Connection Engineering Study Report for Filing

AESO Project 1693
Dry Creek 186S Upgrade

Date: 2016-08-25

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Executive Summary

Project Overview

FortisAlberta Inc. (FortisAlberta), in its capacity as the legal owner of the distribution facilities (DFO), has submitted a System Access Service Request (SASR) to the Alberta Electric System Operator (AESO) to serve load growth in the City of Airdrie area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of 42.7 MW, from 10.0 MW to 52.7 MW, for the system access provided at the existing Dry Creek 186S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Dry Creek 186S substation.

The scheduled in-service date for the Project is August 1, 2017.

This report details the system performance studies undertaken to assess the impact of the Project on the Alberta Interconnected Electric System (AIES).

Existing System

The Project is geographically located in the AESO planning area of Calgary (Area 6), but is electrically associated with the AESO planning area of Airdrie (Area 57). For the purposes of this study, the Project is considered to be a component of Airdrie (Area 57), which is part of the AESO Calgary Planning Region.

From a transmission system perspective, the Airdrie planning area consists of a looped 138 kV transmission system, and has four main sources, the Crossfield Energy Centre, the Balzac combined cycle plant, the Beddington SS-162 substation and the East Crossfield 64S substation. The existing Dry Creek 186S substation connects to the Alberta Interconnected Electric System (AIES) through two 138 kV transmission lines: 631L, which connects the Dry Creek 186S substation to the East Airdrie 199S substation; and the 611L, which connects to the Balzac 391S substation in Calgary (Area 6).

The existing constraints in the Calgary Planning Region are managed in accordance with Section 302.1 of the ISO rules, Real Time Transmission Constraint Management.

Study Summary

Study Area for the Project

The Study Area for the Project consists of Airdrie (Area 57), including the tie lines connecting Airdrie (Area 57) to the rest of the AIES: the 240 kV transmission line 901L and the 138 kV transmission line 611L. All transmission facilities within the Study Area were studied and monitored for violations of the Reliability Criteria (defined in 2.1.1).

Studies Performed for the Project

Power flow analysis was performed using the 2017 summer peak (SP) and 2017 winter peak (WP) pre-Project and post-Project scenarios.

Voltage stability analysis was performed using the 2017 WP post-Project scenario.

Results of the pre-Project Studies

No Reliability Criteria violations were observed in any of the pre-Project scenarios.

Connection alternatives examined for the Project

The AESO, the DFO and the legal owner of transmission facilities (TFO), examined three transmission alternatives to meet the DFO's request for system access service.

Alternative 1 - Modify the Dry Creek 186S substation

Alternative 1 involves modifying the existing Dry Creek 186S substation, including adding two 25 kV feeder breakers. Additionally, one 138 kV bus tie breaker is required to meet DFO reliability requirements. The distribution facility scope associated with Alternative 1 includes the development of approximately 10 km of 25 kV distribution feeders.

Alternative 2 - Modify the Dry Creek 186S substation and Upgrade the East Airdrie 199S substation

Alternative 2 involves modifying the existing Dry Creek 186S substation, including adding one 25 kV feeder breaker, and upgrading the existing East Airdrie 199S substation, including adding one 25 kV feeder breaker. The existing 19.3 MVA voltage regulator at the East Airdrie 199S substation would also be replaced with a 25 MVA voltage regulator. Additionally, one 138 kV bus tie breaker would be added at both Dry Creek 186S substation and East Airdrie 199S substation, to meet DFO reliability requirements. The distribution facility scope associated with Alternative 2 includes the development of approximately 9 km of 25 kV distribution feeders, which would require crossing Highway 2 and directional drilling to facilitate crossings of roads and driveways in a developed urban area.

Alternative 3 - Modify the Dry Creek 186S substation and the Balzac 391S substation

Alternative 3 involves modifying the existing Dry Creek 186S substation, including adding one 25 kV feeder breaker, and modifying the existing Balzac 391S substation, including adding one 25 kV feeder breaker. Additionally, one 138 kV bus tie breaker would be added at the Dry Creek 186S substation to meet DFO reliability requirements. The distribution facility scope associated with Alternative 3 includes the development of approximately 21 km of new 25 kV distribution feeders, which would require crossing Highway 2 and directional drilling to facilitate crossings of roads in a developed commercial area.

Connection alternative selected for further studies

Alternative 1 was selected for further study. Alternative 2 involves additional transmission facility and distribution development and hence, additional cost compared to Alternative 1. Alternative 2 was not selected for further study. Alternative 3 involves additional distribution facility development and hence, additional cost compared to Alternative 1. Alternative 3 was not selected for further study.

Results of the post-Project studies

Under Category A conditions, no Reliability Criteria violations were observed in either the 2017 SP or 2017 WP scenarios.

Power flow analysis identified a thermal criteria violation under Category B contingency conditions in the post-Project 2017 SP study scenario. Details of the observed thermal criteria violation and applicable mitigation measure are shown in Table E-1 below.

Table E–1 Identified Reliability Criteria Violations and Mitigation Measures

Identified Reliability Criteria Violation			System Condition	Mitigation Measures
Violation	Severity	Contingency		
Thermal criteria violation on 611L	Exceeds the continuous seasonal rating but is below the short-term rating	Loss of 901L	2017 SP Post-Project	Can be managed by using real time operational practices

Conclusions and Recommendation

Based on the study results, Alternative 1 is technically viable. The connection assessment identified a system performance issue on the 138 kV transmission line 611L, following the loss of the 240 kV transmission line 901L. Real time operational practices can be used to manage this identified post-Project system performance issue.

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.

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1. Introduction

This Engineering Study Report presents the results of the study conducted 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. Project Overview

FortisAlberta Inc. (FortisAlberta), in its capacity as the legal owner of the distribution facilities (DFO), has submitted a System Access Service Request (SASR) to the Alberta Electric System Operator (AESO) to serve load growth in the City of Airdrie area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase of 42.7 MW, from 10.0 MW to 52.7 MW, for the system access provided at the existing Dry Creek 186S substation, and a request for transmission development (collectively, the Project). Specifically, the DFO requested modifications to the existing Dry Creek 186S substation.

The scheduled in-service date for the Project is August 1, 2017.

1.1.2. Load Component

The existing Rate DTS contract for the system access provided at the Dry Creek 186S substation is 10.0 MW. The DFO has requested a Rate DTS increase to 52.7 MW. Existing loads and forecast load growth consist of residential, rural, commercial, and industrial loads.

This connection assessment assumed a 0.9 lagging power factor (pf) for the load served by the Dry Creek 186S substation.

1.1.3. Generation Component

There is no generation component associated with the Project.

1.2. Study Scope

1.2.1. Study Objectives

The objectives of the study are the following:

1. Assess the impact of the Project connection on the AIES.
2. Identify any violations of the relevant criteria, standards, or requirements of the AESO, both pre-and post-Project.
3. Recommend mitigation measures, if required, to enable the reliable connection of the Project to the AIES.

1.2.2. Study Area

1.2.2.1. Study Area Description

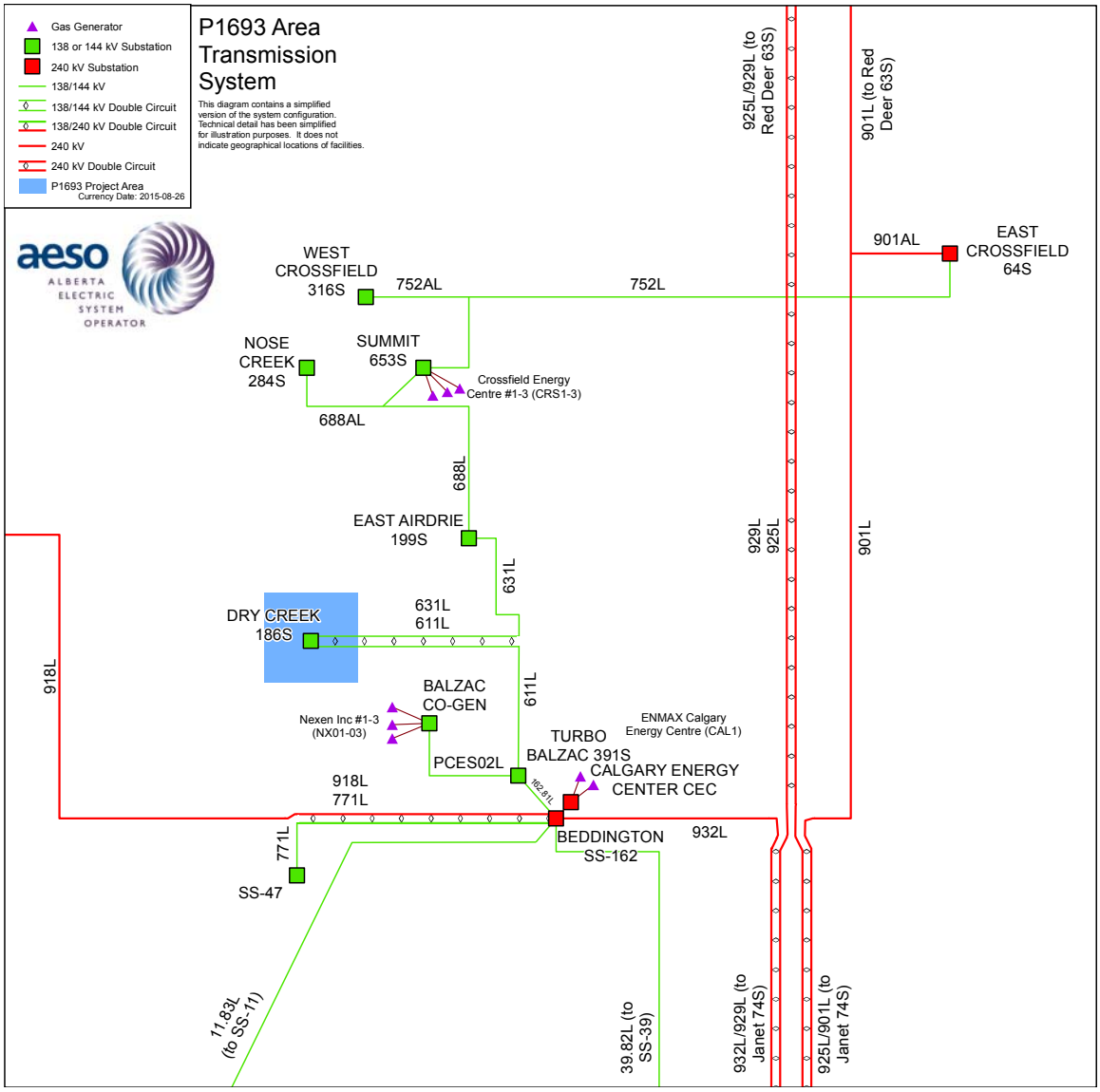
The Project is geographically located in the AESO planning area of Calgary (Area 6), but is electrically associated with the AESO planning area Airdrie (Area 57). For the purposes of this study, the Project is considered to be a component of Airdrie (Area 57), which is part of the AESO Calgary Planning Region. Airdrie (Area 57) is electrically connected to the AESO planning areas of Red Deer (Area 35) and Calgary (Area 6).

From a transmission system perspective, Airdrie (Area 57) consists of a looped 138 kV transmission system, and has four main sources, the Crossfield Energy Centre, the Balzac combined cycle plant, the Beddington SS-162 substation, and the East Crossfield 64S substation. The existing Dry Creek 186S substation connects to the AIES through two 138 kV transmission lines: the transmission line 631L, which connects the Dry Creek 186S substation to the East Airdrie 199S substation; and the transmission line 611L, which connects to the Balzac 391S substation in Calgary (Area 6).

The Study Area for the Project consists of Airdrie (Area 57), including the tie lines connecting Airdrie (Area 57) to the rest of the AIES: the 240 kV transmission line 901L and the 138 kV transmission line 611L. All transmission facilities within the Study Area were studied and monitored for violations of the Reliability Criteria (defined in 2.1.1).

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

Figure 1-1: Existing Study Area Transmission System



1.2.2.2. Existing Constraints

The existing constraints in Calgary Planning Region are managed in accordance with 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 Plans

Table 1.2-1 shows the near-term transmission developments in the vicinity of the Study Area[1] per the *AESO 2015 Long-term Transmission Plan* (2015 LTP). There are no transmission system development projects planned for the Study Area.

[1] The 2015 LTP identifies the near-term (predicted to be in-service by 2020) transmission developments in Airdrie (Area 57) on page 40.

Table 1.2-1: 2015 LTP near term components

Time Frame	Development
Near-term	• Convert 240 kV connection at East Crossfield substation from a tap to an in/out arrangement • Rebuild entire 138 kV loop from East Crossfield substation to Balzac substation to higher capacity except line between East Airdrie substation in northeast corner of Airdrie and Dry Creek substation in southwest corner of Airdrie • Build new 138 kV lines from East Crossfield substation to East Airdrie substation • Build new 138 kV line from Beddington substation to Dry Creek substation • Open 138 kV line between East Airdrie and Dry Creek substations

1.2.3. Studies Performed

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

- Power Flow analysis

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

- Power Flow analysis
- Voltage Stability analysis

1.3. Report Overview

The Executive Summary provides a high-level summary of the study and its conclusions. Section 1 provides an introduction to the Project and describes the study scope. Section 2 describes the criteria, system data, and assumptions used in this study. Section 3 describes the methodology used for this study. Section 4 discusses the pre-Project assessment of the system. Section 5 presents the connection alternatives examined. Section 6 provides a technical analysis of the post-Project system assessment for the alternative that was selected for further study. Section 7 presents any dependencies the Project may have on other AESO plans to expand or enhance the transmission system. Section 8 presents the conclusions and recommendations of this study.

2. Criteria, System Data, and Study Assumptions

2.1. Criteria, Standards, and Requirements

2.1.1. Transmission Planning Standards and 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* [2] (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.

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

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

The Alberta Reliability Standards include the Transmission Planning (TPL) standards that specify the desired system performance under different contingency categories with respect to the Applicable Ratings. The transmission system performance under various system conditions is defined in Appendix 1 of the TPL standards. For the purpose of applying the TPL standards to this study, the Applicable Ratings shall mean:

- 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 should follow the AESO Information Document ID# 2010-007RS, which relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage*. 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*.

[2] Filed under a separate cover.

- Desired post-contingency voltage change limits for three defined post event timeframes as provided in Table 2.1-1.

Table 2.1-1: Post Contingency POD Bus Voltage Deviation Guidelines

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 POD low voltage bus	±10%	±7%	±5%

2.1.2. AESO Rules

The AESO ID # 2010-007RS will be applied to establish pre-contingency voltage profiles in the Study Area. The TCM Rule will be followed in setting up the study scenarios and assessment of the impact of the Project connection.

2.2. Study Scenarios

Table 2.2-1 provides a list of the scenarios used for the connection studies. Scenarios 1 and 2 are the 2017 SP and WP pre-Project scenarios, respectively, with the existing Rate DTS of 10 MW at the Dry Creek 186S POD substation. Scenarios 3 and 4 are the 2017 SP and WP post-Project scenarios, respectively, with the requested Rate DTS of 52.7 MW at the Dry Creek 186S substation. A power factor of 0.9 lagging was used for the pre-Project load. A power factor of 0.9 lagging was used for the post-Project load.

Table 2.2-1: List of the Connection Study Scenarios

Scenario	Year/Season Load	Condition	Project Load (MW)
1	2017 SP	Pre-Project	10
2	2017 WP	Pre-Project	10
3	2017 SP	Post Project	52.7
4	2017 WP	Post-Project	52.7

2.3. Load and Generation Assumptions

2.3.1. Load Assumptions

The Study Area load forecast used for this connection study is reflected in Table 2.3-1 and is at the Calgary Planning Region peak, and based on the *AESO 2016 Long-term Outlook* (2016

LTO)[3]. In this study, the active power to reactive power ratio in the base case scenarios was maintained when modifying the planning area loads.

Table 2.3-1: Forecast Load *(2016 LTO at Calgary Planning Region Peak)*

Area or Region Name and Season		Forecast Peak Load (MW)
		2017
Airdrie (Area 57)	SP	123
	WP	136
Calgary Planning Region (Areas 57 and 6)	SP	1,706
	WP	1,745
Alberta Internal Load (AIL) w/o Losses	SP	10,940
	WP	11,899

2.3.2. Generation Assumptions

The dispatch assumptions used for the generating units in the vicinity of the Study Area in the study scenarios are presented in Table 2.3-2 and Table 2.3-3. Unit G1 at the Crossfield Energy Center was determined to be the critical generator, and was modelled as being offline to simulate the N-G condition in all the study scenarios. Unit G1 is connected to the AIES through the Summit 653S substation.

Table 2.3-2: Local Generation in the Study Cases

Plant Name	Bus Number	AESO Planning Area	PMax (MW)	2017 SP Unit Generation (MW)	2017 WP Unit Generation (MW)
Nexen Inc #1&2	4290	6	64.1	9.9	11.6
Nexen Inc #1&2	4290	6	26.5	4.1	4.8
Nexen Inc #3	3290	6	64.1	9.8	11.5
Calgary Energy Center (CECGT)	4187	6	190	Offline	Offline
Calgary Energy Center (CECST)	3187	6	135		
Crossfield Energy Center (Unit G1)	4503	57	60.5	Offline (N-G)	Offline (N-G)
Crossfield Energy Center (Unit G2)	3503	57	60.5	Offline	Offline
Crossfield Energy Center (Unit G3)	2503	57	60.5	Offline	Offline
Total				14.0	16.4

[3] The 2016 LTO document is available on the AESO website.

Table 2.3-3: Summary of Existing and Under Construction Wind Power Generating Facilities in the Study Scenarios

Project	AESO Planning Area	Bus Numbers	Maximum Capacity (MW)	2017 Unit Net Generation (MW)
Existing in AESO South Planning Region				
Ardenville Wind (ARD1)	53	4735, 4740	68	62.6
Blue Trail Wind (BTR1)	53	66328, 67328	66	60.7
Castle River #1 (CR1)	53	2234, 3234	39	35.9
Castle Rock Wind Farm (CRR1)	53	67221	77	70.8
Cowley Ridge (CRWD)	53	255, 265, 4264	20	18.4
Enmax Taber (TAB1)	52	15343, 16343	81	74.5
Kettles Hill (KHW1)	53	2402, 3402	63	58.0
McBride Lake Windfarm (AKE1)	53	2901, 3901, 4901	75	69.0
Soderglen Wind (GWW1)	53	12358, 13358	68	62.6
Summerview 1 (IEW1)	53	2338, 3338	66	60.7
Summerview 2 (IEW2)	53	4339, 5337	66	60.7
Suncor Chin Chute (SCR3)	54	2389	30	27.6
Suncor Magrath (SCR2)	53	11002	30	27.6
Suncor Wintering Hills (SCR4)	43	60789, 60791, 60793, 60846, 60848, 60850	88	81.0
Old Man River (OMRH)	53	61543	46	42.3
Blackspring Ridge (BSR1)	49	61736, 61737	300	276.0
			South Region Subtotal	**1088.4**
Existing in AESO Central Planning Region				
Ghost Pine (NEP1)	42	2621 to 2625	82	75.5
Halkirk (HAL1)	42	66435, 67435	150	138.0
Under Construction in AESO Central Planning Region				
Fortis Bull Creek Phases 1 and 2	37	994,999	29.5	26.7
			Central Region Subtotal	**240.2**
			Total	**1328.6**

2.3.3. Intertie Flow and HVDC Assumptions

Intertie assumptions are included for the British Columbia-Alberta (BC-AB), Montana Alberta Tie-Line (MATL), and Saskatchewan-Alberta (SK-AB) interties. All the study scenarios (pre- and post-Project) assumed 800 MW import from B.C., 150 MW import from SK, and 300 MW import from MATL.

The 500 kV high voltage DC (HVDC) power orders were set based on the minimum transmission system loss assumptions in pre-Project and post-Project study scenarios.

2.4. System Projects

No transmission system projects were included in the study scenarios.

2.5. Customer Connection Projects

There are no applicable customer projects in the Study Area that have passed Gate 2 of the AESO Connection Process. As a result, no customer connection projects were included in the study scenarios

2.6. Facility Ratings and Shunt Elements

The legal owner of transmission facilities (TFO) provided the ratings of the existing key transmission lines and the existing transformers in the Study Area. The key transmission line ratings and the key transmission lines in the Study Area are provided in Table 2.6-1 and Table 2.6-2, respectively.

Table 2.6-1: Summary of Key Transmission Line Ratings in the Study Area (*MVA on 138 kV Base*)

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)		Short-term[a] Rating (MVA)	
			Summer	Winter	Summer	Winter
162.81L	Beddington 162S - Balzac 391S	138	287	287	316	316
611L	Balzac 391S – Dry Creek 186S	138	119	147	131	162
631L	Dry Creek 186S – East Airdrie 199S	138	106	117	117	129
688L	East Airdrie 199S – Summit 653S Tap Point	138	121	142	133	156
688L	Summit 653S Tap Point – Summit 653S	138	121	148	133	163
752L	Summit 653S – 752L Tap Point	138	121	142	133	156
752L	752L Tap Point – East Crossfield 64S	138	119	136	131	150

Notes:
[a] When line loading in post Category B contingency is observed to exceed nominal rating and is less than the short-term (emergency) rating, it is assumed that AESO and TFO operating practices can manage the constraint within the time requirements of TFO short term (emergency) rating.

Table 2.6-2: Summary of Key Transformer Ratings in the Study Area

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
East Airdrie 199S	199ST1	138/25	25
	199ST2	138/25	25/33/42
Dry Creek 186S	186ST1	138/25	25/33/42
	186ST2	138/25	25/33/42
East Crossfield 64S	64ST2	240/138	120/160/200

The details of key shunt elements in the Study Area are given in Table 2.6-3.

Table 2.6-3: Summary of Key Shunt Elements in the Study Area

Substation Name and Number	Voltage Class (kV)	Capacitors				Reactors			
		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Status in Study (on or off)		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Status in Study (on or off)	
				2017 SP (MVAr)	2017 WP (MVAr)			2017 SP (MVAr)	2017 WP (MVAr)
Dry Creek 186S	138	1 x 27.17 MVAr	27.17	(on)	(on)	No reactors present			
East Airdrie 199S	138	1 x 27.17 MVAr	27.17	(on)	(on)	No reactors present			

2.7. Voltage Profile Assumptions

The AESO ID # 2010-007RS was used to establish normal system (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 the ID # 2010-007RS. These voltages were used to set the voltage profile for the study cases prior to conducting power flow analysis.

A list of operating voltages for the key nodes in the Study Area and its vicinity are listed in Table 2.7-1.

Table 2.7-1: Operating Voltages at Key Nodes in the Study Area and Vicinity

Bus No. and Substation Name	Nominal Voltage (kV)	AESO ID 2010-007RS		
		Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)
Bus 156 - East Crossfield 64S	240	240	240 – 254	255
Bus 312 - East Crossfield 64S	138	138	138 – 144	145

3. Study Methodology

The analyses performed in this connection assessment were completed using PTI PSS/E version 33.

3.1. Connection Studies Performed

Table 3.1-1 summarizes the studies that were carried out for this connection assessment.

Table 3.1-1: Summary of Studies Performed

Scenario and Condition	Project Load (MW)	System Conditions	Power Flow	Voltage Stability
2017 SP Pre-project	10	Category A and Category B	Yes	No
2017 WP Pre-Project	10	Category A and Category B	Yes	No
2017 SP Post-Project	52.7	Category A and Category B	Yes	No
2017 WP Post-Project	52.7	Category A and Category B	Yes	Yes

3.2. Power Flow Analysis

The purpose of the power flow analysis is to quantify any incremental post-Project violations in the Study Area. Pre-Project and post-Project power flow analysis was conducted to identify thermal overloads or transmission voltage violations as per the Reliability Criteria, and to identify any point-of-delivery (POD), low voltage, bus deviations from the desired limits in Table 2.1-1.

POD, low voltage, bus deviations were assessed by first locking all tap changers and area shunt reactive devices to identify any post-transient voltage deviations above 10%. Second, tap changers were then allowed to move while shunt reactive devices remained locked to determine if any voltage deviations above 7% were found in the area. Third, all taps and shunt reactive device controls were allowed to adjust, voltage deviations above 5% were reported for both the pre- and post-Project networks.

3.2.1. Contingencies Studied

The study included all Category B contingencies (138 kV facilities and above) within the Study Area.

For the power flow analysis, all transmission facilities in the Study Area were monitored for voltage and thermal violations under Category A conditions and under Category B contingency conditions.

3.3. Voltage Stability 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 is a representation of voltage change as a result of increased power transfer between two systems. The reported incremental transfers will be to the collapse point. As per the AESO requirements, no assessment based upon other criteria such as minimum voltage will be made at the PV minimum transfer. Voltage stability analysis for the post-Project scenarios will be performed. For load connection projects, the load level modelled in post-Project scenarios are the same or higher than in pre-Project scenarios. Therefore, voltage stability analysis for pre-Project scenarios will only be performed if post-Project scenarios show voltage stability criteria violations.

Voltage stability analysis was performed according to the Western Electricity Coordinating Council (WECC) Voltage Stability Assessment Methodology. The 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 WECC standard, the reference load level is the maximum established planned load.

Typically, voltage stability analysis is carried out assuming the worst case scenarios in terms of loading. The voltage stability analysis was performed by increasing load in Airdrie (Area 57), with a corresponding increase in generation in the AESO planning area of Wabamun (Area 40).

As per the voltage stability criteria, post transient technique (all tap changers, all discrete capacitors locked, but static var compensators will be allowed to adjust) will used in applying the criteria and this information is reflected in all tables and graphs. Also for this analysis, no limit will be selected for the generation sources, non-negative active power constant MVA loads will be enforced and the existing power factor for the reference will be maintained.

3.3.1. Contingencies Studied

Voltage stability analysis was performed for Category A conditions and all Category B contingencies (138 kV facilities and above) in the Study Area. The voltage at busses rated at 25 kV and above was monitored in the Study Area.

4. Pre-Project System Assessment

4.1. Pre-Project Power Flow Analysis

The pre-Project system is defined as the system configuration without the Project. The steady-state performance of the pre-Project system was assessed using the 2017 SP and 2017 WP study scenarios. The power flow analyses were based on the criteria, system data and study assumptions as described in Section 2. The power flow diagrams for the pre-Project scenarios are shown in Attachment A.

4.1.1. 2017 Summer Peak

No Reliability Criteria violations were observed under Category A (N-G-0) conditions or Category B (N-G-1) contingency conditions.

4.1.2. 2017 Winter Peak

No Reliability Criteria violations were observed under Category A (N-G-0) conditions or Category B (N-G-1) contingency conditions.

5. Connection Alternatives

5.1. Overview

The AESO, the DFO and the legal owner of transmission facilitiesy owner (TFO), examined three transmission alternatives to meet the DFO's request for system access service.[4]

5.2. Connection Alternatives Examined

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

Alternative 1 - Modify the Dry Creek 186S substation

Alternative 1 involves modifying the existing Dry Creek 186S substation, including adding two 25 kV feeder breakers. Additionally, one 138 kV bus tie breaker is required to meet DFO reliability requirements. The distribution facility scope associated with Alternative 1 includes the development of approximately 10 km of 25 kV distribution feeders.

Alternative 2 - Modify the Dry Creek 186S substation and Upgrade the East Airdrie 199S substation

Alternative 2 involves modifying the existing Dry Creek 186S substation, including adding one 25 kV feeder breaker, and upgrading the existing East Airdrie 199S substation, including adding one 25 kV feeder breaker. The existing 19.3 MVA voltage regulator at the East Airdrie 199S substation would also be replaced with a 25 MVA voltage regulator. Additionally, one 138 kV bus tie breaker would be added at both Dry Creek 186S substation and East Airdrie 199S substation, to meet DFO reliability requirements. The distribution facility scope associated with Alternative 2 includes the development of approximately 9 km of 25 kV distribution feeders, which would require crossing Highway 2 and directional drilling to facilitate crossings of roads and driveways in a developed urban area.

Alternative 3 - Modify the Dry Creek 186S substation and the Balzac 391S substation

Alternative 3 involves modifying the existing Dry Creek 186S substation, including adding one 25 kV feeder breaker, and modifying the existing Balzac 391S substation, including adding one 25 kV feeder breaker. Additionally, one 138 kV bus tie breaker would be added at the Dry Creek 186S substation to meet DFO reliability requirements. The distribution facility scope associated with Alternative 3 includes the development of approximately 21 km of new 25 kV distribution feeders, which would require crossing

[4] These alternatives reflect more up to date engineering design than the alternatives identified in *FortisAlberta Distribution Deficiency Report, Need for Development Dry Creek 186S Upgrade*, which is filed under a separate cover.

Highway 2 and directional drilling to facilitate crossings of roads in a developed commercial area.

5.3. Connection Alternatives Selected for Further Studies

Alternative 1 was selected for further study.

5.4. Connection Alternatives Not Selected for Further Studies

Alternative 2 involves additional transmission facility and distribution development and hence, additional cost compared to Alternative 1. Alternative 2 was not selected for further study. Alternative 3 involves additional distribution facility development and hence, additional cost compared to Alternative 1. Alternative 3 was not selected for further study.

6. Technical Analysis of Alternative 1

This section describes the technical analyses conducted to assess the impact of Alternative 1 on the AIES. Power flow analysis and voltage stability analysis are described below in Sections 6.1 and 6.2, respectively. Mitigation measures are outlined in Section 6.3 and the results of the technical analysis are summarized in Section 6.4.

6.1. Power Flow Analysis

6.1.1. 2017 Summer Peak

Category A condition:

Under Category A conditions, no Reliability Criteria violations were observed.

Category B contingency conditions:

Under Category B contingency conditions, no voltage criteria violations were observed.

A thermal criteria violation was observed under Category B contingency condition, as follows:

- Thermal loading above the short-term rating on the 138 kV transmission line 611L (between the Balzac 391S substation and the Dry Creek 186S substation) was observed following the loss of 240 kV transmission line 901L line (between Red Deer 63S substation and Janet 74S substation).

Table 6.1-1 provides further detail about the observed thermal criteria violation under Category B contingency condition.

The power flow diagrams are shown in Attachment B.

Table 6.1-1: Summary of 2017 SP Category B Thermal Criteria Violations[a]

Contingency	Limiting Branch	Continuous Line Rating (MVA)	Short-term[b] Rating (MVA)	Pre-Project		Post-Project		% Loading Differ-ence
				Power Flow (MVA)[c]	% Loading	Power Flow (MVA)[c]	% Loading	Post-Pre
901L (Red Deer 63S - Janet 74S)	611L (Balzac 391S - Dry Creek 186S)	119	131	82.7	69.5	123.8	104.0	34.5

Notes:
[a] All line flows of power flow analysis are reported as percentage loading relative to normal line rating as shown in in Table 2.6-1.
[b] 10 minute summer MVA
[c] Power flow (MVA) is current expressed as MVA (ie. S =√3 x Vbase x Iactual)

6.1.2. 2017 Winter Peak

Category A conditions:

Under Category A conditions, no Reliability Criteria violations were observed.

Category B contingency conditions:

Under Category B contingency conditions, no Reliability Criteria violations were observed.

6.2. Voltage Stability Analysis

Voltage stability analysis was conducted using the 2017 WP post-Project scenario to investigate the system active power margins after the Project under Category A conditions and Category B contingency conditions.

6.2.1. 2017 Winter Peak

Voltage stability analysis was performed for the 2017 WP scenario. The reference load level for the Airdrie area (Area 57) is 136 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load or 6.8 MW to meet the voltage stability criteria (0.05 x 116.6 MW = 6.8 MW). Table 6.2-1 summarizes the voltage stability transfer margins results for Category A and for the five worst contingencies under Category B system conditions.

The voltage stability margin is met for all studied conditions.

The voltage stability diagrams are shown in Attachment C.

Table 6.2-1: Scenario 4- 2017 WP Post-Project – Voltage Stability Analysis Results for Category A and the Five Worst Category B Contingencies (Minimum transfer = 6.8 MW)

Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System Normal		230	Yes
611L	Balzac 391S	Dry Creek 186S	70	Yes
901L	Red Deer 63S	Janet 74S	130	Yes
64ST2	East Crossfield 64S 240/138 kV transformer		230	Yes
631L	Dry Creek 186S	East Airdrie 199S	130	Yes
162.81L	Beddington 62S	Balzac 391S	120	Yes

6.3. Mitigation Measures

The connection assessment identified a post-Project thermal criteria violation on the 138 kV transmission line 611L (between the Balzac 391S substation and the Dry Creek 186S substation) in the 2017 SP study scenario under Category B contingency conditions. This concern can be mitigated by real-time operational practices.

6.4. Summary of the Technical Analysis of Alternative 1

Based on the study results, Alternative 1 is technically viable. The study results confirm that the voltage stability margin in the Study Area meets the AESO requirements after the Project. Power flow studies identified a post-Project thermal criteria violation under Category B contingency conditions; however, this thermal criteria violation can be managed by real time operational practices. Details of the observed thermal criteria violation and applicable mitigation measure are shown in Table 6.4-1 below.

Table 6.4-1: Identified Reliability Criteria Violations and Mitigation Measures

Identified Reliability Criteria Violation			System Condition	Mitigation Measures
Violation	Severity	Contingency		
Thermal criteria violation on 611L	Exceeds the continuous seasonal rating but is below the short-term rating	Loss of 901L	2017 SP Post-Project	Can be managed by using real time operational practices

7. Project Interdependencies

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

8. Conclusion and Recommendations

Based on the study results, Alternative 1 is technically viable. The connection assessment identified a system performance issue on 138 kV transmission line 611L, following the loss of 240 kV transmission line 901L. Real time operational practices can be used to manage this identified post-Project system performance issue.

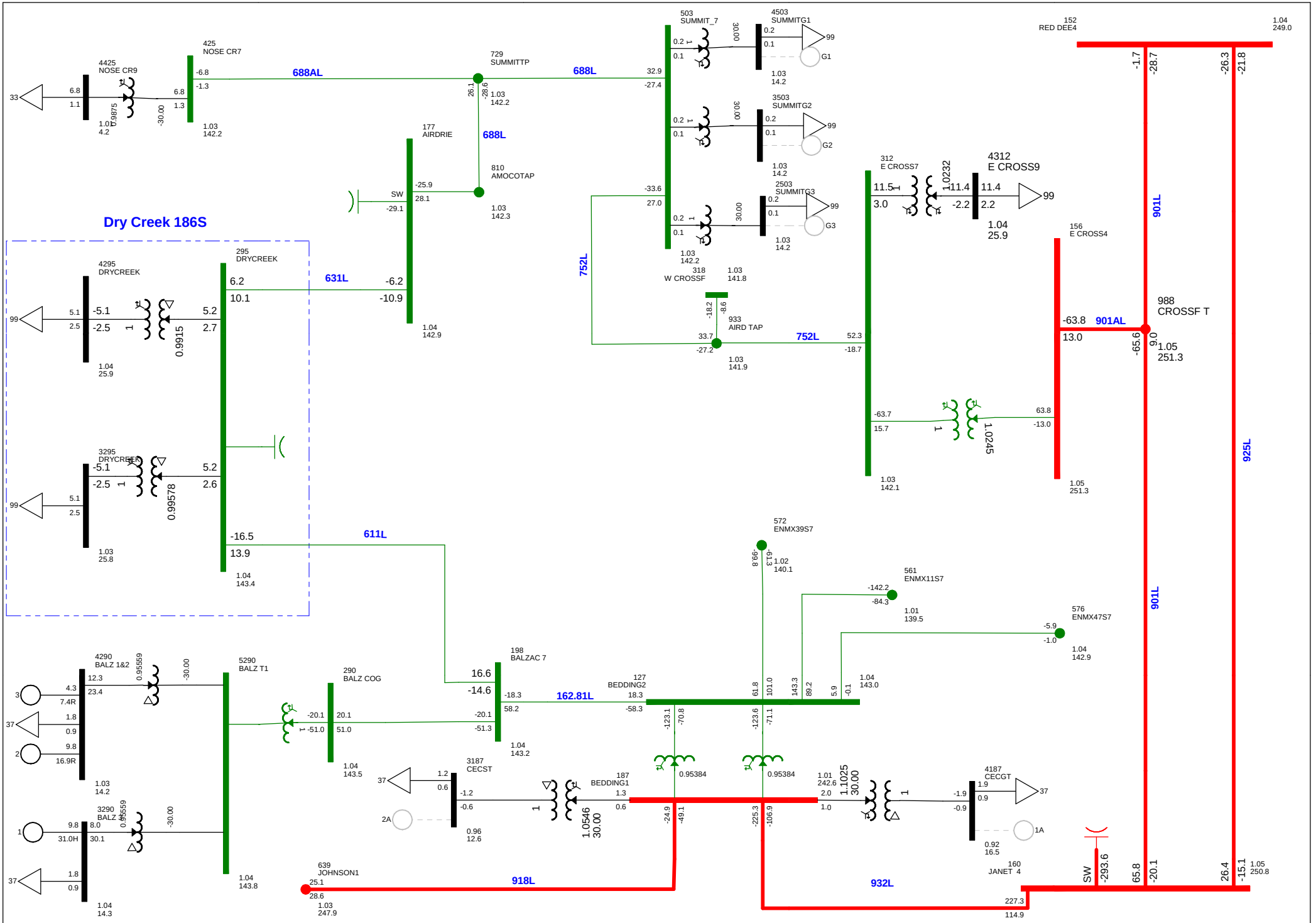
It is recommended to proceed with the Project using Alternative 1 as the preferred option to respond to the DFO's request for system access service and use real time operational practices to manage the identified system performance issue on the 138 kV transmission line 611L.

Attachment A

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

Table A-1: Pre-Project Contingency Lists

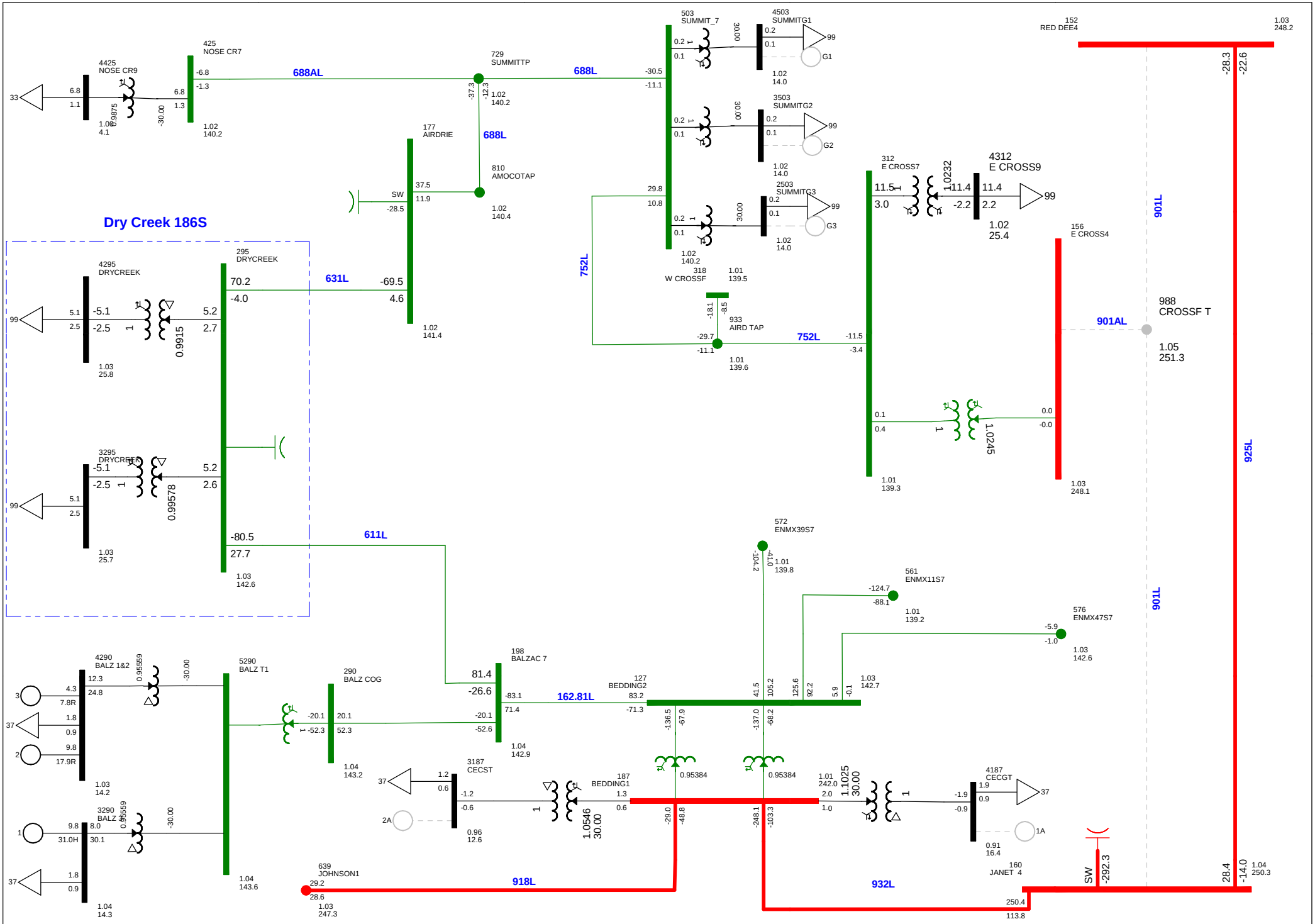
Figure #	Scenario	Condition	
A-1	2017 SP Pre-Project	Base Case (N-G-0)	
A-2	2017 SP Pre-Project	901L (N-G-1)	East Crossfield 64S - Red Deer 63S to Janet 74S
A-3	2017 SP Pre-Project	64ST2 (N-G-1)	East Crossfield 64S
A-4	2017 SP Pre-Project	631L (N-G-1)	East Airdrie 199S - Dry Creek 186S
A-5	2017 SP Pre-Project	611L (N-G-1)	Balzac 391S - Dry Creek 186S
A-6	2017 SP Pre-Project	186ST1 (N-G-1)	Dry Creek 186S
A-7	2017 SP Pre-Project	186ST2 (N-G-1)	Dry Creek 186S
A-8	2017 SP Pre-Project	162.81L (N-G-1)	Balzac 391S - Beddington SS-162
A-9	2017 WP Pre-Project	Base Case (N-G-0)	
A-10	2017 WP Pre-Project	901L (N-G-1)	East Crossfield 64S - Red Deer 63S to Janet 74S
A-11	2017 WP Pre-Project	64ST2 (N-G-1)	East Crossfield 64S
A-12	2017 WP Pre-Project	631L (N-G-1)	East Airdrie 199S - Dry Creek 186S
A-13	2017 WP Pre-Project	611L (N-G-1)	Balzac 391S - Dry Creek 186S
A-14	2017 WP Pre-Project	186ST1 (N-G-1)	Dry Creek 186S
A-15	2017 WP Pre-Project	186ST2 (N-G-1)	Dry Creek 186S
A-16	2017 WP Pre-Project	162.81L (N-G-1)	Balzac 391S - Beddington SS-162



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
BASE CASE (N-G-0)
FIG A-1
FRI, AUG 26 2016 14:55

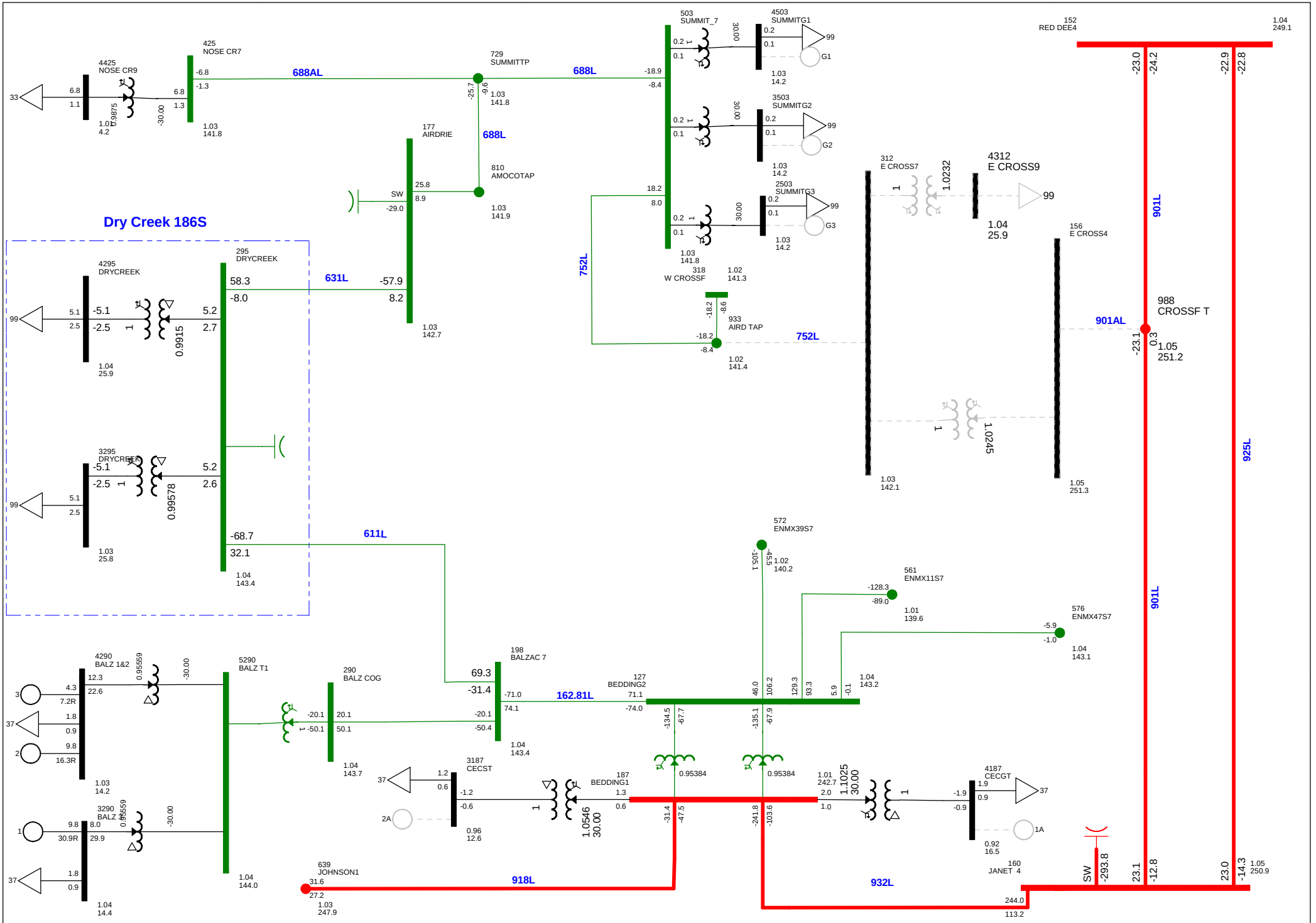
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
901L (N-G-1)
FIG A-2
FRI, AUG 26 2016 14:55

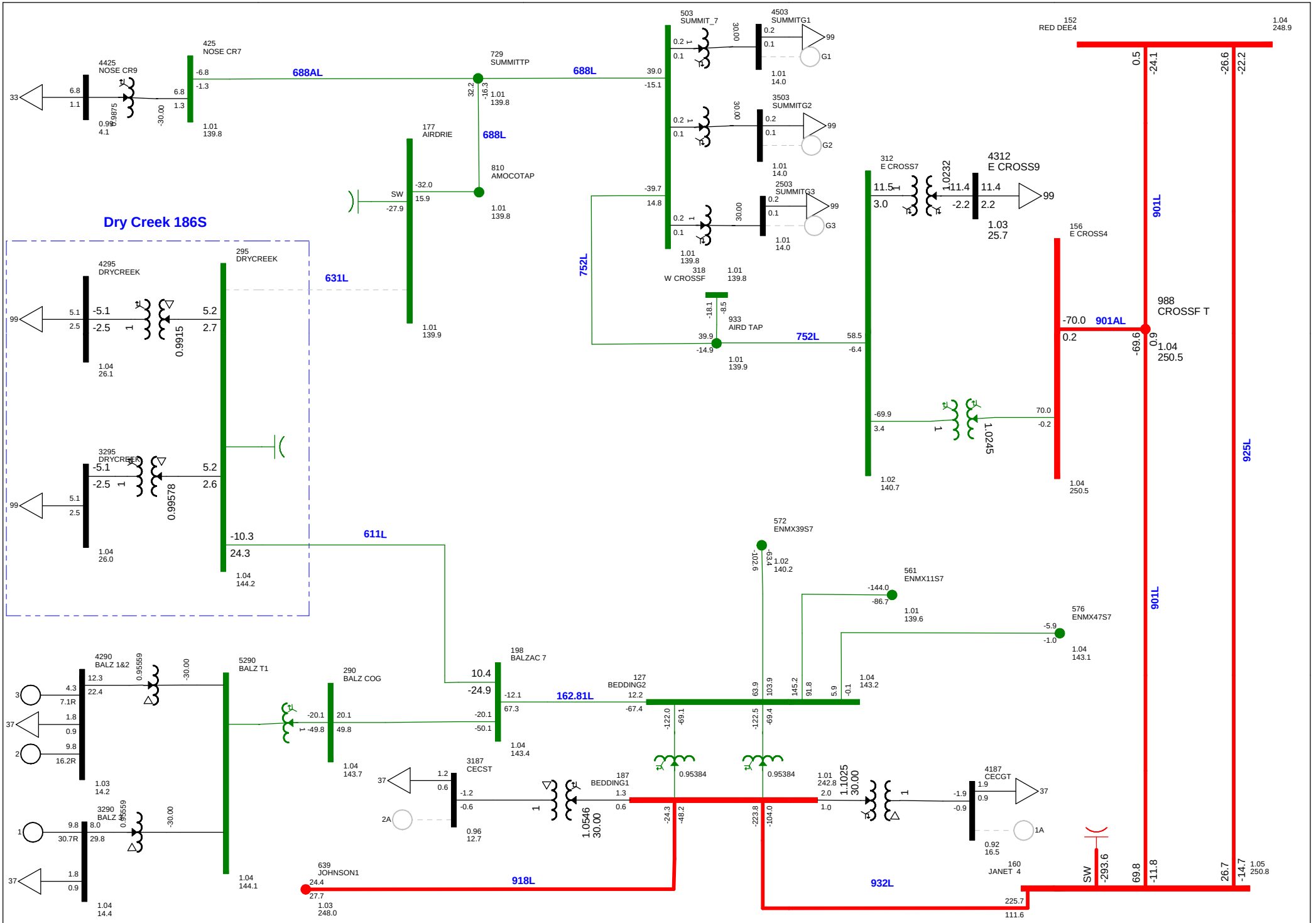
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
64ST2 (N-G-1)
FIG A-3
FRI, AUG 26 2016 14:55

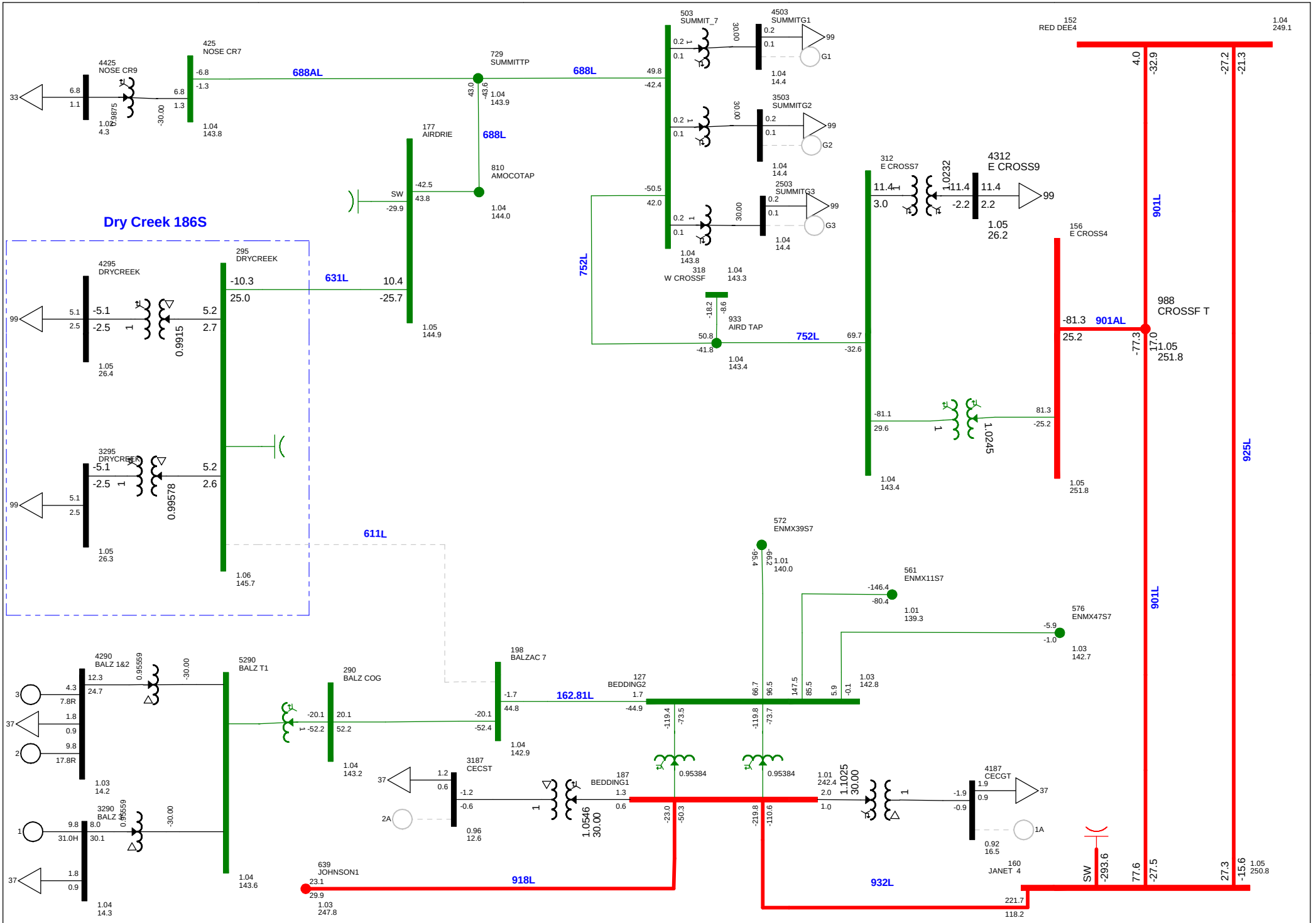
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
631L (N-G-1)
FIG A-4
FRI, AUG 26 2016 14:55

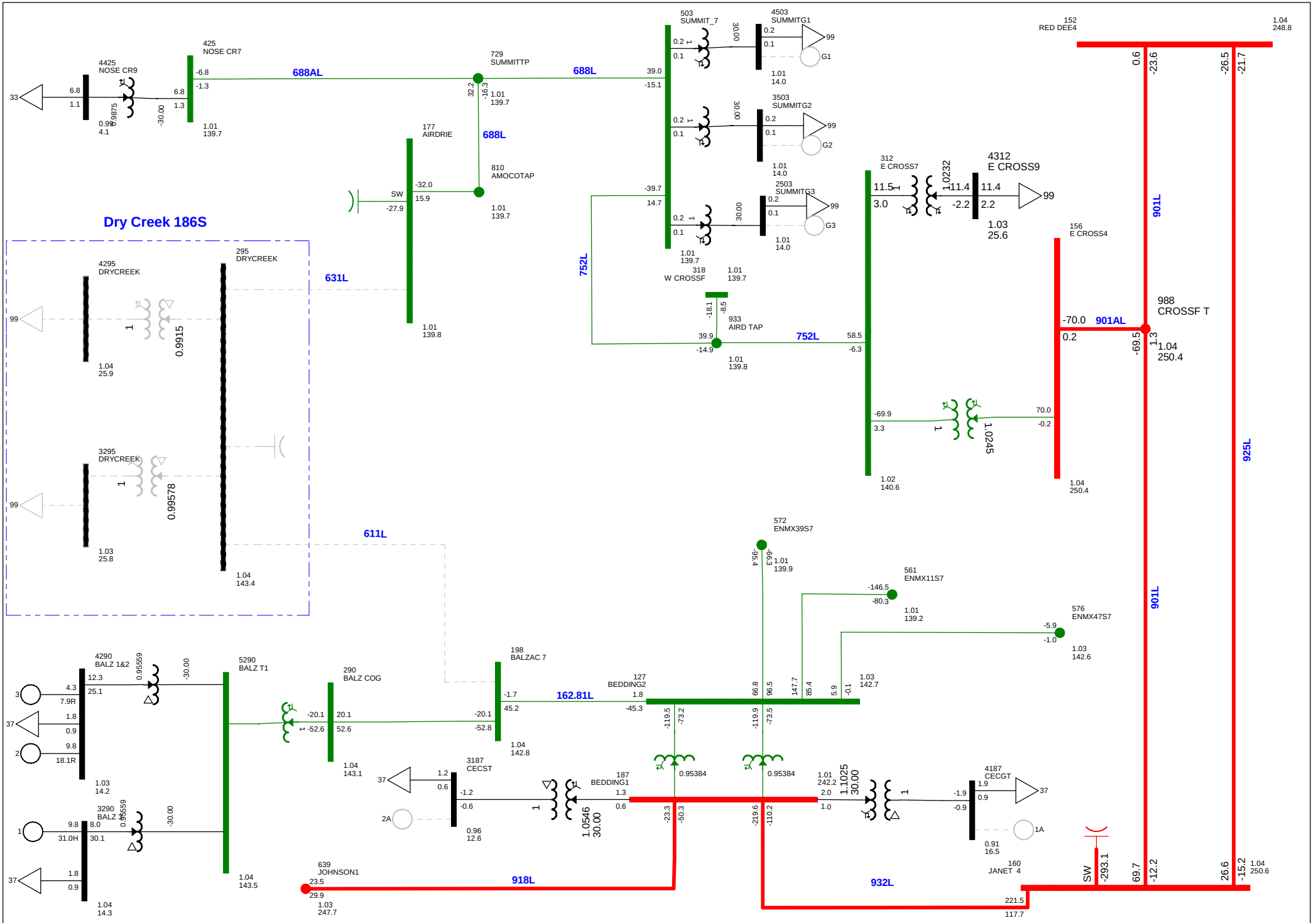
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
611L (N-G-1)
FIG A-5
FRI, AUG 26 2016 14:55

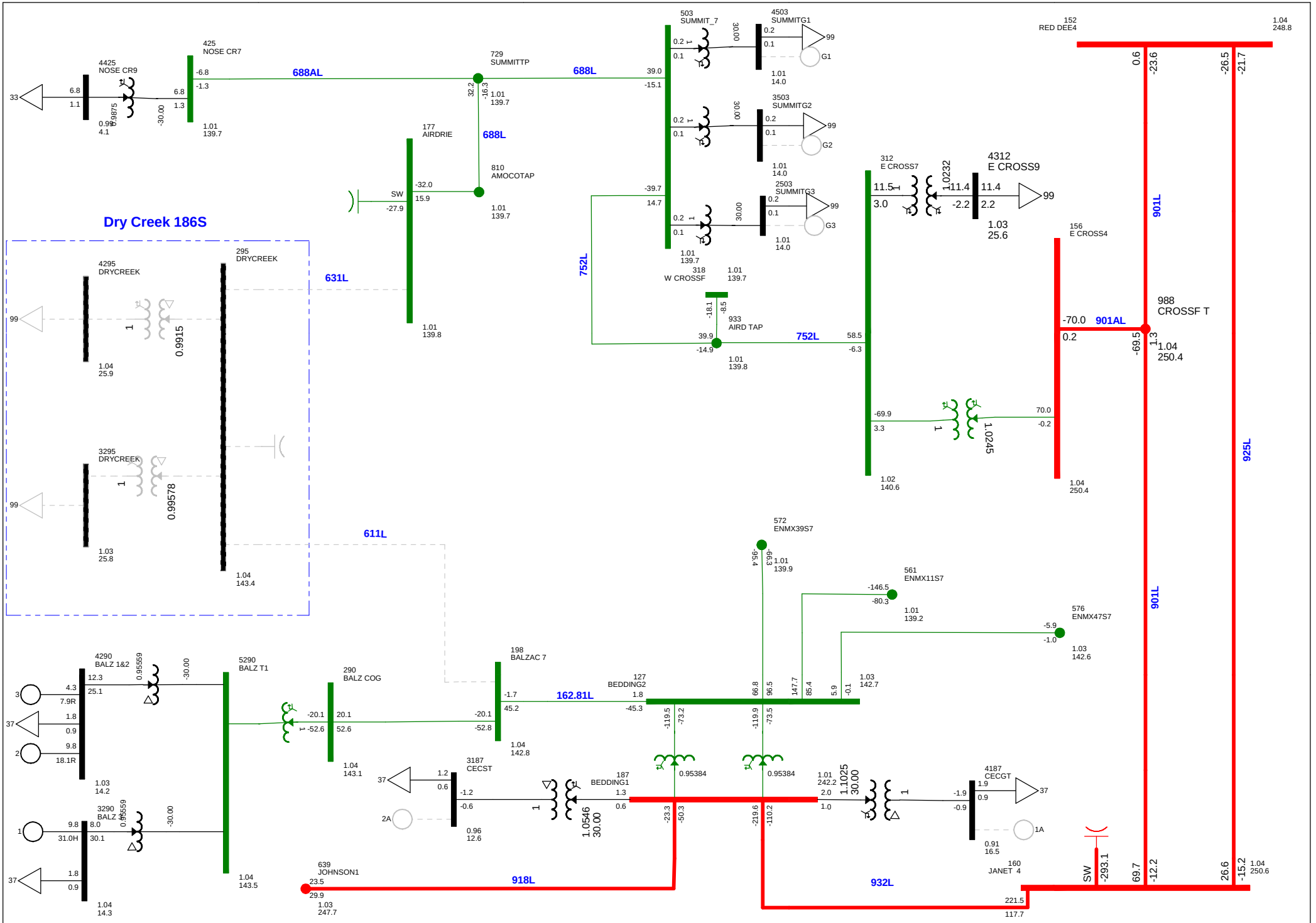
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

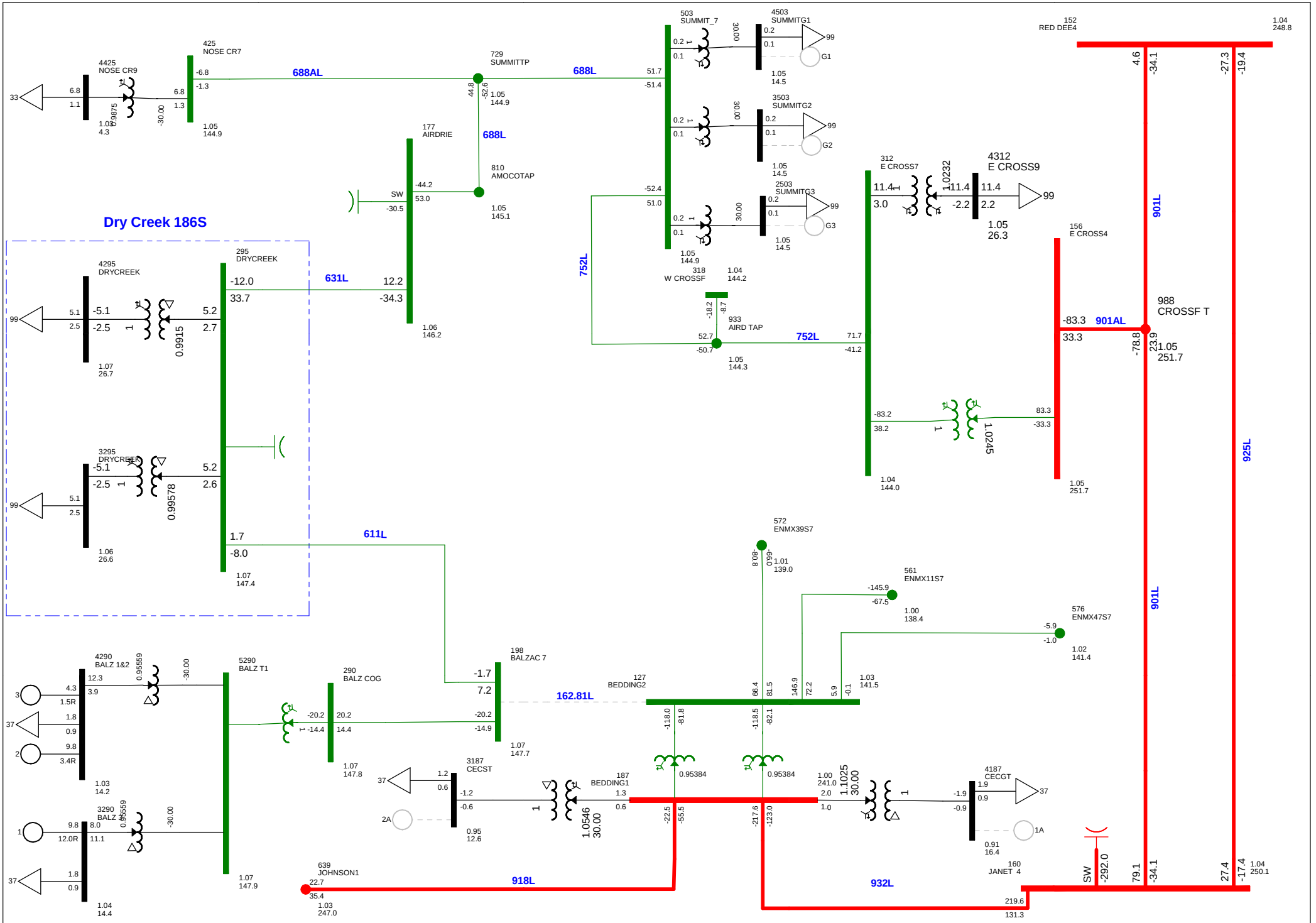
PROJECT 1693: 2017 SP PRE-PROJECT
186ST1 (N-G-1)
FIG A-6
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

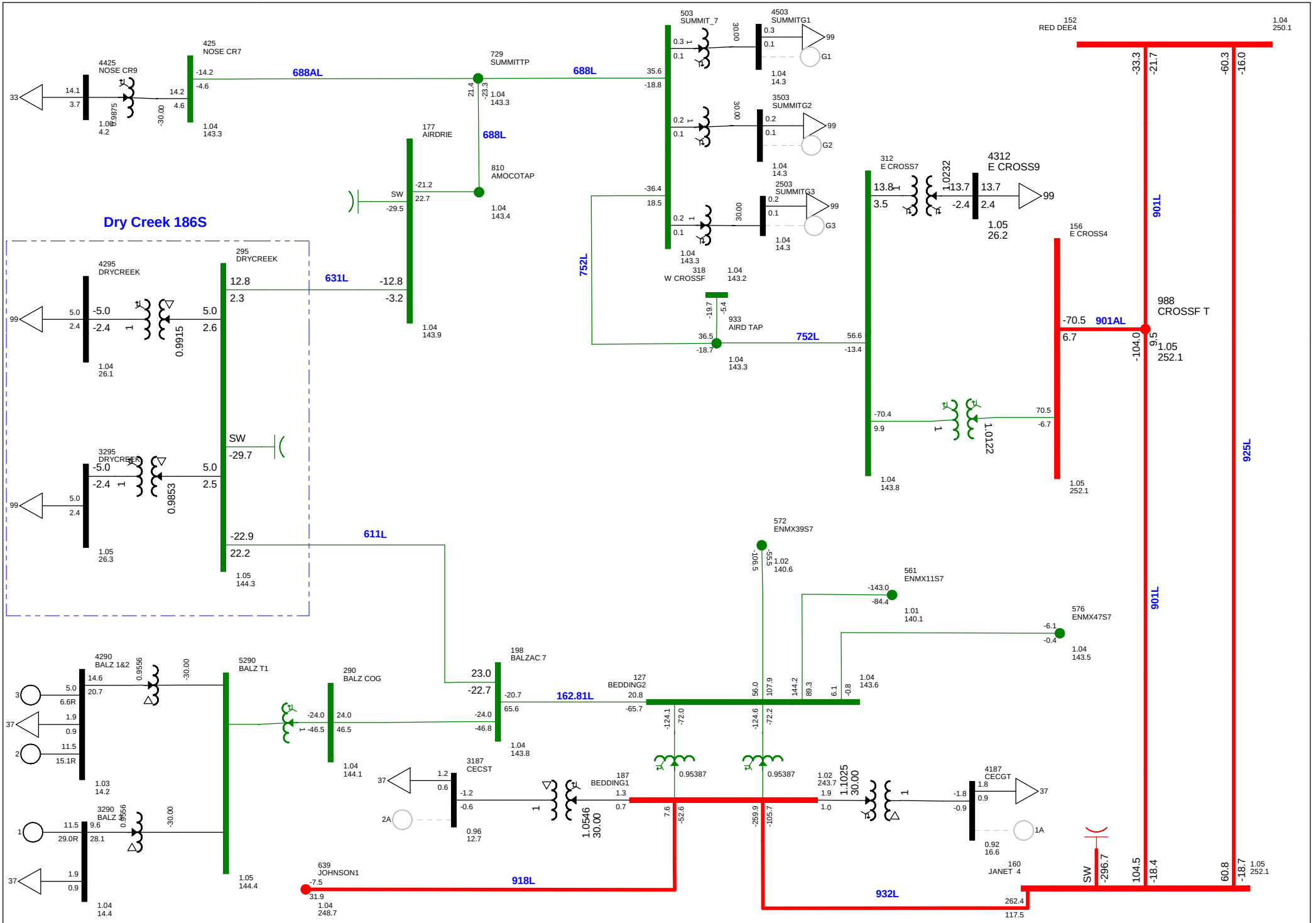
PROJECT 1693: 2017 SP PRE-PROJECT
186ST2 (N-G-1)
FIG A-7
FRI, AUG 26 2016 14:55



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP PRE-PROJECT
162.81L (N-G-1)
FIG A-8
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

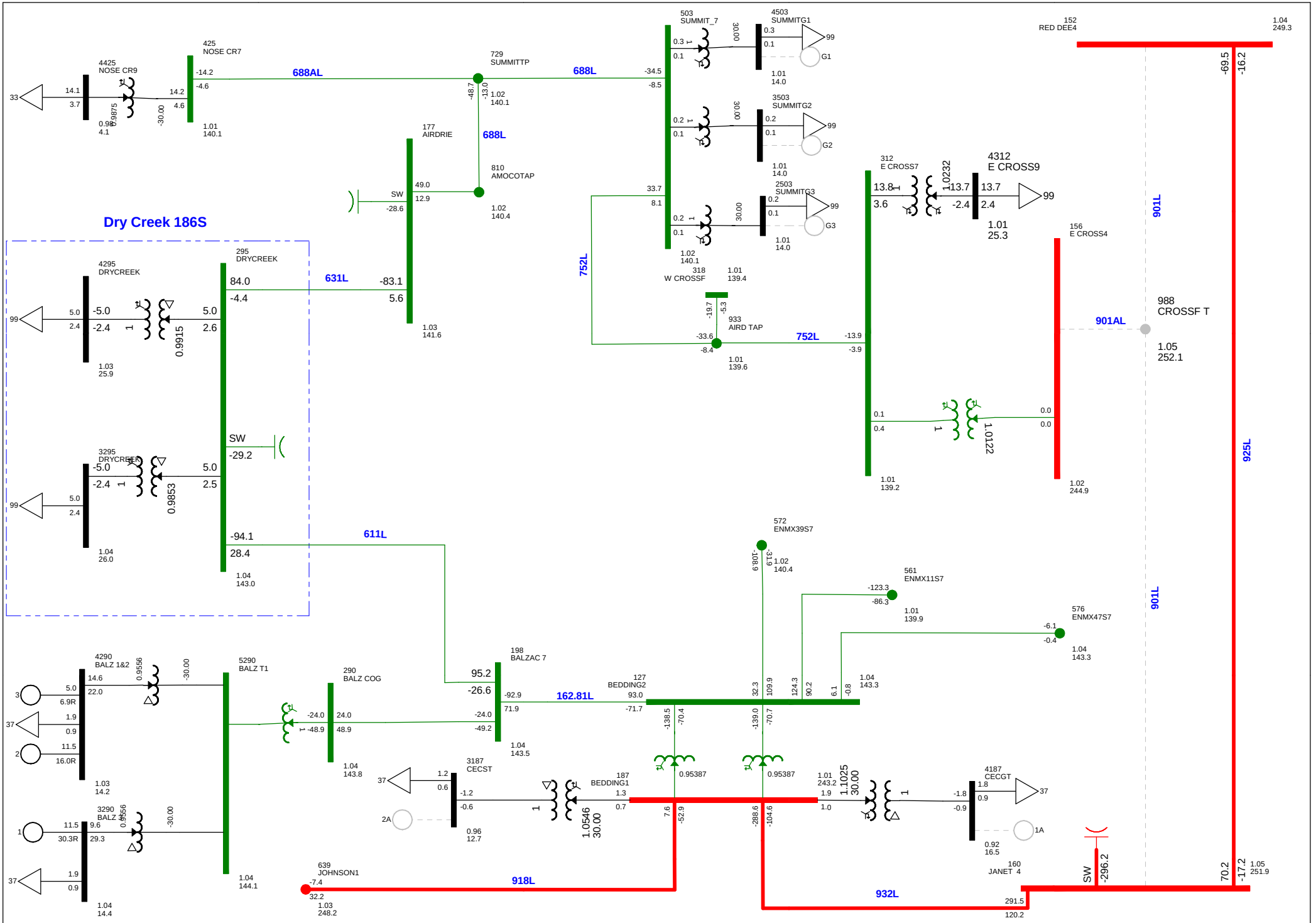


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
BASE CASE (N-G-0)
FIG A-9
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

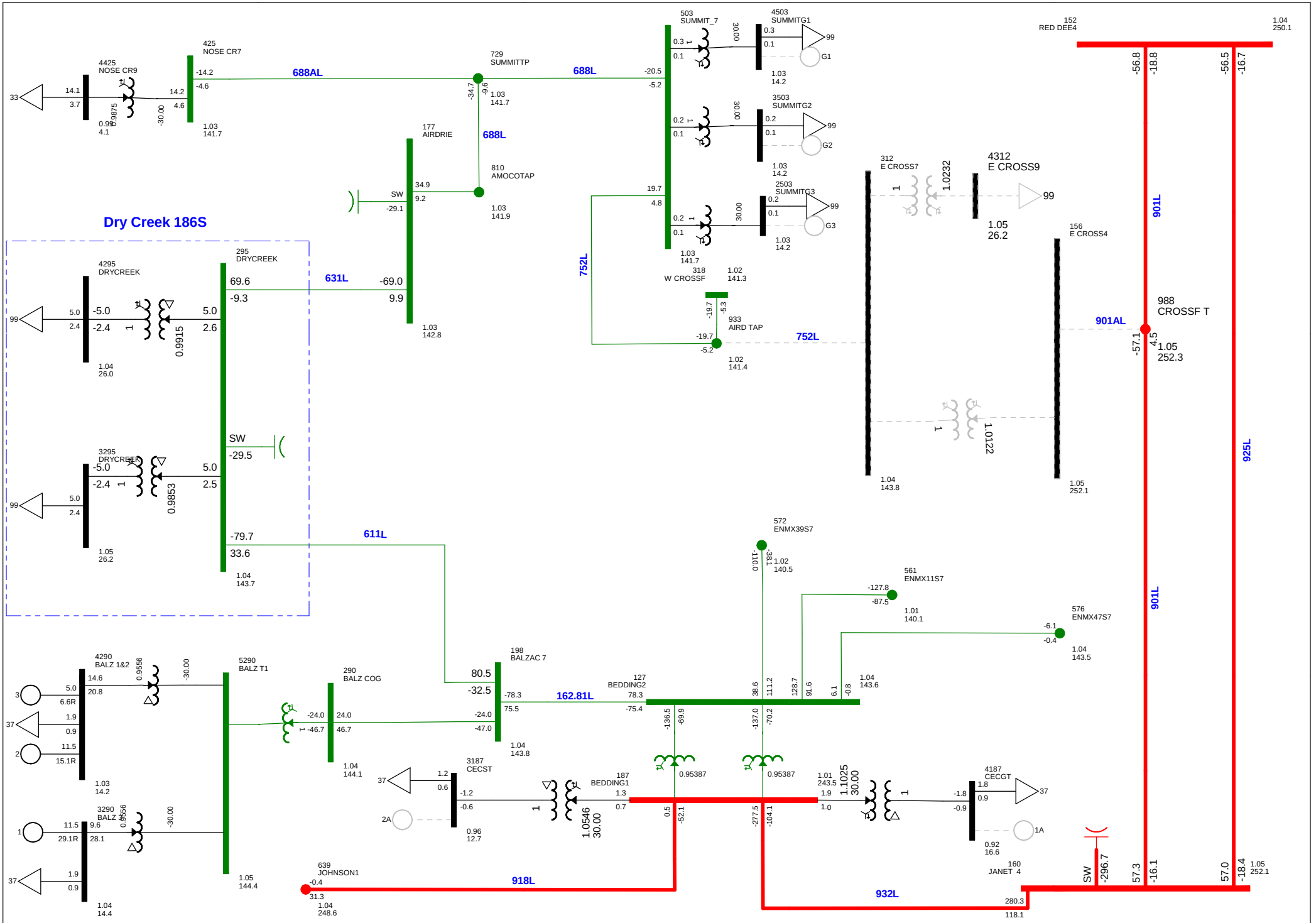


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
901L (N-G-1)
FIG A-10
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

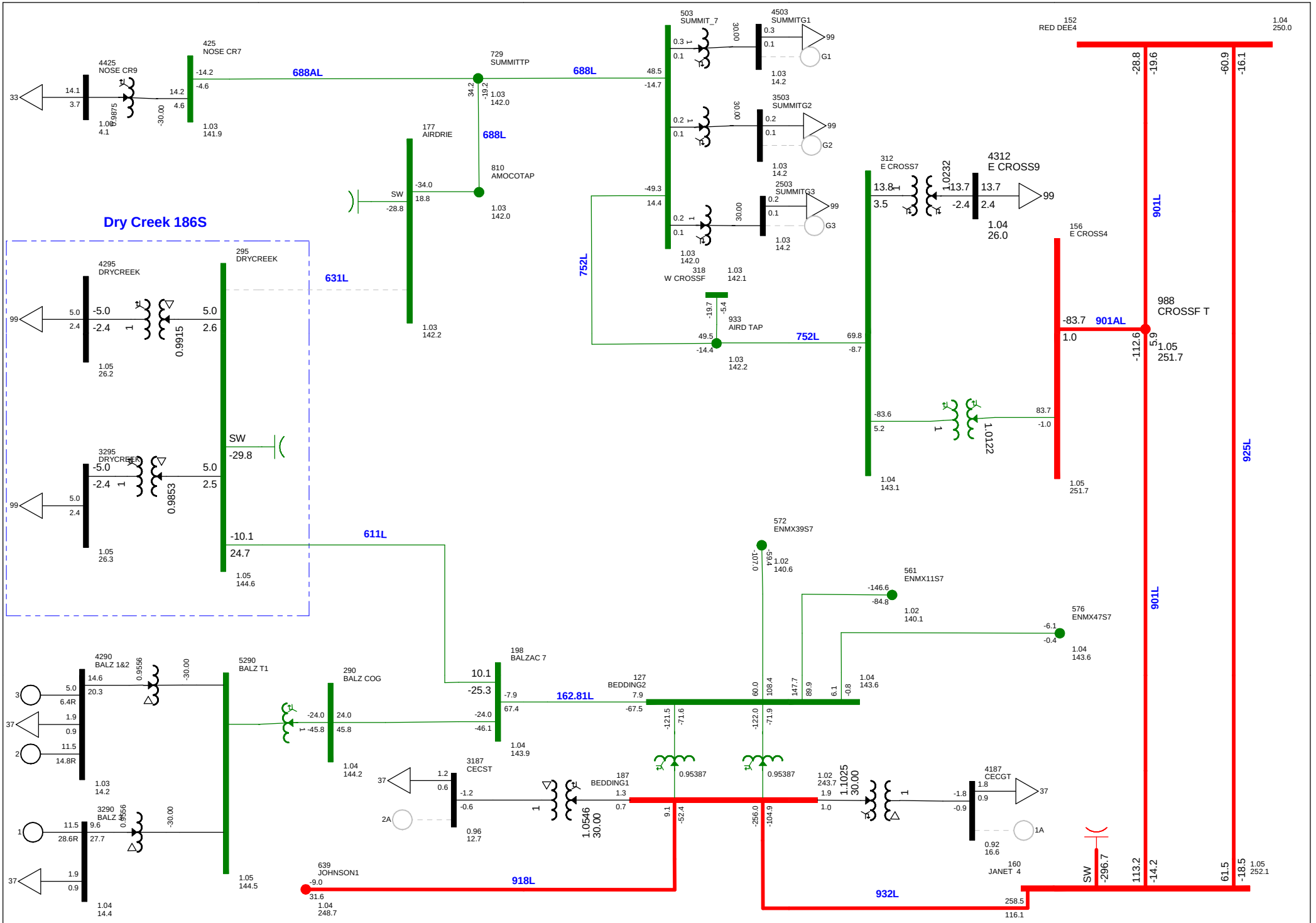


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
64ST2 (N-G-1)
FIG A-11
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

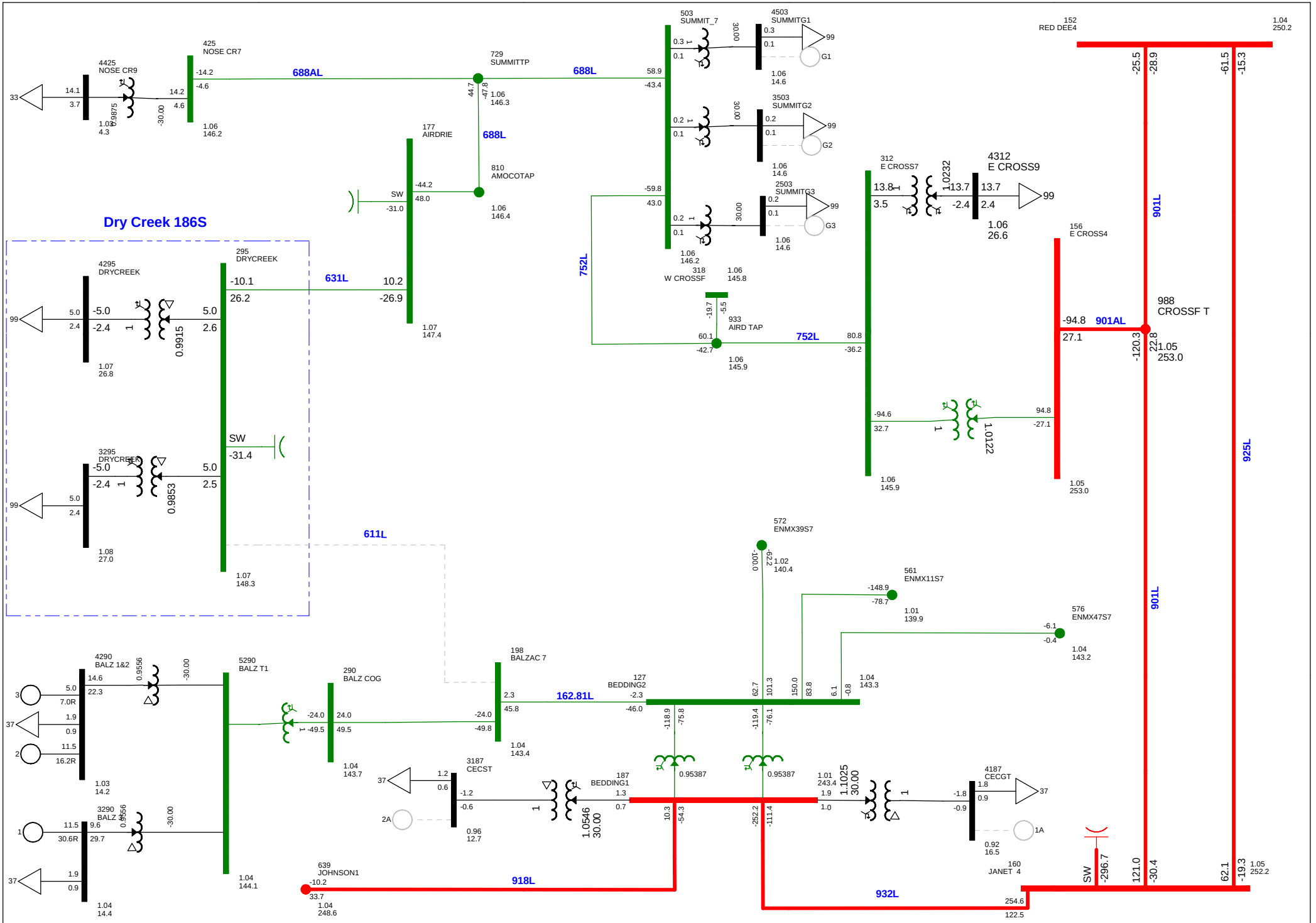


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
631L (N-G-1)
FIG A-12
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

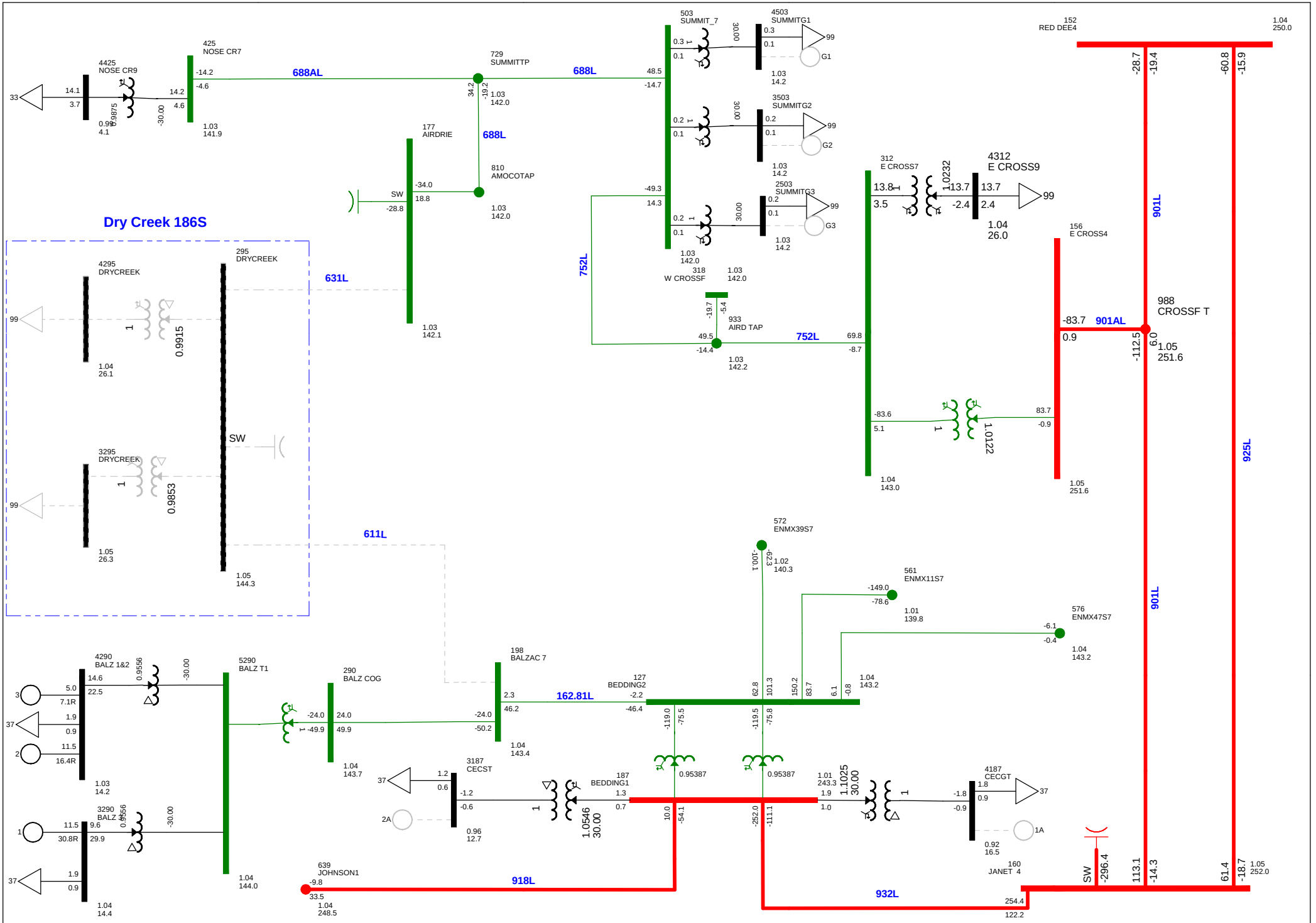


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
611L (N-G-1)
FIG A-13
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

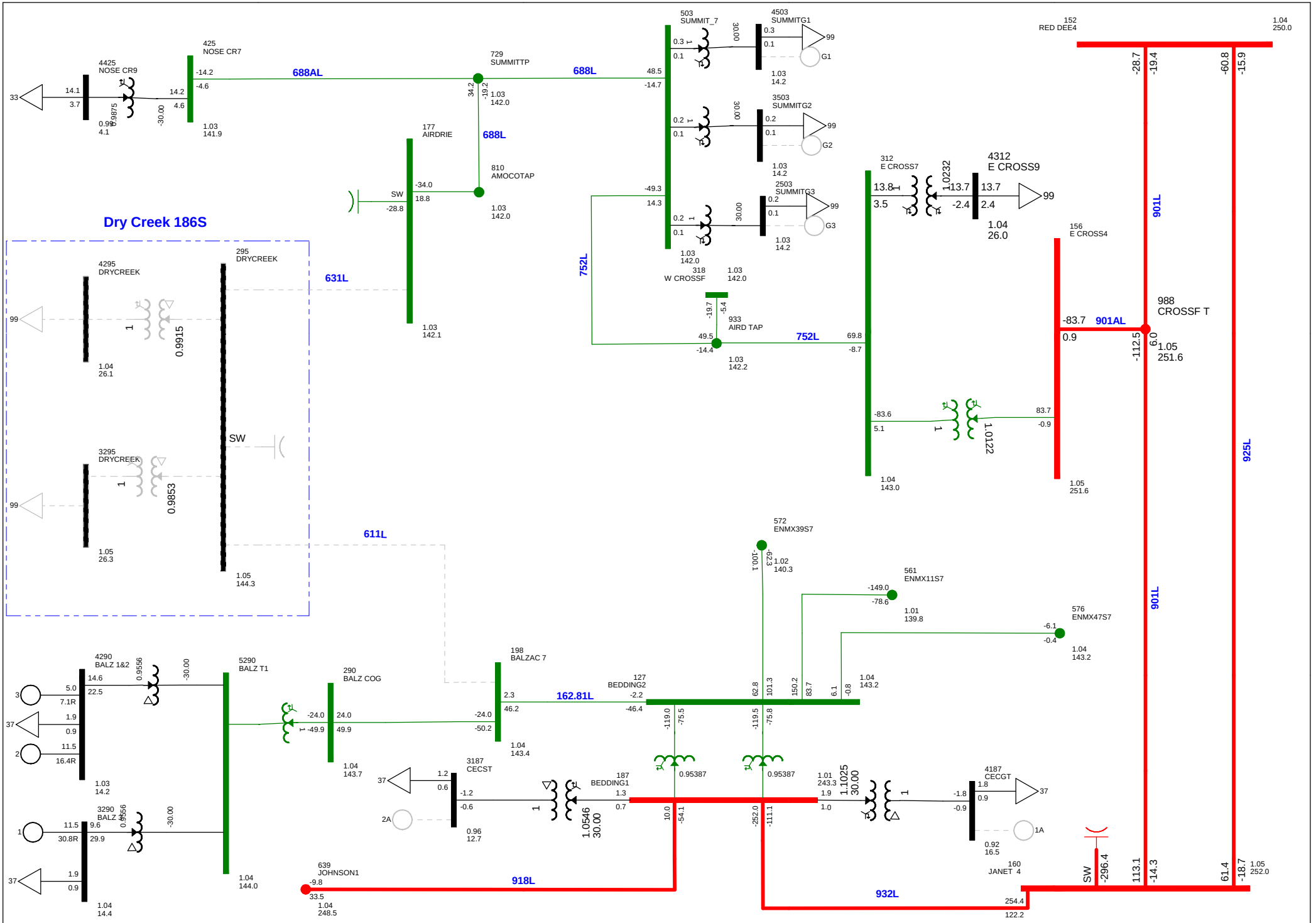


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
186ST1 (N-G-1)
FIG A-14
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

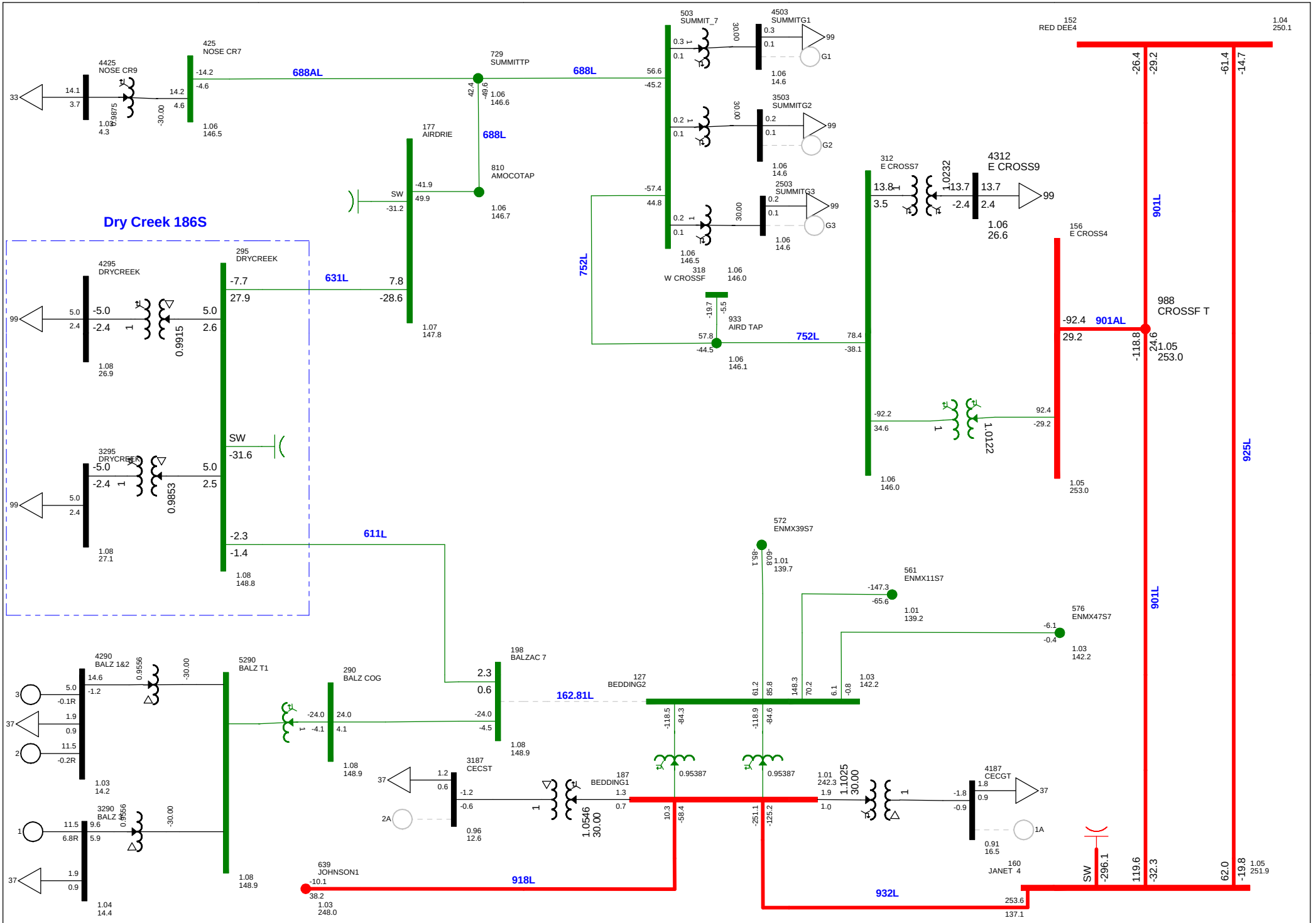


Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
186ST2 (N-G-1)
FIG A-15
FRI, AUG 26 2016 14:55

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

P1693: 2017WP

PROJECT 1693: 2017 WP PRE-PROJECT
162.81L (N-G-1)
FIG A-16
FRI, AUG 26 2016 14:55

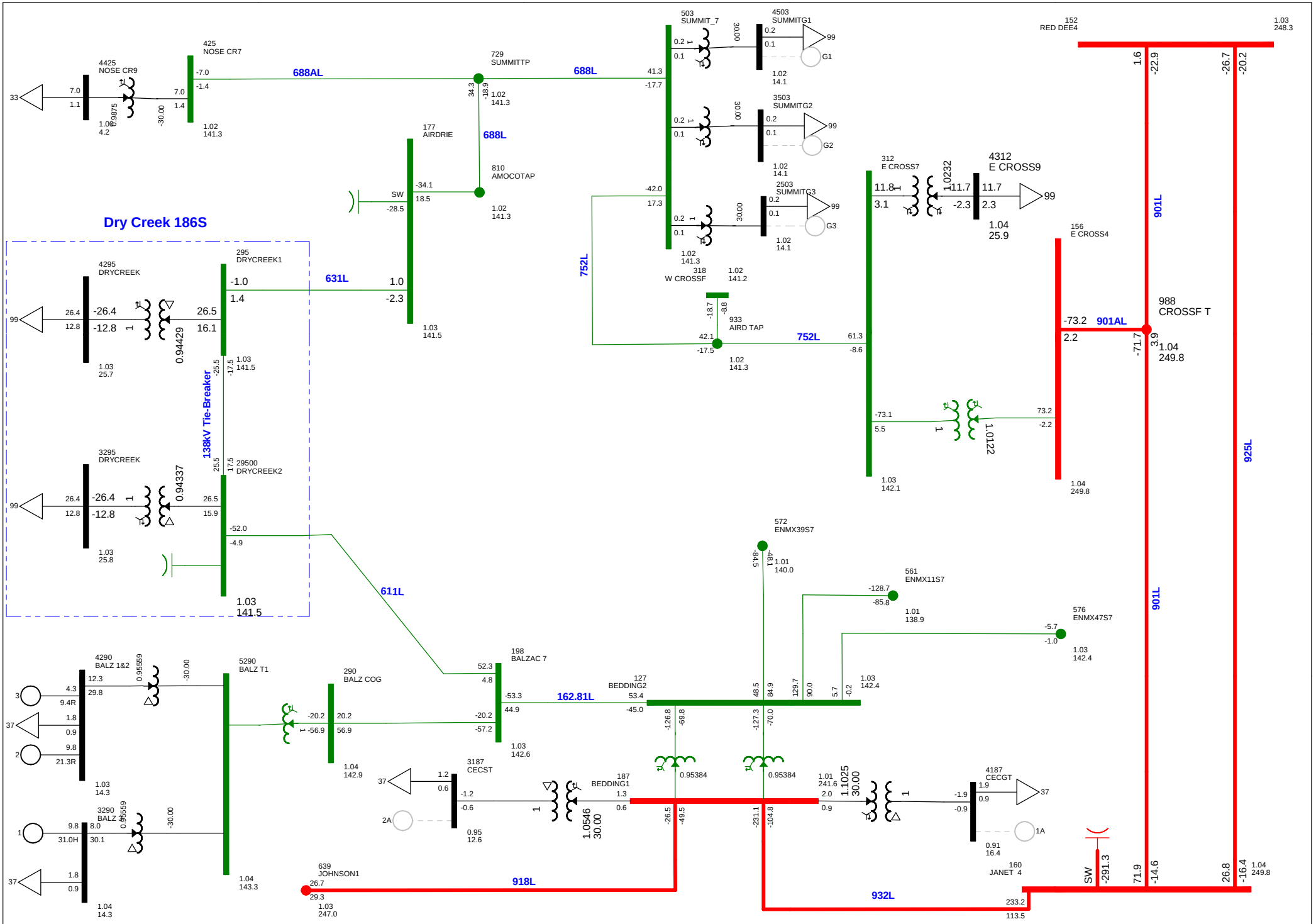
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment B

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

Table B-1: Post-Project Contingency Lists

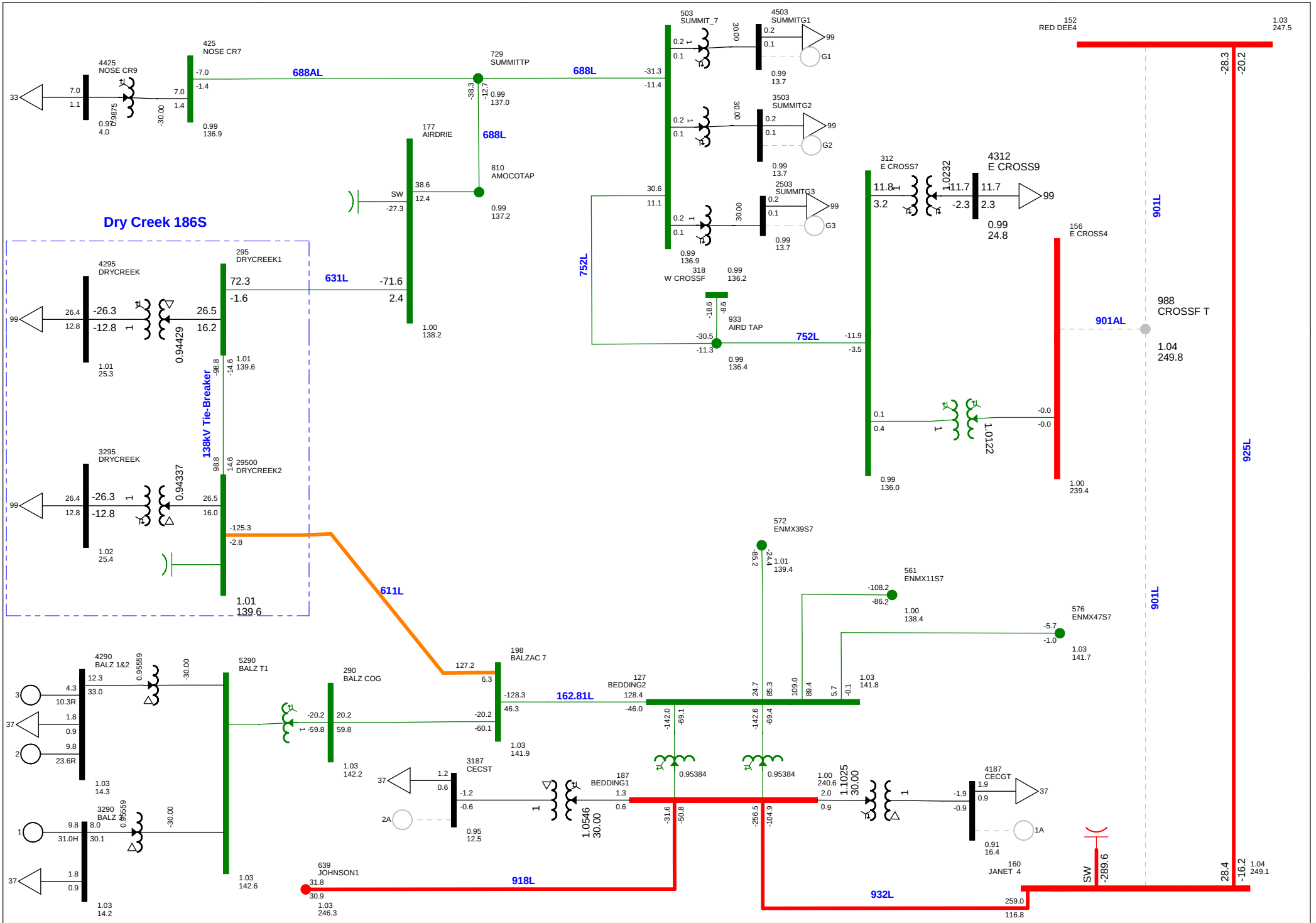
Figure #	Scenario	Condition	
B-1	2017 SP Post-Project	Base Case (N-G-0)	
B-2	2017 SP Post-Project	901L (N-G-1)	East Crossfield 64S - Red Deer 63S - Janet 74S
B-3	2017 SP Post-Project	64ST2 (N-G-1)	East Crossfield 64S
B-4	2017 SP Post-Project	631L (N-G-1)	East Airdrie 199S - Dry Creek 186S
B-5	2017 SP Post-Project	611L (N-G-1)	Balzac 391S - Dry Creek 186S
B-6	2017 SP Post-Project	186ST1 (N-G-1)	Dry Creek 186S
B-7	2017 SP Post-Project	186ST2 (N-G-1)	Dry Creek 186S
B-8	2017 SP Post-Project	162.81L (N-G-1)	Balzac 391S - Beddington SS-162
B-9	2017 WP Post-Project	Base Case (N-G-0)	
B-10	2017 WP Post-Project	901L (N-G-1)	East Crossfield 64S - Red Deer 63S - Janet 74S
B-11	2017 WP Post-Project	64ST2 (N-G-1)	East Crossfield 64S
B-12	2017 WP Post-Project	631L (N-G-1)	East Airdrie 199S - Dry Creek 186S
B-13	2017 WP Post-Project	611L (N-G-1)	Balzac 391S - Dry Creek 186S
B-14	2017 WP Post-Project	186ST1 (N-G-1)	Dry Creek 186S
B-15	2017 WP Post-Project	186ST2 (N-G-1)	Dry Creek 186S
B-16	2017 WP Post-Project	162.81L (N-G-1)	Balzac 391S - Beddington SS-162



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
BASE CASE (N-G-0)
FIG B-1
FRI, AUG 26 2016 15:14

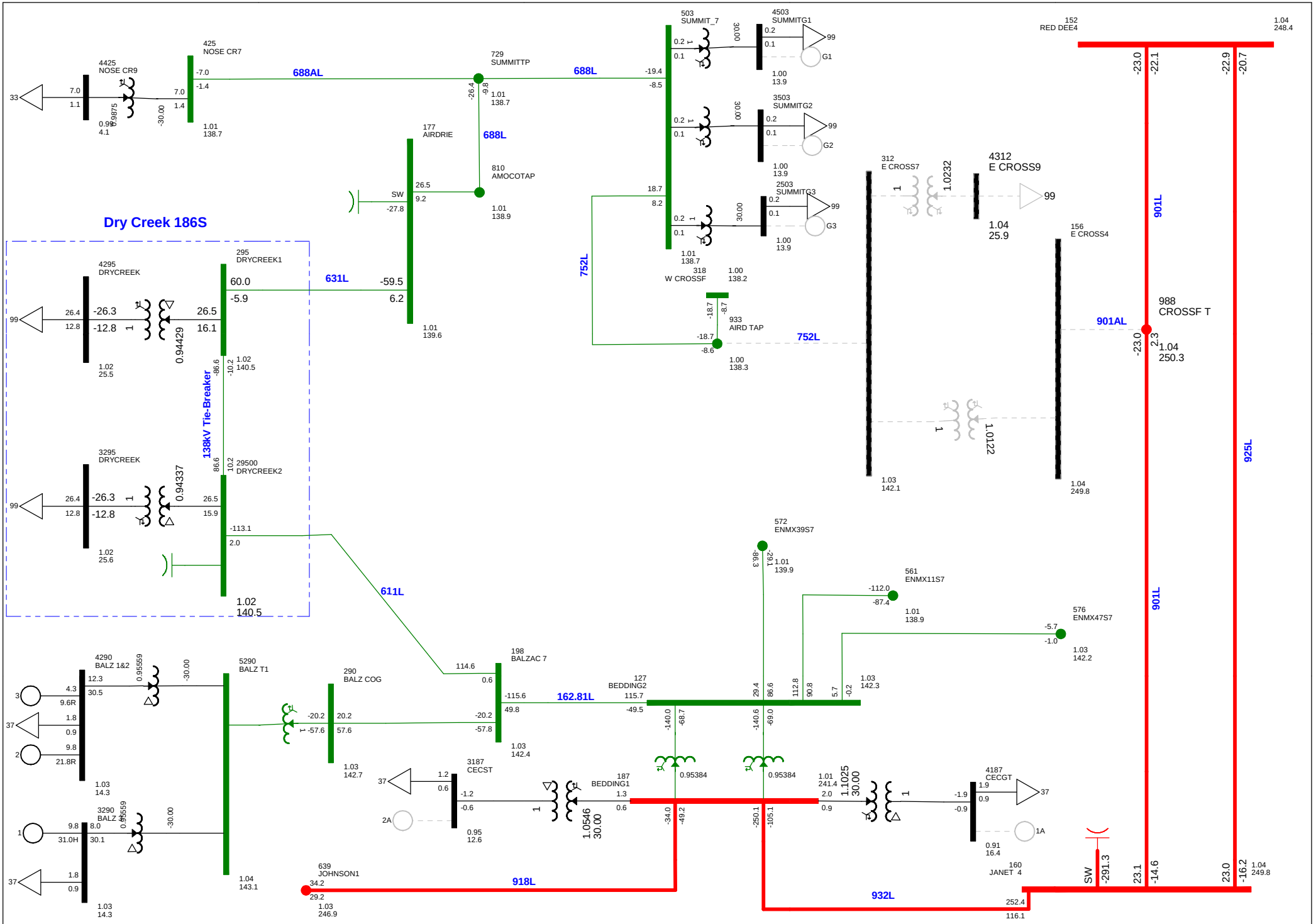
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
901L (N-G-1)
FIG B-2
FRI, AUG 26 2016 15:14

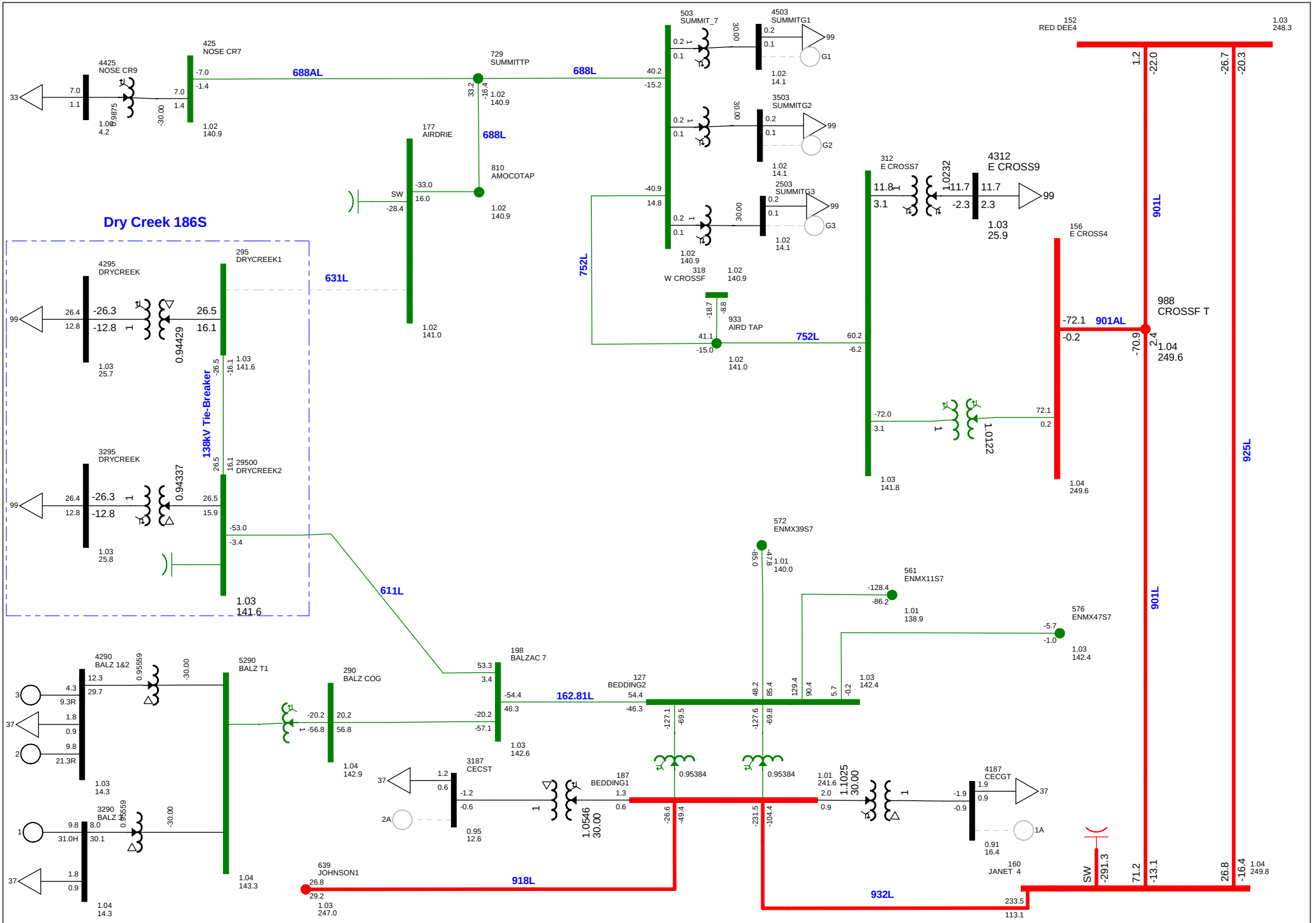
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
64ST2 (N-G-1)
FIG B-3
FRI, AUG 26 2016 15:14

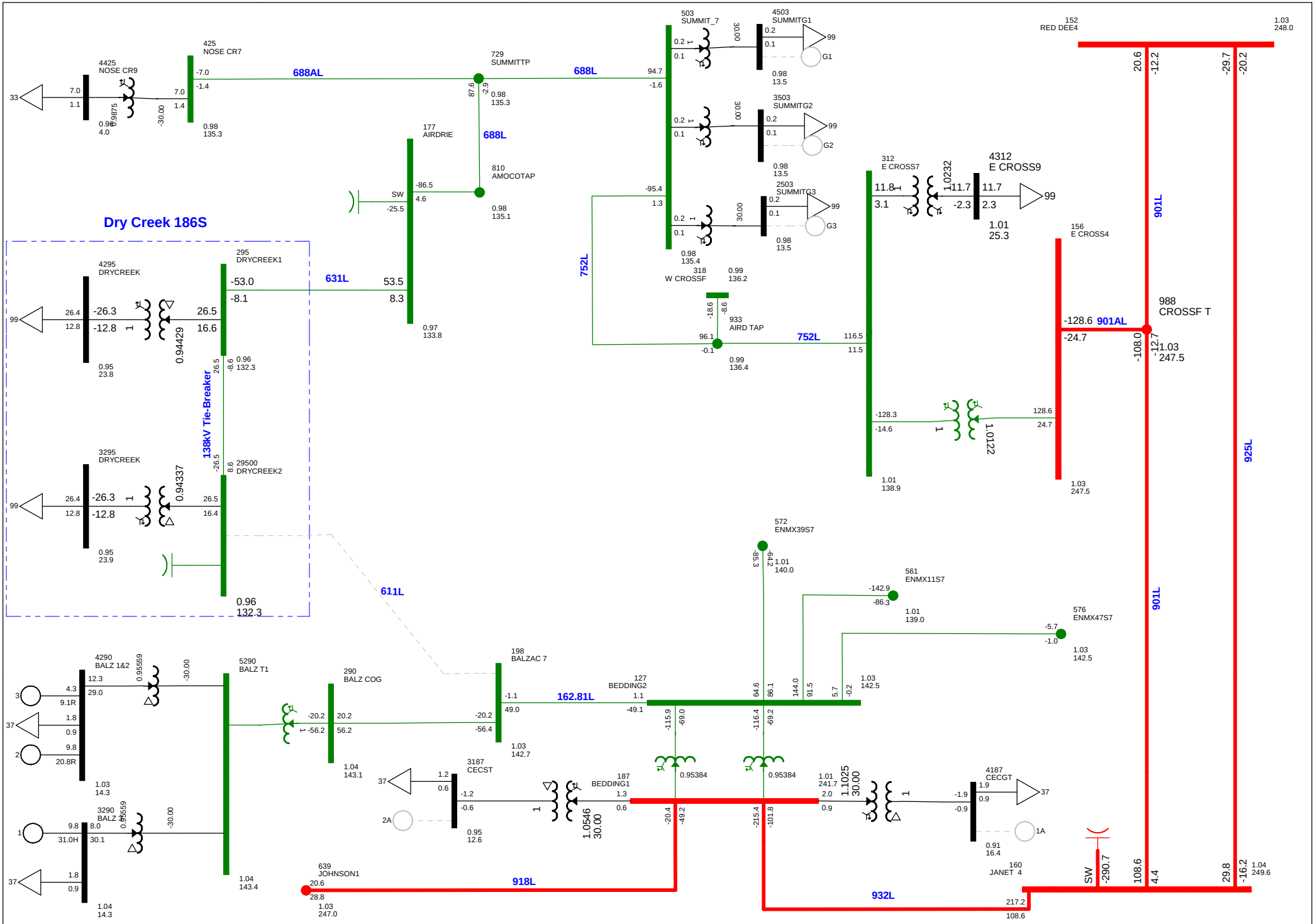
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
631L (N-G-1)
FIG B-4
FRI, AUG 26 2016 15:14

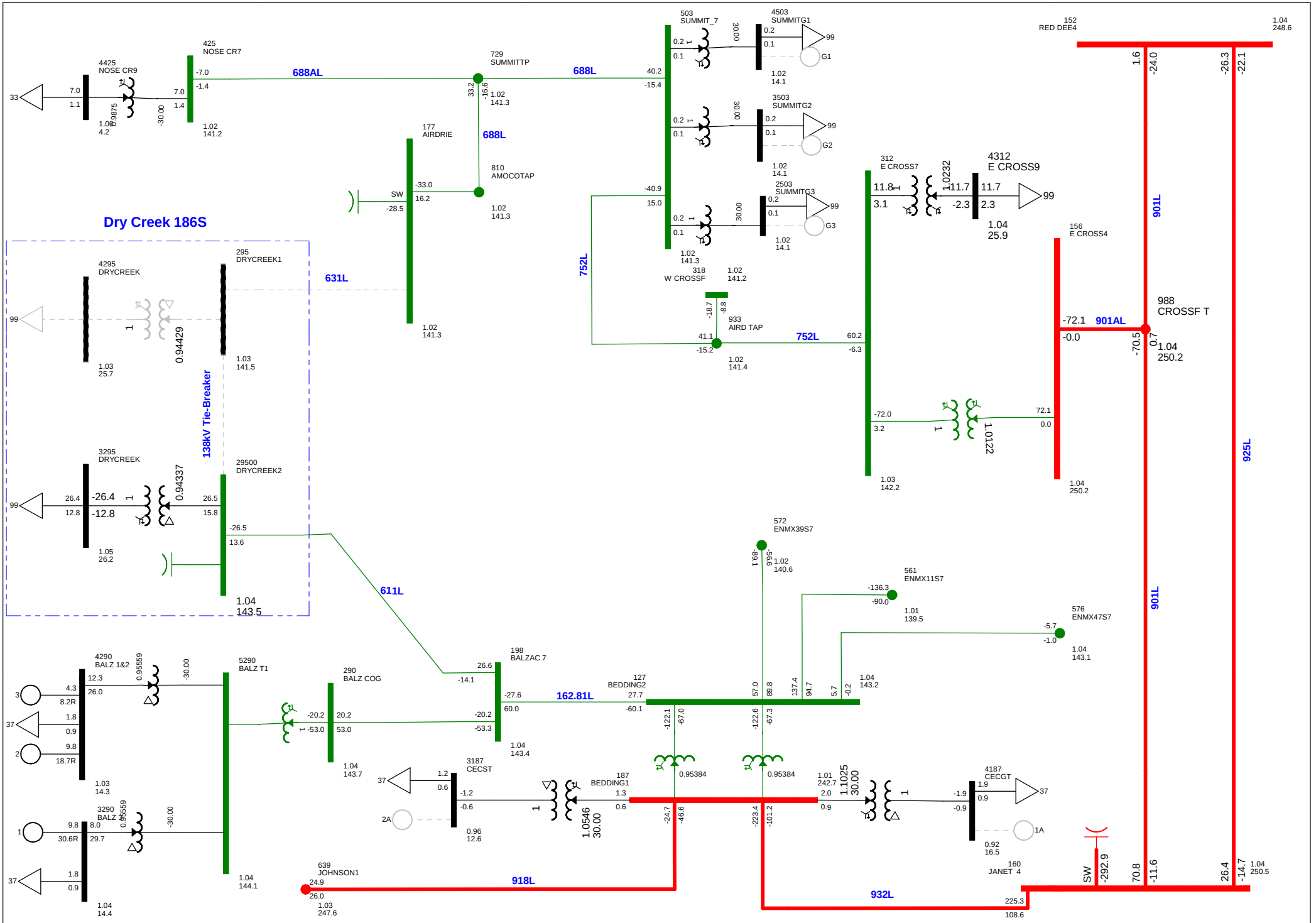
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
611L (N-G-1)
FIG B-5
FRI, AUG 26 2016 15:14

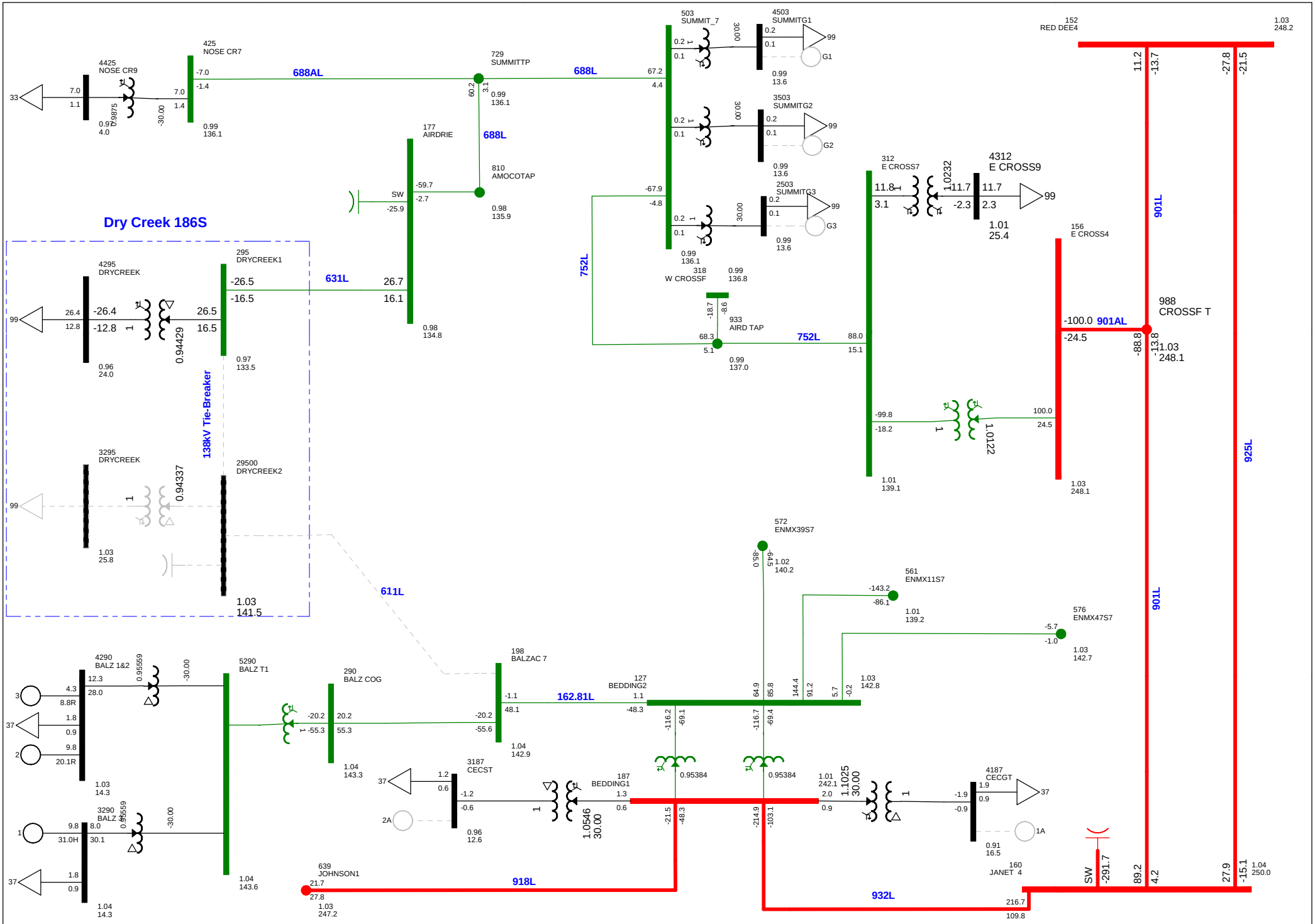
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
186ST1 (N-G-1)
FIG B-6
FRI, AUG 26 2016 15:14

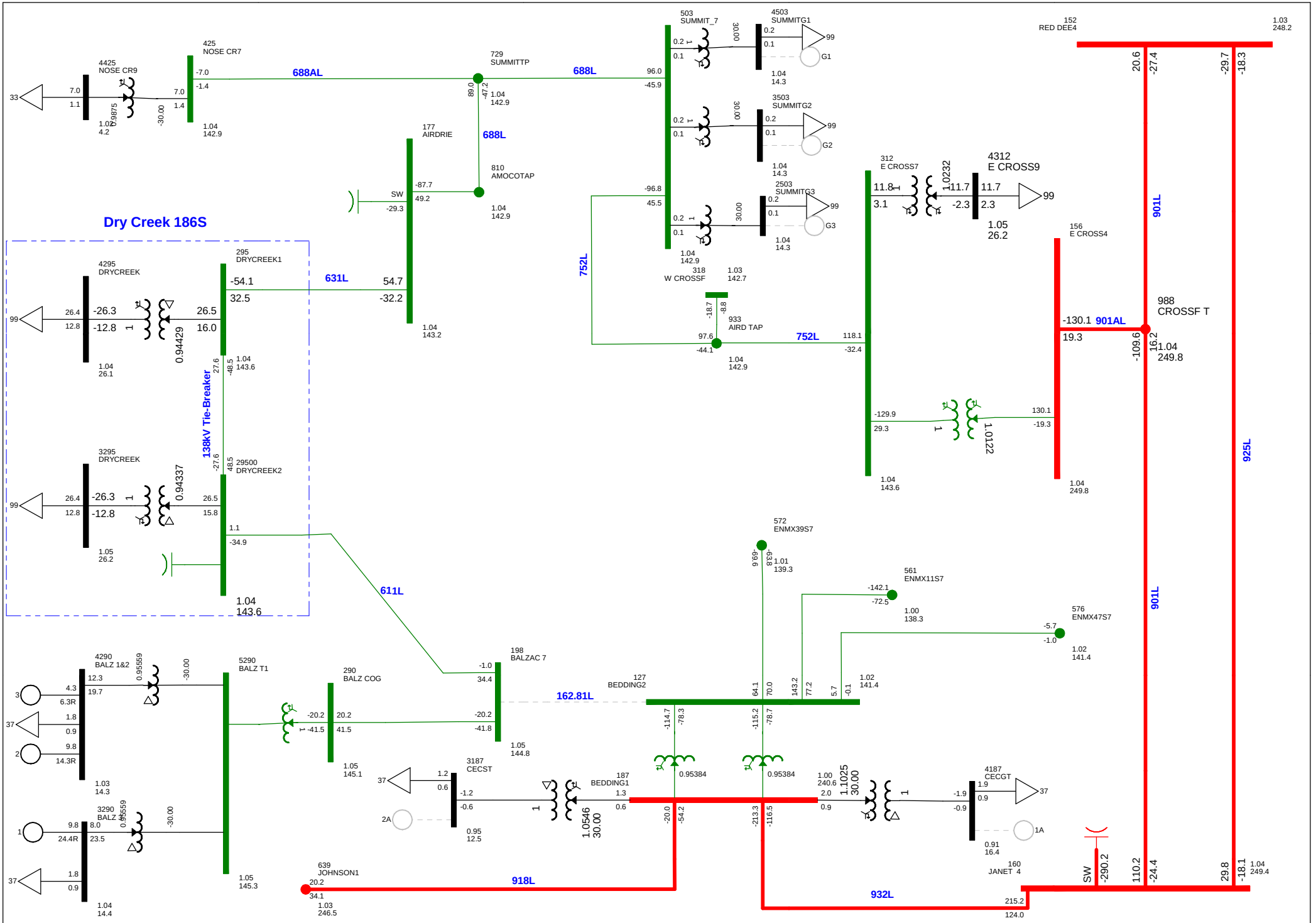
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
186ST2 (N-G-1)
FIG B-7
FRI, AUG 26 2016 15:14

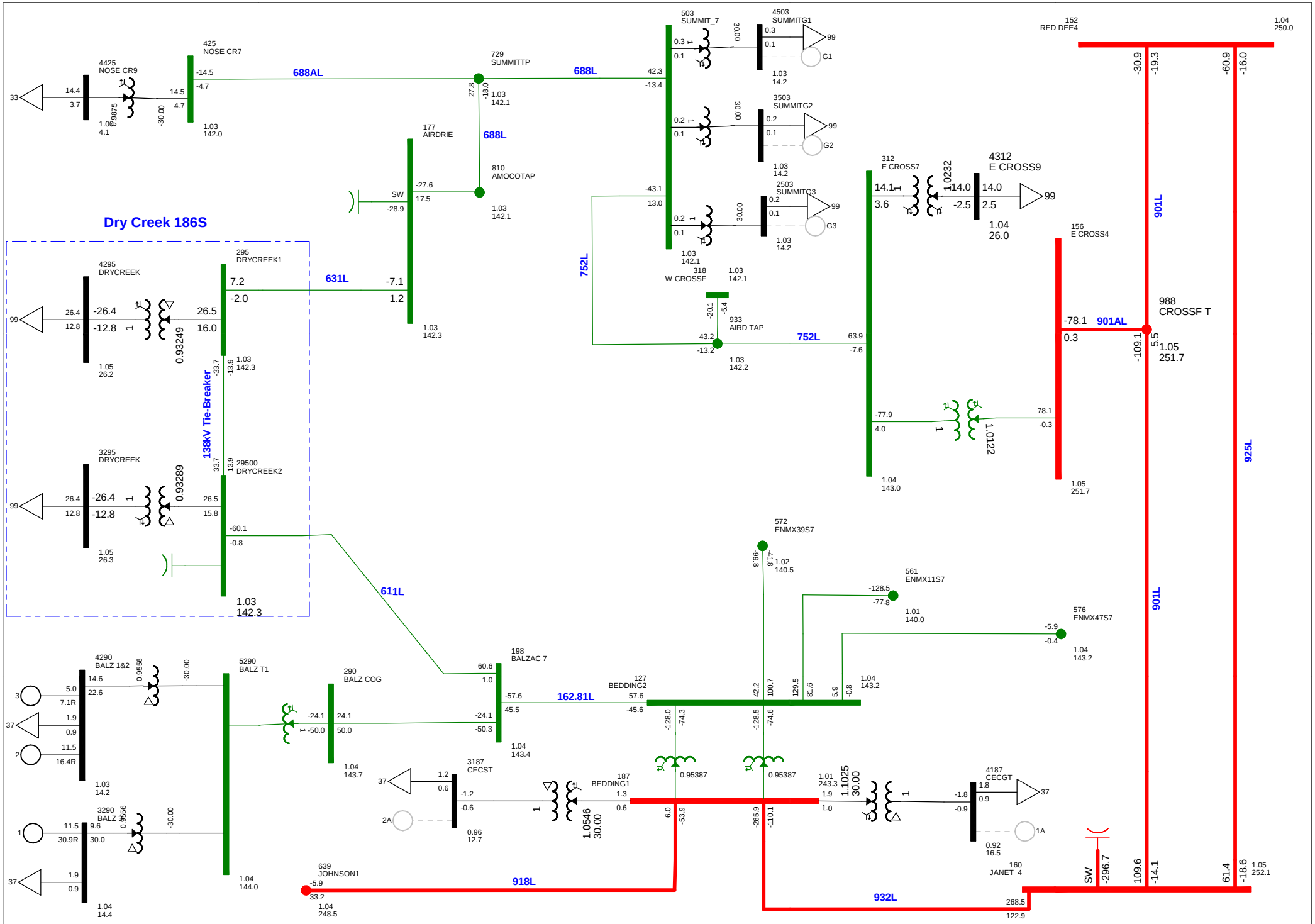
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 SP POST-PROJECT
162.81L (N-G-1)
FIG B-8
FRI, AUG 26 2016 15:14

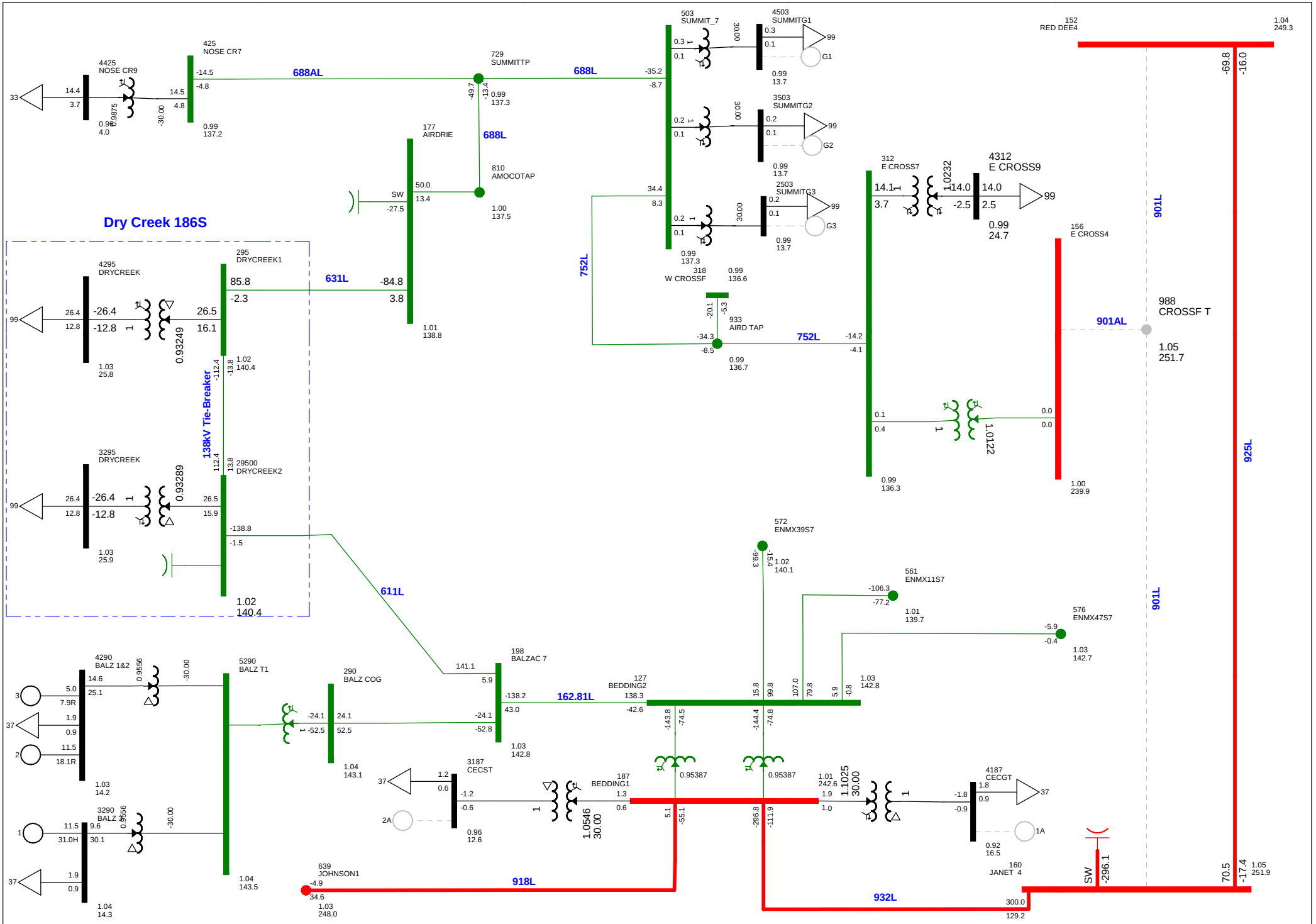
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
BASE CASE (N-G-0)
FIG B-9
FRI, AUG 26 2016 15:14

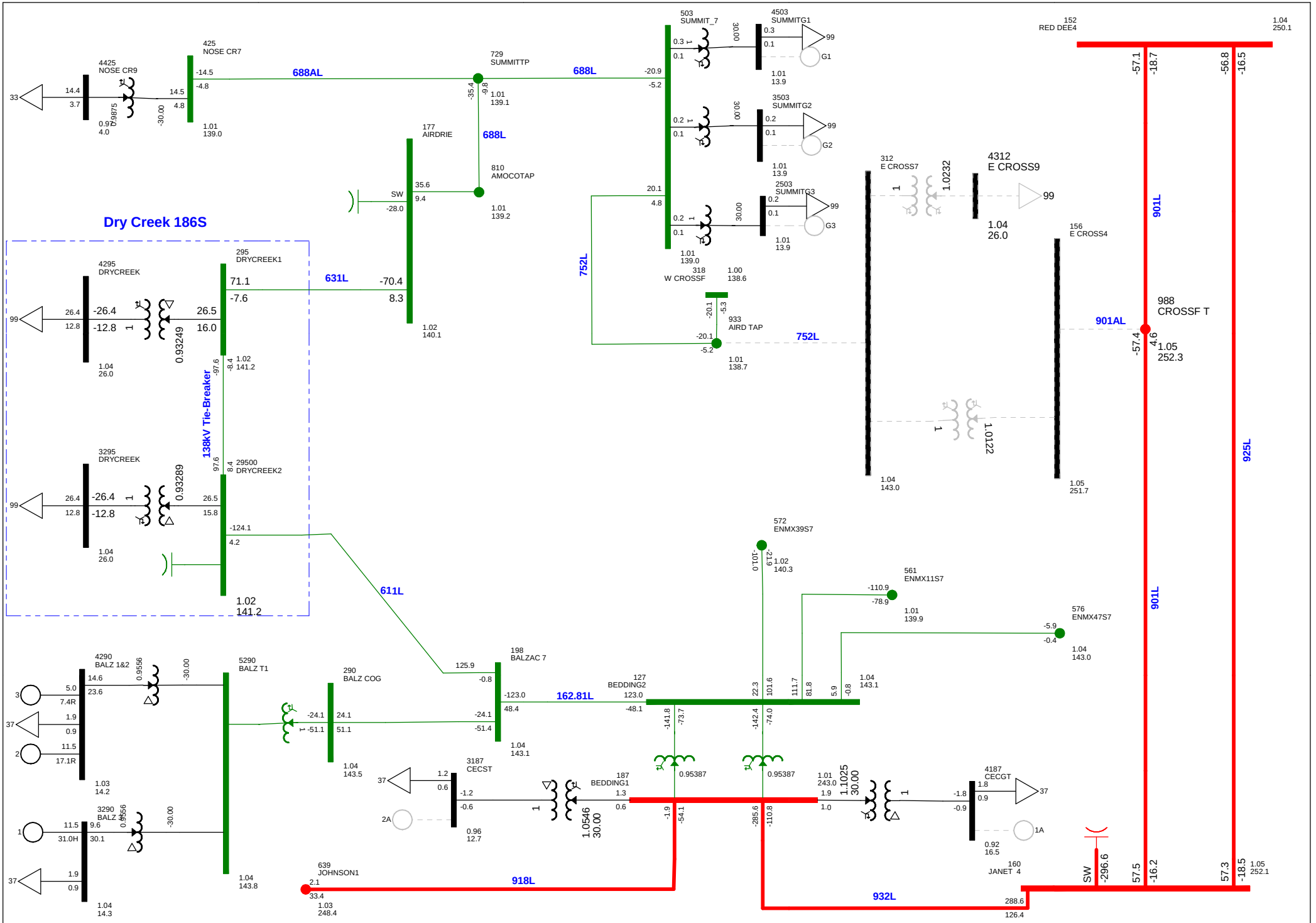
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
901L (N-G-1)
FIG B-10
FRI, AUG 26 2016 15:14

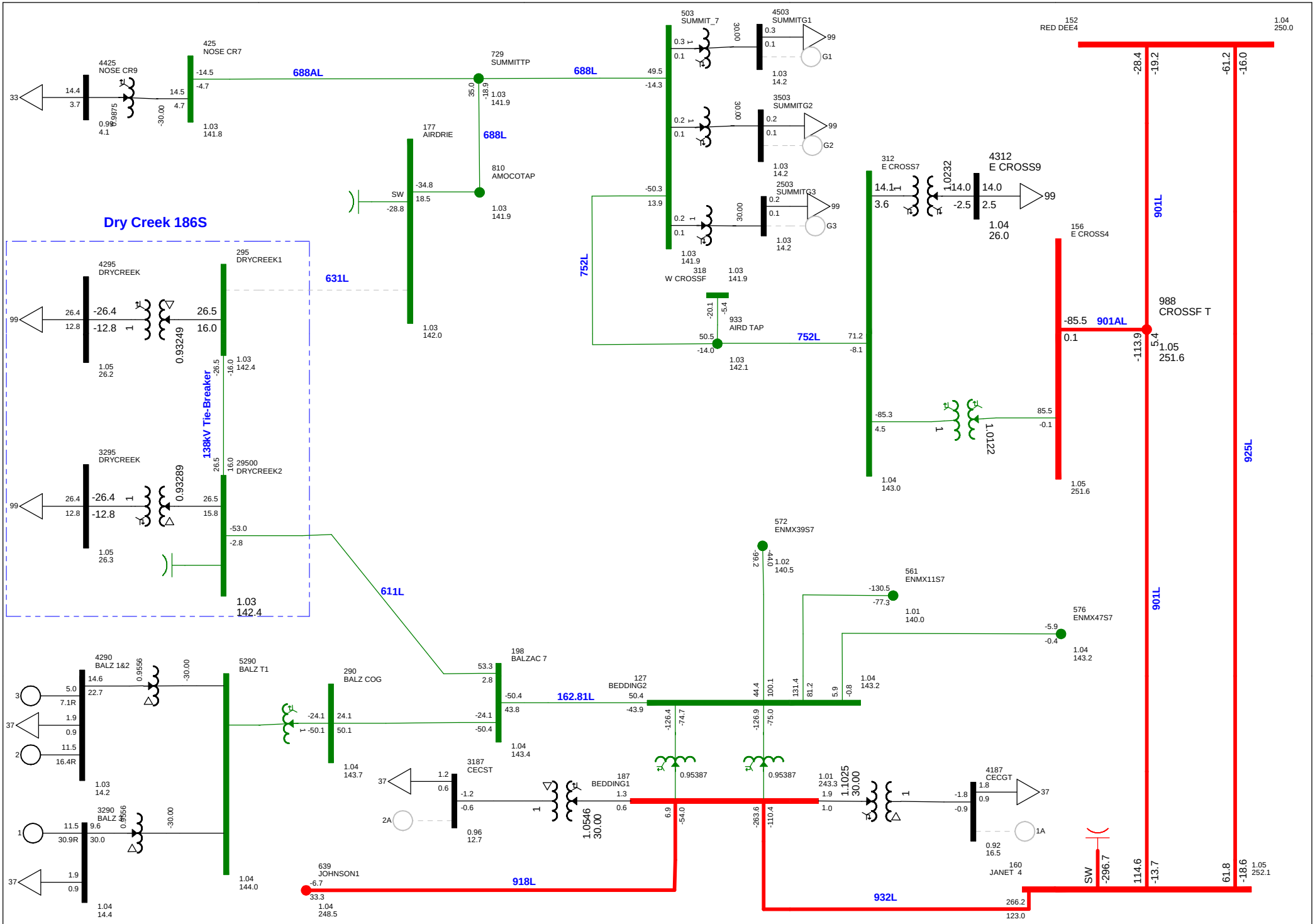
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
64ST2 (N-G-1)
FIG B-11
FRI, AUG 26 2016 15:14

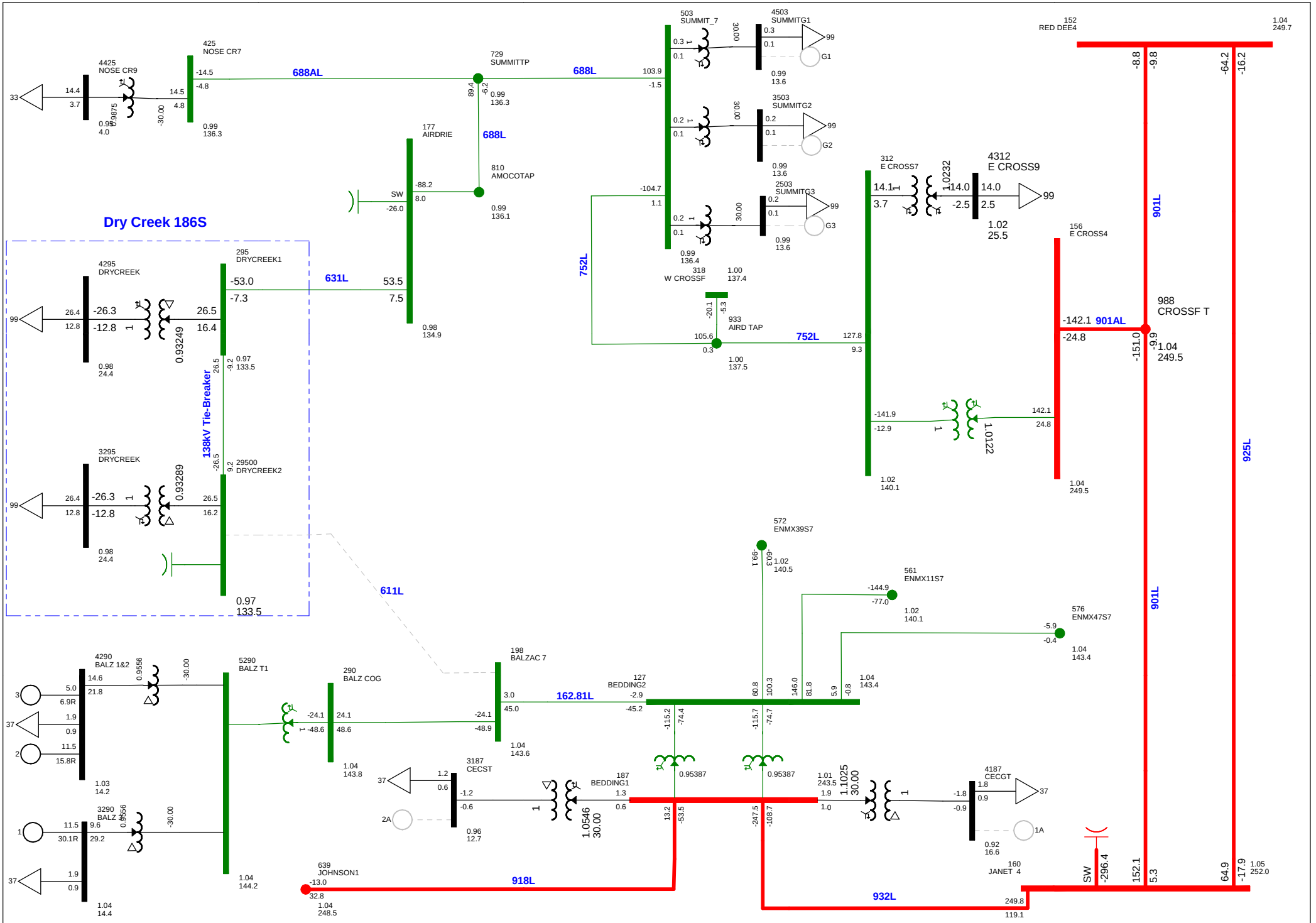
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
631L (N-G-1)
FIG B-12
FRI, AUG 26 2016 15:14

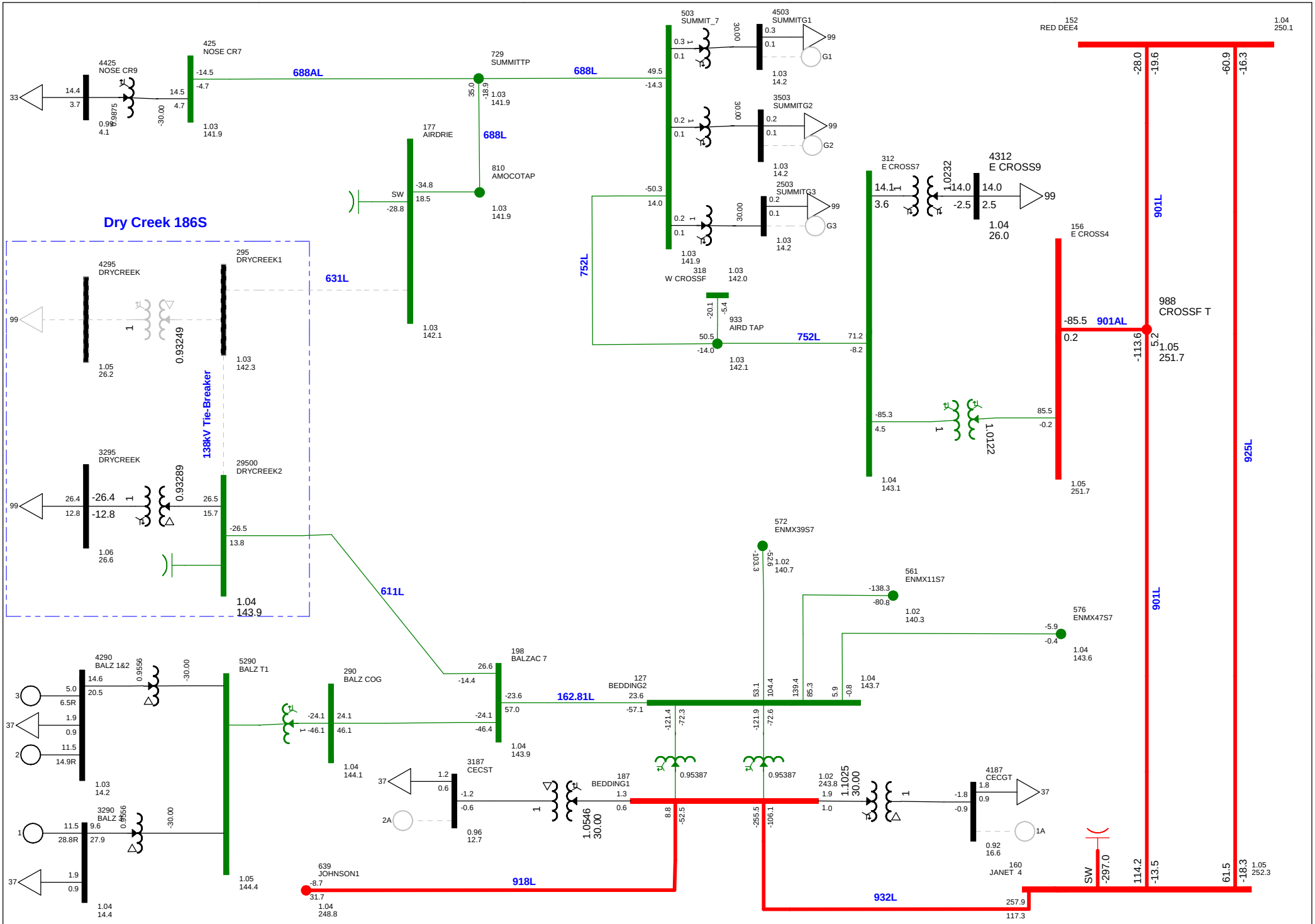
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
611L (N-G-1)
FIG B-13
FRI, AUG 26 2016 15:14

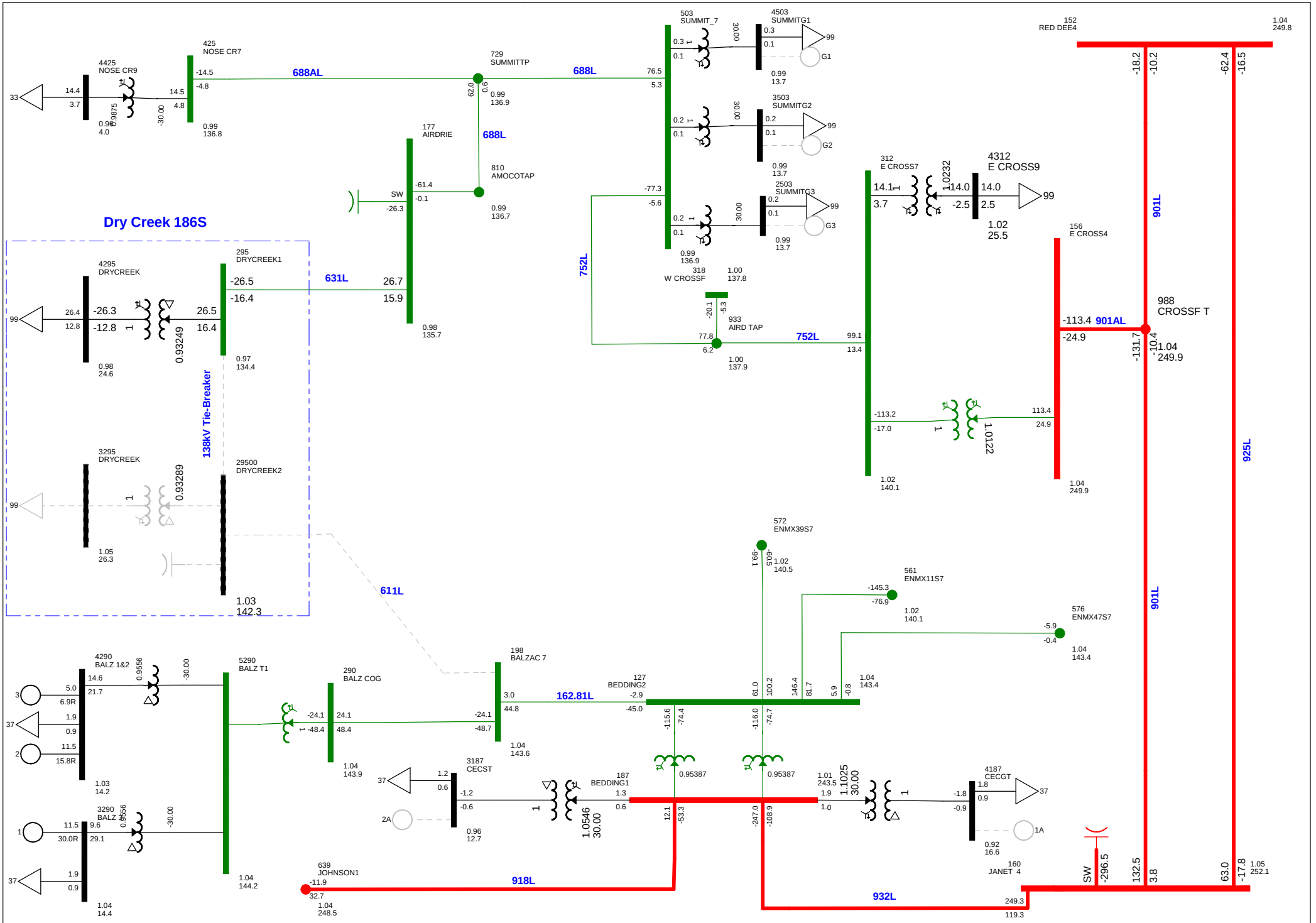
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
186ST1 (N-G-1)
FIG B-14
FRI, AUG 26 2016 15:14

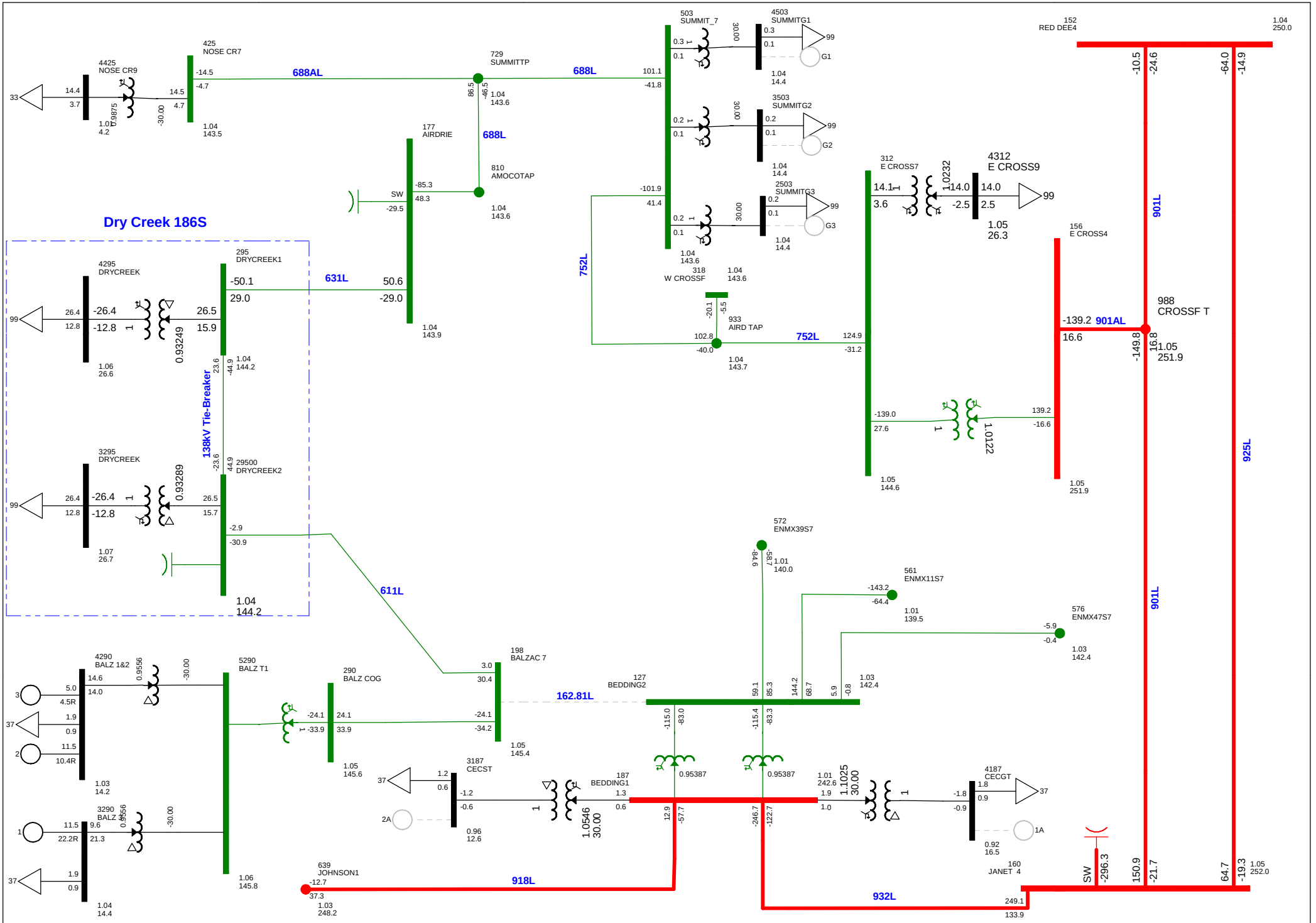
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
186ST2 (N-G-1)
FIG B-15
FRI, AUG 26 2016 15:14

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



Dry Creek 186S Upgrades

PROJECT 1693: 2017 WP POST-PROJECT
162.81L (N-G-1)
FIG B-16
FRI, AUG 26 2016 15:14

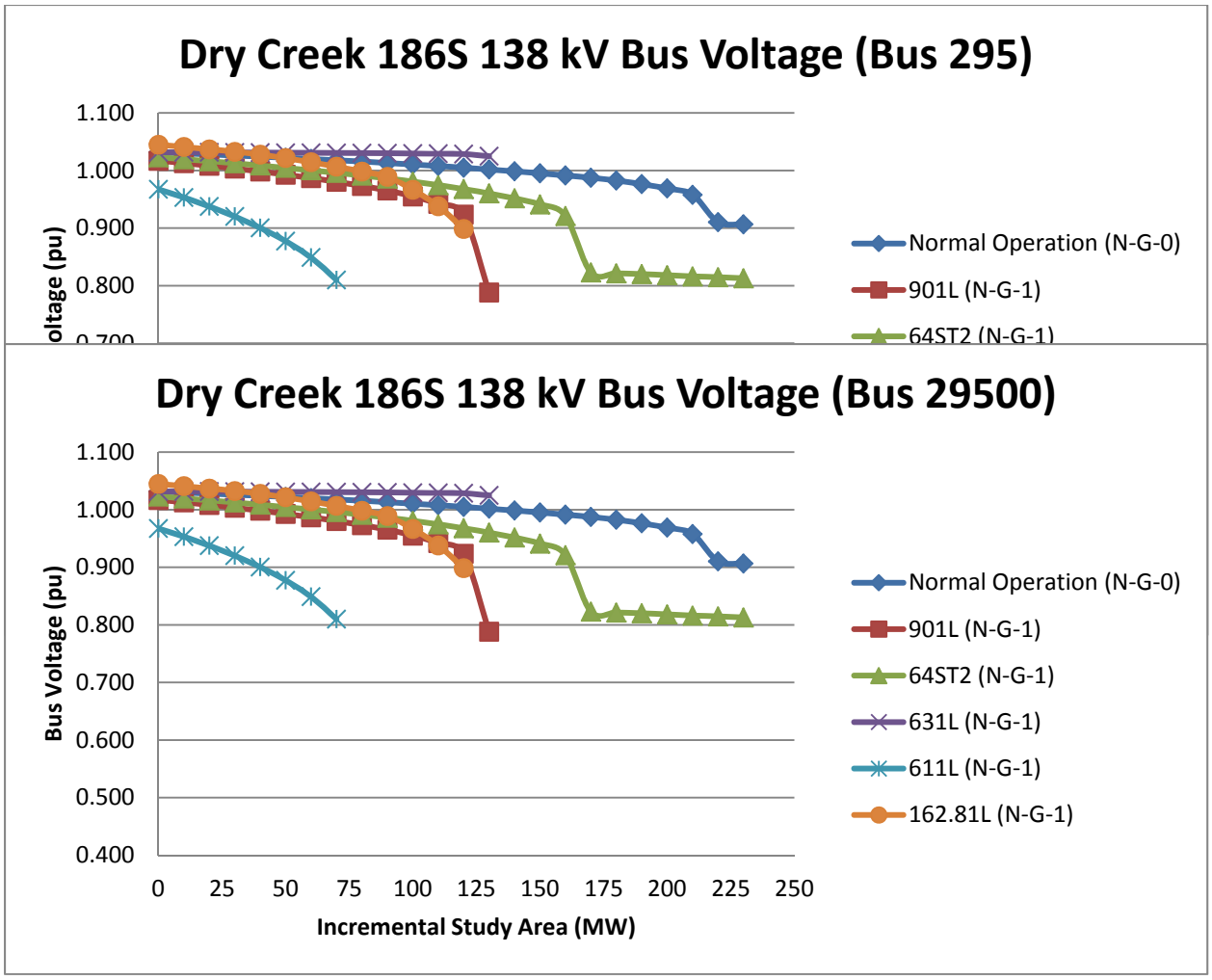
Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate B
1.105OV 0.899UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

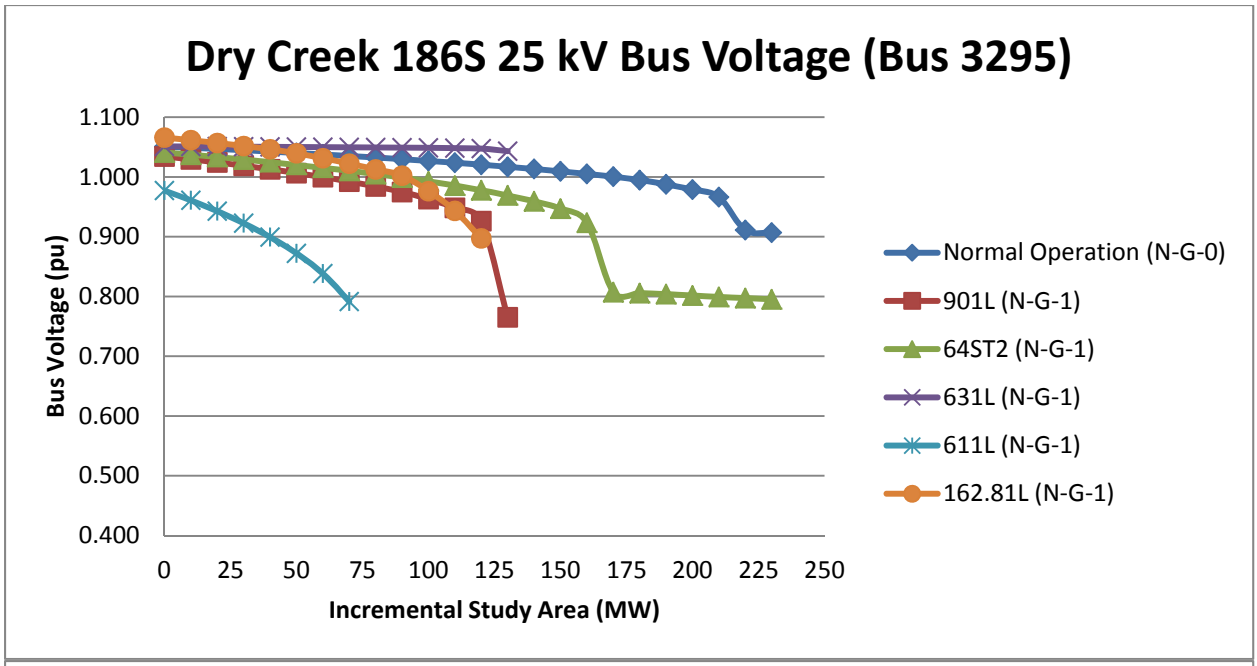
Attachment C

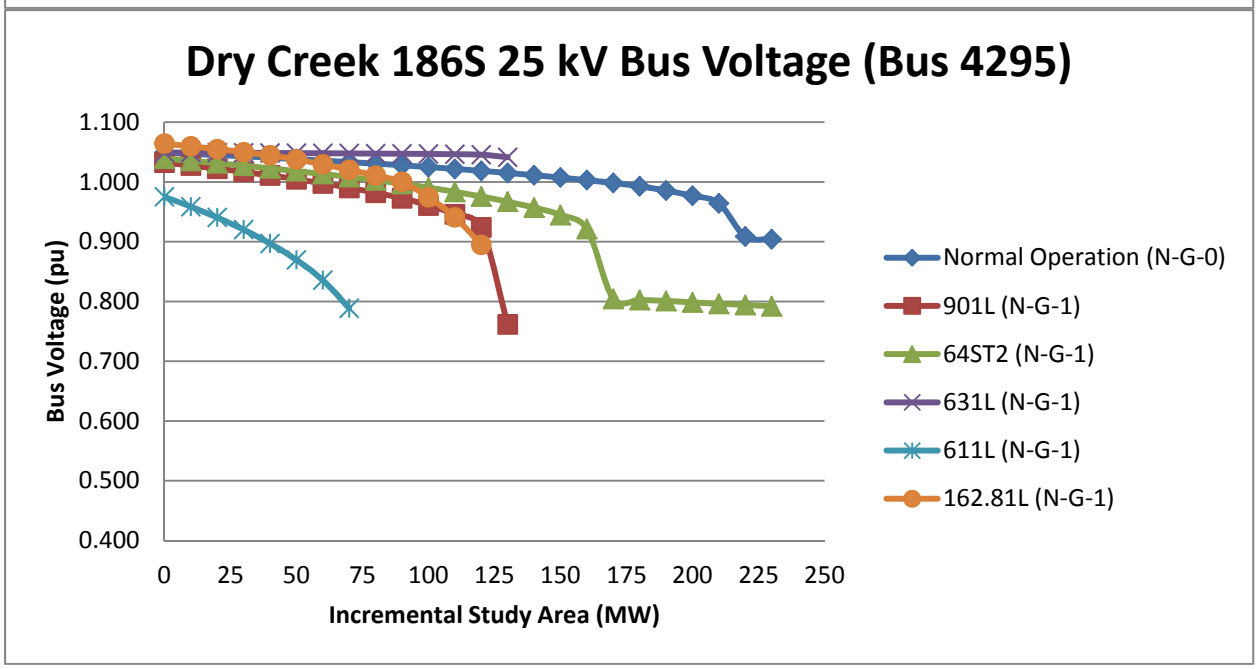
Post-Project Voltage Stability Diagrams (Scenarios 4)

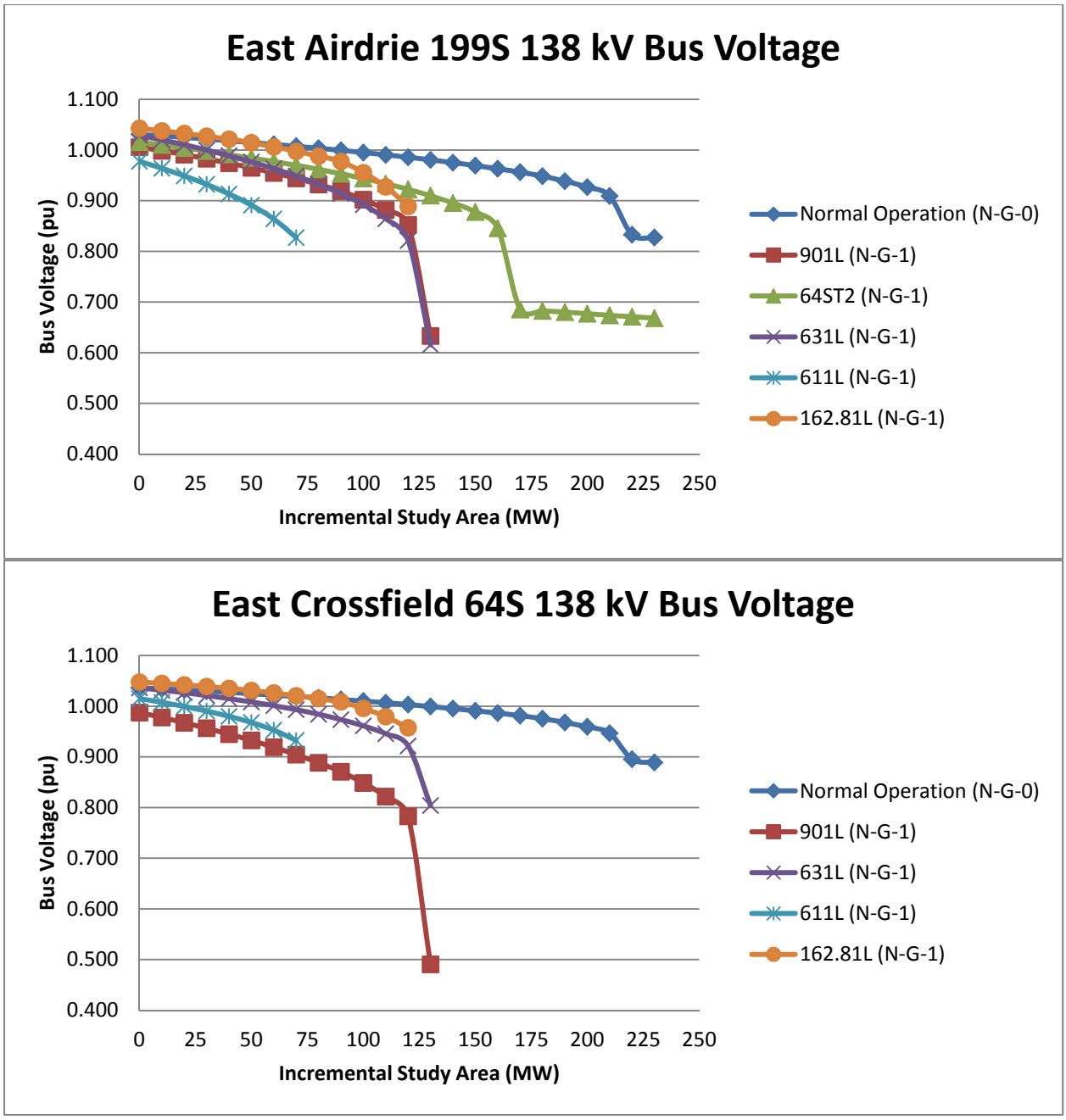
Table C-1: Post-Project Contingency Lists

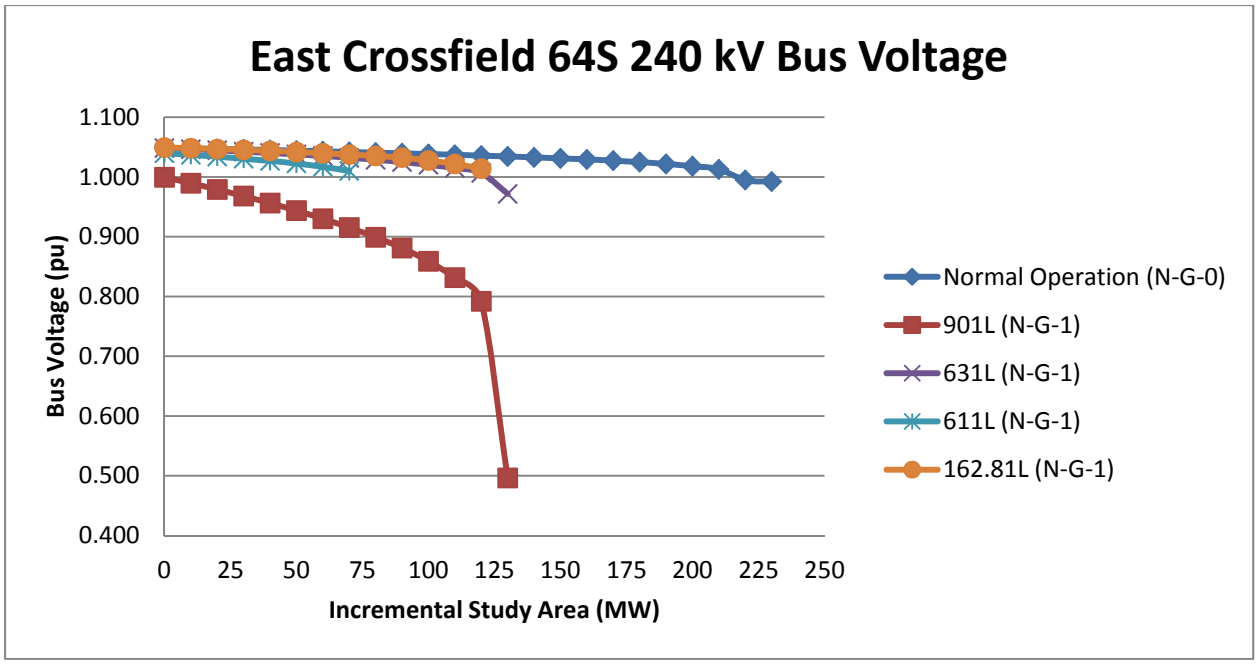
Contingency	From	To	Maximum incremental transfer (MW)	Meets 105% transfer criteria?
N-G-0	System Normal		230	Yes
611L	Balzac 391S	Dry Creek 186S	70	Yes
901L	Red Deer 63S	Janet 74S	130	Yes
64ST2	East Crossfield 64S 240/138 kV transformer		230	Yes
631L	Dry Creek 186S	East Airdrie 199S	130	Yes
162.81L	Beddington 62S	Balzac 391S	120	Yes


Dry Creek 186S 138 kV Bus Voltage (Bus 295)
1.100
1.000
0.900
0.800
Normal Operation (N-G-0)
901L (N-G-1)
64ST2 (N-G-1)
Dry Creek 186S 138 kV Bus Voltage (Bus 29500)
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
64ST2 (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)


Dry Creek 186S 25 kV Bus Voltage (Bus 3295)
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
64ST2 (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)


Dry Creek 186S 25 kV Bus Voltage (Bus 4295)
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
64ST2 (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)


East Airdrie 199S 138 kV Bus Voltage
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
64ST2 (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)
East Crossfield 64S 138 kV Bus Voltage
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)


East Crossfield 64S 240 kV Bus Voltage
Bus Voltage (pu)
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0
25
50
75
100
125
150
175
200
225
250
Incremental Study Area (MW)
Normal Operation (N-G-0)
901L (N-G-1)
631L (N-G-1)
611L (N-G-1)
162.81L (N-G-1)