	16:27	Union	17:11	17:15	Oakville	17:44	17:54	Willowbrook	18:06		**RETURN**								
30	15:58	Union	16:00	16:04	Bloomington	16:55	17:02	Union	17:53	17:55	Kitchener	19:30		**RETURN**					
31	20:23	Hamilton	22:31	22:38	Bowmanville	0:46		**RETURN**											
32	16:29	Union	16:31	16:35	Aldershot Exp	17:12	17:22	Willowbrook	17:42		**RETURN**								
33	14:40	Union-Milton	16:28	16:40	Union-Milton	**18:28**	18:40	Union-Milton	20:28	20:40	Union-Milton	22:28	22:40	Union-Milton	0:28	0:35	Union	1:23	1:30
34	16:34	Union	16:36	16:40	Whitby Exp	17:11	17:27	Union	18:13	18:17	Oakville	18:46	18:58	Union	19:30	19:34	Bloomington	20:25	
35	15:37	Union	15:52	15:56	Whitby	16:38	16:50	Union DH	17:18	17:22	Aldershot Exp	17:58	18:05	Union	18:52	18:56	Whitby	19:38	
36	20:38	Bowmanville	22:46	22:53	Hamilton	1:01		**RETURN**											
37	15:47	Union	16:35	16:45	Milton	17:33	17:45	Union	18:33	18:50	Milton	19:38		**RETURN**					
38	18:26	Union	18:28	18:30	Kitchener	20:05		**RETURN**											
39	16:39	Union	16:41	16:45	Aldershot Exp	17:22	17:32	Willowbrook	17:52		**RETURN**								
40	15:22	Union	15:37	15:45	Bramalea	16:15	16:25	Whitby	17:43	17:57	Union	18:41	18:45	Bramalea	19:15	19:22	Union Exp	19:48	19:56
41	20:53	Hamilton	23:01	23:08	Bowmanville	1:16		**RETURN**											
42	16:37	Union	16:52	16:56	Bowman. Exp.	17:52		**RETURN**											
43	16:08	Union	16:10	16:15	Georgetown	17:03	17:18	Bloomington	19:04	19:19	Union	**20:10**	20:15	Georgetown	21:03	21:19	Bloomington	23:04	23:19
44	16:17	Union	17:05	17:15	Milton	18:03		**RETURN**											
45	16:54	Union	16:56	17:00	Milton	17:48	18:00	Union	18:48	19:00	Kitchener	20:35		**RETURN**					
46	16:53	Union	16:55	17:04	Bloomington	17:55	18:04	Union	18:55	19:04	Bloomington	19:55		**RETURN**					
47	17:15	Union	17:30	17:34	Bloomington	18:25	18:45	Union	19:36	19:56	Whitby	20:38		**RETURN**					
48	15:41	Union	15:43	15:47	Aldershot	16:33	16:51	Union Exp	17:27	17:31	Whitby Exp	18:02	18:27	Union	19:13	19:17	Aldershot	20:03	20:13
49	16:18	Bloomington	18:04	18:19	Georgetown	20:03	20:18	Union	**21:08**	21:13	Bloomington	22:04	22:19	Georgetown	0:03	0:18	Bloomington	2:04	

See Appendix G for summary data

2021 EMU Equipment Cycling

Train ID	Late Night PM Equipment Cycling: 13th Run To	Ar	Dp	Deadhead To		Train Returns to Same Place Deployed in AM?	Equipment Cycling Daily Miles per Train per Corridor (by Revenue (R) and Non-Revenue (NR)): LSW-R	LSW-NR	LSE-R	LSE-NR	Geor-R	Geor-NR	Milton-R	Milton-NR	Rhill-R	Rhill-NR
1						Yes	0	0	0	0	277.4	3.8	0	0	114	0
2	**RETURN**					Yes	0	0	0	0	242.6	0	0	0	207.6	0
3						No - Crew Rides Bef/Aft	359.1	0	386.8	0	0	0	0	0	0	0
4						Yes	69.2	55.8	83.7	13.4	0	0	0	0	0	0
5						No - Crew Rides Bef/Aft	359.1	0	386.8	0	0	0	0	0	0	0
6						Yes	0	0	41.9	6.7	125.2	6.7	0	0	0	0
7						Yes	0	0	0	0	0	0	624	0	0	0
8						No - Crew Rides Bef/Aft	359.1	0	386.8	0	0	0	0	0	0	0
9						Yes	0	0	0	0	125.2	1.3	0	0	57	1.3
10						Yes	85.6	3	57.7	0	0	0	0	0	0	0
11						Yes	85.6	3	0	0	0	0	0	0	57	0
12	Mount Pleasant	1:56		**RETURN**		Coordinated Crew Swap	0	0	0	0	204.1	3	0	0	114	0
13						Yes	69.2	55.8	70.7	42.23	0	0	0	0	0	0
14						Yes	0	0	0	0	0	0	249.6	0	0	0
15						No - Crew Rides Bef/Aft	359.1	0	386.8	0	0	0	0	0	0	0
16						Yes	0	0	0	0	0	0	233.4	0	0	0
17						Coordinated Crew Swap	0	0	0	0	204.1	3.8	0	0	171	0
18						Yes	42.8	0	57.7	0	0	0	0	0	114	0
19						Yes	319.2	0	343.8	0	0	0	0	0	0	0
20						Yes	0	0	0	0	0	0	249.6	0	0	0
21						Yes	112	0	115.3	0	0	0	0	0	0	0
22						Yes	0	0	0	0	125.2	3	0	0	0	0
23						Yes	69.2	55.8	86.5	42.23	0	0	0	0	0	0
24						Yes	0	0	0	0	176.0	3	0	0	114	0
25						Yes	0	0	0	0	125.2	3	0	0	0	0
26						Yes	319.2	0	343.8	0	0	0	0	0	0	0
27						No - Crew Rides After	138.4	0	129.5	0	0	0	0	0	0	0
28						Yes	0	0	0	0	0	0	249.6	0	0	0
29						Yes	56	42.6	57.7	0	0	0	0	0	0	0
30						Yes	0	0	0	0	125.2	4.3	0	0	57	1.3
31						Yes	319.2	0	343.8	0	0	0	0	0	0	0
32						Yes	69.2	58.8	0	0	0	0	0	0	0	0
33	Milton	2:18		**RETURN**		Yes	0	0	0	0	0	0	624	0	0	0
34	**RETURN**					Yes	42.8	0	57.7	1.3	0	0	0	0	57	1.3
35	**RETURN**					Yes	69.2	0	78.6	50.13	0	0	0	0	0	0
36						Yes	319.2	0	343.8	0	0	0	0	0	0	0
37						Yes	0	0	0	0	0	0	187.2	0	0	0
38						Yes	0	0	0	0	125.2	3	0	0	0	0
39						Yes	69.2	58.8	0	0	0	0	0	0	0	0
40	Whitby	20:38		**RETURN**		Yes	0	0	115.3	6.7	69.6	6.7	0	0	0	0
41						Yes	319.2	0	343.8	0	0	0	0	0	0	0
42						No - Crew Rides After	0	0	71.8	13.4	0	0	0	0	0	0
43	Mount Pleasant	0:56	1:03	Willowbrook	**RETURN**	Yes	34.6	29.4	0	0	141.5	32.3	0	0	114	0
44						Yes	0	0	0	0	0	0	124.8	0	0	0
45						Yes	0	0	0	0	125.2	1.5	62.4	1.5	0	0
46						Yes	0	0	0	0	0	0	0	0	114	2.6
47						Yes	0	0	57.7	6.7	0	0	0	0	57	6.7
48	Willowbrook	20:33		**RETURN**		Yes	138.4	58.8	57.7	0	0	0	0	0	0	0
49	**RETURN**					Yes	0	0	0	0	234.7	0	0	0	313.5	0
	See Appendix G for summary data						**4183.8**	**421.8**	**4405.7**	**182.8**	**2426.3**	**75.5**	**2604.6**	**1.5**	**1661.1**	**13.2**

Appendix I: 2031 Peak Demand

2031 Peak Demand

LAKESHORE WEST

Peak Hour/Point	
2021	2031
19,200	23,000

Union Ar				
LOCAL		*EXPRESS*		
2021	**2031**	**2021**	**2031**	**NOTES**
AM PEAK SHOULDER RAMP UP				
6:28	6:28			All-day
6:43	6:40			
	6:52			All-day (2031)
6:58	7:04			All-day
7:13	7:16			
AM PEAK HOUR				
7:28	7:28			All-day
7:38	7:35	*7:35*	*7:33*	
	7:43	*7:47*	*7:42*	All-day (2031)
7:48	7:50	*7:55*	*7:51*	
7:58	7:58		*8:00*	All-day
8:08	8:05	8:05	8:09	
8:18	8:13	8:18	8:17	All-day (2031)
	8:20	8:21	8:24	
AM PEAK SHOULDER RAMP DOWN				
8:28	8:28			All-day
8:43	8:43	*EMU Cycle*		All-day (2031)
	8:51	*Cycle*		
8:58	8:58	*EMU Cycle*		All-day
9:13	9:13	*Cycle*		All-day (2031)
9:28	9:28	*Cycle*		All-day
9:58	9:43	*Cycle*		All-day (2031)
EV 1/2hr	Ev 1/4hr			

ASSUMED; NOT A METROLINX TIMETABLE

Peak:Shoulder	3:1

4 New LHCs Required
0 (same with EMUs)

PTC?: **Required**
Corridor lacks width for more track east of Willowbrook Yard

LAKESHORE EAST

Peak Hour/Point	
2021	2031
12,800	19,725

2021 demand interpreted from the Reference Case, 2031 as published in "The Big Move", with 25% reduction for Lakeshore East demand projection as per Union Station Demands and Opportunities Study

Union Ar				
LOCAL		*EXPRESS*		
2021	**2031**	**2021**	**2031**	**NOTES**
AM PEAK SHOULDER RAMP UP				
6:30	6:30			All-day
	6:40			
6:45	6:50			All-day(2031)
7:00	7:00			All-day
	7:10			
7:15	7:20			All-day(2031)
7:30	7:30			All-day
AM PEAK HOUR				
7:42	7:40	7:36	7:35	All-day (Local)
	7:50	7:50	7:45	
8:00	8:00	8:00	7:55	All-day(Local)
8:09	8:10	8:09	8:05	
8:19	8:20		8:15	*EMU Cycle*
			8:25	
AM PEAK SHOULDER RAMP DOWN				
8:30	8:30			All-day
	8:40	*EMU Cycle*		
8:45	8:50	*Cycle*		All-day(2031)
9:00	9:00	*Cycle*		All-day
	9:10	*Cycle*		
9:15	9:20	*Cycle*		All-day(2031)
9:30	9:30	*Cycle*		All-day
10:00	9:45	*Cycle*		All-day
Ev 1/2hr	Ev 1/4hr			

ASSUMED; NOT A METROLINX TIMETABLE

Peak:Shoulder	2:1

6 New LHCs Required
2 Fewer with EMUs via equipment cycling

PTC?: **Required**
Corridor lacks width for more track west of Scarborough Junction.

GEORGETOWN

(Georgetown, Milton, and Richmond Hill 2031 values combine peak point peak hour values of both express rail and regional rail in The Big Move)

Peak Hour/Point	
2021	2031
11,200	23,500

2021 demand interpreted from the Reference Case, 2031 as published in "The Big Move" (2 components)

Union Ar				
LOCAL		*EXPRESS*		
2021	**2031**	**2021**	**2031**	**NOTES**
AM PEAK SHOULDER RAMP UP				
6:34	6:34			Kitchener
	6:41			All-day (2031)
	6:48			
6:54	6:55			O-Kit-AD (2031)
7:02	7:02			All-day (2021)
	7:09			All-day (2031)
AM PEAK HOUR				
7:14	7:16			Kitchener
	7:23		7:25	All-day (2031)
7:29	7:30			Kitchener
	7:37	7:33	7:35	Kit Exp, AD Local
7:42	7:44		7:45	Brmlea-L, EMU Cycle
	7:51			All-day (2031)
	7:58		7:55	
8:02	8:05	8:03	8:05	Kit Exp, AD Local
8:04	8:12		8:15	Kit-L, *EMU-X Cycle*
AM PEAK SHOULDER RAMP DOWN				
	8:19	*EMU Cycle*		All-day (2031)
8:26	8:28			Kitchener
	8:37	*Cycle*		All-day (2031)
8:46	8:45			Kitchener
	8:52	*Cycle*		All-day (2031)
9:02	9:07	*Cycle*		All-day
9:04	9:22			Kitchener
10:02	Ev 1/4hr			
11:02				All-day
Ev 1hr				

ASSUMED; NOT A METROLINX TIMETABLE

Peak:Shoulder	2:1

12 New LHCs Required
2 Fewer with EMUs via equipment cycling

PTC?: Very strongly recommended
(Likely required before 2041 anyway)

MILTON

Peak Hour/Poin	
2021	2031
9,600	24,500

Union Ar		
LOCAL		
2021	**2031**	**NOTES**
AM PEAK RAMP UP		
	6:30	
6:36	6:38	All-day (2031)
	6:46	
6:56	6:54	All-day (2031)
	7:02	
	7:10	All-day (2031)
7:17	7:18	
AM PEAK HOUR		
7:24	7:24	All-day
7:27	7:28	
	7:32	
	7:36	
	7:40	All-day (2031)
7:42	7:44	
	7:48	
	7:52	All-day (2031)
7:57	7:56	
	8:00	
	8:04	*EMU Cycle*
	8:08	All-day (2031)
8:12	8:12	*EMU Cycle*
	8:16	
	8:20	*Cycle*
8:24	8:24	All-day *Cycle*
8:27	8:27	
AM PEAK RAMP DOWN		
	8:33	*Cycle*
8:37	8:39	All-day (2031)
	8:46	*Cycle*
8:57	8:54	All-day (2031)
	9:01	*Cycle*
	9:09	All-day (2031)*Cycle*
9:17	9:17	*Cycle*
9:24	9:25	All-day *Cycle*
10:24	9:40	*Cycle*
Ev 1hr	Ev 1/4hr	

ASSUMED; NOT A METROLINX TIMETABLE

Peak:Shoulder	2:1

13 New LHCs Required
2 Fewer w/EMUs via cycling

PTC?: **Required**
Only 2 GO tracks in corridor

RICHMOND HILL

Peak Hour/Point	
2021	2031
4,800	19,300

Union Ar		
LOCAL		
2021	**2031**	**NOTES**
AM PEAK RAMP UP		
	6:32	
	6:42	
6:52	6:52	2031 AD
	6:57	
	7:02	
7:09	7:07	All-Day
	7:12	
	7:17	
7:22	7:22	2031 AD
AM PEAK HOUR		
	7:27	
	7:32	
	7:37	2031 AD
	7:42	
	7:47	
7:52	7:52	2031 AD
	7:57	
	8:02	*EMU Cycle*
8:09	8:07	All-Day
	8:12	*EMU Cycle*
	8:17	
8:22	8:22	2031AD,*Cycle*
AM PEAK RAMP DOWN		
	8:27	*Cycle*
	8:32	*EMU Cycle*
	8:37	2031AD,*Cycle*
	8:42	*Cycle*
	8:47	*Cycle*
8:52	8:52	2031AD, *Cycle*
	8:57	*Cycle*
	9:02	*Cycle*
9:09	9:07	AD, *Cycle*
	9:12	*Cycle*
	9:17	*Cycle*
9:22	9:22	2031AD*Cycle*
10:09	9:37	*Cycle*
Ev 1hr	Ev 1/4hr	

ASSUMED; NOT A METROLINX TIMETABLE

Peak:Shoulder	1:1

16 New LHCs Required
3 Fewer with EMUs

PTC?: **Required** (2-trk corridor)

Legend

Cycle means new train not required to make this run
EMU Cycle means a new EMU train is not required for providing this run

	Trip that does not exist in 2021
12:34	Scheduled shoulder hr trip that is new in that yr
12:34	Scheduled peak hour trip that is new in that year
12:34	Existing trip, possibly rescheduled in 2031

Appendix J: Capital Costs of Rolling Stock

Capital Costs of Rolling Stock

All $ figures are in millions of dollars

Req.'d Coach Retirement Replacements for LHCs in 2031			
Corridor	Corridor LHCs	As % of Total	Coaches Allocated
Lakeshore	53	42.1%	27
Georgetown	26	20.6%	13
Milton	24	19.0%	12
Richmond Hill	23	18.3%	12
Total	**126**	**100.0%**	**64**

Note: Based on schedule models in other appendices.

For detailed unit costs, see Appendix A

Retirements in 2031	Coaches	Cabs
Quantity	64	First batch
Replacement Cost	$175.36	lasts until 2036

LEGEND

DLHC: Diesel Locomotive-Hauled Consist
ELHC: Electric Locomotive-Hauled Consist
EMUC: Electric Multiple-Unit Consist
PTC: Positive Train Control

2021 LAKESHORE FLEET ESTIMATES BY TECHNOLOGY

Calculations based on assumption Lakeshore first to electrify

CAPITAL COSTS	DLHC	ELHC	EMUC
Revenue Consists	37	37	27
Revenue Coaches	333	333	162
Revenue Cabs/EMUs	37	37	162
Revenue Electric Loco.'s	n/a	29	n/a
Revenue Diesel Loco.'s	37	8	n/a
Revenue DMU Cars	n/a	n/a	8
Spare Electric Loco.'s	n/a	5	n/a
Spare Diesel Loco.'s	6	2	n/a
Spare Coaches	17	17	9
Spare Cabs/EMUs	4	4	25
Spare DMUs	n/a	n/a	2
Diesel Locomotives Total $	$336.26	$78.2	n/a
Electric Locomotives Total $	n/a	$380.80	n/a
Coaches Total $	$959.00	$959.00	$468.54
Cabs/EMUs Total $	$125.46	$125.46	$785.40
DMUs Total $	n/a	n/a	$45.80
Fleet Total $	$1,420.72	$1,543.46	$1,299.74
2021 Incremental Vehicle $	0	$122.74	($120.98)
EMUC vs ELHC			($243.72)
Ref. Case Incremental Figure		$122.64	
On-Board PTC $	$4.3	$4.4	$18.7

NOTE: DMUs already purchased if not used for ARL scheme

2021 GEORGETOWN FLEET ESTIMATES BY TECHNOLOGY

Calculations based on assumption Lakeshore is electrified

CAPITAL COSTS	DLHC	ELHC	EMUC
Revenue Consists	14	14	11
Revenue Coaches	126	126	66
Revenue Cabs/EMUs	14	14	66
Revenue Locomotives	14	14	n/a
Spare Locomotives	3	2	n/a
Spare Coaches	6	6	3
Spare Cabs/EMUs	2	2	10
Exist. Diesel Loco. Rebuilds	9	n/a	n/a
Exist. Coach Rebuilds	118	118	n/a
Exist. Cab Car Rebuilds	11	11	n/a
Locomotives Total $	$80.56	$179.20	n/a
Coaches Total $	$116.24	$116.24	$189.06
Cabs/EMUs Total $	$23.00	$23.00	$319.20
Cab Conversion Total $	n/a	$0.03	n/a
Sell Locomotives	n/a	($13.6)	($13.6)
Sell Coaches	n/a	n/a	($53.1)
Sell Cab Cars	n/a	n/a	($5.4)
Conventional Fleet Total $	$219.80	$304.88	$436.18
2021 Incremental Vehicle $	$0.00	$85.08	$216.38
EMUC vs ELHC			$131.30
Air-Rail Link Fleet Size	12	12	*thru-route*
Air-Rail Link Car Unit $	$4.58	$5.58	*thru-route*
Air-Rail Link Fleet Total $	$54.96	$66.96	*thru-route*
Air-Rail Link Incremental $	$0.00	$12.00	*thru-route*
Complete Fleet Total $	$274.76	$371.84	*thru-route*
Ref. Case Incremental Figure		$64.99	
On-Board PTC $	$1.7	$1.6	$7.6

NOTE: If current ARL proposal abandoned, DMUs can go to St Cats

2031 LAKESHORE FLEET ESTIMATES BY TECHNOLOGY

Estimate to reach "Big Move" service levels from Ref. Case

CAPITAL COSTS	DLHC	ELHC	EMUC
2021-2031 New Consists	10	10	8
New Locomotives (w/spares)	11	12	n/a
New Coaches (w/spares)	94	94	51
New Cabs/EMUs (w/spares)	11	11	55
2021-2031 Fleet Growth	$377.24	$425.62	$370.74
2031 Retired Replacements	$73.98	$73.98	n/a
2031 Total Growth $	$451.22	$499.60	$370.74
2031 Incremental Vehicle $	$80.48	$128.86	$0.00
2021-2031 On-Board PTC $	$1.2	$1.2	$5.6

2031 GEORGETOWN FLEET ESTIMATES BY TECHNOLOGY

Estimate to reach "Big Move" service levels from Ref. Case

CAPITAL COSTS	DLHC	ELHC	EMUC
2021-2031 New Consists	12	12	10
New Locomotives (w/spares)	14	14	n/a
New Coaches (w/spares)	113	113	63
New Cabs/EMUs (w/spares)	14	14	69
2021-2031 Fleet Growth	$461.94	$509.26	$462.42
2031 Retired Replacements	$35.62	$35.62	n/a
2031 Total Growth $	$497.56	$544.88	$462.42
2031 Incremental Vehicle $	$35.14	$82.46	$0.00
2021-2031 On-Board PTC $	$1.4	$1.4	$6.9

Capital Costs of Rolling Stock

All $ figures are in millions of dollars

2021 MILTON FLEET ESTIMATES BY TECHNOLOGY

Calculations assume Lakeshore & Georgetown are electrified
Cab cars, non-EMU coaches, & diesel locomotives are rebuilds

CAPITAL COSTS	DLHC	ELHC	EMUC
Revenue Consists	11	11	8
Revenue Coaches	99	99	48
Revenue Cabs/EMUs	11	11	48
Revenue Locomotives	11	11	n/a
Spare Locomotives	1	2	n/a
Spare Coaches	5	5	2
Spare Cabs/EMUs	1	1	7
Exist. Diesel Loco. Rebuilds	12	n/a	n/a
Exist. Coaches Rebuilds	104	104	n/a
Exist. Cab Cars Rebuilds	12	12	n/a
Locomotives Total $	$24.00	$145.60	n/a
Coaches Total $	$68.64	$68.64	$137.00
Cabs/EMUs Total $	$8.40	$8.40	$231.00
Cab Conversion Total $	n/a	0.18	n/a
Sell Locomotives	n/a	($18.12)	($18.12)
Sell Coaches	n/a	n/a	($46.8)
Sell Cab Cars	n/a	n/a	($5.9)
Fleet Total $	$101.04	$204.70	$297.20
2021 Incremental Vehicle $	$0.00	$103.66	$196.16
EMUC vs ELHC			$92.50
Ref. Case Incremental Figure		$133.78	
On-Board PTC $	$1.2	$1.3	$5.5

2021 RICHMOND HILL FLEET ESTIMATES BY TECHNOLOGY

Assumes Lakeshore, Georgetown, & Milton are electrified
All R.Hill cab cars, non-EMU coaches, and d.loco.'s are rebuilds

CAPITAL COSTS	DLHC	ELHC	EMUC
Revenue Consists	7	7	3
Revenue Coaches	63	63	18
Revenue Cabs/EMUs	7	7	18
Revenue Locomotives	7	7	n/a
Spare Locomotives	2	1	n/a
Spare Coaches	4	4	1
Spare Cabs/EMUs	0	0	3
Exist. Diesel Loco. Rebuilds	9	n/a	n/a
Exist. Coach Rebuilds	67	67	n/a
Exist. Cab Car Rebuilds	7	7	n/a
Locomotives Total $	$18.00	$89.60	n/a
Coaches Total $	$44.22	$44.22	$52.06
Cabs/EMUs Total $	$4.90	$4.90	$88.20
Cab Conversion Total $	n/a	0.105	n/a
Sell Locomotives	n/a	($13.59)	($13.59)
Sell Coaches	n/a	n/a	($30.15)
Sell Cabs	n/a	n/a	($3.43)
Fleet Total $	$67.12	$125.24	$93.09
2021 Incremental Vehicle $	$0.00	$58.12	$25.97
EMUC vs ELHC (2031)			($32.15)
Ref. Case Incremental Figure		$81.60	
On-Board PTC $	$0.9	$0.8	$2.1

2031 MILTON FLEET ESTIMATES BY TECHNOLOGY

Estimate to reach "Big Move" service levels from Ref. Case

CAPITAL COSTS	DLHC	ELHC	EMUC
2021-2031 New Consists	13	13	11
New Locomotives (w/spares)	15	15	n/a
New Coaches (w/spares)	123	123	69
New Cabs/EMUs (w/spares)	14	14	76
2021-2031 Fleet Growth	$497.16	$547.86	$508.26
2031 Retired Replacements	$32.88	$32.88	n/a
2031 Total Growth $	$530.04	$580.74	$508.26
2031 Incremental Vehicle $	$21.78	$72.48	$0.00
2021-2031 On-Board PTC $	$1.6	$1.6	$7.6

2031 RICHMOND HILL FLEET ESTIMATES BY TECHNOLOGY

Estimate to reach "Big Move" service levels from Ref. Case

CAPITAL COSTS	DLHC	ELHC	EMUC
2021-2031 New Consists	16	16	13
New Locomotives (w/spares)	19	18	n/a
New Coaches (w/spares)	151	151	82
New Cabs/EMUs (w/spares)	17	17	89
2021-2031 Fleet Growth	$614.34	$667.36	$598.48
2031 Retired Replacements	$32.88	$32.88	n/a
2031 Total Growth $	$647.22	$700.24	$598.48
2031 Incremental Vehicle $	$48.74	$101.76	$0.00
2021-2031 On-Board PTC $	$1.9	$1.9	$9.0

SUMMARIES

2021 Network Summary	DLHC	ELHC	EMUC
Lakeshore	$1,420.72	$1,543.46	$1,299.74
Georgetown	$274.76	$371.84	$436.18
Milton	$101.04	$204.70	$297.20
Richmond Hill	$67.12	$125.24	$93.09
TOTAL	$1,863.64	$2,245.24	$2,126.21
2021 Total Incremental $	$0.00	$381.60	$262.57

2031 Network Summary	DLHC	ELHC	EMUC
Lakeshore	$1,871.94	$2,043.06	$1,670.48
Georgetown	$772.32	$916.72	$898.60
Milton	$631.08	$785.44	$805.46
Richmond Hill	$714.34	$825.48	$691.57
TOTAL	$3,989.68	$4,570.70	$4,066.11
2031 Total Incremental $	$0.00	$581.01	$76.43

LEGEND

DLHC: Diesel Locomotive-Hauled Consist
ELHC: Electric Locomotive-Hauled Consist
EMUC: Electric Multiple-Unit Consist
PTC: Positive Train Control

For detailed unit costs, see Appendix A

Scarborough corridor vehicle costs are in Appendix O.

Stouffville & Barrie peak operations expected to remain diesel for medium term, therefore no rolilng stock estimate generated.

Appendix K: Electricity Demand Charges

APPENDIX K

Electricity Demand Charges

SUBSTATION READINGS FOR PEAK HOUR *(Units are MVA)*

Substation (SS)	T1	T2	Total	Line 1	Line 2	Line 3
Guelph	2.2	3.2	5.4	Georgetown		
Bramalea - Dixie Rd	3	16.8	19.8	Georgetown	Milton	Air-Rail Link
Newmarket	5.1	7.5	12.6	Barrie		
Mimico	9.9	5.8	15.7	Lakeshore W	Milton & GTown	Barrie & LSE
Burlington	5.7	10.7	16.4	Lakeshore W	TH&B/Grimsby	
Scarborough	13.7	14.5	28.2	Lakeshore E	Stouffville	Richmond Hill
Oshawa	6.3	3.9	10.2	Lakeshore E		
ALL	*all*		108.3	FULL NETWORK		

Above are approximations from graph in the 2010 electrification study Appendix 7E (pg 180)

ESTIMATED POWER DRAW BY LINE*

Corridor (SS)	MVA
Georgetown	11.082
Air-Rail Link	3.409
Milton (Dixie)	10.709
TH&B/Grimsby	4.28
Lakeshore W	20.65
Lakeshore E	19.9
Richmond Hill	7.5
Barrie	12.6
Stouffville	11
Milton (Mimico)	1.55
Barrie (Mimico)	3.08
GTown (Mimico)	0.79
LSE (Mimico)	1.75
TOTAL	108.3

DEMAND CHARGE CALCULATIONS FOR 2021 BY CORRIDOR*

Corridor	Tech.	Peak kVA	Peak kW	Consist Equivalent	In-Service Fleet % Equivalent	Monthly Charge	Transformer Discount	Charge after Discount/mo.	Annual Demand Charge
Lakeshore West (Less TH&B/Grimsby)	LHC	20,650	20,237	4.3	35.7%	$111,716.50	$12,390.00	$99,326.50	$1,191,918.00
	EMU	23,495	23,975	5.0		$127,109.49	$14,097.17	$113,012.32	$1,356,147.83
Lakeshore East	LHC	21,650	21,217	4.5	26.4%	$117,126.50	$12,990.00	$104,136.50	$1,249,638.00
	EMU	16,146	16,476	3.4		$87,350.11	$9,687.63	$77,662.48	$931,949.80
Georgetown	LHC	11,872	11,635	2.5	17.6%	$64,227.52	$7,123.20	$57,104.32	$685,251.84
	EMU	9,097	9,283	1.9		$49,215.25	$5,458.25	$43,756.99	$525,083.93
Milton	LHC	12259	12014	2.5	23.1%	$66,321.19	$7,355.40	$58,965.79	$707,589.48
	EMU	8,695	8,872	1.8		$47,039.58	$5,216.96	$41,822.63	$501,871.50
Richmond Hill	LHC	7500	7350	1.6	22.2%	$40,575.00	$4,500.00	$36,075.00	$432,900.00
	EMU	3,135	3,199	0.7		$16,958.82	$1,880.83	$15,077.99	$180,935.87
Barrie(Benchmark)	LHC	15,680	15,366	3.2	32.5%	$84,828.80	$9,408.00	$75,420.80	$905,049.60
ARL (Benchmark)	EMU	3,409	3,341	1.5	38.4%	$18,442.69	$2,045.40	$16,397.29	$196,767.48
Stouffville (Bnchmk)	LHC	11,000	10,780	2.3	19.0%	$59,510.00	$6,600.00	$52,910.00	$634,920.00
TH&B/Grimsby	LHC	4,280	4,194	0.9	11.1%	$23,154.80	$2,568.00	$20,586.80	$247,041.60

**Costs above are based on electrification of the entire network, as corridor by corridor simulations are unrealistic according to LTK Consulting*
See Appendix A for typical unit costs

Appendix L: Annual Electricity Cost Calculations

See Appendices B, G & H for background data

See Appendix A for typical units

APPENDIX L

Annual Electricity Cost Calculations

Corridor	Electrify To	Technology (*See notes in Chapter 4*)	Weekday							
			Revenue Miles	Deploy Miles	Midday Miles	Return Miles	Total Miles	Revenue Ton-Miles	Non-Rev. Ton-Miles	Daily Ton-Miles
Lakeshore West	Hamilton (James)	D-Loco	3,296.4	97.8	176.8	97.8	3,668.8	2,661,843.0	256,025.0	2,917,868.0
		E-Loco						2,344,189.9	220,139.2	2,564,329.1
		EMU (1:1)						2,579,796.9	246,698.1	2,826,495.0
	TH&B	EMU (Best)	4,183.8	421.8			4,605.6	2,698,466.7	279,423.3	2,977,890.0
Lakeshore East	Bow-man-ville	D-Loco	3,529.3	76.2	251.64	60.8	3,917.9	2,849,901.7	267,190.0	3,117,091.7
		E-Loco						2,509,806.5	229,739.2	2,739,545.7
		EMU (1:1)						2,762,059.0	257,456.3	3,019,515.4
		EMU (Best)	4,405.7	182.8			4,588.5	2,898,833.2	121,090.1	3,019,923.3
Georgetown	Kit-che-ner	D-Loco	2,220.0	6.7	47.1	6.7	2,280.5	1,792,650.0	41,593.8	1,834,243.8
		E-Loco						1,578,722.7	35,763.8	1,614,486.5
		EMU (1:1)						1,737,395.1	40,078.5	1,777,473.6
		EMU (Best)	2,426.3	75.5			2,501.7	1,506,279.8	49,993.2	1,556,273.0
Milton	Milton	D-Loco	1,626.60	14.80	748.80	14.80	2,405.0	1,313,479.5	535,150.0	1,848,629.5
		E-Loco						1,156,734.4	460,140.5	1,616,875.0
		EMU (1:1)						1,272,994.1	515,654.6	1,788,648.7
		EMU (Best)	2604.6	1.5			2606.1	1,875,604.1	993.7	1,876,597.7
Richmond Hill	Bloo-ming-ton	D-Loco	1,197.00	35.20	127.0	35.2	1,394.4	966,577.5	135,712.5	1,102,290.0
		E-Loco						851,230.2	116,690.3	967,920.5
		EMU (1:1)						936,784.6	130,768.5	1,067,553.2
		EMU (Best)	1661.1	13.2			1674.3	972,863.0	8,744.4	981,607.4
Barrie (Benchmark)	Barrie	D-Loco	2522	28.2	337.8	49.7	2937.7	2,036,515.0	285,793.8	2,322,308.8
Stouffville (Bnchmk)	Lincolnville	D-Loco	1545.3	179.7	212.7	179.7	2117.4	1,247,829.8	393,318.8	1,641,148.5
TH&B/Grimsby (Bmk)	St. Cat.'s	D-Loco	888.8	0	0	0	888.8	717,706.0	0.0	717,706.0
ARL (Benchmark)	Pearson	2-car EMU	2,154.4	26.8	0.0	26.8	2,208.0	383,479.9	8,040.0	391,519.9

See Appendices B, G & H for background data

See Appendix A for typical units

APPENDIX L

Annual Electricity Cost Calculations

Corridor	Electrify To	Technology (*See notes in Chapter 4*)	Annual					
			Weekday Ton-Miles	Wknd (% of Wkdy)	Weekend Ton-Miles	Total Ton-Miles	Demand Charge	Total Cost of Electricity
Lakeshore West	Hamilton (James)	D-Loco	729,467,000.0	32.8%	137,221,692.2	866,688,692.2	*inclusive*	$6,552,166.5
		E-Loco	641,082,272.7		123,877,662.5	764,959,935.2	$1,191,918.0	$5,923,000.1
		EMU (1:1)	706,623,740.3		133,772,893.5	840,396,633.7	$1,210,342.0	$6,407,980.8
	TH&B	EMU (Best)	744,472,509.4	n/a	86,184,186.5	830,656,696.0	$1,356,147.8	$6,493,547.6
Lakeshore East	Bow-man-ville	D-Loco	779,272,918.8	36.1%	129,418,894.0	908,691,812.7	*inclusive*	$6,869,710.1
		E-Loco	684,886,423.3		113,743,518.2	798,629,941.5	$1,249,638.0	$6,189,000.1
		EMU (1:1)	754,878,839.1		125,367,611.4	880,246,450.5	$1,268,954.2	$6,713,097.6
		EMU (Best)	754,980,824.4	n/a	92,837,000.9	847,817,825.3	$931,949.8	$6,175,528.8
Georgetown	Kit-che-ner	D-Loco	458,560,937.5	19.0%	40,105,816.6	498,666,754.1	*inclusive*	$3,769,920.7
		E-Loco	403,621,619.3		35,300,814.6	438,922,434.0	$685,251.8	$3,400,352.3
		EMU (1:1)	444,368,391.2		38,864,534.2	483,232,925.4	$695,844.1	$3,685,041.8
		EMU (Best)	389,068,254.6	n/a	15,214,832.9	404,283,087.5	$525,083.9	$3,025,911.2
Milton	Milton	D-Loco	462,157,375.0	24.8%	52,773,106.4	514,930,481.4	*inclusive*	$3,892,874.4
		E-Loco	404,218,738.6		46,157,174.3	450,375,912.9	$707,589.5	$3,493,549.3
		EMU (1:1)	447,162,169.5		51,060,824.8	498,222,994.3	$718,527.0	$3,800,461.9
		EMU (Best)	469,149,435.4	n/a	22,464,048.6	491,613,484.0	$501,871.5	$3,542,920.9
Richmond Hill	Bloo-ming-ton	D-Loco	275,572,500.0	30.7%	38,874,034.8	314,446,534.8	*inclusive*	$2,377,215.8
		E-Loco	241,980,136.4		34,135,279.3	276,115,415.7	$432,900.0	$2,140,203.2
		EMU (1:1)	266,888,290.9		37,648,984.3	304,537,275.2	$439,591.5	$2,322,635.4
		EMU (Best)	245,401,843.8	n/a	17,100,037.0	262,501,880.8	$180,935.9	$1,804,062.5
Barrie (Benchmark)	Barrie	D-Loco	580,577,187.5	29.1%	77,724,701.9	658,301,889.4	$905,049.6	$4,976,762.3
Stouffville (Bnchmk)	Lincolnville	D-Loco	410,287,125.0	26.8%	50,540,147.8	460,827,272.8	$634,920.0	$3,483,854.2
TH&B/Grimsby (Bmk)	St. Cat.'s	D-Loco	179,426,500.0	None	0.0	179,426,500.0	$247,041.6	$1,356,464.3
ARL (Benchmark)	Pearson	2-car EMU	n/a - 365-day-a-year service			142,904,772.6	$196,767.5	$1,080,360.1

See Appendices B, G & H for background data

See Appendix A for typical units

APPENDIX L

Annual Electricity Cost Calculations

Corridor	Electrify To	Technology (*See notes in Chapter 4*)	Annual: Regenerative Braking Saving	Annual: Total Cost Post-Regen. Braking	Annual: Annual kWh	Annual: kWh/ Ton-Mile	Cross-Reference: $ Published in 2010 e-study	Cross-Reference: Deviation from 2010 e-study $
Lakeshore West	Hamilton (James)	D-Loco	($982,825.0)	$5,569,341.5	62,692,965	0.0723	$6,568,462	0.25%
		E-Loco	($888,450.0)	$5,034,550.1	55,334,294	0.0723	*Note: Weekend cost based on % of weekday service that includes St. Cats and TH&B service, even when those aren't electrified.*	
		EMU (1:1)	($1,281,596.2)	$5,126,384.6	60,791,098	0.0723		
	TH&B	EMU (Best)	($1,298,709.5)	$5,194,838.1	60,086,547	0.0723		
Lakeshore East	Bow-man-ville	D-Loco	($1,030,456.5)	$5,839,253.6	65,731,837	0.0723	$6,841,409	0.41%
		E-Loco	($928,350.0)	$5,260,650.0	57,770,316	0.0723	*Note: Lakeshore East & West combined deviation from the 2010 electrification study's estimate is less than 0.001%.*	
		EMU (1:1)	($1,342,619.5)	$5,370,478.0	63,674,192	0.0723		
		EMU (Best)	($1,235,105.8)	$4,940,423.0	61,328,409	0.0723		
Georgetown	Kit-che-ner	D-Loco	($565,488.1)	$3,204,432.6	36,077,998	0.0723	$3,775,137	0.14%
		E-Loco	($510,052.8)	$2,890,299.5	31,755,561	0.0723	*ARL is listed separately, except in the EMU (Best) scenario where through-routing regular GO service via Pearson is assumed.*	
		EMU (1:1)	($737,008.4)	$2,948,033.4	34,961,377	0.0723		
		EMU (Best)	($605,182.2)	$2,420,729.0	29,249,442	0.0723		
Milton	Milton	D-Loco	($583,931.2)	$3,308,943.3	37,254,795	0.0723	$3,892,875	0.00%
		E-Loco	($524,032.4)	$2,969,516.9	32,584,325	0.0723		
		EMU (1:1)	($760,092.4)	$3,040,369.5	36,046,022	0.0723		
		EMU (Best)	($708,584.2)	$2,834,336.7	35,567,829	0.0723		
Richmond Hill	Bloo-ming-ton	D-Loco	($356,582.4)	$2,020,633.4	22,740,536	0.0723	$2,377,218	0.00%
		E-Loco	($321,030.5)	$1,819,172.7	19,968,458	0.0723		
		EMU (1:1)	($464,527.1)	$1,858,108.4	22,023,906	0.0723		
		EMU (Best)	($360,812.5)	$1,443,250.0	18,983,938	0.0723		
Barrie (Benchmark)	Barrie	D-Loco	($746,514.3)	$4,230,247.9	47,622,371	0.0723	$4,973,957	0.06%
Stouffville (Bnchmk)	Lincolnville	D-Loco	($522,578.1)	$2,961,276.1	33,320,868	0.0723	$3,485,055	0.03%
TH&B/Grimsby (Bmk)	St. Cat.'s	D-Loco	($203,469.7)	$1,152,994.7	12,975,705	0.0723	$1,340,170	1.20%
ARL (Benchmark)	Pearson	2-car EMU	($162,054.0)	$918,306.07	10,334,416	0.0723	$1,080,468	0.01%

Appendix M: Annual Operating Costs

Annual Operating Costs

Train Crewing Labour Costs

Corridor	Lakeshore		Kitchener		Milton		Richmond Hill	
LABOUR	**DLHC/ELHC**	**EMU/DMU**	**DLHC/ELHC**	**EMU**	**DLHC/ELHC**	**EMU**	**DLHC/ELHC**	**EMU**
Off-Peak Coverage (in Corridor Miles)	75.6	82.88	24.1	29.3	23.1	31.2	21.0	28.5
2021 AM Peak Trains	37	31	14	11	11	8	7	3
Off-Peak Trains	12	9	3	2	2	2	2	2
Reduced Off-Peak Buses	0	-2	0	-1	0	-2	0	-1
Weekday Peak Labour Cost	$7,920,456	$6,636,058	$2,996,929	$2,354,730	$2,354,730	$1,712,531	$1,498,465	$642,199
Weekday Off-Peak Labour $	$5,137,593	$3,425,062	$1,284,398	$642,199	$856,266	$428,133	$856,266	$642,199
Non-Weekday Labour Cost	$3,038,519	$2,025,680	$759,630	$379,815	$506,420	$253,210	$506,420	$379,815
2021 Annual Labour Cost	$16,096,568	$12,086,799	$5,040,957	$3,376,744	$3,717,416	$2,393,874	$2,861,150	$1,664,213
EMUs vs LHCs (2021)		($4,009,769)		($1,664,213)		($1,323,542)		($1,196,937)
2031 AM Peak Trains	47	35	26	21	24	19	23	16
2021 Off-Peak Frequency	30		60					
2031 Off-Peak Frequency	15		15					
2031 Annual Labour Cost	$29,176,765	$20,318,206	$15,179,539	$9,481,469	$11,696,109	$7,503,292	$11,459,646	$8,299,157
EMUs vs LHCs (2031)		($8,858,559)		($5,698,070)		($4,192,817)		($3,160,490)

See Appendix A for typical unit costs

Connecting Bus Services Notes

Lakeshore East Bus Connections: All trains connect with buses east of Oshawa, buses reduced with EMUs
Kitchener Bus Connections: Hourly bus service to Georgetown at most times, eliminated with EMUs
Milton Bus Connections: EMUs eliminate need for Meadowvale-Milton bus services
Richmond Hill Bus Connections: Assumed hourly Bloomington-Richmond Hill off-peak bus without EMUs

Connecting Bus Services' Fuel Consumption

Corridor	From	To	Round-trip-km	Time (h)	Round Trips per Hour	Speed (km/h)	L/100km*	Bus Fuel $/yr
Lakeshore East	Oshawa2	Bowmanville	23.2	0.70	2	33.14	46	$212,370.33
Kitchener	Mount Pleasant	Wesleyan**	22.4	0.73	1	30.55	47	$104,752.38
Milton	Meadowvale	Milton	34.2	0.90	1	38.00	45	$153,128.72
Richmond Hill	Richmond Hill	Bloomington	31.6	0.73	1	43.09	45	$141,487.35

*UITP Vienna 2009, "Bus Systems: An Efficient Mode of Transport," pg 3, Consumption vs. Commercial Speed graph, UITP SORT method
**Wesleyan is an on-street bus looping route in Georgetown west of Georgetown GO/VIA station

Diesel fuel converted from 2009 to 2021 prices, electricity consumption converted from 2010 to 2021 prices (demand charge rate unchanged)

APPENDIX M

LAKESHORE ANNUAL OPERATING COSTS (2021)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	37	37	27
Revenue Coaches	333	333	162
Revenue Cabs/EMUs	37	37	162
Revenue Electric Loco.'s	n/a	29	n/a
Revenue Diesel Loco.'s	37	8	n/a
Revenue DMU Cars	n/a	n/a	8
Spare Electric Loco.'s	n/a	5	n/a
Spare Diesel Loco.'s	6	2	n/a
Spare Coaches	17	17	9
Spare Cabs/EMUs	4	4	25
Spare DMUs	n/a	n/a	2
Annual Diesel Loco. Total $	$12.1991	$2.8370	n/a
Annual Electric Loco. Total $	n/a	$8.2892	n/a
Annual Coach Total $	$48.6850	$48.6850	$23.7861
Annual Cab/EMU Total $	$6.9454	$6.9454	$56.8480
Annual DMU Total $	n/a	n/a	$2.8300
Annual Energy $	$71.2466	$28.1399	$22.4823
Annual Bus Fuel $ Difference	n/a	n/a	($0.2124)
Labour $ Savings	n/a	n/a	($4.0098)
Incremental Debt Servicing $	$7.6621	$15.4356	$0.0000
Annual Total $	$146.7382	$110.3321	$101.7242
EMUC vs ELHC			($8.608)

KITCHENER ANNUAL OPERATING COSTS (2021)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	14	14	11
Revenue Coaches	126	126	66
Revenue Cabs/EMUs	14	14	66
Revenue Locomotives	14	14	n/a
Spare Locomotives	3	2	n/a
Spare Coaches	6	6	3
Spare Cabs/EMUs	2	2	10
Annual Locomotive Total $	$4.8229	$3.9008	n/a
Annual Coach Total $	$18.3612	$18.3612	$9.5979
Annual Cab/EMU Total $	$2.7104	$2.7104	$23.1040
Annual ARL Fleet Total $	$3.3960	$3.0276	n/a
Annual Energy (GO) $	$15.1681	$6.5409	$5.2724
Annual Energy (ARL) $	$5.9471	$1.8741	*thru-route*
Annual Bus Fuel $ Difference	n/a	n/a	($0.1048)
Labour $ Savings (GO)	n/a	n/a	($1.6642)
Labour $ (ARL)	$4.6881	$4.6881	*thru-route*
Incremental Debt Servicing $	$0.0000	$5.3884	$13.7041
Annual Total $	$55.0937	$46.4914	$49.9094
EMUC vs ELHC			$3.4180

LEGEND

DLHC: Diesel Locomotive-Hauled Consist
ELHC: Electric Locomotive-Hauled Consist
EMUC: Electric Multiple-Unit Consist

MILTON ANNUAL OPERATING COSTS (2021)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	11	11	8
Revenue Coaches	99	99	48
Revenue Cabs/EMUs	11	11	48
Revenue Locomotives	11	11	n/a
Spare Locomotives	1	2	n/a
Spare Coaches	5	5	2
Spare Cabs/EMUs	1	1	7
Annual Locomotive Total $	$3.4044	$3.1694	n/a
Annual Coach Total $	$14.4664	$14.4664	$6.9550
Annual Cab/EMU Total $	$2.0328	$2.0328	$16.7200
Annual Energy $	$17.6188	$6.7542	$6.2747
Annual Bus Fuel $ Difference	n/a	n/a	($0.1531)
Labour Savings	n/a	n/a	($1.3235)
Incremental Debt Servicing $	$0.0000	$6.5651	$12.4235
Annual Total $	$37.5224	$32.9879	$40.8965
EMUC vs ELHC			$7.9085

RICHMOND HILL ANNUAL OPERATING COSTS(2021)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	7	7	3
Revenue Coaches	63	63	18
Revenue Cabs/EMUs	7	7	18
Revenue Locomotives	7	7	n/a
Spare Locomotives	2	1	n/a
Spare Coaches	4	4	1
Spare Cabs/EMUs	0	0	3
Annual Locomotive Total $	$2.5533	$1.9504	n/a
Annual Coach Total $	$9.3197	$9.3197	$2.6429
Annual Cab/EMU Total $	$1.1858	$1.1858	$6.3840
Annual Energy $	$8.3122	$4.1238	$3.2621
Annual Bus Fuel $ Difference	n/a	n/a	($0.1415)
Labour Savings	n/a	n/a	($1.1969)
Incremental Debt Servicing $	$0.0000	$3.6806	$1.6448
Annual Total $	$21.3710	$20.2603	$12.5954
EMUC vs ELHC			($7.6650)

Diesel fuel converted from 2009 to 2031 prices, electricity consumption converted from 2010 to 2031 prices (demand charge rate unchanged)

APPENDIX M

LAKESHORE ANNUAL OPERATING COSTS (2031)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	47	47	35
Revenue Coaches	423	423	210
Revenue Cabs/EMUs	47	47	210
Revenue Electric Loco.'s	n/a	39	n/a
Revenue Diesel Loco.'s	47	8	n/a
Revenue DMU Cars	n/a	n/a	8
Spare Electric Loco.'s	n/a	7	n/a
Spare Diesel Loco.'s	8	2	n/a
Spare Coaches	22	22	12
Spare Cabs/EMUs	5	5	33
Spare DMUs	n/a	n/a	2
Annual Diesel Loco. Total $	$15.6035	$2.8370	n/a
Annual Electric Loco. Total $	n/a	$11.2148	n/a
Annual Coach Total $	$61.8995	$61.8995	$30.8802
Annual Cab/EMU Total $	$8.8088	$8.8088	$73.8720
Annual DMU Total $	n/a	n/a	$2.8300
Annual Energy $	$285.7759	$78.0437	$49.7909
Annual Bus Fuel $ Difference	n/a	n/a	($0.8754)
Labour $ Savings	n/a	n/a	($8.8586)
Incremental Debt Servicing $	$11.5493	$21.1595	$0.0000
Annual Total $	$383.6370	$183.9633	$147.6392
EMUC vs ELHC			($36.324)

KITCHENER ANNUAL OPERATING COSTS (2031)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	26	26	21
Revenue Coaches	234	234	126
Revenue Cabs/EMUs	26	26	126
Revenue Locomotives	26	26	n/a
Spare Locomotives	5	4	n/a
Spare Coaches	12	12	6
Spare Cabs/EMUs	4	4	19
Annual Locomotive Total $	$8.7947	$7.3140	n/a
Annual Coach Total $	$34.2186	$34.2186	$18.3612
Annual Cab/EMU Total $	$5.0820	$5.0820	$44.0800
Annual ARL Fleet Total $	$3.3960	$3.0276	n/a
Annual Energy (GO) $	$75.7271	$21.4050	$15.3263
Annual Energy (ARL) $	$12.2571	$3.2006	*thru-route*
Annual Bus Fuel $ Difference	n/a	n/a	($0.8636)
Labour $ Savings (GO)	n/a	n/a	($5.6981)
Labour $ (ARL)	$5.1785	$5.1785	*thru-route*
Incremental Debt Servicing $	$2.2255	$9.7601	$11.5403
Annual Total $	$146.8795	$89.1864	$82.7461
EMUC vs ELHC			($6.4402)

LEGEND

DLHC: Diesel Locomotive-Hauled Consist
ELHC: Electric Locomotive-Hauled Consist
EMUC: Electric Multiple-Unit Consist

MILTON ANNUAL OPERATING COSTS (2031)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	24	24	19
Revenue Coaches	216	216	114
Revenue Cabs/EMUs	24	24	114
Revenue Locomotives	24	24	n/a
Spare Locomotives	4	5	n/a
Spare Coaches	11	11	6
Spare Cabs/EMUs	3	3	9
Annual Locomotive Total $	$7.9436	$7.0702	n/a
Annual Coach Total $	$31.5757	$31.5757	$16.6920
Annual Cab/EMU Total $	$4.5738	$4.5738	$37.3920
Annual Energy $	$105.4089	$28.4114	$25.0098
Annual Bus Fuel $ Difference	n/a	n/a	($1.2624)
Labour Savings	n/a	n/a	($4.1928)
Incremental Debt Servicing $	$1.3794	$10.1189	$10.4619
Annual Total $	$150.8814	$81.7500	$84.1004
EMUC vs ELHC			$2.3504

RICHMOND HILL ANNUAL OPERATING COSTS(2031)

OPS & MAINTENANCE $	DLHC	ELHC	EMUC
Revenue Consists	23	23	16
Revenue Coaches	207	207	96
Revenue Cabs/EMUs	23	23	96
Revenue Locomotives	23	23	n/a
Spare Locomotives	5	4	n/a
Spare Coaches	12	12	5
Spare Cabs/EMUs	2	2	15
Annual Locomotive Total $	$7.9436	$6.5826	n/a
Annual Coach Total $	$30.4629	$30.4629	$14.0491
Annual Cab/EMU Total $	$4.2350	$4.2350	$33.7440
Annual Energy $	$55.9306	$20.3237	$16.3846
Annual Bus Fuel $ Difference	n/a	n/a	($1.1664)
Labour Savings	n/a	n/a	($3.1605)
Incremental Debt Servicing $	$3.0869	$9.5443	$1.3851
Annual Total $	$101.6589	$71.1485	$61.2358
EMUC vs ELHC			($9.9126)

Barrie Annual Off-Peak Fuel Costs

Lakeshore West Local/Express Fuel Comparison					
From	**To**	**Direction**	**Service**	**Fuel (g)**	**Δ Fuel**
Toronto	St Catharines	Inbound	Local	153.8	16
			Express	137.8	
		Outbound	Local	158.5	16.7
			Express	141.8	
	TH&B	Inbound	Local	105.8	16
			Express	89.8	
		Outbound	Local	108	14.4
			Express	93.6	

Barrie With/Without Additional Stations Fuel Comparison					
From	**To**	**Direction**	**Service**	**Fuel (g)**	**L (g x 4.546)**
Toronto	Bradford	Inbound	Existing	85.39	388.18
		Outbound	Existing	100.06	454.87
		Inbound	Add Stns	101.39	460.92
		Outbound	Add Stns	116.76	530.79

2021 Off-peak Trips/Day for Toronto-Bradford						
Day Type	**Round Trips**	**Fuel (L)**	**Fuel $**	**EMUC ton-mi.**	**EMUC Elec. $**	**ELHC Elec. $**
Weekday	14	3,470,985	$6,200,340	75,782,773	$889,789	$2,425,580
Weekend	10	1,140,466	$2,037,255	24,900,054	$292,359	$796,976
Annual	4,650	4,611,451	**$8,237,595**	100,682,827	**$1,182,148**	**$3,222,556**

2031 Off-peak Trips/Day for Toronto-Bradford						
Day Type	**Round Trips**	**Fuel (L)**	**Fuel $**	**EMUC ton-mi.**	**EMUC Elec. $**	**ELHC Elec. $**
Weekday	56	13,883,939	$51,116,388	303,131,091	$6,373,906	$17,375,376
Weekend	40	4,561,866	$16,795,385	99,600,216	$2,094,284	$5,709,052
Annual	18,600	18,445,804	**$67,911,773**	402,731,306	**$8,468,190**	**$23,084,428**

Annual Operating Costs

2021 Network Summary	**DLHC**	**ELHC**	**EMUC**
Lakeshore	$146.74	$110.33	$101.72
Kitchener	$55.09	$46.49	$49.91
Milton	$37.52	$32.99	$40.90
Richmond Hill	$21.37	$20.26	$12.60
Barrie (Off-Peak Fuel $ Only)	$8.24	$3.22	$1.18
TOTAL	$268.96	$213.29	$206.31
2021 Incremental Op-$	$62.66	$6.99	$0.00

2031 Network Summary	**DLHC**	**ELHC**	**EMUC**
Lakeshore	$383.64	$183.96	$147.64
Kitchener	$146.88	$89.19	$82.75
Milton	$150.88	$81.75	$84.10
Richmond Hill	$101.66	$71.15	$61.24
Barrie (Off-Peak Fuel $ Only)	$67.91	$23.08	$8.47
TOTAL	$850.97	$449.13	$384.19
2031 Incremental Op-$	$466.78	$64.94	$0.00

See Appendix A for typical unit costs

LEGEND
DLHC: Diesel Locomotive-Hauled Consist
ELHC: Electric Locomotive-Hauled Consist
EMUC: Electric Multiple-Unit Consist

Annual Operating Costs

Expenses Saved by EMUs (Interpolated/Extrapolated Values) 2021-2036

Method	Year	Corridor						Total Over Time	
		Lakeshore	Kitchener	Milton	Rich. Hill	Barrie	Total	Cumulative	Inflated
Data	2021	$45.01	$5.18	($3.37)	$8.78	$7.06	$50.20	$50.20	$62.42
Linear Interpolation	2022	$64.11	$11.08	$3.64	$11.94	$12.29	$78.83	$129.03	$163.64
	2023	$83.21	$16.97	$10.66	$15.11	$17.53	$110.84	$239.87	$310.30
	2024	$102.31	$22.87	$17.67	$18.27	$22.77	$161.12	$400.99	$529.10
	2025	$121.41	$28.76	$24.69	$21.43	$28.01	$196.29	$597.29	$803.87
	2026	$140.51	$34.66	$31.70	$24.60	$33.25	$264.72	$862.00	$1,183.35
	2027	$159.60	$40.55	$38.72	$27.76	$38.49	$305.13	$1,167.13	$1,634.27
	2028	$178.70	$46.45	$45.73	$30.93	$43.73	$345.54	$1,512.68	$2,160.47
	2029	$197.80	$52.34	$52.75	$34.09	$48.97	$385.95	$1,898.63	$2,765.95
	2030	$216.90	$58.24	$59.77	$37.26	$54.20	$426.37	$2,325.00	$3,454.82
Data	2031	$236.00	$64.13	$66.78	$40.42	$59.44	$466.78	$2,791.78	$4,231.40
Linear Extrapolation	2032	$255.10	$70.03	$73.80	$43.59	$64.68	$507.19	$3,298.97	$5,100.14
	2033	$274.19	$75.92	$80.81	$46.75	$69.92	$547.60	$3,846.57	$6,065.66
	2034	$293.29	$81.82	$87.83	$49.92	$75.16	$588.02	$4,434.59	$7,132.76
	2035	$312.39	$87.71	$94.84	$53.08	$80.40	$628.43	$5,063.02	$8,306.41
	2036	$331.49	$93.61	$101.86	$56.25	$85.64	$668.84	$5,731.86	$9,591.79

Values not in the "Inflated" column are in 2010-$

Appendix N: Lakeshore Fixed Infrastructure Costs

APPENDIX N

Lakeshore Fixed Infrastructure Costs

LAKESHORE CORRIDOR TRACKAGE

From (mile)	To (mile)	Length (km)	Rwy	Subdiv.	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK
Hamilton Junction (37.36)	Bayview (36.13)	1.98	CN	Oakville	Yes	2	3	1.98	$3.96	5.94
Bayview (36.13)	Burlington Junction (32.17)	6.37				3	3	0.00	$0.00	19.12
Burlington Junction (32.17)	Fourth Line (23.13)	14.55				3	4	14.55	$29.10	58.19
Fourth Line (23.13)	Cross Ave (21.7)	2.30	GO			3	4	2.30	$4.60	9.21
Cross Ave (21.7)	W. of Joshua Creek (19.00)	4.35				3	5	8.69	$17.38	21.73
W. of Joshua Creek (19.00)	Kipling Ave (8.05)	17.62				3	4	17.62	$35.24	70.49
Kipling Ave (8.05)	Royal York Rd (6.77)	2.06				3	5	4.12	$8.24	10.30
Royal York Rd (6.77)	Exhibition (2.26)	7.26				4	6	14.52	$29.03	43.55
Exhibition (2.26)	Strachan (1.57)	1.11				5	6	1.11	$2.22	6.66
▲Lakeshore West Corridor	Lakeshore West Length:	60.13	rte-km from Strachan to Hamilton Jct.					64.89	$129.78	245.18
USRC (West) = 2.53km								35% Contingency	$45.42	
UNION STATION								**LAKESHORE (EAST & WEST) TOTAL**	**$254.66**	
USRC (East) = 2.66km								35% Contingency	$20.60	
▼Lakeshore East Corridor	Lakeshore East Length:	41.5	rte-km from Don River to East of Ajax					29.43	$58.86	147.15
Don River (332.15)	Scarborough Jct. (325.56)	10.61	GO	Kingston	Yes	4	5	10.61	$21.22	53.05
Scarborough Jct. (325.56)	Galloway Rd (320.95)	7.42				3	4	7.42	$14.84	29.68
Galloway Rd (320.95)	Durham Junction (313.87)	11.4				3	4	11.4	$22.80	45.6
Durham Junction (0)	East of Ajax (5.85)	9.41		Durham	No	2	2	0	$0.00	18.82

Galloway Rd-Durham Junction 3rd Track (Unfunded Reference Case): **$62**

OCS STK Beyond Reference Case:	94.32
M$/STK:	$1.9
Subtotal	**$179.21**
35% Contingency	$62.72
TOTAL	**$241.93**

Positive Train Control (Wayside) - Lakeshore-Specific

Corridor Item	By 2021	By 2031
$/ Single-Track-Km ($M)	$0.14	
Lakeshore West	25.24	$9.08
Lakeshore East	$16.48	$4.12
Lakeshore Corridor	**$41.72**	**$13.20**
35% Contingency	$14.60	$4.62
TOTAL	**$56.32**	**$17.83**

Positive Train Control (Wayside) - Network-Wide (by 2021)

Network Item	Estimate ($M)	35% Contingency	Total
Positive Train Control Centre	*$100*	$35.00	**$135**
Union Station Rail Corridor	*$10.17*	$3.56	**$13.73**

LAKESHORE CORRIDOR SUMMARY

New Grade Separations $	$533.3
Bridge Widenings (Road) $	$145.80
Bridge Widenings (River) $	$176.18
Stations $	$240.30
Positive Train Control $	$222.88
Electrified Track $	$558.59
Yard $	$213.00
TOTAL	**$2,090.00**

See subsequent pages of this appendix for detailed breakdown

APPENDIX N

Lakeshore Fixed Infrastructure Costs

LAKESHORE WEST CORRIDOR CROSSINGS

Bridge Widenings

Subdivision	Road	Existing Tracks	Required Tracks	Existing GS?	Estimate ($M)	Notes
CN Oakville	Plains Rd	3	4	Yes	$6.0	Widen for 4th track
	Brant St	3	4	Yes	$2.5	Widen for 4th track
	Walkers Line	3	4	Yes	$2.0	Widen for 4th track
GO Oakville	Dorval Dr	3	4	Yes	$2.0	Widen for 4th track
	Kerr St	3	4	In Progress	$0.0	Project already started
	Ford Dr	3	4	Yes	$2.0	Widen for 4th track
	Winston Churchill Blvd	3	4	Yes	$2.0	Widen for 4th track
	Mississauga Rd	3	4	Yes	$2.5	Widen for 4th track
	Dixie Rd	3	4	Yes	$2.0	Widen for 4th track
	Thirtieth St	4	5	Yes	$2.0	Widen for service track
	Park Lawn Rd	5	6	Yes	$2.5	Widen for 6th track
	South Kingsway	4	6	Yes	$4.0	Widen for 5th & 6th track
	Ellis Ave	5	6	Yes	$2.0	Widen for 6th track
	Colborne Lodge Dr	4	6	Yes	$3.5	Widen for 5th & 6th track
	Parkside Dr	4	6	Yes	$2.5	Widen for 5th & 6th track
	Dowling Ave	4	6	Yes	$10.0	Reconstruct underpass
	Jameson Ave	4	6	Yes	$10.0	Reconstruct underpass
	Dunn Ave	4	6	Yes	$10.0	Reconstruct underpass
				Subtotal	**$68**	
				35% Contingency	23.63	
				TOTAL	**91.13**	

General Note: Heightening of existing underpasses required for electrification included in Metrolinx estimate.

CN Oakville subdivision for the Lakeshore Corridor runs from Hamilton Junction to Fourth Line in Oakville, Halton Region

GO Oakville subdivision runs from Fourth Line in Oakville to Union Station (including the western half of the Union Station Rail Corridor)

Additional Platforms

Bronte	$2.0	
Port Credit	$2.0	
Long Branch	$2.0	
Danforth	$3.5	reconstruction?
Eglinton	$5.0	Substantial reno.
Guildwood	$2.0	
Subtotal	**$16.5**	
35% Contin.	5.775	
TOTAL	**$22.3**	

Widened Platforms

Burlington	$1.5	
Appleby	$1.5	
Clarkson	$1.5	
Scarborough	$5.0	Station building impacts
Rouge Hill	$3.0	x 2 platforms
Subtotal	**$12.5**	
35% Contingency	$4.38	
TOTAL	**$16.9**	
Added and Widened Platforms Total:	**$39.2**	

Lakeshore Fixed Infrastructure Costs

LAKESHORE WEST CORRIDOR CROSSINGS

Grade Separations

	Road	Existing Tracks	Required Tracks	Existing GS?	Estimate ($M)
CN Oakville	King Rd	4	3	*Under Construction*	$0
	Burloak Dr	3	4	No	$15
	4 Line	3	4	No	$20
GO Oakville	Chartwell Rd *(Ford Plant)*	4	4	No	$25
	Clarkson Rd	3	4	No	$20
	Lorne Park Rd	3	4	No	$20
	Stavebank Rd	3	4	No	$15
	Revus Ave *(Note 1)*	4	4	No	$40.0
	Alexandra Ave *(Note 2)*	3	4	No	
	Ogden Ave *(Note 2)*	3	4	No	$120.0
	Haig Blvd *(Note 2)*	3	4	No	
				Subtotal	**$275.0**
				35% Contingency	$96.3
				TOTAL	**$371.3**

Note 1: Combination of raising rail corridor and lowering road

Note 2: Raise rail corridor, new crossing for Strathy Ave, station to be built along elevated portion (separately costed)

New Stations by 2021

Lakeshore West	Est. $(M)
Burloak	$7
Kerr Village	$7
Morrison	$7
Sherwood Heights	$7
Lorne Park	$5
Lakeview *(elevated)*	$50
Humber Bay	$7
Swansea	$8
Subtotal	**$98**
35% Contingency	$34.3
TOTAL	**$132.3**

New Stations by 2031

Dynes	$7
Alderwood	$7
Fort York	*Special*
Subtotal	$14
35% Contingency	$4.9
TOTAL	**$18.9**

River Bridge Widenings

	River	Existing Tracks	Required Tracks	Length (km)	Estimate ($M)
CN Oakville	Sheldon Creek	3	4	0.025	$3.75
	Sheldon Creek East	3	4	0.015	$2.25
	Bronte Creek	3	4	0.15	$22.50
	Fourteen Mile Creek	3	4	0.015	$2.25
GO Oakville	McCraney Creek	3	4	0.005	$0.75
	Sixteen Mile Creek	3	4	0.2	$30.00
	Joshua Creek	3	4	0.02	$3.00
	Credit River	3	4	0.09	$13.50
	Etobicoke Creek	3	4	0.05	$7.50
	Mimico Creek	4	6	0.05	$7.50
	Humber River	4	6	0.09	$13.50
				Subtotal	**$106.50**
				35% Contingency	$37.28
				TOTAL	**$143.78**

New Stations by 2021

Lakeshore East	Est. $(M)
West Shore	$7
East Ajax	$7
Subtotal	$14
35% Contingency	$4.90
TOTAL	**$18.90**

New Stations by 2031

Distillery	*Special*
South Riverdale	*Special*
Coxwell	$8
Birch Cliff	$15
Subtotal	**$23**
35% Contingency	$8.05
TOTAL	**$31.05**

Lakeshore Fixed Infrastructure Costs

LAKESHORE EAST CORRIDOR CROSSINGS

River Bridge Widenings

	River	Ex Trk	Req Trk	Length (km)	Estimate ($M)	Notes
GO Kingston	Highland Creek	2	4	0.06	$9	1 of 2 new tracks in Reference Case
	Rouge River	2	4	0.1	$15	1 of 2 new tracks in Reference Case
				Subtotal	**$24**	
				35% Contingency	$8.4	
				TOTAL	**$32.4**	

Bridge Widenings

	Road	Ex Trk	Req Trk	Existing GS?	Estimate ($M)	Notes
GO Kingston	Logan Ave	4	5	Yes	$4.0	Widen for 5th track
	Carlaw Ave	4	5	Yes	$4.0	Widen for 5th track
	Gerrard St E	4	5	Yes	$4.0	Widen for 5th track
	Jones Ave	4	5	Yes	$2.5	Widen for 5th track
	Coxwell Ave	4	5	Yes	$2.0	Widen for 5th track
	Woodbine Ave	4	5	Yes	$2.0	Widen for 5th track
	Warden Ave	(3) 4	5	Yes	$3.0	Widen for 5th track (4th in Ref. Case)
	Danforth Ave	(3) 4	5	Yes	$3.0	Widen for 5th track (4th in Ref. Case)
	St Clair Ave W	4	5	Yes	$8.0	Station on bridge
	Eglinton Ave E	3	4	Yes	$8.0	Widen for 4th track, station impacts
				Subtotal	**$40.5**	
				35% Contingency:	$14.2	
				TOTAL	**$54.7**	

Grade Separations

	Road	Ex Trk	Req Trk	Existing GS?	Estimate ($M)	Notes
GO Kingston	Scarborough Golf Club Rd	3	4	No	$15.0	
	Galloway Rd	3	4	No	$20.0	
	Poplar Rd	2	4	No	$15.0	
	Morningside Ave	2	4	No	$20.0	
	Manse Rd	2	4	No	$15.0	
	Beechgrove Dr	2	4	No	$15.0	
	Chesterton Shores	2	4	No	$5.0	6m-wide underpass; almost no traffic
	Rodd Ave	2	4	No	$15.0	
				Subtotal	**$120.0**	
				35% Contingency:	$42.0	
				TOTAL	**$162.0**	

GO Kingston subdivision runs from Durham Junction (near Dixie Rd at Kingston Rd) to Union Station (incl. the eastern half of Union Station Rail Corridor)

Lakeshore Fixed Infrastructure Costs

BOWMANVILLE EXTENSION

Trackwork

Hwy 401 Overpass	$25.00
CP GM Spur Underpass	$30.00
2.5km Connecting Track	$3.75
15.5km CP Belleville Track	$23.25
Subtotal	**$82.00**
35% Contingency	$28.70
TOTAL	**$110.70**

Stations

Oshawa 1	$15.00
Oshawa 2	$7.00
Courtice	$7.00
Bowmanville	$10.00
Subtotal	**$39.00**
35% Contingency	$13.65
TOTAL	**$52.65**

Grade Separations

Subdivision	Road	Existing Tracks	Required Tracks	Existing GS?	Estimate ($M)	Notes
CP Belleville	Bloor St E	1	2	No	$15.00	
	Rural Rd TBD	1	2	No	$12.00	
	Rural Rd TBD	1	2	No	$12.00	
	Baseline Rd	1	2	No	$9.00	Realign road
	New road	n/a	n/a	n/a	$7.00	Road network adjustment
				Subtotal	**$55.00**	
				35% Contingency	$19.25	
				TOTAL	**$74.25**	

Four rural crossings to be closed, determined in combination with new grade separations.

River Bridge Twinnings

	River	Existing Tracks	Required Tracks	Length (km)	Estimate ($M)
CP Belleville	Harmony Creek	1	2	0.035	$5.25
	Farewell Creek	1	2	0.02	$3.00
				Subtotal	**$8.25**
				35% Contingency	$2.89
				TOTAL	**$11.14**

Bowmanville Extension Summary Estimate

Trackwork	Stations	Grade Separations	River Bridges	**TOTAL**
$110.70	$52.65	$74.25	$11.14	**$248.74**

Lakeshore Fixed Infrastructure Costs

WHITBY REALIGNMENT

Grade Separations

Subdivision	Road	Existing Tracks	Required Tracks	Existing GS?	Estimate ($M)	Notes
CP Belleville	Rossland Rd W	1	3	Insufficient	$25.00	Existing GS too narrow
	Garden St	1	3	Yes	$8.00	
	Dundas St E	2	3	Yes	$4.00	
	Hopkins St	2	3	No	$18.00	
	Thickson Rd S	2	3	Yes	$4.00	
	Thornton Rd S	1	3	No	$13.00	
	Simcoe St	2	3	Yes	$8.00	Widen underpass for EMU Case
	Albert St	2	3	Yes	$8.00	Widen underpass for EMU Case
	Wilson Rd	2	3	Yes	$4.00	Additional span for EMU Case
				Subtotal	**$92.00**	
				35% Contingency	$32.20	
				TOTAL	**$124.20**	

River Bridge Twinnings

	River	Ex Trk	Req Trk	Length (km)	Estimate ($M)	Notes
CP Belleville	Otter Creek	1	3	0.025	$7.50	
	Pringle Creek	1	3	0.015	$4.50	
	Unknown Name	1	3	0.01	$3.00	
	Harmony	2	3	0.035	$5.25	
	Farewell	2	3	0.02	$3.00	
				Subtotal	**$23.25**	
				35% Contingency	$8.14	
				TOTAL	**$31.39**	

Other Costs

407 Connector Crossing	$15.00
24 Single-Track-Kilomtres	$36.00
Oshawa-Bowmanville 3rd Trk.	$27.00
Subtotal	**$78.00**
35% Contingency	$27.30
TOTAL	**$105.30**

Stations

Williamsburg	$7.00	Kendalwood	$7.00
Downtown Whitby	$10.00	Vanier	$7.00
Centretown	$7.00		
		Subtotal	**$38.00**
		35% Contingency	$13.30
		TOTAL	**$51.30**

SUMMARY OF WHITBY REALIGNMENT

Trackwork	Stations	Road Crossings	River Bridges	**TOTAL**
$105.30	$51.30	$124.20	$31.39	**$312.19**

Appendix O: Stouffville Costs

Stouffville Costs

STOUFFVILLE & SCARBOROUGH CORRIDORS TRACKAGE

Stouffville South (south from Enterprise Dr (GO Uxbridge mile 50.53))

From (mile)	To (mile)	Length (km)	Rwy	Subdivision	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	Notes
Scarborough Jct. (60.53)	Enterprise Dr (50.53)	16.09	GO	Uxbridge	?	1	2	14.76	**$29.52**	32.19	Hagerman already 2 tracks
								35% Contingency	$10.33		
								TOTAL	**$39.85**		

STOUFFVILLE PTC

Positive Train Control Wayside Equipment (2021)

$/Single-Trk-Km ($M)	$0.14
Stouffville Corridor	$4.51
35% Contingency	$1.58
Stouffville Total:	**$6.08**

Positive Train Control In-Vehicle (LHCs) Equipment (2021)

$0.1	Cost per car ($M)
$1.40	LHCs for Stouffville (incl. spares)
$0.49	35% Contingency
$1.89	**Total ($M) for Scarborough fleet**

STOUFFVILLE CORRIDOR CROSSINGS

Grade Separations

Road	GS?	Tracks	Sufficient	Cost($M)	Notes
Danforth Rd	No	1	2	$30.00	Major rail regrading
Progress Ave	No	1	2	$0.10	Remains Level
Havendale Rd	No	1	2	$0.10	Remains Level
Huntingwood Dr	No	1	2	$20.00	
Finch Ave E	No	1	2	$25.00	
McNicoll Ave	No	1	2	$20.00	
Passmore Ave	No	1	2	$0.10	Remains Level
Steeles Ave E	No	1	2	$25.00	Planned from 1994
Kennedy Rd	No	1	2	$12.00	York Region figure
Denison St	No	1	2	$20.00	
			Subtotal	**$152.30**	
			35% Contingency	$53.31	
			TOTAL	**$205.61**	

STOUFFVILLE CORRIDOR STATIONS

Station Reconstructions

Station	Cost ($M)
Kennedy	$40
35% Contingency	$14.0
TOTAL	**$54.0**

River Crossings

River	Length	Tracks	Sufficient	Cost($M)
Highland Creek 1	0.032	1	2	$4.8
Highland Creek 2	0.03	1	2	$4.5
			Subtotal	**$9.3**
			35% Contingency	$3.26
			TOTAL	**$12.56**

Additional Platforms

Station	Cost ($M)
Agincourt	$2.0
Milliken	$2.0
Unionville	$2.0
Subtotal	**$6.0**
35% Contingency	$2.1
TOTAL	**$8.1**

Rolling Stock

Vehcile	Qty	Cost($M)
Rebuilt Locomotives	14	$28.00
Rebuilt Coaches	114	$75.24
Rebuilt Cab Cars	14	$9.80
	TOTAL	**$113.04**

Scarborough Junction

Length	1.5
$/km	$70
Subtotal	**$105**
35% Contingency	36.75
TOTAL	**$141.75**

New Stations (Existing Stations Decommissioned)

Station	Cost ($M)
Lawrence East	$10
Ellesmere	$15
Finch Ave E	$15
Subtotal	**$40**
35% Contingency	$14
TOTAL	**$54**

STOUFFVILLE CORRIDOR SUMMARY (2021)

Rd X-ing $	River X-ing $	Stn $	PTC $	Track $	Veh. $	TOTAL
$205.61	$12.56	$116.10	$7.97	$181.60	$113.04	**$636.87**

Appendix P: Scarborough Costs

Scarborough Costs

SCARBOROUGH CORRIDOR TRACKAGE

Scarborough Subdivision (NEW - GO Uxbridge mile 57 to SW Havelock mile 178)

From (mile)	To (mile)	Length (km)	Rwy	Subdivision	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	Notes
GO Uxbridge Sub mile 57 (0)	Borough Dr E (1.2)	1.93	GO	Scarborough (NEW)	?	0	2	3.86	$183.47	3.86	Trenched; Replaces exist. SRT
Borough Dr E (1.2)	Brimley Rd (1.98)	1.26					2	2.51	$178.05	2.51	Mostly elevated, 150m at-grade
Brimley Rd (1.98)	Markham Rd (2.50)	0.84					2	1.67	$62.07	1.67	At-grade, 390m bridge over creek
Markham Rd (2.50)	Progress Campus Gt (2.67)	0.27					2	0.55	$13.68	0.55	Portal approach
Progress Campus Gt (2.67)	Milner Business Ct (2.92)	0.40					2	0.80	$144.84	0.80	Tunneled station (3-face bore)
Milner Business Ct (2.92)	Milner Ave (3.14)	0.35					2	0.71	$70.81	0.71	Cut-and-cover ventilated tunnel
Milner Ave (3.14)	Sheppad Ave E (3.52)	0.61					2	1.22	$30.58	1.22	Portal approach
Sheppad Ave E (3.52)	Washburn Way (4.37)	1.37					2	2.74	$205.19	2.74	Elevated
								Subtotal	**$888.69**	14.07	
								35% Contingency	$311.04		
								TOTAL	**########**		

Above for 2021; Below for 2031

From (mile)	To (mile)	Length (km)	Rwy	Subdivision	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	
Washburn Way (4.37)	McLevin Ave (4.82)	0.72	GO	Scarborough (NEW)	?	0	2	1.45	$108.63	1.45	Elevated
McLevin Ave (4.82)	CP Belleville (4.95)	0.21					1	0.21	$18.83	0.21	Elevated*, Neilson widening
CP Belleville (4.95)	North of Crow Trail (5.14)	0.31					1	0.31	$15.29	0.31	Portal approach*, widen Neilson
North of Crow Trail (5.14)	CP Staines Connector (5.89)	1.21					1	1.21	$132.77	1.21	Cut-and-cover ventilated tunnel*
CP Staines Connector (5.89)	McNicoll Ave (6.23)	0.55					1	0.55	$8.21	0.55	Portal approach*
McNicoll Ave (6.23)	SW Havelock mile 178 (6.54)	0.50					1	0.50	$2.00	0.50	At grade
	Scarborough Subdivision Length:	10.53						**Subtotal**	**$285.72**	4.22	**To be sized for gauntlet track*
								35% Contingency	$100.00		
								TOTAL	**$385.73**		

New Stations (Extended Scarborough Corridor)

Station	Cost ($M)	Notes
Progress Campus**	$30	Underground
Malvern	$40	Elevated
Subtotal	$70	
35% Contingency	$24.5	
TOTAL	$94.5	

***Bored box included in track estimate, cost for exits and interior finishes only*

New Scarborough Corridor Grade Separations

Brimley	$30
Borough Dr W	$20
Borough Dr E	$20
Markham Rd	$30
Sheppard Ave E	$40
Subtotal	$140
35% Contingency	$49.0
TOTAL	$189.0

Station Reconstructions

Station	Cost ($M)
Scarborough Centre	$50
35% Contingency	$17.5
TOTAL	**$67.5**

Vehicles *(Omitted in Rolling Stock estimates as there's no Scarborough Corridor in Reference Case)*

Vehicle Type	Revenue	Spare	Total Qty	Total $
EMU	16	3	19	79.8
Coach	16	1	17	46.58

Positive Train Control Wayside Equipment (2021)

$/Single-Trk-Km ($M)	$0.14
Scarborough Corridor (2021)	14.07
35% Contingency	$4.92
Scarborough Total:	**$18.99**

Other Costs

Temp. Bus Terminal	$25

Positive Train Control In-Vehicle (EMUs) Equipment (2021)

$0.1	Cost per car ($M)
$1.90	EMUs for Scarborough (incl. spares)
$0.67	35% Contingency
$2.57	**TOTAL**

SCARBOROUGH CORRIDOR SUMMARY (2021)

Rd X-ing $	Bus Term. $	Stn $	PTC $	Track $	Veh. $	TOTAL
$189.00	$25.00	$162.00	$21.55	########	$126.38	**$1,723.66**

Scarborough Costs

New Stations (beyond 2021)

Station	Cost ($M)	Notes
Morningside Heights	$15	Bus terminal
Cedar Grove	$12	Bus terminal
Locust Hill	$15	Small layover
Subtotal	**$42**	
35% Contingency	14.7	
TOTAL	**$57**	

Positive Train Control Equipment (2031)

$0.1	Cost per car ($M)	$0.14	$/Single-Trk-Km ($M)
$1.40	EMUs for Scarborough (incl. spares) - 2031 growt	4.22	Scarborough Corridor (2031)
$0.49	35% Contingency	$1.48	35% Contingency
$1.89	**Total ($M) for Scarborough fleet**	**$5.69**	**Scarboro. Wayside Total**

Vehicles for Scarborough Service Between 2021 and 2031

Vehicle Type	Revenue	Spare	Total Qty	Total $
EMU	12	2	14	58.8
Coach	12	1	13	35.62

Electrification along Havelock line

km	6.76
$/km	$2.25
Subtotal	**$15.21**
Contingency	*Embedded in per-km cost*
TOTAL	**$15.21**

SCARBOROUGH CORRIDOR SUMMARY (2031)

Stn $	PTC $	Track $	Elec. $	Veh. $	TOTAL
$57	$7.58	$385.73	$15.21	94.42	$560

Appendix Q: Kitchener Fixed Infrastructure Costs

Kitchener Fixed Infrastructure Costs

KITCHENER CORRIDOR TRACKAGE

Georgetown North *(West from Airport Junction, 21.73km west of Union)*

From (mile)	To (mile)	km	Railway	Subdiv.	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	Notes
Airport Jct. (13.5)	Halwest East (16.0)	4.02	GO	Weston	Yes	1	3	8.05	$16.09	12.07	
Halwest East (16.0)	Halwest West (17.0)	1.61				1	4	4.83	$9.66	6.44	Extra track for freight
Halwest West (11.02)	Brampton (14.74)	5.99	CN	Halton		3	3	0	0	17.97	Major CN freight corridor
Brampton (14.74)	Fletchers (15.75)	1.63				2	2	0	0	3.25	Only 2 trks at Brampton Stn
Fletchers (15.75	Mt Pleasant (18.86)	5.01				3	3	0	0	15.02	Major CN freight corridor
Mt Pleasant (18.86)	Georgetown (23.13)	6.87				2	3	6.87	$13.75	20.62	
Georgetown (23.13)	Georgetown (23.67)	0.87				2	4	1.74	$3.48	3.48	
Georgetown (23.67)	Silver (24.16)	0.79				2	3	0.79	$1.58	2.37	
Silver (29.98)	Kitchener (62.69)	52.64	GEXR/CN	Guelph		1	2	52.64	$105.28	105.28	
Kitchener Length (excl. Toronto):		79.43					**Subtotal**	**74.92**	**$149.83**	**186.50**	
							35% Contingency		$52.44		
							TOTAL		**$202.28**		

Positive Train Control (Wayside)

$/Single-Trk-Km ($M)	$0.14
Kitchener Corridor	$35.24
35% Contingency	$12.33
Kitchener Total:	**$47.57**

New Stations by 2021

Station	Est. ($M)
Harwood	$80
Peel Village	$7
Subtotal	**$87**
35% Contingency	$30.45
TOTAL	**$117.45**

New Stations by 2031

Station	Est. ($M)
Northwood Park	$7
Rockwood	$5
Subtotal	**$12**
35% Contingency	4.2
TOTAL	**$16**

Additional Platforms

Station	Est. ($M)
Georgetown	$2.0
35% Contingency	0.7
TOTAL	**$2.7**

Additional Stations in Reference Case

Station	Est. ($M)
Mount Dennis	$15
35% Contingency	5.25
TOTAL	**$20**

Georgetown South , currently under construction, is considered paid for.

KITCHENER CORRIDOR SUMMARY *(see subsequent pages of this appendix for detailed breakdowns)*

Rd X-ing $	River X-ing $	Stn $	PTC $	Track $	Brampton Stn 3rd Trk	TOTAL
$839.2	$185.6	$156.60	$47.57	$202.28	$50	**$1,481.2**

Kitchener Fixed Infrastructure Costs

KITCHENER CORRIDOR CROSSINGS

River Crossings

River	Length	Tracks	Sufficient	Est. ($M)	Notes
Mimico Creek	0.02	3	*Special*	*Special*	
Spring Creek	0.005	4	Yes	$0.0	
Etobicoke Creek	0.025	2	3	*Special*	1
Fletchers Creek	0.02	3	Yes	$0.0	
Credit River	0.21	1	3	$63.0	
Black Creek	0.01	2	Yes	$0.0	
Creek in Acton	0.01	2	Yes	$0.0	
Stream west of Harris St	0.1	1	2	$15.0	
Eramosa River	0.16	1	2	$24.0	
Stream east of Guelph	0.02	1	2	$3.0	
Speed River	0.08	1	2	$12.0	
Stream by Woolwich-Guelph	0.05	1	2	$7.5	
Grand River	0.13	1	2	$13.0	2
			Subtotal	**$137.5**	
			35% Contingency:	$48.1	
			TOTAL	**$185.6**	

Note 1: Bridgework here is tied to John/James grade separation work.
Note 2: Bridge used to be twinned; supports appear to still be in place.

KITCHENER CORRIDOR CROSSINGS

Grade Separations

Subdiv.	Road	GS?	Tracks	Sufficient	Est. ($M)	Notes
CN Halton	Bramalea Rd	Yes	Overpass	Yes	$0	
	Steeles Ave	Yes	Overpass	Yes	$0	
	Dixie Rd	Yes	4	Yes	$0	
	West Dr	Yes	Overpass	Yes	$0	
	Highway 410	Yes	Overpass	Yes	$0	
	Rutherford Rd	Yes	6	Yes	$0	
	Kennedy Rd	Yes	3	4	$2	
	Centre St	Yes	2	4	$20	Special
	James St	No	2	4	$20	
	John St	No	2	4	$20	
	Queen St	Yes	2	4	$4	
	Main St (Hwy 10)	Yes	2	4	$6	
	Mill St	No	2	4	$30	
	McLaughlin Rd	Yes	3	Yes	$0	
	Chinguancousy Rd	Yes	Overpass	Yes	$0	
	Williams Pkwy	Yes	Overpass	Yes	$0	
	Bovaird Dr	Yes	Overpass	Yes	$0	
	Mississauga Rd	No	2	3	$20	
	Heritage Rd	No	2	3	$20	
	Winston Churchill Blvd	No	2	3	$20	
	Maple Ave	Yes	Overpass	Yes	$0	
	Mountainview Rd	Yes	Overpass	Yes	$0	
	McNabb St	Yes	2	3	$2	
	Main St(Georgetown)	Yes	Overpass	Yes	$0	
				Subtotal	**$164**	
				35% Contingency	$57.4	
				TOTAL	**$221.4**	

Bramalea to Georgetown is along CN Halton subdivision

Kitchener Fixed Infrastructure Costs

KITCHENER CORRIDOR CROSSINGS

Grade Separations City of Guelph and east to Silver Jct

Subdivision	Road	GS?	Tracks	Sufficient	Est. ($M)
GEXR Guelph	Trafalgar Rd	No	1	2	$20
	6 Line	Yes	1	2	$2
	Sideroad 22	Yes	Overpass	Yes	$0
	Queen St Acton	No	2	2	$22
	Mill St Acton	No	2	2	$25
	Main St Acton	No	1	2	$30
	Eramosa-Erin	Yes	1	2	$4
	6 Line	Yes	Overpass	Yes	$0
	Main St (Hwy 27)	No	1	2	$25
	Watson Pkwy	Yes	1	2	$3
	Victoria Rd	Yes	1	2	$3
	Stevenson St	Yes	1	2	$2
	Elizabeth St	Yes	1	2	$3
	Wellington St	Yes	1	2	$3
	Wyndham St	Yes	4	Yes	$0
	Gordon St	Yes	2	Yes	$0
	Dublin St	No	2	2	$125
	Glasgow St	No	2	2	
	Yorkshire St	No	2	2	
	Edinburg Rd	No	4	4	
	Hanlon Pkwy	Yes	2	Yes	$0
	Paisley Rd	Yes	2	Yes	$0
	Imperial Rd	Yes	1	2	$2
	Elmira Rd	Yes	1	2	$2
				Subtotal	**$271**
				35% Contingency	$94.9
				TOTAL	**$365.9**

Silver Jct is in Georgetown by Carruthers Rd

KITCHENER CORRIDOR CROSSINGS

Grade Separations City of Kitchener

Subdivision	Road	GS?	Tracks	Sufficient	Est. ($M)
GEXR Guelph	Shantz Station Rd	Yes	1	2	$2
	Fountain St	Yes	Overpass	Yes	$0
	Woolwich St	No	1	2	$20
	Victoria St (Hwy 7)	Yes	1	2	$3
	Bingemans Cntr Dr	No	1	2	$20
	Conestoga Pkwy	Yes	2	Yes	$0
	Lancaster St	No	2	2	$22
	St Leger St	No	2	2	$18
	Margaret Ave	Yes	Overpass	Yes	$0
	Ahrens St	Grade separation may not be feasible			
	Weber St	No	2	2	$0*
	Duke St	No	2	2	$20
	Waterloo St	No	2	2	$25
	King St	No	2	2	*LRT***
				Subtotal	**$130**
				35% Contingency	$45.5
				TOTAL	**$175.5**

**Part of existing (funded?) $51M plan*
***Funded as part of Waterloo LRT project*

Grade Separations Region of Peel

Subdivision	Road	GS?	Tracks	Sufficient	Est. ($M)
GO Weston	Derry Rd	Yes	4	Yes	$0
	Airport Rd	Yes	4	Yes	$0
	Scarboro St	No	3	4	$25
	Torbram Rd	No	3	4	$30
	Highway 407	Yes	Overpass	Yes	$0
				Subtotal	**$55**
				35% Contingency	$19.3
				TOTAL	**$74.3**

GO Weston subdivision runs east from Bramalea

Kitchener Fixed Infrastructure Costs

KITCHENER CORRIDOR CROSSINGS

Level Crossings to Remain Level

Subdivision	Road	Tracks	Sufficient	Est. ($M)	Notes
GEXR Guelph	4 Line	1	2	$0.1	
	3 Line	1	2	$0.1	
	Private	1	2	$0.1	
	Dublin Line	1	2	$0.1	
	Sideroad 22	1	2	$0.1	Unnecessary (redundant; close road?)
	7 Line	1	2	$0.1	
	Harris St	1	2	$0.1	
	Fourth Line	1	2	$0.1	
	Third Line	1	2	$0.1	
	Wellington Rd 29	1	2	$0.1	
	Jones Baseline	1	2	$0.1	
	Watson Rd	1	2	$0.1	
	Wellington Rd 22	1	2	$0.1	
	12 Township	1	2	$0.1	
	Woolwich-Guelph	1	2	$0.1	
	Woolwich St	1	2	$0.1	
			Subtotal	**$1.6**	
			35% Contingency	$0.56	
			TOTAL	**$2.2**	

GEXR Guelph subdivision runs west from Silver Junction in Georgetown

Appendix R: Milton Fixed Infrastructure Costs

APPENDIX R

Milton Fixed Infrastructure Costs

MILTON CORRIDOR TRACKAGE

From (mile)	To (mile)	km	Rwy	Subdiv.	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	Notes
Union (0)	W. Toronto (4.73)	7.61	GO	Lwr. Galt	No	2	2	0	$0.00	15.22	Typ. no freight
W. Toronto (4.73)	Keele St (4.9)	0.27	CP	Galt		3	4	0.27	$0.55	1.09	
Keele St (4.9)	Humber (6.89)	3.20				2	4	6.41	$12.81	12.81	
Humber (7.12)	Humber (7.61)	0.79				2	4	1.58	$3.15	3.15	
Humber (7.61)	Islington (8.79)	1.90				3	4	1.90	$3.80	7.60	
Islington (8.79)	Kipling (9.38)	0.79				4	4	0	$0.00	3.15	
Kipling (9.38)	Etobicoke Crk (11.84)	3.96				3	4	3.96	$7.92	15.84	
Etobicoke Crk (11.84)	Woodlands (15.75)	6.29				2	4	12.59	$25.17	25.17	
Woodlands (15.75)	Highway 403 (18.58)	4.55				3	4	4.55	$9.11	18.22	
Highway 403 (18.58)	Ontario St. (21.18)	4.18				2	4	8.37	$16.74	16.74	
Ontario St. (21.18)	Streetsville Jct. (21.32)	0.23				3	4	0.23	$0.45	0.90	
Streetsville Jct. (21.32)	6th Line (29.23)	12.73				2	4	25.46	$50.92	50.92	
6th Line (29.23)	Thompson Rd (31)	2.85				3	4	2.85	$5.70	11.39	
Thompson Rd (31)	End of Line (31.74)	1.19				3	4	1.19	$2.38	4.76	
	Milton Length:	50.55					**Subtotal**	**69.35**	**$138.69**	**186.97**	
							35% Contingency		$48.54		
							TOTAL		**$187.24**		

Positive Train Control (Wayside)

$/Single-Trk-Km ($M)	$0.14
Milton Corridor	$26.18
35% Contingency	$9.16
Milton Total:	**$35.34**

Rail-Rail Grade Separation*

Subdivision A	A Trks	Subdivision B	B Trks	Est. ($M	Notes
CP Galt	2 (GO)	CP Galt	2 (CP)	$75	GO-exclusive
			35% Contingency	$26.25	
			TOTAL	**$101.25**	

**0.23 miles long, just east of Humber Valley*

MILTON CORRIDOR SUMMARY

Rd X-ing $	$396.90
River X-ing $	$172.13
Rail-Rail X-ing $	$101.25
Stn $	$91.8
PTC $	$35.34
Track $	$187.24
TOTAL	**$984.65**

(see subsequent pages of this appendix for detailed breakdowns)

Milton Fixed Infrastructure Costs

MILTON CORRIDOR CROSSINGS

Grade Separations by 2021

Subdiv.	Road	GS?	Ex Trks	Sufficient	Est. ($M)
CP Galt	Tannery St	No	2	4	$25
	Thomas St	No	2	4	$30
	Mississauga Rd	No	2	4	$30
	Erindale Station Rd	No	3	4	$30
	Wolfdale Rd	No	3	4	$30
	Haines Rd	No	3	4	$25
	Stanfield Rd	No	2	4	$30
				Subtotal	**$200**
				35% Contingency	$70
				TOTAL	**$270**

Grade Separations 2021-2031

Subdiv.	Road	GS?	Ex Trks	Sufficient	Est. ($M)
CP Galt	5 Line	No	2	4	$15
	6 Line	No	2	4	$15
	9 Line	No	2	4	$25
	10 Line	No	2	4	$25
				Subtotal	**$80**
				35% Contingency	28
				TOTAL	**$108**

Bridge Widenings by 2021

Subdiv.	Road	GS?	Tracks	Sufficient	Est. ($M)
CP Galt	Thompson Rd	Yes	3	4	$2
	James Snow Pkwy	Yes	3	4	$2
	Winston Churchill Blvd	Yes	3	4	$2
	Mavis Rd	Yes	3	4	$2
	Hurontario St	Yes	2	4	$4
	Dixie Rd	Yes	3	4	$2
				Subtotal	**$14**
				35% Contingency	$4.9
				TOTAL	**$18.9**

River Crossings by 2021

Subdiv.	River	km	Ex Trks	Sufficient	Est. ($M)
CP Galt	West Oakville Creek	0.02	2	4	$6.00
	Middle Oakville Creek	0.025	2	4	$7.50
	East Oakville Creek	0.01	2	4	$3.00
	Mullet Creek	0.02	3	4	$3.00
	Credit River	0.09	2	4	$27.00
	Cooksville Creek	0.035	2	4	$10.50
	Pallet's Creek	0.02	2	4	$6.00
	Etobicoke Creek	0.055	3	4	$8.25
	Mimico Creek	0.055	3	4	$8.25
	Humber River	0.16	2	4	$48.00
				Subtotal	**$127.50**
				35% Contingency	$44.63
				TOTAL	**$172.13**

Widened Platforms

Station	Est($M)
Dixie	$1.5
Cooksville	$1.5
Meadowvale	$1.5
Lisgar	$1.5
Subtotal	**$6.0**
35% Contingency	2.1
TOTAL	**$8.1**

New Station Post-202

Station	Est. ($M)
Lambton	$10
Chestnut Hil	$7
Islington	$15
Applewood	$5
Fairview	$5
Erin Mills	$15
Subtotal	**$57**
35% Contingency	$20
TOTAL	**$77**

New Station by 2021 (Reference Case)

Station	Est($M)
Agerton	$5.0
35% Contingency	$1.8
TOTAL	**$6.8**

Appendix S: Richmond Hill Fixed Infrastructure Costs

APPENDIX S

Richmond Hill Fixed Infrastructure Costs

RICHMOND HILL CORRIDOR TRACKAGE (USING DON BRANCH ROUTE)

From (mile)	To (mile)	km	Rwy	Subdivision	VIA	Ex. Trk	Req. Trk	New STK	M$Track	Net STK	Notes
Union (0)	Gerrard St E (2.53)	4.07	GO	Bala	?	2	2	0	$0.00	8.14	Usually no freight
Gerrard St E (209.47)	Leaside (206.3)	5.10		Don Branch	No	1	2	5.10	$15.30	10.20	Rehab. exist. trk.
Leaside (206.3)	DVP (203.6)	4.35	CP	Belleville		2	4	8.69	$17.38	17.38	Busy freight route
DVP (0)	Lawrence Ave E (0.6)	1	GO	Wynford		0	2	2	$37.50	2	New connection
Lawrence Ave E (9.6)	Doncaster (16)	10.30		Bala	?	1	2	10.30	$20.60	20.60	1mi. upgraded trk
Doncaster (16)	Richmond Hill (20.71)	7.58	CN			2	3	7.58	$15.16	22.74	Busy freight route
Richmond Hill (20.71)	Crosby Ave (21.49)	1.26				3	3	0.00	$0.00	3.77	End of exist. line
Crosby Ave (21.49)	Elgin Mills (22.14)	1.05				2	2	0.00	$0.00	2.09	Start of extension
Elgin Mills (22.14)	Gormley (26.14)	6.44				1	2	6.44	$12.87	12.87	Busy freight route
Gormley (26.14)	Pond at 1714 Bethesda (27.54)	2.25				2	2	0.00	$0.00	4.51	Busy freight route
Pond at 1714 Bethesda (27.54)	Bloomington (29)	2.35				1	2	2.35	$4.70	4.70	Busy freight route
	Richmond Hill Length:	45.74					**Subtotal**	**42.46**	**$123.52**	**109.01**	

NOTE: *Gerrard St E to Lawrence Ave E different from Reference Case: Uses CP line instead of CN line.*

35% Contingency $43.23

TOTAL $166.75

Don Branch Only	North of Lawrence Ave
$94.75	$72.00

Positive Train Control (Wayside)

$/Single-Trk-Km ($M)	$0.14
Richmond Hill Corridor	$15.26
35% Contingency	$5.34
Richmond Hill Total:	**$20.60**

Crosby Ave to Elgin Mills Rd*

stk	1.5	$M	$6

35% Contingency $2.10

TOTAL $8.10

**3rd electrified track to Elgin Mills not in Reference Case*

RICHMOND HILL CORRIDOR SUMMARY *(see subsequent pages of this appendix for detailed breakdowns)*

Road Crossing $	River Crossing $	Rail-Rail Crossing $	Station $	PTC $	Track $	**TOTAL $**
$154.6	$251.44	$100	$145.80	$20.60	$174.85	**$847.3**

Richmond Hill Fixed Infrastructure Costs

RICHMOND HILL CORRIDOR REFERENCE CASE CROSSINGS (North of Lawrence Ave E)

River Crossings

Subdivision	River	km	Existing Tracks	Sufficient	Est. ($M)
GO Bala	E Don River Tributary	0.075	1	2	$11.25
	E Don River	0.1	1	2	$15
				Subtotal	**$26.25**
				35% Contingency	$9.19
				TOTAL	**$35.44**

Grade Separations

Subdivision	Road	GS?	Existing Tracks	Sufficient	Est. ($M)	Notes
CN Bala	Green Ln	No	2	3	n/a	Grade separation expected with redevelopment project
	Langstaff Rd E	No	2	3	n/a	Expected to be included with Doncaster project
	Weldrick Rd	No	2	3	$10	Planned to happen in 2018 by York Region
	Centre St (extension)	No	3	3	$22	Not in Reference Case
	Crosby Ave (extension)	No	3	3	$30	Above average property impacts
	Elgin Mills Rd (extension)	No	2	3	$25	In York Region Transportation Master Plan, no date/funding
	19th Ave (extension)	No	1	3	$0	Engineering work already funded and underway
	Bethesda Sideroad (ext.)	No	1	2	$0	Part of new 404 interchange, not needed for GO service
				Subtotal	**$87**	
				35% Contingency	$30.28	
				TOTAL	**$116.78**	

Rail-Rail Grade Separations

Diamond	Subdivision A	A Trks	Subdivision B	B Trks	Est. ($M)	Notes
Doncaster	GO/CN Bala	2	CN York	2	$100	Includes Green Ln
				Contingency included		
				TOTAL	**$100**	

Richmond Hill Fixed Infrastructure Costs

RICHMOND HILL CORRIDOR

New Stations

Station (by 2021)	Est. ($M)	Notes
Elgin Mills	$12	
Thornhill (John St/Bayview Ave)	$30	
Steeles Ave E	$8	
Sheppard Ave E (relocated Oriole)	$15	Bridge station, TTC subway connecton
Subtotal	**$65**	
35% Contingency	$22.75	
TOTAL	**$87.75**	

Station (by 2031)	Est. ($M)	Notes
Richvale (16th Ave)	$7	
York Mills Rd/Leslie St	$7	
Eglinton Ave E/Leslie St	$12	TTC rapid transit connection
Leaside (Laird Dr/Millwood Rd)	$10	
Subtotal	**$36**	
35% Contingency	$12.60	
TOTAL	**$48.60**	

Other New Stations (future phase)

Station	Est. ($M)	Notes
Trailwood (Bayview/19th Aves)	- (future)	
Cabbagetown (Gerrard-Dundas Sts	- (future)	Requires substantial TTC improvements

Additional Platforms

Station	Est. ($M)	Notes
Richmond Hill	$2.0	
Langstaff	$2.0	
Finch Ave E (shift platform south)	$3	Adjusted Old Cummer station
Subtotal	**$7.0**	
35% Contingency	$2.45	
TOTAL	**$9.5**	

REFERENCE CASE CROSSINGS NOT APPLICABLE TO DON BRANCH

River Crossings

Subdiv.	River	km	Tracks	Sufficient	Est. ($M)
GO Bala	Don by Pottery Rd	0.041	1	2	$6.15
	Don by Beechwood Dr	0.032	1	2	$4.80
	W Don by Don Mills Rd	0.028	1	2	$4.20
	E Don by Waterman Ave	0.033	1	2	$4.95
	E Don by Eglinton Ave E	0.077	1	2	$11.55
	E Don by Wynford Hts	0.05	1	2	$7.50
	E Don by CP Mainline	0.058	1	2	$8.70
				Subtotal	**$47.85**
				35% Contingency	$16.75
				TOTAL	**$64.60**

Grade Separations

Subdiv.	Road	GS?	Tracks	Sufficient	Est. ($M)
GO Bala	Pottery Rd	No	1	2	$20
				35% Contingency	$7
				TOTAL	**$27**

Bridge Widenings

Subdiv.	Bridge	km	Tracks	Sufficient	Est. ($M)
GO Bala	DVP by Codeco Ct	0.068	1	2	$10.2
				35% Contingency	$3.57
				TOTAL	**$13.77**

Richmond Hill Fixed Infrastructure Costs

DON BRANCH-EXCLUSIVE CROSSINGS

River Crossings

Subdivision	River	km	Tracks	Sufficient	Est. ($M)	Notes
CP Belleville	W Don River	0.25	2	4	$75	
GO Don Branch	Don R. (Todmorden	0.35	1	2	$70	Not in use; requires rehabilitation
	Don R. (Riverdale)	0.075	1	2	$15	Not in use; requires rehabilitation
				Subtotal	**$160.00**	
				35% Contingency	$56.00	
				TOTAL	**$216.00**	

Grade Separations

Subdivision	Road	GS?	Tracks	Sufficient	Est. ($M)
CP Belleville	Don Mills Rd	Yes	2	4	$4
	Eglinton Ave E	Yes	2	4	$4
	Wicksteed Ave	No	2	4	$20
				Subtotal	**$28.0**
				35% Contingency	$9.8
				TOTAL	**$37.8**

Appendix T: Barrie Fixed Infrastructure Costs

Barrie Fixed Infrastructure Costs

BARRIE TRACKAGE

Subdivision	From (mile)	To (mile)	km	Ex. Trk	Req. Trk	New STK	M$Track
GO Newmarket	Toronto (0)	Parkdale (2.98)	4.80	0	2	9.59	$19.18
	Parkdale (2.98)	Finch HEPC (12.14)	14.74	1	2	14.74	$29.48
	Finch HEPC (12.14)	Steeles (12.94)	1.29	2	2	0	$0.00
	Steeles (12.94)	Holland River (41.11)	45.34	1	2	45.34	$90.67
	Holland River (41.11)	Industrial Rd (42.15)	1.67	2	2	0	$0.00
	Industrial Rd (42.15)	Allandale (63.04)	33.62	1	1	0	$0.00
			101.45		**Subtotal**	69.67	**$139.34**
						35% Contingency	$48.77
						TOTAL	**$188.10**

Positive Train Control (Wayside)

$/Single-Trk-Km ($M)	$0.14
Subtotal	**$23.70**
35% Contingency	$8.30
TOTAL	**$32.00**

e Separations by 2021

Subdivision	Muncipality	Road	GS?	Ex Trks	Sufficient	Est. ($M)	Notes
GO Newmarket	Vaughan	Rutherford Rd	No	1	2	$25.00	Lower road under railway
	King City	Dufferin St	No	1	2	$25.00	Lower road under railway
	Aurora	Yonge St	Yes	1	2	$9.23	Twinning (river bridge style), regraded railway
	Newmarket	St John's Sideroad	No	1	2	$20.00	Lower road under railway
		Mulock Dr	No	1	2	$40.00	Raise road over railway, rebuild river bridge, property access
		Davis Dr	No	1	2	$60.00	Raise road over railway (lower railway slightly), reconstruct road bridge over river (Includes Newmarket GO station)
					Subtotal	**$179.23**	
					35% Contingency	$62.73	
					TOTAL	**$241.95**	

Barrie Fixed Infrastructure Costs

Grade Separations by 2031

Subdivision	Muncipality	Road	GS?	Ex Trks	Sufficient	Est. ($M)	Notes
GO Newmarket	Toronto	Wallace Ave	No	1	2	*Special*	*See Davenport Diamond*
		Carl Hall Rd	No	1	3	$30.00	Raise railway over road
	Vaughan	McNaughton Rd	No	1	2	$25.00	Lower road under railway
	Aurora	Engelhard Dr	No	1	2	$20.00	Lower road under regraded railway
		Wellington St E	No	1	2	*Special*	Raise railway Yonge to St John's
		Centre St	No	1	2		(Includes the Aurora GO station)
	Newmarket	Water St	No	1	2	$35.00	Raise road over railway, incl. Duncan Dr
		Timothy St	No	1	2	$35.00	Raise road over railway (and over Duncan Dr)
		Queen St	Yes	1	2	$10.00	Reconstruct existng overpass
		Green Ln	No	1	3	$20.00	Raise road over railway, overtake point
	Holland Landing	Yonge St	No	1	2	$40.00	Raise road over railway, rebuild river bridge
		Bathurst St	No	1	2	$50.00	Raise road over railway, incl. HL Rd, interchange w/Hwy 11
					Subtotal	**$265.00**	
					35% Contingency	$92.75	
					TOTAL	**$357.75**	

At-Grade Crossings Requiring Extra Track

Subdivision	Muncipality	Road	GS?	Tracks	Sufficient	Est. ($M)	Notes
GO Newmarket	Toronto	Castlefield Ave	No	1	2	$0.1	Complicated; Industrial
		York U. BRT	No	1	2	$0.1	May not be in use post-TYSSE
	Vaughan	Rivermede Rd	No	1	2	$0.1	Industrial Local
		Langstaff Rd	No	1	2	$0.1	Industrial Local
		Teston Rd	No	1	2	$0.1	Industrial Local
		Kirby Rd	No	1	2	$0.1	Rural, possible overtake
	King City	King Vaughan Rd	No	1	2	$0.1	Rural, possible overtake
		Station Rd	No	1	2	$0.1	Rural
		15th Sideroad	No	1	2	$0.1	Rural
	Newmarket	London Rd	No	1	2	$0.1	Pedestrian-only crossing
	Holland Landing	Concession Rd 2	No	1	2	$0.1	Rural
		Chapman St	No	1	2	$0.1	Close and realign for private property access
		Bradford St	No	1	2	$0.1	Semi-rural, volume OK
		Oriole Dr	No	1	2	$0.1	Rural
		Toll Rd (link RR1)	No	1	2	$0.1	Rural
		Kalvers St	No	1	2	$0.1	Rural
	Bradford	Private Dr	No	1	2	$0.1	Rural
		Given Rd	No	1	2	$0.1	Rural
					Subtotal	**$1.8**	
					35% Contingency	$0.6	
					TOTAL	**$2.4**	

Barrie Fixed Infrastructure Costs

Existing Grade Separations Already Sufficient Width

Subdivision	Muncipality	Road	GS?	Width	Sufficient	Est. ($M)	Notes
GO Newmarket	Toronto	Queen St W	Yes	8	2	$0.0	Under Construction (Weston Sub)
		Brock St	Yes	8	2	$0.0	Under Construction (Weston Sub)
		Lansdowne Ave	Yes	8	2	$0.0	Under Construction (Weston Sub)
		Dundas St W	Yes	2	2	$0.0	
		Bloor St W	Yes	2	2	*Special*	*See Davenport Diamond*
		Dupont St	Yes	3	2	*Special*	*See Davenport Diamond*
		Davenport Rd	Yes	3	2	$0.0	
		St Clair Ave W	Yes	2	2	$0.0	
		Rogers Rd	Yes	2	2	$0.0	
		Eglinton Ave W	Yes	2	2	$0.0	
		Lawrence Ave W	Yes	3	2	$0.0	Possilbe overtake track for express
		Highway 401	Yes	3	2	$0.0	
		Wilson Ave	Yes	3	3	$0.0	
		Sheppard Ave W	Yes	3	3	$0.0	
		Finch Ave W	Yes	3	+ service tra	$0.0	Freight Activity
		Steeles Ave W	Yes	2	2	$0.0	
	Vaughan	Highway 407	Yes	2	2	$0.0	
		Highway 7	Yes	2	2	$0.0	
		Major MacKenzie W	Yes	2	2	$0.0	
		Keele St	Yes	2	2	$0.0	
	King City	King Rd	Yes	2	2	$0.0	
		Keele St	Yes	2	2	$0.0	
		Bathurst St	Yes	2	2	$0.0	
					TOTAL	**$0.0**	

River Bridges

Subdivision	Muncipality	River	L(km)	Tracks	Sufficient	Est. ($M)
GO Newmarket	Bradford	Holland River	0.088	1	2	$13.20
	Newmarket	Holland River	0.022	1	2	$3.30
	Aurora	Holland River	0.010	1	2	$1.50
	Vaughan	Don River	0.021	1	2	$3.15
					Subtotal	**$21.15**
					35% Contingency	$7.40
					TOTAL	**$28.55**

Davenport Diamond (Pre-2021 construction)

Subdivision	Crossing	From	To	L(km)	Est. ($M)	Description
GO Newmarket	CP N. Toronto	Lansdowne Ave	Davenport R	2.8	$350	Lower the Barrie corridor
	TTC Bloor	Bloor St W	Wallace Ave	0.4	$50	New GO station link to Bloor subway
				Subtotal	**$400**	
			35% Contingency		$140	
				TOTAL	**$540**	

Barrie Fixed Infrastructure Costs

Expand Existing Stations

Station	Est. ($M)
York University	$2.0
Rutherford	$2.0
Maple	$2.0
King City	$2.0
Aurora	$2.0
East Gwillimbury	$2.0
Bradford	$2.0
Subtotal	**$14.0**
35% Contingency:	$4.9
TOTAL	**$18.9**

New Stations (Reference Case)

Station	Est. ($M)	Notes
Downsview	$20.0	Subway Connection
Innisfil	$10.0	
Subtotal	**$30.0**	
35% Contingency:	10.5	
TOTAL	**$40.5**	

New Stations (York Region-proposed)

Station	Est. ($M)
Kirby Rd	$10.0
Oak Ridges	$15.0
Mulock Dr	$15.0
Subtotal	**$40.0**
35% Contingency:	$14.0
TOTAL	**$54.0**

New Stations (Metrolinx-proposed)

Station	Est. ($M)	Notes
Earlscourt	$15.0	Streetcar connection
Fairbank	$20.0	LRT Connection
Concord	$20.0	BRT Connection
Subtotal	**$55.0**	
35% Contingency:	$19.25	
TOTAL	**$74.25**	

Comparative Fleet Capital Costs

	Scenario	
	1	**2**
Revenue Consists for 2021	11	
Rebuilt Locomotives (w/spare)	$26.00	
Rebuilt Coaches (w/spares)	$68.64	
Rebuilt Cab Cars (w/spare)	$8.40	
Reference Case Fleet Total $	$103.04	
2021-2031 New Consists	4	
New Locomotives (w/spares) $	$39.1	$10.00
New Coaches (w/spares) $	$104.1	$25.08
New Cabs/EMUs (w/spares) $	$15.3	$3.50
2021-2031 Fleet Growth $	$158.5	$38.6
Reference Case PTC $	$1.3	
2021-2031 On-Board PTC $	$0.5	
2031 Total Growth $	$160.3	$40.4
2031 Incremental*		($119.9)

*Diesel savings from other lines' electrification

Scenario 1 involves no electrification in entire GO system.
Scenario 2 assumes busier GO lines have been electrified.

Reconstructed Stations by 2021

Station	Est. ($M)	Notes
Newmarket	$25.0	Shift south for improved safety
35% Contingency:	$8.8	
TOTAL	**$33.75**	

Reconstructed Stations by 2031

Station	Est. ($M)	Notes
Aurora	$100.0	Reconstruction as Viaduct
35% Contingency:	$35	
TOTAL	**$135.0**	

New Stations (not in existing plans)

Station	Est. ($M)	Notes
Lawrence Ave W	$15.0	
Wilson Ave	$15.0	
Highland	$30.0	Bridge station, regrading involved, BRT Connection
Holland Landing	$18.0	0.6km road extensions
Subtotal	**$78.0**	
35% Contingency:	$27.3	
TOTAL	**$105.3**	

Appendix U: USRC Fixed Infrastructure Costs

USRC Fixed Infrastructure Costs

Category	Unit	Qty	Unit $	Total $	Notes
Removed Track (W)	Single-track-km	14.43	$1.5	$21.6	Various locations for construction purposes
New Track (West)	Single-track-km	14.195	$3	$42.6	South Bathurst Yard, re-aligned tracks Spadina-Strachan
Strachan Portal	Double-track-km	1.16	$100	$116.0	Located to avoid modifications to Strachan structure
Bathurst Portals	Single-track-km	0.695	$60	$41.7	VIA Rail fly-under (also for GO overflow, equip. moves)
Cut-and-Cover	Single-track-km	0.2	$100	$20.0	
Tunnel (West)	Double-track-km	1.91	$175	$334.3	West of Spadina Ave
At-Grade Fort York Station	Single-track-km	1.6	$3	$4.8	Serves Milton & Barrie lines, plus one track for Kitchener
	Elev'd track-km	0.8	$50	$40.0	
	Platform sqm	9300	$0.002	$18.6	
Underground Fort York Station	Single-track-km	1.6	$157.5	$252.0	Lakeshore lines, all non-overflow trains stop at station
	Platform sqm	13360	$0.045	$601.2	
Trenched Track	Double-track-km	1.85	$50	$92.5	Fort York station for Kitchener services
Mined Tunnel	Single-track-km	4.76	$200	$952.0	Spadina Ave to Yonge St, except between Simcoe St and Bay St
	Double-track-km	0.89	$350	$311.5	
	Triple-track-km	0.25	$500	$125.0	
Underground Level	Single-track-km	1.56	$182	$283.9	Deepen existing structure between York St and Bay St
at Union Station	Platform sqm	9760	$0.052	$507.5	New structure between Simcoe St and York St
Cut-and-Cover	Single-track-km	1.1	$100	$110.0	East of Yonge St
Tunnel (East)	Double-track-km	1.98	$175	$346.5	
Underground	Single-track-km	1.6	$147	$235.2	Lakeshore lines, all trains stop at station
Distillery Station	Platform sqm	8680	$0.042	$364.6	
Elevated	Single-track-km	3.2	$50	$160.0	Serves Richmond Hill, Stouffville, and Milton lines
Distillery Station	Platform sqm	10800	$0.006	$64.8	
Don Portal	Double-track-km	1.28	$100	$128.0	West of Don River
Elevated Track	Single-track-km	0.5	$75	$37.5	From Queen St to Cherry St
	Double-track-km	0.5	$125	$62.5	
	Quad-track-km	0.8	$200	$160.0	
Sunken track	Double-track-km	0.2	$50	$10.0	Between Eastern Ave and Don River
New Track (East)	Single-track-km	15.627	$3	$46.9	T.H.C. S/D, Parliament-to-Queen realignments
Removed Track (E)	Single-track-km	15.613	$1.5	$23.4	Various locations for construction purposes
Jarvis St Bridge	Bridge sqm	160	$0.0082	$1.3	New tracks for Milton
Sherbourne St Bridge	Bridge sqm	160	$0.0082	$1.3	
Parliament St Bridge	Bridge sqm	160	$0.0082	$1.3	New station
Bridge Reconstructions	Eastern Ave	$40	-	$40.0	Split-level bridge structure
	Don River	$50	-	$50.0	Double-decked structure
	Cherry St	$45	-	$45.0	Subdivisions at different elevations
Relocated Station	Dufferin Gates	$25	-	$25.0	Moved Exhibition station
TOTAL		**$**	**-**	**$5,678.5**	**USRC Expansion Rough Estimate**
Separate Investments Related to USRC					
At-grade Stations	Parkdale	$35	-	$35.0	Stations conditional on ability of TTC infrastructure to manage demands exerted by new GO stations
	Cabbagetown	$15	-	$15.0	
	Riverdale	$20	-	$20.0	
TOTAL				$70.0	

Appendix V: Network Cost Summary

APPENDIX V

Network Cost Summary
Lakeshore Corridor (West & East)

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$62.00	$254.66
	Whitby Yard (Electric)*	$213.00	$0.00
	Bowmanville Extension	$248.74	$0.00
	Grade Separations (Road-Rail)	$533.25	$0.00
	Bridge Widenings (Road)	$0.00	$145.80
	Bridge Widenings (River)	$0.00	$176.18
	Fleet (Capital)	$1,420.72	$451.22
	Expanding Existing Stations	$0.00	$39.15
	Subtotal	**$2,477.71**	**$1,067.01**
Electrification	Infrastructure (incremental)	$1,020.00	$241.93
	EMU Fleet (incremental)	($120.98)	($80.48)
	Subtotal (incremental)	**$899.02**	**$161.45**
EMU Case	Positive Train Control Centre*	$135.00	$0.00
	USRC Positive Train Control*	$13.73	$0.00
	Wayside PTC	$56.32	$17.83
	PTC for LHCs	$4.30	$1.20
	PTC for EMUs (incremental)	$14.40	$4.40
	New Stations	$151.20	$49.95
	Whitby Realignment Along CP Belleville	$312.19	$0.00
	Hamilton Hunter Tunnel	$440.00	$0.00
	Subtotal	**$1,127.15**	**$73.38**
Hamilton-St Cats	**DMU Fleet**	$55.00	$0.00
CORRIDOR TOTAL		**$4,558.87**	**$1,301.83**

**Network-wide cost*

Network Cost Summary

Stouffville Corridor

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$39.85	$0.00
	Grade Separations (Road-Rail)	$205.61	$0.00
	Grade Separations (Rail-Rail)	$141.75	$0.00
	Bridge Widenings (River)	$12.56	$0.00
	Fleet (Capital)	$113.04	$0.00*
	Expanding Existing Stations	$62.10	$0.00
	Subtotal	**$574.90**	**$0.00**
Electrification	Infrastructure (incremental)	$90.00	$0.00
	Subtotal (incremental)	**$90.00**	**$0.00**
EMU Case	Wayside PTC	$6.08	$0.00
	PTC for LHCs	$1.89	$0.00
	New Stations	$54.00	$0.00
	Subtotal	**$61.97**	**$0.00**
CORRIDOR TOTAL		**$726.87**	**$0.00**

** The Big Move projects 2031 ridership as lower than in the 2021 Reference Case*

Network Cost Summary

Scarborough Corridor (NEW)

Category	Element	2021($M)	2031($M)
EMU Case	Wayside PTC	$18.99	$5.69
	EMU Fleet (incremental)	$126.38	$94.42
	PTC for EMUs (incremental)	$2.57	$1.89
	Track & Running Structures	$1,199.73	$385.73
	Grade Separations (Road-Rail)	$189.00	$0.00
	Electrification along Havelock Line	$0.00	$15.21
	New Stations	$162.00	$56.70
	Temporary Bus Terminals	$25.00	$0.00
CORRIDOR TOTAL		**$1,723.66**	**$559.64**

Network Cost Summary
Kitchener Corridor (via Pearson Airport)

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$202.28	$50.00
	Bridge Widenings (River)	$185.63	$0.00
	Grade Separations (Road-Rail)	$297.81	$541.35
	Fleet (Capital)	$219.80	$497.56
	Expanding Existing Stations	$2.70	$0.00
	New Stations	$20.25	$0.00
	Subtotal	**$928.46**	**$1,088.91**
Through-Route Airport GO Rail Service	Airport GO Rail Access East of Airport	$1,000.00	$0.00
	Airport GO Rail Access North of Airport	$0.00	$350.00
	Subtotal	**$1,000.00**	**$350.00**
Electrification	Infrastructure (incremental)	$412.00	$3.00
	EMU Fleet (incremental)	$216.38	($35.14)
	Subtotal (incremental)	**$628.38**	**($32.14)**
EMU Case	New Stations	$117.45	$16.20
	Wayside PTC	$47.57	$0.00
	PTC for LHCs	$1.70	$1.40
	PTC for EMUs (incremental)	$5.90	$5.50
	Credit for Air-Rail Link DMUs	($55.00)	$0.00
	Subtotal	**$117.62**	**$23.10**
CORRIDOR TOTAL		**$2,674.46**	**$1,429.87**

Network Cost Summary
Milton Corridor

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$187.24	$0.00
	Grade Separations (Rail-Rail)	$101.25	$0.00
	Grade Separations (Road-Rail)	$270.00	$108.00
	Bridge Widenings (River)	$172.13	$0.00
	Bridge Widenings (Road)	$18.90	$0.00
	Fleet (Capital)	$101.04	$530.04
	Expanding Existing Stations	$8.10	$0.00
	New Stations	$6.75	$0.00
	Subtotal	**$865.40**	**$638.04**
Electrification	Infrastructure (incremental)	$0.00	$202.00
	EMU Fleet (incremental)	$0.00	$174.38
	Subtotal (incremental)	**$0.00**	**$376.38**
EMU Case	Wayside PTC	$0.00	$35.34
	PTC for LHCs	$0.00	$2.80
	PTC for EMUs (incremental)	$0.00	$10.30
	New Stations	$0.00	$76.95
	Subtotal	**$0.00**	**$125.39**
CORRIDOR TOTAL		**$865.40**	**$1,139.81**

Milton electrification not expected until 2022

Network Cost Summary
Richmond Hill Corridor

Category	Element	2021($M)	2031($M)
Diesel Case (North of Lawrence)	Bridge Widenings (River)	$35.44	$0.00
	Grade Separations (Road-Rail)	$116.78	$0.00
	Grade Separations (Rail-Rail)	$100.00	$0.00
	New Track	$72.00	$8.10
	Fleet (Capital)	$67.12	$647.22
	Expanding Existing Stations	$9.45	$0.00
	Subtotal	**$400.78**	**$655.32**
Don Branch	Bridge Widenings (River)	$0.00	$216.00
	Grade Separations (Road-Rail)	$0.00	$37.80
	New Track	$0.00	$94.75
	Subtotal	**$0.00**	**$348.55**
Electrification	Infrastructure (incremental)	$0.00	$250.00
	EMU Fleet (incremental)	$0.00	($22.77)
	Subtotal (incremental)	**$0.00**	**$227.23**
EMU Case	Wayside PTC	$0.00	$20.60
	PTC for LHCs	$0.00	$2.80
	PTC for EMUs (incremental)	$0.00	$8.30
	New Stations	$87.75	$48.60
	Subtotal	**$87.75**	**$80.30**
CORRIDOR TOTAL		**$488.53**	**$1,311.40**

Richmond Hill electrification not expected until 2024

Network Cost Summary
Barrie Corridor

Category	Element	2021($M)	2031($M)
Diesel Case	New Track	$188.10	$14.00
	Bridge Widenings (River)	$28.55	$0.00
	Grade Separations (Road-Rail)	$244.38	$357.75
	Grade Separations (Road-Rail)	$270.00	$0.00
	Fleet (Capital)	$103.04	$40.38
	Expanding Existing Stations	$18.90	$0.00
	New Stations	$40.50	$128.25
	Subtotal	**$893.48**	**$540.38**
Electrification	Infrastructure (incremental)	$0.00	$331.00
	EMU Fleet (incremental)	$0.00	$0.00
	Subtotal (incremental)	**$0.00**	**$331.00**
EMU Case	PTC for LHCs	$0.00	$1.80
	Wayside PTC	$0.00	$32.00
	Grade Separations (Road-Rail)	$270.00	$0.00
	New Stations	$0.00	$105.30
	Rebuilt Stations	$33.75	$135.00
	Subtotal	**$303.75**	**$274.10**
CORRIDOR TOTAL		**$1,197.23**	**$1,145.48**

Barrie electrification south from Bradford not expected until 2026

Network Cost Summary

REGIONAL RAPID RAIL NETWORK COST SUMMARY

Corridor	Category	2021($M)	2031($M)
Lakeshore (West & East)	Diesel Case	$2,477.71	$1,067.01
	Electrification	$899.02	$161.45
	EMU Case	$1,127.15	$73.38
	DMU Fleet	$55.00	$0.00
	TOTAL	**$4,558.87**	**$1,301.83**
Stouffville	Diesel Case	$574.90	$0.00
	Electrification	$90.00	$0.00
	EMU Case	$61.97	$0.00
	TOTAL	**$726.87**	**$0.00**
Kitchener	Diesel Case	$928.46	$1,088.91
	Through-Route Airpo	$1,000.00	$350.00
	Electrification	$628.38	($32.14)
	EMU Case	$117.62	$23.10
	TOTAL	**$2,674.46**	**$1,429.87**
Milton	Diesel Case	$865.40	$638.04
	Electrification	$0.00	$376.38
	EMU Case	$0.00	$125.39
	TOTAL	**$865.40**	**$1,139.81**
Richmond Hill	Diesel Case(North o	$400.78	$655.32
	Don Branch	$0.00	$348.55
	Electrification	$0.00	$227.23
	EMU Case	$87.75	$80.30
	TOTAL	**$488.53**	**$1,311.40**
Barrie	Diesel Case	$893.48	$540.38
	Electrification	$0.00	$331.00
	EMU Case	$303.75	$274.10
	TOTAL	**$1,197.23**	**$1,145.48**

Corridor	2021($B)	2031($B)
Lakeshore (West & East)	$4.56	$1.30
Stouffville	$0.73	$0.00
Scarborough	$1.72	$0.56
Kitchener	$2.67	$1.43
Milton	$0.87	$1.14
Richmond Hill	$0.49	$1.31
Barrie	$1.20	$1.15
USRC	$1.00	$4.68
NETWORK TOTAL	**$13.24**	**$11.57**

Appendix W: Station Index

Station Index

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
Arterial Road:	Nearest arterial road to the station, usually an arterial that crosses the tracks. See municipality column when same street appears twic
Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

Lakeshore Corridor

Subdivision Abbreviation Key for the Lakeshore Corridor

Ham: CP Hamilton	Oak: CN/GO Oakville	Kin: GO Kingston	Dur: GO (Durham)

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. W.	Next Stn. E.	Parking	PPUDO	Connections
035	Hamilton TH&B	Exist	Hamilton	James St	Express	Ham57.50	-	8.88km	No	No	GO, HSR
034	Aldershot	Exist	Burlington	Waterdown Rd	Express	Oak34.60	8.88km	4.99km	Yes	Yes	VIA, BT
033	Burlington	Exist		Brant St	Express	Oak31.50	4.99km	2.01km	Yes	Yes	GO, BT
032	Dynes	New		Cumberland Ave	Local	Oak30.25	2.01km	3.62km	Limited	Yes	BT
031	Appleby	Exist		Appleby Line	Local	Oak28.00	3.62km	2.01km	Yes	Yes	BT
030	Pinedale	New	Oakville	Burloak Dr	Local	Oak26.75	2.01km	3.30km	Yes	Yes	BT, OT
029	Bronte	Exist		Third Line	Local	Oak24.70	3.30km	3.22km	Yes	Yes	OT
028	Kerr Village	New		Dorval Dr	Local	Oak22.70	3.22km	2.09km	No	Yes	OT
027	Oakville	Exist		Trafalgar Rd	Express	Oak21.40	2.09km	2.33km	Yes	Yes	VIA, GO, OT
026	Morrison	New		Morrison Rd	Local	Oak19.95	2.33km	2.17km	Limited	Yes	OT
025	Sherwood Heights	New		Ford Dr	Local	Oak18.60	2.17km	3.06km	Limited	Yes	OT
024	Clarkson	Exist	Mississauga	Southdown Rd	Express	Oak16.70	3.06km	2.86km	Yes	Yes	OT, MiWay
023	Lorne Park	Restored		Lorne Park Rd	Local	Oak14.92	2.86km	3.41km	No	No	MiWay
022	Port Credit	Exist		Hurontario St	Express	Oak12.80	3.41km	3.01km	Yes	Yes	MiWay
021	Lakeview	New		Ogden Ave	Local	Oak10.93	3.01km	2.14km	No	No	MiWay
020	Long Branch	Exist	Toronto	Browns Line	Local	Oak9.60	2.14km	2.30km	Yes	Yes	MiWay, TTC
019	Alderwood	New		Kipling Ave	Express	Oak8.17	2.30km	3.60km	No	No	TTC
018	Mimico	*Moved*		Park Lawn Rd	Local	Oak5.93	3.60km	2.06km	Yes	Yes	TTC
017	Swansea	New		Windermere Ave	Local	Oak4.65	2.06km	3.75km	No	No	TTC
016	Exhibition	*Moved*		Dufferin St	Local	Oak2.32	3.75km	1.87km	No	No	TTC
002	Fort York	New		Bathurst St	Express	Oak1.16	1.87km	1.87km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts	Express	Oak0.00/Kin333.84	1.87km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St	Express	Kin332.72	1.80km	2.45km	No	No	GO, TTC
004	Riverdale	New		Gerrard St E	Local	Kin331.20	2.45km	2.25km	No	No	TTC
005	Leslieville	New		Coxwell Ave	Local	Kin329.80	2.25km	2.01km	No	No	TTC
006	Danforth	Exist		Main St	Local	Kin328.55	2.01km	3.52km	No	No	TTC
007	Birch Cliff	New		Birchmount Rd	Local	Kin326.45	3.52km	2.01km	No	No	TTC
008	Scarborough	*Rebuilt*		St Clair Ave E	Local	Kin325.20	2.01km	3.22km	Limited	Yes	GO, TTC
009	Eglinton	Exist		Eglinton Ave E	Express	Kin323.20	3.22km	3.22km	Limited	Yes	TTC
010	Guildwood	Exist		Kingston Rd	Local	Kin321.20	3.22km	6.20km	Yes	Yes	VIA, TTC
011	Rouge Hill	Exist		Lawrence Ave E	Express	Kin317.35	6.20km	3.65km	Yes	Yes	TTC, DRT
012	West Shore	New	Pickering	Whites Rd	Local	Kin315.08	3.65km	3.56km	Limited	Yes	DRT
013	Pickering	Exist		Liverpool Rd	Express	Dur1.00	3.56km	4.02km	Yes	Yes	DRT
014	Ajax	Exist	Ajax	Westney Rd S	Express	Dur3.50	4.02km	2.01km	Yes	Yes	DRT
015	Ajax East	New		Harwood Ave S	Express	Dur4.75	2.01km	?	No	Yes	DRT
	15				Average Station Spacing Along Corridor:		3.07km				

Due to incomplete data available, stations along Whitby realignment and Bowmanville extension are not listed above

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
Arterial Road:	Nearest arterial road to the station, usually an arterial that crosses the tracks. See municipality column when same street appears twic
Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Kitchener Corridor

Subdivision Abbreviation Key for the Kitchener Corridor

Gue: GEXR (CN) Guelph	Hal: CN Halton	Wes: GO Weston	Air: GO Airport (New)	Bal: CN/GO Bala

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. W.	Next Stn. E.	Parking	PPUDO	Connections
067	Kitchener	Exist	Kitchener	King St W	Express	Gue62.60	-	6.92km	No	No	VIA, GRT
066	Breslau	Exist		Fountain St N	Express	Gue58.30	6.92km	15.29km	Yes	Yes	None
065	Guelph	Exist	Guelph	Wyndham St	Express	Gue48.80	15.29km	12.23km	Limited	Yes	VIA, GT
064	Rockwood	New	Rockwood	Main St N	Express	Gue41.20	12.23km	8.21km	Limited	Yes	None
063	Acton	Exist	Acton	Queen St	Express	Gue36.10	8.21km	10.91km	Limited	Yes	None
062	Georgetown	Exist	Georgetown	River Dr	Express	Hal23.50	10.91km	8.37km	Yes	Yes	VIA
061	Mount Pleasant	Exist	Brampton	Creditview Rd	Express	Hal18.30	8.37km	2.01km	Yes	Yes	BT
060	Northwood Park	New		Chinguacousy Rd	Local	Hal17.05	2.01km	2.66km	Yes	Yes	BT
059	Brampton	Exist		Main St	Express	Hal15.40	2.66km	2.00km	Yes	Yes	VIA, GO, BT
058	Peel Village	New		Kennedy Rd	Local	Hal14.16	2.00km	4.12km	No	No	BT
057	Bramalea	Exist		Bramalea Rd	Express	Hal11.60	4.12km	4.55km	Yes	Yes	GO, BT
056	Malton	Exist	Mississauga	Airport Rd	Local	Wes14.70	4.55km	4.60km	Yes	Yes	MiWay, BT
055	Pearson	New		Hwy 409	Express	Air*X.YZ*	4.60km	2.00km	No	No	GO, TTC, MiWay, BT, YRT
054	Carlingview	New	Toronto	Carlingview Dr	Local	Air*X.YZ*	2.00km	4.10km	No	No	GO, TTC, MiWay
053	Rexdale *(Etob. N.)*	*Moved*		Islington Ave	Express	Wes10.50	4.10km	3.54km	Yes	Yes	GO, TTC
052	Weston	Exist		Lawrence Ave W	Local	Wes8.30	3.54km	2.17km	Limited	Yes	TTC
051	Mount Dennis	New		Eglinton Ave W	Express	Wes6.95	2.17km	2.49km	No	Yes	TTC
050	Harwood	New		St Clair Ave W	Local	Wes5.40	2.49km	2.25km	No	No	TTC
049	Bloor	Exist		Bloor St W	Express	Wes4.00	2.25km	2.35km	No	No	GO, TTC
048	Parkdale	New		Queen St W	Local	Wes2.54	2.35km	2.16km	No	No	GO, TTC
002	Fort York	New		Bathurst St	Express	Wes1.20	2.16km	1.93km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts	Express	Wes0.00/Bal0.00	1.93km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St	Express	Bal1.12	1.80km	2.06km	No	No	GO, TTC
	8				Average Station Spacing Along Corridor:		4.85km				

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
Arterial Road:	Nearest arterial road to the station, usually an arterial that crosses the tracks. See municipality column when same street appears twic
Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Stouffville Corridor

Subdivision Abbreviation Key for the Stouffville Corridor

Nmk: GO Newmarket	Kin: GO Kingston	Uxb: GO Uxbridge

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. W.	Next Stn. E.	Parking	PPUDO	Connections
002	Fort York	New	Toronto	Bathurst St	Express	Nmk1.20	2.16km	1.93km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts	Express	Nmk0.00/Kin333.84	1.93km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St	Express	Kin332.72	1.80km	2.45km	No	No	GO, TTC
004	Riverdale	New		Gerrard St E	Local	Kin331.20	2.45km	2.25km	No	No	TTC
005	Leslieville	New		Coxwell Ave	Local	Kin329.80	2.25km	2.01km	No	No	TTC
006	Danforth	Exist		Main St	Local	Kin328.55	2.01km	3.52km	No	No	TTC
007	Birch Cliff	New		Birchmount Rd	Local	Kin326.45	3.52km	2.01km	No	No	TTC
008	Scarborough	*Rebuilt*		St Clair Ave E	Express	Uxb60.77	2.01km	2.04km	Limited	Yes	GO, TTC
036	Kennedy	*Rebuilt*		Eglinton Ave E	Express	Uxb59.62	2.04km	2.00km	TTC	Yes	TTC
037	Lawrence Ave E	New		Lawrence Ave E	Local	Uxb58.38	2.00km	2.00km	Limited	Yes	TTC
038	Ellesmere Rd	New		Ellesmere Rd	Local	Uxb57.14	2.00km	2.64km	Limited	Yes	GO, TTC
039	Agincourt	Exist		Sheppard Ave E	Express	Uxb55.50	2.64km	2.00km	Limited	Yes	TTC
040	L'Amoreaux	New		Finch Ave E	Express	Uxb54.26	2.00km	2.19km	Yes	Yes	TTC
041	Milliken	Exist		Steeles Ave E	Express	Uxb52.90	2.19km	3.54km	Yes	Yes	TTC, YRT
042	Unionville	Exist	Markham	Enterprise Dr	Express	Uxb50.70	3.54km	3.54km	Yes	Yes	GO, TTC
043	Centennial	Exist		McCowan Rd	Express	Uxb48.50	3.54km	2.33km	Limited	Yes	YRT
044	Markham	Exist		Highway 48	Express	Uxb47.05	2.33km	1.95km	Limited	Improv.	YRT
045	Mount Joy	Exist		Bur Oak Dr	Express	Uxb45.84	1.95km	8.43km	Yes	Yes	YRT
046	Stouffville	Exist	Whitchurch-Stouffville	Main St (RR14)	Express	Uxb40.60	8.43km	2.90km	Limited	No	None
047	Lincolnville	Exist		10th Line	Express	Uxb38.80	2.90km	-	Limited	No	None
		3			Average Station Spacing Along Corridor:		2.71km				

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
Arterial Road:	Nearest arterial road to the station, usually an arterial that crosses the tracks. See municipality column when same street appears twic
Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Milton Corridor

Subdivision Abbreviation Key for the Stouffville Corridor

Gal: CP/GO Galt	THC: GO Toronto Harbour Commission (New (USRC))

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. W.	Next Stn. E.	Parking	PPUDO	Connections
081	Milton	Exist	Milton	Thompson Rd S	Local	Gal31.26	-	6.07km	Yes	Yes	Milton Transit
080	Trafalgar	New		Trafalgar Rd		Gal27.49	6.07km	3.70km	Yes	Yes	None
079	Lisgar	Exist	Mississauga	10th Line		Gal25.19	3.70km	3.30km	Yes	Yes	MiWay
078	Meadowvale	Exist		Derry Rd W		Gal23.14	3.30km	4.43km	Yes	Yes	MiWay
077	Streetsville	Exist		Thomas St		Gal20.39	4.43km	2.00km	Yes	Yes	MiWay
076	Erin Mills	New		Eglinton Ave W		Gal19.15	2.00km	2.00km	No	No	MiWay
075	Erindale	*Rebuilt*		Burnhamthorpe Rd W		Gal17.91	2.00km	2.27km	Yes	Yes	MiWay
074	Fairview	New		Mavis Rd		Gal16.69	2.27km	2.14km	No	Yes	MiWay
073	Cooksville	Exist		Hurontario St		Gal15.36	2.14km	2.59km	Yes	Yes	MiWay
072	Applewood	New		Cawthra Rd		Gal13.75	2.59km	2.11km	No	No	MiWay
071	Dixie	Exist		Dixie Rd		Gal12.44	2.11km	5.87km	Yes	Yes	MiWay
070	Islington *(Kipling)*	*Moved*	Toronto	Islington Ave		Gal8.79	5.87km	2.00km	No	Yes	TTC, MiWay
069	Chestnut Hills	New		Royal York Rd		Gal7.55	2.00km	2.29km	No	Yes	TTC
068	Lambton	New		Jane St		Gal6.13	2.29km	3.43km	Limited	Yes	TTC
049	Bloor	New		Bloor St W		Gal4.00	3.43km	2.35km	No	No	GO, TTC
048	Parkdale	New		Queen St W		Gal2.54	2.35km	2.16km	No	No	GO, TTC
002	Fort York	New		Bathurst St		Gal1.20	2.16km	1.93km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts		Gal0.00/THC0.00	1.93km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St		THC1.12	1.80km	-	No	No	GO, TTC
		7			Average Station Spacing Along Corridor:		2.91km				

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
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Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Richmond Hill Corridor

Subdivision Abbreviation Key for the Richmond Hill Corridor

Bal: CN/GO Bala	Blv: CP Belleville

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. S.	Next Stn. N.	Parking	PPUDO	Connections
002	Fort York	New	Toronto	Bathurst St	Express	Wes1.20	2.16km	1.87km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts	Express	Wes0.00/Bal0.00	1.87km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St	Express	Bal1.12	1.80km	2.06km	No	No	GO, TTC
082	Cabbagetown	New		Gerrard St E	Local	Bal2.40/Blv209.00	2.06km	4.59km	No	No	TTC
083	Leaside	New		Millwood Rd	Express	Blv206.15	4.59km	2.01km	Limited	Yes	TTC
084	Seton Park	New		Eglinton Ave E	Express	Blv204.90	2.01km	4.41km	No	Yes	TTC
085	Windfields	New		York Mills Rd	Local	Bal11.02	4.41km	2.54km	No	Yes	TTC
086	Oriole	*Moved*		Sheppard Ave E	Express	Bal12.60	2.54km	2.24km	TTC	TTC	TTC
087	Old Cummer	*Shifted*		Finch Ave E	Local	Bal13.99	2.24km	2.00km	Limited	Yes	TTC
088	Bayview Glen	New		Steeles Ave E	Local	Bal15.23	2.00km	2.32km	No	No	TTC, YRT
089	Thornhill	New	Markham	John St	Local	Bal16.44	2.32km	2.85km	No	No	YRT
090	Langstaff	Exist	Richmond Hill	Highway 7 E	Express	Bal18.21	2.85km	2.00km	Yes	Yes	GO, YRT
091	Richvale	New		16th Ave	Local	Bal19.45	2.00km	2.40km	No	Yes	YRT
092	Richmond Hill	Exist		Major Mackenzie Dr E	Express	Bal20.94	2.40km	2.19km	Yes	Yes	YRT
093	Elgin Mills	New		Elgin Mills Rd	Express	Bal22.30	2.19km	2.57km	No	No	YRT
094	Trailwood	New		19th Ave	Express	Bal23.90	2.57km	3.73km	Yes	Yes	Limited
095	Gormley	Exist		Stouffville Rd	Express	Bal26.22	3.73km	3.83km	Yes	Yes	Limited
096	Bloomington	New	Whitchurch-Stouffville	Bloomington Rd E	Express	Bal28.60	3.83km	-	Yes	Yes	Limited

10 Average Station Spacing Along Corridor: 2.67km

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
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Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Barrie Corridor

Subdivision Abbreviation Key for the Barrie Corrido

Nmk: GO Newmarket	Kin: GO Kingston

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. N.	Next Stn. S.	Parking	PPUDO	Connections
119	Allandale	Exist	Barrie	Lakeshore Dr	Express	Nmk62.95	-	5.55km	Limited	Yes	Barrie Transit
118	Barrie South	Exist		Mapleview Dr E	Express	Nmk59.50	5.55km	6.16km	Yes	Yes	Barrie Transit
117	Innisfil	New	Innisfil	Innisfil Beach Rd	Express	Nmk55.67	6.16km	22.69km	Yes	Yes	None
116	Bradford	Exist	Bradford	Holland St E	Express	Nmk41.57	22.69km	6.31km	Yes	Yes	None
115	Holland Landing	New	Holland Landing	Yonge St	Local	Nmk37.65	6.31km	3.46km	Yes	Yes	Limited
114	East Gwillimbury	Exist	Newmarket	Green Lane	Local	Nmk35.50	3.46km	2.25km	Yes	Yes	YRT
113	Newmarket	*Rebuilt*		Davis Dr	Express	Nmk34.10	2.25km	2.09km	Limited	Yes	YRT
112	Mulock	New		Mulock Dr	Local	Nmk32.80	2.09km	4.67km	Limited	Yes	YRT
111	Aurora	*Rebuilt*	Aurora	Wellington St	Express	Nmk29.90	4.67km	2.25km	Yes	Yes	YRT
110	South Aurora	New		Yonge St	Express	Nmk28.50	2.25km	3.64km	No	Yes	YRT
109	Temperanceville	New	King Township	Bloomington Rd W	Local	Nmk26.24	3.64km	5.79km	Yes	Yes	Limited
108	King City	Exist		n/a	Local	Nmk22.64	5.79km	3.41km	Yes	No	Limited
107	Kirby	New	Vaughan	Kirby Rd	Local	Nmk20.52	3.41km	3.70km	Yes	Yes	Limited
106	Maple	Exist		Major Mackenzie Dr W	Express	Nmk18.22	3.70km	2.38km	Limited	Yes	YRT
105	Rutherford	Exist		Rutherford Rd	Local	Nmk16.74	2.38km	4.25km	Yes	Yes	YRT
104	Concord	New		Highway 7 W	Express	Nmk14.10	4.25km	2.41km	Yes	Yes	YRT
103	York University	*Moved*	Toronto	n/a	Local	Nmk12.60	2.41km	2.98km	No	No	Limited
102	Downsview	New		Sheppard Ave W	Express	Nmk10.75	2.98km	2.38km	No	TTC	TTC
101	Wilson Ave	New		Wilson Ave	Local	Nmk9.27	2.38km	2.12km	No	No	TTC
100	Lawrence Ave W	New		Lawrence Ave W	Local	Nmk7.95	2.12km	2.14km	No	No	TTC
099	Fairbank	New		Eglinton Ave W	Express	Nmk6.62	2.14km	2.04km	No	Maybe	TTC
098	Earlscourt	New		St Clair Ave W	Local	Nmk5.35	2.04km	2.04km	No	Yes	TTC
097	Wallace Emmerson	New		Bloor St W	Express	Nmk4.08	2.04km	2.48km	No	No	Subway
048	Parkdale	New		Queen St W	Local	Nmk2.54	2.48km	2.16km	No	No	TTC
002	Fort York	New		Bathurst St	Express	Nmk1.20	2.16km	1.93km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts	Express	Nmk0.00/Kin333.84	1.93km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St	Express	Kin332.72	1.80km	2.45km	No	No	GO, TTC

13 Average Station Spacing Along Corridor: 3.97km

Column Headings

Station numbers:	Stations are given an identification number to avoid double-counting where multiple lines serve a station.
Arterial Road:	Nearest arterial road to the station, usually an arterial that crosses the tracks. See municipality column when same street appears twic
Milepost:	Specific station location on the railway network with an abbreviated subdivision name followed by the mile along that subdivision.
PPUDO:	Passenger Pick-Up/Drop-Off area, a temporary waiting area for cars wherein the driver does not leave their vehicle.

APPENDIX W

Station Index

Scarborough Corridor

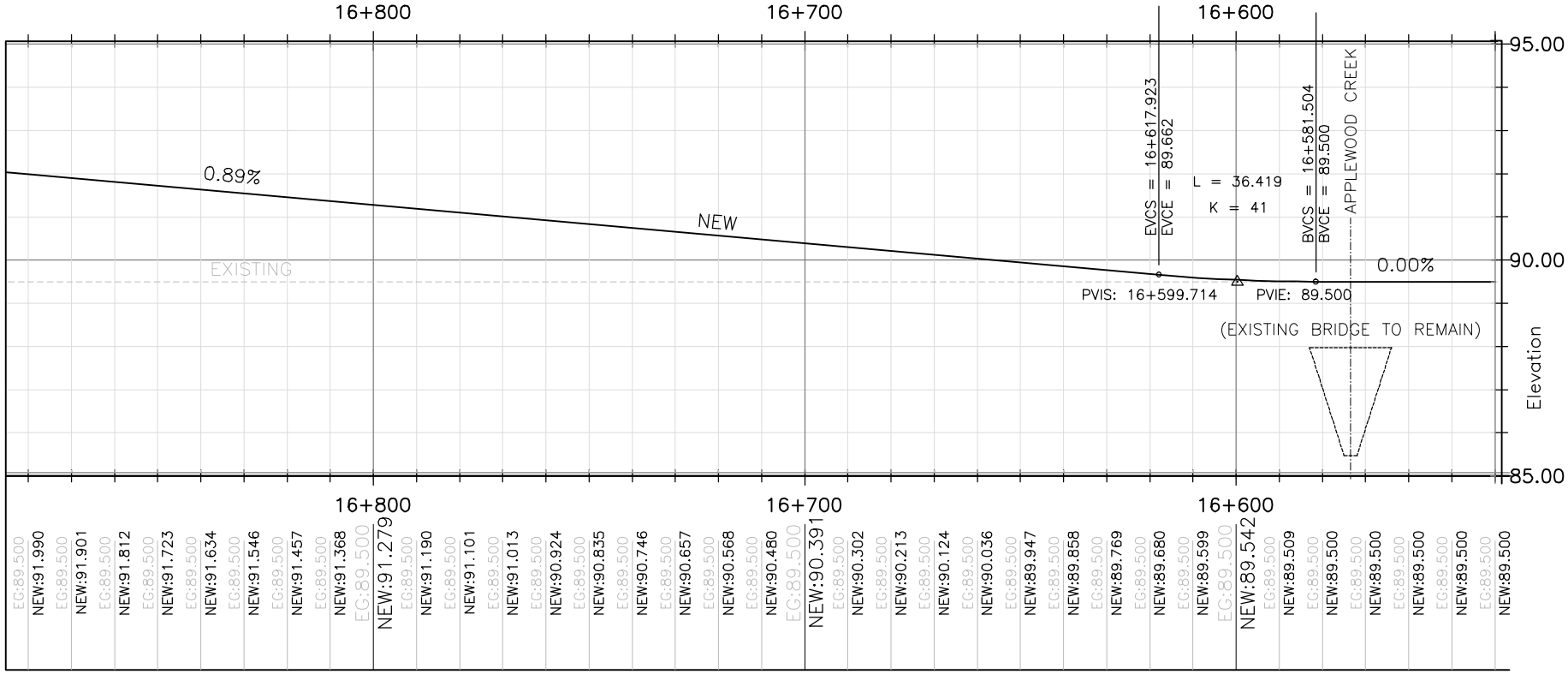
Subdivision Abbreviation Key for the Scarborough Corridor

Kin: GO Kingston	Uxb: GO Uxbridge	Sca: GO Scarborough (New)	Hav: SW Havelock

Stn.#	Station Name	New/Exist	Municipality	Arterial Road	Local/Express	Milepost	Next Stn. W.	Next Stn. E.	Parking	PPUDO	Connections
002	Fort York	New		Bathurst St		*varies by thru-rte*	*varies*	1.9km	No	No	GO, TTC
001	Union	Exist		Bay/York Sts		Kin333.84	1.9km	1.80km	No	No	VIA, GO, TTC, ONR
003	Distillery	New		Parliament St		Kin332.72	1.80km	2.45km	No	No	GO, TTC
004	Riverdale	New		Gerrard St E		Kin331.20	2.45km	2.25km	No	No	TTC
005	Leslieville	New		Coxwell Ave		Kin329.80	2.25km	2.01km	No	No	TTC
006	Danforth	Exist		Main St		Kin328.55	2.01km	3.52km	No	No	TTC
007	Birch Cliff	New		Birchmount Rd		Kin326.45	3.52km	2.01km	No	No	TTC
008	Scarborough	*Rebuilt*	Toronto	St Clair Ave E		Uxb60.77	2.01km	2.04km	Limited	Yes	GO, TTC
036	Kennedy	*Rebuilt*		Eglinton Ave E	Local	Uxb59.62	2.04km	2.00km	TTC	Yes	TTC
037	Lawrence Ave E	New		Lawrence Ave E		Uxb58.38	2.00km	2.00km	Limited	Yes	TTC
038	Ellesmere Rd	New		Ellesmere Rd		Uxb57.14	2.00km	1.90km	Limited	Yes	GO, TTC
120	Scarborough Centre	New		Brimley Rd		Sca1.04	1.90km	3.04km	No	No	GO, TTC
121	Centennial College	New		Highway 401		Sca2.93	3.04km	2.20km	No	No	GO, TTC
122	Malvern	New		Tapscott Rd		Sca4.30	2.20km	3.72km	Yes	Yes	TTC
123	Morningside Heights	New		Passmore Ave		Hav178.22	3.72km	4.14km	No	Yes	TTC, YRT
124	Cedar Grove	New	Markham	14th Ave		Hav175.65	4.14km	2.82km	Yes	Yes	YRT
125	Locust Hill	New		Highway 7 E		Hav173.90	2.82km	-	Yes	Yes	YRT
	6			Average Station Spacing Along Corridor:			2.49km				

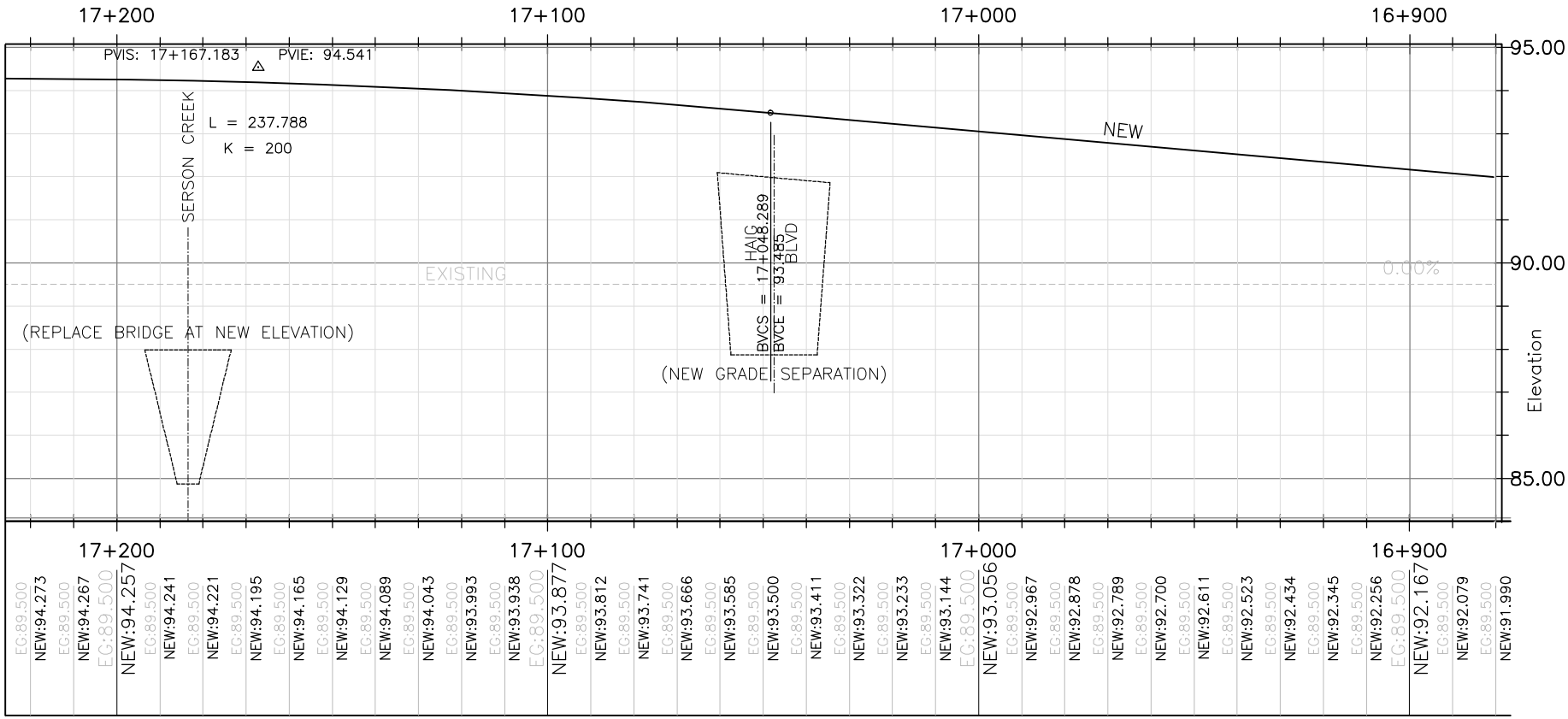
Appendix X: Drawings

Lakeshore West Corridor Vertical Realignment East of Hurontario St



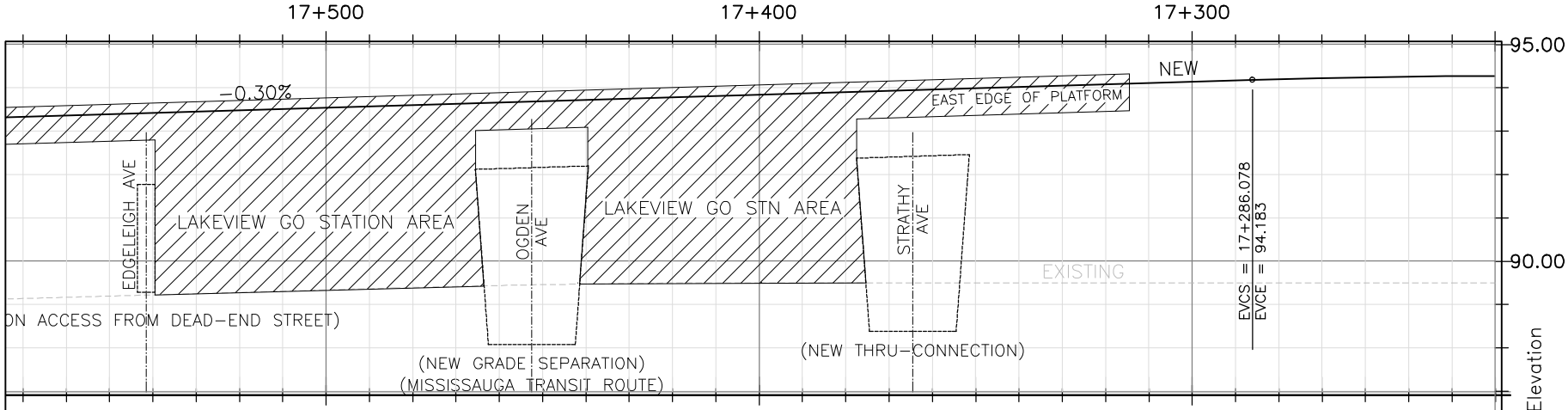
CONCEPTUAL

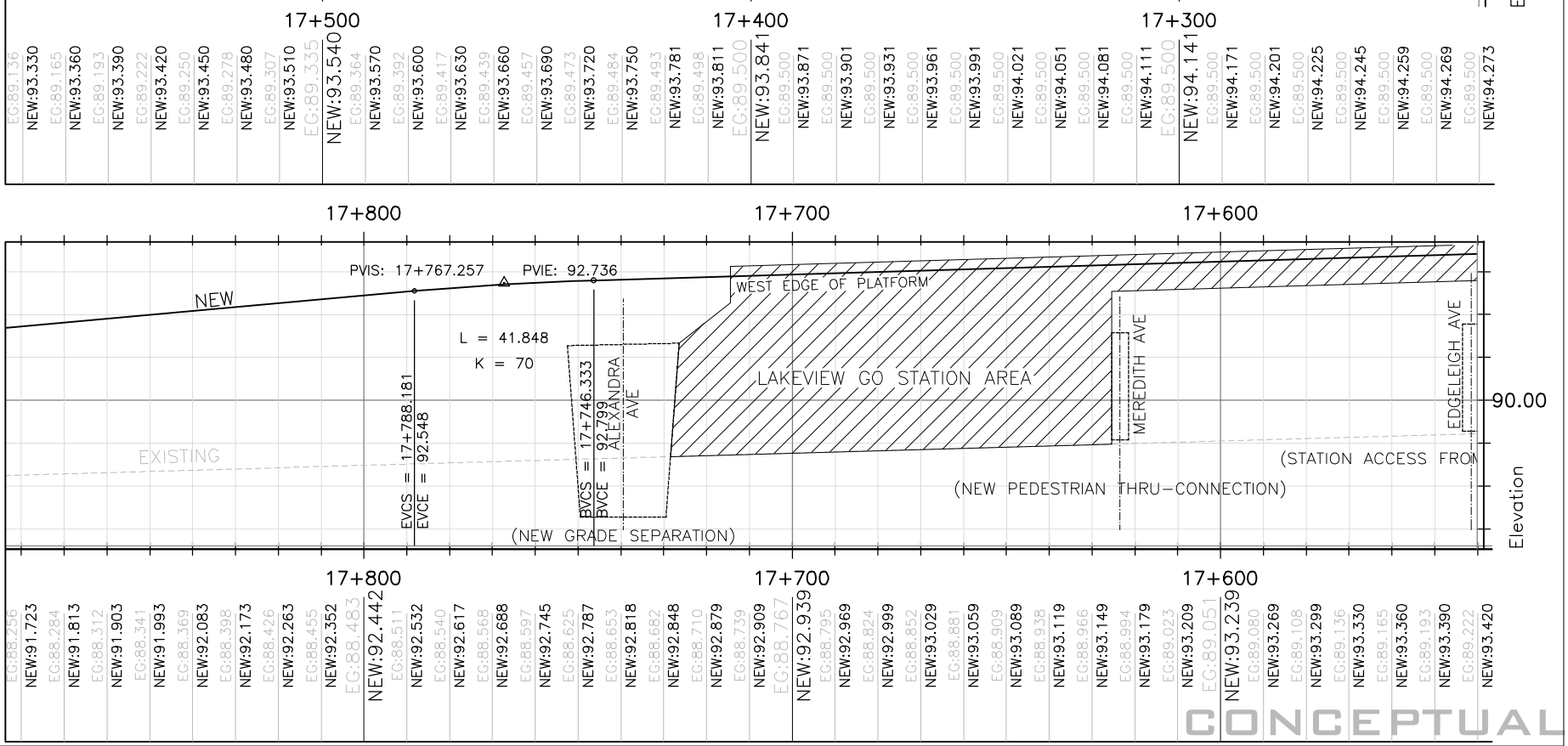
GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment			6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500	VA-1
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150	
◀West to Port Credit GO Station [Hurontario St]	East to Long Branch GO Station [Browns Line]▶		◀◀◀◀◀◀



CONCEPTUAL

GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment			6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500	VA-2
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150	
◀West to Port Credit GO Station [Hurontario St]	East to Long Branch GO Station [Browns Line]▶		◀◀◀◀◀◀





GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment			6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500	**VA-3**
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150	
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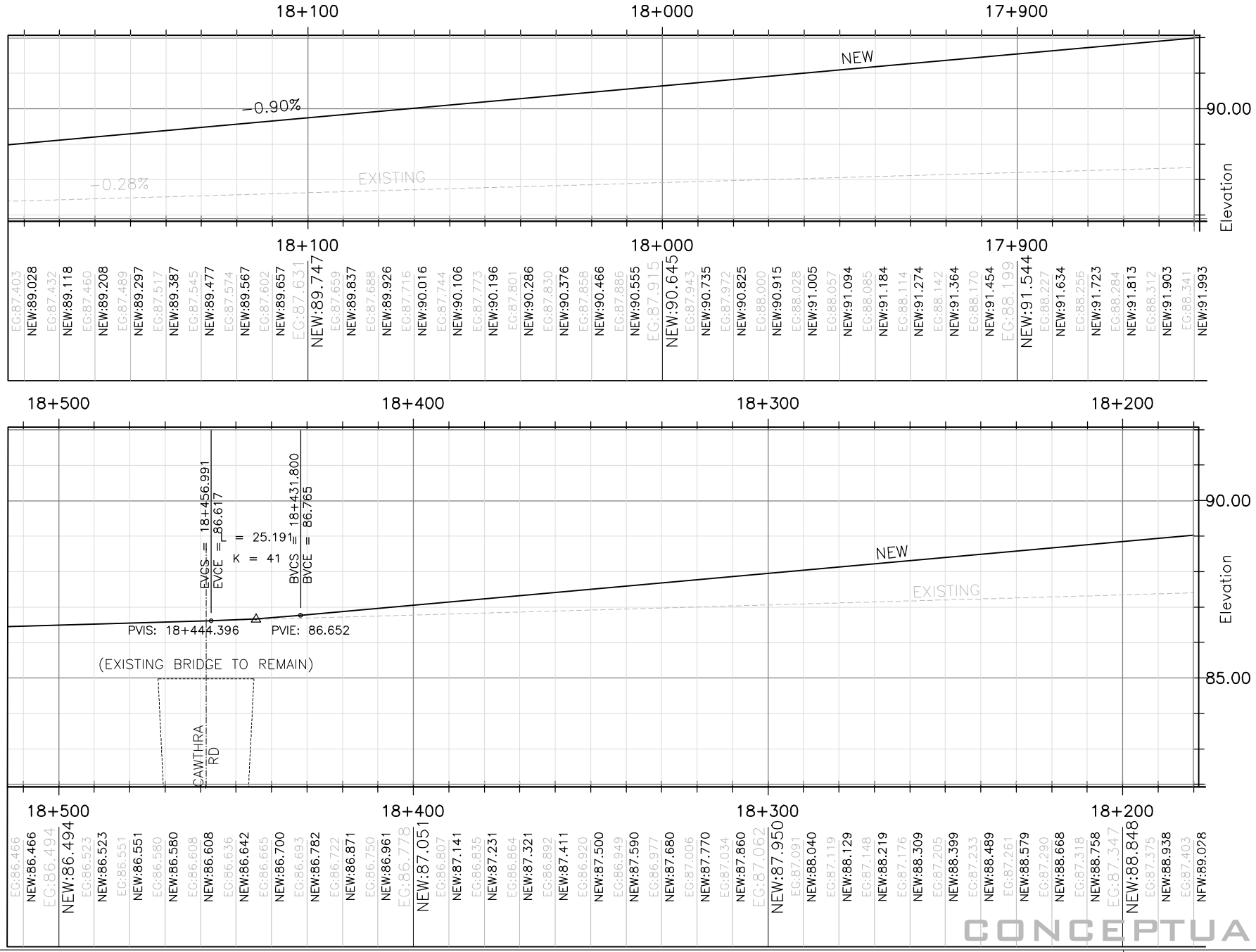
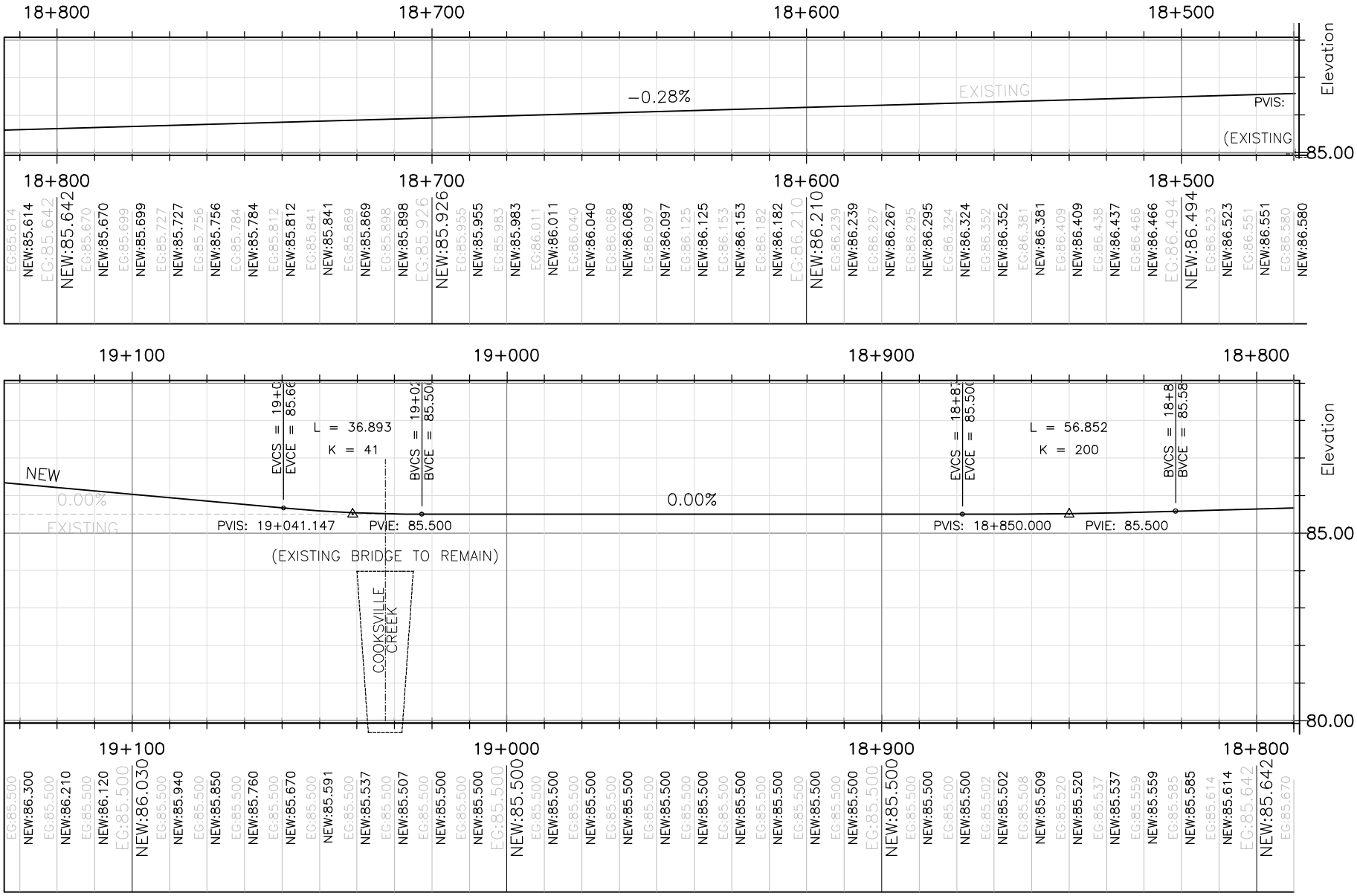
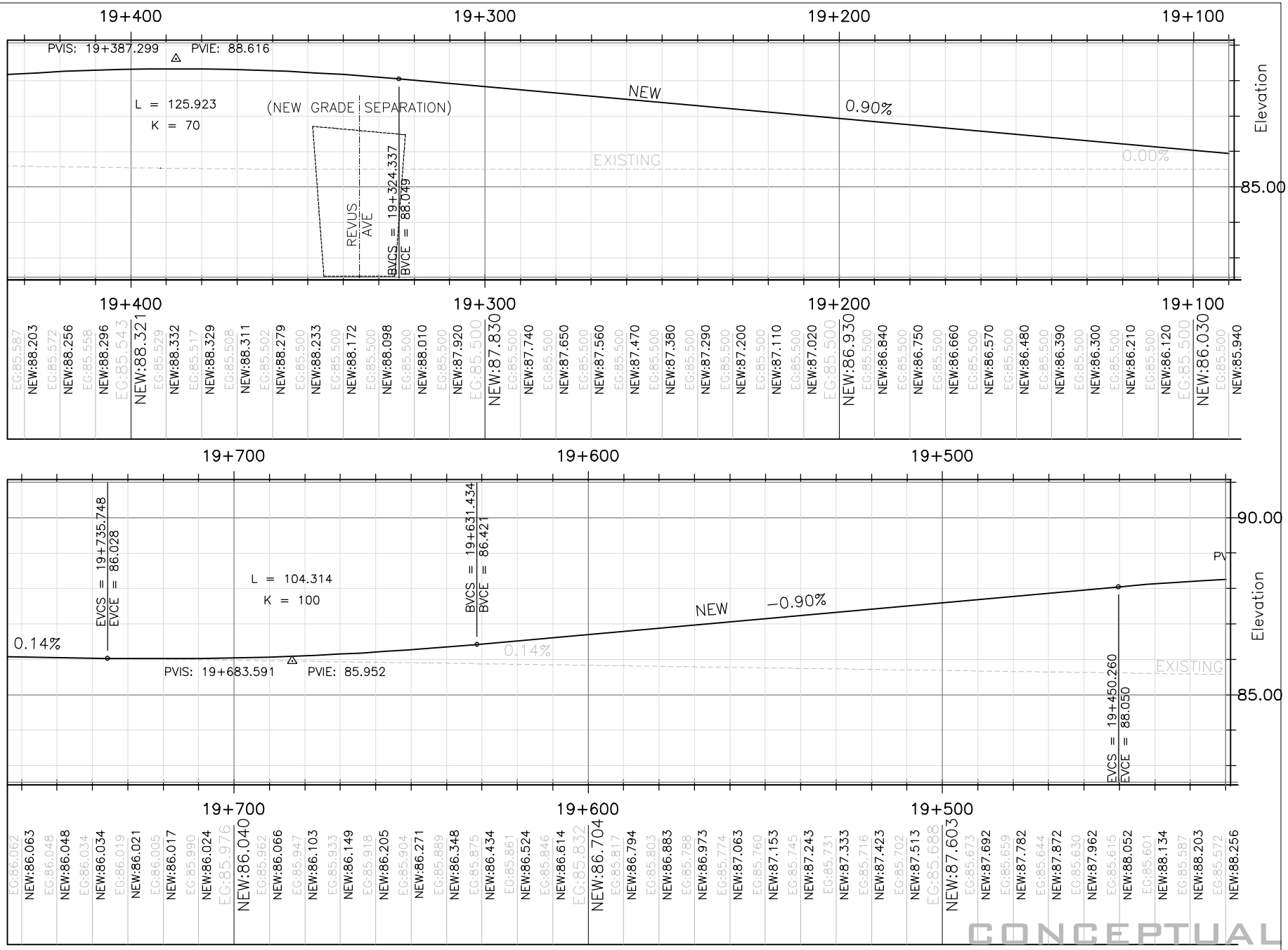


GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment			6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500	VA-4
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150	
◀West to Port Credit GO Station [Hurontario St]	East to Long Branch GO Station [Browns Line]▶		



CONCEPTUAL

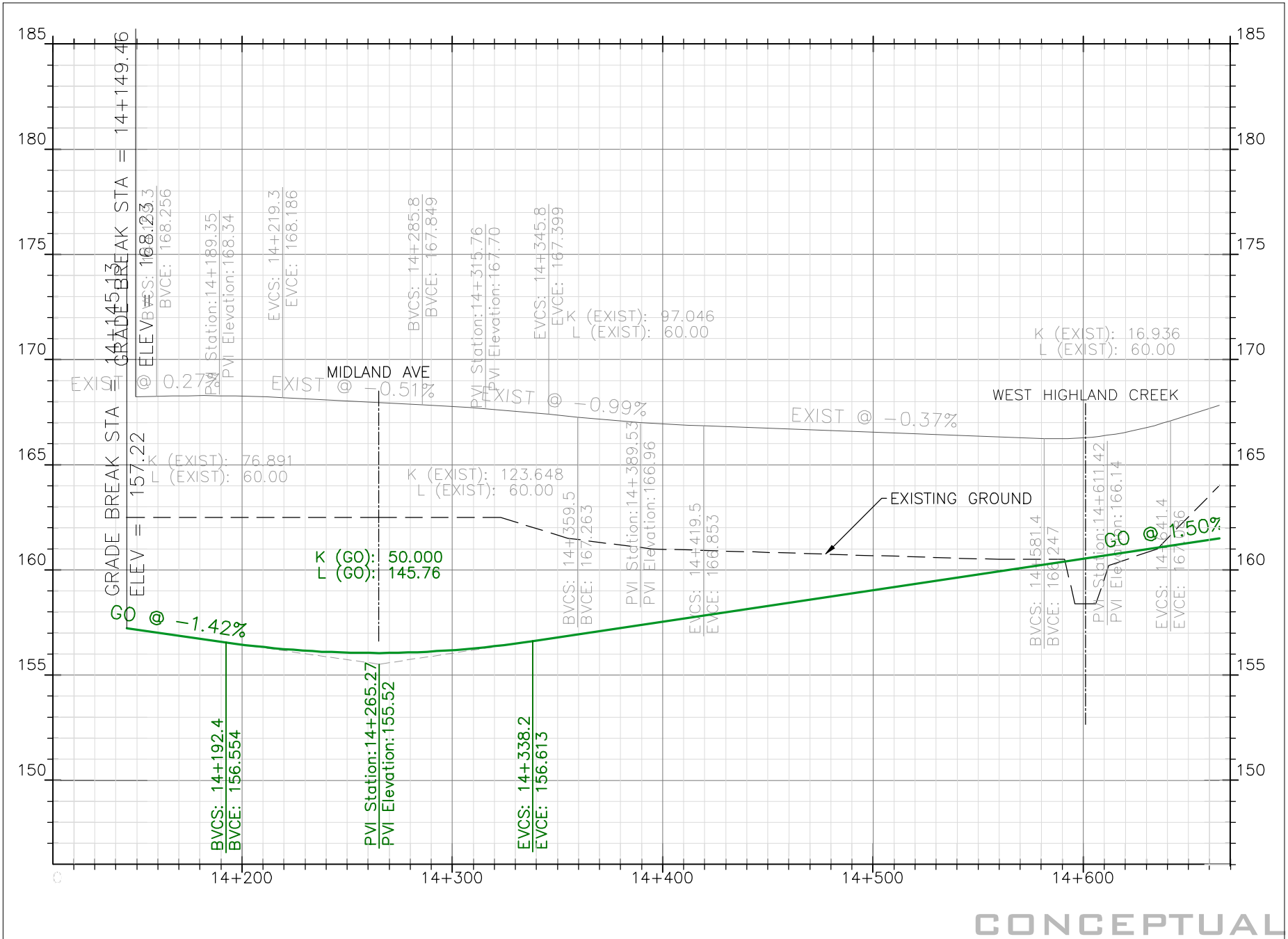
GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment			6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500	VA-5
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150	
◀West to Port Credit GO Station [Hurontario St]	East to Long Branch GO Station [Browns Line]▶		



GO Oakville Subdivision Lakeview [Cawthra Rd] Area Vertical Realignment		6 Dwgs in Set
Data Compiled from: Metrolinx Electrification Study Appendix 3	Date: April 18, 2012	HScale = 1:1500
City of Mississauga eMaps	Drawn by: Karl Junkin	VScale = 1:150
◀West to Port Credit GO Station [Hurontario St]	East to Long Branch GO Station [Browns Line]▶	

VA-6

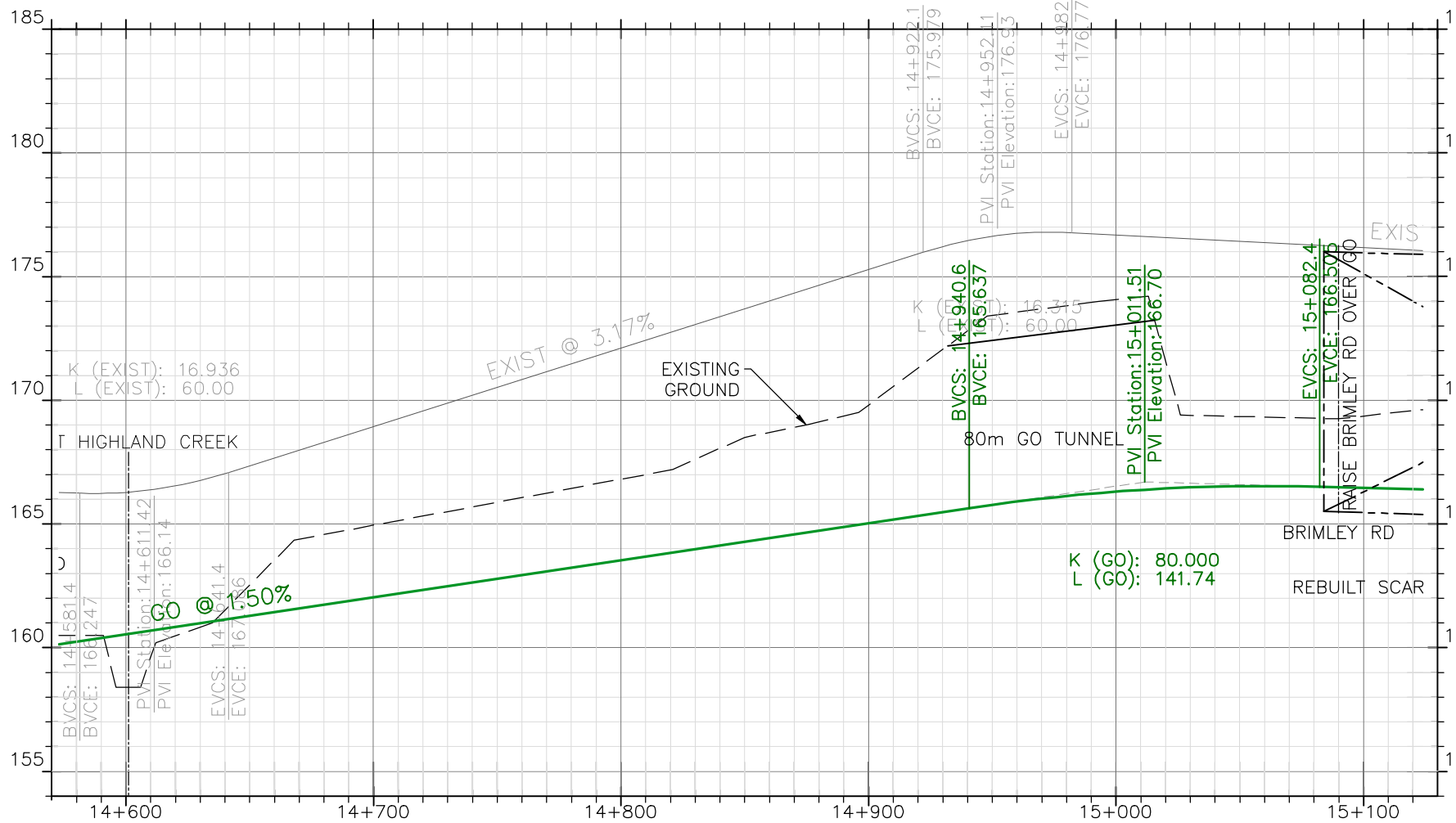
Scarborough Corridor Vertical Alignment Compared with SRT LRT Line



CONCEPTUAL

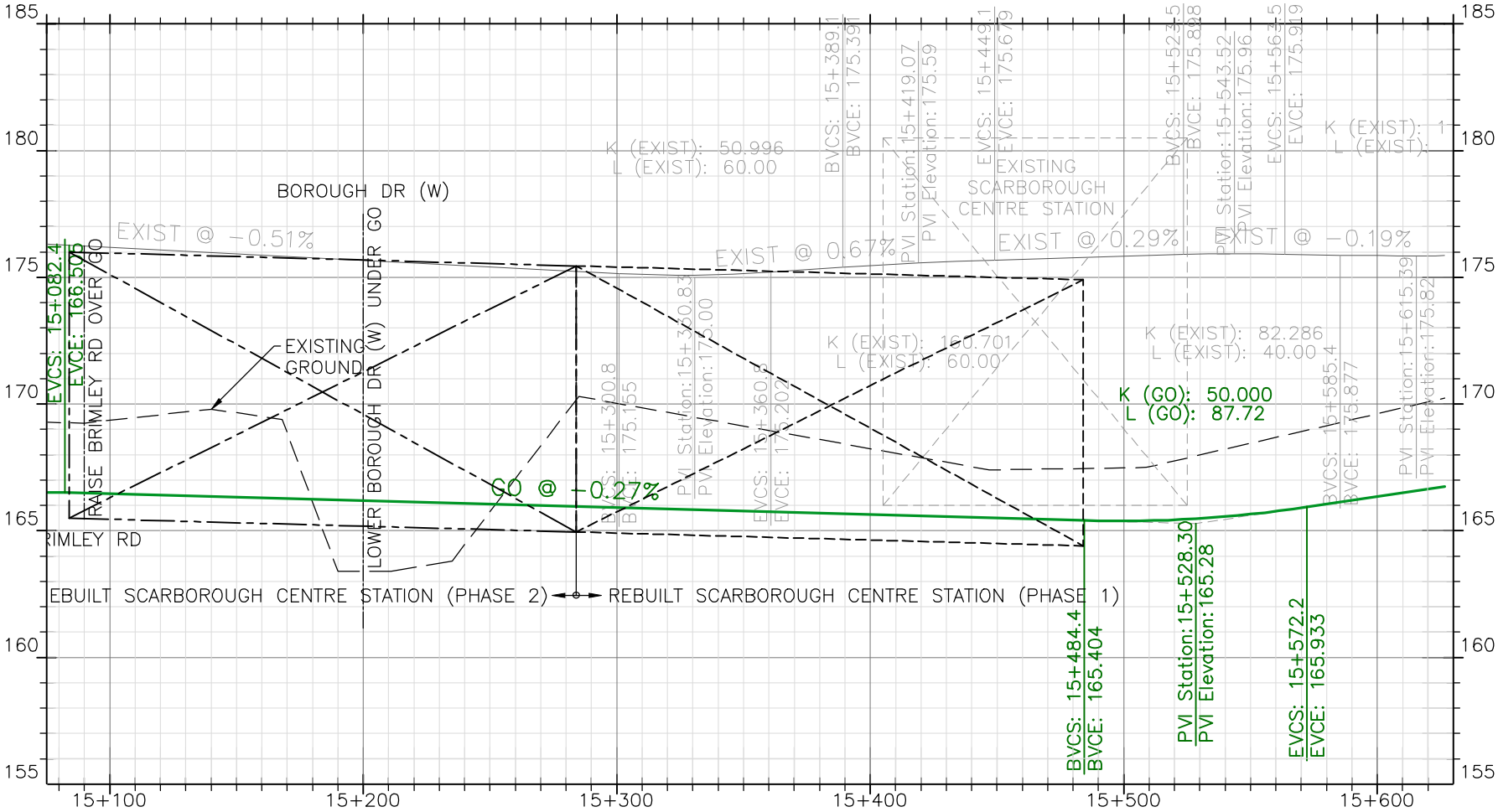
GO Scarborough Subdivision Vertical Alignment		
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500
Midland Ave Crossing	Drawn by: Karl Junkin	VScale = 1:250
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶	

VA-1



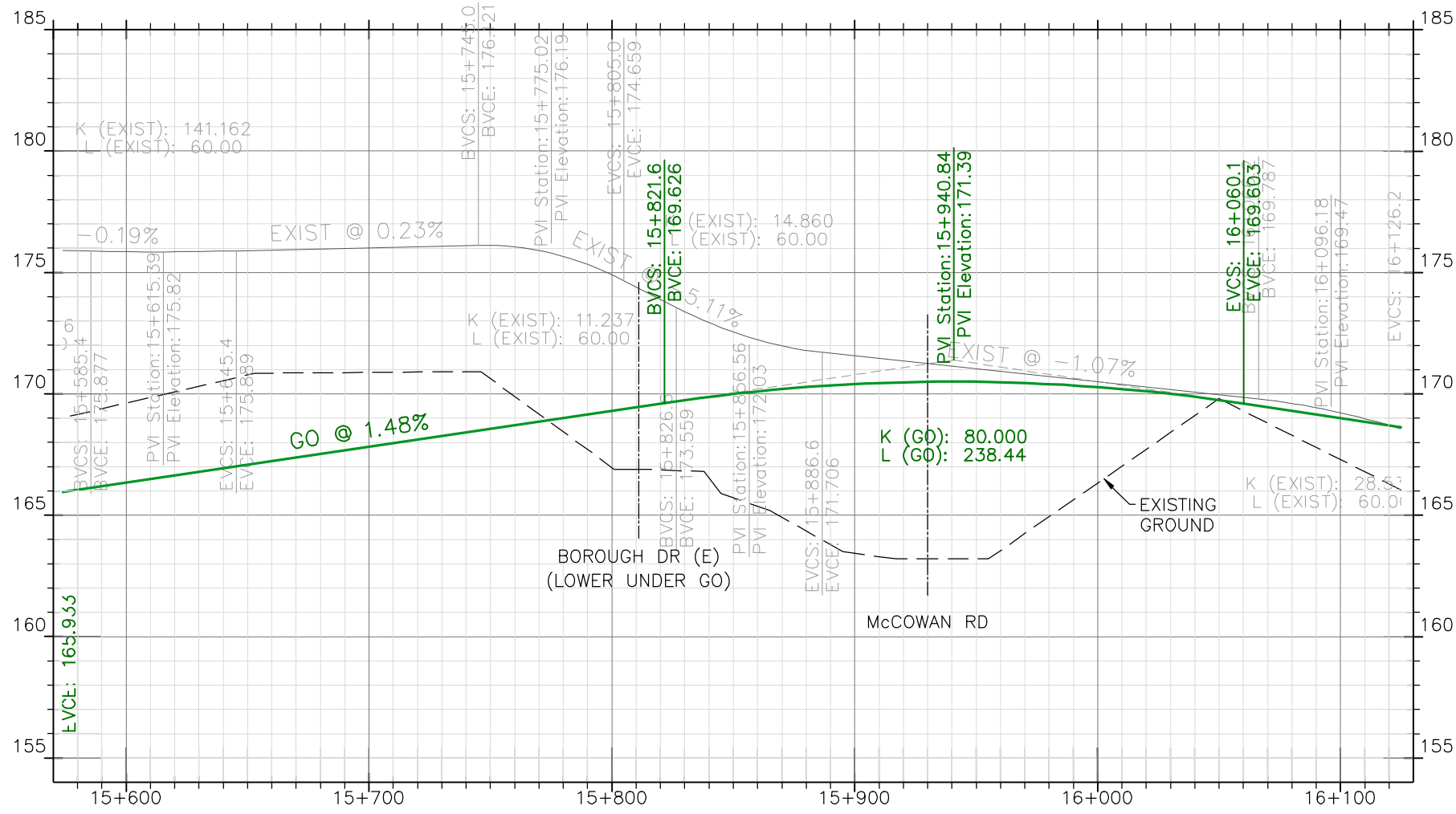
CONCEPTUAL

GO Scarborough Subdivision Vertical Alignment			**VA-2**
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Brimley Rd Crossing	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



CONCEPTUAL

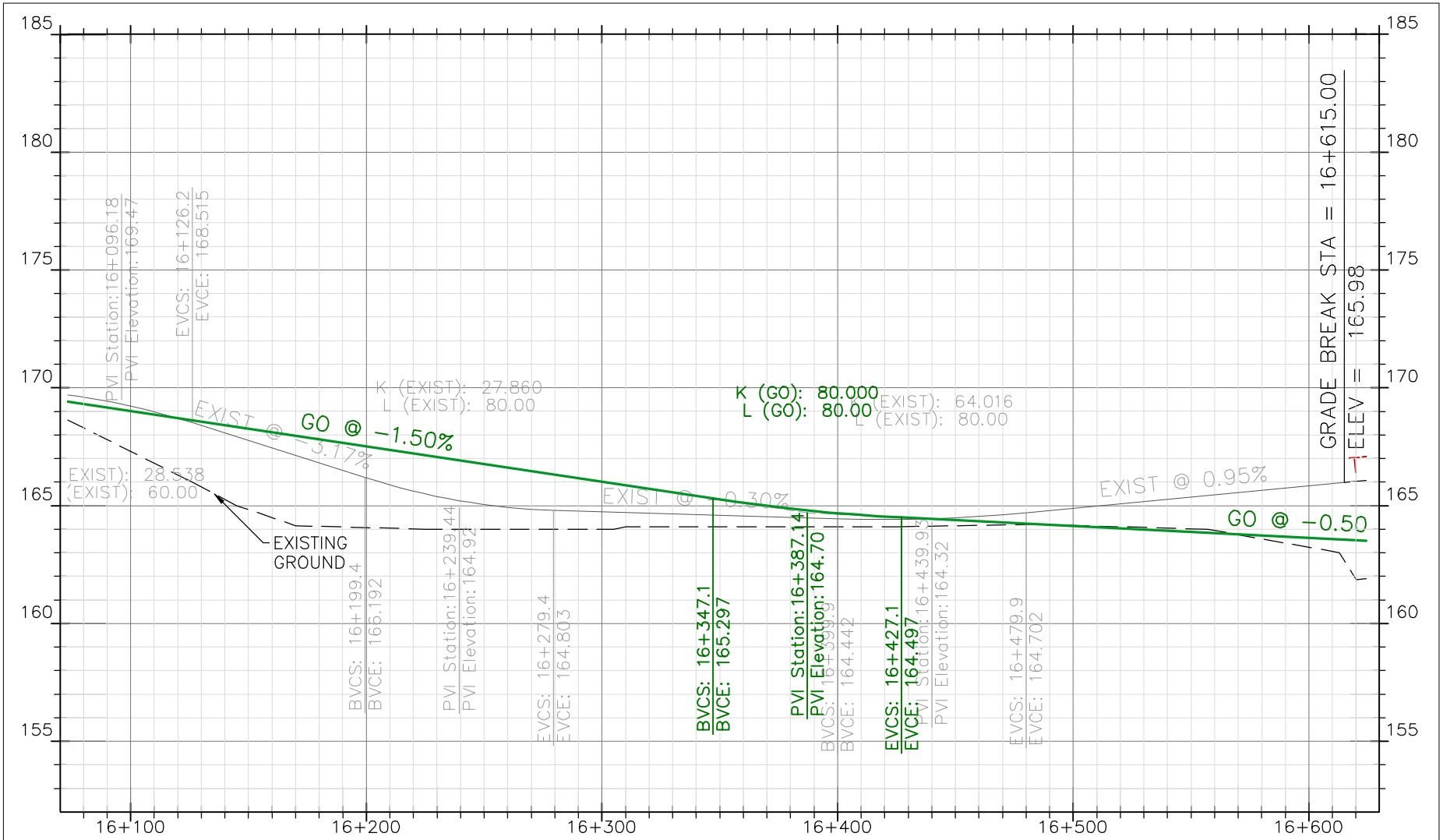
GO Scarborough Subdivision Vertical Alignment			
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	VA-3
Scarborough Centre Station	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶		



CONCEPTUAL

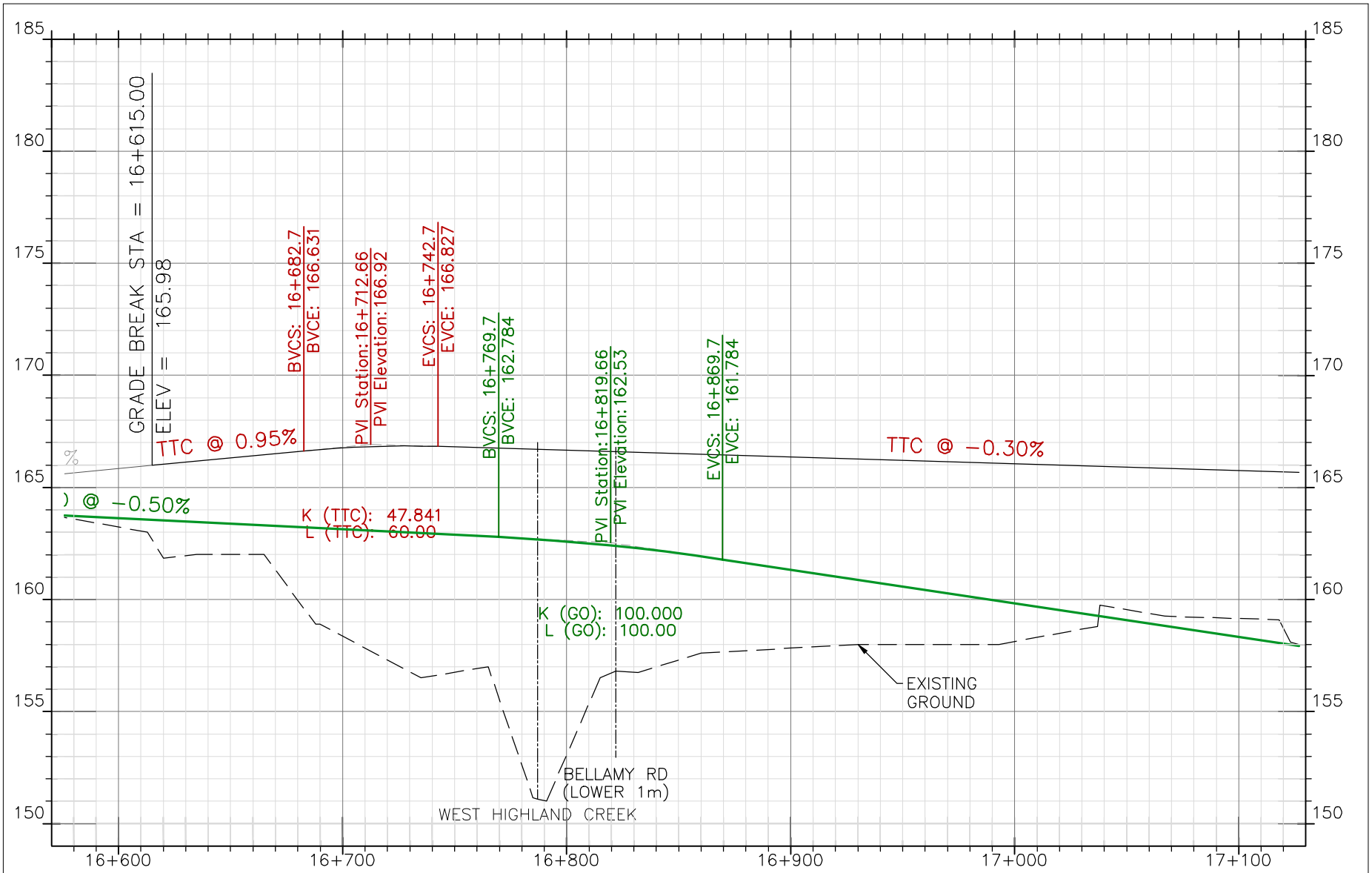
GO Scarborough Subdivision Vertical Alignment		
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500
McCowan Rd Crossing	Drawn by: Karl Junkin	VScale = 1:250
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶	

VA-4



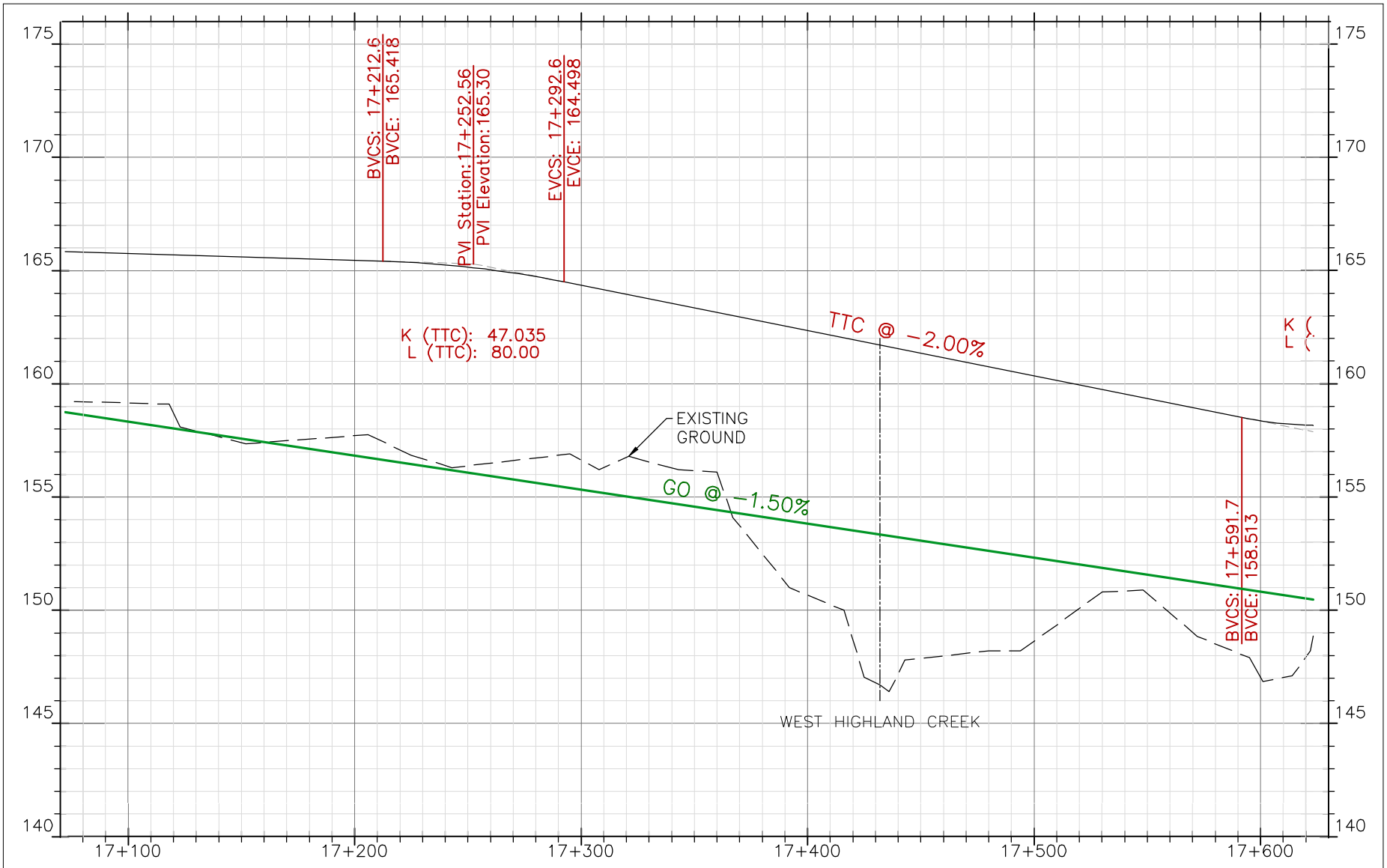
CONCEPTUAL

GO Scarborough Subdivision Vertical Alignment			VA-5
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Existing TTC McCowan Yard Area	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



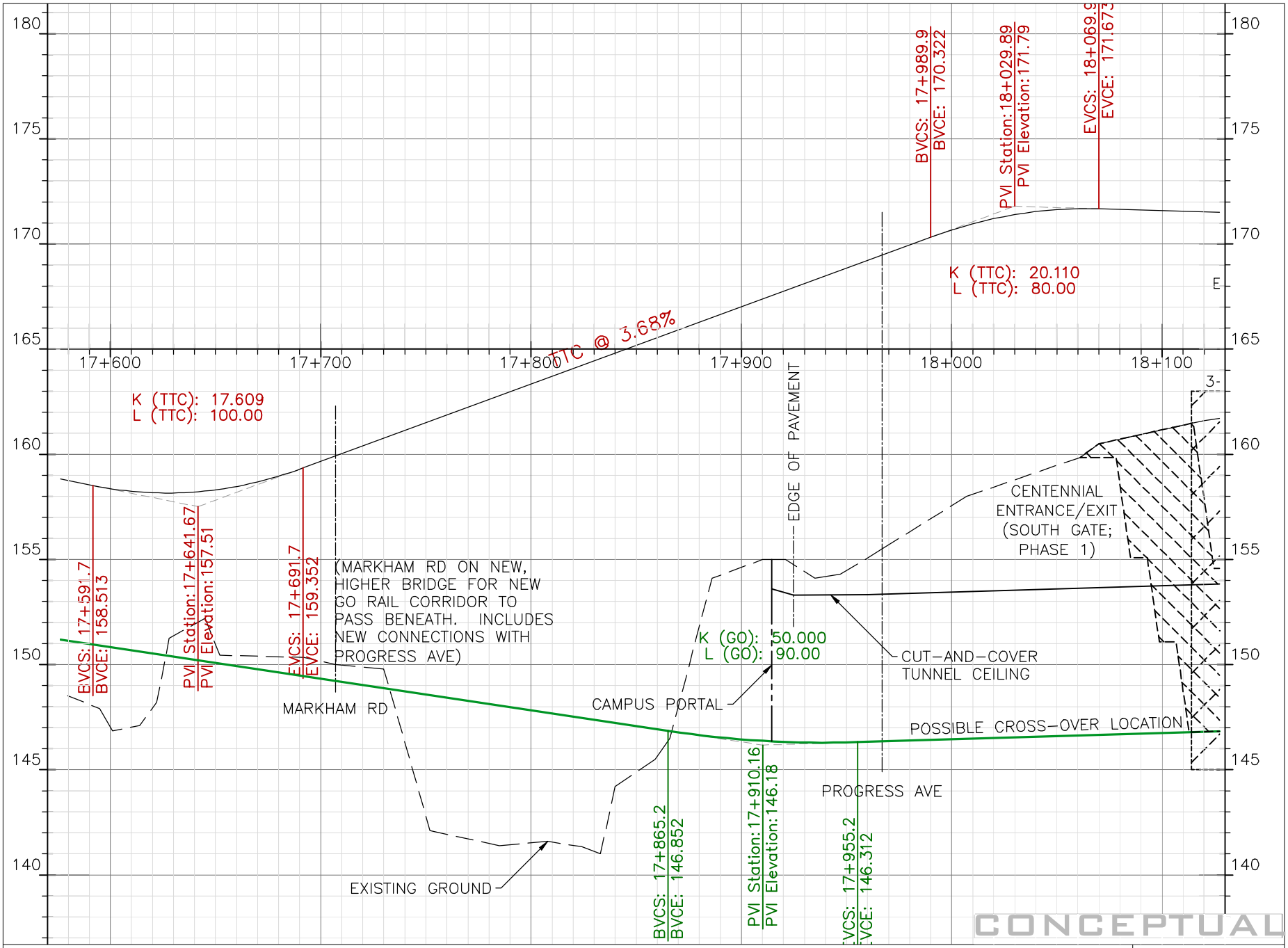
CONCEPTUAL

GO Scarborough Subdivision Vertical Alignment			VA-6
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Bellamy Rd Crossing	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



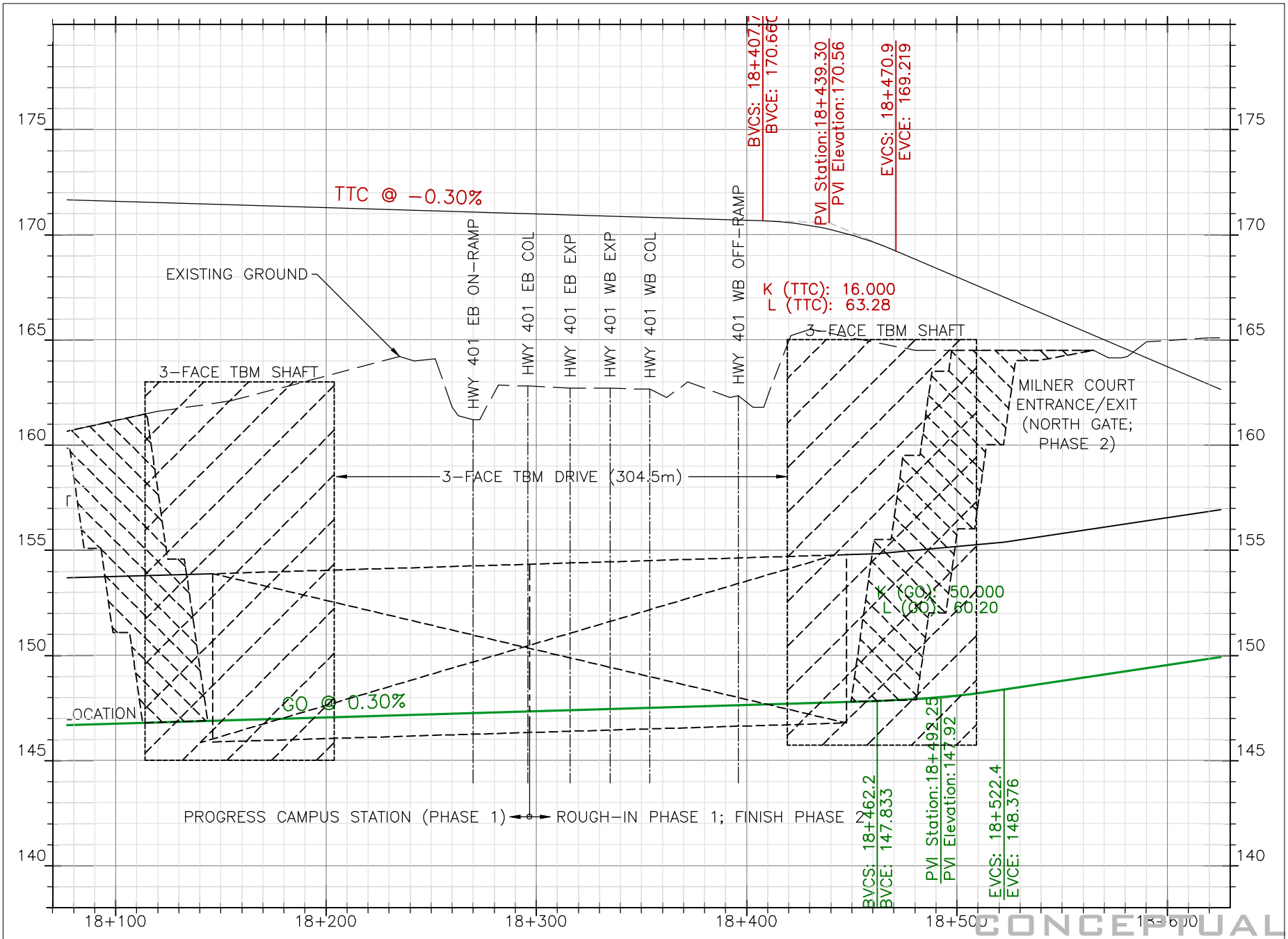
CONCEPTUAL

GO Scarborough Subdivision Vertical Alignment			VA-7
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Third West Highland Creek Crossing	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



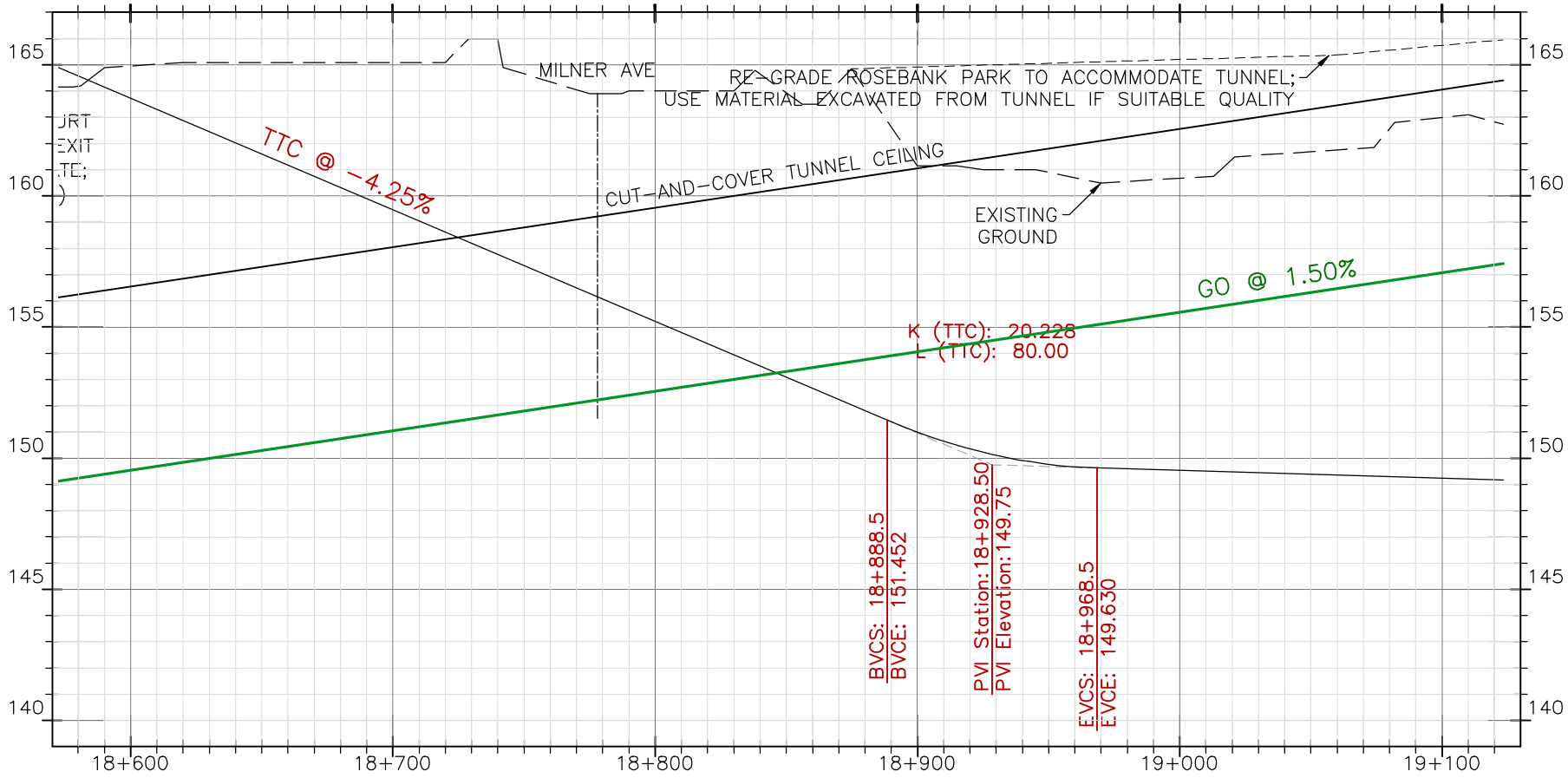
GO Scarborough Subdivision Vertical Alignment		
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500
Markham Rd Crossing	Drawn by: Karl Junkin	VScale = 1:250
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶	

VA-8



CONCEPTUAL

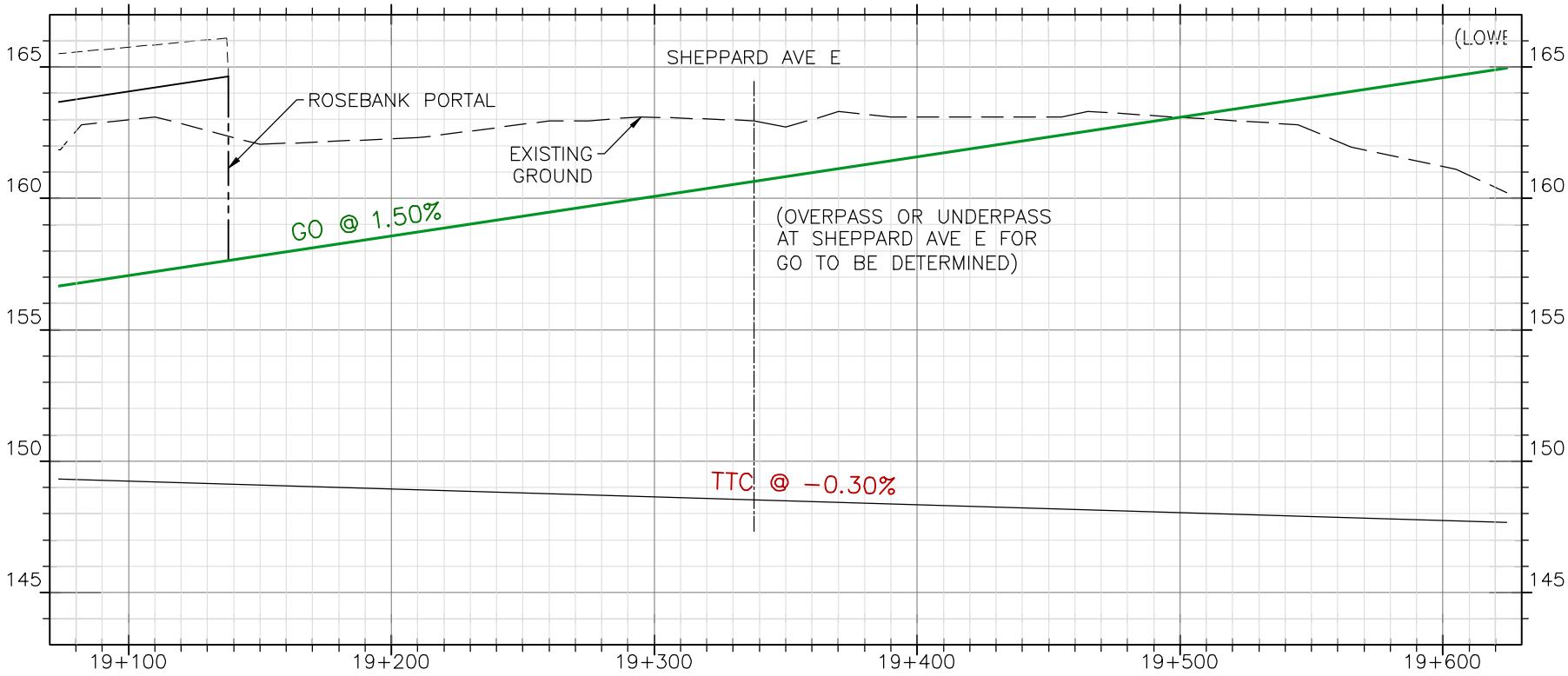
GO Scarborough Subdivision Vertical Alignment			**VA-9**
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Progress Campus Station	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



CONCEPTUAL

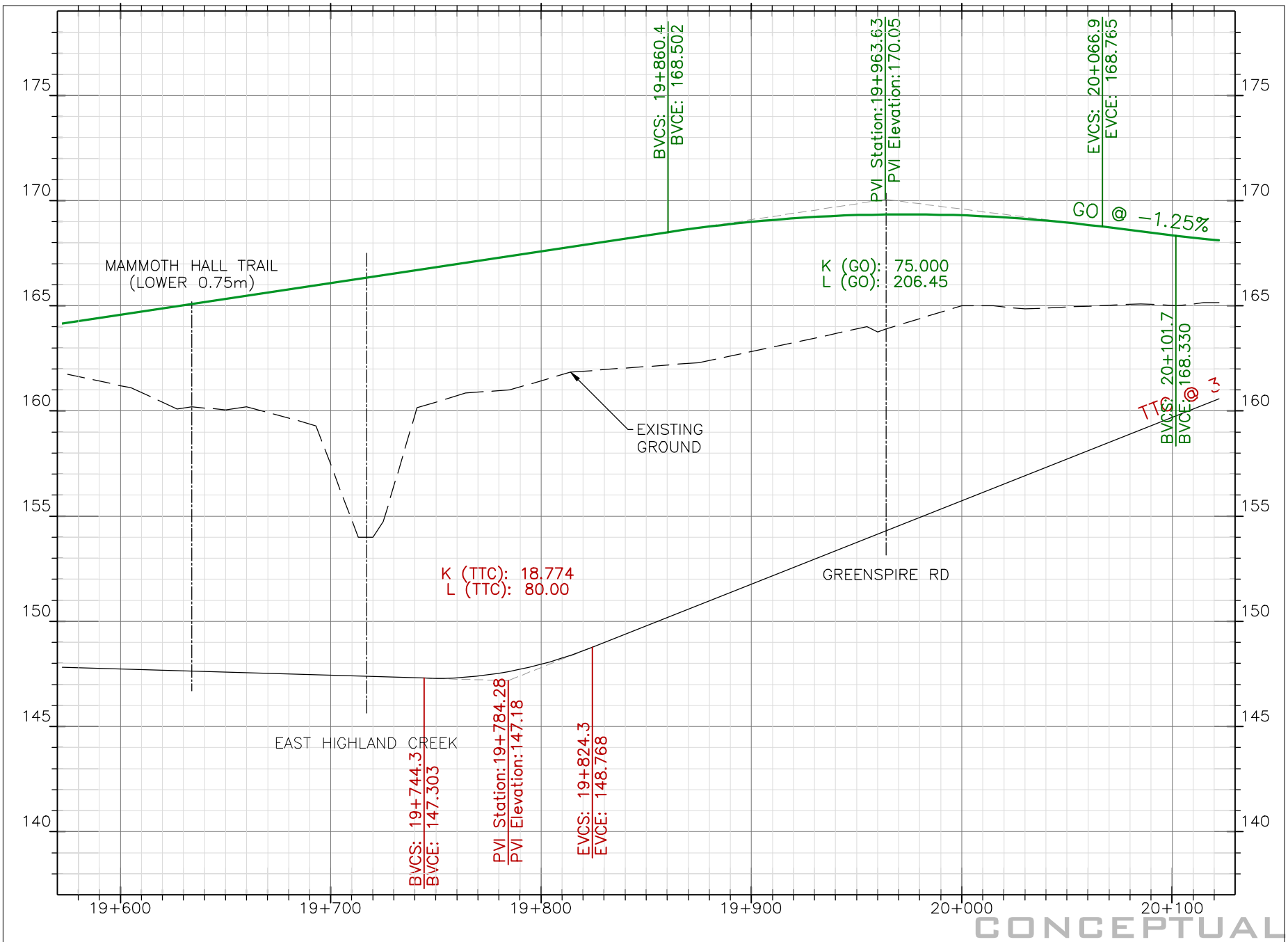
GO Scarborough Subdivision Vertical Alignment		
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500
Milner Ave Crossing	Drawn by: Karl Junkin	VScale = 1:250
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶	

VA-10



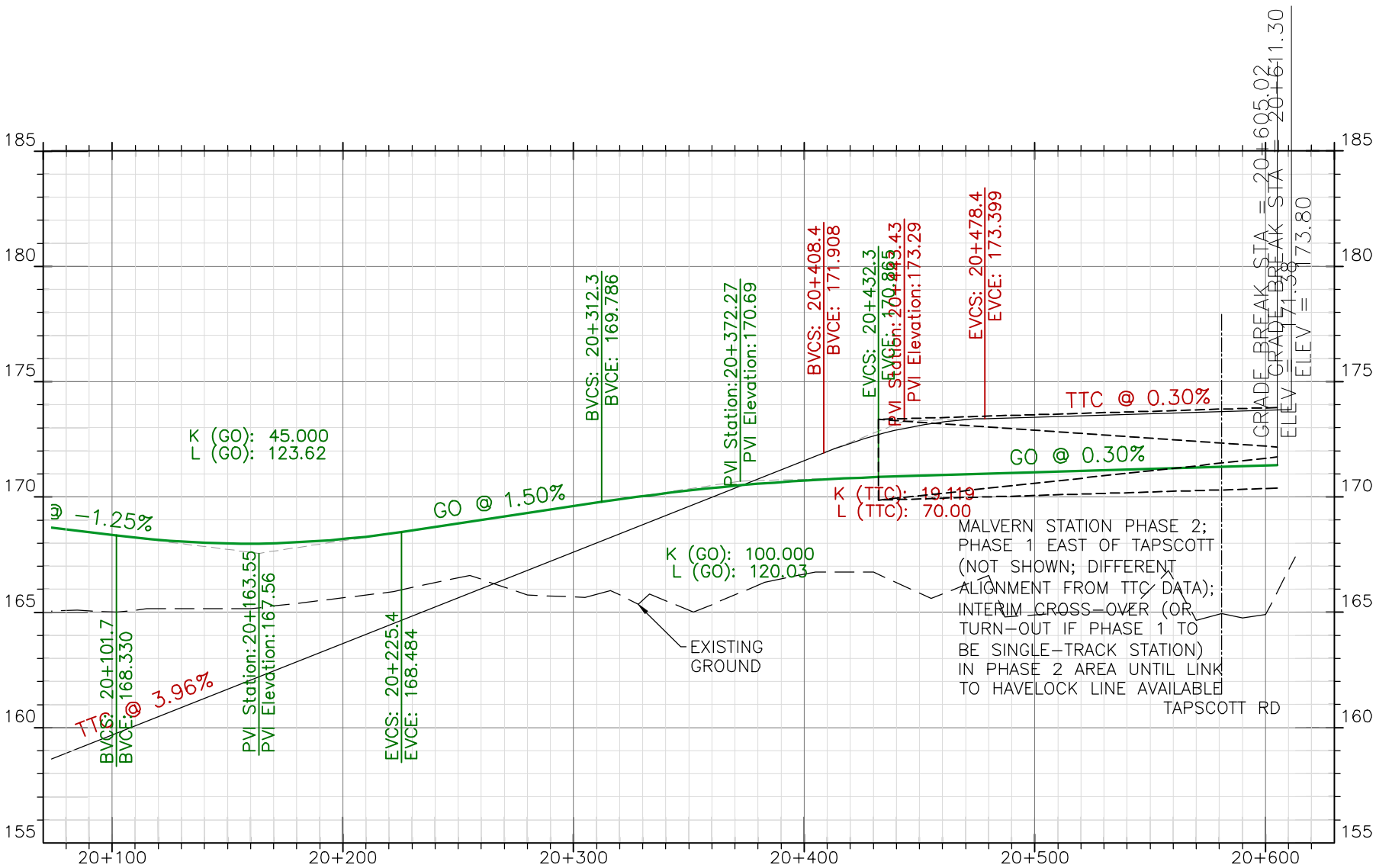
CONCEPTUAL

GO SCARBOROUGH SUBDIVISION VERTICAL ALIGNMENT			VA-11
DATA COMPILED FROM: SRT ENVIRONMENTAL ASSESSMENT DATA	DATE: SEPT. 29, 2012	HSCALE = 1:2500	
SHEPPARD AVE E CROSSING	DRAWN BY: KARL JUNKIN	VSCALE = 1:250	
◀WEST TO UXBRIDGE SUBDIVISION [STOUFFVILLE GO CORRIDOR]		EAST TO MALVERN [TAPSCOTT RD]▶	



CONCEPTUAL

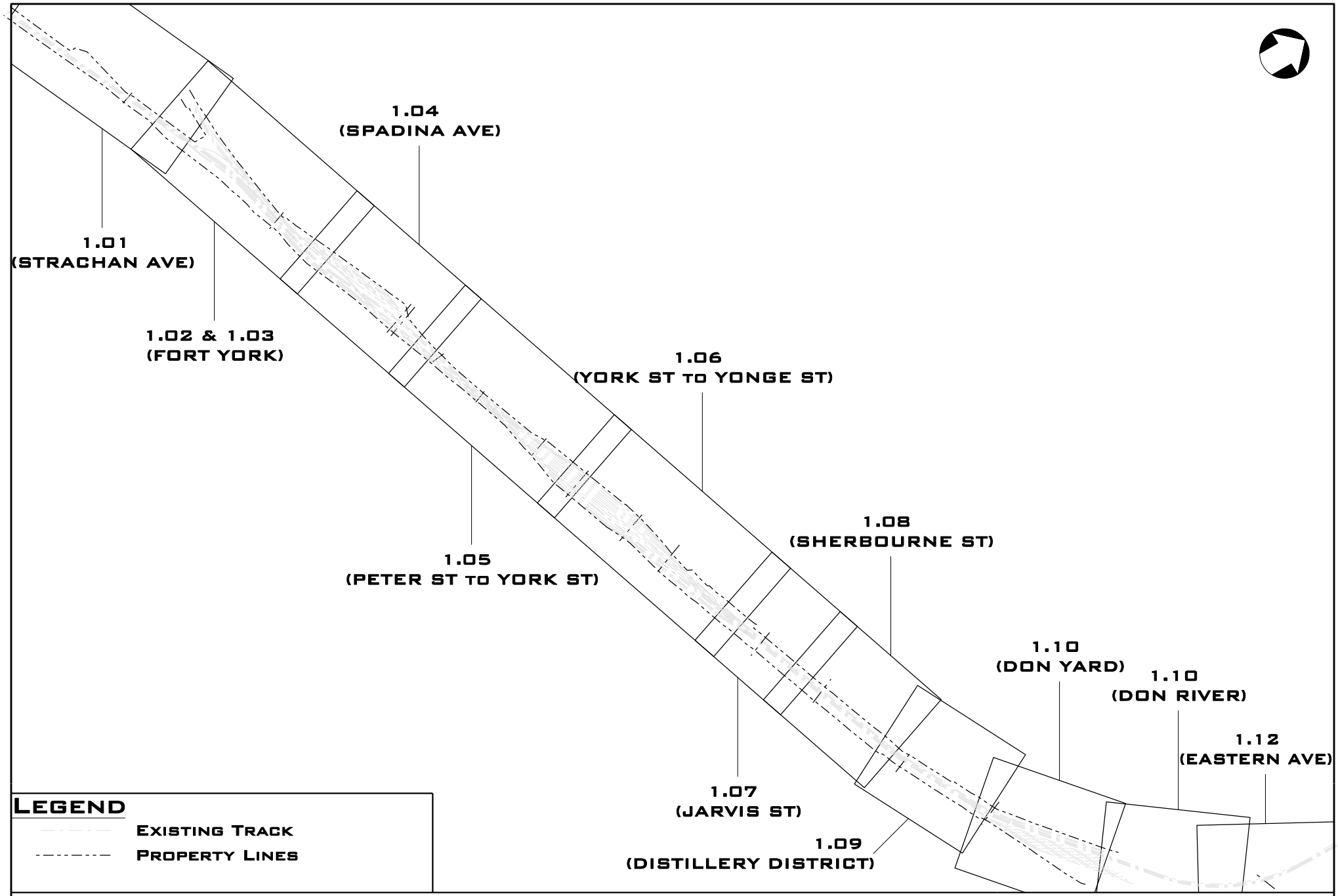
GO Scarborough Subdivision Vertical Alignment			**VA-12**
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500	
Greenspire Rd Crossing	Drawn by: Karl Junkin	VScale = 1:250	
◀West to Uxbridge Subdvision [Stouffville GO Corridor]		East to Malvern [Tapscott Rd]▶	



CONCEPTUAL

GO Scarborough Subdivision Vertical Alignment		**VA-13**
Data Compiled from: SRT Environmental Assessment Data	Date: Sept. 29, 2012	HScale = 1:2500
Tapscott Rd Crossing [Malvern Station Phase 2]	Drawn by: Karl Junkin	VScale = 1:250
◀West to Uxbridge Subdvision [Stouffville GO Corridor]	East to Malvern [Tapscott Rd]▶	

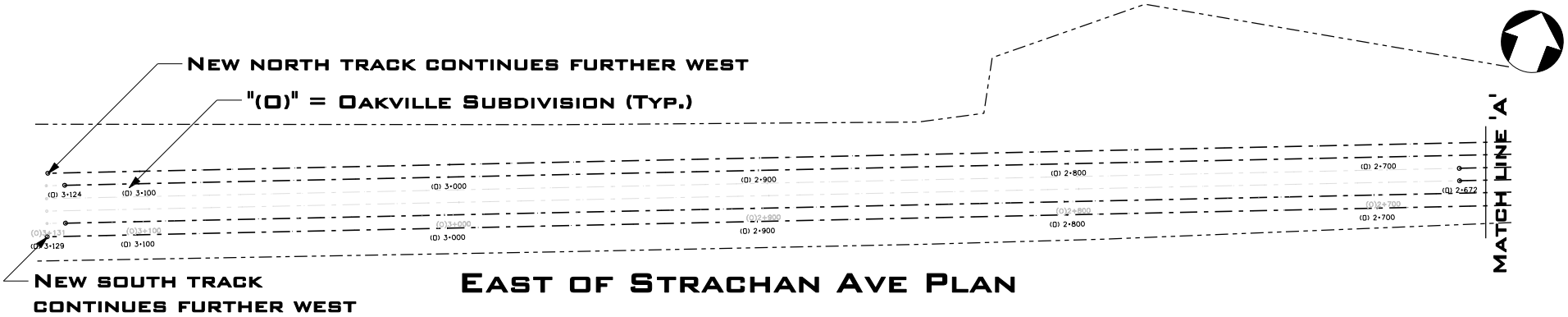
Union Station Rail Corridor Expansion - Underground Level



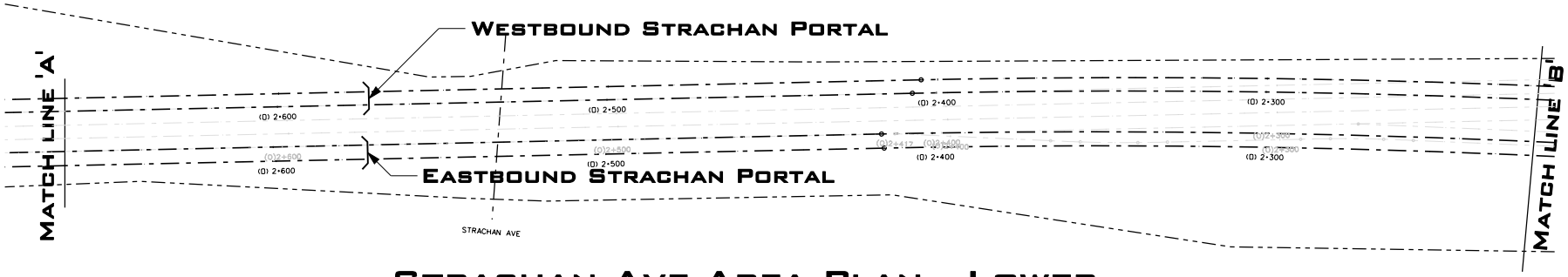
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:20000	0.01
Union Station Rail Corridor Key Plan	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	

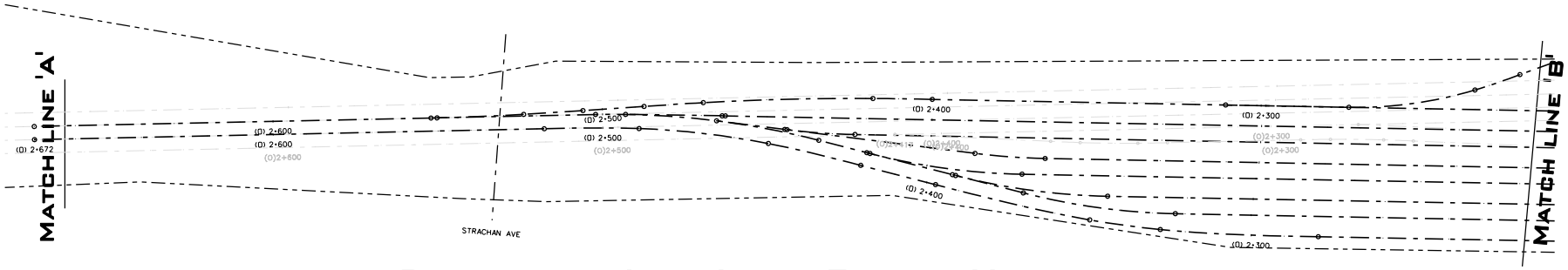
[Academic use only]



East of Strachan Ave Plan



Strachan Ave Area Plan - Lower



Strachan Ave Area Plan - Upper

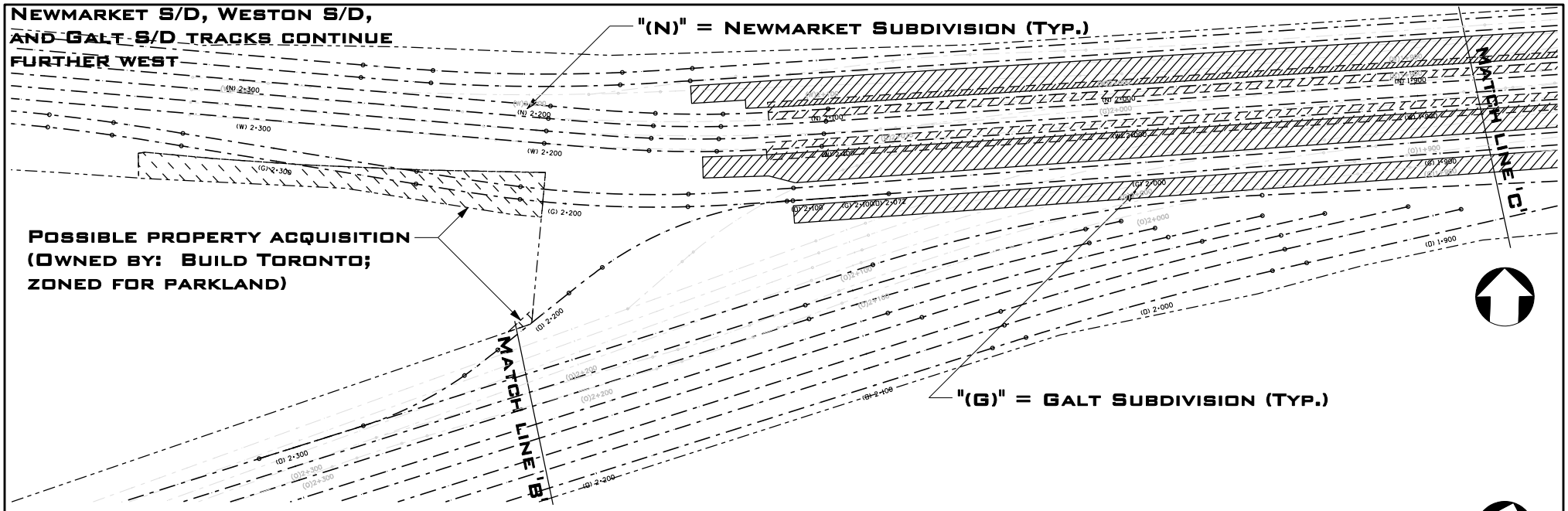
Legend

- Existing Track
- Property Lines
- New Track

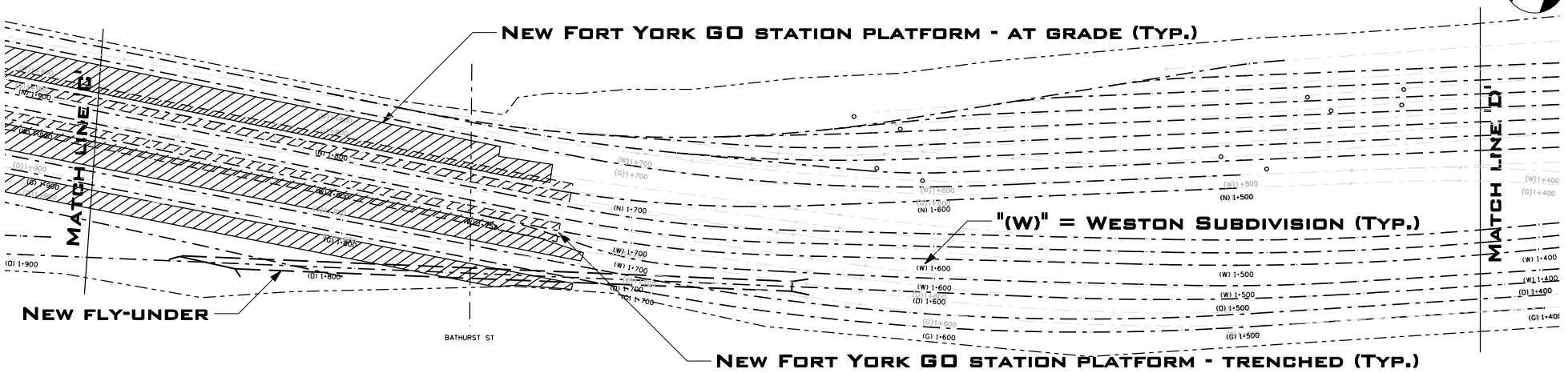
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	**1.01**
Strachan Ave Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Fort York Area Plan (West) - Upper



Fort York Area Plan (East) - Upper

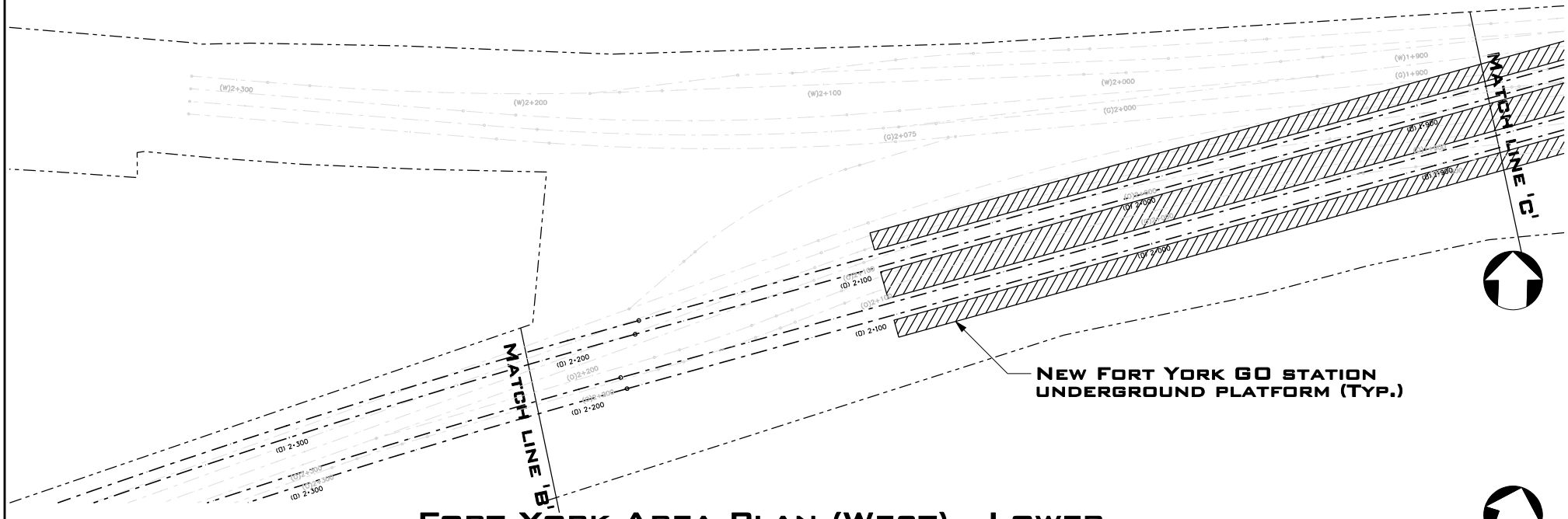
Legend

- Existing Track
- Property Lines
- New Track (Incl. Trenched)

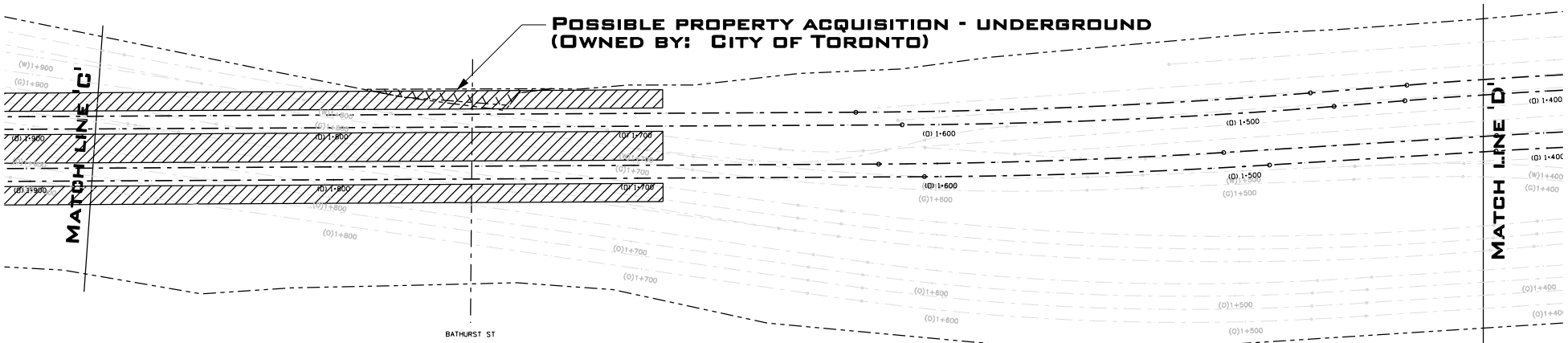
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	**1.02**
Fort York Area Plans - Surface Level (Plus Trenched Tracks)	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Fort York Area Plan (West) - Lower



Fort York Area Plan (East) - Lower

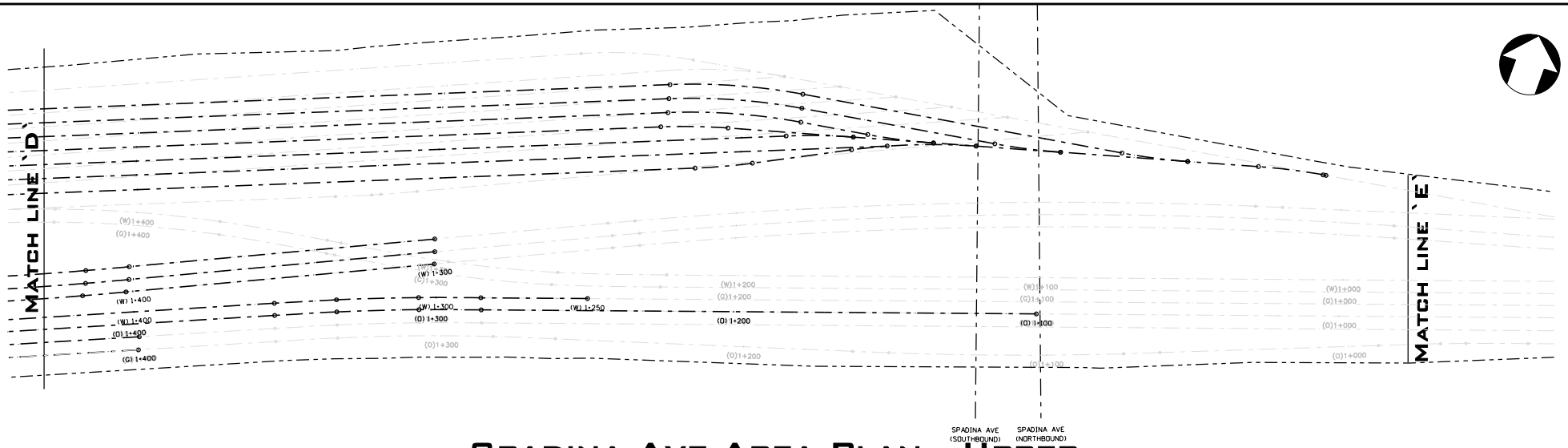
Legend

- Existing Track
- Property Lines
- New Track - Underground

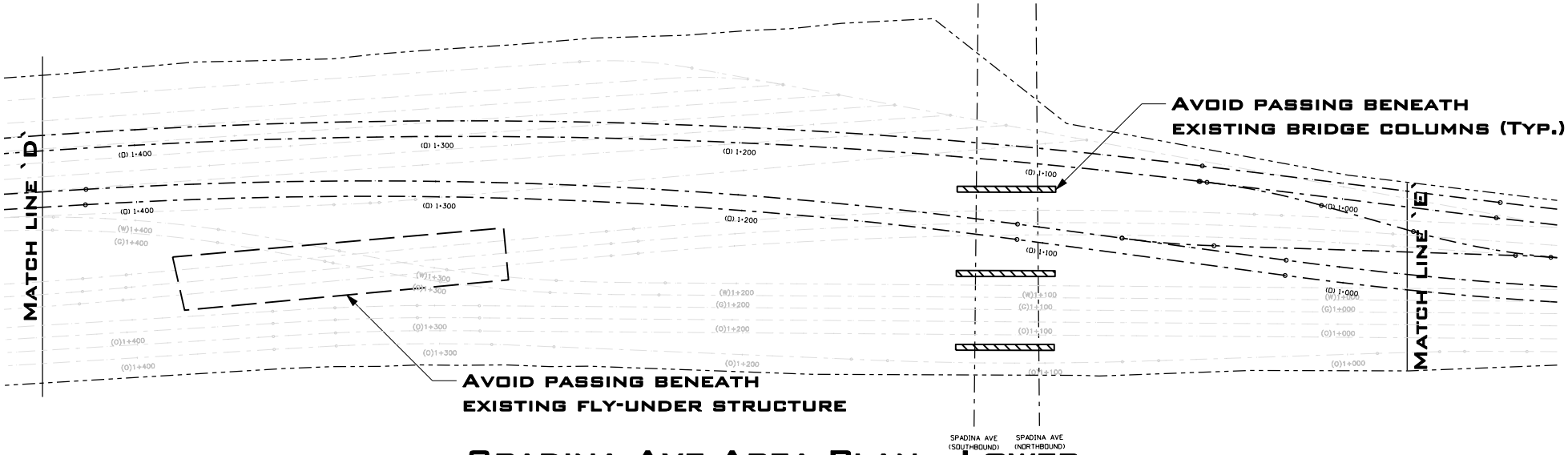
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	1.03
Fort York Area Plans - Underground Level	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Spadina Ave Area Plan - Upper



Spadina Ave Area Plan - Lower

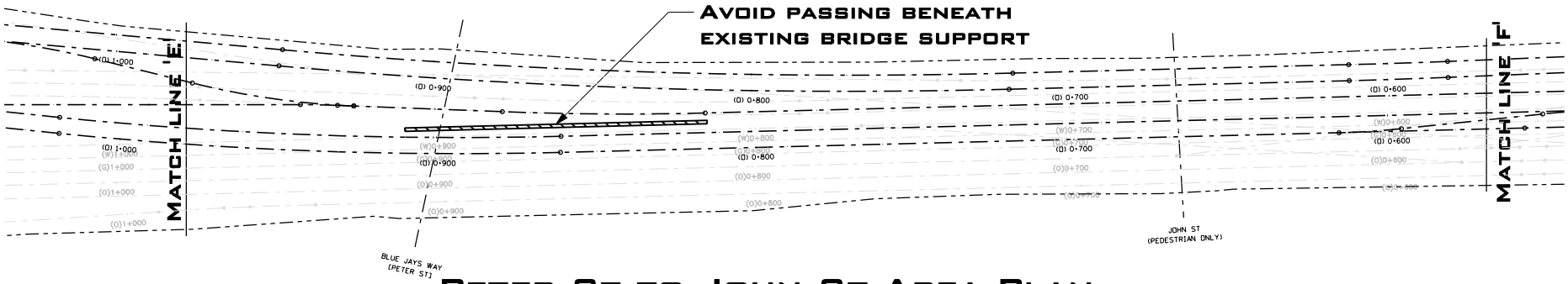
Legend

- Existing Track
- Property Lines
- New Track

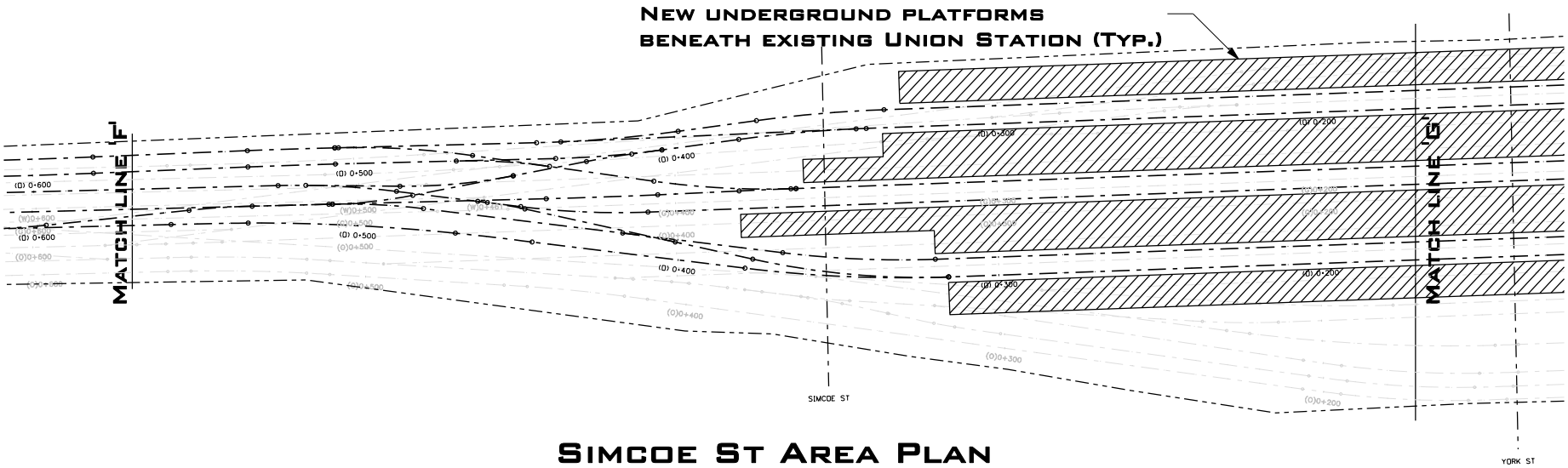
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	1.04
Spadina Ave Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



PETER ST TO JOHN ST AREA PLAN



SIMCOE ST AREA PLAN

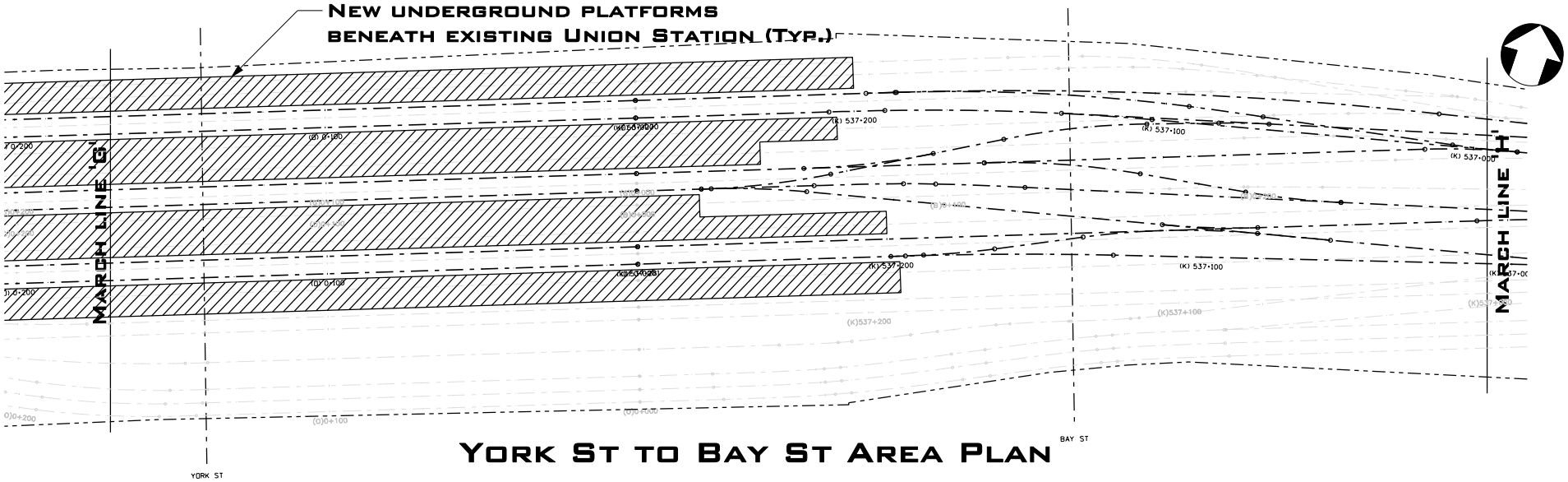
LEGEND

- Existing Track
- Property Lines
- New Underground Track

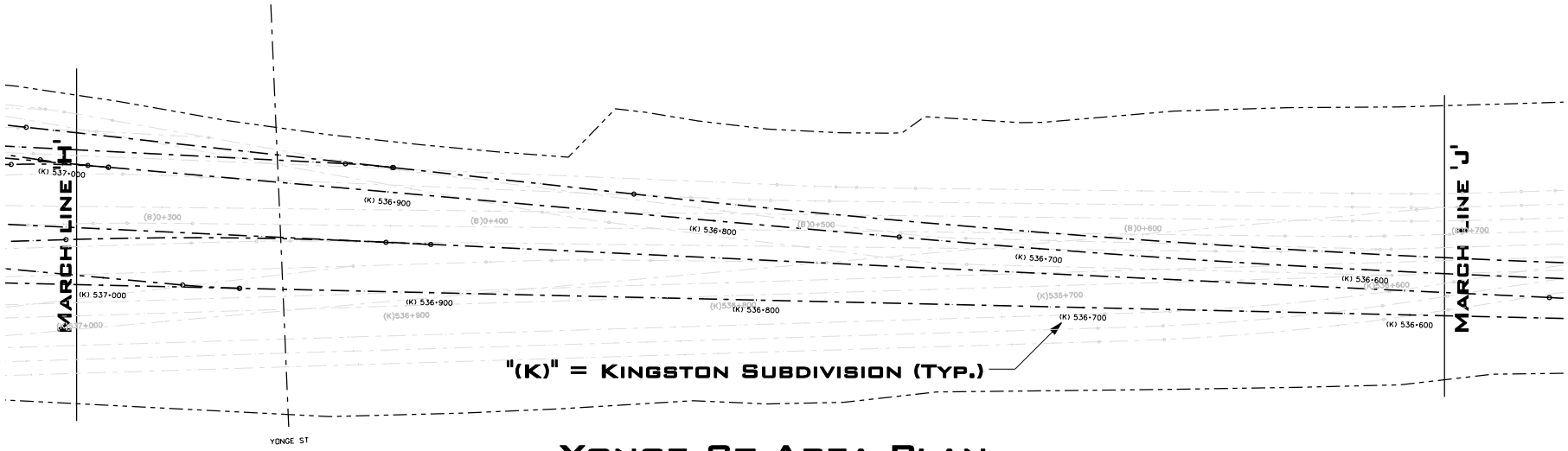
CONCEPTUAL - NOT FOR CONSTRUCTION; EXISTING FEATURES ARE APPROXIMATE AND REQUIRE CONFIRMATION BY A QUALIFIED SURVEYOR

PROJECT: UNION STATION RAIL CORRIDOR 2031	DATE: 10/07/2012 SCALE: 1:2000	1.05
PETER ST TO YORK ST AREA PLANS	DRAWN BY: KARL JUNKIN	
BASE DATA INTERPRETED FROM CITY OF TORONTO MAPS, DAFT LOGIC	DRAWN FOR: TRANSPORT ACTION ONTARIO	1.01-1.12

[Academic use only]



York St to Bay St Area Plan



Yonge St Area Plan

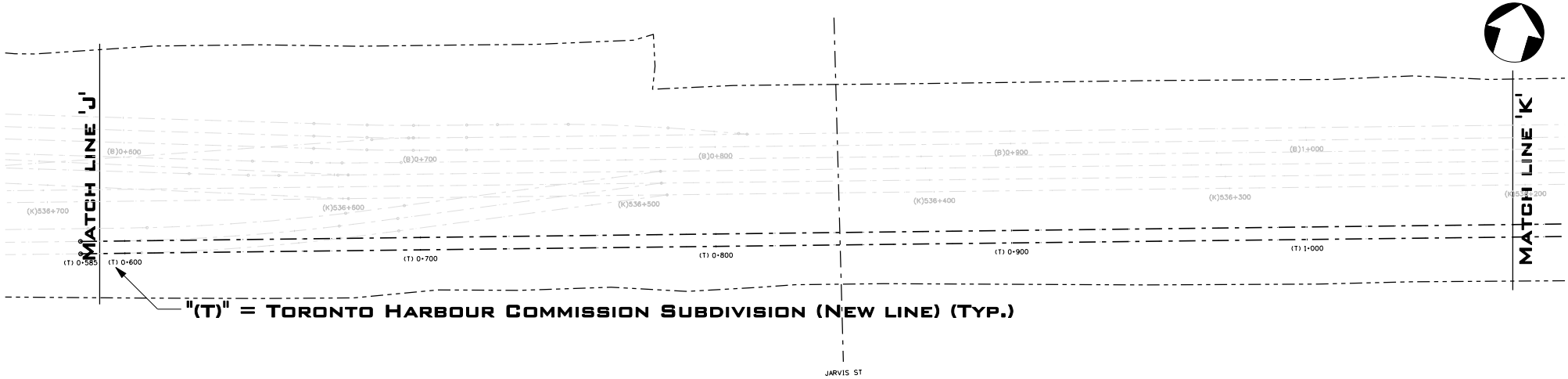
Legend

- Existing Track
- Property Lines
- New Underground Track

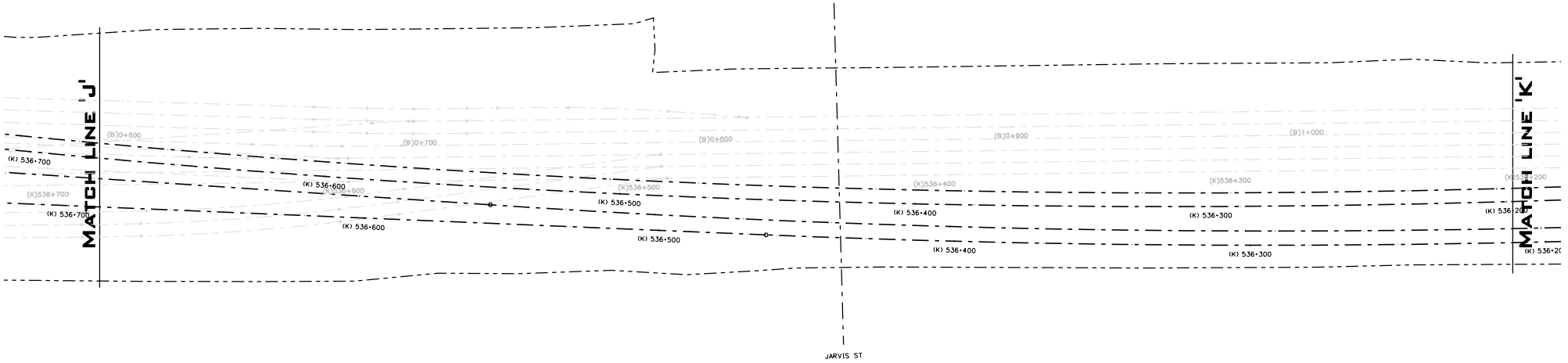
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	1.06
York St to Yonge St Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Jarvis St Area Plan - Upper



Jarvis St Area Plan - Lower

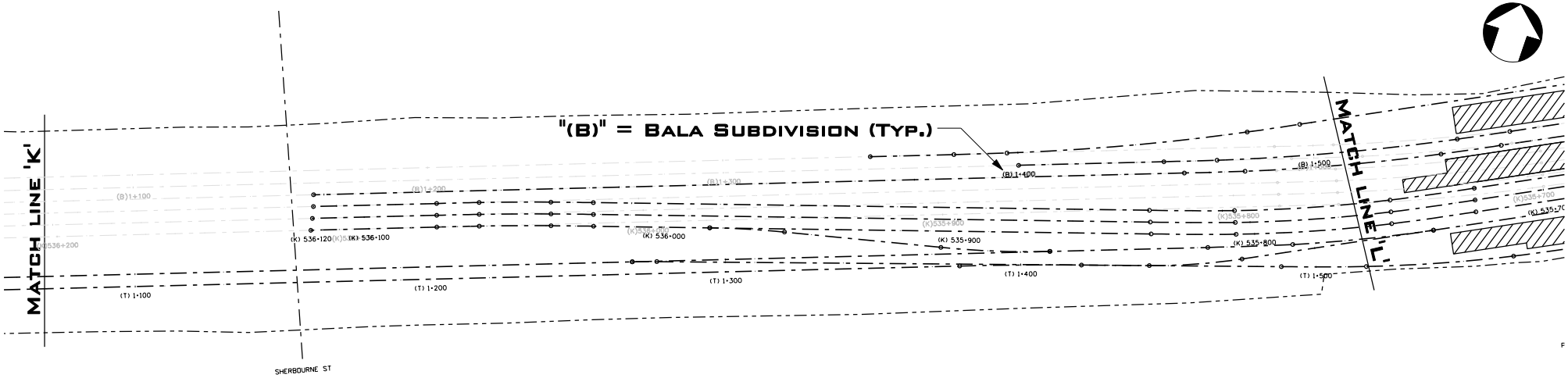
Legend

- Existing Track
- Property Lines
- New Track

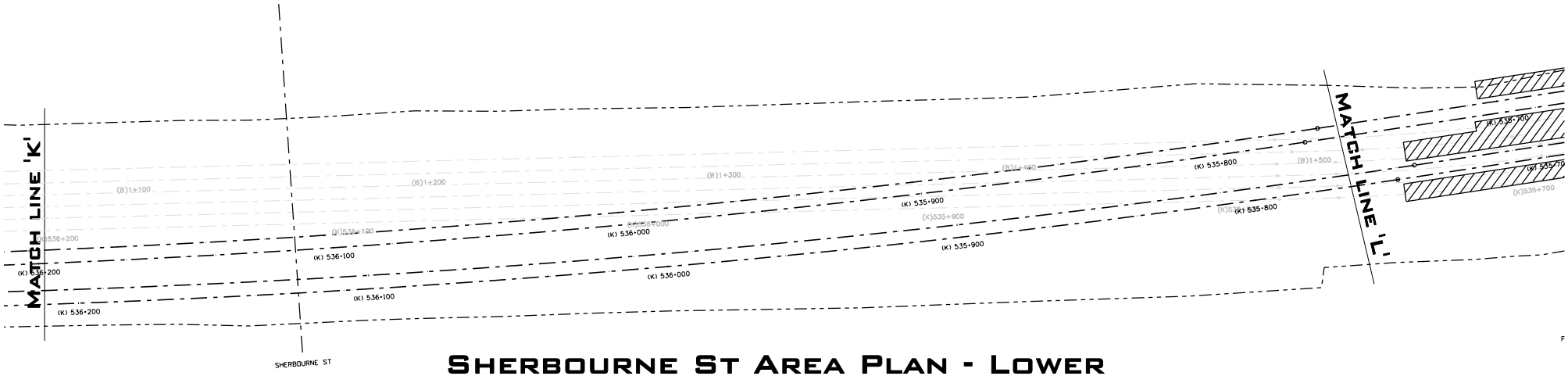
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	1.07
Jarvis St Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Sherbourne St Area Plan - Upper



Sherbourne St Area Plan - Lower

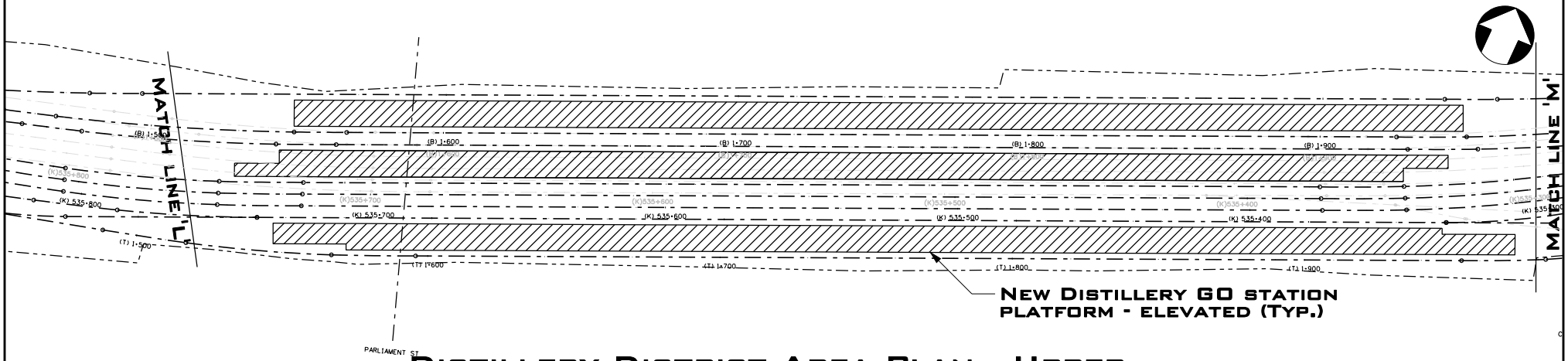
Legend

- Existing Track
- Property Lines
- New Track

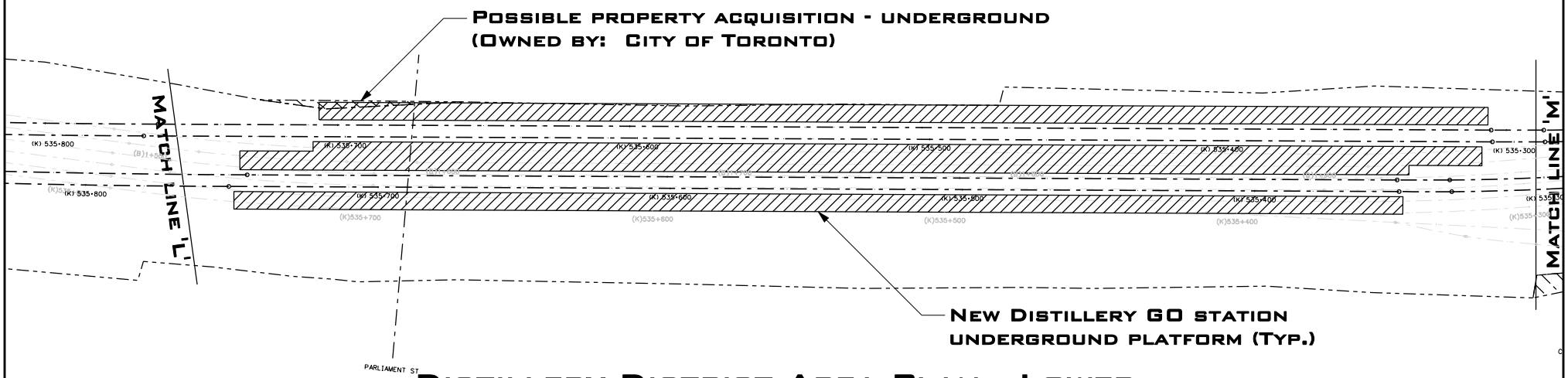
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	**1.08**
Sherbourne St Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



DISTILLERY DISTRICT AREA PLAN - UPPER



DISTILLERY DISTRICT AREA PLAN - LOWER

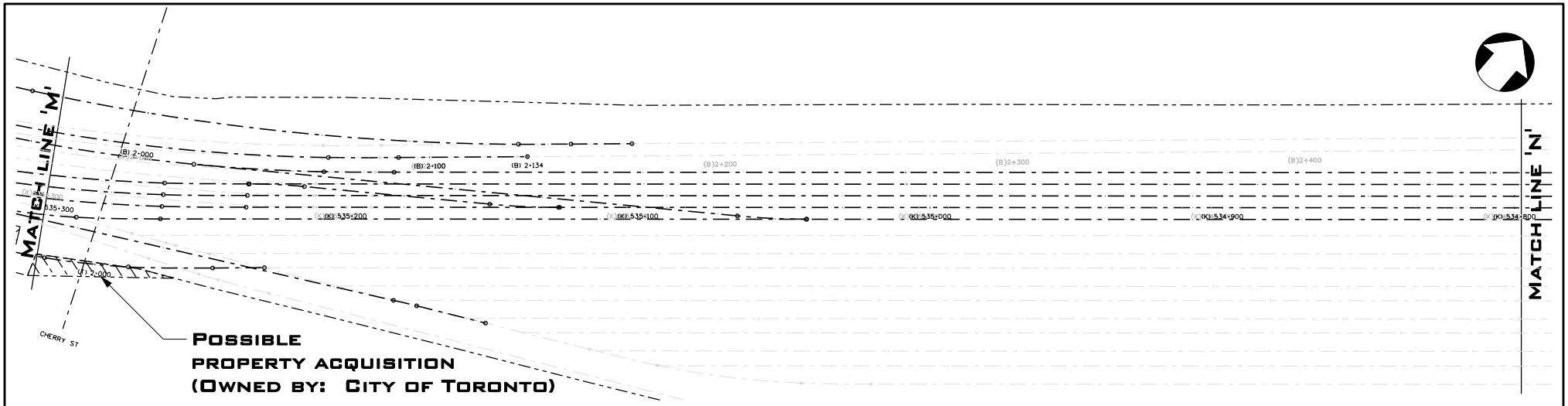
LEGEND

- Existing Track
- Property Lines
- New Track

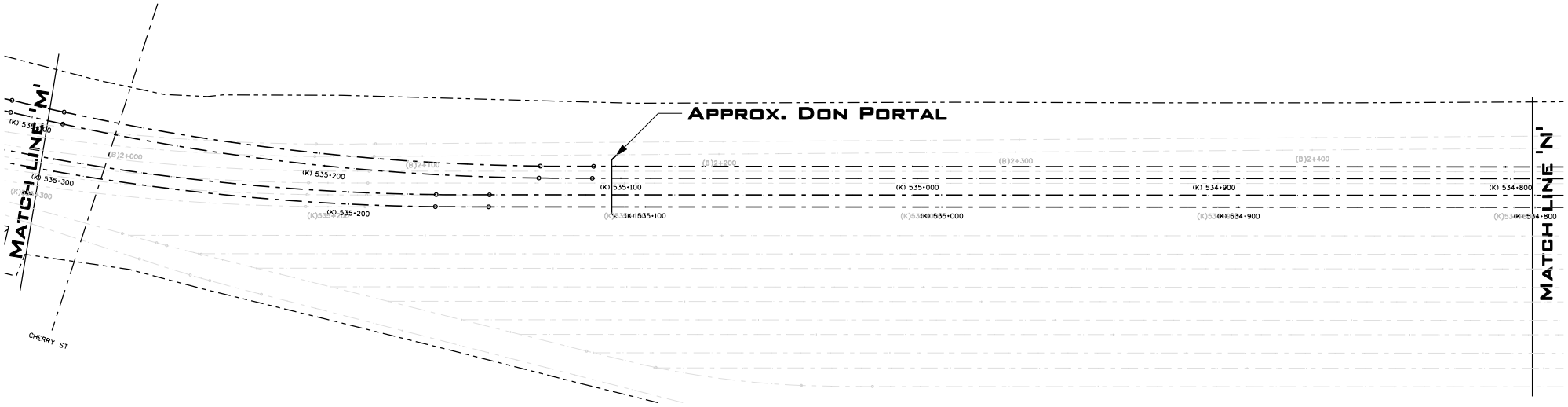
CONCEPTUAL - NOT FOR CONSTRUCTION; EXISTING FEATURES ARE APPROXIMATE AND REQUIRE CONFIRMATION BY A QUALIFIED SURVEYOR

PROJECT: UNION STATION RAIL CORRIDOR 2031	DATE: 10/07/2012 SCALE: 1:2000	1.09
DISTILLERY DISTRICT AREA PLANS	DRAWN BY: KARL JUNKIN	
BASE DATA INTERPRETED FROM CITY OF TORONTO MAPS, DAFT LOGIC	DRAWN FOR: TRANSPORT ACTION ONTARIO	1.01-1.12

[Academic use only]



DON YARD AREA PLAN - UPPER



DON YARD AREA PLAN - LOWER

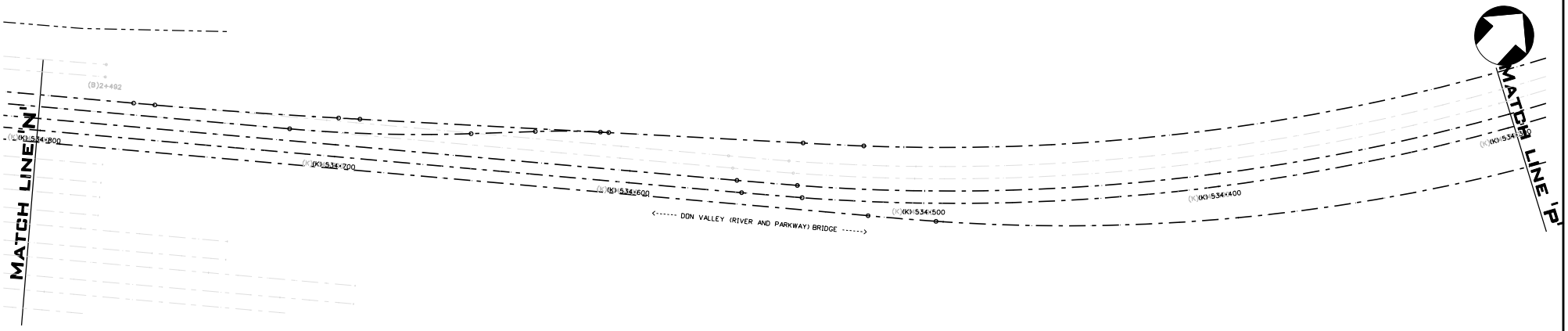
LEGEND

- Existing Track
- Property Lines
- New Track

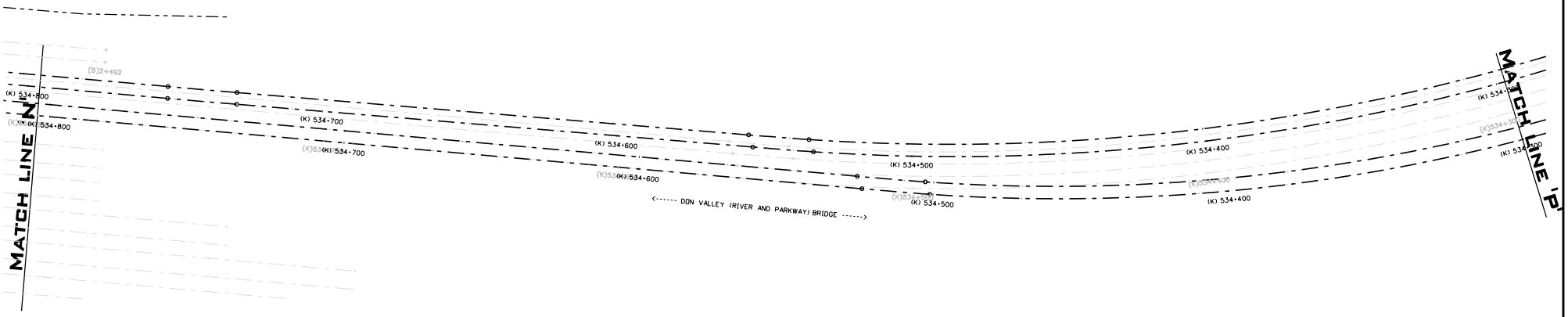
CONCEPTUAL - NOT FOR CONSTRUCTION; EXISTING FEATURES ARE APPROXIMATE AND REQUIRE CONFIRMATION BY A QUALIFIED SURVEYOR

PROJECT: UNION STATION RAIL CORRIDOR 2031	DATE: 10/07/2012 SCALE: 1:2000	1.10
DON YARD AREA PLANS	DRAWN BY: KARL JUNKIN	
BASE DATA INTERPRETED FROM CITY OF TORONTO MAPS, DAFT LOGIC	DRAWN FOR: TRANSPORT ACTION ONTARIO	1.01-1.12

[Academic use only]



Don River Area Plan - Upper



Don River Area Plan - Lower

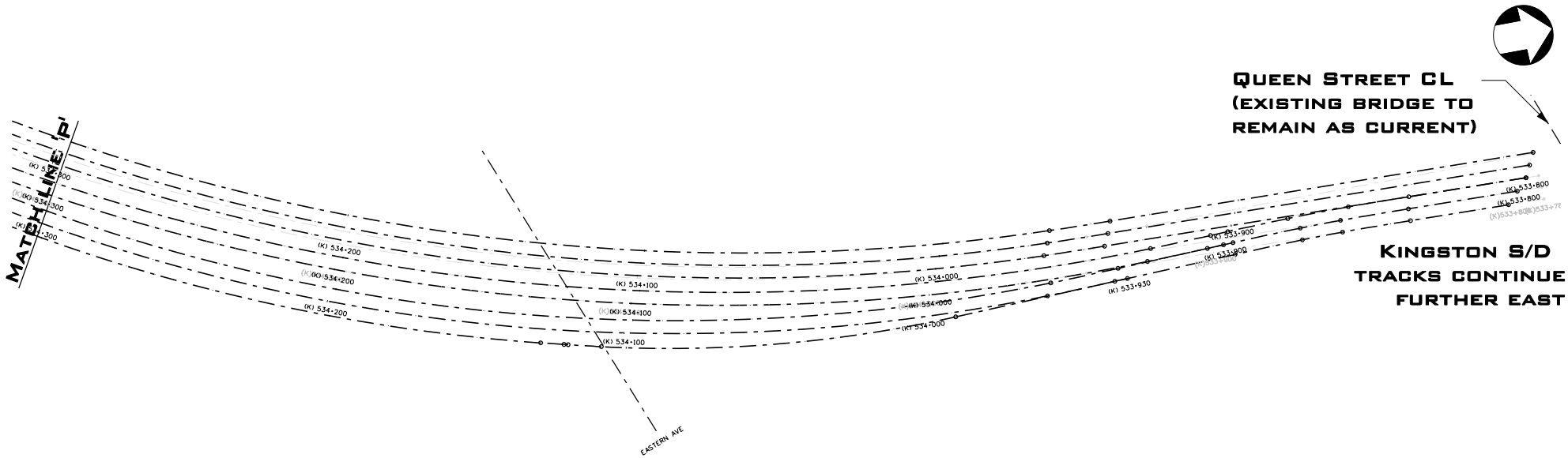
Legend

- Existing Track
- Property Lines
- New Track

Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	**1.11**
Don River Area Plans	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]



Eastern Ave Area Plan

Legend

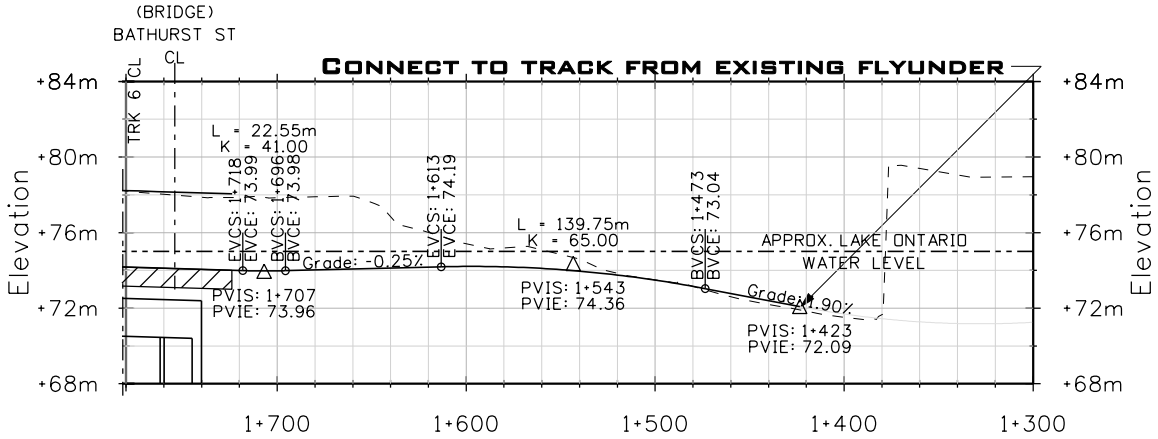
- Existing Track
- Property Lines
- New Track

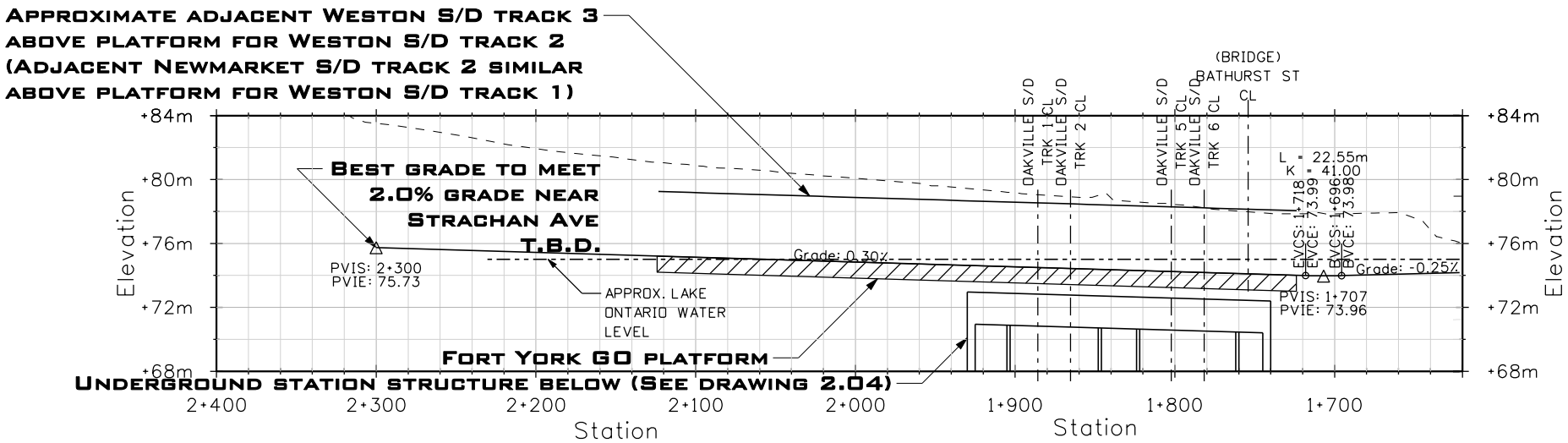
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 Scale: 1:2000	**1.12**
Eastern Ave Area Plan	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	1.01-1.12

[Academic use only]

Weston Subdivision Vertical Realignment - Track 2





Legend

- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

NOTES:

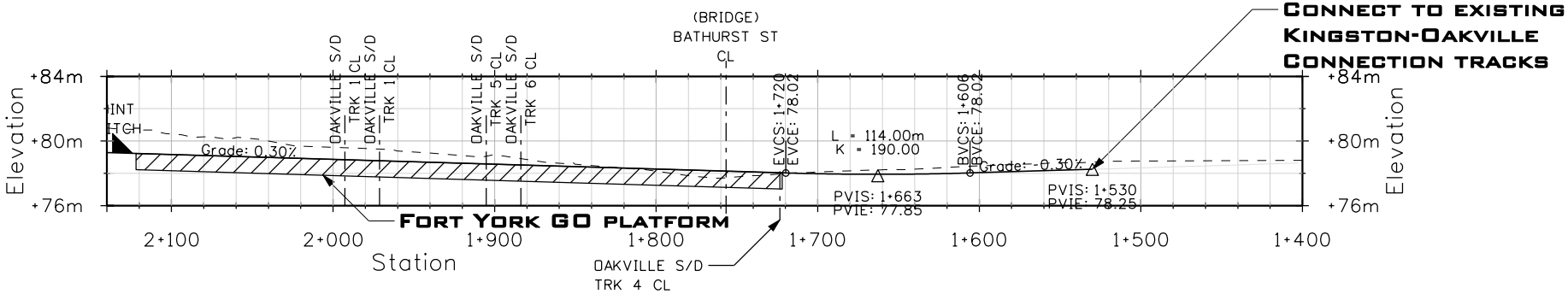
1. WESTON S/D TRACK 1 SIMILAR
2. EXISTING FLY-UNDER TRACKS ORIGINALLY PART OF OAKVILLE S/D

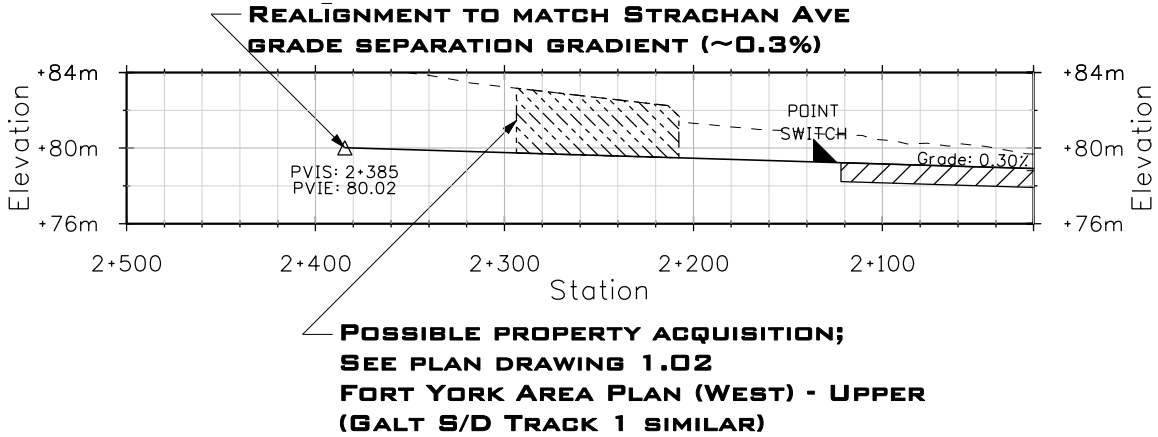
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	2.01
Weston Subdivision (Kitchener Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Galt Subdivision Vertical Realignment - Track 2





Legend

- - - - - - Approx. Exist. Ground Line
——— New Track
——— Approximate Existing Track

NOTES:

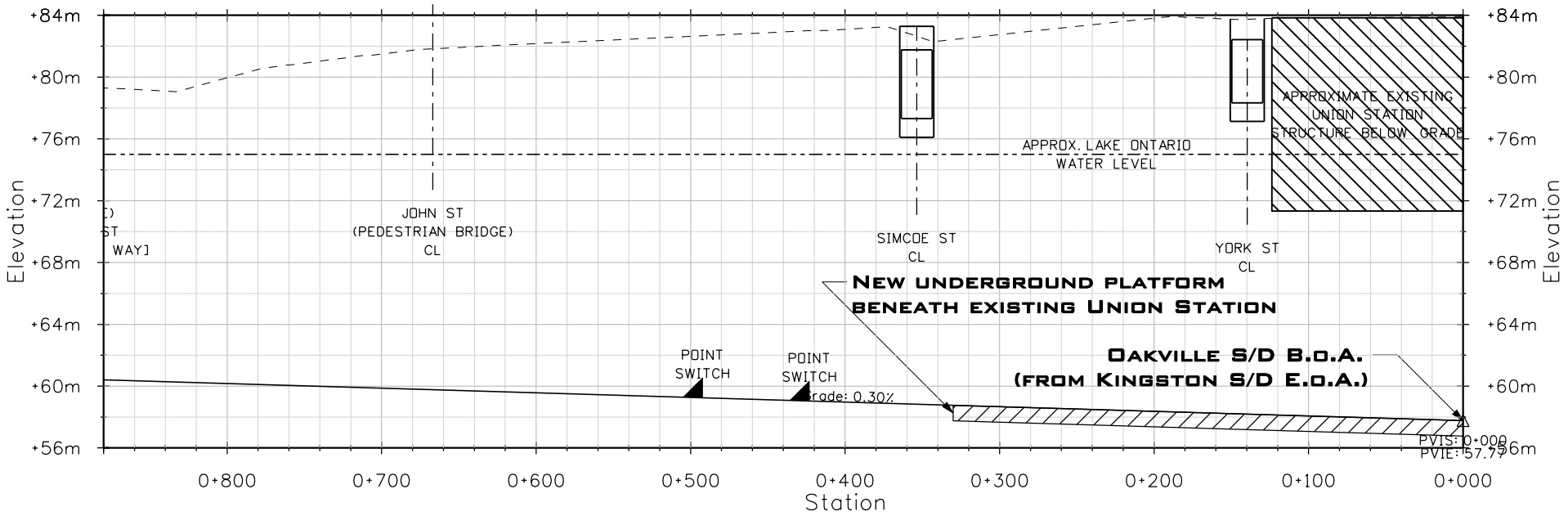
1. GALT S/D TRACK 1 SIMILAR
2. WESTON S/D TRACK 1 SIMILAR, BUT CONNECTS TO EXISTING FLY-UNDER
3. NEWMARKET S/D TRACKS 1 AND 2 SIMILAR, BUT PASS ABOVE EXISTING FLY-UNDER (ORIGINALLY WESTON S/D AND GALT S/D)

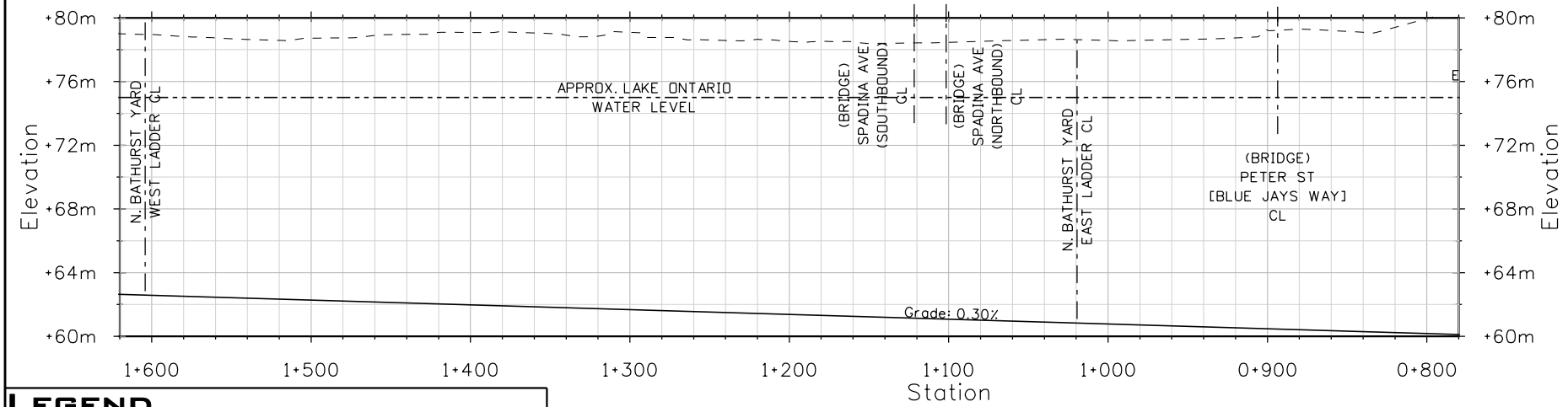
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.02**
Galt Subdivision (Milton Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Oakville Subdivision Vertical Realignmnet - Track 1 (Sheet 1 of 2)





Legend

- - - - - - Approx. Exist. Ground Line

——— New Track

NOTES:

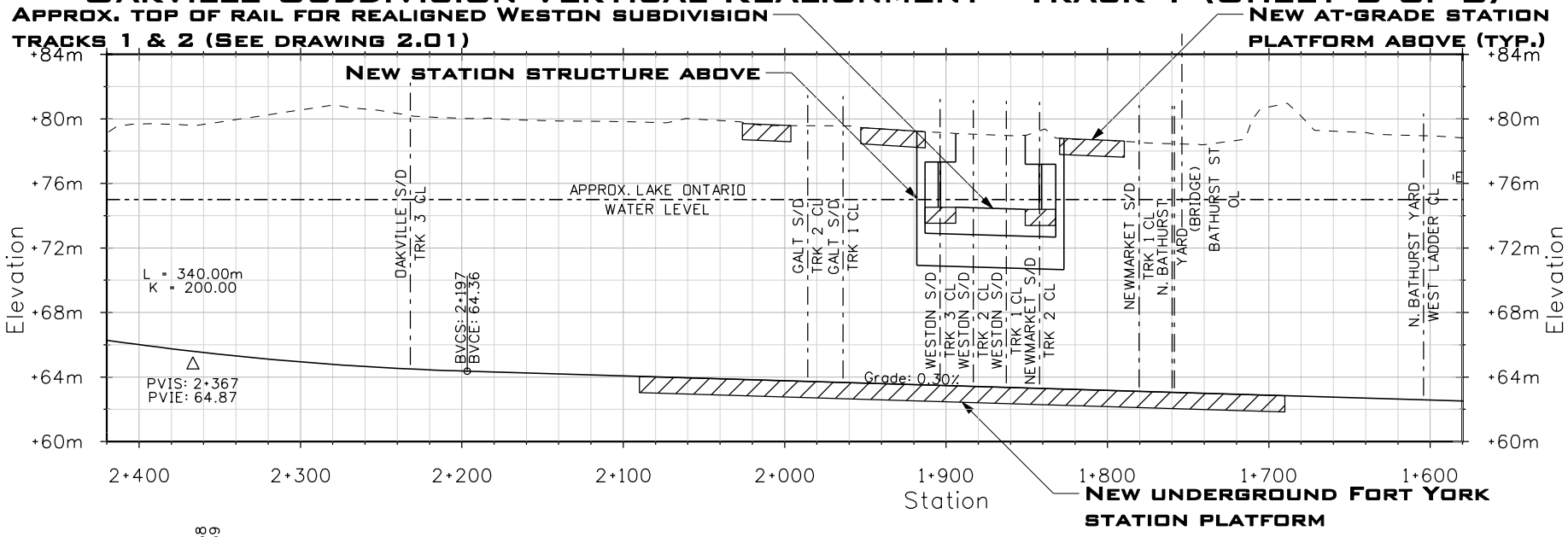
1. OAKVILLE S/D TRACKS 2, 5, AND 6 SIMILAR
2. VERTICAL REALIGNMENT CONTINUED ON SHEET 2.04

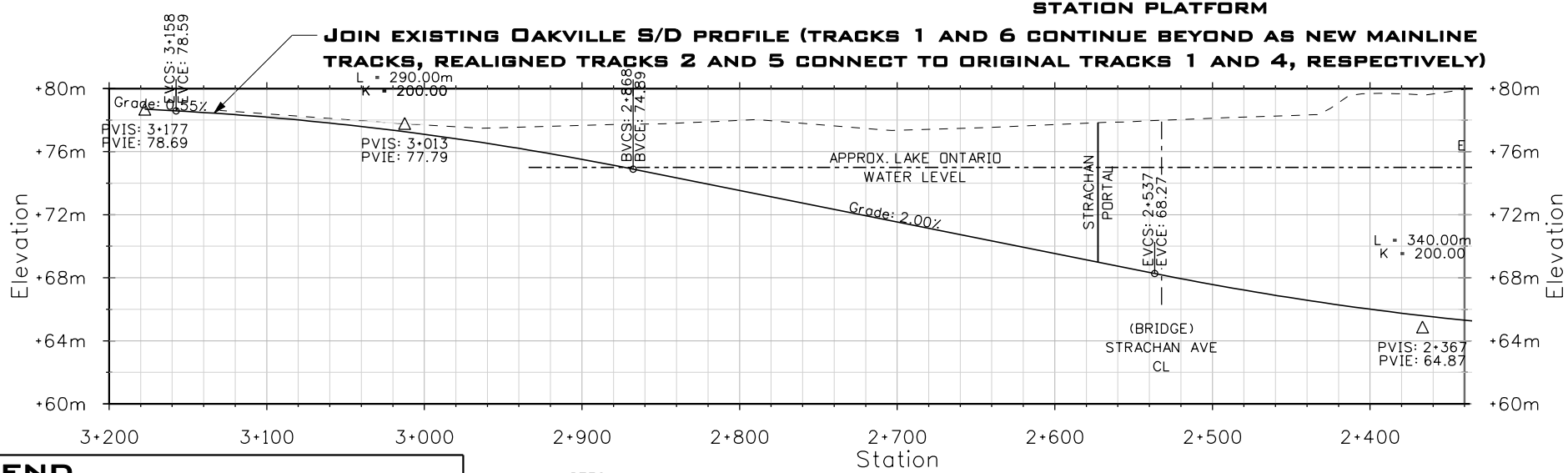
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.03**
Oakville Subdivision (Lakeshore West Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Oakville Subdivision Vertical Realignment - Track 1 (Sheet 2 of 2)





Legend

- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

NOTES:

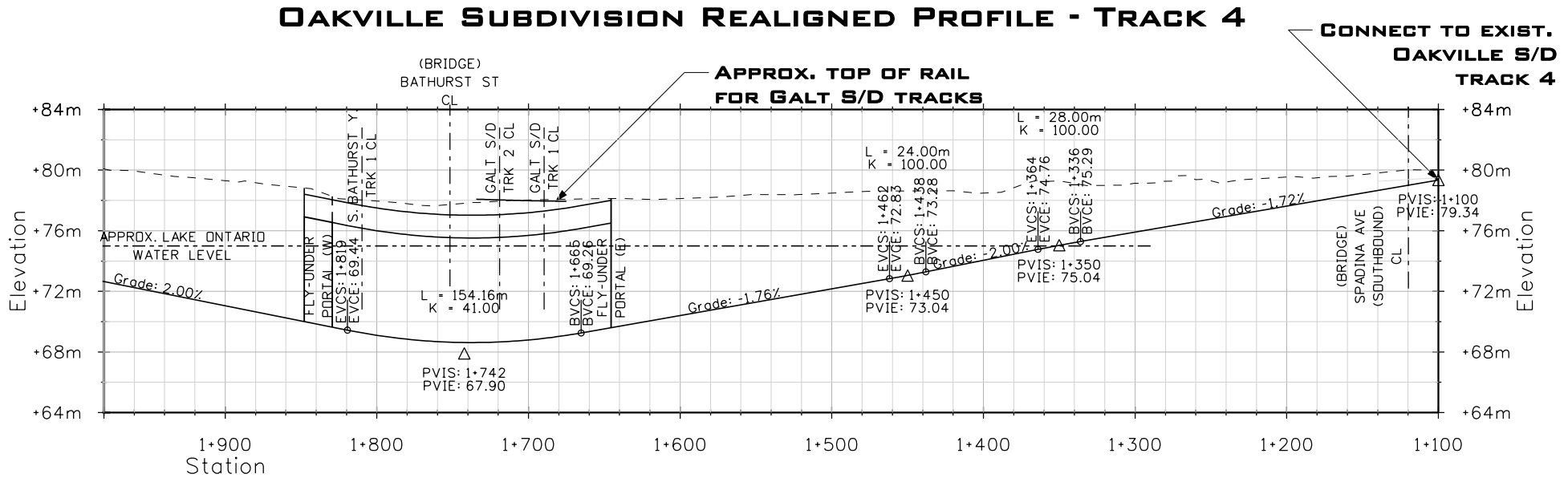
1. OAKVILLE S/D TRACKS 2, 5, AND 6 SIMILAR
2. VERTICAL REALIGNMENT CONTINUED FROM SHEET 2.03

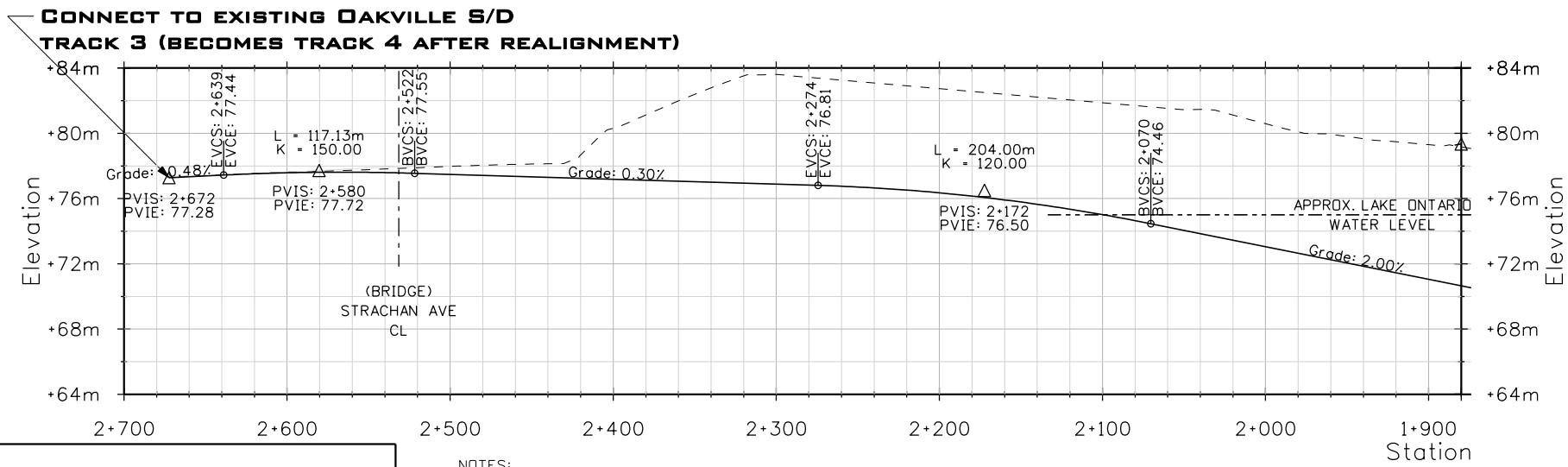
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.04**
Oakville Subdivision (Lakeshore West Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Oakville Subdivision Realigned Profile - Track 4





Legend

- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

NOTES:

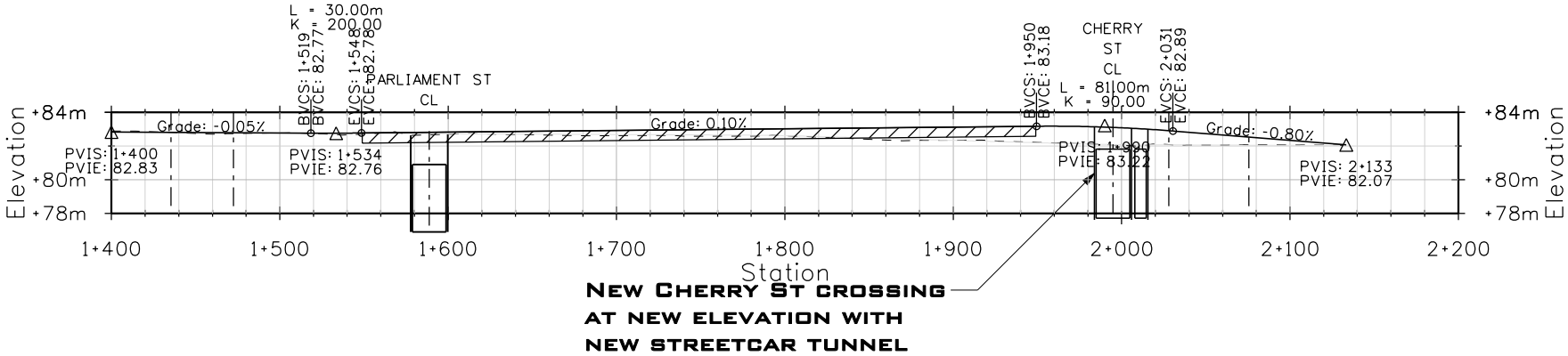
1. PROVIDES VIA RAIL ACCESS TO UNION STATION FROM OAKVILLE S/D WHILE MINIMIZING CONFLICTS WITH GO OPERATIONS
2. PROVIDES NON-REVENUE GO RAIL ACCESS BETWEEN NORTH BATHURST YARD AND WILLOWBROOK YARD

Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.05**
Weston Subdivision (Kitchener Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Bala Subdivision Vertical Realignment - Track 2



New Cherry St crossing at new elevation with new streetcar tunnel

Legend

- - - - - - Approx. Exist. Ground Line
——— New Track
——— Approximate Existing Track

NOTES:

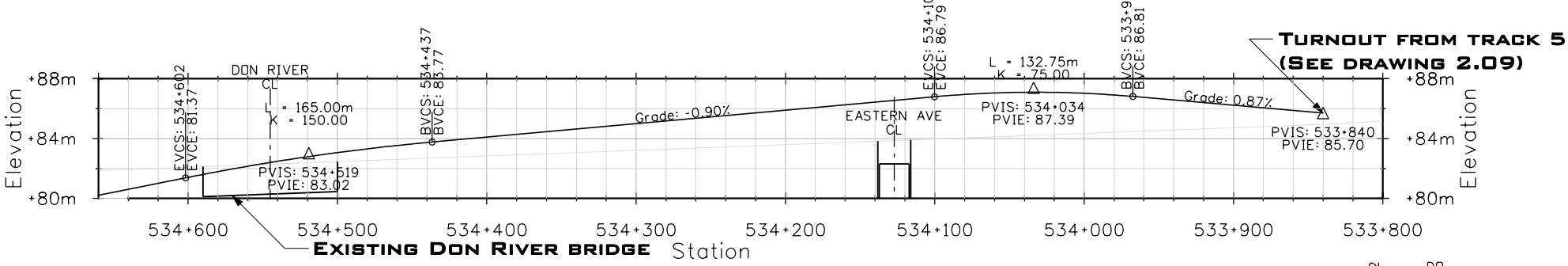
1. BALA S/D TRACK 1 SIMILAR

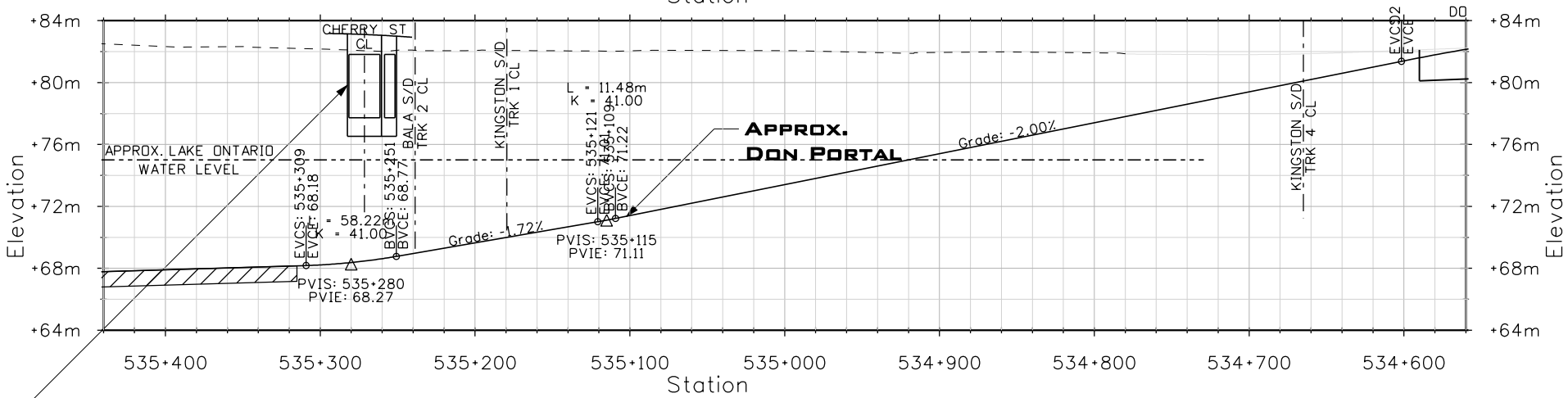
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.06**
Bala Subdivision (Richmond Hill Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Kingston Subdivision Vertical Realignment - Track 3 (Sheet 1 of 2)



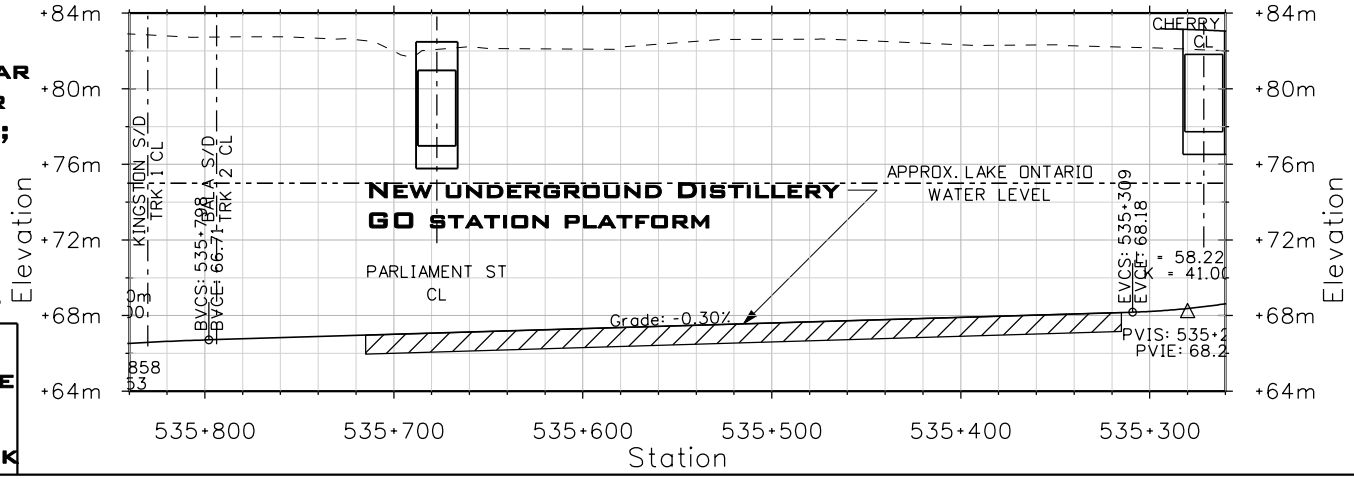


Rebuilt Cherry St crossing at new elevation with new streetcar tunnel (Bala S/D top of rail for track 2 shown above Cherry St; See drawing 2.06)

NOTES:

1. KINGSTON S/D TRACK 2 SIMILAR

2. VERTICAL REALIGNMENT CONTINUED ON DRAWING 2.08



Legend

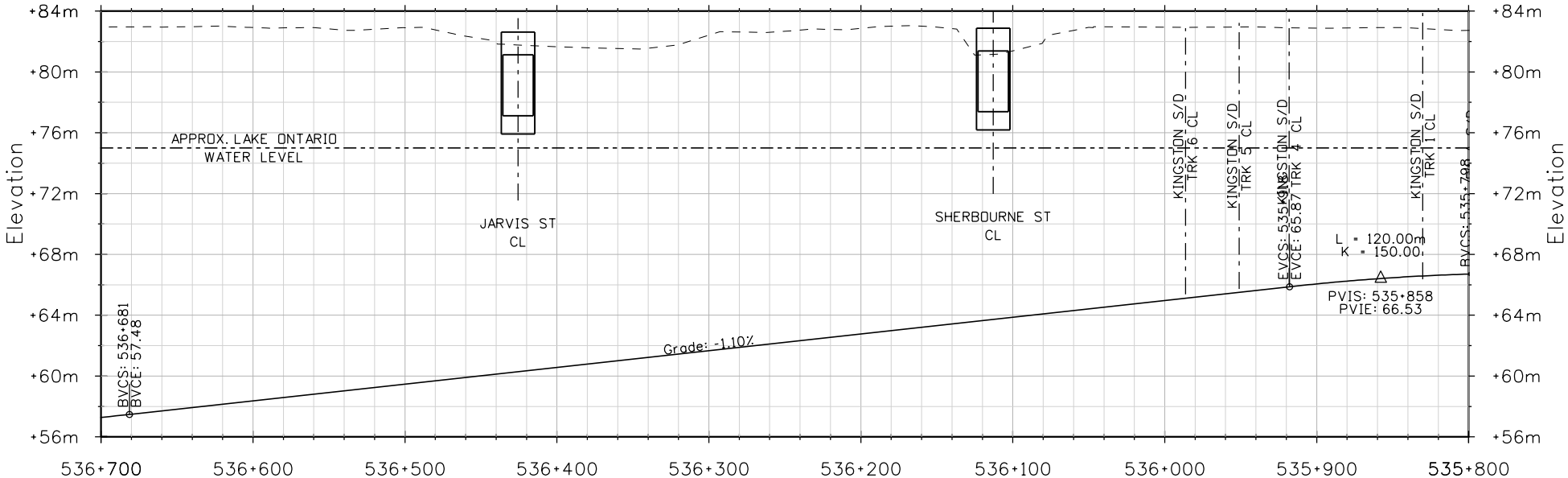
- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

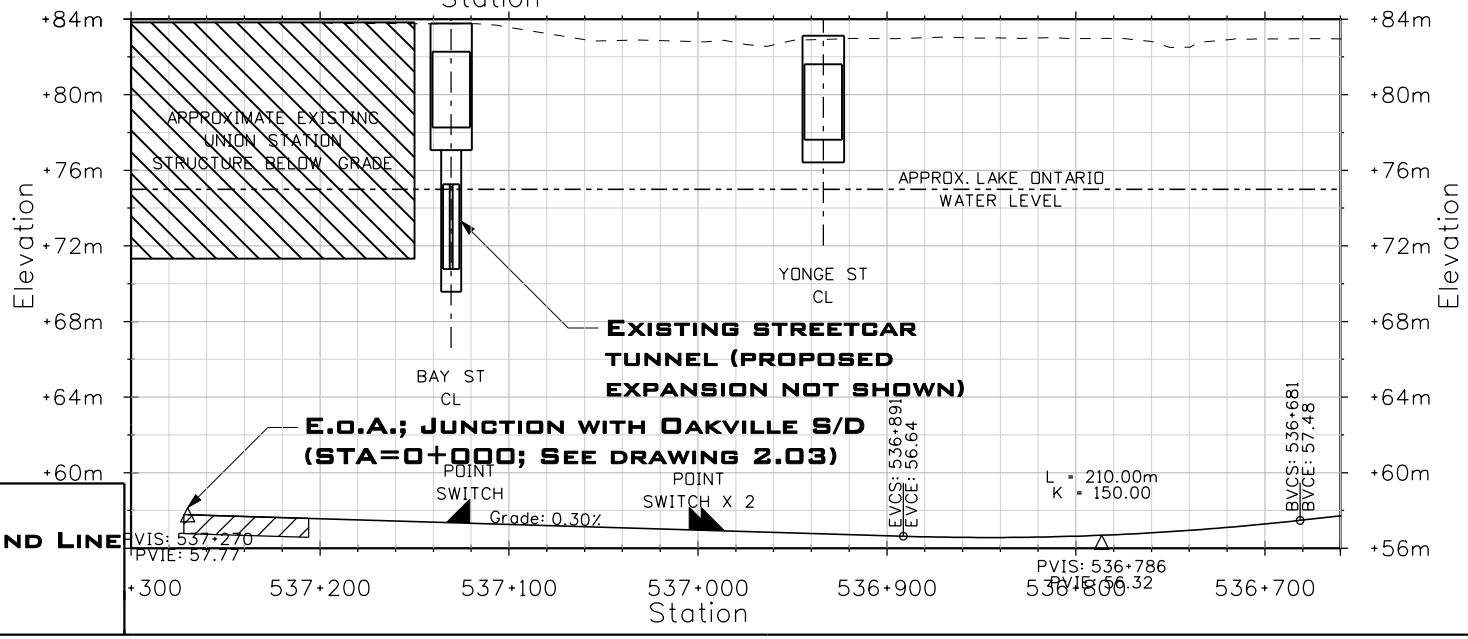
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.07**
Kingston Subdivision (Lakeshore East Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Kingston Subdivision Vertical Realignment - Track 3 (Sheet 2 of 2)





NOTES:

1. KINGSTON S/D TRACKS 2, 7, AND 8 SIMILAR

2. VERTICAL REALIGNMENT FOR TRACKS 2 AND 3 CONTINUED FROM DRAWING 2.07

3. SEE DRAWING 2.09 FOR TRACKS 7 AND 8 EAST OF NEW DISTILLERY GO STATION

Legend

- - - - - - Approx. Exist. Ground Line

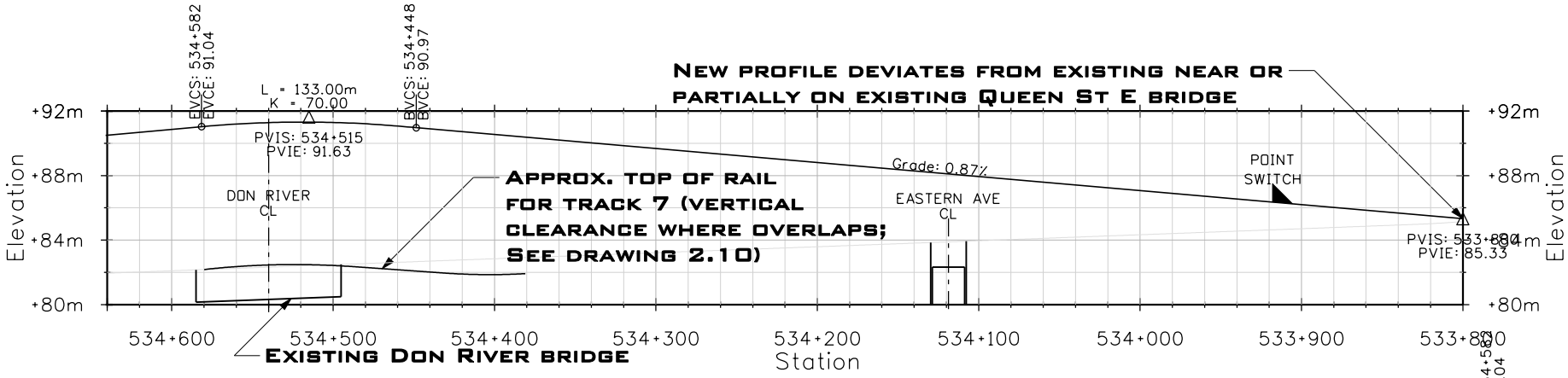
——— New Track

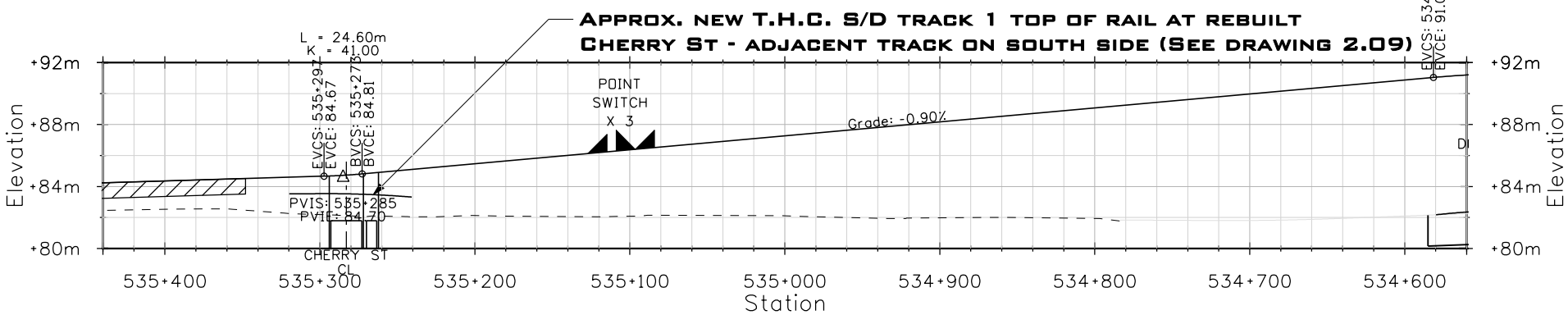
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

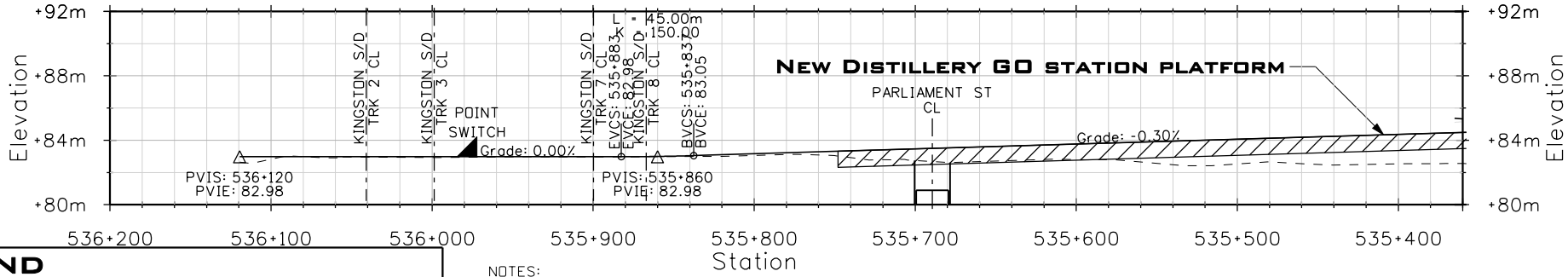
PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.08**
Kingston Subdivision (Lakeshore East Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Kingston Subdivision Vertical Realignment - Track 6 (Originally Track 4)







Legend

- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

NOTES:

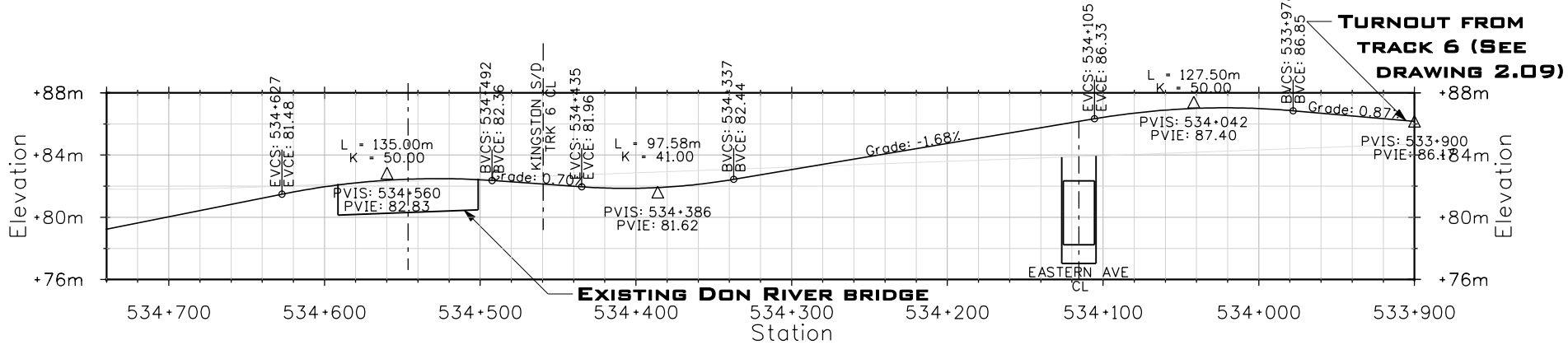
1. KINGSTON S/D TRACKS 1, 5 SIMILAR; TRACK 4 WEST OF STA 534+700 SIMILAR
2. ORIGINAL KINGSTON S/D TRACKS 2, 3, AND 4 BECOME REALIGNED KINGSTON S/D TRACKS 4, 5, AND 6, RESPECTIVELY (SEE DRAWING 1.12)

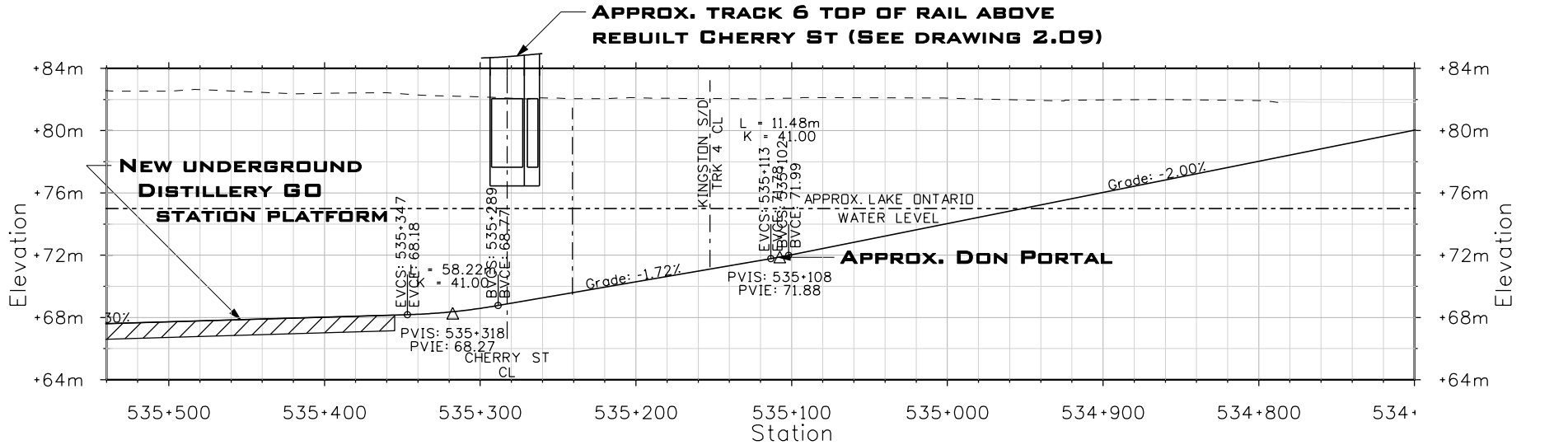
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.09**
Kingston Subdivision (Lakeshore East Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Kingston Subdivision Vertical Realignment - Track 7





Legend

- Approx. Exist. Ground Line
- New Track
- Approximate Existing Track

NOTES:

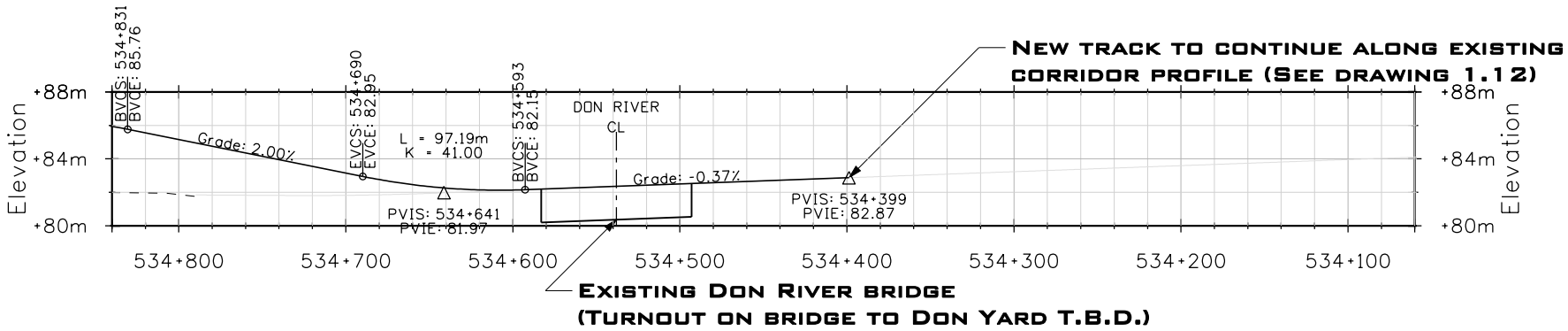
1. KINGSTON S/D TRACK 8 SIMILAR
2. FROM DISTILLERY GO STATION AND WEST THEREOF (APPROX. STA 535+350), KINGSTON S/D TRACKS 7 AND 8 SIMILAR TO TRACKS 2 AND 3

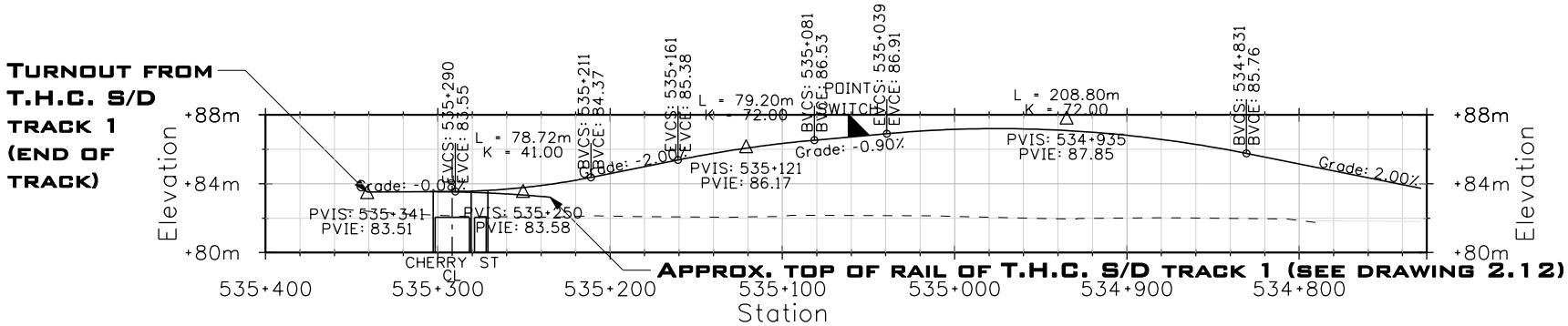
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.10**
Kingston Subdivision (Lakeshore East Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Kingston Subdivision Vertical Realignment - Pullback Track





Legend

- - - - - - Approx. Exist. Ground Line
——— New Track
——— Approximate Existing Track

NOTES:

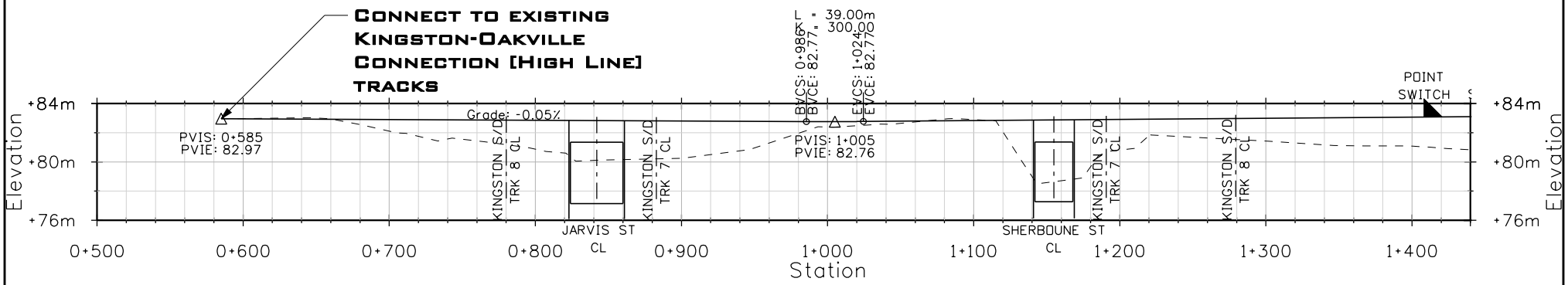
1. THIS TRACK USED FOR NON-REVENUE GO RAIL EQUIPMENT MOVES, EXCEPT IN THE EVENT OF SERVICE DISRUPTIONS

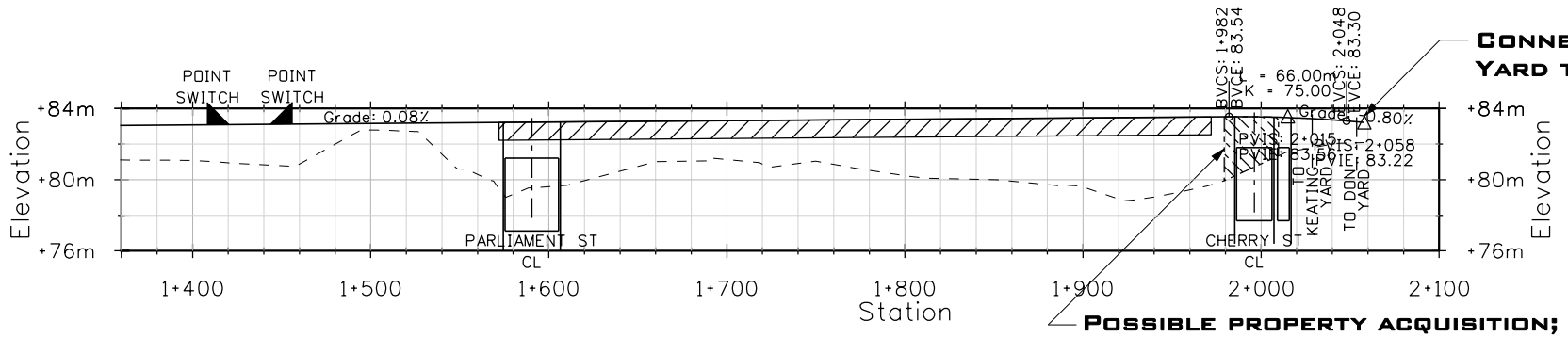
Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.11**
Kingston Subdivision (Lakeshore East Corridor) Vertical Realignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Toronto Harbour Commission Subdivision (New) Vertical Alignment - Track 2





Connect to Don Yard track 3

Possible property acquisition; See plan drawing 1.10 Don Yard Area Plan - Upper (Owned by: City of Toronto)

Legend

- - - - - - Approx. Exist. Ground Line

——— New Track

NOTES:

1. T.H.C. S/D TRACK 1 SIMILAR
2. T.H.C. S/D STA 0+000 AT GALT S/D STA 0+000; SIMILAR STATIONING TO BALA S/D
3. T.H.C. S/D SERVES AS EXTENSION EAST OF REALIGNED GALT S/D STA 0+000 TO BRING MILTON CORRIDOR TRAINS TO DISTILLERY STATION AND DON YARD

Conceptual - Not for Construction; Existing features are approximate and require confirmation by a qualified surveyor

PROJECT: Union Station Rail Corridor 2031	Date: 10/07/2012 HScale: 1:4000 VScale: 1:400	**2.12**
Toronto Harbour Commission Subdivision (New) Vertical Alignment	Drawn by: Karl Junkin	
Base data interpreted from City of Toronto Maps, Daft Logic	Drawn for: Transport Action Ontario	2.01-2.12

[Academic use only]

Appendix Y: Milton Service Simulation Model

APPENDIX Y

Milton Service Simulation

Summary of Travel Times in Minutes by Arrangement and Technology from Milton to Union Station

Station	Diesel (EX)	Diesel (RC)	Diesel (RRR)	EMU (EX)	EMU (RC)	EMU (RRR)	EMU (SSA)	EMU (SSB)
Milton	0	0	0	0	0	0	0	0
Agerton	X	5	5	X	4	4	4	X
Lisgar	7	10	10	6	8	8	X	6
Meadowvale	12	15	15	9	11	11	10	9
Streetsville	17	20	20	14	16	16	14	X
Erin Mills	X	X	24	X	X	19	X	16
Erindale	23	26	28	19	21	22	19	X
Fairview	X	X	32	X	X	25	X	20
Cooksville	28	31	36	23	25	28	23	23
Applewood	X	X	40	X	X	31	26	X
Dixie	33	36	44	27	29	34	X	27
Islington*	39	42	50	32	34	38	32	32
Chestnut Hills	X	X	54	X	X	41	35	X
Lambton	X	X	58	X	X	45	X	37
Bloor	X	50	63	X	41	49	41	41
Parkdale	X	X	67	X	X	52	44	X
Fort York	X	X	71	X	X	55	X	46
Union Station	57	62	78	48	51	61	52	52

* *Islington is a relocation of the existing Kipling station*

(EX): *Existing arrangement of service as operated at time of writing, current as of 2013.*

(RC): *Reference Case arrangement as outlined in Appendix 3 of the 2010 electrification study.*

(RRR): *Arrangement as outlined in Chapter 9 of this Regional Rapid Rail report.*

(SSA): *Skip Stop 'A' arrangement - not viable with 12-car trains, cannot meet projected demand.*

(SSB): *Skip Stop 'B' arrangement - not viable with 12-car trains, cannot meet projected demand.*

See Appendix Y spreadsheet file for the complete details of the simulation model.

Appendix Z: “The Case for ‘Super GO’” 1974 Electrification Report

See website http://rrr.transport-action.ca for a link to the 1974 report “The Case for ‘Super GO’”

GREATER TORONTO AND HAMILTON AREA

REGIONAL RAPID RAIL

A VISION FOR THE FUTURE

TRANSPORT ACTION ONTARIO

JULY 2013