

System Impact Study Report for PSCo OASIS Request # T-2007-1

**20 MW Firm Point-to-point Transmission Service Request from
Ault Substation to Midway Substation
Xcel Energy Transmission Planning
July 2007**

Executive Summary

Public Service Company of Colorado (PSCo) Transmission received a transmission service request for 20 MW of firm point-to-point transmission service from the Ault Substation to the Midway Substation for the period of January 1, 2008 through January 1, 2012. In response to this request, a System Impact Study was conducted. The purpose of the System Impact Study was to determine if adequate capacity would be available on the Transmission Provider's (PSCo) transmission system to accommodate the request.

The PSCo system between the Ault Substation and the Midway Substation includes one WECC¹-recognized transfer path (TOT7) and one PSCo internal transfer path (South of Ft.St.Vrain). Power flowing from the Ault Substation to the Midway Substation flows on these two transfer paths. The TOT7 transfer path is a constrained interface between the Northern Colorado Area and North Denver Metro Area. It is jointly-owned by PSCo and Platte River Power Authority (Platte River). It has a WECC-accepted rating of 890 MW (in a north-to-south direction) and has a real-time rating that varies from 890 MW down to approximately 500 MW, depending on the demand in the Foothills Area² and the level of generation scheduled from the Colorado Big Thompson Project (CBT³) hydro units. Figure No. 2 in this report contains a graph that illustrates the relationship between the TOT7 real-time transfer limit and the demand in the Foothills Area for three levels of CBT generation. PSCo and Platte River recognize that transmission enhancements would be necessary to increase the real-time rating of TOT7 to at least 890 MW. This System Impact Study describes the transmission system improvements that would be

¹ Western Electricity Coordinating Council

² The Foothills Area includes the transmission system from the North Boulder Area in the south to the Colorado/Wyoming border in the north and from Estes Park in the east to Greeley in the west. Demand in the area impacts the TOT7 transfer limit. As demand increases, the TOT7 transfer limit decreases.

³ The Colorado-Big Thompson Project (CBT) is a trans-mountain water diversion system that diverts water from the Colorado River headwaters on the western slope to the Big Thompson River, a South Platte River tributary on the eastern slope, for distribution to project lands and communities. Hydroelectric facilities on the Big Thompson River include Big Thompson 4.2kV No. 1, Estes 6.9kV No. 1, 2 and 3, Mary's Lake Power Plant 6.9kV No. 1, Pole Hill 13.8kV No. 1, and Flat Iron 13.8kV No. 1, 2 and 3. Operating studies show that as the CBT generation decreases, the transfer limit of TOT7 decreases.

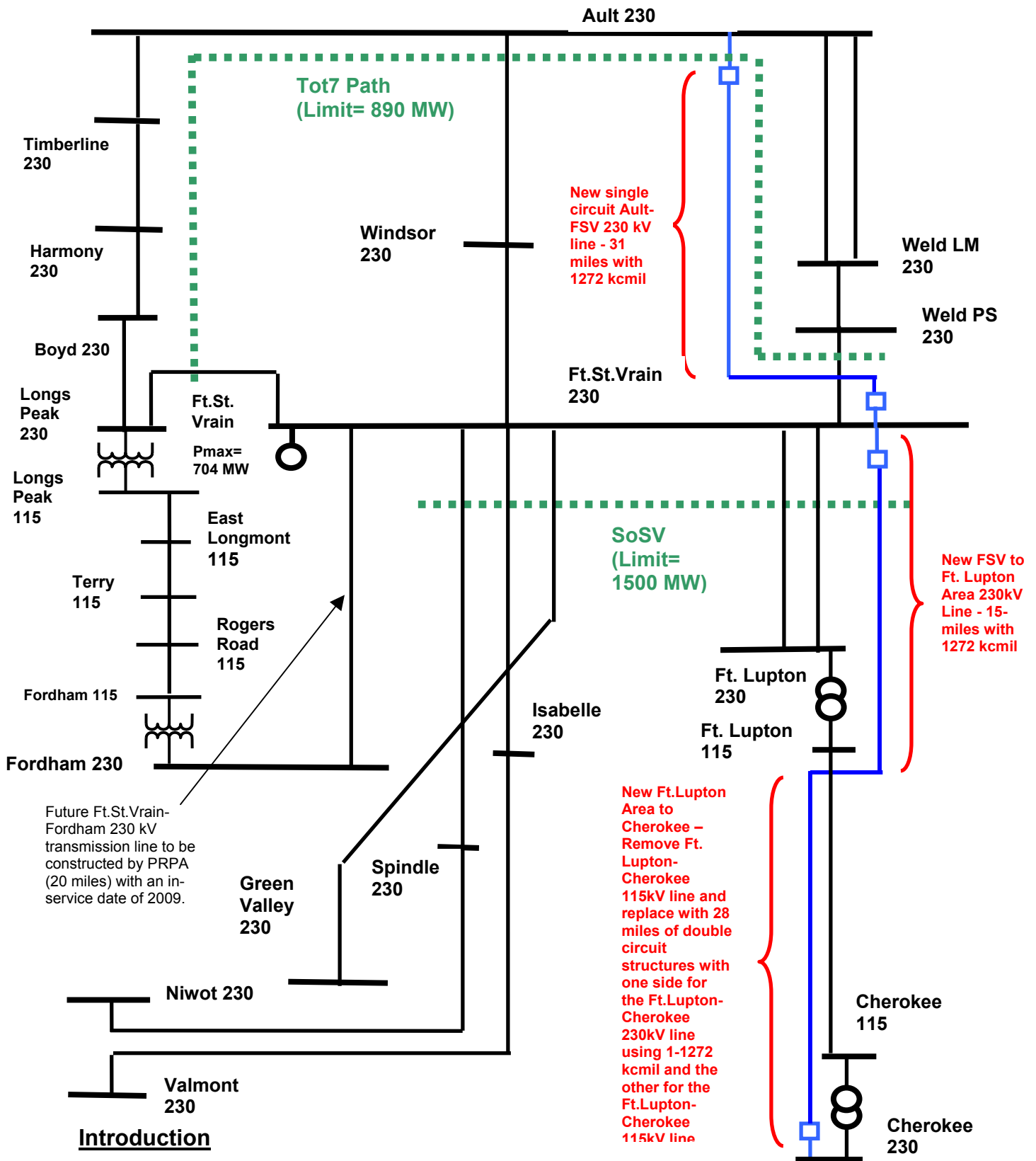
required to achieve a TOT7 transfer limit of at least 910 MW, an additional 20 MW above the 890 MW WECC-accepted rating. The “South of Ft.St.Vrain” transfer path includes the 230kV transmission lines that connect Ft.St.Vrain Substation to load areas south of Ft.St.Vrain in the Denver Metro Area. It has a maximum rating of approximately 1500 MW. This path is impacted by the level of generation at Ft.St.Vrain and the power transfers across TOT7. Load flow studies demonstrate that PSCo’s transmission system would require significant transmission additions in order to increase the TOT7 real-time transfer limit to at least 910 MW (the 890 MW WECC-approved rating plus transmission capacity for an additional 20 MW transfer). The required transmission additions include the following:

- Construct a new 31-mile single-circuit 230 kV transmission line using 1-1272⁴ kcmil conductor from the Ault Substation to the Ft.St. Vrain Substation.
- Construct a new 15-mile single-circuit 230 kV transmission line using 1-1272 kcmil conductor from the Ft. St. Vrain Substation to a location near the Ft. Lupton Substation.
- Construct a new 28-mile double-circuit 230 kV transmission line from a location near the Ft.Lupton Substation to the Cherokee Substation. The new double-circuit 230 kV transmission line would use the existing transmission corridor that includes the existing Ft. Lupton-Platte Valley-Cherokee 115 kV line. The new 230 kV line would use 1-1272 kcmil conductor and share the double-circuit towers along the existing corridor with the existing Ft.Lupton-Platte Valley-Cherokee 115kV line.

PSCo Transmission Engineering and PSCo Substation Engineering evaluated the transmission enhancements listed above and created a cost for the new transmission facilities. The cost of the new transmission facilities is approximately \$42.541 million. The estimated cost is an “indicative” (+/-30%) preliminary cost in 2007 dollars and is based on typical construction costs for similar construction previously performed. The estimated length of time required to complete the project is at least 42 months from the initiation of the project under the terms of a signed Transmission Service Agreement. The System Impact Study demonstrated that after the construction of the Ault-Ft.St.Vrain-Cherokee 230kV transmission line, the TOT7 real-time transfers could increase to approximately 960 MW, the limit to transfers due to contingency overloads on the Ft.St.Vrain-Ft.Lupton 230kV lines. If PSCo and Platte River were to proceed with re-rating the TOT7 transfer path, joint transmission studies with other potentially affected utilities would be required to obtain acceptance of the new TOT7 transfer limit based on the proposed transmission system additions. The Western Electricity Coordinating Council (WECC) Path Rating Process requires joint transmission studies be performed to demonstrate that the new rating would not negatively impact other transfer paths and neighboring systems. A system one-line diagram showing the proposed infrastructure to increase the TOT7 transfer limit and the “South of Ft.St.Vrain transfer limit is shown below in Figure No. 1.

⁴ Bundled 954 kcmil conductor is more typical of PSCo’s new 230kV transmission projects; however, it is more expensive than 1-1272 kcmil conductor.

Figure No. 1 - Upgrades Required for the Transmission Service





PSCo Transmission received a transmission service request for 20 MW of firm point-to-point transmission service from the Ault Substation to the Midway Substation for the period of January 1, 2008 through January 1, 2012. A System Impact Study was conducted to determine the adequacy of the Transmission Provider’s transmission system to accommodate the Applicant’s request for transmission service and any required transmission system upgrades and the estimated cost of transmission system upgrades.

Path Definitions

The transmission service request impacts two power transfer paths – the TOT7 Path and the “South of Ft.St.Vrain” Path. The TOT 7 transfer path provides a path for power transfers into the northern metro Denver area and is also known as Path 40 in the WECC Path Rating Catalog. The “South of Ft.St.Vrain” transfer path is a conduit for power transfers across TOT7 and generation schedules at Ft.St.Vrain in the Denver Metro Area. The transfer paths are described in more detail below.

TOT7

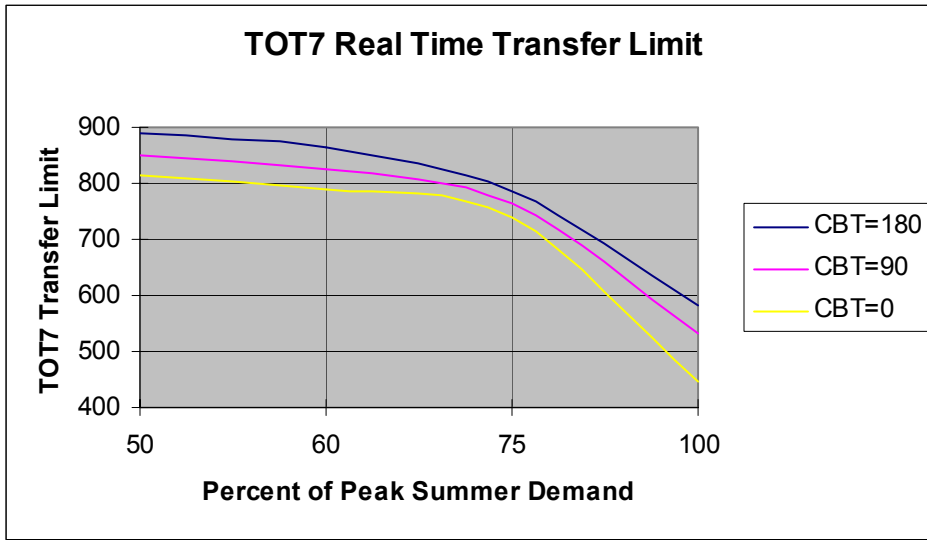
“TOT7” is a WECC-defined power transfer path located in the vicinity of the study area. TOT7 is comprised of transmission lines that allow power to be transferred between northern Colorado and the north Denver Metro Area. The path is shown in Figure No. 1. The TOT7 path owners include Platte River Power Authority (Platte River) and PSCo. The facilities that comprise TOT7 are as follows:

<u>Transmission Line</u>	<u>Metered End</u>
Ault-Windsor 230 kV	Ault
WeldPS-Ft.St.Vrain 230 kV	WeldPS
Longs Peak-Ft.St.Vrain 230 kV	Ft.St.Vrain

The TOT7 Transfer Path has a maximum accepted north-to-south rating of 890 MW; however, the real-time path rating is highly dependant on the level of demand in the Foothills Area and the on-line generation in the area called the Colorado-Big Thompson generation. The Foothills Area includes the transmission system that extends from the North Boulder Area in the south to the Colorado/Wyoming border in the north and from Estes Park in the east to Greeley in the west. As demand in the Foothills Area increases, the TOT7 real-time transfer limit decreases. Similarly, as the Colorado-Big Thompson (CBT) generation decreases, the TOT7 real time rating decreases. Figure No. 2 below illustrates this effect. Figure No. 2 summarizes the results from a previous operating study. The TOT7 transfer limit for various levels of Foothills Area demand (expressed as a percentage of the peak summer demand) and various levels of CBT generation are plotted. The blue line represents the TOT7 transfer limit with CBT generation at 180 MW. At a Foothills Area demand level of 50% of summer peak demand, the TOT7 Transfer Limit is 890 MW, the WECC-accepted rating of the transmission path. With CBT generation fixed at 180 MW, increasing Foothills Area

demand results in a reduced TOT7 Real Time Transfer Limit that decreases to approximately 580 MW at the point where the Foothills Area demand reaches approximately 100% of summer peak. Similarly, plots of the TOT7 Real Time Transfer Limit for levels of Foothills Area demand at a CBT generation fixed at 90 MW and fixed at 0 MW are also displayed. The graph demonstrates the decrease in the TOT7 Real Time Transfer Limit as CBT generation decreases.

Figure No. 2 TOT7 Real Time Transfer Limit



The Foothills Area has experienced a steady increase in demand over that last few years. As a result, the real-time rating of the TOT7 transfer path has decreased and continues to decrease as Foothills Area demand increases. The TOT7 Path owners, PSCo and Platte River, have demonstrated this relationship between the TOT7 real-time transfer limit and the Foothills Area and CBT generation in annual operating studies. Recently, PSCo performed an evaluation of the TOT7 Transfer Path facilities to determine if there are minor equipment modifications that can be made to address the decrease in real-time rating in the near term until significant transmission facilities can be constructed. The minor equipment modifications are described in the report.

South of Ft. St. Vrain (SoSV)

“South of Ft. St. Vrain” (SoSV) Path is a PSCo internal power transfer path in the vicinity of the study area. “South of Ft. St. Vrain” is comprised of 230kV transmission lines lines that allow power to be transferred into the Denver Metro Area from Ft.St.Vrain. The “South of Ft. St. Vrain” Path must accommodate the TOT7 power transfers along with generation scheduled at Ft. St. Vrain to loads in the Denver Metro Area. The path is shown in Figure No. 1 shown above. The north-to-south path rating is approximately 1500 MW and is comprised of the following transmission facilities:



Transmission Line

Metered End

Ft. St. Vrain-Ft. Lupton 230 kV #1
Ft. St. Vrain-Ft. Lupton 230 kV #2
Ft. St. Vrain-Green Valley 230 kV
Ft. St. Vrain-Spindle (Valmont) 230 kV
Ft. St. Vrain-Isabelle 230 kV

Ft. St. Vrain
Ft. St. Vrain
Ft. St. Vrain
Ft. St. Vrain
Ft. St. Vrain

Study Scope and Analysis

The Transmission Service System Impact Study evaluated the feasibility of increasing the real-time rating of the TOT7 Transfer Path to 910 MW in order to accommodate the 20 MW of firm point-to-point transmission service from the Ault Substation to the Midway Substation. The study consisted of load flow analyses and provided a preliminary identification of thermal or voltage limit violations resulting from the transmission service request.

PSCo adheres to NERC / WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, transmission system bus voltages are to be maintained between 0.95 per unit and 1.05 per unit of system nominal/normal conditions, and steady state transmission line flows should be maintained within 100% of the continuous current (or MVA) rating of the transmission line. PSCo Operations tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at generation buses, to 1.0 per unit or higher at transmission load buses. Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per unit to 1.10 per unit, and transmission line flows within 100% of the continuous current rating of the transmission line.

Load Flow Study Models:

WECC creates the operating and planning cases for transmission planning studies. For this study, these include the 2007 HS3A approved operating case (approved on December 19, 2006) and the 2011 HS1B approved base case (approved on January 11, 2007).

Load Flow Study Results and Conclusions

The study used a 2007 heavy summer case and a 2011 heavy summer case. These cases represent of the approximate system conditions at the beginning and at the end of the transmission service request period for the seasons the TOT7 Transfer Path and “South of Ft.St.Vrain” Transfer Path experience the most significant reductions in transfer limit. The TOT7 Transfer Path should have a summer seasonal rating of 890 MW; however, demand increases in the Foothills Area have reduced the TOT7 real-time transfer limit. This was demonstrated using the 2007 heavy summer case. The Colorado-Big Thompson (CBT) generation was scheduled at 180 MW (high generation

condition) to maximize the TOT7 heavy summer season transfer limit, and transfers across TOT7 were increased until a contingency violation was encountered. These transfers were accomplished by increasing WAPA⁵-RMR control area to PSCo control area schedules. To achieve this, generation was increased in the WAPA-RMR control area and generation was decreased in PSCo's southeast Colorado system. With approximately 600 MW flowing across TOT7, an outage of the Ault-Windsor 230kV branch resulted in a flow on the WeldPS-Ft.St.Vrain 230kV line at 100% of the 498 MW line rating. The 600 MW transfer limit is considerably less than the 890 MW WECC-approved transfer limit. Reducing the CBT generation would decrease the TOT7 transfer limit to a level even less than 600 MW.

PSCo Transmission Planning, Transmission Engineering, and Substation Engineering evaluated the transmission lines that make up the TOT7 transfer path and identified minor equipment upgrades to increase the TOT7 transfer limit. These include CT replacements and jumper additions at the Ault, Windsor, Weld and Ft.St.Vrain substations, and higher wind speed assumptions (four ft/sec instead of two ft/sec) for the lines connecting these substations. Assuming these minor modifications were incorporated, the TOT7 transfer limit for the 2007 heavy summer season was recalculated. After these additions, the transfer limit increased to approximately 740 MW (with CBT generation at 180 MW) and increased to approximately 682 MW (with CBT generation off-line). Although this was a significant improvement, these levels are significantly less than the 890 MW transfer limit for the TOT7 path. In addition, the lines comprising the "South of Ft.St.Vrain" Transfer Path experience contingency overloads at the 740 MW TOT7 transfer level.

PSCo Transmission Planning studied additional transmission upgrades to increase the TOT7 transfer limit to at least 910 MW (890 MW transfer limit plus the 20 MW transmission service request) under heavy summer demand conditions with CBT generation off-line. Since significant transmission upgrades would likely be required and could not be constructed by 2008, the 2011 heavy summer case was obtained. The case was modified to reflect any expected transmission upgrades to the PSCo and Platte River systems. The case was benchmarked to reflect CT replacements, jumper additions and higher wind speed assumptions that were considered to the 2007 heavy summer case. The CBT generation was removed from service. The WAPA-RMR control area to PSCo control area interchange was increased. The study found that the TOT7 transfer limit after these modifications were made was approximately 774 MW, still considerably less than the 910 MW target. In addition, the lines comprising the "South of Ft.St.Vrain" Transfer Path experience contingency overloads at the 774 MW TOT7 transfer level.

Transmission alternatives were developed to achieve at least a TOT7 transfer limit of 910 MW (890 MW transfer limit plus the 20 MW transmission service request) assuming 2011 heavy summer demand conditions with CBT generation off-line. The preferred alternative identified would be to construct a 31-mile Ault-Ft.St.Vrain 230 kV line (with required substation terminations) and a 43-mile Ft.St.Vrain-Cherokee 230kV line (with required substation terminations) that would be double-circuited with the existing

⁵ Western Area Power Administration – Rocky Mountain Region



Ft.Lupton-Platte Valley-Cherokee 230kV line. This alternative allows the TOT7 transfer limit to be increased to approximately 960 MW, an amount adequate to support the 20 MW transmission service request along with the TOT7 approved transfer limit of 890 MW. In addition, the contingency flows on the lines comprising the “South of Ft.St.Vrain” Transfer Path are within their ratings at a TOT7 level of 960 MW. For example, an outage of the Ft.St.Vrain-Ft.Lupton 230kV line #2 results in a flow on the Ft.St.Vrain-Ft.Lupton 230kV line #1 of 99.8% of its 435 MVA rating. Similarly, an outage of the Ft.St.Vrain-Ft.Lupton 230kV line #1 results in a flow on the Ft.St.Vrain-Ft.Lupton 230kV line #2 of 99.8% of its 435 MVA rating. The details of these load flow studies can be found in “Appendix A – Load Flow Study Details”. Transmission Engineering and Substation evaluated these proposed transmission additions and determined that they would require at least 42 months from the initiation of the project under the terms of a signed Transmission Service Agreement.

The study concludes that the transmission service request from Ault Substation to Midway Substation cannot be achieved without significant transmission system upgrades and that these upgrades would take at least 42 months from the initiation of the project under the terms of a signed Transmission Service Agreement.

Costs Estimates and Assumptions:

To provide transmission service for the request, transmission system upgrades must be made on the transmission system. Transmission and Substation Engineering evaluated the preferred alternative and developed cost estimates for the transmission and substation modifications.

The estimated indicative total cost for the transmission system upgrades is:

\$42,541,000

The estimated cost shown is an “indicative” (+/-30%) preliminary budgetary cost in 2007 dollars and is based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new transmission system facilities. This estimate also does not include any costs that may be required for other entities’ systems. The following table describes the transmission system upgrades that would be required to support the transmission service request.

Table No. 1 Transmission System Upgrades to Increase the TOT7 Transfer Limit to 910 MW

Element	Description	Cost (\$millions)
Transmission	<ul style="list-style-type: none"> • Construct a new single circuit 230kV transmission line from WAPA's Ault Substation to Ft. St Vrain Substation (approx. 31 miles) using 1272 kcmil "Bittern" conductor with OPGW on tubular steel poles with foundations. • Construct a new single circuit 230kV transmission line from Ft. St Vrain Substation to the Ft. Lupton Substation general area (approx. 15 miles) using 1272 kcmil "Bittern" conductor with OPGW on tubular steel poles with foundations. • Remove the existing 115kV wood H-frame transmission line and rebuild to double circuit 230kV transmission line within the existing 75 foot wide ROW (approx. 28 miles) using 1272 kcmil "Bittern" conductor with OPGW on tubular steel poles with foundations. One circuit will continue to operate at 115kV. 	\$32.740
WAPA's Ault Substation	<p>One new 230kV line termination for a new transmission line to Ft. St. Vrain Substation. Assumes that WAPA will require two breakers in the existing 230-kV breaker-and-a-half scheme to terminate the line. The following equipment will be required:</p> <ul style="list-style-type: none"> • two (2) 230kV 3000 amp 50kA circuit breakers • four (4) 230kV switches • misc. supporting steel • electrical bus work • associated metering control and relaying 	\$1.040
Ft. St. Vrain Substation	<p>Two new 230kV line terminations for a new transmission line from WAPA's Ault Substation and new transmission line to Cherokee Substation. The following equipment will be required:</p> <ul style="list-style-type: none"> • three (3) 230kV 3000 amp 50kA circuit breakers • six (6) 230kV switches • misc. supporting steel • electrical bus work • associated control and relaying 	\$1.549
Cherokee Substation	<p>One new 230kV line termination for new transmission line from Ft. St. Vrain Substation. The following equipment will be required:</p> <ul style="list-style-type: none"> • one (1) 230kV 3000 amp 50 kA circuit breaker • two (2) 230kV switches • misc. supporting steel • electrical bus work • associated control and relaying 	\$0.634
Siting, Permitting and Acquisition	Activities include siting study, acquisition & permitting	\$6.578
TOTAL		\$42.541 million
Time Frame		42 Months

Assumptions:

- The estimated costs provided are “Scoping Estimates” with an accuracy of \pm 30%.
- Estimates are based on 2007 dollars.
- PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
- It is anticipated that a Certificate of Public Convenience and Necessity (CPCN) will be required from Colorado Public Utility Commission (CPUC).
- A Siting Study and public involvement will be required. Permitting is expected to be difficult and potentially controversial. Land use permits will be required from multiple local jurisdictions. The proposed transmission additions would be located in counties or other jurisdictions that may attempt to require the transmission lines to be placed underground. This requirement would drastically increase the scope, difficulty and cost of the project.
- The estimated time for siting, permitting, acquisition, design and construction for the transmission system upgrades is at least 42 months from the initiation of the project under the terms of a signed Transmission Service Agreement.
- This estimate is based upon other identified assumptions for Siting and Land Rights, Substation Engineering and Transmission Engineering.
- There is adequate space available at WAPA’s Ault Substation for the new 230kV line termination, and WAPA will agree to allow this new installation.
- New Ft. Lupton Substation-Platte Valley-Cherokee Substation 230kV double circuit transmission line can be constructed within the existing ROW, and the existing 115kV single circuit line can be taken out of service for the duration of the double circuit rebuild. One circuit of the double circuit rebuild will continue to operate at 115kV and be re-connected to the previous terminations points.
- New ROW acquisition is required for the new Ault-Ft. St. Vrain transmission line, and the new Ft. St Vrain to Ft. Lupton transmission line. Minimal additional ROW required for the Ft. Lupton-Cherokee 230kV double circuit transmission line rebuild.

APPENDIX A

LOAD FLOW STUDY DETAILS

2007 Heavy Summer Season – CBT Generation Off-Line

The 2007 Heavy Summer Operating Case was obtained. The CBT generation was removed from service. The ratings of transmission line segments of the lines that comprise the TOT7 Transfer Path were modified to reflect minor substation or transmission improvements that have been identified to increase the TOT7 transfer path rating. The proposed minor transmission facility improvements include the following:

- Upgrade the CT's at the Ault Substation (owned by WAPA-RMR) thereby increasing the rating of WAPA's Ault-WeldLM 230kV No. 1 and No. 2 lines from 478 MVA. The rating of the Ault-WeldLM 230kV No. 1 and No. 2 lines becomes the 1-1272 kcmil conductor limit of the Ault-WeldLM 230kV No. 1 and No. 2 lines using a four ft/sec wind speed assumption (WAPA-RMR new rating standard). The new rating is 540 MVA at a 75 degree C design temperature.
- Upgrade the CT's of the WeldLM-WeldPS 230kV bus tie thereby increasing the bus tie rating from 637 MVA. The new rating of the WeldLM-WeldPS 230kV bus tie becomes the 230kV switch rating of 2000 amps or 797 MVA.
- Add 1-1272 kcmil jumpers at the Ft.St.Vrain Substation thereby increasing the rating from 498 MVA. The new limit of the WeldPS-Ft.St.Vrain 230kV line becomes the 1-1033 kcmil conductor limit using a four ft/sec wind speed assumption (PSCo's new rating standard) at a 121 degree C design temperature or 580 MVA.
- Upgrade the CT's at the Ault Substation (owned by WAPA-RMR) thereby increasing the rating of PSCo's Ault-Windsor 230kV line from 478 MVA. Also, adding 1-1272 jumpers on the Ault-Windsor 230kV line at the Windsor Substation would increase the rating. The rating of the Ault-Windsor 230kV line becomes the 1-1272 kcmil conductor limit of the Ault-Windsor 230kV line using a four ft/sec wind speed assumption (PSCo new facility rating standard⁶). The new rating becomes 575 MVA.
- Add 1-1272 kcmil jumpers at the Windsor and Ft.St.Vrain substations on the Windsor-Ft.St.Vrain 230kV line increasing the rating from 498 MVA. The rating of the Windsor-Ft.St.Vrain 230kV line becomes the 1-1272 kcmil conductor limit of the Windsor-Ft.St.Vrain 230kV line using a four ft/sec wind speed assumption (PSCo new rating standard). The new rating becomes 575 MVA.

The minor modifications listed above were modeled in the 2007 heavy summer operating case with CBT generation off-line. Schedules between WAPA-RMR (Area73) and PSCo (Area 70) were increased and outages of transmission facilities

⁶ PSCo Transmission Facility Equipment Ratings Fac-009 Version 1.0 dated June 4, 2007

in the study area were simulated. At a TOT7 flow of 682 MW, an outage of the Ault-Windsor 230kV line results in a contingency flow on the WeldPS-Ft.St.Vrain 230kV line of 99.8% of its 580 MVA rating. In order to reach that TOT7 level, a flow on TOT3 of 1664 MW was required. That level exceeds the TOT3 transfer limit of 1605 MW; however, this was noted but not used to limit the TOT7 transfer limit. The results are listed in Table No. 2 below.

Table No. 2 2007 Heavy Summer (CBT generation off-line) Results

Case: 07HS-BNCH-C6 (TOT7=681.7, TOT3=1664.0)					
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L
AULT 230.00-WELD LM 230.00	2	AULT 230.0-WELD LM 230.0-1	540.0	534.9	99.1
AULT 230.00-WELD LM 230.00	1	AULT 230.0-WELD LM 230.0-2	540.0	534.9	99.1
FTLUPTON 230.00-JLGREEN 230.00	1	FTLUPTON 230.0-HENRYLAK 230.0-1	495.0	526.0	106.3
FTLUPTON 230.00-ST.VRAIN 230.00	2	FTLUPTON 230.0-ST.VRAIN 230.0-1	435.0	494.9	113.8
FTLUPTON 230.00-ST.VRAIN 230.00	1	FTLUPTON 230.0-ST.VRAIN 230.0-2	435.0	494.9	113.8
AULT 345.00-LAR.RIVR 345.00	1	LAR.RIVR 345.0-STORY 345.0-1	956.0	993.8	104.0
PAWNEE 230.00-QUINCY 230.00	1	DANIELPK 230.0-PAWNEE 230.0-1	478.0	553.7	115.8
ST.VRAIN 230.00-LONGPEAK 230.00	1	HARMONY 230.0-TIMBERLN 230.0-1	377.7	369.6	97.9
ST.VRAIN 230.00-WELD PS 230.00	1	WINDSOR 230.0-AULT 230.0-1	580.0	579.0	99.8
ST.VRAIN 230.00-WINDSOR 230.00	1	WELD PS 230.0-WELD LM 230.0-1	575.0	512.8	89.2
WASHINGT 230.00-JLGREEN 230.00	1	FTLUPTON 230.0-HENRYLAK 230.0-1	495.0	493.6	99.7
WELD LM 115.00-WELD LM 230.00	1	HARMONY 230.0-TIMBERLN 230.0-1	150.0	166.3	110.9
WELD PS 115.00-WELD PS 230.00	T1	HARMONY 230.0-TIMBERLN 230.0-1	150.0	156.7	104.5
WELD PS 230.00-WELD LM 230.00	1	WINDSOR 230.0-AULT 230.0-1	797.0	698.9	87.7
WINDSOR 230.00-AULT 230.00	1	WELD PS 230.0-WELD LM 230.0-1	575.0	519.1	90.3

At a TOT7 flow level of 681.7 MW, the WeldPS-Ft.St.Vrain 230kV line contingency overload reaches 99.8% of its 580 MVA limit based on a conductor limit rated at four ft/sec. In addition, the Ft.St.Vrain-Ft.Lupton 230kV line contingency overload reaches 113.8% of its 435 MVA rating based on the transmission conductor limit. The Pawnee-Quincy 230kV contingency overload reaches 115.8% of its 478 MVA rating; however, that section is part of the Pawnee-Quincy-Smoky Hill 230kV line that is being uprated in 2008 to achieve 637 MVA continuous rating. The Ft.Lupton-JLGreen 230kV contingency overload reaches 106.3% of its 495 MVA rating. The contingency overloads of the WeldLM 230-115kV and WeldPS 230-115kV transformers are within the four-hour emergency limits of these load-serving transformers.

Contingency overloads (not listed in the table) occur for the Cherokee-Silver Saddle 230kV line at 109.5% of its 326.0 MVA rating, Jordan-Orchard 230kV line at 123.0% of its 346.0 MVA rating, the Meadow Hill-Orchard 230kV line at 135.8% of its 346.0 MVA rating, the Meadow Hill-Smoky Hill 230kV line at 165.2% of its 328.0 MVA rating, the Niwot-Isabelle 230kV line at 117.9% of its 346.0 MVA rating, Pawnee-Quincy 230kV line at 111.8% of its 478.0 MVA rating, the Smoky Hill-Spruce 230kV line at 187.3% of its 471.0 MVA rating, Smoky Hill-Powhatan 230kV line at 187.4% of its 478.0 MVA rating, Smoky Hill-Murphy 230kV line at 118.3% of its 340.0 MVA

rating, Silver Saddle-Reunion 230kV at 116.9% of its 326.0 MVA rating, These contingency overloads under high TOT3/TOT7 flow levels are being studied by PSCo Transmission Planning to determine if transmission system upgrades will be needed to mitigate these contingency overloads.

The addition of the minor transmission facility upgrades (with CBT generation out-of-service) did not increase the TOT7 transfer limit to 910 MW (890 MW transfer limit plus the 20 MW service request). Therefore, the CBT generation was increased to the 180 MW level to determine if CBT generation at 180 MW could increase the TOT7 transfer limit to its 890 MW rating.

2007 Heavy Summer Season – CBT Generation at 180 MW

Previous studies have indicated that increasing the CBT generation can increase the TOT7 transfer limit. The 2007 heavy summer operating case was modified by increasing the CBT generation level to 180 MW. Schedules between WAPA-RMR (Area73) and PSCo (Area 70) were increased and outages of transmission facilities in the study area simulated. As each system overload was encountered, the proposed facility enhancement was modeled and the schedules between WAPA-RMR and PSCo were increased to the next limit. The results are listed in Table No. 3 below.

Table No. 3 2007 Heavy Summer (CBT Generation=180 MW) Transfer Limit Progression

TOT7	Limiting Outage	Limiting Element	Rate	Flow	Recommended Upgrade	Next Limit
600	Ault-Windsor 230kV	WeldPS-St.Vrain 230 (Jumper, 1-1272kcmil at two ft/sec wind speed)	498	99.3	Add jumpers at St. Vrain	Weld-St Vrain 1033 kcmil conductor limit of 580 MVA at four ft/sec, 121C
635	Ault-Weld 230 #1 and #2	Ault-Weld 230 #1 and #2 (WAPA Line) Note: If two ft/sec used for Weld-FSV 230, contingency flow of 103.4% for outage of Ault-Windsor 230 Note: If two ft/sec used for Ault-Windsor 230, contingency flow of 90.9% for outage of Weld-FSV 230	478	100.0	Replace CTs at Ault (WAPA)	Conductor limit based on four ft/sec rating, design temp 540 MVA at 75C 647 MVA at 100C
654	Ault-Windsor 230	WeldLM-WeldPS 230	637	100.2	Replace CT's at Weld on the WeldPS-WeldLM 230 bus tie	Weld 230kV switches (2000amp) rated at 797 MVA
695	Weld-FSV 230kV	Windsor-FSV 230	478	100.0	Replace CT's at Ault on Ault-Windsor-FSV 230kV line	1-1272 jumpers at Ault, Windsor, FSV on Ault-Windsor-FSV 230kV line rated at 495 MVA
725	Weld-FSV 230kV	Windsor-FSV 230kV	495	99.9	Add jumpers at Ault, Windsor, FSV on the Ault-Windsor-	Ault-Windsor-FSV 230kV conductor

	Weld-FSV 230kV	Ault-Windsor 230	498	100.6	FSV 230kV line	limit based on four ft/sec rating of 575 MVA.	
740	Ault-Windsor	Weld-FSV 230	580	100.2	Add the Ault-FSV-Cherokee 230kV transmission line		

The table demonstrates that increasing CBT generation increases the TOT7 transfer limit from 682 MW to 740 MW, an increase of 58 MW. The new level is well below the 910 MW transfer limit requirement (890 MW transfer limit plus the 20 MW transmission service request). Table No. 4 below provides the results of outage simulations at the TOT7 transfer level of 740 MW.

Table No. 4 2007 Heavy Summer (CBT Gen=180 MW) at a TOT7 Flow of 740 MW

Case: 07HS-BNCH-B5A (TOT7= 739.5, TOT3=1534.1)							
Monitored Element	Ckt	Limiting Contingency	Rating	LnFlow	%O/L		
AULT 230.00-WELD LM 230.00	2	AULT 230.0-WELD LM 230.0-1	540.0	515.2	95.4		
AULT 230.00-WELD LM 230.00	1	AULT 230.0-WELD LM 230.0-2	540.0	515.2	95.4		
FTLUPTON 115.00-FTLUPTON 230.00	T3	FTLUPTON 230.0-JLGREEN 230.0-1	280.0	288.5	103.0		
FTLUPTON 230.00-JLGREEN 230.00	1	FTLUPTON 230.0-HENRYLAK 230.0-1	495.0	536.5	108.4		
FTLUPTON 230.00-ST.VRAIN 230.00	2	FTLUPTON 230.0-ST.VRAIN 230.0-1	435.0	521.3	119.8		
FTLUPTON 230.00-ST.VRAIN 230.00	1	FTLUPTON 230.0-ST.VRAIN 230.0-2	435.0	521.3	119.8		
PAWNEE 230.00-QUINCY 230.00	1	DANIELPK 230.0-PAWNEE 230.0-1	478.0	538.9	112.7		
ST.VRAIN 230.00-WELD PS 230.00	1	WINDSOR 230.0-AULT 230.0-1	580.0	580.9	100.2		
ST.VRAIN 230.00-WINDSOR 230.00	1	WELD PS 230.0-WELD LM 230.0-1	575.0	504.7	87.8		
WASHINGTON 230.00-JLGREEN 230.00	1	FTLUPTON 230.0-HENRYLAK 230.0-1	495.0	504.3	101.9		
WELD LM 115.00-WELD LM 230.00	1	WELD PS 115.0-WELD PS 230.0-T1	150.0	192.9	128.6		
WELD PS 115.00-WELD PS 230.00	T1	WELD LM 115.0-WELD LM 230.0-1	150.0	188.6	125.7		
WELD PS 230.00-WELD LM 230.00	1	WINDSOR 230.0-AULT 230.0-1	797.0	688.8	86.4		
WINDSOR 230.00-AULT 230.00	1	WELD PS 230.0-WELD LM 230.0-1	575.0	512.9	89.2		

The impact of the CBT generation at 180 MW can be seen in Table No. 4. The WeldPS-Ft.St.Vrain 230kV line contingency overload reaches 100.2% of its 580 MVA limit based on a conductor limit rated at four ft/sec. In addition, the Ft.St.Vrain-Ft.Lupton 230kV line contingency overload reaches 119.8% of its 435 MVA rating based on the transmission conductor limit. The Pawnee-Quincy 230kV contingency overload reaches 112.7% of its 478 MVA rating; however, that section is part of the Pawnee-Quincy-Smoky Hill 230kV line that is being uprated in 2008 to achieve 637 MVA continuous rating. The Ft.Lupton-JLGreen 230kV contingency overload reaches 108.4% of its 495 MVA rating. The contingency overloads of the WeldLM 230-115kV and WeldPS 230-115kV transformers exceed the four-hour emergency limits of these load-serving transformers.

Contingency overloads occur for the Cherokee-Silver Saddle 230kV line at 112.1% of its 326.0 MVA rating, the Meadow Hill-Orchard 230kV line at 132.5% of its 346.0 MVA rating, the Meadow Hill-Smoky Hill 230kV line at 161.3% of its 328.0 MVA rating, the Niwot-Isabelle 230kV line at 119.7% of its 346.0 MVA rating, Pawnee-Quincy 230kV line at 109.4% of its 478.0 MVA rating, the Smoky Hill-Spruce 230kV line at 185.1% of its 471.0 MVA rating, Smoky Hill-Powhatan 230kV line at 185.1% of its 478.0 MVA rating, Smoky Hill-Murphy 230kV line at 112.7% of its 340.0 MVA

rating, Silver Saddle-Reunion 230kV at 119.5% of its 326.0 MVA rating, the Smoky Hill-Quincy 230kV line at 108.3% of its 478.0 MVA rating, Homestead-Sulphur 230kV at 106.5% of its 340.0 MVA rating, and the Homestead-Murphy 230kV line at 111.9% of its 340.0 MVA rating. These contingency overloads under high TOT3/TOT7 flow levels are being studied by PSCo Transmission Planning to determine if transmission system upgrades will be needed to mitigate these contingency overloads.

The study results demonstrate that even under a favorable system condition (with CBT generation at 180 MW), the TOT7 transfer limit increases to only 740 MW. In addition, the Ft.St.Vrain-Ft.Lupton 230kV No. 1 and No. 2 contingency flows are well above the line ratings. Therefore, significant transmission upgrades are needed to the system. Since transmission upgrades are required and could not be constructed by January 1, 2008 (the start of the proposed contract) the 2011 heavy summer study case was used to investigate transmission upgrades.

2011 Heavy Summer Season – CBT Generation Off-Line

The study results from the 2007 heavy summer operation case demonstrate that as CBT generation decreases, the TOT7 transfer limit decreases. Platte River has indicated that CBT generation levels in the summer can be as low as 35 MW. Therefore, the study case for 2011 heavy summer season was obtained and modified to reflect the proposed changes that have been identified by Platte River. Operating studies conducted by PSCo and Platter River have demonstrated that as the CBT generation decreases, the transfer limit of TOT7 decreases. The studies also show that as demand in the Front Range of Colorado increases, the TOT7 transfer limit decreases.

The minimum CBT generation (the CBT generation off-line) was also modeled. The Sidney DC tie schedule was modified to reflect a WAPA-LM import of 180 MW. The new ratings are based on replacing the CT's at the Ault Substation increasing the rating WAPA's Ault-WeldLM 230kV No. 1 and No. 2 lines from 478 MVA to 540 MVA at a 75 degree C design temperature and four ft/sec wind speed assumption, replacing the CT's of the WeldLM-WeldPS 230kV bus tie increasing the rating of the WeldLM-WeldPS 230kV bus tie to the 230kV switch limit of 797 MVA, adding 1-1272 kcmil jumpers at the Ft.St.Vrain substation increasing the rating to the 1-1033 kcmil conductor limit (using a four ft/sec wind speed assumption at a 121 degree C design temperature) of 580 MVA, replacing the CT's at the Ault Substation increasing the rating PSCo's Ault-Windsor 230kV line to the 1-1272 conductor limit on the Ault-Windsor 230kV line using a four ft/sec wind speed assumption of 575 MVA and adding 1-1272 kcmil jumpers at the Windsor and Ft.St.Vrain substations on the Windsor-Ft.St.Vrain 230kV line increasing the rating of the Windsor-Ft.St.Vrain 230kV line to the 1-1272 kcmil conductor limit using a four ft/sec wind speed assumption of 575 MVA.

Table No. 5 2011 Heavy Summer (CBT Gen=0 MW) at Maximum TOT7 Flow

Case: 2011HS-BNCH-D4 (TOT7= 774.2, TOT3= 1789.3)									
Monitored Element			Ckt	Limiting Contingency			Rating	LnFlow	%O/L
AULT	230.00-WELD LM	230.00	2	AULT	230.0-WELD LM	230.0-1	540.0	523.0	96.8
AULT	230.00-WELD LM	230.00	1	AULT	230.0-WELD LM	230.0-2	540.0	523.0	96.8
FTLUPTON	230.00-JLGREEN	230.00	1	FTLUPTON	230.0-HENRYLAK	230.0-1	495.0	522.1	105.5
FTLUPTON	230.00-JLGREEN	230.00	1	AULT	345.0-CRAIG	345.0-1	495.0	412.5	83.3
FTLUPTON	230.00-ST.VRAIN	230.00	2	FTLUPTON	230.0-ST.VRAIN	230.0-1	435.0	514.8	118.3
FTLUPTON	230.00-ST.VRAIN	230.00	1	FTLUPTON	230.0-ST.VRAIN	230.0-2	435.0	514.8	118.3
ST.VRAIN	230.00-WELD PS	230.00	1	WINDSOR	230.0-AULT	230.0-1	580.0	579.0	99.8
ST.VRAIN	230.00-WINDSOR	230.00	1	WELD PS	230.0-WELD LM	230.0-1	575.0	503.4	87.6
WASHINGTON	230.00-JLGREEN	230.00	1	FTLUPTON	230.0-HENRYLAK	230.0-1	495.0	493.7	99.7
WELD LM	115.00-WELD LM	230.00	1	WELD PS	115.0-WELD PS	230.0-T1	150.0	170.1	113.4
WELD PS	115.00-WELD PS	230.00	T1	WELD LM	115.0-WELD LM	230.0-1	150.0	167.1	111.4
WELD PS	230.00-WELD LM	230.00	1	WINDSOR	230.0-AULT	230.0-1	797.0	695.9	87.3
WINDSOR	230.00-AULT	230.00	1	WELD PS	230.0-WELD LM	230.0-1	575.0	514.5	89.5

Schedules from WAPA-RMR and PSCo were increased until the TOT7 limit was reached. At a TOT7 flow of 774.2 MW, the Weld-Ft.St.Vrain 230kV contingency flow reached 99.8% of its 580 MVA rating. The TOT3 flow at this TOT7 limit was 1789.2 MW, considerably higher than the 1680 MW rating in the 2011HS case. The TOT7 transfer limit of 774 MW is considerably less than the 910 MW required level.

In addition, contingency overloads occur for the Cherokee-Conoco 230kV line at 106.6% of its 134.8 MVA rating, the Valmont-Lafayette 115kV line at 104.6% of its 135.0 MVA rating, the Pawnee-Story 230kV at 173.2% of its 625.0 MVA rating, the Smoky Hill-Peakview 115kV at 113.8% of its 186.6 MVA rating, the Silver Saddle-Reunion 230kV at 105.9% of its 326.0 MVA rating, and the LRS-Ault 345kV at 138.7% of its 956.0 MVA rating. These contingency overloads under high TOT3/TOT7 flow levels are being studied by PSCo Transmission Planning to determine if transmission system upgrades would be needed to mitigate these contingency overloads.

The study determined the transmission system upgrades that will be required to achieve a 910 MW transfer limit on TOT7. The transmission system upgrades include the following:

- A new single circuit 230kV transmission line from WAPA’s Ault Substation to Ft. St Vrain Substation (approx. 31 miles) using 1272 kcmil “Bittern” conductor with OPGW on tubular steel poles with foundations.
- A new single circuit 230kV transmission line from Ft. St Vrain Substation to the Ft. Lupton Substation general area (approx. 15 miles) using 1272 kcmil “Bittern” conductor with OPGW on tubular steel poles with foundations.

- The removal of the existing 115kV wood H-frame transmission line and rebuild to a double-circuit 230kV transmission line within the existing 75 foot wide ROW (approx. 28 miles) using 1272 kcmil “Bittern” conductor with OPGW on tubular steel poles with foundations. One circuit will continue to operate at 115kV.
- One new 230kV line termination at WAPA’s Ault Substation for a new 230kV transmission line from the Ault Substation to the Ft.St.Vrain Substation. This assumes that WAPA will require two breakers in the existing 230-kV breaker-and-a-half scheme to terminate the line. The following equipment will be required:
 - Two (2) 230kV 3000 amp 50kA circuit breakers
 - Four (4) 230kV switches
 - Miscellaneous supporting steel
 - Electrical bus work
 - Associated control and relaying
- Two new 230kV line terminations at the Ft.St.Vrain Substation, one to terminate a new 230kV transmission line from Ault Substation to the Ft.St.Vrain Substation and the other to terminate a new 230kV transmission line from Ft.St.Vrain Substation to the Cherokee Substation. The following equipment will be required:
 - Three (3) 230kV 3000 amp 50 kA circuit breaker
 - Six (6) 230kV switches
 - Miscellaneous supporting steel
 - Electrical bus work
 - Associated control and relaying
- One new 230kV line termination at the Cherokee Substation to terminate a new 230kV transmission line from the Ft. St. Vrain Substation. The following equipment will be required:
 - One (1) 230kV 3000 amp 50kA circuit breakers
 - Two (2) 230kV switches
 - Miscellaneous supporting steel
 - Electrical bus work
 - Associated metering control and relaying

The proposed modifications were made to the 2011 Heavy Summer operating case and schedules across TOT7 and “South of Ft. St. Vrain” were increased until the TOT7 flow reached approximately 960 MW and the TOT3 flow reached approximately 1900 MW. Outages of transmission lines in the study area were simulated and the results listed in Table No. 6.

Table No. 6 - Alternative No. 1 (Ault-FSV-Cherokee 230kV Line) at High TOT7(960 MW)

Case: 2011HS-BNCH-ALT1-5.sav (TOT7=960.9, TOT3=1900.3)									
Monitored Element			Ckt	Limiting Contingency			Rating	LnFlow	%O/L
AULT	230.00-AULT	345.00	1	AULT	230.0-AULT	345.0-3	500.0	488.5	97.7
AULT	230.00-AULT	345.00	2	AULT	230.0-AULT	345.0-3	500.0	485.1	97.0
AULT	230.00-AULT	345.00	3	AULT	230.0-AULT	345.0-1	560.0	512.9	91.6
AULT	230.00-WELD LM	230.00	2	AULT	230.0-WELD LM	230.0-1	540.0	458.6	84.9
AULT	230.00-WELD LM	230.00	1	AULT	230.0-WELD LM	230.0-2	540.0	458.6	84.9
AULT	345.00-LAR.RIVR	345.00	1	PAWNEE	230.0-STORY	230.0-1	956.0	1343.9	140.6
B.CK PS	115.00-BEAVERCK	115.00	1	PAWNEE	230.0-STORY	230.0-1	319.0	343.7	107.8
FTLUPTON	230.00-JLGREEN	230.00	1	FTLUPTON	230.0-HENRYLAK	230.0-1	495.0	461.5	93.2
FTLUPTON	230.00-ST.VRAIN	230.00	2	FTLUPTON	230.0-ST.VRAIN	230.0-1	435.0	434.2	99.8
FTLUPTON	230.00-ST.VRAIN	230.00	1	FTLUPTON	230.0-ST.VRAIN	230.0-2	435.0	434.2	99.8
PAWNEE	230.00-BRICKCTR	230.00	1	DANIELPK	230.0-PAWNEE	230.0-1	637.0	547.3	85.9
WASHINGT	230.00-JLGREEN	230.00	1	FTLUPTON	230.0-HENRYLAK	230.0-1	495.0	435.2	87.9
WELD LM	115.00-WELD LM	230.00	1	WELD PS	115.0-WELD PS	230.0-T1	150.0	161.6	107.7
WELD PS	115.00-WELD PS	230.00	T1	WELD LM	115.0-WELD LM	230.0-1	150.0	159.0	106.0

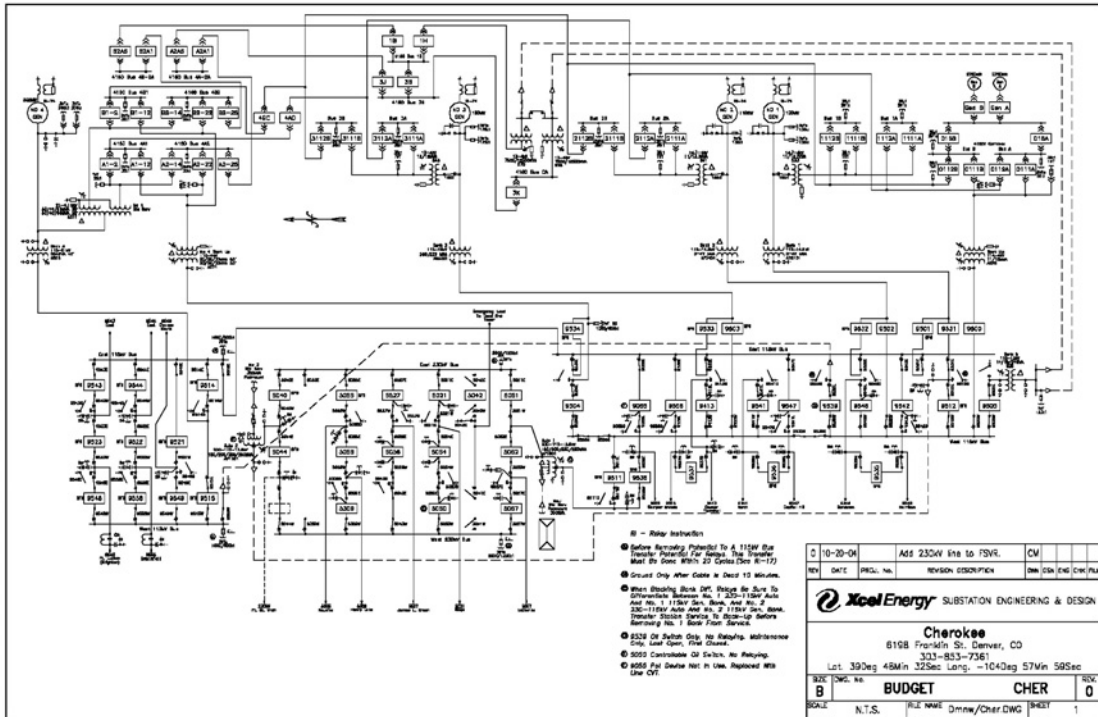
The Ft.Lupton-Ft.St.Vrain 230kV contingency flow reached 99.8% of its 435 MVA limit. The WeldPS 230-115kV transformer and WeldLM 230-115kV transformer contingency overloads are within the emergency ratings for these load-serving transformers. At the TOT3 transfer level of approximately 1900 MW (required to achieve 960 MW on TOT7), the study results indicate that transmission enhancements on the TOT3 transfer path and associated area may be required, an issue that is beyond the scope of this study. The TOT7 transfer limit after adding in the trans. Higher TOT7 transfer levels beyond 960 MW could be possible with transmission upgrades to the Ft.Lupton-Ft.St.Vrain 230kV lines and transmission enhancements to the TOT3 transfer path and area.

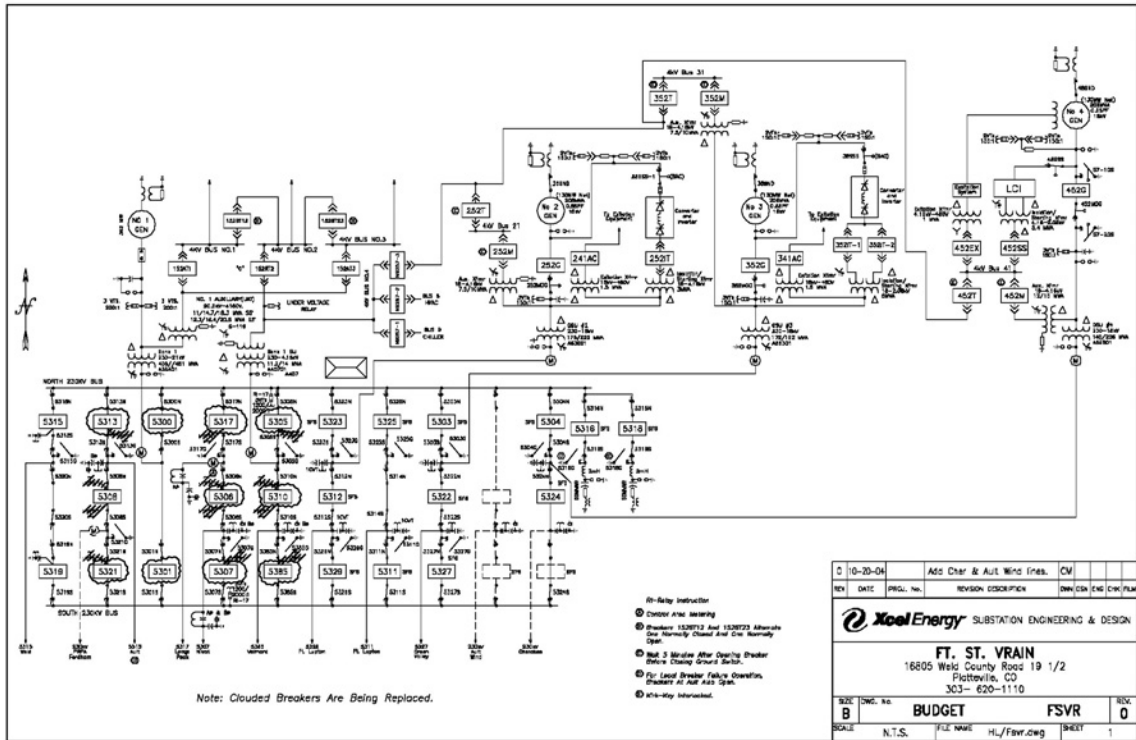
In addition, contingency overloads occur for the Cherokee-Conoco 230kV line at 107.9% of its 134.8 MVA rating, the Valmont-Lafayette 115kV line at 102.8% of its 135.0 MVA rating, the Pawnee-Story 230kV at 165.3% of its 625.0 MVA rating, the Smoky Hill-Peakview 115kV at 113.8% of its 186.6 MVA rating, the ParkerPS-Sulphur 115kV at 106.9% of its 186.6 MVA rating. These contingency overloads under high TOT3/TOT7 flow levels are being studied by PSCo Transmission Planning to determine if transmission system upgrades would be needed to mitigate these contingency overloads.




APPENDIX B

ONE-LINES





- ① Relay Instruction
- ② Circuit Breaker
- ③ Breakers 152072 And 152073 Alternate One Normally Closed And One Normally Open.
- ④ Bus 3 Marker After Opening Breaker Shows Change Ground Status.
- ⑤ For Local Breaker Failure Detection, Openers At All Bus Open.
- ⑥ Not-to-be Installed.

0	10-20-04	Add Char & Aux Wind (Ines.	CV		
REV	DATE	PROJ. NO.	REVISION DESCRIPTION	ENR/CEN	ENG/CWK/FLM
 SUBSTATION ENGINEERING & DESIGN					
FT. ST. VRAIN 16605 Weld County Road 19 1/2 Platteville, CO 303-620-1110					
SIZE	DWG. NO.			REV.	
B	BUDGET	FSVR		0	
SCALE	N.T.S.	FILE NAME	H_/FSVR.dwg	SHEET	1

