HYDRO ONE'S TRANSMISSION SYSTEM ADEQUACY IN ONTARIO

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TAB INDEX

TAB 1

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Brian Gabel
Vice-President and Chief Regulatory Officer

hydro one

April 15, 2005

Mr. John Zych 4/18
Board Secretary
Ontario Energy Board
P.O. Box 2319
2300 Yonge Street, 26th Floor
Toronto, Ontario M4P 1E4

Dear Mr. Zych:

Review of Hydro One's Transmission System Adequacy in Ontario

On February 18, 2005, you wrote to Hydro One, pursuant to s. 13 of our Transmission licence, requesting a report on transmission system adequacy in Ontario. As requested, the attached report focuses on critical transmission reinforcements, those that are required for local area supply reliability, during the period 2005-2008. In addition to the reinforcements required by 2008, the report highlights other areas from our 10-year plan, that are of concern and that will require direction given the time required to implement transmission solutions. We also attach another copy of the most recent version of our ten-year plan, a copy of which was previously sent to you. This plan outlines anticipated system needs along with preferred and/or conceptual transmission solutions.

We have provided you with construction timelines and the status of environmental and regulatory approvals. With the need for public consultation and the recent establishment of the Ontario Power Authority (OPA) the timelines before construction begins is uncertain and often contingent on the degree of public participation in a particular project.

Of immediate interest is the supply to York Region, supply to Simcoe County and long term solutions for supply to Toronto. Long-term supply to Toronto was highlighted in our recent application for the Construction of 230kV Underground Transmission Lines: John Street TS X Esplanade Street TS (EB-2004-0436). Given the in-service dates that have been identified in the IESO's plans and time required to complete construction, the time available to obtain OPA, environmental assessment and OEB approvals will be tight should a transmission solution be selected. If the transmission option is selected in any local area, Hydro One is ready to proceed.

With respect to York Region, some attention has been focused on building transmission facilities underground. This option, while more fully detailed in the attached report is clearly not in the public interest. A much more viable solution, one that lies within the control of the affected communities and local utilities, is the use of distribution facilities. This is an option that the utilities have not wanted to pursue, however it could satisfy he area needs for up to 10 years. Hydro One stands ready to offer its assistance to the OPA to help in this regard.

Hydro One, as Ontario's largest and most experienced distribution company, has developed a distribution plan that is worth consideration. This plan is outlined in the attached report.

Yours truly,

M. R. Aldred for

Brian Gabel

Copy to: Jan Carr, CEO, OPA

Attachments:
1. Hydro One's Report on the Status of Critical Transmission Reinforcements for the Period 2005-2008
2. Hydro One's 10-year Transmission Plan
3. Electrical Supply for the City of Toronto
4. York Region Supply Study
5. Simcoe County Supply Study
6. Detweiler Area Supply Study

TAB 2

HYDRO ONE'S REPORT ON THE STATUS OF CRITICAL TRANSMISSION REINFORCEMENTS FOR THE PERIOD 2005-2008

Introduction

This report has been prepared in response to a request from the OEB, pursuant to s.13 of Hydro One's Transmission licence. The report contains a summary of the critical areas needing transmission reinforcements during the period of 2005-2008. Reinforcements are required for area supply reliability, although it is recognized that transmission is but one solution to the problems in these critical areas.

Area supply reinforcements that are required as the result of the retirement of coal fired generation facilities are not known. There is currently a Ministry of Energy working group that will be addressing solutions associated with these retirements. Provincial plans with respect to interconnections and the connection of new generation facilities (proposals selected as part of the government's 2500MW request for proposal) are not known at this time, as such, transmission required to facilitate such initiatives are also not known, and therefore not a part of this report.

Implementing Transmission Solutions

As Ontario's communities continue to grow and prosper, options for providing adequate and reliable electricity supply include conservation, enhanced local distribution, generation, and/or enhanced transmission.

Planning for and building new transmission facilities takes several years. Once needs have been identified and potential solutions developed, consultation and approvals processes are carried out. Approvals that could be required include technical approvals (such as the IESO approval through their Connection Assessment and Approval Process), environmental approvals (such as the Environmental Assessment Approval required by the Ontario Ministry of Environment), and regulatory approvals (such as Ontario Energy Board's Leave to Construct). Once the required approvals are in place, construction can begin.

Until recently, Hydro One relied on the Independent Electricity System Operator (IESO) forecasts and planning, as well as our own assessment of how transmission could be a solution to adequacy and reliability concerns (see attached Hydro One's 10-year plan). As you know, both the IESO and Hydro One had earlier identified reliability concerns in York Region and elsewhere in the Province. In accordance with how the electricity market was originally envisioned, Hydro One has stepped in and provided supply solutions. Other transmitters, generators or distributors could have provided solutions as well. Our objective has been to bring forward projects to address concerns with respect to maintaining transmission system reliability, although there was no legal requirement to do so.

The Ontario Power Authority (OPA) has been established and given the mandate to forecast electricity demand and ensure the adequacy and reliability of electricity resources in the medium and long term. In doing so, they are responsible to develop an integrated system plan. This plan will identify conservation, local area distribution, generation and transmission projects to address system reliability issues. This will fill in the gaps and address some of the issues in the planning and approvals process that have fallen outside of Hydro One's mandate. In undertaking its mandate, it is clear that the OPA will identify solutions other than transmission.

The IESO continues with its mandate to maintain the reliability of the IESO-controlled grid, but also supports the OPA with information relating to the current and short-term electricity needs of Ontario and the adequacy and reliability of the integrated power system.

If transmission options are selected by the OPA and the OEB as the preferred option to satisfy the needs, Hydro One will proceed with the implementation of these solutions.

The OPA's integrated planning process will serve to address many of the concerns that have been expressed to Hydro One, by the public and others, during the planning and approval phases of transmission projects undertaken to date. Community opposition can have a significant impact on the timing of projects. This has recently been the case with Hydro One's proposed plan to upgrade an existing corridor in York Region. Similar opposition has been experienced for a proposed generating facility in York Region. It is estimated that opposition to proposed projects could extend the process by several years. For transmission projects, the objections tend to hinge on two primary issues: perceived health effects from electromagnetic fields (EMF) and potential property value effects. Community concerns regarding aesthetics often lead to proposed design changes. This may be manageable, depending on the expectations of the community.

<u>Perceived Health Effects from EMF</u>
Project opponents have concerns about the perceived health effects from EMF. For EMF issues, Hydro One takes guidance from Health Canada. To date, the advice from Health Canada has been that a health risk has not been established. An intergovernmental committee of health experts has recently confirmed this position.

<u>Effects on Property Values</u>
Another common concern with respect to transmission projects is the perception that the upgraded transmission line will negatively affect the value of properties in the immediate vicinity of the corridor. In cases where the existing transmission line was constructed prior to development along the corridor, if there were an effect, it should have been factored into the initial selling price of these homes. In cases where new transmission corridors are being established, there is a process that is followed for land and/or land rights acquisition and, if required, expropriation.

<u>Alternate Transmission Line Designs</u>
The conventional transmission facility design found throughout Ontario consists of overhead lines supported by lattice tower structures. Other designs are used in some cases based on technical or financial reasons. In some cases, communities request that alternative designs be utilized. In cases where it is technically possible, where there will be no increased risks to the system operation, maintenance or reliability, and where costs are not prohibitive, Hydro One may be willing to install designs that differ from this standard transmission infrastructure. In several instances, steel pole designs have been used. If however, communities wish to have different, more expensive design features (e.g. underground cables), Hydro One will consider

these features provided those requesting the alternative design (and who receive the benefit of the design change) are willing to pay the incremental cost.

SUPPLY TO DOWNTOWN TORONTO

Need

The need for electricity in the central area of the City of Toronto is forecast to continue to grow at a steady pace. This growing demand for electricity means that solutions must be implemented in order to maintain adequate and reliable supply to the area.

Currently there are two major transmission line corridors that supply the east and west sectors of the Central Toronto Area. A 230 kV corridor running from Cherrywood Transformer Station in Pickering, to Leaside TS in Toronto supplies the Leaside (east) sector. The Manby (west) sector is supplied by a 230kV corridor running from Richview TS to Manby TS.

Relief for the existing 230kV facilities that deliver electricity to the city are forecast to exceed their capacity by 2008.

Potential Solutions

Potential solutions to ensure reliable supply to Toronto include conservation, enhanced local distribution, generation and transmission.

An independent assessment by the IESO and a joint assessment by Hydro One and Toronto Hydro (Electrical Supply for the City of Toronto, 2003) have identified transmission solutions to meet the growing electricity needs in Toronto. These solutions are described below as solutions that meet the long-term supply needs, and economic short-term solutions:

- Transmission solutions to meet the long term needs involve a third supply path to the Central Toronto Area. Direct Current (DC) and Alternating Current (AC) options exist for this new supply. Both transmission solutions will take a significant amount of time to implement and require substantial investment (several hundreds of $M).
- An economic short-term measure that will provide relief and operating flexibility is underway. This involves the reinforcement of the existing network between the Manby and Leaside sectors by constructing and operating two 230kV transmission circuits between John TS and Esplanade TS. Facilities installed under this plan will provide immediate benefits, are common elements of long term transmission supply options and defer the need for a substantial third supply project investment until at least 2010.

Implementation Schedule

The long-term transmission solution is expected to take at least 4-5 years to implement.

As you are aware, Hydro One applied for, and received OEB approval for the short-term project on March 11, 2005. About 30 months is required for engineering and construction. The new facilities are planned to be in-service by fall 2007.

Project Status

- If a transmission solution is selected by the OPA and the OEB as the preferred option to satisfy the long-term needs, Hydro One will proceed with implementing the transmission solution.
- The short-term project is on schedule and proceeding as planned.

Estimated Cost

- Long-term solution: several hundreds of $M.
- Short-term solution: $44.7M

SUPPLY TO YORK REGION

Need

York Region is one of the fastest growing areas in Ontario. Electrical load grew at an annual rate of 5% from 1992 to 1997. Growth increased to 6.5% annually between 1997 and 2002 and is expected to be about 4% annually until 2008 and 3.4% up to 2013.

Given this rate of load growth, the transmission facilities that supply electricity to the overall area will not be capable of delivering the forecast electricity requirements. Currently, there is only one transmission corridor that serves the northern communities of York Region. This is the 230 kV corridor which runs north east from Claireville TS in Vaughan to Brown Hill TS near Keswick (circuits B82V and B83V) and continuing to Minden TS.

During the winter of 2005/06, load transfers during winter peak times will allow Hydro One to reliably meet the demand for electricity in northern York Region. Forecasts indicate that by the winter of 2006/07 a supply solution is required to maintain reliable electricity supply.

Potential Solutions

Potential solutions to ensure reliable supply to York Region include conservation, enhanced local distribution, generation and transmission.

An independent assessment by the Independent Electricity System Operator (IESO) and a joint assessment by Hydro One and the York Region electric utilities (York Region Supply Study, 2003) concluded that there is a need for reinforcement of transmission facilities within the Region.

The transmission solution for new supply to the area is to rebuild the existing transmission facilities between Parkway TS in Markham and Armitage TS in Newmarket. This is the best overall long-term transmission solution that provides the most load meeting capability, in the areas that the local utilities would like it, with the least environmental and socio-economic impact. This solution provides diversity of supply, makes best use of an existing transmission corridor, and is the shortest and least costly route.

Underground transmission facilities
Some stakeholders have suggested that the new facilities be buried. Generally, underground facilities cost about 5–7 times that of conventional overhead designs. For this project specifically, preliminary estimates indicate that to bury a 12km portion of this circuit would result in additional costs of about $70M, more than doubling the project cost.

Distribution solutions
While distribution options were discussed by the participants in the joint study at the onset of the transmission planning process, these options were quickly dismissed by the local utilities and not pursued further.

While planning of distribution facilities within this area is not Hydro One's accountability, as the largest distributor in Ontario, we have extensive distribution planning experience. Following is the outline of a reasonable distribution solution. Although the distribution option does not provide all of the reliability benefits of the transmission solution, it is less costly than having parts of the transmission line underground and could satisfy the needs for up to 10 years. As such, we believe the distribution option is a better solution than burying some of the transmission facilities as suggested by some stakeholders. The potential distribution solution is as follows:

- Build a new Hydro One connection station at Buttonville TS.
- Transfer load from Armitage TS to the new station.
- Local utilities build distribution feeders north out of Buttonville TS.
  Hydro One would be agreeable to distribution lines being run down the edges of the existing transmission corridor as long as adequate clearances are maintained to allow building a transmission line in the future.*
- In the absence of the previously proposed transmission line, connection stations planned by Powerstream to supply the northern areas of the City of Vaughan and the Towns of Markham and Richmond Hill would have to be sited somewhere along the Parkway belt with distribution feeders carrying the power north.

Regulatory Approvals

Environmental Assessment Approval and OEB Leave to Construct are required for the transmission solution.

Implementation

The original market design construct anticipated that market forces and competition would address the demand for new facilities. In alignment with the design of the electricity sector, Hydro One had stepped in, as any other transmitter, generator or distributor could have done, but did not. Our objective was to bring forward projects to address concerns with respect to maintaining transmission system reliability.

Meetings with local elected officials began in March 2004. Once public consultation began, as part of the environmental assessment process (April 2004), it became apparent that additional time for consultation time would be beneficial. Hydro One determined that it would be possible

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* Pending the agreement of the owner of this land which is primarily the Management Board Secretariat

to extend the process without jeopardizing the ability to meet the required in service date. The time for public consultation was extended, as was the time period for public review of the draft Environmental Study Report. These processes ended in December of 2004.

Since this time, the Minister of Energy has requested that the OPA identify and assess possible long term solutions to address local reliability issues, including those in York Region. It is expected that the OPA's decision, including the OEB's approval of the integrated plan and selected options, will be completed by the end of 2005.

Hydro One has withdrawn its Environmental Study Report for this project.

The time required to build this transmission solution, once all approvals are in place, is 18 months.

Project Status

If the transmission solution is selected by the OPA and the OEB as the preferred option, Hydro One will proceed with implementing this solution.

In the meantime:

- The plan for one new connection station (out of a total of 4 stations required this decade based on local utility load forecasts) is on hold pending the determination of the final supply solution. This represents a critical need for customers of Newmarket, Aurora and the surrounding area
- We are in the process of developing operating measures in order to protect the integrity of the transmission system and ensure that any reliability problems do not cascade outside the affected electrical area. The electrical load shedding control schemes will prevent any wide spread problem by implementing local load cutting measures in a controlled fashion. This scheme may result in the interruption of electricity supply to an increasing number of customers over time, in the event that existing capacity limits are exceeded.
- The design and implementation of an automatic scheme will be subject to approvals from the IESO and North American reliability organizations to which the IESO is responsible. This load shedding scheme will be required to ensure the safe and reliable operation of the transmission system and will remain in service until an adequate long term solution is found.

Estimated Cost

Preliminary estimates are that this project will cost

- Parkway TS to Armitage TS (overhead): $60 M
- Parkway TS to Armitage TS (~12km underground): $130M
- Distribution: $30M - $40M

SUPPLY TO SIMCOE COUNTY

Need

Based on load forecasts provided by the Simcoe County utilities, electrical load growth is expected to continue at a rate of about 3% per year for the next ten years.

Based on load forecasts the transmission facilities that supply electricity to Simcoe County will not be capable of continuing reliable delivery of electricity. Electricity supply in this area is provided via 500kV, 230kV and 115kV transmission lines and transformation facilities. Growth in the area is expected to give rise to a variety of issues, including voltage deficiencies, and overloading of a number of transformer stations and of the 115kV lines in the area. Over the past several years interim measures have been put in place to manage the delivery of electricity. However, the growth in the area has now exceeded the capability of these measures to manage the area's electricity needs.

Potential Solutions

Potential solutions to ensure reliable supply to Simcoe County include conservation, enhanced local distribution, generation and transmission.

An independent assessment by the Independent Electricity System Operator (IESO) and a joint assessment by Hydro One and several Hydro One customers including the electric utilities (Simcoe County Supply Study, 2004) concluded that there is a need for reinforcement of supply in the area. The Simcoe County Supply Study developed and assessed transmission solutions to meet the electricity needs of the area.

The transmission solution for supply to Simcoe County is to convert Stayner TS from 115 kV to 230 kV, and rebuild the existing 115 kV circuit (S2E) from Stayner TS to Essa TS to a double circuit 230 kV transmission line. A 230/115 kV auto-transformer at Stayner TS is required to maintain the electrical connection to Meaford TS. As mentioned above, this plan also includes upgrading the existing two stepdown transformers at Stayner TS to 75/125 MVA capacity, to supply local load.

Regulatory Approvals

Environmental Assessment Approval has already been granted for this transmission solution as a component of the 1991 Supply to Collingwood EA approval. Leave to Construct is required.

Implementation

The time required to build this project, once all approvals are in place, is estimated to be 2 years.

Project Status

If the transmission solution is selected by the OPA and the OEB, Hydro One will proceed with implementing this solution.

Estimated Cost

Preliminary estimates are that this project will cost $40M - $60 M.

SUPPLY TO WATERLOO REGION

Each of the local distribution companies (LDC's) in the area has observed significant load growth in the last five years. Several LDC's have seen 3% to 5% growth over this period and a high rate of growth is expected to continue for the next five to ten years.

With the load growth expected, the transmission facilities that supply electricity to the overall area will run out of capacity to meet the forecast load growth. Electrical supply in this area is provided via 230kV and 115kV transmission lines and transformation facilities. With the growth expected, a variety of needs will be experienced on these facilities including voltage deficiencies and overloading of both the 230kV lines that provide supply to the region and the 115kV lines that deliver electricity throughout the region. Some of these are existing needs for which Hydro One has been working with the local utilities to develop acceptable solutions, others are forecast to be required between 2009 and 2011.

Proposed Solutions

Potential solutions to ensure reliable supply to the Waterloo Region include conservation, enhanced local distribution, generation and transmission.

An independent assessment by the Independent Electricity System Operator (IESO) and a joint assessment by Hydro One and several Hydro One customers including the electric utilities (Detweiler Area Supply Study, 2003) concluded that there is a need for reinforcement of supply in the area. The Detweiler Area Supply Study developed and assessed transmission solutions to meet the electricity needs of the area.

Hydro One's transmission solution to address the 115kV line loading is the installation of autotransformers at Preston TS and the construction of a short distance of new line. This is consistent with the long term plan for a new 230kV supply path to the area and the local utilities are fully supportive of this option.

To address the 230kV line loading and satisfy the long term needs of the region, the transmission solution is to build a new 500kV – 230kV autotransformer station and a new 230kV line.

Regulatory Approvals

Environmental Assessment Approval is required for these transmission solutions.
OEB Leave to construct approval is only required for the long term solution.

Implementation

- The time required to build the Preston TS solution, once all approvals are in place, is estimated to be 18 months.
- New station and associated lines: it is estimated that it will take about 4 to 5 years for route and site activities and for construction of the new facilities.

Project Status

If the transmission solution is selected by the OPA and the OEB as the preferred option Hydro One will proceed with implementing this solution.

Estimated Cost

Preliminary estimates indicate that this will cost about:

- $15M - $20M for the new autotransformer and associated line.
- $75M - $100M for the new autotransformer station and associated lines.

LONDON AREA LINE RELOCATION

Negotiations for land permit renewals with affected First Nations are currently underway for a section of 230 kV line between Longwood TS and Buchanan TS. The existing permit expires in 2008. If negotiations are not successful, Hydro One will have to relocate these facilities.

Proposed Solutions

While negotiations are underway, Hydro One is also exploring options in case the route needs to be changed. There are several options available. However, all options require that additional property rights be acquired.

Regulatory approvals

Environmental Assessment Approval and OEB Leave to Construct are required for this project.

Implementation

Hydro One does not believe that there are any options other than transmission if these negotiations are not successful. In order to relocate these facilities by the time the permit expires, the process for obtaining the required approvals would begin early in 2006. The time required to build the new line is anticipated to be about 18 months.

TAB 3

Electrical Supply for the City of Toronto

November 12, 2003

Foreward

This report is a result of a joint study by Toronto Hydro Electric System and Hydro One Networks. The study team members were:

Ben LaPianta, Toronto Hydro-Electric System
Ramesh Chadha, Toronto Hydro-Electric System
John Sabiston, Hydro One Networks
Ibrahim El Nahas, Hydro One Networks
Peter Huang, Hydro One Networks

This report is for the internal use of the participating utilities.

The load forecast is based on information available to Toronto Hydro at the time of the study.

The preferred plan has been selected based on technical considerations. The issue of cost allocation is not addressed.

Ben LaPianta
Manager, Investement Planning
Toronto Hydro Electric system

John Sabiston
Supervisor, System Development
Hydro One Networks Inc.

We have reviewed this report and concur with its recommendations.

Joe Bailey
Senior Vice President, Asset Management
Toronto Hydro Electric System

Carmine Marcello
Director, System Development
Hydro One Networks

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Executive Summary

The load in the central Toronto area[1] is supplied from a number of Hydro One 115kV step-down transformer stations, which are themselves supplied from two Hydro One 230-115kV autotransformation facilities at Leaside TS and Manby TS. Approximately 70% of the load in the area is supplied from Leaside TS while the other 30% is supplied from Manby TS. Under the assumption where there is no new local generation coming online, a substantial part of the high voltage electrical facilities supplying the area becomes inadequate by 2008 and reinforcement is required around that date. Reliability and diversity of supply need to be considered in the context of the occurrence of a low-probability-high-impact event, such as the loss of one of the major supply points to the central area or the loss of one of the major step-down transformer stations in the downtown area[2].

Need

The needs identified for central Toronto area are:

- Provide relief for Leaside TS autotransformers and Cherrywood x Leaside 230kV circuits by 2008,
- Provide voltage support in the central Toronto area, and
- Reduce the impact of low-probability-high-impact events.

Options

To meet these needs, three transmission options have been identified and examined:

<u>Direct Current (“DC”) Option</u>:

- Upgrade Hearn SS
- Build 2x230kV underground cable circuits 7 km in length between John TS and Hearn SS, routed through or nearby the “Roundhouse TS” site
- Provide one 250 MW back-to-back HVDC connection at Hearn SS to increase the load transfer capability between the Leaside sector (west) and the Manby sector (east)
- When required, provide two 500 MW HVDC connections between Beck 2 TS in the Niagara area and Hearn SS (via submarine cables under Lake Ontario), together with the required converters
- Build new 115-13.8kV “Roundhouse TS”
- Provide additional 13.8 infrastructure to enable switching of supply between supply stations

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[1] The central area of Toronto is roughly bounded by Eglinton Ave., Lake Ontario, the Humber River, and Victoria Park Ave..

[2] The downtown area is roughly bounded by Bloor St., Lake Ontario, Sherbourne St., and Bathurst St..

<u>230 kV Alternating Current (“AC”) Option</u>:

- Build 2x230kV underground cable circuits between Manby TS and Esplanade TS. Also install a 1x230kV underground cable circuit between John TS and Esplanade TS, routed through or nearby the “Roundhouse TS” site
- Rebuild 6.9 km of overhead portion of K14J between Manby and Riverside Jct. for 230kV operation
- Build 2x230kV circuits between Richview TS and Manby TS
- Build 230kV-13.8kV Esplanade TS-II.
- Upgrade the existing 115kV John TS and Esplanade TS to 230kV operation
- Build 2x230kV underground cable circuits between John TS and Esplanade Jct., routed through or nearby a new “Roundhouse TS” site and connect to Terauley TS
- Build new 230-13.8kV “Roundhouse TS”
- Provide additional 13.8 infrastructure to enable switching of supply between supply stations

<u>115 kV AC Option</u>:

- Build one 230kV underground cable circuit between Manby TS and John TS to be initially operated at 115kV. A 2Ω series reactor is to be provided for the new cable. Also install 2x230kV underground cable circuits between John TS and Esplanade TS to be initially operated at 115kV and routed through the “Roundhouse TS” site
- Build one 230kV overhead circuit between Richview TS and Manby TS
- Install one 250 MVA, 230-115kV autotransformer at Manby TS
- Upgrade 6.9 km 115kV overhead circuits K6J/H2JK/K13J/K14J between Manby TS and Riverside Jct.
- Provide additional 13.8 infrastructure to enable switching of supply between supply stations

With Lakeview expected to be retired in April 2005, installing shunt capacitor banks at John TS, Leaside TS, Richview TS, and Burlington TS can help compensate for the loss of MVAr generation in the area. In addition, installation of series capacitors at suitable sites can optimize the use of existing infrastructures.

Recommendations

Any of the above options would require building major new facilities that could take a significant amount of time to plan, design and install. Also, due to the uncertainty associated with the known generation development projects in the Greater Toronto Area, it is necessary to take economic short-term measures to provide relief to overloaded facilities to the extent that long-term relief can be provided in a timely and cost effective manner. It is therefore recommended to build transmission facilities that are common to all options in the near term.

The following facilities will provide short term relief to downtown Toronto:

- Build 2x230kV underground cable circuits 2.5 km in length between John TS and Esplanade TS to be operated initially at 115kV. The cables are to be routed through or nearby the new “Roundhouse TS” site. The cables will also be connected to existing circuits C5E and C7E. The required in-service date for the circuits is summer 2008. These circuits will provide increased load transfer flexibility between the Leaside (east) and Manby (west) sectors.

- Install shunt capacitor banks equipped with power quality improvement devices at the following locations to provide voltage support:
  John TS: 125MVAr rated at 127kV
  Leaside TS: 125MVAr rated at 127kV
  Richview TS: 411.6MVAr rated at 249.8kV
  Burlington TS: 300MVAr rated at 249.8kV

- Provide additional 13.8 infrastructure to enable switching of supply between downtown stations.

The required in-service date for the capacitors is April 2005, when Lakeview GS is retired. The in-service date for the 230kV underground cable circuits is May 2008.

1. Introduction

The load in the central Toronto area is supplied from a number of Hydro One Networks Inc. (“Hydro One”) 115kV step-down transformer stations, which are themselves supplied from two Hydro One 230-115kV autotransformation facilities at Leaside TS and Manby TS, as shown in figures 1A and 1B. Currently, approximately 70% of the load in the area is supplied from Leaside TS while the remaining 30% is supplied from Manby TS. The central area has a combined load that exceeded 2100 MW in 2002.

Hydro One and Toronto Hydro-Electric System Ltd. (“Toronto Hydro”) conducted a joint study during 2003 to review the load growth in the central Toronto area to ensure that adequate facilities are available to meet future electrical demand requirements. The focus of the study was on the identification of a third supply point for load in downtown Toronto. This report provides the results of the joint study, including the assessment of the need for a third supply point, alternative solutions, simulation assessments and recommendations.

2. Load Growth

Toronto Hydro’s latest summer peak load forecast was considered in an assessment of the ability of the existing transmission facilities to meet the growing electricity needs in Toronto. The summer peak load is currently higher than the winter peak load, and the gap is expected to widen over time due to increasing air-conditioning load. Since the load carrying capability for transmission lines and station facilities is lower in summer compared to winter, the area is generally summer critical.

Table 1 summarizes the load growth for stations in the central Toronto area. The summer peak load forecast in the central Toronto area is estimated at 1.62% on average over the next 12 years (Source: Toronto Hydro Load Forecast, January 2003).

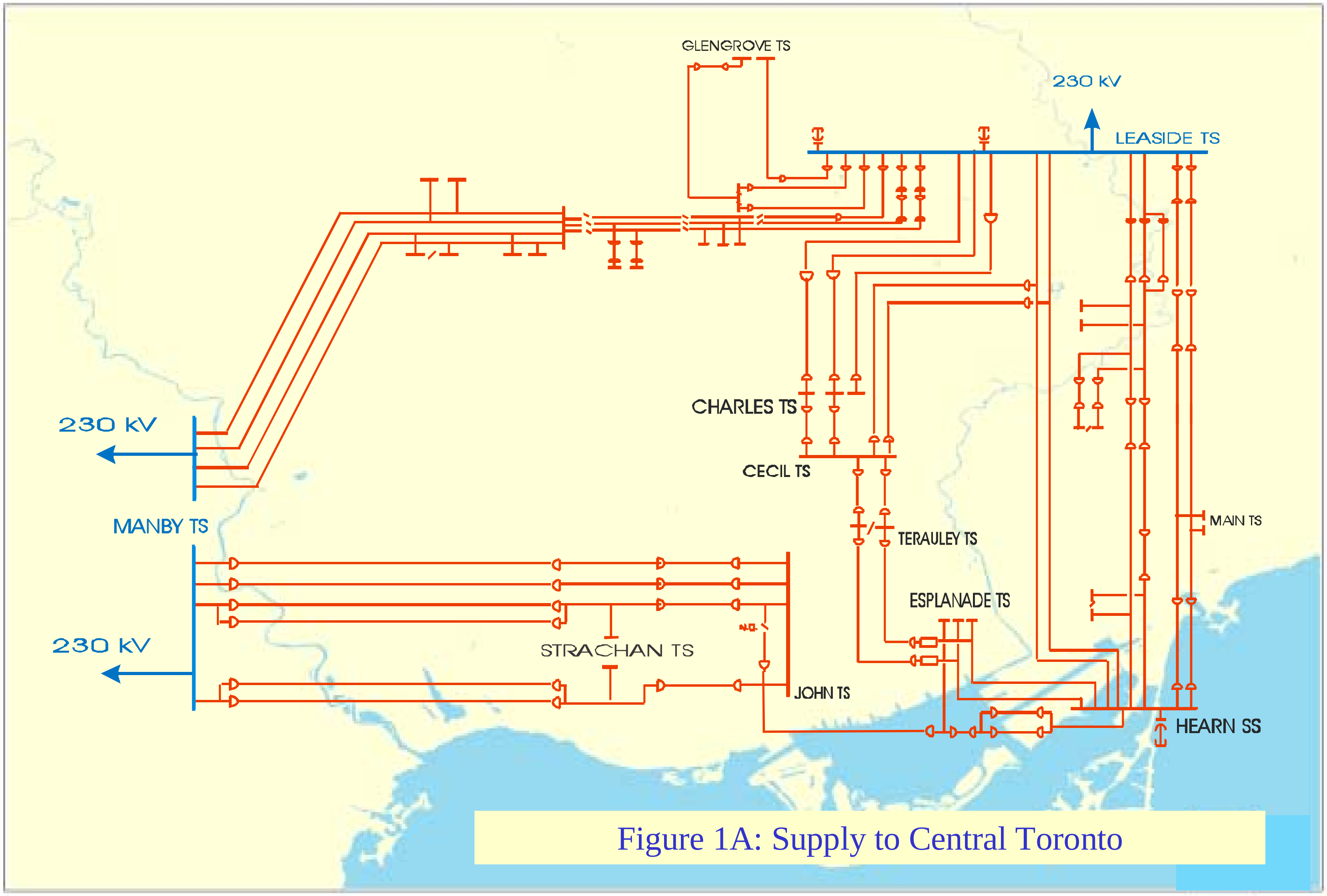


Figure 1A: Supply to Central Toronto

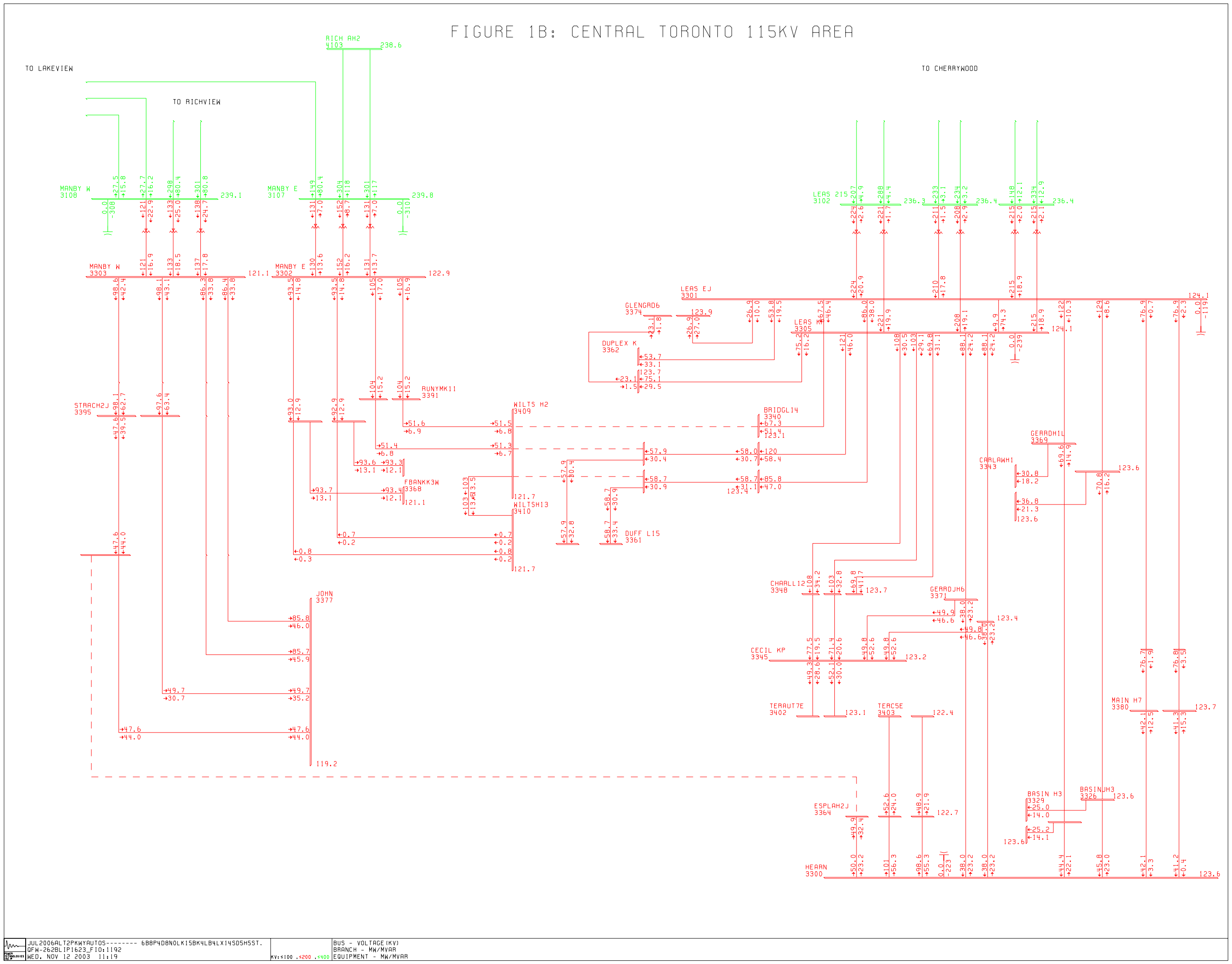


FIGURE 1B: CENTRAL TORONTO 115KV AREA
TO LAKEVIEW
TO RICHVIEW
TO CHERRYWOOD

Table 1: Toronto Area Stations: Summer Peak Load Forecast (in MW)

Station	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Basin	48.5	50.1	51.7	53.4	54.0	54.5	55.1	55.6	56.2	56.7	57.3	57.8	58.4	59.0
Birdgeman	153.6	155.7	157.7	159.8	161.6	163.3	165.1	166.9	168.6	170.4	172.2	174.0	175.9	177.7
Carlaw	67.0	67.2	67.5	67.8	68.5	69.3	70.1	70.6	71.2	71.7	72.2	72.8	73.3	73.9
Cecil	138.9	146.5	154.6	163.1	169.2	175.5	182.0	185.1	188.3	191.5	194.8	198.1	201.5	205.0
Charles	130.6	131.2	131.8	132.4	133.8	135.3	136.7	137.9	139.0	140.2	141.4	142.6	143.8	145.0
Dufferin	114.8	116.0	117.1	118.3	119.8	121.2	122.7	123.5	124.4	125.3	126.2	127.1	127.9	128.8
Duplex	104.0	104.9	105.8	106.8	108.0	109.2	110.4	111.4	112.3	113.2	114.1	115.1	116.0	117.0
Esplanade	144.9	146.9	148.9	151.0	153.9	156.8	159.8	163.2	166.8	170.3	174.0	177.8	181.6	185.5
Fairbank	170.4	186.0	187.5	188.9	191.8	194.6	197.5	199.0	200.4	201.9	203.4	204.8	206.3	207.8
Gerrard	42.0	42.1	42.3	42.5	42.6	42.7	42.9	43.1	43.3	43.5	43.7	43.9	44.1	44.3
Glengrove	49.3	49.6	49.9	50.2	50.7	51.3	51.9	52.1	52.4	52.7	53.0	53.3	53.6	53.9
John	271.5	267.4	263.3	259.4	265.3	271.4	277.6	283.2	289.0	294.9	300.9	307.1	313.4	319.7
Leaside	146.6	148.4	150.1	151.9	153.3	154.8	156.2	158.0	159.7	161.5	163.3	165.1	166.9	168.7
Main	68.5	69.8	71.1	72.3	73.6	74.9	76.2	76.8	77.4	78.1	78.7	79.4	80.0	80.7
Runnymede	104.9	105.3	105.6	105.9	107.0	108.0	109.0	110.1	111.1	112.1	113.2	114.2	115.3	116.4
Strachan	93.7	98.1	102.8	107.6	110.8	114.0	117.4	120.8	124.3	128.0	131.7	135.6	139.5	143.6
Terauley	203.6	201.8	200.1	198.4	200.7	201.8	203.6	207.3	211.1	214.9	218.8	222.8	226.8	231.0
Wiltshire	100.8	100.8	100.8	100.8	101.8	102.8	103.8	104.7	105.7	106.7	107.7	108.8	109.8	110.8
Total	2153.7	2187.8	2208.6	2230.3	2265.5	2301.4	2337.9	2369.3	2401.2	2433.6	2466.6	2500.0	2534.1	2568.7

3. System Assumptions

In order to study the effects of contingencies and verify the system capacity, the following assumptions are made in this report:

1. A study period of 2003 to 2015 is chosen to assess transmission requirements.

2. Peak loads are based on the summer peak load forecast provided by Toronto Hydro.

3. The following generation resource assumptions are assumed:
   - Lakeview GS will be retired completely by April 2005, and is thus excluded from the study
   - No new generation facilities are available in downtown Toronto (i.e. at John TS or Hearn SS) or in close proximity.
   - All four Pickering B GS units are available throughout the study
   - One Pickering A GS unit is available immediately. Starting in 2007, all solution simulations have assumed a second Pickering A unit in service.

4. Leaside TS 115kV buses and Richview TS 230kV buses are assumed closed in this study.

5. With a complete Lakeview retirement, 230kV buses at Lakeview are closed to provide flexibility and improve transfer capability between Richview TS and Manby TS.

6. 115kV bus at Terauley TS is quartered and split, with two buses at Terauley TS supplied from the Esplanade TS side and another two buses supplied from the Cecil TS side.

7. All new transmission in the downtown Toronto area is underground.

8. Overhead equipment continuous Limited Time Ratings (LTR) are based on an ambient temperature of 30°C for summer and a wind speed of 4km/hr.

9. Voltage dependent load models were assumed based on $P \propto V^{1.5}$ and $Q \propto V^2$ for post-contingency.

10. Maximum voltage decline is limited to 10% for a single element contingency. Minimum voltages on the 115kV and 230kV transmission system under normal conditions is 113kV and 230kV respectively.

4. Adequacy of Existing Facilities

This section reviews the adequacy of the existing transmission facilities supplying central Toronto. Power Technologies Inc.'s PSS/E load flow software was used to run simulations and the results obtained are shown in Appendix A and B. Under contingency conditions (i.e. one transmission element out of service), Appendix A shows the power flow on critical circuits while Appendix B shows the voltage decline of critical buses.

4.1 Leaside TS and Cherrywood x Leaside Corridor

The Leaside 230-115kV TS is supplied from 6x230kV overhead circuits located on the double circuit tower lines C2L/C3L, C14L/C15L, C16L/C17L from Cherrywood TS. The autotransformation facilities at Leaside TS comprise six autotransformers rated at 250MVA each. The station supplies twelve 115-13.8kV and one 230-13.8kV step down transformer stations, which represent about 70% of central Toronto load.

Figure 2 shows the autotransformation capacity at Leaside and load growth at stations supplied by the autotransformation facilities, while figure 3 shows the capacity of the 6x230kV circuits between Cherrywood and Leaside and the load growth pattern:

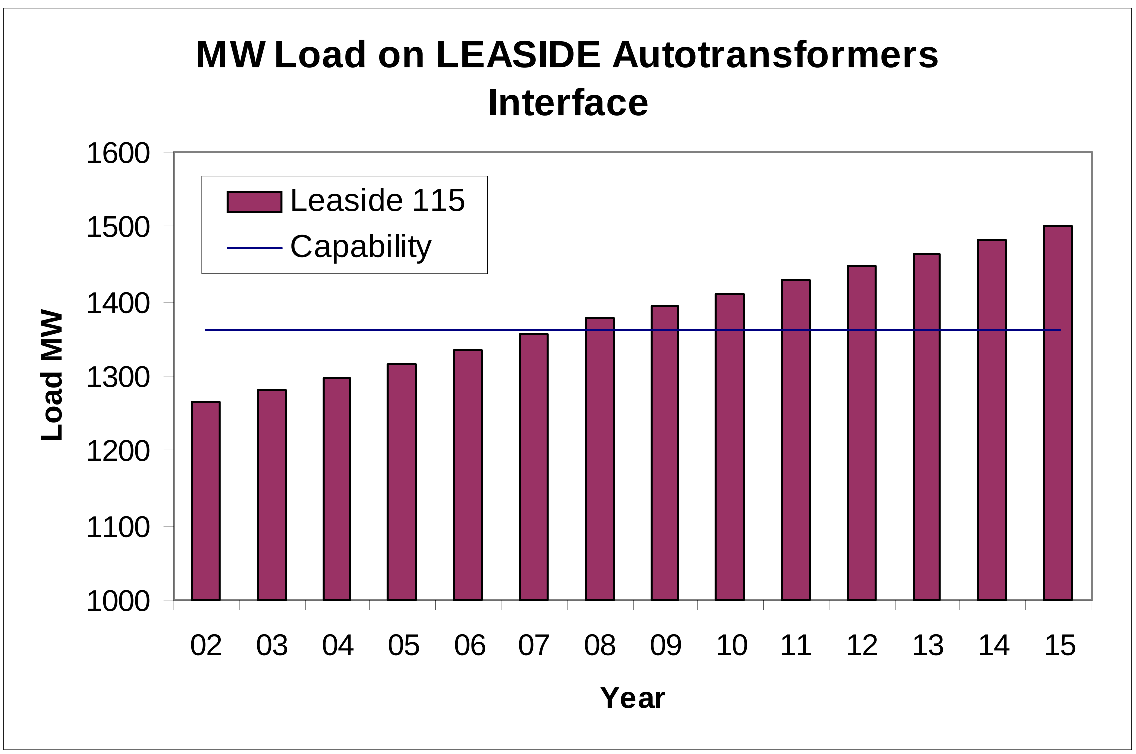


Figure 2: MW Load on Leaside Autotransformers

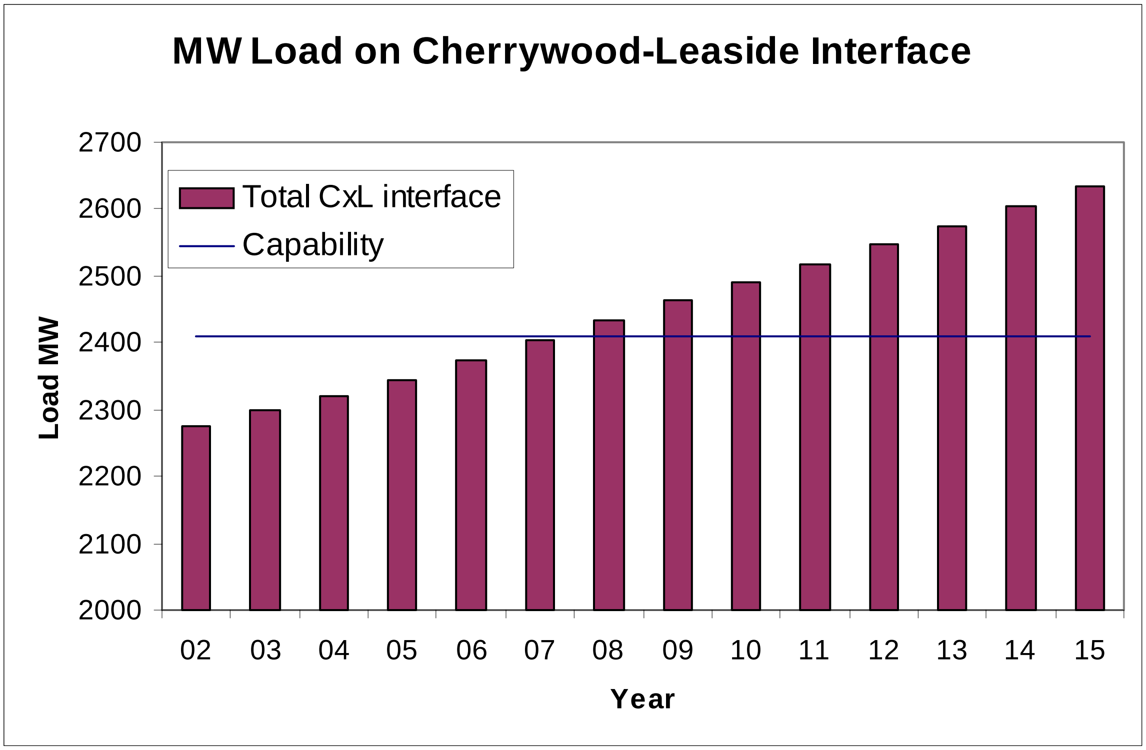


Figure3: MW Load on Cherrywood-Leaside Interface

The capacity curve is obtained by taking the smaller of two constraints: either the thermal limit or the voltage performance limit. The thermal limit considers the capability of the circuits or autotransformers in the interface with one element out of service. The continuous rating of the overhead circuits and autotransformers were used to evaluate the thermal limit. The voltage performance limit is obtained by plotting the P-V (Power-Voltage) curve of the area to find the critical point, and taking 90% of the critical point loading to account for a safety margin (done in accordance to IMO's Transmission Assessment Criteria).

Both figures 2 and 3 suggest that transmission reinforcements for the Leaside sector are required by 2008 under peak loading conditions. This assumes that during a steady state post-contingency situation, a portion of the load in the Leaside sector is transferred to the adjacent Manby sector. Together with the use of shorter time thermal ratings, overloading can be avoided under all single-circuit contingency conditions and most double-circuit contingency conditions.

Leaside 115kV buses are assumed to be closed and operated solid in this study. However, if new generation development in the Leaside sector comes online, Leaside 115kV buses will be operated split to ensure that the short circuit level does not exceed the equipment's limit.

4.2 Manby TS and Richview x Manby Corridor

Manby 230-115kV TS is supplied by 4x230kV overhead circuits R1K/R13K and R2K/R15K from Richview TS. The 230-115kV autotransformation facilities at Manby TS comprise six autotransformers each rated at 250 MVA. Manby TS is split into two halves: Manby East and Manby West. In total, the station supplies five 115kV step-down transformer stations and two 230kV step-down facilities.

Manby TS is also connected to Lakeview GS through 3x230kV overhead circuits L21K/L22K (Manby West) and L23CK (Manby East). Under the assumption that Lakeview GS will retire in April 2005 and that the 230kV bus at Lakeview will be operated closed, these circuits will supply Manby TS through L24CR, from Richview TS through Lakeview TS to Manby TS. Other studies are in progress to identify the optimal configuration of these circuits.

Figure 4 shows the autotransformation capacity at Manby West TS and load growth at stations supplied by the autotransformation facilities. Figure 5 shows the autotransformation capacity at Manby East TS. Figure 6 shows the capacity of the 230kV circuits between Richview TS and Manby TS and the load growth pattern:

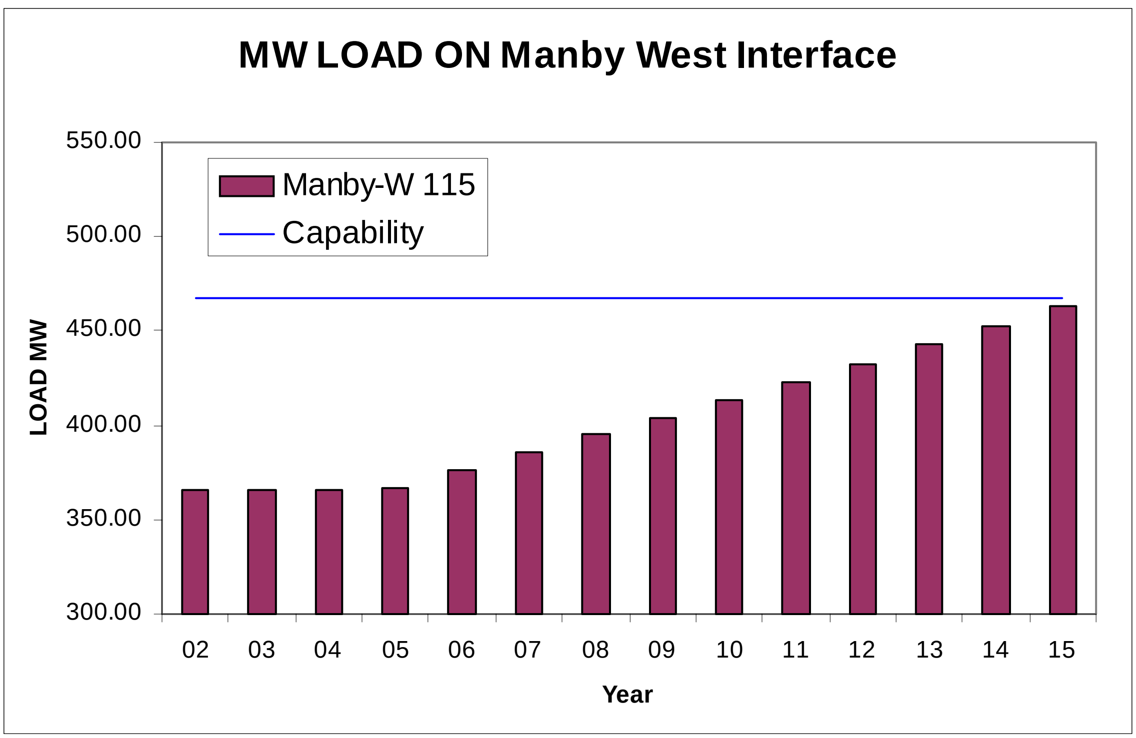


Figure 4: MW Load on Manby West Autotransformers

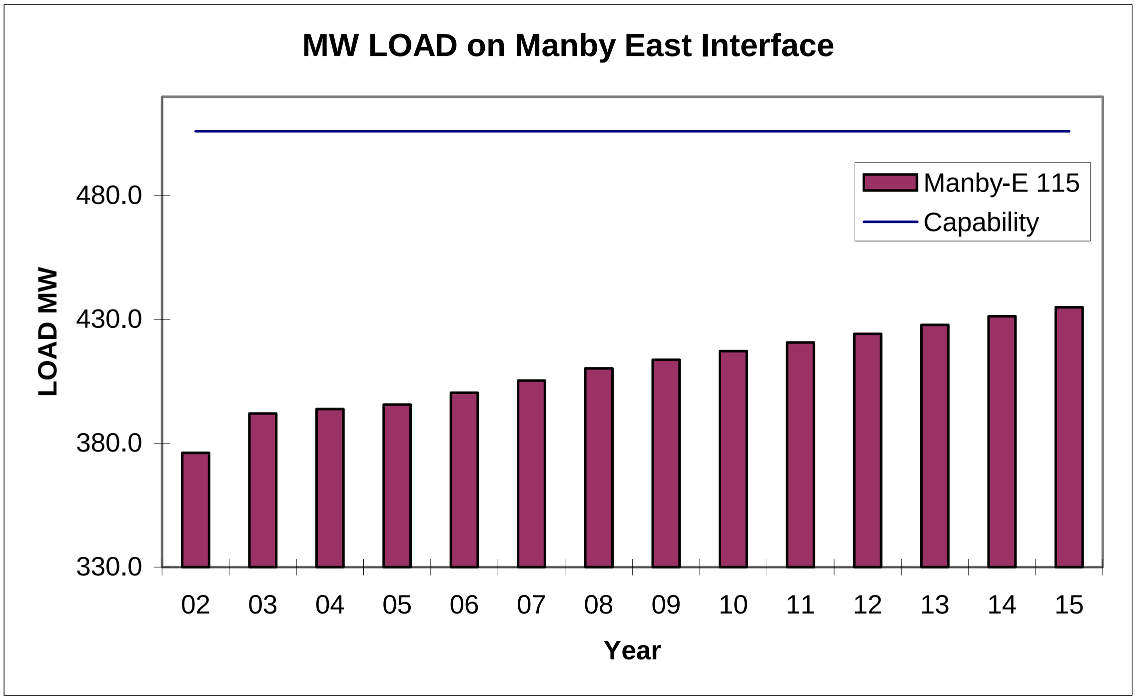


Figure 5: MW load on Manby East Autotransformer

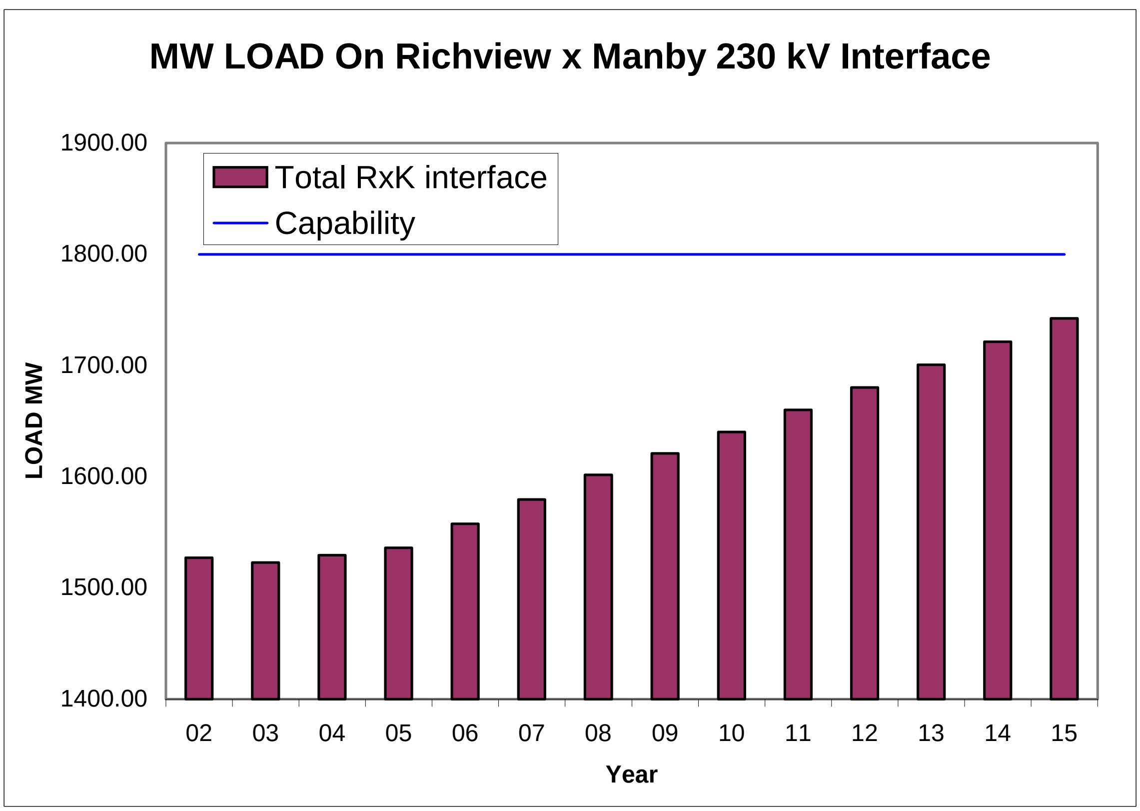


Figure 6: MW Load on Richview x Manby Interface

Figures 4 to 6 show that the capacity at the Manby autotransformer interfaces and the Richview by Manby interface is adequate until 2015. However, the limitation on load transfer capability between the Leaside sector (east) and the Manby sector (west) under contingency situations will be reduced if no reinforcement is added.

4.3 Voltage Support in Central Toronto

With the retirement of Lakeview GS and the assumption of no new generation facilities in or near central Toronto, voltage at transmission stations in the area is low. From Appendix B, 2 buses at Terauley TS have a voltage of 113.9kV by 2007, which barely meets the Market Rules requirements. It is noted that, while not a requirement, the IMO prefers that the 230 kV and 115 kV bus voltages at Leaside TS be maintained at a minimum of 238kV and 119 kV, respectively, for system security reasons.

Thus, in the absence of any new facilities to reinforce the transmission system, further voltage support is required by 2008.

4.4 Infrastructure Risk

Load in Toronto area is supplied by Manby TS and Leaside TS or stations supplied by the two autotransformer stations. Currently Manby TS supplies about 30% of Toronto load while Leaside TS supplies about 70%. In a catastrophic event of losing either the entire Manby or Leaside station, the impact on supply to Toronto area is significant. System wide reinforcement, such as a third supply point, is needed to improve transmission system reliability in the area.

Customers in the downtown Toronto are supplied from only one single transformer station. These supply feeders are not tied with any other transformer station feeders to provide a secondary backup support. Therefore, with the total loss of any transformer station in downtown Toronto area, the customers supplied from the station would be without power; and only after the restoration of the station customers could be supplied. However, for other none-downtown stations supplying the rest of the city, there exists a backup feeder connected to another transformer station that can pickup the entire load of the faulted feeder. Table 2 summarizes the risk:

Table 2: Risk Assessment of Stations Supplying Downtown Toronto Load

	% of downtown load	Full backup from other TS	Risk
John TS	32%	No	Low probability, very high impact
Terauley TS	24%	No	Low probability, very high impact
Esplanade TS	16%	No	Low probability, very high impact
Cecil TS	16%	No	Low probability, very high impact
Strachan TS	12%	No	Low probability, very high impact
Other Toronto Hydro stations	N/A	Yes	Low probability, moderate impact

As Table 2 indicated, with the loss of entire John TS, 32% of downtown customers would be without power. These stations supply the most critical load in the area. Further reinforcement is desirable to reduce the impact of these low probability-high-impact events.

4.5 Overall Need Summary

Based on the above assessment, the following needs have been identified:

- Provide relief for Leaside autotransformers and Cherrywood x Leaside 230kV circuits by 2008,
- Provide voltage support in the central Toronto area, and
- Reduce the impact of low-probability-high-impact events.

5. Possible Options

This section investigates different options that can address the needs mentioned in the previous section.

5.1 "Do Nothing"

The "Do Nothing" option does not meet the need. Equipment loading will continue to increase and supply reliability will be adversely impacted in case of a contingency. This option is not acceptable and is not considered further.

5.2 Direct Current (DC) Option

Also known as the Toronto Niagara Link Option, the DC Option links Hearn SS in downtown Toronto to Beck 2 TS in Niagara through a permanent High Voltage Direct Current (HVDC) connection. Two new 230kV circuits linking John TS and Hearn SS will be built and initially operated at 115kV. The cables will be routed through or by the new "Roundhouse TS" site to facilitate the future connection to a new Roundhouse TS. The cables will also be routed through Esplanade TS and will make a connection to circuits C5E and C7E to allow future load transfers from Esplanade TS and Terauley TS.

In order to accommodate the connection, Hearn SS needs to be rebuilt using the "breaker and one third" configuration as opposed to the existing ring configuration. (For breaker and one third configuration, there are four breakers on each diameter allowing three lines to be terminated on the diameter.) A 250MW back-to-back HVDC connection linking the Leaside sector and Manby sector will be provided to allocate a portion of the supply to the Manby sector. The back-to-back HVDC conversion facility is to be located at Hearn SS, and a cable connection will be provided between John TS and Hearn SS.

HVDC facilities will be installed at both Hearn SS and Beck 2 TS, and ultimately two 500 MW HVDC connections will be provided between the two stations. The HVDC cables will run through Lake Ontario, with a landing point located at Hearn SS and Beck 2 TS. If there is not a suitable landing location at the Niagara River downstream from Beck 2 TS, the cable can land at a suitable point near Niagara-on-the-Lake. Figure 7 shows the proposed connection for the DC Option:

In addition, 13.8kV cable circuit infrastructure reinforcement will be provided for the area served by John TS and Esplanade TS. The infrastructure addition can improve load transfer capability between supply stations and provide more operational flexibility.

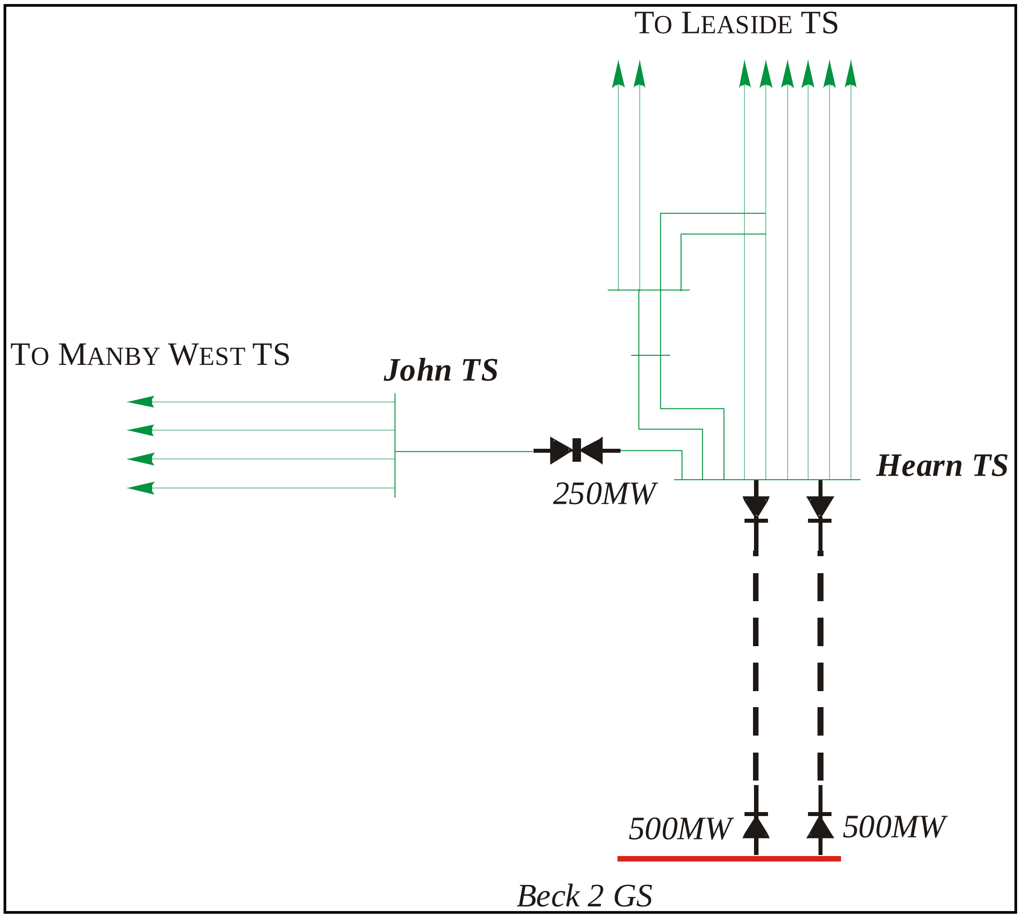


Figure 7: DC Option: HVDC Connection Between Beck 2 x Hearn SS and Hearn SS x John TS

When fully implemented, the DC Option can provide 1000 MW of additional supply to downtown Toronto. The DC Option provides relief for Leaside TS autotransformers and Cherrywood x Leaside 230kV circuits by injecting 750 MW into the Leaside sector; the option also reduces the need for reinforcing Manby TS by injecting 250 MW into the Manby sector.

The DC Option does not contribute to any additional short circuit fault current. In addition, rebuilding Hearn SS also accommodates the need for Portlands Energy Center to connect to the new Hearn SS, if this proposed generation project is implemented.

5.3 230 kV Alternating Current (AC) Option

Under the 230 kV AC Option, 230-13.8kV step-down facilities will be introduced to downtown Toronto. The 230kV transmission system will be constructed to supply these 230-13.8kV stations from Manby TS. John TS and Esplanade TS will be converted from 115kV to 230kV operation; a new "Roundhouse TS" will be built at the Roundhouse site as the last stage of the option.

In order to maintain an adequate level of load supply security in the Lakeview/Manby area, meet the growing load demands that are supplied from the Richview TS x Manby TS transmission facilities and to accommodate the increased transfers following the cease of operation of Lakeview GS, additional 230 kV transmission capability is required. Three alternatives exist to achieve the goal:

1. Two new 230kV overhead circuits between Richview TS and Manby TS
2. Two new 230kV overhead circuits between Oakville TS and Trafalgar TS
3. One new 230kV overhead circuit between Richview and Applewood Jct. to share the same tower carrying the L24CR circuit

Alternative 1 is chosen for simulation and planning for 230 kV AC Option, but other alternatives can be considered to achieve other system requirements not evaluated in this study for other areas. Alternative 1 is used because it is the preferred technical option to meet the forecasted load demands for central Toronto, Manby/Mississauga south area.

Two 230kV circuits from Manby TS (Manby East) to John TS and Esplanade TS will be built, and the cable will run through or by the new "Roundhouse TS" site to facilitate the future connection of Roundhouse TS. In addition, 6.9 km of K14J between Manby West and Riverside Jct. will need to be rebuilt for 230kV operation. At the same time, the new Esplanade TS-II, a 230-13.8kV step-down station, will be constructed to enable the Esplanade TS and John TS upgrades to 230 kV, and to provide connection room for further load growth in the area.

For the 115kV reinforcement, two 115kV 2.5 km circuits will be built between John TS and Esplanade Jct., and will connect to Terauley TS. The 115kV circuits will be an extension of the existing K6J and K13J circuits, which will be supplied from Manby TS West and provide power to Terauley TS. After full implementation of the AC Option, these 115kV circuits will no longer supply John TS. The connection from Hearn SS to the old 115kV Esplanade Jct. and to Terauley TS will also be disconnected and operated as normally open circuits. Similar to DC Option, additional 13.8kV cable circuit infrastructure will be provided for John TS and Esplanade TS.

With 230kV and 115kV circuit reinforcement completed in the Manby sector, the 230kV AC Option relieves the Leaside sector by transferring the load at Esplanade TS and Terauley TS to the Manby sector. The overall circuit connection diagram is shown in Figure 8.

When fully implemented, the 230kV AC Option can increase the supply capability to central Toronto by about 750MW. The 230 kV AC Option does not contribute to short circuit fault current at stations located in the central Toronto area.

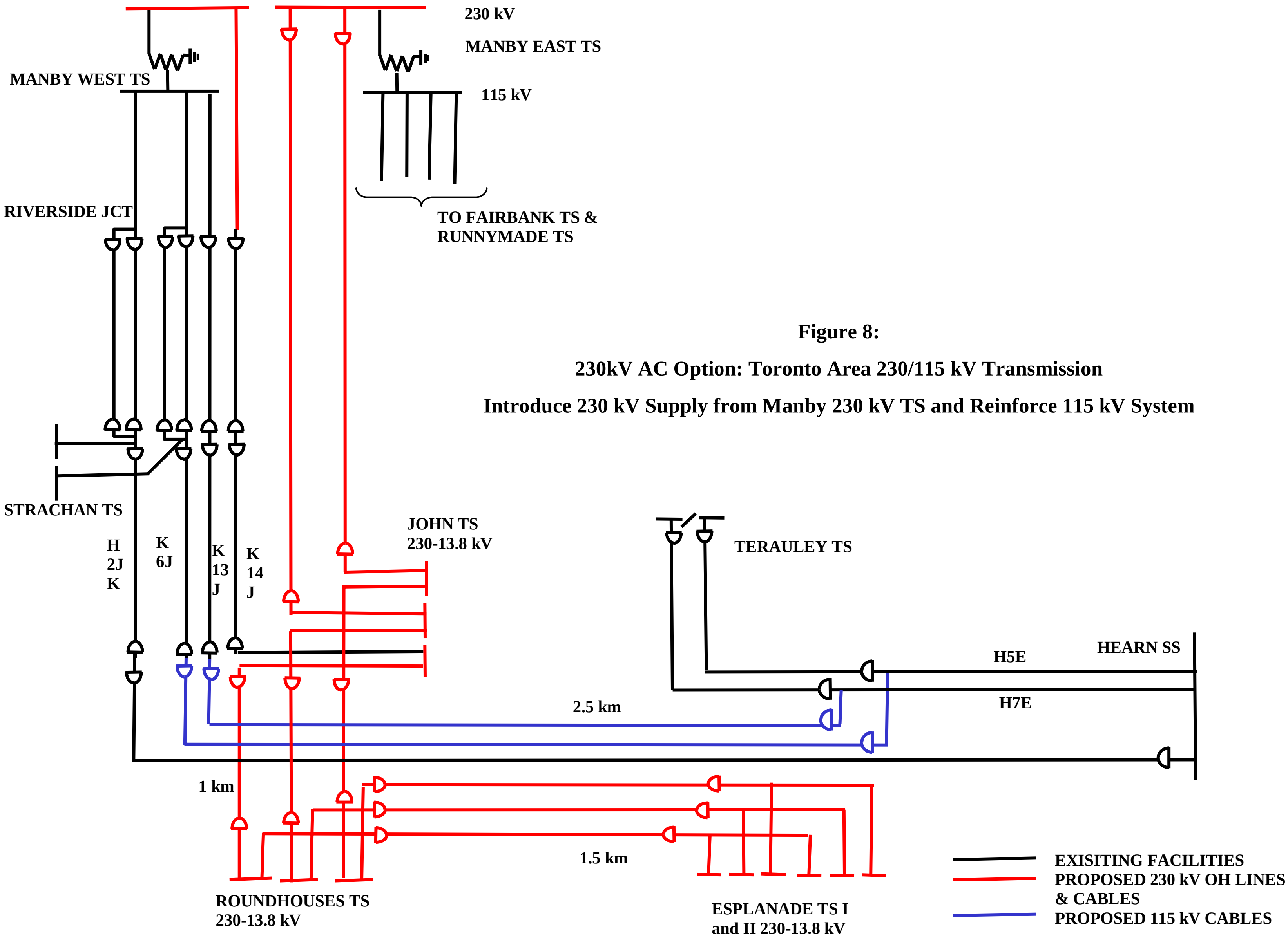


Figure 8:

230kV AC Option: Toronto Area 230/115 kV Transmission

Introduce 230 kV Supply from Manby 230 kV TS and Reinforce 115 kV System

5.4 115 kV Alternating Current (AC) Option

The 115 kV AC Option involves reinforcing the existing 115kV transmission facilities at Manby TS and in downtown Toronto. A 230kV circuit will be installed to reinforce the Richview x Manby interface. The 230kV circuit is to be terminated at Manby TS West, where a 250 MVA 230-115kV autotransformer will be installed as well to increase the autotransformation capability in the area. A 230kV cable between Manby TS West and John TS will be installed and initially operated at 115kV to reinforce the supply to John TS. Due to impedance difference between the existing circuits and the proposed underground cable circuit, a 2Ω series reactor is proposed to be connected to the new underground cable circuit so that a balanced flow can be achieved among all five 115kV circuits supplying John TS.

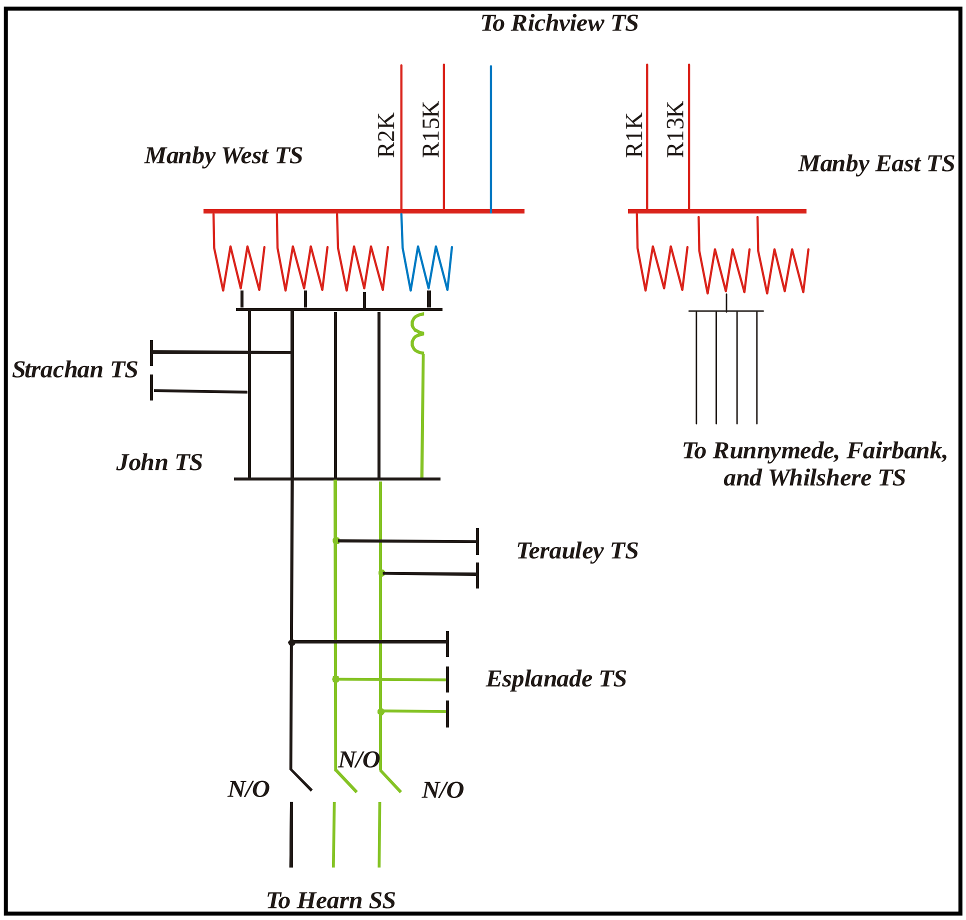


Figure 9: 115 kV AC Option: Reinforcing the 115kV System in Manby Sector

Two 230kV circuits will be installed between John TS and Esplanade TS to be initially operated at 115kV. The cable will be routed through or by the new "Roundhouse TS" site to facilitate the future connection to the new station located on the Roundhouse site. All the 115kV overhead circuits between Manby TS and Riverside Jct., 6.9km in length for

K6J, H2JK, K13J, and K14J, will be upgraded to enable load transferred from Esplanade TS, which is to be supplied by the four 115kV circuits. Similar to DC and 230kV AC Option, additional 13.8kV cable circuit infrastructure will be provided at John TS and Esplanade TS. Figure 9 shows the circuit configuration for the 115 kV AC Option.

When fully implemented, the 115 kV AC Option can increase the capability of supply to downtown Toronto by about 350 MW. However, the option does not constitute a third supply, and it provides a relatively smaller upgrade compared to the other two options.

5.5 System Improvement for Lakeview Retirement

In addition to the three options mentioned in the previous sections, other system reinforcement will be needed to accommodate the retirement of Lakeview. With Lakeview out of service, the flow from Richview TS to Manby TS increases. The circuits in the interface can overload in a companion circuit contingency. To mitigate this problem, two options are considered.

The first option is the series reactor option. A 13.26mH (5Ω) series reactors rated at 230kV will be placed at Manby TS West for the Richview x Manby circuits terminated at Manby TS West, namely R2K/R15K, while a zero impedance bypass will be provided for normal operation.

With Lakeview retired and the HV bus closed, there exists an alternative route between Richview TS and Manby TS. Supply can be achieved by going through circuit L24CR to Lakeview, then through circuits L21K/L22K/L23CK to Manby TS. Supply can also go through Manby TS East and loop back to Manby TS West through Lakeview. However, the alternative route has higher impedance; the series reactors can increase the impedance of the direct connection and force more power through the alternative route during a contingency to avoid overloading on circuits R2K or R15K. This scheme has the drawback of causing a small increase of 17MVAr per circuit in reactive power loss due to the reactor addition. However, this loss only occurs when the reactors are switched on during a companion circuit contingency.

Another option is the series capacitor option. A 5.23Ω series capacitor is installed at Lakeview TS and connected to L24CR circuit, and a 2.9Ω series capacitor is also installed at Lakeview TS and connected to L21K circuit. The capacitors are sized for a 70% impedance compensation of the line it is connected to. In addition, the tap-off point on L24CR located at Applewood Junction is moved to L22K at the same junction point. By doing so, more power can be forced onto the electrically shortened circuit of L24CR and L21K, providing another parallel circuit between Richview TS and Manby TS. The configuration can help off-load the flow on existing direction circuit connection between Richview TS and Manby TS, namely R1/2/13/15K.

Based on the existing transmission system (i.e. no system upgrades), voltage stability can only be maintained up until 2007. Very low voltages can be observed at certain stations in year 2007, such as the 113.9kV observed at Terauley TS. To compensate for the loss of Lakeview generation and maintain the voltage profile at a reliable level, reactive power injection is needed in the Manby sector and the surrounding areas. Shunt capacitors in various sizes are proposed to be installed at the following stations for voltage support once Lakeview GS is completely out of service with the 230kV bus closed:

John TS: 125MVAr rated at 127kV
Leaside TS: 125MVAr rated at 127kV
Richview TS: 411.6MVAr rated at 249.8kV
Burlington TS: 300MVAr rated at 249.8kV

By installing large shunt capacitor banks at key supply transformer stations, the lack of MVAr due to the loss of Lakeview can be compensated. These capacitor banks also have the advantage of helping the voltage profile for stations located in central Toronto by strengthening the supply stations.

With the installation of capacitor banks, temporary transient over-voltage may occur due to capacitor switching. The over-voltage transient problem causes power quality issue at the stations where the capacitor banks are installed. To improve power quality, zero crossing IPO switching device will be provided for the above capacitor bank installations as per Hydro One design philosophy.

6. Third Supply Options Assessment and Other Short Term Plans

6.1 Option 1. HVDC Supply to Downtown Toronto

This development would be completed in three stages:

Stage	Investment	Date
1	• Build 2x230kV underground cable circuits 2.5km in length between John TS and Esplanade TS to be operated initially at 115kV. The cables are to be routed through or by the new “Roundhouse TS “ site. The cables will be connected to circuits C5E and C7E to allow future load transfer from Esplanade TS and Terauley TS. • Provide additional 13.8kV cable circuits between John TS and Esplanade TS to enhance load transfer capability.	May 2008
2	• Upgrade Hearn SS[3] • Build 1x230kV underground circuit 3.6km in length from Esplanade TS	May 2010

[3] The timing of Hearn SS upgrade depends on the timing for the incorporation of the proposed Portlands Energy Centre. The current earliest date for this is Q1 2006.

	to Hearn SS. • Provide 250MW back-to-back HVDC connection at Hearn SS to connect Leaside and Manby sectors • Provide a 500MW HVDC connection between Beck 2 TS and Hearn SS • Provide 500MW HVDC converter facilities at Beck 2 TS and Hearn SS	
3	• Provide a second 500MW HVDC connection between Beck 2 TS and Hearn SS • Provide a second set of 500MW HVDC converter facilities at Beck 2 TS and Hearn SS	May 2020

Appendix C and D show the power flow on critical circuits and voltage decline under contingencies at critical buses for the DC Option. From the study, the following qualitative conclusions are drawn:

- All circuit loading is within the emergency continuous 50 hours/year rating. Switching can be performed to bring the loading on the circuit down to the regular continuous rating in case of a sustained outage.

- All transformer loading is within the 10-day LTR rating. Switching or load transfers can be performed to bring loading on the transformers down to the regular continuous rating in case of a sustained outage.

- Line loading on the 115kV circuits between Manby TS and John TS, namely circuits H2JK, K6J, K13J, and K14J, is very light. Thus it is concluded that the 115kV circuits will be able to support the flow in any contingency involving the outage of one of the companion circuits.

- Voltage decline for post contingency situation is within 10% of pre-contingency voltage as required by Market Rules.

- Voltage support is needed at John TS in 2013.

Double circuit contingencies are investigated for the circuits at Richview x Manby and Cherrywood x Leaside interfaces. Only single circuit contingencies are considered for circuits between Manby TS and John TS due to its radial configuration design.

6.2 Option 2. 230kV AC Supply to Downtown Toronto

This development would be completed in three stages:

Stage	Investment	Date
1	• Build 2x230kV underground cable circuits 2.5km in length between John TS and Esplanade TS to be operated initially at 115kV. The cables are to be routed through or by the new "Roundhouse TS" site. The cables will be connected to circuits C5E and C7E to allow future load transfer from Esplanade TS and Terauley TS. • Establish Roundhouse TS site • Provide additional 13.8kV cable circuits between John TS and Esplanade TS to enhance load transfer capability.	May 2008
2	• Install 2x230kV underground circuits between Manby TS and John TS • Install new 230kV facilities at Manby TS • Reinforce Richview x Manby interface by installing 2x230kV overhead circuits • Build 230kV-13.8kV Esplanade TS-II • Rebuild 6.9km overhead line K14J between Manby TS West and Riverside Jct. for 230kV operation • Build a 2.5km 2-cct 115kV underground circuit between John TS and Esplanade Jct. and connect to Terauley TS • Install 1x230kV underground circuit between John TS and Esplanade TS • Upgrade Esplanade-I TS to 230kV operation • Upgrade John TS to 230kV operation	May 2010
3	• Build 230-13.8kV Roundhouse TS	May 2020

Appendices E and F show the power flow on critical circuits and voltage decline under contingencies at critical buses for the 230 kV AC Option. From the study, the following qualitative conclusions are drawn:

- All circuit loadings are within their emergency continuous 50 hours/year ratings. Switching can be performed to bring loading on the circuit down to the regular continuous rating in case of a sustained outage.

- All transformer loadings are within their 10-day LTR ratings. Switching or load transfer can be performed to bring loading on the transformers down to the regular continuous rating in case of a sustained outage.

- Voltage decline for post contingency situations is within 10% of pre-contingency voltage for all high voltage buses. For low voltage buses, the 230 kV AC Option creates a rather large voltage swing, and some low voltage buses may have a decline of more than 10% in certain contingencies. Voltage support at Terauley TS is required to conform to Market Rules.

- Voltage support is needed by 2014 at Manby TS.

Since the 230kV AC-Option is stressing the supply circuits to Manby TS, an assessment was conducted to study the effect of the proposed 13.26mH (5Ω) series reactor. The simulation assumed that the implementation of the 2x230kV overhead circuit at the Richview x Manby corridor was delayed. Appendix G shows the power flow on critical circuits under contingencies. From the study, the following conclusions can be reached:

- With the series reactors in place, power flow on the companion circuit under single circuit contingencies involving circuits R2K and R15K is within the continuous rating of the circuits.

- A double circuit contingency will severely overload R1K or R13K beyond its 50 hours/year continuous emergency rating. However, power flow on R2K and R15K is just within the continuous rating.

The series reactors are very beneficial in the case of a single circuit contingency involving circuits R2K and R15K. It prevents overloading on the two circuits. However, it aggravates the problem on the circuits R1K and R13K in case of double circuit contingencies. Thus, the additional 2x230kV circuits between Richview TS and Manby TS are required if the 230 kV AC Option is implemented.

6.3 Option 3. 115kV AC Supply to Downtown Toronto

This development would be completed in two stages:

Stage	**Investment**	**Date**
1	• Build 2x230kV underground cable circuits 2.5km in length between John TS and Esplanade TS to be operated initially at 115kV. The cables are to be routed through or by the new "Roundhouse TS" site. The cables will be connected to circuits C5E and C7E to allow future load transfers from Esplanade TS and Terauley TS. • Establish Roundhouse TS site • Provide additional 13.8kV cable circuits between John TS and Esplanade TS to enhance load transfer capability.	May 2008
2	• Install 1x230kV underground circuit between Manby TS and John TS to be initially operated at 115kV. A 2Ω series reactor will be installed at Manby sector • Reinforce Richview x Manby interface by installing one 230kV overhead circuit • Install a 250 MVA, 230-115kV autotransformer at Manby TS West	May 2010

	• Upgrade 6.9km 115kV overhead lines K6J/H2JK/K13J/K14J between Manby TS West and Riverside Jct., and transfer Esplanade TS and Terauley TS to Manby sector	

Appendix H shows the power flow on critical circuits under contingencies at critical buses for the 115 kV AC Option. From the study, the following qualitative conclusions are drawn:

- All circuit loadings are within the emergency continuous 50 hours/year ratings. Switching can be performed to bring loading on the circuit down to the regular continuous rating in case of a sustained outage.

- All transformer loadings are within the 10-day LTR ratings. Switching or load transfers can be performed to bring loading on the transformers down to the regular continuous rating in case of a sustained outage.

- The Richview x Manby interface will not be able to sustain a double circuit contingency using the continuous rating by 2011 (assuming the newly added circuit has the same rating as the existing circuits) or by 2012 (assuming the newly added circuit has a higher rating than the existing circuits). Further reinforcement will be needed, such as building another Richview x Manby circuit.

- Voltage support is needed by 2010 at John TS.

6.4 Infrastructure Risk

The DC Option provides a "physical" third power supply point; while the 230 kV AC Option creates a third supply point "electrically" and the 115 kV AC Option only reinforces the existing 115kV system and does not act as a third supply point. Both DC and 230 kV AC Options provide increased reliability and flexibility for maintenance. However, the DC Option can effectively reduce the impact of a low-probability-high-impact contingency, such as the outage of the entire Leaside or Manby Transformer Station. More load can be supported by the remaining two supply points when such a contingency occurs. Either AC options do not improve the supply strength in case of catastrophic outage of entire Manby TS.

Regardless of which option is chosen the 13.8kV distribution network for downtown Toronto supply should be reinforced. With the existing single supply station setup, total loss of the supply station will blackout a significant portion of load in downtown Toronto, up to 32% of total downtown load. Secondary feeder connecting the main feeder to another backup station supply point can improve reliability. Outside of downtown Toronto area, the load can be picked up from a neighbouring station through secondary backup feeders. Distribution network connected to downtown Toronto stations should provide the same level of reliability.

6.5 System Improvement for Lakeview Retirement

Voltage support after Lakeview cease operation can be provided by shunt capacitor installations. For the four proposed capacitors at Burlington, Richview, Leaside, and John, local voltage can be boosted significantly. Figure 10 shows the voltage profile of key supply stations under different system configurations:

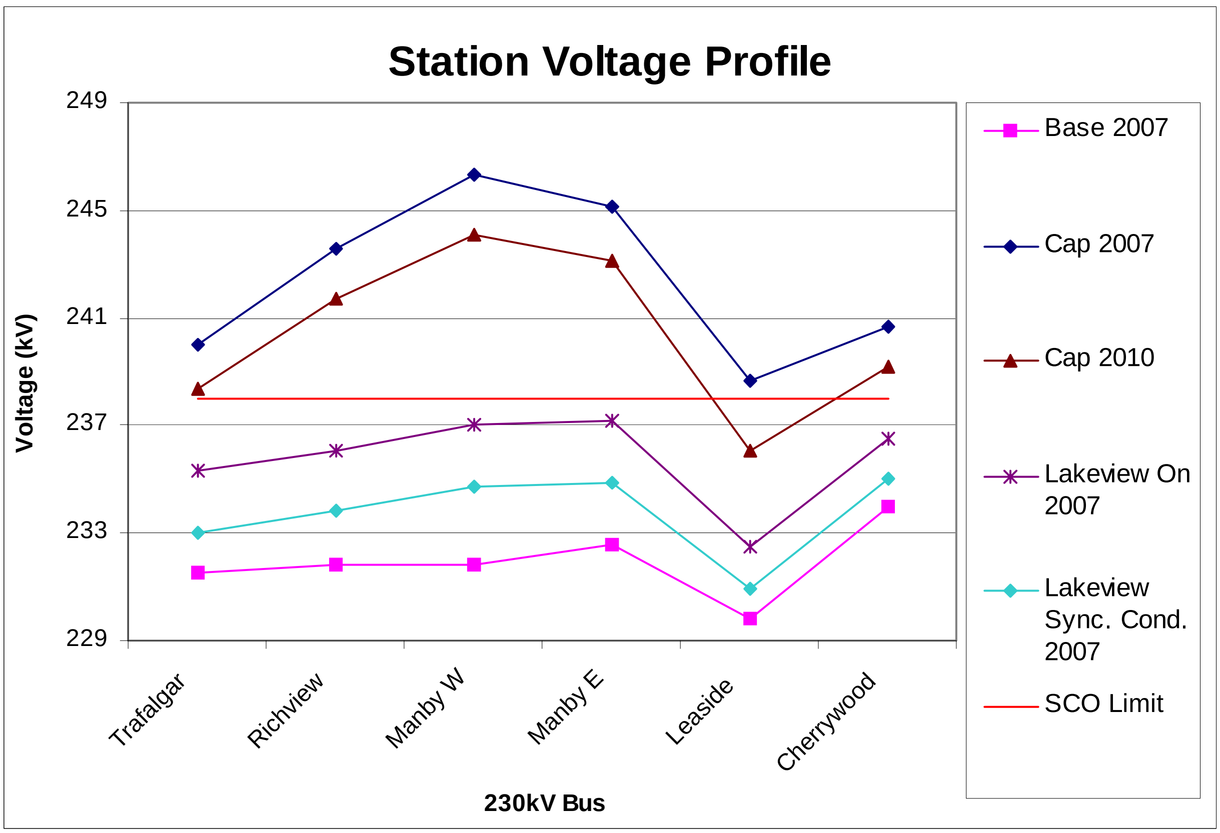


Figure 10: Station Voltage Profile Comparison

Figure 10 shows that voltage at the Manby TS West 230kV bus can be increased by as high as 14.5kV. Since most of the additions are in the Manby sector, the voltage at stations in the Manby sector is maintained at a higher level. Figure 10 also shows the voltage profile for the condition when Lakeview GS is not retired (diagram is plotted with 590 MW of generation from Lakeview) or Lakeview GS is operated as synchronous condensers. Under these two configurations, the Lakeview 230kV bus is operated split to respect the short circuit level. It is clear that capacitor bank installation is a much more effective method to maintain the local voltage level.

In Appendix K, the Q-V (Reactive Power-Voltage) plots at the Claireville TS 500kV bus is shown. The base case plot suggests that there is a VAr shortage in the area in year 2007 when B560V circuit is out of service. The situation gets worse when B561M is also out of service. For both cases, the system requires additional VAr support in order to prevent a voltage collapse in the area. With the addition of capacitor banks, the Q-V plot in Appendix K shows an improvement of approximately 1250MVAr in the area for the all-element-in-service case. Most importantly, the plot shows that the system can stay stable even in the event of B560V/B561M double circuit contingency.

The capacitors also change the flow on circuits connected to Richview TS. With large amount of new capacitor banks located in Richview TS and Manby sector, Richview TS and Manby TS become the major source of reactive power. The flow of MVAr out of the two stations increases significantly to the neighbouring stations. Table 2 summarizes the flow on circuits flowing out of Richview TS:

Table 3: Power Flow on Circuits Out of Richview TS

Circuit	Without Cap, 2007			With Cap, 2007			Lakeview On, 2007			Lakeview Sy. Cd., 2007			With Cap, 2010		
	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA	MW	MVAr	MVA
R1K	314.9	-89.3	327.3	314.5	-148.1	347.6	246.6	-104	267.7	326.4	-110	344.4	324.3	-134.2	351
R13K	311.9	-88.7	324.3	311.5	-146.9	344.4	244.3	-103.2	265.2	323.3	-109.2	341.2	321.2	-133.2	347.8
R2K	394	-34.7	395.5	393.6	-245.1	463.6	231.8	-87	247.6	373.9	-97.3	386.3	410.8	-220.6	466.3
R15K	396.3	-34.6	397.8	395.8	-245.3	465.7	233.8	-86.9	249.5	376.1	-97.2	388.5	413.2	-220.8	468.4
L24CR	215.4	12.8	215.8	216.5	-45.3	221.2	116.3	0.2	116.3	232.9	-13.3	233.3	223.4	-35.3	226.2
C4R	-62.8	19.8	65.8	-59.4	76.9	97.1	-46	36.5	58.7	-62.2	31.5	69.7	-55.3	71.2	90.2
C5R	-89.7	8.1	90.1	-86.5	64.3	107.8	-73.3	24.7	77.3	-89.2	19.2	91.2	-82.5	58.7	101.3
C11R	130.5	74	150	134.3	115	176.8	144.2	85.3	167.5	131.4	82.7	155.2	136.1	110.5	175.4
C12R	169.6	83.6	189.1	172.9	125.4	213.6	183.5	96.3	207.2	170.4	92.7	194	175	121.6	213.1
C18R	25	28.9	38.2	25.7	82	85.9	40.8	45.3	61	25.1	39.5	46.8	30.1	77.5	83.2
C20R	23	38	44.4	23.7	92.3	95.3	39.1	55.1	67.5	23.1	48.7	53.9	28.2	88.4	92.8
R14T	-150.4	86	173.2	-145.5	162.2	218	-78.5	83.3	114.5	-149.6	98.7	179.2	-161.7	157.9	226
R17T	-150.9	85.9	173.7	-146.1	162.2	218.3	-79.1	83.3	114.8	-150.2	98.6	179.7	-162.2	157.9	226.3
R19T	-102.5	81.2	130.8	-97.5	157.4	185.1	-30.5	77.8	83.6	-101.7	94.8	139	-113.7	152.8	190.4
R21T	-101.6	81.5	130.2	-96.6	157.6	184.9	-29.6	78	83.5	-100.8	95	138.5	-112.7	153	190.1
V76R	-309.8	-10.7	310	-316.1	72.6	324.4	-274	5.6	274	-310.9	6	310.9	-319.6	61.9	325.5
V73R	-333.2	-7.8	333.3	-339.5	75.2	347.8	-297.5	8.6	297.7	-334.3	8.6	334.4	-343	64.7	349
V72R	-307.8	-19.2	308.4	-315.3	65.4	322.1	-271.5	-2.3	271.5	-309.1	-2.2	309.1	-318.8	55	323.5
V71R	-339.7	-12.4	339.9	-347.2	72.3	354.7	-303.5	4.9	303.6	-341	4.4	341.1	-350.6	61.5	356
V74R	-277.9	-17	278.4	-284.2	65.7	291.7	-242.2	-1.1	242.2	-279	-0.3	279	-287.7	55.4	293

For the series reactor and series capacitor options, Appendix C shows the power flow on critical circuits in the Manby TS area under contingencies in year 2007. With Lakeview out of service, Appendix C shows that the direct connected circuits between Richview TS and Manby TS will be stressed due to the increase in real power flow from Richview TS, the only source of power after Lakeview retirement. The added shunt capacitors further stress the circuits by increasing reactive power flow from Manby TS to Richview TS.

With the installation of series reactors, overloading can be prevented for single element contingencies involving circuits between Manby W TS and Richview TS. However, a double contingency, namely R1/13K or R2/15K, creates a significant overloading on either R1K or R13K for the series reactor option. To mitigate the problem, an special protection scheme (SPS) can be employed whenever either R1K or R13K is out of service. The scheme opens the two breakers for L23CK at Manby E TS to off load R1K or R13K, forcing the power to flow onto other parallel circuits. By doing so, all the flows on circuits are within the 50hours/year rating for year 2007.

With series capacitor option, Appendix C shows that the flow on all circuits in the area under contingencies is within circuits' respective 50hr/year emergency ratings. No SPS is required to prevent overloading even in double circuit contingencies. In addition, L24CR is better utilized to transport real power from Richview to Manby and reactive power from Manby to Richview. Thus, the series capacitor option is a very beneficial option for reinforcing system supply in anticipation of Lakeview retirement. However, the preferred option for reconfiguring these circuits is still to be evaluated.

6.6 Adequacy of 115 kV Circuits in Central Toronto

The 115kV circuits located in central Toronto stay unchanged if the DC Option is implemented. The 230kV AC Option and 115kV AC Option moved Esplanade TS load and half of Terauley TS load from the Leaside sector to the Manby sector. The 230kV AC Option also converts circuit K14J from 115kV to 230kV operation. The power flows on the central Toronto 115kV circuits and cables are shown in Appendix J.

The results show all three options have in a similar flow pattern in central Toronto. The six circuits connecting Leaside TS and Hearn TS are significantly off-loaded under all three options, relieving them from any danger of overloading in single element contingencies. Small relief can also be observed on circuits between Leaside TS and Cecil TS under all three options. The biggest difference in circuit loading between the three options is observed on circuits H2JK and K6J from Manby TS West. While power flows from Manby TS are reduced under the DC Option and the 230kV AC Option, the flow increases for the 115kV AC Option. As shown in Appendix I, the flow on the companion circuits is very close to the limit in 2015 if a single element contingency occurs.

Bridgman TS and Dufferin TS are currently supplied from the Leaside sector. However, they can be supplied by Manby TS East if the need arises. Table 4 below shows the effect of a load transfer on Manby TS East circuits and autotransformers:

Table 4: MVA Flow on Circuits and Autotransformers at Manby East TS after Bridgman TS and Dufferin TS Load Transfer from Leaside to Manby

Circuit	Limit	Base 2007*	DC 2007	230kV AC 2007	115kV AC 2007
K1W	225	98.7	182.8	182.7	184.8
K3W	225	98.7	182.8	182.7	184.8
K11W	225	110.3	198.2	198.1	200.3
K12W	225	110.5	198.4	198.2	200.4
T7	250/307	135.2	249.4	248.8	253.1
T8	369/369	157.8	291.1	290.5	295.5
T9	250/307	135.6	250.2	249.6	253.9

* Load flow base case with load transfer does not converge. The base case flow shown in the table does not include load transfer.

For both the DC Option and the 230kV AC Option, the flows through the autotransformers at Manby TS East are just below the limit. Flows in the 115kV AC Option are slightly higher due to the low voltage profile in the area, reducing the ability of capacitor banks to supply MVAr. However, the flow suggests that the load at Bridgman TS and Dufferin TS should continue to be supplied from Leaside TS. Transfer to Manby TS should only occur under system contingencies.

6.7 Evaluating the Three Options

The three options are assessed against the following economic, technical, risk and environmental selection criteria:

Overall MW Injection: The DC Option provides 1000 MW of additional power supply to downtown Toronto while the 230 kV AC Option and the 115 kV AC Option provide 750MW and 350MW respectively.

Voltage Profile: The 230 kV AC Option provides the best overall system voltage profile for the central Toronto area. Figures 11 and 12 show the voltage profile at the four main supply 230kV buses for the base case, DC Option, and 230 kV AC Option:

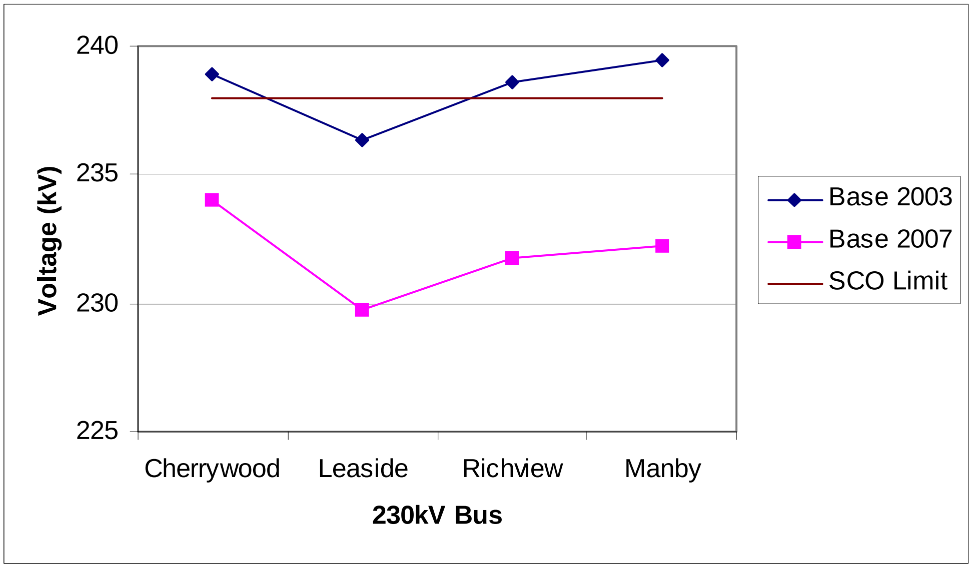


Figure 11: Voltage profile for base case

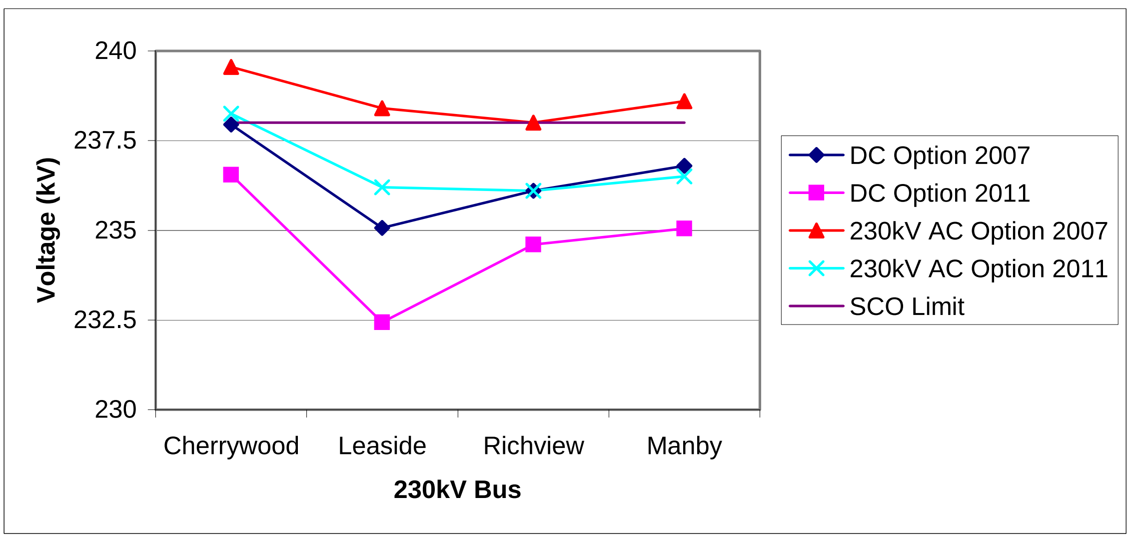


Figure 12: Voltage profile for DC Option and 230 kV AC Option

Figure 12 shows that the 230kV AC Option has a smoother and higher overall voltage profile across all four 230kV supply stations. The 230 kV AC Option does not require voltage support facilities until 2014, while the DC Option and the 115 kV AC Option need voltage support facilities in 2012 and 2009 respectively.

Appendix J includes the QV plot at the Claireville 500kV bus for the three options. The plots show that 230kV AC Option has the best MVAr margin, followed by the DC Option and the 115kV AC Option. With only the option considered (i.e. without additional capacitor banks for Lakeview retirement voltage support), the 230kV AC

Option is the only option that meets MVAr requirements in the event of a B560V/B561M double circuit contingency.

Relief for Leaside sector: Relief is provided to the Leaside sector through MW injection at Hearn TS for the DC Option. For both AC options, relief is provided by transferring a small portion of the Leaside load (namely the entire Esplanade TS load and half of the Terauley TS load) to the Manby sector (namely Manby TS 230kV sector or Manby West respectively). The DC Option can provide a total of 750 MW of supply to the Leaside sector, but both AC options only transfer about 300 MW of load (using year 2015 load forecast). With the AC options, further reinforcement will be needed at an earlier date for Leaside sector relief when compared with the DC option.

Relief for Manby Sector: The DC Option injects 250 MW of supply to the Manby sector through the back-to-back HVDC connection at John TS. The injection effectively eliminates the need for reinforcement in the Manby TS West sector in the near future. Both AC options add more load to the Manby sector. Therefore, supply from Richview to Manby is required.

Other System Impacts: The DC Option is supplied from Niagara Beck 2 GS. The direct connection between Beck and Toronto can help reduce the flow on the FETT (Flow East Towards Toronto) and QFW (Queenston Flow West) interfaces. For both AC options, relief for the Leaside sector comes at the cost of transferring load to the Manby sector, further stressing the circuits and autotransformers (e.g., the Claireville autotransformers) supplying Richview TS and subsequently Manby TS. The negative impact will accelerate the need date for station reinforcements in the Greater Toronto Area.

Extreme Contingency Performance: For blackouts in August 2003 and November 1965, widespread system collapses occurred in northeastern North America. In both blackouts, electrical supply was maintained at the Beck switchyard. A system separation occurred between the Beck sector and the Middleport/Beach/Burlington system. Under this system behaviour, the DC Option would help facilitate the rapid restoration of service to downtown Toronto should the AC system between the Beck sector and the rest of the Ontario grid collapses.

Impact of Other Generation Facilities: This report assumes that Lakeview will retire in 2005, and there is no new addition of generation facilities in or near Toronto area. However, if the Portlands Energy Center (PEC) project is to materialize, rebuilding Hearn SS under the DC Option is also beneficial for the PEC project. The PEC project can also delay the need date for stage 3 of the DC Option to a later date. The 230 kV AC Option can benefit from the PEC project by delaying the load transfer from the Leaside sector, thus reducing the negative impact on neighbouring stations. However, if the DC Option is chosen and the PEC project proceeds, the 115kV circuits between Hearn SS and Leaside TS will need to be assessed for possible upgrades. Other generation facilities in the GTA area, such as Pickering or other proposed plans, can provide further voltage support for central and downtown Toronto. Such an advantage can be best captured if the 230 kV AC Option is chosen and the generation facility is located in the Manby sector.

The 2x230kV circuits between John TS and Esplanade TS are common to all options. This item can proceed initially because it provides load transfer flexibility between the two sectors; and the cable section is required for any option. The two circuits can effectively delay the need date for the DC or AC option. In addition, with many generation facility uncertainties, such as Lakeview retirement, the PEC project, other downtown generation projects and the Pickering A restart, it is better to delay the decision regarding the third supply point to downtown Toronto until there is more information available.

8. Recommendations

This report has reviewed the transmission supply adequacy to central Toronto over the period between 2003 and 2015. The study shows that reinforcement will be needed by 2008, and a long term solution may be needed as early as 2010.

The addition of 2x230kV circuits between John TS and Esplanade TS is common to all options. This item can proceed initially because it provides load transfer flexibility between the two sectors (Leaside and Manby). The two circuits can effectively delay the need date for the DC or AC option. In addition, with many generation facility uncertainties, such as Lakeview retirement, PEC development project, other possible generation developments, and the Pickering A restart, it is prudent to take economic short-term relief measures to provide relief to overloaded facilities to the extent that longer-term relief can be provided in a timely and cost effective manner. It is, therefore recommended to build facilities that are common to all options until uncertainty clears.

- Build 2x230kV underground cable circuits 2.5 km in length between John TS and Esplanade TS to be operated initially at 115kV. The cables are to be routed through or by the new “Roundhouse TS” site. The cables will also be connected to circuits C5E and C7E. (In service date: May 2008)

- Install shunt capacitor banks equipped with power quality improvement devices at the following locations to provide voltage support: (In service date: By April 2005, when Lakeview retires)
  John TS: 125MVAr rated at 127kV
  Leaside TS: 125MVAr rated at 127kV
  Richview TS: 411.6MVAr rated at 249.8kV
  Burlington TS: 300MVAr rated at 249.8kV

- Provide additional 13.8 infrastructure to enable switching of supply between downtown supply stations.

Appendix A: Circuit Loading under Contingency (Base Case) (in MVA)

CASE/CONT.	CKT	RATING	2003	2004	2005	2006	2007
NONE	C2L	579/754	350.4	355.4	360.8	366.9	373.3
NONE	C3L	579/754	369.1	374.0	379.5	385.7	392.4
NONE	C14L	579/754	372.2	377.1	382.6	388.9	395.7
NONE	C15L	579/754	436.8	441.4	446.7	453.7	461.8
NONE	C16L	579/754	414.3	418.5	423.5	429.9	437.6
NONE	C17L	579/754	403.8	408.1	413.0	419.4	426.9
NONE	LEASIDE AUTO 11	275/378	224.1	227.0	230.1	233.9	238.0
NONE	LEASIDE AUTO 15	283/369	221.4	224.2	227.3	231.1	235.2
NONE	LEASIDE AUTO 12	312/419	210.6	213.5	216.5	220.3	224.3
NONE	LEASIDE AUTO 17	283/422	208.5	211.3	214.3	218.0	222.0
NONE	LEASIDE AUTO 14	275/489	215.3	218.2	221.3	225.0	229.1
NONE	LEASIDE AUTO 16	275/384	215.1	218.0	221.1	224.8	228.9
NONE	MANBY AUTO 12	250/296	123.4	123.8	124.4	128.4	132.6
NONE	MANBY AUTO T1	368/368	139.9	140.4	141.0	145.5	150.4
NONE	MANBY AUTO T2	408/408	135.5	135.9	136.5	140.9	145.6
NONE	MANBY AUTO T7	250/307	130.8	131.3	131.9	133.5	135.2
NONE	MANBY AUTO T8	369/369	152.7	153.3	154.0	155.9	157.8
NONE	MANBY AUTO T9	250/307	131.2	131.7	132.3	134.0	135.6
NONE	R2K	579/669	384.9	385.2	385.9	390.5	395.5
NONE	R15K	579/669	387.1	387.4	388.1	392.8	397.8
NONE	R1K	579/669	324.8	324.1	324.1	325.7	327.3
NONE	R13K	579/669	321.8	321.1	321.1	322.7	324.3
C2L	C2L	579/754	0.0	0.0	0.0	0.0	0.0
C2L	C3L	579/754	491.4	497.9	504.9	512.9	521.4
C2L	C14L	579/754	483.3	489.7	496.5	504.5	513.0
C2L	C15L	579/754	439.0	444.0	449.5	456.8	464.7
C2L	C16L	579/754	461.6	466.4	471.8	478.8	487.1
C2L	C17L	579/754	450.2	454.9	460.3	467.3	475.4
C2L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0
C2L	LEASIDE AUTO 15	283/369	286.1	289.4	293.0	297.4	302.2
C2L	LEASIDE AUTO 12	312/419	248.1	251.2	254.6	258.7	263.0
C2L	LEASIDE AUTO 17	283/422	245.5	248.6	252.0	256.0	260.3
C2L	LEASIDE AUTO 14	275/489	251.6	254.7	258.2	262.3	266.6
C2L	LEASIDE AUTO 16	275/384	251.3	254.5	257.9	262.0	266.4

CASE/CONT.	CKT	RATING	2003	2004	2005	2006	2007
C3L	C2L	579/754	488.8	495.4	502.5	510.5	518.9
C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0
C3L	C14L	579/754	458.0	464.0	470.6	478.3	486.3
C3L	C15L	579/754	509.4	514.7	520.7	528.5	537.2
C3L	C16L	579/754	446.9	451.5	456.9	463.8	471.8
C3L	C17L	579/754	426.0	430.7	436.0	442.8	450.6
C3L	LEASIDE AUTO 11	275/378	255.5	258.6	262.0	266.1	270.4
C3L	LEASIDE AUTO 15	283/369	252.5	255.6	258.9	262.9	267.2
C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0
C3L	LEASIDE AUTO 17	283/422	257.2	260.4	263.8	268.0	272.4
C3L	LEASIDE AUTO 14	275/489	258.8	262.1	265.6	269.8	274.3
C3L	LEASIDE AUTO 16	275/384	258.5	261.8	265.3	269.5	274.0
C14L	C2L	579/754	458.3	464.5	471.3	479.0	487.1
C14L	C3L	579/754	481.3	487.5	494.4	502.2	510.5
C14L	C14L	579/754	0.0	0.0	0.0	0.0	0.0
C14L	C15L	579/754	472.9	477.8	483.5	490.8	499.2
C14L	C16L	579/754	415.2	420.1	425.5	432.3	439.8
C14L	C17L	579/754	499.0	504.1	509.9	517.7	526.4
C14L	LEASIDE AUTO 11	275/378	266.2	269.5	273.0	277.2	281.7
C14L	LEASIDE AUTO 15	283/369	263.0	266.2	269.7	273.9	278.4
C14L	LEASIDE AUTO 12	312/419	238.0	241.1	244.4	248.4	252.5
C14L	LEASIDE AUTO 17	283/422	235.6	238.7	241.9	245.8	249.9
C14L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0
C14L	LEASIDE AUTO 16	275/384	278.8	282.0	285.5	289.9	294.7
C15L	C2L	579/754	428.9	434.2	440.2	446.9	454.3
C15L	C3L	579/754	425.9	431.4	437.4	444.2	451.6
C15L	C14L	579/754	401.2	406.4	412.0	418.6	425.6
C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0
C15L	C16L	579/754	563.3	568.8	575.1	583.7	593.7
C15L	C17L	579/754	506.6	511.9	517.9	525.8	535.1
C15L	LEASIDE AUTO 11	275/378	242.0	245.1	248.4	252.3	256.5
C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0
C15L	LEASIDE AUTO 12	312/419	255.9	259.0	262.4	266.4	270.8
C15L	LEASIDE AUTO 17	283/422	253.3	256.4	259.7	263.7	268.0
C15L	LEASIDE AUTO 14	275/489	265.2	268.4	271.9	276.1	280.7
C15L	LEASIDE AUTO 16	275/384	264.9	268.1	271.6	275.8	280.4
C16L	C2L	579/754	387.8	393.1	398.9	405.3	412.2

C16L	C3L	579/754	403.3	408.5	414.3	420.8	427.9
CASE/CONT.	**CKT**	**RATING**	**2003**	**2004**	**2005**	**2006**	**2007**
C16L	C14L	579/754	448.6	453.5	459.2	466.0	473.7
C16L	C15L	579/754	592.4	598.4	605.1	614.2	624.7
C16L	C16L	579/754	0.0	0.0	0.0	0.0	0.0
C16L	C17L	579/754	499.9	505.1	511.1	518.9	528.0
C16L	LEASIDE AUTO 11	275/378	269.0	272.1	275.5	279.7	284.3
C16L	LEASIDE AUTO 15	283/369	265.8	268.9	272.3	276.4	280.9
C16L	LEASIDE AUTO 12	312/419	257.0	260.2	263.5	267.6	272.1
C16L	LEASIDE AUTO 17	283/422	254.4	257.5	260.8	264.9	269.3
C16L	LEASIDE AUTO 14	275/489	235.8	239.1	242.6	246.6	250.7
C16L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0
C17L	C2L	579/754	372.9	378.1	383.7	390.0	396.7
C17L	C3L	579/754	421.2	426.3	432.1	438.6	445.8
C17L	C14L	579/754	465.9	471.7	477.9	485.4	493.3
C17L	C15L	579/754	530.6	536.2	542.6	550.9	560.5
C17L	C16L	579/754	537.2	542.6	548.8	557.1	566.6
C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 11	275/378	275.4	278.7	282.2	286.5	291.1
C17L	LEASIDE AUTO 15	283/369	272.1	275.4	278.8	283.1	287.7
C17L	LEASIDE AUTO 12	312/419	241.8	245.0	248.3	252.4	256.6
C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 14	275/489	245.6	248.6	251.9	255.8	260.1
C17L	LEASIDE AUTO 16	275/384	245.3	248.4	251.6	255.5	259.8
C2L & C3L	C2L	579/754	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C14L	579/754	634.3	642.4	651.1	661.2	671.6
C2L & C3L	C15L	579/754	537.7	543.5	549.9	558.1	566.8
C2L & C3L	C16L	579/754	510.8	516.0	522.0	529.7	537.9
C2L & C3L	C17L	579/754	483.7	488.8	494.6	502.1	510.2
C2L & C3L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 15	283/369	328.6	332.1	335.9	340.6	345.4
C2L & C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 17	283/422	314.7	318.3	322.1	326.7	331.4
C2L & C3L	LEASIDE AUTO 14	275/489	312.9	316.5	320.2	324.7	329.3
C2L & C3L	LEASIDE AUTO 16	275/384	312.6	316.1	319.8	324.4	329.0
C16L & C17L	C2L	579/754	421.4	426.9	432.9	439.6	444.4
C16L & C17L	C3L	579/754	498.5	504.0	510.3	517.2	523.1

C16L & C17L	C14L	579/754	628.4	634.6	641.5	650.2	657.1
CASE/CONT.	**CKT**	**RATING**	**2003**	**2004**	**2005**	**2006**	**2007**
C16L & C17L	C15L	579/754	753.8	761.3	769.5	780.7	793.2
C16L & C17L	C16L	579/754	0.0	0.0	0.0	0.0	0.0
C16L & C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 11	275/378	353.2	356.8	360.5	365.1	369.2
C16L & C17L	LEASIDE AUTO 15	283/369	349.0	352.5	356.2	360.8	364.8
C16L & C17L	LEASIDE AUTO 12	312/419	299.4	302.8	306.2	310.5	313.8
C16L & C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 14	275/489	254.4	257.5	260.7	264.3	267.2
C16L & C17L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C2L	579/754	554.2	560.9	568.1	576.6	585.2
C14L & C15L	C3L	579/754	555.9	562.8	570.1	578.7	587.2
C14L & C15L	C14L	579/754	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C16L	579/754	571.4	577.6	584.4	593.2	602.6
C14L & C15L	C17L	579/754	622.1	628.4	635.4	644.8	655.1
C14L & C15L	LEASIDE AUTO 11	275/378	303.9	307.5	311.2	315.6	319.8
C14L & C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 12	312/419	302.3	305.8	309.4	313.7	318.0
C14L & C15L	LEASIDE AUTO 17	283/422	299.2	302.6	306.2	310.5	314.7
C14L & C15L	LEASIDE AUTO 14	275/489	250.0	250.0	250.0	250.0	250.0
C14L & C15L	LEASIDE AUTO 16	275/384	355.9	359.5	363.4	368.4	373.5
R1K	MANBY AUTO 12	250/296	123.4	123.8	124.4	128.4	132.6
R1K	MANBY AUTO T1	368/368	139.9	140.4	141.0	145.5	150.3
R1K	MANBY AUTO T2	408/408	135.5	135.9	136.5	140.9	145.6
R1K	MANBY AUTO T7	250/307	131.4	131.8	132.4	134.0	135.6
R1K	MANBY AUTO T8	369/369	153.4	153.9	154.6	156.4	158.3
R1K	MANBY AUTO T9	250/307	131.8	132.3	132.9	134.4	136.1
R1K	R2K	579/669	420.5	420.8	421.5	426.3	431.4
R1K	R15K	579/669	422.8	423.1	423.8	428.6	433.7
R1K	R1K	579/669	0.0	0.0	0.0	0.0	0.0
R1K	R13K	579/669	539.4	538.3	538.2	540.7	543.4
R13K	MANBY AUTO 12	250/296	123.4	123.8	124.4	128.4	132.6
R13K	MANBY AUTO T1	368/368	139.9	140.4	141.0	145.5	150.4
R13K	MANBY AUTO T2	408/408	135.5	135.9	136.5	140.9	145.6
R13K	MANBY AUTO T7	250/307	131.3	131.8	132.4	134.0	135.6
R13K	MANBY AUTO T8	369/369	153.4	153.9	154.6	156.4	158.3

R13K	MANBY AUTO T9	250/307	131.8	132.3	132.9	134.4	136.1
CASE/CONT.	**CKT**	**RATING**	**2003**	**2004**	**2005**	**2006**	**2007**
R13K	R2K	579/669	420.0	420.2	420.9	425.7	430.8
R13K	R15K	579/669	422.2	422.5	423.2	428.0	433.2
R13K	R1K	579/669	541.1	539.9	539.8	542.4	545.0
R13K	R13K	579/669	0.0	0.0	0.0	0.0	0.0
R2K	MANBY AUTO 12	250/296	123.1	123.5	124.0	127.9	132.1
R2K	MANBY AUTO T1	368/368	139.6	140.0	140.6	145.0	149.7
R2K	MANBY AUTO T2	408/408	135.1	135.5	136.1	140.4	145.0
R2K	MANBY AUTO T7	250/307	130.4	131.0	131.5	133.1	134.8
R2K	MANBY AUTO T8	369/369	152.3	152.9	153.6	155.5	157.4
R2K	MANBY AUTO T9	250/307	130.9	131.4	132.0	133.6	135.2
R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0
R2K	R15K	579/669	617.5	617.9	619.2	627.0	635.4
R2K	R1K	579/669	362.2	361.6	361.7	363.7	365.8
R2K	R13K	579/669	358.8	358.2	358.3	360.3	362.4
R15K	MANBY AUTO 12	250/296	123.1	123.4	124.0	127.9	132.0
R15K	MANBY AUTO T1	368/368	139.5	139.9	140.6	145.0	149.7
R15K	MANBY AUTO T2	408/408	135.1	135.5	136.1	140.3	144.9
R15K	MANBY AUTO T7	250/307	130.4	130.9	131.5	133.1	134.8
R15K	MANBY AUTO T8	369/369	152.3	152.9	153.5	155.4	157.3
R15K	MANBY AUTO T9	250/307	130.9	131.4	132.0	133.6	135.2
R15K	R2K	579/669	614.8	615.2	616.4	624.3	632.6
R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0
R15K	R1K	579/669	362.2	361.6	361.7	363.7	365.9
R15K	R13K	579/669	358.9	358.2	358.4	360.4	362.5
R1K & R2K	MANBY AUTO 12	250/296	123.2	123.5	124.0	127.9	132.0
R1K & R2K	MANBY AUTO T1	368/368	139.6	140.0	140.6	145.0	149.7
R1K & R2K	MANBY AUTO T2	408/408	135.2	135.6	136.1	140.4	144.9
R1K & R2K	MANBY AUTO T7	250/307	131.0	131.5	132.0	133.5	135.1
R1K & R2K	MANBY AUTO T8	369/369	153.0	153.5	154.1	155.9	157.8
R1K & R2K	MANBY AUTO T9	250/307	131.4	131.9	132.5	134.0	135.6
R1K & R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R15K	579/669	683.0	683.3	684.5	692.6	701.2
R1K & R2K	R1K	579/669	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R13K	579/669	608.8	607.7	607.8	611.1	614.6
R13K & R15K	MANBY AUTO 12	250/296	123.1	123.4	124.0	127.8	132.0

R13K & R15K	MANBY AUTO T1	368/368	139.6	140.0	140.6	145.0	149.6
CASE/CONT.	**CKT**	**RATING**	**2003**	**2004**	**2005**	**2006**	**2007**
R13K & R15K	MANBY AUTO T2	408/408	135.1	135.5	136.1	140.3	144.9
R13K & R15K	MANBY AUTO T7	250/307	130.9	131.4	132.0	133.5	135.1
R13K & R15K	MANBY AUTO T8	369/369	152.9	153.5	154.1	155.9	157.7
R13K & R15K	MANBY AUTO T9	250/307	131.4	131.9	132.4	134.0	135.6
R13K & R15K	R2K	579/669	679.1	679.4	680.6	688.8	697.4
R13K & R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0
R13K & R15K	R1K	579/669	610.6	609.5	609.6	613.0	616.5
R13K & R15K	R13K	579/669	0.0	0.0	0.0	0.0	0.0

Rating: continuous rating/emergency continuous rating for 50h/year for circuits; continuous rating/10 day LTR for transformers

Appendix B: Voltage Decline under Contingency (Base Case) (in kV)

CASE/CONT.	BN	BUS NAME	2003 Pre	%	SS%	2004 Pre	%	SS%	2005 Pre	%	SS%	2006 Pre	%	SS%	2007 Pre	%	SS%
C2L	2100	CHERYDK1 220	238.5	-0.2	-0.2	237.4	-0.2	-0.2	236.2	-0.2	-0.2	234.9	-0.1	-0.2	233.4	-0.1	-0.3
C2L	2102	CHERYDK3 220	239.4	-0.2	-0.3	238.4	-0.2	-0.3	237.2	-0.3	-0.3	236.0	-0.3	-0.3	234.7	-0.3	-0.4
C2L	3102	LEAS 215 220	236.3	-0.4	-0.5	235.0	-0.4	-0.5	233.4	-0.5	-0.5	231.7	-0.5	-0.5	229.7	-0.6	-0.8
C2L	3103	LEAS 317 220	236.4	-0.7	-0.8	235.1	-0.7	-0.8	233.5	-0.8	-0.8	231.7	-0.8	-0.9	229.8	-0.9	-1.2
C2L	3104	LEAS1416 220	236.4	-0.7	-0.8	235.1	-0.7	-0.8	233.5	-0.8	-0.8	231.7	-0.8	-0.9	229.8	-0.9	-1.2
C2L	3301	LEAS EJ 118	124.1	-0.7	-0.8	123.2	-0.7	-0.8	122.1	-0.8	-0.9	120.9	-0.9	-1.0	119.6	-1.1	-1.4
C2L	3300	HEARN 118	123.6	-0.7	-0.8	122.6	-0.7	-0.8	121.5	-0.8	-0.9	120.3	-0.9	-1.0	118.8	-1.1	-1.4
C2L	3364	ESPLAH2J 118	123.2	-0.7	-0.8	122.3	-0.7	-0.8	121.1	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C2L	3365	ESPLAH5E 118	122.7	-0.7	-0.8	121.8	-0.7	-0.8	120.6	-0.8	-0.9	119.3	-0.9	-1.0	117.9	-1.1	-1.4
C2L	3366	ESPLAH7E 118	122.7	-0.7	-0.8	121.8	-0.7	-0.8	120.6	-0.8	-0.9	119.4	-0.9	-1.0	117.9	-1.1	-1.4
C2L	3401	TERAUT5E 118	123.1	-0.7	-0.8	122.2	-0.7	-0.8	121.0	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C2L	3402	TERAUT7E 118	123.1	-0.7	-0.8	122.2	-0.7	-0.8	121.0	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C2L	3403	TERC5E 118	122.4	-0.7	-0.8	121.5	-0.7	-0.8	120.3	-0.8	-0.9	119.0	-0.9	-1.0	117.6	-1.1	-1.4
C2L	3404	TERC7E 118	122.4	-0.7	-0.8	121.5	-0.7	-0.8	120.3	-0.8	-0.9	119.1	-0.9	-1.0	117.6	-1.1	-1.4
C2L	3664	ESPLNJ12 13.8	13.7	-0.7	-0.7	13.8	-0.7	-0.8	13.8	-0.8	-0.9	13.9	-1.0	-1.0	13.8	-1.1	-1.4
C2L	3767	TERAUA12 13.8	13.8	-0.7	-0.8	13.9	-0.7	-0.8	13.8	-0.8	-0.9	13.8	-1.0	-1.0	13.8	-1.1	-1.5
C3L	2100	CHERYDK1 220	238.5	-0.1	-0.2	237.4	-0.1	-0.2	236.2	-0.1	-0.2	234.9	-0.1	-0.1	233.4	-0.1	-0.2
C3L	2102	CHERYDK3 220	239.4	-0.3	-0.3	238.4	-0.3	-0.3	237.2	-0.3	-0.3	236.0	-0.3	-0.3	234.7	-0.3	-0.4
C3L	3102	LEAS 215 220	236.3	-0.8	-0.8	235.0	-0.8	-0.8	233.4	-0.9	-0.9	231.7	-0.9	-1.0	229.7	-1.0	-1.2
C3L	3103	LEAS 317 220	236.4	-0.4	-0.5	235.1	-0.5	-0.5	233.5	-0.5	-0.5	231.7	-0.5	-0.6	229.8	-0.6	-0.8
C3L	3104	LEAS1416 220	236.4	-0.6	-0.6	235.1	-0.6	-0.6	233.5	-0.7	-0.7	231.7	-0.7	-0.8	229.8	-0.8	-1.0
C3L	3301	LEAS EJ 118	124.1	-0.7	-0.7	123.2	-0.7	-0.8	122.1	-0.8	-0.9	120.9	-0.9	-1.0	119.6	-1.1	-1.4
C3L	3300	HEARN 118	123.6	-0.7	-0.8	122.6	-0.7	-0.8	121.5	-0.8	-0.9	120.3	-0.9	-1.0	118.8	-1.1	-1.4
C3L	3364	ESPLAH2J 118	123.2	-0.7	-0.8	122.3	-0.7	-0.8	121.1	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C3L	3365	ESPLAH5E 118	122.7	-0.7	-0.8	121.8	-0.7	-0.8	120.6	-0.8	-0.9	119.3	-1.0	-1.0	117.9	-1.1	-1.4
C3L	3366	ESPLAH7E 118	122.7	-0.7	-0.8	121.8	-0.7	-0.8	120.6	-0.8	-0.9	119.4	-1.0	-1.0	117.9	-1.1	-1.4
C3L	3401	TERAUT5E 118	123.1	-0.7	-0.7	122.2	-0.7	-0.8	121.0	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C3L	3402	TERAUT7E 118	123.1	-0.7	-0.7	122.2	-0.7	-0.8	121.0	-0.8	-0.9	119.8	-0.9	-1.0	118.4	-1.1	-1.4
C3L	3403	TERC5E 118	122.4	-0.7	-0.8	121.5	-0.7	-0.8	120.3	-0.8	-0.9	119.0	-1.0	-1.0	117.6	-1.1	-1.4
C3L	3404	TERC7E 118	122.4	-0.7	-0.8	121.5	-0.7	-0.8	120.3	-0.8	-0.9	119.1	-1.0	-1.0	117.6	-1.1	-1.4
C3L	3664	ESPLNJ12 13.8	13.7	-0.7	-0.7	13.8	-0.8	-0.8	13.8	-0.8	-0.9	13.9	-1.0	-1.0	13.8	-1.1	-1.4
C3L	3767	TERAUA12 13.8	13.8	-0.7	-0.8	13.9	-0.8	-0.8	13.8	-0.9	-0.9	13.8	-1.0	-1.0	13.8	-1.1	-1.5
C14L	2100	CHERYDK1 220	238.5	-0.1	-0.2	237.4	-0.1	-0.1	236.2	-0.1	-0.1	234.9	-0.1	-0.1	233.4	-0.1	-0.2

C14L	2102	CHERYDK3 220	239.4	-0.3	-0.3	238.4	-0.3	-0.3	237.2	-0.3	-0.3	236.0	-0.3	-0.4	234.7	-0.4	-0.5
CASE/CONT.	**BN**	**BUS NAME**	**2003**			**2004**			**2005**			**2006**			**2007**		
			Pre	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**
C14L	3102	LEAS 215 220	236.3	-0.7	-0.8	235.0	-0.7	-0.7	233.4	-0.8	-0.8	231.7	-0.8	-0.9	229.7	-0.9	-1.1
C14L	3103	LEAS 317 220	236.4	-0.8	-0.9	235.1	-0.9	-0.9	233.5	-0.9	-1.0	231.7	-1.0	-1.0	229.8	-1.1	-1.3
C14L	3104	LEAS1416 220	236.4	-0.4	-0.5	235.1	-0.4	-0.5	233.5	-0.5	-0.5	231.7	-0.5	-0.6	229.8	-0.6	-0.8
C14L	3301	LEAS EJ 118	124.1	-0.7	-0.8	123.2	-0.8	-0.8	122.1	-0.9	-0.9	120.9	-1.0	-1.1	119.6	-1.1	-1.5
C14L	3300	HEARN 118	123.6	-0.7	-0.8	122.6	-0.8	-0.8	121.5	-0.9	-0.9	120.3	-1.0	-1.1	118.8	-1.2	-1.5
C14L	3364	ESPLAH2J 118	123.2	-0.7	-0.9	122.3	-0.8	-0.8	121.1	-0.9	-0.9	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C14L	3365	ESPLAH5E 118	122.7	-0.7	-0.9	121.8	-0.8	-0.8	120.6	-0.9	-0.9	119.3	-1.0	-1.1	117.9	-1.2	-1.5
C14L	3366	ESPLAH7E 118	122.7	-0.7	-0.9	121.8	-0.8	-0.8	120.6	-0.9	-0.9	119.4	-1.0	-1.1	117.9	-1.2	-1.5
C14L	3401	TERAUT5E 118	123.1	-0.7	-0.8	122.2	-0.8	-0.8	121.0	-0.9	-0.9	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C14L	3402	TERAUT7E 118	123.1	-0.7	-0.8	122.2	-0.8	-0.8	121.0	-0.9	-0.9	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C14L	3403	TERC5E 118	122.4	-0.7	-0.9	121.5	-0.8	-0.8	120.3	-0.9	-0.9	119.0	-1.0	-1.1	117.6	-1.2	-1.5
C14L	3404	TERC7E 118	122.4	-0.7	-0.9	121.5	-0.8	-0.8	120.3	-0.9	-0.9	119.1	-1.0	-1.1	117.6	-1.2	-1.5
C14L	3664	ESPLNJ12 13.8	13.7	-0.7	-0.7	13.8	-0.8	-0.8	13.8	-0.9	-0.9	13.9	-1.0	-1.0	13.8	-1.2	-1.4
C14L	3767	TERAUA12 13.8	13.8	-0.7	-0.8	13.9	-0.8	-0.8	13.8	-0.9	-0.9	13.8	-1.0	-1.0	13.8	-1.2	-1.5
C15L	2100	CHERYDK1 220	238.5	-0.3	-0.4	237.4	-0.3	-0.4	236.2	-0.4	-0.4	234.9	-0.4	-0.4	233.4	-0.4	-0.5
C15L	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	0.0	-0.1	234.7	0.0	-0.1
C15L	3102	LEAS 215 220	236.3	-0.7	-0.8	235.0	-0.8	-0.8	233.4	-0.9	-0.9	231.7	-0.9	-1.0	229.7	-1.0	-1.3
C15L	3103	LEAS 317 220	236.4	-0.7	-0.8	235.1	-0.8	-0.8	233.5	-0.8	-0.9	231.7	-0.9	-0.9	229.8	-1.0	-1.2
C15L	3104	LEAS1416 220	236.4	-0.6	-0.7	235.1	-0.7	-0.7	233.5	-0.7	-0.8	231.7	-0.8	-0.8	229.8	-0.8	-1.1
C15L	3301	LEAS EJ 118	124.1	-0.7	-0.8	123.2	-0.8	-0.8	122.1	-0.9	-1.0	120.9	-1.0	-1.1	119.6	-1.2	-1.5
C15L	3300	HEARN 118	123.6	-0.7	-0.8	122.6	-0.8	-0.8	121.5	-0.9	-1.0	120.3	-1.0	-1.1	118.8	-1.2	-1.5
C15L	3364	ESPLAH2J 118	123.2	-0.7	-0.9	122.3	-0.8	-0.8	121.1	-0.9	-1.0	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C15L	3365	ESPLAH5E 118	122.7	-0.7	-0.9	121.8	-0.8	-0.8	120.6	-0.9	-1.0	119.3	-1.0	-1.1	117.9	-1.2	-1.5
C15L	3366	ESPLAH7E 118	122.7	-0.7	-0.9	121.8	-0.8	-0.8	120.6	-0.9	-1.0	119.4	-1.0	-1.1	117.9	-1.2	-1.5
C15L	3401	TERAUT5E 118	123.1	-0.7	-0.8	122.2	-0.8	-0.8	121.0	-0.9	-1.0	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C15L	3402	TERAUT7E 118	123.1	-0.7	-0.8	122.2	-0.8	-0.8	121.0	-0.9	-1.0	119.8	-1.0	-1.1	118.4	-1.2	-1.5
C15L	3403	TERC5E 118	122.4	-0.7	-0.9	121.5	-0.8	-0.8	120.3	-0.9	-1.0	119.0	-1.0	-1.1	117.6	-1.2	-1.5
C15L	3404	TERC7E 118	122.4	-0.7	-0.9	121.5	-0.8	-0.8	120.3	-0.9	-1.0	119.1	-1.0	-1.1	117.6	-1.2	-1.5
C15L	3664	ESPLNJ12 13.8	13.7	-0.7	-0.7	13.8	-0.8	-0.8	13.8	-0.9	-0.9	13.9	-1.0	-1.0	13.8	-1.2	-1.4
C15L	3767	TERAUA12 13.8	13.8	-0.7	-0.8	13.9	-0.8	-0.8	13.8	-0.9	-0.9	13.8	-1.0	-1.0	13.8	-1.2	-1.5
C16L	2100	CHERYDK1 220	238.5	-0.3	-0.3	237.4	-0.3	-0.3	236.2	-0.3	-0.3	234.9	-0.3	-0.3	233.4	-0.4	-0.5
C16L	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	0.0	-0.1
C16L	3102	LEAS 215 220	236.3	-0.6	-0.7	235.0	-0.7	-0.7	233.4	-0.7	-0.8	231.7	-0.8	-0.8	229.7	-0.9	-1.1
C16L	3103	LEAS 317 220	236.4	-0.6	-0.7	235.1	-0.7	-0.7	233.5	-0.7	-0.7	231.7	-0.8	-0.8	229.8	-0.8	-1.0
C16L	3104	LEAS1416 220	236.4	-0.7	-0.8	235.1	-0.8	-0.8	233.5	-0.8	-0.9	231.7	-0.9	-0.9	229.8	-1.0	-1.2
C16L	3301	LEAS EJ 118	124.1	-0.7	-0.7	123.2	-0.8	-0.8	122.1	-0.9	-0.9	120.9	-1.0	-1.0	119.6	-1.1	-1.4

CASE/CONT.	BN	BUS NAME	2003 Pre	%	SS%	2004 Pre	%	SS%	2005 Pre	%	SS%	2006 Pre	%	SS%	2007 Pre	%	SS%
C16L	3300	HEARN 118	123.6	-0.7	-0.8	122.6	-0.8	-0.8	121.5	-0.9	-0.9	120.3	-1.0	-1.0	118.8	-1.1	-1.4
C16L	3364	ESPLAH2J 118	123.2	-0.7	-0.8	122.3	-0.8	-0.8	121.1	-0.9	-0.9	119.8	-1.0	-1.0	118.4	-1.1	-1.4
C16L	3365	ESPLAH5E 118	122.7	-0.7	-0.8	121.8	-0.8	-0.8	120.6	-0.9	-0.9	119.3	-1.0	-1.0	117.9	-1.1	-1.4
C16L	3366	ESPLAH7E 118	122.7	-0.7	-0.8	121.8	-0.8	-0.8	120.6	-0.9	-0.9	119.4	-1.0	-1.0	117.9	-1.1	-1.4
C16L	3401	TERAUT5E 118	123.1	-0.7	-0.7	122.2	-0.8	-0.8	121.0	-0.9	-0.9	119.8	-1.0	-1.0	118.4	-1.1	-1.4
C16L	3402	TERAUT7E 118	123.1	-0.7	-0.7	122.2	-0.8	-0.8	121.0	-0.9	-0.9	119.8	-1.0	-1.0	118.4	-1.1	-1.4
C16L	3403	TERC5E 118	122.4	-0.7	-0.8	121.5	-0.8	-0.8	120.3	-0.9	-0.9	119.0	-1.0	-1.0	117.6	-1.1	-1.4
C16L	3404	TERC7E 118	122.4	-0.7	-0.8	121.5	-0.8	-0.8	120.3	-0.9	-0.9	119.1	-1.0	-1.0	117.6	-1.1	-1.4
C16L	3664	ESPLNJ12 13.8	13.7	-0.7	-0.7	13.8	-0.8	-0.8	13.8	-0.9	-0.9	13.9	-1.0	-1.0	13.8	-1.1	-1.4
C16L	3767	TERAUA12 13.8	13.8	-0.7	-0.8	13.9	-0.8	-0.8	13.8	-0.9	-0.9	13.8	-1.0	-1.0	13.8	-1.1	-1.5
C17L	2100	CHERYDK1 220	238.5	-0.3	-0.4	237.4	-0.4	-0.4	236.2	-0.4	-0.4	234.9	-0.4	-0.4	233.4	-0.4	-0.6
C17L	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	0.0	-0.1
C17L	3102	LEAS 215 220	236.3	-0.6	-0.7	235.0	-0.7	-0.7	233.4	-0.7	-0.7	231.7	-0.8	-0.8	229.7	-0.8	-1.1
C17L	3103	LEAS 317 220	236.4	-0.7	-0.8	235.1	-0.8	-0.8	233.5	-0.8	-0.9	231.7	-0.9	-1.0	229.8	-1.0	-1.3
C17L	3104	LEAS1416 220	236.4	-0.9	-1.0	235.1	-0.9	-0.9	233.5	-1.0	-1.0	231.7	-1.0	-1.1	229.8	-1.1	-1.4
C17L	3301	LEAS EJ 118	124.1	-0.8	-0.9	123.2	-0.8	-0.9	122.1	-1.0	-1.0	120.9	-1.1	-1.1	119.6	-1.2	-1.6
C17L	3300	HEARN 118	123.6	-0.8	-0.9	122.6	-0.8	-0.9	121.5	-1.0	-1.0	120.3	-1.1	-1.1	118.8	-1.2	-1.6
C17L	3364	ESPLAH2J 118	123.2	-0.8	-0.9	122.3	-0.8	-0.9	121.1	-1.0	-1.0	119.8	-1.1	-1.1	118.4	-1.2	-1.6
C17L	3365	ESPLAH5E 118	122.7	-0.8	-0.9	121.8	-0.9	-0.9	120.6	-1.0	-1.0	119.3	-1.1	-1.1	117.9	-1.2	-1.7
C17L	3366	ESPLAH7E 118	122.7	-0.8	-0.9	121.8	-0.9	-0.9	120.6	-1.0	-1.0	119.4	-1.1	-1.1	117.9	-1.2	-1.7
C17L	3401	TERAUT5E 118	123.1	-0.8	-0.9	122.2	-0.8	-0.9	121.0	-1.0	-1.0	119.8	-1.1	-1.1	118.4	-1.2	-1.6
C17L	3402	TERAUT7E 118	123.1	-0.8	-0.9	122.2	-0.8	-0.9	121.0	-1.0	-1.0	119.8	-1.1	-1.1	118.4	-1.2	-1.6
C17L	3403	TERC5E 118	122.4	-0.8	-0.9	121.5	-0.9	-0.9	120.3	-1.0	-1.0	119.0	-1.1	-1.1	117.6	-1.2	-1.7
C17L	3404	TERC7E 118	122.4	-0.8	-0.9	121.5	-0.9	-0.9	120.3	-1.0	-1.0	119.1	-1.1	-1.1	117.6	-1.2	-1.7
C17L	3664	ESPLNJ12 13.8	13.7	-0.8	-0.7	13.8	-0.9	-0.8	13.8	-1.0	-0.9	13.9	-1.1	-1.0	13.8	-1.2	-1.4
C17L	3767	TERAUA12 13.8	13.8	-0.8	-0.8	13.9	-0.9	-0.8	13.8	-1.0	-0.9	13.8	-1.1	-1.0	13.8	-1.2	-1.5
C2L & C3L	2100	CHERYDK1 220	238.5	0.0	-0.1	237.4	0.1	0.0	236.2	0.1	-0.1	234.9	0.1	0.0	233.4	0.2	-0.3
C2L & C3L	2102	CHERYDK3 220	239.4	-0.4	-0.7	238.4	-0.5	-0.6	237.2	-0.5	-0.7	236.0	-0.5	-0.8	234.7	-0.6	-1.3
C2L & C3L	3102	LEAS 215 220	236.3	-1.2	-1.6	235.0	-1.2	-1.5	233.4	-1.4	-1.8	231.7	-1.5	-2.0	229.7	-1.7	-3.1
C2L & C3L	3103	LEAS 317 220	236.4	-1.1	-1.5	235.1	-1.2	-1.4	233.5	-1.3	-1.8	231.7	-1.4	-2.0	229.8	-1.6	-3.0
C2L & C3L	3104	LEAS1416 220	236.4	-1.5	-2.0	235.1	-1.6	-1.9	233.5	-1.7	-2.2	231.7	-1.8	-2.4	229.8	-2.0	-3.5
C2L & C3L	3301	LEAS EJ 118	124.1	-1.4	-2.2	123.2	-1.6	-2.0	122.1	-1.9	-2.7	120.9	-2.1	-3.1	119.6	-2.5	-4.8
C2L & C3L	3300	HEARN 118	123.6	-1.4	-2.2	122.6	-1.6	-2.0	121.5	-1.9	-2.7	120.3	-2.1	-3.2	118.8	-2.5	-5.0
C2L & C3L	3364	ESPLAH2J 118	123.2	-1.4	-2.3	122.3	-1.6	-2.0	121.1	-1.9	-2.7	119.8	-2.1	-3.2	118.4	-2.5	-5.0
C2L & C3L	3365	ESPLAH5E 118	122.7	-1.4	-2.3	121.8	-1.6	-2.0	120.6	-1.9	-2.8	119.3	-2.2	-3.2	117.9	-2.5	-5.0
C2L & C3L	3366	ESPLAH7E 118	122.7	-1.4	-2.3	121.8	-1.6	-2.0	120.6	-1.9	-2.8	119.4	-2.2	-3.2	117.9	-2.5	-5.0
C2L & C3L	3401	TERAUT5E 118	123.1	-1.4	-2.2	122.2	-1.6	-2.0	121.0	-1.9	-2.7	119.8	-2.1	-3.1	118.4	-2.5	-4.9

CASE/CONT.	BN	BUS NAME	2003			2004			2005			2006			2007		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
C2L & C3L	3402	TERAUT7E 118	123.1	-1.4	-2.2	122.2	-1.6	-2.0	121.0	-1.9	-2.7	119.8	-2.1	-3.1	118.4	-2.5	-4.9
C2L & C3L	3403	TERC5E 118	122.4	-1.4	-2.3	121.5	-1.6	-2.0	120.3	-1.9	-2.8	119.0	-2.2	-3.2	117.6	-2.5	-5.1
C2L & C3L	3404	TERC7E 118	122.4	-1.4	-2.3	121.5	-1.6	-2.0	120.3	-1.9	-2.8	119.1	-2.2	-3.2	117.6	-2.5	-5.0
C2L & C3L	3664	ESPLNJ12 13.8	13.7	-1.5	0.4	13.8	-1.7	-0.7	13.8	-1.9	-1.5	13.9	-2.2	-0.7	13.8	-2.5	-1.3
C2L & C3L	3767	TERAUA12 13.8	13.8	-1.5	-1.0	13.9	-1.7	-2.0	13.8	-1.9	-0.2	13.8	-2.2	-0.7	13.8	-2.5	-1.4
C16L & C17L	2100	CHERYDK1 220	238.5	-0.9	-1.2	237.4	-0.9	-1.2	236.2	-1.0	-1.4	234.9	-1.1	-1.8	233.4	-1.4	-3.1
C16L & C17L	2102	CHERYDK3 220	239.4	-0.1	-0.3	238.4	-0.1	-0.3	237.2	-0.1	-0.3	236.0	0.0	-0.4	234.7	0.0	-1.1
C16L & C17L	3102	LEAS 215 220	236.3	-1.7	-2.4	235.0	-1.9	-2.4	233.4	-2.0	-2.9	231.7	-2.2	-3.4	229.7	-2.5	-5.3
C16L & C17L	3103	LEAS 317 220	236.4	-1.9	-2.6	235.1	-2.1	-2.6	233.5	-2.2	-3.1	231.7	-2.4	-3.7	229.8	-2.9	-5.9
C16L & C17L	3104	LEAS1416 220	236.4	-2.4	-3.2	235.1	-2.6	-3.2	233.5	-2.8	-3.7	231.7	-3.0	-4.3	229.8	-3.5	-6.5
C16L & C17L	3301	LEAS EJ 118	124.1	-2.1	-3.3	123.2	-2.3	-3.3	122.1	-2.6	-4.1	120.9	-2.9	-5.0	119.6	-3.5	-8.0
C16L & C17L	3300	HEARN 118	123.6	-2.1	-3.3	122.6	-2.3	-3.3	121.5	-2.6	-4.2	120.3	-2.9	-5.1	118.8	-3.5	-8.3
C16L & C17L	3364	ESPLAH2J 118	123.2	-2.1	-3.4	122.3	-2.3	-3.3	121.1	-2.6	-4.2	119.8	-2.9	-5.1	118.4	-3.5	-8.3
C16L & C17L	3365	ESPLAH5E 118	122.7	-2.1	-3.4	121.8	-2.3	-3.3	120.6	-2.6	-4.3	119.3	-3.0	-5.2	117.9	-3.5	-8.4
C16L & C17L	3366	ESPLAH7E 118	122.7	-2.1	-3.4	121.8	-2.3	-3.3	120.6	-2.6	-4.3	119.4	-3.0	-5.2	117.9	-3.5	-8.4
C16L & C17L	3401	TERAUT5E 118	123.1	-2.1	-3.3	122.2	-2.3	-3.3	121.0	-2.6	-4.2	119.8	-2.9	-5.1	118.4	-3.5	-8.2
C16L & C17L	3402	TERAUT7E 118	123.1	-2.1	-3.3	122.2	-2.3	-3.3	121.0	-2.6	-4.2	119.8	-2.9	-5.1	118.4	-3.5	-8.2
C16L & C17L	3403	TERC5E 118	122.4	-2.1	-3.4	121.5	-2.3	-3.3	120.3	-2.6	-4.3	119.0	-3.0	-5.2	117.6	-3.5	-8.4
C16L & C17L	3404	TERC7E 118	122.4	-2.1	-3.4	121.5	-2.3	-3.3	120.3	-2.6	-4.3	119.1	-3.0	-5.2	117.6	-3.5	-8.4
C16L & C17L	3664	ESPLNJ12 13.8	13.7	-2.1	-0.7	13.8	-2.4	-0.8	13.8	-2.6	-1.7	13.9	-3.0	-1.4	13.8	-3.6	-1.3
C16L & C17L	3767	TERAUA12 13.8	13.8	-2.1	-0.8	13.9	-2.4	-2.1	13.8	-2.7	-0.5	13.8	-3.0	-1.5	13.8	-3.6	-1.4
C14L & C15L	2100	CHERYDK1 220	238.5	-0.5	-0.7	237.4	-0.5	-0.7	236.2	-0.5	-0.8	234.9	-0.6	-0.9	233.4	-0.6	-1.6
C14L & C15L	2102	CHERYDK3 220	239.4	-0.4	-0.6	238.4	-0.4	-0.6	237.2	-0.4	-0.7	236.0	-0.4	-0.7	234.7	-0.5	-1.4
C14L & C15L	3102	LEAS 215 220	236.3	-1.8	-2.3	235.0	-1.9	-2.4	233.4	-2.0	-2.8	231.7	-2.2	-2.9	229.7	-2.4	-4.4
C14L & C15L	3103	LEAS 317 220	236.4	-1.8	-2.4	235.1	-1.9	-2.4	233.5	-2.1	-2.8	231.7	-2.2	-2.9	229.8	-2.4	-4.4
C14L & C15L	3104	LEAS1416 220	236.4	-1.3	-1.8	235.1	-1.4	-1.9	233.5	-1.5	-2.2	231.7	-1.6	-2.4	229.8	-1.8	-3.7
C14L & C15L	3301	LEAS EJ 118	124.1	-1.8	-2.7	123.2	-2.0	-2.8	122.1	-2.3	-3.5	120.9	-2.6	-3.8	119.6	-3.0	-6.0
C14L & C15L	3300	HEARN 118	123.6	-1.8	-2.8	122.6	-2.0	-2.9	121.5	-2.3	-3.5	120.3	-2.6	-3.9	118.8	-3.0	-6.2
C14L & C15L	3364	ESPLAH2J 118	123.2	-1.8	-2.8	122.3	-2.0	-2.9	121.1	-2.3	-3.6	119.8	-2.6	-3.9	118.4	-3.0	-6.3
C14L & C15L	3365	ESPLAH5E 118	122.7	-1.8	-2.8	121.8	-2.0	-2.9	120.6	-2.3	-3.6	119.3	-2.6	-3.9	117.9	-3.0	-6.3
C14L & C15L	3366	ESPLAH7E 118	122.7	-1.8	-2.8	121.8	-2.0	-2.9	120.6	-2.3	-3.6	119.4	-2.6	-3.9	117.9	-3.0	-6.3
C14L & C15L	3401	TERAUT5E 118	123.1	-1.8	-2.8	122.2	-2.0	-2.8	121.0	-2.3	-3.5	119.8	-2.6	-3.9	118.4	-3.0	-6.2
C14L & C15L	3402	TERAUT7E 118	123.1	-1.8	-2.8	122.2	-2.0	-2.8	121.0	-2.3	-3.5	119.8	-2.6	-3.9	118.4	-3.0	-6.2
C14L & C15L	3403	TERC5E 118	122.4	-1.8	-2.8	121.5	-2.0	-2.9	120.3	-2.3	-3.6	119.0	-2.6	-4.0	117.6	-3.0	-6.3
C14L & C15L	3404	TERC7E 118	122.4	-1.8	-2.8	121.5	-2.0	-2.9	120.3	-2.3	-3.6	119.1	-2.6	-4.0	117.6	-3.0	-6.3
C14L & C15L	3664	ESPLNJ12 13.8	13.7	-1.9	-0.2	13.8	-2.1	-0.3	13.8	-2.3	-1.1	13.9	-2.6	-1.4	13.8	-3.0	-1.5
C14L & C15L	3767	TERAUA12 13.8	13.8	-1.9	-1.5	13.9	-2.1	-1.6	13.8	-2.3	-1.1	13.8	-2.6	-1.5	13.8	-3.0	-1.6

CASE/CONT.	BN	BUS NAME	2003 Pre	%	SS%	2004 Pre	%	SS%	2005 Pre	%	SS%	2006 Pre	%	SS%	2007 Pre	%	SS%
R1K	2100	CHERYDK1 220	238.5	0.0	0.0	237.4	0.0	0.0	236.2	0.0	0.0	234.9	0.0	0.0	233.4	0.0	0.0
R1K	2102	CHERYDK3 220	239.4	0.0	0.0	238.4	0.0	0.0	237.2	0.0	0.0	236.0	0.0	0.0	234.7	0.0	0.0
R1K	4103	RICH AH2 220	238.6	0.0	0.0	237.2	0.0	0.0	235.5	0.0	0.0	233.7	0.0	0.0	231.8	0.0	0.0
R1K	3107	MANBY E 220	239.8	0.3	0.3	238.2	0.3	0.3	236.5	0.2	0.2	234.6	0.2	0.2	232.6	0.2	0.2
R1K	3302	MANBY E 118	122.9	0.3	0.3	122.0	0.3	0.3	121.0	0.2	0.2	120.0	0.2	0.2	118.8	0.2	0.2
R1K	3108	MANBY W 220	239.1	0.0	0.0	237.5	0.0	0.0	235.8	0.0	0.0	233.8	0.0	0.0	231.8	0.0	0.0
R1K	3303	MANBY W 118	121.1	0.0	0.0	120.3	0.0	0.0	119.3	0.0	0.0	118.1	0.0	0.0	116.8	0.0	0.0
R1K	3377	JOHN 118	119.2	0.0	0.0	118.3	0.0	0.0	117.4	0.0	0.0	116.0	0.0	0.0	114.6	0.0	0.0
R1K	4143	COOKVL15 220	238.6	0.1	0.1	237.0	0.1	0.1	235.2	0.1	0.1	233.3	0.1	0.1	231.3	0.1	0.1
R1K	4192	LORNEB15 220	238.0	0.1	0.1	236.4	0.1	0.1	234.7	0.1	0.1	232.7	0.1	0.1	230.7	0.1	0.1
R1K	5240	OAKV B15 220	237.3	0.1	0.1	235.7	0.1	0.1	233.9	0.1	0.1	231.9	0.1	0.1	229.9	0.1	0.1
R1K	3697	JOHN A13 13.8	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0
R13K	2100	CHERYDK1 220	238.5	0.0	0.0	237.4	0.0	0.0	236.2	0.0	0.0	234.9	0.0	0.0	233.4	0.0	0.0
R13K	2102	CHERYDK3 220	239.4	0.0	0.0	238.4	0.0	0.0	237.2	0.0	0.0	236.0	0.0	0.0	234.7	0.0	0.0
R13K	4103	RICH AH2 220	238.6	0.0	0.0	237.2	0.0	0.0	235.5	0.0	0.0	233.7	0.0	0.0	231.8	0.0	0.0
R13K	3107	MANBY E 220	239.8	0.3	0.3	238.2	0.3	0.3	236.5	0.2	0.2	234.6	0.2	0.2	232.6	0.2	0.2
R13K	3302	MANBY E 118	122.9	0.3	0.3	122.0	0.3	0.3	121.0	0.2	0.2	120.0	0.2	0.2	118.8	0.2	0.2
R13K	3108	MANBY W 220	239.1	0.0	0.0	237.5	0.0	0.0	235.8	0.0	0.0	233.8	0.0	0.0	231.8	0.0	0.0
R13K	3303	MANBY W 118	121.1	0.0	0.0	120.3	0.0	0.0	119.3	0.0	0.0	118.1	0.0	0.0	116.8	0.0	0.0
R13K	3377	JOHN 118	119.2	0.0	0.0	118.3	0.0	0.0	117.4	0.0	0.0	116.0	0.0	0.0	114.6	0.0	0.0
R13K	4143	COOKVL15 220	238.6	0.1	0.1	237.0	0.1	0.1	235.2	0.1	0.1	233.3	0.1	0.1	231.3	0.1	0.1
R13K	4192	LORNEB15 220	238.0	0.1	0.1	236.4	0.1	0.1	234.7	0.1	0.1	232.7	0.1	0.1	230.7	0.1	0.1
R13K	5240	OAKV B15 220	237.3	0.1	0.1	235.7	0.1	0.1	233.9	0.1	0.1	231.9	0.1	0.1	229.9	0.1	0.1
R13K	3697	JOHN A13 13.8	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0
R2K	2100	CHERYDK1 220	238.5	-0.1	-0.1	237.4	-0.1	-0.1	236.2	-0.1	-0.1	234.9	-0.1	-0.1	233.4	-0.1	-0.1
R2K	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	-0.1	-0.1
R2K	4103	RICH AH2 220	238.6	-0.2	-0.2	237.2	-0.2	-0.2	235.5	-0.2	-0.2	233.7	-0.2	-0.2	231.8	-0.2	-0.2
R2K	3107	MANBY E 220	239.8	-0.2	-0.2	238.2	-0.2	-0.2	236.5	-0.2	-0.2	234.6	-0.2	-0.2	232.6	-0.2	-0.2
R2K	3302	MANBY E 118	122.9	-0.2	-0.2	122.0	-0.2	-0.2	121.0	-0.2	-0.2	120.0	-0.2	-0.2	118.8	-0.2	-0.2
R2K	3108	MANBY W 220	239.1	-0.2	-0.2	237.5	-0.2	-0.2	235.8	-0.2	-0.2	233.8	-0.2	-0.3	231.8	-0.3	-0.3
R2K	3303	MANBY W 118	121.1	-0.2	-0.2	120.3	-0.2	-0.3	119.3	-0.2	-0.2	118.1	-0.2	-0.3	116.8	-0.3	-0.3
R2K	3377	JOHN 118	119.2	-0.2	-0.2	118.3	-0.2	-0.3	117.4	-0.2	-0.2	116.0	-0.2	-0.3	114.6	-0.3	-0.4
R2K	4143	COOKVL15 220	238.6	-0.2	-0.2	237.0	-0.2	-0.2	235.2	-0.2	-0.2	233.3	-0.2	-0.2	231.3	-0.2	-0.3
R2K	4192	LORNEB15 220	238.0	-0.2	-0.2	236.4	-0.2	-0.2	234.7	-0.2	-0.2	232.7	-0.2	-0.2	230.7	-0.2	-0.3
R2K	5240	OAKV B15 220	237.3	-0.2	-0.2	235.7	-0.2	-0.2	233.9	-0.2	-0.2	231.9	-0.2	-0.2	229.9	-0.2	-0.3
R2K	3697	JOHN A13 13.8	13.9	-0.2	-0.2	13.9	-0.2	-0.3	13.8	-0.2	-0.2	13.8	-0.2	-0.3	13.8	-0.3	-0.4

CASE/CONT.	BN	BUS NAME	2003			2004			2005			2006			2007		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
R15K	2100	CHERYDK1 220	238.5	-0.1	-0.1	237.4	-0.1	-0.1	236.2	-0.1	-0.1	234.9	-0.1	-0.1	233.4	-0.1	-0.1
R15K	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	-0.1	-0.1
R15K	4103	RICH AH2 220	238.6	-0.2	-0.2	237.2	-0.2	-0.2	235.5	-0.2	-0.2	233.7	-0.2	-0.2	231.8	-0.2	-0.2
R15K	3107	MANBY E 220	239.8	-0.2	-0.2	238.2	-0.2	-0.2	236.5	-0.2	-0.2	234.6	-0.2	-0.2	232.6	-0.2	-0.2
R15K	3302	MANBY E 118	122.9	-0.2	-0.2	122.0	-0.2	-0.2	121.0	-0.2	-0.2	120.0	-0.2	-0.2	118.8	-0.2	-0.3
R15K	3108	MANBY W 220	239.1	-0.2	-0.2	237.5	-0.2	-0.3	235.8	-0.2	-0.3	233.8	-0.3	-0.3	231.8	-0.3	-0.4
R15K	3303	MANBY W 118	121.1	-0.2	-0.2	120.3	-0.2	-0.3	119.3	-0.2	-0.3	118.1	-0.3	-0.3	116.8	-0.3	-0.4
R15K	3377	JOHN 118	119.2	-0.2	-0.2	118.3	-0.2	-0.3	117.4	-0.2	-0.3	116.0	-0.3	-0.3	114.6	-0.3	-0.4
R15K	4143	COOKVL15 220	238.6	-0.2	-0.2	237.0	-0.2	-0.2	235.2	-0.2	-0.3	233.3	-0.2	-0.3	231.3	-0.2	-0.3
R15K	4192	LORNEB15 220	238.0	-0.2	-0.2	236.4	-0.2	-0.2	234.7	-0.2	-0.3	232.7	-0.2	-0.3	230.7	-0.2	-0.3
R15K	5240	OAKV B15 220	237.3	-0.2	-0.2	235.7	-0.2	-0.3	233.9	-0.2	-0.3	231.9	-0.2	-0.3	229.9	-0.2	-0.3
R15K	3697	JOHN A13 13.8	13.9	-0.2	-0.2	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.3	-0.3	13.8	-0.3	-0.4
R1K & R2K	2100	CHERYDK1 220	238.5	-0.1	-0.1	237.4	-0.1	-0.1	236.2	-0.1	-0.1	234.9	-0.1	-0.1	233.4	-0.1	-0.1
R1K & R2K	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	-0.1	-0.1
R1K & R2K	4103	RICH AH2 220	238.6	-0.2	-0.2	237.2	-0.2	-0.2	235.5	-0.2	-0.2	233.7	-0.2	-0.2	231.8	-0.2	-0.3
R1K & R2K	3107	MANBY E 220	239.8	0.1	0.1	238.2	0.1	0.0	236.5	0.1	0.0	234.6	0.0	0.0	232.6	0.0	-0.1
R1K & R2K	3302	MANBY E 118	122.9	0.1	0.1	122.0	0.1	0.0	121.0	0.1	0.0	120.0	0.0	0.0	118.8	0.0	-0.1
R1K & R2K	3108	MANBY W 220	239.1	-0.1	-0.2	237.5	-0.2	-0.2	235.8	-0.2	-0.2	233.8	-0.2	-0.3	231.8	-0.3	-0.3
R1K & R2K	3303	MANBY W 118	121.1	-0.1	-0.2	120.3	-0.2	-0.2	119.3	-0.2	-0.2	118.1	-0.2	-0.3	116.8	-0.3	-0.4
R1K & R2K	3377	JOHN 118	119.2	-0.1	-0.2	118.3	-0.2	-0.2	117.4	-0.2	-0.2	116.0	-0.2	-0.3	114.6	-0.3	-0.4
R1K & R2K	4143	COOKVL15 220	238.6	0.0	-0.1	237.0	0.0	-0.1	235.2	-0.1	-0.1	233.3	-0.1	-0.1	231.3	-0.1	-0.2
R1K & R2K	4192	LORNEB15 220	238.0	0.0	-0.1	236.4	0.0	-0.1	234.7	-0.1	-0.1	232.7	-0.1	-0.1	230.7	-0.1	-0.2
R1K & R2K	5240	OAKV B15 220	237.3	0.0	-0.1	235.7	0.0	-0.1	233.9	-0.1	-0.1	231.9	-0.1	-0.1	229.9	-0.1	-0.2
R1K & R2K	3697	JOHN A13 13.8	13.9	-0.1	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.3	13.8	-0.3	-0.4
R13K & R15K	2100	CHERYDK1 220	238.5	-0.1	-0.1	237.4	-0.1	-0.1	236.2	-0.1	-0.1	234.9	-0.1	-0.1	233.4	-0.1	-0.1
R13K & R15K	2102	CHERYDK3 220	239.4	-0.1	-0.1	238.4	-0.1	-0.1	237.2	-0.1	-0.1	236.0	-0.1	-0.1	234.7	-0.1	-0.1
R13K & R15K	4103	RICH AH2 220	238.6	-0.2	-0.3	237.2	-0.2	-0.3	235.5	-0.2	-0.3	233.7	-0.2	-0.3	231.8	-0.2	-0.3
R13K & R15K	3107	MANBY E 220	239.8	0.1	0.0	238.2	0.1	0.0	236.5	0.0	0.0	234.6	0.0	0.0	232.6	0.0	-0.1
R13K & R15K	3302	MANBY E 118	122.9	0.1	0.0	122.0	0.1	0.0	121.0	0.0	0.0	120.0	0.0	0.0	118.8	0.0	-0.1
R13K & R15K	3108	MANBY W 220	239.1	-0.2	-0.2	237.5	-0.2	-0.3	235.8	-0.2	-0.3	233.8	-0.3	-0.3	231.8	-0.3	-0.4
R13K & R15K	3303	MANBY W 118	121.1	-0.2	-0.2	120.3	-0.2	-0.3	119.3	-0.2	-0.3	118.1	-0.3	-0.3	116.8	-0.3	-0.4
R13K & R15K	3377	JOHN 118	119.2	-0.2	-0.2	118.3	-0.2	-0.3	117.4	-0.2	-0.3	116.0	-0.3	-0.3	114.6	-0.3	-0.4
R13K & R15K	4143	COOKVL15 220	238.6	0.0	-0.1	237.0	-0.1	-0.1	235.2	-0.1	-0.1	233.3	-0.1	-0.2	231.3	-0.2	-0.2
R13K & R15K	4192	LORNEB15 220	238.0	0.0	-0.1	236.4	-0.1	-0.1	234.7	-0.1	-0.1	232.7	-0.1	-0.2	230.7	-0.2	-0.2
R13K & R15K	5240	OAKV B15 220	237.3	0.0	-0.1	235.7	-0.1	-0.1	233.9	-0.1	-0.1	231.9	-0.1	-0.2	229.9	-0.2	-0.2
R13K & R15K	3697	JOHN A13 13.8	13.9	-0.2	-0.2	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.3	-0.3	13.8	-0.3	-0.4

Appendix C: Circuit Loading under Contingency for Lakeview Retirement Voltage Support

Case/Cont.	Circuit/Auto	Rating	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10
None	R1K	579/669	327.3	347.6	357.1	357.1	310.7	347.6	347.6	340.7	267.7	344.4
None	R13K	579/669	324.3	344.4	353.8	353.8	307.8	344.4	344.4	337.5	265.2	341.2
None	R2K	579/669	395.5	463.6	382.4	382.4	388.9	463.6	463.6	447.3	247.6	386.3
None	R15K	579/669	397.8	465.7	384.4	384.4	390.9	465.7	465.7	449.3	249.5	388.5
None	L21K	579/701	31.9	76.3	315.9	315.9	207.1	76.3	76.3	93.4	133.8	40.9
None	L22K	579/701	32.3	77.3	211.5	211.5	75.1	77.3	77.3	93.4	135	41.1
None	L23CK	880/880	177.5	157.2	208.4	208.4	88.2	157.2	157.2	144.8	80.5	185.9
None	L24CR	946/946	215.8	221.2	341.4	341.4	432.4	221.2	221.2	219.2	116.3	233.3
None	Claireville T13	811/994	882.1	868.8	869.5	869.5	868.9	868.9	868.9	866.1	831.2	878.6
None	Claireville T14	722/1030	898.6	883.7	884.5	884.5	883.7	883.7	883.7	881	846.7	894.8
None	Claireville T15	750/840	889.8	876.3	877	877	876.3	876.3	876.3	873.5	838.5	886.3
None	Claireville T16	937/1152	827	814.6	815.3	815.3	814.7	814.6	814.6	812.1	779.3	823.8
R1K	R1K	579/669	0	0	0	0	0	0	0	0	0	0
R1K	R13K	579/669	543.4	577.3	695.4	568.9	500.5	577.3	572.1	561	474.4	610.5
R1K	R2K	579/669	431.4	501.9	387.6	418.9	416.9	501.9	503.6	486.9	247.5	386.1
R1K	R15K	579/669	433.7	504	389.6	421.1	419	504	505.8	489	249.4	388.3
R1K	L21K	579/701	63.7	84	320.5	347.6	177.4	84	111.7	94.2	133.8	41.5
R1K	L22K	579/701	64.3	85	225.9	409.2	77.8	85	113	94.2	135.1	41.6
R1K	L23CK	880/880	123.8	85.9	195.3	0	95	85.9	0	82.8	107.6	131.2
R1K	L24CR	946/946	250.6	258.9	346.1	376.1	494.8	258.9	269.2	257.3	172.5	307
R1K	Claireville T13	812/994	882.3	869.2	869.8	867	869.2	869.2	869.2	866.5	831.4	878.8
R1K	Claireville T14	722/1030	898.8	884	884.8	882	884	884	884	881.3	847	895
R1K	Claireville T15	750/840	890	876.6	877.2	874.4	876.6	876.6	876.6	873.9	838.7	886.4
R1K	Claireville T16	937/1152	827.2	815	815.5	812.9	815	815	814.9	812.4	779.5	824
R13K	R1K	579/669	545	579	695.7	568.9	502.3	579	572	562.8	475.4	611.7
R13K	R13K	579/669	0	0	0	0	0	0	0	0	0	0
R13K	R2K	579/669	430.8	501.3	387.5	418.9	416.5	501.3	503.6	486.3	247.5	386.1
R13K	R15K	579/669	433.2	503.4	389.5	421.1	418.5	503.4	505.8	488.4	249.4	388.3
R13K	L21K	579/701	63.2	83.7	320.4	347.6	177.8	83.7	111.7	94	133.8	41.5
R13K	L22K	579/701	63.8	84.7	225.7	409.2	77.7	84.7	113	94	135.1	41.6
R13K	L23CK	880/880	124.2	86.4	195.6	0	93.9	86.4	0	82.9	107	132
R13K	L24CR	946/946	250.1	258.3	346	376.1	493.8	258.3	269.2	256.7	171.5	305.7
R13K	Claireville T13	812/994	882.3	869.2	869.8	867	869.2	869.2	869.1	866.5	831.4	878.8

R13K	**Claireville T14**	722/1030	898.8	884	884.8	882	884	884	884	881.3	847	895
Case/Cont.	**Circuit/Auto**	**Rating**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**	**Case 10**
R13K	**Claireville T15**	750/840	889.9	876.6	877.2	874.4	876.6	876.6	876.6	873.9	838.7	886.4
R13K	**Claireville T16**	937/1152	827.2	815	815.5	812.9	815	815	814.9	812.4	779.5	824
R2K	**R1K**	579/669	365.8	394.5	360.7	360.7	339.5	463.6	463.6	450	267.4	344
R2K	**R13K**	579/669	362.4	390.8	357.4	357.4	336.3	459.3	459.3	445.8	264.9	340.8
R2K	**R2K**	579/669	0	0	0	0	0	0	0	0	0	0
R2K	**R15K**	579/669	635.4	740.9	570	570	555.5	514.6	514.6	469.4	475.5	755.3
R2K	**L21K**	579/701	45	120.2	480.5	480.5	340.5	244.7	244.7	267.7	133.7	40.9
R2K	**L22K**	579/701	45.5	121.7	204.5	204.5	87.7	247.3	247.3	267.7	134.9	41
R2K	**L23CK**	880/880	252.4	240.7	215.8	215.8	136.1	365.2	365.2	339.5	78.6	185
R2K	**L24CR**	946/946	275.6	288.9	504.1	504.1	572.4	385.7	385.7	412.5	115.9	232.9
R2K	**Claireville T13**	812/994	880.3	867.8	868.1	868.1	867.5	869.2	869.2	866.1	829.9	877.2
R2K	**Claireville T14**	722/1030	896.9	882.7	883.1	883.1	882.4	884.1	884.1	881	845.4	893.5
R2K	**Claireville T15**	750/840	888	875.2	875.5	875.5	874.9	876.6	876.6	873.5	837.1	884.8
R2K	**Claireville T16**	937/1152	825.4	813.6	814	814	813.4	815	815	812	778.1	822.5
R15K	**R1K**	579/669	365.9	394.4	360.7	360.7	339.4	463.5	463.5	449.8	267.3	343.9
R15K	**R13K**	579/669	362.5	390.8	357.3	357.3	336.2	459.2	459.2	445.7	264.9	340.8
R15K	**R2K**	579/669	632.6	737.5	566.6	566.6	552.1	511.5	511.5	466.5	472.9	752.9
R15K	**R15K**	579/669	0	0	0	0	0	0	0	0	0	0
R15K	**L21K**	579/701	45.1	119.6	480.3	480.3	339.7	244.3	244.3	267.3	133.7	41.2
R15K	**L22K**	579/701	45.6	121.1	204.3	204.3	87.1	246.9	246.9	267.3	135	41.3
R15K	**L23CK**	880/880	253.2	241.1	215.8	215.8	136.4	365.2	365.2	339.5	78.5	184.9
R15K	**L24CR**	946/946	275.9	289	504	504	572.5	385.7	385.7	412.4	115.9	232.9
R15K	**Claireville T13**	812/994	880.1	867.5	867.9	867.9	867.2	869	869	865.8	829.7	877
R15K	**Claireville T14**	722/1030	896.7	882.4	882.9	882.9	882.1	883.9	883.9	880.8	845.2	893.3
R15K	**Claireville T15**	750/840	887.8	875	875.3	875.3	874.6	876.4	876.4	873.2	836.9	884.7
R15K	**Claireville T16**	937/1152	825.2	813.4	813.7	813.7	813.1	814.7	814.7	811.8	777.9	822.3
R1/2K	**R1K**	579/669	0	0	0	0	0	0	0	0	0	0
R1/2K	**R13K**	579/669	614.6	663.1	702.5	567.4	550.9	795.6	569.6	766.4	473.8	609.6
R1/2K	**R2K**	579/669	0	0	0	0	0	0	0	0	0	0
R1/2K	**R15K**	579/669	701.2	812.9	577.9	631.9	600.5	569.8	667.9	521.6	475.3	754.9
R1/2K	**L21K**	579/701	12.1	96.8	487.6	533.5	310.5	221.8	189.8	246	133.7	41.4
R1/2K	**L22K**	579/701	12.4	98	218.6	409.1	83	224.2	192	246	135	41.5
R1/2K	**L23CK**	880/880	167.8	130	202.3	0	74.9	237.6	0	210.7	106	129.8
R1/2K	**L24CR**	946/946	321.6	339.5	511.2	560.8	653.1	460.9	595.2	492.4	172.1	306.5

R1/2K	Claireville T13	812/994	880.4	868.2	868.3	865.4	867.8	869.8	869.9	866.7	830	877.4
R1/2K	Claireville T14	722/1030	897	883.1	883.3	880.5	882.7	884.8	884.8	881.6	845.6	893.6
Case/Cont.	**Circuit/Auto**	**Rating**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**	**Case 10**
R1/2K	Claireville T15	750/840	888.1	875.6	875.7	872.9	875.2	877.3	877.3	874.1	837.3	885
R1/2K	Claireville T16	937/1152	825.5	814	814.1	811.5	813.6	815.6	815.6	812.6	778.2	822.6
R13/15K	R1K	579/669	616.5	665	702.7	567.2	552.7	797.5	569.4	768.3	474.7	610.8
R13/15K	R13K	579/669	0	0	0	0	0	0	0	0	0	0
R13/15K	R2K	579/669	697.4	808.3	574.4	628.5	596.4	565.9	664.9	517.8	472.7	752.5
R13/15K	R15K	579/669	0	0	0	0	0	0	0	0	0	0
R13/15K	L21K	579/701	12.6	96.3	487.2	533.7	310.1	221.7	189.5	245.9	133.8	41.7
R13/15K	L22K	579/701	12.8	97.6	218.2	408.9	82.5	224.1	191.6	245.9	135	41.9
R13/15K	L23CK	880/880	169.8	132.2	202.6	0	75.3	239.7	0	212.8	105.3	130.6
R13/15K	L24CR	946/946	321.2	338.9	511	561.1	652	459.6	595.2	491	171.1	305.2
R13/15K	Claireville T13	812/994	880.2	867.9	868.1	865.2	867.5	869.6	869.6	866.4	829.8	877.2
R13/15K	Claireville T14	722/1030	896.8	882.8	883.1	880.2	882.4	884.6	884.6	881.4	845.4	893.4
R13/15K	Claireville T15	750/840	887.9	875.3	875.5	872.6	874.9	877	877.1	873.8	837.1	884.8
R13/15K	Claireville T16	937/1152	825.3	813.8	813.9	811.2	813.4	815.4	815.4	812.4	778.1	822.4
L21K	R1K	579/669	329.4	345.4	360.4	360.4	296.3	345.4	345.4	338.6	267.5	344.3
L21K	R13K	579/669	326.3	342.2	357.1	357.1	293.6	342.2	342.2	335.5	265.1	341.1
L21K	R2K	579/669	388.8	465.8	535.3	535.3	433.4	465.8	465.8	453	244.4	383.9
L21K	R15K	579/669	391.1	467.8	537.5	537.5	435.4	467.8	467.8	455.1	246.3	386.1
L21K	L21K	579/701	0	0	0	0	0	0	0	0	0	0
L21K	L22K	579/701	51.6	123.1	207.9	207.9	157.5	123.1	123.1	151.8	266.8	67.2
L21K	L23CK	880/880	188	169	213.4	213.4	96.3	169	169	153.2	79.7	185.6
L21K	L24CR	946/946	221.4	222.8	36	36	380	222.8	222.8	218	116.1	233.1
L21K	Claireville T13	812/994	881.8	868.4	869.6	869.6	868.7	868.4	868.4	866.1	830.9	878.3
L21K	Claireville T14	722/1030	898.3	883.3	884.6	884.6	883.5	883.3	883.3	881	846.5	894.6
L21K	Claireville T15	750/840	889.5	875.8	877.1	877.1	876.1	875.8	875.8	873.5	838.2	886
L21K	Claireville T16	937/1152	826.8	814.2	815.4	815.4	814.5	814.3	814.3	812.1	779.1	823.5
L22K	R1K	579/669	329.5	345.4	424.4	424.4	315.8	345.4	345.4	338.6	267.5	344.3
L22K	R13K	579/669	326.4	342.2	420.4	420.4	312.9	342.2	342.2	335.5	265.1	341.1
L22K	R2K	579/669	388.7	466	342.7	342.7	379.1	466	466	453	244.4	384
L22K	R15K	579/669	391	468	344.4	344.4	381	468	468	455.1	246.4	386.2
L22K	L21K	579/701	51.2	122.2	281.8	281.8	260.5	122.2	122.2	151.8	266.8	67.7
L22K	L22K	579/701	0	0	0	0	0	0	0	0	0	0
L22K	L23CK	880/880	188	169.1	406.2	406.2	129.1	169.1	169.1	153.2	79.7	185.6

L22K	L24CR	946/946	221.5	222.9	303.4	303.4	400.2	222.9	222.9	218	116.1	233.1
L22K	Claireville T13	812/994	881.8	868.4	866.4	866.4	865.8	868.4	868.4	866.1	830.9	878.3
L22K	Claireville T14	722/1030	898.3	883.3	881.4	881.4	880.7	883.3	883.3	881	846.5	894.6
Case/Cont.	**Circuit/Auto**	**Rating**	**Case 1**	**Case 2**	**Case 3**	**Case 4**	**Case 5**	**Case 6**	**Case 7**	**Case 8**	**Case 9**	**Case 10**
L22K	Claireville T15	750/840	889.5	875.9	873.8	873.8	873.2	875.9	875.9	873.5	838.2	886
L22K	Claireville T16	937/1152	826.8	814.3	812.4	812.4	811.8	814.3	814.3	812.1	779.1	823.5
L23CK	R1K	579/669	272.4	285.7	284.7	284.7	285.6	285.6	285.6	285.9	277.1	274.4
L23CK	R13K	579/669	269.8	283	282.1	282.1	283	283	283	283.3	274.5	271.9
L23CK	R2K	579/669	426.7	483.9	418.7	418.7	393.9	483.9	483.9	484.5	247.5	386.2
L23CK	R15K	579/669	429	486.1	420.9	420.9	395.9	486.1	486.1	486.6	249.4	388.4
L23CK	L21K	579/701	80.4	106.7	347.4	347.4	221.5	106.7	106.7	121.6	133.8	41.3
L23CK	L22K	579/701	81.3	108	409.5	409.5	131.2	108	108	121.6	135	41.5
L23CK	L23CK	880/880	0	0	0	0	0	0	0	0	0	0
L23CK	L24CR	946/946	284.1	278.2	375.9	375.9	436.9	278.2	278.2	260.1	142.9	389.9
L23CK	Claireville T13	812/994	879.2	865.8	866.6	866.6	865.8	865.8	865.8	866	828.8	876.1
L23CK	Claireville T14	722/1030	895.7	880.6	881.5	881.5	880.7	880.6	880.6	880.9	844.3	892.3
L23CK	Claireville T15	750/840	886.9	873.1	874	874	873.2	873.1	873.1	873.4	836	883.7
L23CK	Claireville T16	937/1152	824.3	811.7	812.5	812.5	811.8	811.7	811.7	812	777.1	821.4
L24CR	R1K	579/669	370.1	389.7	360.5	360.5	377.1	389.7	389.7	437.8	303.6	440
L24CR	R13K	579/669	366.7	386.1	357.2	357.2	373.7	386.1	386.1	433.7	300.8	435.9
L24CR	R2K	579/669	438.6	505	544.8	544.8	533.2	505	505	486	247.3	385.9
L24CR	R15K	579/669	441	507.2	547	547	535.5	507.1	507.1	487.9	249.2	388.1
L24CR	L21K	579/701	77.3	97.5	38.1	38.1	156.8	97.5	97.5	1.3	133.9	42.3
L24CR	L22K	579/701	78.1	98.6	206.7	206.7	108.3	98.6	98.6	1.3	135.2	42.4
L24CR	L23CK	880/880	283	259	214.2	214.2	208.1	259	259	415	161.3	394.1
L24CR	L24CR	946/946	0	0	0	0	0	0	0	0	0	0
L24CR	Claireville T13	812/994	879.1	865.7	869.5	869.5	868.7	865.7	865.7	865.7	828.5	875.8
L24CR	Claireville T14	722/1030	895.6	880.6	884.5	884.5	883.6	880.6	880.6	880.6	844	892
L24CR	Claireville T15	750/840	886.7	873.1	876.9	876.9	876.1	873.1	873.1	873.1	835.7	883.4
L24CR	Claireville T16	937/1152	824.2	811.7	815.2	815.2	814.5	811.7	811.7	811.7	776.8	821.1

Case 1: Base condition used in all simulations
Case 2: Base condition with the capacitors installed at Manby, Richview, Leaside, and John
Case 3: Case 2 plus series capacitor installed at L21K and L24CR for 70% compensation, L22K and L23CK opened between Applewood and Lakeview
Case 4: Case 3 plus SPS (opening of breakers for L23CK in Manby for R1K or R13K contingency, no load is shed)
Case 5: Case 2 plus series capacitor installed at L21K and L24CR for 70% compensation, L22K and L23CK closed between Applewood and Lakeview
Case 6: Case 2 plus the installation of reactors at Manby W TS

Case 7: Case 6 plus a SPS (opening of breakers for L23CK in Manby for R1K or R13K contingency, no load is shed)
Case 8: Case 6 plus Lakeview TS is abandoned, L24CR is connected to L21/22K at Applewood Junction
Case 9: Base case with Lakeview on and generating 590MW, Lakeview HV bus is split in this case
Case 10: Base case with Lakeview operated as Synchronous Condenser

Appendix D: Circuit Loading under Contingency (DC Option) (in MVA)

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*
NONE	C2L	579/754	360.3	366.2	371.9	377.6	383.6	389.9	395.7	402.8	409.5
NONE	C3L	579/754	379.4	385.5	391.3	397.2	403.4	409.8	415.9	423.1	429.9
NONE	C14L	579/754	383.5	389.9	395.7	401.7	407.8	414.3	420.3	427.6	434.7
NONE	C15L	579/754	379.0	385.4	391.3	397.2	403.2	409.5	415.6	422.8	429.7
NONE	C16L	579/754	358.9	365.1	370.5	376.0	381.6	387.4	393.1	399.8	406.3
NONE	C17L	579/754	346.5	352.4	358.1	363.9	369.9	376.0	382.0	389.1	395.9
NONE	LEASIDE AUTO 11	275/378	194.7	198.5	201.7	205.1	208.6	212.3	215.9	220.0	224.2
NONE	LEASIDE AUTO 15	283/369	192.4	196.1	199.3	202.7	206.1	209.8	213.4	217.4	221.5
NONE	LEASIDE AUTO 12	312/419	181.2	184.9	188.0	191.2	194.6	198.2	201.6	205.6	209.6
NONE	LEASIDE AUTO 17	283/422	179.4	183.0	186.1	189.3	192.6	196.1	199.6	203.5	207.5
NONE	LEASIDE AUTO 14	275/489	185.5	189.1	192.3	195.6	199.1	202.7	206.3	210.3	214.4
NONE	LEASIDE AUTO 16	275/384	185.3	188.9	192.1	195.4	198.9	202.5	206.1	210.1	214.2
NONE	MANBY AUTO 12	250/296	50.2	54.4	58.5	62.8	67.3	72.2	64.3	67.8	71.7
NONE	MANBY AUTO T1	368/368	57.0	61.8	66.4	71.2	76.3	81.9	72.8	76.9	81.3
NONE	MANBY AUTO T2	408/408	55.0	59.7	64.2	68.8	73.8	79.1	70.5	74.4	78.7
NONE	MANBY AUTO T7	250/307	135.1	136.8	138.0	139.2	140.4	141.7	143.0	144.2	145.5
NONE	MANBY AUTO T8	369/369	157.8	159.7	161.1	162.5	163.9	165.4	166.9	168.4	169.9
NONE	MANBY AUTO T9	250/307	135.6	137.2	138.4	139.7	140.9	142.2	143.4	144.7	146.0
NONE	R2K	579/669	302.5	307.6	312.0	316.6	321.5	326.6	339.1	343.1	348.0
NONE	R15K	579/669	304.6	309.8	314.1	318.8	323.8	328.8	341.3	345.3	350.3
NONE	R1K	579/669	314.4	317.2	318.9	320.7	322.7	324.3	329.0	330.8	333.1
NONE	R13K	579/669	311.5	314.2	316.0	317.7	319.7	321.3	326.0	327.7	330.0
NONE	H2JK	249/267	57.8	61.3	64.6	68.0	71.6	75.4	60.0	64.1	68.0
NONE	K6J	249/267	57.7	61.2	64.5	67.9	71.5	75.4	59.8	63.8	67.7
NONE	K13J	225/225	48.1	51.0	53.8	56.6	59.7	63.0	48.2	51.6	55.0
NONE	K14J	214/214	48.1	51.0	53.8	56.6	59.7	63.0	48.2	51.7	55.0
C2L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	C3L	579/754	503.1	510.9	518.4	526.3	534.3	542.5	550.4	559.7	568.7
C2L	C14L	579/754	495.1	503.0	510.3	518.0	525.9	534.0	541.8	550.9	559.8
C2L	C15L	579/754	396.1	402.8	408.8	414.9	421.0	427.5	433.7	441.0	448.1
C2L	C16L	579/754	403.1	409.8	415.9	421.9	428.2	434.6	440.9	448.3	455.5
C2L	C17L	579/754	389.3	395.8	402.1	408.5	415.2	421.8	428.5	436.3	443.7
C2L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	LEASIDE AUTO 15	283/369	242.4	246.8	250.7	254.8	259.0	263.3	267.8	272.6	277.5
C2L	LEASIDE AUTO 12	312/419	215.3	219.4	222.9	226.5	230.3	234.3	238.2	242.6	247.1

C2L	LEASIDE AUTO 17	283/422	213.1	217.2	220.6	224.2	227.9	231.9	235.8	240.1	244.6

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*
C2L	LEASIDE AUTO 14	275/489	218.4	222.5	226.0	229.8	233.6	237.6	241.6	246.1	250.6
C2L	LEASIDE AUTO 16	275/384	218.2	222.3	225.8	229.5	233.4	237.4	241.4	245.9	250.4
C3L	C2L	579/754	500.2	508.1	515.6	523.5	531.4	539.8	547.6	556.9	566.0
C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	C14L	579/754	469.9	477.6	484.5	491.8	499.2	507.0	514.3	523.0	531.6
C3L	C15L	579/754	449.6	456.9	463.8	470.6	477.5	484.7	491.7	499.9	507.9
C3L	C16L	579/754	388.4	395.0	400.9	406.8	412.8	419.1	425.2	432.4	439.4
C3L	C17L	579/754	381.8	388.3	394.3	400.4	406.8	413.2	419.7	427.2	434.4
C3L	LEASIDE AUTO 11	275/378	222.5	226.7	230.2	233.9	237.7	241.6	245.7	250.1	254.6
C3L	LEASIDE AUTO 15	283/369	219.9	224.0	227.4	231.1	234.8	238.8	242.7	247.1	251.6
C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	LEASIDE AUTO 17	283/422	214.2	218.3	222.0	225.8	229.6	233.7	237.8	242.3	246.9
C3L	LEASIDE AUTO 14	275/489	225.4	229.7	233.3	237.1	241.1	245.2	249.4	253.9	258.6
C3L	LEASIDE AUTO 16	275/384	225.2	229.4	233.1	236.9	240.8	245.0	249.1	253.7	258.3
C14L	C2L	579/754	468.5	476.1	483.2	490.5	498.1	506.1	513.6	522.4	530.9
C14L	C3L	579/754	492.8	500.5	507.9	515.4	523.2	531.3	539.0	548.0	556.6
C14L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	C15L	579/754	411.5	418.3	424.7	431.1	437.5	444.3	450.9	458.6	465.9
C14L	C16L	579/754	373.6	380.1	385.6	391.3	397.0	403.1	409.0	415.8	422.5
C14L	C17L	579/754	441.2	448.5	455.5	462.5	469.7	477.1	484.5	492.9	500.9
C14L	LEASIDE AUTO 11	275/378	233.6	238.0	241.6	245.5	249.4	253.6	257.8	262.4	267.1
C14L	LEASIDE AUTO 15	283/369	230.8	235.1	238.7	242.6	246.5	250.6	254.7	259.3	263.9
C14L	LEASIDE AUTO 12	312/419	204.6	208.6	211.9	215.4	219.0	222.9	226.7	230.9	235.3
C14L	LEASIDE AUTO 17	283/422	202.5	206.4	209.7	213.2	216.8	220.6	224.4	228.6	232.9
C14L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	LEASIDE AUTO 16	275/384	234.7	239.1	243.0	247.0	251.2	255.5	259.9	264.7	269.5
C15L	C2L	579/754	415.9	422.8	429.3	435.9	442.7	450.0	456.7	464.8	472.5
C15L	C3L	579/754	433.4	440.4	447.0	453.7	460.7	468.0	474.9	483.0	490.8
C15L	C14L	579/754	409.9	416.7	422.7	429.1	435.6	442.4	448.8	456.4	463.9
C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	C16L	579/754	495.2	503.3	510.4	517.5	524.6	532.0	539.3	547.8	556.0
C15L	C17L	579/754	434.7	442.1	449.2	456.3	463.7	471.2	478.7	487.4	495.8
C15L	LEASIDE AUTO 11	275/378	217.8	221.9	225.3	228.9	232.6	236.5	240.4	244.8	249.2
C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	LEASIDE AUTO 12	312/419	218.8	223.0	226.5	230.2	234.0	238.1	242.1	246.5	251.1
C15L	LEASIDE AUTO 17	283/422	216.6	220.7	224.2	227.9	231.7	235.6	239.6	244.0	248.5

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013*	2014*	2015*
C15L	LEASIDE AUTO 14	275/489	227.5	231.8	235.5	239.4	243.4	247.7	251.9	256.6	261.3
C15L	LEASIDE AUTO 16	275/384	227.3	231.6	235.3	239.2	243.2	247.4	251.7	256.3	261.1
C16L	C2L	579/754	395.2	401.7	407.8	414.0	420.4	427.2	433.5	441.1	448.3
C16L	C3L	579/754	410.7	417.2	423.5	429.9	436.5	443.3	449.9	457.6	464.9
C16L	C14L	579/754	438.6	445.8	452.3	459.2	466.2	473.3	480.2	488.4	496.4
C16L	C15L	579/754	522.7	531.2	538.7	546.3	553.9	561.9	569.6	578.6	587.3
C16L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L	C17L	579/754	427.8	435.1	442.0	449.0	456.3	463.7	471.1	479.6	487.8
C16L	LEASIDE AUTO 11	275/378	231.6	236.0	239.6	243.5	247.5	251.7	255.9	260.6	265.3
C16L	LEASIDE AUTO 15	283/369	228.9	233.1	236.8	240.6	244.6	248.7	252.9	257.5	262.1
C16L	LEASIDE AUTO 12	312/419	220.1	224.4	227.9	231.7	235.6	239.7	243.7	248.2	252.8
C16L	LEASIDE AUTO 17	283/422	217.9	222.1	225.6	229.3	233.2	237.2	241.2	245.7	250.3
C16L	LEASIDE AUTO 14	275/489	209.9	214.0	217.4	221.0	224.7	228.7	232.6	237.0	241.4
C16L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	C2L	579/754	379.7	386.0	391.9	398.0	404.2	410.9	417.0	424.4	431.5
C17L	C3L	579/754	409.4	415.9	422.3	428.8	435.5	442.4	449.1	457.0	464.2
C17L	C14L	579/754	476.0	483.6	490.7	497.9	505.1	512.9	520.1	528.7	537.1
C17L	C15L	579/754	457.9	465.6	472.8	479.9	487.1	494.7	502.1	510.7	519.0
C17L	C16L	579/754	468.6	476.4	483.5	490.5	497.6	505.2	512.5	521.0	529.3
C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 11	275/378	207.8	211.8	215.2	218.8	222.6	226.5	230.4	234.8	239.2
C17L	LEASIDE AUTO 15	283/369	235.8	240.1	243.9	247.8	251.8	256.1	260.3	265.0	269.7
C17L	LEASIDE AUTO 12	312/419	217.3	221.5	225.0	228.6	232.4	236.4	240.3	244.6	249.2
C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 14	275/489	207.8	211.8	215.2	218.8	222.6	226.5	230.4	234.8	239.2
C17L	LEASIDE AUTO 16	275/384	207.6	211.6	215.0	218.6	222.4	226.3	230.2	234.6	239.0
C2L & C3L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C14L	579/754	644.9	655.0	664.2	673.8	683.8	694.1	703.9	715.3	726.4
C2L & C3L	C15L	579/754	492.5	500.5	507.6	514.8	522.1	529.8	537.3	545.8	553.8
C2L & C3L	C16L	579/754	448.1	455.6	462.2	468.9	475.7	482.8	489.8	497.8	505.2
C2L & C3L	C17L	579/754	434.2	441.5	448.1	454.9	462.0	469.1	476.3	484.5	492.2
C2L & C3L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 15	283/369	279.0	284.0	288.2	292.6	297.1	301.9	306.7	311.9	317.0
C2L & C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 17	283/422	266.9	271.7	275.9	280.2	284.6	289.3	294.0	299.1	304.1
C2L & C3L	LEASIDE AUTO 14	275/489	274.4	279.2	283.3	287.4	291.8	296.4	301.1	306.1	311.0

C2L & C3L	LEASIDE AUTO 16	275/384	274.1	279.0	283.0	287.2	291.5	296.1	300.8	305.8	310.7
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***	**2014***	**2015***
C16L & C17L	C2L	579/754	423.8	430.7	437.2	443.8	450.6	457.7	464.7	472.1	479.5
C16L & C17L	C3L	579/754	478.6	486.0	493.2	500.5	508.0	515.6	523.4	531.8	539.5
C16L & C17L	C14L	579/754	609.1	618.5	627.2	636.1	644.9	654.2	663.2	673.1	682.9
C16L & C17L	C15L	579/754	659.7	670.3	679.7	689.2	698.7	708.7	718.5	729.7	740.6
C16L & C17L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 11	275/378	304.0	309.2	313.7	318.3	323.1	328.0	333.1	338.3	343.7
C16L & C17L	LEASIDE AUTO 15	283/369	300.4	305.5	309.9	314.5	319.2	324.1	329.1	334.3	339.6
C16L & C17L	LEASIDE AUTO 12	312/419	265.2	270.0	273.9	278.1	282.3	286.7	291.3	295.8	300.8
C16L & C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 14	275/489	219.6	223.7	227.0	230.5	234.3	238.1	242.2	246.3	250.6
C16L & C17L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C2L	579/754	538.7	547.3	555.5	563.8	572.4	581.4	590.1	600.1	609.6
C14L & C15L	C3L	579/754	563.1	571.9	580.2	588.6	597.3	606.4	615.1	625.2	634.7
C14L & C15L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C16L	579/754	518.4	526.9	534.1	541.4	548.5	556.2	563.7	572.3	580.8
C14L & C15L	C17L	579/754	547.4	556.3	564.9	573.4	582.3	591.3	600.4	610.6	620.5
C14L & C15L	LEASIDE AUTO 11	275/378	275.2	280.0	284.0	288.2	292.4	296.9	301.5	306.4	311.4
C14L & C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 12	312/419	259.1	263.8	267.7	271.8	276.0	280.5	285.0	289.8	294.8
C14L & C15L	LEASIDE AUTO 17	283/422	256.5	261.1	265.0	269.0	273.2	277.6	282.1	286.9	291.8
C14L & C15L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 16	275/384	299.8	305.0	309.7	314.5	319.4	324.6	329.8	335.4	341.1
R1K	MANBY AUTO 12	250/296	50.2	54.4	58.5	62.8	67.3	72.1	64.3	67.8	71.7
R1K	MANBY AUTO T1	368/368	57.0	61.8	66.4	71.2	76.3	81.8	72.8	76.9	81.2
R1K	MANBY AUTO T2	408/408	55.0	59.7	64.2	68.8	73.8	79.1	70.5	74.4	78.6
R1K	MANBY AUTO T7	250/307	135.6	137.3	138.4	139.6	140.8	142.0	143.4	144.6	145.9
R1K	MANBY AUTO T8	369/369	158.4	160.3	161.6	163.0	164.4	165.8	167.4	168.9	170.3
R1K	MANBY AUTO T9	250/307	136.1	137.8	138.9	140.1	141.3	142.5	143.9	145.1	146.4
R1K	R2K	579/669	337.3	342.7	347.2	352.0	357.1	362.2	375.5	379.7	384.9
R1K	R15K	579/669	339.5	344.9	349.4	354.2	359.3	364.5	377.8	382.0	387.2
R1K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K	R13K	579/669	522.1	526.6	529.5	532.4	535.7	538.3	546.1	548.9	552.7
R13K	MANBY AUTO 12	250/296	50.2	54.4	58.5	62.8	67.3	72.1	64.3	67.8	71.7

R13K	MANBY AUTO T1	368/368	57.0	61.8	66.4	71.2	76.3	81.8	72.8	76.9	81.2
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***	**2014***	**2015***
R13K	MANBY AUTO T2	408/408	55.0	59.7	64.2	68.8	73.8	79.1	70.5	74.4	78.6
R13K	MANBY AUTO T7	250/307	135.6	137.3	138.4	139.6	140.8	142.0	143.4	144.6	145.9
R13K	MANBY AUTO T8	369/369	158.4	160.3	161.6	163.0	164.4	165.8	167.4	168.9	170.3
R13K	MANBY AUTO T9	250/307	136.1	137.7	138.9	140.1	141.3	142.5	143.9	145.1	146.4
R13K	R2K	579/669	336.8	342.1	346.6	351.4	356.5	361.7	375.0	379.1	384.3
R13K	R15K	579/669	338.9	344.3	348.8	353.7	358.8	364.0	377.2	381.4	386.6
R13K	R1K	579/669	523.7	528.2	531.1	534.0	537.4	540.0	547.8	550.6	554.4
R13K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	MANBY AUTO 12	250/296	50.1	54.3	58.4	62.6	67.0	71.9	64.2	67.7	71.5
R2K	MANBY AUTO T1	368/368	56.8	61.6	66.2	71.0	76.1	81.5	72.7	76.7	81.1
R2K	MANBY AUTO T2	408/408	54.9	59.5	64.0	68.6	73.5	78.8	70.4	74.3	78.5
R2K	MANBY AUTO T7	250/307	134.8	136.5	137.6	138.8	140.1	141.3	142.6	143.9	145.2
R2K	MANBY AUTO T8	369/369	157.4	159.3	160.7	162.1	163.5	165.0	166.5	168.0	169.5
R2K	MANBY AUTO T9	250/307	135.3	136.9	138.1	139.3	140.5	141.8	143.1	144.4	145.7
R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	R15K	579/669	483.0	491.7	498.9	506.6	514.7	523.0	541.2	547.8	556.3
R2K	R1K	579/669	343.6	346.9	349.0	351.2	353.7	355.7	362.3	364.4	367.2
R2K	R13K	579/669	340.4	343.7	345.8	348.0	350.4	352.4	359.0	361.0	363.8
R15K	MANBY AUTO 12	250/296	50.1	54.3	58.4	62.5	67.0	71.8	64.1	67.6	71.5
R15K	MANBY AUTO T1	368/368	56.8	61.6	66.2	71.0	76.0	81.5	72.7	76.7	81.0
R15K	MANBY AUTO T2	408/408	54.9	59.5	64.0	68.6	73.5	78.8	70.4	74.2	78.4
R15K	MANBY AUTO T7	250/307	134.8	136.4	137.6	138.8	140.0	141.3	142.6	143.9	145.1
R15K	MANBY AUTO T8	369/369	157.4	159.3	160.7	162.1	163.5	164.9	166.5	168.0	169.5
R15K	MANBY AUTO T9	250/307	135.3	136.9	138.1	139.3	140.5	141.7	143.1	144.4	145.6
R15K	R2K	579/669	480.2	488.9	496.1	503.8	511.9	520.2	538.1	544.7	553.3
R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	R1K	579/669	343.6	346.9	349.1	351.2	353.7	355.7	362.3	364.4	367.2
R15K	R13K	579/669	340.4	343.7	345.8	348.0	350.4	352.4	359.0	361.0	363.8
R1K & R2K	MANBY AUTO 12	250/296	50.1	54.3	58.4	62.6	67.0	71.8	64.2	67.7	71.5
R1K & R2K	MANBY AUTO T1	368/368	56.9	61.6	66.2	71.0	76.1	81.5	72.7	76.7	81.0
R1K & R2K	MANBY AUTO T2	408/408	54.9	59.6	64.0	68.6	73.5	78.8	70.4	74.2	78.4
R1K & R2K	MANBY AUTO T7	250/307	135.3	136.9	138.1	139.2	140.4	141.6	143.0	144.2	145.5
R1K & R2K	MANBY AUTO T8	369/369	158.0	159.9	161.2	162.6	163.9	165.3	167.0	168.4	169.9
R1K & R2K	MANBY AUTO T9	250/307	135.8	137.4	138.5	139.7	140.9	142.1	143.5	144.7	146.0
R1K & R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R15K	579/669	545.4	554.7	562.2	570.2	578.6	587.2	607.2	614.1	623.1

R1K & R2K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013***	**2014***	**2015***
R1K & R2K	R13K	579/669	577.4	582.9	586.5	590.1	594.2	597.5	608.6	612.0	616.7
R13K & R15K	MANBY AUTO 12	250/296	50.1	54.3	58.4	62.5	67.0	71.8	64.1	67.6	71.5
R13K & R15K	MANBY AUTO T1	368/368	56.8	61.6	66.2	71.0	76.0	81.5	72.7	76.7	81.0
R13K & R15K	MANBY AUTO T2	408/408	54.9	59.5	64.0	68.6	73.5	78.8	70.4	74.2	78.4
R13K & R15K	MANBY AUTO T7	250/307	135.3	136.9	138.0	139.2	140.4	141.6	143.0	144.2	145.4
R13K & R15K	MANBY AUTO T8	369/369	158.0	159.8	161.2	162.5	163.9	165.3	166.9	168.4	169.8
R13K & R15K	MANBY AUTO T9	250/307	135.7	137.4	138.5	139.7	140.8	142.0	143.5	144.7	145.9
R13K & R15K	R2K	579/669	541.6	550.9	558.4	566.3	574.8	583.3	603.1	610.0	619.0
R13K & R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	R1K	579/669	579.1	584.6	588.2	591.8	595.9	599.3	610.4	613.8	618.5
R13K & R15K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	H2JK	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	K6J	249/267	87.9	92.5	96.9	101.4	106.2	111.3	87.4	93.0	98.4
H2JK	K13J	225/225	70.8	74.6	78.2	81.9	85.8	90.1	67.4	72.0	76.6
H2JK	K14J	214/214	70.9	74.6	78.2	81.9	85.9	90.1	67.4	72.0	76.6
K6J	H2JK	249/267	87.8	92.3	96.7	101.2	105.9	111.0	87.2	92.8	98.2
K6J	K6J	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K6J	K13J	225/225	70.6	74.3	77.9	81.6	85.4	89.6	67.1	71.7	76.2
K6J	K14J	214/214	70.6	74.3	77.9	81.6	85.5	89.6	67.1	71.7	76.2
K13J	H2JK	249/267	77.6	81.9	86.1	90.4	94.9	99.8	78.4	83.6	88.8
K13J	K6J	249/267	77.4	81.8	86.0	90.2	94.8	99.7	78.1	83.3	88.4
K13J	K13J	225/225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K13J	K14J	214/214	66.1	69.8	73.4	77.0	80.9	85.1	64.9	69.4	73.8
K14J	H2JK	249/267	77.6	81.9	86.1	90.4	95.0	99.8	78.4	83.6	88.8
K14J	K6J	249/267	77.4	81.8	86.0	90.3	94.8	99.7	78.1	83.3	88.4
K14J	K13J	225/225	66.0	69.8	73.4	77.0	80.9	85.1	64.8	69.4	73.8
K14J	K14J	214/214	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Rating: continuous rating/emergency continuous rating for 50h/year for circuits; continuous rating/10 day LTR for transformers
* 2013 to 2015: one 125MVAr/127kV cap bank is placed at John TS for voltage support

Appendix E: Voltage Decline under Contingency (DC Option) (in kV)

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013*			2014*			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
C2L	2100	CHERYDK1 220	237.8	-0.1	-0.2	237.5	-0.1	-0.2	237.2	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.1	-0.2	235.9	-0.1	-0.2	236.2	-0.1	-0.2	235.5	-0.1	-0.3	235.0	-0.1	-0.3
C2L	2102	CHERYDK3 220	238.1	-0.2	-0.3	237.8	-0.2	-0.3	237.5	-0.3	-0.4	237.1	-0.3	-0.4	236.7	-0.3	-0.4	236.1	-0.3	-0.4	236.5	-0.3	-0.4	235.7	-0.3	-0.5	235.2	-0.3	-0.6
C2L	3102	LEAS 215 220	235.0	-0.4	-0.6	234.4	-0.5	-0.6	233.8	-0.5	-0.7	233.1	-0.5	-0.8	232.4	-0.6	-0.8	231.5	-0.6	-0.8	231.6	-0.6	-0.9	230.4	-0.7	-1.1	229.6	-0.7	-1.2
C2L	3103	LEAS 317 220	235.1	-0.7	-0.9	234.5	-0.7	-0.9	233.8	-0.8	-1.0	233.2	-0.8	-1.1	232.4	-0.9	-1.2	231.5	-0.9	-1.2	231.6	-0.9	-1.2	230.4	-1.0	-1.5	229.5	-1.0	-1.5
C2L	3104	LEAS1416 220	235.1	-0.7	-0.9	234.5	-0.7	-0.9	233.9	-0.8	-1.0	233.2	-0.8	-1.1	232.5	-0.9	-1.2	231.5	-0.9	-1.2	231.6	-0.9	-1.2	230.4	-1.0	-1.5	229.6	-1.0	-1.5
C2L	3301	LEAS EJ 118	123.0	-0.7	-1.0	122.5	-0.8	-1.0	122.0	-0.9	-1.2	121.5	-0.9	-1.4	120.9	-1.0	-1.5	120.2	-1.1	-1.5	120.1	-1.2	-1.6	119.2	-1.3	-2.1	118.5	-1.4	-2.2
C2L	3300	HEARN 118	122.6	-0.7	-1.0	122.1	-0.8	-1.0	121.5	-0.9	-1.2	120.9	-0.9	-1.4	120.3	-1.0	-1.5	119.5	-1.1	-1.5	119.4	-1.2	-1.7	118.5	-1.3	-2.1	117.7	-1.4	-2.2
C2L	3401	TERAUT5E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-0.9	-1.5	119.7	-1.0	-1.5	118.9	-1.1	-1.5	118.8	-1.2	-1.7	117.9	-1.3	-2.1	117.1	-1.4	-2.2
C2L	3402	TERAUT7E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-0.9	-1.5	119.7	-1.0	-1.5	118.9	-1.1	-1.5	118.8	-1.2	-1.7	117.9	-1.3	-2.1	117.1	-1.4	-2.2
C2L	3403	TERC5E 118	121.4	-0.7	-1.1	120.8	-0.8	-1.0	120.2	-0.9	-1.3	119.6	-0.9	-1.5	118.9	-1.0	-1.6	118.1	-1.1	-1.6	117.9	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.3
C2L	3404	TERC7E 118	121.4	-0.7	-1.1	120.9	-0.8	-1.0	120.3	-0.9	-1.3	119.6	-0.9	-1.5	119.0	-1.0	-1.6	118.2	-1.1	-1.6	118.0	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.3
C2L	3664	ESPLNJ12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.6	-1.0	-0.2	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.0
C2L	3767	TERAUA12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.8	-1.0	-1.5	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.1
C3L	2100	CHERYDK1 220	237.8	-0.1	-0.2	237.5	-0.1	-0.2	237.2	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.1	-0.2	235.9	-0.1	-0.2	236.2	-0.1	-0.2	235.5	-0.1	-0.3	235.0	-0.1	-0.2
C3L	2102	CHERYDK3 220	238.1	-0.3	-0.3	237.8	-0.3	-0.3	237.5	-0.3	-0.4	237.1	-0.3	-0.4	236.7	-0.3	-0.4	236.1	-0.3	-0.4	236.5	-0.3	-0.5	235.7	-0.3	-0.6	235.2	-0.4	-0.6
C3L	3102	LEAS 215 220	235.0	-0.8	-1.0	234.4	-0.8	-1.0	233.8	-0.9	-1.1	233.1	-0.9	-1.2	232.4	-1.0	-1.2	231.5	-1.0	-1.3	231.6	-1.0	-1.3	230.4	-1.1	-1.6	229.6	-1.1	-1.6
C3L	3103	LEAS 317 220	235.1	-0.5	-0.6	234.5	-0.5	-0.6	233.8	-0.5	-0.7	233.2	-0.6	-0.9	232.4	-0.6	-0.9	231.5	-0.7	-0.9	231.6	-0.7	-1.0	230.4	-0.7	-1.2	229.5	-0.8	-1.3
C3L	3104	LEAS1416 220	235.1	-0.6	-0.8	234.5	-0.6	-0.8	233.9	-0.7	-0.9	233.2	-0.7	-1.0	232.5	-0.7	-1.0	231.5	-0.8	-1.0	231.6	-0.8	-1.1	230.4	-0.9	-1.3	229.6	-0.9	-1.4
C3L	3301	LEAS EJ 118	123.0	-0.7	-1.0	122.5	-0.8	-1.0	122.0	-0.9	-1.2	121.5	-1.0	-1.4	120.9	-1.0	-1.5	120.2	-1.1	-1.5	120.1	-1.2	-1.6	119.2	-1.3	-2.0	118.5	-1.4	-2.2
C3L	3300	HEARN 118	122.6	-0.7	-1.0	122.1	-0.8	-1.0	121.5	-0.9	-1.2	120.9	-1.0	-1.5	120.3	-1.0	-1.5	119.5	-1.1	-1.5	119.4	-1.2	-1.7	118.5	-1.3	-2.1	117.7	-1.4	-2.2
C3L	3401	TERAUT5E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-1.0	-1.5	119.7	-1.0	-1.5	118.9	-1.1	-1.5	118.8	-1.2	-1.7	117.9	-1.3	-2.1	117.1	-1.4	-2.2
C3L	3402	TERAUT7E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-1.0	-1.5	119.7	-1.0	-1.5	118.9	-1.1	-1.5	118.8	-1.2	-1.7	117.9	-1.3	-2.1	117.1	-1.4	-2.2
C3L	3403	TERC5E 118	121.4	-0.7	-1.1	120.8	-0.8	-1.0	120.2	-0.9	-1.3	119.6	-1.0	-1.5	118.9	-1.0	-1.5	118.1	-1.1	-1.6	117.9	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.3
C3L	3404	TERC7E 118	121.4	-0.7	-1.1	120.9	-0.8	-1.0	120.3	-0.9	-1.3	119.6	-1.0	-1.5	119.0	-1.0	-1.5	118.2	-1.1	-1.6	118.0	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.3
C3L	3664	ESPLNJ12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.6	-1.0	-0.2	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.0
C3L	3767	TERAUA12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.8	-1.0	-1.5	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.1
C14L	2100	CHERYDK1 220	237.8	-0.1	-0.2	237.5	-0.1	-0.2	237.2	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.1	-0.2	235.9	-0.1	-0.2	236.2	-0.1	-0.2	235.5	-0.1	-0.2	235.0	0.0	-0.2
C14L	2102	CHERYDK3 220	238.1	-0.3	-0.4	237.8	-0.3	-0.4	237.5	-0.3	-0.4	237.1	-0.3	-0.5	236.7	-0.3	-0.5	236.1	-0.4	-0.5	236.5	-0.4	-0.5	235.7	-0.4	-0.6	235.2	-0.4	-0.7
C14L	3102	LEAS 215 220	235.0	-0.7	-0.9	234.4	-0.7	-0.9	233.8	-0.8	-1.0	233.1	-0.8	-1.1	232.4	-0.8	-1.1	231.5	-0.9	-1.2	231.6	-0.9	-1.2	230.4	-1.0	-1.5	229.6	-1.0	-1.5
C14L	3103	LEAS 317 220	235.1	-0.9	-1.1	234.5	-0.9	-1.0	233.8	-0.9	-1.2	233.2	-1.0	-1.3	232.4	-1.0	-1.3	231.5	-1.1	-1.4	231.6	-1.1	-1.4	230.4	-1.2	-1.7	229.5	-1.2	-1.8
C14L	3104	LEAS1416 220	235.1	-0.4	-0.7	234.5	-0.5	-0.6	233.9	-0.5	-0.7	233.2	-0.6	-0.9	232.5	-0.6	-0.9	231.5	-0.6	-0.9	231.6	-0.7	-1.0	230.4	-0.7	-1.2	229.6	-0.8	-1.3
C14L	3301	LEAS EJ 118	123.0	-0.8	-1.1	122.5	-0.9	-1.1	122.0	-0.9	-1.3	121.5	-1.0	-1.6	120.9	-1.1	-1.6	120.2	-1.2	-1.6	120.1	-1.2	-1.8	119.2	-1.3	-2.2	118.5	-1.4	-2.3
C14L	3300	HEARN 118	122.6	-0.8	-1.2	122.1	-0.9	-1.1	121.5	-0.9	-1.3	120.9	-1.0	-1.6	120.3	-1.1	-1.6	119.5	-1.2	-1.6	119.4	-1.2	-1.8	118.5	-1.3	-2.2	117.7	-1.4	-2.3
C14L	3401	TERAUT5E 118	122.0	-0.8	-1.1	121.5	-0.9	-1.1	120.9	-0.9	-1.3	120.3	-1.0	-1.6	119.7	-1.1	-1.6	118.9	-1.2	-1.6	118.8	-1.2	-1.8	117.9	-1.3	-2.2	117.1	-1.4	-2.3
C14L	3402	TERAUT7E 118	122.0	-0.8	-1.1	121.5	-0.9	-1.1	120.9	-0.9	-1.3	120.3	-1.0	-1.6	119.7	-1.1	-1.6	118.9	-1.2	-1.6	118.8	-1.2	-1.8	117.9	-1.3	-2.2	117.1	-1.4	-2.3
C14L	3403	TERC5E 118	121.4	-0.8	-1.2	120.8	-0.9	-1.1	120.2	-0.9	-1.4	119.6	-1.0	-1.6	118.9	-1.1	-1.6	118.1	-1.2	-1.7	117.9	-1.2	-1.9	117.0	-1.4	-2.3	116.2	-1.5	-2.4
C14L	3404	TERC7E 118	121.4	-0.8	-1.2	120.9	-0.9	-1.1	120.3	-0.9	-1.4	119.6	-1.0	-1.6	119.0	-1.1	-1.6	118.2	-1.2	-1.7	118.0	-1.2	-1.9	117.0	-1.4	-2.3	116.2	-1.5	-2.4
C14L	3664	ESPLNJ12 13.8	13.7	-0.8	0.3	13.8	-0.9	-1.0	13.7	-0.9	0.0	13.6	-1.0	-0.2	13.7	-1.1	-0.3	13.8	-1.2	-0.3	13.7	-1.3	-0.4	13.8	-1.4	-0.9	13.9	-1.5	-1.0
C14L	3767	TERAUA12 13.8	13.7	-0.8	0.3	13.8	-0.9	-1.0	13.7	-0.9	0.0	13.8	-1.0	-1.5	13.7	-1.1	-0.3	13.8	-1.2	-0.3	13.7	-1.3	-0.4	13.8	-1.4	-0.9	13.9	-1.5	-1.1
C15L	2100	CHERYDK1 220	237.8	-0.2	-0.3	237.5	-0.3	-0.3	237.2	-0.3	-0.4	236.8	-0.3	-0.4	236.4	-0.3	-0.4	235.9	-0.3	-0.4	236.2	-0.3	-0.4	235.5	-0.3	-0.5	235.0	-0.3	-0.5
C15L	2102	CHERYDK3 220	238.1	0.0	-0.1	237.8	0.0	-0.1	237.5	0.0	-0.1	237.1	0.0	-0.1	236.7	0.0	-0.1	236.1	0.0	-0.1	236.5	0.0	-0.1	235.7	0.0	-0.1	235.2	0.0	-0.1
C15L	3102	LEAS 215 220	235.0	-0.6	-0.8	234.4	-0.7	-0.8	233.8	-0.7	-0.9	233.1	-0.7	-1.0	232.4	-0.8	-1.0	231.5	-0.8	-1.0	231.6	-0.9	-1.1	230.4	-0.9	-1.4	229.6	-1.0	-1.4
C15L	3103	LEAS 317 220	235.1	-0.6	-0.8	234.5	-0.7	-0.8	233.8	-0.7	-0.9	233.2	-0.8	-1.0	232.4	-0.8	-1.1	231.5	-0.8	-1.0	231.6	-0.9	-1.1	230.4	-0.9	-1.3	229.5	-1.0	-1.4
C15L	3104	LEAS1416 220	235.1	-0.5	-0.7	234.5	-0.6	-0.7	233.9	-0.6	-0.8	233.2	-0.6	-0.9	232.5	-0.7	-0.9	231.5	-0.7	-0.9	231.6	-0.7	-1.0	230.4	-0.8	-1.2	229.6	-0.8	-1.2
C15L	3301	LEAS EJ 118	123.0	-0.7	-0.9	122.5	-0.7	-0.9	122.0	-0.8	-1.1	121.5	-0.9	-1.4	120.9	-1.0	-1.4	120.2	-1.0	-1.3	120.1	-1.1	-1.5	119.2	-1.2	-1.9	118.5	-1.3	-2.0
C15L	3300	HEARN 118	122.6	-0.7	-1.0	122.1	-0.7	-0.9	121.5	-0.8	-1.1	120.9	-0.9	-1.4	120.3	-1.0	-1.4	119.5	-1.0	-1.3	119.4	-1.1	-1.6	118.5	-1.2	-2.0	117.7	-1.3	-2.0
C15L	3401	TERAUT5E 118	122.0	-0.7	-0.9	121.5	-0.7	-0.9	120.9	-0.8	-1.1	120.3	-0.9	-1.4	119.7	-1.0	-1.4	118.9	-1.0	-1.3	118.8	-1.1	-1.6	117.9	-1.2	-2.0	117.1	-1.3	-2.0
C15L	3402	TERAUT7E 118	122.0	-0.7	-0.9	121.5	-0.7	-0.9	120.9	-0.8	-1.1	120.3	-0.9	-1.4	119.7	-1.0	-1.4	118.9	-1.0	-1.3	118.8	-1.1	-1.6	117.9	-1.2	-2.0	117.1	-1.3	-2.0

C15L	3403	TERC5E 118	121.4	-0.7	-1.0	120.8	-0.7	-0.9	120.2	-0.8	-1.2	119.6	-0.9	-1.4	118.9	-1.0	-1.5	118.1	-1.1	-1.3	117.9	-1.1	-1.6	117.0	-1.2	-2.0	116.2	-1.3	-2.1

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013*			2014*			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
C15L	3404	TERC7E 118	121.4	-0.7	-1.0	120.9	-0.7	-0.9	120.3	-0.8	-1.2	119.6	-0.9	-1.4	119.0	-1.0	-1.5	118.2	-1.1	-1.3	118.0	-1.1	-1.6	117.0	-1.2	-2.0	116.2	-1.3	-2.1
C15L	3664	ESPLNJ12 13.8	13.7	-0.7	0.3	13.8	-0.7	-1.0	13.7	-0.8	0.0	13.6	-0.9	-0.2	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.1	-0.4	13.8	-1.2	-0.9	13.9	-1.3	-1.0
C15L	3767	TERAUA12 13.8	13.7	-0.7	0.3	13.8	-0.7	-1.0	13.7	-0.8	0.0	13.8	-0.9	-1.5	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.1	-0.4	13.8	-1.2	-0.9	13.9	-1.3	-1.1
C16L	2100	CHERYDK1 220	237.8	-0.2	-0.3	237.5	-0.2	-0.3	237.2	-0.2	-0.3	236.8	-0.2	-0.3	236.4	-0.3	-0.4	235.9	-0.3	-0.3	236.2	-0.3	-0.4	235.5	-0.3	-0.5	235.0	-0.3	-0.4
C16L	2102	CHERYDK3 220	238.1	0.0	-0.1	237.8	0.0	-0.1	237.5	0.0	-0.1	237.1	0.0	-0.1	236.7	0.0	-0.1	236.1	0.0	-0.1	236.5	0.0	-0.1	235.7	0.0	-0.2	235.2	0.0	-0.1
C16L	3102	LEAS 215 220	235.0	-0.6	-0.7	234.4	-0.6	-0.7	233.8	-0.6	-0.8	233.1	-0.7	-0.9	232.4	-0.7	-0.9	231.5	-0.7	-0.9	231.6	-0.8	-1.0	230.4	-0.8	-1.2	229.6	-0.9	-1.2
C16L	3103	LEAS 317 220	235.1	-0.5	-0.7	234.5	-0.6	-0.7	233.8	-0.6	-0.8	233.2	-0.6	-0.9	232.4	-0.7	-0.9	231.5	-0.7	-0.8	231.6	-0.7	-1.0	230.4	-0.8	-1.2	229.5	-0.8	-1.2
C16L	3104	LEAS1416 220	235.1	-0.6	-0.7	234.5	-0.7	-0.7	233.9	-0.7	-0.8	233.2	-0.7	-1.0	232.5	-0.8	-1.0	231.5	-0.8	-0.9	231.6	-0.9	-1.1	230.4	-0.9	-1.3	229.6	-1.0	-1.3
C16L	3301	LEAS EJ 118	123.0	-0.6	-0.9	122.5	-0.7	-0.9	122.0	-0.8	-1.0	121.5	-0.9	-1.2	120.9	-0.9	-1.3	120.2	-1.0	-1.2	120.1	-1.1	-1.5	119.2	-1.2	-1.8	118.5	-1.3	-1.8
C16L	3300	HEARN 118	122.6	-0.6	-0.9	122.1	-0.7	-0.9	121.5	-0.8	-1.1	120.9	-0.9	-1.3	120.3	-0.9	-1.4	119.5	-1.0	-1.2	119.4	-1.1	-1.5	118.5	-1.2	-1.9	117.7	-1.3	-1.8
C16L	3401	TERAUT5E 118	122.0	-0.6	-0.9	121.5	-0.7	-0.9	120.9	-0.8	-1.1	120.3	-0.9	-1.3	119.7	-0.9	-1.4	118.9	-1.0	-1.2	118.8	-1.1	-1.5	117.9	-1.2	-1.9	117.1	-1.3	-1.9
C16L	3402	TERAUT7E 118	122.0	-0.6	-0.9	121.5	-0.7	-0.9	120.9	-0.8	-1.1	120.3	-0.9	-1.3	119.7	-0.9	-1.4	118.9	-1.0	-1.2	118.8	-1.1	-1.5	117.9	-1.2	-1.9	117.1	-1.3	-1.9
C16L	3403	TERC5E 118	121.4	-0.6	-0.9	120.8	-0.7	-0.9	120.2	-0.8	-1.1	119.6	-0.9	-1.3	118.9	-0.9	-1.4	118.1	-1.0	-1.2	117.9	-1.1	-1.6	117.0	-1.2	-1.9	116.2	-1.3	-1.9
C16L	3404	TERC7E 118	121.4	-0.6	-0.9	120.9	-0.7	-0.9	120.3	-0.8	-1.1	119.6	-0.9	-1.3	119.0	-0.9	-1.4	118.2	-1.0	-1.2	118.0	-1.1	-1.6	117.0	-1.2	-1.9	116.2	-1.3	-1.9
C16L	3664	ESPLNJ12 13.8	13.7	-0.6	0.3	13.8	-0.7	-1.0	13.7	-0.8	0.0	13.6	-0.9	-0.2	13.7	-0.9	-0.3	13.8	-1.0	-0.3	13.7	-1.1	-0.4	13.8	-1.2	-0.9	13.9	-1.3	-1.0
C16L	3767	TERAUA12 13.8	13.7	-0.6	0.3	13.8	-0.7	-1.0	13.7	-0.8	0.0	13.8	-0.9	-1.5	13.7	-0.9	-0.3	13.8	-1.0	-0.3	13.7	-1.1	-0.4	13.8	-1.2	-0.9	13.9	-1.3	-1.1
C17L	2100	CHERYDK1 220	237.8	-0.3	-0.3	237.5	-0.3	-0.3	237.2	-0.3	-0.4	236.8	-0.3	-0.4	236.4	-0.3	-0.4	235.9	-0.3	-0.4	236.2	-0.3	-0.5	235.5	-0.4	-0.6	235.0	-0.4	-0.6
C17L	2102	CHERYDK3 220	238.1	0.0	-0.1	237.8	0.0	-0.1	237.5	0.0	-0.1	237.1	0.0	-0.1	236.7	0.0	-0.1	236.1	0.0	-0.1	236.5	0.0	-0.1	235.7	0.0	-0.2	235.2	0.0	-0.1
C17L	3102	LEAS 215 220	235.0	-0.5	-0.7	234.4	-0.5	-0.7	233.8	-0.6	-0.7	233.1	-0.6	-0.9	232.4	-0.7	-0.9	231.5	-0.7	-0.8	231.6	-0.7	-1.0	230.4	-0.8	-1.2	229.6	-0.8	-1.2
C17L	3103	LEAS 317 220	235.1	-0.6	-0.8	234.5	-0.6	-0.8	233.8	-0.7	-0.9	233.2	-0.7	-1.0	232.4	-0.8	-1.0	231.5	-0.8	-1.0	231.6	-0.8	-1.1	230.4	-0.9	-1.3	229.5	-0.9	-1.4
C17L	3104	LEAS1416 220	235.1	-0.8	-1.0	234.5	-0.8	-1.0	233.9	-0.9	-1.1	233.2	-0.9	-1.2	232.5	-1.0	-1.2	231.5	-1.0	-1.2	231.6	-1.0	-1.3	230.4	-1.1	-1.6	229.6	-1.2	-1.6
C17L	3301	LEAS EJ 118	123.0	-0.7	-1.0	122.5	-0.8	-1.0	122.0	-0.9	-1.1	121.5	-0.9	-1.4	120.9	-1.0	-1.4	120.2	-1.1	-1.3	120.1	-1.1	-1.6	119.2	-1.3	-2.0	118.5	-1.3	-2.1
C17L	3300	HEARN 118	122.6	-0.7	-1.0	122.1	-0.8	-1.0	121.5	-0.9	-1.2	120.9	-0.9	-1.4	120.3	-1.0	-1.5	119.5	-1.1	-1.4	119.4	-1.2	-1.6	118.5	-1.3	-2.1	117.7	-1.3	-2.1
C17L	3401	TERAUT5E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-0.9	-1.4	119.7	-1.0	-1.5	118.9	-1.1	-1.4	118.8	-1.2	-1.6	117.9	-1.3	-2.1	117.1	-1.3	-2.1
C17L	3402	TERAUT7E 118	122.0	-0.7	-1.0	121.5	-0.8	-1.0	120.9	-0.9	-1.2	120.3	-0.9	-1.4	119.7	-1.0	-1.5	118.9	-1.1	-1.4	118.8	-1.2	-1.6	117.9	-1.3	-2.1	117.1	-1.3	-2.1
C17L	3403	TERC5E 118	121.4	-0.7	-1.0	120.8	-0.8	-1.0	120.2	-0.9	-1.2	119.6	-0.9	-1.4	118.9	-1.0	-1.5	118.1	-1.1	-1.4	117.9	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.2
C17L	3404	TERC7E 118	121.4	-0.7	-1.0	120.9	-0.8	-1.0	120.3	-0.9	-1.2	119.6	-0.9	-1.4	119.0	-1.0	-1.5	118.2	-1.1	-1.4	118.0	-1.2	-1.7	117.0	-1.3	-2.1	116.2	-1.4	-2.2
C17L	3664	ESPLNJ12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.6	-0.9	-0.2	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.0
C17L	3767	TERAUA12 13.8	13.7	-0.7	0.3	13.8	-0.8	-1.0	13.7	-0.9	0.0	13.8	-0.9	-1.5	13.7	-1.0	-0.3	13.8	-1.1	-0.3	13.7	-1.2	-0.4	13.8	-1.3	-0.9	13.9	-1.4	-1.1
C2L & C3L	2100	CHERYDK1 220	237.8	0.1	-0.2	237.5	0.1	-0.2	237.2	0.1	-0.2	236.8	0.1	-0.2	236.4	0.2	-0.2	235.9	0.2	-0.2	236.2	0.2	-0.2	235.5	0.2	-0.5	235.0	0.3	-0.6
C2L & C3L	2102	CHERYDK3 220	238.1	-0.5	-0.8	237.8	-0.5	-0.8	237.5	-0.5	-0.9	237.1	-0.5	-1.1	236.7	-0.6	-1.1	236.1	-0.6	-1.2	236.5	-0.6	-1.3	235.7	-0.7	-2.0	235.2	-0.7	-2.2
C2L & C3L	3102	LEAS 215 220	235.0	-1.2	-2.0	234.4	-1.3	-2.1	233.8	-1.4	-2.4	233.1	-1.5	-2.7	232.4	-1.6	-2.9	231.5	-1.7	-3.0	231.6	-1.8	-3.4	230.4	-1.9	-4.5	229.6	-2.0	-4.8
C2L & C3L	3103	LEAS 317 220	235.1	-1.1	-1.9	234.5	-1.2	-2.0	233.8	-1.3	-2.3	233.2	-1.4	-2.6	232.4	-1.5	-2.8	231.5	-1.6	-2.9	231.6	-1.7	-3.3	230.4	-1.8	-4.4	229.5	-1.9	-4.7
C2L & C3L	3104	LEAS1416 220	235.1	-1.5	-2.4	234.5	-1.6	-2.5	233.9	-1.7	-2.8	233.2	-1.8	-3.2	232.5	-1.9	-3.3	231.5	-2.0	-3.4	231.6	-2.1	-3.8	230.4	-2.2	-4.8	229.6	-2.4	-5.2
C2L & C3L	3301	LEAS EJ 118	123.0	-1.6	-2.9	122.5	-1.8	-3.0	122.0	-1.9	-3.6	121.5	-2.1	-4.3	120.9	-2.3	-4.6	120.2	-2.5	-4.8	120.1	-2.7	-5.4	119.2	-2.9	-7.2	118.5	-3.2	-7.7
C2L & C3L	3300	HEARN 118	122.6	-1.6	-3.0	122.1	-1.8	-3.1	121.5	-2.0	-3.7	120.9	-2.2	-4.4	120.3	-2.3	-4.8	119.5	-2.6	-4.9	119.4	-2.7	-5.6	118.5	-2.9	-7.4	117.7	-3.2	-8.0
C2L & C3L	3401	TERAUT5E 118	122.0	-1.6	-3.0	121.5	-1.8	-3.1	120.9	-2.0	-3.7	120.3	-2.2	-4.4	119.7	-2.3	-4.8	118.9	-2.6	-4.9	118.8	-2.7	-5.6	117.9	-2.9	-7.4	117.1	-3.2	-8.0
C2L & C3L	3402	TERAUT7E 118	122.0	-1.6	-3.0	121.5	-1.8	-3.1	120.9	-2.0	-3.7	120.3	-2.2	-4.4	119.7	-2.3	-4.8	118.9	-2.6	-4.9	118.8	-2.7	-5.6	117.9	-2.9	-7.4	117.1	-3.2	-8.0
C2L & C3L	3403	TERC5E 118	121.4	-1.6	-3.0	120.8	-1.8	-3.2	120.2	-2.0	-3.8	119.6	-2.2	-4.5	118.9	-2.4	-4.9	118.1	-2.6	-5.0	117.9	-2.7	-5.8	117.0	-3.0	-7.6	116.2	-3.2	-8.2
C2L & C3L	3404	TERC7E 118	121.4	-1.6	-3.0	120.9	-1.8	-3.2	120.3	-2.0	-3.8	119.6	-2.2	-4.5	119.0	-2.4	-4.9	118.2	-2.6	-5.0	118.0	-2.7	-5.8	117.0	-3.0	-7.6	116.2	-3.2	-8.2
C2L & C3L	3664	ESPLNJ12 13.8	13.7	-1.6	-0.4	13.8	-1.8	-0.6	13.7	-2.0	0.0	13.6	-2.2	0.5	13.7	-2.4	0.1	13.8	-2.6	-1.3	13.7	-2.7	-0.9	13.8	-3.0	-0.5	13.9	-3.3	-1.2
C2L & C3L	3767	TERAUA12 13.8	13.7	-1.6	-0.4	13.8	-1.8	-0.6	13.7	-2.0	0.0	13.8	-2.2	-0.8	13.7	-2.4	0.0	13.8	-2.6	-1.4	13.7	-2.7	-0.9	13.8	-3.0	-0.6	13.9	-3.3	-1.3
C16L & C17L	2100	CHERYDK1 220	237.8	-0.7	-1.0	237.5	-0.7	-1.1	237.2	-0.7	-1.1	236.8	-0.8	-1.3	236.4	-0.8	-1.4	235.9	-0.9	-1.6	236.2	-0.9	-1.7	235.5	-1.0	-2.7	235.0	-1.1	-3.0
C16L & C17L	2102	CHERYDK3 220	238.1	0.0	-0.2	237.8	0.0	-0.2	237.5	0.0	-0.2	237.1	0.1	-0.3	236.7	0.1	-0.3	236.1	0.1	-0.4	236.5	0.1	-0.4	235.7	0.1	-0.9	235.2	0.2	-1.0
C16L & C17L	3102	LEAS 215 220	235.0	-1.5	-2.3	234.4	-1.6	-2.4	233.8	-1.7	-2.6	233.1	-1.7	-3.0	232.4	-1.8	-3.2	231.5	-2.0	-3.5	231.6	-2.0	-3.8	230.4	-2.2	-5.2	229.6	-2.3	-5.6
C16L & C17L	3103	LEAS 317 220	235.1	-1.6	-2.5	234.5	-1.7	-2.6	233.8	-1.8	-2.8	233.2	-1.9	-3.2	232.4	-2.1	-3.5	231.5	-2.2	-3.8	231.6	-2.3	-4.1	230.4	-2.5	-5.7	229.5	-2.6	-6.1
C16L & C17L	3104	LEAS1416 220	235.1	-2.2	-3.0	234.5	-2.3	-3.2	233.9	-2.4	-3.4	233.2	-2.5	-3.9	232.5	-2.7	-4.1	231.5	-2.8	-4.5	231.6	-2.9	-4.8	230.4	-3.1	-6.4	229.6	-3.3	-6.9
C16L & C17L	3301	LEAS EJ 118	123.0	-1.9	-3.3	122.5	-2.1	-3.5	122.0	-2.3	-3.9	121.5	-2.5	-4.7	120.9	-2.7	-5.1	120.2	-2.9	-5.6	120.1	-3.1	-6.2	119.2	-3.4	-8.4	118.5	-3.6	-9.1
C16L & C17L	3300	HEARN 118	122.6	-1.9	-3.4	122.1	-2.1	-3.6	121.5	-2.3	-4.1	120.9	-2.5	-4.8	120.3	-2.7	-5.2	119.5	-2.9	-5.7	119.4	-3.1	-6.4	118.5	-3.4	-8.7	117.7	-3.7	-9.4
C16L & C17L	3401	TERAUT5E 118	122.0	-1.9	-3.4	121.5	-2.1	-3.6	120.9	-2.3	-4.0	120.3	-2.5	-4.8	119.7	-2.7	-5.2	118.9	-2.9	-5.7	118.8	-3.1	-6.4	117.9	-3.4	-8.7	117.1	-3.7	-9.4
C16L & C17L	3402	TERAUT7E 118	122.0	-1.9	-3.4	121.5	-2.1	-3.6	120.9	-2.3	-4.0	120.3	-2.5	-4.8	119.7	-2.7	-5.2	118.9	-2.9	-5.7	118.8	-3.1	-6.4	117.9	-3.4	-8.7	117.1	-3.7	-9.4

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013*			2014*			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
C16L & C17L	3403	TERC5E 118	121.4	-1.9	-3.5	120.8	-2.1	-3.6	120.2	-2.3	-4.1	119.6	-2.5	-4.9	118.9	-2.7	-5.4	118.1	-3.0	-5.9	117.9	-3.1	-6.6	117.0	-3.4	-8.9	116.2	-3.7	-9.6
C16L & C17L	3404	TERC7E 118	121.4	-1.9	-3.5	120.9	-2.1	-3.6	120.3	-2.3	-4.1	119.6	-2.5	-4.9	119.0	-2.7	-5.4	118.2	-3.0	-5.9	118.0	-3.1	-6.6	117.0	-3.4	-8.9	116.2	-3.7	-9.6
C16L & C17L	3664	ESPLNJ12 13.8	13.7	-1.9	-0.9	13.8	-2.1	-1.1	13.7	-2.3	-0.3	13.6	-2.5	0.1	13.7	-2.7	-0.4	13.8	-3.0	-1.0	13.7	-3.1	-0.5	13.8	-3.4	-0.7	13.9	-3.7	-1.6
C16L & C17L	3767	TERAUA12 13.8	13.7	-1.9	0.4	13.8	-2.1	-1.1	13.7	-2.3	-0.4	13.8	-2.5	-1.2	13.7	-2.7	-0.4	13.8	-3.0	-1.1	13.7	-3.1	-0.6	13.8	-3.4	-0.9	13.9	-3.7	-1.7
C14L & C15L	2100	CHERYDK1 220	237.8	-0.4	-0.7	237.5	-0.4	-0.7	237.2	-0.4	-0.7	236.8	-0.4	-0.8	236.4	-0.4	-0.9	235.9	-0.4	-0.9	236.2	-0.4	-1.0	235.5	-0.4	-1.4	235.0	-0.5	-1.7
C14L & C15L	2102	CHERYDK3 220	238.1	-0.3	-0.6	237.8	-0.3	-0.7	237.5	-0.4	-0.7	237.1	-0.4	-0.8	236.7	-0.4	-0.8	236.1	-0.4	-0.9	236.5	-0.4	-0.9	235.7	-0.4	-1.4	235.2	-0.4	-1.6
C14L & C15L	3102	LEAS 215 220	235.0	-1.7	-2.4	234.4	-1.7	-2.5	233.8	-1.9	-2.8	233.1	-1.9	-3.1	232.4	-2.0	-3.3	231.5	-2.2	-3.5	231.6	-2.2	-3.7	230.4	-2.4	-4.7	229.6	-2.5	-5.2
C14L & C15L	3103	LEAS 317 220	235.1	-1.7	-2.5	234.5	-1.8	-2.6	233.8	-1.9	-2.9	233.2	-2.0	-3.2	232.4	-2.1	-3.4	231.5	-2.2	-3.6	231.6	-2.3	-3.8	230.4	-2.4	-4.8	229.5	-2.6	-5.2
C14L & C15L	3104	LEAS1416 220	235.1	-1.2	-2.0	234.5	-1.3	-2.1	233.9	-1.4	-2.3	233.2	-1.5	-2.6	232.5	-1.5	-2.8	231.5	-1.6	-2.9	231.6	-1.7	-3.1	230.4	-1.8	-4.1	229.6	-1.9	-4.6
C14L & C15L	3301	LEAS EJ 118	123.0	-1.8	-3.1	122.5	-2.0	-3.3	122.0	-2.2	-3.8	121.5	-2.4	-4.4	120.9	-2.6	-4.8	120.2	-2.8	-5.0	120.1	-2.9	-5.5	119.2	-3.2	-7.1	118.5	-3.4	-7.8
C14L & C15L	3300	HEARN 118	122.6	-1.8	-3.2	122.1	-2.0	-3.4	121.5	-2.2	-3.9	120.9	-2.4	-4.6	120.3	-2.6	-4.9	119.5	-2.8	-5.2	119.4	-2.9	-5.7	118.5	-3.2	-7.4	117.7	-3.4	-8.1
C14L & C15L	3401	TERAUT5E 118	122.0	-1.8	-3.2	121.5	-2.0	-3.4	120.9	-2.2	-3.9	120.3	-2.4	-4.6	119.7	-2.6	-4.9	118.9	-2.8	-5.2	118.8	-2.9	-5.7	117.9	-3.2	-7.4	117.1	-3.4	-8.1
C14L & C15L	3402	TERAUT7E 118	122.0	-1.8	-3.2	121.5	-2.0	-3.4	120.9	-2.2	-3.9	120.3	-2.4	-4.6	119.7	-2.6	-4.9	118.9	-2.8	-5.2	118.8	-2.9	-5.7	117.9	-3.2	-7.4	117.1	-3.4	-8.1
C14L & C15L	3403	TERC5E 118	121.4	-1.8	-3.2	120.8	-2.0	-3.5	120.2	-2.2	-4.0	119.6	-2.4	-4.7	118.9	-2.6	-5.0	118.1	-2.8	-5.3	117.9	-2.9	-5.8	117.0	-3.2	-7.6	116.2	-3.4	-8.3
C14L & C15L	3404	TERC7E 118	121.4	-1.8	-3.2	120.9	-2.0	-3.5	120.3	-2.2	-4.0	119.6	-2.4	-4.7	119.0	-2.6	-5.0	118.2	-2.8	-5.3	118.0	-2.9	-5.8	117.0	-3.2	-7.6	116.2	-3.4	-8.3
C14L & C15L	3664	ESPLNJ12 13.8	13.7	-1.8	-0.6	13.8	-2.0	-0.9	13.7	-2.2	-0.2	13.6	-2.4	0.4	13.7	-2.6	-0.1	13.8	-2.8	-0.4	13.7	-3.0	-0.9	13.8	-3.2	-0.5	13.9	-3.5	-1.3
C14L & C15L	3767	TERAUA12 13.8	13.7	-1.9	-0.7	13.8	-2.0	-1.0	13.7	-2.2	-0.2	13.8	-2.4	-1.0	13.7	-2.6	-0.1	13.8	-2.8	-0.5	13.7	-3.0	-1.0	13.8	-3.2	-0.6	13.9	-3.5	-1.4
R1K	2100	CHERYDK1 220	237.8	0.0	0.0	237.5	0.0	0.0	237.2	0.0	0.0	236.8	0.0	0.0	236.4	0.0	0.0	235.9	0.0	0.0	236.2	0.0	0.0	235.5	0.0	0.0	235.0	0.0	0.0
R1K	2102	CHERYDK3 220	238.1	0.0	0.0	237.8	0.0	0.0	237.5	0.0	0.0	237.1	0.0	0.0	236.7	0.0	0.0	236.1	0.0	0.0	236.5	0.0	0.0	235.7	0.0	0.0	235.2	0.0	0.0
R1K	4103	RICH AH2 220	236.1	0.0	0.0	235.8	0.0	0.0	235.5	0.0	0.0	235.1	0.0	0.0	234.6	0.0	0.0	233.8	0.0	0.0	234.9	0.0	0.0	233.9	0.0	0.0	233.4	0.0	0.0
R1K	3107	MANBY E 220	237.1	0.2	0.2	236.8	0.2	0.2	236.4	0.2	0.2	235.9	0.2	0.2	235.4	0.2	0.2	234.5	0.2	0.2	235.7	0.2	0.2	234.7	0.2	0.2	234.1	0.1	0.2
R1K	3302	MANBY E 118	121.2	0.2	0.2	121.0	0.2	0.2	120.7	0.2	0.2	120.4	0.2	0.2	120.1	0.2	0.2	119.6	0.2	0.2	120.1	0.2	0.2	119.5	0.2	0.2	119.2	0.2	0.2
R1K	3108	MANBY W 220	236.5	0.0	0.0	236.2	0.0	0.0	235.7	0.0	0.0	235.3	0.0	0.0	234.7	0.0	0.0	233.8	0.0	0.0	235.5	0.0	0.0	234.4	0.0	0.0	233.8	0.0	0.0
R1K	3303	MANBY W 118	119.8	0.0	0.0	119.5	0.0	0.0	119.2	0.0	0.0	118.8	0.0	0.0	118.3	0.0	0.0	117.6	0.0	0.0	120.3	0.0	0.0	119.6	0.0	0.0	119.0	0.0	0.0
R1K	4143	COOKVL15 220	235.8	0.1	0.1	235.5	0.1	0.1	235.1	0.1	0.1	234.6	0.1	0.1	234.1	0.1	0.1	233.1	0.1	0.1	234.5	0.1	0.1	233.5	0.1	0.1	232.8	0.1	0.1
R1K	4192	LORNEB15 220	235.3	0.1	0.1	235.0	0.1	0.1	234.5	0.1	0.1	234.0	0.1	0.1	233.5	0.1	0.1	232.5	0.1	0.1	233.9	0.1	0.1	232.8	0.1	0.1	232.2	0.1	0.1
R1K	5240	OAKV B15 220	234.5	0.1	0.1	234.2	0.1	0.1	233.7	0.1	0.1	233.2	0.1	0.1	232.7	0.1	0.1	231.7	0.1	0.1	233.0	0.1	0.1	231.9	0.1	0.1	231.3	0.1	0.1
R1K	3697	JOHN A13 13.8	13.7	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.6	0.0	0.0	13.7	0.0	0.0
R13K	2100	CHERYDK1 220	237.8	0.0	0.0	237.5	0.0	0.0	237.2	0.0	0.0	236.8	0.0	0.0	236.4	0.0	0.0	235.9	0.0	0.0	236.2	0.0	0.0	235.5	0.0	0.0	235.0	0.0	0.0
R13K	2102	CHERYDK3 220	238.1	0.0	0.0	237.8	0.0	0.0	237.5	0.0	0.0	237.1	0.0	0.0	236.7	0.0	0.0	236.1	0.0	0.0	236.5	0.0	0.0	235.7	0.0	0.0	235.2	0.0	0.0
R13K	4103	RICH AH2 220	236.1	0.0	0.0	235.8	0.0	0.0	235.5	0.0	0.0	235.1	0.0	0.0	234.6	0.0	0.0	233.8	0.0	0.0	234.9	0.0	0.0	233.9	0.0	0.0	233.4	0.0	0.0
R13K	3107	MANBY E 220	237.1	0.2	0.2	236.8	0.2	0.2	236.4	0.2	0.2	235.9	0.2	0.2	235.4	0.2	0.2	234.5	0.2	0.2	235.7	0.2	0.2	234.7	0.2	0.2	234.1	0.1	0.1
R13K	3302	MANBY E 118	121.2	0.2	0.2	121.0	0.2	0.2	120.7	0.2	0.2	120.4	0.2	0.2	120.1	0.2	0.2	119.6	0.2	0.2	120.1	0.2	0.2	119.5	0.2	0.2	119.2	0.1	0.2
R13K	3108	MANBY W 220	236.5	0.0	0.0	236.2	0.0	0.0	235.7	0.0	0.0	235.3	0.0	0.0	234.7	0.0	0.0	233.8	0.0	0.0	235.5	0.0	0.0	234.4	0.0	0.0	233.8	0.0	0.0
R13K	3303	MANBY W 118	119.8	0.0	0.0	119.5	0.0	0.0	119.2	0.0	0.0	118.8	0.0	0.0	118.3	0.0	0.0	117.6	0.0	0.0	120.3	0.0	0.0	119.6	0.0	0.0	119.0	0.0	0.0
R13K	4143	COOKVL15 220	235.8	0.1	0.1	235.5	0.1	0.1	235.1	0.1	0.1	234.6	0.1	0.1	234.1	0.1	0.1	233.1	0.1	0.1	234.5	0.1	0.1	233.5	0.1	0.1	232.8	0.1	0.1
R13K	4192	LORNEB15 220	235.3	0.1	0.1	235.0	0.1	0.1	234.5	0.1	0.1	234.0	0.1	0.1	233.5	0.1	0.1	232.5	0.1	0.1	233.9	0.1	0.1	232.8	0.1	0.1	232.2	0.1	0.1
R13K	5240	OAKV B15 220	234.5	0.1	0.1	234.2	0.1	0.1	233.7	0.1	0.1	233.2	0.1	0.1	232.7	0.1	0.1	231.7	0.1	0.1	233.0	0.1	0.1	231.9	0.1	0.1	231.3	0.1	0.1
R13K	3697	JOHN A13 13.8	13.7	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	13.6	0.0	0.0	13.7	0.0	0.0
R2K	2100	CHERYDK1 220	237.8	0.0	-0.1	237.5	0.0	-0.1	237.2	0.0	-0.1	236.8	0.0	-0.1	236.4	0.0	-0.1	235.9	-0.1	-0.1	236.2	-0.1	-0.1	235.5	-0.1	-0.1	235.0	-0.1	-0.1
R2K	2102	CHERYDK3 220	238.1	0.0	-0.1	237.8	0.0	-0.1	237.5	0.0	-0.1	237.1	0.0	-0.1	236.7	-0.1	-0.1	236.1	-0.1	-0.1	236.5	-0.1	-0.1	235.7	-0.1	-0.1	235.2	-0.1	-0.1
R2K	4103	RICH AH2 220	236.1	-0.1	-0.2	235.8	-0.1	-0.2	235.5	-0.1	-0.2	235.1	-0.1	-0.2	234.6	-0.1	-0.2	233.8	-0.1	-0.2	234.9	-0.1	-0.2	233.9	-0.1	-0.2	233.4	-0.1	-0.2
R2K	3107	MANBY E 220	237.1	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.2	-0.2	235.9	-0.2	-0.2	235.4	-0.2	-0.2	234.5	-0.2	-0.2	235.7	-0.1	-0.2	234.7	-0.2	-0.2	234.1	-0.2	-0.2
R2K	3302	MANBY E 118	121.2	-0.1	-0.2	121.0	-0.1	-0.2	120.7	-0.2	-0.2	120.4	-0.2	-0.2	120.1	-0.2	-0.2	119.6	-0.2	-0.2	120.1	-0.1	-0.2	119.5	-0.2	-0.2	119.2	-0.2	-0.2
R2K	3108	MANBY W 220	236.5	-0.1	-0.2	236.2	-0.1	-0.2	235.7	-0.2	-0.2	235.3	-0.2	-0.3	234.7	-0.2	-0.3	233.8	-0.3	-0.4	235.5	-0.1	-0.2	234.4	-0.1	-0.2	233.8	-0.2	-0.2
R2K	3303	MANBY W 118	119.8	-0.1	-0.2	119.5	-0.1	-0.2	119.2	-0.2	-0.2	118.8	-0.2	-0.3	118.3	-0.2	-0.3	117.6	-0.3	-0.4	120.3	-0.1	-0.2	119.6	-0.1	-0.3	119.0	-0.2	-0.2
R2K	4143	COOKVL15 220	235.8	-0.1	-0.2	235.5	-0.1	-0.2	235.1	-0.2	-0.2	234.6	-0.2	-0.2	234.1	-0.2	-0.2	233.1	-0.2	-0.3	234.5	-0.1	-0.2	233.5	-0.1	-0.2	232.8	-0.2	-0.2
R2K	4192	LORNEB15 220	235.3	-0.1	-0.2	235.0	-0.1	-0.2	234.5	-0.2	-0.2	234.0	-0.2	-0.2	233.5	-0.2	-0.2	232.5	-0.2	-0.3	233.9	-0.1	-0.2	232.8	-0.1	-0.2	232.2	-0.2	-0.2
R2K	5240	OAKV B15 220	234.5	-0.1	-0.2	234.2	-0.1	-0.2	233.7	-0.2	-0.2	233.2	-0.2	-0.2	232.7	-0.2	-0.2	231.7	-0.2	-0.3	233.0	-0.1	-0.2	231.9	-0.1	-0.2	231.3	-0.2	-0.2
R2K	3697	JOHN A13 13.8	13.7	-0.1	-0.2	13.7	-0.1	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.3	13.8	-0.2	-0.3	13.7	-0.3	-0.4	13.8	-0.1	-0.2	13.6	-0.1	0.9	13.7	-0.2	-0.2
R15K	2100	CHERYDK1 220	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.2	-0.1	-0.1	236.8	-0.1	-0.1	236.4	-0.1	-0.1	235.9	-0.1	-0.1	236.2	-0.1	-0.1	235.5	-0.1	-0.1	235.0	-0.1	-0.1

CASE/CONT.	BN	BUS NAME	2007 Pre	%	SS%	2008 Pre	%	SS%	2009 Pre	%	SS%	2010 Pre	%	SS%	2011 Pre	%	SS%	2012 Pre	%	SS%	2013* Pre	%	SS%	2014* Pre	%	SS%	2015* Pre	%	SS%
R15K	2102	CHERYDK3 220	238.1	-0.1	-0.1	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.1	-0.1	-0.1	236.7	-0.1	-0.1	236.1	-0.1	-0.1	236.5	-0.1	-0.1	235.7	-0.1	-0.1	235.2	-0.1	-0.1
R15K	4103	RICH AH2 220	236.1	-0.1	-0.2	235.8	-0.1	-0.2	235.5	-0.2	-0.2	235.1	-0.2	-0.2	234.6	-0.2	-0.2	233.8	-0.2	-0.2	234.9	-0.2	-0.2	233.9	-0.2	-0.2	233.4	-0.2	-0.2
R15K	3107	MANBY E 220	237.1	-0.2	-0.2	236.8	-0.2	-0.2	236.4	-0.2	-0.2	235.9	-0.2	-0.2	235.4	-0.2	-0.2	234.5	-0.2	-0.3	235.7	-0.2	-0.2	234.7	-0.2	-0.2	234.1	-0.2	-0.2
R15K	3302	MANBY E 118	121.2	-0.2	-0.2	121.0	-0.2	-0.2	120.7	-0.2	-0.2	120.4	-0.2	-0.2	120.1	-0.2	-0.2	119.6	-0.2	-0.3	120.1	-0.2	-0.3	119.5	-0.2	-0.2	119.2	-0.2	-0.2
R15K	3108	MANBY W 220	236.5	-0.2	-0.2	236.2	-0.2	-0.2	235.7	-0.2	-0.3	235.3	-0.2	-0.3	234.7	-0.3	-0.3	233.8	-0.3	-0.4	235.5	-0.1	-0.2	234.4	-0.2	-0.3	233.8	-0.2	-0.3
R15K	3303	MANBY W 118	119.8	-0.2	-0.2	119.5	-0.2	-0.2	119.2	-0.2	-0.3	118.8	-0.2	-0.3	118.3	-0.3	-0.4	117.6	-0.3	-0.4	120.3	-0.1	-0.2	119.6	-0.2	-0.3	119.0	-0.2	-0.3
R15K	4143	COOKVL15 220	235.8	-0.2	-0.2	235.5	-0.2	-0.2	235.1	-0.2	-0.2	234.6	-0.2	-0.2	234.1	-0.2	-0.3	233.1	-0.2	-0.3	234.5	-0.1	-0.2	233.5	-0.2	-0.3	232.8	-0.2	-0.2
R15K	4192	LORNEB15 220	235.3	-0.2	-0.2	235.0	-0.2	-0.2	234.5	-0.2	-0.2	234.0	-0.2	-0.2	233.5	-0.2	-0.3	232.5	-0.2	-0.3	233.9	-0.1	-0.2	232.8	-0.2	-0.3	232.2	-0.2	-0.2
R15K	5240	OAKV B15 220	234.5	-0.2	-0.2	234.2	-0.2	-0.2	233.7	-0.2	-0.2	233.2	-0.2	-0.2	232.7	-0.2	-0.3	231.7	-0.2	-0.3	233.0	-0.1	-0.2	231.9	-0.2	-0.3	231.3	-0.2	-0.2
R15K	3697	JOHN A13 13.8	13.7	-0.2	-0.2	13.7	-0.2	-0.2	13.8	-0.2	-0.3	13.7	-0.2	-0.3	13.8	-0.3	-0.4	13.7	-0.3	-0.4	13.8	-0.1	-0.2	13.6	-0.2	0.9	13.7	-0.2	-0.3
R1K & R2K	2100	CHERYDK1 220	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.2	-0.1	-0.1	236.8	-0.1	-0.1	236.4	-0.1	-0.1	235.9	-0.1	-0.1	236.2	-0.1	-0.1	235.5	-0.1	-0.1	235.0	-0.1	-0.1
R1K & R2K	2102	CHERYDK3 220	238.1	-0.1	-0.1	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.1	-0.1	-0.1	236.7	-0.1	-0.1	236.1	-0.1	-0.1	236.5	-0.1	-0.1	235.7	-0.1	-0.1	235.2	-0.1	-0.1
R1K & R2K	4103	RICH AH2 220	236.1	-0.2	-0.2	235.8	-0.2	-0.2	235.5	-0.2	-0.2	235.1	-0.2	-0.2	234.6	-0.2	-0.2	233.8	-0.2	-0.3	234.9	-0.2	-0.2	233.9	-0.2	-0.3	233.4	-0.2	-0.2
R1K & R2K	3107	MANBY E 220	237.1	0.1	0.0	236.8	0.1	0.0	236.4	0.1	0.0	235.9	0.0	0.0	235.4	0.0	-0.1	234.5	0.0	-0.1	235.7	0.0	0.0	234.7	0.0	-0.1	234.1	0.0	-0.1
R1K & R2K	3302	MANBY E 118	121.2	0.1	0.0	121.0	0.1	0.0	120.7	0.1	0.0	120.4	0.0	0.0	120.1	0.0	-0.1	119.6	0.0	-0.1	120.1	0.0	0.0	119.5	0.0	-0.1	119.2	0.0	-0.1
R1K & R2K	3108	MANBY W 220	236.5	-0.1	-0.2	236.2	-0.1	-0.2	235.7	-0.2	-0.2	235.3	-0.2	-0.3	234.7	-0.2	-0.3	233.8	-0.3	-0.4	235.5	-0.1	-0.2	234.4	-0.1	-0.3	233.8	-0.2	-0.3
R1K & R2K	3303	MANBY W 118	119.8	-0.1	-0.2	119.5	-0.1	-0.2	119.2	-0.2	-0.2	118.8	-0.2	-0.3	118.3	-0.2	-0.3	117.6	-0.3	-0.4	120.3	-0.1	-0.2	119.6	-0.1	-0.3	119.0	-0.2	-0.3
R1K & R2K	4143	COOKVL15 220	235.8	0.0	-0.1	235.5	0.0	-0.1	235.1	-0.1	-0.1	234.6	-0.1	-0.1	234.1	-0.1	-0.2	233.1	-0.1	-0.2	234.5	0.0	-0.1	233.5	-0.1	-0.2	232.8	-0.1	-0.2
R1K & R2K	4192	LORNEB15 220	235.3	0.0	-0.1	235.0	0.0	-0.1	234.5	-0.1	-0.1	234.0	-0.1	-0.1	233.5	-0.1	-0.2	232.5	-0.1	-0.2	233.9	0.0	-0.1	232.8	-0.1	-0.2	232.2	-0.1	-0.2
R1K & R2K	5240	OAKV B15 220	234.5	0.0	-0.1	234.2	0.0	-0.1	233.7	-0.1	-0.1	233.2	-0.1	-0.1	232.7	-0.1	-0.2	231.7	-0.1	-0.2	233.0	0.0	-0.1	231.9	-0.1	-0.2	231.3	-0.1	-0.2
R1K & R2K	3697	JOHN A13 13.8	13.7	-0.1	-0.2	13.7	-0.1	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.3	13.8	-0.2	-0.3	13.7	-0.3	-0.4	13.8	-0.1	-0.2	13.6	-0.2	0.9	13.7	-0.2	-0.3
R13K & R15K	2100	CHERYDK1 220	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.2	-0.1	-0.1	236.8	-0.1	-0.1	236.4	-0.1	-0.1	235.9	-0.1	-0.1	236.2	-0.1	-0.1	235.5	-0.1	-0.1	235.0	-0.1	-0.1
R13K & R15K	2102	CHERYDK3 220	238.1	-0.1	-0.1	237.8	-0.1	-0.1	237.5	-0.1	-0.1	237.1	-0.1	-0.1	236.7	-0.1	-0.1	236.1	-0.1	-0.1	236.5	-0.1	-0.1	235.7	-0.1	-0.1	235.2	-0.1	-0.1
R13K & R15K	4103	RICH AH2 220	236.1	-0.2	-0.2	235.8	-0.2	-0.2	235.5	-0.2	-0.2	235.1	-0.2	-0.2	234.6	-0.2	-0.3	233.8	-0.2	-0.3	234.9	-0.2	-0.3	233.9	-0.2	-0.3	233.4	-0.2	-0.3
R13K & R15K	3107	MANBY E 220	237.1	0.1	0.0	236.8	0.1	0.0	236.4	0.0	0.0	235.9	0.0	0.0	235.4	0.0	-0.1	234.5	-0.1	-0.1	235.7	0.0	0.0	234.7	0.0	-0.1	234.1	0.0	-0.1
R13K & R15K	3302	MANBY E 118	121.2	0.1	0.0	121.0	0.1	0.0	120.7	0.0	0.0	120.4	0.0	0.0	120.1	0.0	-0.1	119.6	-0.1	-0.1	120.1	0.0	0.0	119.5	0.0	-0.1	119.2	0.0	-0.1
R13K & R15K	3108	MANBY W 220	236.5	-0.1	-0.2	236.2	-0.2	-0.2	235.7	-0.2	-0.3	235.3	-0.2	-0.3	234.7	-0.3	-0.3	233.8	-0.3	-0.4	235.5	-0.1	-0.2	234.4	-0.2	-0.3	233.8	-0.2	-0.3
R13K & R15K	3303	MANBY W 118	119.8	-0.1	-0.2	119.5	-0.2	-0.2	119.2	-0.2	-0.3	118.8	-0.2	-0.3	118.3	-0.3	-0.4	117.6	-0.3	-0.4	120.3	-0.1	-0.2	119.6	-0.2	-0.3	119.0	-0.2	-0.3
R13K & R15K	4143	COOKVL15 220	235.8	0.0	-0.1	235.5	-0.1	-0.1	235.1	-0.1	-0.1	234.6	-0.1	-0.2	234.1	-0.1	-0.2	233.1	-0.2	-0.2	234.5	-0.1	-0.1	233.5	-0.1	-0.2	232.8	-0.1	-0.2
R13K & R15K	4192	LORNEB15 220	235.3	0.0	-0.1	235.0	-0.1	-0.1	234.5	-0.1	-0.1	234.0	-0.1	-0.2	233.5	-0.1	-0.2	232.5	-0.2	-0.2	233.9	-0.1	-0.1	232.8	-0.1	-0.2	232.2	-0.1	-0.2
R13K & R15K	5240	OAKV B15 220	234.5	0.0	-0.1	234.2	-0.1	-0.1	233.7	-0.1	-0.1	233.2	-0.1	-0.2	232.7	-0.1	-0.2	231.7	-0.2	-0.2	233.0	-0.1	-0.1	231.9	-0.1	-0.2	231.3	-0.1	-0.2
R13K & R15K	3697	JOHN A13 13.8	13.7	-0.1	-0.2	13.7	-0.2	-0.2	13.8	-0.2	-0.3	13.7	-0.2	-0.3	13.8	-0.3	-0.4	13.7	-0.3	-0.4	13.8	-0.1	-0.2	13.6	-0.2	0.9	13.7	-0.2	-0.3
H2JK	3107	MANBY E 220	237.1	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.1	-0.2	235.9	-0.1	-0.2	235.4	-0.1	-0.2	234.5	-0.1	-0.2	235.7	-0.1	-0.2	234.7	-0.1	-0.3	234.1	-0.1	-0.2
H2JK	3302	MANBY E 118	121.2	-0.1	-0.2	121.0	-0.1	-0.2	120.7	-0.1	-0.2	120.4	-0.1	-0.2	120.1	-0.1	-0.2	119.6	-0.1	-0.2	120.1	-0.1	-0.2	119.5	-0.1	-0.3	119.2	-0.1	-0.2
H2JK	3108	MANBY W 220	236.5	-0.2	-0.3	236.2	-0.2	-0.3	235.7	-0.2	-0.3	235.3	-0.2	-0.3	234.7	-0.2	-0.3	233.8	-0.2	-0.3	235.5	-0.2	-0.3	234.4	-0.2	-0.4	233.8	-0.2	-0.3
H2JK	3303	MANBY W 118	119.8	-0.6	-0.8	119.5	-0.6	-0.9	119.2	-0.6	-0.9	118.8	-0.6	-0.9	118.3	-0.6	-0.9	117.6	-0.6	-1.0	120.3	-0.6	-0.9	119.6	-0.6	-1.1	119.0	-0.6	-1.0
H2JK	3377	JOHN 118	118.2	-1.3	-1.7	117.8	-1.3	-1.8	117.4	-1.4	-1.9	116.9	-1.4	-2.0	116.3	-1.4	-2.0	115.5	-1.5	-2.1	119.2	-1.2	-1.6	118.3	-1.3	-2.0	117.7	-1.3	-1.9
H2JK	3697	JOHN A13 13.8	13.7	-1.3	-0.5	13.7	-1.3	0.6	13.8	-1.4	-0.7	13.7	-1.4	0.4	13.8	-1.4	-0.9	13.7	-1.5	0.2	13.8	-1.2	-0.5	13.6	-1.3	0.4	13.7	-1.3	-0.7
K6J	3107	MANBY E 220	237.1	-0.1	-0.2	236.8	-0.1	-0.2	236.4	-0.1	-0.2	235.9	-0.1	-0.2	235.4	-0.1	-0.2	234.5	-0.1	-0.2	235.7	-0.1	-0.2	234.7	-0.1	-0.2	234.1	-0.1	-0.2
K6J	3302	MANBY E 118	121.2	-0.1	-0.2	121.0	-0.1	-0.2	120.7	-0.1	-0.2	120.4	-0.1	-0.2	120.1	-0.1	-0.2	119.6	-0.1	-0.2	120.1	-0.1	-0.2	119.5	-0.1	-0.2	119.2	-0.1	-0.2
K6J	3108	MANBY W 220	236.5	-0.2	-0.3	236.2	-0.2	-0.3	235.7	-0.2	-0.3	235.3	-0.2	-0.3	234.7	-0.2	-0.3	233.8	-0.2	-0.3	235.5	-0.2	-0.3	234.4	-0.2	-0.3	233.8	-0.2	-0.3
K6J	3303	MANBY W 118	119.8	-0.5	-0.8	119.5	-0.5	-0.9	119.2	-0.5	-0.9	118.8	-0.5	-0.9	118.3	-0.5	-0.9	117.6	-0.5	-0.9	120.3	-0.6	-0.9	119.6	-0.6	-1.0	119.0	-0.6	-1.0
K6J	3377	JOHN 118	118.2	-1.3	-1.7	117.8	-1.3	-1.8	117.4	-1.3	-1.9	116.9	-1.4	-1.9	116.3	-1.4	-2.0	115.5	-1.4	-2.0	119.2	-1.2	-1.6	118.3	-1.2	-1.9	117.7	-1.3	-1.9
K6J	3697	JOHN A13 13.8	13.7	-1.3	-0.5	13.7	-1.3	0.6	13.8	-1.3	-0.7	13.7	-1.4	0.5	13.8	-1.4	-0.8	13.7	-1.4	0.2	13.8	-1.2	-0.5	13.6	-1.2	0.4	13.7	-1.3	-0.7
K13J	3107	MANBY E 220	237.1	-0.1	-0.1	236.8	-0.1	-0.1	236.4	-0.1	-0.1	235.9	-0.1	-0.1	235.4	-0.1	-0.1	234.5	-0.1	-0.1	235.7	-0.1	-0.1	234.7	-0.1	-0.1	234.1	-0.1	-0.1
K13J	3302	MANBY E 118	121.2	-0.1	-0.1	121.0	-0.1	-0.1	120.7	-0.1	-0.1	120.4	-0.1	-0.1	120.1	-0.1	-0.1	119.6	-0.1	-0.1	120.1	-0.1	-0.1	119.5	-0.1	-0.1	119.2	-0.1	-0.1
K13J	3108	MANBY W 220	236.5	-0.1	-0.1	236.2	-0.1	-0.1	235.7	-0.1	-0.1	235.3	-0.1	-0.1	234.7	-0.1	-0.1	233.8	-0.1	-0.1	235.5	-0.1	-0.1	234.4	-0.1	-0.1	233.8	-0.1	-0.1
K13J	3303	MANBY W 118	119.8	-0.3	-0.3	119.5	-0.3	-0.3	119.2	-0.3	-0.3	118.8	-0.3	-0.3	118.3	-0.3	-0.3	117.6	-0.3	-0.3	120.3	-0.3	-0.3	119.6	-0.3	-0.3	119.0	-0.3	-0.3
K13J	3377	JOHN 118	118.2	-0.8	-0.9	117.8	-0.8	-0.9	117.4	-0.8	-0.9	116.9	-0.9	-1.0	116.3	-0.9	-0.9	115.5	-0.9	-1.0	119.2	-0.7	-0.7	118.3	-0.7	-0.8	117.7	-0.7	-0.8
K13J	3697	JOHN A13 13.8	13.7	-0.8	-0.9	13.7	-0.8	0.3	13.8	-0.8	-0.9	13.7	-0.9	0.2	13.8	-0.9	-1.0	13.7	-0.9	0.2	13.8	-0.7	-0.7	13.6	-0.7	0.4	13.7	-0.7	-0.8

K14J	3107	MANBY E 220	237.1	-0.1	-0.1	236.8	-0.1	-0.1	236.4	-0.1	-0.1	235.9	-0.1	-0.1	235.4	-0.1	-0.1	234.5	-0.1	-0.1	235.7	-0.1	-0.1	234.7	-0.1	-0.1	234.1	-0.1	-0.1
K14J	3302	MANBY E 118	121.2	-0.1	-0.1	121.0	-0.1	-0.1	120.7	-0.1	-0.1	120.4	-0.1	-0.1	120.1	-0.1	-0.1	119.6	-0.1	-0.1	120.1	-0.1	-0.1	119.5	-0.1	-0.1	119.2	-0.1	-0.1
K14J	3108	MANBY W 220	236.5	-0.1	-0.1	236.2	-0.1	-0.1	235.7	-0.1	-0.1	235.3	-0.1	-0.1	234.7	-0.1	-0.1	233.8	-0.1	-0.1	235.5	-0.1	-0.1	234.4	-0.1	-0.1	233.8	-0.1	-0.1
K14J	3303	MANBY W 118	119.8	-0.3	-0.3	119.5	-0.3	-0.3	119.2	-0.3	-0.3	118.8	-0.3	-0.3	118.3	-0.3	-0.3	117.6	-0.3	-0.3	120.3	-0.3	-0.3	119.6	-0.3	-0.3	119.0	-0.3	-0.3
CASE/CONT.	**BN**	**BUS NAME**	**2007**			**2008**			**2009**			**2010**			**2011**			**2012**			**2013***			**2014***			**2015***		
			Pre	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**
K14J	3377	JOHN 118	118.2	-0.8	-0.9	117.8	-0.8	-0.9	117.4	-0.8	-0.9	116.9	-0.9	-1.0	116.3	-0.9	-0.9	115.5	-0.9	-1.0	119.2	-0.7	-0.7	118.3	-0.7	-0.8	117.7	-0.7	-0.8
K14J	3697	JOHN A13 13.8	13.7	-0.8	-0.9	13.7	-0.8	0.3	13.8	-0.8	-0.9	13.7	-0.9	0.2	13.8	-0.9	-1.0	13.7	-0.9	0.2	13.8	-0.7	-0.7	13.6	-0.7	0.4	13.7	-0.7	-0.8

* 2013 to 2015: one 125MVAr/127kV cap bank is placed at John TS for voltage support

Appendix F: Circuit Loading under Contingency (AC Option-1) (in MVA)

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
NONE	C2L	579/754	355.0	359.8	363.8	368.1	372.2	376.7	381.0	385.2	390.2
NONE	C3L	579/754	374.6	379.5	383.7	388.1	392.4	397.0	401.6	406.0	411.2
NONE	C14L	579/754	378.7	383.7	387.9	392.3	396.6	401.2	405.8	410.1	415.3
NONE	C15L	579/754	372.8	377.9	382.1	386.4	390.7	395.2	399.6	403.9	408.9
NONE	C16L	579/754	353.5	358.5	362.2	366.2	370.1	374.3	378.4	382.4	387.0
NONE	C17L	579/754	341.6	346.4	350.4	354.6	358.8	363.3	367.6	372.0	376.9
NONE	LEASIDE AUTO 11	275/378	195.2	197.7	199.4	201.2	203.1	205.0	207.0	209.2	211.3
NONE	LEASIDE AUTO 15	283/369	192.9	195.3	197.0	198.8	200.6	202.5	204.5	206.7	208.8
NONE	LEASIDE AUTO 12	312/419	181.7	184.0	185.6	187.2	188.9	190.7	192.6	194.6	196.5
NONE	LEASIDE AUTO 17	283/422	179.9	182.1	183.7	185.3	187.0	188.8	190.6	192.6	194.5
NONE	LEASIDE AUTO 14	275/489	185.9	188.2	189.9	191.6	193.4	195.2	197.2	199.3	201.3
NONE	LEASIDE AUTO 16	275/384	185.7	188.0	189.7	191.4	193.2	195.0	197.0	199.1	201.1
NONE	MANBY AUTO 12	250/296	74.5	75.5	76.7	78.0	79.4	80.9	82.5	84.6	86.3
NONE	MANBY AUTO T1	368/368	84.4	85.5	86.9	88.3	90.0	91.7	93.5	95.8	97.8
NONE	MANBY AUTO T2	408/408	81.8	82.8	84.2	85.6	87.2	88.8	90.6	92.8	94.7
NONE	MANBY AUTO T7	250/307	135.1	136.8	137.9	139.1	140.4	141.6	142.9	144.0	145.3
NONE	MANBY AUTO T8	369/369	157.8	159.7	161.1	162.5	163.9	165.4	166.9	168.2	169.7
NONE	MANBY AUTO T9	250/307	135.6	137.2	138.4	139.6	140.8	142.1	143.4	144.5	145.8
NONE	R2K	579/669	279.8	282.6	285.2	287.8	291.0	293.9	297.0	303.9	306.8
NONE	R15K	579/669	281.9	284.7	287.3	289.9	293.1	296.0	299.2	306.1	309.0
NONE	CB		303.6	306.5	309.2	311.8	315.2	318.2	321.4	329.2	332.1
NONE	R1K	579/669	302.2	304.9	307.1	309.6	312.3	314.9	317.6	350.3	351.2
NONE	R13K	579/669	299.4	302.1	304.3	306.7	309.4	311.9	314.6	347.1	347.9
NONE	CB		326.9	329.6	331.9	334.5	337.3	339.9	342.8	379.3	380.0
NONE	H2JK	249/267	63.2	65.0	67.0	69.0	71.2	73.4	76.2	78.4	81.0
NONE	K6J	249/267	104.8	107.0	110.0	113.2	116.2	119.5	122.3	125.3	129.1
NONE	K13J	225/225	51.5	52.1	53.2	54.3	55.5	56.8	58.0	59.1	60.4
NONE	K14J		139.2	142.3	145.5	148.8	152.2	155.6	159.3	161.9	165.8
NONE	K1J		148.1	150.6	153.2	155.9	158.7	161.6	164.8	168.4	171.7
NONE	K2J		149.2	151.8	154.5	157.3	160.3	163.4	166.4	169.6	172.9
C2L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	C3L	579/754	496.1	502.4	508.0	513.7	519.6	525.6	531.8	537.3	544.0
C2L	C14L	579/754	488.8	495.2	500.5	506.0	511.6	517.5	523.4	528.8	535.3
C2L	C15L	579/754	390.2	395.6	399.6	403.8	408.1	412.6	417.0	421.2	426.1
C2L	C16L	579/754	397.3	402.7	406.9	411.2	415.7	420.3	424.8	429.3	434.3

C2L	C17L	579/754	383.9	389.1	393.5	398.1	402.9	407.7	412.6	417.3	422.7
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014***	**2015***
C2L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	LEASIDE AUTO 15	283/369	242.8	245.7	247.9	250.2	252.6	255.0	257.6	260.4	263.0
C2L	LEASIDE AUTO 12	312/419	217.0	219.5	221.3	223.0	224.9	226.8	228.9	231.3	233.4
C2L	LEASIDE AUTO 17	283/422	214.8	217.3	219.0	220.8	222.6	224.5	226.6	228.9	231.0
C2L	LEASIDE AUTO 14	275/489	220.1	222.6	224.4	226.2	228.2	230.2	232.3	234.7	236.9
C2L	LEASIDE AUTO 16	275/384	219.8	222.4	224.2	226.0	228.0	229.9	232.1	234.5	236.6
C3L	C2L	579/754	492.6	499.0	504.5	510.3	516.1	522.2	528.3	533.9	540.5
C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	C14L	579/754	464.7	470.8	475.9	481.1	486.2	491.8	497.2	502.4	508.5
C3L	C15L	579/754	442.5	448.5	453.3	458.2	463.3	468.6	473.8	478.9	484.6
C3L	C16L	579/754	382.9	388.2	392.2	396.3	400.6	405.1	409.4	413.7	418.5
C3L	C17L	579/754	377.5	382.6	386.7	391.0	395.5	400.2	404.6	409.3	414.3
C3L	LEASIDE AUTO 11	275/378	224.7	227.3	229.1	230.9	232.8	234.8	236.9	239.4	241.5
C3L	LEASIDE AUTO 15	283/369	222.0	224.5	226.3	228.1	230.0	232.0	234.1	236.5	238.7
C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	LEASIDE AUTO 17	283/422	214.7	217.3	219.2	221.1	223.1	225.2	227.4	229.8	232.0
C3L	LEASIDE AUTO 14	275/489	226.5	229.2	231.1	233.1	235.1	237.2	239.5	242.0	244.3
C3L	LEASIDE AUTO 16	275/384	226.3	229.0	230.9	232.8	234.9	237.0	239.2	241.7	244.0
C14L	C2L	579/754	462.0	468.0	473.1	478.5	483.8	489.5	495.2	500.4	506.6
C14L	C3L	579/754	486.8	493.1	498.5	504.1	509.5	515.3	521.2	526.7	533.1
C14L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	C15L	579/754	405.0	410.5	414.9	419.5	424.1	428.9	433.7	438.3	443.6
C14L	C16L	579/754	368.8	373.8	377.5	381.3	385.2	389.2	393.3	397.2	401.7
C14L	C17L	579/754	434.6	440.4	445.5	450.8	456.1	461.5	467.1	472.3	478.3
C14L	LEASIDE AUTO 11	275/378	235.0	237.8	239.7	241.8	243.8	246.0	248.3	250.8	253.2
C14L	LEASIDE AUTO 15	283/369	232.2	234.9	236.9	238.9	240.9	243.0	245.3	247.8	250.1
C14L	LEASIDE AUTO 12	312/419	206.8	209.2	210.7	212.3	214.1	215.9	217.8	220.1	222.0
C14L	LEASIDE AUTO 17	283/422	204.7	207.0	208.6	210.2	211.9	213.7	215.6	217.8	219.7
C14L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	LEASIDE AUTO 16	275/384	234.9	237.8	239.9	242.1	244.5	246.8	249.3	252.0	254.6
C15L	C2L	579/754	410.7	416.1	420.8	425.7	430.4	435.6	440.6	445.6	451.3
C15L	C3L	579/754	427.5	433.2	438.0	443.0	447.9	453.3	458.4	463.5	469.3
C15L	C14L	579/754	405.3	410.6	415.0	419.5	424.0	428.8	433.5	438.2	443.5
C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	C16L	579/754	488.1	494.7	499.8	504.8	510.0	515.4	520.6	525.8	531.8
C15L	C17L	579/754	429.0	434.9	439.9	445.0	450.3	455.8	461.1	466.5	472.5

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
C15L	LEASIDE AUTO 11	275/378	219.4	222.0	223.7	225.5	227.3	229.3	231.3	233.7	235.8
C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	LEASIDE AUTO 12	312/419	220.5	223.0	224.9	226.7	228.7	230.6	232.8	235.2	237.4
C15L	LEASIDE AUTO 17	283/422	218.2	220.8	222.6	224.4	226.3	228.3	230.4	232.8	234.9
C15L	LEASIDE AUTO 14	275/489	228.6	231.3	233.3	235.3	237.4	239.6	242.0	244.5	246.9
C15L	LEASIDE AUTO 16	275/384	228.4	231.1	233.1	235.1	237.2	239.4	241.7	244.3	246.7
C16L	C2L	579/754	389.9	395.0	399.4	403.9	408.3	413.1	417.8	422.3	427.6
C16L	C3L	579/754	406.0	411.2	415.7	420.4	425.0	429.8	434.7	439.5	444.9
C16L	C14L	579/754	433.9	439.5	444.4	449.3	454.3	459.6	464.6	469.9	475.7
C16L	C15L	579/754	514.7	521.6	527.1	532.6	538.1	544.0	549.6	555.2	561.6
C16L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L	C17L	579/754	422.6	428.3	433.2	438.2	443.4	448.7	454.0	459.3	465.1
C16L	LEASIDE AUTO 11	275/378	233.1	235.9	237.9	239.9	242.0	244.2	246.5	249.1	251.5
C16L	LEASIDE AUTO 15	283/369	230.3	233.0	235.0	237.0	239.1	241.3	243.5	246.1	248.5
C16L	LEASIDE AUTO 12	312/419	221.4	224.0	225.9	227.7	229.7	231.8	234.0	236.4	238.6
C16L	LEASIDE AUTO 17	283/422	219.1	221.7	223.6	225.4	227.4	229.4	231.6	234.0	236.2
C16L	LEASIDE AUTO 14	275/489	211.5	213.9	215.6	217.3	219.2	221.0	223.1	225.3	227.3
C16L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	C2L	579/754	374.6	379.5	383.7	388.1	392.3	396.9	401.5	405.9	410.9
C17L	C3L	579/754	404.8	409.9	414.5	419.2	423.9	428.7	433.7	438.5	444.0
C17L	C14L	579/754	469.4	475.6	480.8	486.2	491.4	497.1	502.7	508.1	514.3
C17L	C15L	579/754	451.2	457.4	462.4	467.5	472.6	478.0	483.4	488.5	494.4
C17L	C16L	579/754	462.1	468.4	473.3	478.4	483.6	489.0	494.3	499.5	505.4
C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 11	275/378	210.0	212.4	214.1	215.8	217.6	219.5	221.5	223.8	225.9
C17L	LEASIDE AUTO 15	283/369	236.6	239.4	241.5	243.6	245.8	248.0	250.4	253.0	255.5
C17L	LEASIDE AUTO 12	312/419	218.4	221.0	222.8	224.6	226.5	228.5	230.6	232.9	235.0
C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 14	275/489	210.0	212.4	214.1	215.8	217.6	219.5	221.5	223.8	225.9
C17L	LEASIDE AUTO 16	275/384	209.8	212.2	213.9	215.5	217.4	219.3	221.3	223.6	225.7
C2L & C3L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C14L	579/754	638.8	646.8	653.5	660.4	667.4	674.7	682.0	688.9	696.8
C2L & C3L	C15L	579/754	487.1	493.5	498.4	503.3	508.4	513.8	519.1	524.3	530.1
C2L & C3L	C16L	579/754	442.6	448.4	452.9	457.5	462.4	467.4	472.2	477.1	482.4
C2L & C3L	C17L	579/754	430.9	436.5	441.0	445.6	450.5	455.5	460.3	465.5	470.9
C2L & C3L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

C2L & C3L	LEASIDE AUTO 15	283/369	281.9	285.0	287.2	289.5	292.0	294.4	297.0	300.1	302.7

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
C2L & C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 17	283/422	269.2	272.2	274.3	276.4	278.7	281.0	283.5	286.5	288.9
C2L & C3L	LEASIDE AUTO 14	275/489	278.8	281.8	283.8	285.8	287.9	290.1	292.5	295.5	297.8
C2L & C3L	LEASIDE AUTO 16	275/384	278.5	281.5	283.5	285.5	287.6	289.8	292.2	295.2	297.5
C16L & C17L	C2L	579/754	419.0	424.3	428.9	433.5	438.2	443.1	448.1	452.9	458.3
C16L & C17L	C3L	579/754	474.7	480.4	485.6	490.9	496.1	501.4	506.9	512.6	518.7
C16L & C17L	C14L	579/754	602.6	610.3	616.8	623.6	630.1	637.1	644.0	651.1	658.7
C16L & C17L	C15L	579/754	651.9	660.5	667.2	674.1	681.0	688.2	695.4	702.3	710.1
C16L & C17L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 11	275/378	306.8	310.2	312.6	315.1	317.7	320.3	323.1	326.5	329.3
C16L & C17L	LEASIDE AUTO 15	283/369	303.1	306.4	308.9	311.3	313.9	316.4	319.3	322.6	325.3
C16L & C17L	LEASIDE AUTO 12	312/419	268.0	270.9	272.9	274.9	277.0	279.2	281.6	284.4	286.6
C16L & C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 14	275/489	225.4	227.5	228.8	230.1	231.7	233.2	234.8	237.2	238.8
C16L & C17L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C2L	579/754	532.3	539.1	545.0	551.1	557.2	563.6	570.1	576.4	583.4
C14L & C15L	C3L	579/754	556.6	563.8	569.8	576.1	582.2	588.8	595.3	601.7	608.9
C14L & C15L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C16L	579/754	512.2	518.9	523.8	528.8	533.8	539.1	544.4	549.5	555.3
C14L & C15L	C17L	579/754	540.4	547.6	553.7	560.1	566.5	573.1	579.7	586.3	593.5
C14L & C15L	LEASIDE AUTO 11	275/378	278.8	281.8	283.8	285.8	287.9	290.0	292.4	295.3	297.5
C14L & C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 12	312/419	263.0	265.8	267.6	269.5	271.6	273.6	275.9	278.7	280.8
C14L & C15L	LEASIDE AUTO 17	283/422	260.3	263.0	264.9	266.7	268.8	270.8	273.0	275.8	277.9
C14L & C15L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 16	275/384	301.5	305.0	307.5	310.2	313.0	315.8	318.8	322.3	325.2
R1K	MANBY AUTO 12	250/296	74.4	75.4	76.6	77.9	79.4	80.9	82.5	84.5	86.3
R1K	MANBY AUTO T1	368/368	84.3	85.4	86.8	88.3	89.9	91.6	93.5	95.8	97.8
R1K	MANBY AUTO T2	408/408	81.7	82.8	84.1	85.5	87.1	88.8	90.5	92.8	94.7
R1K	MANBY AUTO T7	250/307	135.2	136.8	138.0	139.1	140.4	141.6	142.9	144.4	145.6
R1K	MANBY AUTO T8	369/369	157.9	159.8	161.1	162.5	163.9	165.3	166.8	168.6	170.1
R1K	MANBY AUTO T9	250/307	135.7	137.3	138.4	139.6	140.8	142.1	143.4	144.9	146.1
R1K	R2K	579/669	294.7	297.6	300.2	302.9	306.3	309.3	312.5	321.2	324.1
R1K	R15K	579/669	296.7	299.7	302.4	305.1	308.4	311.5	314.7	323.5	326.4

R1K	CB		319.5	322.6	325.3	328.1	331.6	334.8	338.1	347.8	350.8
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014***	**2015***
R1K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K	R13K	579/669	413.9	417.6	420.6	424.0	427.6	431.1	434.8	480.3	481.4
R1K	CB		450.8	454.7	457.9	461.4	465.2	468.9	472.8	523.4	524.5
R13K	MANBY AUTO 12	250/296	74.4	75.4	76.6	77.9	79.4	80.9	82.5	84.5	86.3
R13K	MANBY AUTO T1	368/368	84.3	85.4	86.8	88.3	89.9	91.6	93.5	95.8	97.8
R13K	MANBY AUTO T2	408/408	81.7	82.8	84.1	85.5	87.1	88.8	90.5	92.8	94.7
R13K	MANBY AUTO T7	250/307	135.2	136.8	138.0	139.1	140.4	141.6	142.9	144.4	145.6
R13K	MANBY AUTO T8	369/369	157.9	159.8	161.1	162.5	163.9	165.3	166.8	168.6	170.1
R13K	MANBY AUTO T9	250/307	135.7	137.3	138.4	139.6	140.8	142.1	143.4	144.9	146.1
R13K	R2K	579/669	294.5	297.4	300.0	302.8	306.1	309.1	312.3	321.0	323.9
R13K	R15K	579/669	296.6	299.5	302.2	304.9	308.2	311.3	314.6	323.2	326.1
R13K	CB		319.3	322.4	325.1	327.9	331.4	334.6	337.9	347.6	350.5
R13K	R1K	579/669	416.3	420.0	423.1	426.4	430.1	433.6	437.4	483.1	484.1
R13K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	CB		449.2	453.1	456.3	459.8	463.6	467.3	471.2	521.6	522.6
R2K	MANBY AUTO 12	250/296	74.3	75.3	76.5	77.7	79.2	80.7	82.3	84.3	86.0
R2K	MANBY AUTO T1	368/368	84.2	85.3	86.6	88.1	89.7	91.4	93.2	95.5	97.5
R2K	MANBY AUTO T2	408/408	81.6	82.6	83.9	85.3	86.9	88.6	90.3	92.6	94.4
R2K	MANBY AUTO T7	250/307	134.8	136.5	137.6	138.8	140.1	141.3	142.6	143.7	145.0
R2K	MANBY AUTO T8	369/369	157.4	159.3	160.7	162.1	163.5	165.0	166.5	167.8	169.3
R2K	MANBY AUTO T9	250/307	135.3	136.9	138.1	139.3	140.5	141.8	143.1	144.2	145.5
R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	R15K	579/669	377.5	381.5	385.0	388.6	393.2	397.2	401.5	410.4	414.4
R2K	CB		404.8	408.9	412.6	416.3	421.1	425.2	429.7	439.6	443.7
R2K	R1K	579/669	314.0	316.8	319.2	321.8	324.6	327.3	330.2	362.0	362.9
R2K	R13K	579/669	311.1	313.9	316.2	318.8	321.6	324.3	327.1	358.6	359.6
R2K	CB		339.4	342.4	344.8	347.5	350.5	353.3	356.2	391.7	392.5
R15K	MANBY AUTO 12	250/296	74.3	75.3	76.5	77.7	79.2	80.7	82.2	84.3	86.0
R15K	MANBY AUTO T1	368/368	84.1	85.2	86.6	88.0	89.7	91.4	93.2	95.5	97.5
R15K	MANBY AUTO T2	408/408	81.5	82.6	83.9	85.3	86.9	88.5	90.3	92.5	94.4
R15K	MANBY AUTO T7	250/307	134.8	136.4	137.6	138.8	140.0	141.3	142.6	143.7	145.0
R15K	MANBY AUTO T8	369/369	157.4	159.3	160.7	162.1	163.5	165.0	166.5	167.8	169.3
R15K	MANBY AUTO T9	250/307	135.3	136.9	138.1	139.3	140.5	141.8	143.1	144.2	145.5
R15K	R2K	579/669	374.3	378.3	381.8	385.4	390.0	393.9	398.2	407.1	411.0
R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	CB		405.1	409.3	412.9	416.6	421.5	425.6	430.1	440.0	444.0

R15K	R1K	579/669	313.9	316.8	319.1	321.7	324.6	327.3	330.2	361.9	362.8
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014***	**2015***
R15K	R13K	579/669	311.0	313.8	316.2	318.7	321.6	324.3	327.1	358.5	359.5
R15K	CB		339.4	342.3	344.7	347.4	350.4	353.2	356.2	391.6	392.4
R1K & R2K	MANBY AUTO 12	250/296	74.3	75.2	76.4	77.7	79.1	80.6	82.2	84.3	86.0
R1K & R2K	MANBY AUTO T1	368/368	84.1	85.2	86.6	88.0	89.7	91.4	93.2	95.5	97.5
R1K & R2K	MANBY AUTO T2	408/408	81.5	82.6	83.9	85.3	86.9	88.5	90.2	92.5	94.4
R1K & R2K	MANBY AUTO T7	250/307	134.9	136.5	137.6	138.8	140.0	141.3	142.5	144.0	145.3
R1K & R2K	MANBY AUTO T8	369/369	157.5	159.4	160.7	162.1	163.5	164.9	166.4	168.1	169.6
R1K & R2K	MANBY AUTO T9	250/307	135.3	137.0	138.1	139.3	140.5	141.7	143.0	144.5	145.8
R1K & R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R15K	579/669	398.6	402.8	406.5	410.3	415.1	419.2	423.7	434.9	438.9
R1K & R2K	CB		427.5	431.8	435.6	439.5	444.5	448.9	453.5	465.9	470.0
R1K & R2K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R13K	579/669	431.1	434.9	438.1	441.7	445.6	449.2	453.1	497.4	498.6
R1K & R2K	CB		469.3	473.4	476.7	480.5	484.6	488.5	492.6	541.9	543.0
R13K & R15K	MANBY AUTO 12	250/296	74.2	75.2	76.4	77.7	79.1	80.6	82.2	84.3	86.0
R13K & R15K	MANBY AUTO T1	368/368	84.1	85.2	86.5	88.0	89.6	91.3	93.1	95.5	97.4
R13K & R15K	MANBY AUTO T2	408/408	81.5	82.6	83.9	85.2	86.8	88.5	90.2	92.5	94.4
R13K & R15K	MANBY AUTO T7	250/307	134.9	136.5	137.6	138.8	140.0	141.2	142.5	144.0	145.2
R13K & R15K	MANBY AUTO T8	369/369	157.5	159.4	160.7	162.0	163.5	164.9	166.4	168.1	169.6
R13K & R15K	MANBY AUTO T9	250/307	135.3	136.9	138.1	139.3	140.5	141.7	143.0	144.5	145.7
R13K & R15K	R2K	579/669	395.2	399.4	403.0	406.8	411.5	415.7	420.1	431.2	435.1
R13K & R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		427.5	431.9	435.7	439.6	444.6	449.0	453.6	465.9	470.0
R13K & R15K	R1K	579/669	433.5	437.4	440.6	444.1	448.1	451.8	455.7	500.1	501.3
R13K & R15K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		467.5	471.6	475.0	478.7	482.8	486.7	490.8	539.8	541.0
H2JK	H2JK	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	K6J	249/267	164.9	168.8	173.8	178.8	183.7	188.9	193.9	198.9	204.8
H2JK	K13J	225/225	53.3	54.0	55.1	56.4	57.7	59.1	60.4	61.4	62.9
H2JK	K14J		139.0	142.1	145.3	148.5	151.9	155.4	159.1	161.7	165.5
H2JK	K1J		147.7	150.2	152.8	155.4	158.2	161.2	164.4	167.9	171.3
H2JK	K2J		148.7	151.3	154.0	156.8	159.8	162.9	165.9	169.1	172.4
K6J	H2JK	249/267	113.1	116.8	120.5	124.4	128.4	132.6	137.5	141.6	146.3
K6J	K6J	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K6J	K13J	225/225	97.7	98.8	100.9	103.0	105.2	107.6	109.8	111.6	114.0

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
K6J	K14J		139.0	142.1	145.3	148.6	152.0	155.4	159.1	161.7	165.6
K6J	K1J		147.5	150.0	152.7	155.3	158.1	161.0	164.2	167.7	171.1
K6J	K2J		148.5	151.1	153.8	156.6	159.6	162.7	165.7	168.9	172.2
K13J	H2JK	249/267	65.8	67.8	69.8	72.0	74.3	76.6	79.6	81.8	84.5
K13J	K6J	249/267	148.5	151.3	155.4	159.4	163.4	168.0	171.3	175.0	179.8
K13J	K13J	225/225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K13J	K14J		139.0	142.2	145.4	148.6	152.0	155.5	159.2	161.8	165.6
K13J	K1J		147.7	150.2	152.8	155.5	158.3	161.2	164.4	168.0	171.3
K13J	K2J		148.7	151.3	154.1	156.9	159.8	162.9	165.9	169.1	172.4
K14J	R2K	579/669	246.2	248.3	250.1	251.9	254.4	256.5	258.7	265.1	267.1
K14J	R15K	579/669	248.2	250.3	252.2	254.0	256.5	258.6	260.8	267.2	269.2
K14J	CB		267.6	269.8	271.6	273.5	276.1	278.2	280.5	287.7	289.6
K14J	R1K	579/669	320.0	323.6	326.7	329.9	333.3	336.9	340.5	364.2	365.8
K14J	R13K	579/669	317.0	320.6	323.6	326.9	330.3	333.8	337.4	360.8	362.4
K14J	CB		345.4	349.2	352.3	355.7	359.3	363.0	366.8	393.5	395.2
K14J	H2JK	249/267	62.9	64.8	66.7	68.8	71.0	73.2	75.9	78.1	80.7
K14J	K6J	249/267	104.4	106.5	109.6	112.8	115.7	119.1	121.9	124.8	128.6
K14J	K13J	225/225	51.3	51.9	53.0	54.1	55.3	56.6	57.8	58.8	60.2
K14J	K14J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K14J	K1J		202.4	207.0	211.1	215.7	220.4	225.5	231.5	236.8	242.2
K14J	K2J		203.4	208.0	212.8	217.5	222.3	227.5	231.6	236.0	241.4
K1J	R2K	579/669	286.1	289.3	292.3	295.3	298.9	302.3	305.8	311.9	315.2
K1J	R15K	579/669	288.2	291.4	294.4	297.5	301.0	304.5	308.1	314.1	317.5
K1J	CB		310.0	313.3	316.4	319.6	323.3	326.9	330.6	337.3	340.8
K1J	R1K	579/669	272.5	275.0	277.2	279.5	281.9	284.2	286.5	314.6	315.2
K1J	R13K	579/669	270.0	272.4	274.6	276.9	279.3	281.6	283.9	311.7	312.3
K1J	CB		294.6	297.2	299.5	301.8	304.3	306.7	309.1	340.8	341.3
K1J	H2JK	249/267	62.6	64.5	66.4	68.5	70.6	72.8	75.6	77.7	80.3
K1J	K6J	249/267	103.9	106.1	109.1	112.2	115.2	118.5	121.2	124.2	128.0
K1J	K13J	225/225	51.1	51.7	52.7	53.9	55.1	56.3	57.6	58.6	59.9
K1J	K14J		205.3	210.2	215.1	219.9	225.1	230.4	235.8	239.1	244.8
K1J	K1J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1J	K2J		208.3	212.8	218.1	223.0	228.0	233.2	237.5	241.9	247.6
K2J	R2K	579/669	286.5	289.7	292.7	295.8	299.3	302.7	306.3	312.3	315.7
K2J	R15K	579/669	288.6	291.8	294.8	297.9	301.5	305.0	308.5	314.5	318.0
K2J	CB		310.4	313.7	316.9	320.1	323.8	327.4	331.1	337.8	341.3

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014*	2015*
K2J	R1K	579/669	272.1	274.6	276.7	278.9	281.3	283.6	286.3	314.7	315.3
K2J	R13K	579/669	269.6	272.0	274.1	276.3	278.7	281.0	283.6	311.8	312.4
K2J	CB		294.2	296.8	298.9	301.2	303.7	306.1	308.8	340.8	341.4
K2J	H2JK	249/267	62.6	64.5	66.4	68.5	70.6	72.8	75.6	77.7	80.3
K2J	K6J	249/267	103.9	106.1	109.1	112.2	115.2	118.5	121.2	124.2	127.9
K2J	K13J	225/225	51.1	51.7	52.8	53.9	55.1	56.3	57.6	58.5	59.9
K2J	K14J		207.2	212.1	217.1	222.1	227.2	232.6	238.1	241.6	247.3
K2J	K1J		205.7	210.2	214.7	219.4	224.3	229.4	235.8	240.8	246.4
K2J	K2J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Rating: continuous rating/emergency continuous rating for 50h/year for circuits; continuous rating/10 day LTR for transformers
* 2014 and 2015: one additional cap bank rated at 260MVAr/230kV is placed at Manby E for voltage support

Appendix G: Voltage Decline under Contingency (AC Option-1) (in kV)

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013			2014			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
C2L	2100	CHERYDK1 220	239.4	-0.2	-0.2	239.0	-0.2	-0.2	238.7	-0.2	-0.2	238.3	-0.2	-0.2	238.1	-0.2	-0.2	237.6	-0.2	-0.2	237.1	-0.2	-0.2	238.3	-0.2	-0.2	237.6	-0.1	-0.3
C2L	2102	CHERYDK3 220	239.7	-0.2	-0.2	239.3	-0.2	-0.2	239.0	-0.2	-0.2	238.6	-0.2	-0.3	238.4	-0.2	-0.3	237.9	-0.2	-0.3	237.5	-0.2	-0.3	238.6	-0.2	-0.3	238.0	-0.3	-0.4
C2L	3102	LEAS 215 220	238.4	-0.2	-0.3	237.8	-0.3	-0.3	237.2	-0.3	-0.4	236.6	-0.3	-0.4	236.2	-0.3	-0.4	235.4	-0.4	-0.5	234.8	-0.4	-0.4	235.9	-0.4	-0.5	234.9	-0.4	-0.6
C2L	3103	LEAS 317 220	238.4	-0.5	-0.6	237.8	-0.6	-0.6	237.3	-0.6	-0.7	236.6	-0.6	-0.7	236.2	-0.7	-0.8	235.4	-0.7	-0.8	234.8	-0.7	-0.8	235.9	-0.7	-0.8	234.9	-0.8	-1.0
C2L	3104	LEAS1416 220	238.4	-0.5	-0.6	237.8	-0.6	-0.6	237.3	-0.6	-0.7	236.7	-0.6	-0.7	236.2	-0.7	-0.8	235.5	-0.7	-0.8	234.8	-0.7	-0.8	235.9	-0.7	-0.8	234.9	-0.8	-1.0
C2L	3301	LEAS EJ 118	126.2	-0.3	-0.3	125.7	-0.4	-0.4	125.4	-0.4	-0.5	124.9	-0.5	-0.6	124.5	-0.5	-0.7	124.0	-0.6	-0.8	123.6	-0.6	-0.7	124.1	-0.6	-0.8	123.4	-0.7	-1.0
C2L	3300	HEARN 118	126.4	-0.3	-0.3	125.9	-0.4	-0.4	125.5	-0.4	-0.5	125.0	-0.5	-0.6	124.6	-0.5	-0.7	124.1	-0.6	-0.8	123.6	-0.6	-0.7	124.1	-0.6	-0.8	123.4	-0.7	-1.0
C2L	3401	TERAUT5E 118	125.4	-0.3	-0.3	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.6	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.6	-0.8	122.4	-0.7	-1.1
C2L	3402	TERAUT7E 118	125.4	-0.3	-0.3	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.6	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.6	-0.8	122.4	-0.7	-1.1
C3L	2100	CHERYDK1 220	239.4	-0.2	-0.2	239.0	-0.1	-0.2	238.7	-0.1	-0.2	238.3	-0.1	-0.2	238.1	-0.1	-0.2	237.6	-0.1	-0.2	237.1	-0.1	-0.2	238.3	-0.1	-0.2	237.6	-0.1	-0.2
C3L	2102	CHERYDK3 220	239.7	-0.2	-0.2	239.3	-0.2	-0.2	239.0	-0.2	-0.3	238.6	-0.2	-0.3	238.4	-0.2	-0.3	237.9	-0.3	-0.3	237.5	-0.3	-0.3	238.6	-0.3	-0.3	238.0	-0.3	-0.4
C3L	3102	LEAS 215 220	238.4	-0.6	-0.7	237.8	-0.7	-0.7	237.2	-0.7	-0.8	236.6	-0.7	-0.8	236.2	-0.8	-0.9	235.4	-0.8	-0.9	234.8	-0.8	-0.9	235.9	-0.8	-0.9	234.9	-0.9	-1.1
C3L	3103	LEAS 317 220	238.4	-0.3	-0.3	237.8	-0.3	-0.4	237.3	-0.3	-0.4	236.6	-0.4	-0.4	236.2	-0.4	-0.5	235.4	-0.4	-0.5	234.8	-0.5	-0.5	235.9	-0.5	-0.5	234.9	-0.5	-0.7
C3L	3104	LEAS1416 220	238.4	-0.4	-0.5	237.8	-0.5	-0.5	237.3	-0.5	-0.5	236.7	-0.5	-0.6	236.2	-0.5	-0.6	235.5	-0.6	-0.7	234.8	-0.6	-0.7	235.9	-0.6	-0.7	234.9	-0.6	-0.9
C3L	3301	LEAS EJ 118	126.2	-0.3	-0.4	125.7	-0.4	-0.4	125.4	-0.4	-0.5	124.9	-0.5	-0.6	124.5	-0.5	-0.7	124.0	-0.6	-0.8	123.6	-0.6	-0.7	124.1	-0.7	-0.8	123.4	-0.7	-1.0
C3L	3300	HEARN 118	126.4	-0.3	-0.4	125.9	-0.4	-0.4	125.5	-0.4	-0.5	125.0	-0.5	-0.6	124.6	-0.5	-0.7	124.1	-0.6	-0.8	123.6	-0.6	-0.7	124.1	-0.7	-0.8	123.4	-0.7	-1.1
C3L	3401	TERAUT5E 118	125.4	-0.3	-0.4	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.6	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.7	-0.8	122.4	-0.7	-1.1
C3L	3402	TERAUT7E 118	125.4	-0.3	-0.4	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.6	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.7	-0.8	122.4	-0.7	-1.1
C14L	2100	CHERYDK1 220	239.4	-0.1	-0.2	239.0	-0.1	-0.2	238.7	-0.1	-0.2	238.3	-0.1	-0.2	238.1	-0.1	-0.2	237.6	-0.1	-0.2	237.1	-0.1	-0.2	238.3	-0.1	-0.2	237.6	-0.1	-0.2
C14L	2102	CHERYDK3 220	239.7	-0.2	-0.3	239.3	-0.3	-0.3	239.0	-0.3	-0.3	238.6	-0.3	-0.3	238.4	-0.3	-0.3	237.9	-0.3	-0.4	237.5	-0.3	-0.3	238.6	-0.3	-0.4	238.0	-0.3	-0.5
C14L	3102	LEAS 215 220	238.4	-0.5	-0.6	237.8	-0.6	-0.6	237.2	-0.6	-0.6	236.6	-0.6	-0.7	236.2	-0.6	-0.8	235.4	-0.7	-0.8	234.8	-0.7	-0.8	235.9	-0.7	-0.8	234.9	-0.8	-1.0
C14L	3103	LEAS 317 220	238.4	-0.7	-0.7	237.8	-0.7	-0.8	237.3	-0.8	-0.8	236.6	-0.8	-0.9	236.2	-0.8	-1.0	235.4	-0.9	-1.0	234.8	-0.9	-1.0	235.9	-0.9	-1.0	234.9	-1.0	-1.2
C14L	3104	LEAS1416 220	238.4	-0.2	-0.3	237.8	-0.3	-0.3	237.3	-0.3	-0.4	236.7	-0.3	-0.4	236.2	-0.3	-0.5	235.5	-0.4	-0.5	234.8	-0.4	-0.5	235.9	-0.4	-0.5	234.9	-0.4	-0.7
C14L	3301	LEAS EJ 118	126.2	-0.4	-0.4	125.7	-0.4	-0.5	125.4	-0.5	-0.6	124.9	-0.5	-0.6	124.5	-0.6	-0.8	124.0	-0.6	-0.9	123.6	-0.7	-0.8	124.1	-0.7	-0.8	123.4	-0.8	-1.2
C14L	3300	HEARN 118	126.4	-0.4	-0.4	125.9	-0.4	-0.5	125.5	-0.5	-0.6	125.0	-0.5	-0.6	124.6	-0.6	-0.8	124.1	-0.6	-0.9	123.6	-0.7	-0.8	124.1	-0.7	-0.9	123.4	-0.8	-1.2
C14L	3401	TERAUT5E 118	125.4	-0.4	-0.4	124.9	-0.4	-0.5	124.5	-0.5	-0.6	124.0	-0.5	-0.6	123.6	-0.6	-0.8	123.1	-0.6	-0.9	122.6	-0.7	-0.8	123.1	-0.7	-0.9	122.4	-0.8	-1.2
C14L	3402	TERAUT7E 118	125.4	-0.4	-0.4	124.9	-0.4	-0.5	124.5	-0.5	-0.6	124.0	-0.5	-0.6	123.6	-0.6	-0.8	123.1	-0.6	-0.9	122.6	-0.7	-0.8	123.1	-0.7	-0.9	122.4	-0.8	-1.2
C15L	2100	CHERYDK1 220	239.4	-0.2	-0.2	239.0	-0.2	-0.2	238.7	-0.2	-0.2	238.3	-0.2	-0.3	238.1	-0.2	-0.3	237.6	-0.2	-0.3	237.1	-0.3	-0.3	238.3	-0.3	-0.3	237.6	-0.3	-0.4
C15L	2102	CHERYDK3 220	239.7	-0.1	-0.1	239.3	-0.1	-0.1	239.0	-0.1	-0.1	238.6	-0.1	-0.1	238.4	-0.1	-0.1	237.9	-0.1	-0.1	237.5	0.0	-0.1	238.6	0.0	-0.1	238.0	0.0	-0.1
C15L	3102	LEAS 215 220	238.4	-0.4	-0.5	237.8	-0.5	-0.5	237.2	-0.5	-0.5	236.6	-0.5	-0.6	236.2	-0.6	-0.6	235.4	-0.6	-0.7	234.8	-0.6	-0.7	235.9	-0.6	-0.7	234.9	-0.7	-0.9
C15L	3103	LEAS 317 220	238.4	-0.5	-0.5	237.8	-0.5	-0.6	237.3	-0.5	-0.6	236.6	-0.6	-0.6	236.2	-0.6	-0.7	235.4	-0.6	-0.7	234.8	-0.6	-0.7	235.9	-0.7	-0.7	234.9	-0.7	-0.9
C15L	3104	LEAS1416 220	238.4	-0.4	-0.4	237.8	-0.4	-0.5	237.3	-0.4	-0.5	236.7	-0.4	-0.5	236.2	-0.5	-0.6	235.5	-0.5	-0.6	234.8	-0.5	-0.6	235.9	-0.5	-0.6	234.9	-0.6	-0.8
C15L	3301	LEAS EJ 118	126.2	-0.3	-0.3	125.7	-0.3	-0.4	125.4	-0.4	-0.4	124.9	-0.4	-0.5	124.5	-0.5	-0.6	124.0	-0.5	-0.7	123.6	-0.6	-0.6	124.1	-0.6	-0.7	123.4	-0.7	-0.9
C15L	3300	HEARN 118	126.4	-0.3	-0.3	125.9	-0.3	-0.4	125.5	-0.4	-0.4	125.0	-0.4	-0.5	124.6	-0.5	-0.6	124.1	-0.5	-0.7	123.6	-0.6	-0.6	124.1	-0.6	-0.7	123.4	-0.7	-1.0
C15L	3401	TERAUT5E 118	125.4	-0.3	-0.3	124.9	-0.3	-0.4	124.5	-0.4	-0.4	124.0	-0.4	-0.5	123.6	-0.5	-0.6	123.1	-0.5	-0.7	122.6	-0.6	-0.6	123.1	-0.6	-0.7	122.4	-0.7	-1.0
C15L	3402	TERAUT7E 118	125.4	-0.3	-0.3	124.9	-0.3	-0.4	124.5	-0.4	-0.4	124.0	-0.4	-0.5	123.6	-0.5	-0.6	123.1	-0.5	-0.7	122.6	-0.6	-0.6	123.1	-0.6	-0.7	122.4	-0.7	-1.0
C16L	2100	CHERYDK1 220	239.4	-0.2	-0.2	239.0	-0.2	-0.2	238.7	-0.2	-0.2	238.3	-0.2	-0.2	238.1	-0.2	-0.2	237.6	-0.2	-0.2	237.1	-0.2	-0.2	238.3	-0.2	-0.2	237.6	-0.2	-0.3
C16L	2102	CHERYDK3 220	239.7	-0.1	-0.1	239.3	-0.1	-0.1	239.0	-0.1	-0.1	238.6	-0.1	-0.1	238.4	-0.1	-0.1	237.9	-0.1	-0.1	237.5	-0.1	-0.1	238.6	-0.1	-0.1	238.0	-0.1	-0.1
C16L	3102	LEAS 215 220	238.4	-0.4	-0.4	237.8	-0.4	-0.5	237.2	-0.5	-0.5	236.6	-0.5	-0.5	236.2	-0.5	-0.6	235.4	-0.5	-0.6	234.8	-0.6	-0.6	235.9	-0.6	-0.6	234.9	-0.6	-0.8
C16L	3103	LEAS 317 220	238.4	-0.4	-0.4	237.8	-0.4	-0.4	237.3	-0.4	-0.5	236.6	-0.5	-0.5	236.2	-0.5	-0.5	235.4	-0.5	-0.6	234.8	-0.5	-0.6	235.9	-0.5	-0.6	234.9	-0.6	-0.7
C16L	3104	LEAS1416 220	238.4	-0.4	-0.5	237.8	-0.5	-0.5	237.3	-0.5	-0.5	236.7	-0.5	-0.6	236.2	-0.6	-0.6	235.5	-0.6	-0.7	234.8	-0.6	-0.7	235.9	-0.6	-0.7	234.9	-0.7	-0.8
C16L	3301	LEAS EJ 118	126.2	-0.2	-0.3	125.7	-0.3	-0.3	125.4	-0.3	-0.4	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.6	123.6	-0.5	-0.6	124.1	-0.6	-0.6	123.4	-0.6	-0.9
C16L	3300	HEARN 118	126.4	-0.2	-0.3	125.9	-0.3	-0.3	125.5	-0.3	-0.4	125.0	-0.4	-0.4	124.6	-0.4	-0.5	124.1	-0.5	-0.6	123.6	-0.5	-0.6	124.1	-0.6	-0.6	123.4	-0.6	-0.9
C16L	3401	TERAUT5E 118	125.4	-0.2	-0.3	124.9	-0.3	-0.3	124.5	-0.3	-0.4	124.0	-0.4	-0.4	123.6	-0.4	-0.5	123.1	-0.5	-0.6	122.6	-0.5	-0.6	123.1	-0.6	-0.6	122.4	-0.6	-0.9
C16L	3402	TERAUT7E 118	125.4	-0.2	-0.3	124.9	-0.3	-0.3	124.5	-0.3	-0.4	124.0	-0.4	-0.4	123.6	-0.4	-0.5	123.1	-0.5	-0.6	122.6	-0.5	-0.6	123.1	-0.6	-0.6	122.4	-0.6	-0.9
C17L	2100	CHERYDK1 220	239.4	-0.2	-0.2	239.0	-0.2	-0.3	238.7	-0.2	-0.3	238.3	-0.3	-0.3	238.1	-0.3	-0.3	237.6	-0.3	-0.3	237.1	-0.3	-0.3	238.3	-0.3	-0.3	237.6	-0.3	-0.4

C17L	2102	CHERYDK3 220	239.7	-0.1	-0.1	239.3	-0.1	-0.1	239.0	-0.1	-0.1	238.6	-0.1	-0.1	238.4	-0.1	-0.1	237.9	-0.1	-0.1	237.5	-0.1	-0.1	238.6	-0.1	-0.1	238.0	0.0	-0.1
CASE/CONT.	**BN**	**BUS NAME**	**2007**			**2008**			**2009**			**2010**			**2011**			**2012**			**2013**			**2014**			**2015***		
			Pre	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**
C17L	3102	LEAS 215 220	238.4	-0.4	-0.4	237.8	-0.4	-0.4	237.2	-0.4	-0.4	236.6	-0.4	-0.5	236.2	-0.5	-0.6	235.4	-0.5	-0.6	234.8	-0.5	-0.6	235.9	-0.5	-0.6	234.9	-0.5	-0.7
C17L	3103	LEAS 317 220	238.4	-0.4	-0.4	237.8	-0.5	-0.5	237.3	-0.5	-0.5	236.6	-0.5	-0.6	236.2	-0.5	-0.6	235.4	-0.6	-0.7	234.8	-0.6	-0.6	235.9	-0.6	-0.7	234.9	-0.6	-0.8
C17L	3104	LEAS1416 220	238.4	-0.6	-0.7	237.8	-0.7	-0.7	237.3	-0.7	-0.8	236.7	-0.7	-0.8	236.2	-0.8	-0.9	235.5	-0.8	-0.9	234.8	-0.8	-0.9	235.9	-0.8	-0.9	234.9	-0.9	-1.1
C17L	3301	LEAS EJ 118	126.2	-0.3	-0.3	125.7	-0.4	-0.4	125.4	-0.4	-0.5	124.9	-0.5	-0.5	124.5	-0.5	-0.7	124.0	-0.6	-0.7	123.6	-0.6	-0.7	124.1	-0.6	-0.7	123.4	-0.7	-1.0
C17L	3300	HEARN 118	126.4	-0.3	-0.3	125.9	-0.4	-0.4	125.5	-0.4	-0.5	125.0	-0.5	-0.5	124.6	-0.5	-0.7	124.1	-0.6	-0.8	123.6	-0.6	-0.7	124.1	-0.6	-0.7	123.4	-0.7	-1.0
C17L	3401	TERAUT5E 118	125.4	-0.3	-0.3	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.5	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.6	-0.8	122.4	-0.7	-1.0
C17L	3402	TERAUT7E 118	125.4	-0.3	-0.3	124.9	-0.4	-0.4	124.5	-0.4	-0.5	124.0	-0.5	-0.5	123.6	-0.5	-0.7	123.1	-0.6	-0.8	122.6	-0.6	-0.7	123.1	-0.6	-0.8	122.4	-0.7	-1.0
C2L & C3L	2100	CHERYDK1 220	239.4	0.0	-0.1	239.0	0.0	-0.1	238.7	0.0	-0.1	238.3	0.0	-0.1	238.1	0.0	-0.1	237.6	0.0	-0.1	237.1	0.0	-0.1	238.3	0.1	-0.1	237.6	0.1	-0.2
C2L & C3L	2102	CHERYDK3 220	239.7	-0.3	-0.4	239.3	-0.4	-0.5	239.0	-0.4	-0.5	238.6	-0.4	-0.5	238.4	-0.4	-0.6	237.9	-0.4	-0.7	237.5	-0.5	-0.6	238.6	-0.5	-0.7	238.0	-0.5	-0.9
C2L & C3L	3102	LEAS 215 220	238.4	-0.7	-0.9	237.8	-0.8	-1.0	237.2	-0.9	-1.1	236.6	-0.9	-1.2	236.2	-1.0	-1.4	235.4	-1.1	-1.6	234.8	-1.2	-1.6	235.9	-1.2	-1.6	234.9	-1.3	-2.1
C2L & C3L	3103	LEAS 317 220	238.4	-0.6	-0.8	237.8	-0.7	-0.9	237.3	-0.8	-1.0	236.6	-0.8	-1.1	236.2	-0.9	-1.3	235.4	-1.0	-1.5	234.8	-1.1	-1.4	235.9	-1.1	-1.5	234.9	-1.2	-2.0
C2L & C3L	3104	LEAS1416 220	238.4	-1.1	-1.3	237.8	-1.2	-1.5	237.3	-1.2	-1.5	236.7	-1.3	-1.7	236.2	-1.4	-1.9	235.5	-1.5	-2.0	234.8	-1.5	-2.0	235.9	-1.6	-2.1	234.9	-1.7	-2.7
C2L & C3L	3301	LEAS EJ 118	126.2	-0.5	-0.7	125.7	-0.7	-0.9	125.4	-0.8	-1.1	124.9	-0.9	-1.3	124.5	-1.0	-1.7	124.0	-1.2	-2.0	123.6	-1.3	-1.9	124.1	-1.3	-2.1	123.4	-1.5	-3.0
C2L & C3L	3300	HEARN 118	126.4	-0.5	-0.7	125.9	-0.7	-1.0	125.5	-0.8	-1.1	125.0	-0.9	-1.3	124.6	-1.0	-1.7	124.1	-1.2	-2.0	123.6	-1.3	-2.0	124.1	-1.3	-2.1	123.4	-1.5	-3.0
C2L & C3L	3401	TERAUT5E 118	125.4	-0.5	-0.7	124.9	-0.7	-1.0	124.5	-0.8	-1.1	124.0	-0.9	-1.3	123.6	-1.0	-1.7	123.1	-1.2	-2.0	122.6	-1.3	-2.0	123.1	-1.3	-2.1	122.4	-1.5	-3.0
C2L & C3L	3402	TERAUT7E 118	125.4	-0.5	-0.7	124.9	-0.7	-1.0	124.5	-0.8	-1.1	124.0	-0.9	-1.3	123.6	-1.0	-1.7	123.1	-1.2	-2.0	122.6	-1.3	-2.0	123.1	-1.3	-2.1	122.4	-1.5	-3.0
C16L & C17L	2100	CHERYDK1 220	239.4	-0.6	-0.7	239.0	-0.6	-0.7	238.7	-0.6	-0.7	238.3	-0.6	-0.8	238.1	-0.7	-0.9	237.6	-0.7	-1.0	237.1	-0.7	-0.9	238.3	-0.7	-1.0	237.6	-0.8	-1.2
C16L & C17L	2102	CHERYDK3 220	239.7	-0.1	-0.2	239.3	-0.1	-0.2	239.0	-0.1	-0.2	238.6	-0.1	-0.2	238.4	-0.1	-0.2	237.9	-0.1	-0.2	237.5	-0.1	-0.2	238.6	0.0	-0.2	238.0	0.0	-0.3
C16L & C17L	3102	LEAS 215 220	238.4	-1.1	-1.3	237.8	-1.1	-1.4	237.2	-1.2	-1.5	236.6	-1.3	-1.6	236.2	-1.3	-1.8	235.4	-1.4	-2.0	234.8	-1.5	-1.9	235.9	-1.5	-2.0	234.9	-1.6	-2.5
C16L & C17L	3103	LEAS 317 220	238.4	-1.1	-1.4	237.8	-1.2	-1.5	237.3	-1.3	-1.6	236.6	-1.4	-1.8	236.2	-1.5	-1.9	235.4	-1.6	-2.2	234.8	-1.6	-2.1	235.9	-1.7	-2.2	234.9	-1.8	-2.7
C16L & C17L	3104	LEAS1416 220	238.4	-1.7	-2.0	237.8	-1.8	-2.1	237.3	-1.9	-2.2	236.7	-2.0	-2.4	236.2	-2.1	-2.6	235.5	-2.2	-2.9	234.8	-2.3	-2.8	235.9	-2.3	-3.0	234.9	-2.5	-3.5
C16L & C17L	3301	LEAS EJ 118	126.2	-0.9	-1.2	125.7	-1.0	-1.4	125.4	-1.1	-1.6	124.9	-1.3	-1.9	124.5	-1.4	-2.2	124.0	-1.6	-2.6	123.6	-1.7	-2.5	124.1	-1.7	-2.6	123.4	-1.9	-3.4
C16L & C17L	3300	HEARN 118	126.4	-0.9	-1.3	125.9	-1.0	-1.4	125.5	-1.1	-1.6	125.0	-1.3	-1.9	124.6	-1.4	-2.2	124.1	-1.6	-2.7	123.6	-1.7	-2.5	124.1	-1.7	-2.7	123.4	-1.9	-3.4
C16L & C17L	3401	TERAUT5E 118	125.4	-0.9	-1.3	124.9	-1.0	-1.4	124.5	-1.1	-1.6	124.0	-1.3	-1.9	123.6	-1.4	-2.2	123.1	-1.6	-2.7	122.6	-1.7	-2.5	123.1	-1.7	-2.7	122.4	-1.9	-3.5
C16L & C17L	3402	TERAUT7E 118	125.4	-0.9	-1.3	124.9	-1.0	-1.4	124.5	-1.1	-1.6	124.0	-1.3	-1.9	123.6	-1.4	-2.2	123.1	-1.6	-2.7	122.6	-1.7	-2.5	123.1	-1.7	-2.7	122.4	-1.9	-3.5
C14L & C15L	2100	CHERYDK1 220	239.4	-0.4	-0.5	239.0	-0.4	-0.5	238.7	-0.4	-0.5	238.3	-0.4	-0.6	238.1	-0.4	-0.6	237.6	-0.4	-0.6	237.1	-0.4	-0.6	238.3	-0.4	-0.6	237.6	-0.4	-0.8
C14L & C15L	2102	CHERYDK3 220	239.7	-0.3	-0.5	239.3	-0.3	-0.5	239.0	-0.4	-0.5	238.6	-0.4	-0.5	238.4	-0.4	-0.6	237.9	-0.4	-0.6	237.5	-0.4	-0.6	238.6	-0.4	-0.6	238.0	-0.4	-0.8
C14L & C15L	3102	LEAS 215 220	238.4	-1.2	-1.5	237.8	-1.3	-1.6	237.2	-1.4	-1.7	236.6	-1.5	-1.8	236.2	-1.5	-2.0	235.4	-1.6	-2.2	234.8	-1.7	-2.1	235.9	-1.7	-2.3	234.9	-1.8	-2.7
C14L & C15L	3103	LEAS 317 220	238.4	-1.3	-1.6	237.8	-1.4	-1.7	237.3	-1.5	-1.8	236.6	-1.6	-1.9	236.2	-1.6	-2.1	235.4	-1.7	-2.3	234.8	-1.8	-2.2	235.9	-1.8	-2.4	234.9	-1.9	-2.8
C14L & C15L	3104	LEAS1416 220	238.4	-0.8	-1.1	237.8	-0.9	-1.1	237.3	-1.0	-1.3	236.7	-1.0	-1.4	236.2	-1.1	-1.5	235.5	-1.1	-1.7	234.8	-1.2	-1.6	235.9	-1.2	-1.7	234.9	-1.3	-2.2
C14L & C15L	3301	LEAS EJ 118	126.2	-0.8	-1.2	125.7	-1.0	-1.3	125.4	-1.1	-1.6	124.9	-1.2	-1.8	124.5	-1.3	-2.1	124.0	-1.5	-2.4	123.6	-1.6	-2.3	124.1	-1.6	-2.5	123.4	-1.8	-3.3
C14L & C15L	3300	HEARN 118	126.4	-0.8	-1.2	125.9	-1.0	-1.3	125.5	-1.1	-1.6	125.0	-1.2	-1.8	124.6	-1.3	-2.1	124.1	-1.5	-2.5	123.6	-1.6	-2.3	124.1	-1.6	-2.6	123.4	-1.8	-3.3
C14L & C15L	3401	TERAUT5E 118	125.4	-0.8	-1.2	124.9	-1.0	-1.3	124.5	-1.1	-1.6	124.0	-1.2	-1.8	123.6	-1.3	-2.2	123.1	-1.5	-2.5	122.6	-1.6	-2.3	123.1	-1.6	-2.6	122.4	-1.8	-3.3
C14L & C15L	3402	TERAUT7E 118	125.4	-0.8	-1.2	124.9	-1.0	-1.3	124.5	-1.1	-1.6	124.0	-1.2	-1.8	123.6	-1.3	-2.2	123.1	-1.5	-2.5	122.6	-1.6	-2.3	123.1	-1.6	-2.6	122.4	-1.8	-3.3
R1K	2100	CHERYDK1 220	239.4	0.0	0.0	239.0	0.0	0.0	238.7	0.0	0.0	238.3	0.0	0.0	238.1	0.0	0.0	237.6	0.0	0.0	237.1	0.0	0.0	238.3	0.0	0.0	237.6	0.0	0.0
R1K	2102	CHERYDK3 220	239.7	0.0	0.0	239.3	0.0	0.0	239.0	0.0	0.0	238.6	0.0	0.0	238.4	0.0	0.0	237.9	0.0	0.0	237.5	0.0	0.0	238.6	0.0	0.0	238.0	0.0	0.0
R1K	4103	RICH AH2 220	238.0	0.0	0.0	237.5	0.0	0.0	237.1	0.0	0.0	236.5	0.0	0.0	236.1	0.0	0.0	235.4	0.0	0.0	234.7	0.0	0.0	237.8	0.0	0.0	236.8	0.0	0.0
R1K	3107	MANBY E 220	238.7	0.0	0.0	238.1	0.0	0.0	237.7	0.0	0.0	237.0	0.0	0.0	236.6	0.0	0.0	235.8	0.0	0.0	235.0	0.0	0.0	239.3	0.1	0.1	238.2	0.1	0.1
R1K	3302	MANBY E 118	122.1	0.0	0.0	121.7	0.0	0.0	121.4	0.0	0.0	121.0	0.0	0.0	120.8	0.0	0.0	120.3	0.0	0.0	119.8	0.0	0.0	122.0	0.2	0.2	121.4	0.1	0.1
R1K	3108	MANBY W 220	238.5	0.0	0.0	238.0	0.0	0.0	237.5	0.0	0.0	236.8	0.0	0.0	236.4	0.0	0.0	235.6	0.0	0.0	234.9	0.0	0.0	238.1	0.0	0.0	237.0	0.0	0.0
R1K	3303	MANBY W 118	122.9	0.0	0.0	122.6	0.0	0.0	122.2	0.0	0.0	121.8	0.0	0.0	121.5	0.0	0.0	121.0	0.0	0.0	120.5	0.0	0.0	122.2	0.0	0.0	121.5	0.0	0.0
R1K	4143	COOKVL15 220	237.6	0.0	0.0	237.1	0.0	0.0	236.6	0.0	0.0	235.9	0.0	0.0	235.5	0.0	0.0	234.7	0.0	0.0	233.9	0.0	0.0	237.7	0.1	0.1	236.6	0.1	0.1
R1K	4192	LORNEB15 220	237.1	0.0	0.0	236.5	0.0	0.0	236.0	0.0	0.0	235.3	0.0	0.0	234.9	0.0	0.0	234.1	0.0	0.0	233.3	0.0	0.0	237.1	0.1	0.1	235.9	0.1	0.1
R1K	5240	OAKV B15 220	236.3	0.0	0.0	235.7	0.0	0.0	235.2	0.0	0.0	234.5	0.0	0.0	234.1	0.0	0.0	233.2	0.0	0.0	232.5	0.0	0.0	236.2	0.1	0.1	235.0	0.1	0.1
R1K	3697	JOHN A13 13.8	13.7	0.0	0.0	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.1	0.1	13.7	0.1	0.1
R1K	3664	ESPLNJ12 13.8	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0	14.0	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.1	0.1	13.8	0.1	0.1
R1K	3767	TERAUA12 13.8	13.7	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	14.0	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0
R13K	2100	CHERYDK1 220	239.4	0.0	0.0	239.0	0.0	0.0	238.7	0.0	0.0	238.3	0.0	0.0	238.1	0.0	0.0	237.6	0.0	0.0	237.1	0.0	0.0	238.3	0.0	0.0	237.6	0.0	0.0
R13K	2102	CHERYDK3 220	239.7	0.0	0.0	239.3	0.0	0.0	239.0	0.0	0.0	238.6	0.0	0.0	238.4	0.0	0.0	237.9	0.0	0.0	237.5	0.0	0.0	238.6	0.0	0.0	238.0	0.0	0.0
R13K	4103	RICH AH2 220	238.0	0.0	0.0	237.5	0.0	0.0	237.1	0.0	0.0	236.5	0.0	0.0	236.1	0.0	0.0	235.4	0.0	0.0	234.7	0.0	0.0	237.8	0.0	0.0	236.8	0.0	0.0

R13K	3107	MANBY E 220	238.7	0.0	0.0	238.1	0.0	0.0	237.7	0.0	0.0	237.0	0.0	0.0	236.6	0.0	0.0	235.8	0.0	0.0	235.0	0.0	0.0	239.3	0.1	0.1	238.2	0.1	0.1
R13K	3302	MANBY E 118	122.1	0.0	0.0	121.7	0.0	0.0	121.4	0.0	0.0	121.0	0.0	0.0	120.8	0.0	0.0	120.3	0.0	0.0	119.8	0.0	0.0	122.0	0.1	0.1	121.4	0.1	0.1

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013			2014			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
R13K	3108	MANBY W 220	238.5	0.0	0.0	238.0	0.0	0.0	237.5	0.0	0.0	236.8	0.0	0.0	236.4	0.0	0.0	235.6	0.0	0.0	234.9	0.0	0.0	238.1	0.0	0.0	237.0	0.0	0.0
R13K	3303	MANBY W 118	122.9	0.0	0.0	122.6	0.0	0.0	122.2	0.0	0.0	121.8	0.0	0.0	121.5	0.0	0.0	121.0	0.0	0.0	120.5	0.0	0.0	122.2	0.0	0.0	121.5	0.0	0.0
R13K	4143	COOKVL15 220	237.6	0.0	0.0	237.1	0.0	0.0	236.6	0.0	0.0	235.9	0.0	0.0	235.5	0.0	0.0	234.7	0.0	0.0	233.9	0.0	0.0	237.7	0.1	0.1	236.6	0.1	0.1
R13K	4192	LORNEB15 220	237.1	0.0	0.0	236.5	0.0	0.0	236.0	0.0	0.0	235.3	0.0	0.0	234.9	0.0	0.0	234.1	0.0	0.0	233.3	0.0	0.0	237.1	0.1	0.1	235.9	0.1	0.1
R13K	5240	OAKV B15 220	236.3	0.0	0.0	235.7	0.0	0.0	235.2	0.0	0.0	234.5	0.0	0.0	234.1	0.0	0.0	233.2	0.0	0.0	232.5	0.0	0.0	236.2	0.1	0.1	235.0	0.1	0.1
R13K	3697	JOHN A13 13.8	13.7	0.0	0.0	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.1	0.1	13.7	0.1	0.1
R13K	3664	ESPLNJ12 13.8	13.9	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.0	0.0	14.0	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.8	0.1	0.1	13.8	0.1	0.1
R13K	3767	TERAUA12 13.8	13.7	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0	13.8	0.0	0.0	14.0	0.0	0.0	13.9	0.0	0.0	13.8	0.0	0.0	13.7	0.0	0.0
R2K	2100	CHERYDK1 220	239.4	0.0	-0.1	239.0	0.0	-0.1	238.7	0.0	-0.1	238.3	0.0	-0.1	238.1	0.0	-0.1	237.6	0.0	-0.1	237.1	0.0	-0.1	238.3	0.0	-0.1	237.6	0.0	-0.1
R2K	2102	CHERYDK3 220	239.7	0.0	-0.1	239.3	0.0	-0.1	239.0	0.0	-0.1	238.6	0.0	-0.1	238.4	0.0	-0.1	237.9	0.0	-0.1	237.5	0.0	-0.1	238.6	0.0	-0.1	238.0	0.0	-0.1
R2K	4103	RICH AH2 220	238.0	-0.1	-0.2	237.5	-0.1	-0.2	237.1	-0.1	-0.2	236.5	-0.1	-0.2	236.1	-0.1	-0.2	235.4	-0.1	-0.2	234.7	-0.1	-0.2	237.8	-0.1	-0.2	236.8	-0.1	-0.2
R2K	3107	MANBY E 220	238.7	-0.1	-0.2	238.1	-0.1	-0.2	237.7	-0.1	-0.2	237.0	-0.1	-0.2	236.6	-0.1	-0.2	235.8	-0.1	-0.2	235.0	-0.1	-0.2	239.3	-0.1	-0.2	238.2	-0.1	-0.2
R2K	3302	MANBY E 118	122.1	-0.1	-0.2	121.7	-0.1	-0.2	121.4	-0.1	-0.2	121.0	-0.1	-0.2	120.8	-0.1	-0.2	120.3	-0.1	-0.2	119.8	-0.1	-0.2	122.0	-0.1	-0.2	121.4	-0.1	-0.2
R2K	3108	MANBY W 220	238.5	-0.1	-0.2	238.0	-0.1	-0.2	237.5	-0.2	-0.2	236.8	-0.2	-0.2	236.4	-0.2	-0.2	235.6	-0.2	-0.2	234.9	-0.2	-0.3	238.1	-0.2	-0.2	237.0	-0.2	-0.3
R2K	3303	MANBY W 118	122.9	-0.1	-0.2	122.6	-0.2	-0.2	122.2	-0.2	-0.2	121.8	-0.2	-0.2	121.5	-0.2	-0.2	121.0	-0.2	-0.2	120.5	-0.2	-0.3	122.2	-0.2	-0.2	121.5	-0.2	-0.3
R2K	4143	COOKVL15 220	237.6	-0.1	-0.2	237.1	-0.1	-0.2	236.6	-0.1	-0.2	235.9	-0.1	-0.2	235.5	-0.2	-0.2	234.7	-0.2	-0.2	233.9	-0.2	-0.2	237.7	-0.2	-0.2	236.6	-0.2	-0.2
R2K	4192	LORNEB15 220	237.1	-0.1	-0.2	236.5	-0.1	-0.2	236.0	-0.1	-0.2	235.3	-0.2	-0.2	234.9	-0.2	-0.2	234.1	-0.2	-0.2	233.3	-0.2	-0.2	237.1	-0.2	-0.2	235.9	-0.2	-0.2
R2K	5240	OAKV B15 220	236.3	-0.1	-0.2	235.7	-0.1	-0.2	235.2	-0.1	-0.2	234.5	-0.2	-0.2	234.1	-0.2	-0.2	233.2	-0.2	-0.2	232.5	-0.2	-0.2	236.2	-0.2	-0.2	235.0	-0.2	-0.2
R2K	3697	JOHN A13 13.8	13.7	-0.1	-0.2	13.9	-0.1	-0.2	13.9	-0.1	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.2
R2K	3664	ESPLNJ12 13.8	13.9	-0.1	-0.2	13.9	-0.1	-0.2	13.8	-0.1	-0.2	13.8	-0.2	-0.2	14.0	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.2
R2K	3767	TERAUA12 13.8	13.7	-0.1	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.2	13.8	-0.2	-0.2	14.0	-0.2	-0.3	13.9	-0.2	-0.3	13.8	-0.2	-0.2	13.7	-0.2	-0.3
R15K	2100	CHERYDK1 220	239.4	0.0	-0.1	239.0	0.0	-0.1	238.7	0.0	-0.1	238.3	0.0	-0.1	238.1	0.0	-0.1	237.6	0.0	-0.1	237.1	0.0	-0.1	238.3	0.0	-0.1	237.6	0.0	-0.1
R15K	2102	CHERYDK3 220	239.7	0.0	-0.1	239.3	0.0	-0.1	239.0	0.0	-0.1	238.6	0.0	-0.1	238.4	0.0	-0.1	237.9	0.0	-0.1	237.5	0.0	-0.1	238.6	0.0	-0.1	238.0	0.0	-0.1
R15K	4103	RICH AH2 220	238.0	-0.1	-0.2	237.5	-0.1	-0.2	237.1	-0.1	-0.2	236.5	-0.1	-0.2	236.1	-0.1	-0.2	235.4	-0.1	-0.2	234.7	-0.1	-0.2	237.8	-0.1	-0.2	236.8	-0.1	-0.2
R15K	3107	MANBY E 220	238.7	-0.1	-0.2	238.1	-0.1	-0.2	237.7	-0.2	-0.2	237.0	-0.2	-0.2	236.6	-0.2	-0.2	235.8	-0.2	-0.2	235.0	-0.2	-0.2	239.3	-0.2	-0.2	238.2	-0.2	-0.2
R15K	3302	MANBY E 118	122.1	-0.1	-0.2	121.7	-0.2	-0.2	121.4	-0.2	-0.2	121.0	-0.2	-0.2	120.8	-0.2	-0.2	120.3	-0.2	-0.2	119.8	-0.2	-0.2	122.0	-0.2	-0.2	121.4	-0.2	-0.2
R15K	3108	MANBY W 220	238.5	-0.2	-0.2	238.0	-0.2	-0.2	237.5	-0.2	-0.2	236.8	-0.2	-0.3	236.4	-0.2	-0.3	235.6	-0.2	-0.3	234.9	-0.2	-0.3	238.1	-0.2	-0.3	237.0	-0.2	-0.3
R15K	3303	MANBY W 118	122.9	-0.2	-0.2	122.6	-0.2	-0.2	122.2	-0.2	-0.2	121.8	-0.2	-0.3	121.5	-0.2	-0.3	121.0	-0.2	-0.3	120.5	-0.2	-0.3	122.2	-0.2	-0.3	121.5	-0.2	-0.3
R15K	4143	COOKVL15 220	237.6	-0.1	-0.2	237.1	-0.2	-0.2	236.6	-0.2	-0.2	235.9	-0.2	-0.2	235.5	-0.2	-0.2	234.7	-0.2	-0.2	233.9	-0.2	-0.3	237.7	-0.2	-0.2	236.6	-0.2	-0.2
R15K	4192	LORNEB15 220	237.1	-0.1	-0.2	236.5	-0.2	-0.2	236.0	-0.2	-0.2	235.3	-0.2	-0.2	234.9	-0.2	-0.2	234.1	-0.2	-0.2	233.3	-0.2	-0.3	237.1	-0.2	-0.2	235.9	-0.2	-0.2
R15K	5240	OAKV B15 220	236.3	-0.2	-0.2	235.7	-0.2	-0.2	235.2	-0.2	-0.2	234.5	-0.2	-0.2	234.1	-0.2	-0.2	233.2	-0.2	-0.2	232.5	-0.2	-0.3	236.2	-0.2	-0.2	235.0	-0.2	-0.2
R15K	3697	JOHN A13 13.8	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.3	13.8	-0.2	-0.2	13.7	-0.2	-0.3
R15K	3664	ESPLNJ12 13.8	13.9	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.2	14.0	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.3	13.8	-0.2	-0.2	13.8	-0.2	-0.3
R15K	3767	TERAUA12 13.8	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.3	13.8	-0.2	-0.3	14.0	-0.2	-0.3	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.7	-0.2	-0.3
R1K & R2K	2100	CHERYDK1 220	239.4	-0.1	-0.1	239.0	-0.1	-0.1	238.7	-0.1	-0.1	238.3	-0.1	-0.1	238.1	-0.1	-0.1	237.6	-0.1	-0.1	237.1	-0.1	-0.1	238.3	-0.1	-0.1	237.6	-0.1	-0.1
R1K & R2K	2102	CHERYDK3 220	239.7	-0.1	-0.1	239.3	-0.1	-0.1	239.0	-0.1	-0.1	238.6	-0.1	-0.1	238.4	-0.1	-0.1	237.9	-0.1	-0.1	237.5	-0.1	-0.1	238.6	-0.1	-0.1	238.0	-0.1	-0.1
R1K & R2K	4103	RICH AH2 220	238.0	-0.2	-0.2	237.5	-0.2	-0.2	237.1	-0.2	-0.2	236.5	-0.2	-0.2	236.1	-0.2	-0.2	235.4	-0.2	-0.2	234.7	-0.2	-0.2	237.8	-0.2	-0.2	236.8	-0.2	-0.2
R1K & R2K	3107	MANBY E 220	238.7	-0.1	-0.1	238.1	-0.1	-0.1	237.7	-0.1	-0.2	237.0	-0.1	-0.2	236.6	-0.2	-0.2	235.8	-0.2	-0.2	235.0	-0.2	-0.3	239.3	0.0	0.0	238.2	0.0	-0.1
R1K & R2K	3302	MANBY E 118	122.1	-0.1	-0.1	121.7	-0.1	-0.1	121.4	-0.1	-0.2	121.0	-0.1	-0.2	120.8	-0.2	-0.2	120.3	-0.2	-0.2	119.8	-0.2	-0.3	122.0	0.0	0.0	121.4	0.0	-0.1
R1K & R2K	3108	MANBY W 220	238.5	-0.2	-0.2	238.0	-0.2	-0.2	237.5	-0.2	-0.3	236.8	-0.2	-0.3	236.4	-0.2	-0.3	235.6	-0.2	-0.3	234.9	-0.3	-0.3	238.1	-0.2	-0.3	237.0	-0.2	-0.3
R1K & R2K	3303	MANBY W 118	122.9	-0.2	-0.2	122.6	-0.2	-0.2	122.2	-0.2	-0.3	121.8	-0.2	-0.3	121.5	-0.2	-0.3	121.0	-0.2	-0.3	120.5	-0.3	-0.3	122.2	-0.2	-0.3	121.5	-0.2	-0.3
R1K & R2K	4143	COOKVL15 220	237.6	-0.1	-0.2	237.1	-0.2	-0.2	236.6	-0.2	-0.2	235.9	-0.2	-0.2	235.5	-0.2	-0.2	234.7	-0.2	-0.2	233.9	-0.2	-0.3	237.7	-0.1	-0.1	236.6	-0.1	-0.2
R1K & R2K	4192	LORNEB15 220	237.1	-0.1	-0.2	236.5	-0.2	-0.2	236.0	-0.2	-0.2	235.3	-0.2	-0.2	234.9	-0.2	-0.2	234.1	-0.2	-0.2	233.3	-0.2	-0.3	237.1	-0.1	-0.1	235.9	-0.1	-0.2
R1K & R2K	5240	OAKV B15 220	236.3	-0.1	-0.2	235.7	-0.2	-0.2	235.2	-0.2	-0.2	234.5	-0.2	-0.2	234.1	-0.2	-0.2	233.2	-0.2	-0.2	232.5	-0.2	-0.3	236.2	-0.1	-0.1	235.0	-0.1	-0.2
R1K & R2K	3697	JOHN A13 13.8	13.7	-0.1	-0.2	13.9	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.7	-0.2	-0.2	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.1	-0.1	13.7	-0.1	-0.2
R1K & R2K	3664	ESPLNJ12 13.8	13.9	-0.1	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.2	14.0	-0.2	-0.2	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.1	-0.1	13.8	-0.1	-0.2
R1K & R2K	3767	TERAUA12 13.8	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.3	13.7	-0.2	-0.3	13.8	-0.2	-0.3	14.0	-0.2	-0.3	13.9	-0.3	-0.3	13.8	-0.2	-0.3	13.7	-0.2	-0.3
R13K & R15K	2100	CHERYDK1 220	239.4	-0.1	-0.1	239.0	-0.1	-0.1	238.7	-0.1	-0.1	238.3	-0.1	-0.1	238.1	-0.1	-0.1	237.6	-0.1	-0.1	237.1	-0.1	-0.1	238.3	-0.1	-0.1	237.6	-0.1	-0.1
R13K & R15K	2102	CHERYDK3 220	239.7	-0.1	-0.1	239.3	-0.1	-0.1	239.0	-0.1	-0.1	238.6	-0.1	-0.1	238.4	-0.1	-0.1	237.9	-0.1	-0.1	237.5	-0.1	-0.1	238.6	-0.1	-0.1	238.0	-0.1	-0.1
R13K & R15K	4103	RICH AH2 220	238.0	-0.2	-0.2	237.5	-0.2	-0.2	237.1	-0.2	-0.2	236.5	-0.2	-0.2	236.1	-0.2	-0.2	235.4	-0.2	-0.2	234.7	-0.2	-0.2	237.8	-0.2	-0.2	236.8	-0.2	-0.2

CASE/CONT.	BN	BUS NAME	2007			2008			2009			2010			2011			2012			2013			2014			2015*		
			Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%	Pre	%	SS%
R13K & R15K	3107	MANBY E 220	238.7	-0.1	-0.2	238.1	-0.1	-0.2	237.7	-0.1	-0.2	237.0	-0.2	-0.2	236.6	-0.2	-0.2	235.8	-0.2	-0.2	235.0	-0.2	-0.3	239.3	0.0	-0.1	238.2	0.0	-0.1
R13K & R15K	3302	MANBY E 118	122.1	-0.1	-0.2	121.7	-0.1	-0.2	121.4	-0.1	-0.2	121.0	-0.2	-0.2	120.8	-0.2	-0.2	120.3	-0.2	-0.2	119.8	-0.2	-0.3	122.0	0.0	-0.1	121.4	0.0	-0.1
R13K & R15K	3108	MANBY W 220	238.5	-0.2	-0.3	238.0	-0.2	-0.3	237.5	-0.2	-0.3	236.8	-0.2	-0.3	236.4	-0.2	-0.3	235.6	-0.3	-0.3	234.9	-0.3	-0.4	238.1	-0.2	-0.3	237.0	-0.2	-0.3
R13K & R15K	3303	MANBY W 118	122.9	-0.2	-0.3	122.6	-0.2	-0.3	122.2	-0.2	-0.3	121.8	-0.2	-0.3	121.5	-0.2	-0.3	121.0	-0.3	-0.3	120.5	-0.3	-0.4	122.2	-0.2	-0.3	121.5	-0.2	-0.3
R13K & R15K	4143	COOKVL15 220	237.6	-0.2	-0.2	237.1	-0.2	-0.2	236.6	-0.2	-0.2	235.9	-0.2	-0.2	235.5	-0.2	-0.2	234.7	-0.2	-0.3	233.9	-0.2	-0.3	237.7	-0.1	-0.2	236.6	-0.1	-0.2
R13K & R15K	4192	LORNEB15 220	237.1	-0.2	-0.2	236.5	-0.2	-0.2	236.0	-0.2	-0.2	235.3	-0.2	-0.2	234.9	-0.2	-0.2	234.1	-0.2	-0.3	233.3	-0.2	-0.3	237.1	-0.1	-0.2	235.9	-0.1	-0.2
R13K & R15K	5240	OAKV B15 220	236.3	-0.2	-0.2	235.7	-0.2	-0.2	235.2	-0.2	-0.2	234.5	-0.2	-0.2	234.1	-0.2	-0.2	233.2	-0.2	-0.3	232.5	-0.2	-0.3	236.2	-0.1	-0.2	235.0	-0.1	-0.2
R13K & R15K	3697	JOHN A13 13.8	13.7	-0.2	-0.2	13.9	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.3	13.7	-0.2	-0.3	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.1	-0.2	13.7	-0.1	-0.2
R13K & R15K	3664	ESPLNJ12 13.8	13.9	-0.2	-0.2	13.9	-0.2	-0.2	13.8	-0.2	-0.2	13.8	-0.2	-0.3	14.0	-0.2	-0.3	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.8	-0.1	-0.2	13.8	-0.1	-0.2
R13K & R15K	3767	TERAUA12 13.8	13.7	-0.2	-0.3	13.9	-0.2	-0.3	13.8	-0.2	-0.3	13.7	-0.2	-0.3	13.8	-0.3	-0.3	14.0	-0.3	-0.3	13.9	-0.3	-0.4	13.8	-0.2	-0.3	13.7	-0.3	-0.3
H2JK	3107	MANBY E 220	238.7	-0.1	-0.2	238.1	-0.1	-0.2	237.7	-0.1	-0.2	237.0	-0.1	-0.2	236.6	-0.1	-0.2	235.8	-0.1	-0.2	235.0	-0.1	-0.2	239.3	-0.1	-0.2	238.2	-0.1	-0.3
H2JK	3302	MANBY E 118	122.1	-0.1	-0.2	121.7	-0.1	-0.2	121.4	-0.1	-0.2	121.0	-0.1	-0.2	120.8	-0.1	-0.2	120.3	-0.1	-0.2	119.8	-0.1	-0.2	122.0	-0.1	-0.2	121.4	-0.1	-0.3
H2JK	3108	MANBY W 220	238.5	-0.2	-0.3	238.0	-0.2	-0.2	237.5	-0.2	-0.3	236.8	-0.2	-0.3	236.4	-0.2	-0.3	235.6	-0.2	-0.3	234.9	-0.2	-0.3	238.1	-0.2	-0.3	237.0	-0.2	-0.3
H2JK	3303	MANBY W 118	122.9	-0.7	-0.9	122.6	-0.7	-0.8	122.2	-0.7	-0.9	121.8	-0.7	-1.0	121.5	-0.7	-0.9	121.0	-0.7	-0.9	120.5	-0.7	-1.0	122.2	-0.7	-1.0	121.5	-0.7	-1.1
H2JK	3403	TERC5E 118	121.2	-1.7	-2.2	120.8	-1.8	-2.2	120.4	-1.8	-2.3	119.9	-1.9	-2.5	119.5	-1.9	-2.5	118.9	-2.0	-2.6	118.3	-2.1	-2.8	120.0	-2.1	-2.9	119.2	-2.2	-3.2
H2JK	3404	TERC7E 118	121.9	-0.8	-1.0	121.5	-0.8	-1.0	121.1	-0.8	-1.1	120.6	-0.8	-1.2	120.3	-0.8	-1.1	119.7	-0.8	-1.1	119.2	-0.8	-1.2	120.8	-0.8	-1.2	120.1	-0.8	-1.4
H2JK	3767	TERAUA12 13.8	13.7	-1.3	-0.3	13.9	-1.3	-1.6	13.8	-1.3	-0.5	13.7	-1.4	-0.6	13.8	-1.4	-0.6	14.0	-1.4	-1.9	13.9	-1.5	-0.8	13.8	-1.5	-0.8	13.7	-1.5	0.2
K6J	3107	MANBY E 220	238.7	-0.2	-0.3	238.1	-0.2	-0.3	237.7	-0.2	-0.3	237.0	-0.2	-0.3	236.6	-0.2	-0.3	235.8	-0.2	-0.3	235.0	-0.2	-0.3	239.3	-0.2	-0.3	238.2	-0.2	-0.4
K6J	3302	MANBY E 118	122.1	-0.2	-0.3	121.7	-0.2	-0.3	121.4	-0.2	-0.3	121.0	-0.2	-0.3	120.8	-0.2	-0.3	120.3	-0.2	-0.3	119.8	-0.2	-0.4	122.0	-0.2	-0.3	121.4	-0.2	-0.4
K6J	3108	MANBY W 220	238.5	-0.2	-0.4	238.0	-0.2	-0.4	237.5	-0.2	-0.4	236.8	-0.2	-0.4	236.4	-0.2	-0.4	235.6	-0.2	-0.4	234.9	-0.2	-0.5	238.1	-0.2	-0.4	237.0	-0.2	-0.5
K6J	3303	MANBY W 118	122.9	-0.9	-1.4	122.6	-0.9	-1.3	122.2	-0.9	-1.4	121.8	-0.9	-1.5	121.5	-0.9	-1.5	121.0	-0.9	-1.5	120.5	-0.9	-1.6	122.2	-0.9	-1.6	121.5	-0.9	-1.7
K6J	3403	TERC5E 118	121.2	*****	*****	120.8	*****	*****	120.4	*****	*****	119.9	*****	*****	119.5	*****	*****	118.9	*****	*****	118.3	*****	*****	120.0	*****	*****	119.2	*****	*****
K6J	3404	TERC7E 118	121.9	-2.6	-3.8	121.5	-2.6	-3.7	121.1	-2.7	-3.9	120.6	-2.7	-4.1	120.3	-2.8	-4.1	119.7	-2.8	-4.2	119.2	-2.9	-4.4	120.8	-2.9	-4.4	120.1	-3.0	-4.8
K6J	3767	TERAUA12 13.8	13.7	-10.3	-0.4	13.9	-10.2	-1.6	13.8	-10.5	-0.8	13.7	-10.8	-0.2	13.8	-10.8	-1.3	14.0	-10.9	-1.6	13.9	-11.2	-1.0	13.8	-11.4	-1.0	13.7	-11.8	-0.6
K13J	3107	MANBY E 220	238.7	-0.1	-0.2	238.1	-0.1	-0.2	237.7	-0.1	-0.2	237.0	-0.1	-0.2	236.6	-0.1	-0.2	235.8	-0.1	-0.2	235.0	-0.1	-0.2	239.3	-0.1	-0.2	238.2	-0.1	-0.2
K13J	3302	MANBY E 118	122.1	-0.1	-0.2	121.7	-0.1	-0.2	121.4	-0.1	-0.2	121.0	-0.1	-0.2	120.8	-0.1	-0.2	120.3	-0.1	-0.2	119.8	-0.1	-0.2	122.0	-0.1	-0.2	121.4	-0.1	-0.2
K13J	3108	MANBY W 220	238.5	-0.2	-0.3	238.0	-0.2	-0.3	237.5	-0.2	-0.3	236.8	-0.2	-0.3	236.4	-0.2	-0.3	235.6	-0.2	-0.3	234.9	-0.2	-0.3	238.1	-0.2	-0.3	237.0	-0.2	-0.3
K13J	3303	MANBY W 118	122.9	-0.6	-0.9	122.6	-0.6	-0.9	122.2	-0.6	-0.9	121.8	-0.6	-1.0	121.5	-0.6	-0.9	121.0	-0.6	-0.9	120.5	-0.6	-1.0	122.2	-0.6	-1.0	121.5	-0.6	-1.1
K13J	3403	TERC5E 118	121.2	-2.1	-2.9	120.8	-2.1	-2.8	120.4	-2.1	-3.0	119.9	-2.2	-3.2	119.5	-2.2	-3.1	118.9	-2.3	-3.1	118.3	-2.3	-3.3	120.0	-2.3	-3.3	119.2	-2.4	-3.7
K13J	3404	TERC7E 118	121.9	*****	*****	121.5	*****	*****	121.1	*****	*****	120.6	*****	*****	120.3	*****	*****	119.7	*****	*****	119.2	*****	*****	120.8	*****	*****	120.1	*****	*****
K13J	3767	TERAUA12 13.8	13.7	-9.2	-0.1	13.9	-9.1	-1.3	13.8	-9.4	-0.5	13.7	-9.7	0.1	13.8	-9.8	-1.0	14.0	-9.9	-2.3	13.9	-10.2	-1.6	13.8	-10.3	-1.6	13.7	-10.7	0.0
K14J	3107	MANBY E 220	238.7	-0.5	-0.6	238.1	-0.5	-0.6	237.7	-0.5	-0.6	237.0	-0.5	-0.6	236.6	-0.5	-0.6	235.8	-0.5	-0.7	235.0	-0.5	-0.7	239.3	-0.5	-0.7	238.2	-0.5	-0.8
K14J	3302	MANBY E 118	122.1	-0.5	-0.6	121.7	-0.5	-0.6	121.4	-0.5	-0.7	121.0	-0.5	-0.6	120.8	-0.5	-0.7	120.3	-0.5	-0.7	119.8	-0.5	-0.7	122.0	-0.5	-0.7	121.4	-0.5	-0.8
K14J	3108	MANBY W 220	238.5	-0.3	-0.4	238.0	-0.3	-0.3	237.5	-0.2	-0.4	236.8	-0.2	-0.4	236.4	-0.2	-0.4	235.6	-0.2	-0.4	234.9	-0.2	-0.4	238.1	-0.2	-0.4	237.0	-0.2	-0.5
K14J	3303	MANBY W 118	122.9	-0.3	-0.4	122.6	-0.3	-0.3	122.2	-0.2	-0.4	121.8	-0.2	-0.4	121.5	-0.2	-0.4	121.0	-0.2	-0.4	120.5	-0.2	-0.4	122.2	-0.2	-0.4	121.5	-0.2	-0.5
K14J	3377	JOHN K13 230	237.6	*****	*****	237.0	*****	*****	236.5	*****	*****	235.8	*****	*****	235.3	*****	*****	234.4	*****	*****	233.6	*****	*****	236.9	*****	*****	235.8	*****	*****
K14J	3376	JOHN K1J 230	238.2	-0.7	-0.9	237.7	-0.7	-0.8	237.2	-0.7	-0.9	236.5	-0.7	-0.9	236.0	-0.7	-0.9	235.2	-0.7	-1.0	234.4	-0.7	-1.0	238.6	-0.7	-1.0	237.5	-0.7	-1.1
K14J	3375	JOHN K2J 230	238.2	-0.7	-0.9	237.6	-0.7	-0.8	237.1	-0.7	-0.9	236.4	-0.7	-0.9	236.0	-0.7	-0.9	235.1	-0.7	-1.0	234.4	-0.7	-1.0	238.6	-0.7	-1.0	237.5	-0.7	-1.1
K14J	3383	ESPLAK13 220	237.5	*****	*****	237.0	*****	*****	236.4	*****	*****	235.7	*****	*****	235.2	*****	*****	234.4	*****	*****	233.5	*****	*****	236.9	*****	*****	235.7	*****	*****
K14J	3384	ESPLAK1J 220	238.2	-0.7	-0.9	237.6	-0.7	-0.9	237.1	-0.7	-0.9	236.4	-0.7	-0.9	236.0	-0.7	-1.0	235.1	-0.7	-1.0	234.3	-0.7	-1.0	238.5	-0.7	-1.0	237.4	-0.8	-1.2
K14J	3385	ESPLAK2J 220	238.1	-0.7	-0.9	237.6	-0.7	-0.8	237.1	-0.7	-0.9	236.4	-0.7	-0.9	235.9	-0.7	-1.0	235.1	-0.7	-1.0	234.3	-0.7	-1.0	238.6	-0.7	-1.0	237.4	-0.8	-1.2
K14J	3403	TERC5E 118	121.2	-0.3	-0.4	120.8	-0.3	-0.4	120.4	-0.3	-0.4	119.9	-0.2	-0.4	119.5	-0.2	-0.4	118.9	-0.2	-0.4	118.3	-0.2	-0.4	120.0	-0.2	-0.4	119.2	-0.2	-0.5
K14J	3404	TERC7E 118	121.9	-0.3	-0.4	121.5	-0.3	-0.4	121.1	-0.3	-0.4	120.6	-0.2	-0.4	120.3	-0.2	-0.4	119.7	-0.2	-0.4	119.2	-0.2	-0.4	120.8	-0.2	-0.4	120.1	-0.2	-0.5
K14J	3697	JOHN A13 13.8	13.7	-7.2	-0.6	13.9	-7.2	-2.1	13.9	-7.4	-1.1	13.8	-7.7	-1.2	13.7	-7.9	-0.2	13.9	-7.9	-1.6	13.8	-8.2	-0.7	13.8	-8.1	-0.5	13.7	-8.4	0.3
K14J	3664	ESPLNJ12 13.8	13.9	-4.1	-1.5	13.9	-4.2	-1.6	13.8	-4.3	-0.4	13.8	-4.5	-0.5	14.0	-4.5	-2.0	13.9	-4.6	-0.7	13.8	-4.7	-1.0	13.8	-4.6	-0.8	13.8	-4.8	-1.1
K1J	3107	MANBY E 220	238.7	-0.6	-0.8	238.1	-0.6	-0.7	237.7	-0.6	-0.7	237.0	-0.6	-0.8	236.6	-0.6	-0.7	235.8	-0.6	-0.8	235.0	-0.5	-0.8	239.3	-0.5	-0.8	238.2	-0.5	-0.9
K1J	3302	MANBY E 118	122.1	-0.6	-0.8	121.7	-0.6	-0.7	121.4	-0.6	-0.7	121.0	-0.6	-0.8	120.8	-0.6	-0.8	120.3	-0.6	-0.8	119.8	-0.5	-0.8	122.0	-0.6	-0.8	121.4	-0.5	-1.0
K1J	3108	MANBY W 220	238.5	-0.5	-0.8	238.0	-0.6	-0.7	237.5	-0.6	-0.7	236.8	-0.6	-0.8	236.4	-0.6	-0.7	235.6	-0.6	-0.7	234.9	-0.6	-0.8	238.1	-0.6	-0.8	237.0	-0.6	-1.0
K1J	3303	MANBY W 118	122.9	-0.6	-0.8	122.6	-0.6	-0.7	122.2	-0.6	-0.7	121.8	-0.6	-0.8	121.5	-0.6	-0.8	121.0	-0.6	-0.8	120.5	-0.6	-0.8	122.2	-0.6	-0.8	121.5	-0.6	-1.0
K1J	3377	JOHN K13 230	237.6	-1.0	-1.3	237.0	-1.0	-1.3	236.5	-1.1	-1.3	235.8	-1.1	-1.4	235.3	-1.1	-1.4	234.4	-1.1	-1.4	233.6	-1.1	-1.5	236.9	-1.1	-1.5	235.8	-1.2	-1.8
K1J	3376	JOHN K1J 230	238.2	*****	*****	237.7	*****	*****	237.2	*****	*****	236.5	*****	*****	236.0	*****	*****	235.2	*****	*****	234.4	*****	*****	238.6	*****	*****	237.5	*****	*****

K1J	3375	JOHN K2J 230	238.2	-0.8	-1.0	237.6	-0.8	-1.0	237.1	-0.8	-1.0	236.4	-0.8	-1.1	236.0	-0.8	-1.1	235.1	-0.8	-1.1	234.4	-0.8	-1.1	238.6	-0.8	-1.1	237.5	-0.8	-1.3
K1J	3383	ESPLAK13 220	237.5	-1.0	-1.4	237.0	-1.1	-1.3	236.4	-1.1	-1.3	235.7	-1.1	-1.4	235.2	-1.1	-1.4	234.4	-1.1	-1.4	233.5	-1.1	-1.5	236.9	-1.1	-1.5	235.7	-1.2	-1.8
K1J	3384	ESPLAK1J 220	238.2	*****	*****	237.6	*****	*****	237.1	*****	*****	236.4	*****	*****	236.0	*****	*****	235.1	*****	*****	234.3	*****	*****	238.5	*****	*****	237.4	*****	*****
K1J	3385	ESPLAK2J 220	238.1	-0.8	-1.1	237.6	-0.8	-1.0	237.1	-0.8	-1.0	236.4	-0.8	-1.1	235.9	-0.8	-1.1	235.1	-0.8	-1.1	234.3	-0.8	-1.1	238.6	-0.8	-1.1	237.4	-0.8	-1.3
CASE/CONT.	**BN**	**BUS NAME**	**2007**			**2008**			**2009**			**2010**			**2011**			**2012**			**2013**			**2014**			**2015***		
			Pre	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**	**Pre**	**%**	**SS%**
K1J	3403	TERC5E 118	121.2	-0.6	-0.8	120.8	-0.6	-0.7	120.4	-0.6	-0.7	119.9	-0.6	-0.9	119.5	-0.6	-0.8	118.9	-0.6	-0.8	118.3	-0.6	-0.8	120.0	-0.6	-0.8	119.2	-0.6	-1.1
K1J	3404	TERC7E 118	121.9	-0.6	-0.8	121.5	-0.6	-0.7	121.1	-0.6	-0.7	120.6	-0.6	-0.8	120.3	-0.6	-0.8	119.7	-0.6	-0.8	119.2	-0.6	-0.8	120.8	-0.6	-0.8	120.1	-0.6	-1.1
K1J	3697	JOHN A13 13.8	13.7	-7.8	-0.1	13.9	-7.8	-1.4	13.9	-8.0	-1.7	13.8	-8.3	-0.8	13.7	-8.5	0.2	13.9	-8.6	-1.2	13.8	-8.8	-0.1	13.8	-9.2	-0.4	13.7	-9.5	0.3
K1J	3664	ESPLNJ12 13.8	13.9	-4.7	-2.3	13.9	-4.8	-1.0	13.8	-5.0	-1.1	13.8	-5.1	-1.3	14.0	-5.1	-1.4	13.9	-5.3	-1.6	13.8	-5.4	-0.4	13.8	-5.7	-0.6	13.8	-5.9	-1.1
K2J	3107	MANBY E 220	238.7	-0.6	-0.8	238.1	-0.6	-0.7	237.7	-0.5	-0.7	237.0	-0.5	-0.7	236.6	-0.5	-0.7	235.8	-0.5	-0.7	235.0	-0.5	-0.7	239.3	-0.5	-0.8	238.2	-0.5	-0.9
K2J	3302	MANBY E 118	122.1	-0.6	-0.8	121.7	-0.6	-0.7	121.4	-0.6	-0.7	121.0	-0.6	-0.7	120.8	-0.5	-0.7	120.3	-0.5	-0.8	119.8	-0.5	-0.8	122.0	-0.6	-0.8	121.4	-0.5	-1.0
K2J	3108	MANBY W 220	238.5	-0.5	-0.8	238.0	-0.5	-0.7	237.5	-0.5	-0.7	236.8	-0.5	-0.7	236.4	-0.5	-0.7	235.6	-0.5	-0.7	234.9	-0.6	-0.8	238.1	-0.6	-0.8	237.0	-0.6	-1.0
K2J	3303	MANBY W 118	122.9	-0.5	-0.8	122.6	-0.5	-0.7	122.2	-0.5	-0.7	121.8	-0.5	-0.8	121.5	-0.6	-0.8	121.0	-0.6	-0.7	120.5	-0.6	-0.8	122.2	-0.6	-0.8	121.5	-0.6	-1.0
K2J	3377	JOHN K13 230	237.6	-1.0	-1.4	237.0	-1.0	-1.3	236.5	-1.1	-1.3	235.8	-1.1	-1.4	235.3	-1.1	-1.4	234.4	-1.1	-1.4	233.6	-1.1	-1.5	236.9	-1.2	-1.5	235.8	-1.2	-1.8
K2J	3376	JOHN K1J 230	238.2	-0.8	-1.0	237.7	-0.8	-1.0	237.2	-0.8	-1.0	236.5	-0.8	-1.0	236.0	-0.8	-1.1	235.2	-0.8	-1.1	234.4	-0.8	-1.1	238.6	-0.8	-1.1	237.5	-0.8	-1.3
K2J	3375	JOHN K2J 230	238.2	*****	*****	237.6	*****	*****	237.1	*****	*****	236.4	*****	*****	236.0	*****	*****	235.1	*****	*****	234.4	*****	*****	238.6	*****	*****	237.5	*****	*****
K2J	3383	ESPLAK13 220	237.5	-1.0	-1.4	237.0	-1.1	-1.3	236.4	-1.1	-1.3	235.7	-1.1	-1.4	235.2	-1.1	-1.5	234.4	-1.1	-1.5	233.5	-1.2	-1.5	236.9	-1.2	-1.5	235.7	-1.2	-1.8
K2J	3384	ESPLAK1J 220	238.2	-0.8	-1.0	237.6	-0.8	-1.0	237.1	-0.8	-1.0	236.4	-0.8	-1.0	236.0	-0.8	-1.1	235.1	-0.8	-1.1	234.3	-0.8	-1.1	238.5	-0.8	-1.1	237.4	-0.8	-1.3
K2J	3385	ESPLAK2J 220	238.1	*****	*****	237.6	*****	*****	237.1	*****	*****	236.4	*****	*****	235.9	*****	*****	235.1	*****	*****	234.3	*****	*****	238.6	*****	*****	237.4	*****	*****
K2J	3403	TERC5E 118	121.2	-0.5	-0.8	120.8	-0.6	-0.7	120.4	-0.6	-0.7	119.9	-0.6	-0.8	119.5	-0.6	-0.8	118.9	-0.6	-0.8	118.3	-0.6	-0.8	120.0	-0.6	-0.8	119.2	-0.6	-1.1
K2J	3404	TERC7E 118	121.9	-0.5	-0.8	121.5	-0.5	-0.7	121.1	-0.5	-0.7	120.6	-0.6	-0.8	120.3	-0.6	-0.8	119.7	-0.6	-0.7	119.2	-0.6	-0.8	120.8	-0.6	-0.8	120.1	-0.6	-1.1
K2J	3697	JOHN A13 13.8	13.7	-0.9	0.2	13.9	-0.9	-1.1	13.9	-0.9	-1.2	13.8	-0.9	-1.2	13.7	-1.0	0.1	13.9	-1.0	-1.3	13.8	-1.0	-1.3	13.8	-1.0	-1.3	13.7	-1.0	-0.2
K2J	3664	ESPLNJ12 13.8	13.9	-0.9	-1.2	13.9	-0.9	-1.2	13.8	-0.9	-1.2	13.8	-1.0	-1.2	14.0	-1.0	-1.3	13.9	-1.0	-1.3	13.8	-1.0	-1.3	13.8	-1.0	-1.3	13.8	-1.0	-0.1

* 2014 and 2015: one additional cap bank rated at 260MVAr/230kV is placed at Manby E for voltage support

Appendix H: Circuit Loading under Contingency (AC Option-1 without Richview x Manby) (in MVA)

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014	2015*
BASE	MANBY AUTO 12	250/296	74.5	75.4	76.7	78.0	79.4	80.9	82.5	84.2	86.4
BASE	MANBY AUTO T1	368/368	84.4	85.5	86.9	88.3	90.0	91.7	93.5	95.5	97.9
BASE	MANBY AUTO T2	408/408	81.8	82.8	84.2	85.6	87.1	88.8	90.6	92.5	94.8
BASE	MANBY AUTO T7	250/307	135.1	136.8	137.9	139.1	140.4	141.6	142.9	144.3	145.2
BASE	MANBY AUTO T8	369/369	157.8	159.7	161.1	162.4	163.9	165.4	166.9	168.5	169.6
BASE	MANBY AUTO T9	250/307	135.6	137.2	138.4	139.6	140.8	142.1	143.4	144.8	145.7
BASE	R2K	579/669	414.6	418.7	422.6	426.7	431.2	435.6	440.2	444.9	455.7
BASE	R15K	579/669	416.8	421.0	424.9	429.0	433.5	438.0	442.6	447.3	458.1
BASE	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASE	R1K	579/669	449.6	453.7	457.2	461.2	465.0	469.2	473.3	477.4	522.7
BASE	R13K	579/669	445.4	449.5	453.0	457.0	460.7	464.8	468.9	473.0	517.8
BASE	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASE	H2JK	249/267	63.1	64.9	66.9	68.9	71.0	73.5	75.5	77.9	80.1
BASE	K6J	249/267	105.3	107.6	110.7	113.8	116.9	119.5	123.7	127.4	130.4
BASE	K13J	225/225	51.5	52.1	53.2	54.3	55.6	56.8	58.1	59.5	60.4
BASE	K14J		139.7	142.8	146.0	149.3	152.7	156.1	159.8	163.6	165.6
BASE	K1J		147.9	150.4	153.0	155.7	158.4	161.5	164.4	167.9	171.2
BASE	K2J		148.8	151.5	154.2	157.0	159.9	162.9	166.3	169.3	173.2
R1K	MANBY AUTO 12	250/296	74.5	75.4	76.6	77.9	79.3	80.9	82.4	84.1	86.4
R1K	MANBY AUTO T1	368/368	84.3	85.4	86.8	88.3	89.9	91.6	93.4	95.4	97.9
R1K	MANBY AUTO T2	408/408	81.7	82.8	84.1	85.5	87.1	88.8	90.5	92.4	94.8
R1K	MANBY AUTO T7	250/307	135.7	137.3	138.4	139.6	140.8	141.9	143.2	144.5	146.5
R1K	MANBY AUTO T8	369/369	158.4	160.3	161.6	163.0	164.3	165.7	167.1	168.7	171.1
R1K	MANBY AUTO T9	250/307	136.2	137.8	138.9	140.1	141.2	142.4	143.6	145.0	147.0
R1K	R2K	579/669	467.8	472.5	476.7	481.3	486.2	491.1	496.2	501.3	517.2
R1K	R15K	579/669	470.1	474.8	479.1	483.7	488.6	493.6	498.7	503.8	519.7
R1K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K	R13K	579/669	739.5	746.0	751.7	758.1	764.2	770.8	777.4	784.1	861.6
R1K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	MANBY AUTO 12	250/296	74.5	75.4	76.6	77.9	79.3	80.9	82.4	84.1	86.4
R13K	MANBY AUTO T1	368/368	84.3	85.4	86.8	88.3	89.9	91.6	93.4	95.4	97.9

R13K	MANBY AUTO T2	408/408	81.7	82.8	84.1	85.5	87.1	88.8	90.5	92.4	94.8
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015***
R13K	MANBY AUTO T7	250/307	135.7	137.3	138.4	139.6	140.8	141.9	143.2	144.5	146.5
R13K	MANBY AUTO T8	369/369	158.4	160.3	161.6	163.0	164.3	165.7	167.1	168.7	171.0
R13K	MANBY AUTO T9	250/307	136.2	137.8	138.9	140.0	141.2	142.4	143.6	145.0	147.0
R13K	R2K	579/669	467.0	471.7	475.9	480.5	485.4	490.3	495.3	500.4	516.3
R13K	R15K	579/669	469.3	474.0	478.3	482.9	487.8	492.7	497.8	503.0	518.8
R13K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	R1K	579/669	741.8	748.4	754.1	760.6	766.7	773.3	779.9	786.6	864.4
R13K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	MANBY AUTO 12	250/296	75.2	76.1	77.3	78.5	79.9	81.4	82.9	84.5	87.0
R2K	MANBY AUTO T1	368/368	85.2	86.3	87.6	89.0	90.5	92.2	93.9	95.8	98.5
R2K	MANBY AUTO T2	408/408	82.6	83.6	84.9	86.2	87.7	89.3	91.0	92.7	95.4
R2K	MANBY AUTO T7	250/307	134.9	136.6	137.7	138.9	140.1	141.3	142.5	143.9	144.9
R2K	MANBY AUTO T8	369/369	157.6	159.4	160.8	162.1	163.5	165.0	166.4	168.0	169.2
R2K	MANBY AUTO T9	250/307	135.4	137.0	138.2	139.3	140.5	141.8	143.0	144.3	145.4
R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	R15K	579/669	465.1	470.3	474.9	479.5	485.1	490.1	495.3	500.7	509.9
R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	R1K	579/669	554.1	559.2	563.5	568.5	573.3	578.5	583.6	588.8	635.5
R2K	R13K	579/669	549.0	554.0	558.3	563.2	568.0	573.1	578.2	583.3	629.6
R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	MANBY AUTO 12	250/296	75.2	76.1	77.3	78.5	79.9	81.3	82.8	84.5	86.9
R15K	MANBY AUTO T1	368/368	85.2	86.2	87.5	88.9	90.5	92.2	93.9	95.7	98.5
R15K	MANBY AUTO T2	408/408	82.5	83.6	84.8	86.2	87.7	89.3	90.9	92.7	95.4
R15K	MANBY AUTO T7	250/307	134.9	136.5	137.7	138.8	140.0	141.3	142.5	143.8	144.9
R15K	MANBY AUTO T8	369/369	157.5	159.4	160.8	162.1	163.5	164.9	166.4	167.9	169.1
R15K	MANBY AUTO T9	250/307	135.4	137.0	138.1	139.3	140.5	141.7	143.0	144.3	145.4
R15K	R2K	579/669	462.6	467.8	472.4	477.1	482.6	487.6	492.9	498.3	507.3
R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	R1K	579/669	554.1	559.1	563.4	568.4	573.3	578.4	583.5	588.7	635.3
R15K	R13K	579/669	548.9	553.9	558.2	563.2	568.0	573.1	578.1	583.3	629.4
R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	MANBY AUTO 12	250/296	75.3	76.2	77.4	78.6	79.9	81.3	82.8	84.4	87.2
R1K & R2K	MANBY AUTO T1	368/368	85.3	86.3	87.6	89.0	90.5	92.2	93.8	95.6	98.8
R1K & R2K	MANBY AUTO T2	408/408	82.7	83.7	84.9	86.2	87.7	89.3	90.9	92.6	95.7

CASE/CONT.	CKT	RATING	2007	2008	2009	2010	2011	2012	2013	2014	2015*
R1K & R2K	MANBY AUTO T7	250/307	135.7	137.2	138.3	139.4	140.5	141.6	142.7	144.0	146.3
R1K & R2K	MANBY AUTO T8	369/369	158.4	160.2	161.5	162.7	164.0	165.3	166.7	168.1	170.8
R1K & R2K	MANBY AUTO T9	250/307	136.1	137.7	138.8	139.8	141.0	142.1	143.2	144.5	146.8
R1K & R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R15K	579/669	533.2	539.0	544.1	549.3	555.3	560.9	566.7	572.6	586.7
R1K & R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R13K	579/669	944.8	953.2	960.4	968.6	976.6	985.0	993.4	1002.0	1086.0
R1K & R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	MANBY AUTO 12	250/296	75.3	76.2	77.3	78.5	79.9	81.3	82.8	84.4	87.2
R13K & R15K	MANBY AUTO T1	368/368	85.3	86.3	87.6	89.0	90.5	92.1	93.8	95.6	98.8
R13K & R15K	MANBY AUTO T2	408/408	82.7	83.6	84.9	86.2	87.7	89.3	90.9	92.6	95.7
R13K & R15K	MANBY AUTO T7	250/307	135.6	137.2	138.2	139.3	140.5	141.6	142.7	143.9	146.2
R13K & R15K	MANBY AUTO T8	369/369	158.4	160.2	161.4	162.7	164.0	165.3	166.6	168.0	170.7
R13K & R15K	MANBY AUTO T9	250/307	136.1	137.6	138.7	139.8	140.9	142.1	143.2	144.4	146.7
R13K & R15K	R2K	579/669	529.6	535.4	540.5	545.6	551.7	557.3	563.0	569.0	582.7
R13K & R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	R1K	579/669	947.2	955.6	962.8	971.1	979.1	987.6	996.0	1004.6	1088.6
R13K & R15K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	H2JK	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	K6J	249/267	165.4	169.4	174.3	179.3	184.4	188.9	195.2	201.0	206.0
H2JK	K13J	225/225	53.3	54.0	55.2	56.4	57.7	59.1	60.5	62.0	62.9
H2JK	K14J		139.4	142.5	145.7	149.0	152.4	155.8	159.5	163.3	165.3
H2JK	K1J		147.4	149.9	152.6	155.2	157.9	161.0	163.9	167.4	170.7
H2JK	K2J		148.3	150.9	153.7	156.5	159.4	162.3	165.7	168.8	172.7
K6J	H2JK	249/267	112.5	116.1	119.9	123.7	127.7	132.5	136.2	140.7	144.7
K6J	K6J	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K6J	K13J	225/225	97.8	98.9	101.0	103.1	105.3	107.6	110.0	112.4	114.1
K6J	K14J		139.5	142.6	145.8	149.1	152.5	155.9	159.6	163.4	165.4
K6J	K1J		147.2	149.7	152.4	155.0	157.8	160.8	163.7	167.2	170.5
K6J	K2J		148.1	150.7	153.4	156.2	159.2	162.1	165.5	168.5	172.4
K13J	H2JK	249/267	65.6	67.5	69.5	71.6	73.9	76.7	78.6	81.1	83.3
K13J	K6J	249/267	149.5	152.5	156.4	160.4	164.6	167.8	173.4	178.1	181.9
K13J	K13J	225/225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

K13J	K14J		139.5	142.6	145.9	149.1	152.5	156.0	159.6	163.4	165.4
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015***
K13J	K1J		147.4	149.9	152.6	155.2	158.0	161.0	163.9	167.4	170.8
K13J	K2J		148.3	150.9	153.7	156.5	159.4	162.4	165.8	168.8	172.7
K14J	R2K	579/669	369.5	372.8	375.7	378.8	382.2	385.5	389.0	392.4	402.8
K14J	R15K	579/669	371.6	374.9	377.8	381.0	384.5	387.8	391.3	394.8	405.1
K14J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K14J	R1K	579/669	477.8	483.1	487.7	492.8	497.7	503.1	508.4	514.0	547.8
K14J	R13K	579/669	473.4	478.6	483.2	488.2	493.1	498.4	503.7	509.2	542.7
K14J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K14J	H2JK	249/267	62.9	64.7	66.6	68.6	70.8	73.3	75.3	77.7	79.9
K14J	K6J	249/267	105.0	107.3	110.3	113.5	116.6	119.1	123.4	127.1	130.0
K14J	K13J	225/225	51.4	52.0	53.0	54.2	55.4	56.6	58.0	59.3	60.3
K14J	K14J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K14J	K1J		193.8	198.0	201.9	205.8	210.3	215.9	219.9	225.5	229.5
K14J	K2J		219.5	224.2	229.3	234.8	239.8	244.1	250.6	255.5	261.7
K1J	R2K	579/669	420.8	425.4	429.8	434.3	439.2	444.1	449.5	454.6	463.9
K1J	R15K	579/669	423.0	427.7	432.1	436.6	441.6	446.5	451.9	457.0	466.3
K1J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1J	R1K	579/669	414.8	418.7	422.3	426.2	429.9	433.7	437.6	441.6	479.5
K1J	R13K	579/669	411.0	414.8	418.4	422.3	425.9	429.7	433.5	437.5	475.0
K1J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1J	H2JK	249/267	62.6	64.4	66.3	68.3	70.4	72.9	74.9	77.3	79.5
K1J	K6J	249/267	104.5	106.8	109.8	112.9	116.0	118.5	122.7	126.4	129.3
K1J	K13J	225/225	51.1	51.7	52.8	53.9	55.1	56.4	57.7	59.0	59.9
K1J	K14J		192.4	197.4	201.5	205.9	210.8	216.1	221.5	226.6	228.6
K1J	K1J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K1J	K2J		225.4	229.9	235.7	241.3	246.7	251.2	257.5	263.0	269.6
K2J	R2K	579/669	424.6	429.4	433.8	438.5	443.5	448.8	454.1	459.6	468.4
K2J	R15K	579/669	426.9	431.7	436.1	440.9	445.9	451.2	456.5	462.1	470.9
K2J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K2J	R1K	579/669	411.9	415.7	419.2	422.9	426.5	430.4	434.0	438.1	477.3
K2J	R13K	579/669	408.1	411.9	415.3	419.0	422.6	426.4	430.0	434.1	472.8
K2J	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K2J	H2JK	249/267	62.6	64.4	66.3	68.3	70.4	72.9	74.9	77.3	79.4
K2J	K6J	249/267	104.5	106.8	109.8	112.9	116.0	118.5	122.7	126.4	129.3
K2J	K13J	225/225	51.1	51.7	52.8	53.9	55.1	56.3	57.6	59.0	59.9
K2J	K14J		207.2	212.4	217.0	222.2	227.3	232.3	238.6	243.8	246.5

K2J	K1J		212.8	217.2	222.1	226.9	232.1	238.0	242.3	249.0	253.5
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015***
K2J	K2J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Rating: continuous rating/emergency continuous rating for 50h/year for circuits; continuous rating/10 day LTR for transformers
* 2014 and 2015: one additional cap bank rated at 260MVAr/230kV is placed at Manby E for voltage support

Appendix I: Circuit Loading under Contingency (AC Option-2) (in MVA)

CASE/CONT.	CKT	RATING	2007	2008	2009	2010*	2011*	2012*	2013*	2014*	2015*
NONE	C2L	579/754	355.6	360.4	364.5	368.7	372.8	377.5	382.1	386.8	391.7
NONE	C3L	579/754	375.0	380.0	384.2	388.7	393.0	397.8	402.6	407.5	412.5
NONE	C14L	579/754	379.1	384.3	388.5	392.9	397.2	402.0	406.8	411.6	416.8
NONE	C15L	579/754	373.1	378.3	382.5	386.8	391.1	395.9	400.5	405.3	410.4
NONE	C16L	579/754	353.7	358.7	362.5	366.5	370.4	374.8	379.1	383.5	388.2
NONE	C17L	579/754	341.7	346.5	350.6	354.8	359.0	363.7	368.2	372.9	378.0
NONE	LEASIDE AUTO 11	275/378	194.7	197.2	199.0	200.8	202.8	204.8	206.9	209.0	211.3
NONE	LEASIDE AUTO 15	283/369	192.4	194.8	196.6	198.4	200.4	202.3	204.4	206.5	208.8
NONE	LEASIDE AUTO 12	312/419	181.2	183.5	185.2	186.9	188.7	190.5	192.4	194.4	196.5
NONE	LEASIDE AUTO 17	283/422	179.4	181.7	183.3	185.0	186.8	188.6	190.5	192.5	194.5
NONE	LEASIDE AUTO 14	275/489	185.4	187.8	189.5	191.2	193.2	195.0	197.0	199.1	201.3
NONE	LEASIDE AUTO 16	275/384	185.2	187.6	189.3	191.1	193.0	194.8	196.8	198.9	201.1
NONE	MANBY AUTO 12	250/296	175.2	180.2	185.5	191.4	184.7	190.7	196.6	202.9	210.0
NONE	MANBY AUTO T1	368/368	198.7	204.4	210.4	217.0	209.5	216.3	223.0	230.1	238.1
NONE	MANBY AUTO T2	408/408	192.4	197.9	203.7	210.1	202.8	209.4	215.9	222.8	230.6
NONE	MANBY AUTO 10		175.2	180.2	185.5	191.4	184.7	190.7	196.7	202.9	210.0
NONE	MANBY AUTO T7	250/307	135.2	136.9	138.0	139.3	140.5	141.9	143.1	144.5	145.9
NONE	MANBY AUTO T8	369/369	157.8	159.8	161.2	162.6	164.0	165.6	167.1	168.7	170.3
NONE	MANBY AUTO T9	250/307	135.6	137.3	138.5	139.8	141.0	142.3	143.6	145.0	146.4
NONE	R2K	579/669	352.1	358.1	364.1	370.7	373.6	380.0	386.6	393.6	401.4
NONE	R15K	579/669	354.3	360.4	366.5	373.0	376.0	382.4	389.1	396.0	403.9
NONE	CB		379.5	385.8	392.2	399.1	402.8	409.5	416.5	423.9	432.1
NONE	R1K	579/669	317.2	319.8	321.8	323.6	327.8	329.3	331.7	333.9	336.0
NONE	R13K	579/669	314.2	316.8	318.8	320.6	324.8	326.3	328.6	330.8	332.9
NONE	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NONE	H2JK	249/267	154.8	158.9	163.2	167.8	162.1	167.0	171.9	176.9	182.5
NONE	K6J	249/267	154.4	158.5	162.7	167.4	161.6	166.5	171.3	176.3	181.8
NONE	K13J	225/225	134.6	138.2	141.8	145.9	140.5	144.7	148.9	153.2	158.0
NONE	K14J		134.7	138.2	141.9	145.9	140.6	144.8	149.0	153.3	158.1
NONE	K1J		146.0	149.8	153.7	158.0	153.1	157.5	162.0	166.5	171.5
C2L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	C3L	579/754	496.8	503.2	508.7	514.8	520.4	526.7	532.8	539.2	545.6
C2L	C14L	579/754	489.4	495.9	501.2	507.0	512.4	518.5	524.5	530.7	536.9
C2L	C15L	579/754	390.5	395.9	400.0	404.3	408.6	413.2	417.7	422.5	427.3
C2L	C16L	579/754	397.4	402.9	407.0	411.5	415.9	420.7	425.4	430.3	435.2

C2L	C17L	579/754	383.9	389.2	393.6	398.4	403.1	408.1	413.1	418.2	423.5
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010***	**2011***	**2012***	**2013***	**2014***	**2015***
C2L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L	LEASIDE AUTO 15	283/369	242.1	245.1	247.4	249.7	252.2	254.7	257.3	260.0	262.6
C2L	LEASIDE AUTO 12	312/419	216.2	218.8	220.6	222.4	224.5	226.4	228.5	230.8	232.8
C2L	LEASIDE AUTO 17	283/422	214.0	216.6	218.4	220.2	222.2	224.1	226.2	228.4	230.5
C2L	LEASIDE AUTO 14	275/489	219.3	221.9	223.8	225.6	227.8	229.8	231.9	234.2	236.4
C2L	LEASIDE AUTO 16	275/384	219.1	221.7	223.5	225.4	227.6	229.5	231.7	233.9	236.1
C3L	C2L	579/754	493.4	499.9	505.4	511.4	517.0	523.3	529.6	535.9	542.4
C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	C14L	579/754	465.2	471.4	476.5	481.7	486.9	492.6	498.3	504.0	509.9
C3L	C15L	579/754	442.7	448.8	453.7	458.7	463.7	469.2	474.6	480.2	485.8
C3L	C16L	579/754	383.0	388.3	392.4	396.6	400.9	405.5	410.0	414.6	419.4
C3L	C17L	579/754	377.4	382.6	386.8	391.2	395.6	400.4	405.1	410.0	415.0
C3L	LEASIDE AUTO 11	275/378	223.8	226.5	228.4	230.2	232.4	234.4	236.5	238.8	240.9
C3L	LEASIDE AUTO 15	283/369	221.1	223.8	225.6	227.5	229.6	231.6	233.7	235.9	238.0
C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C3L	LEASIDE AUTO 17	283/422	214.0	216.7	218.6	220.6	222.8	224.9	227.1	229.5	231.7
C3L	LEASIDE AUTO 14	275/489	225.8	228.6	230.5	232.5	234.8	236.9	239.2	241.5	243.8
C3L	LEASIDE AUTO 16	275/384	225.6	228.4	230.3	232.3	234.5	236.7	238.9	241.3	243.6
C14L	C2L	579/754	462.7	468.8	474.0	479.5	484.7	490.6	496.4	502.4	508.3
C14L	C3L	579/754	487.4	493.7	499.2	504.8	510.3	516.3	522.3	528.6	534.6
C14L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	C15L	579/754	405.2	410.8	415.3	419.9	424.5	429.5	434.4	439.5	444.6
C14L	C16L	579/754	368.9	373.9	377.7	381.6	385.5	389.7	393.9	398.3	402.5
C14L	C17L	579/754	434.8	440.7	445.9	451.2	456.5	462.1	467.7	473.7	479.3
C14L	LEASIDE AUTO 11	275/378	234.3	237.1	239.2	241.2	243.5	245.6	248.0	250.4	252.7
C14L	LEASIDE AUTO 15	283/369	231.5	234.3	236.3	238.3	240.6	242.7	245.0	247.4	249.6
C14L	LEASIDE AUTO 12	312/419	206.0	208.4	210.0	211.7	213.7	215.4	217.4	219.4	221.4
C14L	LEASIDE AUTO 17	283/422	203.9	206.3	207.9	209.5	211.5	213.2	215.2	217.2	219.1
C14L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L	LEASIDE AUTO 16	275/384	234.3	237.2	239.5	241.7	244.2	246.5	249.1	251.7	254.2
C15L	C2L	579/754	411.0	416.5	421.2	426.0	430.8	436.2	441.5	446.8	452.3
C15L	C3L	579/754	428.0	433.8	438.5	443.6	448.5	454.0	459.4	464.9	470.4
C15L	C14L	579/754	405.6	411.1	415.4	420.0	424.5	429.5	434.4	439.3	444.4
C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	C16L	579/754	488.4	495.2	500.2	505.3	510.5	516.2	521.6	527.2	533.4
C15L	C17L	579/754	429.1	435.2	440.1	445.3	450.5	456.2	461.9	467.6	473.7

C15L	LEASIDE AUTO 11	275/378	218.7	221.3	223.1	224.9	227.0	228.9	231.0	233.1	235.3
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010***	**2011***	**2012***	**2013***	**2014***	**2015***
C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C15L	LEASIDE AUTO 12	312/419	219.7	222.3	224.2	226.1	228.2	230.2	232.4	234.6	236.8
C15L	LEASIDE AUTO 17	283/422	217.4	220.1	221.9	223.8	225.9	227.9	230.0	232.2	234.4
C15L	LEASIDE AUTO 14	275/489	227.9	230.7	232.7	234.8	237.1	239.3	241.6	244.1	246.5
C15L	LEASIDE AUTO 16	275/384	227.6	230.5	232.5	234.5	236.8	239.0	241.4	243.8	246.3
C16L	C2L	579/754	390.4	395.5	399.9	404.5	408.9	413.9	418.8	423.8	428.7
C16L	C3L	579/754	406.3	411.6	416.1	420.8	425.4	430.5	435.6	440.7	445.8
C16L	C14L	579/754	434.0	439.8	444.6	449.6	454.5	460.0	465.4	470.8	476.4
C16L	C15L	579/754	515.1	522.2	527.6	533.2	538.7	544.8	550.7	556.8	563.3
C16L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L	C17L	579/754	422.6	428.4	433.3	438.5	443.6	449.1	454.7	460.3	466.2
C16L	LEASIDE AUTO 11	275/378	232.3	235.2	237.2	239.3	241.6	243.8	246.1	248.6	251.0
C16L	LEASIDE AUTO 15	283/369	229.6	232.3	234.4	236.4	238.7	240.9	243.2	245.6	248.0
C16L	LEASIDE AUTO 12	312/419	220.7	223.4	225.3	227.2	229.4	231.4	233.6	235.9	238.2
C16L	LEASIDE AUTO 17	283/422	218.4	221.1	223.0	224.9	227.0	229.1	231.3	233.5	235.8
C16L	LEASIDE AUTO 14	275/489	210.8	213.3	215.1	216.8	218.8	220.7	222.8	224.9	227.0
C16L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	C2L	579/754	375.1	380.0	384.3	388.7	392.9	397.7	402.5	407.3	412.0
C17L	C3L	579/754	404.9	410.1	414.7	419.5	424.2	429.3	434.4	439.6	444.6
C17L	C14L	579/754	469.9	476.2	481.5	486.8	492.1	498.0	503.8	509.6	515.4
C17L	C15L	579/754	451.5	457.8	462.8	468.0	473.1	478.7	484.3	490.1	496.0
C17L	C16L	579/754	462.3	468.6	473.7	478.8	483.9	489.6	495.1	500.8	506.7
C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 11	275/378	209.1	211.6	213.3	215.1	217.1	219.0	221.0	223.2	225.3
C17L	LEASIDE AUTO 15	283/369	235.9	238.8	241.0	243.1	245.4	247.7	250.1	252.6	255.0
C17L	LEASIDE AUTO 12	312/419	217.7	220.4	222.3	224.1	226.2	228.2	230.3	232.5	234.7
C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C17L	LEASIDE AUTO 14	275/489	209.1	211.6	213.3	215.1	217.1	219.0	221.0	223.2	225.3
C17L	LEASIDE AUTO 16	275/384	208.9	211.4	213.1	214.9	216.9	218.8	220.8	222.9	225.0
C2L & C3L	C2L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C3L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	C14L	579/754	639.3	647.5	654.2	661.3	668.0	675.6	683.1	690.7	698.7
C2L & C3L	C15L	579/754	487.2	493.7	498.6	503.6	508.7	514.2	519.7	525.1	530.7
C2L & C3L	C16L	579/754	442.4	448.3	452.9	457.6	462.4	467.5	472.5	477.5	482.7
C2L & C3L	C17L	579/754	430.5	436.2	440.7	445.5	450.3	455.4	460.5	465.6	470.9
C2L & C3L	LEASIDE AUTO 11	275/378	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

C2L & C3L	LEASIDE AUTO 15	283/369	280.7	283.8	286.2	288.5	291.2	293.6	296.2	298.9	301.5
CASE/CONT.	**CKT**	**RATING**	**2007**	**2008**	**2009**	**2010***	**2011***	**2012***	**2013***	**2014***	**2015***
C2L & C3L	LEASIDE AUTO 12	312/419	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2L & C3L	LEASIDE AUTO 17	283/422	268.1	271.2	273.4	275.6	278.1	280.4	282.9	285.4	287.9
C2L & C3L	LEASIDE AUTO 14	275/489	277.5	280.6	282.7	284.6	287.2	289.3	291.7	294.1	296.5
C2L & C3L	LEASIDE AUTO 16	275/384	277.3	280.3	282.4	284.4	286.9	289.0	291.4	293.8	296.2
C16L & C17L	C2L	579/754	419.2	424.7	429.2	434.0	438.6	443.5	448.3	453.4	457.3
C16L & C17L	C3L	579/754	474.5	480.3	485.4	490.7	496.0	501.5	506.8	512.5	516.9
C16L & C17L	C14L	579/754	602.7	610.4	617.1	623.6	630.4	637.3	644.2	651.1	657.0
C16L & C17L	C15L	579/754	652.3	660.9	667.8	674.6	681.5	689.0	696.2	703.8	711.6
C16L & C17L	C16L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	C17L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 11	275/378	305.6	309.0	311.6	314.0	316.9	319.4	322.1	324.9	327.2
C16L & C17L	LEASIDE AUTO 15	283/369	301.9	305.3	307.8	310.3	313.1	315.6	318.2	321.1	323.3
C16L & C17L	LEASIDE AUTO 12	312/419	266.9	269.9	272.0	274.0	276.4	278.4	280.7	283.0	284.8
C16L & C17L	LEASIDE AUTO 17	283/422	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C16L & C17L	LEASIDE AUTO 14	275/489	223.9	226.1	227.3	228.8	230.7	232.1	233.6	235.3	236.5
C16L & C17L	LEASIDE AUTO 16	275/384	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C2L	579/754	532.7	539.5	545.5	551.7	557.8	564.4	571.0	577.6	584.1
C14L & C15L	C3L	579/754	557.1	564.3	570.4	576.6	582.8	589.5	596.2	602.9	609.5
C14L & C15L	C14L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C15L	579/754	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	C16L	579/754	512.3	519.1	524.2	529.2	534.3	539.7	545.1	550.5	556.0
C14L & C15L	C17L	579/754	540.5	547.8	554.0	560.4	566.8	573.6	580.4	587.4	594.3
C14L & C15L	LEASIDE AUTO 11	275/378	277.6	280.7	282.8	284.8	287.2	289.3	291.6	293.9	296.1
C14L & C15L	LEASIDE AUTO 15	283/369	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 12	312/419	261.7	264.5	266.5	268.4	270.8	272.8	275.0	277.2	279.4
C14L & C15L	LEASIDE AUTO 17	283/422	259.0	261.8	263.7	265.7	268.0	270.0	272.1	274.4	276.5
C14L & C15L	LEASIDE AUTO 14	275/489	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C14L & C15L	LEASIDE AUTO 16	275/384	300.5	304.0	306.7	309.3	312.4	315.1	318.2	321.2	324.1
R1K	MANBY AUTO 12	250/296	175.1	180.1	185.4	191.3	184.6	190.6	196.5	202.7	209.8
R1K	MANBY AUTO T1	368/368	198.6	204.3	210.3	216.9	209.3	216.1	222.9	229.9	237.9
R1K	MANBY AUTO T2	408/408	192.3	197.8	203.6	210.0	202.7	209.3	215.8	222.6	230.4
R1K	MANBY AUTO 10		175.1	180.2	185.4	191.3	184.6	190.6	196.5	202.8	209.8
R1K	MANBY AUTO T7	250/307	135.5	137.2	138.3	139.5	140.8	142.1	143.3	144.6	145.9
R1K	MANBY AUTO T8	369/369	158.2	160.1	161.5	162.9	164.4	165.9	167.3	168.8	170.4
R1K	MANBY AUTO T9	250/307	136.0	137.6	138.8	140.0	141.2	142.5	143.8	145.1	146.4
R1K	R2K	579/669	375.9	382.1	388.3	394.9	398.6	405.0	411.8	418.8	426.7

CASE/CONT.	CKT	RATING	2007	2008	2009	2010*	2011*	2012*	2013*	2014*	2015*
R1K	R15K	579/669	378.3	384.4	390.6	397.3	401.0	407.5	414.2	421.3	429.2
R1K	CB		405.3	411.8	418.3	425.3	429.7	436.5	443.6	451.1	459.4
R1K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K	R13K	579/669	523.7	527.9	531.2	534.2	541.1	543.5	547.5	551.0	554.4
R1K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	MANBY AUTO 12	250/296	175.1	180.1	185.4	191.3	184.6	190.6	196.5	202.8	209.8
R13K	MANBY AUTO T1	368/368	198.6	204.3	210.3	216.9	209.3	216.1	222.9	229.9	237.9
R13K	MANBY AUTO T2	408/408	192.3	197.8	203.6	210.0	202.7	209.3	215.8	222.6	230.4
R13K	MANBY AUTO 10		175.2	180.2	185.4	191.3	184.6	190.6	196.5	202.8	209.8
R13K	MANBY AUTO T7	250/307	135.5	137.2	138.3	139.5	140.8	142.1	143.3	144.6	146.0
R13K	MANBY AUTO T8	369/369	158.2	160.1	161.5	162.9	164.3	165.9	167.3	168.8	170.4
R13K	MANBY AUTO T9	250/307	136.0	137.6	138.8	140.0	141.2	142.5	143.8	145.1	146.4
R13K	R2K	579/669	375.6	381.7	387.9	394.5	398.2	404.6	411.4	418.4	426.3
R13K	R15K	579/669	377.9	384.1	390.3	396.9	400.6	407.1	413.9	420.9	428.8
R13K	CB		404.8	411.4	417.9	424.9	429.3	436.1	443.2	450.7	459.0
R13K	R1K	579/669	525.3	529.6	532.9	535.9	542.8	545.2	549.2	552.7	556.2
R13K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	MANBY AUTO 12	250/296	174.1	179.1	184.3	190.0	183.6	189.4	195.3	201.4	208.3
R2K	MANBY AUTO T1	368/368	197.5	203.1	209.0	215.5	208.2	214.8	221.5	228.4	236.2
R2K	MANBY AUTO T2	408/408	191.2	196.6	202.3	208.6	201.6	208.0	214.4	221.2	228.7
R2K	MANBY AUTO 10		174.2	179.1	184.3	190.0	183.6	189.5	195.3	201.4	208.3
R2K	MANBY AUTO T7	250/307	134.8	136.5	137.6	138.9	140.1	141.4	142.6	144.0	145.4
R2K	MANBY AUTO T8	369/369	157.4	159.3	160.7	162.1	163.6	165.1	166.5	168.1	169.8
R2K	MANBY AUTO T9	250/307	135.2	136.9	138.1	139.3	140.6	141.9	143.1	144.5	145.9
R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R2K	R15K	579/669	482.3	490.6	498.9	508.1	511.1	520.2	529.3	539.1	549.8
R2K	CB		515.1	523.8	532.7	542.4	546.1	555.7	565.3	575.7	586.9
R2K	R1K	579/669	335.6	338.5	340.8	343.0	347.9	349.8	352.4	355.0	357.4
R2K	R13K	579/669	332.5	335.3	337.6	339.8	344.7	346.5	349.2	351.7	354.1
R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	MANBY AUTO 12	250/296	174.1	179.0	184.2	190.0	183.5	189.4	195.2	201.3	208.2
R15K	MANBY AUTO T1	368/368	197.4	203.0	208.9	215.4	208.1	214.8	221.4	228.3	236.1
R15K	MANBY AUTO T2	408/408	191.1	196.5	202.2	208.6	201.5	207.9	214.4	221.1	228.6
R15K	MANBY AUTO 10		174.1	179.0	184.2	190.0	183.5	189.4	195.2	201.4	208.2
R15K	MANBY AUTO T7	250/307	134.8	136.4	137.6	138.8	140.0	141.4	142.6	144.0	145.4
R15K	MANBY AUTO T8	369/369	157.3	159.3	160.7	162.1	163.5	165.1	166.5	168.1	169.7

R15K	MANBY AUTO T9	250/307	135.2	136.9	138.1	139.3	140.5	141.9	143.1	144.5	145.9

CASE/CONT.	CKT	RATING	2007	2008	2009	2010*	2011*	2012*	2013*	2014*	2015*
R15K	R2K	579/669	479.2	487.4	495.8	505.0	507.8	516.9	526.0	535.8	546.5
R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R15K	CB		516.0	524.8	533.7	543.5	547.0	556.6	566.3	576.7	588.0
R15K	R1K	579/669	335.6	338.4	340.7	342.9	347.9	349.7	352.4	355.0	357.4
R15K	R13K	579/669	332.5	335.3	337.6	339.8	344.6	346.5	349.2	351.7	354.1
R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	MANBY AUTO 12	250/296	174.0	178.9	184.1	189.9	183.4	189.3	195.1	201.2	208.0
R1K & R2K	MANBY AUTO T1	368/368	197.4	202.9	208.8	215.3	208.0	214.6	221.2	228.1	235.9
R1K & R2K	MANBY AUTO T2	408/408	191.1	196.5	202.1	208.5	201.4	207.8	214.2	220.9	228.4
R1K & R2K	MANBY AUTO 10		174.0	179.0	184.1	189.9	183.5	189.3	195.1	201.2	208.0
R1K & R2K	MANBY AUTO T7	250/307	135.0	136.6	137.8	139.0	140.2	141.5	142.7	144.0	145.3
R1K & R2K	MANBY AUTO T8	369/369	157.7	159.6	160.9	162.3	163.7	165.2	166.6	168.1	169.6
R1K & R2K	MANBY AUTO T9	250/307	135.5	137.1	138.3	139.5	140.7	142.0	143.2	144.5	145.8
R1K & R2K	R2K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R15K	579/669	517.2	525.7	534.3	543.6	547.7	556.9	566.2	576.2	587.0
R1K & R2K	CB		552.7	561.7	570.8	580.7	585.5	595.2	605.1	615.6	627.0
R1K & R2K	R1K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R1K & R2K	R13K	579/669	556.8	561.6	565.4	568.9	577.1	580.1	584.5	588.7	592.6
R1K & R2K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	MANBY AUTO 12	250/296	174.0	178.9	184.0	189.8	183.4	189.2	195.0	201.1	207.9
R13K & R15K	MANBY AUTO T1	368/368	197.3	202.9	208.7	215.2	207.9	214.6	221.2	228.1	235.8
R13K & R15K	MANBY AUTO T2	408/408	191.0	196.4	202.1	208.4	201.3	207.8	214.1	220.8	228.3
R13K & R15K	MANBY AUTO 10		174.0	178.9	184.1	189.8	183.4	189.2	195.0	201.1	208.0
R13K & R15K	MANBY AUTO T7	250/307	135.0	136.6	137.8	139.0	140.2	141.5	142.7	144.0	145.3
R13K & R15K	MANBY AUTO T8	369/369	157.6	159.5	160.9	162.2	163.7	165.2	166.6	168.1	169.6
R13K & R15K	MANBY AUTO T9	250/307	135.4	137.1	138.2	139.4	140.7	142.0	143.2	144.5	145.8
R13K & R15K	R2K	579/669	513.5	522.0	530.5	539.9	543.8	553.0	562.3	572.3	583.1
R13K & R15K	R15K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		553.1	562.1	571.2	581.1	585.8	595.5	605.4	616.0	627.5
R13K & R15K	R1K	579/669	558.5	563.3	567.1	570.7	578.8	581.9	586.3	590.5	594.5
R13K & R15K	R13K	579/669	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R13K & R15K	CB		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	H2JK	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
H2JK	K6J	249/267	196.6	201.7	206.9	212.7	204.2	210.3	216.3	222.4	229.0
H2JK	K13J	225/225	167.8	172.1	176.5	181.3	173.6	178.7	183.7	188.9	194.4
H2JK	K14J		167.9	172.2	176.5	181.4	173.6	178.7	183.8	188.9	194.5

CASE/CONT.	CKT	RATING	2007	2008	2009	2010*	2011*	2012*	2013*	2014*	2015*
H2JK	K1J		181.4	185.9	190.5	195.6	188.3	193.6	198.9	204.3	210.0
K6J	H2JK	249/267	195.1	200.1	205.4	210.9	201.9	207.9	213.8	219.9	226.8
K6J	K6J	249/267	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K6J	K13J	225/225	166.2	170.3	174.8	179.4	171.2	176.2	181.1	186.3	192.0
K6J	K14J		166.2	170.4	174.8	179.5	171.2	176.2	181.2	186.3	192.1
K6J	K1J		179.4	183.8	188.5	193.3	185.5	190.8	195.9	201.3	207.2
K13J	H2JK	249/267	185.8	190.5	195.6	201.0	192.7	198.5	204.2	210.1	216.6
K13J	K6J	249/267	185.3	190.1	195.1	200.5	192.2	197.9	203.6	209.5	215.8
K13J	K13J	225/225	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K13J	K14J		162.8	166.9	171.2	176.0	168.3	173.3	178.2	183.3	188.9
K13J	K1J		176.0	180.3	184.9	189.9	182.7	187.9	193.1	198.4	204.2
K14J	H2JK	249/267	189.3	194.3	199.4	205.0	197.8	203.7	209.6	215.6	222.4
K14J	K6J	249/267	188.8	193.8	198.8	204.5	197.2	203.1	209.0	215.0	221.6
K14J	K13J	225/225	165.8	170.1	174.6	179.4	172.8	177.9	183.0	188.3	194.0
K14J	K14J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K14J	K1J		179.6	184.2	188.9	194.0	187.9	193.3	198.6	204.1	210.1
K1J	H2JK	249/267	199.5	204.9	210.6	216.9	208.6	215.3	222.0	229.4	237.9
K1J	K6J	249/267	199.0	204.4	210.0	216.3	208.0	214.7	221.4	228.8	237.0
K1J	K13J	225/225	174.9	179.7	184.6	190.0	182.4	188.3	194.1	200.5	207.8
K1J	K14J		175.0	179.7	184.6	190.1	182.4	188.3	194.1	200.6	207.9
K1J	K1J		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

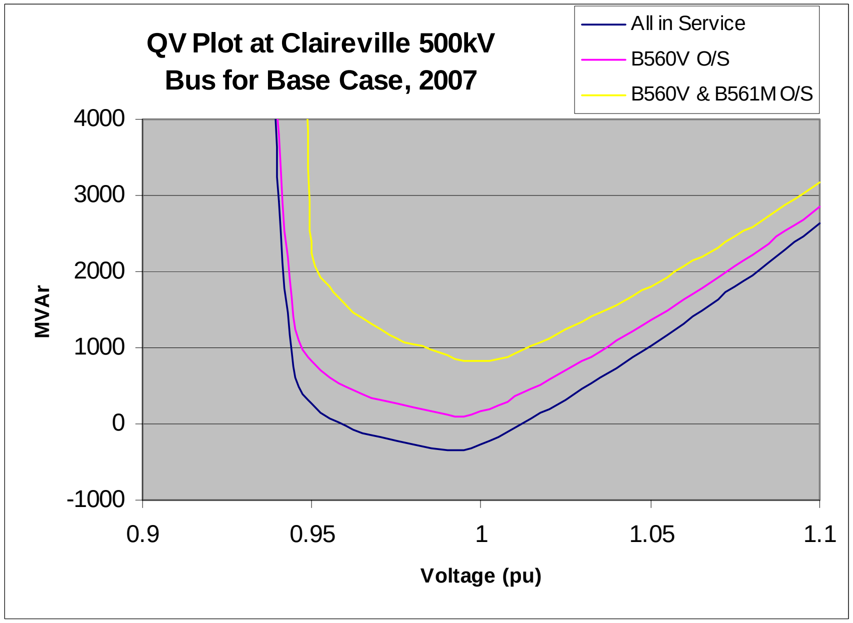
Rating: continuous rating/emergency continuous rating for 50h/year for circuits; continuous rating/10 day LTR for transformers
* 2010 to 2015: one cap bank rated at 125MVAr/127kV is placed at John for voltage support

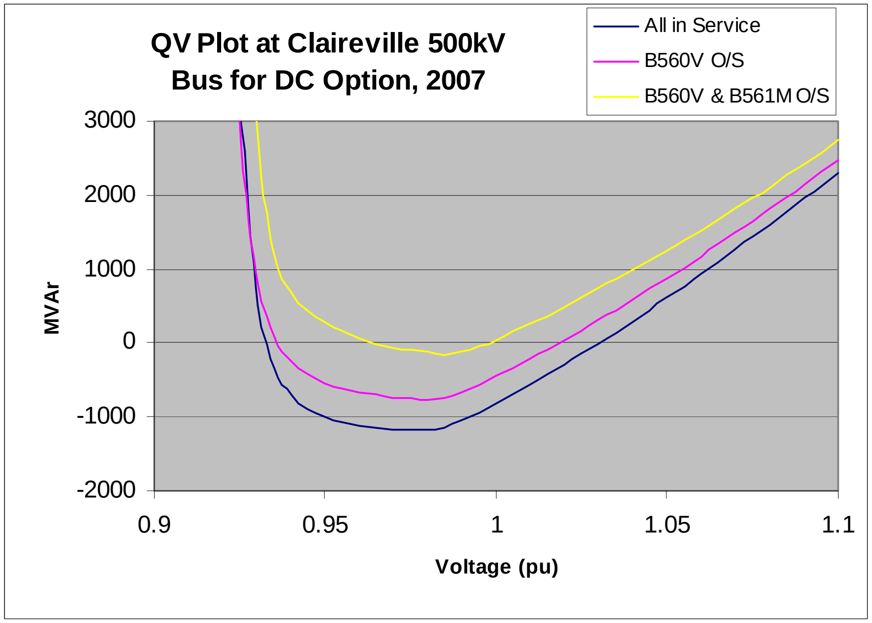
Appendix J: MVA Flow on 115kV Central Toronto Circuits

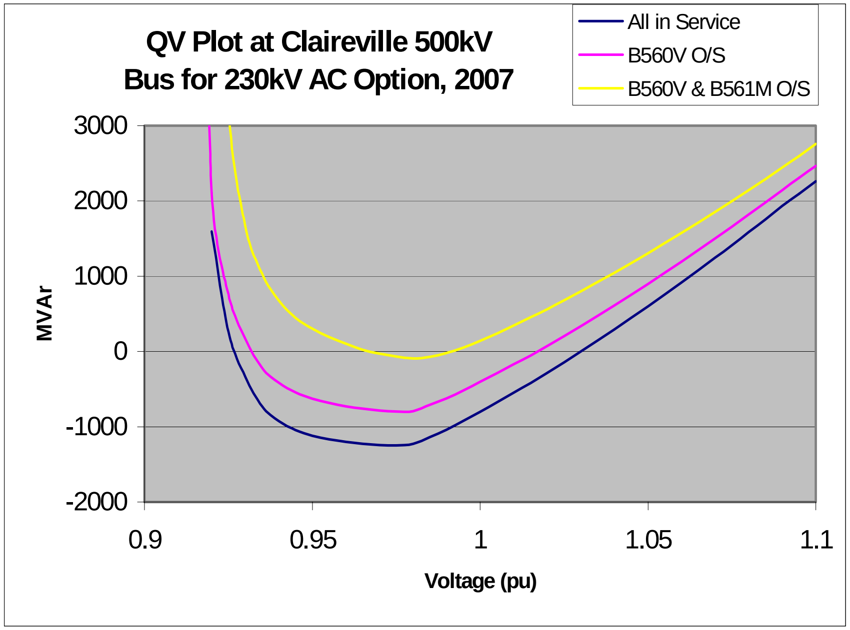
From		To		Circuit	Limit	Base 2007	DC 2007	230kV AC 2007	115kV AC 2007	DC 2015	230kV AC 2007	115kV AC 2007	Full DC 2015
Bus #	Bus Name	Bus #	Bus Name										
3301	LEASEJ	3379	LUMSDJ11	H11L	147	81.9	52	51	50.7	64.1	54.6	54.1	19.5
3379	LUMSDJ11	3381	MAINH11		102	81.8	52.2	50.5	50.3	64.3	54.3	53.9	21.4
3381	MAINH11	3300	HEARN		116	45.8	17.6	32.6	31.9	22.5	30.6	29.4	38.2
3301	LEASEJ	3378	LUMSDJH7	H7L	147	82.6	51.7	50.7	50.6	65.1	54.6	54.8	18.7
3378	LUMSDJH7	3380	MAINH7		102	82.5	51.9	50.2	50.2	65.3	54.4	54.6	20.5
3380	MAINH7	3300	HEARN		116	44.3	16.7	30.4	29.6	20.4	28.5	27.2	39.5
3301	LEASEJ	3370	GERRDH3L	H3L	302	137.5	85.3	84.6	84.2	105.8	90.3	89.7	29.5
3370	GERRDH3L	3326	BASINJH3		143	77.8	27.1	49.4	48.2	39.6	46.4	44.6	65
3326	BASINJH3	3300	HEARN		239	52.6	19.1	52.2	51.1	10.9	47.6	45.1	94.6
3301	LEASEJ	3369	GERRDH1L	H1L	239	130.5	80.2	78.7	78.4	100.7	84.4	84.4	29.5
3369	GERRDH1L	3325	BASINJH1		143	74.3	27.1	48.2	47.1	36.9	45.5	43.5	62.1
3325	BASINJH1	3300	HEARN		239	49.2	19.2	50.1	49	9.5	46	44.6	92.3
3305	LEASKP	3371	GERRDJH6	H6LC	241	99.9	75.8	71.7	71.8	93	81.9	82.2	50.3
3371	GERRDJH6	3300	HEARN		269	42.3	25.6	53.2	52.1	17.5	54.8	53	94
3371	GERRDJH6	3345	CECILKP		223	76.1	92.9	100.9	100.7	103.6	116.5	116.1	139.2
3305	LEASKP	3372	GERRDJH8	H8LC	241	99.9	75.8	71.7	71.8	93	81.9	82.1	50.3
3372	GERRDJH8	3300	HEARN		269	42.3	25.6	53.2	52.1	17.5	54.8	53	94
3372	GERRDJH8	3345	CECILKP		223	76.1	92.9	100.8	100.6	103.6	116.5	116.1	139.2
3305	LEASKP	3349	CHARLL4	L4C	215	80.1	78.6	77.9	78.1	86.2	84.9	85.3	83.7
3305	LEASKP	3347	CHARLL9	L9C	210	117.9	98.8	94.3	94.5	118.8	108.7	109.1	84.1
3347	CHARLL9	3345	CECILKP		234	81.9	62.5	59	59.1	79.4	69.9	70.3	45.3
3305	LEASKP	3348	CHARLL12	12C	210	123.9	103.5	98.6	98.8	124.7	113.8	114.2	87.5
3348	CHARLL12	3345	CECILKP		234	89	68.3	64.3	64.5	86.5	76.2	76.6	50
3345	CECILKP	3401	TERAUT5E	C5E	234	60.2	60.2	60.1	60.1	70.1	69.8	69.9	69.9
3345	CECILKP	3402	TERAUT7E	C7E	234	57.1	57.1	57	57	66.5	66.2	66.3	66.2
3300	HEARN	3365	ESPLAH5E	H5E	269	120	119.7	0	0	142	0	0	141.8
3365	ESPLAH5E	3403	TERC5E	C5E	148	58.1	57.9	55.3	58.5	67.7	64.1	68.4	67.5
3300	HEARN	3366	ESPLAH7E	H7E	269	117.7	117.4	0	0	139.5	0	0	139.2
3366	ESPLAH7E	3404	TERC7E	C7E	148	53.9	53.7	56.3	54.3	62.9	66.4	63.5	62.7

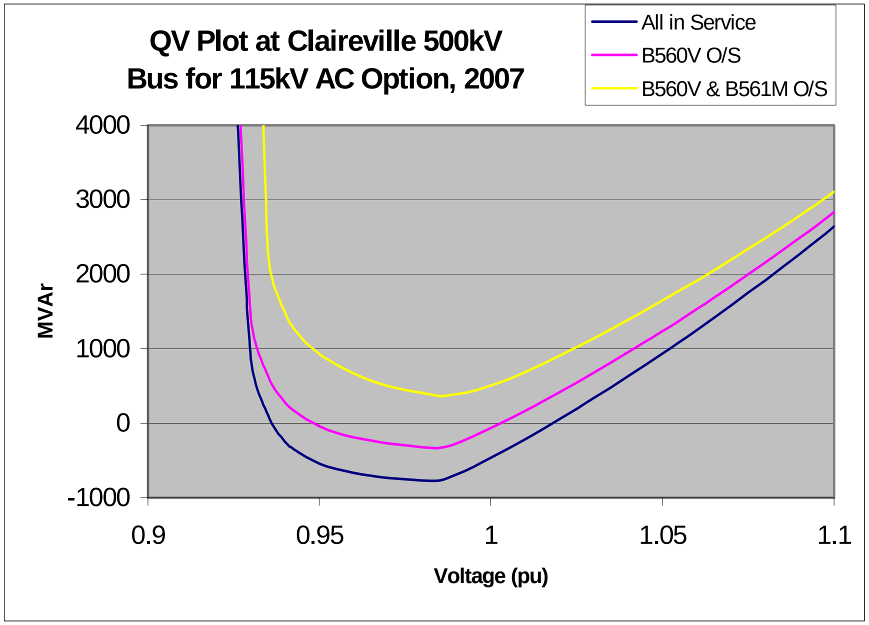
3301	LEASEJ	3373	GLENGRL2	L2Y	223	29.9	29.7	29.6	29.7	30.8	31.3	31.4	30.7
From		**To**		**Circuit**	**Limit**	**Base 2007**	**DC 2007**	**230kV AC 2007**	**115kV AC 2007**	**DC 2015**	**230kV AC 2007**	**115kV AC 2007**	**Full DC 2015**
Bus #	**Bus Name**	**Bus #**	**Bus Name**										
3301	LEASEJ	3362	DUPLEXK	L5D	220	60.2	60	59.7	59.8	65.2	64.8	65	64.9
3305	LEASKP	3363	DUPLEXP	L16D	223	80.8	80.4	80.1	80.2	87.4	86.3	86.6	87
3363	DUPLEXP	3374	GLENGRD6	D6Y	131	24	23.9	23.9	23.9	25.4	25.1	25.2	25.3
3305	LEASKP	3339	BRIDGL13	L13W	215	137.1	136.3	135.3	135.9	149.2	148.1	148.3	148.4
3301	LEASEJ	3340	BRIDGL14	L14W	140	86.3	86.1	86.7	85.9	94.2	93.7	93.6	94
3301	LEASEJ	3341	BRIDGL15	L15W	146	99.4	98.9	98.3	98.7	107.4	106.4	107.6	107
3302	MANBYE	3393	STCLRJK1	K1W	225	98.7	98.6	98.5	98.7	106.8	106.7	107.1	106.8
3302	MANBYE	3364	ESPLAH2J	K3W	225	98.7	98.6	98.5	98.7	106.8	106.7	107.1	106.8
3302	MANBYE	3391	RUNYMK11	K11W	225	110.3	110.2	110	110.3	119.6	119.4	119.8	119.5
3302	MANBYE	3392	RUNYMK12	K12W	225	110.5	110.4	110.2	110.5	119.8	119.5	120	119.7
3303	MANBYW	3386	RIVERJH2	H2JK	249	115.4	57.8	63.2	154.8	68	81	182.5	67.7
3303	MANBYW	3387	RIVERJK6	K6J	249	115	57.7	104.8	154.4	67.7	129.1	181.8	67.4
3303	MANBYW	3388	RIVRJK13	K13J	225	99.1	48.1	51.5	134.6	55	60.4	158	54.7
3303	MANBYW	3389	RIVRJK14	K14J	225	99.1	48.1	51.5	134.7	55	60.4	158.1	54.7

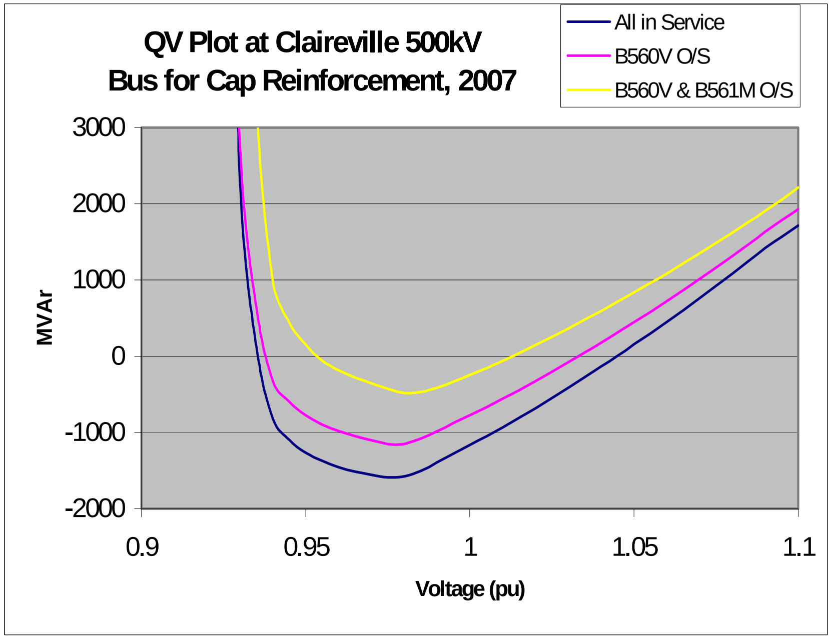
Appendix K: QV Plots

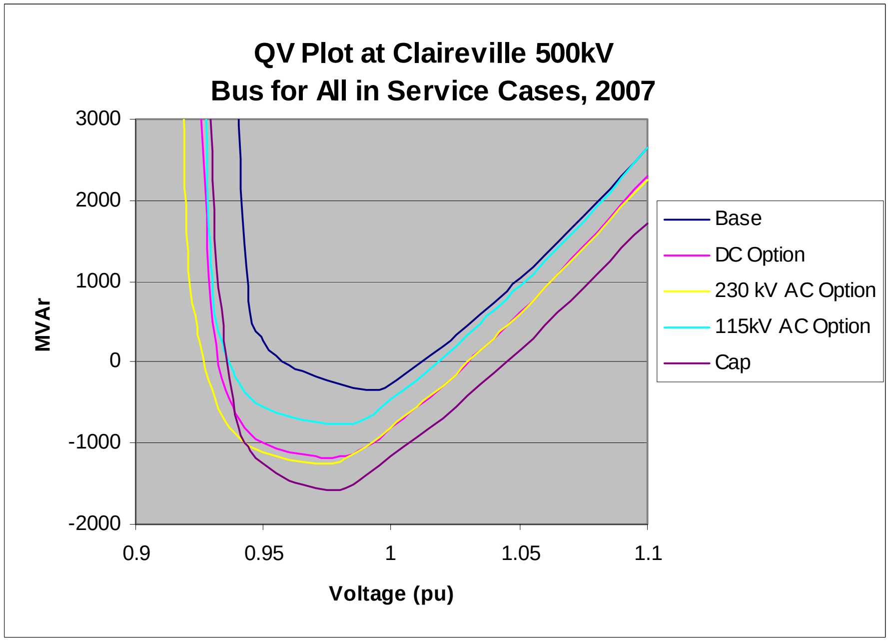


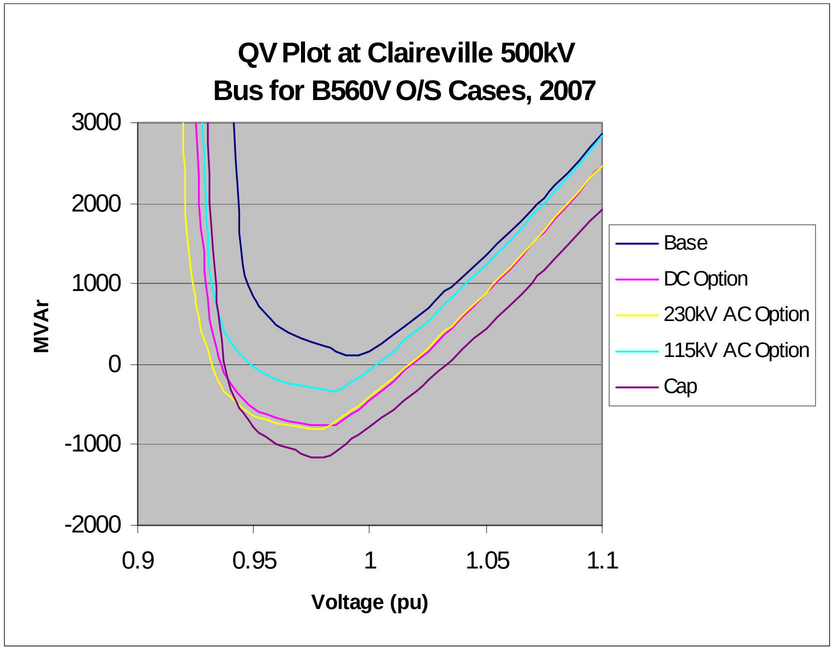


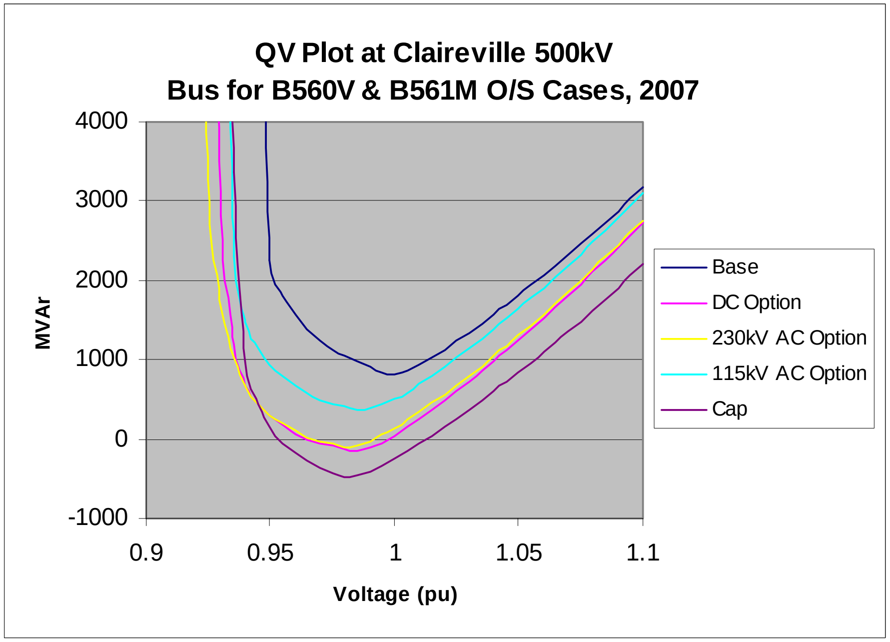





QV Plot at Claireville 500kV
Bus for Cap Reinforcement, 2007
All in Service
B560V O/S
B560V & B561M O/S
3000
2000
1000
0
-1000
-2000
MVAr
0.9
0.95
1
1.05
1.1
Voltage (pu)


QV Plot at Claireville 500kV
Bus for All in Service Cases, 2007
3000
2000
1000
0
-1000
-2000
MVAr
0.9
0.95
1
1.05
1.1
Voltage (pu)
Base
DC Option
230 kV AC Option
115kV AC Option
Cap


QV Plot at Claireville 500kV
Bus for B560V O/S Cases, 2007
3000
2000
1000
0
-1000
-2000
MVAr
0.9
0.95
1
1.05
1.1
Voltage (pu)
Base
DC Option
230kV AC Option
115kV AC Option
Cap


QV Plot at Claireville 500kV
Bus for B560V & B561M O/S Cases, 2007
4000
3000
2000
1000
0
-1000
MVAr
0.9
0.95
1
1.05
1.1
Voltage (pu)
Base
DC Option
230kV AC Option
115kV AC Option
Cap

TAB 4

York Region Supply Study

Adequacy of Transmission Facilities

And

Transmission Supply Plan 2003-2013

10 July 2003

Richmond Hill Hydro Inc.
1150 Elgin Mills Road East, P.O. Box 418
Richmond Hill, Ontario L4C 4Y6

Foreword

This report is the result of a joint study by Aurora Hydro, Hydro Vaughan, Newmarket Hydro, Markham Hydro and Richmond Hill Hydro and Hydro One Networks. The study team members were:

Leo McGinty, Aurora Hydro
Glenn Allen, Markham Hydro
Sammy Chinn, Richmond Hill Hydro
Stan Dafoe, Hydro One Networks
John Sabiston, Hydro One Networks
Robert Zeni, Hydro Vaughan
Gaye-Donna Young, Newmarket Hydro
Charlie Lee, Hydro One Networks
Paul Cook, Hydro One Networks
Farooq Qureshy, Hydro One Networks

This report is for the internal use of the participating utilities.

The load forecast is based on information available to Aurora Hydro, Hydro Vaughan, Newmarket Hydro, Markham Hydro, Richmond Hill Hydro and Hydro One Networks - Distribution at the time of the study.

The preferred plan has been selected based on technical considerations. The issue of cost allocation between utilities was not addressed.

F. Qureshy

Signatures

We have reviewed this report and concur with its recommendations.

Utility	Signature	Title
Aurora Hydro		Leo McGinty Line Superintendent
Newmarket Hydro		Dave Akers Director, Technical Operations
Markham Hydro		Kevin Willett Manager of Operations
Richmond Hill Hydro		Sammy Chinn Technical Services and Planning Engineer
Hydro Vaughan		Robert Zeni Planning Engineer
Hydro One Networks – Distribution		Charlie Lee Senior Network Management Engineer
Hydro One Networks - Transmission		John Sabiston Supervisor Transmission Development

Date: July 10, 2003

Table of Contents

Executive Summary

The Region of York comprises nine municipalities - Aurora, East Gwillimbury, Georgina, King, Markham, Newmarket, Richmond Hill, Vaughan and Whitchurch-Stouffville with a combined load of over 1700MW. Electrical supply to the area is provided by 500kV and 230kV transmission and step down facilities as shown in Map 1 and Figure 1.

The Region in general and the southern part in particular – Markham, Richmond Hill and Vaughan – is one of the fastest growing areas in the province. This study was conducted jointly with all of the York Region utilities to review the area load growth and to ensure that adequate facilities are planned for and available to meet the electrical demand requirements over the next ten years. The York Region utilities are:

- Aurora Hydro
- Markham Hydro
- Newmarket Hydro
- Richmond Hill Hydro
- Hydro Vaughan
- Hydro One Networks – Distribution

Need

The main issue for York Region is the capacity of the transmission facilities that currently serves customers in the region. Two of the four corridors that serve the area are at or are approaching capacity limits due to significant load growth (exceeding 6.5%/year between 1997 and 2002). A number of York Region step-down transformer stations are heavily loaded and the forecast is for continuing strong load growth. The York Region utilities expect to connect seven new step-down transformer stations over the study period and transmission facilities need to be reinforced to supply them. They would also be reviewing the benefits of adding capacitor banks at step-down transformer stations not currently equipped with capacitors.

Another concern is the lack of supply diversity. About 90% of the Town of Markham load is supplied from 230kV circuits C11R/C12R out of Cherrywood TS. Similarly, about 70% of the City of Vaughan load and about 80% of the Town of Richmond Hill load is supplied from the 230kV V71R/V75R circuits out of Claireville TS. The loss of either line could severely impact a wide area within each of these municipalities.

A separate but related issue is the capacity of the main 500-230kV autotransformers that connect to the 500 kV network at Claireville TS and Cherrywood TS and supply the entire GTA. The loading on these autotransformers is a function of the load in the GTA area and existing facilities are expected to be fully loaded by summer 2005 following the retirement of Lakeview GS. Even if all of the currently proposed new generation in the GTA (e.g. the Portlands Energy Center, all four units of Pickering A GS) were to come into service, and Lakeview GS is not retired, additional transformation capacity would be required by summer 2009.

Proposed Transmission Reinforcement

The proposed transmission reinforcements to meet the identified needs are as follows:

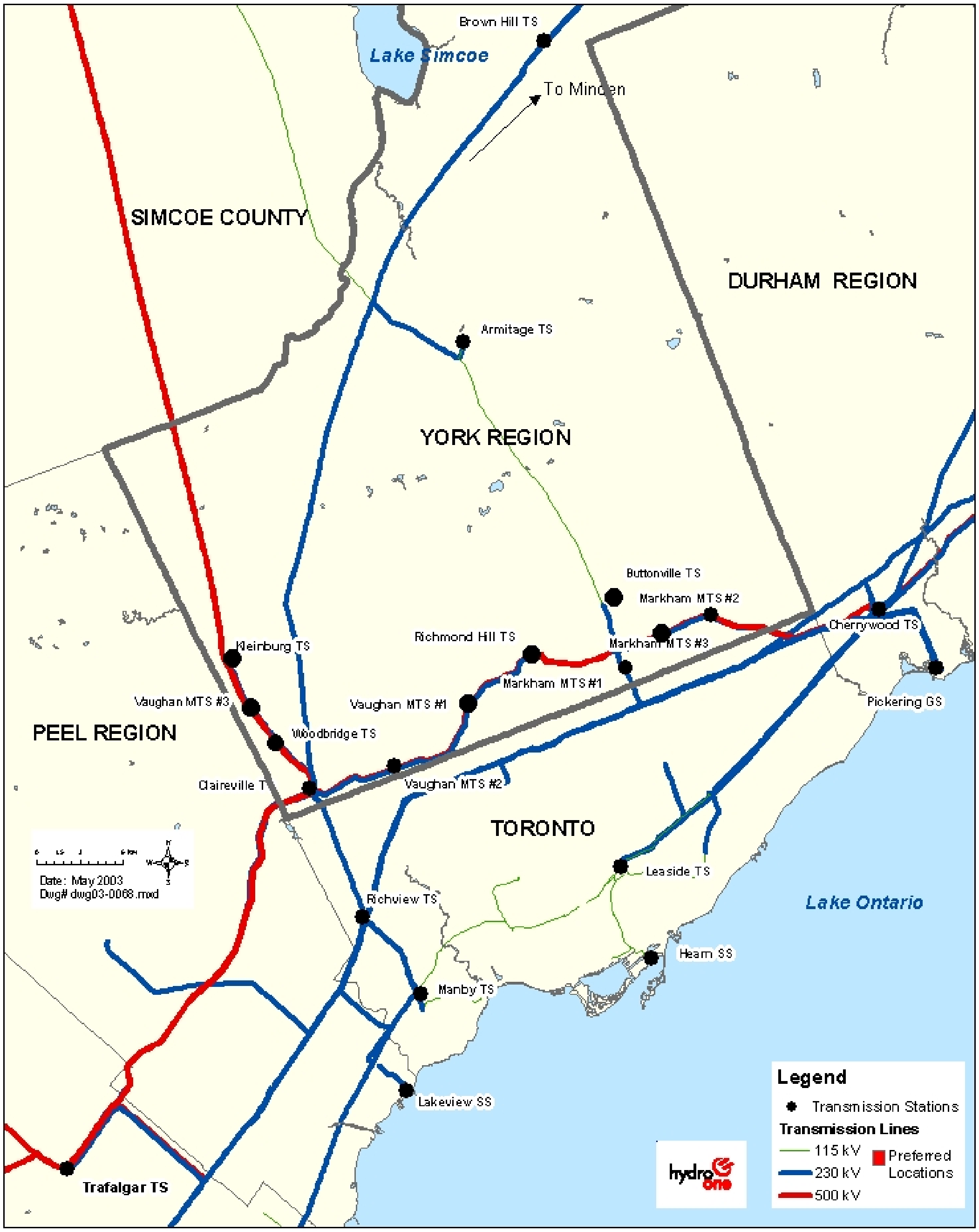
- Increase 500/230kV autotransformation capacity in the GTA by building a new 500-230kV autotransformer station “Parkway” TS at Parkway Jct. – located midway between Cherrywood TS and Claireville TS. Sufficient space is available at the Parkway Jct. site adjacent to the Claireville TS x Cherrywood TS right-of-way.
- Reinforce supply to Richmond Hill and Vaughan by building a new 6.5km double circuit 230kV line along the Parkway belt corridor from the new “Parkway” TS to Richmond Hill Jct. This new line will provide relief for the existing 230kV radial circuits V71R/V75R out of Claireville TS. There is space available for the new 230kV circuit on the existing right-of-way.
- Reinforce supply to Markham by opening the Cherrywood TS x Richview TS 230kV circuits C11R/C12R at Parkway Jct. and terminating the open circuits at “Parkway” TS. This will provide relief for 230kV circuits C11R/C12R.
- Build a new 230kV double circuit line between “Parkway” TS and Armitage TS. The new line will increase the load supply capability to Aurora, Newmarket and surrounding areas and will provide relief for the Claireville TS x Brown Hill TS circuits B82V/B83V allowing for a future Vaughan station as required during the study period. The new line is proposed to be built on the existing 115kV right of way between Buttonville TS and Armitage TS.

Recommendations

The required in-service date for the new facilities varies from an immediate need to provide relief for circuits V71R/V75R to winter 2005/2006 for providing relief for circuits B82V/B83V. To have the required facilities in-service as soon as possible, the report recommends the following steps:

- Hydro One Networks initiate environmental assessment, preliminary engineering and project development work for the proposed transmission work.
- The York Region utilities review the loading at their transformer stations to assess the benefits, timing and size of future low voltage capacitor banks.

Discussions have been initiated between the IMO, York Region utilities and Hydro One Networks to identify measures such as load transfers, voltage reduction etc, to maintain supply reliability between now and the time the new facilities can be placed in-service.



MAP 1. Existing Transmission Facilities in York Region

1.0 Introduction

The Region of York comprises nine municipalities - Aurora, East Gwillimbury, Georgina, King, Markham, Newmarket, Richmond Hill, Vaughan and Whitchurch-Stouffville with a combined load of over 1700MW. Electrical supply to the area is provided by 500kV and 230kV transmission and step down facilities as shown in Map 1 and Figure 1.

The Region in general and the southern part in particular –Markham, Richmond Hill and Vaughan – is one of the fastest growing areas in the province. The area is served by six utilities - Aurora Hydro, Newmarket Hydro, Markham Hydro, Richmond Hill Hydro, Hydro Vaughan and Hydro One Networks – Distribution. The York Region Utilities and Hydro One Networks have initiated this joint study to review the area load growth and to ensure that adequate facilities are available to meet the electrical demand requirements over the next ten years.

2.0 Existing Systems and Needs

There are four separate power corridors that serve the area, of which two are approaching the capacity limits due to significant load growth (exceeding 6.5%/year in recent years). Current load forecasts indicate that this strong growth is expected to continue in the area. The four corridors are:

1. A 230 kV corridor from Claireville TS to Richmond Hill MTS alongside Highway 407 (circuits V71R/V75R) that serves Vaughan and Richmond Hill;

2. A 230 kV corridor from Cherrywood TS to Parkway Jct. to Richview TS (circuits C11R/C12R). This corridor also runs alongside Highway 407 between Cherrywood TS and Parkway Jct. and serves Markham and part of Richmond Hill; and

3. A 230 kV corridor from Claireville TS to Minden TS (circuits B82V/B83V) that serves northern York region as well as Hydro One Networks – Distribution load supplied from Lindsay TS and Beaverton TS.

4. A 230kV corridor from Claireville TS to Kleinburg TS (circuits V74R/V75R) that serves Hydro Vaughan load as well as other loads outside of York Region.

The loading on both the Claireville TS to Richmond Hill MTS 230kV double circuit line V71R/V75R and the Cherrywood TS to Markham MTS#3 section of 230kV double circuit line C11R/C12R exceeds 500MVA. Loss of either line could severely impact a wide area, particularly since the V71R/V75R circuits supply about 70% of the City of Vaughan load and about 80% of the Town of Richmond Hill load. Similarly over 90% of the Town of Markham load is supplied from circuits C11R/C12R.

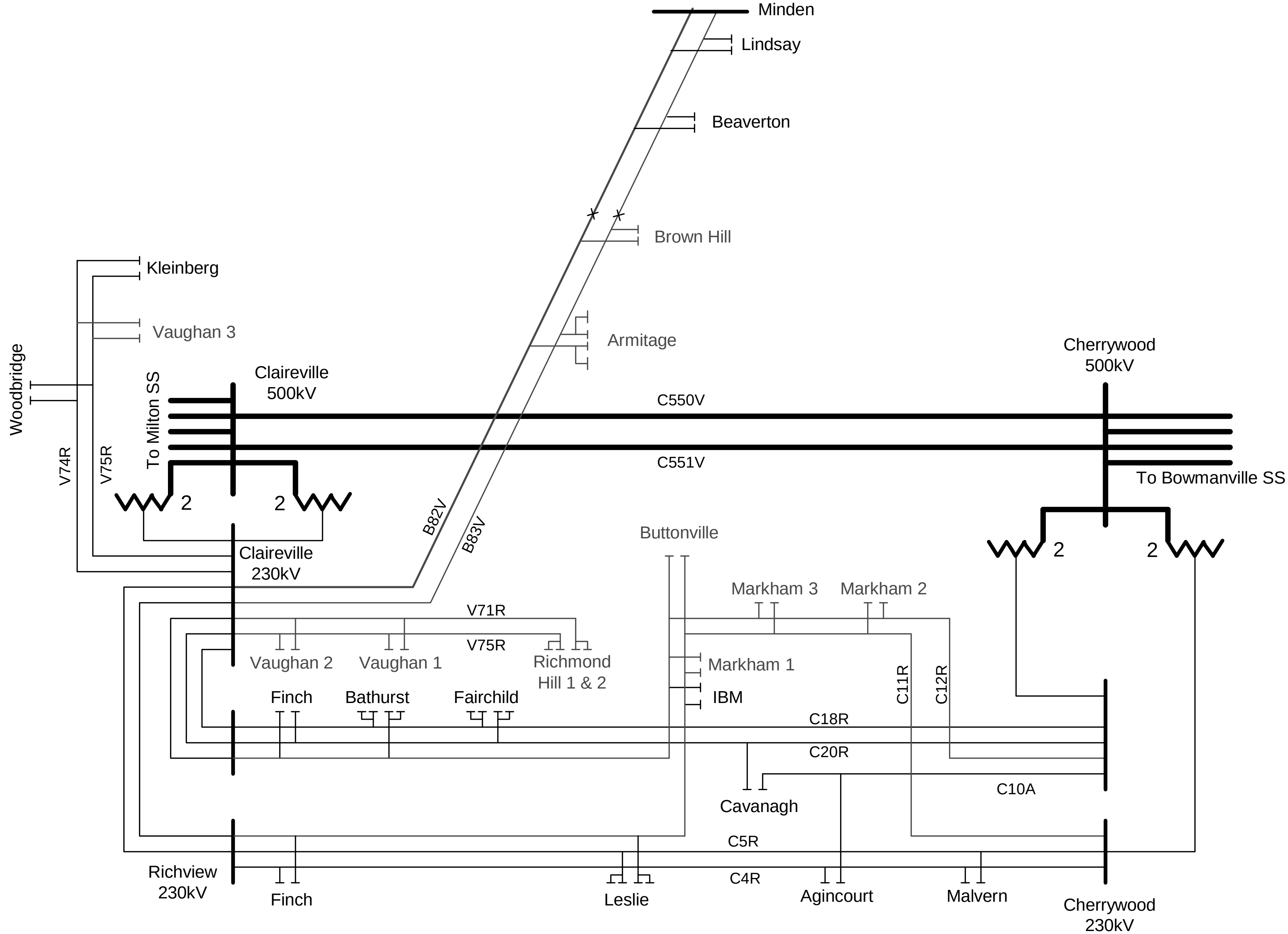


Figure 1 - Existing Transmission Facilities in York Region and surrounding area

The Claireville TS x Kleinburg TS 230kV double circuit line V74R/V75R supplies Woodbridge TS, Vaughan MTS3 and Kleinburg TS. This line has enough capacity to meet the load growth at these three stations for the duration of the study period.

With the strong load growth over the study period, a number of York Region transformer stations are heavily loaded. York Region utilities plan to connect seven new stations during the study period and new transmission facilities need to be provided to connect them. There is also a need to add low voltage capacitors at a number of existing stations.

A separate but related issue is the capacity of the main 500-230kV autotransformer stations that connect to the 500 kV network at Claireville TS and Cherrywood TS and essentially supply the entire GTA. The existing facilities are expected to be fully loaded by summer 2005 following the proposed retirement of Lakeview GS. Even if all the currently proposed new generation in the GTA (e.g. Portlands Energy Center, all four units of Pickering A) were to come into service, and Lakeview GS is not retired, additional transformation capacity would be required by summer 2008.

3.0 Load Growth

The load in the York Region is expected to increase at a rate of about 4.0% annually to 2008. The long term growth rate from 2008 to 2013 is about 3.4%. This compares with an historic growth rate of about 5% between 1992 and 1997 and about 6.5% between 1997 and 2002.

The forecast growth rate varies from about 5% in Vaughan and Richmond Hill to less than 2% for the rural areas supplied by Hydro One Networks – Distribution in northern York region. Table 1 below gives the total area summer and winter load forecast until the end of the study period.

Table 1 (a). York Region Forecast Summer Peak Load (MW)

Utility	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Markham Hydro	465	479	493	505	517	532	545	558	572	582	599	612
Richmond Hill Hydro	254	264	278	292	305	319	333	346	360	373	385	398
Hydro Vaughan	580	614	645	677	711	747	784	815	848	882	917	954
Newmarket Hydro	128	133	138	144	149	155	160	166	173	179	186	193
Aurora	71	74	77	80	83	86	89	92	96	99	103	107
HON – Distribution	138	141	143	146	148	151	154	157	159	162	165	167
Grand Total	1636	1706	1774	1843	1913	1989	2065	2135	2207	2280	2355	2431

Table 1 b. York Region Forecast Winter Peak Load (MW)

Utility	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Markham Hydro	372	383	394	404	413	425	436	446	457	465	479	490
Richmond Hill Hydro	203	212	222	233	244	255	266	277	288	298	308	318
Hydro Vaughan	464	492	516	542	569	597	627	652	678	706	734	763
Newmarket Hydro	113	117	122	126	131	136	141	146	152	158	164	170
Aurora	63	65	68	70	73	75	78	81	84	87	91	94
HON – Distribution	137	139	142	144	147	150	152	155	158	160	163	166
Grand Total	1351	1408	1464	1520	1577	1639	1701	1758	1817	1877	1938	2012

The area summer load is higher than winter load and it is expected that this gap will widen over time due to an increase in air-conditioning load. As the ampacity for transmission lines and station facilities is lower in summer compared to winter, the area is in general summer critical. The one exception is the loading on the Claireville x Minden circuits, which supply Armitage TS. Here the load meeting capability is determined by voltage requirements and both the summer and winter load forecasts have been considered.

4.0 System Assumptions

In order to study the effects of contingency and verify the system capacity, the following assumptions are made in this report:

1. A study period of 2003 to 2013 is chosen to assess the transmission requirement.
2. Peak loads are based on the forecast growth rates provided by the York Region Utilities.
3. The availability of generation resources in the GTA area affects the loading on the Claireville TS and Cherrywood TS 500-230kV autotransformers. It is assumed that:
    - All four Pickering B GS units are available throughout the study period.
    - The first Pickering A GS unit is assumed to go into service in 2005 followed by the second unit in 2009.
    - Portlands Energy Center, connected to Hearn SS, has peak capacity of 500MW available starting summer 2005.
    - Lakeview GS is retired as planned by spring 2005.

- Adequate generation is available elsewhere on the system to meet load demand.

4. Equipment continuous Limited Time Ratings (LTR) are based on an ambient temperature of 35°C for summer and a wind speed of 4km/hour.

5. The minimum voltage on the 230kV transmission system under normal conditions is 230kV. The maximum voltage decline is limited to 10% for a single element contingency.

The report also assumes that Markham Hydro, Richmond Hill Hydro and Hydro Vaughan loads supplied from Hydro One Networks owned transformer stations will remain constant.

5.0 Adequacy of Existing Facilities

This section reviews the adequacy of the existing Hydro One Networks 500kV and 230kV transmission facilities supplying York Region.

5.1 500kV Bulk Transmission System

Bulk electric supply to York Region is provided by 500-230kV transformation facilities at Claireville TS and Cherrywood TS. These autotransformers together with those at Trafalgar TS also provide the bulk of the GTA supply.

Both Claireville TS and Cherrywood TS have 4x750MVA, 500-230kV autotransformers stepping down power brought in on the 500kV system from generating stations located across the province.

While adequate 500kV transmission line capacity is available to supply the load during the study period, there is an urgent need to provide additional transformation capacity particularly if Lakeview GS is taken out-of-service. The forecast loading on the Claireville TS and Cherrywood TS autotransformers is given in Figure 2 for different generation scenarios. It is expected that loading will reach the Claireville TS autotransformer T14 continuous ratings with all transformers in service by summer 2004 and will exceed the 10–day limited time ratings under contingency conditions (one transformer out of service) by summer 2005. Figure 2A also shows that, two units at Pickering A and Portlands Energy GS do not provide adequate relief for Claireville TS following Lakeview GS retirement in 2005. Even if Lakeview GS were to remain available and all four Pickering A units return to service, relief would be required for the Claireville autotransformers by summer 2009.

The loading on the Cherrywood TS autotransformers is also expected to exceed ratings by summer 2004. However, the overloading is eliminated by the return of Pickering A units and availability of Portlands Energy Center GS.

Figure 2a. Loading on Claireville TS T14 Autotransformer

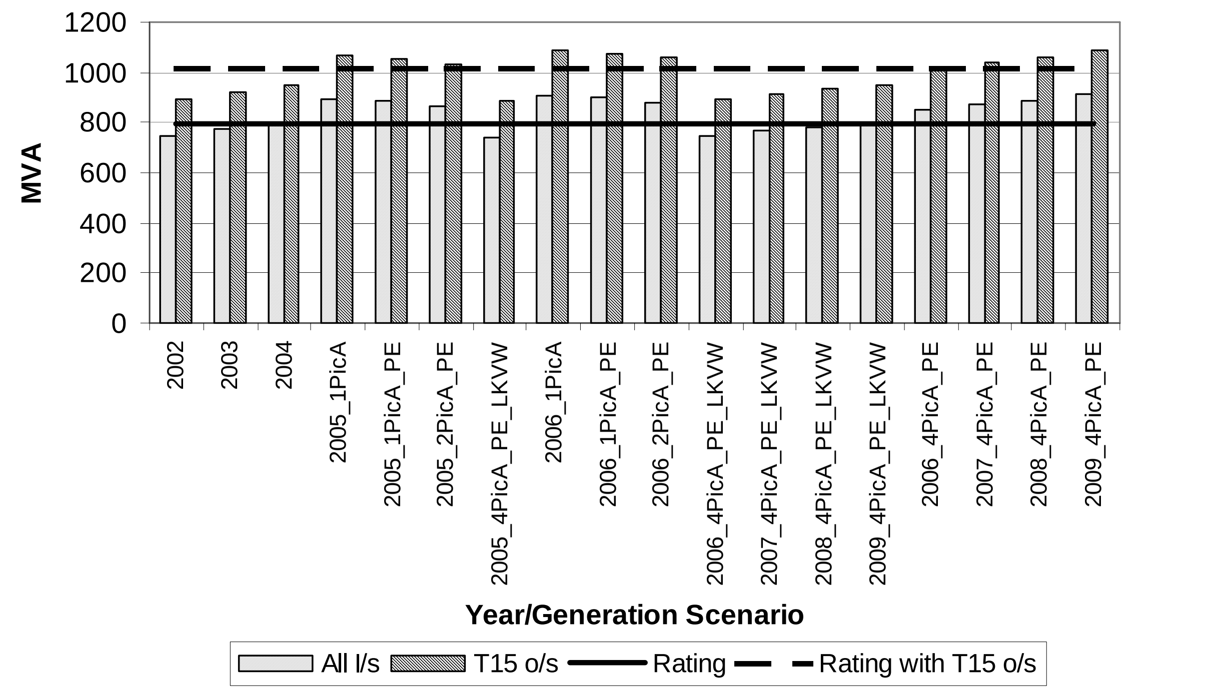
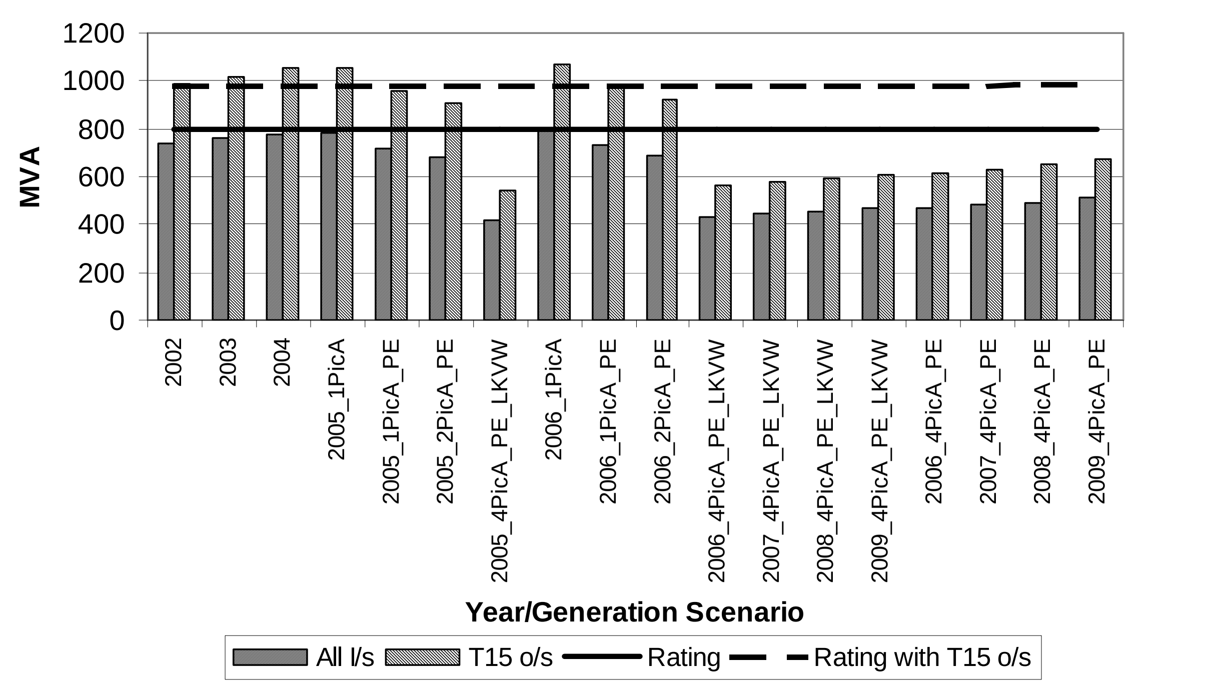


Figure 2b. Loading on Cherrywood TS T16 Autotransformer



NOTE: PicA = Pickering A; PE = Portlands Energy at Hearn; LKVW = Lakeview

5.2 230kV Transmission Line Capability

Four 230kV double circuit lines supply power from Claireville TS and Cherrywood TS to step down transformer stations in York Region:

- Armitage TS from the 230kV double circuit line B82V/B83V;
- Vaughan MTS #1, Vaughan MTS #2, Richmond Hill MTS #1 and Richmond Hill MTS #2 from 230kV double circuit line V71R/V75R;
- Markham MTS #1, Markham MTS #2, Markham MTS#3 and Buttonville TS from 230kV circuits C11R/C12R
- Woodbridge TS, Vaughan MTS #3 and Kleinburg TS from 230kV circuits V74R/V75R.

5.2.1 230kV circuits B82V/B83V

The 230kV circuits B82V/B83V form part of the Claireville TS x Minden TS corridor that also includes in-line breakers in both circuits at Brown Hill, 230 kV circuits M80B, M81B and loads at Armitage, Brown Hill, Beaverton and Lindsay (See Figure 1). Peak summer 2002 and winter 2002/2003 loading on these circuits was about 478MW and 508MW respectively.

Figure 3a shows the summer and winter forecast for the loads connected to the Claireville TS x Minden TS circuits. Figure 3b shows the voltages for the Armitage TS 230kV and 44kV buses as a function of this load when circuit B82V is out of service between Claireville TS and Brown Hill TS. Allowing a 5 percent margin gives a load meeting capability (LMC) of about 541MW. The LMC is drawn along with the load forecast in Figure 3a and shows that relief is expected to be required by winter 2005/2006. It should be noted that by 2008 this 5% margin would also have been exhausted.

5.2.2 230kV Circuits C11R/C12R

The 230kV C11R/C12R circuits supply over 90% of the Town of Markham load as well as a number of other stations on the Finch right-of-way between Cherrywood TS and Richview TS (Figure 1). These circuits form part of the Cherrywood – Claireville – Richview (CCR) interface and

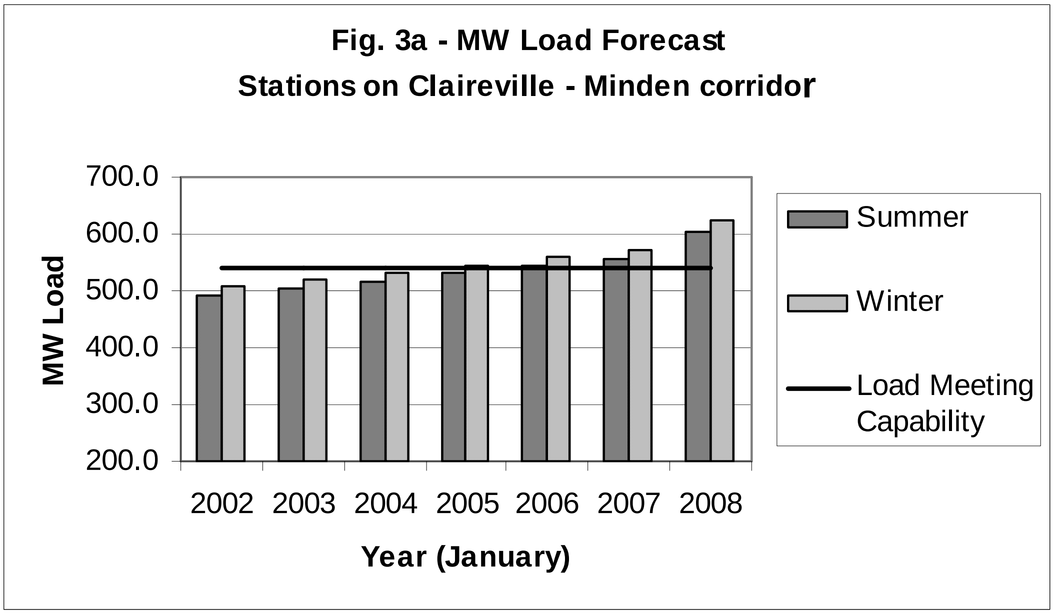


Fig. 3a - MW Load Forecast
Stations on Claireville - Minden corridor
700.0
600.0
500.0
400.0
300.0
200.0
MW Load
2002
2003
2004
2005
2006
2007
2008
Year (January)
Summer
Winter
Load Meeting Capability

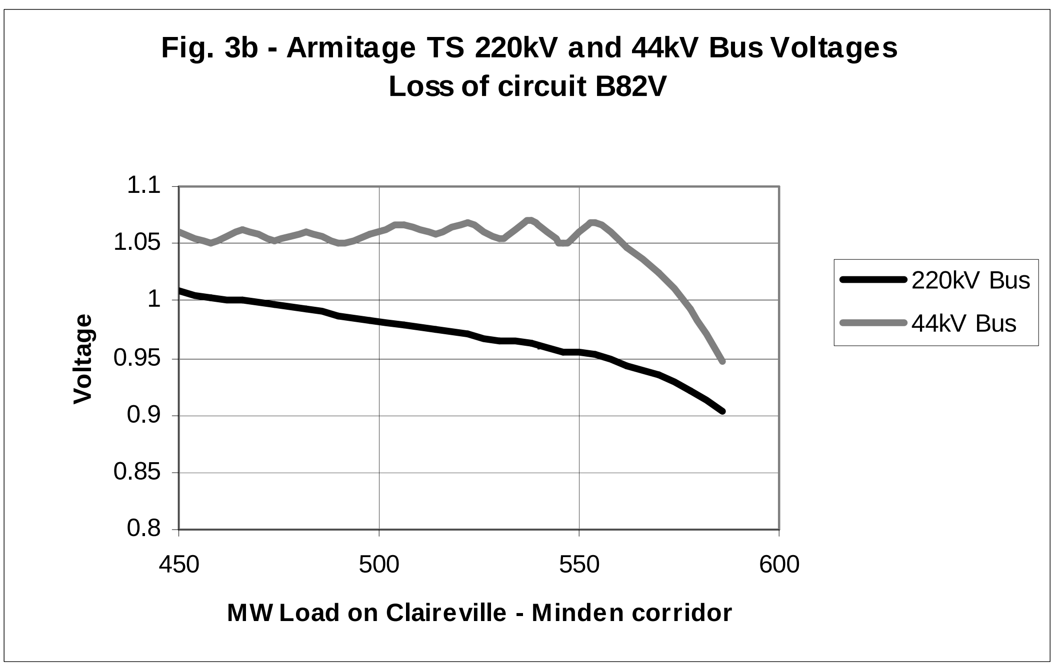


Fig. 3b - Armitage TS 220kV and 44kV Bus Voltages
Loss of circuit B82V
1.1
1.05
1
0.95
0.9
0.85
0.8
Voltage
450
500
550
600
MW Load on Claireville - Minden corridor
220kV Bus
44kV Bus

Figure 4a. Loading on 230kV circuit C11R

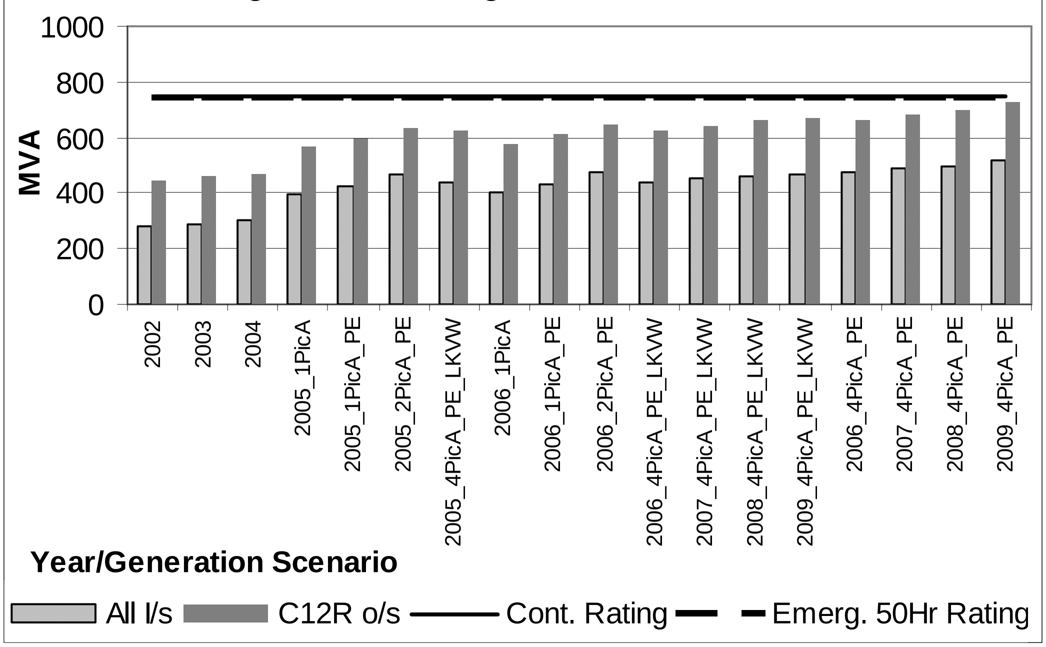
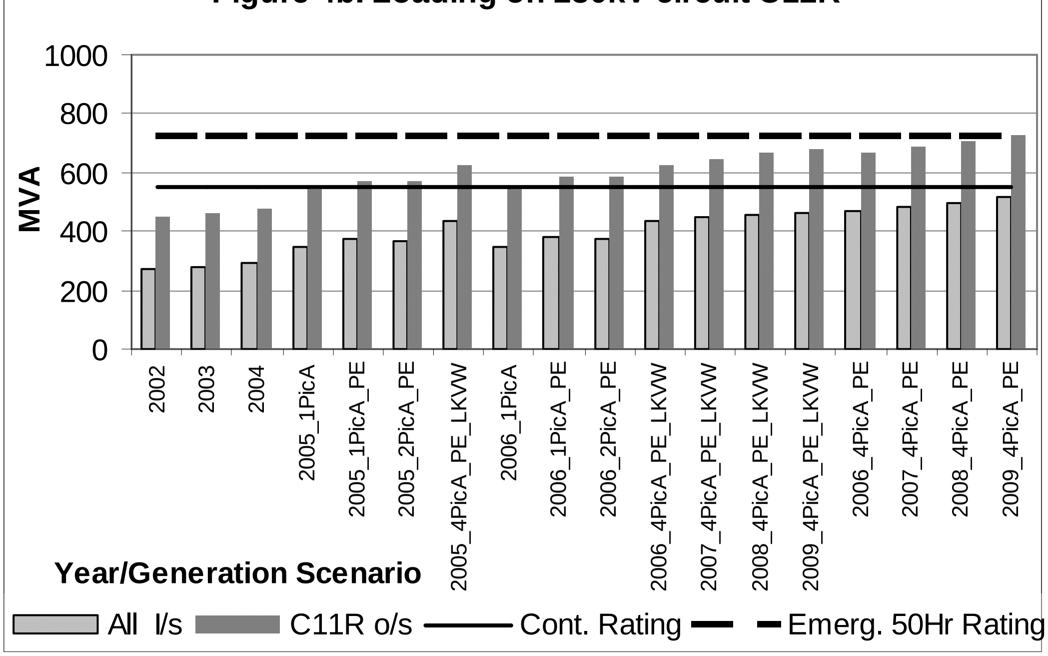


Figure 4b. Loading on 230kV circuit C12R



NOTE: PicA = Pickering A; PE = Portlands Energy at Hearn; LKVW = Lakeview

Figure 5a. Loading on 230kV circuit V71R

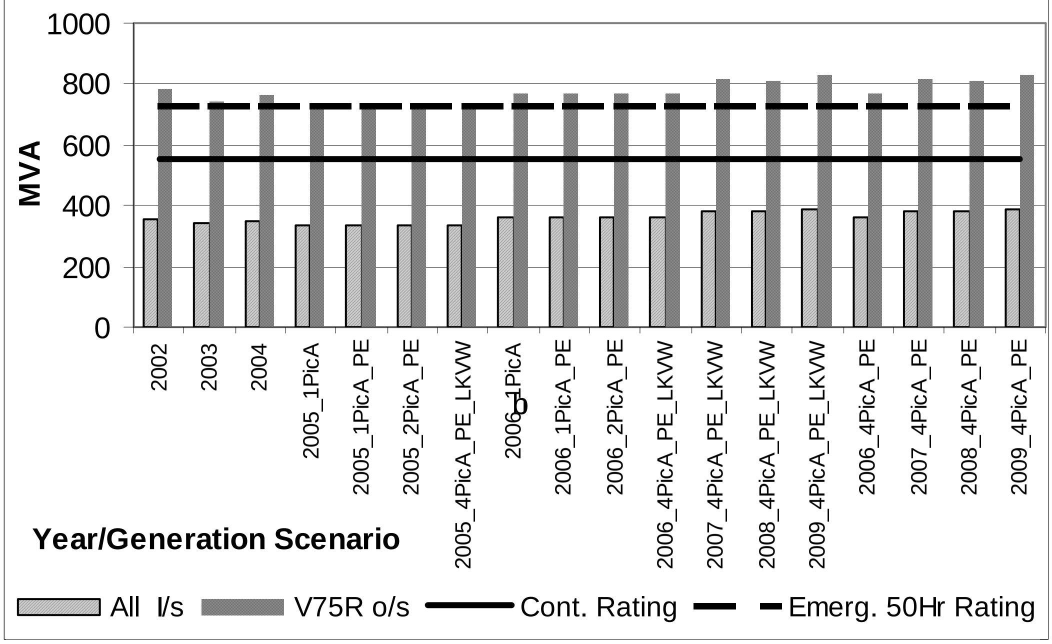
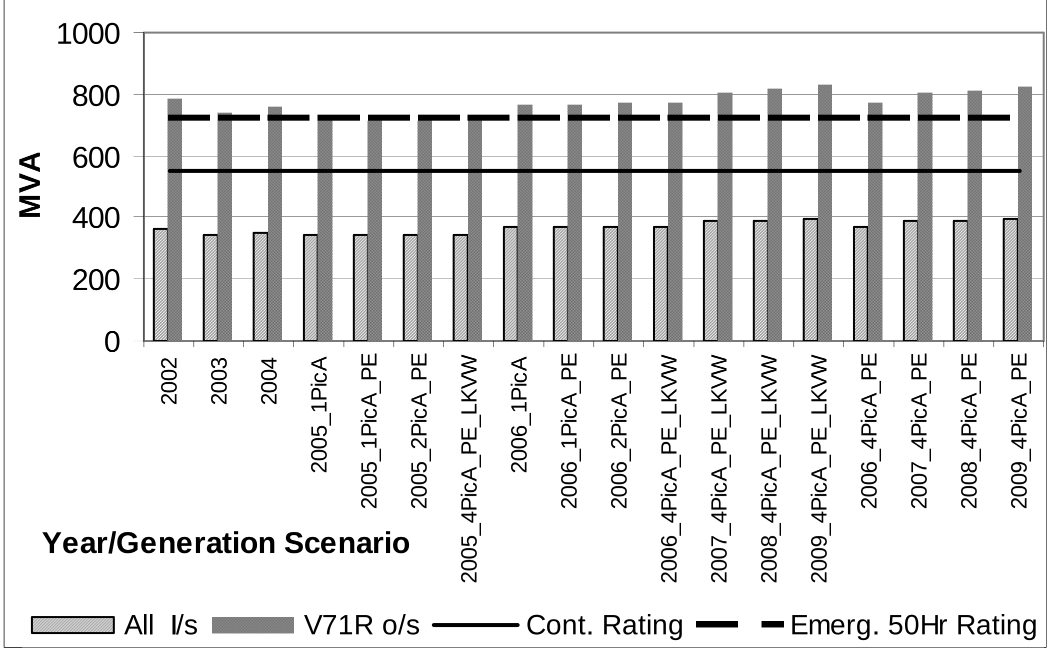


Figure 5b. Loading on 230kV circuit V75R



NOTE: PicA = Pickering A; PE = Portlands Energy at Hearn; LKVW = Lakeview

peak loading is a function of the loads in the area and generation east of Cherrywood TS. Summer is the critical loading period and forecast circuit loading is shown in Figure 4 for different generation scenarios. Note that the continuous rating and emergency rating of circuit C11R are the same (749MVA). The continuous rating of circuit C12R is lower at 550MVA, because of a short 1.6km section east of Cherrywood TS strung with 1843kcmil high aluminum content conductor. To prevent annealing in the conductor, emergency current capacity is limited to 728MVA, based on a maximum operating time of 50 hours per year under such conditions. Assuming that single circuit operation during contingency conditions will be less than this 50 hour limit, these circuits are expected to be adequate to about 2009.

5.2.3 230kV circuits V71R/V75R

The 230kV circuits V71R/V75R supply about 70% of City of Vaughan load and about 80% of the Town of Richmond Hill load. These circuits are radial from Claireville TS and forecast loading is shown in Figure 5. These circuits are also strung with the same high aluminum content 1843kcmil conductor. It is shown that under contingency conditions – with one circuit out of service – current loading exceeds the emergency capability of the remaining in-service circuit and there is an immediate need to reinforce these circuits.

5.2.4 230kV circuits V74R/V75R

The 230kV circuits V74R/V75R extend radially from Claireville TS to Kleinburg TS. Peak loading on these circuits will increase from 440MVA in summer 2003 to over 530MVA by the end of the study period. The rating of the circuit is 550MVA leaving ample margin for growth. A significant part of the load supplied from these circuits lies outside York Region. However, the load increase is attributable largely to Hydro Vaughan loads supplied from Vaughan MTS#3.

5.3 Step down Transformation Facilities

There are ten transformer stations in the study area. Hydro One Networks owns two of them with the remaining stations owned by Markham Hydro (3), Richmond Hill Hydro (2) and Vaughan Hydro (3). All three utilities also have part of their load supplied form Hydro One Networks owned transformer stations. Kleinburg TS and Woodbridge TS are excluded from the study area since a significant part of their service area lies largely outside York Region.

Due to the heavy load growth, several of the area stations are fully loaded and additional facilities are required to meet the load demand. The forecast load at the existing stations and the future station requirements are given in Appendix A. The new stations expected to be required are as follows:

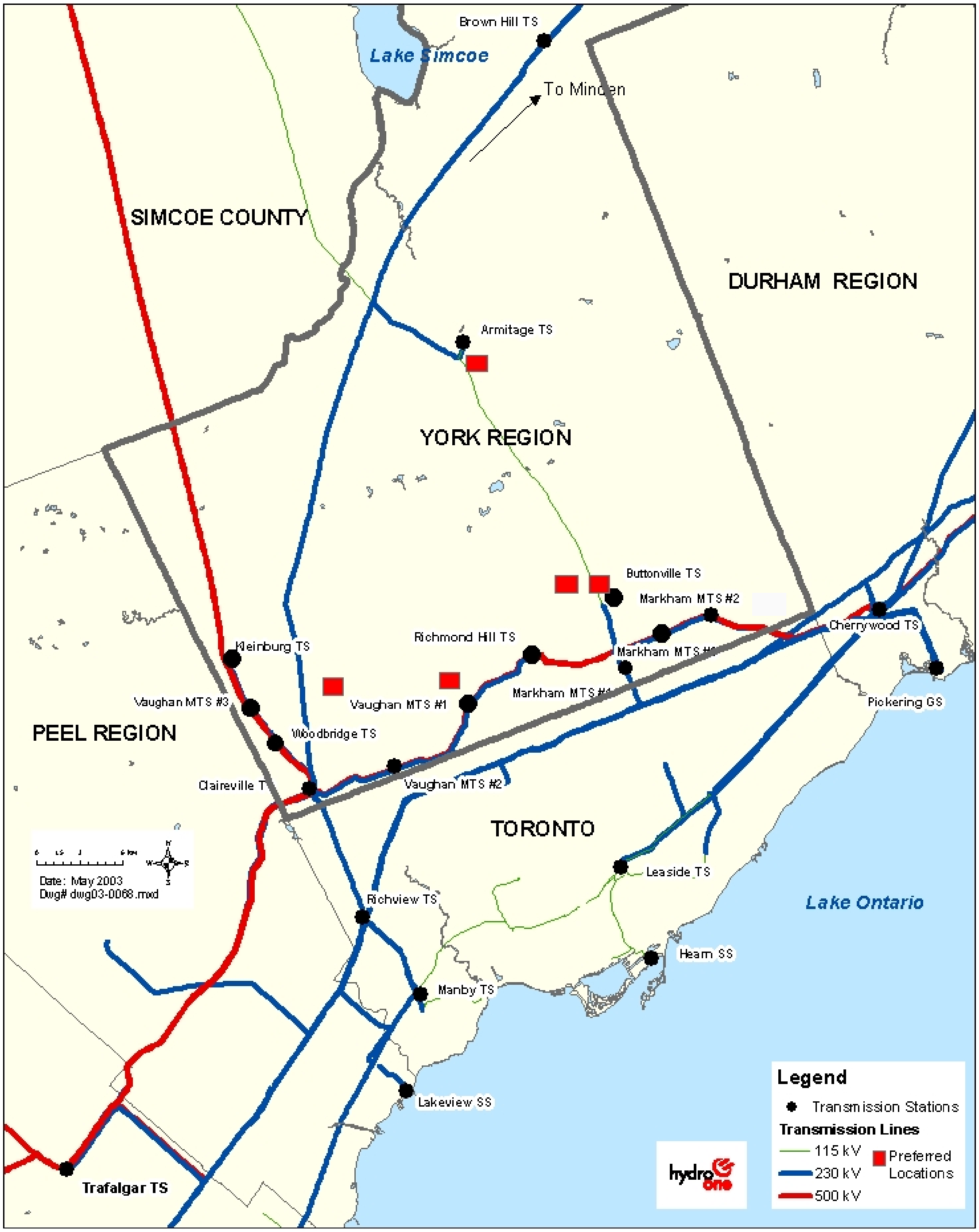


Figure 6. Preferred locations for new step down transformer stations

Aurora Hydro, Newmarket Hydro, Hydro One Networks – Distribution Service Area

1. New Station - 2005

Markham Hydro Service Area

1. Markham 3E* – summer 2004

2. Markham 4 - summer 2007

Richmond Hill Hydro Service Area

1. Richmond Hill 3 – summer 2013

Hydro Vaughan Service Area

1. Vaughan 1E* – summer 2005

2. Vaughan 4 – summer 2008

3. Vaughan 5 – summer 2013

(* - E indicate capacity added at existing stations)

All new stations will be located close to existing right-of-ways to minimize building new 230kV transmission line taps to stations. The preferred location for the new transformer stations is given in Figure 6.

5.3.1 Capacitor banks at step down transformer stations.

As mentioned above, several of the area transformer stations are loaded up to their limit. In case of a loss of a transformer or a transmission line, the whole load is picked up by the remaining in-service transformer. The heavy load results in excessive voltage drop in the transformer and increased line current flow. The total loading on the transformer is greater than the sum of the pre-contingency loading on two transformers. This situation is particularly aggravated at stations that are not equipped with LV capacitor banks. Table 2 shows the pre and post contingency loading on three municipally owned stations without capacitor banks based on forecast 2004 loads and the MVA reduction if capacitor banks were to be installed at these stations. Loading on Vaughan MTS #1 which is equipped with LV capacitor banks is also shown for comparison. There is therefore a benefit in installing capacitor banks at all stations so that var resources are locally available at the transformer station.

Table 2 – Pre and Post Contingency MVA loading on area Transformer stations

Station	Station Load (MVA)	Cap Banks (MVAR)	Flow Both Transformers I/S (MVA)	Flow One Transformer O/S (MVA)	Flow One Transformer o/s (with 20 MVAR caps per bus)	MVA Reduction due to Caps
Markham MTS #2	102.2	0.0	107.6	114.9	100.7	14.2
Richmond Hill MTS #1	176.0	0.0	194.7	209.3	180.6	28.7
Vaughan MTS #1*	200.0	43.2	190.6	-------	200.0	------
Vaughan MTS #2	200.0	0.0	215.2	232.6	203.7	28.9

* Vaughan MTS#1 is equipped with two 21.6MVAR capacitor banks.

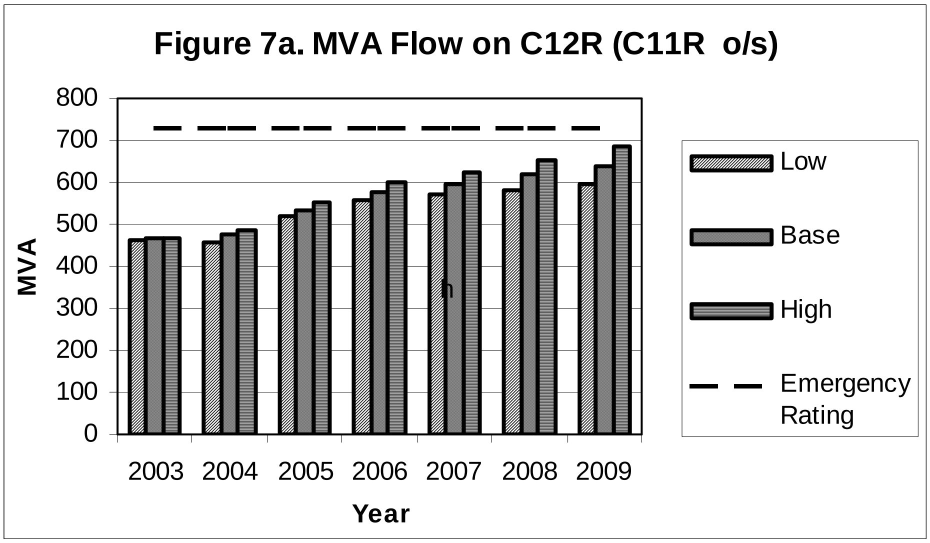
5.4 Sensitivity Analysis

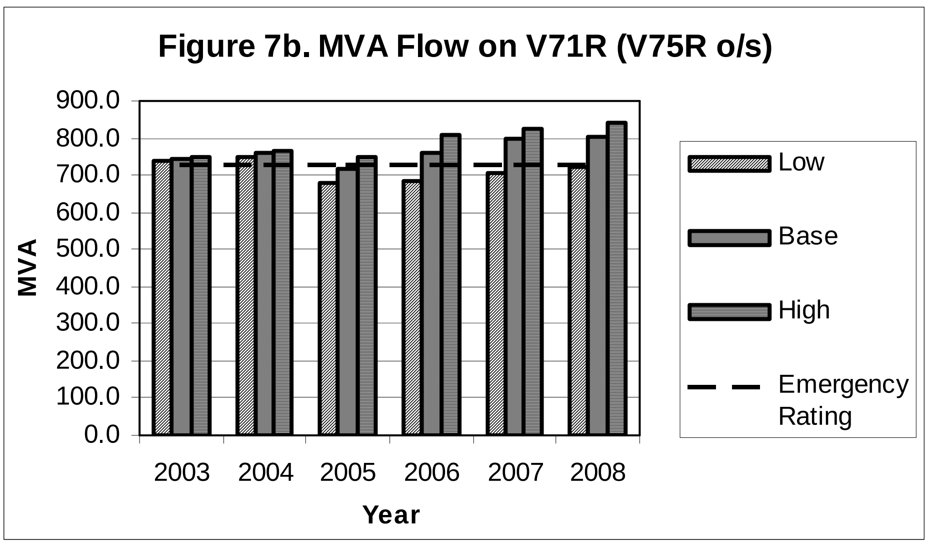
A sensitivity analysis study was carried out to determine the impact of varying load growth rates on flows on the three 230kV transmission line corridors – C11R/C12R, V71R/V75R and B82V/B83V. The high growth rate scenario assumed that load growth rate was 1% higher than that given for the base case in Table 1. The low growth rate scenario assumed that load growth rate was 1.5% below the base case forecast.

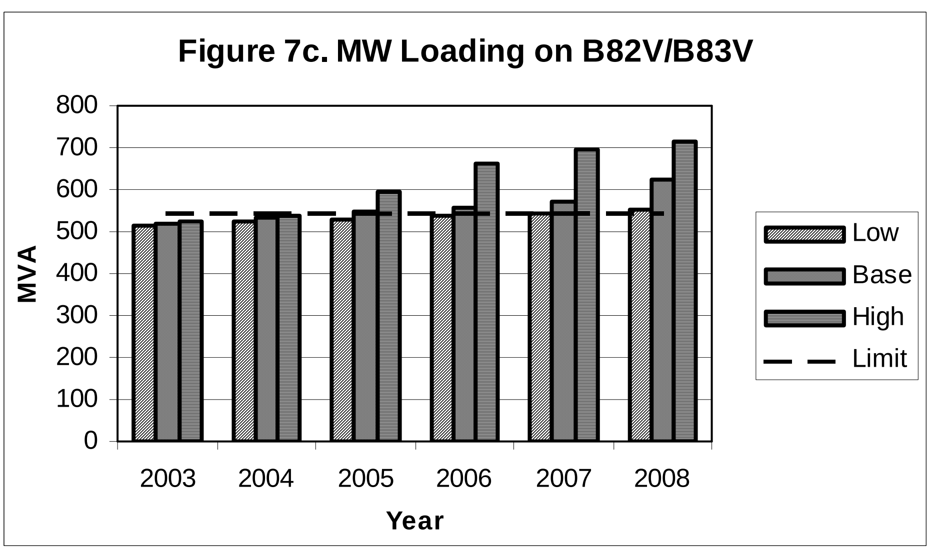
Figure 7a show the line loading for the high and low growth rates for the C12R circuit under contingency condition assuming one Pickering A unit and Portlands Energy Center are in–service. This circuit is the more limiting of the C11R and C12R circuits and under this scenario is expected to be adequate beyond 2009 under both the high and low growth cases. However, as shown previously in Figure 4a, the circuit flow is dependent on generation east of Cherrywood and would reach the emergency limit by summer 2009 if all four Pickering A units were in-service by 2009 for the base case.

Figure 7b shows the loading on the V71R circuit with V75R out of service. The loading on theV75R circuit would be the same in case V71R were out of service. It is seen that the loading under contingency condition exceeds the circuit emergency rating in 2003.

Figure 7c shows MW loading on the B82V/B83V corridor. Loading will exceed the line voltage limit by January 2005 under the high growth scenario and by January 2008 under the low growth scenario.







Note: These curves assume one Pickering A unit and Portlands Energy Center in-service.

5.5 Need Summary

Based on the above the following actions are required:

- Provide relief for Claireville TS 500-230kV autotransformers by summer 2005.
- Provide relief for 230kV circuits V71R, V75R as soon as possible.
- Provide adequate transmission facilities to connect the new transformer stations identified in Section 5.3.

Discussions have been initiated between the IMO, Hydro One Networks and the York Region Utilities to ensure that appropriate operational control actions and procedures are in place to meet load demand on an interim basis, in the event of contingencies.

6.0 Possible Options to Provide Adequate Supply Capacity

6.1 "Do Nothing"

The "Do Nothing" option will aggravate the existing overload situation. Equipment loading will continue to increase and supply reliability will be adversely impacted in case of a contingency. This alternative is not acceptable and is not considered further.

6.2 Options for Providing Relief for Auto-transformation Capacity

Two options have been considered to provide relief for the 500-230kV auto-transformation capacity.

6.2.1 Option T1 – Add additional 500-230kV transformer capability at Claireville TS.

Under this option, new 500-230kV transformation capability is added at Claireville TS (Figure 8). Claireville TS is a gas insulated indoor (GIS) station and incorporation of the autotransformer will require installation of new GIS breakers in each of the 500kV and 230kV buildings.

Transformation is required to be added in two stages. The first 750MVA, 500-230kV autotransformer will be installed in 2005 and the second one in 2009.

This option will increase the fault level on the Claireville 230kV bus. The bus may have to be split after the second auto is added in 2009, depending on the availability of new generation in the GTA and the number of Lakeview units used as synchronous condensers.

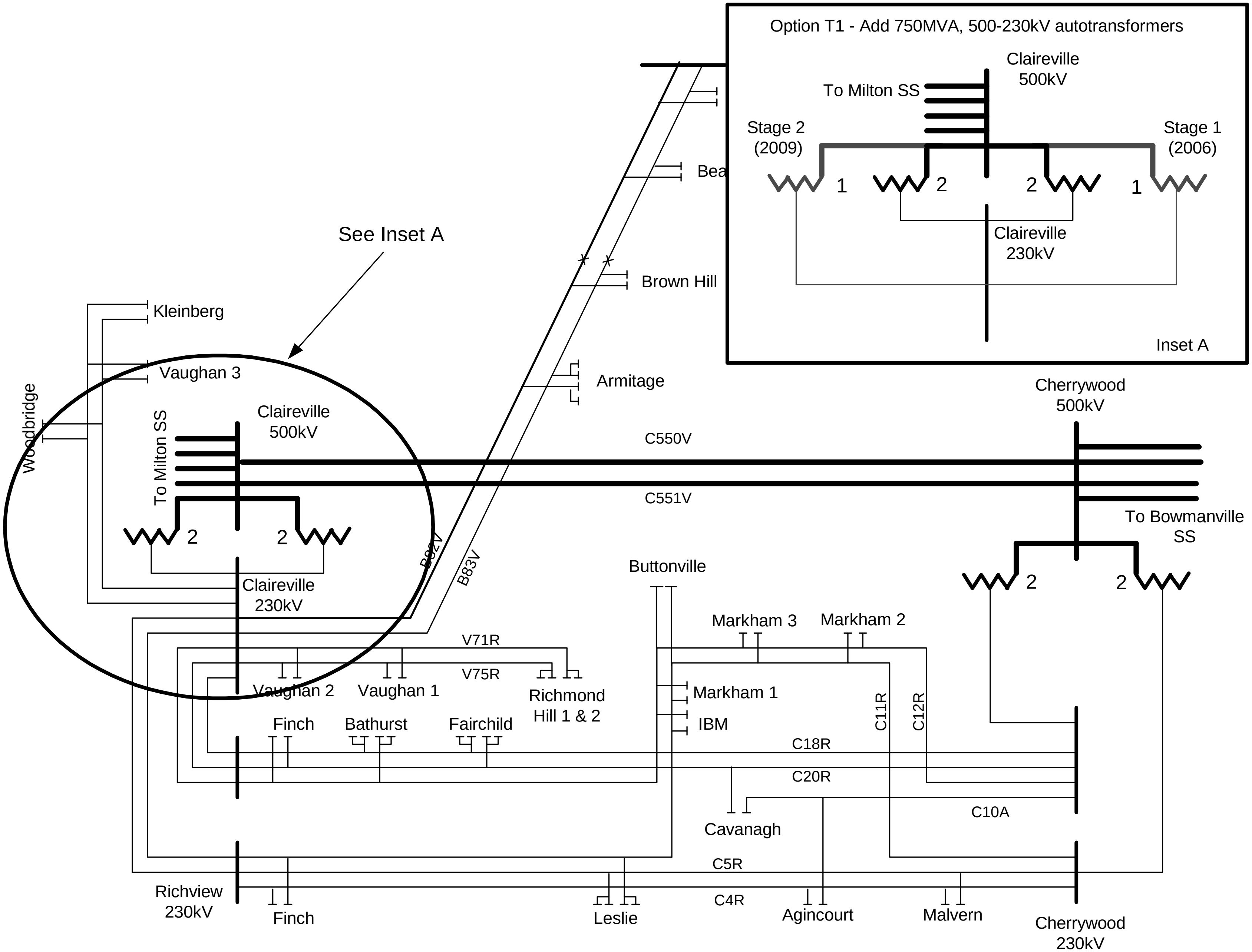


Figure 8. Option T1 - Add New 750MVA, 500-230kV autotransformers at Claireville TS

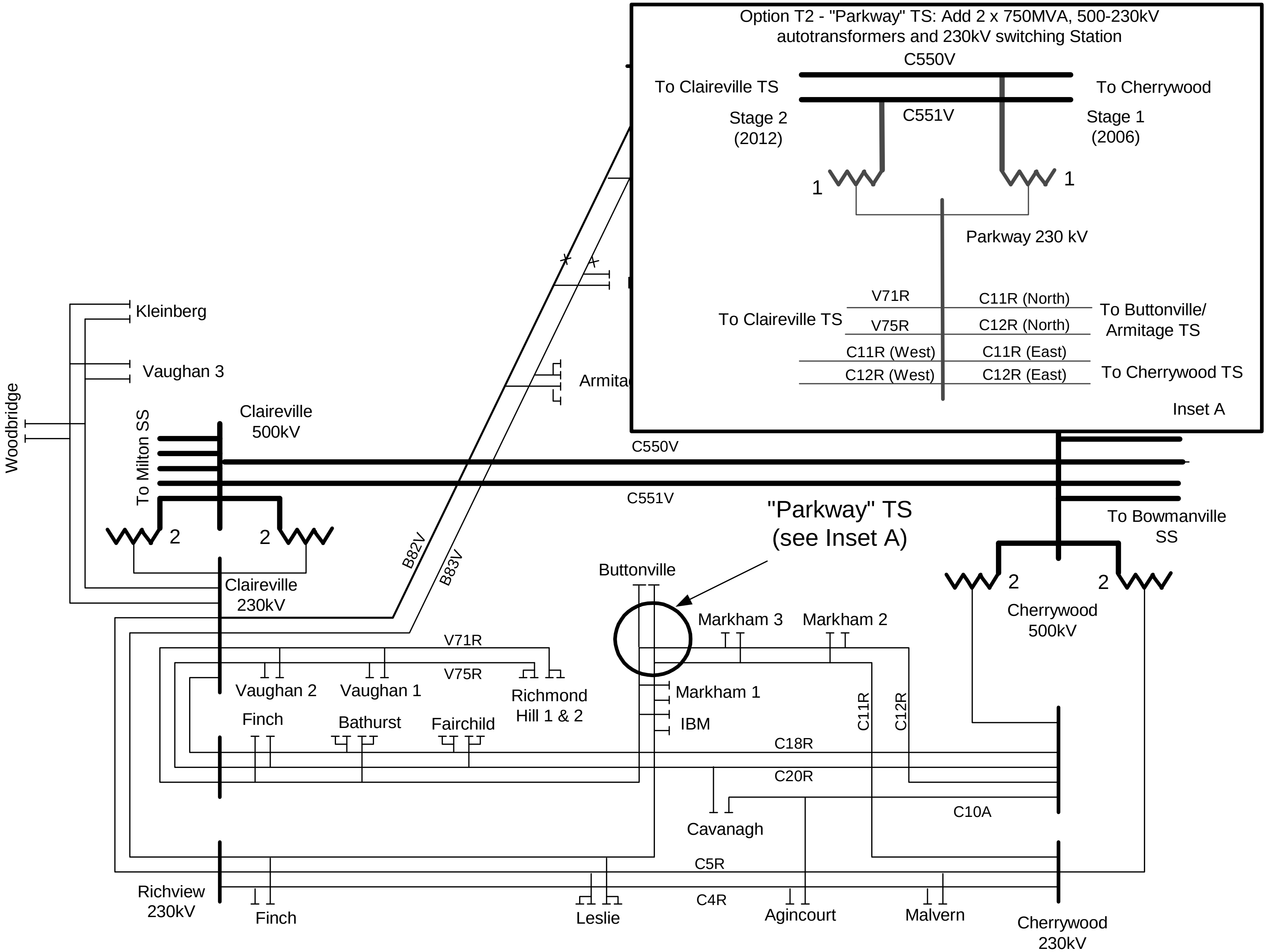


Figure 9 Option T2 - Build new "Parkway" TS

6.2.2 Option T2- Build a new 500-230kV autotransformer station at the Parkway TS site.

Under this option a new 500-230kV autotransformer station - "Parkway" TS will be built between Cherrywood TS and Claireville TS on space available at Parkway Jct. Two 750MVA, 500-230kV autotransformers will be installed and a 230kV switching station built (Figure 9). The existing 230kV circuit C11R/C12R will be split at Parkway Jct. and each of the three circuits (to Cherrywood, Richview and Buttonville TS) will terminate at this new station. A third 750MVA autotransformer will be required at Parkway TS in 2012.

6.3 Options for Providing Relief for 230kV Circuits

The following options were considered for providing relief for the overloaded 230kV circuits identified in section 5.3. Options L1 and L3 address the supply to Armitage TS, Options L2 and L4 address the overloading of circuits V71R/V75R and option L5 provides relief for circuit C12R.

6.3.1 Option L1 – Add new 230kV circuit from Claireville TS x Armitage TS.

Under this option, a new 44km 230kV double circuit line is built adjacent to the existing 230kV circuits B82V/B83V between Claireville TS and Armitage TS (Figure 10). This option reinforces the supply to Armitage TS and provides adequate capacity to supply the planned new Hydro Vaughan MTS 4 in northeast Vaughan as well as a new DESN station in the Aurora, Newmarket area.

To reduce the cost of this option the new lines will share the Claireville TS terminations with circuits B82V/B83V.

6.3.2 Option L2 – Build a new 4.5km double circuit line between Claireville TS x Torstar Jct.

This option provides relief for the 230kV circuits V71R/V75R by transferring Vaughan MTS #2 to a new radial tap from Claireville TS (Figure 11)

This alternative would require installation of two 230kV GIS breakers at Claireville TS to terminate the new circuits. Also, the tap to Vaughan MTS #2 from circuits V71R/V75R will be moved and connected to the new circuits.

6.3.3 Option L3 – Build a new 230kV double circuit line from Parkway TS x Armitage TS.

Under this option, a 24km 230kV double circuit line will be built between Parkway TS and Armitage TS by winter 2005/2006 (Figure 11). This option may require replacing the existing Parkway Jct x Buttonville TS line with a new four circuit tower line due to the narrow width of the right-of-way. The new line will supply two of the four transformers at Armitage TS as well as the planned new station for the Aurora/Newmarket area.

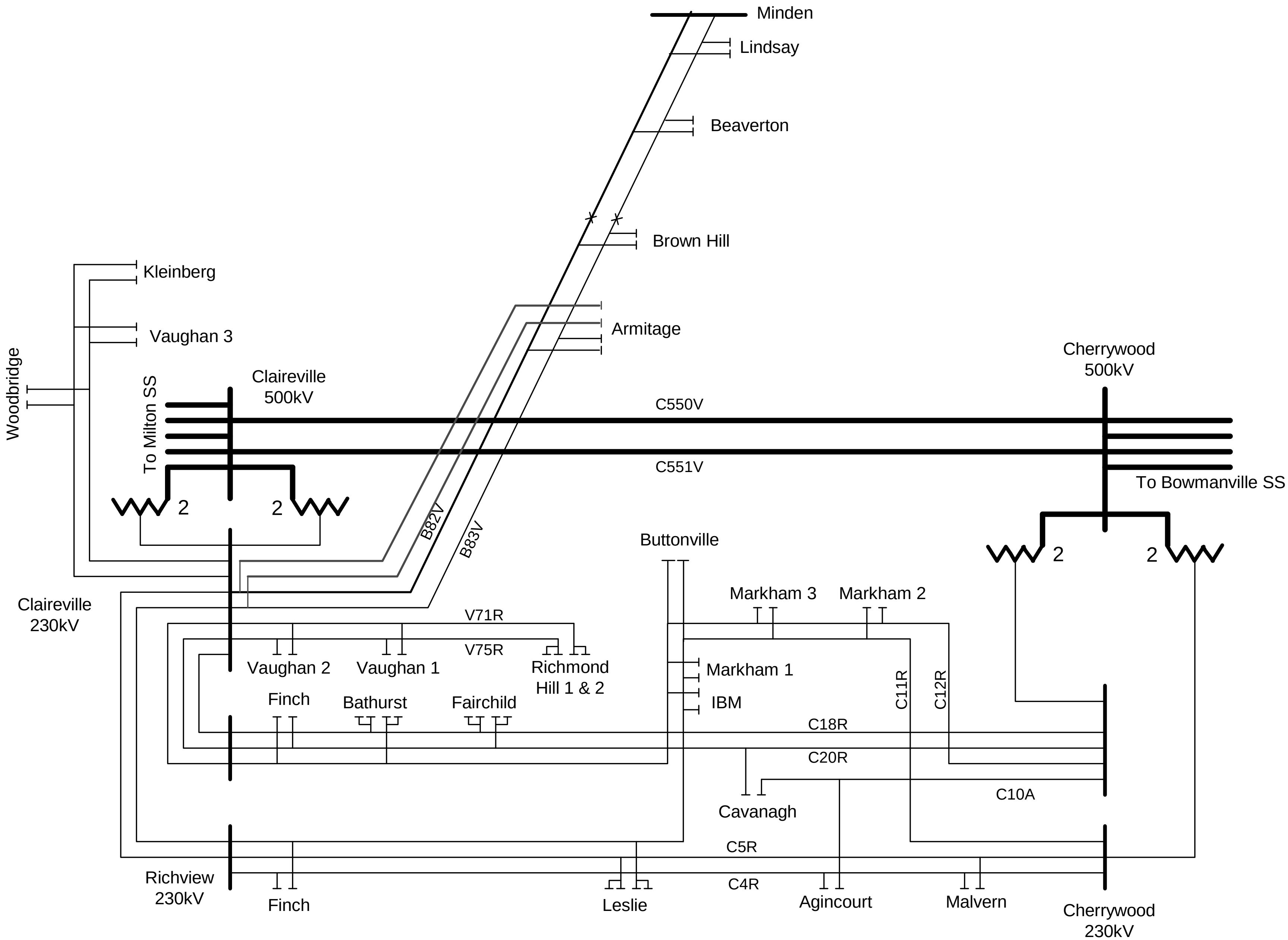


Figure 10. Option L1 - Build new 230kV Line Claireville TS x Armitage TS

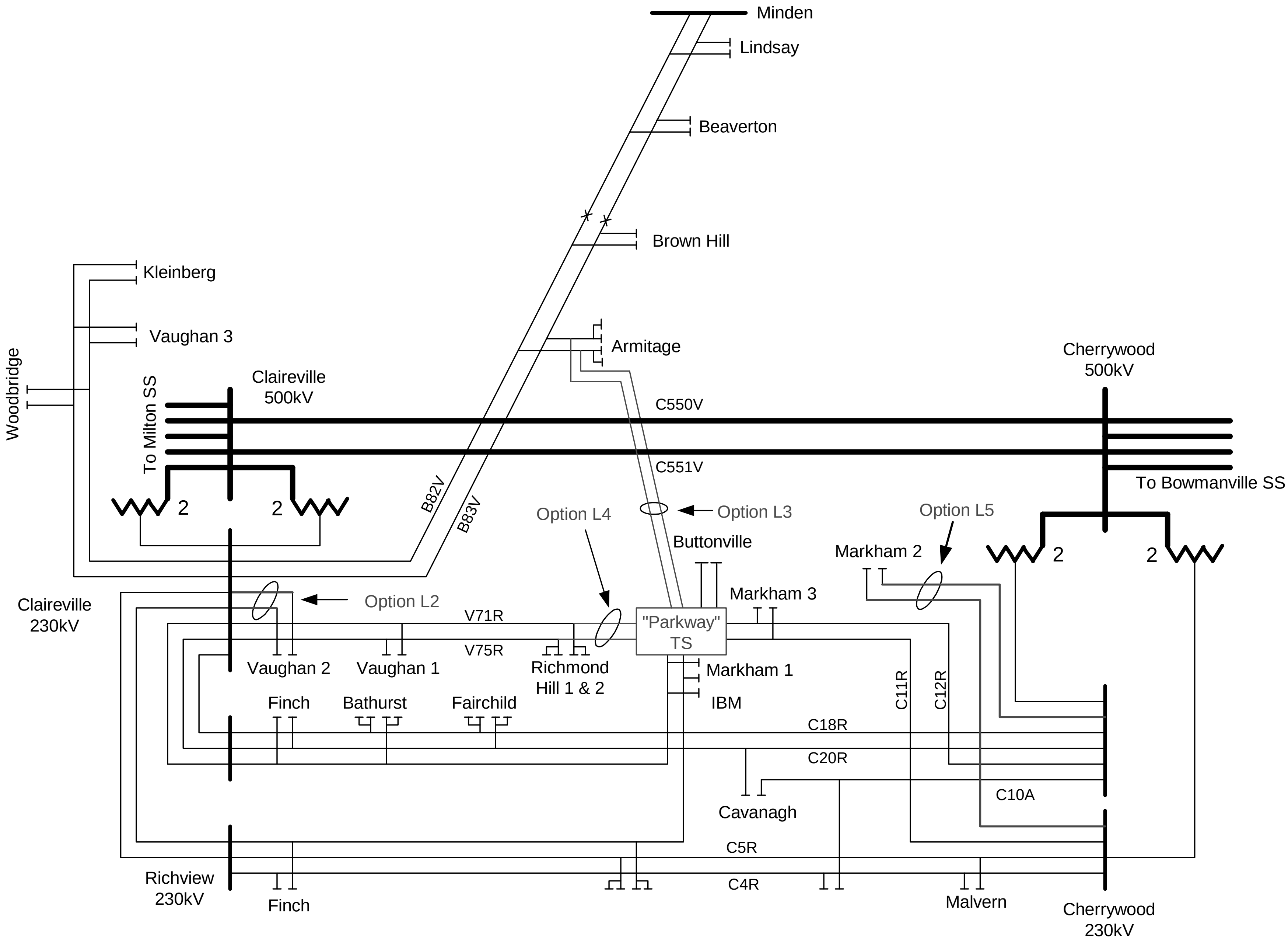


Figure 11. Transmission Options L2, L3, L4, and L5

This option transfers load off the Claireville TS x Brown Hill TS circuits freeing up sufficient capacity to supply Hydro Vaughan MTS #4. The Parkway Jct. x Buttonville TS line will be reterminated at Parkway TS.

This option would also allow the future Markham Hydro MTS #4 and Richmond Hill Hydro MTS #3 to be located north of Buttonville TS to meet Markham Hydro and Richmond Hill Hydro requirements.

6.3.4 Option L4 – Build a new double 6.5km circuit line Parkway TS x Richmond Hill Jct.

This option provides relief for the 230kV circuits V71R/V75R by supplying Richmond Hill MTS #1 and 2 from Parkway TS. A new 230kV double circuit line is built connecting Richmond Hill TS to Parkway TS (Figure 11). Sufficient space is available adjacent to the Claireville TS x Cherrywood TS 500kV right-of-way for the new line.

6.3.5 Option L5 – Build a new double 12.2km circuit line Cherrywood TS x Markham MTS#2

This option provides relief for the 230kV circuits C11R/C12R. Markham MTS #2 is taken off the C11R/C12R circuit and supplied directly from Cherrywood TS by a new 12.2km long 230kV double circuit line (Figure 11). New 230kV breakers would be required at Cherrywood TS to terminate the new circuits. The taps to Markham MTS #2 would be connected to the new circuits.

6.4 Option V1 - Improving Power Factor at Transformer Stations

Power factor improvement is recommended at step down transformer stations not equipped with low voltage capacitor banks. These stations are as follows:

1. Markham MTS #1, #2 and #3.
2. Richmond Hill MTS #1
3. Vaughan MTS #2

Markham Hydro, Richmond Hill Hydro and Hydro Vaughan will be reviewing their respective station loading to determine the benefits, timing and size of capacitors.

6.5 Other Options studied and eliminated from Final Consideration

A number of other options, particularly for supplying Armitage TS, were considered but eliminated due to technical or environmental concerns. A brief description of these options is given in Appendix C.

7.0 Selection of Preferred Plan

Two plans were identified based on an assessment of the options described above and are given in Table 3 below.

<u>Table 3 – Transmission Plans considered</u>

Alternate Plans	**Autotransformer Relief**				**Line Relief**				
Options	T1 (1)		T2 (1)		L1	L2	L3	L4	L5
Timing of Options (2)	2006	2009	2006	2012	2006	2006	2006	2006	2009
Plan A	x	x			x	x			x
Plan B			x	x			x	x	

Notes:

1. Two autotransformers are required at Claireville TS under Option T1. The first one in 2006 and the second in 2009.
2. While most facilities are required by 2005, it may not be possible to have them available for service by that time. Earliest possible in-service date is summer 2006. Operational measures will be taken to ensure satisfactory system operation during the interim period.
3. The options are summarized below:
   - T1 – add autotransformer capacity at Claireville TS
   - T2 – add autotransformer capacity at new “Parkway “ TS built midway between Claireville TS and Cherrywood TS
   - L1 – build 230kV line from Claireville TS to Armitage TS
   - L2 – build 230kV line from Claireville TS to Vaughan MTS #2
   - L3 – build 230kV line from “Parkway” TS to Armitage TS
   - L4 – build 230kV line from “Parkway” TS to Richmond Hill Jct.
   - L5 – build 230kV line from Cherrywood TS to Markham MTS #2

Plan A is based on adding new autotransformer capacity at Claireville TS. Transmission line relief is provided by building new lines out of Claireville to Armitage and Vaughan MTS#2. A new line is provided to relieve the C11R/C12R circuits by 2009.

Plan B covers building a new 500-230kV autotransformer station at Parkway TS between Cherrywood TS and Claireville TS. New Lines are built to Armitage TS and Richmond Hill TS to provide relief for circuits B82V/B83V and V71R/V75R. Relief is provided for circuits C11R/C12R by terminating these circuits at Parkway TS.

Both Plan A and B result in an increase in fault level at Claireville TS and may require splitting the station 230kV bus in the future if new generation is installed in the GTA.

Plan B is preferred based on a comparative evaluation of the two plans in terms of major equipment requirements and kilometers of new 230kV lines required to be constructed (Table 4).

Table 4 – Major Equipment and 230kV Line Requirements under Plans A and B.

Major Equipment or Line (km)	Autotransformer Relief				Line Relief					Summary of Alternative Plans requirements	
	T1 (1)		T2 (1)		L1	L2	L3	L4	L5	Plan A*	Plan B**
Timing	2005	2009	2005	2012	2006	2006	2006	2006	2009		
Autos	1	1	2	1						2	3
GIS Breakers 500kV	1	1								2	
GIS Breakers 230kV	1	1				2				4	
GIS Bus duct	1	1				1				3	
Breakers 500kV			2	1							3
Breakers 230kV			10	1			2		2	2	14
230kV Line km					44	4.5	24	6.5	12.3	60.8	30.5

Note:

* Plan A includes options T1, L1, L2 and L5
** Plan B includes options T1, L3 and L4. (shaded cells represent requirements for Plan B).

Plan B is preferred for the following reasons:

1. Requires 30.5km of new line construction compared to 60.8km of new line required under Plan A. Line construction costs for Plan B are therefore expected to be half that for Plan A and it is expected to have a lesser environmental impact.
2. The new "Parkway" TS Station will be based on an outdoor layout. While it requires more equipment (one more transformer, one more 500kV breaker and eight more 230kV breakers) over the study period, overall cost is expected to be less because of the higher cost of GIS equipment and the need to make modifications to the existing GIS equipment at Claireville TS.
3. Results in a smaller increase in short circuit levels particularly at the Claireville TS 230kV station. It will allow greater amount of generation to be incorporated in the GTA west area compared to Plan A before the Claireville bus is required to be split.
4. Provides greater supply diversity for all of York Region loads. Under Plan A all utilities load would be supplied from one source – either Claireville TS or Cherrywood TS. Plan B would provide two sources for each utility load.

5. Results in increased security as it provides a new supply point for the GTA area. Plan A would result in 4500MVA of step down capacity at a single location.

6. Provides more operating flexibility – outages will be easier to obtain, both during construction and after the new "Parkway" TS has been placed in-service.

An assessment of the impact of Plan B (loading on autotransformers and lines and the effect on short circuit levels at Claireville TS) is given in Appendix B.

Further project development work will be carried out to develop plan costs and these costs will be factored in the assessment.

8.0 Conclusions and Recommendations

This report has reviewed the transmission supply adequacy supply to York Region over the 2003-2013 study period and shows that under certain contingency conditions existing 500-230kV auto-transformation facilities and 230kV transmission circuits would be loaded beyond their limited time rating or result in unacceptable voltage declines.

The required in-service date for the new facilities varies from an immediate need to provide relief for circuits V71R/V75R to winter 2005/2006 for providing relief for circuits B82V/B83V. A number of options were considered and two alternative plans developed to meet load demand over the study period. A qualitative assessment of the two plans indicates significant economical and technical advantages for Plan B. Because of the urgency of the need to provide relief and to have the required facilities in-service as soon as possible, the report recommends the following steps:

- Initiate environmental assessment, preliminary engineering and project development work under Plan B.
- Confirm that Plan B is indeed the lowest cost plan. Obtain estimates for work under Plans A and B by September 2003 and revise work plan as appropriate.

The work under Plan B is as follows:

- Build a new 500-230kV "Parkway" transformer station at Parkway Jct. on the Cherrywood TS x Claireville TS 500kV right-of-way. The new "Parkway" TS will have two 750MVA, 500-230kV autotransformers and a 230kV switching station.
- Build a new 6.5-km long double circuit 230kV line from Parkway TS to Richmond Hill Jct. to connect to 230kV circuits V71R/V75R.
- Build a new 230kV double circuit line between "Parkway" TS and Armitage TS.

- Split the Cherrywood TS x Richview TS 230kV circuits C11R/C12R at Parkway Jct. and terminate at “Parkway” TS.

- Markham Hydro, Richmond Hill Hydro and Hydro Vaughan to review the benefits and timing for low voltage capacitor banks at their stations.

The earliest the recommended work can be done to alleviate the voltage and loading concerns is summer 2006. To permit an uninterrupted load supply in the interim period, Hydro One Networks and the York Region utilities have initiated mutual discussions with the IMO to ensure that appropriate mitigating actions and procedures are in place.

Appendix A. York Region Stations Load Forecast

Table A1 – Existing and Future Station MW Requirements for York Region

This load forecast for stations serving York Region has been provided by York Region utilities.

Table A1 - Existing and Future Station MW Requirements for York Region

No	Station name	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Markham Hydro													
1*	Buttonville	82	84	85	85	85	80	80	80	80	80	80	80
2*	Leslie	30	31	31	31	32	32	32	33	33	33	33	33
3*	Agincourt	9	9	7	7	7	7	7	7	7	7	7	7
4	Richmond Hill 2	33	28	28	30	30	15	0	0	0	0	0	0
5	Markham 1	100	106	94	94	94	94	94	94	94	94	94	94
6	Markham 2	110	116	92	94	95	80	70	70	84	84	84	84
7	Markham 3	101	105	94	94	94	94	94	94	94	94	94	94
8**	Markham 3E	0	0	62	70	80	90	90	90	90	90	90	90
9**	Markham 4	0	0	0	0	0	40	78	90	90	103	117	130
		465	479	493	505	517	532	545	558	572	585	599	612
Richmond Hill Hydro													
1*	Buttonville	49	53	56	58	61	64	67	69	72	75	77	40
2	Richmond Hill 1	176	152	160	168	176	176	176	176	176	176	176	176
3	Richmond Hill 2	28	59	62	65	68	79	90	101	112	122	132	122
4**	Richmond Hill 3	0	0	0	0	0	0	0	0	0	0	0	60
		254	264	278	292	305	319	333	346	360	373	385	398
Hydro Vaughan													
1*	Fairchild	40	40	40	40	40	40	40	40	40	40	40	40
2*	Finch	29	29	29	29	29	29	29	29	29	29	29	29
3*	Woodbridge	53	53	53	53	53	53	53	53	53	53	53	53
4	Vaughan 1	210	180	180	180	180	180	180	180	180	180	180	180
5	Vaughan 2	186	180	180	180	180	180	180	180	180	180	180	180
6	Vaughan 3	62	133	164	180	180	180	180	180	180	180	180	180
7**	Vaughan 1E	0	0	0	16	50	85	90	90	90	90	90	90
8**	Vaughan 4	0	0	0	0	0	0	33	64	97	131	166	180
9**	Vaughan 5	0	0	0	0	0	0	0	0	0	0	0	22
		580	614	645	677	711	747	784	815	848	882	917	954
Aurora Hydro, Newmarket Hydro and Hydro One Retail													
1	Armitage	321	331	340	321	321	321	321	321	321	321	321	321
2**	New				30	40	51	62	74	86	98	110	123
		321	331	341	351	361	372	383	395	407	419	431	444

Note:

* Hydro One owned stations

** New Stations

Appendix B. Impact assessment

Plan B – New “Parkway” TS and 230kV transmission facilities reinforcement.

B1.0 Impact Assessment

Alternative Plan B covering the installation of a new 500-230kV transformer station “Parkway” TS is likely the most cost effective and technically preferred plan for supplying the long term electrical needs for York Region.

Plan B covers the following work:

1. Increase 500/230kV autotransformation capacity in the GTA by building a new 500-230kV autotransformer station “Parkway” TS at Parkway Jct. – located midway between Cherrywood and Claireville TS. Sufficient space is available at the Parkway Jct. site adjacent to the Claireville TS Cherrywood TS right-of-way.

2. Reinforce supply to Richmond Hill and Vaughan by building a new 6.5km double circuit 230kV line along the Parkway belt corridor from the new “Parkway” TS to Richmond Hill Jct. This new line will provide relief for the existing 230kV radial circuits V71R/V75R out of Claireville TS. There is space available for the new 230kV circuit on the existing right-of-way.

3. Reinforce supply to Markham by opening the Cherrywood TS x Richview TS 230kV circuits C11R/C12R at Parkway Jct. and terminating the open circuits at “Parkway” TS. This will provide relief for 230kV circuits C11R/C12R.

4. Build a new 230kV double circuit line between “Parkway” TS and Armitage TS. The new line will increase the load supply capability to Aurora, Newmarket and surrounding areas and will provide relief for the Claireville TS x Brown Hill TS circuits B82V/B83V. The new line is proposed to be built on the existing 115kV right of way between Buttonville TS and Armitage TS.

The system configuration under Plan B is shown in Figure B1. New stations expected in the area, as per forecast in Appendix A, are assumed to be connected as shown.

B1.1 Impact on Autotransformers

The new 500-230kV autotransformers at “Parkway” TS will provide relief for the existing autotransformers at Claireville TS. Based on the forecast loads two 750MVA, 500-230kV autotransformers will be adequate till 2013, the last year of the study. A third autotransformer will be required at that time.

The loading on autotransformers in the Greater Toronto Area - Claireville TS, Cherrywood TS, the new “Parkway” TS and Trafalgar TS is shown in Figure B2. While Trafalgar TS is outside the immediate study area, its loading impacts the loading on the Claireville TS autotransformers and has been included for completeness.

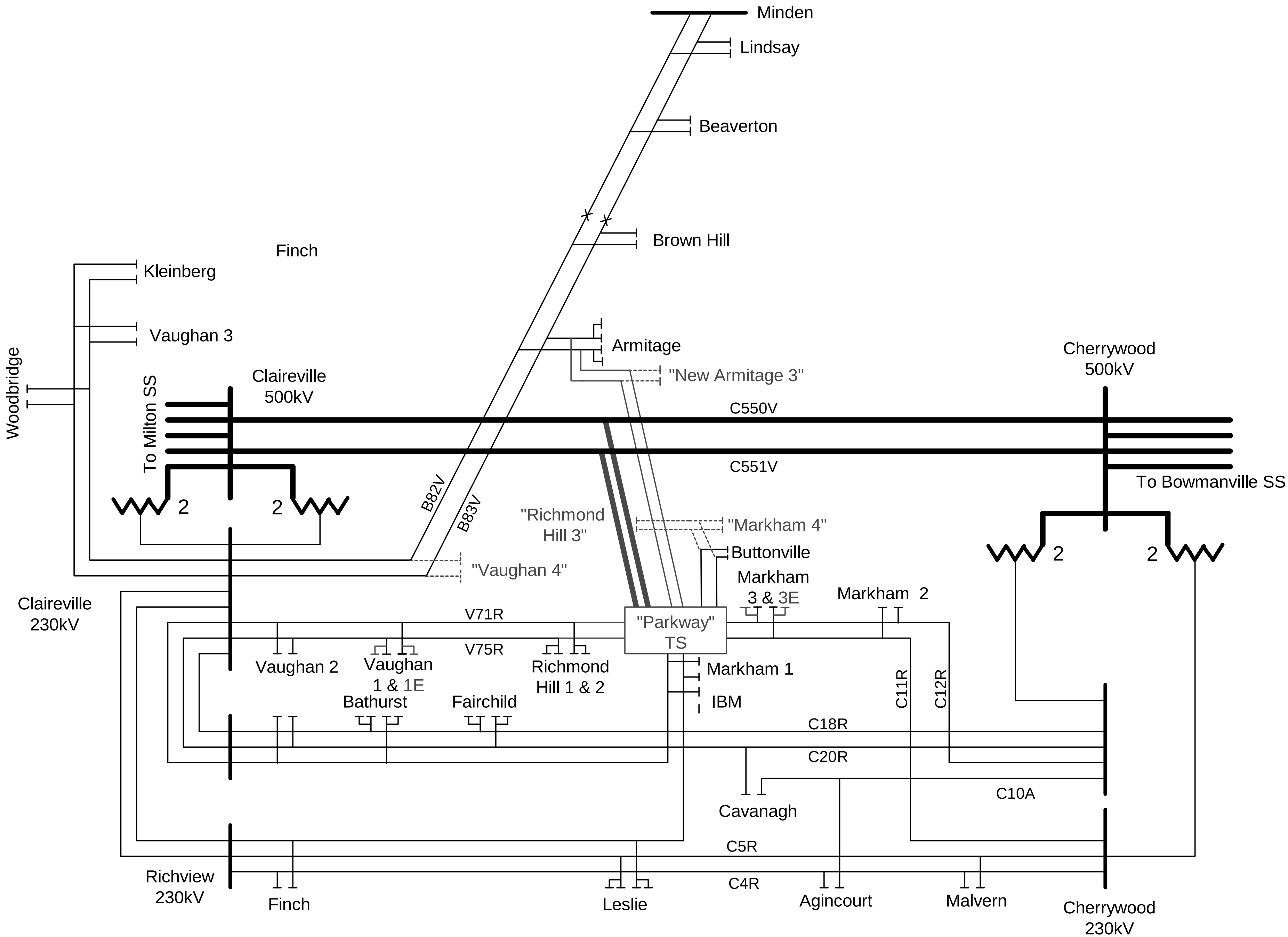


Figure B1. New Facilities required under Plan B. Also shows new transformer stations expected during study period. (For timing of new stations see Appendix A)

B1.2 Impact on Transmission Line Loading

The addition and reconfiguration of 230kV supply circuits allow the loads in York Region to be adequately supplied until 2013 and beyond. The alternative provides relief for the three corridors – B82V/B83V, C11R/C12R and V71R/V75R.

Figure B3 shows the loading on these circuits up to the year 2013. All transmission corridors are expected to be adequate during the study period.

B1.3 Impact on Transmission System Voltage

Steady state voltages at all York Region buses meet the minimum IMO adequacy criteria under the Market Rules (230kV under normal conditions for the 230kV system).

Voltage performance under contingency conditions is also within the 10% voltage decline criteria following for loss of a 230kV on any of the three corridors.

Section B2.0 - Short Circuit Impact

The main impact of the new Parkway TS is on the fault levels at Claireville TS 230kV bus. Table B1 shows the short circuit levels at the Claireville TS and Parkway TS 230kV buses. It is seen that the resulting fault levels at Claireville TS are within the ratings of the Claireville TS breakers.

The fault levels were calculated based on the following scenario:

- Maximum system generation – 4 Darlington, 8 Pickering, 6 Bruce, 8 Nanticoke, 4 Lennox, 4 Lakeview and 16 Saunders units.
- 2 x 750MVA, 500/230kV autotransformers at Parkway TS
- Cherrywood and Richview TS 230kV buses operated split.

Lakeview GS has been considered in-service to allow for possible future operation as a synchronous condenser for reactive power support.

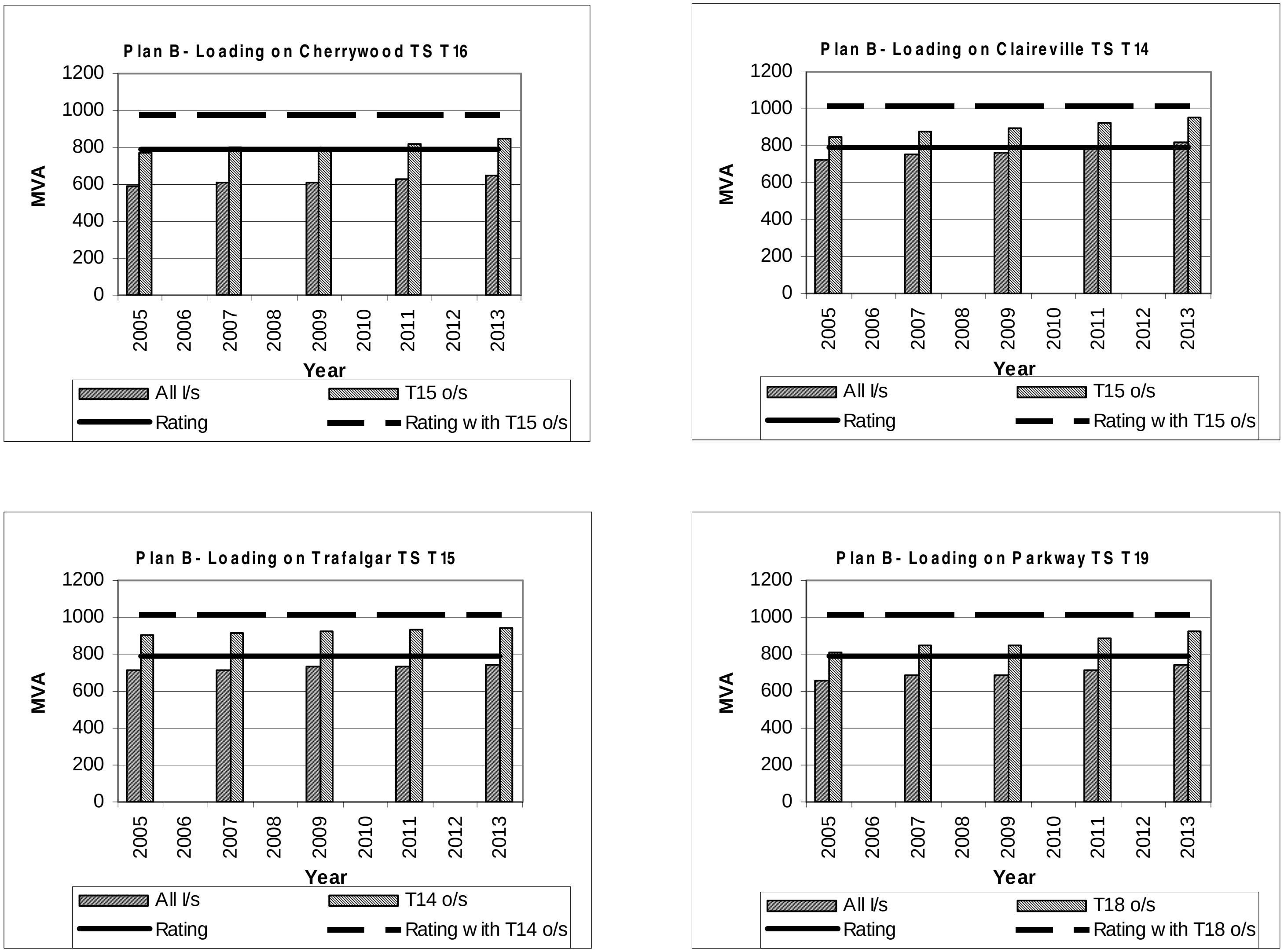


Figure B2. Loading on the GTA area 500-230kV autotransformers under Plan B.

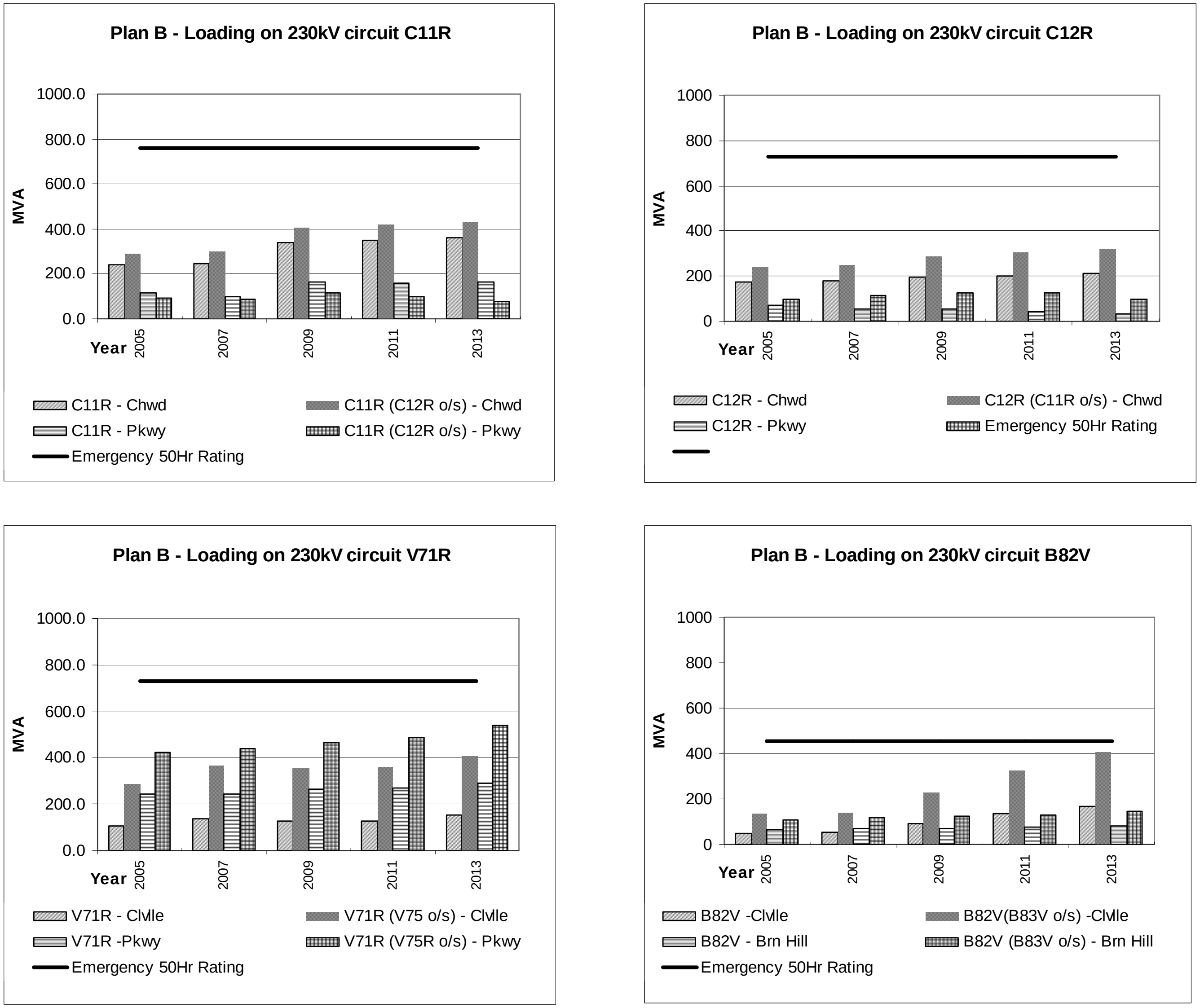


Figure B3. Loading on 230kV circuits under Plan B

There are proposals in the IMO queue for new generation in the Brampton and south Mississauga areas. These generation proposals, if they go ahead, will increase the fault levels at Claireville TS and require mitigation measures. Case B shows the fault levels at Claireville TS with Brampton area generation and Parkway TS in-service. In this case opening the V71R/V75R circuits between Parkway TS and Claireville TS reduces the fault levels at Claireville TS to within ratings. The short circuit impact of the proposed south Mississauga generation was not explicitly considered as we expect it to replace generation at Lakeview GS.

Table B1. Fault Levels at Claireville TS and Parkway TS

Station	Breaker Ratings KA	Fault MVA	Three Phase kA	L-G kA	Double L -G kA
Case A: All facilities inservice (new Parkway TS)					
Claireville 230kV	80	29680	68.2	77.2	75.3
Parkway 230	70	26319	60.8	69.7	67.9
Case B: Case A + Brampton Area Generation					
Claireville 230kV	80	32069	74.1	83.1	81.5
Parkway 230	70	27306	63.2	71.7	70.0
Case C: Case B + V71R/V75R open					
Claireville 230kV	80	30408	70.2	79.3	77.5
Parkway 230	70	24795	57.3	66.4	64.3

Appendix C. Other Transmission Options Considered

Other Options considered and eliminated from Final Consideration

This appendix provides a brief description of other options considered, particularly to supply Armitage TS. The options were however eliminated because of technical or environmental concerns.

C1.0 Supply Armitage from Essa TS

Under this option, Armitage would be supplied with a new 60km line form Essa TS. This alternative would require adding additional 500-230kV capacity at Essa TS. However, it would not provide sufficient relief for the Claireville TS autotransformers. Action would still be required to relieve Claireville TS and 230kV circuits V71R/V75R and C11R/C12R. This alternative was therefore not considered further.

C2.0 Supply Armitage TS from Kleinburg TS

Under this option, the 230kV circuits supplying Kleinburg TS would be extended 38km to Armitage TS. This option does not provide adequate capacity to supply additional load and was not considered further.

C3.0 Supply Armitage TS from Cherrywood TS

Under this option, a new 230kV 34km line would be built to supply Armitage TS directly from Cherrywood TS. This option would result in overloading of the Cherrywood autotransformers as Armitage load is transferred from Claireville TS to Cherrywood TS. In addition, a new direct line would require a new right-of-way through an environmentally sensitive area. This alternative was therefore dropped from further consideration.

C4.0 Provide relief for 230kV circuits V71R/V75R by operating two of the Claireville TS x Cherrywood TS 500kV circuits at 230kV

The Claireville TS x Cherrywood TS 500kVcorridor consists of two double circuit tower lines. The conductors on both tower lines are paralleled together to form the two 500kV circuits C550V/C551V. Consideration was given to unbundling the circuits and operating one circuit on each line at 230kV. These converted 230kV circuits would connect Cherrywood TS to the Claireville TS x Richmond Hill Jct. circuits V71R/V75R.

This option transfers load from the Claireville autotransformers to the Cherrywood autotransformers. However, no new autotransformation capacity is added, and additional transformation would still be required between 2005 and 2007 depending on the number of units in-service at Pickering A to provide relief for the Claireville autotransformers. This alternative will also require expensive ferroresonance mitigation measures at all transformer stations connected to these circuits.

This alternative was therefore eliminated from further consideration.

TAB 5

Simcoe County Supply Study

Adequacy of Transmission Facilities

And

Transmission Supply Plan 2004-2014

November 12, 2004

Forward

This report is the result of a joint study by Barrie Hydro Distribution Inc., COLLUS Power Corp., Honda of Canada, Hydro One Networks Inc., Innisfil Hydro Distribution Systems Limited, Midland Power Utility Corp. and Wasaga Distribution Inc. The study team members were:

Alessia Celli, Hydro One Networks
Shelly Cunningham, Barrie Hydro
Wayne Dupuis, Midland Power Utility
Raj Ghai, Hydro One Networks
Chong Han, Honda of Canada
Charlie Lee, Hydro One Networks
Richard Shannon, Hydro One Networks
George Shaparew, Innisfil Hydro Systems
Christine Spears, Hydro One Networks
Paul Trace, Wasaga Distribution
Darius Vaiciunas, COLLUS Power

The load forecast is based on information available to Barrie Hydro, Midland Power Utility, COLLUS Power, Innisfil Hydro Systems, Wasaga Distribution and Hydro One-Distribution, at the time the study was initiated (December 2003).

The preferred plans have been selected and endorsed based primarily on technical considerations. Where applicable, these plans will be subject to Environmental Assessment approval and / or Ontario Energy Board (OEB) approval. The issue of cost allocation between utilities was not addressed.

Signatures

We have reviewed this report and concur with its recommendations. This endorsement shall not operate as a waiver of any participant's rights due to material changes in load forecasts or economic considerations.

Utility	Signature	Title
Barrie Hydro Distribution Inc.		Shelly Cunningham Manager – System Planning and Control
COLLUS Power Corp.		Darius Vaiciunas Load Management & Regulatory Coordinator
Honda of Canada Manufacturing		Terry Walsh Engineering Facilities Department
Hydro One Networks Inc. – Distribution		Bob Singh Manager, Distribution Development
Innisfil Hydro Distribution Systems Limited		George Shaparew President
Midland Power Utility Corp.		Wayne Dupuis Manager of Operations
Wasaga Distribution Inc.		Paul Trace Manager Planning and Technical Services
Hydro One Networks Inc. – Transmission		John Sabiston Team Leader/ Senior Advisor

Date: November 12, 2004

TABLE OF CONTENTS

Executive Summary

Background

Simcoe County is located between the southeastern shore of Georgian Bay and Lake Simcoe. Electrical supply in this area is provided through 500 kV, 230 kV, and 115 kV transmission lines and step down transformation facilities as shown in Map 1 and Figure 1. Load forecasts provided by the Local Distribution Companies (LDCs) in Simcoe County indicate that electrical load growth is expected to continue at a summer average rate of 3.1% per year and a winter average rate of 2.7% per year, for the next ten years.

In November of 2003, a joint utility planning study was initiated between six of the LDCs in Simcoe County, one large industrial customer and Hydro One Networks Inc. - Transmission. LDCs and industrial customer participants in this joint study were:

- Barrie Hydro Distribution Inc.
- COLLUS Power Corp.
- Hydro One Networks Inc. – Distribution
- Innisfil Hydro Distribution Systems Limited
- Midland Power Utility Corp.
- Wasaga Distribution Inc.
- Honda of Canada Mfg.

This study assessed the transmission system in Simcoe County. The supply stations in the area were also reviewed to identify additional capacity requirements to meet the projected load growth. The study then investigated several transmission alternatives for addressing the needs and deficiencies as soon as practical.

Need

The needs assessed in the study were divided into two areas - (1) North Simcoe County - north of and including Essa Transmission Station (TS); and, (2) South Simcoe County - south of Essa TS. The needs of both areas are independent and the available options are mutually exclusive (i.e. northern options are not dependent on southern options and vice versa).

1. North:

<u>Station Overloads</u>

- Waubaushene TS is currently loaded beyond its station winter capacity limit;
- Meaford TS is expected to reach the station capacity limit by winter 2006;
- The 230/115 kV auto-transformers at Essa TS are expected to be at their capacity limit by 2007;
- The 750 MVA 500/230 kV auto-transformers at Essa TS are expected to be at their capacity limit by 2014; and,
- Midhurst TS is expected to be near station capacity by summer 2014.

<u>Voltage Deficiencies</u>

- Stayner TS is currently experiencing voltage deficiencies during winter peak periods. It is expected to be below operation and planning standards in peak loading periods by summer 2007. A load rejection scheme was installed at Stayner TS ten years ago to reduce the risk of a voltage collapse in the area in the event of a contingency;
- Meaford TS is currently experiencing voltage deficiencies on long distribution lines supplying load that was originally transferred from Stayner TS in the last decade;
- The 230 kV and 115 kV voltages in the Essa area are expected to be below operation and

planning standards by 2009; and,

- The 230 kV voltage in the local area is expected to be below operation and planning standards by 2014.

<u>Circuit Overloads</u>

- Distribution lines emanating from Meaford TS are currently at capacity. These lines are supplying load that is local to Stayner. Voltage deficiencies at Stayner TS prohibit the transfer of this additional load to the station.

2. South:

<u>Station Overloads</u>

- Alliston TS is currently loaded at its station capacity and local area load is forecasted to grow.

The study was conducted under the assumption that by 2006 additional voltage support would be provided by means of a 245 MVar capacitor bank on the 230 kV bus at Essa TS. The additional voltage support is needed in order to prevent excessive voltage decline in the event that one auto-transformer at Essa TS is out of service for maintenance and the companion auto-transformer is forced out of service. Hydro One will be installing the required capacitor by summer 2006.

Recommended Transmission Reinforcements

Various options were assessed in the study. Viable options were combined to effectively resolve problems in the specific geographical areas. Two independent projects are recommended for implementation as soon as possible to address the immediate needs listed above:

1. North

Convert Stayner TS from 115 kV to 230 kV, and rebuild the existing 115 kV circuit (S2E) from Stayner TS to Essa TS to a double circuit 230 kV transmission line. A 230/115 kV auto-transformer at Stayner TS is required to maintain the electrical connection to Meaford TS. This plan also includes upgrading the existing transformers at Stayner TS to 75/125 MVA capacity, to serve local load growth.

This plan will resolve voltage deficiencies and will create additional capacity at Stayner TS. The additional capacity can be used to address overload issues at Meaford TS and voltage deficiencies on Meaford distribution lines. Increasing capacity at Stayner TS also provides the opportunity for relieving capacity at Waubaushene TS by cascading load transfers to Stayner TS, through Midhurst TS. Finally, the conversion of Stayner TS from 115 kV to 230 kV relieves capacity on the remaining 115 kV system and 230/115 kV auto-transformers at Essa TS to accommodate future load growth in the Barrie and Innisfil areas. The earliest possible in service date for this plan is winter 2007.

2. South

A new transformer station near Alliston will resolve the electrical supply requirements in the growing South Simcoe area including local areas (New Tecumseth, Adjala-Tosorontio and Essa Townships), and Innisfil, for the next 10 years. The earliest possible in service date for this plan is summer 2006.

Recommendations

Several recommendations can be drawn from this study to address the current system deficiencies and provide system capacity to meet forecasted load growth. These recommendations are:

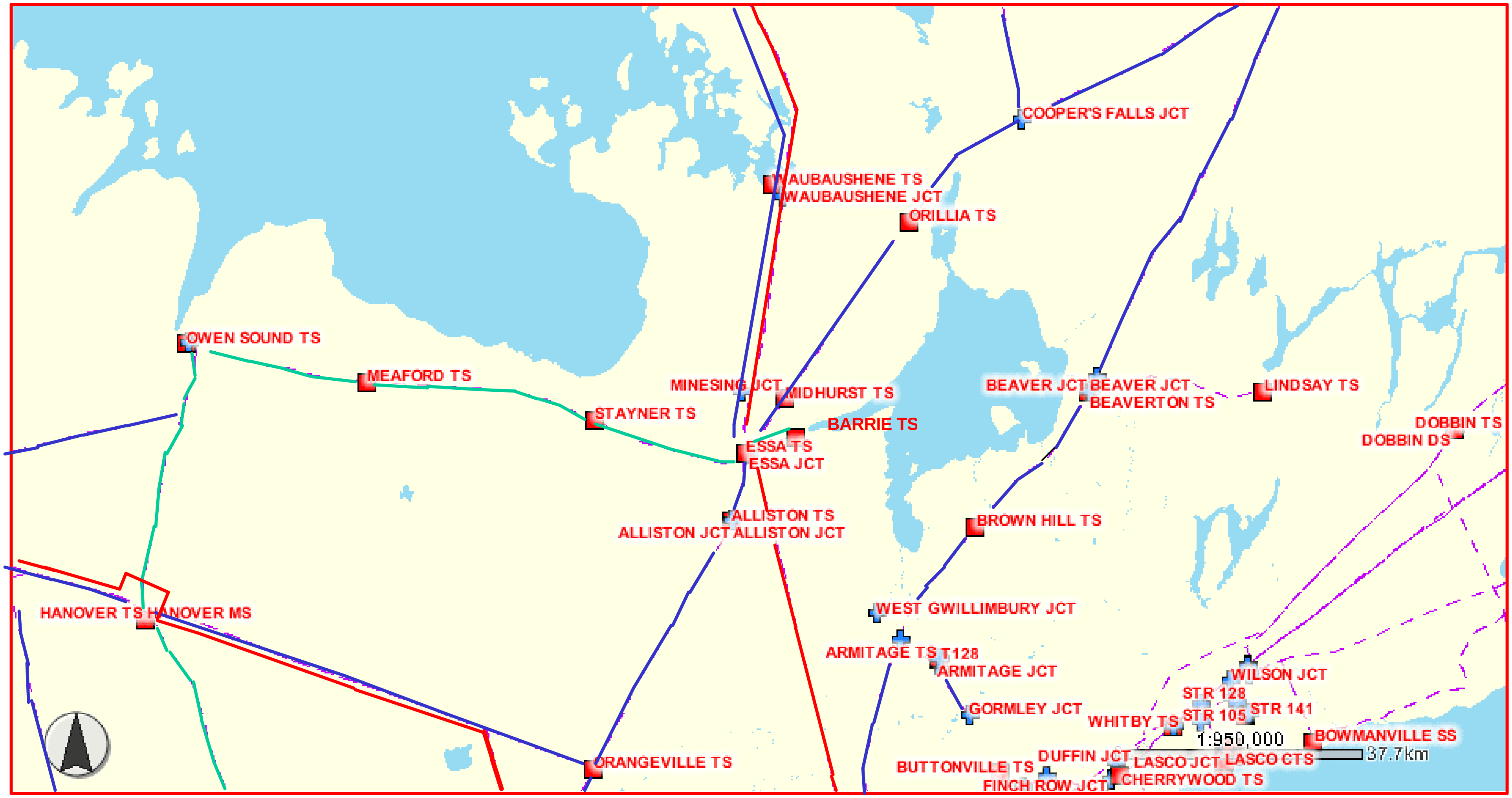
1. Hydro One Networks Inc. to initiate the approval processes required for the conversion of Stayner TS from 115 kV to 230 kV, and the upgrading of the existing 115 kV transmission line from Stayner TS to Essa TS (circuit S2E) to a double circuit 230 kV transmission line.

2. Hydro One Networks Inc. to commence the preliminary engineering and consultation with the local distribution companies, and to initiate the approval processes on the construction of a new transformer station, near Alliston.

3. Hydro One Networks Inc. to review the study in 2007 with updated Simcoe County load forecasts for the potential need for a 2nd 230 kV, 245 MVAR capacitor bank and a 3rd 500/230 kV, 750 MVA auto-transformer at Essa TS for implementation in 2009 and 2014, respectively.

4. The local electric utilities to continue to monitor load growth in the southern Simcoe County area and to review options for long-term growth based on the location of new developments and load forecasts.

5. The local electric utilities in the northern Simcoe County area (specifically in the Barrie area) to continue to monitor load growth and the loading of Midhurst TS.



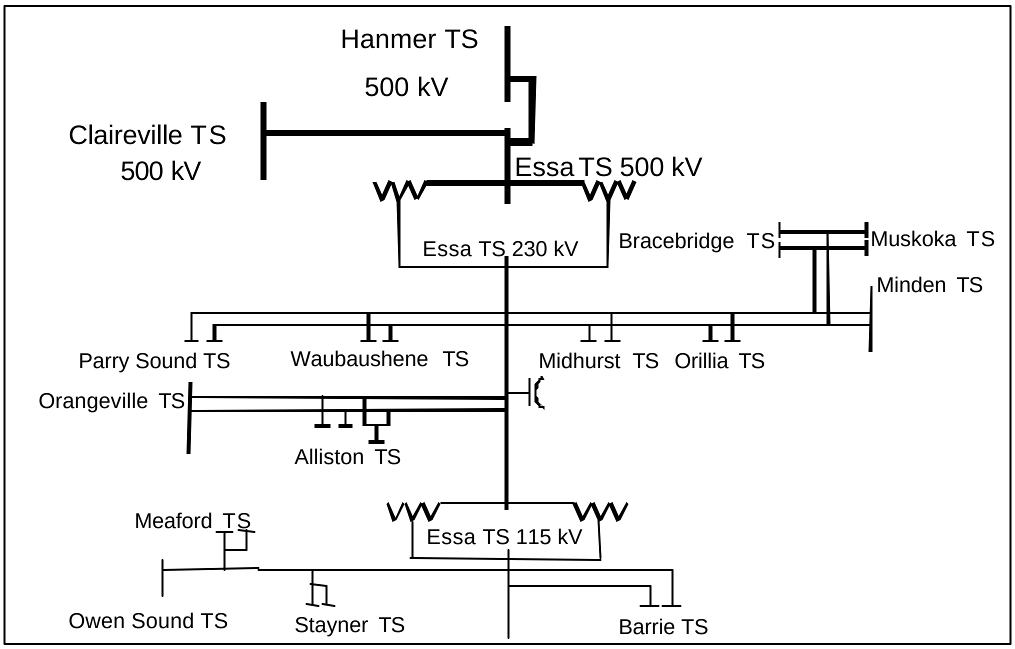
500 kV Right of Way Corridor	230 kV Right of Way Corridor	115 kV Right of Way Corridor

Map 1: Existing Transmission Facilities in Simcoe County

1. Introduction

Simcoe County is located between the southeastern shore of Georgian Bay and Lake Simcoe. It consists of eighteen townships and/or municipalities - Adjala-Tosorontio, Barrie, Bradford West Gwillimbury, Clearview, Collingwood, Essa, Innisfil, Midland, New Tecumseth, Orillia, Oro-Medonte, Penetanguishene, Ramara, Severn, Springwater, Tay, Tiny, and Wasaga Beach. The Simcoe County has a combined electrical load of over 800 MW. Electrical supply in this area is provided through 500 kV, 230 kV and 115 kV transmission lines and step down transformation facilities (transmission stations, TS) as shown in Map 1 and Figure 1.

Figure 1: Existing Transmission System in Simcoe County



Load growth in Simcoe County has been increasing, and the transmission stations in the area are consistently peaking above their capacity limits (limited time ratings[1]), as well as experiencing voltage problems related to high loading. In November of 2003, a joint study was initiated between six LDCs in Simcoe County, one large industrial customer and Hydro One.

The purpose of this joint study was to assess the load growth in the Simcoe County area and ensure that adequate transmission and connection facilities will be available to meet the electrical demand requirements over the next decade. LDCs and industrial customer participants in this joint study were:

- Barrie Hydro Distribution Inc.
- COLLUS Power Corp.

[1] Limited Time Rating (LTR): With respect to transformers, LTRs are a set of 15-minute, 2-hour and 10-day MVA ratings to accommodate shorter time interval emergency loading periods. With respect to transmission lines, LTR are a set of 5-minute and 15-minute summer and winter ampacity ratings to accommodate shorter time interval emergency loading periods.

- Hydro One Networks Inc. – Distribution
- Innisfil Hydro Distribution Systems Limited
- Midland Power Utility Corp.
- Wasaga Distribution Inc.
- Honda of Canada Mfg.

2. Existing Transmission System and Needs

The hub of the electrical system in Simcoe County is Essa TS. Essa TS provides the single connection to the 500 kV system in this area, through which is provided the majority of resources to meet demand in Simcoe County. Simcoe County transmission system is connected from Essa TS as follows (refer to Figure 1 and Map 1):

1. Two 230 kV radial circuits (E26/E27) emanating north to supply Waubaushene TS and Parry Sound TS;
2. Two 230 kV circuits (E8V/E9V) first heading south to Orangeville TS, and then going west providing a connection to Bruce A Generation Station (GS);
3. Two 230 kV circuits (M6E/M7E) heading northeast to Midhurst TS and making a network connection at Minden TS;
4. Two 115 kV circuits (E3B/E4B) into Barrie TS; and,
5. One 115 kV circuit (S2E-S2S) heading west connecting Stayner TS and Meaford TS.

Load forecasts provided by the LDCs in Simcoe County indicate that electrical load growth is expected to continue at a summer average rate of 3.1% per year and a winter average rate of 2.7% per year, for the next ten years. Some stations in the area are consistently peaking above their capacity limits (LTRs), as well as experiencing voltage deficiencies related to high loading.

In the early 1990's, an analysis of the adequacy of the transmission system and step-down transformation facilities in the Stayner - Collingwood Wasaga Beach area was conducted. A preferred system plan and route was approved by the Ministry of Environment upon completion of the Class Environmental Assessment (EA) process. The preferred system plan is described in the 1991 Supply to Collingwood Environmental Study Report (ESR)[2]. This consists of replacing the existing 115 kV transmission line from Essa TS towards Stayner TS with two 230 kV circuits, and build a new transmission station to supply the load growth expected in the Stayner - Collingwood – Wasaga Beach area. Subsequently, this transmission expansion was deferred and demand management and load transfer options were implemented. Load was transferred to stations further from the Stayner area, to Meaford TS, and to Midhurst TS, causing cascading[3] load transfers up to Waubaushene TS. However, we have now reached a point where Stayner TS is experiencing voltage deficiencies, the load growth in the Stayner area continues to increase and the stations carrying load located closer to Stayner TS are beyond capacity. The 1991 preferred system plan is one of the options considered in this study.

All stations in the Simcoe County study area were considered and this joint study addresses those stations where capacity and load growth were an issue, and where there were known voltage deficiencies in the system.

[2] Ontario Hydro, Design and Development Division-Transmission: Supply to Collingwood Environmental Study Report. August 1991, Report # 90337.

[3] Cascading: The transferring of load in successive stages using the distribution network to numerous transmission stations (TS). Each stage of load transfer depends on the cumulative load at a particular station. For example, once the cumulative Midhurst local load and the load transferred from Stayner TS to Midhurst TS reached Midhurst TS station capacity, some Midhurst local load was then transferred to Waubaushene TS.

The needs assessed in the study were divided into two areas - (1) North Simcoe County - north of and including Essa Transmission Station (TS); and, (2) South Simcoe County - south of Essa TS. The needs of both areas are independent and the available options are mutually exclusive (i.e. northern options are not dependent on southern options and vice versa).

1. North:

Station Overloads

- Waubaushene TS is currently loaded beyond its station winter capacity limit;
- Meaford TS is expected to reach the station capacity limit by winter 2006;
- The 230/115 kV auto-transformers at Essa TS are expected to be at their capacity limit by 2007;
- The 750 MVA 500/230 kV auto-transformers at Essa TS are expected to be at their capacity limit by 2014; and,
- Midhurst TS is expected to be near station capacity by summer 2014.

Voltage Deficiencies

- Stayner TS is currently experiencing voltage deficiencies during winter peak periods. It is expected to be below operation and planning standards in peak loading periods by summer 2007. A load rejection scheme was installed at Stayner TS ten years ago to reduce the risk of a voltage collapse in the area in the event of a contingency;
- Meaford TS is currently experiencing voltage deficiencies on long distribution lines supplying load that was originally transferred from Stayner TS in the last decade;
- The 230 kV and 115 kV voltages in the Essa area are expected to be below operation and planning standards by 2009; and,
- The 230 kV voltage in the local area is expected to be below operation and planning standards by 2014.

Circuit Overloads

- Distribution lines emanating from Meaford TS are currently at capacity. These lines are supplying load that is local to Stayner. Voltage deficiencies at Stayner TS prohibit the transfer of this additional load to the station.

2. South:

Station Overloads

Alliston TS is currently loaded at its station capacity and local area load is forecasted to grow.

3. Load Growth

Load forecasts provided by the LDCs in Simcoe County indicate that electrical load growth is expected to continue at a summer average rate of 3.1% per year and a winter average rate of 2.7% per year, for the next ten years.

The summer loading at the stations that were observed in this study are expected to increase at an average rate of 3.4% annually until 2009, with the long-term growth rate between 2009 and 2014 at 2.7% annually. The winter loading at the stations that were observed in this study are expected to increase at an average rate 3.1% annually until 2009, with the long-term growth rate between 2009 and 2014 at 2.3% annually.

Tables 1 and 2 indicate the summer and winter load forecasts at each connection station covered in this study until the end of the study period for summer and winter respectively.

Table 1: Forecast - Summer Peak Load (MVA)

Transmission Station	Station LTR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Alliston TS	99.9	121.6	124.4	130.2	130.9	134.6	138.3	142.0	145.8	149.4	153.2	156.9	160.8
Barrie TS*	115.0	140.6	137.8	113.7	104.1	108.5	114.5	115.0	115.6	116.2	116.8	117.4	118.0
Meaford TS	53.9	27.9	30.5	31.9	34.4	35.9	37.4	37.8	38.2	38.6	39.0	39.5	39.9
Midhurst TS DESN #2 (planned in-service date of 2004)	208.0	0.0	0.0	55.0	80.4	87.0	94.4	107.2	120.0	132.8	145.6	158.5	171.3
Midhurst TS DESN #1 (existing)	171.5	145.2	165.5	153.8	152.6	156.8	159.6	161.2	162.7	164.2	165.7	167.3	168.8
Stayner TS*	111.6	83.8	84.8	85.8	86.8	87.9	90.2	91.1	92.3	93.5	94.8	96.0	97.4
Waubaushene TS	99.6	96.2	98.5	99.8	102.0	103.3	104.4	105.6	106.9	108.1	109.3	110.5	111.8
Alliston TS #2	99.9	30.1	39.9	41.0	42.3	43.5	44.9	46.2	47.6	49.0	50.5	52.0	53.6
TOTAL:		***645.4***	***681.4***	***711.1***	***733.5***	***757.5***	***783.7***	***806.1***	***829.1***	***851.8***	***874.8***	***898.1***	***921.6***

Station LTR: Summer 10-day Limited Time Ratings
* Station load does not reflect the power factor correction afforded by the existing capacitors

Table 2: Forecast - Winter Peak Load (MVA)

Transmission Station	Station LTR	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Alliston TS	114.9	115.0	117.8	123.3	123.2	126.0	129.1	132.3	135.4	138.8	142.1	145.5	149.0
Barrie TS*	127.7	110.1	110.1	118.7	94.8	86.5	92.5	93.0	93.6	94.2	94.8	95.4	96.0
Meaford TS	60.8	53.9	56.6	59.3	61.9	64.6	66.3	66.9	67.5	68.1	68.7	69.3	69.9
Midhurst TS DESN #2 (planned in-service date of 2004)	140	0.0	0.0	0.0	44.0	65.1	72.6	82.5	92.4	102.3	112.2	122.0	131.9
Midhurst TS DESN #1 (existing)	193.9	138.8	162.9	175.0	166.4	165.9	165.7	167.5	169.1	170.9	172.6	174.5	176.3
Stayner TS*	126.5	105.8	108.0	110.2	111.4	112.7	114.0	115.0	116.4	117.8	119.3	120.7	122.2
Waubaushene TS	109.9	118.2	120.4	121.6	123.8	125.1	126.3	127.5	128.8	130.0	131.3	132.6	133.9
Alliston TS #2	114.9	29.6	30.5	31.5	32.4	35.6	36.7	37.8	38.9	40.1	41.3	42.6	43.8
TOTAL:		***671.4***	***706.3***	***739.6***	***758.0***	***781.5***	***803.1***	***822.5***	***842.1***	***862.1***	***882.2***	***902.6***	***923.2***

Station LTR: Winter 10-day Limited Time Ratings
*Station load does not reflect the power factor correction afforded by the existing capacitors

The major load centre in Simcoe County exists around the city of Barrie. The load in the Barrie area is summer peaking and is supplied from Barrie TS and Midhurst TS. Load in the Alliston area is also summer peaking and is supplied from Alliston TS. All other load, particularly in the Collingwood area, is winter peaking and is supplied from Stayner TS, Meaford TS and Waubaushene TS. Overall, the total forecasted seasonal loads are greater in the winter for the period of study. Near the end of the study, the seasonal load growths become fairly similar due to a slight decline in the winter growth rates in the latter part of the study.

Due to equipment limitations, various transmission stations are either summer or winter critical[4]. Barrie TS and Midhurst TS are summer critical; Stayner TS and Meaford TS are winter critical; and Alliston TS and Waubaushene TS are both summer and winter critical.

Since the ampacity limitations for stations and transmission lines are generally lower in summer, as compared to winter, the Simcoe County area is in general summer critical. The one exception in this study was Stayner TS, which tended to have a more critical winter load due to the large winter tourist activity in the Collingwood and Blue Mountain (part of Grey County) areas which experiences voltage deficiencies under heavy load with certain contingencies.

[4] winter/summer critical means less available margin between loading and applicable equipment rating for a particular season

4. System Assumptions

Certain assumptions were made in order to assess the effects of different contingencies to verify the system capacity. The assumptions used in the study were:

1. A study period of 10 years, from 2004 to 2014, was used to assess the transmission requirements.

2. Peak loads were based on forecasts provided by the participating utilities. The forecasted loads were provided in MVA, with an assumed power factor of 0.92 for summer loads and 0.94 for winter loads.

3. Equipment continuous and limited time ratings were based on an ambient temperature of 30°C for summer and 10°C for winter with a wind speed of 4km/hour for both seasons.

4. The minimum voltage on the 230 kV transmission system under normal conditions is 220 kV, with a maximum allowable decline of 10% for a single element contingency. One exception to this is that the minimum acceptable voltage at Essa TS is 238 kV, which is consistent with the Independent Electricity Market Operator's (IMO) operating guidelines (SCO S-South, Table 4).

5. The minimum acceptable voltage on the 115 kV buses is 113 kV with a maximum allowable voltage decline of 10% for a single element contingency.

6. The study was conducted under the assumption that by 2006 additional voltage support would be provided by means of a 245 MVar capacitor bank on the 230 kV at Essa TS. The additional voltage support is needed in order to prevent excessive voltage decline in the event that one auto-transformer at Essa TS is out of service for maintenance and the companion auto-transformer is forced out of service. Hydro One will be installing the required capacitor by summer 2006.

5. Adequacy of Existing Facilities

This section reviews the adequacy of the existing 500 kV, 230 kV and 115 kV transmission facilities to supply the load in Simcoe County from step-down transformation facilities Alliston TS, Barrie TS, Essa TS, Meaford TS, Midhurst TS, Stayner TS and Waubaushene TS. It also reviews the transformation capacity at these load stations.

5.1. 500 kV Bulk Transmission System

The majority of electricity supply in Simcoe County is provided via the 500/230 kV auto-transformers located at Essa TS. The connection between the 500 and 230 kV systems via the two 750 MVA auto-transformers at Essa supplies the local area with adequate voltage support. The voltage on the 230 and 115 kV systems in this area is adequate under single contingency condition (one auto-transformer out of service); however, it does expose the area to a risk of unacceptable voltages if the remaining auto-transformer is unexpectedly forced out of service. Consequently, the periodic maintenance and sustainability of the auto-transformers and associated 500 and 230 kV equipment, becomes difficult to achieve. In addition, due to the load growth in the area, the two 750 MVA auto-transformers would be nearing capacity[5] by 2014.

During the study period, the voltage in the area was increasingly dependent on the full-time operation of the two 750 MVA auto-transformers at Essa TS. Thus, the study was run under the assumption that a planned 245 MVAR capacitor bank on the 230 kV bus at Essa TS would be in-service by the time any of the results from this study could be implemented. Nevertheless, even with this capacitor bank available by 2006, a second capacitor bank would be required by 2009 to support the voltage due to increased loading in the area. An additional 230 kV supply source (i.e., a third 500/230 auto-transformer) would be required to support the voltage in the local area by the end of the study period.

5.2. 230 kV Transmission System & Line Capability

Three double circuit 230 kV lines emanate out of Essa TS to supply power to step-down transformation stations in Simcoe County:

- Parry Sound TS and Waubaushene TS are supplied via two radial northward circuits (E26 and E27);
- Alliston TS is supplied via a double circuit line (E8V and E9V) running southwest towards Orangeville TS; and,
- Midhurst TS and several other transformer stations outside of the study area, are supplied via double circuit line (M6E and M7E) running northeast towards Minden TS.

The 230 kV circuits were all within continuous ratings throughout the 10-year study period for all load forecasts and contingency situations. Relief for these circuits is not anticipated prior to 2014.

[5] Auto-transformers nearing capacity means running the transformer continuously over 50% of its capacity under normal operating conditions, and over 95% of its capacity after the loss of a companion auto-transformer.

The 230/115 kV auto-transformers at Essa TS are nearing their capacity limits. Assuming no major element is changed on the 115 kV system in this area, these 115 MVA auto-transformers are sufficient to handle the existing load forecast until 2007. Auto-transformer T1 is the limiting element and will be loaded to 100% of its summer 10-day LTR in the event that its companion auto-transformer T2 is removed from service.

5.3. 115 kV Transmission Line Capability

Two 115 kV lines supply power to step-down transformation stations in Simcoe County:

- One single circuit 115 kV line from Essa TS to Stayner TS (S2E) and from Stayner TS to Owen Sound TS via Meaford TS (S2S); and,
- Two single circuit 115 kV lines from Essa TS to Barrie TS (E3B and B4B).

Under normal operating conditions, the Bruce (GS) supplies nearly half of the load at Stayner TS via the 115 kV circuit between Owen Sound TS and Stayner TS, through Meaford TS. This situation becomes particularly problematic during the contingency loss of the 115 kV circuit (S2E), which runs between Stayner TS and Essa TS. During this contingency, the voltage at Stayner TS drops below acceptable levels when Stayner TS is under heavily loaded conditions (winter peaks). Temporary measures have been in place in the form of a load rejection scheme[6] to address this problem.

The two 115 kV lines between Essa TS and Barrie TS (E3B and E4B) are also nearing capacity as the load at Barrie TS increases. This is particularly apparent on one half-kilometre section of circuit E3B near Essa TS. These lines will be sufficient to supply Barrie TS in its existing state, however, if station capacity is increased at Barrie TS, and/or a new connection is made to circuits E3B and E4B, these circuits will require upgrading.

5.4. Step Down Transformation Facilities

Capacity of step-down transformers posed a problem at several stations. Load forecasts for these stations throughout the study period are shown in Tables 1 and 2.

- Alliston TS, consisting of two 50/83 MVA transformers, has currently peaked beyond its summer 10-day LTR, and will be loaded beyond its winter 10-day LTR by 2004. This station has no additional capacity to supply the increasing load in the area. Distribution lines emanating out of the station have taken up all available road allowance space.

- Waubaushene TS is currently over its winter 10-day LTR, and will also be loaded beyond its summer 10-day LTR by 2005.

- Meaford TS will be over its winter 10-day LTR by 2006 and distribution lines emanating from the station are overloaded as of 2004. Due to the existing voltage issues at Stayner TS, building new distribution lines to Stayner to relieve Meaford TS or its distribution lines is not an

[6] load rejection scheme: a load rejection scheme disconnects pre-defined amounts of load to prevent equipment overloads and/or excessive voltage declines which jeopardize system security. The load rejection scheme is armed for activation under severe system conditions or when there are outages to key transmission facilities. Activation of the load rejection scheme occurs only if there is further deterioration of system conditions or there is a loss of another critical facility.

acceptable option. This problem can be addressed via an overall transmission solution that will address several transmission needs simultaneously.

- Barrie TS is currently over its summer 10-day LTR. To support the growing Barrie Hydro load, Hydro One is currently building a second DESN at Midhurst TS thus providing relief to Barrie TS by 2005.

- The load forecasts show that both the existing Midhurst TS DESN #1 and the new Midhurst TS DESN #2 (to be placed in service in December 2004) will be near capacity limits by 2014.

5.5. Needs Summary

A summary of the needs to be addressed via transmission and step-down transformation facilities as proposed in this study are shown in Figure 2.

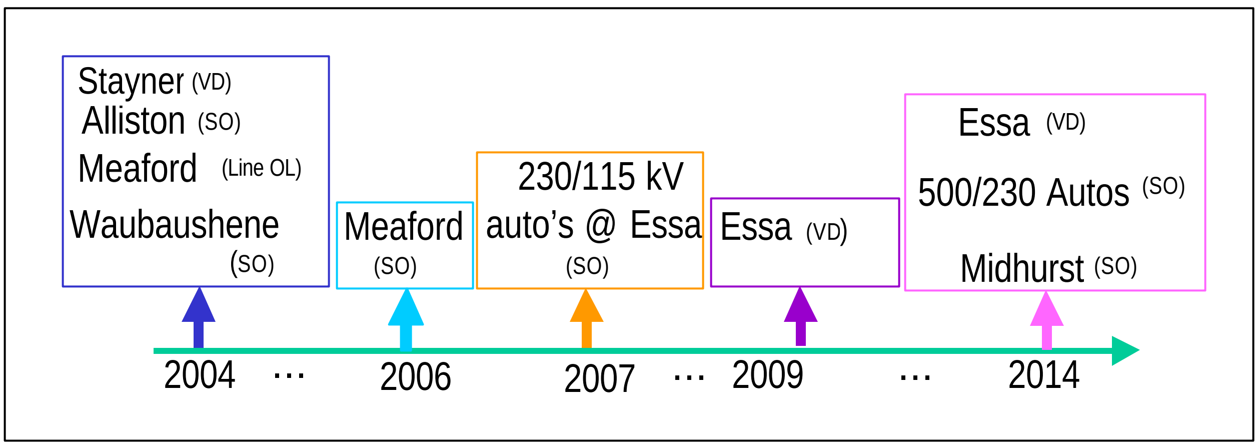


Figure 2: Summary of Needs 2004 – 2014

Legend:
VD= Voltage Deficiencies
SO= Station Overload
Line OL = Line Overload

6. Possible Options to Address Supply Capacity & Voltage Stability

This section outlines all possible options considered in the study in order to address the identified needs in Simcoe County. Table 4 itemizes the options that are rejected and those that are further analyzed. Detailed descriptions of all options are given in Appendix A.

Table 4: Summary of Considered Options

Option	**Description**	**Status**
"Do Nothing"	"Do Nothing"	Rejected
Relief for Stations North of Essa TS		
S1	Cascading Load Transfers to Stayner TS	Rejected in isolation – however, part of overall plans in Section 7
S2	Build a New 115 kV Circuit to Stayner TS and 2nd DESN at Stayner	Further analyzed
S3	Convert Stayner TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa TS	Further analyzed
S4	Upgrade the Existing 115 kV Circuit to a double 230 kV Circuit from Essa TS and build "Collingwood Area" TS (operated at both 115 kV and 230 kV)	Component of option S4 is further analyzed in option S3
Relief for Stations North of Essa TS – Stayner TS, Meaford TS & Waubaushene TS		
B1	2nd DESN at Barrie TS	Rejected
B2	Convert Barrie TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa TS	Rejected in isolation – however, part of overall plans in Section 7
230 kV and 115 kV System Capacity & Voltage Support		
E1	2nd 245 MVAR Capacitor Bank at Essa TS	Further analyzed
E2	3rd 750 MVA Auto-transformer at Essa TS	Further analyzed
E3	Build a 230 kV Double Circuit from Holland Marsh to Essa TS	Rejected
E4	Essa 230/115 kV Auto-transformers Upgraded to 250 MVA	Rejected in isolation – however, part of overall plans in Section 7
Relief for Stations South of Essa TS		
A1	Upgrade Alliston TS to 75/125 MVA	Further analyzed
A2	New DESN Near Alliston, 50/83 MVA	Further analyzed
I1	Innisfil TS Supplied from Holland Marsh Junction	Rejected
I2	Innisfil TS Supplied from E3B/E4B	Rejected
I3	Holland Marsh TS Supplied	Rejected
I4	Innisfil TS Supplied from Essa TS	Rejected

6.1. "Do Nothing"

The "Do Nothing" approach will aggravate the existing problems at Alliston TS, Waubaushene TS, Meaford TS and Stayner TS and accelerate issues with the auto-transformers at Essa TS.

Stayner TS currently experiences voltage deficiencies during winter peak conditions in the event of a single contingency (i.e. loss of S2E). For this reason a load rejection scheme was implemented at this station as a means of decreasing the risk of a voltage collapse. Stayner TS is also nearing voltage limitations on the high voltage bus during summer load peaks under a single contingency event, specifically the loss of S2E. The forecasted summer load is such that the voltage decline under this contingency is 9% by 2006, and greater than 10% of the pre-contingency voltage by 2007. If this voltage is allowed to continue its decline, it could cause a voltage collapse in the Collingwood area without greater reliance on load rejection schemes.

This alternative is not acceptable and is not considered further.

6.2. Relief for Stations North of Essa TS

Stayner TS, Meaford TS & Waubaushene TS

S1: ***Cascading Load Transfers to Stayner TS***
Load could be transferred from Waubaushene TS and cascaded down to Stayner TS via Midhurst TS. This would relieve the loading at Waubaushene TS and would be a reverse of load transfers originally made in the mid 1990s. Similarly, load from Meaford TS could also potentially be transferred to Stayner TS – originally transferred from Stayner TS. This option was considered in isolation but rejected, as it would only exacerbate existing problems at Stayner TS. However, it is utilized in combination with other options as part of the plans in Section 7.

S2: ***Build a New 115 kV Circuit to Stayner TS and 2nd DESN at Stayner***
The option improves voltage stability and reliability at Stayner TS by building an additional 27 km 115 kV circuit from Stayner TS to Essa TS alongside existing circuit S2E. This solution would also allow for building a second 50/83 MVA DESN at Stayner TS to accommodate the load transfers from Waubaushene TS and Meaford TS.

S3: ***Convert Stayner TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa TS***
A component of option S4 was considered. This consists of replacing 27 km of existing 115 kV circuit (S2E) with a double 230 kV circuit between Essa TS and Stayner TS. Option S3 also consists of converting Stayner TS from 115 kV to 230 kV, placing a 115 MVA, 230/115 kV auto-transformer at Stayner TS to maintain the electrical connection to Meaford TS, and upgrading the existing 50/83 MVA transformers to 75/125 MVA.

S4: ***Upgrade the Existing 115 kV Circuit to a double 230 kV Circuit from Essa TS and build "Collingwood Area" TS (operated at both 115 kV and 230 kV)***
This is the preferred system plan recommended in the 1991 ESR as stated previously in Section 2. At that time, high load growth was projected for the Collingwood area. This plan was considered as one of the options in this study as well. About 37 km of existing 115 kV circuit is replaced with a double 230 kV circuit between Essa TS and a new 230/44 kV DESN station to be built in the Collingwood area. One circuit would operate at 115 kV and the other at 230 kV. The new DESN would operate initially at both 115 kV and 230 kV. In addition to servicing the local Collingwood and Stayner load, load could be transferred from Waubaushene TS and Meaford TS as in option S1.

This option requires more line and station construction than options S2 or S3. It would require voltage relief at Stayner TS by 2014. Option S4 is a more costly option compared to S2 and S3 due to the additional 10 km of double 230 kV circuit and construction of an entirely new station, "Collingwood area" TS in Nottawa. Further, option S4 provides significantly more transformation connection capacity in the area than the load forecast justifies as the high load growth projected during the 1991 study has not yet fully materialized in the Collingwood area. Thus, a component of option S4 was considered and further analyzed in option S3.

Barrie TS

B1: ***2nd DESN at Barrie TS***
Capacity at Barrie TS is increased by installing a second 50/83 MVA DESN at the station. This option would require line upgrades to the limiting section(s) of circuit E3B. Increasing capacity at Barrie TS would strand capacity until such time as Midhurst TS would be at capacity (~2014) and not affect the immediate needs that exist elsewhere in the system. Thus, this option was considered and rejected for this study because it would not be required for at least 10 years in the future.

B2: ***Convert Barrie TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa TS***
Barrie TS is converted to 230 kV, 8.5 km 115 kV circuits E3B/E4B are converted to a double 230 kV circuit and the two step-down transformers at Barrie TS are upgraded to 75/125 MVA. This option would temporarily strand capacity at Barrie for the first 10 years, before being more efficiently utilized. This option does not address any of the immediate concerns in Simcoe County except that it would provide available capacity on the 115 kV system. Thus, this option was considered in isolation but rejected; however, it is utilized in combination with other options as part of the plans in Section 7.

6.3. 230 kV and 115 kV System Capacity & Voltage Support

E1: ***2nd 245 MVAR Capacitor Bank at Essa TS***
A second 245 MVAR capacitor bank on the 230 kV bus will be needed at Essa TS by 2009 to provide further voltage support.

E2: ***3rd 750 MVA Auto-transformer at Essa TS***
Additional 500/230 kV autotransformation capacity will be required by 2014. This option could be accelerated and used in place of E1 (*2nd 245 MVAR Capacitor Bank*) in 2009 to provide additional voltage support.

E3: ***Build a 230 kV Double Circuit from Holland Marsh to Essa TS***
Voltage support could be supplied via an additional 230 kV circuit connection to the 230 kV system near the Greater Toronto Area, specifically, supplied from Holland Marsh Junction, along B82V and B83V. This option was considered and rejected due to technical inferiority to option E2, combined with the relative cost of constructing two new 230 kV circuits to a third auto-transformer.

E4: ***Essa 230/115 kV Auto-transformers Upgraded to 250 MVA***
Capacity on the 115 kV system would be increased by upgrading Essa T1 and T2 230/115 kV auto-transformers from 115 MVA to 250 MVA. This option performed technically well for the 10-year period; however, in the longer term, the 115 kV system experiences more significant voltage

problems than those which exist today. Thus, this option was considered in isolation but rejected; however, it is utilized in combination with other options as part of the plans in Section 7.

6.4. Relief for Stations South of Essa TS

A1: ***Upgrade Alliston TS to 75/125 MVA***
Replace the two 50/83 MVA step-down transformers at Alliston TS with two 75/125 MVA transformers. This capacity would be sufficient to cover the expected load growth in the Alliston and Innisfil areas until 2022. The upgrade would require at least four station egress positions to make efficient use of the additional capacity. Existing distribution lines emanating out of the station have taken up all available road allowances. The additional distribution lines could potentially be brought out of the station underground; however, due to local issues with road allowances, these distribution lines would need to be underground for several kilometres which would present significant distribution costs.

A2: ***New DESN Near Alliston, 50/83 MVA***
A new 50/83 MVA DESN near Alliston TS would be built to supply load growth in the local area and in Innisfil. Two potential study areas for this DESN were evaluated – in the vicinity of Highway 89 and Adjala 2nd Line, and in the vicinity of County Road 15 and County Road 5. Both study areas would be acceptable from a technical performance perspective. The transmission costs for either station would be the same. As such, the deciding factor is the distribution costs associated with these two locations.

I1: ***Innisfil TS Supplied from Holland Marsh Junction***
This option consists of building a new step-down transformer station in the Municipality of Innisfil supplied via double circuit 230 kV lines emanating from Holland Marsh Junction in the south. This option would require a new high voltage capacitor bank located either at Holland Marsh Junction or at the new Innisfil TS. This option was considered for south Simcoe's immediate need and rejected because the Alliston area would still require further relief by 2010, and does not address any of the other immediate concerns of Simcoe County.

I2: ***Innisfil TS Supplied from E3B/E4B***
This option consists of a new transformer station built along the border of the Barrie and Innisfil Municipalities supplied via 115 kV circuits (continuation of E3B and E4B). This option would require upgrades to limiting sections of circuit E3B and would need to incorporate Option E4 or S3. Connection of these facilities would be limited to a 50/83 MVA DESN station. This option was considered for south Simcoe's immediate need and rejected because the Alliston area would still require further relief by 2010, and does not address any of the other immediate concerns of Simcoe County.

I3: ***Holland Marsh TS Supplied***
This option consists of a new 230/44 kV, 75/125 MVA transformer station built at Holland Marsh Junction. This option presents opportunities for supplying load in the south end of Innisfil, as well as load at all the identified locations where new communities may develop. This location would not benefit south Barrie load in the long term. The station required a high voltage capacitor bank on the 230 kV bus at Holland Marsh. This option was considered for south Simcoe's immediate need and rejected because the Alliston area would still require further relief by 2010, and does not address any of the other immediate concerns of Simcoe County.

I4: ***Innisfil TS Supplied from Essa TS***

Option I1 could be implemented supplying the new transformer station via double 230 kV circuits from Essa TS. This option was explored, and performed technically well, however there would be insufficient room along the right of way of circuits E3B and E4B in which to string two additional 230 kV conductors. This option was thus considered and rejected. In addition, this option was considered for south Simcoe's immediate need and rejected because the Alliston area would still require further relief by 2010, and does not address any of the other immediate concerns of Simcoe County.

7. Plans: Option Combinations

Those options not rejected as discussed in Section 6 were combined in Tables 5, 6 and 7 to address with the immediate problems in specific geographical areas.

7.1. Relief for Stations North of Essa TS

The needs in the North consist of:

- 230/115 kV auto-transformers capacity limits at Essa TS;
- Voltage deficiency at Stayner TS;
- Capacity limits at Waubaushene TS; and,
- Capacity limits at Meaford TS and voltage deficiency on Meaford TS distribution lines.

Table 5: Plans (Option Combinations) for North Simcoe County Needs

Plan	Option	Title	Need Addressed	Year in Service
NORTH 1	S3	Convert Stayner TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa; Include auto-transformer	• Capacity limits on 230/115 kV auto-transformers at Essa TS • Voltage deficiencies at Stayner TS • Creates capacity at Stayner	2007
	S1	Cascading Load Transfers to Stayner TS	• Off-load Waubaushene TS (already over capacity) • Off-load Meaford TS (nearing capacity) • Made possible by Option S3 – effectively increasing capacity at Stayner TS	2007
NORTH 2	S2	Build a New 115 kV Circuit to Stayner and 2nd DESN at Stayner	• Voltage deficiency at Stayner TS • Creates capacity at Stayner TS	2007
	S1	Cascading Load Transfers to Stayner TS	• Off-load Waubaushene TS (already over capacity) • Off-load Meaford TS (nearing capacity) • Made possible by Option S2 – effectively increasing capacity at Stayner TS	2007
	B2	Barrie TS Conversion to 230 kV, 75/125 MVA	• Capacity limits on 230/115 kV auto-transformers at Essa TS • Some impact on the South Simcoe area, but relatively small	2007
NORTH 3	S2	Build a New 115 kV Circuit to Stayner and 2nd DESN at Stayner	• Voltage at Stayner TS • Creates capacity at Stayner TS	2007
	S1	Cascading Load Transfers to Stayner TS	• Off-load Waubaushene TS (already over capacity) • Off-load Meaford TS (nearing capacity) • Made possible by Option S2 – effectively increasing capacity at Stayner TS	2007
	E4	Essa T1 and T2 Upgraded to 250 MVA	• Capacity limits on 230/115 kV auto-transformers at Essa TS	2007

Plans NORTH1, NORTH 2 and NORTH 3 met the needs for the northern Simcoe County area identified in this study and performed well from a technical perspective throughout the 10-year study period. Technical performance results of these plans are given in Appendix B.

7.2. Relief for Stations South of Essa TS

The needs in the South consist of:
- Capacity limits at Alliston TS;
- Insufficient connection capacity to accommodate expected load growth in Innisfil; and,
- Insufficient connection capacity to accommodate expected load growth in south Barrie.

Table 6: Plans (Options) for South Simcoe County

Plan	Option	Title	Need Addressed	Year In Service
SOUTH 1	A1	Upgrade Alliston to 75/125 MVA	• Capacity limits at Alliston TS • Load growth in Innisfil	2006
SOUTH 2	A2	New DESN Near Alliston, 50/83 MVA (2 potential locations)	• Capacity limits at Alliston TS • Load growth in Innisfil	2006

Both plans (options) met the needs for the southern Simcoe County area identified in this study and performed well from a technical perspective throughout the 10-year study period. Technical performance results of these plans are given in Appendix B.

7.3. 230 kV and 115 kV System Capacity & Voltage Support

There were also options to deal with the transmission system needs that currently exist in Simcoe County, or that are expected to arise during the 10-year period over which this study takes place. The transmission system needs consist of:
- Voltage support on the 230 and 115 kV systems by 2009; and,
- Need for additional 230 kV supply by 2014

Table 7: Options for 230 kV and 115 kV Transmission System

Option	Title	Need Addressed	Year In Service
E1	2nd 245 MVAR Capacitor Bank	• Voltage support on 230 and 115 kV systems by 2009	2009
E2	3rd 750 MVA Auto-transformer at Essa	• Voltage support on 230 and 115 kV systems by2009 • Need for additional 230 kV supply by 2014	2009 or 2014

8. Selection of Preferred Plan

8.1. Technical Evaluation

As stated in sections 7.1 and 7.2, all plans met or exceeded the needs addressed during the 10-year study period. These plans were further technically evaluated with respect to the long-term system planning requirements by assessing them for expected 2024 conditions. This method provides a snapshot of the long-term viability of each of the plans, and how each would perform under the increasing load growth that is expected in Simcoe County. Load forecasts as far out as 2024 were provided by the participants of this study. The outcome of this evaluation enables a selection of a preferred plan for each geographical area. A point system was used to rank the options based on their technical performance (refer to Table 8).

Table 8: Point System for Technical Performance Ranking

Points	***Description***	***Minimum Requirements***
1	Technical performance did not meet minimum requirements in 2024	One point is awarded under the following criteria : • Flows are greater than 100% OR • 115 kV voltages are less than 113 kV
3	Technical performance met minimum requirements in 2024	Three points are awarded under the following criteria: • May require additional facilities before 2024 OR • Flows are between 70-100 % of rating OR • 115 kV voltages are between 113 kV and 120 kV
5	Technical performance exceeded minimum requirements in 2024	Five points are awarded if all the following criteria are met: • No additional facilities are required before 2024 AND • Flows are less than 70 % of rating AND • 115 kV voltages are greater than or equal to 120 kV

A detailed comparison of the technical performance of all options can be seen in Appendix C. The scored points were summed to provide an indication of how the plans performed relative to each other and relative to the longer-term (2024) requirements. The final results are shown in Table 9 indicating the preferred solution considering the technical performance criteria.

Table 9: Final Results of Technical Performance Ranking of Plans

NORTH		
Plan	***Scored Points***	***Ranking***
NORTH 1	**46**	**1**
NORTH 2	42	2
NORTH3	40	3

SOUTH		
Plan	***Scored Points***	***Ranking***
SOUTH A1	20	2
SOUTH A2	**22**	**1**

8.2. Cost Comparison

The cost comparison between the different plans is shown in Table 10. These estimated costs are preliminary and used for the purpose of ranking.

Table 10: Cost Comparison of Options

NORTH PLANS	Costs
NORTH 1	$ 41M
NORTH 2	$ 57M
NORTH 3	$ 40M

SOUTH PLANS	Costs
SOUTH A1	$ 11M
SOUTH A2	$ 12M

Table 10 indicates that the cost of plans NORTH1 and NORTH 3 are comparable and both outrank the cost of plan NORTH 2. As plan NORTH 1 outranks NORTH 3 technically when evaluated with respect to the long-term system planning requirements as concluded in section 8.1 (Table 9), NORTH 1 is therefore the preferred plan in the north Simcoe County area.

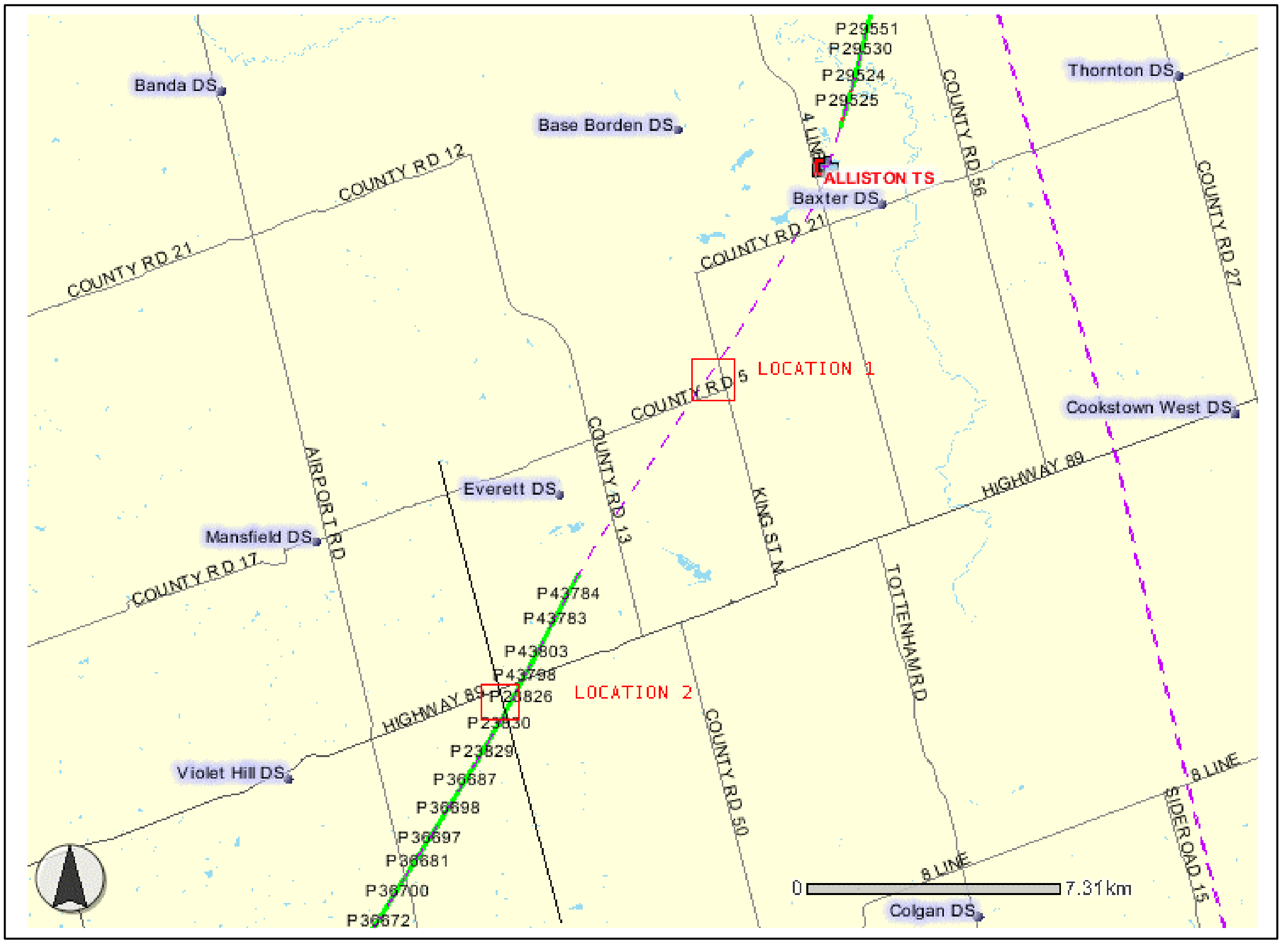
Table 10 also indicates that the cost of plans SOUTH A1 and SOUTH A2 are comparable. The costs associated with SOUTH A1 and A2 options were therefore further assessed in terms of the impact on the distribution costs that would be reflected on the customers in the area. These distribution costs are shown in Table 11.

Table 11: Distribution Costs for SOUTH A1 and SOUTH A2

Plan	Description	Relative Distribution Cost
South A1	Alliston – upgrade to 75/125 DESN	$6.0M
South A2	New 50/83 DESN west of Alliston adjacent to the right of way (in the vicinity of County Rd 15 & County Rd 5)	$0.0M

The least cost plan is SOUTH A2 as shown in Table 11. This is due to its proximity to the growing communities, to the better use of existing distribution facilities and to the accessibility for new distribution lines. SOUTH A2 improves reliability of south Simcoe supply and avoids extensive new distribution costs. It is noted that a second study location for a new 50/83 DESN was considered west of Alliston adjacent to the right of way (E9V/E9V) in the vicinity of Hwy 89 and Adjala 2nd Line, and the relative distribution cost was of $3.0M.

Conclusively, plan SOUTH A2 is both technically and economically superior to SOUTH A1 and is therefore the preferred plan in the south Simcoe County area.



Map 2: Location of Existing Alliston TS and Potential Study Area for Plan SOUTH A2

9. Discussion

North

NORTH 1 is the preferred plan in northern Simcoe County. NORTH 1 plan performed consistently well under all relevant contingencies for the 10-year period beyond 2014. The contingencies considered can be seen in Appendix C along with the results for each plan. NORTH 1 displayed voltage stability in the Stayner area, without any additional voltage support beyond a second high voltage capacitor on the Essa 230 kV bus placed in service for summer 2009. Waubaushene TS reaches capacity again in 2022, but could be deferred until 2024 by transferring approximately 3 MVA of load to Stayner TS in 2022. Meaford TS also reaches capacity again by 2024. Voltages at Barrie TS were acceptable and the station loading was within the limits of the existing transformers until 2022, assuming the use of the low voltage capacitor bank. Beyond 2022, additional capacity would be required to support Barrie TS and satisfy the long-term electrical capacity requirements in the southern Simcoe County area.

The NORTH 2 plan performed well in the Barrie area; however, there is some concern that capacity would be stranded at Barrie TS until 2014 when it may become necessary to transfer Midhurst TS load to Barrie TS. If load were transferred from Midhurst TS to Barrie TS in order to prevent overloading Midhurst TS transformers, the incremental load transfer could occur until the upgraded Barrie TS transformers reach capacity in 2023 (combined Midhurst overflow plus Barrie TS load forecast). At the same time, Stayner TS experiences low voltages due to the loading on the 115 kV circuits. Also under consideration was the poor voltage performance in the Stayner area in the event that T3 and the proposed T5 auto-transformers at Essa TS were out of service (existing T4 auto-transformer is limiting). In order to maintain acceptable voltages in the Stayner area, low voltage capacitors would be required on the second Stayner low voltage bus. Under this option, action would be required in the Stayner TS, Midhurst TS and Barrie TS areas before 2024, unlike NORTH 1 where action would only be required in the Midhurst and possibly Barrie areas before 2024. In addition, to implement this plan a wider right-of-way would be required from that which currently exits to build the second 115 kV circuit from Essa TS to Stayner TS.

The NORTH 3 plan performed moderately well under technical consideration. In order to implement this a wider right-of-way would be required from that which currently exists to build the second 115 kV circuit from Essa TS to Stayner TS. There were no technical performance issues with this plan provided a low voltage capacitor is installed on the low voltage bus of the new Stayner DESN. However, other options performed technically better.

South

SOUTH A2 is the preferred plan in northern Simcoe County. SOUTH A2 plan performed well under technical consideration. The new 50/83 DESN station near Alliston TS was sufficient for the load growth in the Alliston area, and the overflow from Barrie TS (Innisfil load) when Barrie TS reaches capacity limits in 2022. SOUTH A2 also presents the opportunity of cascading transfers between Midhurst TS and Alliston TS, via Barrie TS once Midhurst TS reaches capacity around 2014. SOUTH A2 is closer to the growing communities, makes better use of existing distribution facilities and to the accessibility for new distribution lines. SOUTH A2 improves reliability of south Simcoe supply and avoids extensive new distribution costs.

SOUTH A1 plan performed moderately well under technical consideration. Upgrading to 75/125 MVA transformers at the existing Alliston TS would be sufficient for the load growth around Alliston until 2022, at which point it reaches 99% of its 10-day LTR. Compared to plan SOUTH A2, this plan incurs higher line losses due to longer distances to the load centres in general. Further, the distribution lines emanating Alliston TS would need to be underground for several kilometres due to local issues with road allowances. This would present significant distribution costs reflected on the customers in the area.

10. Conclusions

The following conclusions can be reached from the analysis performed for this study.

- Alliston TS is currently loaded beyond its capacity limit. The earliest possible option to relieve this problem cannot be implemented until 2006.
- Waubaushene TS is currently loaded beyond its capacity limit. The earliest possible option to relieve this problem cannot be implemented until 2007.
- Meaford TS is nearing capacity, expected to be loaded beyond its capacity limit in 2006. Distribution lines emanating from this station are currently overloaded and experiencing voltage deficiencies. The earliest possible option to relieve these problems cannot be implemented until 2007.
- Stayner TS is nearing IMO prescribed limitations in voltage decline. The voltage decline under a single contingency is expected to be greater than 10% by 2007. The earliest possible option to deal with this problem can be implemented by 2007.
- The 230/115 kV auto-transformers at Essa TS are expected to be loaded to 100% of their capacity by 2007. The earliest possible option to resolve this problem can be implemented by 2007.
- The preferred plans to meet all of these needs are:
  1. NORTH 1: Convert Stayner TS to 230 kV, 75/125 MVA fed via a new 230 kV double circuit from Essa TS and cascade load transfers to Stayner TS.
  2. SOUTH A2: New DESN Near Alliston, 50/83 MVA in the vicinity of County Road 15 and County Road 5.

11. Recommendations

Several recommendations can be drawn from this study to address the current system deficiencies and provide system capacity to meet forecasted load growth. These recommendations are:

1. Hydro One Networks Inc. to initiate the approval processes required for the conversion of Stayner TS from 115 kV to 230 kV, and the upgrading of the existing 115 kV transmission line from Stayner TS to Essa TS (circuit S2E) to a double circuit 230 kV transmission line.

2. Hydro One Networks Inc. to commence the preliminary engineering and consultation with the distribution customers, and to initiate the approval processes on the construction of a new transformer station, near Alliston.

3. Hydro One Networks Inc. to review the study in 2007 with updated Simcoe County load forecasts for the potential need of a 2nd 230 kV, 245 MVAR capacitor bank and a 3rd 500/230 kV, 750 MVA auto-transformer both at Essa TS for implementation in 2009 and 2014, respectively.

4. The local electric utilities to continue to monitor load growth in the southern Simcoe County area and to review options for long-term growth based on location of new developments and load forecasts.

5. The local electric utilities in the northern Simcoe County area (specifically in the Barrie area) to continue to monitor load growth and the loading of Midhurst TS.

Appendices

Appendix A: Description of Options

Relief for Stayner, Meaford & Waubaushene

S1: ***Cascading Load Transfers to Stayner TS***

Load could be transferred from Waubaushene TS to and cascaded down to Stayner TS via Midhurst TS. This would relieve the loading at Waubaushene TS and Meaford TS and would be a reverse of load transfers originally made in the mid 1990s to defer the need for additional capacity for load growth in the Stayner TS area. Similarly, load from Meaford could also potentially be transferred to Stayner TS – originally transferred from Stayner TS for the same transmission expansion deferral. However, there is currently insufficient capacity at Stayner TS to account for these load transfers and the voltage at Stayner is such that it would prohibit load transfers, especially those that are winter peaking. At the same time, there is insufficient capacity on the 115 kV system to supply these load transfers. Any load transfers onto the 115 kV system at Stayner TS would overload the 230/115 kV auto-transformers at Essa.

S2: ***Build a New 115 kV Circuit to Stayner and 2nd DESN at Stayner***

Improving voltage stability and reliability at Stayner could be accomplished by building an additional 27 km 115 kV circuit alongside S2E, Stayner by Essa. This solution would also allow for building a second 50/83 MVA DESN at Stayner TS to accommodate the load transfers from Waubaushene TS and Meaford TS. This solution would require providing additional capacity on the 115 kV system, which could be accomplished via options B2 (*Barrie TS Conversion to 230 kV, 75/125 MVA)* or E5 (*Essa T1 and T2 Upgraded to 250 MVA)*. By selecting option B2, a new diameter with three new 230 kV breakers at Essa TS is required. In order to implement this solution, a wider right-of-way would be required from that which currently exists. This caused the option to be more costly than other alternatives investigated in this study. There were no technical performance issues with this option provided a low voltage capacitor is installed on the low voltage bus of the new DESN. However, other options performed technically better.

S3: ***Convert Stayner TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa***

A third option in the Stayner TS area was to convert Stayner TS to 230 kV, and convert S2E to a double 27 km 230 kV circuit. This option also consists of placing a 115 MVA, 230/115 kV auto-transformer at Stayner TS to maintain the electrical connection to Meaford TS. A new diameter with three new 230 kV breakers at Essa TS is required for this option. Converting Stayner TS to 230 kV performed well technically. No voltage issues were encountered at Stayner TS, Meaford TS, or along the S2E 230 kV circuit corridor during the study period. The capacity at Stayner was increased enough to provide for a 13.7 MVA load transfer from Meaford TS and a 25.9 MVA load transfer from Waubaushene TS as well as for load growth in the Stayner TS area for the next 20 years. Under these load transfers, Meaford TS again reaches capacity in the winter of 2024. Waubaushene TS reaches capacity again in 2022, however the additional 2.65 MVA of load could be transferred to Stayner TS to defer changes to Waubaushene TS for two more years (2024). This option does not have the same real estate issues as S2 (*Build a New 115 kV Circuit to Stayner and 2nd DESN at Stayner*) since the existing line would be required to be rebuilt on a single tower. This option would experience some difficulties in construction, as outage windows for S2E would be limited to early spring and late fall, to maintain appropriate voltages at Stayner TS. Another advantage to this option is that it allows for improved voltage stability in the event that wind generation develops in the Meaford/Stayner TS areas. Additional capacity on the 115 kV system (i.e. upgrades to the existing 230/115 kV auto-transformers at Essa TS) would not be required.

S4: ***Upgrade the Existing 115 kV Circuit to a double 230 kV Circuit from Essa TS and build "Collingwood Area" TS (operated at both 115 kV and 230 kV)***
Under this option, about 37 km of existing 115 kV circuit is replaced with a double 230 kV circuit between Essa TS and the new "Collingwood Area" TS. Operate one circuit at 115 kV and the other at 230 kV. A new diameter with three new 230 kV breakers at Essa TS is required for this option. The new 230/44 kV DESN near Collingwood would operate initially at both 115 kV and 230 kV. Besides servicing the local Collingwood and Stayner loads, load could be transferred from Waubaushene TS and Meaford TS as in option S1. Additional capacity on the 115 kV system (i.e. upgrades to the existing 230/115 kV auto-transformers at Essa TS) would not be required within the study period, however, this option would require voltage relief at Stayner TS by 2014. Further, this option requires more line and station construction than options S2 or S3 and provides significantly more connection capacity in the area than the load forecast justifies.

Relief for Barrie TS

B1: ***2nd DESN at Barrie TS***
Increase capacity at Barrie TS by installing a second DESN at the station. This option would require line upgrades to limiting section(s) of E3B, and would need to be incorporated with increasing capacity on the 115 kV system as discussed in Option E4. Increasing capacity at Barrie TS by the amount of an additional 50/83 MVA DESN would strand capacity until such time as Midhurst TS would be at capacity (~2014) and not affect the immediate needs that exist elsewhere in the system, namely in the Stayner, Meaford, Waubaushene and Alliston areas. Even if this option were selected, further investments would be required to address these other immediate issues.

B2: ***Barrie TS Conversion to 230 kV, 75/125 MVA***
Converting Barrie TS to 230 kV and converting the two step-down transformers at Barrie TS to 75/125 MVA would be more than sufficient to cover off the load growth expected in the Innisfil area for the entire study period. A new diameter with three new 230 kV breakers at Essa TS is required for this option. However, as in option B1 (*2nd DESN at Barrie TS*), this option would temporarily strand capacity at Barrie the first 10 years, before being more efficiently utilized. At the same time, it would not address any of the immediate concerns in Simcoe County except that it would provide available capacity on the 115 kV system to effectively allow the auto-transformers at Essa TS to support load transfers from Waubaushene and Meaford to Stayner.

230 and 115 kV System Capacity & Voltage Support

E1: ***2nd 245 MVAR Capacitor Bank***
By about 2009, further voltage support will be required to support the increasing load growth on the 230/115 kV systems. This could be supplied via a second 245 MVAR capacitor bank on the 230 kV bus at Essa.

E2: ***3rd 750 MVA Auto-transformer at Essa***
By 2014, more auto-transformation capacity will be required. Under contingency of the loss of the companion auto-transformer, the remaining auto is loaded at 82% for T3 and 90% for T4. This option could be accelerated and used in place of E2 (*2nd 245 MVAR Capacitor Bank*) in 2009 to provide additional voltage support to prevent a voltage collapse in the event that one auto-transformer is out of service for maintenance and the companion auto-transformer is forced from service on contingency.

However, the auto-transformer becomes necessary by 2014, as a capacitor is insufficient to provide the necessary voltage support.

E3: ***230 kV Double Circuit from Holland Marsh Junction to Essa TS***
Voltage support could be supplied via an additional 230 kV circuit connection to the 230 kV system near the Greater Toronto Area, specifically, supplied from Holland Marsh Junction, along B82V and B83V. Although this solution provides some voltage support, it does not provide sufficient support by 2014 to maintain acceptable voltage levels on the Essa 230 kV system in the event of a contingency. This option was investigated, however proved to be technically inferior to E2. The cost of constructing two new 230 kV circuits to a third auto-transformer also needs to be considered.

E4: ***Essa T1 and T2 Upgraded to 250 MVA***
Capacity on the 115 kV system would be increased by upgrading Essa T1 and T2, (230/115 kV auto-transformers) from 115 MVA to 250 MVA. This option performed technically well for the 10-year period to 2014. However, in the long term, the 115 kV system experiences worse voltage issues than those which exist today. This option would not provide long term voltage stability for the loads on the 115 kV system, without additional reactive support on the 115 kV system.

Relief for Alliston TS and growing load in Innisfil

A1: ***Upgrade Alliston to 75/125 MVA***
Replace the two 50/83 MVA step-down transformers at Alliston TS with two 75/125 MVA transformers. This capacity would be sufficient to cover the expected load growth in the Alliston and Innisfil areas until 2022. Land is available at Alliston, and environmental approvals would not be required to make these changes. Upgrades to Alliston TS would however present some difficulty in moving power out of the station. An upgrade from 50/83 to 75/125 MVA would require at least 4 feeder positions to make efficient use of the additional capacity. Additional feeders could potentially be brought out of the station underground, however due to local issues with road allowances, these feeders would need to be underground for several kilometres which would present significant distribution costs.

A2: ***New DESN Near Alliston, 50/83 MVA***
Building a new 50/83 MVA DESN near Alliston TS to supply load growth in the local area and in Innisfil. Two potential locations for this DESN were evaluated – in the vicinity of Adjala 2nd Line & Highway 89 and in the vicinity of County Road 5 & County Road 15. The first location presents significant feeder construction while the second location makes use of existing distribution facilities and to the accessibility for new distribution lines. Furthermore, the second location is closer to the load centres. Both locations would be acceptable from a technical performance perspective.

I1: ***Innisfil TS Supplied from Holland Marsh Junction***
This option consists of building a new step-down transformer station in the Municipality of Innisfil supplied via double circuit 230 kV lines emanating from Holland Marsh Junction in the south. This option would require a new HV capacitor bank located either at Holland Marsh Junction or at the new Innisfil TS. There were two locations identified for this option: K10SB crossing of County Road 88 and K10SB crossing of Concession Road 6. Both locations performed technically the similar and differ only in cost of line construction. Concession Road 6 is south of Bradford, and would be advantageous for any new communities in this area. County Road 88 is more central to Innisfil and would meet growing demands in Innisfil, in addition to new community developments either south or west.

I2: ***Innisfil TS Supplied from E3B/E4B***

This option consists of a new transformer station built along the border of the Barrie and Innisfil Municipalities supplied via 115 kV circuits, continuation of E3B and E4B. The station would be located at the K10SB crossing of Lockhart Road. This option would require upgrades to limiting sections of E3B and would need to incorporate Option E5 (*Essa T1 and T2 Upgraded to 250 MVA*) or S3 (*Convert Stayner TS to 230 kV, 75/125 MVA Fed Via a New 230 kV Double Circuit from Essa*). Connection of these facilities would be limited to a 50/83 MVA DESN station.

I3: ***Holland Marsh TS Supplied***

This option consists of a new 230/44 kV, 75/125 MVA transformer station built at Holland Marsh Junction. This option presents opportunities for supplying load in the south end of Innisfil, as well as load at all the identified locations where new communities may develop. This location would not benefit south Barrie load in the long term. Technical performance of this option was consistent with option I1 (*Innisfil TS Supplied from Holland Marsh).* The station required a high voltage capacitor bank on the 230 kV bus at Holland Marsh, which is also consistent with the performance of I1.

I4: ***Innisfil TS Supplied from Essa***

Option I1 could be implemented supplying the new transformer station via double 230 kV circuits from Essa TS. This option was explored, and performed technically well, however there would be insufficient room along the right of way of E3B and E4B in which to string two additional 230 kV conductors. This option was thus considered and rejected.

Appendix B: Results of North & South Alternatives technical performance 2004 to 2014.

Appendix B is a contingency analysis of the plans outlined in Section 7: Plans: Option Combinations. This analysis indicates that plans NORTH 1, NORTH 2, NORTH 3, SOUTH A1 and SOUTH A2 perform technically well and satisfy their respective needs throughout the study period. Included in this appendix is the contingency analysis for the preferred system plan in the 1991 ESR. The analysis highlights that this system plan violates planning criteria by year 2014.

South A1: Upgrade Alliston to 75/125 MVA

	Loss of Barrie T1	Loss of Barrie T2	Loss of Alliston T3	Loss of Alliston T5	Loss of E3B			Loss of E4B			Loss of E8V						Loss of E9V					
	Barrie T2	Barrie T1	Alliston T5	Alliston T3	E4B	Barrie hv kv	Barrie lv kv	E3B	Barrie hv kv	Barrie lv kv	E9 - ExA	E9 - OxA	E8 - OxA	Essa kV	Al. Lv kv	Al. Hv kv	E8 ExA	E8 - OxA	E9 - OxA	Essa kV	Al. Lv kv	Al. Hv kv
2004	111%	110%	58%	58%	60%	122.9	46.2	85%	122.2	46.5	26%	13%	16%	249.3	46.1	236.2	28%	10%	11%	249.0	46.4	238.7
2005	86%	87%	62%	62%	47%	127.7	46.2	65%	127.2	46.7	26%	12%	17%	249.0	46.6	235.7	28%	10%	11%	248.8	46.2	238.3
2006	80%	80%	62%	62%	44%	124.8	46.0	61%	124.4	46.5	26%	12%	17%	248.6	46.5	235.4	28%	10%	11%	248.4	46.1	238.1
2007	84%	84%	64%	64%	46%	124.4	46.3	64%	123.8	46.1	26%	12%	18%	248.2	46.3	234.9	28%	10%	11%	247.9	46.6	237.7
2008	89%	89%	66%	66%	49%	123.7	46.4	68%	123.2	46.2	26%	11%	18%	247.6	46.1	234.2	28%	9%	10%	247.4	46.4	237.3
2009	90%	89%	69%	69%	49%	123.5	46.3	68%	122.9	46.0	26%	11%	19%	247.3	46.5	233.8	28%	9%	10%	247.0	46.2	236.9
2010	91%	90%	71%	71%	49%	123.2	46.1	70%	122.7	46.5	26%	11%	19%	246.8	46.4	233.3	28%	9%	10%	246.6	46.1	236.5
2011	91%	91%	73%	73%	50%	122.9	46.0	70%	122.4	46.4	26%	11%	20%	246.5	46.2	232.7	28%	9%	10%	246.2	46.5	236.1
2012	90%	89%	73%	73%	49%	125.6	46.5	68%	125.1	46.3	30%	16%	20%	251.8	46.3	235.1	32%	13%	14%	251.5	46.6	238.5
2013	91%	90%	75%	75%	49%	125.3	46.3	70%	124.8	46.1	30%	14%	21%	251.3	46.1	234.5	32%	13%	14%	251.0	46.4	238.0
2014	91%	91%	78%	78%	50%	125.0	46.2	70%	124.4	46.6	30%	14%	21%	250.8	46.5	234.0	32%	12%	13%	250.5	46.2	237.5

- % values are a percentage of applicable equipment ratings
- voltages in kV

South A2: New 50/83 TS Near Alliston																						
	Loss of Barrie T1	Loss of Barrie T2	Loss of Alliston T3	Loss of Alliston T5	Loss of E3B			Loss of E4B			Loss of E8V						Loss of E9V					
	Barrie T2	Barrie T1	Alliston T5	Alliston T3	E4B	Barrie hv kv	Barrie lv kv	E3B	Barrie hv kv	Barrie lv kv	E9 - ExA	E9 - OxA	E8 - OxA	Essa kV	Al. Lv kv	Al. Hv kv	E8 - ExA	E8 - OxA	E9 - OxA	Essa kV	Al. Lv kv	Al. Hv kv
2004	112%	112%	43%	43%	62%	121.7	46.3	86%	121.0	46.5	30%	16%	13%	247.1	46.5	233.3	31%	13%	9%	246.9	46.1	235.6
2005	89%	89%	45%	45%	49%	123.3	46.3	67%	122.7	46.0	30%	16%	14%	246.8	46.3	232.8	32%	13%	9%	246.6	46.6	235.2
2006	79%	79%	45%	45%	44%	126.6	46.1	60%	126.3	46.6	34%	20%	14%	252.7	46.1	235.7	37%	18%	9%	252.5	46.3	238.2
2007	83%	82%	46%	46%	45%	126.2	46.4	63%	125.6	46.2	34%	19%	14%	252.0	46.5	235.2	36%	18%	9%	251.8	46.1	237.7
2008	88%	88%	48%	48%	48%	125.5	46.6	67%	125.0	46.3	34%	19%	16%	251.5	46.3	234.7	36%	17%	10%	251.3	46.5	237.2
2009	89%	88%	49%	49%	48%	125.2	46.4	67%	124.6	46.1	33%	19%	17%	251.0	46.2	234.2	36%	17%	10%	250.8	46.4	236.8
2010	89%	89%	50%	50%	49%	124.9	46.2	68%	124.4	46.7	34%	19%	17%	250.6	46.0	233.6	36%	17%	10%	250.3	46.3	236.4
2011	90%	90%	52%	52%	49%	124.6	46.1	68%	124.1	46.5	34%	18%	18%	250.1	46.5	233.2	36%	17%	11%	249.9	46.2	236.0
2012	91%	90%	53%	53%	49%	124.4	46.6	70%	123.7	46.3	33%	18%	18%	249.6	46.3	232.6	36%	16%	11%	249.4	46.0	235.6
2013	92%	91%	55%	55%	50%	124.0	46.4	70%	123.4	46.1	33%	18%	19%	249.1	46.2	232.0	36%	16%	11%	248.8	46.5	235.1
2014	92%	92%	56%	56%	50%	123.6	46.2	71%	123.1	46.6	33%	17%	19%	248.6	46.6	231.5	36%	16%	12%	248.3	46.3	234.6

- % values are a percentage of applicable equipment ratings
- voltages in kV

North 1: Stayner/S2E conversion to 230 kV (double cct)

	Loss of Stayner T3		Loss of Stayner T4			Loss of Meaford T1		Loss of Waubaushene T5		Loss of S2E						Loss of S3E (New 230kV)					
	T4	Stayner lv kv	T3	Stay. T5 hv kv	Stay. T5 2nd-v kv	T2	Meaford lv kv	T6	Waub. Lv kv	S3E	S2S1 (MxS)	Stayner lv kv	Stayner hv kv	S3E hv kv (@ Stay)	S2S2 (OxM)	S2E	S2E hv kv	S2S1 (MxS)	Stayner lv kv	Stayner auto 2nd kv	S2S2 (OxM)
2004	26%	47.0	28%	248.2	123.1	23%	46.3	37%	47.0	12%	30%	46.3	237.7	246.6	34%	15%	245.0	27%	46.0	121.7	32%
2005	26%	46.9	28%	247.9	122.9	25%	46.1	37%	47.0	12%	30%	46.2	237.1	246.2	35%	15%	244.8	28%	46.6	121.5	33%
2006	26%	46.8	29%	247.4	122.7	28%	46.4	38%	46.8	13%	30%	46.0	236.3	245.8	36%	16%	244.3	27%	46.4	121.3	33%
2007	25%	46.7	28%	246.7	122.4	31%	46.2	36%	46.7	13%	30%	46.5	235.9	245.3	37%	16%	243.7	27%	46.2	121.0	34%
2008	26%	47.0	28%	246.2	122.1	33%	46.0	36%	47.1	13%	30%	46.3	234.8	244.7	38%	16%	243.2	27%	46.6	120.7	35%
2009	26%	46.9	29%	245.7	121.9	33%	46.4	37%	47.0	13%	30%	46.1	234.3	244.2	39%	17%	242.7	28%	46.5	120.5	35%
2010	26%	46.8	29%	245.3	121.7	34%	46.3	37%	46.8	15%	31%	46.6	234.2	243.9	39%	17%	242.1	28%	46.2	120.2	36%
2011	26%	46.7	29%	244.7	121.4	34%	46.3	36%	46.8	15%	31%	46.5	233.6	243.5	41%	17%	241.7	28%	46.1	120.0	36%
2012	27%	46.8	29%	248.2	123.0	35%	46.1	40%	46.7	18%	31%	46.2	227.2	246.6	42%	24%	244.0	28%	46.3	121.1	36%
2013	28%	46.7	30%	247.4	122.6	36%	46.0	40%	47.1	18%	32%	46.7	226.9	246.0	42%	24%	243.4	28%	46.1	120.8	36%
2014	28%	47.1	31%	246.8	122.3	36%	46.4	40%	46.9	19%	32%	46.5	226.1	245.4	43%	24%	242.8	28%	46.6	120.5	37%

	Loss of S2S1 (MxS)			Loss of S2S2 (OxM)				Loss of E26 (WxE)			Loss of E27 (WxE)		
	S2S2 (OxM)	Meaford hv kv	Meaford lv kv	S2S1 (MxS)	Meaford hv kv	Meaford lv kv	Stayner lv kv	E27	Waub. Hv kv	Waub. Lv kv	E26	Waub. Hv kv	Waub. Lv kv
2004	9%	122.8	46.8	10%	121.0	46.1	46.7	20%	246.0	46.4	20%	246.0	46.4
2005	10%	122.6	46.7	11%	120.6	46.5	46.6	21%	245.6	46.3	20%	245.6	46.3
2006	11%	122.2	46.5	12%	120.0	46.2	46.5	21%	245.1	46.1	21%	245.1	46.1
2007	12%	122.0	46.3	13%	119.6	46.0	47.0	21%	244.5	46.4	21%	244.5	46.4
2008	13%	121.7	46.2	14%	119.0	46.2	46.8	21%	243.9	46.3	21%	243.9	46.3
2009	13%	121.6	46.1	14%	118.7	46.1	46.7	22%	243.4	46.1	21%	243.4	46.1
2010	13%	121.5	46.1	15%	118.4	46.0	46.5	22%	242.9	46.5	22%	242.9	46.5
2011	13%	121.5	46.6	15%	118.1	46.4	47.0	22%	242.4	46.4	22%	242.4	46.4
2012	13%	121.8	46.2	15%	120.0	46.0	46.1	22%	247.4	46.3	22%	247.4	46.3
2013	14%	121.7	46.1	15%	119.7	46.5	46.5	22%	246.8	46.1	22%	246.8	46.1
2014	14%	121.6	46.0	15%	119.3	46.3	46.4	23%	246.2	46.5	22%	246.2	46.5

- % values are a percentage of applicable equipment ratings
- voltages in kV

North 2: New 115 kV Stayner x Essa; Barrie conversion to 230 kV; new DESN @ Stayner																						
	Loss of Stayner T3			Loss of Stayner T1			Loss of Meaford T1		Loss of Waubaushene T5		Loss of S2E						Loss of S3E (New 115kV)					
	T4	Stayner lv kv	Stayner hv kv	T2	Stayner lv kv	Stayner hv kv	T2	Meaford lv kv	T6	Waub. Lv kv	S3E	S2S1 (MxS)	Stayner lv kv	Stayner hv kv	Stayner2 lv kv	S2S2 (OxM)	S2E	Stayner 2 lv kv	S2S1 (MxS)	Stayner lv kv	Stayner hv kv	S2S2 (OxM)
2004	58%	46.4	124.5	50%	46.5	122.2	23%	46.8	35%	47.1	26%	38%	46.3	122.8	46.1	41%	26%	46.1	36%	46.4	121.7	42%
2005	59%	47.1	124.5	51%	46.3	121.9	25%	46.0	35%	46.9	26%	38%	46.1	122.5	46.5	42%	27%	46.0	36%	46.2	121.3	43%
2006	59%	47.0	124.1	52%	46.1	121.6	28%	46.3	36%	46.8	27%	38%	46.0	122.1	46.3	43%	28%	46.4	36%	46.0	120.9	44%
2007	50%	46.9	124.1	52%	46.4	122.3	30%	46.4	41%	46.9	30%	37%	46.4	122.5	46.2	43%	33%	46.5	35%	46.1	120.8	44%
2008	51%	46.7	123.6	53%	46.2	121.9	33%	46.1	41%	46.8	31%	38%	46.2	122.0	46.0	45%	34%	46.4	36%	46.6	120.4	45%
2009	51%	46.5	123.3	53%	46.1	121.6	33%	46.0	39%	46.7	31%	38%	46.1	121.7	46.4	45%	34%	46.2	36%	46.4	120.0	45%
2010	51%	47.1	123.1	54%	46.0	121.2	33%	46.5	39%	47.1	32%	38%	46.6	121.4	46.3	46%	35%	46.6	36%	46.3	119.7	46%
2011	51%	46.9	122.7	54%	46.3	120.8	34%	46.3	39%	46.9	32%	39%	46.5	121.1	46.2	46%	35%	46.4	37%	46.0	119.3	46%
2012	52%	46.8	122.4	55%	46.1	120.4	35%	46.2	40%	46.8	33%	39%	46.3	120.7	46.0	47%	35%	46.3	37%	46.6	119.1	47%
2013	52%	46.6	122.0	55%	46.0	120.2	36%	46.1	38%	46.7	33%	39%	46.1	120.3	46.4	47%	36%	46.1	37%	46.4	118.6	48%
2014	53%	46.4	121.6	56%	46.3	119.8	36%	46.0	39%	47.0	33%	40%	46.7	120.1	46.4	48%	37%	46.4	38%	46.2	118.2	48%

	Loss of S2S1 (MxS)			Loss of S2S2 (OxM)				Loss of E26 (WxE)			Loss of E27 (WxE)		
	S2S2 (OxM)	Meaford hv kv	Meaford lv kv	S2S1 (MxS)	Meaford hv kv	Meaford lv kv	Stayner lv kv	E27	Waub. Hv kv	Waub. Lv kv	E26	Waub. Hv kv	Waub. Lv kv
2004	9%	121.8	46.4	10%	121.8	46.4	47.0	20%	243.4	46.4	20%	243.4	46.4
2005	10%	121.6	46.3	11%	121.2	46.1	46.9	21%	242.9	46.2	20%	242.9	46.2
2006	11%	121.2	46.1	12%	120.4	46.3	46.6	21%	242.4	46.6	21%	242.4	46.6
2007	12%	121.5	46.1	13%	120.9	46.5	46.2	21%	248.3	46.1	21%	248.3	46.1
2008	13%	121.3	46.0	14%	120.2	46.2	46.6	21%	247.7	46.5	21%	247.7	46.5
2009	13%	121.2	45.9	14%	119.8	46.0	46.5	21%	247.2	46.4	21%	247.2	46.4
2010	13%	121.1	46.5	14%	119.2	46.3	46.3	22%	246.5	46.2	0%	244.3	46.1
2011	13%	121.0	46.4	15%	118.7	46.1	46.1	22%	246.0	46.6	22%	246.0	46.6
2012	13%	120.8	46.4	15%	118.4	46.0	46.6	22%	245.4	46.4	22%	245.4	46.4
2013	14%	120.7	46.3	15%	117.8	46.3	46.4	23%	244.7	46.2	22%	244.8	46.2
2014	14%	120.6	46.2	16%	117.3	46.0	46.2	23%	244.2	46.6	22%	244.2	46.6

- % values are a percentage of applicable equipment ratings
- voltages in kV

North 3: New 115 kV Stayner x Essa; new DESN @ Stayner; Upgrade Essa Autos T1/T2 to 250 MVA

	Loss of Stayner T3			Loss of Stayner T1			Loss of Meaford T1		Loss of Waubaushene T5		Loss of Essa T1		Loss of S2E					
	T4	Stayner lv kv	Stayner hv kv	T2	Stayner lv kv	Stayner hv kv	T2	Meaford lv kv	T6	Waub. Lv kv	T2	115 kv bus kv	S3E	S2S1 (MxS)	Stayner lv kv	Stayner hv kv	Stayner2 lv kv	S2S2 (OxM)
2004	58%	47.1	124.2	51%	46.3	121.7	23%	46.1	35%	47.0	41%	123.3	25%	39%	46.1	122.3	46.4	43%
2005	59%	47.1	124.4	51%	46.3	121.9	25%	46.0	25%	46.9	36%	123.8	25%	39%	46.1	122.4	46.5	43%
2006	59%	47.0	124.2	51%	46.2	121.7	28%	46.3	36%	46.8	34%	123.9	26%	39%	46.0	122.2	46.3	44%
2007	50%	47.1	124.6	52%	46.1	122.8	30%	46.4	41%	46.9	36%	125.6	30%	38%	46.5	122.8	46.3	44%
2008	50%	46.9	124.1	53%	46.4	122.3	33%	46.2	41%	46.8	38%	125.1	31%	39%	46.2	122.2	46.0	45%
2009	51%	46.7	123.8	53%	46.3	122.1	33%	46.1	39%	46.7	38%	124.9	31%	39%	46.1	121.9	46.5	46%
2010	51%	46.6	123.4	54%	46.1	121.7	33%	46.0	39%	47.1	39%	124.6	31%	39%	46.0	121.6	46.4	46%
2011	51%	47.1	123.1	54%	46.0	121.3	34%	46.4	39%	46.9	39%	124.3	32%	40%	46.5	121.3	46.3	47%
2012	52%	46.9	122.8	55%	46.3	120.9	35%	46.3	40%	46.8	40%	124.0	32%	40%	46.3	120.9	46.1	48%
2013	52%	46.8	122.4	55%	46.2	120.6	36%	46.1	38%	47.2	40%	123.7	33%	40%	46.2	120.5	46.5	48%
2014	53%	46.6	122.0	56%	46.0	120.3	36%	46.0	39%	47.0	41%	123.4	33%	41%	46.0	120.2	46.3	49%

	Loss of S3E (New 115kV)						Loss of S2S1 (MxS)			Loss of S2S2 (OxM)				Loss of E26 (WxE)			Loss of E27 (WxE)		
	S2E	Stayner2 lv kv	S2S1 (MxS)	Stayner lv kv	Stayner hv kv	S2S2 (OxM)	S2S2 (OxM)	Meaford hv kv	Meaford lv kv	S2S1 (MxS)	Meaford hv kv	Meaford lv kv	Stayner lv kv	E27	Waub. Hv kv	Waub. Lv kv	E26	Waub. Hv kv	Waub. Lv kv
2004	25%	46.5	41%	46.2	121.2	44%	9%	121.8	46.4	10%	121.0	46.1	46.7	20%	243.3	46.4	20%	243.3	46.4
2005	26%	45.9	41%	46.2	121.3	44%	10%	121.6	46.3	11%	120.9	46.0	46.7	21%	242.9	46.2	20%	242.9	46.2
2006	27%	46.4	40%	46.1	121.0	45%	11%	121.2	46.1	12%	120.3	46.3	46.6	21%	242.4	46.6	21%	242.4	46.6
2007	33%	46.1	40%	46.3	121.2	45%	12%	121.5	46.1	13%	121.2	46.0	46.3	21%	248.3	46.1	21%	248.3	46.1
2008	34%	46.4	40%	46.0	120.5	46%	13%	121.3	46.0	14%	120.5	46.3	46.7	21%	247.7	46.5	21%	247.7	46.5
2009	34%	46.3	40%	46.6	120.4	46%	13%	121.2	45.9	14%	120.1	46.1	46.6	21%	247.1	46.3	21%	247.1	46.3
2010	34%	46.2	41%	46.4	120.0	47%	13%	121.0	46.5	14%	119.6	46.5	46.4	22%	246.5	46.2	21%	246.5	46.2
2011	35%	46.5	41%	46.2	119.6	48%	13%	120.9	46.4	15%	119.1	46.2	46.2	22%	246.0	46.6	22%	246.0	46.6
2012	35%	46.3	41%	46.0	119.2	48%	13%	120.8	46.4	15%	118.6	46.0	46.1	22%	245.3	46.4	22%	245.3	46.4
2013	35%	46.2	42%	46.5	119.0	49%	14%	120.7	46.3	15%	118.2	46.4	46.6	23%	244.7	46.2	22%	244.7	46.2
2014	36%	46.6	42%	46.3	118.6	49%	14%	120.6	46.2	16%	117.8	46.2	46.4	23%	244.1	46.6	22%	244.1	46.6

- % values are a percentage of applicable equipment ratings
- voltages in kV

Option S4 & S1: S2E conversion to 230 kV (double cct)/Build new "Collingwood Area" TS/ operate at both 115 kV & 230 kV

	Loss of Stayner T3		Loss of Nottawa T1		Loss of Nottawa T2		Loss of Waubaushene T5		Loss of SxE (New 230kV, run at 115 kV)					
	T4	Stayner lv kv	Nottawa T2	Nottawa lv kv	Nottawa T1	Nottawa lv kv	T6	Waub. Lv kv	ExN	SxN	NxM	Stayner lv kv	Stayner auto 2nd kv	MxO
2004	67%	46.5	32%	46.8	12%	46.4	64%	46.2	11%	16%	43%	46.0	123.6	45%
2005	67%	46.7	31%	46.8	12%	46.5	66%	46.1	11%	17%	44%	46.6	123.6	46%
2006	68%	46.0	31%	46.7	12%	46.4	67%	46.5	11%	17%	44%	46.4	123.1	47%
2007	67%	46.5	32%	47.2	12%	46.3	68%	46.3	12%	17%	44%	46.3	122.7	48%
2008	67%	46.4	35%	46.7	11%	46.4	70%	46.1	12%	17%	44%	46.4	123	49%
2009	67%	46.2	37%	46.8	10%	46.0	70%	46.5	12%	17%	44%	46.0	121.9	50%
2010	67%	46.1	38%	46.7	11%	46.2	72%	46.3	12%	17%	45%	46.5	121.8	50%
2011	68%	46.0	37%	46.9	10%	46.4	73%	46.2	12%	17%	45%	46.3	121.3	51%
2012	72%	46.3	46%	46.7	12%	46.0	74%	46.1	18%	20%	44%	46.3	113.6	52%
2013	72%	46.3	49%	46.9	11%	46.2	75%	46.5	19%	20%	45%	46.1	113.2	53%
2014	73%	46.1	46%	47.1	12%	46.4	76%	46.3	18%	20%	45%	46.2	**112.2**	54%

Note: Nottawa TS is the name of the "Collingwood Area" transmission station (for example: circuit Stayner by Nottawa is SxN) This is the preferred system plan from the 1991 Supply to Collingwood Environmental Study Report

Loss of SxN										Loss of E26 (WxE)			Loss of Meaford T1	
Essa T2 230/115 auto	Essa T1 230/115 auto	ExN	ExS	NxM	MxO	Stayner lv kv	Stayner hv kv	Nottawa lv kv	Nottawa hv kv	E27	Waub. Hv kv	Waub. Lv kv	T2	Meaford lv kv
57%	67.3%	7%	17%	21%	25%	46.4	124.7	46.4	125.6	20%	244.5	46.1	23%	46.1
50%	59.8%	7%	17%	21%	25%	46.6	125.3	46.3	125.5	21%	244.2	46.5	25%	46.1
48%	56.7%	7%	17%	21%	26%	46.0	125.3	46.2	125.1	21%	243.7	46.3	28%	46.4
49%	58.2%	7%	17%	21%	27%	46.5	125.0	46.0	124.7	21%	243.0	46.1	31%	46.2
51%	60.1%	8%	17%	22%	28%	46.4	124.6	46.2	125.0	22%	242.5	46.5	33%	46.0
51%	60.4%	7%	17%	22%	29%	46.3	124.4	46.4	124.1	22%	241.9	46.3	33%	46.4
51%	60.7%	7%	17%	22%	29%	46.2	124.1	46.2	123.8	22%	241.4	46.2	34%	46.3
51%	61.0%	7%	17%	22%	30%	46.1	123.9	46.1	123.5	22%	240.7	46.6	34%	46.2
53%	62.7%	8%	18%	23%	30%	46.4	123.4	46.9	125.0	22%	246.2	46.6	34%	46.4
53%	63.2%	9%	18%	24%	31%	46.2	123.0	46.9	126.1	22%	245.5	46.4	35%	46.4
53%	63.4%	9%	18%	24%	31%	46.7	122.8	47.0	125.1	23%	244.9	46.2	36%	46.2

Loss of ExN (new 230 kV)								Loss of NxM (115 kV)			Loss of MxO			Loss of Essa T1		
Essa T2 230/115 auto	Essa T1 230/115 auto	SxE	MxO	Nottawa lv kv	Nottawa hv lv	Stayner lv kv	Stayner lv kv	MxO	Meaford lv kv	Meaford hv kv	Essa T2 230/115 auto	NxM	ExS	Essa T2 230/115 auto	Essa 118 kv	Stayner hv kv
50.9%	60.3%	9%	41%	46.5	121.7	46.2	122.7	9%	46.1	122.6	58.2%	9%	18%	78.4%	124	124.1
44.5%	52.8%	9%	41%	46	122.1	46.4	123.1	9%	46	122.4	53.0%	10%	19%	68.2%	124.8	124.8
42.4%	50.2%	9%	42%	46.6	122	46.4	123.1	11%	46.4	122.1	51.4%	12%	19%	64.6%	125	124.9
44.0%	52.2%	9%	43%	46.4	121.6	46.2	122.7	11%	46.3	121.9	53.0%	13%	20%	66.7%	124.6	124.5
46.3%	54.9%	9%	44%	46.1	121	46	122.1	12%	46.1	121.6	54.9%	13%	20%	69.5%	124.2	124.3
46.6%	55.2%	9%	45%	46	120.8	46.6	122	12%	46.1	121.5	55.4%	14%	20%	70.4%	123.7	123.6
47.0%	55.8%	9%	45%	46.5	120.5	46.5	121.6	13%	46	121.4	55.9%	14%	20%	70.8%	123.5	123.4
47.5%	56.4%	9%	46%	46.3	120.2	46.3	121.4	13%	46	121.3	56.4%	14%	21%	71.2%	123.3	123.2
52.0%	61.6%	9%	46%	46.1	119.8	46	120.9	13%	46.7	121.7	56.7%	15%	20%	75.2%	123.3	122.3
52.6%	62.3%	9%	47%	45.9	119.4	46.4	120.6	13%	46.6	121.6	57.0%	15%	21%	75.2%	123.2	122.2
53.2%	63.0%	9%	47%	45.7	119.1	46.3	120.2	14%	46.6	121.5	57.9%	15%	21%	76.7%	122.6	121.5

- % values are a percentage of applicable equipment ratings
- voltages in kV
- **Planning Criteria Violation**

Appendix C: Results of Future Planning Consideration 2014 to 2024.

	TRANSFORMERS						LINES						
Plan	Loss of Midhurst T1 --> resulting flow on T2	Loss of Midhurst T3 --> resulting flow on T4	Loss of Barrie T1 --> resulting flow on T2	Loss of Stayner T3 --> resulting flow on T4	Loss of Meaford T1 --> resulting flow on T2	Loss of Waubaushene T5 --> resulting flow on T6	Loss of S2E	Loss of S2S - Stayner x Meaford	Loss of S2S - Meaford x Owen Sound	Loss of E3B or E4B	Loss of M6E	Loss of Minden x Coopflj	**Total Scored Points**
NORTH 1	95.0%	(4) voltage collapse – prefault flow 125% of Rate A	71.7%	62.6%	44.6%	95.0%	S3E --> 18%; 115 kV voltages look good (121kV+)	voltages good	can support Meaford load via Stayner & voltages good (120kV+)	E4B --> 49.7%	M7E →119% and overloads Midhurst Desn #2	Minden x CoopfljM7 - 54%	
Scored Points	3	1	3	5	5	3	5	5	5	5	1	5	**46**
NORTH 2	93.0%	(4) voltage collapse - prefault flow 125% of Rate A or 73% of Rate B	53.0%	65.0%; HV bus --> 116.0kV (requires LV cap)	46.0%	96.0%	S3E --> 36%; S2S (SxM) --> 39%; S2S (OxM) --> 49%; Meaford HV bus 118.4kV	Voltage good	Essa T1 --> 60%; Essa T2 --> 50%; Meaford HV bus 119.9kV	E4B --> 20.8%	M7E →118% and overloads Midhurst Desn #2 (124%); overloads Minden x Coopflj (96%)	Minden x CoopfljM7 - 57%	
Scored Points	3	1	5	3	5	3	3	5	3	5	1	5	**42**
NORTH 3	95.0%	(4) voltage collapse – prefault flow 125% of Rate A or 73% of Rate B	72.0%	51%; resulting flow on S3E: 39% (w/ LV cap)	46.3%	97.0%	Stayner HV bus: 120.5kV (added LV cap on 2nd Stayner LV bus); Meaford HV bus 121.0kV;flow on S3E: 29%	32% on S2E/S3E; Meaford HV bus 124.1kV	Meaford HV bus 125.2kV; flow on S2E: 41%; Stayner S2E HV bus 125.8kV (w/ LV cap) (caps required)	E4B --> 37.8%	M7E --> 117.4%; Midhurst T2 --> 91.7%; Midhurst T4 --> 131.0%; Minden x CoopfljM7 --> 102.3%	Minden x CoopfljM7 - 54%	
Scored Points	3	1	3	3	5	3	3	5	3	5	1	5	**40**

Plan	Loss of Barrie T1 --> resulting flow on T2	Loss of Alliston T5 --> resulting flow on T6	Loss of E3B --> resulting flow on E4B	Loss of E4B --> resulting flow on E3B	Loss of E8V --> resulting flow on E9V	Loss of E9V --> resulting flow on E9V	Total Scored Points
SOUTH A1	102% (reaches capacity in 2022)	105.0%	50.0%	72.0%	26%; Orangeville voltage: 236.2kV (2x245 MX Essa cap I/s)	29%; Orangeville voltage 237.5 kV 2x(245 MX Essa cap I/s)	
Scored Points	1	1	5	3	5	5	**20**
SOUTH A2	103% (reaches capacity in 2022)	74.0%	50.0%	72.0%	29%; Orangeville voltage: 232.2kV (2x245 MX Essa cap I/s)	31%; Orangeville voltage 233.1 kV (2x245 MX Essa cap I/s)	
Scored Points	1	3	5	3	5	5	**22**

Notes:

(1) Flow percentages of Rate B (10-day LTR for transformers, 15-min. LTR for lines) unless specified otherwise

(2) "--" indicates contingency was non-impactive or was the same as corresponding contingency (ie. effect of T3 loss on T4 = effect of T4 loss on T3

(3) These studies indicate that further relief for Midhurst TS is required sometime between 2014 and 2024.

(4) 5 points are awarded if all the following criteria are met:
- No additional facilities are required before 2024 AND
- Flows are less than 70 % of rating AND
- 115 kV voltages are greater than or equal to 120 kV

3 points are awarded under the following criteria:
- May require additional facilities before 2024 OR
- Flows are between 70-100 % of rating OR
- 115 kV voltages are between 113 kV and 120 kV

1 point is awarded under the following criteria:
- Flows are greater than 100% OR
- 115 kV voltages are less than 113 kV

TAB 6

hydro one

Energy+ Cambridge and North Dumfries Hydro Inc.

Kitchener-Wilmot Hydro Inc.

Guelph Hydro Electric Systems Inc.

Waterloo North Hydro Inc.

DETWEILER AREA SUPPLY STUDY

An Area Transmission Supply Assessment

of the

Kitchener, Waterloo, Cambridge, Guelph

and Surrounding Areas

June 30, 2003

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IMPORTANT NOTICE

This report is for the internal use only of Hydro One Networks Inc., Kitchener-Wilmot Hydro Inc., Waterloo North Hydro Inc., Cambridge and North Dumfries Hydro Inc., and Guelph Hydro Electric Systems Inc.

Load forecasts are based on information available to Hydro One Networks Inc., Kitchener-Wilmot Hydro Inc., Waterloo North Hydro Inc., Cambridge and North Dumfries Hydro Inc., and Guelph Hydro Electric Systems Inc. at the time of the study.

The ampacity rating Of Hydro One Networks facilities are established based on assumptions used in Hydro One Networks for transmission planning studies. The actual ampacity ratings used during operations may be determined in real time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

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EXECUTIVE SUMMARY

In June 2002, a joint study was initiated to assess the Detweiler area transmission system that supplies Kitchener, Waterloo, Cambridge, Guelph and surrounding areas. The participants of this study were Hydro One Networks Transmission, Hydro One Distribution, Kitchener-Wilmot Hydro Inc., Waterloo North Hydro Inc., Cambridge and North Dumfries Hydro Inc., and Guelph Hydro Electric Systems Inc.

Each of the local distribution companies (LDC's) in the area has observed significant load growth in the last five years. Several LDC's have seen 3% to 5% growth over this period and a high rate of growth is expected to continue for the next five to ten years. Based on the planning needs and the capacity issues raised by the LDC's, it became evident that a detailed review of the area transmission system would be required to ensure that adequate facilities are available to meet the demand requirements over the next ten years.

Because of timeliness issues and potentially competing needs among the LDC's in the area, a coordinated study with involvement from the affected LDC's was deemed to be the best approach to establish reliable and economic solutions that collectively address the needs of all parties.

This study assessed the adequacy of the Detweiler area transmission for the ten year period from 2002 to 2011. The study was conducted in essentially two phases. The first phase involved the identification of transmission constraints as a result of load growth, addition of new facilities and bulk power system transfers over the study period. The analysis also takes into consideration projects identified in the IMO Connection Assessment and Approvals (CAA) queue that may have an impact on the Detweiler area.

The second phase involves the development of feasible near and long-term alternatives to address the constraints in an economic and reliable manner. Recommendations of any alternative is based on considerations of effectiveness, cost, practicality of construction, and timeliness with due regard for the IMO Market Rules, the Transmission System Code and other Regulatory requirements.

The issue of funding and cost (or benefit) allocation was not considered in the evaluation of alternatives.

The assessment has identified that under certain contingency conditions the capacity of some transmission facilities would be exceeded. The assessment also identified conditions where unacceptable pre and post contingency voltages could exist.

New or upgrade transmission facilities for addressing the supply adequacy issues over the study period have been identified. The following tables summarizes these facilities and their need dates:

Reactive Compensation Facilities

Year	Station	Voltage (kV)	MVAr
2004	Burlington	115	125
2004	Scheifele	13.8	20
2006	Kitchener #5	13.8	20
2007	Detweiler	230	225
2007	Cambridge #1	27.6	20
2007	Cedar	13.8	20
2007	Hanlon	13.8	20

Line Capacity Upgrades

Year	Circuit(s)	kV	Section	Upgrade Description
2002	D7G/D9G	115	Detweiler x Siebert Jct	Reconductor with high temperature conductors or add new U/G cable or additional alternatives under review
2010	D7G/D9G	115	Seibert Jct x Freeport Jct	Reconductor with 997.2 kcmil or higher
2009	M20D/M21D	230	Galt Jct x Courtice Jct	Reconductor with 1192.5 kcmil
2011	M20D/M21D	230	Courtice Jct x Preston Jct	Reconductor with 1192.5 kcmil

Transformation Upgrades

Year	Station	Voltage (kV)	Upgrade Description
2004	Detweiler	230/115	Replace T3 with new 250MVA unit
2005	Hanlon	115/13.8	Add new transformer(s)
2009	Burlington	230/115	Replace T4 and T6 with new 250MVA units

This assessment has identified several immediate concerns:

1. Post contingency loading on the Detweiler x Siebert Jct section of D7G/D9G
2. Post contingency loading on the Detweiler TS autotransformation
3. Post contingency loading on the Burlington TS autotransformation and area voltage

It is recommended that the capacity relief for D7G/D9G be provided as soon as possible; however, the earliest possible in-service date is June 2005 given the extent of the potential work and the technical challenges involved. Hydro One has requested engineering assessments and the preparation of release estimates for the capacity relief options identified for D7G/D9G.

The funding issues arising from regulatory requirements for funding upgrades of Connection Line facilities were beyond the scope of this technical study. It is recommend that discussions between Hydro One, Kitchener-Wilmot Hydro and Guelph Hydro begin as soon as possible once the cost estimates for the various options are available to resolve the funding issues and to avoid potential delays in providing the capacity relief for D7G/D9G. Until capacity relief can be provided it is recommended that Hydro One, Kitchener-Wilmot and Guelph Hydro communicate closely to establish operational measures to mitigate the risk of overloads as a result of contingencies during summer peak loading periods.

Hydro One has also initiated plans to replace the T3 autotransformer at Detweiler TS and to install the 125MVAr capacitor bank at Burlington TS. In-service dates are expected in 2004.

An overall finding of this study is that by 2011 the primary 230kV and 115kV transmission supply circuits in the Detweiler area are approaching or exceeding its capacity. The options evaluated to maximize the existing facilities did not yield significant capacity improvements. To provide long term supply to the area beyond 2011, a new major 230/115kV supply point is required. An option was proposed which would provide new supply via a connection to the 500kV system near Guelph. Such a proposal would provide a supply point directly to where new load growth is expected and relieve many of the existing critical supply circuits to the Kitchener, Cambridge and Guelph areas.

Recognizing that development is growing in the vicinity of Preston TS and that obtaining right-of-way rights will become increasingly difficult, there is a need to make the necessary provisions to secure a transmission route in advance. Therefore, it is recommended that Hydro One and the LDC's work jointly with municipal agencies beginning in 2004 to identify feasible routes and initiate processes for securing land rights.

Although this study indicates that the new 230/115kV supply point will be required by 2011 based on the load forecasts provided, there have been indications by Kitchener-Wilmot Hydro and Cambridge and North Dumfries Hydro that higher than expected growth and the need to connect additional stations in the Kitchener and Cambridge areas may require the new supply to be advanced. To ensure that the development of the new supply and other major transmission facilities is initiated at an appropriate time to meet the supply needs of the area, it is recommended that Hydro One and the LDC's in the Detweiler area conduct annual reviews to reflect updated forecasts and assess new developments.

1.0 INTRODUCTION

In June 2002, a joint study was initiated to assess the Detweiler area transmission system that supplies Kitchener, Waterloo, Cambridge, Guelph and surrounding areas. The participants of this study were Hydro One Networks Transmission, Hydro One Distribution, Kitchener-Wilmot Hydro Inc., Waterloo North Hydro Inc., Cambridge and North Dumfries Hydro Inc., and Guelph Hydro Electric Systems Inc.

Each of the local distribution companies (LDC's) in the area has observed significant load growth in the last five years. Several LDC's have seen 3% to 5% growth over this period and a high rate of growth is expected to continue for the next five to ten years. Based on the planning needs and the capacity issues raised by the LDC's, it became evident that a detailed review of the area transmission system would be required to ensure that adequate facilities are available to meet the demand requirements over the next ten years.

Because of timeliness issues and potentially competing needs among the LDC's in the area, a coordinated study with involvement from the affected LDC's was deemed to be the best approach to establish reliable and economic solutions that collectively address the needs of all parties. This study assesses the adequacy of the Detweiler area transmission system over a ten year period and identifies feasible alternatives to provide the necessary capacity relief. This report documents the findings of this study.

2.0 DESCRIPTION OF DETWEILER AREA TRANSMISSION SYSTEM

A single-line representation of the Detweiler area transmission system is shown in Figure B1 of Appendix B. The area transmission consists of 230kV and 115kV transmission facilities supplying 24 load stations. All but three load stations have dual circuit supply at the 230 or 115kV level. The total coincident area peak load in 2002 was approximately 1300MW.

The major terminal station in the area is Detweiler TS which connects four 230kV double circuit lines from Middleport TS, Orangeville TS, Buchanan TS and Bruce A TS. There are three autotransformers at Detweiler which provide 230-115kV autotransformation. At the 115kV level, Detweiler connects radially three double circuit lines one of which splits into two single circuits, one to Palmerston and the other to St. Marys. All the load stations in the Detweiler area are connected to circuits emanating from Detweiler TS with the exception of 5 load stations connected to the 115kV circuits B5G/B6G which is supplied radially from Burlington TS.

Table A1 in Appendix A summarizes the supply circuits and their connected stations in the Detweiler area. The table also shows the circuit capabilities and the station capacities. The total load station transformation capacity is approximately 2100MVA.

There are no local generation facilities in the Detweiler area. The nearest sources of major generation are found at Nanticoke GS, Sir Adam Beck GS, and Bruce GS. The area relies entirely on the transmission system to deliver electricity from generation sources external to the area. With the lack of local generation to provide reactive sources, support for the area voltage come from static capacitor banks installed at the high voltage (HV) 230kV and 115kV terminal stations and at the low voltage (LV) side of load stations.

HV capacitor banks provide voltage support for not only load supply but also for bulk system transfers. On the 230kV system, there is a 225MVAr capacitor bank installed at Detweiler TS and a 300MVAr capacitor bank at Burlington TS. On the 115kV system, there are two 96MVAr capacitor banks at Detweiler TS.

Presently, LV capacitor banks can be found at Galt TS, Campbell TS, Cedar TS and Elmira TS. LV capacitor banks provide local area voltage support, reduce the overall loading on the connection line and provide power factor correction. As the load grows, a combination of HV and LV capacitor banks must be added correspondingly to maintain adequate voltage performance and minimize system losses.

3.0 AREA LOAD CHARACTERISTICS AND GROWTH

There has been significant load growth in the Detweiler area over the last 6 years. Over this period the peak area loads have occurred during the summer months. The table below shows the summer coincident area peak load since 1997:

Year	Area Load (MW)	Area Load (MVA)
1997	923	1022
1998	1082	1188
1999	1157	1279
2000	1107	1221
2001	1250	1391
2002	1292	1444

The load totals do not include loads such as St. Marys TS and Palmerston TS that may be transferred to the Detweiler area supply.

The following sections were provided by the participants and give a description of the load and growth characteristics of the distribution areas that they service.

3.1 KITCHENER-WILMOT HYDRO INC.

Kitchener-Wilmot Hydro distributes power in the City of Kitchener (2001 population 190,399) and the Township of Wilmot (2001 population 14,865).

The Township of Wilmot is primarily rural with small residential settlement areas. Customers in the Township of Wilmot are supplied power from a 27.6 kV bus inside Detweiler Transformer Station. A freeze on development in Wilmot was lifted in 1999 when new sewage capacity was placed in service. The summer peak load on the 27.6 kV bus at Detweiler was 34.1 MVA in 2002. Growth over the next five years is forecast at 2.5% per annum.

The north and east parts of the City of Kitchener can be characterized as primarily residential with pockets of commercial and light industrial uses scattered evenly throughout. The southwest features a significant industrial park and large pockets of residential development. Customers in the City of Kitchener are supplied with power from six transformer stations connected to the 115 kV and 230 kV transmission systems. A seventh transformer station is scheduled to begin delivering power to the southwest in the fall of 2004. It is anticipated that additional transformer station capacity will have to be added late in the study period to serve projected load growth in the south. Kitchener MTS#7 and MTS#8 were both designed to facilitate a doubling of capacity.

The summer peak load in the City of Kitchener was 379.4 MVA in 2002. The compound annual growth rate from 1997 to 2002 was 3.39%. Growth over the next five years is forecast at 3.0% per annum and 2.6% per annum for the five years after that, reflecting the belief that the current growth rate is unlikely to be sustained. The majority of new residential and industrial development will be in green field areas in the south of Kitchener. These developments must be supplied from Kitchener MTS#3, MTS#6 and the new MTS#8. The remaining green field development areas are concentrated along the northwest and northeast boundaries of the city. These developments will be supplied from Kitchener MTS#4 and MTS#5 respectively and should be mostly built out within the next ten or fifteen years.

As the City of Kitchener runs out of developable land in the north, local planners are considering urban intensification and brown field redevelopment. It is not known to what extent these initiatives will contribute to load growth.

The final component of load growth in Kitchener is from load maturation, the re-occupation/redevelopment of empty buildings and from intensified use of existing industrial sites. This form of load intensification tends to be diffused over the entire service area, adding load to all transformer stations.

3.2 WATERLOO NORTH HYDRO INC.

Waterloo North Hydro's (WHN) load is comprised mostly of commercial and residential load. The largest power consumer is the University of Waterloo (12 MVA). WNH has experienced a significant load growth in recent years, with average annual growth rates of 4.6% over the last 5 years. The average annual load growth over the last 10 years has been 3.8%.

Waterloo North Hydro's future load growth has the following geographical centres:

1) east side of the City of Waterloo serviced mainly by Scheifele TS,
2) west side of the City of Waterloo serviced by MTS #3, and Eby Rush T.S.
3) the Town of Elmira, east Wellesley Township and north Woolwich Township serviced by Elmira TS, and the future Waterloo MTS #4
4) the Town of Breslau and south Woolwich Township between Hwy 7 and boundary with Cambridge North Dumfries Hydro serviced by Preston TS and the future Waterloo MTS #4.
5) west Wellesley Township serviced from Detweiler T.S.

Land use in the City of Waterloo is expected to be predominantly commercial and residential. Land in the area of Elmira is intended for industrial use whereas the area of Breslau is planned to have mixed land use with residential, commercial, and industrial sections. Waterloo North Hydro anticipates the high growth to continue for the next 4-5 years at an annual growth rate of 5.3%. For the period thereafter the annual growth rates are estimated to fall between 3.8% to 5.3%.

3.3 CAMBRIDGE NORTH DUMFRIES HYDRO INC.

The load of Cambridge and North Dumfries Hydro Inc. (CNDHI) is split 62% industrial, 13% commercial and 25% residential. CNDHI supplies the large Toyota automobile assembly plant and other manufacturers. These industrial customers require a reliable supply of power free of disturbances.

The load growth in Cambridge is primarily centred immediately north and south of the highway 401 corridor. This area has shown strong industrial, commercial and residential growth in the past and it is planned to continue with ongoing development of both industrial/commercial and residential subdivisions. Over the next decade, CNDHI's peak load is expected to grow by at least 120MW. CNDHI's peak load in 2002 was 280MW.

The load growth in the Cambridge and North Dumfries area has been very strong. The load growth rate over the past 5, 10, 15 and 20 year periods has been 4.9%, 5.3%, 4.5% and 4.1% respectively. Long term, our historic load growth rate has been 3.5% but this number has been rising as load growth continues to remain strong. The load forecasts in this report for CNDHI assumed our long-term growth rate of 3.5% to avoid overstating the load growth. The actual growth rate may be higher.

CNDHI will require another transformer station (113 MVA summer LTR) towards the end of the study period in about the year 2010. The ideal location would be North of the 401 between highway 24 and Fountain Street so as to be close to the high concentration of present and future industrial load in this area. The closest transmission circuits to this location are the 115 kV D7G and D9G circuits. Connection of CNDHI's next TS to these transmission circuits will only be possible if these circuits are significantly reinforced prior to 2010.

3.4 GUELPH HYDRO ELECTRIC SYSTEMS INC.

As of April 1, 2003, Guelph Hydro Electric Systems Inc. (GHESI) had 40,945 metered customers, comprised of 37,206 residential, 3,736 general service and 3 large user customers. Large users include the University of Guelph, Polycon and Owens-Corning. Annual growth in number of customers is close to 3.0%.

From 1997 to 2002 the annual peak load increased from 214.7 MW to 261.0 MW, or an average of 4.0% per year. The average of monthly peaks increased by 3.7 % per year over the same period. Average annual growth of 3.0% is anticipated over the study period.

Major contributions to load growth include:

- More than 1,000 new residential customers per year, approximately 55% in the south end (Hanlon TS area), 40% in the west and northeast (Campbell TS area) and only about 5% in the central part (Cedar TS area).
- More than 30 new general service customers per year, many of these being medium sized industrial customers, primarily in the Hanlon TS and Campbell TS areas.
- Increased use of air conditioning by all classes of customers causing GHESI to become a summer peaking utility.
- Expansion of the University of Guelph facilities.

3.5 HYDRO ONE DISTRIBUTION

Hydro One Networks distribution supplies embedded LDCs and serves retail customers that are essentially outside other LDC's licensed service territories. The retail customer base is a mix of relatively low density residential/commercial/farm/industrial loads. The embedded LDC loads are supplied from HON owned distribution system by way of wholesale revenue meters for settlement. The retail customer load (not including the embedded LDC load) was about 68MW in 2001. The load growth rate is expected to be about 1% per year for the purpose of this study.

4.0 SCOPE OF STUDY

This study assessed the adequacy of the Detweiler area transmission for the ten year period from 2002 to 2011. The study was conducted in essentially two phases. The first phase involved the identification of transmission constraints as a result of load growth, addition of new facilities and bulk power system transfers over the study period. The impacts on the thermal loading of transmission facilities and on the area voltage performance were assessed under normal and contingency conditions. Full AC power flow analysis was used to perform the assessment. The analysis also takes into consideration projects identified in the IMO Connection Assessment and Approvals (CAA) queue that may have an impact on the Detweiler area.

The second phase involves the development of feasible near and long-term alternatives to address the constraints in an economic and reliable manner. Recommendations of any alternative is based on considerations of effectiveness, cost, practicality of construction, and timeliness with due regard for the IMO Market Rules, the Transmission System Code and other Regulatory requirements. The issue of funding and cost (or benefit) allocation was not considered in the evaluation of alternatives.

5.0 STUDY ASSUMPTIONS

This section describes the assumptions used to perform the analysis.

5.1 SYSTEM CONDITIONS AND ASSUMPTIONS

The following study and system conditions were adopted for the transmission assessment:

- 2002 summer peak conditions
- Load forecasts for the Detweiler area provided by LDC's
- 1.1% summer load growth in all areas in south, central and eastern Ontario as recommended by the IMO
- All loads modeled as constant MVA
- Post-contingency assessments assumes steady-state post-ULTC operation
- Summer continuous and limited time ratings (LTR) for transmission facilities are based on ambient temperatures of 30°C and 4km/hr wind speed which represents hot windless conditions.
- Line overloads are assessed based on ampacity. MVA ratings and flows are dependent on the voltage and are provided for convenience.

5.2 LOAD FORECASTS

The load forecast for the individual station buses over the study period is shown in Table A2. The load forecasts provided by the LDC's were deemed to be conservatively estimated with load diversity considered where appropriate. The overall Detweiler area load growth is about 3.3% in the next five years and 2.5% from five to ten years. The area load grows from 1292MW (1444MVA) in 2002 to 1665MW (1857MVA) in 2011. The overall area load power factor is approximately 0.9.

5.3 DEVELOPMENT OF STUDY CASES

Study cases for power flow simulation were developed for 2002 to 2011 to assess the impact of the loading in each year. To assess the impact of bulk power transfers, study cases were produced to reflect three system transfer conditions: base transfer, high east transfer, and high west transfer. All study cases represent summer peak conditions with all facilities in-service.

The base transfer case reflects relatively balanced conditions with generation matching load in the major transmission zones across the province. The system transfers in the base condition are comparable to those observed on peak days in 2002. The table below shows the 2002 flows on the Buchanan Longwood Input (BLIP) and Flow East To Toronto (FETT) interface flows on high demand days (≈25,000MW) in July and August.

Interface	2002 Base Condition	July 17 (MW)	Aug 13 (MW)
BLIP	1000	905	600
FETT	2200	1870	2640

BLIP measures the flow to southwestern Ontario west of London. FETT measures the flow to the GTA east of Orangeville and Burlington. These interfaces are essentially west and east of the Detweiler area. BLIP and FETT provide a good measure of the level of system transfers passing through the Detweiler area.

High transfer levels east and west of approximately 2000MW were applied to the base transfer condition. To produce the Eastbound case, generation was increased by 500MW in Sarnia along with an import via Michigan of 1500MW. Darlington generation was correspondingly reduced by 2000MW.

To produce the Westbound case, Pickering A generation was increased by 1500MW and Lennox by 500MW. Lambton generation was correspondingly reduced by 1000MW along with a 1000MW export via Michigan. The following table shows the resulting BLIP and FETT flows:

Interface	Base	Eastbound	Westbound
BLIP	1000	-900	3000
FETT	2200	4100	200

6.0 AREA TRANSMISSION ASSESSMENT: RESULTS & OBSERVATIONS

The results of the area transmission assessment are presented in this section. Analysis was conducted to assess the following concerns:

1. voltage performance in the Detweiler area
2. 230-115kV autotransformation capability at Detweiler TS and Burlington TS
3. thermal loading of the 230kV and 115kV area supply circuits

Analysis was also performed to review the impact of bulk system transfers on the 230kV area transmission and to assess the ability of the 115kV system to transfer load between neighbouring area supply systems. The section concludes with a summary of the transmission needs observed and some possible relief options.

6.1 DETWEILER AREA VOLTAGE

This section assesses the voltage performance in the Detweiler area. It looks at the steady state voltages under normal conditions. The impacts of bulk system transfers on the area voltage were reviewed. Potential relief options to address voltage issues are also discussed.

The voltage performance under post contingency conditions is discussed in Sections 6.4 and 6.5 where the capability of the 230kV and 115kV area supply circuits are assessed.

6.1.1 230kV Voltage Profile

The voltage profile of the 230kV system from southwestern Ontario to central Toronto is shown in Figure B2 of Appendix B. The voltage profiles for the study years 2002, 2005, 2008, and 2011 are shown to illustrate the voltage trend as the result of load growth in the Detweiler area. The 230kV voltage is weakest at Detweiler and Orangeville and to a lesser extent at Burlington. The voltage is maintained at higher levels in the west and east as a result of major reactive sources provided by generation at Bruce, Nanticoke, and Lakeview, and by HV capacitor banks at Longwood, Richview and Manby. In 2002, the pre-contingency Detweiler voltage is nearly 240kV. With a projected Detweiler area load growth from 1295MW in 2002 to 1665MW in 2011, the Detweiler voltage decreases to just below 227kV by 2011.

6.1.2 Impact of Bulk Transfers on Detweiler Area Voltages

Figure B3 of Appendix B compares the 230kV voltage profile in 2002 for the Base, Eastbound, and Westbound transfer scenarios. The profiles are fairly comparable with the eastbound and westbound cases showing a 3kV drop at Detweiler.

Figure B4 of Appendix B compares the voltage profile in 2011 for the three transfer scenarios. The Eastbound and Westbound cases show a 2-3kV reduction at Detweiler. As with the Base condition, the voltage is significantly lower at Detweiler and Orangeville. The Detweiler voltage is approximately 225kV for the high transfer cases. As mentioned earlier, the significant load growth and lack of reactive sources in the Detweiler area result in weak 230kV voltages.

Figures B3 and B4 indicate that the impact on the Detweiler 230kV voltage is similar for east and west system transfers. The impact of high transfers is relatively independent of the area loading. The area load level is the primary factor affecting the area voltage.

6.1.3 Voltage Issues

By 2006, the pre-contingency voltage at the Cedar 115kV connection points on circuits D7G and D9G will be below the Market Rules 113kV minimum voltage requirement under the Westbound or Eastbound transfer scenarios. The pre-contingency voltage at the Cedar 115kV connection points on circuits B5G and B6G will be below the minimum voltage requirement for eastbound transfers. By 2007, the pre-contingency voltage at Cedar would also be below 113kV for the Base transfer scenario.

2006 Pre-contingency Voltage (kV) - Existing System

Station	kV Level	Base	Westbound	Eastbound
Orangeville	230	236.	234	235
Detweiler	230	234	231	231
Detweiler	115	118	117	117
Freeport Jct	115	114	113	113
Cedar TS (D7G/D9G)	115	113	**112**	**112**
Cedar TS (B5G/B6G)	115	113	113	**112**
Elmira TS	115	115	114	114

Also in 2006, the Detweiler 230kV voltage is below 235kV for all transfer scenarios. Current IMO operating practices requires a minimum voltage of 235kV at both Detweiler and Orangeville. Voltages below 238kV at both these stations result in penalties to the FLow Away from Bruce Complex (FABC) interface.

6.1.4 Voltage Relief Options

To address the low system voltages in the 2006/2007 time frame, a combination of HV and LV reactive compensation will be required. A second 225MVAr 230kV capacitor bank at Detweiler will improve the overall voltage for circuits supplied from Detweiler. A 125MVAr 115kV capacitor bank at Burlington will improve the 115kV voltages for circuits supplied from Burlington and will allow minimum voltage to be met at stations connected to B5G/B6G over the study period. A 115kV capacitor bank has the added benefit of reducing the reactive loading on the autotransformers at Burlington which is discussed further in Section 6.3.

In situations where the supply circuits are long and the loading is high, the most effective means to address low voltages is to add not only HV capacitor banks at the terminal stations but also LV capacitor banks at load stations. Installing LV capacitor banks at stations connected near the end of radial circuits provides local voltage support and reduces the reactive loading on such circuits. With the high loading on the 115kV circuits D7G/D9G, adding another 20MVAr of reactive compensation at Cedar TS would improve the local voltage and reduce the line loading.

Similarly, high loading on the Galt x Cambridge x Preston taps of the M20D/M21D circuits will require additional reactive compensation at Cambridge MTS #1 or Preston TS to support local voltages and provide line loading relief beyond 2007. The IMO CAA report for the Cambridge and North Dumfries Hydro MTS #1 identified that by 2007, a 20MVAr capacitor bank will be required at the station to reduce the line loading. The report further identified that the capacitor bank may be required sooner for power factor correction.

Line loading issues of D7G/D9G and M20D/M21D are discussed further in Section 6.4.

Figure B5 shows a 9kV improvement in the Detweiler 230kV voltage in 2011 with the addition of the following reactive compensation (see "2011-1HV, 2LV" curve):

1. 225MVAr at Detweiler 230kV
2. 20MVAr at Cambridge MTS #1 27.6kV
3. 20MVAr at Cedar TS 13.8kV

Figure B5 also shows the improved voltage profile with additional capacitor banks. The curve "2011-1HV, 4LV" includes two additional LV banks one at Scheifele TS and one at Kitchener MTS #5. The curve "2011-2HV, 5LV" also includes a 115kV capacitor bank at Burlington and an LV bank at Hanlon TS. The additional LV banks address post contingency line loading and voltage issues at the LV side, and are discussed in the following sections.

With the above reactive compensation, adequate pre and post contingency voltages are maintained for the study period.

6.2 DETWEILER AUTOTRANSFORMATION

Based on the forecast for the Detweiler 115kV system, the autotransformer loading will exceed its summer 10-day LTR capability of 450MVA by 2003 as shown in the table below:

2003 Detweiler Autotransformer Loading (MVA)

	T2	T3	T4
Continuous Rating	250	215	225
10-day LTR	291	232	301
Pre-contingency	147	157	147
Loss of T4	219	**234**	0

For the loss of T4, the loading on T3 will exceed it 10-day LTR. T3 is loaded slightly higher pre-contingency and has the lowest 10-day LTR of the three autotransformers.

Hydro One is currently developing a plan to replace the T3 autotransformer with a unit that has a 10-day LTR (≈300MVA) comparable to the existing T2 and T4 transformers. This will improve the 10-day rating to approximately 600MVA and provide adequate autotransformation capacity over the study period.

6.3 BURLINGTON AUTOTRANSFORMATION

The Burlington 230/115kV autotransformation loading will exceed its summer 10-day LTR capability of approximately 750MVA beyond 2004 as shown in the table below:

Burlington Autotransformer Loading (MVA)

	T4	T6	T9	T12
Continuous Rating	215	215	250	250
10-day LTR	254	254	297	297
2004 Pre-contingency	184	185	184	186
2004 Loss of T4	249	250	250	0
2005 Pre-contingency	187	188	188	189
2005 Loss of T4	254	**255**	254	0

The Burlington 115kV area load was based on the forecasts provided for loads connected to B5G/B6G and on a growth of 1.1% for all other loads in the area. The base 2002 Burlington area load was approximately 735MVA. The 1.1% growth projection is conservative for the Burlington area and relief of the autotransformer loading will be required in the 2004/2005 time frame.
As discussed in Section 6.1.3, the voltages at Cedar TS supplied from Burlington will be below the Market Rules pre-contingency minimum voltage of 113kV in 2007. The addition of a 125MVAr 115kV capacitor bank at Burlington TS would provide the necessary voltage support to meet the minimum voltage requirement for the study period.

The capacitor bank would also reduce the reactive loading and defer the need for additional autotransformation capability up to 2008. Beyond 2008, upgrade of the T4 and T6 autotransformers will be required. The overall transformation capability is limited by T4 and T6 which have the lowest 10-day LTR. Replacing T4 and T6 with units having a 10-day LTR (≈300MVA) comparable to T9 and T12 would improve the total capability from 750MVA to 900MVA. Adding a fifth autotransformer would improve the total capability to 1000MVA, but this option would be significantly more costly since major station work would be required to incorporate the autotransformer and to accommodate the increase in short circuit levels.

6.4 230kV Area Transmission

Power flows into the Detweiler area come primarily from the four 230kV circuits M20D, M21D, D6V and D7V. The ratio of the flow from these circuits to the other four 230kV circuits B22D, B23D, D4W, and D5W is approximately 3 to 1 under base transfer conditions. Even for the Eastbound transfer scenario the ratio is still almost 2 to 1. This implies that each incremental increase in the area load will have a greater impact on the loading of the M20D/M21D and D6V/D7V circuits.

The B22D/B23D circuits from Bruce are long circuits and represent a high impedance path for the generation at Bruce GS to Detweiler TS. D4W/D5W have no load connected to them. Other than under high eastbound transfers, these circuits are lightly loaded given their continuous capability of 610MVA.

6.4.1 M20D/M21D - Supply to Kitchener and CNDHI

The 230kV circuits M20D/M21D supply the following stations: Kitchener MTS #6, Kitchener #8, Galt TS, Cambridge MTS #1, Preston TS and Courtice Steel. The total connected load in 2002 is 377MW (421MVA) and in 2011 is 521MW (581MVA). The load on the Galt Jct radial tap in 2002 is 309MW (345MVA) and in 2011 is 420MW (469MVA). Courtice Steel is supplied entirely from M21D and as result the contingency involving the loss of M20D is more severe than M21D.

For the M20D contingency, it was observed that the post-contingency voltage decline at the HV and LV buses was acceptable for the study period. From 2004 to 2006 transformer taps reached their limits at the Kitchener #3 and #5 stations. Although, the LV voltages were acceptable, this indicated that some additional LV reactive support at some of these stations may be needed beyond 2006.

The contingency assessment for M20D/M21D from 2007 to 2011 assumes the addition of the HV capacitor bank at Detweiler and the LV banks at Cedar and Cambridge #1 by 2007. With these capacitor banks, the taps for the Kitchener #3, and #5 transformers do not reach their limits until 2009. Again, LV voltages were acceptable.

In 2009, it was observed that the flow on the Galt Jct x Courtice Jct section of M21D will exceed its continuous rating of 473MVA (1160A). By 2011, this section will reach 100% of its 15-minute LTR and the continuous rating of the Courtice x Preston Jct section of M21D will also be exceeded. Supplying additional load from the Galt Jct radial tap would require line uprating of the sections between Galt Jct and Preston Jct.

By 2010, the load supplied by M20D/M21D will exceed 500MW. The IMO is presently considering a requirement which limits the loss of load to 500MW for a double circuit contingency. If the IMO establishes such a requirement, measures such as in-line breakers between Galt Jct and the future Kitchener #8 station would be required. Such breakers would have limited effectiveness since 80% of the load in 2011 would be supplied from the Galt Jct radial tap.

The table below shows the 2011 post contingency loading on the Middleport x Galt and Detweiler x Detweiler Jct sections of M21D under the different transfer scenarios.

2011 - Post Contingency Flow on M21D for loss of M20D (all values in MVA)

	Rating (Cont/LTR)	Base	Eastbound Transfer	Westbound Transfer
Middleport x Galt Out @ Middleport	762/924	687	626	815
Detweiler x Detweiler Jct Out @ Detweiler	762/924	150 (-71MW/131MX)	96 (4MW/95MX)	211 (-177MW/115MX)

It is interesting to note that even for eastbound transfers, the MW flow out of Detweiler is virtually zero (4MW), and for the other conditions the MW flow is into Detweiler. This indicates that any additional load on these circuits (especially on the Galt Jct radial tap) will be entirely supplied out of Middleport.

There is capacity on M20D/M21D to accommodate some additional load beyond 2011. The amount of additional load would be affected by bulk power system transfers. Assuming that the Galt x Courtice x Preston are upgraded as needed, the limiting condition would be the circuit sections out of Middleport under westbound transfers. Notwithstanding the IMO 500MW limitation, the M20D/M21D circuits could accommodate up to another 100MVA of load depending on where the load is connected and assuming that adequate reactive compensation was provided. Load levels which result in flows greater than 762MVA will require control actions to reduce the loading to continuous ratings within 15 minutes. There may be uneconomic implications for control actions involving significant generation redispatch.

6.4.2 D6V/D7V - Supply to Waterloo, Guelph & Surrounding Areas

The 230kV D6V/D7V circuits supply the following stations: Waterloo MTS #3, Waterloo MTS #4, Scheifele MTS, Campbell TS and Fergus TS. The total connected load in 2002 is 377MW (425MVA) and in 2011 is 514MW (574MVA). All the stations are supplied by both circuits with essentially equal loading on each circuit.

The table below shows the 2011 post contingency flow on the Orangeville x Fergus and Detweiler x Waterloo Jct sections of D7V under the different transfer scenarios. For the loss of D6V, flows on all sections of D7V are less than 80% of their continuous ratings.

2011 - Post Contingency Flow on D7V for loss of D6V (all values in MVA)

	Rating (cont/LTR)	Base	Eastbound Transfer	Westbound Transfer
Orangeville x Fergus Out @ Orangeville	612/746	356	290	444
Detweiler x Waterloo Jct Out @ Detweiler	457/514	333	361	301

There is adequate capacity to accommodate a wide range of additional bulk system transfers as well as additional load beyond 2011. For additional load, the limiting condition would be the circuit sections out of Detweiler under eastbound transfers. Notwithstanding the IMO 500MW limitation, the D6V/D7V circuits could accommodate approximately another 150MVA to 200MVA of load depending on where the load is connected and assuming adequate reactive compensation was also provided.

For a D6V/D7V contingency, post-contingency 230kV and 115kV voltage decline were within 10% over the study period. By 2004, the post-contingency decline at the LV of the Scheifele T1/T2 exceeds 10% with a bus voltage of 12.7kV. The JH and QT buses were at 13.6kV. Taps at all Scheifele transformers were at their limits. Addition of 20MVAr of reactive compensation at Scheifele T1/T2, results in acceptable voltage declines until 2009. With the addition of the Detweiler HV, and the Cambridge, Cedar, Kitchener #5 and Scheifele LV capacitor banks the post contingency voltage at the JH and QT buses are at 13.5kV with transformer taps at their limit in 2011. Beyond 2011, additional reactive compensation at the JH and/or QT buses may be required to maintain adequate voltages for the loss of D6V or D7V.

By 2010, the load supplied by D6V/D7V will exceed 500MW. An option to address the IMO 500MW limitation is to install in-line breakers potentially at the future Waterloo MTS #4. This approach would be much more effective in this case since in-line breakers at such a location would sectionalize the circuits and split the supplied load by approximately 50%. A double circuit contingency would result in the loss of only half the existing load with the other half supplied radially from Detweiler or Orangeville.

6.5 115kV Area Transmission

6.5.1 D7G/D9G - Supply to Kitchener, Guelph and Surrounding Areas

The circuits D7G/D9G supply the following stations: Wolverton DS, Kitchener #3, #5, #7 and Cedar TS. The total connected load in 2002 is 243MW (269MVA) and in 2011 is 313MW (347MVA). Wolverton DS is supplied entirely by D7G. The contingency involving the loss of D9G is more severe than D7G.

For the D9G contingency in 2002, the 15-minute LTR (302 MVA /1380A) of the Detweiler x Detweiler Jct section of D7G) is exceeded. The continuous rating (241MVA/1100A) of the Detweiler Jct x Seibert Jct section is also exceeded.

By 2004, the 15-minute LTR of Detweiler Jct x Seibert Jct would be exceeded.

For the D9G contingency, the transformer taps of Kitchener #3 and #5 are at their limits for 2002 to 2004. In 2005, taps at Kitchener #7 are also at their limits. However, the post-contingency voltage is acceptable.

Post-contingency voltage decline exceeds 10% at Kitchener #3 and #5 beginning in 2006, and at 115kV buses beginning in 2008. LV reactive compensation (such as 20MVAr cap bank at Kitchener #5) will be required by 2006 to ensure adequate LV voltages and adequate tap room. Reactive compensation could be installed earlier as a means to reduce the reactive loading.

Reactive compensation added at stations such as Kitchener #5 and Cedar TS also serve to reduce the reactive loading on these circuits,. With 20MVAr of reactive compensation at each of these stations, the Detweiler x Detweiler Jct post contingency flow (303MVA) would not exceed the 15-minute LTR until 2007.

By 2006, the continuous rating (241MVA /1100A) of the Seibert Jct x Freeport Jct section will be exceeded. With the additional reactive support in 2007, as noted above, the post contingency flow on the Seibert x Freeport section would not exceed the continuous rating until 2010. At that time, upgrading this section with 997.2 kcmil or larger conductor would provide the necessary relief.

With the additional reactive support in 2007, the post contingency flow on Detweiler x Detweiler Jct would reach 337MVA by 2009. By 2011, the post contingency flow reaches 377MVA.

Continuous ratings of 1600A (≈330MVA) represent approximately the maximum practical ampacity for conventional 115kV lines. With the circuits uprated to 1600A and the two additional LV cap banks, the D7G/D9G circuits will be out of capacity in 2009 given the forecasted load. Other means of providing line loading relief are discussed in Section 7.1.

6.5.2 B5G/B6G - Supply to Guelph and Surrounding Areas

The circuits B5G/B6G supply the following stations: IPP Westover, Puslinch DS, Hanlon TS, Cedar TS and ABB CTS. The total connected load in 2002 is 109MW (120MVA) and in 2011 is 123MW (135MVA). IPP Westover is supplied entirely by B5G. The contingency involving the loss of B6G is more severe than B5G.

Based on the load forecast, the voltages at Cedar TS were observed to be below the Market Rules pre-contingency minimum voltage of 113kV beyond 2007. The addition of a 125MVAr 115kV capacitor bank at Burlington TS prior to 2007 will provide the necessary voltage support to meet the minimum voltage requirement for the study period.

Based on the forecast provided for Hanlon TS, the station will exceed the LTR of 47.7 MVA by 2005. And additional transformation capacity will be required. The projected load for Hanlon in 2011 is 60MVA.

With the Burlington 115kV cap bank, the line loading of the Burlington x Harper Jct x Puslinch Jct sections of B5G for the loss of B6G will exceed its continuous rating of 140MVA by 2007. By 2009, for the same B6G contingency, the post-contingency 115kV voltage decline at Cedar TS will exceed 10%.

A possible solution is the addition of 20MVAr of reactive compensation at Hanlon or Cedar. This will result in acceptable post-contingency voltages and defer the B5G/B6G line upgrades until 2012. The reactive compensation will be required in 2007.

6.5.3 Load Transfer Capability between D7G/D9G and B5G/B6G

Based on the supply assessments described above for the 115kV circuits D7G/D9G and B5G/B6G, additional load cannot be transferred to D7G/D9G for normal operations under peak loading conditions.

Under peak loading conditions, approximately 25MVA of load could be transferred to B5G/B6G. Assuming the Burlington 115kV cap bank is available in 2004, the amount of transfer capability would reduce from 25MVA to zero by 2007. Although, the load increase on B5G/B6G is less than 10MW between 2002 and 2007, the reactive flow increases by 23MVAr as a result of reduced voltages.

Installing 20MVAr of reactive compensation at Hanlon or Cedar as early as 2004 improves the transfer capability to 30MVA and this capability would reduce more gradually to zero by 2011. Uprating the Burlington x Harper Jct x Puslinch Jct line sections could be considered to improve the transfer capability and relieve the loading on D7G/D9G. These sections are currently sag limited to 93°C and 100°C operation. Improving the sag to 127°C would improve the continuous rating to 170MVA.

6.5.4 D11K/D12K - Supply to Kitchener

The circuits D11K/D12K supply the Kitchener #1 and #4 stations. The total connected load in 2002 is 97MW (107MVA) and in 2011 is 105MW (117MVA).

The continuous and 15-minute limited time ratings of the D11K/D12K circuits are 158MVA and 168MVA respectively. For the loss of either circuit in 2011, the post contingency loading on the remaining circuit is 92% of the continuous rating and 87% of the 15-minute LTR. With the additional reactive support by 2007, as noted above in the discussion of the Detweiler area voltage, the post contingency loading is 86% of the continuous rating and 81% of the 15-minute LTR as a result of improved area voltage.

For the study period, post-contingency voltages are acceptable and LV buses regulate within transformer tap ranges.

6.5.5 D8S/D10H - Supply to Waterloo and Surrounding Areas

The circuits normally supply the Elmira TS and Rush MTS stations. The total connected load in 2002 is 69MW (77MVA) and in 2011 is 62MW (70MVA).

The continuous and 15-minute limited time ratings of the D8S/D10H circuits are 147MVA and 158MVA respectively. The Detweiler x Leong Jct section of D8S was recently uprated in 2002 from 107MVA to 147MVA by increasing the sag clearances.

In 2011, for the loss of D8S, the post contingency loading on D10H is 49% of the continuous rating and 46% of 15-minute LTR. For the loss of D10H, the post contingency loading on D8S is 25% of the continuous rating and 23% of the 15-minute LTR. Post-contingency voltages are acceptable and LV buses regulate within transformer tap range.

Currently the loads at Palmerston TS are normally supplied by D10H from Hanover TS and the loads at St. Marys and Blue Circle Cement are supplied by L7S from Seaforth TS. There are some operating scenarios where the Palmerston load is transferred to D10H and the St Marys and Blue Circle Cement is transferred to D8S. The table below shows the flows on the limiting sections of D8S and D10H in 2002 and 2011 under these load transfer situations:

Flows on D8S and D10H with Load Transfers

Year	Contingency	D10H - Detweiler x Waterloo 147MVA Continuous 158MVA 15-min LTR			D8S - Detweiler x Leong 147MVA Continuous 158MVA 15-min LTR		
		MW	MVAr	MVA	MW	MVAr	MVA
2002	Pre	95	25	98	58	22	62
	Loss D8S	117	44	125			
	Loss D10H				78	39	87
2011	Pre	100	29	104	56	22	60
	Loss D8S	116	42	123			
	Loss D10H				70	32	77

In all cases with the additional load transferred on D10H and D8S, the post-contingency voltages were acceptable and the LV buses were regulated within transformer tap ranges. The table above indicates that there is some spare line capacity for additional loads of approximately 25MVA on D10H and 70MVA on D8S in addition to the load transfers.

In order to accommodate new loads, some reactive compensation may be required to address the low pre-contingency voltages. The table below shows the 115kV voltages on D8S and D10H in 2011 under different load transfer combinations.

2011 Pre-contingency 115kV Voltages on D8S and D10H

Load Transfer	Detweiler	Waterloo Jct	Wallensten Jct	Elmira	Palmerston	Leong Jct	Rush	St Mary's
None	120.6	120.1	118.9	118.3	120.9	120.5	120.1	120.8
St Marys	119.8	119.4	118.3	117.7	118.8	119.5	119.3	113.7
Palmerston	119.0	118.1	114.7	114.1	**111.8**	118.8	118.1	115.9
St Marys + Palmerston	118.7	117.8	114.3	113.7	**111.4**	118.4	117.7	**112.5**

Although voltages below 113kV were observed at Palmerston and St. Marys, all LV voltages were regulated within transformer tap ranges. The above assessments for 2011 assumes that the HV capacitor bank at Detweiler TS and the four LV capacitor banks described previously have been installed by 2011.

6.6 NEED SUMMARY

This section summarizes the needs for additional reactive compensation, line capacity and transformation capacity identified in the transmission assessment of Sections 6.1 to 6.5.

6.6.1 Reactive Compensation Requirements

The table below summarizes the reactive compensation requirements. It consists of 2HV capacitor banks at the Detweiler and Burlington terminal stations and 5 LV capacitor banks at various load stations in the area.

Summary of Reactive Compensation Requirements

Year	MVAr	Voltage (kV)	Station	Supply Circuits
2004	125	115	Burlington	
2004	20	13.8	Scheifele	D6V/D7V
2006	20	13.8	Kitchener #5	D7G/D9G
2007	225	230	Detweiler	
2007	20	27.6	Cambridge #1	M20D/M21D
2007	20	13.8	Cedar	D7G/D9G
2009	20	13.8	Hanlon	B5G/B6G

The reactive compensation identified in the above table results in adequate pre and post contingency voltage performance for the Detweiler area over the study period. LV capacitor banks at Kitchener #5, Cedar, Cambridge #1 and Hanlon could be advanced to address line loading and power factor correction issues.

6.6.2 Line Capacity Requirements

Under normal operating conditions, no line overloads were observed over the study period. Under contingency conditions, overloads were observed on the D7G/D9G and M20D/M21D circuit pairs. The table below summarizes the sections and when these overloads were observed.

Summary of Post Contingency Line Section Overloads

Year	Circuit(s)	kV	Section	Length (km)	Overload
2002	D7G	115	Detweiler x Detweiler Jct	1.1	15-min LTR
2002	D7G/D9G	115	Detweiler Jct x Seibert Jct	8.6	Continuous
2004	D7G/D9G	115	Detweiler x Seibert Jct	8.6	15-min LTR
2010*	D7G/D9G	115	Seibert Jct x Freeport Jct	2.4	Continuous
2009*	M20D/M21D	230	Galt Jct x Courtice Jct	13.6	Continuous
2011*	M20D/M21D	230	Galt Jct x Courtice Jct	13.6	15-min LTR
2011*	M20D/M21D	230	Courtice Jct x Preston Jct	1.6	Continuous

*Note: Assumes additional reactive compensation by 2007 as summarized in Section 6.6.1

6.6.3 Transformation Capacity Requirements

The table below summarizes the transformation capacity requirements.

Summary of Transformation Requirements

Year	Station	Voltage (kV)	Upgrade Description
2004	Detweiler	230/115	Replace T3 with new 250MVA unit
2005	Hanlon	115/13.8	Add new transformer(s)
2009	Burlington	230/115	Replace T4 and T6 with new 250MVA units

The loads supplied from Burlington, with the exception those supplied from the B5G/B6G circuits, was not the primary focus of this study and a scaled load growth of 1.1% was applied to the forecast. More detailed assessments of the Burlington area may identify a need to provide additional autotransformation capability sooner than 2009.

7.0 OPTIONS FOR INCREASED SUPPLY CAPACITY

This section considers options for providing relief for the overloaded 115kV and 230kV circuits identified in the area transmission assessment of Section 6.0. This section also looks at the need to provide additional transmission capacity beyond 2011.

7.1 RELIEF OF D7G/D9G

As mentioned in the capacity assessment for D7G/D9G, the loading on the Detweiler x Detweiler Jct x Siebert Jct sections by 2009 exceeds the practical limit of conventional 115kV circuits for the distances involved. The following subsections discuss possible options to provide relief for D7G/D9G. Additional alternatives such as autotransformer(s) at Preston TS and peaking generation options will be explored in subsequent investigations. Hydro One and the impacted customers (Kitchener-Wilmot Hydro, Guelph Hydro Electric Systems and Hydro One Distribution) will be investigating the feasibility of autotransformers at Preston TS. This investigation is expected to be completed by the first quarter of 2004. Peaking generation connected to D7G/D9G is an option being explored by Kitchener-Wilmot Hydro and other third party generation providers.

7.1.1 Upgrade with Low Sag High Temperature Conductors

This option involves reconductoring the 8.6km Detweiler x Siebert Jct section with new low sag high temperature conductors. These conductors allow significantly higher ampacities than conventional ACSR conductors of comparable size. This has the advantage of avoiding major tower work and the associated outage implications that is required when upgrading to much larger conductors. Any significant tower work would have outage impacts on the supply to Kitchener #6 since there is a 3km section on which the D7G/D9G and the M20D/M21D tap to Kitchener #6 share common (4 circuit) towers.

Using high temperature conductors comparable in size to the existing D7G/D9G conductors (795 ACSR), continuous summer ampacities in the 1650A to 1800A range are achievable . Hydro One has requested a preliminary engineering assessment and a detail cost estimate for this alternative. A budgetary estimate for this reconductoring work is $8M.

This option would provide relief up to the 2010 to 2011 time frame. Other relief measures would be required if additional load is connected to D7G/D9G beyond 2010/2011.

7.1.2 Add New 115kV Underground Cable to Siebert Jct

This option involves adding a single 115kV underground circuit from Detweiler TS to Siebert Jct. Figure B7 in Appendix B shows the new connection arrangement with the new circuit. This circuit would have a capacity of approximately 150MVA. This circuit would supply Wolverton DS and a portion of the Kitchener #3 load under normal operations. For contingencies involving D9G, an automatic transfer scheme would be installed so that all the load at Kitchener #3 would be supplied by the new circuit. This transfer would be achieved by opening the LV breakers connected to the D7G supply. This approach would effectively provide nearly 120MVA of relief on D7G/D9G and would be would provide the necessary relief over the study period.

Hydro One has requested a preliminary engineering assessment and a detail cost estimate for this alternative. A budgetary estimate for the new cable and associated modifications is $10M.

The underground cable has the added benefit of providing additional reactive support and improving the local voltage. There is also the future option of extending the cable for another 2.5km to Freeport Jct to pick up the Kitchener #7 load.

7.1.3 Transfer of Load to Other Load Stations

By 2011, there is only a small amount of capacity available at other stations in Kitchener and Guelph. The forecast shows that Kitchener #1 and #8 has about 15MVA and 20MVA of spare capacity respectively. Kitchener #4 and #6 are at their capacity. Kitchener-Wilmot Hydro has indicated that Kitchener #1 is not suitable for transferring loads supplied by D7G/D9G.

The stations supplying Guelph are near capacity in 2011. Depending on the amount of transformation added to Hanlon in 2005, there may be some available capacity. However, Hanlon is supplied by B5G/B6G and some sections on these circuits are expected to reach their capacity in 2012. Transfers to Hanlon will advance the need to uprate portions of B5G/B6G. There is an idle winding at one of the transformer pairs at Campbell TS; however, Guelph Hydro has indicated that Campbell TS is at the north end of Guelph but the load growth is occurring at the south end. This makes additional supply from Campbell somewhat impractical.

The relief that can be provided to D7G/D9G by load transfers is very limited. Some small transfers could be made as interim measures until additional line capacity can be added.

7.2 Relief of M20D/M21D

It was observed that additional capacity would be required for the Galt Jct x Courtice Jct section (13.6km) in 2009 and the Courtice Jct x Preston Jct section (1.6km) in 2011. These sections currently have 932.7 kcmil ACSR conductor and have a summer continuous capability of 1160A (473MVA). Reconductoring with 1192.5 kcmil conductor and sagged for 127°C operation would improve the capability to 1440A (587MVA) and provide the necessary relief for the study period. At this capacity, the load supplied from these radial sections would exceed the potential IMO 500MW restriction. Other means to supply additional load in the vicinity beyond 2011 will need to be considered. The budgetary estimate for reconductoring is $5M assuming minor tower work.

7.3 Options for Long Term Area Capacity

Presently the Detweiler area is primarily supplied by the 230kV circuits M20D/M21D and D6V/D7V. The circuits B22D/B23D provide little support into the area due to its long distance (190km) from Bruce GS. The circuits D4W/D5W from Buchanan are under-utilized as a result of system characteristics and flow patterns.

For long term supply to the Detweiler area beyond the study period, the options are to maximize the existing 230kV system or introduce a new supply point. As indicated earlier, the D6V/D7V may have another 200MVA of capacity and M20D/M21D may have another 100MVA of capacity. The total will be less than the sum of 300MVA as the loading of these circuit pairs are not independent of each other and the load additions may not be at the ideal locations to maximize the remaining capacity. A range of 200 to 250MVA likely represents the maximum load meeting potential of the Detweiler area transmission system beyond 2011. The following options were assessed:

1. Sectionalizing with in-line breakers on D6V/D7V and M20D/M21D
2. Join Campbell to Preston with a new 230kV double circuit line and associated switching
3. Provide series compensation to D4W/D5W
4. Provide new 230kV supply via connection to 500kV

7.3.1 Sectionalizing with 230KV In-line Breakers

Figure B8 in Appendix B shows in-line breakers on D6V/D7V at the future Waterloo #4 stations and breakers on M20D/M21D at the future Kitchener #8 station. The in-line breakers on D6V/D7V effectively split the load on these circuits. A double circuit contingency would result in the loss of only half the load. The in-line breakers on M20D/M21D is a less effective split as 80% of the load is connected to the Galt Jct radial tap.

Other than to reduce the load loss for a double circuit contingency, sectionalizing with in-line breakers has limited improvement in reducing the post-contingency loading. Under westbound transfer scenarios, the reduction in the post contingency flow on D7V out of Detweiler and the flow on M21D out of Middleport is less than 5%.

7.3.2 Series Compensation on D4W / D5W

Figure B9 in Appendix B shows the installation of series capacitors on D4W/D5W to reduce the impedance of the circuits to allow more flow into Detweiler. A series compensation of 70% was tested. The series capacitors reduces the post contingency loading on M21D out of Middleport less than 5% for westbound transfers and increases post contingency loading on D7V out of Detweiler by 10% for eastbound transfers. The series capacitors do improve the pre-contingency voltage at Detweiler voltage by nearly 3.5kV. Overall, supply capacity was not significantly improved with this approach.

7.3.3 230kV Galt Jct x Guelph Jct Loop

This option, shown in Figure B10, involves building 20km of double circuit 230kV line from Campbell TS to Preston TS to connect the radial taps from Guelph Jct on D6V/D7V and Galt Jct on M20D/M21D. A full switching arrangement is included at both Guelph Jct and Galt Jct.

Figure B11 shows the resulting flows with this option for 2011 westbound transfer conditions. By creating the new 230kV loop, the flow on the Galt tap of M20D/M21D increases slightly. Figure B12 shows the post contingency flows for the loss of the Middleport x Galt Jct section of M20D. The post contingency loading on M21D out of Middleport is increased slightly. For other transfer conditions the flow out of Middleport is not significantly reduced (less than 10%). Even with the "loop" connection, the load on the Galt Jct radial tap is naturally supplied from the Middleport end.

Although this option does not significantly reduce the line loading, it does improve reliability to the stations connected to the Galt tap by reducing line exposure by almost 70% for a M20D/M21D contingency. This option also addresses the IMO 500MW concern as a result of sectionalizing D6V/D7V and M20D/M21D.

The difficulty with this option is obtaining a right-of-way for the 20km of new line. Rebuilding the existing 115kV D7G/D9G circuit from Speedville Jct to Campbell TS to 230kV is a possibility but this would require converting ABB and Cedar stations to 230kV supply. Temporary facilities would have to be provided to supply these stations during the conversion work. This would also remove any capability to make 115kV load transfers to B5G/B6G in the event of emergencies. Converting Cedar TS to 230kV supply would off-load the D7G/D9G circuits but would further load the D6V/D7V supply circuits. The estimated cost for this option including the 230kV conversion work is $50 to $60 million.

7.3.4 New 230kV / 115kV Supply to Detweiler Area

This option, shown in Figure B13, proposes to install 500/230kV autotransformers near HWY 401 between HWY 6 North and HWY 6 South and then build approximately 15km of double circuit 230kV line along the 401 to connect to Preston TS. To provide relief of the 115kV D7G/D9G circuits, 230kV/115kV autotransformer(s) would be installed at Preston TS. A short (≈1km) 115kV overhead line or underground cable would be built to connect to D7G/D9G at Speedville Jct.

This option would provide nearly 800MW of additional supply into the Detweiler area and would represent a third major 230kV supply point at a location where significant new load is expected. The stations on the Galt Jct radial tap would then be supplied from two ends. A significant portion of the 115kV load on the D7G/D9G could be supplied radially including some load (i.e. Cedar TS) that is currently supplied by B5G/B6G.
Figure B13 shows one of several possible connection arrangements with normally open points on the 230kV at Galt TS and on the 115kV at Kitchener #7 and at Cedar TS. In this arrangement, Preston, Cambridge #1,

Kitchener #5, ABB, and both Cedar TS would be supplied by the new supply point. Doing so would relieve the loads on M20D/M21D by 240MVA, on D7G/D9G by 230MVA, and on B5G/B6G by 45MVA. The selection of open points would depend on the balance of supply required between the existing circuits and the new supply point to accommodate new loads. Depending on the loading pattern, it would be possible to connect the new 230kV supply to Preston TS as a parallel connection without an isolation point. More detailed analysis would be required to better define the facilities and their arrangement at more advanced planning stages.

Implementation of this option in the 2010/2011 time frame would avoid the need to provide increase capacity on the Galt Jct x Preston Jct section of M20D/M21D, Siebert Jct x Freeport Jct section of D7G/D9G and the Burlington x Puslinch Jct section of B5G/B6G.

This option would require property and easement acquisition to obtain a new right-of-way for the new 230kV line. A full environmental assessment, an OEB Section 92 leave to construct and IMO approvals will be required. From an approvals perspective, one of the advantages of this option is that the proposed route parallels the 401 highway for much of its length and thereby minimizes socioeconomic impacts. The portion of the route coming into Preston TS on the east side of Cambridge will be more difficult as there may be concerns from some commercial areas. At this time there is undeveloped land at the 500kV connection point, and there appears to be adequate space at Preston TS to accommodate the new line, 230/115kV autotransformers and associated switching. In order to secure the necessary right-of-way lands, especially over the built up areas near Preston, Hydro One and the LDC's should work jointly with municipal agencies as early as 2004 to identify feasible routes.

This option represents a major new supply point to the Detweiler area and is expected to provide sufficient transmission supply capacity for a 10 to 15 year period beyond 2011. The estimated cost is $60-$70 million. This includes the 500/230kV and 230kV/115kV autotransformation, the double circuit 230kV line to Preston TS and associated switching.

8.0 CONCLUSIONS AND RECOMMENDATIONS

This assessment has reviewed the Detweiler area transmission supply for the 2002 to 2011 study period. The assessment has identified that under certain contingency conditions the capacity of some transmission facilities would be exceeded. The assessment also identified conditions where unacceptable pre and post contingency voltages could exist.

New or upgrade transmission facilities for addressing the supply adequacy issues over the study period have been identified. The following tables summarizes these facilities and their need dates:

Reactive Compensation Facilities

Year	Station	Voltage (kV)	MVAr
2004	Burlington	115	125
2004	Scheifele	13.8	20
2006	Kitchener #5	13.8	20
2007	Detweiler	230	225
2007	Cambridge #1	27.6	20
2007	Cedar	13.8	20
2007	Hanlon	13.8	20

Line Capacity Upgrades

Year	Circuit(s)	kV	Section	Upgrade Description
2002	D7G/D9G	115	Detweiler x Siebert Jct	Reconductor with high temperature conductors or add new U/G cable or additional alternatives under review
2010	D7G/D9G	115	Seibert Jct x Freeport Jct	Reconductor with 997.2 kcmil or higher
2009	M20D/M21D	230	Galt Jct x Courtice Jct	Reconductor with 1192.5 kcmil
2011	M20D/M21D	230	Courtice Jct x Preston Jct	Reconductor with 1192.5 kcmil

Transformation Upgrades

Year	Station	Voltage (kV)	Upgrade Description
2004	Detweiler	230/115	Replace T3 with new 250MVA unit
2005	Hanlon	115/13.8	Add new transformer(s)
2009	Burlington	230/115	Replace T4 and T6 with new 250MVA units

This assessment has identified several immediate concerns:

1. Post contingency loading on the Detweiler x Siebert Jct section of D7G/D9G
2. Post contingency loading on the Detweiler TS autotransformation
3. Post contingency loading on the Burlington TS autotransformation and area voltage

It is recommended that the capacity relief for D7G/D9G be provided as soon as possible; however, the earliest possible in-service date is June 2005 given the extent of the potential work and the technical challenges involved. Hydro One has requested engineering assessments and the preparation of release estimates for the capacity relief options identified for D7G/D9G.

The funding issues arising from regulatory requirements for funding upgrades of Connection Line facilities were beyond the scope of this technical study. It is recommend that discussions between Hydro One, Kitchener-

Wilmot Hydro and Guelph Hydro begin as soon as possible once the cost estimates for the various options are available to resolve the funding issues and to avoid potential delays in providing the capacity relief for D7G/D9G. Until capacity relief can be provided it is recommended that Hydro One, Kitchener-Wilmot and Guelph Hydro communicate closely to establish operational measures to mitigate the risk of overloads as a result of contingencies during summer peak loading periods.

Hydro One has also initiated plans to replace the T3 autotransformer at Detweiler TS and to install the 125MVAr capacitor bank at Burlington TS. In-service dates are expected in 2004.

An overall finding of this study is that by 2011 the primary 230kV and 115kV transmission supply circuits in the Detweiler area are approaching or exceeding its capacity. The options evaluated to maximize the existing facilities did not yield significant capacity improvements. To provide long term supply to the area beyond 2011, a new major 230/115kV supply point is required. An option was proposed which would provide new supply via a connection to the 500kV system near Guelph. Such a proposal would provide a supply point directly to where new load growth is expected and relieve many of the existing critical supply circuits to the Kitchener, Cambridge and Guelph areas.

Recognizing that development is growing in the vicinity of Preston TS and that obtaining right-of-way rights will become increasingly difficult, there is a need to make the necessary provisions to secure a transmission route in advance. Therefore, it is recommended that Hydro One and the LDC's work jointly with municipal agencies beginning in 2004 to identify feasible routes and initiate processes for securing land rights.

Although this study indicates that the new 230/115kV supply point will be required by 2011 based on the load forecasts provided, there have been indications by Kitchener-Wilmot Hydro and Cambridge and North Dumfries Hydro that higher than expected growth and the need to connect additional stations in the Kitchener and Cambridge areas may require the new supply to be advanced. To ensure that the development of the new supply and other major transmission facilities is initiated at an appropriate time to meet the supply needs of the area, it is recommended that Hydro One and the LDC's in the Detweiler area conduct annual reviews to reflect updated forecasts and assess new developments.

Appendix A: Tables

Table A1: Existing Detweiler Area Transmission

Circuit	MVA Capability (Continuous/15-min LTR)	Connected Stations	Station Capacity (MVA)
D6V/D7V	612 / 746 Orangville x Fergus 457 / 514 Fergus x Detweiler 583 / 681 Guelph Jct x Campbell	Fergus TS Campbell TS Scheifele TS Waterloo North MTS #3	190 256 179 85
M20D/M21D	762 / 924 Middleport x Detweiler 473 / 538 Galt Jct x Preston Jct	Galt TS Preston TS Cambridge MTS #1 Kitchener #6 Direct Customer	178 125 115 83 102
		Total 230kV	**1313**
D7G / D9G	241 / 302 Detweiler x Freeport 136 / 147 Freeport x Cedar	Kitchener #3 Kitchener #5 Kitchener #7 Cedar TS (T1/T2) Woverton DS	104 83 50 108 30
D11K / D12K	158 / 168	Kitchener #1 KItchener #4	50 83
B5G / B6G (from Burlington)	140 / 147 Burlington x Harper 136 / 147 Harper x Cedar 308 / 361 Cedar x CGE 109 /114 CGE x ABB 188 / 206 ABB x Campbell	Cedar TS (T7/T8) Hanlon TS Puslinch DS Direct Customer Direct Customer	44 48 33 11 6
D8S	147 / 158 Detweiler x Leong Jct 153 / 164 Leong Jctx St Marys	Rush MTS	41
D10H	147 / 158 Detweiler x Leong Jct 153 / 164 Leong Jct x Hanover	Elmira	42
Detweiler TS		Detweiler T5/T6	52
		Total 115kV	**782**
		Total Area	**2098**

Table A2: Detweiler Area Load Forecast 2002 to 2011

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
Station Bus	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX	MW	MX
Customer CTS	1.9	0.9	2.0	0.9	2.0	1.0	2.1	1.0	2.2	1.0	2.3	1.1	2.3	1.1	2.4	1.1	2.5	1.2	2.6	1.2
Cambridge #1	12.0	5.8	18.3	8.9	24.9	12.1	34.0	16.5	44.9	21.7	56.2	27.2	67.9	32.9	80.0	38.7	92.5	44.8	105.4	51.1
Campbell TS JQ	45.2	21.9	46.9	22.7	48.2	23.3	49.4	23.9	51.0	24.7	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4
Campbell TS BY	45.2	21.9	46.9	22.7	48.2	23.3	49.4	23.9	51.0	24.7	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4
Campbell TS ZE	45.2	21.9	46.9	22.7	48.2	23.3	49.4	23.9	51.0	24.7	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4	52.4	25.4
Cedar TS T1/T2 BY	45.0	21.8	45.1	21.8	46.8	22.7	48.8	23.6	48.6	23.5	48.6	23.5	48.6	23.5	48.6	23.5	48.6	23.5	48.6	23.5
Cedar TS T1/T2 ID	0.0	0.0	0.0	0.0	6.6	3.2	7.0	3.4	8.6	4.2	11.6	5.6	19.2	9.3	26.9	13.0	35.0	16.9	43.1	20.9
Cedar TS T7/T8	45.0	21.8	45.5	22.0	39.5	19.1	39.5	19.1	39.5	19.1	39.5	19.1	39.5	19.1	39.5	19.1	39.5	19.1	39.5	19.1
Customer CTS	8.6	4.4	8.9	4.5	9.2	4.7	9.5	4.8	9.9	5.0	10.2	5.2	10.6	5.3	10.9	5.5	11.3	5.7	11.7	5.9
Customer CTS	8.6	4.4	8.9	4.5	9.2	4.7	9.5	4.8	9.9	5.0	10.2	5.2	10.6	5.3	10.9	5.5	11.3	5.7	11.7	5.9
Customer CTS	8.6	4.4	8.9	4.5	9.2	4.7	9.5	4.8	9.9	5.0	10.2	5.2	10.6	5.3	10.9	5.5	11.3	5.7	11.7	5.9
Detweiler TS	25.7	16.7	27.2	17.7	27.8	18.1	28.5	18.6	29.2	19.0	29.7	19.3	30.1	19.6	30.6	19.9	31.0	20.2	31.5	20.5
Elmira TS	27.6	15.1	32.0	17.3	33.1	17.9	34.3	18.5	35.5	19.1	31.0	16.8	31.3	17.0	31.6	17.1	31.9	17.3	32.3	17.4
Fergus TS	84.2	47.7	86.1	48.8	88.0	50.0	90.0	51.1	92.0	52.4	94.1	53.6	96.2	54.9	98.4	56.2	100.7	57.5	103.0	58.9
Galt TS J	86.5	41.2	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5
Galt TS Y	86.5	41.2	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5	86.5	41.5
Guelph Hanlon TS	37.0	17.9	39.1	18.9	41.0	19.9	43.2	20.9	45.6	22.1	47.1	22.8	48.7	23.6	50.3	24.4	52.0	25.2	53.7	26.0
Kitchener #1	25.9	12.5	26.0	12.5	26.1	12.6	26.1	12.6	26.8	12.9	27.5	13.2	28.1	13.6	28.8	13.9	29.5	14.2	30.2	14.5
Kitchener #3 A	32.8	15.4	32.9	15.5	33.1	15.6	33.3	15.6	33.4	15.7	33.6	15.8	33.8	15.9	33.9	15.9	34.1	16.0	34.3	16.1
Kitchener #3 B1	18.7	8.8	20.0	9.4	20.7	9.7	13.3	6.2	16.3	7.7	18.0	8.5	19.6	9.2	21.2	10.0	22.8	10.7	24.4	11.5
Kitchener #3 B2	18.7	8.8	20.0	9.4	20.7	9.7	13.3	6.2	16.3	7.7	18.0	8.5	19.6	9.2	21.2	10.0	22.8	10.7	24.4	11.5
Kitchener #4 B1	35.6	16.8	36.1	17.0	36.6	17.2	37.3	17.6	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
Station	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**	**MW**	**MX**
Kitchener #4 B2	35.6	16.8	36.1	17.0	36.6	17.2	37.3	17.6	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7
Kitchener #5 B1	33.8	17.2	34.1	17.4	34.3	17.5	34.6	17.7	34.9	17.8	35.1	17.9	35.3	18.0	35.4	18.1	35.6	18.1	35.7	18.2
Kitchener #5 B2	33.8	17.2	34.1	17.4	34.3	17.5	34.6	17.7	34.9	17.8	35.1	17.9	35.3	18.0	35.4	18.1	35.6	18.1	35.7	18.2
Kitchener #6 B1	34.1	16.0	35.3	16.6	37.2	17.5	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7
Kitchener #6 B2	34.1	16.0	35.3	16.6	37.2	17.5	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7	37.6	17.7
Kitchener #7	39.5	19.0	40.9	19.7	42.9	20.6	45.0	21.7	45.0	21.7	45.0	21.7	45.0	21.7	45.0	21.7	45.0	21.7	45.0	21.7
Kitchener #8	0.0	0.0	0.0	0.0	0.0	0.0	19.0	8.9	20.5	9.7	21.6	10.2	22.7	10.7	23.8	11.2	24.9	11.7	26.0	12.2
Preston TS J	49.0	26.8	50.7	27.5	52.5	28.5	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9
Preston TS Q	49.0	26.8	50.7	27.5	52.5	28.5	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9	53.3	28.9
Puslinch DS B1	10.1	3.3	10.2	3.4	10.3	3.4	10.4	3.4	10.5	3.5	10.6	3.5	10.7	3.5	10.9	3.6	11.0	3.6	11.1	3.6
Puslinch DS B2	10.1	3.3	10.2	3.4	10.3	3.4	10.4	3.4	10.5	3.5	10.6	3.5	10.7	3.5	10.9	3.6	11.0	3.6	11.1	3.6
Rush MTS	41.1	19.7	35.2	16.9	35.5	17.0	35.9	17.2	32.3	15.5	28.8	13.8	29.1	14.0	29.4	14.1	29.7	14.2	30.0	14.4
Scheifele MTS T1/T2	62.9	32.9	58.5	29.5	60.6	29.5	62.7	29.5	61.0	29.5	61.6	29.5	62.2	29.5	62.9	29.5	63.5	29.5	64.1	29.5
Scheifele T3/T4 JH	47.2	24.7	43.9	22.1	45.4	22.1	47.0	22.1	45.8	22.1	46.2	22.1	46.7	22.1	47.1	22.1	47.6	22.1	48.1	22.1
Scheifele T3/T4 QT	47.2	24.7	43.9	22.1	45.4	22.1	47.0	22.1	45.8	22.1	46.2	22.1	46.7	22.1	47.1	22.1	47.6	22.1	48.1	22.1
Waterloo #3	0.0	0.0	24.7	12.4	30.8	15.4	37.2	18.6	57.5	28.8	64.3	32.1	67.5	33.7	68.1	34.1	68.8	34.4	69.5	34.8
Waterloo #4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.9	2.4	9.7	4.9	14.6	7.3	19.4	9.7	24.3	12.1
Wolverton DS T1	10.2	3.8	10.3	3.9	10.4	3.9	10.5	3.9	10.5	3.9	10.6	3.9	10.7	4.0	10.7	4.0	10.8	4.0	10.9	4.0
Wolverton DS T2	10.2	3.8	10.3	3.9	10.4	3.9	10.5	3.9	10.5	3.9	10.6	3.9	10.7	4.0	10.7	4.0	10.8	4.0	10.9	4.0
Total	**1292**	**643**	**1335**	**662**	**1379**	**681**	**1424**	**701**	**1471**	**726**	**1506**	**742**	**1546**	**762**	**1585**	**780**	**1625**	**799**	**1665**	**818**

PF	0.90		0.90		0.90		0.90		0.90		0.90		0.90		0.90		0.90		0.90	
Growth (MW)			42.5		43.9		45.6		46.9		34.7		40.7		38.8		39.8		40.5	
Growth (%)			3.3		3.3		3.3		3.3		2.4		2.7		2.5		2.5		2.5	

APPENDIX B: FIGURES AND DIAGRAMS

DETWEILER AREA TRANSMISSION SYSTEM

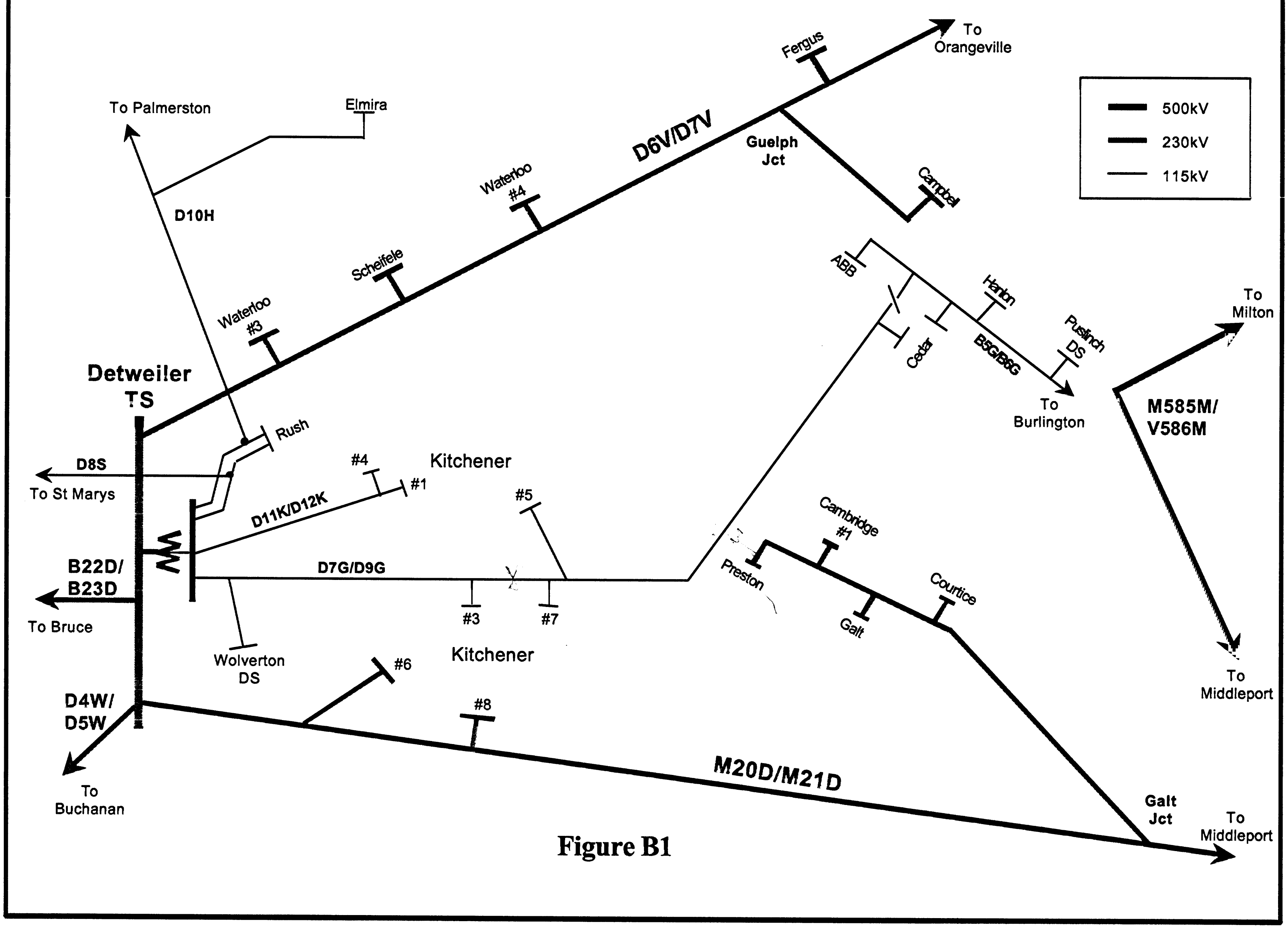


Figure B1

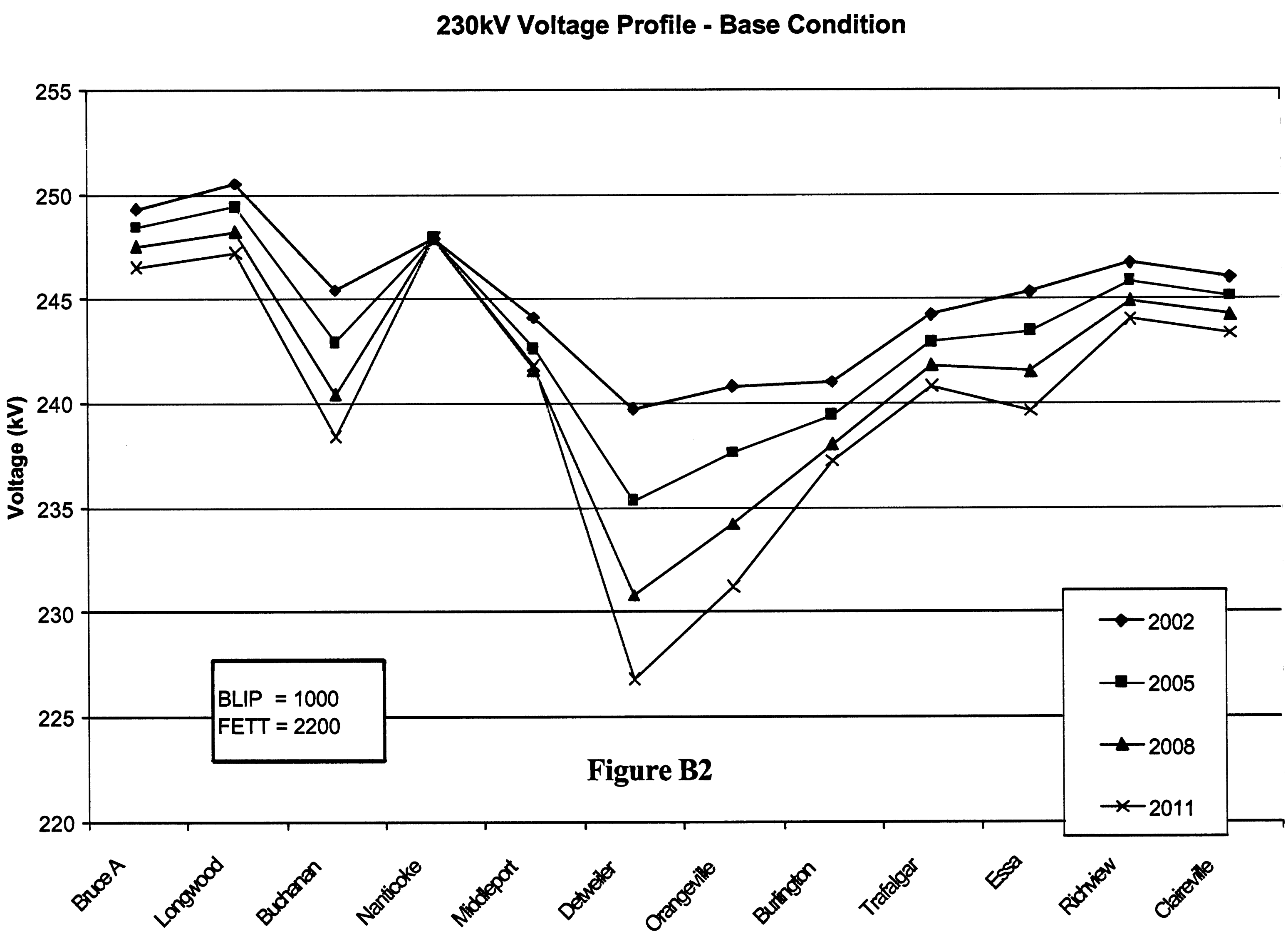

230kV Voltage Profile - Base Condition
Voltage (kV)
255
250
245
240
235
230
225
220
BLIP = 1000
FETT = 2200
2002
2005
2008
2011
Bruce A
Longwood
Buchanan
Nanticoke
Middleport
Detweiler
Orangeville
Burlington
Trafalgar
Essa
Richview
Claireville

Figure B2

2002 - 230kV Voltage Profile

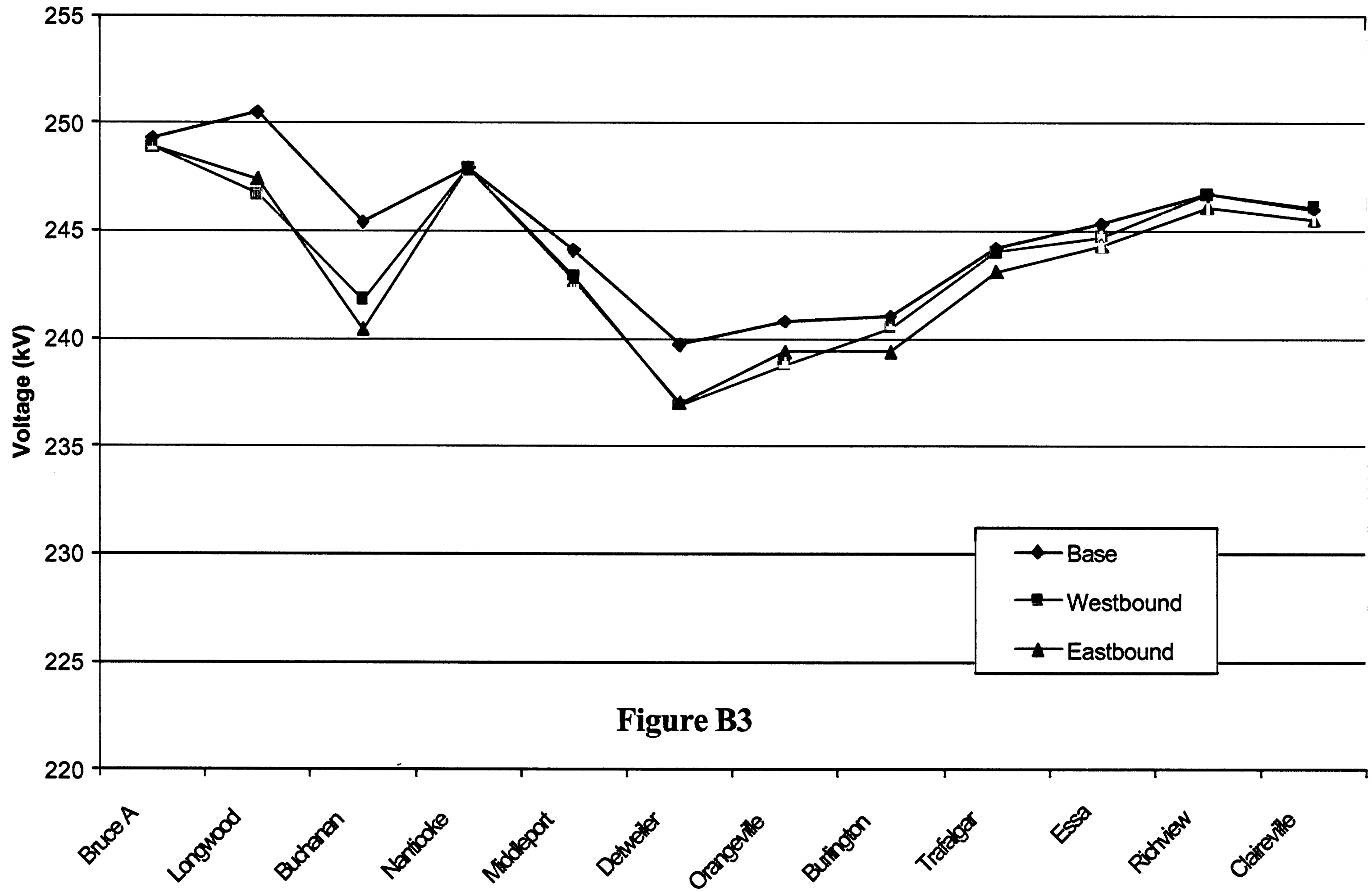


Figure B3

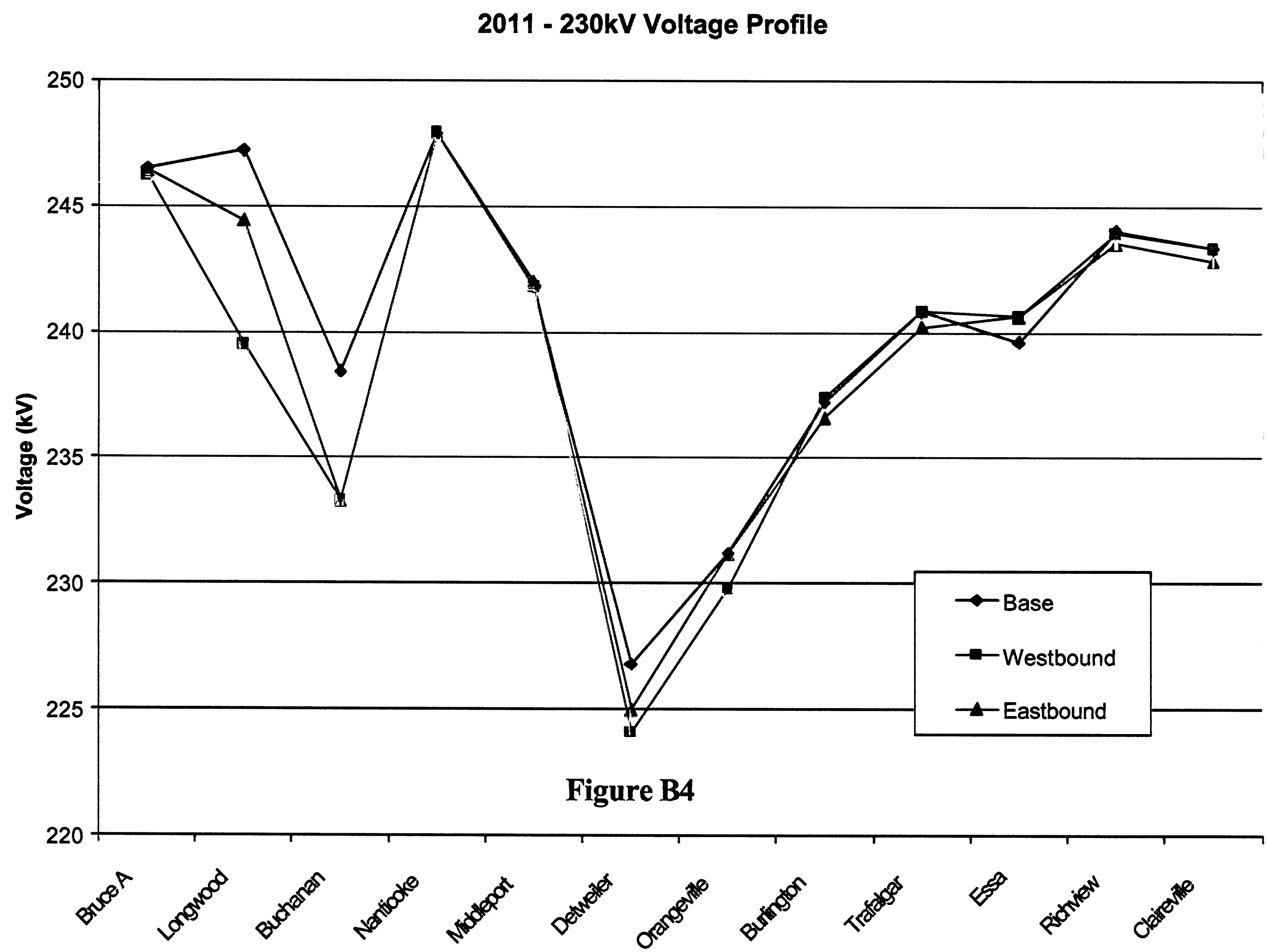

2011 - 230kV Voltage Profile
Voltage (kV)
250
245
240
235
230
225
220
Bruce A
Longwood
Buchanan
Nanticoke
Middleport
Detweiler
Orangeville
Burlington
Trafalgar
Essa
Richview
Claireville
Base
Westbound
Eastbound

Figure B4

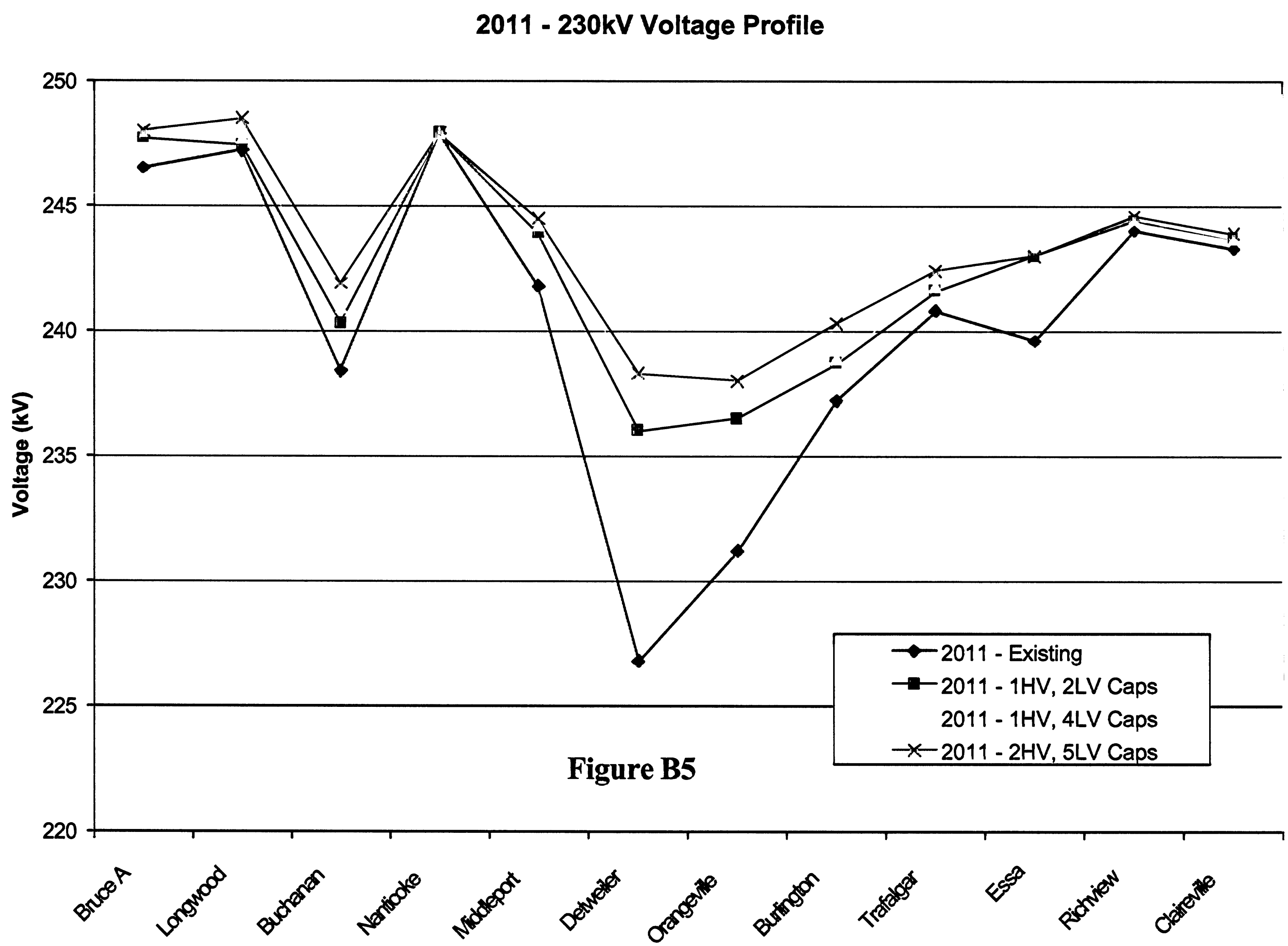

2011 - 230kV Voltage Profile
Voltage (kV)
250
245
240
235
230
225
220
Bruce A
Longwood
Buchanan
Nanticoke
Middleport
Detweiler
Orangeville
Burlington
Trafalgar
Essa
Richview
Claireville
2011 - Existing
2011 - 1HV, 2LV Caps
2011 - 1HV, 4LV Caps
2011 - 2HV, 5LV Caps

Figure B5

Figure B6: Upgrade D7G/D9G with High Temperature Conductors

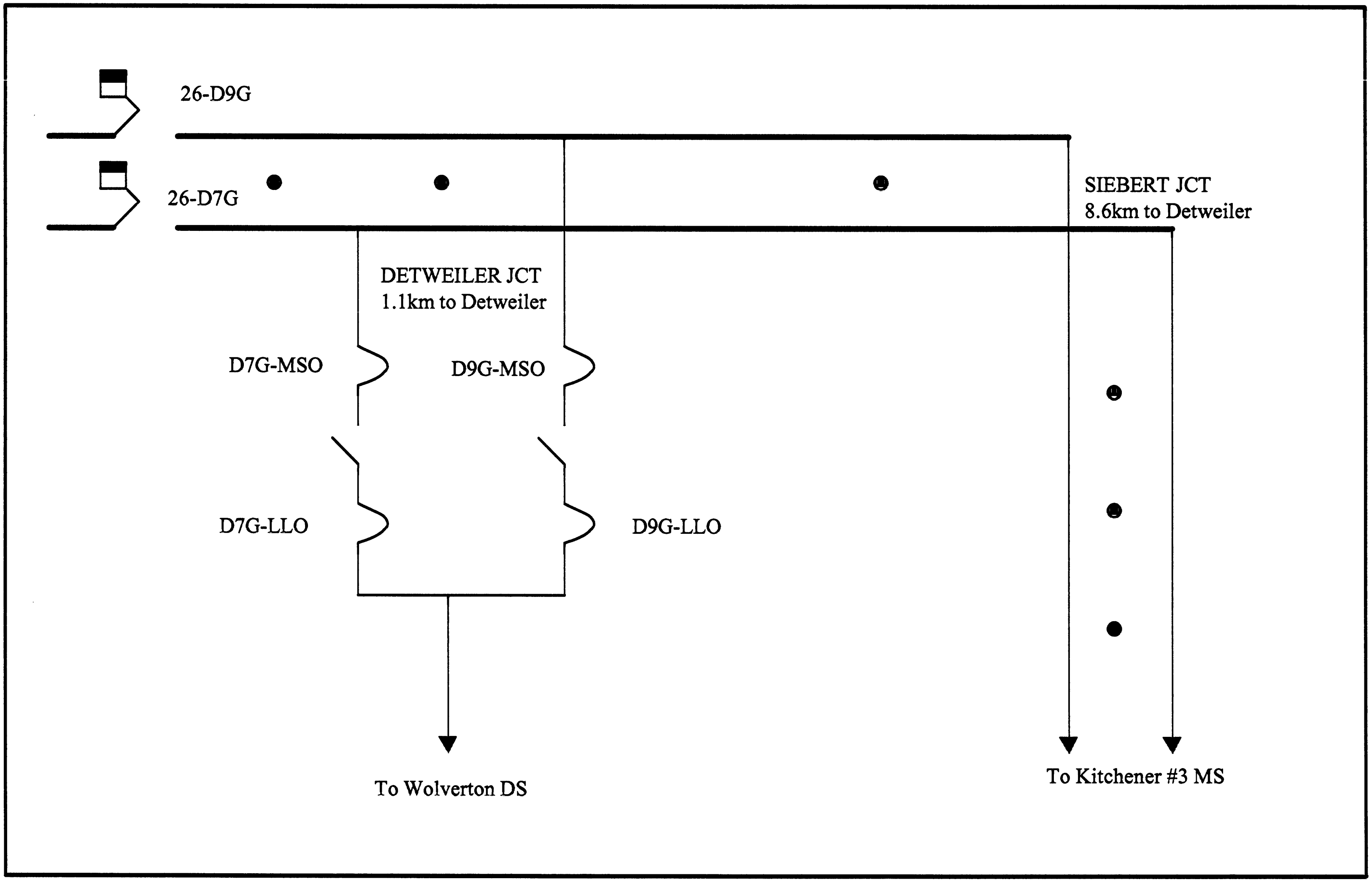
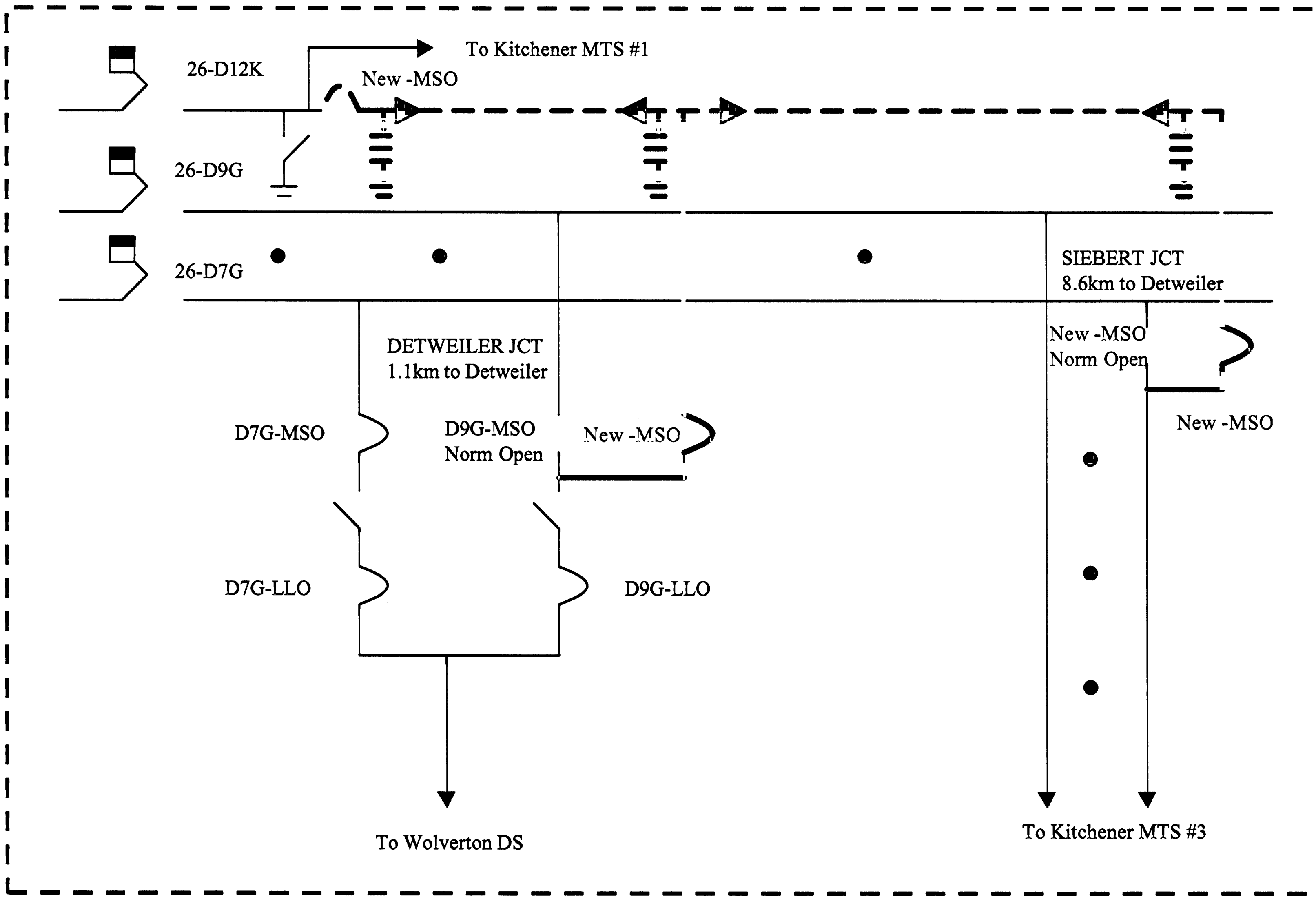


Figure B7: New 115kV U/G Cable Detweiler TS x Siebert Jct



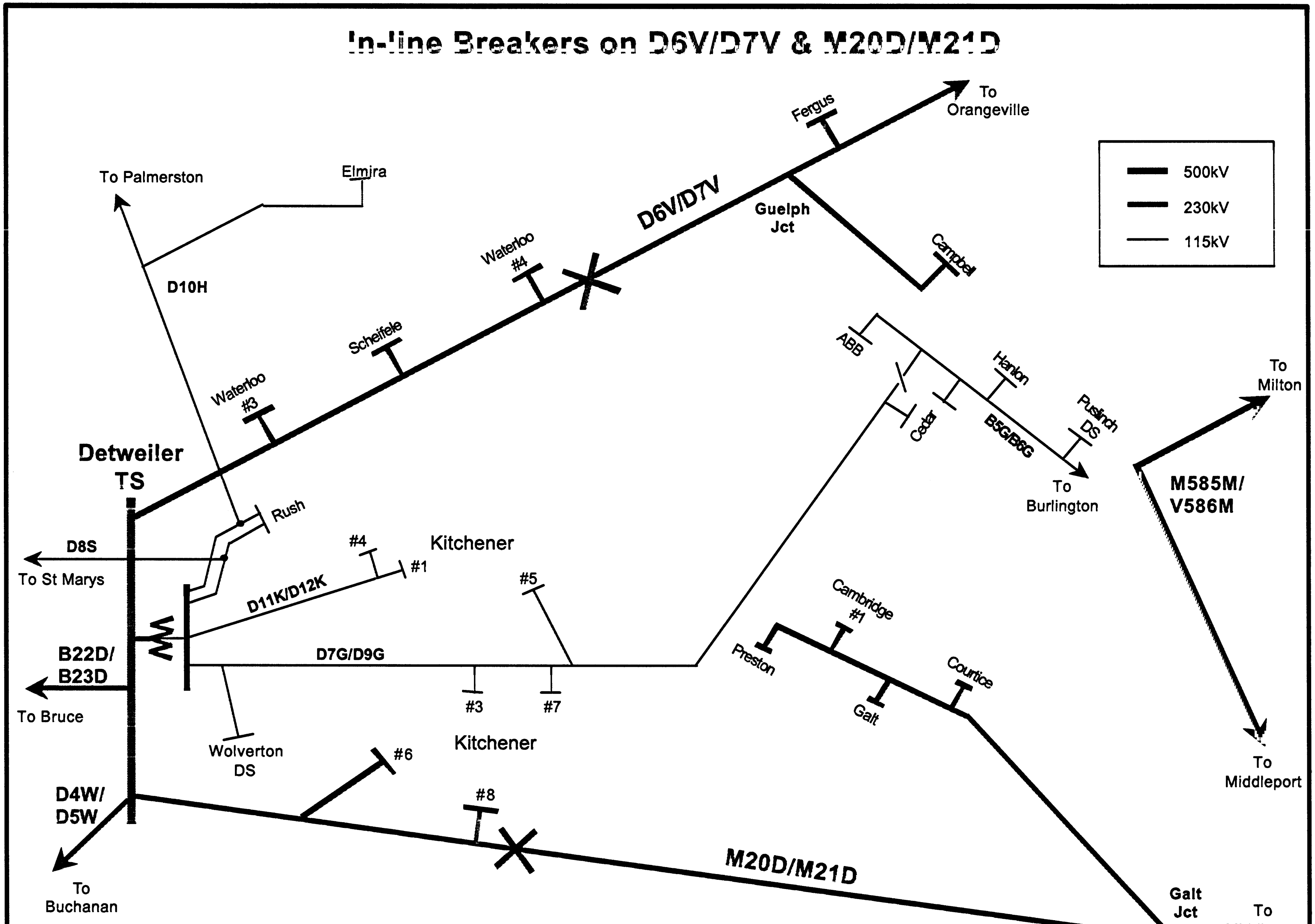

In-line Breakers on D6V/D7V & M20D/M21D
To Orangeville
Fergus
Guelph Jct
Campbel
D6V/D7V
Waterloo #4
Scheifele
Waterloo #3
Detweiler TS
To Palmerston
Elmira
D10H
Rush
D8S
To St Marys
B22D/ B23D
To Bruce
D4W/ D5W
To Buchanan
#4
#1
Kitchener
D11K/D12K
#5
D7G/D9G
#3
#7
Kitchener
Wolverton DS
#6
#8
M20D/M21D
ABB
Cedar
Hanlon
B5G/B6G
Puslinch DS
To Burlington
500kV
230kV
115kV
To Milton
M585M/ V586M
To Middleport
Cambridge #1
Preston
Galt
Courtice
Galt Jct
To Middleport

FIGURE B8

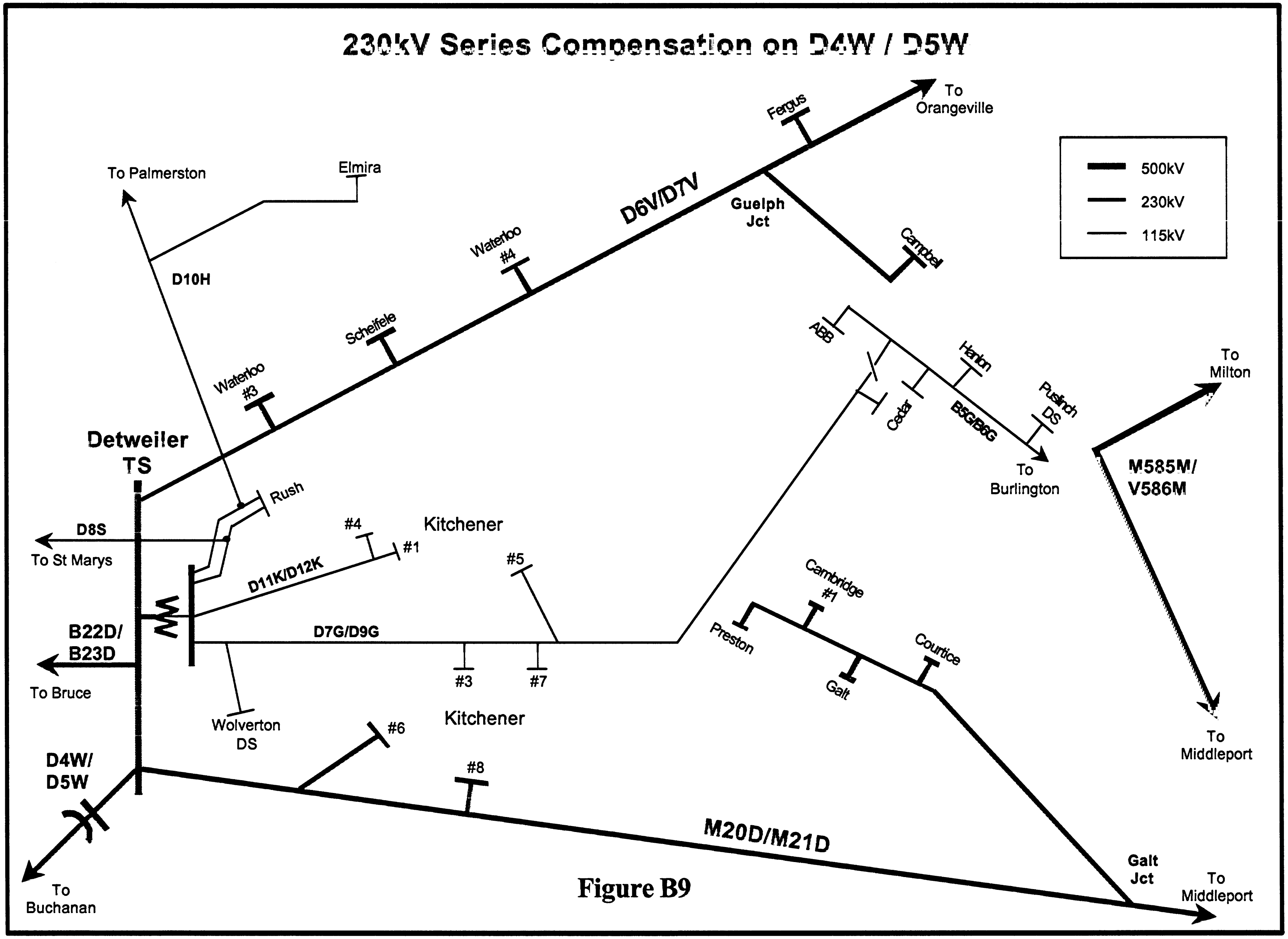

230kV Series Compensation on D4W / D5W
500kV
230kV
115kV
To Orangeville
Fergus
To Palmerston
Elmira
D6V/D7V
Guelph Jct
Campbel
D10H
Waterloo #4
Scheifele
Waterloo #3
Detweiler TS
Rush
D8S
To St Marys
#4
#1
Kitchener
D11K/D12K
#5
D7G/D9G
#3
#7
B22D/ B23D
To Bruce
Wolverton DS
Kitchener
#6
#8
D4W/ D5W
To Buchanan
M20D/M21D
ABB
Hanlon
Cedar
B5G/B6G
Puslinch DS
To Burlington
To Milton
M585M/ V586M
To Middleport
Cambridge #1
Preston
Galt
Courtice
Galt Jct
To Middleport

Figure B9

New Galt Jct x Guelph Jct 230kV Loop

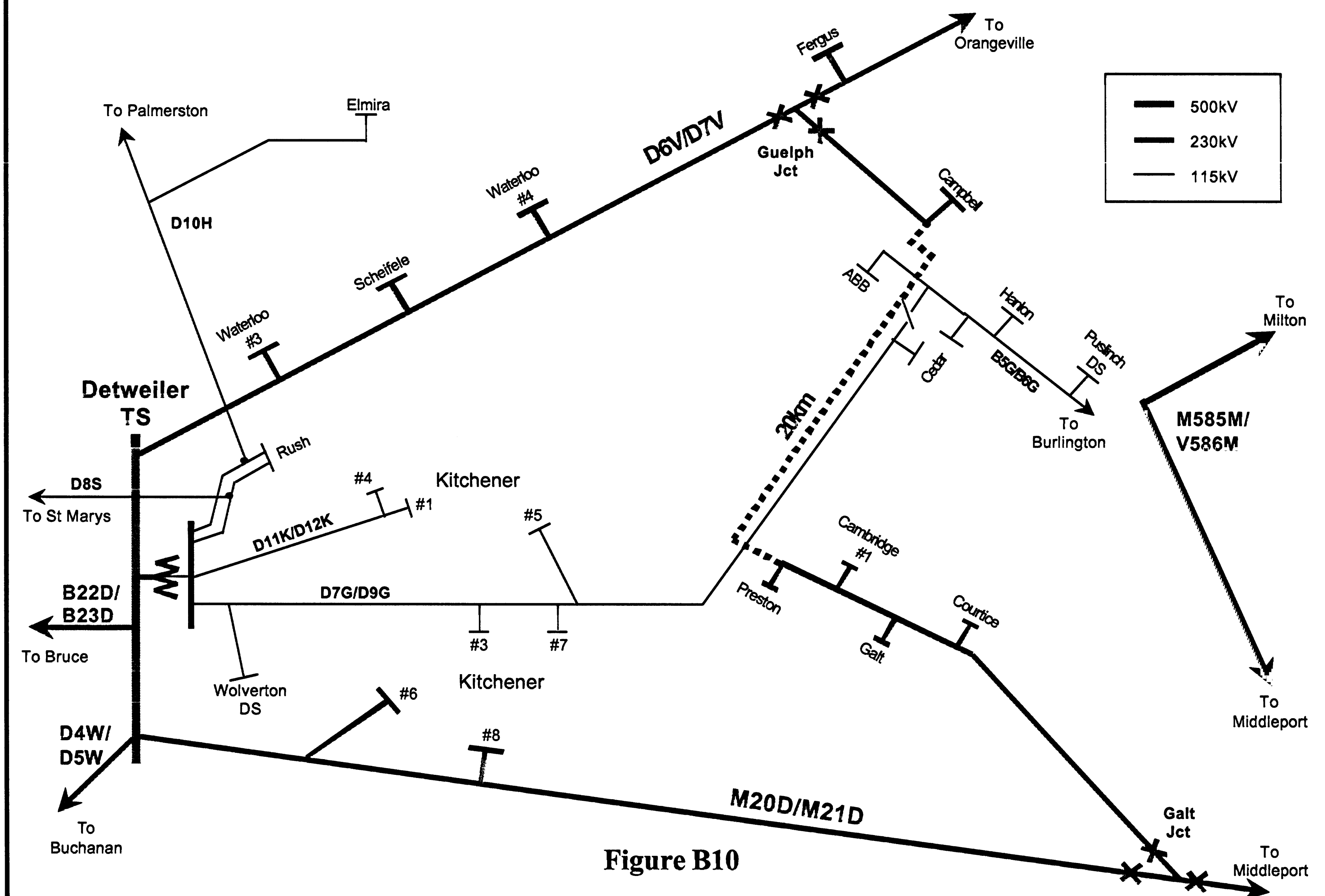


Figure B10

2011 Westbound: Galt x Guelph Loop

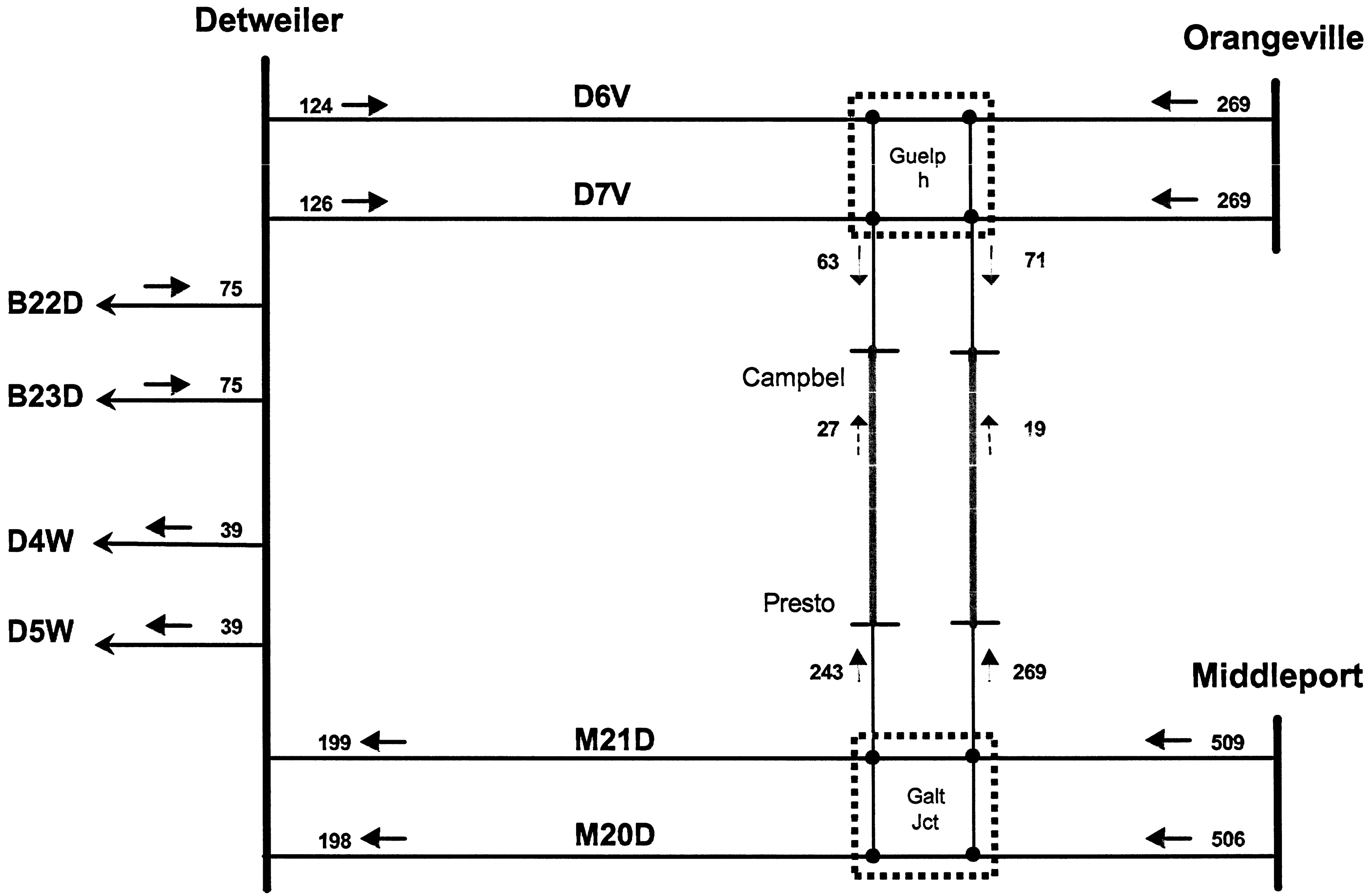


Figure B11

2011 Westbound: Galt x Guelph Loop - Loss of M20D

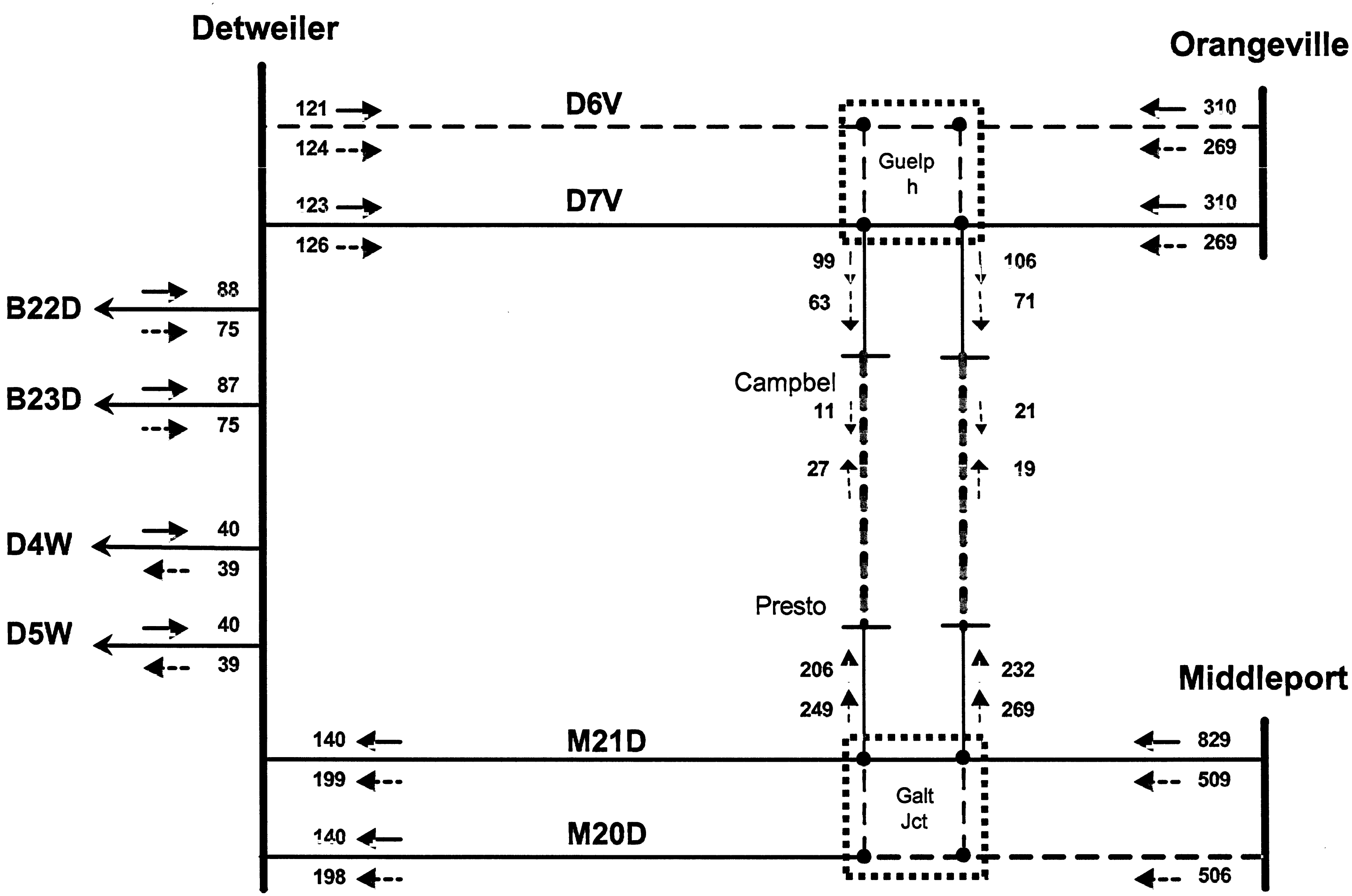


Figure B12

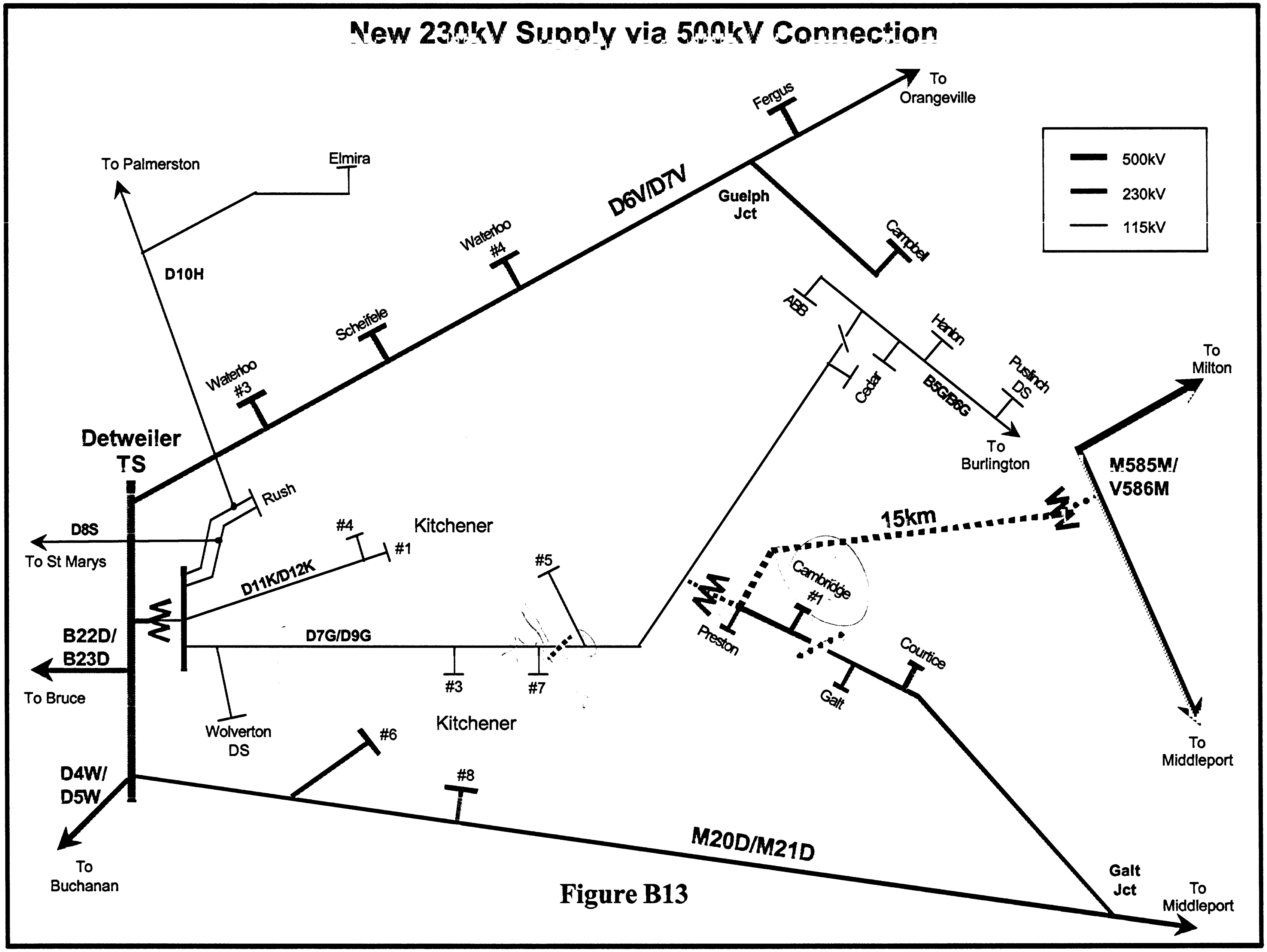

New 230kV Supply via 500kV Connection
500kV
230kV
115kV
To Orangeville
Fergus
D6V/D7V
Guelph Jct
Campbel
To Palmerston
Elmira
D10H
Waterloo #4
Scheifele
Waterloo #3
Detweiler TS
Rush
D8S
To St Marys
#4
#1
Kitchener
D11K/D12K
B22D/ B23D
To Bruce
D7G/D9G
#5
#3
#7
Wolverton DS
Kitchener
#6
#8
D4W/ D5W
To Buchanan
M20D/M21D
Galt Jct
To Middleport
ABB
Cedar
Hanlon
B5G/B6G
Puslinch DS
To Burlington
To Milton
M585M/ V586M
15km
Cambridge #1
Preston
Galt
Courtice
To Middleport

Figure B13