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CONNECTION ASSESSMENT & APPROVAL PROCESS

Preliminary Assessment Report For Vaughan MTS#1 Station Expansion

CAA ID 2003-89

Final Report

Long Term Forecasts & Assessments Department
Consistent Information Set

March 3, 2004

Station A Box 4474 Toronto On M5W eE5 Canada, Tel. 905.855.6406 fax 905.855.6373 www.theIMO.com

Preliminary Assessment Report

Vaughan MTS#1 – Transformer Addition

Acknowledgement

The IMO wished to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IMO 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 IMO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IMO 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 IMO. 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 IMO-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 IMO in accordance with Chapter 4, section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IMO 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 IMO provides a draft of this report to the connection applicant, you must be aware that the IMO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IMO 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.

Hydro One

The results reported in this preliminary feasibility 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 provided by the connection proponent 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 preliminary feasibility 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 rating 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. Additional facility studies may be necessary to confirm constructability and the time required for construction. System impact or further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

1.0 Project Description

Hydro Vaughan Inc. is proposing to increase the capacity of their Vaughan MTS#1 (Greenwood TS) by installing a third transformer at the existing station. The additional transformation capacity is required to be in service before the summer of 2005, due to substantial new developments and expansion of the exiting customer loads in the area. The new transformer will have the capability to connect to either of the 230 kV circuits V71R or V75R.

The in service date for the proposed project is April 2005.

It is projected that in the summer of 2005, the station will supply about 16 MW of new peak residential and commercial load as well as off load feeders from the existing Vaughan MTS#1. The latter would allow MTS#1 to operate at or below 200 MVA during normal summer peak conditions. The ultimate forecast indicates that Vaughan MTS#1 Expansion will be fully loaded in 2008, supplying a peak load of about 90 MW.

A schematic representation of the electrical connectivity for the new Vaughan MTS#1 station expansion is shown in Figure 1.

2.0 Review of Connection Arrangement

The proposed third transformer at Vaughan MTS#1 is to be connected to the 230 kV circuits V71R and V75R via two motorized disconnect switches which will be equipped with switching logic and interlocks to ensure that the two switches cannot be in closed position simultaneously.

The new transformer will be similarly rated to the existing two units. The rating of the new equipment will be as follows:

Transformer

Transformation	215.5/28-28 kV
Continuous Rating	75/100/125 MVA
Limited Time Rating	165 MVA[1]
Impedance (HX,HY,XY)	11.3% on 37.5 MVA, 11.3% on 37.5 MVA, 11.9% on 75 MVA
Configuration	solidly grounded wye winding on the high side and reactor grounded (1.5 ohms) zigzag double winding on the low side;
LV Grounding Reactor	Continuous rating of 1000A and 15 s current rating of 6000A
Tapping	under-load tap changer with 32 steps is to provide a voltage range of ± 40 kV;

[1] Based on long term operation of the transformer

HV Disconnect Switch

Rated Voltage	242 kV
Rated Continuous Current	1200 A

It should be noted that the bulk system normal voltage could vary from 250 kV to 220 kV. All the equipment connected to the IMO controlled grid is required, by the Market Rules, to be rated for continuous operation over this voltage range.

LV Circuit Breakers

Rated Voltage	N/A
Rated Continuous Current	2400 A
Rated Interrupting Capability	31.5 kA

As required by the Transmission System Code, Hydro Vaughan is to provide transfer trip of the Transmitter's breakers at Claireville TS and Richview TS for transformer faults and for failure to operate of the LV breakers. It is also required that the protection system initiate simultaneously both signals for transfer trip and the opening of the HV disconnect switch. Full opening of the disconnect switch shall then block the sending of the transfer trip signal.

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 under-frequency demand of up to 35% of its peak demand.

Hydro Vaughan will install six new feeders at the station as part of this project and will ensure that the UFLS requirements as defined in the Market Rules will be met by incorporating sufficient relays in the new installation.

Voltage Reduction Facilities Requirements

The Market Rules (Chapter 4 Appendix 4.3) requires that the distributors and wholesale customers install facilities to reduce, when instructed by the IMO, the distribution voltage by 3% to 5%. The new transformer will be equipped with under-load tap changer and is considered to be compliant with the Market Rules requirements.

On-line Monitoring

The Market Rules (Chapter 4 section 7.5) require that each distributor and connected wholesale customer shall provide the IMO on a continual basis with on-line monitored quantities as specified in Appendix 4.17.

Hydro Vaughan Inc. indicated that operational metering would be provided in accordance with the Market Rules.

Power Factor

Appendix 4.3 reference 1 of the *Market Rules* require that wholesale customers and distributors connected to the IMO-controlled grid shall operate at a power factor within the range 90%

lagging to 90% leading as measured at the *defined meter point.* In the case of a municipal transformer station the *defined meter point* is "the point at a voltage above 50 kV at which the designed radial line is connected to the high voltage bus of the facility."

The existing Vaughan MTS#1 and Vaughan MTS#3 are equipped with two 21.6 Mvar (@ 27.6 kV) LV shunt capacitors each.

It should be noted that the three municipal transformer stations that are connected to V71R and V75R do not have lower voltage shunt capacitors. It may be required that in the near future LV shunt capacitors be installed at Vaughan MTS#2, Richmond Hill MTS#1 and Richmond Hill MTS#2.

3.0 Data Verification

The information provided by the connection applicant as part of the application for preliminary assessment was complete.

Hydro Vaughan is required to confirm that the new HV disconnect switches are capable for continuous operation at 250 kV.

The rating of the remaining new equipment was found to meet all applicable standards.

4.0 Fault Level Assessment

In general, radial loads do not have a large impact on the system fault levels. A short circuit study was not required for this proposed development.

5.0 Impact on System Reliability

The assessment of the impact of incorporating the proposed project has assumed in service all the projects that have already been approved for connection in the electrical vicinity of Claireville TS. Explicitly, the baseline assumptions include Vaughan MTS#3 connected between Kleinburg TS and Woodbridge TS and Richmond Hill MTS#2.

5.1 Local Transmission Facilities

The third transformer at Vaughan MTS#1 will have a dual supply from the 230 kV double-circuit line V71R/V75R. Figure 2 shows a schematic representation of the IMO-controlled Grid in the area surrounding Claireville TS together with the location of the new proposed transformer. Circuit V71R is a three-ended circuit connecting Claireville TS to Richview to and to Richmond Hill MTS#2. The circuit designated as V75R also branches into two sections one terminating at Kleinburg TS and the other one at Richmond Hill MTS#2.

Presently, four municipal transformer stations are being supplied via V71R and V75R, namely Vaughan #1, Vaughan #2, Richmond Hill MTS#1 and Richmond Hill MTS#2. With the addition of the third transformer at Vaughan MTS#1 the station capability will increase from 165 MVA to 330 MVA.

The summer continuous rating for the two 230 kV circuits V71R and V75R is 550 MVA and the emergency rating is 729 MVA.

These summer ratings were determined for a continuous operating temperature of 93^0C and 127^0C respectively and an operating voltage of 235 kV, and based on a 35^0C ambient temperature. Commonly, for overhead circuits with conductors of high aluminum content, the continuous rating corresponds to 93^0C operating temperature and the emergency rating corresponds to 127^0C. The voltage level was selected based on the rationale that under contingency situation the voltage at Claireville could be much lower than the 240 kV to 248 kV range observed for a system with all elements in service.

For dual radial supply of load, the common practice is to use the continuous rating of the conductor in calculating the post contingency loading of the remaining line, since no operating measures are normally implemented to lower the loading of the remaining single supply. In exceptional situations, for the loss of a companion circuit the post-contingency on the remaining circuit is allowed to reach its emergency rating.

5.2 Area Load Forecast

The northern part of the greater Toronto area has experienced sustained and substantial increase in load in the last decade. Recently, a joint study was performed by Hydro One and York Region utilities to review the area load growth and the adequacy of the existing transmission system to supply the demand for the next ten years.

The study concluded that the area transmission system requires immediate reinforcement to provide relief to circuit V71/75R and further plans to alleviate transmission over-loading and voltage concerns.
At the same time the study identified that the four municipal stations that are being supplied off V71R and V75R may be reaching their maximum capability under peak load conditions.

A summary of the load forecast for Richmond Hill #1, Richmond Hill #2, Vaughan #1 and Vaughan #2 is shown in table 2. The summary was prepared by Hydro One under the assumption that the peak load supplied by a station will not exceed the station capability. Any load growth above the station capability will be accommodated with new transformation facilities, as is the case of the proposed Vaughan MTS#1 expansion.

Table 2. Load Forecast (MW, limited to station capability where necessary)

Station	**Max Cap**	**2002 Actual**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
RichH #1	176	170.5	152.3	160.1	168.1	176.2	176	176	176	176	176	176
RichH #2	122	96.3	87.3	90.4	95.3	98.2	94.4	90.3	101	111.7	122.1	132.3
Vaughan#1	180	160.5	180	180	180	180	180	180	180	180	180	180
Vaughan#1E			0	0	16	50	85	90	90	90	90	90
Vaughan #2	180	193.9	180	180	180	180	180	180	180	180	180	180
Total Load (MW)	**636**	**622**	**600**	**611**	**639**	**684**	**715**	**716**	**727**	**738**	**748**	**758**
Total Load (MVA) @0.9 pf	**707**	**691**	**666**	**678**	**710**	**760**	**795**	**796**	**808**	**820**	**831**	**842**

The IMO guidelines to availability of supply state that:

"With all transmission elements in service, any single element contingency or double circuit contingency should not result in an interruption of supply to a load level of 500 MW or more."

Since the peak load connected to V71R and V75R is larger than 500 MW and in the event of the permanent loss of the 230 kV double circuit line the supply would be interrupted, the IMO availability guideline is exceeded.

In response to the joint study findings and other system emerging needs, Hydro One has submitted to the IMO connection assessment applications for transmission reinforcement projects in the area. The IMO approved Hydro One' s proposal to build a new 500/230 kV transformer station at Parkway TS and extend the 230 kV circuit V71R and V75R to the new station, while sectionalizing these circuits at a location west of Richmond Hill MTS#1. The first phase of the project consists of the installation of one autotransformer and the extension of the 230 kV circuits. The planned in service date for this phase is May 2006. A copy of the complete Parkway TS SIA report can be found on the IMO web page.

5.4 Assessment of Transmission Thermal Loading

A detailed assessment of the capability of the radial 230 kV circuits V71R and V75R to supply the loads for the next ten years was not performed because, the "York Region Supply Study" carried out by Hydro One already found that this transmission corridor is at the capacity limit and Hydro One has already initiated transmission expansion plans to correct this problem.

However, in order to confirm the severity of the problem a 2006 load flow case was studied for pre contingency and post contingency situations. By 2006 the 230 kV lines V71R and V75R are expected to supply a total load of about 760 MVA. The studies results are summarized in table 3.

All station loads were modeled at 0.9 power factor on the LV side of the transformer station and the two 21.6 Mvar (at 27.6 kV) LV shunt capacitors available at Vaughan MTS No. 1 were assumed to be in service. It should be noted that none of the other three municipal transformer stations that are connected to V71R and V75R are equipped with low voltage shunt capacitors.

Table 3: Pre-contingency and Post-contingency Line

Circuit/ Ratings	Pre-contingency With existing LV shunt capacitors		Post-contingency Loss of V75R			
	MW, Mvar per circuit % of Cont. Rating		Loss of V75R, pre-ULTC MW, Mvar, % Cont. Emergency Rating		Loss of V75R, post-ULTC MW, Mvar, % Cont. Emergency Rating	
V71R/V75R Cont. Rate **550MVA** Emerg. Rate **729MVA**	339 MW	184 Mvar	685.5 MW	610.7 Mvar	682.6 MW	511.1 Mvar
	386 MVA		918.1 MVA		852.7 MVA	
	70%		126%		117%	
	Pre-contingency With LV shunt capacitors at all four MTS's*		**Post-contingency Loss of V75R**			
	MW, Mvar per circuit % of Cont. Rating		Loss of V75R, pre-ULTC MW, Mvar, % Cont. Emergency Rating		Loss of V75R, post-ULTC MW, Mvar, % Cont. Emergency Rating	
V71R/V75R Cont. Rate **550MVA** Emerg. Rate **729MVA**	338 MW	97.1 Mvar	683 MW	415 Mvar	681 MW	319 Mvar
	352 MVA		799 MVA		752 MVA	
	64%		110%		103%	

* Shunt caps assumed in service: one new 21.6 Mvar at Vaughan MTS#1 for a total of three, two new 21.6 Mvar Vaughan MTS#2, two new 21.6 Mvar Richmond Hill MTS#1, two new 21.6 Mvar Richmond Hill MTS#2.

The study results confirmed that, with the existing LV shunt capacitors in service, the loss of one of the 230 kV circuits supplying these stations could result in the overloading of the remaining circuit. It was observed that due to the heavy MW loading of these two circuits the reactive power flows are also very high. After the loss of one of the two circuits the Mvar consumption over the remaining circuit could become extremely high resulting in power flows that are over the MVA circuit's capacity. This problem could be partly alleviated by reducing the reactive power flow over the V71R/V75R transmission corridor. This could be achieved by the installation of low voltage shunt capacitors at the three municipal transformer stations that do not presently have LV reactive support.

Without Parkway Transmission Reinforcement

The results of this analysis indicated that by summer 2006, the emergency rating of the 230 kV circuits would be exceeded by 13% under contingency situations. In this case low voltage shunt capacitors would need to be installed before 2006 to reduce the power flow close to, but slightly above the emergency rating of the 230 kV circuits.

The second part of Table 3 show results of power flows over the V71R/V75R corridor when additional low voltage shunt capacitors are connected at the transformer stations as specified in the table below. With nominal capacitor banks with a rating of 21.6Mvar the potential overloads are reduced to less than 10%.

	Existing Capacitor Banks	*Additional Capacitor Banks*	
• Vaughan MTS No. 1	Two 21.6MVAr	One 21.6MVAr *	(if necessary for power factor correction)
• Vaughan MTS No. 2	-	Two 21.6MVAr*	(proposed)
• Richmond Hill MTS No. 1	-	Two 21.6MVAr*	
• Richmond Hill MTS No. 2	-	Two 21.6MVAr*	

Note: * A rating of 24MVAr is preferred.

Installing capacitor banks with a rating of approximately 24MVAr would be expected to eliminate these overloads. Furthermore, studies have shown that switching a 24 Mvar capacitor bank at Richmond Hill MTS No. 2 (the most remote location) would result in a voltage change of up to 3.4%.

If the Parkway transmission reinforcement suffers major delays due to unforeseen circumstances then, by the end of year 2006:

One additional 21.6MVAr shunt capacitor bank is required to be installed at Vaughan MTS No. 1 as part of the proposed expansion of this station.

Vaughan Hydro and Richmond Hill Hydro are required to install sufficient shunt capacitor banks at the remaining MTSs associated with circuits V71R & V75R to ensure compliance with the requirements of the Market Rules with respect to the power factor at the defined meter point.

It is recommended that both Hydro Vaughan and Richmond Hill Hydro consider increasing the size of any capacitor banks that they need to install to comply with the Market Rules so that the reactive power demand on circuits V71R & V75R is reduced.

In the event that all of the additional capacitor banks that have been 'proposed' are not installed, the IMO will require a temporary load rejection scheme to be installed to address possible overloading of circuits V71R & V75R until Parkway TS is established and circuits V71R & V75R are extended and terminated on to the new 230kV station.

With Parkway Transmission Reinforcement

With the implementation of Hydro One's Parkway project, only Hydro Vaughan MTS#1 and MTS#2 load will continue to be supplied from Claireville, while the Richmond Hill MTS#1 and MTS#2 load will effectively be transferred to Cherrywood TS. The Parkway transmission reinforcement is scheduled for in-service by the summer of 2006, and will resolve the thermal overloading problems in the area.

If the Parkway transmission reinforcement is on schedule then:

Hydro Vaughan and Richmond Hill Hydro are required to install sufficient shunt capacitor banks at the remaining MTS's associated with circuits V71R & V75R to ensure compliance with the requirements of the Market Rules with respect to the power factor at the defined meter point.

6.0 Conclusions and Recommendations

This Preliminary Assessment has examined the impact of connecting a third 230/28 kV transformer at Vaughan MTS#1 to accommodate the sustained load growth in the area, on the reliability of the IMO-controlled grid. The assessment concluded that:

1. The connection of the new transformer to the IMO-controlled grid will not have an adverse impact on the reliability of the system.
2. Due to sustained and higher than expected load growth in the area the 230 kV corridor supplying Vaughan MTS#1,Vaughan MTS#2, Richmond Hill MTS#1 and Richmond Hill MTS#2 has reached its maximum power transfer capability.
3. The IMO supply availability guideline would be exceeded because a permanent loss of the 230 kV double circuit line would result in a loss of load greater than 500 MW.

It is required that Hydro Vaughan install with the new transformer all the equipment needed to monitor the information required by the IMO on a continuous basis as described in Chapter 4 section 7.5 and Appendix 4.17 of the Market Rules.

Hydro Vaughan Inc is required to install sufficient low voltage reactive compensation to ensure compliance with the requirements of the Market Rules with respect to the power factor at the defined meter point.

If the Parkway transmission reinforcement is considerably delayed :

It is recommended that both Hydro Vaughan and Richmond Hill Hydro consider increasing the size of any capacitor banks that they need to install to comply with the Market Rules so that the reactive power demand on circuits V71R & V75R is reduced.

In the event that all of the additional capacitor banks that have been 'proposed' are not installed, the IMO will require a temporary load rejection scheme to be installed to address possible overloading of circuits V71R & V75R until, Parkway TS can be established and circuits V71R & V75R are extended and terminated on to the new 230kV station.

Hydro Vaughan Inc is required to install sufficient low voltage reactive compensation to ensure compliance with the requirements of the Market Rules with respect to the power factor at the defined meter point.

7.0 Notification of Approval

Section 6.0 of the Preliminary Assessment Report lists all the requirements identified by the IMO for the incorporation of the new transformer at Vaughan MTS#1. It is recommended that approval be granted and Notification of Approval be issued subject to the acceptance by the proponent of the IMO requirements.

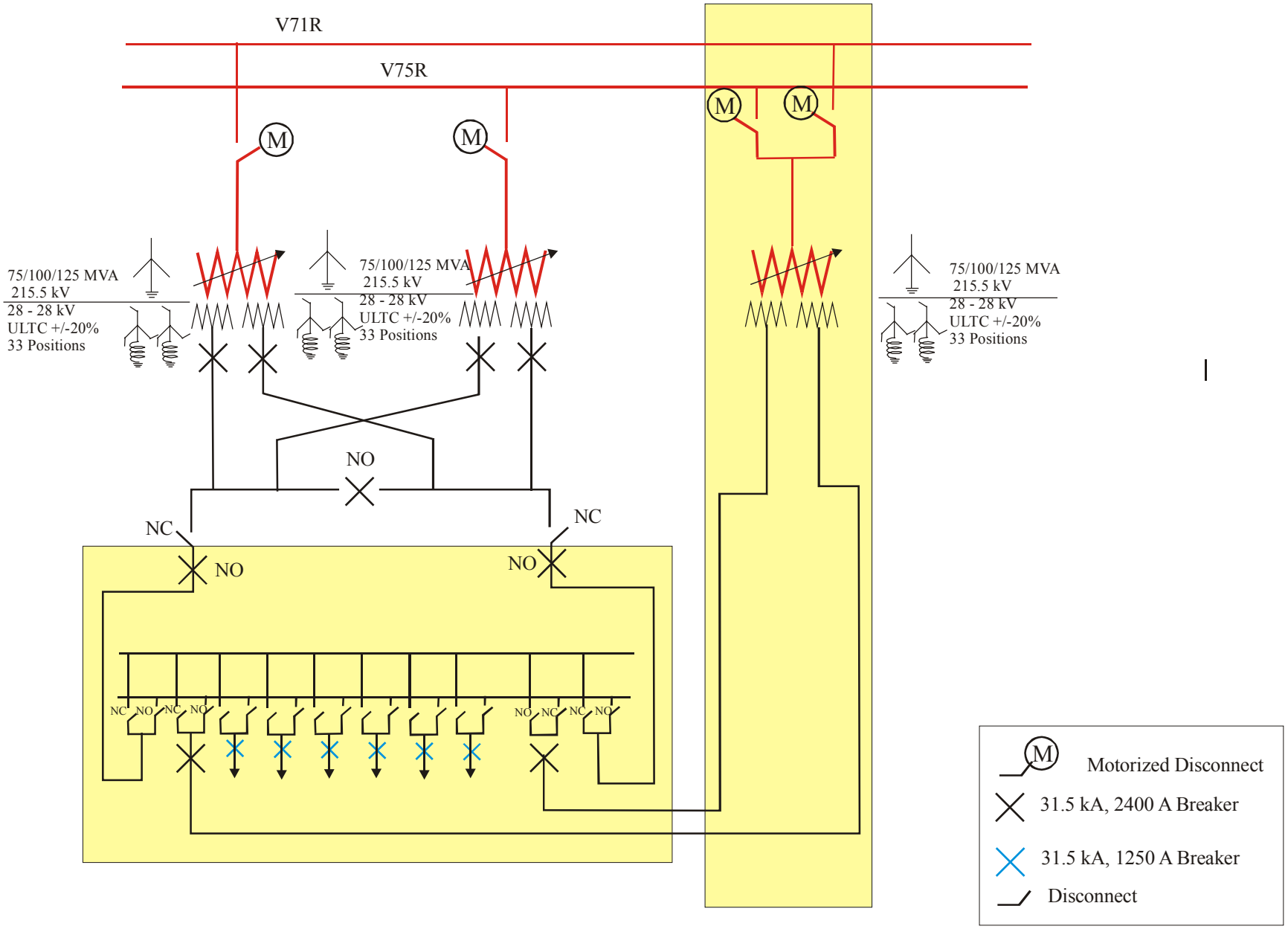

Figure 1. Vaughan MTS#1TS Single Line Diagram

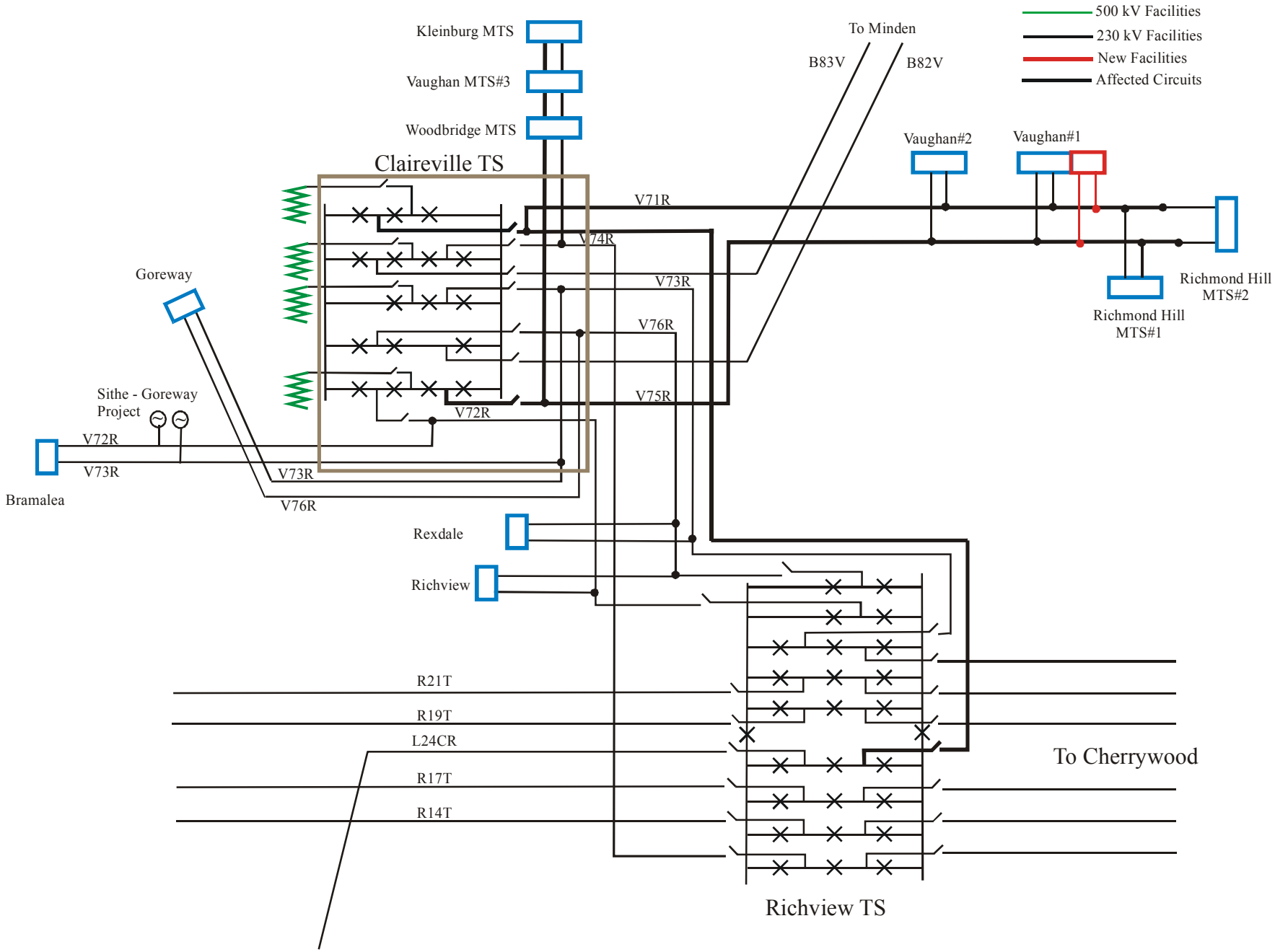

Figure 2. Vaughan MTS#1 New Transformer Location -Claireville Area Transmission -