



## **Interconnection Feasibility Study Report Request # GI-2015-1**

250 MW Wind Generation Facility  
Tapping Comanche – Daniels Park 345 kV Line  
Elbert County, Colorado

Public Service Company of Colorado  
Transmission Planning  
**January 21, 2016**

(Final version from January 21, 2016 reposted without “Draft” Watermark)

### **Executive Summary**

GI-2015-1 is a 250 MW wind generation facility that will be located in Elbert County, Colorado. The generation facility will be comprised of one hundred and forty (140) GE 1.79 MW wind turbines connected in two groups. Each group will consist of seventy (70) wind turbines, one 0.69/34.5 kV, 140 MVA generator step up transformer and one 34.5/345 kV, 140 MVA main step up transformer.

The primary Point of Interconnection requested by the Interconnection Customer is a tap on the mid-point of the Comanche – Daniels Park 345 kV line (L7015) at approximately 57.24 miles from the Comanche (or the Daniels Park) Substation. The generation facility will interconnect to the POI using an approximately 45 miles long customer owned 345 kV transmission line. The Interconnection Customer did not propose a secondary POI.

The Interconnection Customer has proposed October 1, 2017 as the Commercial Operation Date (COD) of the generation facility. The Interconnection Customer did not provide a back-feed date, so it is assumed to be April 1, 2017; six months before the COD. The 34.5/345 kV, 140 MVA main step-up transformer currently proposed by the Interconnection Customer is a grounded-wye / grounded- wye, buried delta tertiary transformer winding design, which differs from PSCo’s preferred delta / grounded-wye winding design. Therefore, for this winding design to be accepted, the Interconnection Customer will be required to demonstrate that the proposed transformer is effectively grounded per IEEE standards.

The interconnection request is for a Feasibility Study for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service (NRIS). The affected parties for this study are Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE) and Intermountain Rural Electric Association (IREA).

This generation interconnection request was evaluated as a stand-alone project. That is, its feasibility is studied without including the potential impact of other interconnection requests existing in PSCo's Generator Interconnection Request queue, other than the interconnection requests that are PSCo's planned resource acquisitions for which Power Purchase Agreements have been signed.

Single contingency analysis results: The benchmark case (before addition of GI-2015-1) showed three (3) thermal overloads in the CSU system. . The study case (after the addition of GI-2015-1) resulted in the increase of all three (3) pre-existing thermal overloads in the CSU system and also produces three (3) new thermal violations in the PSCo system. . Implementing the Palmer Lake – Monument 115 kV line operating procedure is effective in mitigating all three (3) CSU thermal overloads in both benchmark and study cases. However, the operating procedure results in one (1) additional PSCo thermal violation in the study case, resulting in a total of four (4) new thermal violations in the PSCo system that are attributable to the addition of GI-2015-1. Therefore, Network Upgrades are needed for GI-2015-1 to address the following PSCo thermal overloads:

- Daniels Park – Prairie1 230 kV line loading increased from 100.3% to 114.9%
- Greenwood – Prairie1 230 kV line loading increased from 86.5% to 101.1%
- Greenwood – Prairie3 230 kV line loading increased from 87.8% to 102.5%
- Greenwood – Monaco12 230 kV line loading increased from 89.5% to 102.5%

Energy Resource Interconnection Service (ERIS): Due to pre-existing thermal overloads interconnected, the GI-2015-1 output for ERIS is 0 MW. However, higher GI-2015-1 output may become feasible on as-available basis depending on the generation dispatch of existing generation resources located in the electrical vicinity of GI-2015-1 (such as Comanche, Midway and Jackson Fuller generators.)

Network Resource Interconnection Service (NRIS): Network Upgrades to address the above mentioned thermal overloads will allow GI-2015-1 to achieve 250MW NRIS. A large majority of, if not all, the network upgrades consist of upgrading the terminal equipment limiters on the overloaded facilities.

### Short Circuit

The POI is a new substation that will be designed for the maximum fault current level, so short circuit analysis at the POI is not needed.

### Cost Estimates

Cost estimates are in 2015 dollars. The total estimated cost of the recommended system improvements to interconnect the project is approximately **\$9.2 Million** and includes:



- \$ 2.423 million for PSCo-Owned, Customer-Funded Transmission Provider Interconnection Facilities
- \$ 6.307 million for PSCo-Owned, PSCo-Funded Interconnection Network Facilities
- \$ 0.473 million for PSCo Network Upgrades for Delivery

This work can be completed in thirty six (36) months following receipt of authorization to proceed. This timeline includes the time to obtain a Certificate for Public Convenience and Necessity (CPCN) from the Colorado Public Utilities Commission and construction of Interconnection Facilities and Network Upgrades. Based on this timeline, the October 1, 2017 ISD for GI-2015-1 is not feasible.

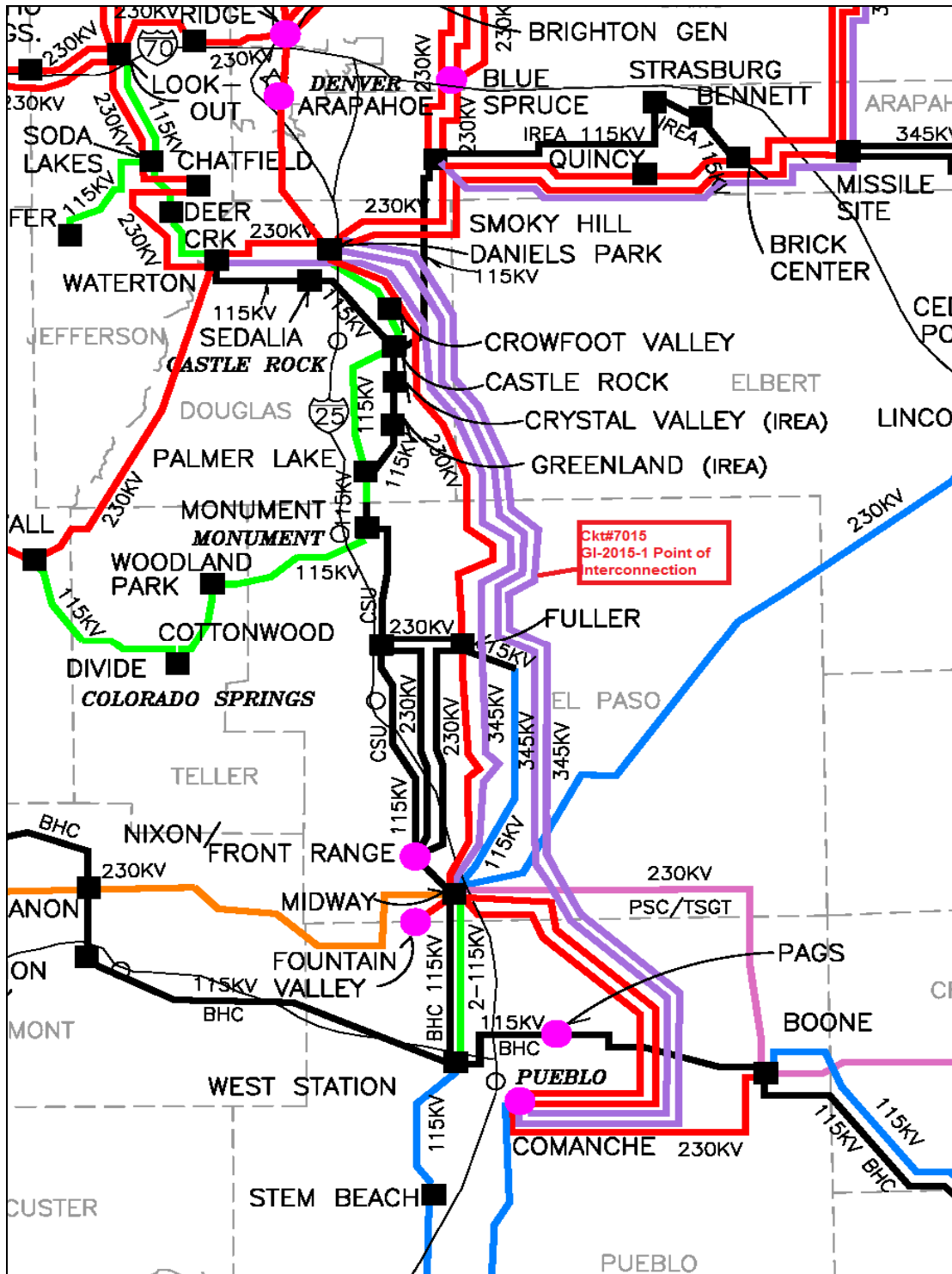


Figure-1: GI-2015-1 Point of Interconnection and Surrounding Study Area

## **Introduction**

GI-2015-1 is a 250 MW wind generation facility that will be located in Elbert County, Colorado. The generation facility will be comprised of one hundred and forty (140) GE 1.79 MW wind turbines connected in two groups. Each group will consist of seventy (70) wind turbines, one 0.69/34.5 kV, 140 MVA generator step up transformer and one 34.5/345 kV, 140 MVA main step up transformer.

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The Interconnection Customer has proposed October 1, 2017 as the Commercial Operation Date (COD) of the generation facility. The Interconnection Customer did not provide a back-feed date, so it is assumed to be April 1, 2017; six months before the COD. The 34.5/345 kV, 140 MVA main step-up transformer currently proposed by the Interconnection Customer is a grounded-wye / grounded- wye, buried delta tertiary transformer winding design, which differs from PSCo's preferred delta / grounded-wye winding design. Therefore, for this winding design to be accepted, the Interconnection Customer will be required to demonstrate that the proposed transformer is effectively grounded per IEEE standards.

The interconnection request is for a Feasibility Study for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service( NRIS).

## **Study Scope and Analysis**

The scope of a Feasibility Study includes power flow analysis and short circuit analysis. The power flow analysis identifies any thermal or voltage limit violations in the PSCo system and the surrounding transmission system resulting from the installation of the proposed generation; several single and double contingencies are studied. The short circuit analysis identifies any new circuit breakers overdutied due to the proposed generation addition.

PSCo adheres to NERC & WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, transmission system bus voltage is maintained between 0.95 and 1.05 per unit of nominal and steady-state power flows should remain below the normal thermal rating of the facility. Operationally, PSCo tries to maintain a transmission system voltage of 1.02 per unit or higher at regulating (generator) buses and 1.0 per unit or higher at transmission load buses in the Daniels Park and Comanche area.



Following a single or double contingency, transmission system steady state bus voltages must remain within 0.90 - 1.05 per unit, and power flows must remain within 100% of the facility's continuous thermal ratings. Also, voltage deviations should not exceed 5%.

GI-2015-1 is studied for both Energy Resource Interconnection Service (ERIS) and Network Resource Interconnection Service( NRIS).

Energy Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service.

Network Resource Interconnection Service shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission system (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

The affected parties for this GI study are Colorado Springs Utilities (CSU), Black Hills Colorado Electric (BHCE) and Intermountain Rural Electric Association (IREA).

### **Power Flow Study Models**

The study was performed using 2017HS power flow case created by CCPG. This case was created from the WECC 2015HS power flow case released on December 5, 2014. The updates included topology, generation, load and rating updates to the entire Rocky Mountain Region.

To assess the impact of the proposed generation on the interconnected transmission system, the generation dispatch in the reference case was adjusted to create a south to north power flow stress on the Comanche – Midway - Jackson Fuller – Daniels Park transmission path. This was accomplished by adopting the generation dispatch described in Table - 8 below. PSCo generation dispatch in zones 700, 703, 704, 705, 706, 709, 710 and 712 is dispatched such that wind generation is at 85% name plate capacity, solar generation is at 80% name plate capacity and conventional non-coal generation is at 90% name palatte capacity, coal generation is dispatched at 100% name plate capacity. The study did not include any generation resources that are in the Generation Interconnection queue except resources for which a Power Purchase Agreement (PPA's) has been signed.

The 75MW wind plant expansion at Twin Buttes is modeled in the power flow cases.

Two power flow cases were created for evaluating the impact of the proposed generator – the benchmark case and the study case. The benchmark case modeled the system before GI-2015-1 interconnection whereas the study case include GI-2015-1 model. PSCo's Fort Saint Vrain#1 is used as the sink for the generation addition. The GI was modeled using the PSSE modeling data provided by the Customer.

### **Power Flow Study Process**

The power flow studies were completed on the benchmark case and the study case using PTI's PSSE Ver. 33.4.0 program and the ACCC contingency analysis tool. For single contingency analysis bus-bus contingencies were run on both Area 70 and 73, also a comprehensive list of breaker-breaker contingencies is run for area 70. The double contingency analysis was performed for all outages in the PSCo, TSGT, CSU, IREA and BHCE system which is the transmission system surrounding the study area. The Results from the benchmark case and study case were compared, any new thermal overloads or existing thermal overloads which increased by more than 1% are monitored, any new voltage violations and existing voltage violations which increased are monitored. The monitored transmission system included zones 700, 703, 704, 705, 706, 709, 710, 712, 752, 757, 791 and 121.

### **Power Flow Results**

#### **Single Contingency Analysis:**

The thermal violations (marked in red) resulting from single contingencies, seen without and with Palmer Lake – Monument 115 kV line operating procedure, are given in Table 5 and Table 6 respectively. From the results in Tables 5 and Table 6 , it is evident that the addition of GI-2015-1 increased the existing thermal overloads and also caused new thermal overloads. The thermal overloads in the CSU system are eliminated when the Palmer Lake- Monument 115 kV line operating procedure is implemented. Therefore, the following four PSCo thermal overloads are attributable to the addition of GI-2015-1 (highlighted in yellow in Table-6)

- Daniels Park – Prairie1 230 kV line loading increased from 100.3% to 114.9%
- Greenwood – Prairie1 230 kV line loading increased from 86.5% to 101.1%
- Greenwood – Prairie3 230 kV line loading increased from 87.8% to 102.5%
- Greenwood – Monaco12 230 kV line loading increased from 89.5% to 102.5%

Addition of GI-2015-1 did not cause any new voltage violations and increases in the existing voltage violations are small as to not require monitoring. There were no voltage violations attributable to GI-2015-1.



Energy Resource Interconnection Service (ERIS): Due to pre-existing thermal overloads interconnected, the GI-2015-1 output for ERIS is 0 MW. However, higher GI-2015-1 output may become feasible on as-available basis depending on the generation dispatch of existing generation resources located in the electrical vicinity of GI-2015-1 (such as Comanche, Midway and Jackson Fuller generators.)

Network Resource Interconnection Service (NRIS): Network Upgrades to address the above mentioned thermal overloads will allow GI-2015-1 to achieve 250MW NRIS. A large majority of, if not all, the network upgrades consist of upgrading the terminal equipment limiters on the overloaded facilities.

The total time for obtaining CPCN for the new substation at the tap point, construction of Network Facilities for Interconnection and construction of Network Upgrades for delivery is expected to take thirty six (36) months. Based on this timeline, the October 1, 2017 Commercial Operation Date for GI-2015-1 is not feasible.

### **Short Circuit**

The Point of Interconnection is a new substation that will be designed for the maximum fault current level, so short-circuit analysis at the POI is not needed.

### **Costs Estimates and Assumptions**

Scoping level cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by Public Service Company of Colorado (PSCO) / Xcel Energy (Xcel) Engineering. The cost estimates are in 2015 dollars with escalation and contingency included. AFUDC is not included. Estimates are developed assuming typical construction costs for previous completed projects. These estimates include all applicable labor and overheads associated with the siting support, engineering, design, material/equipment procurement, construction, testing and commissioning of these new substation and transmission line facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

The estimated total cost for the required upgrades for GI-2015-1 is **\$9.2M**. Figure 1 below represents a conceptual one-line of the proposed new interconnection for the 345kV Rush Creek Substation. These estimates do not include costs for any other Customer owned equipment and associated design and engineering. The following tables list the improvements required to accommodate the interconnection and the delivery of the Project generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed and refined design.



**Table 1: PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities**

Element	Description	Cost Est. (Millions)
<b>Rush Creek 345 kV Transmission Substation</b>	Interconnect Customer to tap at the new Rush Creek 345kV Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• (1) 345kV line position &amp; associated protective relaying</li> <li>• (2) 345kV circuit breakers</li> <li>• (3) 345kV CCVTs</li> <li>• (2) 345kV Line Traps</li> <li>• (3) 345kV Meter Units</li> <li>• (1) 345kV dead-end structure</li> <li>• 20% land footprint, earthwork, ground grid</li> </ul>	<b>\$2.408</b>
	Siting and Land Rights support for siting studies, land and ROW acquisition and construction.	<b>\$0.015</b>
	<b>Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities</b>	<b>\$2.423</b>

**Table 2: PSCo Owned; PSCo Funded Interconnection Network Facilities**

Element	Description	Cost Estimate (Millions)
<b>Rush Creek 345kV Transmission Substation</b>	PSCo to construct new Rush Creek 345kV Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• (2) 345kV line positions &amp; associated protective relaying</li> <li>• (2) 345kV circuit breakers</li> <li>• (8) 345kV CCVTs</li> <li>• (1) EEE</li> <li>• (2) 345kV dead-end structures</li> <li>• (1) Lot 345kV buswork</li> <li>• (10) 345kV disconnect switches</li> <li>• (2) 345kV Line traps</li> <li>• (1) Station Service transformer unit</li> <li>• 345kV bus protection</li> <li>• RTU, DFR, SPABX, SCADA</li> <li>• 80% land footprint, earthwork, ground grid</li> </ul>	<b>\$6.244</b>
	Siting and Land Rights support for substation land acquisition (22 acres) and construction.	<b>\$0.063</b>
	<b>Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities</b>	<b>\$6.307</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 Months</b>

**Table 3 – PSCo Network Upgrades for Delivery**

<b>Element</b>	<b>Description</b>	<b>Cost Est. (Millions)</b>
<b>Prairie 230kV Substation</b>	Upgrades required to the Daniels Park – Prairie1-Greenwood and Daniels Park – Prairie3-Greenwood 230 kV transmission lines to facilitate the new generation. The new equipment includes: <ul style="list-style-type: none"> <li>• Upgraded Jumpers</li> </ul>	<b>\$0.047</b>
<b>Monaco 230kV Substation</b>	Upgrades required to the Greenwood – Monaco 230 KV transmission line to facilitate the new generation. The new equipment includes: <ul style="list-style-type: none"> <li>• Upgraded Jumpers</li> </ul>	<b>\$0.033</b>
<b>Greenwood 230kV Substation</b>	Upgrades required to the Daniels Park – Prairie1-Greenwood and Daniels Park – Prairie3-Greenwood 230 kV transmission lines to facilitate the new generation. The new equipment includes: <ul style="list-style-type: none"> <li>• Upgraded Jumpers</li> <li>• Upgraded line traps</li> </ul>	<b>\$0.209</b>
<b>Daniels Park 230kV Substation</b>	Upgrades required to the transmission network to facilitate the new generation. The new equipment includes: <ul style="list-style-type: none"> <li>• Upgraded Jumper</li> <li>• Upgraded line traps</li> </ul>	<b>\$0.184</b>
	<b>Total Cost</b>	<b>\$0.473</b>

**Cost Estimate Assumptions**

- Scoping level project cost estimates for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery (+/- 30% accuracy) were developed by PSCo / Xcel Engineering.
- Estimates are based on 2015 dollars (appropriate contingency and escalation included).
- AFUDC has been excluded.
- Labor is estimated for straight time only – no overtime included.
- Lead times for materials were considered for the schedule.
- The Wind Generation Facility is not in PSCo’s retail service territory. Therefore, no costs for retail load (distribution) facilities and metering required for station service are included in these estimates.
- PSCo / Xcel (or our Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- The estimated time to site, design, procure and construct the interconnection and network delivery facilities is approximately 18 months after authorization to proceed has been obtained.
- The S&LR’s estimate assumes the acquisition of 22 acres of land in Elbert County, Colorado for the new Rush Creek substation.

- Substation will be constructed directly adjacent to the transmission line.
- A CPCN will be required for the interconnection and network delivery facilities construction and will add 18 months in front of the siting, design, procure construct window (of 18 months), totaling an estimated 36 month window to complete from authorization to proceed.
- The Customer will be required to design, procure and install a Load Frequency/Automated Generation Control (LF/AGC) RTU at their Customer Substation. PSCo / Xcel will need indications, readings and data from the LFAGC RTU.
- Customer will string OPGW fiber into substation as part of the transmission line construction scope.



## A. Power Flow Contingency Analysis Results

### Notes –

1. All thermal violations are identified in red.
2. For Single Contingency Analysis, thermal overloads on:
  - PSCo facilities are calculated using the applicable Normal Rating.
  - CSU facilities are calculated using the applicable Emergency Rating.
3. For Double Contingency Analysis, thermal overloads on All facilities are calculated using applicable Emergency Rating of the facility

**Table 5 – Summary of thermal violations from Single Contingency Analysis  
Without Palmer Lake– Monument 115 kV Line Operating Procedure**

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Single Contingency
				N-1 Flow MVA	N-1 Flow % of Rating	N-1 Flow MVA	N-1 Flow % of Rating		
Daniels Park – Prairie1 230 kV	Line	PSCo	478/478	474.7	99.3%/99.3%	544	113.8%/113.8%	14.5%	Daniels Park – Prairie3 – Greenwood 230 kV Line
Greenwood – Prairie1 230kV	Line	PSCo	478/478	408.2	85.4%/85.4%	478	99.9%/99.9%	14.5%	Daniels Park – Prairie3 – Greenwood 230 kV Line
Greenwood – Prairie3 230kV	Line	PSCo	478/478	415	86.8%/86.8%	484.2	101.3%/101.3%	14.5%	Daniels Park – Prairie1 – Greenwood 230 kV Line
Daniels Park – SantaFe 230 kV	Line	PSCo	319/319	272.7	85.5%/85.5%	309.1	96.9%/96.9%	11.4%	Leetsdale – Monaco – Greenwood 230 kV
Greenwood – Monaco12 230 kV	Line	PSCo	404/480	360.8	89.3%/75.2%	413.3	102.3%/86.1%	13%	Arapahoe – SantaFe – DanielsPark 230 kV
Midway 230 kV Bus tie	Line	PSCo/ WAPA	430/478	386.1	89.8%/80.1%	418.4	97.3%/87.5%	7.5%	Midway – Jackson Fuller 230 kV
Palmer Lake – Monument 115 kV	Line	PSCo/ CSU	142/157	131.4	92.5%/83.7%	139	97.9%/88.5%	5.4%	Daniels Park – Jackson Fuller 230 kV
Portland – Skala 115 kV	Line	BHCE	119/119	106.9	89.8%/89.8%	114.2	96%/96%	6.2%	MidwayBR – West Canyon 230 kV
DesertCov – West Station 115 kV	Line	BHCE	120/120	109.8	91.5%/91.5%	118.7	98.9%/98.9%	7.4%	Midway 230 kV bus tie

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Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Single Contingency
				N-1 Flow MVA	N-1 Flow % of Rating	N-1 Flow MVA	N-1 Flow % of Rating		
Waterton – Martin1Tap 115 kV	Line	PSCo	139/153	136.8	98.4%/89.4%	141.2	101.6%/92.3%	3.2%	Arapahoe 230/115 kV # T5
Waterton – Martin2Tap 115 kV	Line	PSCo	125/138	129.6	103.7%/93.9%	137.1	109.7%/99.4%	6%	Sodalakes 230/115 kV #T2
Brairgate S – Cottonwood S 115 kV	Line	CSU	150/192	176.6	117.7%/91.9%	182.1	121.4%/94.8%	2.9%	Cottonwood N-KettleCreek S 115 kV
Cottonwood N - KettleCreek S 115 kV	Line	CSU	162/180	190.4	117.8%/100.6%	197	121.6%/109.4%	8.8%	Brairgate S – Cottonwood S 115 kV
Kelker N 230/115 kV # 1	Xfmr	CSU	280/319	283.4	101.2%/88.8%	286.2	102.2%/89.7%	0.9%	Kelker S 230/115 kV #1
Kelker S 230/115 kV #1	Xfmr	CSU	280/322	280	99.8%/86.8%	282.5	100.9%/87.7%	0.9%	Kelker N 230/115 kV # 1
Monument – Flyhorse N 115 kV	Line	CSU	142/156	142.6	100.4%/91.4%	150.8	106.2%/96.7%	5.3%	Daniels Park – Jackson Fuller 230 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	82.5	101.8%/101.8%	86.9	107.3%/107.3%	5.5%	Flyhorse S – Flyhorse N 115 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	82.5	101.8%/101.8%	86.9	107.3%/107.3%	5.5%	Flyhorse S – Kettlecreek N 115 kV
Fuller 230/115 kV #1	Xfmr	CSU	100/100	96	96%/96%	97.4	97.4%/97.4%	1.4%	MidwayBR – Rancho 115 kV
Flyhorse S – KettleCreek N 115 kV	Line	CSU	162/180	153.4	94.7%/85.2%	162	99.8%/90%	4.8%	Daniels Park – Jackson Fuller 230 kV



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  - CSU facilities are calculated using the applicable Emergency Rating.
3. For Double Contingency Analysis, thermal overloads on All facilities are calculated using applicable Emergency Rating of the facility

**Table 6 – Summary of thermal violations from Single Contingency Analysis  
With Palmer Lake – Monument 115 kV Line Operating Procedure**

				Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1			
Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	N-1 Flow MVA	N-1 Flow % of Rating	N-1 Flow MVA	N-1 Flow % of Rating	% Change	NERC Cat B Contingency
Happy Canyon – Crowfoot Valley 115 kV	Line	PSCo	120/120	120.7	100.6%/100.6%	122.6	102.2%/102.2%	1.6%	Parker – Bayou 115 kV
Happy Canyon – Daniels Park 115 kV	Line	PSCo	120/120	131	109.2%/109.2%	132.8	110.7%/110.7%	1.5%	Parker – Bayou 115 kV
Daniels Park – Prairie1 230 kV	Line	PSCo	478/478	479.4	100.3%/100.3%	549.2	114.9%/114.9%	14.6%	Daniels Park – Prairie3 – Greenwood 230 kV Line
Greenwood – Prairie1 230kV	Line	PSCo	478/478	413.5	86.5%/86.5%	483.3	101.1%/101.1%	14.6%	Daniels Park – Prairie3 – Greenwood 230 kV Line
Greenwood – Prairie3 230kV	Line	PSCo	478/478	419.7	87.8%/87.8%	490	102.5%/102.5%	14.7%	Daniels Park – Prairie1 – Greenwood 230 kV Line
Daniels Park – SantaFe 230 kV	Line	PSCo	319/319	273.7	85.8%/85.8%	310.4	97.3%/97.3%	11.5%	Leetsdale – Monaco – Greenwood 230 kV
Greenwood – Monaco12 230 kV	Line	PSCo	404/480	361.6	89.5%/75.3%	414.1	102.5%/86.3%	13%	Arapahoe – SantaFe – DanielsPark 230 kV
Midway 230 kV Bus tie	Line	PSCo/WAPA	430/478	360.7	83.9%/75.5%	391.3	91%/81.9%	7.1%	Midway – Jackson Fuller 230 kV
Palmer Lake – Monument 115 kV	Line	PSCo/CSU	142/157		N/A		N/A		Daniels Park – Jackson Fuller 230 kV

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With Palmer Lake – Monument 115 kV Line Operating Procedure**

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Cat B Contingency
				N-1 Flow MVA	N-1 Flow % of Rating	N-1 Flow MVA	N-1 Flow % of Rating		
Portland – Skala 115 kV	Line	BHCE	119/119	108.8	91.4%/91.4%	116.4	97.8%/97.8%	6.4%	MidwayBR – West Canyon 230 kV
DesertCov – West Station 115 kV	Line	BHCE	120/120	103.8	86.5%/86.5%	112.2	93.5%/93.5%	7%	Midway 230 kV bus tie
Waterton – Martin1Tap 115 kV	Line	PSCo	139/153	135.5	97.5%/88.6%	140	100.7%/91.5%	3.2%	Arapahoe 230/115 kV # T5
Waterton – Martin2Tap 115 kV	Line	PSCo	125/138	119.1	95.3%/86.3%	120	96%/86.9%	0.7%	Sodalakes 230/115 kV #T2
Brairgate S – Cottonwood S 115 kV	Line	CSU	150/192	137.3	91.5%/71.5%	139.8	93.2%/72.8%	1.3%	Cottonwood N-KettleCreek S 115 kV
Cottonwood N-KettleCreek S 115 kV	Line	CSU	162/180	144	88.9%/80%	146.8	90.6%/81.5%	1.5%	Brairgate S – Cottonwood S 115 kV
Kelker N 230/115 kV # 1	Xfmr	CSU	280/319	270.2	96.5%/84.7%	272.4	97.3%/85.4%	0.7%	Kelker S 230/115 kV #1
Kelker S 230/115 kV #1	Xfmr	CSU	280/319	266.8	95.3%/83.4%	268.8	96%/84.3%	0.9%	Kelker N 230/115 kV # 1
Monument – Flyhorse N 115 kV	Line	CSU	142/156	61.1	43%/39.1%	64.6	45.5%/41.4%	2.5%	Daniels Park – Jackson Fuller 230 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	62.1	76.7%/76.7%	64.8	80.1%/80.1%	3.4%	Flyhorse S – Flyhorse N 115 kV
BLKFORTP – BLK SQMV 115 kV	Line	CSU	81/81	62.1	76.7%/76.7%	64.8	80.1%/80.1%	3.4%	Flyhorse S – Kettlecreek N 115 kV
Fuller 230/115 kV #1	Xfmr	CSU	100/100	81.4	81.4%/81.4%	81.8	81.8%/81.8%	0.4%	MidwayBR – Rancho 115 kV
Flyhorse S – KettleCreek N 115 kV	Line	CSU	162/180	72.1	44.5%/40.5%	75.7	46.7%/42%	2.2%	Daniels Park – Jackson Fuller 230 kV



**Notes –**

1. All thermal violations are identified in **red**.
2. For Single Contingency Analysis, thermal overloads on:
  - PSCo facilities are calculated using the applicable Normal Rating.
  - CSU facilities are calculated using the applicable Emergency Rating.
3. For Double Contingency Analysis, thermal overloads on All facilities are calculated using applicable Emergency Rating of the facility

**Table 7 – Summary of thermal violations from Double Contingency Analysis**

Without Palmer Lake– Monument 115 kV Line Operating Procedure

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Cat C Contingency
				N-2 Flow MVA	N-2 Flow % of Rating	N-2 Flow MVA	N-2 Flow % of Rating		
HydePark - West Station 115 kV	Line	BHCE	119/119	111.7	93.9%/93.9%	117.9	99.1%/99.1%	5.2%	Baculite – West Station 115 kV#1 & 2
MidwayPS – Northridge 115 kV	Line	BHCE	100/100	107	107%/107%	109.4	109.4%/109.4%	2.4%	Baculite – West Station 115 kV#1 & 2
PuebloPlant – Reader 115 kV	Line	BHCE	160/160	159	99.4%/99.4%	165.4	103.4%/103.4%	4%	Baculite – West Station 115 kV#1 & 2
DesertCove – West Station 115 kV	Line	BHCE	120/120	175.3	146.1%/146.1%	185.6	154.6%/154.6%	8.5%	MidwayBR 230 kV bus outage & MidwayPS – Fuller 230 kV
Arapahoe – SantaFe 230 kV	Line	PSCo	300/330	317.1	105.7%/96%	336.5	121.6%/101.9%	5.9%	Greenwood- Prairie – Daniels Park 230 kV # 1&2
Arapahoe – SantaFe 230 kV	Line	PSCo	300/330	317.1	105.7%/96%	336.5	121.6%/101.9%	5.9%	Greenwood 230 kV breaker failure
Daniels Park - SantaFe 230 kV	Line	PSCo	319/319	352.8	110.6%/110.6%	400.7	125.6%/125.6%	15%	Greenwood- Prairie – Daniels Park 230 kV # 1&2
Daniels Park - SantaFe 230 kV	Line	PSCo	319/319	352.8	110.6%/110.6%	400.7	125.6%/125.6%	15%	Greenwood 230 kV breaker failure
Daniels Park – Fuller 230 kV	Line	PSCo	478/478	605	126.6%/126.6%	N/A	N/A	N/A	Comanche – Daniels Park 345 kV #1&2
Daniels Park – Fuller 230 kV	Line	PSCo	478/478	N/A	N/A	594.2	124.3%	N/A	Comanche-Daniels Park 345 kV #1 Comanche – GI-2015-1 Tap 345 kV
Fountain Valley – DesertCov 115 kV	Line	BHCE	115/115	153	133.1%/133.1%	165.6	144%/144%	10.9%	Midway BR-MidwayPS 230 kV & MidwayPS – Fuller 230 kV
Fountain Valley – MidwayBR 115 kV	Line	BHCE	115/115	151.9	132.1%/132.1%	164.5	143%/143%	10.9%	Midway BR-MidwayPS 230 kV & MidwayPS – Fuller 230 kV





**Table 7 – Summary of thermal violations from Double Contingency Analysis**

Without Palmer Lake– Monument 115 kV Line Operating Procedure

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Cat C Contingency
				N-2 Flow MVA	N-2 Flow % of Rating	N-2 Flow MVA	N-2 Flow % of Rating		
Greenwood – Monaco 230 kV	Line	PSCo	404/480	379.8	94%/79.1%	433.5	107.3%/90.3%	11.2%	Daniels Park – Marcy – Waterton 230 kV & Daniels Park – SantaFe – Arapahoe 230 kV
Leetsdale – Monaco 230 kV	Line	PSCo	396/436	344.1	86.9%/78.9%	397.6	100.4%/91.2%	12.3%	Daniels Park – Marcy – Waterton 230 kV & Daniels Park – SantaFe – Arapahoe 230 kV
Midway 230/115 kV #T1	Xfmr	PSCo	97/97	126.2	130.1%/130.1%	N/A	N/A	N/A	Comanche – Daniels Park 345 kV #1&2
Midway 230/115 kV #T1	Xfmr	PSCo	97/97	N/A	N/A	126.7	130.6%/130.6%	N/A	Comanche-Daniels Park 345 kV #1 Comanche – GI-2015-1 Tap 345 kV
MidwayPS-Midway BR 230 kV	Bus tie	WAPA / PSCo	430/478	580	134.9%/121.4%	619.6	144.1%/129.6%	8.2%	Midway – waterton 345 kV & Midway – Fuller 230 kV
Palmer Lake – Monument 115 kV	Line	CSU	142/157	197.8	139.3%/126%	207.9	146.4%/132.4%	6.4%	Midway – waterton 345 kV & Daniels Park – Fuller 230 kV
BrairgateS-CottonwoodS 115 kV	Line	CSU	162/180	193.4	119.4%/107.5%	199.3	123%/110.7%	3.2%	Cottonwood North 115 kV Bus outage
CottonwoodN-KettlecreekS 115 kV	Line	CSU	150/192	174	116%/90.6%	180.8	120.5%/94.1%	3.5%	Midway – Waterton 345 kV & Daniels Park – Fuller 230 kV
BlackForest Tap – BLK SQMV 115kV	Line	CSU	81/81	127	156.9%/156.9%	206	162.2%/162.2%	5.3%	Cottonwood 115 kV tie breaker outage
Blk SQMV – Fuller 115 kV	Line	CSU	143/143	150.3	105.1%/105.1%	154.6	108.1%/108.1%	3%	Cottonwood 115 kV tie breaker outage
Fuller 230/115 kV	Xfmr	CSU	100/100	128.8	128.8%/128.8%	130.5	130.5%/130.5%	1.7%	Cottonwood 115 kV tie breaker outage
Fountain S-RD_Nixon 115kV	Line	CSU	195/212	243.8	125%/115%	247	126.7%/116.5%	1.5%	KelKer 230 kV Tie breaker outage
Waterton – Martin1tap 115kV	Line	PSCo	139/153	145.4	104.6%/95%	152.8	109.9%/99.8%	4.8%	Sodalakes – Waterton 230 kV & 115 kV
Waterton – martin2tap 115 kV	Line	PSCo	125/138	142.5	114%/103.3%	152.6	122.1%/110.6%	7.3%	Sodalakes 230 kV breaker failure
West Canyon 230/115 kV # T1	Xfmr	BHCE	100/100	116	116%/116%	117.4	117.4%/117.4%	1.4%	Portland – West Station 230 kV # 1 & 2

**Table 7 – Summary of thermal violations from Double Contingency Analysis**  
Without Palmer Lake– Monument 115 kV Line Operating Procedure

Monitored Facility (Line or Transformer)	Type	Owner	Branch Rating MVA (Norm/Emer)	Branch Contingency Loading Without GI-2015-1		Branch Contingency Loading With GI-2015-1		% Change	NERC Cat C Contingency
				N-2 Flow MVA	N-2 Flow % of Rating	N-2 Flow MVA	N-2 Flow % of Rating		
MidwayBR 230/115 kV #1	Xfmr	WAPA	100/120	124	124%/103%	125.3	125.3%/104.4%	1.4%	RDnixon – Frontrange 115 kV RDnixon – MidwayBR 115 kV
MidwayBR – RD Nixon 115 kV	Line	CSU	159/159	152.5	95.9%/95.9%	158	99.4%/99.4%	4.4%	RDnixon – Frontrange 115 kV RDnixon – MidwayBR 115 kV
FlyhorseS-KettlecreekN 115 kV	Line	CSU	162/180	222.8	137.5%/123.8%	233.8	144.3%/129.9%	6.1%	Midway – Waterton 345 kV & Daniels Park – Fuller 230 kV
Monument – FlyhorseN 115 kV	Line	CSU	142/156	211.9	149.2%/135.8%	222.8%	156.9%/142.8%	7%	Midway – Waterton 345 kV & Daniels Park – Fuller 230 kV
MidwayBR – Rancho 115 kV	Line	CSU	92/92	96.2	104.6%/104.6%	N/A	N/A	N/A	Comanche – Daniels Park 345 kV # 1&2
MidwayBR – Rancho 115 kV	Line	CSU	92/92	N/A	N/A	95.6	103.9%/103.9%	N/A	Comanche-Daniels Park 345 kV #1 Comanche – GI-2015
Rancho – LorsonRanch 115 kV	Line	CSU	92/92	94.4	102.6%/102.6%	N/A	N/A	N/A	Comanche – Daniels Park 345 kV # 1&2
Rancho – LorsonRanch 115 kV	Line	CSU	92/92	N/A	N/A	93.8	102%/102%	N/A	Comanche-Daniels Park 345 kV #1 Comanche – GI-2015

**Table 8- Generation Dispatch of Major Generating Units in the Study area (MW is Gross value)**

**PSCo:**

<b><u>Bus</u></b>	<b><u>LF ID</u></b>	<b><u>MW</u></b>
Comanche PV	S1	102
Comanche	C1	360
Comanche	C2	365
Comanche	C3	805
Lamar DC Tie	DC	140
Fountain Valley	G1	36
Fountain Valley	G2	36
Fountain Valley	G3	36
Fountain Valley	G4	36
Fountain Valley	G5	36
Fountain Valley	G6	36
Colorado Green	1	81
Colorado Green	2	81
Twin Butte	1	75
Twin Butte-II	W1	75
Jackson Fuller	W1	200
Alamosa CT	G1	0
Alamosa CT	G2	0
Cogentrix	S1	25.5
Greater Sandhill	S1	14.5
Blanca Peak	S1	19.5
SLV Solar	S1	44.2

**BHE:**

<b><u>Bus</u></b>	<b><u>LF ID</u></b>	<b><u>MW</u></b>
BUSCHWRTG1	G1	3.6
BUSCHWRTG2	G2	3.6
E Canon	G1	0
PP_MINE	G1	0
Pueblo Diesels	G1	0
Pueblo Plant	G1	0
Pueblo Plant	G2	0.0
R.F. Diesels	G1	0.0
Airport Diesels	G1	0.0
Canyon City	C1	0
Canyon City	C1	0
Baculite 1	G1	90
Baculite 2	G1	90
Baculite 3	G1	40.0
Baculite 3	G2	40.0
Baculite 3	S1	24
Baculite 4	G1	40.0

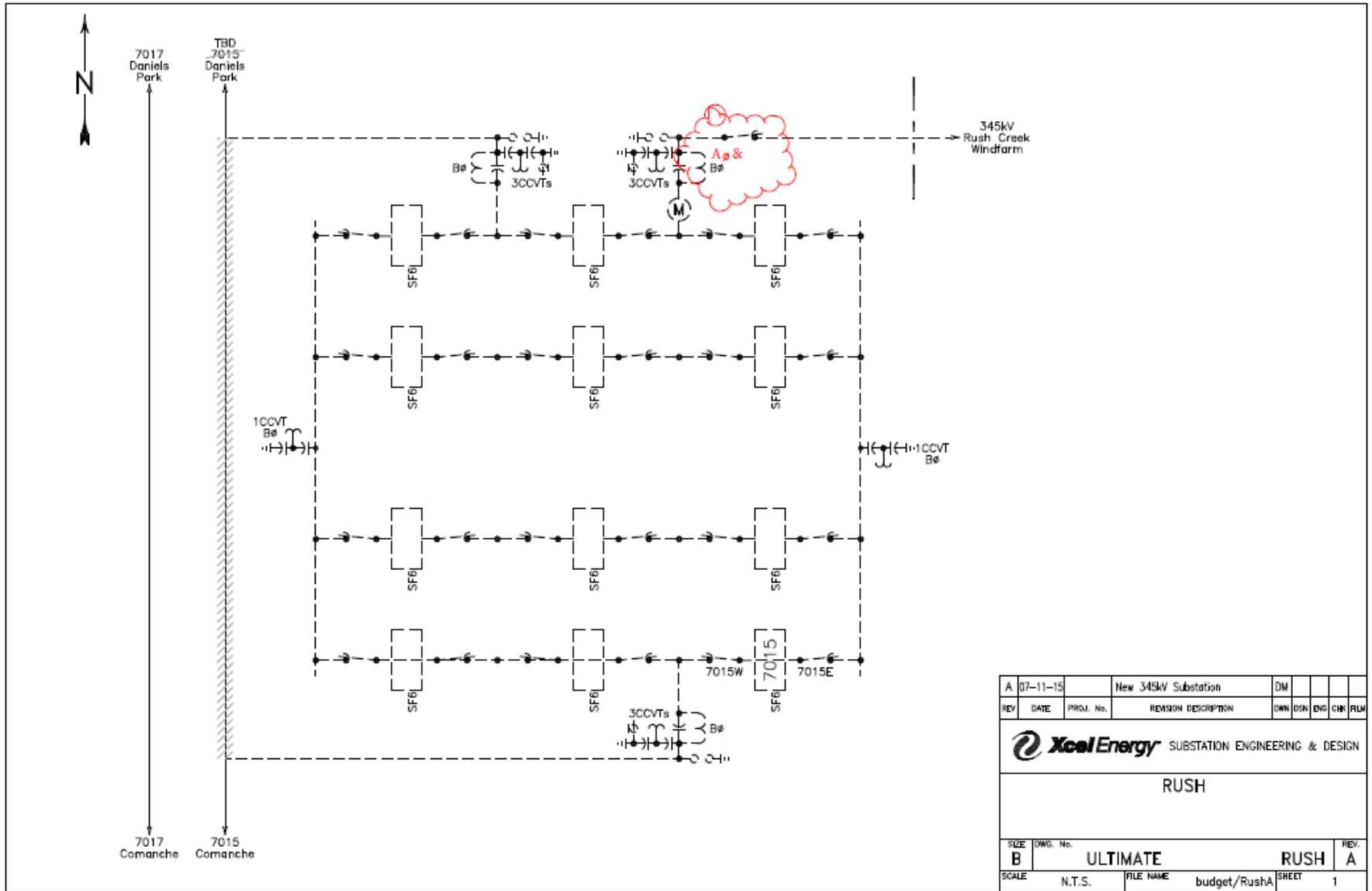


Baculite 4	G2	40.0
Baculite 4	S1	24
Baculite 5	G1	90

**CSU:**

<b><u>Bus</u></b>	<b><u>LF ID</u></b>	<b><u>MW</u></b>
Birdsale1	1	0.0
Birdsale 2	1	0.0
Birdsale 3	1	0.0
RD_Nixon	1	225.39
Tesla	1	13.2
Drake 5	1	49.65
Drake 6	1	81.19
Drake 7	1	138.03
Nixon CT 1	1	0.0
Nixon CT 2	1	0.0
Front Range CC 1	1	125.4
Front Range CC 2	1	125.8
Front Range CC 3	1	124.0

Figure -1-GI-2015-1 Conceptual One-Line Diagram of the POI



REV	DATE	PROJ. No.	REVISION DESCRIPTION	OWN	DSN	ENG	CHK	FLW
A	07-11-15		New 345kV Substation	DM				
SUBSTATION ENGINEERING & DESIGN								
RUSH								
SIZE	DWG. No.		ULTIMATE	RUSH			REV.	
B							A	
SCALE	FILE NAME		SHEET					
N.T.S.	budget/RushA		1					

