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May 25, 2020

Board of Commissioners of Public Utilities
Prince Charles Building
120 Torbay Road, P.O. Box 21040
St. John's, NL A1A 5B2

Attention: Ms. Cheryl Blundon
Director of Corporate Services & Board Secretary

Dear Ms. Blundon:

Re: Newfoundland and Labrador System Operator Annual Assessments

The Newfoundland and Labrador System Operator ("NLSO") Transmission Planning Process involves the execution of power system studies to demonstrate that the power system meets Transmission Planning Criteria. These power system studies are performed by the NLSO and include an annual assessment of the Newfoundland and Labrador bulk transmission system, which is comprised of transmission infrastructure operating at a voltage level of 230 kV or higher including the Labrador-Island Link, the Labrador Transmission Assets, and Island Interconnected System. Newfoundland and Labrador Hydro ("Hydro") also performs an assessment of all other transmission system facilities with a rated voltage of 46 kV and above that are under its operational control.

As a result of these power system studies two reports were generated:

- TP-R-037: "NLSO Report – 2020 Annual Planning Assessment," Newfoundland and Labrador Hydro, May 2020; and
- TP-R-038: "NL Hydro Report – 2020 Annual Planning Assessment," Newfoundland and Labrador Hydro, March 2020.

Details of the assessments are provided to the Board of Commissioners of Public Utilities for its information as committed in Hydro's response to PUB-NLH-025 of the *Reliability and Resource Adequacy Study Review* proceeding, filed May 24, 2019.

Should you have any questions, please contact the undersigned.

Yours truly,

NEWFOUNDLAND AND LABRADOR HYDRO

Shirley A. Walsh
Senior Legal Counsel, Regulatory
SAW/sk

Encl.

ecc: **Board of Commissioners of Public Utilities**
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Randy Dillon, Town of Happy Valley-Goose Bay

NLSO Report

2020 Annual Planning Assessment

Doc # TP-R-037

Date: May 2020

newfoundland labrador hydro
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Executive Summary

A key function of the Newfoundland and Labrador System Operator (NLSO) is to ensure the coordinated development of a safe, reliable and economical transmission system for transmission customers.
The NLSO Transmission Planning Process involves the execution of power system studies to demonstrate that the power system meets Transmission Planning Criteria. An annual assessment of the transmission system is utilized to determine the timing of system additions/modifications to ensure long term safe, reliable, and economical operation.

This report addresses the NL Transmission System, which is comprised of transmission facilities located in NL, operating at a voltage level of 230 kV or higher, including, the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System.[1]

Conclusions of the 2020 Annual Planning Assessment are specified as follows:

- The NL Transmission System includes Radial and Local Networks where outages to system elements may result in customer impacts. Transmission Planning Criteria are not strictly applied in these cases. Rather, these systems are designed to meet customer reliability and cost requirements.
- The steady state contingency analysis on the Labrador West Local Network indicates:
    - As per the Labrador Transmission Expansion Study, there is a violation to planning criteria following the loss of a synchronous condenser or capacitor bank. Such contingencies would result in low voltage conditions. The installation of 83 MVar of reactive support will resolve this voltage violation. This project will be included by Hydro as part of its 2021 Capital Budget Application.
- Transmission Planning Criteria are strictly applied to the Primary Transmission System. Steady state analyses were performed and the following conditions were confirmed for the long-term horizon:
    - There are no pre-contingency transmission equipment overloads or voltage violations
    - There are no steady state overloads or voltage violations due to a transmission line, generator, synchronous condenser, or shunt element contingencies
    - There are no steady state transformer overloads
- The short circuit analyses were performed and it was confirmed that there are no issues with circuit breaker ratings in the near-term or long-term planning horizons.
- Transient stability analysis is currently in progress as part of ongoing operational studies. These studies will be completed in 2020

[1] A separate annual assessment is performed by Newfoundland and Labrador Hydro (Hydro) to address all other transmission system facilities in both Newfoundland and Labrador with a rated voltage of 46 kV and above

Table of Contents

1 INTRODUCTION

The NLSO Transmission Planning Process involves the execution of power system studies to ensure compliance with Transmission Planning Criteria and to determine the timing of system additions and modifications.

The 2020 Annual Planning Assessment covers the period extending to 2029. Cases are assessed to investigate the capability of the transmission system to meet peak load and to meet firm transmission commitments.[2]

This report addresses the NL Transmission System, which is comprised of transmission facilities located in NL, operating at a voltage level of 230 kV or higher, including, the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System[3]. Analysis is performed to ensure compliance with TP-S-007 NLSO Standard – Transmission Planning Criteria.

Figure 1 provides a map of the Newfoundland and Labrador Interconnected System post completion of the Lower Churchill Project.

[2] It is noted that the firm export limits for the Maritime Link (ML) is specified at 250 MW; however, there is insufficient generating capacity within the NL Transmission System for exports of this magnitude over peak. For this reason, separate cases are developed to assess:

1) Near-Peak Load conditions with 250 MW export over the ML
2) Peak Load conditions with 158 MW of ML to reflect firm commitments over peak

[3] Newfoundland and Labrador Hydro (Hydro) performs an annual assessment of NL interconnected system, which includes all system elements 46 kV and above that are under its operational control and not included in the NLSO assessment

Figure 1 : Newfoundland and Labrador Interconnected System

2 SELECTION OF STUDY CASES

System models have been developed to reflect the latest load forecast with completed system changes including proposed additions/modifications for future years ranging to 2029. The following assumptions are made for the long term planning of the NL Transmission System:

- The Muskrat Falls Generating Station (MFAGS) is complete, with four 206 MW units in service
- The MFATS2 315 kV, 150 MVAR shunt reactor is removed from service
- The LIL is operating in Bipole Mode up to its rated capacity of 900 MW (Rdc = 19.29 ohm)
    - All filter banks are available at each of Muskrat Falls and Soldiers Pond Converter Stations
    - Electrode lines and electrode sites are in service
- Churchill Falls recall power (less Labrador loads) is available to send to the Island
- There are two Soldiers Pond 175 MVAR synchronous condensers in service for analysis (the third unit is available)
- Holyrood Thermal Generating Station is placed out of service with Unit 3 operating in synchronous condenser mode
- Stephenville gas turbine has been removed from service
- Hardwoods gas turbine is out of service as a generator, but can be operated as a synchronous condenser
- Happy Valley Terminal Station (HVYTS) is supplied via a new 138 kV transmission line L1303 from the Muskrat Falls Terminal Station 2 (MFATS2)
- 138 kV transmission line L1301 from Churchill Falls to Muskrat Falls TS1, as well as Muskrat Falls TS3 have been decommissioned
- HVYTS has an additional 138/25 kV 50 MVA transformer (T5)
- The Happy Valley North Side Diesel Plant is out of service
- The CF T31 power transformer has been relocated to Holyrood to replace failed T7.
- A new power transformer will be installed in Bottom Brook as a backup supply for Stephenville as the gas turbine is no longer in service. 400L is normally in service.
- Wabush Terminal Station upgrades include:
    - 83 MVar of reactive support
    - Transformers T4 and T5 have been replaced with 125 MVA units
- Wabush Substation upgrades include:
    - Transformers T3 and T5 have been removed from service
    - Transformer T6 is connected to bus B3, in parallel with transformer T4
    - A new 25 MVA transformer T7 has been connected to bus B5
    - A bus tie has been added to connect buses B3 and B5.

Load flow plots for the Year Ten cases are provided in Appendix A.

3 SPECIAL CONSIDERATIONS

Special considerations for this study period are discussed in the section(s) below.

3.1 Operational Studies

Hydro is undertaking a set of operational studies for the interconnection of Lower Churchill Project assets into the NL Transmission System. The objective of the studies is to identify system impacts and operating limits to allow for the development of instructions to be used by NLSO. These operational studies include assessments of the transient stability. Transient stability considerations will therefore be outside of the scope of annual assessments until the operational studies are complete. The studies are expected to be completed in 2020.

4 LOAD FORECAST

The 2020 Annual Planning Assessment is based upon the following load forecasts prepared by the Market Analysis Section, Rural Planning Department, Newfoundland and Labrador Hydro:

- Island Interconnected 10 Year P50 and P90 Peak Demand Summary – Fall 2019 dated November 2019; and
- Labrador Interconnected 10 Year P50 and P90 Peak Demand Summary – Summer 2019 dated June 2019.

The Island and Labrador Interconnected P90 forecasted peaks are summarized in Table 1.

Table 1 – Operating Load Forecasts (P90) - Island and Labrador Interconnected System

Forecasted Demand (MW)				
Year	Island Interconnected (Fall 2019)	Labrador Interconnected (Spring 2019)		
		Lab East	Lab West	Total
2019/20	1,717	78.2	368.5	441.9
2020/21	1,723	80.5	379.9	448.6
2021/22	1,725	80.8	380.2	449.1
2022/23	1,735	81.1	380.3	449.4
2023/24	1,745	81.4	380.4	449.8
2024/25	1,753	81.8	380.8	450.6
2025/26	1,762	82.3	381.0	451.2
2026/27	1,773	83.2	381.2	452.1
2027/28	1,782	83.9	381.3	452.9
2028/29	1,792	84.6	381.5	453.7

5 STEADY STATE ANALYSIS

The NL Transmission System consists of Radial Networks, Local Networks as well as the Primary Transmission System. Radial Network and Local Networks allow for the delivery of electricity to specific customers and Transmission Planning Criteria are not strictly applied. Rather, these systems are designed to meet customer reliability and cost requirements. In such a network, the loss of a transmission system element may result in a customer impact. This is in contrast to the Primary Transmission System, where all Transmission System Criteria are strictly enforced.

Steady state analysis is performed on all systems when fully intact (pre-contingency) and following the loss of each single transmission element (single contingency). The pre-contingency analysis is performed to ensure that with all equipment in service under normal operation, power flow through all elements does not exceed their normal rating and voltages are within acceptable limits. Similarly, the single contingency analysis assesses the system impact following the loss of each individual transmission element. The ratings of each type of transmission element are defined as per TP-S-001 - NLSO Facilities Rating Guide. The results of the steady state analysis are described in the sections below.

Load flow plots during normal operation of the NL Transmission System for Year Ten (2029) is provided in Appendix A.

5.1 Radial Networks

5.1.1 Supply to Vale Inco

Vale Inco is supplied by radial transmission line TL208. There are no overloads to this transmission line under normal operation. In the event of an outage to this transmission line, there will be an interruption of electrical supply which is deemed acceptable by Vale Inco.

5.1.2 Supply to Stephenville Area

The Stephenville area is supplied by radial transmission line TL209. There are no overloads to this transmission line under normal operation. In the event of an outage to this transmission line, the network is supplied by the local 66 kV network. The 66kV network is addressed as part of the NL Hydro 2020 Annual Assessment.

5.2 Local Networks

5.2.1 The Labrador West System

The transmission system in western Labrador is considered a local network and consists of two 230 kV transmission lines that connect Churchill Falls Terminal Station #1 to the Wabush Terminal Station. These transmission lines are designated as L23 and L24. This network also includes three synchronous condensers at the Wabush Terminal Station (SC1, SC2, and SC3[4]).

Criteria for this local network were defined as part of Hydro's Labrador Interconnected System Transmission Expansion Study that was completed in 2018. Criteria were defined to ensure that there shall be no customer interruption for the loss of a synchronous condenser, a capacitor bank, or a power transformer. Loss of load is permitted for a transmission line outage.

For the purposes of the NLSO annual assessment, analysis was performed to assess the impact of the loss of the transmission line, a synchronous condenser, a capacitor bank. Other contingencies are addressed as part of Hydro's annual assessment.

As per the Labrador Transmission Expansion Study, there is a violation to planning criteria following the loss of a synchronous condenser or capacitor bank. Such contingencies would result in low voltage conditions. The installation of 83 MVar of reactive support will resolve this voltage violation. This project will be included by Hydro as part of its 2021 Capital Budget Application.

5.3 Primary Transmission System

Analysis was performed to assess steady state contingencies for the Primary Transmission System. Transmission Planning Criteria are applied to the network to ensure that no system events result in the interruption of load or firm imports or export commitments.

5.3.1 Bay d'Espoir System

The Bay d'Espoir System consists of a network of 230 kV transmission lines that includes the following:

- TL234 between Bay d'Espoir Terminal Station and Upper Salmon Terminal Station
- TL263 between Upper Salmon Terminal Station to Granite Canal Terminal Station
- TL269 between Granite Canal Terminal Station to Bottom Brook Terminal Station

[4] SC3 is owned and operated by IOC

This network also includes hydraulic generating facilities at Bay d'Espoir, Upper Salmon and Granite Canal Generation Stations. The Bay d'Espoir Generation Station is the largest plant on the Island Interconnected System with a total capacity of approximately 613 MW. The largest unit at the Bay d'Espoir Generation Station is BDE Unit #7 (154.4 MW), which can also operate as a synchronous condenser.

This network also includes a 15 MVAR reactor at Granite Canal Tap Terminal Station.

Steady state analysis indicates that within the long term horizons, there are no violations within this network under normal operation or any contingency event involving the loss of any 230 kV line, generator, reactor or synchronous machine.

In the event of an outage to the Granite Canal Tap Shunt Reactor, TL269 would be removed from service in accordance with NLSO operating instruction TOP-P-068 - Granite Canal Tap Shunt Reactor. There are no violations to Transmission Planning Criteria associated with this scenario.

5.3.2 Bay d'Espoir - Western Avalon Corridor

Bay d'Espoir Terminal Station is interconnected to Western Avalon Terminal station through a network of 230 kV transmission lines that includes the following:

- TL202 and TL206 between Bay d'Espoir Terminal Station and Sunnyside Terminal Station
- TL267 between Bay d'Espoir Terminal Station and Western Avalon Terminal Station
- TL203 between Sunnyside Terminal Station and Western Avalon Terminal Station
- TL207 between Sunnyside Terminal Station and Come by Chance Terminal Station
- TL237 between Come by Chance Terminal Station and Western Avalon Terminal Station

This network also includes four 37.35 MVAR capacitor banks at Come by Chance Terminal Station.

Steady state analysis indicates that within the near and long term horizons there are no violations in this corridor under normal operation or any contingency event involving the loss of a line or capacitor bank.

Operating limits in this corridor are defined in accordance with NLSO Operating instruction TOP-P-076 - NL Transmission System Operating Limits. Transient stability considerations are being assessed as part of operational studies, as addressed in Section 7.

5.3.3 Avalon Peninsula System

The Avalon Peninsula is the largest load center on the Island Interconnected System that is comprised of a network of 230 kV transmission lines that include the following:

- TL201 and TL217 between Western Avalon Terminal Station and Soldiers Pond Terminal Station

- TL265 and TL268 between Soldiers Pond Terminal Station and Holyrood Terminal Station
- TL242 and TL266 between Soldiers Pond Terminal Station and Hardwoods Terminal Station
- TL236 between Hardwoods Terminal Station and Oxen Pond Terminal Station
- TL218 between Oxen Pond Terminal Station and Holyrood Terminal Station

This network also includes synchronous condensers at Soldiers Pond as well as Unit 3 as Holyrood Generating Station.

Steady state analysis indicates that within the long term horizons, there are no violations within this network under normal operation or any contingency event involving the loss of any 230 kV line, generator, or synchronous condenser.

Operating limits on the Avalon Peninsula are defined in accordance with NLSO Operating instruction TOP-P-076 - NL Transmission System Operating Limits. Transient stability considerations included in this operating instruction are to be assessed as part of operational studies, as addressed in Section 7.

5.3.4 Western Island Interconnected System

The Western Island Interconnected system consists of a network of 230 kV transmission lines that include the following:

- TL204 and TL231 between Bay d'Espoir Terminal Station and Stony Brook Terminal Station
- TL205 and TL232 between Stony Brook Terminal Station and Buchans Terminal Station
- TL233 between Buchans Terminal Station and Bottom Brook Terminal Station
- TL211 between Bottom Brook Terminal Station and Massey Drive Terminal Station
- TL228 between Buchans Terminal Station and Massey Drive Terminal Station
- TL248 between Massey Drive Terminal Station and Deer Lake Terminal Station
    - Loss of this line isolates Cat Arm generation
- TL247 between Deer Lake Terminal Station and Cat Arm Terminal Station
    - Loss of this line isolates Cat Arm generation

This network also includes two hydro generating facilities, Cat Arm and Hinds Lake Generation Stations.

Steady state analysis indicates that within the near and long term horizons, there are no violations on this network under normal operation or the loss of any 230kV line or generator.

Operating limits for the Western Island Interconnected are defined in accordance with NLSO Operating instruction TOP-P-076 - NL Transmission System Operating Limits. Transient stability considerations are being investigated as part of operational studies, as addressed in Section 7.

Considerations associated with outages to TL248 are defined in accordance with NLSO Operating instruction TOP-P-022 - TL248 Planned and Forced Outage

5.3.5 The Exploits System

This network only includes the 230 kV line from Stony Brook Terminal Station to the Grand Falls Terminal Station (TL235). The loss of this line isolates Exploits generation from the rest of the Island Interconnected System, which results in no violations.

5.3.6 The Labrador 315 kV System

The Labrador Interconnected System consists of two 315 kV transmission lines between Churchill Falls Terminal Station #2 and Muskrat Falls Terminal Station #2. These two lines are designated as L3101 and L3102.

Table 3 provides a summary of the pre-contingency transformer loading levels across the planning horizons for transformers located on the Labrador Island Interconnected System that fall under the planning authority of the NLSO.

Table 2 - Transformer Peak Loads

Transformer	2029	
	MVA	%
CFTS2-T1	91.6	10.9
CFTS2-T2	91.3	10.3

Table 4 provides the transformer loading with the largest transformer out of service.

Table 3 – Transformer Peak Loads – Loss of Largest Transformer

Transformer	2029	
	MVA	%
CFTS2-T1	168.4	20.2
CFTS2-T2	***Out of Service***	

Operational studies for the Labrador 315 kV system are complete. The analysis was performed by TransGrid Solutions and the “Stage 4C: Labrador Transfer Analysis” report was filed on September 30, 2019 to the Public Utilities Board.

5.3.7 The Labrador Island Link

The Labrador Island Link (LIL) is an HVdc bipole that electrically connects the Island and Labrador Interconnected Systems and terminates at the Muskrat Falls Converter Station and the Soldiers Pond Converter Station. Steady state analysis indicates that within the near and long term horizons, there are no violations under normal operation or any contingency event involving the loss of pole or an ac filter at the Muskrat Falls or Soldiers Pond terminal stations.

It is noted that Transmission Planning Criteria are not defined for the loss of a bipole. In 2019, Hydro undertook studies[5,6] as part of its Reliability and Resource Adequacy initiative to assess system performance in the event of an outage to the LIL bipole. The results of the analysis included a recommendation for the adoption of Emergency Transmission Planning Criteria with the following considerations:

> *The appropriateness of the Emergency Transmission Planning Criteria as a long term solution is dependent on whether incremental generation is installed and on where the generation is located. The criteria and the resulting impacts shall therefore be re-evaluated as Hydro's Reliability and Resource Adequacy study continues. In the interim, they will provide a basis for Transmission Planning and will serve to further inform the discussion as Hydro looks to ensure long term reliability for its customers.*

Hydro's analysis in support of the Reliability and Resource Adequacy initiative and operating studies will continue in 2020. LIL operational limits and system performance when the LIL is out of service is therefore excluded from the scope of this assessment.

5.3.8 The Maritime Link

The Maritime Link (ML) is an HVdc bipole that electrically connects the Island Interconnected System to Nova Scotia via two 170km subsea cables. The link terminates at Bottom Brook Terminal Station in Newfoundland and Woodbine Terminal Station in Nova Scotia. Steady state analysis indicates that within the near and long term horizons, there are no violations under normal operation or any contingency event involving the loss of pole or an ac filter at Bottom Brook Terminal Station.

A detailed assessment of system operating limits associated with the Maritime Link will be performed as part of operational studies to be performed in 2020.

[5] Newfoundland and Labrador Hydro Avalon Capacity Study - Solutions to Serve Island Demand during a LIL Bipole Outage, TGS, Technical Note: TN1529.01.02, May 23, 2019

[6] TP-TN-068 Application of Emergency Transmission Planning Criteria for a LIL Bipole Outage, Hydro, July 30, 2019.

6 SHORT CIRCUIT ANALYSIS

Short circuit analysis is required to ensure that the prospective short circuits are equipment locations do not exceed the interrupting capacity of the circuit breakers used to protect the equipment. All circuit breakers with known asset information were assessed.[7] Short circuit analysis was performed and the results indicate that there are no circuit breaker rating violations.

7 STABILITY ANALYSIS

As discussed in previous sections, Hydro is undertaking operational studies to assess the transient stability of the NL Transmission System. Until these studies are complete, the dynamic analysis of the NL Transmission System shall remain outside of the scope of the annual assessment process. Operational studies are ongoing and expected to be completed in 2020.

[7] All circuit breaker information has been collected from Emera relating to 230 kV equipment at Bottom Brook Terminal Station and at Granite Canal Tap Terminal Station. All circuit breaker information has been collected Nalcor Power Supply relating to 315 kV equipment in Labrador and 230 kV equipment at Soldiers Pond Terminal Station. Hydro is undertaking an initiative to provide all incomplete 230 kV circuit breaker information in advance of the 2021 annual assessment process

8 CONCLUSIONS

The 2020 Annual Planning Assessment focuses on the planning horizon to 2029. Conclusions of the 2020 Annual Planning Assessment are specified as follows:

- The NL Transmission System includes Radial and Local Networks where outages to system elements may result in customer impacts. Transmission Planning Criteria are not strictly applied in these cases. Rather, these systems are designed to meet customer reliability and cost requirements.
- The steady state contingency analysis on the Labrador West Local Network indicates:
    - As per the Labrador transmission expansion study, there is a violation to planning criteria following the loss of a synchronous condenser or capacitor bank. Such contingencies would result in low voltage conditions. The installation of 83 MVar of reactive support will resolve this voltage violation. This project will be included by Hydro as part of its 2021 Capital Budget Application.
- Transmission Planning Criteria are strictly applied to the Primary Transmission System. Steady state analyses were performed and the following conditions were confirmed for the long-term horizon:
    - There are no pre-contingency transmission equipment overloads or voltage violations
    - There are no steady state overloads or voltage violations due to a transmission line, generator, synchronous condenser, or shunt element contingencies
    - There are no steady state transformer overloads
- The short circuit analyses were performed and it was confirmed that there are no issues with circuit breaker ratings.
- The transient stability analysis for the NL Transmission System currently in progress as part of ongoing operational studies. These studies will be completed in 2020

9 REFERENCE DOCUMENTS

- Operational Study - Stage 4C: Labrador Transfer Analysis (TP-R-034)
- Labrador Interconnected System - Expansion Study (TP-R-019)
- Application of Emergency Transmission Planning Criteria for a Labrador Island Link Bipole Outage (TP-TN-069)
- NLSO Operating instruction TOP-P-022 - TL248 Planned and Forced Outage
- NLSO operating instruction TOP-P-068 - Granite Canal Tap Shunt Reactor
- NLSO Operating instruction TOP-P-076 - NL Transmission System Operating Limits
- TP-S-001 NLSO Standard – Facilities Rating Guide
- TP-S-003 NLSO Standard – Annual Planning Assessment
- TP-S-007 NLSO Standard – Transmission Planning Criteria
- TP-TN-068 Application of Emergency Transmission Planning Criteria for a LIL Bipole Outage
- Newfoundland and Labrador Hydro Avalon Capacity Study - Solutions to Serve Island Demand during a LIL Bipole Outage

APPENDIX A

Load Flow Plots Primary Transmission System Year Ten (2029) – Peak and Light Cases

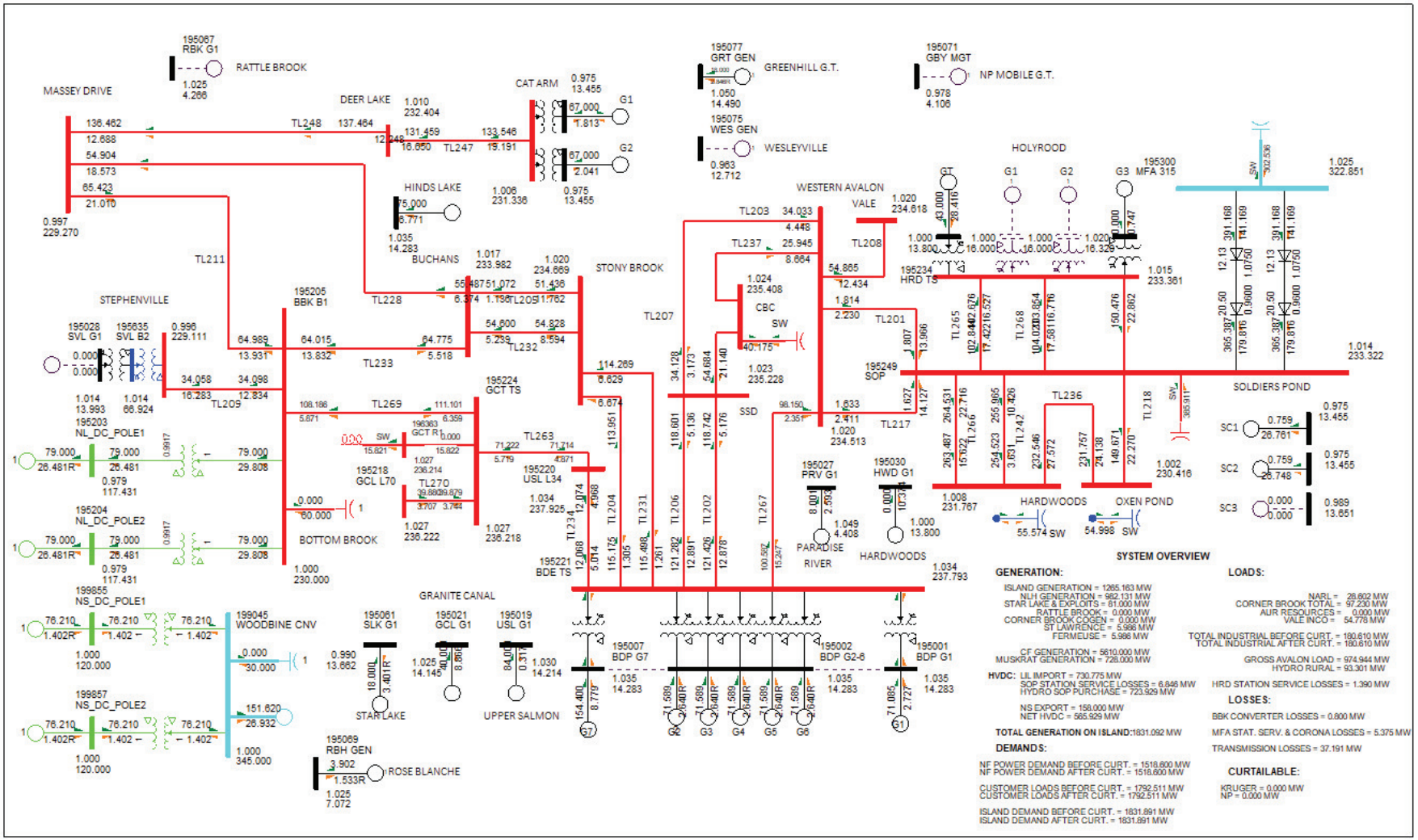

Figure 2 – IIS (2029 Peak Conditions – ML Exports (Emera Block – 158 MW))

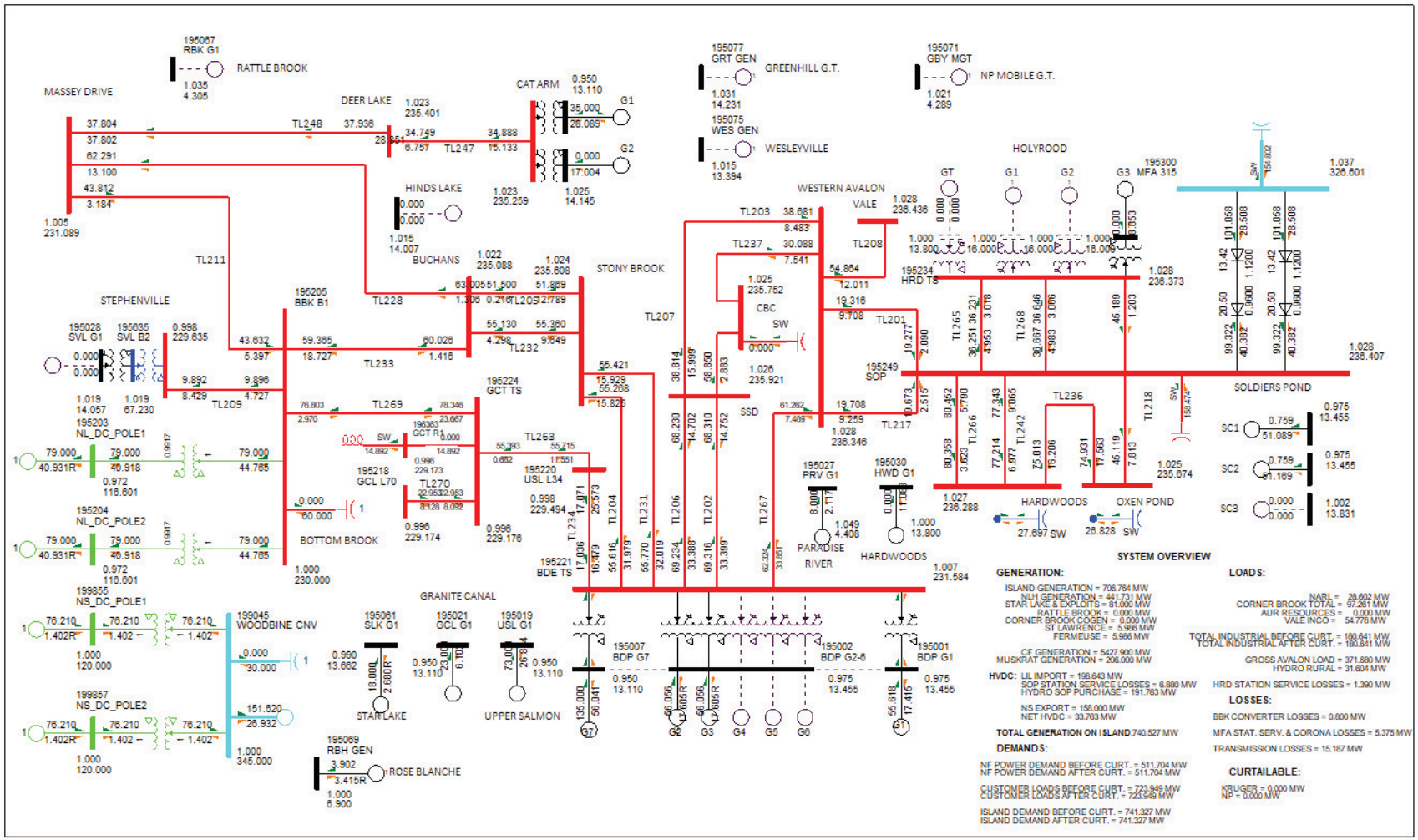

Figure 3 - IIS (2029 Light Conditions – ML Exports (Emera Block – 158 MW))

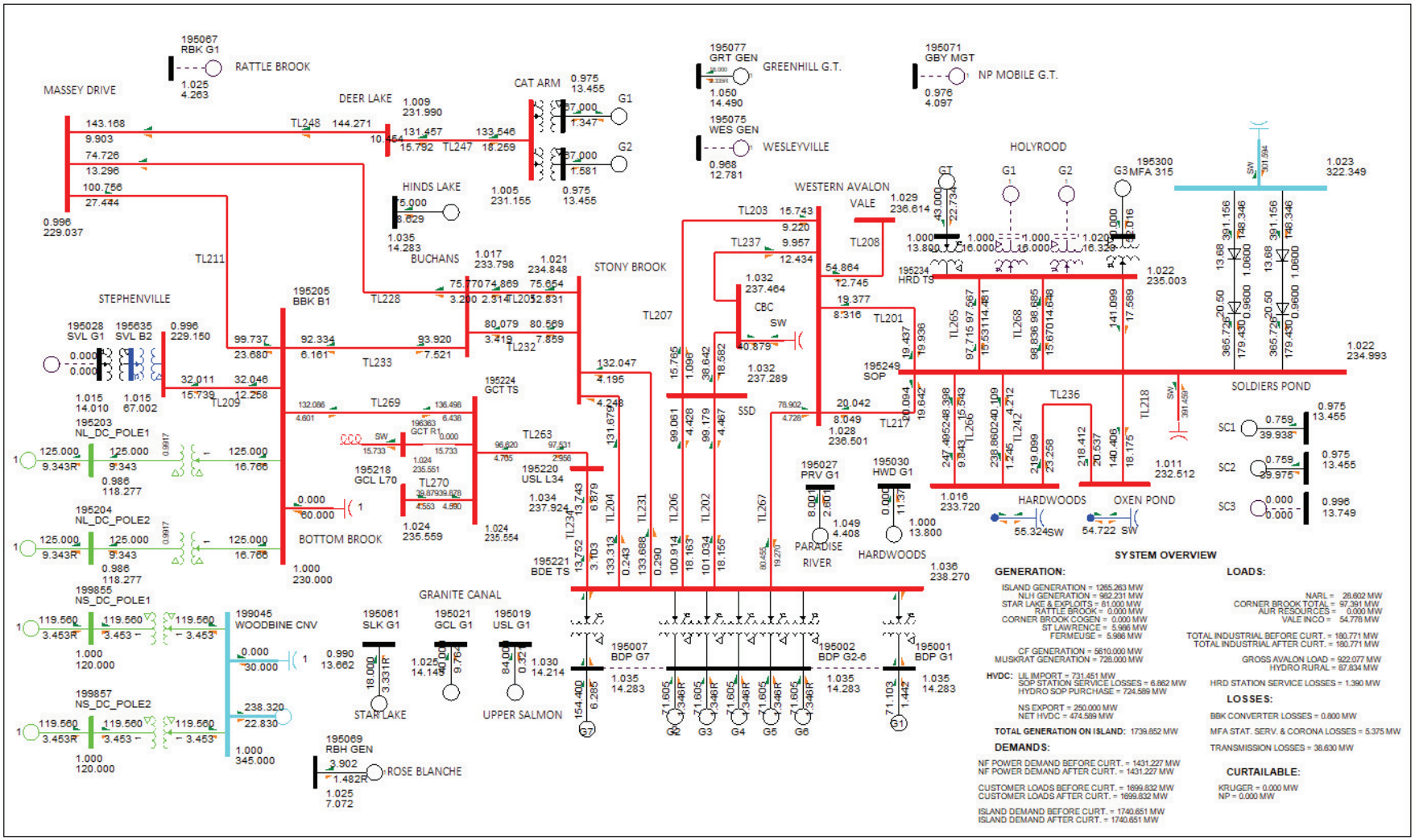

Figure 4 - IIS (2029 High Load Conditions – ML Firm Exports (250 MW))

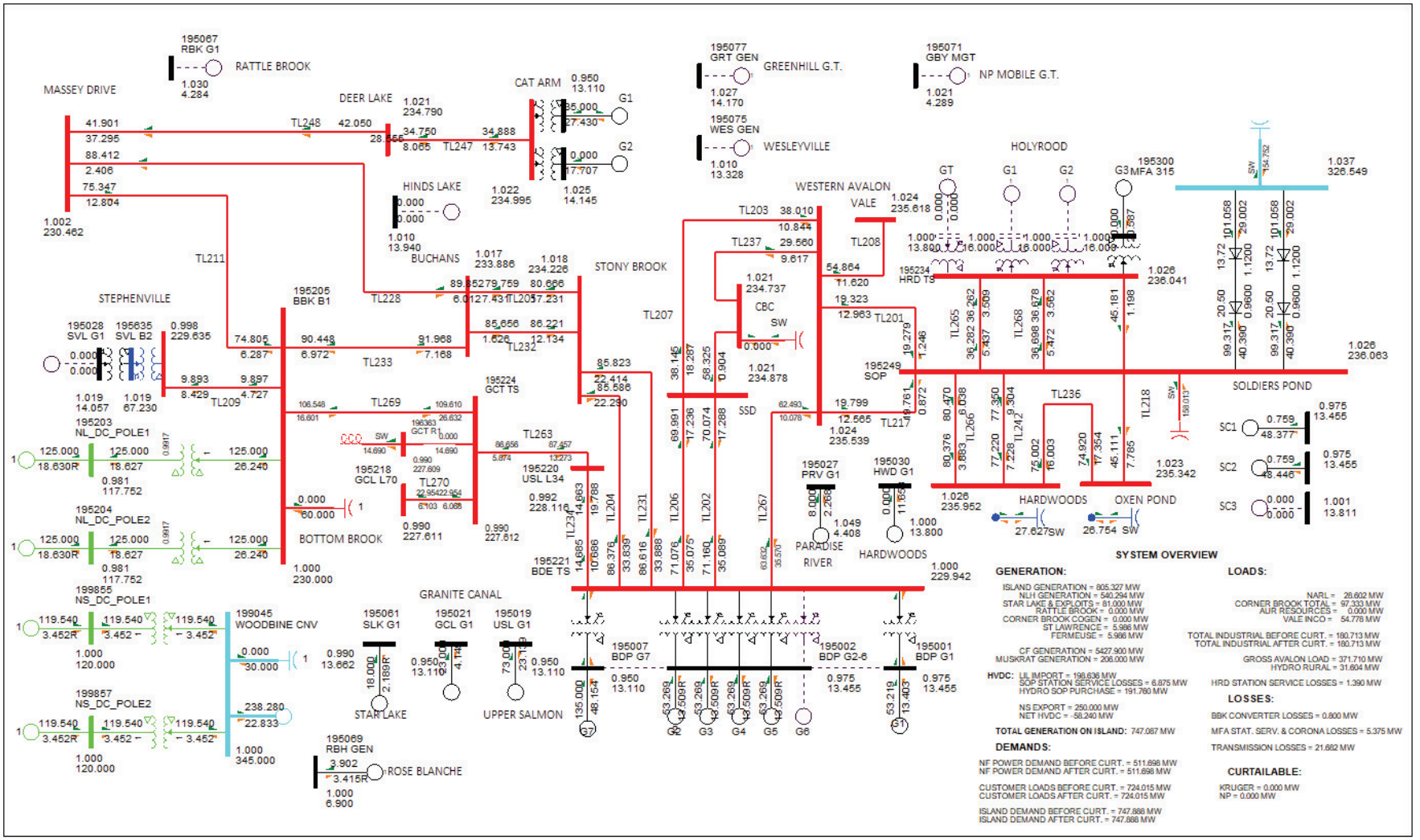

Figure 5 - IIS (2029 Light Conditions – ML Firm Exports (250 MW))

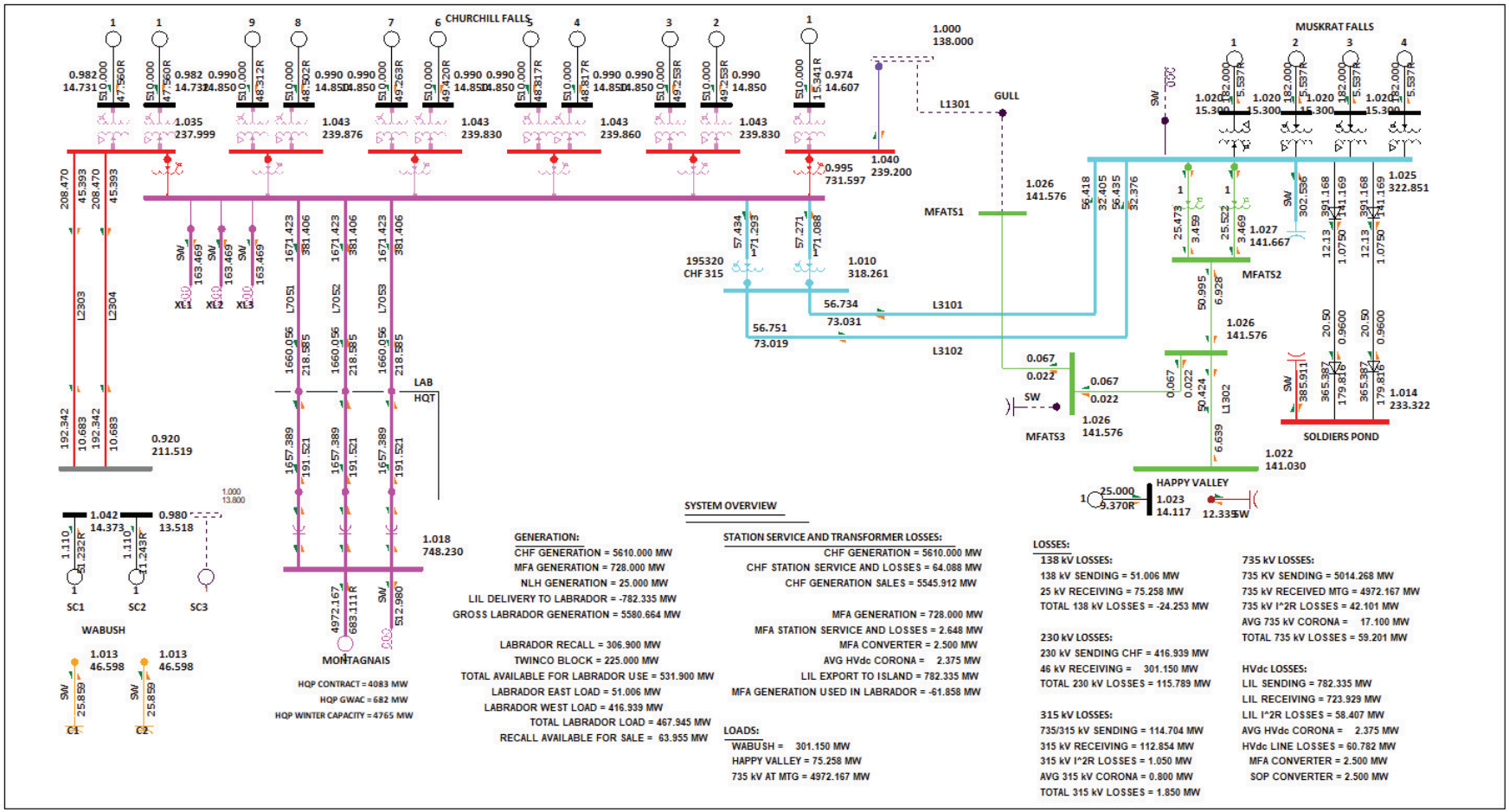

Figure 6 – LIS (2029 Peak Conditions)

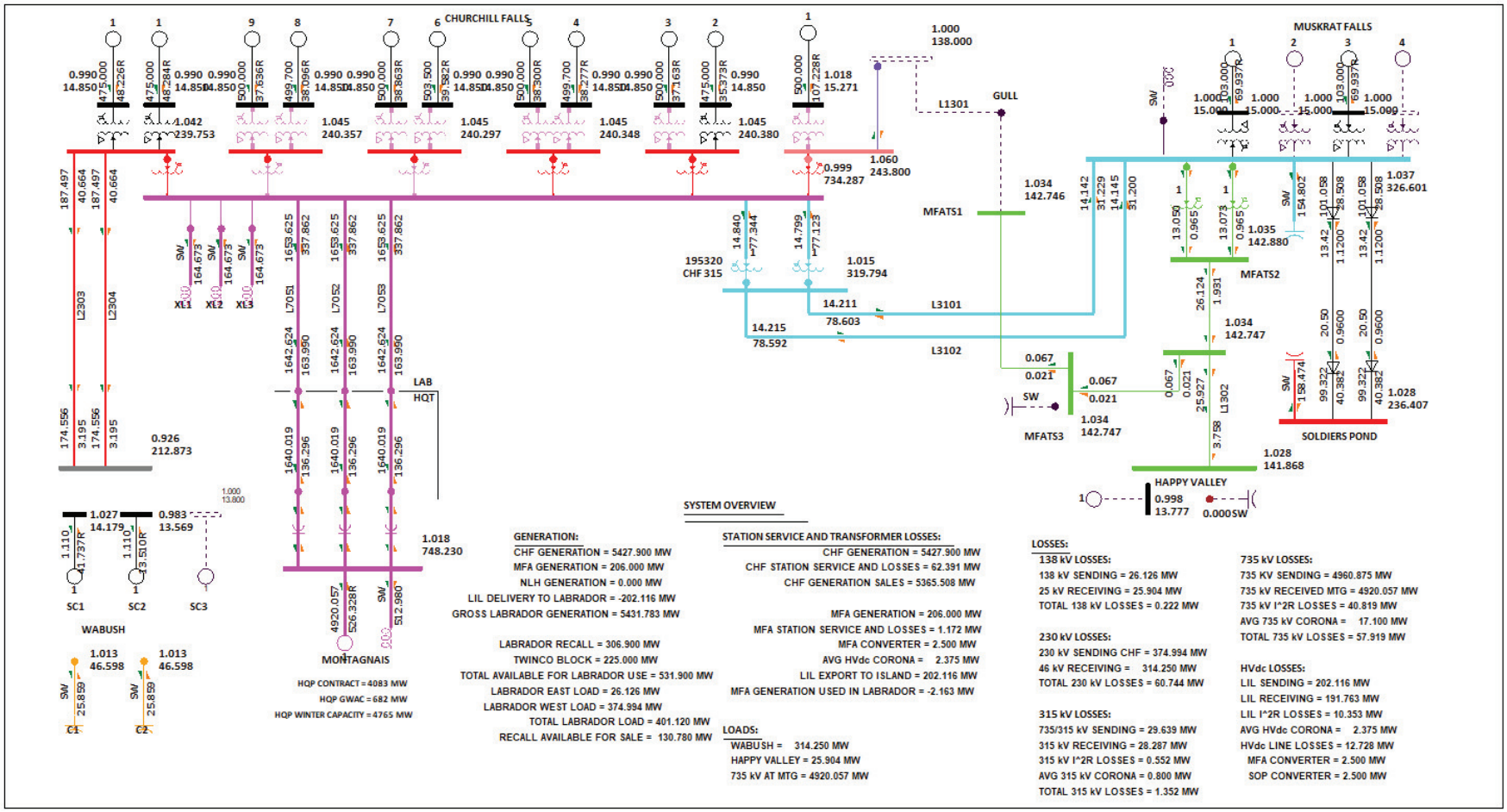

Figure 7 - LIS (2029 Light Conditions)

Document Summary

Document Owner:	Transmission Planning
Document Distribution:	NLSO

Revision History

Revision	Prepared by	Reason for change	Effective Date
1	M. Carter	Draft release for review	2020/03/23
2	M. Carter	Final document released	2020/05/01
3	M. Carter	Minor Edits (Regulatory Review)	2020/05/19

Document Approvers

Position	Signature	Approval Date
Manager, Transmission Planning		2020/05/01

Document Control

Regarding NLSO documents: The electronic version of this document is the CONTROLLED version. Please check the NLSO Document Management System SharePoint site for the official copy of this document. This document, when downloaded or printed, becomes UNCONTROLLED.

NL Hydro Report

2020 Annual Planning Assessment

Doc # TP-R-038

Date: March, 2020

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EXECUTIVE SUMMARY

Newfoundland and Labrador Hydro (Hydro) ensures the coordinated development of a safe, reliable and economical transmission system for the benefit of users within the Province of Newfoundland and Labrador. The Hydro transmission planning process involves the execution of power system studies to ensure compliance with Transmission Planning Criteria and to determine the timing of system additions and modifications.

The annual assessment of the NL Transmission System is performed by the Newfoundland and Labrador System Operator (NLSO) and is summarized in a separate document.[1] The NL Transmission system is comprised of transmission facilities located in NL operating at a voltage level of 230 kV or higher including the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System. This document provides an overview of Hydro's assessment, which addresses all other transmission system facilities with a rated voltage of 46 kV and above that are under the operational control of Hydro. The 2020 Annual Planning Assessment reveals:

- The pre-contingency and single contingency analysis indicates there are no transmission equipment overloads or voltage violations in the near-term or long-term planning horizons. This is assuming the previously identified violations and proposed capital upgrades will be executed by Year Ten (or 2029), which include:
    - As per the Labrador Transmission Expansion Study[2] submitted to the Public Utilities Board in October 31,2019, the following planning criteria violations were identified and will be addressed by Hydro as part of its 2021 Capital Budget Application:
        - The loss of a synchronous condenser or capacitor bank at the Wabush Terminal Station would result in low voltage conditions. The installation of 83 MVar of reactive support will resolve this voltage violation.
        - The loss of the largest transformer (T7) at Wabush Terminal Station results in the overload of transformers T4, T5, and T6. The replacement of 230/46 kV transformers T4 and T5 with 125 MVA units, complete with OLTC, would resolve this violation.
        - The loss of a transformer (T6) at the Wabush Substation would result in a transformer overload. An additional 26.7 MVA unit, T7, complete with OLTC for voltage regulation, will be installed.
    - The following planning criteria violations will be resolved following the completion of the Muskrat Falls – Happy Valley Interconnection Project
        - The transfer capability of the existing 138 kV transmission system configuration serving the Happy Valley-Goose Bay ("HVGB") has reached its capacity. For

[1] NLSO Annual Transmission Assessment (2020) – TP-R-037

[2] TP-R-019

load levels beyond 77 MW, system voltages levels will rapidly decline, ultimately resulting in system voltage collapse and customer outages. The most recent P90 peak load forecast indicates that Happy Valley peak demand has exceeded 77 MW.

- The loss of a transformer (T1) at the Happy Valley Terminal Station would result in transformer overloads. This will be mitigated by the installation of a fourth 30/40/50 MVA transformer (T5) as part of the Muskrat Falls – Happy Valley Interconnection project. This transformer will be service in 2021.

- Following the retirement of the Stephenville Gas Turbine, backup supply for the area will be addressed by the addition of a 230/66 kV, 40/53.3/66.7 MVA power transformer at Bottom Brook Terminal Station. This addition will provide capacity to the Stephenville area via the 66 kV network in the event of the loss of existing 230/66 kV transformer T3 at Stephenville Terminal Station or loss of 230 kV transmission line TL209. This project will be included by Hydro as part of its 2021 Capital Budget Application.
- The 125 MVA transformer (CHF-T31[3]) at the Churchill Falls Terminal Station #1 will be relocated to Holyrood to replace the failed HRD-T7 in 2021.

- The short circuit analysis reveals no issues with circuit breaker ratings in the near-term or long-term planning horizons.
- Transient stability analysis is currently in progress as part of ongoing operational studies. These studies will be completed in 2020

[3] Currently supplies the Labrador East System. This transformer will no longer be required in Churchill Falls following the decommissioning of L1301 when the 138KV interconnection from Muskrat Falls to Happy Valley is established and released for service.

Table of Contents

1 INTRODUCTION

The Hydro Transmission Planning Process involves the execution of power system studies to ensure compliance with Transmission Planning Criteria and to determine the timing of system additions and modifications. The 2020 Annual Planning Assessment covers the period extending to 2029. Cases are assessed to investigate the capability of the transmission system to meet peak load and to meet firm transmission commitments.[4]

This report addresses the NL Interconnected Transmission System, which is comprised of transmission facilities located in NL, operating at a voltage level of 46 kV or higher. It is noted that NL Transmission System facilities are addressed separately as part of the NLSO 2020 Annual Planning Assessment[5]. Analysis is performed to ensure compliance with appropriate criteria, including those defined in TP-S-007 NLSO Standard – Transmission Planning Criteria.

Figure 1 provides a map of the Newfoundland and Labrador Interconnected System post completion of the Lower Churchill Project.

4 It is noted that the firm export limits for the Maritime Link (ML) is specified at 250 MW; however, there is insufficient generating capacity within the NL Transmission System for exports of this magnitude over peak. For this reason, separate cases are developed to assess:

1) Near-Peak Load conditions with 250 MW export over the ML

2) Peak Load conditions with 158 MW of ML to reflect firm commitments over peak

[5] The NLSO 2020 Annual Planning Assessment addresses the NL Transmission System, which is comprised of transmission facilities located in NL, operating at a voltage level of 230 kV or higher, including, the Labrador-Island Link, the Labrador Transmission Assets and Island Interconnected System

Figure 1 –Newfoundland and Labrador Interconnected System

2 SELECTION OF STUDY CASES

System models have been developed to reflect the latest load forecast with completed system changes including proposed additions/modifications for future years ranging to 2029. The following assumptions are made for the long term planning of the NL Transmission System:

- The Muskrat Falls Generating Station (MFAGS) is complete, with four 206 MW units in service
- The MFAST2 315 kV, 150 MVAR shunt reactor is removed from service
- The LIL is operating in Bipole Mode up to its rated capacity of 900 MW
    - All filter banks are available at Muskrat Falls and Soldiers Pond Converter Stations
    - Electrode lines and electrode sites are in service
- Churchill Falls recall power (less Labrador loads) is available to send to the Island
- There are two Soldiers Pond 175 MVAR synchronous condensers in service for analysis (the third unit is available)
- Holyrood Thermal Generating Station is placed out of service with Unit 3 operating in synchronous condenser mode
- Stephenville gas turbine has been removed from service
- Hardwoods gas turbine is out of service as a generator, but can be operated as a synchronous condenser
- Happy Valley Terminal Station (HVYTS) is supplied via a new 138 kV transmission line L1303 connecting the Muskrat Falls Terminal Station 2 (MFATS2) to the Muskrat Falls Construction Power Station (MFATS3), where it taps into existing 138 kV transmission line L1302
- 138 kV transmission line L1301 from Churchill Falls to Muskrat Falls TS1
- Muskrat Falls TS3 have been decommissioned
- HVYTS has an additional 138/25 kV 50 MVA transformer, T5
- The Happy Valley North Side Diesel Plant is assumed out of service
- The CF T31 power transformer has been relocated to Holyrood to replace failed T7.
- A new power transformer will be installed in Bottom Brook as a backup supply for Stephenville as the gas turbine is no longer in service. 400L is normally in service.
- Wabush Terminal Station upgrades include:
    - 83 MVar of additional reactive support
    - Transformers T4 and T5 have been replaced with 125 MVA units
- Wabush Substation upgrades include:
    - Transformers T3 and T5 have been removed from service
    - Transformer T6 is connected to bus B3, in parallel with transformer T4
    - A new 26.7 MVA transformer T7 has been connected to bus B5
    - A bus tie circuit breaker has been added to connect buses B3 and B5.

Load flow plots for the Year Ten cases are provided in Appendix A.

3 Special Considerations

Special considerations for this study period are discussed in the section(s) below.

3.1 Operational Studies

Hydro is undertaking a set of operational studies for the interconnection of Lower Churchill Project assets into the NL Transmission System. The objective of the studies is to identify system impacts and operating limits to allow for the development of instructions to be used by NLSO. These operational studies include assessments of the transient stability. Transient stability considerations will therefore be outside of the scope of annual assessments until the operational studies are complete. The studies are expected to be completed in 2020.

4 LOAD FORECAST

The 2020 Annual Planning Assessment is based upon the following load forecasts prepared by the Market Analysis Section, Rural Planning Department, Newfoundland and Labrador Hydro:

- Island Interconnected 10 Year P50 and P90 Peak Demand Summary – Fall 2019 dated November 2019; and
- Labrador Interconnected 10 Year P50 and P90 Peak Demand Summary – Summer 2019 dated June 2019.

The Island and Labrador Interconnected forecasts are summarized in Table 1.

Table 1 – Operating Load Forecasts (P90) - Island and Labrador Interconnected System

Forecasted Demand (MW)				
Year	Island Interconnected (Fall 2019)	Labrador Interconnected (Spring 2019)		
		Lab East	Lab West	Total
2019/20	1,717	78.2	368.5	441.9
2020/21	1,723	80.5	379.9	448.6
2021/22	1,725	80.8	380.2	449.1
2022/23	1,735	81.1	380.3	449.4
2023/24	1,745	81.4	380.4	449.8
2024/25	1,753	81.8	380.8	450.6
2025/26	1,762	82.3	381.0	451.2
2026/27	1,773	83.2	381.2	452.1
2027/28	1,782	83.9	381.3	452.9
2028/29	1,792	84.6	381.5	453.7

5 STEADY STATE ANALYSIS

The steady state analysis consists of pre-contingency analysis, for which the assessment assumes that all equipment is in service, and contingency analysis. The analysis is performed to ensure that with all equipment in service under normal operation, power flows in all elements are at or below normal rating and voltages are within acceptable limits. The ratings are defined as per TP-S-001 - NLSO Facilities Rating Guide. The results of the steady state analysis are described in the sections below.

Load flow plots during normal operation of the NL Transmission System for Year Ten (2029) is provided in Appendix A.

5.1 Summary of Pre-Contingency Transformer Peak Loads

Table 2 provides a summary of the pre-contingency transformer loading levels in Year Ten. A review of the pre-contingency peak cases for long-term horizons indicates that there are no transformer overloads.

Table 2 – Pre Contingency Transformer Load Levels[1]

Station	Unit	Rating MVA	2029	
			MVA	%
Barachoix	T1	10/13.3/16.7	7.80	46.7%
Bay d'Espoir	T10	15/20/25	10.87	43.5%
	T12	15/20/25	10.79	43.2%
	T11	10/13.3/16.7	7.29	43.6%
Bear Cove	T1	10/13.3/16.7	5.63	33.7%
Berry Hill	T1	15/20/25	2.07	8.3%
Bottom Brook[2]	T1	25/33.3/41.7	25.75	61.8%
	T3	25/33.3/41.7	7.67	18.4%
	T4	40/53.3/66.6	15.94	23.9%
Bottom Waters	T1	10/13.3/16.7	10.73	64.3%
Buchans	T1	40/53.3/66.6	15.34	23.0%
	T2	5/6.6/8.3	2.72	32.8%
Coney Arm	T1	2.5/3.3/4.0	0.00	0.0%
Conne River	T1	2.5	2.86	86.7%
Cooper Hill	T1	7.5/10	2.56	25.6%
Corner Brook Converter	T1	21/28	9.00	32.2%
	T2	21/28	9.29	33.2%
Cow Head	T1	5/6.7/8.3	2.01	24.2%
Daniel's Harbor	T1	1/1.3	0.59	45.3%
	T2	1	0.58	44.9%
Deer Lake	T1	25/33.3/41.7	9.94	29.8%
	T2	45/60/75	20.30	27.1%
Doyles	T1	25/33.3/41.7	25.66	61.5%
English Harbour West	T1	5/6.7	2.88	42.9%
Farewell Head	T1	10/13.3/16.7	6.71	40.2%
Glenburnie	T1	1.5/3.3	2.19	66.3%
Grand Falls Frequency Converter	T1	30/40/50	23.09	46.2%
	T2	30/40/50	24.07	48.1%
	T3	30/40/50	20.38	40.8%

Grandy Brook	T1	7.5/10/12.5	5.32	42.6%
Hampden	T1	2.5/3.3/4.0	1.50	37.5%
Happy Valley[3]	T1	30/40/50	19.28	38.6%
	T2	15/20/25//28	10.75	38.4%
	T4	15/20/25//28	10.75	38.4%
	T5	30/40/50	19.28	38.6%
Hardwoods	T1	75/100/125	96.37	77.1%
	T2	40/53.3/66.6	49.17	73.7%
	T3	40/53.3/66.6	53.10	79.6%
	T4	75/100/125	95.60	76.5%
Hawke's Bay	T1	5/6	***NOTE 4***	
	T2	2.5/3.3		
Holyrood[5]	T5	15/20/25	21.61	86.4%
	T10	15/20/25	21.04	84.2%
	T6	25/33.3/41.7	9.70	23.3%
	T7	75/100/125	27.46	22.0%
	T8	75/100/125	24.92	19.9%
Howley[6]	T2	7.5/10/12.5	1.24	9.9%
Jackson's Arm	T1	5/6.6/8.3	1.62	19.6%
Main Brook	T1	1.5	0.80	53.0%
Massey Drive	T1	75/100/125	47.09	37.7%
	T2	40/53.3/66.6	33.93	50.9%
	T3	75/100/125	60.14	48.1%
Muskrat Falls TS1	T1	2	0.07	3.7%
Muskrat Falls TS2	T5	75/100/125	30.36	24.3%
	T6	75/100/125	30.42	24.3%
Oxen Pond	T1	75/100/125	160.03	64.0%
	T2	150/200/250	77.17	61.7%
	T3	150/200/250	160.03	64.0%
Parson's Pond	T1	1/1.3	0.80	61.7%
Peter's Barren	T1	15/20/25	2.35	9.4%
Plum Point	T1	10/13.3/16.7	4.01	24.0%
Quartzite	T1	15/20/25	17.01	68.0%
	T2	15/20/25	16.90	67.6%
Rocky Harbour	T2	5/6.6/8.3	4.16	50.1%
Roddickton	T2	5/6.6/8.3	2.88	57.6%
South Brook	T1	5/6.6/8.3	7.78	93.7%
Stephenville	T3	40/53.3/66.6	38.09	57.1%
Stony Brook	T1	75/100/125	91.00	72.8%
	T2	75/100/125	101.38	81.1%
St. Anthony Airport[7]	T1	15/20/25	6.06	24.2%
Sunnyside	T1	75/100/125	73.32	58.7%
	T4	75/100/125	73.84	59.1%
	T5	15/20/25	11.73	46.9%
Vanier	T1	15/20/25	12.70	50.8%
	T2	15/20/25	12.90	51.6%
Wabush Terminal[8]	T1	35/47/65	37.21	57.3%
	T2	35/47/65	38.37	59.0%
	T3	35/47/65	37.77	58.1%
	T4	75/100/125	77.94	62.4%
	T5	75/100/125	77.94	62.4%
	T6	35/47/65	35.87	55.2%
	T7	50/66.6/83.3	51.96	62.4%
	T8	50/66.6/83.3	52.88	63.5%
Wabush Substation[9]	T4	5/6.6/8.3	0.00	0.0%
	T6	10/13.3/16.7	14.13	87.0%
	T7	20/26.7	9.47	36.0%
Western Avalon	T1	15/20/25	14.92	59.7%
	T2	15/20/25	15.19	60.8%

	T3	25/33.3/41.7	15.96	38.3%
	T4	25/33.3/41.7	15.88	38.1%
	T5	75/100/125	46.53	37.2%
Wiltondale	T1	1.0	0.07	4.4%

Notes:

1. Generator step up transformers and converter transformers are not included as these units have been sized for the full unit capability.
2. A new 230/66 kV, 40/53.3/66.7 MVA power transformer (BBK-T4) will be added at Bottom Brook Terminal Station prior to Year 10 (2029)
3. As part of the Muskrat Falls – Happy Valley Interconnection project, a fourth 138/25 kV, 30/40/50 MVA transformer (HVY-T5) will be in service by 2021.
4. The Hawke's Bay system is typically supplied by 15 MVA mobile transformer during the winter season. Peak load expected to be approximately 6.3 MW in Year 10 (2029)
5. The 125 MVA transformer (CHF-T31) at the Churchill Falls Terminal Station #1 will be relocated to Holyrood to replace the failed HRD-T7 by 2021
6. Rattle Brook assumed to in operation at 4 MW
7. St. Anthony Diesel Plant is in-service for capacity support
8. Transformers T4 and T5 will both be replaced with 125 MVA units prior to Year 10.
9. An additional 26.7 MVA transformer (T7) will be installed prior to Year 10. Transformer T4 will serve as a spare transformer during normal operation

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5.2 Review of Radial Systems

Radial systems will be impacted by loss of a transmission line are summarized in Table 3.

Table 3 – Radial Transmission Systems and Impact of Line Loss

TL #	kV	From	To	Impact
214	138	Bottom Brook	Doyles	Loss of load in Doyles/Port-aux-Basques area. Newfoundland Power owns mobile gas turbine and mobile diesel located at Grand Bay as well as Rose Blanche hydro site which can supply limited load in area.
215	66	Doyles	Grand Bay	Loss of load in Port-aux-Basques area. Newfoundland Power owns mobile gas turbine and mobile diesel located at Grand Bay as well as Rose Blanche hydro site which can supply limited load in area.
220	69	Bay d'Espoir	Barachoix	Loss of load on the Connaigre Peninsula
221	66	Peter's Barren	Hawke's Bay	Loss of load in the Hawke's Bay/Port Saunders area. Hydro maintains a 5 MW diesel plant at Hawke's Bay that provides limited back up.
226	66	Deer Lake	Berry Hill	Loss of load in Bonne Bay. TL226 can be isolated in various locations such that Bonne bay area loads can be supplied from Berry Hill following line switching.
227	66	Berry Hill	Daniel's Harbour	Loss of load from Sally's Cove to Parson's Pond. TL227 can be isolated in various locations such that loads from Sally's Cove to Daniel's Harbour can be supplied from either Berry Hill or Peter's Barren following line switching.
229	66	Wiltondale	Glenburnie	Loss of load on western arm of Bonne Bay to Woody Point
239	138	Deer Lake	Berry Hill	Loss of load on Great Northern Peninsula north of Bonne Bay. Hydro maintains 5 MW diesel plant at Hawke's Bay and 9.7 MW diesel plant at St. Anthony. With TL239 out switching on the 66 kV will permit up to 25 MVA to be supplied from Deer Lake on the 66 kV TL226 to Berry Hill and then through the Berry Hill 138/66 kV transformer to the 138 kV system via TL259.
241	138	Berry Hill	Plum Point	Loss of load on Great Northern Peninsula north of Daniel's Harbour. Hydro maintains 9.7 MW diesel plant at St. Anthony that provides limited back up.
244	138	Plum Point	Bear Cove	Loss of load on Great Northern Peninsula Bear Cove and north. Hydro maintains 9.7 MW diesel plant at St. Anthony that provides limited back up.
250	138	Bottom Brook	Grandy Brook	Loss of load in Burgeo
251	69	Howley	Hampden	Loss of load in White Bay
252	69	Hampden	Jackson's Arm	Loss of load Jackson's area of White Bay
254	66	Boyd's Cove	Farewell Head	Loss of load Fogo and Change Islands
256	138	Bear Cove	St. Anthony Airport	Loss of load St. Anthony – Roddickton area. Hydro maintains 9.7 MW diesel plant at St. Anthony that provides limited back up.
257	69	St. Anthony Airport	Roddickton	Loss of load main brook and Roddickton
259	138	Berry Hill	Peter's Barren	Loss of load on Great Northern Peninsula north of Parson's Pond. Hydro maintains 5 MW diesel plant at Hawke's Bay and 9.7 MW diesel plant at St. Anthony. With TL259 out switching on the 66 kV will permit up to 25 MVA to be supplied from Berry Hill on the 66 kV TL227 to Peter's Barren and then through the Peter's Barren 138/66 kV transformer to the 138 kV system via TL259.
260	138	Seal Cove	Bottom Waters	Loss of load on the Baie Verte Peninsula
261	69	St. Anthony Airport	St. Anthony Diesel	Loss of load in the St. Anthony area. Hydro maintains 9.7 MW diesel plant at St. Anthony that provides limited back up.
262	66	Peter's Barren	Daniel's Harbour	Loss of load in Daniel's Harbour area. Switching on the 66 kV results in supply of Daniel's harbour via TL227
264	66	Buchans	Duck Pond	Loss of industrial customer

L1301	138	Churchill Falls/Muskrat Falls	Happy Valley	The system is being reconfigured as part of the Muskrat Falls – Happy Valley interconnection, but will remain a radial system. Loss of load upper Lake Melville area. Hydro maintains a 25 MW gas turbine in Happy Valley that provides limited back up.

5.3 Review of Steady State Contingencies

5.3.1 Line Out Contingencies

A review of the steady state line out contingency analysis concluded that there are no violations to the Transmission Planning Criteria following the loss of the following Hydro owned equipment:

- All 46kV and above transmission lines
- All Shunt Device (Capacitor Banks and Reactors)
- All generation units
- HVdc poles

5.3.2 Summary of Multi Transformer Station Contingency Loading

Table 4 provides the transformer loading for each multi transformer station with the largest transformer out of service.

Table 4– Multi Transformer Contingency Load Levels[1]

Station	Unit	Rating MVA	2020	
			MVA	%
Bay d'Espoir	T10	15/20/25	*Out-of-Service*	
	T12	15/20/25	22.22	88.9%
Bottom Brook[2]	T1	25/33.3/41.7	25.75	61.8%
	T3	25/33.3/41.7	*Out-of-Service*	
Daniel's Harbour	T1	1/1.3	*Out-of-Service*	
	T2	1	1.17	90.2%
Grand Falls Frequency Converter	T1	30/40/50	*Out-of-Service*	
	T2	30/40/50	30.38	60.8%
	T3	30/40/50	34.66	69.3%
Happy Valley[3]	T1	30/40/50	*Out-of-Service*	
	T2	15/20/25//28	15.82	56.5%
	T4	15/20/25//28	15.82	56.5%
	T5	30/40/50	28.37	56.7%
Hawke's Bay	T1	5/6.7	*Note 4*	
	T2	2.5/3.3		
Holyrood[5]	T5	15/20/25	12.90	51.6%
	T10	15/20/25	*Out-of-Service*	
Massey Drive[6]	T1	75/100/125	*Out-of-Service*	
	T2	40/53.3/66.6	53.08	79.7%
	T3	75/100/125	89.38	71.5%
Muskrat Falls TS2	T5	75/100/125	*Out-of-Service*	
	T6	75/100/125	86.40	69.1%
Wabush Terminal[7]	T1	35/47//65	54.54	83.9%

	T2	35/47//65	56.23	86.5%
	T3	35/47//65	55.35	85.2%
	T4	75/100/125	*Out-of-Service*	
	T5	35/47//65	114.94	91.9%
	T6	35/47//65	52.89	81.4%
	T7	50/66.6/83.3	76.62	92.0%
	T8	75/100/125	*Out-of-Service*	
Wabush Substation[8]	T4	5/6.6/8.3	7.92	97.0%
	T6	10/13.3/16.7	15.84	99.0%
	T7	20/26.7	Out-of-Service	
Western Avalon	T1	15/20/25	*Out-of-Service*	
	T2	15/20/25	22.24	89.0%

Notes:

1. The loading provided is with the largest transformer in the station removed from service and back up generation on line where applicable.
2. Bottom Brook 138 kV bus tie switch B2B3 closed
3. As part of the Muskrat Falls – Happy Valley Interconnection project, a fourth 138/25 kV, 30/40/50 MVA transformer (HVY-T5) will be in service by 2021.
4. The Hawke's Bay system is typically supplied by 15 MVA mobile transformer during the winter season. Peak load expected to be approximately 6.3 MW in Year 10 (2029)
5. The 66kV loop between Holyrood and Hardwoods must be opened to avoid the overload of transformer T5
6. 66 kV bus tie B2B4-1 closed
7. Transformers T4 and T5 will both be replaced with 125 MVA units prior to Year 10.
8. An additional 26.7 MVA transformer (T7) will be installed prior to Year 10. Transformer T4 will be utilized following the loss of T7.

5.3.3 Summary of Looped System Transformer Contingency Loading

Table 5 provides the transformer loading for each Looped System following the loss of the largest transformer in the Loop. Mitigations for each prospective overload condition are addressed in the following section. The analysis of looped system transformer contingencies indicates:

Table 5– Looped System Transformer Contingency Load Levels[1]

Station	Unit[2]	Rating MVA	2029	
			MVA	%
Hardwoods – Oxen Pond 66 kV Loop				
Hardwoods	T1*	75/100/125	115.3	90.2%
	T2*	40/53.3/66.6	58.9	88.6%
	T3*	40/53.3/66.6	63.6	95.7%
	T4*	75/100/125	114.4	91.8%
Oxen Pond	T1	75/100/125	227.5	88.2%
	T2*	150/200/250	109.7	85.1%
	T3	150/200/250	*Out-of-Service*	
Holyrood - Western Avalon 138 kV Loop[2]				
Holyrood	T6*	25/33.3/41.7	11.4	27.1%
	T7	25/33.3/41.7	32.3	25.0%
	T8	75/100/125	29.5	23.1%
Western Avalon	T1*	15/20/25	16.9	66.7%
	T2*	15/20/25	17.2	67.9%
	T3*	25/33.3/41.7	31.8	75.2%
	T4*	25/33.3/41.7	31.6	74.8%
	T5	75/100/125	*Out-of-Service*	

Stony Brook - Sunnyside 138 kV Loop[3]				
Sunnyside	T1	75/100/125	90.0	71.4%
	T4*	75/100/125	90.6	71.9%
Stony Brook	T1*	75/100/125	*Out-of-Service*	
	T2*	75/100/125	120.4	98.5%
Stephenville – Bottom Brook 66kV Loop				
Stephenville	T3	40/53.3/66.6	*Out-of-Service*	
Bottom Brook	T4	40/53.3/66.6	54.8	82.2%
Quartzite – Vanier 25kV Loop[4]				
Quartzite	T1	15/20/25	19.83	79.3%
	T2	15/20/25	19.83	79.3%
Vanier	T1	15/20/25	19.83	79.3%
	T2	15/20/25	Out-of-Service	

Notes:

***The analysis of the looped system s accounted for the de-rating of these transformers based on their Tap Position**

1. The operation of each loop of transformers assumes the loss of the largest unit contained within the loop at each end to provide for maximum operational reliability. If there is more than one transformer with the same rating, the one with the lowest impedance is chosen to be switched off. In scenarios where there is a transformer overloaded, it may be mitigated by breaking the loop in various locations to offload the overloaded transformer.

2. The 125 MVA transformer (CHF-T31) at the Churchill Falls Terminal Station #1 will be relocated to Holyrood to replace the failed HRD-T7 by 2021

3. The following generation is assumed to be online within this 138kV loop: Greenhill Gas Turbine, Paradise River, Wesleyville Gas Turbine, St. Anthony Diesels, Hind's Lake, Hawke's Bay Diesel and Rattle Brook. With the loss of a transformer, the 138kV loop would also have to be opened to offload the remaining transformers within the loop

4. Using gang operated tie-switches within the Labrador City distribution system, load can be transferred between QTZ and VAN to evenly load the remaining transformers

5.3.4 Generator and Synchronous Condenser Contingency Analysis

There are no violations to the Transmission Planning Criteria following the loss of any other generator or synchronous condenser.

5.3.5 Shunt Contingency Analysis

There are no violations to the Transmission Planning Criteria following the loss of any other shunt device.

6 SHORT CIRCUIT ANALYSIS

Short circuit analysis is required to ensure that the prospective short circuits are equipment locations do not exceed the interrupting capacity of the circuit breakers used to protect the equipment. All circuit breakers with known asset information were assessed.[6] Short circuit analysis was performed and the results indicate that there are no circuit breaker rating violations.

7 STABILITY ANALYSIS

Hydro is currently undertaking operational studies to assess the transient stability of the NL Transmission System. Until these studies are complete, the dynamic analysis of the NL Transmission System shall remain outside of the scope of the annual assessment process. Operational studies are ongoing and expected to be completed in 2020.

[6] All circuit breaker information has been collected from Emera relating to the 230 kV equipment at Bottom Brook Terminal Station and at Granite Canal Tap Terminal Station. All circuit breaker information has been collected from Nalcor Power Supply relating to equipment in Labrador and at Soldiers Pond Terminal Station. Hydro is undertaking an initiative to provide all incomplete circuit breaker information in advance of the 2021 annual assessment process.

8 CONCLUSIONS

The 2020 Annual Planning Assessment focuses on the long-term planning horizon (Years 6-10). Conclusions of the 2020 Annual Planning Assessment are specified as follows:

- The pre-contingency and single contingency analysis indicates there are no transmission equipment overloads or voltage violations in the near-term or long-term planning horizons. This is assuming the previously identified violations and proposed capital upgrades will be executed by Year Ten (or 2029), which include:
    - As per the Labrador Transmission Expansion Study[7] submitted to the Public Utilities Board in October 31,2019, the following planning criteria violations were identified and will be addressed by Hydro as part of its 2021 Capital Budget Application:
        - The loss of a synchronous condenser or capacitor bank at the Wabush Terminal Station would result in low voltage conditions. The installation of 83 MVar of reactive support will resolve this voltage violation.
        - The loss of the largest transformer (T7) at Wabush Terminal Station results in the overload of transformers T4, T5, and T6. The replacement of 230/46 kV transformers T4 and T5 with 125 MVA units, complete with OLTC, would resolve this violation.
        - The loss of a transformer (T6) at the Wabush Substation would result in a transformer overload. An additional 26.7 MVA unit, T7, complete with OLTC for voltage regulation, will be installed.
    - The following planning criteria violations will be resolved following the completion of the Muskrat Falls – Happy Valley Interconnection Project
        - The transfer capability of the existing 138 kV transmission system configuration serving the Happy Valley-Goose Bay (“HVGB”) has reached its capacity. For load levels beyond 77 MW, system voltages levels will rapidly decline, ultimately resulting in system voltage collapse and customer outages. The most recent P90 peak load forecast indicates that Happy Valley peak demand has exceeded 77 MW.
        - The loss of a transformer (T1) at the Happy Valley Terminal Station would result in transformer overloads. This will be mitigated by the installation of a fourth 30/40/50 MVA transformer (T5) as part of the Muskrat Falls – Happy Valley Interconnection project. This transformer will be in service in 2021.
    - Following the retirement of the Stephenville Gas Turbine, backup supply for the area will be addressed by the addition of a 230/66 kV, 40/53.3/66.7 MVA power transformer at Bottom Brook Terminal Station. This addition will provide capacity to

[7] TP-R-019

the Stephenville area via the 66 kV network in the event of the loss of existing 230/66 kV transformer T3 at Stephenville Terminal Station or loss of 230 kV transmission line TL209. This project will be included by Hydro as part of its 2021 Capital Budget Application.

- The 125 MVA transformer (CHF-T31[8]) at the Churchill Falls Terminal Station #1 will be relocated to Holyrood to replace the failed HRD-T7 by 2021.

- The short circuit analysis reveals no issues with circuit breaker ratings in the near-term or long-term planning horizons.
- Transient stability analysis is currently in progress as part of ongoing operational studies. These studies will be completed in 2020.

[8] Currently supplies the Labrador East System. This transformer will no longer be required in Churchill Falls following the decommissioning of L1301 when the 138KV interconnection from Muskrat Falls to Happy Valley is released for service.

9 REFERENCE DOCUMENTS

- 2020 NLSO Annual Assessment (TP-R-037)
- Labrador Interconnected System - Expansion Study (TP-R-019)
- NLSO Standard – Transmission Facilities rating Guide (TP-S-001)
- TP-S-003 NLSO Standard – Annual Planning Assessment
- TP-S-007 NLSO Standard – Transmission Planning Criteria

APPENDIX A

Load Flow Plots Primary Transmission System Year Ten (2029) – Peak and Light Case

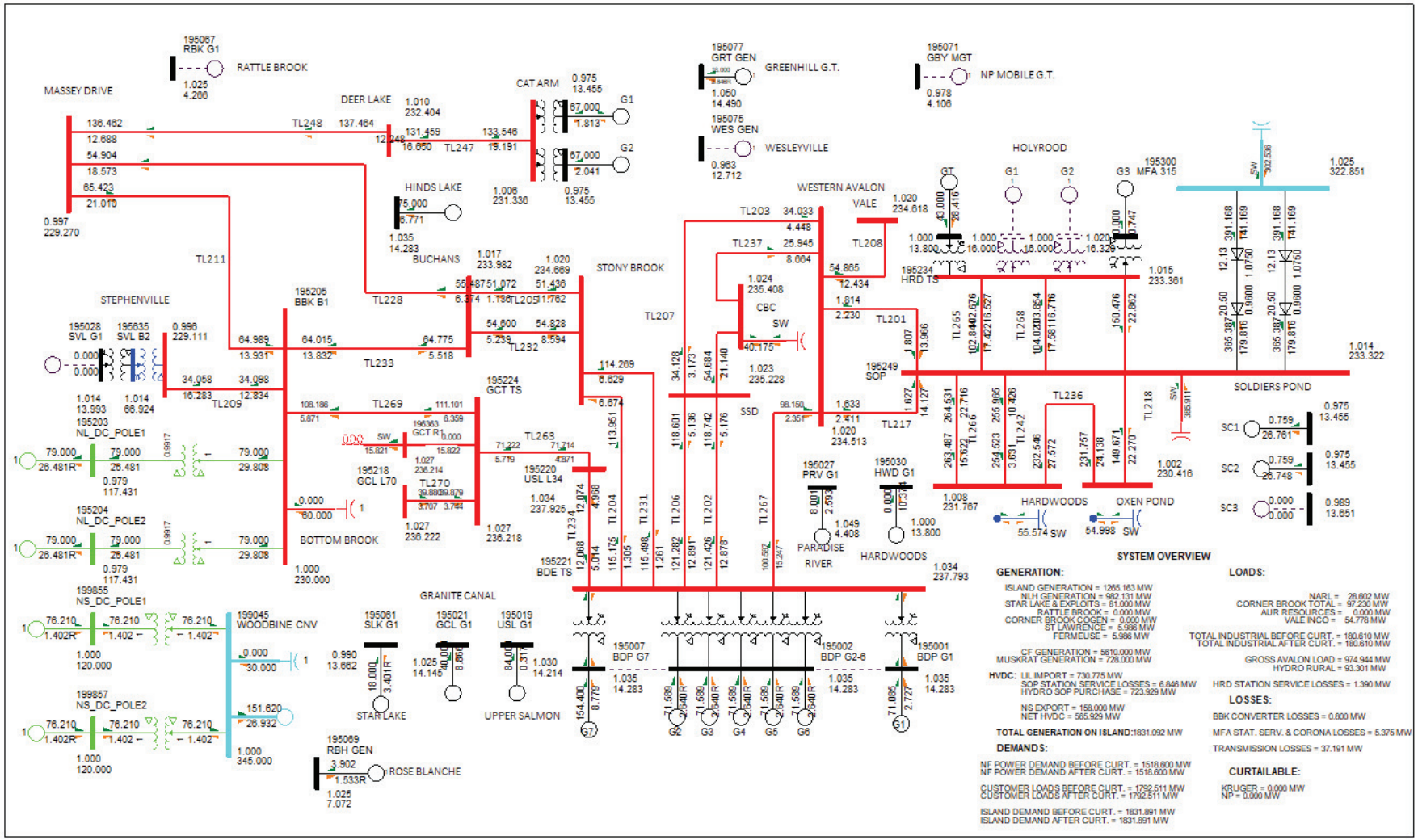

Figure 1 – IIS (2029 Peak Conditions – ML Exports (Emera Block – 158 MW))

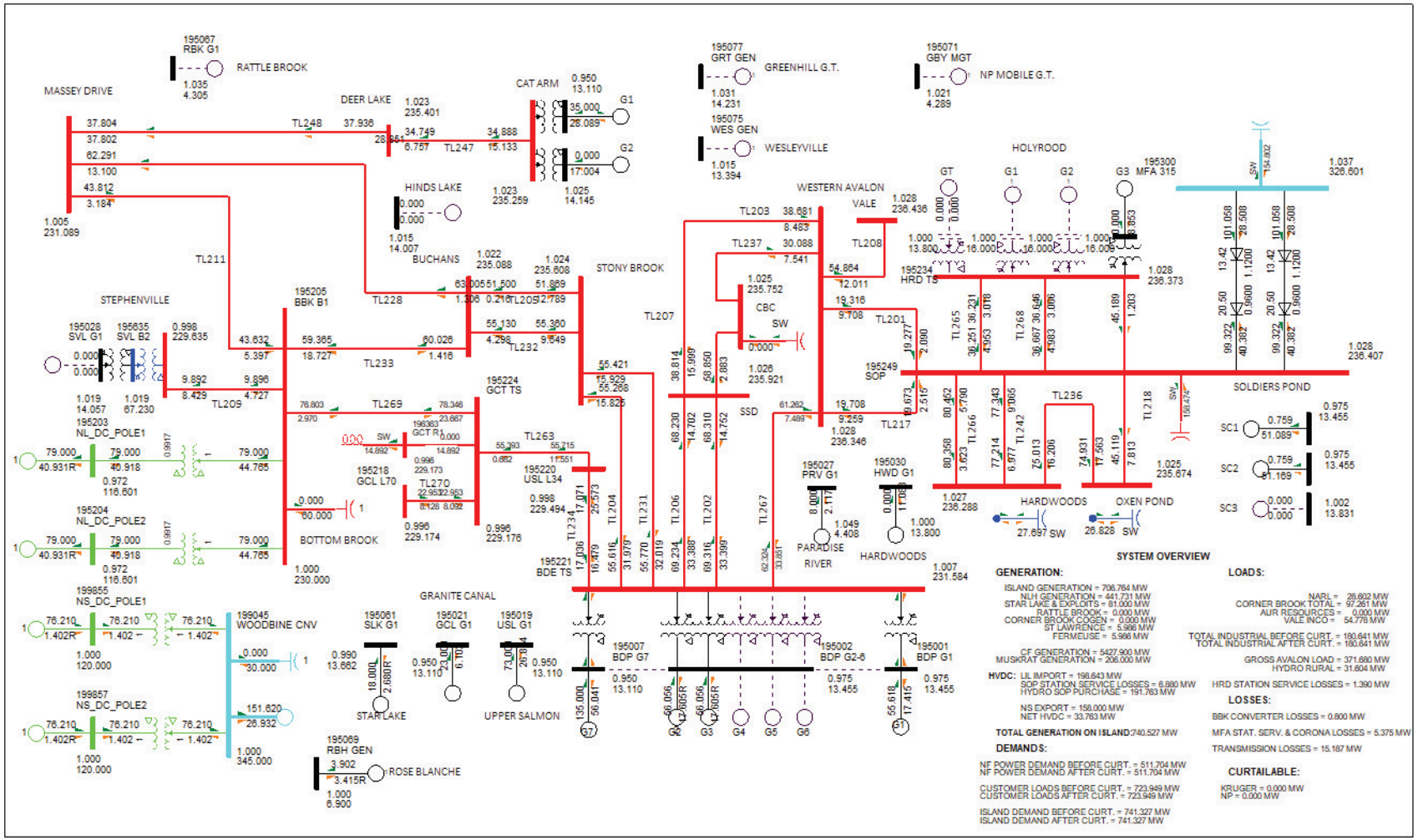

Figure 2 - IIS (2029 Light Conditions – ML Exports (Emera Block – 158 MW))

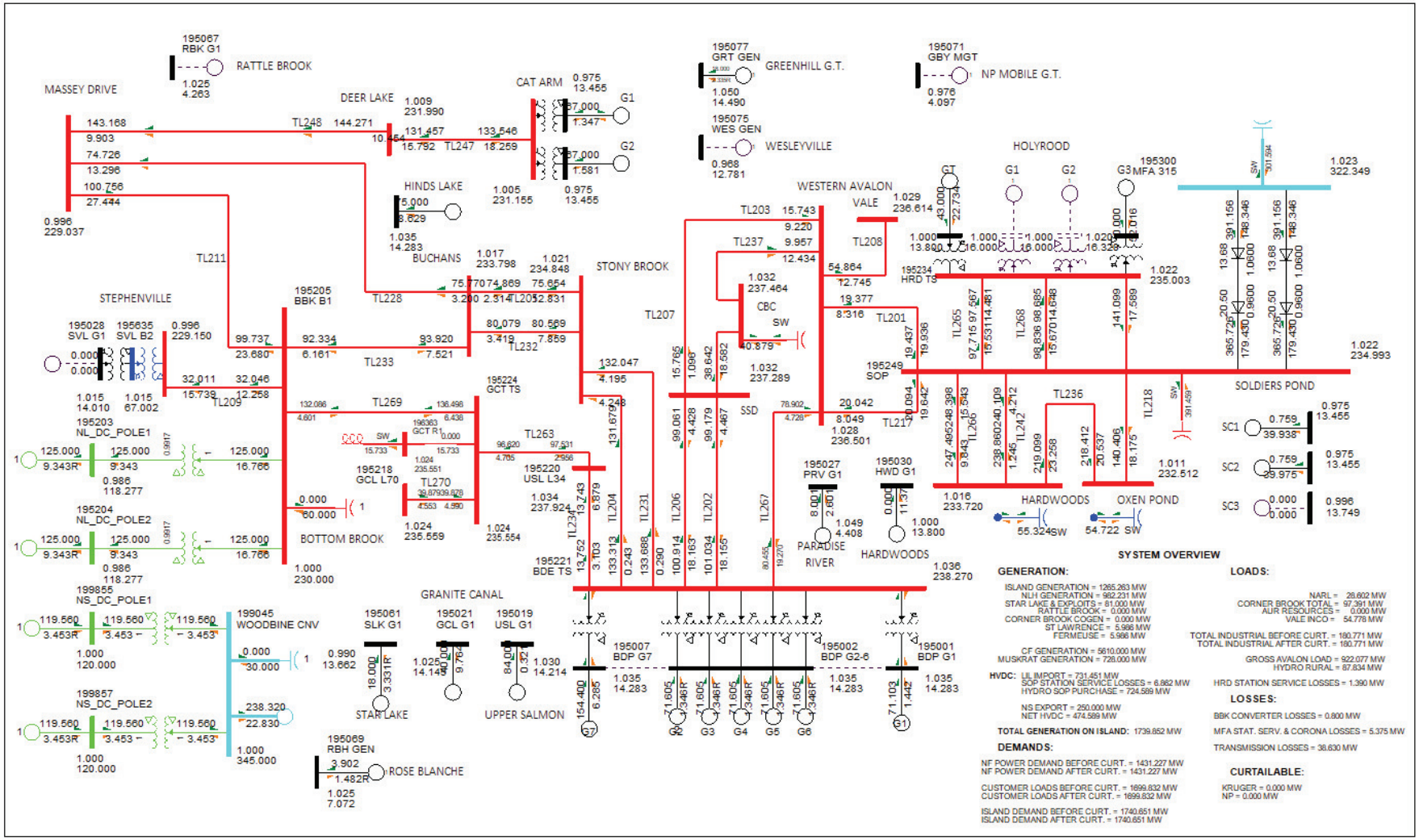

Figure 3 - IIS (2029 High Load Conditions – ML Firm Exports (250 MW))

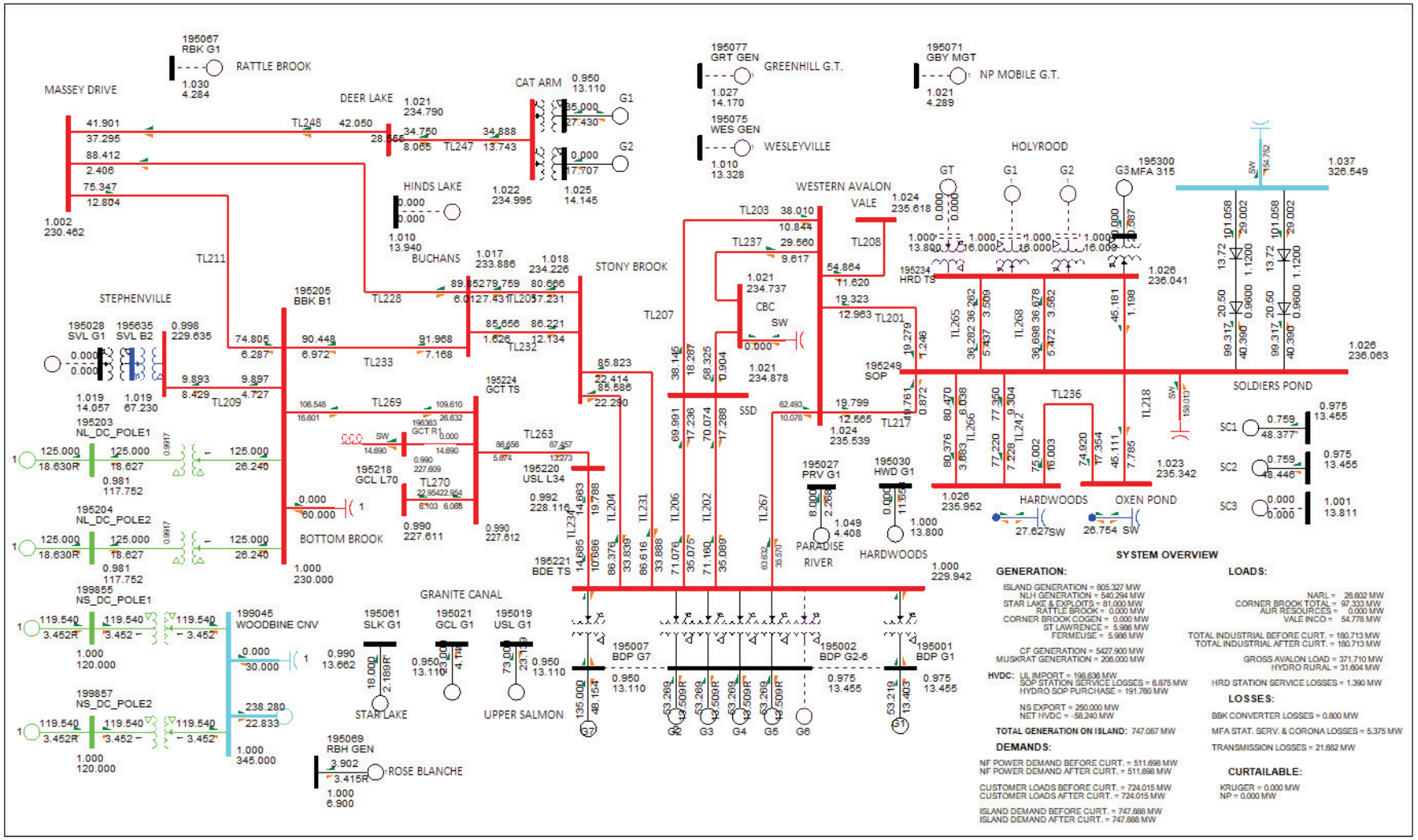

Figure 4 - IIS (2029 Light Conditions – ML Firm Exports (250 MW))

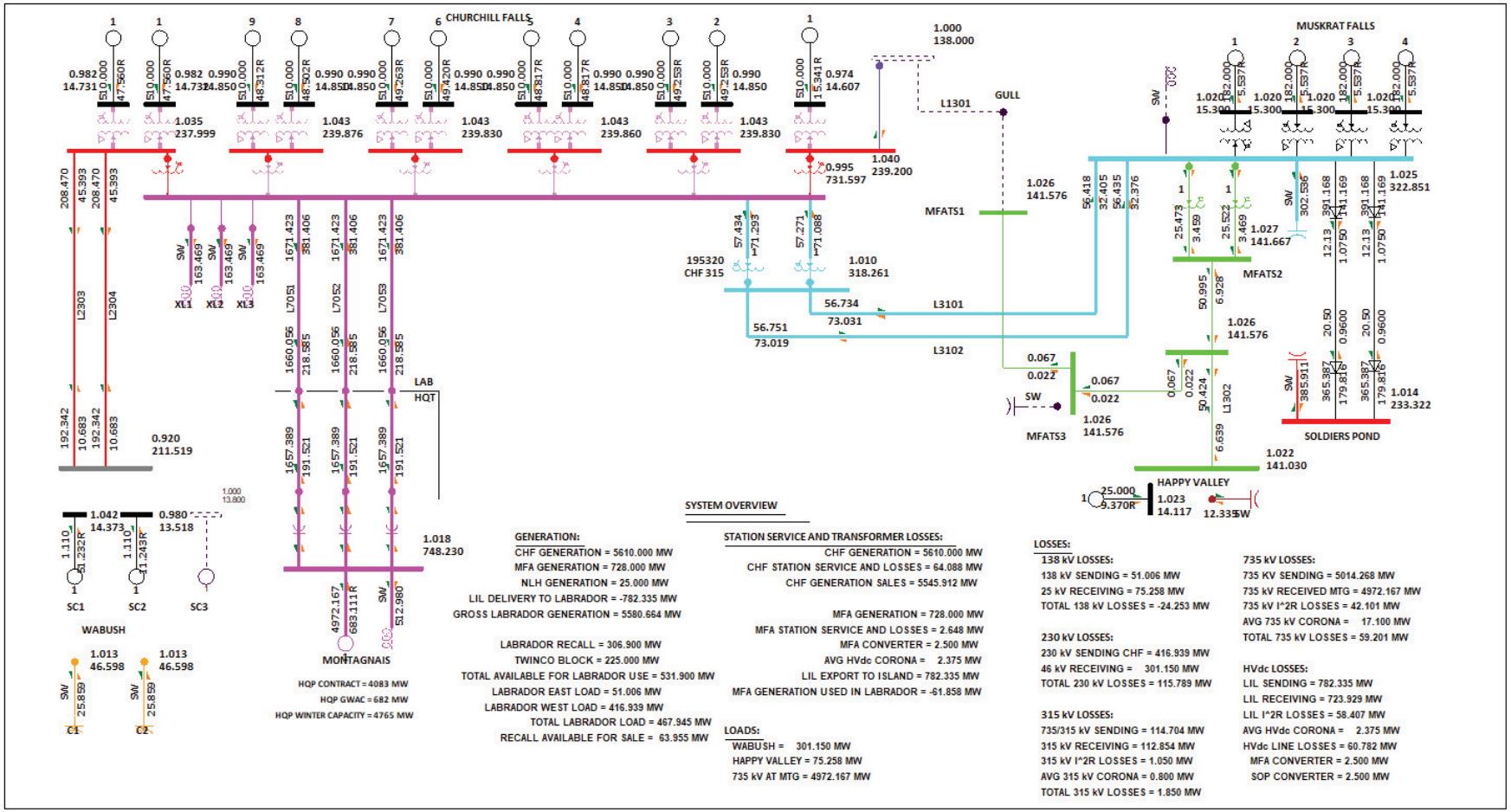

Figure 5 – LIS (2029 Peak Conditions)

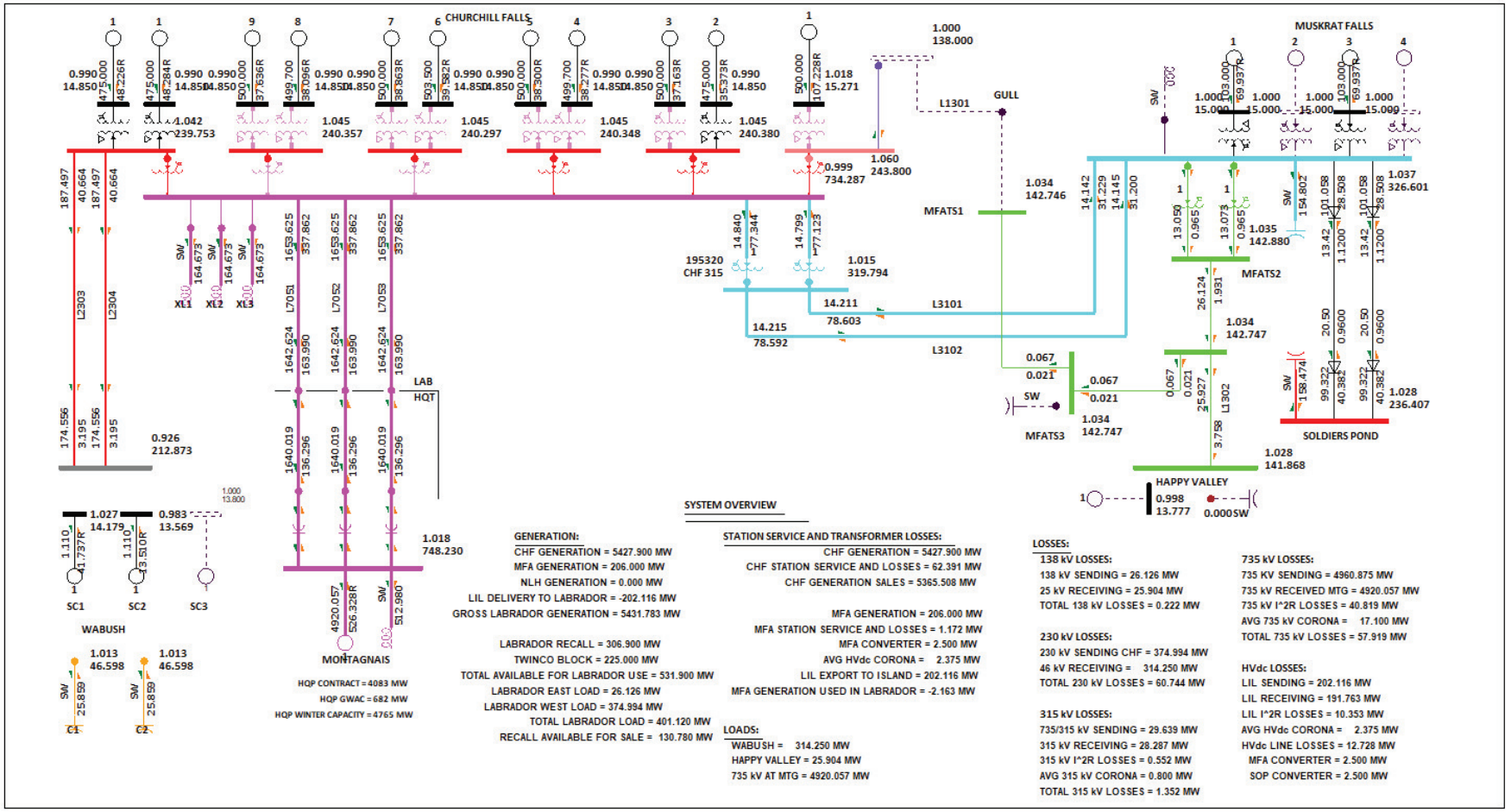

Figure 6 - LIS (2029 Light Conditions)

Document Summary

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Revision History

Revision	Prepared by	Reason for change	Effective Date
1	M. Carter	Approved for release	2020/03/28
2	M. Carter	Minor Edits	2020/05/01
3 to 5	M. Carter	Minor Edits (Regulatory Review)	2020/05/19

Document Approvers

Position	Signature	Approval Date
Manager, Transmission Planning		2020/03/30

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