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CONNECTION ASSESSMENT & APPROVAL PROCESS

Preliminary Assessment Report For Great Lakes Power Limited Transmission Reinforcement

Applicant: Great Lakes Power Limited – Transmission Division

CAA ID 2002-070

Final Report

Long Term Forecasts & Assessments Department
Consistent Information Set Department

June 20, 2003

Preliminary Assessment Report

Great Lakes Power Limited – Transmission Redevelopment Project

Acknowledgement

The IMO wishes to acknowledge the assistance of Great Lakes Power Limited - Transmission Division 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.

Great Lakes Power Limited– Transmission Division

The results reported in this preliminary feasibility study are based on the information available to GLP, at the time of the study, suitable for a preliminary assessment of this transmission system reinforcement 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 facilities on load and generation customers.

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

The ampacity rating of GLP facilities are established based on assumptions used in GLP 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 facilities have been identified to the extent permitted by a preliminary assessment under the current IMO 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.

Preliminary Assessment Report

Executive Summary

Introduction

The Great Lakes Power Limited transmission system between Anjigami TS and Mississagi TS, shown in Figure 1, provides supply to a peak load of about 380 MW and transmission corridors for peak generation of about 470 MW. Great Lake Power Limited - Transmission Division (GLPL) is pursuing plans to reinforce the transmission system between Anjigami TS and Third Line TS and between Third Line TS and Mississagi TS in order to eliminate present transmission system limitations and provide improved reliability of supply and connectivity.

GLPL submitted to the IMO for evaluation three alternatives for reinforcing their transmission system, together with a report containing the results of a feasibility study investigating the effects of each transmission option on system voltages and power flows.

The purpose of the Connection Assessment was to evaluate the results of studies performed by GLPL and the IMO and identify the effect on system reliability of each transmission reinforcement option. This assessment also recognized the benefits of one of the alternatives, which includes extensive system additions and modifications.

Proposed Development

Option 1 (Figure 2)

This option involves the redevelopment of all five 115 kV circuits between Anjigami TS, MacKay TS and Third Line TS, including structure replacements, and replacement of conductors to 336 kcmil and of skywire where necessary. With the exception of the replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and the replacement of two under-rated breakers at Anjigami TS (814 & 824) as part of the Transmission Reinforcement Project, no other station modifications are planned for Anjigami TS, MacKay TS or Third Line TS under this option. This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

Option 2 (Figure 3)

This option involves the complete rebuilt of only one 115 kV circuit between Anjigami TS and MacKay TS and two 115 kV circuits between MacKay TS and Third Line TS. The second existing 115 kV Anjigami and Sault circuits would be removed and the third 115 kV circuit between MacKay TS and Third Line TS would be refurbished and radially connected at Third Line TS.

Under this option, slight modifications to station configurations are required as follows:
- Replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and replacement of two under-rated breakers at Anjigami TS (814 & 824) as part of the Transmission Reinforcement Project
- Breakers 814 and 824 at Anjigami would be joined together and provide the connection for the new 115 kV circuit,
- Breaker 648 at MacKay TS would be removed,

- An alternative connection of the 115 kV circuit No.1 Sault would be provided to Third Line TS south bus via a new 115 kV breaker.

This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

Option 3 (Figure 4)

In its final stage, this option will consist of the following new and modified transmission facilities:

- One new 230 kV circuit from Wawa to MacKay to Third Line, that will be connected to MacKay TS via one 115/230 kV auto-transformer,
- The installation of one additional 230 kV breaker at Wawa,
- Building a new 230 kV four breaker ring bus at MacKay TS, which will be equipped initially with three breakers, providing the connection for the new auto-transformer and the north and south sections of the new line
- The upgrading of No.3 Sault 115 kV circuit to 90 MVA,
- Building a 230 kV switchyard at Third Line including a ring bus of four 230kV breakers to connect the new 230 kV circuit, P21G and P22G circuits, and the two auto-transformers,
- The removal of four 115 kV circuits; No.1 Anjigami, No.2 Anjigami, No.1 Sault, and No.2 Sault,
- Replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and the removal of two breakers (814 & 824) at Anjigami TS and four breakers (622, 632, 648 & 658) at MacKay TS,
- Re-terminate No.1 MacKay and No.2 Gartshore on separate breaker diameters at MacKay TS, and
- Re-terminate the Third Line TS T1 115 kV connection and No.3 Sault 115 kV line on separate 115 kV diameters at Third Line TS.

This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

Option 3 – System Benefits

The GLPL proposed Option 3 of transmission reinforcement represents a major enhancement to the Northeast transmission system, which results in extensive improvement in the reliability of the IMO-controlled grid and brings increased efficiencies to the electricity market. This Connection Assessment identified the following benefits associated with the new 230 kV link between Wawa TS and Third Line TS.

A. The bottling of the Michipicoten River hydraulic plants (connected to Anjigami TS) due to transmission limitation will be eliminated (when all elements in service) or reduced (for situations of outages), resulting in a decrease in CMSC payments to the market.

B. The GLPL inflow limit will be enhanced and substantially reduce the dependence on the special protection systems that are presently employed in the area.

   Due to the weakness of the existing transmission system in this area, the operation of the system relies extensively on special protection system, including load and generation rejection schemes:

- Up to 100 MW of load is armed for rejection continuously at Third Line, to prevent the collapse of the GLPL system in post-contingency when the GLPL internal load is supplied mainly via the Mississagi TS and Wawa TS transformers.
- Wells GS and Lake Superior Power are armed for rejection under high Mississagi Flow east conditions and storm weather in order to provide improvement to the east flow power transfer limit.
- A relay is installed at Wawa TS that will separate the GLPL system from Hydro One system if the post-contingency flow at Wawa exceeds its settings.
- A cross-tripping scheme is in service which, in the event of a double circuit contingency involving P25/26W will disconnect the auto-transformers T1 and T2 at Wawa TS, thus again isolating the GLPL system from the Hydro One system at Wawa.

With the addition of the proposed transmission some of these special protection systems might not be necessary or could be used to further enhance the system operating limits. The IMO will establish the usefulness of these SPS's as part of future system limits studies.

C. For most system conditions, including high East-West power flows eastbound or westbound, the proposed transmission reinforcement is likely to provide increased voltage support at Wawa TS, which results in an improvement in the voltage stability for the area. This may possibly result in an increased in the power transfer limit over the EW interface for certain conditions of power flows over the Northwest interconnections with the neighbouring utilities.

D. For conditions of high flow east on the Mississagi East interface an improvement of about 50 MW in power transfer East limit may be achieved and the need to reject Wells GS and Lake Superior Power GS generation in post-contingency could be reduced or eliminated. This would considerably reduce the bottling of generation west of Mississagi, during high flows eastbound and storm conditions.

It should be noted that any possible improvement in the Northwest system power transfer limits,such as those referred in C and D above, requires detailed interconnection studies, to ensure that there is no adverse impact on neighbouring utilities. In addition, agreement to increase the limits must be obtained from the MidWest ISO, Manitoba Hydro and Minnesota Hydro.

E. This transmission development and, in particular, the proposed configuration of the 230 kV MacKay TS and Third Line TS will allow for future transmission system expansions and possible incorporation of generation projects.

Before the proposed development is brought into service, the IMO will perform detailed operating studies to establish the new power transfer limits over the East-West and Mississagi East interfaces.

Conclusions and Recommendations

This Preliminary Assessment has examined the impact of each of the three transmission reinforcement alternatives proposed by Great Lakes Power Limited –Transmission for the reinforcement of their 115 kV system between Anjigami TS and Mississagi TS. The Connection Assessment evaluated the results of studies performed by Great Lakes Power Limited – Transmission and the IMO and identified the effect on system reliability and the some of the benefits of each transmission reinforcement option. In particular, the IMO assessment concentrated on identifying the impact of the proposed Option 3 (the 230 kV reinforcement)

The general conclusions and recommendations of this assessment with respect to each of the three transmission reinforcement options are summarized in the sections below.

Option 1

1. Options 1 will provide an improvement in the reliability of the GLPL transmission system by eliminating the post-contingency thermal overloading concerns associated with the existing system and the need to bottle some of the generation internal to the GLPL system as a result of transmission constraints.
2. Option 1 is not likely to affect the existing Northwest system operating limits, and in particular the East-West interface power transfer limits eastbound and westbound.
3. Option 1 is not likely to affect the existing Northeast system operating limits, and in particular the Mississagi Flow East power transfer limit eastbound during adverse weather conditions.
4. Under Option 1, the station configurations that are proposed for connecting the upgraded 115 kV circuits at Anjigami TS, MacKay TS and Third Line TS are identical to those of the existing arrangement; hence there are no new critical contingencies that will not adversely affect the reliability of the IMO-controlled grid.
5. If Option 1 is adopted, it is required that Anjigami 115 kV breakers 814 and 824 be replaced with 40 kA breakers. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.

Option 2

1. Option 2 appears to reduce the pre-contingency voltage at Wawa TS which is likely to lower, under certain system conditions, the East-West interface power transfer limit.
2. The ultimate station arrangement for Wawa 230/115 kV and Anjigami 115 kV stations for this option will retain all the existing 115 kV breakers with the new 115kV Anjigami line terminated on two breakers (814 and 824).
3. The configuration of MacKay TS will remain unchanged with the exception of the removal from service of breaker 648, which becomes redundant when No.2 Anjigami is permanently removed from service.
4. The configuration of Third Line TS will remain substantially unchanged except for the addition of a second breaker for No.1 Sault.
6. Option 2 will not be introducing any new critical contingencies that will not adversely affect the reliability of the IMO-controlled grid are being.
7. If Option 2 is adopted, it is required that Anjigami 115 kV breakers 814 and 824 used to connect the new line be replaced with a 40 kA breaker. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.

Option 3

1. The modifications at Wawa TS and Anjigami TS that are proposed to accommodate the 230 kV reinforcement option do not introduce a new critical contingency and will not reduce the present level of transmission system reliability.
2. The IMO strongly recommends that the MacKay 115 kV connection of No.2 Gartshore 115 kV circuit be located between breakers 635 and 632 at MacKay 115 kV switchyard, as shown in Figure 5B. This final configuration will also result in removal of the four redundant breakers (612, 622, 648 & 658).

3. The IMO recommends that GLPL consider building a new 230 kV switchyard at MacKay TS as shown in Figure 4. The new switchyard is to be designed as a four breaker ring bus and be initially equipped with three breakers.
4. The proposed final arrangement and the recommended changes for MacKay 115 kV switchyard (Figure 5B) will not adversely affect the reliability of the IMO-controlled grid and will represent an improvement with both No.1 MacKay circuit and No.2 Gartshore circuit terminated on dedicated breaker positions.
5. The new 230 kV switchyard at MacKay TS (Figure 5B), which will be designed as a four breaker ring bus and initially equipped with three breakers, will ensure the independent isolation of each 230 kV connected transmission element for planned or forced outages.
6. The *Connection Applicant* has the choice to design the new 230 kV Third Line TS to three-breaker or four-breaker configuration, subject to ensuring that the final future stages at Third Line TS the station will be configured with three diameters.
7. The new Third Line 230 kV switchyard configuration (Figure 5C) will not adversely affect the reliability of the IMO-controlled grid
8. The proposed new Third Line 230 kV switchyard configuration will result in the separation of the two auto-transformers from the Third Line TS to Mississagi 230 kV circuits, which is considered to be an improvement to system reliability. This configuration (Figure 5C) will eliminate the loss of two transmission system elements in case of a single contingency and the removal from service of more than two transmission system elements for a breaker-failure operation on the 230kV or for breaker-failure of breaker 508 on the 115kV system.
9. The new proposed supply arrangement for Batchawana TS and Goulais Bay TS (Figure 4B) off the 115 kV circuit No.3 Sault meets the IMO availability standards.
10. Short circuit studies performed by GLPL indicate that the system short circuit currents are within the interrupting capability of the proposed new breakers and the existing breakers that are to be retained under Option 3. Should all facilities assumed in the ultimate system configuration materialize, then some of the 115 kV breakers at MacKay TS will have to be replaced to accommodate the increase in short circuit currents. The adequacy of these breakers will be revisited with every future new proposed development in the area.
11. Post-contingency thermal overloading of the upgraded 115 kV circuit No.3 Sault could occur in the event of the loss of the MacKay auto-transformer or the south section of the new 230 kV line.

Based on the findings of the linear analysis performed under extreme system conditions represented by cases A to G, for the proposed transmission reinforcement Option 3 the following were concluded:

12. Pre-contingency power flows will not exceed the continuous rating of the transmission facilities,
13. The loss of MacKay TS to Third Line TS section of the new 230 kV circuit (Table 9) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
14. The loss of the new MacKay auto-transformer (Table 10) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
15. The loss of new 230 kV circuit and MacKay transformer (Table 11) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking.

Based on the findings of the voltage and transient stability studies that were performed for cases A and F the following were concluded:

16. The new 230 kV line between Wawa TS and Third Line TS results in limited voltage improvement at Wawa TS and substantial voltage improvement at Third Line TS and Mississagi TS.
17. The new 230 kV line between Wawa TS and Third Line TS will provide an overall improvement in the transient stability for the system East of Wawa TS.
18. For conditions of high flow east on the Mississagi East interface an improvement of about 50 MW in power transfer east limit may be achieved with the new 230 kV line. This would considerably reduce the bottling of generation west of Mississagi, during high flows eastbound and storm conditions.

It should be noted that any possible improvement in the Northwest system power transfer limits, such as those referred in C and D above, requires detailed interconnection studies, to ensure that there is no adverse impact on neighbouring utilities. In addition, agreement to increase the limits must be obtained from the MidWest ISO and Manitoba Hydro.

IMO Requirements

The IMO's requirements that have been identified in this assessment are as follows:

Option 1

If option 1 is pursued then the Anjigami TS breakers 814 and 824 are required to be replaced.

Option 2

Option 2 of transmission reinforcement is not acceptable to the IMO because it will weaken the overall system reliability.

Option 3

1. During the various stages of this project GLPL will have to inform the IMO well in advance of any scheduled modifications to the transmission system connectivity.

2. The IMO requires that GLPL provide the "as built" ratings for all the new or modified equipment as soon as they become available.

3. Is it required that the new 230/115 kV auto-transformer at MacKay TS be equipped with under-load tap changer and have exposed tertiaries to facilitate the connection of reactive compensation devices.

4. GLPL is required to install a shunt reactor, with a rating of about 40 Mvar, connected to the 13.8 kV tertiary winding of the new 230/115 kV auto-transformer at MacKay TS. The reactor is to be connected via one SF6, 13.8 kV circuit breaker and must be equipped with an automated switching scheme. GLPL is required to provide to the IMO detailed planning specification for the shunt reactor, when available.

5. The IMO requires the installation of a motorized 115 kV in-line disconnect switch at MacKay TS on No.3 Sault 115 kV circuit.

6. Since a new Third Line 230 kV switchyard will be constructed which substantially changes the existing 230 kV configuration, the IMO requires that five breakers be installed to allow for the individual connection of each 230 kV transmission element (Figure 5C).

7. The Connection Applicant has the choice to design the new 230 kV Third Line TS to three-breaker or four-breaker configuration, subject to ensuring that the final future stages at Third Line TS the station will be configured with three diameters. The initial connection of the 230 kV transmission onto the Third Line switchyard should be selected with care to allow for the connection of future elements without having to re-terminate existing elements. In selecting the switchyard connectivity, a breaker failure condition should not remove from service two parallel transmission elements.

8. The two new 230 kV switchyards at MacKay TS and Third Line TS must be equipped with breaker disconnect switches to allow the isolation of individual breakers for maintenance and/or repairs. The station buswork and disconnect switches must be adequately rated.

9. It is required that GLPL install all the equipment necessary to monitor the information required by the IMO on a continuous basis. This includes the status of all isolating disconnect switches and breakers, power flows (MW, Mvar) on transformers and transmission circuits.

10. The *Connection Applicant* will have to adhere the Transmission System Code technical requirements for transformer stations and transmission lines with respect to the protection and telecommunication requirements. Some of the existing protection settings will have to be modified to match the modified connectivity, and the new protections will have to be coordinated with the exiting schemes.

11. GLPL is required to perform short circuit studies and ensure that all installed breakers, permanent or temporary, are safe and have adequate interrupting capability. In the third stage of transmission reinforcement (section 2.2.3) it is planned to provide a temporary 115 kV connection of the new 230 kV line section at Anjigami via the two exiting 115 kV breakers 814 and 824. It should be noted that either breaker may not be adequately rated to interrupt the short circuit currents that could be experienced by the system and this arrangement was selected in order to alleviate concerns related to the low interrupting capability of one single breaker. Both breakers will be employed for clearing any faults associated with this section of line.

12. A generation rejection scheme will have to be implemented at MacKay TS in advance of the second stage of the transmission reinforcement. The scheme is required to reject sufficient Montreal River generation in the event of the loss of one Sault 115 kV circuit, such that the post-contingency flow on the remaining circuit does nor exceed its continuous rating. It is to be noted that during the second stage (section 2.2.3) of the proposed transmission reinforcement only No.1 Sault and No.2 Sault 115 kV circuits will be in service.

13. Upon completion of the transmission reinforcement and in view of eliminating the No.3 Sault 115 kV circuit thermal overloading concern , GLPL Limited Transmission is required to either:
   A. Modify as needed and retain the generation rejection scheme required under point12. Above which will initiate the rejection of selected Montreal River generation (up to 67 MVA) in the event of loss of the new 230 kV circuit and the MacKay 230/115 kV auto-transformer, or the loss of the new MacKay auto-transformer, or the loss of the south section of the new circuit, OR
   B. Design the new No.3 Sault 115 circuit with a 15 minute summer limited time rating which could accommodate the peak output of the Montreal River plants and disable the generation rejection scheme.

Budgetary Cost Estimates

Great Lake Power limited – Transmission has been working closely with Hydro One Networks to coordinate the proposed connection of the new 230 kV line at Wawa TS. GLPL has obtained cost estimates from Hydro One Network Inc. for all the Wawa 230 kV switchyard new or modified equipment and protection systems that are required to facilitate the connection of the new line.

Need for System Impact Assessment

This Preliminary Assessment evaluated all the aspects related to the impact of the proposed developments on the reliability of the IMO-controlled grid and no further analysis is required.

A separate System Impact Assessment is therefore not required for this project.

Notification of Approval

Section 10.0 of the Preliminary Assessment Report lists all the requirements identified by the Connection Assessment and Approval process for the GLPL transmission reinforcement options.

Since the Connection Assessment identified that Option 3 would represent a major improvement to the GLPL system and also help enhance the power transfer capability for the system East of Wawa, GLPL has decided to pursue Option 3.

The IMO has concluded that Option 1 and Option 3 provide an improvement to the system reliability and recommends that approval be granted for both options. Notification of Approval is to be issued for both options subject to the implementation by the proponent of their preferred option together with the IMO respective requirements.

Preliminary Assessment Report

Great Lakes Power Limited – Transmission Reinforcement Project

1.0 Background

The Great Lakes Power Limited transmission system between Anjigami TS and Mississagi TS provides supply to a peak load of about 380 MW and transmission corridors for peak generation of about 470 MW. Great Lake Power Limited - Transmission Division (GLP) is pursuing plans to redevelop the transmission system between Anjigami TS and Third Line TS and between Third Line TS and Mississagi TS in order to eliminate present transmission system limitations and provide improved reliability of supply.

GLPL selected three alternatives for reinforcing their transmission system. As a start, the *Connection Applicant* has performed a transmission system study to identify the effect that each of the three options would have on the power transfer capability of the GLPL system and the neighbouring Hydro One transmission system. The *Connection Applicant* performed detailed system studies for the existing system and each of the proposed options and provided a comprehensive report of study results to the IMO for review and use in the course of this assessment. After the examination of this report the IMO identified the additional studies that have to be performed for fully complete this preliminary assessment.

The purpose of the Connection Assessment is to evaluate the results of studies performed by Great Lakes Power and the IMO and identify the effect on system reliability. The assessment will recognize the benefits of one of the alternatives, which includes extensive system additions and modifications.

2.0 Proposed Development

2.1 Description of Existing Transmission

A diagram of the existing Great Lakes Power transmission system is shown in Figure 1. The bulk GLPL transmission system runs north-south between Wawa and Third Line and east-west from Third Line to Mississagi and comprises of:

- Anjigami 115 kV switchyard which is adjacent to Wawa 115 kV switchyard and together form a ring bus,
- Two 115 kV circuits, No.1 Anjigami and No.2 Anjigami, providing a connection into Mackay TS which is located about 73 km south of Anjigami,
- Three 115 kV circuits, No.1 Sault, No.2 Sault and No.3 Sault providing a connection between Mackay TS and Third Line TS which is located about 91 km south on Mackay TS,
- Two 115/230 kV auto-transformers at Third Line rated 150/200/250 MVA and
- Two 230 kV circuits, P21G and P22G, between Third Line 230 kV bus and Mississagi TS.

The following generation resources are incorporated in this system:
- 147.3 MW peak generation connected at Anjigami TS
- 150.2 MW peak generation connected at MacKay TS
- 174. 1 MW peak generation connected at Third Line TS.

For most part the GLPL load is supplied via 115 kV circuits off Third Line TS. The system peak load is about 300 MW summer and 380MW winter.

2.2 Description of Proposed Options

GLPL has submitted to the IMO a Connection Assessment Application containing three options for the reinforcement of their system. Schematic representations of the three options are shown in Figures 2, 3 and 4.

Although this assessment has carefully investigated each of the three transmission reinforcement options proposed by Great Lakes Power, special attention was given to Option 3 because it represents major modification of the existing transmission system.

2.2.1 Option 1 (Figure 2)

This option involves the redevelopment of all five 115 kV circuits between Anjigami, Mackay and Third Line, including structure replacements and replacement of conductors to 336 kcmil and skywire where necessary. With the exception of the replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and replacement of two under-rated breakers at Anjigami TS (814 & 824) as part of the Transmission Reinforcement Project, no other station modifications are planned for Anjigami TS, Mackay TS or Third Line TS under this option. This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

Table 1 lists the thermal capability of the GLPL 115 kV and 230 kV transmission system, after the completion of this redevelopment option. The limited time ratings for the new circuits will be determined after the option selection is complete.

Table 1. Circuit Ratings for Option 1

Circuit/ Terminals	***Conductor (ACSR)***	*Minimum Continuous Rating*	
230 kV P22G Third Line to Mississagi	864 kcmil	940 A	374 MVA
230 kV P22G Third Line to Mississagi	864 kcmil	940 A	374 MVA
No.1 Anjigami Anjigami to Mackay	336 kcmil	500 A	100 MVA
No.2 Anjigami Anjigami to Mackay	336 kcmil (new)	500 A	100 MVA
No.1 Sault Mackay to Third Line	336 kcmil	500 A	100 MVA
No.2 Sault Mackay to Third Line	336 kcmil (new)	500 A	100 MVA
No.3 Sault MacKay to Third Line	336 kcmil (new)	500 A	100 MVA

2.2.2 Option 2 (Figure 3)

This option involves the complete rebuilt of only one 115 kV circuit between Anjigami TS and MacKay TS and two 115 kV circuits between MacKay and Third Line. The second existing 115 kV Anjigami and Sault circuits would be removed and the third 115 kV circuit between Mackay TS and Third Line TS would be refurbished and radially connected at Third Line TS.

Under this option, slight modifications to station configurations are required as follows:

- Replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and replacement of two under-rated breakers at Anjigami TS (814 & 824) as part of the Transmission Reinforcement Project
- Breakers 814 and 824 at Anjigami would be joined together and provide the connection for the new 115 kV circuit,
- Breaker 648 at Mackay TS would be removed,
- An alternative connection of the 115 kV circuit No.1 Sault will be provided to Third Line TS south bus via a new 115 kV breaker.

This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

Table 2 lists the thermal capability of the GLPL 115 kV and 230 kV transmission system, after the completion of this redevelopment option. The limited time ratings for the new circuits will be determined after the option selection is complete.

Table 2. Circuit Ratings for Option 2

Circuit/ Terminals	***Conductor (ACSR)***	*Minimum Continuous Rating*	
230 kV P22G Third Line to Mississagi	864 kcmil	940 A	374 MVA
230 kV P22G Third Line to Mississagi	864 kcmil	940 A	374 MVA
No.1 Anjigami Anjigami to Mackay	795 kcmil	900 A	180 MVA
No.1 Sault Mackay to Third Line	795 kcmil	900 A	180 MVA
No.2 Sault Mackay to Third Line	795 kcmil	900 A	180 MVA
No.3 Sault Radial from Mackay	266.8 kcmil	375 A	75 MVA

2.2.3 Option 3 (Figure 4)

In its final stage, this option will consist of the following new and modified transmission facilities:

- One new 230 kV circuit from Wawa to MacKay to Third Line, that will be connected to MacKay TS via one 115/230 kV auto-transformer,
- The installation of one additional 230 kV breaker at Wawa,

- Building a new 230 kV four breaker ring bus at MacKay TS, which will be equipped initially with three breakers, providing the connection for the new auto-transformer and the north and south sections of the new line
- The upgrading of No.3 Sault 115 kV circuit to 90 MVA,
- Building a 230 kV switchyard at Third Line including a ring bus of four 230kV breakers to connect the new 230 kV circuit, P21G and P22G circuits, and the two auto-transformers,
- The removal of four 115 kV circuits; No.1 Anjigami, No.2 Anjigami, No.1 Sault, and No.2 Sault,
- Replacement of three under-rated breakers at Anjigami TS (834, 854 & 864) during 2003 as part of another project and the removal of two breakers (814 & 824) at Anjigami TS and four breakers (622, 632, 648 & 658) at MacKay TS,
- Re-terminate No.1 MacKay and No.2 Gartshore on separate breaker diameters at MacKay TS, and
- Re-terminate the Third Line TS T1 115 kV connection and No.3 Sault 115 kV line on separate 115 kV diameters at Third Line TS.

This option also includes the upgrading of the 230 kV line P21G to match the thermal capability of P22G.

This project involves extensive system modifications and requires careful and clear staging of the work to give IMO a preliminary indication of the intermediate system configurations. During the various stages of this project GLPL will have to inform the IMO well in advance of any modifications to the system connectivity and their schedule. The IMO will use this information to update the system operating limits. A description of the major construction stages is given in section 2.3.5.

The ratings of the new and modified facilities are presented in the next sections. It should be noted that only minimum continuous ratings were provided for the new circuits. The Limited Time Ratings (LTR) for this equipment will be provided by the *Connection Applicant* when available.

In addition, this assessment of this option will be mindful of possible future resources developments in the area and may recommend that equipment be rated higher than it was proposed by the *Connection Applicant*. It is also noted that actual circuit ampacity ratings during operations will 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.

115 kV and 230 kV Circuits

The normal operating temperatures for the new conductors were not available at the time of this assessment but GLPL provided the minimum design current ratings for the new conductors. The minimum thermal ratings of the new circuits are listed in table 3, below.

Table 3. Circuit Ratings for Option 3

Circuit/ Terminals	***Conductor (ACSR)***	*Minimum Continuous Rating**	
230 kV P22G Third Line to Mississagi	864 kcmil	940 A	374 MVA
New 230 kV circuit Wawa to Mackay	1272 kcmil	940 A	374 MVA
New 230 kV circuit Mackay to Third Line	1272 kcmil	940 A	374 MVA
No.3 Sault Mackay to Third Line	266.8 kcmil	450 A	90 MVA

*Ratings calculated on 115 kV and 230 kV respectively

MacKay TS 115/230 kV Auto-transformer

The new auto-transformer will be 3-phase oil-immersed with cooling provided by forced oil and /or forced air and the windings configuration is to be wye-wye delta. The tertiary will be buried and operated closed. The positive sequence impedance will be about 8% on 100MVA.

The MacKay 230/115 kV auto-transformer is to be rated as follows:

	Normal	Emergency	
		10 Day	½ Hour
Summer	200 MVA	Not Available	Not Available
Winter	200 MVA	Not Available	Not Available

The *Connection Applicant* indicated that the new auto-transformer at MacKay will only be equipped with an off-load-tap-changer with the following tap positions:

241.5 kV 235.75 kV 230 kV 224.25 kV 218.5 kV
for a low voltage of 115 kV.

The IMO system operating instructions require that the system operating voltage in the Northwest system be maintained between 235 kV to 250 kV to ensure the system security. While the off-load tap position range proposed by the proponent, as described in section 2.2, is expected to be adequate for voltage variations it does not allow sufficient voltage control, if required by the system conditions.

Schedule H of the Transmission System Code requires that:

> A Transmitter's tapped transformer stations shall have adequate on-load tap changer or other voltage regulating facilities to operate continuously within normal variations on the transmission system as set out in the Market Rules and to operate in emergencies with a further transmission system voltage variation of ±6%.

Is it thus required that the new 230/115 kV auto-transformer at MacKay TS be equipped with under-load tap changer and have exposed tertiaries to facilitate the connection of reactive devices.

230 kV Circuit Breakers and Disconnect Switches (Wawa TS, MacKay TS, Third Line TS)

The new 230 kV SF6 circuit breakers that are proposed for installation at Wawa TS, the new MacKay TS and Third Line TS are rated follows:

Rated operating voltage:	250 kV
Fault interrupting capability:	40 kA symmetrical
Continuous current rating:	2000 A
Rated interrupting time:	3-cycles
BIL	650 kV

All new station disconnect switches will be adequately rated.

115 kV Circuit Breakers and Disconnect Switches

Under option three the *Connection Applicant* proposes to retire those 115 kV breakers that remain unused after station reconfigurations at Anjigami TS and MacKay TS.

The proposed final Anjigami TS 115 kV switchyard station configuration would comprise of a total of four 40 kA breakers. In the final configuration the existing breakers 814 and 824 will not be necessary and will be removed. This arrangement is shown in Figure 5A.

The proposed final MacKay TS 115 kV switchyard station configuration would comprise of a total of eight breakers (618, 615, 612, 638, 635, 668, 665 and 662). The short circuit interrupting capability of these breakers ranges from 40 kA (615, 635 and 665) to 10.5 kA (638) and 7.5 kA (618, 612, 668 and 662). In the proposed final configuration breakers 648, 658, 632 and 622 will become unnecessary and will be removed. This arrangement is shown in Figure 5B**.**

The Connection Applicant plans to keep the Third Line TS 115 kV switchyard station configuration substantially unchanged, with the exception of the following:

- Breaker 488 will be moved and form a new diameter with breaker 472
- Auto-transformer T1 115kV connection will be reconfigured to terminate on the two breaker diameter 482 and 492,
- No.3 Sault circuit will be reconfigured to terminate on the two breaker diameter 472 and 488(new position), and

The rating for the one new 115 kV in-line disconnect switch proposed for the new MacKay TS auto-transformer are:

Rated operating voltage:	138 kV
Continuous current rating:	2000 A

This arrangement is shown in Figure 5C.

The ratings of all new or modified equipment provided by GLPL in view of this assessment are design ratings and could be different than the ratings of the installed equipment. The IMO requires that GLPL provide the "as built" ratings for all the new or modified equipment as soon as it becomes available.

2.3 Assessment of Connection Arrangements

This section investigates the impact of the proposed final transformer station layouts for each of the proposed options.

2.3.1 Wawa/Anjigami TS Configuration

Option 1

The proposed ultimate station arrangement for Wawa 230/115 kV and Anjigami 115 kV stations for this option is essentially unchanged from the existing arrangement. However, due to inadequate interrupting capability, this option includes the replacement of two more breakers (814 and 824) in addition the replacement of three underrated Anjigami TS breakers (834,854 & 864) as a separate project.

The proposed connectivity is identical to the existing arrangement, does not introduce a new critical contingency and will not adversely affect the reliability of the IMO-controlled grid.

Option 2

The proposed ultimate station arrangement for Wawa 230/115 kV and Anjigami 115 kV stations for this option will retain all the existing 115 kV breakers with the new 115kV Anjigami line terminated on two breakers (814 and 824). Due to inadequate interrupting capability, this option includes the replacement of two more breakers (814 and 824) in addition the replacement of three underrated Anjigami TS breakers (834,854 & 864) as a separate project.

The proposed connectivity does not introduce a new critical contingency and will not adversely affect the reliability of the IMO-controlled grid.

Option 3 (Figure 5A)

The proposed station arrangement for Wawa 230 kV involves the addition of one 230 kV breaker to facilitate the termination of the new 230 kV circuit. The new breaker will separate the new 230 kV circuit and W22M. Examination of the station configurations shows that the worst case breaker-failure condition will result in a post-contingency configuration with three 230 kV lines and one Wawa auto-transformer still connected. This post-contingency configuration is more robust then the post-contingency configuration of the existing system for a similar contingency.

At Anjigami, the removal from service of both No.1 and No.2 Anjigami 115 kV circuits will result in breakers 814 and 824 becoming redundant. These breakers will be removed from the system in the last stage of the project.

The modifications at Wawa TS and Anjigami TS that are proposed to accommodate the 230 kV redevelopment option do not introduce a new critical contingency and will not reduce the present level of transmission system reliability.

2.3.2 MacKay TS Configuration

Option 1

If option 1 is adopted, the present configuration of MacKay TS will remain unchanged; hence this arrangement will not adversely affect the reliability of the IMO-controlled grid.

Option 2

If option 2 is adopted, the configuration MacKay TS will remain unchanged with the exception of the removal from service of breaker 648, which becomes redundant when No.2 Anjigami is permanently removed from service.

With No.3 Sault operating radial from Third Line TS or alternately from MacKay TS there is a need for a motorized line disconnect switch to be installed at MacKay TS on No.3 Sault to allow for the bus at the station to be closed if the disconnect switch is open. This will ensure continued reliability at the station during the normal radial feed of No.3 Sault.

The IMO requires that the final configuration include the installation of a 115 kV motorized line disconnect switch on No.3 Sault at MacKay TS for this option.

This arrangement with the recommended addition does not introduce a new contingency and will not adversely affect the reliability of the IMO-controlled grid.

Option 3(Figure 5B - Final) - MacKay 115 kV

If Option 3 is adopted, Mackay 115 kV switchyard will undergo a number of modifications.

The *Connection Applicant* plans to reconnect No.1 MacKay circuit and No.2 Gartshore circuit to the diameter positions that are left vacant by the disconnection of No.1 Anjigami and No.1 Sault circuits. The new No.3 Sault circuit will remain connected on the same position and the 115 kV side of new auto-transformer will be connected to the North bus through a new 115kV motorized disconnect switch.

With this arrangement both Gartshore lines are connected to the same diameter and a breaker failure condition for breaker 615 will result in the loss of Gartshore GS, Andrew GS and Hogg GS. The *Connection Applicant* indicated that this arrangement was selected to allow for splitting of the 115kV switchyard with MacKay lines and Gartshore lines isolated on either the auto-transformer/line flowing north or the No.3 Sault line flowing south for conditions where the south section of the new 230kV line are out of service.

Examination of the station configuration shows that the retermination of No.2 Gartshore between breakers 635 and 632 is preferred because it reduces the risk of loosing both Gartshore lines for a breaker- failure condition associated with 615. Also, with this arrangement some of the desired splits of the 115kV switchyard can still be achieved when the south section of the new 230kV line are out of service. However, the Gartshore GS Andrews GS and Hogg GS can only be evacuated via No.3 Sault, whose continuous capability will be adequate to accommodated the peak MW production of these units.

After reviewing the two alternatives, the IMO strongly recommends that No.2 Gartshore circuit be connected between breakers 635 and 632 as shown in Figure 5B. This final configuration will also result in removal of the four redundant breakers (612, 622, 648 & 658).

Under this option No.3 Sault will be normally operated closed between MacKay TS and Third Line TS. Alternatively, the circuit could be operated radially from Third Line TS or MacKay TS. To facilitate the radial mode of operation a line disconnect switch needs to be installed at MacKay TS on No.3 Sault to allow for the bus closing if the disconnect switch is open. Thus, the continued reliability at the station during the radial feed of No.3 Sault is maintained.

The IMO requires that in the event of a fault associated with No.3 Sault the supply to local load be restored in eight hours. This could be achieved by either ensuring that personnel is available to manually perform the switching operation in eight hours or by installing a remotely operated motorized disconnect.

The IMO requires that the final configuration include the installation of a 115 kV line disconnect switch on No.3 Sault at MacKay TS for this option.

The final arrangement for MacKay 115 kV switchyard with the recommended changes will not adversely affect the reliability of the IMO-controlled grid and will represent an improvement with both No.1 MacKay circuit and No.2 Gartshore circuit terminated on dedicated breaker positions.

Option 3(Figure 5B - Final) - MacKay 230 kV

The original connectivity of the new 230 kV line at MacKay TS (Figure 4) constited of two 230 kV motorized in-line disconnect switches, one on each side of the MacKay TS auto-transformer tap and one 230 kV disconnect switch on the 230 kV side of the auto-transformer. The 115 kV isolation point would be provided by one 115 kV motorized disconnect switch connected on the 115 kV side of the auto-transformer.

However, in the course of this assessment the original configuration suffered a number of modifications.

Motorized Disconnect at MacKay TS – Original Design (Figure 4)

Should a forced outage associated with either the north or the south section of the 230 kV line or the 230/115 kV auto-transformer occur, when a 230 kV motorized disconnect is installed at MacKay TS on the auto-transformer side, the fault will remove from service both sections of the new line and the new auto-transformer.

If either section of the new 230 kV line is permanently faulted that section can be isolated by opening the corresponding disconnect, while the remaining healthy section and the auto-transformer could be restored to service by closing the remaining two 230 kV disconnects at MacKay TS.

Similarly, the clearance of an auto-transformer fault must send transfer trip to Wawa TS and Third Line TS and remove from service the new 230 kV line.

Should a planned outage to either the transformer or a section of the new 230 kV line occur, the temporary removal from service of both, the new auto-transformer and the 230 kV line will be required to switch the element out of service.

Consequently, with three disconnect switches at MacKay TS there could be fairly frequent temporary outages to the new 230 kV facilities depending on the number of planned or forced outages.

Circuit Switcher at MacKay TS – IMO Recommendation (Figure 4A)

If a 230 kV circuit switcher is installed at MacKay TS on the HV side of the auto-transformer, the transformer isolation for faults or planned outages would be provided by the circuit switcher, without having to remove from service the 230 kV line.

The 230 kV circuit switcher should be rated for a maximum operating voltage of 260 kV and minimum ambient temperature of -40^0C.

In-line Breakers at MacKay TS – CIA Requirement (Figure 4A)

Following connected customer concerns that were identified in the transmitter's Customer Impact Assessment, GLPL proposed to install two 230 kV in-line breakers, one on each side of the MacKay TS auto-transformer tap. This arrangement together with the 230 kV circuit switcher identified in the previous section will allow the independent isolation of either the north section, the south section of the new 230 kV line or the new auto-transformer for a fault involving the respective transmission element.

Three Breaker Ring Bus at MacKay TS– IMO Recommendation (Figure 4B)
Final Arrangement

The main concern associated with the configuration proposed in the above two sections is that the new 230 kV line section would be out of service every time when maintenance work is being performed on its in-line breaker.

Therefore, the IMO has recommended that GLPL consider building a new 230 kV switchyard at MacKay TS as shown in Figure 4B. The new switchyard is to be designed as a four breaker ring bus, which will be initially equipped with three breakers.

GLPL has reviewed IMO's recommendation and confirmed that they will be including the proposed MacKay 230 kV station configuration in the transmission redevelopment plans as shown in Figure 5B.

2.3.3 Third Line TS Configuration

Option 1

If option 1 is adopted, the present configuration of Third Line TS will remain unchanged; hence this arrangement will not adversely affect the reliability of the IMO-controlled grid.

Option 2

If option 2 is adopted, the configuration of Third Line TS will remain substantially unchanged except for the addition of a second breaker for No.1 Sault.

With No.3 Sault operating radial from Third Line TS or alternately from MacKay TS there is a need for a line disconnect switch to be installed at Third Line TS on No.3 Sault to allow for the bus at the station to be closed if the disconnect switch is open. This will ensure the continued reliability at the station during the normal radial feed of No.3 Sault.

The IMO requires that in the event of a fault associated with No.3 Sault the supply to local load be restored in eight hours. This could be achieved by either ensuring that personnel is available to manually perform the switching operation in eight hours or by installing a remotely operated motorized disconnect.

The IMO requires that the final configuration includes the installation of a 115 kV line disconnect switch on No.3 Sault at Third Line TS for this option.

This final arrangement with the suggested changes will not introduce a new contingency and will not adversely affect the reliability of the IMO-controlled grid.

Option 3 (Figure 5C)

As with the other stations, if the 230 kV transmission reinforcement is pursued, Third Line TS will undergo extensive additions and modifications.

A new 230 kV switchyard will be constructed which is to be initially equipped with two diameters but will be designed for an ultimate three-diameter configuration.

For the initial stage of the 230 kV switchyard, the *Connection Applicant* has proposed a four breaker ring bus configuration where, the one transformer and one PxG 230 kV line are connected on the same breaker position. For the worst case breaker-failure condition this configuration will result in a post-contingency configuration with only P21G and T1 in service or P22G and T2 in service. The proposed "IMO Transmission Assessment Criteria" specifies that any new switchyard configuration should ensure that every transmission element (one auto-transformer or one line) should have a dedicated diameter position.

Since a new switchyard is being constructed which substantially changes the existing 230 kV configuration, the IMO requires that five breakers be installed to allow for the individual connection of each 230 kV transmission element (Figure 5C).

The ultimate configuration for 230 kV Third Line TS was developed by taking into consideration any foreseeable future 230 kV developments in the area and ensuring that their connection can be accommodated (Figure 5D). Under the current station design each diameter will ultimately accommodate three breaker positions.

It should be mentioned that depending on the space availability a four-breaker diameter design could be more compact than the three-breaker design. The *Connection Applicant* indicated that based on the preliminary Engineering the third diameter could be a four breaker diameter if designed that way when it is installed as part of a future expansions. The first two diameters will be designed for a maximum of three breakers.

However, should a four-breaker design be selected for all three diameters, the ultimate station arrangement must consist of three diameters with three breakers each, in order to avoid a ring bus arrangement. Hence the *Connection Applicant* has the choice to design the station to three-breaker or four-breaker configuration, subject to ensuring that the final future stages at the station will be configured with three diameters.

The initial connection of the 230 kV transmission onto the Third Line switchyard should be selected with care to allow for the connection of future elements without having to re-terminate existing elements. In selecting the switchyard connectivity, a breaker failure condition should not remove from service two parallel transmission elements (two transformers or a double circuit line). Figure 5D shows an ultimate arrangement that meets this criterion.

Based on the ultimate arrangement, the final configuration of the new 230 kV switchyard at Third Line TS should be as shown in Figure 5C. This final arrangement will not adversely affect the reliability of the IMO-controlled grid. In addition, this arrangement will provide the separation of the auto-transformers from the Third Line to Mississagi 230 kV lines which will eliminate the loss of two transmission system elements for a single contingency and the removal of more than two transmission system elements for a breaker-failure operation on the 230kV or for breaker-failure of breaker 508 on the 115kV system.

2.3.4 Supply to Local Loads (Option 3)

For Option 3, the permanent removal from service of No.1 Sault and No.2 Sault 115 kV circuits, will result in major modifications to the supply to Batchawana TS and Goulais TS.

Presently, the two distribution systems are supplied via one of the three Sault circuits with available switching for load transfer to any of the other two circuits, as shown in Figure 1. At Goulais Bay TS switch 584 and 585 are remotely controlled circuit switchers while the other disconnect switch (581) is manually controlled. At Batchawana T.S. all the existing switches are manually controlled. The distribution transformers are protected by HV fuses.

After the implementation of this transmission reinforcement option only one 115 kV circuit, the upgraded No.3 Sault, will be available to supply these loads, as shown in Figure 4B.

Batchawana TS and Goulais TS connection to No.3 Sault circuit will each be provided via two line taps, located on each side of in-line disconnect switches (motorized and remotely controlled for Goulais Bay TS). For each station a third disconnect switch is provided on the 115 kV side of the distribution transformer just ahead of the HV fuses that protect the distribution transformers at each station. Under the existing and proposed connection any fault associated with the distribution transformers at Batchawana TS and Goulais Bay TS will be cleared by these HV fuses.

The proposed 115 kV in-line disconnect switches allow these loads to be supplied from either end of the No.3 Sault, in the event of a permanent fault on either line section or the section of line between the two stations.

The IMO availability standards which, states that:
“With all transmission elements in service, for any single element contingency that results in a supply interruption to a load less than 75MW, all load should be restored within a maximum period of 8 hours.”

Since the peak load at these two stations totals between 6 to 7 MW the proposed arrangement at Batchawana TS and Goulais Bay TS meets the IMO availability standards for load supply; hence this arrangement will not adversely affect the reliability of the IMO-controlled grid.

2.3.5 Project Stages

In discussions with the *Connection Applicant,* the scheduled work for 2003 which is outside of this project and the major project implementation stages were identified as shown in the diagrams included in Appendix A and described below. The diagrams include all the requirements and recommendations the IMO has specified in this report.

1. The first stage is considered to be the replacement of three underrated Anjigami TS breakers (834,854 & 864) as shown in Figure O3.1. This work is planned for completion in 2003 as a separate project.

2. The second stage starts with the permanent removal of the two existing 115 kV Anjigami circuits in 2004. These circuits were taken out of service in May 2003 with IMO approval. As part of the second stage one breaker (648) at MacKay TS becomes redundant and will be permanently removed. Also, the supply configurations to Batchawana TS and Goulais Bay TS will be modified and 115 kV No.3 Sault circuit will be temporarily taken out of service to perform upgrading work. A diagram capturing these modifications is shown in Figure O3.2. The work in the second stage is scheduled for completion by December 2004.

3. The third stage involves the in service of the new 230 kV line north section between Anjigami TS and MacKay TS, which will be initially connected at 115 kV for operation in January 2005, as shown in Figure O3.3. It is planned to provide the Anjigami connection of the new line section via the exiting 115 kV breakers 814 and 824.

4. The fourth stage involves permanent removal from service of the No.1 Sault and No.2 Sault 115 kV circuits scheduled for February 2005 to allow for construction of the new 230kV line south section between MacKay TS and Third Line TS as shown in Figure O3.4. This stage includes the connection of Batchawana TS and Goulais Bay TS as shown in the Figure and the construction of the new 230 kV line section between MacKay TS and Third Line TS. The work in the fourth stage is scheduled for completion by late November 2005.

   It should be noted that during the period when the new north 230 kV line section is operated at 115 kV, the new line section would not be equipped with 115kV line disconnects. When necessary, the north section can be isolated be opening the station breakers.

5. In the final stage the installation of the following equipment must be completed before bringing the new circuits to 230 kV operation:

- a new 230 kV breaker at Wawa TS,
- a new 230/115 kV auto-transformer including reactor at MacKay TS,
- a new 230 kV switchyard at MacKay initially equipped with three breakers and
- a new Third Line TS 230 kV switchyard initially equipped with five breakers.

The station work will be completed in 2004 and 2005 with the final in service of the north and south line sections at 230kV by late November 2005.

With the final reconfiguration of the 115kV systems, the following breakers will become redundant and removed: two breakers (814 & 824) at Anjigami TS and four breakers (612, 622, 648 & 658) at MacKay TS.

The diagram of the final arrangement proposed by the connection applicant is shown in Figure O3.5

3.0 On-line Monitoring

The *Market Rules* (Chapter 4 section 7.4) require that each transmitter shall provide the IMO on a continual basis with on-line monitored quantities as specified in Appendix 4.16. It is required that Great Lakes Power Inc. install all the equipment needed to monitor the information required by the IMO on a continuous basis. The IMO requires that the status of all isolating disconnect switches and breakers, power flows (MW, Mvar) on transformers and transmission circuits be monitored on a continual basis.

4.0 Protection Systems

With respect to the protection and telecommunication requirements, the *Connection Applicant* will have to follow the Transmission System Code technical requirements for transformer stations and transmission lines. Some of the existing protection settings will have to be modified to match the modified connectivity, and the new protections will have to be coordinated with the exiting schemes.

It should be noted that commencing with stage three of the transmission redevelopment, where the north section of new 230 kV circuit will be connected at 115 kV, faults involving this section of line should be cleared at Anjigami TS by breakers 864 and 854.

5.0 Fault Level Assessment

Great Lakes Power T&D performed short circuit studies to identify the impact of each transmission reinforcement option on the short circuit currents in the area.

The system model used in these studies included all the existing transmission facilities and the impactive projects that have completed the CAA process and obtained approval for connection. The model included:

- All the Northwest system generation and transmission in service,
- All the Great Lakes Power generation in service, including the new High Falls GS
- Lake Superior Power GS in service,

Since option three involves the addition of two new 230 kV switching yards at MacKay and Third Line which is expected to provide opportunities for incorporation of future resources, additional short circuit studies were performed to assess the fault levels for an ultimate GLPL system configuration. The main purpose of this study was to ensure that the new 115 kV and 230 kV breakers selected for installation at Anjigami, Mackay and Third Line will be adequately rated for the *ultimate system* expansions. The *ultimate system* model used in this study included:

- New 230 kV line between Wawa TS and Third Line TS, tapped at MacKay TS,

- Two 230/115 kV auto-transformers at MacKay TS,
- New 200 MW generation connected at MacKay 115 kV switchyard,
- Three 230/115 kV auto-transformers at Third Line TS,
- New 200 MW generation connected at Third Line 115 kV switchyard,
- New 300 MW generation connected at Third Line 230 kV switchyard,
- Third 230 kV line between Third Line TS and Mississagi TS,
- Third 230 kV line between Wawa TS and Marathon TS and
- One large fictitious generator connected at Mississagi TS.

The results of the short circuit studies are summarized in Table 4.

Table 4. Short Circuit Study Results

BUS kV	TOTAL FAULT CURRENT Symmetrical (kA)		Breaker Ratings (kA)
	3-phase fault	L-G	Symm.
OPTION 1			
Anjigami 115	*8.32*	*10.01*	**40 kA** (834,844,854,864) **7.5 kA** (814, 824)
MacKay 115 kV	*6.66*	*7.03*	**40 kA** (615,635,665) **10.5 kA** (638,648,658) **7.5 kA** (618,668,612,622,632,662)
Third Line 115 kV	*9.64*	*11.83*	**25 kA (All Existing)**
Third Line 230 kV	*4.08*	*4.68*	**31.5 kA** (510)
OPTION 2			
Anjigami 115	*7.79*	*9.44*	**40 kA** (834,844,854,864) **7.5 kA** (814, 824)
MacKay 115 kV	*5.5*	*5.95*	**40 kA** (615,635,665) **10.5 kA** (638,658) **7.5 kA** (618,668,612,622,632,662)
Third Line 115 kV	*9.32*	*11.48*	**25 kA (All Existing)** **40kA (New No.1 Sault)**
Third Line 230 kV	*4.02*	*4.13*	**31.5 kA (510)**
OPTION 3			
Anjigami 115	*7.54*	*9.26*	**40 kA** (834,844,854,864)
MacKay 115 kV	*5.93*	*6.58*	**40 kA** (615,635,665) **10.5 kA** (638) **7.5 kA** (618,668,632,662)
Third Line 115 kV	*9.44*	*11.81*	**25 kA (All Existing)**
Third Line 230 kV	*5.36*	*5.29*	**40 kA (All New)**
OPTION 3 –Ultimate System Configuration			
Anjigami 115	*8.38*	*10.1*	**40 kA**(834,844,854,864)
MacKay 115 kV	***12.45***	***11.02***	**40 kA** (615,635,665) **10.5 kA** (638) **7.5 kA** (618,668,632,662)
Third Line 115 kV	*20.12*	***25.11***	**25 kA (All Existing)**
Third Line 230 kV	*13.29*	*14.43*	**40 kA (All New)**

The short circuit study results indicate that:

- If *Option 1* is adopted, it is required that Anjigami 115 kV breakers 814 and 824 be replaced with 40 kA breakers. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.

- If *Option 2* is adopted, it is required that Anjigami 115 kV breakers 814 and 824 used to connect the new line be replaced with a 40 kA breaker. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.
- If *Option 3* is adopted, the system short circuit currents are within the interrupting capability of the proposed new breakers and the existing breakers that are to be retained. Should all facilities assumed in the ultimate system configuration materialize, then some of the 115 kV breakers at MacKay TS will have to be replaced to accommodate the increase in short circuit currents. The adequacy of these breakers will be revisited with every future new proposed development in the area.

Under stage 3 (Option 3) of transmission redevelopment it is planned to provide the temporary Anjigami connection of the new 230 kV line section via the exiting 115 kV breaker 814 and 824 to alleviate concerns related to the low interrupting capability of these breakers.

GLPL is required to perform short circuit studies and ensure that all installed equipment, permanent or temporary, is safe and adequately rated.

6.0 Existing System and Operating Limits

While a description of the Great Lakes Power system was provide in section 2.1, it is also necessary to provide a description of the Hydro One Northwest transmission system, because the two systems run in parallel and affect each others capability and operation.

This section describes the Northwest transmission system and the existing power transfer limits for the system between Marathon TS and Mississagi TS.

Descriptions of the study criteria, the selected study scenarios and the study results are also provided in this section.

6.1 Description of Northwest System

A schematic diagram of the Northwest Transmission system is shown in Figure 6. The Northwest bulk system is that part of the power system between Kenora TS in the west, Algoma TS in the east and Fort Frances TS. The main transmission interface between Mackenzie and Mississagi comprises of the following main facilities:

- Double circuit 230 kV line (A21L, A22L) between Mackenzie TS and Lakehead TS,
- Double circuit 230 kV line (M23L, M24L) between Lakehead TS and Marathon TS,
- Double circuit 230 kV line (W21M, W22M) between Marathon TS and Wawa TS, and
- Double circuit 230 kV line (W21M, W22M) between Wawa TS and Mississagi TS.

Parallel 115 kV systems exist between Lakehead TS to Marathon TS, and Wawa TS to Third Line TS. The main connections to the 115 kV systems are provided by 2x250 MVA auto-transformers at Lakehead TS, 2x125 MVA auto-transformers at Marathon TS, 2x125 auto-transformers at Wawa TS MVA (summer 10 day LTR of 205.3 MVA), and 2x250MVA auto-transformers at Third Line TS.

Reactive compensation devices are present at the following point in the area bulk transmission system:

- At Lakehead TS – two synchronous condensers rated 48 Mvar each, connected to the tertiary winding of the each auto-transformers,
- At Marathon TS – two shunt capacitors rated 36 Mvar each, connected to the tertiary winding of the each auto-transformers,
- At Wawa TS – two 40 Mvar shunt reactors and 39.6 Mvar shunt capacitors (future Hydro One installations that were assumed to be in service), each connected to the tertiary winding of the one auto-transformer.
- At Third Line TS – two 19.8 Mvar shunt capacitors each connected to the tertiary winding of the one auto-transformer.

Northwest system generation comprises of a mix of hydraulic and thermal units with a total installed capacity of about 1500 MW. Electricity demand records indicate that the load in the area could vary between 700 MW and 1100 MW, with loads exceeding 900 MW for more than 50% of the time.

6.2 Existing Operating Security Limits

Great Lakes Power

The operating instructions for the present system include a number of restrictions on the GLPL system that were implemented in view of mitigating the impact on the 230 kV system between Wawa TS and Algoma TS. These instructions state that:

- GLPL must provide sufficient reactive power and adjust voltages on its system to maintain a minimum steady state voltage of 118 kV at Third Line TS,
- The voltage at Third Line TS cannot exceed 124 kV,
- To avoid severe post contingency voltage decline the maximum power inflow into the GLPL system via the Wawa auto-transformers and P21/22G out of Mississagi, must be less than 325 MW with 100 MW of load armed for rejection,
- The GLPL power inflow is limited to 175 MW if on load is armed for rejection,
- The GLPL power inflow is limited to 235 MW if either P21G or P22G is out of service, with 100 MW of load armed for rejection.

After the opening of the electricity market, detailed operating instructions have been developed to observe Great Lakes Power system internal contingencies and protect GLPL own transmission system from overloads. The IMO uses equipment ratings provided by Great Lakes Power-Transmission Inc. and power distribution factors computed by the IMO to direct the operation of the system in such away as to avoid the thermal overloading of this equipment. The following possible overloads within the GLPL system have been identified:

- With peak Anjigami TS and MacKay TS generation in service the existing 115 kV circuits between MacKay TS and Third Line TS could become loaded over their continuous capability in pre-contingency situations.
- With peak Anjigami TS generation in service, MacKay TS generation out of service and Lake Superior Power GS out of service No.1 Anjigami and No.2 Anjigami 115 kV circuit will be loaded over their continuous rating. In this case the generation connected to Anjigami TS is bottled due to the transmission constraints.

- For most system conditions and peak generation within the GLPL system No.2 Anjigami circuit will become overloaded for the loss of the companion circuit. The output of generating units connected to Anjigami TS has been restricted due to these constraints.
- For most system conditions and little generation in service at Third Line TS a contingency associated with No.2 Sault will result in the overloading of the No.1 Sault circuit.
- The generation in the GLPL system has been further constrained during maintenance planned outages to various transmission elements.

Northwest System

The 230 kV circuit between Marathon TS and Wawa TS constitute the transmission interface commonly known as the East-West Tie (EWT). Further, The Ontario Northwest system is interconnected to:

- Manitoba via two 230 kV lines, K21W and K22W, each equipped with one regulating and phase shifting transformer, from Kenora TS to Whiteshell TS referred to as Manitoba Interconnection and
- Minnesota via two180 MVA, 115 kV phase shifter transformers connected in series, with a phase shifting capability of 76^0 each providing an interconnection between Fort Frances TS and International Falls.

The present set of operating limits restrict the power flowing over these three interfaces to levels required to maintain system security. Presently, different operating limits are used for fair weather conditions, when the critical contingency is the loss of a single circuit, and for adverse weather conditions, when the critical contingency is the loss a double circuit line. A detailed description of the Northwest system operating limits is included in Appendix B.

7.0 Assessment of Impact on System Reliability

7.1 Study Criteria

The set of reliability guidelines used in this study was formulated based on the operating practice that is currently used for the Northwest region and the GLPL system, IMO’s proposed “Transmission Assessment Criteria” and the requirements of the *Market Rules*.

The current operating directives require that:

- the voltages at Marathon TS and Wawa TS be maintained above 235 kV level to ensure the validity of the operating security limits,
- the voltage at Mississagi TS be maintained above 230 kV, the voltage at Algoma TS above 227 kV to ensure the validity of the operating security limits and,
- the power flows over the three main Northwest interfaces be maintained within the limits presented in section 6.2.

Additionally, IMO’s proposed “Transmission Assessment Criteria” for evaluating the effect of new developments on the system reliability and establishing the need to reinforce the transmission system define the “design criteria contingencies” as follows:

- Single transmission element contingency,
- Double-circuit line contingency (presently applicable in the Northwest region for adverse weather conditions),
- Stuck breaker condition (presently not applicable everywhere in the Northwest region).

The proposed general guidelines specify that with all transmission elements in service in pre-contingency:

- the power flows over the transmission elements must be within their continuous thermal ratings.
- following any design-criteria contingency the power flows must not exceed the limited time ratings of the equipment.
- the steady state voltages must be within the ranges required by the *Market Rules*.
- the post-contingency decline in voltage cannot exceed 10%,
- the system shall remain stable during and after the most severe contingency,

The load was modelled as constant MVA in pre-contingency with a 0.92 power factor. In post contingency situations, before and after tap changer action, the loads were modeled as variable active and reactive power as follows:

- 50% of the active power was proportional to the square of the voltage and 50% to the voltage
- 100% of reactive power load is proportional to the square of the voltage.

Because the Northwest Ontario transmission stretches over very long distances, the main phenomena which limit the transfer of power over this system are related to the system's capability to maintain adequate pre and post contingency voltages to avoid voltage collapse, and to prevent the tripping of the interconnection circuits with Manitoba and Minnesota, in case of contingency. These power transfer limits are well below the continuous or LTR ratings of the transmission elements.

7.2 Study Scenarios and Simulated Contingencies

The system operating scenarios selected for this assessment represent stressed system conditions where the power flows over the affected interfaces are at acceptable maximum levels. These operating points are defined in Table 5 below.

Table 5. Study Scenarios- Generation, Load Main Interfaces Flows

Scenario/ Contingencies	GLPL Load (MW)	GLPL Generation (MW)	Aubrey Falls/Wells GS (MW)	East-West Transfer (MW)	OMTR/MPF	Miss Flow (MW)
Scenario A	350	418	80/0	326 E	297 E /75 S	472 East
Scenario B	350	418	0/0	320 E	300 E/75 S	382 East
Scenario C	350	35	0/0	324 E	300 E/75 S	28.8 East
Scenario D	300	368	135/200	350 W	300 W/75 S	73.6 East
Scenario E	300	368	0/0	350 W	300W/75 S	262.8 West
Scenario F	300	35	0/0	350 W	300 W/75 S	609 West
Scenario G	350	418	135/60	200 E	275E/0	462 East

For each scenario described in Table 5, linear load flow analysis was performed to determine the impact of installing the new 230 kV connection on the distribution of power flowing over the various transmission elements, and identify possible thermal overloads.

The transient stability assessment was carried out only for the scenarios that are highlighted in green in table 5. Transient stability simulations were carried out for the following contingencies:

1. Line-to-line to ground on the new 230 kV line at Wawa and loss of new auto at MacKay,
2. Line-to-line to ground on P26W at Wawa and loss of Wawa T2 by configuration,
3. Line-to-line to ground on W22M at Wawa and loss of Wawa T1 by configuration and
4. Loss of A23P&A24P.

7.3 Assessment Results

The majority of studies performed by the IMO concentrated on the impact of the 230 kV option. This is the option that involves major modifications to the GLPL transmission system and will have a significant effect on the system reliability. For the assessment of the other two GLPL transmission reinforcement options the IMO relied on the study results provided by GLPL as part of their connection application.

This assessment concentrated mainly on the impact of the proposed redevelopment on the system between Marathon TS and Algoma TS. The effect of the proposed plan on the Ontario-Manitoba and Ontario-Minnesota power transfer capability was not evaluated in detail. Once the proposed reinforcement is committed and before coming into service the IMO will perform detailed operating security studies to establish the new power flows interdependence among the major Northwest system interfaces.

7.3.1 Local Impact - Linear Load Flow Study

A series of linear load flow studies were performed to determine the distribution of power flows over the 230 kV and 115 kV transmission between Wawa TS and Algoma TS. A first set of simulations was performed with all elements in service when the generation in the GLP system is being displaced by power generated West of Wawa TS or East of Algoma TS. Table 6 below summarizes the system Transmission Distribution Factors for the generation shifts indicated under "Generation Displacement" column.

Table 6. Transmission Distribution Factors (Scenario A)

Circuit # /Section	Monitored Line		Base Case	Generation Displacement					
				FROM Mississagi TO Kenora	Anjigami Generation	MacKay Generation		Third Line Generation	
					East	West	East	West	East
	From	To	MW						
	230 kV Lines								
W21M	Marathon	Wawa	-180.5	0.21	0.09	0.23	0.074	0.22	0.06
W22M	Marathon	Wawa	-180.5	0.21	0.09	0.23	0.074	0.22	0.06
P25W/West	Wawa	Aubrey	-86.9	0.14	-0.27	-0.03	-0.13	0.07	-0.04
P26W/West	Wawa	Aubrey	-86.9	0.14	-0.27	-0.03	-0.13	0.07	-0.04
P25W/East	Aubrey	Mississagi	-19.9	0.14	-0.27	-0.03	-0.13	0.07	-0.04
P26W/East	Aubrey	Mississagi	-19.9	0.14	-0.27	-0.03	-0.13	0.07	-0.04
NewCr./North	Wawa	MacKay	-81.1	0.15	-0.28	0.53	0.42	0.3	0.20
New Cr./South	MacKay	Third Line	16.2	0.13	-0.24	-0.28	-0.38	0.20	0.12
P21G	Third Line	Mississagi	-104.2	0.07	-0.14	-0.235	-0.29	-0.35	-0.40
P22G	Third Line	Mississagi	-104.2	0.07	-0.14	-0.235	-0.29	-0.35	-0.40
A23P	Mississagi	Algoma	-38.1	-0.19	-0.26	-.017	-0.27	-0.18	-0.28
A24P	Mississagi	Algoma	-38.1	-0.19	-0.26	-0.17	-0.27	-0.18	-0.28
X74P	Mississagi	Hanmer	-104.6	-0.21	-0.3	-0.19	-0.31	-0.2	-0.32
	Transformers								
Wawa T1	115 kV	230 kV	54.8	0	-0.5	0	0	0	0
Wawa T2	115 kV	230 kV	54.8	0	-0.5	0	0	0	0
MacKay TS	115 kV	230 kV	91	0	0.04	-0.81	-0.80	-0.1	-0.08
Third Line T1	115 kV	230 kV	-133.6	0.01	-0.02	-0.09	-0.1	-0.45	-0.46
Third Line T2	115 kV	230 kV	-133.6	0.01	-0.02	-0.09	-0.1	-0.45	-0.46
	115 kV Lines								
No.3 Sault	MacKay	Third Line	34.9	0.02	-0.04	-0.19	-0.20	0.1	0.08

These results indicate that with the new 230 kV line connecting Wawa TS to MacKay TS and Third Line TS, and the upgraded No.3 Sault 115 kV line the power flows would distribute as described below.

- For power injected at Mississagi and removed from Kenora, 43% will flow west and 57% will flow east, with the following westbound distributions:
  - 14% on P25W
  - 14% on P26W
  - 13% on Third Line to MacKay section of the new circuit and
  - 2% on No.3 Sault

- For power injected at Anjigami and removed from Hanmer, 82 % will flow east and 18 % will flow west, with the following eastbound distributions:
  - 27% on P25W
  - 27% on P26W
  - 28% on Wawa to MacKay section of the new line (from which 4% appears on No.3 Sault 115 kV circuit)

- For power injected at MacKay TS and removed from Kenora TS, 81 % will flow over the MacKay transformer to the 230 kV system and 19 % will flow south on No.3 Sault 115 kV circuit. From the power flowing over the 230 kV system, 53% would flow north to Wawa and 28% south to Third Line. A total of 47% of the amount of power injected at MacKay will appear on P21/22G.

- When the power injected at MacKay TS is removed from Hanmer, 80 % will flow over the MacKay transformer to the 230 kV system and 20 % will flow south on No.3 Sault 115 kV circuit. From the power flowing over the 230 kV system, 42% would flow north to Wawa and 38% south to Third Line. A total of 58% of the amount of power injected at MacKay will appear on P21/22G.

- For power injected at Third Line TS and removed from Kenora, 90 % will flow over the two Third Line 230/115 kV auto-transformers to the 230 kV system and 10 % will flow north on No.3 Sault 115 kV circuit. From the power flowing over the 230 kV system, 20% would flow north to MacKay TS and 70% east to Mississagi. From Mississagi, 14% would circulate to Wawa TS and 56% would flow east to Algoma.

- When the power injected at Third Line TS is removed from Hanmer, 92 % will flow over the two Third Line 230/115 kV auto-transformers to the 230 kV system and 8 % will flow north on No.3 Sault 115 kV circuit. From the power flowing over the 230 kV system, 12% would flow north to MacKay TS and 80% east to Mississagi. From Mississagi, 88% would flow east to Algoma.

An investigation of the linear power flow study results shows that with Option 3 transmission reinforcement, all transmission elements in service and for most extreme load/generation patterns, transmission thermal overloads between Wawa TS and Mississagi TS will not occur in pre-contingency conditions.

Linear analysis technique was also used to establish the distribution of post-contingency power flows for various single contingencies.

Table 7. Post-contingency Flows Loss of P25W

Pre-contingency Flow (MW) 230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'															
Case	W21M	W22M	P25W	P26W	Wawa T1(230 to 115)	Wawa T2(230 to 115)	Wawa-Mack	Mack-3rdL	Mack T1(230 to 115)	No.3 Sault	P21G	P22G	A23P	A24P	X74P
A	163	163	154	154	-57.5	-57.5	135	206	-73.7	59	54	61	166	166	140
B	160	160	151	151	-57	-57	124	198	-75.2	57	49	57	140	140	109
C	162	162	78.4	78.4	13	13	142	109	30.9	31	-60	-51	26.9	26.9	-25
D	-175	-175	-69.3	-69.3	-59	-59	-94.1	10	-104	28.2	-57.5	-50	41.2	41.2	-8.8
E	-176	-176	-64	-64	-59	-59	-107	-1.5	-107	25.6	-64.3	-56.7	-63.9	-63.9	-135
F	-177	-177	-138	-138	10	10	-99.4	-101	-0.5	0.5	-156	-148	-204	-204	-201
G	98	98	109	109	-57	-57	94	172	-79.5	53	35	43	163	163	136
Post-contingency Flow (MW) LOSS OF P25W 230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'															
Case	W21M	W22M	P25W	P26W	Wawa T1(230 to 115)	Wawa T2(230 to 115)	Wawa-Mack	Mack-3rdL	Mack T1(230 to 115)	No.3 Sault	P21G	P22G	A23P	A24P	X74P
A	153.3	153.3	0.0	218.9	-57.5	-57.5	204.6	265.9	-61.3	68.7	88.7	95.7	208.8	207.7	188.2
B	150.4	150.4	0.0	214.7	-57.0	-57.0	192.2	256.7	-64.5	66.5	83.0	91.0	182.0	180.9	156.3

C	***157.0***	***157.0***	***0.0***	***111.5***	***13.0***	***13.0***	***177.4***	***139.5***	***38.0***	***36.0***	***-42.4***	***-33.4***	***48.7***	***48.1***	***-0.5***
D	***-170.6***	***-170.6***	***0.0***	***-98.5***	***-59.0***	***-59.0***	***-125.4***	***-16.9***	***-108.5***	***23.8***	***-73.1***	***-65.6***	***21.9***	***22.4***	***-30.5***
E	***-172.0***	***-172.0***	***0.0***	***-91.0***	***-59.0***	***-59.0***	***-135.9***	***-26.4***	***-109.5***	***21.6***	***-78.7***	***-71.1***	***-81.7***	***-81.2***	***-155.0***
F	***-168.3***	***-168.3***	***0.0***	***-196.2***	***10.0***	***10.0***	***-161.8***	***-154.6***	***-7.5***	***-8.2***	***-187.1***	***-179.1***	***-242.4***	***-241.4***	***-244.2***
G	***91.1***	***91.1***	***0.0***	***155.0***	***-57.0***	***-57.0***	***143.2***	***214.4***	***-71.1***	***59.9***	***59.5***	***67.5***	***193.3***	***192.5***	***170.1***
Rating[1]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 7 indicate that for the loss of P25W or P26W the post contingency power flows on the remaining transmission elements will be below their continuous rating.

Table 8. Post-contingency Flows Loss of North Wawa to MacKay section of New Line

Pre-contingency Flow (MW) 230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*163*	*163*	*154*	*154*	*-57.5*	*-57.5*	*135*	*206*	*-73.7*	*59*	*54*	*61*	*166*	*166*	*140*
B	*160*	*160*	*151*	*151*	*-57*	*-57*	*124*	*198*	*-75.2*	*57*	*49*	*57*	*140*	*140*	*109*
C	*162*	*162*	*78.4*	*78.4*	*13*	*13*	*142*	*109*	*30.9*	*31*	*-60*	*-51*	*26.9*	*26.9*	*-25*
D	*-175*	*-175*	*-69.3*	*-69.3*	*-59*	*-59*	*-94.1*	*10*	*-104*	*28.2*	*-57.5*	*-50*	*41.2*	*41.2*	*-8.8*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-107*	*-1.5*	*-107*	*25.6*	*-64.3*	*-56.7*	*-63.9*	*-63.9*	*-135*
F	*-177*	*-177*	*-138*	*-138*	*10*	*10*	*-99.4*	*-101*	*-0.5*	*0.5*	*-156*	*-148*	*-204*	*-204*	*-201*
G	*98*	*98*	*109*	*109*	*-57*	*-57*	*94*	*172*	*-79.5*	*53*	*35*	*43*	*163*	*163*	*136*
Post-contingency Flow (MW) LOSS OF WAWA TO MACKAY SECTION OF NEW LINE 230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*154.2*	*154.2*	*212.7*	*212.7*	*-57.5*	*-57.5*	*0.0*	*89.9*	*-92.6*	*40.1*	*-13.8*	*-6.2*			*133.7*
B	*151.9*	*151.9*	*204.9*	*204.9*	*-57.0*	*-57.0*	*0.0*	*91.3*	*-92.5*	*39.7*	*-13.3*	*-4.7*			*103.3*
C	*152.7*	*152.7*	*140.1*	*140.1*	*13.0*	*13.0*	*0.0*	*-13.1*	*11.0*	*11.1*	*-131*	*-122*			*-31.6*
D	*-169*	*-169*	*-110*	*-110*	*-59.0*	*-59.0*	*0.0*	*90.9*	*-90.8*	*41.4*	*-10.3*	*-3.1*			*-4.4*
E	*-169*	*-169*	*-111*	*-111*	*-59*	*-59*	*0*	*91*	*-92*	*41*	*-11*	*-42*			*-130*
F	*-171*	*-171*	*-181*	*-181*	*10*	*10*	*0*	*-16*	*13*	*14*	*-156*	*-134*			*-196*
G	*92*	*92*	*150*	*150*	*-57*	*-57*	*0*	*91*	*-93*	*40*	*-12*	*-4*			*132*
Rating[1]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 8 indicate that for the loss of the northern section of the new 230 kV circuit 87% of the pre-contingency power will appear on P25/26W. *However, none of the remaining transmission elements will become thermally overloaded after the loss of either P25W or P26W.*

[1] The circuit ratings listed in the last row of each table represent continuous MVA summer thermal ratings calculated at 220 kV or 115 kV.

Table 9. Post-contingency Flows Loss of North MacKay to Third Line section of New Line

Pre-contingency Flow (MW) ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*163*	*163*	*154*	*154*	*-57.5*	*-57.5*	*135*	*206*	*-73.7*	*59*	*54*	*61*	*166*	*166*	*140*
B	*160*	*160*	*151*	*151*	*-57*	*-57*	*124*	*198*	*-75.2*	*57*	*49*	*57*	*140*	*140*	*109*
C	*162*	*162*	*78.4*	*78.4*	*13*	*13*	*142*	*109*	*30.9*	*31*	*-60*	*-51*	*26.9*	*26.9*	*-25*
D	*-175*	*-175*	*-69.3*	*-69.3*	*-59*	*-59*	*-94.1*	*10*	*-104*	*28.2*	*-57.5*	*-50*	*41.2*	*41.2*	*-8.8*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-107*	*-1.5*	*-107*	*25.6*	*-64.3*	*-56.7*	*-63.9*	*-63.9*	*-135*
F	*-177*	*-177*	*-138*	*-138*	*10*	*10*	*-99.4*	*-101*	*-0.5*	*0.5*	*-156*	*-148*	*-204*	*-204*	*-201*
G	*98*	*98*	*109*	*109*	*-57*	*-57*	*94*	*172*	*-79.5*	*53*	*35*	*43*	*163*	*163*	*136*
Post-contingency Flow (MW) LOSS OF MACKAY TO THIRD LINE SECTION OF NEW LINE ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21 M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*153*	*153*	*220*	*220*	*-58*	*-58*	*-16*	*0*	*-19*	*114*	*47*	*54*			*133*
B	*151*	*151*	*214*	*214*	*-57*	*-57*	*-21*	*0*	*-23*	*110*	*42*	*50*			*102*
C	*157*	*157*	*113*	*113*	*13*	*13*	*62*	*0*	*60*	*60*	*-64*	*-55*			*-29*
D	*-175*	*-175*	*-66*	*-66*	*-59*	*-59*	*-101*	*0*	*-101*	*31*	*-58*	*-50*			*-9*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-106*	*0*	*-107*	*25*	*-64*	*-57*			*-135*
F	*-172*	*-172*	*-170*	*-170*	*10*	*10*	*-25*	*0*	*-27*	*-26*	*-152*	*-144*			*-198*
G	*90*	*90*	*164*	*164*	*-57*	*-57*	*-32*	*0*	*-34*	*99*	*29*	*37*			*130*
Rating[2]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 9 indicate that for the loss of the southern section of the proposed 230 kV circuit 73% of the power will be flowing on the northern section and 27% will appear on the No.3 Sault 115 kV circuit. For conditions of heavy flows eastbound and peak Montreal River generation in service (cases A, B and G) the continuous rating of the upgrated No. 3 Sault 115 kV circuit will be exceeded. The post contingency flow could be even higher if the Third Line generation is low.

Since the 15 minute limited time rating of No.3 Sault circuit is not available, it is not clear at this time if post-contingency power flows on this circuit will be within the required limits. In the absence of the LTR for No.3 Sault circuit the following solutions should be considered:

i. If the final Limited Time Rating of No.1 Sault will be higher than the post-contingency flow on this circuit, then no additional mitigation measures are required, but operating instructions will be implemented to reduce in 15 minutes the generation at MacKay to a level which brings the flow on the No.3 Sault circuit under the continuous rating.

ii. If the final Limited Time Rating of No.1 Sault will be lower than the post-contingency flow on this circuit, then one of the two requirements below have to met:
    a. A generation rejection scheme has to be install that, in the event of the loss of the southern section of the new 230 kV line will be required to trigger the rejection of sufficient Montreal River generation to bring the post

[2] The circuit ratings listed in the last row of each table represent continuous MVAsummer thermal ratings calculated at 220 kV or 115 kV.

contingency flow on the No.3 Sault 115 kV circuit below the continuos rating of this circuit, OR

b. The thermal capability of the upgraded No.3 Sault 115 circuit must be high enough to accommodate anticipated post-contingency flows.

Table 10. Post-contingency Flows Loss of MacKay Transformer

Pre-contingency Flow (MW) ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*163*	*163*	*154*	*154*	*-57.5*	*-57.5*	*135*	*206*	*-73.7*	*59*	*54*	*61*	*166*	*166*	*140*
B	*160*	*160*	*151*	*151*	*-57*	*-57*	*124*	*198*	*-75.2*	*57*	*49*	*57*	*140*	*140*	*109*
C	*162*	*162*	*78.4*	*78.4*	*13*	*13*	*142*	*109*	*30.9*	*31*	*-60*	*-51*	*26.9*	*26.9*	*-25*
D	*-175*	*-175*	*-69.3*	*-69.3*	*-59*	*-59*	*-94.1*	*10*	*-104*	*28.2*	*-57.5*	*-50*	*41.2*	*41.2*	*-8.8*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-107*	*-1.5*	*-107*	*25.6*	*-64.3*	*-56.7*	*-63.9*	*-63.9*	*-135*
F	*-177*	*-177*	*-138*	*-138*	*10*	*10*	*-99.4*	*-101*	*-0.5*	*0.5*	*-156*	*-148*	*-204*	*-204*	*-201*
G	*98*	*98*	*109*	*109*	*-57*	*-57*	*94*	*172*	*-79.5*	*53*	*35*	*43*	*163*	*163*	*136*
Post-contingency Flow (MW) LOSS OF MACKAY TRANSFORMER ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*164*	*164*	*144*	*144*	*-57.5*	*-57.5*	*158*	*155*	*0*	*133*	*65*	*72*			*141*
B	*162*	*162*	*141*	*141*	*-57*	*-57*	*147*	*146*	*0*	*132*	*61*	*69*			*110*
C	*161*	*161*	*83*	*83*	*13*	*13*	*132*	*130*	*0*	*0*	*-65*	*-56*			*-25*
D	*-173*	*-173*	*-83*	*-83*	*-59*	*-59*	*-62*	*-62*	*0*	*133*	*-41*	*-34*			*-7*
E	*-174*	*-174*	*-78*	*-78*	*-59*	*-59*	*-74*	*-75*	*0*	*132*	*-48*	*-40*			*-133*
F	*-176*	*-177*	*-138*	*-138*	*10*	*10*	*-99*	*-101*	*0*	*1*	*-156*	*-148*			*-201*
G	*100*	*100*	*98*	*98*	*-57*	*-57*	*119*	*117*	*0*	*132*	*47*	*55*			*137*
Rating[3]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 10 indicate that the loss of the new MacKay auto-transformer 69% of the lost power will back off the power flow on the south section of the new 230 kV circuit and 31% would be fed via the north section of the new 230 kV circuit. When Montreal River generation is high the continuous rating and the limited time rating of the upgrated No.3 Sault 115 kV circuit could be exceeded.

Since the 15 minute limited time rating of No.3 Sault circuit is not available, it is not clear at this time if post-contingency power flows on this circuit will be within the required limits. In the absence of the LTR for No.3 Sault circuit the following solutions should be considered:

iii. If the final Limited Time Rating of No.3 Sault will be higher than the post-contingency flow on this circuit, then no additional mitigation measures are required, but operating instructions will be implemented to reduce in 15 minutes the generation at MacKay to a level which brings the flow on the No.3 Sault circuit under the continuous rating.

iv. If the final Limited Time Rating of No.3 Sault will be lower than the post-contingency flow on this circuit, then one of the two requirements below have to met:

[3] The circuit ratings listed in the last row of each table represent continuous MVA summer thermal ratings calculated at 220 kV or 115 kV.

c. A generation rejection scheme has to be install that, in the event of the loss of the MacKay 230/115 kV auto-transformer, will be required to trigger the rejection of sufficient Montreal River generation to bring the post contingency flow on the No.3 Sault 115 kV circuit below the continuos rating of this circuit, OR

d. The thermal capability of the upgraded No.3 Sault 115 circuit must be high enough to accommodate anticipated post-contingency flows.

Table 11. Post-contingency Flows Loss of New Line - Wawa to Third Line and MacKay Transformer

Pre-contingency Flow (MW) ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*163*	*163*	*154*	*154*	*-57.5*	*-57.5*	*135*	*206*	*-73.7*	*59*	*54*	*61*	*166*	*166*	*140*
B	*160*	*160*	*151*	*151*	*-57*	*-57*	*124*	*198*	*-75.2*	*57*	*49*	*57*	*140*	*140*	*109*
C	*162*	*162*	*78.4*	*78.4*	*13*	*13*	*142*	*109*	*30.9*	*31*	*-60*	*-51*	*26.9*	*26.9*	*-25*
D	*-175*	*-175*	*-69.3*	*-69.3*	*-59*	*-59*	*-94.1*	*10*	*-104*	*28.2*	*-57.5*	*-50*	*41.2*	*41.2*	*-8.8*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-107*	*-1.5*	*-107*	*25.6*	*-64.3*	*-56.7*	*-63.9*	*-63.9*	*-135*
F	*-177*	*-177*	*-138*	*-138*	*10*	*10*	*-99.4*	*-101*	*-0.5*	*0.5*	*-156*	*-148*	*-204*	*-204*	*-201*
G	*98*	*98*	*109*	*109*	*-57*	*-57*	*94*	*172*	*-79.5*	*53*	*35*	*43*	*163*	*163*	*136*
Post-contingency Flow (MW) LOSS OF NEW LINE AND MACKAY TRANSFORMER ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*154*	*154*	*213*	*213*	*-57.5*	*-57.5*	*0*	*0*	*0*	*133*	*91*	*98*			*108*
B	*152*	*152*	*205*	*205*	*-57*	*-57*	*0*	*0*	*0*	*132*	*87*	*95*			*78*
C	*153*	*153*	*140*	*140*	*13*	*13*	*0*	*0*	*0*	*0*	*-75*	*-66*			*-41*
D	*-169*	*-169*	*-110*	*-110*	*-59*	*-59*	*0*	*0*	*0*	*132*	*-58*	*2*			*-13*
E	*-169*	*-169*	*-111*	*-111*	*-59*	*-59*	*0*	*0*	*0*	*133*	*-11*	*-3*			*-137*
F	*-171*	*-171*	*-181*	*-181*			*0*	*0*	*0*	*1*	*-156*	*-148*			*-186*
G	*92*	*92*	*150*	*150*	*-57*	*-57*	*0*	*0*	*0*	*133*	*75*	*83*			*109*
Rating[4]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 11 indicate that the permanent loss of the new 230 kV line and the MacKay auto-transformer results in 87% the power flowing on the faulted element appearing of P25/26W and 13% on W21/22M. When Montreal River generation is high the continuous rating and the limited time rating of the upgrated No.3 Sault 115 kV circuit could be exceeded.

Since the 15 minute limited time rating of No.3 Sault circuit is not available, it is not clear at this time if post-contingency power flows on this circuit will be within the required limits. In the absence of the LTR for No.3 Sault circuit the following solutions should be considered:

v. If the final Limited Time Rating of No.3 Sault will be higher than the post-contingency flow on this circuit, then no additional mitigation measures are required, but operating instructions will be implemented to reduce in 15 minutes the generation at MacKay to a level which brings the flow on the No.3 Sault circuit under the continuous rating.

[4] The circuit ratings listed in the last row of each table represent continuous MVA summer thermal ratings calculated at 220 kV or 115 kV.

vi. If the final Limited Time Rating of No.3 Sault will be lower than the post-contingency flow on this circuit, then one of the two requirements below have to met:

e. A generation rejection scheme has to be install that, in the event of loss of the new 230 kV circuit and the MacKay 230/115 kV auto-transformer, will be required to trigger the rejection of sufficient Montreal River generation to bring the post contingency flow on the No.3 Sault 115 kV circuit below the continuos rating of this circuit, OR

f. The thermal capability of the upgraded No.3 Sault 115 circuit must be high enough to accommodate anticipated post-contingency flows.

Table 12. Post-contingency Flows Loss of P21G

Pre-contingency Flow (MW) ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A	*163*	*163*	*154*	*154*	*-57.5*	*-57.5*	*135*	*206*	*-73.7*	*59*	*54*	*61*	*166*	*166*	*140*
B	*160*	*160*	*151*	*151*	*-57*	*-57*	*124*	*198*	*-75.2*	*57*	*49*	*57*	*140*	*140*	*109*
C	*162*	*162*	*78.4*	*78.4*	*13*	*13*	*142*	*109*	*30.9*	*31*	*-60*	*-51*	*26.9*	*26.9*	*-25*
D	*-175*	*-175*	*-69.3*	*-69.3*	*-59*	*-59*	*-94.1*	*10*	*-104*	*28.2*	*-57.5*	*-50*	*41.2*	*41.2*	*-8.8*
E	*-176*	*-176*	*-64*	*-64*	*-59*	*-59*	*-107*	*-1.5*	*-107*	*25.6*	*-64.3*	*-56.7*	*-63.9*	*-63.9*	*-135*
F	*-177*	*-177*	*-138*	*-138*	*10*	*10*	*-99.4*	*-101*	*-0.5*	*0.5*	*-156*	*-148*	*-204*	*-204*	*-201*
G	*98*	*98*	*109*	*109*	*-57*	*-57*	*94*	*172*	*-79.5*	*53*	*35*	*43*	*163*	*163*	*136*
Post-contingency Flow (MW) LOSS OF P21G ***230 to 115 kV flows are '+', East and South flows are '+', West and North flows are '-'***															
Case	**W21M**	**W22M**	**P25W**	**P26W**	**Wawa T1(230 to 115)**	**Wawa T2(230 to 115)**	**Wawa-Mack**	**Mack-3rdL**	**Mack T1(230 to 115)**	**No.3 Sault**	**P21G**	**P22G**	**A23P**	**A24P**	**X74P**
A			*160*	*160*	*-57.5*	*-57.5*	*122*	*195*	*-76*	*57*	*0*	*102*			
B			*156*	*156*	*-57*	*-57*	*112*	*188*	*-77*	*55*	*0*	*94*			
C			*72*	*72*	*13*	*13*	*157*	*122*	*33*	*33*	*0*	*-96*			
D			*-75*	*-75*	*-59*	*-59*	*-80*	*22*	*-102*	*30*	*0*	*-93*			
E			*-71*	*-71*	*-59*	*-59*	*-91*	*12*	*-105*	*28*	*0*	*-105*			
F			*-155*	*-155*	*10*	*10*	*-61*	*-68*	*5*	*6*	*0*	*-266*			
G			*113*	*113*	*-57*	*-57*	*85*	*165*	*-81*	*52*	*0*	*69*			
Rating[5]	**354**	**384**	**354**	**354**	**125**	**125**	**374**	**374**	**150**	**90**	**204**	**374**	**476**	**476**	**549**

The study results listed in Table 12 indicate that the loss of the 230 kV line P21G will result in:

- about 75% of the P21G pre-contingency flow appearing on the companion circuit, P22G,
- about 21% of the P21G pre-contingency flow appearing on the new 230 kV line and
- about 4% of the P21G pre-contingency flow appearing on the two Third Line TS auto-transformers.

Linear analysis was not performed for the loss of P22G, but it is expected that post-contingency power flow distribution would be similar to the distribution calculated for the loss of P21G. Because the thermal rating of P21G is lower than the thermal rating of P22G, post-contingency overloading of P21G for the loss of P22G could occur, during system conditions of high flows

[5] The circuit ratings listed in the last row of each table represent continuous MVA summer thermal ratings calculated at 220 kV or 115 kV.

west and low GLPL internal generation in service. To alleviate this concern, GLPL Limited-Transmission has included in their transmission redevelopment plan the upgrading of P21G by 2008.

Based on the findings of the linear analysis performed under extreme system conditions represented by cases A to G, for the proposed transmission reinforcement Option 3 the following are concluded:

1. Pre-contingency power flows will not exceed the continuous rating of the transmission facilities,
2. The loss of MacKay TS to Third Line TS section of the new 230 kV circuit (Table 9) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
3. The loss of the new MacKay auto-transformer (Table 10) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
4. The loss of new 230 kV circuit and MacKay transformer (Table 11) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking.

Discussions of Results

A G/R scheme is presently available at MacKay TS to reject unit G3 at Andrews GS in response to a contingency involving the Gartshore No.1 circuit. To address the possible overloading of No.3 Sault in post-contingency situation the existing scheme could be expended to initiate the automatic trip of up to 67 MVA of generation in response to contingencies associated with MacKay auto-transformer or the south section of the new 230 kV line.

It should be noted that the final 230 kV transmission redevelopment option includes a new 230 kV ring bus at MacKay TS. This will allow the independent isolation of the auto-transformer, the north or the south section of the new line for planned or forced outages. Since forced outages to the new 230 kV line and MacKay TS auto-transformer are expected to be rare anyway the probability of Montreal River generation being rejected is very low.

In order to eliminate the thermal overloading concern of No.3 Sault circuit, GLPL Limited Transmission is required to either:

- *Install a contingency based generation rejection scheme which will initiate the rejection of selected Montreal River generation (up to 67 MVA) in the event of loss of the south section of the new 230 kV circuit or the loss of the new MacKay auto-transformer, OR*
- *Design the new No.3 Sault 115 circuit with a 15 minute summer limited time rating which could accommodate the peak output of the Montreal River plants.*

If G/R is selected to eliminate the post-contingency overloading problem then, the existing Gartshore generation rejection scheme could be expanded to meet this requirement

If real-time monitoring of No.3 Sault circuit will be implemented is the likely that the arming of the generation rejection scheme could only be required for periods during the summertime when the thermal rating of 115 kV No.3 Sault circuit is inadequate to accommodate peak Montreal

River generation.

It should be noted that during the second stage (section 2.2.3) of the proposed transmission redevelopment only No.1 Sault and No.2 Sault 115 kV circuits will be in service. A generation rejection scheme will have to be implemented before the second stage configuration. The scheme is required to reject sufficient Montreal River generation in the event of the loss of one Sault 115 kV circuit, such that post-contingency flows on the remaining circuit does nor exceed its continuous rating.

7.3.2 Local Impact - Voltage Stability

Voltage stability studies were performed by Great Lakes Power Limited – Transmission and the results were submitted to the IMO. The study was performed for conditions of high power flows on the East-West interface. The assessment recorded the voltage at Wawa for increased EW power flow east, for the existing system and each of the transmission reinforcement options. Power-voltage curves were produced for W21M outage and P26W outage and are shown in Figures 7 and 8 respectively.

The High east flow load flow used in these studies is slightly different than those that were set up by the IMO. The pre-contingency voltages at the main buses are shown in Table 13 for the existing system and each of the three options that are being considered by the connection applicant.

Table 13. Pre-contingency Voltages

Bus Name	Existing With Shunt Caps at Wawa	Option 1	Option 2	Option 3
Marathon 230 kV	236.7	237.8	235.1	237.2
Wawa 230 kV	243.9	246.0	241.6	244.6
Mississagi 230 kV	235.4	237.3	235.2	239.6
Algoma 230 kV	235.4	236.9	235.1	238.7
Third Line 115 kV	121.3	121.5	121.4	121.3
Third Line 230 kV	-	-	-	237.4

In pre-contingency situations, Option 1 and 3 appear to provide an improvement of about 2% on the voltage at Mississagi and also a slight improvement on the voltage at Wawa TS.

The post contingency PV curves indicate that Option 1 and Option 3 provide a slight improvement on voltage stability at Wawa TS for the critical contingency, the loss of W21M. Had a PV curve been created for the loss of the double circuit A23P and A24P, it is expected that a considerable improvement would have been observed on the voltage stability at Mississagi TS. This observation could be verified with the results obtained in the transient stability study.

7.3.3 Local Impact – MacKay TS Reactive Compensation Requirements

Generally, when power flows over the East West transmission interface are low, the voltages in the area raise above acceptable levels and existing shunt reactors are switched on to correct the problem.

A study was performed to identify the approximate size of a shunt reactor required to be installed at MacKay TS, using a load flow simulating East-West power transfer East of 32 MW, low generation at Anjigami TS, and about 110 MW generation at MacKay TS. The results are summarized below.

Shunt Reactors I/S	***Wawa TS Voltage (kV)***	***MacKay TS Voltage (kV)***	***Third Line TS Voltage (kV)***
2x40 MVAR @ Wawa	252.8 kV	253.2 kV	252.6 kV
2x40 MVAR @ Wawa 1x40 MVAR @ MacKay	248.9 kV	246 kV	248.6 kV

Based on the study results, it can be concluded that a shunt reactor of about 40 MVAR could be sufficient to control the MacKay voltage within acceptable limits.

It is required that the shunt reactor switching be provided via an automated switching scheme. The scheme should be able to trip the reactor at 220 kV and switch on at about 260 kV with a time delay of about 1 second.

As part of the system limits studies the IMO will carry out a study to investigate the need to coordinate the switching of the Wawa TS shunt reactive devices (shunt reactors and capacitors) and the new MacKay TS shunt reactor.

GLPL is required to install a shunt reactor connected to the 13.8 kV tertiary winding of the new 230/115 kV auto-transformer at MacKay TS. The reactor is to be rated around 40 Mvar and connected via one SF6, 13.8 kV circuit breaker. The reactor switching must be provided via an automated switching scheme.

GLPL is required to provide to the IMO detailed planning specification for the shunt reactor when available.

7.3.4 Local Impact - Transient Stability Studies

The purpose of the transient stability studies was two-folded.

Firstly, the assessment had to identify the negative impact, if any, of the proposed development on the reliability of the existing system. To facilitate a comparison between the existing system configuration and a system with the proposed development, two additional cases representing the *existing* Great Lakes Power Transmission configuration were set up with identical load, generation, and power flows patterns as in case A and F.

Secondly, the assessment is expected to identify any projected reliability benefits of the new proposed transmission development. In order to be able to quantify the some of the benefits of this transmission reinforcement, two more base cases (Case A1 and Case F1) were created in addition to the two study cases highlighted in Table 5 (Case A and Case F). The two new cases investigated the approximate improvement in the existing Mississagi flow East power transfer limit (adverse weather conditions) that could be attributed to the proposed project.

A comparison of the steady state voltages and power flows for the existing system and the new proposed transmission redevelopment is shown in Table 14 below. It should be noted that in all these cases the shunt capacitors at Wawa TS and Third Line TS were in service.

Table 14. System Steady State Comparison

Case A (Table 5)	**Existing System (with Wawa Shunt Caps I/S)**	**With 230 kV line I/S (Wawa shunt caps I/S)**	**Comments**
Marathon 230 kV Voltage (kV)	238.3 kV	238.2 kV	Voltage unchanged
Wawa 230 kV Voltage (kV)	242.7 kV	244.3 kV	1.5 kV voltage improvement
Third Line 230 kV Voltage (kV)	225 kV	237.4 kV	12 kV voltage improvement
Mississagi 230 kV Voltage (kV)	230.9 kV	239.3 kV	8.4 kV voltage improvement
MacKay kV Voltage (kV)	-	240.6 kV	Healthy voltage
Anjigami 115 kV Voltage (kV)	119.9 kV	119.4 kV	The 115 kV voltages were maintained at similar levels
MacKay 115 kV Voltage (kV)	120.1 kV	120 kV	
Third Line 115 kV Voltage (kV)	121.2 kV	121.4 kV	
East West Flow East @ Wawa (MW)	327 MW	328 MW	East West flow east was maintained at the same level.
Mississagi Flow East @ Mississagi (MW)	699 MW	674 MW	
P25/26 W East @ Wawa (MW)	378 MW	308 MW	About 30% of Wawa to Mississagi power flow will go over the new line.
New Line South @ Wawa (MW)	-	135 MW	
Case F (Table 5)	**Existing System (with Wawa Shunt Caps I/S)**	**With 230 kV line I/S (Wawa shunt caps I/S)**	**Comments**
Marathon 230 kV Voltage (kV)	245.5 kV	249.9 kV	4.4 kV voltage improvement
Wawa 230 kV Voltage (kV)	247.1 kV	252.3 kV	5.2 kV voltage improvement
Third Line 230 kV Voltage (kV)	235.5 kV	246.7 kV	11.2 kV voltage improvement
Mississagi 230 kV Voltage (kV)	236.5 kV	246.7 kV	10.2 kV voltage improvement
MacKay kV Voltage (kV)	-	250 kV	
Anjigami 115 kV Voltage (kV)	119 kV	119.8 kV	With the exception of MacKay TS the 115 kV voltages were maintained at similar levels.

MacKay 115 kV Voltage (kV)	120.9 kV	124.5 kV	
Third Line 115 kV Voltage (kV)	120.9 kV	120.9 kV	
East West Flow East @ Wawa (MW)	-360 MW	-354 MW	Power flows westbound are comparable.
Mississagi Flow East @ Mississagi (MW)	-612 MW	-609 MW	
P25/26 W East @ Wawa (MW)	-346 MW	-276 MW	
New Line South @ Wawa (MW)	-	-99.4 MW	

A comparison of the steady state voltage profiles shows that the new 230 kV line between Wawa and Third line results in limited voltage improvement at Wawa TS and substantial voltage improvement at Third Line TS and Mississagi TS.

The major improvement in Mississagi 230 kV voltage would indicate that the current Mississagi Flow East power transfer limit could be raised after the implementation of the proposed reinforcement. New cases simulating high flow east scenarios were set up, to carry out a cursory verification of the possible Mississagi Flow East power transfer improvement. The loss of the 230 kV double circuit line between Mississagi TS and Algoma TS was simulated and plots of the 230 kV transient voltages are shown in Appendix C. Figure T1 shows plots for the existing system with Mississagi flow east of 471 MW and Figure T2 shows voltages for new 230 kV line in service with Mississagi flow east and 532 MW.

An evaluation of the two cases and the two sets of transient plots shows that, with 50 MW increase in the Mississagi Flow East the pre-contingency voltages at Mississagi TS and Algoma TS are higher and the transient voltage declines are lower for a system with the new 230 kV line in service.

It can be concluded that an improvement in Mississagi Flow East storm limit of at least 50 MW could be achieved and attributed to the new GLPL 230 kV transmission reinforcement.

Transient stability studies were performed for all six cases identified at the beginning of this section, and the transient stability voltage responses were recorded and compared.

The following contingencies were simulated for all cases:

- Line-to-ground fault on W22M at Wawa and loss of Wawa T1 by configuration,
- Line-to-ground fault on P26W at Wawa and loss of Wawa T2 by configuration,
- Loss of double circuit line (LLG) A23P&A24P between Mississagi and Algoma,
- Line-to-ground fault on the new circuit at Wawa TS.

The following system quantities were monitored:

- Voltages at 230 kV buses: Lakehead, Marathon, Wawa, Mississagi, Algoma, Third Line, MacKay
- Voltages at 115 kV buses; Lakehead, Wawa (Anjigami), MacKay, Third Line
- Generators P, Q, GLPL machines including Wells GS, Aubrey GS and Lake Superior Power,

Table 15. Result of Transient Stability Studies

Transient Stability Results (Appendix C) ***Figure #***						
	Case A **GLP Load = 350 MW, GLP Gen =452 MW**					
System	**EW Transfer**	**MISS Flow**	**LLG on W22M@Wawa**	**LLG on P25W@ Wawa**	**LLG on New Line@Wawa**	**LLG on New Line @ Third Line**
Exist	**327 E**	**699 E**	**Stable**	**Stable**	**-**	**-**
New 1	**327 E**	**713 E**	***Figure T3, T4*** **Wawa first swing voltage dip is lower with new line i/s**	***Figure T5, T6***	**Stable** ***Figure T7***	**Stable** ***Figure T8***
New 2	**348 E**	**713 E**	**Stable**	**Stable**	**Stable** ***Figure T9***	**Stable** ***FigureT10***
System	**Case F** **GLP Load = 300 MW, GLP Gen =75 MW**					
Exist	**360 W**	**612 W**	**Stable** ***Figure T11***	**Stable** ***Figure T13***	**-**	**-**
New 1	**357 W**	**605 W**	**Stable** ***Figure T12***	**Stable** ***Figure T14***	**Stable** ***Figure T16***	**Stable** ***Figure T17***
New 2	**387 W**	**638 W**	**Stable**	**Stable**	**Stable** ***Figure T18***	**Stable** ***Figure T19***
Loss of Double 230 kV line (Mississagi x Algoma) under Storm Weather Conditions **GLP Load = 350 MW, GLP Gen = 452 MW**						
Exist	**328 E**	**471 E**	**Stable** ***Figure T1***			
New 1	**326 E**	**532 E**	**Stable** ***Figure T2***			

Upon examining the results of transient stability studies it was concluded that for a system with all transmission elements in service:

- The proposed transmission reinforcement does not have a negative impact on the system transient stability.
- The proposed transmission redevelopment is likely to provide increased voltage support at Wawa TS. This will result in an improvement in the voltage stability for the area and *could* lead to an increased in the power transfer limits over the EW interface for certain conditions of power flows over the Northwest interconnections.[6]

[6] *It should be noted that any possible improvement in the Northwest system power transfer limits requires detailed interconnection studies, to ensure that there is no adverse impact onto the neighbouring utilities, and agreement to increase the limits must be obtained from the MidWest ISO and Manitoba Hydro.*

- For conditions of high flow east on the Mississagi East interface an improvement of about 50 MW in power transfer East limit *could* be achieved. This would considerably reduce the bottling of generation west of Mississagi, during high flows eastbound and storm conditions.[7]

8.0 Customer Impact Assessment

Great Lakes Power Limited - Transmission has performed a Customer Impact Assessment and requested feedback from the existing connected customers regarding the impact of the proposed transmission system redevelopment on their equipment and operation. Upon receiving responses from the connected customers and consulting with the IMO, GLPL concluded that:

- There are no concerns with respect to the impact of the new development on the fault levels that would be experienced by the existing customer equipment,
- The post-contingency voltage declines due to the loss of the new 230 kV line was considered to be within the acceptable levels,
- To most connected customers Option 3 appeared to provide increased reliability of supply and higher performance standard,
- The design at MacKay TS must be modified to include a 230 kV ring bus equipped with three breakers to allow for the independent isolation of the auto-transformer and the north or south sections of the new 230 kV line,
- One connected customer expressed concern with respect to the significant impact on their operations during the construction phases of the project. They required to be involved to the fullest extent possible in providing comments during project's implementation stages.

9.0 Conclusions and Recommendations

This Preliminary Assessment has examined the impact of each of the three transmission redevelopment alternatives proposed by Great Lakes Power Limited –Transmission for the reinforcement of their 115 kV system between Anjigami TS and Mississagi TS. The Connection Assessment evaluated the results of studies performed by Great Lakes Power Limited – Transmission and the IMO and identified the effect on system reliability and the some of the benefits of each transmission reinforcement option. In particular, the IMO assessment concentrated on identifying the impact of the proposed Option 3 (the 230 kV redevelopment)

The general conclusions of this assessment with respect to each of the three transmission redevelopment options are summarized in the sections below.

Option 1

1. Options 1 will be providing an improvement in the reliability of the local GLPL transmission system by eliminating the post-contingency thermal overloading concerns associated with the existing system and the need to bottle some of the generation internal to the GLPL system as a result of the transmission constraints.
2. Option 1 is not likely to affect the existing Northwest system operating limits, and in particular the East-West interface power transfer limits eastbound and westbound.

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[7] *It should be noted that any possible improvement in the Northwest system power transfer limits requires detailed interconnection studies, to ensure that there is no adverse impact onto the neighbouring utilities, and agreement to increase the limits must be obtained from the MidWest ISO and Manitoba Hydro.*

3. Option 1 is not likely to affect the existing Northeast system operating limits, and in particular the Mississagi Flow East power transfer limit eastbound during adverse weather conditions.
4. Under Option 1, the station configurations that are proposed for connecting the upgraded 115 kV circuits at Anjigami TS, MacKay TS and Third Line TS are identical to those of the existing arrangement; hence there are no new critical contingencies that will not adversely affect the reliability of the IMO-controlled grid.
5. If Option 1 is adopted, it is required that Anjigami 115 kV breakers 814 and 824 be replaced with 40 kA breakers. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.

Option 2

1. Option 2 appears to reduce the pre-contingency voltage at Wawa TS which is likely to lower, under certain system conditions, the East-West interface power transfer limit.
2. The ultimate station arrangement for Wawa 230/115 kV and Anjigami 115 kV stations for this option will retain all the existing 115 kV breakers with the new 115kV Anjigami line terminated on two breakers (814 and 824).
3. The configuration of MacKay TS will remain unchanged with the exception of the removal from service of breaker 648, which becomes redundant when No.2 Anjigami is permanently removed from service.
4. The configuration of Third Line TS will remain substantially unchanged except for the addition of a second breaker for No.1 Sault.
5. Option 2 will not be introducing any new critical contingencies that will not adversely affect the reliability of the IMO-controlled grid are being.
6. If Option 2 is adopted, it is required that Anjigami 115 kV breakers 814 and 824 used to connect the new line be replaced with a 40 kA breaker. All the other 230 kV and 115 kV breakers in the GLPL system are adequately rated.

Option 3

This Connection Assessment concentrated on the analysis of this option since it comprises of major modifications to the existing transmission system and will likely have a considerable effect on the reliability of the existing system. The conclusions and recommendations are listed below.

1. The modifications at Wawa TS and Anjigami TS that are proposed to accommodate the 230 kV reinforcement option do not introduce a new critical contingency and will not reduce the present level of transmission system reliability.
2. The IMO strongly recommends that the MacKay 115 kV connection of No.2 Gartshore 115 kV circuit be between breakers 635 and 632 at MacKay 115 kV switchyard, as shown in Figure 5B. This final configuration will also result in removal of the four redundant breakers (612, 622, 648 & 658).
3. The IMO recommends that GLPL consider building a new 230 kV switchyard at MacKay TS as shown in Figure 4B. The new switchyard is to be designed as a four breaker ring bus and be initially equipped with three breakers.
4. MacKay TS final arrangement and the recommended changes will not adversely affect the reliability of the IMO-controlled grid and will represent an improvement with both No.1 MacKay circuit and No.2 Gartshore circuit terminated on dedicated breaker positions.
5. The new 230 kV switchyard at MacKay TS (Figure 5B), which will be designed as a four breaker ring bus and initially equipped with three breakers, will ensure the independent isolation of each 230 kV connected transmission element for planned or forced outages.

6. The *Connection Applicant* has the choice to design the new 230 kV Third Line TS to three-breaker or four-breaker configuration, subject to ensuring that the final future stages at Third Line TS the station will be configured with three diameters.
7. The new Third Line 230 kV switchyard configuration will not adversely affect the reliability of the IMO-controlled grid
8. The new Third Line 230 kV switchyard configuration will result in the separation of the two auto-transformers from the Third Line TS to Mississagi 230 kV circuits, which is considered to be an improvement to system reliability. This configuration (Figure 5C) will eliminate the loss of two transmission system elements in case of a single contingency and the removal from service of more than two transmission system elements for a breaker-failure operation on the 230kV or for breaker-failure of breaker 508 on the 115kV system.
9. The new proposed supply arrangement for Batchawana TS and Goulais Bay TS off the 115 kV circuit No.3 Sault meets the IMO availability standards.
10. Short circuit studies performed by GLPL indicate that the system short circuit currents are within the interrupting capability of the proposed new breakers and the existing breakers that are to be retained under Option 3. Should all facilities assumed in the ultimate system configuration materialize, then some of the 115 kV breakers at MacKay TS will have to be replaced to accommodate the increase in short circuit currents. The adequacy of these breakers will be revisited with every future new proposed development in the area.
11. Post-contingency thermal overloading of the upgraded 115 kV circuit No.3 Sault could occur in the event of the loss of the MacKay auto-transformer or the south section of the new 230 kV line.

Based on the findings of the linear analysis performed under extreme system conditions represented by cases A to G, for the proposed transmission reinforcement Option 3 the following were concluded:

12. Pre-contingency power flows will not exceed the continuous rating of the transmission facilities,
13. The loss of MacKay TS to Third Line TS section of the new 230 kV circuit (Table 9) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
14. The loss of the new MacKay auto-transformer (Table 10) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking,
15. The loss of new 230 kV circuit and MacKay transformer (Table 11) could result, during the summer, in thermal overloading of No.3 Sault circuit when the hydraulic generation at MacKay is peaking.

Based on the findings of the voltage and transient stability studies and performed for cases A and F the following were concluded:

16. The new 230 kV line between Wawa TS and Third Line TS results in limited voltage improvement at Wawa TS and substantial voltage improvement at Third Line TS and Mississagi TS.
17. The new 230 kV line between Wawa TS and Third Line TS will provide an overall improvement in the transient stability for the system East of Wawa TS.
18. For conditions of high flow east on the Mississagi East interface an improvement of about 50 MW in power transfer East limit *could* be achieved with the new 230 kV line. This would considerably reduce the bottling of generation west of Mississagi, during high flows eastbound and storm conditions.

It should be noted that any possible improvement in the Northwest system power transfer limits requires detailed interconnection studies, to ensure that there is no adverse impact onto the neighbouring utilities and agreement to increase the limits must be obtained from the MidWest ISO and Manitoba Hydro.

10.0 IMO Requirements

The IMO's requirements that have been identified in this assessment are as follows:

Option 1

If option 1 is pursued then the Anjigami TS breakers 814 and 824 are required to be replaced.

Option 2

Option 2 of transmission reinforcement is not acceptable to the IMO because it will weaken the overall system reliability.

Option 3

1. During the various stages of this project GLPL will have to inform the IMO well in advance of any scheduled modifications to the transmission system connectivity.
2. The IMO requires that GLPL provide the "as built" ratings for all the new or modified equipment as soon as it becomes available.
3. Is it required that the new 230/115 kV auto-transformer at MacKay TS be equipped with under-load tap changer and have exposed tertiaries to facilitate the connection of reactive compensation devices.
4. GLPL is required to install shunt reactor, with a rating of about 40 Mvar, connected to the 13.8 kV tertiary winding of the new 230/115 kV auto-transformer at MacKay TS. The reactor is to be connected via one SF6, 13.8 kV circuit breaker and must be equipped with an automated switching scheme. GLPL is required to provide to the IMO detailed planning specification for the shunt reactor when available.
5. The IMO requires the installation of a motorized 115 kV in-line disconnect switch at MacKay TS on No.3 Sault 115 kV circuit.
6. Since a new Third Line 230 kV switchyard will be constructed which substantially changes the existing 230 kV configuration, the IMO requires that five breakers be installed to allow for the individual connection of each 230 kV transmission element (Figure 5C).
7. The Connection Applicant has the choice to design the new 230 kV Third Line TS to three-breaker or four-breaker configuration, subject to ensuring that the final future stages at Third Line TS the station will be configured with three diameters. The initial connection of the 230 kV transmission onto the Third Line switchyard should be selected with care to allow for the connection of future elements without having to re-terminate existing elements. In selecting the switchyard connectivity, a breaker failure condition should not remove from service two parallel transmission elements.
8. The two new 230 kV switchyards at MacKay TS and Third Line TS must be equipped with breaker disconnect switches to allow the isolation of individual breakers for maintenance and/or repairs. The station buswork and disconnect switches must be adequately rated.
9. It is required that Great Lakes Power install all the equipment necessary to monitor the information required by the IMO on a continuous basis. The IMO requires that the status of

all isolating disconnect switches and breakers, power flows (MW, Mvar) on transformers and transmission circuits be monitored on a continual basis.

10. The *Connection Applicant* will have to follow the Transmission System Code technical requirements for transformer stations and transmission lines with respect to the protection and telecommunication requirements. Some of the existing protection settings will have to be modified to match the modified connectivity, and the new protections will have to be coordinated with the exiting schemes.
11. GLPL is required to perform short circuit studies and ensure that all installed breakers, permanent or temporary, are safe and have adequate interrupting capability. In the third stage of transmission redevelopment (section 2.2.3) it is planned to provide a temporary 115 kV connection of the new 230 kV line section at Anjigami via the two exiting 115 kV breakers 814 and 824. It should be noted that either breaker may not be adequately rated to interrupt the short circuit currents that could be experienced by the system and this arrangement was selected in order to alleviate concerns related to the low interrupting capability of one single breaker. Both breakers will be employed for clearing any faults associated with this section of line.
12. A generation rejection scheme will have to be implemented at MacKay TS in advance of the second stage of the transmission redevelopment. The scheme is required to reject sufficient Montreal River generation in the event of the loss of one Sault 115 kV circuit, such that the post-contingency flow on the remaining circuit does nor exceed its continuous rating. It is to be noted that during the second stage (section 2.2.3) of the proposed transmission redevelopment only No.1 Sault and No.2 Sault 115 kV circuits will be in service.
13. Upon completion of the transmission redevelopment and in view of eliminating the No.3 Sault 115 kV circuit thermal overloading concern , GLP is required to either:

    A. Modify as needed and retain the generation rejection scheme required under poit 12. Above which will initiate the rejection of selected Montreal River generation (up to 67 MVA) in the event of loss of the new 230 kV circuit and the MacKay 230/115 kV auto-transformer, or the loss of the new MacKay auto-transformer, or the loss of the south section of the new circuit, OR
    B. Design the new No.3 Sault 115 circuit with a 15 minute summer limited time rating which could accommodate the peak output of the Montreal River plants and disable the generation rejection scheme.

11.0 System Benefits – Option 3

The GLPL proposed Option 3 of transmission reinforcement represents a major enhancement to the Northeast transmission system which results in extensive improvement in the reliability of the Imo-controlled grid and brings increased efficiencies to the electricity market. This Connection Assessment identified the following benefits associated with the new 230 kV link between Wawa TS and Third Line TS.

1. The bottling of the Michipicoten River hydraulic plants (connected to Anjigami TS) due to transmission limitation will be drastically reduced, resulting in a decrease in CMSC payments to the market.
2. It is expected that the proposed transmission reinforcement will provide an enhancement to the GLPL inflow limit and substantially reduce the dependence on the special protection systems that are presently employed in the area.

Due to weakness of the present transmission system in this area, the operation of this the system relies extensively on special protection system including load and generation rejection schemes. These are:

- Up to 100 MW of load is armed for rejection all the time at Third Line, to prevent the collapse of the GLPL system in post-contingency when the GLPL internal load is supplied mainly via the Mississagi TS and Wawa TS transformers.
- Wells GS and Lake Superior Power are being armed for rejection under high Mississagi Flow east conditions and storm weather in order to provide improvement to the east flow power transfer limit.
- A relay is installed at Wawa TS that may separate the GLPL system from Hydro One system if the post-contingency flow at Wawa exceeds its settings.
- A cross-tripping scheme is in service which, in the event of a double circuit contingency involving P25/26W will disconnect the auto-transformers T1 and T2 at Wawa TS, thus again isolating the GLPL system from the Hydro One system at Wawa TS.

With the addition of the proposed transmission some of these special protection systems might not be necessary or could be used to further enhance the system operating limits. The IMO will establish the usefulness of these SPS's as part of future system limits studies.

A. For most system conditions, including high East-West power flows eastbound or westbound, the proposed transmission reinforcement is likely to provide increased voltage support at Wawa TS, which results in an improvement in the voltage stability for the area. This could result in an increased in the power transfer limit over the EW interface for certain conditions of power flows over the Northwest interconnections with the neighbouring utilities.

B. For conditions of high flow east on the Mississagi East interface an improvement of about 50 MW in power transfer East limit *could* be achieved and the need to reject Wells GS and Lake Superior Power GS generation in post-contingency could be reduced or eliminated. This would considerably reduce the bottling of generation west of Mississagi, during high flows eastbound and storm conditions.

It should be noted that any possible improvement in the Northwest system power transfer limits requires detailed interconnection studies, to ensure that there is no adverse impact onto the neighbouring utilities and agreement to increase the limits must be obtained from the MidWest ISO and Manitoba Hydro.

A. This transmission development and, in particular, the proposed configuration of the 230 kV MacKay TS and Third Line TS will allow for future transmission system expansions and possible incorporation of generation projects.

Before the proposed development is brought into service, the IMO will perform detailed operating studies to establish the new power transfer limits over the East-West and Mississagi East interfaces.

12.0 Budgetary Cost Estimates

Great Lake Power Limited – Transmission has been working closely with Hydro One Networks to coordinate the proposed connection of the new 230 kV line at Wawa TS. GLPL is to obtain cost estimates from Hydro One Network Inc. for all the Wawa 230 kV switchyard new or modified equipment and protection systems that are required to facilitate the connection of the new line.

13.0 Need for System Impact Assessment

This Preliminary Assessment evaluated all the aspects related to the impact of the proposed developments on the reliability of the IMO-controlled grid and no further analysis is required.

A separate System Impact Assessment is therefore not required for this project.

14.0 Notification of Approval

Section 10.0 of the Preliminary Assessment Report lists all the requirements identified by the Connection Assessment and Approval process for the GLPL transmission redevelopment options.

Since the Connection Assessment identified that Option 3 would represent a major improvement to the GLPL system and also help enhance the power transfer capability East of Wawa, GLPL has decided to pursue Option 3.

The IMO has concluded that Option 1 and Option 3 provide an improvement to the system reliability and recommends that approval be granted for both options. Notification of Approval is to be issued for both options subject to the implementation by the proponent of their preferred option together with the IMO respective requirements.

FIGURES

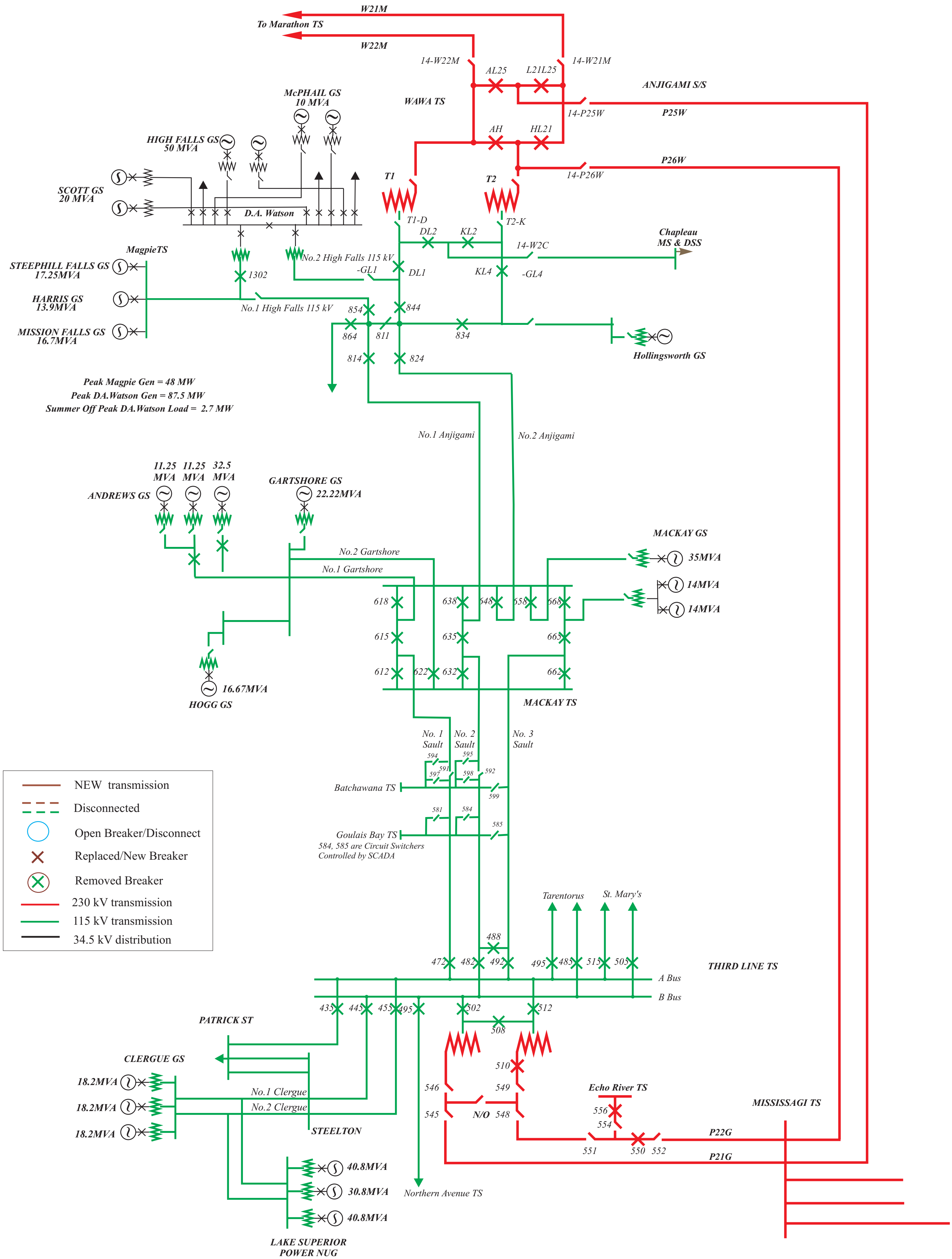

Figure 1. GLP Existing System

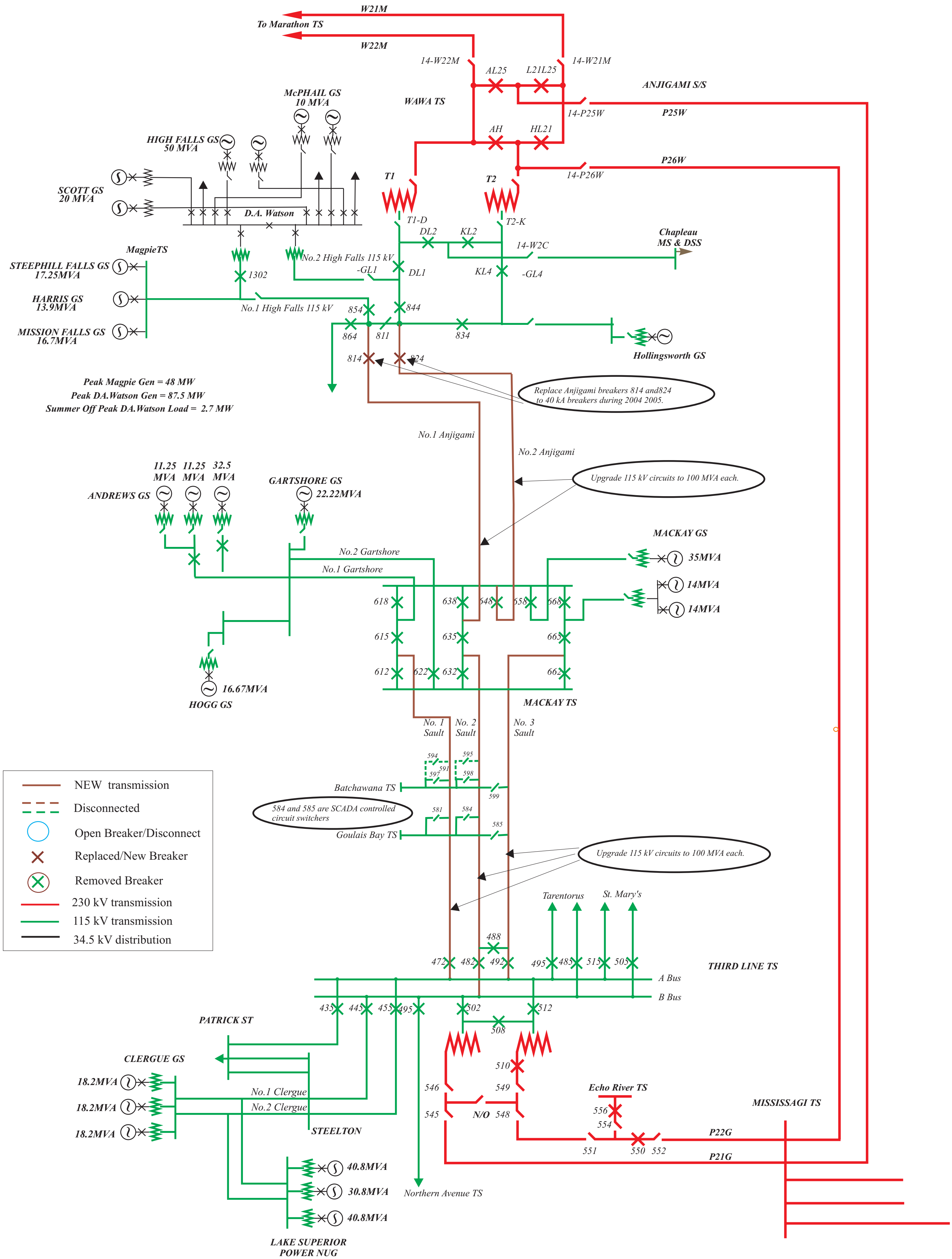

Figure 2. GLP Transmission Reinforcement - Option 1

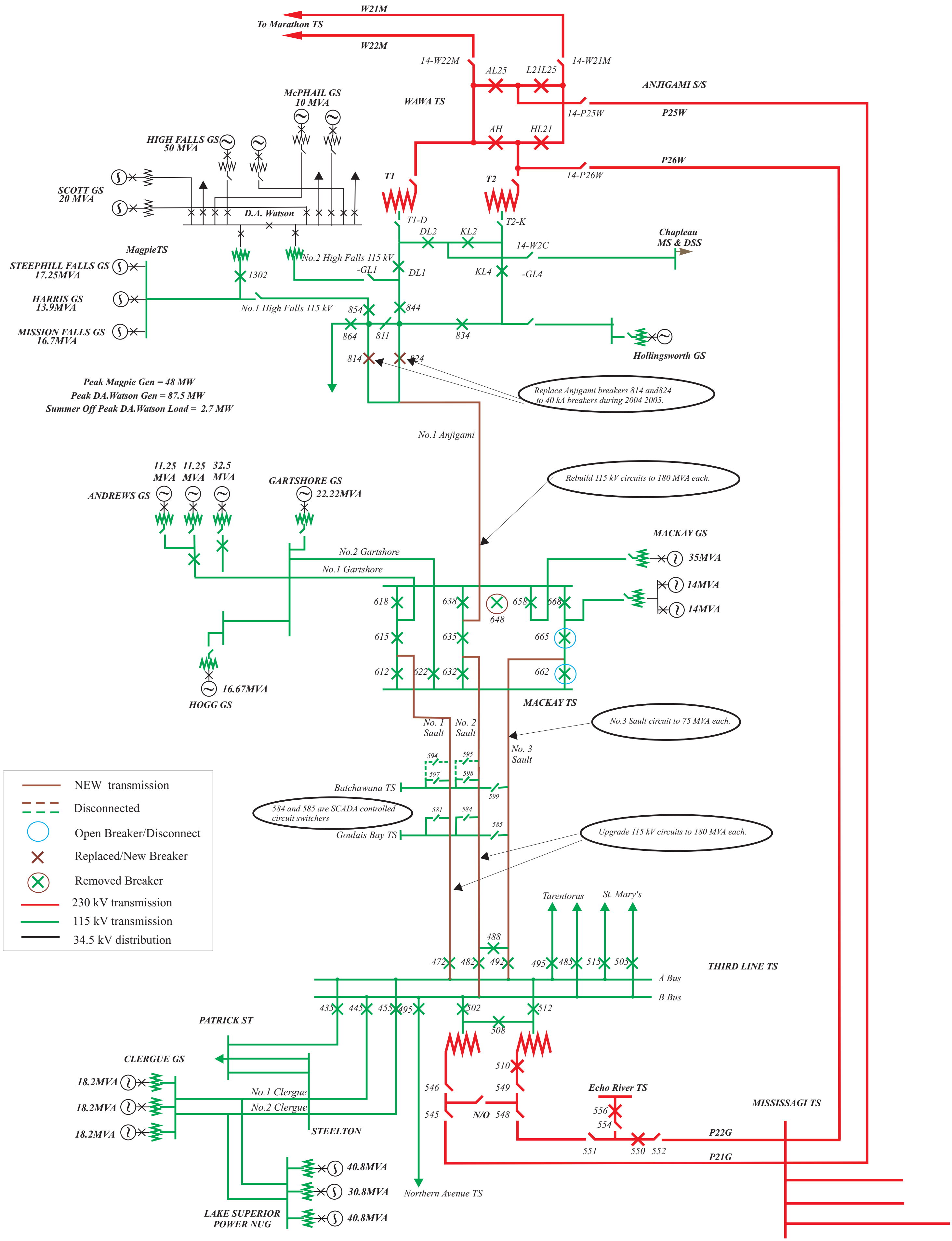

Figure 3. GLP Transmission Reinforcement - Option 2

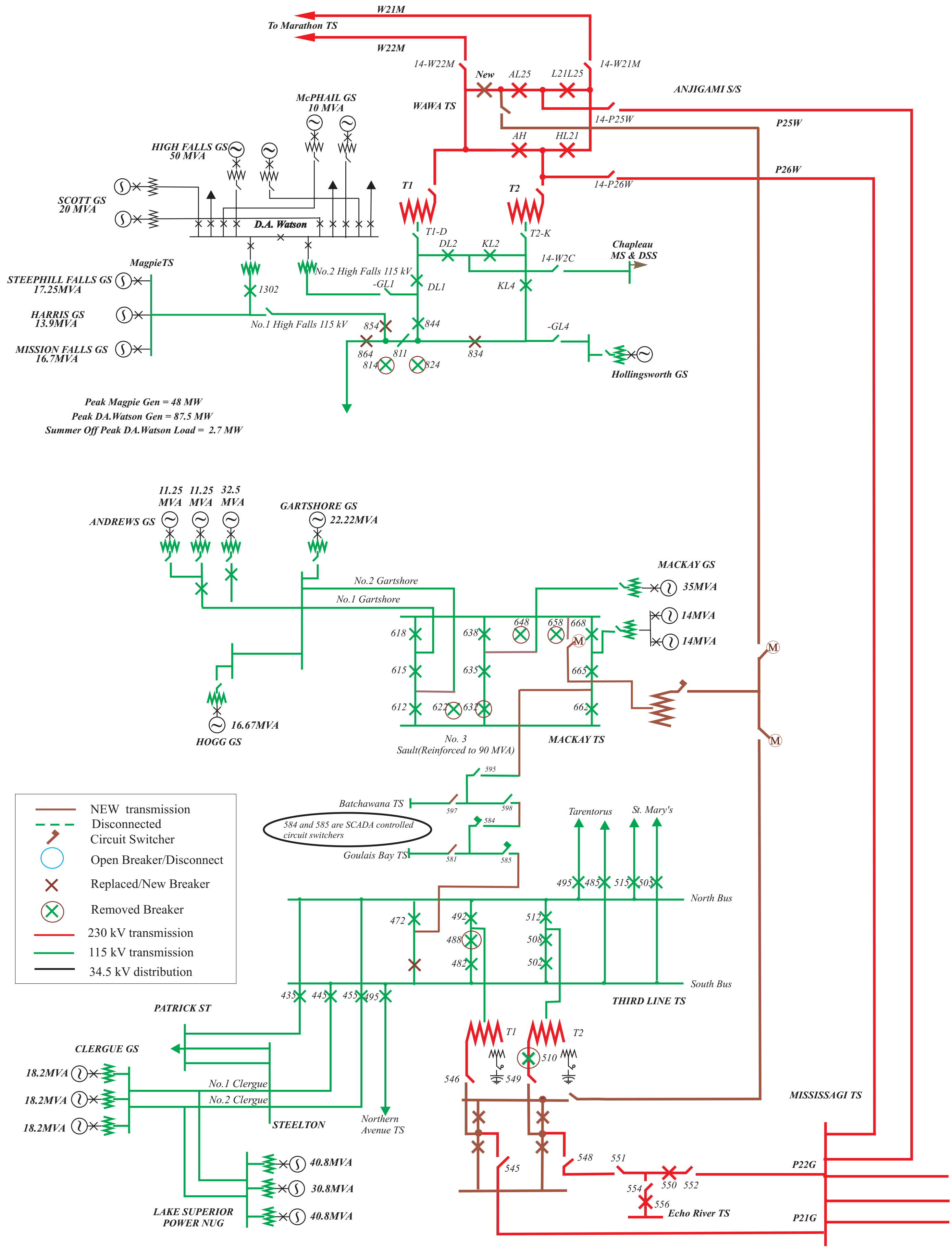

Figure 4. GLP Transmission Reinforcement - Option 3 (original proposal)

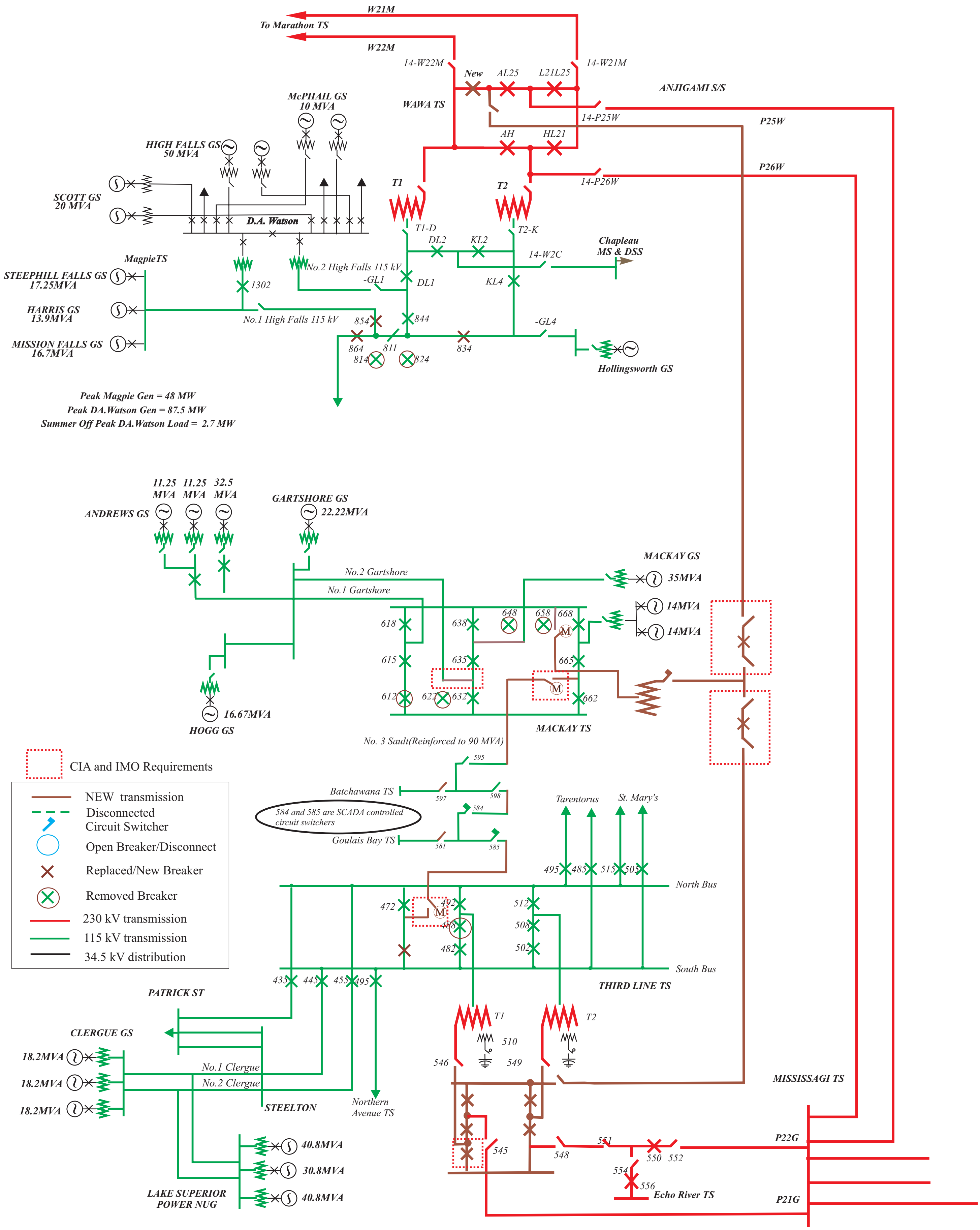

Figure 4 A. GLP Transmission Reinforcement - Option 3
(CIA and IMO requirements incorporated)

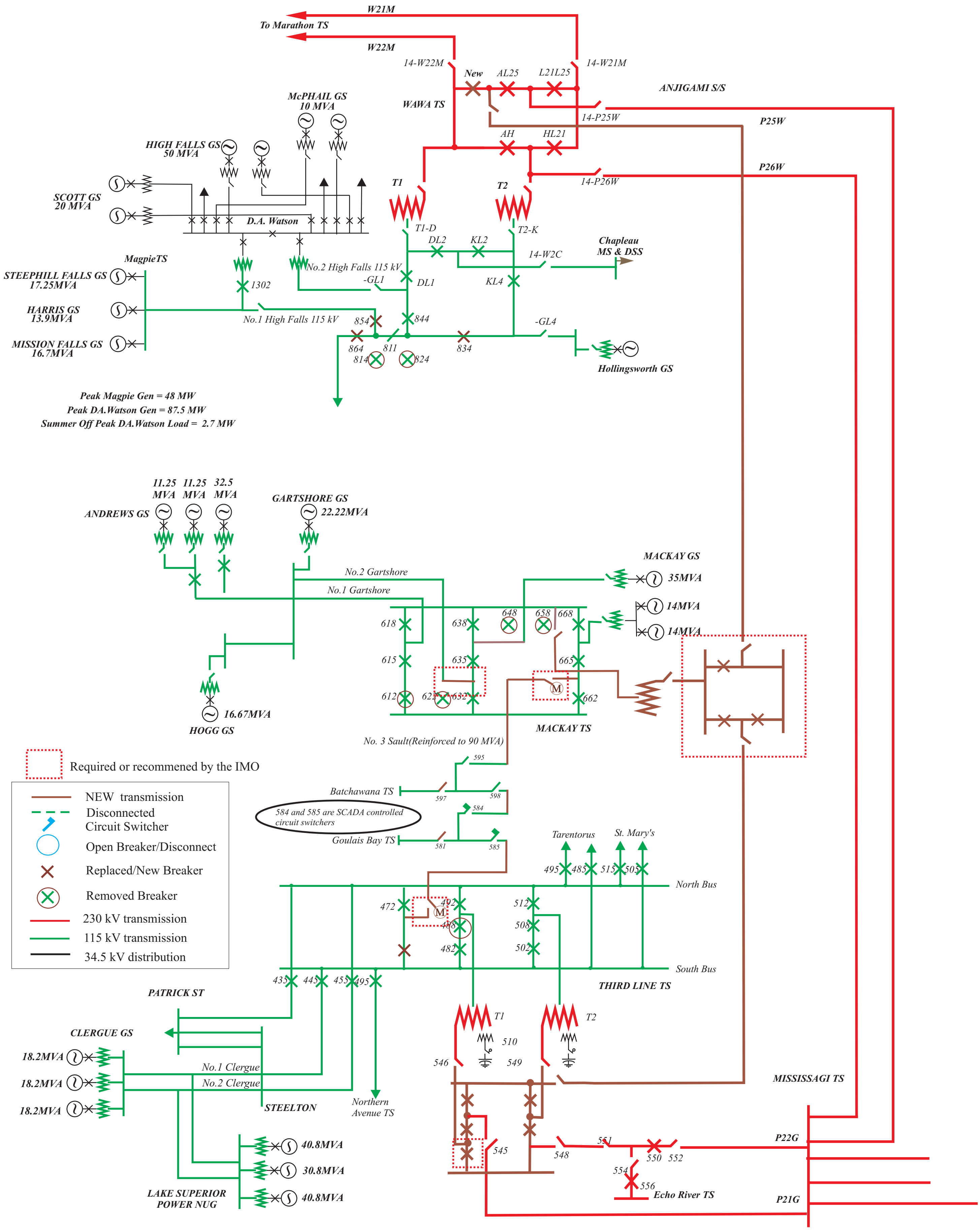

Figure 4B. GLP Transmission Reinforcement - Option3 Final
(Includes IMO requirements and recommendations)

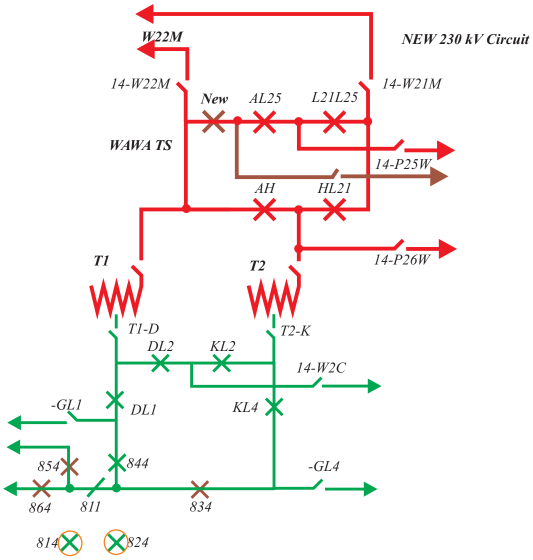

Figure 5A. Wawa/Anjigami Station Final Configuration- Option 3

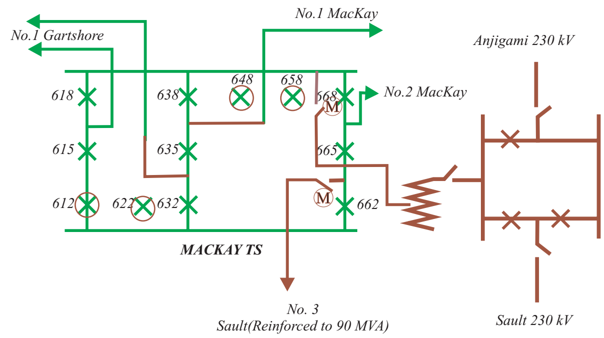

Figure 5B. MacKay Station Final Configuration- Option 3

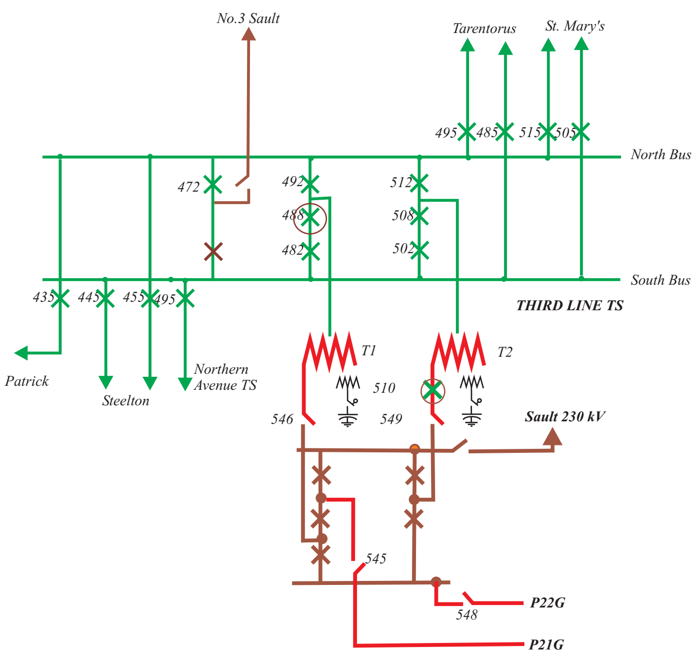

Figure 5C. Third Line Station Final Configuration- Option 3

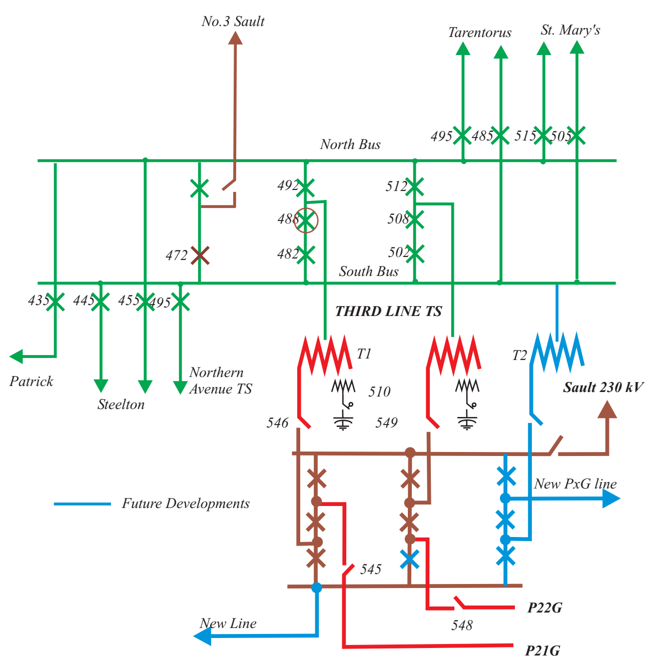

Figure 5D. Third Line Station Ultimate Configuration- Ultimate

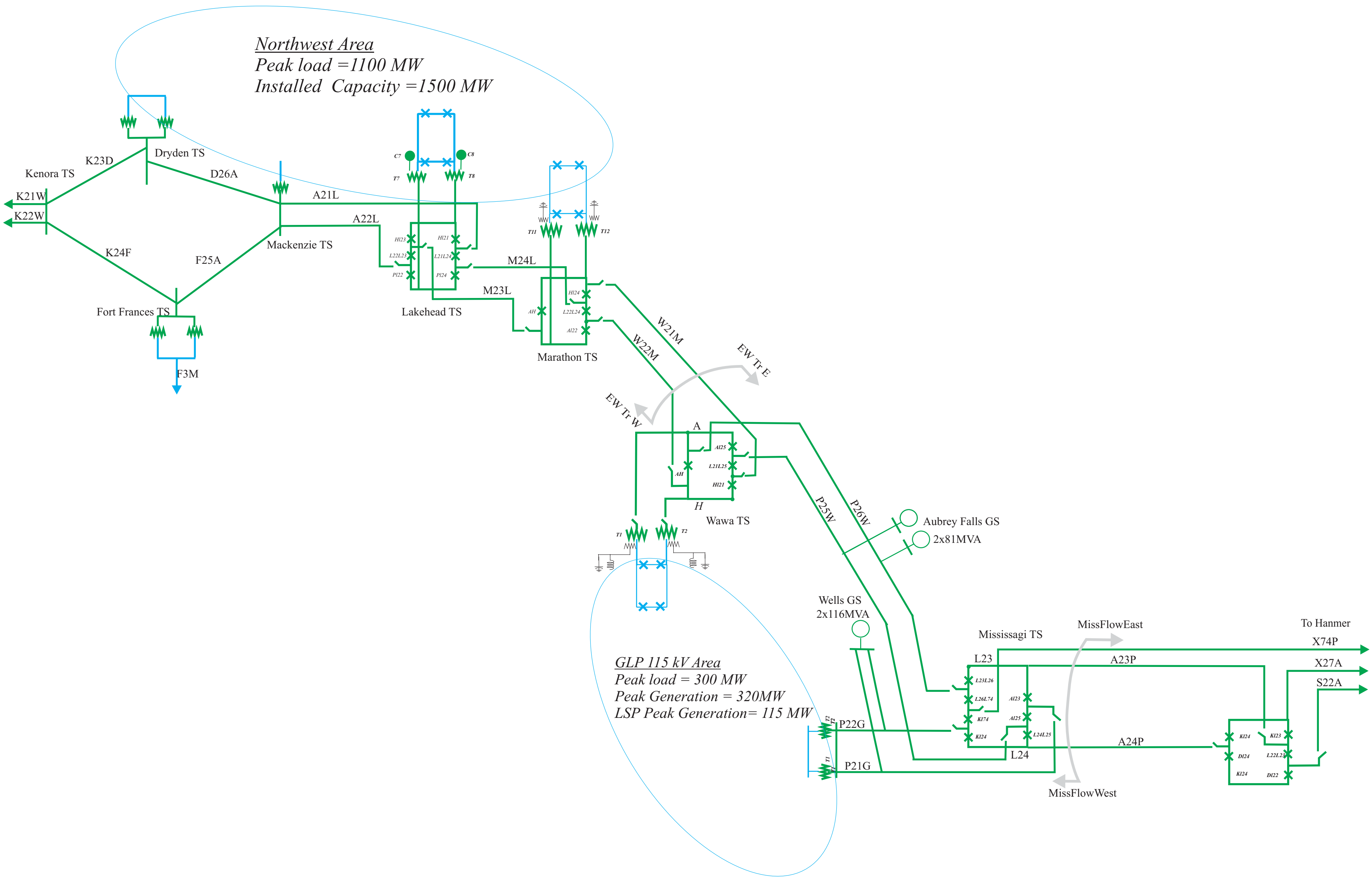

Figure 6. Existing Northwest System Diagram

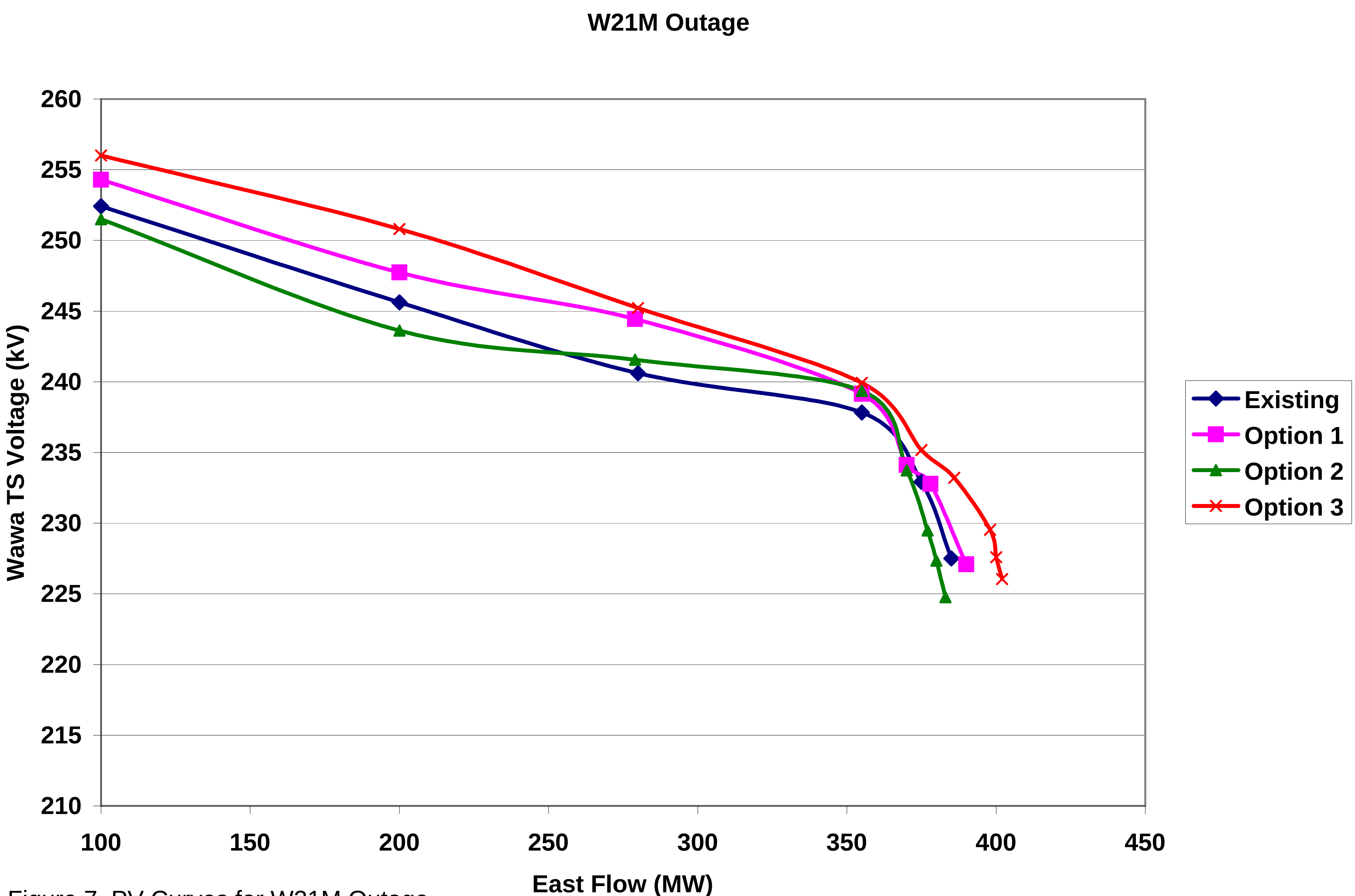

Figure 7. PV Curves for W21M Outage

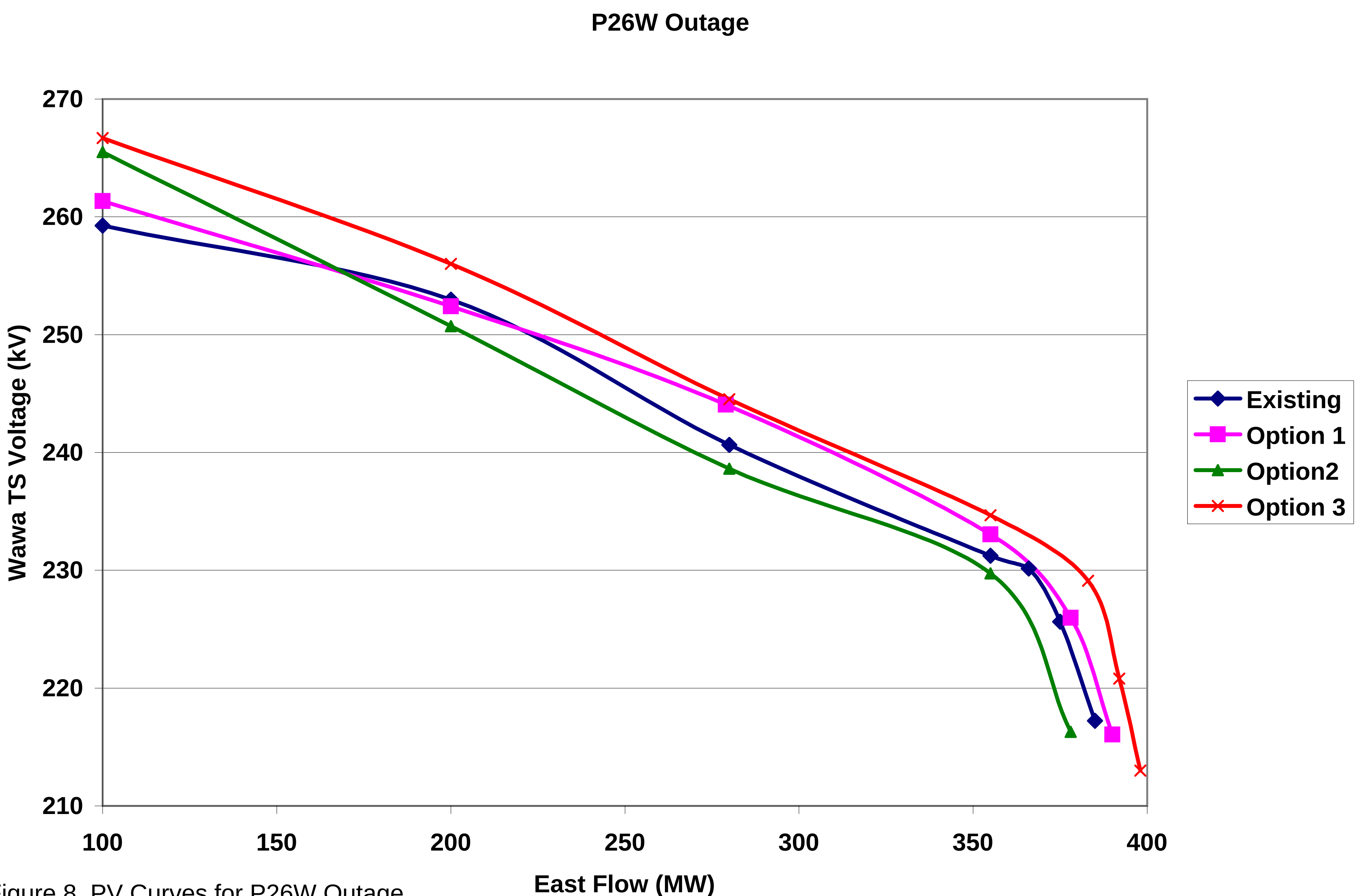

Figure 8. PV Curves for P26W Outage

APPENDIX A

Option 3 Staged Diagrams

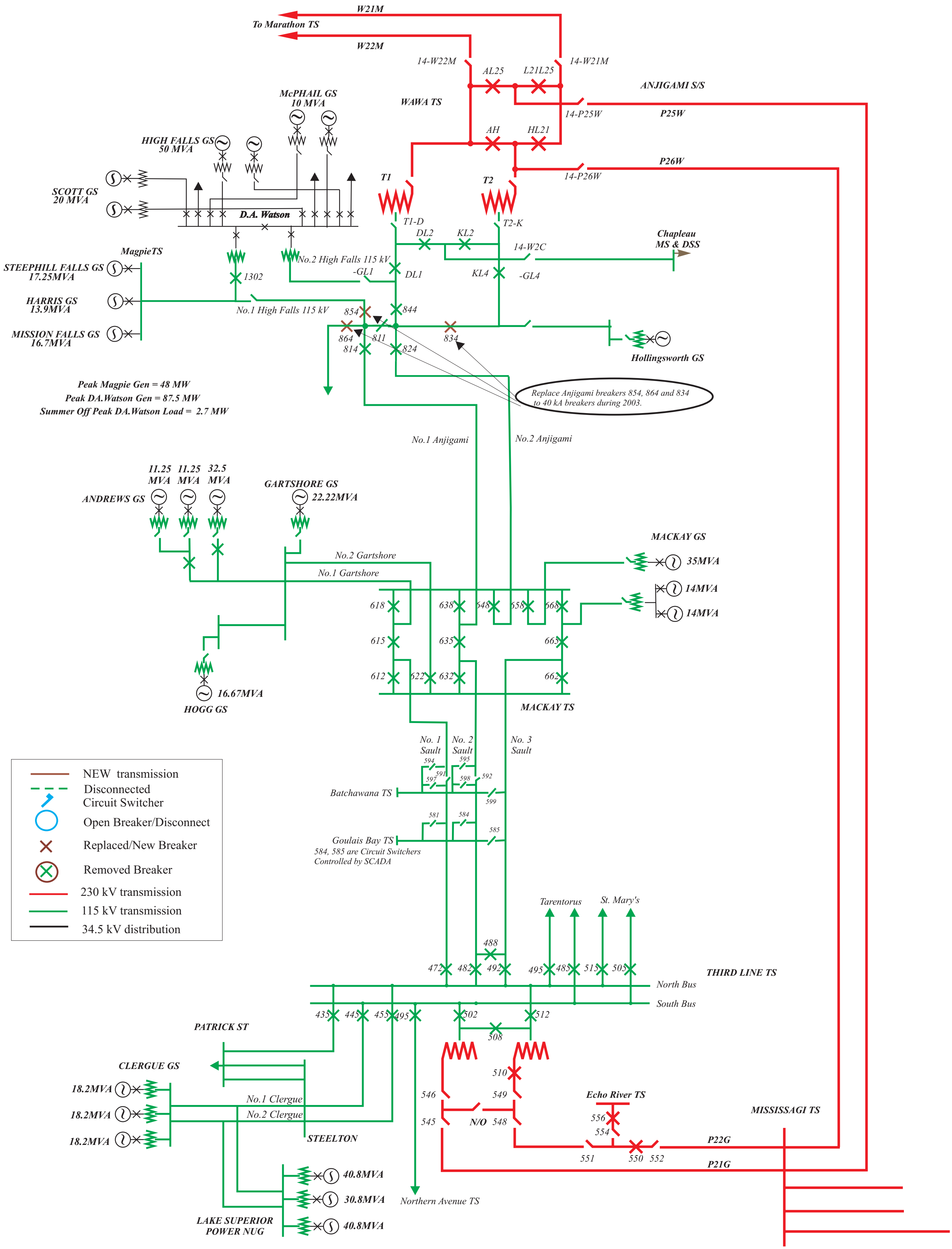

Figure O3.1: GLP System 230 kV Option 3 - Stage 1

(Existing system with three new 115 kV breakers at Anjigami)

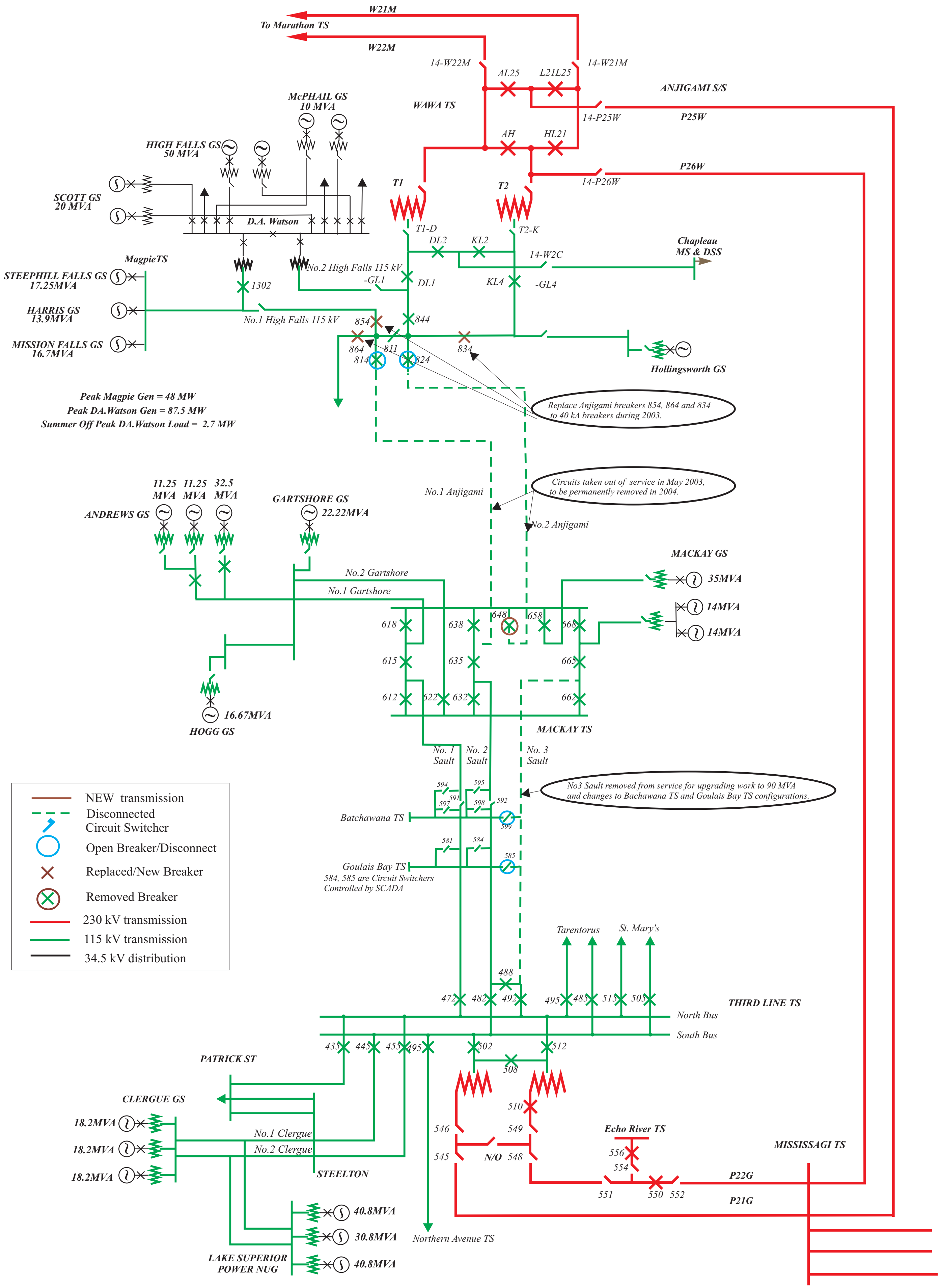

Figure O3.2: GLP System 230 kV Option 3 - Stage 2

(No.1 and No.2 Anjigami and No.3 Sault circuits removed from service)

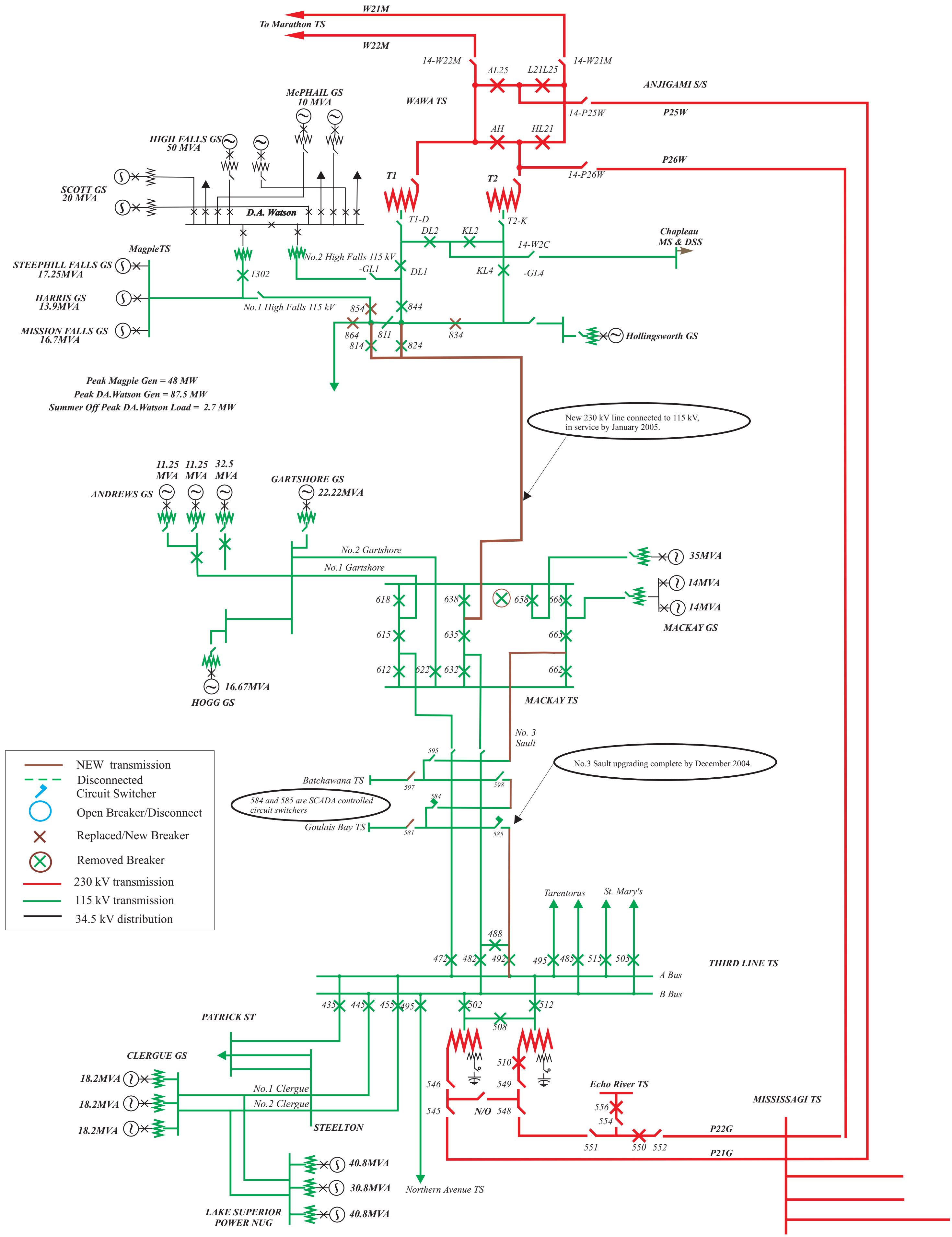

Figure O3.3: GLP System 230kV Option 3 - Stage 3

(Upgrade of No3 Sault 115 kV circuit to 90 MVA and New Circuit between Wawa and MacKay in service at 115 kV)

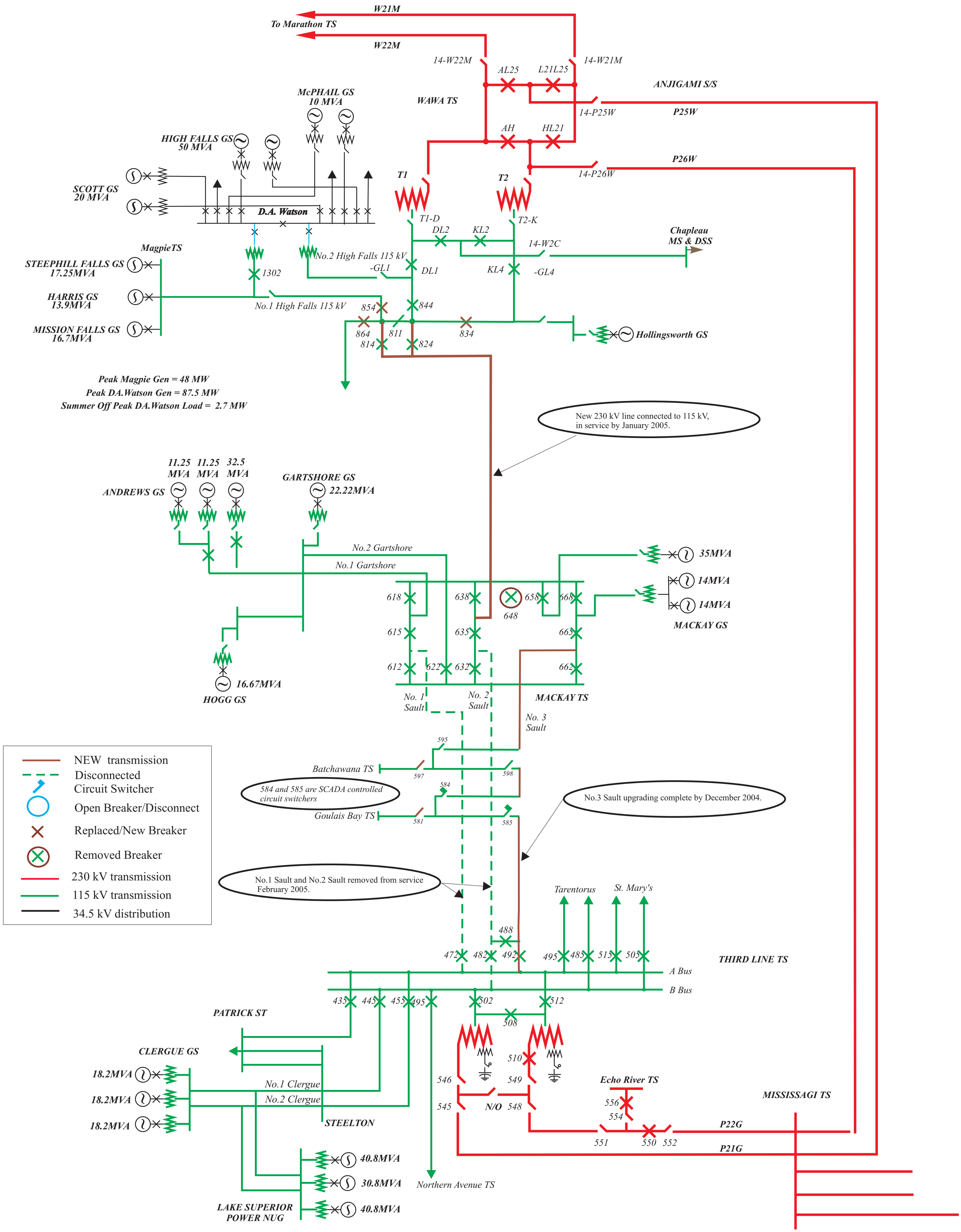

Figure O3.4: GLP System 230kV Option - Stage 4

(Remove from service No.1 Sault and No.2 Sault)

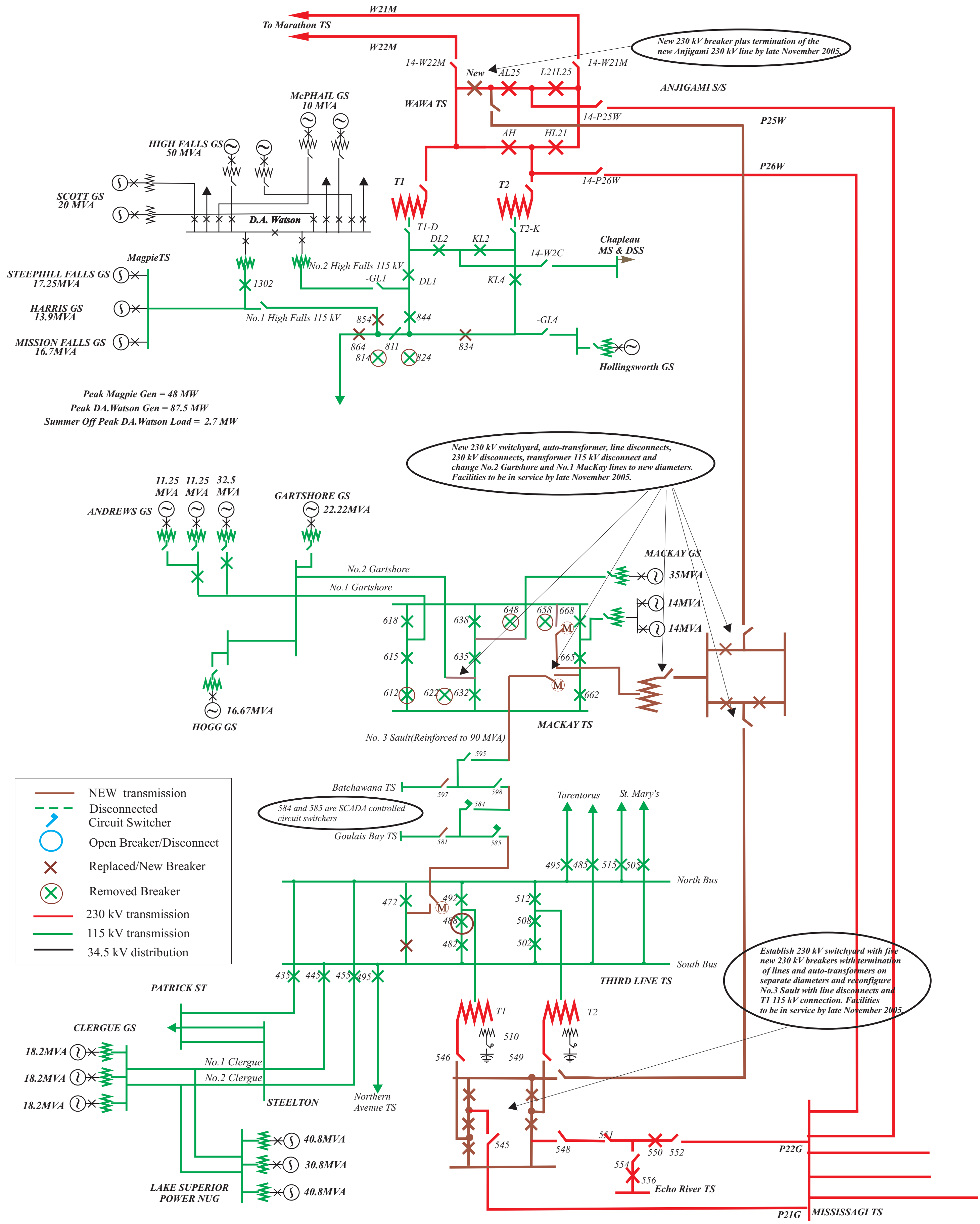

Figure O3.5. GLP Transmission Reinforcement Option 3 - Final Stage
(Complete work at Wawa/Anjigami/MacKay/Third Line stations and connect new 230 kV line at 230 kV)

APPENDIX B

Northwest System Operating Limits

Fair Weather Conditions between Marathon and Mississagi

The East-West power transfer is presently limited to a maximum of 325 MW east and 350 MW west. With Hydro One's approved addition of the new shunt capacitors at Wawa TS the transfer limits on the East-West interface could reach 355 MW eastbound and 380 MW westbound. However, power transfer limit eastbound on the EW tie could be as low as 160 MW for conditions of maximum exports over the Ontario-Manitoba ties (300 MW).

Similarly, power transfers westbound on the EW tie could become limited to as low as 300 MW when imports from Minnesota reach 100 MW. The Mississagi flow east or west is not restricted for a single element contingency. A summary of the phenomena that determine the fair weather operating limits is given in Table B1.

Table B1. Basis for Operating Limits (fair weather)

	East West Transfer East (fair weather)				**East West Transfer West (fair weather)**			
OMTR	**Ontario Manitoba Transfer West**		**Ontario Manitoba Transfer East**		**Ontario Manitoba Transfer West**		**Ontario Manitoba Transfer East**	
MPF	**High OMTW (a)**	**High EWTRE (b)**	**MPFS< 100 (c)**	**MPFS> 100 (d)**	**MPFN<50 (e)**	**MPFN> 50 (f)**	**MPFN<50 (g)**	**MPFN> 50 (h)**
Critical Contingency	Loss of both OM ties	Loss of both OM ties	Loss of W21M And T12 at Marathon	Loss of Ontario Minnesota	Steady State	Loss of both OM ties	Steady State or Loss of OM ties	Loss of both OM Ties
Operating Limit Phenomenon	To prevent F3M out-of-step relay operation	Maintaining minimum voltage between Marathon – Mississagi after automatic phase shifter action at International Falls operation	Limit set to respect the relay margins along East-West tie	Min voltage between Marathon – Mississagi after automatic phase shifter action at Whiteshell	Maintaining minimum voltage at Marathon	To prevent F3M out-of-step relay operation	Maintaining minimum voltage at Marathon or To prevent voltage decline at International Falls or F3M out-of-step relay operation	To prevent voltage decline at International Falls or F3M out-of-step relay operation
	Mississagi Flow East				**Mississagi Flow East**			
Critical Contingency	Loss of A23P or A24P				Loss of A23P or A24P			
Operating Limit Phenomenon	There is no limiting phenomenon				There is no limiting phenomenon			

Adverse weather conditions between Marathon and Mississagi

The East-West transfer east could be as high as 225 MW depending on the flows on the interconnections. The East-West transfer west limit could be as high as 350 MW.

The power flow over the Mississagi circuits could be as high as 560 MW eastbound and 500 MW westbound if the local generation (Aubrey GS, Wells GS, Lake Superior Power GS) is in service and armed for rejection for the loss of A23P and A24P. A summary of the phenomena that determine the adverse weather operating limits is given in Table B2.

Table B2. Basis for Operating Limits (adverse weather)

	East West Transfer East (adverse weather)			**East West Transfer West (adverse weather)**			
OMTR	**Ontario Manitoba Transfer West**		**Ontario Manitoba Transfer East**	**Ontario Manitoba Transfer West**		**Ontario Manitoba Transfer East**	
MPF	**High OMTW (a)**	**Low OMTW (b)**		**High OMTW**	**Low OMTW**	**High OMTE**	**Low OMTE**
Critical Contingency	Loss of both OM ties	Loss of both OM ties	Loss of W21M & W22M	Loss of W21M & W22M	Loss of W21M & W22M	Loss of W21M & W22M	Loss of W21M & W22M
Operating Limit Phenomenon	To prevent F3M out-of-step relay operation or undamped oscillations on the EW tie	Maintaining minimum voltage between Marathon – Mississagi after automatic phase shifter action at International Falls operation	Limit set to respect voltage decline at Whiteshell	To prevent F3M out-of-step relay operation	To prevent severe voltage decline at International Falls	To prevent severe voltage decline at Whiteshell	To prevent severe voltage decline at International Falls
	Mississagi Flow East (adverse weather)			**Mississagi Flow West (adverse weather)**			
Critical Contingency	Loss of A23P & A24P			Loss of A23P & A24P			
Operating Limit Phenomenon	To respect post-contingency voltage stability at Mississagi and relay margin on X74P (Arming Wells GS and Lake Superior Power for rejection improve the limit)			To respect voltage stability at Mississagi and Algoma			

APPENDIX C

Transient Study Results

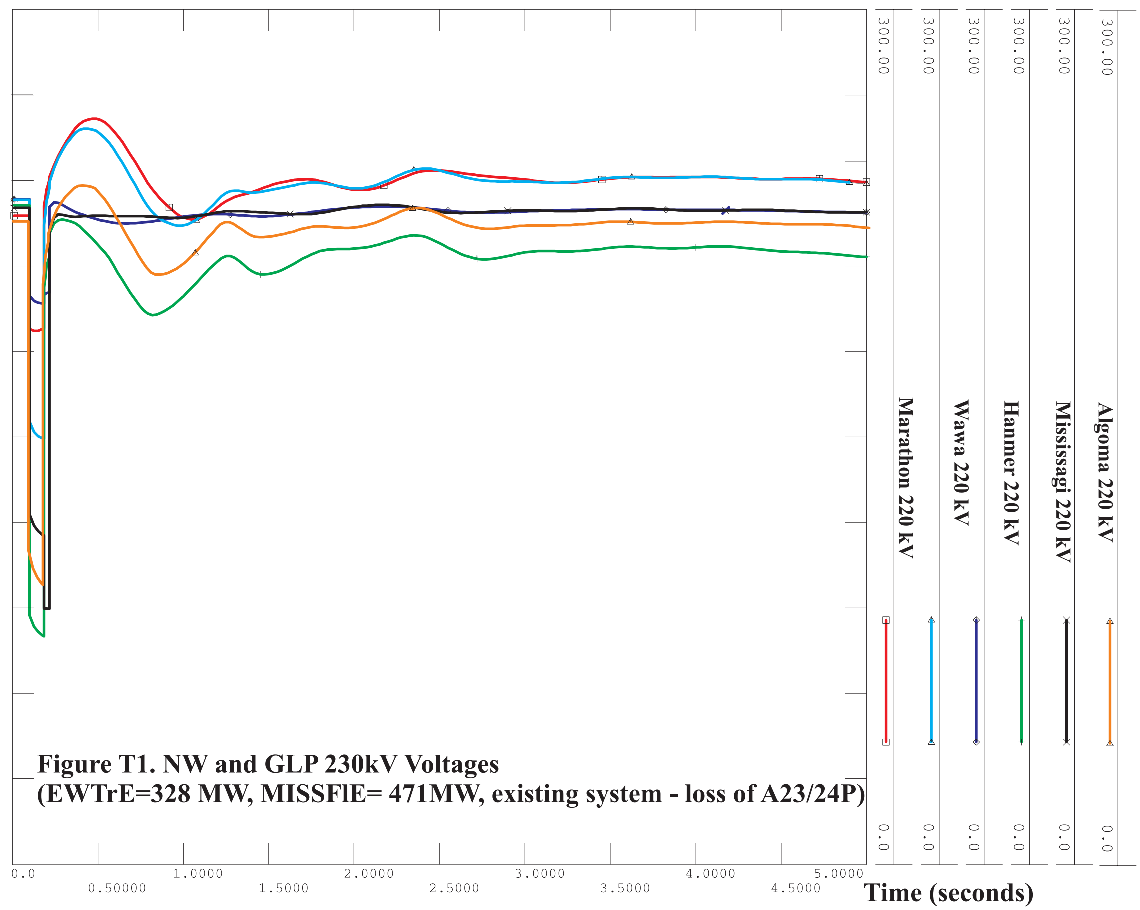

Figure T1. NW and GLP 230kV Voltages
(EWTrE=328 MW, MISSFIE= 471MW, existing system - loss of A23/24P)

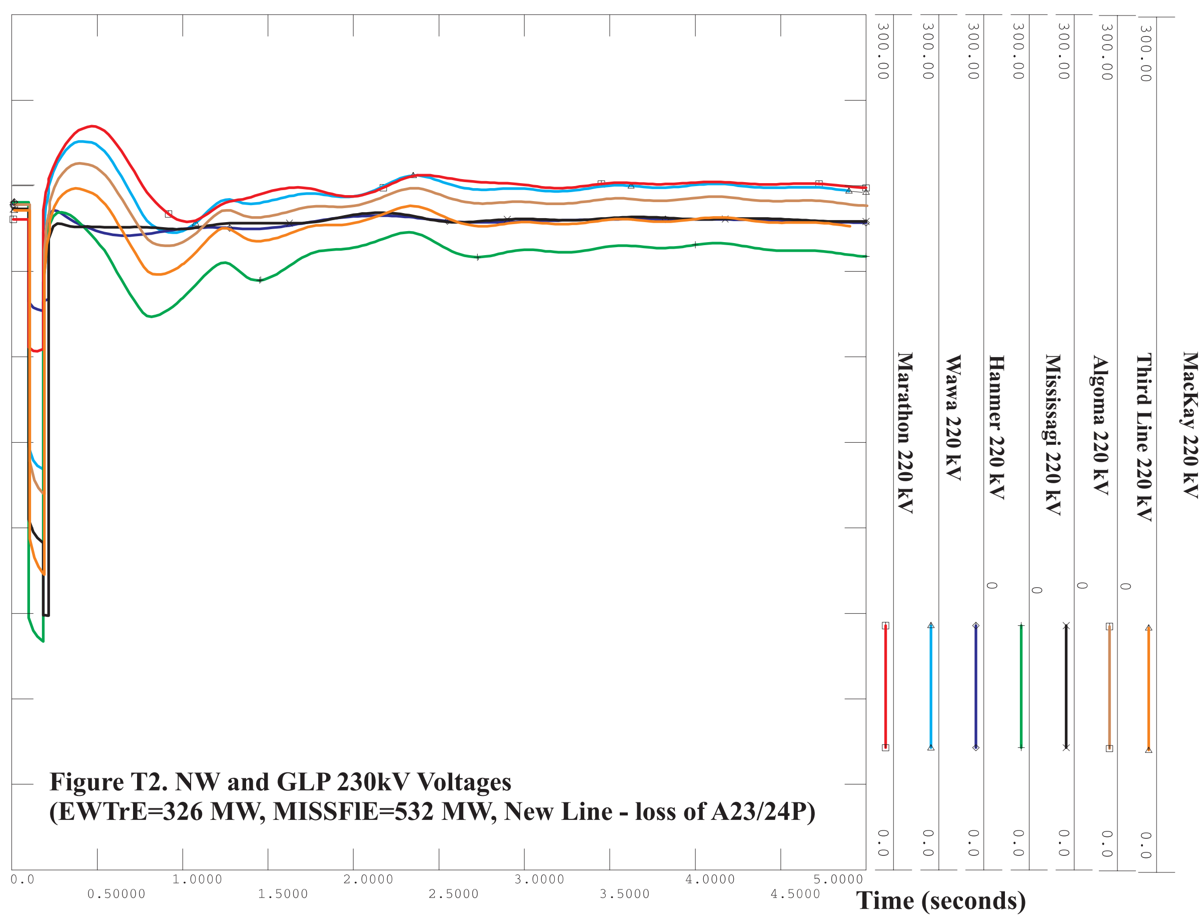

Figure T2. NW and GLP 230kV Voltages
(EWTrE=326 MW, MISSFIE=532 MW, New Line - loss of A23/24P)

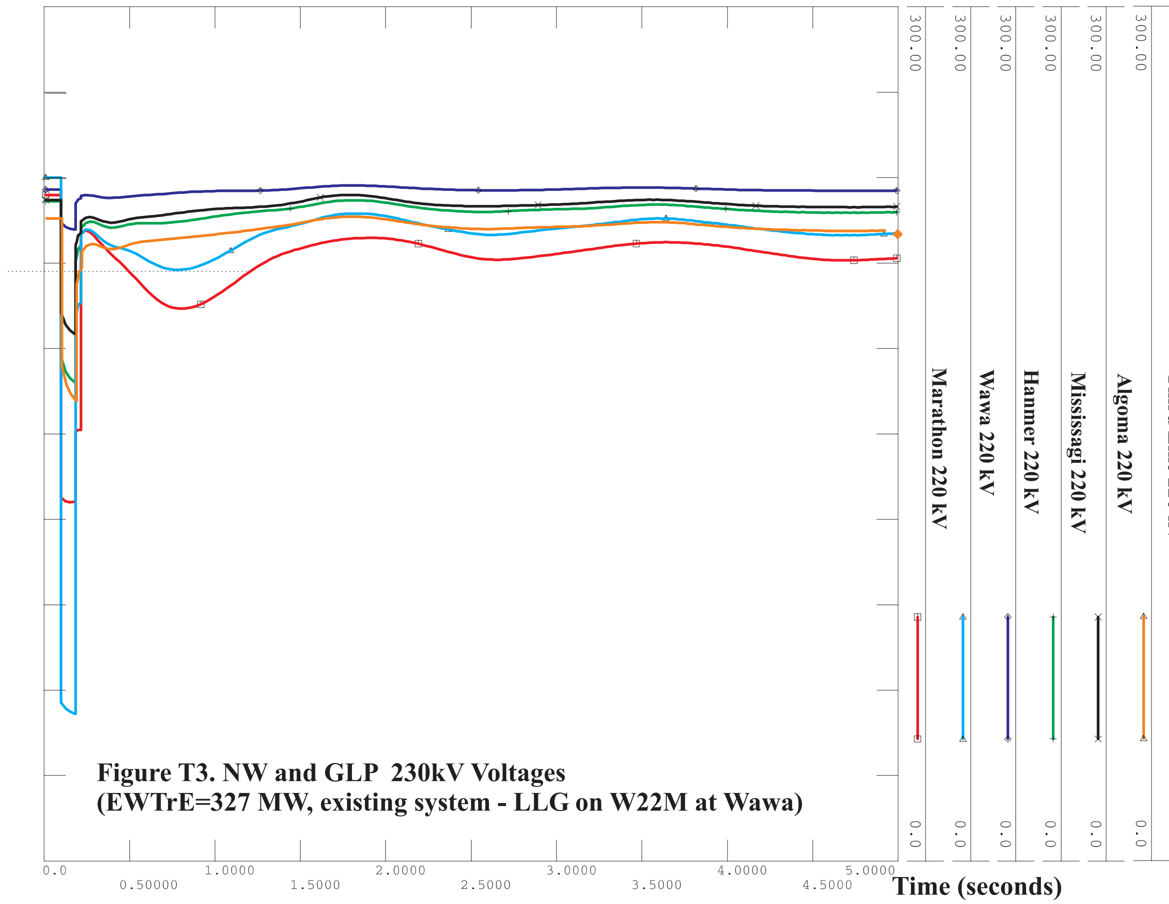

Figure T3. NW and GLP 230kV Voltages (EWTrE=327 MW, existing system - LLG on W22M at Wawa)

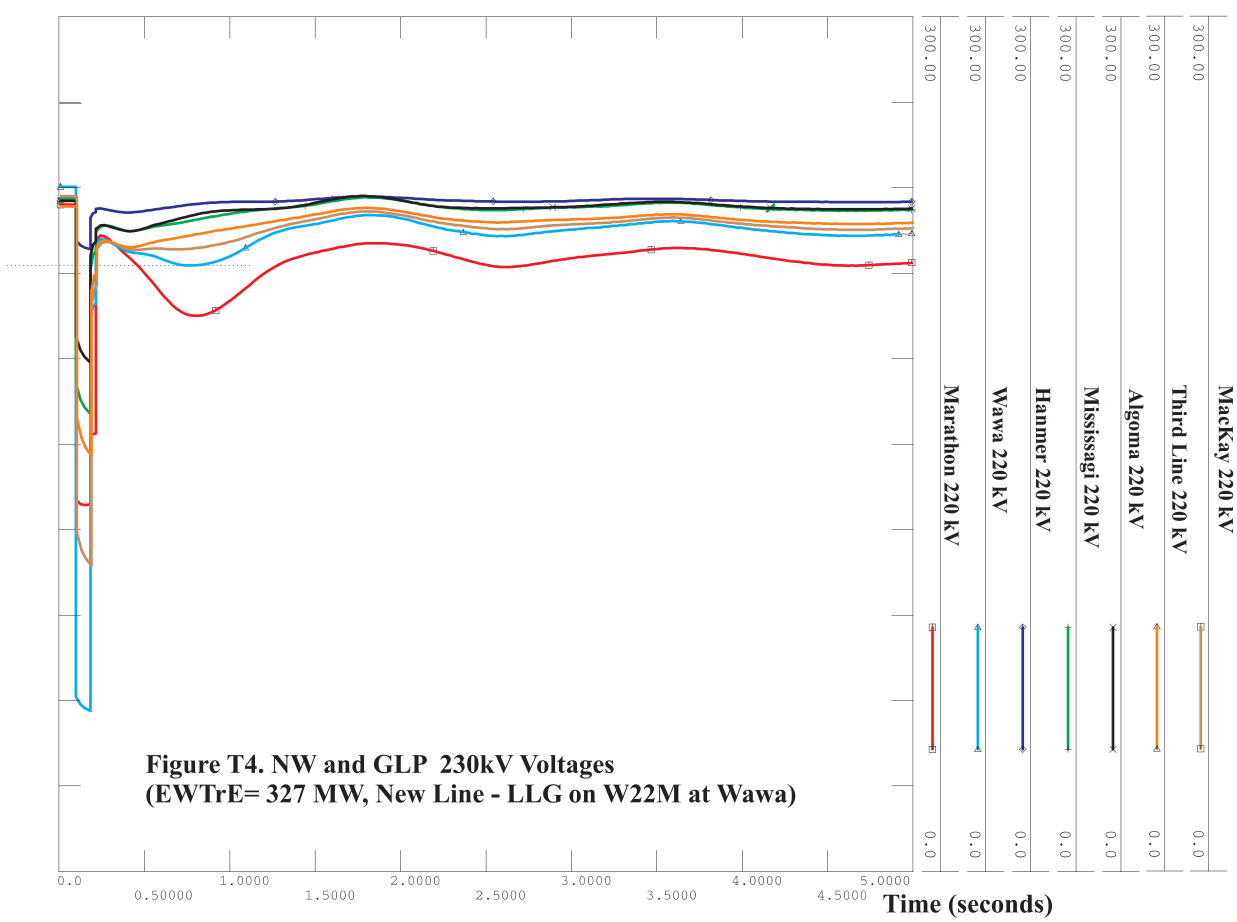

Figure T4. NW and GLP 230kV Voltages (EWTrE= 327 MW, New Line - LLG on W22M at Wawa)

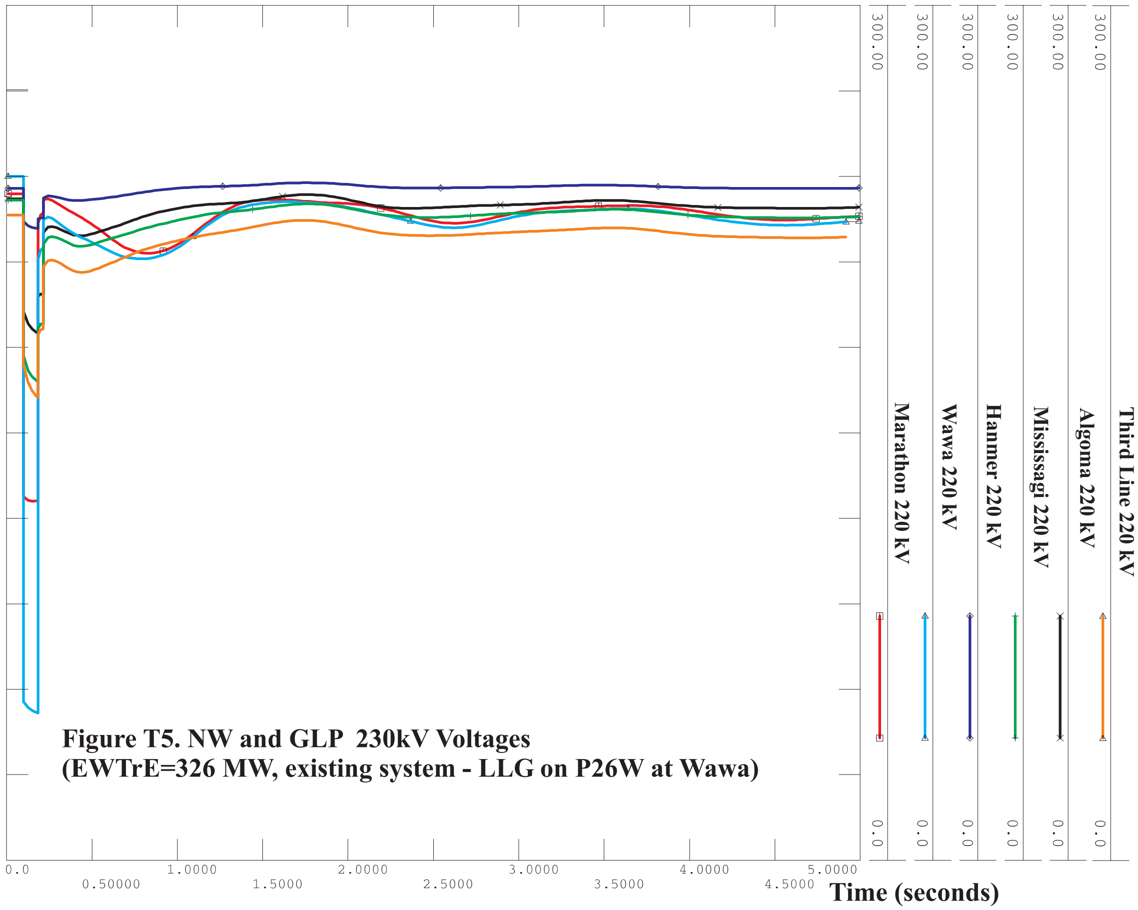

Figure T5. NW and GLP 230kV Voltages
(EWTrE=326 MW, existing system - LLG on P26W at Wawa)

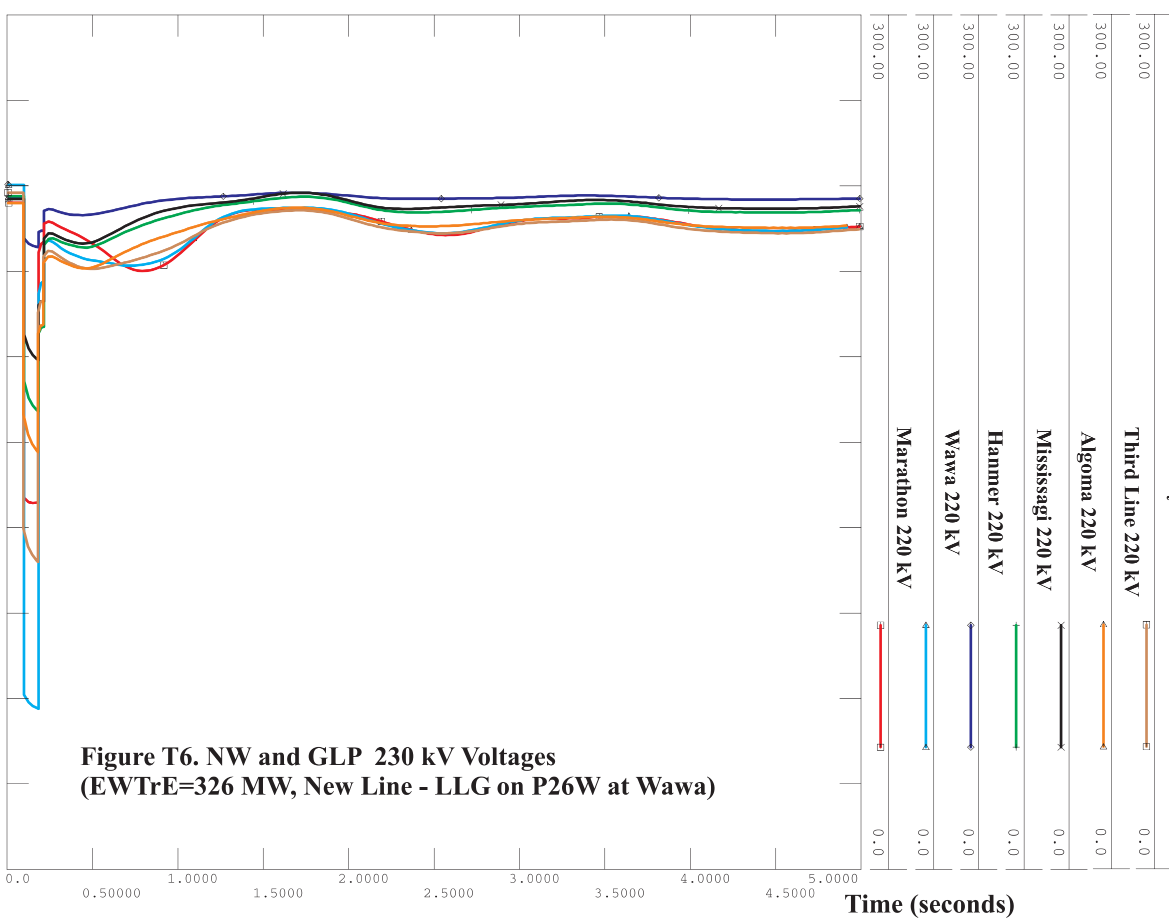

Figure T6. NW and GLP 230 kV Voltages
(EWTrE=326 MW, New Line - LLG on P26W at Wawa)

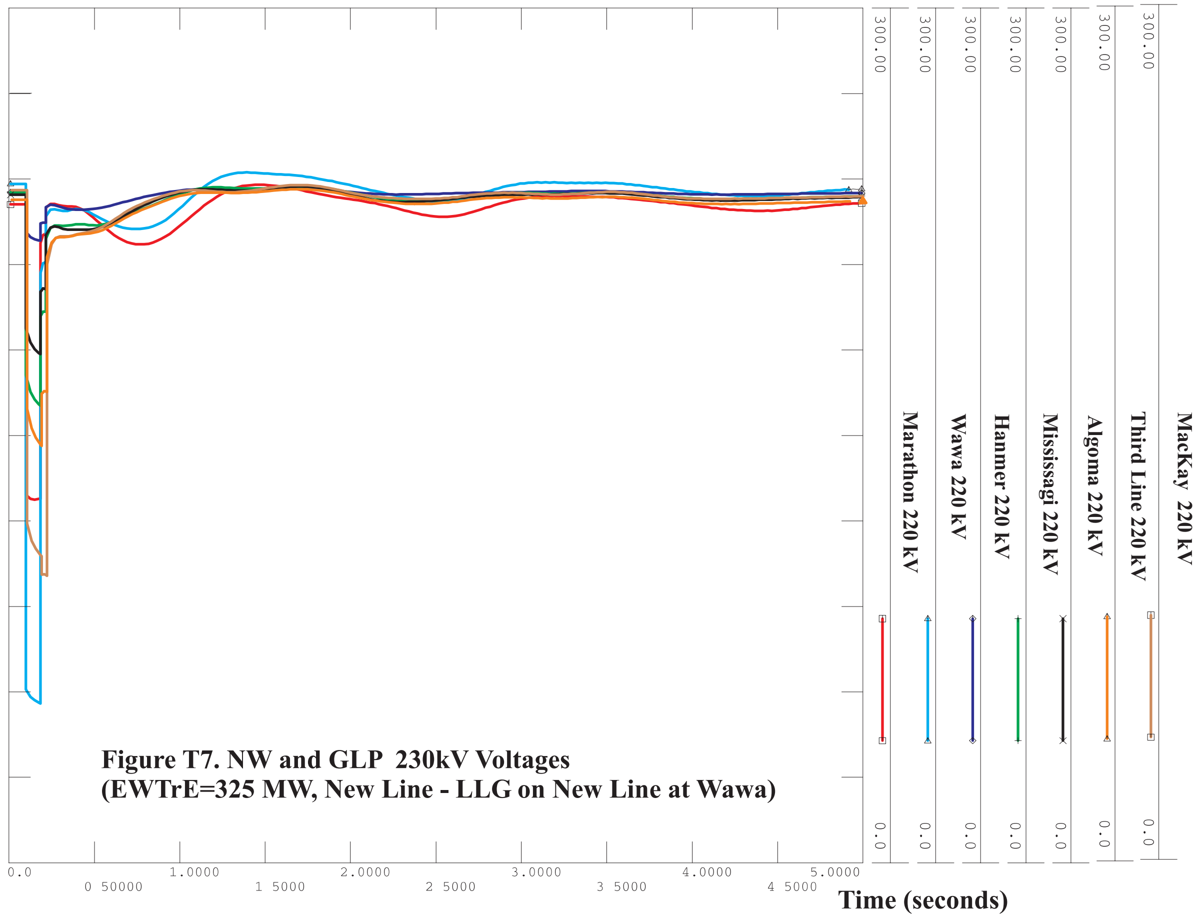

Figure T7. NW and GLP 230kV Voltages
(EWTrE=325 MW, New Line - LLG on New Line at Wawa)

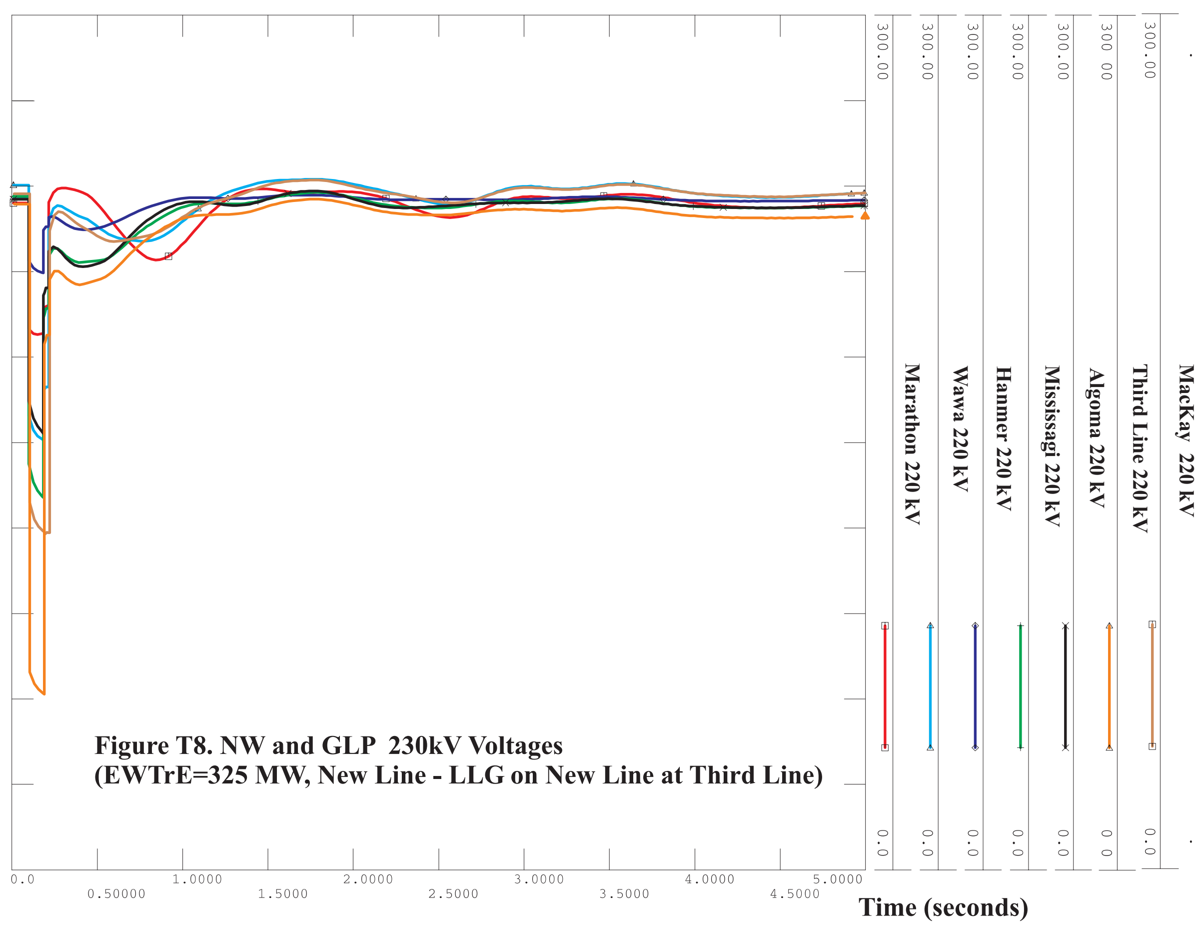

Figure T8. NW and GLP 230kV Voltages
(EWTrE=325 MW, New Line - LLG on New Line at Third Line)

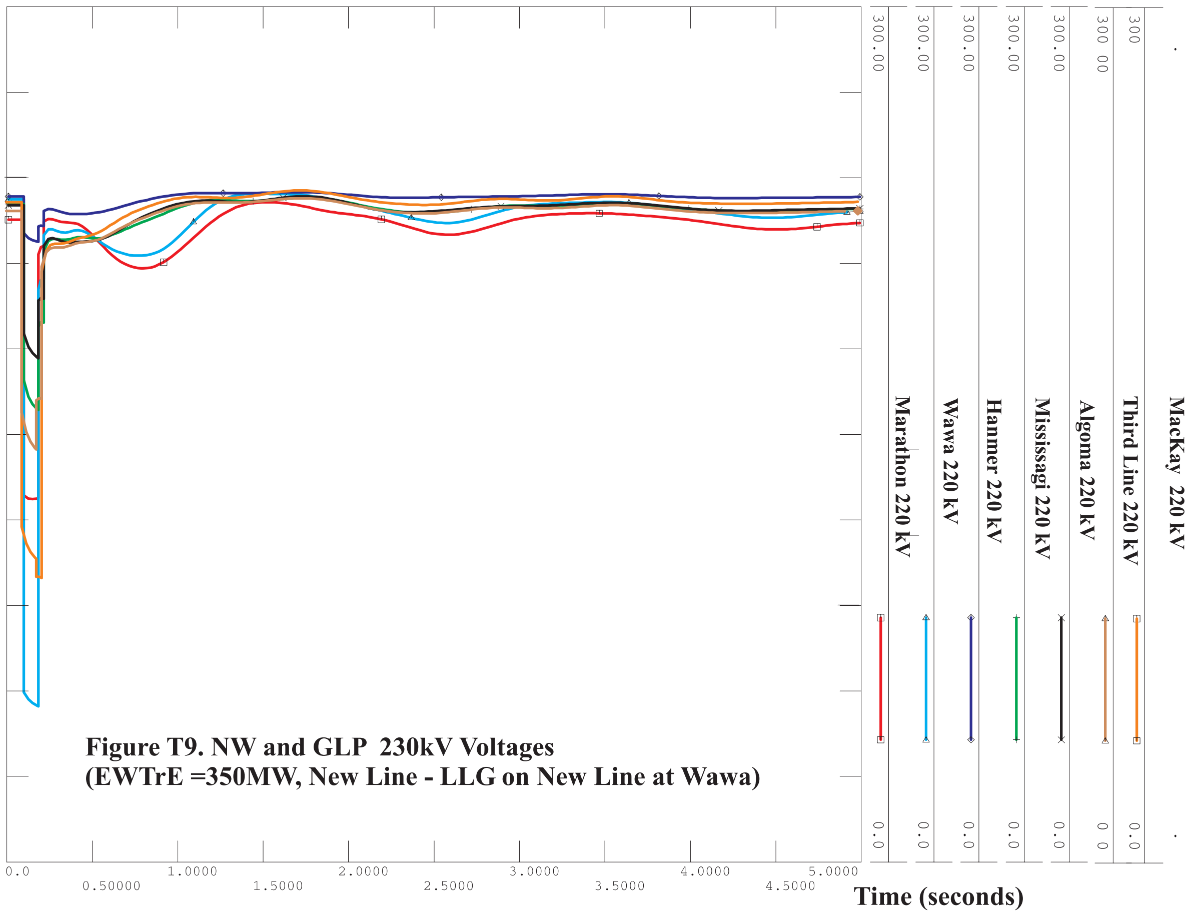

Figure T9. NW and GLP 230kV Voltages
(EWTrE =350MW, New Line - LLG on New Line at Wawa)

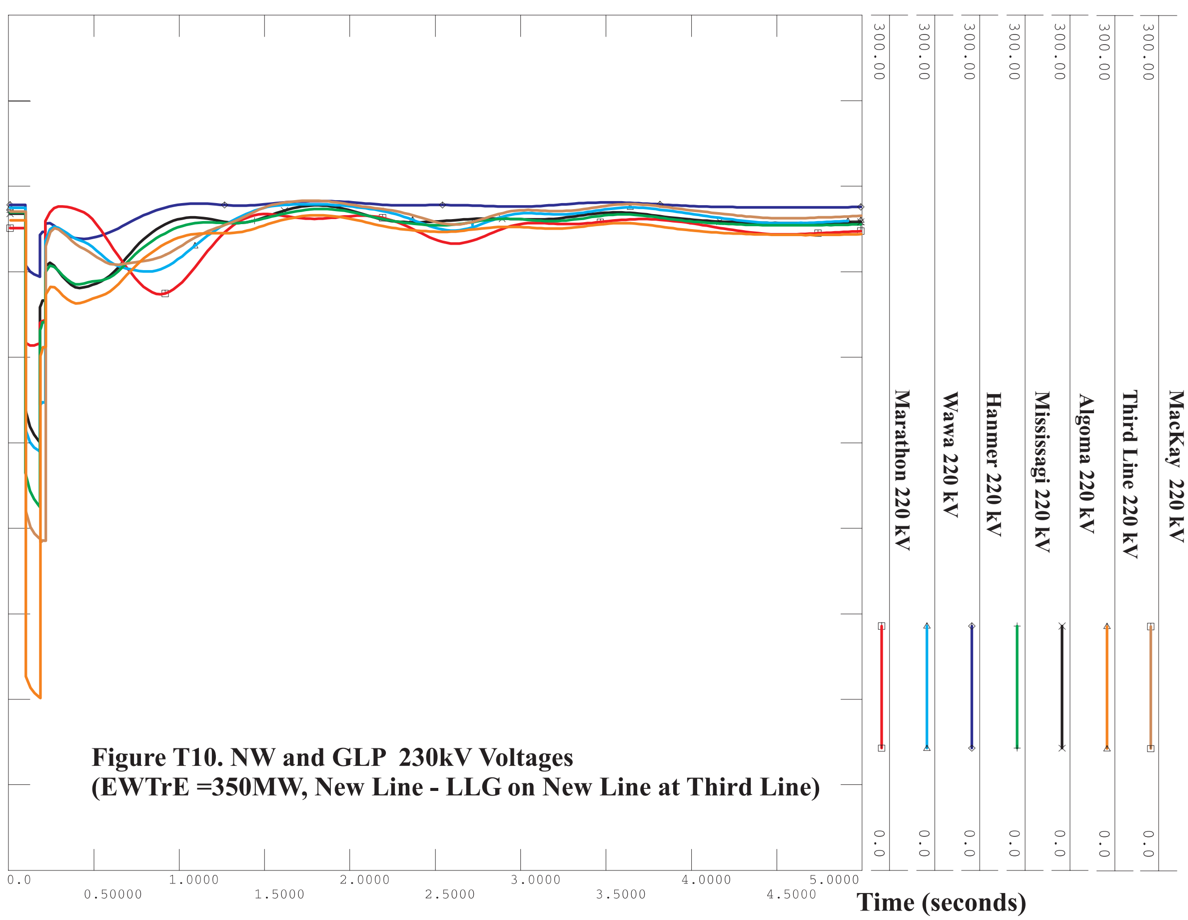

Figure T10. NW and GLP 230kV Voltages
(EWTrE =350MW, New Line - LLG on New Line at Third Line)

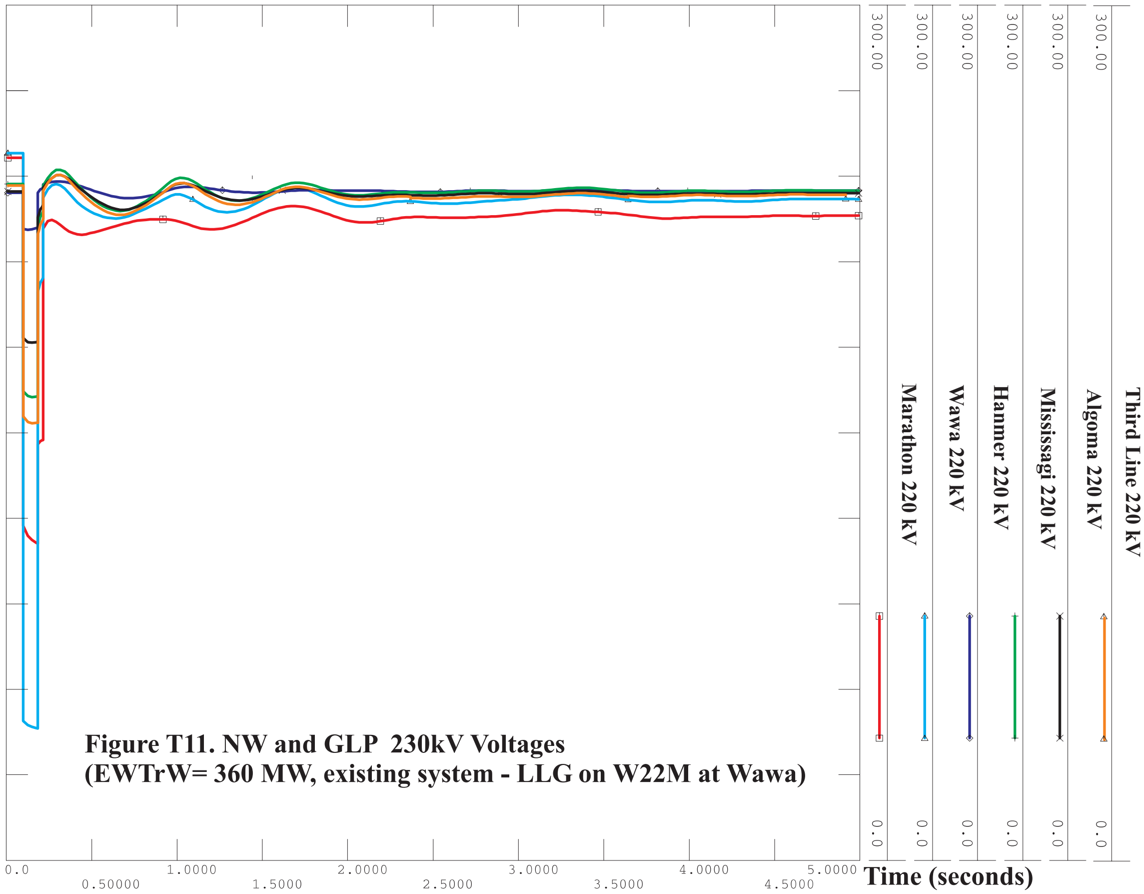

Figure T11. NW and GLP 230kV Voltages (EWTrW= 360 MW, existing system - LLG on W22M at Wawa)

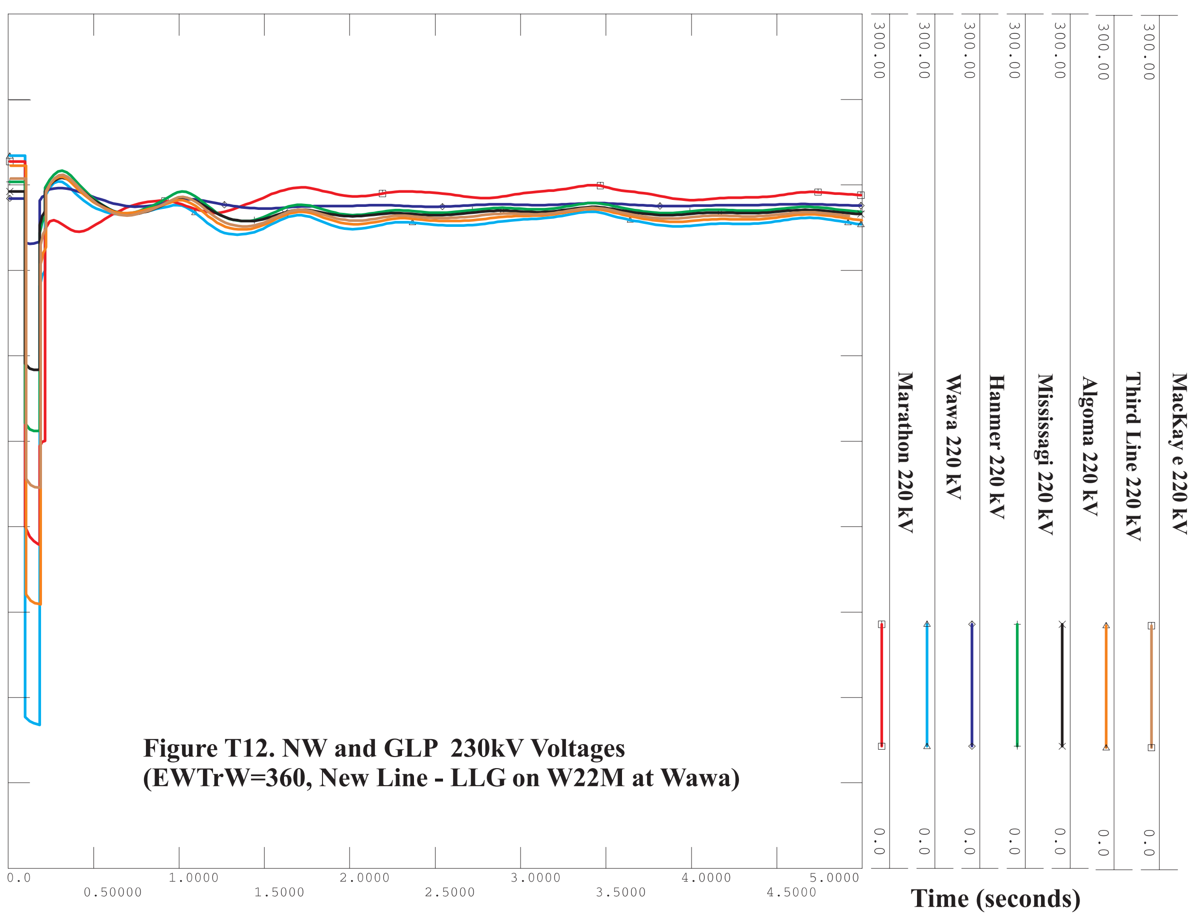

Figure T12. NW and GLP 230kV Voltages (EWTrW=360, New Line - LLG on W22M at Wawa)

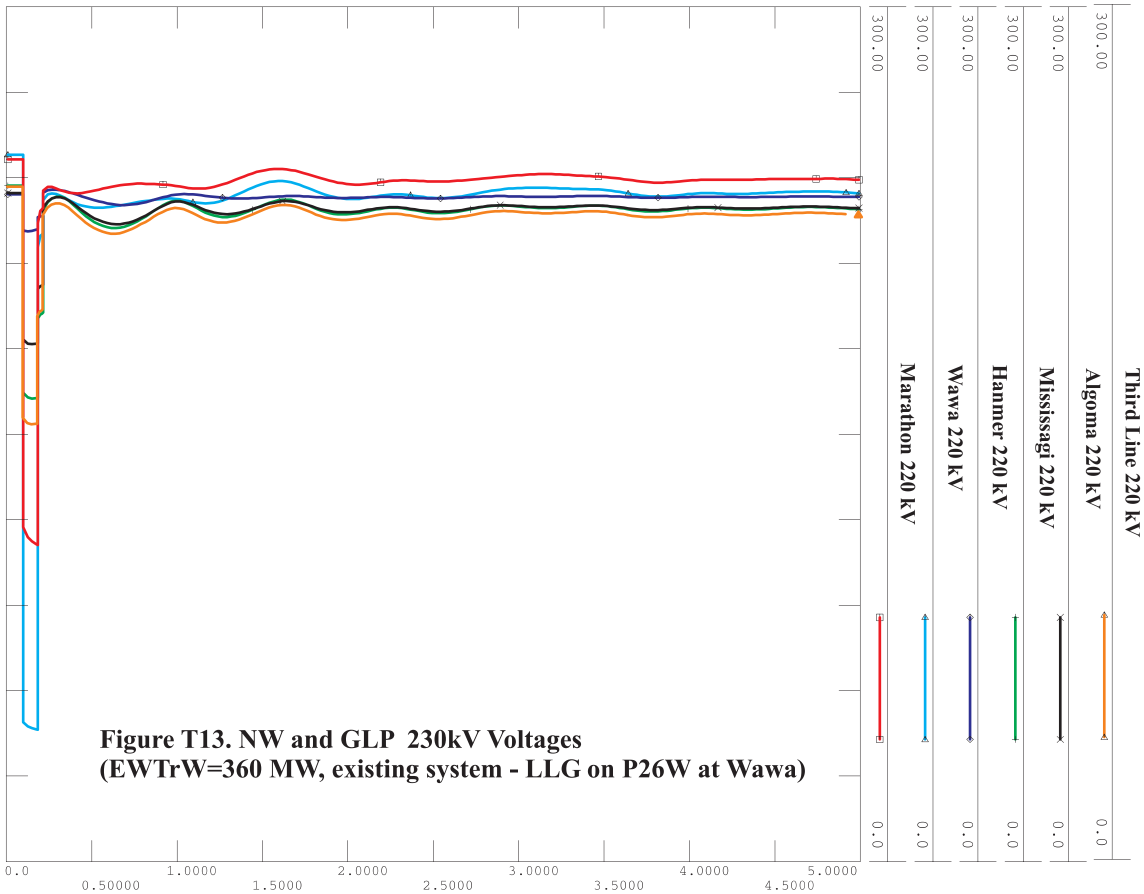

Figure T13. NW and GLP 230kV Voltages
(EWTrW=360 MW, existing system - LLG on P26W at Wawa)

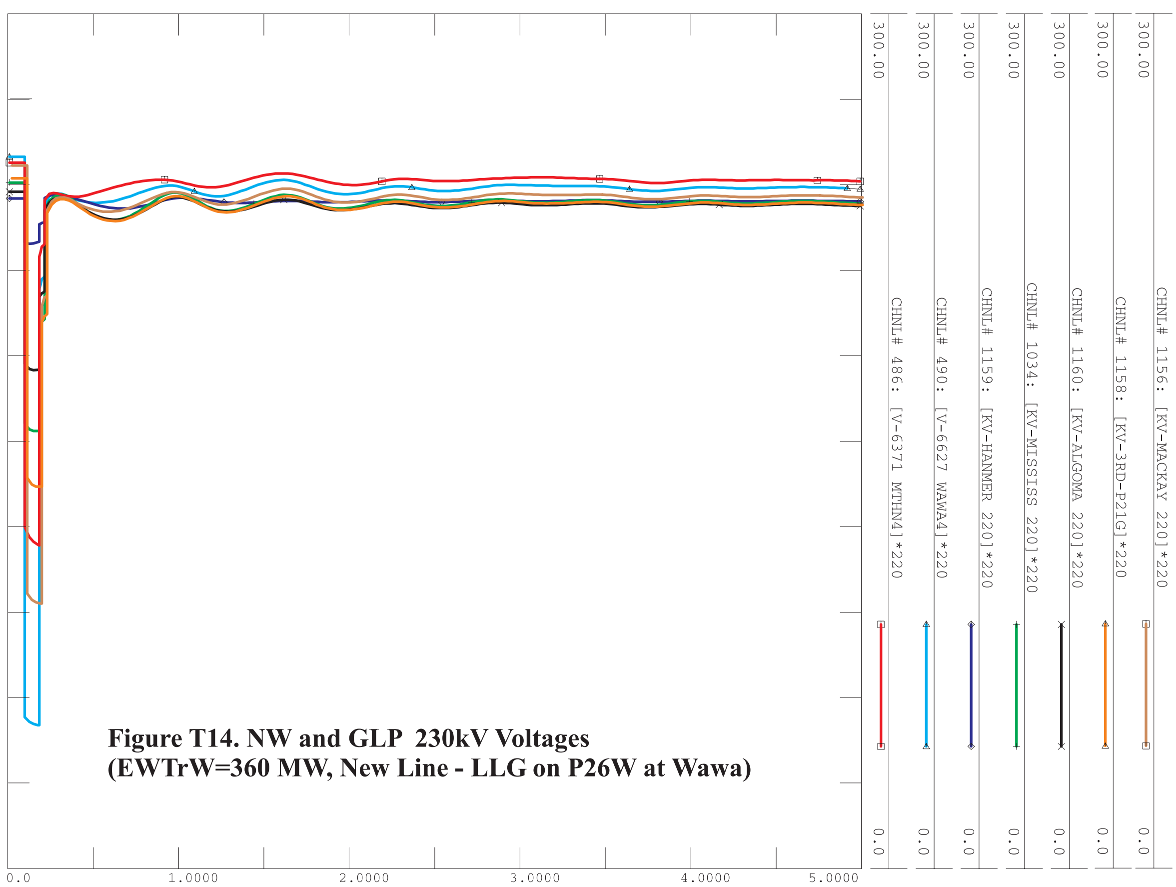

Figure T14. NW and GLP 230kV Voltages
(EWTrW=360 MW, New Line - LLG on P26W at Wawa)

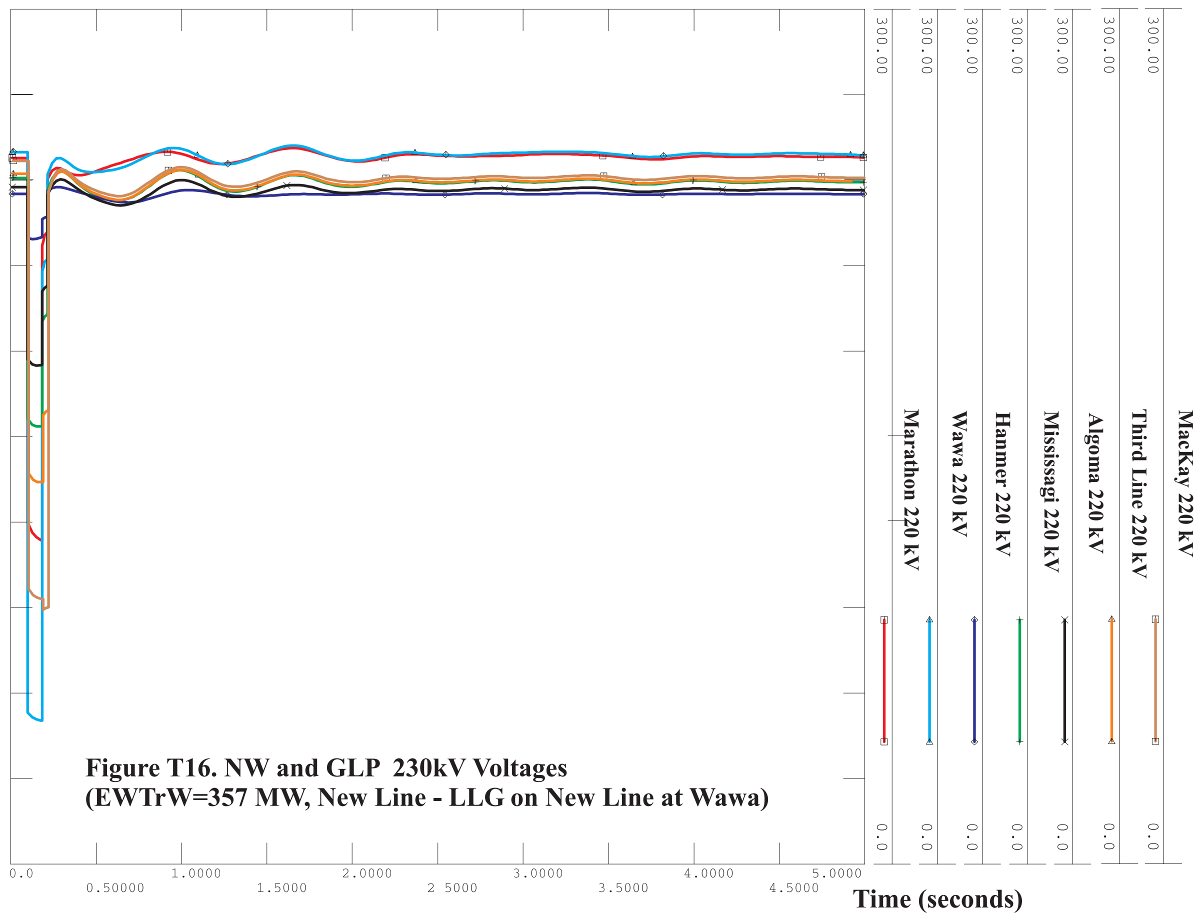

Figure T16. NW and GLP 230kV Voltages (EWTrW=357 MW, New Line - LLG on New Line at Wawa)

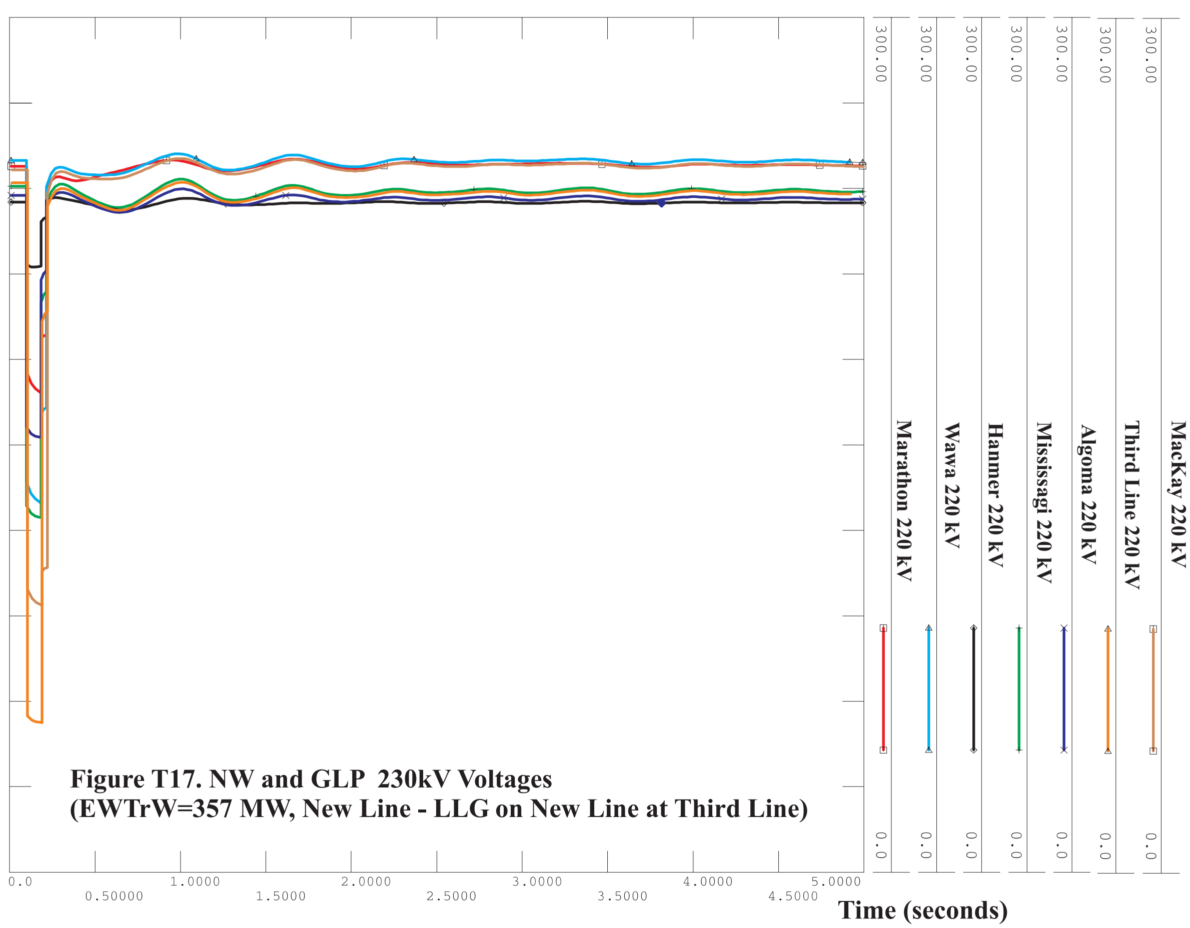

Figure T17. NW and GLP 230kV Voltages (EWTrW=357 MW, New Line - LLG on New Line at Third Line)

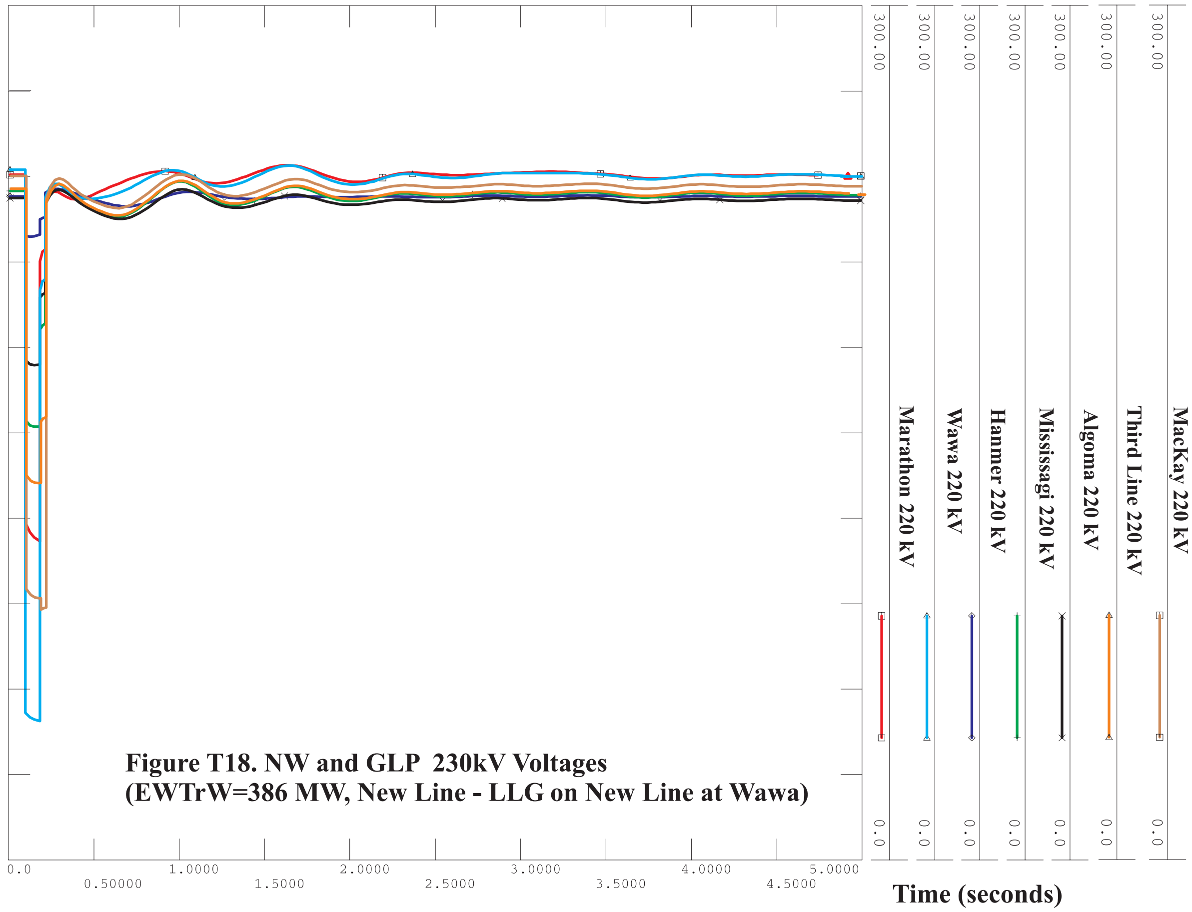

Figure T18. NW and GLP 230kV Voltages
(EWTrW=386 MW, New Line - LLG on New Line at Wawa)

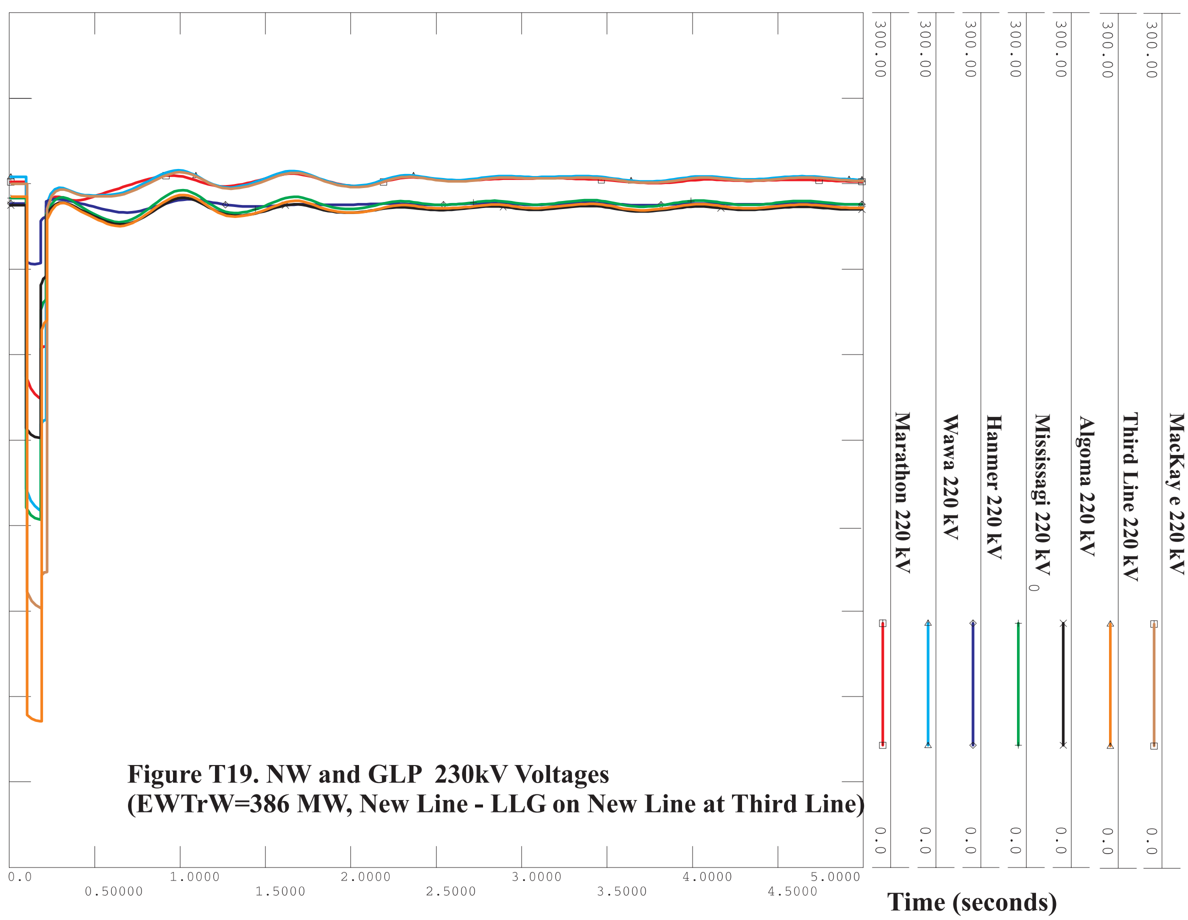

Figure T19. NW and GLP 230kV Voltages
(EWTrW=386 MW, New Line - LLG on New Line at Third Line)