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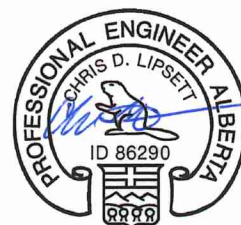
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Lethbridge Transmission Development Planning Report

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Sept 29, 2026

Executive Summary

The AESO 2025 *Long-term Transmission Plan* identified reliability violations in the Lethbridge area, specifically thermal overloads on the 138 kV system serving load in and around the City of Lethbridge. The AESO investigated these violations further and determined that transmission development is required to reliably serve load in the future.

The AESO conducted transmission planning studies to identify the need, evaluated transmission development options, and selected the Preferred Transmission Development to mitigate the constraints. These activities were undertaken to ensure compliance with the Alberta Reliability Standards, the *Electric Utilities Act*, and the *Transmission Regulation*.

Need Assessment

The AESO conducted planning studies to assess the performance of the existing transmission system in the Lethbridge Area. The studies observed Category B thermal constraints on the 138 kV transmission line 207L (North Lethbridge 370S – Coalbanks 111S).

Preferred Transmission Development

The AESO considered different transmission development options to alleviate the constraints on 207L.

Based on the technical performance, cost estimates, and environmental and land use effects, the AESO selected the following Preferred Transmission Development:

- Replace the existing conductor on the existing 138 kV transmission line 207L (North Lethbridge 370S – Coalbanks 111S) with a conductor with a minimum summer continuous rating of 160 MVA.

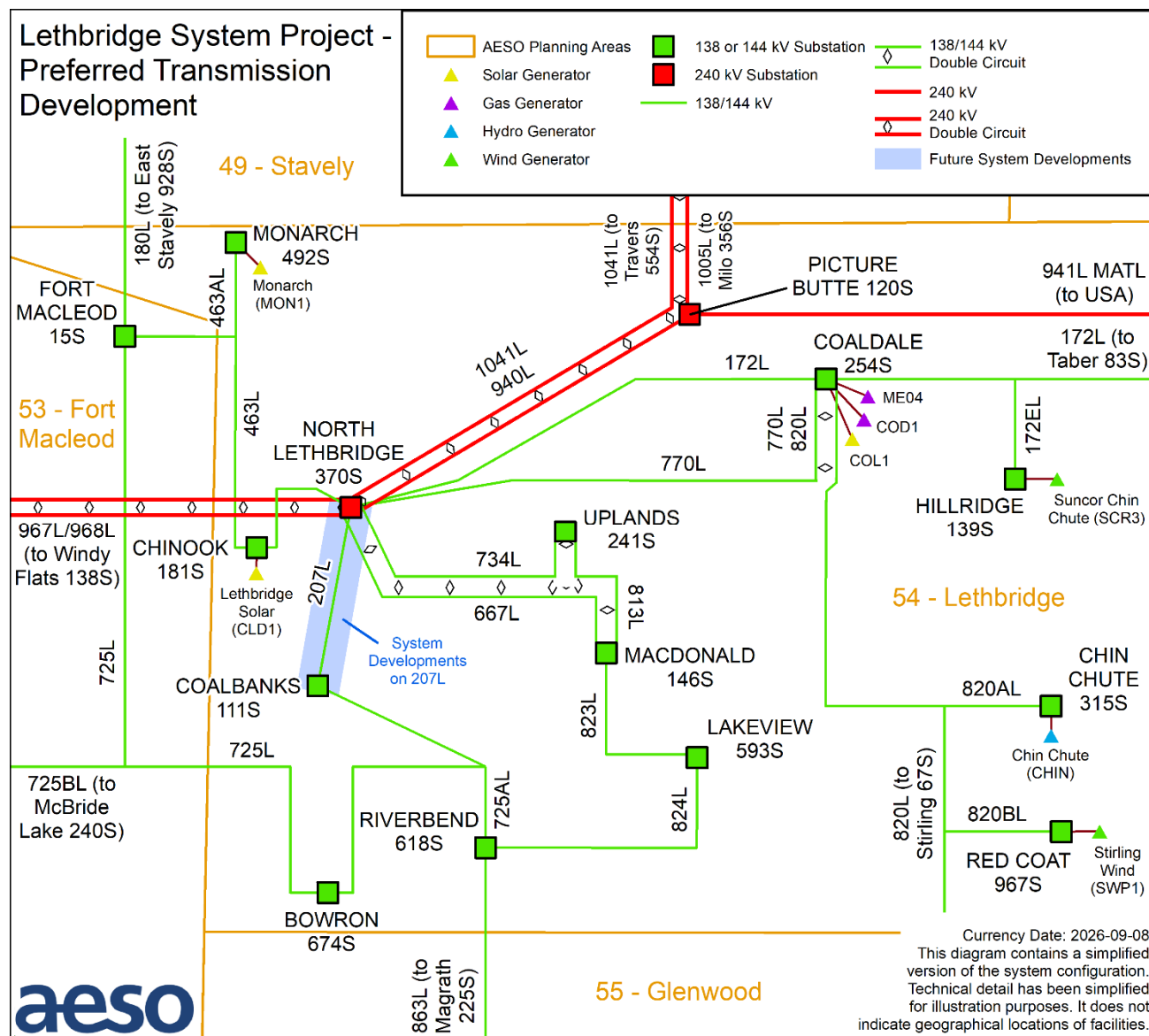
The Preferred Transmission Development is estimated to cost \$6 million¹ and was selected because it:

- Resolves the thermal constraints for the 20-year planning horizon
- Is the lowest cost option
- Has the lowest environmental and land use effects

A diagram of the Preferred Transmission Development is shown in Figure 1 below.

¹ Based on a \$5.81M ±30% estimate from AltaLink and a 0.23M +50/-30% estimate from the City of Lethbridge.

Figure 1: Preferred Transmission Development



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Abbreviations

AESO	Alberta Electric System Operator
AC	alternating current
AIES	Alberta Interconnected Electric System
ARS	Alberta Reliability Standards
BC	British Columbia
DC	direct current
EATL	Eastern Alberta Transmission Line
km	kilometer
kV	kilovolt
LTO	AESO's Long-term Outlook
LTP	AESO's Long-term Transmission Plan
MATL	Montana-Alberta Tie Line
MVA	megavolt ampere
MVA _r	megavolt ampere reactive
MW	megawatt
NID	Needs Identification Document
OTP	Optimal Transmission Planning
RAS	Remedial Action Scheme
TFO	legal owner of a transmission facility
TPL	Transmission Planning Standards (part of the Alberta Reliability Standards)
VA _r	volt ampere reactive
WATL	Western Alberta Transmission Line

1. Introduction

The *Electric Utilities Act* and the *Transmission Regulation* require the Alberta Electric System Operator (AESO) to forecast the needs of Alberta and plan, for at least the next 20 years, a transmission system that satisfies the Alberta Reliability Standards (ARS).²

The 2025 Long-Term Transmission Plan (LTP) identified reliability violations in the Lethbridge area, specifically thermal overloads on the 138 kV system serving load in and around the City of Lethbridge under transmission contingency conditions.³ The AESO investigated these violations further and determined that transmission development is required to reliably serve load in the future.

The AESO conducted transmission planning studies to identify the need, evaluated transmission development options, and selected the Preferred Transmission Development to mitigate the constraints. These activities were undertaken to ensure compliance with the ARS, the *Electric Utilities Act*, and the *Transmission Regulation*.

1.1 Study Area

The Lethbridge System Development Study Area (Study Area) consists of Lethbridge (Area 54) and a subset of the Fort Macleod (Area 53) and Glenwood (Area 55) planning areas. The Study Area covers the 138 kV transmission system between East Stavely 928S, North Lethbridge 370S, Magrath 225S, Stirling 67S, and Coaldale 254S. This area is primarily an urban load center surrounded by wind, solar, and hydro resources.

1.2 Transmission System in the Study Area

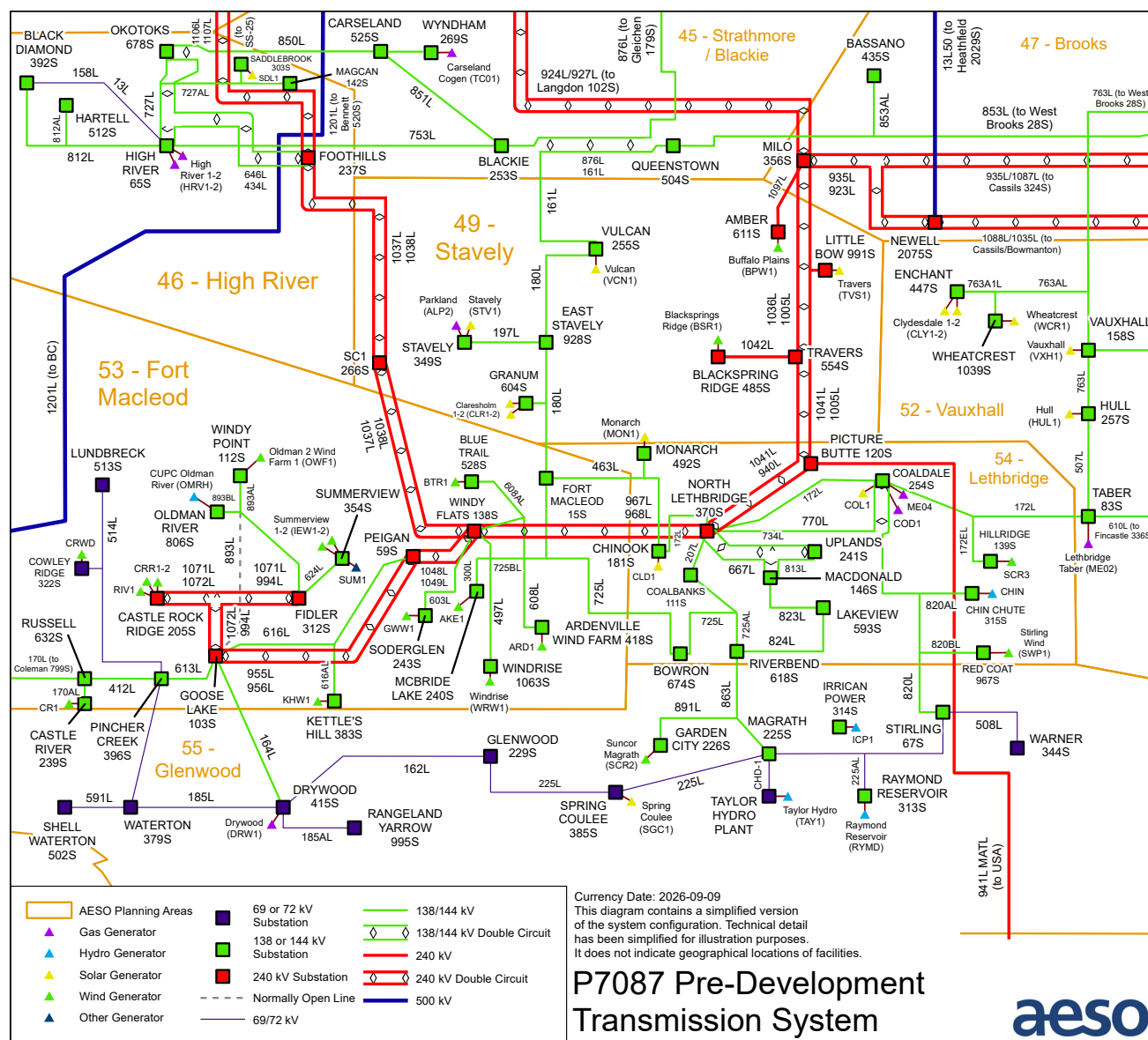
Figure 2 shows the pre-development⁴ transmission system in the Study Area.

² *Electric Utilities Act*, SA 2003, c E-5-1, sections 17(i) and 33(1) and *Transmission Regulation*, Alta Reg 86/2007, sections 8, 10(1) and 15(1)(a).

³ AESO 2025 Long-Term Transmission Plan, Page 49, which is available on the AESO website.

⁴ The pre-development transmission system is the existing transmission system and connection projects which met the project inclusion criteria.

Figure 2: Pre-Development Transmission System



1.3 Study Objectives

The study objectives were to:

- Assess the need for transmission development in the Study Area
- Propose transmission development options to alleviate the constraints
- Evaluate the transmission development options
- Select a Preferred Transmission Development to address the need

1.4 Study Scope

The AESO completed studies as described in this section:

- **Need Assessment**

The AESO evaluated system performance to determine the need for transmission development using power flow and voltage stability analysis. The analysis was performed for the pre-development system.

- **Transmission Development Options**

The AESO considered the following transmission development options to resolve the thermal overloads on 207L (North Lethbridge 370S – Coalbanks 111S):

- Option 1: Upgrade 138 kV transmission line 207L to a 160MVA Rating
- Option 2a-f: Add a fourth path from the 240 kV system to the city of Lethbridge
- Option 3a: Upgrade Coalbanks 111S substation - Phase Shifting Transformer
- Option 3b: Upgrade Coalbanks 111S substation - Flow Control Device

- **Technical Assessment of the Transmission Development Options**

The AESO determined the efficacy of each Option through power flow analysis.

- **Selection of the Preferred Transmission Development**

The AESO selected the Preferred Transmission Development based on a comparison of technical performance, cost, and environmental and land use effects.

2. Transmission Reliability Standards and Criteria

The AESO evaluated system performance considering the ARS for transmission planning (the TPL standards) and the *Transmission Planning Criteria – Basis and Assumptions*.⁵

The TPL standards (including TPL-001-AB-0 and TPL-002-AB1-0) require that system elements be operated within applicable ratings or limits for:

- Category A system conditions (all elements in service)
- Category B contingencies (single element outages)

Applicable ratings include:

- Thermal ratings
 - For transmission lines, the seasonal normal ratings
 - For transformers, the highest specified normal and emergency rating
- Voltage limits
 - For Category A conditions:
 - The Normal Minimum and Normal Maximum voltage range in Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions*
 - For Category B contingency conditions:
 - The Extreme Minimum and Extreme Maximum voltage range in Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions*

⁵ Attachment A: Transmission Planning Criteria – Basis and Assumptions

3. Study Assumptions

3.1 Study Years

The AESO conducted the technical assessment for years 2030, 2035, and 2045.

- The year 2030 was selected based on the anticipated need and the earliest possible in-service year of the Preferred Transmission Development.
- Years 2035 and 2045 were selected to validate the long-term efficacy of the Preferred Transmission Development.

3.2 Study Scenarios

The AESO performed a market simulation of the study years using AURORA, based on the *AESO 2024 Long-term Outlook (2024 LTO)*. The market simulation process generated a time series of transmission system states representing each hour in the year and then a selection process was used to identify the hours that stress the study area. Specifically, transmission system study conditions were found wherein:

- Load in Area 54 was maximized and generation in Area 54 was maximized
- Load in Area 54 was maximized and generation in Area 54 was minimized
- Load in Area 54 was minimized and generation in Area 54 was maximized
- Load in Area 54 was minimized and generation in Area 54 was minimized

When creating these study conditions, the Eastern Alberta Transmission Line (EATL) and the Western Alberta Transmission Line (WATL) were dispatched to minimize losses, generators were dispatched according to economic merit, the interties were dispatched according to economic merit, and generator dispatch was not limited by transmission constraints.

The AESO developed study cases for the scenarios shown in Table 1. Additional details regarding Table 1 are provided in the following sections.

Table 1: Study Scenarios

Scenario	Year	Generation Pattern	Area 54 Load (MW)	Season	EATL (MW) (+ N→S)	WATL (MW) (+ N→S)
1	2030	Low	304 (High)	Summer	0	-100
2	2030	Low	122 (Low)	Winter	0	-100
3	2030	High	219 (High)	Summer	-500	-800
4	2030	High	134 (Low)	Summer	-100	-400
5	2035	Low	316 (High)	Summer	-1000	-100
6	2035	Low	145 (Low)	Summer	-100	0

Scenario	Year	Generation Pattern	Area 54 Load (MW)	Season	EATL (MW) (+ N→S)	WATL (MW) (+ N→S)
7	2045	Low	354 (High)	Summer	0	0

3.3 Generation, Load, and Transmission Forecast

The study scenarios modelled future load, generation, and transmission as follows:

- Load was based on the 2024 LTO Reference Case forecast
- Generation included existing generators and new generator projects that meet the AESO's project inclusion criteria (based on the project ISD and status as published in the January 2025 Connection Project List)
- Generators were dispatched according to the anticipated economic merit order, and security constraints were not enforced

The study scenarios did not include any planned transmission development in Alberta, except the options under study (when applicable), because no other planned development would affect the conclusions. Details for the load forecast can be found in the supporting information section of the Lethbridge Transmission Development project.⁶

Table 2 provides the detailed generation dispatch in the Study Area.

⁶ Forecast Appendix at www.aeso.ca/grid/transmission-projects/lethbridge-transmission-development/.

Table 2: Study Scenario Generation Dispatch in Study Area

Generator	MC (MW)	Dispatch (MW)						
		Scenario 1 2030	Scenario 2 2030	Scenario 3 2030	Scenario 4 2030	Scenario 5 2035	Scenario 6 2035	Scenario 7 2045
Chin Chute (CHIN)	12.4	11.9	1.3	10.1	8.2	12.1	0	12.4
Suncor Chin Chute (SCR3)	30	0.6	0.5	24.3	28.5	12.7	0.8	4.6
Lethbridge Coaldale (ME04)	6.4	0	0	0	0	0	0	0
Lethbridge Solar (CLD1)	9	0.3	0	8.5	4.8	3.6	0	3
Stirling Wind (SWP1)	115	3.5	3.6	107.2	109.3	27.4	2.3	13.3
Coaldale (COL1)	23	5.6	0	22.9	22.9	0.8	0	2.4
Taylor Hydro (TAY1)	13.7	12.9	2	9.5	8.6	3.9	0	12.9
Suncor Magrath (SCR2)	30	1.1	0	28.9	28.9	2.1	0	2.9
Raymond Reservoir (RYMD)	26	25.5	2.9	12.6	9.7	0	0	17.5
McBride Lake Windfarm (AKE1)	73	0.7	0	68	54.9	4.7	0	19
Claresholm 1&2 (CLR1, CLR2)	133	0.7	0	129.2	33.2	4.2	3.9	13.2
Irrican Hydro (ICP1)	6	4.6	1.0	3.6	3.8	5	0	5
P2729 Coaldale DER (S)	5	2.3	0	5.3	5	2.5	1	0.9
P2729 Coaldale DER (W)	25	12.3	0.1	27.8	26.3	12.9	0.2	5
P2863 Raymond Reservoir BESS	15	7	0	0	0	0	1	0
P2490 TransAlta Tempest MPC	103	1.8	1.7	80.3	94.2	42.3	2.5	15.3
P2466 Prominence	80	19.6	0	77.7	77.4	2.7	1.3	8.2
Total	693.1	98.5	11.8	605.8	507.5	124.8	13	123.2

3.3.1 Generation Project Changes

The study cases were created using the January 2025 Connection Project List. Since then, the status of some planned connection projects changed, as follows:

- Project 2490 TransAlta Tempest was cancelled
- Project 2466 Prominence was cancelled
- Project 2863 Raymond Reservoir BESS capacity was reduced from 15 MW to 8 MW
- Project 3029 Irrican Chin Battery met project inclusion criteria, with a 7 MW capacity

The AESO assessed the project changes to determine whether they would affect the conclusions of this report and made the following adjustments:

- Projects P2466 and P2490 were removed from all short circuit study cases
- Projects P2466 and P2490 were removed from Scenarios 3 and 4
- Canceling projects P2466 and P2490 does not materially affect the other scenarios, so they were not removed from the scenarios
- P2863 and P3029 project changes do not materially affect the conclusions of the study, so they were not adjusted

3.4 Interties

The Alberta Interconnected Electric System (AIES) is connected to British Columbia (BC) via the Alberta-BC intertie (WECC Path 1), to Saskatchewan via the McNeil back-to-back HVDC link (WECC Path 2), and to Montana via MATL (WECC Path 83). Intertie flows do not have a material effect on this study.

3.5 Voltage Profile Assumptions

The study scenarios had voltage profiles that complied with the applicable limits in Section 2 and where possible comply with the Normal Low and Normal High voltage range within Information Document #2010-007RS, *General Operating Practices – Voltage Control* (ID #2010-007RS)

3.6 Transmission Facility Ratings

The study scenarios modelled the facility ratings provided by the TFO. Table 3 and Table 4 provide the ratings of key transmission lines and transformers.

Table 3: Key Transmission Line Ratings in the Study Area

		From Substation	To Substation	Normal Rating
--	--	-----------------	---------------	---------------

Base Voltage (kV)	Transmission Line			Summer (MVA)	Winter (MVA)
138	207L	North Lethbridge 370S	Coalbanks 111S	120	148
138	734L	North Lethbridge 370S	Uplands 241S	167	201
138	667L	North Lethbridge 370S	Macdonald 146S	174	215
138	813L	Macdonald 146S	Uplands 241S	175	215
138	823L	Macdonald 146S	Lakeview 593S	142	174
138	824L	Lakeview 593S	Riverbend 618S	166	199
138	725AL	Riverbend 618S	Riverbend Tap	120	148
138	725L	Riverbend Tap	Coalbanks 111S	122	150
138	725L	Riverbend Tap	Bowron 674S	122	150
138	725L	Bowron 674S	Fort Macleod 15S	118	146
138	463L	Fort Macleod 15S	Monarch Tap	107	138
138	463L	Monarch Tap	Chinook 181S	117	144
138	172L	North Lethbridge 370S	Chinook 181S	117	145
138	863L	Riverbend 618S	Magrath 225S	120	148
138	770L	North Lethbridge 370S	Coaldale 254S	120	148
138	172L	North Lethbridge 370S	Coaldale 254S	119	146
138	820L	Stirling 67S	Coaldale 254S	120	148
138	180L	Fort Macleod 15S	East Stavely 928S	120	148

Table 4: Key Transformer Ratings in the Study Area

Substation	Transformer	Base KV	Rating (MVA)
North Lethbridge 370S	T3	240/138	193.6
	T5		200
	T6		200

3.7 HVDC Power Order Assumptions

The study scenarios dispatched EATL and WATL to minimize system losses and configured the HVDC filters and reactive power compensation to comply with the limits in Table 5 for net reactive power interchange.

Table 5: Limits for VAR Interchange between HVDC and System

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

3.8 Existing and Planned Remedial Action Schemes (RAS) in Study Area

The studies modelled the remedial action schemes in Table 6.

Table 6: List of RAS in the Study Area

APS #	Condition	Action
36	863L line terminal open at Riverbend 618S	Trip Suncor Magrath (SCR2) (mitigates thermal overloads on 225L)
167	1. 820L line terminal open at Coaldale 254S 2. 820L thermal overload at Coaldale 254S	1. Trip Stirling Wind (SWP1) and 820L at Stirling 67S (mitigates thermal overloads on 225L) 2. Trip Stirling Wind (SWP1)
169	725L thermal overload at Bowron 674S	Trip Claresholm 1 & 2 (CLR1 & CLR2)
178	463L thermal overload at either end	Trip Claresholm 1 & 2 (CLR1 & CLR2), followed by Vulcan (VCN1) and Stavely (STV1)
217	180L thermal overload at Fort Macleod 15S	Trip Claresholm 1 & 2 (CLR1 & CLR2)
219	1. 172L thermal overload and 770L line terminal open 2. 770L thermal overload and 172L line terminal open	Trip Stirling Wind (SWP1)

3.9 Considered Contingencies

The studies simulated the Category B (N-1) contingencies listed in Table 7.

Table 7: Contingencies List

Base Voltage (kV)	Branch Name	From Substation	To Substation
138	207L	North Lethbridge 370S	Coalbanks 111S
138	734L	North Lethbridge 370S	Uplands 241S
138	667L	North Lethbridge 370S	Macdonald 146S
138	813L	Macdonald 146S	Uplands 241S
138	823L	Macdonald 146S	Lakeview 593S
138	824L	Lakeview 593S	Riverbend 618S
138	725L/725AL	Riverbend 618S	Coalbanks 111S Bowron 674S
138	725L	Bowron 674S	Fort Macleod 15S
138	463L	Fort Macleod 15S	Chinook 181S
138	172L	North Lethbridge 370S	Chinook 181S
138	863L	Riverbend 618S	Magrath 225S
240/138	T3	North Lethbridge 370S	North Lethbridge 370S
138	180L	Fort Macleod 15S	East Stavelly 928S
138	853L	Queenstown 504S	West Brooks 28S
240	923L	Milo 358S	Langdon 102S
138	770L	Coaldale 254S	North Lethbridge 370S
500	EATL	Newell 2075S	Heathfield 2029S

4. Planning Methodology

To determine the Preferred Transmission Development, the AESO:

- Developed study scenarios based on market simulation results
- Conducted need assessment studies to determine constraints in the Study Area
- Identified transmission development options to alleviate the transmission system constraints
- Evaluated the performance of the transmission development options
- Selected a Preferred Transmission Development
- Further evaluated the performance of the Preferred Transmission Development through loss and short circuit analysis

4.1 Technical Studies

The AESO conducted analysis for the system as-is to show upgrades are required. These analyses were repeated with various transmission development options to show how the options alleviate the constraints or impact the transmission system.

4.1.1 Power Flow

The analysis calculated power flows and voltages for each scenario in Table 1 and each contingency in Table 7. All elements listed in Table 3 and Table 4 were monitored.

4.1.2 Voltage Stability

The analysis calculated the static voltage stability limit for the low-generation scenarios in Table 1 and each contingency in Table 7 by:

- Defining Area 54 as the sink system and Northwest, Northeast and Edmonton Planning Regions as the source system
- Increasing the transfer from source to sink in small increments and recalculating power flow at each increment to find the transfer level at which voltage collapse occurs
 - As power transfer into Area 54 increases, post-contingency voltages in Area 54 decrease
- Establishing a transfer limit that allows for a 5% margin relative to the nose point, per WECC Practice⁷

4.2 Sensitivity Studies

The AESO assessed the performance of the Preferred Transmission Development through the following sensitivity studies.

⁷ Guide to WECC/NERC Planning Standards I.D: Voltage Support and Reactive Power - <https://apiproxy.utc.wa.gov/cases/GetDocument?docID=1768&year=2022&docketNumber=220066>.

4.2.1 Loss Analysis

The AESO assessed the impacts of the Preferred Transmission Development on system losses. The analysis calculated the Area 54 losses in every scenario with and without the Preferred Transmission Development.

4.2.2 Short Circuit Analysis

The AESO assessed the short-circuit current levels for the pre- and post-Preferred Transmission Development using the 2030 and 2035 study cases. The analysis determined the maximum three-phase and single line-to-ground short-circuit current levels in the Study Area and vicinity for the following assumptions:

- All existing generators and generation projects which have met the AESO project inclusion criteria in the Lethbridge (Area 54), Glenwood (Area 55), Vauxhall (Area 52), Stavely (Area 49) and Fort Macleod (Area 53) planning areas were turned on
- Machines and loads downstream of the faulted bus were not turned off
- The project changes listed in Section 3.3.1 were modelled in the short circuit studies
- Normal system operation with all transmission elements in service and generation dispatched

5. Need Assessment

The AESO evaluated system performance of the existing transmission system in the Study Area. The evaluation included power flow and voltage stability analysis for the scenarios in Section 3.2.

The results demonstrate the need to reinforce the Lethbridge area transmission system in the near-term. The transmission system cannot reliably serve load during periods of high demand and low generation due to thermal overloads on 207L (North Lethbridge 370S – Coalbanks 111S). This reliability risk will grow more severe as organic load growth in the Lethbridge area continues.

5.1 Power Flow Analysis

The AESO conducted power flow analysis as described in Section 4.1.1 and the results are listed in Table 8 and Table 9.

The results show:

- Category A (N-0) and Category B (N-1) thermal violations in high generation scenarios
- Category B (N-1) thermal violations in high load, low generation scenarios
 - 207L experiences thermal overloads following an 823L contingency
- No voltage range violations were observed

Table 8: Category A Thermal Violations (Existing System)

Scenario	Constraint	Thermal Loading		
		Flow (MVA)	Nominal Rating (MVA)	Loading (%)
3: 2030 Low Load High Generation	172L (Chinook to North Lethbridge)	119.5	117	102.2
	463L (Chinook to Monarch Tap)	119.5	117	102.2
	172L (Coaldale to North Lethbridge)	133.6	120	111.4
	770L (Coaldale to North Lethbridge)	149.9	119	125.9
	180L (Fort Macleod to Claresholm tap)	167.9	120	139.9
	463L (Fort Macleod to Monarch Tap)	118.1	107	110.3
4: 2030 High Load High Generation	172L (Coaldale to North Lethbridge)	127.4	119	107.2

Table 9: Category B Thermal Violations (Existing System)

Scenario	Contingency	Constraint	Thermal Loading		
			Nominal Rating (MVA)	Flow (MVA)	%Loading (%)
1: 2030 High Load Low Generation	823L (Macdonald to Lakeview)	207L (North Lethbridge to Coalbanks)	120	127.7	106.5
3: 2030 Low Load High Generation	172L (Taber to Coaldale)	180L (Fort Macleod to Claresholm Tap)	120	189.2	150
		463L (Fort Macleod to Monarch Tap)	107	125.2	116.8
		172L (Chinook to North Lethbridge)	117	125.7	108.3
		463L (Chinook to Monarch Tap)	117	125.7	108.3
		725L (Bowron to McBride Lake Tap)	118	118.3	100.5
	172L (N Lethbridge to Chinook)	725L (Bowron to McBride Lake Tap)	118	207.9	179.5
		725L (Bowron to Riverbend Tap)	122	187.3	159.8
		172L (Coaldale to North Lethbridge)	119	149.8	129.4
		725L (Coalbanks to Riverbend Tap)	122	150.3	127.9
		180L (Fort Macleod to Claresholm Tap)	120	152	120.4
		725L (Fort Macleod to McBride Lake Tap)	119	138.5	116.8
		770 (Coaldale to North Lethbridge)	120	133.6	114.4
		207L (North Lethbridge to Coalbanks)	120	125.3	108.4
		172L (Coaldale to North Lethbridge)	119	160.3	136.5
		770 (Coaldale to North Lethbridge)	120	142.9	120.7
	207L (North Lethbridge to Coalbanks)	180L (Fort Macleod to Claresholm Tap)	120	173.9	138.5
		172L (Coaldale to North Lethbridge)	119	148.5	127.5
		463L (Fort Macleod to Monarch Tap)	107	127	120.1
		770 (Coaldale to North Lethbridge)	120	132.4	112.7
		463L (Chinook to Monarch Tap)	117	126.6	110.9
		172L (Chinook to North Lethbridge)	117	126.5	110.7
	370S North Lethbridge T3	180L (Fort Macleod to Claresholm Tap)	120	171.9	137.3
		172L (Coaldale to North Lethbridge)	119	139.8	121.4
		463L (Fort Macleod to Monarch Tap)	107	113.9	108.5
		370S T5 240/138	200	216.6	108.3
		770 (Coaldale to North Lethbridge)	120	124.7	107.4
		370S T6 240/138	200	213.6	106.8
		172L (Chinook to North Lethbridge)	117	113.1	100.5

Scenario	Contingency	Constraint	Thermal Loading		
			Nominal Rating (MVA)	Flow (MVA)	%Loading (%)
		463L (Chinook to Monarch Tap)	117	113.2	100.4
		172L (Coaldale to Hillridge Tap)	119	163.4	139.1
		180L (Fort Macleod to Claresholm Tap)	120	172.3	135.8
		463L (Chinook to Monarch Tap)	117	153.2	132.9
		172L (Chinook to North Lethbridge)	117	153	132.8
		172L (Coaldale to North Lethbridge)	119	152.1	129.9
		770 (Coaldale to North Lethbridge)	120	135.6	114.9
	770L (North Lethbridge to Coaldale)	172L (Coaldale to North Lethbridge)	119	248.4	213.2
		180L (Fort Macleod to Claresholm Tap)	120	178.1	141.7
		463L (Fort Macleod to Monarch Tap)	107	118.7	111.8
		172L (Chinook to North Lethbridge)	117	118.3	103.6
		463L (Chinook to Monarch Tap)	117	118.4	103.6
	853L (West Brooks to Queenstown)	180L (Fort Macleod to Claresholm Tap)	120	219.8	176.8
		463L (Fort Macleod to Monarch Tap)	107	140.1	134.2
		463L (Chinook to Monarch Tap)	117	138.9	123.1
		172L (Chinook to North Lethbridge)	117	138.8	122.9
		172L (Coaldale to North Lethbridge)	119	142	122.6
		725L (Bowron to McBride Lake Tap)	118	130.1	113.7
		770 (Coaldale to North Lethbridge)	120	126.6	108.5
	923L (Milo to Langdon)	180L (Fort Macleod to Claresholm Tap)	120	194.8	156.3
		172L (Coaldale to North Lethbridge)	119	169	147.5
		770 (Coaldale to North Lethbridge)	120	150.7	130.5
		463L (Fort Macleod to Monarch Tap)	107	126.7	121.2
		463L (Chinook to Monarch Tap)	117	125.6	111.5
		172L (Chinook to North Lethbridge)	117	125.5	111.4
		725L (Bowron to McBride Lake Tap)	118	119.1	104
4: 2030 High Load High Generation	172L (N Lethbridge to Chinook)	725L (Bowron to McBride Lake Tap)	118	125.9	107.5
		172L (Coaldale to North Lethbridge)	119	120.9	102
	770L (North Lethbridge to Coaldale)	172L (Coaldale to North Lethbridge)	119	201.1	168.5
	725L (Bowron to Coalbanks)	463L (Chinook to Monarch Tap)	117	117.3	101.8
		172L (Chinook to North Lethbridge)	117	115.9	100.5
5: 2035 High Load Low Generation	823L (Macdonald to Lakeview)	207L (North Lethbridge to Coalbanks)	120	129.7	110.2

Scenario	Contingency	Constraint	Thermal Loading		
			Nominal Rating (MVA)	Flow (MVA)	%Loading (%)
7: 2045 High Load Low Generation	823L (Macdonald to Lakeview)	207L (North Lethbridge to Coalbanks)	120	134.6	110.4

5.2 Existing Solutions to Mitigate Thermal Constraints

The Government of Alberta directed the AESO to design and implement the Restructured Electricity Market (REM) and Optimal Transmission Planning (OTP).

- The new framework moves away from the zero-congestion policy
 - With OTP, the AESO will mitigate congestion when the benefits outweigh the costs
- REM introduces security constrained economic dispatch (SCED), which determines the most efficient dispatch of generators and interties while respecting transmission system constraints

SCED, in combination with RAS, may be able to mitigate some of the thermal violations in Section 5.1.

High Generation Thermal Violations

The results in Table 8 and Table 9 show overloads in high renewable scenarios but not in low renewable scenarios. This demonstrates that SCED and RAS can mitigate the overloads:

- 180L, 463L, 172L (Chinook to North Lethbridge) and 725L thermal overloads can be mitigated by existing RAS 169, 178 and 217 and/or economic dispatch of CLR1, CLR2, AKE1, MON1, STV1 and VCN1 generators.
- 172L and 770L (Coaldale to North Lethbridge) thermal overloads can be mitigated by existing RAS 219 and/or curtailment of SWP1, COL1, ME04 and COD1 generators as well as other generation in the Vauxhall region.

Mitigating overloads that can be managed by SCED and RAS is out of scope of this project. The AESO will evaluate these constraints using the OTP framework.⁸

207L (North Lethbridge 370S – Coalbanks 111S) Thermal Violations

The AESO investigated whether SCED could dispatch generation to mitigate the thermal violation on 207L. SCED cannot mitigate this violation:

- Dispatchable generation at Coaldale has a negligible effect on the loading of 207L
- The hydro generation in the Lethbridge and Glenwood area is run-of-river and therefore is not dispatchable
- P2863 Raymond Reservoir BESS is not effective enough to eliminate the constraint. Dispatching the battery from 0 to 7 MW reduces the thermal overload by approximately 1.5%
- All other effective generation in the study area is non-dispatchable

5.3 Voltage Stability Analysis

The AESO conducted P-V analysis as described in Section 4.1.2 and the results are shown in

⁸ The AESO is proposing ISO rule 401.1 – Optimal Transmission Planning, which specifies the requirements for planning transmission.

Table 10 below. Full PV results can be found in Attachment C. The area meets the required 5% margin.

Table 10: Voltage Stability for Low Renewable Scenarios

Scenario	Minimum Incremental Load increase for 5% margin (MW)	Contingency	Maximum Incremental Transfer (MW)	Meets 5% Margin	Load Serving Capability (MW)	Minimum Voltage Bus (138kV)	Minimum Bus Voltage (p.u.)
1. 2030 High Load Low Generation	15.2	Base	128.1	Yes	432.1	181S Chinook	0.946
		172L (Chinook – North Lethbridge)	77.5		381.5	181S Chinook	0.807
		207L (North Lethbridge-Coalbanks)	126.6		430.6	111S Coalbanks	0.923
		823L (Macdonald-Lakview)	127.1		431.1	181S Chinook	0.946
		725L (Bowron-Riverbend-Coalbanks)	126.1		430.1	15S Fort Macleod	0.927
2. 2030 Low Load Low Generation	5.6	Base	>200	Yes	-	-	-
		Any N-1	>200		-	-	-
5. 2035 High Load Low Generation	15.8	Base	>200	Yes	-	-	-
		Any N-1	>200		-	-	-
6. 2035 Low Load Low Generation	7.3	Base	>200	Yes	-	-	-
		Any N-1	>200		-	-	-
7. 2045 High Load Low Generation	17.7	Base	>200	Yes	-	-	-
		Any N-1	>200		-	-	-

6. Transmission Development Options

The AESO considered the following transmission development options to alleviate the constraints.

6.1 Option 1: Upgrade 138 kV Transmission Line 207L

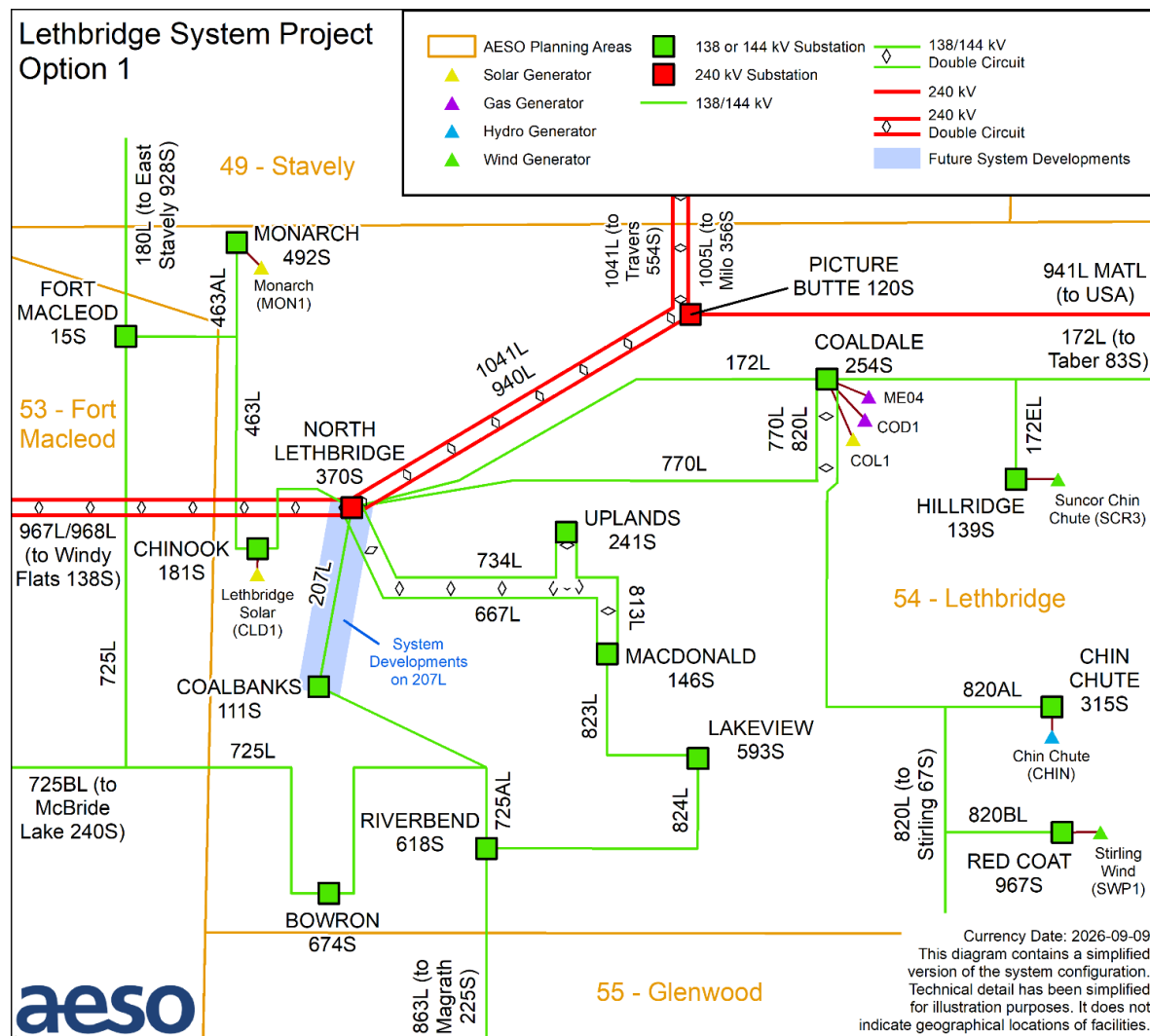
Option 1 includes the following developments:

- Replace the existing conductor on 207L (North Lethbridge 370S – Coalbanks 111S) with a conductor with a minimum summer continuous rating of 160 MVA; and

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

Figure 3 shows the simplified diagram for Option 1.

Figure 3: Option 1



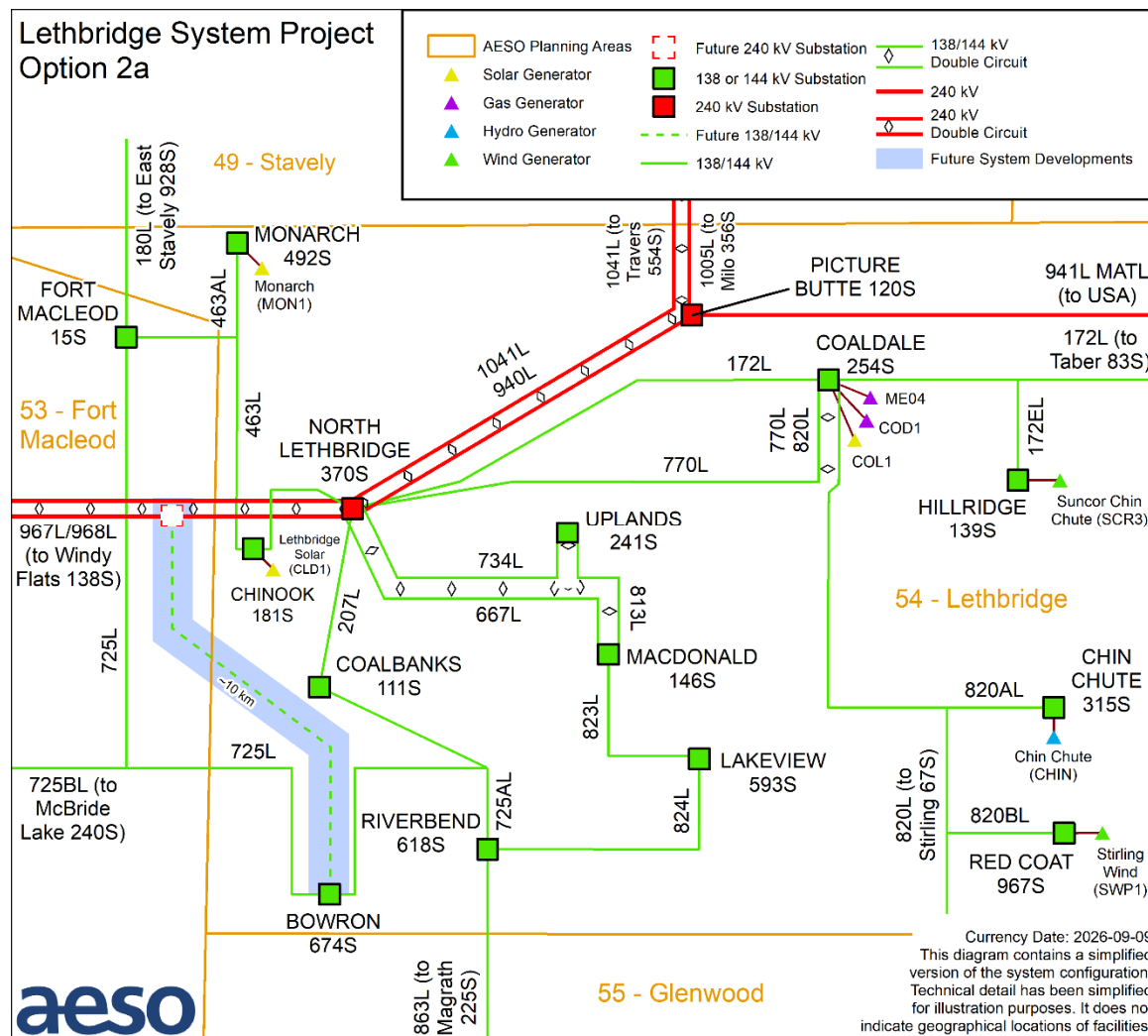
6.2 Option 2a: 240 kV Substation on 968L and 138 kV Circuit to Bowron 674S substation

Option 2a includes the following developments:

- Add a new substation west of Lethbridge, including one 240/138 kV transformer with a minimum continuous rating of 150 MVA, connected to the existing 240 KV line 968L (North Lethbridge 370S – Windy Flats 138S) in an in-and-out configuration;
- Add one 138 kV circuit, with a minimum summer continuous rating of 120 MVA, between the new substation to Bowron 674S; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 4 shows the simplified diagram for Option 2a.

Figure 4: Option 2a



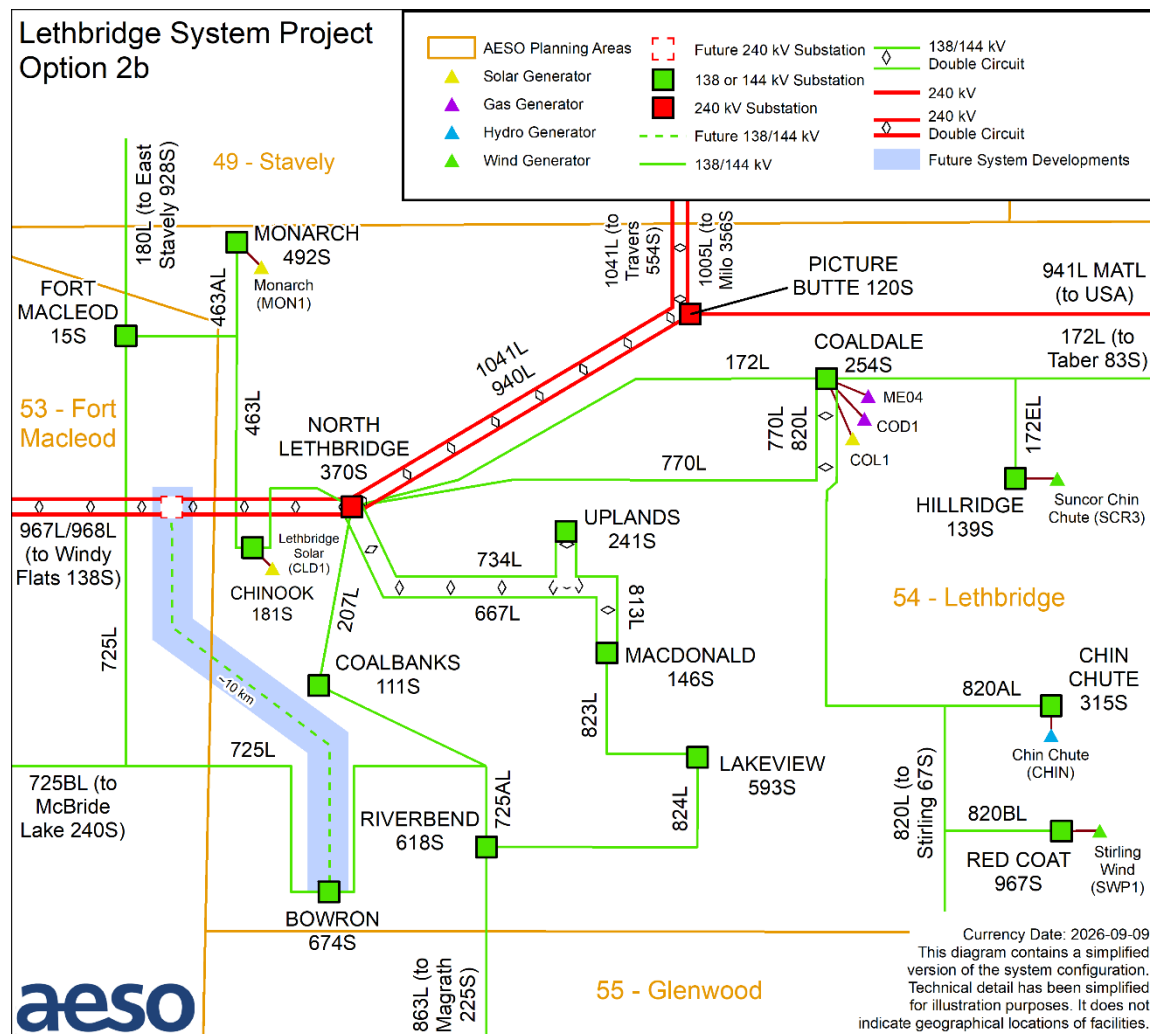
6.3 Option 2b: 240 kV Substation on 968L and 967L and 138 kV Circuit to Bowron 674S substation

Option 2b includes the following developments:

- Add a new substation west of Lethbridge, including one 240/138 kV transformer with a minimum continuous rating of 150 MVA, connected to the existing 240 kV transmission lines 967L and 968L (North Lethbridge 370S – Windy Flats 138S) in an in-and-out configuration;
- Add a new 138 kV circuit, with a minimum summer continuous rating of 120 MVA, between the new substation and Bowron 674S substation; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 5 shows the simplified diagram for Option 2b.

Figure 5: Option 2b



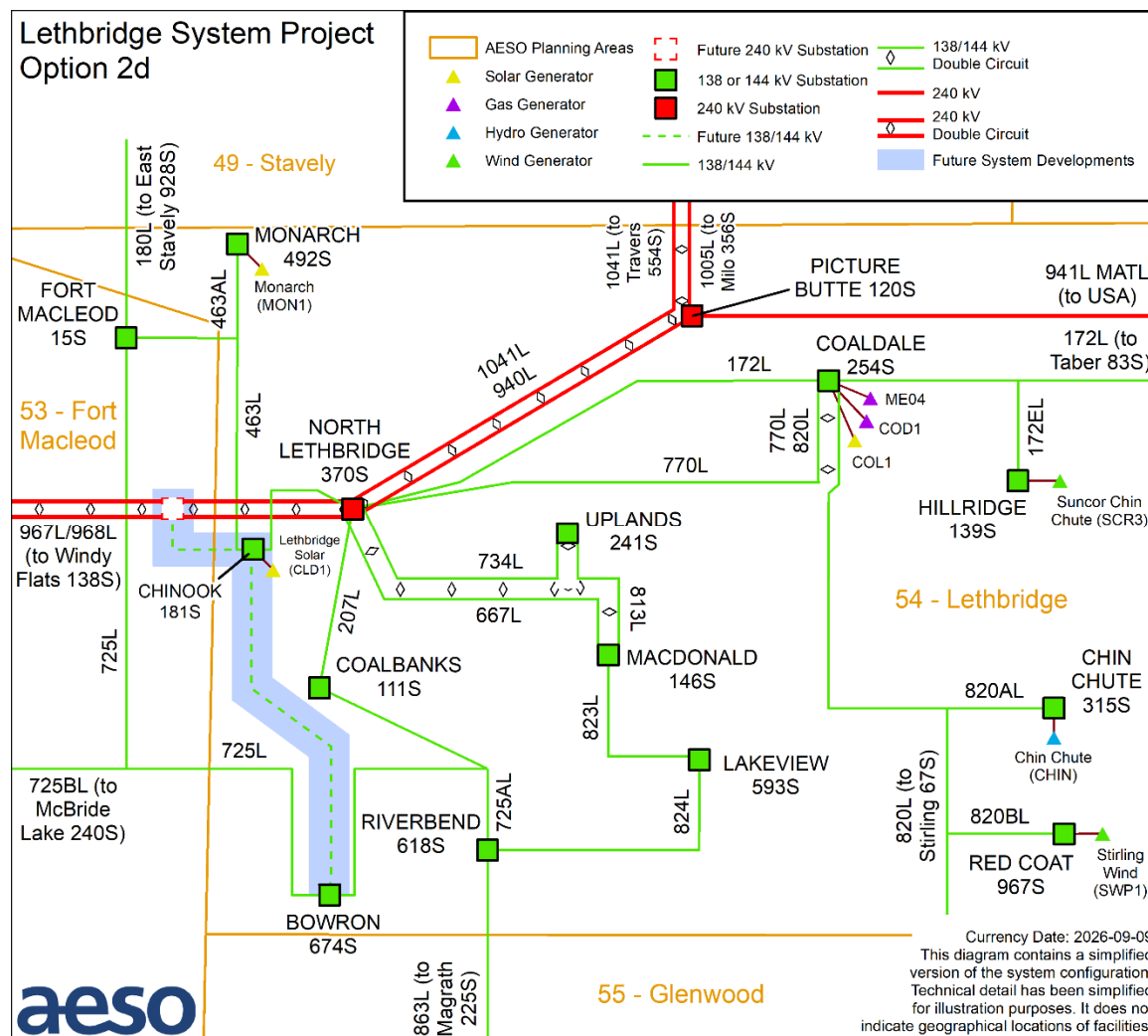
6.5 Option 2d: 240 kV Substation on 968L and 967L and add a 138 kV Circuit to Chinook 181S and Bowron 647S substations

Option 2d includes the following developments:

- Add a new substation west of Lethbridge, including one 240/138 kV transformer with a minimum continuous rating of 150 MVA, connected to the existing 240 kV transmission lines 967L and 968L (North Lethbridge 370S – Windy Flats 138S) in an in-and-out configuration;
- Add a 138 kV circuit, with a minimum summer continuous rating of 120 MVA, between the new substation and Chinook 181S substation;
- Add a 138 kV circuit between Chinook 181S and Bowron 674S substations; and
- Add or modify associated equipment as required for the above transmission developments.

Figure 7 shows the simplified diagram for Option 2d.

Figure 7: Option 2d



6.8 Option 3a: Upgrade Coalbanks 111S substation - Phase Shifting Transformer

Option 3a includes the following developments:

- Upgrade Coalbanks 111S substation, including adding one phase shifting transformer, with a minimum continuous rating of 150MVA, and a phase angle range of +10/-10 degrees, at; and
- Add or modify associated equipment as required for the above transmission developments.

6.9 Option 3b: Upgrade Coalbanks 111S substation - Power Flow Control

Option 3b includes the following developments:

- Upgrade Coalbanks 111S substation, including adding a power flow controller capable of increasing the reactance on 207L by .05 p.u.; and
- Add or modify associated equipment as required for the above transmission developments.

7. Selection of the Preferred Transmission Development

The AESO evaluated the transmission development options described in Section 6 and selected a Preferred Transmission Development. The evaluation included:

- Technical assessments of the transmission system performance
- Cost estimates
- Environmental and land use effects

The following sections provide the evaluation and rationale for the Preferred Transmission Development.

7.1 Technical Assessment

The AESO evaluated the technical performance of the transmission development options for the scenarios with thermal overloads on 207L (North Lethbridge 370S – Coalbanks 111S).

The results demonstrate that all of the transmission development options mitigate the constraints on 207L.

7.1.1 Power Flow Analysis

The AESO analysed the Category B performance of each transmission development option as described in Section 4.1.1 with the results listed in Table 11.

All of the transmission development options mitigate the thermal overloads on 207L in the near-term and long-term scenarios.

Table 11: Category B Thermal Loadings

Option	Constraint	Scenario 1		Scenario 5		Scenario 7	
		Worst Contingency	Loading (%)	Worst Contingency	Loading (%)	Worst Contingency	Loading (%)
1	207L	823L	81%	823L	83%	823L	84%
2a	207L	New Line	74%	823L	82%	New Line	76%
2b	207L	New Line	74%	823L	82%	New Line	76%
2c	207L	823L	74%	823L	79%	823L	76%
2d	207L	823L	73%	823L	79%	823L	76%
2e	207L	823L	73%	823L	78%	823L	76%
2f	207L	823L	73%	823L	78%	823L	76%
3a*	207L	823L	79%	823L	82%	823L	84%
3b**	207L	823L	98%	823L	100%	823L	99%

*assuming a phase shift of +5°

**assuming the full impedance (.05 p.u.)

7.2 Cost Estimates

The AESO directed AltaLink and the City of Lethbridge to provide AACE class 4 cost estimates for the transmission development options in Section 6.⁹ Table 12 provides a summary of the cost estimates for each option. Detailed TFO cost estimates for the Transmission Development Options can be found in the supporting information section of the Lethbridge Transmission Development project page.¹⁰

⁹ The cost estimates are in nominal dollars using a base year of 2025 with escalation considered. These cost estimates have an accuracy level of +50/-30% for the City of Lethbridge and +30/-30% for AltaLink.

¹⁰ See www.aeso.ca/grid/transmission-projects/lethbridge-transmission-development/.

Table 12: Cost Estimates

Option	Description	Cost (\$M)		
		AltaLink (+/- 30%)	City of Lethbridge (+50/-30%)	Total
1	Upgrade 138 kV Transmission Line 207L	5.81	0.226	6.03
2a	240 kV Substation on 968L and 138 kV Circuit to Bowron 674S substation	39.55	18.43	57.98
2b	240 kV Substation on 968L and 967L and 138 kV Circuit to Bowron 674S substation	44.98	18.43	63.41
2c	240 kV Substation on 968L and 138 kV Circuit to Chinook 181S and Bowron 647S substations	39.55	27.36	66.91
2d	240 kV Substation on 968L and 967L and 138 kV Circuit Chinook 181S and Bowron 647S substations	44.98	27.36	72.34
2e	Connect Chinook 181S to 968L and add a 138 kV circuit to Bowron 674S substation	14.14	42.36	56.50
2f	Connect Chinook 181S to 968L and 967L and add a 138 kV Circuit to Bowron	22.96	59.21	82.17
3a	Upgrade Coalbanks 111S- Phase Shifting Transformer	-	19.93	19.93
3b	Upgrade Coalbanks 111S- Power Flow Control	-	42.37	42.37

7.3 Environmental and Land Use Effects

The AESO directed AltaLink and the City of Lethbridge to assess the environmental and land use effects for each option, as contemplated in AUC Rule 007, *Facility Applications*, Section 7.1.1, NID2. The environmental and land use effects information was prepared by the TFOs for their respective service territories. AltaLink compared Transmission Development Options 1 and 2 and the City of Lethbridge compared Options 2a, 2c, 2e, and Option 3.¹¹ Detailed TFO Environmental and Land Use Assessments can be found in the supporting information section of the Lethbridge Transmission Development project page.¹²

AltaLink and the City of Lethbridge determined that all transmission development options are feasible from an environmental and land use perspective. In addition, they concluded:

- Option 1 has the lowest potential environmental and land use effects as no new transmission line development and no substation expansion is required
- All of the Option 2 variants have higher land use impacts than the other Options due to their requirement of the addition of new transmission lines
- Options 3a and 3b have a low land use impact since they require a small expansion of the footprint of Coalbanks 111S, but are located in sensitive habitat

¹¹Options 4a and 4b in the AltaLink and City of Lethbridge assessments are AESO Options 3a and 3b in this Report. Options 3 and 5 in the AltaLink assessment and Option 5 in the City of Lethbridge assessment were later determined to not be technically viable and were therefore not considered for further assessment.

¹² See www.aeso.ca/grid/transmission-projects/lethbridge-transmission-development/.

7.4 Selection of the Preferred Transmission Development

Table 13 provides a summary of the performance comparison for the considered transmission development options.

The AESO selected Option 1 as the Preferred Transmission Development for the following reasons:

- It meets the technical requirements
- It has a significantly lower cost
- It has the lowest environmental and land use effects

Table 13: Comparison of the Transmission Development Options

Option		Technically Viable	Cost (\$M)	Land Impact
1	Upgrade 138 kV Transmission Line 207L	Yes	6.03	Negligible
2a	240 kV Substation on 968L and 138 kV Circuit to Bowron 674S substation	Yes	57.98	High
2b	240 kV Substation on 968L and 967L and 138 kV Circuit to Bowron 674S substation	Yes	63.41	High
2c	240 kV Substation on 968L and 138 kV Circuit to Chinook 181S and Bowron 647S substations	Yes	66.91	High
2d	240 kV Substation on 968L and 967L and 138 kV Circuit Chinook 181S and Bowron 647S substations	Yes	72.34	High
2e	Connect Chinook 181S to 968L and add a 138 kV circuit to Bowron 674S substation	Yes	56.50	High
2f	Connect Chinook 181S to 968L and 967L and add a 138 kV Circuit to Bowron	Yes	82.17	High
3a	Upgrade Coalbanks 111S - Phase Shifting Transformer	Yes	19.93	Low
3b	Upgrade Coalbanks 111S - Power Flow Control	Yes	42.37	Low

7.5 Preferred Transmission Development

The Preferred Transmission Development includes the following developments:

- Replace the existing conductor on 207L (North Lethbridge 370S – Coalbanks 111S) with a conductor with a minimum summer continuous rating of 160 MVA; and
- Add or modify associated equipment as required for the above transmission developments.

The AESO has determined that this constitutes expansion or enhancement of the capability of the transmission system.

8. Additional Assessments for the Preferred Transmission Development

8.1 Loss Analysis

The AESO assessed the system losses pre- and post-development. Table 14 provide the system losses for each scenario. The results demonstrate that the Preferred Transmission Development slightly reduces system losses in high-load scenarios.

Table 14: System Losses with the Preferred Transmission Development

Scenario	Area 54 Losses (MW)		
	Pre Development	Post-Development	Delta
1 – 2030 HL-LG	5.1	4.8	-0.3
2 – 2030 LL-LG	2.1	2.1	0
5 – 2035 HL-LG	13.5	13.2	-0.3
6 – 2035 LL-LG	1.9	1.9	0
7 – 2035 HL-LG	4.3	4	-0.3

8.2 Short Circuit Analysis

The AESO assessed the maximum three-phase fault and single line-to-ground short-circuit current levels for relevant substations. The Preferred Transmission Development has a negligible effect on short circuit currents. The full short circuit result tables can be found in Attachment D.

9. Alignment with AESO's Long Term Plan

The AESO's long-term transmission plans are high-level assessments of transmission capability and required transmission system development in Alberta focusing on broad technical aspects. More detailed studies are performed in preparation of a needs identification document application to ensure that the AESO's Preferred Transmission Development will address the identified reliability violations in the most efficient manner.

The Preferred Transmission Development is aligned with the 2025 LTP. The 2025 LTP identified the need for transmission development on the 138 kV transmission system in the Lethbridge area to reliably serve local load.

10. Project Interdependencies

The Preferred Transmission Development is not dependent on other transmission developments that are currently planned within the AIES in this timeframe.

11. Summary and Conclusions

The AESO conducted transmission planning studies to identify the need, evaluated transmission development options and selected the Preferred Transmission Development to mitigate the constraints. The AESO undertook these activities to ensure compliance with ARS, the *Electric Utilities Act*, and the *Transmission Regulation*.

Need Assessment

The AESO conducted planning studies to assess the performance of the existing transmission system in the Lethbridge Area. The studies observed Category B thermal constraints on 207L (North Lethbridge 370S – Coalbanks 111S).

Preferred Transmission Development

The AESO considered nine different transmission development options to alleviate the constraints on 207L.

Based on the technical performance, cost estimates and environmental and land use effects, the AESO selected the following Preferred Transmission Development to satisfy reliability standards and comply with the *Transmission Regulation*:

- Replace the existing conductor on 207L (North Lethbridge 370S – Coalbanks 111S) with a conductor with a minimum summer continuous rating of 160 MVA

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

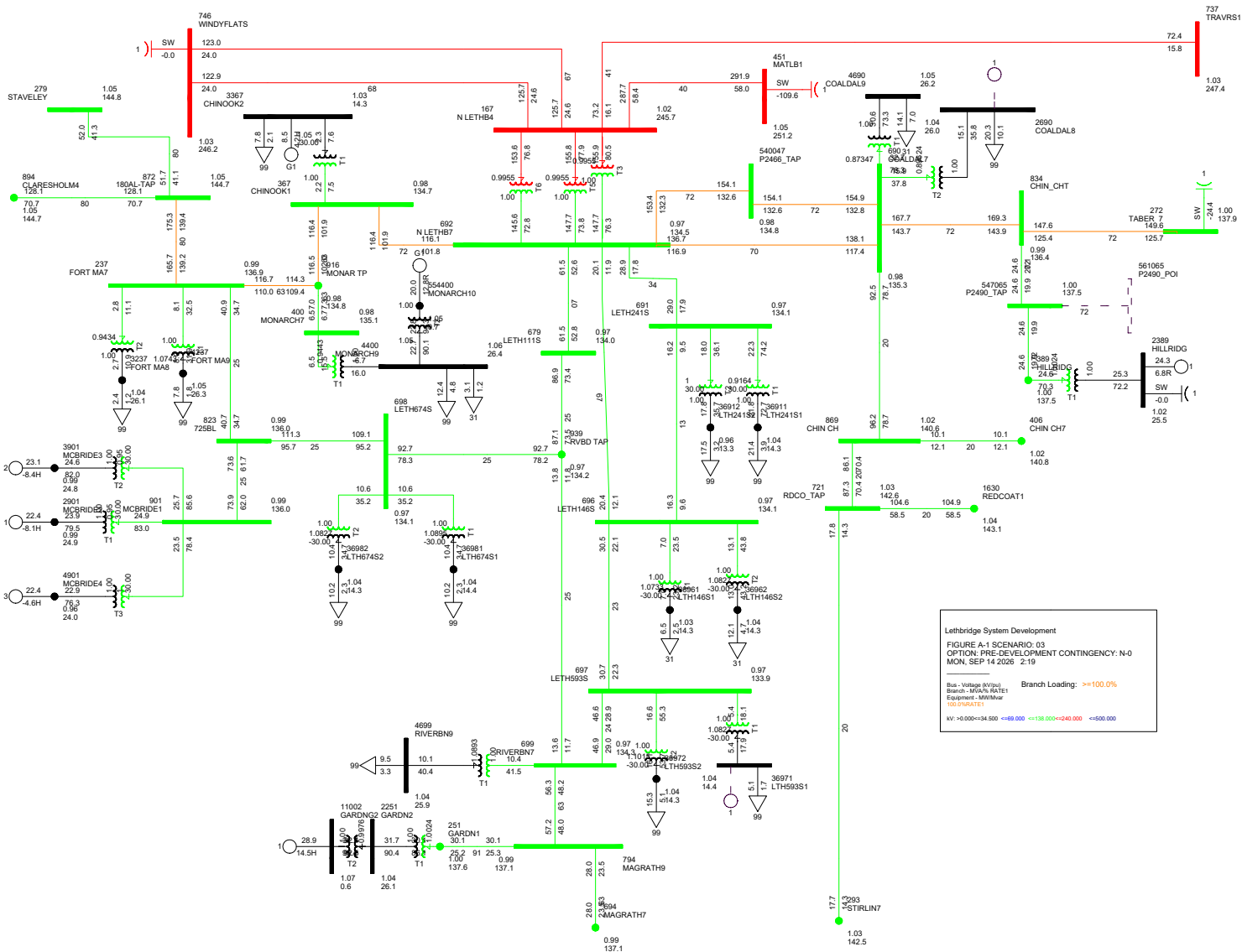
Attachment B:

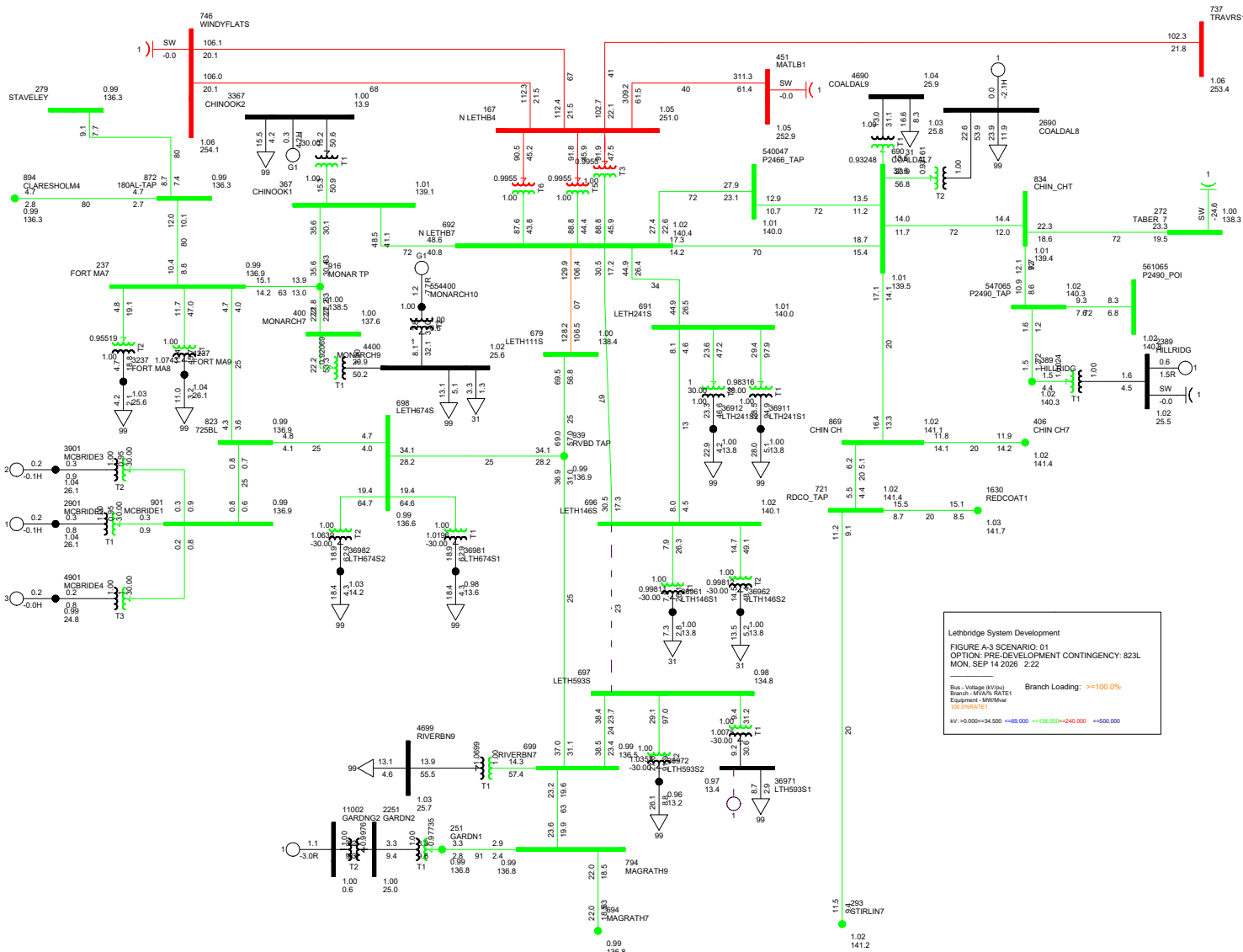
Power Flow Analysis SLDs

Table 15: SLD Legend

SLD	Scenario	Option	Contingency
A-1	3	Pre-Development	N-0
A-2	4	Pre-Development	N-0
A-3	1	Pre-Development	823L
A-4	3	Pre-Development	172L Taber-Coaldale
A-5	3	Pre-Development	172 North Lethbridge to Chinook
A-6	3	Pre-Development	180L
A-7	3	Pre-Development	207L
A-8	3	Pre-Development	370S T3
A-9	3	Pre-Development	770L
A-10	3	Pre-Development	853L
A-11	3	Pre-Development	923L
A-12	4	Pre-Development	172L North Lethbridge to Chinook
A-13	4	Pre-Development	770L
A-14	4	Pre-Development	725L
A-15	5	Pre-Development	823L
A-16	7	Pre-Development	823L
B-1	1	1	823L
B-2	5	1	823L
B-3	7	1	823L
B-4	1	2a	New Line
B-5	5	2a	823L
B-6	7	2a	New Line
B-7	1	2b	New Line
B-8	5	2b	823L
B-9	7	2b	New Line
B-10	1	2c	823L
B-11	5	2c	823L
B-12	7	2c	823L
B-13	1	2d	823L
B-14	5	2d	823L
B-15	7	2d	823L
B-16	1	2e	823L

B-17	5	2e	823L
B-18	7	2e	823L
B-19	1	2f	823L
B-20	5	2f	823L
B-21	7	2f	823L
B-22	1	3a	823L
B-23	5	3a	823L
B-24	7	3a	823L
B-25	1	3b	823L
B-26	5	3b	823L
B-27	7	3b	823L



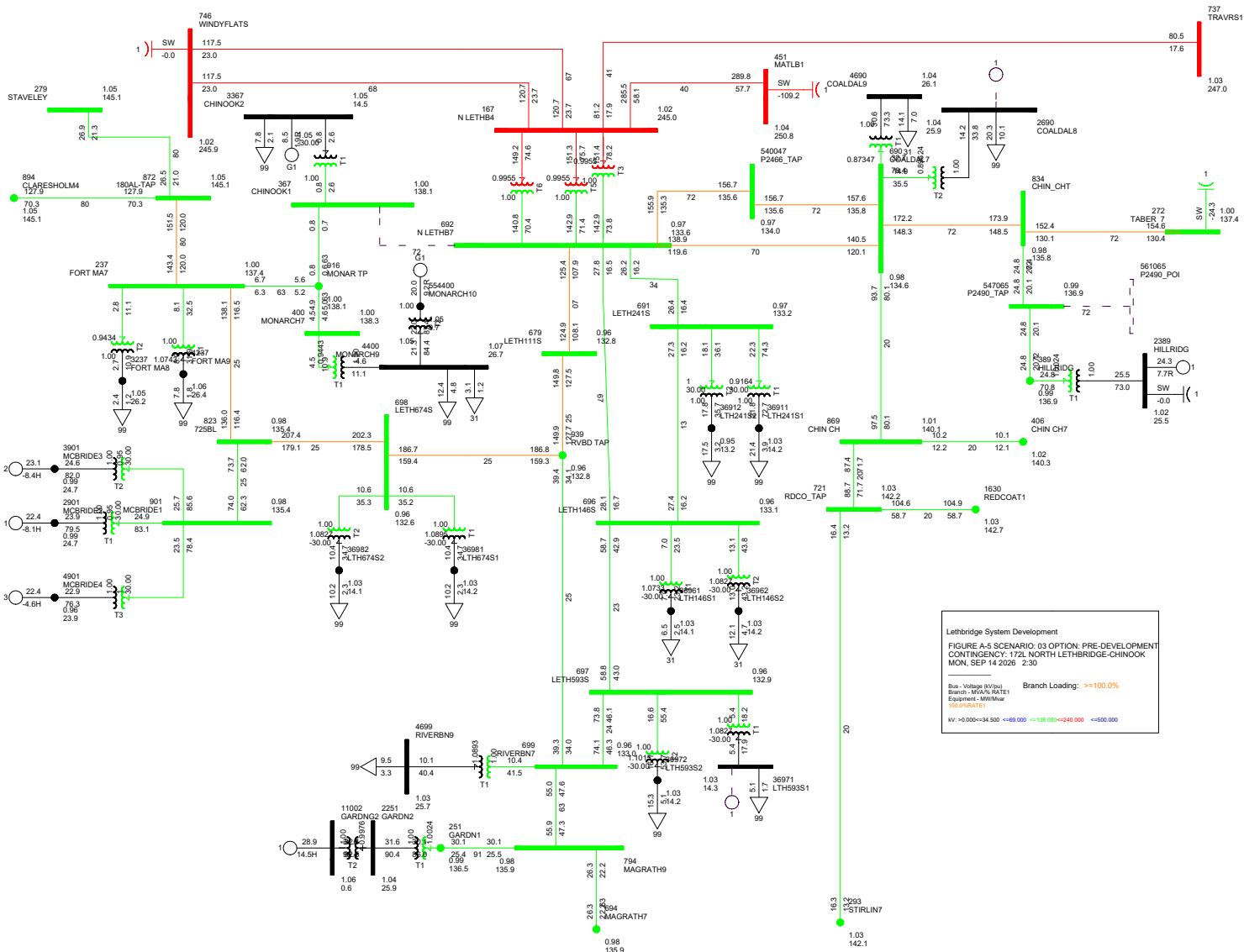


Lethbridge System Development
 FIGURE A-3 SCENARIO: 01
 OPTION: PRE-DEVELOPMENT CONTINGENCY: 823L
 MON. SEP 14 2026 2:22

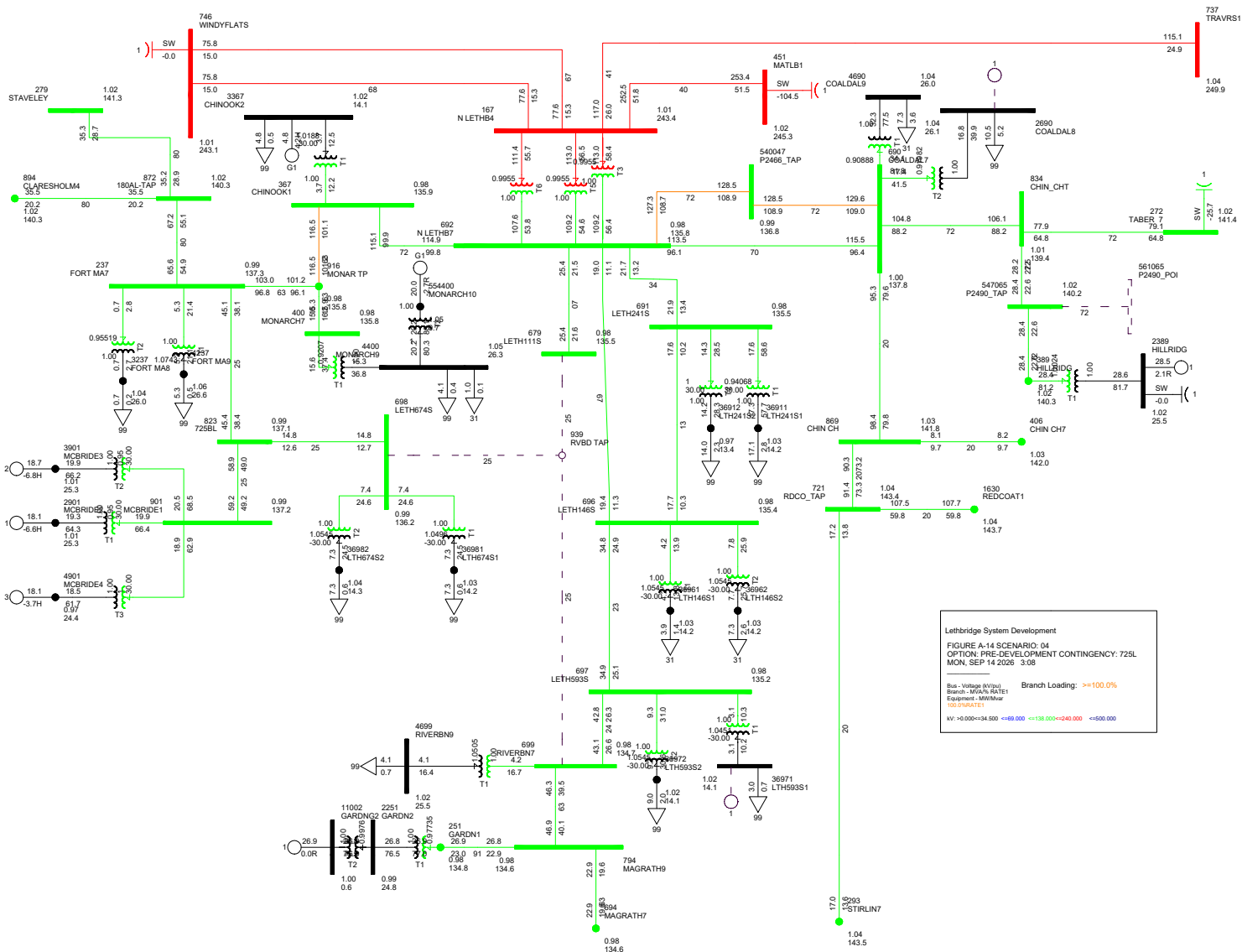
Bus - Voltage (kV) = 100.00
 Branch - MVA/MAT1
 Equipment - MVA/MAT1
 MVA/MAT1

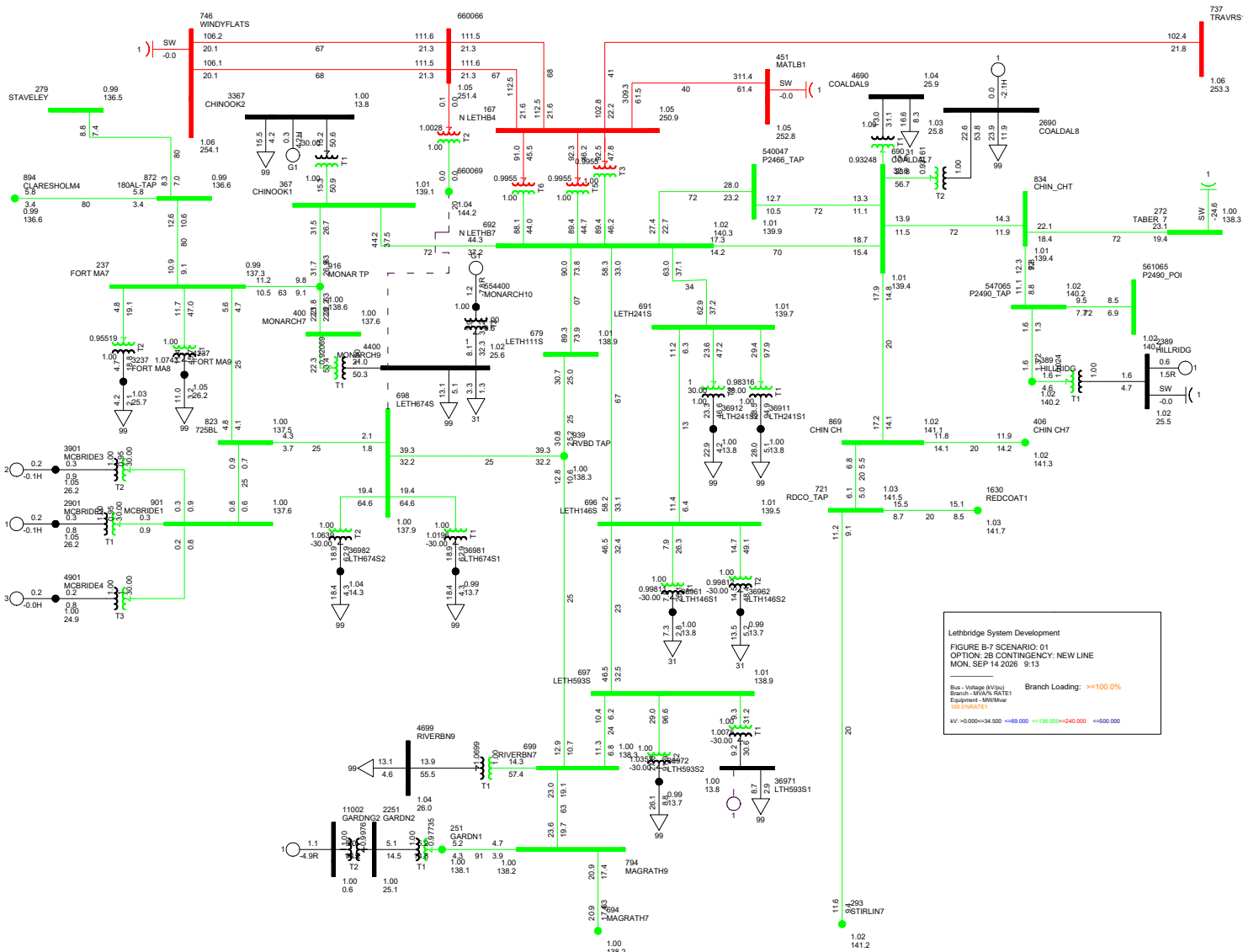
Branch Loading: >=100.0%

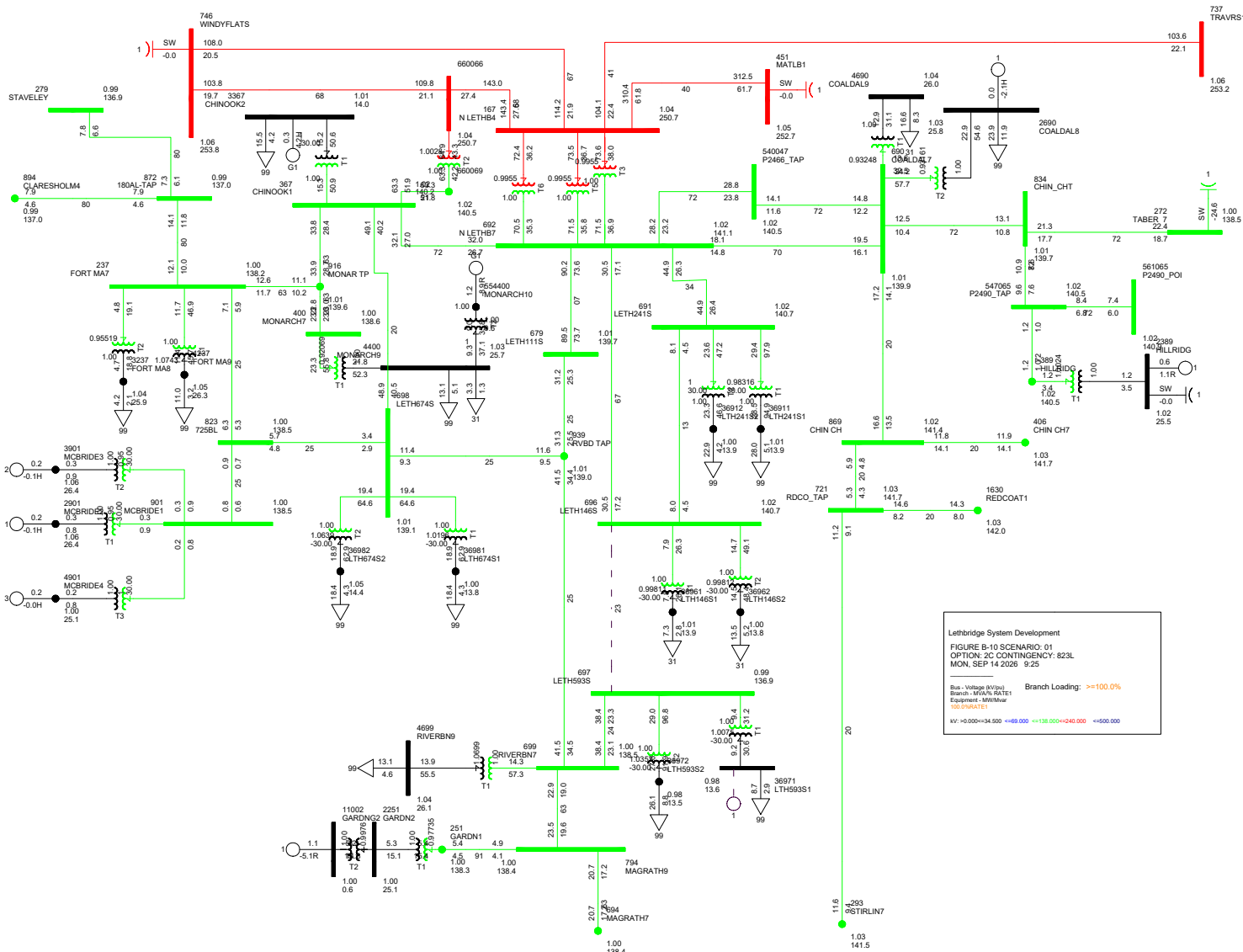
kV: >=100.00 <=100.00 <=100.00 <=100.00 <=100.00

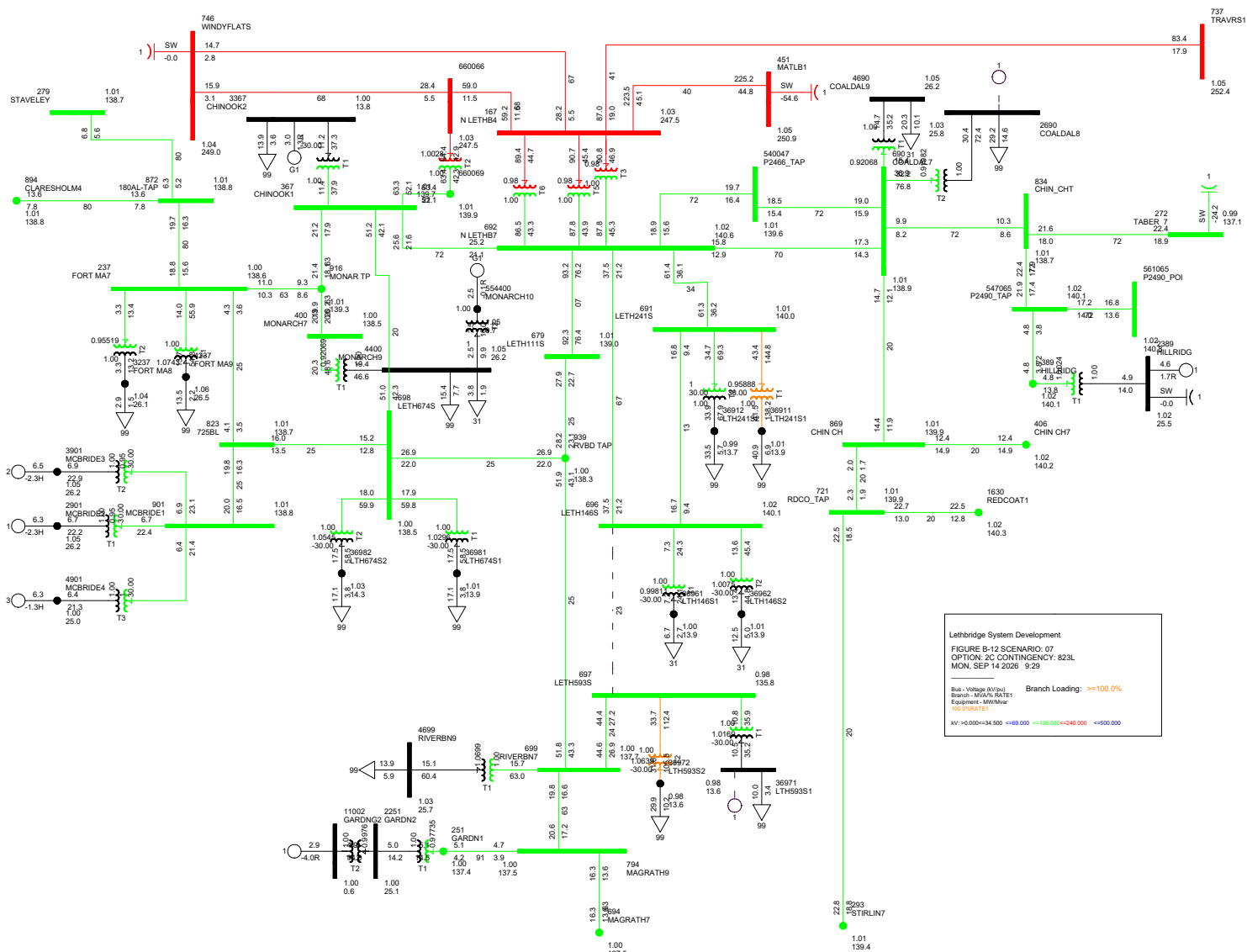


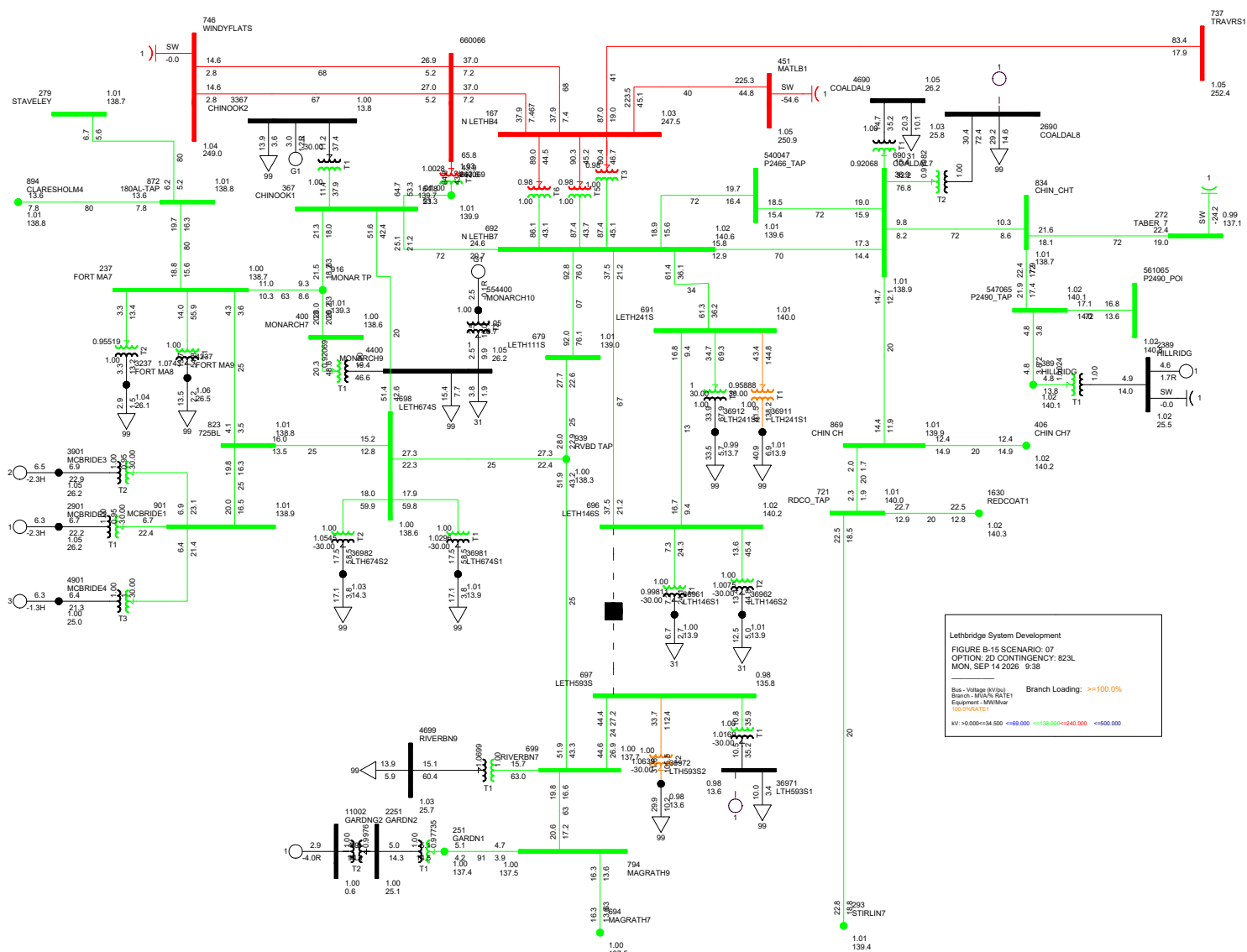


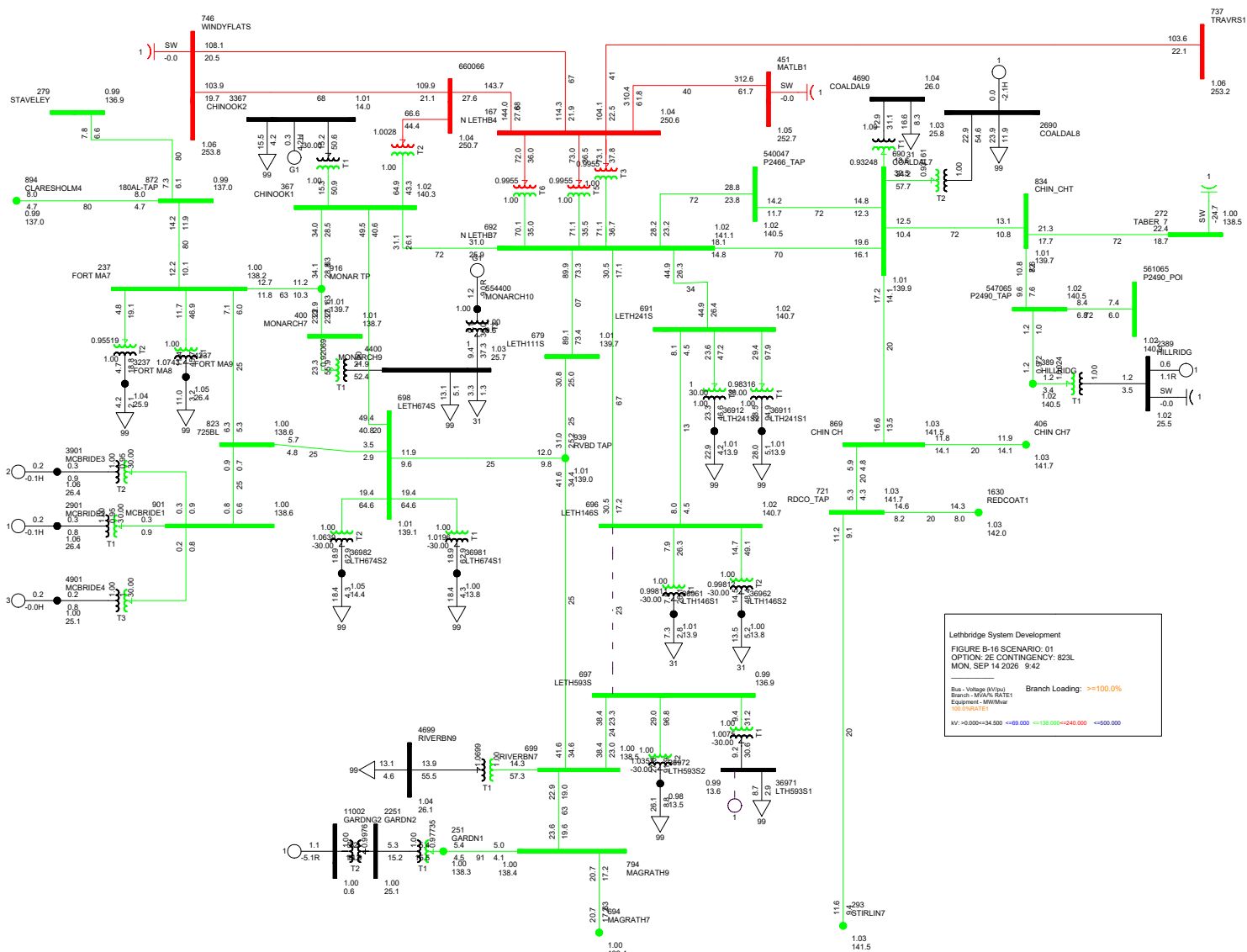


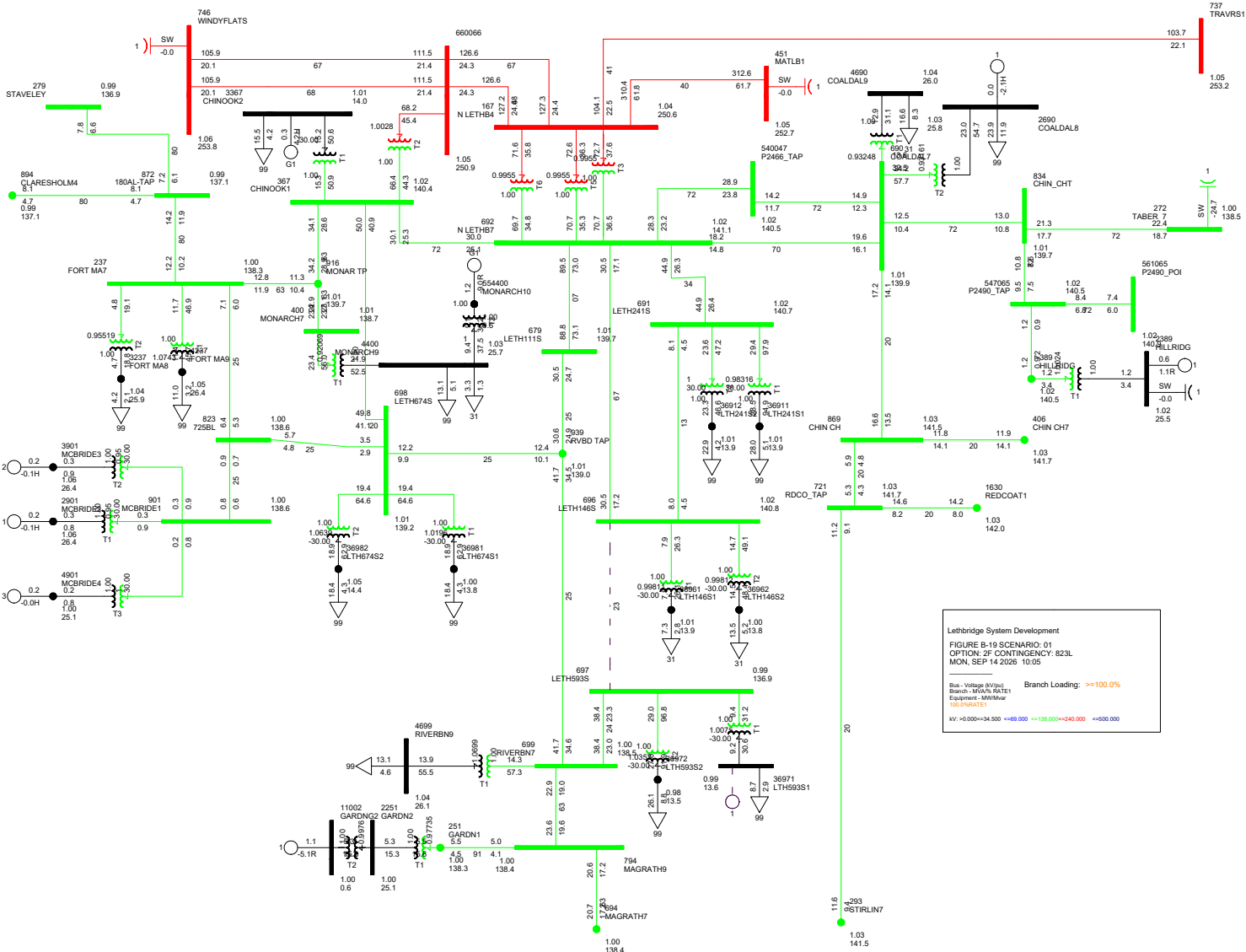


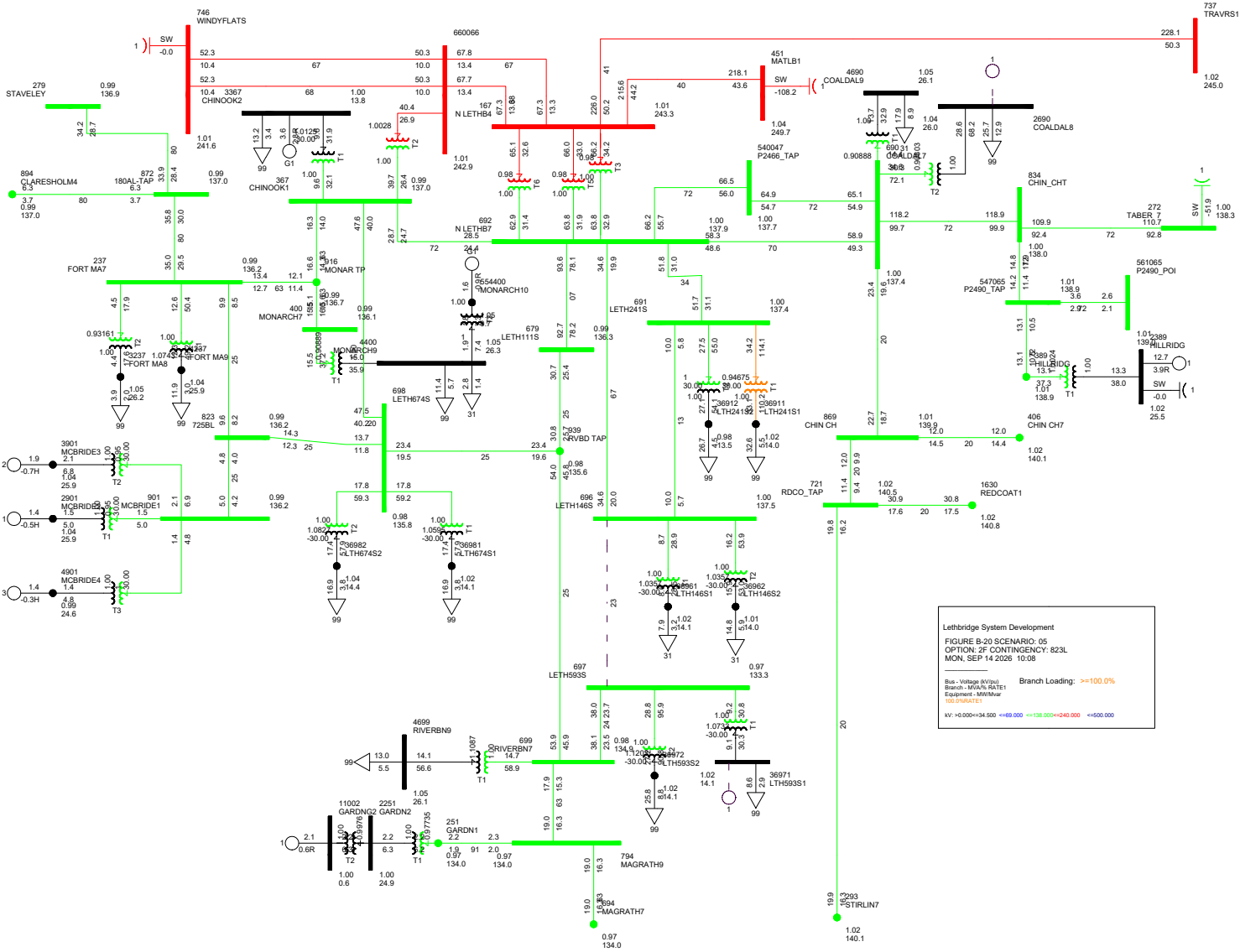


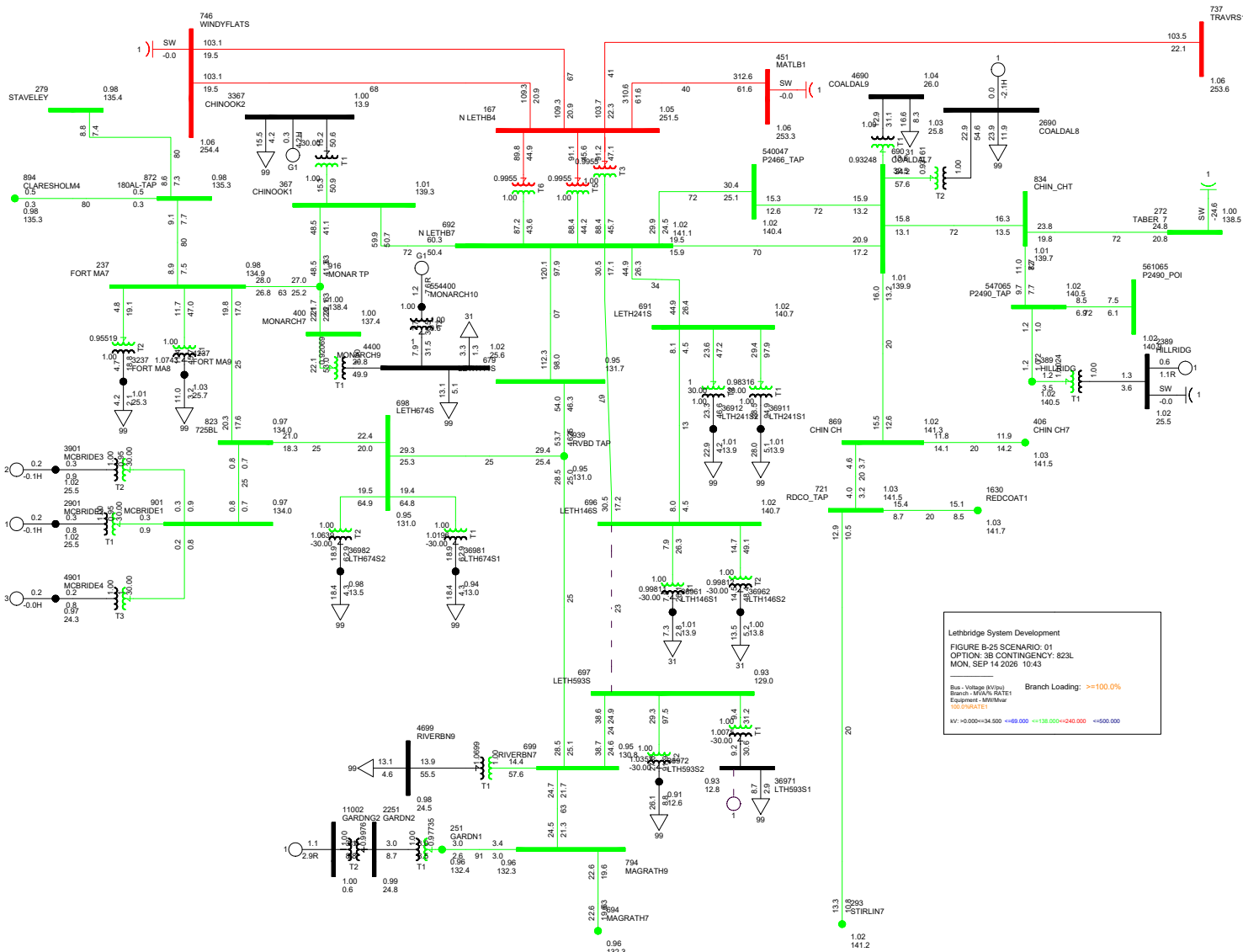










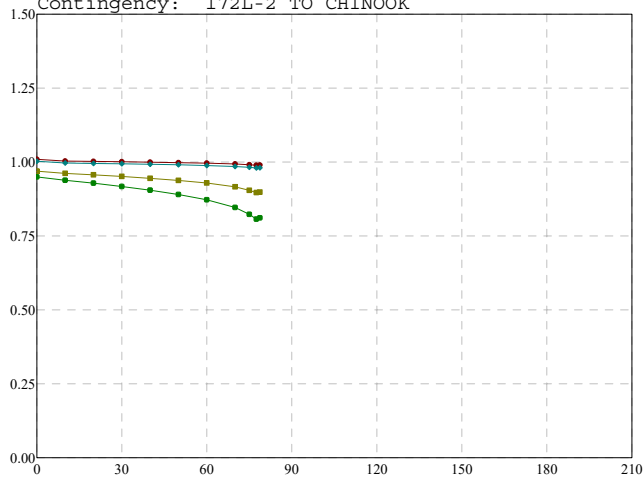


Attachment C:

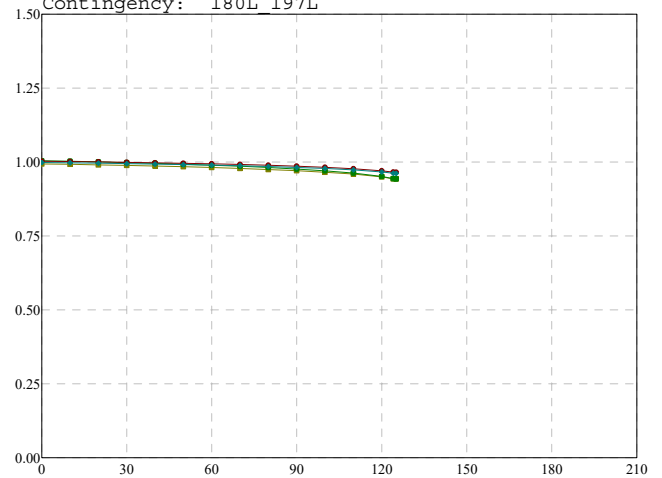
Voltage Stability PV Curves

SCENARIO 01 - 2030 SUMMER
HIGH LOAD - LOW GENERATION
THU, JUL 23 2026 10:52

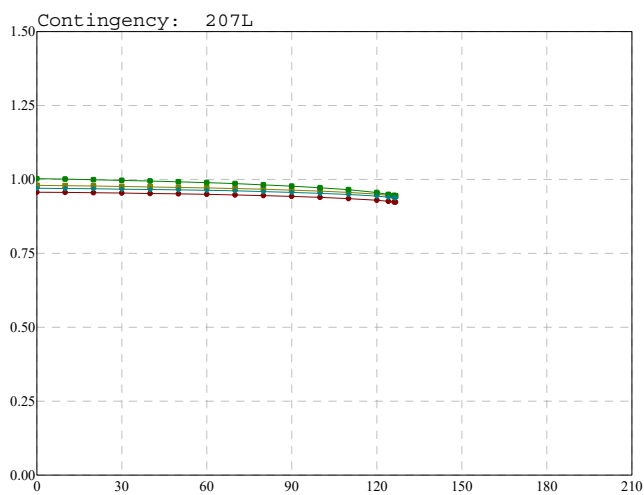
Contingency: 172L-2 TO CHINOOK



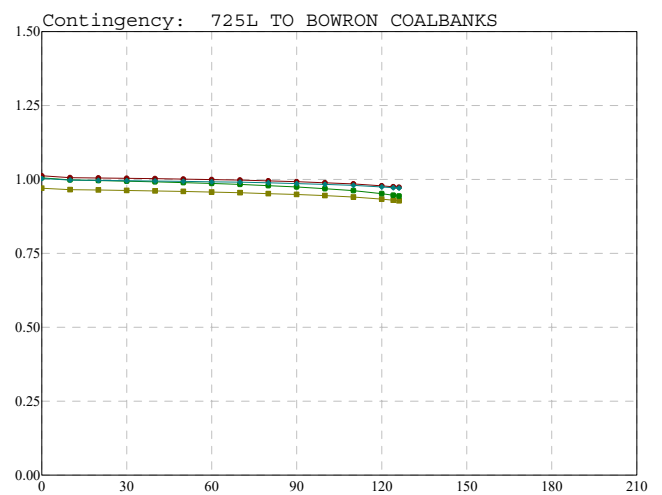
Contingency: 180L_197L



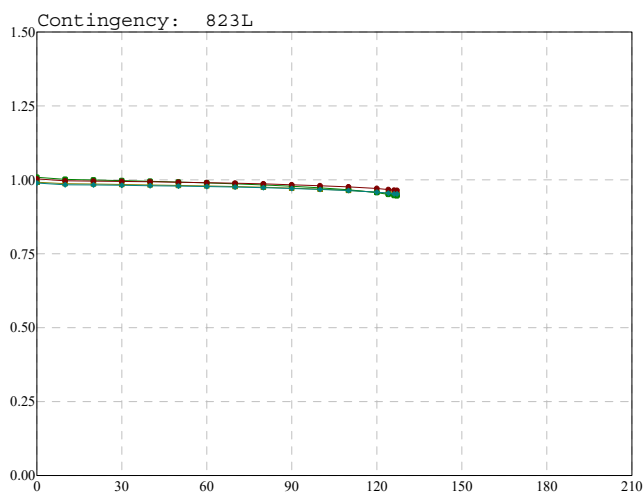
Contingency: 207L



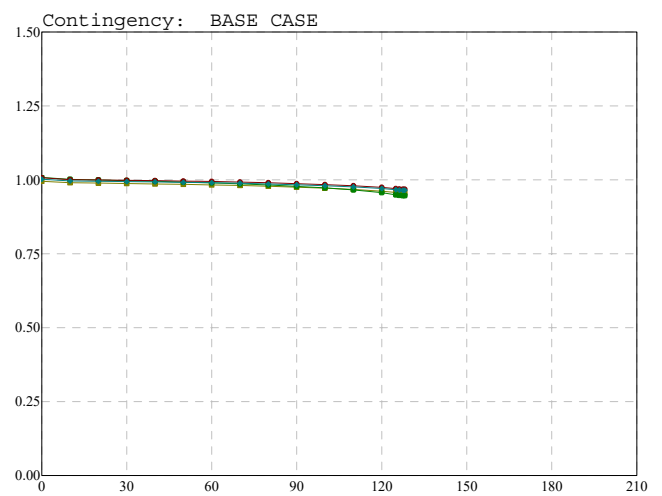
Contingency: 725L TO BOWRON COALBANKS



Contingency: 823L



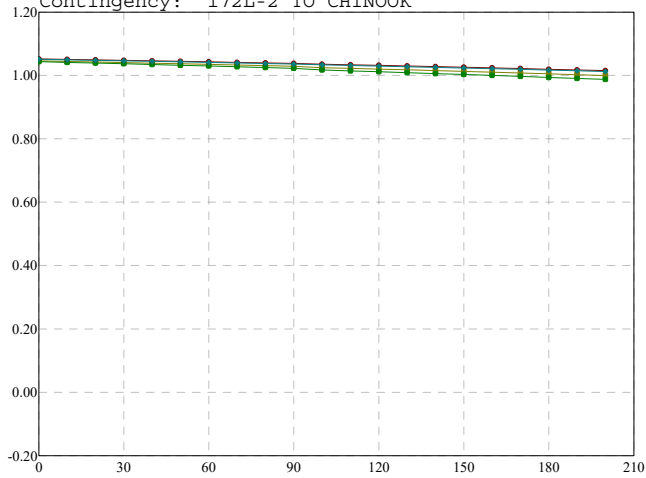
Contingency: BASE CASE



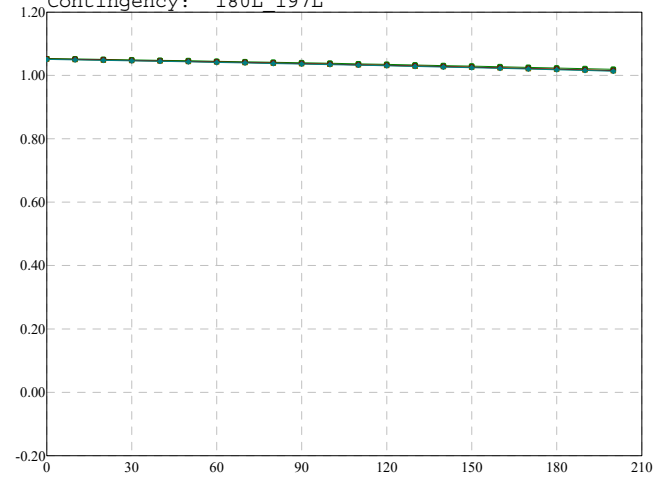
Mark	Bus	
237	FORT MA7	138.00
367	CHINOOK1	138.00
679	LETH111S	138.00
699	RIVERBN7	138.00

SCENARIO 02 - 2030 WINTER
LOW LOAD - LOW GENERATION
THU, JUL 23 2026 12:04

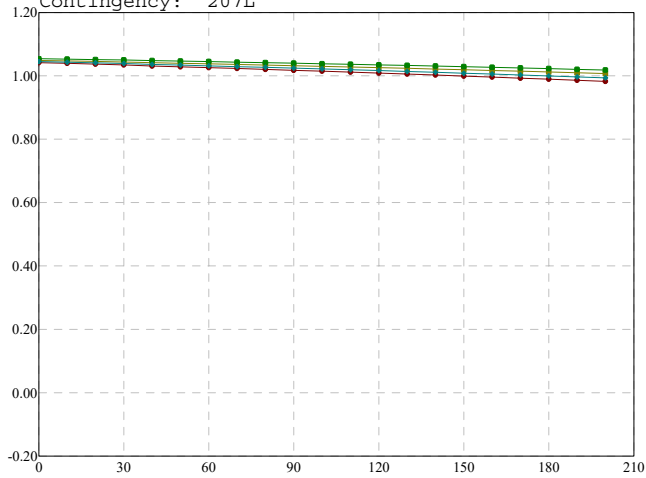
Contingency: 172L-2 TO CHINOOK



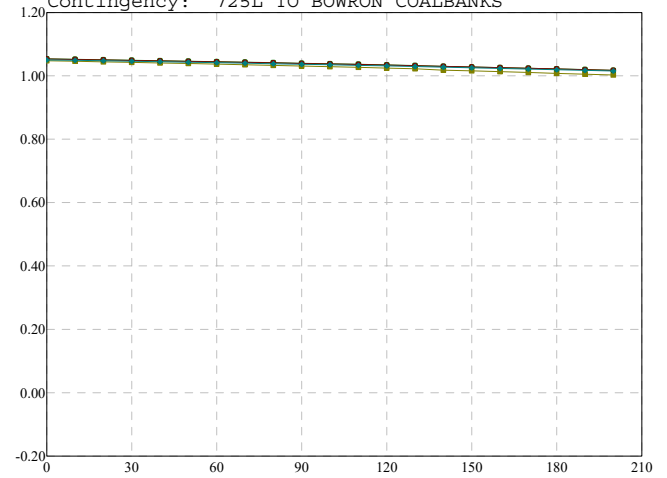
Contingency: 180L_197L



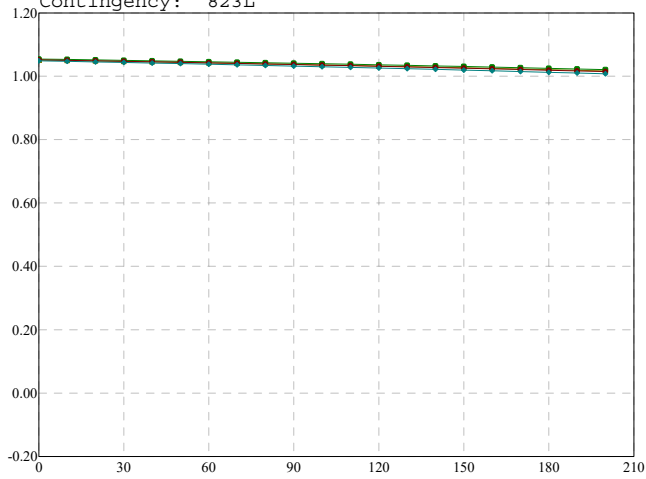
Contingency: 207L



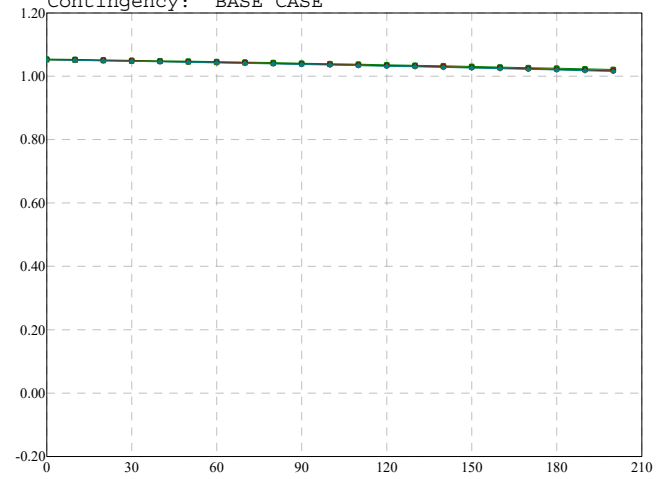
Contingency: 725L TO BOWRON COALBANKS



Contingency: 823L



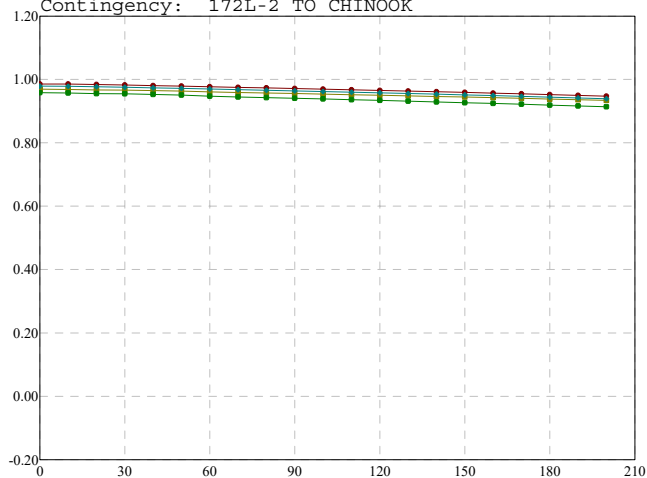
Contingency: BASE CASE



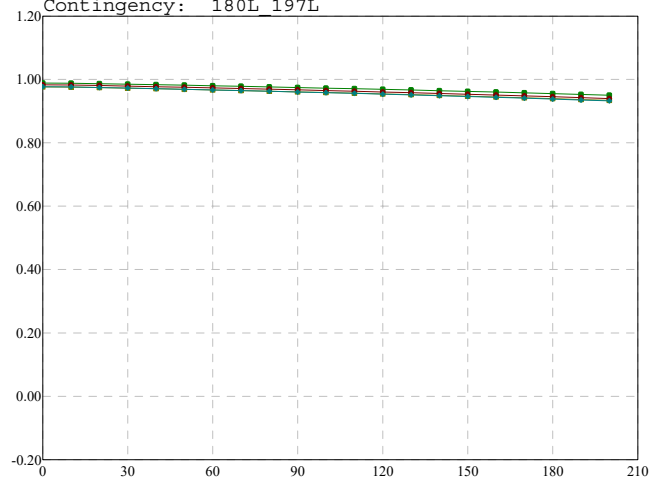
Mark	Bus	
237	FORT MA7	138.00
367	CHINOOK1	138.00
679	LETH111S	138.00
699	RIVERBN7	138.00

SCENARIO 05 - 2035 SUMMER
HIGH LOAD - LOW GENERATION
THU, JUL 23 2026 13:24

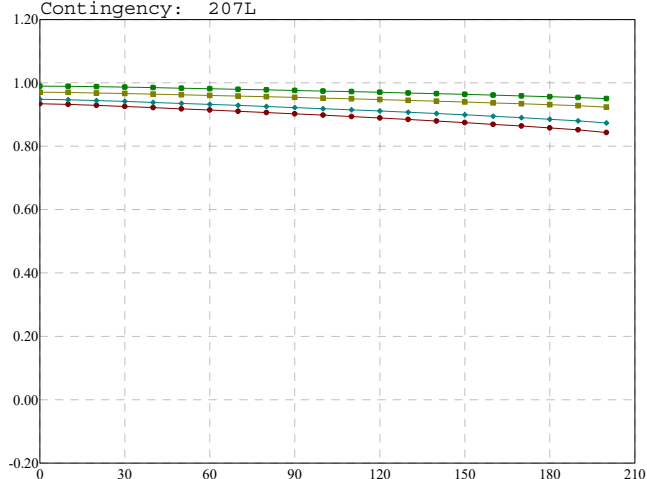
Contingency: 172L-2 TO CHINOOK



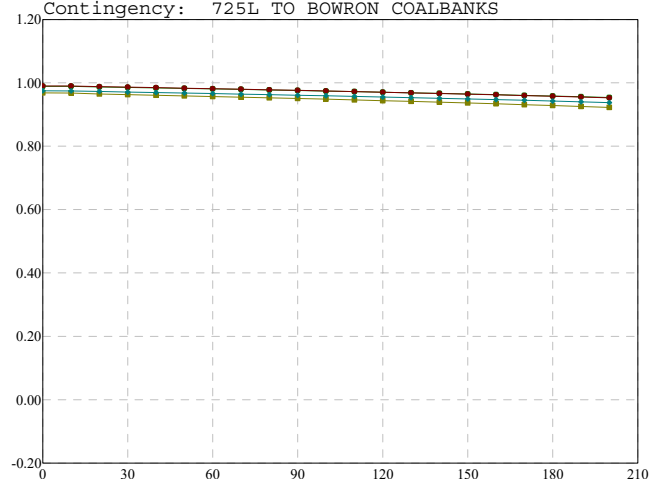
Contingency: 180L 197L



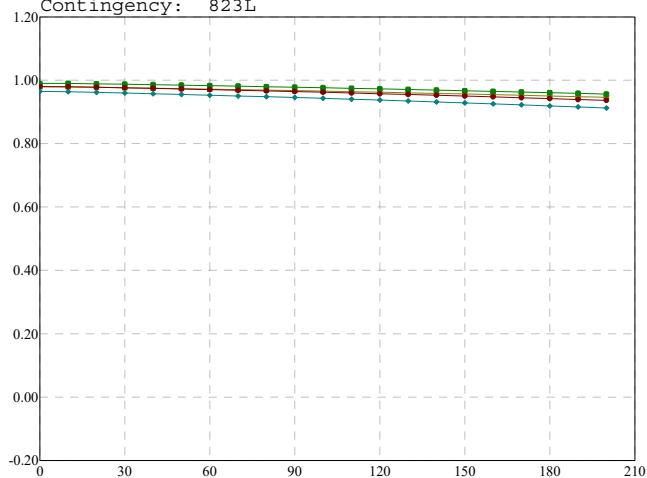
Contingency: 207L



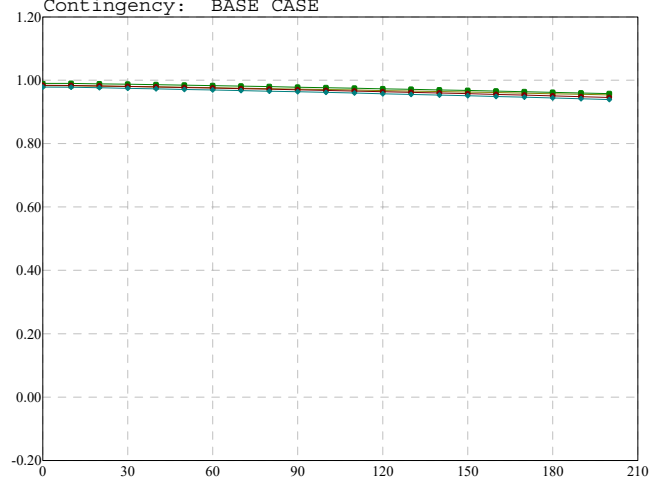
Contingency: 725L TO BOWRON COALBANKS



Contingency: 823L



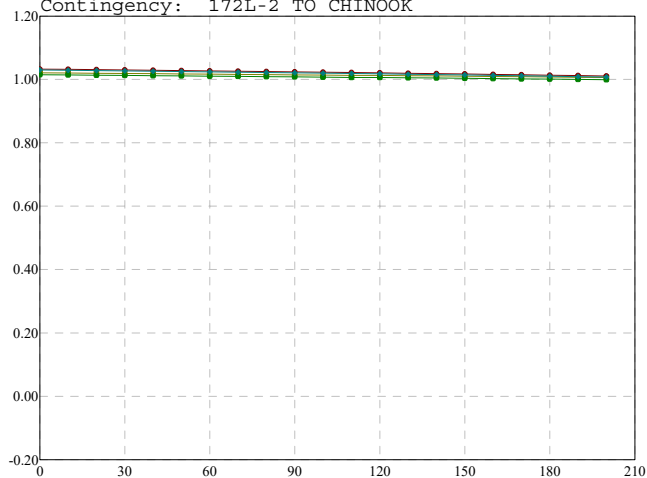
Contingency: BASE CASE



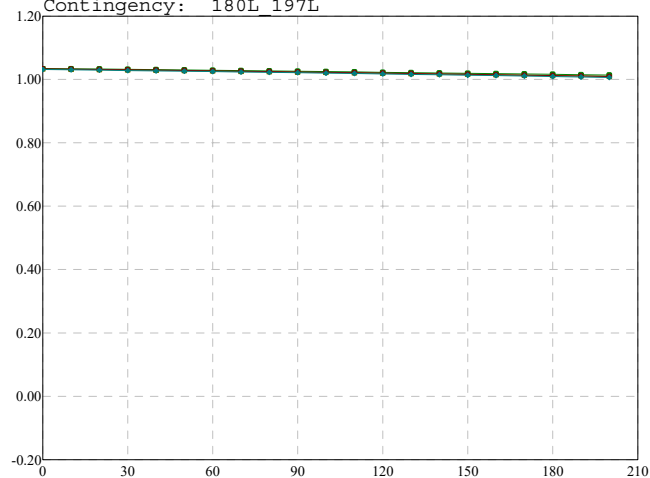
Mark	Bus	
237	FORT MA7	138.00
367	CHINOOK1	138.00
679	LETH111S	138.00
699	RIVERBN7	138.00

SCENARIO 06 - 2035 SUMMER
LOW LOAD - LOW GENERATION
THU, JUL 23 2026 13:35

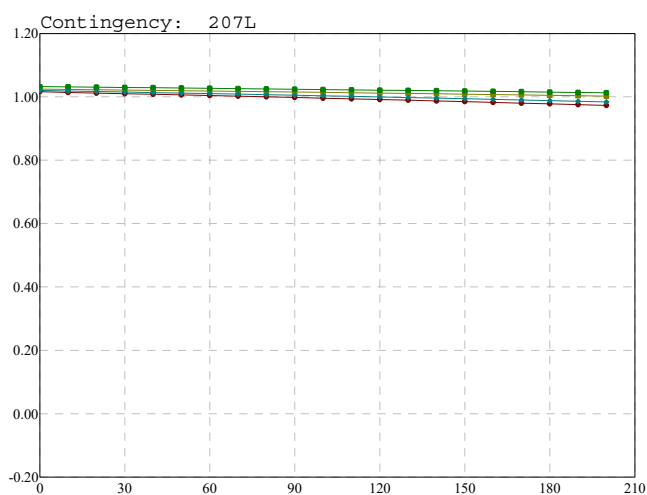
Contingency: 172L-2 TO CHINOOK



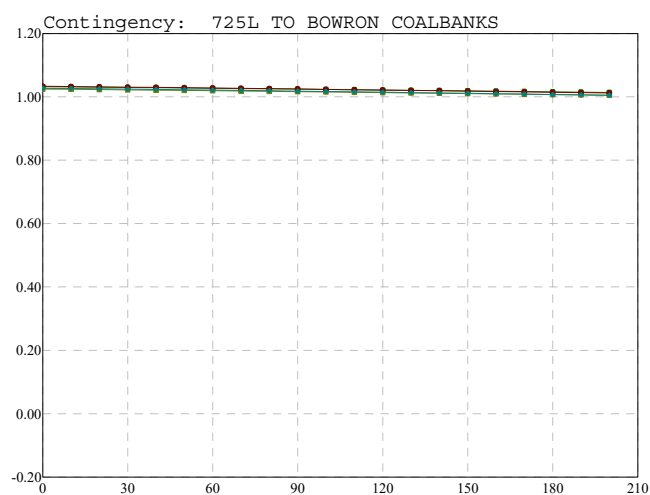
Contingency: 180L_197L



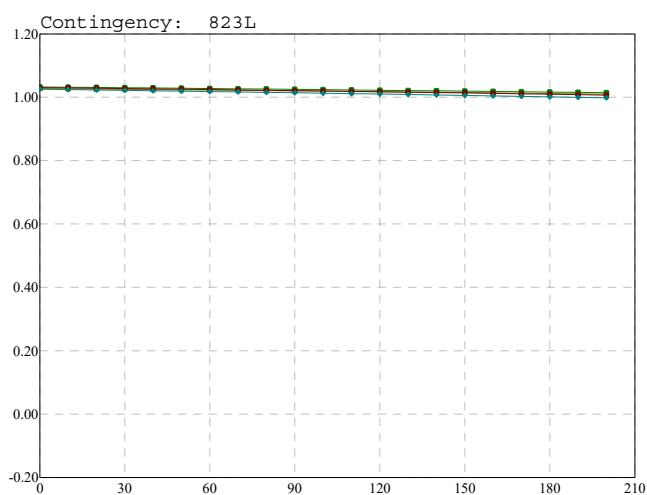
Contingency: 207L



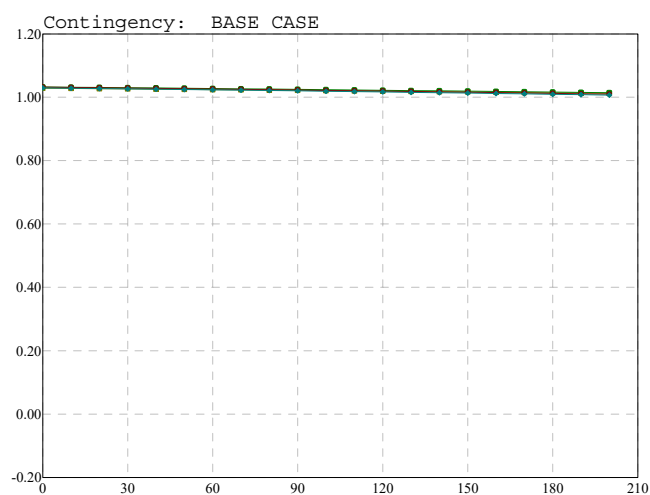
Contingency: 725L TO BOWRON COALBANKS



Contingency: 823L



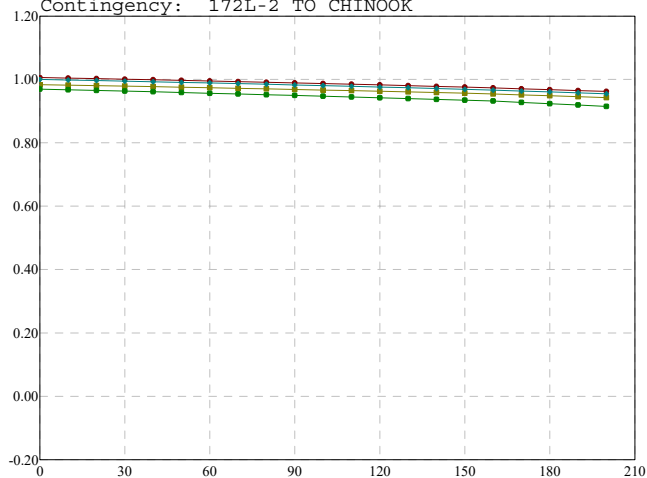
Contingency: BASE CASE



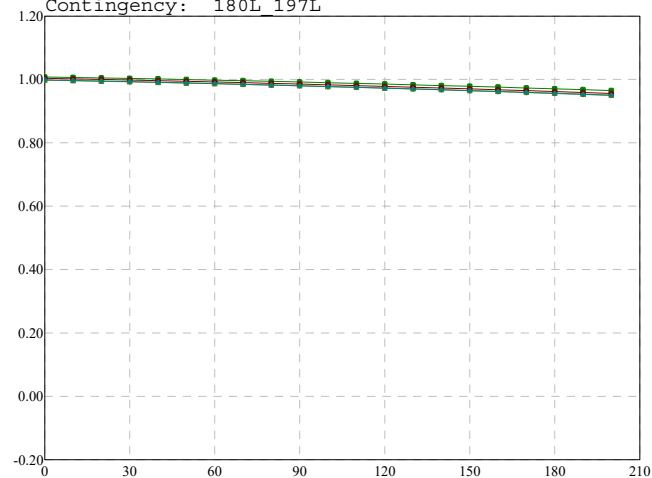
Mark	Bus	
237	FORT MA7	138.00
367	CHINOOK1	138.00
679	LETH111S	138.00
699	RIVERBN7	138.00

SCENARIO 07 - 2045 SUMMER
HIGH LOAD - LOW GENERATION
THU, JUL 23 2026 14:29

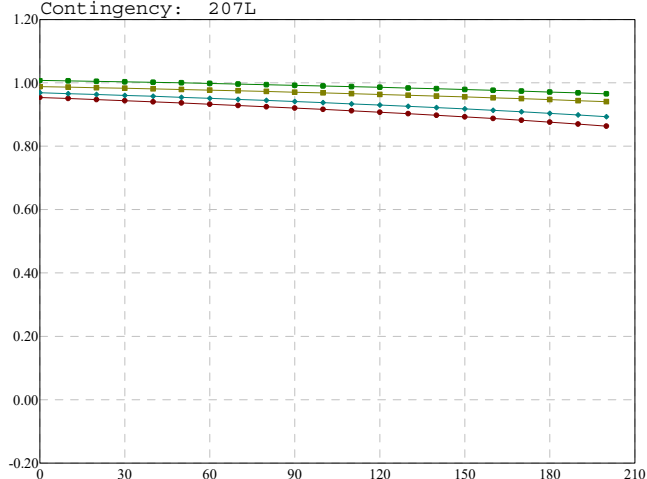
Contingency: 172L-2 TO CHINOOK



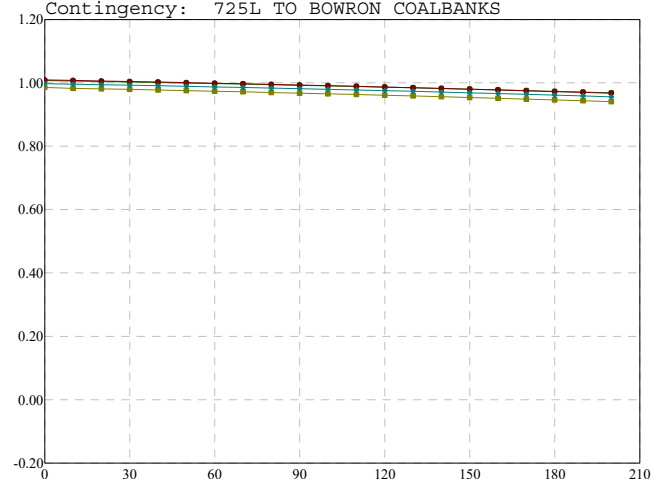
Contingency: 180L 197L



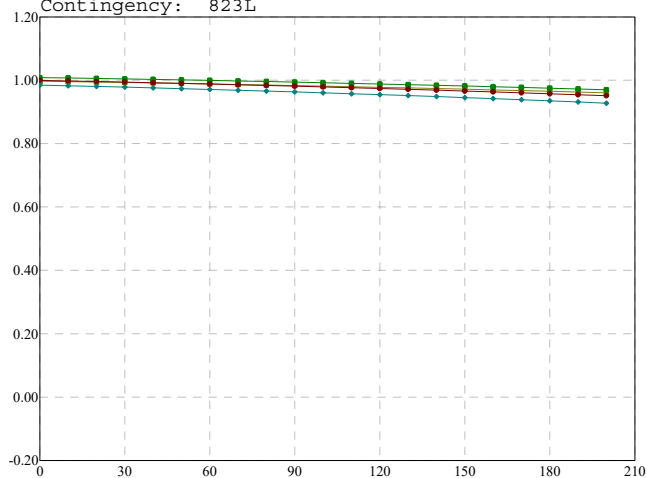
Contingency: 207L



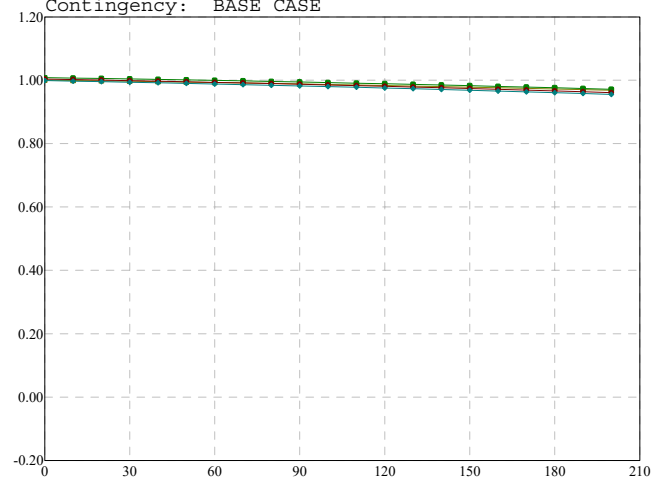
Contingency: 725L TO BOWRON COALBANKS



Contingency: 823L



Contingency: BASE CASE



Mark	Bus	
237	FORT MA7	138.00
367	CHINOOK1	138.00
679	LETH111S	138.00
699	RIVERBN7	138.00

Attachment D:

Short Circuit Analysis Results

Table 16: 2030 Pre-development Maximized short-circuit Levels

Substation	Base Voltage (kV)	Pre-fault Voltage (kV)	3-Phase fault (kA)	Positive Sequence Thevenin Source Impedance (R1jX1)(p.u.)	1-phase Fault (kA)	Zero Sequence Thevenin Source Impedance (R0jX0)(p.u.)
Bowron 674S	138	137.93	8.2	0.016+j0.048	5.3	0.032+j0.129
Chinook 181S	138	139.55	8.7	0.014+j0.047	5.7	0.032+j0.122
Coalbanks 111S	138	138.87	10.7	0.011+j0.038	7.3	0.022+j0.091
Coaldale 254S	138	139.09	9.3	0.014+j0.043	6.2	0.025+j0.110
Fort Macleod 15S	138	137.83	5.9	0.023+j0.068	3.6	0.050+j0.195
Lakeview 593S	138	138.86	9.5	0.012+j0.043	6.3	0.026+j0.108
Macdonald 146S	138	139.46	11.5	0.009+j0.036	8.0	0.019+j0.083
Monarch 492S	138	139.09	4.7	0.031+j0.084	3.0	0.064+j0.232
North Lethbridge 207L	240	249.79	12.6	0.004+j0.020	8.3	0.012+j0.049
North Lethbridge 207L	138	140.21	14.3	0.007+j0.029	10.4	0.012+j0.061
Picture Butte 120S	240	244.75	14.4	0.008+j0.029	10.8	0.013+j0.058
Riverbend 618S	138	138.23	8.8	0.014+j0.046	6.0	0.027+j0.111
Uplands 241S	138	139.59	11.4	0.009+j0.036	8.0	0.019+j0.083
Windy Flats 138S	240	252.12	13.0	0.003+j0.019	9.2	0.009+j0.041

Table 17: 2030 Post-development Maximized short-circuit Levels

Substation	Base Voltage (kV)	Pre-fault Voltage (kV)	3-Phase fault (kA)	Positive Sequence Thevenin Source Impedance (R1jX1)(p.u.)	1-phase Fault (kA)	Zero Sequence Thevenin Source Impedance (R0jX0)(p.u.)
Bowron 674S	138	138.28	8.4	0.015+j0.048	5.4	0.031+j0.127
Chinook 181S	138	139.61	8.7	0.014+j0.047	5.7	0.032+j0.122
Coalbanks 111S	138	139.35	11.1	0.009+j0.037	7.6	0.019+j0.088
Coaldale 254S	138	139.13	9.3	0.014+j0.043	6.2	0.025+j0.110
Fort Macleod 15S	138	137.99	5.9	0.023+j0.068	3.6	0.050+j0.195
Lakeview 593S	138	138.99	9.5	0.012+j0.043	6.3	0.026+j0.108
Macdonald 146S	138	139.55	11.5	0.009+j0.036	8.0	0.019+j0.083
Monarch 492S	138	139.16	4.7	0.031+j0.084	3.0	0.064+j0.232
North Lethbridge 207L	240	249.82	12.6	0.004+j0.020	8.3	0.012+j0.049
North Lethbridge 207L	138	140.26	14.3	0.007+j0.029	10.4	0.012+j0.061
Picture Butte 120S	240	244.75	14.4	0.008+j0.029	10.8	0.013+j0.058
Riverbend 618S	138	138.55	8.9	0.013+j0.045	6.1	0.026+j0.110
Uplands 241S	138	139.67	11.4	0.009+j0.036	8.0	0.019+j0.083
Windy Flats 138S	240	252.14	13.0	0.003+j0.019	9.2	0.009+j0.041

Table 18: 2035 Post-development Maximized short-circuit Levels

Substation	Base Voltage (kV)	Pre-fault Voltage (kV)	3-Phase fault (kA)	Positive Sequence Thevenin Source Impedance (R1jX1)(p.u.)	1-phase Fault (kA)	Zero Sequence Thevenin Source Impedance (R0jX0)(p.u.)
Bowron 674S	138	136.29	7.3	0.015+j0.047	4.9	0.025+j0.109
Chinook 181S	138	137.37	7.5	0.014+j0.046	5.4	0.023+j0.096
Coalbanks 111S	138	137.28	9.3	0.009+j0.036	7.1	0.012+j0.067
Coaldale 254S	138	137.42	8.3	0.014+j0.043	5.8	0.020+j0.095
Fort Macleod 15S	138	136.40	5.2	0.023+j0.067	3.3	0.044+j0.175
Lakeview 593S	138	136.92	8.1	0.012+j0.042	5.8	0.019+j0.088
Macdonald 146S	138	137.50	9.6	0.009+j0.035	7.5	0.012+j0.062
Monarch 492S	138	136.08	4.2	0.030+j0.082	3.1	0.037+j0.166
North Lethbridge 207L	240	243.31	11.1	0.003+j0.017	10.2	0.003+j0.021
North Lethbridge 207L	138	138.29	12.0	0.006+j0.028	10.3	0.005+j0.039
Picture Butte 120S	240	249.70	8.5	.004+j0.023	7.4	0.005+j0.033
Riverbend 618S	138	136.47	7.7	0.013+j0.044	5.5	0.020+j0.092
Uplands 241S	138	137.61	9.6	0.009+j0.035	7.6	0.012+j0.061
Windy Flats 138S	240	243.34	11.4	0.002+j0.016	11.3	0.002+j0.016