Engineering Connection Assessment

P2716 Pakenham 2103S Substation

ATCO Electric Ltd.

Date: August 31, 2026

Version: V1

Classification: Public

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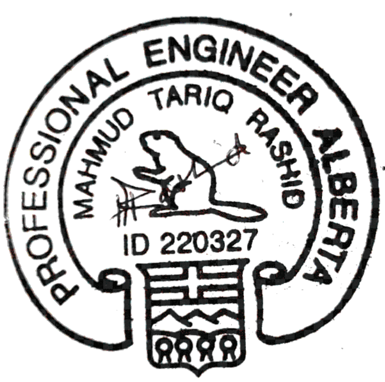

2026-09-15

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NOTE:

The conclusions and recommendations in this report are based on the results presented in *Attachment B: Engineering Connection Assessment: Study Results*, which was prepared by a third party consultant in accordance with the AESO Connection Process.

The AESO has reviewed the *Engineering Connection Assessment: Study Results*, and finds it acceptable for the purpose of assessing the potential impacts of the proposed connection on the performance of the Alberta interconnected electric system.

Contents

Tables

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Attachments

1 Introduction

This AESO Engineering Connection Assessment describes the engineering studies that were completed to assess the impact of the Project (as defined below) on the performance of the Alberta interconnected electric system (AIES). This report also provides the AESO's conclusions and recommendations based on the results of the engineering studies.

Attached to this Engineering Connection Assessment are the results of the engineering studies (see Attachment B) and the scope and methodology used to perform the studies (see Attachment B1 to Attachment B). These attachments provide details regarding the technical criteria, assumptions, and methods for performing these engineering studies, and the results of the engineering studies.

1.1 Project Overview

ATCO Electric Ltd. (Market Participant), in its capacity as the legal owner of an electric distribution system (DFO), has submitted a request for system access service to the Alberta Electric System Operator (AESO) to serve new load in the Grand Prairie area (Area 20).

The DFO's request includes a new Rate DTS, *Demand Transmission Service*, contract capacity of 28 MW, in the Grand Prairie area and a request for transmission development (collectively, the Project). Details on the need for transmission development are provided in the DFO's Distribution Deficiency Report (DDR).

The scheduled in-service date (ISD) for the Project is April 1, 2028.

2 Assessment Scope

2.1 Objectives

The objectives of the AESO Engineering Connection Assessment are as follows:

- Assess the impact of the Project on the performance of the AIES.
- Evaluate Project connection alternatives and identify the AESO's preferred alternative.
- Recommend mitigation measures, if required, to reliably connect the Project to the AIES.
- Identify Project dependencies, including any TFO projects or AESO plans to expand or enhance the transmission system that must be completed prior to connection.

2.2 Existing System

Geographically, the Project is located in the AESO planning area Grand Prairie (Area 20), which is part of the AESO's Northwest planning region. Grande Prairie area is surrounded by the planning areas of Peace River (Area 19), Valleyview (Area 23), and Grande Cache (Area 22).

From a transmission system perspective, Grande Prairie area consists primarily of a 144 kV transmission system. Grande Prairie area is connected to Peace River via one 144 kV transmission line 7L73; to Valleyview via three 144 kV transmission lines 7L32, 7L45, and 7L46; and to Grande Cache via one 144 kV transmission line 7L228.

Existing constraints in the Northwest planning region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, Real Time Transmission Constraint Management (TCM Rule).

2.3 Study Area

The Study Area for the Project consists of the AESO Planning areas of Peace River (Area 19), Grande Prairie (Area 20), Grande Cache (Area 22), and Valleyview (Area 23), including the tie lines connecting these planning areas to the rest of the AIES. All transmission facilities within the Study Area will be studied and monitored for violations of the Reliability Criteria (defined in Section 3.1 of Attachment B1: Engineering Connection Assessment Scope).

3 Connection Alternatives

3.1 Overview

The AESO, in consultation with the TFO in the Study Area and the DFO, examined 9 transmission and distribution alternatives to meet the DFO's request for system access service, as detailed in Section 3.2.[1] The DFO has evaluated and ruled out the Distribution only alternatives due to lack of capacity to serve the proposed load.[2]

3.2 Connection Alternatives Examined

Below is a description of the developments associated with the transmission alternatives that were examined for the Project.

Alternative 1 – Point of Delivery with a T-tap connection to the 144 kV transmission line 7L228

This alternative includes the following developments:

- Add one point of delivery (POD) substation, including one 144/25 kV transformer, and one 144 kV circuit breaker;
- Add one 144 kV circuit, approximately 15 km in length[3], to connect the proposed POD substation to the existing 144 kV transmission line 7L228 (between Big Mountain 845S and Thornton 2091S substations) using T-tap configuration; and
- Add or modify associated equipment as required for the above transmission developments.

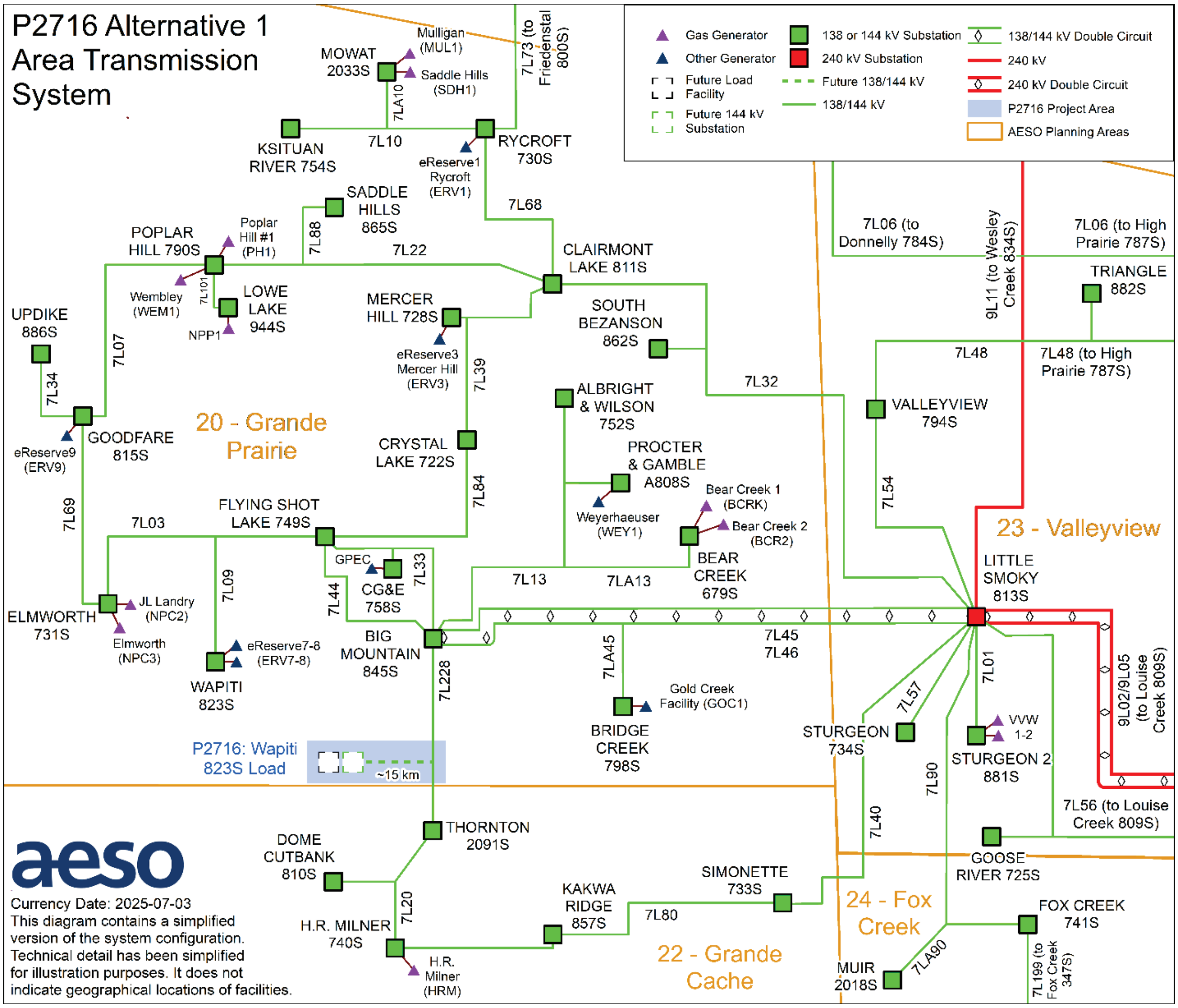
The proposed connection configuration is shown in Figure 3-1.

[1] These alternatives reflect more up to date engineering design than the alternatives identified in ATCO's *Distribution Deficiency Report*, See Appendix D of Needs Identification Document.

[2] ATCO's *Distribution Deficiency Report*, See Appendix D of Needs Identification Document.

[3] Exact line length to be determined by TFO

Figure 3-1: Connection Alternative 1



Alternative 2 – POD with an in-and-out connection to the 144 kV transmission line 7L228

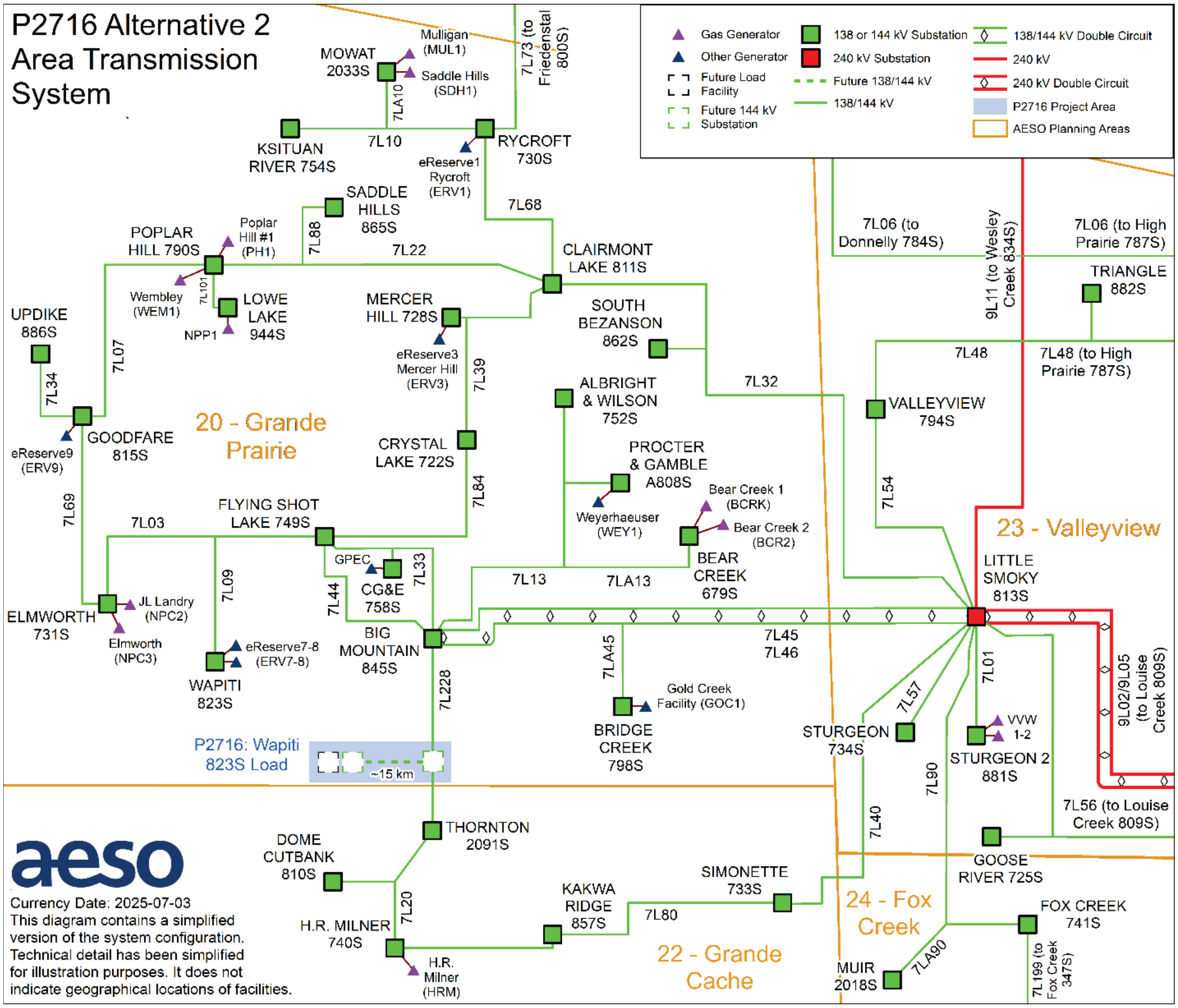
This alternative includes the following developments:

- Add one POD substation, including one 144/25 kV transformer, and one 144 kV circuit breaker;
- Add one 144 kV switching substation, including three 144 kV circuit breakers, connected to the existing 144 kV transmission line 7L228 (between Big Mountain 845S and Thornton 2091S substations) using an in-and-out configuration[4];
- Add one 144 kV circuit, approximately 15 km in length[4], to connect the POD substation to the 144 kV switching substation; and
- Add or modify associated equipment as required for the above transmission developments.

[4] Exact location of the substation and circuit length will be determined by the TFO

The proposed connection configuration is shown in Figure 3-2

Figure 3-2: Connection Alternative 2



Alternative 3 – POD with a T-tap connection to the 144 kV transmission 7L46

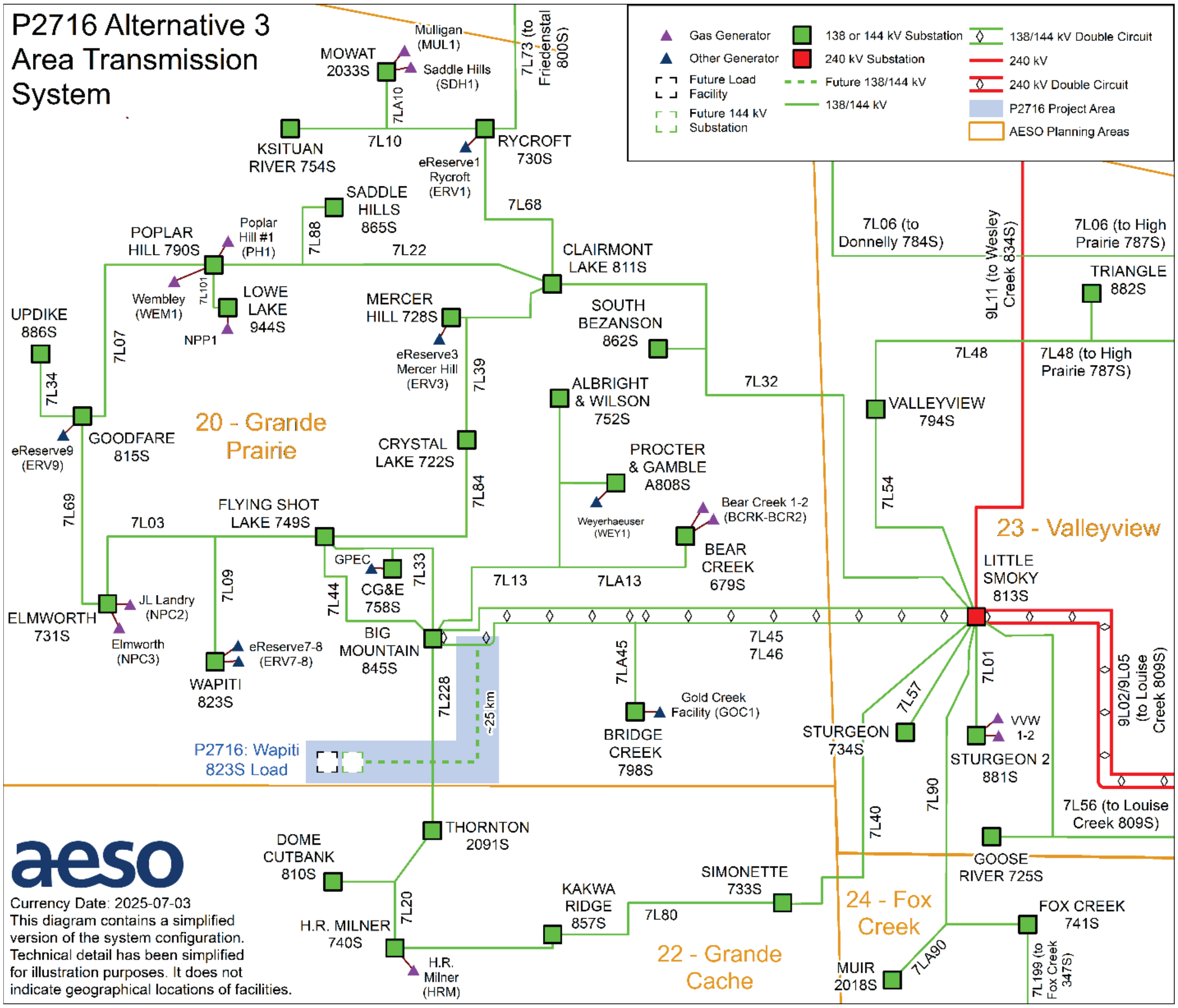
This alternative includes the following developments:

- Add one POD substation, including one 144/25 kV transformer, and one 144 kV circuit breaker;
- Add one 144 kV circuit, approximately 25 km in length[5], to connect the proposed POD to the existing 144 kV transmission line 7L46 (between Big Mountain 845S and Little Smoky 813S substations) using a T-tap configuration, which would require crossing the 144 kV transmission line 7L228; and
- Add or modify associated equipment as required for the above transmission developments.

[5] Exact line length to be determined by TFO

The proposed connection configuration is shown in Figure 3-3.

Figure 3-3: Connection Alternative 3



Alternative 4 – POD with an in-and-out connection to the 144 kV transmission line 7L46

This alternative includes the following developments:

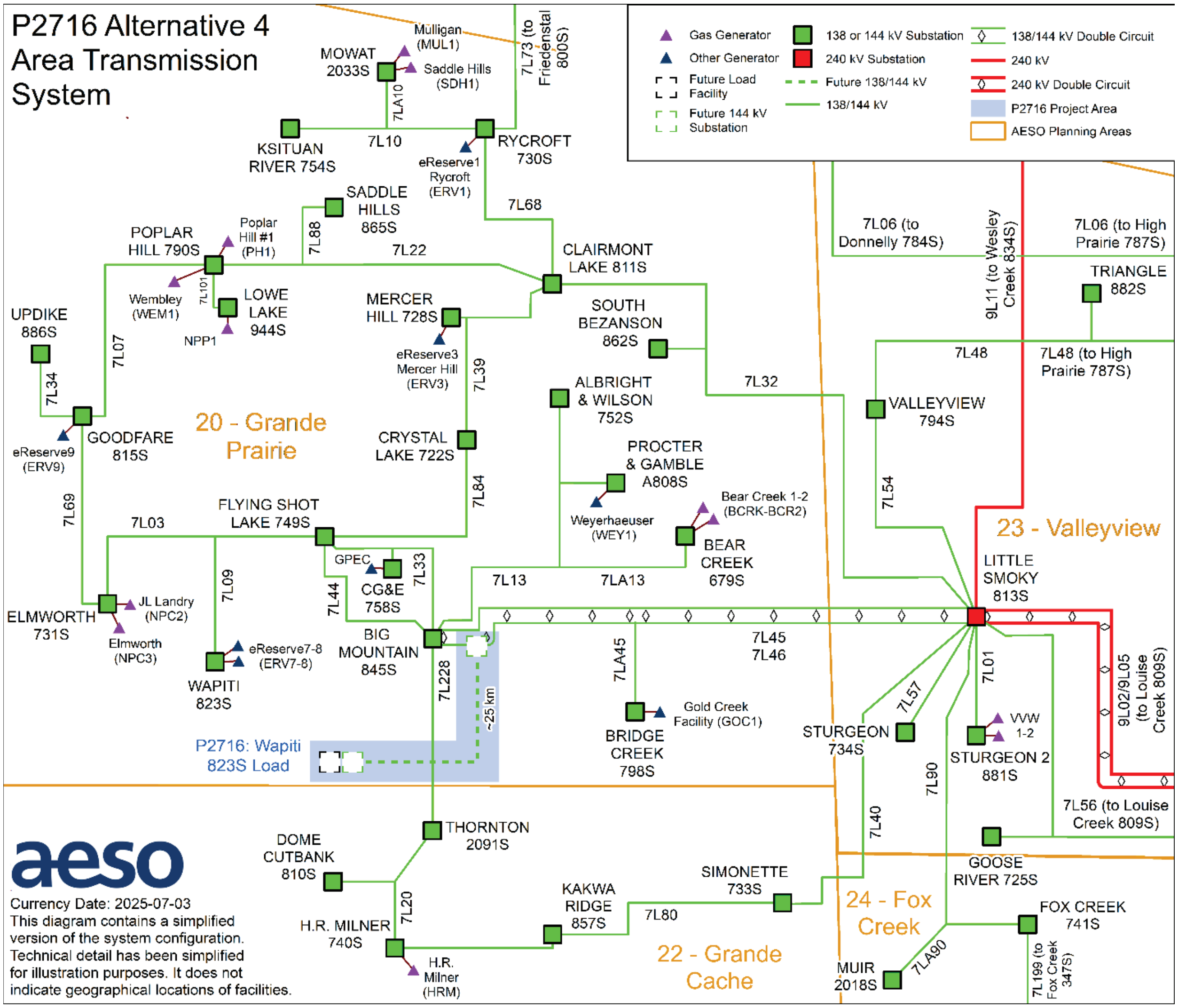
- Add POD substationincluding one 144/25 kV transformer, and one 144 kV circuit breaker;
- Add one 144 kV switching substation, including three 144 kV circuit breakers, connected to the existing 144 kV transmission line 7L46 (between Big Mountain 845S and Little Smoky 813S substations) using an in-and-out configuration [6], which would require crossing the 144 kV transmission line 7L228;

[6] Exact location of the substation and circuit length will be determined by the TFO

- Add one 144 kV circuit, approximately 25 km in length[7], to connect the proposed POD to the 144 kV switching substation; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-4.

Figure 3-4: Connection Alternative 4



Alternative 5 – POD with a radial connection to the Wapiti 823S Substation

This alternative includes the following developments:

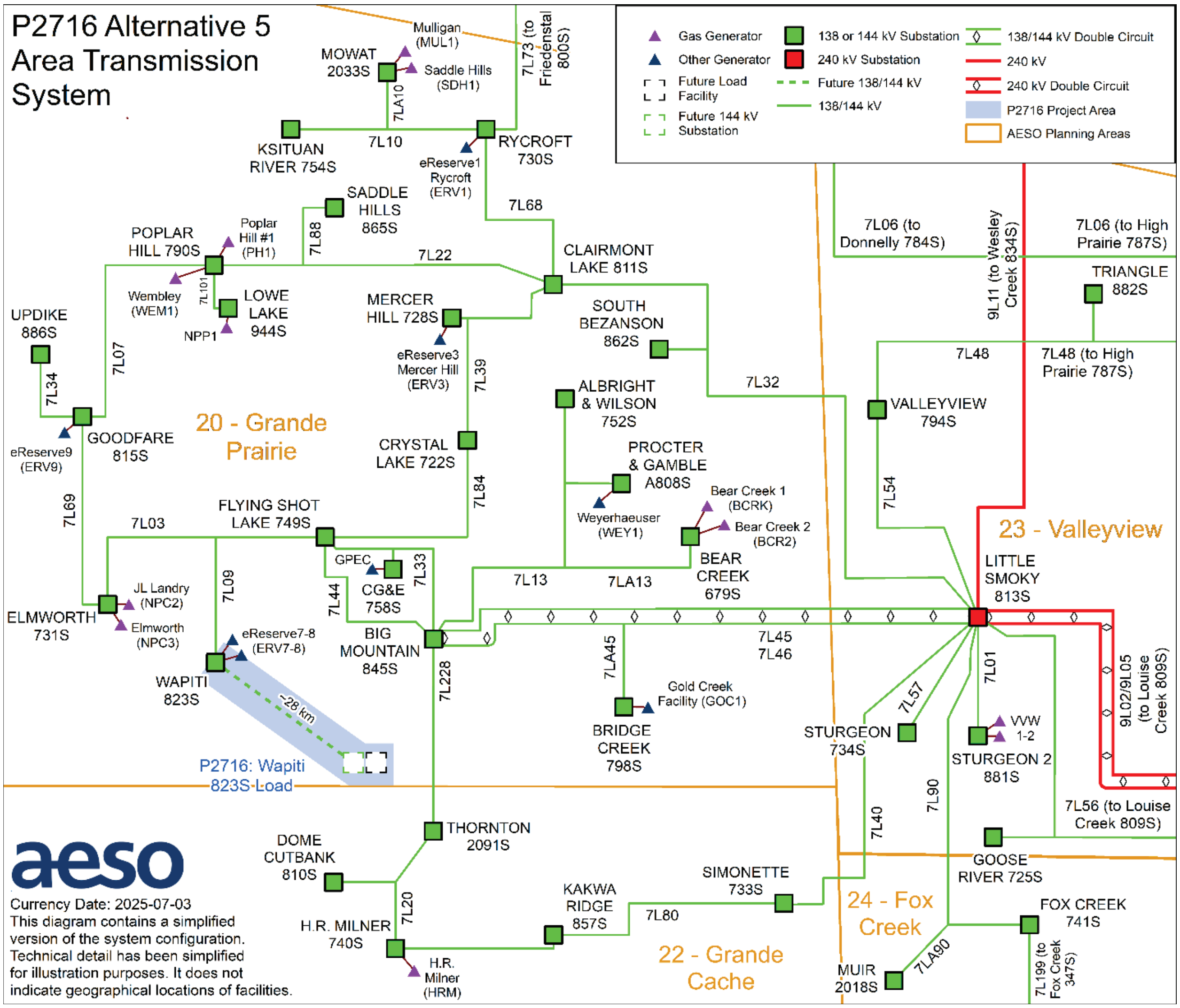
- Add one POD substation, including one 144/25 kV transformer, and one 144 kV circuit breaker;

[7] Exact line length to be determined by TFO

- Add one 144 kV circuit, approximately 28 km in length[8], to connect the proposed Pakenham 2103S substation to the existing Wapiti 823S substation using a radial configuration;
- Modify Wapiti 823S substation, including adding one 144 kV circuit breaker; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-5.

Figure 3-5: Connection Alternative 5



Alternative 6 – POD with a radial connection to the Big Mountain 845S substation

This alternative includes the following developments:

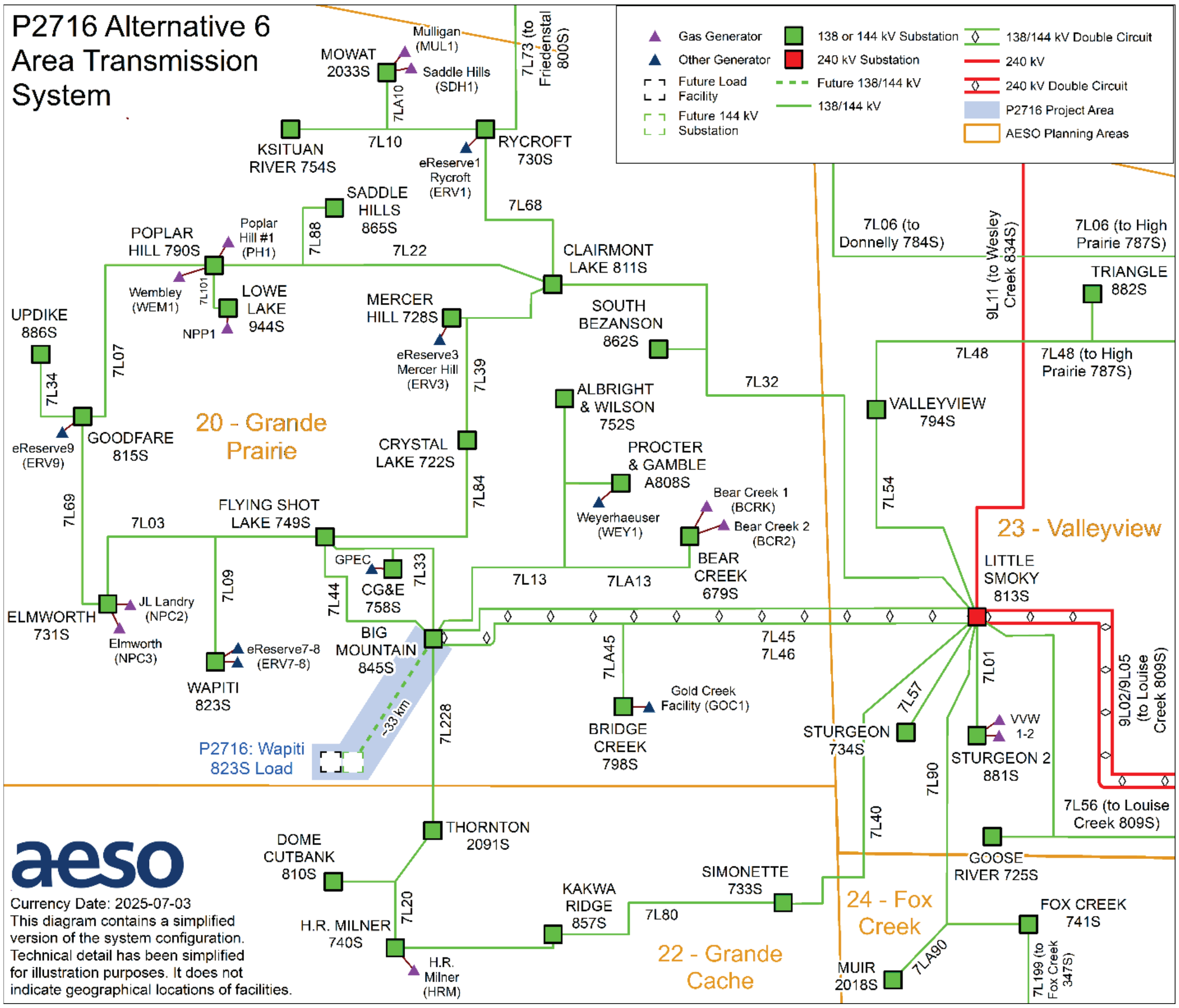
- Add one POD substation, including one 144/25 kV transformer, and one 144 kV circuit breaker;

[8] Exact line length to be determined by TFO

- Add one 144 kV circuit, approximately 33 km in length[9], to connect the proposed POD substation to the existing Big Mountain 845S substation using a radial configuration;
- Modify Big Mountain 845S substation, including adding one 144 kV circuit breaker; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-6.

Figure 3-6: Connection Alternative 6



Alternative 7 – Upgrade Wapiti 823S substation

This alternative includes the following developments:

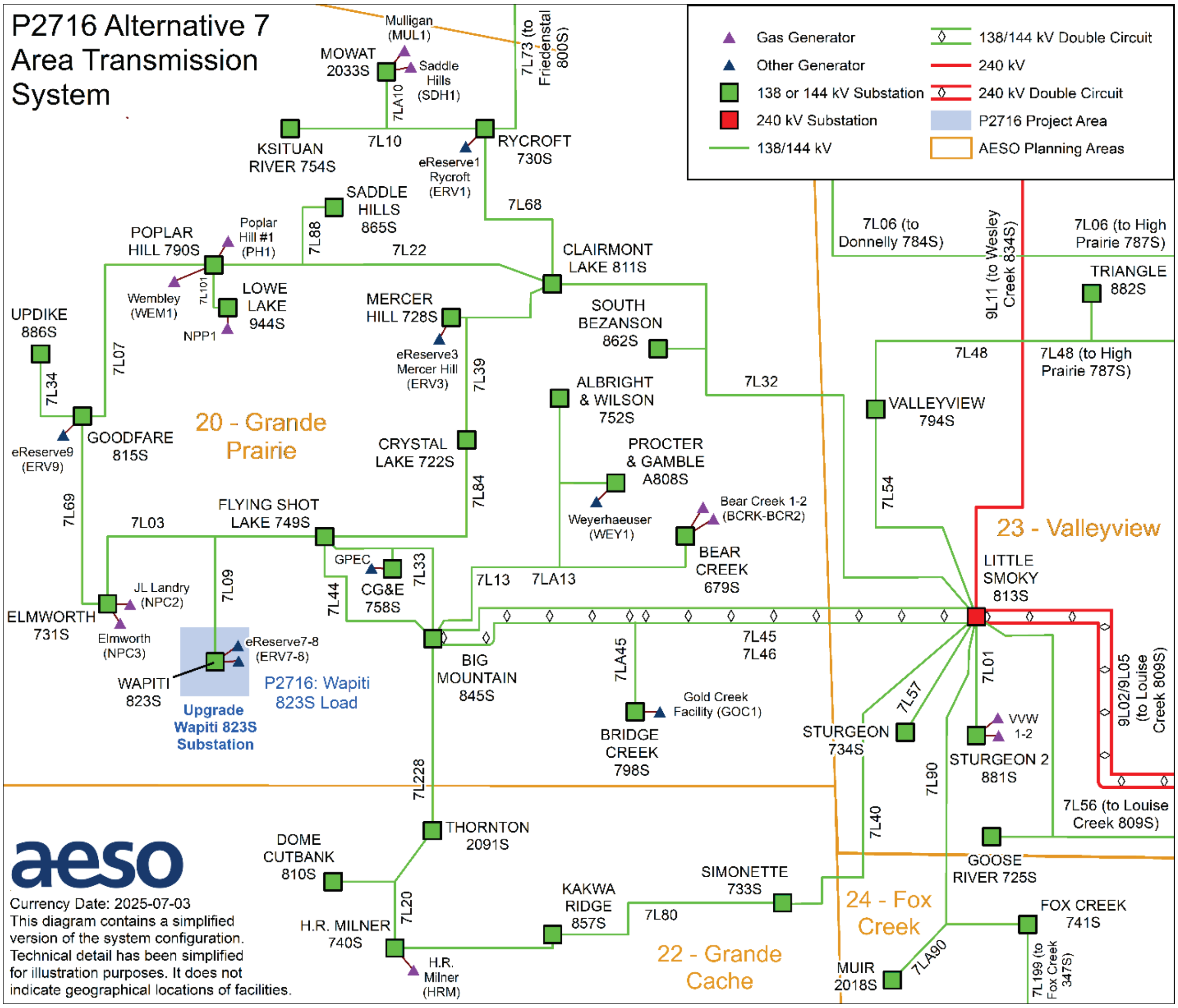
- Upgrade the existing Wapiti 823S substation, including adding one 144/25 kV transformer; and

[9] Exact line length to be determined by TFO

- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-7.

Figure 3-7: Connection Alternative 7



3.3 Connection Alternatives Not Selected for Further Study

Alternatives 2, 3, 4, 5 and 6 involve increased transmission development and hence increased cost, compared to Alternatives 1 and 7, and were therefore ruled out.

Additional Information Provided by the TFO and DFO

To support the AESO's alternative selection decision, the TFO and DFO provided cost information and the TFO provided an environment and land use assessment for Alternatives 1 and 7.

In addition to the transmission facilities described above, the DFO has advised that Alternative 1 would require the addition of two distribution feeders approximately 1 km in length each. The DFO advised that Alternative 7 would require adding three distribution feeders, each approximately 38 km in length with two voltage regulators and one 3 Mvar reactive compensator.

The cost estimate summary is provided in Table 3-1, which indicates that Alternative 7 has an overall higher cost than Alternative 1.

Table 3-1: Cost Estimate Summary

Alternative No.	Alternative Description	Cost of the Transmission Component (+50%/-30%)[10]	Cost of the Distribution Component (+50%/-30%)[11]	Total cost
1	T-Tap connection to 7L228	$32.1 million	$0.7 million	$32.8 million
7	Upgrade Wapiti 823S Substation	$14.6 million	$36.0 million	$50.6 million

From an environment and land use perspective, the TFO concluded that Alternative 7 is expected to have a greater environmental impact than Alternative 1.[12]

Furthermore, the DFO has advised that Alternative 7 reduces the maximum feeder capacity due to the long distance between Wapiti 823S substation and the load center and offers limited potential for growth.[13]

Alternative 7 was ruled out because it involves higher costs, greater potential for environmental impacts and reduced feeder capacity, compared to Alternative 1.

3.4 Connection Alternatives Selected for Further Study

Alternative 1 is considered technically feasible and was selected for further study.

[10] See Appendix B of Needs Identification Document.

[11] See Appendix D of Needs Identification Document.

[12] See Appendix E of Needs Identification Document.

[13] See Appendix D of Needs Identification Document.

4 Assessment Approach

4.1 Standards, Criteria and Assumptions

A detailed description of the standards, criteria, and assumptions that were used for the connection assessment is provided in Attachment B (see Attachment B1).

4.2 Studies Performed

Studies were performed using scenarios for 2028 Summer Peak (SP) and 2028 Winter Peak (WP). After completion of studies, the Project DTS was increased from 21.3 MW to 28 MW. The AESO determined that the DTS increase would not have material impact on the connection alternative, mitigation measures, or the conclusions for the study scenarios conducted.

Short-circuit studies were performed using the 2028 WP pre-Project and post-Project scenarios, as well as 2033 WP scenarios.

The ISD used for the connection studies was based on the original ISD of March 15, 2027 (Attachment B). The ISD of the project was later updated to April 1, 2028. The AESO determined that the ISD change does not materially alter the connection study results or affect the conclusions and recommendations in this report.Table 4-1 lists the study scenarios. Post-Project scenarios reflect the requested Rate DTS contract capacity of 21.3 MW at the new Pakenham 2103 substation.

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	New POD Load (MW)
Pre-Project				
1	2028 Summer Peak (2028 SP)	Low Generation (LG)	2028 SP Pre-Project	0
2	2028 Winter Peak (2028 WP)		2028 WP Pre-Project	0
Post-Project				
3	2028 SP	LG	2028 SP Post-Project	21.3[14]
4	2028 WP		2028 WP Post-Project	21.3
5	2033 WP	All study area generation in-service	2033 WP Post-Project	21.3

The AESO Planning Region load forecasts used for the connection studies were based on the 2023 Long-term Outlook (2023 LTO). While the AESO has updated its regional forecasts since the connection studies were performed, the use of the current AESO forecast, the 2024 LTO, would not materially alter the connection study results or affect the conclusions and recommendations in this report.

[14] After completion of studies, the project DTS was increased from 21.3 MW to 28 MW. A sensitivity study was performed and AESO determined that the DTS increase would not have material impact on the connection alternative, mitigation measures, or the study conclusions.

4.2.1 Power Flow Studies

The purpose of the power flow studies is to identify and quantify any thermal and voltage criteria violations in the Study Area.

In addition, power flow studies are also used to identify POD low voltage bus voltage deviations beyond the limits listed in Table 3-1 of Attachment B – B1: Engineering Connection Assessment Scope.[15]

Power flow studies were performed for 2028 SP and 2028 WP pre-Project and post-Project scenarios.

4.2.2 Voltage Stability Studies

The purpose of the voltage stability studies is to determine the ability of the transmission system to maintain voltage stability at the busses in the Study Area.

Voltage stability studies were performed for 2028 WP pre-Project and post-Project scenarios.

4.2.3 Transient Stability Studies

Since the Project connects via T-tap to 7L228, which is part of the existing RAS 171 H.R. Milner 740S Overload and Transient Instability Mitigation logic, transient stability studies are performed to verify the effectiveness of this RAS in mitigating pre-existing transient stability issues after the Project connection.

The transient stability study evaluates the transmission system's stability by applying three-phase-to-ground faults, single-phase-to-ground faults, and breaker open conditions on selected transmission lines within the Study Area.

Transient stability studies were performed for 2028 SP pre-Project and post-Project scenarios.

4.2.4 Short-Circuit Current Level Studies

The purpose of short-circuit current level studies is to determine the expected system short-circuit current levels in the vicinity of the Project.

Short circuit studies were performed for the 2028 WP pre-Project scenario and for 2028 WP and 2033 WP post-Project scenarios.

4.3 Mitigation Measure Development and Evaluation

As explained in Attachment B1, mitigation measures were developed to address system performance issues that were identified in the post-Project scenarios. Studies performed to assess the effectiveness of mitigation measures are briefly outlined below.

4.3.1 Post-Mitigation Studies

Power flow, voltage stability and transient studies were performed to assess the impact of the Project on the performance of the AIES following implementation of the AESO's proposed mitigation measures.

[15] The AESO's desired post-contingency voltage deviations for low voltage busses represent guidelines rather than criteria. A POD bus voltage deviation that exceeds the desired limits shown in Table 3-1 of Attachment B1 - Engineering Connection Assessment Scope does not represent a Reliability Criteria violation. Mitigation measures would not be developed to specifically address POD bus voltage deviations that exceed the desired values in Table 3-1 of Attachment B1.

5 Interpretation of Results

5.1 Results Overview

This section provides an assessment of the impact of the Project on the performance of the AIES. The Reliability Criteria violations observed during the connection assessment studies, and the proposed mitigation measures are summarized in Attachment A.

- Section 5.2 includes an overview of the pre-Project studies results.
- Section 5.3 includes an overview of the post-Project studies results.
- Section 5.4 includes a description of the proposed mitigation measures to address observed Reliability Criteria violations and an overview of the post-mitigation studies results.

Detailed study results are provided in Attachment B.

5.2 Pre-Project Study Results

5.2.1 Category A Conditions

No Reliability Criteria violations were identified for the pre-Project scenarios under Category A conditions (i.e., all elements in service).

The short-circuit fault levels were found to be within the typical capabilities of the nearby facilities.

5.2.2 Category B Conditions

The pre-Project power flow studies identified a number of thermal and voltage stability violations under Category B conditions (i.e., loss of a single system element).

Voltage deviations beyond the limits listed in Table 3-1 of Attachment B – B1: Engineering Connection Assessment Scope (hereafter referred to as POD bus voltage deviations) were observed under Category B conditions.

Transient instability was identified under Category B conditions.

See Attachment A for details.

5.3 Post-Project Study Results

5.3.1 Category A Conditions

No Reliability Criteria violations were observed under the Category A conditions for any post-Project scenarios. Post-Project short-circuit fault levels were not significantly higher than pre-Project levels.

The long-term short circuit levels were found to be within the designed capabilities of the nearby facilities.

5.3.2 Category B Conditions

All of the thermal, voltage and transient stability criteria violations observed in the pre-Project studies were also observed in the post-Project studies under Category B conditions. Following the connection of the Project, some of the Category B thermal criteria violations observed in the pre-connection assessment were exacerbated. No new thermal, voltage or transient stability violations were observed.

No new POD bus voltage deviations were observed under Category B conditions. The observed POD bus voltage violations under Category B were the same as the violations reported in pre-project scenarios.

5.4 Mitigation Measures

This section discusses the AESO's proposed mitigation measures to address the system performance issues that were identified pre-Project and post-Project.

5.4.1 Pre-Project

Prior to the connection of the Project, all of the observed thermal and voltage stability criteria violations under Category B system conditions can be managed by using real-time operational practices (RTOP), including dispatching generation under Transmission Must-Run (TMR) service.

The transient stability violations can be mitigated by the existing RAS 171.

5.4.2 Post-Project

After the connection of the Project, all of the thermal, voltage range, and voltage stability criteria violations observed under Category B system conditions can be mitigated by using RTOP, including the existing TMR service. This project is not expected to require any additional application of TMR service beyond the existing TMR requirements.

Transient stability violations identified under post-project Category B system conditions can be mitigated by modifying RAS 171. The modification of RAS 171 will be completed under the TFO's capital maintenance program with a planned ISD of December 31, 2026. The TFO's capital maintenance project includes telecom additions to the 7L20/7L228 path which are needed prior to the energization of the Project.

Under Category B conditions, all of the observed Reliability Criteria violations requiring RAS were mitigated.

6 Project Dependencies

The TFO has an ongoing capital maintenance project that adds telecom to the 7L20/7L228 path, which reduces the fault clearing time on those lines and simplifies the existing RAS 171 logic. All transient studies and RAS investigations were conducted with the assumption that the telecom is in-service prior to the Project. Therefore, the telecom additions must be in-service before the energization of the Project (the TFO has advised that it expects to have telecom in place by December 31, 2026). Otherwise, transient stability studies are not valid, and the modified RAS design needs to be revisited.

Furthermore, the Project depends on the addition of capacitor banks which are contemplated under AESO Project P3072 Greenview Area Load which has a planned ISD of March 1, 2028.[16] If the capacitor bank addition is delayed, further studies are required to determine required temporary mitigation. If the P3072 Greenview Area Load transmission development does not proceed, additional capacitor bank and tele-protection scope may be required in the area.

[16] The AESO expects to file its Needs Identification Document in early 2027.

7 Conclusions and Recommendations

Based on the study results, Alternative 1 is technically viable. The connection assessment identified a number of pre-Project and post-Project system performance issues.

All of the thermal, voltage range, and voltage stability criteria violations observed under Category B conditions can be mitigated through RTOP, including dispatching generation under TMR service, alone or in combination, as appropriate.

Prior to the energization of the Project, telecom will be added on the 7L20/7L228 path as part of the TFO's capital maintenance program, resulting in modification of existing RAS 171. The transient stability violations under Category B system conditions can be mitigated by modified RAS 171. The Project also depends on the addition of capacitor banks under AESO Project P3072 Greenview Area Load which has a planned ISD of March 1, 2028. If the capacitor bank addition is delayed or cancelled, temporary mitigation and additional transmission development may be required.

The AESO recommends proceeding with the Project using Alternative 1 as the preferred alternative to respond to the DFO's request for system access service. RTOP and RAS 171 are recommended to mitigate the identified system performance issues.

Alternative 1 involves adding a substation, designated as Pakenham 2103S substation, including one 144 kV circuit breaker, and one 144/25 kV transformer with a minimum capacity of 30 MVA, and adding one 144 kV circuit to connect the Pakenham 2103S substation to the existing 144 kV transmission line 7L228 (between Big Mountain 845S and Thornton 2091S substations) using a T-tap configuration.

The 144/25 kV transformer should have a minimum capacity of 30 MVA to meet the DFO's required DTS contract capacity. The conductor used for the 144 kV circuit connecting the Project to 7L228 should have a thermal capacity of 110 MVA match to rating of the existing 138 kV line 7L228.

Attachment A:
Table A-1: Summary of Category B Reliability Criteria Violations, Project Impact and Mitigation Measures- All Scenarios

Table A-1: Summary of Category B Reliability Criteria Violations, Project Impact and Mitigation Measures

Scenario	Type of Reliability Criteria Violation		Contingency (System Element Lost)	Details of Violation	Project Impact	Pre-Project Mitigation Measures	Post-Project Mitigation Measures
	Pre-Project	Post-Project					
2028 Summer Peak	Voltage stability	Voltage stability	7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage Collapse	No impact	Dispatching Transmission Must-Run (TMR)	Dispatching TMR
	Thermal - above emergency rating	Thermal - above emergency rating	7L69 (Goodfare 815S - Elmworth 731S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	No impact	Dispatching TMR	Dispatching TMR
	Thermal - above emergency rating	Thermal - above emergency rating	7L03 (Elmworth 731S - Flyingshot Lake 749S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	No impact	Dispatching TMR	Dispatching TMR
	Thermal - above normal rating	Thermal - above normal rating	7L45 (Big Mountain 845S - Little Smoky 813S)	7L46 (Big Mountain 845S - P2843 Tap)	Materially increased violation	Real-Time Operation Practices (RTOP)	RTOP
	Thermal - above normal rating	Thermal - above normal rating	7L46 (Big Mountain 845S - Little Smoky 813S)	7L45 (Bridge Creek Tap - P2843 Tap)	Materially increased violation	RTOP	RTOP
	Transient stability	Transient stability	7L20 (H.R. Milner 740S - Dome Cutbank 810S - Thornton 2091S)	Area generators rotor angle instability. Voltage oscillations at the monitored buses.	No impact	Existing RAS 171	Modified Existing RAS 171
	Transient stability	Transient stability	7L80 (H.R. Milner 740S - Kakwa Ridge 857S - Simonette 733S)	Area generators rotor angle instability. Voltage oscillations at the monitored buses.	No impact	Existing RAS 171	Modified Existing RAS 171
	Transient stability	Transient stability	7L40 (Simonette 733S - Little Smoky 813S)	Area generators rotor angle instability. Voltage oscillations at the monitored buses.	No impact	Existing RAS 171	Modified Existing RAS 171
	Transient stability	Transient stability	7L228 (Thorton 2091S - Big Mountain 845S)	Area generators rotor angle instability. Voltage oscillations at the monitored buses.	No impact	Existing RAS 171	Modified Existing RAS 171
2028 Winter Peak	Voltage stability	Voltage stability	7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage Collapse	No impact	Dispatching TMR	Dispatching TMR

Notes:
- Marginally increased (or marginally decreased) refers to a percent loading difference (post-Project percent loading minus pre-Project percent loading) between 0% and 3% (or -3%).
- Materially increased (or materially decreased) refers to a percent loading difference (post-Project percent loading minus pre-Project percent loading) above or equal to 3% (or below or equal to -3%).
- Modified existing RAS 171 refers to revised RAS logic following addition of telecom on the 7L20/7L228 path as part of a TFO capital maintenance project.

Attachment B:
Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

P2716 Wapiti 823S Load

ATCO Electric Ltd.

Date: August 28, 2025

Version: V1 (Final)

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1 Introduction

This report presents the results of the engineering studies that were completed by ATCO Electric Ltd. (the Studies Consultant) to assess the impact of the Project (as defined in the AESO's Study Scope) on the performance of the Alberta interconnected electric system (AIES). The studies were performed in accordance with the AESO's Study Scope titled "P2716 Wapiti 823S Load" dated January 7, 2025, Version V1.

The power system network analysis tool that was used for the studies in this connection assessment was PSS/E version 35.

2 Pre-Project Study Results

This section describes the results of the pre-Project power flow studies.

2.1 Power Flow Studies

Power flow diagrams illustrating the pre-Project power flow studies results for Category A and Category B conditions are provided in Attachment A2.

2.1.1 Scenario 1: 2028 Summer Peak (SP) Low Generation (LG) Pre-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

Thermal Criteria Violations

Thermal criteria violations were observed under certain Category B conditions as shown in Table 2-1.

Table 2-1: Thermal Criteria Violations under Category B Conditions for Scenario 1

Contingency (System Element Lost)	Violation Location Details	Thermal Ratings[a] (MVA)		Pre-Project Results	
		Normal Rating	Emergency Rating	Power Flow[b] (MVA)	% Loading[c]
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occurred				
7L03 (Elmworth 731S - Flyingshot Lake 749S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	130.5	120.5
7L69 (Goodfare 815S - Elmworth 731S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	131.9	121.8
7L45 (Big Mountain 845S - Little Smoky 813S)	7L46 (Big Mountain 845S - P2843 tap)	139	159.1	140.7	101.2
7L46 (Big Mountain 845S - Little Smoky 813S)	7L45 (Bridge Creek Tap – P2843 Tap)	139	159.1	150.3	108.1

Voltage Criteria Violations

The following voltage criteria violations were observed under Category B conditions as shown in Table 2-2.

Table 2-2: Voltage Criteria Violations under Category B Conditions for Scenario 1

Contingency (System Element Lost)	Violation Location Details		Voltage Ratings (kV)			Pre-Project Results	
	Substation Name and No.	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse						

POD Bus Voltage Deviations

The following POD bus voltage deviations were observed under Category B conditions as shown Table 2-23.

Table 2-3: POD Bus Voltage Deviations under Category B Conditions for Scenario 1

Contingency (System Element Lost)	Voltage Deviation Location Details			Pre-Project Results						
					Voltage Deviations at POD Low Voltage Buses					
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse									

2.1.2 Scenario 2: 2028 Winter Peak (WP) Low Generation (LG) Pre-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

Thermal Criteria Violations

Thermal criteria violations were observed under certain Category B conditions as shown in Table 2-14.

Table 2-4: Thermal Criteria Violations under Category B Conditions for Scenario 2

Contingency (System Element Lost)	Violation Location Details	Thermal Ratings[a] (MVA)		Pre-Project Results	
		Normal Rating	Emergency Rating	Power Flow[b] (MVA)	% Loading[c]
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occurred				

Voltage Criteria Violations

The following voltage criteria violations were observed under Category B conditions as shown in Table 2-25.

Table 2-5: Voltage Criteria Violations under Category B Conditions for Scenario 2

Contingency (System Element Lost)	Violation Location Details		Voltage Ratings (kV)			Pre-Project Results	
	Substation Name and No.	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse						

POD Bus Voltage Deviations

The following POD bus voltage deviations were observed under Category B conditions as shown Table 2-26.

Table 2-6: POD Bus Voltage Deviations under Category B Conditions for Scenario 2

Contingency (System Element Lost)	Voltage Deviation Location Details			Pre-Project Results						
					Voltage Deviations at POD Low Voltage Buses					
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage Collapse									

2.2 Voltage Stability Studies

2.2.1 Scenario 2: 2028 WP Pre-Project

Voltage stability analysis was performed for scenario 2 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22) and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 2 is 503.2 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 25.2 MW (0.05 x 503.2 MW = 25.2 MW) for the scenario 2.

Table 2-7 provides the voltage stability study results under Category A conditions and for the six worst contingencies under Category B conditions. The corresponding diagrams are listed in Attachment A4. The study results show that the voltage stability margin was met for all studied conditions except for contingency of 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

Table 2-7: Voltage Stability Study Results under Category A and B Conditions for Scenario 2

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		165	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	0	No
7L03	Flyingshot Lake 749S	Elmworth 731S	70	Yes
7L75	Friednestal 800S	West Peace River 793S	90	Yes
7L73	Friednestal 800S	Rycroft 730S	110	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		115	Yes

2.3 Transient Stability Studies

Transient stability studies were completed under selected 3-phase and 1-phase Category B contingencies for scenario 3 2028 SP Post-Project scenario. Transient stability studies were also completed under selected Category B contingencies for 2028 SP Pre-Project scenario when the post-Project plots were unstable. The following section gives a summary of the results for the studied scenario. Transient stability plots are provided in Attachment A5. Post-RAS transient stability plots are provided in Attachment A8.

2.3.1 Scenario 1: 2028 SP Pre-Project

Scenario 1 2028 SP Pre-Project resulted in transient stability issues for both Category B 3-phase and 1-phase contingencies of 7L20 and 7L228 as shown in Table 2-8. All the other Category B events studied were stable.

Table 2-8: Summary of Transient Stability Study Results under Category B Conditions for Scenario 1

Studied Contingency	Fault Description and Location	Results
System Normal (Category A)		Stable
7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	Unstable
	3-phase fault at Thornton 2091S	Unstable
	1-phase fault at H.R. Milner 740S	Unstable
	1-phase fault at Thornton 2091S	Unstable
7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	Unstable
	3-phase fault at Thornton 2091S	Unstable
	1-phase fault at Big Mountain 845S	Unstable
	1-phase fault at Thornton 2091S	Unstable

Results for both ends breaker open condition for 7L20 and 7L80 for Scenario 1 2028 SP Pre-Project are shown in Table 2-9.

Table 2-9: Transient Stability Study Results under Breaker Open Condition for Scenario 1

Category	Line Element	Substation terminals		Fault End	Performance
Breaker Open	7L20	H.R. Milner 740S	Thornton 2091S	2091S	HR Milner Generators – Unstable Bear Creek 1 Generator - Unstable Daishowa Generator - Unstable CG&E Generator - Unstable Elmworth G1 Generator - Unstable Monitored buses voltage recovery was oscillatory - Unacceptable
				740S	

3 Post-Project Study Results

This section describes the results of the post-Project power flow, voltage stability and transient stability studies. The post-Project studies were performed using Alternative 1.

3.1 Power Flow Studies

Power flow diagrams illustrating the post-Project power flow studies results for Category A and Category B conditions are included in Attachment A3.

3.1.1 Scenario 3: 2028 Summer Peak (SP) Low Generation (LG) Post-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

Thermal criteria violations were observed under Category B conditions as shown in Table 3-1.

Table 3-1: Thermal Criteria Violations under Category B Conditions for Scenario 3

Contingency (System Element Lost)	Violation Location Details	Thermal Ratings[a] (MVA)		Pre-Project Results		Post-Project Results		(Post-Pre) %
		Normal Rating	Emergency Rating	Power Flow[b] (MVA)	% Loading[c]	Power Flow[b] (MVA)	% Loading[c]	
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occurred							
7L03 (Elmworth 731S - Flyingshot Lake 749S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	130.5	120.5	131.4	121.3	0.8
7L69 (Goodfare 815S - Elmworth 731S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	131.9	121.8	132.9	122.7	0.9
7L45 (Big Mountain 845S - Little Smoky 813S)	7L46 (Big Mountain 845S - P2843 tap)	139	159.1	140.7	101.2	148.2	106.6	5.4
7L46 (Big Mountain 845S - Little Smoky 813S)	7L45 (P2843 Tap – Bridge Creek tap)	139	159.1	150.3	108.1	158.3	113.9	5.8

Voltage Criteria Violations

The following voltage criteria violations were observed under Category B conditions as shown in Table 3-2.

Table 3-2: Voltage Criteria Violations under Category B Conditions for Scenario 3

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Pre-Project Results		Post-Project Results		% Voltage Difference (kV)
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Initial Voltage (kV)	Post-contingency Steady State (kV)	
7L69 (Goodfare 815S - Elmworth 731S)	Updike 886S	1114	144	130	155	140.5	130.2	140.5	129.1	-0.8
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse occurred									

POD Bus Voltage Deviations

The following POD bus voltage deviations were observed under Category B conditions as shown Table 3-3.

Table 3-3: POD Bus Voltage Deviations under Category B Conditions for Scenario 3

Contingency (System Element Lost)	Voltage Deviation Location Details			Post-Project Results						
					Voltage Deviations at POD Low Voltage Buses					
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse occurred									

3.1.2 Scenario 4: 2028 Winter Peak (WP) Low Generation (LG) Post-Project

Category A Conditions

No Reliability Criteria violations were observed under Category A conditions.

Category B Conditions

Thermal criteria violations were observed under Category B conditions as shown in Table 3-4.

Table 3-4: Thermal Criteria Violations under Category B Conditions for Scenario 4

Contingency (System Element Lost)	Violation Location Details	Thermal Ratings (MVA)		Pre-Project Results		Post-Project Results		(Post-Pre) %
		Normal Rating	Emergency Rating	Power Flow[b] (MVA)	% Loading	Power Flow (MVA)	% Loading	
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occurred							

Voltage Criteria Violations

The following voltage criteria violations were observed under Category B conditions as shown in Table 3-5.

Table 3-5: Voltage Criteria Violations under Category B Conditions for Scenario 4

Contingency (System Element Lost)	Details of Violation (Violation Observed On)		Voltage Ratings (kV)			Pre-Project Results		Post-Project Results		% Voltage Difference (kV)
	Substation Name and Number	Bus No.	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Initial Voltage (kV)	Post-contingency Steady State (kV)	Initial Voltage (kV)	Post-contingency Steady State (kV)	
7L22 (Poplar Hill 790S – Clairmont Lake 811S)	Voltage Collapse occurred									

POD Bus Voltage Deviations

The following voltage criteria violations were observed under Category B conditions as shown in Table 3-6.

Table 3-6: POD Bus Voltage Deviations under Category B Conditions for Scenario 4

Contingency (System Element Lost)	Voltage Deviation Location Details			Post-Project Results						
					Voltage Deviations at POD Low Voltage Buses					
	Substation Name and No.	Bus No.	Nominal Bus Voltage (kV)	Initial Voltage (kV)	Post Transient (kV)	% Change	Post Auto Control (kV)	% Change	Post Manual (kV)	% Change
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage Collapse occurred									

3.2 Voltage Stability Studies

3.2.1 Scenario 4: 2028 WP Post-Project

Voltage stability analysis was performed for scenario 4 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 4 is 524.5 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 26.2 MW (0.05 x 524.5 MW = 26.2 MW) for the scenario 4.

Table 3-7 provides the voltage stability study results under Category A conditions and for the six worst contingencies under Category B conditions. The corresponding diagrams are listed in Attachment A4. The study results show that the voltage stability margin was met for all studied conditions except for contingency 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

Table 3-7: Voltage Stability Study Results under Category A and B Conditions for Scenario 4

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		155	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	0	No
7L03	Flyingshot Lake 749S	Elmworth 731S	60	Yes
7L75	Friednestal 800S	West Peace River 793S	80	Yes
7L73	Friednestal 800S	Rycroft 730S	100	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		105	Yes

3.3 Transient Stability Studies

Transient stability studies were completed under selected 3-phase and 1-phase Category B contingencies for scenario 3 2028 SP Post-Project scenario. Transient stability studies were also completed under selected 3-phase and 1-phase Category B contingencies for 2028 SP Pre-Project scenario when the post-Project plots were unstable and the results are summarized in section 2.3. The following section gives a summary of the results for the studied scenario. Transient stability plots are provided in Attachment A5. Post-RAS transient stability plots are provided in Attachment A8.

3.3.1 Scenario 3: 2028 SP Post-Project

Scenario 3 2028 SP Post-Project resulted in transient stability issues for Category B contingencies of 7L20 and 7L228 as shown in Table 3-8. All the other Category B events studied were stable.

Table 3-8: Summary of Transient Stability Study Results under Category B Conditions for Scenario 3

Studied Contingency	Fault Description and Location	Results
System Normal (Category A)		Stable
7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	Unstable
	3-phase fault at Thornton 2091S	Unstable
	1-phase fault at H.R. Milner 740S	Unstable
	1-phase fault at Thornton 2091S	Unstable
7L80 (H.R. Milner 740S – Simonette 733S)	3-phase fault at H.R. Milner 740S	Stable
	3-phase fault at Simonette 733S	Stable
	1-phase fault at H.R. Milner 740S	Stable
	1-phase fault at Simonette 733S	Stable
7L40 (Little Smoky 813S – Simonette 733S)	3-phase fault at Little Smoky 813S	Stable
	1-phase fault at Simonette 733S	Stable
	1-phase fault at Little Smoky 813S	Stable
	3-phase fault at Simonette 733S	Stable
7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	Unstable
	3-phase fault at Thornton 2091S	Unstable
	1-phase fault at Big Mountain 845S	Unstable
	1-phase fault at Thornton 2091S	Unstable

Results for both ends breaker open condition for 7L20 and 7L80 as well as Big Mountain 845S end breaker open condition for Scenario 3 2028 SP Post-Project are shown in Table 3-9.

Table 3-9: Transient Stability Study Results under Breaker Open Scenario for Scenario 3

Category	Line Element	Substation terminals		Fault End	Performance
Breaker Open	7L20	H.R. Milner 740S	Thornton 2091S	2091S 740S	HR Milner Generators – Unstable Bear Creek 1 Generator - Unstable Daishowa Generator - Unstable CG&E Generator - Unstable Elmworth G1 Generator - Unstable Monitored buses voltage recovery was oscillatory - Unacceptable
Breaker Open	7L80	H.R. Milner 740S	Simonette 733S	740S 733S	All monitored generators – Stable All monitored buses voltage recovery - Acceptable
Breaker Open	7L228	Big Mountain 845S	Thornton 2091S	Big Mountain 845S	All monitored generators – Stable All monitored buses voltage recovery - Acceptable

4 Short Circuit Studies

4.1 Pre-Project Results

4.1.1 Scenario 2: 2028 WP Pre-Project

Pre-Project short-circuit current levels are provided in Table 4-1[1].

Table 4-1: 2028 WP Pre-Project Short-Circuit Current Levels for Scenario 2

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Thornton 2091S	138	146.97	3.00	0.048829+j0.137953	2.94	0.022786+j0.167356
Wapiti Junction 823S	138	146.27	2.46	0.07592+j0.161411	2.44	0.02955+j0.197712
Big Mountain 845S	138	149.76	6.76	0.021195+j0.061411	7.90	0.006942+j0.050757
Bridge Creek 798S	138	149.82	6.40	0.022386+j0.064844	7.23	0.008904+j0.059738
H.R. Milner 740S	138	145.44	2.25	0.071271+j0.181887	3.15	0.002257+j0.037872
Little Smoky 813S	240	266.98	6.68	0.008508+j0.036869	7.91	0.001707+j0.021728
Little Smoky 813S	138	151.00	10.12	0.012018+j0.04172	13.98	0.000825+j0.010387

4.2 Post-Project Results

4.2.1 Scenario 4: 2028 WP Post-Project

Post-Project short-circuit current levels for Scenario 6 are provided in Table 4-2.

Table 4-2: 2028 WP Post-Project Short-Circuit Current Levels for Scenario 4

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Thornton 2091S	138	145.27	3.03	0.049553+j0.136093	3.03	0.02133+j0.156397
Wapiti Junction 823S	138	145.51	2.47	0.076011+j0.160746	2.44	0.029572+j0.197538
Big Mountain 845S	138	148.96	6.83	0.021479+j0.060665	8.04	0.006733+j0.048983

[1] Short-circuit current studies were based on modeling information provided to the AESO by third parties. The authenticity of the modeling information has not been validated. Fault levels could change as a result of system developments, new customer connections, or additional generation in the area. It is recommended that these changes be monitored and fault levels reviewed to ensure that the fault levels are within equipment operating limits. The information provided in this study should not be used as the sole source of information for electrical equipment specifications or for the design of safety-grounding systems.

Bridge Creek 798S	138	149.06	6.46	0.022664+j0.064126	7.32	0.008796+j0.058428
H.R. Milner 740S	138	143.86	2.26	0.071762+j0.180411	3.17	0.002267+j0.037813
Little Smoky 813S	240	266.81	6.67	0.008571+j0.036868	7.90	0.001707+j0.021728
Little Smoky 813S	138	151.00	10.11	0.012157+j0.041735	13.96	0.000825+j0.010387
Pakenham 2103S	138	145.87	3.09	0.051684+j0.132679	2.94	0.025358+j0.176434
Pakenham 2103S	25	25.82	6.22	0.083509+j0.380889	8.37	0.016769+j0.098223

4.2.2 Scenario 5: 2033 WP Post-Project

Post-Project short-circuit current levels for Scenario 7 are provided in Table 4-3.

Table 4-3: 2033 WP Post-Project Short-Circuit Current Levels for Scenario 5

Substation Name and Number	Base Voltage (kV)	Pre-Fault Voltage (kV)	3-Φ Fault (kA)	Positive Sequence Thevenin Source Impedance (R1+jX1) (pu)	1-Φ Fault (kA)	Zero Sequence Thevenin Source Impedance (R0+jX0) (pu)
Thornton 2091S	138	146.80	5.11	0.019143+j0.083818	4.21	0.01799+j0.138597
Wapiti Junction 823S	138	149.13	5.19	0.027529+j0.080044	4.13	0.028651+j0.14136
Big Mountain 845S	138	151.76	11.12	0.008852+j0.038484	9.71	0.00702+j0.055738
Bridge Creek 798S	138	152.08	10.28	0.00994+j0.041553	8.36	0.010139+j0.070906
H.R. Milner 740S	138	147.08	7.16	0.008597+j0.060737	8.08	0.002267+j0.037451
Little Smoky 813S	240	262.16	7.08	0.006906+j0.035011	8.34	0.001548+j0.020274
Little Smoky 813S	138	150.42	12.30	0.008446+j0.034697	16.47	0.000806+j0.010472
Pakenham 2103S	138	147.90	4.05	0.03359+j0.10309	3.34	0.025206+j0.175997
Pakenham 2103S	25	26.20	6.73	0.063493+j0.354436	8.87	0.016746+j0.098171

5 Mitigation Measure Development and Evaluation

The Studies Consultant, in consultation with the AESO, developed mitigation measures to address the system performance issues that were identified in the pre-Project and post-Project scenarios.

As part of this Project, mitigation measures will not be specifically developed for the POD bus voltage deviations observed under certain Category B conditions during pre-Project and post-Project scenarios.[2] POD bus voltage deviations observed at several substations (voltage collapse) under Category B contingency of 7L22 for all studies scenarios 1, 2, 3 and 4 were mitigated with the Poplar Hill generator turned on and dispatched to 10 MW.

5.1 Pre-Project

Pre-Project mitigation measures are summarized in Table 5-1 and Table 5-2.

Table 5-1: Pre-Project Mitigation Measures (Scenario 1)

Mitigation Measure	Observed Violation	Contingency
PH Gen 1 (on bus 16118) =10 MW	Voltage collapse	7L22 (Poplar Hill 790S - Clairmont Lake 811S)
PH Gen 1 (on bus 16118) =22 MW	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	7L69 (Goodfare 815S - Elmworth 731S)
PH Gen 1 (on bus 16118) =22 MW	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	7L03 (Elmworth 731S - Flyingshot Lake 749S)
RTOP	7L46 (Big Mountain 845S – P2843 Tap)	7L45 (Big Mountain 845S - Little Smoky 813S)
RTOP	7L45 (Bridge Creek Tap – P2843 Tap)	7L46 (Big Mountain 845S - Little Smoky 813S)
Existing RAS 171: H.R. Milner 740S Overload and Transient Stability Mitigation	Transient Instability	7L20 (H.R. Milner 740S – Thornton 2091S)
	Transient Instability	7L228 (Big Mountain 845S – Thornton 2091S)

Table 5-2: Pre-Project Mitigation Measures (Scenario 2)

Mitigation Measure	Location of Observed Violation	Contingency
PH Gen 1 (on bus 16118) =10 MW	Voltage collapse	7L22 (Poplar Hill 790S - Clairmont Lake 811S)

5.2 Post-Project

Post-Project mitigation measures are summarized in Table 5-3, and Table 5-4.

Table 5-3: Post-Project Mitigation Measures (Scenario 3)

Mitigation Measure	Observed Violation	Contingency
PH Gen 1 (on bus 16118) =10 MW	Voltage collapse	7L22 (Poplar Hill 790S - Clairmont Lake 811S)

[2] The AESO's desired post-contingency voltage deviations for low voltage busses represent guidelines rather than criteria. A POD bus voltage deviation that exceeds the desired limits shown in Table 3-1 of the AESO's Connection Study Scope does not represent a Reliability Criteria violation.

Mitigation Measure	Observed Violation	Contingency
PH Gen 1 (on bus 16118) =22 MW	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	7L69 (Goodfare 815S - Elmworth 731S)
PH Gen 1 (on bus 16118) =22 MW	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	7L03 (Elmworth 731S - Flyingshot Lake 749S)
RTOP	7L46 (Big Mountain 845S – P2843 Tap)	7L45 (Big Mountain 845S - Little Smoky 813S)
RTOP	7L45 (Bridge Creek Tap – P2843 Tap)	7L46 (Big Mountain 845S - Little Smoky 813S)
Modified existing RAS 171: H.R. Milner 740S Overload and Transient Stability Mitigation*	Transient Instability	7L20 (H.R. Milner 740S – Thornton 2091S)
	Transient Instability	7L228 (Big Mountain 845S – Thornton 2091S)

*Existing RAS 171 is modified as part of this project due to addition of telecom on the 7L20/7L228 path

Table 5-4: Post-Project Mitigation Measures (Scenario 4)

Mitigation Measure	Location of Observed Violation	Contingency
PH Gen 1 (on bus 16118) =10 MW	Voltage collapse	7L22 (Poplar Hill 790S - Clairmont Lake 811S)

5.3 Evaluation of Mitigation Measures

This section describes the results of the power flow studies that were performed to assess the impact of the Project on the performance of the AIES following the implementation of the proposed mitigation measures.

The post-mitigation measures studies were performed under Category B conditions for the post-Project Scenario 3 and 4 using Alternative 1 and the mitigation measures described in Section 5.2.

The post-mitigation power flow diagrams for selected Category B conditions are provided in Attachment A6. Post-mitigation power flow diagrams present only those contingencies that result in thermal criteria violations that require mitigation. Contingencies that result in thermal criteria violations that can be mitigated by real-time operational practices, or TFO capital maintenance projects were not studied.

5.3.1 Scenario 3: 2028 SP LG Post-Project

Category B Conditions

Thermal and voltage criteria violations observed under certain Category B conditions in the post-Project studies were mitigated by proposed mitigation measures as shown in Table 5-5 and Table 5-6.

Table 5-5: Post-Mitigation Power Flow Study Results for Scenario 3

Contingency (System Element Lost)	Details of Violation (Violation Observed On)	Seasonal Continuous Rating (MVA)	Short-term (Emergency) Rating (MVA)	Post-Project Results		Post-Mitigation Results	
				Power Flow (MVA)	% Loading	Power Flow (MVA)	% Loading
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occurred					No Reliability Criteria violations	
7L69 (Goodfare 815S - Elmworth 731S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	134.6	124.3	106.0	97.9
7L03 (Elmworth 731S - Flyingshot Lake 749S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	132.7	122.6	106.0	97.9

Table 5-6: Voltage Range Violations under Category B Conditions for Scenario 3

Contingency (System Element Lost)	Substation Name and Number	Bus Number	Nominal kV	Emergency Minimum Voltage (kV)	Emergency Maximum Voltage (kV)	Initial Voltage (kV)	Steady State Voltage (kV)	Post-Mitigation Steady State (kV)
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occured							No Reliability Criteria violations
7L69 (Goodfare 815S - Elmworth 731S)	Updike 886S	1114	144	130	155	140.5	129.1	141.7

Table 5-7: Post-RAS Transient Stability Study Results for Scenario 3

Studied Contingency	Fault Description and Location	Results
7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	Stable
	3-phase fault at Thornton 2091S	Stable
	1-phase fault at H.R. Milner 740S	Stable
	1-phase fault at Thornton 2091S	Stable
	Breaker Open condition at Both Ends	Stable
7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	Stable
	3-phase fault at Thornton 2091S	Stable
	1-phase fault at Big Mountain 845S	Stable
	1-phase fault at Thornton 2091S	Stable

	Breaker Open condition at Both Ends	Stable

5.3.2 *Scenario 4: 2028 WP LG Post-Project*

Category B Conditions

Thermal and voltage criteria violations observed under certain Category B conditions in the post-Project studies were by proposed mitigation measures as shown in Table 5-8, 5-9 and Table 5-10.

Table 5-8: Post-Mitigation Power Flow Study Results for Scenario 4

Contingency (System Element Lost)	Details of Violation (Violation Observed On)	Seasonal Continuous Rating (MVA)	Short-term (Emergency) Rating (MVA)	Post-Project Results		Post-Mitigation Results	
				Power Flow (MVA)	% Loading	Power Flow (MVA)	% Loading
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse					No Reliability Criteria violations	

Table 5-9: Voltage Range Violations under Category B Conditions for Scenario 4

Contingency (System Element Lost)	Substation Name and Number	Bus Number	Nominal kV	Emergency Minimum Voltage (kV)	Emergency Maximum Voltage (kV)	Initial Voltage (kV)	Steady State Voltage (kV)	Post-Mitigation Steady State (kV)
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse occured							No Reliability Criteria violations

Voltage stability studies

The voltage stability margin violation was mitigated by the proposed mitigation measures. The voltage stability study results under Category A conditions and for the five worst contingencies under Category B conditions are listed in Table 5-10, and the corresponding diagrams are listed in Attachment A7.

Table 5-10 Voltage Stability Study Results under Category B Conditions for Scenario 4_ Post-Mitigation

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		180	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	60	Yes

7L75	Friednestal 800S	West Peace River 793S	105	Yes
7L03	Flyingshot Lake 749S	Elmworth 731S	110	Yes
7L73	Friednestal 800S	Rycroft 730S	125	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		130	Yes

6 Project Interdependencies

The Project is not dependent on the future developments of the AESO Long Term Plan for the region.

Attachment A1

Engineering Connection Assessment Study Scope

Study Scope

P2716 Wapiti 823S Load

ATCO Electric Ltd.

Date: Jan 7, 2025

Version: V1

Classification: Public

Company Name	Name and Credentials	Date	Signature
ATCO (Study Consultant)	Vijitha Wijetilleke, P.Eng.	1/14/2025	Signed by: Vijitha Wijetilleke
AESO	Yasaman Mozafari, P.Eng.	1/15/2025	DocuSigned by: Yasaman Mozafari Jovein 163A5D5335A3449...
ATCO Electric Ltd. (TFO)	Vik Gautam, P.Eng.	1/14/2025	Signed by: 7E97686BAD6A4A3...
ATCO Electriv Ltd. (DFO/Market Participant)	Landon Kelly	1/15/2025	Signed by: 666316D3C7FD4E8...

Contents

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1 Introduction

This Study Scope provides an overview of the engineering studies to be completed by ATCO Electric Ltd. (the Studies Consultant) to assess the impact of the Project (as defined in section 1.1) on the performance of the Alberta interconnected electric system (AIES). Technical criteria, assumptions and methods for performing these engineering studies are provided in this document.

1.1 Project Overview

ATCO Electric Ltd. (Market Participant), in its capacity as the legal owner of an electric distribution system (DFO), has submitted a request for system access service to the Alberta Electric System Operator (AESO) to serve multiple load requests near the city of Grande Prairie area.

The DFO's request includes a request for a Rate DTS, Demand Transmission Service, contract capacity of 21.3 MW for a new system access service in the Grand Prairie planning area (Area 20) and a request for transmission development (collectively, the Project). Specifically, the DFO requested a new point of delivery (POD) substation.

The Project in-service date (ISD) used for the purpose of the studies is April 1, 2027.

Load components of the Project are listed in Table 1-1.

Table 1-1: Project Load Details

Project Component		Description
Load	Existing Rate DTS, *Demand Transmission Service,* contract capacity	No existing contract
	Requested Rate DTS	21.3 MW
	Type	industrial (except oilsands)
	Motors (number and size)	NA
	Power factor	0.9 pf
	Future load expansion plans	No

1.2 Existing System Overview

1.2.1 Study Area

Geographically, the Project is located in the AESO planning area of Grand Prairie (Area 20).

The Study Area consists of the AESO planning areas of Peace River (Area 19), Grande Prairie (Area 20), Grande Cache (Area 22), and Valleyview (Area 23), including the tie lines connecting these planning areas to the rest of the AIES.

The existing transmission system in the Study Area is shown in Figure 1-1.

1.2.2 Existing Constraints

Existing constraints in the Study Area are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management* (TCM Rule).

There are a number of constraints in the Study Area that are mitigated by existing remedial action schemes (RASs) and/or other protection schemes.

The following existing RASs and/or other protection schemes are used to manage constraints in the area:

- RAS 158: Ksituan 754S Voltage Stability Mitigation
- RAS 171: H.R. Milner 740S Overload and Transient Instability Mitigation

2 Connection Alternative to be Studied

The following alternative will be studied:

2.1 Alternative 1 – New Point of Delivery with a T-tap connection to the 144 kV transmission line 7L228

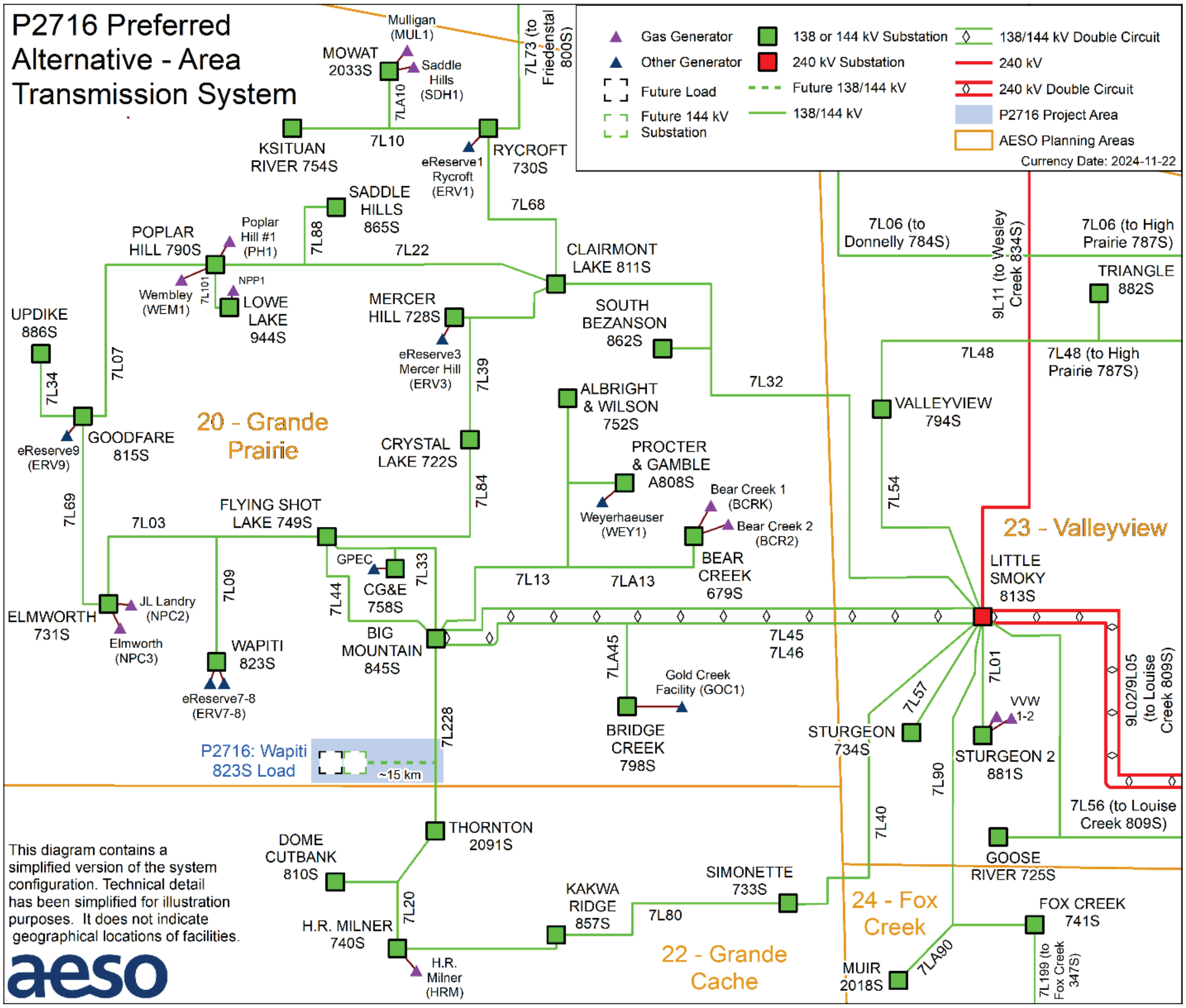
This alternative includes the following developments:

- Add a new 144/25 kV Point of Delivery (POD) substation, including one 144/25 kV transformer, one 144 kV circuit breaker and two 25 kV feeder breakers;
- Add one 144 kV circuit, approximately 15 km in length[1], to connect the proposed substation to the existing 144 kV transmission line 7L228 (between Big Mountain 845S and Thornton 2091S substations) using T-tap configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 1-1.

[1] Exact length to be determined by the TFO

Figure 1-1: Connection Alternative 1



3 Criteria, Standards and Requirements

3.1 AESO Reliability Criteria

The Transmission Planning (TPL) Standards, which are included in the Alberta Reliability Standards, and *Transmission Planning Criteria – Basis and Assumptions (see Attachment A),* (collectively, the Reliability Criteria) will be applied to evaluate system performance under Category A system conditions (i.e., all elements in-service) and following Category B contingencies (i.e., single element outage), prior to and following the studied alternatives. Below is a summary of Category A and Category B system conditions.

Category A, often referred to as the N-0 condition, represents a normal system with no contingencies and all facilities in service. Under this condition, the system must be able to supply all firm load and firm transfers to other areas. All equipment must operate within its applicable rating, voltages must be within their applicable range, and the system must be stable with no cascading outages.

Category B events, often referred to as an N-1 or N-G-1 with the most critical generator out of service, result in the loss of any single specified system element under specified fault conditions with normal clearing. These elements are a generator, a transmission circuit, a transformer, or a single pole of a DC transmission line. The acceptable impact on the system is the same as Category A. Planned or controlled interruptions of electric supply to radial customers or some local network customers, connected to or supplied by the faulted element or by the affected area, may occur in certain areas without impacting the overall reliability of the interconnected transmission systems. To prepare for the next contingency, system adjustments are permitted, including curtailments of contracted firm (non-recallable reserved) transmission service electric power transfers.

The TPL standards, TPL-001-AB-0 and TPL-002-AB1-0, have referenced Applicable Ratings when specifying the required system performance under Category A and Category B events. For the purpose of applying the TPL standards to the studies documented in this report, Applicable Ratings are defined as follows:

- Normal thermal rating of the line's loading limits for each season;
- The highest specified loading limits for transformers;
- For Category A conditions: Voltage range under normal operating condition per AESO Information Document #2010-007RS, *General Operating Practices – Voltage Control* (ID #2010-007RS). For the busses not listed in ID #2010-007RS, Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions* applies;
- For Category B conditions: The extreme voltage range values per Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions; and*
- Desired post-contingency voltage deviation limits for three defined post-event timeframes as provided in Table 3-1.

Table 3-1: Post-Contingency Voltage Deviation Guidelines for Low Voltage Busses

Parameter and reference point	Time Period		
	Post Transient (up to 30 sec)	Post Auto Control (30 sec to 5 min)	Post Manual Control (Steady State)
Voltage deviation from steady state at point of delivery (POD) low voltage bus.	±10%	±7%	±5%

3.2 ISO Rules and Information Documents

ID #2010-007RS will be used to establish system normal (i.e., pre-contingency) voltage profiles for the Study Area.

The TCM Rule will be followed to set up the study scenarios and assess the impact of the Project. In addition, due regard will be given to the following:

- The AESO's *Connection Study Requirements*;
- Section 502.7 of the ISO rules, *Load Facility Technical Requirements*.

4 Scenarios and Assumptions

4.1 Scenarios

The following section describes the scenarios to be studied and the assumptions to be used in the studies.

Connection scenarios must be studied as outlined in Table 4-1.

Table 4-1: Connection Study Scenarios

Scenario No.	Year/Season	System Generation Dispatch Conditions	Scenario Name	Project Load (MW)
Pre-Project				
1	2028 Summer Peak (SP)	Low Generation (LG)	2028 SP Pre-Project	0
2	2028 Winter Peak (WP)		2028 WP Pre-Project	0
Post-Project				
3	2028 SP	LG	2028 SP Post-Project	21.3
4	2028 WP		2028 WP Post-Project	21.3
5	2033 WP	All generator in Study Area in-service	2033 WP Post-Project	21.3

4.2 Assumptions

4.2.1 System Project Assumptions

The pre-Project and post-Project connection assessment will not include any system transmission projects because there are no planned system transmission developments in the Study Area that are expected to be in service before the scheduled Project ISD.

4.2.2 Connection Project Assumptions

Table 4-4 summarizes the connection projects in the Study Area that should be included in the studies.

4.2.3 Load Assumptions

The load forecast to be used for the studies is shown in Table 4-2 and is a forecast for the AESO Northwest Planning Region peak based on the AESO's preliminary 2023 Long-term Outlook (2023 LTO) with modifications to incorporate the latest forecast intelligence. For the post-Project studies, when the Study Area loads are modified to align with the regional load forecast, the active power to reactive power ratio in the base case scenarios shall be maintained.

Table 4-2: Forecast Load (at AESO Northwest Planning Region Peak)

AESO Planning Region Name	Forecast Peak Load by Year/Season (MW)	
	2028 SP	2028 WP
Northwest Planning Region[1]	1071	1208

Note:
[1] The Northwest Region comprises the following AESO planning areas: 17, 18, 19, 20, 21, 22, 23, 24, 26.

IDEV files contain non-motor loads in zones 34, 36, and 351. These loads are not accounted for in the forecasted peak loads shown above and should not be considered when scaling load. The AESO engineer will provide guidance to load scaling procedures as required.

4.2.4 Generation Assumptions

The generation forecast to be used for the studies is based on the 2023 LTO with modifications to incorporate the latest forecast intelligence. The generation assumptions for the studies will assume low generation condition in the Northwest region. Additional studies may be required in the event of changes to the AESO's corporate forecast.

The existing generation (excluding wind and solar) dispatch conditions for the study scenarios are described in Table 4-3.

H.R. Milner (HRM) was determined to be the critical generator, and shall be modelled as being offline to simulate the N-G condition in all the study scenarios.

Table 4-3: Existing Generation (excluding Wind and Solar) and Energy Storage Dispatch Conditions

Facility Name	Unit No.	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
					2028 SP [LG][b]	2028 WP [LG][b]
Fort Nelson (FNG1)	1, 2	1015 1019	73	17	66	72
Bear Creek 2 (BCR2)	2	18142	36	20	27	30
Bear Creek 1 (BCRK)	1	19142	64	20	59	63
Mulligan (MUL1)	G5, G6	557216	5	20	4	5
Rainbow Lake (RB4)	4	1035	47	17	42	47
Saddle Hills (SDH1) (P2208)	G1-4	557116	10	20	9	10
Whitecourt Power (EAGL)	1	408	25	26	25	25
Grande Prairie EcoPower (GPEC)	2	17101	27	20	8	8
NRGreen (NRG3)	G1	2674	16	26	12	13

Facility Name	Unit No.	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation[a] (MW) by Scenario	
					2028 SP [LG][b]	2028 WP [LG][b]
Slave Lake (SLP1)	G1, G2, G3	1232	9	21	9	9
Weyerhaeuser (WEY1)	1	1146	48	20	0	35
DAI1 Daishowa (DAI1)	1, 2	1087 1089	52	19	46	46
Gold Creek Facility (GOC1)	1	19145	5	20	0	0
AB Newsprint (ANC1)	G1 - 10	2296, 4296	63	26	0	57
Judy Creek (GEN6)	JC	19272	15	26	0	0
Carson Creek (GEN5)	1	2335	15	26	0	0
H.R. Milner (HRM)	1, G2	1148, 557147	300	22	111 (N-G)	111 (N-G)
NPC3 Elmworth (NPC3)	G1	19134	8	20	8	8
NPC2 JL Landry (NPC2)	5, 6, 7, 8, 10	17134, 18134, 21134	9	20	0	0
Northern Prairie Power Project (NPP1)	1	17120	105	20	0	0
Poplar Hill #1 (PH1)	1	16118	48	20	0	0
Rainbow #5 (RB5)	5	1037	50	17	0	0
Valley View 1 (VVW1)	1	1171	50	23	0	0
Valley View 2 (VVW2)	2	1173	50	23	0	0
West Cadotte (WCD1)	G1	19083	20	19	17	16
eReserve1 Rycroft (ERV1)	1	557101	20	20	0	0
eReserve3 Mercer Hill (ERV3) (P2387)	G4	19109	20	20	0	0
Swan Hills Geothermal (SRL1) (P2242)	G1, G2	558266 558366	21	26	18	18
Cascade 1 (CAS1)	G1	557014	450	29	311	311
Cascade 2 (CAS2)	G2	558014	450	29	311	311

Notes:
[a] "Unit Net Generation" refers to gross generating unit output (MW) less unit service load.
[b] "N-G" indicates the critical generating unit that is assumed by the AESO to be offline to test the N-G contingency condition

Table 4-4: Dispatch Conditions for Planned Generation Facilities

Facility Name and Code	Bus No.	MC (MW)	AESO Planning Area No.	Unit Net Generation (MW) by Scenario	
				2028 SP [LG]	2028 WP [LG]
P1885 Northern Lights WAGF	565005,565006	408	26	22	129
P2843 Prairie Lights Power Gas	549758	310	20	114.7	114.7
P2452 ATCO Poplar Hill 790S DER Gas	18118	6	20	0	0
P2456 Kiwetinohk Opal Gas	557024,557025	99	24	44	44
P2499 Kiwetinohk Black Bear Gas	557027,557028	466	26	317	317
P2554 ATCO Goodfare 815S DER Battery	19119	20	20	0	0
P2560 ATCO Wapiti 823S DER Battery	19135	40	20	0	0
P2631 Smoky River MPC Wind	569053	160	19	9	51
P2676 Kaybob South 3 Cogen	558342 558442	33	24	33	33

4.2.5 Intertie Flow Assumptions

The Alberta-British Columbia (AB-BC), Alberta-Saskatchewan (AB-SK), and Alberta-Montana (MATL) intertie points are deemed to be too far away from the Study Area to have any material impact on the connection assessment. Therefore, intertie flow values shall be set to the AESO planning base case values and will not be adjusted for the studies.

4.2.6 HVDC Power Order Assumptions

The Western Alberta Transmission Line (WATL) and the Eastern Alberta Transmission Line (EATL) are high-voltage direct current (HVDC) transmission lines. WATL and EATL are not expected to have a material impact on the connection assessment. Therefore, the HVDC assumptions shall be the same as in the AESO planning base cases and will not be adjusted for the studies.

The reactive power limits of the MVAr exchanges between the HVDC terminals (WATL and EATL) and the connected alternating current (AC) transmission systems are shown in Table 4-5. These limits must be maintained when performing the studies.

Table 4-5: HVDC to Adjacent AC System MVAr Exchange Limits

HVDC Facility	North Terminal Reactive Power Limit (MVAr)	South Terminal Reactive Power Limit (MVAr)
EATL	-85 to 75	-35 to 35
WATL	-75 to 75	-35 to 35

4.2.7 Transmission Facility Ratings

The legal owners of transmission facilities (TFOs) provided the thermal ratings assumptions for the existing transmission lines in the Study Area. Table 4-6 shows the normal ratings and emergency ratings for the key transmission lines in the Study Area, which will be used to perform the engineering studies.

Table 4-6: Thermal Rating Assumptions for Key Transmission Lines in the Study Area

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
7L03	Elmworth 731S – Flyingshot Lake 749S	144	130	162	144	184
7L04	Daishowa 839S – West Peace River 793S	144	85 Prot	85 Prot	85 Prot	85 Prot
7L06	High Prairie 787S – Donnelly 784S tap	144	114	151	127	173
7L06	West Peace River 793S – Donnelly 784S tap	144	114	150GS	127	150GS
7L07	Poplar Hill 790s – Goodfare 815S	144	113	151	126	173
7L10	Rycroft 730S – Mowat T-tap point	144	129	150CT	144	150CT
7L10	Ksituan 754S – Mowat T-tap point	144	129	162	144	184
7L13	Big Mountain 845S – Proctor & Gamble 808S	144	147	196	174	240
7L20	H.R. Milner 2091S – Dome cutbank tap	144	257 bus cond	299 GS	277 bus cond	299 GS
7L20	Thornton 2091S – Dome Cutbank tap	144	291	299GS	299GS	299GS
7L22	Poplar Hill 790S – 7L88 tap	144	113	151	126	172
7L22	Clairmont Lake 811S – 7L88 tap	144	114	151	126	171
7L27	Wesley Creek 834S – West Peace River793S	144	130	163	139	181
7L32	Clairmont Lake 811S – South Bezanson 826S	144	114	151	122	165
7L32	Little Smoky 813S – South Bezanson 826S	144	114	151	120	163

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
7L33	Flyingshot Lake 749S - CG&E 758S tap	144	167	210	195	251
7L33	Big Mountain 845S – CG&E 758S tap	144	167	265CT	197	265CT
7L34	Goodfare 815S – Updike 886S	144	114	146	129	149 CT
7L39	Clairmont Lake 811S – Mercer Hill 728S tap	144	130	162	141	180
7L39	Crystal Lake 722S – Mercer Hill 728S tap	144	130	150GS	141	150GS
7L40	Little Smoky 813S – Simonette 733S	144	129	162	134	179
7L43	Louise Creek 809S – Edith Lake 739S	144	112	133CT	125	133CT
7L44	Flyingshot 749S – Big Mountain 845S	144	167	210	190	248
7L45	Little Smoky 813S – Big Mountain 845S	144	145	195	166	229
7L46	Little Smoky 813S – Big Mountain 845S	144	145	195	166	229
7L48	Valleyview 794S – High Prairie 787S	144	114	151	127	172
7L49	Mitsue 732S – Otauwau 749S	144	114	152	127	173
7L51	West Peace River 793S – Buchanan Creek 927S tap	144	116	133CT	130	133CT
7L51	Hotchkiss 788S – Buchanan Creek 927S tap	144	117	156	131	179
7L54	Little Smoky 813S – Valleyview 794S	144	116	155	129	177
7L55	Louise Creek 809S – Sarah Lake 743S	144	112	120CT	120CT	120CT
7L56	Louise Creek 809S – Virginia Hills 738S tap	144	112	150	123	168
7L56	Little Smoky 813S – Goose River 725S tap	144	114	152	126	171
7L56	Virgenia Hills 738S tap - Goose River 725S	144	112	149	123	168
7L68	Rycroft 730S – Clairmont Lake 811S	144	116	155	129	178
7L69	Goodfare 815S – Elmworth 731S	144	115	155	129	178
7L73	Friedenstal 800S – Boucher Creek 829S tap	144	114	152	124	169
7L73	Rycroft 730S – Boucher Creek 829S tap	144	114	152	125	170
7L75	Friedenstal 800S – West Peace 793S	144	117 bus cond	147 bus cond	141 bus cond	150GS
7L80	H.R. Milner 733S – Kakwa Ridge tap	144	129	162	140	181
7L80	Kakwa Ridge tap– Simonette 733S	144	128	160	139	180

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
7L82	Ring Creek 853S – Hamburg 855S tap	144	112	150CT	126	150CT
7L82	Hotchkiss 788S – Hamburg 855S tap	144	112	150	126	173
7L84	Crystal Lake 722S – Flyingshot Lake 749S	144	168	211	198	256
7L90	Little Smoky 813S – Muir 7LA90 tap	144	113	151	122	167
7L90	Fox Creek 741S – Muir 7LA90 tap	144	113	150GS	122	150GS
7L120	Hotchkiss 788S – Meikle 905S	144	115	153	127	174
7L138	Hotchkiss 788S – Meikle 905S	144	131	164	143	187
7L199/199L	Fox Creek 741S – Fox Creek 347S	144	119	150GS	131	150GS
7L228	Thornton 2091S – Big Mountain 845S	144	261	265CT	265CT	265CT
7L230	Sarah Lake 743S – Fort Assiniboine 234S	144	114	151	125	172
9L02/9L05	Little Smoky 813 – Louise Creek 809S	240	499GS	499GS	499GS	499GS
9L10	Brintnell 876S – Livock 939S	240	491	658	583	798
9L11	Wesley Creek 834S - Little Smoky 813S	240	499GS	499GS	499GS	499GS
9L15	Wesley Creek 834S - Brintnell 876S	240	546	734	666	831
9L40	Mitsue 732S - Louise Creek 809S	240	499CT	499CT	499CT	499CT
9L913	Mitsue 732S – Barrhead 69S	240	496	499CT	499CT	499CT
9L938	Louise Creek 809S – Sagitawah 77S	240	500	644	642	663CT
9L939	Louise Creek 809S – Sagitawah 77S	240	500	644	614 bus cond	663CT
720L	Fox Creek 347S – Benbow 397S	138	120	149	132	164
685L	Benbow 397S – Deer Hill 1012S	138	167	201	184	218
199L	Fox Creek 347S – 199L T-tap	138	119	122	131	134
199L	199L T-tap – Whitecourt 268S	138	90	117	99	129
797L	Whitecourt 268S – Whitecourt Industrial 364S	138	93 LTD-L	129 LTD-L	102 LTD-L	142 LTD-L
798L	Whitecourt Industrial 364S – Sagitawah 77S	138	119	132 LTD-L	131	145 LTD-L
799L	Sagitawah 77S – South Mayerthorpe 443S	138	85	90	94	99
919L	Sagitawah 77S – Sundance 310P	240	489	606	587	727

Line ID	Line Description	Voltage Class (kV)	Normal Rating (MVA)		Emergency Rating (MVA)	
			Summer	Winter	Summer	Winter
989L	Sagitawah 77S – Sundance 310P	240	489	599	587	648

The TFOs provided the details of the substation transformers in the Study Area. The key transformers in the Study Area are shown in Table 4-7.

Table 4-7: Summary of Key Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	Transformer Rating (MVA)
Little Smoky 813S	901T	240/144/25	Summer:200 Winter: 237.5
Little Smoky 813S	902T	240/144/25	
Wesley Creek 834S	901T	240/144/25	Summer: 299CT Winter: 299CT
Wesley Creek 834S	902T	240/144/25	

The TFOs provided the details of the shunt elements in the Study Area. The key shunt elements in the Study Area are shown in Table 4-8.

Table 4-8: Summary of Key Shunt Elements in the Study Area

Substation Name and Number	Voltage Class (kV)	Capacitors		Reactors	
		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)
Wesley Creek 834S	240	-	-	1X-25.0	-25
	25	-	-	1X-20.0	-20
Little Smoky 813S	138	3X27.54	82.62	-	-
	25	-	-	1X-20.0	-20
	25	-	-	1X-20.0	-20
Little Smoky 813S - SVC	34.5	1X40.0+1X60.0	100	1X-60.0+1X-40.0	-100
Rycroft 730S - SVC	21	-	50	-	-
Poplar Hill 790S	138	1X22.67	22.67	-	-
	25	1X12.6	12.6	-	-
W Peace 793S	138	2X13.78	27.56	-	-
Ksituan River 754S	138	1X13.78	13.78	-	-

Substation Name and Number	Voltage Class (kV)	Capacitors		Reactors	
		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)
Friedenstal 800S	138	1X13.77	13.77	-	-
	25	1x4.8	4.8		
Mowat 2033S	138	1X9.18+1X13.78	22.96	-	-
Clairmont Lake 811S	138	1X22.98	22.98	-	-
Goodfare 815S	138	2X13.77	27.54	-	-
Crystal Lake 722S	138	1X27.17	27.17	-	-
Big Mountain 845S	138	1X27.54	27.54	-	-

4.2.8 Protection Fault Clearing Times

The transient stability studies will be performed using the actual fault clearing times for the selected contingencies, as provided by the TFO and as shown in Table 4-9. Only those contingencies shown in Table 4-9 will be studied for transient stability studies. If the TFO did not specify the fault clearing times (e.g. for new transmission lines) for a selected contingency, then the studies for that contingency will be performed using the standard fault clearing times that are specified in Table 2-3 of the AESO's *Transmission Planning Criteria – Basis and Assumptions*.

Table 4-9: Protection Fault Clearing Times

Contingency (System Element Lost)	Fault Location	Clearing Times (Cycles)	
		Near End	Far End
7L20 (H.R. Milner 740S – Dome Cutbank 810S – Thornton 2091S)	H.R. Milner 740S	5	8
7L20 (H.R. Milner 740S – Dome Cutbank 810S – Thornton 2091S)	Thornton 2091S	6	8
7L80 (H.R. Milner 740S – Kakwa Ridge 857S – Simonette 733S)	H.R. Milner 740S	6	42
7L80 (H.R. Milner 740S – Kakwa Ridge 857S – Simonette 733S)	Simonette 733S	6	24
7L40 (Simonette 733S – Little Smoky 813S)	Simonette 733S	6	24
7L40 (Simonette 733S – Little Smoky 813S)	Little Smoky 813S	6	42
7L228 (Thorton 2091S – Big Mountain 845S)*	Thorton 2091S	5	8
7L228 (Thorton 2091S – Big Mountain 845S)*	Big Mountain 845S	6	8

Notes:

* 7L228 does not have a line breaker at Thornton 2091S, and 7L20 line breaker clears the fault at this substation.

4.2.9 Project Dynamic Data

Dynamic data for the Project will be based on the Stage 1 Project Data Update Package (PDUP-1).

4.2.10 Voltage Profile Assumption

ID #2010-007RS will be used to establish system normal (i.e., pre-contingency) voltage profiles for key area busses prior to commencing any studies. Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions* applies for the busses not included in ID #2010-007RS. These voltages will be used to set the voltage profile for the study base cases prior to the power flow studies.

5 Study Methodology

The studies to be performed for this connection assessment are identified in Table 5-1.

Table 5-1: Summary of the Studies to be Performed

Scenario No. and Name		Power Flow		Voltage Stability		Transient Stability		Short Circuit
		Category		Category		Category		Category A
		A	B	A	B	A	B	
Pre-Project								
1	2028 SP LG	X	X					
2	2028 WP LG	X	X	X*	X*			X
Post-Project								
3	2028 SP LG	X	X			X**	X**	
4	2028 WP LG	X	X	X	X			X
5	2033 WP							X

Notes:
* Only required if post-project studies show potential stability issues.
** For the transient stability studies, switch on and dispatch H. R. Milner generation to 300 MW.

For the engineering studies, all transmission facilities 69 kV and above, within the Study Area and the transmission lines connecting these planning areas to neighbouring planning areas will be studied and monitored to assess the impact of the Project on the performance of the AIES, including any violations of the Reliability Criteria (as defined in Section 3.1).

5.1 Study Case Validation

The study will be conducted on the AIES system model using the AESO's planning base cases. The seasonal light/peak scenarios will be studied as required. The base cases will be modified by the AESO to include the corresponding load and generation forecast information. The resulting cases, or seed cases, along with the project IDEVs, will be provided by the AESO to the Studies Consultant. These cases are provided in PSS/E v34 and/or v33 format. Upon request, the AESO can provide RAW and SEQ files. Software used by the Studies Consultant must be able to read and write these file types. Manual adjustments may be required to ensure full alignment with the details outlined in this Study Scope, as described in the process outlined below. The AESO will provide guidance to the Studies Consultant with regard to the setup of the study cases should any questions arise.

The expected process for the creation of acceptable study cases is as follows:

1. The AESO provides seed cases and the appropriate incremental IDEVs to use and any other applicable information required to the Studies Consultant.

2. The Studies Consultant applies the identified IDEVs to the seed cases to create the study cases. The Studies Consultant verifies and makes adjustments as required to ensure the study cases represent the assumptions outlined within the Study Scope.
3. Upon creating the study cases, all the study cases are forwarded to the AESO for approval.
4. The Studies Consultant proceeds with the required engineering studies only after the study cases are approved by the AESO.

5.2 Power Flow Studies

Power flow studies will be performed to identify thermal and voltage criteria violations as per the Reliability Criteria, and any deviations from the limits listed in Table 3-1.

For information purposes, the Studies Consultant must also provide, as a separate file, a list of any transmission elements where the thermal loading exceeds 95% of the element's normal rating under Category A and Category B conditions.

For the Category B power flow studies, the transformer taps and switched shunt reactive compensating devices such as shunt capacitors and reactors will be locked and continuous shunt devices will be enabled.

Voltage deviations at point-of-delivery (POD) low voltage busses will also be assessed for both the pre-Project and post-Project networks by first locking all tap changers and area shunt reactive compensating devices to identify any post-transient voltage deviations above 10%. Second, tap changers will be allowed to move while shunt reactive compensating devices remained locked to determine if any voltage deviations above 7% would occur in the area. Third, all the taps and shunt reactive compensating devices will be allowed to adjust, and voltage deviations above 5% will be reported.

The scenarios to be studied are shown in Table 5-1.

5.2.1 Contingencies to be Studied

Power flow studies will be performed for the Category A and all Category B conditions in the Study Area.

5.3 Voltage Stability Studies

The objective of the voltage stability studies is to determine the ability of the transmission system to maintain voltage stability margin at all busses under Category A and Category B conditions. The power-voltage (PV) curve is a representation of voltage change as a result of increased power transfer between two systems. The incremental transfers will be reported at the collapse point.

Voltage stability studies will be performed for the post-Project scenarios. For load connection projects, the load level modeled in post-Project scenarios is the same as, or higher than, in pre-Project scenarios. Therefore, voltage stability studies for pre-Project scenarios will only be performed if post-Project scenarios show voltage stability criteria violations.

Voltage stability studies will be performed according to the Western Electricity Coordinating Council (WECC) Voltage Stability Assessment Methodology. WECC voltage stability criteria states, for load areas, post-transient voltage stability margin is required for the area modeled at a minimum of 105% of the reference load level for Category A conditions and for Category B conditions. For this standard, the reference load level is the maximum established planned load.

Typically, voltage stability studies are carried out assuming the worst case scenarios in terms of loading. In this connection assessment, the voltage stability studies will be performed by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing generation in Wabamun (Area 40) and Fort McMurray (Area 25).

The scenarios and cases to be studied are shown in Table 5-1.

5.3.1 Contingencies to be Studied

Voltage stability studies will be performed for all Category B contingencies in the Study Area. The Category A condition and the five contingencies with the smallest stability margin will be presented in the results.

5.4 Transient Stability Studies

The Genesee Unit #3 in Wabamun (Area 40) will be used as the reference for the studies.

The report presenting the results of the transient stability studies must provide response plots for several variables, including rotor angle, and active and reactive power output for the H.R. Milner generation and other generating units in the study area. The results report must also provide the 500 kV, 240 kV and 138 kV bus voltage levels for substations near the point of connection. Other busses will be monitored and will be reported as determined by the results. The results report must also provide the key branch active and reactive power flow surrounding the Facility.

Transient stability studies will be performed for the post-Project scenarios as shown in Table 5-1. The studies are to be performed for scenario 3 (2028 SP LG). The H.R. Milner generation needs to be switched on and dispatched to its MC of 300 MW for the purpose of these studies.The transient stability concerns at H.R. Milner is a known issue and performing studies for the pre-Project scenarios is not required.

The transient stability studies are required to confirm the effectiveness of the existing RAS 171 after connection of this project and telecom upgrade at H.R Milner substation 740S, and to determine if any modifications to the RAS settings is needed as a result of this project. Due to the existing stability concerns for H.R. Milner generation, transient stability studies will be performed for three-phase faults, single line-to-ground faults and breaker open conditions.

5.4.1 Contingencies to be Studied

Transient stability studies will be performed for the contingencies shown in Table 4-9

5.5 Short-Circuit Current Level Studies

A maximum fault level must be provided for the substations in the vicinity of the Project assuming normal system operation with all transmission elements in service and generation dispatched. Three-phase faults and single line-to-ground faults will be simulated. Polar coordinates and per-unit values will be used for reporting the results.

Winter peak scenarios will be used for the short-circuit studies because winter peak scenarios generally produce higher short-circuit current levels than summer peak scenarios.

Estimated maximum three-phase faults and single line-to-ground short-circuit current levels will be reported for the following substations:

- Big Mountain 845S
- Little Smoky 813S
- Thornton 2091S
- H.R. Milner 740S
- Bridge Creek 798S
- Wapiti 823S
- New POD substation (including in post-Project studies only)

Further sensitivity studies, in consultation with the TFO, may be required if the primary short-circuit analysis indicates a potential to exceed or approach the existing fault rating of the transmission facilities.

The scenarios to be studied are as shown in Table 5-1.

6 Mitigation Measures

6.1 Development

Mitigation measures may be required if the post-Project study results identify system performance issues. Mitigation measures for the Project may involve modifying or adding real-time operational practices and/or remedial action schemes (RASs).

The Studies Consultant must notify the AESO of any system performance issues in a timely manner, following which the AESO Studies Engineer may instruct the Studies Consultant as follows:

- Develop tables showing the constraint effective factors[2] for generation or load based on thermal criteria violations that are observed.
- Collaborate with the AESO to propose changes, if any, to the connection alternatives that could remove the requirement for a RAS.
- Collaborate with the AESO to study modifications to existing and/or planned RASs, proposed by the AESO, to ensure the coordination of existing protection schemes with the addition of any proposed protection schemes.
- Collaborate with the AESO to identify and study new RASs, if any, that may be required to ensure system reliability is maintained after connecting the Project to the AIES.

The AESO Studies Engineer will work closely with the Studies Consultant and guide the development and/or modifications of the proposed mitigation measures to ensure system reliability, security and compliance with AESO ID #2018-018T, *Provision of System Access Service and the Connection Process*.

6.2 Evaluation

6.2.1 Post-Mitigation Studies

Studies to evaluate the effectiveness of mitigation measures, if required, will be performed in accordance with the technical criteria, assumptions, and methods provided in this Study Scope and in accordance with further instructions from the AESO.

6.2.2 Constraint Effective Factor Studies

Constraint effective factor analysis are used to determine the generator- and load- constraint effective factors and to identify the most effective generators or loads to manage the thermal criteria violations, if any, that are observed under Category B conditions.

[2] Constraint effective factor studies are performed to determine the generator- and load- constraint effective factors. Constraint effective factors are used to estimate the ability of generators and loads to manage transmission constraints. A generator's or load's constraint effective factor is defined as the change in power flow over a specific transmission line following a change in the generator's energy production or in the load's energy consumption. The greater the constraint effective factor, the more effective a generator or load can be in managing a thermal criteria violation on the specific transmission line.

7 Changes to Study Assumptions

This study will utilize the AESO's planning base cases, which are based on the AESO's current corporate forecast (2021 LTO) with modifications to incorporate the latest forecast intelligence. Sensitivity studies or restudy may be required in the event of revisions to the AESO's corporate forecast, forecast intelligence, or other study assumptions. Additional engineering studies may also be required to assess new connection alternatives, changes to project ISD, or delays in proposed system developments. Any additional or revised study requirements shall be captured in a signed Study Scope Amendment document.

Attachment A: Transmission Planning Criteria – Basis and Assumptions

Transmission Planning Criteria – Basis and Assumptions

Date: July 9, 2019

Version: V1.2

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1. Introduction

This document presents the reliability standards, criteria, and assumptions to be used as the basis for planning the Alberta Transmission System. The criteria, standards and assumptions identified in this document supersede those previously established.

2. Transmission Reliability Standards and Criteria[1]

The AESO applies the following Alberta Reliability Standards to ensure that the transmission system is planned to meet applicable performance requirements under a defined set of system conditions and contingencies. A brief description of each of these standards is given below:

1. **TPL-001-AB-0: System Performance Under Normal Conditions**
   Category A represents a normal system condition with all elements in service (N-0). All equipment must be within its applicable rating, voltages must be within their applicable ratings and the system must be stable with no cascading outages. Under Category A, electric supply to load cannot be interrupted and generating units cannot be removed from service.

2. **TPL-002-AB1-0: System Performance Following Loss of a Single BES Element**
   Category B events result in the loss of any single element (N-1) under specified fault conditions with normal clearing. The specified elements are a generating unit, a transmission circuit, a transformer or a single pole of a direct current transmission line. The acceptable impact on the system is the same as Category A with the exception that radial customers or some local network customers, including loads or generating units, are allowed to be disconnected from the system if they are connected through the faulted element. The loss of opportunity load or opportunity interchanges is allowed. No cascading can occur.

3. **TPL-003-AB-0: System Performance Following Loss of Two or More BES Elements**
   Category C events result in the loss of two or more bulk electric system elements (sequential, N-1-1 or concurrent, N-2) under specified fault conditions and include both normal and delayed fault clearing. All of the system limits for Category A and B events apply with the exception that planned and controlled loss of firm load, firm transfers and/or generation is acceptable provided there is no cascading.

4. **TPL-004-AB-0: System Performance Following Extreme BES Events**
   Category D represents a wide variety of extreme, rare and unpredictable events, which may result in the loss of load and generation in widespread areas. The system may not be able to reach a new stable steady state, which means a blackout is a possible outcome. The AESO needs to evaluate these events, at its discretion, for risks and consequences prior to creating mitigation plans.

5. **FAC-014-AB1-2: Establishing and Communicating System Operating Limits**
   The AESO is required to establish system operating limits where a contingency is not mitigated through construction of transmission facilities

[1] A complete description of the *Alberta Reliability Standards* can be found on the AESO's website: https://www.aeso.ca/rules-standards-and-tariff/alberta-reliability-standards/

2.1 Thermal Loading Criteria

The AESO Thermal Loading Criteria require that the continuous thermal rating of any transmission element is not exceeded under normal and post-contingency operating conditions. Thermal limits are assumed to be 100% of the respective normal summer and winter ratings. Emergency limits are not considered in the planning evaluations.

2.2 Voltage Range and Voltage Stability Criteria

The normal minimum and maximum voltage limits as specified in the following table are used to identify Category A system voltage violations, while the extreme minimum and maximum limits are used to identify Category B and C system violations. Table 2-1 presents the acceptable steady state and contingency state voltage ranges for the AIES. Table 2-2 provides voltage stability criteria used to test the system performance.

Table 2-1: Acceptable Range of Steady State Voltage (kV)

Nominal Voltage	Extreme Minimum	Normal Minimum	Normal Maximum	Extreme Maximum
500	475	500	525	550
240	216	234	252	264
260 (Northeast & Northwest)*	234	247	266	275
144	130	137	151	155
138	124	135	145	150
72	65	68.5	75.5	79
69	62	65.5	72.5	76

Table 2-2: Voltage Stability Criteria

Performance Level	Disturbance (1)(2)(3)(4) Initiated by: Fault of No Fault DC Disturbance	MW Margin (P-V method) (5)(6)(7)	MVAr Margin (V-Q method) (6)(7)
A	Any element such as: One Generator One Circuit One Transformer One Reactive Power Source One DC Monopole	≥5%	Worst Case Scenario(8)
B	Bus Section	≥5%	50% of Margin Requirement in Level A
C	Any combination of two elements such as: A Line and a Generator A Line and a Reactive Power Source Two Generators Two Circuits Two Transformers Two Reactive Power Sources DC Bipole	≥2.5%	50% of Margin Requirement in Level A
D	Any combination of three or more elements such as: Three or More Circuits on ROW Entire Substation Entire Plant Including Switchyard	> 0	> 0

2.3 Transient Stability Analysis Assumptions

Standard fault clearing times as shown in Table 2-3 are used for the new facilities or when the actual clearing times are not available for the existing facilities. Double line-to-ground faults are applied for the Category C5 events with normal clearing times. Single line-to-ground faults are applied for Category C6 to C9 events with delayed clearing times as depicted in Table 2-4 and Table 2-5.

Table 2-3: Fault Clearing Times

Nominal (kV)	Near End (Cycles)	Far End (Cycles)
500	4	5
240	5	6
144/138 with telecommunications	6	8
144/138 without telecommunications	6	30

Table 2-4: Stuck Breaker Clearing Times for Lines

Voltage (kV)	Fault Clearing Times (Cycles)		
	Near End	Far End	2nd Ckt (C5 and C7 only)
138/144	15	24	24
240	12	6	14
500	9	5	11

Table 2-5: Stuck Breaker Clearing Times for Transformers

Voltage (kV)	Fault Location	Fault Clearing Times (Cycles)		
		High Side	Low Side	2nd Ckt (breaker fail)
240/138	240 kV side	12	6	14
	138 kV side	5	15	24
500/240	500 kV side	9	5	11
	240 kV side	4	12	14

Attachment A2
Pre- Project Power Flow Diagrams (Scenario 1, 2)

Pre-Project Power Flow Results

Power Flow Diagrams

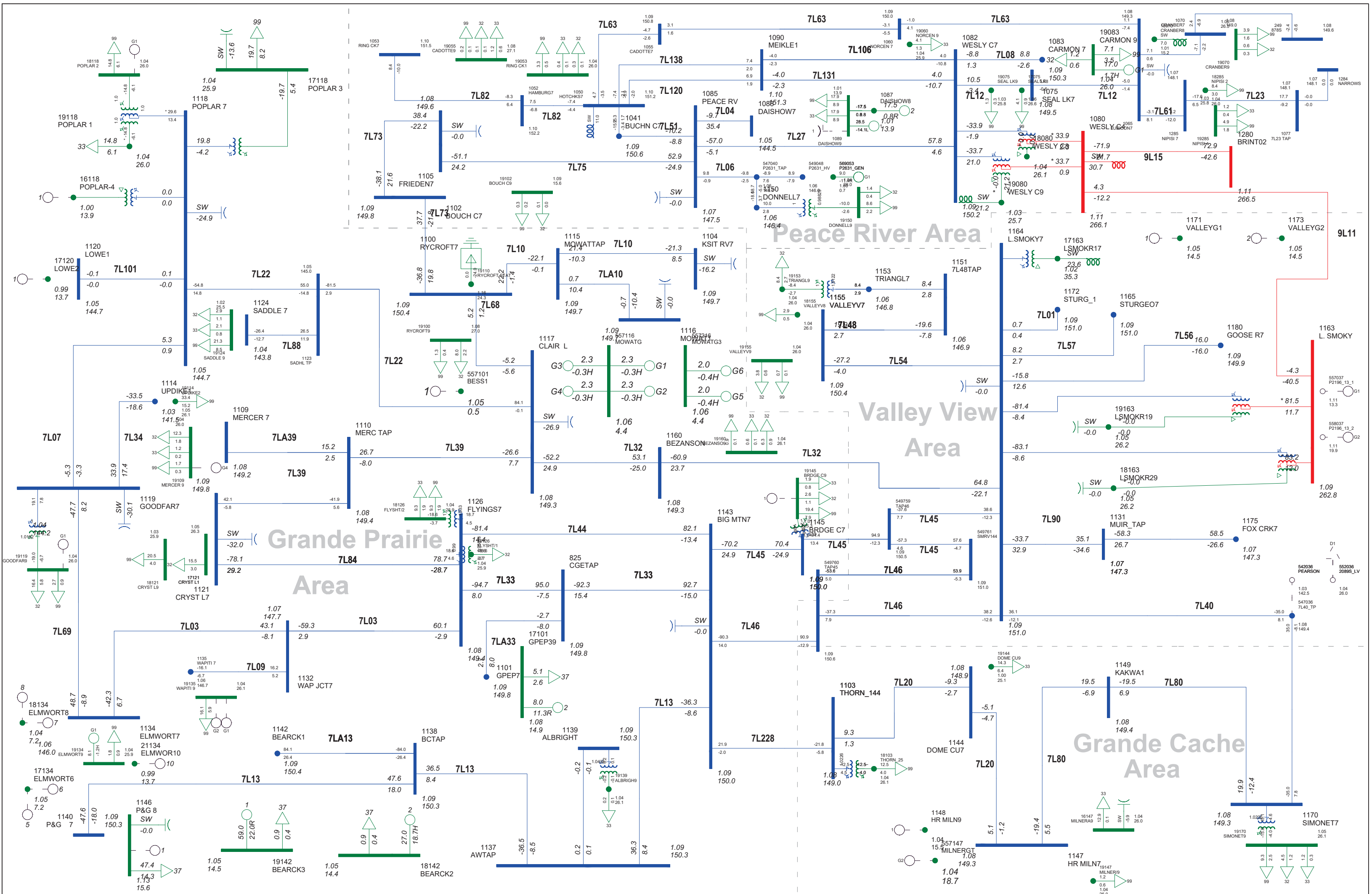
The pre-Project power flow diagrams for Scenario 1 2028 SP and Scenario 2 2028 WP under Category A condition and Category B contingencies are provided in this attachment as identified in the following tables.

Table A2-1: List of pre-Project Scenario 1 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Scenario 1	N-0, System Normal Condition	A2-3
	N-1, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A2-4
	N-1, Loss of 7L03 (Elmworth 731S - Flyingshot Lake 749S)	A2-5
	N-1, Loss of 7L69 (Goodfare 815S - Elmworth 731S)	A2-6
	N-1, Loss of 7L46 (Big Mountain 845S - Little Smoky 813S)	A2-7
	N-1, Loss of 7L45 (Big Mountain 845S - Little Smoky 813S)	A2-8

Table A2-2: List of pre-Project Scenario 2 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Scenario 2	N-0, System Normal Condition	A2-9
	N-1, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A2-10



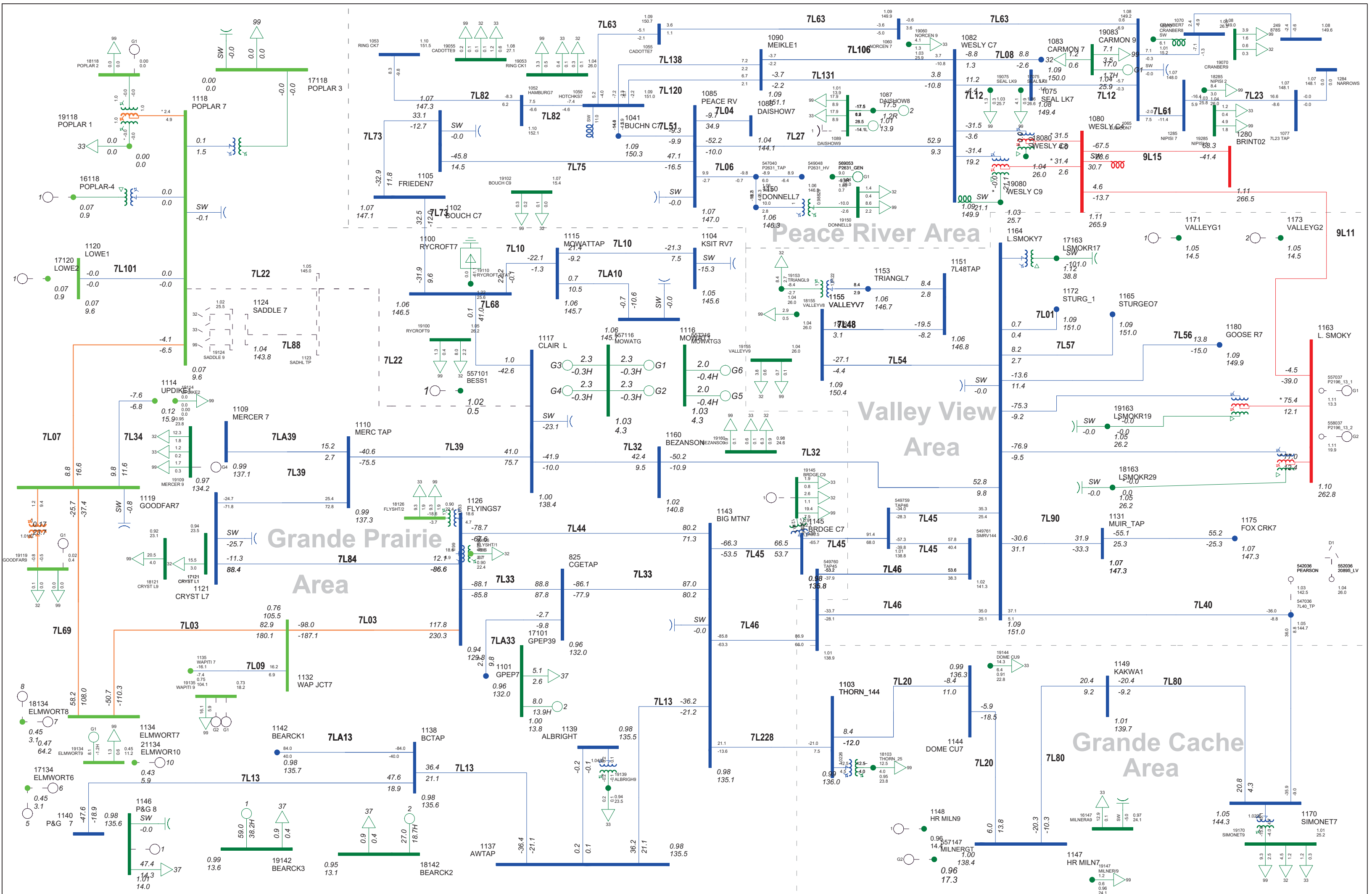
P2716

ATCO Wapiti 823S Load

CATEGORY A, N-0
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUN 16 2025 16:23

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

A2 - 3



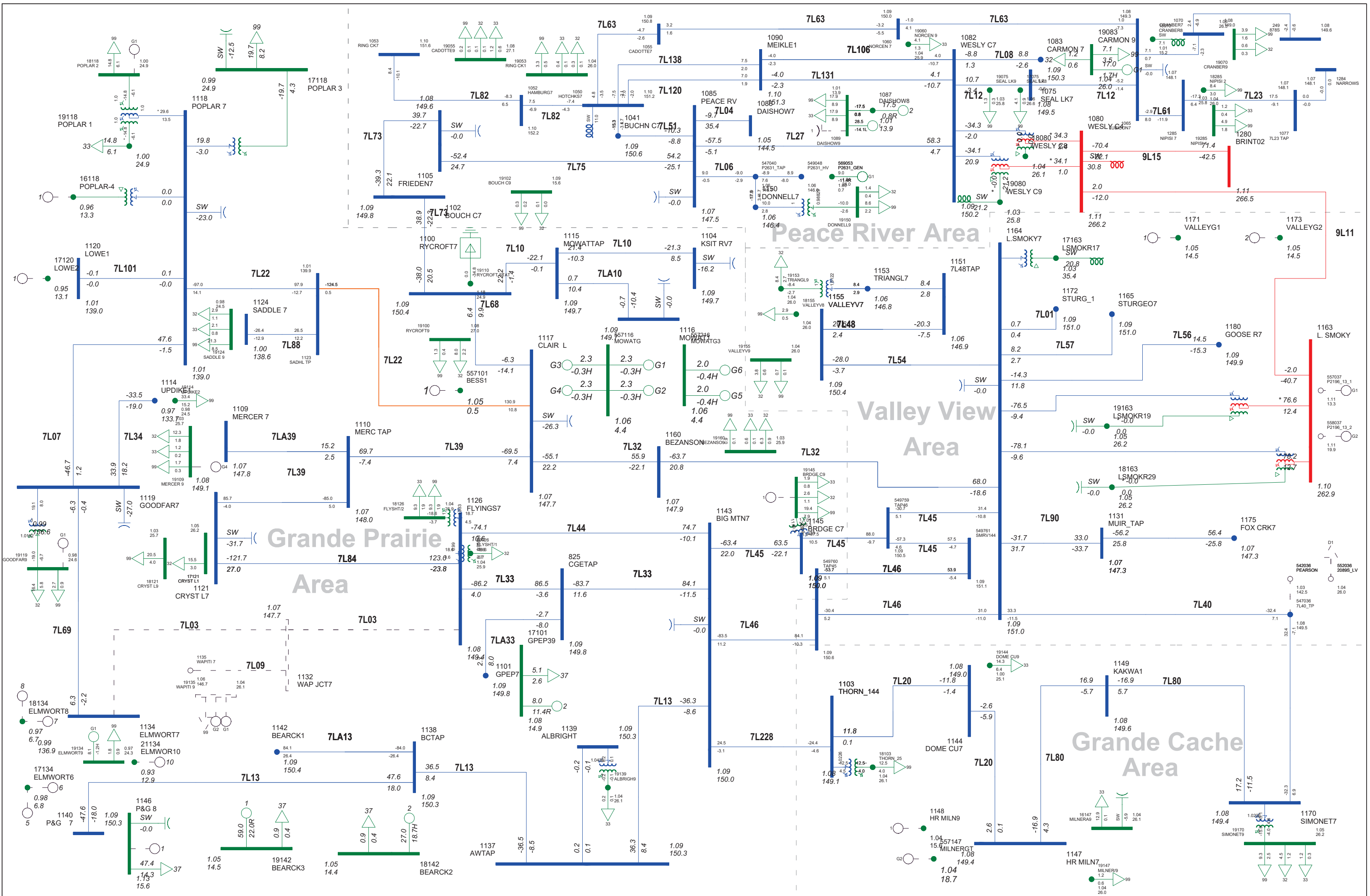
P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (Poplar Hill 790S - Clairemont Lake 811S)
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUN 16 2025 16:23MON, JUN 16 2025 16:23

A2 - 4

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



P2716

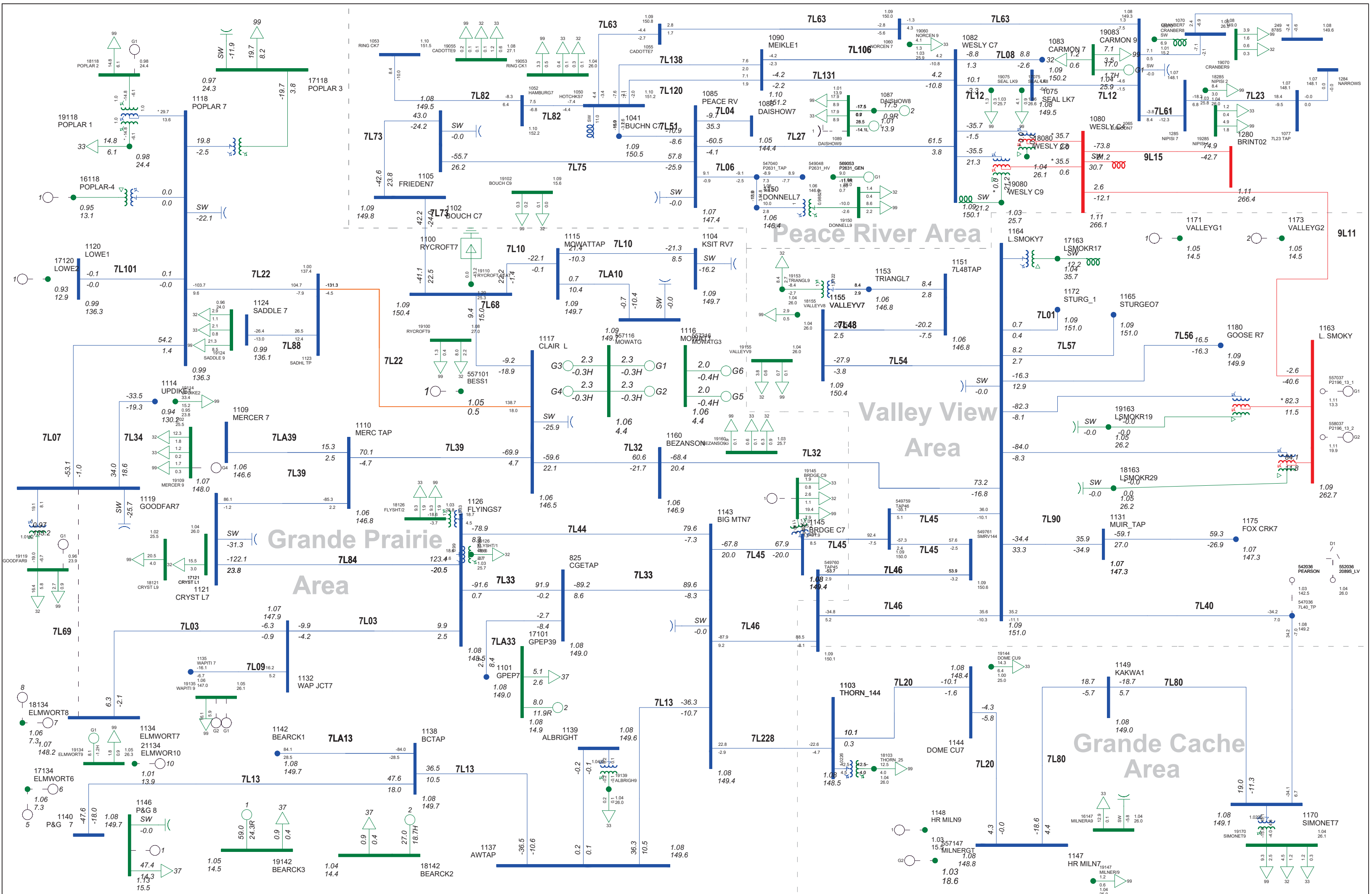
ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L03 (Elmworth 731S - Flyingshot Lake 749S)
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUN 16 2025 16:23MON, JUN 16 2025 16:23MON, JUN 16 2025

A2 - 5

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

16:23



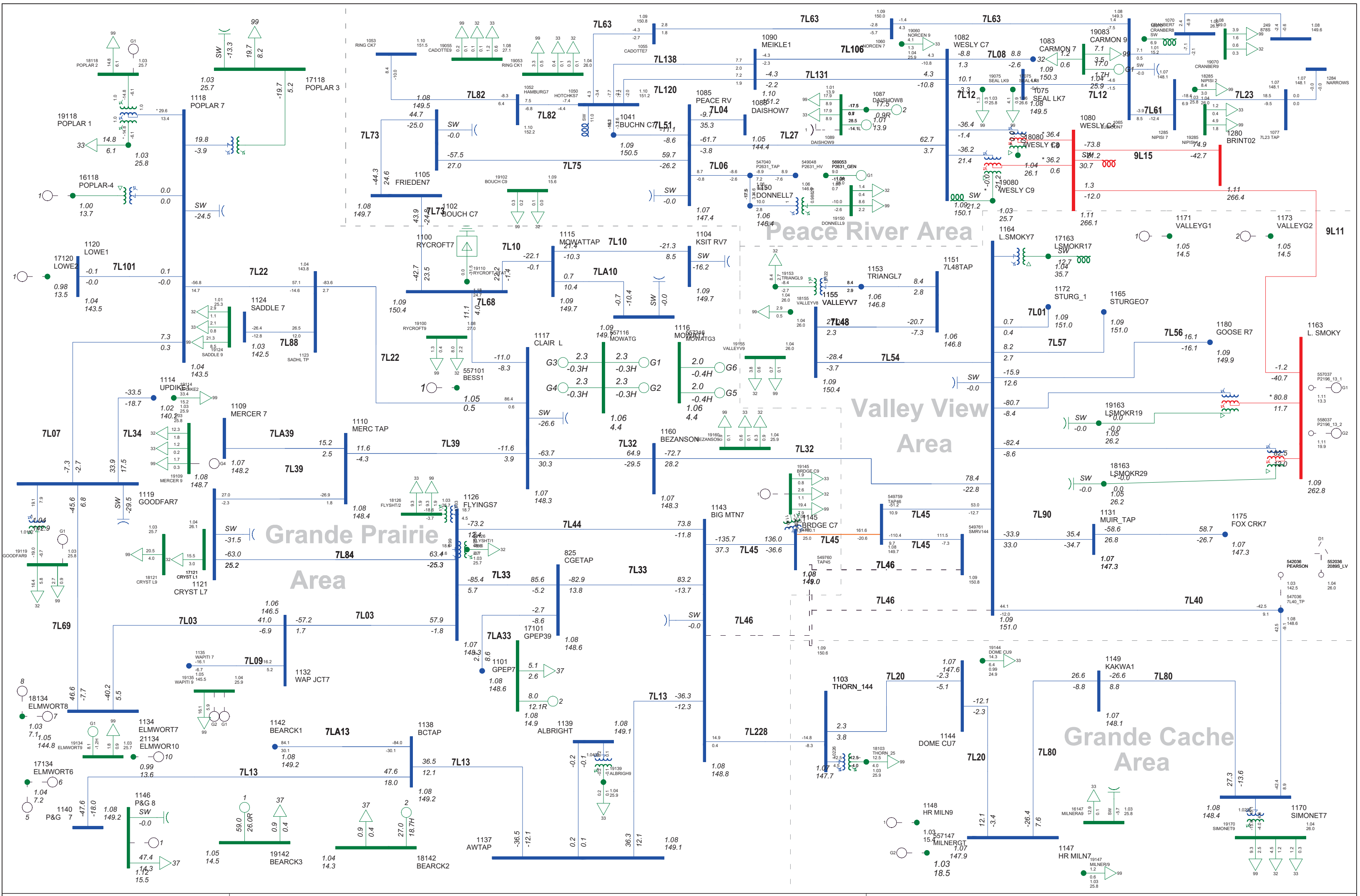
P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L69 (Goodfare 815S - Elmworth 731S)
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUN 16 2025 16:23MON, JUN 16 2025 16:23

A2 - 6

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



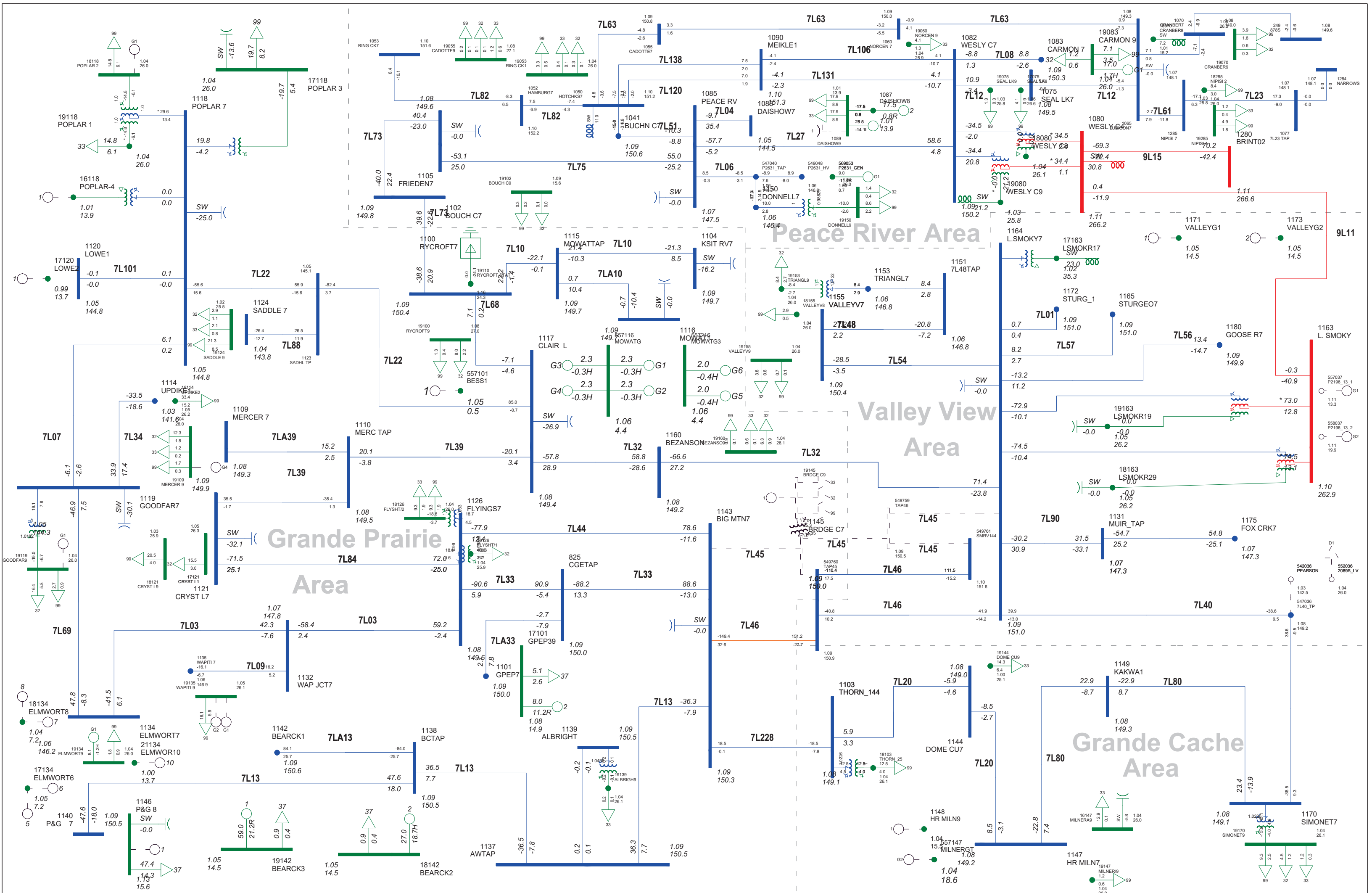
P2716

ATCO Wapiti 823S Load

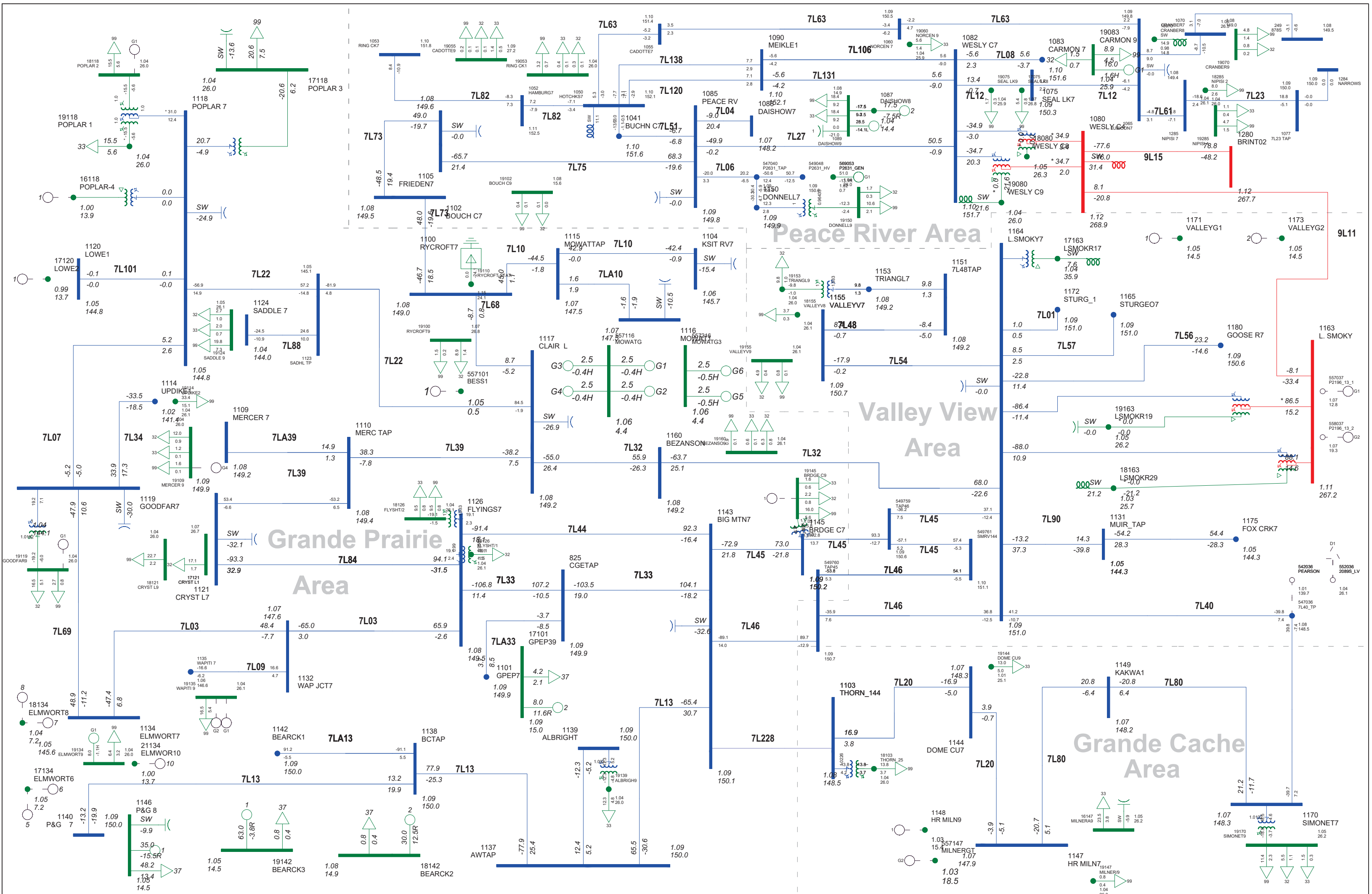
CATEGORY B, LOSS OF 7L46 (Big Mountain 845S - Little Smoky 813S)
SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
MON, JUN 16 2025 16:23MON, JUN 16 2025 16:23

A2 - 7

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



P2716 **ATCO Wapiti 823S Load**	**CATEGORY B, LOSS OF 7L45 (Big Mountain 845S - Little Smoky 813S)** **SCENARIO 1_2028 SUMMER PEAK PRE-PROJECTS** **MON, JUN 16 2025 16:23MON, JUN 16 2025 16:23** A2 - 8	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%RATE1 1.250OV 0.900UV kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



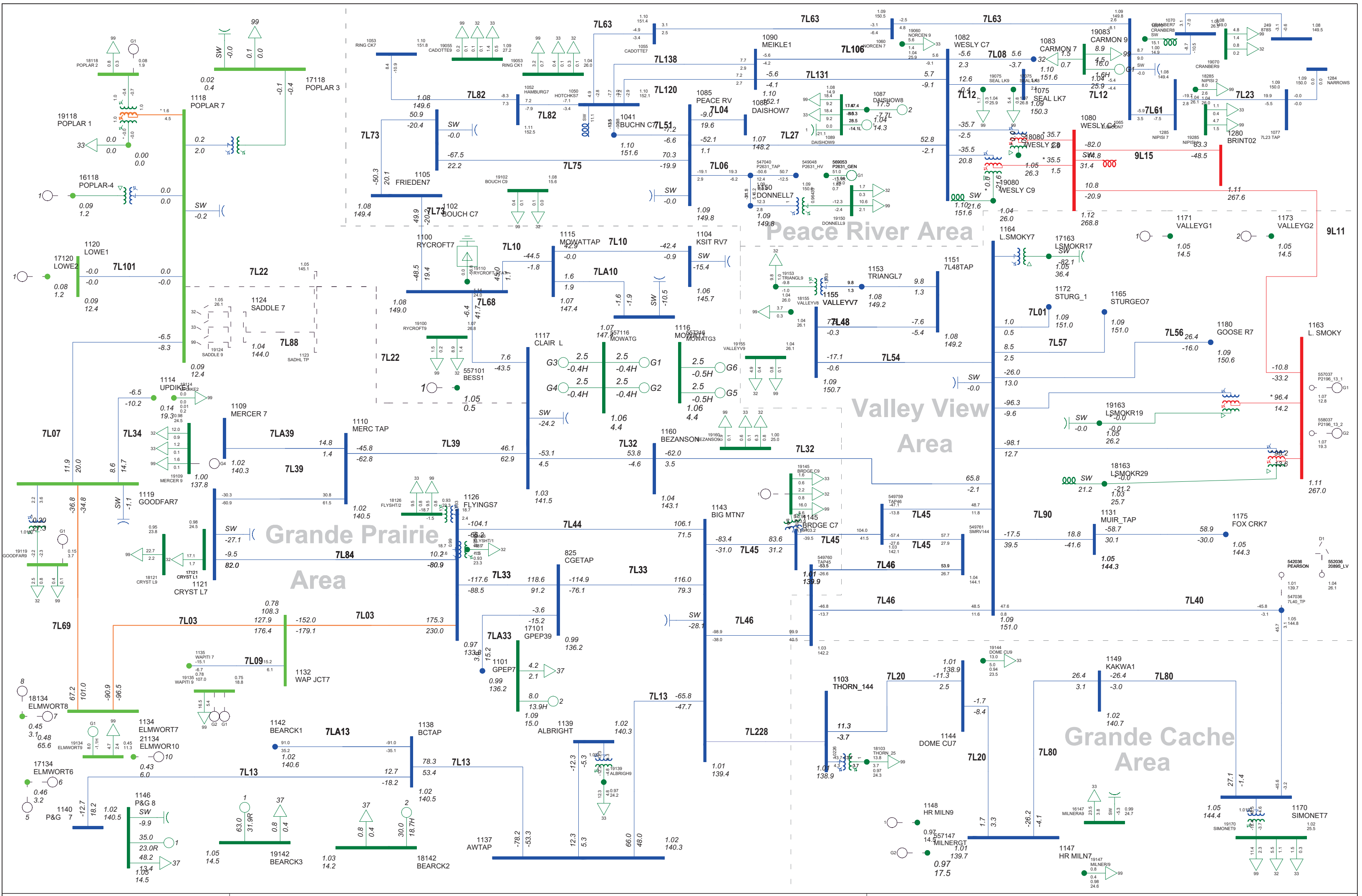
P2716

ATCO Wapiti 823S Load

CATEGORY A, N-0
SCENARIO 2_2028 WINTER PEAK PRE-PROJECT
TUE, JUN 17 2025 7:42

A2 - 9

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE2
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (Poplar Hill 790S - Clairmont Lake 811S)
SCENARIO 2_2028 WINTER PEAK PRE-PROJECT
TUE, JUN 17 2025 7:42TUE, JUN 17 2025 7:42

A2 - 10

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE2
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

Attachment A3
Post- Project Power Flow Diagrams
(Scenario 3, 4)

Pre-Project Power Flow Results

Power Flow Diagrams

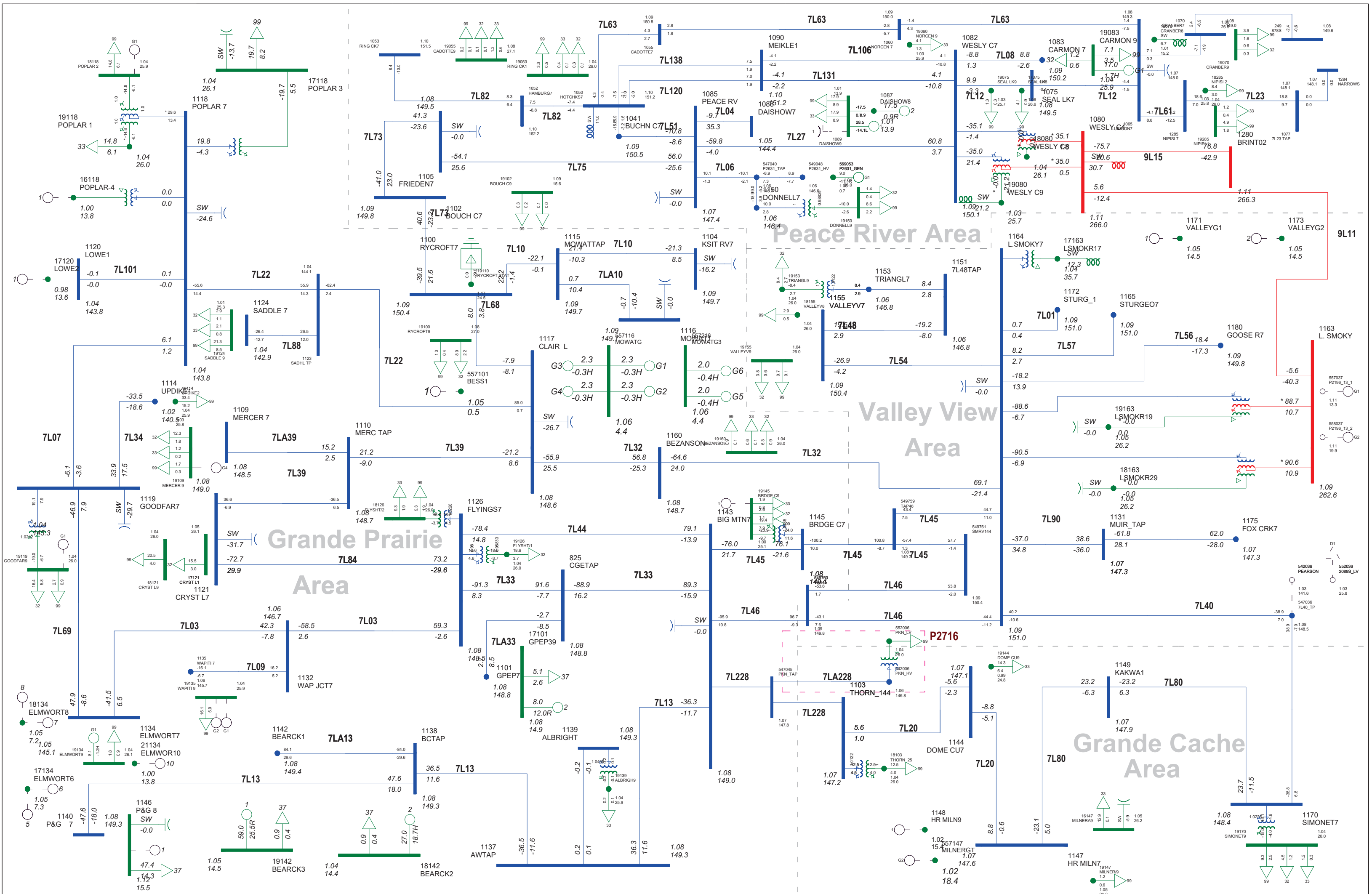
The post-Project power flow diagrams for Scenario 3 2028 SP and Scenario 4 2028 WP under Category A condition and Category B contingencies are provided in this attachment as identified in the following tables.

Table A3-1: List of post-Project Scenario 3 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Scenario 3	N-0, System Normal Condition	A3-3
	N-1, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A3-4
	N-1, Loss of 7L03 (Elmworth 731S - Flyingshot Lake 749S)	A3-5
	N-1, Loss of 7L69 (Goodfare 815S - Elmworth 731S)	A3-6
	N-1, Loss of 7L46 (Big Mountain 845S - Little Smoky 813S)	A3-7
	N-1, Loss of 7L45 (Big Mountain 845S - Little Smoky 813S)	A3-8

Table A3-2: List of pre-Project Scenario 4 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Scenario 4	N-0, System Normal Condition	A3-9
	N-1, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A3-10



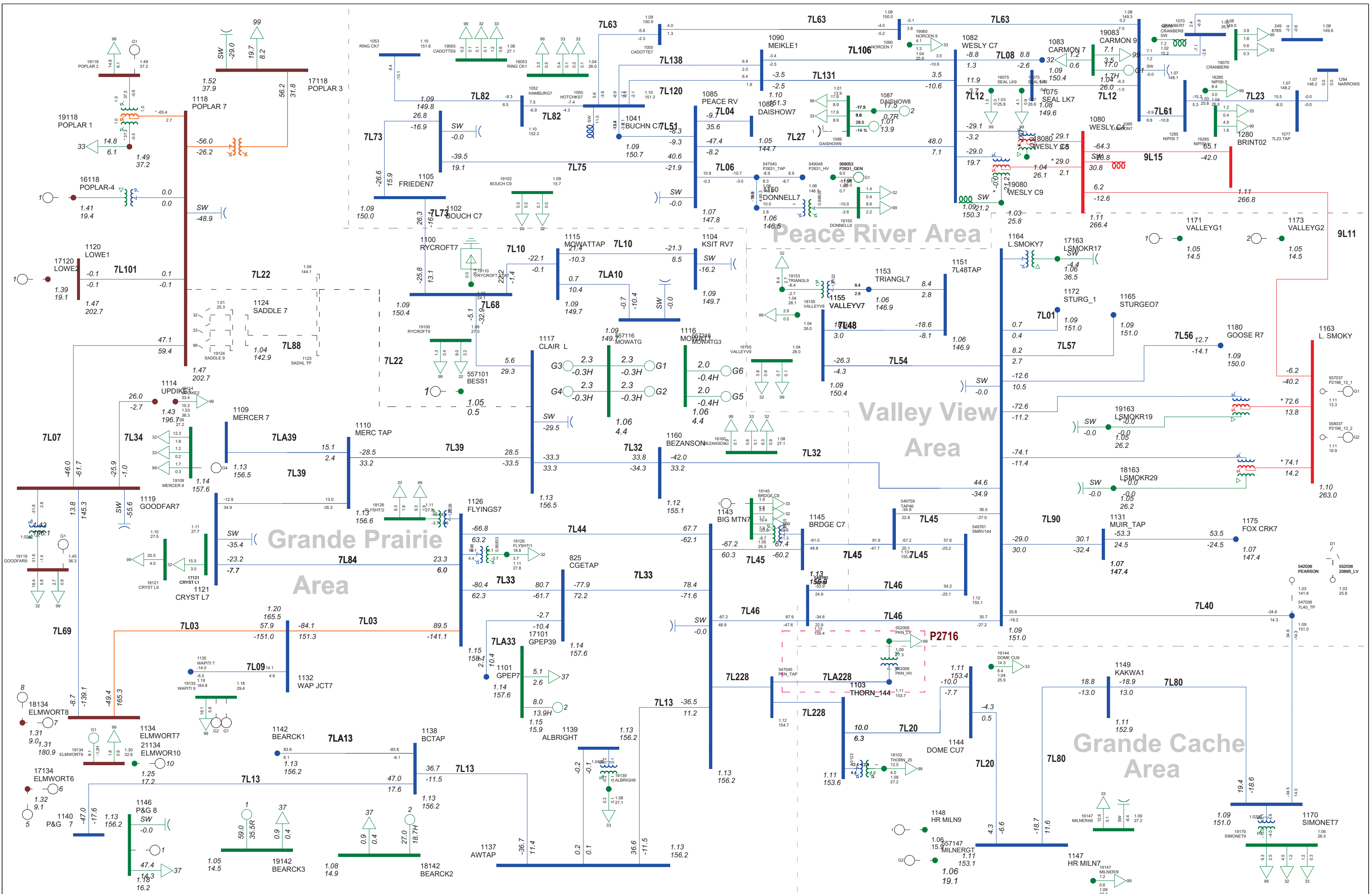
P2716

ATCO Wapiti 823S Load

CATEGORY A, N-0
SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
MON, JUN 16 2025 16:36

A3 - 3

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



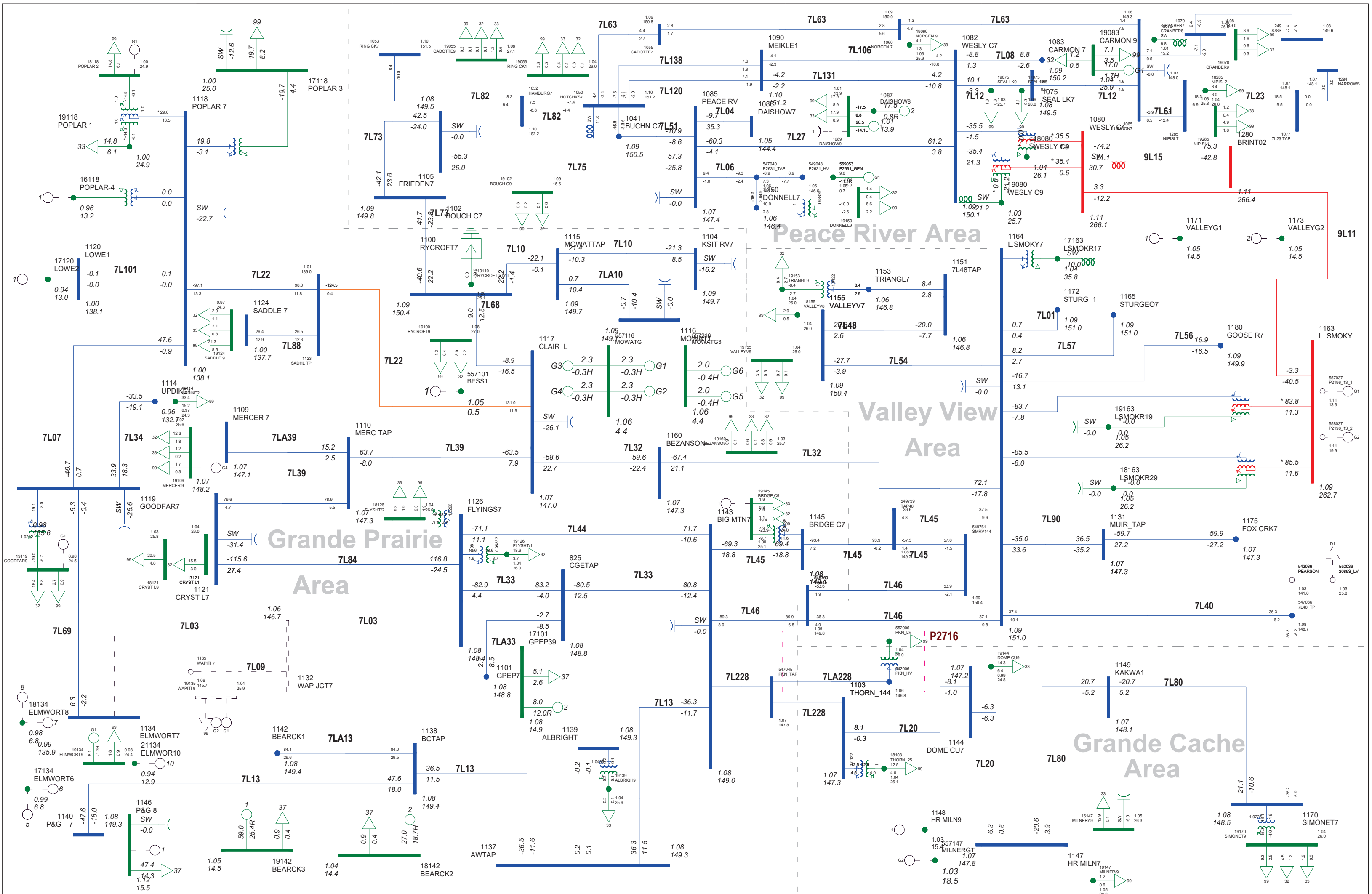
P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (POPLAR HILL 790S - CLAIRMONT LAKE
SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
MON, JUN 16 2025 16:37

A3 - 4

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



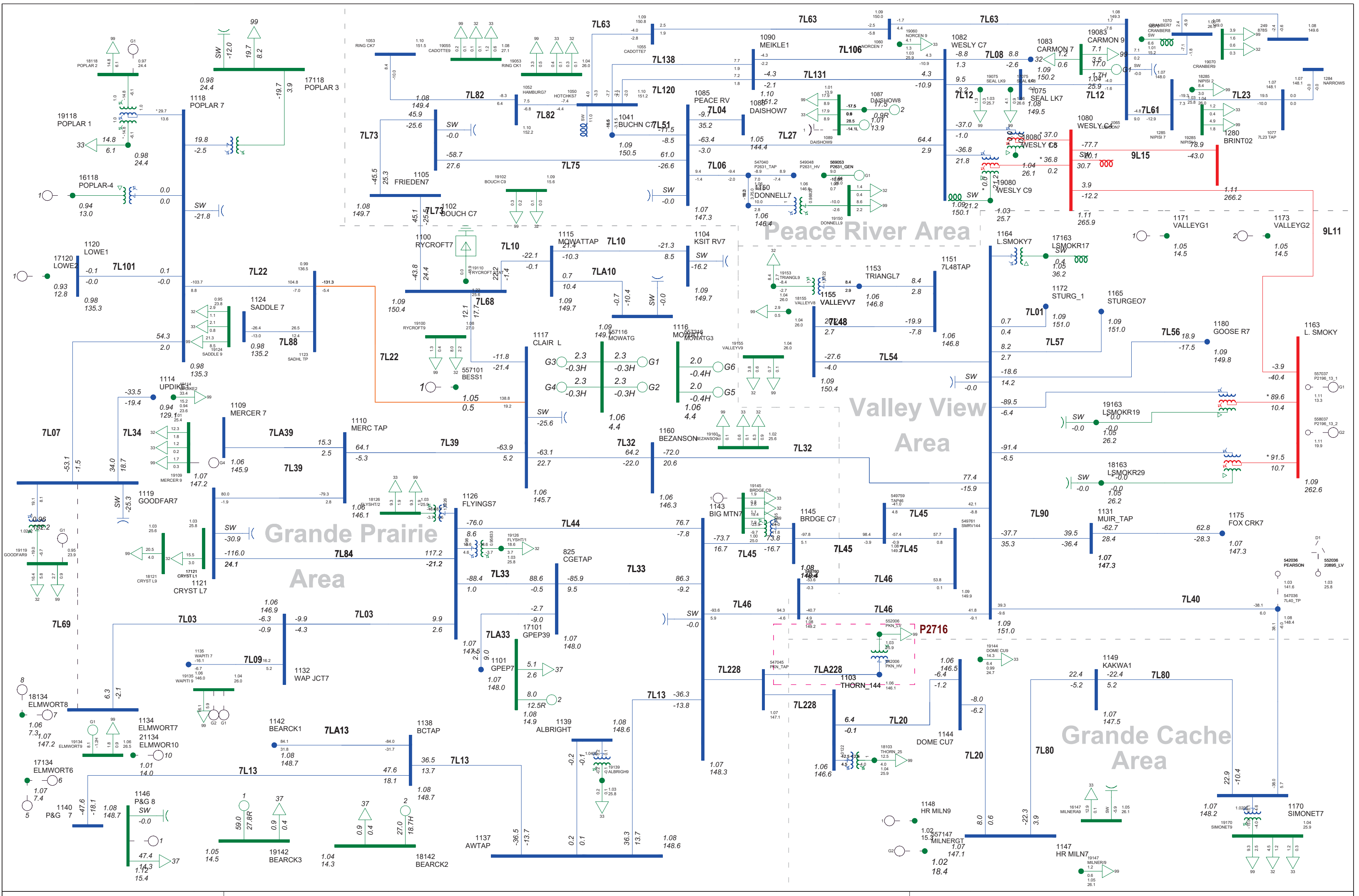
P2716

ATCO Wapiti 823S Load

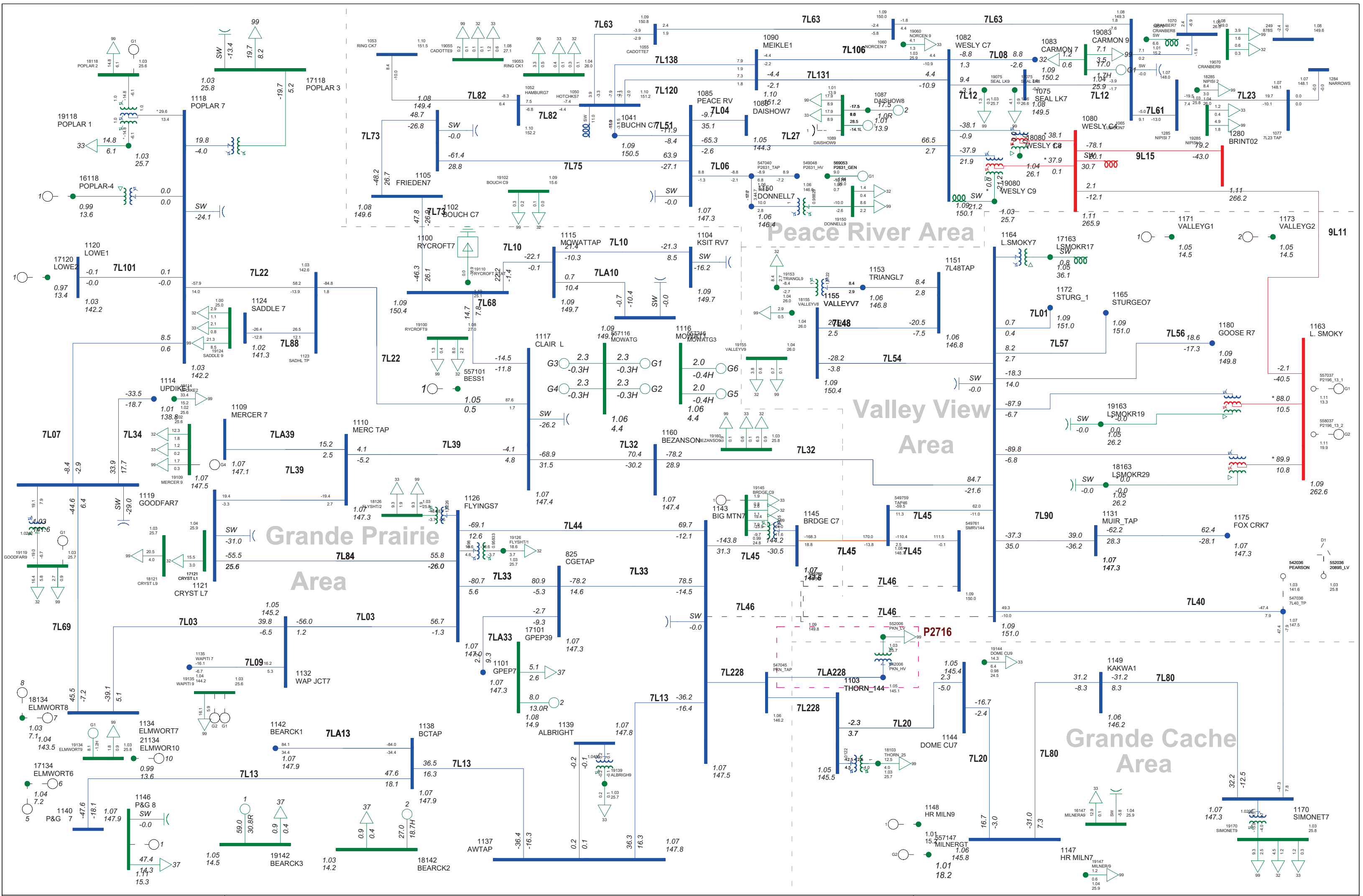
CATEGORY B, LOSS OF 7L03 (ELMWORTH 731S - FLYINGSHOT LAKE 74
SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
MON, JUN 16 2025 16:37

A3 - 5

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



P2716 **ATCO Wapiti 823S Load**	**CATEGORY B, LOSS OF 7L69 (GOODFARE 815S - ELMWORTH 731S)** **SCENARIO 3_2028 SUMMER PEAK POST-PROJECT** **MON, JUN 16 2025 16:37** A3 - 6	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%RATE1 1.250OV 0.900UV kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



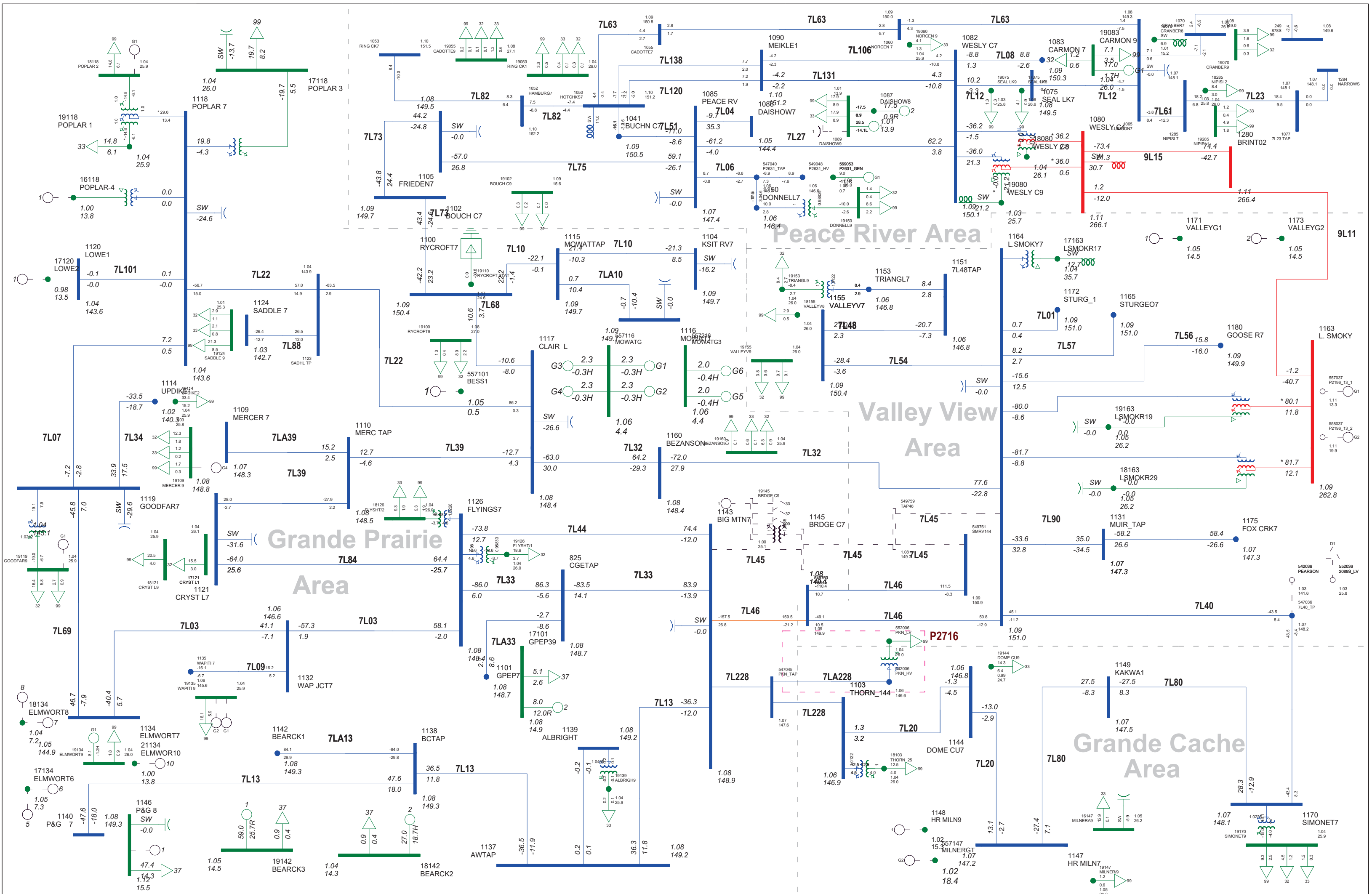
P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L46 (BIG MOUNTAIN 845S - LITTLE SMOKY 8
SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
MON, JUN 16 2025 16:37

A3 - 7

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



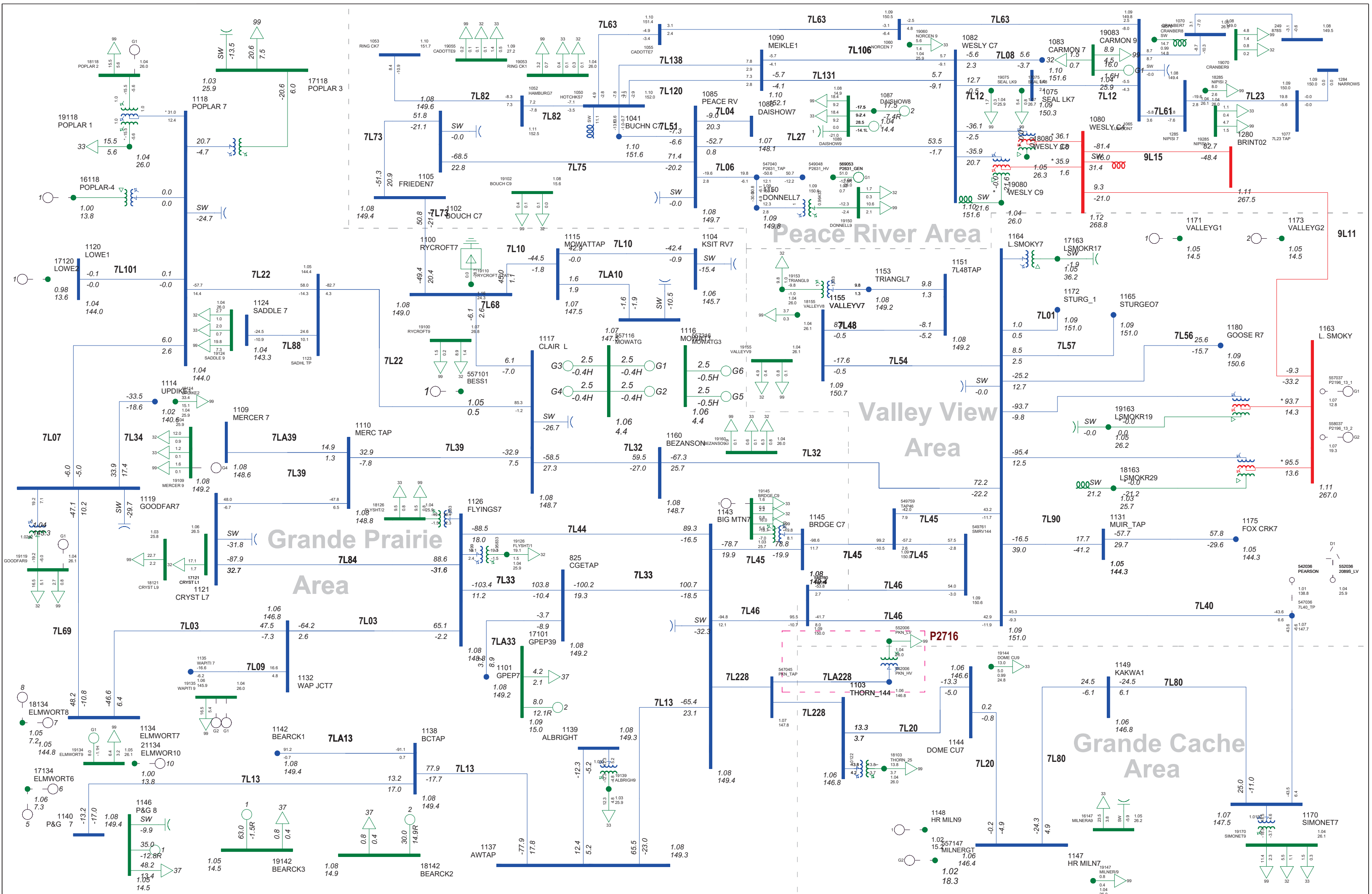
P2716

ATCO Wapiti 823S Load

CATEGORY C, LOSS OF 7L45 (BIG MOUNTAIN 845S - LITTLE SMOKY 8
SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
MON, JUN 16 2025 16:38

A3 - 8

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



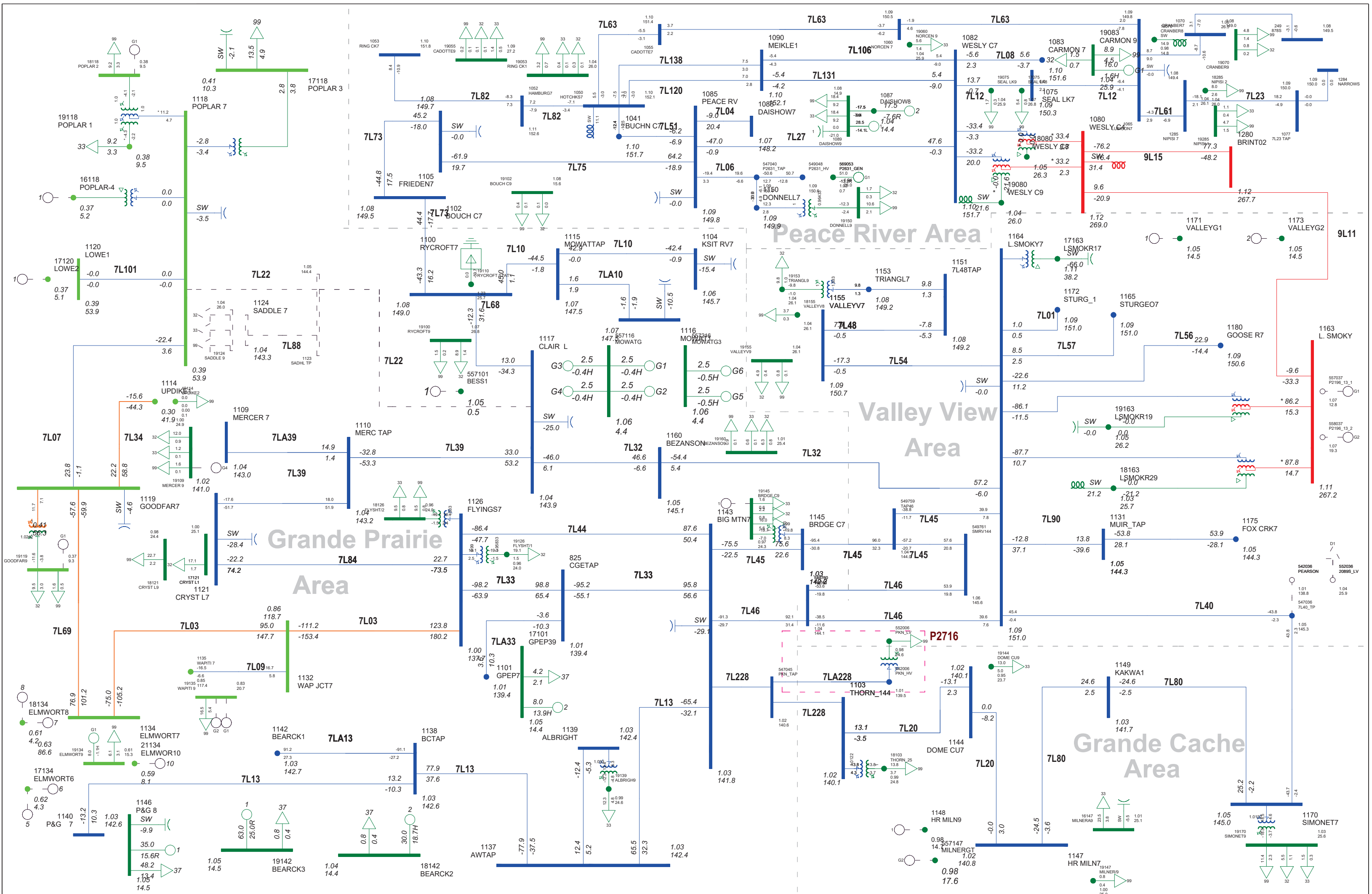
P2716

ATCO Wapiti 823S Load

CATEGORY A, N-0
SCENARIO 4_2028 WINTER PEAK POST-PROJECT
TUE, JUN 17 2025 7:43

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE2
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

A3 - 9



P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (Poplar Hill 790S - Clairmont Lake 811S)
SCENARIO 4_2028 WINTER PEAK POST-PROJECT
TUE, JUN 17 2025 7:43TUE, JUN 17 2025 7:43

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE2
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

Attachment A4
Pre- and Post- Project Voltage Stability Diagrams
(Scenario 2, 4)

P2716_Voltage Stability Studies

Scenario 2: 2028 WP Pre-Project

Voltage stability analysis was performed for scenario 2 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 4 is 524.5 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 25.2 MW (0.05 x 503.2 MW = 25.2 MW) for the scenario 4.

Table 1 provides voltage stability study results under Category A condition and for the six (6) worst contingencies under Category B conditions. The voltage stability diagrams are provided in Figure 1a. Based on the study results, the voltage stability margin was met for all studied conditions except for the contingency of 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

The following Buses were selected for the study:

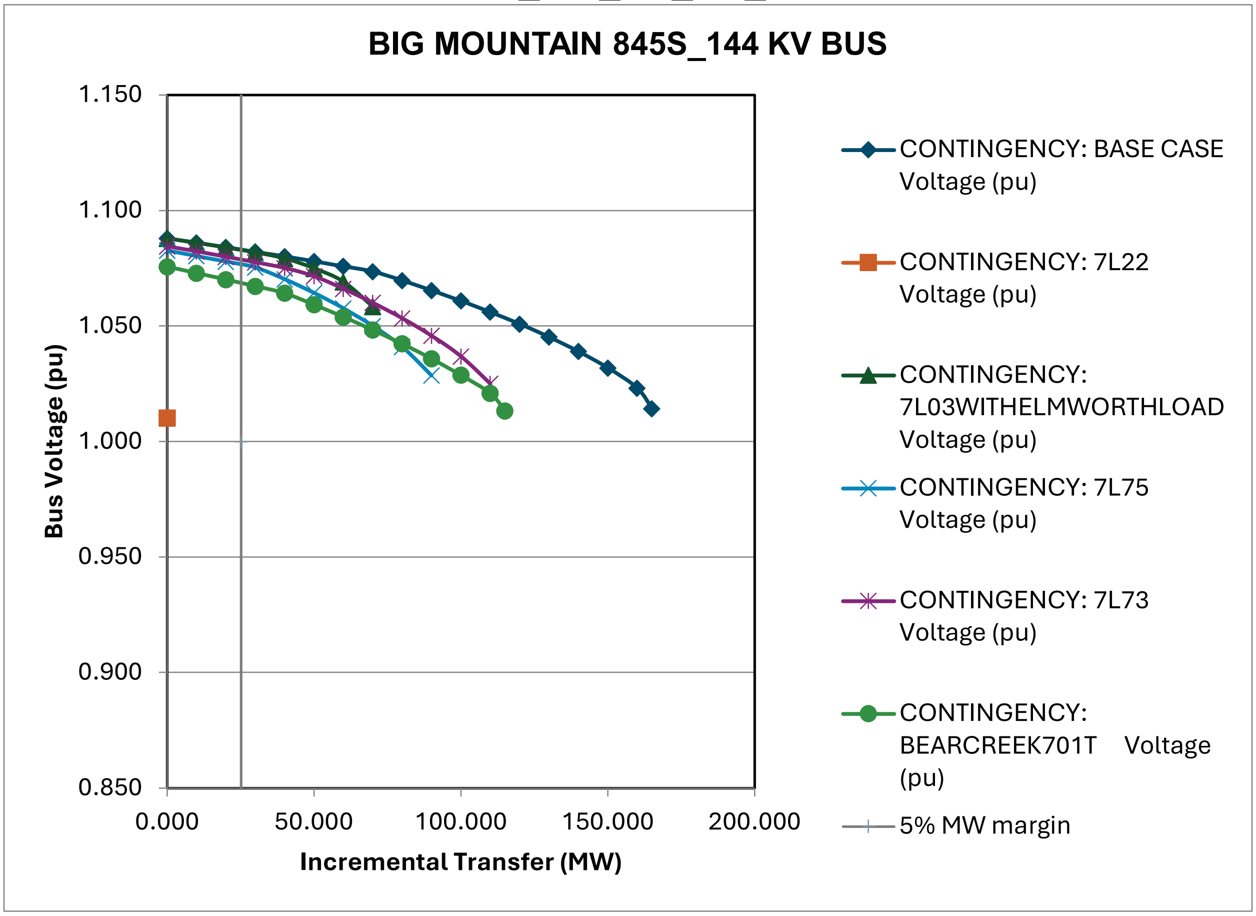
- Big Mountain 845S 138 kV Bus (bus 1143)
- H.R. Milner 740S 138 kV bus (bus 1147)
- Thornton 2091S 138 kV bus (bus 1103)
- Simonette 733S 138 kV bus (bus 1170)
- Dome Cut Bank 810S 138 kV bus (bus 1144)

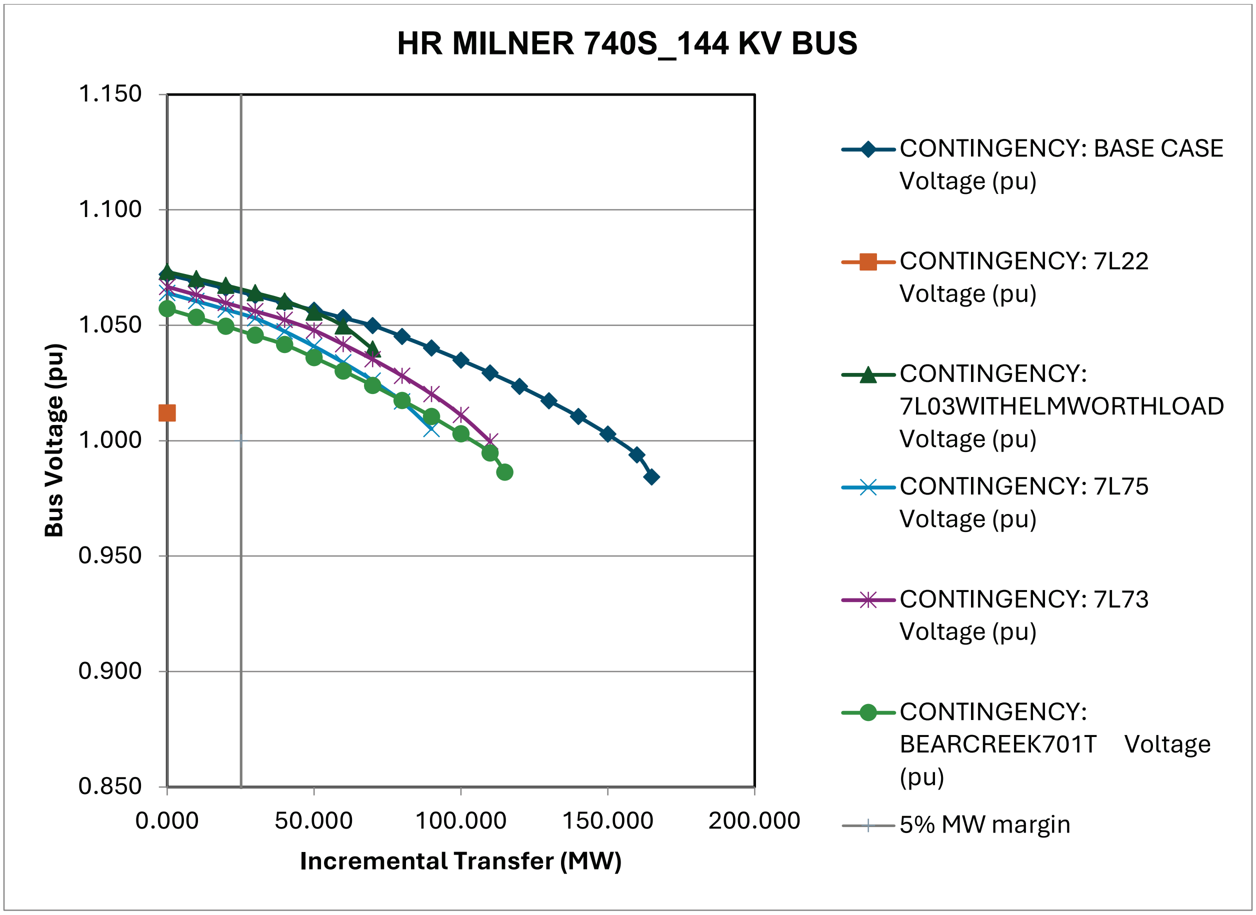
Table 1: Summary of Results under Category B Conditions for Scenario 2

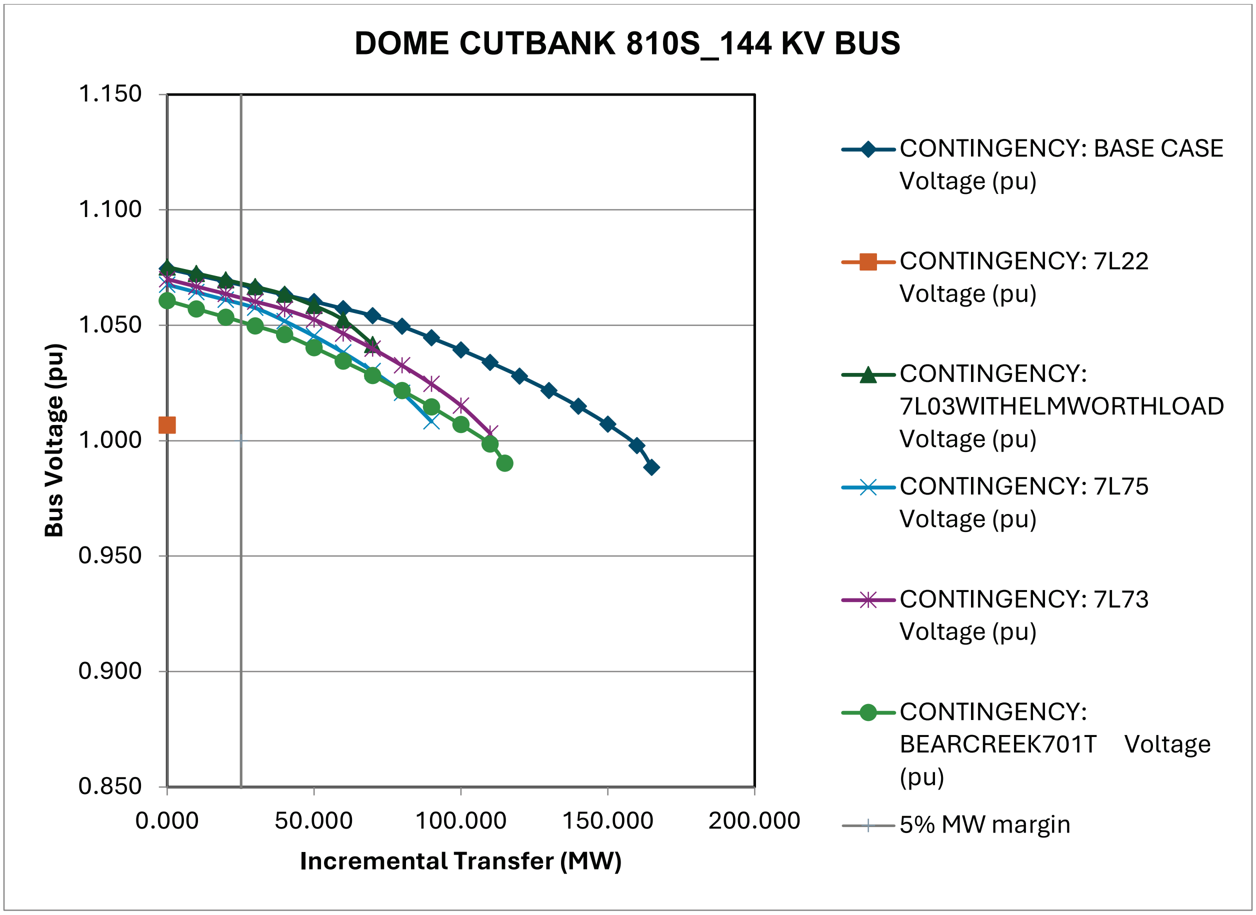
Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		165	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	0	No
7L03	Flyingshot Lake 749S	Elmworth 731S	70	Yes
7L75	Friednestal 800S	West Peace River 793S	90	Yes
7L73	Friednestal 800S	Rycroft 730S	110	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		115	Yes

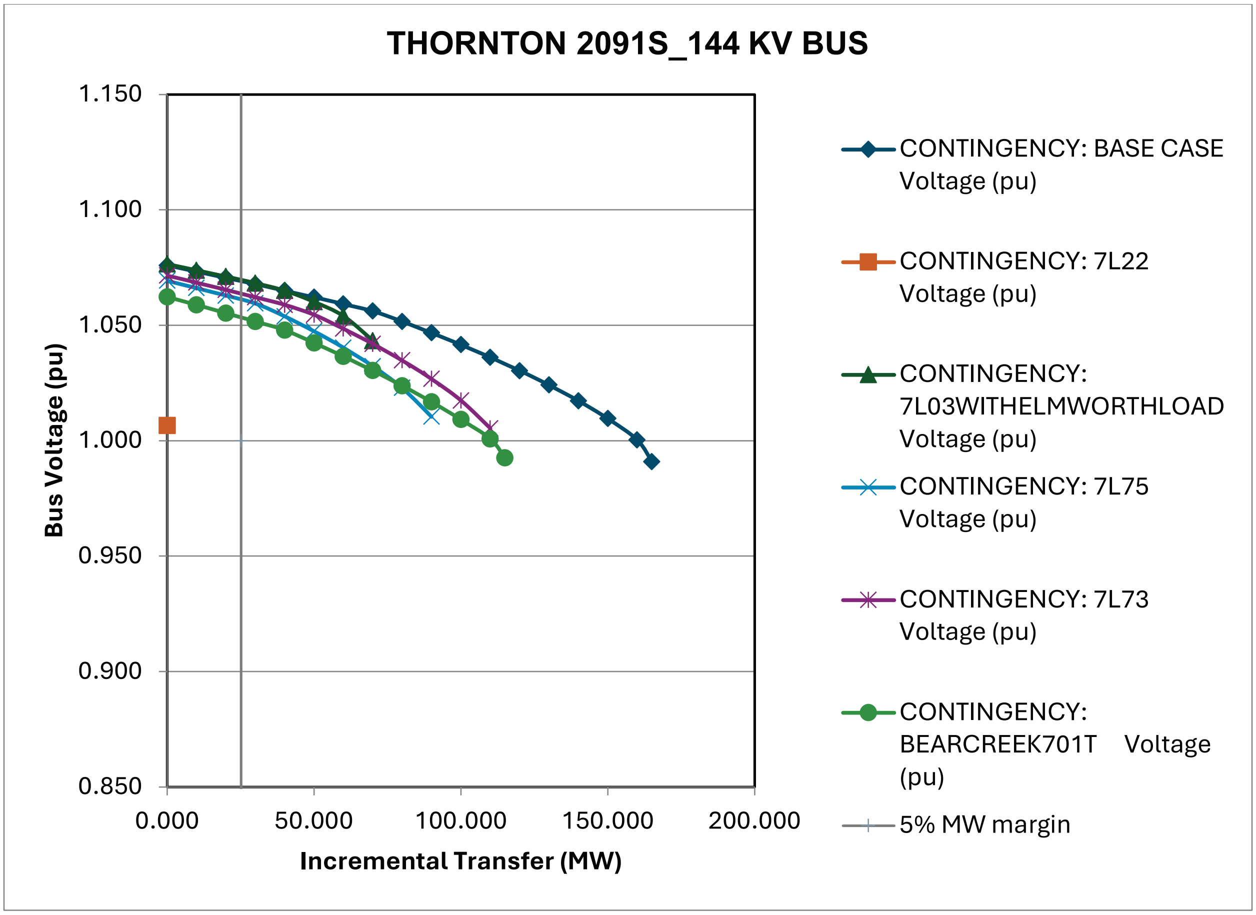
Figure 1:

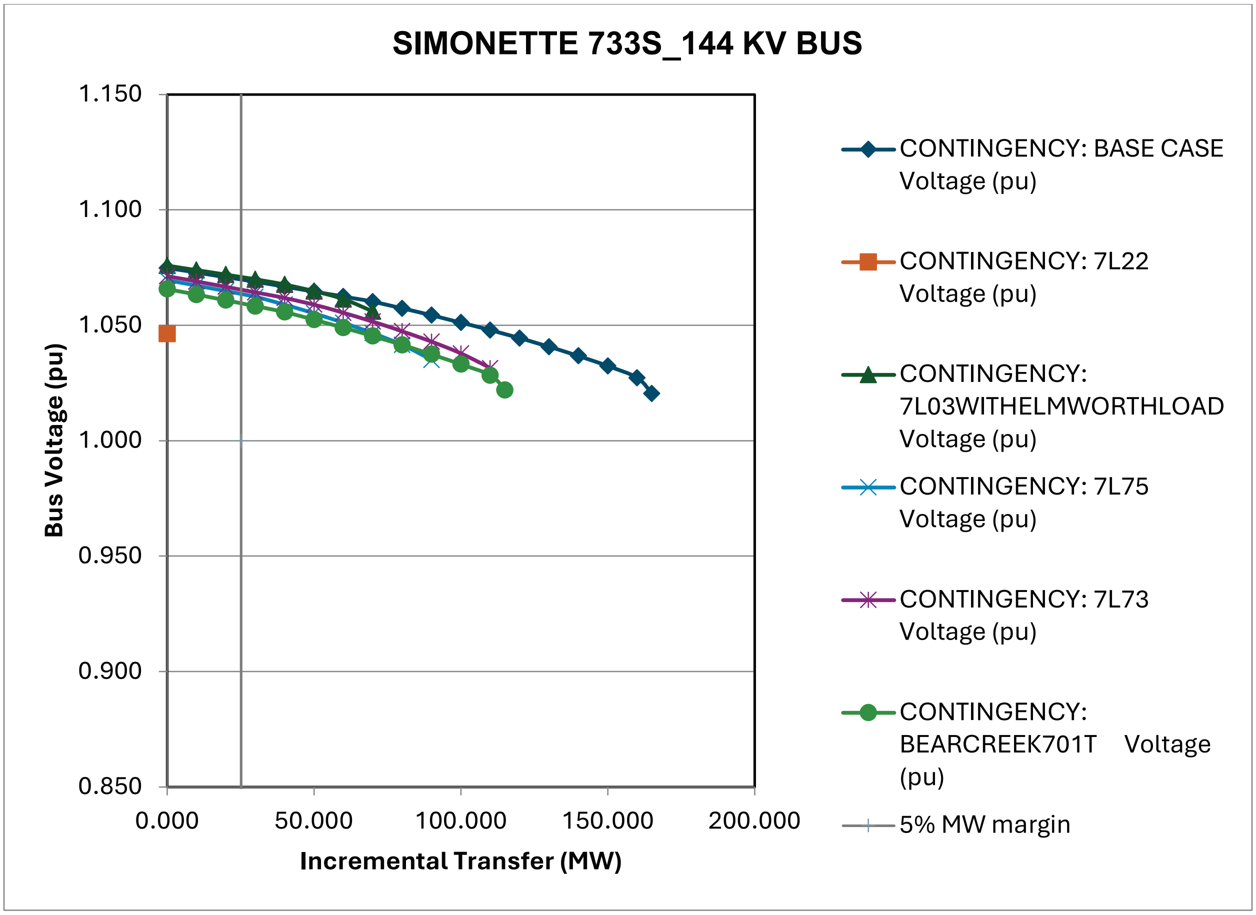
Scenario 2: 2028_WP_NE_LG_PRE-PROJECT




HR MILNER 740S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
Bus Voltage (pu)
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


DOME CUTBANK 810S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


THORNTON 2091S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



SIMONETTE 733S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
Bus Voltage (pu)
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin

P2716_Voltage Stability Studies

Scenario 4: 2028 WP Post-Project

Voltage stability analysis was performed for scenario 4 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 4 is 524.5 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 26.2 MW (0.05 x 524.5 MW = 26.2 MW) for the scenario 4.

Table 1 provides voltage stability study results under Category A condition and for the six (6) worst contingencies under Category B conditions. The voltage stability diagrams are provided in Figure 1. Based on the study results, the voltage stability margin was met for all studied conditions except for the contingency of 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

The following Buses were selected for the study:

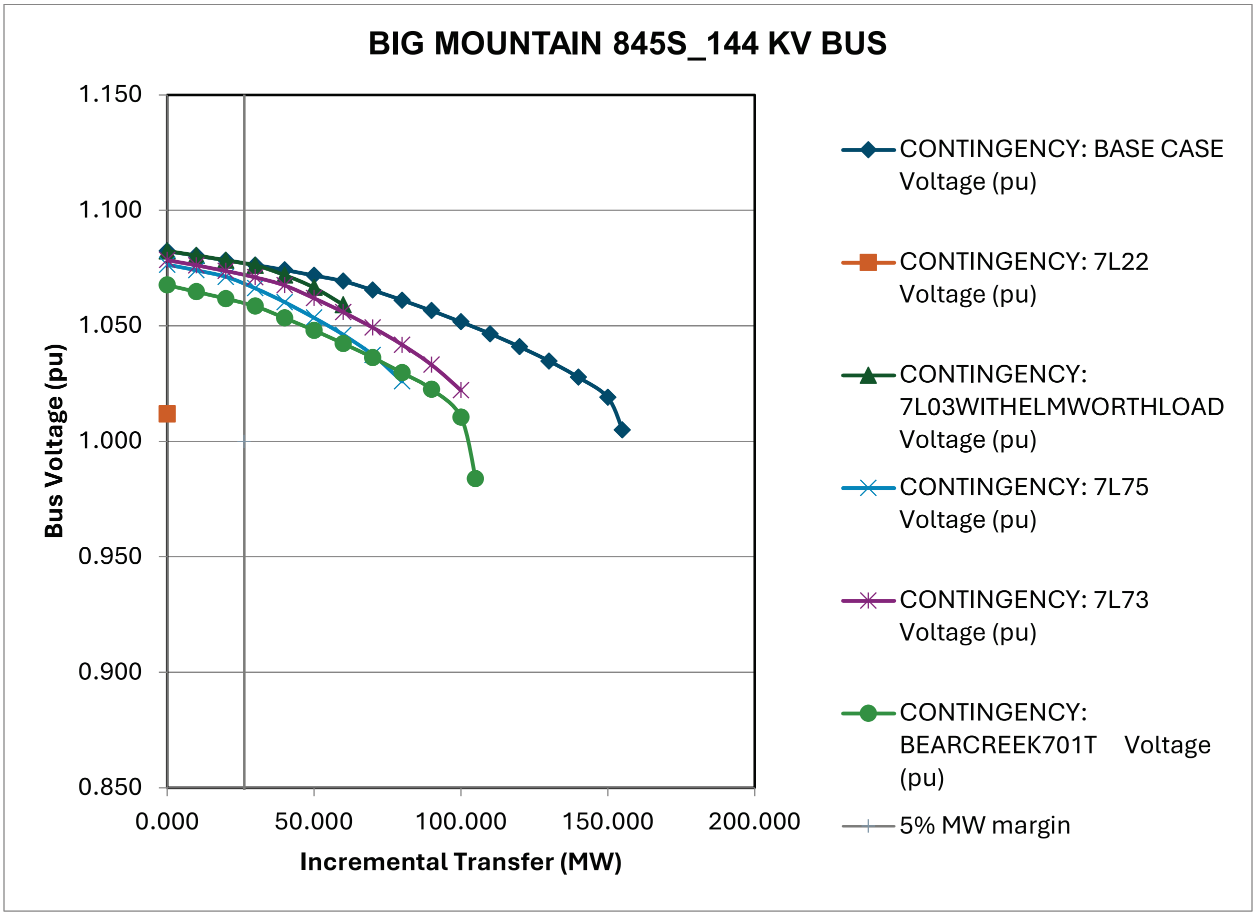
- Big Mountain 845S 138 kV Bus (bus 1143)
- H.R. Milner 740S 138 kV bus (bus 1147)
- Thornton 2091S 138 kV bus (bus 1103)
- Simonette 733S 138 kV bus (bus 1170)
- Pakenham 2103S 138 kV bus (bus 542006)
- Dome Cut Bank 810S 138 kV bus (bus 1144)

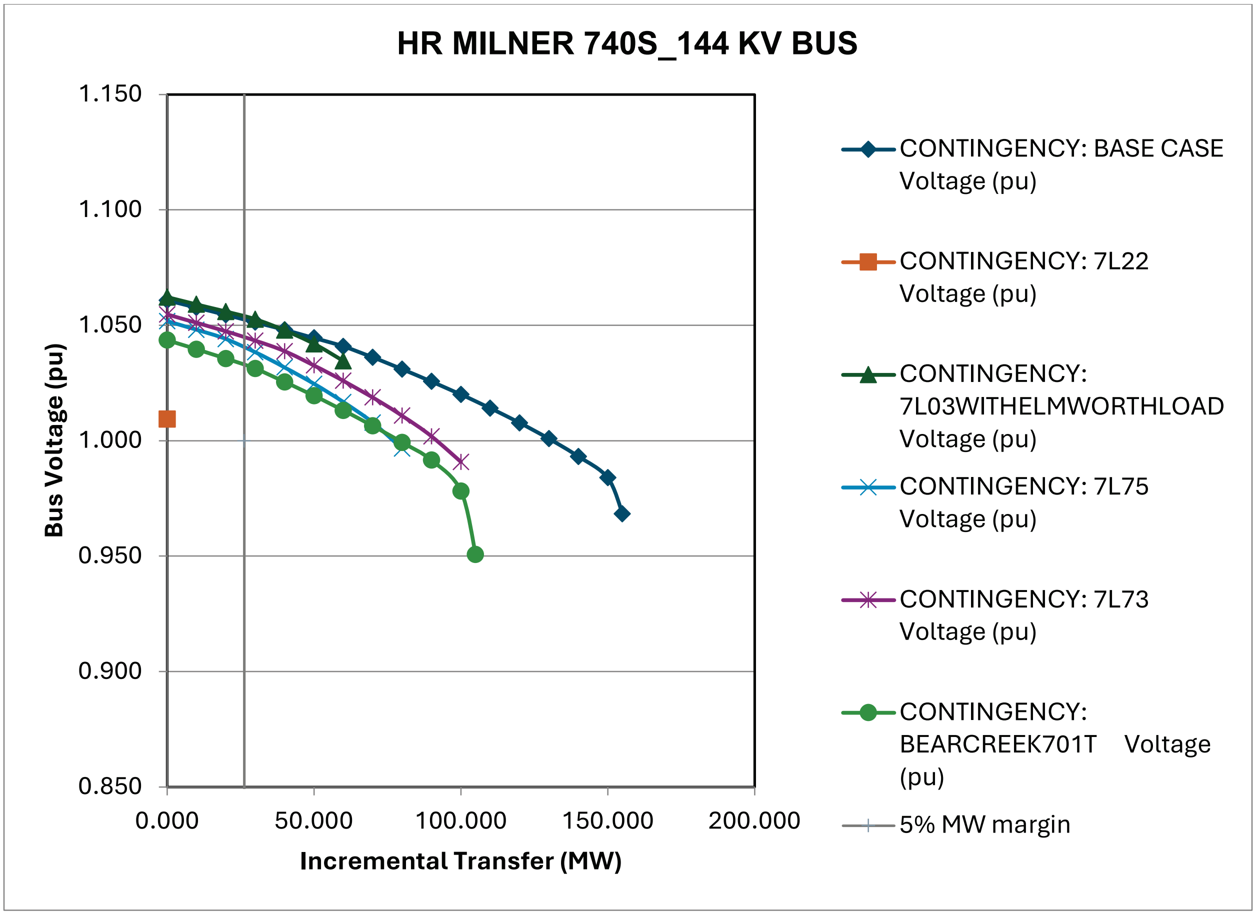
Table 1: Summary of Results under Category B Conditions for Scenario 4

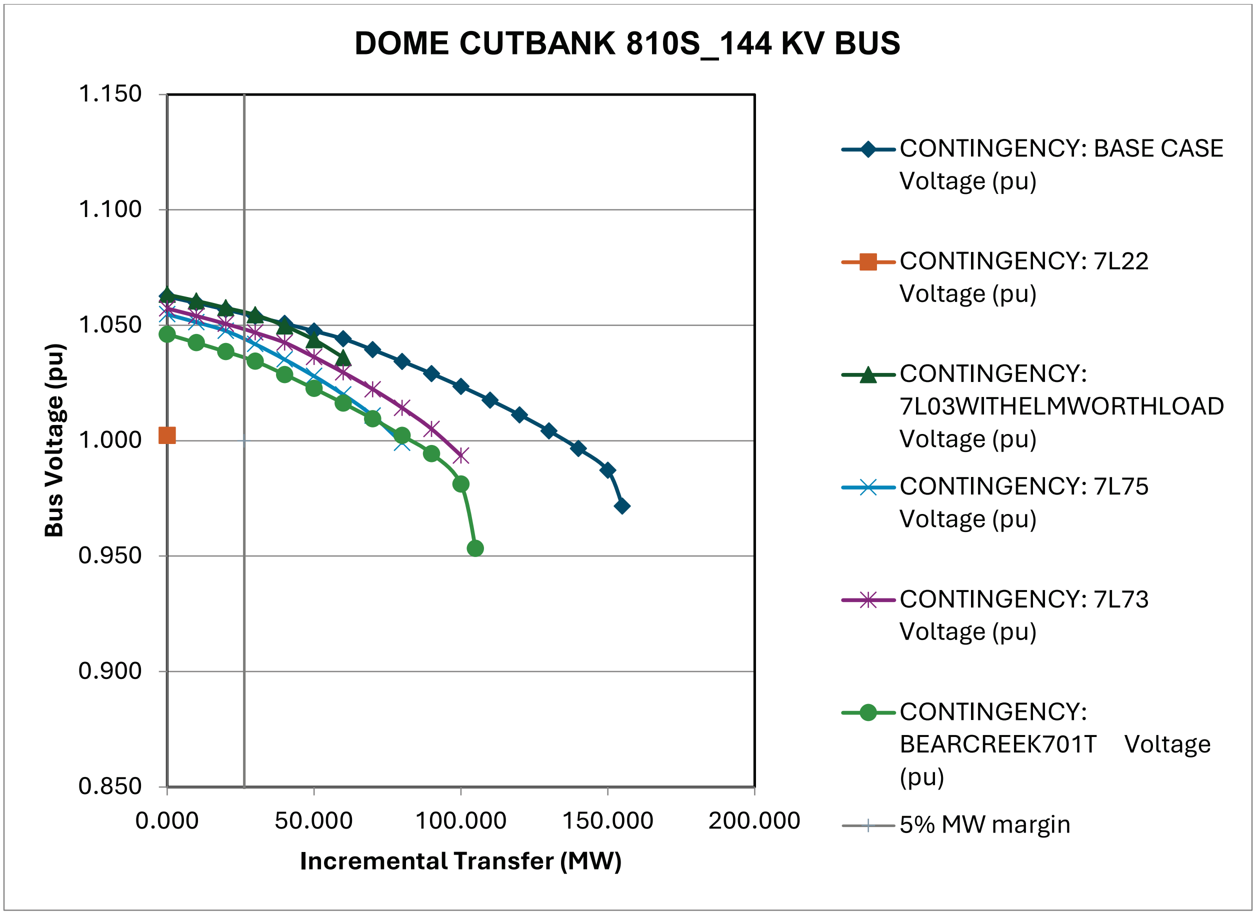
Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		155	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	0	No
7L03	Flyingshot Lake 749S	Elmworth 731S	60	Yes
7L75	Friednestal 800S	West Peace River 793S	80	Yes
7L73	Friednestal 800S	Rycroft 730S	100	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		105	Yes

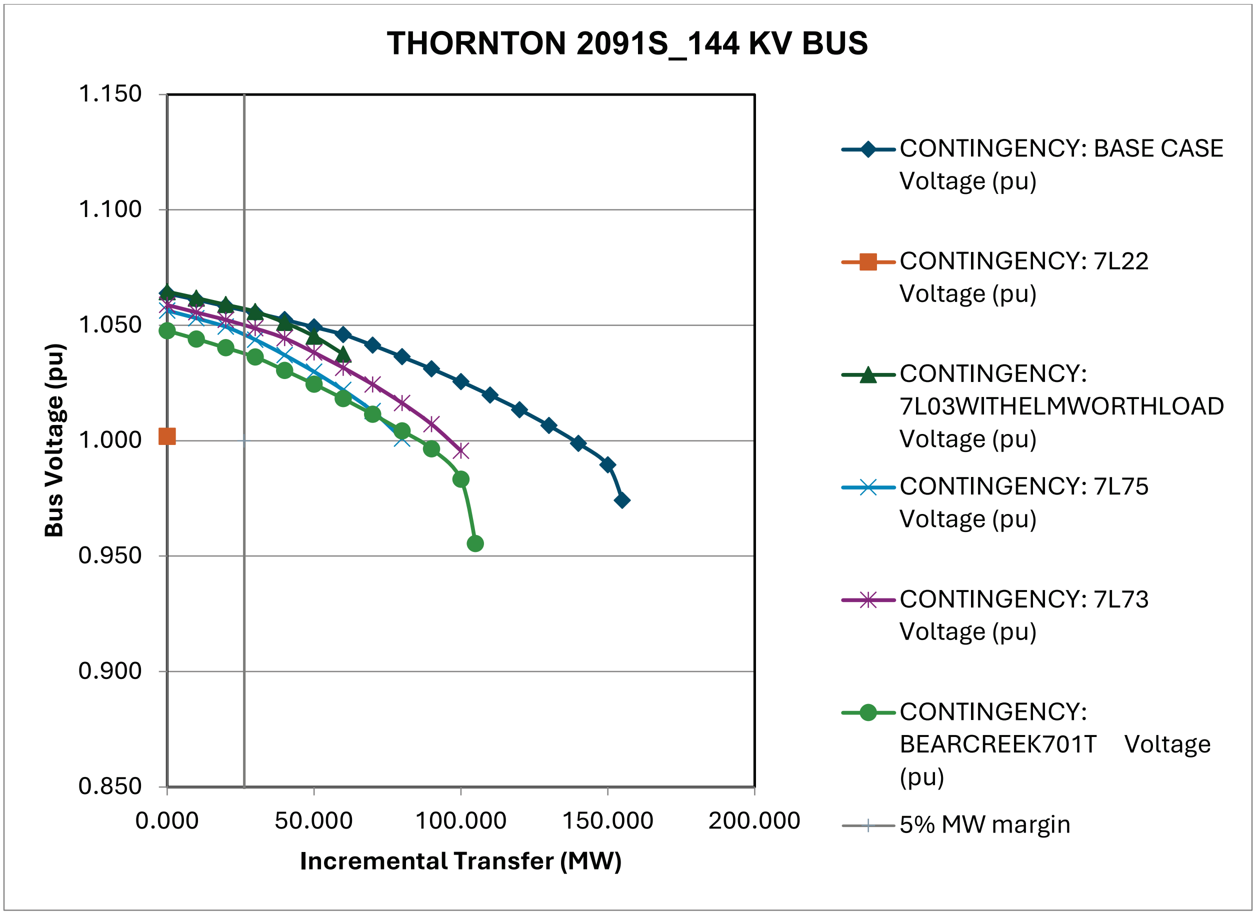
Figure 1:

Scenario 4: 2028_WP_NE_LG_POST-PROJECT

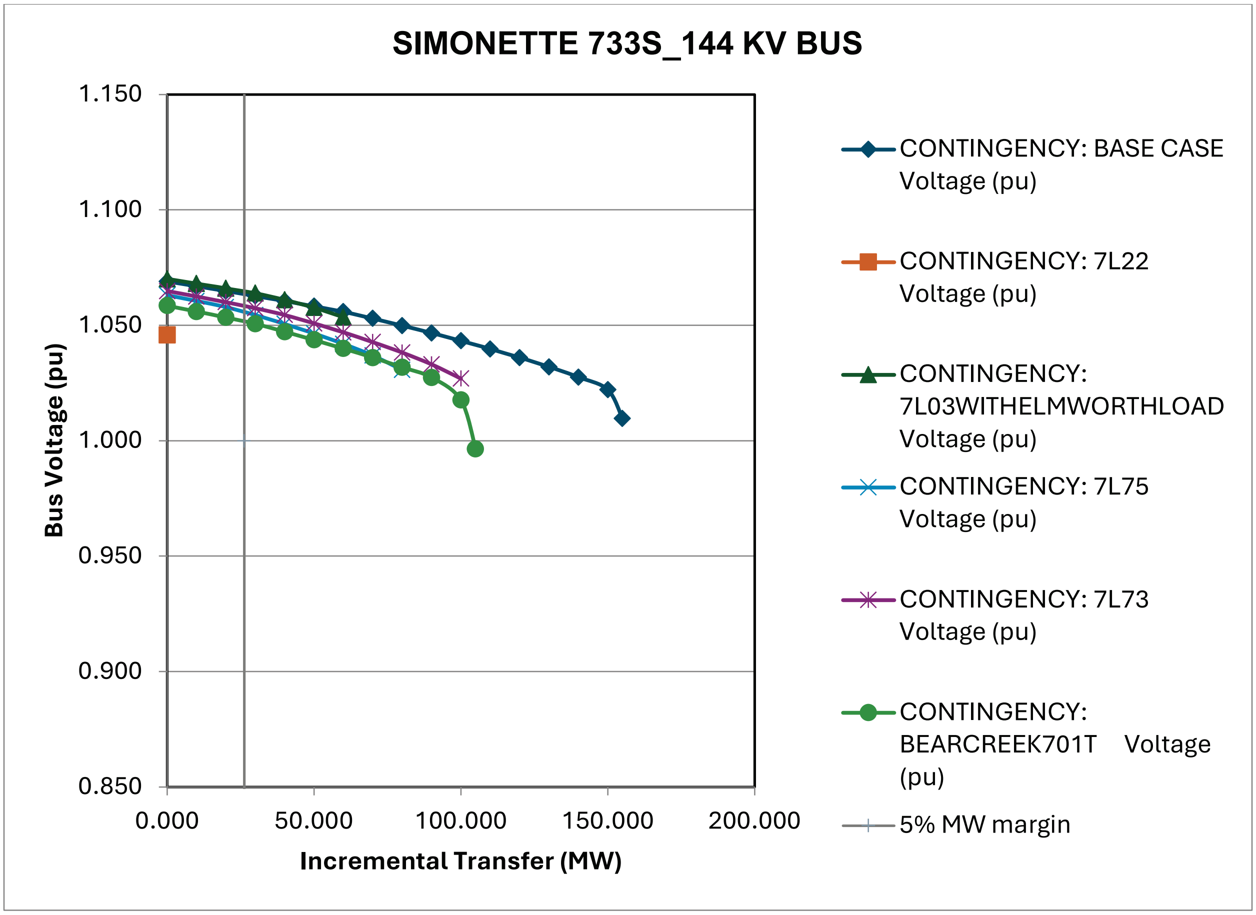


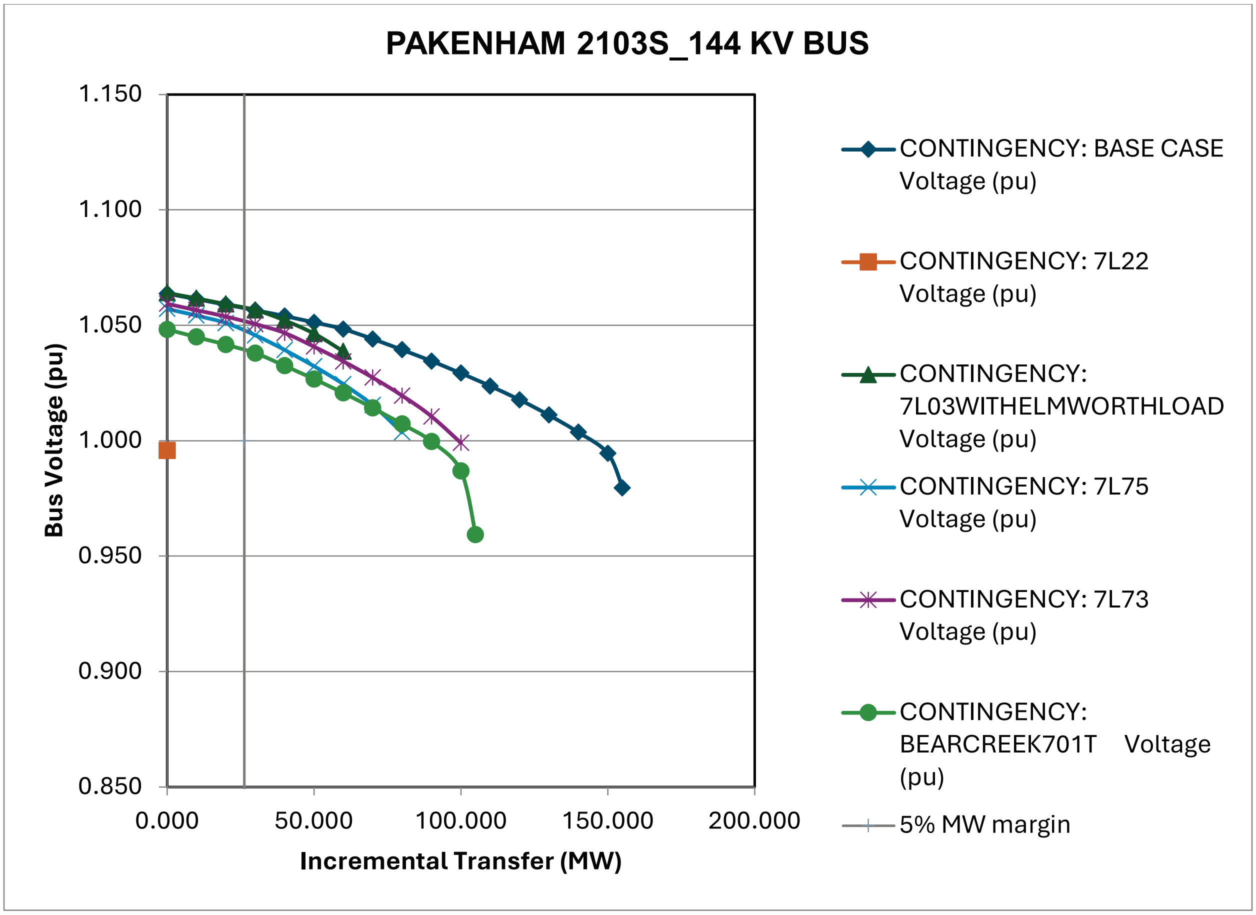

HR MILNER 740S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


DOME CUTBANK 810S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



THORNTON 2091S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


SIMONETTE 733S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



PAKENHAM 2103S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
Bus Voltage (pu)
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin

Attachment A5

Pre-Project and Post-Project Transient Stability Diagrams

(Scenario 1, 3)

Transient Stability Diagrams for 2028 SP Base case Scenario

Transient stability analysis was performed using the 2028 SP Post-Project (scenario 3) for the Category B contingencies identified in Table A5-1.

Table A5-1: List of Contingencies Studied for Transient Stability –Scenario 3 2028 SP Post-Project

System Condition	Contingency	Fault Description (fault location)	Page #
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	A5-4
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at H.R. Milner 740S	A5-5
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at Thornton 2091S	A5-6
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at Thornton 2091S	A5-7
Category B (N-1)	7L80 (H.R. Milner 740S – Simonette 733S)	3-phase fault at H.R. Milner 740S	A5-8
Category B (N-1)	7L80 (H.R. Milner 740S – Simonette 733S)	1-phase fault at H.R. Milner 740S	A5-9
Category B (N-1)	7L80 (H.R. Milner 740S – Simonette 733S)	3-phase fault at Simonette 733S	A5-10
Category B (N-1)	7L80 (H.R. Milner 740S – Simonette 733S)	1-phase fault at Simonette 733S	A5-11
Category B (N-1)	7L40 (Little Smoky 813S – Simonette 733S)	3-phase fault at Little Smoky 813S	A5-12
Category B (N-1)	7L40 (Little Smoky 813S – Simonette 733S)	1-phase fault at Little Smoky 813S	A5-13
Category B (N-1)	7L40 (Little Smoky 813S – Simonette 733S)	3-phase fault at Simonette 733S	A5-14
Category B (N-1)	7L40 (Little Smoky 813S – Simonette 733S)	1-phase fault at Simonette 733S	A5-15
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Thornton 2091S	A5-16
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Thornton 2091S	A5-17
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	A5-18
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Big Mountain 845S	A5-19

Table 5-2 lists the transient stability analysis performed using the 2028 SP Pre-Project (scenario 1) for the unstable Category B contingencies identified in 2028 SP Post-Project (Scenario 3) transient stability analysis.

Table A5-2: List of Contingencies Studied for Transient Stability –Scenario 1 2028 SP Pre-Project

System Condition	Contingency	Fault Description (fault location)	Page #
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	A5-20
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at Thornton 2091S	A5-21
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at H.R. Milner 740S	A5-22
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at Thornton 2091S	A5-23

System Condition	Contingency	Fault Description (fault location)	Page #
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	A5-24
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Thornton 2091S	A5-25
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Big Mountain 845S	A5-26
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Thornton 2091S	A5-27

Table 5-3 lists the transient stability analysis performed using the 2028 SP Post-Project (scenario 3) for the breaker open condition on 7L20, 7L80 and 7L228 lines.

Table A5-3: List of Contingencies Studied for Transient Stability under Breaker Open condition – Scenario 3 2028 SP Post-Project

System Condition	Line Element	Substation terminals		Fault End	Page #
Breaker Open	7L20	H.R. Milner 740S	Thornton 2091S	Both H.R. Milner 740S and Thornton 2091S ends	A5-28
Breaker Open	7L80	H.R. Milner 740S	Simonette 733S	Both H.R. Milner 740S and Simonette 733S ends	A5-29
Breaker Open	7L228	Big Mountain 845S	Thornton 2091S	Big Mountain 845S end	A5-30

Table 5-4 lists the transient stability analysis performed using the 2028 SP Pre-Project (scenario 1) for the unstable breaker open condition identified on 7L20 line in the 2028 SP Post-Project (scenario 3).

Table A5-4: List of Contingencies Studied for Transient Stability under Breaker Open condition – Scenario 1 2028 SP Pre-Project

System Condition	Line Element	Substation terminals		Fault End	Page #
Breaker Open	7L20	H.R. Milner 740S	Thornton 2091S	Both H.R. Milner 740S and Thornton 2091S ends	A5-31

Figure 1: 2028 SP_Post-Project Cat B 7L20 - 3 Phase Fault at HRMilner 740S

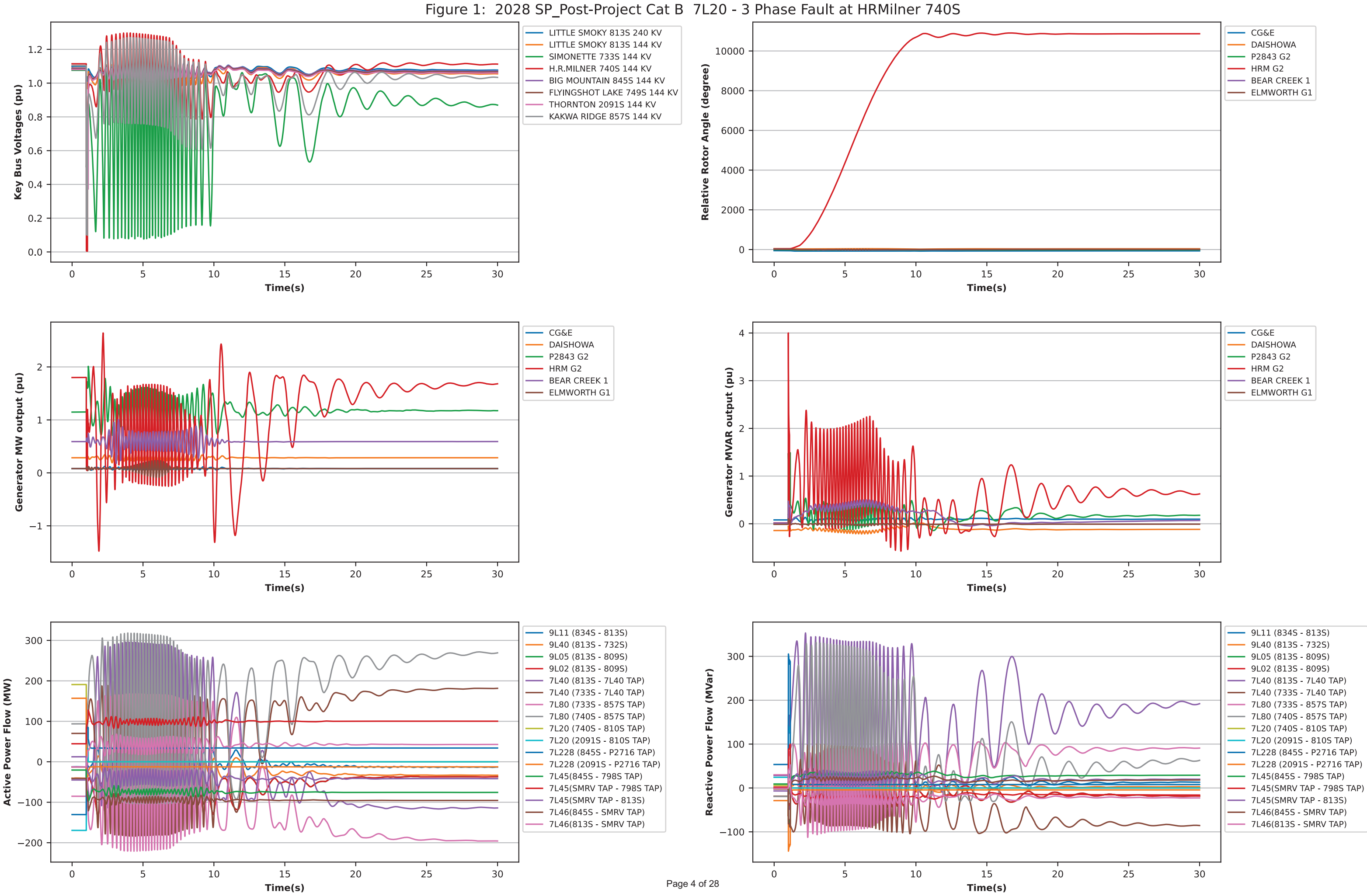


Figure 1A: 2028 SP_Post-Project Cat B 7L20 - 1 Phase Fault at HRMilner 740S

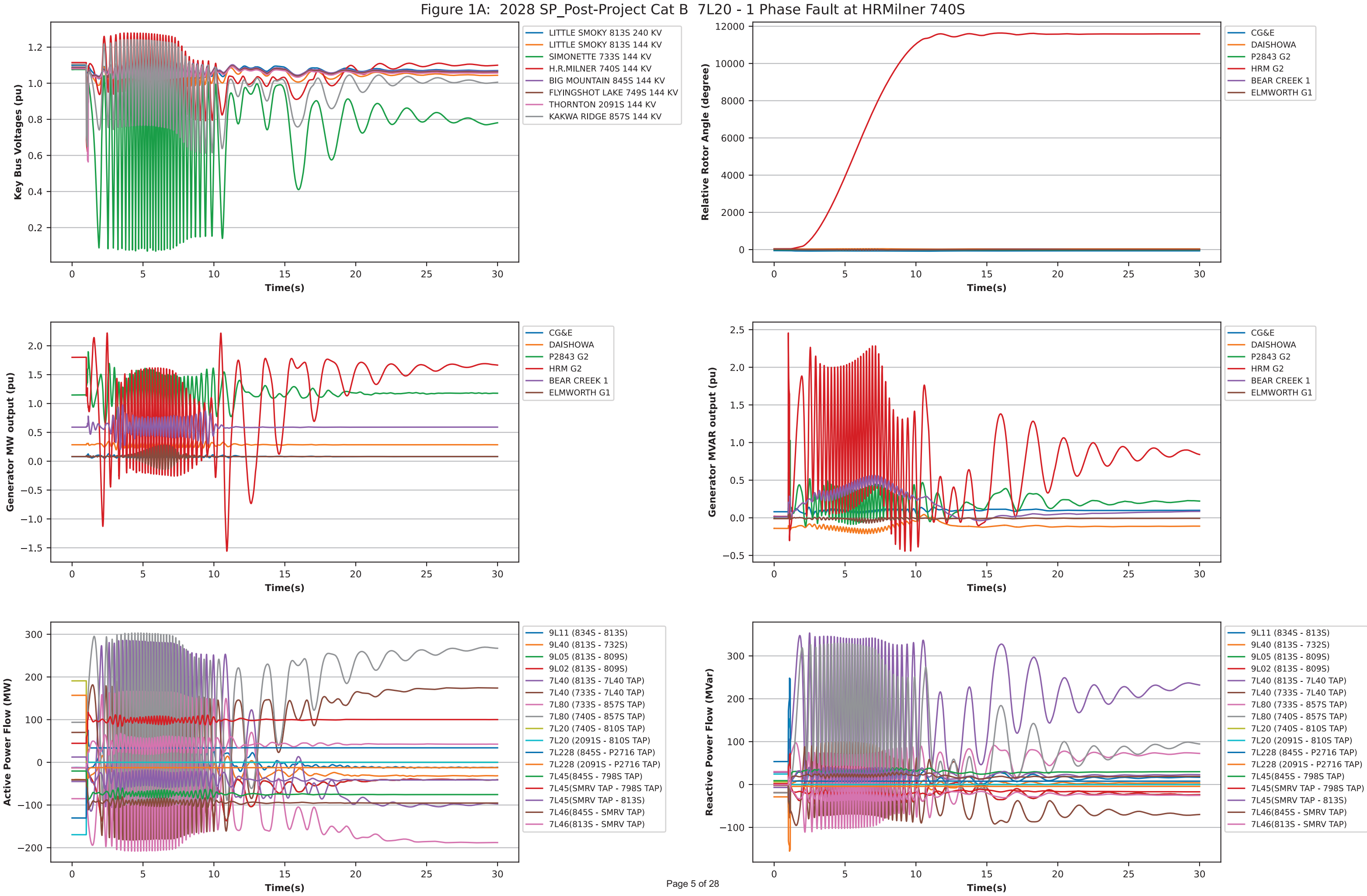


Figure 2: 2028 SP_Post-Project Cat B 7L20 - 3 Phase Fault at Thornton 2091S

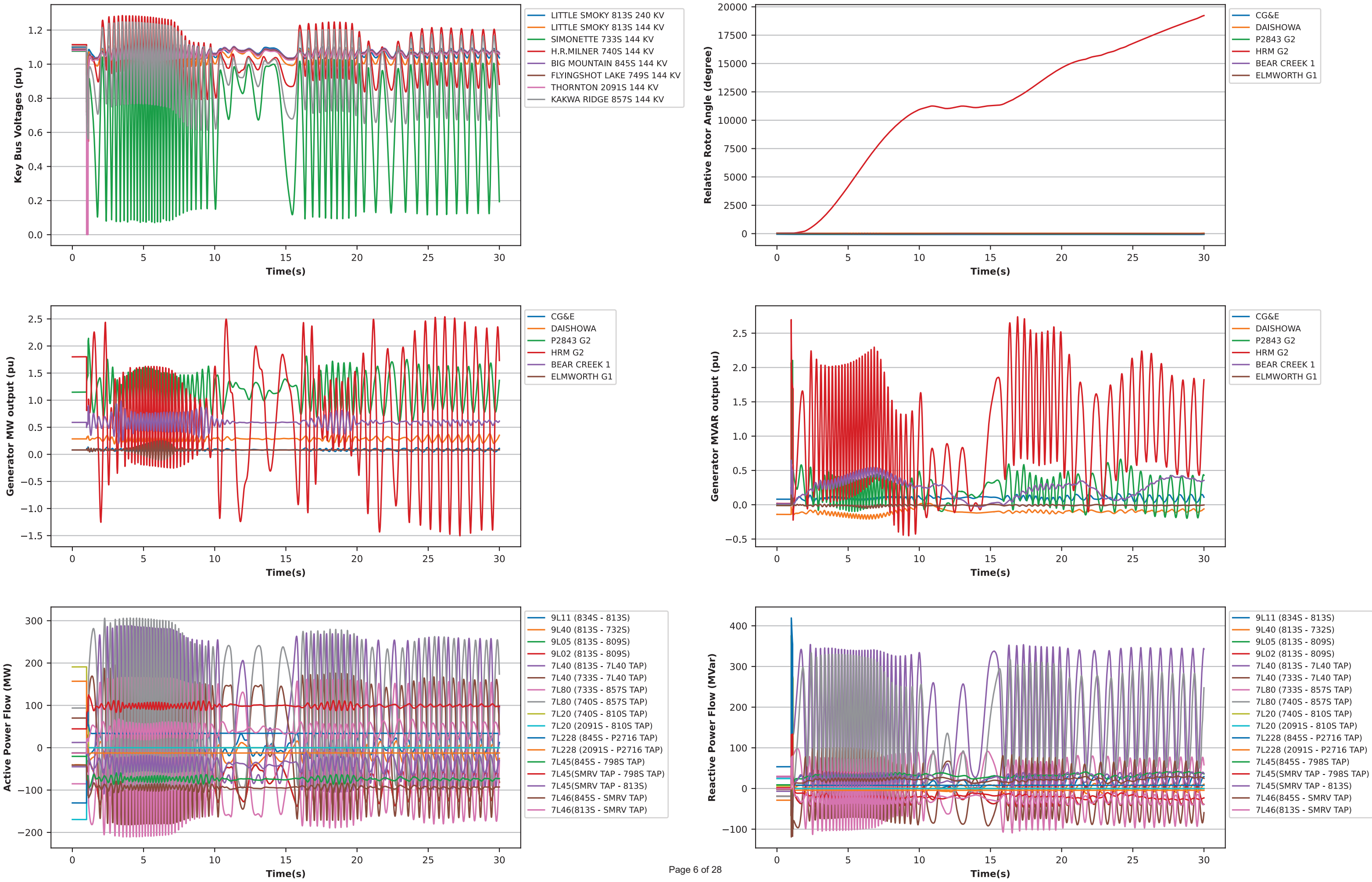


Figure 2A: 2028 SP_Post-Project Cat B 7L20 - 1 Phase Fault at Thornton 2091S

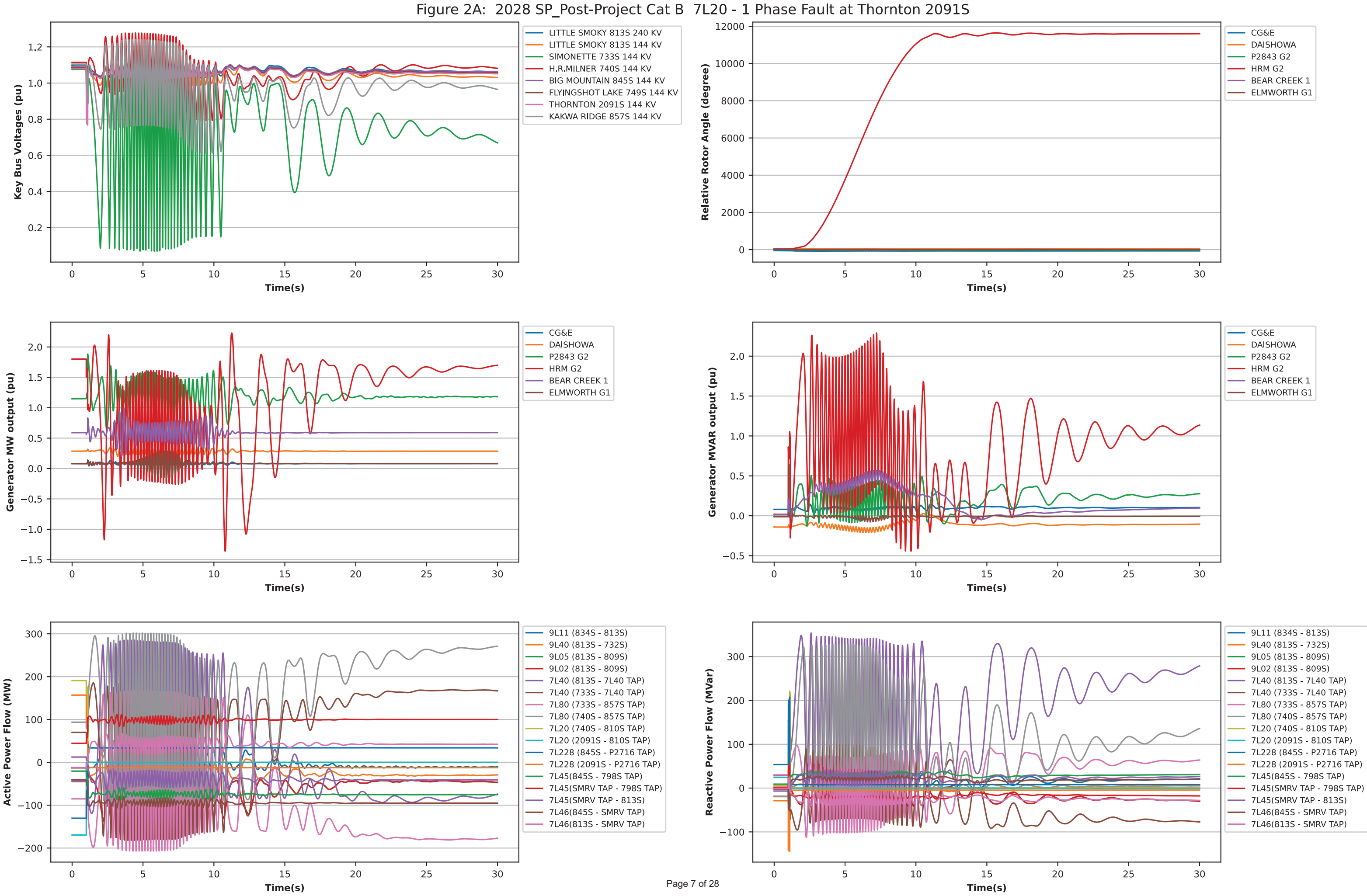


Figure 3: 2028 SP_Post-Project Cat B 7L80 - 3 Phase Fault at HRMilner 740S

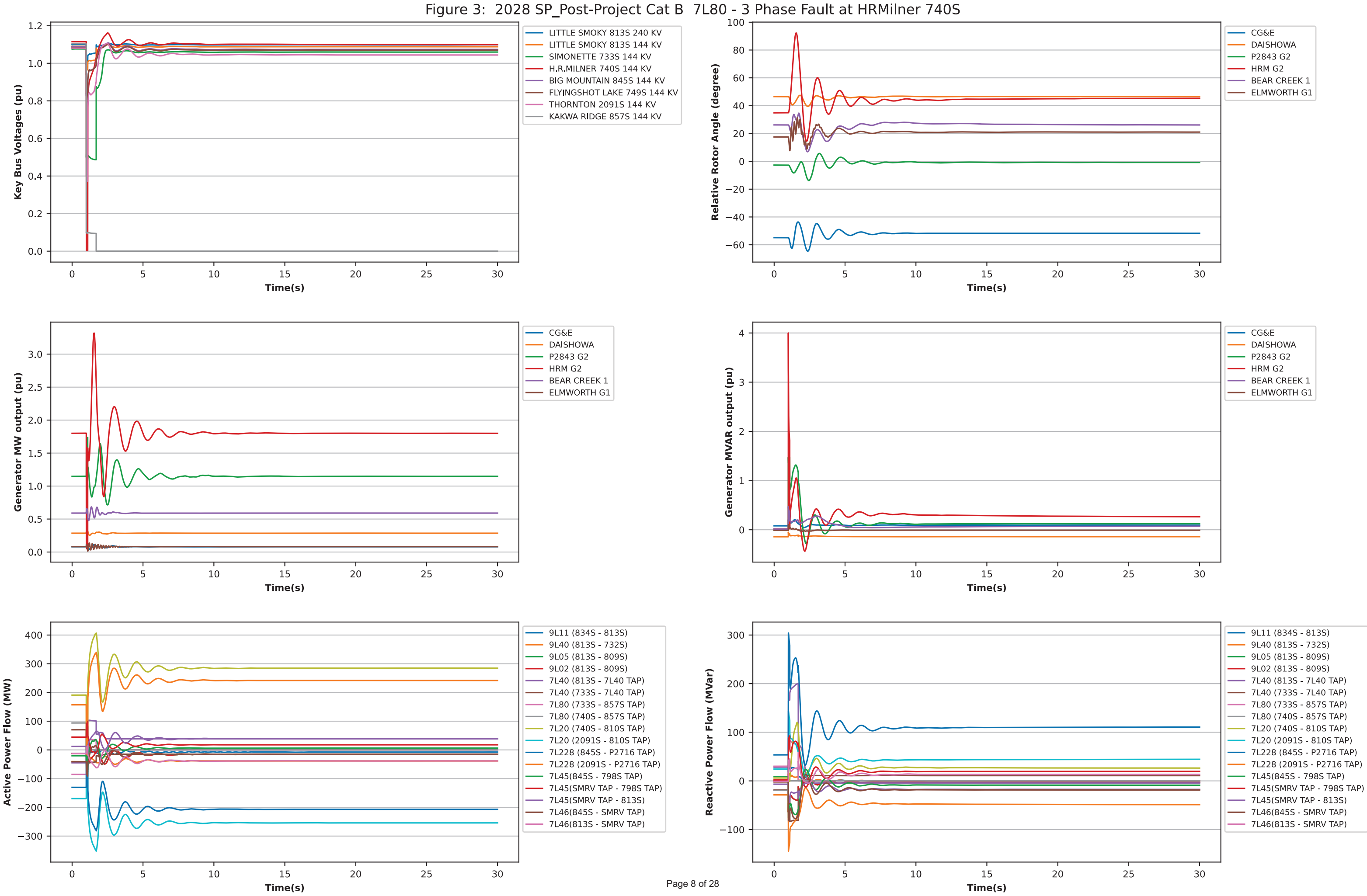


Figure 3A: 2028 SP_Post-Project Cat B 7L80 - 1 Phase Fault at HRMilner 740S

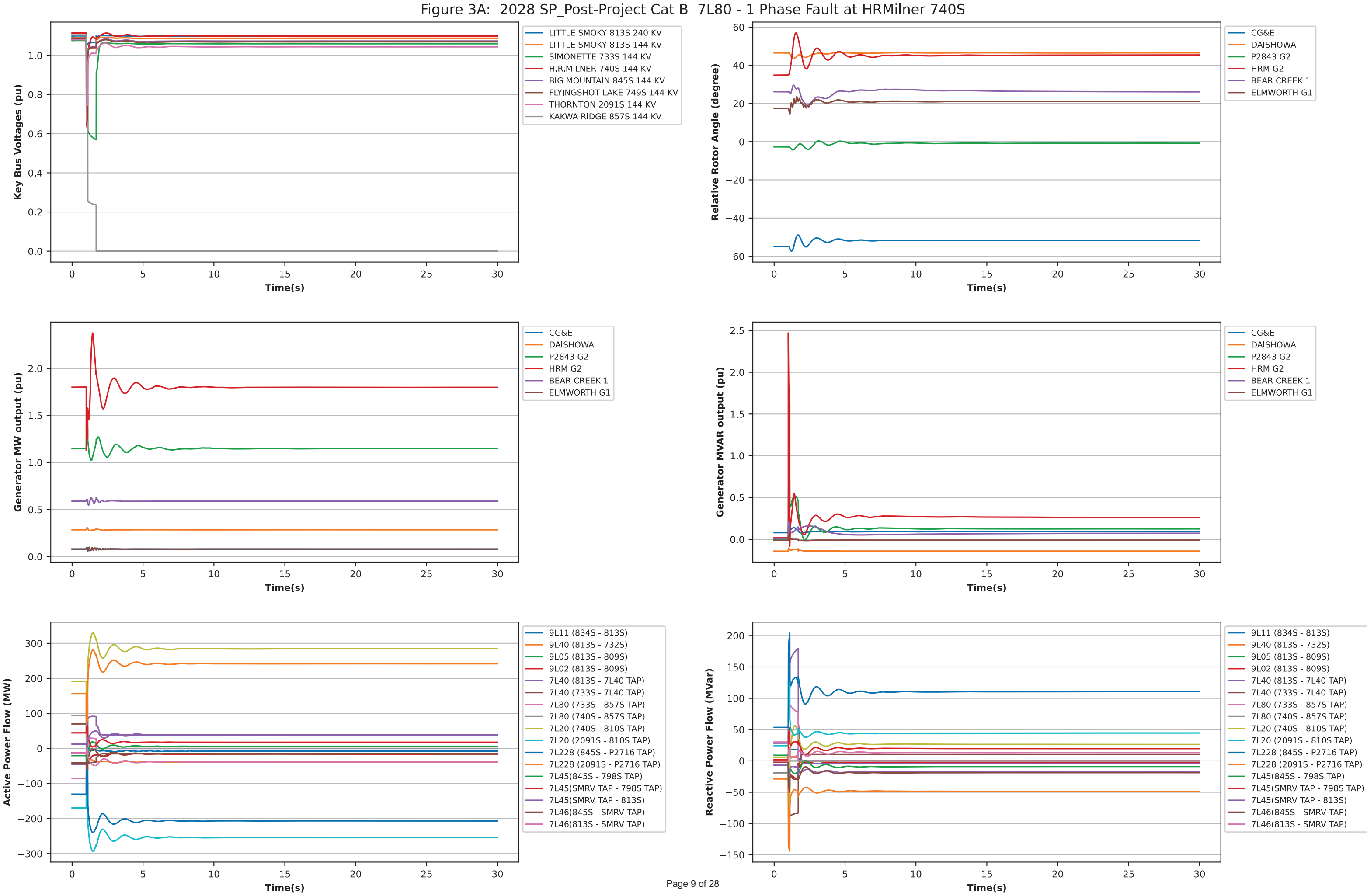


Figure 4: 2028 SP_Post-Project Cat B 7L80 - 3 Phase Fault at Simonette 733S

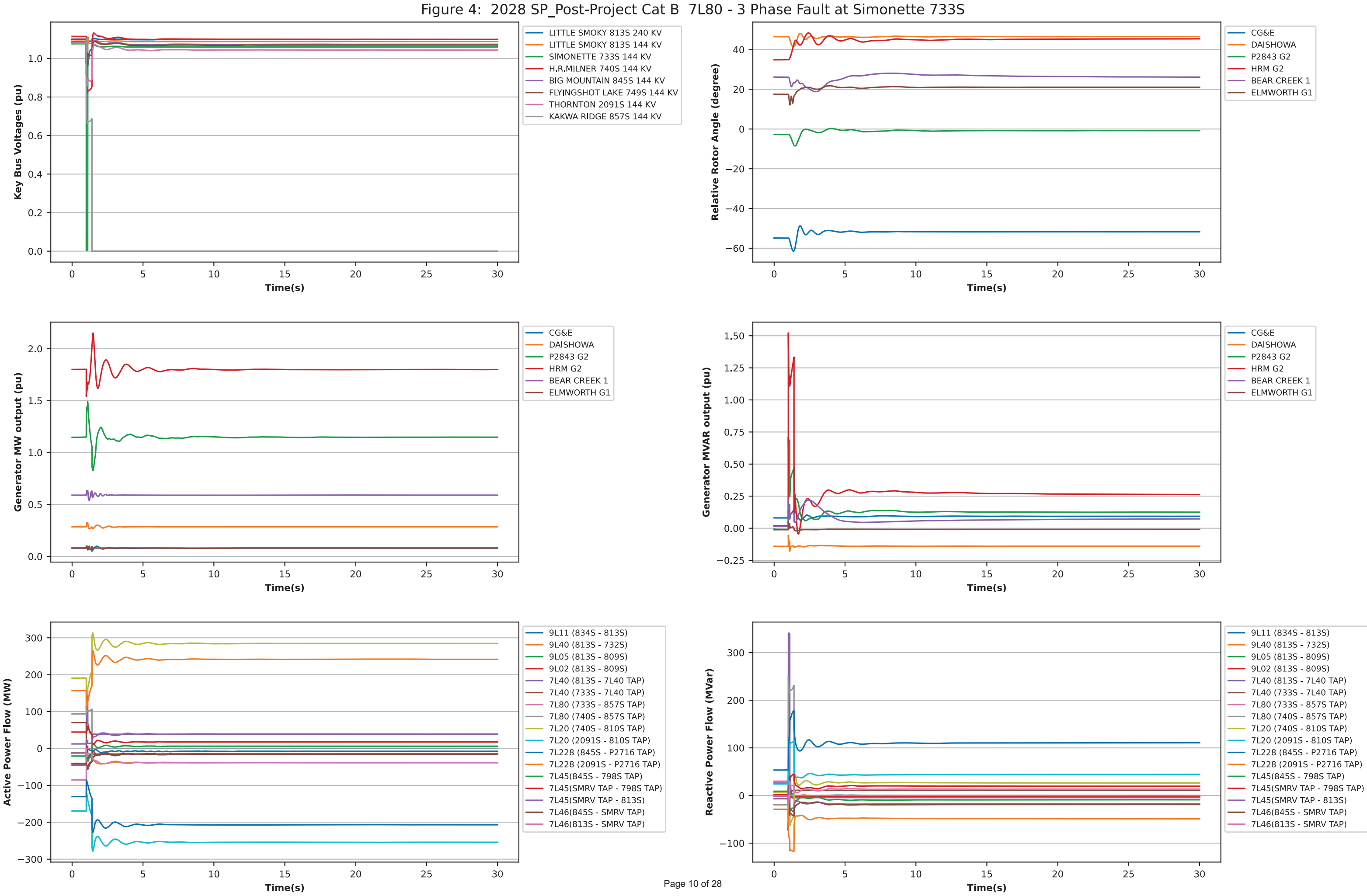


Figure 4A: 2028 SP_Post-Project Cat B 7L80 - 1 Phase Fault at Simonette 733S

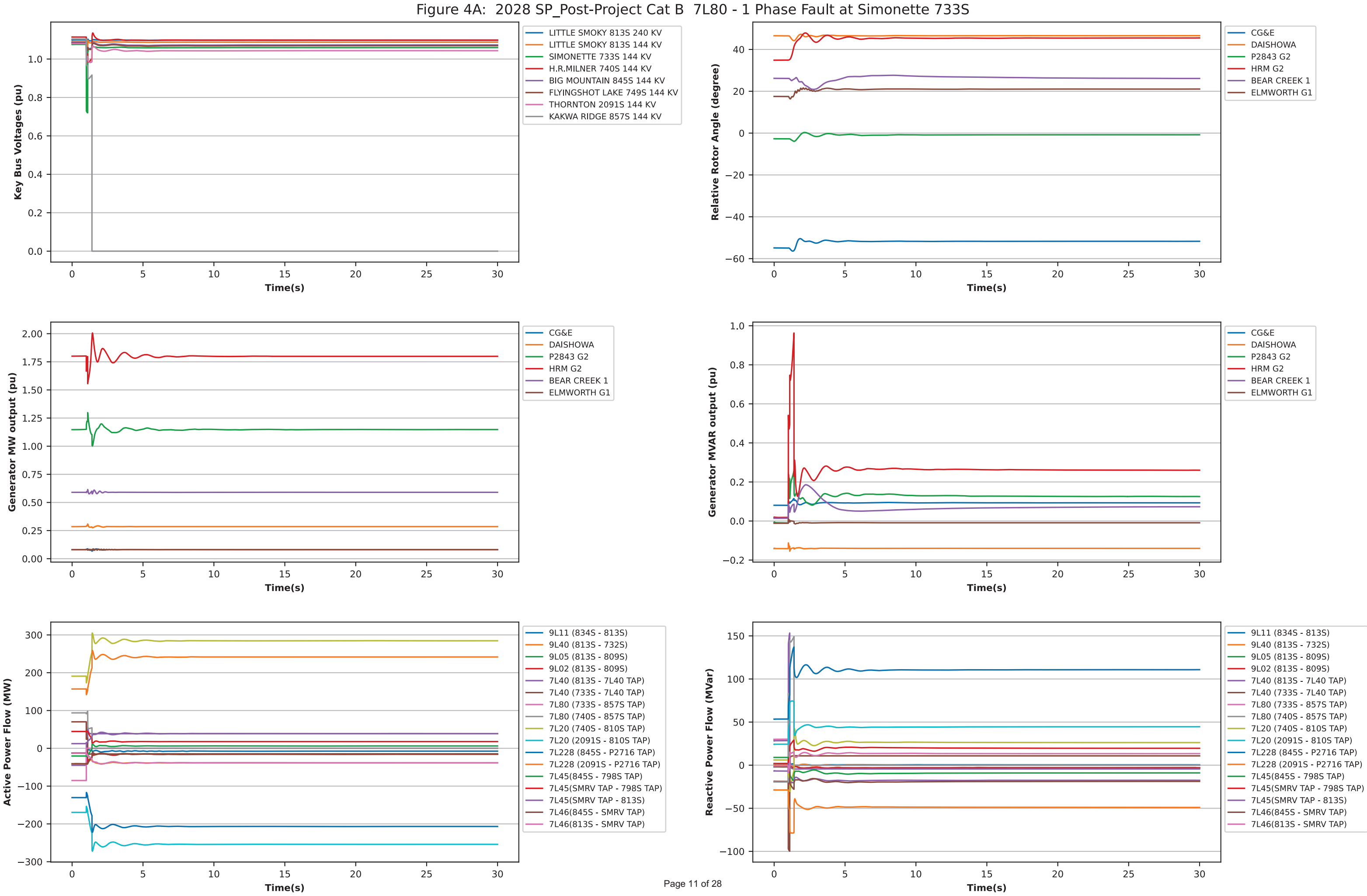


Figure 5: 2028 SP_Post-Project Cat B 7L40 - 3 Phase Fault at Simonette 733S

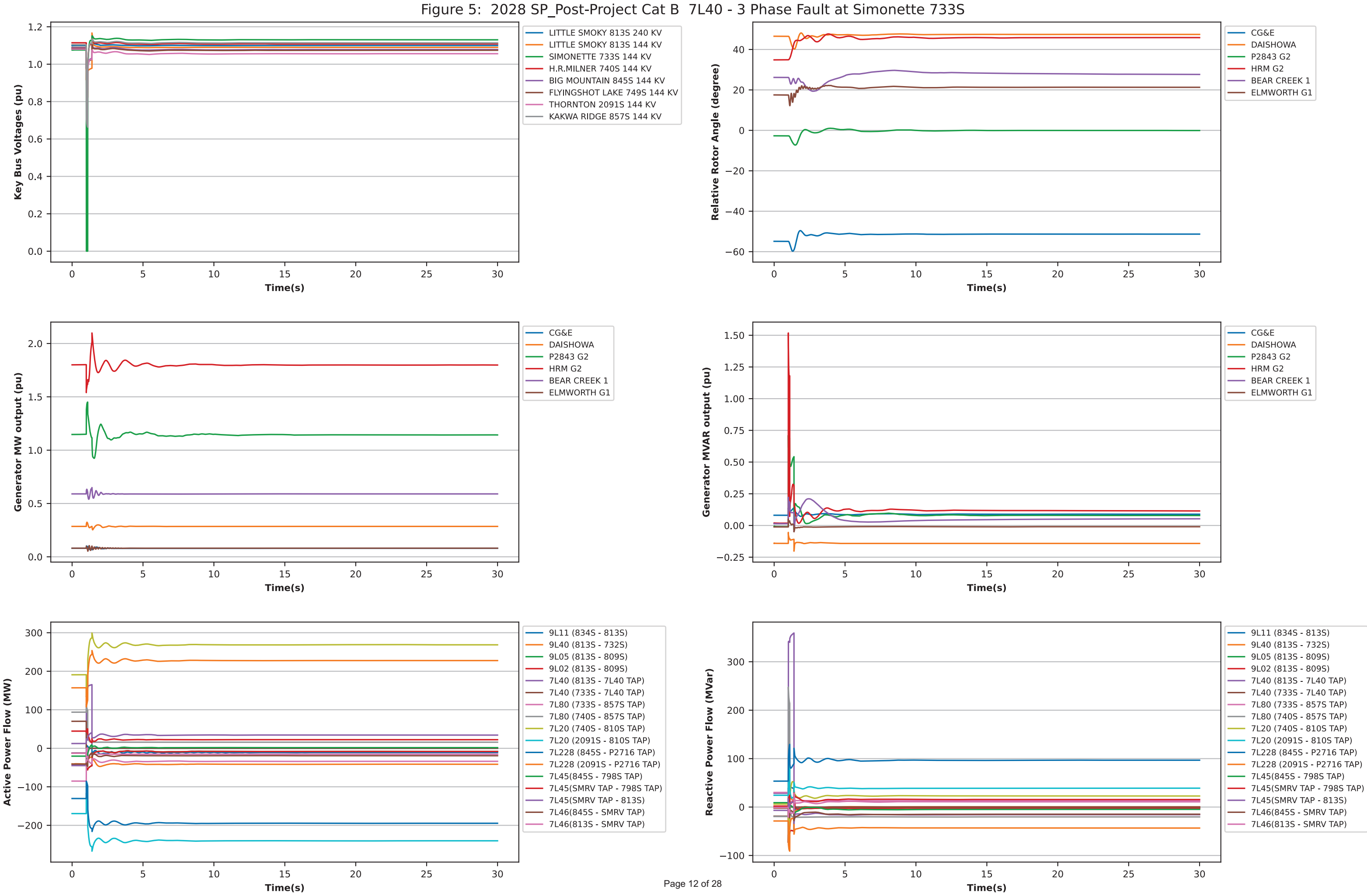


Figure 5A: 2028 SP_Post-Project Cat B 7L40 - 1 Phase Fault at Simonette 733S

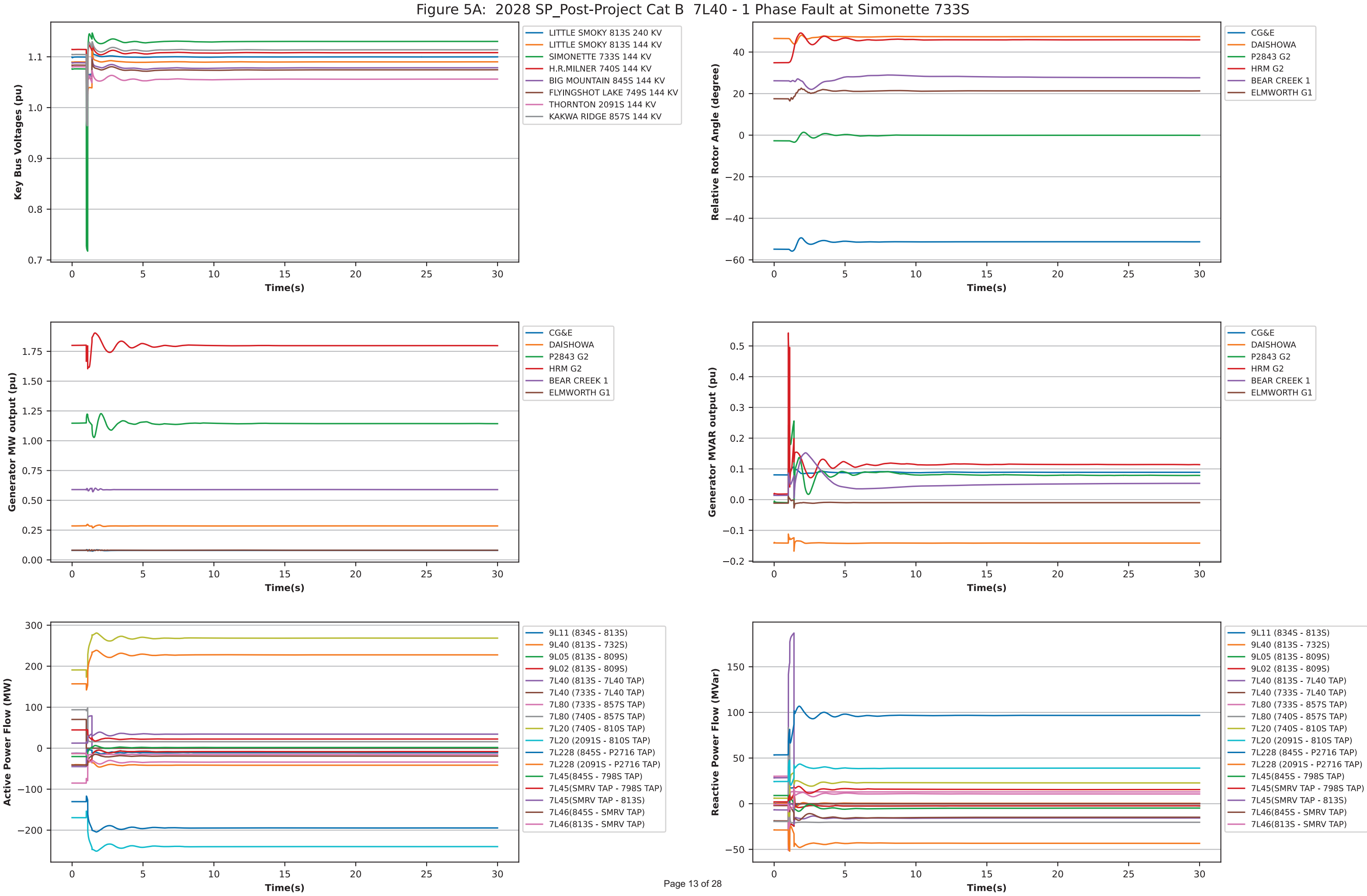


Figure 6: 2028 SP_Post-Project Cat B 7L40 - 3 Phase Fault at Little Smoky 813S

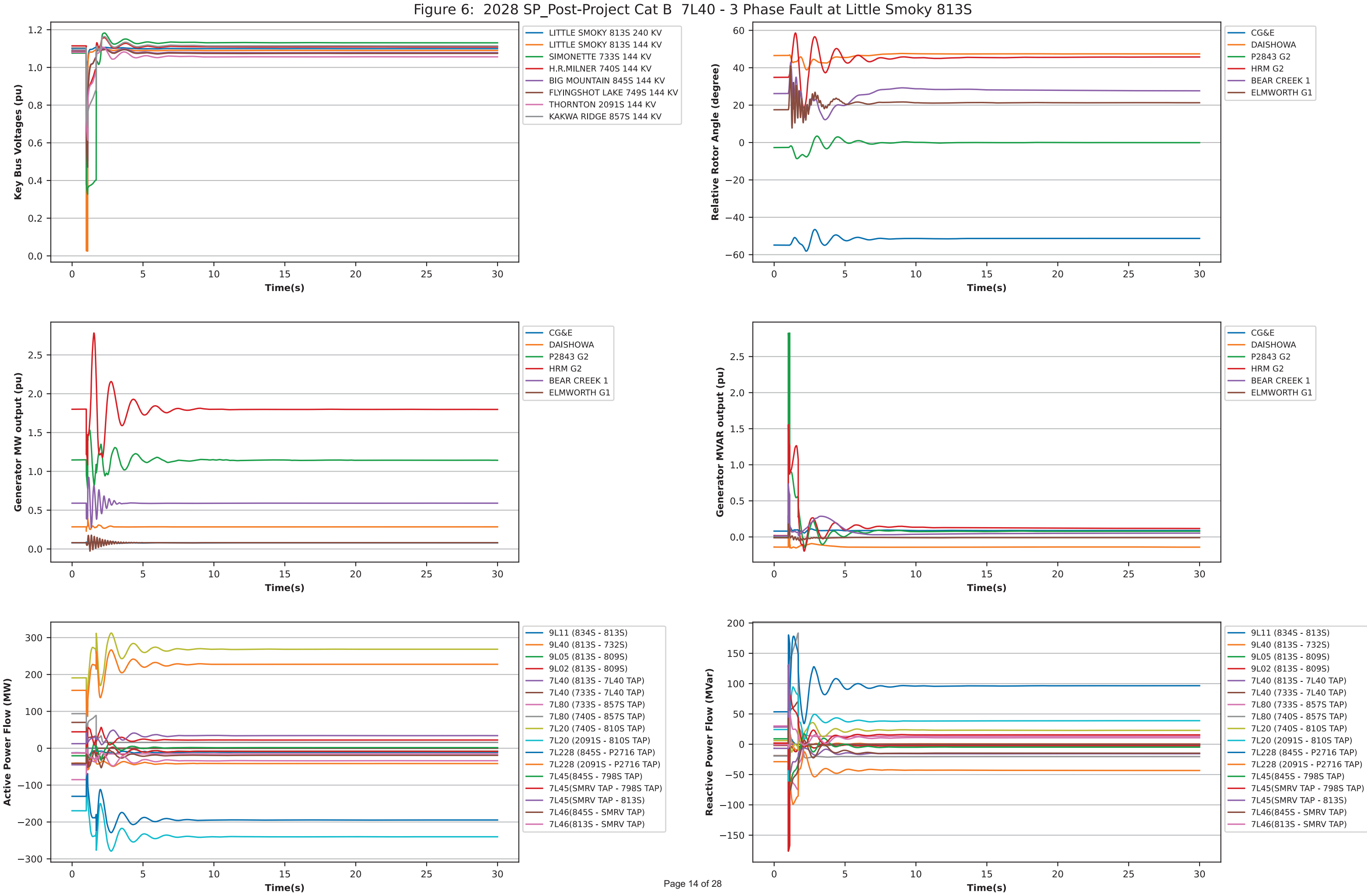


Figure 6A: 2028 SP_Post-Project Cat B 7L40 - 1 Phase Fault at Little Smoky 813S

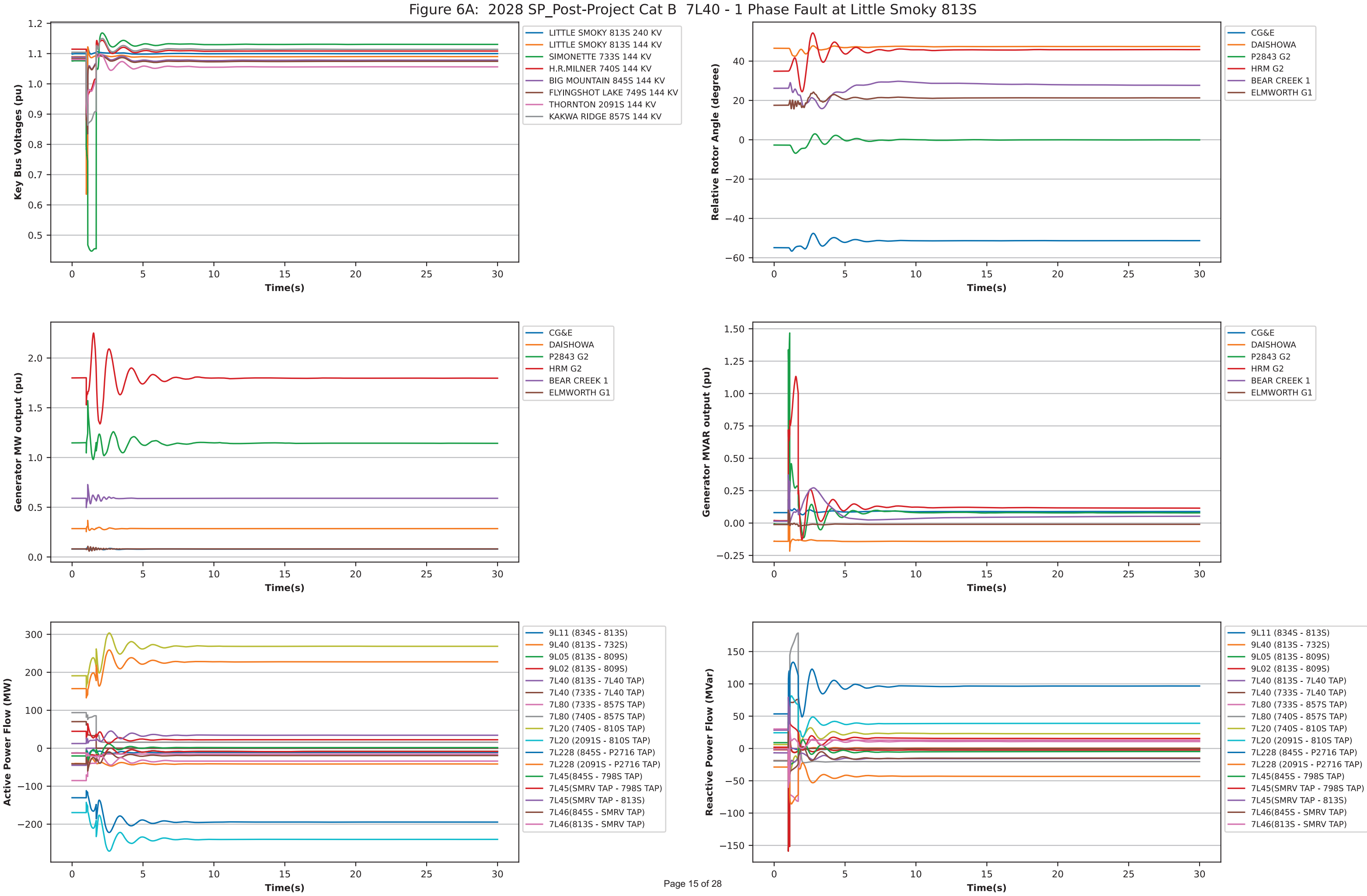


Figure 7: 2028 SP Post-Project_Cat_B_7L228 - 3 Phase Fault at Thornton 2091S

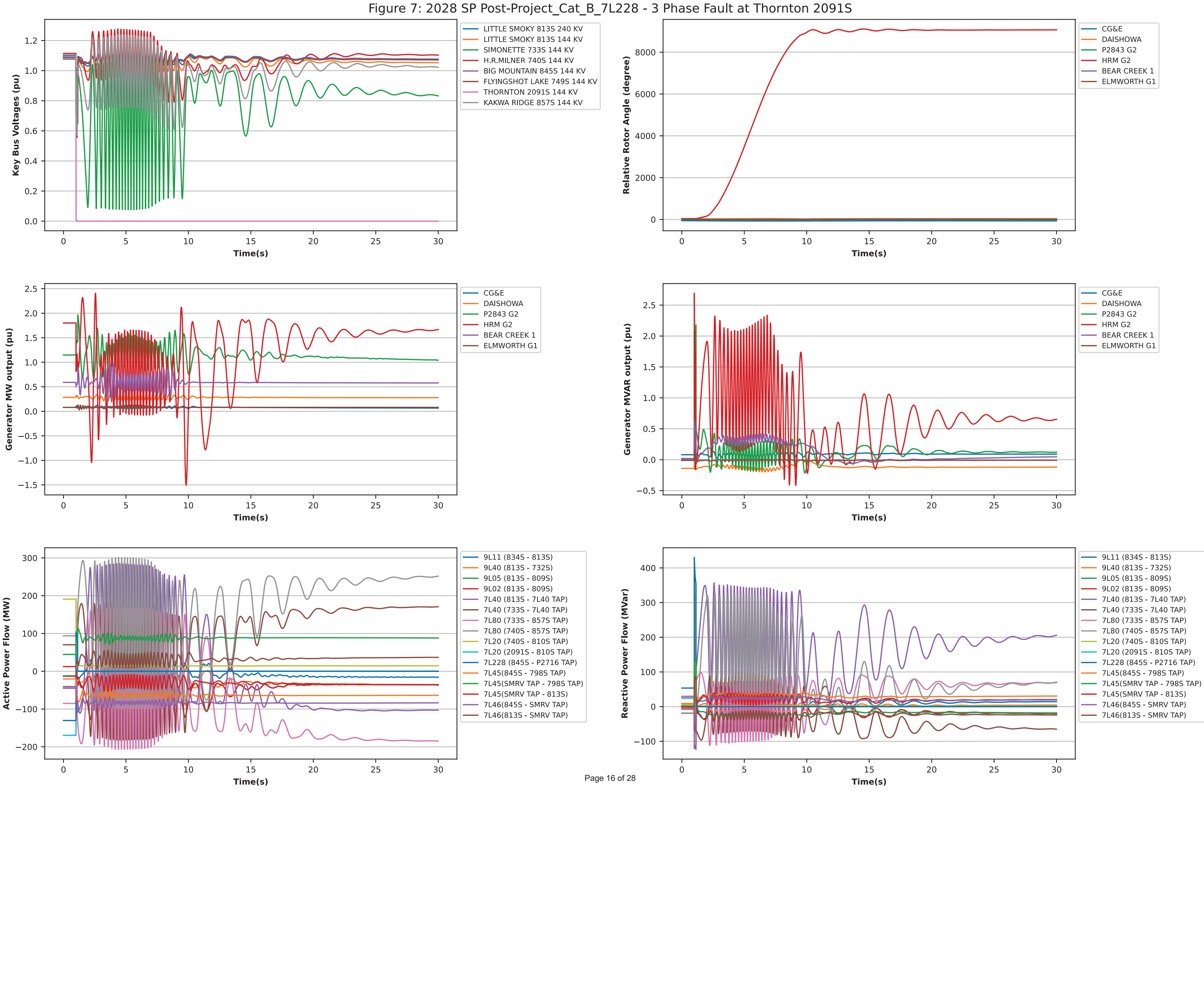


Figure 7A: 2028 SP Post-Project_Cat_B_7L228 - 1 Phase Fault at Thornton 2091S

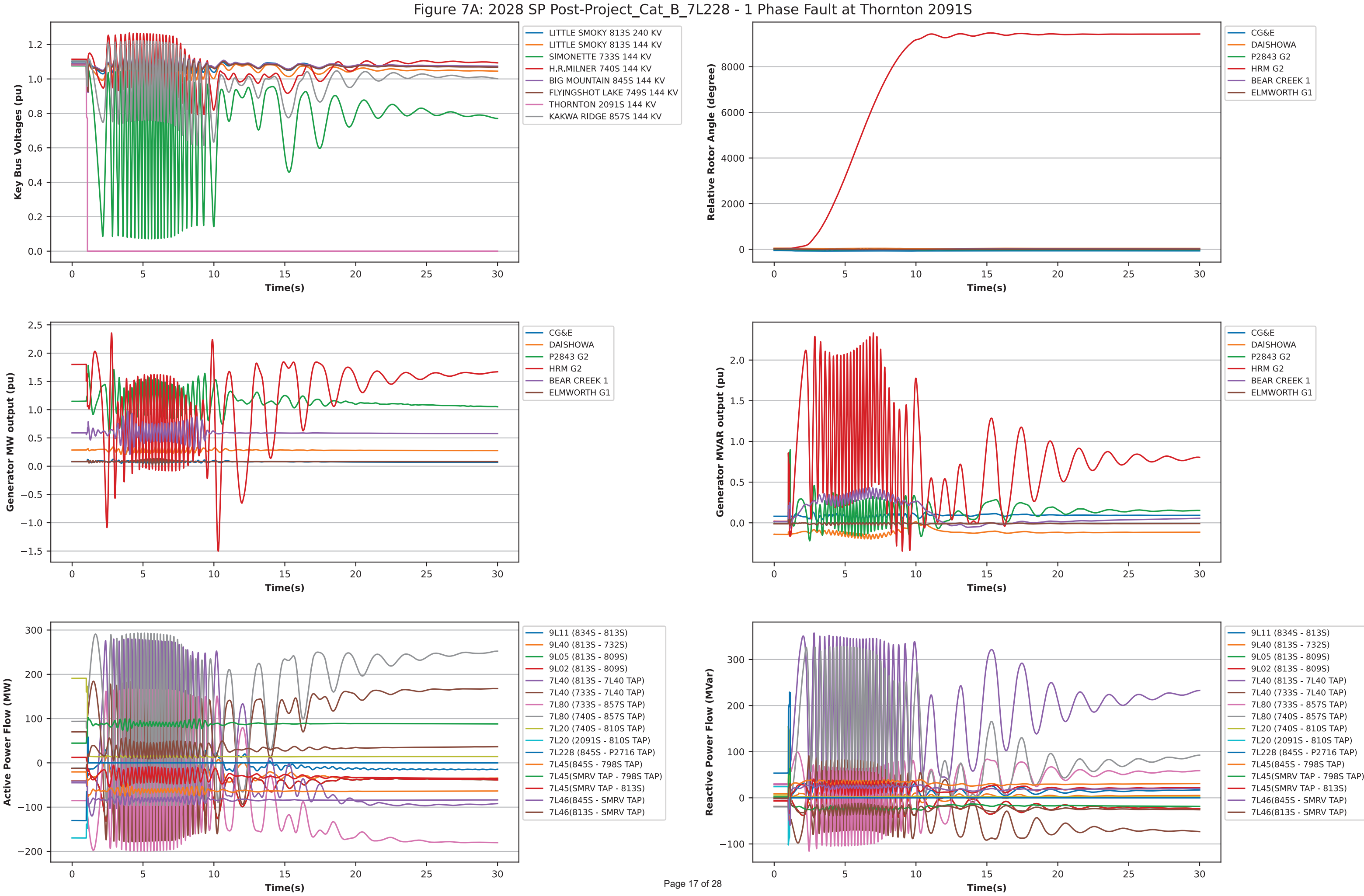


Figure 8: 2028 SP Post-Project_Cat_B_7L228 - 3 Phase Fault at Big Mountain 845S

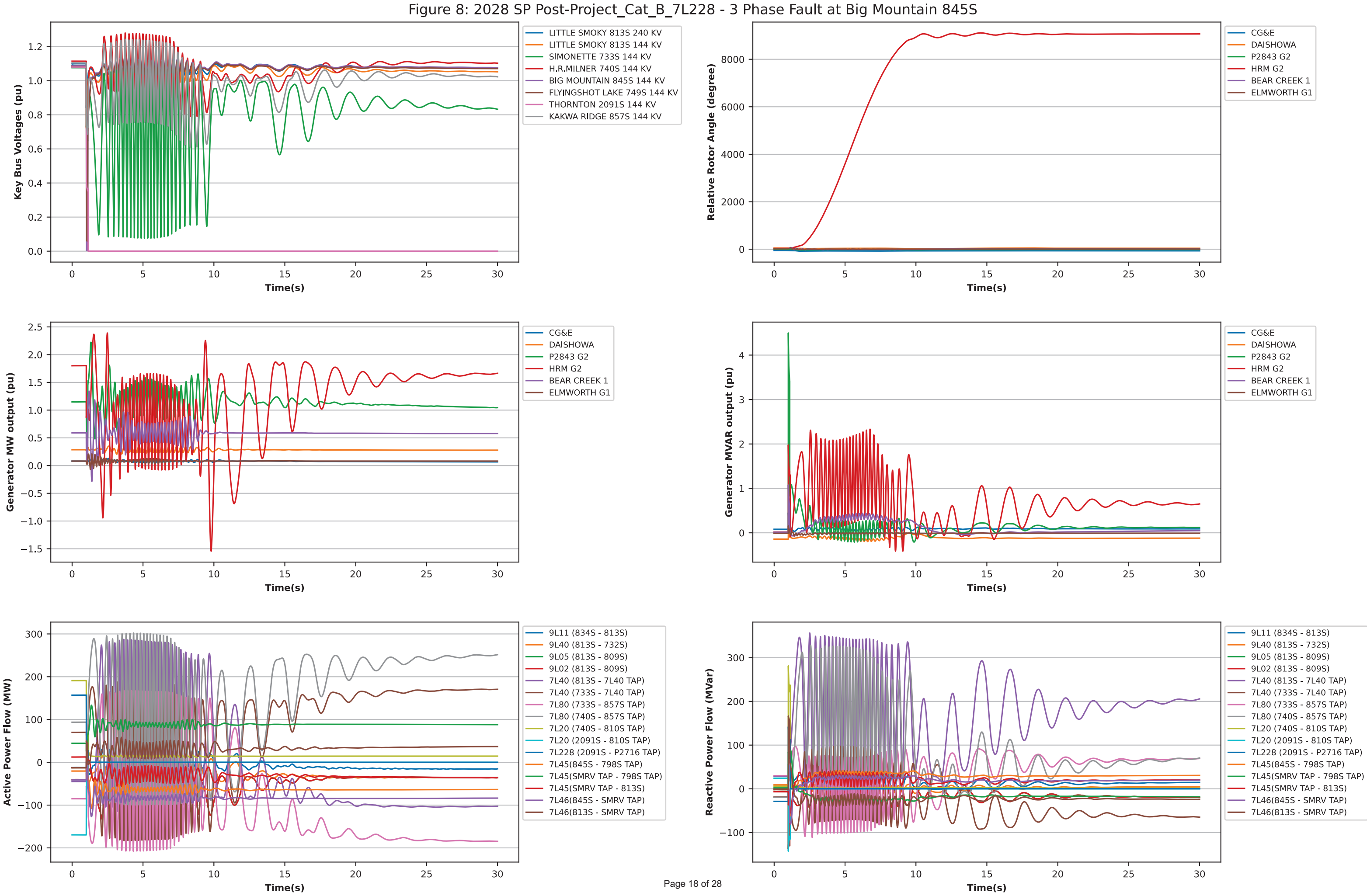


Figure 8A: 2028 SP Post-Project_Cat_B_7L228 - 1 Phase Fault at Big Mountain 845S

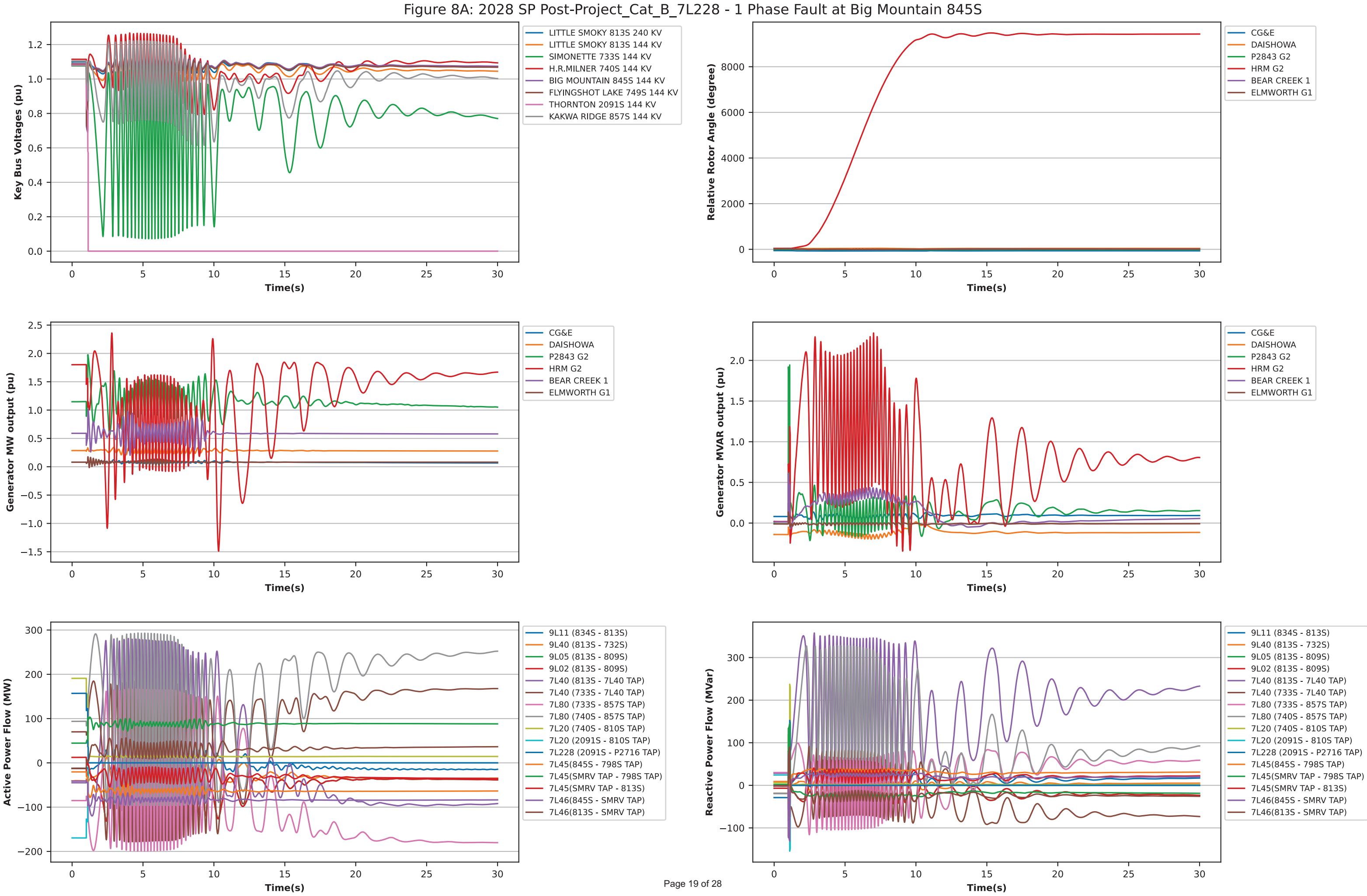


Figure 9: 2028 SP_Pre-Project Cat B 7L20 - 3 Phase Fault at HRMilner 740S

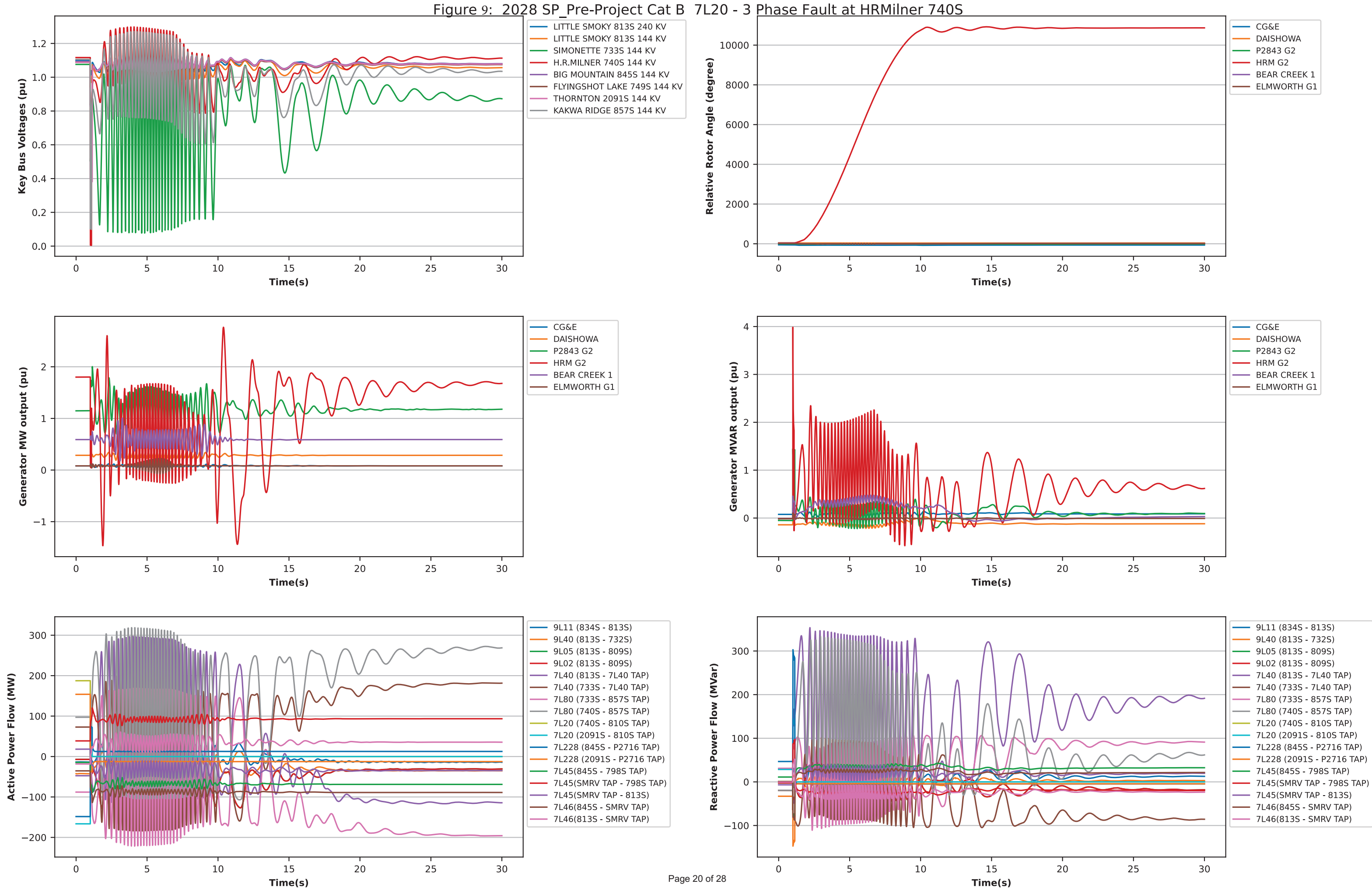


Figure 9A: 2028 SP_Pre-Project Cat B 7L20 - 1 Phase Fault at HRMilner 740S

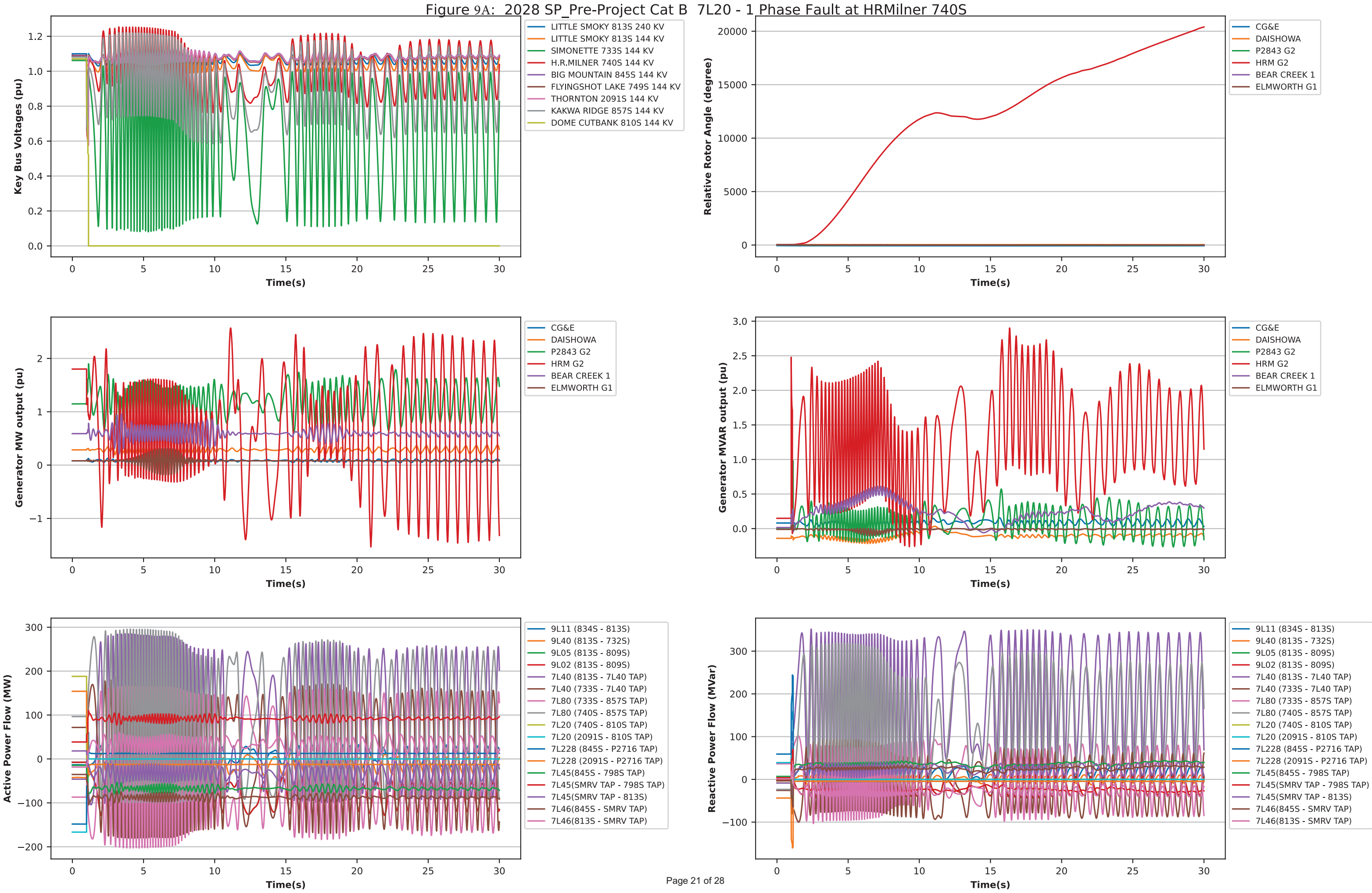


Figure 10: 2028 SP_Pre-Project Cat B 7L20 - 3 Phase Fault at Thornton 2091S

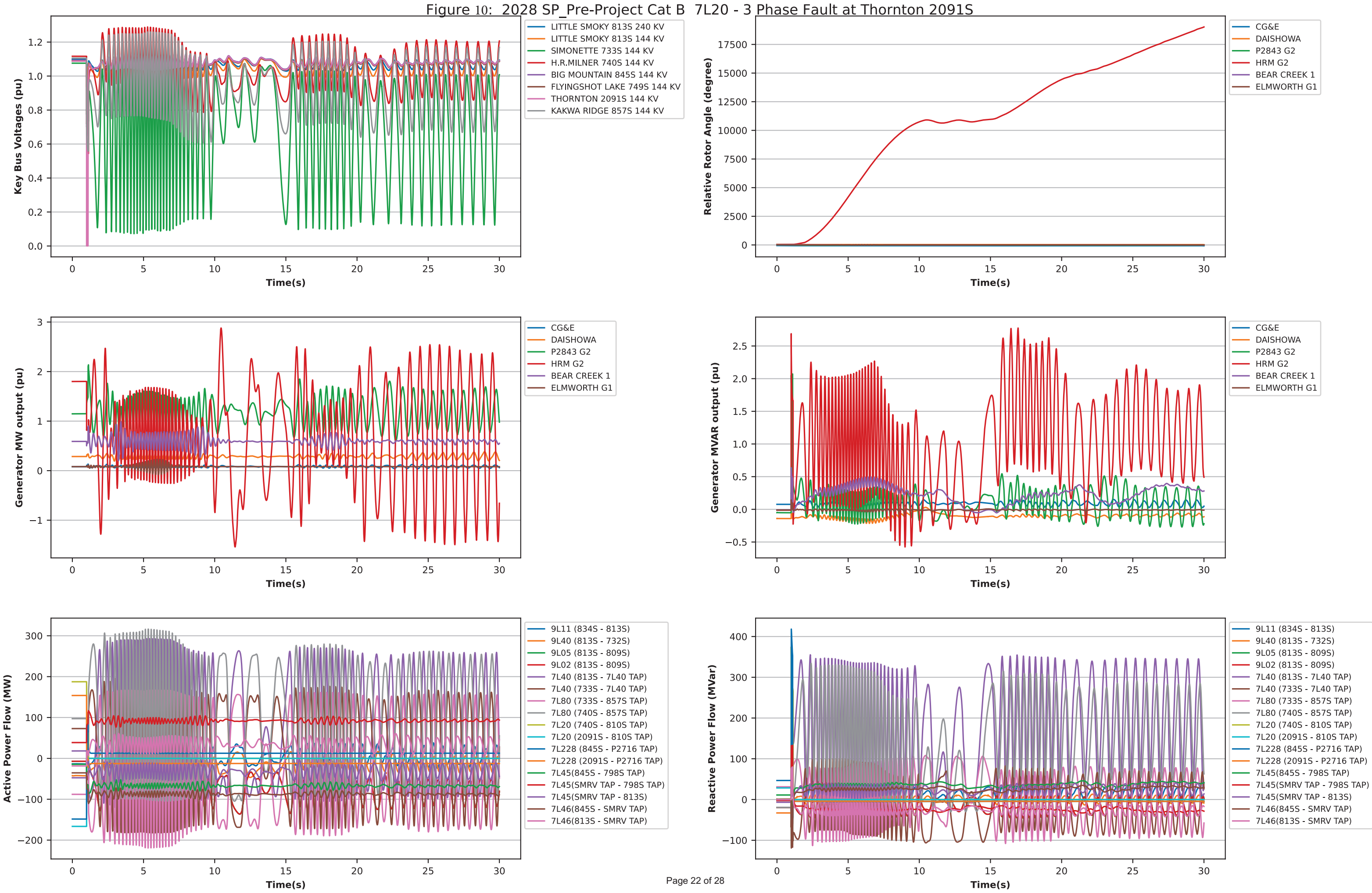


Figure 10A: 2028 SP_Pre-Project Cat B 7L20 - 1 Phase Fault at Thornton 2091S

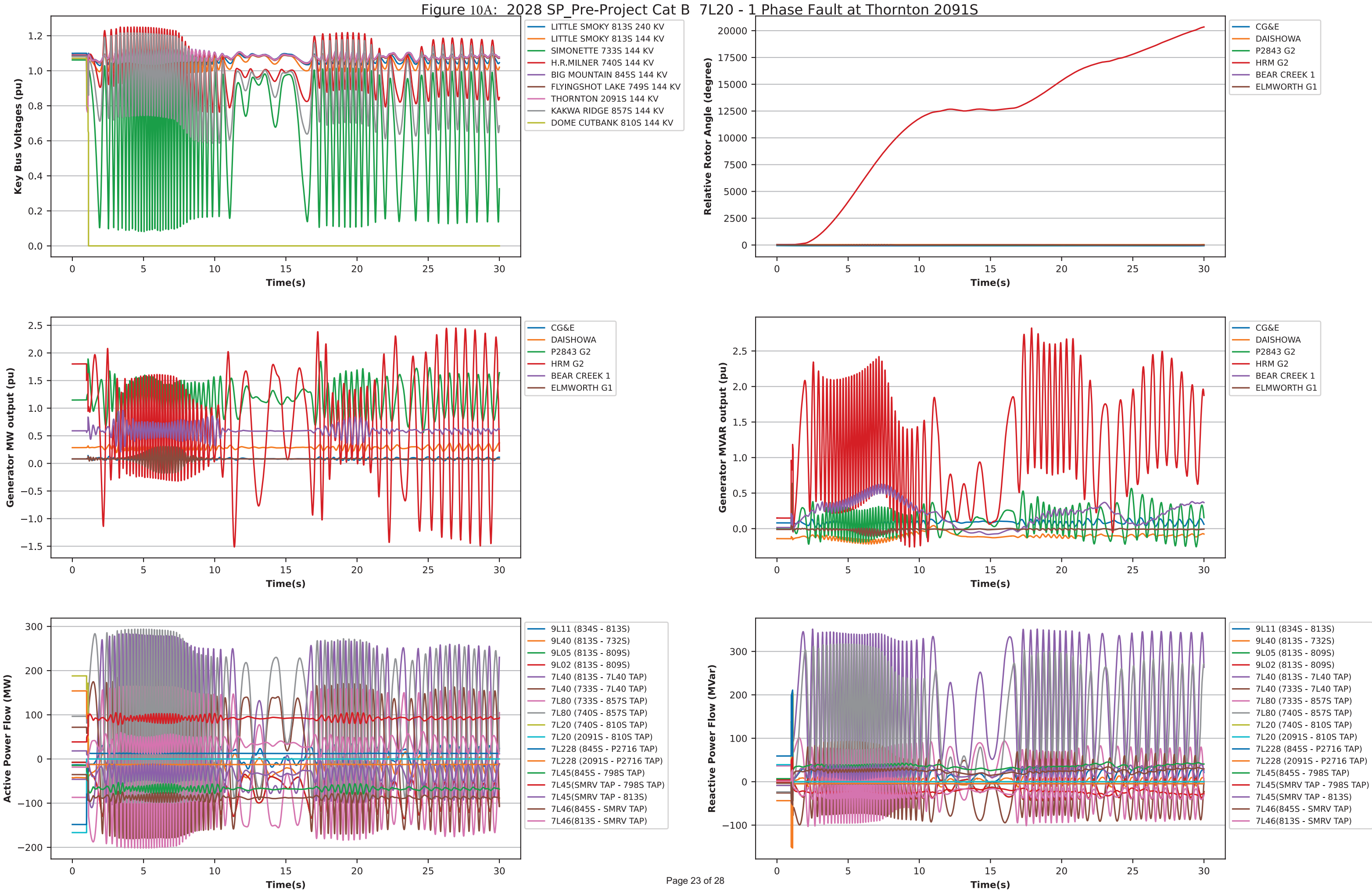


Figure 11: 2028 SP Pre-Project_Cat_B_7L228 - 3 Phase Fault at Thornton 2091S

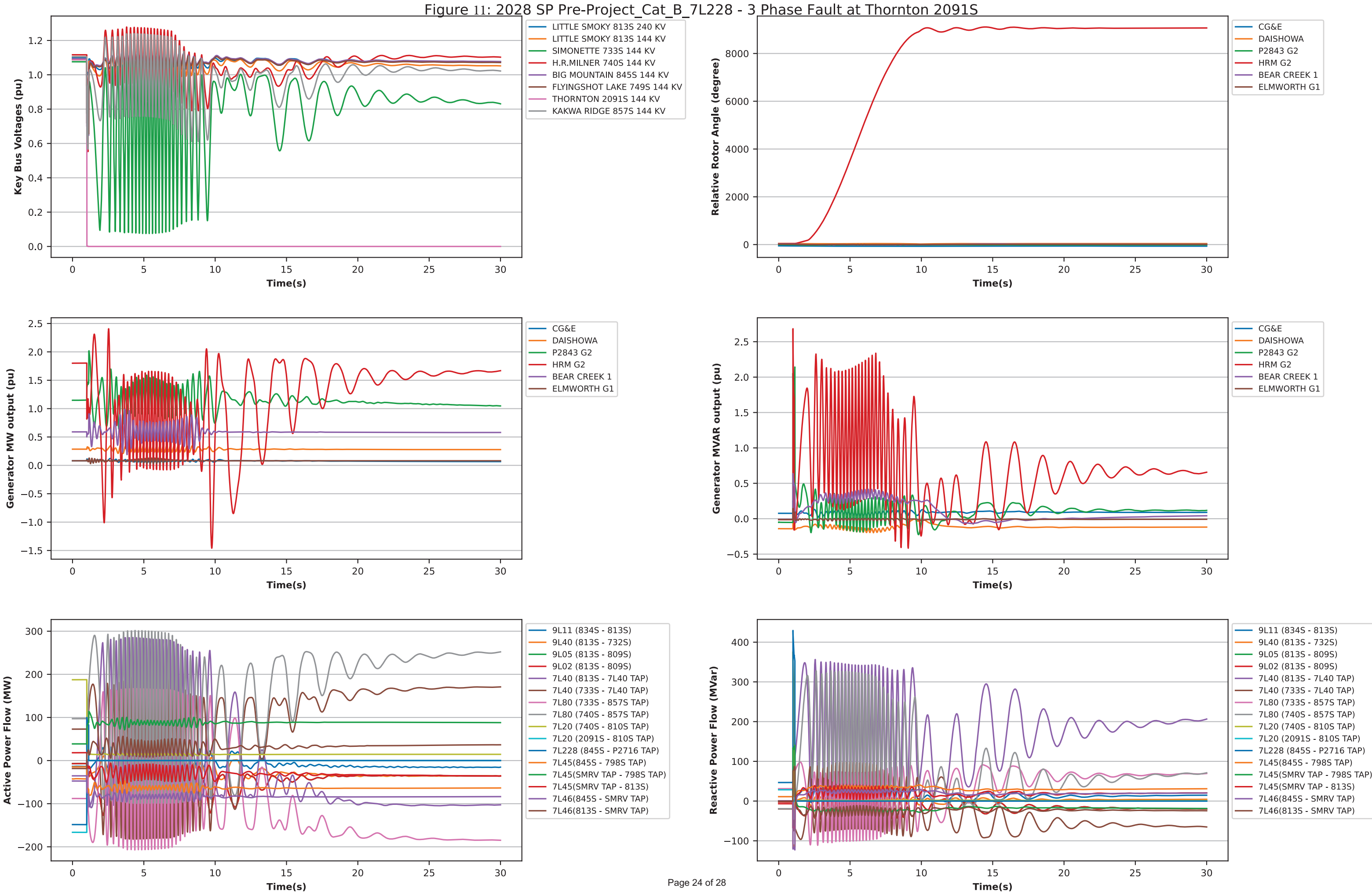


Figure 11A: 2028 SP Pre-Project_Cat_B_7L228 - 1 Phase Fault at Thornton 2091S

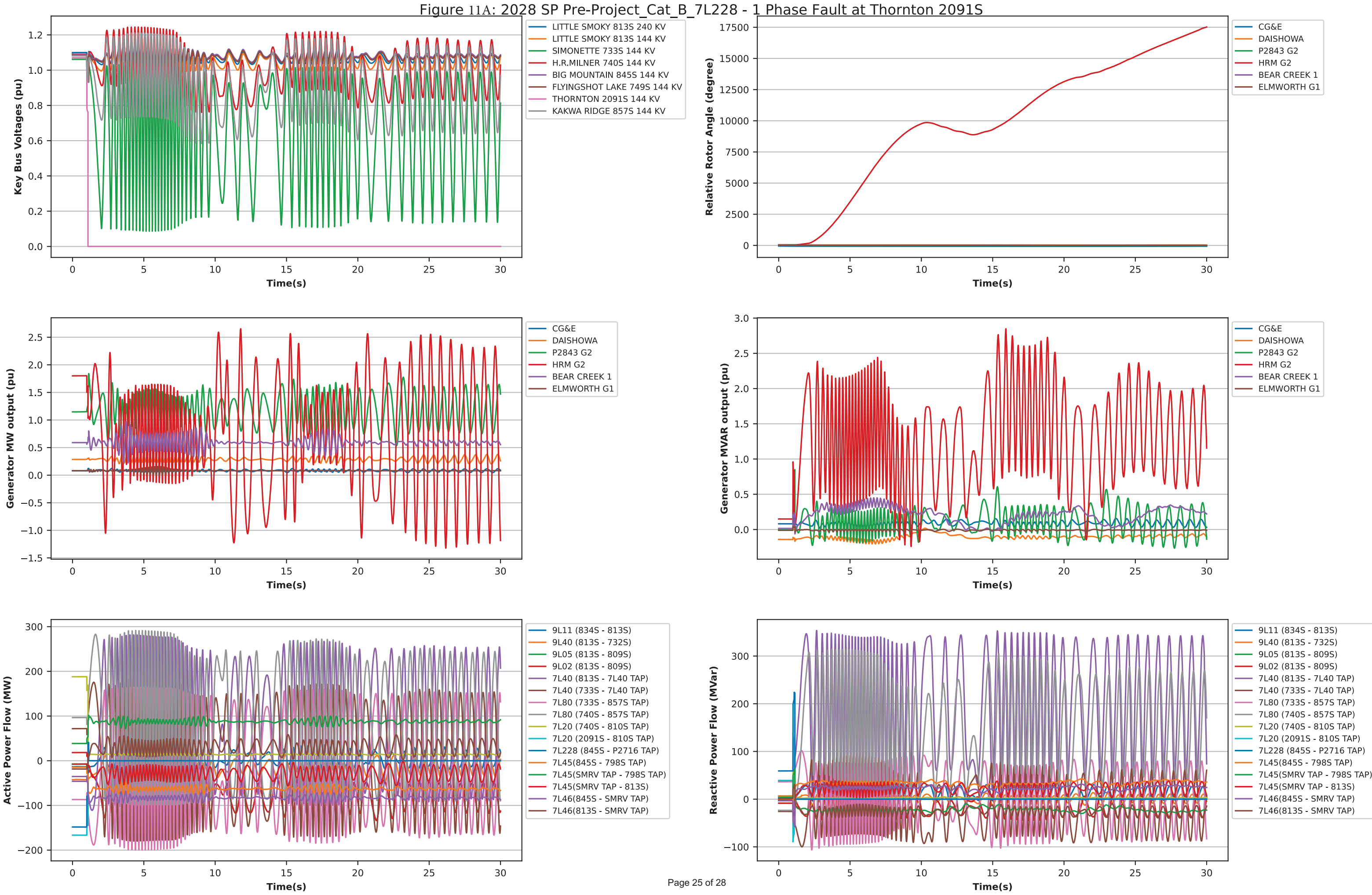


Figure 12: 2028 SP Pre-Project_Cat_B_7L228 - 3 Phase Fault at Big Mountain 845S

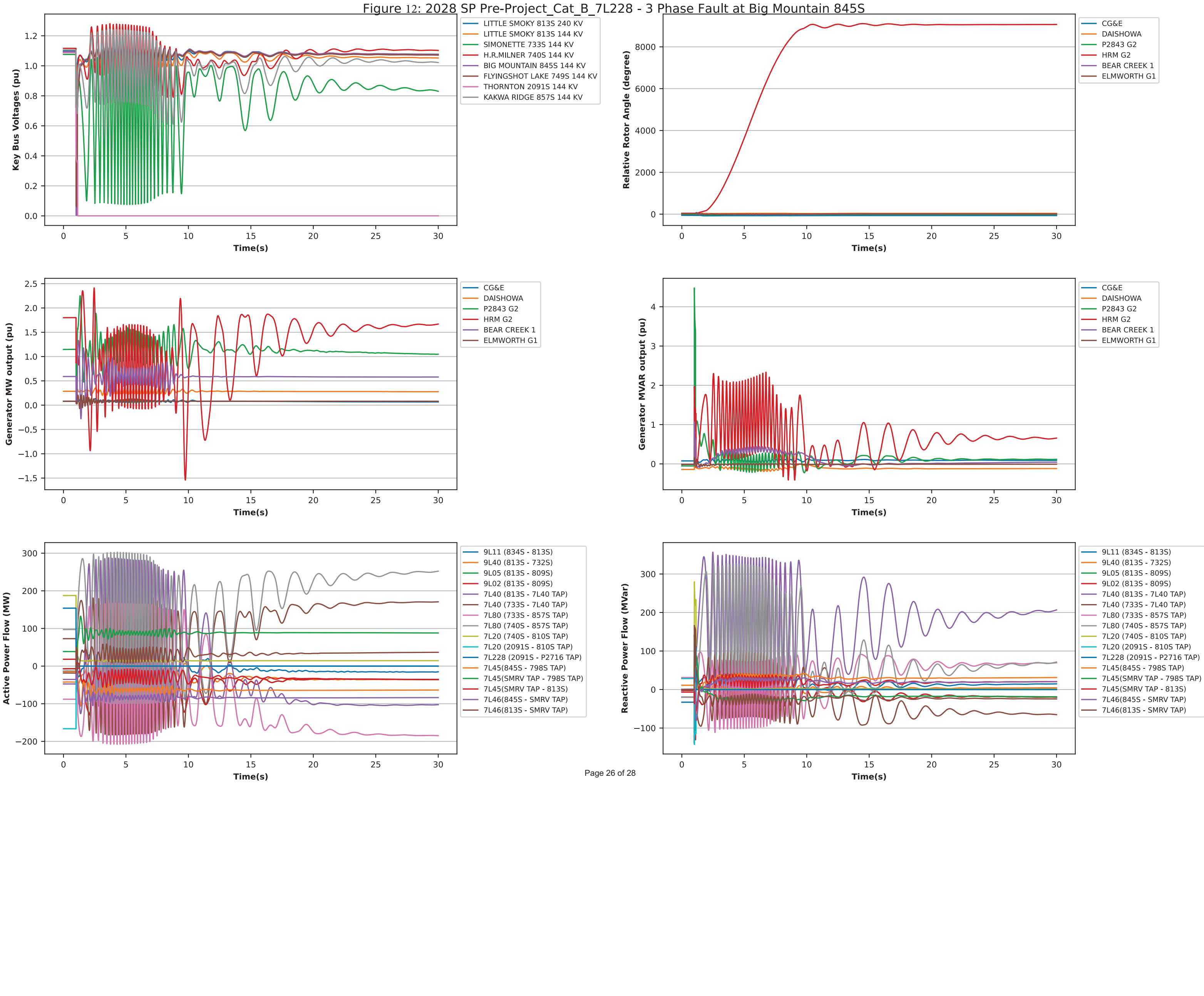


Figure 12A: 2028 SP Pre-Project_Cat_B_7L228 - 1 Phase Fault at Big Mountain 845S

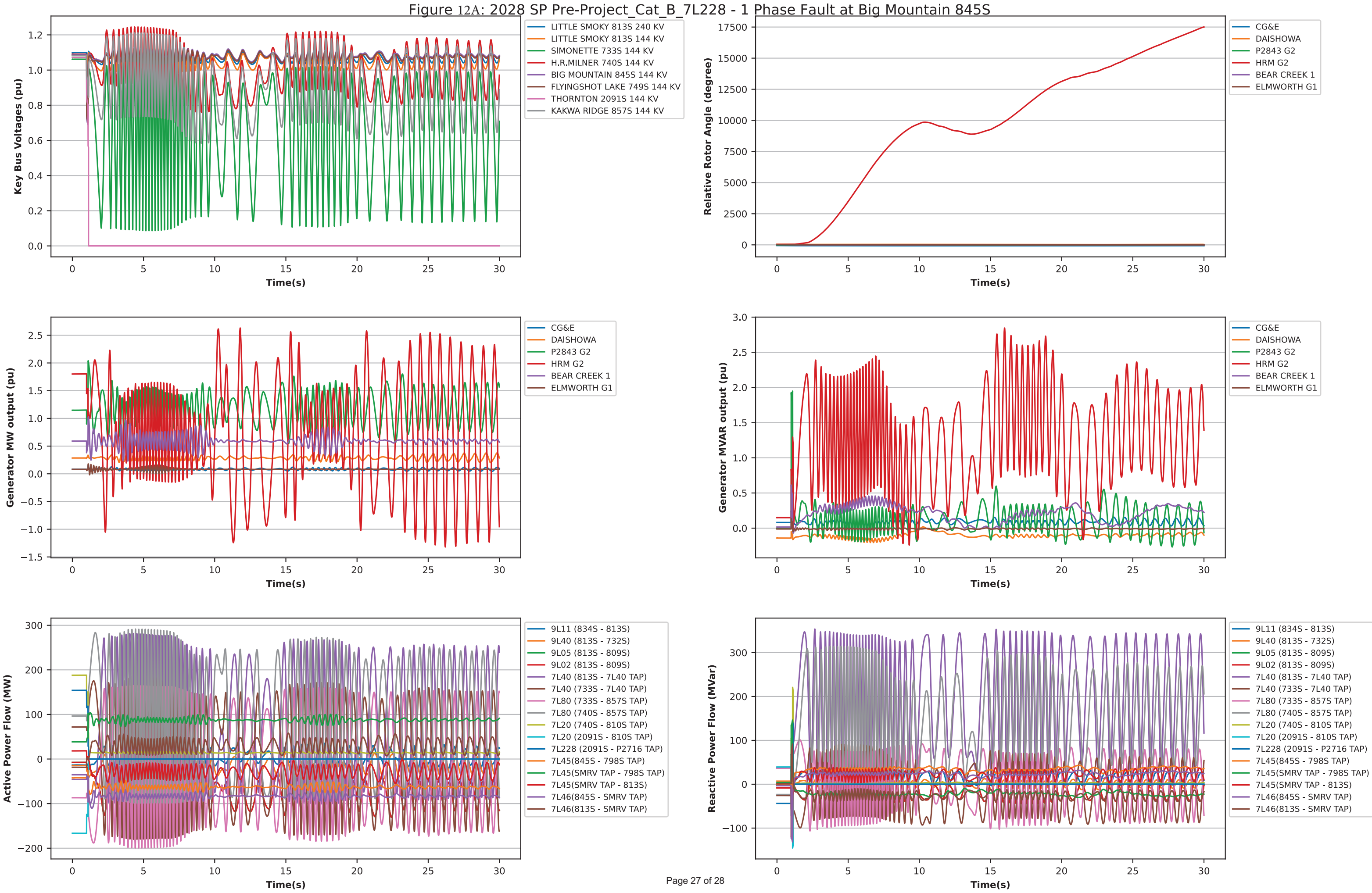


Figure 13: 2028 SP_Post-Project_7L20 - Line Open

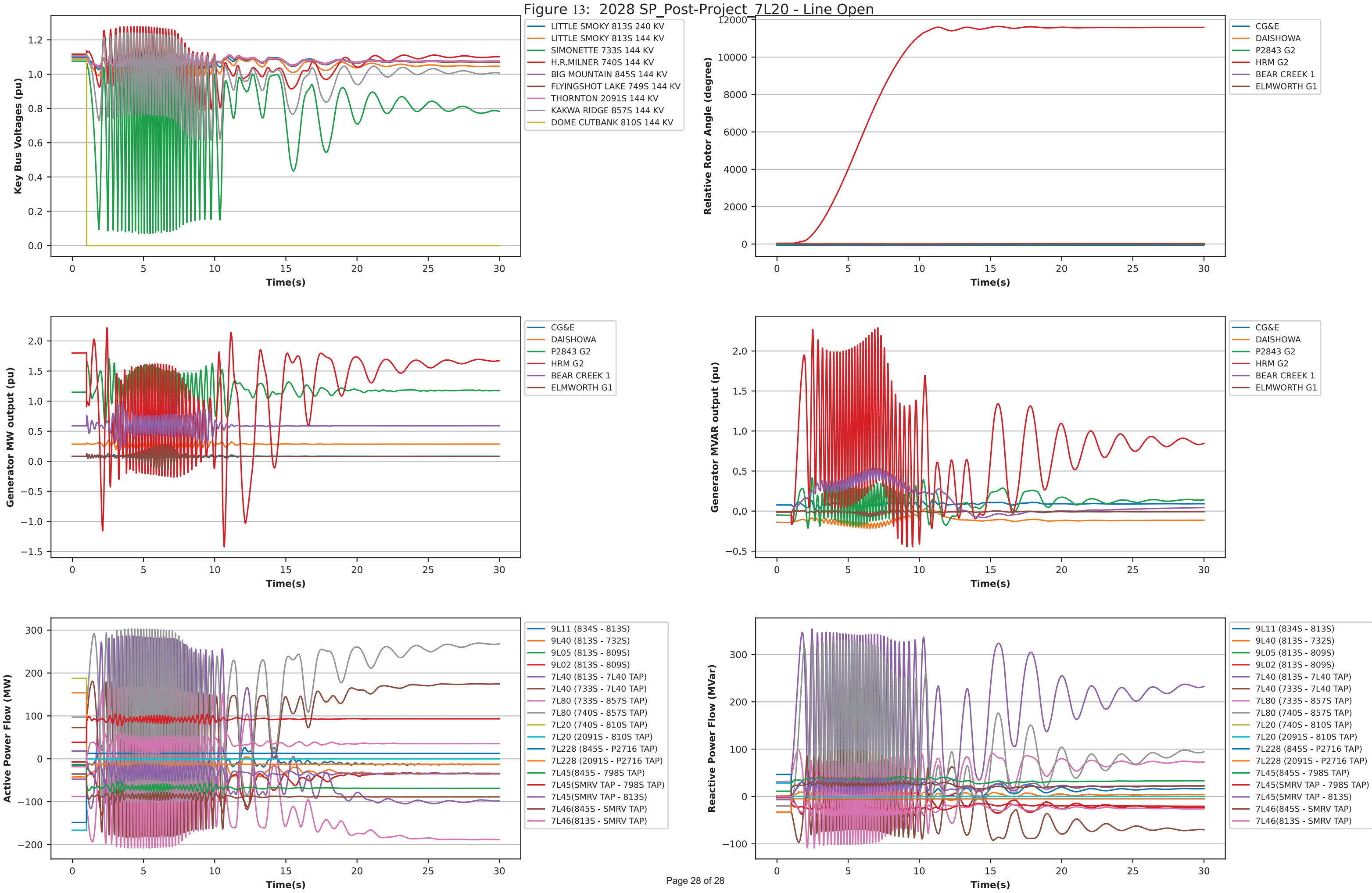


Figure 14: 2028 SP_Post-Project_7L80 - Line Open

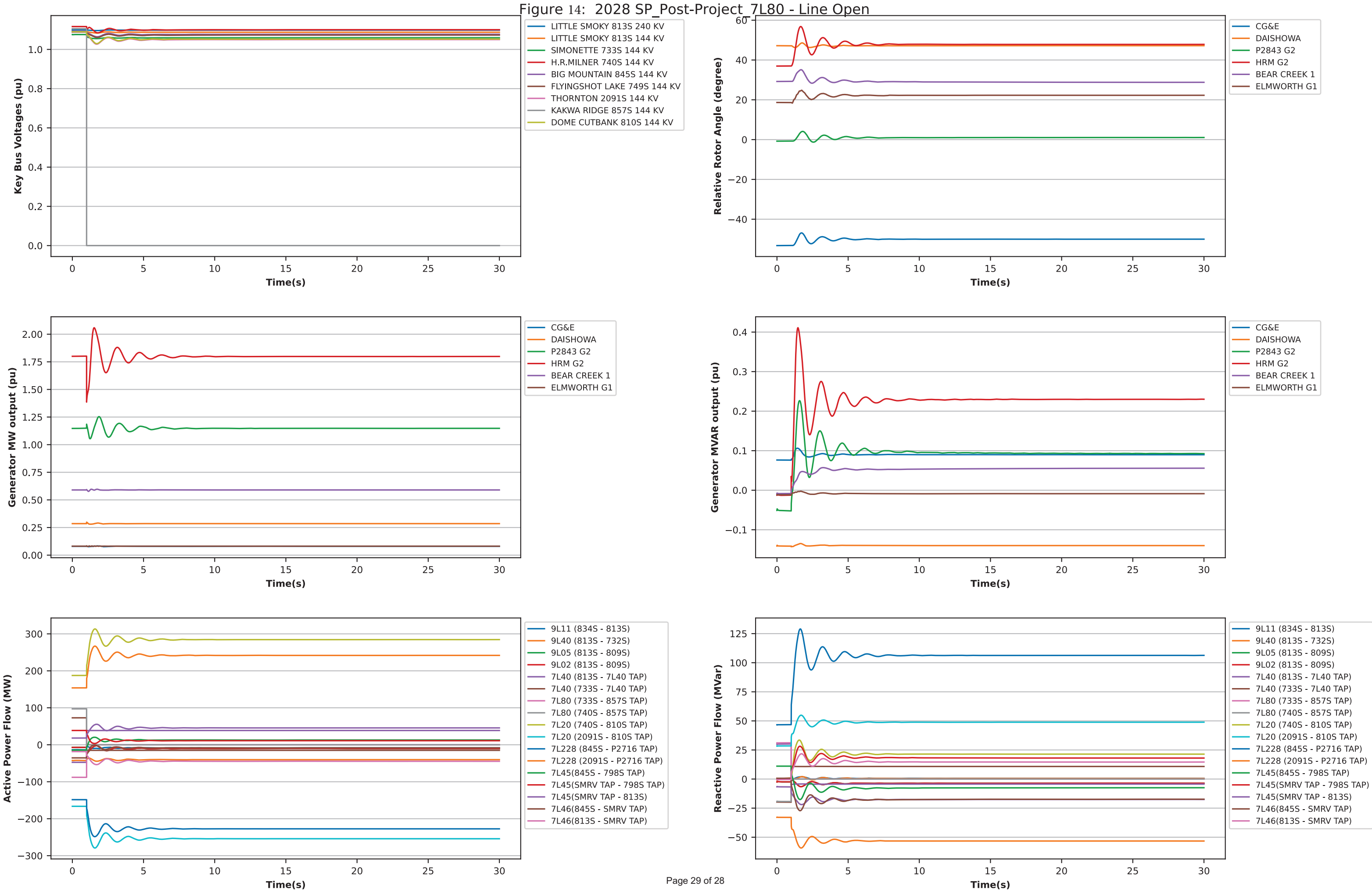


Figure 15: 2028 SP_Post-Project_7L228 - Line Open at Big Mountain End

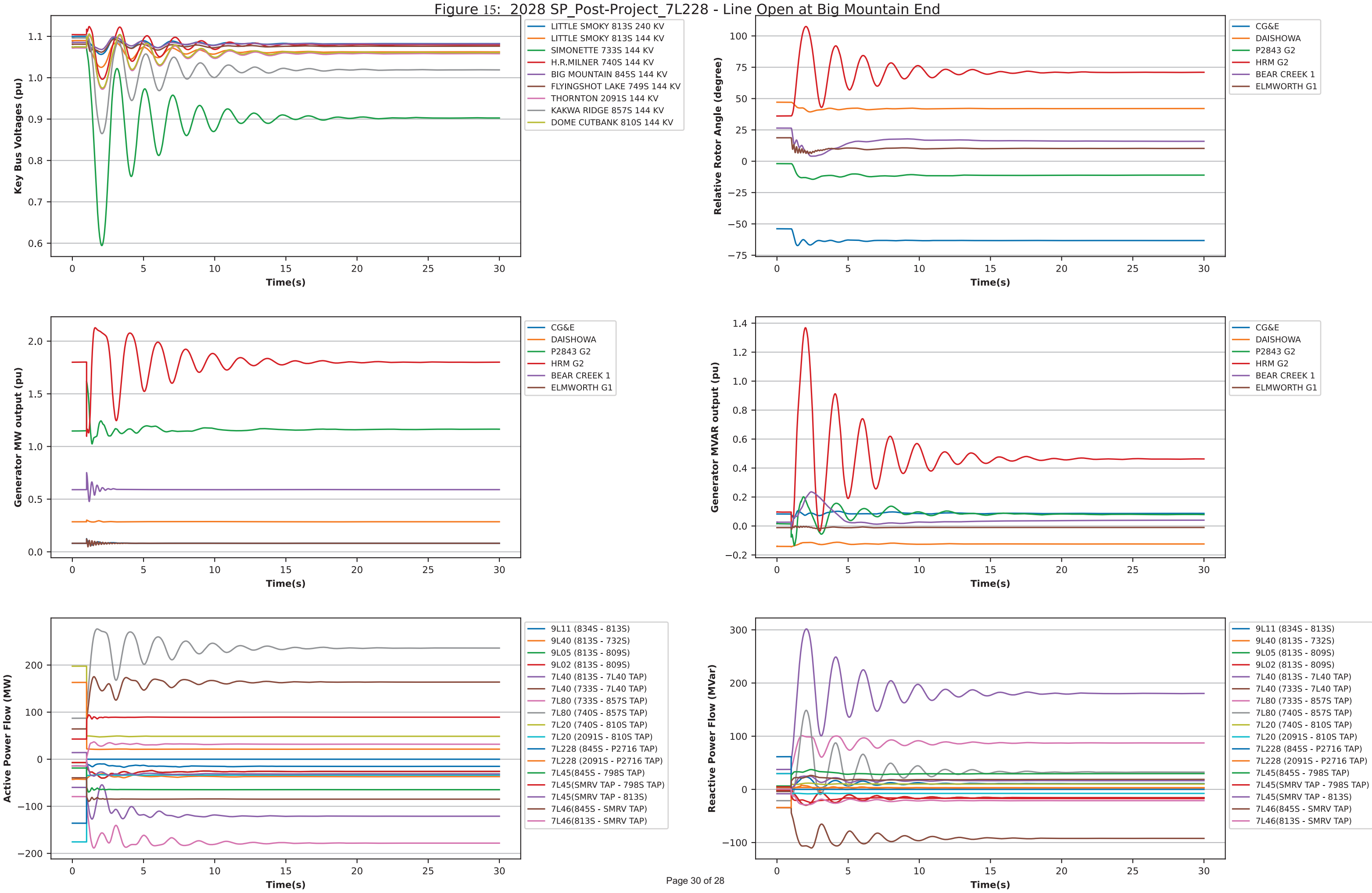
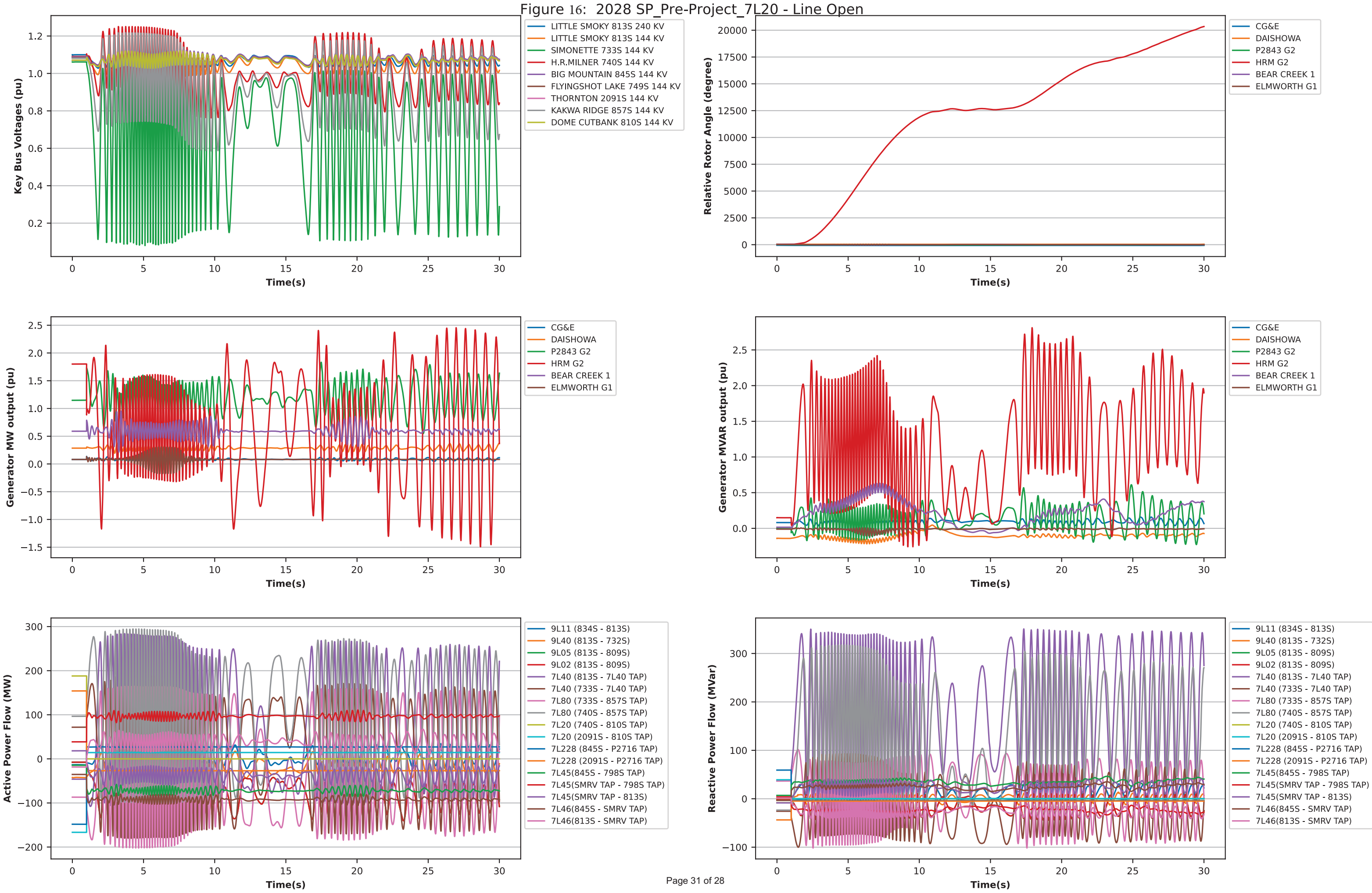


Figure 16: 2028 SP_Pre-Project_7L20 - Line Open



Attachment A6
Alternative 1 Post- Mitigation Power Flow Diagrams
(Scenarios 3, 4)

Post-Project Power Flow Results

Power Flow Diagrams

Alternative 1 Post-Mitigation Power flow diagrams for Scenario 3 2028 SP, and Scenario 4 2028 WP under Category A condition and Category B contingencies are provided in this attachment as identified in the following tables.

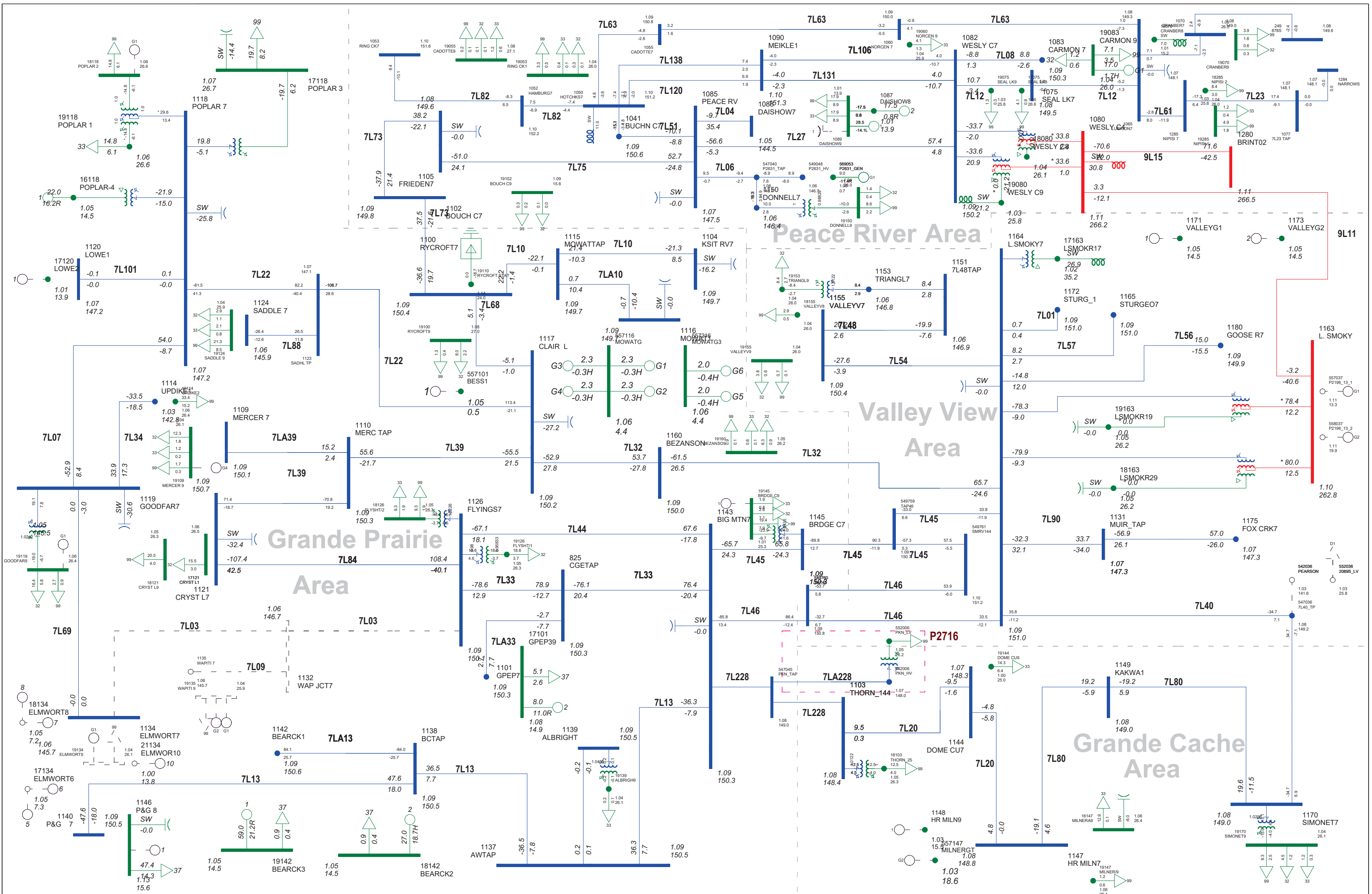
Table A6-1: List of Alternative 1 Post-Mitigation Scenario 3 2028 SP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 SP Scenario 3	CATEGORY B, Loss of 7L03 (Elmworth 731S - Flyingshot Lake 749S)	A6-3
	CATEGORY B, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A6-4
	CATEGORY B, Loss of 7L69 (Goodfare 815S - Elmworth 731S)	A6-5

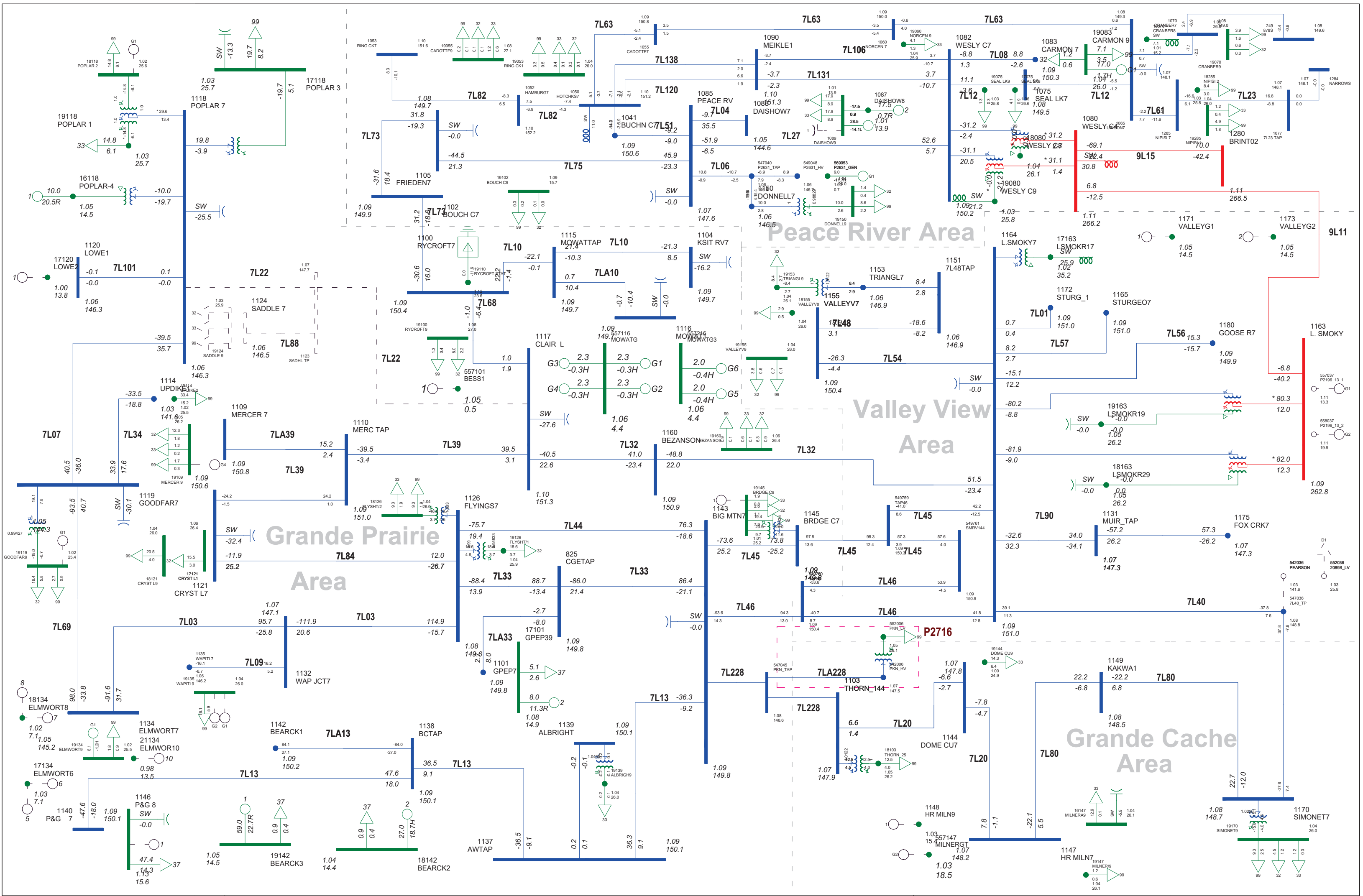
Table A6-2: List of Alternative 1 Post-Mitigation Scenario 4 2028 WP Power Flow Diagrams

Scenario	Load flow diagram	Page number
2028 WP Scenario 4	CATEGORY B, Loss of 7L22 (Poplar Hill 790S - Clairmont Lake 811S)	A6-6

Scenario 3
2028 SP Post-Project (Alternative 1)



P2716 **ATCO Wapiti 823S Load**	**CATEGORY B, LOSS OF 7L03 (Elmworth 731S - Flyingshot Lake 749S)** **SCN3_2028 SP POST-PROJECT_7L03_WITH POPLAR HILL GENERATOR** **TUE, JUN 17 2025 7:59** A6 - 3	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%RATE1 1.250OV 0.900UV kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000



P2716

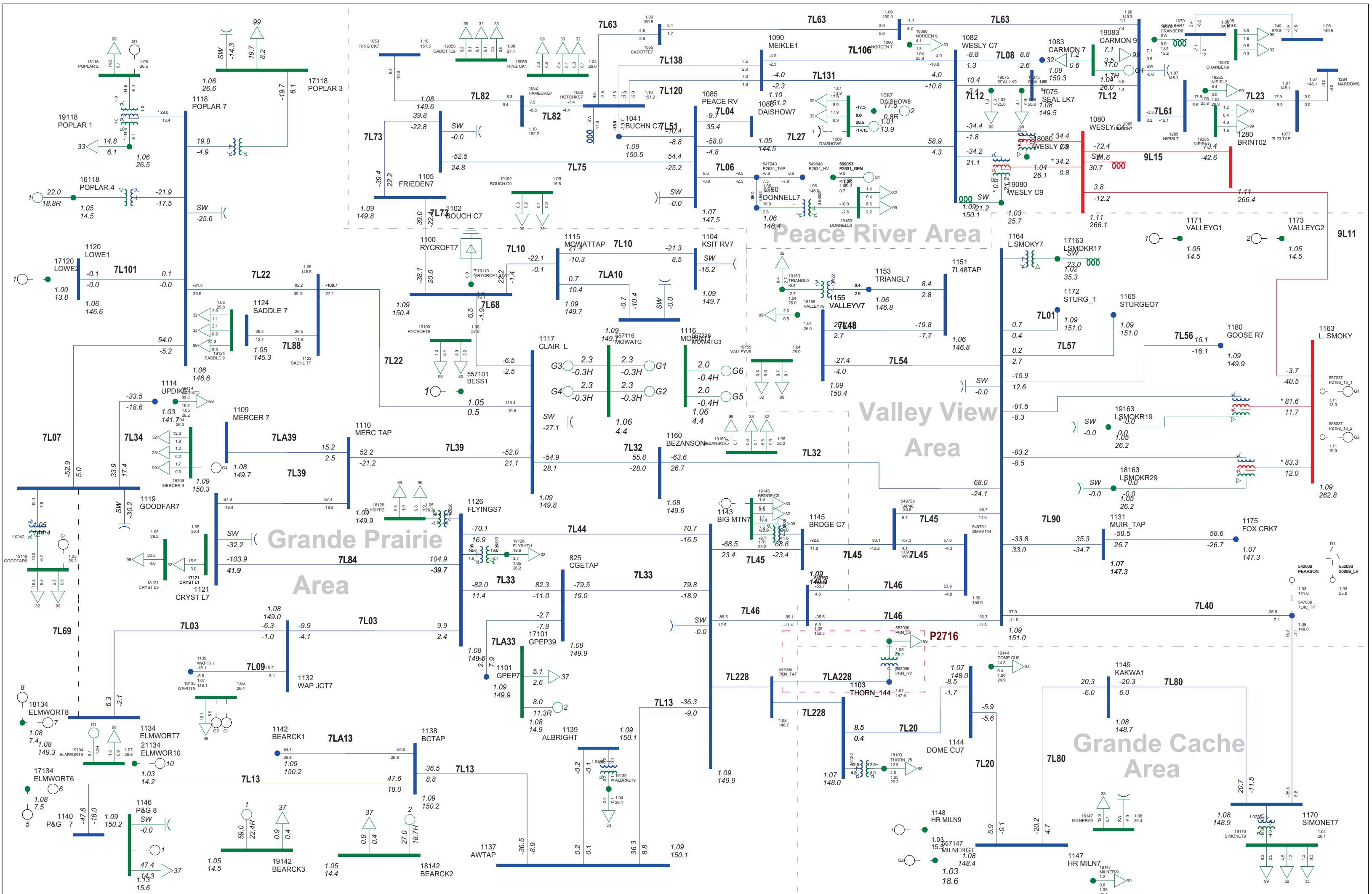
ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (Poplar Hill 790S - Clairmont Lake 811S)
SCN3_2028 SP POST-PROJECT_7L22_WITH POPLAR HILL GENERATOR

TUE, JUN 17 2025 7:59

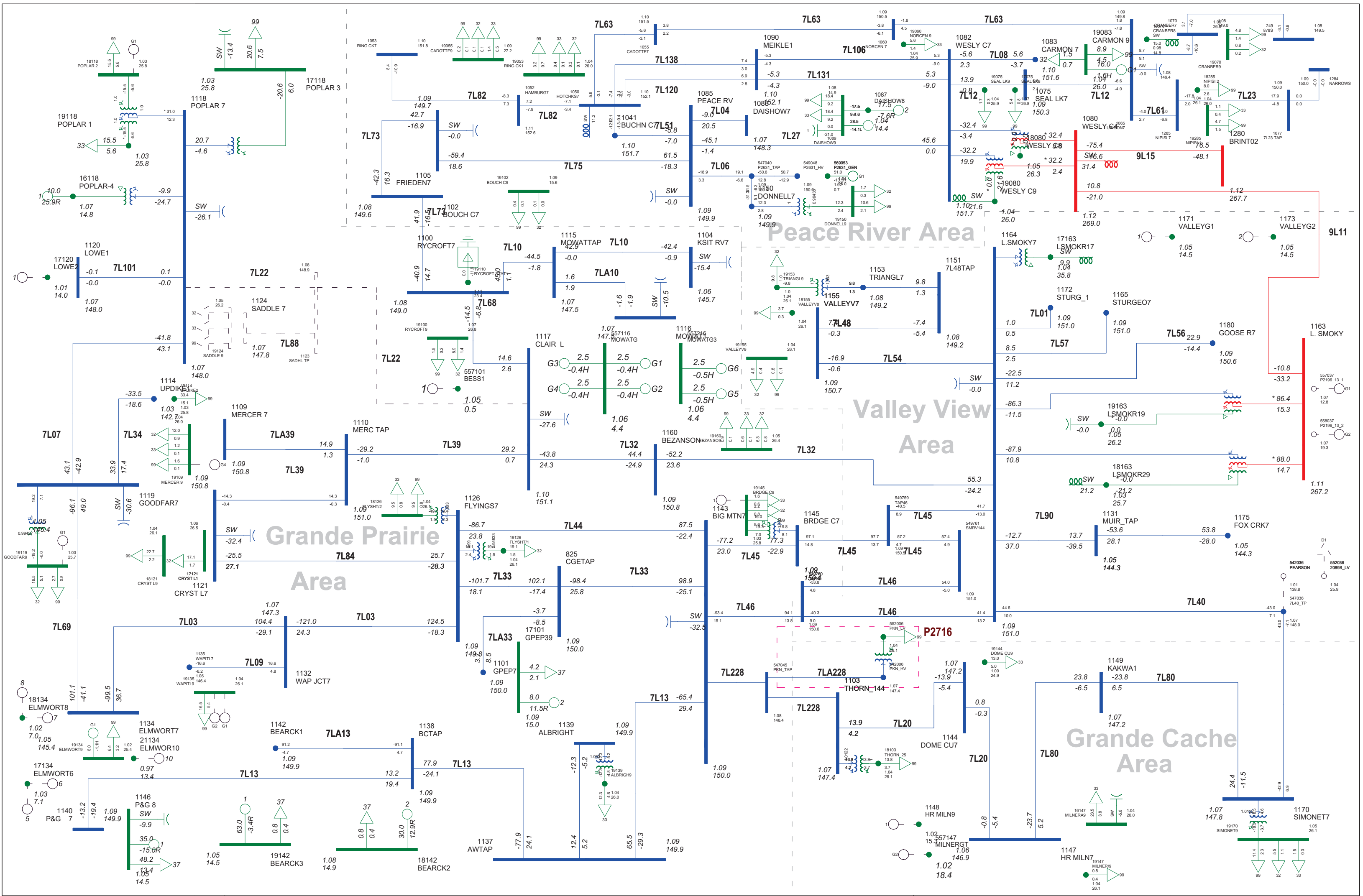
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE1
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

A6 - 4



P2716 **ATCO Wapiti 823S Load**	**CATEGORY B, LOSS OF 7L69 (Elmworth 731S - Goodfare 815S)** **SCN3_2028 SP POST-PROJECT_7L69_WITH POPLAR HILL GENERATOR** **TUE, JUN 17 2025 7:59** A6 - 5	Bus - Voltage (kV/pu) Branch - MW/Mvar Equipment - MW/Mvar 100.0%RATE1 1.250OV 0.900UV kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

Scenario 4
2028 WP Post-Project (Alternative 1)



P2716

ATCO Wapiti 823S Load

CATEGORY B, LOSS OF 7L22 (Poplar Hill 790S - Clairmont Lake 811S)
SCN4_2028 WP POST-PROJECT_7L22_WITH POPLAR HILL GENERATOR

TUE, JUN 17 2025 8:33

A6 - 6

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%RATE2
1.250OV 0.900UV
kV: >0.000 <=34.500 <=72.000 <=144.000 <=240.000

Attachment A7

Post Mitigation Pre- and Post- Project Voltage Stability Diagrams

(Scenario 2, 4)

P2716_Voltage Stability Studies (with PH Generator ON)

Scenario 2: 2028 WP Pre-Project

Voltage stability analysis was performed for scenario 2 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 4 is 524.5 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 25.2 MW (0.05 x 503.2 MW = 25.2 MW) for the scenario 4.

Table 1 provides voltage stability study results under Category A condition and for the six (6) worst contingencies under Category B conditions. The voltage stability diagrams are provided in Figure 1a. Based on the study results, the voltage stability margin was met for all studied conditions except for the contingency of 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

The following Buses were selected for the study:

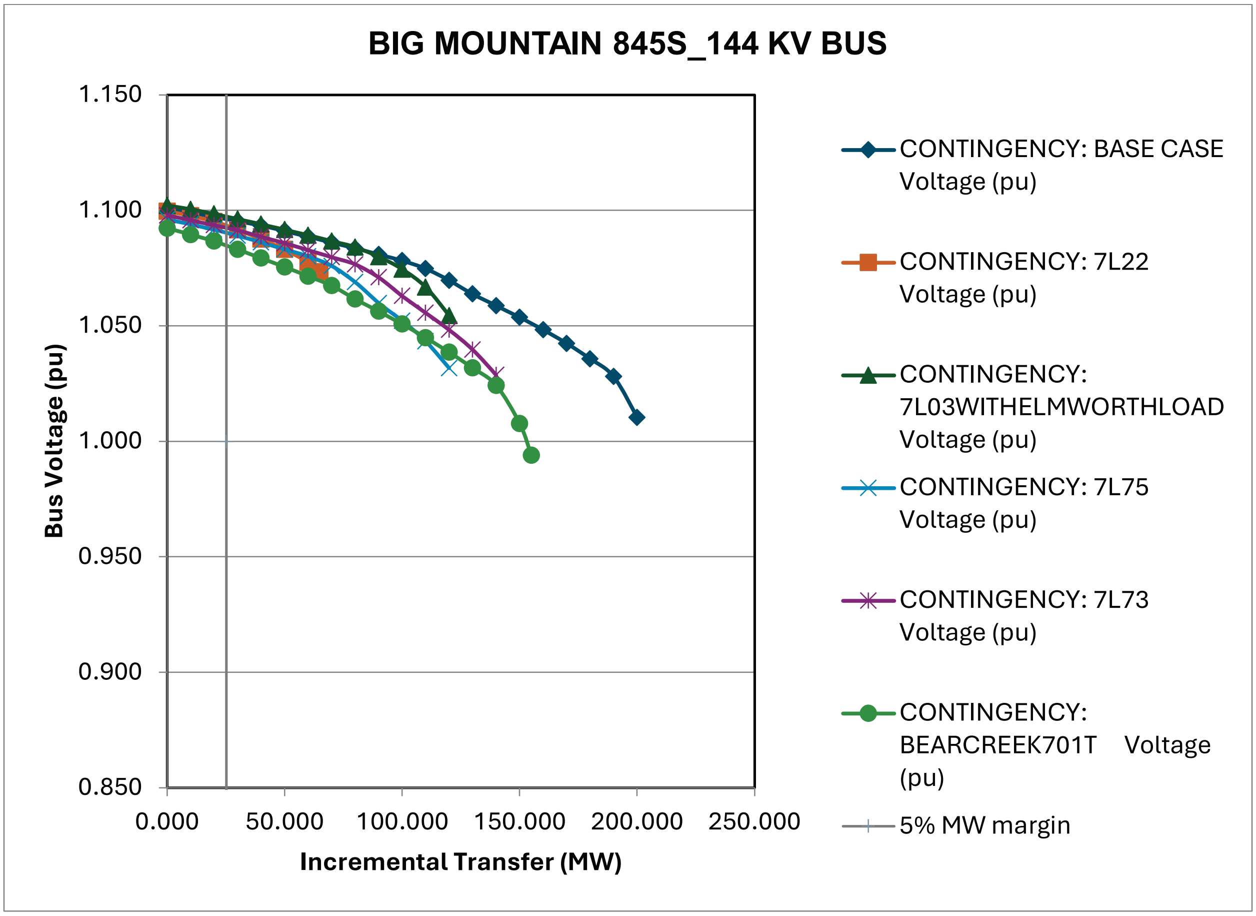
- Big Mountain 845S 138 kV Bus (bus 1143)
- H.R. Milner 740S 138 kV bus (bus 1147)
- Thornton 2091S 138 kV bus (bus 1103)
- Simonette 733S 138 kV bus (bus 1170)
- Dome Cut Bank 810S 138 kV bus (bus 1144)

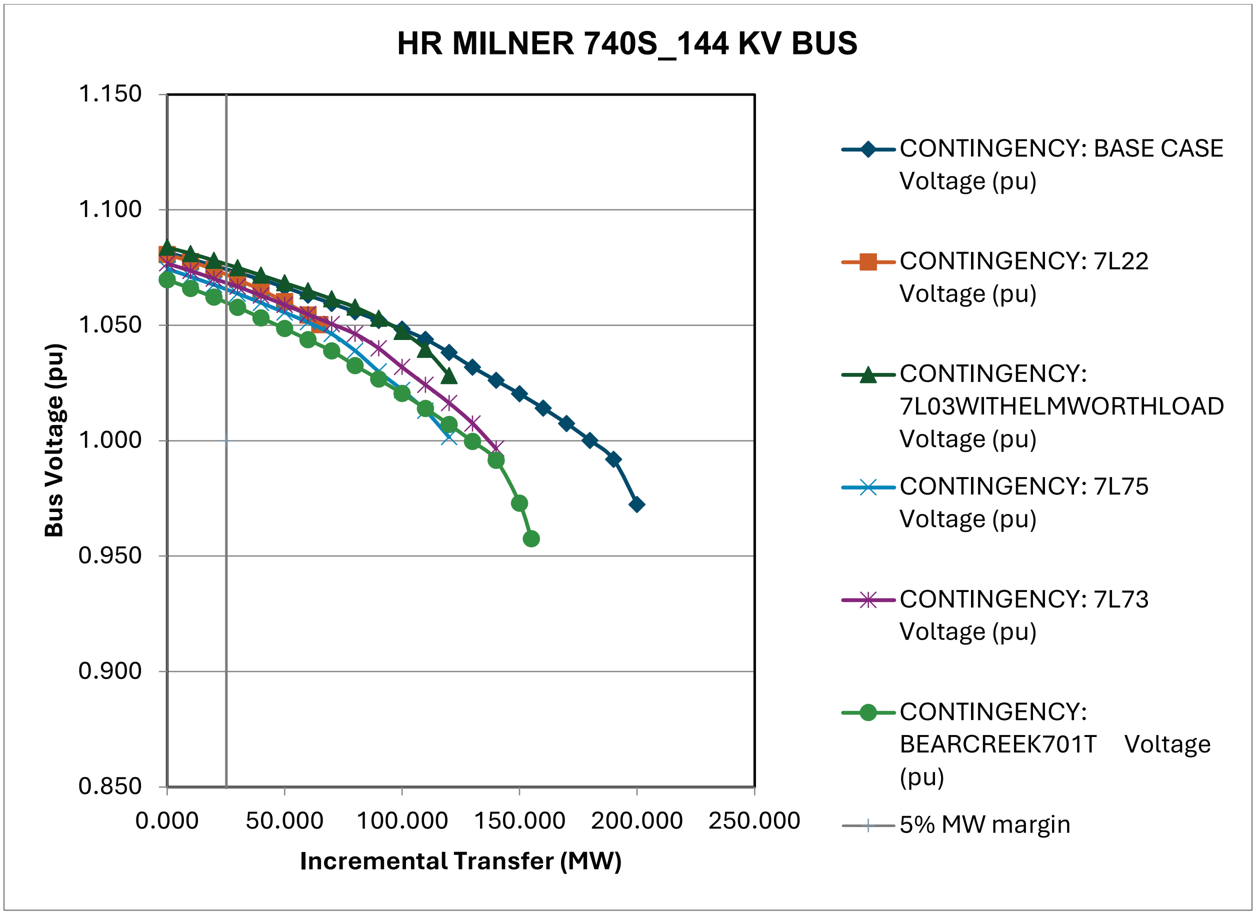
Table 1: Summary of Results under Category B Conditions for Scenario 2

Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		200	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	65	Yes
7L03	Flyingshot Lake 749S	Elmworth 731S	120	Yes
7L75	Friednestal 800S	West Peace River 793S	120	Yes
7L73	Friednestal 800S	Rycroft 730S	140	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		155	Yes

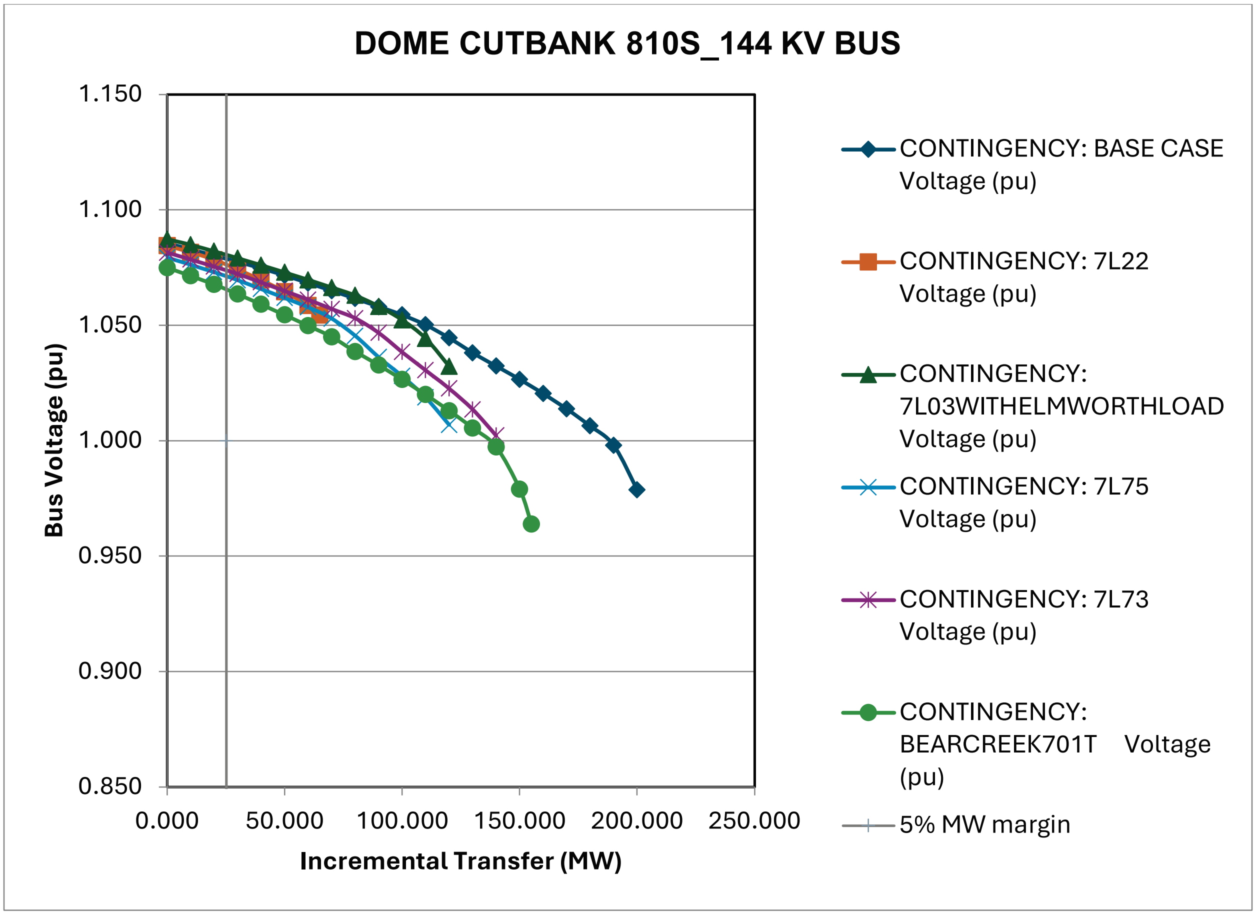
Figure 1:

Scenario 2: 2028_WP_NE_LG_PRE-PROJECT

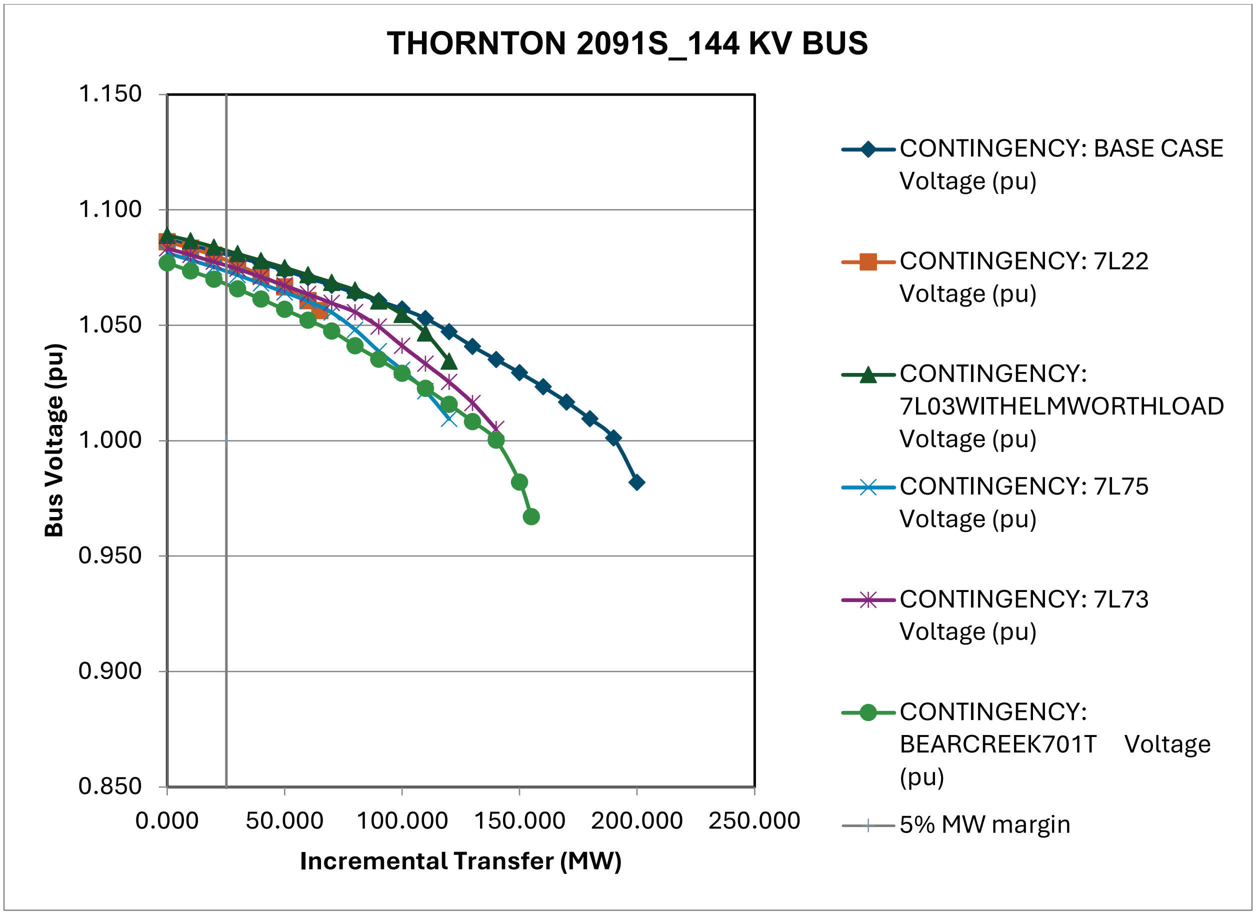




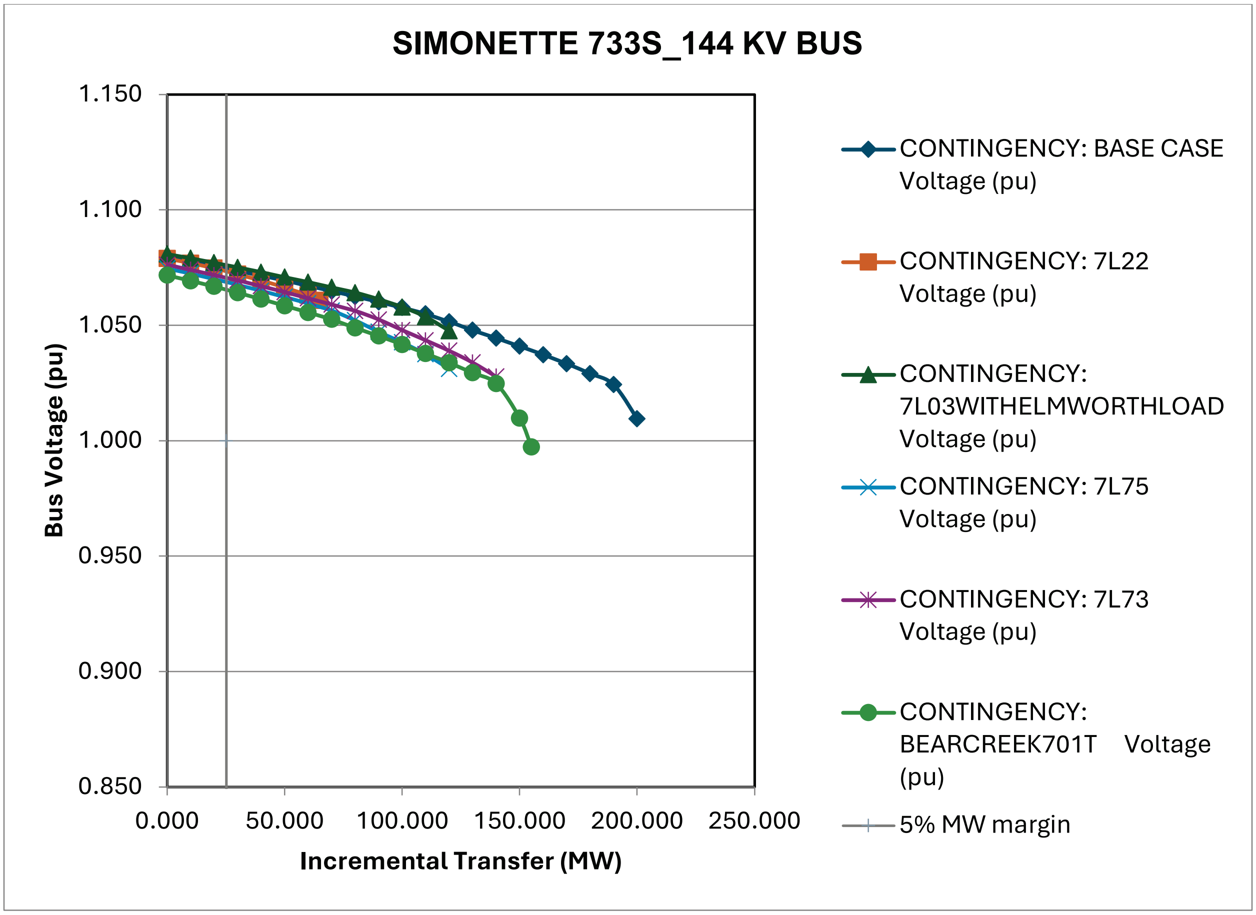
HR MILNER 740S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
250.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



DOME CUTBANK 810S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
250.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



THORNTON 2091S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
250.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


SIMONETTE 733S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
250.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin

P2716_Voltage Stability Studies (with PH Generator ON)

Scenario 4: 2028 WP Post-Project

Voltage stability analysis was performed for scenario 4 by increasing load in Grande Prairie (Area 20) and Grande Cache (Area 22), and increasing the generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the study area for scenario 4 is 524.5 MW. To meet the voltage stability criteria for Category B contingencies, the required minimum incremental load transfer is 5% of the reference load, or 26.2 MW (0.05 x 524.5 MW = 26.2 MW) for the scenario 4.

Table 1 provides voltage stability study results under Category A condition and for the six (6) worst contingencies under Category B conditions. The voltage stability diagrams are provided in Figure 1. Based on the study results, the voltage stability margin was met for all studied conditions except for the contingency of 7L22 (Clairmont Lake 811S – Poplar Hill 790S).

The following Buses were selected for the study:

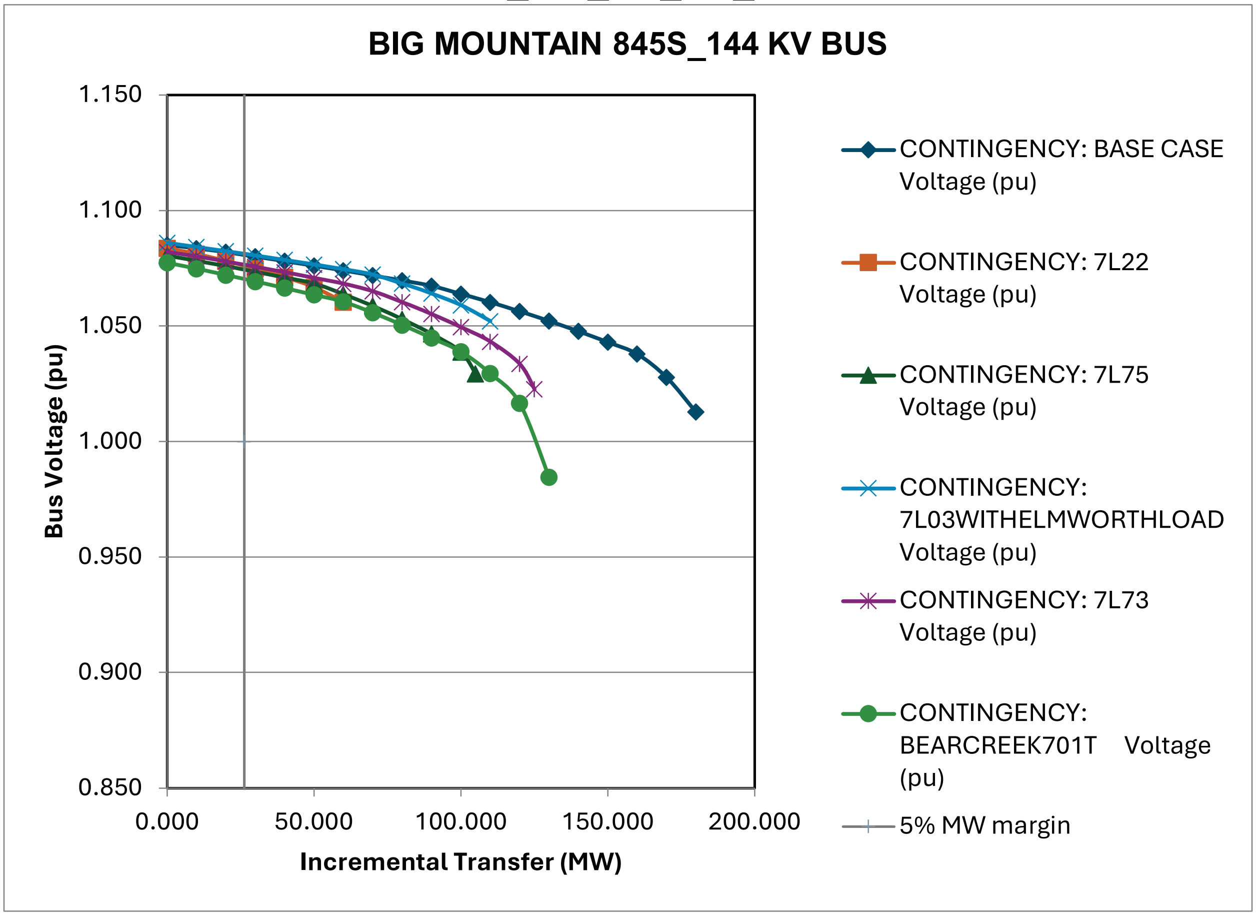
- Big Mountain 845S 138 kV Bus (bus 1143)
- H.R. Milner 740S 138 kV bus (bus 1147)
- Thornton 2091S 138 kV bus (bus 1103)
- Simonette 733S 138 kV bus (bus 1170)
- Pakenham 2103S 138 kV bus (bus 542006)
- Dome Cut Bank 810S 138 kV bus (bus 1144)

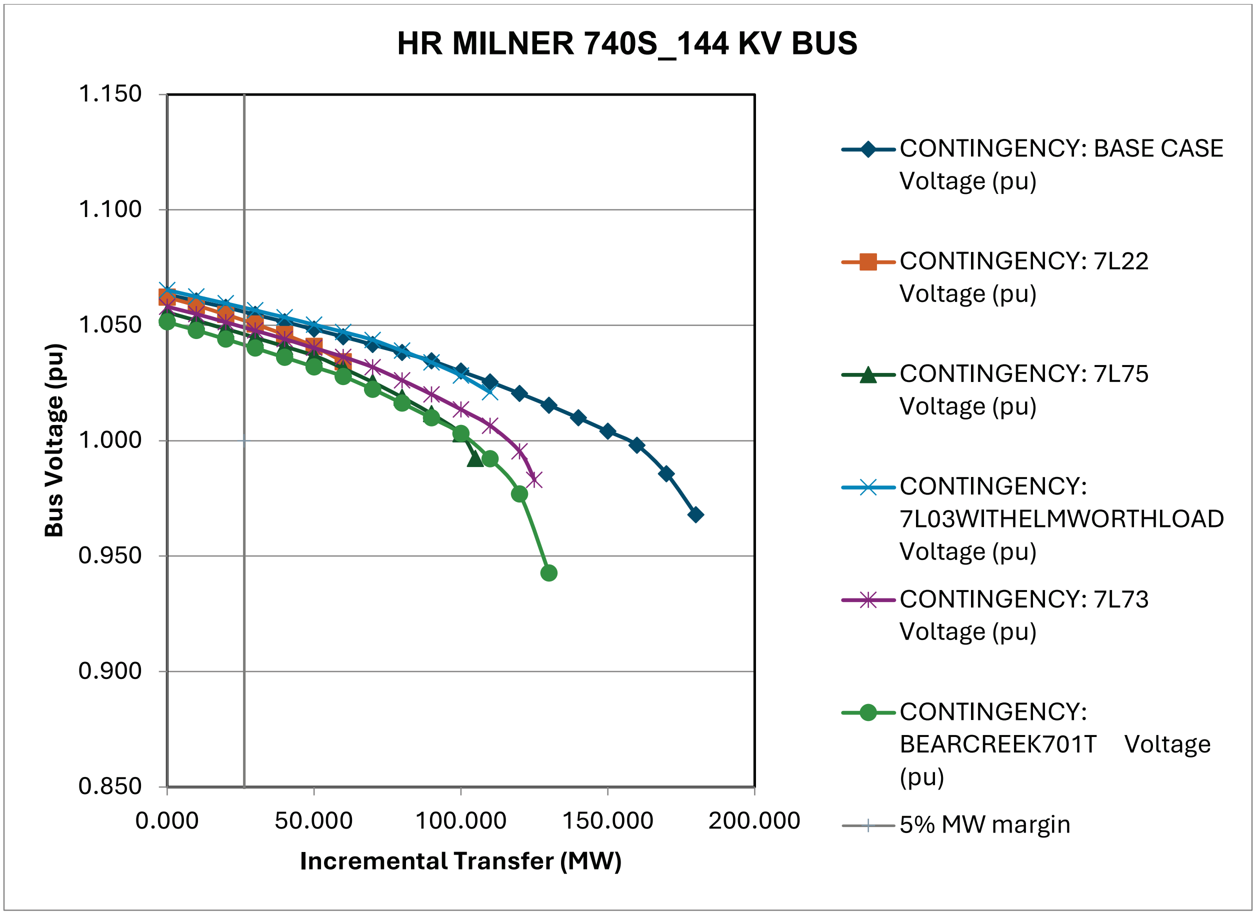
Table 1: Summary of Results under Category B Conditions for Scenario 4

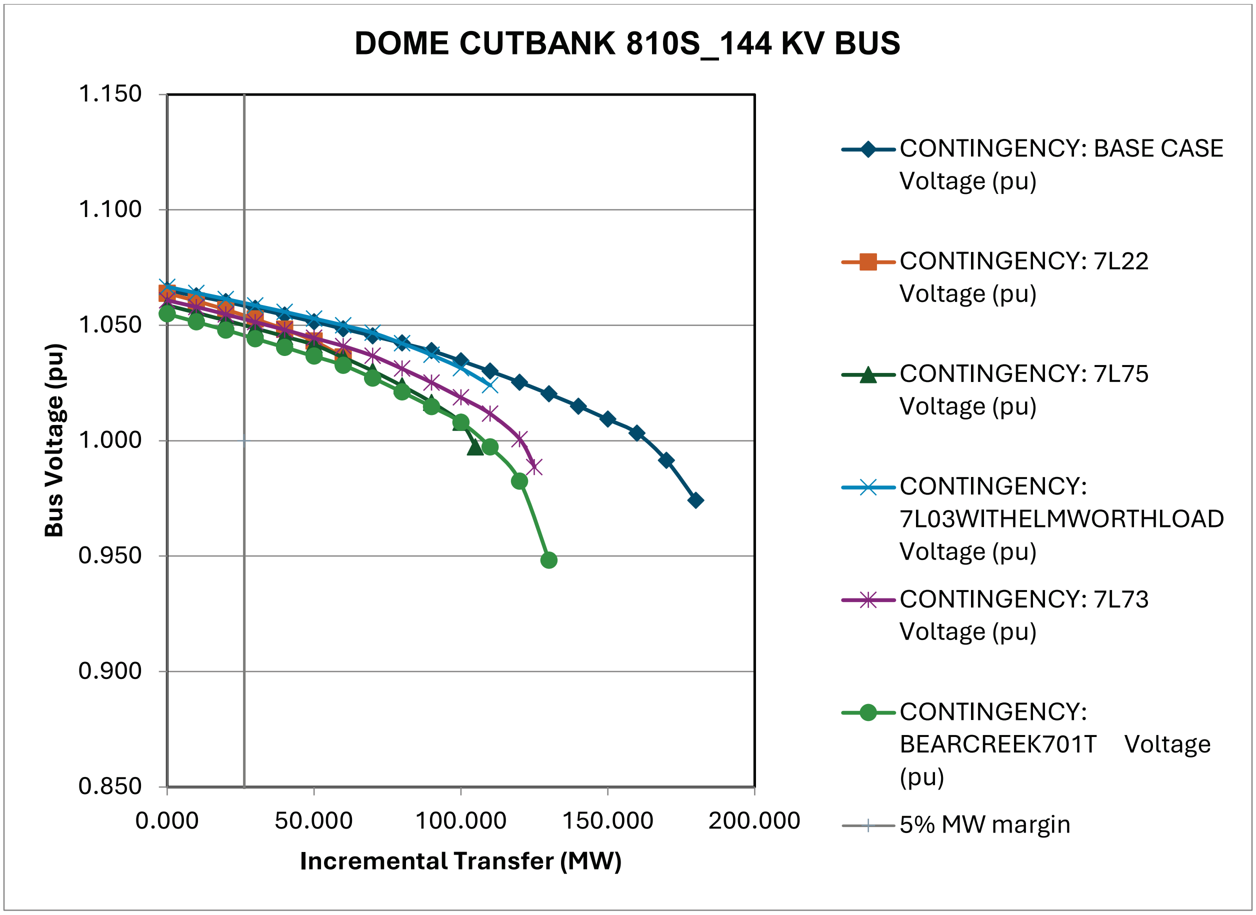
Contingency (System Element Lost)	From	To	Maximum Incremental Transfer (MW)	Meets Criteria?
N-0	Base case (System Normal)		180	Yes
7L22	Poplar Hill 790S	Clairmont Lake 811S	60	Yes
7L75	Friednestal 800S	West Peace River 793S	105	Yes
7L03	Flyingshot Lake 749S	Elmworth 731S	110	Yes
7L73	Friednestal 800S	Rycroft 730S	125	Yes
Bear Creek 679S 701T	Bear Creek 679S 701T		130	Yes

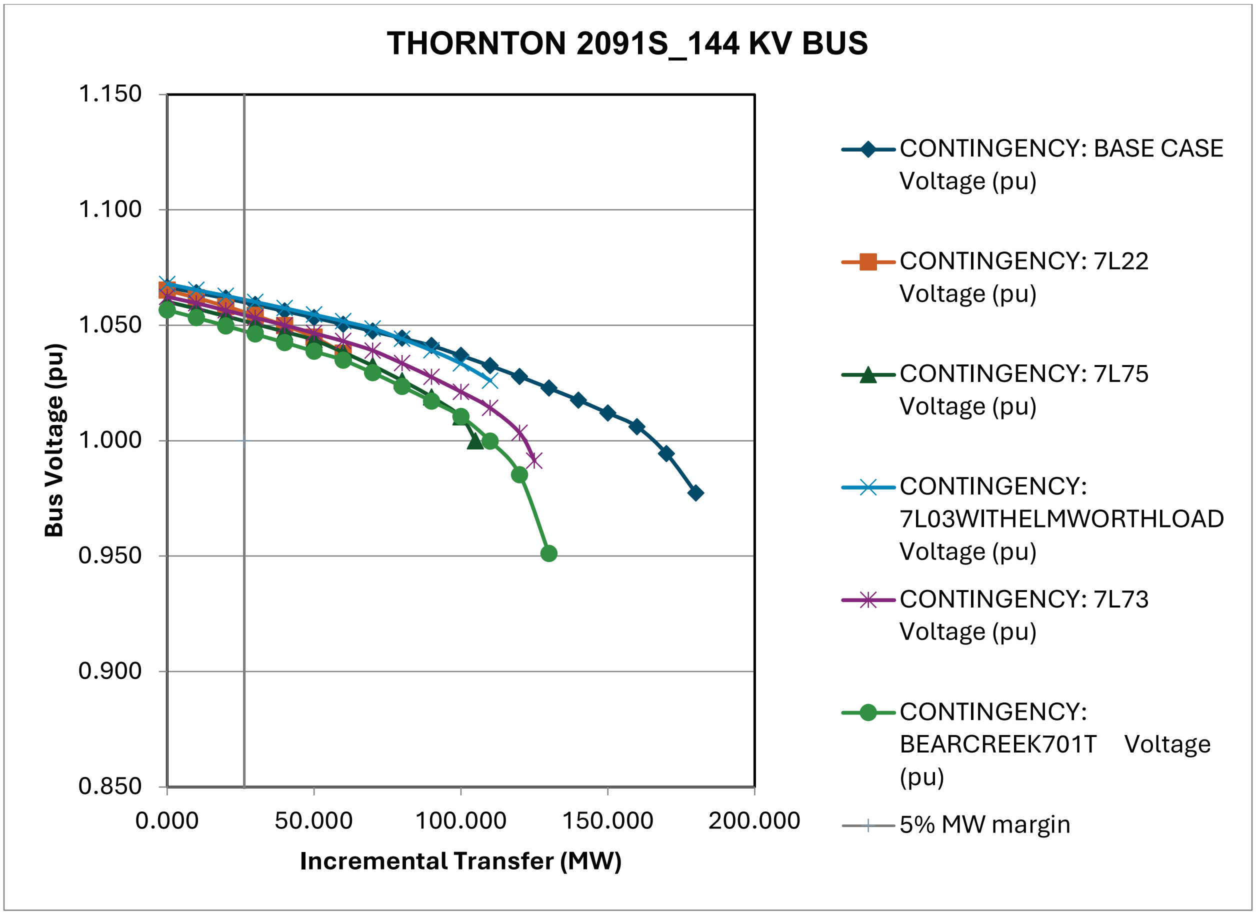
Figure 1:

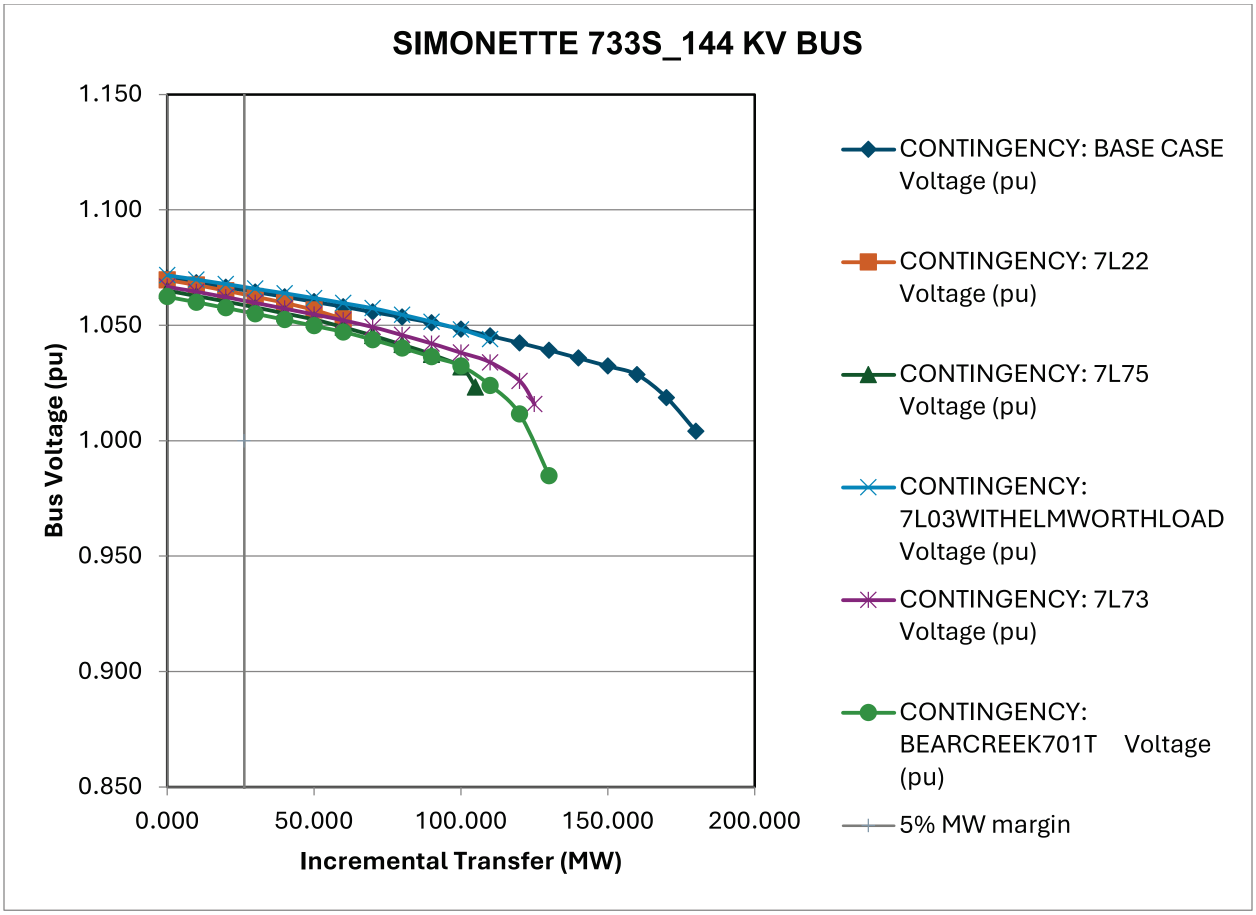
Scenario 4: 2028_WP_NE_LG_POST-PROJECT



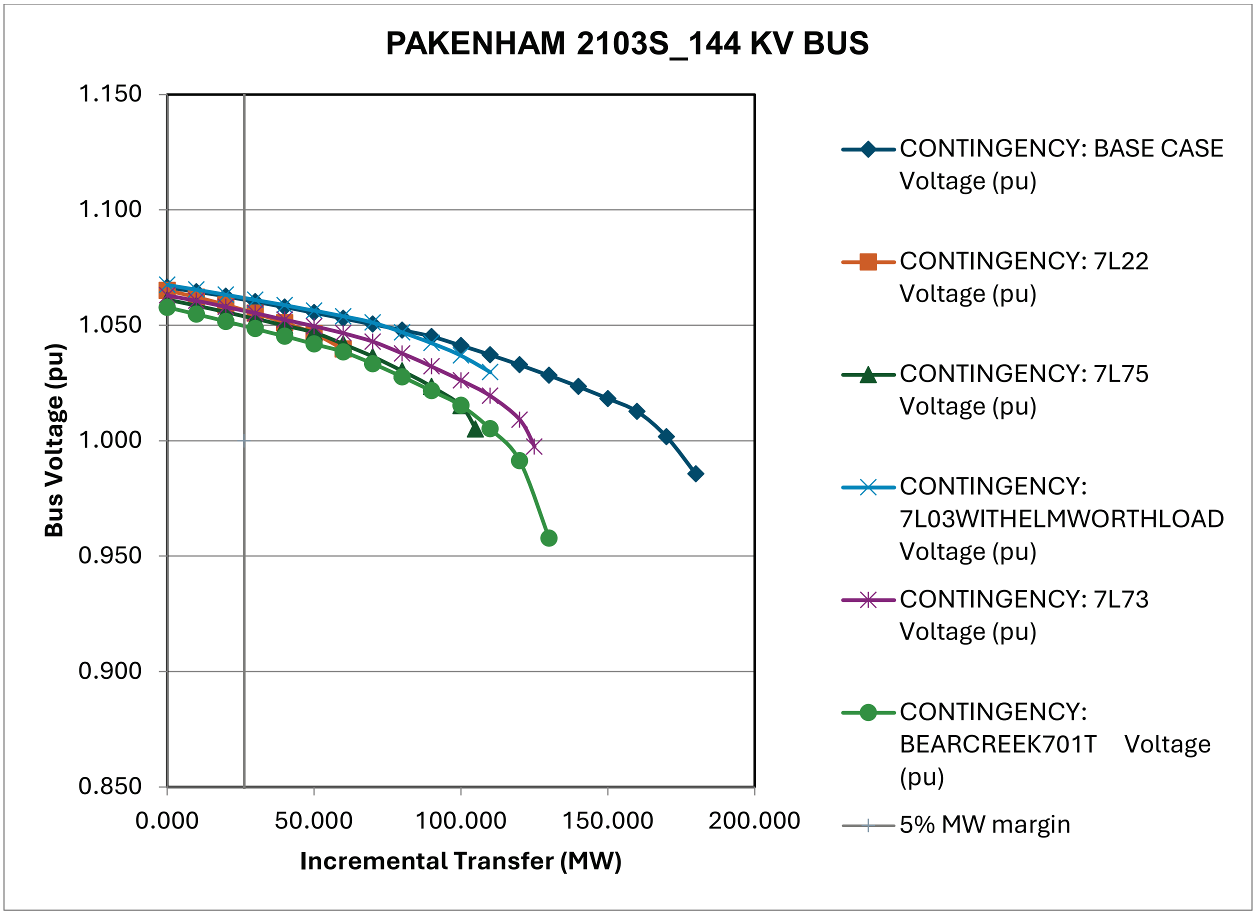

HR MILNER 740S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


DOME CUTBANK 810S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
Bus Voltage (pu)
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


THORNTON 2091S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
Bus Voltage (pu)
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin



SIMONETTE 733S_144 KV BUS
Bus Voltage (pu)
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin


PAKENHAM 2103S_144 KV BUS
1.150
1.100
1.050
1.000
0.950
0.900
0.850
0.000
50.000
100.000
150.000
200.000
Bus Voltage (pu)
Incremental Transfer (MW)
CONTINGENCY: BASE CASE Voltage (pu)
CONTINGENCY: 7L22 Voltage (pu)
CONTINGENCY: 7L75 Voltage (pu)
CONTINGENCY: 7L03WITHELMWORTHLOAD Voltage (pu)
CONTINGENCY: 7L73 Voltage (pu)
CONTINGENCY: BEARCREEK701T Voltage (pu)
5% MW margin

Attachment A8

Post Mitigation Transient Stability Diagrams

(Scenario 3)

Transient Stability Diagrams for 2028 SP Base case (Scenario 3)

Post mitigation transient stability analysis was performed using RAS 171 (tripping both generators at H.R. Milner 740S with 10 cycles delay from the fault inception) for the 2028 SP Post-Project (scenario 3) for the Category B contingencies identified in Table A8-1.

Table A8-1: List of Contingencies Studied for Transient Stability –Scenario 3 2028 SP Post-Project

System Condition	Contingency	Fault Description (fault location)	Page #
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at H.R. Milner 740S	A8-3
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at H.R. Milner 740S	A8-4
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	3-phase fault at Thornton 2091S	A8-5
Category B (N-1)	7L20 (H.R. Milner 740S – Thornton 2091S)	1-phase fault at Thornton 2091S	A8-6
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Thornton 2091S	A8-7
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Thornton 2091S	A8-8
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	3-phase fault at Big Mountain 845S	A8-9
Category B (N-1)	7L228 (Big Mountain 845S – Thornton 2091S)	1-phase fault at Big Mountain 845S	A8-10

Figure 1: 2028 SP Post-Project_Cat_B_7L20 - 3 Phase Fault at H.R.Milner 740S_with RAS (10cyc)

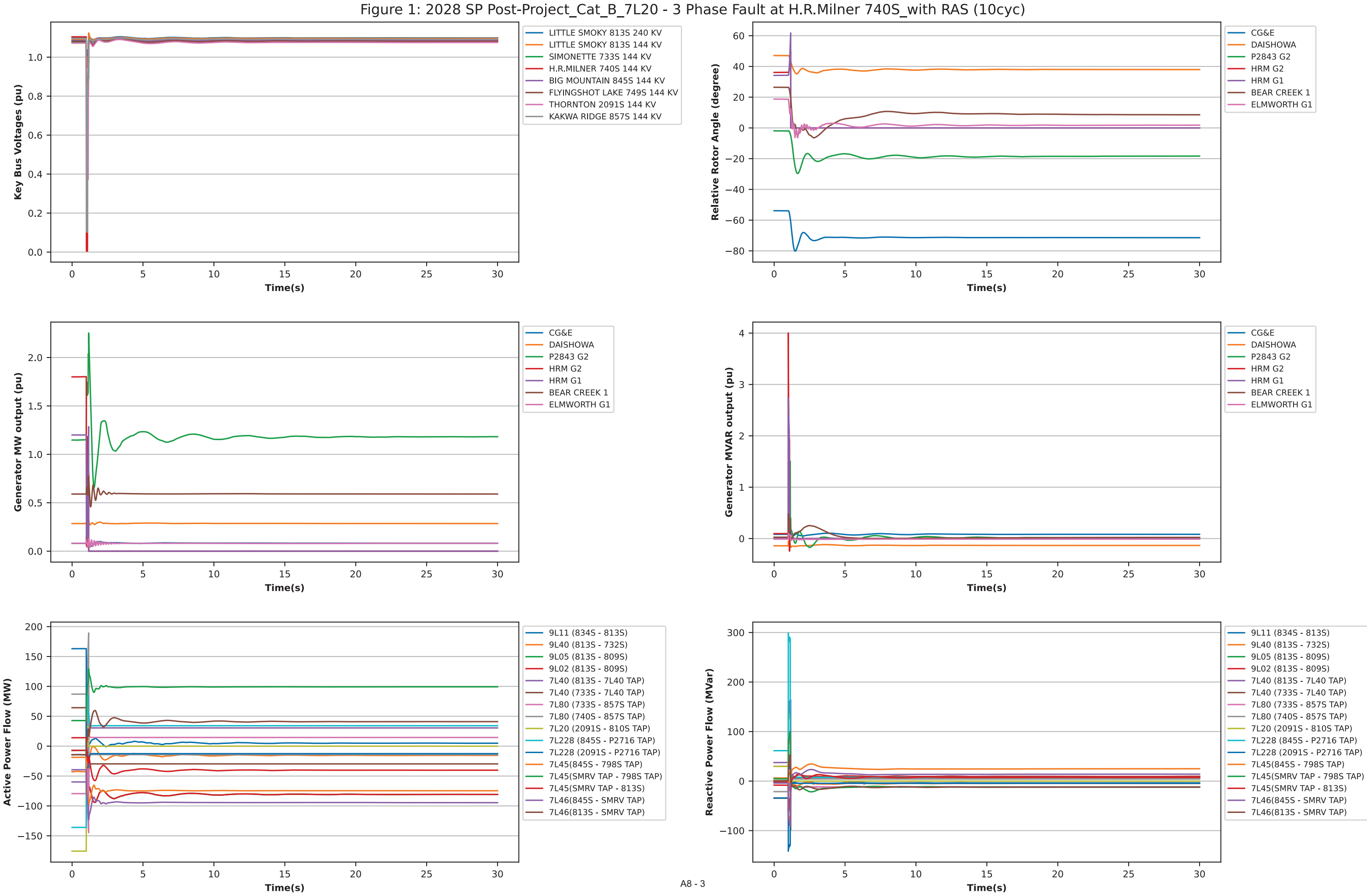


Figure 1A: 2028 SP Post-Project_Cat_B_7L20 - 1 Phase Fault at H.R.Milner 740S_with RAS (10cyc)

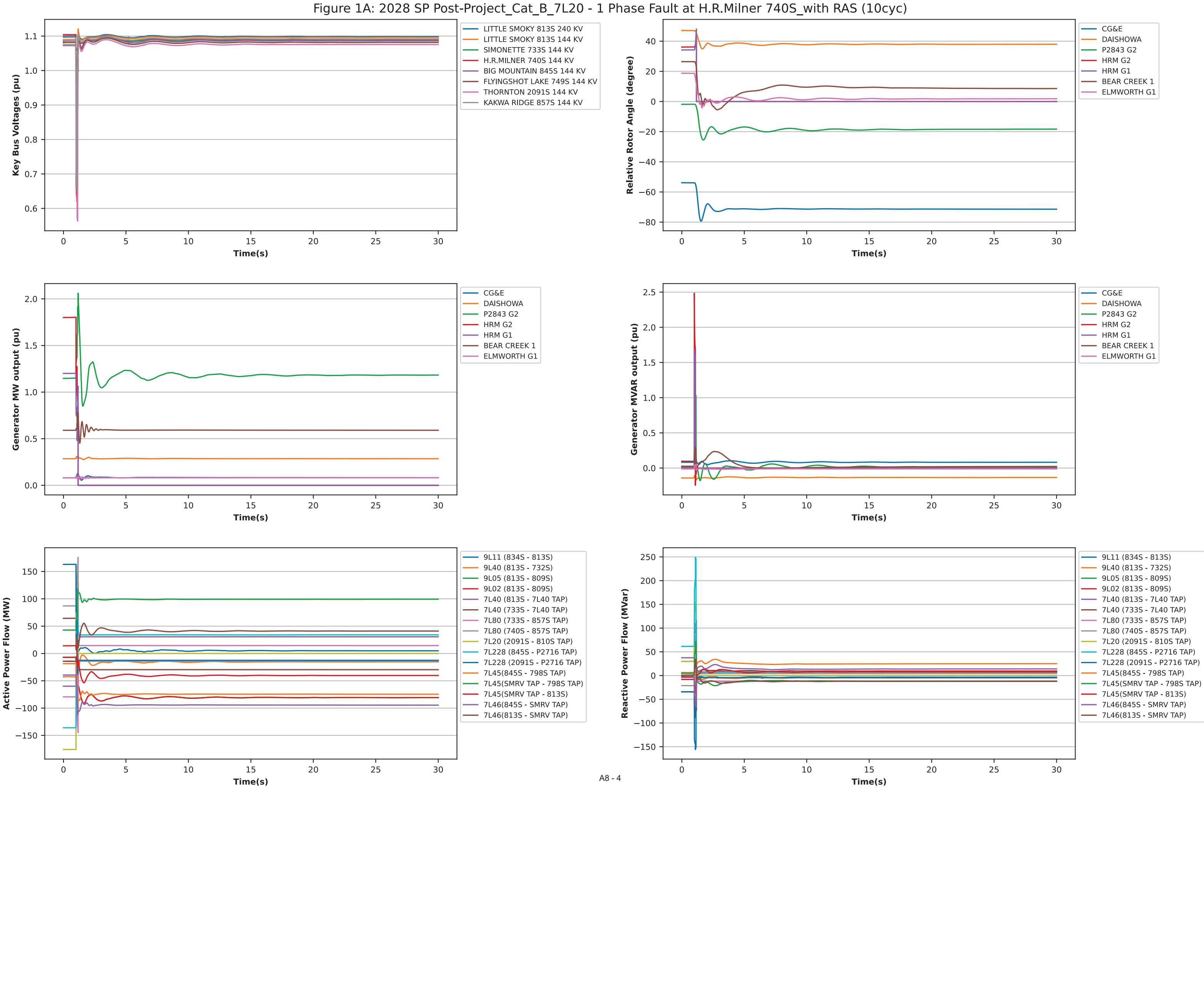


Figure 2: 2028 SP Post-Project_Cat_B_7L20 - 3 Phase Fault at Thornton 2091S_with RAS (10cyc)

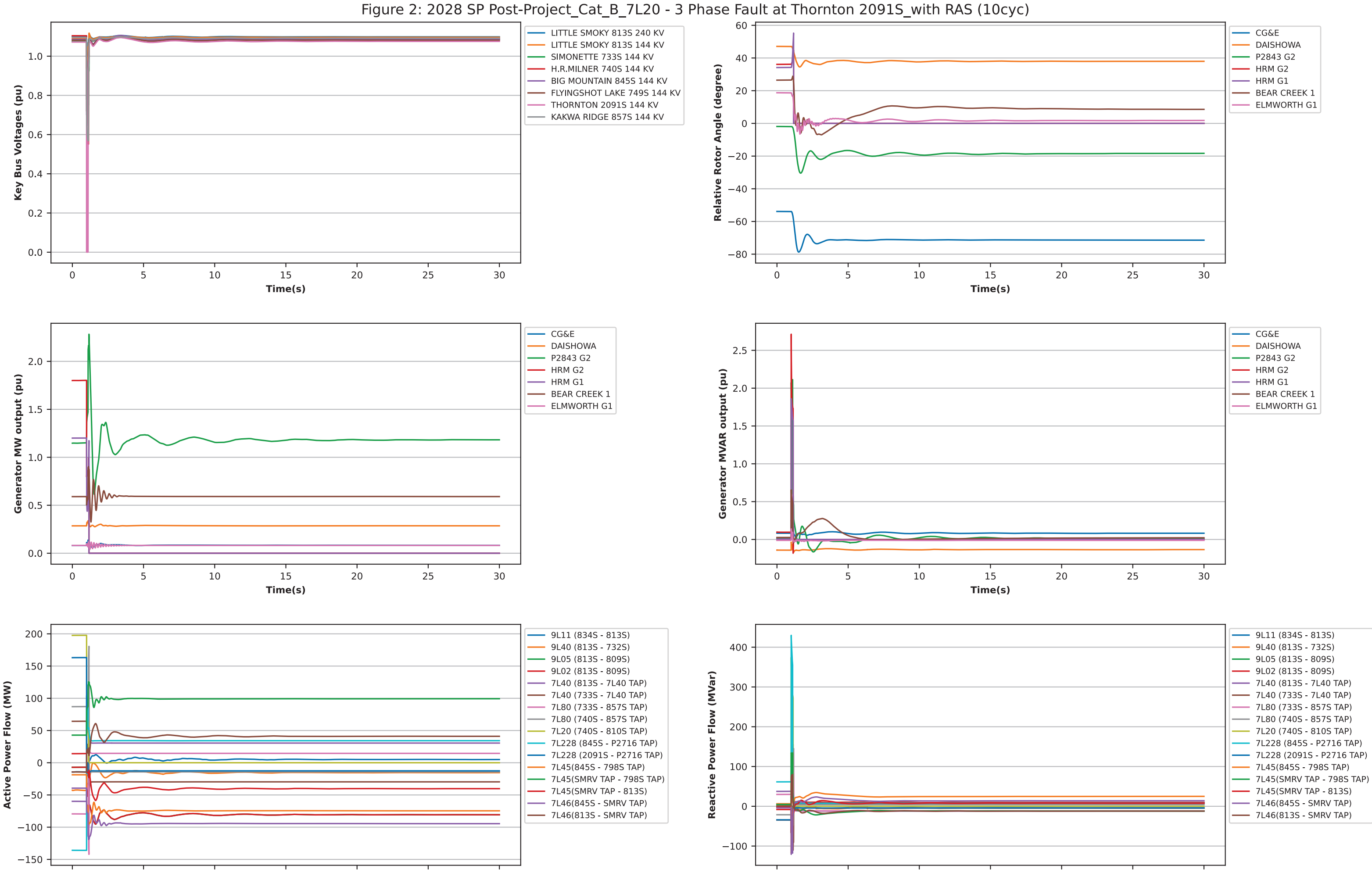


Figure 2A: 2028 SP Post-Project_Cat_B_7L20 - 1 Phase Fault at Thornton 2091S_with RAS (10cyc)

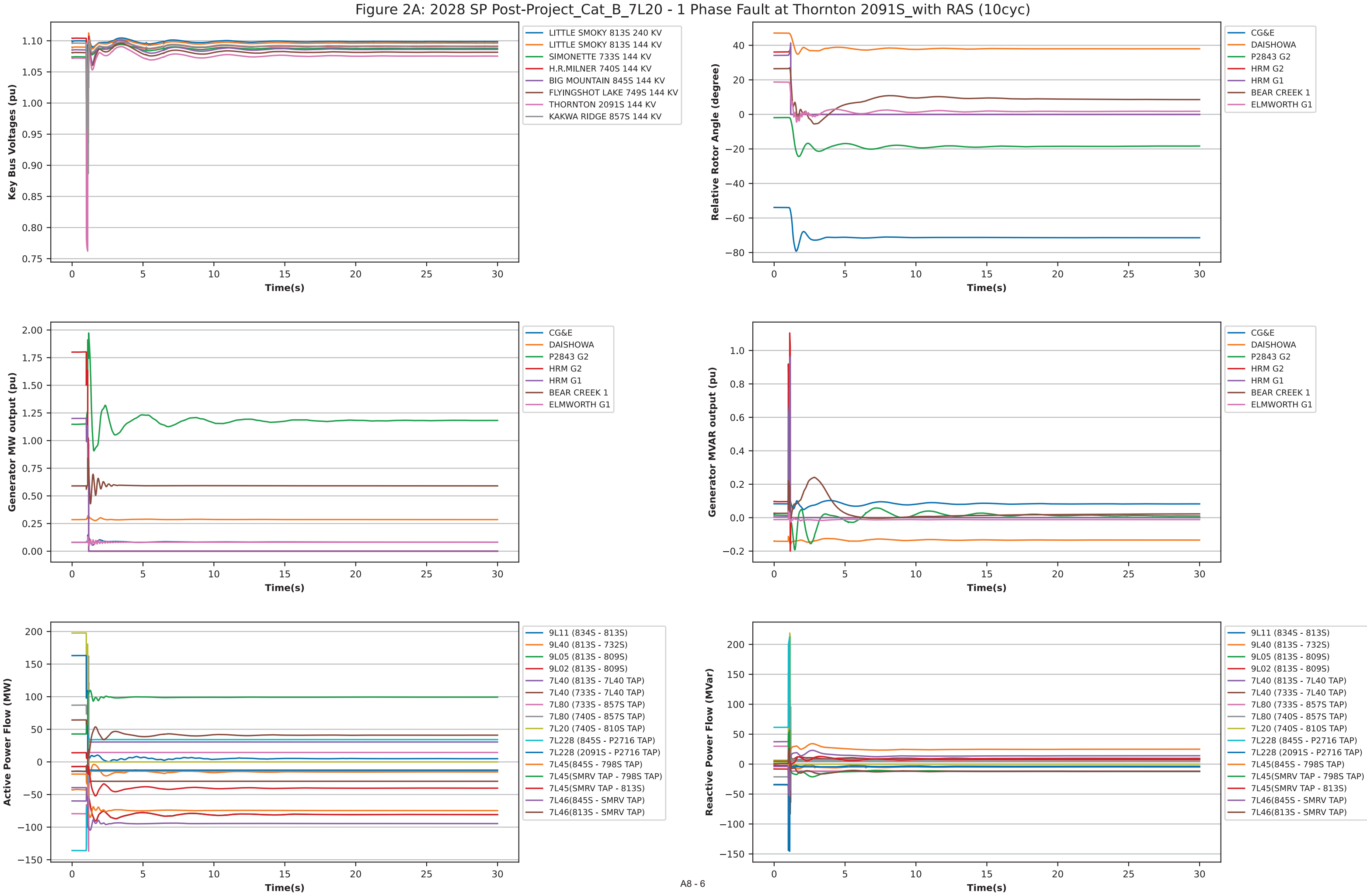


Figure 3: 2028 SP Post-Project_Cat_B_7L228 - 3 Phase Fault at Thornton 2091S_with RAS (10cyc)

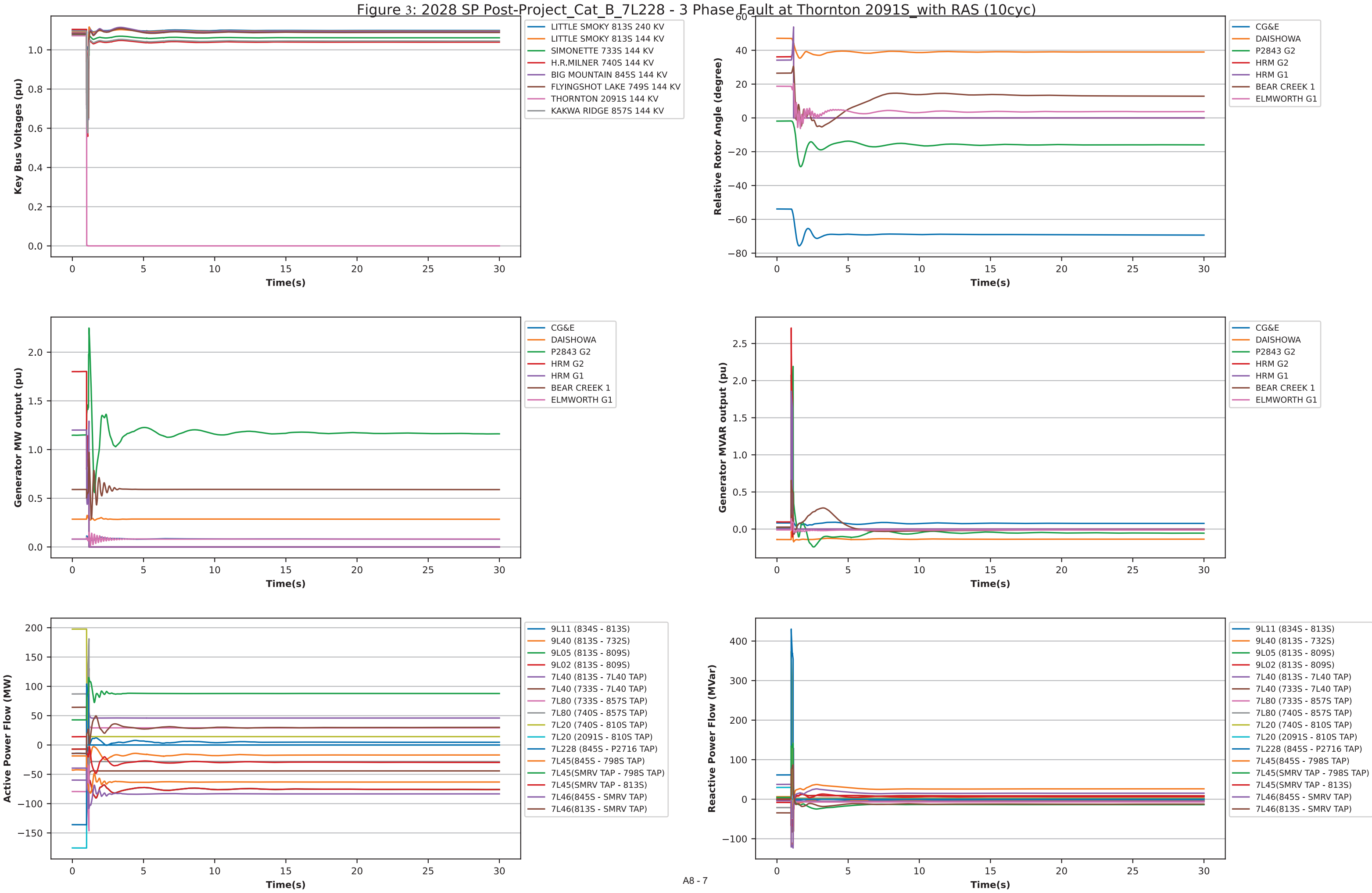


Figure 3A: 2028 SP Post-Project_Cat_B_7L228 - 1 Phase Fault at Thornton 2091S_with RAS (10cyc)

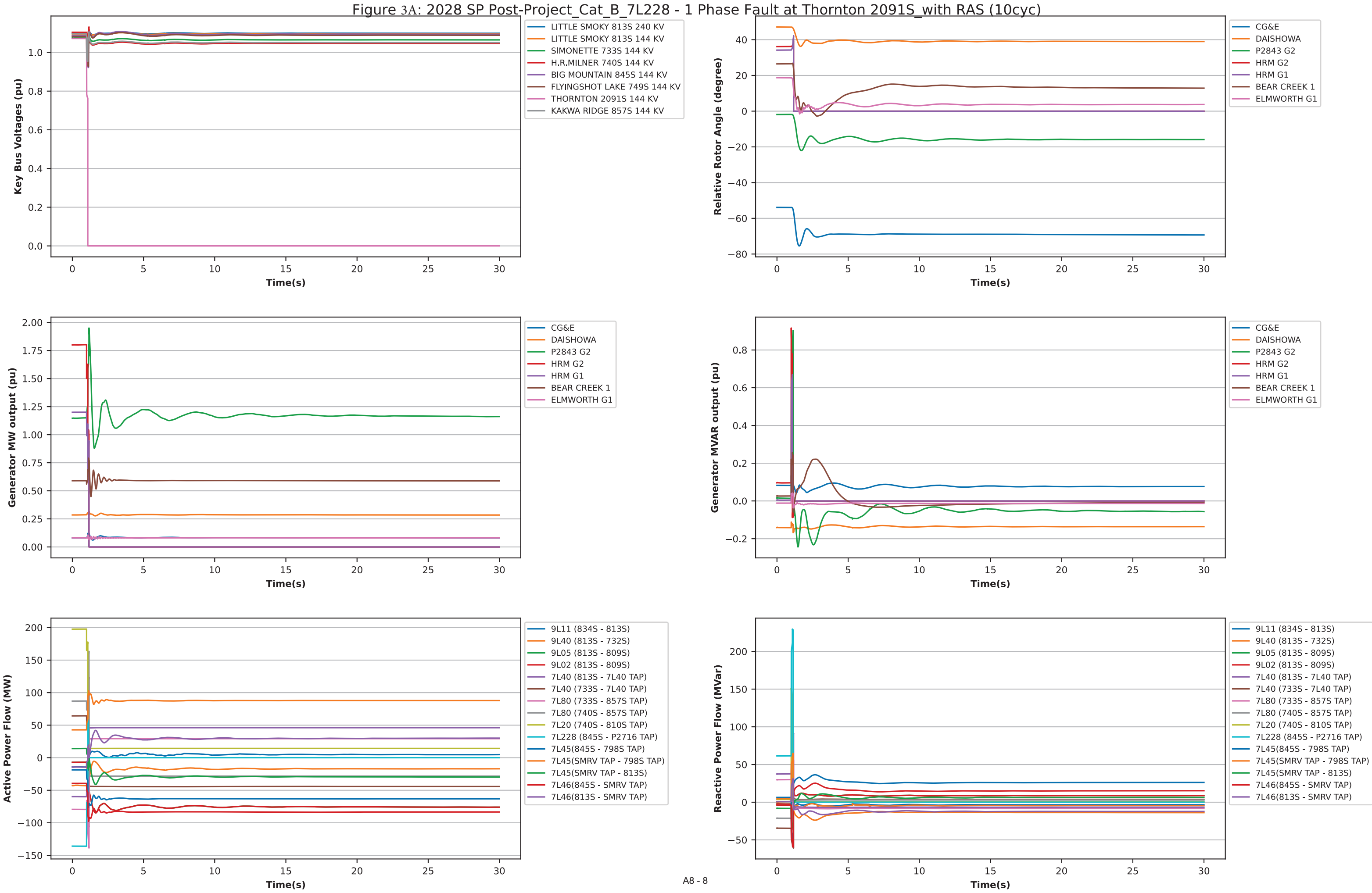


Figure 4: 2028 SP Post-Project_Cat_B_7L228 - 3 Phase Fault at Big Mountain 845S_with RAS (10cyc)

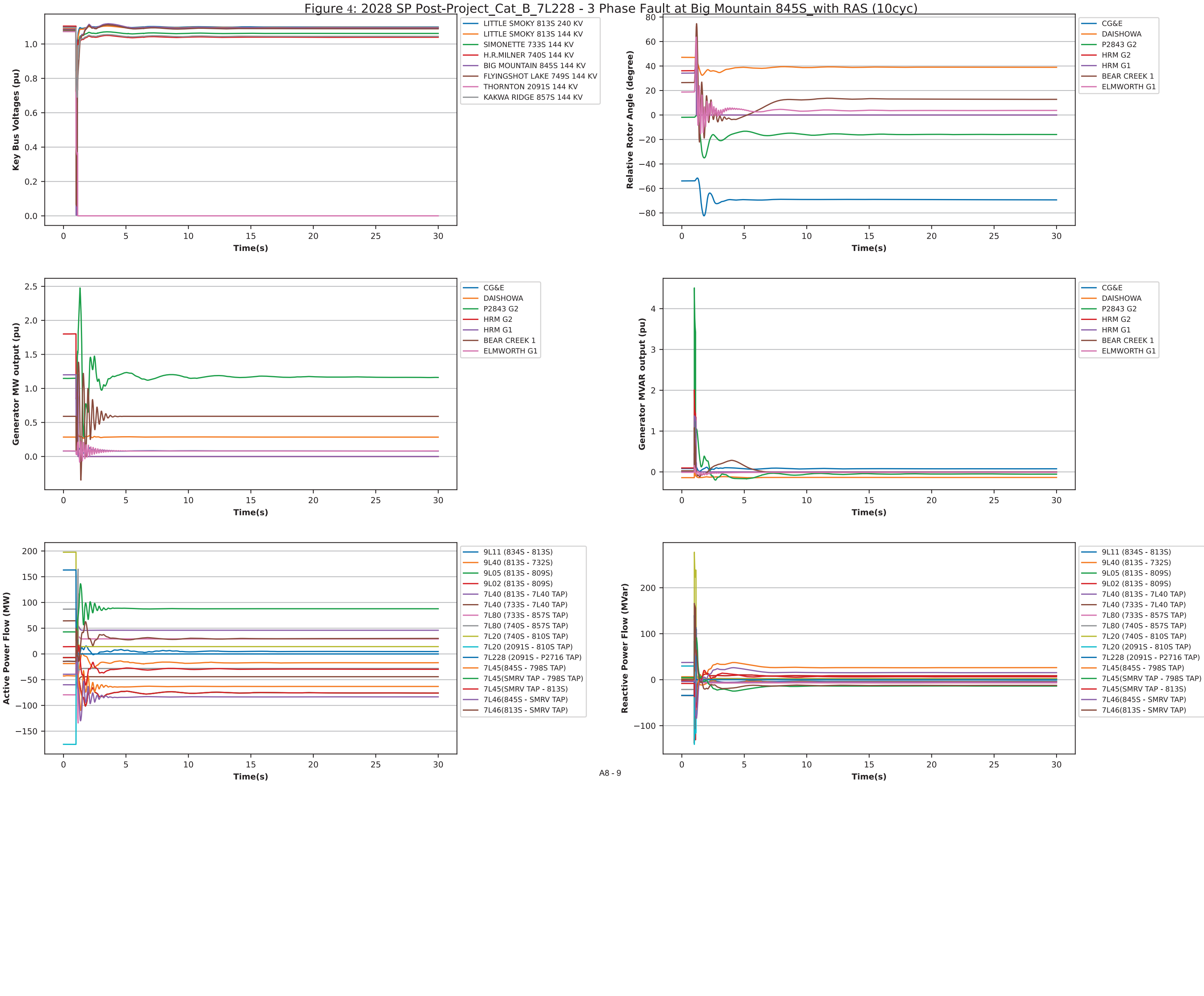
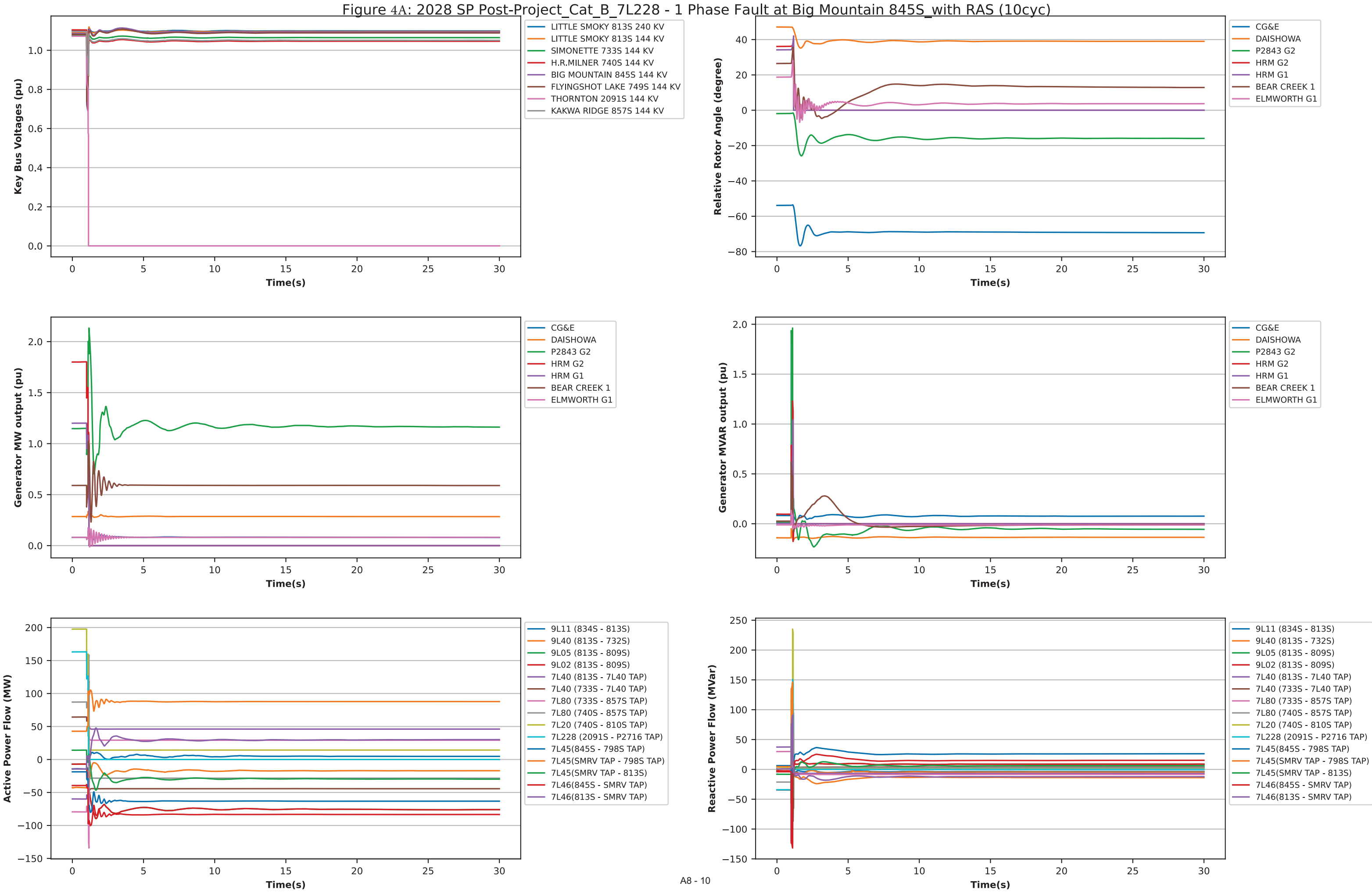


Figure 4A: 2028 SP Post-Project_Cat_B_7L228 - 1 Phase Fault at Big Mountain 845S_with RAS (10cyc)



Attachment A9

Constraints Summary Table – Loading and Voltage Performance (Scenarios 3, 4)

Table 9-1: Loading and Voltage Performance (Scenario 3, 4)

Triggering Events (Element out of Service)	Type of System Constraint (Nature of constraint) (ex. thermal violation, instability, voltage range violation)	Details of Constraint (ex. %I of MVA loading of nominal rating, nominal and short-term emergency rating, and direction of flow, or what type of instability, or voltage level)																			Assumed System Conditions (ex. Summer peak, year, and other critical project assumptions)	Mitigation Approach (RAS or Procedure, also include post-RAS system performance, ex. %I of MVA loading of nominal rating)							Total Generation Curtailment (MW)	Comments
		Thermal								Voltage (Steady State)													Post RAS Action							
		Nominal Rating (MVA)	Short-term Rating (MVA)	Pre-Project		Post-Project		Post - Pre (%)	Does Loading Exceed Emergency Rating?	Substation	Bus #	Nominal Voltage	Emergency Minimum Voltage	Emergency Maximum Voltage	Pre-Project		Post-Project		% Voltage Difference (kV)	Stability		Automatic (RAS) Or Real Time Operating Practice	Action 1 Power Flow (MVA) / Voltage (kV)	Action 1 % of MVA Continuous Rating	Action 2 % of MVA Continuous Rating	Action 3 % of MVA Continuous Rating	Action 4 % of MVA Continuous Rating	Action 5 % of MVA Continuous Rating		
				Load Flow (MVA)	%I of MVA Continuous Ratings	Load Flow (MVA)	%I of MVA Continuous Ratings								Initial Voltage (kV) Pre	Voltage (KV) Pre	Initial Voltage (kV) Pre	Voltage (KV) Pre												
7L22 (Poplar Hill 790S - Clairmont Lake 811S)	Voltage collapse in both Pre and Post cases																			-	2028SP	No violations for 7L22 contingency with PH Gen 1 (bus 16118) turned ON and set = 10MW								
	Voltage collapse in both Pre and Post cases																			-	2028WP	No violations for 7L22 contingency with PH Gen 1 (bus 16118) turned ON and set = 10MW								
7L69 (Goodfare 815S - Elmworth 731S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	131.9	121.8	132.9	122.7	0.9	*Yes*	-	-	-	-	-	-	-	-	-	-	-	2028SP	Action 1: PH Gen 1 (on bus 16118) =22 MW	106.0	97.9						
7L03 (Elmworth 731S - Flyingshot Lake 749S)	7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap)	108.3	120.8	130.5	120.5	131.4	121.3	0.8	*Yes*	-	-	-	-	-	-	-	-	-	-	-	2028SP	Action 1: PH Gen 1 (on bus 16118) =22 MW	106.0	97.9						
7L45 (Big Mountain 845S - Little Smoky 813S)	7L46 (Big Mountain 845S – P2843 Tap)	139	159.1	140.7	101.2	148.2	106.6	5.4	*No*	-	-	-	-	-	-	-	-	-	-	-	2028SP	Realtime Operating Practice (RTOP)								
7L46 (Big Mountain 845S - Little Smoky 813S)	7L45 (Bridge Creek Tap – P2843 Tap)	139	159.1	150.3	108.1	158.3	113.9	5.8	*No*	-	-	-	-	-	-	-	-	-	-	-	2028SP	Realtime Operating Practice (RTOP)								
7L69 (Goodfare 815S - Elmworth 731S)	-	-	-	-	-	-	-	-	-	Updike 886S	1114	144	130	155	140.5	130.2	140.5	129.1	-0.8		2028SP	Action 1: PH Gen 1 (on bus 16118) =22 MW	141.7kV							