Connection Engineering Study Report for AUC Application

EPCOR
VICTORIA SUBSTATION E511S BREAKER ADDITION

File No. 1711

Revision: 0

Revision Date: 2016-11-16

	Name	Date	Signature
Prepared by:	Bipul Karki, P. Eng.	2016-11-16	
Reviewed and Approved by:	Mohamed Kamh, P. Eng.	2016-11-16	

PROFESSIONAL ENGINEER
DR. BIPUL KARKI
ALBERTA

APEGA Permit to Practice P8200

APEGA
Permit-to-Practice
P-8200

Executive Summary

Project Overview

EPCOR Distribution & Transmission Inc. (EDTI), in its capacity as the legal owner of an electric distribution system (DFO), submitted a system access service request to the Alberta Electric System Operator (AESO) to reliably serve new loads in downtown Edmonton.

The DFO's request for system access service includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of approximately 6 MW (from 133.92 MW to 140 MW) at the existing Victoria substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Victoria substation.

The scheduled in-service date (ISD) for the Project is March 13, 2017.

This report details the engineering studies undertaken to assess the impact of the Project on the performance of the Alberta interconnected electric system (AIES).

Existing System

The Project is located in the AESO planning area of Edmonton (Area 60). Edmonton (Area 60) is surrounded by the planning areas of Fort Saskatchewan (Area 33), Athabasca/Lac La Biche (Area 27), Wabamun (Area 40), and Wetaskiwin (Area 31).

From a transmission system perspective, Edmonton (Area 60) consists of 240 kV, 138/144 kV, and 69/72 kV transmission systems. The Victoria substation is connected to the Castle Downs substation by the 240 kV transmission line 240CV5, and is connected to the Rossdale substation by the 72 kV transmission lines 72RV4, 72RV6 and 72RV2. The Castle Downs substation connects to the North Calder 37S and Lamoureux 71S substations via the 240 kV transmission line 920L. The Victoria substation connects to the Argyll Transfer Station through the Bellamy substation.

Existing constraints in the Edmonton Planning Region are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management*.

Study Summary

<u>Study Area</u>

The Study Area for the Project consists of Edmonton (Area 60), including the tie lines connecting this planning area to neighbouring planning areas. All transmission facilities within the Study Area were 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 2.1.1).

Studies Performed

Power flow studies were performed for the 2017 summer peak (SP) and winter peak (WP) pre-Project and post-Project scenarios.

Voltage stability analysis was performed for the 2017 SP and 2017 WP post-Project scenarios.

Results of Pre-Project studies

The following is a brief summary of the pre-Project studies results. The pre-Project studies results and applicable mitigation measures are shown in greater detail in Table E-1 below.

Category A conditions (N-G-0)

No Reliability Criteria violations were observed under Category A conditions for any of the pre-Project scenarios.

Category B contingency conditions (N-G-1)

The pre-Project power flow studies identified a number of system performance issues, namely thermal criteria violations, under Category B contingency conditions.

Connection Alternatives Examined for the Project

The AESO, in consultation with the DFO and the legal owner of transmission facilities, examined three transmission alternatives to meet the DFO's request for system access service. Each of the transmission alternatives involves the addition of two 15 kV distribution feeders to serve the new loads and a third 15 kV distribution feeder to provide standby capability.

Alternative 1 – Modifications at the Victoria substation (two 15 kV circuit breakers)

Alternative 1 involves modifying the existing Victoria substation, including adding two 15 kV circuit breakers to accommodate the addition of two 15 kV distribution feeders.

EDTI has advised that there is an existing spare 15 kV circuit breaker at the Victoria substation, which can be used to connect a third 15 kV distribution feeder.

Alternative 2 – Modifications at the Rossdale substation

Alternative 2 involves modifying the existing Rossdale substation, including adding a 15 kV circuit breaker to accommodate the addition of a 15 kV distribution feeder.

EDTI has advised that there is an existing spare 15 kV circuit breaker at the Rossdale substation, which can be used to connect a second 15 kV distribution feeder. As mentioned under the description of Alternative 1, there is an existing spare 15 kV circuit breaker at the Victoria substation, which can be used to connect a third 15 kV distribution feeder.

Alternative 3 – Modifications at the Victoria substation (one 15 kV circuit breaker)

Alternative 3 involves modifying the Victoria substation, including adding one 15 kV circuit breaker to accommodate the addition of one 15 kV distribution feeder.

As mentioned above, there is an existing spare 15 kV circuit breaker at each of the Victoria and Rossdale substations, which can be used to connect two additional 15 kV distribution feeders.

Connection Alternative Selected for Further Study

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

Connection Alternatives Not Selected for Further Study

Alternative 2 and Alternative 3 are considered technically feasible. The DFO has advised that these alternatives involve increased overall development and hence, increased costs compared to Alternative 1. Therefore, these alternatives were not selected for further study.

Results of Post-Project Studies

The following is a brief summary of the post-Project studies results. The post-Project studies results, Project impact on the performance of the AIES, and applicable mitigation measures are shown in greater detail in Table E-1, below.

Category A conditions (N-G-0)

No Reliability Criteria violations were observed under Category A conditions for any of the post-Project scenarios.

Category B contingency conditions (N-G-1)

The post-Project power flow studies identified the same system performance issues under Category B contingency conditions that were identified in the pre-Project power flow studies. No new Reliability Criteria violations were observed.

Project Dependencies

No project dependencies were identified.

Conclusions and Recommendations

Analysis and Conclusions

Table E-1 provides analysis of, and conclusions about, the impact of the Project for selected contingencies, including mitigation measures for observed Reliability Criteria violations. The contingencies in Table E-1 were selected on the basis that Reliability Criteria violations were observed following those contingencies.

Table E-1: Project Impact and Mitigation Measures

Reliability Criteria Violations		Occurrence (Pre-Project or Post-Project Scenarios)	Project Impact	Year/ Season Load	Mitigation Measures (Pre-Project and Post-Project)
Violation	Contingency				
747L (N. Calder - Genster)	902L (Sundance 310P – Wabamun 19S)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices
					Post: Real-time operational practices
72RG1	72RG7	Pre-Project and	Reduced	2017 SP	**Pre:** Real-time

Reliability Criteria Violations		Occurrence (Pre-Project or Post-Project Scenarios)	Project Impact	Year/ Season Load	Mitigation Measures (Pre-Project and Post-Project)
Violation	Contingency				
(Rossdale - Garneau)	(Rossdale - Garneau)	Post-Project	thermal loading		operational practices **Post:** Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CK13 (Clover Bar - Kennedale)	72CK12 (Clover Bar - Kennedale)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CK12 (Clover Bar - Kennedale)	72CK13 (Clover Bar - Kennedale)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 WP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 WP	**Pre:** Real-time operational practices **Post:** Real-time operational practices

The connection assessment identified pre-Project and post-Project system performance issues under Category B contingency conditions. However, the connection assessment indicates that the Project will not adversely impact the performance of the AIES because the magnitude of each of the thermal criteria violations in the post-Project scenarios was lower than the corresponding thermal criteria violations observed in the pre-Project scenarios.

Real-time operational practices are currently being used to manage the pre-Project system performance issues, and can be used to address the post-Project system performance issues.

Based on the study results, Alternative 1 is technically viable.

Recommendations

It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service. It is also recommended to continue to use real-time operational practices to manage the identified system performance issues.

Contents

Attachments

Figures

Tables

1. Introduction

This report details the engineering studies undertaken to assess the impact of the Project (as defined below) on the performance of the Alberta interconnected electric system (AIES).

1.1. Project

1.1.1. Overview

EPCOR Distribution & Transmission Inc. (EDTI), in its capacity as the legal owner of an electric distribution system (DFO), submitted a system access service request to the Alberta Electric System Operator (AESO) to reliably serve new loads in downtown Edmonton.

The DFO's request for system access service includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of approximately 6 MW (from 133.92 MW to 140 MW) at the existing Victoria substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Victoria substation.

The scheduled in-service date (ISD) for the Project is March 13, 2017.

1.1.2. Load Component

The existing Rate DTS contract capacity for the system access service provided at the existing Victoria substation is 133.92 MW.

The DFO requested a Rate DTS contract capacity increase of 6.08 MW.

The Project load was studied assuming a 0.9 power factor (PF) lagging.

1.1.3. Generation Component

There is no generation component associated with the Project.

1.2. Study Scope

1.2.1. Objectives

The objectives of the studies were as follows:

- Assess the impact of the Project on the performance of the AIES.
- Identify any violations of the relevant AESO criteria, standards or requirements, both pre-Project and post-Project.
- Recommend mitigation measures, if required, to reliably connect the Project to the AIES.

1.2.2. Study Area

1.2.2.1. Study Area Description

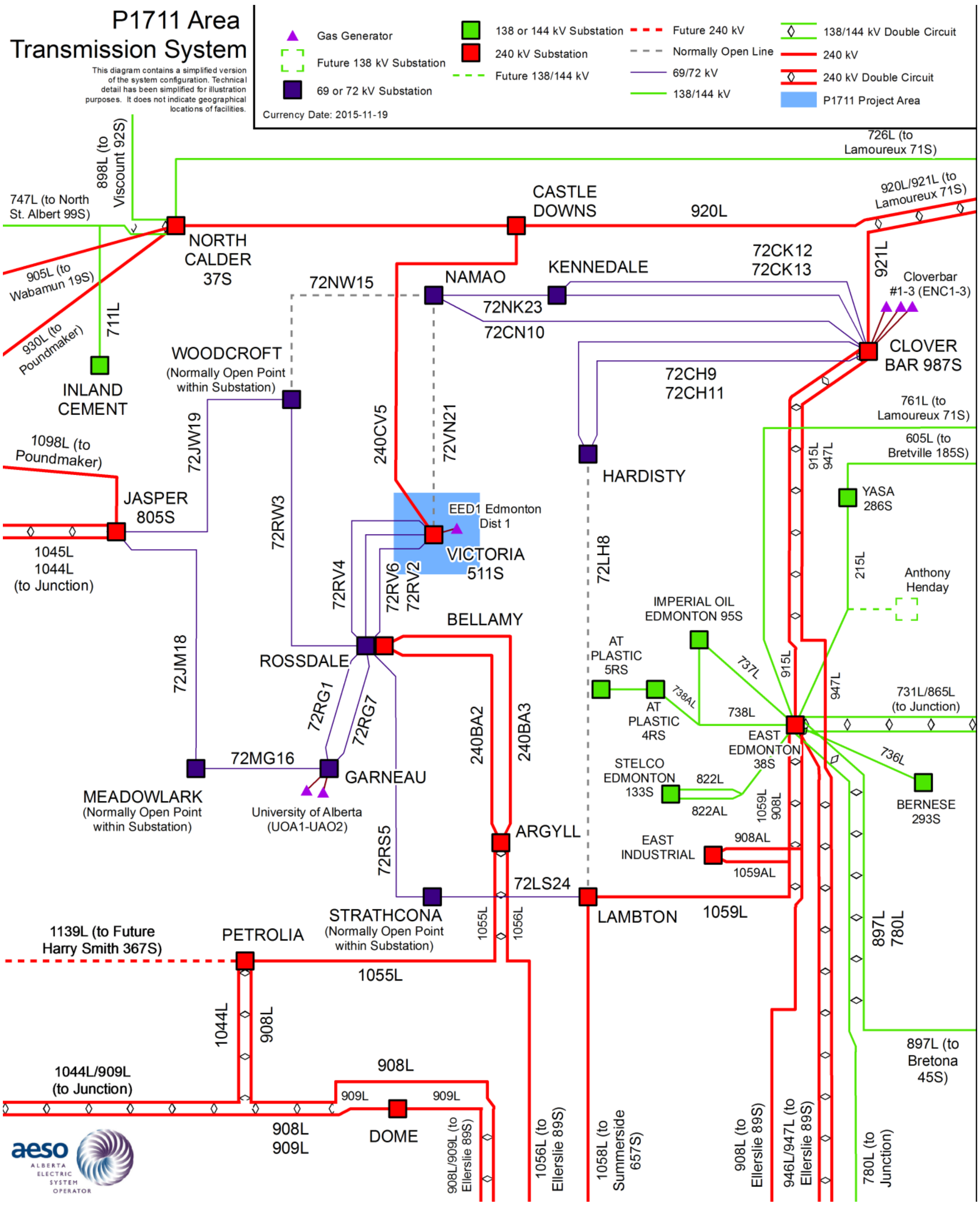
The Project is located in the AESO planning area of Edmonton (Area 60). Edmonton (Area 60) is surrounded by the planning areas of Fort Saskatchewan (Area 33), Athabasca/Lac La Biche (Area 27), Wabamun (Area 40), and Wetaskiwin (Area 31).

From a transmission system perspective, Edmonton (Area 60) consists of 240 kV, 138/144 kV, and 69/72 kV transmission systems. The Victoria substation is connected to the Castle Downs substation by the 240 kV transmission line 240CV5, and is connected to the Rossdale substation by the 72 kV transmission lines 72RV4, 72RV6 and 72RV2. The Castle Downs substation connects to the North Calder 37S and Lamoureux 71S substations via the 240 kV transmission line 920L. The Victoria substation connects to the Argyll Transfer Station through the Bellamy substation.

The Study Area for the Project consists of Edmonton (Area 60), including the tie lines connecting this planning area to neighbouring planning areas. All transmission facilities within the Study Area were 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 2.1.1).

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

Figure 1-1: Study Area Transmission System



1.2.2.2. Existing Constraints

Existing constraints in the Edmonton 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).

1.2.2.3. AESO Long-Term Transmission Plans

The *AESO 2015 Long-term Transmission Plan* (2015 LTP)[1] includes the following transmission developments that are in the vicinity of the Study Area in the near term (by 2020):[2]

- Convert Hardisty substation in east Edmonton to 240/15 kV from 72/15 kV.
- Add new 240 kV loop from Lambton substation in southeast Edmonton to Hardisty substation and onto Bellamy substation at Rossdale.
- Discontinue use of 72 kV lines from Rossdale substation (Bellamy) to Strathcona substation to Lambton substation.
- Replace existing 240/72 kV transformer at Clover Bar substation in northeast Edmonton with larger units.
- Add new 240/72 kV substation near Namao in northeast, cut into 240 kV line between Castle Downs substation and Victoria substation on north edge of downtown Edmonton.
- Add new 72 kV line from new substation to existing Namao substation
- Add new 240/72 kV transformer at Castle Downs substation in the northeast
- Add new 72 kV transmission lines from Castle Downs substation to Kennedale substation, and onto Namao substation
- Discontinue use of 72 kV lines between Clover Bar and Hardisty substations, and Hardisty and Lambton substations
- Discontinue use of existing 72 kV lines that connect Clover Bar, Victoria, Namao, Kennnedale, and Woodcroft substations
- Convert Victoria substation from 240/72/15 kV to 240/15 kV
- Add new 240 kV line from Victoria substation to Bellamy substation
- Discontinue use of 72 kV lines between Rossdale and Victoria substations

The above developments were not included in the system topology for the pre-Project and post-Project studies because these transmission developments are not expected to be in service before the Project ISD.

[1] The 2015 LTP document is available on the AESO website.

[2] The 2015 LTP identifies the near-term transmission developments in the City of Edmonton area on page 62.

The Edmonton Region 240 kV Line Upgrades project is also progressing in the Edmonton Planning Region. This developments associated with this project were included in the topology for the connection assessment, as discussed in Section 2.4.[3]

1.2.3. Studies Performed

The following studies were performed for the pre-Project scenarios:

- Power flow studies (Category A conditions and Category B contingencies)

The following studies were performed for the post-Project scenarios:

- Power flow studies (Category A conditions and Category B contingencies)
- Voltage stability studies (Category A conditions and Category B contingencies)

1.3. Report Overview

The Executive Summary provides a high-level summary of the report and its conclusions. Section 1 provides an introduction of the Project. Section 2 describes the criteria, system data, and study assumptions used in the studies. Section 3 presents the study methodology used in the studies. Section 4 discusses the pre-Project system assessment. Section 5 presents the connection alternatives that were examined and the alternatives that were studied. Section 6 presents the post-Project system assessment for the alternatives that were selected for further study. Section 7 identifies project dependencies, if any. Section 8 presents the conclusions and recommendations of this report.

2. Criteria, System Data, and Study Assumptions

2.1. Criteria, Standards, and Requirements

2.1.1. AESO Reliability Criteria

The Transmission Planning (TPL) Standards, which are included in the Alberta Reliability Standards, and the AESO's *Transmission Planning Criteria – Basis and Assumptions*[4] (collectively, the Reliability Criteria) were 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.

[3] The *Edmonton Region 240 kV Line Upgrades Needs Identification Document* (NID) was originally approved by the Alberta Utilities Commission in Approval No. U2009-62 on February 24, 2009.

[4] Filed under a separate cover

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

- Seasonal continuous thermal rating of the line's loading limits.
- Highest specified loading limits for transformers.
- For Category A conditions: Voltage range under normal operating condition per AESO Information Document # 2010-007RS (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*.
- Desired post-contingency voltage change limits for three defined post event timeframes as provided in Table 2-1, below.

Table 2-1: Post Contingency Voltage Deviations 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 low voltage bus	± 10%	± 7%	± 5%

2.1.2. Authoritative Documents (ADs)

AESO ID #2010-007RS, *General Operating Practices - Voltage Control*, relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage.* ID #2010-007RS was used to establish system normal (i.e., pre-contingency) voltage profiles for the Study Area.

2.2. Study Scenarios

The scheduled ISD for the Project is March 13, 2017. Therefore, the studies were performed using the 2017 summer peak (SP) and 2017 winter peak (WP) scenarios.

Table 2-2 provides a list of the study scenarios. Scenario 1 and Scenario 2 are the pre-Project 2017 SP and 2017 WP scenarios. Scenario 3 and Scenario 4 are the post-Project 2017 SP and 2017 WP scenarios. The post-Project scenarios reflect the requested Rate DTS contract capacity increase of 6.08 MW. A 0.9 PF lagging was used for the Project load.

Table 2-2: Study Scenarios and Assumptions

Scenario No.	Year/Season Load	Project Load (MW)
Pre-Project system		
1	2017 SP	133.92
2	2017 WP	133.92
Post-Project system		
3	2017 SP	140
4	2017 WP	140

2.3. Load and Generation Assumptions

2.3.1. Load Assumptions

The load forecast used for the studies is shown in Table 2-3 and is based on the *AESO 2016 Long-term Outlook* (2016 LTO).

Table 2-3: Forecast Area Load (2016 LTO at Edmonton Planning Region Peak)

Area or Region Name and Year/Season		Forecast Peak Load (MW)
Wetaskiwin (Area 31)	2017 SP	131
	2017 WP	140
Wabamun (Area 40)	2017 SP	179
	2017 WP	197
Edmonton (Area 60)	2017 SP	2,008
	2017 WP	1,971
Edmonton Planning Region	2017 SP	2,318
	2017 WP	2,308

Area or Region Name and Year/Season		Forecast Peak Load (MW)
Alberta Internal Load (AIL) w/o Losses	2017 SP	10,941
	2017 WP	11,900

2.3.2. Generation Assumptions

The generation assumptions for the studies are described in Table 2-4.

The Cloverbar #3 generating unit was identified as the critical generating unit, and was considered to be out of service to represent the N-G condition for all studies.

Table 2-4: Local Generators in the Study Scenarios

Existing/Future	Unit Name	Bus Number	Area	Pmax (MW)	2017 SP Unit Net Generation (MW)	2017 WP Unit Net Generation (MW)
Existing	Cloverbar #1	25516	60	48	0	0
Existing	Cloverbar #2	26516	60	101	42	73
Existing	Cloverbar #3	27516	60	101	Offline	Offline
Existing	University of Alberta	25352	60	39	9	27

2.3.3. Intertie Flow and HVDC Assumptions

The Alberta-BC, Alberta-Montana, and Alberta-Saskatchewan intertie points were deemed to be too far away from the Study Area to have any material effect on the assessment of the Project's impact on the performance of the AIES. Therefore, the intertie flows were assumed to be the same as in the AESO planning base cases and were not adjusted for the studies.

The Western Alberta Transmission Line (WATL) and the Eastern Alberta Transmission Line (EATL) assumptions were expected to have minimal effects on the assessment of the Project's impact on the performance of the AIES. Therefore, the HVDC assumptions were assumed to be the same as in the AESO planning base cases and were not adjusted for the studies.

2.4. System Projects

Project 786 (Edmonton Region 240 kV Line Upgrades), which has an ISD of November 30, 2016, was modeled in the study scenarios.

2.5. Customer Connection Projects

Customer connection projects within the Study Area that have passed Gate 2 of the AESO Connection Process as of November 2016 were modelled in the study scenarios based on their positions in the AESO Connection Queue. Table 2-5 summarizes the customer connection project assumptions that were used in the studies. Information in this table is subject to change as projects progress.

Table 2-5: Customer Connection Projects in the Study Area[a]

Planning Area	Queue Position*	Project Number	Project Description	Planned ISD	Modelled in the study cases
60	42	1440	Genesee Generating Units 4 (G4) and 5 (G5)	Q1- 2019	No[c]
60	36	1442	Fortis New Anthony Henday Substation	Q1- 2019	No[b]
60	84	1649	EPCOR Garneau Area Upgrade	Q4- 2018	No[c]
60	91	1659	EPCOR Strathcona Capacity Increase	Q4- 2018	No[b]
60	77	1674	Fortis Cooking Lake 522A Capacity Increase	Q1- 2018	Yes

Notes:

[a] Per the AESO Connection Queue posted in November 2016. The projects in the Study Area, if any, that have queue positions after Project 1711 are not listed in this table and were not modelled in the study cases.

[b] This project is deemed to be too far away from the Project to have any material effect on the assessment of the Project's impact on the performance of the AIES.

[c] Including these projects in the customer connection assumptions would result in less stressed study cases for this connection assessment. Therefore, for the purpose of assessing the impact of the Project on the performance of the AIES, these projects were not included in the customer connection project assumptions.

2.6. Facility Ratings and Shunt Elements

The legal owner of transmission facilities (TFO) provided the seasonal continuous thermal ratings and the short-term emergency ratings for the transmission lines in the Study Area. The seasonal continuous thermal ratings and the short-term emergency ratings for the main transmission lines in the Study Area are shown in Table 2-6.

Table 2-6: Main Transmission Lines in the Study Area (MVA on a 69/138/240 kV Base)

Line ID	Line Description (Substation)		Voltage Class (kV)	Line Ratings			
				Seasonal Continuous Thermal Ratings (MVA)[5]		Short-term Emergency Ratings (MVA)	
	From	To		Summer	Winter	Summer	Winter
921L	Clover Bar	Lamoureux 71S	240	417	499	500	620
915L	Clover Bar	East Edmonton 38S	240	492	499	590	648
947L	Clover Bar	Ellerslie 89S	240	493	611	592	733
240CV5	Victoria	Castle Downs	240	475	503	475	503
908AL	East Industrial	908AL tap point	240	587	754	704	905
1057L	Summerside	Ellerslie 89S	240	594	713	654	773
908L	Petrolia	Ellerslie 89S	240	505	648	606	773
909L	Dome	Keephills 320P	240	481	581	577	697
909L	Ellerslie 89S	Dome	240	499	599	599	648
1059L	1059L tap point	Lambton	240	499	499	694	853
1058L	Lambton	Summerside	240	499	499	694	853
908L	908AL tap point	East Edmonton 38S	240	499	499	599	648
1059L	1059AL tap point	East Edmonton 38S	240	499	499	599	648
1056L	Ellerslie 89S	Argyll	240	419	517	503	620
1055L	Petrolia	Argyll	240	419	517	503	620
240BA2	Argyll	Bellamy	240	400	479	400	479
240BA3	Argyll	Bellamy	240	400	479	400	479
908L	Ellerslie 89S	908AL tap point	240	505	648	606	773
1044L	Petrolia	Jasper	240	481	581	577	697
1045L	Jasper	Sundance	240	481	581	577	697

[5] Ratings for the 72 kV transmission lines are provided on the system base voltage of 69 kV.

Line ID	Line Description (Substation)		Voltage Class (kV)	Line Ratings			
				Seasonal Continuous Thermal Ratings (MVA)[5]		Short-term Emergency Ratings (MVA)	
	From	To		Summer	Winter	Summer	Winter
		310P					
72RS5	Rossdale	Strathcona	69	23.9	23.9	67.4	70.3
72LH8	Lambton	Hardisty	69	86.3	118.8	101.0	129.7
72LS24	Lambton	Strathcona	69	86.2	118.8	101.0	129.7
72JM18	Meadowlark	Jasper	69	57.5	62.3	57.5	62.3
72JW19	Jasper	Woodcroft	69	57.5	62.3	57.5	62.3
72RW3	Woodcroft	Rossdale	69	57.0	62.0	57.0	62.0
72RG7	Garneau	Rossdale	69	76.0	86.0	76.0	86.0
72RV2	Victoria	Rossdale	69	63.9	63.9	63.9	63.9
72RG1	Garneau	Rossdale	69	57.0	62.0	57.0	62.0
72RV4	Victoria	Rossdale	69	63.9	63.9	63.9	63.9
72RV6	Victoria	Rossdale	69	63.9	63.9	63.9	63.9
72VN21	Victoria	Namao	69	57.5	62.3	57.5	62.3
72CH11	Clover Bar	Hardisty	69	38.0	38.0	77.0	77.0
72CH9	Clover Bar	Hardisty	69	38.0	38.0	77.0	77.0
72NW15	Woodcroft	Namao	69	61.3	85.3	71.7	92.6
72NK23	Namao	Kennedale	69	57.0	57.0	57.0	57.0
72CN10	Namao	Clover Bar	69	57.5	57.5	57.5	57.5
72CK12	Kennedale	Clover Bar	69	46.0	53.6	61.0	65.0
72CK13	Kennedale	Clover Bar	69	46.0	53.6	61.0	65.0

The TFO also provided the details of the substation transformer elements in the Study Area. The key transformers in the Study Area are shown in Table 2-7.

Table 2-7: Summary of key transformer in the Study Area

Station Name and Number	Transformer	MVA Rating
Victoria	T5 – 240/72 kV	450
	T1 – 72/14.4 kV	66.7
	T2 – 72/14.4 kV	66.7
	T3 – 72/14.4 kV	66.7

	T4 – 72/14.4 kV	66.7
Jasper	T1 – 240/72 kV	300
Lambton	T3 – 240/72 kV	80
Bellamy	T1 – 240/72 kV	375
	T2 – 240/72 kV	375

The TFO also provided the details of the shunt elements in the Study Area, as shown in Table 2-8. No shunt reactors are present in the Study Area.

Table 2-8: Summary of Shunt Elements in the Study Area

Station Name and Number	Voltage Class (kV)	Capacitor (MVAr)
East Edmonton 38S	138	2 x 48.91
Nisku 149S	138	1 x 30
Acheson 305S	138	1 x 24.46
Jasper	240	1 x 105.31
Rossdale	69	2 x 47.75
Clover Bar	69	1 x 31.57
Stelco Edmonton 133S	34.5	2 x 23.4

2.7. Voltage Profile Assumptions

The AESO ID #2010-007RS was used to establish system normal (i.e., pre-contingency) voltage profiles for key area busses prior to commencing any studies. Table 2-1 of the *Transmission Planning Criteria – Basis and Assumptions* applies for all the busses not included in ID #2010-007RS. These voltages were used to set the voltage profile for the study base cases prior to performing the power flow studies. The key bus voltages for the Study Area for the Project are shown in Table 2-9.

Table 2-9: Summary of the Voltage at Key Nodes in Study Scenarios

Substation Name and Number	Nominal Voltage (kV)	ID #2010-007RS			Voltage in the Study Cases under Category A conditions (kV)			
		Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)	Pre-Project		Post-Project	
					2017 SP	2017 WP	2017 SP	2017 WP
East Edmonton 38S	240	240	240-253	255	246.09	250.79	246.54	250.8
	138	139	139-144	145	140.01	141.43	140.1	141.45
Bigstone 86S	240	Left Blank[6]	243-253	260	244.65	249.01	246.32	249.02
	138	135	141-145	145	144.44	143.00	142.81	143.02
Acheson 305S	138	138	138-144	145	138.75	140.00	138.17	140.04
Ellerslie 89S	500	505	520-540	550	533.62	539.14	534.31	539.15
	240	243	246-254	255	247.71	252.03	248.23	252.03
Petrolia	240	240	245-254	255	247.96	252.32	248.53	252.31
Clover Bar	240	240	245-254	255	246.64	251.07	247.08	251.08
Lambton	240	240	245-254	255	246.00	250.71	246.48	250.72
Bellamy	240	Left Blank[7]	Left Blank[8]	255	247.44	252.31	247.99	252.3
Jasper	240	240	245-254	255	247.87	252.23	248.73	252.23

3. Study Methodology

The studies for this connection assessment were completed using PTI PSS/E version 33.

3.1. Study Objectives

The objectives of the studies were as follows:

- Assess the impact of the Project on the performance of the AIES.
- Identify any violations of the relevant AESO criteria, standards or requirements, both pre-Project and post-Project.
- Recommend mitigation measures, if required, to reliably connect the Project to the AIES.

[6] This value was intentionally left blank, per ID #2010-007RS.

[7] This value was intentionally left blank, per ID #2010-007RS.

[8] This value was intentionally left blank, per ID #2010-007RS.

3.2. Connection Studies Carried Out

The following studies were performed for the pre-Project scenarios:

- Power flow studies (Category A conditions and Category B contingencies)

The following studies were performed for the post-Project scenarios:

- Power flow studies (Category A conditions and Category B contingencies)
- Voltage stability studies (Category A conditions and Category B contingencies)

Table 3-1 summarizes the studies that were carried out for this connection assessment.

Table 3-1: Summary of Studies Performed

Scenario(s) Studied		Studies Performed	System Conditions Studied
Pre-Project	Post-Project		
1, 2	3, 4	Power flow	Category A and Category B
-	3, 4	Voltage stability	Category A and Category B

3.3. Power Flow Analysis

Pre-Project and post-Project power flow studies were performed to identify thermal and voltage criteria violations as per the Reliability Criteria, and any deviations from the limits listed in Table 2-1. The purpose of the power flow analysis is to quantify any incremental violations in the Study Area after the Project is connected. For the Category B power flow studies, the transformer taps and switched shunt reactive compensating devices such as shunt capacitors and reactors were locked and continuous shunt devices were enabled.

Point-of-delivery (POD) low voltage bus deviations were 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 were 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 were allowed to adjust, and voltage deviations above 5% would be reported.

3.3.1. Contingencies Studied for Power Flow Analysis

The power flow studies included all Category B contingencies (69 kV facilities and above) within the Study Area.

All transmission facilities in the Study Area were monitored for voltage criteria violations and thermal criteria violations under Category A conditions and under Category B contingency conditions.

3.4. Voltage Stability (PV) Analysis

The objective of the voltage stability analysis is to determine the ability of the network to maintain voltage stability at all the busses in the system under normal and abnormal system conditions. The power-voltage (PV) curve represents voltage change as a result of increased power transfer between two systems. The reported incremental transfers are to the collapse point. As per the AESO requirements, no assessment based upon other criteria such as minimum voltage were made at the PV minimum transfer.

Voltage stability analyses were performed for post-Project scenarios. For load connection projects, the load level modelled in post-Project scenarios is the same or higher than in pre-Project scenarios. Therefore, voltage stability analysis for pre-Project scenarios would only be performed if the post-Project scenarios show voltage stability criteria violations.

The voltage stability analyses followed the Western Electricity Coordinating Council (WECC) Voltage Stability Assessment Methodology. WECC voltage stability criteria states, for load areas, post-transient voltage stability is required for the area modeled at a minimum of 105% of the reference load level for system normal conditions (Category A) and for single contingencies (Category B). For this standard, the reference load level is the maximum established planned load.

Typically, voltage stability analysis is carried out assuming worst case loading scenarios. For the Project's worst case scenario, load was increased in Edmonton (Area 60) and corresponding generation was increased in Fort McMurray (Area 25).

3.4.1. Contingencies Studied for Voltage Stability Analysis

The voltage stability analyses were performed for the Category A condition and all Category B contingencies (69 kV facilities and above) in the Study Area to determine the system voltage stability margin in the area.

4. Pre-Project System Assessment

This section provides the results of the pre-Project power flow studies and includes the mitigation measures for observed Reliability Criteria violations, if any.

4.1. Pre-Project Power Flow Studies

The pre-Project power flow diagrams are provided in Attachment A.

4.1.1. Scenario 1 (2017 SP pre-Project)

<u>Category A conditions (N-G-0)</u>

No Reliability Criteria violations were observed under Category A conditions.

<u>Category B contingency conditions (N-G-1)</u>

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

Thermal criteria violations were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table 4-1.

- Loading above the short-term emergency rating of the 72 kV transmission line 72RG1 (between the Rossdale and Garneau substations) was observed following the loss of the 72 kV transmission line 72RG7 (between the Rossdale and Garneau substations).
- Loading above the short-term emergency rating of the 138 kV transmission line 747L (between the North Calder and Genster substations) was observed following the loss of the 240 kV transmission line 902L (between the Sundance 310P and Wabamun 19S substations).
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH9 (between the Clover Bar and Hardisty substations) was observed following the loss of the 72 kV transmission line 72CH11 (between the Clover Bar and Hardisty substations).
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH11 was observed following the loss of the 72 kV transmission line 72CH9.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CK13 (between the Clover Bar and Kennedale substations) was observed following the loss of the 72 kV transmission line 72CK12 (between the Clover Bar and Kennedale substations).
- Loading below the short-term emergency rating of the 72 kV transmission line 72CK12 was observed following the loss of the 72 kV transmission line 72CK13.

These thermal criteria violations are currently being managed by using real-time operational practices.

Table 4-1: Summary of pre-Project System Performance – Scenario 1

Contingency	Limiting Facilities	Line Ratings		Details of Reliability Criteria Violations		Mitigation Measures
		Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Load Flow (MVA)	% Loading	
72RG7 (Rossdale - Garneau)	72RG1 (Rossdale - Garneau)	57	57	69.6	122.1	Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	38	77	60.6	159.5	Real-time operational practices
72CH9	72CH11	38	77	60.6	159.5	Real-time

(Clover Bar - Hardisty)	(Clover Bar - Hardisty)					operational practices
72CK12 (Clover Bar - Kennedale)	72CK13 (Clover Bar - Kennedale)	46	61	54.9	119.3	Real-time operational practices
72CK13 (Clover Bar - Kennedale)	72CK12 (Clover Bar - Kennedale)	46	61	54.9	119.3	Real-time operational practices
902L (Sundance 310P – Wabamun 19S)	747L (N. Calder - Genster)	119	131	136.14	114.4	Real-time operational practices

4.1.2. Scenario 2 (2017 WP pre-Project)

Category A conditions (N-G-0)

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions (N-G-1)

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

Thermal criteria violations were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table 4-2.

- Loading below the short-term emergency rating of the 72 kV transmission line 72CH9 was observed following the loss of the 72 kV transmission line 72CH11.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH11 was observed following the loss of the 72 kV transmission line 72CH9.

These thermal criteria violations are currently being managed by using real-time operational practices.

Table 4-2: Summary of pre-Project System Performance – Scenario 2

Contingency	Limiting Facilities	Line Ratings		Details of Reliability Criteria Violations		Mitigation Measures
		Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Load Flow (MVA)	% Loading	
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	38	77	59.3	156.1	Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	38	77	59.3	156.1	Real-time operational practices

5. Connection Alternatives

5.1. Overview

The AESO, in consultation with the DFO and the TFO, examined three transmission alternatives to meet the DFO's request for system access service.[9]

5.2. Connection Alternatives Examined

Below is a description of the developments associated with the transmission alternatives that were examined for the Project. Each of the transmission alternatives involves the addition of two 15 kV distribution feeders to serve the new loads and a third 15 kV distribution feeder to provide standby capability. Table 5-1 also summarizes the transmission alternatives.

Alternative 1 – Modifications at the Victoria substation (two 15 kV circuit breakers)

Alternative 1 involves modifying the existing Victoria substation, including adding two 15 kV circuit breakers to accommodate the addition of two 15 kV distribution feeders.

EDTI has advised that there is an existing spare 15 kV circuit breaker at the Victoria substation, which can be used to connect a third 15 kV distribution feeder.

Alternative 2 – Modifications at the Rossdale substation

Alternative 2 involves modifying the existing Rossdale substation, including adding a 15 kV circuit breaker to accommodate the addition of a 15 kV distribution feeder.

EDTI has advised that there is an existing spare 15 kV circuit breaker at the Rossdale substation, which can be used to connect a second 15 kV distribution feeder. As mentioned under the description of Alternative 1, there is an existing spare 15 kV circuit breaker at the Victoria substation, which can be used to connect a third 15 kV distribution feeder.

Alternative 3 – Modifications at the Victoria substation (one 15 kV circuit breaker)

Alternative 3 involves modifying the Victoria substation, including adding one 15 kV circuit breaker to accommodate the addition of one 15 kV distribution feeder.

As mentioned above, there is an existing spare 15 kV circuit breaker at each of the Victoria and Rossdale substations, which can be used to connect two additional 15 kV distribution feeders.

[9] These alternatives reflect more up to date engineering design than the alternatives identified in EPCOR Distribution & Transmission Inc.'s *Distribution Deficiency Report (DDR), Victoria Substation (E511S) Breaker Additions*, which is filed under a separate cover.

Table 5-1: Summary of examined transmission alternatives

Alternative no.	**Alternative 1**	**Alternative 2**	**Alternative 3**
Substation(s) involved	**Victoria**	**Rossdale and Victoria**	**Rossdale and Victoria**
Existing spare circuit breakers involved	1 x 15 kV (Victoria)	1 x 15 kV (Victoria) 1 x 15 kV (Rossdale)	1 x 15 kV (Victoria) 1 x 15 kV (Rossdale)
Additional circuit breakers involved	2 x 15 kV (Victoria)	1 x 15 kV (Rossdale)	1 x 15 kV (Victoria)
Distribution feeder length, approx. (From substation to load centre(s))	3 km (Victoria)	5 km (Rossdale[a]) 1 km (Victoria)	2.5 km (Rossdale[a]) 2 km (Victoria)
Total distribution feeder length, approx.	3 km	6 km	4.5 km

Notes:

[a] Additional costs due to complexity associated with routing the distribution feeders across 102 Avenue

5.2.1. Connection Alternatives Selected for Further Studies

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

5.2.2. Connection Alternatives Not Selected for Further Studies

Alternative 2 and Alternative 3 are considered technically feasible. The DFO has advised that these alternatives involve increased overall development and hence, increased costs compared to Alternative 1. Therefore, these alternatives were not selected for further study.

6. Technical Analysis of Alternative 1

This section provides the analysis of the post-Project power flow and voltage stability studies and includes the study results and the mitigation measures for observed Reliability Criteria violations, if any.

6.1. Power Flow Studies

The post-Project power flow diagrams are provided in Attachment B.

6.1.1. Scenario 3 (2017 SP post-Project)

Category A conditions (N-G-0)

No Reliability Criteria violations were observed under Category A conditions.

Category B contingency conditions (N-G-1)

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

Thermal criteria violations were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table 6-1. All of these post-Project system performance issues were identified in the pre-Project Scenario 1 (2017 SP). However, the magnitude of each of the violations in the post-Project Scenario 3 was lower than the corresponding thermal criteria violations observed in the pre-Project Scenario 1.

- Loading above the short-term emergency rating of the 72 kV transmission line 72RG1 was observed following the loss of the 72 kV transmission line 72RG7.
- Loading above the short-term emergency rating of the 138 kV transmission line 747L was observed following the loss of the 240 kV transmission line 902L.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH9 was observed following the loss of the 72 kV transmission line 72CH11.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH11 was observed following the loss of the 72 kV transmission line 72CH9.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CK13 was observed following the loss of the 72 kV transmission line 72CK12.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CK12 was observed following the loss of the 72 kV transmission line 72CK13.

These thermal criteria violations can be managed by using real-time operational practices.

Table 6-1: Summary of post-Project System Performance – Scenario 3

Contingency	Limiting Facilities	Line Ratings		Details and Comparison of Reliability Criteria Violations				Difference % Loading Between Pre-Project and Post-Project Scenarios	Mitigation Measures (Post-Project)
				Pre-Project (Scenario 1)		Post-Project (Scenario 3)			
		Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Load Flow (MVA)	% Loading	Load Flow (MVA)	% Loading		
72RG7 (Rossdale - Garneau)	72RG1 (Rossdale - Garneau)	57	57	69.6	122.1	69.1	121.2	-0.9	Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar to Hardisty)	38	77	60.6	159.5	60.3	158.7	-0.8	Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	38	77	60.6	159.5	60.3	158.7	-0.8	Real-time operational practices
72CK12 (Clover Bar - Kennedale)	72CK13 (Clover Bar - Kennedale)	46	61	54.9	119.3	54.6	118.7	-0.7	Real-time operational practices
72CK13 (Clover Bar - Kennedale)	72CK12 (Clover Bar - Kennedale)	46	61	54.9	119.3	54.6	118.7	-0.7	Real-time operational practices
902L (Sundance 310P - Wabamun 19S)	747L (N. Calder to Genster)	119	131	136.14	114.4	131.38	110.4	-4.0	Real-time operational practices

6.1.2. Scenario 4 (2017 WP post-Project)

<u>Category A conditions (N-G-0)</u>

No Reliability Criteria violations were observed under Category A conditions.

<u>Category B contingency conditions (N-G-1)</u>

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

Thermal criteria violations were observed under Category B contingency conditions.

The thermal criteria violations and the applicable mitigation measures, which are also described below, are shown in Table 6-2. All of these post-Project system performance issues were identified in the pre-Project Scenario 2 (2017 WP). However, the magnitude of each of the violations in the post-Project Scenario 4 was lower than the corresponding thermal criteria violations observed in the pre-Project Scenario 2.

- Loading below the short-term emergency rating of the 72 kV transmission line 72CH9 was observed following the loss of the 72 kV transmission line 72CH11.
- Loading below the short-term emergency rating of the 72 kV transmission line 72CH11 was observed following the loss of the 72 kV transmission line 72CH9.

These thermal criteria violations can be managed by using real-time operational practices.

Table 6-2: Summary of post-Project System Performance – Scenario 4

Contingency	Limiting Facilities	Line Ratings		Details and Comparison of Reliability Criteria Violations				Difference % Loading Between Pre-Project and Post-Project Scenarios	Mitigation Measures (Post-Project
				Pre-Project (Scenario 2)		Post-Project (Scenario 4)			
		Seasonal Continuous Thermal Rating (MVA)	Short-term Emergency Rating (MVA)	Load Flow (MVA)	% Loading	Load Flow (MVA)	% Loading		
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	38	77	59.3	156.1	59.09	155.5	-0.6	Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	38	77	59.3	156.1	59.09	155.5	-0.6	Real-time operational practices

6.2. Voltage Stability Studies

The voltage stability diagrams are provided in Attachment C.

6.2.1. Scenario 3 (2017 SP post-Project)

For Scenario 3, the reference load level for the Study Area is 2,008 MW. For Category B contingencies, the minimum incremental load transfer to meet the 105% load criterion is 5.0% of the reference load, or 100.4 MW (0.05 x 2,008 MW = 100.4 MW). Table 6-3 provides the voltage stability studies results under Category A conditions and for the five worst contingencies under Category B conditions. The voltage stability margin was met for all studied conditions.

Table 6-3: Voltage stability analysis results – Scenario 3 (Minimum transfer = 100.4 MW)

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System normal		331.25	Yes
Category B (Minimum Transfer = 100.4 MW)				
Transformer T2 at the Clover Bar substation	Clover Bar bus 514	Clover Bar bus 516	315.63	Yes
240 kV transmission line 240CV5	Castle Downs bus 519	Victoria bus 520	315.63	Yes
Transformer T5 at the Victoria substation	Victoria bus 520	Victoria bus 533	315.63	Yes
Transformer T1 at the Clover Bar substation	Clover Bar bus 514	Clover Bar bus 516	315.63	Yes

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
240 kV transmission line 902L	Wabamun 19S bus 133 532	Sundance 310P bus 135 542	323.44	Yes

6.2.2. Scenario 4 (2017 WP post-Project)

For Scenario 4, the reference load level for the Study Area is 1,971 MW. For Category B contingencies, the minimum incremental load transfer to meet the 105% load criterion is 5.0% of the reference load, or 98.55 MW (0.05 x 1,890 MW = 98.55 MW). Table 6-4 provides the voltage stability studies results under Category A conditions and for the five worst contingencies under Category B conditions. The voltage stability margin was met for all studied conditions.

Table 6-4: Voltage stability analysis results – Scenario 4 (Minimum transfer = 98.55 MW)

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System normal		312.5	Yes
Category B (Minimum Transfer = 100.4 MW)				
Transformer T2 at the Clover Bar substation	Clover Bar bus 514	Clover Bar bus 516	312.5	Yes
240 kV transmission line 240CV5	Castle Downs bus 519	Victoria bus 520	300	Yes
Transformer T5 at the Victoria substation	Victoria bus 520	Victoria bus 533	300	Yes
Transformer T1 at the Clover Bar substation	Clover Bar bus 514	Clover Bar bus 516	312.5	Yes
240 kV transmission line 902L	Wabamun 19S bus 133 532	Sundance 310P bus 135 542	312.5	Yes

6.3. Results Summary

The Reliability Criteria violations observed during the connection assessment studies are summarized in Table 6-5.

Table 6-5: Project Impact and Mitigation Measures

Reliability Criteria Violations		Occurrence (Pre-Project or Post-Project Scenarios)	Project Impact	Year/ Season Load	Mitigation Measures (Pre-Project and Post-Project)
Violation	Contingency				
747L (N. Calder - Genster)	902L (Sundance 310P – Wabamun 19S)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72RG1 (Rossdale - Garneau)	72RG7 (Rossdale - Garneau)	Pre-Project and	Reduced	2017 SP	**Pre:** Real-time operational practices

Reliability Criteria Violations		Occurrence (Pre-Project or Post-Project Scenarios)	Project Impact	Year/ Season Load	Mitigation Measures (Pre-Project and Post-Project)
Violation	**Contingency**				
		Post-Project	thermal loading		**Post:** Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CK13 (Clover Bar - Kennedale)	72CK12 (Clover Bar - Kennedale)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CK12 (Clover Bar - Kennedale)	72CK13 (Clover Bar - Kennedale)	Pre-Project and Post-Project	Reduced thermal loading	2017 SP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH9 (Clover Bar - Hardisty)	72CH11 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 WP	**Pre:** Real-time operational practices **Post:** Real-time operational practices
72CH11 (Clover Bar - Hardisty)	72CH9 (Clover Bar - Hardisty)	Pre-Project and Post-Project	Reduced thermal loading	2017 WP	**Pre:** Real-time operational practices **Post:** Real-time operational practices

The power flow studies results identified pre-Project and post-Project system performance issues under Category B contingency conditions. However, the connection assessment indicates that the Project will not adversely impact the performance of the AIES because the magnitude of each of the thermal criteria violations in the post-Project scenarios was lower than the corresponding thermal criteria violations observed in the pre-Project scenarios.

Real-time operational practices are currently being used to manage the pre-Project system performance issues, and can be used to address the post-Project system performance issues.

The post-Project voltage stability analyses confirm that the voltage stability margin of the Study Area was met under all studied conditions.

Based on the study results, Alternative 1 is technically viable.

7. Project Dependencies

The Project is not dependent on the AESO's plans to expand or enhance the transmission system.

8. Conclusions and Recommendations

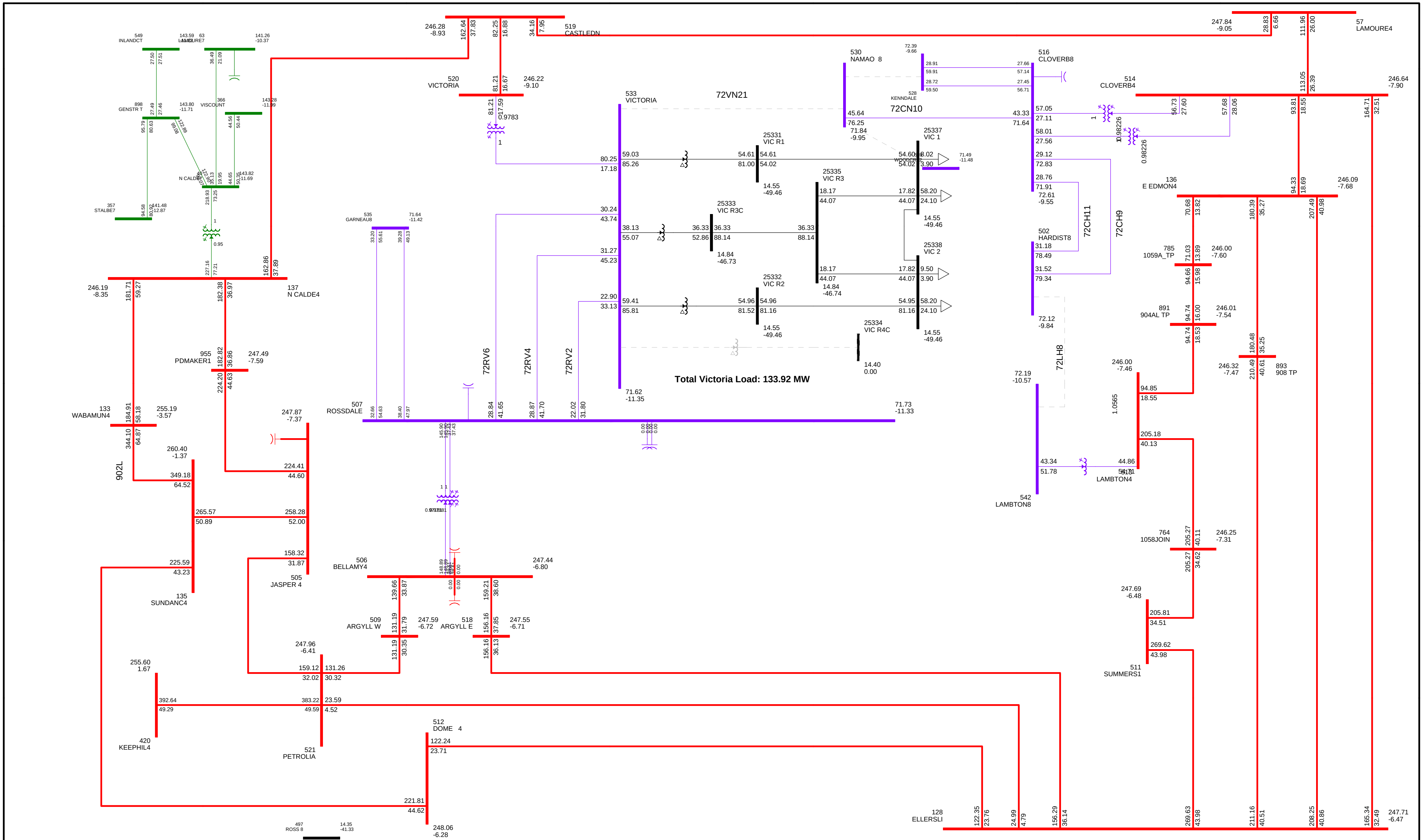
Based on the study results, Alternative 1 is technically viable. The connection assessment identified a number of pre-Project and post-Project system performance issues. However, the connection assessment indicates that the Project will not adversely impact the performance of the AIES because the magnitude of each of the thermal criteria violations in the post-Project scenarios was lower than the corresponding thermal criteria violations observed in the pre-Project scenarios.

Real-time operational practices are currently being used to manage the pre-Project system performance issues, and can be used to address the post-Project system performance issues.

It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service. It is also recommended to continue to use real-time operational practices to manage the identified system performance issues.

Attachment A

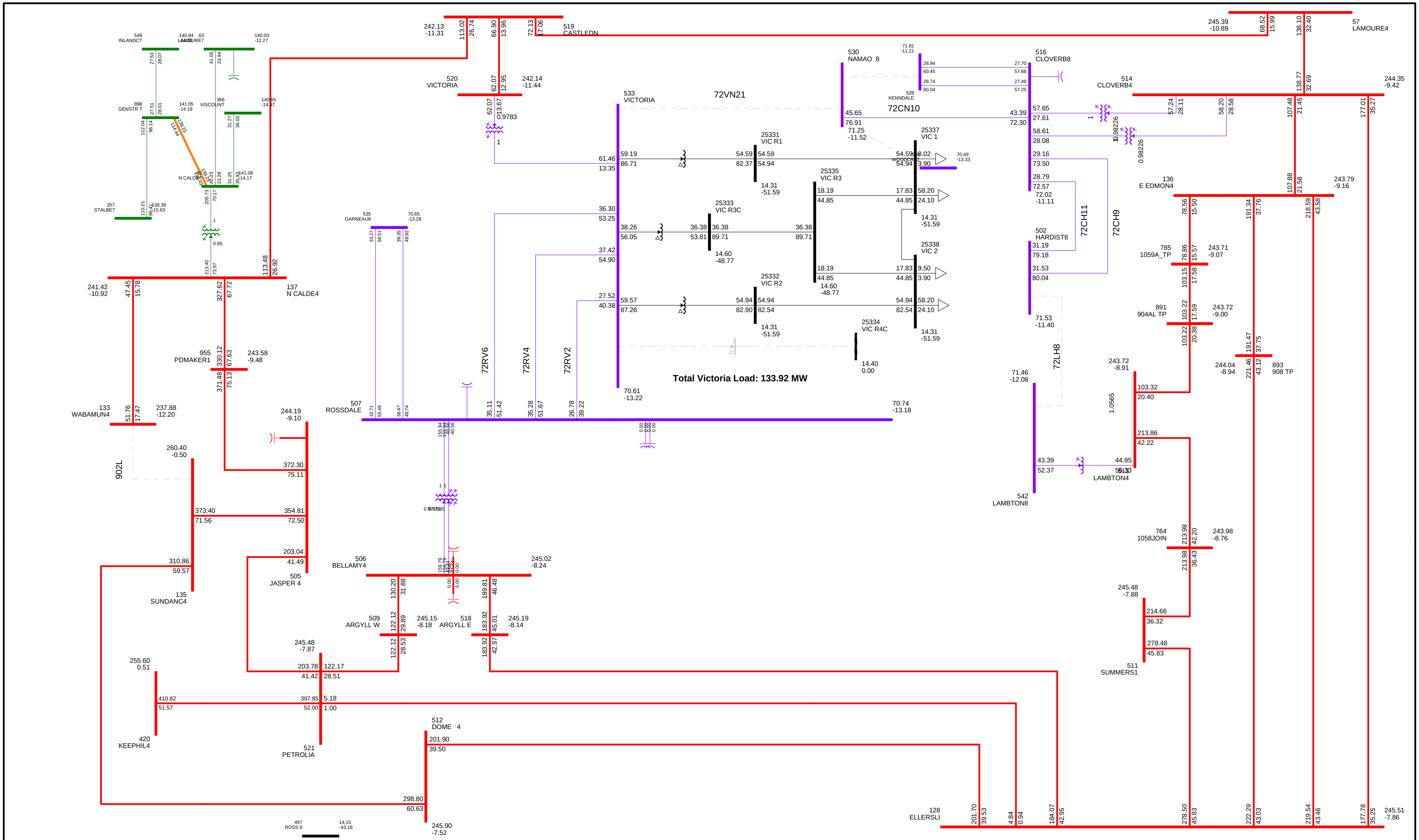
Pre-Project Power Flow Diagrams (Scenarios 1 and 2)



2017SP AESO
BASE CASE (N-0)
FIG A-1
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

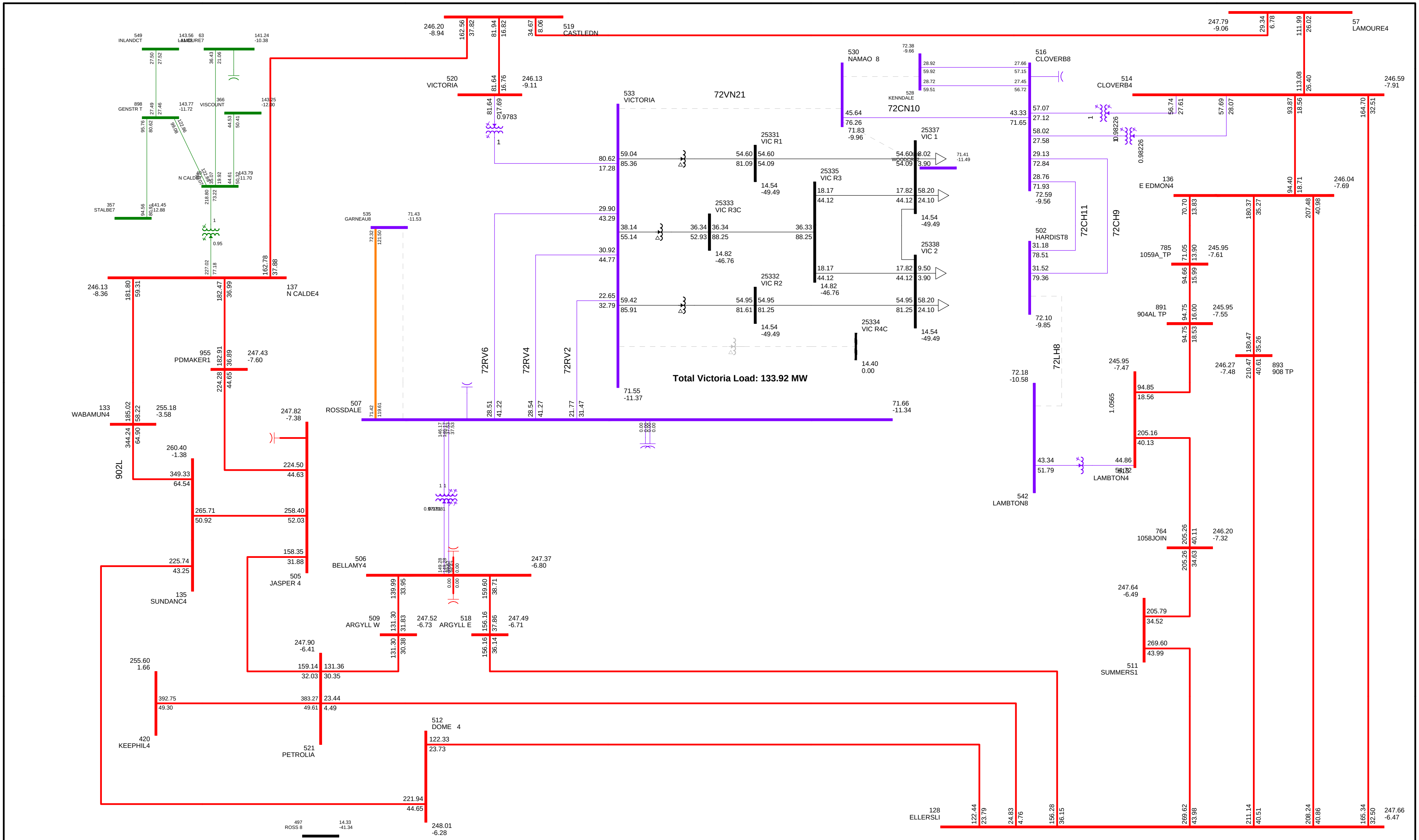
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 902L (SUNDANCE TO WABAMUN)
FIG A-2
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

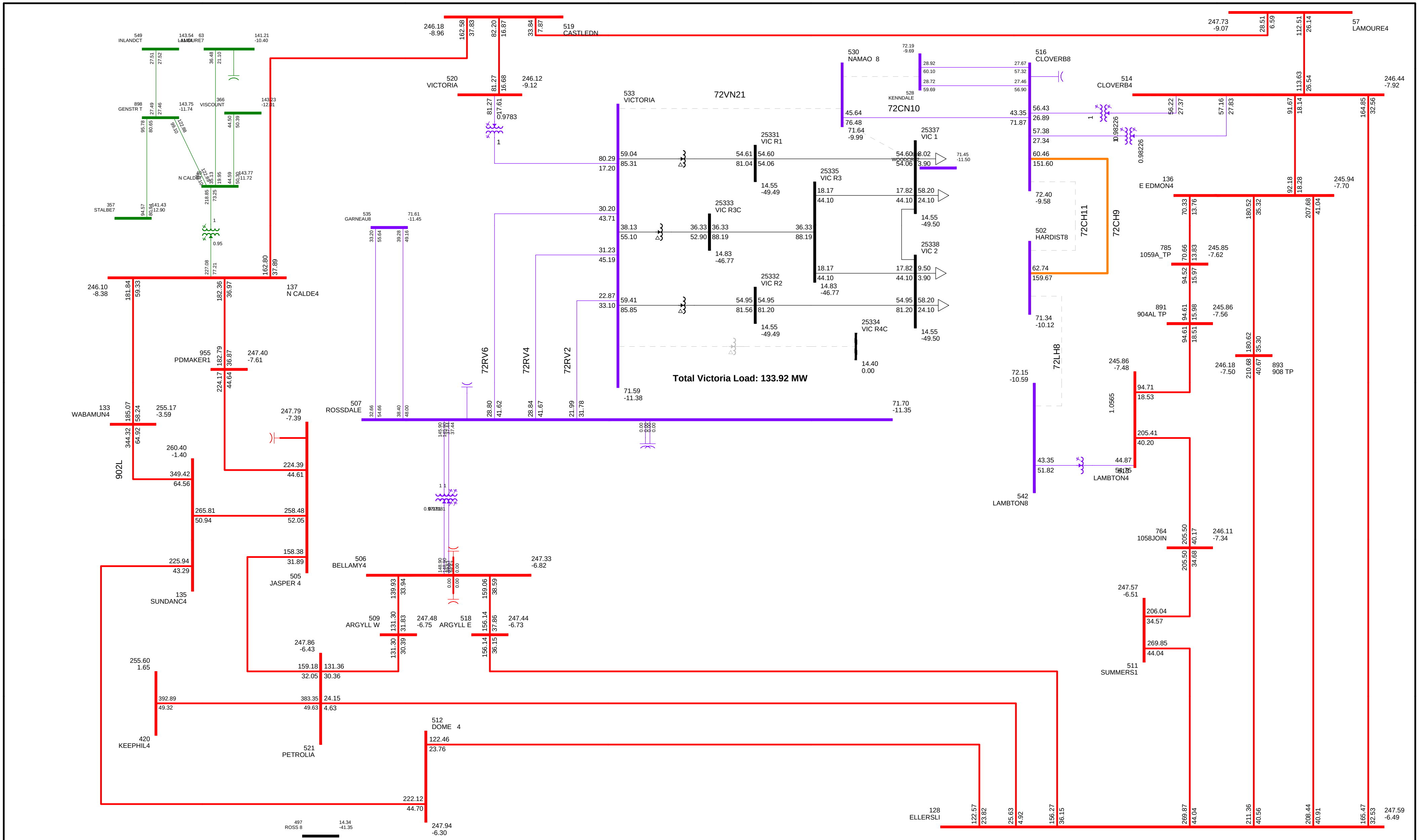
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72RG7 (ROSSDALE TO GARNEAU)
FIG A-3
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

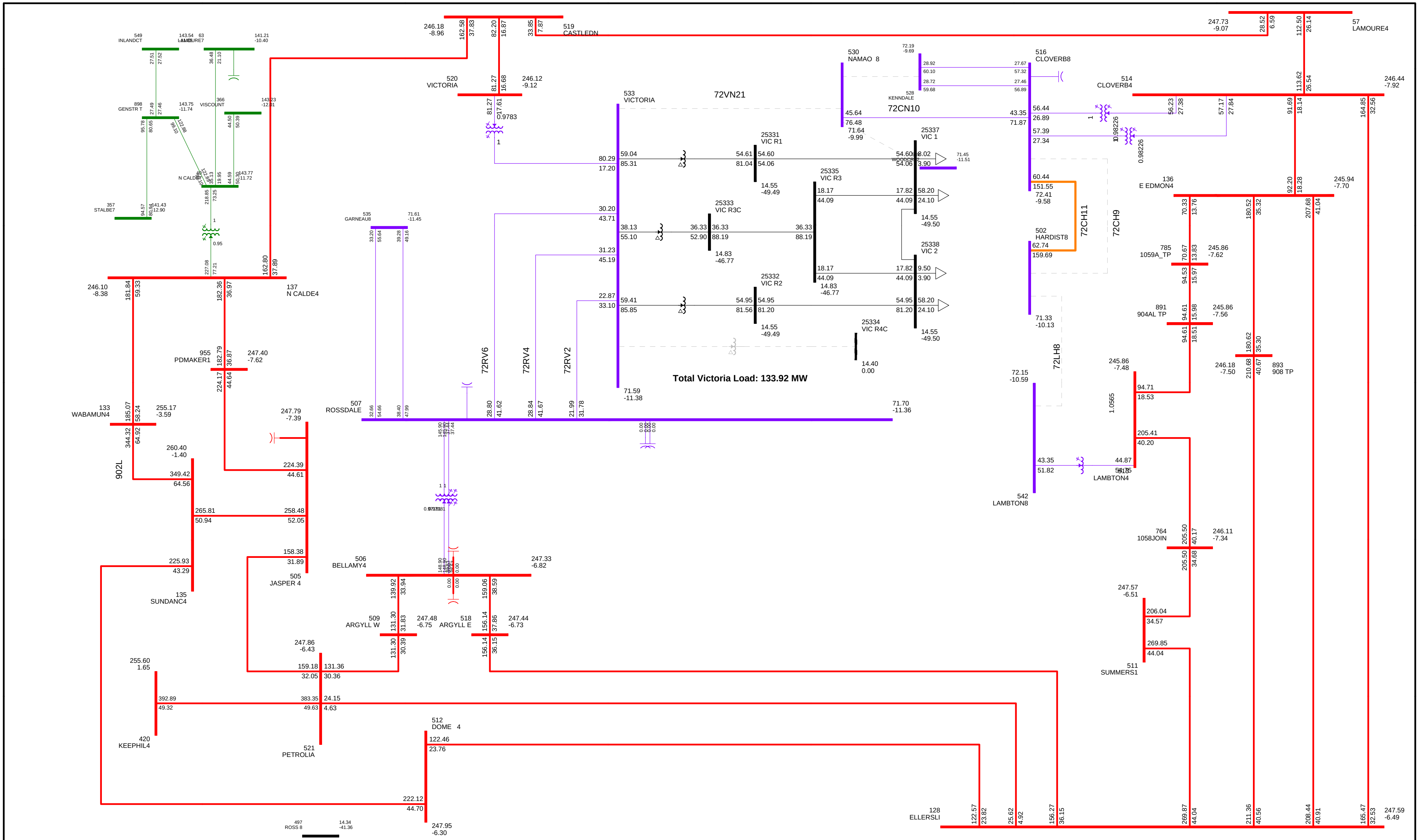
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CH11 (CLOVERBAR TO HARDISTY)
FIG A-4
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

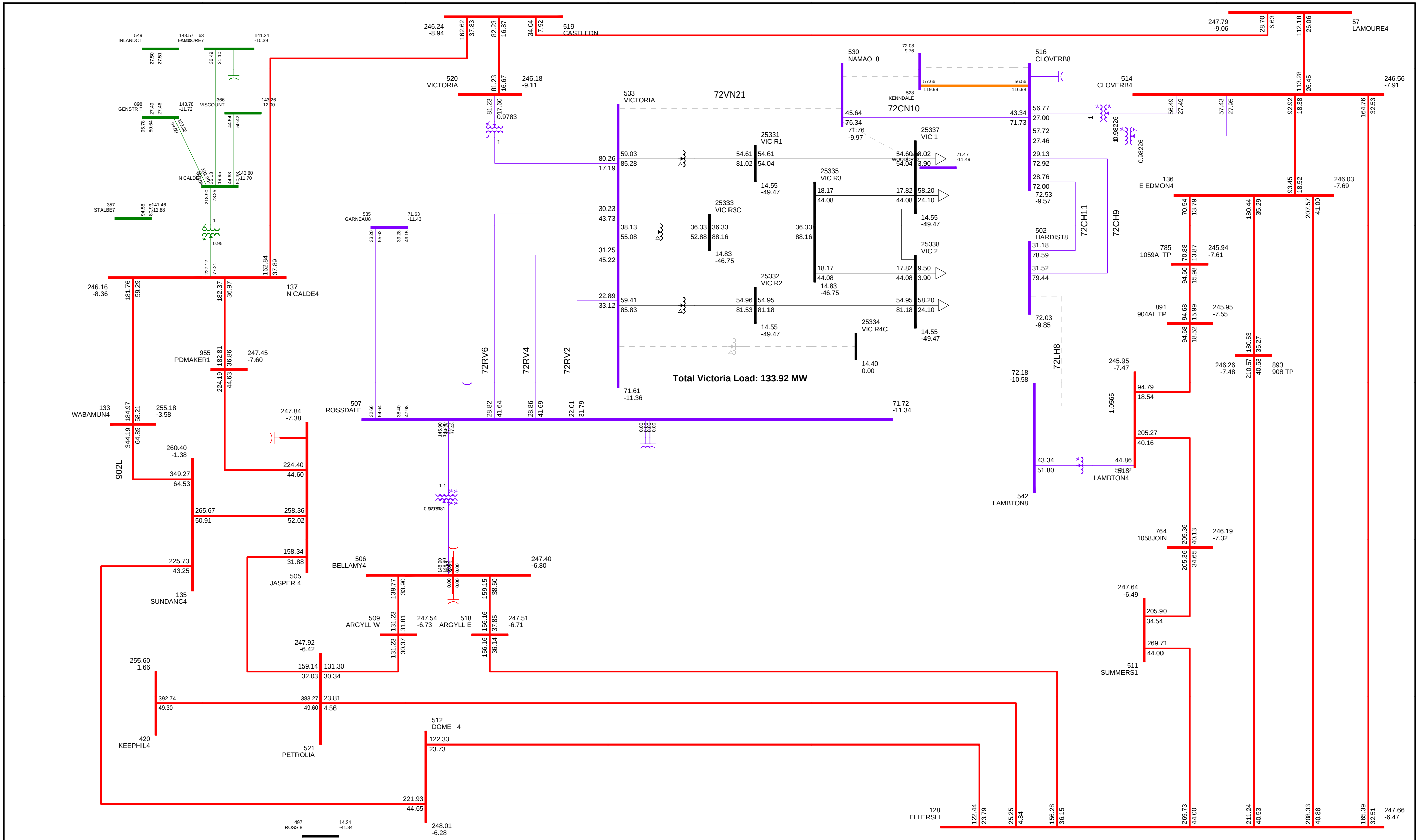
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CH9 (CLOVERBAR TO HARDISTY)
FIG A-5
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

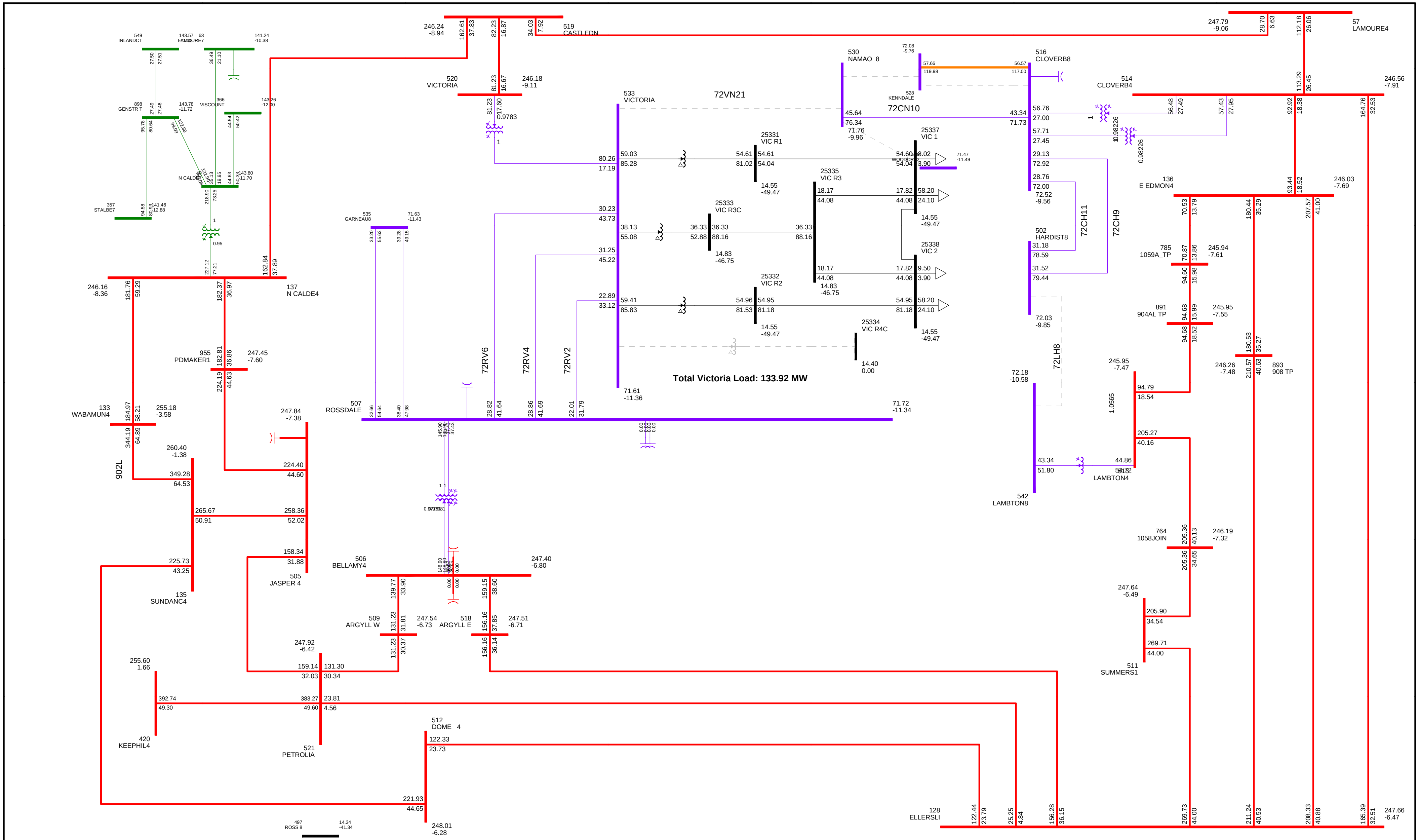
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CK12 (CLOVERBAR TO KENNEDALE)
FIG A-6
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

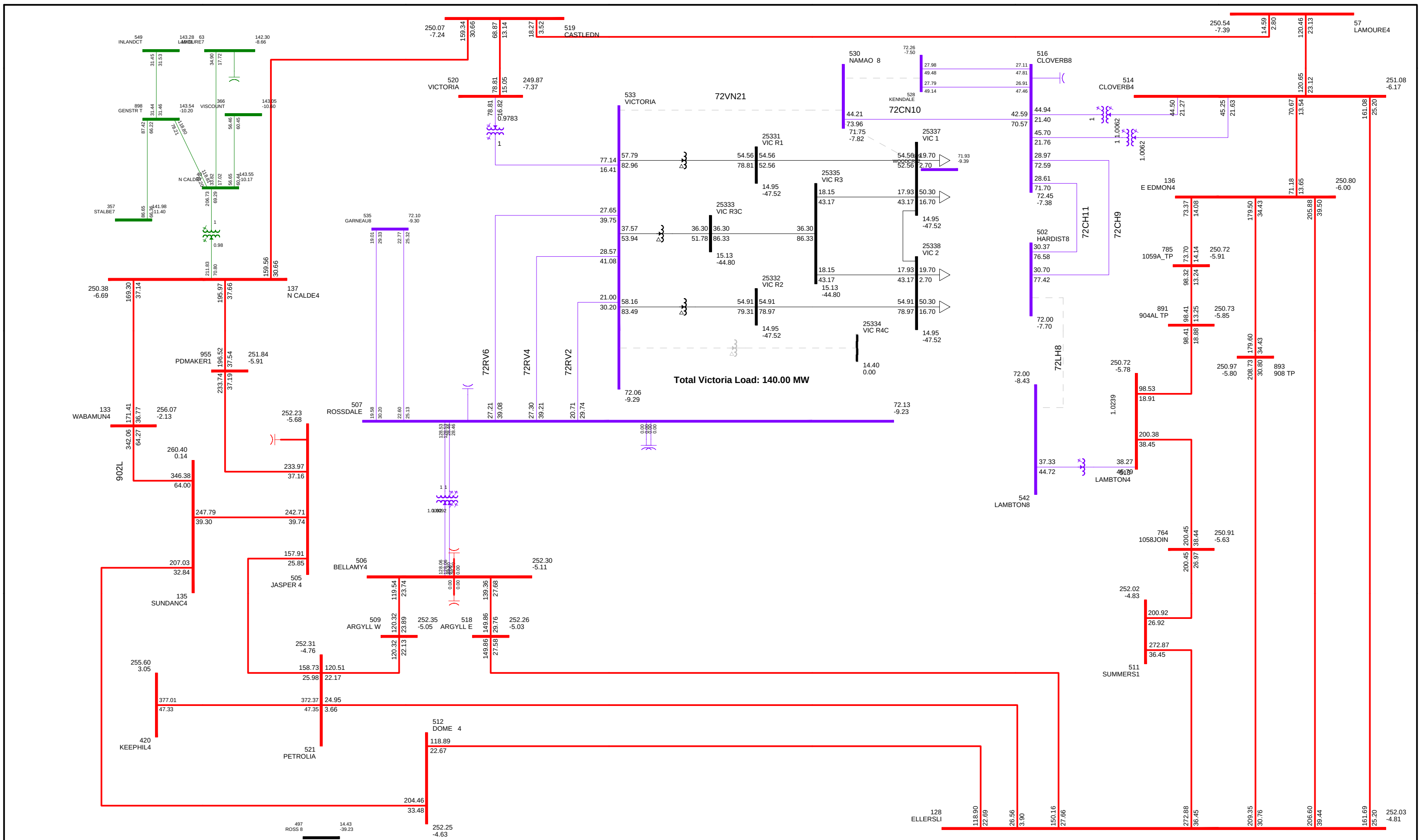
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CK13 (CLOVERBAR TO KENNEDALE)
FIG A-7
THU, NOV 03 2016 15:16

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

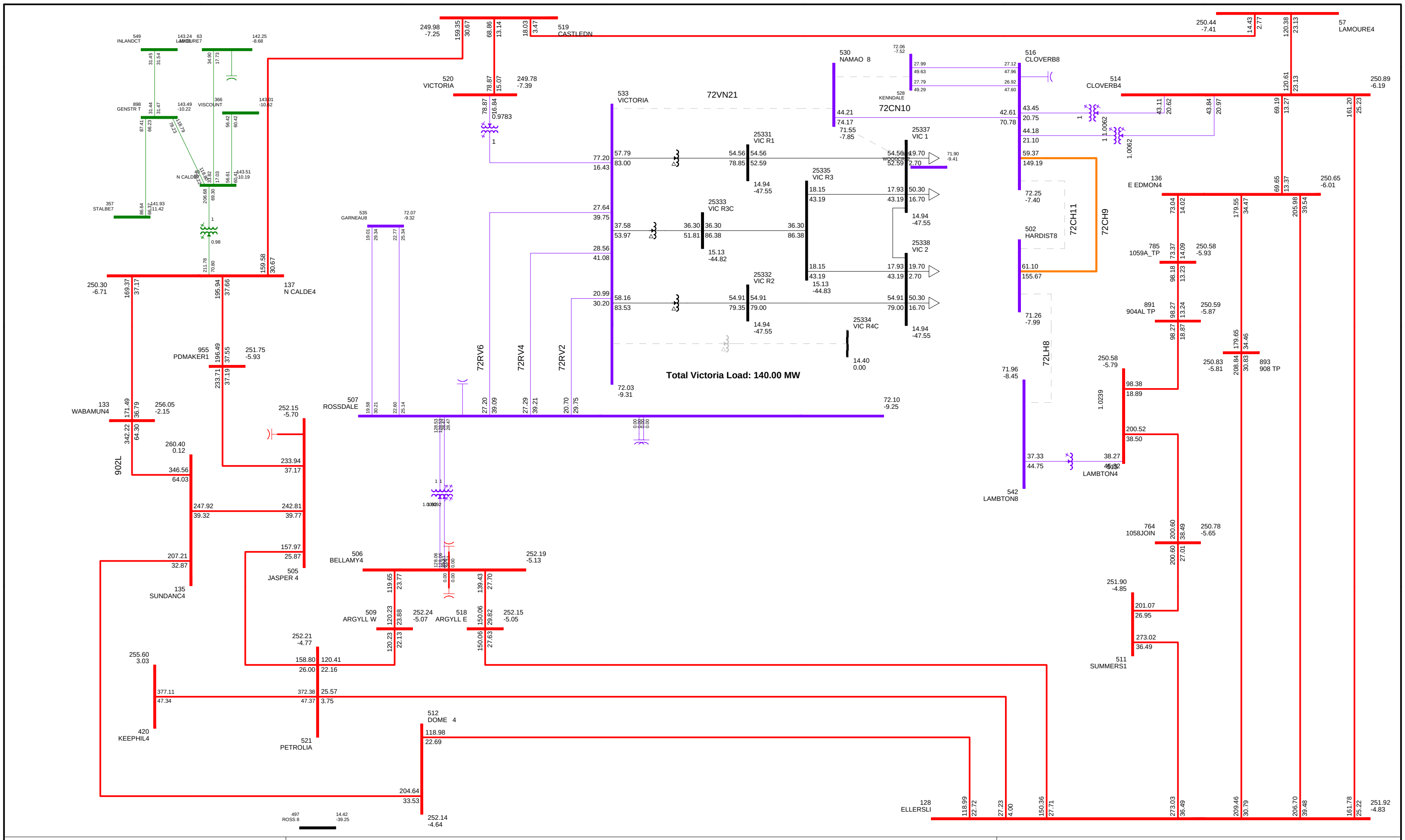
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017WP AESO
BASE CASE (N-0)
FIG A-1
WED, NOV 16 2016 10:44

Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

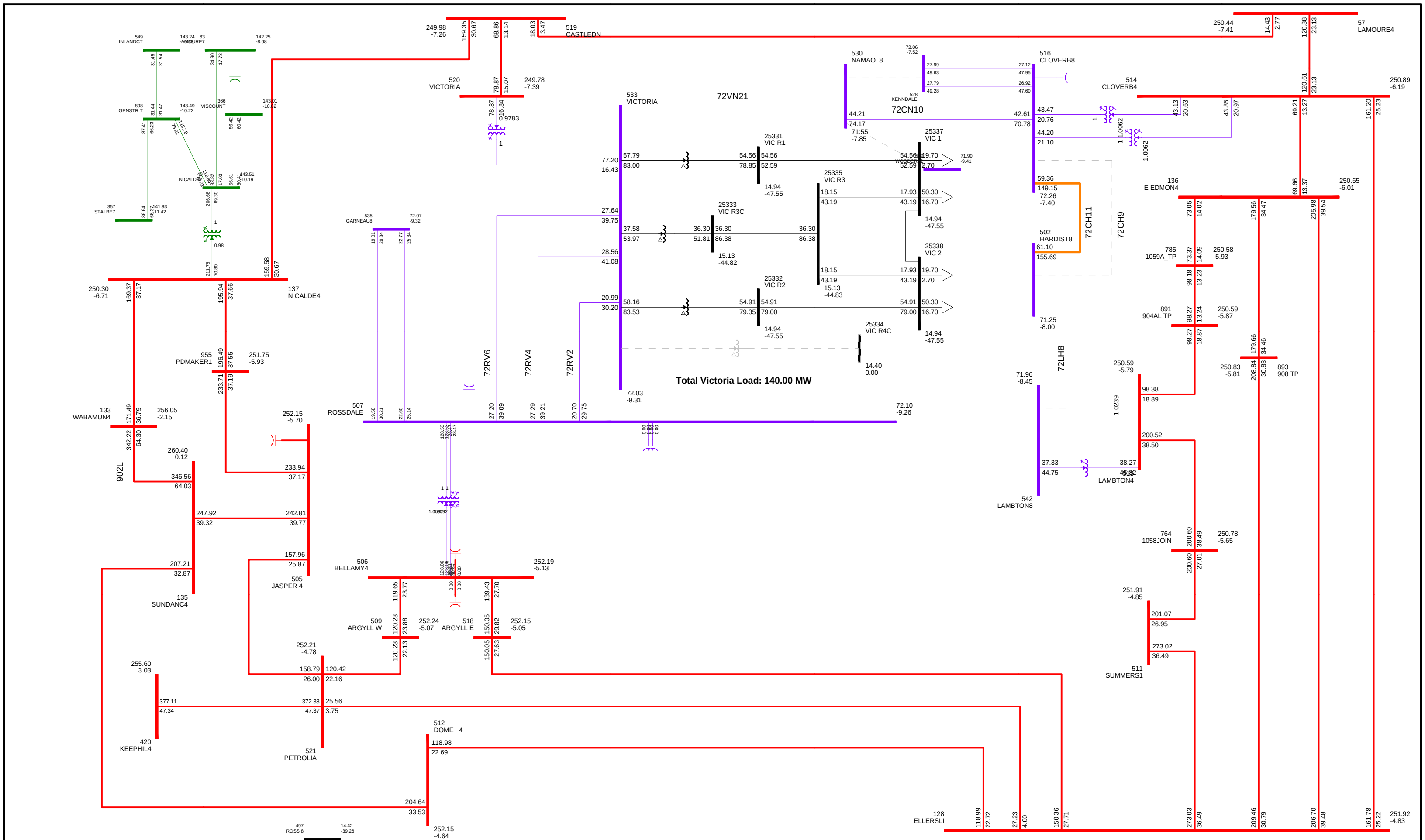
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017WP AESO
LOSS OF 72CH11 (CLOVERBAR TO HARDISTY)
FIG A-2
WED, NOV 16 2016 10:44

Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



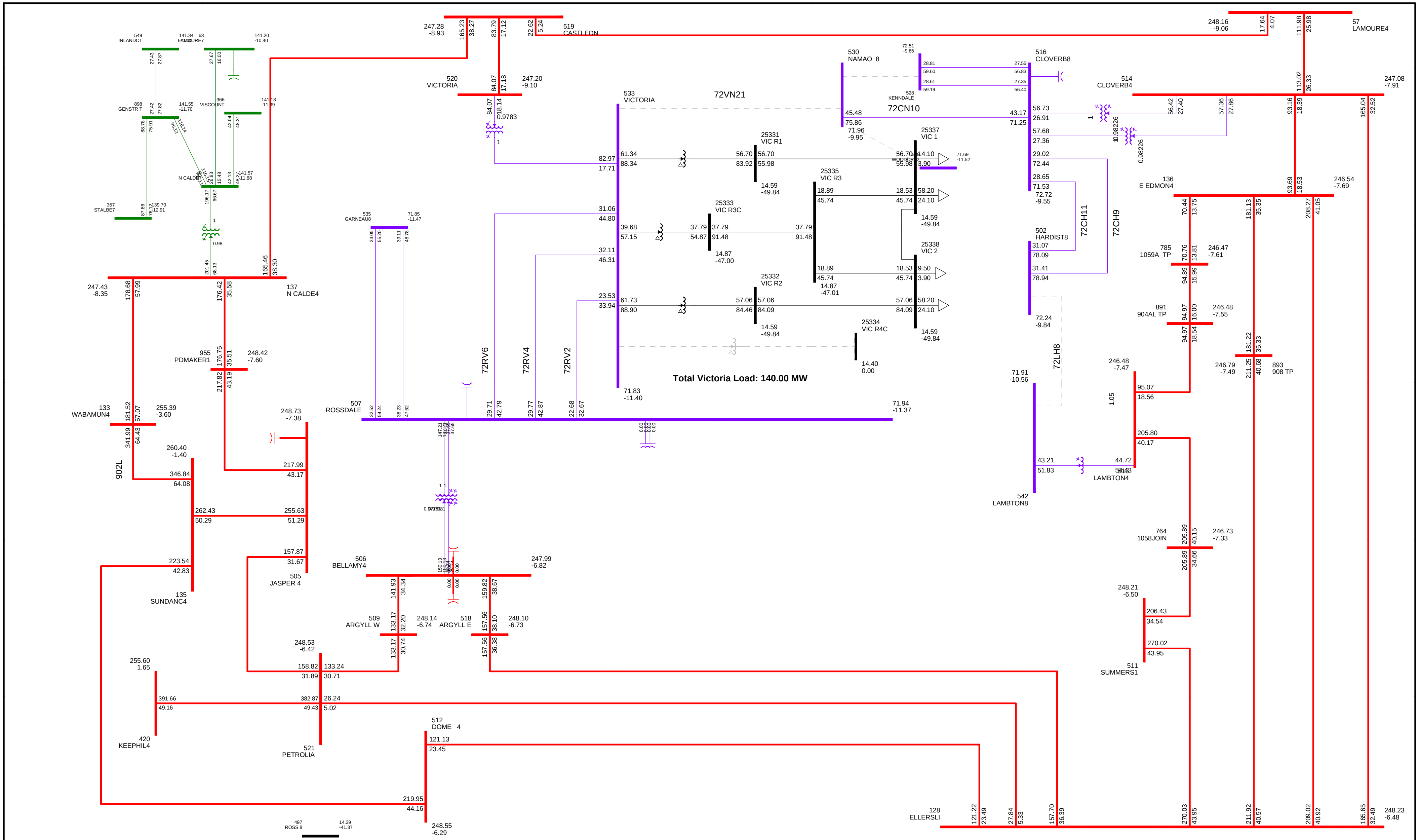
2017WP AESO
LOSS OF 72CH9 (CLOVERBAR TO HARDISTY)
FIG A-3
WED, NOV 16 2016 10:45

Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment B

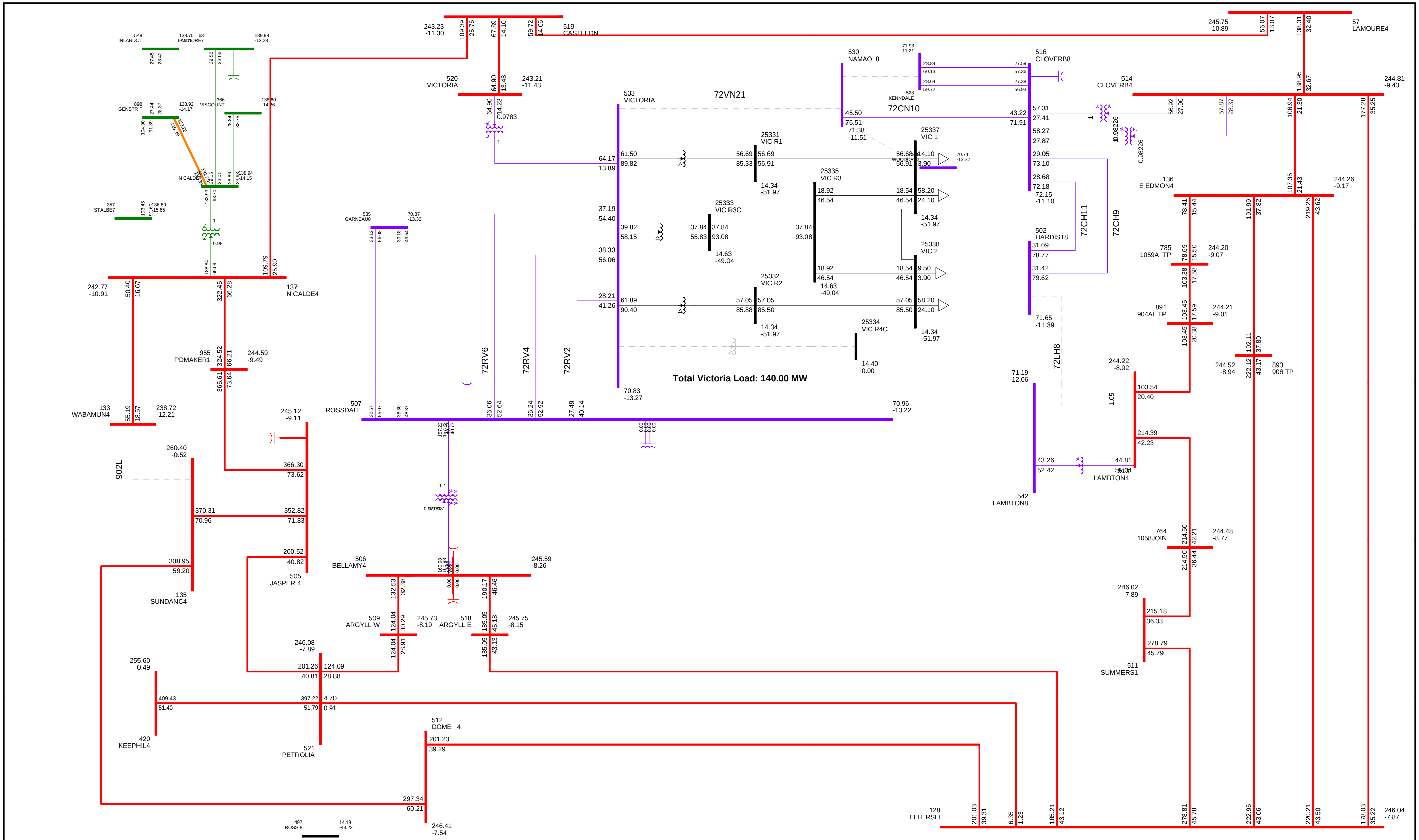
Post-Project Power Flow Diagrams (Scenarios 3 and 4)



2017SP AESO
BASE CASE (N-0)
FIG A-1
THU, NOV 03 2016 15:13

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

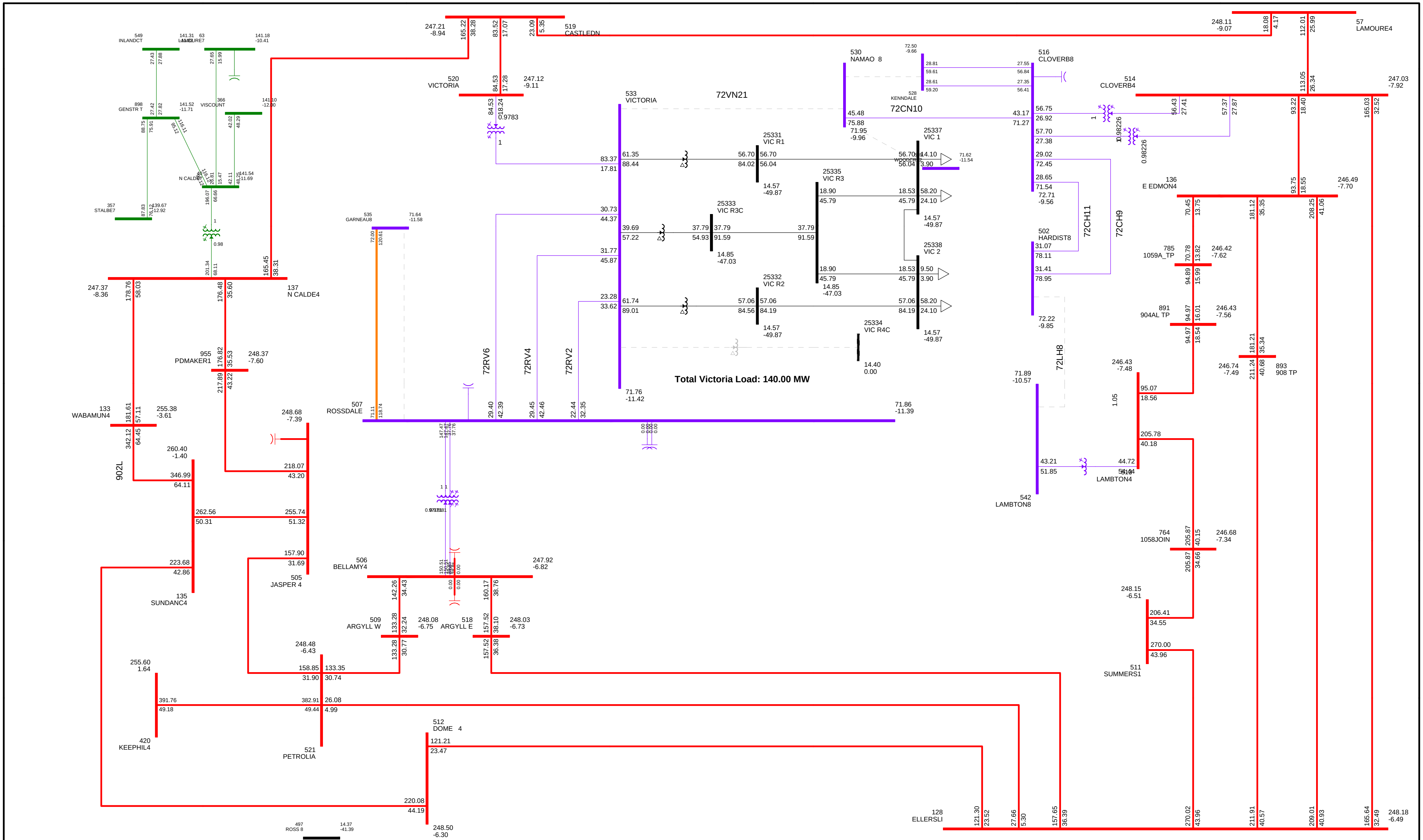
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 902L (SUNDANCE TO WABAMUN)
FIG A-2
THU, NOV 03 2016 15:13

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

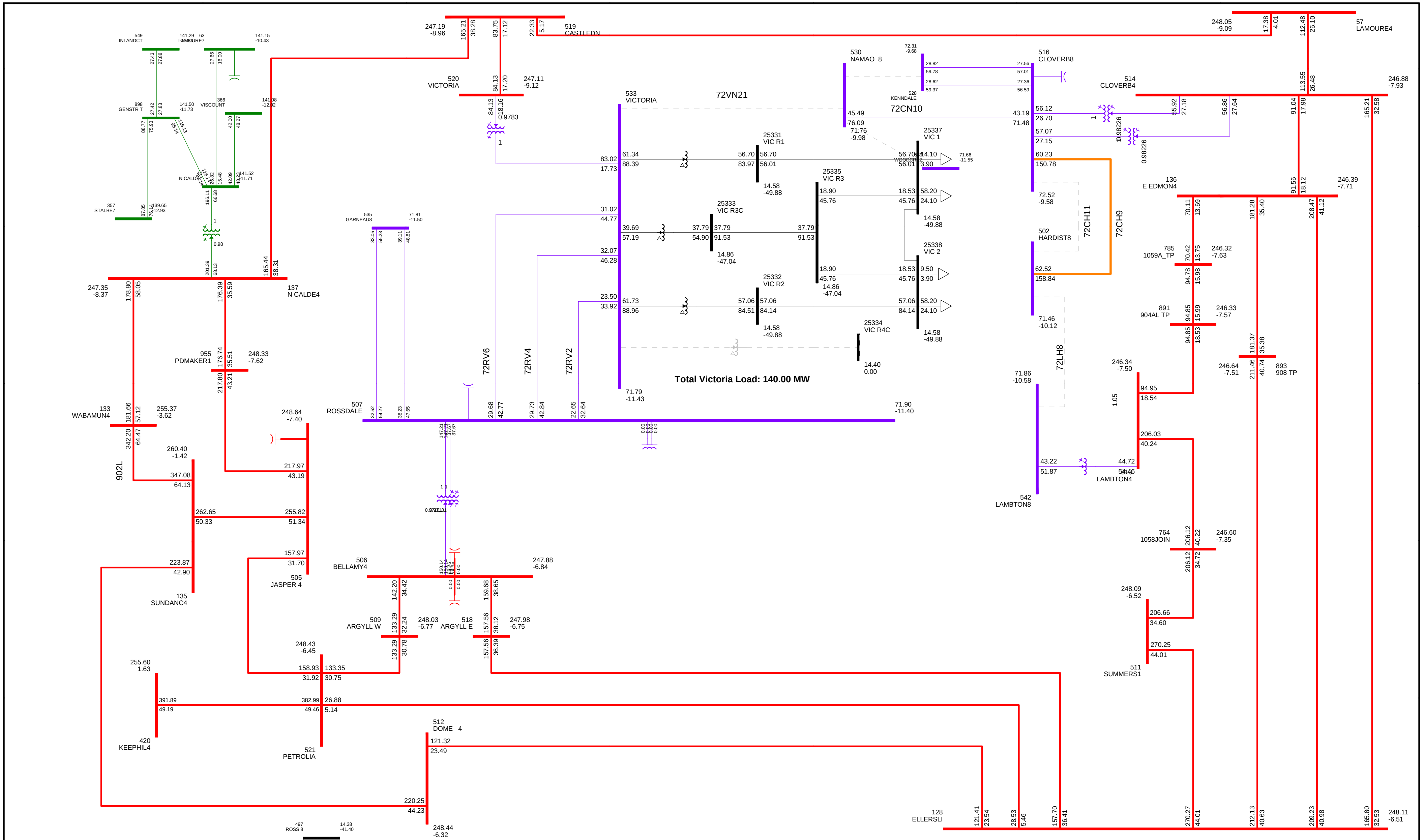
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72RG7 (ROSSDALE TO GARNEAU)
FIG A-3
THU, NOV 03 2016 15:14

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

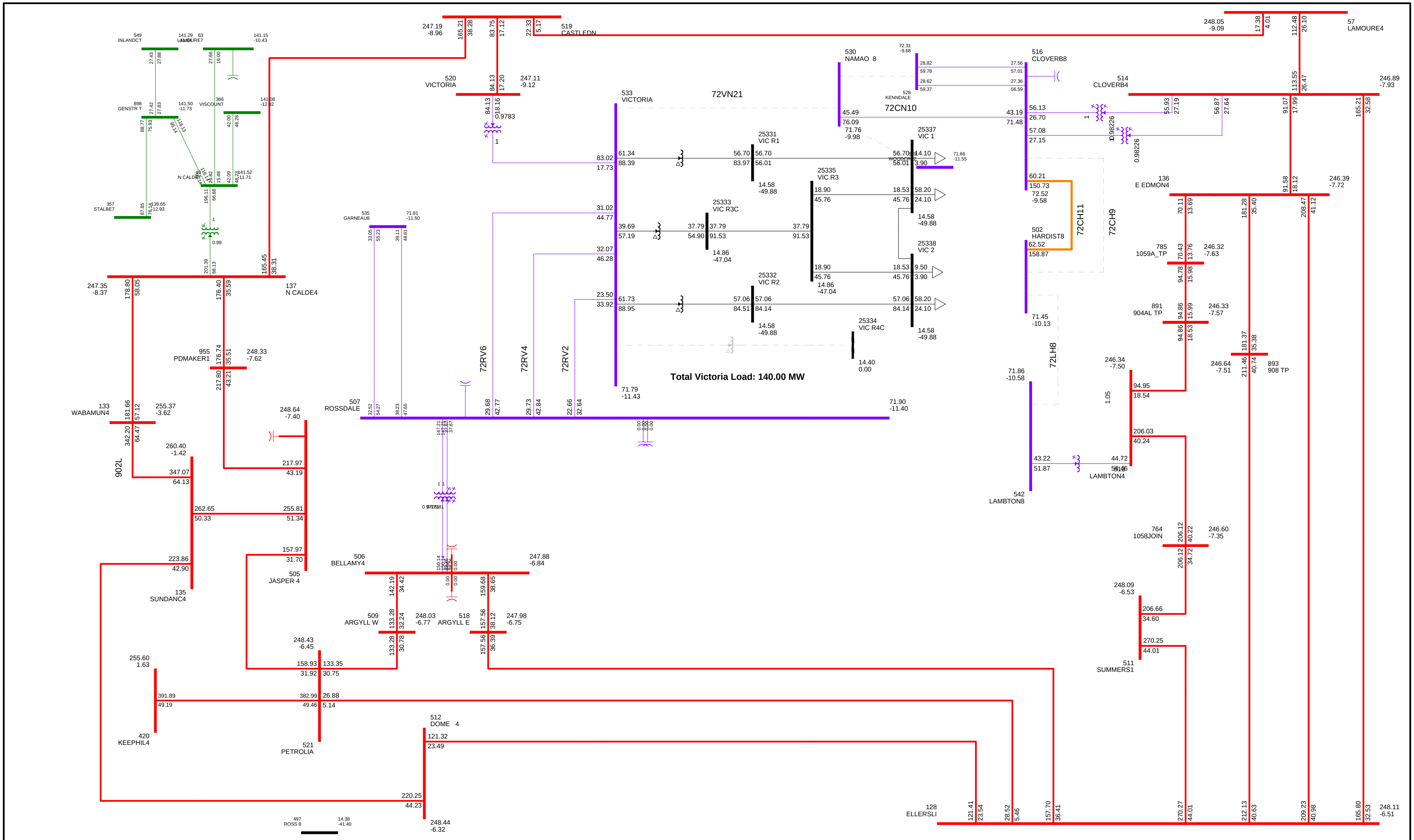
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CH11 (CLOVERBAR TO HARDISTY)
FIG A-4
THU, NOV 03 2016 15:14

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

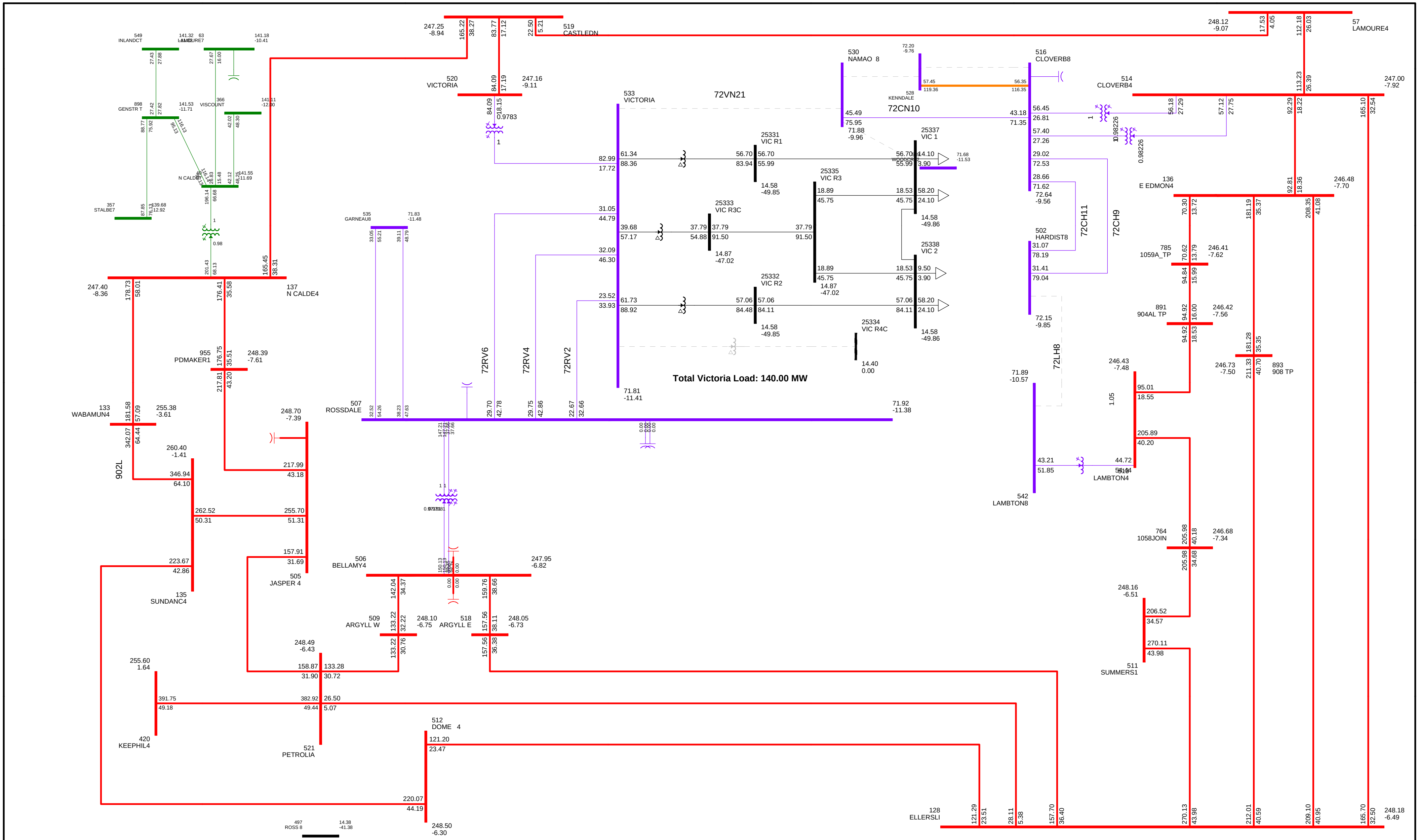
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CH9 (CLOVERBAR TO HARDISTY)
FIG A-5
THU, NOV 03 2016 15:14

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

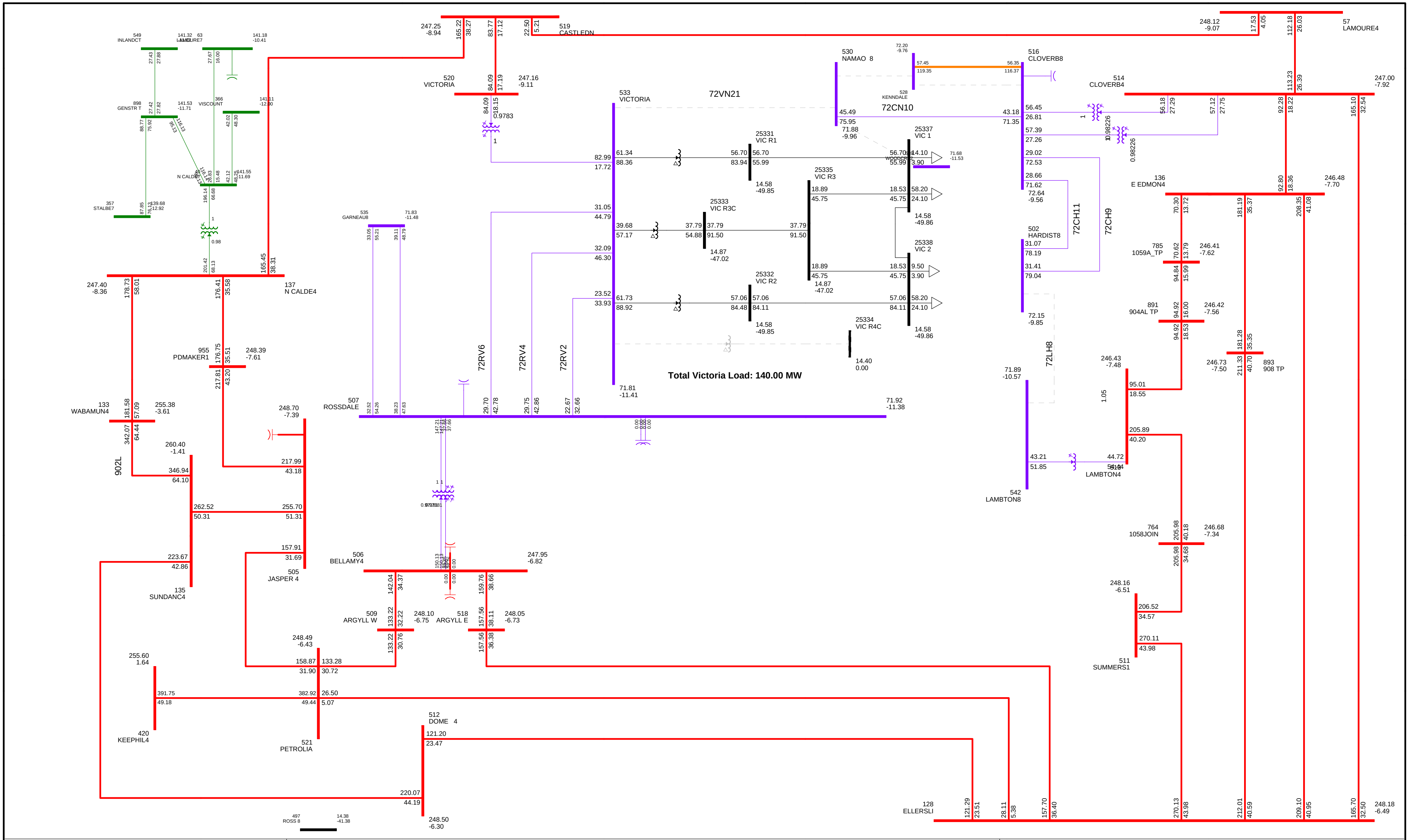
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CK12 (CLOVERBAR TO KENNEDALE)
FIG A-6
THU, NOV 03 2016 15:14

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

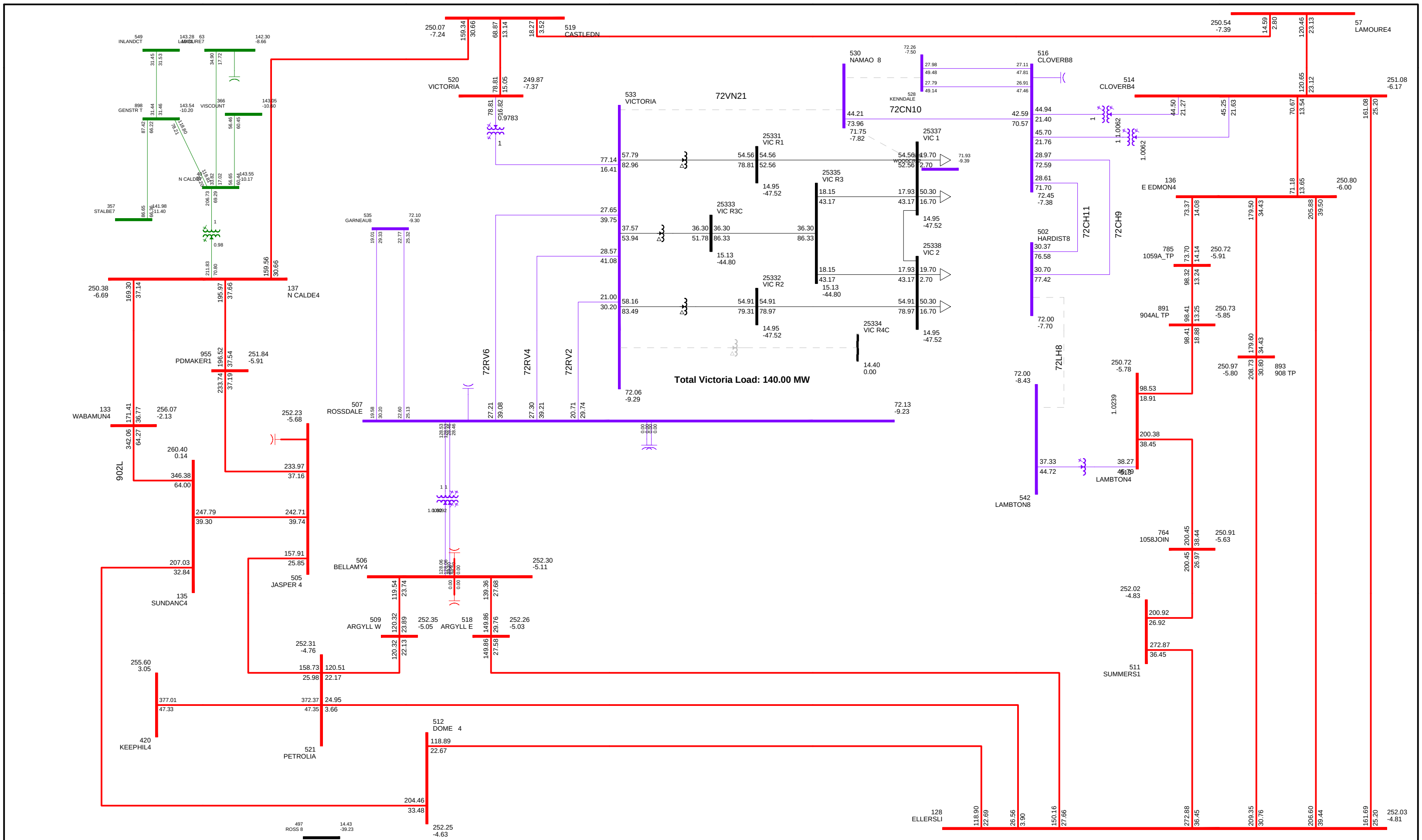
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017SP AESO
LOSS OF 72CK13 (CLOVERBAR TO KENNEDALE)
FIG A-7
THU, NOV 03 2016 15:14

Bus - Base voltage (kV)
Branch - MVA/% Rate A
Equipment - MW/Mvar
100.0%Rate A

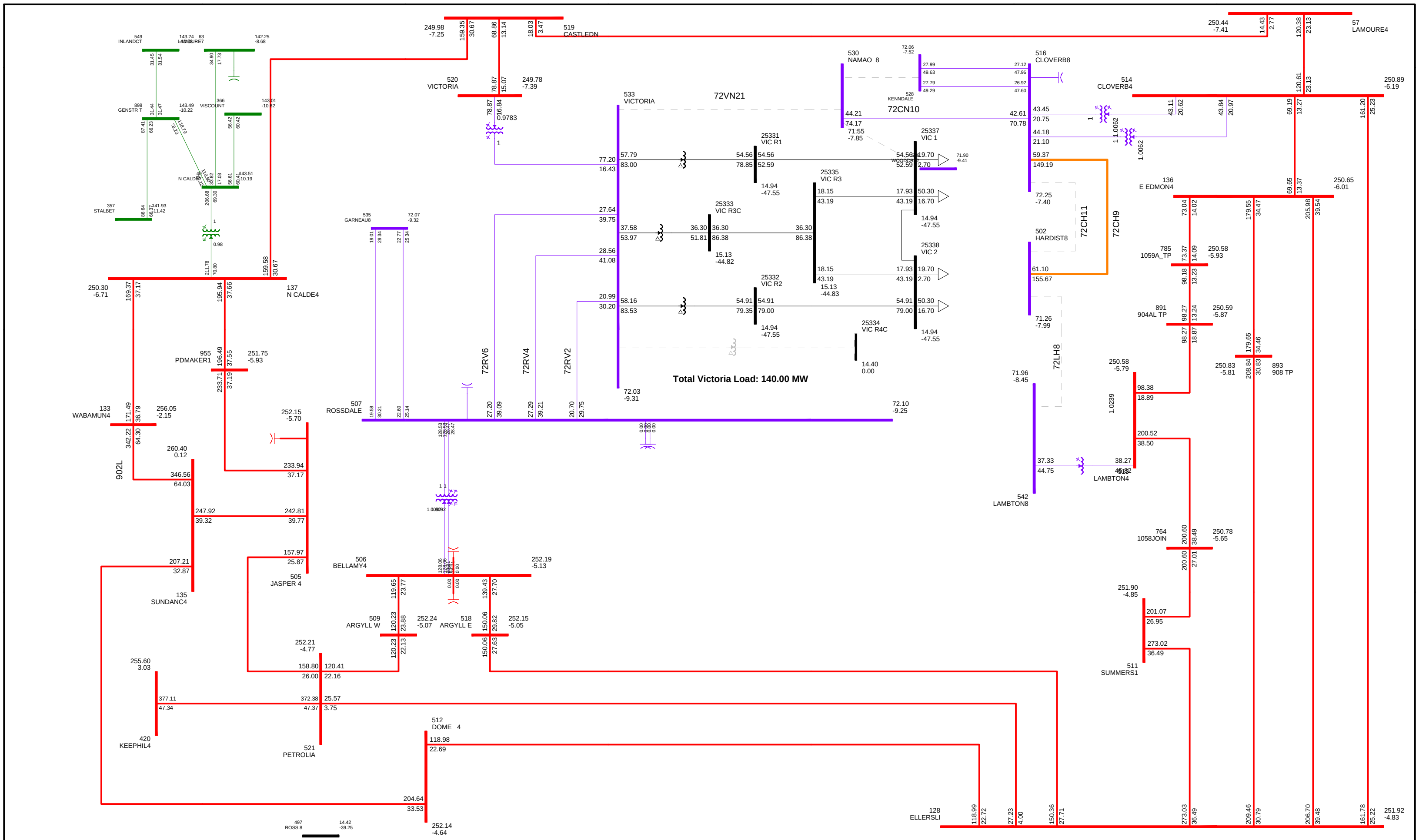
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017WP AESO
BASE CASE (N-0)
FIG A-1
WED, NOV 16 2016 10:45

Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

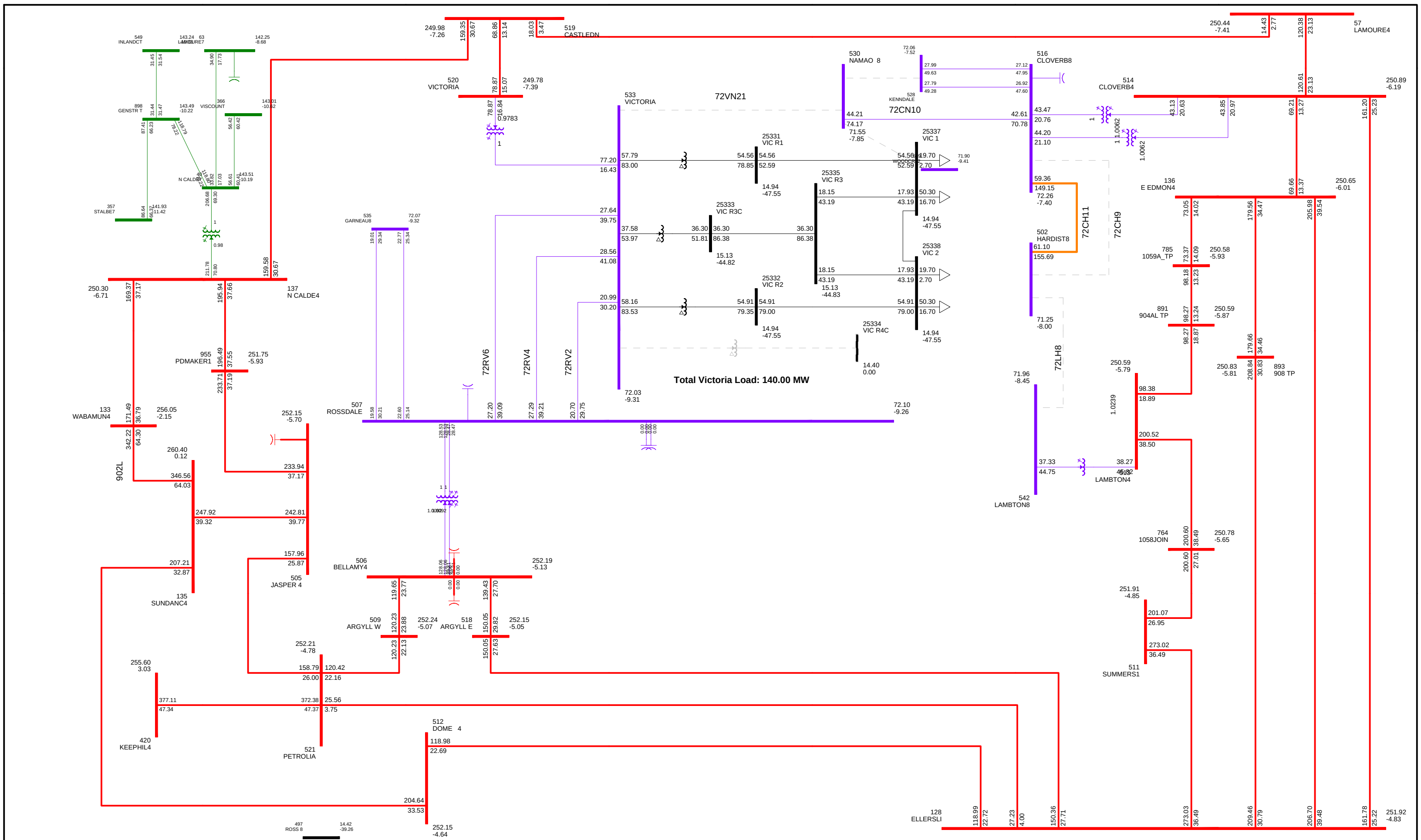
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017WP AESO
LOSS OF 72CH11 (CLOVERBAR TO HARDISTY)
FIG A-2
WED, NOV 16 2016 10:46

Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



2017WP AESO
LOSS OF 72CH9 (CLOVERBAR TO HARDISTY)
FIG A-3
WED, NOV 16 2016 10:46

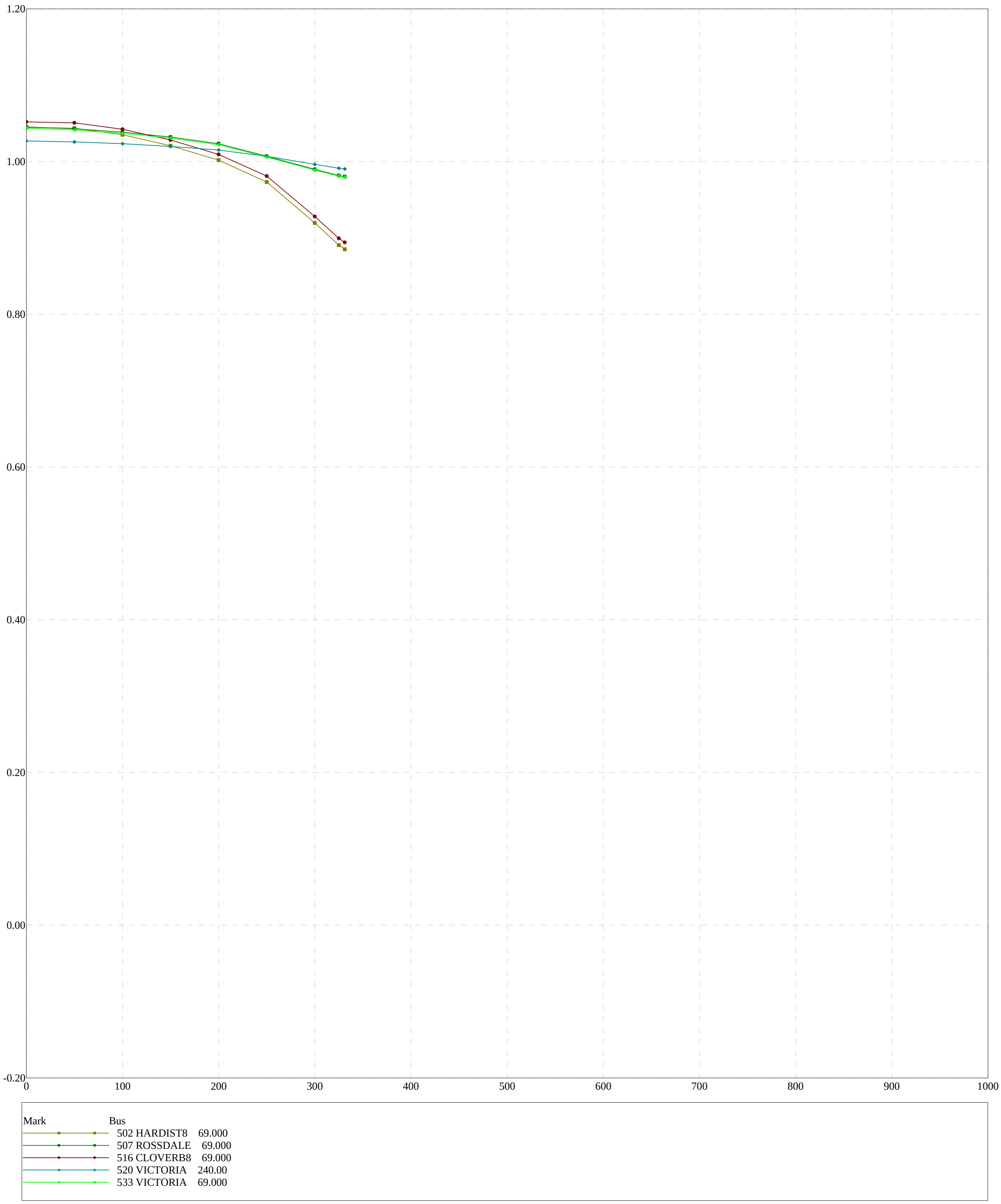
Bus - Base voltage (kV)
Branch - MVA/% Rate B
Equipment - MW/Mvar
100.0%Rate B

kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

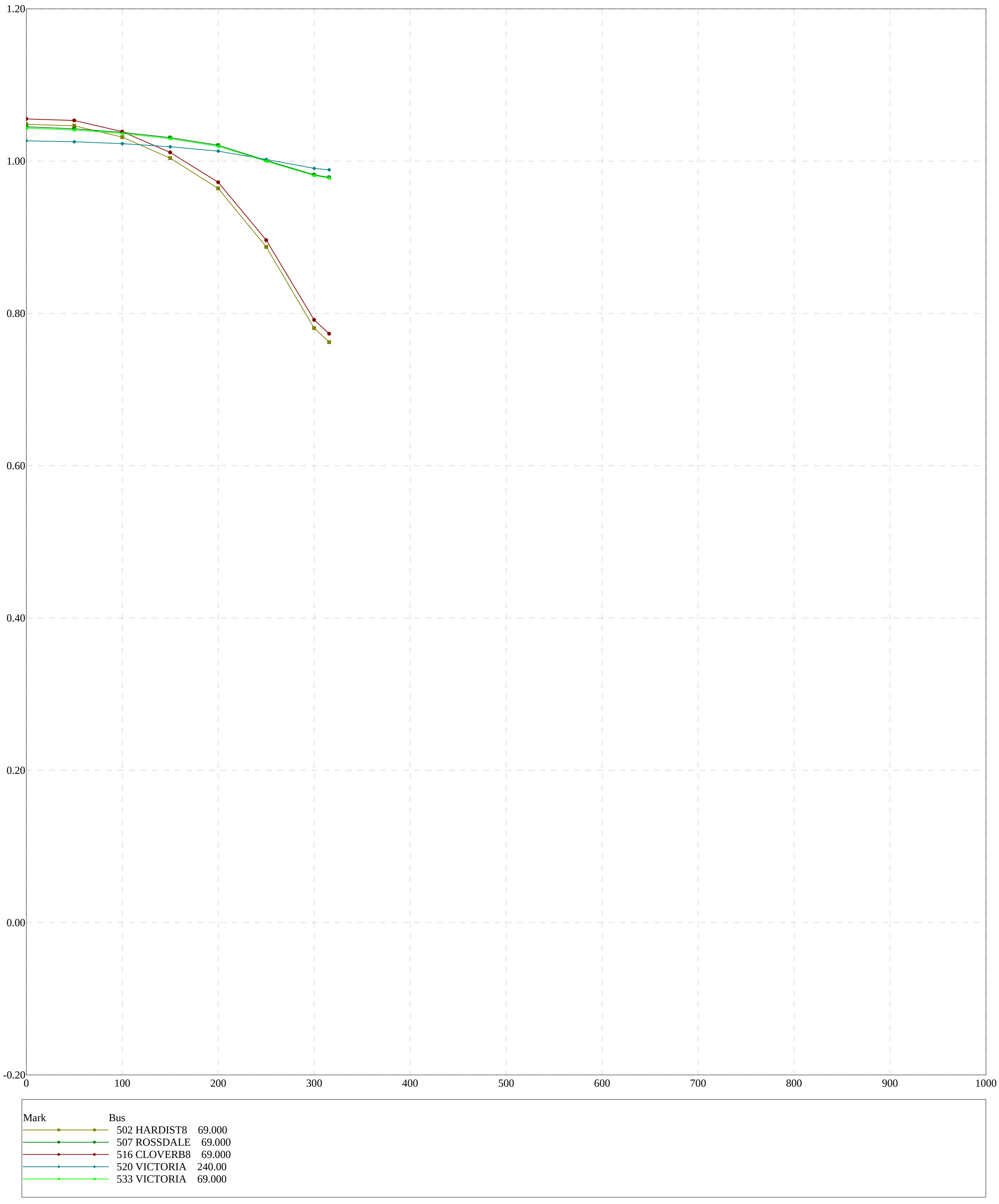
Attachment C

Post-Project Voltage Stability Diagrams (Scenarios 3 and 4)

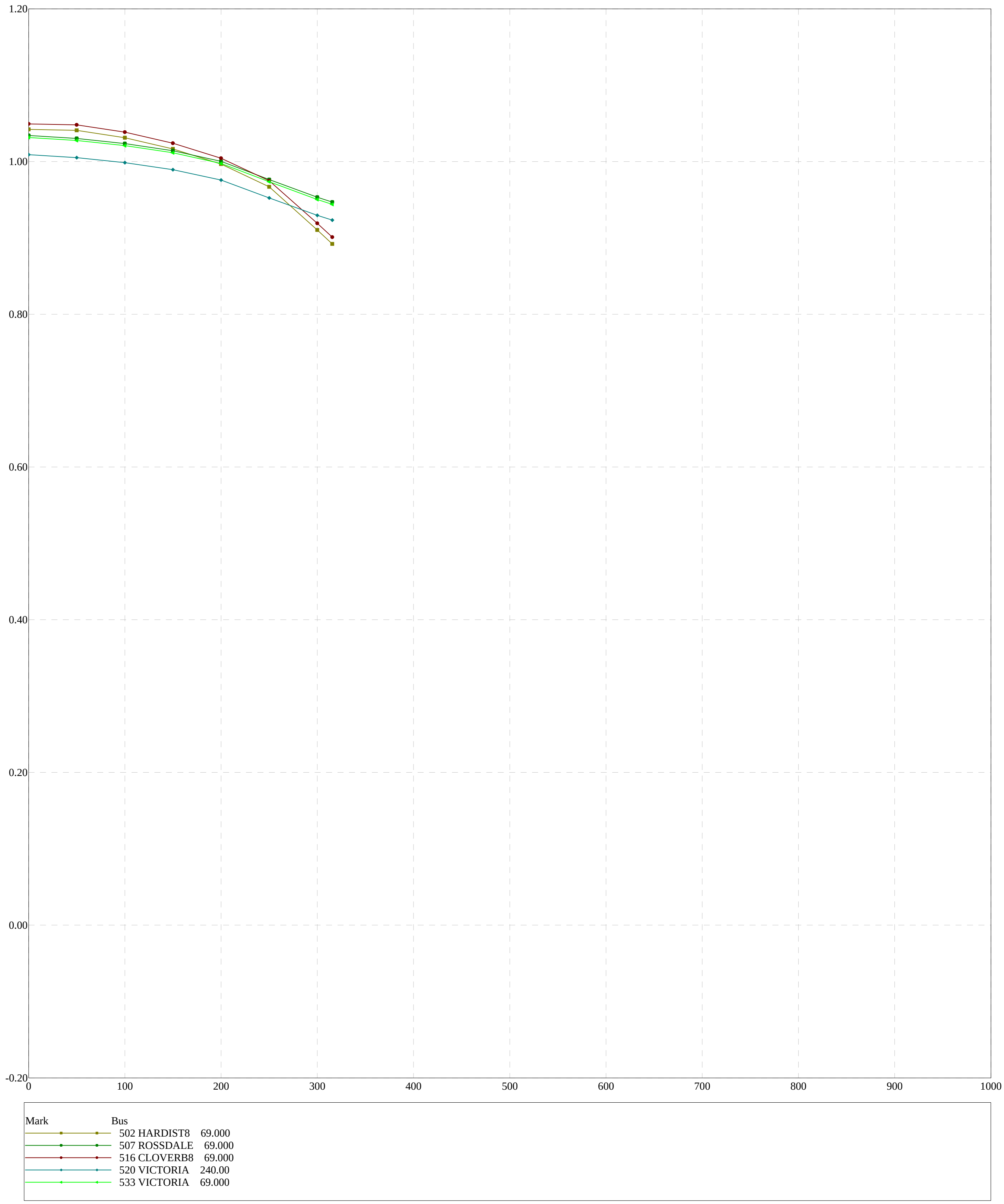
AESO 2016 PBCS - 2018SP: Base Case



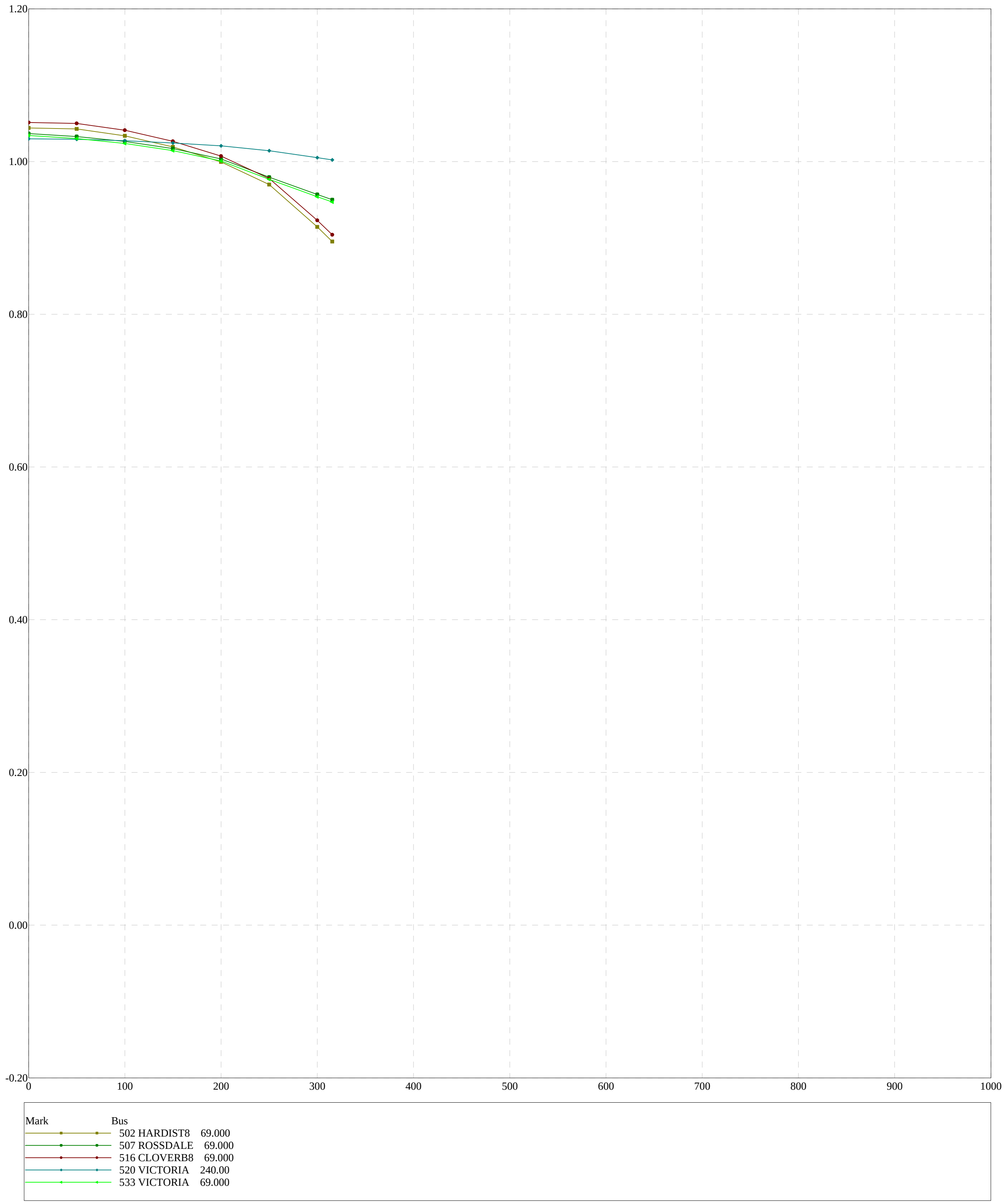
AESO 2016 PBCS - 2018SP: Contingency CBT2



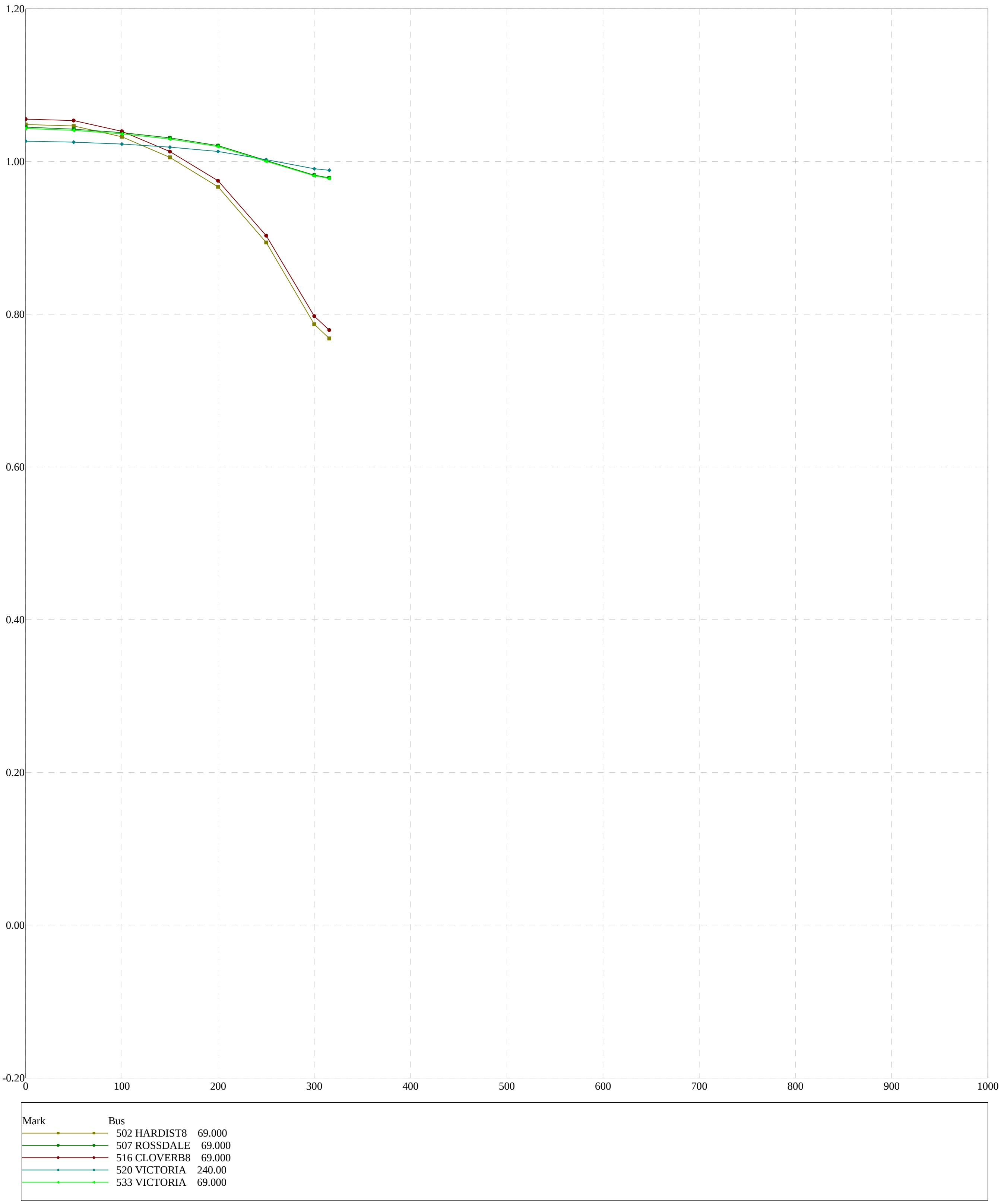
AESO 2016 PBCS - 2018SP: Contingency 240CV5



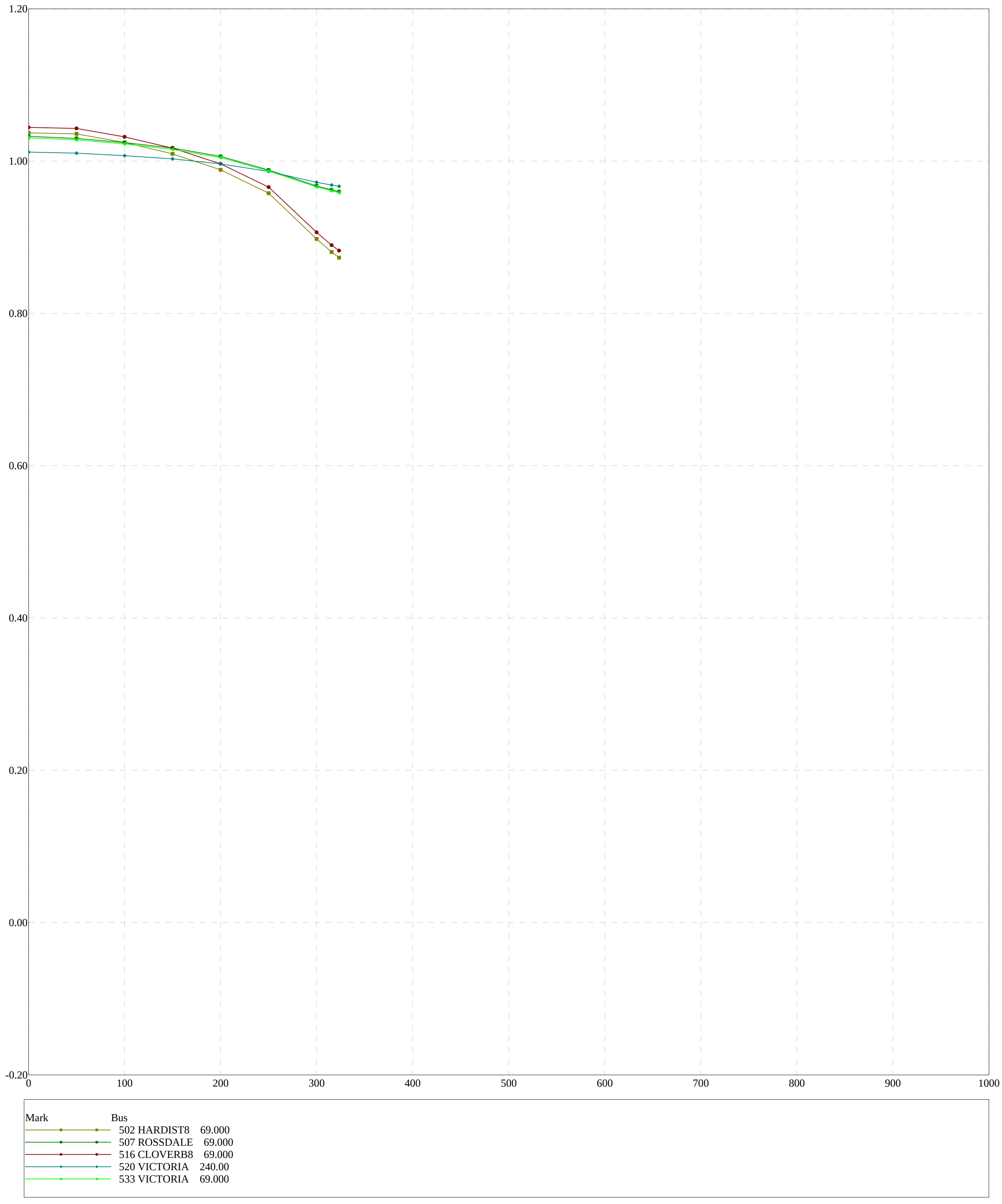
AESO 2016 PBCS - 2018SP: Contingency VIC-T5



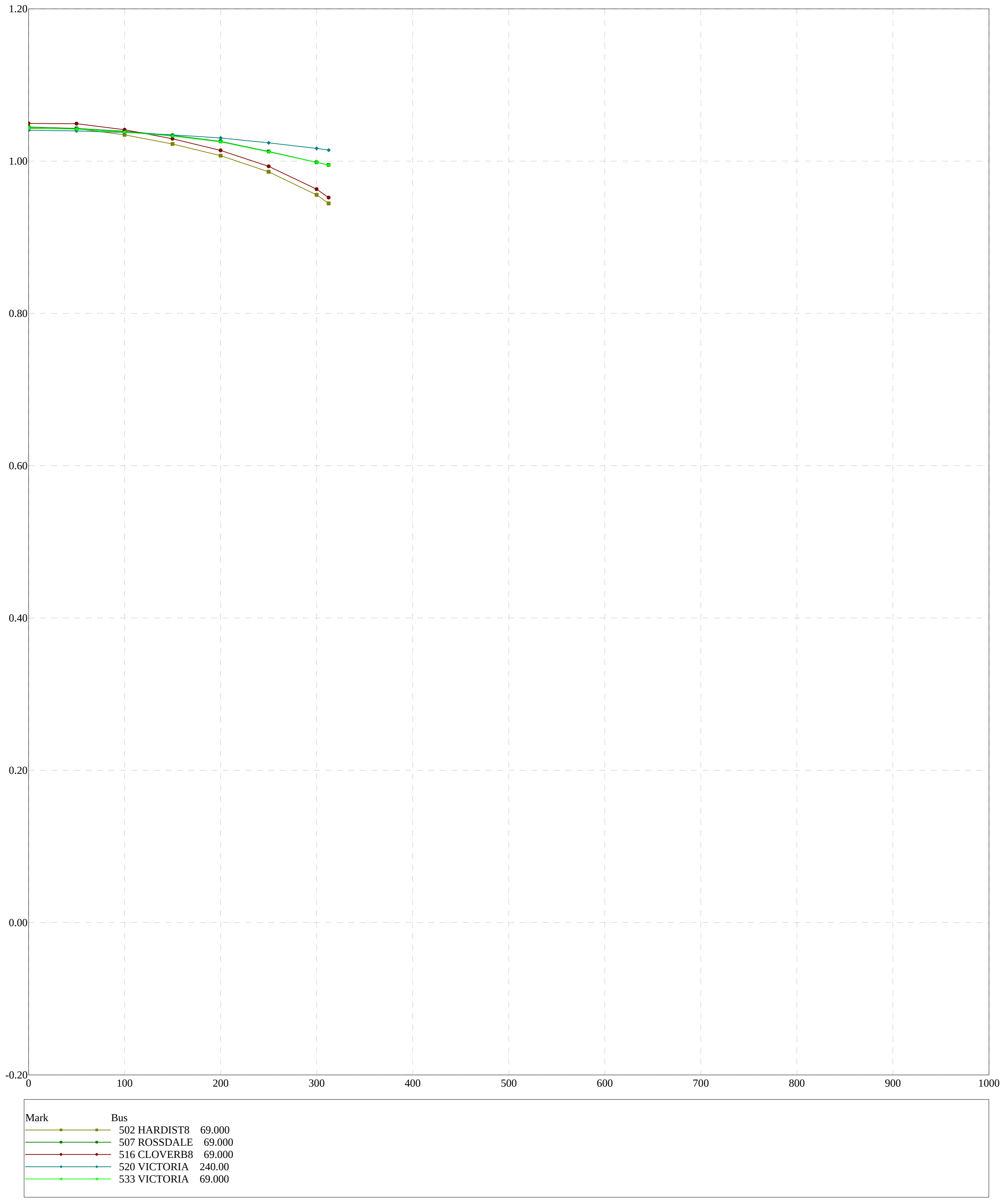
AESO 2016 PBCS - 2018SP: Contingency CBT1



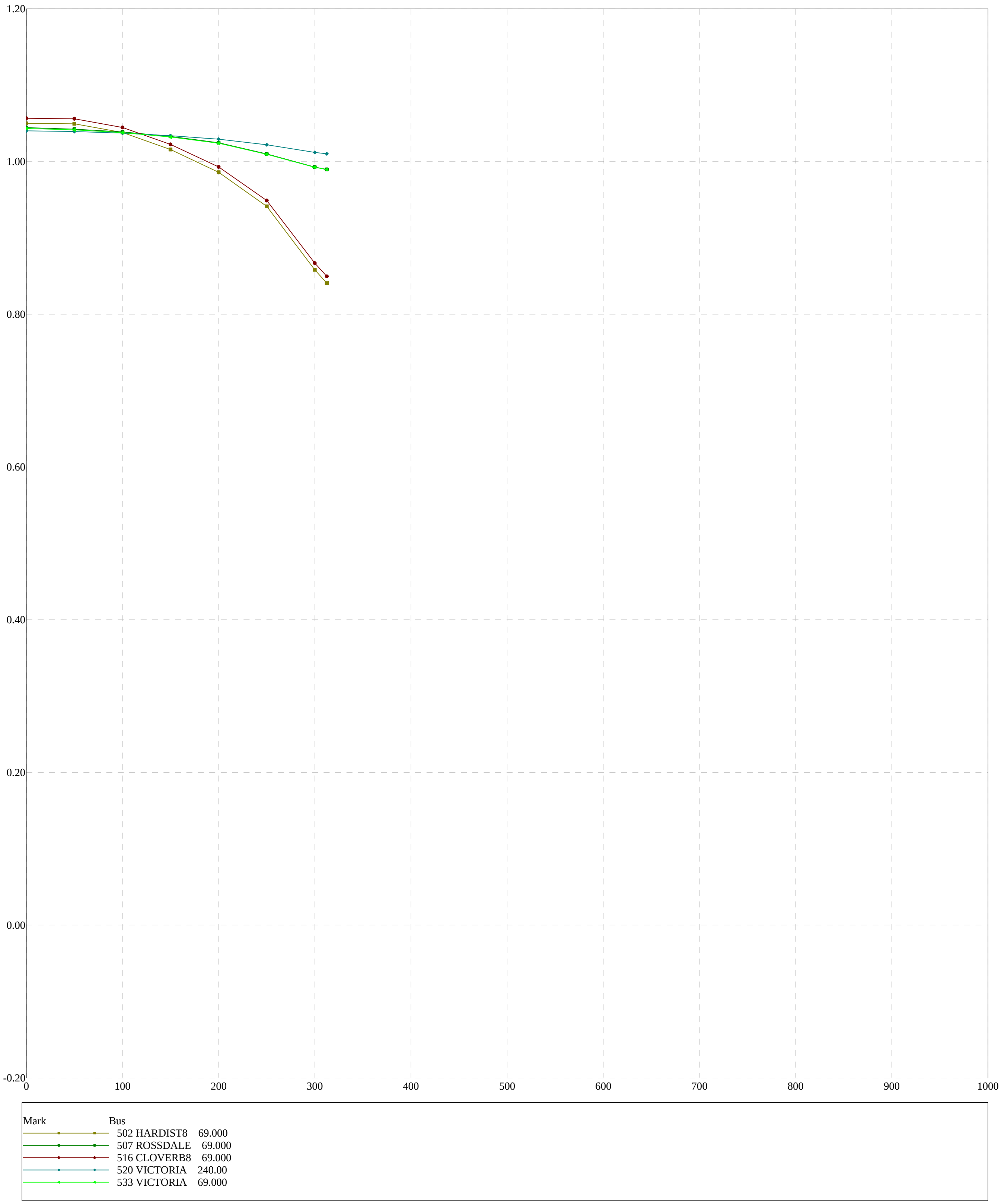
AESO 2016 PBCS - 2018SP: Contingency 902L



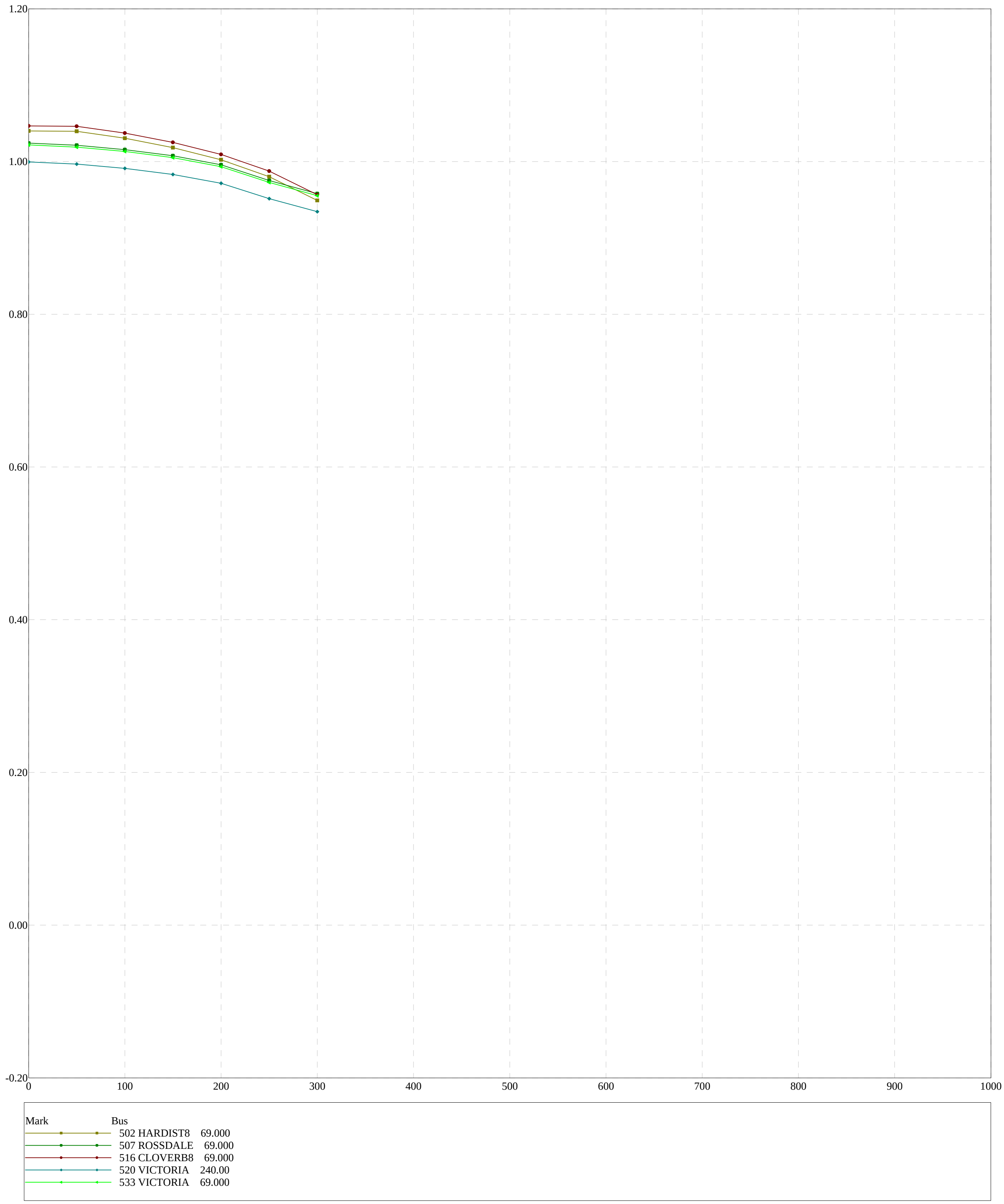
AESO 2016 PBCS - 2018WP: Base Case



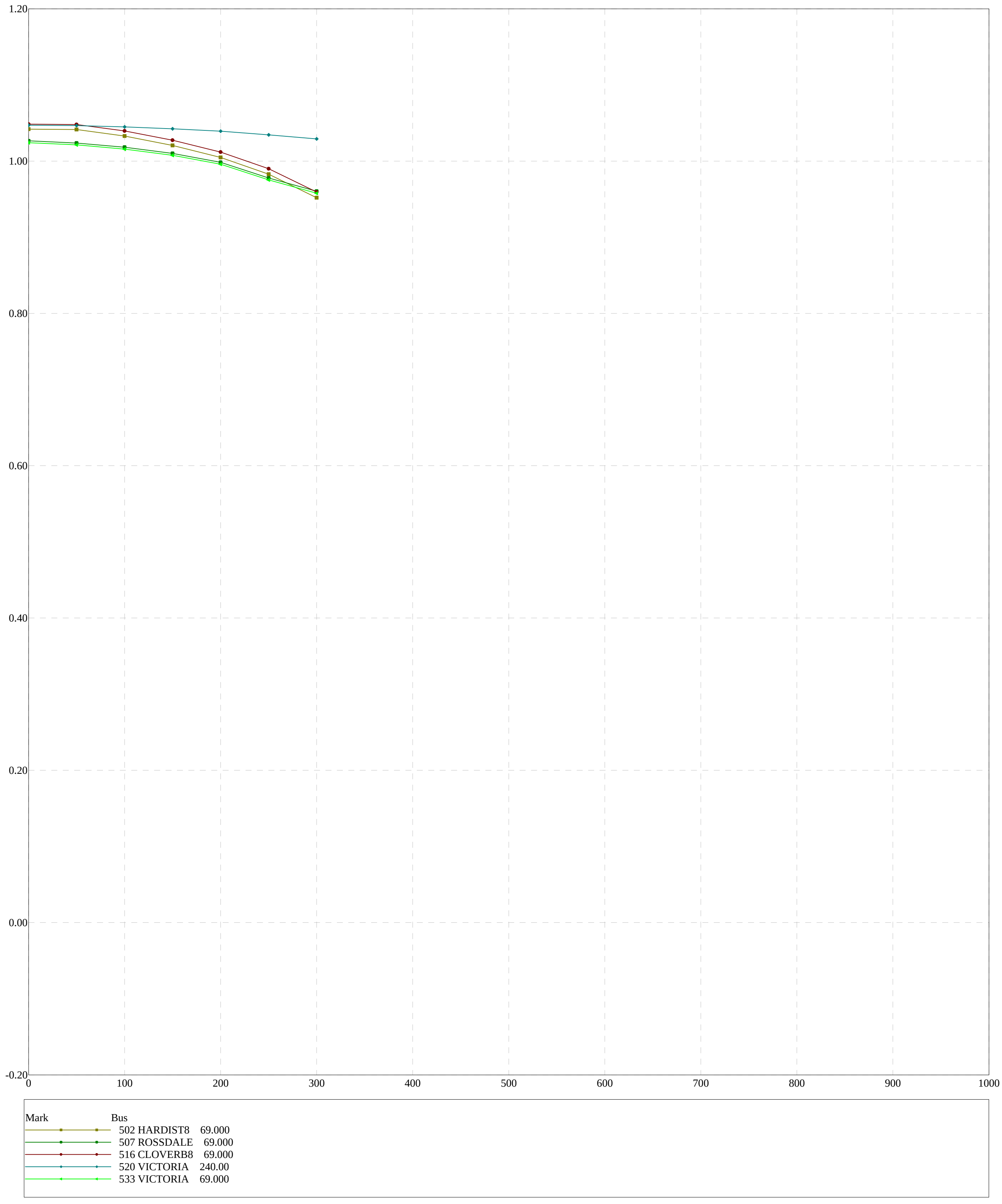
AESO 2016 PBCS - 2018WP: Contingency CBT2



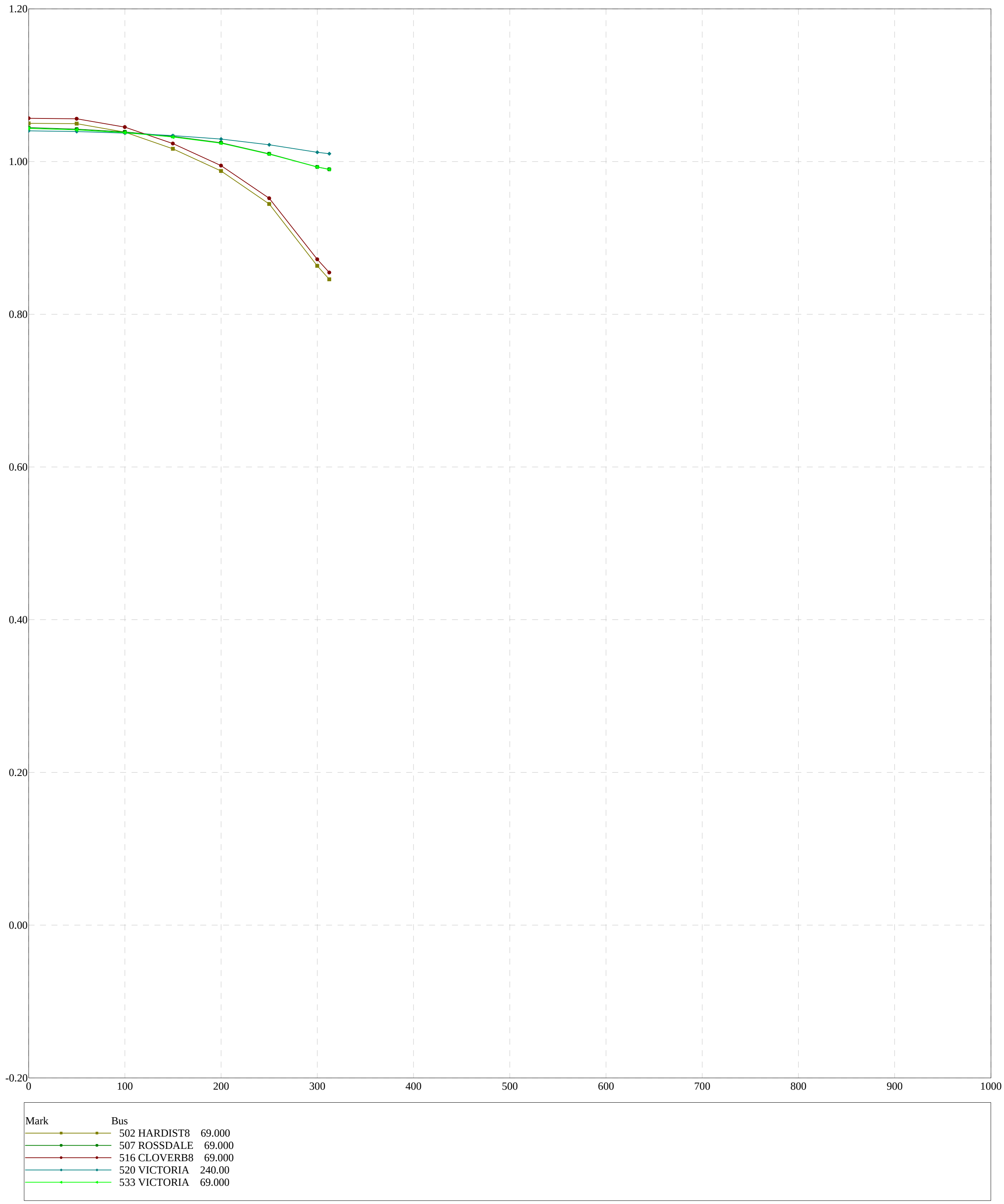
AESO 2016 PBCS - 2018WP: Contingency 240CV5



AESO 2016 PBCS - 2018WP: Contingency VIC-T5



AESO 2016 PBCS - 2018WP: Contingency CBT1



AESO 2016 PBCS - 2018WP: Contingency 902L