APPENDIX A CONNECTION ASSESSMENT

Fortis Bullshead 523S Upgrade
Project Number: 1681

The attached engineering study report has been prepared by a third party as part of the AESO Connection Process. The AESO has reviewed the report and the conclusions that it contains, and finds it acceptable for the purpose of assessing potential impacts of the Project on the transmission system.

Information regarding the AESO Connection Process can be found at: http://www.aeso.ca/8602.html

Date: June 1, 2016

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While the DFO's plans are considered during the transmission planning process, the AESO, in exercising its duties to plan the transmission system, does not oversee distribution planning or the development of specific DFO planning criteria.

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Engineering Study Report

Fortis Bullshead 523S Upgrade

AESO Project No: P-1681

Revision: 0

Revision Date: May 30, 2016

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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 meet distribution reliability criteria and serve load growth in the Cypress County area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase from 12.36 MW to 15.7 MW for the system access service provided at the existing Bullshead 523S substation, and a request for transmission development (collectively, the Project). The DFO also requested upgrades to the existing Bullshead 523S substation.

The requested 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

Geographically, the Project is located in the AESO planning area of Medicine Hat (Area 4), which is part of the AESO South Planning Region. The Medicine Hat area (Area 4) is located in the southeast corner of Alberta and is bounded to the north and west by the AESO planning areas of Empress (Area 48), Brooks (Area 47), Vauxhall (Area 52), and Glenwood (Area 55).

From a transmission system perspective, the Medicine Hat planning area mainly consists of 138 kV and 240 kV transmission systems. The Medicine Hat planning area is connected to neighboring planning areas as follows:

- to the Brooks planning area (Area 47) via the 138 kV transmission line 100L and 240 kV transmission lines 1034L and 1035L;
- to the Vauxhall planning area (Area 52) via the 138 kV transmission line 879L, and
- to the Empress planning area (Area 48) via the 138 kV transmission line 658L.

There are a number of existing constraints in the Medicine Hat planning area that are mitigated by remedial action schemes (RASs). Following RAS activation, these constraints are managed in accordance with Section 302.1 of the ISO rules, *Real Time Transmission Constraint Management*.

Study Summary

<u>Study Area for the Project</u>

The Study Area for the Project consisted of the Medicine Hat (Area 4), Vauxhall (Area 52) and Brooks (Area 47) planning areas, including the tie lines connecting the three planning areas to the rest of the AIES. All transmission facilities within the study area were studied and monitored for violations of the Reliability Criteria (as defined in Section 2.1.1 of this document).

Studies Performed for the Project

A power flow analysis was performed for the 2017 summer peak (SP) pre-Project and post-Project scenarios to determine the impact of the Project's connection on the AIES.

A voltage stability analysis was performed for the 2017 SP post-Project scenario.

Results of the Pre-Project Studies

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

Connection Alternatives Examined for the Project

Fortis examined and ruled out the use of distribution-based solutions to serve the additional load per the Bullshead 523S *Need for Development* (NFD)[1]. This engineering study report examines the following transmission alternatives to serve 15.7 MW of DTS at Bullshead 523S:

Alternative 1: Upgrade the existing Bullshead 523S substation by adding a 138/25 kV transformer, a 138 kV breaker, and a new 25 kV bus and associated isolating devices.

Alternative 2: Alternative 2 consists of upgrades at the existing Chappice Lake 649S substation and the existing Suffield 895S substation, coupled with upgrades to the distribution system between Chappice Lake 649S and Bullshead 523S substations, and between Suffield 895S and Bullshead 523S substations. Upgrades at Chappice Lake 649S substation include adding a new 138/25kV transformer and a new 25kV feeder. Upgrades at the Suffield 895S substation include replacement of the existing 138/25 kV transformer with a new 138/25 kV transformer of higher capacity and replacement of the voltage regulator.

Connection Alternatives Selected for Further Examination

Alternative 1 was selected for further study. Alternative 2 requires increased transmission development, and hence increased capital costs and was therefore not selected for further study.

Results of the Post-Project Studies

The following is a summary of the results of the post-Project studies.

Category A (N-G-0)

No reliability criteria violations were observed for 2017 SP Medicine Hat import scenario or the 2017 SP Medicine Hat export scenario after the Project.

Category B (N-G-1)

No reliability criteria violations were observed for 2017 SP Medicine Hat import scenario or the 2017 SP Medicine Hat export scenario after the Project.

[1] Bullshead 523S Upgrade, *Need for Development*, July 8, 2015.

Conclusions and Recommendation

Based on the study results, Alternative 1 is technically viable and addresses the need identified in the DFO's request for system access service. The connection assessment indicates that the Project will not adversely impact the performance of the AIES. 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.

For Alternative 1, a transformer size of 42 MVA would be recommended based on good electric industry practice and under advisement from the legal owner of transmission facilities regarding its asset management and inventory practices.

Contents

Executive Summary 1
1. Introduction 5
1.1. Project 5
1.1.1. Project Overview 5
1.1.2. Load Component 5
1.1.3. Generation Component 5
1.2. Study Scope 6
1.2.1. Study Objectives 6
1.2.2. Study Area 6
1.2.3. Studies Performed 8
1.3. Report Overview 8
2. Criteria, System Data, and Study Assumptions 10
2.1. Criteria, Standards, and Requirements 10
2.1.1. Transmission Planning Standards and Criteria 10
2.1.2. AESO Rules 11
2.2. Study Scenarios 11
2.3. Load and Generation Assumptions 12
2.3.1. Load Assumptions 12
2.3.2. Generation Assumptions 12
2.3.3. Intertie Flow Assumptions 12
2.3.4. HVDC Power Order 13
2.4. System Projects 13
2.5. Customer Connection Projects 13
2.6. Facility Ratings and Shunt Elements 14
2.7. Voltage Profile Assumptions 16
3. Study Methodology 17
3.1. Connection Studies Carried Out 17
3.2. Power Flow Analysis 17
3.2.1. Contingencies Studied 18
3.3. Voltage Stability (PV) Analysis 18
3.3.1. Contingencies Studied 18
4. Pre-Project System Assessment 18
4.1. Pre-Project Power Flow Analysis 18
4.1.1. Scenario 1- 2017 Summer Peak (Medicine Hat Import from AIES), 19
4.1.2. Scenario 2 - 2017 Summer Peak (Medicine Hat Export to AIES), 19
5. Connection Alternatives 20
5.1. Overview 20
5.2. Connection Alternatives Examined 20
5.2.1. Connection Alternatives Selected for Further Study 20
5.2.2. Connection Alternatives Not Selected for Further Study 21
6. Technical Analysis of the Connection Alternative 21
6.1. Results Summary 21
6.2. Power Flow 21
6.2.1. Scenario 3 - 2017 Summer Peak (Medicine Hat Import from AIES) 21

6.2.2. Scenario 4 - 2017 Summer Peak (Medicine Hat Export to AIES) 22
6.3. Voltage Stability 22
6.3.1. Scenario 3 - 2017 Summer Peak (Medicine Hat Import from AIES) 22
6.4. Mitigation Measures 23
6.5. Conclusions 23
7. Project Interdependencies 24
8. Conclusions and Recommendation 25
8.1. Project Overview 25
8.2. Conclusions and Recommendation 25

Attachments

Attachment A	Pre-Project Power Flow Diagrams (Scenarios 1 to 2)
Attachment B	Alternative 1: Power Flow Diagrams (Scenarios 3 to 4)
Attachment C	Alternative 1: Voltage Stability Results (Scenarios 3)

Figures

Figure 1-1: Existing Transmission System Surrounding the Bullshead 523S Substation 7

Tables

Table 1.2-1: Summary of System Projects 8
Table 2.1-1: Post -Contingency Voltage Deviation Guidelines for Low -Voltage Busses 11
Table 2.2-1: List of the Connection Study Scenarios 11
Table 2.3-1: Forecast Area Load (2014 LTO at South Region Peak) 12
Table 2.3-2: Intertie Assumptions 13
Table 2.4-1: Summary of System Projects Included in the Study Cases 13
Table 2.5-1: Summary of Customer Connection Projects included in the Study Cases 14
Table 2.6-1: Summary of Transmission Line Ratings in the Study Area (MVA on Voltage Class Bases) 14
Table 2.6-2: Summary of Transformer Ratings in the Study Area 15
Table 2.6-3: Summary of Shunt Elements in the Study Area 16
Table 2.7-1: Summary of Voltage at Key Nodes in the Study Area 16
Table 3.1-1: Summary of Studies Performed 17
Table 4.1-1: Overview of Pre-Connection Study Results 19
Table 4.1-2: Summary of Pre-Project System Performance – Scenario 1 19
Table 4.1-3: Summary of Pre-Project System Performance – Scenario 2 19
Table 6.1-1: Overview of Post-Connection Study Results 21
Table 6.2-1: Summary of Post-Project System Performance – Scenario 3 21
Table 6.2-2: Summary of Post-Project System Performance – Scenario 4 22
Table 6.3-1: Scenario 3 - 2017 SP MH Import – Voltage Stability Analysis Results (Minimum transfer = 10.0 MW) ... 22

1. Introduction

This engineering study report (ESR) presents the results of the study conducted to analyze the impact of the Project (as defined below) on the Alberta Interconnected Electrical 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 meet distribution reliability criteria and serve load growth in the Cypress County area.

The SASR includes a request for a Rate DTS, *Demand Transmission Service*, contract capacity increase from 12.36 MW to 15.7 MW for the system access service provided at the existing Bullshead 523S substation, and a request for transmission development (collectively, the Project). The DFO also requested upgrades to the existing Bullshead 523S substation.

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

1.1.2. Load Component

- The existing Rate DTS contract capacity for the system access service at the Bullshead 523S substation is 12.36 MW.
- The DFO has requested a Rate DTS contract capacity increase to 15.7 MW, based on a load addition of 3.34 MW.
- The load type is residential, industrial, and commercial services.
- Currently there is no plan for future expansion with Bullshead substation.
- The connection assessment will assume a 0.9 lagging power factor (pf) for the load associated with the Project.

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 this study are as follows:

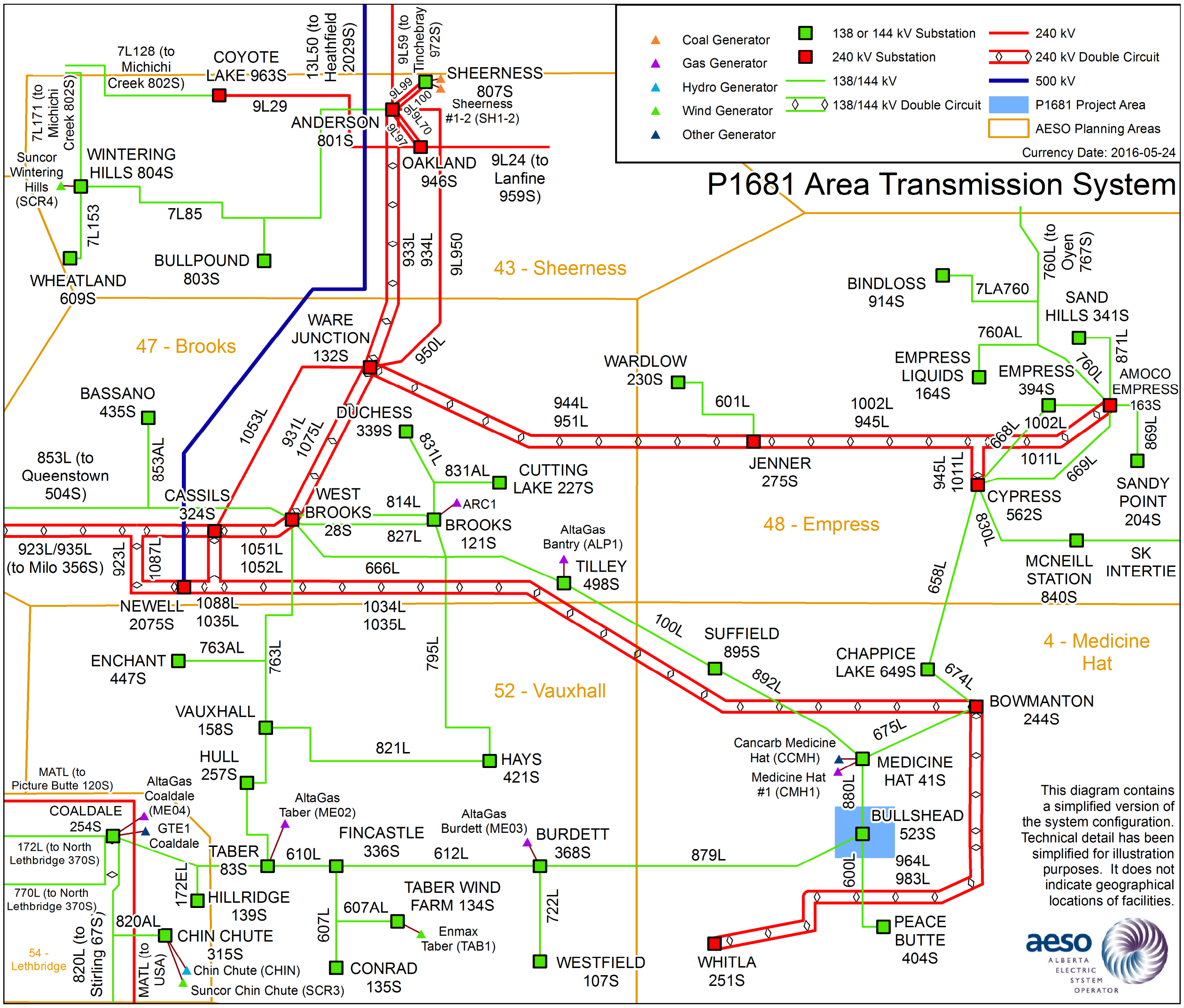
1. Assess the impact of the Project connection on the AIES.
2. Identify any violations of the relevant criteria, standards, or requirements of the AESO, both pre-Project and post-Project connection.
3. Recommend the Project connection alternative and any mitigation measures to address system performance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

1.2.2. Study Area

1.2.2.1. Study Area Description

Geographically, the Project is located in the AESO planning area of Medicine Hat (Area 4), which is part of the AESO South Planning Region. The Study Area for the Project consisted of the Medicine Hat (Area 4), Vauxhall (Area 52) and Brooks (Area 47) planning areas, including the tie lines connecting the three planning areas to the rest of the AIES. The existing transmission system surrounding the Bullshead 523S substation is shown in Figure 1-1.

Figure 1-1: Existing Transmission System Surrounding the Bullshead 523S Substation



1.2.2.2. Existing Constraints

There are a number of existing constraints in the study area that are mitigated by remedial action schemes (RASs). Following RAS activation, these constraints are managed in accordance with the procedures set out in Section 302.1 of the ISO rules, *Real Time Constraint Management* (TCM Rule).

1.2.2.3. AESO Long-Term Transmission Plans

Transmission developments are planned as part of the approved Southern Alberta Transmission Reinforcement (SATR) Project. The in-service dates of SATR developments in and around the study area are shown in Table 1.2-1. Based on the in-service data for the Project, projects 787-6 and 787-12 were included in all the study scenarios.

Table 1.2-1: Summary of System Projects

Project Name	In-Service Date
SATR Medicine Hat Area 138 kV Line Development (Project 787-6)	Q4 2016
SATR 240 kV Line from Journault 260S to Whitla 251S (Project 787-10)	Q1 2020
SATR Reactive Power Addition to Cypress Substation (Project 787-12)	Q2 2017

In addition to the SATR, the *AESO 2015 Long-term Transmission Plan* (2015 LTP)[2] includes the following system development within the study area in the near term (by 2020)[3]:

- Rebuild the 138 kV line from Cypress Substation to Empress Substation at a higher capacity.

1.2.3. Studies Performed

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

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

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

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

1.3. Report Overview

The Executive Summary provides a high-level summary of the study and its conclusions. Section 1 provides an introduction of the Project and describes the study scope. Section 2 describes the criteria, system data, and other study 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 all the connection alternatives examined. Section 6 provides a technical analysis of the post-Project system assessment for the alternative selected for further study. Section 7 presents any dependencies the Project may have on other AESO plans to

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

[3] The 2015 LTP identifies the near-term transmission developments in the south planning region on page 34.

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 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 referred to as "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., a 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 condition" or "N-G-1 condition", 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 for 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 should follow the AESO Information Document ID# 2010-007RS. For the busses not listed in ID#2010-007RS, Table 2-1 in the *Transmission Planning Criteria – Basis and Assumptions* applies.

[4] Filed under separate cover.

- 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 2.1-1.

Table 2.1-1: Post -Contingency Voltage Deviation Guidelines for Low -Voltage Busses

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

2.1.2. AESO Rules

AESO Information document ID# 2010-007RS, *General Operating Practices - Voltage Control*, which relates to Section 304.4 of the ISO rules, *Maintaining Network Voltage*, was applied to establish system normal (i.e., pre- contingency) voltage profiles in the study area. Section 302.1 of the TCM Rule, was followed to set up the study scenarios and identify criteria violations as a result of the connection studies.

2.2. Study Scenarios

Table 2.2-1 summarizes the study scenarios used for the connection studies. Scenarios 1 and 2 are the pre-Project scenarios for 2017 SP. Scenarios 3 and 4 are the post-Project scenarios for 2017 SP.

The Medicine Hat Import condition refers to scenarios where power flows from the AIES to the City of Medicine Hat system. The Medicine Hat export condition refers scenarios where power flows from the City of Medicine Hat system to the AIES.

A power factor of 0.9 lagging was used for the Project load.

Table 2.2-1: List of the Connection Study Scenarios

Scenario	Year/Season Load	Condition	Project Load (MW)	Project Generation (MW)	System Generation Dispatch Conditions
1	2017 SP	Pre Project	12.36	0	Medicine Hat Import from AIES
2	2017 SP	Pre Project	12.36	0	Medicine Hat Export to AIES
3	2017 SP	Post Project	15.70	0	Medicine Hat Import from AIES
4	2017 SP	Post Project	15.70	0	Medicine Hat Export to AIES

2.3. Load and Generation Assumptions

2.3.1. Load Assumptions

The relevant area and region load forecasts used for this connection study are shown in Table 2.3-1 and are from the *AESO 2014 Long-term Outlook* (2014 LTO)[5]. 2016LTO is not expected to materially affect the results of this connection assessment or the conclusions and recommendations contained in this report. 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 Area Load (2014 LTO at South Region Peak)

Area or Region Name	Season	2017 Forecast Peak Load (MW)
Area 4 (Medicine Hat)	SP	200.1
South Region (Planning Areas: 4, 6, 43, 44, 45, 46, 47, 48, 49, 52, 53, 54, 55, and 57)	SP	3207.3
Alberta Internal Load (AIL) w/o Losses	SP	11440.4

2.3.2. Generation Assumptions

This study identified City of Medicine Hat Unit 9 as the critical generator, so it was turned off to represent the N-G study condition in the Medicine Hat area for all analyses. All other generators in the City of Medicine Hat were then dispatched to create the City of Medicine Hat import/export scenarios from/to the AIES as needed. All wind generation is also turned off in the study scenarios.

2.3.3. Intertie Flow Assumptions

The intertie assumptions are shown in Table 2.3-2.

The Alberta-BC, Alberta-Montana, and Alberta-Saskatchewan intertie points are deemed to be too far away to have any material impact on the assessment of the requested connection. Therefore the intertie flows were dispatched to zero.

The Medicine Hat import condition was dispatched to 26 MW of power flowing from the AIES into the Medicine Hat system. The Medicine Hat export condition was dispatched to 102 MW of power flowing into the AIES from the Medicine Hat system.

[5] The 2014 LTO document is available on the AESO website.

Table 2.3-2: Intertie Assumptions

Case No.	Year / Condition	Intertie			
		Import (+) /Export (-) to BC (MW)	Import (+) /Export (-) to Saskatchewan (MW)	Import (+) /Export (-) to MATL (MW)	Medicine Hat Import (+)/Export (-) from/to AIES (MW)
1	2017 SP (Pre Project)	0	0	0	26
2	2017 SP (Pre Project)	0	0	0	-102
3	2017 SP (Post Project)	0	0	0	26
4	2017 SP (Post Project)	0	0	0	-102

2.3.4. HVDC Power Order

The Western Alberta Transmission HVDC Line (WATL) and the Eastern Alberta Transmission HVDC Line (EATL) are expected to have minimal impact for this connection study, but they were dispatched to minimize total system loss in all study scenarios.

2.4. System Projects

Table 2.4-1 lists the system projects in or near the study area that were modeled in the study cases. The 138 kV bus tie breaker and switch in Bowmanton 244S are assumed to be closed in all 2017 SP study cases.

Table 2.4-1: Summary of System Projects Included in the Study Cases

Project	Subproject	Subproject Name	In-Service Date
1326	1	Replacement point of connection from 41S to MHS-7	Q2 2017
787	12	SATR Reactive Power Addition to Cypress Substation	Q2 2017
787	6	SATR Medicine Hat Area 138 kV Line Development	Q4 2016

2.5. Customer Connection Projects

The list of customer projects included in the study is shown in Table 2.5-1.

Table 2.5-1: Summary of Customer Connection Projects included in the Study Cases

Planning Area	Queue Position *	Planned In-Service Date	Project Name	Project #	Gen (MW)	Load (MW)	Included/ Excluded from Studies
4	1	Dec. 2016	Pteragen Peace Butte 116 MW Wind Farm	513	116.0	0.1	Included
4	12	Dec. 2017	NaturEner Wild Rose Wind Farm	479	210.0	6.0	Included
4	14	Dec. 2016	NaturEner Wild Rose Wind Farm phase 2	693	189.0	6.0	Included
47	60	July 2016	Fortis Blue Earth Inc./JBS DG	1550	10.2	0.0	included
4	72	Mar. 2016	CMH3R Generator Recertification	1604	0	0	included

* Per the AESO Connection Queue posted in February 2016.

2.6. Facility Ratings and Shunt Elements

The Transmission Facility Owner (TFO) provided the ratings for the key transmission lines (Table 2.6-1) and the key transformers (Table 2.6-2) in the study area.

Table 2.6-1: Summary of Transmission Line Ratings in the Study Area (MVA on Voltage Class Bases)

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)
			Summer
964L	Bowmanton 244S – Whitla 251S	240	952
983L	Whitla 251S – Elk Water 264S	240	952
1074L	Bowmanton 244S – Elk Water 264S	240	952
1034L	Bowmanton 244S – Cassils 324S	240	931
1035L	Bowmanton 244S – Cassils 324S	240	931
879L	Bowmanton 244S – Burdett 368S	138	85
100L	Suffield 895S – Tilley 498S	138	69
892L	Bowmanton 244S – Suffield 895S	138	67
675L	Bowmanton 244S – Al Rothbauer 321S	138	365
880L	Bullshead 523S – Al Rothbauer 321S	138	123
676L	Bowmanton 244S – Bullshead 523S	138	365

Line ID	Line Description	Voltage Class (kV)	Nominal Rating (MVA)
			Summer
600L	Bullshead 523S – Peace Butte 404S	138	121
612L	Fincastle 336S – Burdett 368S	138	85
610L	Taber 83S – Fincastle 336S	138	85
658L	Chappice Lake 649S – Cypress 562S	138	81
674L	Bowmanton 244S – Chappice Lake 649S	138	121
763L	West Brooks 28S – Vauxhall 158S	138	120
763AL	Enchant 447S – 763L TAP	138	96
821L	Hays 421S – Vauxhall 158S	138	85
795L	Hays 421S – Brooks 121S	138	96
763L	Vauxhall 158S – Hull 257S	138	120

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

Substation Name and Number	Transformer ID	Transformer Voltages (kV)	MVA Rating
Bowmanton 244S	T1	240/138 kV	200
	T2	240/138 kV	200
Medicine Hat 41S	T11	138/69 kV	112
	T1	138/13.8 kV	56
Chappice Lake 649S	T1	138/25 kV	15
Bullshead 523S	T1	138/25 kV	28
	T2	138/25 kV	42
Suffield 895S	T2	138/25 kV	25
	T3	138/25 kV	42
West Brooks 28S	T1	240/138/25 kV	400
	T2	240/138/25 kV	400

The details of shunt elements in the study area are provided in Table 2.6-3.

Table 2.6-3: Summary of 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		Number of Switched Shunt Blocks	Total at Nominal Voltage (MVAr)	Status in Study	
				2017 SP MH Import (MVAr)	2017 SP MH Export (MVAr)			2017SP MH Import (MVAr)	2017SP MH Export (MVAr)
Bullshead 523S	138	1x18.3 MVAr	18.3	0.0	0.0	-	-	-	-
Whitla 251S	240	-	-	-	-	2x75 MVAr	150	75.0	75.0
Medicine Hat 41S	138	2x7.2 MVAr 1x9.0 MVAr	23.4	23.4	0.0	-	-	-	-
Burdett 368S	138	1x24.46 MVAr 1x24.50 MVAr	48.9	24.46	24.46	-	-	-	-
West Brook 28S	240	-	-	-	-	1x50 MVAr	50	50.0	50.0
McNeil 840S	138	2x24.8 MVAr	49.6	0.0	0.0	-	-	-	-
Tilley 498S	138	1x27.17 MVAr	27.17	27.17	27.17	-	-	-	-

2.7. Voltage Profile Assumptions

The AESO ID# 2010-007RS is 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 Reliability Criteria applies for all the busses not included in the ID# 2010-007RS. These voltages were used to set the voltage profile for the study base cases prior to the power flow analysis.

The voltage profile for the key nodes in the study area under normal operation condition is listed in Table 2.7-1.

Table 2.7-1: Summary of Voltage at Key Nodes in the Study Area

Substation	Nominal Voltage (kV)	Minimum Operating Limit (kV)	Desired Range (kV)	Maximum Operating Limit (kV)
West Brooks 28S	240	245	245-260	264
	138	138	138-144	145
Medicine Hat 41S	138	135	138-144	145
Ware Junction 132S	240	250	254-262	264
Bullshead 523S	138	135	138-144	145

3. Study Methodology

3.1. Connection Studies Carried Out

The studies to be carried out for this connection assessment are identified in Table 3.1-1:

Table 3.1-1: Summary of Studies Performed

Scenario and Condition		Project 1681		System Conditions	Power Flow	Voltage Stability
		Load (MW)	Generation (MW)			
1	2017 SP Pre-Project MH import from AIES	12.36	0	Category A and Category B	X	
2	2017 SP Pre-Project MH export to AIES	12.36	0	Category A and Category B	X	
3	2017 SP Post-Project MH import from AIES	15.70	0	Category A and Category B	X	X
4	2017 SP Post-Project MH export to AIES	15.70	0	Category A and Category B	X	

3.2. Power Flow Analysis

The purpose of the power flow analysis is to quantify any incremental violations in the study area after the Project is connected. Pre-Project and Post-Project power flow analysis was completed for all 2017 SP study scenarios to identify thermal overloads or transmission voltage violations as per the Reliability Criteria. Transformer tap and switched shunt reactive compensation devices such as shunt capacitors and reactors were locked and continuous shunt devices were enabled when performing the Category B power flow analysis.

Point-of-Delivery (POD) low-voltage bus deviations were assessed by first locking all tap changers, area capacitors and reactors to identify any post-transient voltage deviations above 10%. Tap changers were then allowed to adjust, while capacitors and reactors remained locked, to determine if any voltage deviations above 7% would occur in the area. Finally, all taps, capacitors and reactors were adjusted, and voltage deviations above 5% were reported, for both the pre-Project and post-Project networks.

3.2.1. Contingencies Studied

The study included all Category B contingencies (69 kV facilities and above) within the study area.

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

3.3. 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 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 post-connection scenarios was performed. For load connection projects, the load level modelled in post-connection scenarios are the same or higher than in pre-connection scenarios. Therefore, voltage stability analysis for pre-connection scenarios would only be performed if the post-connection scenarios show voltage stability criteria violations.

A voltage stability (PV) 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 analysis was performed by increasing load in Medicine Hat (Area 4), and by increasing the corresponding generation in the Wabamun area (Area 40).

3.3.1. Contingencies Studied

A voltage stability analysis was performed for the Category A condition and all Category B contingencies (69 kV facilities and above) in the study area for all post-Project scenarios.

4. Pre-Project System Assessment

4.1. Pre-Project Power Flow Analysis

Table 4.1-1 provides an overview of the pre-connection power flow analysis and applicable mitigation measures.

Table 4.1-1: Overview of Pre-Connection Study Results

Condition	Scenario	Results		Mitigation Measure
		Contingency	Result	
Category A	2017 SP MH import from AIES	Not applicable	No violations	None required
	2017 SP MH export to AIES	Not applicable	No violations	None required
Category B	2017 SP MH import from AIES	All	No violations	None required
	2017 SP MH export to AIES	All	No violations	None required

4.1.1. Scenario 1- 2017 Summer Peak (Medicine Hat Import from AIES),

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 4.1-2 and shown in the power flow diagrams in Attachment A.

Table 4.1-2: Summary of Pre-Project System Performance – Scenario 1

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

4.1.2. Scenario 2 - 2017 Summer Peak (Medicine Hat Export to AIES),

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 4.1-3 and shown in the power flow diagrams in Attachment A.

Table 4.1-3: Summary of Pre-Project System Performance – Scenario 2

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

5. Connection Alternatives

5.1. Overview

FortisAlberta, as the DFO in the Cypress County area, examined and ruled out distribution system upgrades to meet FortisAlberta's distribution reliability criteria and serve load growth in the area.[6]

This report examined two transmission alternatives to meet the DFO's request for system access service.[7]

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 Upgrade the Bullshead 523S substation

Upgrade the existing Bullshead 523S substation by adding a 138/25 kV transformer, a 138 kV breaker, and a new 25 kV bus and associated isolating devices. A transformer size of 42 MVA would be recommended based on good electric industry practice and under advisement from the legal owner of transmission facilities regarding its asset management and inventory practices.

Alternative 2 Upgrade the Chappice Lake 649S substation and the Suffield 895S substation

Alternative 2 consists of upgrades at the existing Chappice Lake 649S substation and the existing Suffield 895S substation, coupled with upgrades to the distribution system between Chappice Lake 649S and Bullshead 523S substation, and between Suffield 895S and Bullshead 523S substations. Upgrades at Chappice Lake 649S substation include adding a new 138/25kV transformer and a new 25kV feeder. Upgrades at the Suffield 895S substation include replacement of the existing 138/25 kV transformer with a new 138/25 kV transformer of higher capacity and replacement of the voltage regulator.

5.2.1. Connection Alternatives Selected for Further Study

Alternative 1 was selected for further study.

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[6] The DFO's analysis is reported in sections 4 and 5 of the FortisAlberta *Need for Development Bullshead 523S Upgrade*, filed under a separate cover.

[7] These alternatives reflect more up to date engineering design than the alternatives identified in the FortisAlberta *Need for Development Bullshead 523S Upgrade*, which is filed under a separate cover.

5.2.2. Connection Alternatives Not Selected for Further Study

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

6. Technical Analysis of the Connection Alternative

6.1. Results Summary

Table 6.1-1 provides an overview of the post-Project analysis. Mitigation measures, where applicable are discussed in section 6.4.

Table 6.1-1: Overview of Post-Connection Study Results

Condition	Scenario	Results			Mitigation Measure
		Contingency	Result	Impact after Project	
Category A	2017 SP MH import from AIES	Not applicable	No violations	No impact	None required
	2017 SP MH export to AIES	Not applicable	No violations	No impact	None required
Category B	2017 SP MH import from AIES	All	No violations	No impact	None required
	2017 SP MH export to AIES	All	No violations	No impact	None required

6.2. Power Flow

6.2.1. Scenario 3 - 2017 Summer Peak (Medicine Hat Import from AIES)

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 6.2-1 and shown in the power flow diagrams in Attachment B.

Table 6.2-1: Summary of Post-Project System Performance – Scenario 3

Contingency	Thermal Overloads	Voltage Performance

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

6.2.2. Scenario 4 - 2017 Summer Peak (Medicine Hat Export to AIES)

No Reliability Criteria violations were observed under Category A conditions.

No Reliability Criteria violations were observed under Category B contingency conditions.

The results of the power flow analysis are summarized in Table 6.2-2 and shown in the power flow diagrams in Attachment B.

Table 6.2-2: Summary of Post-Project System Performance – Scenario 4

Contingency	Thermal Overloads	Voltage Performance
N-G-0: System normal	None	Acceptable
N-G-1: All studied contingencies	None	Acceptable

6.3. Voltage Stability

6.3.1. Scenario 3 - 2017 Summer Peak (Medicine Hat Import from AIES)

A voltage stability analysis was performed for the 2017 SP MH import scenario. The reference load level for the Medicine Hat planning area (Area 4) is 200.1 MW. The minimum incremental load transfer for the Category B contingencies is 5.0% of the reference load or 10.0 MW to meet the voltage stability criteria (0.05 x 200.1 MW = 10.0 MW). Table 6.3-1 summarizes the voltage stability results for Category A and 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 6.3-1: Scenario 3 - 2017 SP MH Import – Voltage Stability Analysis Results (Minimum transfer = 10.0 MW)

Contingency	From	To	Maximum Incremental Transfer (MW)	Meets 105% Transfer Criteria?
N-G	System Normal		120	Yes

Contingency	From	To	Maximum Incremental Transfer (MW)	Meets 105% Transfer Criteria?
675L	Bowmanton 244S	Al Rothbauer 321S	70	Yes
1034L	Bowmanton 244S	Cassils 324S	100	Yes
1035L	Bowmanton 244S	Newell 2075S	100	Yes
676L	Bowmanton 244S	Bullshead 523S	110	Yes
666L	West Brooks 28S	Tilley 498S	110	Yes

6.4. Mitigation Measures

Alternative 1 does not adversely impact the performance of the AIES.

The Project does not reduce the effectiveness of existing RASs in the study area, nor does the Project create the need for new RASs in the study area.

6.5. Conclusions

Based on the study results, Alternative 1 is technically viable. Power flow results indicate that there are no thermal criteria violations or voltage criteria violations prior to and after the Project. The voltage stability results confirm that the voltage stability margin of the study area meets the AESO requirement after the Project.

7. Project Interdependencies

SATR Medicine Hat Area 138 kV Reconfiguration (Project 787-6) was assumed to be in service in this study. If this SATR project is delayed beyond the in-service date of the proposed connection, a re-assessment of the proposed connection will be required. No other interdependencies were identified.

8. Conclusions and Recommendation

8.1. Project Overview

FortisAlberta, in its capacity as the DFO, has submitted a SASR to the AESO to meet distribution reliability criteria and serve load growth in the Cypress County area.

The SASR includes a request for a Rate DTS, contract capacity increase from 12.36 MW to 15.7 MW for the system access service provided at the existing Bullshead 523S substation, and a request for transmission development (collectively, the Project). The DFO also requested upgrades to the existing Bullshead 523S substation.

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

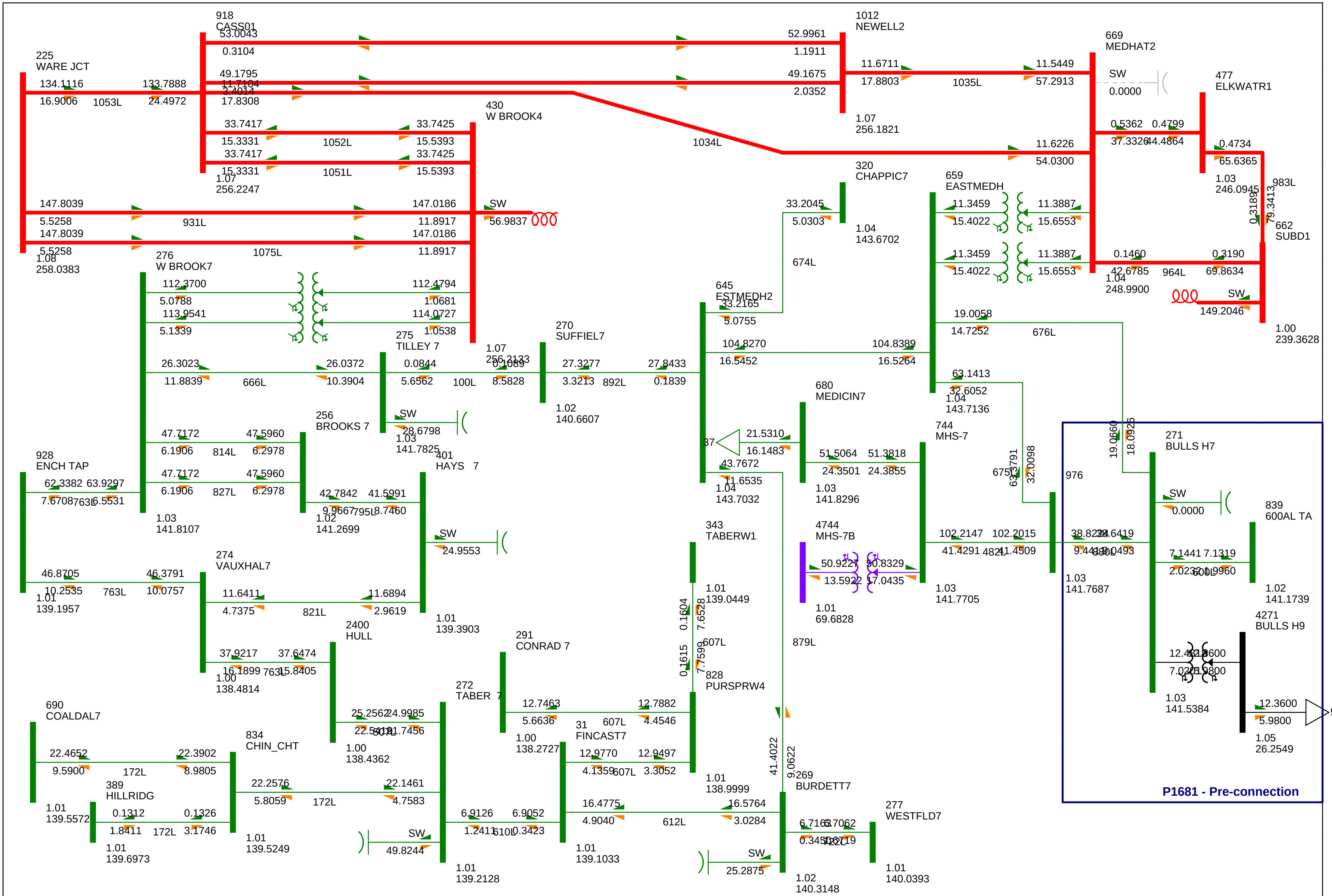
This report detailed the system performance studies undertaken to assess the impact of the Project on the AIES.

8.2. Conclusions and Recommendation

Based on the study results, Alternative 1 is technically viable and will not adversely impact the performance of the AIES. Power flow results indicate that there are no thermal criteria violations or voltage criteria violations prior to and after the Project. The voltage stability results confirm that the voltage stability margin of the study area meets the AESO requirement after the Project. Therefore, it is recommended that the Project be connected using Alternative 1.

Attachment A

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



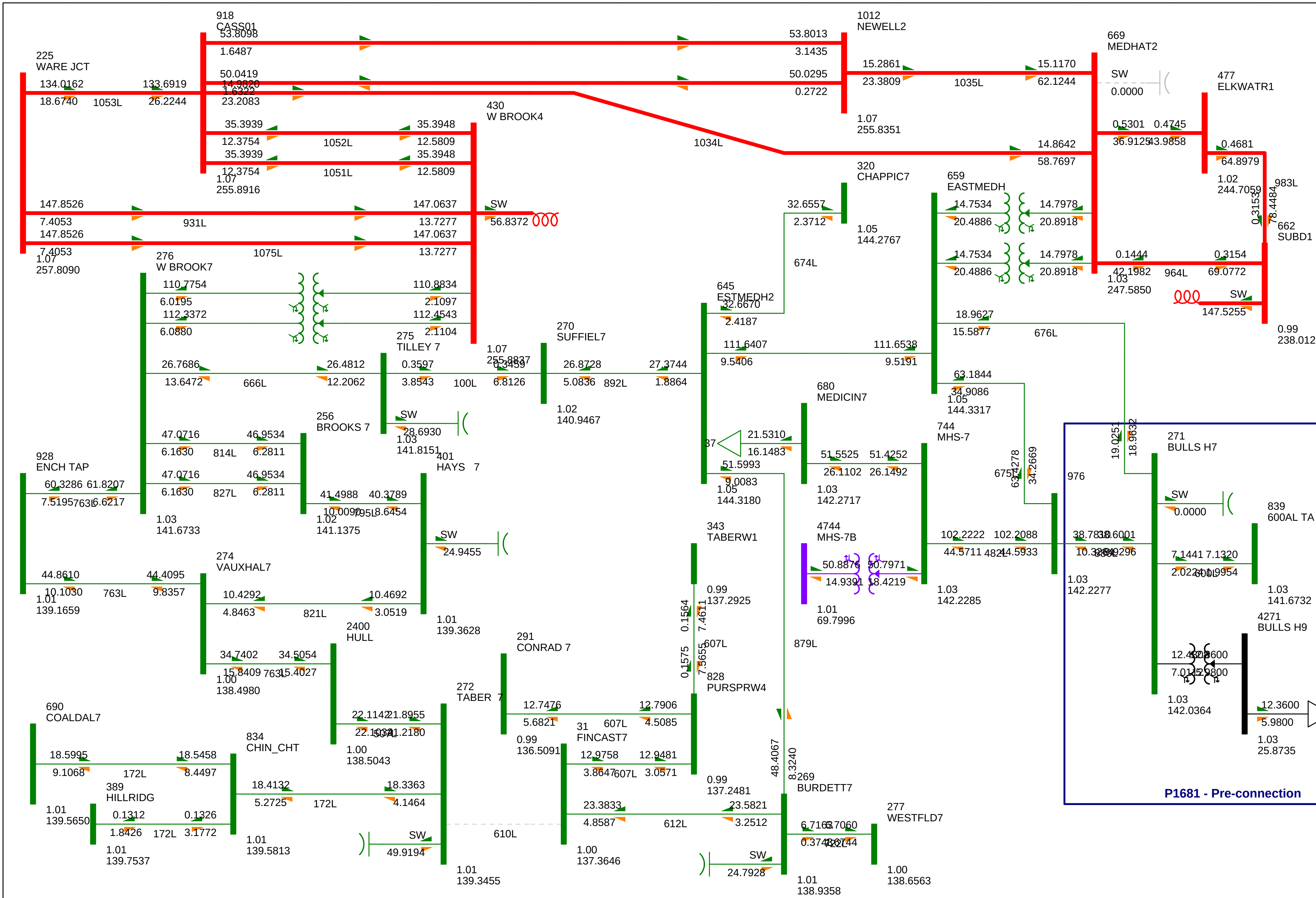
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.5371 MW

MH Tie (Import from AIES): -102.2147 MW

FIGURE A1-1-N-0: NORMAL OPERATION
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

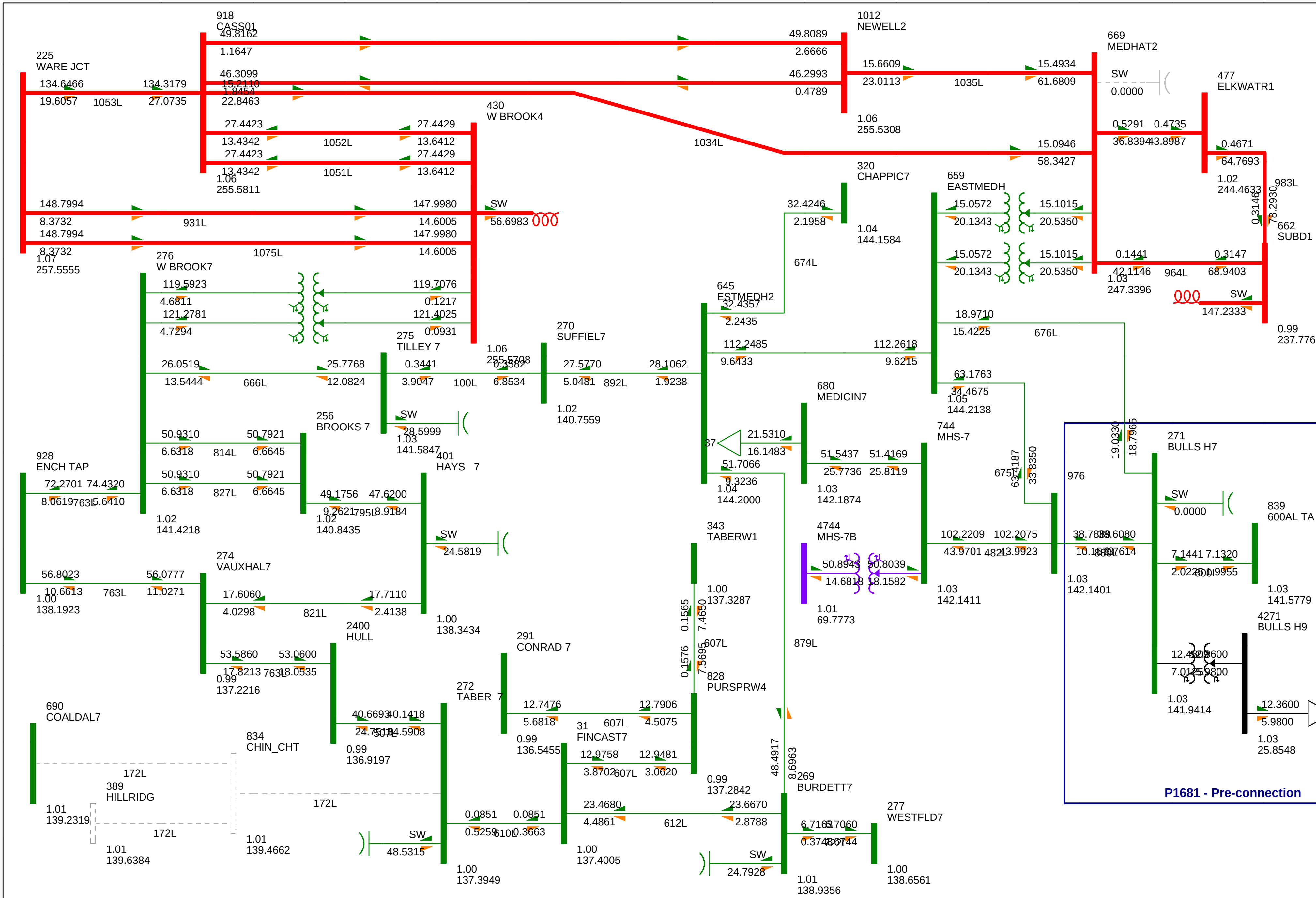


P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.5365 MW

MH Tie (Import from AIES): -102.2222 MW

FIGURE A1-2 N-1: 610L (TABER 83S TO FINCASTLE 336S)
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016



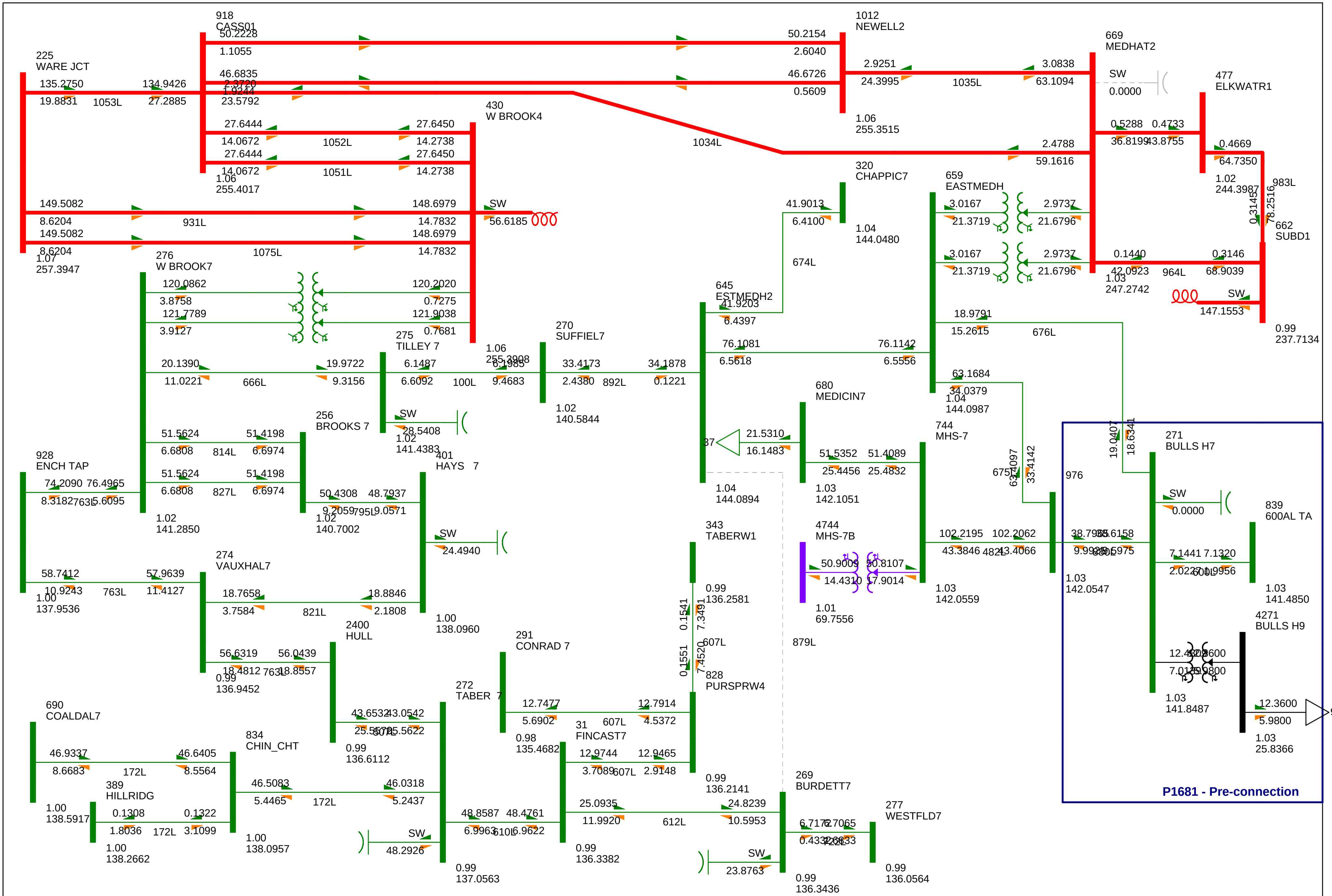
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.6422 MW

MH Tie (Import from AIES): -102.2209 MW

FIGURE A1-3 N-1: 172L (TABER 83S TO COALDALE 254S)
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



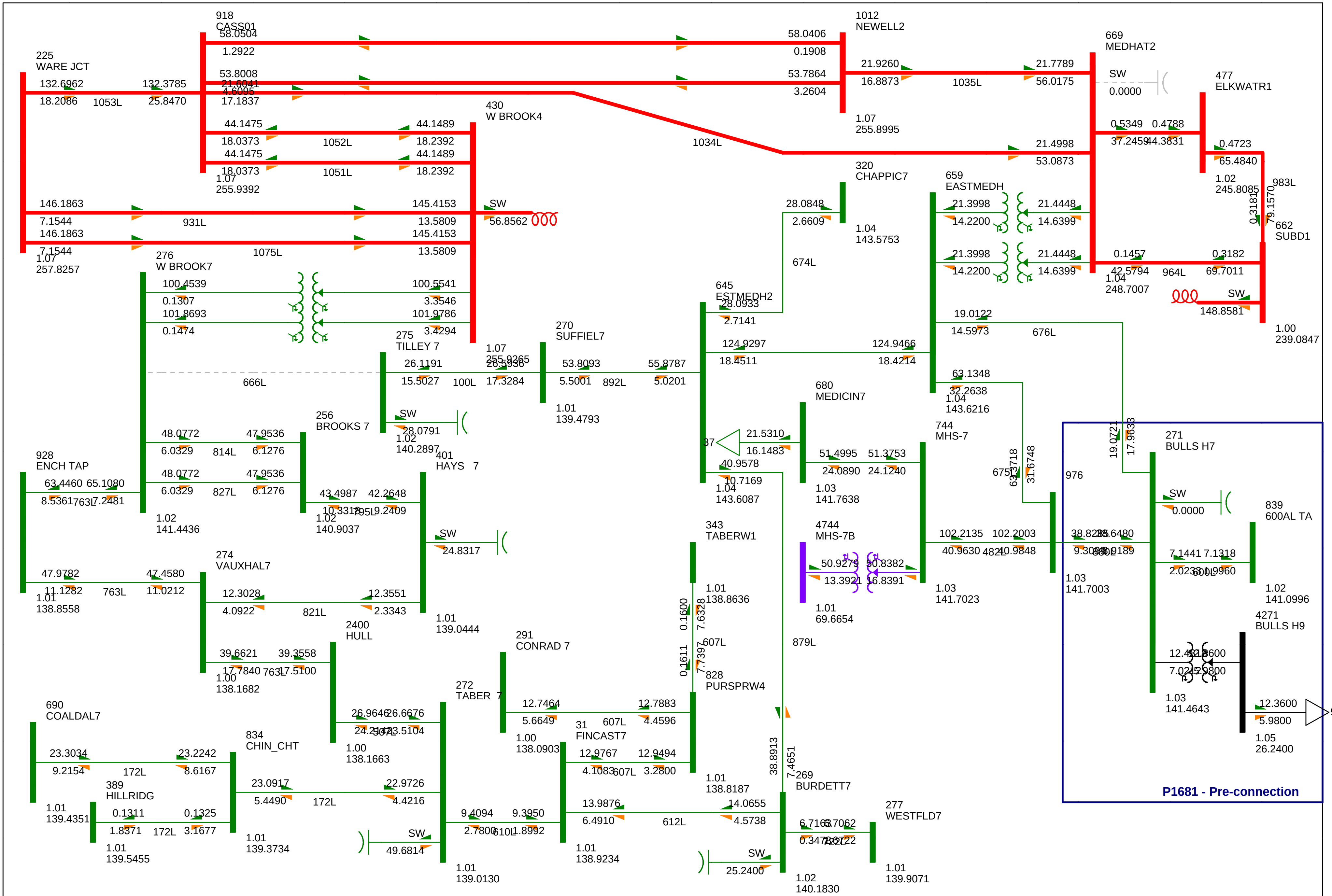
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -3.9279 MW

MH Tie (Import from AIES): -102.2195 MW

FIGURE A1-4 N-1: 879L (BOWMANTON 244S TO BURDETT
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



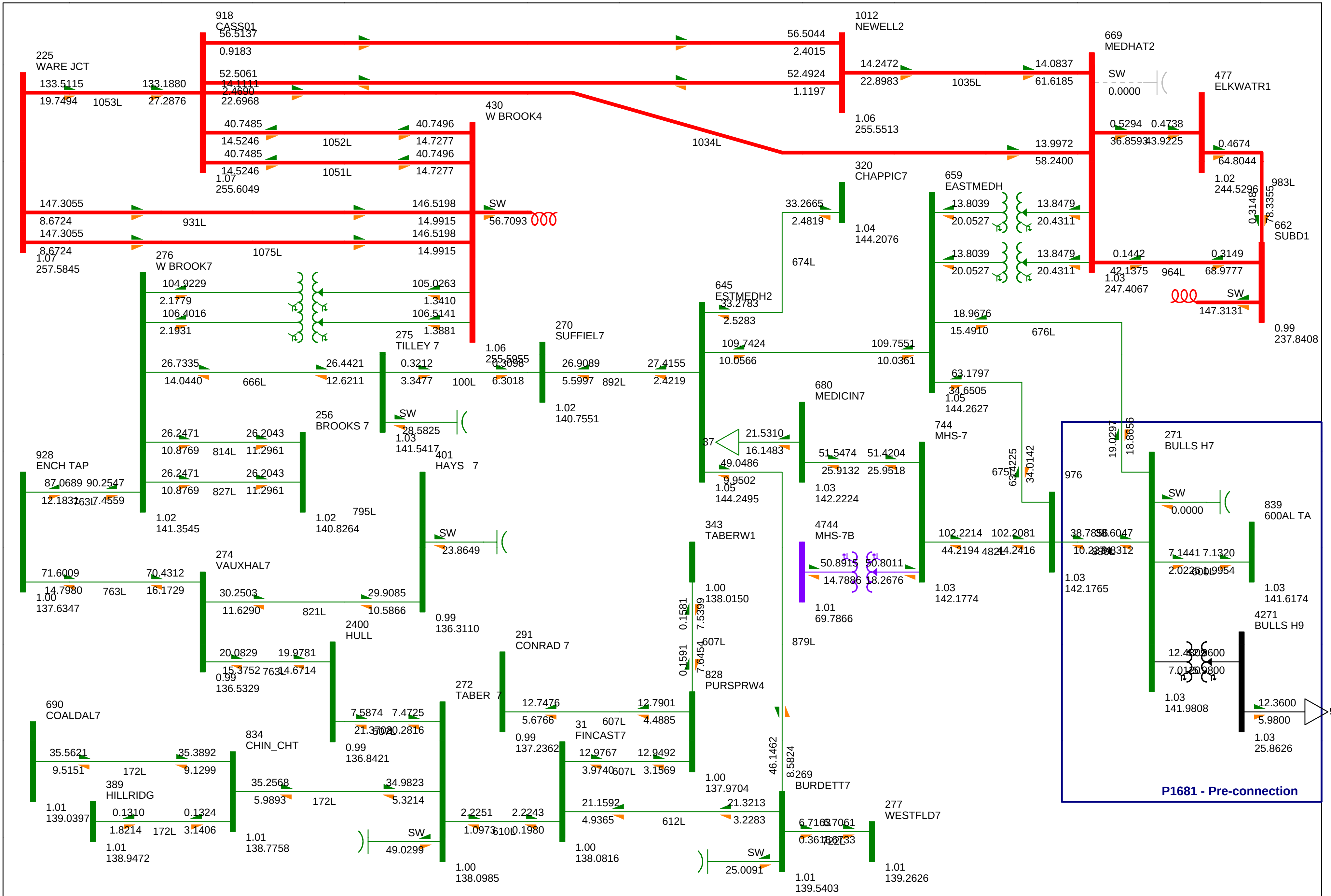
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.3596 MW

MH Tie (Import from AIES): -102.2135 MW

FIGURE A1-5 SINGLE 275-276(66)
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



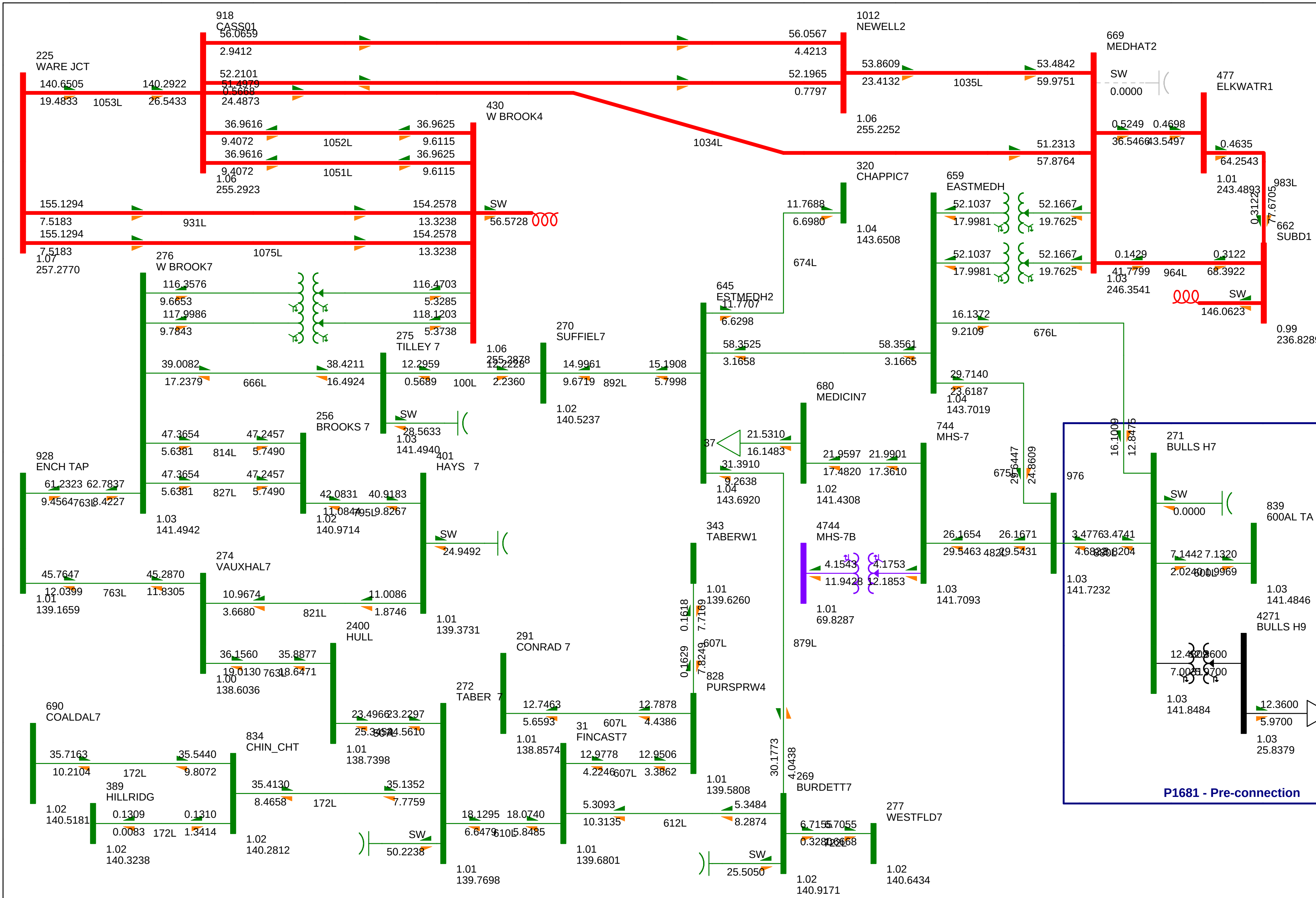
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.1136 MW

MH Tie (Import from AIES): -102.2215 MW

FIGURE A1-6 N-1: 795L (BROOKS 121S TO HAYS 421S)
2017 SUMMER PEAK MH EXPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



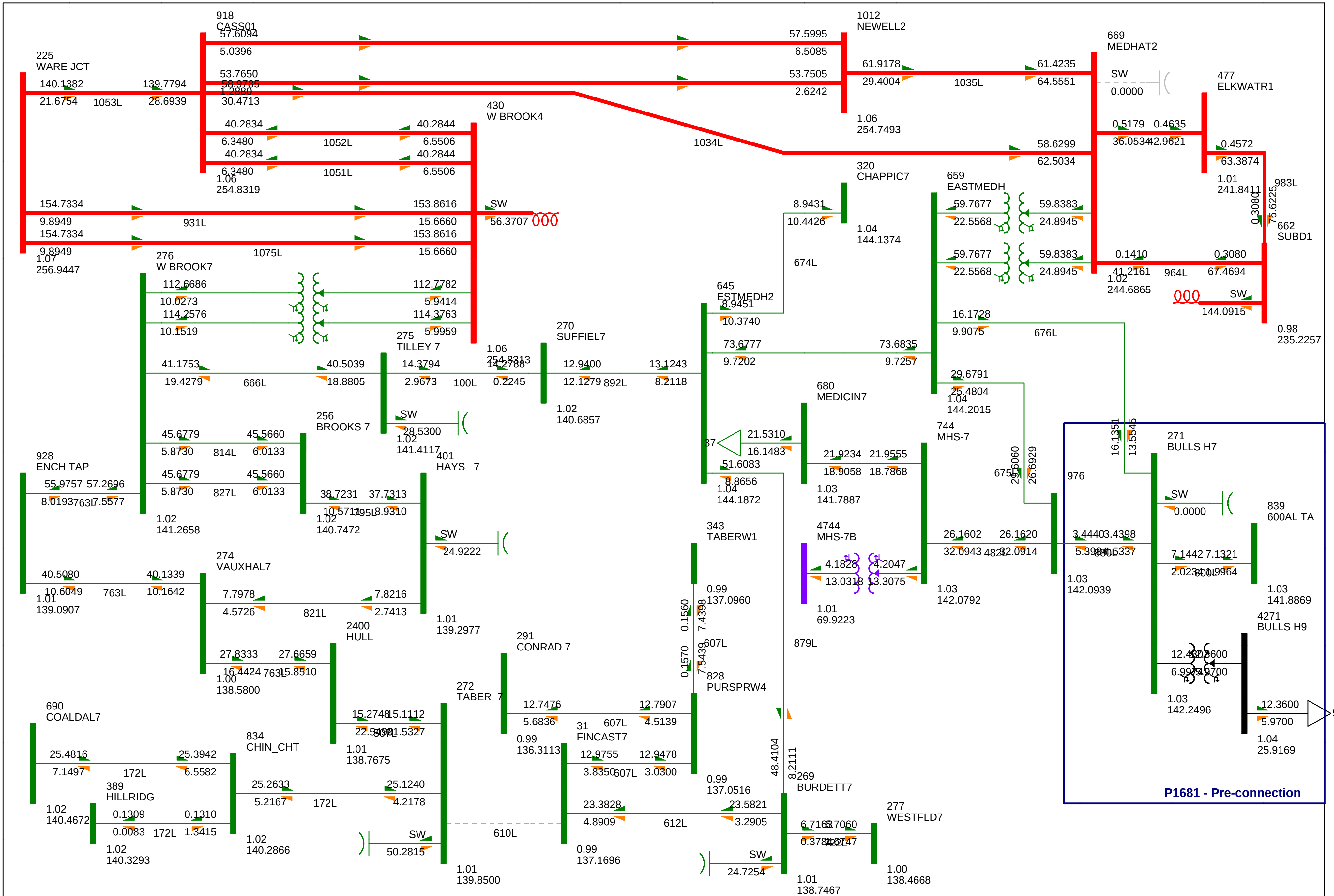
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -4.2552 MW

MH Tie (Import from AIES): 26.1654 MW

FIGURE A2-1-N-0: NORMAL OPERATION
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



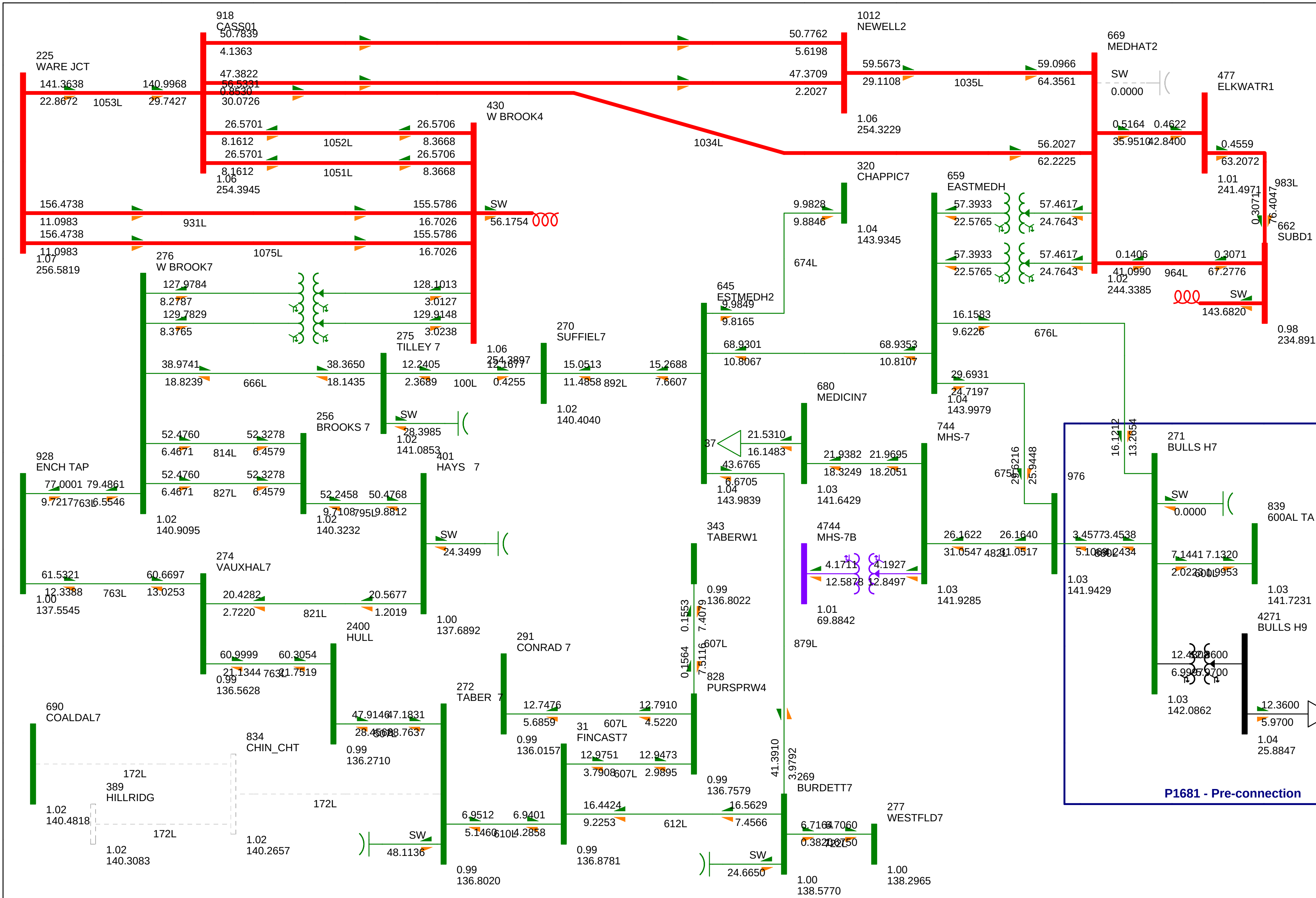
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -4.2594 MW

MH Tie (Import from AIES): 26.1602 MW

FIGURE A2-2 N-1: 610L (TABER 83S TO FINCASTLE 336S)
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



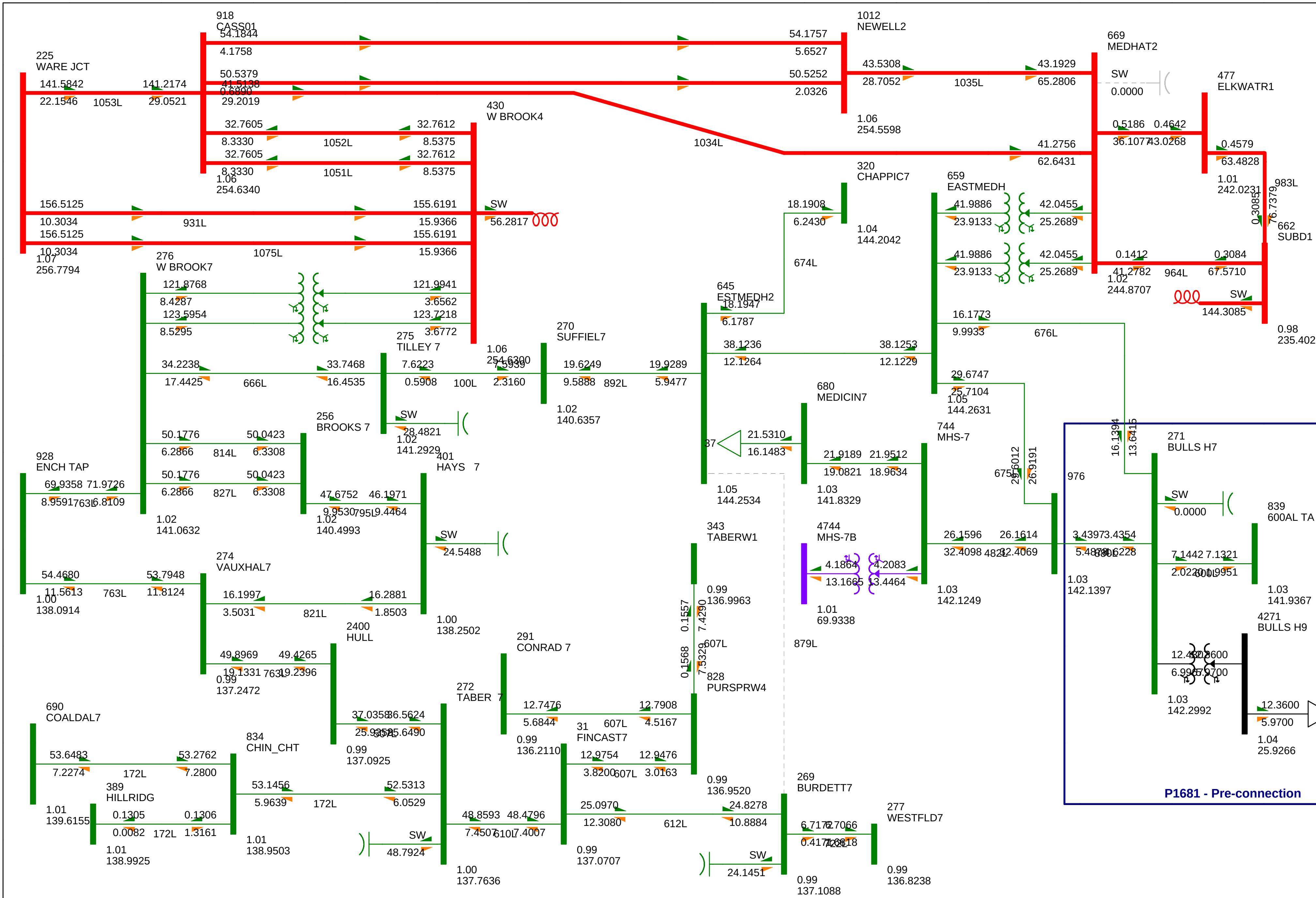
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -4.4103 MW

MH Tie (Import from AIES): 26.1622 MW

FIGURE A2-3 N-1: 172L (TABER 83S TO COALDALE 254S)
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



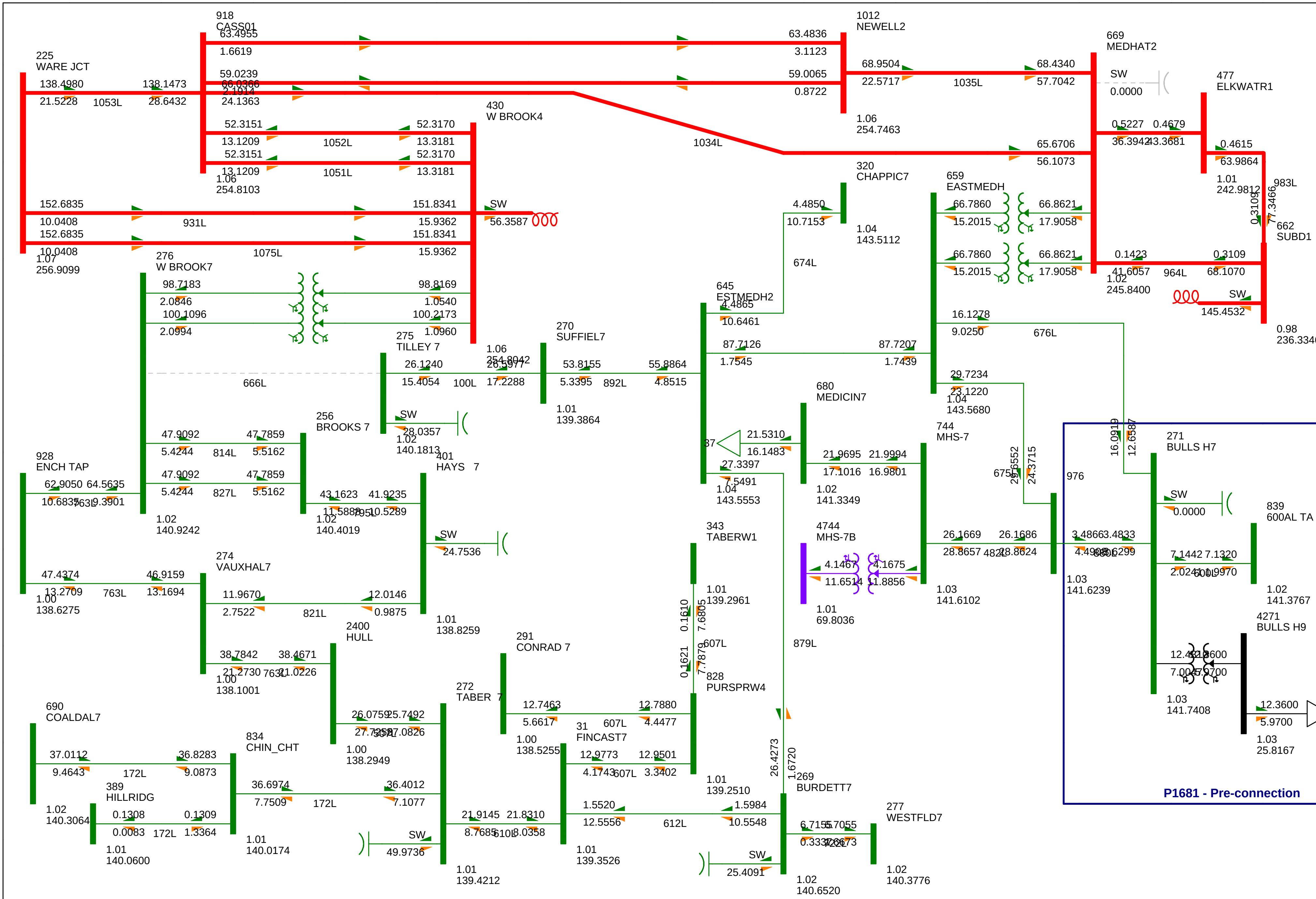
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -3.8072 MW

MH Tie (Import from AIES): 26.1596 MW

FIGURE A2-4 N-1: 879L (BOWMANTON 244S TO BURDETT
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

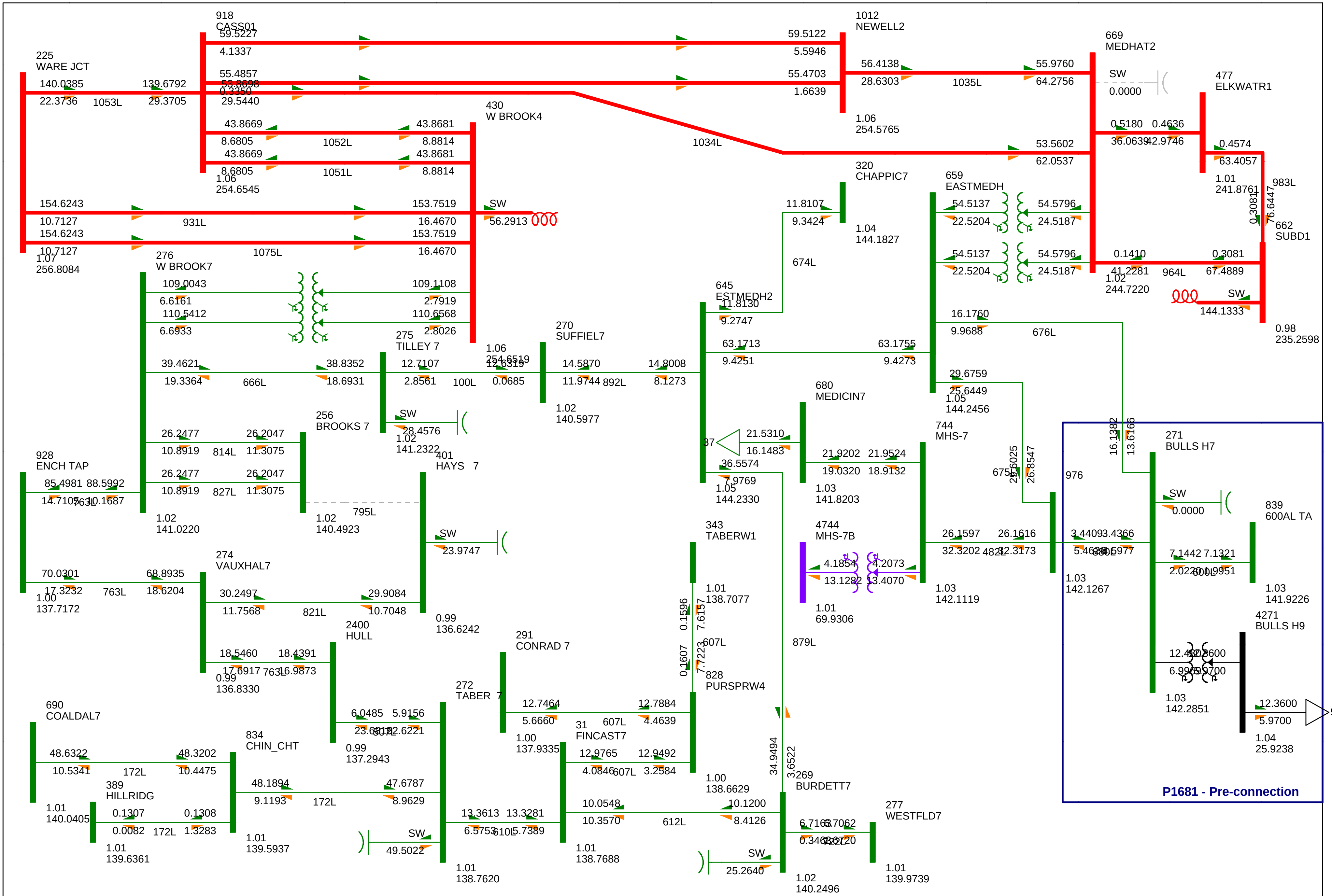


P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -3.9883 MW

MH Tie (Import from AIES): 26.1669 MW

FIGURE A2-5 SINGLE 275-276(66)
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016



P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1123 MW BC and MATL (Import): -3.8279 MW

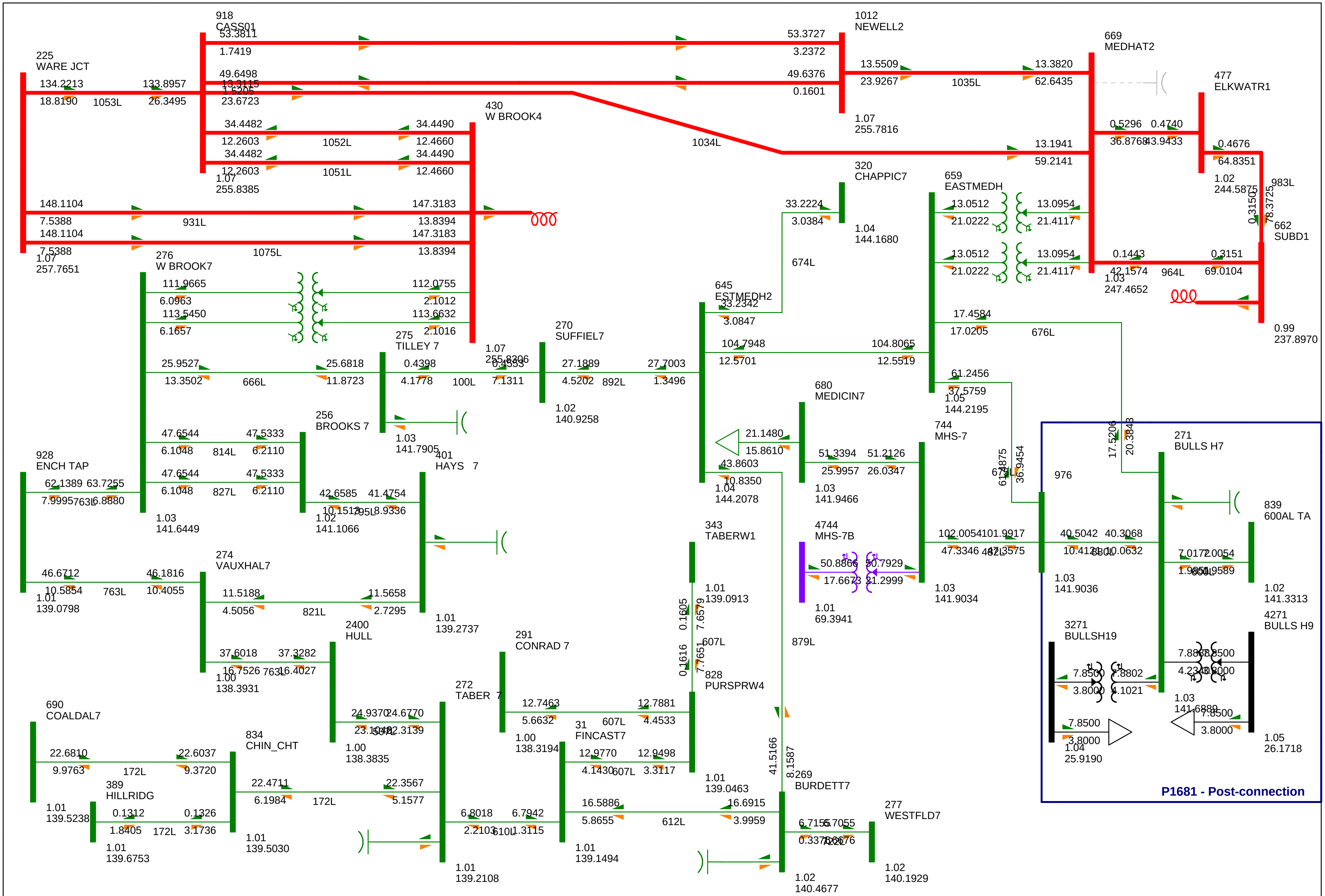
MH Tie (Import from AIES): 26.1597 MW

FIGURE A2-6 N-1: 795L (BROOKS 121S TO HAYS 421S)
2017 SUMMER PEAK MH IMPORT (PRE-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

Attachment B

Alternative 1: Power Flow Diagrams (Scenarios 3 to 4)



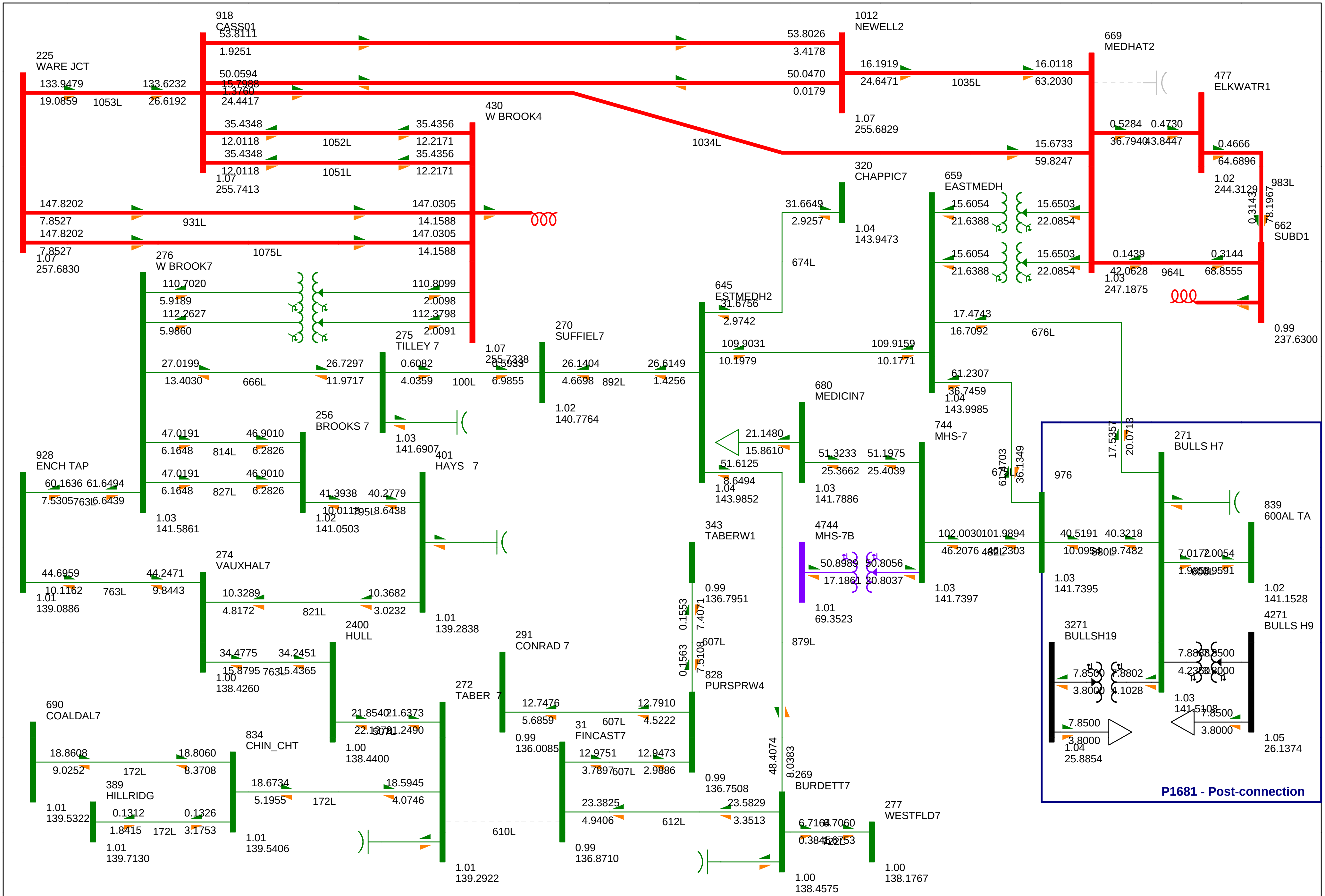
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.8654 MW

MH Tie (Import from AIES): -102.0054 MW

FIGURE B1-1-N-0: NORMAL OPERATION
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



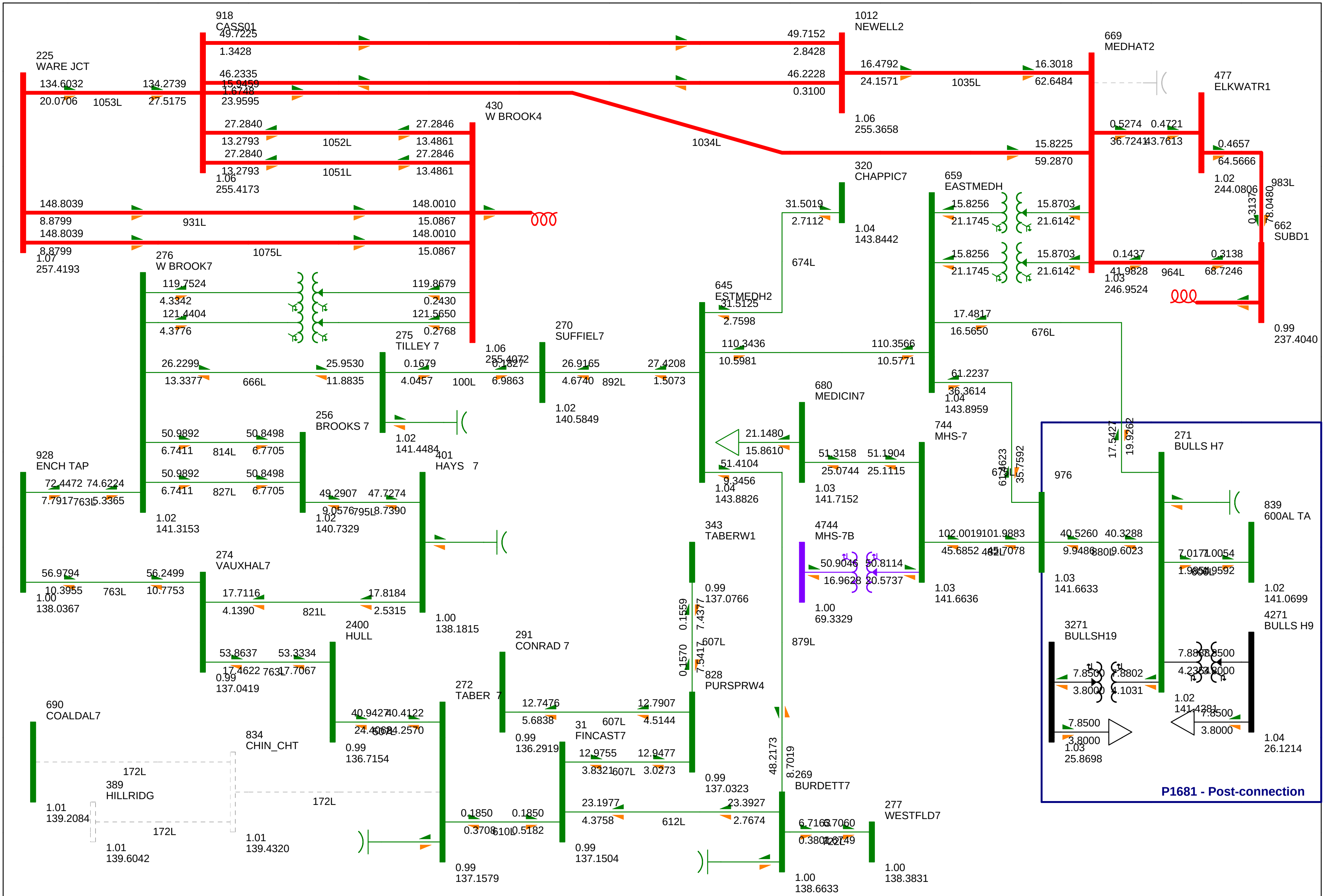
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.8731 MW

MH Tie (Import from AIES): -102.0030 MW

FIGURE B1-2 N-1: 610L (TABER 83S TO FINCASTLE 336S)
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



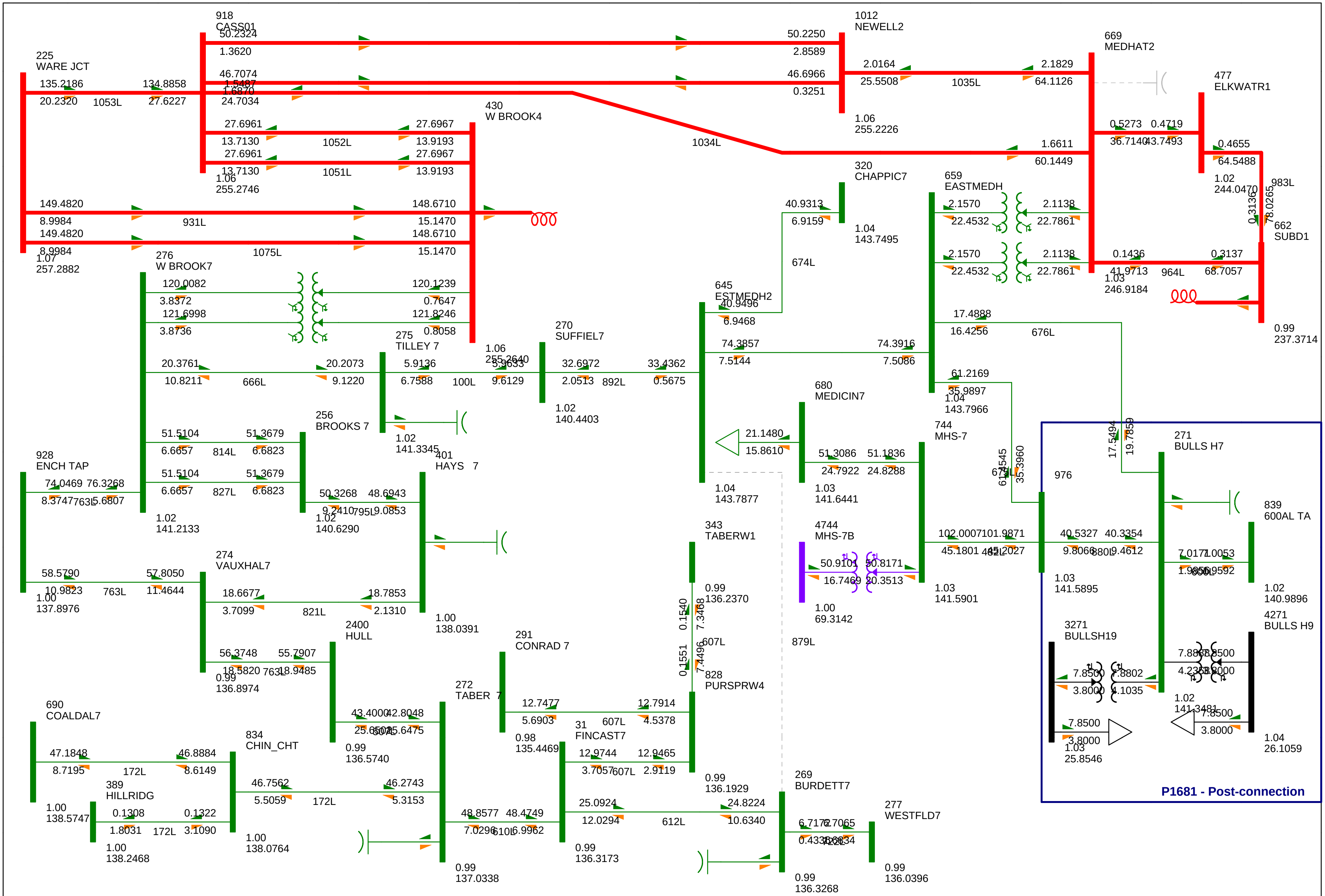
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.9809 MW

MH Tie (Import from AIES): -102.0018 MW

FIGURE B1-3 N-1: 172L (TABER 83S TO COALDALE 254S)
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

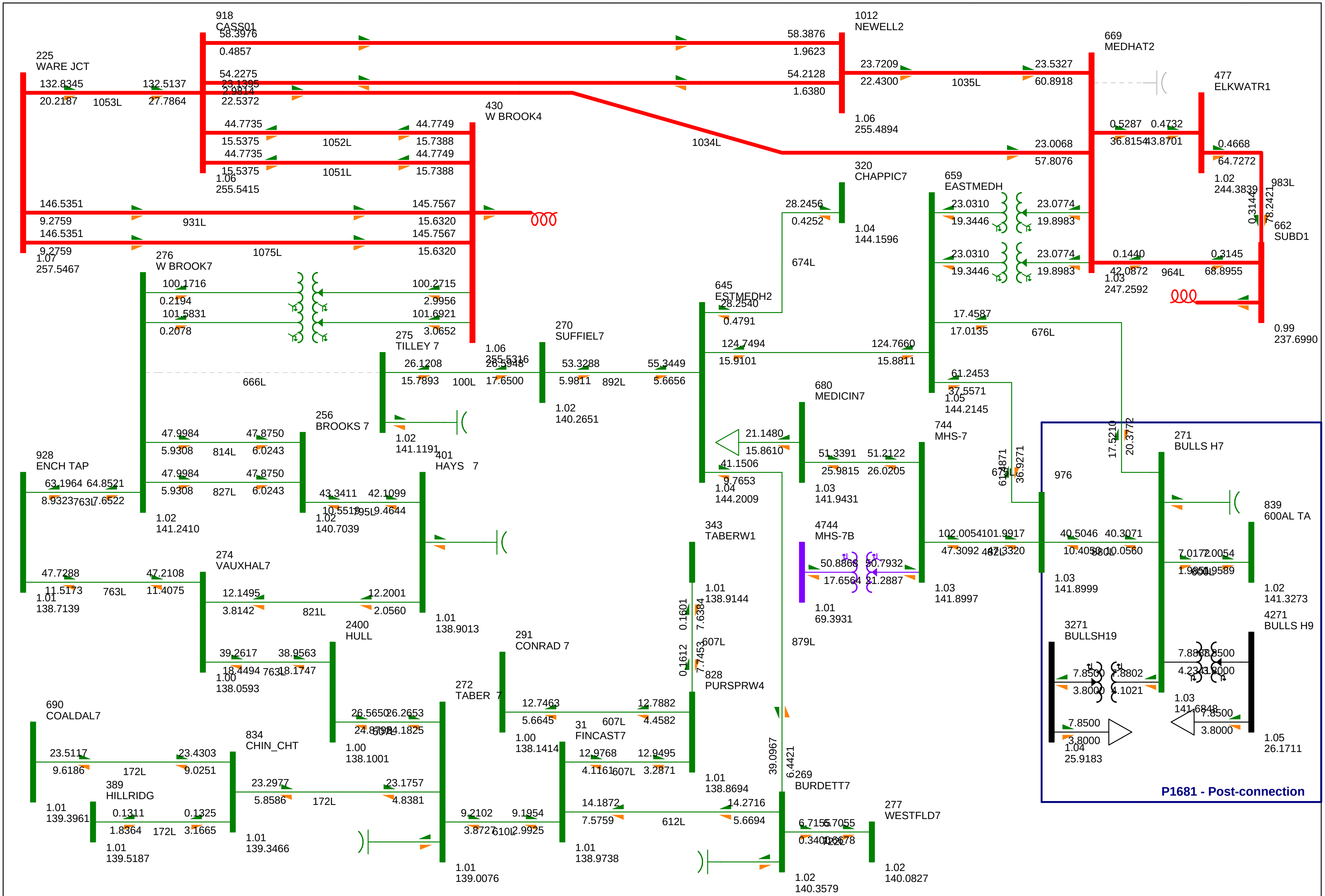


P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.2699 MW

MH Tie (Import from AIES): -102.0007 MW

FIGURE B1-4 N-1: 879L (BOWMANTON 244S TO BURDETT
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016



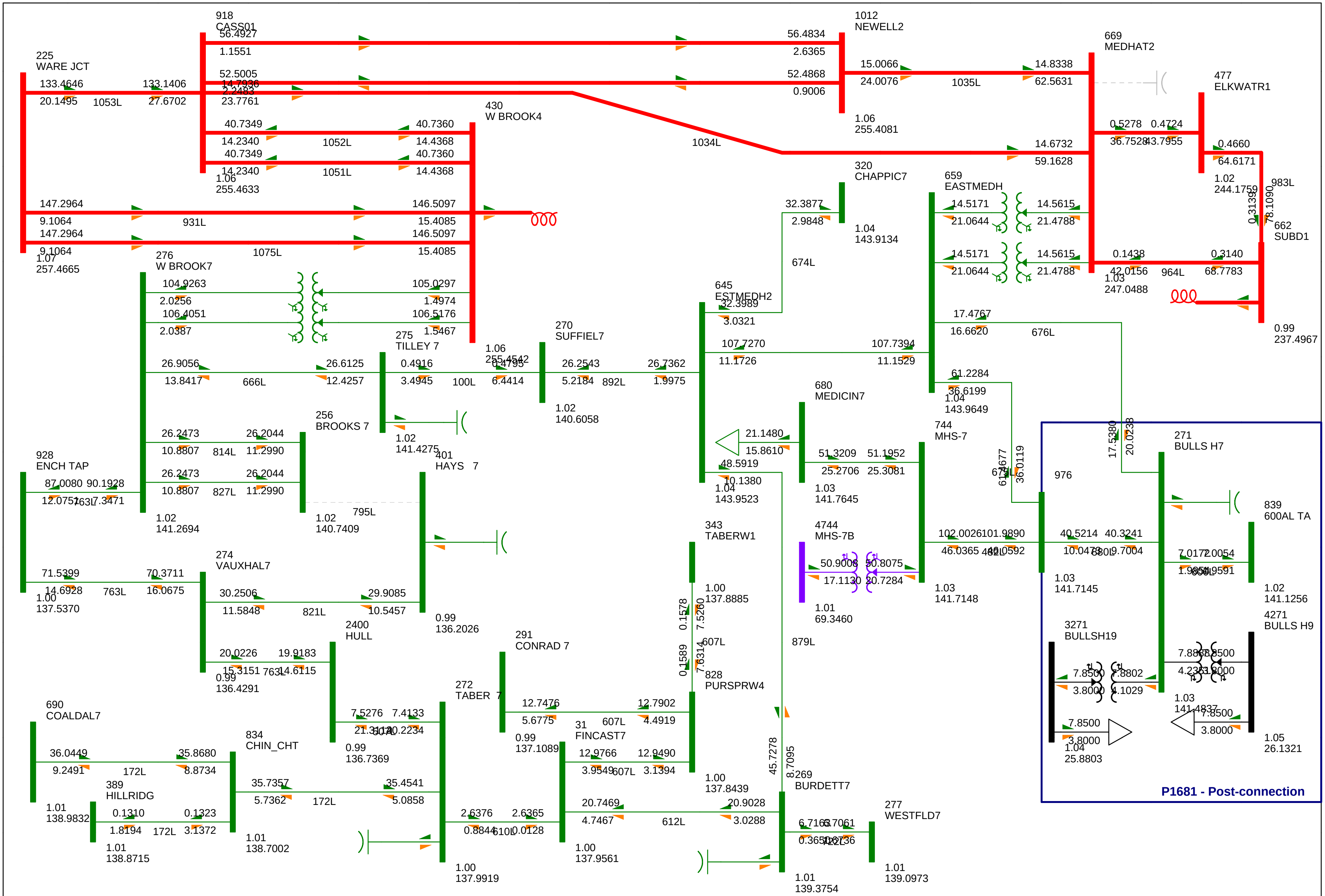
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.6894 MW

MH Tie (Import from AIES): -102.0054 MW

FIGURE B1-5 SINGLE 275-276(66)
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



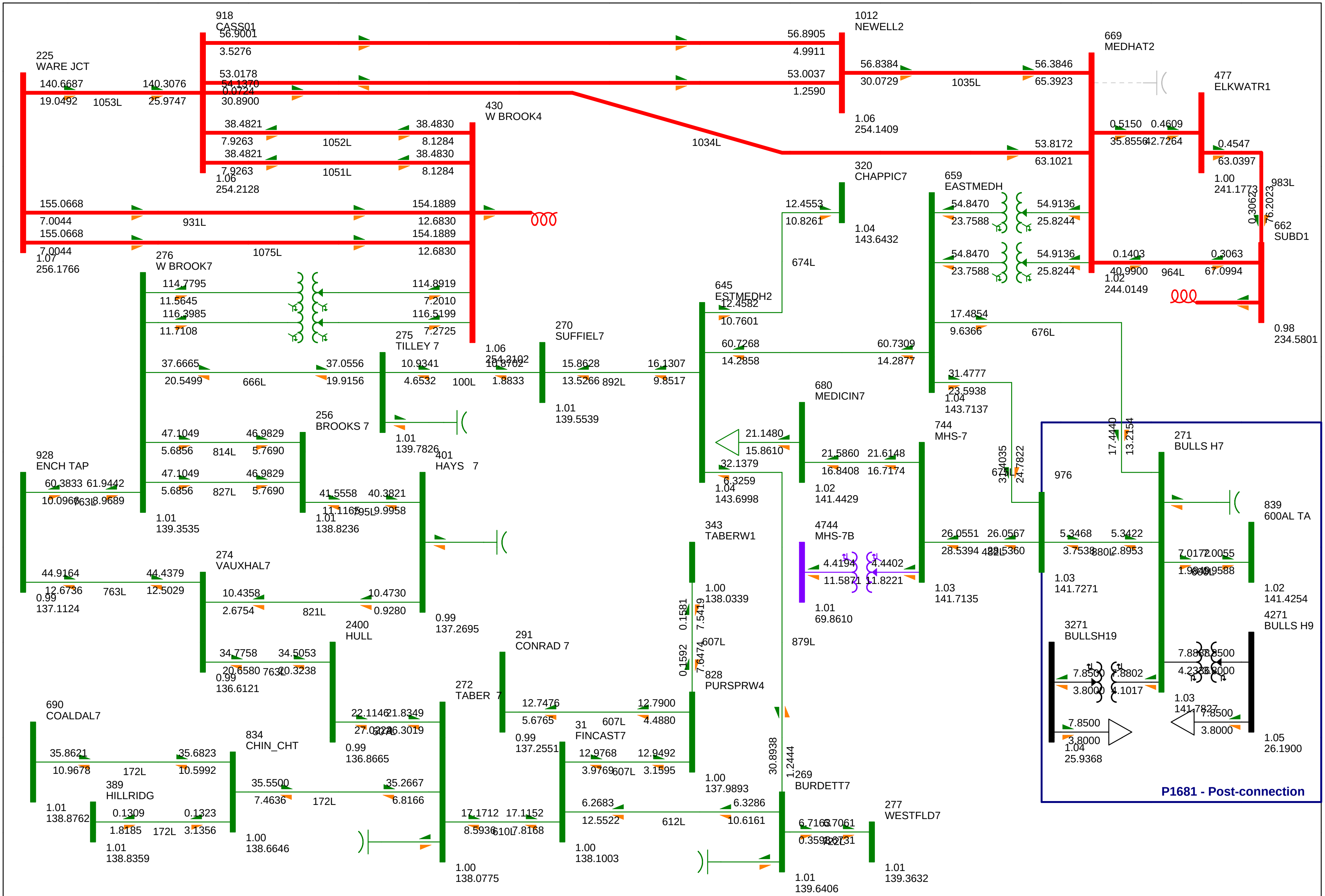
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.4499 MW

MH Tie (Import from AIES): -102.0026 MW

FIGURE B1-6 N-1: 795L (BROOKS 121S TO HAYS 421S)
2017 SUMMER PEAK MH EXPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

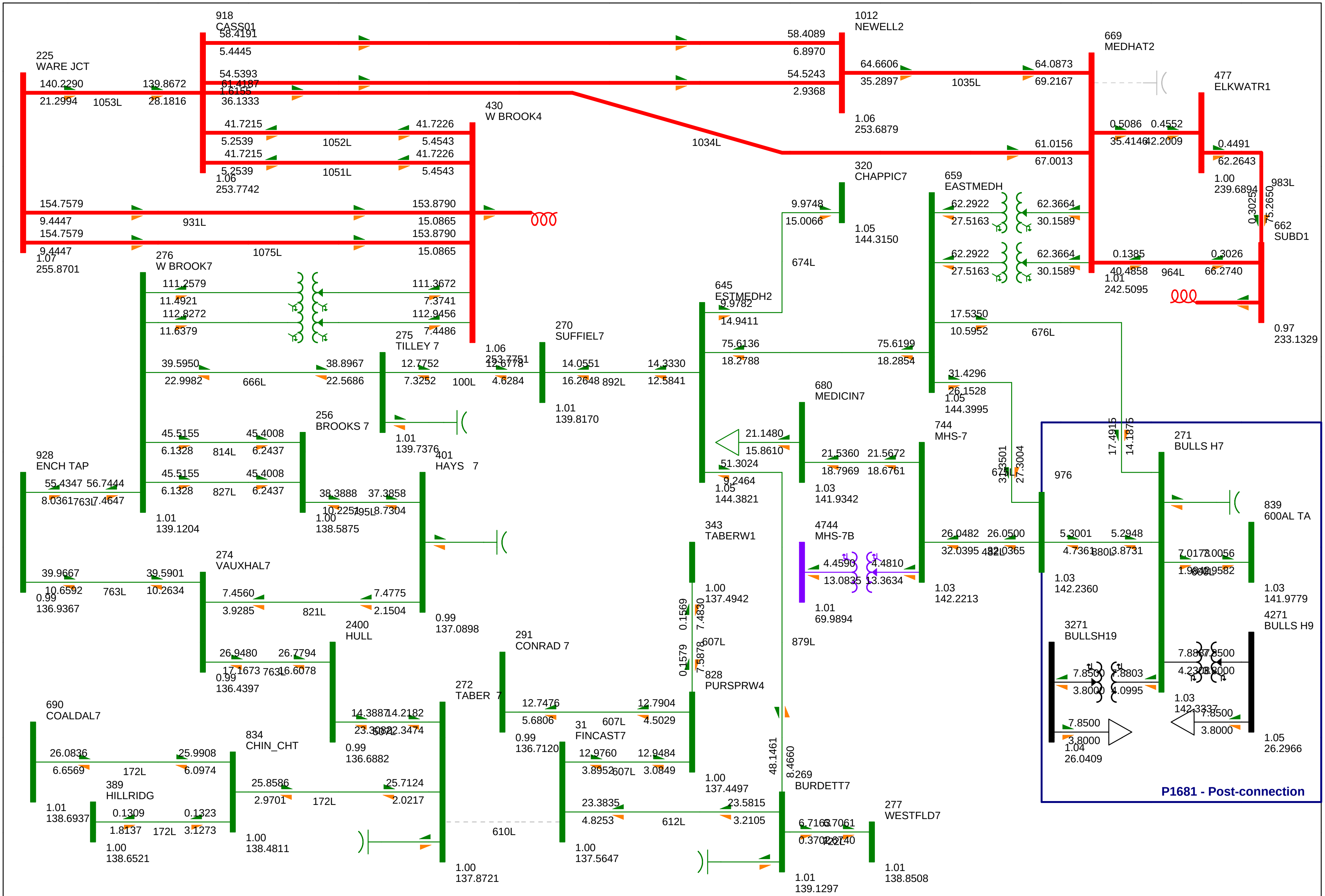


P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.1063 MW

MH Tie (Import from AIES): 26.0551 MW

FIGURE B2-1-N-0: NORMAL OPERATION
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016



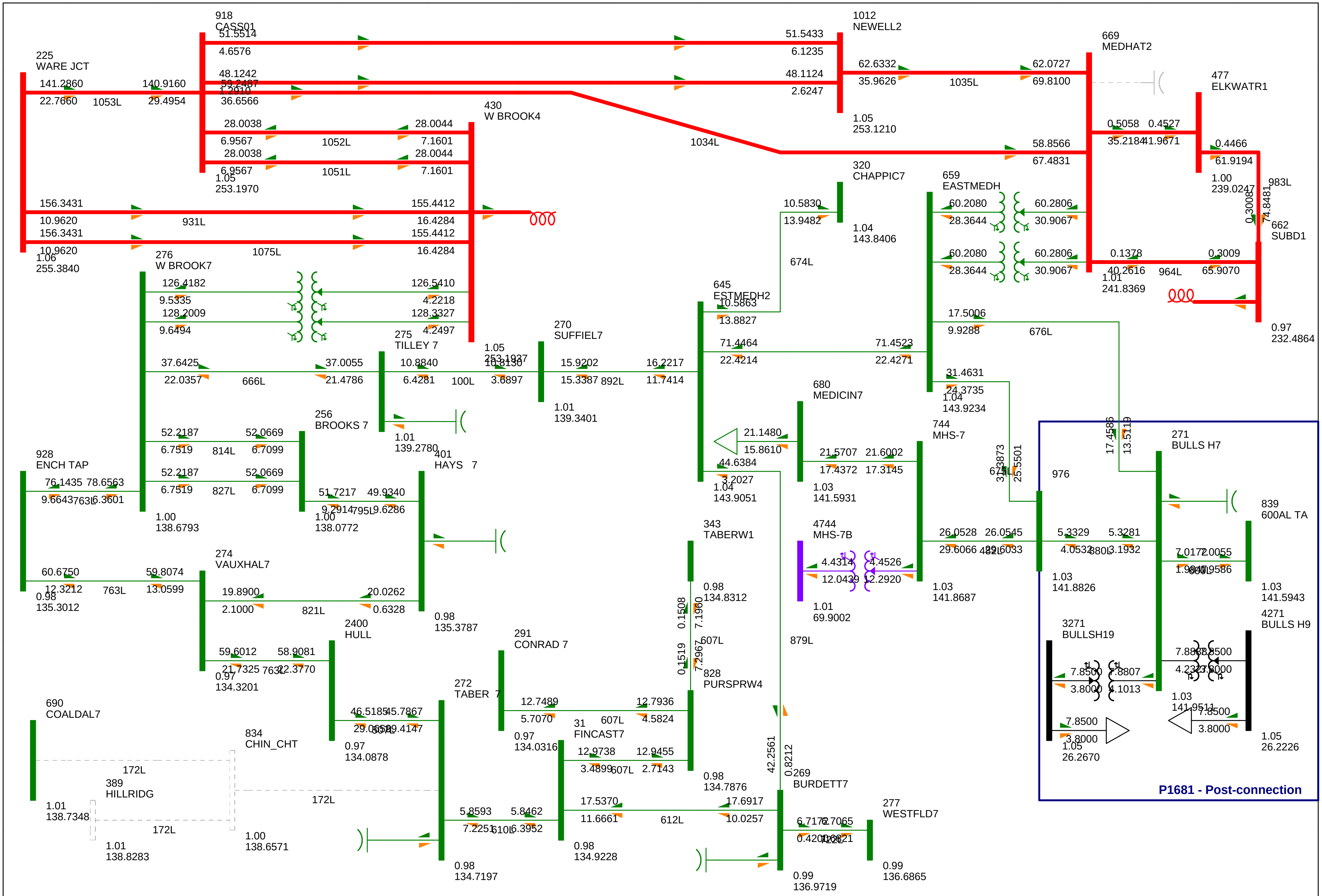
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.1060 MW

MH Tie (Import from AIES): 26.0482 MW

FIGURE B2-2 N-1: 610L (TABER 83S TO FINCASTLE 336S)
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



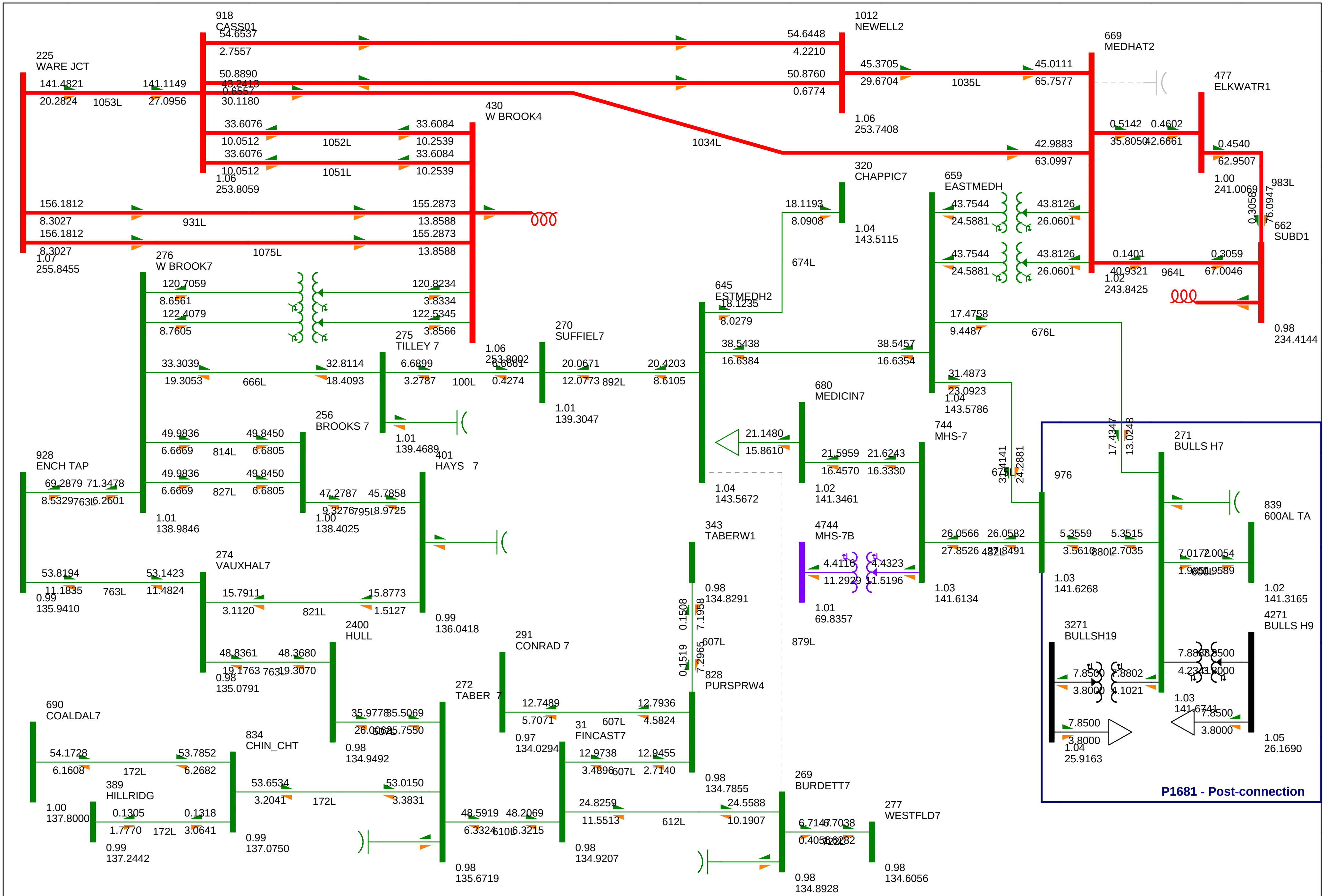
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -4.2468 MW

MH Tie (Import from AIES): 26.0528 MW

FIGURE B2-3 N-1: 172L (TABER 83S TO COALDALE 254S)
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000



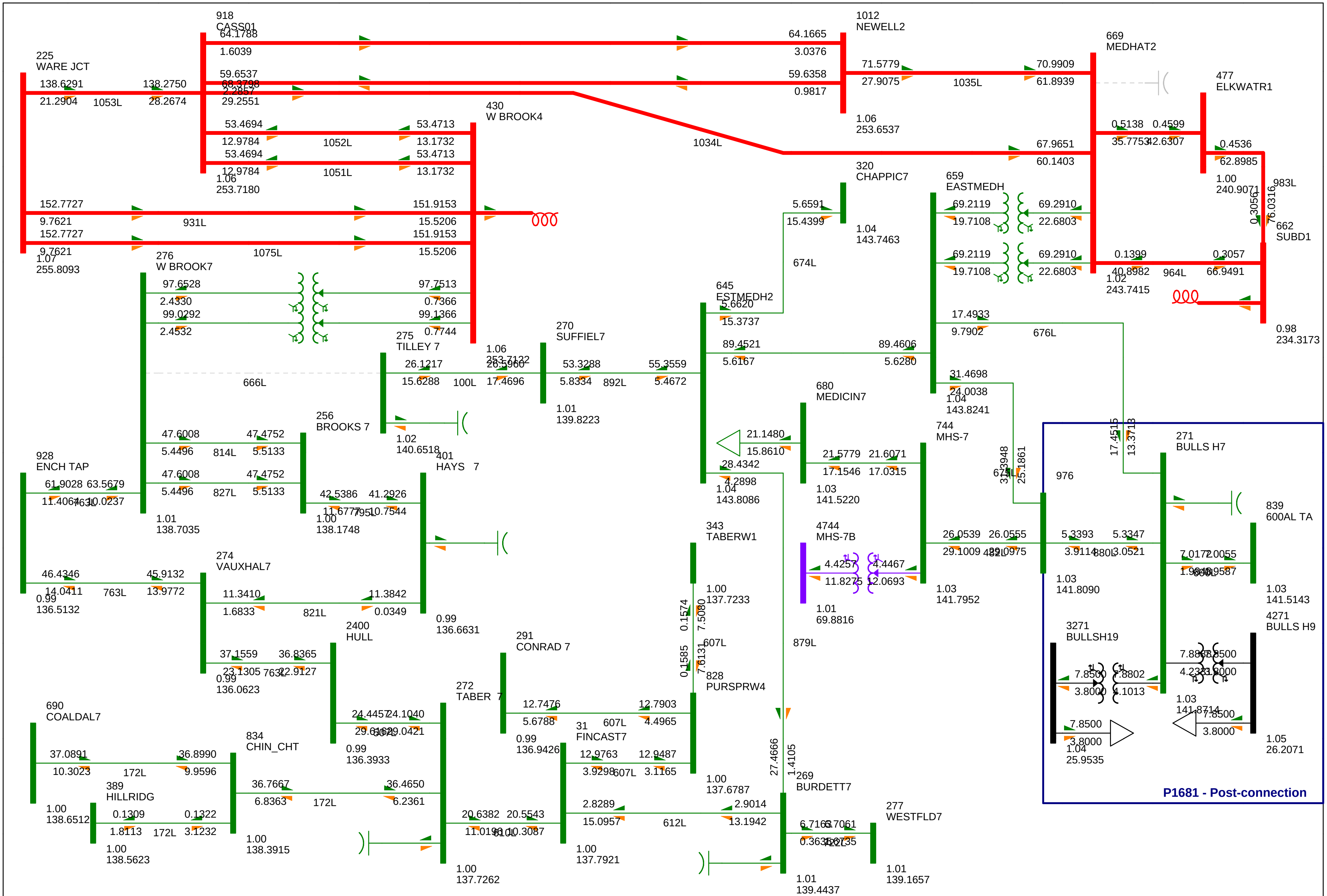
P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -3.6727 MW

MH Tie (Import from AIES): 26.0566 MW

FIGURE B2-4 N-1: 879L (BOWMANTON 244S TO BURDETT
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

Bus - Voltage (kV/pu)
Branch - MW/Mvar
Equipment - MW/Mvar
100.0%Rate A
1.200OV 0.900UV
kV: <=25.000 <=69.000 <=138.000 <=240.000 <=500.000 >500.000

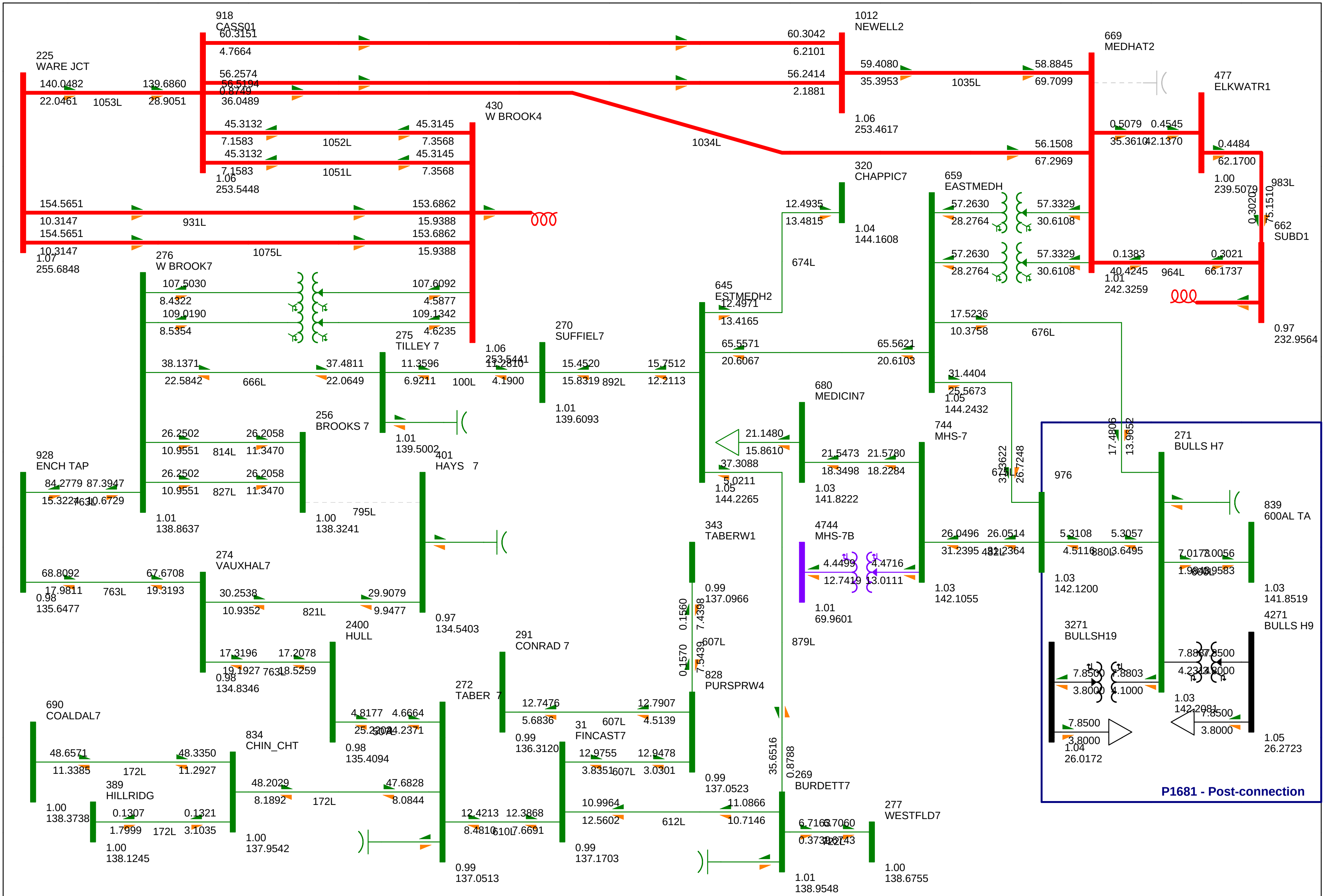


P1681 - Bullshead 523S Upgrades

SK Tie (Import): -0.1092 MW BC and MATL (Import): -3.8488 MW

MH Tie (Import from AIES): 26.0539 MW

FIGURE B2-5 SINGLE 275-276(66)
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016



P1681 - Bullshead 523S Upgrades

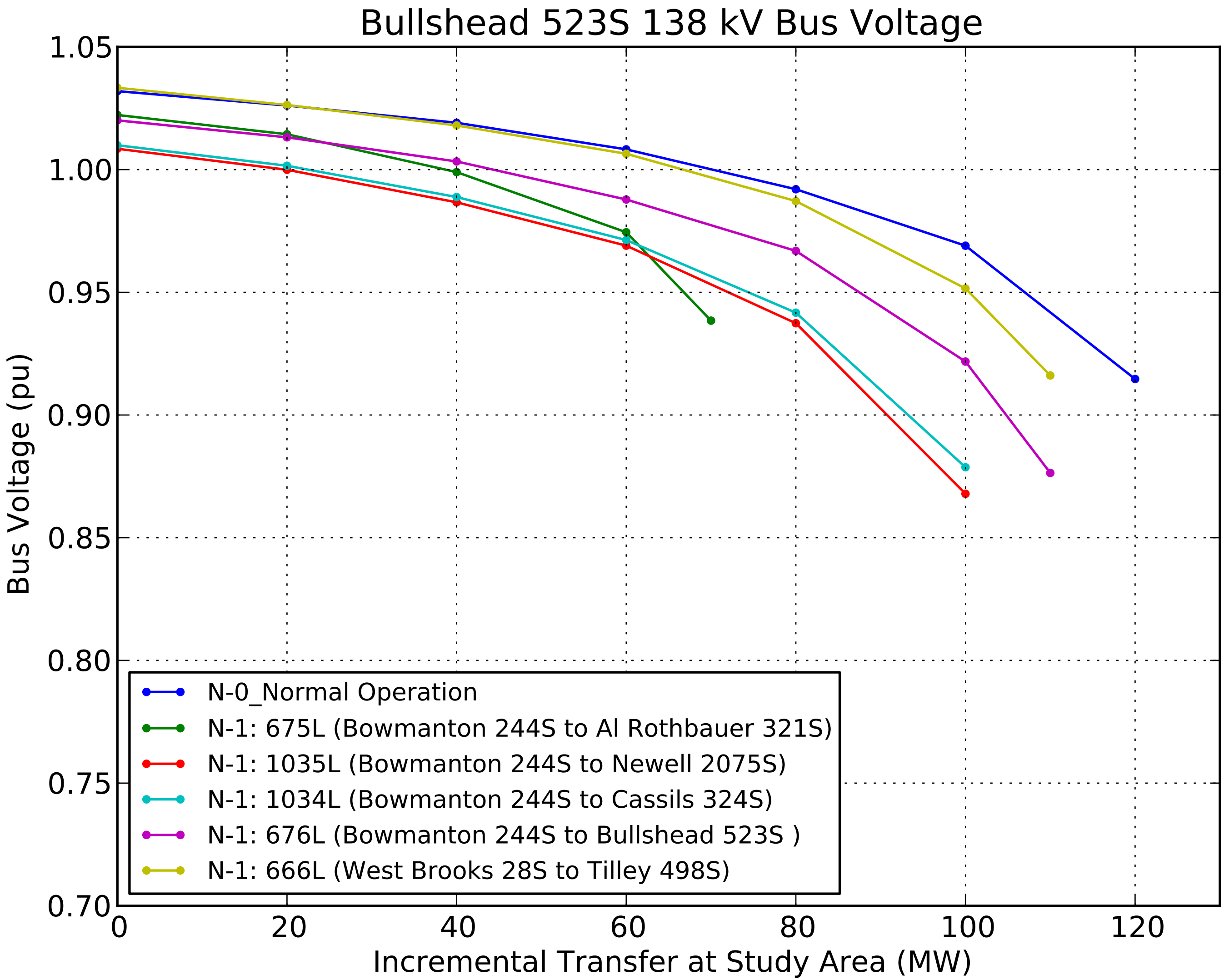
SK Tie (Import): -0.1092 MW BC and MATL (Import): -3.6683 MW

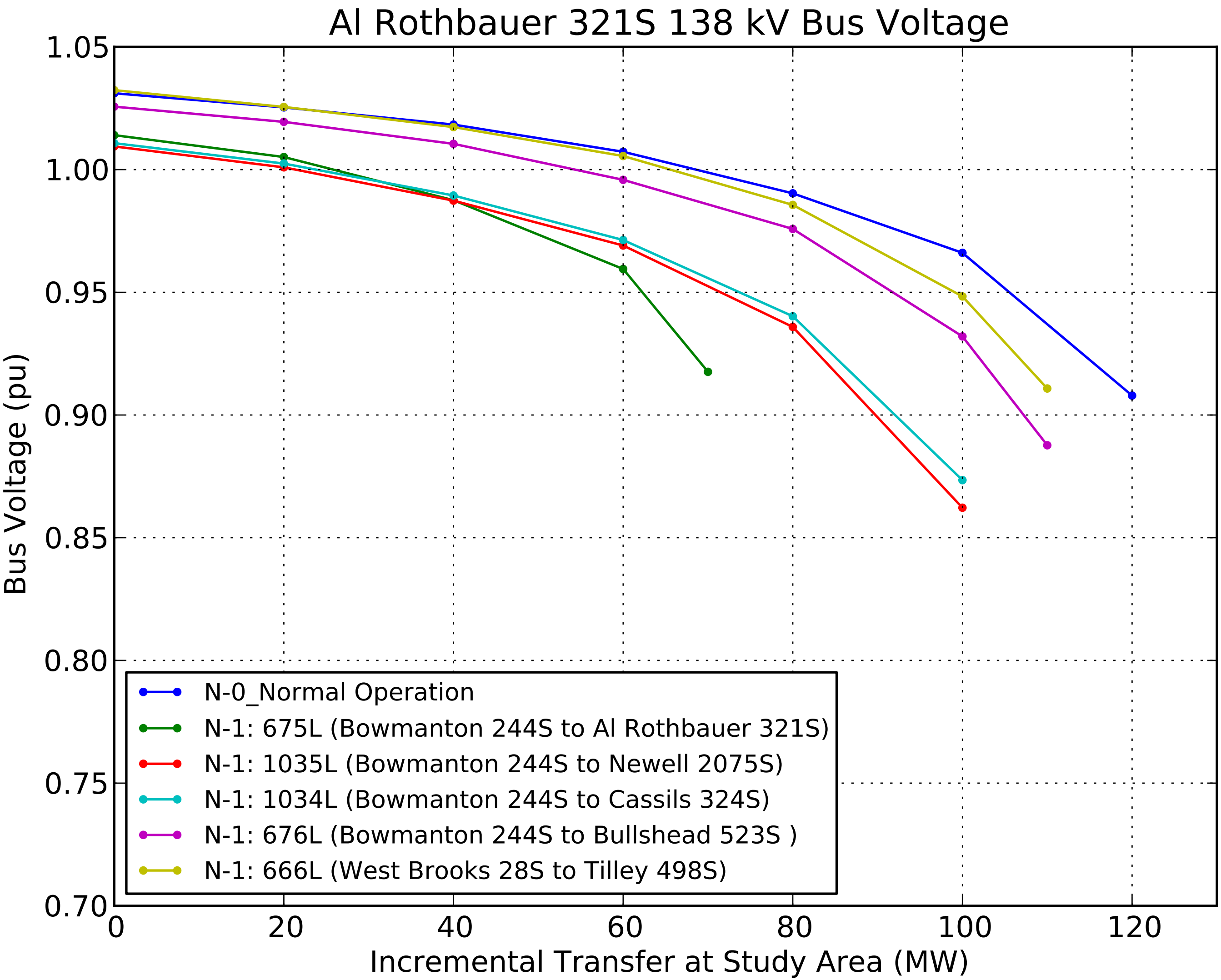
MH Tie (Import from AIES): 26.0496 MW

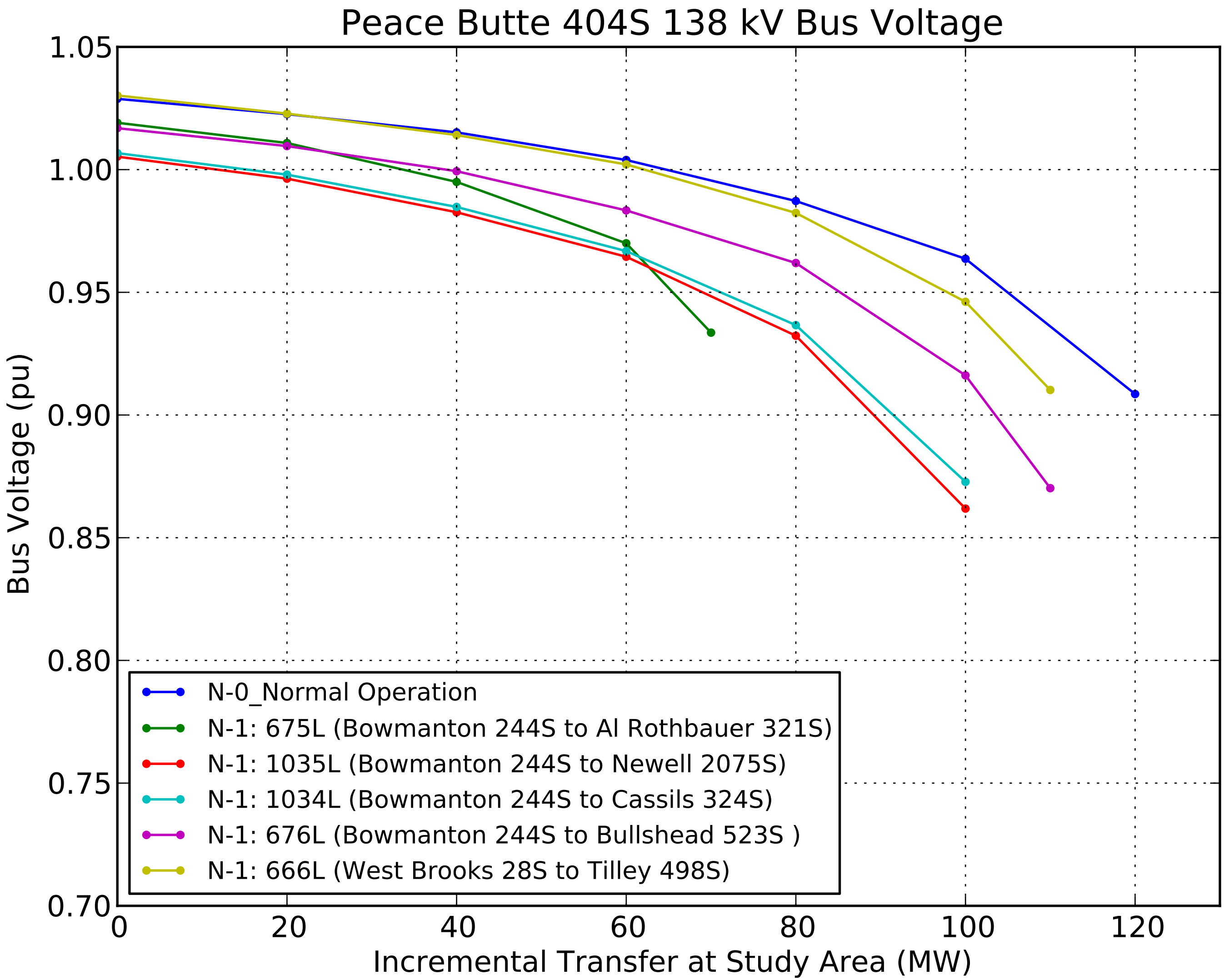
FIGURE B2-6 N-1: 795L (BROOKS 121S TO HAYS 421S)
2017 SUMMER PEAK MH IMPORT (POST-CONNECTION)
PRINTED ON WEDNESDAY 04. MAY 2016

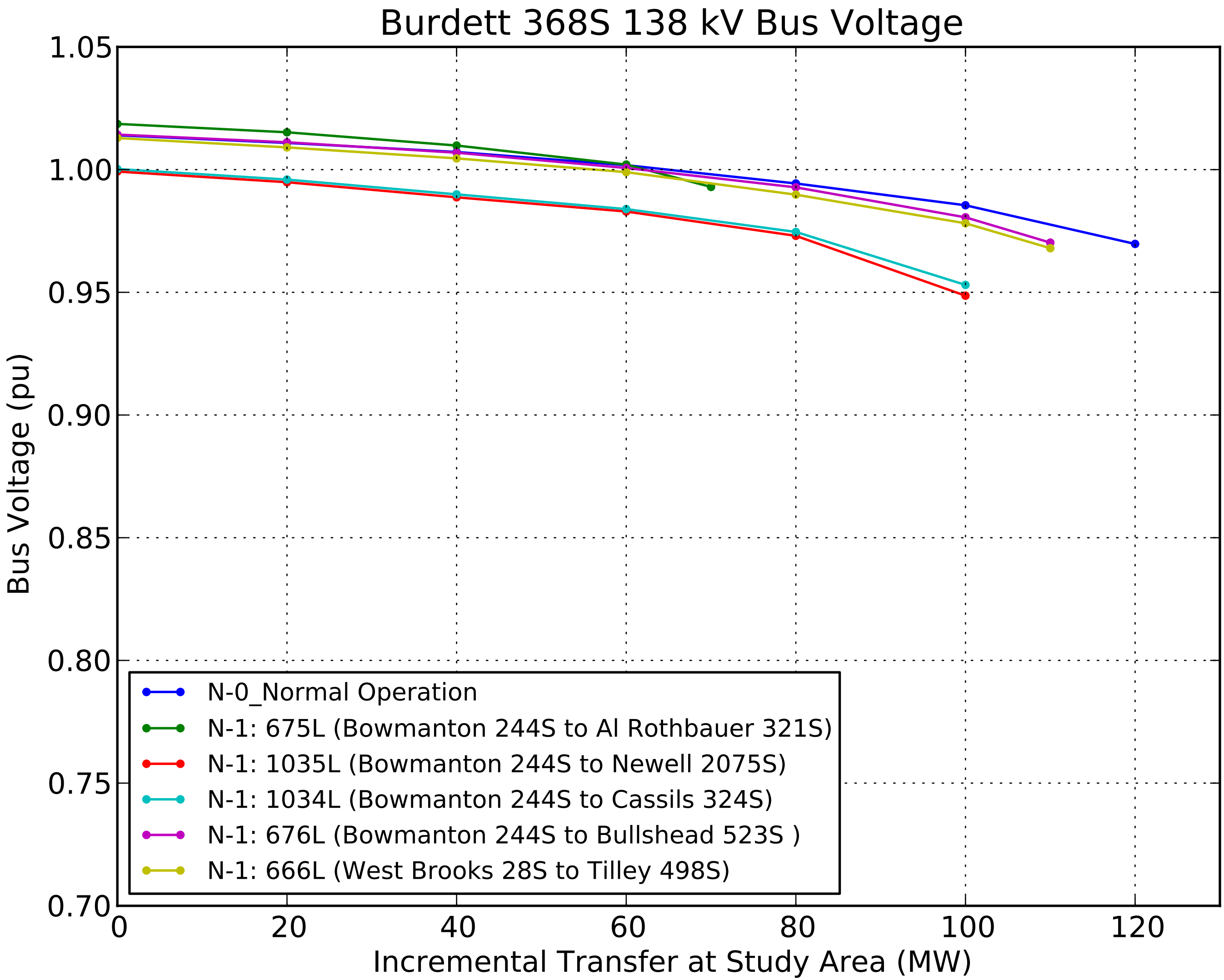
Attachment C

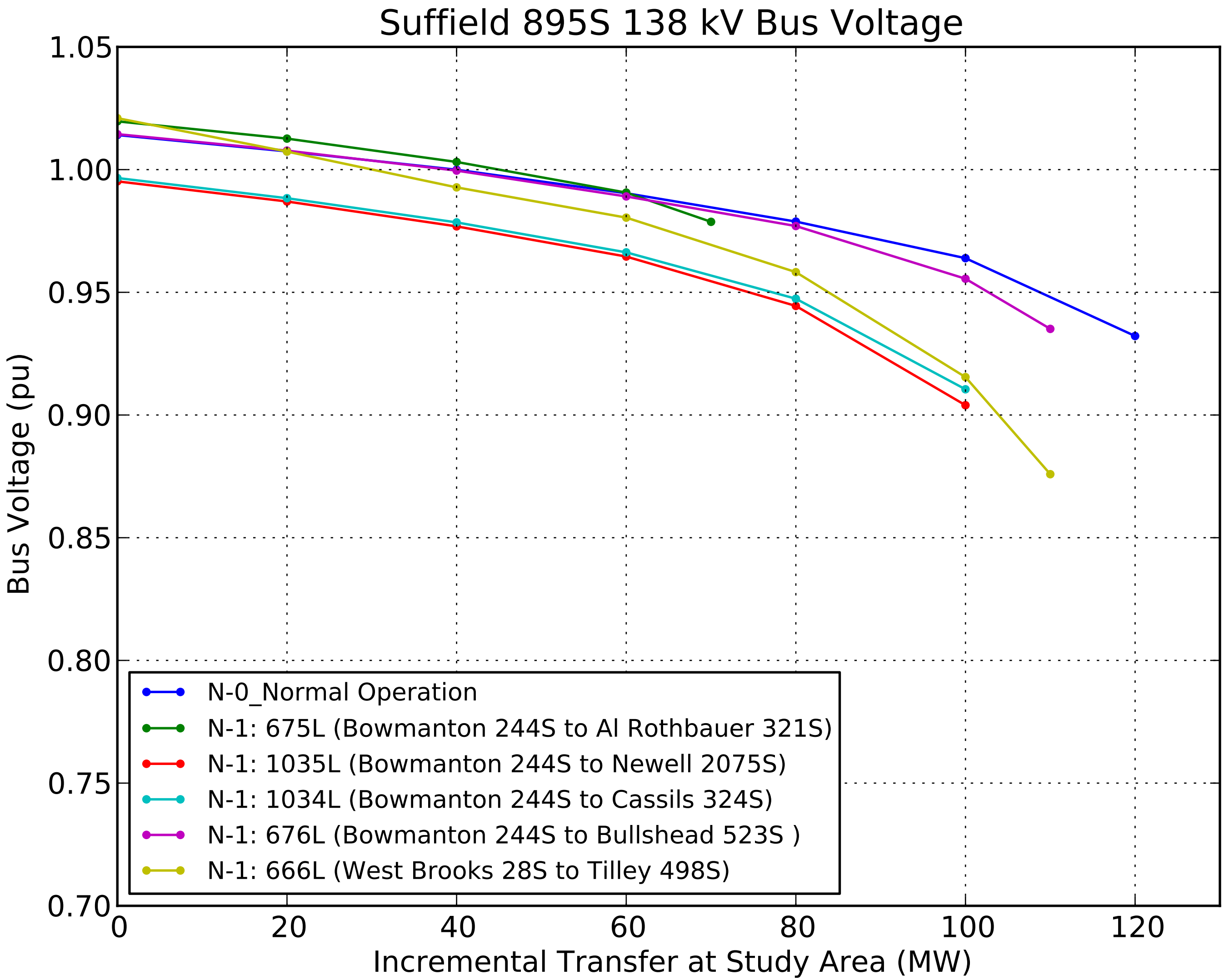
Alternative 1: Voltage Stability Results (Scenarios 3)


Bullshead 523S 138 kV Bus Voltage
Bus Voltage (pu)
Incremental Transfer at Study Area (MW)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
20
40
60
80
100
120
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)

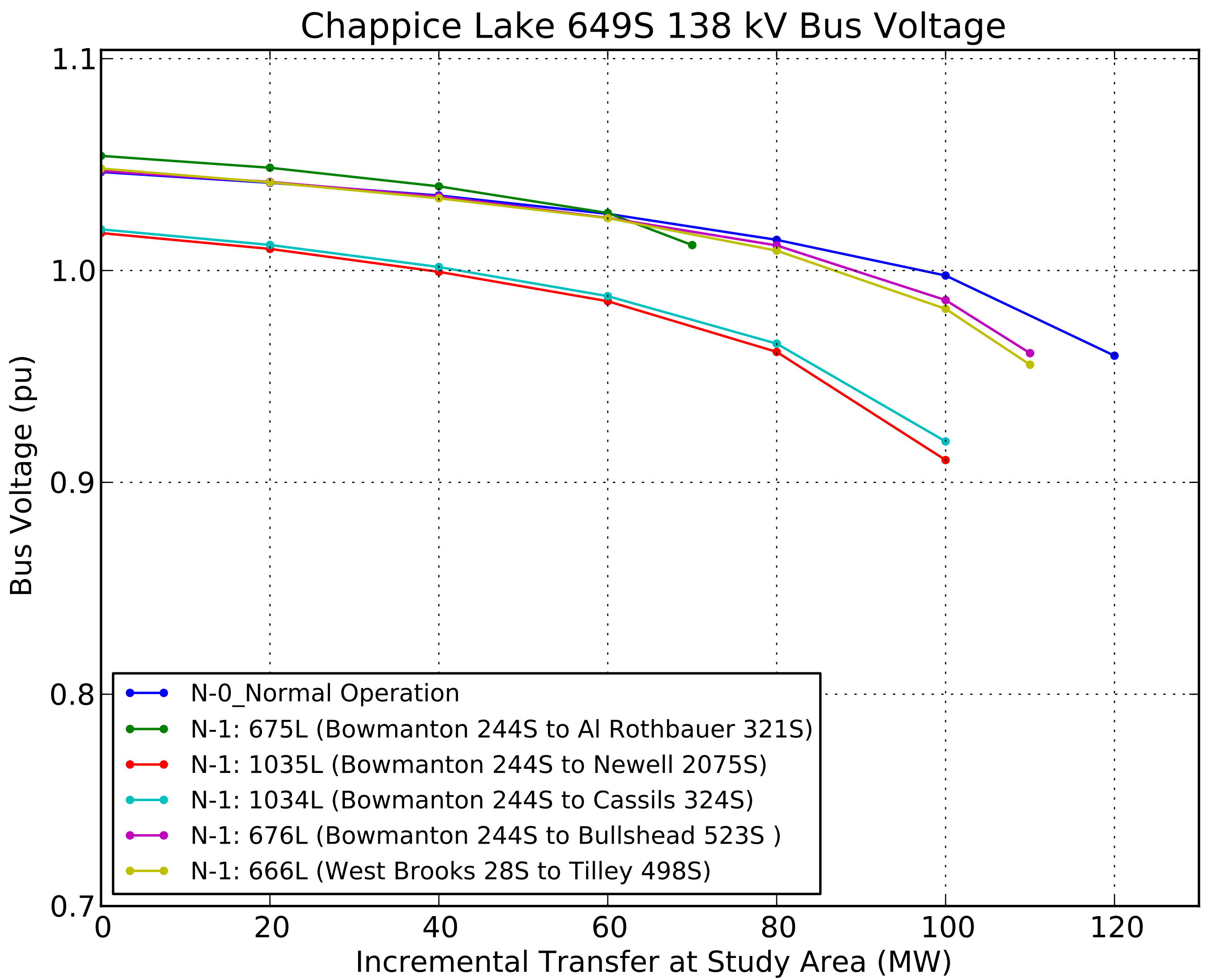

Al Rothbauer 321S 138 kV Bus Voltage
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
20
40
60
80
100
120
Incremental Transfer at Study Area (MW)
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)


Peace Butte 404S 138 kV Bus Voltage
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
20
40
60
80
100
120
Incremental Transfer at Study Area (MW)
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)


Burdett 368S 138 kV Bus Voltage
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Bus Voltage (pu)
0
20
40
60
80
100
120
Incremental Transfer at Study Area (MW)
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)



Suffield 895S 138 kV Bus Voltage
Bus Voltage (pu)
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0
20
40
60
80
100
120
Incremental Transfer at Study Area (MW)
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)



Chappice Lake 649S 138 kV Bus Voltage
Bus Voltage (pu)
Incremental Transfer at Study Area (MW)
1.1
1.0
0.9
0.8
0.7
0
20
40
60
80
100
120
N-0_Normal Operation
N-1: 675L (Bowmanton 244S to Al Rothbauer 321S)
N-1: 1035L (Bowmanton 244S to Newell 2075S)
N-1: 1034L (Bowmanton 244S to Cassils 324S)
N-1: 676L (Bowmanton 244S to Bullshead 523S)
N-1: 666L (West Brooks 28S to Tilley 498S)