REPORT

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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

Project: *Windsor Area Transmission Reinforcement*

Applicant: Hydro One Networks Inc.

CAA ID 2008-318

Final Draft Report

Market Facilitation Department

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System Impact Assessment Report

Windsor Area Transmission Reinforcement

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Approval of the proposed connection is based on information provided to the IESO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by the transmitter(s) at the request of the IESO. Furthermore, the connection approval is subject to further consideration due to changes to this information, or to additional information that may become available after the approval has been granted. Approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed facility to the IESO-controlled grid. However, connection approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that it is using the most recent version of this report.

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Special Notes and Limitations of Study Results

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result

of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPGI) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings 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.

The additional facilities or upgrades which are required to incorporate the proposed connection have been identified to the extent permitted by a preliminary assessment under the current IESO Connection Assessment and Approval process. Additional facility studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

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SIA Findings

The proposed Windsor area transmission reinforcement is a developmental project which is required to provide reliable power supply to the Windsor area loads.

Conclusions

This System Impact Assessment has examined the impact of the proposed Windsor Area Transmission Reinforcement, on the reliability of the IESO-Controlled grid. The studies concluded that:

1. The proposed project will not have a materially adverse effect on the reliability of the IESO-Controlled grid.

2. The increases in fault level, due to the proposed Windsor Area Transmission Reinforcement, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

3. The proposed project will significantly improve the voltage profile and increase the power supply capability in Windsor area.

4. All the pre-contingency voltages, post-contingency voltages and voltage declines meet Market Rules requirements.

5. No thermal overload concerns were identified for the monitored transmission circuits in the studied scenarios. All power flows on the monitored circuits were observed to be within the continuous ratings of the circuits.

6. With the reinforcement project the frequency of using Connectivity-based LR scheme and Voltage-based LR scheme will be significantly reduced.

Notification of Approval for Connection Proposal

It is recommended that Notification of Conditional Approval for connection be issued to Hydro One, subject to IESO's Requirements for Connection listed below, and any further requirements that may be identified by Hydro One Networks Inc. in the Customer Impact Assessment.

IESO's Requirements for Windsor Area Transmission Reinforcement Connection

The IESO requirements for the connection of the proposed Windsor Area Transmission Reinforcement are as follows:

- To meet the load power factor requirement at the new Leamington TS LV 10 MVAr shunt capacitors are required to be installed and available in 2012. Hydro One and the area LDC shall work together to initiate a plan for reactive load compensation at the station and/or customer side to ensure compliance with the Market Rules and to inform the IESO.

- HONI is required to install facilities at the Leamington TS to allow for the detection of under frequency conditions, and the selection and tripping of feeder circuit breakers for load shedding, for immediate or future deployment. In the event that the existing under frequency load shedding (UFLS) area load is insufficient in meeting the UFLS targets with the addition of Leamington TS, HONI is required to submit during the IESO Market Entry process a revised schedule of feeder selections and their related load amounts for each shedding stage that will ultimately satisfy the UFLS targets

- Hydro One is required to commit to install voltage reduction capability that provides 3% and 5% voltage reduction within five minutes.

- Hydro One is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.

- Prior to connection, the connection applicant must demonstrate to the satisfaction of the IESO that the proposed connection will not result in any existing equipment exceeding its rating.

1. Project Description

Hydro One Networks is proposing to increase the power supply capability in Windsor area by reinforcing the local transmission system.

The Windsor area comprises the municipalities of Amherstburg, Essex, Kingsville, Lakeshore, La Salle, Leamington, Tecumseh, and Windsor, and portions of the municipality of Chatham-Kent. Electricity distribution in the area is carried out by ENWIN Powerlines Ltd., Essex Powerlines Corporation, Essex-Lakeshore-Kingsville (E.L.K.) Inc., Chatham-Kent Hydro Inc. and Hydro One.

The Windsor area is bounded by circuits C24Z and C23Z from Chatham to Lauzon, circuits C22J and C21J from Chatham to Keith and by circuit J5D from Keith to Michigan. The Windsor 115 kV area load is supplied from Lauzon 230/115 kV autotransformers T1 and T2, Keith 230/115 kV autotransformers T11 and T12, West Windsor GS G1 and G2, the Windsor TransAlta CGS G1 and G2 and Brighton Beach CGS G1A.

The Windsor Area is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. As a result a number of special protection schemes are employed to facilitate operation of the area. The armed schemes in Windsor area include Connectivity Based L/R Scheme, Voltage Dependent L/R Scheme, Windsor Area Overload Protection Scheme, and Kingsville High-Voltage-Switching Scheme.

The proposed Windsor area transmission reinforcement will address the voltage and overload concerns and increase the area transmission supply capability by providing a new 230 kV power supply point and upgrading transmission circuits and transformers in Windsor area. The proposed project includes modifying the existing system and installing new facilities as follows:

(1) Build 230 kV transmission line from Sandwich Jct (C21J/C22J) to Lauzon TSand reconfigure the existing terminations at Lauzon TS

(2) Install a new 230/27.6 – 27.6 kV DESN, Leamington TS, that will connect circuits C21J and C22J and supply part of the existing Kingsville TS load

(3) Upgrade 115 kV circuits J3E/J4E

(4) Replace Keith transformers T11 and T12

This connection assessment study will examine the proposed (1), (2) and (3) above and their impact on reliability of the IESO-controlled grid. Item (4), the replacement of Keith transformers, will be addressed in a separate SIA study (CAA ID: 2007 - 265).

A schematic diagram of the proposed new 230 kV transmission development, the new configuration at Sandwich Jct and the proposed arrangement of Leamington TS is shown in figures 1, 2 and 3, respectively.

Items (1) and (2) are scheduled for completion by April 2012 . HO indicated that the in service date for the J3E/J4E upgrade, item (3), is uncertain at this time and would depend on the economic situation and load level in the area.

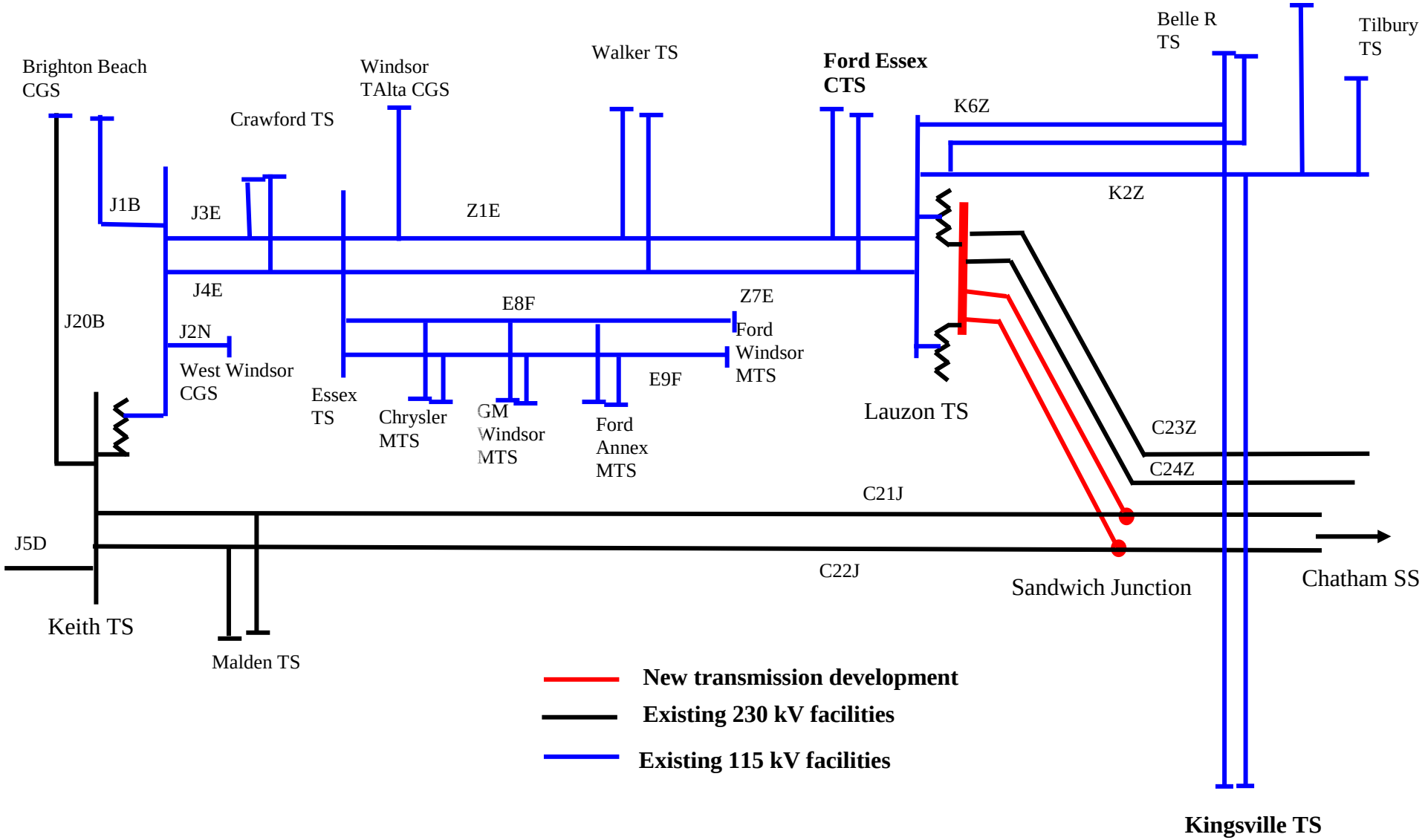

Figure 1: Windsor Area Transmission with New Transmission Development

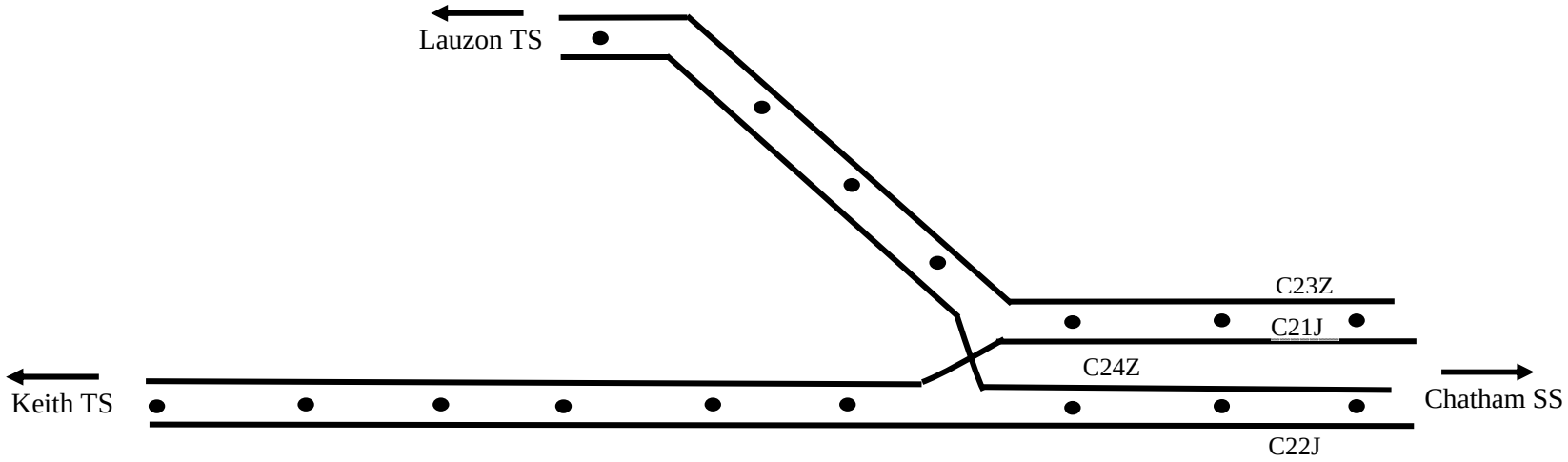

Figure 2A: Existing connections at Sandwich Jct - C21J, C22J, C23Z and C24Z

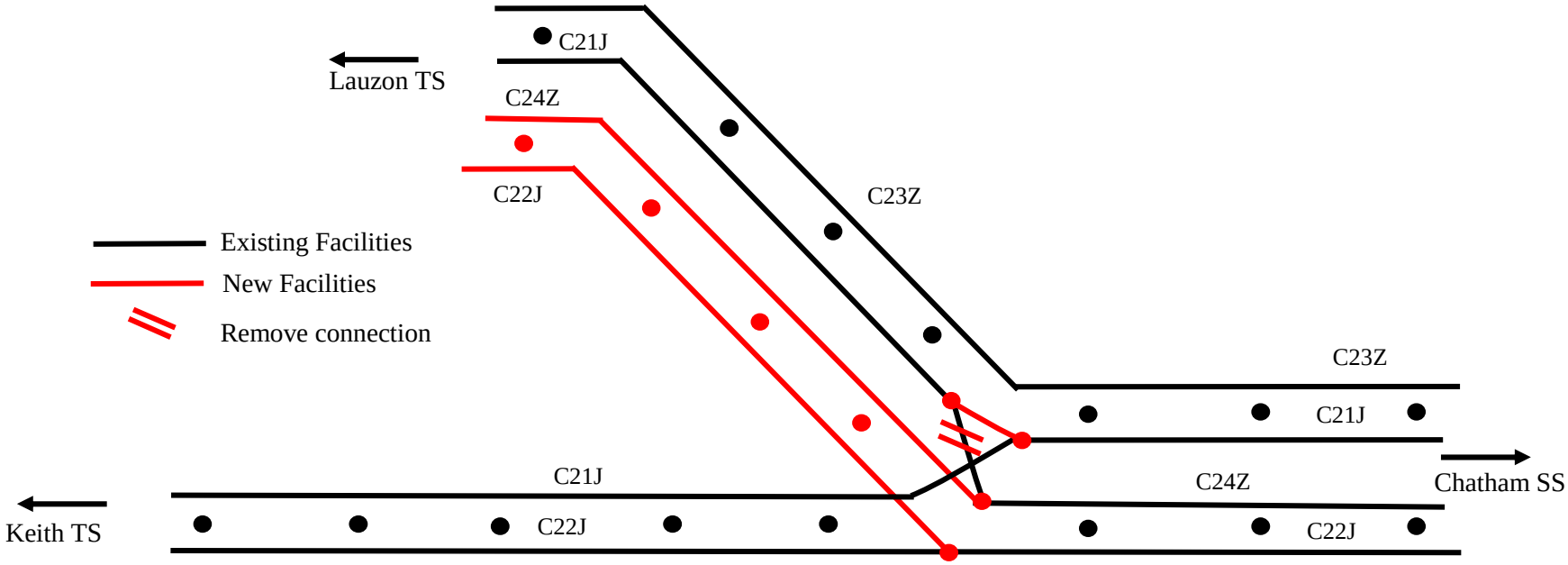

Figure 2B: Planned connections at Sandwich Jct - C21J, C22J, C23Z and C24Z

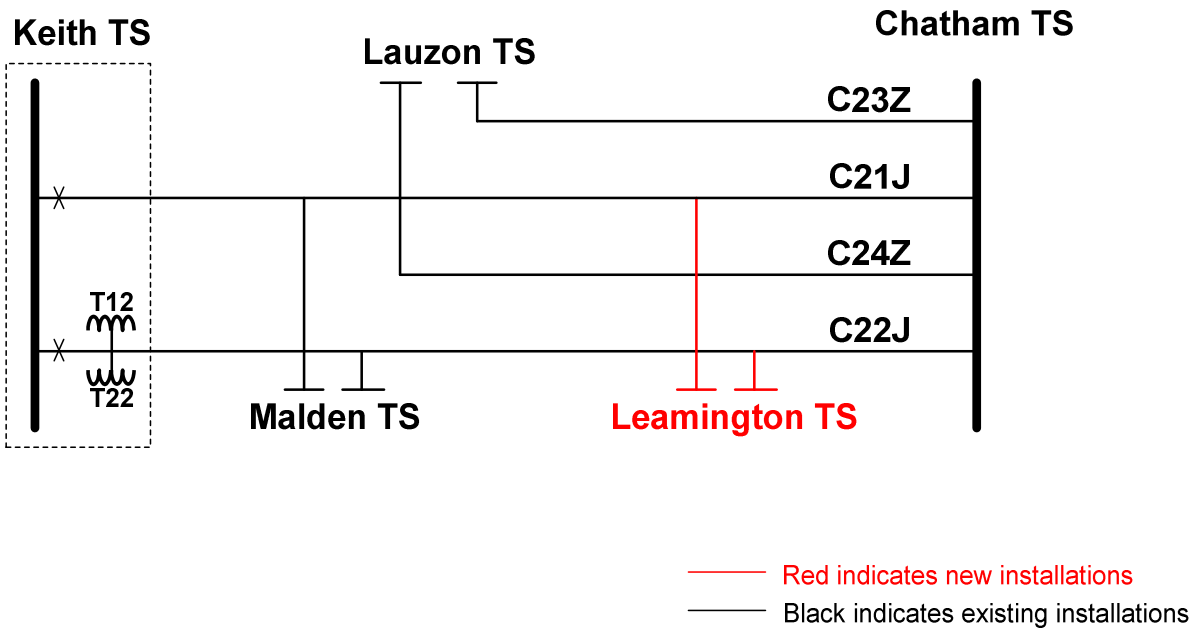

Figure 3: Location of Leamington TS

2. Review of Connection Proposal

2.1 Connection Arrangement

2.1.1 Lauzon SS

The 230 kV existing terminations at Lauzon SS are shown in Figure 4. This work will involve terminating the new circuits and reconfiguring the existing terminations as shown in Figure 5.

All 230 kV equipment and connections should be capable of operating at a continuous voltage of 250 kV and are to have a summer continuous rating of 3000A.

All 230 kV breakers are to have capable of interrupting a fault current of 63 kA symmetrical at 250 kV with a three cycle interrupting capability. All line and breaker disconnect switches are to be motorized and capable of being remotely controlled.

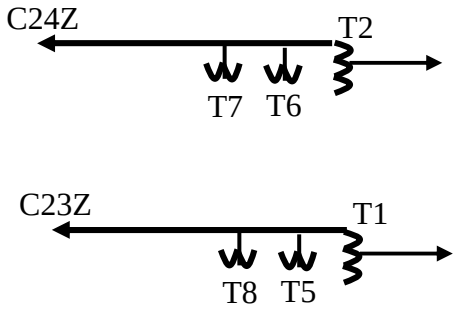

Figure 4: Existing 230 kV Connections at Lauzon TS

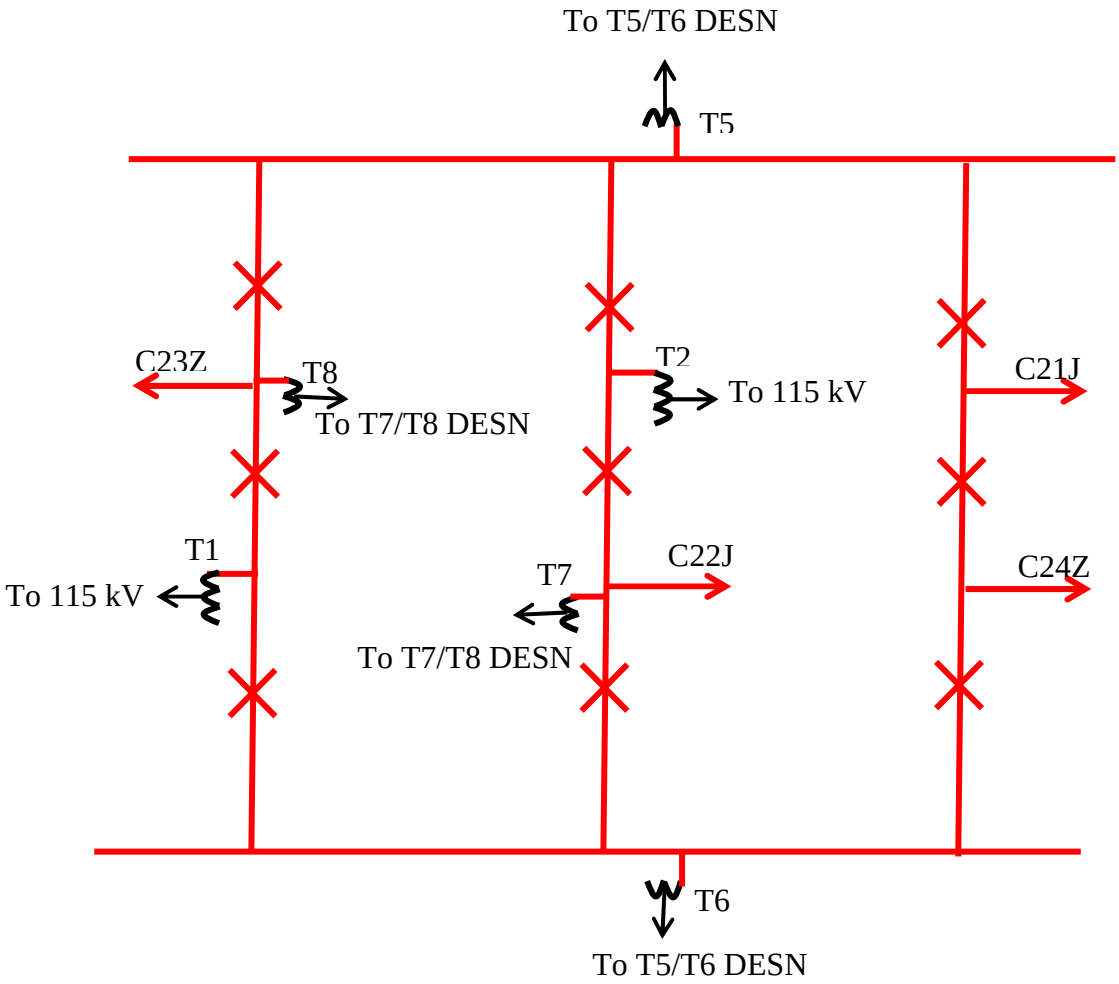

Figure 5: New 230 kV Connections at Lauzon TS

2.1.2 Leamington TS

South Essex County is currently supplied by Kingsville TS. The peak load at Kingsville TS exceeds the 10-day LTR of the station and the circuits that supply Kingsville TS (K2Z and K6Z) are overloaded as well. To relieve Kingsville TS and provide additional load capacity to the area, the WATR project includes building a new station in the municipality of Leamington.

13 km 230 kV line taps will be built on a new right-of-way between the 230 kV Chatham TS to Keith TS corridor and the new Leamington station as shown in Figure 2. The new circuits will tap into C21J/C22J at approximately 47 km from Chatham SS.

The 230 kV line taps are to meet the following requirements:

Nominal system voltage	230 kV
Maximum continuous operating voltage	250 kV
Continuous rating	800 A
One hour emergency	1050 A
Short circuit capacity	63 kA

The proposed Leamington TS will be equipped with two 75/100/125 MVA, 230/27.6 -27.76 kV transformers. The two transformers are identical and each transformer is configured with a wye winding on the high side (neutral solidly grounded). The LV windings are zig-zag connected (2 windings per transformer) and the neutral is to be grounded through a 1.5 ohm reactor. The neutral reactor shall have a current rating of 1000 A continuous, 6000 A for 15 seconds.

Each transformer is equipped with under-load tap changers located on the 230 kV winding with ± 40 kV voltage band achieved in 32 steps.

The connection applicant indicated that the HV to LV impedance should be approximately 11.35% on the rating of 37.5 MVA for each HV to LV winding.

Hydro One proposes to connect each autotransformer to the IESO-controlled grid via one motor operated 230 kV circuit switcher. Manually operated 3-pole grounding switches are also to be provided. The disconnect switches shall meet the requirements as specified for 230 kV line taps and each disconnect switch shall be rated to interrupt the maximum magnetising current of the specified transformer.

The low voltage facilities will consist of a 27.6 kV switchyard with the switching equipment as shown in the following table.

Table 1: LV Equipment at Leamington TS

Equipment	Number	Nominal Voltage (kV)	Continuous Current Rating (A)	SC circuit Interrupting Capability (kA/cycles)	Normal Operation (Closed/ Open)
Transformer Breakers	4	27.6	2500	17/5	Closed
Bus Tie Breaker	1	27.6	2000	17/5	Closed
Feeder Breakers	6	27.6	1200	17/5	Closed
Feeder Tie Switches	3	27.6	600		Open
Capacitor Breakers	1	27.6	1200	17/5	Closed
Feeder Breaker	6 spaces				
Feeder Tie Switches	3 space				
Capacitor Breakers	1 spaces				

The minimum ratings for LV buses and transformer connections shall be adequate for carrying the transformer 10-day LTR ratings of the 75/125 MVA units.

A new control building will be built to accommodate all new equipment associated with this DESN, including future capacitor bank and feeders to the full compliment of the DESN.

The single line diagram of Leamington TS is shown in Figure 6.

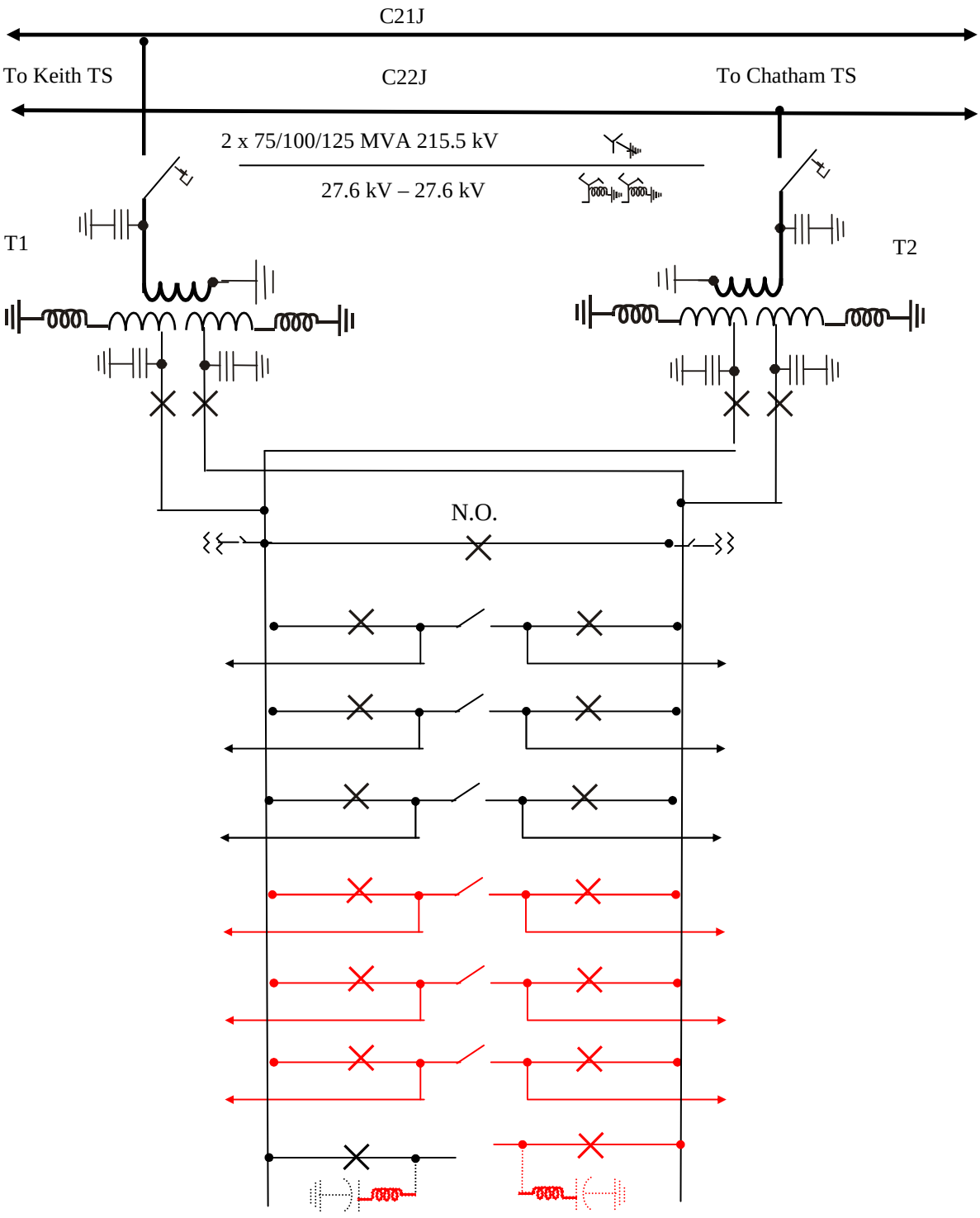

Figure 6: Single Line Diagram of Leamington TS

2.2 Power Factor

The Market Rules require that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range of 90% lagging to 90% leading as measured at the defined meter point.

As indicated by Hydro One, the load at the proposed Leamington TS will be almost half of the load at the existing Kingsville TS. Therefore, the load profile at Kingsville TS can be used as an indication for the typical load profile at Leamington TS.

IESO records indicate that the 2007 average load power factor measured on the LV side at the existing Kingsville TS was 0.98, as shown in Figure 7. The peak load at Kingvsville TS was about 131 MW on the date of system peak demand (June 26).

It should be noted that presently the Kingsville TS is equipped with four low voltage shunt capacitors: 2×20 MVAr and 2×10 MVAr. The graph in Figure 3 shows the power factor after the conpensation of the capacitors.

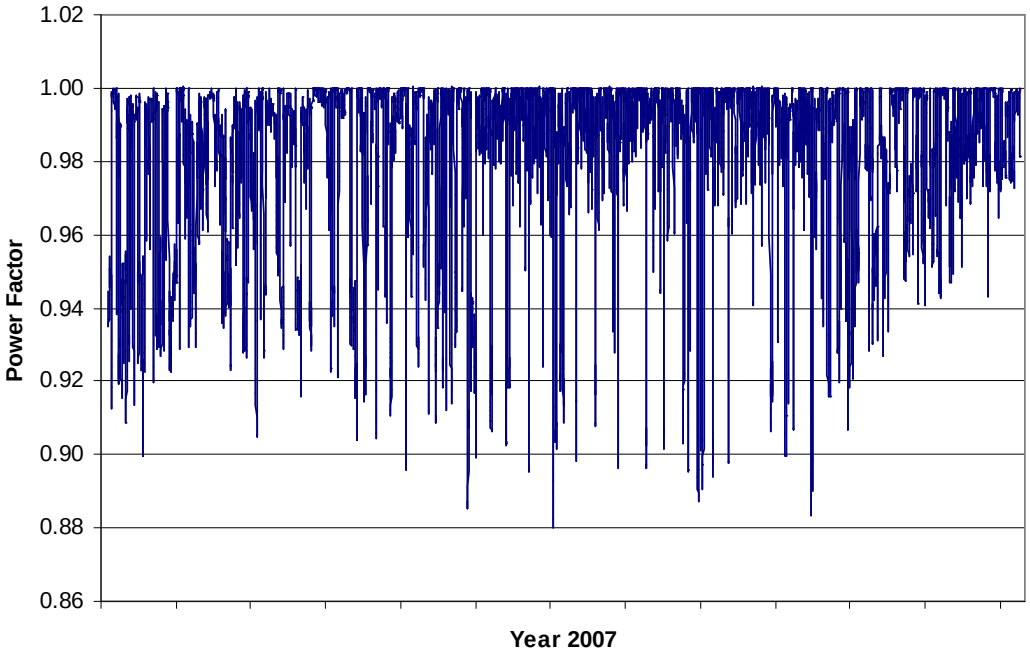

Figure 7: LV Power Factor at Kingsville TS in 2007

Further analysis on the power factor profile was carried out for June 26 considering the service of the LV shunt capacitors. Figure 8 shows the load power factor before the compensation of shunt capacitors.

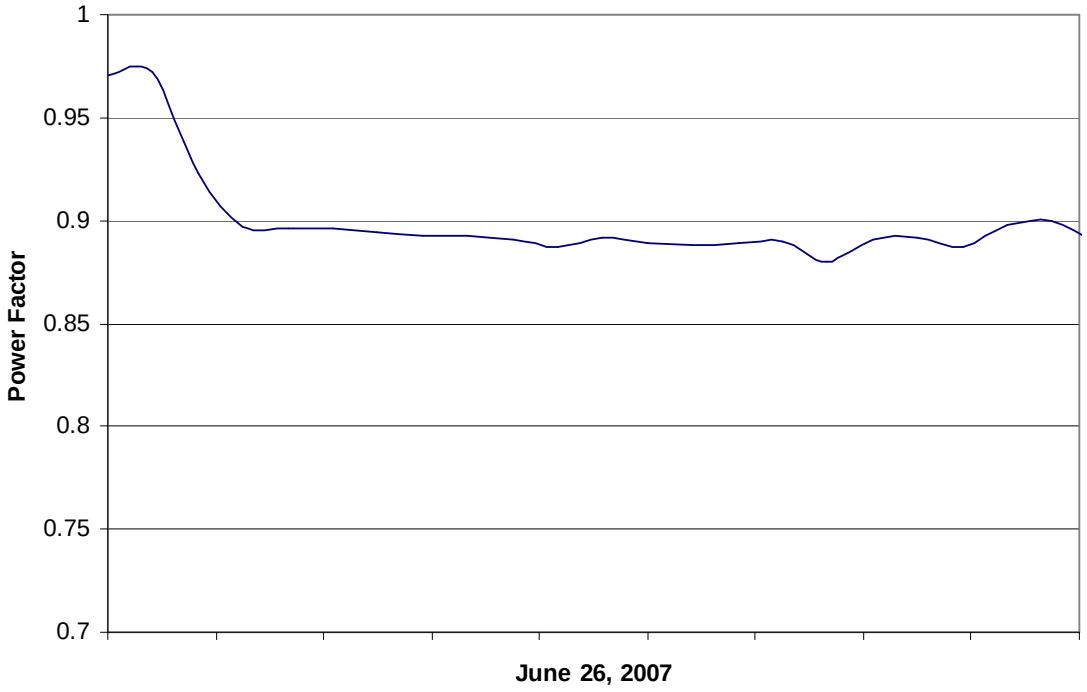

Figure 8: LV Power Factor at Kingsville TS on June 26 Before Compensation

It can be seen that the load power factor was as low as 0.88. using this power factor for the load at Leamington TS it can be concluded that power factor correction equipment must be installed at the new station. Based on the load forecast for Leamington TS provided by Hydro One, further study was carried out to figure out the time schedule for the needed reactive compensation. The reactive power consumed by the transformers was estimated and the results are shown in Table 2 below.

Table 2: Reactive Power Compensation at Leamington TS

Year	2012	Ultimate
28.8 kV Load (MW)	60	180
Mvar at LV with 0.88 p.f.	32.5	97
Mvar at HV with Loss in Transformers	36	128.6
Compensation Needed for 0.9 p.f (Mvar)	7	37

Based on the load information at Kingsville the power factor at the defined metered point at Leamington TS will be below 0.9 lagging when the station is placed in service. As the load increases, additional reactive compensation will become necessary. Hydro One and the area LDC shall work together to initiate a plan for reactive load compensation at the station and/or customer side to ensure compliance with the Market Rules and to inform the IESO.

To meet the load power factor requirement at the new Leamington TS LV 10 MVAr shunt capacitors are required to be installed and available in 2012.

Appendix 4.4 of the Market Rules states that it is a required for all Transmitters to maintain abrupt voltage changes less than 4% of steady state rms for capacitor switching operations.

Further study was performed to investigate if the effect of LV capacitors switching on the voltage performance meets Market Rules requirements. 10 Mvar LV capacitors were placed on the LV sides of the new leamington DESN. Voltages pre and post capacitor switching were captured in order to distinguish voltage changes and the results are summarized in Table 3.

Table 3: Voltage Study: with Capacitor Switching Operations

Bus	Bus Voltage (kV)	Voltage Pre-Caps (pu)	Voltage Post-Caps (pu)	Voltage Difference (%)
Leamington 230 kV	230	247.42	249.46	0.82
Leamington 27.6 kV	27.6	29.56	30.12	1.89

As shown in Table 3, both the HV bus and LV bus connected to the New Leamington DESN exhibit voltages changes less than 4% which meets Market Rules requirements.

2.3 Underfrequency Load Shedding Requirements

The Market Rules (Chapter 5, Section 10.4) require that each distributor and connected wholesale customer, in conjunction with the relevant transmitter, make arrangements to enable the automatic disconnection of up to 35% of its peak demand for conditions of system under-frequency. For the purposes of administrating this, the province is divided up into a number of UFLS areas and the UFLS targets must be met for each of these areas.

A detailed description of the UFLS requirements is given is Market Manual 7: System Operations, Part 7.4, Chapter 4, Section 4.4

HONI is required to install facilities at the Leamington TS to allow for the detection of under frequency conditions, and the selection and tripping of feeder circuit breakers for load shedding, for immediate or future deployment. In the event that the existing under frequency load shedding (UFLS) area load is insufficient in meeting the UFLS targets with the addition of Leamington TS, HONI is required to submit during the IESO Market Entry process a revised schedule of feeder selections and their related load amounts for each shedding stage that will ultimately satisfy the UFLS targets.

2.4 Voltage Reduction Facilities Requirements

The Market Rules (Chapter 4 Appendix 4.3) require that distributors connected to the IESO controlled grid with directly connected load facilities of aggregated rating of 20 MVA or more and the capability to regulate distribution voltage under load, shall install and maintain facilities to provide voltage reduction capability to achieve load reduction during periods when supply resources are limited. Voltage reduction capability represents the capability of reducing demand by lowering the customer voltage by 3% and 5% and having the controlling authority to be able to effect the voltage reduction within five minutes of receipt of the direction from the IESO.

Hydro One is required to commit to install voltage reduction capability that provides 3% and 5% voltage reduction within five minutes.

2.5 On-line Monitoring

The Market Rules (Chapter 4 section 7.4) require that each transmitter shall provide the IESO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. It is required that Hydro One install all the equipment needed to monitor the information required by the IESO on a continuous basis.

The IESO requires that the following quantities at Lauzon TS and Leamington TS be provided to the IESO on a continual basis via approved communication protocols:

Lauzon TS:

1. The status of the 230 kV breakers and disconnect switches
2. The voltage on the 230 kV bus
3. The real and reactive power flow on 230 kV transmission lines

Leamington TS:

1. The status of the 230 kV disconnect switches
2. The voltage on the 230 kV bus
3. The real and reactive power flow through both transformers
4. The transformer tap position for both transformers
5. The voltage on the 27.6 kV bus
6. The status of the transformer 27.6 kV breakers

Hydro One is required to install all the equipment needed to continuously monitor the information that is required by the IESO. The IESO will finalize items to be monitored during the IESO Facility Registration Process.

2.6 Protection Systems

With respect to the protection and telecommunication requirements, the connection applicant will have to follow the Transmission System Code technical requirements for tapped transformer stations supplying load.

The diagram that was provided by the applicant shows each transformer being separated from the transmission system via a motorized disconnection switch. For this particular arrangement the Transmission System Code requires that transfer trip of the Transmitter's breakers at the terminal stations be provided for transformer faults or for a condition of failure to operate of the LT breakers. In the case of Leamington TS, which is to be connected to the double circuit 230 kV lines C21J/C22J the transfer trip must be sent to the Keith TS, Chatham TS and Lauzon TS terminals of the faulted circuit.

The connection applicant indicated that standard protective relaying is to be provided for the new Leamington TS. The existing C21J/C22J protections at Chatham and Keith will be reviewed and modified as required to accommodate the new proposed connections.

– End of Section –

3. Data Verification

Based on standards for supply of municipal electrical utilities the capability of a transformer station is defined as the maximum load that one transformer can carry for a predefined period of time. This value is usually computed using specific transformer data and daily loading curves, and temperature data specific to the transformer location. Hydro One has provided a 10 day summer Limited Time Rating of 200 MVA.

The system performance standards listed in the Transmission System Code require that the 230 kV system fault levels not exceed 63 kA. The connection applicant has indicated that all new 230 kV equipment and components are capable of withstanding (interrupting) the effects of the station short circuits currents of 63 kA.

A full description of the connection arrangement of the proposed Windsor Area Transmission Reinforcement is included in Section 2.1 of this report.

– End of Section –

4. Fault Level Assessment

Fault level studies were completed by Hydro One to specifically examine the effect of the Windsor Area Transmission Reinforcement (WATR) on fault levels at existing facilities.

Table 4 summarizes the symmetric fault levels near Leamington TS. In the study the system with one transformer at Leamington TS in service was used to represent the existing system.

Table 4: Fault Levels Near Leamington TS

BUS BAR		Symmetrical Fault Current in KA		Asymmetrical Fault Current in KA	
		3-phase	L-G	3-phase	L-G
Chatham 230 kV	Existing	21.8	14.3	23.5	15.3
	With WATR	21.9	14.5	23.6	15.5
Lauzon 230 kV	Existing	10.0	10.1	11.2	12.2
	With WATR	17.2	16.1	19.3	19.1
Leamington 230 kV	Existing	7.0	5.3	7.4	5.4
	With WATR	8.0	5.8	8.6	6.0
Leamington 27.6 kV	Existing	6.1	4.9	7.7	5.0
	With WATR	12.0	9.8	15.0	9.9
Malden 230 kV	Existing	16.1	16.0	18.9	17.7
	With WATR	17.5	17.3	20.4	19.2
Keith 230 kV	Existing	19.8	21.9	26.7	30.6
	With WATR	21.0	23.2	28.3	32.2

* Based on a pre-fault voltage level of 250 kV for the 220 kV system and a pre-fault level of 29 kV for the 27.6 kV system.

The results in Table 4 generally show that there is a slight increase in fault currents with the addition of the WATR except for the fault level at Lauzon TS. However, the fault levels meet the requirements of Hydro One equipment in the stations identified. Therefore, it can be concluded that the increases in fault level, due to the proposed Windsor Area Transmission Reinforcement, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

– End of Section –

5. Further Analysis

This connection assessment study concentrated on identifying the effect of the proposed Windsor Area Transmission Reinforcement on thermal loading of the transmission elements and system voltages for pre and post contingency situations.

5.1 Study Assumptions

5.1.1 Load Forecasts

The load forecasts in Windsor area before and with conservation were provided by Hydro One. The summer peak loads in 2010 are summarized in Table 5. The load before conservation was used in the For voltage decline studies, these loads were modeled as voltage dependant loads; P was modeled as 50% constant impedance and 50% constant current and Q was modeled as 100% constant impedance.

Table 5: Load levels assumed in the study

Station	Before Conservation		With Conservation	
	P (MW)	Q (MVAr)	P (MW)	Q (MVAr)
Tilbury TS	1.4	0.46	1.3	0.43
Tilbury West DS	25.2	11.16	23.2	10.28
Kingsville	154.3	74.24	143.8	69.19
Walker #2	98.4	49.25	91.3	45.7
Walker	73.5	36.75	68.2	34.1
Essex	50.1	25.05	46.5	23.25
Crawford	95	47.5	88.6	44.3
Keith BY	74.8	38.84	70.3	36.5
Malden Y	69	34.5	63.8	31.9
Malden B	89.6	44.85	82.9	41.5
Lauzon EJ	97	48.48	90.1	53.39
Lauzon BQ	108.3	54.15	100.6	50.3
Ford Essex	8.5	3.98	7.6	3.56
Chrysler	36.7	16.43	32.9	14.73
GM Windsor	18.9	10.54	17	9.48
Ford Annex	12	2.81	10.8	2.53
Ford Windsor	16.7	3.92	15	3.52
Belle River	34.6	17.3	32.7	16.35
Total	1064	520.21	986.6	491.01

5.1.2 System Scenario

This system impact study was performed for 2010 summer peak area loads.

The Windsor 115 kV System was considered to be ‘closed’ in this study which means there is a continuous 115 kV transmission path between Lauzon TS and Keith TS.

Data from Kruger Wind Farm project which is ahead of the Reinforcement project was then added. The total generation assumed in this study is shown in Table 6. Depending on the scenario, Brighton Beach generation will be different from what is shown below.

Table 6: Generation assumed in the study

Generator	Output (MW)
West Windsor GS	135.2
Windsor TransAlta	64.8
Brighton Beach	525.2
Kruger Wind Farm	100
East Windsor Cogeneration Center	95

5.1.3 Flow on J5D

The following graphs show the MW flow on J5D in one hour average samples during the period of Jan 1-Dec 31, 2007. The positive is flow out of Ontario.

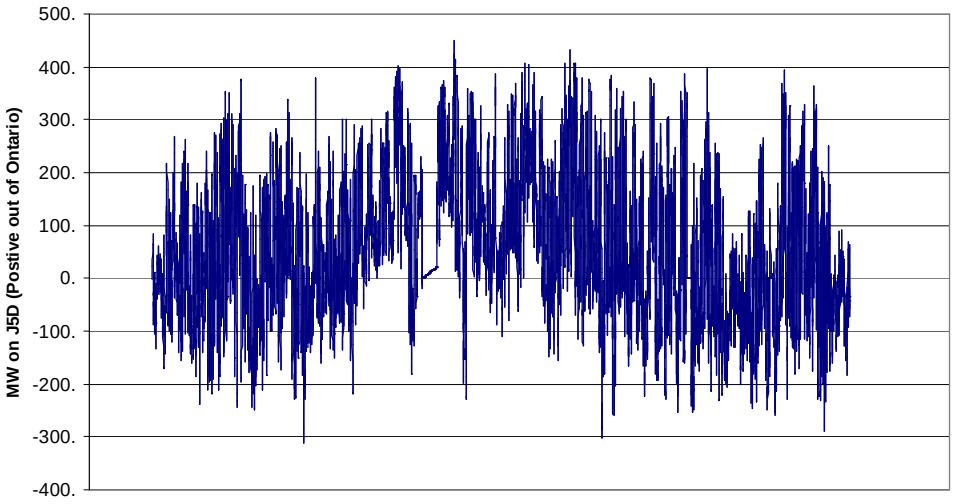

Figure 9: Flow on J5D in 2007

It can be seen that the maximum import and export on J5D could be 300 MW and 400 MW, respectively. However, the import on J5D can not exceed 150 MW when Brighton Beach is at full output, because the loss of the Brighton Beach generating station will overload J5D. Therefore, the maximum import on J5D is 150 MW while the maximum export is 400 MW in this study.

5.1.4 Cases Studied

Based on the above assumptions three cases were developed for this study - a case without Brighton Beach in service during peak load conditions, an import on J5D case and an export on J5D case. The first case stressed the 230 kV transmission lines that supply the Windsor area and the second case stressed the 115 kV transmission lines in the Windsor area. The export case stressed the autotransformers at Keith.

Three cases are described in Table 7 below.

Table 7: Three Cases Studied

Case	Conditions	Total generation (MW)	Total Load (MW)	Status of Brighton Beach	MW Flow on J5D (positive is out of Ontario)
1	Brighton Beach out	395	986.6	Out of service	0
2	Export	920	986.6	In service	400
3	Import	920	986.6	In service	-150

For all three cases, load flow studies were completed to ensure that the pre-contingency and post-contingency flows on the transmission system and the voltage declines satisfied the IESO's requirements.

5.1.5 115 kV Circuits J3E/J4E

Hydro One is going to upgrade 115 kV circuits J3E/J4E (Keith × Essex).

The Keith × Essex 115 kV circuits J3E and J4E (12.2 km) are strung with 795 kcmil (26/7) ACSR conductor. The summer emergency ratings (127°C conductor temperature or sag limit) of the circuits are 1070 A and 1000 A, respectively. The summer continuous rating (93°C conductor temperature) of both circuits is 810 A.

After upgrading the circuits are to have the following ratings as provided by Hydro One:

- Maximum Operating Voltage: 127 kV
- Maximum Continuous Rating: 1100 A (Summer, 35 °C, 4 km/hr wind speed)
- Maximum Emergency Rating: 1600 A (Summer, 35 °C, 4 km/hr wind speed)

The above ratings are used in this assessment.

5.1.6 Recognized Contingencies

The recognized contingencies in the Windsor area which were studied in this assessment are summarized in Table 8 below.

Table 8: Recognized Contingencies

Single Contingencies:	Double Contingencies:
1. J3E	1. C21J + C23Z
2. J4E	2. C21J + C22J
3. Z1E	3. C22J + C24Z
4. Z7E	4. C23Z + C24Z
5. C22J	5. J4E + J3E
6. C21J	
7. C23Z	
8. C24Z	
9. K2Z	
10. K6Z	

5.2 Voltage Analysis

The following IESO criteria must be satisfied before any new equipment is connected to the transmission system:

1. The pre-contingency voltage on 230 kV buses can not be less than 220 kV.
2. The post-contingency voltage on 230 kV buses can not be less than 207 kV.
3. The pre-contingency voltage on 115 kV buses can not be less than113 kV.
4. The post-contingency voltage on 115 kV buses can not be less than 108 kV.
5. The voltage drop following a contingency can not exceed 10% pre-ULTC and 10% post-ULTC.

Load flow studies have been carried out for each case to examine the voltage declines at various buses in the Windsor area for all of the recognized contingencies. The results including pre-contingency voltages, pre-ULTC voltages and post-ULTC voltages are attached in Appendix A. The pre-ULTC voltage declines are the voltage declines before the automatic taps on the transformers move and the post-ULTC voltage declines are the voltage declines after the taps move.

In order to easier identify voltage analysis results from Appendix A, a summary of the contingency results showing bus suffering the largest voltage declines is tabulated in Table 9. In case where double circuits exits, the loss of either companion circuit results in similar post-contingency voltage. Therefore, single contingency results for only one companion circuit are presented.

Table 9: Summary of Voltage Study Results

Case 1					
Contingency	**Bus suffering greatest voltage decline**	**Voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**Voltage decline %**
C21J+C23Z	Malden B 27.6 kV	-7.3	J3E	Crawford 115 kV	4.6
C21J+C22J	Keith 220 kV	2.9	Z1E	Walker 27.6 kV	-6.0
C22J+C24Z	Malden B 27.6 kV	-6.8	C21J	Malden B 27.6 kV	-6.5
C23Z+C24Z	Belle River 115 kV	-1.9	C23Z	Lauzon 27.6 kV	-1.2
J4E+J3E	Walker 115 kV	0.7	K2Z	Belle River 27.6 kV	-3.3
Case 2					
Contingency	**Bus suffering greatest voltage decline**	**voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**voltage decline %**
C21J+C23Z	Malden B 27.6 kV	-6.3	J3E	Crawford 115 kV	4.9
C21J+C22J	Chatham 220 kV	1.3	Z1E	Walker 115 kV	-6.5
C22J+C24Z	Malden B 27.6 kV	-6.0	C21J	Malden B 27.6 kV	-5.9
C23Z+C24Z	Lauzon 27.6 kV	-1.5	C23Z	Lauzon 27.6 kV	-0.8
J4E+J3E	Keith 115 kV	-0.3	K2Z	Belle River 27.6 kV	-3.3
Case 3					
Contingency	**Bus suffering greatest voltage decline**	**voltage decline %**	**Contingency**	**Bus suffering greatest voltage decline**	**voltage decline %**
C21J+C23Z	Malden B 27.6 kV	-6.5	J3E	Crawford 27.6 kV	4.8
C21J+C22J	Tilbury 115 kV	-1.5	Z1E	Walker 27.6 kV	-5.2
C22J+C24Z	Malden B 27.6 kV	-6.2	C21J	Malden B 27.6 kV	-6.1

C23Z+C24Z	Belle River 27.6 kV	-1.2	C23Z	Malden B 27.6 kV	-0.7
J4E+J3E	Keith 220 kV	-0.3	K2Z	Belle River 27.6 kV	-3.1

The study results indicate that all the pre-contingency voltages and post-contingency voltage declines meet the Market Rules requirements.

5.3 Thermal Study

This section covers an investigation of thermal capability of the 230 kV and 115 kV circuits and transformers related to the proposed project and any new thermal problems introduced by the new project.

Load flow studies have been carried out to examine the thermal loading capability for transmission elements with the proposed Windsor Area Transmission Reinforcement project. The results including circuit and transformer ratings are attached in Appendix B. The pre-contingency flow on each transmission element is expressed as a percentage of the continuous rating and the post-contingency flow on each transmission element is expressed as a percentage of either the emergency rating or the 15 min. LTR. The 15 min. LTR was used if there are post-contingency actions available that can reduce the flow on that transmission element to its emergency rating; otherwise, the emergency ratings were used.

In order to easier identify thermal analysis results from Appendix B, a summary of the pre-contingency and post-contingency results showing line with greatest % loading and magnitude of % loading is tabulated in Table 10.

Table 10: Summary of Thermal Study Results

Case 1					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	C22J	48	J3E	C21J	44
C21J+C23Z	C22J	75	Z1E	Z7E	70
C21J+C22J	C24Z	53	C21J	C22J	58
C22J+C24Z	C21J	54	C23Z	C24Z	47
C23Z+C24Z	C22J	70	K2Z	K6Z	37
J4E+J3E	C24Z	38			
Case 2					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	C22J	40	J3E	J4E	50
C21J+C23Z	C22J	61	Z1E	Z7E	61
C21J+C22J	C24Z	37	C21J	C22J	48
C22J+C24Z	K2Z	36	C23Z	C22J	44
C23Z+C24Z	K2Z	36	K2Z	K6Z	36
J4E+J3E	C24Z	38			
Case 3					
Contingency	**Line with greatest % percentage**	**% Loading**	**Contingency**	**Line with greatest % percentage**	**% Loading**
Pre-C	C21J	51	J3E	J4E	67
C21J+C23Z	C22J	84	Z1E	Z7E	68
C21J+C22J	J4E	70	C21J	C22J	78

C22J+C24Z	C21J	80	C23Z	C21J	48
C23Z+C24Z	C21J	49	K2Z	K6Z	66
J4E+J3E	C22J	64			

The results indicate that pre-contingency power flows are far below the circuit continuous ratings and the post-contingency power flows on the remaining circuits are well within the LTR of the circuits. Therefore, it can be concluded that there is no thermal concern for the 230 kV and 115 kV circuits with the proposed Windsor Area Transmission Reinforcement project.

The results in Appendix B also show the percentage loading on the transformers as well as the transformer ratings in Windsor area.

5.4 SPS in Windsor Area

As described in Project Description, the Windsor Area is susceptible to a variety of operational problems including pre-contingency voltage instability, post-contingency voltage decline and thermal overload. As a result a number of special protection schemes are employed to facilitate operation of the area such as Connectivity Based L/R Scheme, Voltage Dependent L/R Scheme, Windsor Area Overload Protection Scheme, and Kingsville High-Voltage-Switching Scheme. It should be noted the studied results showed in this report did not take account these schemes.

5.4.1 Connectivity Based L/R Scheme

In the existing system a number of single and double element contingencies can result in excessive post-contingency voltage declines at Kingsville and Tilbury. The Connectivity Based L/R Scheme is intended to address the loss of the Lauzon 230/115 kV connection which may result in excessive voltage declines and/or voltage collapse at high load levels. Upon detection of the loss of the Lauzon 230/115 kV connection, the scheme trips circuits K2Z and K6Z at Lauzon, and Lauzon SC12.

The study results show that with the Windsor Area Transmission Reinforcement project the Windsor local area system performance will be significantly improved. With the new configuration at Lauzon TS, the frequency of using the scheme will be significantly reduced.

5.4.2 Voltage Dependent L/R Scheme

In the existing system, Kingsville 115 kV buses may experience an unacceptable level of voltage declines following contingencies that result in the loss of circuits C23Z and/or C24Z. The voltage dependent L/R scheme is designed to trip up to two blocks of load at the 27.6 kV Kingsville TS bus when the voltage at the 115 kV Kingsville TS buses remain below 106 kV for 7 seconds.

As almost half of the Kingsville load will be transferred to the proposed Leamington TS the voltage is not a concern anymore as showed in the study results. The voltage dependent L/R scheme will be required only when the load at Kingsville is heavy.

5.4.3 Windsor Area Overload Protection Scheme

The Windsor Area Overload Protection Scheme located at Keith TS is designed to mitigate post contingency thermal overload of Keith autotransformers and circuits emanating from Keith and Essex, and to manage possible high voltage following the splitting of Essex. The scheme provides for the rejection of the Brighton Beach units, the splitting of the Essex HV bus, the tripping of Keith autotransformers T11 and T12, and the tripping of the Keith 115 kV capacitor bank and Essex LV capacitor banks. The scheme is based on network connectivity at Keith and Essex.

Since the Windsor Area Overload Protection Scheme is related to the load capability of Keith autotransformers, it will be investigated in the SIA study for the replacement of Keith transformers (CAA ID 2007- 265).

5.5 Summary

The findings of analysis are summarized as follows:

1. The proposed project will significantly improve the voltage profile and increase the supply capability in Windsor area.

2. Pre-contingency and post-contingency voltages in Windsor area with the proposed project meet Market Rules requirements.

3. There is no thermal overloading concern associated with the 230 kV and the 115 kV circuits with the proposed Windsor Area Transmission Reinforcement project.

4. With the reinforcement project the frequency of using Connectivity-based LR scheme and Voltage-based LR scheme will be significantly reduced.

– **End of Report –**

Appendix A – Voltage Study Results

Table A1 – Pre-ULTC Voltage Declines – Case 1: Brighton Beach out

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	245	-0.1	1.2	0.2	0.0	-0.1	0.0	-0.2	0.0	-0.1	0.0	-0.3	0.0	0.2	0.1	0.2
Lauzon 115 kV	124	-2.3	-0.3	-1.8	-1.8	-0.2	0.0	-0.1	0.3	-0.9	-1.0	-1.0	-0.7	0.4	-0.1	0.6
Keith 115 kV	123	-1.6	0.8	-1.3	-1.4	-0.3	-0.2	-0.7	-0.4	-0.7	-0.8	-0.7	-0.5	0.3	0.0	-0.1
Essex 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Tilbury 115 kV	121	-2.3	-0.3	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Tilbury 27.6 kV	30	-2.3	-0.3	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Tilbury West 115 kV	121	-2.3	-0.3	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Tilbury West 27.6 kV	29	-2.3	-0.3	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Tilbury West 27.6 kV	29	-2.3	-0.3	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Kingsville K6Z 115 kV	123	-2.3	-	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-0.3	-	0.6
Kingsville K2Z 115 kV	122	-2.3	-	-1.9	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Kingsville 27.6 kV	29	-2.3	-	-1.9	-1.9	-0.2	0.0	-0.1	0.3	-1.0	-1.1	-1.0	-0.7	-	-0.1	0.6
Walker Z1E 115 kV	123	-2.0	0.0	-1.6	-1.6	-0.2	-0.1	-	-0.7	-0.9	-1.0	-0.9	-0.6	0.3	-0.1	0.7
Walker Z7E 115 kV	123	-2.0	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-	-0.9	-1.0	-0.9	-0.6	0.4	-0.1	0.7
Walker #2 27.6 kV	29	-2.0	0.0	-1.6	-1.6	-0.2	-0.1	-6.0	-5.7	-0.9	-1.0	-0.9	-0.6	0.4	-0.1	0.7
Walker 27.6 kV	29	-2.0	0.0	-1.6	-1.6	-0.2	-0.1	-3.3	-2.8	-0.9	-1.0	-0.9	-0.6	0.4	-0.1	0.7
Essex 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Essex 27.6 kV	28	-2.0	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Crawford J3Z 115 kV	123	-1.8	0.4	-1.4	-1.5	-	-0.5	-0.9	-0.6	-0.8	-0.9	-0.8	-0.6	0.3	-0.1	-
Crawford J4Z 115 kV	122	-1.8	0.4	-1.4	-1.5	-0.2	-	-0.9	-0.6	-0.8	-0.9	-0.8	-0.6	0.3	-0.1	-
Crawford 27.6 kV	29	-1.8	0.4	-1.4	-1.5	4.6	-6.7	-0.9	-0.6	-0.8	-0.9	-0.8	-0.6	0.3	-0.1	-
Keith 220 kV	237	-1.6	2.9	-1.2	-1.4	-0.2	-0.1	-0.4	-0.1	-0.7	-0.8	-0.7	-0.5	0.3	0.0	0.2
Keith 27.6 kV	29	-1.6	2.0	-1.3	-1.4	-0.2	-0.1	-0.4	-0.1	-0.7	-0.8	-0.7	-0.5	0.3	0.0	0.2
Malden C21J 220 kV	237	-	-	-1.6	-1.5	-0.2	-0.1	-0.4	-0.1	-0.9	-	-0.8	-0.5	0.3	0.0	0.2
Malden C22J 220 kV	237	-1.9	-	-	-1.5	-0.2	-0.1	-0.4	-0.1	-	-1.0	-0.8	-0.5	0.3	0.0	0.2
Malden Y 27.6 kV	30	-5.1	-	-4.7	-1.5	-0.2	-0.1	-0.4	-0.1	-4.0	-4.2	-0.8	-0.6	0.3	0.0	0.2
Malden B 27.6 kV	29	-7.3	-	-6.8	-1.5	-0.2	-0.1	-0.4	-0.1	-6.1	-6.5	-0.8	-0.6	0.3	0.0	0.2
Lauzon C23Z 220 kV	236	-	-1.2	-2.3	-	-0.2	-0.1	-0.3	0.1	-1.2	-1.3	-	-0.8	0.4	0.0	0.3
Lauzon EJ 27.6 kV	29	-2.9	-1.2	-2.4	-	-0.2	-0.1	-0.3	0.1	-1.2	-1.3	-1.2	-0.8	0.4	0.0	0.3
Lauzon BQ 27.6 kV	29	-2.9	-1.2	-2.4	-	-0.2	-0.1	-0.3	0.1	-1.2	-1.3	-1.2	-0.8	0.4	0.0	0.3
Ford Essex Z1E 115 kV	124	-2.2	-0.2	-1.8	-1.8	-0.2	-0.1	-	0.0	-0.9	-1.0	-1.0	-0.7	0.4	-0.1	0.6
Ford Essex Z7E 115 kV	124	-2.2	-0.2	-1.8	-1.8	-0.2	-0.1	-0.4	-	-0.9	-1.0	-1.0	-0.7	0.4	-0.1	0.6
Ford Essex 13.8 kV	15	-2.2	-0.2	-1.8	-1.8	-0.2	-0.1	-1.2	-0.8	-0.9	-1.0	-1.0	-0.7	0.4	-0.1	0.6
Chrysler E8V 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Chrysler E9V 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Chrysler 27.6 kV	29	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
GM Windsor E8F 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
GM Windsor E9F 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
GM Windsor 27.6 kV	29	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Annex E8V 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Annex E9V 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Annex 13.8 kV	15	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Windsor E8F 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Windsor E9F 115 kV	123	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Ford Windsor 27.6 kV	29	-1.9	0.0	-1.6	-1.6	-0.2	-0.1	-1.2	-0.7	-0.9	-0.9	-0.9	-0.6	0.3	-0.1	0.7
Belle River K6Z 115 kV	124	-2.3	-0.3	-1.8	-1.9	-0.2	-0.1	-0.1	0.3	-1.0	-1.0	-1.0	-0.7	-0.3	-	0.6
Belle River K2Z 115 kV	124	-2.3	-0.3	-1.8	-1.8	-0.2	0.0	-0.1	0.3	-0.9	-1.0	-1.0	-0.7	-	-0.7	0.6
Belle River 27.6 kV	29	-2.3	-0.3	-1.8	-1.9	-0.2	-0.1	-0.1	0.3	-0.9	-1.0	-1.0	-0.7	-2.7	-3.3	0.6

Table A2– Post-ULTC Voltage Declines – Case 1: Brighton Beach out

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	245	-0.3	1.2	-0.1	-0.1	-0.1	-0.1	-0.3	0.0	-0.2	-0.2	-0.3	0.0	0.2	0.1	0.2
Lauzon 115 kV	124	-2.7	-0.3	-2.2	-2.0	-0.1	-0.1	-0.3	0.1	-1.1	-1.2	-1.0	-0.7	0.4	-0.1	0.6
Keith 115 kV	123	-1.9	0.8	-1.6	-1.5	-0.2	-0.2	-0.8	-0.5	-0.9	-1.0	-0.8	-0.5	0.2	-0.1	-0.1
Essex 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Tilbury 115 kV	121	-2.8	-0.3	-2.3	-2.1	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	0.7
Tilbury 27.6 kV	30	-1.7	-0.3	-1.1	-2.1	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	-0.5
Tilbury West 115 kV	121	-2.8	-0.3	-2.3	-2.1	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	0.7
Tilbury West 27.6 kV	29	-0.6	-0.3	-0.8	-1.3	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	-0.1
Tilbury West 27.6 kV	29	-0.6	-0.3	-0.8	-1.3	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	-0.1
Kingsville K6Z 115 kV	123	-2.7	-0.3	-2.2	-2.0	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.1	-0.8	-0.3	-	0.6
Kingsville K2Z 115 kV	122	-2.8	-0.3	-2.3	-2.1	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	0.7
Kingsville 27.6 kV	29	-1.4	-0.3	-0.8	-0.6	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.1	0.7
Walker Z1E 115 kV	123	-2.3	0.0	-1.9	-1.8	-0.2	-0.1	-	-1.0	-1.1	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Walker Z7E 115 kV	123	-2.3	0.0	-1.9	-1.8	-0.2	-0.1	-1.4	-	-1.1	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Walker #2 27.6 kV	29	-1.3	0.0	-0.8	-1.8	-0.2	-0.1	-1.7	-1.4	-1.1	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Walker 27.6 kV	29	-2.3	0.0	-1.9	-1.8	-0.2	-0.1	-3.5	-3.1	-1.1	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Essex 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Essex 27.6 kV	28	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Crawford J3Z 115 kV	123	-2.1	0.4	-1.7	-1.6	-	-0.5	-1.1	-0.8	-1.0	-1.0	-0.8	-0.6	0.3	-0.1	-
Crawford J4Z 115 kV	122	-2.1	0.4	-1.7	-1.6	-0.1	-	-1.1	-0.8	-1.0	-1.0	-0.8	-0.6	0.3	-0.1	-
Crawford 27.6 kV	29	-0.9	0.4	-0.5	-0.4	1.0	-1.1	-1.1	-0.8	-1.0	-1.1	-0.8	-0.6	0.3	-0.1	-
Keith 220 kV	237	-1.9	2.9	-1.6	-1.5	-0.1	-0.1	-0.5	-0.2	-0.9	-1.0	-0.8	-0.5	0.2	0.0	0.2
Keith 27.6 kV	29	-0.9	-0.2	-1.6	-1.5	-0.1	-0.1	-0.5	-0.2	-0.9	-1.0	-0.8	-0.5	0.2	0.0	0.2
Malden C21J 220 kV	237	-	-	-1.9	-1.6	-0.1	-0.1	-0.5	-0.2	-1.2	-	-0.8	-0.6	0.3	0.0	0.2
Malden C22J 220 kV	237	-2.3	-	-	-1.6	-0.1	-0.1	-0.5	-0.2	-	-1.3	-0.8	-0.6	0.3	0.0	0.2
Malden Y 27.6 kV	30	1.6	-	2.1	-0.5	-0.1	-0.1	-0.5	-0.2	1.7	1.5	-0.8	-0.6	0.3	0.0	0.2
Malden B 27.6 kV	29	-0.7	-	0.0	-0.5	-0.1	-0.1	-0.5	-0.2	-0.5	-0.8	-0.8	-0.6	0.3	0.0	0.2
Lauzon C23Z 220 kV	236	-3.4	-1.2	-2.7	-2.4	-0.1	-0.1	-0.4	0.0	-1.4	-1.5	-1.2	-0.9	0.3	0.0	0.3
Lauzon C24Z 220 kV	235	-	-	-5.1	-1.6	-0.1	-0.1	-0.4	-0.1	-4.2	-	-0.8	-0.5	0.3	0.0	0.3
Lauzon EJ 27.6 kV	29	-0.1	-0.1	-0.5	-0.2	-0.1	-0.1	-0.4	0.0	-0.3	-0.4	-0.1	0.2	0.4	0.0	0.3
Lauzon BQ 27.6 kV	29	-1.2	-1.2	-0.5	-1.3	-0.1	-0.1	-0.4	0.0	-1.4	-0.4	-1.2	-0.9	0.4	0.0	0.3
Ford Essex Z1E 115 kV	124	-2.6	-0.2	-2.1	-1.9	-0.1	-0.1	-	-0.2	-1.1	-1.2	-1.0	-0.7	0.4	-0.1	0.6
Ford Essex Z7E 115 kV	124	-2.6	-0.2	-2.1	-1.9	-0.1	-0.1	-0.6	-	-1.1	-1.2	-1.0	-0.7	0.4	-0.1	0.6
Ford Essex 13.8 kV	15	-0.1	-0.2	-0.8	-0.7	-0.1	-0.1	-0.2	-1.0	0.1	0.0	-1.0	-0.7	0.4	-0.1	0.6
Chrysler E8V 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Chrysler E9V 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Chrysler 27.6 kV	29	0.3	0.0	-0.3	0.1	-0.2	-0.1	0.2	-0.2	-0.3	-0.4	-0.2	0.1	0.3	-0.1	0.7
GM Windsor E8F 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
GM Windsor E9F 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
GM Windsor 27.6 kV	29	0.1	0.0	-0.1	0.1	-0.2	-0.1	-0.2	0.3	0.2	0.1	-0.3	0.0	0.3	-0.1	0.7
Ford Annex E8V 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Ford Annex E9V 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Ford Annex 13.8 kV	15	-0.6	0.0	-1.0	-0.9	-0.2	-0.1	-0.5	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	-0.1
Ford Windsor E8F 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Ford Windsor E9F 115 kV	123	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Ford Windsor 27.6 kV	29	-2.3	0.0	-1.9	-1.7	-0.2	-0.1	-1.4	-1.0	-1.0	-1.1	-0.9	-0.7	0.3	-0.1	0.7
Belle River K6Z 115 kV	124	-2.7	-0.3	-2.2	-2.0	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-0.3	-	0.6
Belle River K2Z 115 kV	124	-2.7	-0.3	-2.2	-2.0	-0.1	-0.1	-0.3	0.1	-1.2	-1.3	-1.0	-0.7	-	-0.8	0.6
Belle River 27.6 kV	29	-0.2	-0.3	0.3	0.5	-0.1	-0.1	-0.3	0.1	0.1	0.0	0.2	0.5	-0.4	0.0	0.6

Table A3 – Pre-ULTC Voltage Declines – Case 2: Export

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	246	0.2	1.3	0.3	0.2	-0.1	0.0	-0.1	0.1	0.1	0.1	-0.1	0.1	0.2	0.0	0.0
Lauzon 115 kV	125	-1.5	-0.7	-1.2	-1.1	-0.2	-0.1	0.2	0.3	-0.6	-0.6	-0.6	-0.4	0.2	-0.1	0.2
Keith 115 kV	124	-0.7	-0.5	-0.6	-0.6	-0.2	-0.1	-0.3	-0.3	-0.3	-0.4	-0.3	-0.2	0.1	-0.1	-0.3
Essex 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.3	0.2	-0.1	0.3
Tilbury 115 kV	122	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Tilbury 27.6 kV	29	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Tilbury West 115 kV	122	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Tilbury West 27.6 kV	29	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Tilbury West 27.6 kV	29	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Kingsville K6Z 115 kV	125	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-0.4	-	0.2
Kingsville K2Z 115 kV	123	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Kingsville 27.6 kV	29	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.4	-0.6	-0.6	-0.6	-0.4	-	-0.1	0.2
Walker Z1E 115 kV	124	-1.3	-0.7	-1.0	-1.0	-0.2	-0.1	-	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Walker Z7E 115 kV	124	-1.3	-0.7	-1.0	-1.0	-0.2	-0.1	-0.8	-	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Walker #2 27.6 kV	29	-1.3	-0.7	-1.0	-1.0	-0.2	-0.1	-5.6	-5.5	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Walker 27.6 kV	29	-1.3	-0.7	-1.0	-1.0	-0.2	-0.1	-2.9	-2.7	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Essex 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.3	0.2	-0.1	0.3
Essex 27.6 kV	28	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Crawford J3Z 115 kV	124	-1.0	-0.6	-0.8	-0.8	-	-0.5	-0.6	-0.4	-0.4	-0.4	-0.4	-0.3	0.1	-0.1	-
Crawford J4Z 115 kV	123	-1.0	-0.6	-0.8	-0.8	-0.1	-	-0.6	-0.4	-0.4	-0.4	-0.4	-0.3	0.1	-0.1	-
Crawford 27.6 kV	30	-1.0	-0.6	-0.8	-0.8	4.9	-6.5	-0.6	-0.4	-0.4	-0.4	-0.4	-0.3	0.1	-0.1	-
Keith 220 kV	238	-0.7	0.2	-0.6	-0.6	-0.1	0.0	-0.1	0.0	-0.3	-0.4	-0.3	-0.2	0.1	0.0	-0.1
Keith 27.6 kV	30	-0.7	-0.7	-0.6	-0.6	-0.1	0.0	-0.1	0.0	-0.3	-0.4	-0.3	-0.2	0.1	0.0	-0.1
Malden C21J 220 kV	238	-	-	-0.9	-0.7	-0.1	0.0	-0.1	0.0	-0.6	-	-0.3	-0.3	0.1	0.0	-0.1
Malden C22J 220 kV	238	-1.0	-	-	-0.7	-0.1	0.0	-0.1	0.0	-	-0.6	-0.3	-0.3	0.1	0.0	-0.1
Malden Y 27.6 kV	30	-4.1	-	-3.9	-0.7	-0.1	-0.1	-0.1	0.0	-3.6	-3.7	-0.3	-0.3	0.1	0.0	-0.1
Malden B 27.6 kV	29	-6.3	-	-6.0	-0.7	-0.1	-0.1	-0.1	0.0	-5.7	-5.9	-0.3	-0.3	0.1	0.0	-0.1
Lauzon C23Z 220 kV	238	-2.0	-0.8	-1.7	-1.5	-0.1	-0.1	0.0	0.1	-0.8	-0.8	-0.8	-0.6	0.2	0.0	-0.1
Lauzon EJ 27.6 kV	29	-2.1	-0.8	-1.7	-1.5	-0.1	-0.1	0.0	0.1	-0.8	-0.8	-0.8	-0.6	0.2	0.0	-0.1
Lauzon BQ 27.6 kV	30	-2.1	-0.8	-1.7	-1.5	-0.1	-0.1	0.0	0.1	-0.8	-0.8	-0.8	-0.6	0.2	0.0	-0.1
Ford Essex Z1E 115 kV	125	-1.4	-0.7	-1.2	-1.1	-0.2	-0.1	-	0.0	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.2
Ford Essex Z7E 115 kV	125	-1.4	-0.7	-1.2	-1.1	-0.2	-0.1	-0.1	-	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.2
Ford Essex 13.8 kV	15	-1.4	-0.7	-1.2	-1.1	-0.2	-0.1	-0.9	-0.7	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.2
Chrysler E8V 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.3	0.2	-0.1	0.3
Chrysler E9V 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.3	0.2	-0.1	0.3
Chrysler 27.6 kV	29	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor E8F 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor E9F 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor 27.6 kV	29	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Annex E8V 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Annex E9V 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Annex 13.8 kV	15	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor E8F 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor E9F 115 kV	124	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor 27.6 kV	29	-1.2	-0.6	-1.0	-0.9	-0.2	-0.1	-0.8	-0.6	-0.5	-0.5	-0.5	-0.4	0.2	-0.1	0.3
Belle River K6Z 115 kV	125	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.3	-0.6	-0.6	-0.6	-0.4	-0.4	-	0.2
Belle River K2Z 115 kV	125	-1.5	-0.7	-1.2	-1.1	-0.2	-0.1	0.2	0.3	-0.6	-0.6	-0.6	-0.4	-	-0.7	0.2
Belle River 27.6 kV	29	-1.5	-0.7	-1.2	-1.2	-0.2	-0.1	0.2	0.3	-0.6	-0.6	-0.6	-0.4	-2.7	-3.3	0.2
Chatham 220 kV	246	0.2	1.3	0.3	0.2	-0.1	0.0	-0.1	0.1	0.1	0.1	-0.1	0.1	0.2	0.0	0.0

Table A4 – Post-ULTC Voltage Declines – Case 2: Export

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	246	0.1	1.3	0.3	0.2	-0.1	0.0	-0.1	0.0	0.0	0.1	-0.1	0.1	0.1	0.0	0.0
Lauzon 115 kV	125	-1.6	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	0.2	-0.2	0.2
Keith 115 kV	124	-0.8	-0.5	-0.7	-0.6	-0.1	-0.1	-0.4	-0.3	-0.4	-0.4	-0.3	-0.2	0.1	-0.1	-0.3
Essex 115 kV	124	-1.4	-0.6	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.3	0.2	-0.1	0.3
Tilbury 115 kV	122	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Tilbury 27.6 kV	29	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Tilbury West 115 kV	122	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Tilbury West 27.6 kV	29	-1.0	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Tilbury West 27.6 kV	29	-1.0	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Kingsville K6Z 115 kV	125	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-0.5	-	0.2
Kingsville K2Z 115 kV	123	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Kingsville 27.6 kV	29	-0.3	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.2	0.2
Walker Z1E 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Walker Z7E 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Walker #2 27.6 kV	29	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.1	-1.0	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Walker 27.6 kV	29	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-3.1	-2.9	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Essex 115 kV	124	-1.4	-0.6	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.3	0.2	-0.1	0.3
Essex 27.6 kV	28	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Crawford J3Z 115 kV	124	-1.1	-0.6	-0.9	-0.8	-	-0.5	-0.7	-0.6	-0.4	-0.5	-0.4	-0.3	0.1	-0.1	-
Crawford J4Z 115 kV	123	-1.1	-0.6	-0.9	-0.8	0.0	-	-0.7	-0.6	-0.4	-0.5	-0.4	-0.3	0.1	-0.1	-
Crawford 27.6 kV	30	-1.1	-0.6	-0.9	-0.8	0.0	-2.4	-0.7	-0.6	-0.5	-0.5	-0.4	-0.3	0.1	-0.1	-
Keith 220 kV	238	-0.8	0.2	-0.6	-0.6	-0.1	-0.1	-0.1	-0.1	-0.4	-0.4	-0.3	-0.2	0.1	0.0	-0.1
Keith 27.6 kV	30	-0.8	-0.8	-0.6	-0.6	-0.1	-0.1	-0.1	-0.1	-0.4	-0.4	-0.3	-0.2	0.1	0.0	-0.1
Malden C21J 220 kV	238	-	-	-1.0	-0.7	-0.1	-0.1	-0.1	-0.1	-0.7	-	-0.3	-0.3	0.1	0.0	-0.1
Malden C22J 220 kV	238	-1.2	-	-	-0.7	-0.1	-0.1	-0.1	-0.1	-	-0.7	-0.3	-0.3	0.1	0.0	-0.1
Malden Y 27.6 kV	30	1.7	-	0.7	-0.7	-0.1	-0.1	-0.1	-0.1	1.0	0.9	-0.3	-0.3	0.1	0.0	-0.1
Malden B 27.6 kV	29	-0.6	-	-1.4	-0.7	-0.1	-0.1	-0.1	-0.1	-1.1	-1.3	-0.3	-0.3	0.1	0.0	-0.1
Lauzon C23Z 220 kV	238	-2.2	-0.8	-1.8	-1.5	-0.1	-0.1	-0.1	0.1	-0.8	-0.9	-0.8	-0.6	0.2	0.0	-0.1
Lauzon EJ 27.6 kV	29	-1.1	-0.8	-0.7	-1.5	-0.1	-0.1	-0.1	0.1	-0.8	-0.9	-0.8	-0.6	0.2	0.0	-0.1
Lauzon BQ 27.6 kV	30	-2.2	-0.8	-1.8	-1.5	-0.1	-0.1	-0.1	-1.0	-0.8	-0.9	-0.8	-0.6	-0.9	0.0	-0.1
Ford Essex Z1E 115 kV	125	-1.6	-0.7	-1.2	-1.1	-0.1	-0.1	-	-0.1	-0.6	-0.6	-0.5	-0.4	0.2	-0.2	0.2
Ford Essex Z7E 115 kV	125	-1.6	-0.7	-1.2	-1.1	-0.1	-0.1	-0.3	-	-0.6	-0.6	-0.5	-0.4	0.2	-0.2	0.2
Ford Essex 13.8 kV	15	-1.6	-0.7	-1.2	-1.1	-0.1	-0.1	-1.0	-0.9	-0.6	-0.6	-0.5	-0.4	0.2	-0.2	0.2
Chrysler E8V 115 kV	124	-1.4	-0.6	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.3	0.2	-0.1	0.3
Chrysler E9V 115 kV	124	-1.4	-0.6	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.3	0.2	-0.1	0.3
Chrysler 27.6 kV	29	-0.6	-0.7	-0.3	-0.2	-0.1	-0.1	-0.2	0.0	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor E8F 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor E9F 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
GM Windsor 27.6 kV	29	-0.7	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	-0.4	-0.1	-0.3
Ford Annex E8V 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Ford Annex E9V 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Ford Annex 13.8 kV	15	-0.5	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor E8F 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor E9F 115 kV	124	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Ford Windsor 27.6 kV	29	-1.4	-0.7	-1.1	-1.0	-0.1	-0.1	-1.0	-0.8	-0.5	-0.6	-0.5	-0.4	0.2	-0.1	0.3
Belle River K6Z 115 kV	125	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-0.5	-	0.2
Belle River K2Z 115 kV	125	-1.7	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-	-0.8	0.2
Belle River 27.6 kV	29	-0.4	-0.7	-1.3	-1.2	-0.1	-0.1	0.1	0.2	-0.6	-0.7	-0.6	-0.4	-0.5	-1.1	0.2
Chatham 220 kV	246	0.1	1.3	0.3	0.2	-0.1	0.0	-0.1	0.0	0.0	0.1	-0.1	0.1	0.1	0.0	0.0

Table A5 – Pre-ULTC Voltage Declines – Case 3: Import

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	248	0.2	0.7	0.4	0.4	-0.1	-0.1	0.0	0.0	0.1	0.1	0.0	0.2	0.0	-0.1	-0.1
Lauzon 115 kV	126	-1.5	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	0.0	-0.3	0.2
Keith 115 kV	125	-0.8	-0.7	-0.7	-0.6	-0.2	-0.2	-0.2	-0.2	-0.4	-0.4	-0.3	-0.2	0.0	-0.1	-0.4
Essex 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Tilbury 115 kV	124	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-2.1	0.2
Tilbury 27.6 kV	29	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-2.1	0.2
Tilbury West 115 kV	124	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-2.1	0.2
Tilbury West 27.6 kV	29	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-2.1	0.2
Tilbury West 27.6 kV	29	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-2.1	0.2
Kingsville K6Z 115 kV	122	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-0.1	-	0.2
Kingsville K2Z 115 kV	126	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-3.6	0.2
Kingsville 27.6 kV	30	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	2.6	-4.7	0.2
Walker Z1E 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Walker Z7E 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.6	-	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Walker #2 27.6 kV	30	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-5.2	-5.2	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Walker 27.6 kV	29	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-2.6	-2.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Essex 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Essex 27.6 kV	33	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Crawford J3Z 115 kV	125	-1.1	-1.1	-1.0	-0.8	-	-0.5	-0.4	-0.3	-0.5	-0.5	-0.4	-0.3	0.0	-0.2	-
Crawford J4Z 115 kV	124	-1.1	-1.1	-1.0	-0.8	-0.1	-	-0.4	-0.3	-0.5	-0.5	-0.4	-0.3	0.0	-0.2	-
Crawford 27.6 kV	29	-1.1	-1.1	-1.0	-0.8	4.8	-6.8	-0.4	-0.3	-0.5	-0.5	-0.4	-0.3	0.0	-0.2	-
Keith 220 kV	241	-0.9	-0.5	-0.8	-0.7	-0.1	-0.1	-0.1	0.0	-0.5	-0.5	-0.3	-0.2	0.0	-0.1	-0.1
Keith 27.6 kV	29	-0.9	-0.6	-0.8	-0.7	-0.1	-0.1	-0.1	0.0	-0.5	-0.5	-0.3	-0.2	0.0	-0.1	-0.1
Malden C21J 220 kV	240	-	-	-1.1	-0.7	-0.1	-0.1	-0.1	0.0	-0.7	-	-0.4	-0.3	0.0	-0.1	-0.2
Malden C22J 220 kV	240	-1.2	-	-	-0.7	-0.1	-0.1	-0.1	0.0	-	-0.7	-0.4	-0.3	0.0	-0.1	-0.2
Malden Y 27.6 kV	30	-4.3	-	-4.1	-0.7	-0.1	-0.1	-0.1	0.0	-3.8	-3.8	-0.4	-0.3	0.0	-0.1	-0.2
Malden B 27.6 kV	29	-6.5	-	-6.2	-0.7	-0.1	-0.1	-0.1	0.0	-5.9	-6.1	-0.4	-0.3	0.0	-0.1	-0.2
Lauzon C23Z 220 kV	240	-2.0	-1.3	-1.8	-1.5	-0.2	-0.1	0.0	0.0	-0.8	-0.8	-0.7	-0.6	0.0	-0.1	-0.3
Lauzon EJ 27.6 kV	29	-2.0	-1.3	-1.8	-1.6	-0.2	-0.1	0.0	0.0	-0.8	-0.8	-0.7	-0.6	0.0	-0.1	-0.3
Lauzon BQ 27.6 kV	30	-2.0	-1.3	-1.8	-1.6	-0.2	-0.1	0.0	0.0	-0.8	-0.8	-0.7	-0.6	0.0	-0.1	-0.3
Ford Essex Z1E 115 kV	125	-1.5	-1.4	-1.3	-1.1	-0.1	-0.1	-	-0.1	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Essex Z7E 115 kV	125	-1.5	-1.4	-1.3	-1.1	-0.1	-0.1	-0.1	-	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Essex 13.8 kV	15	-1.5	-1.4	-1.3	-1.1	-0.1	-0.1	-0.9	-0.9	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Chrysler E8V 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Chrysler E9V 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Chrysler 27.6 kV	29	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
GM Windsor E8F 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
GM Windsor E9F 115 kV	125	-1.3	-1.3	-1.1	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
GM Windsor 27.6 kV	29	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Annex E8V 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Annex E9V 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Annex 13.8 kV	15	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Windsor E8F 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Windsor E9F 115 kV	125	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Ford Windsor 27.6 kV	30	-1.3	-1.3	-1.2	-1.0	-0.2	-0.1	-0.5	-0.5	-0.6	-0.6	-0.5	-0.4	0.0	-0.2	0.3
Belle River K6Z 115 kV	124	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-0.6	-	0.2
Belle River K2Z 115 kV	125	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-	-0.8	0.2
Belle River 27.6 kV	29	-1.6	-1.5	-1.4	-1.2	-0.1	-0.1	0.1	0.1	-0.7	-0.7	-0.6	-0.4	-3.3	-3.1	0.2

Table A6 – Post-ULTC Voltage Declines – Case 3: Import

From Bus	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z	J4E+J3E
Chatham 220 kV	248	0.1	0.7	0.3	0.4	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	0.2	0.0	-0.1	-0.1
Lauzon 115 kV	126	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	0.0	-0.3	0.2
Keith 115 kV	125	-0.9	-0.8	-0.8	-0.6	-0.2	-0.2	-0.3	-0.3	-0.5	-0.5	-0.3	-0.2	0.0	-0.1	-0.4
Essex 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Tilbury 115 kV	124	-1.7	-1.6	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-2.3	0.2
Tilbury 27.6 kV	29	-1.7	-1.6	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-1.1	0.2
Tilbury West 115 kV	124	-1.7	-1.6	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-2.3	0.2
Tilbury West 27.6 kV	29	-1.0	-0.8	-0.8	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-0.8	0.2
Tilbury West 27.6 kV	29	-1.0	-0.8	-0.8	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-0.8	0.2
Kingsville K6Z 115 kV	122	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-0.1	-	0.2
Kingsville K2Z 115 kV	126	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-3.8	0.2
Kingsville 27.6 kV	30	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	2.6	-2.0	0.2
Walker Z1E 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Walker Z7E 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Walker #2 27.6 kV	30	-1.5	-1.3	-1.3	-1.0	-0.1	-0.1	-1.5	-1.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Walker 27.6 kV	29	-1.5	-1.3	-1.3	-1.0	-0.1	-0.1	-2.7	-2.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Essex 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Essex 27.6 kV	33	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Crawford J3Z 115 kV	125	-1.2	-1.1	-1.0	-0.8	-	-0.5	-0.5	-0.4	-0.6	-0.6	-0.4	-0.3	0.0	-0.2	-
Crawford J4Z 115 kV	124	-1.2	-1.1	-1.0	-0.8	-0.1	-	-0.5	-0.4	-0.6	-0.6	-0.4	-0.3	0.0	-0.2	-
Crawford 27.6 kV	29	-1.2	-1.1	-1.1	-0.8	-0.1	-1.3	-0.5	-0.4	-0.6	-0.6	-0.4	-0.3	0.0	-0.2	-
Keith 220 kV	241	-1.0	-0.5	-0.9	-0.7	-0.1	-0.1	-0.1	-0.1	-0.6	-0.6	-0.3	-0.2	0.0	-0.1	-0.1
Keith 27.6 kV	29	0.1	-0.6	0.2	-0.7	-0.1	-0.1	-0.1	-0.1	-0.6	-0.6	-0.3	-0.2	0.0	-0.1	-0.1
Malden C21J 220 kV	240	-	-	-1.2	-0.7	-0.1	-0.1	-0.1	-0.1	-0.8	-	-0.4	-0.3	0.0	-0.1	-0.2
Malden C22J 220 kV	240	-1.3	-	-	-0.7	-0.1	-0.1	-0.1	-0.1	-	-0.8	-0.4	-0.3	0.0	-0.1	-0.2
Malden Y 27.6 kV	30	1.4	-	1.6	-0.8	-0.1	-0.1	-0.1	-0.1	2.0	1.9	-0.4	-0.3	0.0	-0.1	-0.2
Malden B 27.6 kV	29	-0.9	-	-0.5	-0.8	-0.1	-0.1	-0.1	-0.1	-0.2	-0.4	-0.4	-0.3	0.0	-0.1	-0.2
Lauzon C23Z 220 kV	240	-2.1	-1.3	-1.9	-1.6	-0.1	-0.1	-0.1	0.0	-0.9	-0.9	-0.7	-0.6	0.0	-0.2	-0.3
Lauzon EJ 27.6 kV	29	-1.1	-0.2	-0.8	-0.5	-0.1	-0.1	-0.1	0.0	-0.9	-0.9	-0.7	-0.6	0.0	-0.2	-0.3
Lauzon BQ 27.6 kV	30	-1.0	-1.3	-1.9	-1.6	-0.1	-0.1	-0.1	0.0	-0.9	-0.9	-0.7	-0.6	0.0	-0.2	-0.3
Ford Essex Z1E 115 kV	125	-1.6	-1.4	-1.4	-1.1	-0.1	-0.1	-	-0.2	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Essex Z7E 115 kV	125	-1.6	-1.4	-1.4	-1.1	-0.1	-0.1	-0.2	-	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Essex 13.8 kV	15	-0.3	-0.2	-0.1	0.2	-0.1	-0.1	-1.0	-0.9	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Chrysler E8V 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Chrysler E9V 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Chrysler 27.6 kV	29	-0.7	-0.5	-0.5	-0.2	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
GM Windsor E8F 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
GM Windsor E9F 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
GM Windsor 27.6 kV	29	-0.2	-0.7	-0.6	-0.4	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Annex E8V 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Annex E9V 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Annex 13.8 kV	15	-0.6	-0.4	-0.4	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Windsor E8F 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Windsor E9F 115 kV	125	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Ford Windsor 27.6 kV	30	-1.4	-1.3	-1.3	-1.0	-0.1	-0.1	-0.7	-0.6	-0.7	-0.7	-0.5	-0.4	0.0	-0.3	0.3
Belle River K6Z 115 kV	124	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-0.7	-	0.2
Belle River K2Z 115 kV	125	-1.7	-1.5	-1.5	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-	-0.9	0.2
Belle River 27.6 kV	29	-0.5	-0.3	-0.3	-1.2	-0.1	-0.1	0.0	0.0	-0.8	-0.8	-0.6	-0.4	-1.1	-0.9	0.2

Appendix B – Thermal Loading Study Results

Table B1 – Thermal loading – Case 1: Brighton Beach out

Circuit	From Bus	To Bus	Con't (93 degrees)	Emergency	15 min. LTR	Pre-contingency	C21J+C23Z	C21J + C22J	C22J + C24Z	C23Z + C24Z	J3E	J4E	Z1E	Z7E	C22J	C21J	C23Z	C24Z	K2Z	K6Z
C21J	CHATHAM	COMBER J	30	1370	1590	36	-	-	54	50	31	31	33	31	42	-	38	38	30	30
	LEAMING J	LEAMIN TS	840	1020	1290	8	-	-	14	6	6	6	6	6	14	-	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	10	-	-	19	30	9	9	8	7	7	-	17	15	6	7
	SANDWICJ	MALDENJ	840	1020	1130	32	-	-	38	22	27	27	30	29	43	-	25	27	30	30
	MALDENJ	KEITH	840	1020	1130	16	-	-	27	14	13	13	15	14	25	-	13	14	15	15
	MALDEN	MALDENJ	840	1020	1130	20	-	-	39	18	18	18	18	18	38	-	18	18	18	18
C22J	CHATHAM	COMBER J	840	1020	1130	48	75	-	-	70	44	44	45	43	-	58	53	53	41	42
	LEAMING J	LEAMIN TS	840	1020	1290	8	14	-	-	6	6	6	6	6	-	14	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	9	21	-	-	29	8	8	7	7	-	6	16	14	6	7
	SANDWICJ	MALDENJ	840	1050	1180	31	33	-	-	21	26	26	28	28	-	41	24	26	28	28
	MALDENJ	KEITH	840	1020	1130	17	30	-	-	15	14	14	15	15	-	26	14	15	16	16
	MALDEN	MALDENJ	840	1020	1130	20	39	-	-	18	18	18	18	18	-	38	18	18	18	18
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	18	-	27	34	-	16	16	16	15	22	22	-	22	14	14
	KRUGERJ	COMBER J	1060	1400	1630	35	-	41	49	-	30	30	31	30	36	37	-	37	28	29
	COMBER J	SANDWICJ	1060	1400	1630	35	-	42	49	-	30	30	31	30	37	37	-	37	29	29
	SANDWICJ	LAUZON	1060	1400	1630	35	-	42	49	-	31	30	31	30	37	37	-	37	29	29
C24Z	CHATHAM	COMBER J	840	1020	1130	40	64	53	-	-	37	37	38	36	45	46	46	-	34	35
	COMBER J	SANDWICJ	840	1020	1130	41	64	53	-	-	37	37	38	36	46	46	47	-	34	35
	SANDWICJ	LAUZON	1060	1590	1830	26	40	33	-	-	23	23	24	23	28	28	29	-	21	22
J4E	KEITH	CRAWFRDJ	1100	1600	1800	24	24	15	23	27	38	-	27	22	19	19	24	23	19	20
	CRAWFRDJ	ESSEX	1100	1600	1800	13	13	1	11	16	14	-	14	11	9	9	13	13	10	10
	CRAWFRDJ	CRAWFORD	810	1140	1260	24	21	21	21	21	37	-	21	21	21	21	21	21	21	21
J3E	KEITH	CRAWFRDJ	1100	1600	1800	26	25	13	23	28	-	38	26	22	20	20	25	24	20	21
	CRAWFRDJ	ESSEX	1100	1600	1800	10	12	7	10	14	-	14	14	10	7	7	12	11	6	7
	CRAWFRDJ	CRAWFORD	810	1140	1260	22	20	20	20	20	-	36	20	20	20	20	20	20	20	20
Z1E	ESSEX	TAWINDSJ	970	1260	1440	17	11	17	12	13	17	17	-	24	16	16	14	15	17	16
	TAWINDSJ	WALKERJ	970	1260	1440	25	21	8	20	25	19	19	-	38	18	17	23	22	19	19
	WALKERJ	JEFFERSJ	910	1190	1380	32	20	29	22	21	30	29	-	53	27	27	25	26	31	29
	JEFFERSJ	LAUZON	910	1190	1380	34	21	30	23	22	31	31	-	55	28	28	26	27	32	30
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	-	3	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	37	34	34	34	34	34	34	-	70	34	34	34	34	34	34
Z7E	ESSEX	WALKERJ	970	1260	1440	24	20	7	19	25	18	18	29	-	17	17	22	22	19	19
	WALKERJ	JEFFERSJ	910	1190	1380	33	20	29	22	21	30	30	58	-	27	27	25	26	31	29
	JEFFERSJ	LAUZON	910	1190	1380	34	21	31	23	22	31	31	61	-	29	28	26	27	32	30
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	3	-	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	38	34	34	34	34	34	34	70	-	34	34	34	34	34	34
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	10	9	9	9	9	9	9	9	9	9	9	9	9	-	16
	LAUZONJ	WOODSLEJ	590	870	930	39	37	37	37	37	37	37	37	37	37	37	37	37	-	37
	WOODSLEJ	GOSFIELD J	590	800	860	28	27	26	27	27	26	26	26	27	26	26	26	26	-	26
	DIVISION J	GOSFIELD J	480	950	950	24	24	24	24	24	24	24	24	24	24	24	24	24	-	24
	GOSFIELD	KINGSVLE	480	950	950	24	24	24	24	24	24	24	24	24	24	24	24	24	-	24
K6Z	LAUZON	LAUZONJ	810	1070	1200	27	24	24	24	24	24	24	24	24	24	24	24	24	32	-
	LAUZONJ	ROURKELJ	810	1070	1200	27	24	24	24	24	24	24	24	24	24	24	24	24	32	-
	ROURKELJ	BELRIVEJ	810	1070	1200	22	19	19	19	19	19	19	19	19	19	19	19	19	19	-
	BELRIVEJ	KINGSVLE	480	690	720	34	32	32	32	32	32	32	32	32	32	32	32	32	32	-
Transformers	Kingsville	T1	41.7	49.3	68.6	55	54	55	54	55	55	55	55	55	54	54	54	55	-	55
	Kingsville	T2	41.7	54.5	67.4	45	43	44	43	43	45	45	44	45	44	44	44	44	44	-
	Kingsville	T3	41.7	73.7	84.9	28	28	28	28	28	28	28	28	28	28	28	28	28	-	28
	Kingsville	T4	41.7	57.6	74.9	43	41	43	42	42	43	43	43	43	42	42	42	43	43	-
	Belle River	T1	41.7	59.03	84.3	39	39	39	39	39	39	39	39	39	39	39	39	39	-	69
	Belle River	T2	41.7	59.03	84.3	29	29	29	29	29	29	29	29	29	29	29	29	29	69	-
	Keith DESN	22	83.3	109.6	109.6	34	34	37	34	34	34	34	34	34	34	34	34	34	35	34
	Keith DESN	23	83.3	109.6	109.6	34	34	32	34	34	34	34	34	34	34	34	34	34	35	34
	Lauzon	T5	83.3	112	112	49	48	48	49	48	49	49	49	49	48	49	48	49	50	49
	Lauzon	T6	83.3	112	112	49	48	48	49	48	49	49	49	49	48	49	48	49	50	49
	Lauzon	T7	83.3	114.7	165.6	43	43	42	42	42	42	43	42	43	42	42	42	43	43	43
	Lauzon	T8	83.3	114.7	165.6	43	43	43	42	42	42	43	42	43	42	42	42	43	43	43
	Keith	11	250	290	360	20	16	10	16	18	14	14	15	14	15	15	16	16	15	15
	Keith	12	250	290	360	20	16	14	16	18	14	14	15	14	15	15	16	16	15	15
	Lauzon	T1	250	280	364.2	47	31	43	33	29	39	39	39	35	37	37	33	34	30	33
	Lauzon	T2	250	280	364.2	46	30	43	32	28	39	38	38	34	37	37	32	33	30	32
	Malden	T1	125	195	214.5	43	-	-	90	43	43	43	43	43	90	-	43	43	43	43

	Malden	T2	125	195	214.5	42	90	-	-	42	42	42	42	42	-	90	42	42	43	42

Table B2 – Thermal loading - Case 2: Export

Circuit	*From Bus*	*To Bus*	*Con't (93 degrees)*	*Emergency*	*15 min. LTR*	*Pre-contingency*	*C21J+C23Z*	*C21J + C22J*	*C22J + C24Z*	*C23Z + C24Z*	*J3E*	*J4E*	*Z1E*	*Z7E*	*C22J*	*C21J*	*C23Z*	*C24Z*	*K2Z*	*K6Z*
C21J	CHATHAM	COMBER J	1060	1370	1590	30	-	-	44	41	26	26	27	26	35	-	32	32	25	25
	LEAMING J	LEAMIN TS	840	1020	1290	8	-	-	13	6	6	6	6	6	13	-	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	9	-	-	17	26	9	9	8	7	6	-	15	13	5	6
	SANDWICJ	MALDENJ	840	1020	1130	24	-	-	27	15	18	18	22	21	31	-	17	20	22	22
	MALDENJ	KEITH	840	1020	1130	8	-	-	25	12	6	6	7	6	20	-	8	8	7	8
	MALDEN	MALDENJ	840	1020	1130	20	-	-	37	18	18	18	18	18	37	-	18	18	18	18
C22J	CHATHAM	COMBER J	840	1020	1130	40	61	-	-	57	36	36	38	36	-	48	44	44	34	35
	LEAMING J	LEAMIN TS	840	1020	1290	8	13	-	-	6	6	6	6	6	-	13	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	8	19	-	-	25	8	8	7	6	-	5	14	13	5	6
	SANDWICJ	MALDENJ	840	1050	1180	23	23	-	-	14	17	17	20	20	-	30	17	19	21	21
	MALDENJ	KEITH	840	1020	1130	9	29	-	-	12	6	6	8	7	-	20	9	9	8	8
	MALDEN	MALDENJ	840	1020	1130	20	38	-	-	18	18	18	18	18	-	37	18	18	18	18
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	13	-	16	26	-	12	11	12	11	16	16	-	17	10	10
	KRUGERJ	COMBER J	1060	1400	1630	30	-	30	41	-	26	26	27	25	31	31	-	31	24	25
	COMBER J	SANDWICJ	1060	1400	1630	30	-	30	41	-	26	26	27	26	31	31	-	31	24	25
	SANDWICJ	LAUZON	1060	1400	1630	30	-	30	41	-	26	26	27	26	31	31	-	31	24	25
C24Z	CHATHAM	COMBER J	840	1020	1130	33	52	36	-	-	31	30	32	30	37	38	38	-	28	29
	COMBER J	SANDWICJ	840	1020	1130	34	52	37	-	-	31	31	32	30	38	38	39	-	28	29
	SANDWICJ	LAUZON	1060	1590	1830	22	33	23	-	-	19	19	20	19	23	24	24	-	18	18
J4E	KEITH	CRAWFRDJ	1100	1600	1800	33	32	33	30	33	50	-	33	29	27	27	31	30	26	27
	CRAWFRDJ	ESSEX	1100	1600	1800	20	19	22	18	22	26	-	21	17	16	16	20	19	15	16
	CRAWFRDJ	CRAWFORD	810	1140	1260	23	21	21	21	21	36	-	21	21	21	21	21	21	21	21
J3E	KEITH	CRAWFRDJ	1100	1600	1800	34	32	33	30	34	-	49	33	29	28	28	32	31	27	28
	CRAWFRDJ	ESSEX	1100	1600	1800	19	19	21	18	21	-	26	21	17	15	15	19	18	13	15
	CRAWFRDJ	CRAWFORD	810	1140	1260	22	20	20	20	20	-	34	20	20	20	20	20	20	20	20
Z1E	ESSEX	TAWINDSJ	970	1260	1440	16	13	16	12	15	13	13	-	35	12	12	14	14	14	13
	TAWINDSJ	WALKERJ	970	1260	1440	33	30	33	29	33	25	25	-	54	27	26	31	30	26	27
	WALKERJ	JEFFERSJ	910	1190	1380	30	20	25	21	22	27	26	-	48	24	23	24	24	27	25
	JEFFERSJ	LAUZON	910	1190	1380	31	20	25	21	23	28	27	-	50	25	24	24	25	28	26
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	-	3	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	37	34	34	34	34	34	34	-	69	34	34	34	34	34	34
Z7E	ESSEX	WALKERJ	970	1260	1440	33	30	33	28	33	24	24	44	-	26	26	30	30	26	26
	WALKERJ	JEFFERSJ	910	1190	1380	30	20	25	21	22	27	27	50	-	24	24	24	24	27	25
	JEFFERSJ	LAUZON	910	1190	1380	31	20	25	22	23	28	28	52	-	25	25	24	25	28	26
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	3	-	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	37	34	34	34	34	34	34	69	-	34	34	34	34	34	34
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	10	9	9	9	9	9	9	9	9	9	9	9	9	-	15
	LAUZONJ	WOODSLEJ	590	870	930	39	37	36	36	36	36	36	36	36	36	36	36	36	-	36
	WOODSLEJ	GOSFIELD J	590	800	860	28	27	26	26	26	26	26	26	26	26	26	26	26	-	26
	GOSFIELD	KINGSVLE	480	950	950	24	24	24	24	24	24	24	24	24	24	24	24	24	-	24
K6Z	LAUZON	LAUZONJ	810	1070	1200	27	24	24	24	24	24	24	24	24	24	24	24	24	32	-
	LAUZONJ	ROURKELJ	810	1070	1200	27	24	24	24	24	24	24	24	24	24	24	24	24	32	-
	ROURKELJ	BELRIVEJ	810	1070	1200	22	19	19	19	19	19	19	19	19	19	19	19	19	19	-
	BELRIVEJ	KINGSVLE	480	690	720	33	32	32	32	32	32	32	32	32	32	32	32	32	32	-
Transformers	Kingsville	T1	41.7	49.3	68.6	54	54	53	53	53	54	54	54	54	53	53	53	53	-	54
	Kingsville	T2	41.7	54.5	67.4	45	44	44	44	44	45	45	45	45	44	44	44	45	44	-
	Kingsville	T3	41.7	73.7	84.9	30	30	29	29	29	30	30	30	30	29	29	30	30	-	30
	Kingsville	T4	41.7	57.6	74.9	43	42	43	42	43	43	43	43	44	43	43	43	43	43	-
	Belle River	T1	41.7	59.03	84.3	39	38	38	38	38	39	39	39	39	38	38	38	39	-	68
	Belle River	T2	41.7	59.03	84.3	29	29	28	28	28	29	29	29	29	29	29	29	29	68	-
	Keith DESN	22	83.3	109.6	109.6	34	34	11	34	34	34	34	34	34	34	34	34	34	34	34
	Keith DESN	23	83.3	109.6	109.6	34	34	79	34	34	34	34	34	34	34	34	34	34	34	34
	Lauzon	T5	83.3	112	112	49	48	49	48	48	49	49	49	48	49	49	49	49	49	49
	Lauzon	T6	83.3	112	112	49	48	49	48	48	49	49	49	48	49	49	49	49	49	49
	Lauzon	T7	83.3	114.7	165.6	43	42	42	42	42	42	42	42	43	42	42	42	42	43	43
	Lauzon	T8	83.3	114.7	165.6	43	42	42	42	42	42	42	42	43	42	42	42	42	43	43
	Keith	11	250	290	360	26	19	79	20	19	22	23	17	19	22	22	20	20	22	22
	Keith	12	250	290	360	26	19	89	20	19	22	23	17	19	22	22	20	20	22	22
	Lauzon	T1	250	280	364.2	38	24	24	25	22	33	33	32	28	29	29	26	27	23	25
	Lauzon	T2	250	280	364.2	37	23	24	25	22	32	32	32	28	29	29	25	26	23	25
	Malden	T1	125	195	214.5	43	-	-	88	43	43	43	43	43	89	-	43	43	43	43

	Malden	T2	125	195	214.5	42	90	-	-	42	42	42	42	42	-	89	42	42	42	42

Table B3 – Thermal loading – Case 3: Import

Circuit	*From Bus*	*To Bus*	*Con't (93 degrees)*	*Emergency*	*15 min. LTR*	*Pre-contingency*	*C21J+C23Z*	*C21J + C22J*	*C22J + C24Z*	*C23Z + C24Z*	*J3E*	*J4E*	*Z1E*	*Z7E*	*C22J*	*C21J*	*C23Z*	*C24Z*	*K2Z*	*K6Z*
C21J	CHATHAM	COMBER J	1060	1370	1590	9	-	-	15	12	8	8	8	8	12	-	9	9	8	8
	LEAMING J	LEAMIN TS	840	1020	1290	8	-	-	13	6	6	6	6	6	13	-	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	20	-	-	27	22	19	19	18	17	24	-	19	18	16	16
	SANDWICJ	MALDENJ	840	1020	1130	32	-	-	44	31	33	33	29	29	44	-	31	29	28	28
	MALDENJ	KEITH	840	1020	1130	50	-	-	80	49	50	50	46	46	78	-	48	45	45	45
	MALDEN	MALDENJ	840	1020	1130	20	-	-	38	18	18	18	18	18	38	-	18	18	18	18
C22J	CHATHAM	COMBER J	840	1020	1130	12	21	-	-	16	11	11	12	11	-	17	13	13	11	11
	LEAMING J	LEAMIN TS	840	1020	1290	8	13	-	-	6	6	6	6	6	-	13	6	6	6	6
	LAUZON	SANDWICJ	1060	1400	1750	21	29	-	-	22	19	19	18	17	-	24	19	18	16	16
	SANDWICJ	MALDENJ	840	1050	1180	31	46	-	-	30	32	32	28	28	-	42	30	27	27	27
	MALDENJ	KEITH	840	1020	1130	50	84	-	-	48	49	49	45	46	-	78	47	45	44	45
	MALDEN	MALDENJ	840	1020	1130	19	38	-	-	17	18	18	18	18	-	38	18	18	18	18
C23Z	CHATHAM	KRUGERJ	1060	1400	1630	10	-	12	10	-	9	9	8	9	9	9	-	9	9	9
	KRUGERJ	COMBER J	1060	1400	1630	11	-	13	15	-	10	10	11	10	12	12	-	11	10	10
	COMBER J	SANDWICJ	1060	1400	1630	12	-	13	16	-	11	10	11	10	12	12	-	12	10	10
	SANDWICJ	LAUZON	1060	1400	1630	12	-	14	16	-	11	11	12	11	13	13	-	12	10	11
C24Z	CHATHAM	COMBER J	840	1020	1130	10	17	15	-	-	10	10	10	9	12	12	12	-	9	9
	COMBER J	SANDWICJ	840	1020	1130	12	18	17	-	-	11	11	11	11	14	14	13	-	11	11
	SANDWICJ	LAUZON	1060	1590	1830	8	12	11	-	-	7	7	8	7	9	9	9	-	7	7
J4E	KEITH	CRAWFRDJ	1100	1600	1800	45	46	70	45	41	67	-	43	39	45	45	41	40	39	40
	CRAWFRDJ	ESSEX	1100	1600	1800	33	34	58	33	29	44	-	31	27	33	33	29	29	28	29
	CRAWFRDJ	CRAWFORD	810	1140	1260	24	21	21	21	21	35	-	21	21	21	21	21	21	21	21
J3E	KEITH	CRAWFRDJ	1100	1600	1800	46	46	70	45	41	-	67	43	39	45	45	41	41	40	40
	CRAWFRDJ	ESSEX	1100	1600	1800	31	34	58	33	29	-	44	30	26	32	32	28	28	27	28
	CRAWFRDJ	CRAWFORD	810	1140	1260	22	20	20	20	20	-	35	20	20	20	20	20	20	20	20
Z1E	ESSEX	TAWINDSJ	970	1260	1440	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	TAWINDSJ	WALKERJ	970	1260	1440	45	47	77	46	41	32	32	-	74	45	45	40	39	38	39
	WALKERJ	JEFFERSJ	910	1190	1380	24	24	55	23	19	17	17	-	40	24	24	20	20	20	20
	JEFFERSJ	LAUZON	910	1190	1380	24	23	53	22	19	18	18	-	39	24	24	20	20	20	20
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	-	3	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	37	33	33	33	33	33	33	-	68	33	33	33	33	34	33
Z7E	ESSEX	WALKERJ	970	1260	1440	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	WALKERJ	JEFFERSJ	910	1190	1380	24	24	54	23	19	17	17	34	-	24	24	20	20	20	20
	JEFFERSJ	LAUZON	910	1190	1380	24	23	53	22	18	18	18	35	-	23	23	20	19	20	19
	FORDESXJ	JEFFERSJ	810	1210	1350	2	2	2	2	2	2	2	3	-	2	2	2	2	2	2
	WALKER	WALKERJ	870	1140	1250	37	33	33	33	33	34	34	68	-	34	34	34	34	34	34
K2Z	LAUZONJ	ROURKELJ	810	1070	1200	10	9	9	9	9	9	9	9	9	9	9	9	9	-	15
	LAUZONJ	WOODSLEJ	590	870	930	37	35	35	35	35	35	35	35	35	35	35	35	35	-	60
	WOODSLEJ	GOSFIELD J	590	800	860	29	26	26	26	27	27	27	27	27	27	27	27	27	-	51
	GOSFIELD	KINGSVLE	480	950	950	24	24	24	24	24	24	24	24	24	24	24	24	24	-	46
K6Z	LAUZON	LAUZONJ	810	1070	1200	29	26	26	26	25	26	26	26	26	26	26	26	26	53	-
	LAUZONJ	ROURKELJ	810	1070	1200	29	26	26	26	25	26	26	26	26	26	26	26	26	53	-
	ROURKELJ	BELRIVEJ	810	1070	1200	22	20	20	20	20	20	20	20	20	20	20	20	20	39	-
	BELRIVEJ	KINGSVLE	480	690	720	35	33	33	33	33	33	33	33	33	33	33	33	33	66	-
Transformers	Kingsville	T1	41.7	49.3	68.6	50	49	49	49	49	50	50	50	50	50	50	50	50	-	104
	Kingsville	T2	41.7	54.5	67.4	46	45	45	45	45	46	46	46	46	46	46	46	46	90	-
	Kingsville	T3	41.7	73.7	84.9	47	45	45	45	46	47	47	47	47	46	46	46	46	-	64
	Kingsville	T4	41.7	57.6	74.9	45	44	44	44	44	45	45	45	45	44	44	44	45	88	-
	Belle River	T1	41.7	59.03	84.3	40	40	40	40	39	40	40	40	40	40	40	40	40	-	68
	Belle River	T2	41.7	59.03	84.3	27	27	27	27	27	27	27	27	27	27	27	27	27	68	-
	Keith DESN	22	83.3	109.6	109.6	34	34	9	34	34	34	34	34	34	34	34	34	34	34	34
	Keith DESN	23	83.3	109.6	109.6	34	34	60	34	34	34	34	34	34	34	34	34	34	34	34
	Lauzon	T5	83.3	112	112	49	48	48	48	48	49	49	49	49	49	49	49	49	49	49
	Lauzon	T6	83.3	112	112	49	48	48	48	48	49	49	49	49	49	49	49	49	49	49
	Lauzon	T7	83.3	114.7	165.6	43	42	42	42	42	42	42	42	43	42	42	42	42	43	42
	Lauzon	T8	83.3	114.7	165.6	43	42	42	42	42	42	42	42	43	42	42	42	42	43	42
	Keith	11	250	290	360	22	20	85	19	18	17	17	17	16	20	20	18	18	17	17
	Keith	12	250	290	360	22	20	19	19	18	17	17	17	16	20	20	18	18	17	17
	Lauzon	T1	250	280	364.2	29	15	27	16	18	27	27	25	22	18	18	20	21	22	23
	Lauzon	T2	250	280	364.2	29	15	27	16	18	26	26	25	22	18	18	20	21	21	23
	Malden	T1	125	195	214.5	43	-	-	90	43	43	43	43	43	90	-	43	43	43	43
	Malden	T2	125	195	214.5	42	89	-	-	42	42	42	42	42	-	90	42	42	42	42