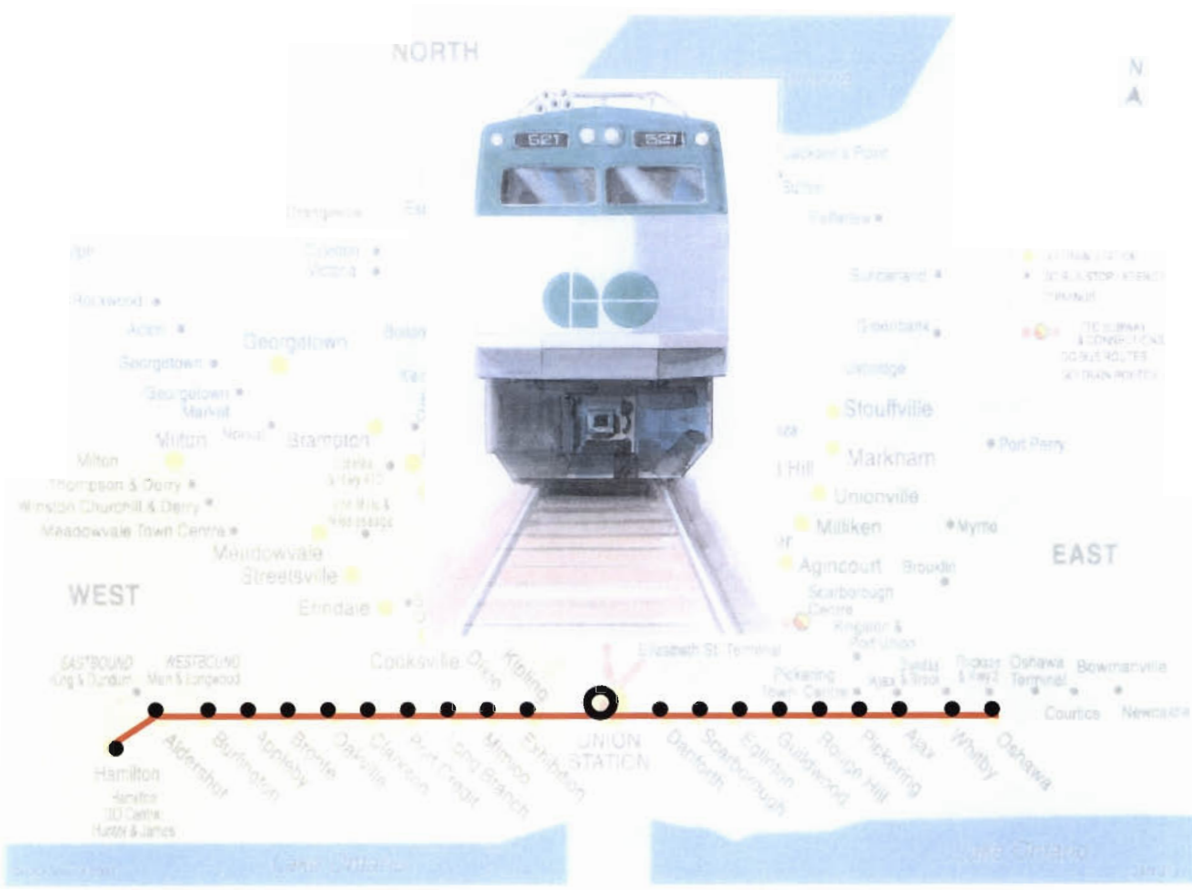
GO Transit

Electrification Study - Update
Lakeshore Line



Hatch Mott MacDonald
In association with
CPCS Technologies Group

April 2001

GO Transit

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EXECUTIVE SUMMARY

<u>Background</u>

GO Transit is currently handling about 40 million passengers annually on its rail system. Most of this traffic is carried on the Lakeshore line, running east and west from Union Station, to Oshawa and Hamilton respectively. It is forecast that this passenger load will double over the next 10 to 15 years or so, requiring significant improvements to the already overstrained railway infrastructure.

A number of studies have been undertaken in the past twenty years to examine the feasibility and economic impact of electrification of GO Transit's rail system. The most recent study, in 1992, concluded that the economic cost of electrification of the Lakeshore line was marginally higher than for diesel operation of the line. That study also found the cost of electrification of the entire GO Rail system did not compare favourably with diesel operation. The 1992 report concluded that the small economic premium for electrifying the Lakeshore line could be justified in terms of the significant environmental benefits and service improvements associated with electrification.

The recent availability of a number of electric locomotives, built in 1983 but still unused or slightly used, and the availability of new and lightly used substation equipment and overhead catenary material has provided new impetus for the electrification question. This equipment, if made suitable with appropriate modifications and retrofits, could lower the initial cost of electrification appreciably below that determined in the 1992 study, which was based on new equipment.

Electrified railways have significant environmental benefits when compared to diesel trains, such as reduced levels of air and noise pollution and also offer the potential for improved service levels due to the better performance of electric locomotives. Given these benefits, the opportunity to implement electrification at reduced cost must be fully examined and pursued if considered feasible. In response, GO Transit has commissioned this review of its last electrification study to determine if an economic justification can now be made for electrification, given the availability of the surplus equipment.

<u>Analysis</u>

The key objectives of this study were to compare the economic costs of diesel and electric operation and produce an addendum to the 1992 study to enable GO Transit to make an informed decision whether to further proceed at this time with electrification of the Lakeshore Line, between Hamilton and Oshawa. Due to the comparative nature of the analysis, only those capital and operating costs that help differentiate between the two modes of operation were considered in the economic analyses. Consequently the cost estimates contained in this report do not represent a definitive cost estimate for either option and only provide a basis for comparison between diesel and electric operation of the line.

Train Performance Calculations (TPC's) were performed to determine train travel times, power demand and energy consumption as inputs to the economic evaluation. The TPC simulations were based on the current train schedule for the Lakeshore line. Future conditions were determined by extrapolating from these simulations to match GO Transit's plan to increase service in 2009 and 2021. Journey times on the Burlington – Union run could be reduced by up to 12 minutes with electrification, but the higher accelerations and speeds would increase energy consumption. It was also determined from analysis of the power requirements that the probable locations for electric substations (transformers) to feed the line would be in the vicinity of Union station, Pickering GO station and Burlington GO station.

Prefeasibility level capital costs were estimated for the following key elements:

- electric locomotives, including necessary modifications
- overhead catenary system, including foundations
- traction power substations
- connection cost to the electricity grid
- signal modifications – to prevent interference from electric trains
- improvement of overhead clearances at a number of structures and Union Station train shed
- maintenance facilities for the electric locomotives and the catenary system.

Operating and maintenance costs were determined for the following key elements, for inclusion in the economic model:

- diesel fuel
- electric power requirements and cost of energy
- routine maintenance
- major equipment overhauls
- major equipment replacement.

An implementation schedule of almost three years was determined for the project including a 14-month planning and approval period before any on-site work can commence. On this basis, revenue service of the electrified line could be targeted for the first quarter of 2004. Capital and operating cost streams used in the economic analysis reflect this schedule. A study horizon of 25 years was considered in the economic analyses.

A report prepared by J.S. Biln of BC Rail Ltd for GO Transit concluded that the available E60C freight locomotives are in good condition and with appropriate minor repairs and modifications, would be suitable for passenger service on GO Transit's system. The report also provided suggestions and cost estimates for upgrading the used equipment.

<u>Conclusions</u>

In the economic analyses, contained in Section 12 of this report, the existing diesel operation demonstrates an economic advantage over the introduction of an electrified railway along the Lakeshore Line. Based on a discount rate of 6% and annual escalation of 3%, the net present value is -$348 million for the diesel option and -$445 million for the electric option. The NPV results are negative because only cost streams were considered, not revenues.

A number of sensitivity analyses were run to test the effect of varying the cost of fuel and electric energy and the effect of changing the rate of inflation. In all cases, the diesel option remained the most economic alternative.

An initial investment of at least $300 million would be required to implement electric service on the line. Although an electrified railway would have significant environmental benefits and would offer superior flexibility to increase service levels, it would likely be difficult at this time, based on this analysis, to raise the funding necessary to proceed with electrification.

Some opportunities to reduce initial capital cost were identified, as follows:

- it may be possible to eliminate one of the three substations. Potential saving is about $3 to $5 million

- Hydro One would be willing to fund part of the substation cost and high voltage connection cost if GO Transit entered into a long-term energy agreement. Potential saving is about $3 to $10 million depending on the magnitude and length of the energy agreement.

Further, more detailed, study would be required to determine if the above, or greater savings could be realized.

1. INTRODUCTION

1.1 Context

There is significant pressure for GO Transit to increase passenger capacity, particularly on the Lakeshore Line because of population growth in the Greater Toronto Area, spreading of the residential area away from the city centre and longer traffic peaks of congestion on all of the highways leading into Toronto. In August 2000, GO Transit published its "Route Map to the Future" which projected that its ridership will almost double by 2021. This forecast concurred with other ridership predictions, such as "The Central Area Transportation Review" undertaken by Metropolitan Toronto Planning Department in 1996, which projected increases in peak GO Rail trips of between 90% to 170% by 2031.

The present GO Transit rail service is now at its capacity limit and will require major infrastructure improvements to enable it to handle the expected doubling of ridership in the next 15 to 20 years.

Recent environmental treaties between Canada and the USA impose substantial reductions in emissions in Ontario, which can be helped, in part by reductions in road traffic through public transport and to a smaller degree by eliminating diesel trains for public transport.

1.2 Objectives of This Study

Electrification of GO Transit's rail system has been studied a number of times in the past twenty years, most recently in 1992. That study produced a report titled "GO Transit Commuter Rail Services Electrification Study" which concluded that the average life cycle cost of an electrified Lakeshore Line would be slightly higher than the existing diesel operation.

GO Transit recently became aware that twenty (20) General Electric type E60C electric locomotives, built in 1983 but still unused or slightly used, have become available. In addition to the locomotives, new and used overhead catenary material from Mexico and from the British Columbia Railway is also currently available at significantly lower cost than new equipment. This equipment, if made suitable with appropriate modifications and retrofits, could lower the initial cost of electrification appreciably below that determined in the 1992 study, which was based on new equipment.

Given the significant environmental benefits of an electrified railway, such as reduced levels of air and noise pollution and the potential for improved service levels due to the better performance of electric locomotives, the opportunity to implement electrification at reduced cost must be fully examined and pursued if considered feasible. GO Transit, therefore, wishes to review the previous electrification study work and update it to reflect the potential use of the available surplus equipment. This study would determine if an economic justification can now be made to electrify part of the GO Rail System.

The objective of this review is to produce an addendum to the 1992 study which will enable GO Transit to make an informed decision whether to further proceed at this time with electrification of the Lakeshore Line, between Hamilton and Oshawa, utilizing the equipment described above. It should be noted that the available surplus equipment identified above would only be sufficient to electrify GO Transit's operation on the Lakeshore Line. Benefits attributable to electrification would have the most significant impact on this line as it is, by far, the busiest in the system.

The primary purpose of this study was to determine if an electrified Lakeshore line would be cost-competitive with the present diesel train operation. This study therefore considered only those capital and operating costs that help differentiate between the two modes of operation. The cost estimates derived do not represent a definitive cost estimate for either option and only provide a basis for comparison between diesel and electric operation of the line.

1.3 Study Team

This study was led by Hatch Mott Macdonald of Mississauga (HMM). CPCS Technologies, as subconsultant to HMM, was responsible for the review and cost estimate for the overhead catenary system and provided input to other areas of the study. Mr. Gabor Furst, as subconsultant to HMM, was responsible for the train simulations and the electrical load calculations for the purpose of sizing and locating the substations and to enable discussions with Hydro One and OPG regarding demand and energy rates.

The study team worked closely with GO Transit staff who provided direction and information regarding current and planned operations and cost data for the existing rail operation.

GO transit also directly engaged Mr. J.S. Biln, P.Eng., Chief Mechanical Engineer of the British Columbia Railway as locomotive consultant to advise on the suitability and quality of the GE type E60C electric locomotives and to provide cost estimates to upgrade to equipment for transit use.

2. ASSUMPTIONS AND CRITERIA

Given the scope of this study, it has been necessary to make a number of simplifying assumptions in order to undertake the work. It is considered that these assumptions do not unduly limit the results of the study. This section discusses only key criteria and assumptions, a more detailed discussion may be found in each of the sections of the report where the criteria apply.

2.1 Planning Horizon

This study considered a 25-year horizon, between years 2001 and 2025.

2.2 Level of Service

Train Performance Calculations (TPC's) for power demand and energy consumption were performed on the basis of the current GO Transit rail schedule. The outputs of the TPC's were extrapolated for future growth by considering GO Transit's 2021 Plan which predicts the addition of 11 trainsets in 2009 and 7 trainsets by 2021.

Current GO Transit practice is to limit train size to ten bi-level cars and one locomotive. The economic comparisons between electric and diesel operation were based on this train size. Longer trains are more feasible with electric locomotives due to the higher locomotive horsepower and unlimited hotel power for the coaches and their better acceleration performance. The effect of longer trains has been considered by including this factor in the economic sensitivity analyses.

2.3 Implementation Schedule

This study has assumed an implementation schedule of approximately 33 months as shown in Figure 2.1. A 14 month approval period has been allowed for to obtain the necessary permits and environmental approvals prior to commencement of on-site work. Subject to the approval of GO Transit's Board, the procurement activities, including the purchase of the locomotives should start prior to obtaining regulatory approvals in order to achieve the above schedule. It will be necessary, at an early stage, to discuss construction access and staging requirements with CN Rail in order to validate the construction schedule, particularly installation of the OCS on the right-of-way.

2.4 Capital and Operating Costs

As discussed earlier, only costs which were considered to be specific to the diesel and electric systems were included in the economic analysis.

Capital, maintenance and operating costs for diesel operation were provided by GO Transit and developed by the Study Team.

Capital and maintenance cost for electric locomotives were primarily obtained from a report titled "Inspection and Assessment of GE E60C-2 Electric Locomotives for GO Transit" prepared November 2000 by J.S. Biln of BC Rail Ltd.

Costs for high voltage connection to the power grid and energy costs for electric operation were developed with assistance from Hydro One and Ontario Power Generation based on energy requirements derived from the TPC simulations.

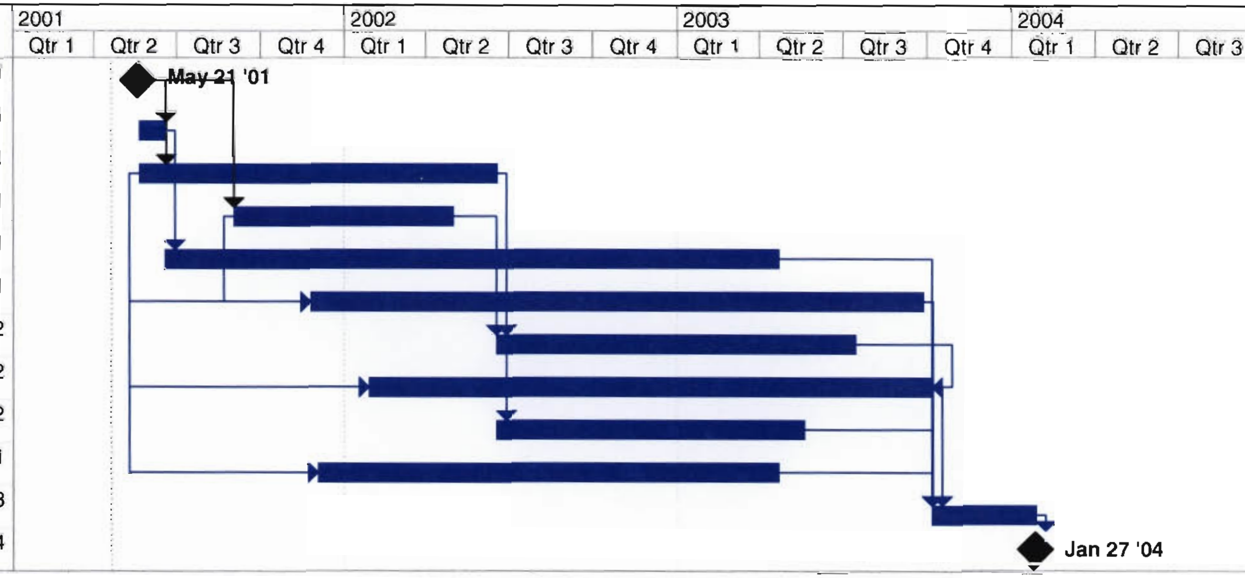
All costs are in 2001 constant dollars, Canadian currency.

2.5 Economic Analysis

The economic analysis in Section 12 was based on a comparison of expenditure streams for an electrified line and diesel operation of the line. Revenue streams for the two options were not considered. A discount rate of 6% was assumed.

FIGURE 2.1 SUMMARY IMPLEMENTATION SCHEDULE

ID	Task Name	Duration	Start
1	GO Transit Board Approval	1 day	Mon 5/21/01
2	Purchase Locomotives	1 mon	Tue 5/22/01
3	Planning & Approvals	14 mons	Tue 5/22/01
4	Design Engineering	8.6 mons	Mon 9/3/01
5	Locomotive Modifications	24 mons	Tue 6/19/01
6	OCS Procure/Construct	24 mons	Mon 11/26/01
7	Civil Works	14 mons	Tue 6/18/02
8	Substation Procure/Install	22 mons	Tue 1/29/02
9	O/Head Clearance - Union	12 mons	Tue 6/18/02
10	Signal Modifications	18 mons	Tue 12/4/01
11	Test & Commission	4 mons	Tue 10/7/03
12	Revenue Service	1 day	Tue 1/27/04



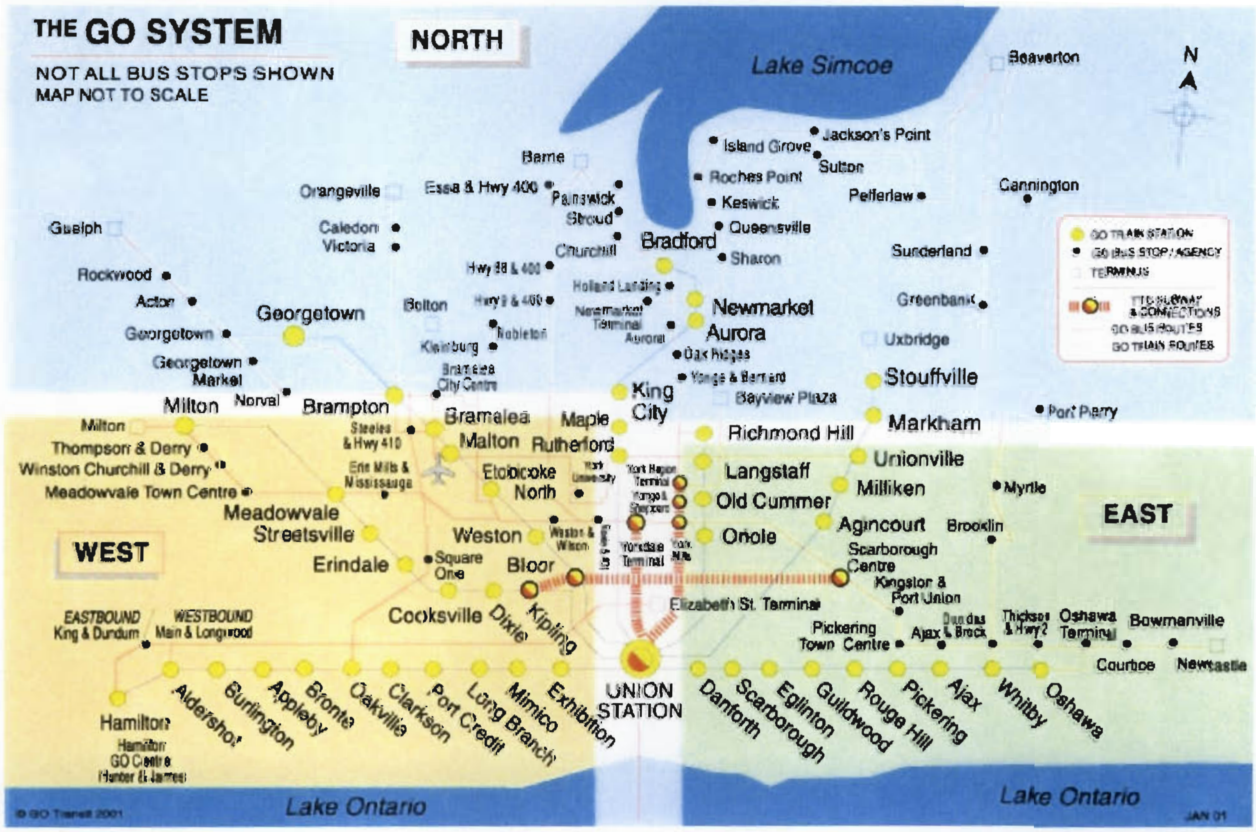
GO Transit Electrification Study - Updat
Date: Fri 4/20/01

3. RAIL NETWORK

3.1 Existing Network

GO Transit's entire rail network is shown in Figure 3.1. This update study was confined to operations on the Lakeshore Line, running between Hamilton in the west and Oshawa in the east, a total of about 114km apart. The twenty-one (21) stations on this line are listed in Appendix A together with each station's distance from Union Station.

Figure 3.1 – The GO Transit Network



3.2 Planned Capacity Increases

GO Transit's "Year 2021 Plan" calls for significant expansion of its system to handle the anticipated passenger growth over the next 20 years. The expansion plans call for an investment of over $1 billion in infrastructure improvements and rolling stock.

By year 2009, an additional 11 consists will be added to the system, four of which will be on the Lakeshore line. A further 7 consists will be added by year 2021, 4 of which have been assumed to be for the Lakeshore operation.

In order to manage the required additional peak period capacity, a third track will be required between Oakville and Port Credit to eliminate the existing bottleneck. A third track will also be necessary between Union Station and Scarborough.

4. TRAIN OPERATIONS

4.1 Lakeshore Schedule

According to the latest GO Transit train schedule, a total of 36 trains operate Eastbound and 38 trains operate Westbound from Union Station on the Lakeshore line on a normal weekday, from about 6am until about 1.30am the following morning. During the morning peak period (6am to 9am), 14 trains operate eastbound and 11 trains westbound. During the evening peak period (3pm to 7pm) 11 trains run eastward and 15 trains run westward. Total revenue distance traveled during a normal weekday is about 5600km. The weekday train schedule is summarized in Table 4.1.

The train schedules for Saturdays and Holidays and for Sundays are shown in Table 4.2. Total train-distance traveled on Saturdays & Holidays is about 2400km and about 2200km on Sundays.

4.2 Shared Track Usage (CN/CP/GO)

The following extract from Section 5 of the 1992 electrification report would still apply to the shared usage of the Lakeshore Line.

"Under the electrification scenario of GO Transit, whether introduced in stages or wholly, the railways CP, VIA, Amtrak, ONR and CN will have to be involved from the outset since electrified and non-electrified trains will be operated in these corridors at the same time. It will be necessary to examine all the operating rules and general instructions for each of the railways in order to ensure the safety of personnel and property under any eventuality.

The impact of the OCS system upon the methods used by CN Rail and CP Rail to facilitate track maintenance and derailment clearing must be investigated given that the OCS will restrict the unencumbered use of certain types of on and off-track machinery such as cranes.

Another use that must be addressed is the incorporation of the electrification control systems with the train operations control systems on these corridors so that information flow is instantaneous between the two functions.

Each of these operational issues will require significant amounts of planning in order to satisfy the railways and the regulatory bodies that the electrification of GO Transit will not detract from the prevailing levels of safety and confidence."

4.3 Benefits/Drawbacks of Diesel Versus Electrification

This section presents an overview of the benefits and drawbacks of the two modes of operation. These are essentially unchanged from those identified in the 1992 report.

4.3.1 Benefits of Diesel Operation

- Unlimited choice of routes and assignment
- Compatibility/interchangeability with other railway equipment in the corridors
- Technical breakdown confined to one train.

4.3.2 Drawbacks of Diesel Operation

- Limited hotel power
- Diesel engine servicing and overhauls
- Noise, fumes, oil and fuel dispersion
- Per unit horsepower limitation
- Slow acceleration to top speed
- Non revenue movements required to refuelling points
- Shorter economic life
- Limited categories of usable fuel
- Powerful cleaning agents required to remove oily residue.

4.3.3 Benefits of Electrified Operation

- Reduced maintenance cost and associated time
- Choice of primary energy source (via electricity)
- Fumes and oil dispersion eliminated
- Reduced noise at layover sites
- Reduced train noise
- Greater per unit horsepower and acceleration
- Shorter headways, significantly higher traffic capacity
- Greater energy efficiency; at source generators; partial recovery of braking energy
- Overtrack property development
- Ample hotel and standby power available via locomotive, with minimal standby maintenance
- Lower energy cost, less prone to erratic price fluctuation.

4.3.4 Drawbacks of Electrified Operation

- Locomotives and power cars confined to electrified areas
- Reduces available clearance envelope
- Replacement of incompatible track circuits and signalling systems – signal systems must be modernized
- Maintenance of OCS
- Train immobilization due to OCS damage – or hydro failure
- Shielding or replacement of incompatible communication cables
- Supplementary operating and safety rules
- Reduced mobility for on-track cranes
- Visual intrusion of OCS.

Table 4.1 - Analysis of GO Transit Rail Schedule (January 2001 – Weekdays)
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Train No.	Depart Station	Depart Time	Arrive Time	Arrive Station	Elapsed Time	Stops	Through Union	Stop Time	Travel Time	Distance mi	Distance km
	Eastbound Morning Peak										
902	Mimico	5:54	7:08	Oshawa	1:14	11	Y	0:14	1:00	38.2	61.5
952	Oakville	5:58	7:36	Oshawa	1:38	15	Y	0:18	1:20	52.9	85.1
904	Burlington	6:13	7:07	Union	0:54	9	N	0:07	0:47	31.5	50.7
960	Hamilton	6:14	8:26	Oshawa	2:12	18	Y	0:21	1:51	70.8	113.9
954	Oakville	7:05	7:42	Union	0:37	6	N	0:04	0:33	21.4	34.4
962	Hamilton	6:34	8:08	Pickering	1:34	9	Y	0:12	1:22	60.2	96.9
906	Oakville	7:25	9:08	Oshawa	1:43	16	Y	0:19	1:24	52.9	85.1
956	Burlington	7:15	8:02	Union	0:47	6	N	0:04	0:43	31.5	50.7
964	Hamilton	7:04	8:08	Union	1:04	8	N	0:06	0:58	39.3	63.2
949	Clarkson	7:58	8:17	Union	0:19	2	N	0:00	0:19	16.7	26.9
958	Oakville	7:58	8:21	Union	0:23	2	N	0:00	0:23	21.4	34.4
966	Port Credit	8:07	8:29	Union	0:22	4	N	0:02	0:20	12.8	20.6
968	Burlington	7:55	8:46	Union	0:51	7	N	0:05	0:46	31.5	50.7
908	Burlington	8:14	9:07	Union	0:53	10	N	0:08	0:45	31.5	50.7
		2:20			14:31				12:31	512.6	824.8
	Eastbound Day Offpeak										
910	Burlington	9:14	11:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
912	Burlington	10:14	12:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
914	Burlington	11:14	13:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
916	Burlington	12:14	14:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
918	Burlington	13:14	15:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
920	Burlington	14:14	16:11	Oshawa	1:57	19	Y	0:22	1:35	63	101.4
		5:00			11:27				9:15	378	608.2
	Eastbound Evening Peak										
970	Union	15:50	16:51	Oshawa	1:01	10	N	0:08	0:53	31.5	50.7
922	Burlington	15:14	17:10	Oshawa	1:56	14	Y	0:17	1:39	63	101.4
972	Union	16:30	17:31	Oshawa	1:01	10	N	0:08	0:53	31.5	50.7
974	Union	16:53	17:38	Oshawa	0:45	5	N	0:03	0:42	31.5	50.7
976	Union	17:03	17:38	Pickering	0:35	5	N	0:03	0:32	20.9	33.6
924	Burlington	16:14	18:04	Oshawa	1:50	16	Y	0:19	1:31	63	101.4
978	Union	17:33	18:14	Pickering	0:41	7	N	0:05	0:36	20.9	33.6
980	Burlington	16:54	18:38	Oshawa	1:44	16	Y	0:19	1:25	63	101.4
926	Union	18:13	19:14	Oshawa	1:01	10	N	0:08	0:53	31.5	50.7
982	Burlington	17:45	19:29	Oshawa	1:44	16	Y	0:19	1:25	63	101.4
928	Burlington	18:14	20:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
		2:24			14:12				12:01	482.8	776.8
	Easbound Night Offpeak										
930	Burlington	19:14	21:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
932	Burlington	20:14	22:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
934	Burlington	21:14	23:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
936	Burlington	22:14	0:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
938	Burlington	23:14	1:08	Oshawa	1:54	19	Y	0:22	1:32	63	101.4
36	Total trains	4:00			9:30				7:40	315	506.8
									17:27	1688.4	2716.6

Table 4.1 - Analysis of GO Transit Rail Schedule (January 2001 – Weekdays)
(Page 2 of 2)

Train No.	Depart Station	Depart Time	Arrive Time	Arrive Station	Elapsed Time	Stops	Through Union	Stop Time	Travel Time	Distance mi	Distance km
	Westbound Morning Peak										
901	Long Branch	6:29	7:05	Burlington	0:36	7	N	0:05	0:31	21.9	35.2
945	Oshawa	5:47	7:45	Burlington	1:58	18	Y	0:21	1:37	63	101.4
949	Oshawa	6:12	7:12	Union	1:00	10	N	0:08	0:52	31.5	50.7
905	Oshawa	6:34	7:34	Union	1:00	10	N	0:08	0:52	31.5	50.7
951	Oshawa	6:57	8:48	Burlington	1:51	14	Y	0:17	1:34	63	101.4
953	Pickering	7:22	8:03	Union	0:41	7	N	0:05	0:36	20.9	33.6
947	Oshawa	7:11	7:55	Union	0:44	5	N	0:03	0:41	31.5	50.7
955	Oshawa	7:23	8:07	Union	0:44	5	N	0:03	0:41	31.5	50.7
957	Pickering	7:45	8:26	Union	0:41	7	N	0:05	0:36	20.9	33.6
907	Oshawa	7:46	9:38	Burlington	1:52	14	Y	0:17	1:35	63	101.4
959	Pickering	8:18	8:59	Union	0:41	19	N	0:17	0:24	20.9	33.6
		1:49			11:48				9:59	399.6	643.0
	Westbound Day Offpeak										
909	Oshawa	8:41	10:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
911	Oshawa	9:41	11:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
913	Oshawa	10:41	12:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
915	Oshawa	11:41	13:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
917	Oshawa	12:41	14:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
919	Oshawa	13:41	15:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
		5:00			11:42				9:30	378	608.2
	Westbound Evening Peak										
921	Oshawa	14:41	16:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
967	Union	16:10	16:39	Oakville	0:29	3	Y	0:06	0:23	21.4	34.4
969	Union	16:13	16:51	Oakville	0:38	6	Y	0:09	0:29	21.4	34.4
971	Union	16:30	17:39	Hamilton	1:09	9	Y	0:12	0:57	39.3	63.2
923	Oshawa	15:41	17:24	Oakville	1:43	16	Y	0:19	1:24	52.9	85.1
973	Union	16:47	17:35	Burlington	0:48	6	Y	0:09	0:39	31.5	50.7
975	Union	17:02	18:11	Hamilton	1:09	9	Y	0:12	0:57	39.3	63.2
977	Union	17:13	17:52	Oakville	0:39	6	Y	0:09	0:30	21.4	34.4
979	Union	17:19	18:04	Burlington	0:45	5	Y	0:08	0:37	31.5	50.7
981	Oshawa	16:21	18:43	Hamilton	2:22	18	Y	0:21	2:01	70.8	113.9
925	Union	17:43	18:43	Burlington	1:00	10	Y	0:13	0:47	31.5	50.7
983	Oshawa	17:01	19:02	Burlington	2:01	19	Y	0:22	1:39	63	101.4
987	Oshawa	17:21	19:44	Hamilton	2:23	19	Y	0:22	2:01	70.8	113.9
927	Oshawa	17:41	19:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
985	Pickering	18:25	19:02	Union	0:37	7	N	0:05	0:32	20.9	33.6
		3:44			19:37				16:06	641.7	1032.5
	Westbound Night Offpeak										
929	Oshawa	18:41	20:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
931	Oshawa	19:41	21:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
933	Oshawa	20:41	22:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
935	Oshawa	21:41	23:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
937	Oshawa	22:41	0:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
939	Oshawa	23:41	1:38	Burlington	1:57	19	Y	0:22	1:35	63	101.4
38	Total trains	5:00			11:42				9:30	378.0	608.2
									21:05	1797.3	2891.9
								Total Daily Revenue km			**5608.5**

Note: The number of stops shown include the origin and destination stop

Table 4.2 - Analysis of GO Transit Rail Schedule (January 2001 - Weekend/Holiday)
(Page 1 of 2)

Train No.	Depart Station	Depart Time	Arrive Time	Arrive Station	Elapsed Time	Stops	Through Union	Stop Time	Travel Time	Distance mi	Distance km
	Eastbound - Saturdays & Holidays										
902	Union	6:13	6:50	Pickering	0:37	7	N	0:05	0:32	20.9	33.6
904	Union	7:13	7:50	Pickering	0:37	7	N	0:05	0:32	20.9	33.6
906	Oakville	7:30	8:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
908	Oakville	8:30	9:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
910	Oakville	9:30	10:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
912	Oakville	10:30	11:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
914	Oakville	11:30	12:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
916	Oakville	12:30	13:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
918	Oakville	13:30	14:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
920	Oakville	14:30	15:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
922	Oakville	15:30	16:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
924	Oakville	16:30	17:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
926	Oakville	17:30	18:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
928	Oakville	18:30	19:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
930	Oakville	19:30	20:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
932	Oakville	20:30	21:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
934	Oakville	21:30	22:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
936	Oakville	22:30	23:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
938	Oakville	23:30	0:50	Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
		17:17			23:54				19:12	760.9	1224.3
	Westbound - Saturdays & Holidays										
903	Union	6:43	7:20	Oakville	0:37	7	N	0:05	0:32	21.4	34.4
905	Union	7:00	8:20	Oakville	1:20	7	N	0:05	1:15	21.4	34.4
907	Pickering	8:00	9:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
909	Pickering	9:00	10:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
911	Pickering	10:00	11:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
913	Pickering	11:00	12:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
915	Pickering	12:00	13:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
917	Pickering	13:00	14:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
919	Pickering	14:00	15:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
921	Pickering	15:00	16:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
923	Pickering	16:00	17:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
925	Pickering	17:00	18:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
927	Pickering	18:00	19:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
929	Pickering	19:00	20:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
931	Pickering	20:00	21:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
933	Pickering	21:00	22:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
935	Pickering	22:00	23:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
937	Pickering	23:00	0:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
939	Pickering	0:01	1:20	Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
		17:18			24:37				19:55	761.9	1225.9
							Total Revenue km Sat & Holidays				**2450.2**

Table 4.2 - Analysis of GO Transit Rail Schedule (January 2001 – Weekend/Holiday)
(Page 2 of 2)

Eastbound - Sundays Only										
908 Oakville	8:30	9:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
910 Oakville	9:30	10:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
912 Oakville	10:30	11:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
914 Oakville	11:30	12:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
916 Oakville	12:30	13:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
918 Oakville	13:30	14:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
920 Oakville	14:30	15:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
922 Oakville	15:30	16:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
924 Oakville	16:30	17:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
926 Oakville	17:30	18:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
928 Oakville	18:30	19:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
930 Oakville	19:30	20:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
932 Oakville	20:30	21:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
934 Oakville	21:30	22:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
936 Oakville	22:30	23:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
938 Oakville	23:30	0:50 Pickering	1:20	13	Y	0:16	1:04	42.3	68.1
			21:20				17:04	676.8	1089.0
Westbound - Sundays Only									
909 Pickering	9:00	10:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
911 Pickering	10:00	11:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
913 Pickering	11:00	12:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
915 Pickering	12:00	13:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
917 Pickering	13:00	14:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
919 Pickering	14:00	15:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
921 Pickering	15:00	16:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
923 Pickering	16:00	17:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
925 Pickering	17:00	18:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
927 Pickering	18:00	19:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
929 Pickering	19:00	20:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
931 Pickering	20:00	21:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
933 Pickering	21:00	22:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
935 Pickering	22:00	23:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
937 Pickering	23:00	0:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
939 Pickering	0:01	1:20 Oakville	1:20	13	Y	0:16	1:04	42.3	68.1
			21:20				17:04	676.8	1089.0
						Total Revenue km Sundays			**2177.9**

Note: ***The number of stops shown include the origin and destination stop***

5. ROLLING STOCK

5.1 Equipment Requirements

The rolling stock requirements assumed in this study are shown in Table 5.1. Bi-level passenger cars are not shown, unless there is a difference between the electric and diesel operation. For example, the planned service expansion in 2007 will require either three electric locomotives or four diesel units. The diesel operation will thus require one more trainset than the electric operation, therefore additional bi-levels are included in the diesel option. The standard consist assumed in this study was a single locomotive, either diesel or electric, hauling ten bi-level cars.

5.2 Locomotives

The following locomotives were considered in this study:

Existing Diesel Fleet GM F95PH	- 3000 HP
Future Diesel Fleet	- 4500 HP
Electric GE E60C	- 4400 kW

The purchase, maintenance, overhaul and replacement schedule, assumed in this study, for the diesel operation was derived from information provided by GO Transit, as follows:

- Ten (10) locomotives replaced in 2006
- Ten (10) locomotives replaced in 2007
- Four (4) additional locomotives in 2007
- Four (4) additional locomotives in 2021
- Major overhaul of 24 locomotives in 2018/2019
- Top deck refurbishment 24 locomotives in 2012/2013
- Top deck refurbishment 24 locomotives in 2018/2019.

For the electric operation, the following schedule was assumed:

- Twenty (20) electric locomotives purchased in 2001/2004
- One (1) diesel locomotive for Hamilton run in 2004
- Three (3) additional locomotives in 2007
- Three (3) additional locomotives in 2021
- Twenty (20) replacement locomotives in 2025
- Major overhaul twenty (20) locomotives in 2015/2016
- Major overhaul three (3) locomotives in 2019.

5.3 Rolling Stock Cost Estimates

The following prices were used in this study:

- New Diesel Locomotive – F59PH — $3.3 million
- New Diesel Locomotive – 4500 HP — $5.2 million
- Refurbished E60C Electric Locomotive — $3.8 million
- New Electric Locomotive — $6.0 million
- Bi-Level Car — $2.6 million

Prices for diesel locomotives and bi-level cars were provided by GO Transit. The prices for the electric locomotive were developed from costs provided by Mr. J.S. Biln of BC Rail and information from equipment suppliers.

Table 5.1 – Rolling Stock Requirements – Lakeshore Line

Year	Electric Operation				Diesel Operation		
	Locomotives			Bi Levels	Locomotives		Bi Levels
	E60	New (E)	New (D)		F59PH	New(D)	(note 1)
2001 Existing					20		
2004 "New"	20		1				
2006 Replacement					-10	10	
2007 Replacement					-10	10	
2007 Expansion		3				4	12
2021 Expansion		3				4	12
2025 Replacement	-20	20					
Total	0	26	1		0	28	24

Notes

1 *Number of Bi level cars represents net difference between electric & diesel operation*

2 *New diesel locomotives are 4500HP units*

6. ELECTRIFICATION CLEARANCES

This section updates Chapter 10 of the Electrification Study, which addressed the vertical clearances, which would be required for electrification. This update looks only at those structures on the Lakeshore Line (East and West) which would be affected by electrification. Evaluated structures include road/rail overpasses, signal structures and station structures. The basic assumptions of the original study remain the same.

6.1 Electrification Clearance Requirements

The required minimum vertical clearance between the top of rail and the underside of the structure is found by summing the vertical space requirements of the track, rolling stock, overhead contact system (OCS) including electrical clearances, and the overhead structure tolerances. Vertical clearances requirements for electrification usually exceed the vertical clearance standards for non-electrified railways. Figure 6.1 illustrates the elements that make up the clearance requirements.

Following AREMA and CSA recommendations and guidelines, clearance requirements have been developed for both the "normal" and "minimum" cases as shown in Table 6.1. With the exception of the platform tracks at Union Station, all GO Transit routes must be available to freight trains. Rolling stock vertical dimensions for the GO Transit bi-level car and the CN Rail double-stack domestic container car were applied to derive vertical clearance standards. Nominal contact wire height above top of rail will be 7000 mm. At locations where vertical clearance is restricted, the height of the contact wire will be decreased to pass under the obstruction.

Table 6.1 - Vertical Clearance Requirements

	Vertical Clearance	Contact Wire Height
No Restriction	-	7000 mm
Passenger (minimum)	5500 mm	5135 mm
Passenger (normal)	6000 mm	5635 mm
Freight (minimum)	6900 mm	6535 mm
Freight (normal)	7400 mm	6885 mm

6.2 Existing Clearance Conditions

A vertical clearance of 7400 mm is normally required. There are existing structures in place, which do not meet the above requirement, with clearances, which fall either between 6900, and 7400 mm. Special engineering of the OCS must be applied where clearances fall between 6900 and 7400 mm. Where vertical clearance is below 6900 mm the clearance must be obtained by either lowering the track, raising the structure or a combination of both. Raising or lowering usually depends on the type of structure involved. In the case of a bridge or building it is usually more feasible and less costly to lower the track. Where, in the case of a light structure such as signal bridge, it is usually less costly to raise the structure to improve clearance. On the Lakeshore Line improvements have been made so that most structures now have a minimum clearance between 6900 and 7400 mm, with all new construction greater than 7400 mm.

An inventory of existing structures on the Lakeshore Line has been collected and those having insufficient clearance have been identified in Table 6.2. Due to the high cost of increasing clearances in the Hunter Street Tunnel near Hamilton, it was decided in consultation with GO Transit staff, for the purposes of this study the electrified line would stop at Burlington. Service to Hamilton would be by diesel locomotive.

Should a decision be made to proceed with electrification, clearances for all structures along the Lakeshore Line must be accurately established by field measurement.

6.3 Clearance Cost Implications

The most feasible and economical alternative to provide the required clearance for each of the structures has also been identified. As none of the structures can be eliminated it is assumed that clearances for road or rail passes will be increased through lowering the tracks while pedestrian overpasses and signal structures will be raised.

Cost estimates have been prepared using the original general assumptions listed in the original report and as listed below.

- all civil work carried out by third parties
- the railway will allow access to each site at no cost to GO
- the road authorities will allow access to each site at no cost to GO
- the railway will provide work trains and crews at GO's expense
- all work to be carried out at night time (some daytime work feasible)
- engineering/architectural services provided by third parties
- cost estimates in 2001 Canadian dollars.

As well an allowance of $6500 per structure per electrified track is included to cover security barriers to prevent human contact with the OCS.

6.4 Overhead Bridges

The original Electrification Study identified six rail/road bridges with less than 6900 mm clearance on the Lakeshore West Line and three on the Lakeshore East Line. It is assumed that the most economical and feasible method to provide the necessary clearance improvement would be through lowering the tracks. There are two methods for track lowering; undercutting and track removal. Where the track lowering can be accomplished within the existing track ballast, undercutting by special track equipment can be used. This does not necessitate the removal of track. This is usually restricted to locations where the lowering is 300 mm or less. Where track lowering will affect the subgrade it is necessary to remove the track to permit excavation, grooming and compacting of the new subgrade surface. Table 6.3 itemizes the unit costs for track lowering and Table 6.4 identifies the locations and total costs.

6.5 Pedestrian Overpasses

Pedestrian overpasses are generally light in construction and have short approaches. Raising the structure is considered the most cost effective alternative to increase the clearance. There is one overpass affected on the Lakeshore East Line at Danforth Platform. Security barriers would also be provided. The estimated cost for raising and providing security barriers is $325,000 as shown in Table 6.5.

6.6 Signal Structures

For signal structures where clearances are inadequate, raising the structure is generally the most viable alternative when considering cost and feasibility. On the Lakeshore West Line many of the existing signal structures have adequate vertical clearance. This study has therefore assumed that 30 signal structures, or about one-third of the total will require modification. The additional headroom would be provided by relocating the existing units on higher concrete piers adjacent to the existing foundations. Protective guards would also be provided on the structures as additional protection for maintenance personnel, against coming in contact with the OCS. Refer to Table 6.6 and Table 6.7 for unit costs and total costs respectively.

6.7 Train Shed

GO Transit uses 6 of the 12 tracks at Union Station, which are covered, by the train shed. To maintain operational flexibility, however it would be prudent to electrify all 12 tracks. The minimum clearance under the shed is 5260 mm, considerably less than the minimum clearance requirement of 5500 mm for electrification under passenger operation. The 1992 electrification study concluded that it would be impractical to lower the track through the station and recommended the clearance be improved by raising the roof. It is expected that the train shed will be replaced by a new roof within 10-12 years as part of GO Transit's Infrastructure Improvement Program for the Union Station corridor. The new roof would provide the required headroom for electrification. This study assumed, therefore, that the electrification project would fund the cost of the new roof for 10 years after which time the roof cost would be assigned to the Infrastructure Program. The estimate assumptions contained in the original report remain the same. Table 6.8 itemizes the costs associated with the new roof.

6.8 Cost Summary

The total cost required to achieve the required clearances for electrification is approximately $39 million as summarized in Table 6.8.

Figure 6.1 – Electrification Clearance Requirements

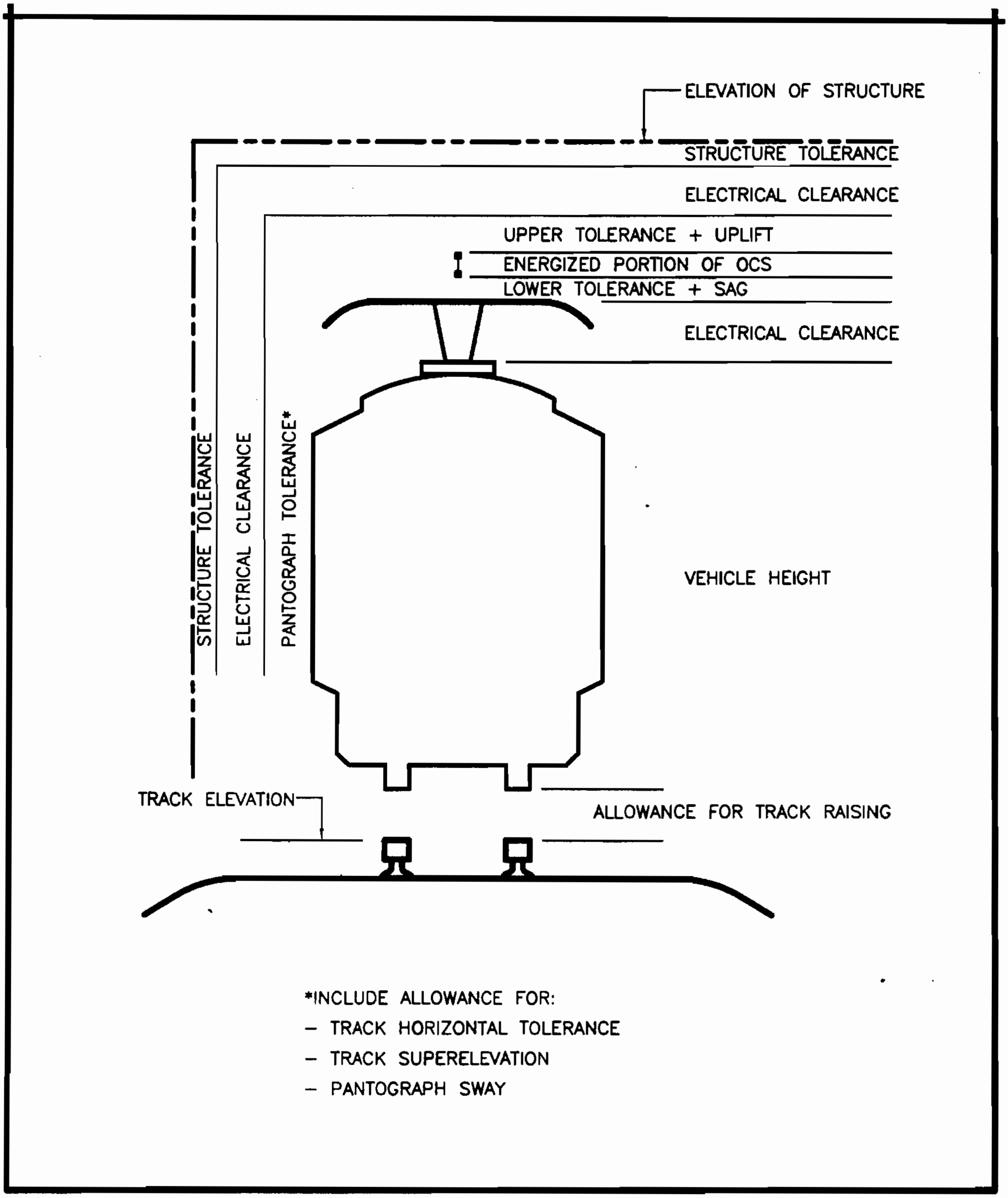


Table 6.2 – Structures with Insufficient Clearance

Structures - Clearances	Recorded Clearance	Minimum Clearance Required	Additional Clearance Needed
Lakeshore East			
Main Street	6575	6900	325
Danforth Platform (ped)	6550	6900	350
Birchmount	6700	6900	200
Union Station			
East End	5260	5500	240
West End	5260	5500	240
Lakeshore West			
John Street (Walkway	?	5500	
Peter Street	?	5500	
Spadina	6700	6900	200
Dufferin	6450	6900	450
Dunn	6450	6900	450
Jamieson	6750	6900	150
Dowling	6575	6900	325
Brown's Line	6750	6900	150
Hamilton Area			
Dundurn (SWYE)	6248	6900	652
Main Street	6517	6900	383
Locke Street	6337	6900	563
Pearl Street	6383	6900	517
Ray Street	6840	6900	60
Hunter Street Tunnel			
North Portal (Sta. 6769.7)	6655	6900	245
Mile 58 (Sta. 6525)	6754	6900	146
Sta. 6480	6883	6900	17
Park Street	6413	6900	487

Table 6.3 Clearances - Overhead Bridges - Unit Costs

Method	Item	Units	Lowering Cost
Undercutting	Excavation and Flagging	metre	$86
	Track Ballast and Alignment	metre	$89
	Total		$175
Track Removal	Track Removal	metre	$33
	Excavation	metre	$108
	Shoring/Track Protection	metre	$104
	Drainage	metre	$65
	Track Replacement	metre	$72
	Track Ballast and Alignment	metre	$127
	Flagging	metre	$20
Total			$529

Table 6.4 Clearances - Overhead Bridges - Total Costs

Subdivision	Description	Mile	Existing Clearance	Track Lowering	Track Length	# of Tracks	Lowering Cost	Security Barriers	Total Cost
Oakville	Brown's Line	9.41	6750	150	310	3	$162,750	$19,500	$182,250
	Dowling	3.02	6575	325	1525	4	$3,226,900	26,000	$3,252,900
	Jameson	2.85	6750	150	inc.	4		26,000	$26,000
	Dunn	2.69	6450	450	inc.	4		26,000	$26,000
	Dufferin	2.38	6450	450	inc.	4		26,000	$26,000
	Spadina	0.69	6700	200	360	8	$504,000	52,000	$556,000
Kingston	Kingston	321.45	6325	575	600	3	$952,200	19,500	$971,700
	Birchmount	326.6	6700	200	360	4	$252,000	26,000	$278,000
	Main Street	328.64	6575	325	430	4	$909,880	26,000	$935,880
Total	9 Locations								$6,254,730

Table 6.5 Clearance - Pedestrian Overpasses

Subdivision	Description	Mile	Existing Clearance	Cost
Kingston	Danforth Platform	326.22	6550	$325,000

Table 6.6 Clearances - Signal Structures - Unit Costs

Item	Units	Cantilever Cost	Bridge Cost
Flagging	per structure	$2,600	$2,600
Excavations/Backfill	per structure	650	1300
Foundations	per structure	2600	5200
Extend Cabling	per structure	2600	2600
Reposition Structure	per structure	3250	5200
Employee Safety Guards	per structure	5200	7800
Total		$16,900	$24,700

Table 6.7 Clearances - Signal Structures - Total Costs

Location	Description	Count	Unit Cost	Cost
Lakeshore	Signal cantilevers	33	$16,900	$557,700
	Signal Bridges	60	$24,700	$1,482,000
	Total (all locations)	93		$2,039,700
Total	Number locations requiring adjustment		30	$657,968

Table 6.8 Clearances - Train Shed - Total Cost

Item	Units	Quantity	Unit Cost	Cost
Demolition	m^2	32,000	$130	$4,160,000
Concrete Foundations	m^3	200	1000	$200,000
Structural Steel	tones	1450	3900	$5,655,000
Roofing	m^2	32,000	100	$3,200,000
Misc. Architectural				1,300,000
Mechanical				2,600,000
Electrical				2,600,000
Total				**$19,715,000**

Table 6.9 Cost Summary for Clearance Program

Item	Basic Cost	Contingency 25%	Engineering 10%	Total (Rounded)
Overhead Bridges	$6,254,730	$1,563,683	$625,473	$8,400,000
Pedestrian Overpasses	325,000	$81,250	$32,500	$400,000
Signal Structures	657,968	$164,492	$65,797	$900,000
Station Shed Roof	19,715,000	$4,928,750	$1,971,500	$26,600,000
O/Head Power Lines	2,000,000	$500,000	$200,000	$2,700,000
Totals	$26,952,698	$6,738,174	$2,695,270	**$39,000,000**

7. ENERGY UTILIZATION ANALYSIS

Train Performance Calculations (TPC's) were developed to:

- Determine electric power, electric energy and diesel fuel requirements
- Determine journey times for trains.

7.1 TPC Model

The TPC model used for this study is the TRANVOL multi-train model. The model performs all the conventional TPC modelling for each train and in addition determines the daily maximum demand and energy requirements and catenary voltage profiles for electrified railways.

7.2 Options Simulated

The following options were studied:

- Diesel traction with F59PH locomotive
- Electric traction with E60C locomotive.

7.3 Assumptions for Simulations

The simulation was based on the current GO Transit timetable for week and week- end days. The simulation covered the Oshawa – Union Station – Burlington line without the Burlington – Hamilton section, but the total daily mileage was adjusted to get a mileage within 10% of the Oshawa – Hamilton daily train mileage. The trip times produced by the simulation were within 10% of the actual trip times. Peak hour schedule simulated was Union Station to Burlington and Union Station to Oshawa.

Train consists were assumed to have one locomotive and 10 passenger cars. The passenger cars were assumed to be fully loaded 64 tons/car.

Both diesel and electric traction was simulated.

- For diesel simulation a generic 3000 HP locomotive was used, based on the F59PH 3000HP locomotive characteristics. The maximum speed for this simulation was 95 km/h with an acceleration of about 0.7 m/sec/sec. The fuel consumption was evaluated on the basis of 0.28 litre / kWh energy requirement

- For the electric traction two versions were considered:

  - Simulation of a generic electric locomotive with the performance characteristics of a 3000 HP diesel 95 km/h maximum speed, but higher efficiency 87% for the electric locomotive versus 82% of the diesel.

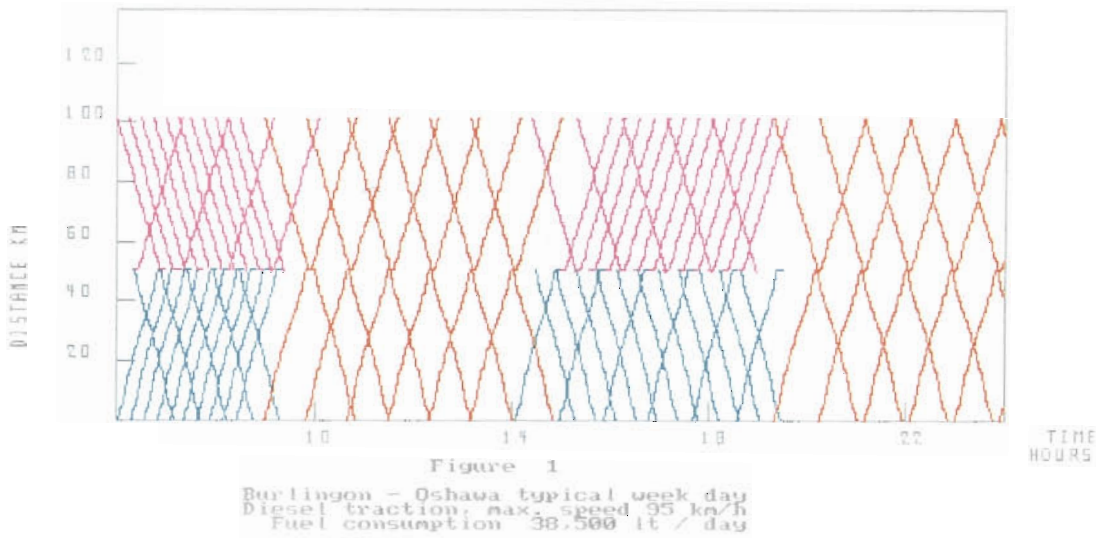
  - Simulation of the 5660 kW E60C locomotive with characteristics as specified for this locomotive. This simulation used a top speed between station of 125 km/h.

The daily mileage used for all simulations was 3500 train-miles for a weekday and 1400 train-miles for a weekend day, no distinction between Sundays and Saturdays or holidays.

7.4 Results of Simulations

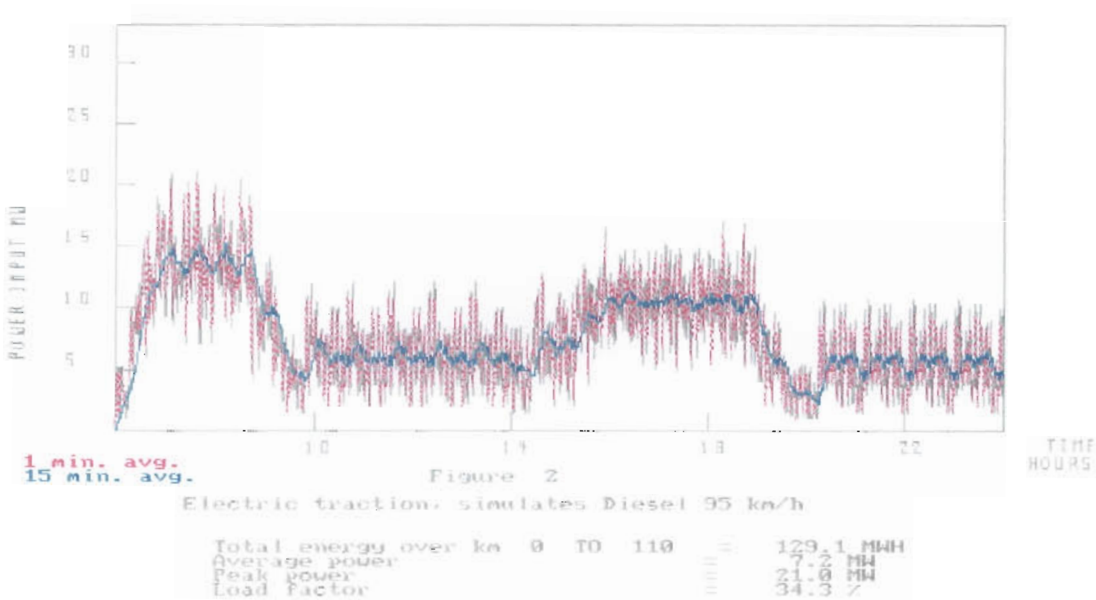
The results of the simulations are shown in Figures 7.1 to 7.6 and may be summarized as follows:

- The daily energy consumption generated by the simulation model was about 38,000 litres of fuel, which is an ideal consumption, and would correspond to about 45, 000 litres in real life (with back travels, slow downs between stations etc. etc.). This compares with the GO Transit figure which amounts to roughly 50,000 lt./week day.
- When considering electric traction, the equivalent for the simulation of a 3000 HP diesel with electric traction has an energy consumption which is about 6% less than the diesel version, due to the higher locomotive efficiency.
- Using the E60C locomotive with 125 km/h max. train speed , the electric energy consumption is about 25% higher.
- The electric traction has a daily load factor of close to 50% when the whole Lakeshore line is considered to be supplied from one source, at least from the point of view Hydro billing.
- Trackside substations are envisaged at Burlington, Pickering and Union Station.
- The capacity of each station is assumed to be 2 x 20 MVA transformers.



Purple lines - Burlington – Union Station
Green lines - Oshawa – Union Station\
Red L lines - Burlington - Oshawa

Figure 7.1



Electric Power Demand in MW Burlington to Oshawa
Based on 0.28 litre diesel/kWh
Max. speed 95 km/h
Fuel equivalent = 36,000 lt/day

Figure 7.2

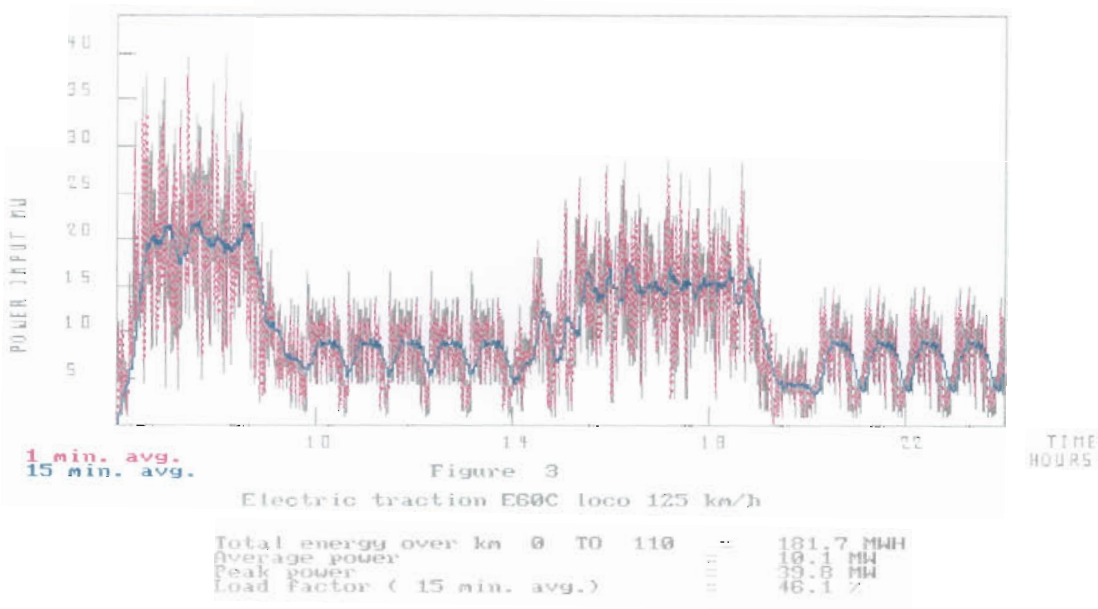


Figure 7.3

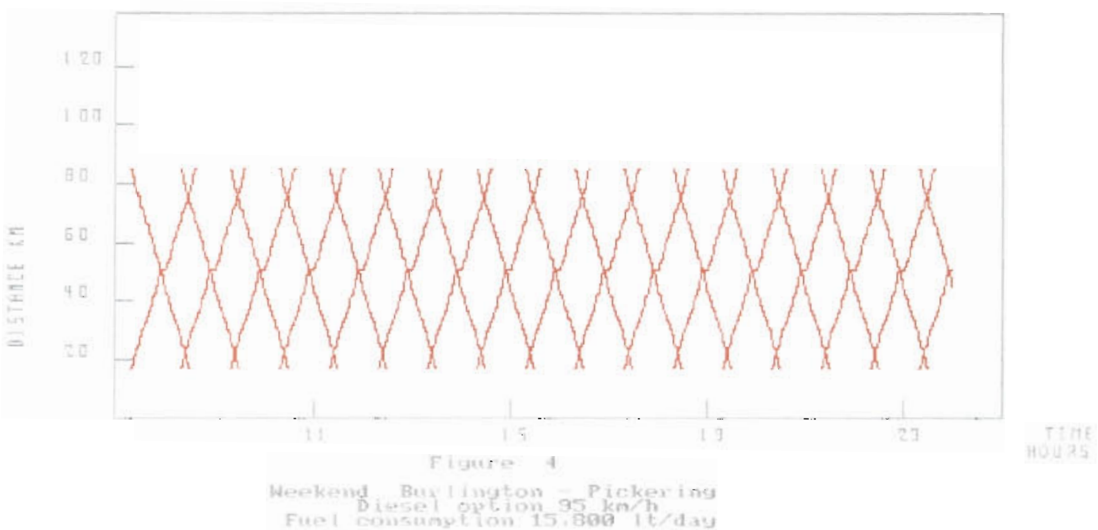


Figure 7.4

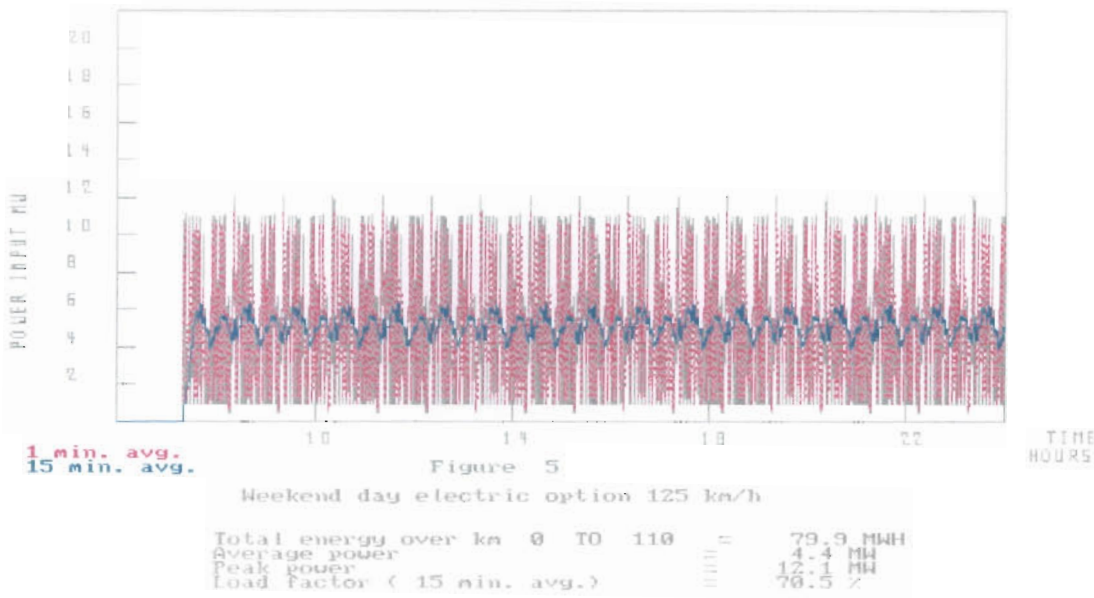
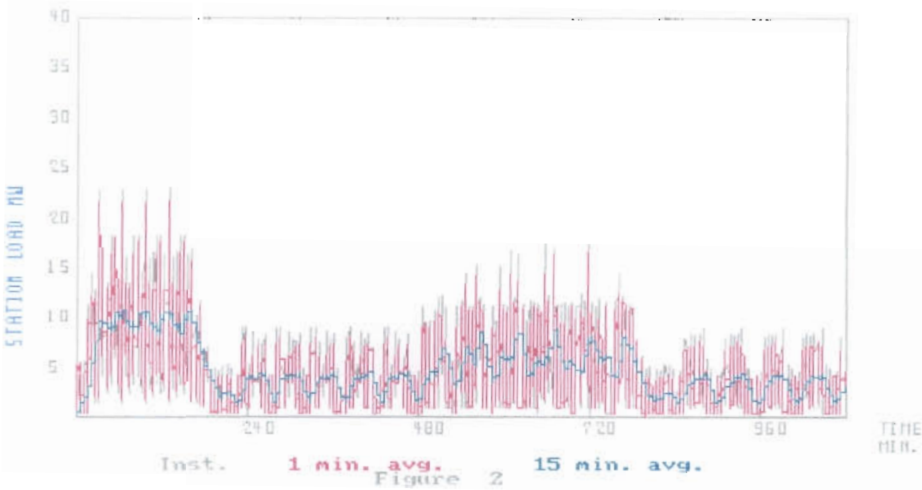


Figure 7.5

Burlington Trackside Substation – Weekday Load Curves
Load Factor 56%
Max. 15 min. daily peak load 12 MVA

Figure 7.6



Oshawa Trackside Substation – Weekday Load Curve
Daily Load Factor 48%
Max. 15 min. daily peak load 11 MVA

Figure 7.7

8. ELECTRIFICATION

8.1 Overview

The 1992 Study concluded that a ± 25 kVac overhead catenary system would be the most cost effective method of electrifying the GO Rail System. This conclusion is still valid, but must be confirmed by a detailed feasibility analysis at the next stage of this project.

The +/- 25 kV system consists of the usual contact wire and messenger wire, and a feeder wire, the two 25 kV poles. Supplying the catenary at +25 kV and the feeder at –25 kV allows 25 kV clearance requirements while providing some of the advantages of 50 kV including longer distances between substations. Main feeder stations can be separated by distances of up 100 km. Autotransformer stations used to convert power from the feeder circuit to the catenary circuit are typically spaced 10 km apart. The autotransformers are installed with their centre point grounded and tied to the rails. Thereby the potential of either of the two poles is 25 kV to rail to supply the locomotive. On the high side of the autotransformer the current circulates in a loop through the two poles, which forms a single phase 50 kV system.

A conceptual arrangement of the electrified lakeshore Line is shown in Figure 8.1, at the end of this section.

8.2 Overhead Catenary System (OCS)

This section covers the 25 kilovolt 60 Hz AC Overhead Contact System as was studied and reported in Section 9 of the 1992 Study.

8.2.1 Basis for the proposed OCS system design

As was the case in the 1992 study, a proven, efficient and cost effective OCS system was assumed, based on the system constructed for the British Columbia Railway (BCR) for its Tumbler Ridge Branch Line in 1983. This 133 km (83 mile) long system is unique in its design in two important ways:

1. The OCS was designed from components proven in service on the Swedish State Railways, in a severe climate similar to Canadian climate extremes. The manufacturing drawings and rights to use these components were acquired by Transport Canada for use by BCR and anywhere else in Canada in 1982. In the process of the design of the BCR system, the Swedish manufacturing drawings were updated to materials and fasteners available locally in Canada, meeting ASTM and CSA specifications. Thus over 90% of the value of the OCS was purchased from local Canadian manufacturers with very short delivery time and at lower prices than for similar imported catalogue items. Replacement or additional parts are also easily obtained from the same or alternate manufacturers using these drawings even many years later.

2. The foundations for the steel masts for the OCS were driven steel H-section piles, which were much less costly and faster to install than the usual poured concrete bases used in nearly all foreign electrification construction. The steel pile foundations were designed and tested for strength and deflection under load by BCR's engineers before installation. The BCR installation rate averaged 15 foundations per day for one 2-man pile driving crew and a 2-man welding crew. As time for track access is especially important for the GO Lakeshore line, this method is recommended. It is also less costly than using poured concrete

foundations. In most cases, it may be possible to install the pile foundations for GO Transit working off-track.

8.2.2 Methodology

To develop an up-to-date cost estimate of the OCS material, new prices for a majority of the value of items used to construct the British Columbia Railway OCS at Tumbler Ridge BC were obtained from potential suppliers. Manufacturing drawings for selected components and materials were sent to some of the original suppliers to BCR and to eligible new suppliers in eastern Canada, mostly in Ontario and prices obtained for conservative quantities of material representing about 50 kilometres of single track OCS construction. Price escalation factors were then calculated, comparing the December 2000 quotes to the original actual prices for the same items from the 1983 BCR a construction. The escalation factors were then applied to all items in the same category using the 1983 actuals for items for which new quotations were not obtained.

The presumption is made that the final design of the OCS for GO Transit will be sufficiently similar to the BC Rail system (except for the 50kV voltage) that component and material prices will be the same. In addition, there will be substantial OCS material supplied at no charge with the purchase of the General Electric E60C electric locomotives. The use of a reasonable estimated quantity of such material is shown as a line item cost reduction from the estimate of OCS material cost. The most significant value items which may be used from the material supplied with the locomotives will be the hard-drawn 107mm^2 copper trolley wire, the 70mm^2 stranded copper messenger wire, ACSR 4/0 ground and feeder wires and galvanized steel H-sections which will be used as pile foundations for new fabricated poles. Open fabricated poles in an "A" shape with the long side perpendicular to the track are preferred to structural tubes or H sections for poles because they're much lighter, less expensive, and have a much lower visual cross section, hence less obtrusive appearance than the solid structures have. The only negative point about these poles is that they will require anti-climbing screens where they are accessible to the public, as they are relatively easy to climb. The cost of these screens is included in the estimates.

As the entire BC Rail OCS system may become available, there may be a cost saving compared to new material. No figures for this possible saving have been established as BCR has not been able to determine a price at this time.

Construction labour costs for erection of the OCS has also been derived from the BC Rail actual costs for the contractor installed portions of the Tumbler Ridge line. These costs have been adjusted for the wage escalation from 1983 to 2001, for the geographic location from Tumbler Ridge BC to the GTA and for the probable lower productivity working on the Oshawa to Hamilton tracks of GO Transit, CN Rail and the TTR due to restricted available track time. Some of the work can be done off track and it is intended that this will be an objective in the construction plan. The use of special machines, wire trains etc. will improve productivity.

8.2.3 Price Review of OCS Parts

This price review was conducted through the selection of the most costly items of steel parts, copper wire items and some clamps and holders. The drawings for the selected items were sent out to numerous Canadian vendors to bid. Bid quantities were adjusted to meet the GO Transit requirement and then reduced to a lesser quantity to conceal the purpose of the enquiry.

The OCS parts were divided into 37 priced categories based on known cost incurred by BCR during their project. Inquires were sent out for some 40% of these categories. The value of the goods represented some 60% of the original total BC Railway OCS costs. Responses from the vendors to our inquires provided December 2000 pricing on 57.2% of the original 1983 BCR costs.

In order to arrive at a current total OCS cost for this project the updated costs for the quoted items were factored against the original BC Railway costs per mile for the material. The not-quoted items, which consist mainly of small steel hardware parts, fasteners and electrical items were also factored based on an average for the type of goods, to arrive at a December 2000 estimated cost per mile. This updated cost per mile was then applied to the total mileage based on upon CN's Great Lakes Region Track Condensed Profile for Oakville and Kingston Subdivisions. It was estimated based upon the current four, three and double track line that there is the equivalent of 152 miles of single track, which would require OCS. An additional 9 miles of track at the Willowbrook Yard was assumed to require electrification.

Adjustments to the cost of portals, which will span 3 and 4 tracks was made by obtaining new quotes for the estimated number of portals some five times more than the number installed by BCR. A typical portal setup is shown on drawing 1-503412 copy in the attached drawings list.

The hard drawn copper trolley wire has been quoted in accordance with specification ASTM B47-64 copy attached for the AWG # 4/0 or 211,000 circular mills, 107 mm^2 size as was used on BCR.

The materials for the OCS system when comprised of all new materials will cost an estimated total of $26,520,000 for the estimated 161 miles of equivalent single track not including material overhead and contractor's profit. Freight, customs duties are added in the Cost Tables. GST/PST are extra, not included as they should be refundable where applicable.

Reductions in material costs can be obtained through the acquisition of surplus materials and used materials. In particular the acquisition of steel H - Beams, trolley wire and messenger wire which has been located in Mexico and in Texas with the General Electric E60C locomotives are like new and have never been used. These items are estimated to have a replacement value of $3,791,000. There are additional "free" materials that will come with the locomotive purchase which have not been estimated as this will involve a more complete design stage to decide where they can be used. The cost saving through use of such material might represent another $1.0 million. This value just represents a possible contingency and is not included in any of the cost figures.

The OCS cost estimate is summarized in Table 8.1. Details of the OCS cost estimate may be found in Appendix B.

**Table 8.1 - Total OCS Cost Estimate
Burlington-Union Station-Oshawa**

New Material	**$26,520,000**
Less Savings on Estimated Use of New Mexican Material	**–3,791,000**
Net OCS Material Estimate	**$22,729,000**
Installation Labour, Engineering and Other Charges, Net Estimate	**$26,768,000**
Grand Total Estimate for 161 Miles of Single Track or Equivalent	**$49,497,000**
Contingency @ 15%	**$7,424,000**
Total	**$56,921,000**

Notes:

1. *Some additional value of material from the Mexican Project and BC Rail may be used as will be determined in a final design.*

2. *The cost is roughly proportional to single track mileage length and can be adjusted proportionally for additions and deletions in track length to be electrified.*

3. *Material estimates are based on representative samples of December 2000 quotations. Labour costs were estimated by escalation of 1982 actual costs using StatsCan construction cost data.*

4. *Does not include any cost for raising of power lines if not paid by the power company. Clearance required over top of OCS and a power line is 3.0 metres.*

8.3 Power Supply to the OCS

This section updates Section 9.5 of the 1992 Study, which addresses the electrical power supply requirements for the electrification project. This update assumes that the +/- 25 kV ac system would be selected for the Lakeshore Line. The basic configuration of the power supply remains as detailed in the original study.

8.3.1 Capacity and Location of Feeder Stations

The capacity of the substations is selected to allow for an extended outage at any power equipment without adverse effect on train operations. The traction power analysis has determined that using 25 kV ac requires three trackside feeder stations, one near Union Station and one near each end of the east and west sections. This would allow the electrification system to meet the basic criteria of maintaining full supply to the system with any one substation out of service.

8.3.2 High Voltage Supply to Feeder Stations

The three main feeder stations will likely be fed at either 230 kV or 115 kV, via underground feeders or overhead feeders, depending on location. Due regard to power demand, voltage profile, load flow, load unbalance, harmonic analysis, supervisory control and data acquisition and protection, along with safety and electromagnetic interference must be given. Detailed studies and engineering will be required to finalize this conceptual work.

Discussions were held with Hydro One (formerly Ontario Hydro) to assess the feasibility of supplying power to three locations, namely: in the vicinity of Union Station, Burlington Station and Pickering Station. The findings of this initial assessment are summarized below for each station location.

Union Station: The downtown Toronto area has only 115 kV and 13.8 kV supply. For 25 kV or 50 kV supply, 115/50 kV or 115/25 kV transformation would be required. Bulk supply to Toronto is from Leaside TS and from Manby or 115/25 kV TS. Best reliability and least system impact would be achieved if the two proposed substations are provided with totally independent supply. Potential connection locations are as follows:

Station #1: At John TS or at Strachan TS via 115 kV underground cable. John TS is closer to the preferred site, but we may have difficulty providing a cable connection since the site is very congested. Space should be available at Strachan TS, but that station is farther from the preferred site – near the east entrance to the Canadian National Exhibition.

Station #2: At either one of the Hearn TS to Esplanade TS overhead circuits or at one of the Hearn TS to Leaside TS overhead circuits between Lakeshore Blvd. And Front Street.

Burlington: The Burlington area has 230 kV and 27.6 kV supply. For 50 kV supply, 230/50 kV transformation would be required. The most likely connection location would be one of the Burlington TS to Cumberland TS 230 kV overhead circuits.

Pickering: Pickering area has 230 kV and 44 kV supply. The 44 kV facilities at Cherrywood TS and at Thornton TS are approaching capacity and are not suitable for the duty intended. The feasibility of providing supply to a 230/50 kV substation has also been considered. 230 kV circuits between Cherrywood TS to the Pickering Nuclear station cross over the eastern side of the preferred location. It would likely be extremely difficult to obtain approval to connect load to these circuits due to the licensing requirements of Ontario Generation's Pickering NGS. North of Finch Ave., any one of several 230 kV circuits terminating at Cherrywood TS are potential connection candidates.

8.3.3 Cost of Feeder Substations

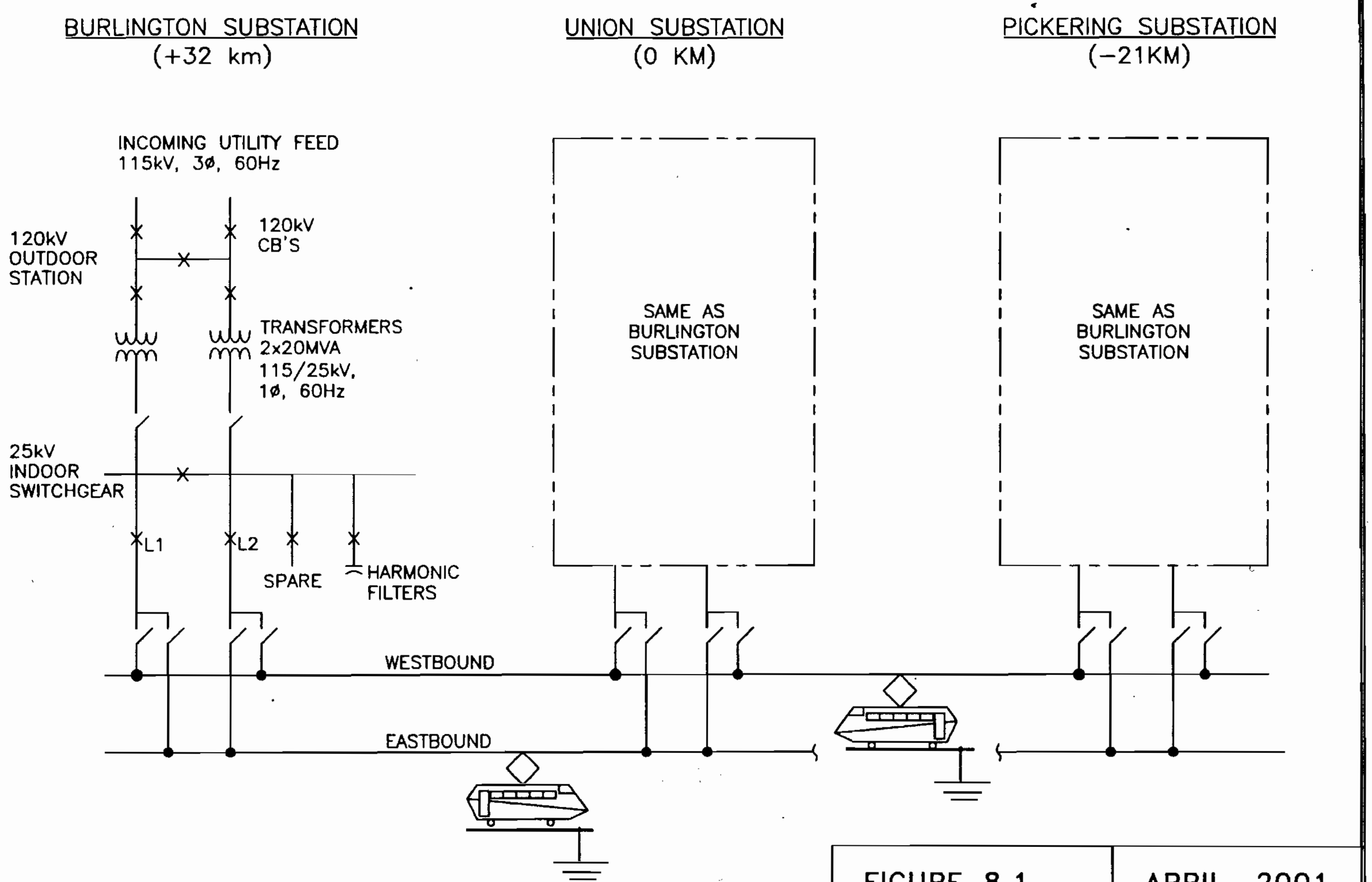
The estimated cost of the feeder substations is $24.5 million as shown in Table 11.2 in Section 11 of this report.

8.3.4 Cost of High Voltage Connections

Preliminary feasibility level cost estimates were provided by Hydro One for the high voltage connections to the three substation locations identified previously. These costs are summarized in Table 8.2.

Table 8.2: Summary Cost Estimate for High Voltage Connections

Union Station Area	$10,000,000
Burlington Station Area	$10,500,000
Pickering Station Area	$7,500,000
Subtotal	$28,000,000
Contingency 25%	$7,000,000
Total	**$35,000,000**



HATCH MOTT MACDONALD

FIGURE 8.1	APRIL, 2001
GO TRANSIT ELECTRIFICATION STUDY UPDATE SINGLE LINE SCHEMATIC	

9. SIGNALLING AND COMMUNICATIONS

9.1 Introduction

Railway signalling ensures the proposed route for a train or engine is safe. In doing so the signal system checks all track conditions, such as opposing routes, broken rail check and ensures that all switches in selected route are locked. Most signal systems also alert engineman of the impending conditions ahead, such as speed requirements, routes and upcoming stops.

The track is configured with areas, which allow switching. These areas are called interlockings. An interlocking consists of an arrangement of switch machine signals and track circuits.

Switch requests, signal requests and indication circuits for an interlocking are generated and processed by a non-vital office control machine. The office may be located hundreds of miles away from the interlocking. This requests/indications can be sent by copper cable and modems or a fibre optic system

All requests are processed by vital interlocking equipment. Typical vital wayside signal equipment used are, electro mechanical relays, stand alone electronic detectors, and computers. This equipment is designed and checked using failsafe technology and techniques as recommended by the America Railways Engineering and Maintenance of Way Association (AREMA).

The whole signal system is based on train detection. On the current the GO lines, track circuits perform train detection. A track circuit detects the presence of a train by sending electrical current along the rails. This current is detected by a vital detector, such as a relay. The limits of track limits are established by the installation of insulated joints.

A meeting was held with CN Rail staff to discuss the project and more specifically, to address issues related to signalling. CN staff provided valuable input to the study including advice on the cost estimates for the signal upgrades. This information was incorporated into the study.

9.2 Interaction Between Electric Traction and Signalling

On electrified railroads the rails typically serve as the return conductors for propulsion current. Track circuits must function in the presence of propulsion currents, which may be hundreds of times greater than the track-circuit current flowing in the same rail. DC track circuits cannot be relied upon to operate in this environment. Immunity from propulsion currents may be achieved with frequency and different AC track circuits

9.3 Re-Signalling GO Transit Routes

Existing signalling, specifically the track circuits on GO Transit routes are incompatible with railway electrification, therefore, the existing signal system must be modified or replaced with equipment that will co-exist with traction return currents. In addition, impedance bonds, which allow passage of current from adjacent track circuits, must be installed.

The new track circuit equipment may require additional insulated joints (DC track circuits can be longer than AC). In addition, tuned impedance bonds, which allow passage of current from adjacent track circuits, must be installed.

When considering new signal technology the requirements of future operational requirements such as closer headway's and high-speed trains must be considered. Some other areas that should be taken into consideration are; interface with existing equipment (control office or fibre optic system), requirement for wayside signals, Automatic Train Control (ATC), Communication Based Train Control (CBTC).

9.4 Added Benefits of Re-Signalling

Most modem electrification schemes have involved the substantial replacement and/or rebuilding of signalling equipment. The necessary investment in re-signalling carries substantial advantages in maintenance and in train operation development such as tighter headways. A new signal could also easily accommodate the supervision of electric power breakers and disconnects and would also permits optimum siting of signals in relation to OCS.

Signal upgrading also allows for more comprehensive testing and commissioning of equipment prior to operational changeover and avoids the serious operational disruption if existing equipment is temporarily shut down for modifications and testing.

9.5 Cost Estimate for Signalling Upgrades

Basic track circuits must be retrofitted with impedance bonds and vital track relays to ensure compatibility with electric train operation.

All level crossings must also be retrofitted if the line is electrified. The total cost of the required signally upgrade program is estimated to be $48 million as shown in Table 9.1.

9.6 Cost Estimate of Re-Signalling

For a complete wayside signal system including cab signalling generators, impedance bonds, the cost is estimated in the range of $ 250,000 to $400,000 per track km, therefore the estimated cost of resignalling the Lakeshore line (490km) is estimated between $120 million and $200 million.

Cab signalling, including automatic "speed enforcement" according to signal status ahead, costs about $100,000 per driving cab, installed.

9.7 Electric Traction and Railway Communication Facilities

Electrification as proposed would cause troublesome interference to open pole line communications and unshielded cables in proximity to the railway right-of-way. However two or more modes of communication are virtually unaffected by electrification.

Mobile train radio VHF and UHF frequencies have been found to be unimpaired.

Fibre optic cable is inherently immune to interference and is a technology currently by CN onto the Lakeshore line.

9.8 Electromagnetic Interference

Further to Section 7.2.3, in the 1992 report, it is anticipated that very little, if any, new electromagnetic interference will be noticed outside the railway right-of-way by users of modern electronic devices lawfully connected and installed. However, to deal with any claims from users of affected equipment, a contingency of $5 million is recommended for site-specific remedies. It is unlikely that any such problems will be identified before electric trains actually start to run in the area.

9.9 Future Signalling/Communication System Upgrades

It is recommended that any future upgrades be specified as electrification compatible systems or at least suitable for upgrading by modular additions.

Table 9.1 – Signal Equipment Upgrades – Cost Estimate

Basic track circuit retrofit			
Vital track relay	1500		
track transformers(2)	500		
wire	200		
tags	100		
Misc	200		
Labour to install (2 men @ 8hrs @ $75 hr)	1200		
Labour to test (2 men @ 8hrs @ $75 hr)	1440		
Engineering/cad work	2000		
Impedance bonds	5000		
CN Rail Adjustment	7860		
	$20,000		
Additional interlocking equipment / work			
100 hz frequency generators 1 per interlocking	25000		
Cabling 2c # 4 for 100 hz feeds (estimate 8000m per interlocking, cable $12.5 labour $12.5 per m)	200000		
CN Rail Adjustment	75000		
	$300,000		
Level Crossing upgrades			
Engineering	15000		
Modify GCPs includes labor and testing	70000		
CN Rail Adjustment	15000		
	$100,000		
Cost of basic upgrading to 100 hz Track circuits			
	Locations	**Cost per**	**Total**
Level crossing retrofits	15	100000	1500000
Track circuit retrofit	1600	20000	32000000
Additional Interlocking equipment and installation	27	300000	8100000
Subtotal			$41,600,000
Contingency	15%		$6,240,000
TOTAL (Rounded)			**$47,800,000**

10. ENVIRONMENTAL CONSIDERATIONS

This section provides a short update of Section 7 in the 1992 report. It is not intended to repeat the previous report here.

Electrification of the GO Transit system would result in significant environmental improvements in the following areas:

- Air quality
- Noise
- Hydrocarbon spills.

With regard to air quality, electrification provides the opportunity to reduce greenhouse gases such as CO_2 and acid rain caused by NO_x emissions. This is particularly beneficial at rail yards and at railway stations and along busy transportation corridors such as the Lakeshore Line and adjacent highway system.

The 1992 electrification report, quantified the benefits of electrification with regard to noise. Marked improvements in noise levels, particularly adjacent to rail yards and at stations, would be realized with electrification. Sound level reductions of 2 to 10 dB have been predicted with electrification.

The elimination of fuelling requirements with electric trains would result in a significant reduction of fuel and cooling water spillage and reduction in the spillage of solvents used to clean diesel locomotives.

The following may be considered negative environmental aspects of electrification:

- Visual impact of the overhead catenary. This can be greatly reduced with good design and slender catenary supports.
- The high voltage catenary presents a potential hazard to railway operators and the public. This issue can largely be mitigated by good design and through adequate training of railway personnel.

In terms of environmental approvals for the undertaking, it is not clear if the proposed undertaking will trigger an environmental assessment or if an exempting Declaration Order would be granted. The 14 month schedule assumed in this report for environmental and other approvals would be a minimum for this type of undertaking.

11. COST ESTIMATE SUMMARY

11.1 Context

This section summarizes the cost estimates developed in preceding sections of this report.

The emphasis of this study was to compare the costs of electric and diesel operations, therefore the work on capital and operating cost estimates focussed on those items considered to differentiate between electric and diesel operation. The derived total cost estimates, used in the economic analyses, therefore do not represent a definitive cost estimate for either the electric or diesel operation; they only serve as a basis of comparison between the two. All cost estimates are expressed in 2001 constant (Canadian) dollars.

11.2 Capital Cost Estimates

The capital costs for both the electric and diesel operations are summarized in Table 11.1. Further breakdown of the estimates are shown in Table 11.2.

An initial investment of approximately $300 million will be required in order to electrify GO Transit's operations on the Lakeshore Line, including the purchase of 20 refurbished electric locomotives.

11.3 Operation and Maintenance Costs

Tables 11.3 and 11.4 summarize the operating and maintenance costs carried forward to the economic analysis.

Table 11.1 – Capital Cost Estimate Summary (Years 2001 to 2025)

Item	Year	Electric Operation Number	Electric Operation $ x 1000 Each	Electric Operation $ x 1000 Total	Diesel Operation Number	Diesel Operation $ x 1000	Diesel Operation $X1000
1 Electric Locomotives	2001/4	20	3,800	76,000	-	-	-
	2007	3	6,000	18,000			
	2021	3	6,000	18,000			
	2025	20	6,000	120,000			
2 Diesel Locomotives	2006				10	5,200	52,000
	2007				14	5,200	72,800
	2021				4	5,200	20,800
3 Bi Level Cars (Additional)	2007				12	2,600	31,200
	2021				12	2,600	31,200
4 Overhead Catenary System (OCS)		1	56,900	56,900			
5 Traction Power Substations		1	24,500	24,500			
6 Hydro Connections		1	35,000	35,000			
7 Signal Modifications		1	47,800	47,800			
8 Overhead Clearance Program		1	39,000	39,000			
9 OCS Maintenance Facility		1	3,000	3,000			
10 Electric Loco Maintenance Facility		1	15,000	15,000			
11 Property/Approvals/Permits		1	1,000	1,000			
Total				**$454,200**			**$208,000**

Notes:
1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that help differentiate between the two modes of opeartion have been considered.***
2. ***Costs are in 2001 constant $***

Table 11.2 – Cost Estimate Details

		Diesel		Electric	
1. Locomotives		**F59PH**	**4500HP**	**Refurbished**	**New**
Unit Cost				1,500,000	
Conversion to AC traction				1,200,000	
Gearing Modifications				90,000	
Truck Modifications				300,000	
Blended Braking Modifications				80,000	
MU Cables				20,000	
Coupler				20,000	
Cab & Window and external modifications				150,000	
Testing/Certification				50,000	
Subtotal				3,410,000	
Contingency	10%			341,000	
Total Each Locomotive		**3,300,000**	**5,200,000**	**3,800,000**	**6,000,000**
2. Overhead Catenary System					
Material Cost (New)				26,519,858	
Adjustment For Used Material				(3,791,243)	
Engineering and Installation Labour				26,768,000	
Subtotal				49,496,615	
Contingency	15%			7,424,492	
Total OCS Cost (Rounded)				**56,900,000**	
3. Feeder Substations					
Main Substation - Union				9,051,000	
Labour	1701000				
Material	6750000				
Other	600000				
	9051000				
Feeder Substations - Burlington & Pickering				3,510,000	
Auto Transformers (11 @10km spacing)				4,950,000	
Subtotal				17,511,000	
Contingency	25%			4,377,750	
Engineering	15%			2,626,650	
Total Substation Cost(Rounded)				**24,500,000**	
4. Overhead Clearance Program					
Overhead Bridges				8,400,000	
Pedestrian Overpasses				400,000	
Signal Structures				900,000	
Train Shed Roof				26,600,000	
Overhead Power Lines (allowance)				2,700,000	
Total Overhead Clearances				**39,000,000**	
5. Signal Modifications					
From detail worksheet (Table 9.1)				**47,800,000**	

Table 11.3 – Annual O&M Costs – Diesel Operation

Fuel	km/year	l/km	Litres/yr	$/litre	Total $
Fuel 2004 to 2007	2,016,714	9.0	18,200,000	0.52	9,464,000
Fuel 2008 to 2021	2,520,893	9.0	22,700,000	0.57	12,898,550
Fuel 2022 to 2025	3,025,072	9.0	27,200,000	0.83	22,696,968

Routine Annual Maintenance	Number	$/year each	Total $
Diesel Locomotives 2004 to 2007	20	106,090	2,121,800
Diesel Locomotives 2008 to 2021	24	122,987	2,951,697
Diesel Locomotives 2022 to 2025	28	180,611	5,057,111
Addit. Bi Level Cars 2004 to 2007	0	53,045	0
Addit. Bi Level Cars 2008 to 2021	12	61,494	737,924
Addit. Bi Level Cars 2022 to 2025	24	90,306	2,167,333
Total Rolling stock Maint 2004 to 2007			2,121,800
Total Rolling stock Maint 2008 to 2021			3,689,622
Total Rolling stock Maint 2022 to 2025			7,224,445

Major Overhaul	Number	$/year each	$/yr escalated	Total $
Major Overhaul 10 Locomotives in 2018	10	1,500,000	2479271	24,792,714
Major Overhaul 10 Locomotives in 2019	10	1,500,000	2553650	25,536,496
Major Overhaul 5 Locomotives in 2019	5	1,500,000	2553650	12,768,248
Top Deck Refurbishment 10 Locomotives in 2012	10	175,000	242241	2,422,409
Top Deck Refurbishment 15 Locomotives in 2013	15	175,000	249508	3,742,622
Top Deck Refurbishment 10 Locomotives in 2018	10	175,000	289248	2,892,483
Top Deck Refurbishment 15 Locomotives in 2019	15	175,000	297926	4,468,887
Total 2012				2,422,409
Total 2013				3,742,622
Toatl 2018				27,685,198
Total 2019				42,773,631

Table 11.4 – Annual O&M costs – Electric Operation

Power	MWh/day	Total Days	MWh/yr	$/MWh	Total $
2004 to 2007					
Power - Weekdays	160.7	253	40,661	89	3,618,804
Power - Sat. & Holidays	66.1	60	3,964	89	352,821
Power - Sundays	66.1	52	3,436	89	305,779
			48,061		4,277,404
2008 to 2021					
Power - Weekdays	200.9	253	50,826	97	4,942,955
Power - Sat. & Holidays	82.6	60	4,955	97	481,922
Power - Sundays	82.6	52	4,295	97	417,666
					5,842,543
2022 to 2025					
Power - Weekdays	241.1	253	60,991	143	8,710,676
Power - Sat. & Holidays	99.1	60	5,946	143	849,262
Power - Sundays	99.1	52	5,154	143	736,027
					10,295,966

Routine Maintenance	Number	$/year each escalated	Total $
Electric Locomotives 2004 to 2007	20	60000	1,200,000
Electric Locomotives 2008 to 2021	23	63654	1,464,042
Electric Locomotives 2022 to 2025	26	90755	2,359,640
2004 to 2007			
OCS Maintenance(2% cost)	1	1138000	1,138,000
Substation Maintenance(2% cost)	1	490000	490,000
2008 to 2021			
OCS Maintenance(2% cost)	1	1207304	1,207,304
Substation Maintenance(2% cost)	1	519841	519,841
2022 to 2025			
OCS Maintenance(2% cost)	1	1721327	1,721,327
Substation Maintenance(2% cost)	1	741169	741,169
Total Routine Maint 2004 to 2007			2,828,000
Total Routine Maint 2008 to 2021			3,191,187
Total Routine Maint 2022 to 2025			4,822,136

Major Overahual	Number	$/year each	$/yr escalated	Total $
Major Overhaul 10 locomotives in 2015	10	500000	756295	7,562,949
Major Overhaul 10 locomotives in 2016	10	500000	778984	7,789,837
Major Overhaul 3 locomotives in 2019	3	500000	851217	2,553,650
Total 2015				7,562,949
Total 2016				7,789,837
Toatl 2019				7,562,949

12. ECONOMIC ANALYSIS

12.1 General

This section updates Section 14 of the 1992 report. Two scenarios were analyzed in this case:

- Electric Operation of the Lakeshore Line
- Diesel Operation of the Lakeshore Line.

In the analysis, the annual expenditure streams for the next 25 years for both O&M costs and for capital costs were compared on a net present value (NPV) basis. The revenue streams were not considered as they were assumed to be the same for diesel and electric operation.

12.2 Assumptions

The following key assumptions were made in the base case analyses:

Discount rate	6%
Annual escalation	3%
Diesel cost per litre	$0.52
Energy cost per mWh	$89
Equipment salvage value	$0

12.3 Sensitivity Analyses

The following sensitivity analyses were performed to assess the impact of changes to the indicated variables.

- Case 1 - Diesel and electric energy costs increased by 10%.
- Case 2 - Diesel and electric energy costs increased by 20%.
- Case 3 - Escalation rate increased from 3% to 4% annually.
- Case 4 - Cost of signal modifications and raising the train shed roof reduced to zero – assumed to be carried in the Union Infrastructure Improvement Program.

12.4 Results

The results of the base case analyses are shown on Tables 12.1 and 12.2 for the electric and diesel options respectively. The results of the sensitivity analyses are shown on Tables 12.1a through 12.1d for the electric option and 12.2a through 12.2c for the diesel option. An overall summary of the results is tabulated below.

For the base case, the diesel operation exhibits a $97 million cost advantage, on an NPV basis, over the electrified option. Even though O&M costs for the electric option are significantly lower than for diesel, its capital cost by comparison is so high that none of the sensitivity scenarios dealing with O&M issues (Case 1 through Case 3) yields any substantial improvement for the electrification option. In Case 4 where the initial capital cost is reduced by about $50 million on the assumption that this cost could be distributed to GO Transit's Infrastructure Program, the NPV gap narrows to $47 still in favour of diesel operation.

Summary of Economic Analyses

Scenario	Net Present Value - $x million (negative)					
	Electric Operation			Diesel Operation		
	O&M	Capital	Total	O&M	Capital	Total
Base Case	119	326	445	199	149	348
Case 1	125	326	452	212	149	361
Case 2	132	326	458	224	149	373
Case 3	130	343	473	221	161	382
Case 4	119	276	395	199	149	348

Table 12.1
Economic Cost - Electrified Operation on Lakeshore Line - Base Case
(Values in $ x thousands unless noted otherwise)

YEAR No.	YEAR Actual	Revenue Service (kmx1000)	OPERATING & MAINTENANCE COSTS Energy Diesel	Energy Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	CAPITAL COSTS Locomotives Diesel	Locomotives Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops & Property	Hydro Connect	Total Capital Costs	Total Annual Costs
1	2001							0		19000								19000	19000
2	2002							0		19000		28450	12250	23900	19500	1000	17500	121600	121600
3	2003							0		19000		28450	12250	23900	19500	9000	17500	129600	129600
4	2004	2017		4277	500	2828		7605	5200	19000						9000		33200	40805
5	2005	2017		4406	515	2913		7834										0	7834
6	2006	2017		4538	530	3000		8069										0	8069
7	2007	2017		4674	546	3090		8311		20867								20867	29178
8	2008	2521		5843	563	3191		9596										0	9596
9	2009	2521		6018	580	3287		9884										0	9884
10	2010	2521		6198	597	3386		10181							-26600			-26600	-16419
11	2011	2521		6384	615	3487		10486										0	10486
12	2012	2521		6576	633	3592		10801										0	10801
13	2013	2521		6773	652	3699		11125										0	11125
14	2014	2521		6976	672	3810		11459										0	11459
15	2015	2521		7186	692	3925	7563	19365										0	19365
16	2016	2521		7401	713	4043	7790	19946										0	19946
17	2017	2521		7623	734	4164		12521										0	12521
18	2018	2521		7852	756	4289		12897										0	12897
19	2019	2521		8087	779	4417	7563	20847										0	20847
20	2020	2521		8330	802	4550		13682										0	13682
21	2021	2521		8580	826	4686		14093		30644								30644	44737
22	2022	3025		10296	851	4822		15969										0	15969
23	2023	3025		10605	877	4967		16448										0	16448
24	2024	3025		10923	903	5116		16942										0	16942
25	2025	3025		11251	930	5269		17450		243935								243935	261385
		55460		160797	15268	86531	22916	285512	5200	371446		56900	24500	47800	12400	19000	35000	572246	857758

Energy Cost 2001($/MWh)	**89**
Discount Rate	**6%**
Annual Escalation %	**3**

NPV O & M Costs	**($119,215)**
NPV Capital Costs	**($326,135)**
Total NPV	**($445,351) thousand**

Notes:
1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***
3. ***Diesel operation to Hamilton is incorporated in electric operation costs***

Table 12.2
Economic Cost - Diesel Operation on Lakeshore Line - Base Case
(Values in $ x thousands unless noted otherwise)

YEAR No.	YEAR Actual	Revenue Service (kmx1000)	OPERATING & MAINTENANCE COSTS: Energy Diesel	Energy Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	CAPITAL COSTS: Locomotives Diesel	Locomotives Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops	Other Equipt	Total Capital Cost	Total Annual Costs
1	2001							0										0	0
2	2002							0										0	0
3	2003							0										0	0
4	2004	2017	9464			2122		11586										0	11586
5	2005	2017	9748			2185		11933										0	11933
6	2006	2017	10040			2251		12291	58526									58526	70818
7	2007	2017	10342			2319		12660	84395		36169							120565	133225
8	2008	2521	10652			3690		14341										0	14341
9	2009	2521	10971			3800		14772										0	14772
10	2010	2521	11301			3914		15215										0	15215
11	2011	2521	11640			4032		15671										0	15671
12	2012	2521	11989			4153	2422	18564										0	18564
13	2013	2521	12348			4277	3743	20368										0	20368
14	2014	2521	12719			4406		17124										0	17124
15	2015	2521	13100			4538		17638										0	17638
16	2016	2521	13493			4674		18167										0	18167
17	2017	2521	13898			4814		18712										0	18712
18	2018	2521	14315			4959	27685	46959										0	46959
19	2019	2521	14745			5107	42774	62626										0	62626
20	2020	2521	15187			5261		20447										0	20447
21	2021	2521	15643			5418		21061	37567		56351							93918	114979
22	2022	3025	22697			7224		29921										0	29921
23	2023	3025	23378			7441		30819										0	30819
24	2024	3025	24079			7664		31744										0	31744
25	2025	3025	24802			7894		32696										0	32696
		55460	316550	0	0	102143	76624	495317	180489	0	92520	0	0	0	0	0	0	273009	768326

Diesel Fuel Cost 2001 ($/litre) 0.52
Discount Rate 6%
Annual Escalation % 3

NPV O & M Costs ($199,032)
NPV Capital Costs ($149,068)

Total NPV ($348,100) thousand

Notes:

1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***

Table 12.1a
Economic Cost - Electrified Operation on Lakeshore Line - Case 1: Energy Cost +10%
(Values in $ x thousands unless noted otherwise)

YEAR		Revenue	OPERATING & MAINTENANCE COSTS						CAPITAL COSTS										Total
		Service	Energy						Locomotives			OCS	Sub	Signals/	O/Head	Maint.	Hydro	Total	Annual
No.	Actual	(kmx1000)	Diesel	Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	Diesel	Electric	Bi Level Cars		Stations	Comms	Clearances	Shops & Property	Connect	Capital Costs	Costs
1	2001							0		19000								19000	19000
2	2002							0		19000		28450	12250	23900	19500	1000	17500	121600	121600
3	2003							0		19000		28450	12250	23900	19500	9000	17500	129600	129600
4	2004	2017		4705	500	2828		8033	5200	19000						9000		33200	41233
5	2005	2017		4846	515	2913		8274										0	8274
6	2006	2017		4992	530	3000		8522										0	8522
7	2007	2017		5141	546	3090		8778		20867								20867	29645
8	2008	2521		6427	563	3191		10181										0	10181
9	2009	2521		6620	580	3287		10486										0	10486
10	2010	2521		6818	597	3386		10801							-26600			-26600	-15799
11	2011	2521		7023	615	3487		11125										0	11125
12	2012	2521		7233	633	3592		11459										0	11459
13	2013	2521		7450	652	3699		11802										0	11802
14	2014	2521		7674	672	3810		12156										0	12156
15	2015	2521		7904	692	3925	7563	20084										0	20084
16	2016	2521		8141	713	4043	7790	20686										0	20686
17	2017	2521		8386	734	4164		13284										0	13284
18	2018	2521		8637	756	4289		13682										0	13682
19	2019	2521		8896	779	4417	7563	21655										0	21655
20	2020	2521		9163	802	4550		14515										0	14515
21	2021	2521		9438	826	4686		14951		30644								30644	45595
22	2022	3025		11326	851	4822		16999										0	16999
23	2023	3025		11665	877	4967		17509										0	17509
24	2024	3025		12015	903	5116		18034										0	18034
25	2025	3025		12376	930	5269		18575		243935								243935	262510
		55460		176877	15268	86531	22916	301592	5200	371446		56900	24500	47800	12400	19000	35000	572246	873838

Energy Cost 2001($/MWh) 97.9
Discount Rate 6%
Annual Escalation % 3

NPV O & M Costs ($125,896)
NPV Capital Costs ($326,135)

Total NPV ($452,032) thousand

Notes:
1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***
3. ***Diesel operation to Hamilton is incorporated in electric operation costs***

Table 12.1b
Economic Cost - Electrified Operation on Lakeshore Line - Case 2: Energy Cost +20%
(Values in $ x thousands unless noted otherwise)

YEAR		Revenue Service	OPERATING & MAINTENANCE COSTS						CAPITAL COSTS										Total Annual Costs
			Energy						Locomotives										
No.	Actual	(kmx1000)	Diesel	Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	Diesel	Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops & Property	Hydro Connect	Total Capital Costs	
1	2001							0		19000								19000	19000
2	2002							0		19000		28450	12250	23900	19500	1000	17500	121600	121600
3	2003							0		19000		28450	12250	23900	19500	9000	17500	129600	129600
4	2004	2017		5133	500	2828		8461	5200	19000						9000		33200	41661
5	2005	2017		5287	515	2913		8715										0	8715
6	2006	2017		5445	530	3000		8976										0	8976
7	2007	2017		5609	546	3090		9245		20867								20867	30112
8	2008	2521		7011	563	3191		10765										0	10765
9	2009	2521		7221	580	3287		11088										0	11088
10	2010	2521		7438	597	3386		11421							-26600			-26600	-15179
11	2011	2521		7661	615	3487		11763										0	11763
12	2012	2521		7891	633	3592		12116										0	12116
13	2013	2521		8128	652	3699		12480										0	12480
14	2014	2521		8372	672	3810		12854										0	12854
15	2015	2521		8623	692	3925	7563	20803										0	20803
16	2016	2521		8881	713	4043	7790	21427										0	21427
17	2017	2521		9148	734	4164		14046										0	14046
18	2018	2521		9422	756	4289		14467										0	14467
19	2019	2521		9705	779	4417	7563	22464										0	22464
20	2020	2521		9996	802	4550		15348										0	15348
21	2021	2521		10296	826	4686		15809		30644								30644	46453
22	2022	3025		12355	851	4822		18029										0	18029
23	2023	3025		12726	877	4967		18569										0	18569
24	2024	3025		13108	903	5116		19126										0	19126
25	2025	3025		13501	930	5269		19700		243935								243935	263636
		55460		192957	15268	86531	22916	317672	5200	371446		56900	24500	47800	12400	19000	35000	572246	889918

Energy Cost 2001($/MWh)	**106.8**	
Discount Rate	**6%**	
Annual Escalation %	**3**	
NPV O & M Costs		**($132,577)**
NPV Capital Costs		**($326,135)**
Total NPV		**($458,713) thousand**

Notes:

1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***
3. ***Diesel operation to Hamilton is incorporated in electric operation costs***

Table 12.1c
Economic Cost - Electrified Operation on Lakeshore Line - Case 3: Escalation 4%
(Values in $ x thousands unless noted otherwise)

YEAR No.	YEAR Actual	Revenue Service (kmx1000)	OPERATING & MAINTENANCE COSTS: Energy Diesel	Energy Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	CAPITAL COSTS: Locomotives Diesel	Locomotives Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops & Property	Hydro Connect	Total Capital Costs	Total Annual Costs
1	2001							0		19000								19000	19000
2	2002							0		19000		28450	12250	23900	19500	1000	17500	121600	121600
3	2003							0		19000		28450	12250	23900	19500	9000	17500	129600	129600
4	2004	2017		4277	500	2828		7605	5200	19000						9000		33200	40805
5	2005	2017		4448	520	2941		7910										0	7910
6	2006	2017		4626	541	3059		8226										0	8226
7	2007	2017		4811	562	3181		8555		21900								21900	30455
8	2008	2521		6014	585	3253		9853										0	9853
9	2009	2521		6255	608	3384		10247										0	10247
10	2010	2521		6505	633	3519		10657							-26600			-26600	-15943
11	2011	2521		6765	658	3660		11083										0	11083
12	2012	2521		7036	684	3806		11526										0	11526
13	2013	2521		7317	712	3958		11987										0	11987
14	2014	2521		7610	740	4117		12467										0	12467
15	2015	2521		7915	770	4281	8658	21624										0	21624
16	2016	2521		8231	801	4453	9005	22489										0	22489
17	2017	2521		8560	833	4631		14024										0	14024
18	2018	2521		8903	866	4816		14584										0	14584
19	2019	2521		9259	900	5009	8658	23826										0	23826
20	2020	2521		9629	936	5209		15775										0	15775
21	2021	2521		10014	974	5417		16406		36465								36465	52870
22	2022	3025		12017	1013	5521		18551										0	18551
23	2023	3025		12498	1053	5741		19293										0	19293
24	2024	3025		12998	1096	5971		20064										0	20064
25	2025	3025		13518	1139	6210		20867		307596								307596	328464
		55460		179209	17124	94964	26321	317618	5200	441961		56900	24500	47800	12400	19000	35000	642761	960379

Energy Cost 2001($/MWh) 89
Discount Rate 6%
Annual Escalation % 4

NPV O & M Costs ($130,150)
NPV Capital Costs ($343,367)

Total NPV ($473,518) thousand

Notes:
1. *The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.*
2. *Revenue stream for Diesel and Electric has not been considered - similar for both options*
3. *Diesel operation to Hamilton is incorporated in electric operation costs*

Table 12.1d
Economic Cost - Electrified Operation on Lakeshore Line - Case 4: Signals & Train Shed Cost Removed
(Values in $ x thousands unless noted otherwise)

YEAR		Revenue Service	OPERATING & MAINTENANCE COSTS						CAPITAL COSTS										Total Annual Costs
			Energy						Locomotives										
No.	Actual	(kmx1000)	Diesel	Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	Diesel	Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops & Property	Hydro Connect	Total Capital Costs	
1	2001							0		19000								19000	19000
2	2002							0		19000		28450	12250		6250	1000	17500	84450	84450
3	2003							0		19000		28450	12250		6250	9000	17500	92450	92450
4	2004	2017		4277	500	2828		7605	5200	19000						9000		33200	40805
5	2005	2017		4406	515	2913		7834										0	7834
6	2006	2017		4538	530	3000		8069										0	8069
7	2007	2017		4674	546	3090		8311		20867								20867	29178
8	2008	2521		5843	563	3191		9596										0	9596
9	2009	2521		6018	580	3287		9884										0	9884
10	2010	2521		6198	597	3386		10181										0	10181
11	2011	2521		6384	615	3487		10486										0	10486
12	2012	2521		6576	633	3592		10801										0	10801
13	2013	2521		6773	652	3699		11125										0	11125
14	2014	2521		6976	672	3810		11459										0	11459
15	2015	2521		7186	692	3925	7563	19365										0	19365
16	2016	2521		7401	713	4043	7790	19946										0	19946
17	2017	2521		7623	734	4164		12521										0	12521
18	2018	2521		7852	756	4289		12897										0	12897
19	2019	2521		8087	779	4417	7563	20847										0	20847
20	2020	2521		8330	802	4550		13682										0	13682
21	2021	2521		8580	826	4686		14093		30644								30644	44737
22	2022	3025		10296	851	4822		15969										0	15969
23	2023	3025		10605	877	4967		16448										0	16448
24	2024	3025		10923	903	5116		16942										0	16942
25	2025	3025		11251	930	5269		17450		243935								243935	261385
		55460		160797	15268	86531	22916	285512	5200	371446		56900	24500	0	12500	19000	35000	524546	810058

Energy Cost 2001($/MWh)	89	
Discount Rate	6%	
Annual Escalation %	3	
NPV O & M Costs		**($119,215)**
NPV Capital Costs		**($276,733)**
Total NPV		**($395,949) thousand**

Notes:

1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***
3. ***Diesel operation to Hamilton is incorporated in electric operation costs***

Table 12.2a
Economic Cost - Diesel Operation on Lakeshore Line - Case 1:Energy Cost +10%
(Values in $ x thousands unless noted otherwise)

YEAR		Revenue	OPERATING & MAINTENANCE COSTS						CAPITAL COSTS										Total
		Service	Energy						Locomotives			OCS	Sub	Signals/	O/Head	Maint.	Other	Total	Annual
No.	Actual	(kmx1000)	Diesel	Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	Diesel	Electric	Bi Level Cars		Stations	Comms	Clearances	Shops	Equipt	Capital Cost	Costs
1	2001							0										0	0
2	2002							0										0	0
3	2003							0										0	0
4	2004	2017	10374			2122		12496										0	12496
5	2005	2017	10685			2185		12871										0	12871
6	2006	2017	11006			2251		13257	58526									58526	71783
7	2007	2017	11336			2319		13654	84395		36169							120565	134219
8	2008	2521	11676			3690		15366										0	15366
9	2009	2521	12026			3800		15827										0	15827
10	2010	2521	12387			3914		16301										0	16301
11	2011	2521	12759			4032		16790										0	16790
12	2012	2521	13141			4153	2422	19717										0	19717
13	2013	2521	13536			4277	3743	21556										0	21556
14	2014	2521	13942			4406		18347										0	18347
15	2015	2521	14360			4538		18898										0	18898
16	2016	2521	14791			4674		19465										0	19465
17	2017	2521	15235			4814		20049										0	20049
18	2018	2521	15692			4959	27685	48335										0	48335
19	2019	2521	16162			5107	42774	64043										0	64043
20	2020	2521	16647			5261		21908										0	21908
21	2021	2521	17147			5418		22565	37567		56351							93918	116483
22	2022	3025	24879			7224		32104										0	32104
23	2023	3025	25626			7441		33067										0	33067
24	2024	3025	26395			7664		34059										0	34059
25	2025	3025	27186			7894		35081										0	35081
		55460	346987	0	0	102143	76624	525754	180489	0	92520	0	0	0	0	0	0	273009	798763

Diesel Fuel Cost 2001 ($/litre)	**0.57**
Discount Rate	**6%**
Annual Escalation %	**3**
NPV O & M Costs	**($211,632)**
NPV Capital Costs	**($149,068)**
Total NPV	**($360,699) thousand**

Notes:

1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***

Table 12.2b
Economic Cost - Diesel Operation on Lakeshore Line - Case 2:Energy Cost +20%
(Values in $ x thousands unless noted otherwise)

YEAR No.	YEAR Actual	Revenue Service (kmx1000)	O&M: Energy Diesel	O&M: Energy Electric	O&M: Power Bureau	O&M: Routine Maint.	O&M: Major O/Haul	O&M: Total Op & Maint.	CAPITAL: Locomotives Diesel	CAPITAL: Locomotives Electric	CAPITAL: Bi Level Cars	CAPITAL: OCS	CAPITAL: Sub Stations	CAPITAL: Signals/ Comms	CAPITAL: O/Head Clearances	CAPITAL: Maint. Shops	CAPITAL: Other Equipt	CAPITAL: Total Capital Cost	Total Annual Costs
1	2001							0										0	0
2	2002							0										0	0
3	2003							0										0	0
4	2004	2017	11284			2122		13406										0	13406
5	2005	2017	11623			2185		13808										0	13808
6	2006	2017	11971			2251		14222	58526									58526	72749
7	2007	2017	12330			2319		14649	84395		36169							120565	135213
8	2008	2521	12700			3690		16390										0	16390
9	2009	2521	13081			3800		16882										0	16882
10	2010	2521	13474			3914		17388										0	17388
11	2011	2521	13878			4032		17910										0	17910
12	2012	2521	14294			4153	2422	20869										0	20869
13	2013	2521	14723			4277	3743	22743										0	22743
14	2014	2521	15165			4406		19570										0	19570
15	2015	2521	15620			4538		20157										0	20157
16	2016	2521	16088			4674		20762										0	20762
17	2017	2521	16571			4814		21385										0	21385
18	2018	2521	17068			4959	27685	49712										0	49712
19	2019	2521	17580			5107	42774	65461										0	65461
20	2020	2521	18108			5261		23368										0	23368
21	2021	2521	18651			5418		24069	37567		56351							93918	117987
22	2022	3025	27062			7224		34286										0	34286
23	2023	3025	27874			7441		35315										0	35315
24	2024	3025	28710			7664		36374										0	36374
25	2025	3025	29571			7894		37465										0	37465
		55460	377425	0	0	102143	76624	556192	180489	0	92520	0	0	0	0	0	0	273009	829201

Diesel Fuel Cost 2001 ($/litre) 0.62
Discount Rate 6%
Annual Escalation % 3

NPV O & M Costs ($224,232)
NPV Capital Costs ($149,068)

Total NPV ($373,299) thousand

Notes:
1. ***The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.***
2. ***Revenue stream for Diesel and Electric has not been considered - similar for both options***

Table 12.2c
Economic Cost - Diesel Operation on Lakeshore Line - Case 3: Escalation 4%
(Values in $ x thousands unless noted otherwise)

YEAR No.	YEAR Actual	Revenue Service (kmx1000)	OPERATING & MAINTENANCE COSTS: Energy Diesel	Energy Electric	Power Bureau	Routine Maint.	Major O/Haul	Total Op & Maint.	CAPITAL COSTS: Locomotives Diesel	Locomotives Electric	Bi Level Cars	OCS	Sub Stations	Signals/ Comms	O/Head Clearances	Maint. Shops	Other Equipt	Total Capital Cost	Total Annual Costs
1	2001							0										0	0
2	2002							0										0	0
3	2003							0										0	0
4	2004	2017	9464			2163		11627										0	11627
5	2005	2017	9843			2250		12092										0	12092
6	2006	2017	10138			2340		12478	60833									60833	73310
7	2007	2017	10543			2433		12977	88572		37960							126532	139509
8	2008	2521	10965			3948		14913										0	14913
9	2009	2521	11404			4106		15509										0	15509
10	2010	2521	11860			4270		16130										0	16130
11	2011	2521	12334			4441		16775										0	16775
12	2012	2521	12828			4618	2694	20140										0	20140
13	2013	2521	13341			4803	4203	22347										0	22347
14	2014	2521	13874			4995		18870										0	18870
15	2015	2521	14429			5195		19624										0	19624
16	2016	2521	15006			5403		20409										0	20409
17	2017	2521	15607			5619		21226										0	21226
18	2018	2521	16231			5844	32627	54702										0	54702
19	2019	2521	16880			6077	50899	73856										0	73856
20	2020	2521	17555			6321		23876										0	23876
21	2021	2521	18258			6573		24831	45575		68363							113938	138769
22	2022	3025	26491			8764		35256										0	35256
23	2023	3025	27551			9115		36666										0	36666
24	2024	3025	28653			9480		38133										0	38133
25	2025	3025	29799			9859		39658										0	39658
		55460	353055	0	0	118617	90423	562095	194980	0	106323	0	0	0	0	0	0	301303	863398

Diesel Fuel Cost 2001 ($/litre) 0.52
Discount Rate 6%
Annual Escalation % 4

NPV O & M Costs ($221,354)
NPV Capital Costs ($160,551)

Total NPV ($381,905) thousand

Notes:
1. *The totals shown do not represent a definitive cost estimate for the total undertaking, only a basis for comparison between Diesel and Electric operation of the Lakeshore Line. Only unique costs that facilitate differentiation between the two modes of opeartion have been considered.*
2. *Revenue stream for Diesel and Electric has not been considered - similar for both options*

APPENDIX A

Stations on Lakeshore Line and Distance from Union Station

Station	Mile	km
Hamilton	39.3	63.2
Aldershot	34.6	55.7
Burlington	31.5	50.7
Appleby	27.9	44.9
Bronte	24.7	39.7
Oakville	21.4	34.4
Clarkson	16.7	26.9
Port Credit	12.8	20.6
Long Branch	9.6	15.4
Mimico	6.7	10.8
Exhibition	2	3.2
Union	0	0.0
Danforth	5.2	-8.4
Scarborough	8.6	13.8
Eglinton	10.6	17.1
Guildwood	12.6	20.3
Rouge Hill	16.5	26.5
Pickering	20.9	33.6
Whitby	28.8	46.3
Ajax	24.6	39.6
Oshawa	31.5	50.7

If you disagree with any information contained herein, please advise immediately.

TABLE B - 1
ORIGINAL MATERIALCOSTS
AND UPDATE ADJUSTMENT

ITEM	TASK	PAGE	CONTRACT	VENDOR	FACTOR	2000 Cost ACTUAL for 133 km	2000 COST ADJUSTED for 133 km	COST / KM for 133 km	COST / mile for 133 km	TOTAL GO COST 161 MILES
1	POLES MISC	5-2	582,768.00	EBCO & L.A. STEEL	2.751	1,603,194.77	1,603,194.77	12,054.10	19,395.04	3,122,601.51
2	C130 X 10.12.8	5-2	425,975.00		3.1943	1,360,691.94	1,360,691.94	10,230.77	16,461.30	2,650,269.83
3	C250 X 30.14.8	5-2	132,381.00		2.3072	305,429.44	305,429.44	2,296.46	3,695.01	594,896.18
4	PRECAST CONCRETE PED.	5-4	147,651.00	OCEAN CONST	1.5	221,476.50	0.00	0.00	0.00	0.00
5	H-BEAM PILES	5-5	404,484.00	ALGOMA	1.6099	651,178.79	651,178.79	4,896.08	7,877.79	1,268,324.92
6	FOOTING PLATES	5-5	118,569.00	NORTHERN STEEL	1.122	133,034.42	133,034.42	1,000.26	1,609.42	259,116.04
7	BOLTS	5-5	46,997.17	MALKIN & PINTEN	1.6	75,195.47	75,195.47	565.38	909.70	146,460.99
8	PORTALS	5-13	153,707.00	L.A. STEEL	1.7635	271,062.29	813,450.61	6,116.17	9,840.92	1,584,387.72
9	SPECIAL CASTINGS & FAB	6-3	950,633.00	EBCO	1.6	1,521,012.80	1,521,012.80	11,436.19	18,400.82	2,962,532.67
10	PATTERNS AND DIE COSTS	6-3	97,106.00	EBCO	1.6	155,369.60	155,369.60	1,168.19	1,879.62	302,619.09
11	INSULATORS	6-8	679,010.20	NGK / OB	1.6	1,086,416.32	1,086,416.32	8,168.54	13,143.19	2,116,053.09
12	SUSPENSION INSULATOR	6-8	41,234.00	NGK	1.6	65,974.40	65,974.40	496.05	798.14	128,500.77
13	55mm TUBING	6-11	78,855.30	EBCO	1.6	126,168.48	126,168.48	948.64	1,526.35	245,743.00
14	42 & 27 mm TUBING	6-11	23,636.15	WIRSBO BRUKS	1.6	37,817.84	37,817.84	284.34	457.51	73,659.20
15	TUBE CUTTING	6-11	3,500.00	P.G. FABRICATING	1.6	5,600.00	5,600.00	42.11	67.75	10,907.33
16	1 1/4" STANDARD GAL. PIPE	6-11	3,229.50		1.6	5,167.20	5,167.20	38.85	62.51	10,064.35
17	MISC HARDWARE	6-13	48,746.41	NEDCO	1.6	77,994.26	77,994.26	586.42	943.55	151,912.29
18	TYE WRAPS	6-13	1,533.75	NEDCO	1	1,533.75	1,533.75	11.53	18.55	2,987.34
19	MISC PFISTERER	6-14	7,175.70	PFISTERER	1.55	11,122.34	11,122.34	83.63	134.56	21,663.38
20	OB CLAMPS	6-14	20,034.30	OHIO BRASS	1.55	31,053.17	31,053.17	233.48	375.67	60,483.39
21	SPRING CLIPS	6-14	79,537.16	EBCO	1.6	127,259.46	127,259.46	956.84	1,539.55	247,867.93
22	NUTS AND BOLTS	6-15	142,457.75	MALKIN & PINTON	1.6	227,932.40	227,932.40	1,713.78	2,757.47	443,952.33
23	NUTS AND BOLTS	6-16	570.24	INDUSTRIAL FASTENER	1.6	912.38	912.38	6.86	11.04	1,777.08
24	WIRE ROPE	6-17	11,739.00	GREENING DONALD	1.6	18,782.40	18,782.40	141.22	227.22	36,583.17
25	4/0 TROLLEY	7-2	877,364.00	CANADA WIRE & CABLE	1.7914	1,571,709.87	1,571,709.87	11,817.37	19,014.14	3,061,277.22
26	2/0 STR. COPPER	7-2	632,200.00	CANADA WIRE & CABLE	1.5046	951,208.12	951,208.12	7,151.94	11,507.47	1,852,703.10
27	4/0 ACSR PENGUIN	7-2	251,187.00	CANADA WIRE & CABLE	1.44	361,709.28	361,709.28	2,719.62	4,375.87	704,514.49
28	WIRE AND CABLE misc	7-2	111,525.46	CANADA WIRE & CABLE	1.2373	137,990.45	137,990.45	1,037.52	1,669.37	268,769.09
29	WIRE FITTINGS	7-4	874.00	ALCAN	1.6	1,398.40	1,398.40	10.51	16.92	2,723.72
30	WIRE FITTINGS	7-4	25,025.00	SLACAN	1.6	40,040.00	40,040.00	301.05	484.39	77,987.38
31	WIRE FITTINGS	7-4	13,794.49	NEDCO	1.6	22,071.18	22,071.18	165.95	267.01	42,988.86
32	WIRE CLAMPS	7-6	177,266.70	SIEMENS	1.6	283,626.72	283,626.72	2,132.53	3,431.24	552,430.21
33	DROPPERS-ASSEMBLY	7-8	24,463.24	PRINCE GEORGE FAB	1.6	39,141.18	39,141.18	294.29	473.52	76,236.73
34	DROPPER MATERIALS	7-9	11,759.50	EBCO	1.6	18,815.20	18,815.20	141.47	227.62	36,647.06
35	SECTION INSULATORS	7-10	40,674.00	GORDON RUSSELL	1.6	65,078.40	65,078.40	489.31	787.30	126,755.60
36	OVERLAP INSULATORS	7-12	1,350.00	JOHN MILLAN	1.6	2,160.00	2,160.00	16.24	26.13	4,207.11
37	SUPPORT MEMBERS	6-19	92,208.70	INLET METAL	1.6	147,533.92	147,533.92	1,109.28	1,784.83	287,357.25
38	KIT COST -NEW									150,000.00
39	STEADY ARMS - NEW									221,000.00
40	ANTI-CLIMB DEVICE ON POLES									160,000.00
41	DANGER HIGH VOLTAGE WARNING SIGNS									40,000.00

TABLE B - 1
ORIGINAL MATERIALCOSTS
AND UPDATE ADJUSTMENT

ITEM	TASK	PAGE	CONTRACT	VENDOR	FACTOR	2000 Cost ACTUAL for 133 km	2000 COST ADJUSTED for 133 km	COST / KM for 133 km	COST / mile for 133 km	TOTAL GO COST 161 MILES
	SUB TOTAL		6,461,222.72			11,763,863.15	12,084,774.96	90,862.97	146,198.52	24,108,961.42
	FACTOR 10% FOR CROSS OVERS ETC					1,176,386.31	1,208,477.50	9,086.30	14,619.85	2,410,896.14
	TOTAL					12,940,249.46	13,293,252.46	99,949.27	160,818.37	26,519,857.56
	COST PER KM and PER MILE	133 K	48,580.62			97,295.11	99,949.27			164,719.61
	MATERIAL REDUCTIONS									
	MATERIAL FROM MEXICAN PROJECT									
	H-BEAM PILES 100% AVAIL	5-5	404,484.00		1.6099	651,178.79				1,268,324.92
	4/0 TROLLEY WIRE 64% AVAIL	7-2	877,364.00		1.7914	1,571,709.87				1,571,709.87
	2/0 STR. COPPER 64% AVAIL	7-2	632,200.00		1.5046	951,208.12				951,208.12
	TOTAL SAVING									3,791,242.91
	TOTAL SAVING PER MILE									23,548.09
	MATERIAL FROM BC RAIL PROJECT									
	POLES MISC 54% AVAIL	5-2								0.00
	C130 X 10 .12.8 54% AVAIL	5-2								0.00
	C250 X 30.14.8 54% AVAIL	5-2								0.00
	4/0 TROLLEY WIRE 36% AVAIL	7-2								0.00
	2/0 STR. COPPER 36% AVAIL	7-2								0.00
	PORTALS BCR 10% AVAIL	5-13								0.00
	SUB TOTAL SAVINGS, BCR									
	LESS REMOVAL COSTS AND SELLING PRICE									
	LESS FREIGHT, CLEANING, AND REPLATING COSTS									
	NET BCR SAVING									
	NET BCR SAVING PER MILE									0.00
	TOTAL POSSIBLE SAVINGS									3,791,242.91
	WITH MEXICO MATERIAL THE REDUCED COST PER MILE IS									141,171.52

TABLE B - 2
INSTALLATION LABOUR
ENGINEERING AND
OTHER CHARGES

OCS Installation Costs	Unit	Original cost	Current cost	Factor	Cost	Job Cost for 161 miles
Installation labor per kilometre		27,625.00		1.75	48,343.75	12,920,000.00
Purchasing contractor			2,650,000.00	1		2,650,000.00
Expediting services			1,325,000.00	1		1,325,000.00
Shipping costs			250,000.00	1		250,000.00
Duty costs			50,000.00	1		50,000.00
Source inspection costs			265,000.00	1		265,000.00
Mark-up on Materials			2,650,000.00	1		2,650,000.00
Profit on installation labor						1,292,000.00
Engineering costs per kilometre		10,432.41		1.75	18,256.71	4,879,000.00
Profit on Engineering pkm		1,043.24		1.75		487,000.00
TOTAL						26,768,000.00
Estimate for raising power line crossings			4,000,000.00	1		4,000,000.00
(These costs may be to the account of the owner of the power line)						

APPENDIX C

Specification for Overhead Contact System

Go Transit Lakeshore Line
Union Station-Hamilton (CN Oakville Subdivision)
The Toronto Terminal Railway (Union Station)
Union Station-Oshawa (CN Kingston Subdivision and GO Subdivision)

CHARACTERISTICS		Constant Tension Overhead Simple Catenary
PURPOSE		Commuter Passenger Train Service
SPECIAL FEATURES		Clearance for AAR Freight Train Equipment using Diesel Locomotives
VOLTAGE AT 60 HZ AC		25,000 Nominal, 27.5 kV Maximum
CURRENT		750 Amperes, nominal
TRAIN SPEED (single pantograph)		100 Miles Per Hour (160 km/h)
TRAIN DENSITY (for OCS)		4 Locomotives of 6,000 hp at full power in any 6-mile segment on same track.
DESIGN STANDARDS (ORIGINAL DESIGN FROM SWEDISH STATE RAILWAYS, "SJ")		CSA Canadian Electrical Code Part III Section 22.8 Guidelines for Railway Electrification , AREA, (American Railway Engineering Association) and CSA for structural steel and other material as appropriate.
STRUCTURES		
	SUPPORTS (POLES)	Open Welded Steel Masts
	FOUNDATIONS	Driven Steel Piles
	SINGLE & DOUBLE TRACK	Steel Tube Cantilever
	THREE OR MORE TRACKS	Overhead Steel Truss Portal
	MATERIAL	Hot Dipped Galvanized Steel
	SPACING	230 Feet max. on tangent track
CONDUCTORS		
	MESSENGER (CATENARY)	HD Stranded Copper 70mm^2 (2/0)
	CONTACT WIRE	HD Solid Copper 107mm^2 (4/0)
	WIRE TENSION	2,200 Pounds (9.8kN)
	FEEDER CONDUCTORS	ACSR, Size per design
	GROUND RETURN	ACSR, Size per design
	GROUND BONDING	HD Stranded Copper various sizes
INSULATORS	CANTILEVERS	Fiberglas or Glazed Porcelain
	STRAIN TERMINATIONS	Glass or Glazed Porcelain
	FEEDER WIRES	Fiberglas or Glazed Porcelain
CLEARANCE	WIRE HEIGHT	23 Feet above top of rail, nominal
	LOAD GAUGE	21 Feet, safe maximum
	LATERAL	10 Ft.-6 IN. from centerline of track from top of rail up to maximum load gauge
	MAXIMUM DIMENSIONAL LOAD	With power turned off, 22 ft. 6 inches height, 21 feet width if centered on track.