

Engineering Connection Assessment

Dobbs 2061S Substation

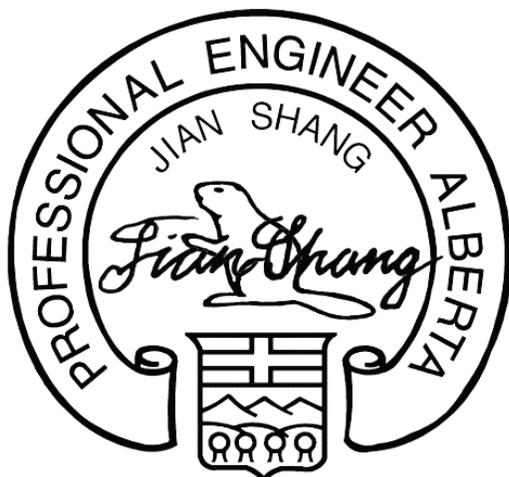
ATCO Electric Ltd.

Date: Dec 1, 2025

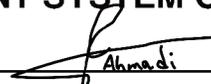
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Engineering Connection Assessment

Dobbs 2061S Substation

V1Final



NOTE:

The conclusions and recommendations in this report are based on the results presented in *Appendix A: 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.

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Attachments

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

Appendix

Appendix A: Engineering Connection Assessment Results

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.

An appendix to this Engineering Connection Assessment is the results of the engineering studies and the scope and methodology used to perform the studies (see Appendix A). 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 loads in the Poplar Hill area.

The DFO's request includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of 12.5 MW, from 52.9 MW to 65.4 MW, at the existing Poplar Hill 790S substation. The DFO's request also includes a request for a new Rate DTS contract capacity of 22 MW for system access service in the Poplar Hill area and a request for transmission development (collectively, the Project). Details on the need for transmission development are provided in the DFO's DDR.

The scheduled in-service date (ISD) for the Project is May 25, 2027.

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

From a transmission system perspective, Grande Prairie (Area 20) consists primarily of a 144 kV transmission system. Grande Prairie (Area 20) is connected to neighboring planning areas by the 144 kV transmission lines 7L73, 7L32, 7L45, 7L46, and 7L40.

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 Appendix A – A1: 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 four transmission alternatives to meet the DFO's request for system access service, as detailed in Section 3.2.¹

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 – New Point of Delivery with a T-tap connection to the 144 kV transmission line 7L22

This alternative includes the following developments:

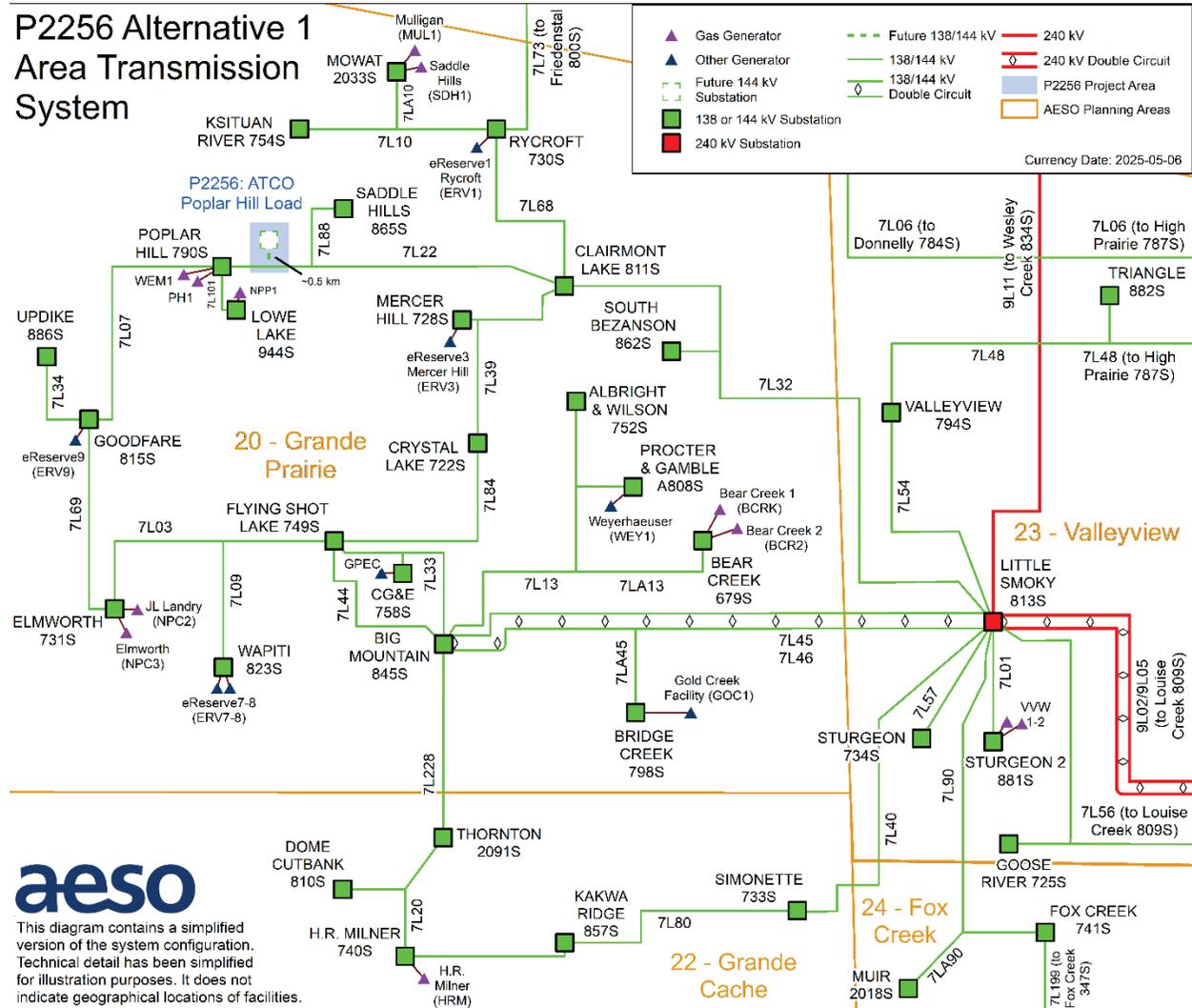
- Add a new 144/25 kV point-of-delivery (POD) substation, designated as Dobbs 2061S, including two 144 kV circuit breakers and one 144/25 kV transformer;
- Add one 144 kV circuit, approximately 0.5 km in length,² to connect the proposed Dobbs 2061S substation to the existing 144 kV transmission 7L22 (between Poplar Hill 790S and 7L88 T-tap point) using a 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 DFO's DDR, which is filed under a separate cover.

² Exact line length to be determined by the TFO

Figure 3-1: Connection Alternative 1



Alternative 2 – New POD with an in-and-out connection to the 144 kV transmission line 7L22

This alternative includes the following developments:

- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including three 144 kV circuit breakers and one 144/25 kV transformer;
- Add two 144 kV circuits, approximately 0.5 km in length each,³ to connect the proposed Dobbs 2061S substation to the existing 144 kV transmission 7L22 (between Poplar Hill 790S and 7L88 T-tap point) using an in-and-out configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 3-2.

³ Exact line length to be determined by the TFO

Alternative 3 – New POD with a radial connection to the 144 kV Poplar Hill 790S substation

This alternative includes the following developments:

- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including two 144 kV circuit breakers and one 144/25 kV transformer;
- Add one 144 kV circuit, approximately 5 km in length,⁴ to connect the proposed Dobbs 2061S substation to the existing Poplar Hill 790S substation using a radial configuration;
- Modify Poplar Hill 790S 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 3-3.

⁴ Exact line length to be determined by the TFO

Alternative 4 – New POD with a radial connection to Clairmont Lake 811S substation

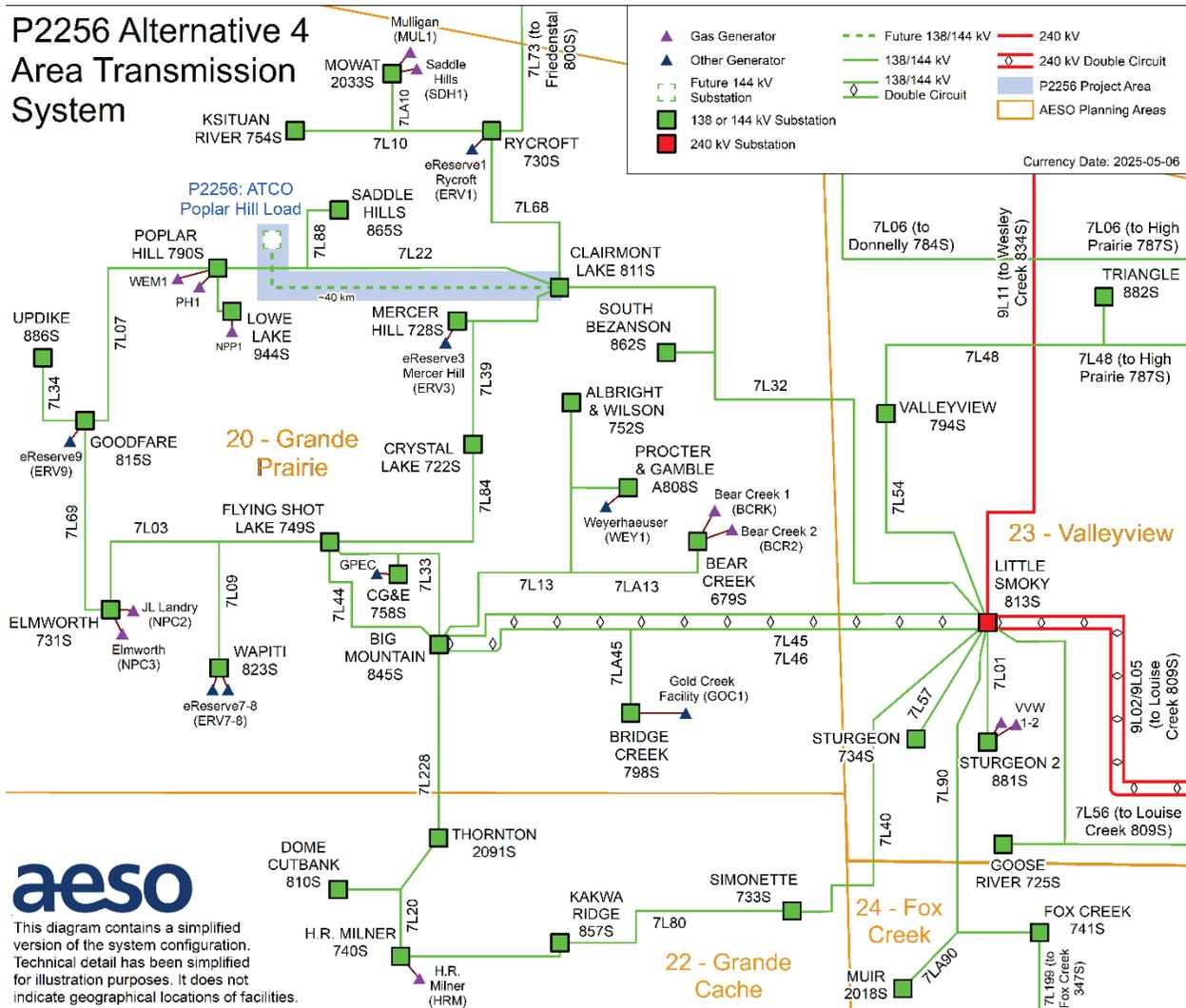
This alternative includes the following developments:

- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including two 144 kV circuit breakers and one 144/25 kV transformer;
- Add one 144 kV circuit, approximately 40 km in length,⁵ to connect the proposed Dobbs 2061S substation to the existing Clairmont Lake 811S substation using a radial configuration;
- Modify Clairmont Lake 811S 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 3-4.

⁵ Exact line length to be determined by the TFO

Figure 3-4: Connection Alternative 4



3.3 Connection Alternatives Selected for Further Study

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

3.4 Connection Alternatives Not Selected for Further Study

Alternatives 2, 3, and 4 involve increased transmission development and hence, increased cost compared to Alternative 1. Therefore, Alternatives 2, 3, and 4 were not selected for further study.

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 Appendix A.

4.2 Studies Performed

Studies were performed using scenarios for the 2028 Winter Peak (WP) and Summer Peak (SP).

Short-circuit studies were performed using the 2033 WP scenario.

Table 4-1 lists the study scenarios. Post-project scenarios reflect the requested Rate DTS contract capacity increase of 12.5 MW at the existing Poplar Hill 790S substation and a new Rate DTS contract capacity of 22 MW at the proposed Dobbs 2061S substation.

Table 4-1: Connection Study Scenarios

| Scenario No. | Year/Season | System Generation Dispatch Conditions | Scenario Name | 790S Load (MW) | New POD Load (MW) |
|---------------------|-----------------------|---|----------------------|----------------|-------------------|
| Pre-Project | | | | | |
| 1 | 2028 Summer Peak (SP) | Low Generation (LG) | 2028 SP Pre-Project | 52.9 | 0 |
| 2 | 2028 Winter Peak (WP) | | 2028 WP Pre-Project | 52.9 | 0 |
| Post-Project | | | | | |
| 3 | 2028 Summer Peak (SP) | Low Generation (LG) | 2028 SP Post-Project | 65.4 | 22 |
| 4 | 2028 Winter Peak (WP) | | 2028 WP Post-Project | 65.4 | 22 |
| 5 | 2033 Winter Peak (WP) | All generators in Study Area in service | 2033 WP Post-Project | 65.4 | 22 |

The AESO Planning Region load forecasts used for the connection studies were based on the AESO's preliminary 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 2024LTO, would not materially alter the connection study results or affect the conclusions and recommendations in this report.

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 point-of-delivery (POD) low voltage bus voltage deviations beyond the limits listed in Table 3-1 of Appendix A – A1: Engineering Connection Assessment Scope.⁶

⁶ 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 Appendix A - Engineering Connection Assessment

Power flow studies were performed for 2028 SP and 2028 WP pre-Project scenarios and for 2028 SP and 2028 WP 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 buses in the Study Area.

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

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

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 Appendix A.

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.
- Section 5.5 includes an overview of the post-mitigation studies results.

Detailed study results are provided in Appendix A.



Table 5-1: Summary of Category A Reliability Criteria Violations, Project Impact, and Mitigation Measures

| Scenario | Type of Reliability Criteria Violation | | Details of Violation | Project Impact | Post-Project Mitigation Measures |
|----------|--|-------------------------------|--|----------------|---|
| | Pre-Project | Post-Project | | | |
| 2028 SP | None | Voltage range violation | Low voltage violations in the Grande Prairie area | New violation | Adding two 15 MVAR capacitor banks at Dobbs 2061S |
| | None | Thermal - above normal rating | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | Dispatch a local generating unit using the AESO TMR service |
| 2028 WP | None | Voltage range violation | Low voltage violations in the Grande Prairie area | New violation | Adding two 15 MVAR capacitor banks at Dobbs 2061S |

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%).

5.2 Pre-Project Study Results

5.2.1 Category A Conditions

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

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 some thermal, voltage range, and voltage stability violations under Category B conditions (i.e., loss of a single system element) without dispatching local generating unit under AESO Transmission Must-Run (TMR) service.

In addition, under Category B conditions, voltage deviations were observed that were beyond the limits listed in Table 3-1 of Appendix A – A1: Engineering Connection Assessment Scope at POD low voltage busses (subsequently referred to as POD bus voltage deviations).

See Attachment A for details.

5.3 Post-Project Study Results

5.3.1 Category A Conditions

Following the connection of the Project, new thermal and voltage range violations were observed, including thermal violations on the 7L22.

A summary of thermal criteria violations observed under Category A system conditions in the 2028 SP scenario is shown in Table 5-2.

Table 5-2: Thermal Criteria Violations under N-0 Condition in the 2028 SP scenario

| Details of Violation (Violation Observed On) | Normal Rating (MVA) | Emergency Rating (MVA) | Pre-Project Results | | Post-Project Results | | % Loading Difference (Post-Pre) |
|--|---------------------------|------------------------------|------------------------------------|-----------|---------------------------------|-----------|---------------------------------------|
| | | | Observed Power Flow (MVA) | % Loading | Observed Power Flow (MVA) | % Loading | |
| 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 81.23 | 75 | 108.4 | 100.1 | 25.1 |

Table 5-2 indicates that the project has a material impact on the Category A thermal criteria violation in the Study Area following the inclusion of the Project. The project's impact on 7L22 overload is greater than 25%.

Post-Project short-circuit fault levels were not significantly higher than pre-Project levels.

5.3.2 Category B Conditions

Post-Project power flow studies and voltage stability studies identified a number of thermal and voltage criteria violations under Category B conditions.

Following the connection of the Project, voltage range and voltage stability violations observed in the pre-Project scenarios were exacerbated. New thermal, voltage range, and voltage stability violations were also observed, in addition to new POD bus voltage deviations.

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, voltage range, and voltage stability criteria violations under Category B system conditions can be managed by dispatching generation under Transmission Must-Run (TMR) service.

5.4.2 Post-Project

The low voltage range violations observed in Post-Project scenarios under the Category A condition can be mitigated by adding two 15 MVar 144 kV capacitor banks and two 240 kV breakers with point-on-wave (POW) control to the proposed Dobbs 2061S substation. The remaining Category A thermal reliability criteria violation observed in the Post-Project scenarios can be managed by applying Section 302.1 of the ISO rules, *Real-Time Transmission Constraint Management* (TCM Rule), to dispatch generation under TMR service until such a time that system developments are in place to alleviate constraints. The AESO's 2025 Long-Term Transmission Plan has identified potential transmission solutions, including non-wires solutions or 240 kV transmission reinforcements in the Grande Prairie area.⁷

After the connection of the Project, a few of the thermal, voltage range, and voltage stability criteria violations observed under Category B system conditions can be mitigated by using real-time operational practices, i.e., dispatching generation under TMR service. The remaining thermal, voltage range, and voltage stability criteria violations can be mitigated by adding a new RAS for 7L22 overload and area voltage, which includes the new Project loads at Poplar Hill and Dobbs substations in the tripping logic.

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. However, the capacitor banks are expected to manage the POD bus voltage deviations at the proposed Dobbs 2061S substation.

5.4.3 Post-Project Mitigation Study Results

Under Category A and B conditions, with the addition of the two 15 MVar capacitor banks, real-time operational practices, and application of a new RAS for 7L22 overload and area voltage with the new Project loads at Poplar Hill and Dobbs substations included in the logic, all of the observed Reliability Criteria violations requiring RAS were mitigated.

⁷ AESO 2025 Long-Term Transmission Plan, January 2025.

6 Project Dependencies

The Project does not require the completion of any other AESO plans to expand or enhance the transmission system prior to connection.

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.

The connection assessment uses credible worst-case conditions to assess the impact of the Facility connecting on the AIES. Category A voltage and thermal criteria violations were observed under these credible worst-case load and generation forecast conditions.

The Category A violations can be mitigated by adding two 15 MVAR 144 kV capacitor banks at the proposed Dobbs 2061S substation and using real-time operational practices, which include applying the TCM Rule to dispatch generation under TMR service as required.

The thermal and voltage criteria violations under Category B conditions can be mitigated through real-time operational practices, including dispatching generation under TMR service and a new RAS for 7L22 overload and area voltage, alone or in combination, as appropriate. With the implementation of these mitigation measures, connecting the project with the preferred alternative does not adversely affect the performance of the AIES.

The probability of Category A and Category B voltage and thermal violations materializing is highly dependent upon the load profile of the Facility and other generation and load facilities in the area. The AESO will continue to monitor the pace of electricity demand and may develop system reinforcement as outlined in the AESO's 2025 Long-term plan. The proposed new RAS for 7L22 overload and area voltage will remain in service until such a time that system developments are in place to alleviate constraints.

The AESO recommends proceeding with the Project using Alternative 1 as the preferred alternative to respond to the Market Participant's request for system access service. Real-time operational practices and the RAS mentioned above are recommended to mitigate the identified system performance issues.

Alternative 1 involves adding a new POD substation, designated as Dobbs 2061S substation, including two 144 kV circuit breakers, two 15 MVAR 144 kV capacitor banks, two 240 kV breakers with point-on-wave (POW) control for the capacitor banks, one 144/25 kV transformer, and adding one 144 kV circuit, approximately 0.5 km in length, to connect the Dobbs 2061S substation to the existing 144 kV transmission line 7L22 using a T-tap configuration.

The conductor used for the 144 kV circuit should have a normal rating no less than the existing transmission line 7L22. The transformer at the Dobbs 2061S substation should have a minimum rating of 30 MVA to meet the Market Participant's requested DTS.

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 SP (30 MW TMR dispatched pre-contingency ¹) | None | Thermal - above emergency rating | 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | None | Dispatching Transmission Must-Run (TMR) & new Remedial Action Scheme (RAS) for 7L22 overload and area voltage |
| | None | Thermal - above normal rating | 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | New violation | None | Real Time Operational Practice (RTOP) |
| | None | Thermal - above emergency rating | 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | None | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | None | Thermal - above normal rating | 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | New violation | None | RTOP |
| | None | Thermal - above normal rating | Poplar Hill 790S 703T | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | None | RTOP |
| 2028 WP | None | Thermal - above emergency rating | 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | None | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | None | Thermal - above normal rating | 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | New violation | None | RTOP |
| | None | Thermal - above emergency rating | 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | New violation | None | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | None | Thermal - above normal rating | 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | New violation | None | RTOP |
| | Voltage | Voltage | 7L22 (Poplar Hill 790S - Clairmont Lake 811S) | Voltage stability & Voltage collapse | Materially increased violation | Dispatching TMR | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | Voltage | Voltage | 7L69 (Goodfare 815S - Elmworth 731S) | Voltage stability & Low voltage violations | Materially increased violation | Dispatching TMR | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | None | Voltage | 7L03 (Elmworth 731S - Flyingshot Lake 749S) | Voltage stability & Low voltage violations | New violation | None | Dispatching TMR & new RAS for 7L22 overload and area voltage |
| | None | Voltage | 7L84 (Crystal Lake 722S - Flyingshot 749S) | Voltage stability | New violation | None | Dispatching TMR & new RAS for 7L22 overload and area voltage |

Notes: The post-Project 2028 SP scenario shows Category A thermal and voltage violations. As such, 30 MW TMR dispatch is proposed to mitigate the Category A violations. The Category B study results presented herein assume the 30 MW TMR dispatched pre-contingency for both pre-Project and post-Project 2028 SP scenarios.

Appendix A: Engineering Connection Assessment Results

Engineering Connection Assessment: Study Results

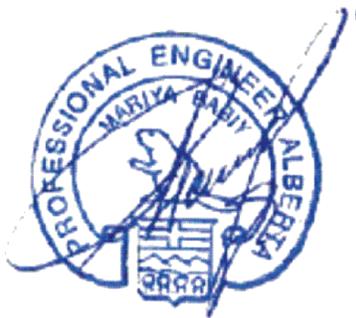
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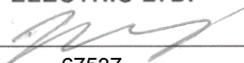
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Attachments

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| Attachment A8 | Engineering Connection Assessment: Study Scope |

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 "P2256 Dobbs 2061S Substation" dated May 13, 2024, Version V1Final.

The power system network analysis tool that was used for the studies in this connection assessment was PSS/E version 34.

2 Pre-Project Study Results

This section describes the results of the Pre-Project power flow studies and voltage stability study.

2.1 Power Flow Studies

Power flow diagrams illustrating the Pre-Project power flow study results for Category A and Category B conditions are provided in Attachment A1.

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

Category A Conditions

No Reliability Criteria (as defined in the AESO's Study Scope) 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.

As advised by AESO, the thermal and voltage violations issues for the Pre-Project Scenario 1 will be mitigated by dispatching the Poplar Hill TMR unit to 30 MW. Refer to Section 5.1 (Table 5-1) for the details of mitigation measures.

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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 |
| 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 138 | 127.4 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 110.7 | 102.2 |
| 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 136.1 | 125.7 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 109.6 | 101.2 |

Notes:

^a The facility ratings shown in the AESO's Study Scope have been adjusted from a [72/144] kV voltage base to a [69/138] kV voltage base, as is used by the power system network analysis tool.

^b Power flow (MVA) is current expressed as MVA (i.e., $S = \sqrt{3} \times V_{\text{base}} \times I_{\text{actual}}$)

^c Reported as a percentage of the power flow (in MVA, i.e., $S = \sqrt{3} \times V_{\text{base}} \times I_{\text{actual}}$) relative to the transmission line's Normal Rating (also in MVA), as shown in the AESO's Study Scope.

Voltage Criteria Violations

Voltage criteria violations were observed under certain 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 | | | | | | |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 886S | 1114 | 144 | 130 | 155 | 140.5 | 127.4 |
| 7L03 (Elmworth 731S - Flyingshot Lake 749S) | Updike 886S | 1114 | 144 | 130 | 155 | 140.5 | 129.6 |

POD Bus Voltage Deviations

POD bus voltage deviations were observed under Category B conditions as shown in Table 2-3.

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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 | | | | | | |
|--|---------------------------------------|---------|-----------------------------------|----------------------------|---|----------|------------------------------|----------|------------------------|----------|
| | Substation Name and No. | Bus No. | Nominal Bus Voltage (kV) | Initial Voltage (kV) | Voltage Deviations at POD Low Voltage Buses | | | | | |
| | | | | | Post Transient (kV) | % Change | Post Auto Control (kV) | % Change | Post Manual (kV) | % Change |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 886S | 19114 | 25 | 25.9 | 23.2 | 10.8% | – | – | – | – |
| | Goodfare 815S | 19119 | 25 | 26 | – | – | – | – | 24.5 | 6.0% |

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

Category A Conditions

No Reliability Criteria (as defined in the AESO's Study Scope) violations were observed under Category A conditions.

Category B Conditions

Thermal Criteria Violations

No thermal criteria violations were observed under Category B conditions.

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 2-4.

As advised by AESO, the voltage violations issues for the Pre-Project Scenario 2 will be mitigated by dispatching the Poplar Hill TMR unit to 20 MW. Refer to Section 5.1 (Table 5-2) for the details of mitigation measures.

Table 2-4: 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 | | | | | | |

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| 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) |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 886S | 1114 | 144 | 130 | 155 | 139.4 | 128.8 |

POD Bus Voltage Deviations

No POD bus voltage deviations were observed.

2.2 Voltage Stability Studies

Scenario 2 was performed for voltage stability analysis by increasing load in Grande Prairie (Area 20), while increasing generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the load area in scenario 2 is 412.4 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 20.62 MW ($0.05 \times 412.4 \text{ MW} = 20.62 \text{ MW}$), to meet the voltage stability criteria.

Table 2-5 provides the voltage stability study results under Category A conditions and for the five worst contingencies under Category B conditions. The corresponding diagrams are listed in Attachment A2. The study results show that the voltage stability margin was met for all studied conditions except for contingency 7L22.

Table 2-5: Voltage Stability Study Results Under Category B Conditions for Scenario 2

| Contingency (System Element Lost) | From | To | Maximum Incremental Transfer (MW) | Meets Criteria? |
|---|-------------------|---------------------|--|--------------------|
| N-0 | System Intact | | 135.93 | Yes |
| 7L22 | Poplar Hill 790S | Clairmont Lake 811S | 0.0 | No |
| 7L69 | Goodfare 815S | Elmworth 731S | 48.44 | Yes |
| 7L03 | Elmworth 731S | Flyingshot 749S | 56.25 | Yes |
| 7L84 | Crystal Lake 722S | Flyingshot 749S | 60.15 | Yes |

3 Post-Project Study Results

This section describes the results of the Post-Project power flow studies and voltage stability study.

As described in Section 2 of the AESO's Study Scope, 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 SP LG Post-Project

Category A Conditions

Low voltages were observed at the following substations under the system intact N-G in the 2028SP Post-Project Scenario 3 and are shown in Table 3-1. To mitigate the system intact N-G low voltages, it is proposed to install new capacitor banks at the proposed Dobbs 2061S substation. The proposed 2X15 MVAR capacitor banks will increase voltages above the minimum voltage requirement as per AESO planning criteria (refer to Table 3.1 for details).

Table 3-1: – Voltages Under System Intact N-G in Scenario 3

| Contingency (System Element Lost) | Violation Location Details | | Voltages (kV) | | |
|-----------------------------------|----------------------------|---------|-----------------|----------------------|---------------------------------------|
| | Substation Name and No. | Bus No. | Nominal Voltage | Initial Voltage (kV) | Voltage with 2x15 MVAR cap banks (kV) |
| System Intact N-G | Dobbs 2061S | 542004 | 144 | 134.85 | 141.27 |
| | Saddle Hills 865S | 1124 | 144 | 135.13 | 140.10 |
| | Poplar Hill 790S | 1118 | 144 | 134.4 | 140.71 |
| | Lowe Lake 944S | 1120 | 144 | 134.4 | 140.71 |
| | Goodfare 815S | 1119 | 144 | 135.04 | 140.62 |
| | Udike 886S | 1114 | 144 | 132.11 | 137.82 |

The switching step change for the proposed 144 kV 2X15 MVAR capacitor banks should be within the ATCO DFO criteria and should be below 3%. A steady-state capacitor banks switching study was conducted to identify the magnitude of the voltage step change using the 2028SP Post-Project Scenario 3. The voltage step changes at the 144 kV Dobbs 2061S bus with the proposed capacitor banks are shown in Table 3-2. The switching steps are within the ATCO DFO criteria and below 3%.

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Table 3-2: 2 x 15 MVAR 144 kV Capacitor Bank at Dobbs 2061S - Switching Step Change for N-G in 2028 WP Scenario 3

| Scenario | Substation Name and Number | Bus No. | kV Base | First 15 MVAR cap bank | | | Second 15 MVAR cap bank | | |
|------------|----------------------------|---------|---------|------------------------|-------------------------|-----------------|-------------------------|-------------------------|-----------------|
| | | | | Pre-Cap Switching p.u. | Post-Cap Switching p.u. | Step Change (%) | Pre-Cap Switching p.u. | Post-Cap Switching p.u. | Step Change (%) |
| Scenario 3 | Dobbs 2061S | 542004 | 138 | 0.97718 | 0.99794 | 2.076 | 1.00089 | 1.02264 | 2.175 |
| | | 552004 | 25 | 1.03555 | 1.05765 | 2.21 | 1.03869 | 1.06137 | 2.268 |
| | Poplar Hill 790S | 1118 | 138 | 0.97397 | 0.99399 | 2.002 | 0.99736 | 1.01834 | 2.098 |
| | | 18118 | 25 | 1.00573 | 1.02648 | 2.075 | 1.03094 | 1.05271 | 2.177 |
| | | 19118 | 25 | 1.00711 | 1.02788 | 2.077 | 1.03228 | 1.05406 | 2.178 |
| | | 17118 | 25 | 1.02777 | 1.04916 | 2.139 | 1.04240 | 1.06459 | 2.219 |
| | Saddle Hill 865S | 1124 | 138 | 0.96965 | 0.98976 | 2.011 | 0.99292 | 1.01399 | 2.107 |
| | | 19124 | 25 | 1.00637 | 1.02746 | 2.109 | 1.03276 | 1.05489 | 2.213 |
| | Goodfare 815S | 1119 | 138 | 0.97858 | 0.99544 | 1.686 | 0.99932 | 1.01700 | 1.768 |
| | | 19119 | 25 | 1.00547 | 1.02290 | 1.743 | 1.02797 | 1.04626 | 1.829 |
| | Updike 886S | 1114 | 138 | 0.95738 | 0.97410 | 1.672 | 0.97865 | 0.99619 | 1.754 |
| | | 19114 | 25 | 1.03234 | 1.05054 | 1.82 | 1.04410 | 1.06298 | 1.888 |

In addition, thermal overloading was observed under the system intact N-G in Scenario 3 and is shown in Table 3-3.

Table 3-3: Thermal Criteria Violations Under System Intact N-G 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 | |
| System Intact N-G | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 81.23 | 75 | 108.4 | 100.1 | 25.1 |

As advised by the AESO, the Poplar Hill TMR unit was dispatched to 30 MW to alleviate this thermal overloading under the system intact N-G in Scenario 3 and is shown in Table 3-4.

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Table 3-4: Thermal Criteria Violations Under System Intact N-G for Scenario 3 with TMR Dispatch

| 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 | |
| System Intact N-G | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 60.88 | 56 | 87.72 | 81 | 25 |

Therefore, the proposed capacitor banks provide enough VAR support to maintain the voltage within the desired operating range and the power flow studies for Scenario 3 were performed with the proposed 2x15 MVar capacitor banks switched on at Dobbs 2061S substation and the Poplar Hill TMR unit dispatched to 30 MW. Thus, no Reliability Criteria (as defined in the AESO's Study Scope) violations were observed under Category A conditions with the above mitigation measures.

Category B Conditions

Thermal Criteria Violations

NOTE: The study results for the Pre-Project are shown with the mitigation measurements (the Poplar Hill TMR unit is dispatched to 30 MW) as detailed in Section 5.1 for the proper comparison with the Post-Project results as the Poplar Hill TMR unit is dispatched in the Post-Project case under the system intact. Therefore, the study results in Table 3-5 show the Project P2256 contribution and the project contributes 36% to the thermal overloads identified in the Pre-Project Scenario 1.

Thermal criteria violations were observed under certain Category B conditions as shown in Table 3-5.

Refer to Section 0 for the details of mitigation measures for Scenario 3.

Table 3-5: 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 | |
| 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 101.2 | 93.4 | 138.3 | 127.7 | 34.3 |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | 108.3 | 163.9 | 80.1 | 74 | 118.5 | 109.4 | 35.4 |
| 7L03 (Elmworth 731S - Flyingshot 749S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 101.2 | 93.4 | 138.6 | 127.9 | 34.5 |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | 108.3 | 163.9 | 80.1 | 74 | 119.5 | 110.3 | 36.3 |
| Poplar Hill 790S 703T | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 81.65 | 75.4 | 108.7 | 100.4 | 25 |

Notes:

^a The facility ratings shown in the AESO's Study Scope have been adjusted from a [72/144] kV voltage base to a [69/138] kV voltage base, as is used by the power system network analysis tool.

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^b Power flow (MVA) is current expressed as MVA (i.e., $S = \sqrt{3} \times V_{\text{base}} \times I_{\text{actual}}$)

^c Reported as a percentage of the power flow (in MVA, i.e., $S = \sqrt{3} \times V_{\text{base}} \times I_{\text{actual}}$) relative to the transmission line's Normal Rating (also in MVA), as shown in the AESO's Study Scope.

Voltage Criteria Violations

No voltage criteria violations were observed under certain Category B conditions.

POD Bus Voltage Deviations

No POD bus voltage deviations were observed.

3.1.2 Scenario 4: 2028 WP LG Post-Project

Category A Conditions

Low voltages were observed at the following substations under the system intact N-G in the 2028WP Post-Project Scenario 4 and are shown in Table 3-6. To mitigate the system intact N-G low voltages, it is proposed to install new capacitor banks at the proposed Dobbs 2061S substation. The proposed 2X15 MVar capacitor banks will increase voltages above the minimum voltage requirement as per AESO planning criteria (refer to Table 3-6 for details).

Table 3-6: Voltages Under system intact N-G in Scenario 4

| Contingency (System Element Lost) | Violation Location Details | | Voltages (kV) | | |
|-----------------------------------|----------------------------|---------|-----------------|----------------------|---------------------------------------|
| | Substation Name and No. | Bus No. | Nominal Voltage | Initial Voltage (kV) | Voltage with 2x15 MVar cap banks (kV) |
| System Intact N-G | Dobbs 2061S | 542004 | 144 | 135.1 | 141.01 |
| | Saddle Hills 865S | 1124 | 144 | 135.39 | 139.98 |
| | Poplar Hill 790S | 1118 | 144 | 134.65 | 140.43 |
| | Lowe Lake 944S | 1120 | 144 | 134.65 | 140.43 |
| | Goodfare 815S | 1119 | 144 | 134.82 | 139.84 |
| | Udike 886S | 1114 | 144 | 131.88 | 141.01 |

The switching step change for the proposed 144 kV 2X15 MVar capacitor banks should be within the ATCO DFO criteria and should be below 3%. A steady-state capacitor banks switching study was conducted to identify the magnitude of the voltage step change using the 2028SP Post-Project Scenario 3. The voltage step changes at the 144 kV Dobbs 2061S bus with the proposed capacitor banks are shown in Table 3-7. The switching steps are within the ATCO DFO criteria and below 3%.

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Table 3-7: 2 x 15 MVAR 144 kV Capacitor Bank at Dobbs 2061S - Switching Step Change for N-G in 2028 WP Scenario 4

| Scenario | Substation Name and Number | Bus No. | kV Base | First 15 MVAR cap bank | | | Second 15 MVAR cap bank | | |
|------------|----------------------------|---------|---------|------------------------|-------------------------|-----------------|-------------------------|-------------------------|-----------------|
| | | | | Pre-Cap Switching p.u. | Post-Cap Switching p.u. | Step Change (%) | Pre-Cap Switching p.u. | Post-Cap Switching p.u. | Step Change (%) |
| Scenario 4 | Dobbs 2061S | 542004 | 138 | 0.97902 | 0.9993 | 2.028 | 1.0017 | 1.02131 | 1.961 |
| | | 552004 | 25 | 1.03763 | 1.05922 | 2.159 | 1.03789 | 1.05993 | 2.204 |
| | Poplar Hill 790S | 1118 | 138 | 0.97579 | 0.99534 | 1.955 | 0.99649 | 1.01686 | 2.037 |
| | | 18118 | 25 | 1.0100 | 1.03031 | 2.031 | 1.03226 | 1.05344 | 2.118 |
| | | 19118 | 25 | 1.01128 | 1.03159 | 2.031 | 1.03350 | 1.05469 | 2.119 |
| | | 17118 | 25 | 1.03563 | 1.05663 | 2.1 | 1.03450 | 1.05591 | 2.141 |
| | Saddle Hill 865S | 1124 | 138 | 0.97258 | 0.99222 | 1.964 | 0.99325 | 1.01372 | 2.047 |
| | | 19124 | 25 | 1.00386 | 1.02433 | 2.047 | 1.02098 | 1.04221 | 2.123 |
| | Goodfare 815S | 1119 | 138 | 0.97697 | 0.99329 | 1.632 | 0.99502 | 1.01205 | 1.703 |
| | | 19119 | 25 | 1.00608 | 1.0230 | 1.692 | 1.02563 | 1.04328 | 1.765 |
| | Updike 886S | 1114 | 138 | 0.95571 | 0.97190 | 1.619 | 0.97423 | 0.99112 | 1.689 |
| | | 19114 | 25 | 1.03044 | 1.0406 | 1.016 | 1.03899 | 1.05717 | 1.818 |

Therefore, the proposed capacitor banks provide enough VAR support to maintain the voltage within the desired operating range and the power flow studies for Scenario 4 were performed with the proposed 2 x 15 MVAR capacitor banks switched on at Dobbs 2061S substation. Thus, no Reliability Criteria (as defined in the AESO's Study Scope) violations were observed under Category A conditions once low voltages were mitigated.

Category B Conditions

Thermal Criteria Violations

Thermal criteria violations were observed under certain Category B conditions as shown in Table 3-8. Refer to Section 5.2 for the details of mitigation measures for Scenario 4.

Table 3-8: 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 (Clairmont Lake 811S - Saddle Hills 865S tap) | 144.7 | 163.9 | 135.10 | 93.4 | 184.3 | 127.4 | 34 |

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| 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 | |
| 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | 144.7 | 163.9 | 110.42 | 76.31 | 157 | 108.5 | 32.19 |
| 7L03 (Elmworth 731S - Flyingshot 749S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 144.7 | 163.9 | 133.45 | 92.2 | 179 | 123.7 | 31.5 |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | 144.7 | 163.9 | 109.54 | 75.7 | 152.9 | 105.7 | 30 |

Voltage Criteria Violations

Voltage criteria violations were observed under certain Category B conditions as shown in Table 3-9.

Table 3-9: Voltage Criteria Violations Under Category B Conditions for Scenario 4

| Contingency (System Element Lost) | Violation Location Details | | Voltage Ratings (kV) | | | Post-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 | | | | | | |
| 7L03 (Elmworth 731S - Flyingshot 749S) | Updike 886S | 1114 | 144 | 130 | 155 | 137 | 121.5 |
| | Poplar Hill 790S | 1118 | 144 | 130 | 155 | 140.4 | 128.3 |
| | Goodfare 815S | 1119 | 144 | 130 | 155 | 139.8 | 124.8 |
| | Lowe Lake 944S | 1120 | 144 | 130 | 155 | 140.4 | 128.3 |
| | Saddle Hills 865S | 1124 | 144 | 130 | 155 | 140 | 128.8 |
| | Elmworth 731S | 1134 | 144 | 130 | 155 | 141.9 | 125 |
| | Dobbs 2061S | 542004 | 144 | 130 | 155 | 141 | 129.7 |
| | Dobbs 2061S tap | 547010 | 144 | 130 | 155 | 141 | 129.7 |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 886S | 1114 | 144 | 130 | 155 | 137 | 117.1 |
| | Poplar Hill 790S | 1118 | 144 | 130 | 155 | 140.4 | 124.8 |
| | Goodfare 815S | 1119 | 144 | 130 | 155 | 139.8 | 120.6 |
| | Lowe Lake 944S | 1120 | 144 | 130 | 155 | 140.4 | 124.8 |
| | Saddle Hills 865S tap | 1123 | 144 | 130 | 155 | 141.1 | 126.8 |
| | Saddle Hills 865S | 1124 | 144 | 130 | 155 | 140 | 125.5 |
| | Dobbs 2061S | 542004 | 144 | 130 | 155 | 141 | 126.4 |
| | Dobbs 2061S tap | 547010 | 144 | 130 | 155 | 141 | 126.4 |

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POD Bus Voltage Deviations

POD bus voltage deviations were observed under Category B conditions as shown in Table 3-10.

Table 3-10: POD Bus Voltage Deviations Under Category B Conditions for Scenario 4

| Contingency (System Element Lost) | Voltage Deviation Location Details | | | Post-Project Results | | | | | | |
|--|---------------------------------------|---------|-----------------------------------|----------------------------|---|----------|------------------------------|----------|------------------------|----------|
| | Substation Name and No. | Bus No. | Nominal Bus Voltage (kV) | Initial Voltage (kV) | Voltage Deviations at POD Low Voltage Buses | | | | | |
| | | | | | Post Transient (kV) | % Change | Post Auto Control (kV) | % Change | Post Manual (kV) | % Change |
| 7L03 (Elmworth 731S - Flyingshot 749S) | Poplar Hill 790S | 18118 | 25 | 25.9 | – | – | – | – | 24.3 | 6.7% |
| | Updike 886S | 19114 | 25 | 25.9 | 22.6 | 13.0% | 23.8 | 8.1% | 23.8 | 8.1% |
| | Poplar Hill 790S | 19118 | 25 | 26 | – | – | – | – | 24.3 | 6.7% |
| | Goodfare 815S | 19119 | 25 | 26 | 23.1 | 11.7% | 23.5 | 10.1% | 23.5 | 10.1% |
| | Saddle Hills 865S | 19124 | 25 | 25.8 | – | – | – | – | 24.5 | 5.2% |
| 7L69 (Goodfare 815S - Elmworth 731S) | Poplar Hill 790S | 17118 | 25 | 25.8 | 22.6 | 12.8% | – | – | 24.3 | 6.4% |
| | Poplar Hill 790S | 18118 | 25 | 25.9 | 22.9 | 12.0% | 23.8 | 8.7% | 23.8 | 8.7% |
| | Updike 886S | 19114 | 25 | 25.9 | 21.7 | 16.8% | 23.1 | 10.9% | 23.1 | 10.9% |
| | Poplar Hill 790S | 19118 | 25 | 26 | 23 | 12.0% | 23.8 | 8.7% | 23.8 | 8.7% |
| | Goodfare 815S | 19119 | 25 | 26 | 22.2 | 15.1% | 22.8 | 12.6% | 22.8 | 12.6% |
| | Saddle Hills 865S | 19124 | 25 | 25.8 | 22.9 | 11.5% | 24 | 7.1% | 24 | 7.1% |
| | Dobbs 2061S | 552004 | 25 | 26 | 23.1 | 11.5% | – | – | – | – |

3.2 Voltage Stability Studies

Scenario 4 was performed for the voltage stability analysis by increasing load in Grande Prairie (Area 20), while increasing generation in Wabamun (Area 40) and Fort McMurray (Area 25). The reference load level for the load area is 446.85 MW. For Category B contingencies, the minimum incremental load transfer is 5% of the reference load, or 22.34 MW ($0.05 \times 446.85 \text{ MW} = 22.34 \text{ MW}$), to meet the voltage stability criteria.

Table 3-11 provides the voltage stability study results under Category A conditions and for the five worst contingencies under Category B conditions. The corresponding diagrams are listed in Attachment A4. The study results show that the voltage stability margin was not met for 7L22, 7L03, 7L69 and 7L84 contingencies.

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Table 3-11: Voltage Stability Study Results Under Category B Conditions for Scenario 4

| Contingency (System Element Lost) | From | To | Maximum Incremental Transfer (MW) | Meets Criteria? |
|-----------------------------------|-------------------|---------------------|-----------------------------------|-----------------|
| N-0 | System Intact | | 103.13 | Yes |
| 7L22 | Poplar Hill 790S | Clairmont Lake 811S | 0.0 | No |
| 7L69 | Goodfare 815S | Elmworth 731S | 7.031 | No |
| 7L03 | Elmworth 731S | Flyingshot 749S | 13.28 | No |
| 7L84 | Crystal Lake 722S | Flyingshot 749S | 21.87 | No |
| 7L32 | Little Smoky 813S | Clairmont Lake 811S | 58.60 | Yes |

4 Short Circuit Studies

4.1 Pre-Project Results

4.1.1 Scenario 2: 2028 WP LG Pre-Project

Pre-Project short-circuit current levels are provided in Table 4-1¹.

Table 4-1: 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) |
|----------------------------|-------------------|------------------------|----------------------|---|----------------------|---|
| Urdike 886S | 138 | 140.05 | 2.46 | 0.072059+j0.163161 | 2.39 | 0.021112+j0.194922 |
| Clairmont Lake 811S | 138 | 148.51 | 6.63 | 0.022928+j0.062165 | 5.13 | 0.029087+j0.120786 |
| Poplar Hill 790S | 138 | 143.62 | 5.38 | 0.023219+j0.078278 | 5.68 | 0.007119+j0.066286 |
| Goodfare 815S | 138 | 142.80 | 3.77 | 0.042756+j0.108338 | 3.23 | 0.035187+j0.168371 |
| Lowe Lake 944S | 138 | 143.62 | 5.28 | 0.023593+j0.079799 | 5.56 | 0.007572+j0.068137 |
| Saddle Hills 865S | 138 | 142.91 | 3.51 | 0.045036+j0.116935 | 2.63 | 0.060087+j0.242561 |
| Elmworth 731S | 138 | 144.27 | 3.75 | 0.039493+j0.110335 | 3.20 | 0.029303+j0.173572 |

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 because 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.

4.2 Post-Project Results

4.2.1 Scenario 4: 2028 WP LG Post-Project

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

Table 4-2: 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) |
|----------------------------|-------------------|------------------------|----------------------|---|----------------------|---|
| Updike 886S | 138 | 138.09 | 2.47 | 0.073112+j0.162163 | 2.41 | 0.020591+j0.191204 |
| Clairmont Lake 811S | 138 | 147.67 | 6.62 | 0.023605+j0.062048 | 5.18 | 0.028587+j0.118379 |
| Poplar Hill 790S | 138 | 141.55 | 5.41 | 0.025129+j0.077287 | 5.88 | 0.006406+j0.05973 |
| Goodfare 815S | 138 | 140.87 | 3.78 | 0.043842+j0.107496 | 3.26 | 0.035005+j0.165626 |
| Lowe Lake 944S | 138 | 141.55 | 5.30 | 0.025485+j0.078829 | 5.74 | 0.007019+j0.062022 |
| Saddle Hills 865S | 138 | 141.10 | 3.51 | 0.047214+j0.115942 | 2.74 | 0.054956+j0.223986 |
| Elmworth 731S | 138 | 142.79 | 3.76 | 0.039942+j0.109802 | 3.21 | 0.029211+j0.172306 |
| Dobbs 2061S | 138 | 142.12 | 5.09 | 0.029263+j0.081202 | 4.55 | 0.019681+j0.114465 |

4.2.2 Scenario 5: 2033 WP LG Post-Project

Post-Project short-circuit current levels for Scenario 5 are provided in Table 4-3.

Table 4-3: 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) |
|----------------------------|-------------------|------------------------|----------------------|---|----------------------|---|
| Updike 886S | 138 | 139.09 | 2.50 | 0.074054+j0.15905 | 2.45 | 0.01995+j0.188124 |
| Clairmont Lake 811S | 138 | 147.60 | 6.38 | 0.024597+j0.064293 | 5.54 | 0.021574+j0.09685 |
| Poplar Hill 790S | 138 | 147.38 | 5.25 | 0.025025+j0.079876 | 5.72 | 0.006473+j0.059976 |
| Goodfare 815S | 138 | 143.61 | 3.76 | 0.044459+j0.108183 | 3.24 | 0.03487+j0.164675 |
| Lowe Lake 944S | 138 | 147.49 | 5.15 | 0.02537+j0.081387 | 5.59 | 0.007077+j0.062252 |
| Saddle Hills 865S | 138 | 146.23 | 3.43 | 0.047192+j0.11895 | 2.70 | 0.054984+j0.223864 |
| Elmworth 731S | 138 | 144.31 | 3.68 | 0.040826+j0.112223 | 3.16 | 0.029301+j0.171901 |
| Dobbs 2061S | 138 | 147.27 | 4.95 | 0.029302+j0.083834 | 4.41 | 0.020444+j0.117125 |

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 and post-Project scenarios. Please refer to Attachment A5.

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

5.1 Pre-Project

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

Table 5-1: Pre-Project Mitigation Measures for Scenario 1

| Mitigation Measure | Location of Observed Violation | Contingency |
|---|--|--|
| Switch the Poplar Hill TMR generator online and dispatch at 30 MW | Voltage collapse | 7L22 (Poplar Hill 790S - Clairmont Lake 811S) |
| Switch the Poplar Hill TMR generator online and dispatch at 30 MW | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 7L69 (Goodfare 815S - Elmworth 731S) |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| | Low voltage at Updike 886S | |
| | 7L22 (Clairmont Lake 811S - Saddle Hills 865S Tap) | 7L03 (Elmworth 731S - Flyingshot Lake 749S) |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| | Low voltage at Updike 886S | |

Table 5-2: Pre-Project Mitigation Measures for Scenario 2

| Mitigation Measure | Location of Observed Violation | Contingency |
|---|--------------------------------|--|
| Switch the Poplar Hill TMR generator online and dispatch at 20 MW | Voltage collapse | 7L22 (Poplar Hill 790S - Clairmont Lake 811S) |
| Switch the Poplar Hill TMR generator online and dispatch at 20 MW | Low voltage at Updike 886S | 7L69 (Goodfare 815S - Elmworth 731S) |

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 Attachment A8 does not represent a Reliability Criteria violation.

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5.2 Post-Project

Post-Project mitigation measures for Scenario 3 and Scenario 4 are summarized in Table 5-3 and Table 5-4 accordingly.

Table 5-3: Post-Project Mitigation Measures for Scenario 3

| Mitigation Measure | Location of Observed Violation | Contingency |
|--|--|---|
| Poplar Hill TMR generator online and dispatched at 30 MW | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | <i>System intact N-G</i> |
| Poplar Hill TMR generator online and dispatched at 30 MW + New RAS for P2256 | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 7L69 <i>(Goodfare 815S - Elmworth 731S)</i> |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| Poplar Hill TMR generator online and dispatched at 30 MW + New RAS for P2256 | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 7L03 <i>(Elmworth 731S - Flyingshot Lake 749S)</i> |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| Real Time Operation | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | Poplar Hill 790S 703T |

Table 5-4: Post-Project Mitigation Measures for Scenario 4

| Mitigation Measure | Location of Observed Violation | Contingency |
|---|--|---|
| Switch the Poplar Hill TMR generator online and dispatch at 20 MW + New RAS for P2256 | Voltage collapse | 7L22 <i>(Poplar Hill 790S - Clairmont Lake 811S)</i> |
| Switch the Poplar Hill TMR generator online and dispatch at 20 MW + New RAS for P2256 | Updike 866S 701T | 7L69 <i>(Goodfare 815S - Elmworth 731S)</i> |
| | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| | Updike 886S | |
| | Poplar Hill 790S | |
| | Goodfare 815S | |
| | Lowe Lake 944S | |
| | Saddle Hills 865S tap | |
| Switch the Poplar Hill TMR generator online and dispatch at 20 MW + New RAS for P2256 | Saddle Hills 865S | 7L03 <i>(Elmworth 731S - Flyingshot Lake 749S)</i> |
| | Updike 866S 701T | |
| | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | |
| | 7L22 (Dobbs 2061S tap - Saddle Hills 865S tap) | |
| | Updike 886S | |
| | Poplar Hill 790S | |
| | Goodfare 815S | |
| | Lowe Lake 944S | |
| | Saddle Hills 865S | |
| | Elmworth 731S | |
| | Dobbs 2061S | |
| Dobbs 2061S tap | | |

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 Pre- and Post-Project Scenario 1 to Scenario 4 using Alternative 1 and the mitigation measures described in Sections 5.1 and 5.2.

The post-mitigation power flow diagrams for selected Category B conditions are provided in Attachment A6 for the Pre and Post-Project scenarios. 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 1: 2028 SP LG Pre-Project

Category B Conditions

Thermal and voltage criteria violations observed under Category B conditions in the Pre-Project Scenario 1 were mitigated by proposed mitigation measures as detailed in Table 5-1 and are shown in Table 5-5 and Table 5-6.

Table 5-5: Post-Mitigation Power Flow Study Results for Scenario 1

| Contingency (System Element Lost) | Details of Violation (Violation Observed On) | Seasonal Continuous Rating (MVA) | Short-term (Emergency) Rating (MVA) | Pre-Project Results | | Post-Mitigation Results | |
|---|--|---|--|------------------------|--------------|----------------------------|--------------|
| | | | | Power Flow (MVA) | % Loading | Power Flow (MVA) | % Loading |
| 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 138 | 127.4 | 101.2 | 93.4 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 110.7 | 102.2 | 80.1 | 74 |
| 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 136.1 | 125.7 | 101.2 | 93.4 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 109.6 | 101.2 | 80.1 | 74 |

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Table 5-6: Voltage Range Violations Under Category B Conditions for Scenario 1

| 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 | | | | | | No Reliability Criteria violations | |
| 7L69 (Goodfare 815S - Elmworth 731S) | Udike 886S | 1114 | 144 | 130 | 155 | 140.5 | 127.4 | 142.66 |
| 7L03 (Elmworth 731S - Flyingshot Lake 749S) | Udike 886S | 1114 | 144 | 130 | 155 | 140.5 | 129.6 | 143.7 |

5.3.2 Scenario 2: 2028 WP LG Pre-Project

Category B Conditions

Voltage criteria violations observed under Category B conditions in the Pre-Project Scenario 2 were mitigated by proposed mitigation measures as detailed in Table 5-2 and are shown in Table 5-7.

Table 5-7: Voltage Range Violations Under Category B Conditions for Scenario 2

| 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 | | | | | | No Reliability Criteria violations | |
| 7L69 (Goodfare 815S - Elmworth 731S) | Udike 886S | 1114 | 144 | 130 | 155 | 139.4 | 128.8 | 143.18 |

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5.3.3 Scenario 3: 2028 SP LG Post-Project

Category B Conditions

Thermal and voltage violations observed under Category B conditions in the Post-Project Scenario 3 were mitigated by proposed mitigation measures as detailed in Table 5-3 and are shown in Table 5-8 and Table 5-9.

Table 5-8: 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 |
| 7L69 (Goodfare 815S - Elmworth 731S) | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 108.3 | 120.8 | 138.3 | 127.7 | 101.6 | 98 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 118.5 | 109.4 | 91 | 84 |
| 7L03 (Elmworth 731S - Flyingshot Lake 749S) | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 138.6 | 127.9 | 101.6 | 98 |
| | 7L22 (Poplar Hill 790S - Saddle Hills 865S tap) | 108.3 | 120.8 | 119.5 | 110.3 | 91 | 84 |

Table 5-9: 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 | | | | | | No Reliability Criteria violations | |

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5.3.4 Scenario 4: 2028 WP LG Post-Project

Category B Conditions

Thermal and voltage criteria violations observed under Category B conditions in the Post-Project Scenario 4 were mitigated by proposed mitigation measures as detailed in Table 5-4 and are shown in Table 5-10 and Table 5-11.

Table 5-10: 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 |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 866S 701T | 42 | 42 | 46 | 109.5 | 36.96 | 88 |
| | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 144.7 | 163.9 | 184.3 | 127.4 | 138.91 | 96 |
| 7L03 (Elmworth 731S - Flyingshot 749S) | Updike 866S 701T | 42 | 42 | 44.1 | 104.9 | 36.54 | 87 |
| | 7L22 (Clairmont Lake 811S - Saddle Hills 865S tap) | 144.7 | 163.9 | 179 | 123.7 | 138.91 | 96 |

Table 5-11: 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) |
|---|----------------------------------|---------------|---------------|--------------------------------------|---|----------------------------|------------------------------------|---|
| 7L03 (Elmworth 731S - Flyingshot 749S) | Updike 886S | 1114 | 144 | 130 | 155 | 137 | 121.5 | 144.3 |
| | Poplar Hill 790S | 1118 | 144 | 130 | 155 | 140.4 | 128.3 | 148.49 |
| | Goodfare 815S | 1119 | 144 | 130 | 155 | 139.8 | 124.8 | 146.92 |
| | Lowe Lake 944S | 1120 | 144 | 130 | 155 | 140.4 | 128.3 | 148.49 |
| | Saddle Hills 865S | 1124 | 144 | 130 | 155 | 140 | 128.8 | 147.4 |
| | Elmworth 731S | 1134 | 144 | 130 | 155 | 141.9 | 125 | 147.12 |
| | Dobbs 2061S | 542004 | 144 | 130 | 155 | 141 | 129.7 | 148.58 |
| | Dobbs 2061S tap | 547010 | 144 | 130 | 155 | 141 | 129.7 | 148.54 |
| 7L69 (Goodfare 815S - Elmworth 731S) | Updike 886S | 1114 | 144 | 130 | 155 | 137 | 117.1 | 143.06 |
| | Poplar Hill 790S | 1118 | 144 | 130 | 155 | 140.4 | 124.8 | 147.73 |

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|---|-----------------------|--------|-----|-----|-----|-------|------------------|--------|
| | Goodfare 815S | 1119 | 144 | 130 | 155 | 139.8 | 120.6 | 145.75 |
| | Lowe Lake 944S | 1120 | 144 | 130 | 155 | 140.4 | 124.8 | 147.73 |
| | Saddle Hills 865S tap | 1123 | 144 | 130 | 155 | 141.1 | 126.8 | 147.72 |
| | Saddle Hills 865S | 1124 | 144 | 130 | 155 | 140 | 125.5 | 146.67 |
| | Dobbs 2061S | 542004 | 144 | 130 | 155 | 141 | 126.4 | 147.8 |
| | Dobbs 2061S tap | 547010 | 144 | 130 | 155 | 141 | 126.4 | 147.84 |
| 7L22 (Poplar Hill 790S - Clairmont Lake 811S) | Poplar Hill 790S | 1118 | 144 | 130 | 155 | 140.4 | Voltage collapse | 148.3 |
| | Goodfare 815S | 1119 | 144 | 130 | 155 | 139.8 | | 144.72 |
| | Lowe Lake 944S | 1120 | 144 | 130 | 155 | 140.4 | | 148.31 |
| | Updike 886S | 1114 | 144 | 130 | 155 | 137 | | 142.0 |
| | Elmworth 731S | 1134 | 144 | 130 | 155 | 141.9 | | 144.07 |

5.3.5 Mitigations for Voltage Stability Studies

The voltage stability margin violation was mitigated by the proposed mitigation measures – dispatching the Poplar Hill TMR to 20 MW and implementing New RAS for P2256. The voltage stability study results under Category A conditions and for the five worst contingencies under Category B conditions are listed in Table 5-12 and the corresponding diagrams are listed in Attachment A7.

Table 5-12: Voltage Stability Study Post-Mitigation Results under Category B Conditions for Scenario 4

| Contingency (System Element Lost) | From | To | Maximum Incremental Transfer (MW) | Meets Criteria? |
|-----------------------------------|-------------------|---------------------|-----------------------------------|-----------------|
| N-0 | System Intact | | 146.09 | Yes |
| 7L22 | Poplar Hill 790S | Clairmont Lake 811S | 93.75 | Yes |
| 7L69 | Goodfare 815S | Elmworth 731S | 87.5 | Yes |
| 7L03 | Elmworth 731S | Flyingshot 749S | 95.31 | Yes |
| 7L84 | Crystal Lake 722S | Flyingshot 749S | 68.75 | Yes |

ATTACHMENT A1

Pre-Project Power Flow Diagrams (Scenarios 1-2)

Pre-Project Power Flow Results

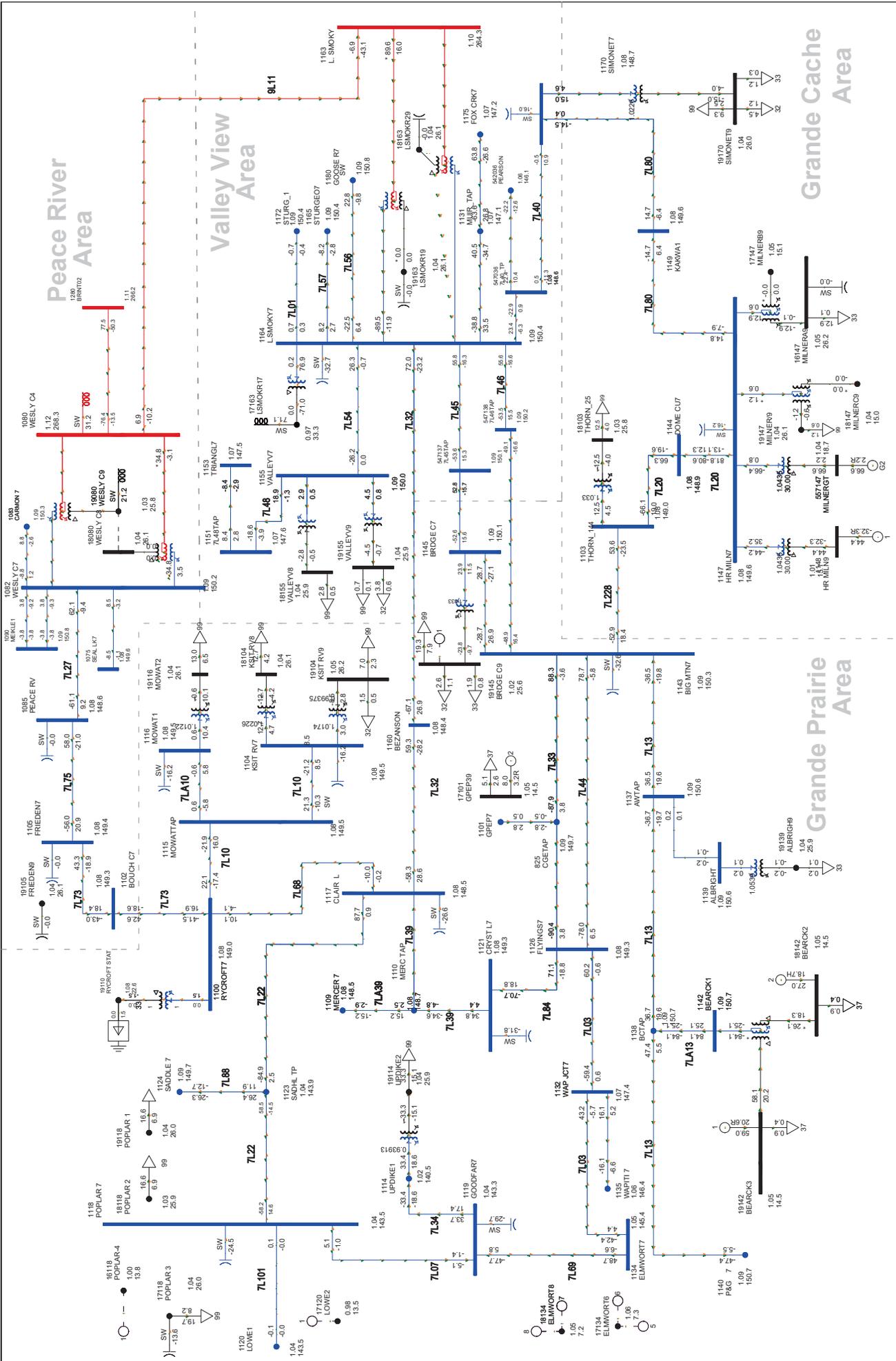
Power Flow Diagrams

The Pre-Project power flow diagrams* are provided in this Attachment. Table A1-1 presents the list of the power flow diagrams.

Table A1-1: List of Pre-Project Power Flow Diagrams

| Scenario | Power flow diagram | Page number |
|----------------------------|--|-------------|
| Scenario 1: 2028 SP | N-0, System Normal Condition | A1-3 |
| | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A1-4 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A1-5 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A1-6 |
| Scenario 2: 2028 WP | N-0, System Normal Condition | A1-7 |
| | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A1-8 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A1-9 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A1-10 |

***Note:** MW/MVA_r flows on SLDs are based on the actual voltage obtained from the power flow solution as opposed to the nominal voltage.



Peace River Area

Valley View Area

Grande Prairie Area

Grande Cache Area

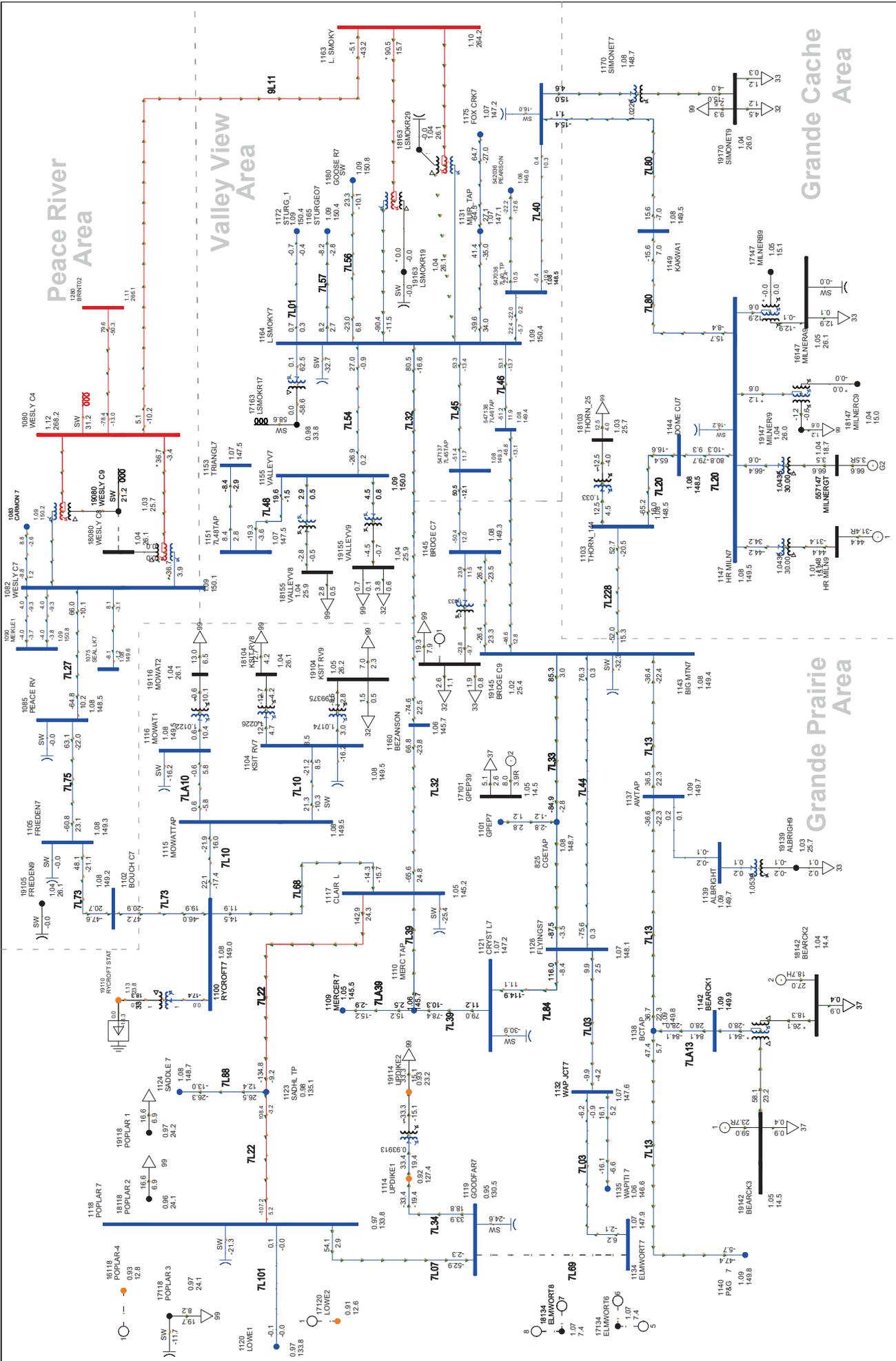
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE 1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

P2256 Dobbs 2061S Substation

CATEGORY A, N-0
 SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
 WED, SEP 25 2024 8:54

Page A1-3



Peace River Area

Valley View Area

Grande Prairie Area

Grande Cache Area

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE 1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >=500.000

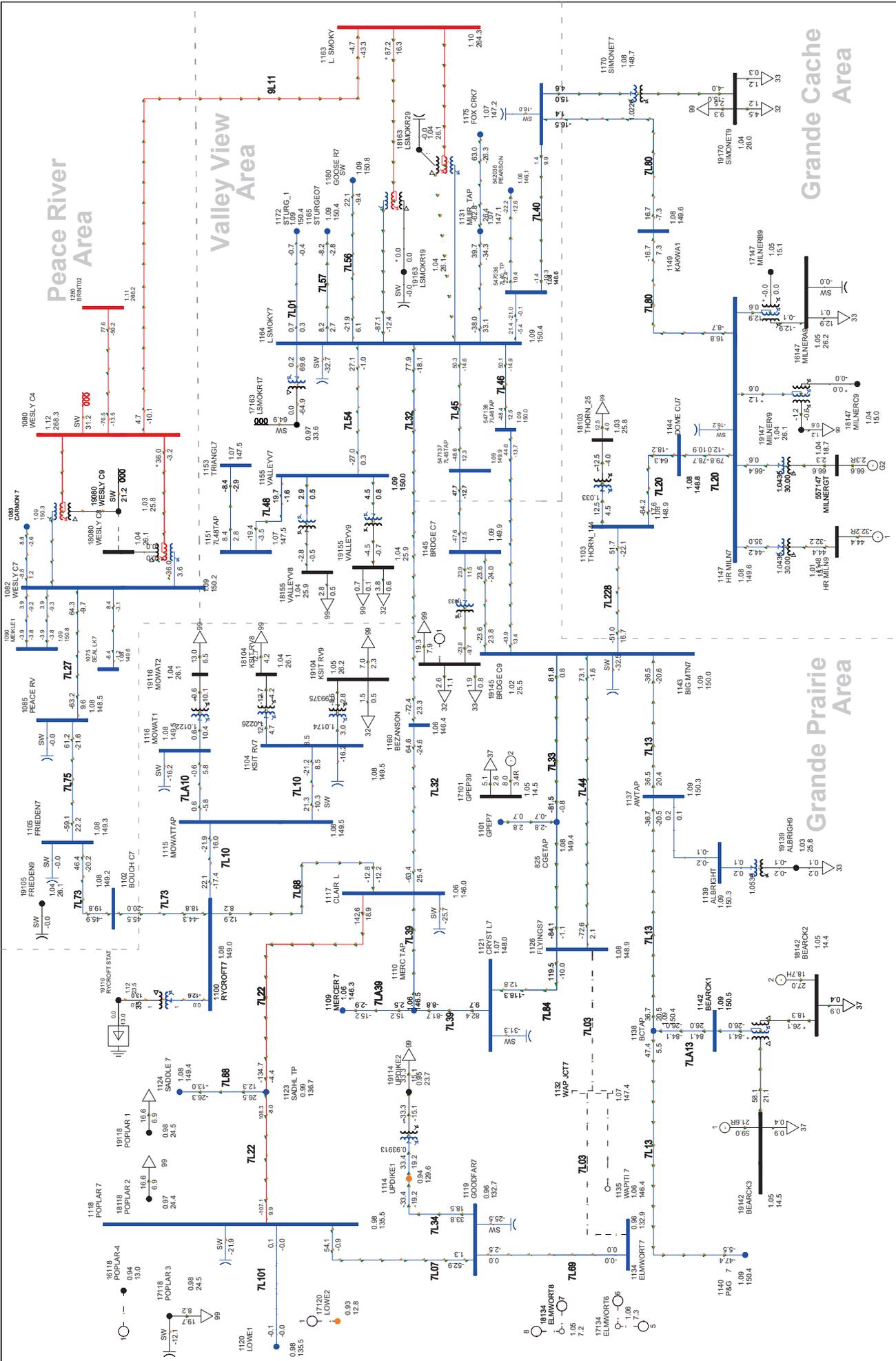
Grande Prairie Area

Grande Cache Area

P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L69
 SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
 WED, SEP 25 2024 8:55

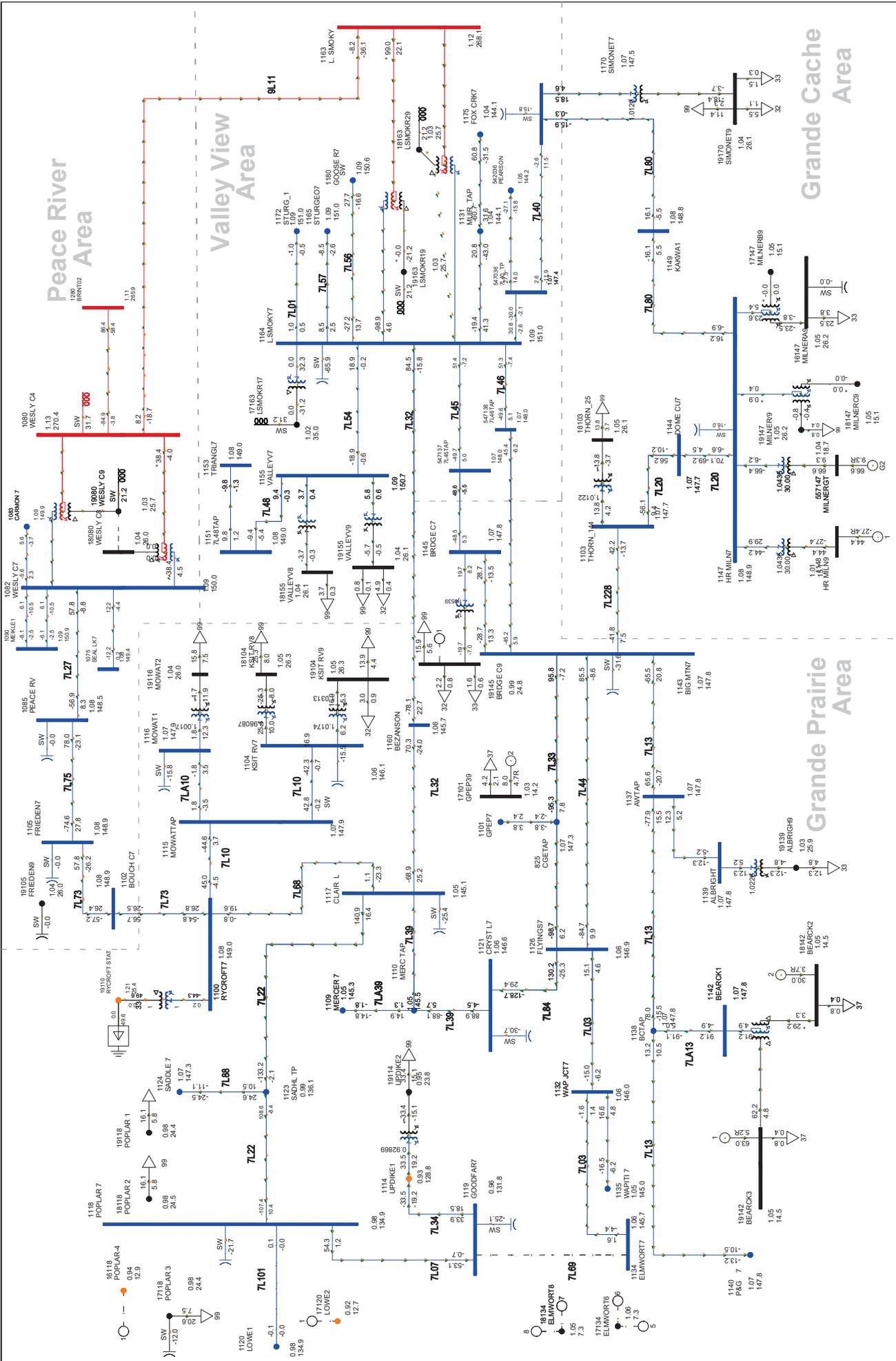
Page A1-5



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L03
 SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT
 WED, SEP 25 2024 8:55

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0%RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >=500.000



Peace River Area

Valley View Area

Grande Prairie Area

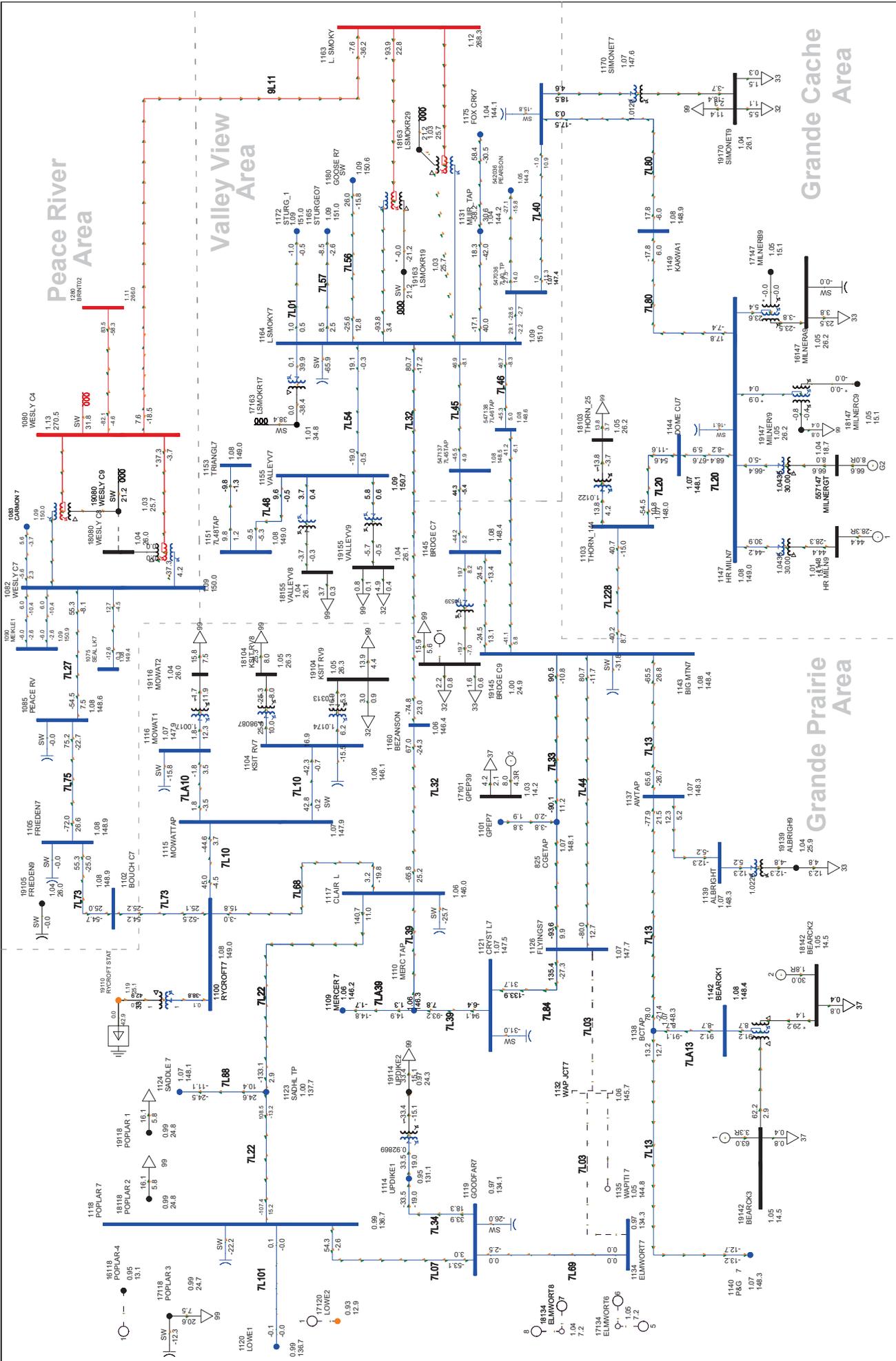
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400V
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=144.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L69
 SCENARIO 2_2028 WINTER PEAK PRE-PROJECT
 WED, SEP 25 2024 8:57

Page A1-9



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L03
SCENARIO 2_2028 WINTER PEAK PRE-PROJECT
WED, SEP 25 2024 8:57

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
100.0% RATE2
1.1400V 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=144.000 <=240.000 <=500.000 >=500.000

Page A1-10

ATTACHMENT A2

Pre-Project Voltage Stability Diagrams (Scenario 2)

Figure A2-1: Scenario 2 2028 WP Pre-Project – System Intact

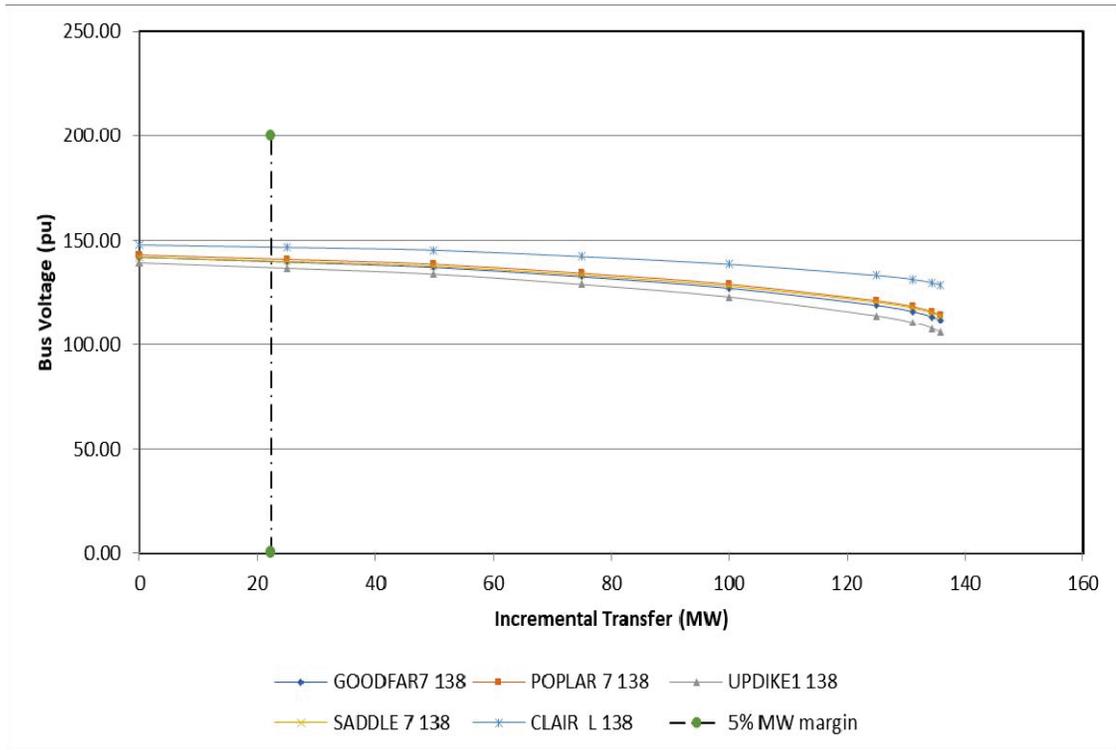


Figure A2-2: Scenario 2 2028 WP Pre-Project – 7L22 Contingency

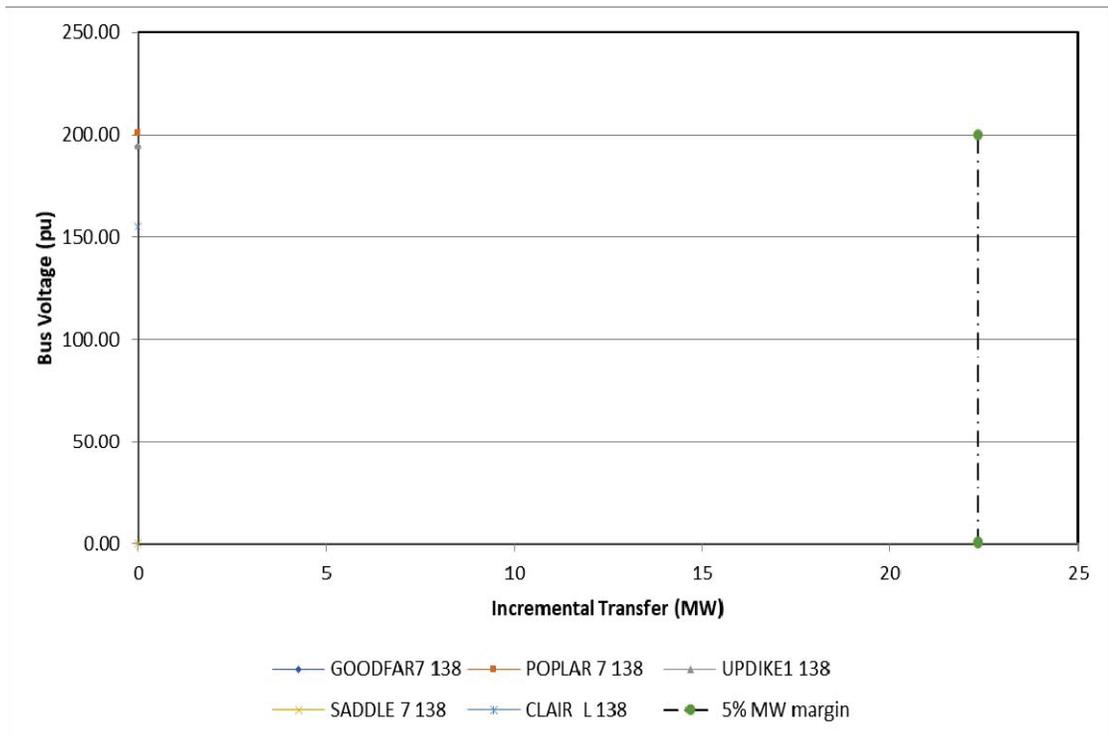


Figure A2-3: Scenario 2 2028 WP Pre-Project – 7L69 Contingency

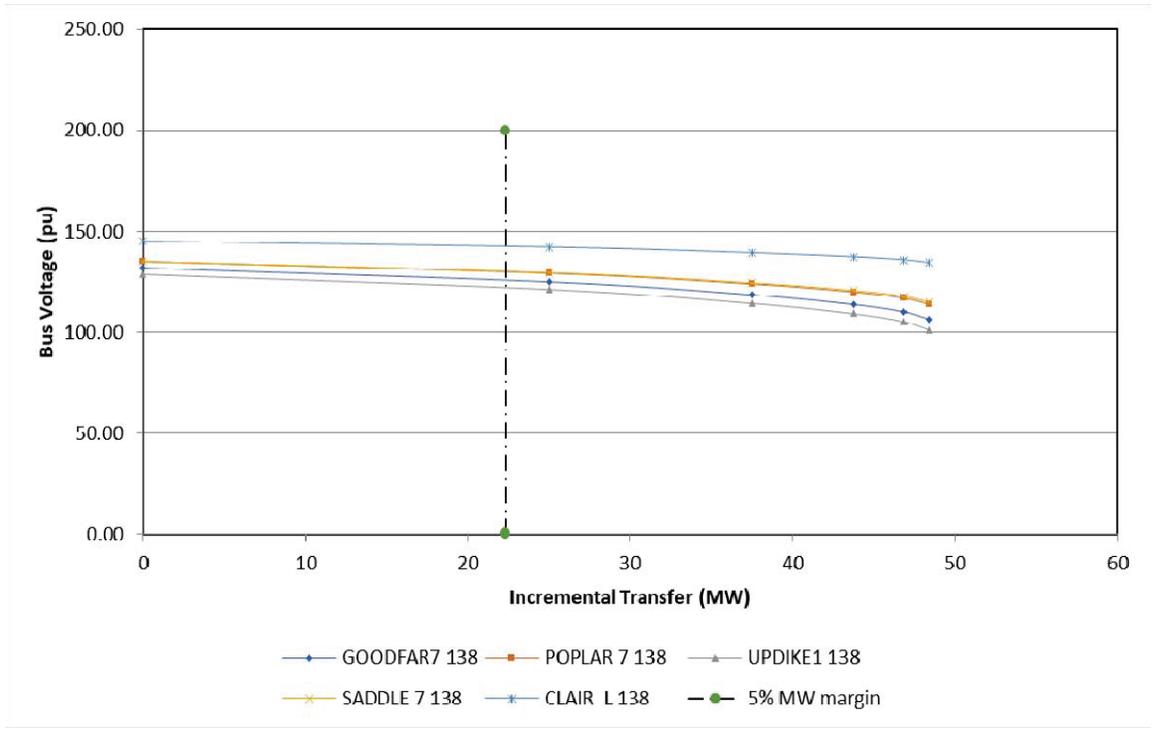


Figure A2-4: Scenario 2 2028 WP Pre-Project – 7L03 Contingency

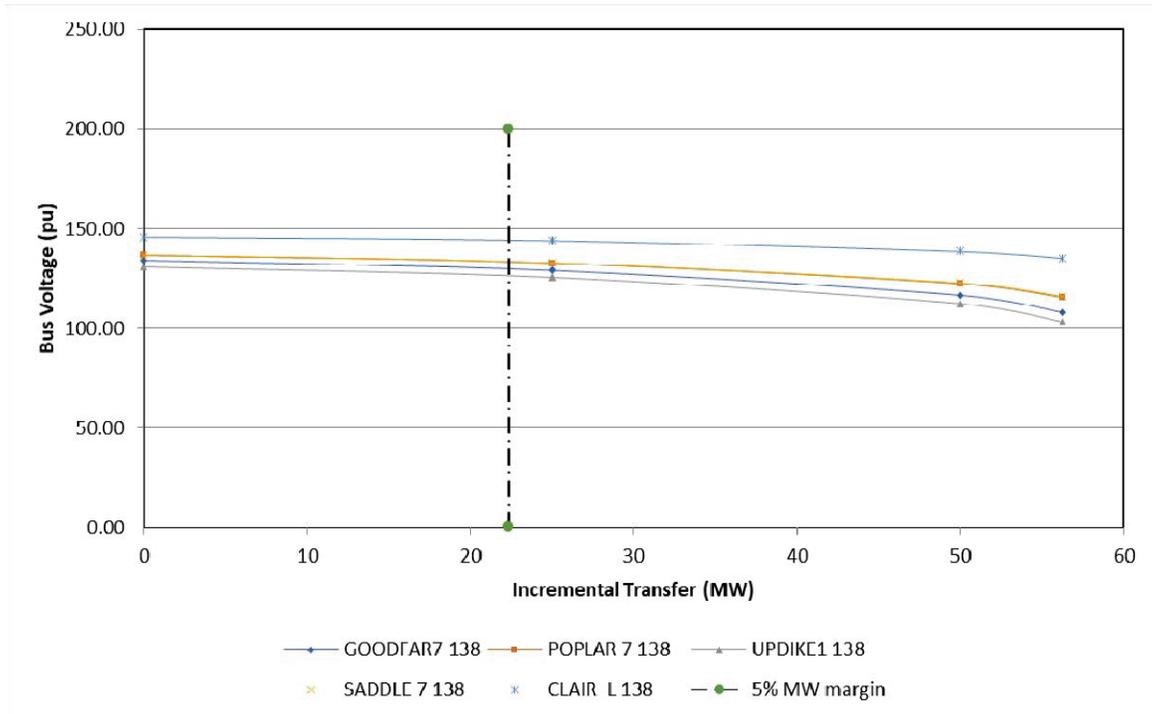
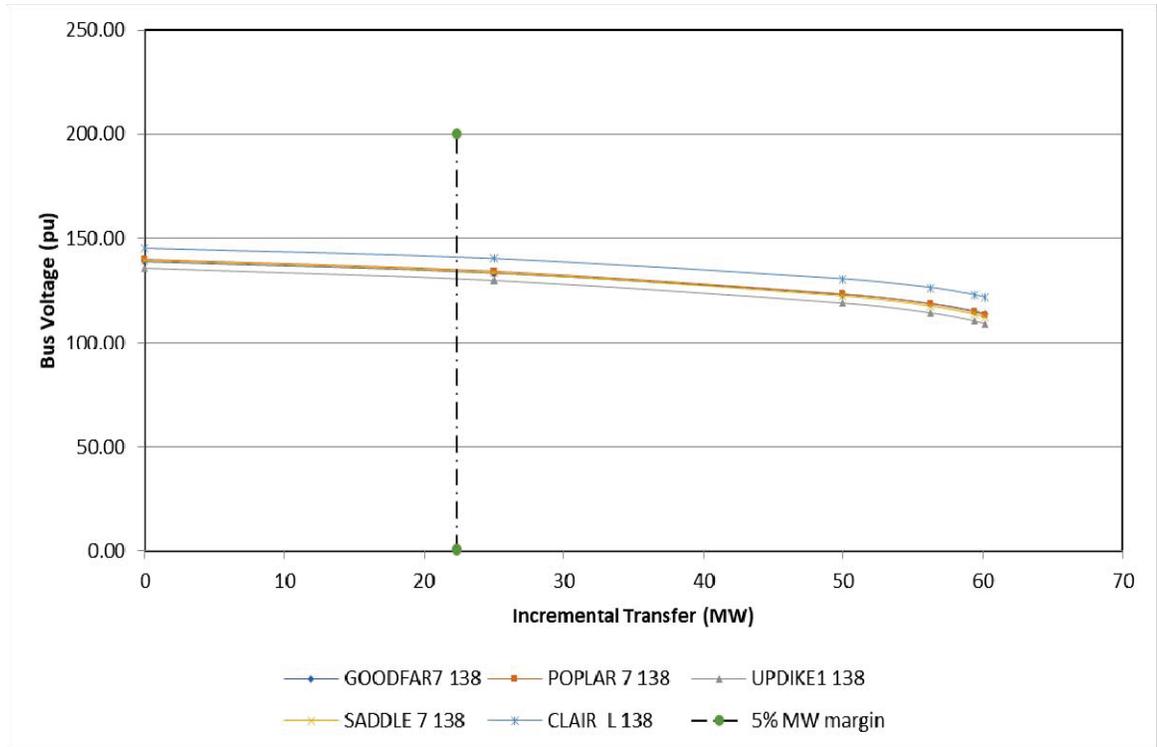


Figure A2-5: Scenario 2 2028 WP Pre-Project – 7L84 Contingency



ATTACHMENT A3

Post-Project Power Flow Diagrams (Scenarios 3-4)

Post-Project Power Flow Results

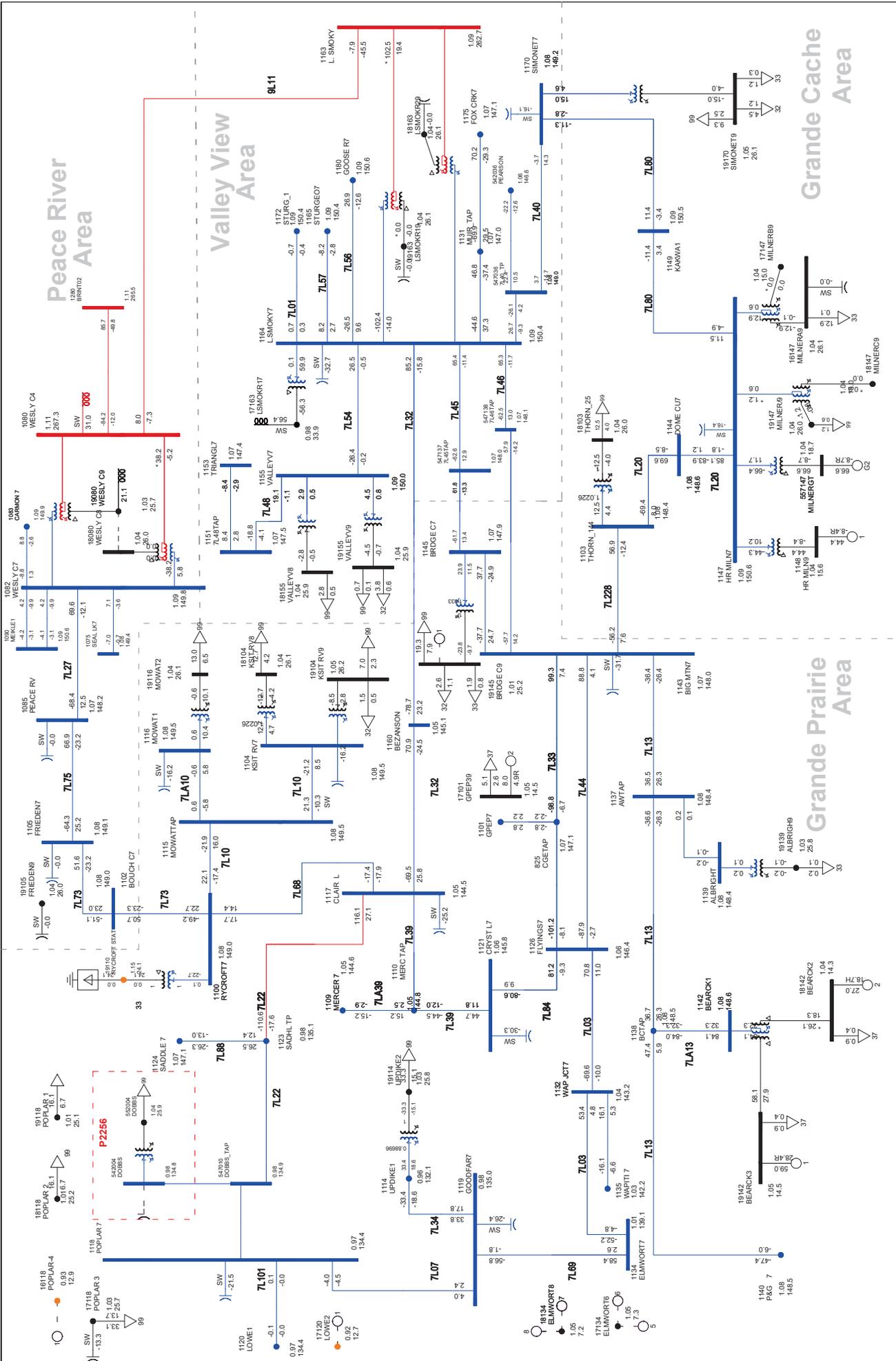
Power Flow Diagrams

The Post-Project power flow diagrams* are provided in this Attachment. Table A3-1 presents the list of the power flow diagrams.

Table A3-1: List of Post-Project Power Flow Diagrams

| Scenario | Power flow diagram | Page number |
|----------------------------|--|-------------|
| Scenario 3: 2028 SP | N-0, System Normal Condition prior to mitigations | A3-3 |
| | N-0, System Normal Condition with mitigations | A3-4 |
| | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A3-5 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A3-6 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A3-7 |
| Scenario 4: 2028 WP | N-0, System Normal Condition prior to mitigations | A3-8 |
| | N-0, System Normal Condition with mitigations | A3-9 |
| | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A3-19 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A3-11 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A3-12 |

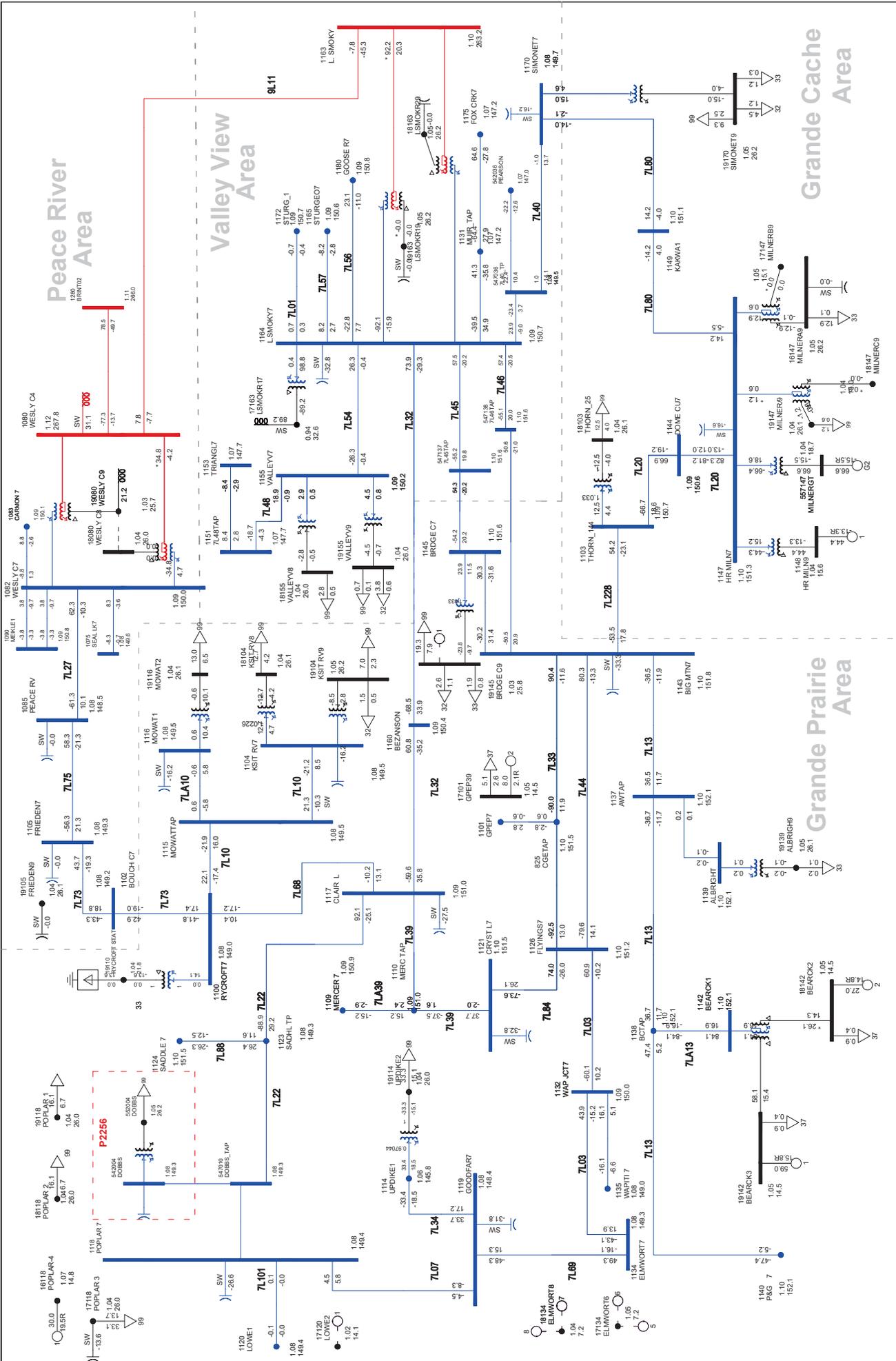
***Note:** MW/MVAr flows on SLDs are based on the actual voltage obtained from the power flow solution as opposed to the nominal voltage.



P2256 Dobbs 2061S Substation

CATEGORY A, N-0
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT PRIOR TO N-0 MITIGA
 WED, SEP 25 2024 9:07

Bus - Voltage (kV/pv)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000



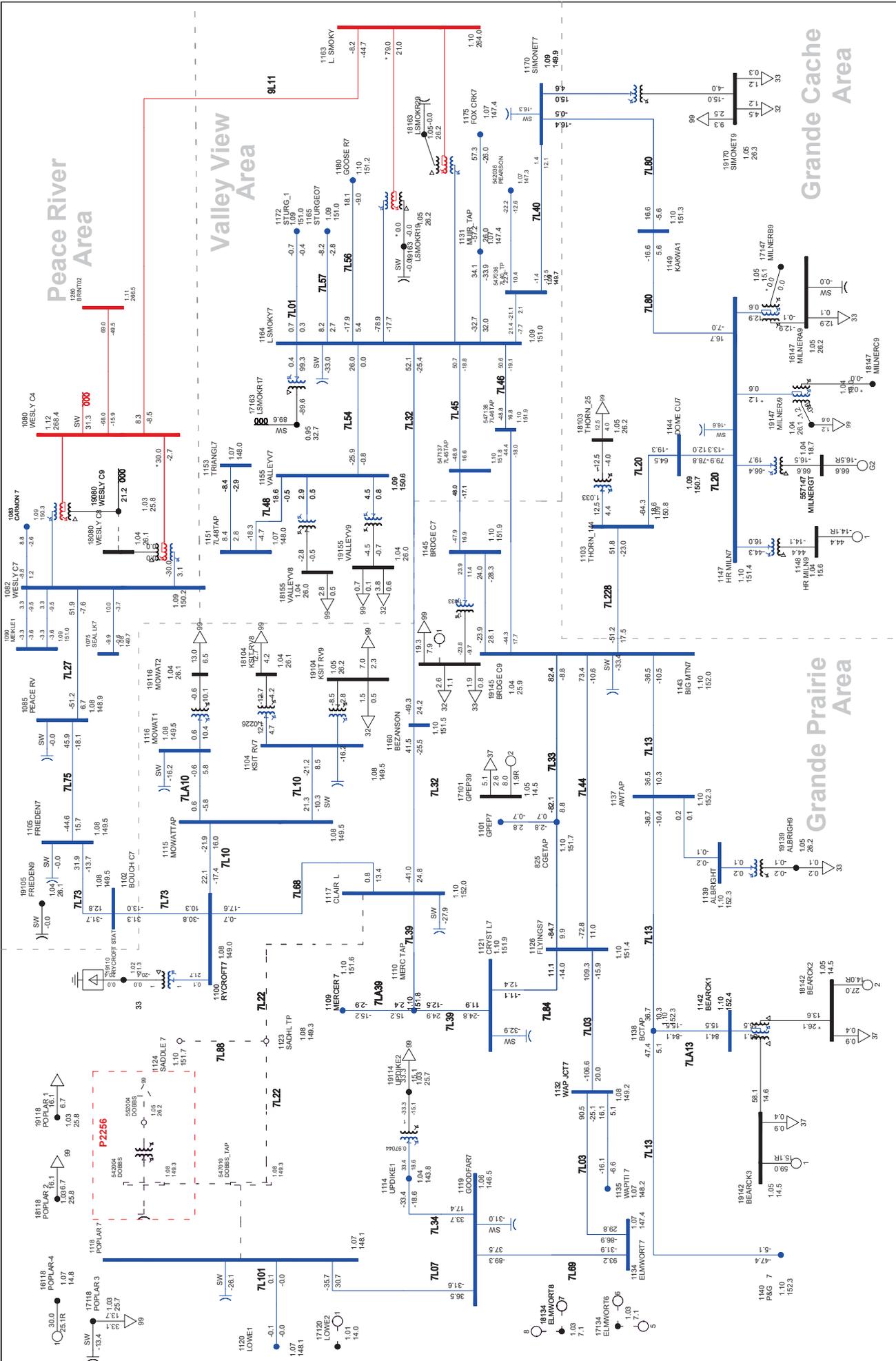
P2256 Dobbs 2061S Substation

SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
WED, SEP 25 2024 9:08

CATEGORY A, N-0

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0% RATE1
1.1300OV 0.9400UV
KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

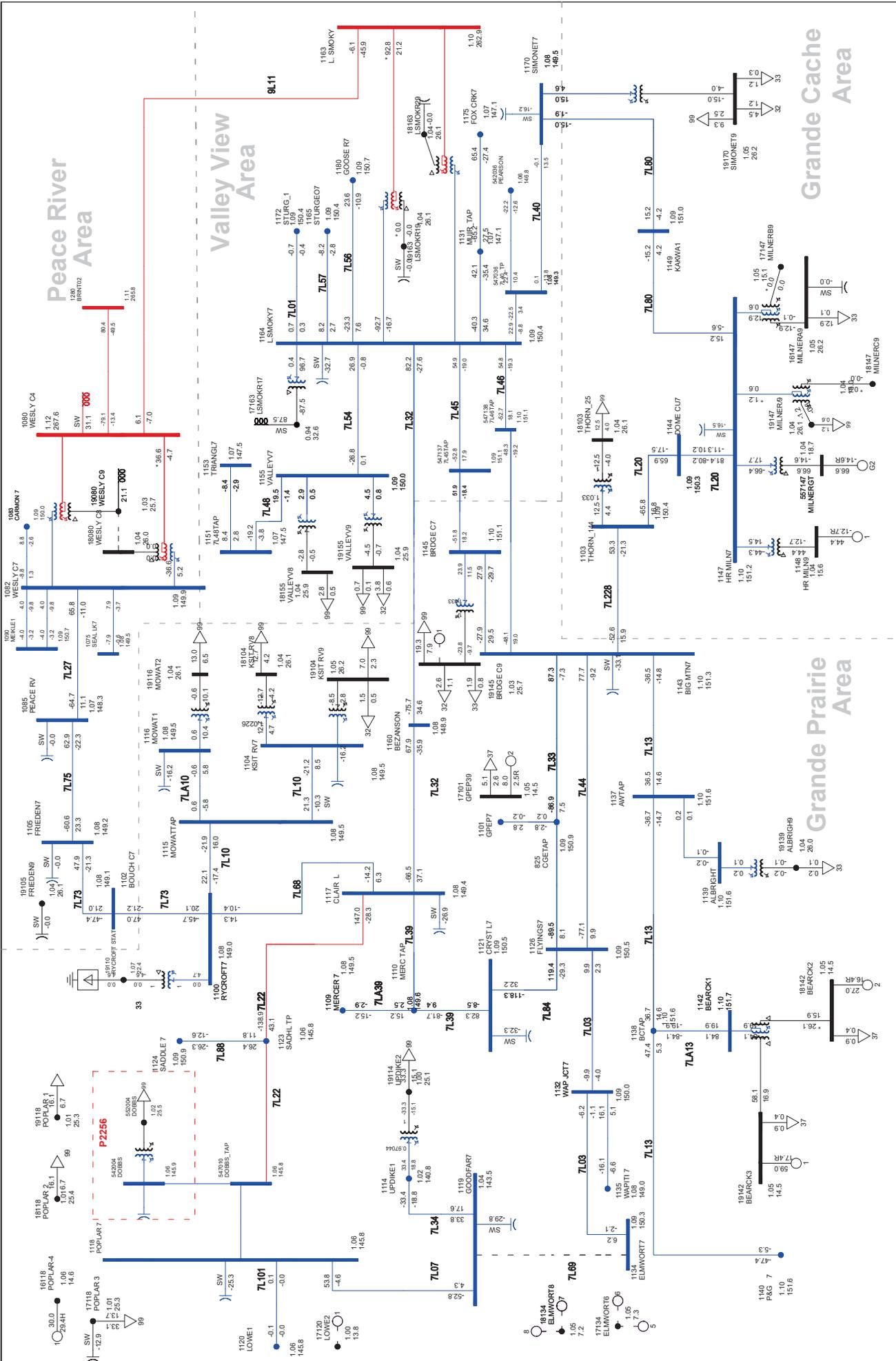
Page A3-4



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L22
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
 WED, SEP 25 2024 9:08

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L69
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
 WED, SEP 25 2024 9:08

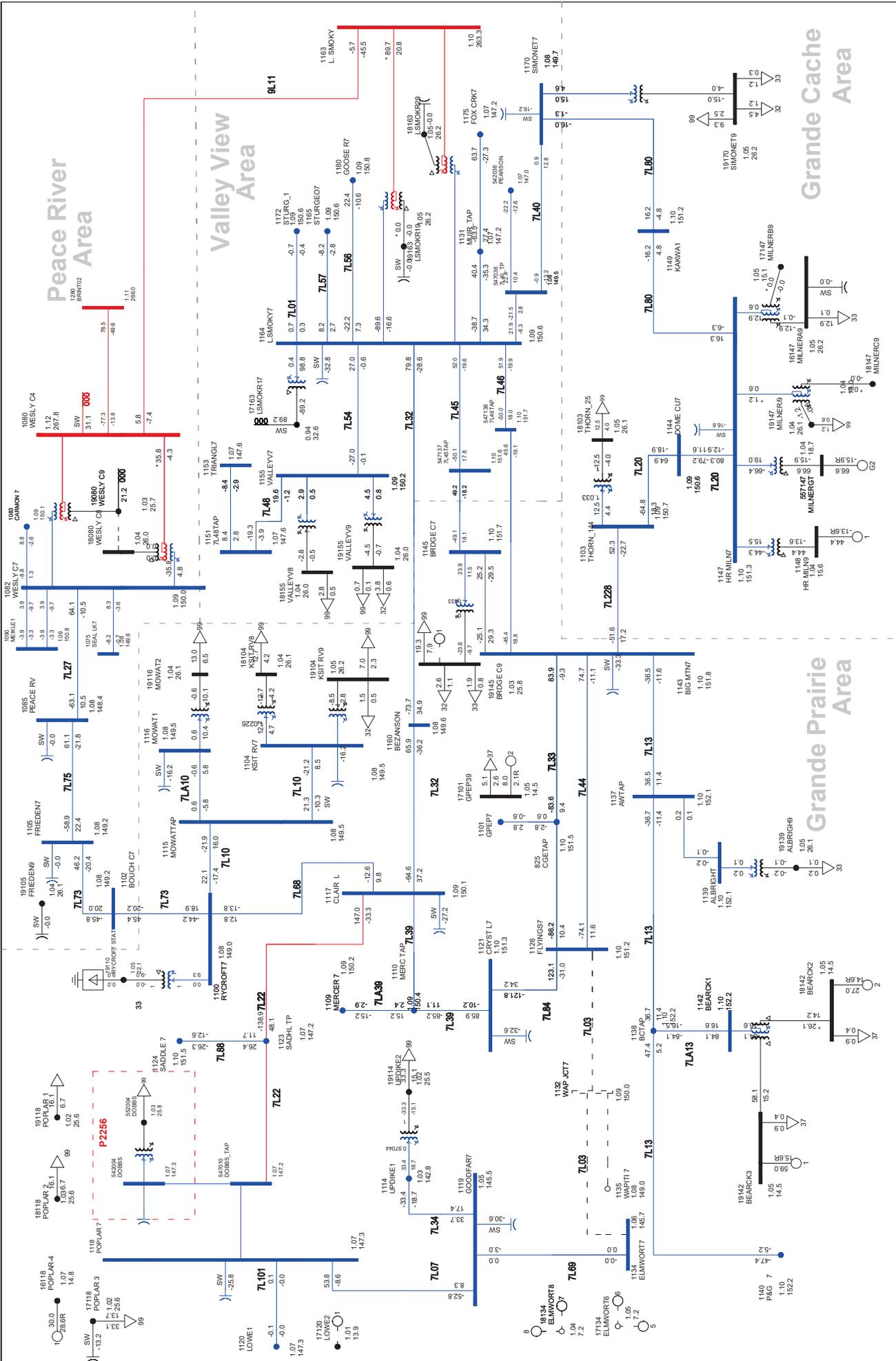
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

Grande Cache Area

Peace River Area

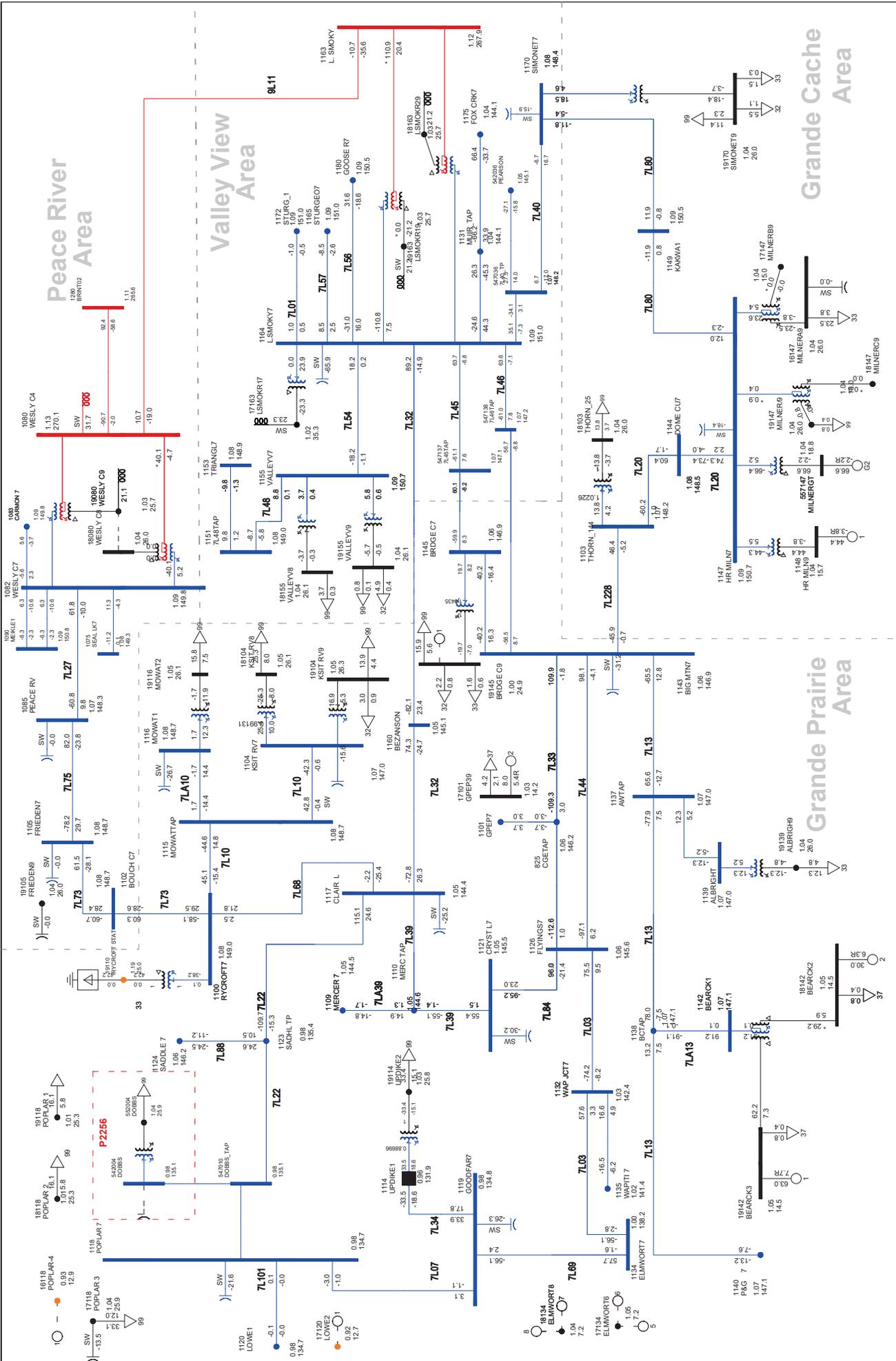
Valley View Area



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L03
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
 WED, SEP 25 2024 9:09

Bus - Voltage (kV/pv)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

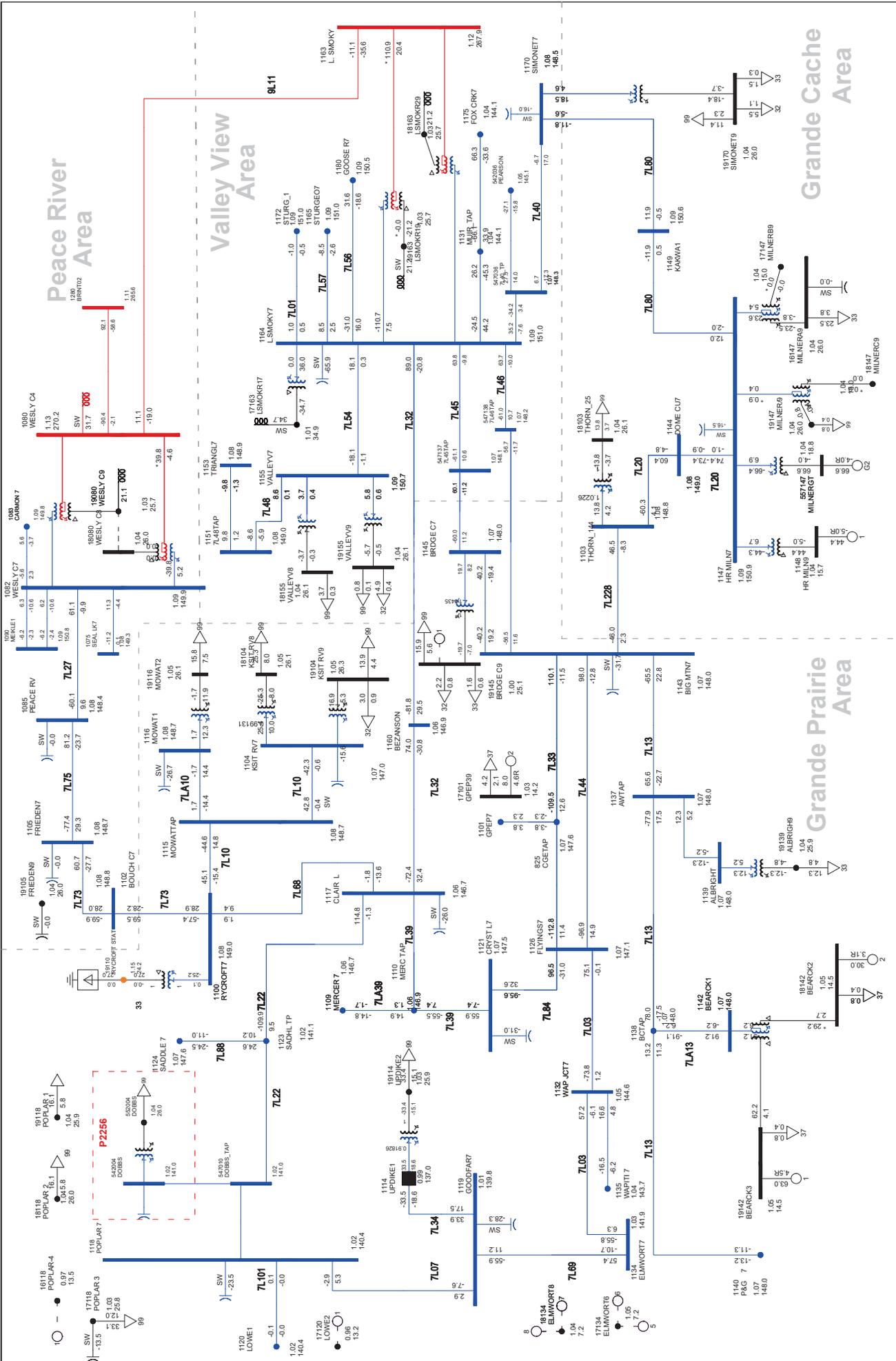


P2256 Dobbs 2061S Substation

SCENARIO 3_2028 WINTER PEAK POST-PROJECT PRIOR TO N-0 MITIGA
WED, SEP 25 2024 9:09

Bus - Voltage (kV/pv)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0% RATE2
1.1400V 0.9400UV
KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >500.000

Page A3-8



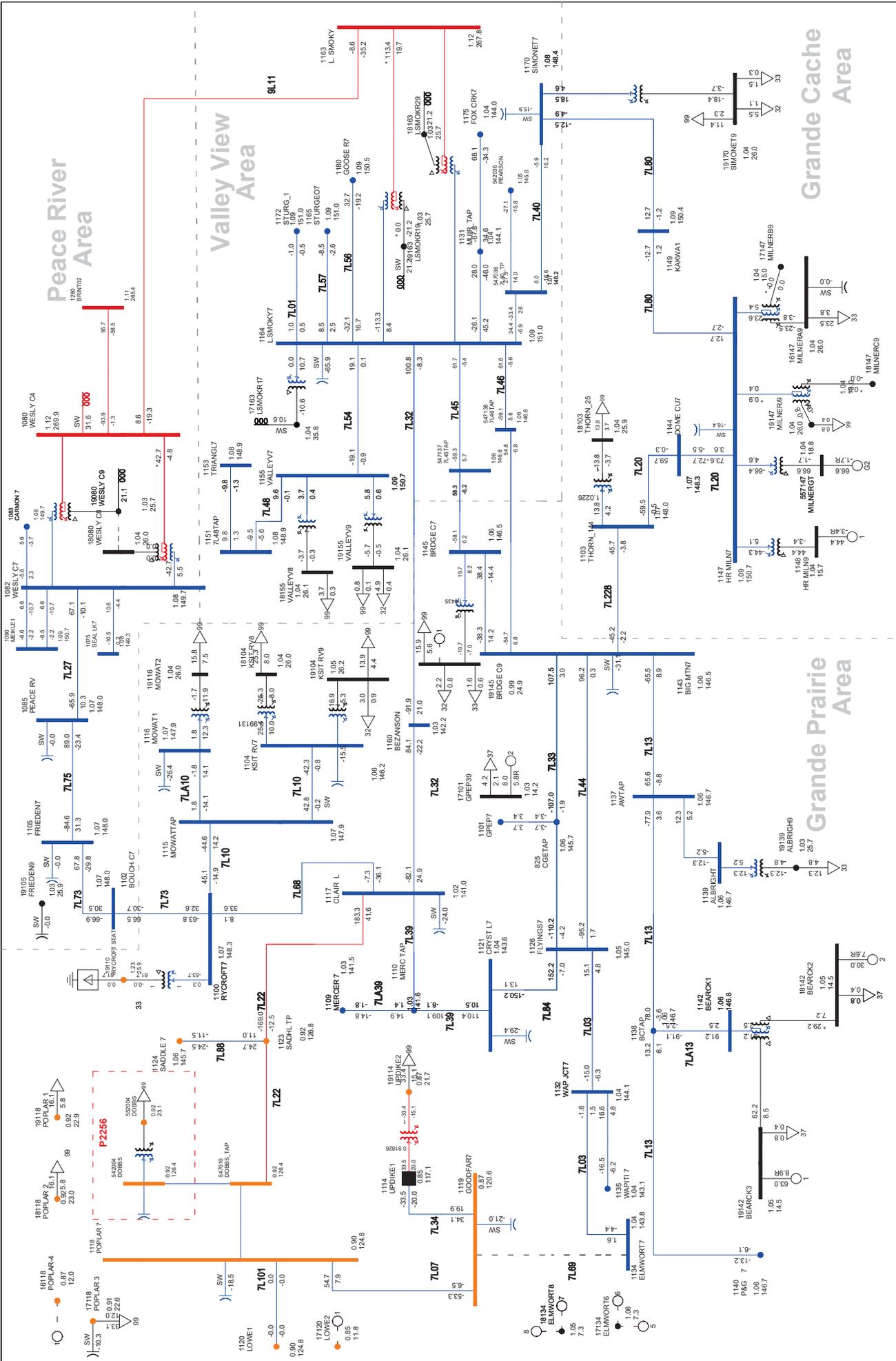
P2256 Dobbs 2061S Substation

CATEGORY A, N-0
 SCENARIO 4_2028 WINTER PEAK POST-PROJECT
 WED, SEP 25 2024 9:10

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

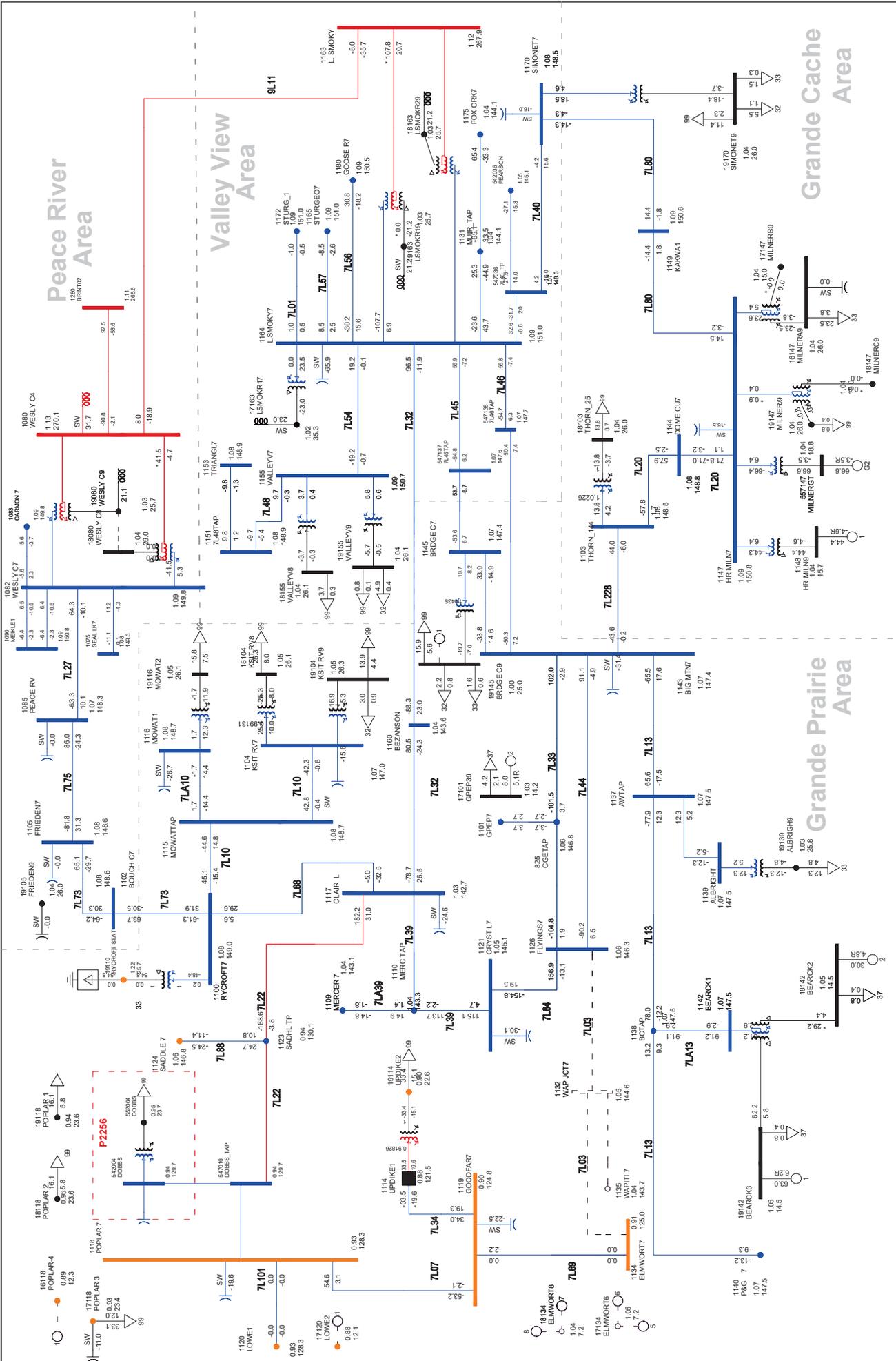
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000



Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400V
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

P2256 Dobbs 2061S Substation
 CATEGORY B, LOSS OF 7L69
 SCENARIO 4_2028 WINTER PEAK POST-PROJECT
 WED, SEP 25 2024 9:11



P2256 Dobbs 2061S Substation

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

CATEGORY B, LOSS OF 7L03
 SCENARIO 4_2028 WINTER PEAK POST-PROJECT
 WED, SEP 25 2024 9:11

Page A3-12

ATTACHMENT A4

Post-Project Voltage Stability Diagrams (Scenario 4)

Figure A4-1: Scenario 4 2028 WP Post-Project – System Intact

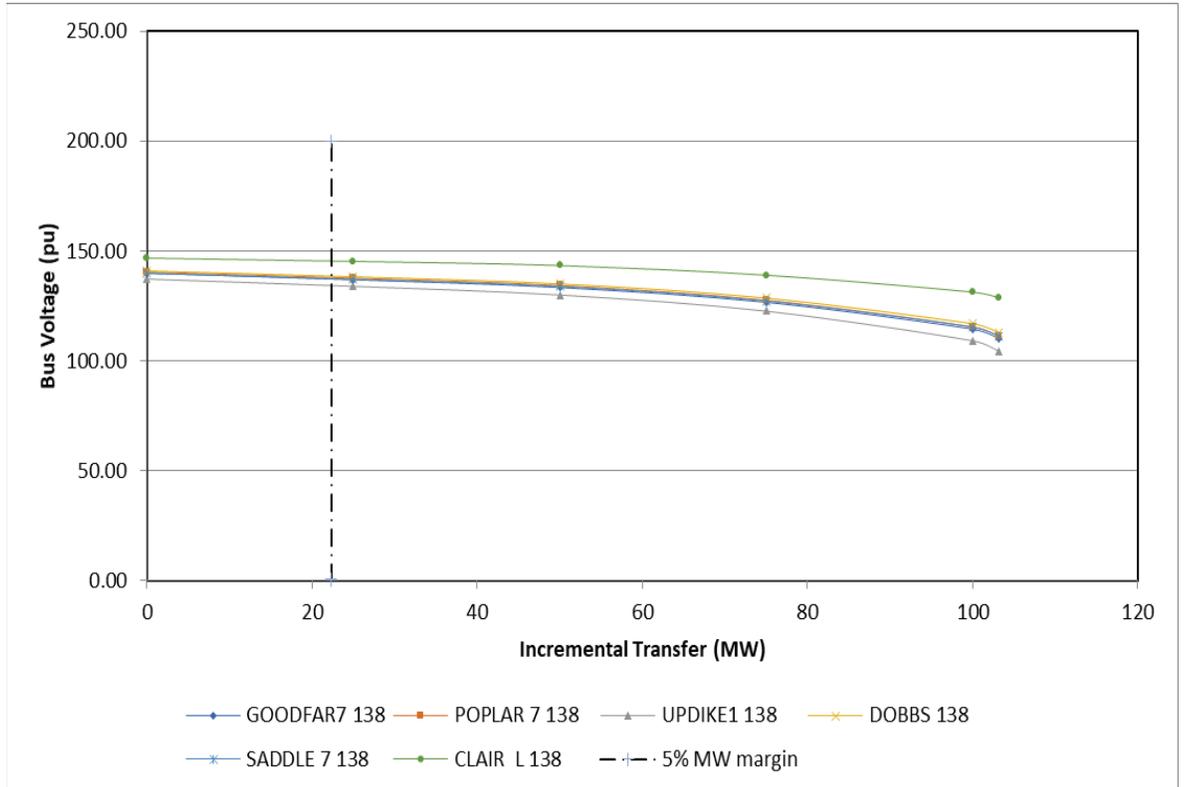


Figure A4-2: Scenario 4 2028 WP Post-Project – 7L22 Contingency

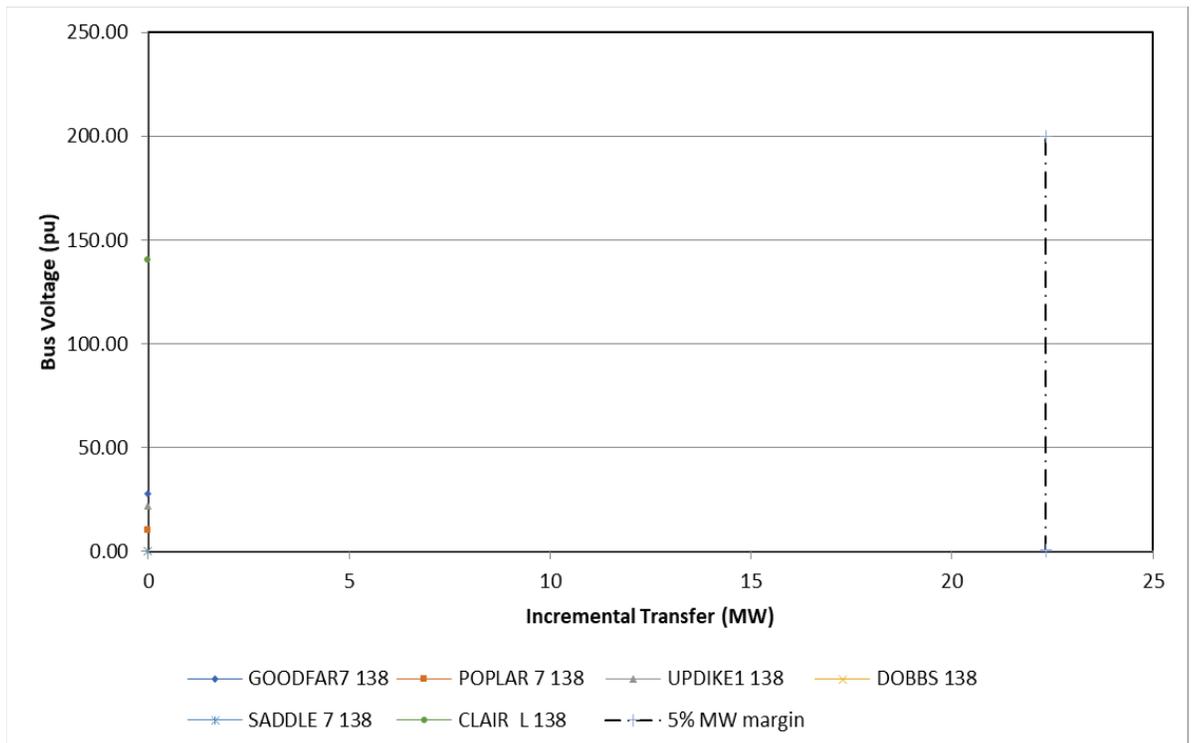


Figure A4-3: Scenario 4 2028 WP Post-Project – 7L69 Contingency

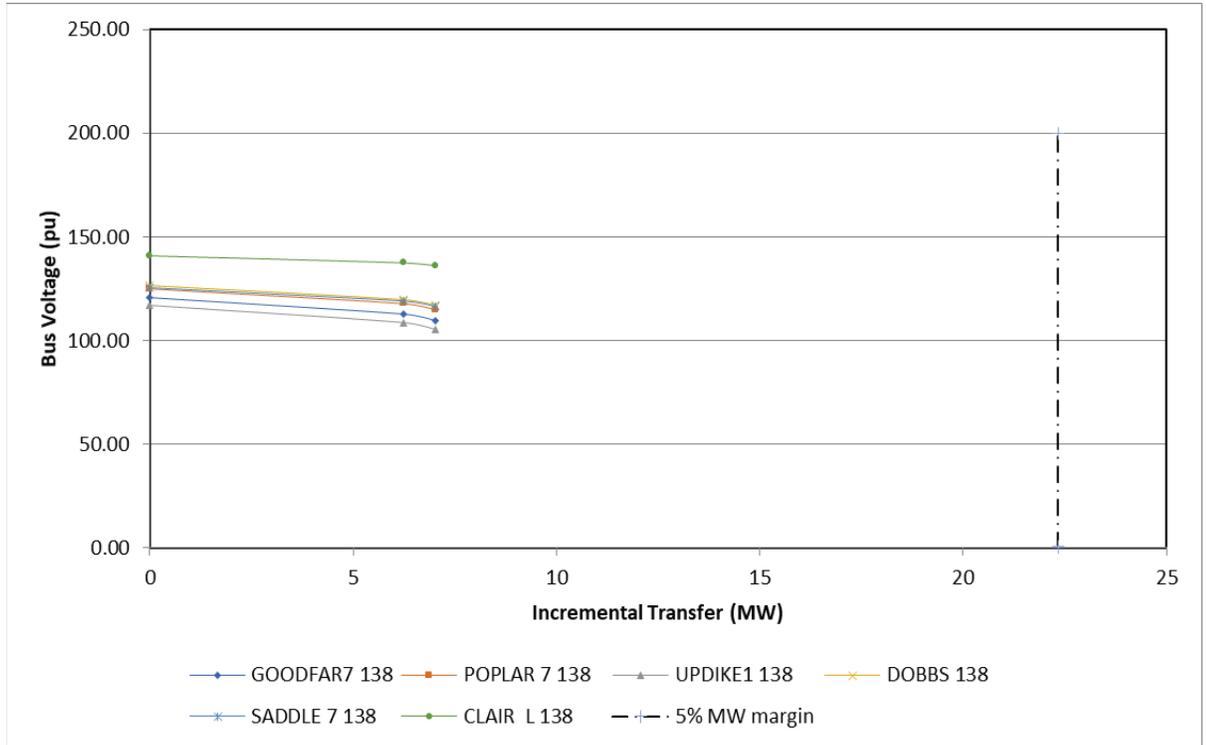


Figure A4-4: Scenario 4 2028 WP Post-Project – 7L03 Contingency

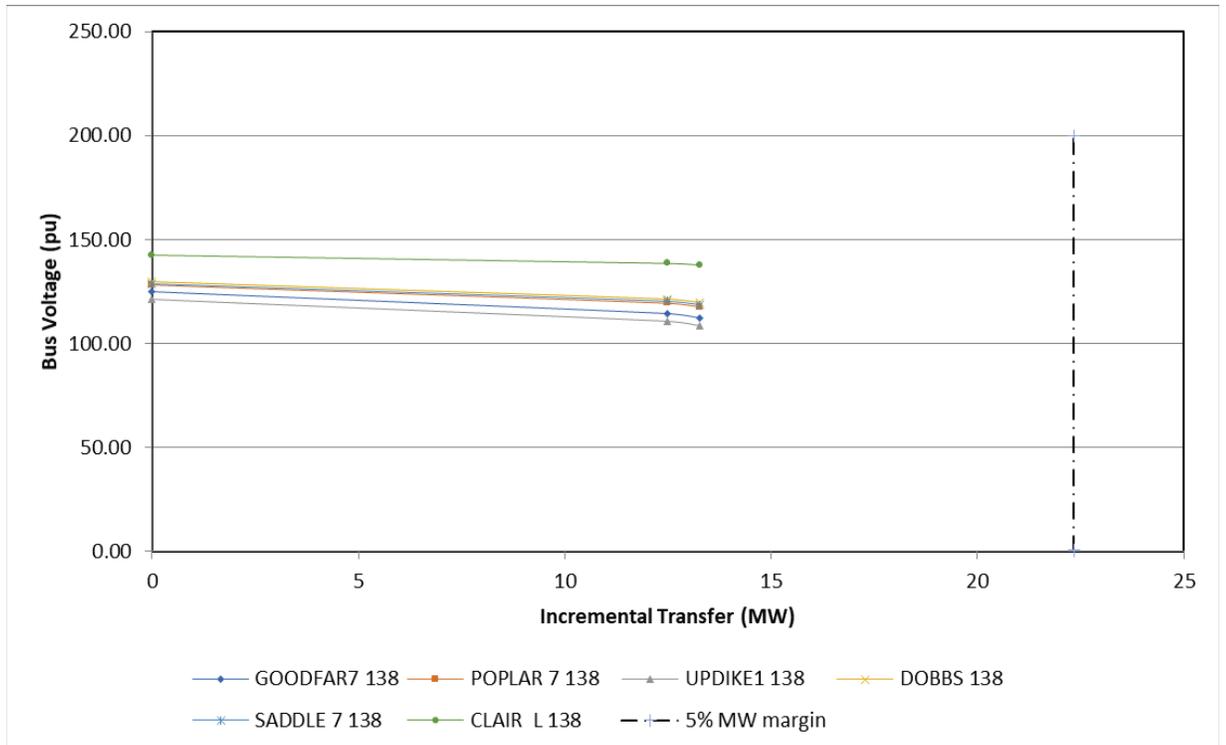


Figure A4-5: Scenario 4 2028 WP Post-Project – 7L84 Contingency

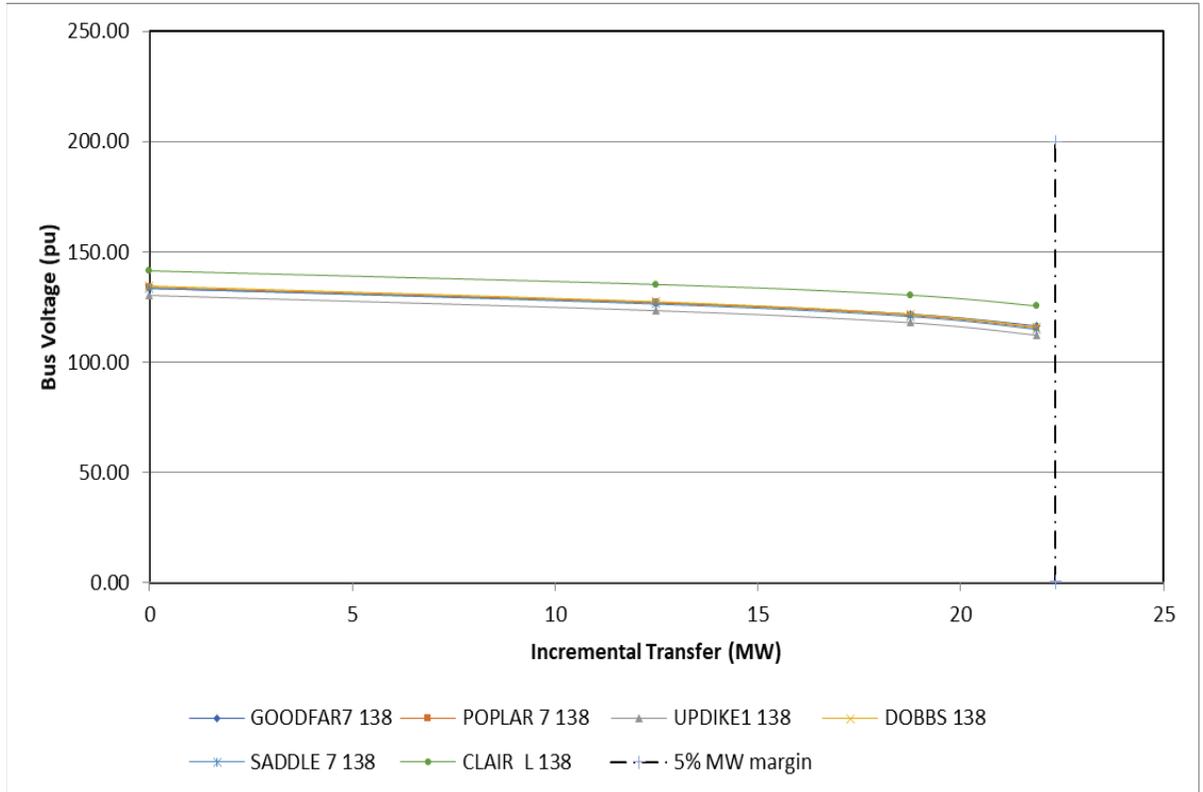
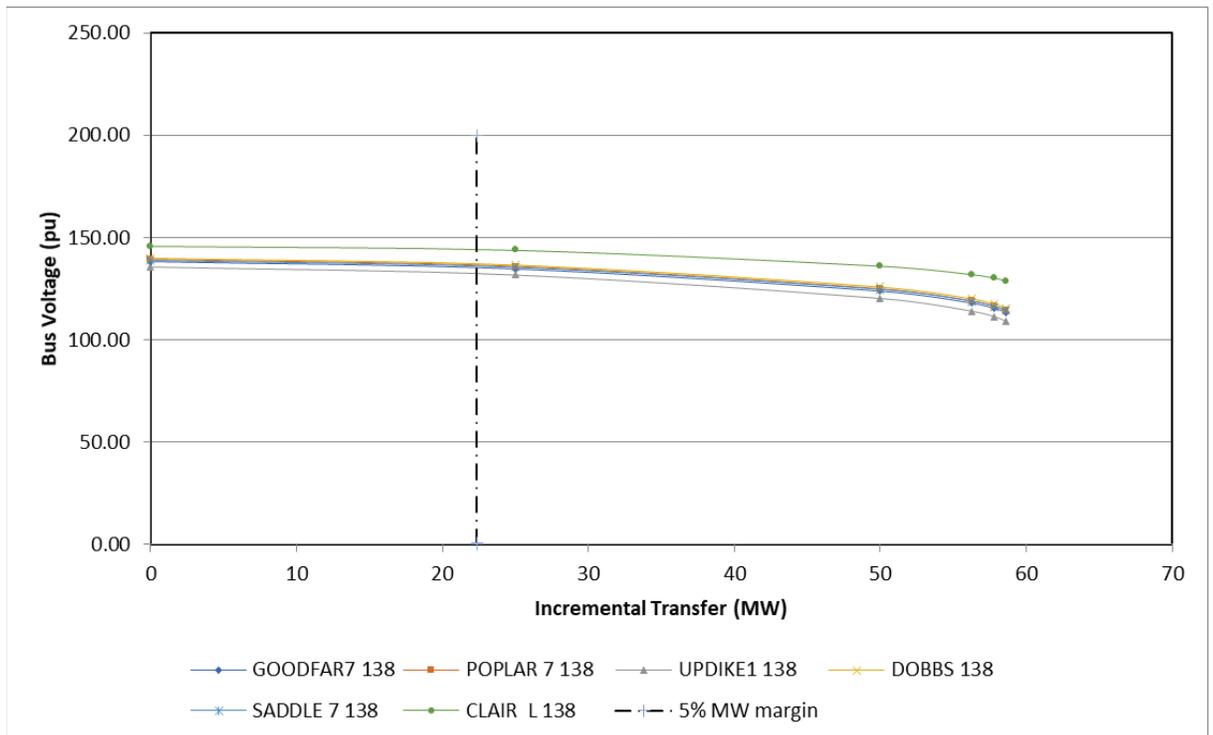


Figure A4-6: Scenario 4 2028 WP Post-Project – 7L32 Contingency



ATTACHMENT A5

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

ATTAFHMENT A6

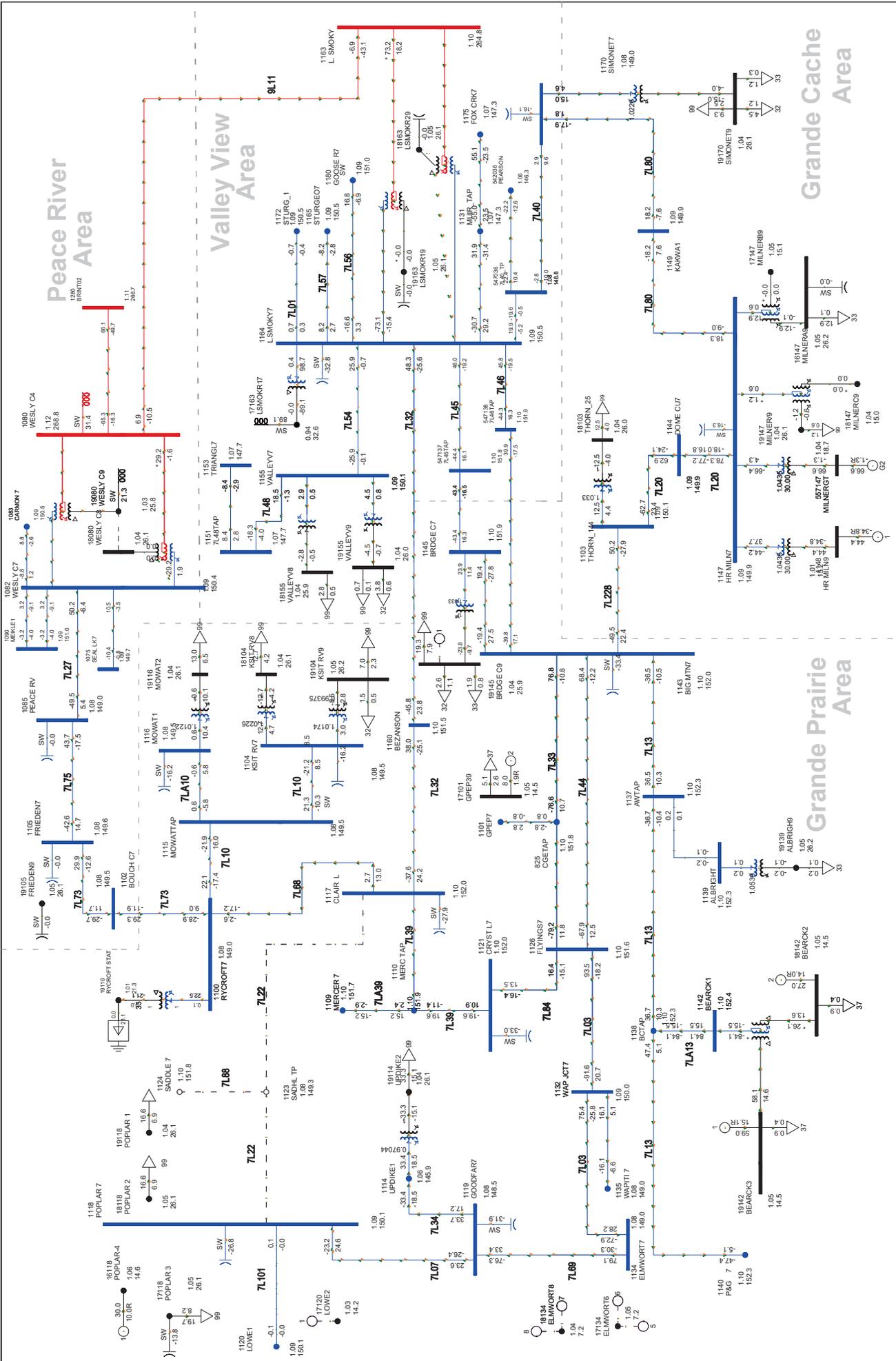
Power Flow Diagrams after Mitigation Measures (Scenario 1 to 4)

The post-mitigation power flow diagrams* are provided in this Attachment. Table A6-1 presents the list of the power flow diagrams.

Table A6-1: List of Power Flow Diagrams for Scenarios 1-4

| Scenario | Power flow diagram | Page number |
|----------------------------|--|-------------|
| Scenario 1: 2028 SP | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A6-3 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A6-4 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A6-5 |
| Scenario 2: 2028 WP | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A6-6 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A6-7 |
| Scenario 3: 2028 SP | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A6-8 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A6-9 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A-10 |
| Scenario 4: 2028 WP | N-1, 7L22 (Poplar Hill 790S – Clairmont Lake 811S) | A-11 |
| | N-1, 7L69 (Goodfare 815S – Elmworth 731S) | A-12 |
| | N-1, 7L03 (Elmworth 931S – Flyingshot Lake 749S) | A-13 |

***Note:** MW/MVAr flows on SLDs are based on the actual voltage obtained from the power flow solution as opposed to the nominal voltage.



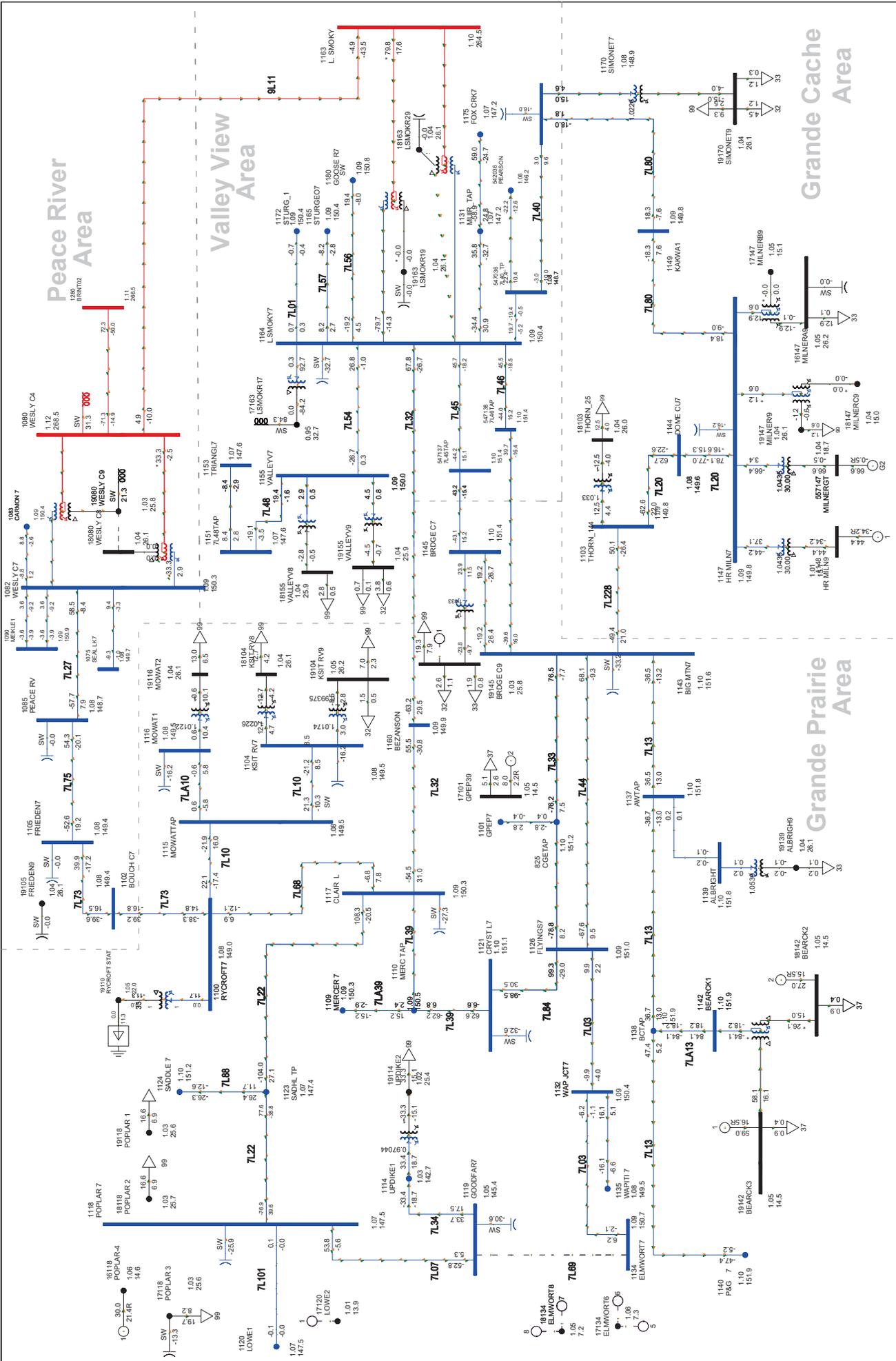
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE 1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >=500.000

P2256 Dobbs 2061S Substation
 CATEGORY B, LOSS OF 7L22
 SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 9:40

Grande Prairie Area
 Grande Cache Area

Valley View Area
 Peace River Area

Page A6-3



Peace River Area

Valley View Area

Grande Prairie Area

Grande Cache Area

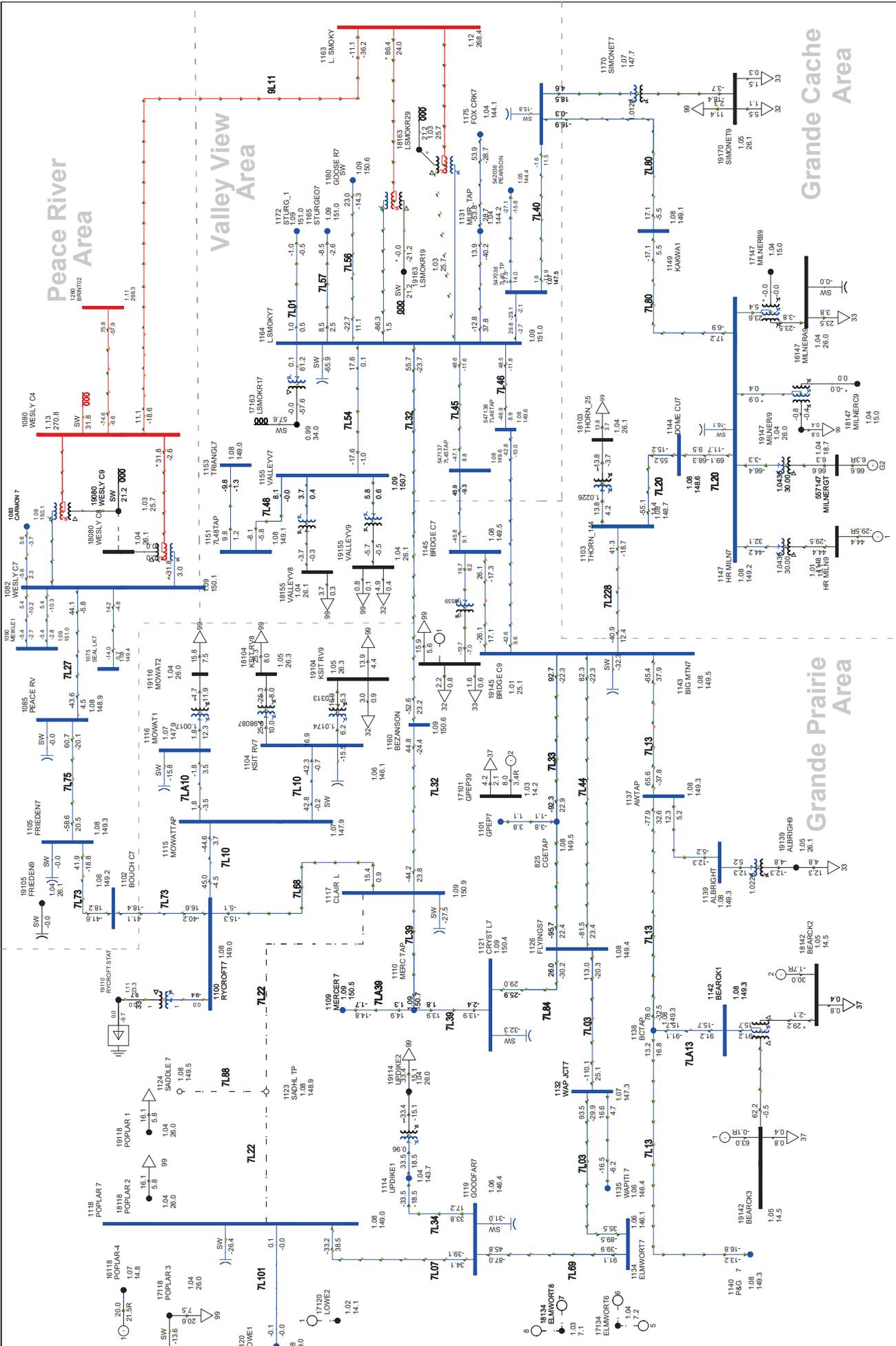
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE 1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=144.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L69
 SCENARIO 1_2028 SUMMER PEAK PRE-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 9:40

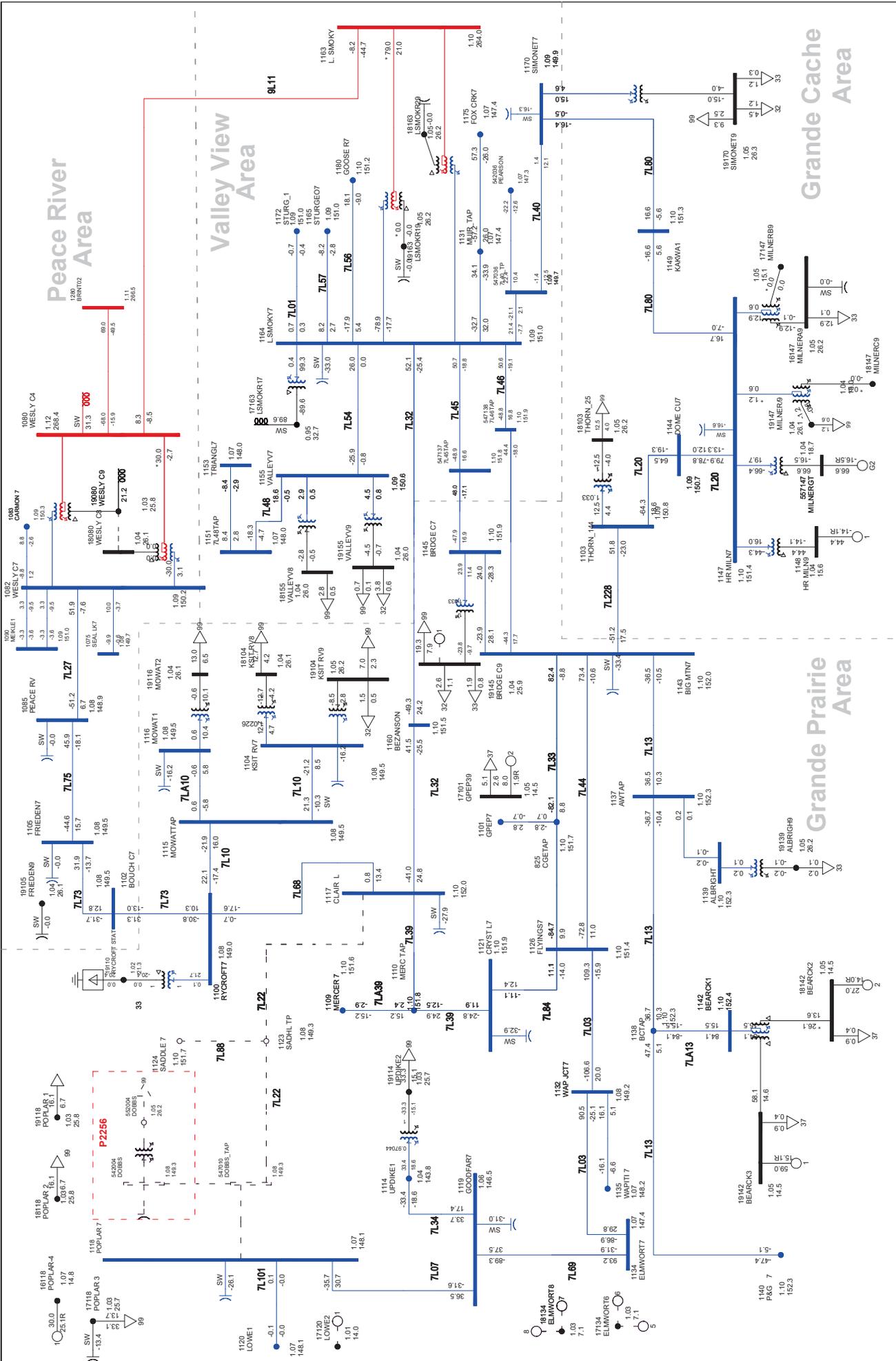
Page A6-4



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L22
 SCENARIO 2_2028 WINTER PEAK PRE-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 9:42

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1400V 0.9400V
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L22
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT
 WED, SEP 25 2024 9:08

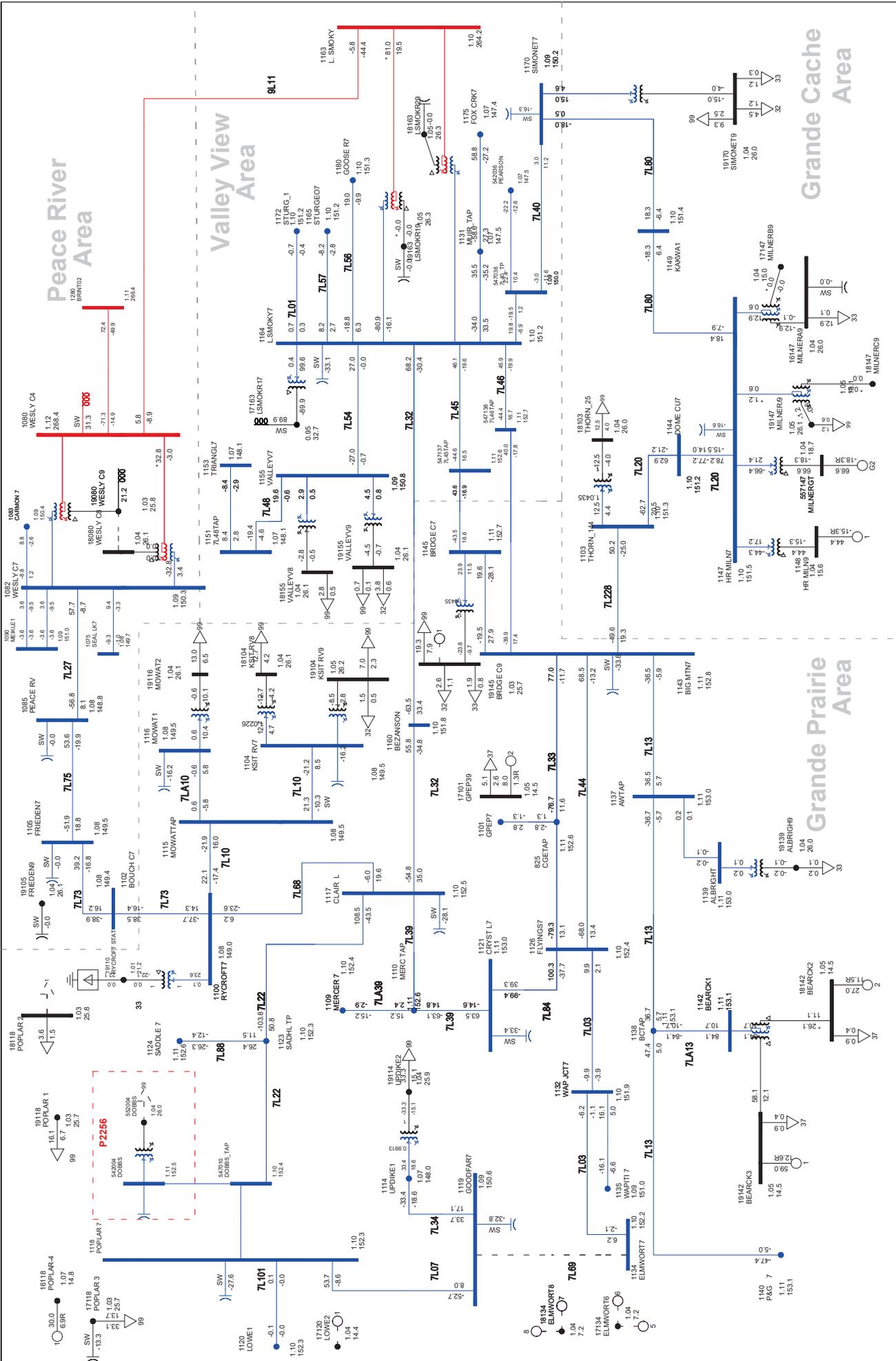
Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

Grande Cache Area

Valley View Area

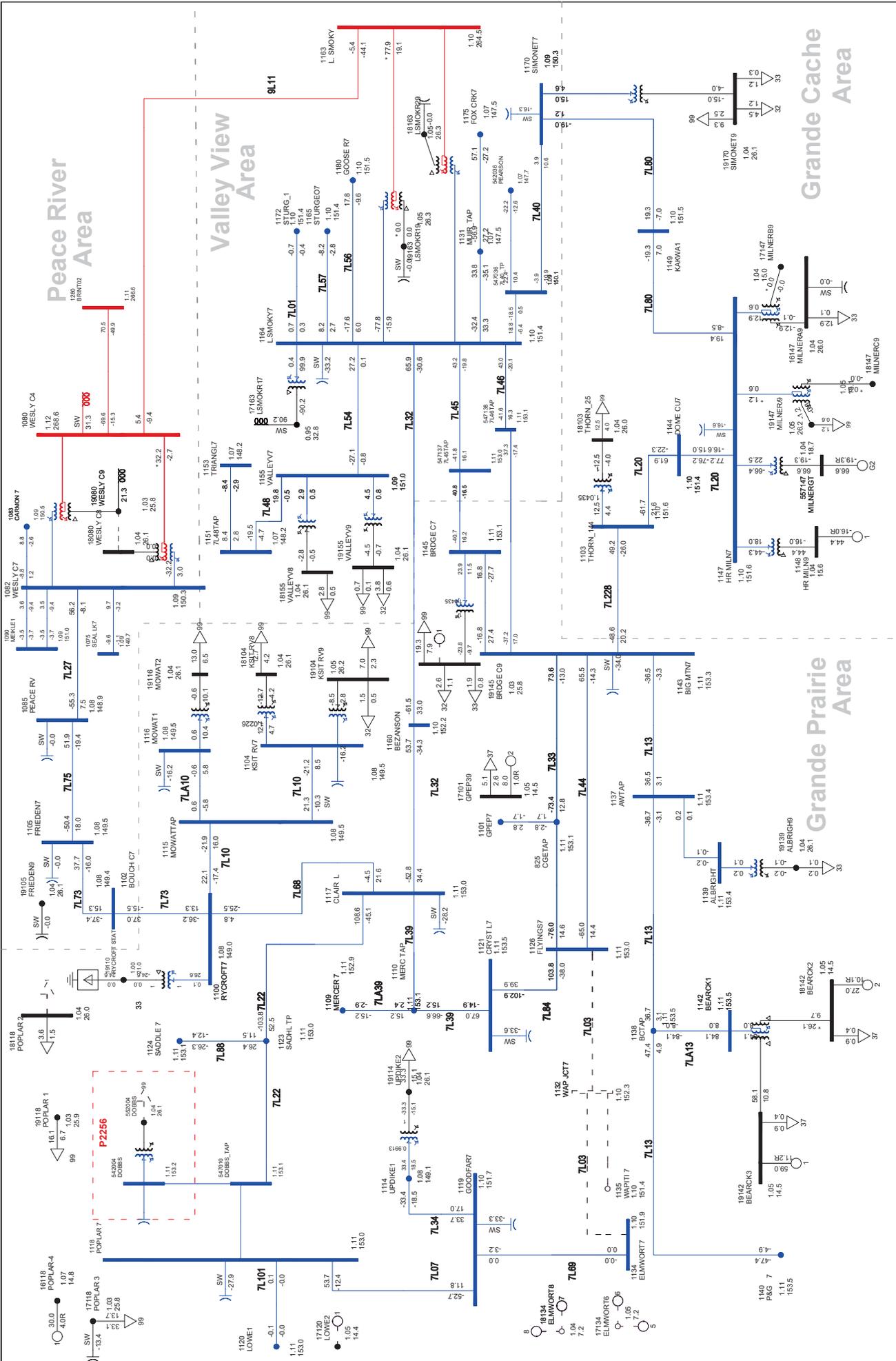
Peace River Area



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L69
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 10:45

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE 1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

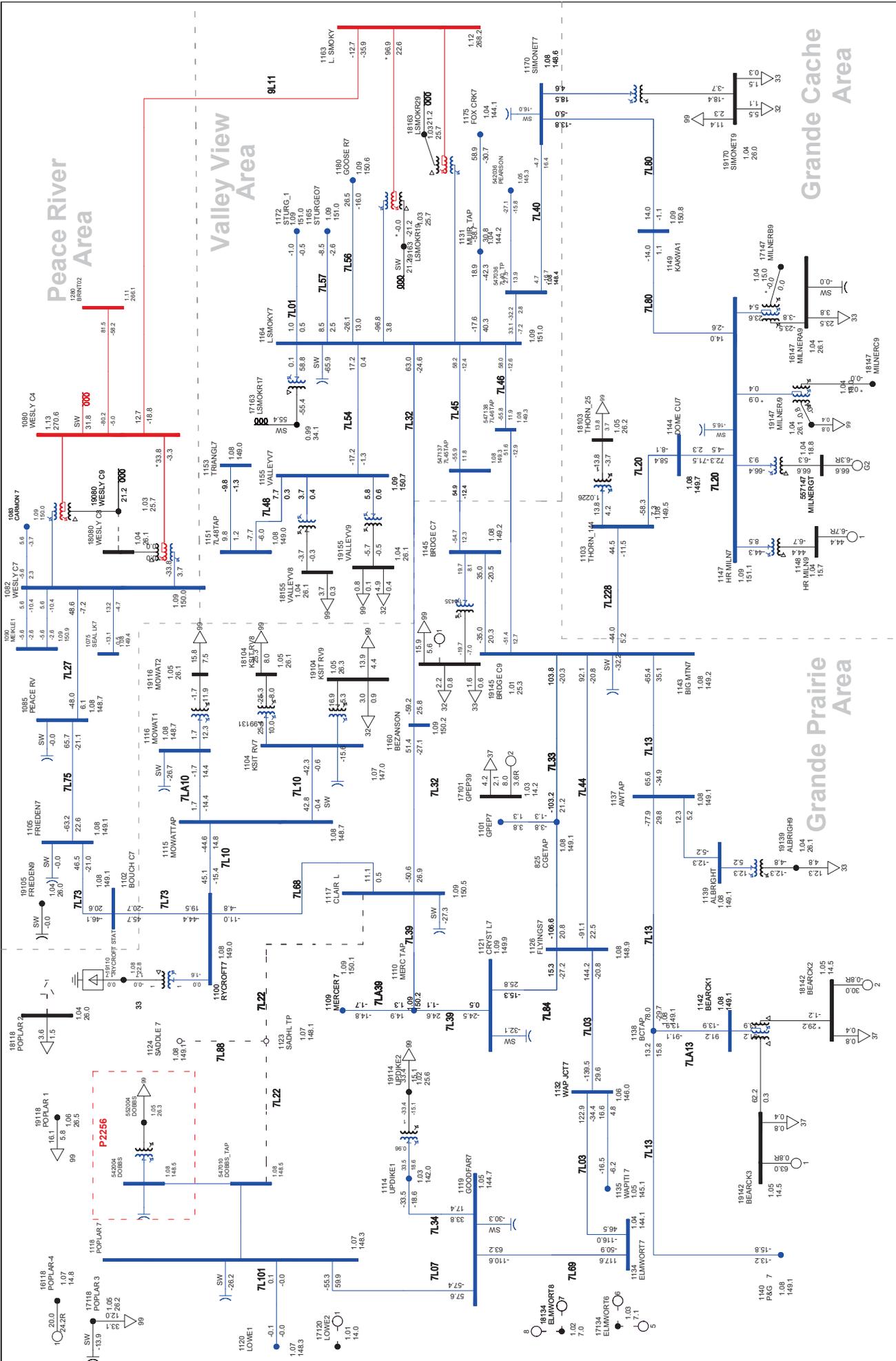


P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L03
 SCENARIO 3_2028 SUMMER PEAK POST-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 10:45

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE1
 1.1300OV 0.9400UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

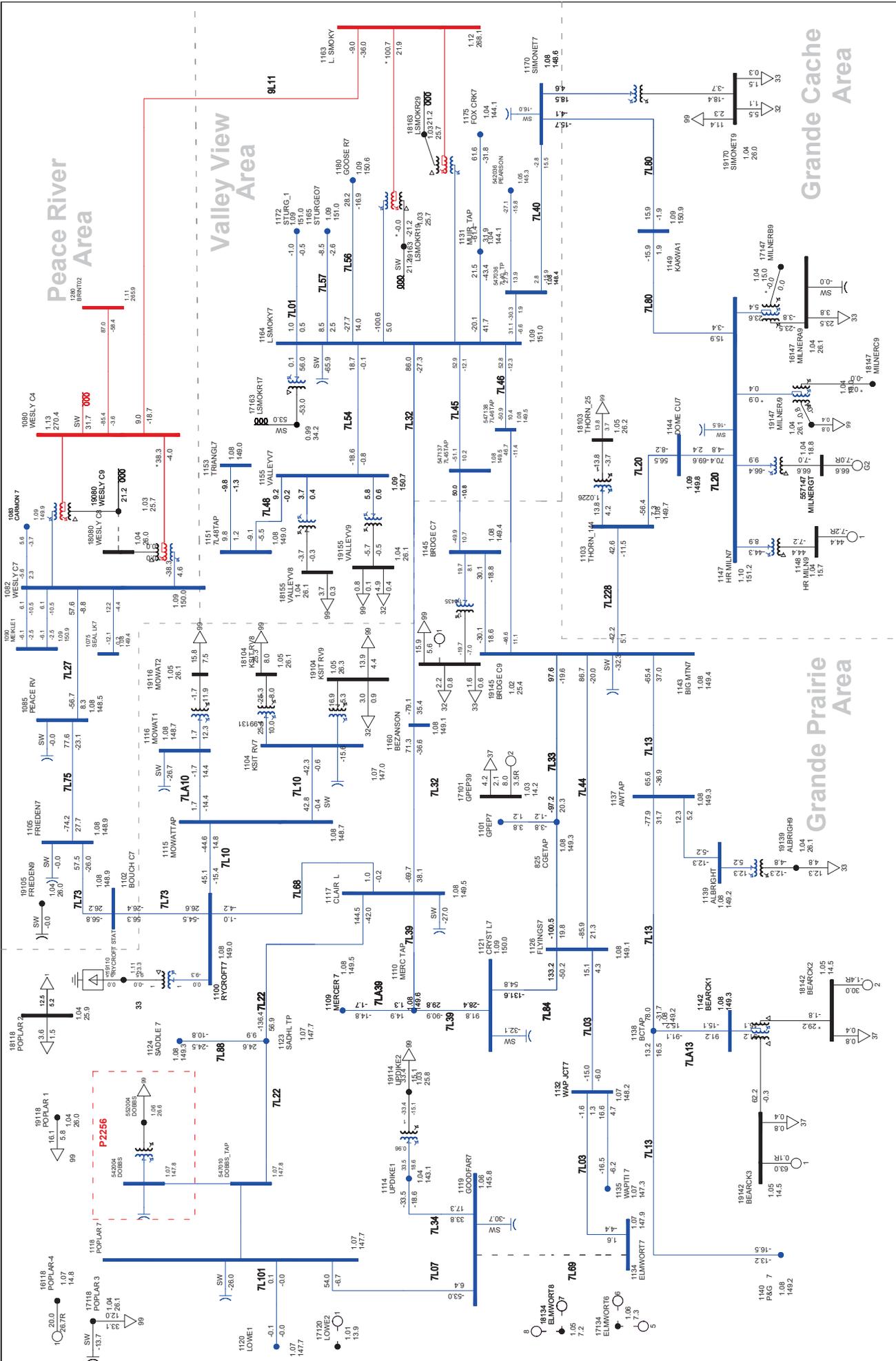
Page A6-10



P2256 Dobbs 2061S Substation

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1300OV 0.940UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area



P2256 Dobbs 2061S Substation

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1300OV 0.940UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

Grande Prairie Area

Grande Cache Area

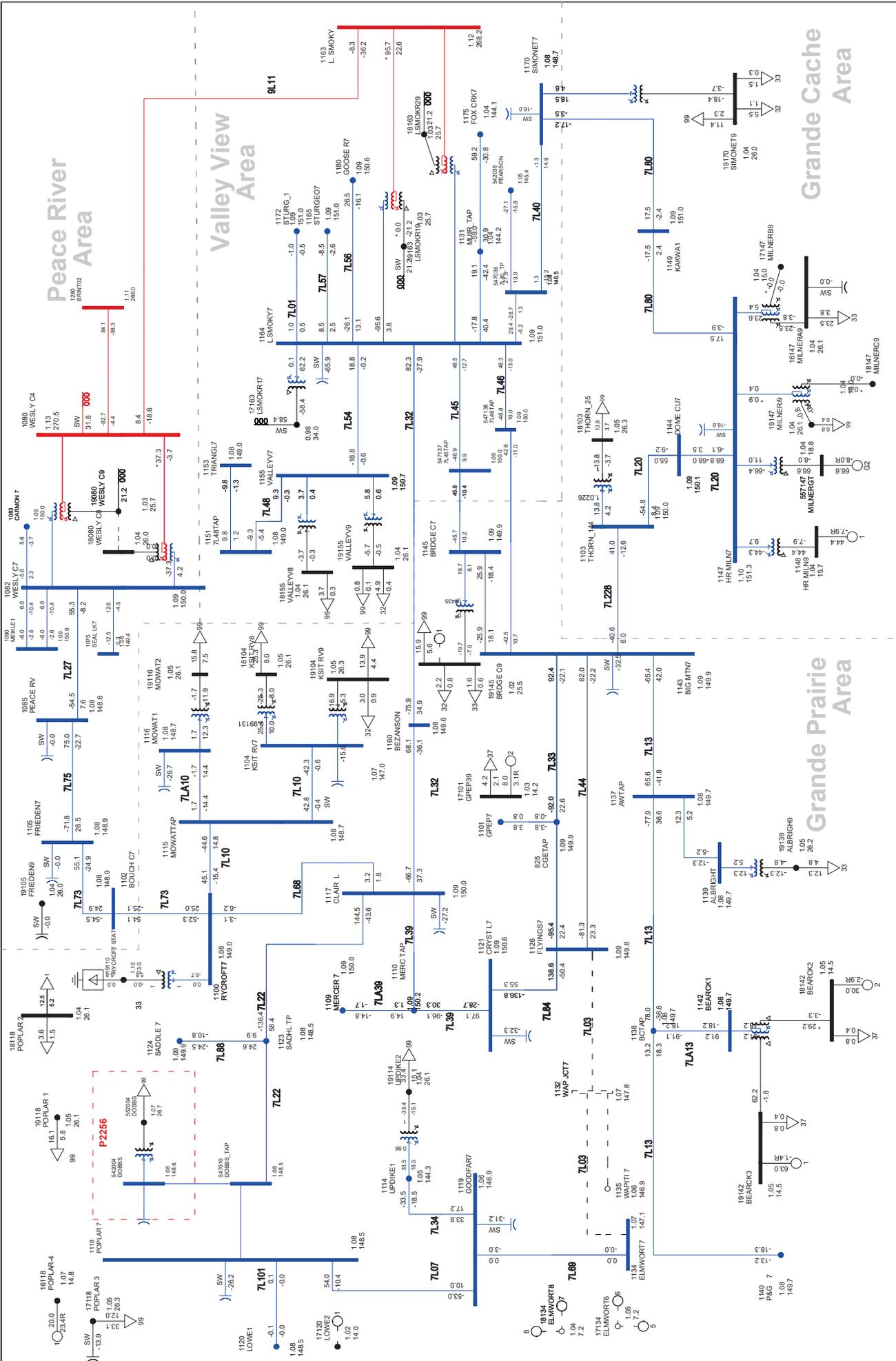
Peace River Area

Valley View Area

Grande Prairie Area

Grande Cache Area

CATEGORY B, LOSS OF 7L69
 SCENARIO 4_2028 WINTER PEAK POST-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 10:49



P2256 Dobbs 2061S Substation

CATEGORY B, LOSS OF 7L03
 SCENARIO 4_2028 WINTER PEAK POST-PROJECT WITH MITIGATIONS
 WED, SEP 25 2024 10:50

Bus - Voltage (kV/pu)
 Branch - MW/Mvar
 Equipment - MW/Mvar
 100.0% RATE2
 1.1300OV 0.940UV
 KV: <=25.000 <=34.500 <=72.000 <=138.000 <=240.000 <=500.000 >=500.000

ATTACHMENT A7

Post-Project Voltage Stability Diagrams after Mitigation Measures (Scenario 4)

Figure A7-1: Scenario 4 2028 WP Post-Project after Mitigation Measures – System Intact

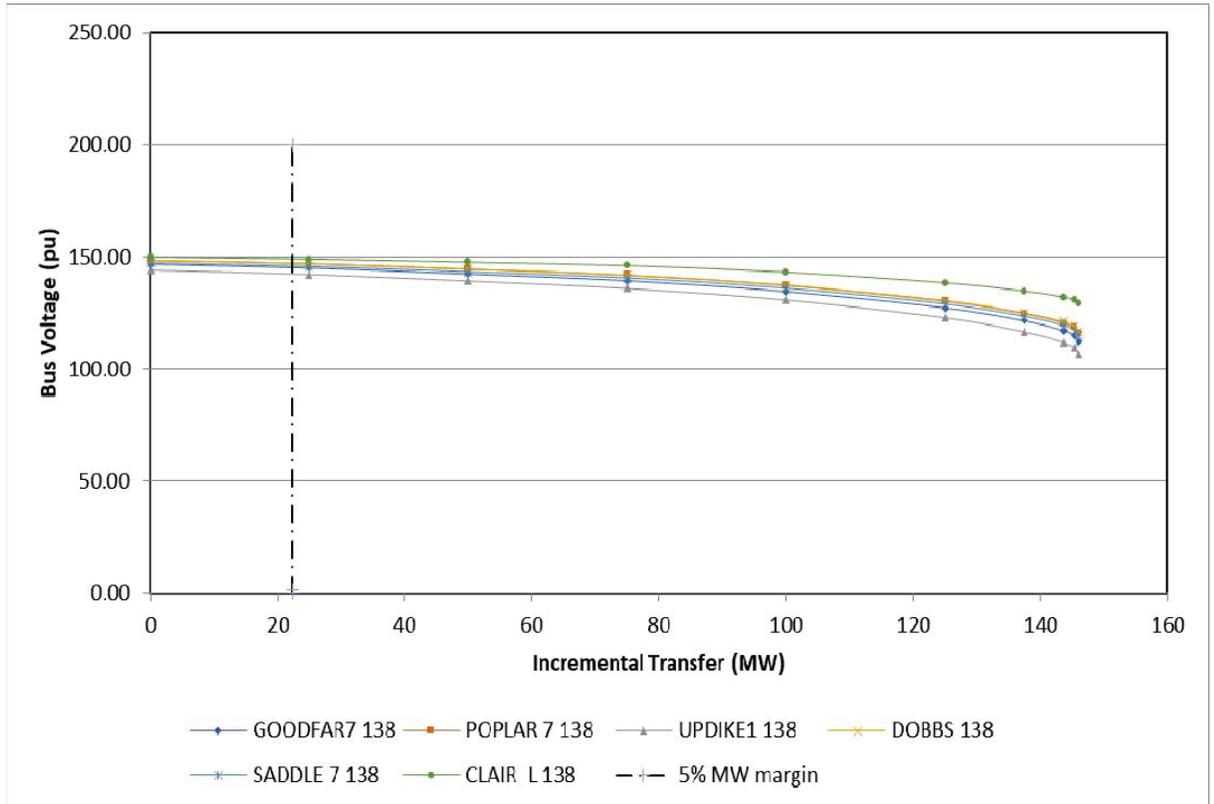


Figure A7-2: Scenario 4 2028 WP Post-Project after Mitigation Measures – 7L22 Contingency

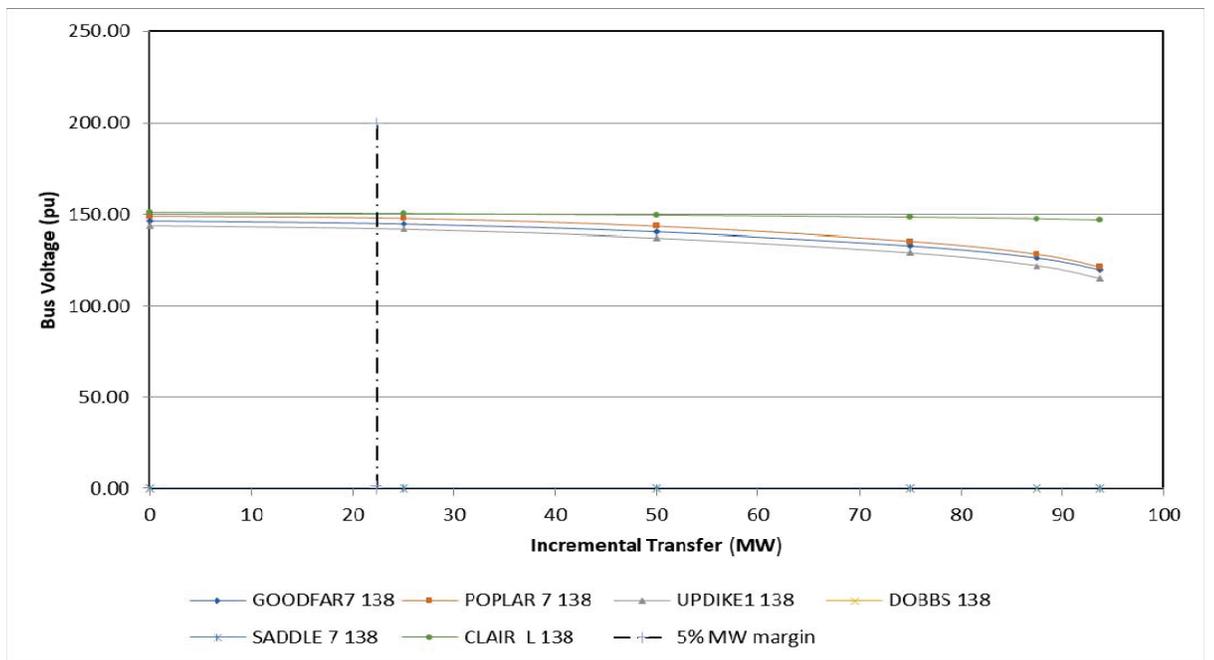


Figure A7-3: Scenario 4 2028 WP Post-Project after Mitigation Measures – 7L69 Contingency

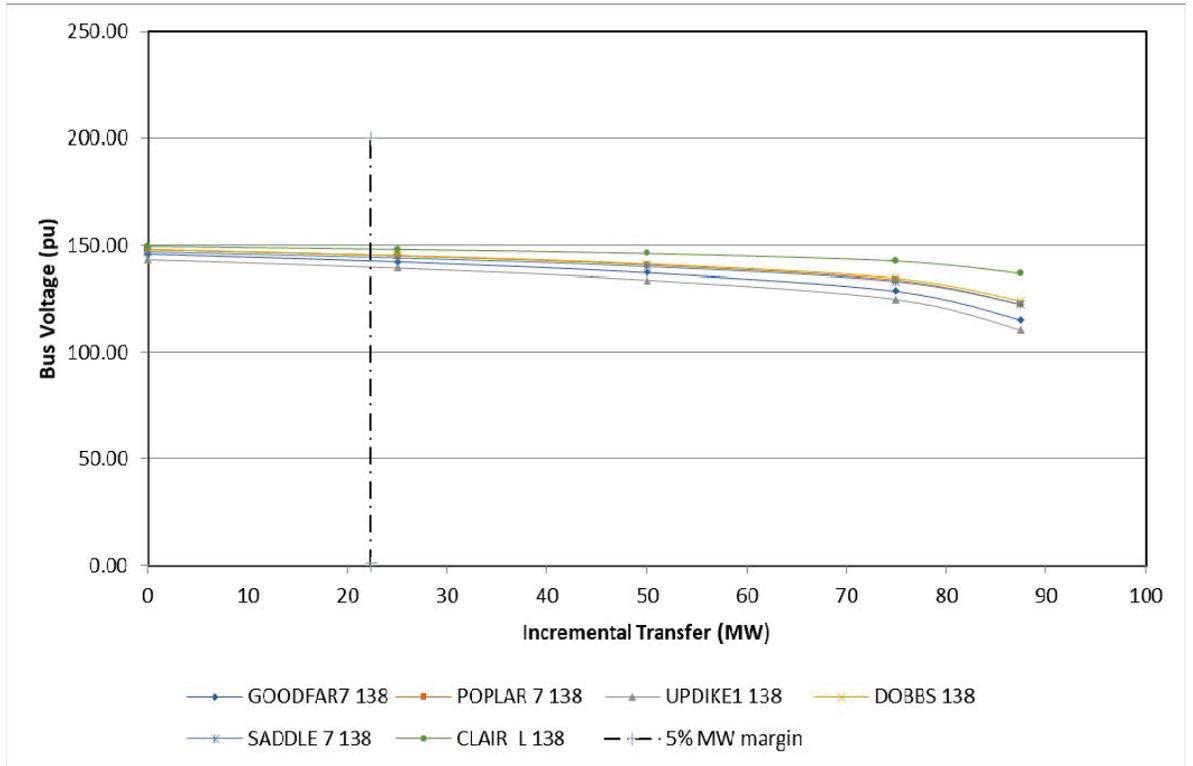


Figure A7-4: Scenario 4 2028 WP Post-Project after Mitigation Measures – 7L03 Contingency

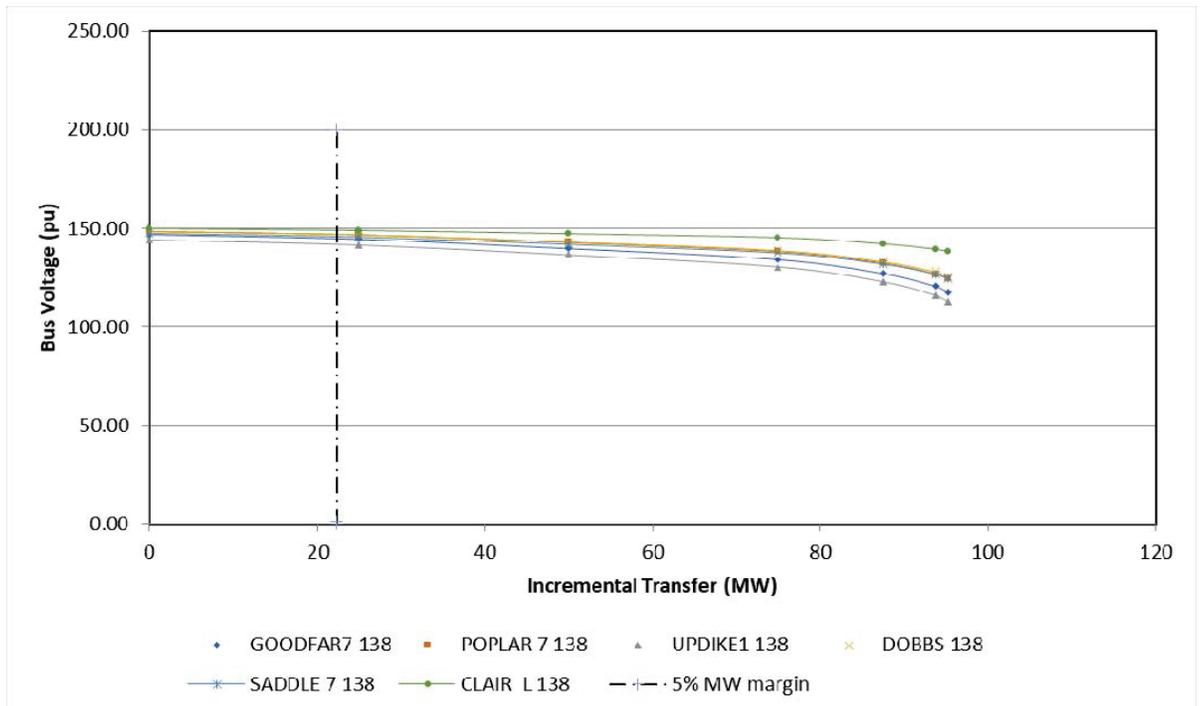
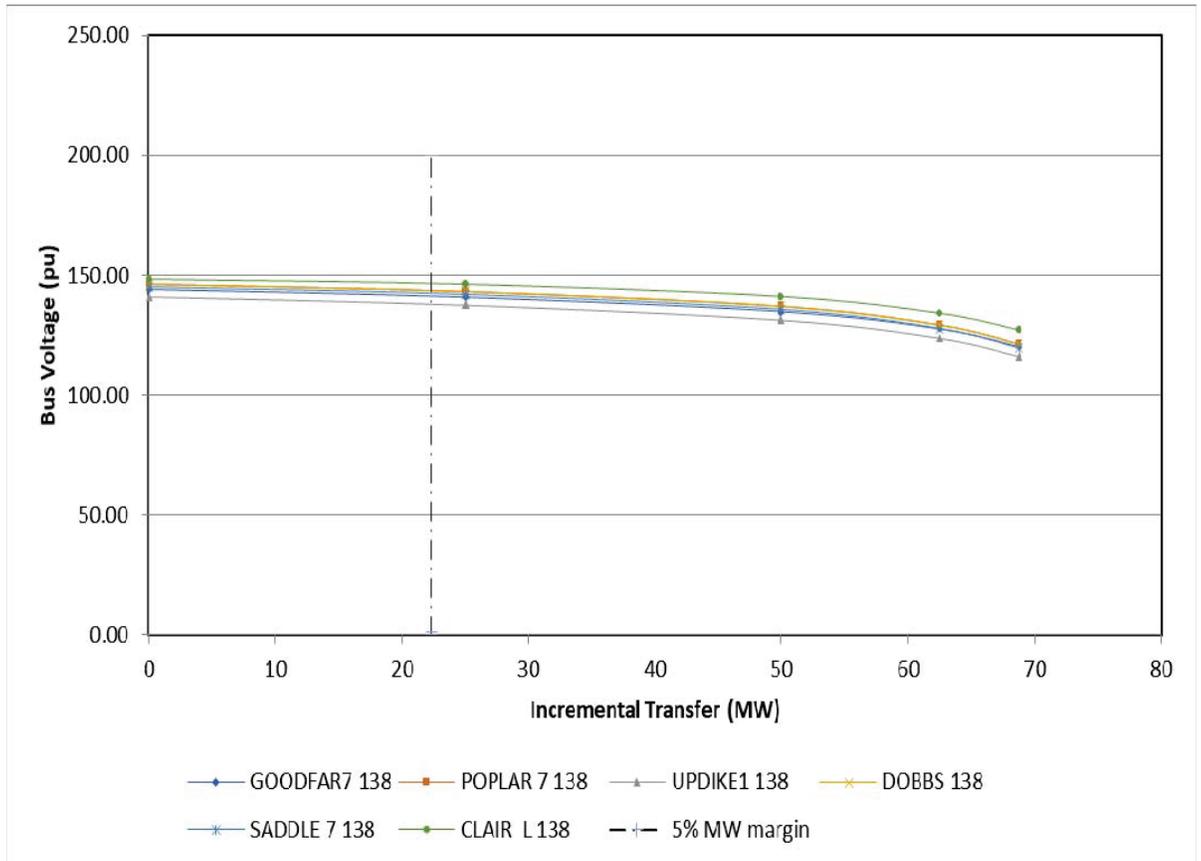


Figure A7-5: Scenario 4 2028 WP Post-Project after Mitigation Measures – 7L84 Contingency



ATTACHMENT A8

Connection Study Scope



Engineering Connection Assessment: Study Scope

Dobbs 2061S Substation

ATCO Electric Ltd.

Date: May 13, 2024

Version: V1Final

Classification: Public

| Company Name | Name and Credentials | Date | Signature |
|-------------------------|--|-----------|---|
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Engineering Connection Assessment: Study Scope

Dobbs 2061S Substation

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Attachments

Attachment A: Transmission Planning Criteria – Basis and Assumptions

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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., 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 in the Poplar Hill 790S surrounding area.

The DFO's request includes a request for a Rate DTS, Demand Transmission Service, contract capacity increase of 12.5 MW, from 52.9 MW to 65.4 MW, for the system access service provided at the existing Poplar Hill 790S. The DFO's request also includes a request for a Rate DTS, Demand Transmission Service, contract capacity of 22 MW for a new system access service in the Grande Prairie (Area 20) and a request for transmission development (collectively, the Project). Specifically, the DFO requested a new point of delivery (POD) substation, to be designated as Dobbs 2061S. Details on the need for the enhancement can be found in the DFO's DDR.

The Project in-service date (ISD) used for the purpose of the studies is May 19, 2026.

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

Table 1-1: Project Load Details

| Project Component | | Description |
|-------------------|---|--|
| Load | Existing Rate DTS, <i>Demand Transmission Service</i> , contract capacity | 52.9 MW at Poplar Hill 790S |
| | Requested Rate DTS | An increase of 12.5 MW at Poplar Hill 790S to 65.4 MW; 22 MW new DTS at the new POD Dobbs 2061S |
| | Type | industrial (except oilsands) |
| | Motors (number and size) | TBD - No large new motors without VFDs |
| | 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 Grande Prairie (Area 20).

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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.

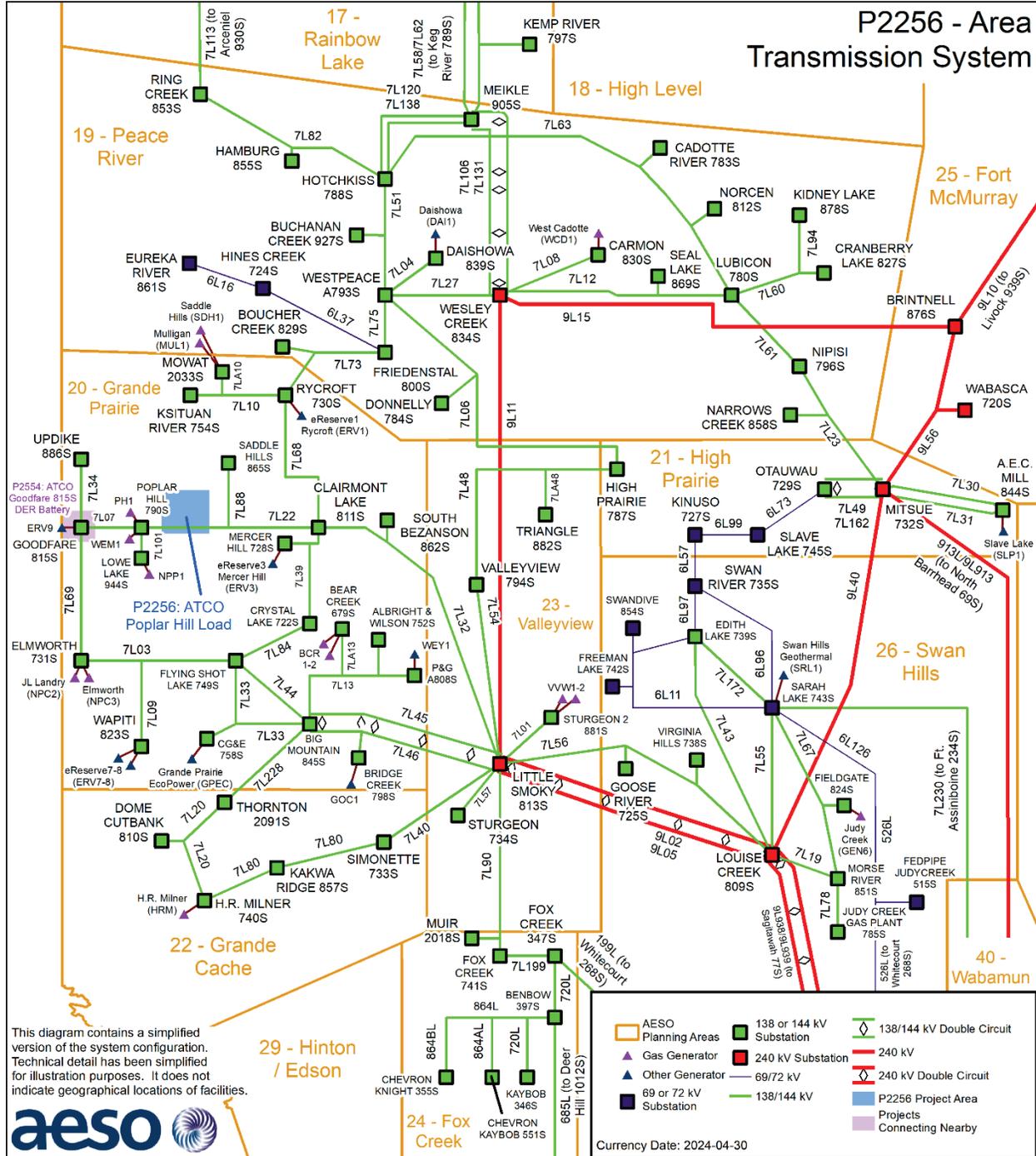
The following existing RASs and/or other protection schemes are used to manage constraints in the area:

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

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Figure 1-1: Transmission System in the Study Area



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2 Connection Alternatives

Alternative 1 – New Point of Delivery with a T-tap connection to the 144 kV transmission line 7L22

This alternative included the following developments:

- Add a new 144/25 kV Point of Delivery (POD) substation, designated as Dobbs 2061S, including three 144 kV circuit breakers and one 144/25 kV transformer;
- Add one 144 kV circuit, approximately 0.5 km in length,¹ to connect the proposed Dobbs 2061S substation to the existing 144 kV transmission 7L22 (between Poplar Hill 790S and 7L88 T-tap point) using a T-tap configuration; and
- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 2-1.

¹ Exact line length to be determined by the TFO

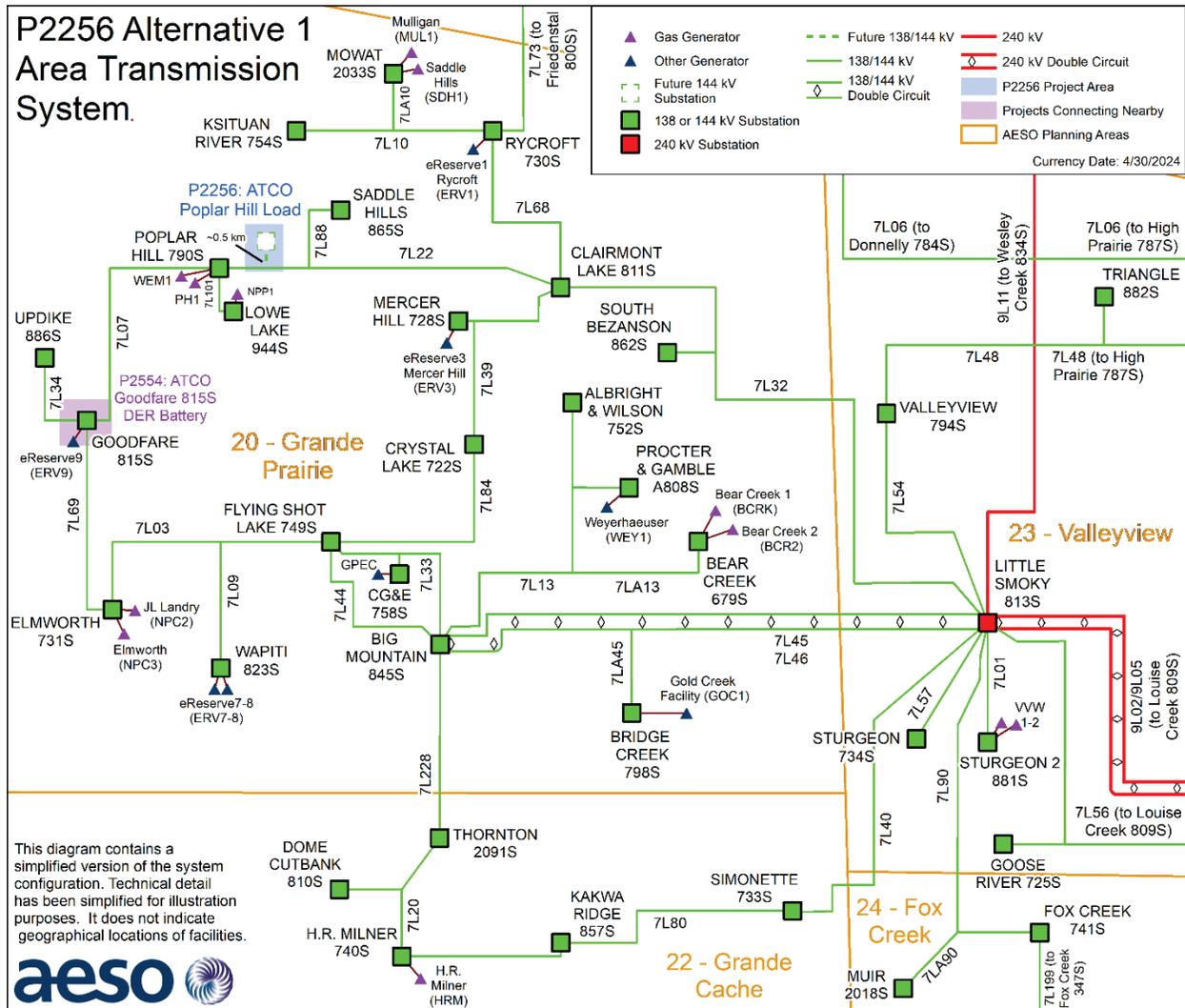
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Figure 2-1: Connection Alternative 1



Alternative 2 – New POD with an in-and-out connection to the 144 kV transmission line 7L22

This alternative included the following developments:

- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including three 144 kV circuit breakers and one 144/25 kV transformer;
- Add two 144 kV circuits, approximately 0.5 km in length each,² to connect the proposed Dobbs 2061S substation to the existing 144 kV transmission 7L22 (between Poplar Hill 790S and 7L88 T-tap point) using an in-and-out configuration; and

² Exact line length to be determined by the TFO

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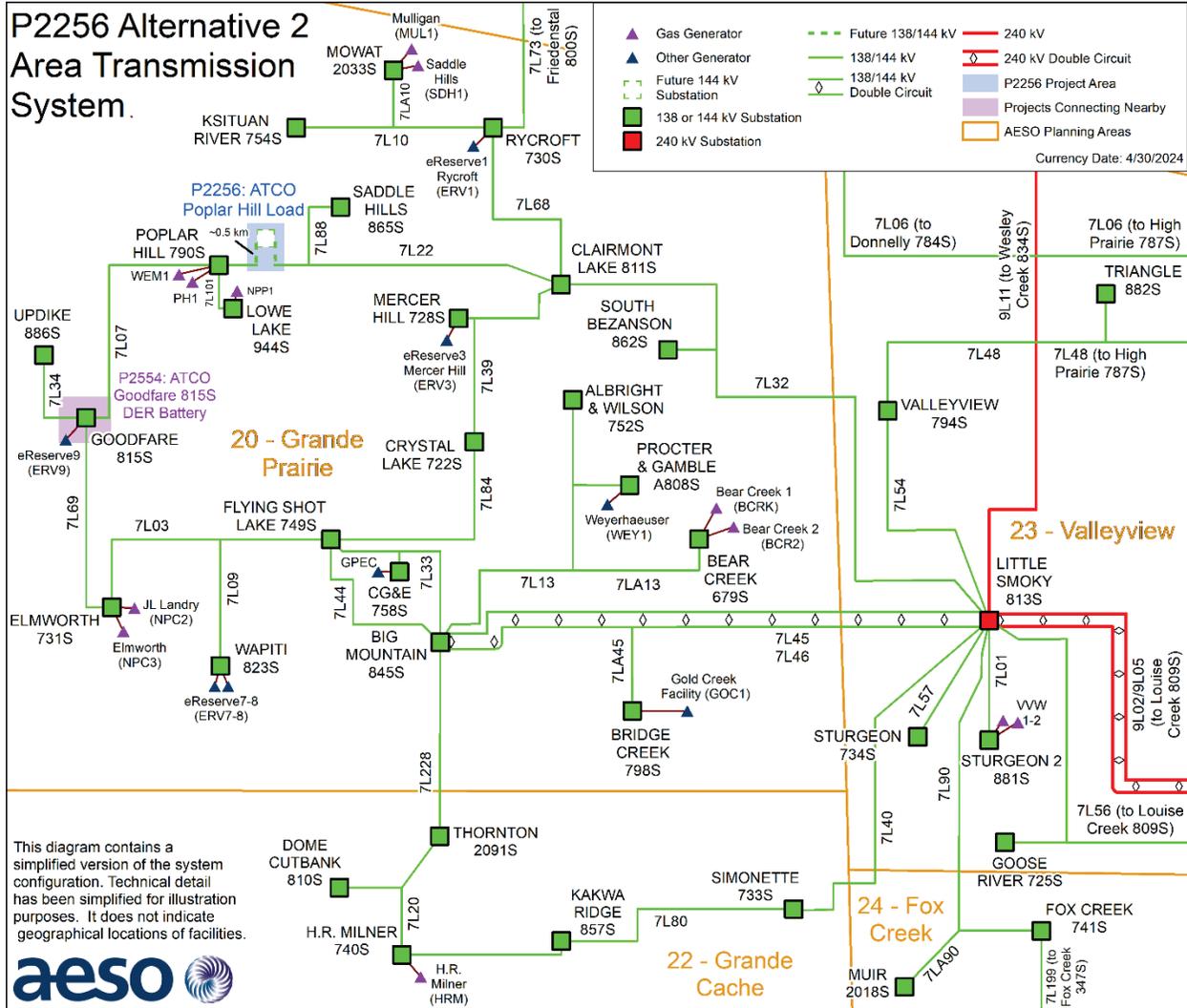
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- Add or modify associated equipment as required for the above transmission developments.

The proposed connection configuration is shown in Figure 2-2.

Figure 2-2: Connection Alternative 2



Alternative 3 – New POD with a radial connection to the 144 kV Poplar Hill 790S substation

This alternative included the following developments:

- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including three 144 kV circuit breakers and one 144/25 kV transformer;

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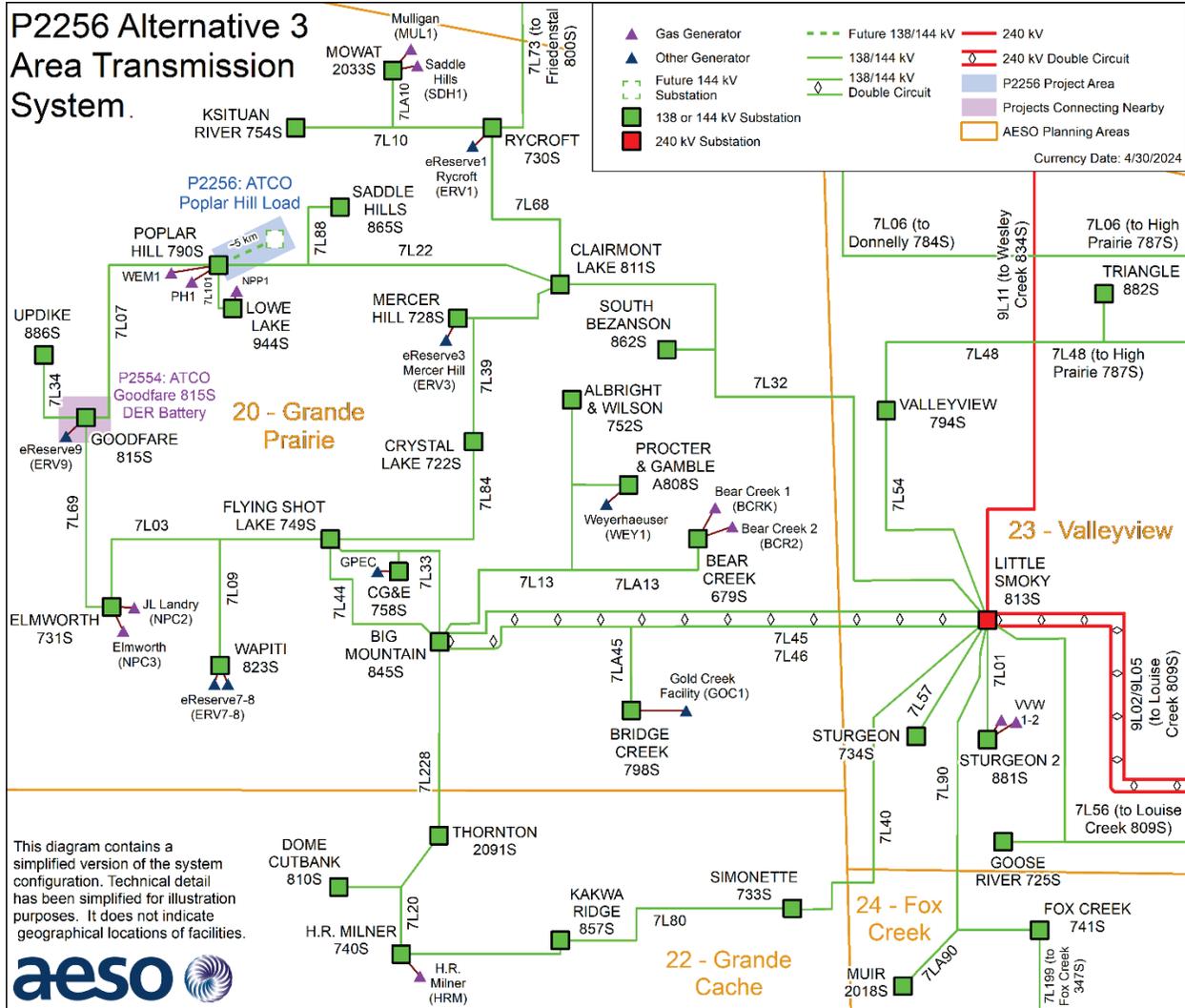
Dobbs 2061S Substation
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- Add one 144 kV circuit, approximately 5 km in length,³ to connect the proposed Dobbs 2061S substation to the existing Poplar Hill 790S substation using a radial configuration;
- Modify Poplar Hill 790S substation by adding 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 2-3.

Figure 2-3: Connection Alternative 3



Alternative 4 – New POD with a radial connection to Clairmont Lake 811S substation

This alternative included the following developments:

³ Exact line length to be determined by the TFO

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- Add a new 144/25 kV POD substation, designated as Dobbs 2061S, including three 144 kV circuit breakers and one 144/25 kV transformer;
- Add a 144 kV circuit, approximately 40 km in length,⁴ to connect the proposed Dobbs 2061S substation to the existing Clairmont Lake 811S substation using a radial configuration;
- Modify Clairmont Lake 811S substation by 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 2-4.

⁴ Exact line length to be determined by the TFO

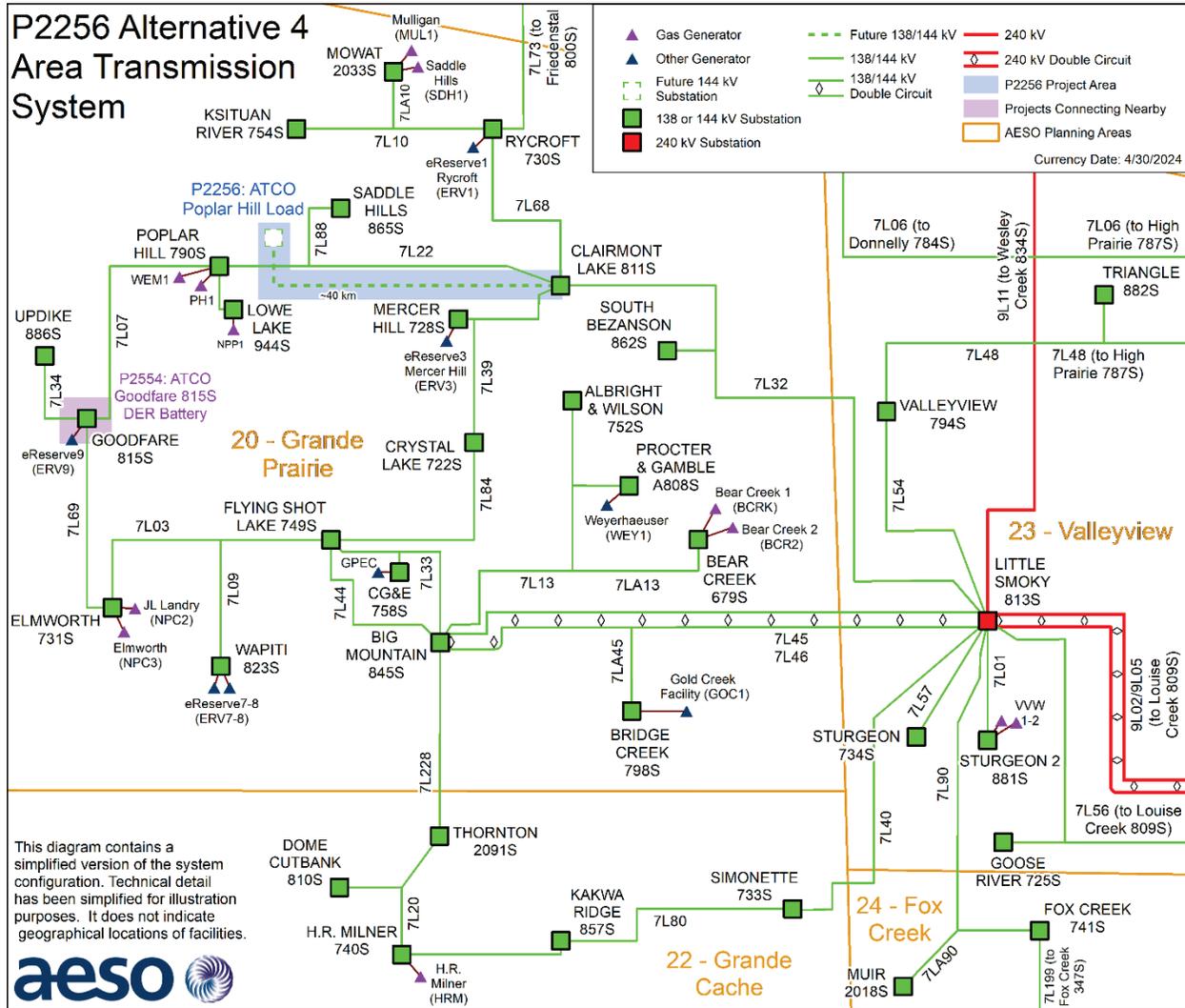
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Figure 2-4: Connection Alternative 4



2.1 Connection Alternatives Selected for Further Study

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

2.2 Connection Alternatives Not Selected for Further Study

Alternatives 2, 3 and 4 involve increased transmission development and hence, increased cost compared to Alternative 1. Therefore, Alternatives 2, 3 and 4 were not selected for further study.

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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, Category B, and Category C5 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.

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**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*;

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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 | 790S Load (MW) | New POD Load (MW) |
|---------------------|-----------------------|--|----------------------|----------------|-------------------|
| Pre-Project | | | | | |
| 1 | 2028 Summer Peak (SP) | Low Generation (LG) | 2028 SP Pre-Project | 52.9 | 0 |
| 2 | 2028 Winter Peak (WP) | | 2028 WP Pre-Project | 52.9 | 0 |
| Post-Project | | | | | |
| 3 | 2028 Summer Peak (SP) | Low Generation (LG) | 2028 SP Post-Project | 65.4 | 22 |
| 4 | 2028 Winter Peak (WP) | | 2028 WP Post-Project | 65.4 | 22 |
| 5 | 2033 Winter Peak (WP) | All generator in Study Area in-service | 2033 WP Post-Project | 65.4 | 22 |

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)⁵ 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.

⁵ The 2023 LTO is available on the AESO website.

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

| AESO Planning Region Name | Forecast Peak Load by Year/Season (MW) | |
|--|--|---------|
| | 2028 SP | 2025 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.

P2196 Grand Prairie MPC Gas 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] ^c | 2028 WP [LG] ^c |
| 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 |

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| Facility Name | Unit No. | Bus No. | MC (MW) | AESO Planning Area No. | Unit Net Generation ^a (MW) by Scenario | |
|---------------------------------------|----------------------|---------------------------|---------|------------------------|---|---------------------------|
| | | | | | 2028 SP [LG] ^c | 2028 WP [LG] ^c |
| Grande Prairie EcoPower (GPEC) | 2 | 17101 | 27 | 20 | 8 | 8 |
| NRGreen (NRG3) | G1 | 2674 | 16 | 26 | 12 | 13 |
| 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 | 111 |
| 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 (VWV1) | 1 | 1171 | 50 | 23 | 0 | 0 |
| Valley View 2 (VWV2) | 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 |

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| Facility Name | Unit No. | Bus No. | MC (MW) | AESO Planning Area No. | Unit Net Generation ^a (MW) by Scenario | |
|------------------|----------|---------|---------|------------------------|---|---------------------------|
| | | | | | 2028 SP [LG] ^c | 2028 WP [LG] ^c |
| 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 ^a (MW) by Scenario | |
|--------------------------------------|------------------|---------|------------------------|---|--------------|
| | | | | 2028 SP [LG] | 2028 WP [LG] |
| P1885 Northern Lights WAGF | 565005,565006 | 408 | 26 | 22 | 129 |
| P2196 Grand Prairie MPC Gas | 557037,558037 | 310 | 20 | N-G | N-G |
| 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

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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 | 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 | 239 |
| 7L20 | H.R. Milner 2091S – Thornton 2091S | 144 | 257 bus cond | 299 GS | 277 bus cond | 299 GS |
| 7L22 | Poplar Hill 790S – Clairmont Lake 811S | 144 | 113 | 151 | 126 | 171 |
| 7L27 | Wesley Creek 834S – West Peace River 793S | 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 |

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| Line ID | Line Description | Voltage Class (kV) | Normal Rating (MVA) | | Emergency Rating (MVA) | |
|---------|---|--------------------|---------------------|--------------|------------------------|--------|
| | | | Summer | Winter | Summer | Winter |
| 7L33 | Flyingshot Lake 749S - Big Mountain 845S | 144 | 167 | 210 | 195 | 251 |
| 7L34 | Goodfare 815S – Updike 886S | 144 | 114 | 146 | 129 | 149 CT |
| 7L39 | Clairmont Lake 811S – Mercer Hill 728S | 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 – Otawau 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 | 144 | 116 | 156 | 130 | 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 – Little Smoky 813S | 144 | 112 | 133 CT | 123 | 133 CT |
| 7L68 | Rycroft 730S – Clairmont Lake 811S | 144 | 116 | 155 | 129 | 178 |
| 7L69 | Goodfare 815S – Elmworth 731S | 144 | 115 | 155 | 129 | 178 |
| 7L73 | Friedenstal 800S – Rycroft 730S | 144 | 114 | 152 | 124 | 169 |
| 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 |
| 7L82 | Ring Creek 853S – Hamburg 855S | 144 | 112 | 150CT | 126 | 150CT |
| 7L82 | Hotchkiss 788S – Hamburg 855S | 144 | 112 | 150 | 126 | 173 |
| 7L84 | Crystal Lake 722S – Flyingshot Lake 749S | 144 | 168 | 211 | 198 | 256 |
| 7L90 | Little Smoky 813S – Fox Creek 741S | 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 |

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| Line ID | Line Description | Voltage Class (kV) | Normal Rating (MVA) | | Emergency Rating (MVA) | |
|------------|--|--------------------|---------------------|-----------|------------------------|-----------|
| | | | Summer | Winter | Summer | Winter |
| 7L199/199L | Fox Creek 741S – Fox Creek 347S | 144 | 119 | 143.8GS | 131 | 143.8GS |
| 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 |
| 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 |
| Little Smoky 813S | 902T | 240/144/25 | Winter: 237.5 |

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

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 | - | - |
| 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 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*

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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.

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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 | | Motor Starting | | Short Circuit |
|-----------------------|------------|------------|---|-------------------|---|---------------------|---|----------------|---|---------------|
| | | Category | | Category | | Category | | Category | | Category A |
| | | A | B | 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 | | | | | | | |
| 4 | 2028 WP LG | X | X | X | X | | | | | X |
| 5 | 2033 WP | | | | | | | | | X |

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.

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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 increasing generation in Wabamun (Area 40) and Fort McMurray (Area 25).

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

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**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 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:

- Poplar Hill 790S
- Lowe Lake 944S
- Saddle Hills 865S
- Clairmont Lake 811S
- Goodfare 815S
- Elmworth 731S
- Updike 886S
- 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.

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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 factors⁶ 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 AES.

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.

⁶ 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.

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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 (preliminary 2023 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

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 Criteria¹

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 or 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 | $\geq 5\%$ | Worst Case Scenario(8) |
| B | Bus Section | $\geq 5\%$ | 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 | $\geq 2.5\%$ | 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 | 2 nd 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 | 2 nd 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 |