Xcel Energy

System Impact Study

TSG&T Request

For 100 MW of Craig Generation (DNR)

To be delivered to points under the NITS Agreement

PSCo Transmission Planning

September 26, 2013

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I. Executive Summary

PSCo and TSG&T executed a System Impact Study (SIS) agreement on July 26th, 2013. The scope of work consists of two phases:

> Phase I - The SIS process will determine whether adequate capacity will be available to provide 100 MW of Designated Network Resources (DNR's) under the current Network Integration Transmission Service (NITS) the current (NITS) from Craig Substation to Points of Delivery, and
>
> Phase II - If the capacity available falls short of the request, options to alleviate the constraint will be determined.

Phase 1

PSCo Transmission Planning, pursuant to the OATT, utilized existing studies to the extent practical in performing this study. PSCo has evaluated the results of the most current TOT5 prior outage documents from Western Area Power Administration (WAPA) the TOT5 Path Operator. PSCo has listed this prior outage information at Table 6 in the Appendix. This document has been distributed to the owners of TOT5 and it is used in real time operations to calculate the total Available Transfer Capability (ATC) and each owners' ATC. These prior outage studies indicate that PSCo's ATC on TOT5 is significantly reduced based on a multitude of transmission lines owned by PSCo. In several prior outage conditions, the PSCo TOT5 ATC is reduced to 0 MW. PSCo has determined based on these prior outage studies (N-1) that there is 0 MW ATC available on TOT5 to meet the TSG&T request.

Phase 2

A study was conducted to evaluate a 100 MW increase in the TOT5 west-to-east transfer capability from 1680 MW to 1780 MW. The 100 MW increase is needed to accommodate TSG&T's request in obtaining 100 MW of firm transmission service across TOT5 to allow its Craig generating units to be considered Designated Network Resources for NITS. The study assumes that TSG&T will be able to use the entire 100 MW of theTOT5 transfer capability increase from 1680 MW to 1780 MW without regard to how this increase would be allocated among the four owners of TOT5. PSCo mentioned in a recent Scoping Meeting with TSG&T that the study would look at network upgrades only to provide their request of 100 MW. PSCo indicated that the study would not determine any allocation of rights among the TOT5 owners or perform any WECC path rating studies. TSG&T at that meeting agreed, indicating the issue would be addressed during a Facilities Study process.

A 2014 winter on-peak stressed case that was developed by the Rocky Mountain Operating Study Group (RMOSG) for the "TOT5 2013-14 Winter SOL" studies recently completed by WAPA was used for the study. The case has TOT5 stressed to 1680 MW (west-to-east). The study used a case model with TOT5 increased from 1680 MW to 1780 MW and determined that TOT5 cannot not be increased to 1780 MW without creating voltage violations and thermal overloads. The study determined that a new Hayden-Blue River 230 kV transmission line of approximately 86 miles would be needed along with re-conductoring approximately 91 miles of four existing 230kV transmission lines in order to accommodate the 100 MW increase in the TOT5 transfer capability to 1780 MW. The study also determined that these projects would increase the TOT5 capability to a level significantly higher than 1780 MW. Although a precise determination of the TOT5 limit above 1780 MW was beyond the scope of the analysis, a preliminary analysis found that with the addition of the Hayden-Blue River 230kV transmission line (86 miles) and with the re-conductoring of 91 miles of transmission lines, the TOT5 capacity could increase to approximately 1900 MW, voltage issues being the limiting condition. Adding shunt capacitors at the Blue River and North Park Substation could increase the TOT5 capability to approximately 1950 MW. Thermal limits on TOT5 (other than those with existing operating solutions) do not appear to limit the path following the completion of the proposed mitigation projects, but determination of a more exact TOT5 limit above 1780 MW accounting for these projects would require additional analysis.

PSCo Siting and Land Rights completed an initial evaluation of the proposed Hayden-Blue River 230 kV transmission line project area and concluded that the proposed project would be feasible and could be permitted. The Siting and Land Rights Group did not find any siting or routing issues that would preclude the project from being completed; however, they maintain that it would be difficult for potential routes (ranging anywhere from 95 to 110 miles in length) to avoid BLM, Routt, White River and Arapahoe/Roosevelt National Forests and/or State lands Depending on the route, crossing federal land would likely trigger an Environmental Impact Statement which can take anywhere from 12 to 24 months to process. Also, up to seven local government permits may be required. Substantial mitigation would likely be involved as well.

PSCo Transmission Planning developed non-binding good faith cost estimates for the proposed network upgrades. The project is estimated to cost approximately $160.0 million.

II. Phase 1 – TOT5 ATC Determination

PSCo Transmission Planning, pursuant to the OATT, utilized existing studies to the extent practical in performing this study. PSCo has evaluated the results of the most current TOT5 prior outage documents from Western Area Power Administration (WAPA) the TOT5 Path Operator. PSCo has listed this prior outage information at Table 6 in the Appendix. This document has been distributed to the owners of TOT5 and it is used in real time operations to calculate the total Available Transfer Capability (ATC) and each owners' ATC. These prior outage studies indicate that PSCo's ATC on TOT5 is significantly reduced based on a multitude of transmission lines owned by PSCo. There are three prior outage conditions in which PSCo's TOT5 ATC is reduced 0 MW. Those lines are the Malta-Tarryall 230kV, Cabin Creek-Lookout 230kV, and the Malta-Breckenridge-Dillon 230kV as delineated in Table 6. In addition, Transmission Planning identified six transmission lines in Table 6 in which PSCo's share of the TOT5 ATC is less than 300 MW for a prior outage of these lines. They are the Hayden-Foidel Creek 230kV, Rifle-Malta 230kV, Basalt-Malta 230kV, Tarryall-Daniel Park 230kV, Blue River-Dillon 230kV, and Cabin Creek-Dillon 230kV.

PSCo currently has an initiative referred to as "asset renewal" that evaluates the conditions of transmission and substation equipment to be refurbished or replaced in the next five years based on needs and capital budget. This initiative creates many more challenges in granting transmission equipment clearances that routinely result in prior outages on TOT5.

PSCo Transmission Planning has concluded there is 0 MW of ATC available on TOT5 to meet the TSG&T request, based on our operational experience with outage coordination and the real time use of Table 6.

III. Phase 2 – Alleviating the TOT5 Constraint

A. Purpose

On July 26, 2013, PSCo and TSG&T executed a System Impact Study (SIS) agreement to determine whether adequate capacity will be available to provide 100 MW of Designated Network Resources (DNR) under the current NITS from Craig Substation to Points of Delivery, and if the capacity available falls short of the request, options to alleviate the constraint will be determined.

The purpose of the study is to determine if PSCo has at least 100 MW of existing capacity in TOT5 such that 100 MW of TSG&T's generating capacity at the Craig Substation can be Designated Network Resource under the NITS Agreement. If insufficient capacity is available, a study would be conducted to identify the network upgrades required to allow 100 MW of TSG&T's generating capacity at the Craig Substation to be Designated Network Resource under the NITS Agreement.

B. TOT5 Definition

The TOT5 WECC-defined path (WECC Path 39) represents the transmission lines that carry the power transfers from western Colorado to eastern Colorado across the Continental Divide. The path has a maximum west-to-east non-simultaneous rating of 1680 MW.

The system operating limit of the TOT5 transfer path is highly dependant on area demand. The transfer path owners include Western Area Power Administration-Rocky Mountain Region (Western-RMR), Tri-State Generation and Transmission (Tri-State G&T), Platte River Power Authority, and Public Service Company of Colorado (PSCo). The following lines comprise TOT5 in the study case:

Line/Transformer	Metered End
-North Park-Terry Ranch Road 230 kV	Terry Ranch Road
-Craig-Ault 345 kV	Craig
-Hayden-Gore Pass 230kV	Gore Pass
-Hayden-Gore Pass 138kV	Gore Pass
-Hopkins-Malta 230kV	Hopkins
-Basalt-Malta 230kV	Basalt
-Gunnison-Poncha 115kV	Poncha
-Curecanti-Poncha 230kV	Curecanti

C. Reliability Criteria

The WECC Reliability Criteria for Transmission System Planning will apply. The following criteria were used to evaluate system reliability:

Category A – System Normal
"N-0" System Performance Under Normal (No Contingency) Conditions (Category A)
NERC Standard TPL-001-0

Voltage:	0.95 to 1.05 per unit
Line Loading:	100 percent of continuous rating
Transformer Loading:	100% of highest 65 °C rating

Category B – Loss of generator, line, or transformer (Forced Outage)
"N-1" System Performance Following Loss of a Single Element
(Category B)
NERC Standard TPL-002-0

Voltage:	0.90 to 1.05 per unit
Line Loading:	100 percent of continuous rating
Transformer Loading:	115% of highest 65 °C rating for load-serving transformers

Note: Transformer loading will not exceed 110 percent of the system normal rating or an established emergency rating. PSCo allows 115%. Western allows 120%.
Platte River Power Authority buses must maintain a voltage of 0.92 p.u. or higher.

Category C – Loss of Bus or a Breaker Failure (Forced Outage)
"N-2 or More" System Performance Following Loss of Two or More Elements (Category C)
NERC Standard TPL-003-0

Voltage and Thermal:	Allowable emergency limits will be considered as determined by the affected parties and the available emergency mitigation plan. Curtailment of firm transfers, generation re-dispatch, and load shedding will be considered if necessary.

Category D – Extreme Events (Forced Outages)
"N-2 or More" System Performance Following Extreme Events (Category D)
NERC Standard TPL-004-0

Voltage and Thermal:	Allowable emergency limits as determined by available emergency mitigation plan. Curtailment of firm transfers, generation re-dispatch, and load shedding are permissible if necessary.

PSCo adheres to NERC Transmission Planning Standards and WECC Reliability Criteria, as well as internal Company criteria for planning studies. Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped. Also, transient voltage performance should meet the following criteria:

- Following fault clearing for Category B contingencies, voltage may not dip more than 25% of the pre-fault voltage at load buses, more than 30% at non-load buses, or more than 20% for more than 20 cycles at any bus.

- Following fault clearing for Category C contingencies, voltage may not dip more than 30% of the pre-fault voltage at any bus or more than 20% for more than 40 cycles at any bus.

In addition, transient frequency performance should meet the following criteria:

- Following fault clearing for Category B contingencies, frequency should not dip below 59.6 Hz for 6 cycles or more at a load bus[1].
- Following fault clearing for Category C contingencies, frequency should not dip below 59.0 Hz for 6 cycles or more at a load bus.

D. Study Case Selection

The case used for this study was developed from the Rocky Mountain Operating Study Group (RMOSG) operating case called "14hw2ap_RMOSG_T5_1680" (the case with TOT5 stressed west-to-east close to 1680 MW) that was developed for the "TOT5 2013-14 Winter SOL" studies.

E. Study Scenarios

This study considered the following study scenarios:

- Original, "base" scenario
- "Base" scenario with TOT5 increased to 1680 MW
- Scenario with TOT5 increased to 1780 MW, 100 MW higher than rating
- Scenario with TOT5 increased to 1780 MW with potential mitigation projects

F. Contingencies

The study area includes transmission equipments within Colorado and Southern Wyoming which roughly bound by Grand Junction to the west, Story to the east, Dave Johnston to the north, and San Luis Valley to the south. The following single and multiple contingency outages will be studied, both with and without operating practices modeled:

<u>Single Contingencies</u>

- Single contingencies of all branches of 69kV or above within the study area

<u>Multiple Contingencies</u>

1. Craig 345 kV Breaker 896 Failure
2. Craig 345 kV Breaker 596 Failure
3. Craig 230 kV Breaker 886 Failure
4. Craig 230 kV Breaker 586 Failure
5. Craig 230 kV Breaker 286 Failure
6. Hayden-Gore Pass 230 and 138-kV lines
7. Curecanti 230 kV Breaker 786 Failure

[1] Load buses include generating unit auxiliary loads.

G. Operating Practices

The following operating practices may be used to achieve the TOT5 1680 MW Limit.

Table 1. Operating Practices Used to Achieve the TOT5 1680 Transfer Limit

Action	Event Initiating the Action	Mechanism to Initiate the Action
Open the Mary's Lake 115-69kV transformer and the Estes-Grandby 69kV cable	Overload of the Mary's Lake 115-69kV transformer or Windy Gap-Mary's Lake 69kV line Craig-Ault 345kV outage Gore Pass-Blue River 230kV outage Blue River-Dillon 230kV + RAS (open Blue River transformer)	Relay Operation
Open the Hayden-Gore Pass 138kV line	Overload of the Hayden-Gore Pass 138kV line	Relay Operation
Open the Fraser-Mill 115kV line	Overload of the Fraser 138-115kV transformer	Relay Operation
Open the Curecanti 230-115kV transformer	Overload of the Curecanti 230-115kV transformer	Relay Operation
Open the Hopkins-Basalt 115kV line	Overload of the Hopkins-Basalt 115kV line	Operating Practice
Open the Cabin Creek-Georgetown 115kV line	Overload of the Cabin Creek 230-115kV transformers or overload of the Mill-Portal-Henderson-Georgetown-Cabin Creek 115kV system	Operating Practice
Open the Craig Breaker 345 kV #896 when TOT5 flows exceed 1500 MW (action done prior to an initiating event)	The failure of the Craig 345kV Breaker No. 896 to open during a fault results in opening Craig Breaker #792 and Craig Breaker #992 to clear the fault with the subsequent loss of the Craig-Ault 345kV line and the Craig-RifleCu 345kV line with system overloads	Operating Practice
Open the Blue River-Mill 115kV line	Overload of the Blue River-Mill 115kV line	Operating Practice
Reduce Cabin Creek generation	Overload of the Cabin Creek-Lookout 230kV line, Cabin Creek-Idaho Springs 230kV line or Idaho Springs-Lookout 230kV line	Operating Practice
Reduce Mt. Elbert generation	Overload of the Malta-Poncha 115kV line	Operating Practice
Reduce Blue Mesa generation (connecting to the 115kV system at Blue Mesa)	Overload of the Blue Mesa-Skito-Gunnison 115kV system	Operating Practice
Reduce Morrow Point generation (connecting to the 230kV system at Curecanti)	Curecanti overloads	Operating Practice

H. Study Case Development

A 2014 winter on-peak stressed operating case that was developed by the Rocky Mountain Operating Study Group (RMOSG) for the "TOT5 2013-14 Winter SOL" Study (recently completed by WAPA) was used for this study. The case includes the Terry Ranch Road Project[2] along with the most up-to-date load and topology representations for the 2013-2014 winter operating season.

The RMOSG operating case was examined and it was determined that TOT5 in the case is stressed to 1660 MW (west-to-east). This is approximately 20 MW less than the 1680 MW limit. The difference is due to how WAPA measured the TOT5 flow in the RMOSG operating case. The RMOSG operating case was modified by increasing the TOT5 west-to-east schedules in the operating case to achieve 1680 MW on TOT5 to make up for the 20 MW difference in the calculation. Due to the failure of the Waterflow phase shifting transformer, all phase shifting transformers at the Waterflow (San Juan) Substation and the Shiprock Substation were bypassed in the "TOT5 2013-14 Winter SOL" Study. These phase shifting transformers remained bypassed in this analysis. As a result, there were overloads in this area in the results that would be resolved by the return of these phase shifting transformers.

The "TOT5 2013-14 Winter SOL" Study report distributed by WAPA was reviewed. The study report indicates that the maximum TOT 5 west to east transfer capability for the 2013-14 winter operating season is 1680 MW (with both Waterflow phase shifting transformers bypassed in the operating case). The report indicates that one of the limiting elements with TOT5 at 1680 MW (west-to-east) is the Craig-Hayden 230 kV #2 line for the failure of Craig 230kV Breaker 886. The failure of this breaker to open during a fault (with the subsequent loss of the Craig-Hayden 230kV line #1 and the Craig-RifleWA 230kV line) results in the overload of the Craig-Hayden 230kV #2 Line. The report indicates that this double line outage (due to the breaker failure) results in the Craig-Hayden 230kV #2 line flow reaching 107.4% of its 442 MVA rating and that this overload can be mitigated by implementing an operating procedure. WAPA was contacted to get more clarification about the operating procedure and WAPA indicated that the Craig-Hayden 230-kV #2 line should be rated at 478 MVA, not 442 MVA. The new Craig-Hayden 230kV #2 line rating was implemented in the case.

I. 2014 Winter TOT5 1680 MW Transfer Capability Confirmation

Category B and Category C contingencies were simulated using the modified 2014 heavy winter operating case. The contingency simulations confirmed the 1680 MW TOT5 rating for the RMOSG case that was used for the 2013-2014 operating season study. This conclusion assumes that certain contingency violations can be mitigated by dispatcher action or that the issues are outside the study area that occurred because of the high TOT5 west-to-east transfer schedules. The results are shown in Table 2 below.

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[2] The Terry Ranch Road Project creates a Terry Ranch Road Substation that sectionalizes the Archer-North Park 230-kV and Cheyenne-Ault 230-kV line near Cheyenne, Wyoming. In November 2013, the connections will be made to sectionalize the Cheyenne-Ault 230kV line at Terry Ranch Road Substation. In March 2014, the connections will be made to sectionalize the Archer-North Park 230kV line at Terry Ranch Road Substation. A 230-115kV transformer will be installed at the Terry Ranch Road Substation to connect the substation to the Cheyenne 115kV Substation. The metering point on the Archer-North Park 230-kV line will be moved to Terry Ranch Road Substation from Archer.

Table 2. Study Results – Modified 2014 Heavy Winter Case (RMOSG), TOT5 at 1660 MW

Transmission Element	Contingency	Rating (MVA)	Flow as Percent of Rating	Mitigating Action
SINGLE CONTINGENCIES				
MONTROSE-NUCLA 115 #1	MONTROSE-HESPERUS 345kV #1	76.0	122.4	Reduce Nucla generation
DAVEJTPN-WAGHN NT 115 #1	DAVEJTPS-WAGHN ST 115 #1	109.0	125.1	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.
DURANGO-HESPERUS 115 #1	HESPERUS-BODO 115 #1	86.0	120.0	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations will be mitigated through network upgrades TSG&T has planned for the area and use of phase shifters.
ALCOVA-MIRACLEM 115 #1	ALCOVA-MIRACLEM 115 #2	109.0	115.8	The study assumes that WAPA System Operations mitigates this criteria violation
ALCOVA-MIRACLEM 115 #2	ALCOVA-MIRACLEM 115 #1	109.0	115.6	The study assumes that WAPA System Operations mitigates this criteria violation
W CANON 230-115 #1	MIDWAYBR-W CANON 230 #1	100.0	108.1	The study assumes that the transformer contingency flow is less than the transformer emergency rating.
MARYLKSB 115-69 #1	System Intact	25.0	102.0	Open the Mary's Lake 115-69kV transformer for high TOT5 conditions
GLENDO-WAGHN ST 115 #1	DAVEJTPN-WAGHN NT 115 #1	110.0	108.3	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.
DAVEJTPS-WAGHN ST 115 #1	DAVEJTPN-WAGHN NT 115 #1	109.0	108.3	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.
BURROBDG-SILVERTN 115 #1	NORWOOD-NUCLA 115 #1	36.0	103.1	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations will be mitigated through network upgrades TSG&T has planned for the area.
BURROBDG-AMES 115 #1	NORWOOD-NUCLA 115 #1	36.0	102.9	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations

				will be mitigated through network upgrades TSG&T has planned for the area.
RIFLE CU-SILTUSBR-NEWCASTL-MITCHLCR 69 #1	RIFLEPS-HOPKINS 230 #1	55.9	115.9 to 107.5	PSCo System Operations mitigates this criteria violation by opening the Glenwood Springs-RifleCu 69kV line at New Castle. Future violations will not occur after the Glenwood Springs-RifleCu 69kV line is upgraded to 115kV.
MULTIPLE CONTINGENCIES[3]				
CURECANTI 230kV CB 786 BREAKER FAILURE	MONTROSE – NUCLA 115 #1	76.0	100.4	At limit; could reduce Nucla generation
CRAIG 230kV CB 286 BREAKER FAILURE	CRAIG – HAYDEN 230 #1	442.0	100.2	At limit
CRAIG 230kV CB 886 BREAKER FAILURE	CRAIG – HAYDEN 230 #2	478.0	99.7	Near limit

J. Study Results with TOT5 at 1780 MW

The TOT5 east-to-west flow was increased 100 MW above the 1680 MW rating to 1780 MW to create a second study case. This was accomplished by increasing generation in Utah and New Mexico and scheduling to generating units[4] on the Colorado Front Range. Contingencies were conducted on the new study case (stressed to 1780 MW) and several violations were observed. These are listed in Table 3 below.

Table 3. Study Results – Modified 2014 Heavy Winter Case (RMOSG) at 1780 MW

Transmission Element	Contingency	Rating (MVA)	Flow as Percent of Rating	Mitigating Action
SINGLE CONTINGENCIES				
MONTROSE-NUCLA 115 #1	MONTROSE-HESPERUS 345kV #1	76.0	136.6	Reduce Nucla generation
DAVEJTPN-WAGHN NT 115 #1	DAVEJTPS-WAGHN ST 115 #1	109.0	129.5	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.

[3] Includes operating practice described in Table 1 to open Craig 345kV CB 896 when TOT5 flow exceeds 1500 MW.
[4] Units used for sinking schedules to generation units in the Front Range were Spindle (SPNDLE1, SPNDLE2) and Spruce (SPRUCE1, SPRUCE2).

DURANGO-HESPERUS 115 #1	HESPERUS-BODO 115 #1	86.0	123.3	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations will be mitigated through network upgrades TSG&T has planned for the area.
ALCOVA-MIRACLEM 115 #1	ALCOVA-MIRACLEM 115 #2	109.0	123.0	The study assumes that WAPA System Operations mitigates this criteria violation
ALCOVA-MIRACLEM 115 #2	ALCOVA-MIRACLEM 115 #1	109.0	122.8	The study assumes that WAPA System Operations mitigates this criteria violation
W CANON 230-115 #1	MIDWAYBR-W CANON 230 #1	100.0	118.6	The study assumes that WAPA System Operations mitigates this criteria violation
MARYLKSB 115-69 #1	System Intact	25.0	114.9	Open the Mary's Lake 115-69kV transformer for high TOT5 conditions
GLENDO-WAGHN ST 115 #1	DAVEJTPN-WAGHN NT 115 #1	110.0	112.7	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.
DAVEJTPS-WAGHN ST 115 #1	DAVEJTPN-WAGHN NT 115 #1	109.0	112.7	Criteria violation is outside the study area. The study assumes that transfer flow of 1680 MW on TOT5 could be accommodated through cooperation with PACE.
SHIP PS-SHIPROCK 230 #1	SAN JUAN-HESPERUS 345 #1	400.0	110.0	Adjust phase-shifting transformer schedule
SAN_JUAN-SANJN PS 345 #3	LOSTCANY-SHIPPS 230 #1	600.0	105.3	Adjust phase-shifting transformer schedule
BURROBDG-SILVERTN 115 #1	MONTROSE-HESPERUS 345 #1	36.0	104.8	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations will be mitigated through network upgrades TSG&T has planned for the area.
BURROBDG-AMES 115 #1	MONTROSE-HESPERUS 345 #1	36.0	104.4	The study assumes TSG&T System Operations mitigates this criteria violation. Future violations will be mitigated through network upgrades TSG&T has planned for the area.
CURECANTI 230-115 #1	BLUEMESA-SKITO 115 #1	90.0	105.0	Reduce Blue Mesa generation. Overload is likely less than the transformer emergency rating.
GORE PASS-BLUE RIVER 230 #1	**HAYDEN-STEAMBT-FOIDEL CREEK 230**	**464.0**	**104.0**	**A critical limiting factor**

CRAIG-HAYDEN 230 #1	**CRAIG-HAYDEN 230 #2**	**442.0**	**103.7**	**The outage of the parallel element is more limiting; however, its rating was increased from 442.0 MVA to 478.0 MVA. A critical limiting factor**
HAYDEN-GORE PASS 230 #1	**HAYDEN-STEAMBT-FOIDEL CREEK 230**	**478.0**	**102.5**	**A critical limiting factor**
WOLCOTT-VAIL 230 #1	WOLCOTT-BEAVERCU 230 #1	120.0	100.6	The line overload is due to contingency low voltages on the Wolcott-Vail 115kV Loop under heavy winter load conditions. These contingency conditions are being investigated by PSCo and Holy Cross Energy.
GLENDO-WHTROCK 115 #1	GLENDO-GUERNTAP 115 #1	109.0	100.3	The study assumes WAPA System Operations mitigates this criteria violation.
GLENDO-GUERNTAP 115 #1	GLENDO-WHTROCK 115 #1	109.0	100.1	The study assumes WAPA System Operations mitigates this criteria violation.
RIFLE CU-SILTUSBR-NEWCASTL-MITCHLCR-GLENWD 69 #1	RIFLEPS-HOPKINS 230 #1	55.9	125.2 to 105.6	PSCo System Operations mitigates this criteria violation by opening the Glenwood Springs-RifleCu 69kV line at New Castle. Future violations will not occur after the Glenwood Springs-RifleCu 69kV line is upgraded to 115kV.
CRAIG-HAYDEN 230 #2	CRAIG-HAYDEN 230 #1	478.0	98.5%	WAPA indicated that the 442 MVA rating should be changed to 478 MVA. At 442 MVA, the contingency overload would be 106.5%.
MULTIPLE CONTINGENCIES				
MONTROSE – NUCLA 115 #1	CURECANTI 230kV CB 786 BREAKER FAILURE	76.0	109.9	Reduce Nucla generation
CRAIG – HAYDEN 230 #1	**CRAIG 230kV CB 286 BREAKER FAILURE**	**442.0**	**105.6**	**A critical limiting factor**
CRAIG – HAYDEN 230 #2	CRAIG 230kV CB 886 BREAKER FAILURE	478.0	104.8	Apply operating practice to open Craig 230kV CB 886 for high TOT5 flows

The study identifies critical limiting factors with TOT5 increased to 1780 MW. These include the following:

1. The Craig-Ault 345kV outage results in a divergent case[5]. This divergence is caused by voltage collapse centered near the Gore Pass and North Park 230kV buses. (Note also that some of the overloads described below would be worst for this contingency if additional shunt capacitance were available to allow the outage to converge.)

[5] An outage of Craig 345kV CB 896 also results in a diverged case due to voltage collapse, though this is not a limiting factor because of the operating practice to open this breaker above a TOT5 flow threshold of 1500 MW.

2. The Craig-Hayden 230kV line #1 post-contingency flow reaches 105.6% of its 442 MVA rating for a breaker failure of Craig 230kV CB 286[6].
3. The Craig-Hayden 230kV line #1 post-contingency flow reaches 103.7% of its 442 MVA rating for an outage of the Craig-Hayden 230kV line #2.
4. The Gore Pass-Blue River 230kV line contingency flow reaches 104.0% of its 464 MVA rating for an outage of the Hayden-Steamboat-Foidel Creek 230kV line.
5. The Hayden-Gore Pass 230kV line contingency flow reaches 102.5% of its 478 MVA rating for an outage of the Hayden-Steamboat-Foidel Creek 230kV line.

The following observations can be made:

- Critical limiting factor #1 is the most significant factor. The divergence of the power flow case for the loss of the Craig-Ault 345kV line underscores the weakness of the system at TOT5 levels around 1780 MW, with heavy line flows well above surge impedance loading levels consuming large quantities of reactive power and driving the system into voltage collapse.
- Critical limiting factor #2 and #3 represent post-contingency flows that are just over the 442 MVA rating of the line. That rating is established by WAPA.
- Critical limiting factors #4 and #5 represent small overloads of transmission facilities that have significantly higher thermal ratings than the ratings in the case. The Hayden-Gore Pass-Blue River 230kV line (Circuit #3000) is 85.7 miles long and uses 345kV double circuit structures and is strung with 2-1272 kcmil ACSR conductor. The bundled 1272 conductor provides the Hayden-Gore Pass-Blue River with a potentially higher rating; however, the rating of this line must be decided among the joint owners.

K. Alternatives to Allow a TOT5 Transfer Limit of 1780 MW

The study considered the results in Section C and determined that some type of transmission alternative would be needed. The study recognized that a future joint study among the TOT5 owners would be the best way to effectively and efficiently address the issues raised in Section C; however, for this study, the study considered the results and noted that transmission issues were found between the Craig Substation and the Blue River Substation along with the system divergence concern (outage of the Craig-Ault 345kV line); therefore, it was decided to study a transmission line from the Hayden Substation to the Blue River Substation. It was shorter than a transmission line from Craig Substation to Blue River but left open the possibility of adding new transmission from the Craig Substation to the Hayden Substation. Therefore, a Hayden-Blue River 230kV transmission line using 1272 conductor on 230kV single circuit towers of approximately 86 miles in length was modeled in the stressed study case.

A new study case was created from the case with 1780 MW on TOT5 to model the proposed projects and evaluate their effectiveness in resolving criteria violations. The Hayden-Blue River 230kV line was initially modeled with bundled 1272 ACSR conductor, similar to the Hayden – Gore Pass and Gore Pass – Blue River 230kV lines, but it was quickly determined that too low an impedance on this new line is actually detrimental to the path rating, so the model was changed to reflect single 1272 kcmil ACSR conductor.

[6] One possible mitigation solution for this outage, establishing an operating practice to open Craig 230kV CB 286 for high TOT5 flows, could pose additional risks of a Craig 230kV bus separation due to the existing operating practice of opening Craig 230kV CB 886 for high TOT5 flows and would need to be studied carefully to be considered a viable option.

A contingency analysis was performed on the study cases and the results are listed in Table 4 below.

Table 4. Study Results – Study Case TOT5 at 1780 MW

Transmission Element	Contingency	Rating (MVA)	Contingency Flow at TOT5=1780 (% Rating)	Contingency Flow at TOT5=1780 with the Hayden-Blue River 230kV Line added (% Rating)
SINGLE CONTINGENCIES				
HAYDEN-GORE PASS 230 #1	CRAIG-AULT 345 #1	478.0	Case diverged	Case converged with contingency flow < 90
HAYDEN-GORE PASS 230 #1	HAYDEN-STMBT-FDLK-WLCT 230	478.0	102.5	< 90
GORE PASS-BLUE RIVER 230 #1	CRAIG-AULT 345 #1	464.0	Case diverged	Case converged with contingency flow < 90
GORE PASS-BLUE RIVER 230 #1	HAYDEN-STMBT-FDLK-WLCT 230	464.0	104.0	< 90
CRAIG-HAYDEN 230 #2	CRAIG-AULT 345 #1	478.0	Case diverged	Case converged with contingency flow < 100.0
CRAIG-HAYDEN 230 #2	CRAIG-HAYDEN 230 #1	478.0	98.3	108.3
CRAIG-HAYDEN 230 #1	CRAIG-HAYDEN 230 #2	478.0	< 90.0	105.6
CRAIG-HAYDEN 230 #1	CRAIG-HAYDEN 230 #2	442.0	103.7	< 90
BLUE RIVER-DILLON 230 #1	CRAIG-AULT 345 #1	472.0	Case diverged	Converged; 115.4
BLUE RIVER-DILLON 230 #1	HAYDEN-STMBT-FDLK-WLCT 230	472.0	95.0	117.1
DILLON-CABINCRK 230 #1	CRAIG-AULT 345 #1	478.0	Case diverged	Converged; 109.5
MULTIPLE CONTINGENCIES				
BLUE RIVER-DILLON 230 #1	CRAIG 345kV CB 896 BREAKER FAILURE	472.0	Case diverged	Converged; 125.9
DILLON-CABINCRK 230 #1	CRAIG 345kV CB 896 BREAKER FAILURE	478.0	Case diverged	Converged; 112.7
CRAIG-HAYDEN 230 #2	CRAIG 345kV CB 896 BREAKER FAILURE	478.0	Case diverged	Converged; 106.3
CRAIG – HAYDEN 230 #1	CRAIG 230kV CB 286 BREAKER FAILURE	442.0	105.6	115.8
CRAIG – HAYDEN 230 #2	CRAIG 230kV CB 886 BREAKER FAILURE	478.0	104.8	114.6

Table 4 above summarizes the issues directly related to TOT5 flow and ignores peripheral area overloads. Based on the results of the study, the following is concluded:

- The new Hayden – Blue River 230kV line would resolve all potential post-contingency overload issues associated with the existing Hayden – Gore Pass – Blue River 230kV path.

- The study confirms the need to re-conductor or otherwise increase the ratings of both Craig – Hayden 230kV lines for this mitigation scenario to mitigate overloads associated with both Category B (parallel line outage) and Category C (CB 286 failure) outages without operating solutions affecting flow on these lines. The results illustrate the probable need to re-conductor lines when adding the Hayden-Blue River 230kV line (using 1272 kcmil ACSR conductor). The Craig-Hayden 230kV #1 line and Craig-Hayden 230kV #2 lines were assumed to be re-conductored with 1272 kcmil ACSS conductor to match the existing 1272 kcmil ACSR conductor to resolve these issues. Changing the Craig – Hayden 230kV conductor from ACSR to ACSS of the same size has virtually no effect on the line impedance.

- The proposed new line allows the Craig – Ault 345kV line outage solution to converge, indicating a significant improvement with respect to avoiding voltage collapse. With the new line, this outage causes no overloads of the 230kV lines between Craig and Blue River. However, significant new overloads appear on the Blue River – Dillon and Dillon – Cabin Creek 230kV lines for this outage and another outage. This suggests the need to either attempt to further increase the impedance of this portion of the path, possibly through the use of series reactors to fine-tune the balance of TOT5 flows, or to opt for the more conventional planning solution of re-conductoring the Blue River – Dillon and Dillon – Cabin Creek 230kV lines to ACSS conductor in addition to the other mitigation work proposed, which is presumed to be the preferred solution, especially since voltage collapse is a consideration in this area under conditions with heavy TOT5 flows.

- If the Blue River – Dillon – Cabin Creek 230kV path is re-conductored, it should be possible to avoid the use of the Craig CB 896 and Craig CB 886 operating practices even with TOT5 at 1780 MW (currently, these breakers are opened when TOT5 flow is above certain thresholds).

- With the mitigation projects modeled, there do not appear to be any significant steady state voltage deviation issues.

- Although precise determination of the TOT5 limit above 1780 MW with the proposed mitigation projects is beyond the scope of this analysis, a preliminary analysis for TOT5 flows at these levels shows that the TOT5 capacity with the mitigation projects modeled is significantly higher than 1780 MW. Without additional modifications, voltage issues will likely limit the TOT5 capacity to roughly 1900 MW or less to protect against voltage problems again occurring for a Craig – Ault 345kV contingency. Modeling shunt capacitors for voltage support at the Blue River and North Park Substation 230kV buses could increase this limit to roughly 1950 MW, and additional voltage support may increase the limit even further. Note, however, that these theoretical limits do not take into account the ability of other "upstream" paths (e.g. TOT1A and TOT2A) and branches to supply this amount of flow to the TOT5 path, and these may be more limiting than the TOT5 path itself. In any case, thermal limits on TOT5 (other than those with existing operating solutions) do not appear to limit the path following the completion of the proposed mitigation projects, but determination of a more exact TOT5 limit above 1780 MW accounting for these projects would require additional analysis.

L. Cost Estimates

Non-binding good faith estimates were developed for this study. A method of developing transmission capital costs proposed for WECC/TEPPC by a consulting firm was used. The results are listed in Table 5 below. The project is estimated to cost approximately $160.0 million. Transmission line costs for the Hayden-Blue River 230kV transmission line (86 miles) would be approximately $112.3 million, substation costs for the Hayden Substation and Blue River Substation to terminate the Hayden-Blue River 230kV line would be approximately $2.9 million, and re-conductoring 91 miles of 230kV transmission with 1272 kcmil ACSS would be approximately $44.8 million. A second method that uses internal cost estimating guides and assumptions (for the Hayden-Blue

River 230kV #1 line and the line terminations at the Hayden Substation and the Blue River Substation) was used to compare with results using the proposed WECC/TEPPC Method and results compare favorably (within about 1.6%).

Table 5. Transmission Capital Cost Estimates for Network Upgrades

Network Upgrade	Description	Cost
Hayden-Blue River 230 #1 Line	86 miles of single circuit 230kV construction using 1272 kcmil ACSR conductor	$112.3 million
Line Terminations at the Hayden Substation and the Blue River Substation	Add a 230kV 3000 amp line breaker bay to the 230kV main-and-transfer arrangement at Hayden Substation. Add a 230kV 3000 amp bus section bay to the 230kV three-breaker ring at Blue River Substation.	$2.9 million
Transmission Line Re-conductoring	Re-conductor 91 miles of existing 230kV transmission replacing 1272 kcmil ACSR conductor with 1272 kcmil ACSS conductor • Craig-Hayden 230kV #1 Line (26.8 miles) • Craig-Hayden 230kV #2 Line (24.9 miles) • Blue River-Dillon 230k#1 Line (17.4 miles) • Dillon-Cabin Creek 230kV #1 Line (21.8 miles)	$44.8 million
TOTAL		**$ 160.0 million**

M. Siting and Routing Issues

PSCo Siting and Land Rights completed an initial evaluation of the proposed Hayden-Blue River 230 kV transmission line project area and concluded that the proposed project would be feasible and could be permitted. The Siting and Land Rights Group did not find any siting or routing issues that would preclude the project from being completed; however, they maintain (based on this cursory examination) that it would be difficult for potential routes (ranging anywhere from 95 to 110 miles in length) to avoid BLM, Routt, White River and Arapahoe/Roosevelt National Forests and/or State lands Depending on the route, crossing federal land would likely trigger an Environmental Impact Statement which can take anywhere from 12 to 24 months to process. Also, up to seven (7) local government permits may be required. Substantial mitigation would likely be involved as well.

The Siting and Land Rights group found that there are three designated Wilderness Areas (Sarvis Creek, Flat Tops and Eagle Nest) within the White River and Routt National Forests that precludes transmission line construction. All of these areas are small enough in size that they can probably be avoided. Another potential issue is the Greater Sage Grouse which is listed as a Candidate Species under the Endangered Species Act. Mapped brood and production areas are scattered throughout the project area. If a potential route crosses one of these areas, a "lek[7] survey" may need to be conducted within the window of April 1-May 7.

[7] A "lek" is an aggregation of males that gather to engage in competitive displays commonly formed before or during the breeding season. A "lek survey" is a monitoring technique to identify new sage grouse leks and to determine whether known leks are active. The significance of the survey is the small window in which to conduct the survey. This may impact project/construction schedules within these areas because the feds would want a survey conducted prior to disturbance. If leks are found as a result of the survey, we may have to reroute around said areas or mitigate for impacts to the grouse.

IV. APPENDIX

Appendix

A. Phase 1 – Supporting Table – TOT5 Allocations 2013 Summer

WAPA has been using the same set of limits/allocations for the last couple of years regardless of season. According to WAPA, the "TOT5 Allocations 2013 Summer" Table listed below contains the most current data and is valid for the winter season.

Table 6. TOT5 Allocations Table – 2013 Summer and 2013-2014 Winter

TOT 5 ALLOCATIONS 2013 SUMMER

Outage Configuration	Actual Limit	WAPA SIMO MAX	PRPA SIMO MAX	PSCO SIMO MAX	TSGT SIMO MAX
SYSTEM INTACT	1680	750	190	480	260
CRG-AU & HDN-NOP-ARH or any N-2 of lines below - unplanned	878	392	99	251	136
CRAIG-AULT (planned)	1156	561	45	480	71
CRAIG-AULT (forced)	1156	516	131	330	179
GORE PASS-BLUE RIVER (planned)	1251	654	94	384	119
GORE PASS-BLUE RIVER (forced)	1251	558	141	357	194
HAYDEN-NORTH PARK-ARCHER (planned)	1528	598	190	480	260
HAYDEN-NORTH PARK-ARCHER (forced)	1528	682	173	437	236
HAYDEN-GORE PASS (planned)	1251	654	94	384	119
HAYDEN-GORE PASS (forced)	1251	558	141	357	194
HAYDEN-FOIDEL CREEK (planned)	1261	750	190	61	260
HAYDEN-FOIDEL CREEK (forced)	1261	563	143	360	195
RIFLE-HOPKINS-MALTA (planned)	1254	750	190	54	260
RIFLE-HOPKINS-MALTA (forced)	1254	560	142	358	194
CURECANTI-PONCHA (planned)	1343	413	190	480	260
CURECANTI-PONCHA (forced)	1343	600	152	384	208
CURECANTI-SALIDA (planned)	1476	546	190	480	260
CURECANTI-SALIDA (forced)	1476	659	167	422	228
BASALT-MALTA (planned)	1443	750	190	243	260
BASALT-MALTA (forced)	1443	644	163	412	223
CRAIG-HAYDEN (WAPA) (planned)	1591	661	190	480	260
CRAIG-HAYDEN (WAPA) (forced)	1591	710	180	455	246
CRAIG-HAYDEN (TSGT, PSCo, PRPA) (planned)	1591	750	172	434	235
CRAIG-HAYDEN (TSGT, PSCo, PRPA) (forced)	1591	710	180	455	246
MALTA-TARRYALL (planned)	1143	714	181	0	248
MALTA-TARRYALL (forced)	1143	510	129	327	177
CABIN CREEK-LOOKOUT (planned)	1146	716	181	0	248
CABIN CREEK-LOOKOUT (forced)	1146	512	130	327	177
TARRYALL-DANIELS (planned)	1295	750	190	95	260
TARRYALL-DANIELS (forced)	1295	578	147	370	200
CRAIG-RIFLE (planned)	1575	645	190	480	260
CRAIG-RIFLE (forced)	1575	703	178	450	244
PONCHA-CCW-MIDWAY (planned)	1458	528	190	480	260
PONCHA-CCW-MIDWAY (forced)	1458	651	165	417	226
BLUE RIVER-DILLON (planned)	1395	750	190	267	188
BLUE RIVER-DILLON (forced)	1395	623	158	398	216
CABIN CREEK-DILLON (planned)	1318	750	190	118	260
CABIN CREEK-DILLON (forced)	1318	588	149	377	204
MALTA-BRECKENRIDGE-DILLON (planned)	1145	716	181	0	248
MALTA-BRECKENRIDGE-DILLON (forced)	1145	511	130	327	177

Table 6a. TOT5 Allocations Table 2013 Summer Transmittal

From: Li, Yishan - Frank [YLi@WAPA.GOV]
Sent: Tuesday, June 18, 2013 1:03 PM
To: Johnson, Robert K; Anderson, William M; Stepanyan, Vahram S; Igor Kormaz; Daniel Thielen; Franklin, Kerry; brownriggj@prpa.org; bookd@prpa.or
Cc: Keirn, Diane; Erickson, Sean; Easton, Bob; Leyba, Rita; Reyes, Orlando; Stellern, Gerald M; Houglum, Michael; Christopher Pink; collinsj@prpa.org
Subject: RE: Most current TOT 5 prior outage Table
Attachments: TOT5 Allocations 2013 Summer.pdf

Hello TOT 5 Participants,

Attached is the TOT 5 Allocations Table for 2013 Summer for your records and comments. Please let me know if you have questions.

Thanks,

Yishan-Frank Li
Transmission Planning Engineer
WAPA-RMR
970-461-7363
yli@wapa.gov

From: Easton, Bob
Sent: Monday, June 17, 2013 11:33 AM
To: Li, Yishan - Frank
Cc: Keirn, Diane; Erickson, Sean
Subject: FW: Most current TOT 5 prior outage Table

Frank - please coordinate a response with Sean back to Bob Johnson. Thx!

From: Reyes, Orlando
Sent: Monday, June 17, 2013 10:55 AM
To: Johnson, Robert K; Easton, Bob; Keirn, Diane
Subject: RE: Most current TOT 5 prior outage Table

Hi Bob!
I have included both Bob Easton and Diane Keirn in my response so that they can provide you the current and accurate information.
Thanks for the note Bob!!
Orlando

From: Johnson, Robert K [mailto:Robert.K.Johnson@XCELENERGY.COM]
Sent: Friday, June 14, 2013 2:46 PM
To: Reyes, Orlando
Subject: Most current TOT 5 prior outage Table

Orlando,

We are updating our TOT 5 documentation.

Please confirm that the attached is the most up to date table or send out a more current version if one is available.

Thanks for your help!!

bob

Robert K. Johnson

Xcel Energy | Responsible by Nature

Principal Operations Engineer

P.O. Box 1078 Golden, Co 80402-1078
P:303-273-4893 C: 303-601-0627 F:303-273-4869
E:robert.k.johnson@xcelenergy.com

B. TOT5 ATC Results for Base, 1680, 1780, and 1780 MW with Mitigation

Table 7. Alternatives Matrix

TOT5 ATC Study Alternatives Studied	Base (1660 MW)	1680 MW (Path Rating)	1780 MW (Rating+100)	1780 MW +Mitigation
• TOT5 Flow (MW)	1660.4 w-e	1680.0 w-e	1780.0 w-e	1780.1 w-e
• TOT1A Flow (MW)	222.2 w-e	231.7 w-e	281.8 w-e	282.5 w-e
• TOT2A Flow (MW)	650.5 s-n	661.9 s-n	720.0 s-n	708.3 s-n
• TOT3 Flow (MW)	403.7 n-s	409.4 n-s	435.3 n-s	422.3 n-s
• Change from Base case - Generation & Schedules in New Mexico (Area 10)	---	14.4	86.5	74.9
• Change from Base case - Generation & Schedules in Utah/PACE (Area 65)	---	13.6	86.8	74.8
• Change from Base case - Generation & Schedules in Colorado/PSCO (Area 70)	---	-29.2	-173.8	-149.2

NOTES:

Base cases derived from WECC 14hw2 2013-14 Heavy Winter case tuned by RMOSG for high TOT5 flow.

1780 MW+Mitigation case reduces overall TOT5 impedance, resulting in less "leakage" flow to other paths (such as TOT3).

COLOR CODING ON SUBSEQUENT TABLES:

Constraints directly related to TOT5, usually of TOT5 component branches.

Xcel Energy

Table 8. Category B Disturbances

TOT5 AVAILABLE TRANSFER CAPABILITY INCREASE STUDY:
ALL TOT5 FLOW SCENARIOS VS. 1780 MW WITH MITIGATION (NEW LINE), CATEGORY B OVERLOADS

The TDF, or Transfer Distribution Factor, for each circuit represents the percentage of the increased TOT5 flow that flows on that circuit.
NOTE: Table is filtered to exclude TDF < 1% to capture only overloads exacerbated by increasing generation.
NOTE: Contingency names followed by "+" model a special protection scheme or operating practice action. Contingency names followed by "-" do not.
NOTE: *Ault-Craig 345kV Line #1** outage includes a fictitious shunt capacitor at Blue River to allow this outage to converge for comparison. (Gore Pass & North Park low voltage points.)

				Base	1680 MW		1780 MW		1780 MW+Mitig	
Circuit	Contingency	Rating		% Rtg	% Rtg	TDF	% Rtg	TDF	% Rtg	TDF
79033 GOREPASS 230 - 79039 HAYDEN 230 #1	*AULT -CRAIG 345 Line #1**	1199.9	Amp				*103.1%*	*27.0%*		
	HAYDEN-STMBT-FDLK-WLCT 230 Ln+	1199.9	Amp	98.7%	99.5%	20.8%	**102.5%**	15.4%		
70053 BLUERIVR 230 - 79033 GOREPASS 230 #1	*AULT -CRAIG 345 Line #1**	1164.7	Amp				*104.3%*	*27.0%*		
	HAYDEN-STMBT-FDLK-WLCT 230 Ln+	1164.7	Amp	97.5%	98.3%	19.2%	**104.0%**	25.5%		
79013 CRAIG 230 - 79039 HAYDEN 230 #2	AULT -CRAIG 345 Line #1+	**1199.9**	Amp				999.0%	999.0%	93.4%	44.4%
	CRAIG -HAYDEN 230 Line #1	1199.9	Amp	93.1%	93.9%	20.2%	98.3%	21.0%	**108.3%**	60.9%
79013 CRAIG 230 - 79039 HAYDEN 230 #1	CRAIG -HAYDEN 230 Line #2	1199.9	**Amp**						**105.6%**	59.0%
		1109.5	**Amp**	98.2%	99.1%	19.7%	103.7%	20.4%		
70053 BLUERIVR 230 - 70156 DILLON 230 #1	AULT -CRAIG 345 Line #1+	1184.8	Amp				999.0%	999.0%	**115.4%**	114.1%
	HAYDEN-STMBT-FDLK-WLCT 230 Ln+	1184.8	Amp				95.0%	28.1%	**117.1%**	115.5%
	COMAN_3 27.00 #C3 Generator+	1184.8	Amp						107.0%	118.0%
	HOPKINS -RIFLE_PS 230 Line #1+	1184.8	Amp						105.9%	103.5%
	HOPKINS -MALTA 230 Line #1	1184.8	Amp						104.5%	102.5%
	COMAN_1 24.00 #C1 Generator+	1184.8	Amp						100.7%	111.2%
	PAWNEE 22.00 #C1 Generator+	1184.8	Amp						100.3%	111.4%
70072 CABINCRK 230 - 70156 DILLON 230 #1	AULT -CRAIG 345 Line #1+	1199.9	Amp	92.0%	93.8%	42.8%	999.0%	999.0%	**109.5%**	69.9%
	*AULT -CRAIG 345 Line #1**	1199.9	Amp				*100.0%*	*43.0%*		
70541 ASPEN_PS 115 - 79003 BASALT 115 #1	BASLTDST-BASALT 115 Line #1	502	Amp	99.8%	100.1%	1.5%	99.8%	0.0%	99.6%	-0.2%
79048 MONTROSE 115 - 79052 NUCLA 115 #1	MONTROSE-HESPERUS 345 Line #1-	381.6	Amp	122.4%	124.7%	8.8%	136.6%	9.0%	134.9%	8.0%
79023 DURANGO 115 - 79071 HESPERUS 115 #1	HESPERUS-BODO 115 Line #1	441.8	Amp	120.0%	120.5%	2.4%	123.3%	2.4%	122.1%	1.6%
	SHIPRK-PSHT-LSTCNYN 230 Ln #1	441.8	Amp	112.1%	113.1%	4.7%	118.9%	5.0%	117.2%	3.8%
	SUNYSIDE-HESPERUS 115 Line #1	441.8	Amp	99.4%	99.7%	1.7%	102.6%	2.4%	101.8%	1.8%
79061 SHIP PS 230 - 79063 SHIPROCK 230 #3	SAN JUAN-HESPERUS 345 Line #1	1004.1	Amp	99.0%	100.6%	33.5%	110.0%	36.9%	107.9%	29.9%
10292 SAN_JUAN 345 - 79060 SANJN PS 345 #3	SHIPRK-PSHT-LSTCNYN 230 Ln #1	1004.1	Amp	95.0%	96.7%	51.0%	105.3%	51.7%	103.7%	43.6%

	COMAN_3 27.00 #C3 Generator+	1004.1	Amp	95.0%	96.5%	45.1%	104.3%	46.6%	102.4%	37.1%
	CRAIG 2 22.00 #1 Generator	1004.1	Amp	93.4%	94.7%	40.9%	101.7%	41.5%	100.5%	35.4%
	CRAIG 1 22.00 #1 Generator	1004.1	Amp	93.4%	94.7%	40.3%	101.7%	41.5%	100.5%	35.4%
	CRAIG 3 22.00 #1 Generator	1004.1	Amp	93.3%	94.6%	40.0%	101.5%	41.3%	100.3%	35.2%
73551 W CANON 230 - 70550 W.CANON 115 #T1	MIDWAYBR-W CANON 230 Line #1	100	MVA	108.1%	109.9%	9.0%	118.6%	8.8%	113.6%	4.6%
73004 ALCOVA 115 - 73137 MIRACLEM 115 #2	ALCOVA -MIRACLEM 115 Line #1	547.2	Amp	115.6%	116.9%	7.2%	122.8%	6.5%	120.4%	4.3%
73004 ALCOVA 115 - 73137 MIRACLEM 115 #1	ALCOVA -MIRACLEM 115 Line #2	547.2	Amp	115.8%	117.1%	7.2%	123.0%	6.6%	120.5%	4.3%
73069 GLENDO 115 - 73568 WHTROCK 115 #1	GLENDO -GUERNTAP 115 Line #1	547.2	Amp	95.8%	96.6%	4.4%	100.3%	4.1%	98.4%	2.4%
73069 GLENDO 115 - 73076 GUERNTAP 115 #1	GLENDO -WHTROCK 115 Line #1	547.2	Amp	95.6%	96.4%	4.5%	100.1%	4.1%	98.2%	2.4%
79194 BURROBDG 115 - 79256 SILVERTN 115 #1	MONTROSE-HESPERUS 345 Line #1+	180.7	Amp	126.6%	129.5%	5.3%	144.6%	5.4%	141.5%	4.5%
	MONTROSE-HESPERUS 345 Line #1-	180.7	Amp				104.8%	5.3%	102.1%	4.5%
	NORWOOD -NUCLA 115 Line #1	180.7	Amp	103.1%	103.1%	0.1%	103.6%	0.2%	103.4%	0.1%
79194 BURROBDG 115 - 79257 AMES 115 #1	MONTROSE-HESPERUS 345 Line #1+	180.7	Amp	126.2%	129.1%	5.3%	144.2%	5.4%	141.1%	4.5%
	MONTROSE-HESPERUS 345 Line #1-	180.7	Amp				104.4%	5.3%	101.7%	4.5%
	NORWOOD -NUCLA 115 Line #1	180.7	Amp	102.9%	103.0%	0.2%	103.4%	0.2%	103.2%	0.1%
79255 MOLASTAP 115 - 79256 SILVERTN 115 #1	MONTROSE-HESPERUS 345 Line #1+	200.8	Amp	117.4%	120.0%	5.3%	133.6%	5.4%	130.8%	4.5%
79045 LOSTCANY 230 - 79061 SHIP PS 230 #1	SAN JUAN-HESPERUS 345 Line #1	1109.5	Amp		91.0%	33.5%	99.6%	37.3%	97.7%	30.2%
79080 CASCADEL 115 - 79088 ROCKWOOD 115 #1	MONTROSE-HESPERUS 345 Line #1+	291.2	Amp	96.8%	98.7%	5.4%	108.3%	5.6%	106.3%	4.6%
73070 DAVEJTPN 115 - 73607 WAGHN NT 115 #1	AULT -CRAIG 345 Line #1+	547.2	Amp	96.9%	97.6%	3.8%	999.0%	999.0%	98.5%	1.4%
	DVJ*S-RFN-CSPR-WG-GLDO 115 #1	547.2	Amp	125.1%	125.9%	4.3%	129.5%	4.0%	127.6%	2.3%
	DAVEJOHN-STEGALL 230 Line #1	547.2	Amp	110.2%	110.9%	3.9%	114.3%	3.8%	112.5%	2.1%
	DAVEJOHN-LAR.RIVR 230 Line #1+	547.2	Amp	107.6%	108.4%	4.3%	112.2%	4.2%	110.3%	2.4%
	COMAN_3 27.00 #C3 Generator+	547.2	Amp	100.6%	101.2%	3.7%	104.9%	4.0%	102.7%	2.0%
	MBPP-2 24.00 #1 Generator+	547.2	Amp	97.9%	98.5%	3.7%	102.0%	3.7%	100.0%	2.0%
	PAWNEE 22.00 #C1 Generator+	547.2	Amp	97.6%	98.2%	3.4%	101.4%	3.4%	99.6%	1.8%
	AULT -CRAIG 345 Line #1*	547.2	Amp				100.7%	3.6%		
	COMAN_1 24.00 #C1 Generator+	547.2	Amp	96.8%	97.4%	3.4%	100.4%	3.3%	98.8%	1.8%
	RAWHIDE 24.00 #C1 Generator+	547.2	Amp	96.3%	96.9%	3.3%	99.8%	3.2%	98.2%	1.7%
79066 VAIL 115 - 79068 WOLCOTT 115 #1	BEAVERCU-WOLCOTT 115 Line #1	602.5	Amp	99.0%	99.3%	1.8%	100.6%	1.7%	98.4%	-0.5%

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Table 9. Category C Disturbances

TOT5 AVAILABLE TRANSFER CAPABILITY INCREASE STUDY:

ALL TOT5 FLOW SCENARIOS VS. 1780 MW WITH MITIGATION (NEW LINE), CATEGORY C OVERLOADS

The TDF, or Transfer Distribution Factor, for each circuit represents the percentage of the increased TOT5 flow that flows on that circuit.

NOTE: Contingencies followed by "+" model a special protection scheme or operating practice action. Contingencies followed by "-" do not.

NOTE: Table is filtered to exclude TDF < 1% to capture only overloads exacerbated by increasing generation.

				Base	1680 MW		1780 MW		1780MW+Mitig	
Contingency	Circuit	Rating		% Rtg	% Rtg	TDF	% Rtg	TDF	% Rtg	TDF
CRAIG 345KV CB 896 BKR FAIL -	70053 BLUERIVR 230 - 70156 DILLON 230 #1	1184.8	Amp	96.0%	97.0%	25.1%	999.0%	999.0%	**125.9%**	117.9%
	70072 CABINCRK 230 - 70156 DILLON 230 #1	1199.9	Amp	94.9%	96.6%	42.6%	999.0%	999.0%	**112.7%**	71.3%
	79013 CRAIG 230 - 79039 HAYDEN 230 #2	1199.9	Amp	96.0%	97.1%	25.5%	999.0%	999.0%	**106.3%**	41.2%
	73070 DAVEJTPN 115 - 73607 WAGHN NT 115 #1	547.2	Amp	97.4%	98.1%	3.9%	999.0%	999.0%	98.8%	1.2%
	79013 CRAIG 230 - 79039 HAYDEN 230 #1	1199.9	Amp				999.0%	999.0%	98.0%	37.9%
		1109.5	Amp	95.7%	96.7%	23.4%				
	79033 GOREPASS 230 - 79039 HAYDEN 230 #1	1199.9	Amp	105.2%	**106.3%**	26.9%				
	70053 BLUERIVR 230 - 79033 GOREPASS 230 #1	1164.7	Amp	106.1%	**107.2%**	27.0%				
CRAIG 230KV CB 886 BKR FAIL -	79013 CRAIG 230 - 79039 HAYDEN 230 #2	1199.9	Amp	99.7%	100.5%	19.0%	104.8%	20.3%	**114.6%**	59.6%
CURECANTI 230KV CB 786 BRFAIL+	79048 MONTROSE 115 - 79052 NUCLA 115 #1	381.6	Amp	100.4%	101.9%	6.0%	109.9%	6.0%	**108.1%**	4.9%
CRAIG 230KV CB 286 BKR FAIL	79013 CRAIG 230 - 79039 HAYDEN 230 #1	1199.9	Amp						**107.1%**	57.6%
		1109.5	Amp	100.2%	101.1%	19.3%	105.6%	19.8%		
CRAIG 230KV CB 586 BKR FAIL	10292 SAN_JUAN 345 - 79060 SANJN PS 345 #3	1004.1	Amp	92.4%	93.8%	40.1%	100.7%	41.5%	99.5%	35.3%
CRAIG 345KV CB 596 BKR FAIL	10292 SAN_JUAN 345 - 79060 SANJN PS 345 #3	1004.1	Amp	92.2%	93.6%	40.0%	100.5%	41.2%	99.3%	35.2%

C. Detailed Cost Estimates

The cost estimates were developed using the “Transmission Capital Costs (WECC – TEPPC)” Method. The “Transmission Capital Costs (WECC/TEPPC)” Method was developed by an outside consultant and proposed for WECC/TEPPC for use in project cost estimating.

Table 10. Transmission Capital Costs – Transmission Line Base Costs and Multipliers

			Equipment	New 230 kV Single Circuit with 1272 kcmil ACSR, one conductor per phase, 400 MW capacity ($/mile)	230kV Re-Conductor ($/mile)
			Base Cost (per mile)	$ 927,000	$ 324,450
Multipliers					
	Conductor				
		ACSR	1.00		
		ACSS	1.08		
		HTLS	3.60		
	Structure				
		Lattice	0.90		
		Tubular Steel	1.00		
	Length				
		> 10 miles	1.00		
		3 – 10 miles	1.20		
		< 3 miles	1.50		
	Age				
		New	1.00		
		Re-conductor	0.35		
	Terrain				
		Flat (scrub, farmland)	1.00		
		Mountain (> 8% slope)	1.50		

<u>TRANSMISSION LINE COST ASSUMPTIONS</u>

CONDUCTOR SIZE ASSUMPTIONS

- 230 kV AC Single
  - 1 conductor/phase
  - ACSR – 1272 kcmil
  - 400 MW Capacity

Total Transmission Line Cost =

[(Base Transmission Cost) x (Conductor Multiplier) x (Structure Multiplier) x

(Length Multiplier) x (Age Multiplier) x (Terrain Multiplier)

+ (ROW Acres/Mile) x (Land Cost/Acre)] x (# of Miles of Segment)

Transmission Line Calculation: Hayden-Blue River 230kV calculation using 230-kV single circuit line with ACSS conductor, lattice steel towers, new (not re-conductored), mountainous terrain, 86 miles long

Total Transmission Line Cost =

[($ 927,000/mile base cost) x (1.00 for ACSR) x (0.90 for lattice steel structure) x 1.0 for >10 mi.) x (1.00 for new line) x (1.50 for mountainous) +(18.18 acres/mi. for 230 kV single circuit and 150' ROW) x ($3000/acre)] x (86 miles) = **$ 112,315,140**

SUBSTATION COST ASSUMPTIONS

- Base Substation
  - Includes land, substation fence, control building, ground grid, etc.
  - Excludes breakers, transformers, etc.
  - Assumes flat, barren land with relatively easy site access
- Line/Transformer Positions
  - Includes switches, bus work, and circuit breakers
  - Transformer
    - Includes foundation and oil containment

Table 11. Transmission Capital Costs – Substation Base Costs and Multipliers

Equipment	230kV Substation
Base Cost (New Substation)	$ 1,648,000
Cost per Position (Line or Transformer)	$ 1,442,000
Ring Bus Multiplier (RB)	1.0
Breaker and a Half Multiplier (BAAH)	1.5
115-230 Transformer ($/MVA)	$7,000
138-230 Transformer ($/MVA)	$7,000
345-230 Transformer ($/MVA)	$ 10,000
500-230 Transformer ($/MVA)	$ 11,000
Shunt Reactor ($/MVAR)	$ 20,000
Series Capacitor ($/MVAR)	$ 50,000
SVC ($/MVAR)	$ 85,000

Total Individual Substation Cost =

[(Substation Base Cost) + (High-Side Line/XFMR Position Base Cost) x (# of Line/XFMR Positions) x (RB or BAAH Multiplier) + (XFMR Cost/MVA) x (XFMR MVA Rating) x (# of XFMRs) + (Low-Side Line/XFMR Position Base Cost) x (# of Line/XFMR Positions) x (RB or BAAH Multiplier) + (SVC Cost/MVAR) x (# MVARs) + (Series Cap. Cost/MVAR) x (# MVARs) + (Shunt Reactor Cost/MVAR) x (# MVARs) + (HVDC Converter Station Cost)]
Note: If existing substation, remove (Base Substation Cost)

Hayden Substation = (1) 230kV Line Position
Total Substation Cost = $ 1,442,000 * 1.0 (multiplier) = **$ 1,442,000**

Blue River Substation = (1) 230kV Line Position
Total Substation Cost = $ 1,442,000 * 1.0 (multiplier) = **$ 1,442,000**

RE-CONDUCTORING COST ASSUMPTIONS

"RE-CONDUCTORING" DEFINITION

- No pole replacement
- No insulator replacement
- Same configuration
- Only conductor replacement
  - This is typically completed with higher rated conductor of similar or less weight and size, e.g. ACSR re-conductor with ACSS

Table 12. Line Mileages for Lines Requiring Re-conductoring

Name	Miles
Craig-Hayden 230kV #1 Line	26.8
Craig-Hayden 230kV #2 Line	24.9
Blue River-Dillon 230kV Line	17.4
Dillon-Cabin Creek 230kV Line	21.78
	90.88

Re-conductor Line Cost (35% of the cost of a new 91-mile line) =

([($ 927,000/mile base cost) x (1.08 for ACSS) x (0.90 for lattice steel structure) x 1.0 for >10 mi.) x (1.00 for new line) x (1.50 for mountainous) +(18.18 acres/mi. for 230 kV and 150' ROW) x ($3000/acre)] x (91 miles)) X 0.35 (for re-conductor) = **$44.78 million**

Total Cost = $112.32 million + $1.44 million + $1.44 million + $44.78 million = **$159.98 million**

Method #2   Transmission Capital Costs (PSCo Transmission Planning Method)

A second method using internal cost estimating guidelines and assumptions was used to check the cost estimates developed using the first method. The results are seen in the table below. Using this method, the cost for the Hayden-Blue River 230kV #1 line and the line terminations at the Hayden Substation and the Blue River Substation is $112.6 million. Adding the re-conductoring cost of $44.8 million (from Method #1) results in a total cost of $157.4 million. The $157.4 million is approximately 1.6% less than the estimated cost using Method #1 of $160.0 million.

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	TOT5 System Impact Study Indicative Planning Costs						
		Capital Costs					
	(Costs taken from Cost Estimating Guide Year 2012 - T-Line factors from earlier guide)						
		Revised: September 2013					
						Year 2012 Costs	Year 2013 Costs
1) Hayden Substation							
			Unit Cost	Number	Cost		
a. Labor and Materials							
230-kV line breaker bay to be			$1,376,000	1	$1,376,000		
added to the existing main-and-							
transfer arrangement							
(Assume 3000 amp breaker)							
Service Building (Cost per sq.ft.)			$100	0	$0		
b. Engineering and Survey (12.0%)				12	$165,120		
c. Land Acquisition ($/acre * acres)			$3,000	1	$3,000		
d. Permitting and Environmental					$12,000		
e. Contingency Factor (% of above)				0	$0		
			Subtotal (Year 2012 Costs)			$1,556,120	
			Subtotal (Year 2013 Costs)				$1,590,355
			(Use 1.022 index to escalate 2012 to 2013)				
f. Admin & General (% of subtotal)				25	$389,030		
g. AFUDC(% of half of subtotal)				7.5	$58,355		
			Subtotal (Year 2012 Costs)			$447,385	
			Subtotal (Year 2013 Costs)				$457,227
			(Use 1.022 index to escalate 2012 to 2013)				
			Year 2012 Sub Cost			**$2,003,505**	
			Year 2013 Sub Cost				**$2,047,582**
2) Blue River Substation							
			Unit Cost	Number	Cost		
a. Labor and Materials							
Add bus section bay to the			$941,000	1	$941,000		
three-breaker ring to create a							
four-breaker ring bus							
(Assume 3000 amp breaker)							
Service Building (Cost per sq.ft.)			$100	0	$0		
b. Engineering and Survey (12.0%)				12	$112,920		
c. Land Acquisition ($/acre * acres)			$3,000	1	$3,000		
d. Permitting and Environmental					$12,000		
e. Contingency Factor (% of above)				0	$0		
			Year 2012 Sub Cpst			$1,068,920	
			Year 2013 Sub Cost				$1,092,436
			(Use 1.022 index to escalate 2012 to 2013)				
f. Admin & General (% of subtotal)				25	$267,230		
g. AFUDC(% of half of subtotal)				7.5	$40,085		
			Subtotal (Year 2012 Sub Costs)			$307,315	
			Subtotal (Year 2013 Sub Costs)				$314,075
			(Use 1.022 index to escalate 2012 to 2013)				
			Year 2012 Sub Cost			**$1,376,235**	
			Year 2013 Sub Cost				**$1,406,512**
3) Hayden-Blue River 230kV Line							
			Cost /mile	Miles	Cost		
a. Labor and Materials							
230-kV lattice steel w/ 1272 kcmil			$402,000	86	$34,572,000		
Lattice Steel - Single Circuit							
Two OHGW							
	Terrain	25	%		$8,643,000		
	(Mountainous Terrain)						
	Foundation	30	%		$10,371,600		
	(Rocky Foundation Conditions)						
	Access	50	%		$17,286,000		
	(Difficult Access Assumed)						
	Length	0	%		$0		
	(Line Length Factor Not Applicable)						
b. Engineering and Survey (8%)				8	$5,669,808		
c. Easement Acquisition							
	ROW (feet)	Line Acres	Cost/Acre				
	150	1563.64	$3,000		$4,690,909		
d. Permitting and Environmental							
		Miles	Cost/mile				
		86	$20,000		$1,720,000		
e. Contingency Factor (% of above)				0	$0		
			Year 2012 Sub Cpst			$82,953,317	
			Year 2013 Sub Cost				$84,778,290
			(Use 1.022 index to escalate 2012 to 2013)				
f. Admin. & General (% of subtotal)				25	$20,738,329		
g. AFUDC (% of half of subtotal)				7.5	$3,110,749		
			Year 2012 T-Line Cost			$23,849,079	
			Year 2013 T-Line Cost				$24,373,758
			(Use 1.022 index to escalate 2012 to 2013)				
			Year 2012 T-Line Cost			**$106,802,396**	
			Year 2013 T-Line Cost				**$109,152,048**