Midway – Waterton 345 kV Transmission Project

Transmission Study Report
Exhibit TG-1

Public Service Company of Colorado
Transmission Reliability & Assessment

Thomas W. Green, P.E.

February 2007

Table Of Contents

I. Executive Summary 3
II. Background 8
A. Front Range Transmission Development 8
B. 2003 Least Cost Resource Plan 8
C. Colorado Long Range Transmission Planning 9
III. Objectives 9
IV. Bench Mark Studies 10
A. Study Models 10
B. Results 10
V. Alternative Analysis 12
A. Proposed Transmission: Midway – Waterton 345 345kV Transmission 12
B. 230kV Transmission Alternatives 13
C. 345kV Transmission Alternatives 15
VI. Stability Analysis 20
VII. Final Conclusions 21
VIII. Study Criteria 22

Appendix A NERC/WECC Criteria Tables

I. Executive Summary

Public Service Company of Colorado (PSCo or Company) must build new transmission to accommodate generation that will be interconnected to the electrical system as a result of successful resource solicitations made in connection with the Company's 2003 Least Cost Resource Plan ("LCP"). The LCP resulted in Xcel Energy Markets (XEM) selecting several new generation projects to meet the growing demand for electricity. Two of the major LCP generation projects will be located south of the Denver-metropolitan load center, and connect into transmission that lies within PSCo's primary transmission corridor that runs between the Pueblo and Denver electric load centers. The corridor is referred to in this document as the Front Range Corridor.

One of the selected LCP generation projects is the Comanche Unit #3 project, which will add a new 750 MW coal-fired generating unit to the existing Comanche facility by the summer of 2010. Previous studies have documented the transmission required for the Comanche Unit #3 Project. That transmission is referred to as the Comanche – Daniels Park 345kV Transmission Project, or the Comanche Transmission Project. Figure 1 shows the basic transmission network between Pueblo and Denver as it is expected to be with the planned Comanche Transmission Project. The Comanche Transmission Project consists of double-circuit 345kV transmission between Comanche and Daniels Park. It also includes rebuilding an existing single-circuit 230kV line between Midway and Daniels Park to double-circuit 345kV-capable transmission (initially proposed to be operated at 230kV).

The other major LCP generation project is the Squirrel Creek Energy Center (Squirrel Creek), which will consist of approximately 500 MW of combined cycle, gas-fired generation. The Squirrel Creek generation has an expected in-service date of May 2009. Squirrel Creek will be located approximately six miles northeast of the PSCo Midway Substation, and will interconnect one of the two Comanche – Daniels Park 345kV transmission lines. System studies indicate that the Comanche Transmission Project alone will not be adequate to reliably accommodate both the Comanche and the Squirrel Creek generation. This Transmission Study Report summarizes the analyses performed by Public Service Company of Colorado (PSCo) during the 2003 LCP transmission planning studies, to determine the necessary transmission upgrades required to accommodate the addition of the Squirrel Creek generation. The new transmission that is proposed to accommodate the Squirrel Creek generation consists primarily of creating a 345kV transmission circuit between the Midway Substation, south of Colorado Springs, and the Waterton Substation, southwest of Denver, and is hereby referred to as the Midway – Waterton 345kV Transmission Project (Project). Figure 2 shows the proposed Midway – Waterton 345kV Transmission Project.

The entire Project will be implemented within existing PSCo transmission corridors. Approximately 90% of the transmission portion of the Project will consist of operating one circuit of the planned double-circuit 345kV capable transmission to be rebuilt as part of the Comanche Transmission Project at 345kV rather than at 230kV as proposed at the time the Comanche Transmission Project was initially being planned. The remaining 10% consists of rebuilding a 230kV transmission line within an existing corridor. The Project will have no significant impact on the regional electrical systems including the Colorado Springs Utilities (CSU), Intermountain Rural Electric Association (IREA), and Mountain View Electric Association (MVEA). It enhances performance of the Front Range and Denver-metro electrical systems by reducing pressure on existing transmission paths. This alternative complies with the plans developed by Colorado Long Range Transmission Planning Group of the Colorado Coordinated Planning Group. The Project is a logical step in the development of 345kV

transmission in the Front Range, as it utilizes transmission that was designed and planned through other PUC-approved projects.

Figure 1 Comanche – Daniels Park 345kV Transmission Project

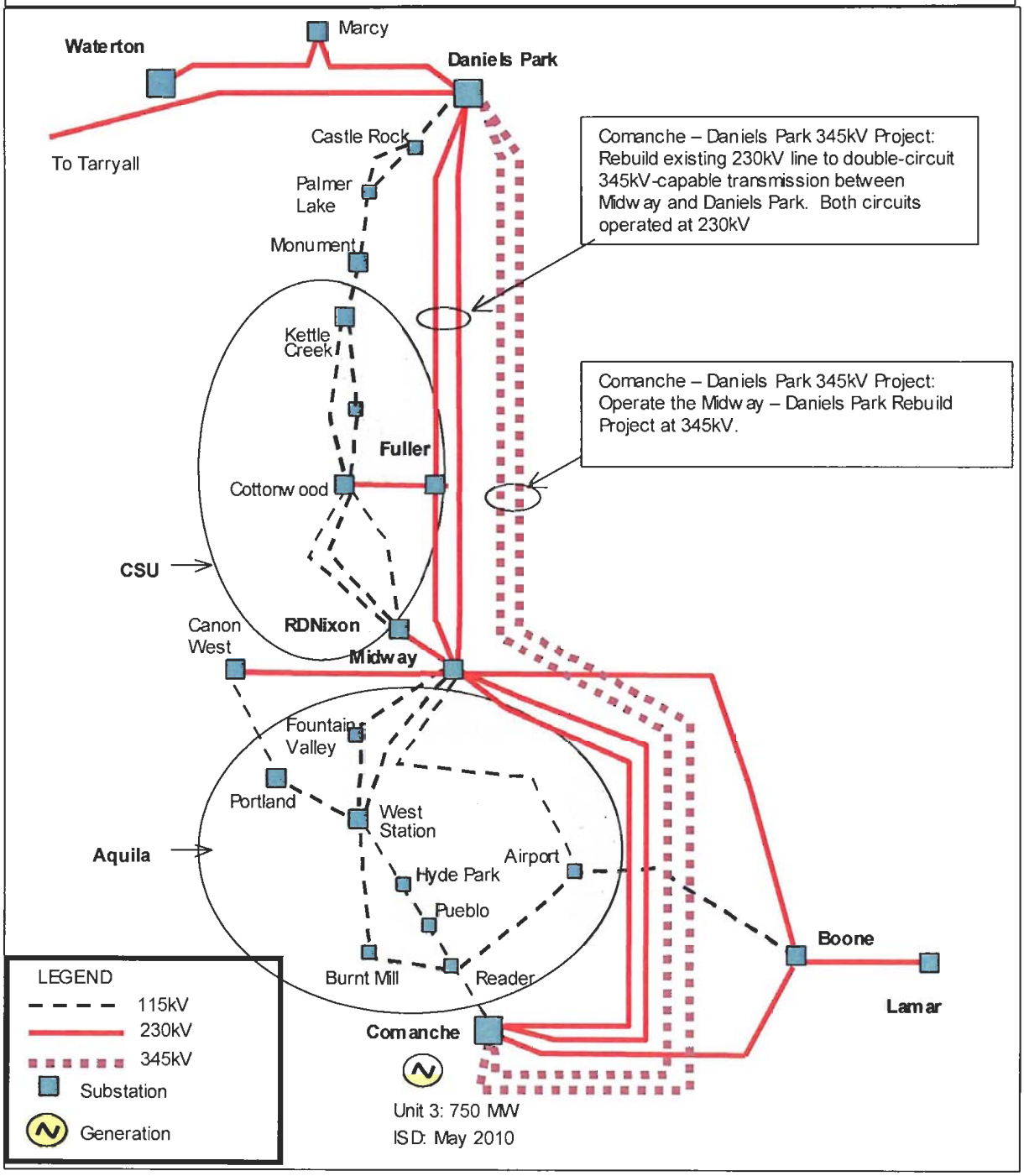
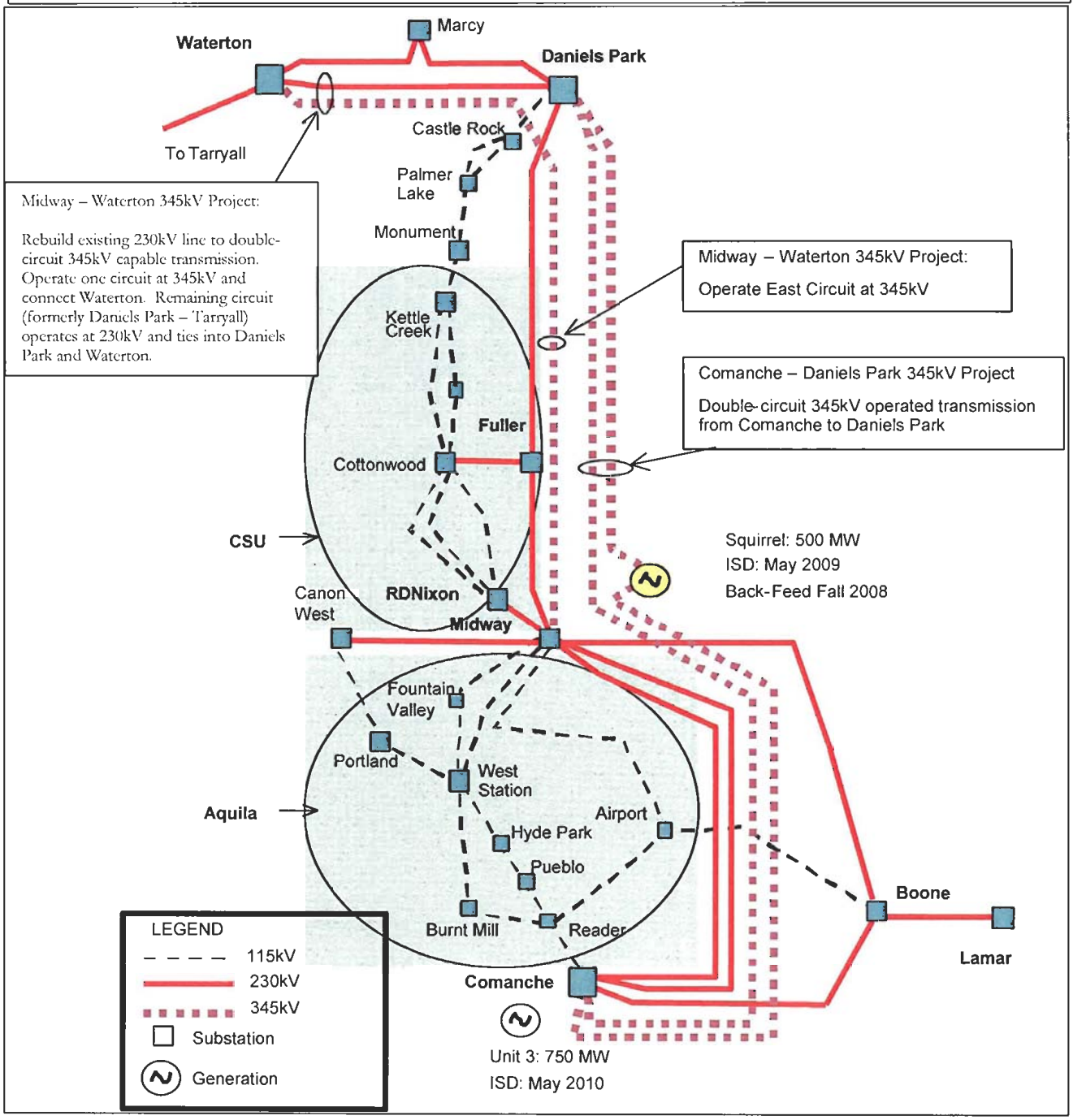


Figure 2 Midway – Waterton 345kV Transmission Project



Proposed Transmission

The Project can be described in two basic sections: the "Southern Section", which includes the upgraded operation of transmission facilities to be rebuilt between Midway and Daniels Park Substations, and the "Northern Section", which includes new upgrades between Daniels Park and Waterton Substations.

- The Southern Section of the Project is approximately 73-miles, or 90% of the total project length. For the Southern Section, an existing (planned) 230kV line will be operated at 345kV. Only minor changes have to be made to the transmission design in that section.
- The Northern Section of the Project is approximately 9 miles, or 10% of the total project length. The Northern Section of the Project consists of rebuilding an existing single-circuit 230kV transmission line to double-circuit 345kV-capable transmission. One of the circuits of the new double-circuit transmission will operate at 230kV and terminate at Daniels Park and Waterton Substations. The other circuit of the double-circuit transmission will operate at 345kV and will run from the Waterton Substation, bypassing the Daniels Park Substation to connect with the Southern Section's 345kV circuit, to create the Midway – Waterton 345kV transmission circuit.
- The Midway – Waterton 345kV transmission will connect to the Midway and Waterton Substations using single 560 MVA 345/230kV autotransformers at each substation.
- Replace the two 100 MVA 230/115kV autotransformers at Waterton with two 280 MVA units.
- The existing 230kV line that runs from Daniels Park to Tarryall will now tie into the Waterton Substation.

The Project expands the development of 345kV transmission in the region using existing corridors. The Project would utilize 345kV-capable transmission that will be constructed as part of the Comanche Transmission Project. During that project, the single-circuit 230kV line that runs between Midway and Daniels Park, through the Fuller Substation will be rebuilt to double-circuit 345kV-capable transmission. For the Midway – Waterton 345kV Project, the eastern circuit of the Midway- Daniels Park double-circuit transmission will be operated at 345kV. To complete the 345kV circuit between Daniels Park and Waterton, an existing 230kV line will be rebuilt to double-circuit 345kV-capable transmission, within the existing transmission corridor.

Total cost of this project is estimated to be **$30 million**[1].

Other alternatives that were studied, but are not proposed, are discussed in the Studies Section.

[1] The level of accuracy for the cost estimates in this study is considered to be ± 30%, which is typical for a project at this budgetary stage in the process. This estimate is based on cost per mile indicators of past projects, average unit costs, and 2007 overhead and labor rates. This estimate is in 2007-year dollars, and it includes all appropriate overheads including AFUDC. At this stage of the project, these are high level, scoping estimates, which are the best estimates that the Company is able to provide prior to detailed engineering of the Transmission Project.

II. Background

A. Front Range Transmission Development

The Front Range Corridor is a PSCo transmission corridor that runs between the Pueblo and Denver electrical load centers. In 2003, PSCo recognized that the Front Range Corridor had the potential to allow for the development of a high-voltage 345kV backbone transmission network. In 2005, PSCo completed the PUC-approved Midway – Daniels Park Rebuild Project, which constructed double-circuit 345kV-capable transmission between the Midway and Daniels Park Substations. The Midway – Daniels Park Rebuild Project is presently operating at 230kV. In 2009, PSCo will increase the operating voltage of that transmission to 345kV as part of the PUC-approved Comanche – Daniels Park 345kV Transmission Project. The Comanche – Daniels Park 345kV Transmission Project consists primarily of double-circuit 345kV transmission between the Comanche and Daniels Park substations. However, the project will also construct a second double-circuit 345kV-capable transmission line between Midway and Daniels Park Substations. As a result of the Midway – Daniels Park Rebuild Project and the Comanche – Daniels Park 345kV Transmission Project, the section of the Front Range Corridor that lies between Midway and Daniels Park will contain four transmission circuits that are capable of 345kV operation. Two of those circuits will operate at 345kV following the implementation of the Comanche Transmission Project. The proposed Midway – Waterton 345kV Transmission Project would be a natural progression of the corridor development by increasing the operating voltage of another one of those circuits to 345kV.

Also, it was determined that transmission alternatives which utilized existing transmission corridors would be more cost-effective than those that required new right-of-way acquisition. The determination was based on studies and siting analyses for previous projects in the region and along the Front Range Corridor. When PSCo evaluated transmission alternatives for the Midway – Daniels Park Rebuild Project in 2003, the estimated cost to build new transmission from Midway to Smoky Hill was at least $80 million. In addition, PSCo determined that the timing required to acquire a new corridor and construct new transmission would not meet the schedule for implementing the Squirrel generation. Other studies have also shown that power injections into the Smoky Hill Substation would require upgrades to the PSCo system west of Smoky Hill.

Since PSCo has designed and planned the Front Range Corridor north of Midway so that it will have the capability for the operation of up to four 345kV transmission circuits, the 2003 LCP studies focused on evaluating how the existing Front Range Corridor and other existing transmission corridors could be optimized to accommodate the Squirrel generation.

B. 2003 Least Cost Resource Plan

This report summarizes and documents the pertinent results from the 2003 LCP studies that were performed to determine the proposed transmission infrastructure to accommodate the Squirrel Creek generation. Public Service filed its 2003 Least Cost Resource Plan with the Colorado Public Utilities Commission (PUC) on April 30, 2004. Following the Company's Request for Proposals (RFP) to meet the resource needs, PSCo's Transmission Reliability and Assessment (TRA) group began studying the transmission requirements to implement the potential generation projects. Although some preliminary studies evaluated individual projects on a "stand-alone" basis, most studies evaluated groups, or portfolios of generation. Most of the portfolio studies included the Squirrel Creek generation. The transmission planning studies that were performed for the 2003 LCP have been posted on the PSCo

Interconnection Queue on the Rocky Mountain Area OASIS (RMAO) web site at http://www.rmao.com/wtpp/PSCO_Transmission_Studies.html.
Squirrel Creek has been included in LCP and other documentation as Bid No. G031. In the fall of 2006, a Power Purchase Agreement was executed between Public Service and Squirrel Creek Energy LLC. The significant study reports that include the Squirrel Creek generation (as well as other LCP resources) are the System Impact Study Reports that deals with Squirrel Creek specifically can be found under GI-2006-1e Final Facilities.pdf. The proposed Midway – Waterton 345kV Transmission Project has been referenced in 2003 LCP (Highly Confidential) Annual Progress Reports to the PUC, and has been included in the May 2006 Rule 3206 filing.

C. Colorado Long Range Transmission Planning

In January 2004, load serving entities within Colorado initiated the Colorado Long Range Transmission Planning Group (CLRTPG) to develop long-range bulk transmission plans to fit the future needs of the State of Colorado given the anticipated load growth, collective knowledge of the transmission system and potential sites of new generation resources. The CLRTPG issued study reports in 2004 and again in 2006. The proposed Midway – Waterton 345kV Transmission Project is consistent with the planning objectives listed above. The CLRTPG participants agreed to include the Midway – Waterton 345kV Project in all of the alternatives in the 2015 studies, which are documented in the 2006 study report[2].

III. Objectives

PSCo adheres to Reliability Criteria published by the North American Electric Reliability Council (NERC) and the Western Electricity Coordinating Council (WECC). The NERC/WECC criteria are provided in Appendix A. In addition, the following objectives were used to develop proposals for transmission upgrades:

- Reliably accommodate proposed generation by meeting the NERC/WECC criteria mentioned above.

- Do not interfere with neighboring electric systems. The NERC/WECC criteria do not allow adverse impacts to neighboring systems. The criteria could be met by proposing upgrades to neighboring systems if necessary. However, the objective here was to develop projects that would be designed to have minimal or no impact to neighboring systems.

- Implement higher-voltage transmission operation. This could be by (a) creating new, high-voltage transmission, (b) increasing the operating voltage of existing high-voltage capable transmission, or (c) building new high-voltage capable transmission for the future.

- Make practical use of existing transmission facilities and corridors.

- Adhere to long-range transmission plans developed by the CLRTPG.

- Align with the 2003 Least Cost Resource Plan.

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[2] Results are documented in the Colorado Long Range Transmission Planning 2015Study Report, dated July 2006: http://www.rmao.com/wtpp/CO_Transmission_Planning_Group.html

IV. Bench Mark Studies

A. Study Models

The 2003 LCP studies of interconnecting the Squirrel Creek generation used powerflow models that represented 2009 and 2010 summer peak loading conditions. The models were developed from Western Electricity Coordinating Council (WECC) models. The Comanche Unit #3 generation and the Comanche – Daniels Park 345kV Transmission Project were modeled in all cases. From the benchmark models, cases were then created which included the Squirrel Creek generation, but without new transmission infrastructure alternatives. The generation in the PSCo powerflow area was balanced by reducing generation north of the Denver-metro area to create heavy power flows from south to north on the transmission in the Front Range Corridor.

B. Results

With the implementation of the new Squirrel Creek generation, contingency analyses showed the potential for unacceptable system loading conditions. The impacted areas were divided into three basic regions of concern:

- The CSU system between Midway and Daniels Park,
- the Aquila system between Comanche and Midway, and
- the PSCo system north of Daniels Park.

The most significant contingency loadings are shown in Tables 1 for both the 2009 and 2010 models. The following sections describe loading issues observed on the regional lower voltage networks prior to implementation of any transmission alternatives.

Table 1 2009 Benchmark Results

Benchmark Results for 2009	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	Reader - West Station 115 'Hyde Park - Pueblo 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	132	135	99	435	439	100
2009 Benchmark Without Squirrel		108%	94%	89%	106%	88%	125%
2009 Benchmark With Squirrel No Additional Transmission		114%	105%	106%	115%	121%	133%
2010 Benchmark Without Squirrel		107%	90%	85%	105%	73%	125%
2010 Benchmark With Squirrel No Additional Transmission		118%	106%	98%	114%	108%	129%

1. CSU

With the Squirrel generation added, there were several contingencies that revealed potential loading issues on the CSU transmission system. The most significant loadings were on the 115kV network between the Palmer Lake and Cottonwood Substations. This underlying 115kV system is electrically in parallel with the Midway – Daniels Park 230kV transmission. As shown in Tables 1 the pertinent contingencies were:

a) An outage of the CSU Briargate – Cottonwood 115kV line loaded the CSU Cottonwood – Kettle Creek 115kV line to 14-18% above its 132 MVA rating. However, as Table 1 shows, even without Squirrel generation, the contingency loading was 7-8% above the rating.
b) An outage of the PSCo Daniels Park – Fuller 230kV line loaded the CSU/PSCo Monument – Palmer 115kV line to 5-6% above its 135 MVA rating.

Previous studies have also identified the 115kV system between Cottonwood and Palmer Lake to have the potential for contingency overloads, especially on the 115kV circuit between Cottonwood and Kettle Creek. The Squirrel Creek studies showed the potential for overloads even without the addition of Squirrel generation. CSU has stated that any new upgrades to this transmission will very likely have to utilize underground construction at a significant cost.

2. Aquila

Aquila has lower voltage transmission in the Pueblo area that is electrically in parallel to the higher voltage PSCo transmission between Comanche and Midway substations. This study and other studies have identified the 115kV transmission between Comanche, Reader, and West Station to have the potential for high contingency loadings. As shown in Tables 1 the pertinent contingencies were:

a) An outage of the Aquila Reader – West Station 115kV line loaded the Aquila Hyde Park – Pueblo 115kV line above its 99 MVA rating. The contingency overloads were approximately 6% with the 2009 models, but were not an issue with the 2010 models.

Aquila has plans to construct a Reader – Airport 115kV by 2009. That line was included in the 2010 models, but not the 2009 models. As seen in Table 1, the Reader – Airport 115kV line (in the 2010 case) alleviates the loading issues on the Reader – West Station 115kV system.

3. North of Daniels Park

When the Squirrel generation was added to the models, the area generation was balanced by reducing generation north of the Denver-metro area. As a result, there were some loading issues north of Daniels Park. As shown in Tables 1 the pertinent contingencies were:

a) An outage of the PSCo Soda Lakes – Lookout 230kV line loaded the Daniels Park – Marcy 230kV line to11-15% above its 435 MVA rating.
b) An outage of the PSCo Smoky Hill – Buckley 230kV line loaded the PSCo Greenwood – Monaco 230kV line to 8-21% above its 439 MVA rating.

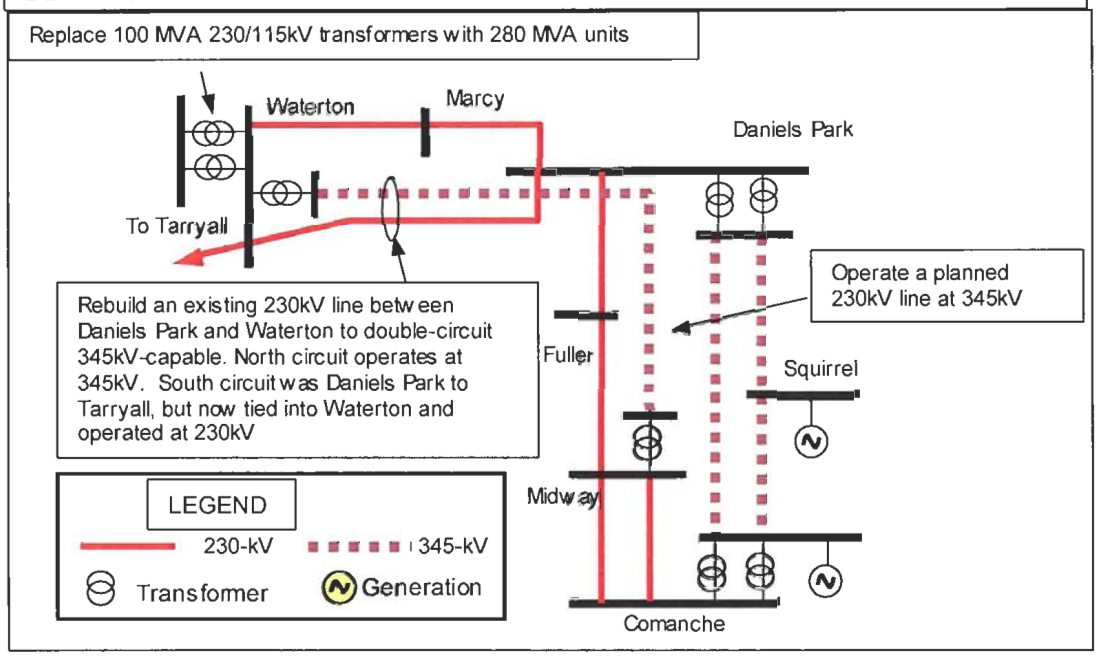
V. Alternative Analysis

From the benchmark analysis, it was clear that the addition of Squirrel Creek generation would require additional transmission. As part of the 2003 LCP studies, many different alternatives that utilized existing transmission corridors were evaluated. However, other than the proposed alternative, none were considered viable since they could not address the loading issues on the regional electrical systems. The alternative studies can be divided into two basic categories: sensitivities that evaluated 230kV alternatives, and those that evaluated 345kV alternatives. The following sections describe the proposed Project, and summarize the alternative analyses for the other 230kV and 345kV studies.

A. Proposed Transmission: Midway – Waterton 345 345kV Transmission

The proposed alternative is shown in Figure 2. Figure 3 is a simplified picture of the Project.

Figure 3 Midway – Waterton 345kV Transmission



1. Results

Table 2 summarizes the contingency performance of the proposed Midway – Waterton 345kV Transmission. The table shows how the project improves the contingency loadings.

a) CSU:

The proposed Midway – Waterton 345kV Project resulted in the CSU contingency performance being close to the same, or better than the benchmark performance. The Monument – Palmer 115kV loading was reduced to less than 100% of its continuous rating for both the 2009 and 2010 models. The Cottonwood – Kettle Creek 115kV loading was reduced significantly from 114-118% to 108-109%. The benchmark analysis showed that even without Squirrel generation, there is a potential for contingency loading on that element of up to 7-8% over the continuous rating. With Squirrel, and with the proposed transmission project, the contingency loading was at most only 2% higher than the benchmark case without Squirrel generation.

Table 2

Contingency Results for Midway – Waterton 345	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	Reader - West Station 115 'Hyde Park - Pueblo 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	132	135	99	435	439	100
2009 Benchmark Without Squirrel		108%	94%	89%	106%	88%	125%
2009 Benchmark With Squirrel No Additional Transmission		114%	105%	106%	115%	121%	133%
2009 with Midway-Waterton 345		108%	91%	107%	40%	106%	165%
2009 with Midway-Waterton 345 AND Replace Waterton 230/115 autos with 280 mva units		108%	91%	107%	40%	106%	90%
2010 Benchmark Without Squirrel		107%	90%	85%	105%	73%	125%
2010 Benchmark With Squirrel No Additional Transmission		118%	106%	98%	114%	108%	129%
2010 with Midway – Waterton 345		109%	94%	98%	70%	98%	169%
2010 with Midway – Waterton 345 Replace Waterton 230/115 autos with 280 MVA units		109%	94%	98%	70%	98%	60%

b) Aquila:
As seen in Table 2, the only moderate concern was the loading on the Hyde Park – Pueblo 115kV line in the 2009 model. However, the 2009 case did not model a planned 115kV line between Reader and Airport substations. That line was modeled in the 2010 cases, and the contingency loadings were less than 100% of continuous ratings.

c) North of Daniels:
The proposed project reduced the loadings on the system north of Daniels Park. By bypassing the Daniels Park substation and terminating at Waterton, the project helps balance the injection of power from southern resources into the Denver-metro load center. The 2009 model still showed a potential for up to 6% overloading on the Greenwood – Buckley 230kV line. However, the 2010 models had less than 100% loading. As seen in Table 2, the proposed Project does increase the contingency loading on the Waterton 230/115kV autotransformers. The loss of one transformer overloads the parallel transformer. Therefore, the Project also includes replacing the existing 100 MVA rated transformers with 280 MVA rated units.

B. 230kV Transmission Alternatives

Several alternatives were evaluated that looked at 230kV upgrades using the existing corridors. However, none of the alternatives were able to mitigate unacceptable contingency overloads that resulted from adding the Squirrel generation. Sensitivity studies were done for interconnecting the Squirrel generation to both the 230kV transmission and the 345kV transmission north of Midway. Most of alternatives had a similar configuration as the proposed 345kV transmission project, but would operate at 230kV instead of 345kV. One of

the circuits of the rebuilt Midway – Daniels Park double-circuit transmission would be modified to bypass Daniels Park. The line would then connect to Waterton by rebuilding a single-circuit line between Daniels Park and Waterton to double-circuit transmission. A typical configuration is shown in Figure 4.

Figure 4 Midway – Waterton 230kV Transmission

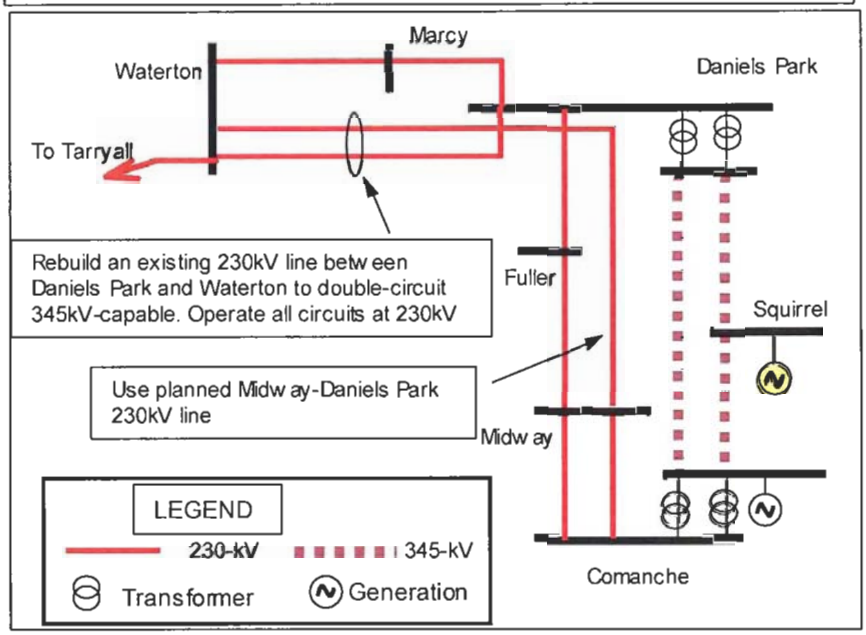


Table 3 shows some typical results of sensitivity studies that modeled adding two new 230kV transmission circuits between Comanche and Midway.

Table 3 230kV Alternative Contingency Results

Select Contingency Results	Contingency / Loaded Element	Briargate - Ctwd N 115 Ctwd N – Kettle Ck 115	Daniels Park - Fuller 230 Mon - Palmer 115	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	132	135	439	100
2009 Benchmark Without Squirrel		108%	94%	88%	125%
2009 Benchmark With Squirrel Generation No Additional Transmission		114%	105%	121%	133%
2009 With Squirrel Generation And Create a Midway – Waterton 230kV circuit		**113%**	**104%**	**114%**	**154%**
2010 Benchmark Without Squirrel		107%	90%	73%	125%
2010 Benchmark With Squirrel Generation No Additional Transmission		118%	106%	108%	129%
2010 with Squirrel Generation And Create a Midway – Waterton 230kV circuit		**116%**	**105%**	**101%**	**151%**

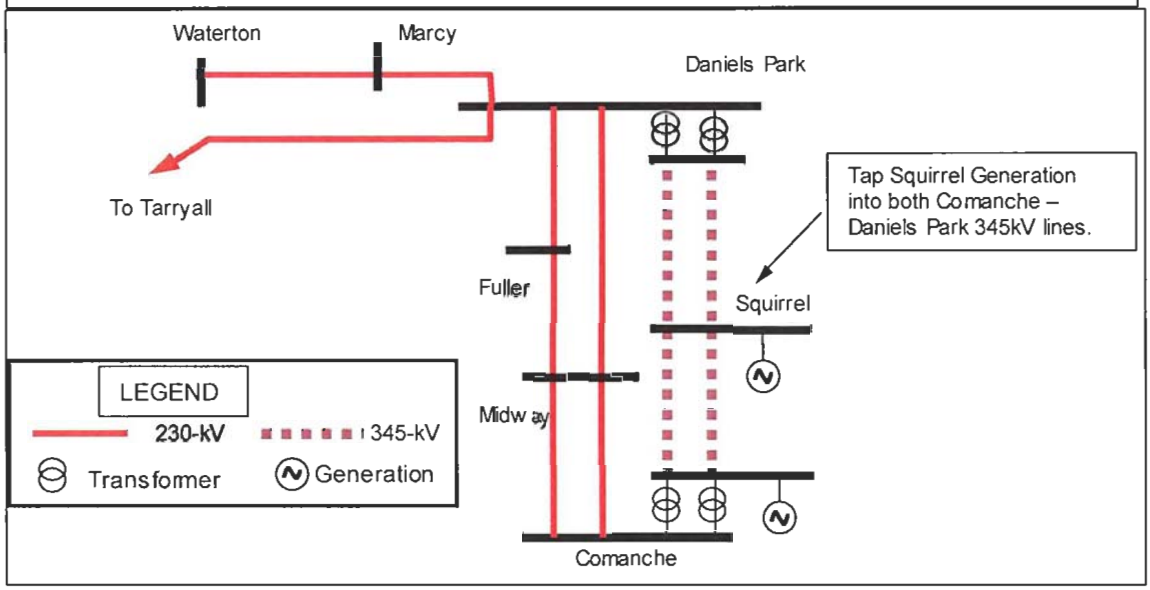
As seen in Table 3, the 230kV alternatives shown did not alleviate loading conditions on the CSU system. Because of the system performance, the 230kV transmission alternatives were not pursued further.

C. 345kV Transmission Alternatives

To meet the objective of implementing higher-voltage transmission, several alternatives were evaluated that looked at 345kV upgrades using the existing corridors. The following sections describe some of the alternatives studied.

1. Interconnect both Comanche – Daniels 345kV lines

Figure 5 Interconnect Squirrel to both Comanche- Daniels Park 345kV circuits



This alternative looked at interconnecting the Squirrel generation to both of the Comanche – Daniels Park 345kV lines, but no additional transmission upgrades, as shown in Figure 5.

Table 4 shows how tying into both Comanche – Daniels Park 345kV transmission lines did not impact the contingency loading results.

Table 4

Contingency Results for Midway – Waterton 345	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	Reader - West Station 115 'Hyde Park - Pueblo 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	132	135	99	435	439	100
2010 Benchmark Without Squirrel		107%	90%	85%	105%	73%	125%

2010 Benchmark With Squirrel No Additional Transmission	118%	106%	103%	114%	106%	129%
2010 With Squirrel Interconnect to both Comanche – Daniels Park 345kV lines	**118%**	**106%**	**103%**	**114%**	**106%**	**130%**

The study results did not indicate any significant differences in system performance between this configuration and the benchmark that connected Squirrel Creek generation to only one Comanche – Daniels Park 345kV circuit. Therefore, subsequent studies modeled the interconnection to only one of the 345kV circuits. PSCo intends to design the Squirrel interconnection to allow for future tie to the other 345kV line, if conditions warrant.

2. Midway – Daniels Park 345kV line

Some preliminary studies evaluated creating a 345kV transmission circuit between Midway and Daniels Park (instead of Waterton) as shown in Figure 6.

Figure 6 Midway – Daniels Park 345kV Transmission

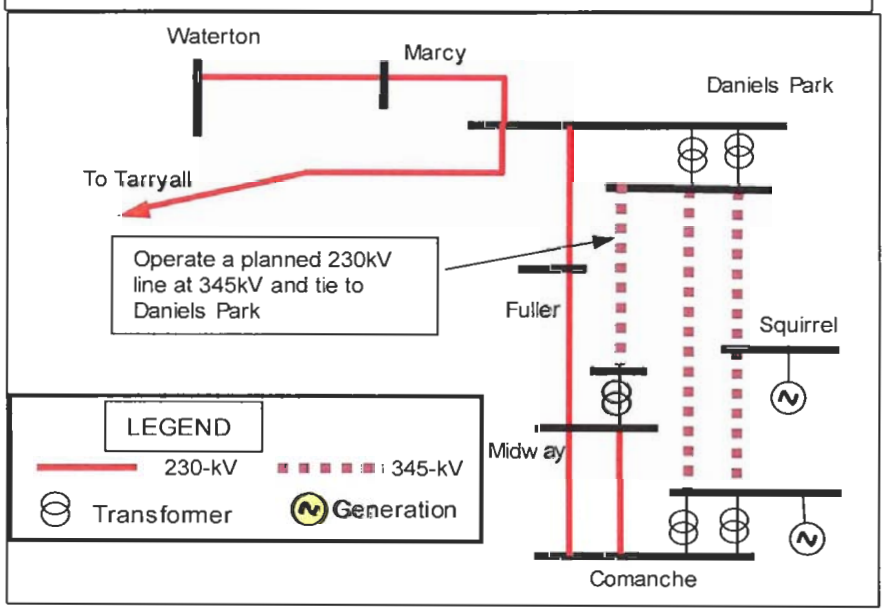


Table 5 shows some typical results of sensitivity studies that modeled a Midway – Daniels Park 345kV transmission circuit.

Table 5

Select Contingency Results	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2	Daniels Park 345/230 #1 Daniels Park 345/230#2
Description	MVA Rating ->	132	135	435	439	100	560
2009 Benchmark Without Squirrel		108%	94%	106%	88%	125%	88%
2009 Benchmark With Squirrel Generation No Additional Transmission		114%	105%	115%	121%	133%	N/A
2009 With Squirrel Generation And Create a Midway – Daniels Park 345kV circuit		**113%**	**101%**	**119%**	**120%**	**134%**	**113%**

The studies indicated that an additional (fourth) 345/230kV transformer would be required, and unacceptable loadings on the lines north of Daniels Park would have to be addressed.

Table 5 shows that this alternative does not alleviate unacceptable loadings on the CSU system. Also, this alternative causes unacceptable loadings on the transmission north of Daniels Park Substation. Because of the system performance, this alternative was not pursued further.

3. Midway – Squirrel Creek Tie

Some alternative studies looked at creating an electrical tie between the Comanche – Daniels Park 345kV transmission and the Midway Substation. An example is shown in Figure 7.

Figure 7 Tie Squirrel Creek into Midway Substation

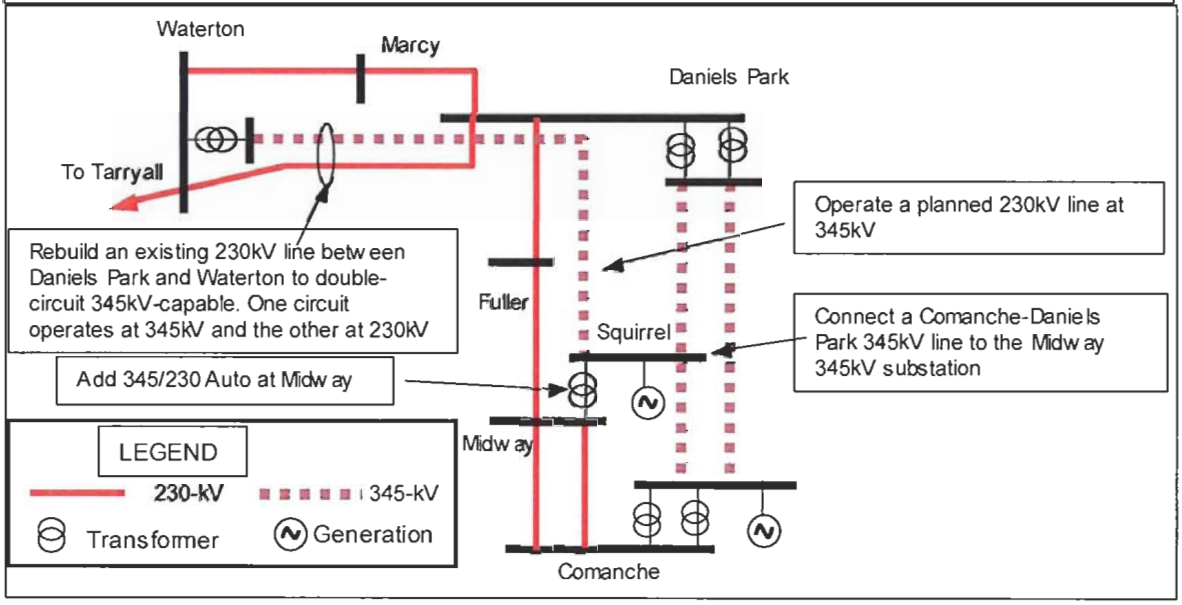


Table 6 shows some typical results of sensitivity studies that modeled a 345kV tie between the Comanche – Daniels Park 345kV transmission and the Midway Substation.

Table 6

Select Contingency Results Midway Tie to Squirrel	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	132	135	435	439	100
2009 Benchmark Without Squirrel		108%	94%	88%	88%	125%
2009 Benchmark With Squirrel Generation No Additional Transmission		114%	105%	121%	121%	133%
2009 With Squirrel Generation And **Same as Proposed Alternative, except:** **Create a Comanche – Daniels Park tie into Midway**		**113%**	**99%**	**30%**	**104%**	**91%**

As seen in Table 6, the studies indicated that although there was some slight improvement in the loadings in the Denver-metro area, the contingency loadings on the CSU system increased. Tying the Comanche – Daniels Park 345kV lines into Midway caused more power to be forced through the CSU system, causing unacceptable loading conditions.

4. Squirrel – Waterton 345kV

This alternative was a sensitivity that was similar to the proposed Midway – Waterton 345kV transmission, except instead of beginning at Midway, the 345kV circuit begins at Squirrel Creek. The basic configuration is shown in Figure 8.

Figure 8 Squirrel – Waterton 345kV Transmission

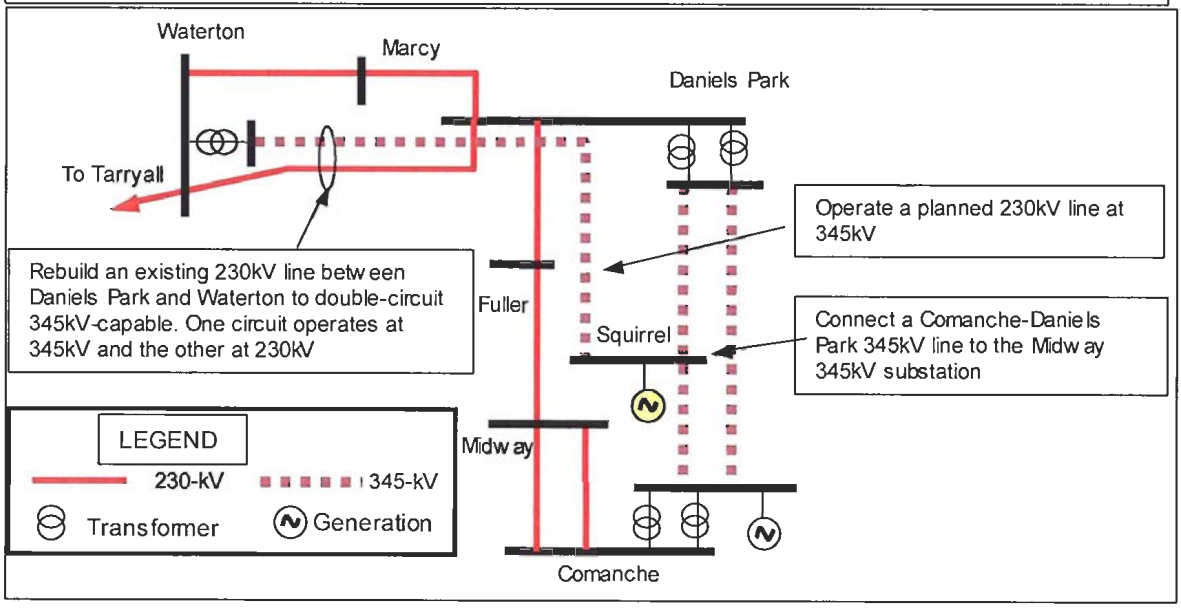


Table 7 shows some typical results of sensitivity studies that modeled a 345kV tie between the Comanche – Daniels Park 345kV transmission and the Midway Substation.

Table 7

Contingency Results for Squirrel – Waterton 345	Contingency / Loaded Element	Briargate - Cotwd N 115 Ctwd N – KettleCk 115	'Daniels Park - Fuller 230 Mon - Palmer 115	Reader - West Station 115 'Hyde Park - Pueblo 115	'Soda Lake - Lookout 230 Daniels - Marcy 230	Smoky - Buckly 230 Greenwood - Monaco 230	Waterton 230/115 #1 Waterton 230/115#2
Description	MVA Rating ->	**132**	**135**	99	435	439	100
2009 Benchmark Without Squirrel		**108%**	**94%**	89%	106%	88%	125%
2009 Benchmark With Squirrel No Additional Transmission		**114%**	**105%**	106%	115%	121%	133%
2009 with Squirrel-Waterton 345		**117%**	**120%**	**86%**	**53%**	**107%**	**86%**

With this configuration, there would be no Midway – Daniels Park 230kV line. Studies showed that there would be unacceptable loading conditions on the CSU transmission system.

VI. Stability Analysis

As part of the 2003 LCP studies, several disturbances were modeled using the 2010 models and including the proposed Project. Disturbances were initiated with a three-phase fault. All disturbances were transiently stable and well damped. Typical stability results are shown below.

CASE	FAULT	ELEMENTS REMOVED	RESULTS
SQCON1	Squirrel 345	Squirrel – Daniels Park 345	Stable / Well Damped
SQCON2	Squirrel 345	Squirrel - Comanche 345	Stable / Well Damped
SQCON3	Daniels Park 345	Squirrel – Daniels Park 345	Stable / Well Damped
SQCON4	Comanche 345	Comanche – Squirrel 345	Stable / Well Damped
SQCON5	Daniels Park 345	Daniels Park - Comanche 345	Stable / Well Damped
SQCON6	Comanche 345	Comanche – Daniels Park 345	Stable / Well Damped
SQCON7	Comanche 345	Comanche 345/230kV Auto	Stable / Well Damped
SQCON8	Comanche 345	Comanche 345/24kV transformer	Stable / Well Damped
SQCON9	Squirrel 345	Squirrel 345/18kV transformer	Stable / Well Damped

VII. Final Conclusions

The proposed project is the preferred transmission alternative to accommodate the Squirrel generation. The Project:

- Fully accommodates the Squirrel generation;
  The primary goal for any transmission alternative is to accommodate the associated generation project. The Midway – Waterton 345kV Transmission Project will provide a means to deliver generation to native load in the most efficient manner. Other alternatives did not alleviate unacceptable loading conditions on PSCo and neighboring transmission systems.

- Does not interfere with neighboring electric systems;
  The proposed project was the only alternative studied that would fully alleviated potential unacceptable loading conditions on the neighboring CSU transmission system. Other alternatives did not meet study objectives in that regard. PSCo should continue to work with neighboring utilities to monitor and evaluate regional transmission plans to verify that PSCo plans have no adverse impacts to those entities.

- Implements higher-voltage transmission;
  The proposed project expands the 345kV transmission in the Front Range Corridor. Simply stated, a transmission line operating at higher voltage can transmit more power than one at a lower voltage. Implementation of higher voltage transmission will allow higher power transfers, lower system losses, and fewer problems on lower voltage networks. This project will allow transmission built for the Comanche Transmission Project to operate at 345kV as it was anticipated to do. The portion of the Project between Midway and Daniels Park has already received county permits to allow operation at the higher voltage.

- Makes practical use of existing transmission facilities and corridors;
  The proposed project utilizes existing transmission corridors. Routing in existing allows PSCo to build significant portions of a Project within areas where a utility facility land use has existed for many years, eliminates the need to purchase additional right-of-way, and expedites the upgrade process. It is important to maximize the utilization of existing transmission line rights-of-way whenever prudent to minimize new right-of-way acquisition costs and potential impacts to the environment and landowners.

- Is the most cost-effective;
  The proposed project utilizes existing transmission corridors and 90% of the transmission portion of the project simply consists of operating a 230kV transmission line at 345kV. Therefore, the project is significantly less costly than any alternative that would require acquisition of a new corridor. Also, the Squirrel Creek generation and the Midway – Waterton 345kV Transmission Project were studied and selected in a manner consistent with the 2003 "Least Cost" planning processes, which were approved the by the PUC.
- Complies with long-term transmission plans
  The proposed Project is in alignment with long term planning and the objectives of the CLRTPG. The CLRTPG participants agreed to include the proposed Project in the most recent (2015) CLRTPG studies.

VIII. Study Criteria

1. NERC/WECC Criteria

As a member of WECC, PSCo adheres to the WECC and NERC Reliability Criteria. Excerpts of the System Performance Tables from the latest Criteria are provided in Appendix A. The complete Reliability Criteria document can be found on the WECC web site at www.wecc.biz.

2. System Normal Condition:

- Line loading monitored for 100 percent of the continuous seasonal rating, the established equipment rating, or applicable operating limits.
- Transformer loading monitored to 100 percent of the highest name plate rating or appropriate owner's top rating.
- Transmission bus voltages maintained between 0.95 p.u. and 1.05 p.u. of nominal system voltage[3].

3. Contingency Conditions

- Line loading monitored for 100% of the continuous seasonal rating, or an established equipment rating. Presently, Transmission Planning considers 110% as the maximum allowed contingency loading for some transmission elements. However, 100% loading was monitored for all transmission elements.
- Transformer loading monitored for 115% of the system normal rating or an established emergency rating. However, 100% loading was monitored for all transmission elements.
- Transmission bus voltages maintained between 0.90 p.u. and 1.10 p.u. of nominal system voltage.

[3] In the benchmark and alternative analyses there were many bus voltages outside the normal range of accepted voltage for both system intact and contingency conditions. Most of the voltage violations were determined to be due to load patterns and the uncertainties with future generation resources, which could be a source of voltage support. This study focused on the development of transmission infrastructure based on system element loadings. Voltage issues will be dealt with in the normal course of business and alleviated with capacitor additions, load shifting, and generation additions.

Appendix A

WECC / NERC Reliability Criteria Tables

WECC DISTURBANCE-PERFORMANCE TABLE OF ALLOWABLE EFFECTS ON OTHER SYSTEMS

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (outage/year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard (See Note 2)
A	Not Applicable	Nothing in addition to NERC		
B	≥ 0.33	Not to exceed **25%** at load buses or **30%** at non-load buses. Not to exceed **20% for more than 20 cycles** at load buses.	Not below **59.6** Hz for 6 cycles or more at a load bus.	Not to exceed **5%** at any bus.
C	0.033 – 0.33	Not to exceed **30%** at any bus. Not to exceed **20% for more than 40 cycles** at load buses.	Not below **59.0** Hz for 6 cycles or more at a load bus.	Not to exceed **10%** at any bus.
D	< 0.033	Nothing in addition to NERC		

Notes:

1. *The WECC Disturbance-Performance Table applies equally to either a system with all elements in service, or a system with one element removed and the system adjusted.*

2. *As an example in applying the WECC Disturbance-Performance Table, a Category B disturbance in one system shall not cause a transient voltage dip in another system that is greater than 20% for more than 20 cycles at load buses, or exceed 25% at load buses or 30% at non-load buses at any time other than during the fault.*

3. *Additional voltage requirements associated with voltage stability are specified in Standard I-D. If it can be demonstrated that post transient voltage deviations that are less than the values in the table will result in voltage instability, the system in which the disturbance originated and the affected system(s) should cooperate in mutually resolving the problem.*

Table W-1

Table I. Transmission Systems Standards — Normal and Contingency Conditions

Category	Contingencies		System Limits or Impacts				
	Initiating Event(s) and Contingency Element(s)	Elements Out of Service	Thermal Limits	Voltage Limits	System Stable	Loss of Demand or Curtailed Firm Transfers	Cascading[c] Outages
A - No Contingencies	All Facilities in Service	None	Applicable Rating[a] (A/R)	Applicable Rating[a] (A/R)	Yes	No	No
B – Event resulting in the loss of a single element.	Single Line Ground (SLG) or 3-Phase (3Ø) Fault, with Normal Clearing: 1. Generator 2. Transmission Circuit 3. Transformer Loss of an Element without a Fault.	 Single Single Single Single	 A/R A/R A/R A/R	 A/R A/R A/R A/R	 Yes Yes Yes Yes	 No[b] No[b] No[b] No[b]	 No No No No
	Single Pole Block, Normal Clearing[f]: 4. Single Pole (dc) Line	Single	A/R	A/R	Yes	No[b]	No
C – Event(s) resulting in the loss of two or more (multiple) elements.	SLG Fault, with Normal Clearing[f]: 1. Bus Section 2. Breaker (failure or internal fault)	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No
	SLG or 3Ø Fault, with Normal Clearing[f], Manual System Adjustments, followed by another SLG or 3Ø Fault, with Normal Clearing[f]: 3. Category B (B1, B2, B3, or B4) contingency, manual system adjustments, followed by another Category B (B1, B2, B3, or B4) contingency	Multiple	A/R	A/R	Yes	Planned/Controlled[d]	No
	Bipolar Block, with Normal Clearing[f]: 4. Bipolar (dc) Line Fault (non 3Ø), with Normal Clearing[f]: 5. Any two circuits of a multiple Circuit towerline[g]	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No
	SLG Fault, with Delayed Clearing[f] (stuck breaker or protection system failure): 6. Generator 8. Transformer 7. Transmission Circuit 9. Bus Section	Multiple Multiple	A/R A/R	A/R A/R	Yes Yes	Planned/Controlled[d] Planned/Controlled[d]	No No