



Generation Interconnection Facilities Study Report

Request # GI-2011-04

**587 MW (summer), 643 MW (winter)
2x1 Combined Cycle Generating Plant
Cherokee Station, Denver, Colorado**

**Public Service Company of Colorado
Transmission Planning**

October 4, 2013

Executive Summary

This Interconnection Facilities Study Report summarizes the analysis performed by Public Service Company of Colorado (PSCo) to specify and estimate the cost of the equipment, engineering, procurement and construction work needed to physically and electrically connect the GI-2011-4 2x1 Combined Cycle Generating Facility to PSCo's transmission system at the existing Cherokee station in Denver, Colorado.

The three new generating units – 2 CT units and 1 HRSG unit – are proposed to interconnect at the South 115 kV bus of the existing Cherokee Station as shown in the budget one-line diagram (see Figure 2). The requested in-service date was June 30, 2015. The Interconnection Customer has targeted attaining commercial operation by August 1, 2015.

The purpose of the project is to interconnect the proposed generation facility (Cherokee #5, #6 and #7) consisting of two identical gas-fired 218 MVA combustion turbine (CT) generators (units #5, #6) and one 300 MVA steam turbine (ST) generator (unit #7) connected in a combined cycle configuration. This 2x1 CC generation facility is proposed to interconnect to the Cherokee South 115 kV switchyard via three (3) separate generator step-up transformers. See Figure 2 for interconnection details.

The interconnection of 3 new generators comprising the 2x1 CC generating facility will be accomplished in five construction sequences within the Cherokee Station, as shown in the one-line diagrams included in Appendix A.

The total estimated cost for the interconnection facilities and network upgrades required for GI-2011-04 is \$10.1 million¹ which includes the following:

- \$4.614 million for Customer-Funded Interconnection Facilities
- \$1.620 million for PSCo-Funded Interconnection Network Facilities
- \$3.865 million for PSCo-Funded Network Upgrades for Delivery

The estimated time required to site, engineer, procure and construct the described facilities is at least 15 months from the date the Customer meets all applicable milestones as agreed to in any future LGIA.

An Engineering & Procurement Agreement was executed to facilitate completion of the interconnection facilities by the requested in-service date of June 30, 2015.

¹ Appropriation estimates considered to have an accuracy of +/- 20%.

Figure 1: Network Diagram with Proposed POI at Cherokee Station

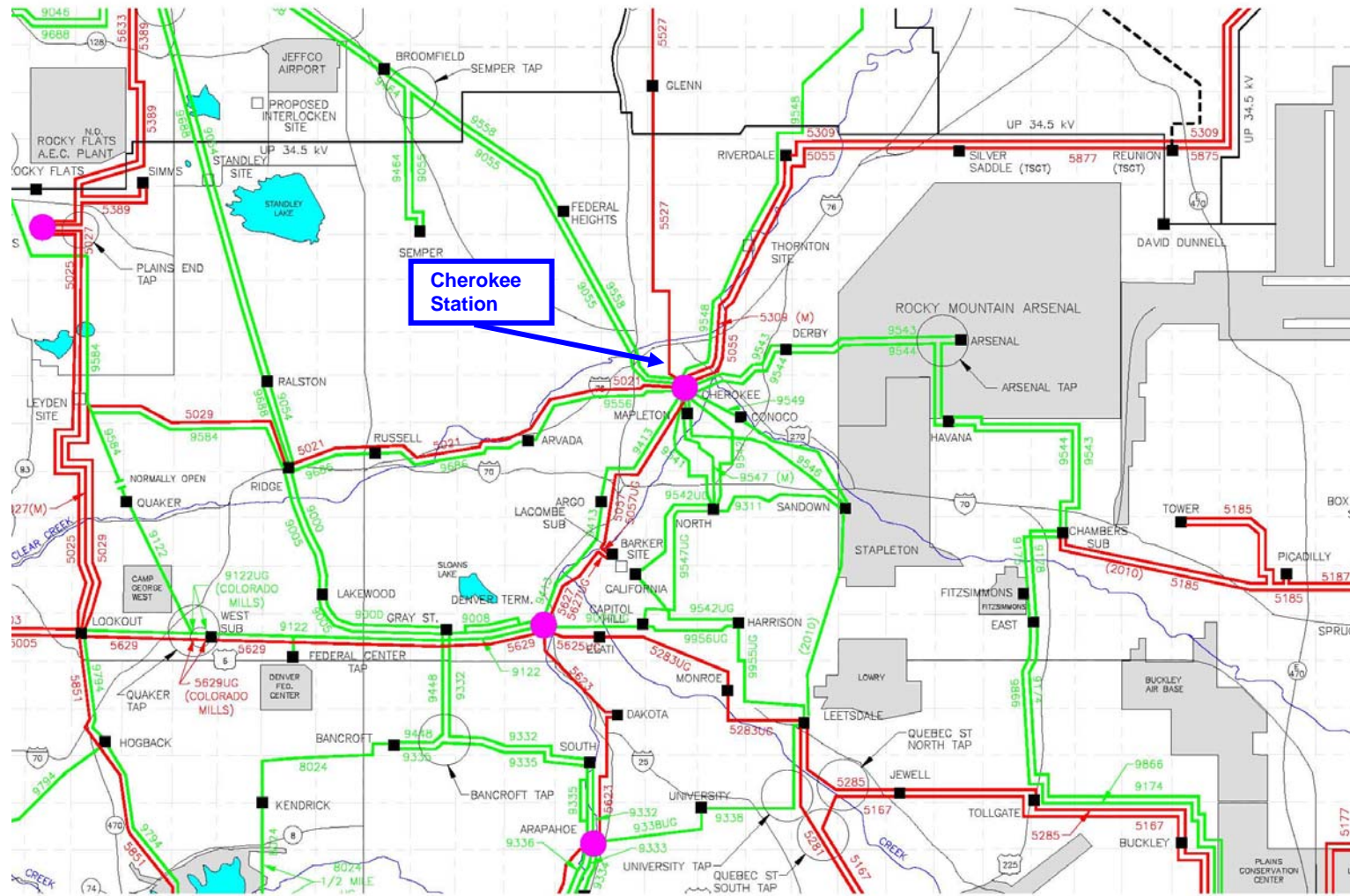
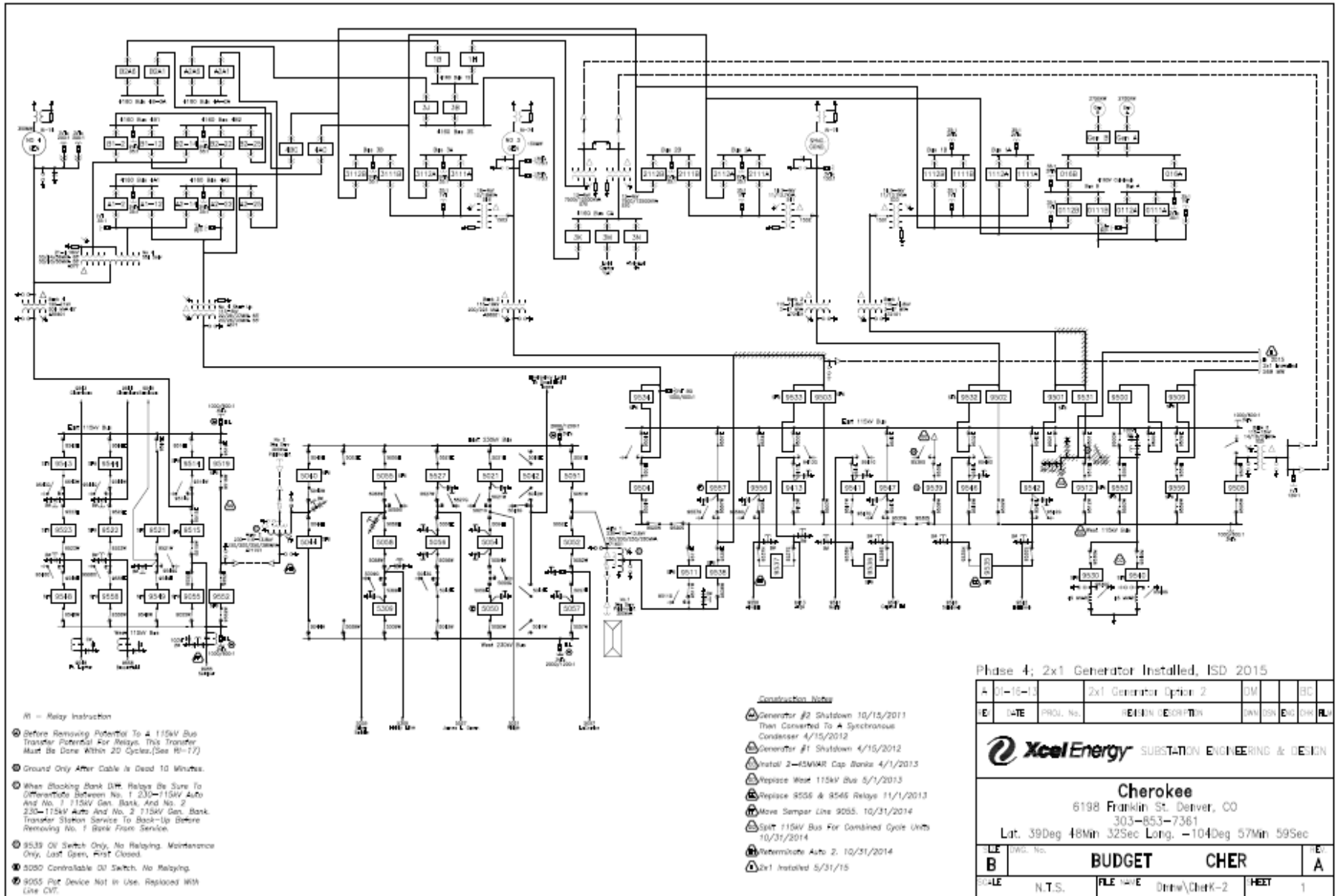


Figure 2: Cherokee Station Budget One-Line Diagram with GI-2011-4 and Station Upgrades



I. Introduction

On April 7, 2011, Public Service Company of Colorado (PSCo) received an interconnection request (GI-2011-04) for a 2 x 1 Combined Cycle (CC) generation facility with 587 MW (summer), 643 MW (winter) rated output. The Point Of Interconnection (POI) for this generation facility is PSCo's Cherokee 115 kV Station in Denver, Colorado, as shown in Figure 1.

The requested in-service date was June 30, 2015. However, as per a plan filed by the Interconnection Customer with the Colorado Public Utilities Commission, the proposed generation facility is required to be placed in commercial service no later than December 31, 2015. The Interconnection Customer has targeted attaining commercial operation by August 1, 2015.

The Feasibility Study was completed on September 24, 2012, followed by the completion of Interconnection System Impact Study on August 30, 2013. The purpose of Interconnection Facilities Study is to specify and estimate the cost of the equipment, engineering, procurement and construction work needed to implement the conclusions of the Interconnection System Impact Study in accordance with Good Utility Practice to physically and electrically connect the GI-2011-04 large generating facility to PSCo's transmission system at the Cherokee 115 kV Station.

II. Project Purpose & Scope

The purpose of the project is to interconnect the proposed generation facility (Cherokee #5, #6 and #7) consisting of two identical gas-fired 218 MVA combustion turbine (CT) generators (#5, #6) and one 300 MVA steam turbine (ST) generator (#7) connected in a combined cycle configuration. This 2x1 CC generation facility is proposed to interconnect to the Cherokee South 115 kV switchyard via three (3) separate generator step-up transformers. See Figure 2 for interconnection details.

The interconnection of 3 new generators comprising the 2x1 CC generating facility will be accomplished in five construction sequences within the Cherokee Station, as identified below, and shown in the one-line diagrams included in Appendix A.

- 1) Rebuild the West Main Bus in the Cherokee South 115KV switchyard from 300 MVA rating to a 750 MVA rating.
- 2) Split the Cherokee 115kV Station into the Cherokee 115kV North and Cherokee 115kV South stations by disconnecting the two existing bus-ties between the North and South 115kV switchyards.
- 3) Reterminate the 115kV side of Auto-Transformer #2 to a new bay in North 115kV switchyard to make available its old bay in the South 115kV switchyard for interconnection of the first new generator.
- 4) Reterminate the existing Cherokee Unit #3 to a new bay in the South switchyard to make its old bay available for interconnection of the second new generator.
- 5) Install two new circuit-breakers in the South switchyard for interconnection of the third new generator.

III. Interconnection Facilities & Network Upgrades for GI-2011-04 Interconnection

Requirements for interconnection of new generation to the Xcel Energy Operating Companies' transmission system can be found in the *Interconnection Guidelines for Transmission Interconnected Producer-Owned Generation Greater than 20 MW – Version 3.0²*, last revised in December 2006. These guidelines describe the technical and protection requirements for generator interconnection and also require that the Interconnection Customer be in compliance with all applicable criteria, guidelines, standards, requirements, regulations, and procedures issued by the North American Electric Reliability Council, Public Utility Commission or their successor organizations.

A. FERC and/or NERC Compliance Requirements

Critical Infrastructure Protection (CIP) Asset

Cherokee is an existing BES station, and it is not identified as a CIP Critical Asset location.

Facility Ratings

All transmission facilities in Cherokee station will be rated as per PSCo's current facility rating methodology.

B. Right of Way / Site Permitting

No new transmission line is identified as a network upgrade – hence no new right of way or site permitting is needed.

C. Electrical Features

Fault Current

All bus-bars and equipment in the Cherokee 115kV switchyard are designed to withstand 63 kA fault current duty. The existing pre-project and the future post-project fault levels in Cherokee 115kV Station are respectively tabulated below.

Existing Pre-Project Fault Levels

Type of Fault Location	Three Phase (A)	Single- Line-to- Ground (A)
115KV East & West bus - each	61,000	62,500

² Interconnection Guidelines can be found at www.xcelenergy.com.

Future Post-Project Fault Levels

Type of Fault Location	Three Phase (A)	Single-Line-to-Ground (A)
North yard 115KV East & West bus	40,121	37,782
South yard 115KV East & West bus	49,634	51,912

Electrical Removals & Relocations

- 1) When the West Bus is rebuilt, the 2000A bus tie Gang Switches 9520N, 9520S, 9530N, & 9530S will be removed because they are physically too high and their rating of 2000A is inadequate for existing loads. New bus support foundations and structures will be installed with double sets of extra high strength insulators for mounting the 6” electrical tubing. This construction will upgrade the South Yard - West 115KV bus load carrying capability to 750MVA and maintain a Short Circuit withstand capability rating of 63KA.
- 2) The North and South 115KV yards will be split for a variety of reasons: 1) To make the bay in the North yard, where the tie connections are, available for the #2 auto transformer output; and also to make way in the South yard for one of the new generators’ output. 2) To lower the fault level value in both the North yard and the South yard. This is necessary in order to keep the fault current availability level at an acceptable value after the new generation is installed.
- 3) Two of the three new generators will be connected to the 115kV switchyard by overhead lines – the third by UG line

Electrical Installations (Major Equipment)

- a) Two sets of bus pots (3 each) – one set each for East and West buses in the South yard.
- b) Four 115KV circuit-breakers:
 - i. Two for the re-termination of #2 Auto in a new bay in North 115KV yard.
 - ii. Two to interconnect one new generator in a new bay in South 115KV yard.
- c) Three 115KV relay panels for line protection, each relay panel with double sets of SEL-311L relays and SEL-351 relays and associated equipment – one for each of three new generating units.
- d) Two 115KV bus differential relay panels
- e) Two CT Summation Cabinets – one for the new bay in North 115KV yard for retermination of #2 Auto and the other for new bay in South 115KV yard to interconnect one new generator.

- f) Three 115KV B-phase CCVTs – one for each new generating unit.
- g) Three sets of CT/VT metering units with station surge arrestors (3 each) – one set for each new generating unit.
- h) One 115KV voltage switching panel

Transmission Lines: Current Carrying Capacity of Affected/Tapped/New

No change.

AC System

One 120/208V 225A AC Load Center to be installed in the vicinity of new 115KV breakers 9509 & 9559 in South yard.

DC System

Two 130V DC Load Centers (one for DC Trip 1 and the other for DC Trip 2) to be installed in the vicinity of new 115KV breakers 9509 & 9559 in South yard.

Grounding

Three runs of grounding will be installed – one for each generator – between the 115kV South transmission switchyard and the 115kV generator switchyards.

Lightning Protection

Shield wires will be provided for the two 115kV overhead lines interconnecting to the 115kV generator switchyards.

Station arrestors will be provided for each of the sets of CT/VT metering units located in the 115kV generation switchyards.

Trenching & Cable

Two 23-pair fiber optic cable runs to the 115kV generation switchyards – one run via OPGW and the other run via underground conduit. OPGW will be for primary relays and underground conduit run for backup relays.

Two 4" conduits each required for four new breakers with associated new cabling.

One set each of 3" conduits with associated new cabling for new bus pots being installed on East and West buses.

One set each of 3" conduits for 3 nos. 115kV B-phase CCVTs for generating unit interconnection line bays and for #2 auto transformer bay.

D. Civil Features

Foundations & Structural

No new oil containment is required.

Civil Removals & Relocations

None.

Civil Installations

Four concrete slab foundations required for four new 115kV circuit breakers.

E. Protection & Control Features

Generator Interconnection Line Protection (115kV)

Primary and Backup SEL-311-L Line Differential Relaying with Breaker Failure for breakers associated with each 115KV transmission line to generating unit.

Control Features

- Generator breakers located in 115KV yard will only be able to be closed after sensing no voltage on lines from incoming new generators (Synchronizing will take place on breakers located in generation area). After the first breaker is closed, the second breaker in the 115kV switchyard will be allowed to be closed (bypassing the voltage sensing blocking).
- Where a breaker and a half situation exists for new generation, center breaker will be interlocked such that the outside breaker must be in a closed position before the center breaker will be able to be closed

Generator Breaker Reclosing Controls

No reclosing on generator breakers.

Protection & Control Panel Locations

Three protective relay panels, one each for transmission line interconnecting to each new generator will be located in existing 115KV South switchyard control building.

Three protective relay panels for generator end breakers will be provided by the Interconnection Customer to be located in the 115kV generation switchyard.

Primary Metering

Primary metering CT/VT assemblies for each generating unit will be located in the 115kV generation switchyard.

SCADA

There will be SCADA control on new breakers in the 115KV generation switchyard via LFC/AGC SCADA. This will include open/closed status indication for each new breaker in the 115KV generation switchyard.

Telephone Protection

Not Applicable

F. Project Operating Concerns and Facility Outages

Facility Outages / Temporary Configurations

- A) The West bus outages will take place in two parts. The south section (w/bus tie gang switches 9530N & 9530S open) will be rebuilt while CHER #4 boiler is out for maintenance. The 9550W Cap Bank gang switch and 9559W gang switch will be attached to West bus in South yard during this same outage.
- B) The East & West bus splits between North and South yards will take place immediately after West bus is rebuilt.
- C) The #2 Auto transformer 115KV output will be relocated to North yard immediately after North/South bus splits.
- D) 9055/9549 line moves can take place at any time (load conditions permitting)
- E) The #3 generating unit can be relocated to its new location at any time after SEMP 9055 has been moved to North switchyard area. One of the new generating units will be attached to the old #3 generating line location after the #3 gen line move.
- F) After the #1 GSU line move to its new location, the second new generating unit can be attached to the old #1 GSU line location
- G) An East bus outage in the South yard will be required to make connection of 9500E Gg Sw and 9509E Gg Sw.
- H) Finally, the third new generating unit can be attached to its two new breakers at any time after that.

Material Staging Plan

All materials will be delivered directly to job site and stored in the existing 115 kV yard. Ample space is available for staging.

G. Cost Estimates and Assumptions

Appropriation level cost estimates for Interconnection Facilities and Network/ Infrastructure Upgrades for Delivery (+/- 20% accuracy) were developed by Xcel Energy/PSCo Engineering staff. The cost estimates are in 2013 dollars with escalation and contingencies applied (AFUDC is not included) and are based upon typical construction costs for previously performed similar construction.

The estimated total cost for the GI-2011-04 interconnection project is **\$10.1M**. This estimate includes all applicable labor and overheads associated with the engineering, design, material/equipment procurement and construction of these new PSCo facilities. This estimate does not include the cost for any other Customer owned equipment and associated design and engineering.

Tables 4, 5 and 6 given below list the transmission improvements required to accommodate the interconnection and delivery of GI-2011-04 generation output. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines.

Table 4 – PSCo Owned; Customer Funded Transmission Provider Interconnection Facilities

Element	Description	Cost Est. (Millions)
PSCo's Cherokee Transmission Substation	Interconnect Customer to the 115kV bus at Cherokee Substation. The new equipment includes: <ul style="list-style-type: none"> • Two 115kV, 3000 amp gang switches • Six 115kV lightning arresters • Primary metering for Load Frequency/Automated Generation Control • Power Quality Metering • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated transmission line communications, fiber, relaying and testing 	\$1.348
PSCo's Cherokee Transmission Substation	Overhead 115kV Transmission line tap from Customer's last line structure outside of PSCo's yard for units 5 and 6 into new bay position (assumed 1000 span, conductor, hardware and labor).	\$0.676
PSCo's Cherokee Transmission Substation	Underground 115kV transmission line tap from Customer's last line structure outside of PSCo's yard for unit 7 into new bay position (assumed 1400' span, conductor, hardware and labor).	\$2.590
	Total Cost Estimate for PSCo-Owned, Customer-Funded Interconnection Facilities	\$4.614
Time Frame	Site, design, procure and construct	15 Months

Table 5: PSCo Owned; PSCo Funded Interconnection Network Facilities

	Description	Cost Estimate (Millions)
PSCo's Cherokee Transmission Substation	Interconnect Customer to the bus at the Cherokee Substation. The new equipment includes: <ul style="list-style-type: none"> • Two 115kV 3000 amp gas circuit breakers • Four 115kV, 3000 amp gang switches • Associated station controls, communications, supervisory and SCADA equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated equipment and system testing • Associated yard surfacing, landscaping, fencing 	\$1.620
	Total Cost Estimate for PSCo-Owned, PSCo-Funded Interconnection Facilities	\$1.620
Time Frame	Site, design, procure and construct	15 months

Table 6 – PSCo Network Upgrades for Delivery

Element	Description	Cost Est. (Millions)
PSCo's Cherokee Transmission Substation	Major equipment for removing 115kV bus ties, re-terminating autotransformer #2 to the north 115kV yard, relocating the Semper 9055 line terminal to the north 115 yard, and replacing the SE strain bus with 6" AL tube. <ul style="list-style-type: none"> • Three 115kV 3000 amp gas circuit breakers • Five 115kV, 3000 amp gang switches • Associated station controls, communications, supervisory and SCADA equipment • Associated electrical equipment, bus, wiring and grounding • Associated foundations and structures • Associated equipment and system testing • Associated yard surfacing, landscaping, fencing 	\$3.256
PSCo's Line 9549 Cherokee to Conoco Transmission Line	Re-conductor 1.985 miles of existing 1-477 ACSR Hawk transmission line with 477 ACSS Hawk conductor	\$0.409
PSCo's Capital Hill Terminal 115kV Transmission Substation	Replace existing 1-795 Al termination jumpers with new bundled 795 ACSR conductor.	\$0.100

Element	Description	Cost Est. (Millions)
PSCo's California Terminal 115kV Transmission Substation	Replace existing 1-795 Al termination jumpers with new 1-1272 AL conductor.	\$0.100
	Total Cost Estimate for PSCo Network Upgrades for Delivery	\$3.865
Time Frame	Site, design, procure and construct	15 Months
	Total Project Estimate	\$10.10

Cost Estimate Assumptions

- Appropriation level cost estimates (+/- 20% accuracy) for Interconnection Facilities and Network/Infrastructure Upgrades for Delivery were developed by Xcel Energy/PSCo Engineering.
- Cost Estimates are based on 2013 dollars (appropriate contingency and escalation applied).
- AFUDC has been excluded.
- Lead times for materials were considered for the schedule.
- PSCo (or it's Contractor) crews will perform all construction, wiring, testing and commissioning for PSCo owned and maintained facilities.
- Construction labor is estimated for straight time only – no overtime included.
- The estimated time to site (support), design, procure and construct the Interconnection Facilities and Network Upgrades is approximately 15 months after authorization to proceed has been obtained.
- A CPCN is not required for the construction of Interconnection Facilities and Network Upgrades.
- Line and station bus outages will be authorized during the construction period to meet the requested back-feed date(s).



IV. Engineering, Procurement & Construction Schedule

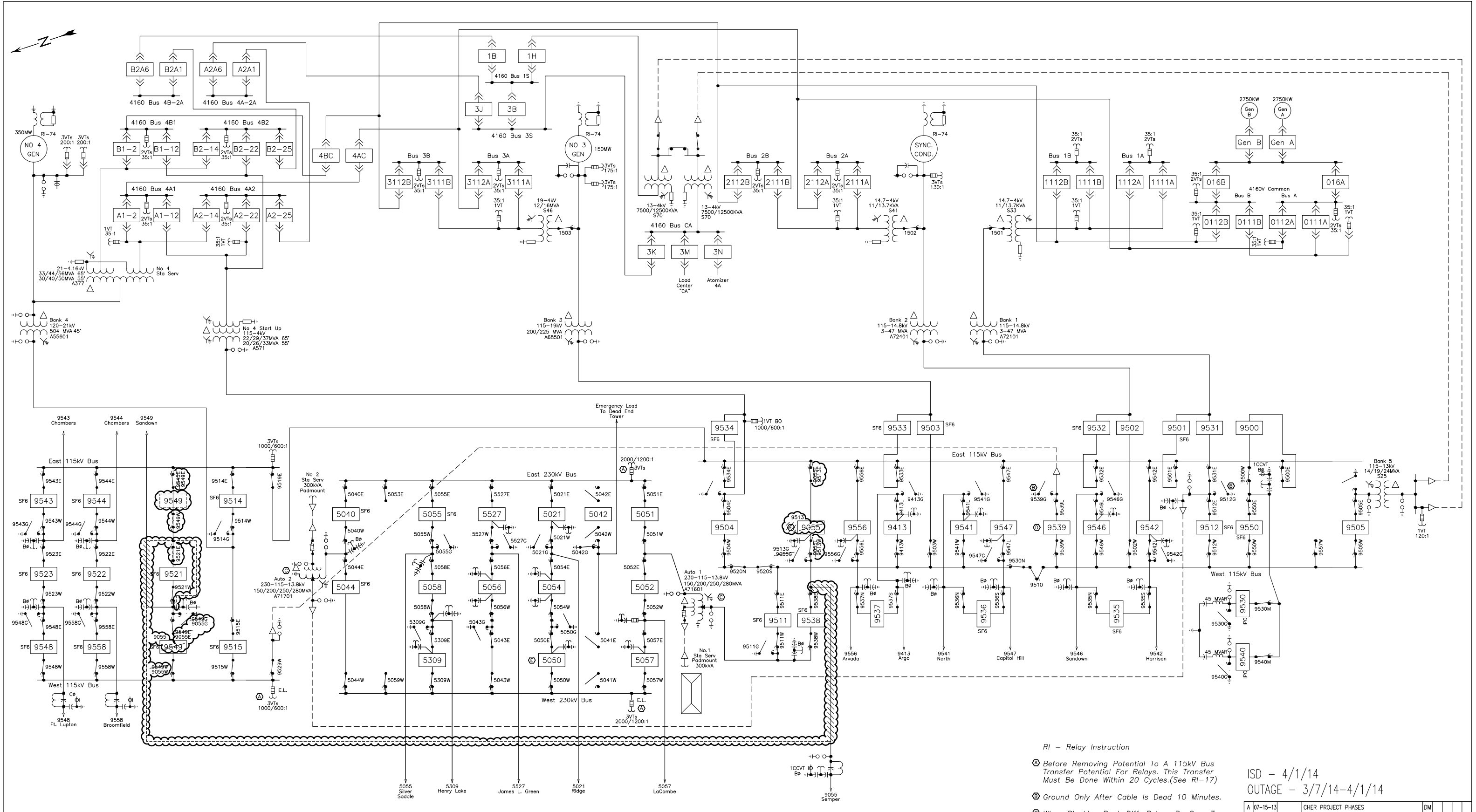
The Interconnection Customer has proposed the following schedule for significant milestones of the GI-2011-04 generation interconnection project:

Back-feed Power to Generator Step-Up (GSU) Transformers –	December 1, 2014
Generation Testing (first-fire) –	March 7, 2015
Commercial Operation –	August 1, 2015

The site, design, procure and construct time-frame of 15 months noted in Tables 4, 5 and 6 is consistent with these meeting these milestones.

Appendix A

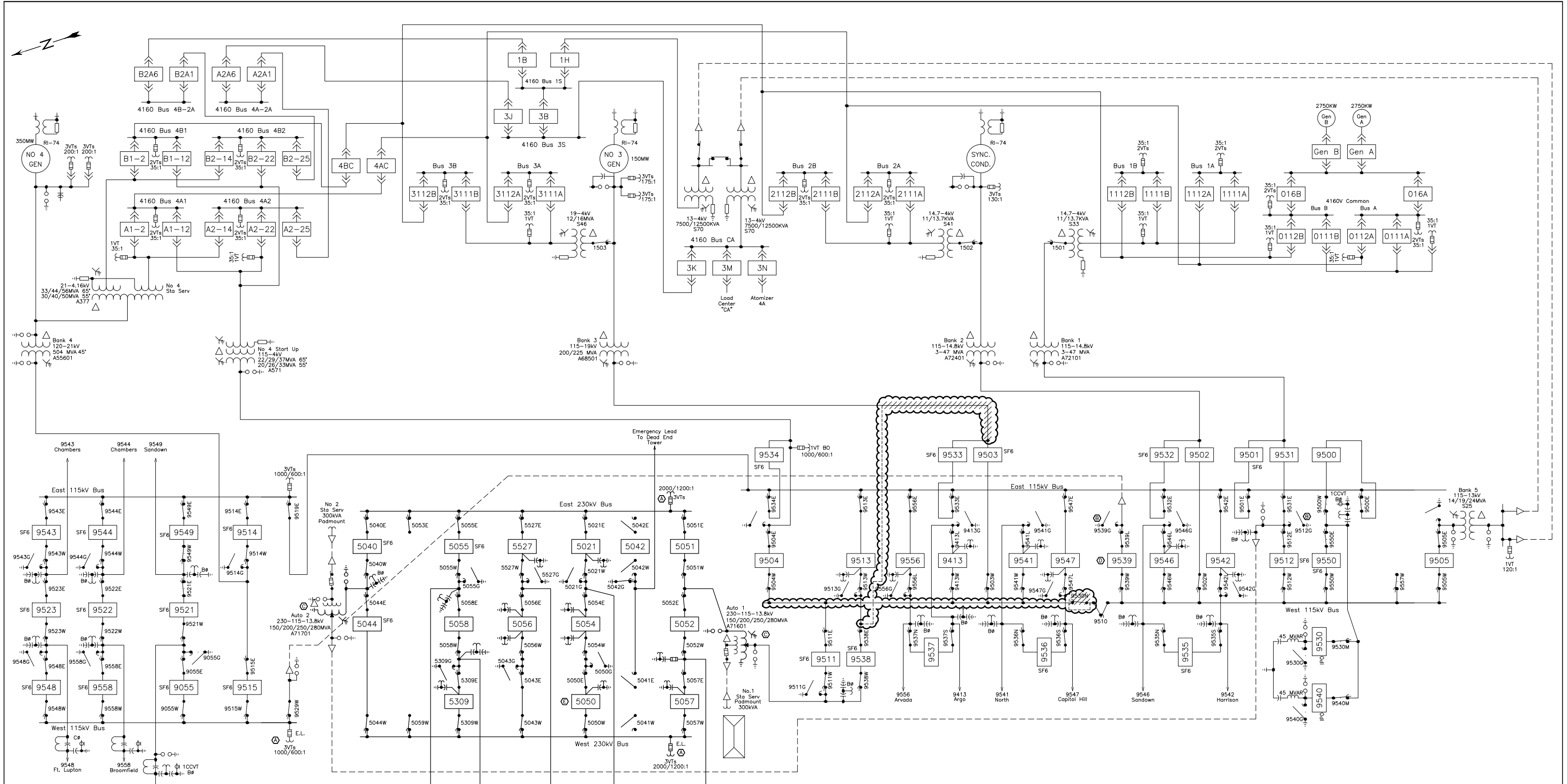
One-Line Diagrams for Construction Sequence at Cherokee Station



- RI - Relay Instruction
- ⊗ Before Removing Potential To A 115kV Bus Transfer Potential For Relays. This Transfer Must Be Done Within 20 Cycles. (See RI-17)
 - ⊗ Ground Only After Cable Is Dead 10 Minutes.
 - ⊗ When Blocking Bank Diff. Relays Be Sure To Differentiate Between No. 1 230-115kV Auto And No. 1 115kV Gen. Bank, And No. 2 230-115kV Auto And No. 2 115kV Gen. Bank. Transfer Station Service To Back-Up Before Removing No. 1 Bank From Service.
 - ⊗ 9539 Oil Switch Only, No Relaying. Maintenance Only, Last Open, First Closed.
 - ⊗ 5050 Controllable Oil Switch. No Relaying.
 - ⊗ 9055 Pot Device Not In Use. Replaced With Line CVT.

ISD - 4/1/14
 OUTAGE - 3/7/14-4/1/14

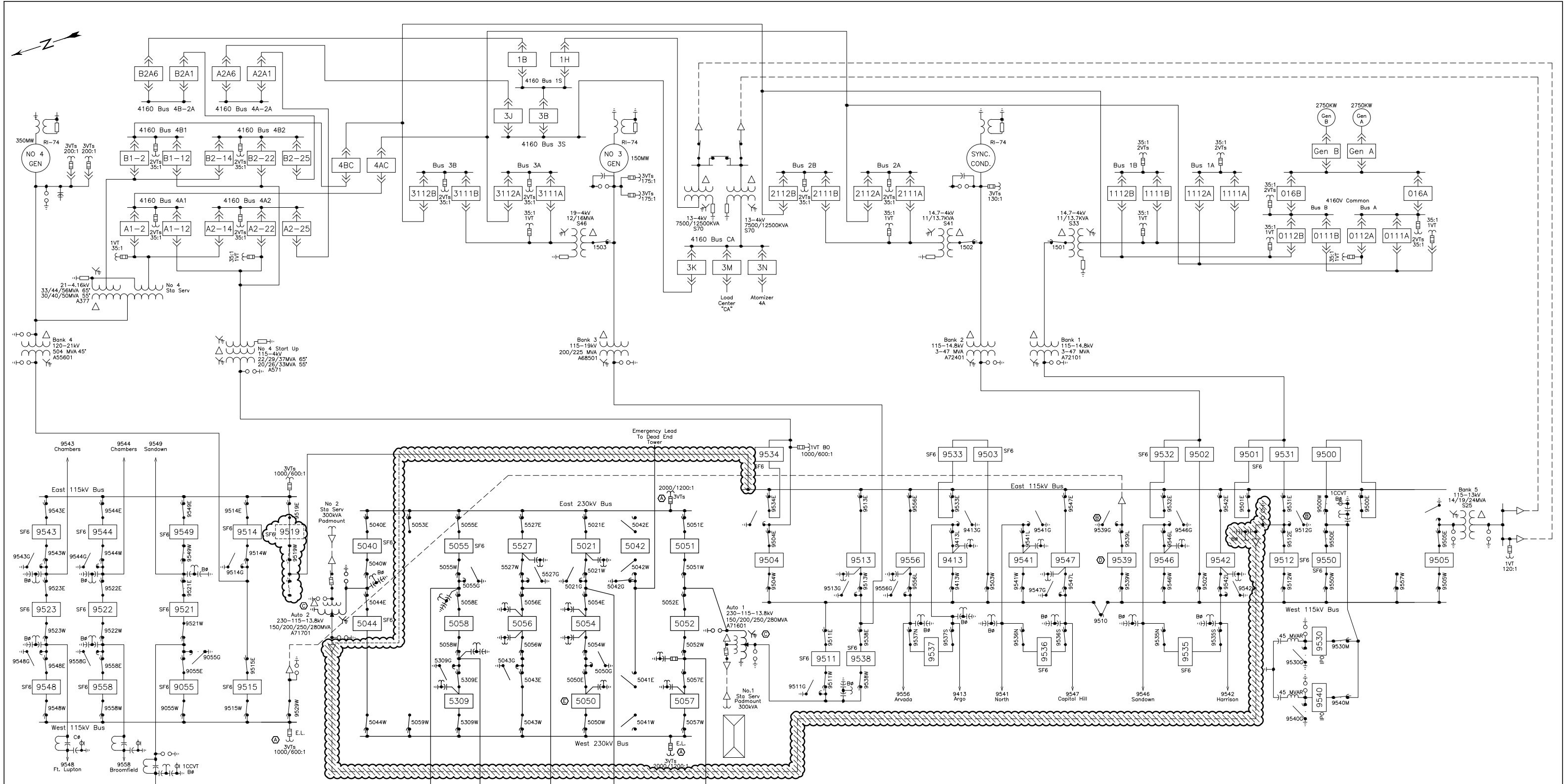
A 07-15-13		CHEROKEE PROJECT PHASES			DM			
REV	DATE	PROJ. No.	REVISION DESCRIPTION	DM	DSN	ENG	CHK	
Xcel Energy SUBSTATION ENGINEERING & DESIGN								
CHEROKEE 6198 Franklin St. Denver, CO 303-853-7361 Lat. 39Deg 48Min 32Sec Long. -104Deg 57Min 59Sec								
SIZE	D						DWG. No.	SEQUENCE 3
SCALE	N.T.S.						FILE NAME	Dmnw\CherN.dwg
							SHEET No.	1



- RI - Relay Instruction
- ⓐ Before Removing Potential To A 115kV Bus Transfer Potential For Relays. This Transfer Must Be Done Within 20 Cycles.(See RI-17)
 - ⓑ Ground Only After Cable Is Dead 10 Minutes.
 - ⓒ When Blocking Bank Diff. Relays Be Sure To Differentiate Between No. 1 230-115kV Auto And No. 1 115kV Gen. Bank, And No. 2 230-115kV Auto And No. 2 115kV Gen. Bank. Transfer Station Service To Back-Up Before Removing No. 1 Bank From Service.
 - ⓓ 9539 Oil Switch Only, No Relaying. Maintenance Only, Last Open, First Closed.
 - ⓔ 5050 Controllable Oil Switch. No Relaying.
 - ⓕ 9055 Pot Device Not In Use. Replaced With Line CVT.

ISD - 5/15/14
 OUTAGE - 4/15/14-5/15/14

REV	DATE	PROJ. No.	REVISION DESCRIPTION	DM	EN	CHK	FLW	
A	07-15-13		CHER PROJECT PHASES					
SUBSTATION ENGINEERING & DESIGN								
CHEROKEE 6198 Franklin St. Denver, CO 303-853-7361 Lat. 39Deg 48Min 32Sec Long. -104Deg 57Min 59Sec								
SIZE	D						DWG. No.	SEQUENCE 4
SCALE	N.T.S.						FILE NAME	Dmnw\CherN.dwg
							SHEET No.	1



- RI - Relay Instruction
- ⊗ Before Removing Potential To A 115kV Bus Transfer Potential For Relays. This Transfer Must Be Done Within 20 Cycles.(See RI-17)
 - ⊗ Ground Only After Cable Is Dead 10 Minutes.
 - ⊗ When Blocking Bank Diff. Relays Be Sure To Differentiate Between No. 1 230-115kV Auto And No. 1 115kV Gen. Bank, And No. 2 230-115kV Auto And No. 2 115kV Gen. Bank. Transfer Station Service To Back-Up Before Removing No. 1 Bank From Service.
 - ⊗ 9539 Oil Switch Only, No Relaying. Maintenance Only, Last Open, First Closed.
 - ⊗ 5050 Controllable Oil Switch. No Relaying.
 - ⊗ 9055 Pot Device Not In Use. Replaced With Line CVT.

ISD - 10/1/14
 OUTAGE - 9/1/14-10/1/14

REV	DATE	PROJ. No.	REVISION DESCRIPTION	DM	EN	CHK	FLW
A	07-15-13		CHER PROJECT PHASES				

Xcel Energy SUBSTATION ENGINEERING & DESIGN

CHEROKEE
 6198 Franklin St. Denver, CO
 303-853-7361
 Lat. 39Deg 48Min 32Sec Long. -104Deg 57Min 59Sec

SIZE	DWG. No.	SEQUENCE 5	REV.	A
SCALE	N.T.S.	FILE NAME Dmnw\CherN.dwg	SHEET No.	1

