LONG RANGE PLANNING STUDY

YEARS 2010-2025

AUGUST 15, 2006

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1. EXECUTIVE SUMMARY

From time to time it is necessary to evaluate the BHP transmission and sub-transmission system to understand its response to growing system loads. Studies were performed looking at the 2010, 2015, 2020 and 2025 study years, taking into account known system additions and improvements and accounting for reasonable load growth. Transmission system additions were studied based on feasible installation timeframes and need. The transmission system additions that were examined were an SVC at the Lange substation at various capacities, a Tekla-Osage-Lange 230 kV line, a Tekla-Osage and Yellow Creek-Lange 230 kV line, a Tekla-Osage-Ben French-Lange 230 kV line and a Tekla-Osage and Yellow Creek-Ben French-Lange 230 kV line.

The 2010 and 2015 cases showed an increase of the required must-run generation for system intact conditions, as well as voltage and thermal violations with maximum must-run generation for four prior outages. The thermal violations require that a number of 69 kV lines be improved to increase their rating. The voltage violations are mitigated with the installation of an SVC. The required SVC capacity is dependent on operational objectives. If the objective of the SVC is to eliminate must-run generation requirements for peak-load system intact conditions, a larger SVC (100-150 MVAR) is required. If the objective is to correct the system to meet criteria with maximum must-run generation for prior outage conditions, then a smaller SVC installation (50 MVAR) will prove adequate. It may be possible to increase the effective SVC capacity in the future through the installation of switched capacitors. It may be possible for the SVC controls to operate this capacitor as needed.

The 2020 and 2025 cases showed additional thermal and voltage violations for prior outage conditions and increased must-run generation requirements for system intact conditions. Of primary concern is the introduction of thermal overloads on the 230 kV transmission system. While the thermal overloads were observed only on the lower rated Westhill-South Rapid 230 kV line, this is a condition that was not previously witnessed in system studies. This indicates that there will be a future need for additional transmission into the Rapid City/Black Hills load center from outside and through the current Black Hills 230 kV loop. Studies show that the Tekla-Osage-Ben French-Lange 230 kV line addition performed the best under system intact and prior outage conditions. Assuming the installation of a large SVC, or a smaller SVC with additional controlled switched capacitors, this line addition would eliminate the need for peak-load must-run generation in the 2025 study year and possibly beyond. Additionally, the must-run generation requirement for many prior outages is eliminated or reduced to RCG2 provided the sub-transmission system upgrades identified in the 2010 and 2015 study years are implemented.

2. INTRODUCTION

Periodically it is necessary for studies to be performed to address potential future system problems. As the load and generation mix changes within the Black Hills region in the next 10 to 20 years, current system issues will be amplified and new issues will develop. This study

will look at the future transmission facilities that will be needed to reliably serve our customers, not only in near future, but for many years beyond.

3. STUDY METHODOLOGY

This planning study focused on the 2010-2025 timeframe with regards to projected load growth and possible system additions that could be accomplished. Potential system additions were studied at various load and generation levels to determine the best solutions.

The Rapid City DC Tie was modeled as out-of-service for this study. From a planning prospective this is not a reliability resource as a base load steam generator would be. The DC tie is typically operated based on market conditions and cannot be relied upon to be at any specific MW level and direction for all conditions.

Load projections for 2010, 2015, 2020 and 2025 were used for this study. The near-term load levels (2010 and 2015) were used to identify future issues with the current transmission system and rate various near-term improvement options. The far-term load levels (2020 and 2025) were used to determine the best combination of near-term and long lead-time improvement combinations. For the study year 2015 and later the Ben French and Osage steam plants were assumed out-of-service per the latest Black Hills Corporation Integrated Resource Plan. The Wygen2, Wygen3 and Dry Fork units were assumed on-line for all study years.

The 69 kV system is typically operated radially for system intact conditions. However, for prior outage conditions the normally open 69 kV segments are closed in as needed based on operational studies. This makes defining 69 kV contingencies very difficult due to the location of open 69 kV segments and the breakers that would operate due to a fault. Additionally, 69 kV contingencies typically result in the dropping of the loads along the line. This often results in better system performance.

Rapid City generation levels were simulated at three levels:

RCG0 – No generation on-line
RCG1 – Ben French steam only (Study year 2010 only) / None (Study years 2015-2025)
RCG2 – Level 1 + Lange CT on-line at 20 MW
RCG3 – Level 2 with Lange CT on-line at 40 MW
RCG4 – Level 3 + Rapid City CT #1 on-line at 17 MW
RCG5 – Level 4 + Rapid City CT #2 on-line at 17 MW
RCG6 – Level 5 + Rapid City CT #3 on-line at 17 MW
RCG7 – All Rapid City area generation on-line

For the purposes of this report the term transmission will refer to the Common Use System 230 kV transmission system. Subtransmission will refer to the underlying 69 kV transmission system and 230/69 kV transformers.

All study work was performed using Power Technologies, Inc. PSS/E version 29.4.

4. BASE CASES

The base case used for this study was a modified WECC 2010 heavy summer case. The modifications were compiled in a collaborative effort by the transmission owners in Wyoming and northern Colorado. This close coordination has resulted in the creation of an up-to-date 2010 heavy summer base case that includes future projects and updated load levels. Significant facility additions that were included in the base case are:

- Hughes-Dry Fork-Arvada-Beatty Gulch 230 kV line
- Wygen2 generating unit
- Dry Fork-Carr Draw 230 kV line
- Spruce Gulch-Whitewood 69 kV line

Per the current Engineering department design, the Spruce Gulch-Whitewood 69 kV line will connect to the existing 69 kV line through a three-way switch. This configuration does not allow the Whitewood-Spruce Gulch, Whitewood-Sturgis BEC and Whitewood-Sturgis 69 kV lines to be simultaneously tied through.

Additional switched capacitors were modeled on the system at Spearfish, Sturgis and Colony. The Spearfish and Sturgis capacitors were modeled at 7 MVAR and were fixed on-line. The Spearfish capacitor was assumed to be a permanent installation, while the Sturgis capacitor was assumed to be a mobile capacitor for use during peak loads. The Colony capacitor was modeled at 2 MVAR and was fixed on-line. This capacitor was assumed to be a permanent installation and would be always-on.

5. PERFORMANCE CRITERIA

Established NERC/WECC performance criteria were used as the basis to determine the suitability of the various addition options. A list of all monitored buses and branches can be found in Appendix A and B, respectively, of this report. A list of the simulated contingencies can be found in Appendix C of this report.

5.1. VOLTAGE

System intact and prior outage voltage was required to be greater than 0.95 p.u. and less than 1.05 p.u. at all buses after transformer taps and switched shunts had been allowed to adjust. Bus voltages were required to be greater than 0.90 p.u. and less than 1.10 p.u. following a forced outage (N-1) with transformer taps and manually switched shunts locked.

5.2. THERMAL

All transmission facilities within the Black Hills were monitored for thermal overloads. Transmission lines were required to be at or less than 100% of their normal rating for system intact and prior outage conditions. Following a forced outage (N-1) the

transmission lines were required to be at or less than 100% of their emergency rating. Black Hills Power currently does not assign emergency ratings to their transmission lines.

All power transformers were monitored for thermal overloads. For system intact and prior outage conditions transformers were required to be at or less than 100% of their FAO rating. Black Hills Power does allow short-time overloading of their transformers without incurring excessive transformer loss-of-life.

Maximum Hours @ Overload	**Allowable Transformer Overload**
½ Hour	153%
1 Hour	135%
2 Hours	120 %

Following a forced outage (N-1) transformers were allowed to be loaded to 150% of their FAO rating.

5.3. PRIOR OUTAGES

The Table 4.3-1 below lists the prior outages that were studied.

TABLE 4.3-1: PRIOR OUTAGES

1. SYSTEM INTACT
2. WYODAK UNIT
3. WYODAK-CARR DRAW 230
4. WYODAK-RENO 230
5. WYODAK-HUGHES 230
6. WYODAK-OSAGE 230
7. LANGE-LOOKOUT 230
8. LANGE-SOUTH RAPID 230
9. WESTHILL-SOUTH RAPID 230
10. OSAGE-WESTHILL 230
11. STEGALL-WESTHILL 230
12. YELLOW CREEK-OSAGE 230
13. HUGHES-LOOKOUT 230
14. YELLOW CREEK-LOOKOUT 230
15. TEKLA-HARTZOG 230
16. CARR DRAW-BUFFALO 230
17. DJ-YELLOWCAKE 230
18. CARR DRAW-BARBER CREEK 230
19. YELLOW CREEK-LANGE 230
20. OSAGE-LANGE 230
21. TEKLA-OSAGE 230
22. YELLOW CREEK-BEN FRENCH 230
23. OSAGE-BEN FRENCH 230
24. LANGE-BEN FRENCH 230

6. STUDY OBJECTIVES

The objective of this study was to identify transmission upgrades that would allow the power system to meet the performance criteria outlined in Section 4 and would minimize Rapid City must-run generation for the projected load levels of the years studied.

The first objective, meeting performance criteria, is important in light of the recently passed Energy Policy Act of 2005. The Energy Policy Act of 2005 now mandates that all utilities comply with previously voluntary planning and operating standards. The performance criteria

described previously is outlined within these planning standards. The future mandatory nature of these standards and criteria make it important that the Black Hills area power system meet these requirements.

The second objective, minimizing Rapid City must-run generation, has a number of benefits. The one benefit is increased reliability margins for the Black Hills area power system. Transmission outages will require fewer units to be run, resulting in additional generating units available to respond to additional, unforeseen system operating issues. An additional benefit is economical. The most recent Black Hills Corporation Integrated Resource Plan stated a retirement date of December 31, 2013 for the Ben French steam plant. Currently, the Ben French generating plant is included in Rapid City must-run generation requirements. While some must-run generation requirements are for voltage support within Rapid City and the Northern Black Hills, a few prior outages require higher must-run generation for local load serving. Minimizing required must-run generation would result in a substantial economic benefit by eliminating the need for running higher-priced gas generation for reliability purposes.

7. POTENTIAL SYSTEM ISSUES

In order to determine potential problem areas of the current transmission system and generation resources, benchmark cases were run simulating forced and prior outages. 2010 timeframe loads were used and Rapid City area generation levels were varied to determine the must-run generation needed to meet performance criteria.

7.1. BEN FRENCH AND OSAGE GENERATING STATIONS

It is anticipated that the Ben French and Osage generating stations will be retired by the end of 2013. The retirement of the Ben French unit is of particular concern due to its location within the Rapid City load center. The loss of this unit will require additional voltage support in the area and the requirement to run additional gas-fired generation.

7.2. RAPID CITY LOAD SERVING

Load growth within Rapid City has resulted in an increased loading of the Lange and South Rapid 230/69 kV transformers. The loss of the South Rapid 230/69 kV transformer causes high loadings on the remaining Lange 230/69 kV transformers. With the future retirement of the Ben French steam generator and the projected load growth, this problem will only intensify. There are currently two methods to reduce or remove overloads on these transformers.

- 69 KV SYSTEM TRANSFERS

  The 69 kV system can help support the Rapid City load from the Yellow Creek, Lookout and Westhill 230/69 kV substations. However, a number of factors minimize this support. First, the distances between the Yellow Creek, Lookout and Westhill substations and Rapid City are substantial, resulting in high path

impedances. Secondly, loads on the 69 kV system reduce the ability to transfer power into Rapid City and maintain acceptable voltage levels.

- COMBUSTION TURBINES

  Operating generation within Rapid City is a fast and direct way to reduce Rapid City 230/69 kV transformer loading. The major disadvantage of this solution is the high cost of running these units. Transformer failures typically result in prolonged outages due to the long lead times required for repairs or a replacement transformer. These long outage periods increase the financial impact of running gas-fired generation to eliminate transformer overloads.

7.3. 230 KV OUTAGES

The Black Hills area loads are primarily served by coal-fired generation located near Gillette, Wyoming. The power generated west of the Black Hills is then transported over the Common Use System (CUS) transmission facilities to the major 230 kV substations at Lookout, Yellow Creek, Lange and South Rapid. The major features of the CUS transmission system include:

- A 230 kV loop around the Black Hills that connects the South Rapid, Lange, Lookout, Yellow Creek, Osage and Westhill substations.
- Two lines connecting the Wyodak generation complex to the Black Hills 230 kV loop. These are the Wyodak-Hughes-Lookout and Wyodak-Osage lines.
- A 230 kV line connecting the Westhill substation to the WAPA system at Stegall south of the Black Hills.

Currently there is sufficient generation within the Rapid City load center to compensate for forced and prior outages of these 230 kV lines. However, with continued load growth and the potential retirement of the Ben French steam plant there may not be enough local generation to serve the load reliably for these outages.

8. SYSTEM ADDITIONS

8.1. LANGE SVC

A Static VAr Compensator (SVC) was added at the Lange 230 kV bus. The SVC was modeled with three different capacities: ±50, 100/-50 and 150/-50 MVAR. The SVC was represented as a switched shunt with continuous control and holding the Lange 230 kV bus voltage at 1.02 per-unit.

8.2. TEKLA-OSAGE-LANGE

A 230 kV line was modeled originating in the PREC Tekla 230 kV substation, running through the Osage 230 kV substation and terminating in the Lange 230 kV substation. The line length was estimated to be 60 miles from Tekla to Osage and 75 miles from Osage to Lange, for a total of 135 miles. The line was assumed to be built with 1295 ACSR conductor.

8.3. TEKLA-OSAGE, YELLOW CREEK-LANGE

A 230 kV line was modeled originating in the PREC Tekla 230 kV substation terminating at the Osage 230 kV substation. An additional 230 kV line was modeled originating at the Yellow Creek 230 kV substation and terminating in the Lange 230 kV substation. The line length was estimated to be 60 miles from Tekla to Osage and 35 miles from Yellow Creek to Lange, for a total of 95 miles. The line was assumed to be built with 1295 ACSR conductor.

8.4. TEKLA-OSAGE-BEN FRENCH-LANGE

A 230 kV line was modeled originating in the PREC Tekla 230 kV substation, running through the Osage 230 kV substation and terminating in a new Ben French 230 kV substation. The line length was estimated to be 60 miles from Tekla to Osage and 75 miles from Osage to Ben French, for a total of 135 miles. The line was assumed to be built with 1295 ACSR conductor. Additionally, the existing triple-circuit 69 kV line between the Ben French and Lange 69 kV substations was modeled as rebuilt as a 230 kV line with a single-circuit 69 kV under build. A 150 MVA 230/69 kV transformer (a copy of South Rapid City transformer) was added at the new Ben French 230 kV bus and connected to the existing Ben French 69 kV bus.

8.5. TEKLA-OSAGE, YELLOW CREEK-BEN FRENCH-LANGE

A 230 kV line was modeled originating in the PREC Tekla 230 kV substation terminating at the Osage 230 kV substation. An additional 230 kV line was modeled originating at the Yellow Creek 230 kV substation and terminating at a new Ben French 230 kV substation. The line length was estimated to be 60 miles from Tekla to Osage and 35 miles from Yellow Creek to Ben French, for a total of 95 miles. The line was assumed to be built with 1295 ACSR conductor. Additionally, the existing triple-circuit 69 kV line between the Ben French and Lange 69 kV substations was modeled as rebuilt as a 230 kV line with a single-circuit 69 kV under build. A 150 MVA 230/69 kV transformer was added at the new Ben French 230 kV bus and connected to the existing Ben French 69 kV bus.

9. STUDY RESULTS

The proposed upgrade options were studied in three steps. The first step looked at the benchmark case and near-term upgrades individually in the near term study years (2010 and 2015). The 2010 timeframe was not studied for the far-term transmission upgrades due to the typical long lead-time required for 230 kV line design and construction. The third step looked at combinations of the far-term transmission and near-term options together in the far-term study years (2020 and 2025).

During the course of the study it was observed that there were a number of prior outages that did not have any effect on the Black Hills area system. The following prior outages will not be addressed in this report:

- Wyodak-Carr Draw 230
- Wyodak-Reno 230
- Tekla-Hartzog 230
- Carr Draw-Buffalo 230
- Dave Johnson-Yellowcake 230
- Carr Draw-Barber Creek 230

Station abbreviations can be found in Appendix D of this report.

9.1. CURRENT SYSTEM

9.1.1. 2010 STUDY YEAR

BASE CASE

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. Four N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
WYD-OSG	LKO-HGH	RCG7	LKO 230 bus voltage (0.899) Multiple 69 bus voltages (0.869)
LNG-LKO	WHL-SRC	RCG7	WTW-STG 69 line (105.5% - 43 MVA)
SRC-WHL	LNG-LKO	RCG7	WTW-STG 69 line (105.5% - 43 MVA)
HGH-LKO	WYD-OSG	RCG7	Multiple 230 & 69 bus voltages (0.863)
	OSG-YWC	RCG7	LKO 230 bus voltage (0.886) Multiple 69 bus voltages (0.857)

The low post-contingent voltages indicate the need for additional reactive resources in the Rapid City/Northern Black Hills area. The Whitewood-Sturgis 69 kV line overloads can be mitigated by rebuilding the line with 795 ACSR construction.

±50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. Two N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	WHL-SRC	RCG7	WTW-STG 69 line (129% - 43 MVA) BGB-PAC 69 line (104% - 75 MVA) YWC-PLM 69 line (108.8% - 75 MVA) CUS-WHL 69 line (100.4% - 37 MVA)
SRC-WHL	LNG-LKO	RCG7	WTW-STG 69 line (128.8% - 43 MVA) BGB-PAC 69 line (103.7% - 75 MVA) YWC-PLM 69 line (108.6% - 75 MVA) CUS-WHL 69 line (100.3% - 37 MVA)

The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

+100/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no must-run generation is required. Two N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	WHL-SRC	RCG7	WTW-STG 69 line (129.7% - 43 MVA) BGB-BFR 69 line (100.2% - 75 MVA) BGB-PAC 69 line (104.3% - 75 MVA) YWC-PLM 69 line (109.4% - 75 MVA) CUS-WHL 69 line (100.7% - 37 MVA)
SRC-WHL	LNG-LKO	RCG7	WTW-STG 69 line (128.9% - 43 MVA) BGB-PAC 69 line (102.2% - 75 MVA) YWC-PLM 69 line (108.9% - 75 MVA)

The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

+150/-50 MVAR SVC

System intact conditions require no Rapid City must-run generation. Two N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	WHL-SRC	RCG7	WTW-STG 69 line (128.8% - 43 MVA) BGB-PAC 69 line (104.2% - 75 MVA) YWC-PLM 69 line (108.3% - 75 MVA) CUS-WHL 69 line (100.4% - 37 MVA)
SRC-WHL	LNG-LKO	RCG7	WTW-STG 69 line (128.4% - 43 MVA) BGB-PAC 69 line (103.8% - 75 MVA) YWC-PLM 69 line (108% - 75 MVA) CUS-WHL 69 line (100.2% - 37 MVA)

The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

9.1.2. 2015 STUDY YEAR

BASE CASE

System intact conditions require a generation level of RCG7 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG4 is required. Six N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
WYD-OSG	WHL-SGL	RCG7	Multiple 69 bus voltages around the Osage and Edgemont areas (0.893)
	LKO-HGH	RCG7	Not solved
LNG-LKO	YWC XFMR	RCG7	HLV-SPB 69 line (100.2% - 43 MVA) SPB-LKO 69 line (113.2% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (131.8% - 100 MVA)
	WHL-SRC	RCG7	Not solved
SRC-WHL	LNG-LKO	RCG7	Not solved
SGL-WHL	WYD-OSG	RCG7	Multiple 69 bus voltages in the Osage, southern and northern Black Hills (0.866)
YWC-OSG	LKO-HGH	RCG7	Not solved
HGH-LKO	WYD-OSG	RCG7	Not solved
	OSG-YWC	RCG7	Not solved

The 2015 study year shows severe N-1-1 issues with the current system network and generation resources. The most severe N-1-1 combinations results in the Rapid City/Black Hills load being isolated from the Wyodak generation center, or being supplied radially from the Westhill 230 kV substation. While there are a few thermal overloads, the majority of violations are due to voltage issues. The increased loads in the 2015 study year further demonstrate the need for reactive support in or near the Rapid City load center. The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

±50 MVAR SVC

System intact conditions require a must-run generation level of RCG5 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG3 is required. Four N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
WYD-OSG	LKO-HGH	RCG7	Not solved
LNG-LKO	WHL-SRC	RCG7	Six 69 bus voltages (0.869) Nine 69 lines (161.3%) Two 230/69 xfmrs (153.5%)
	YWC XFMR	RCG7	SPB-LKO 69 line (111.0% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (127.9% - 100 MVA)
SRC-WHL	LNG-LKO	RCG7	Six 69 bus voltages (0.862) Nine 69 lines (162.2%) Two 230/69 xfmrs (153.6%)
HGH-LKO	WYD-OSG	RCG7	Not solved
	OSG-YWC	RCG7	LKO 230 bus voltage (0.880) Multiple 69 bus voltages (0.840)

The addition of the 50 MVAR SVC improves the system performance when compared to the base case, but there are still numerous voltage issues. The transformer thermal overload can be mitigated by replacement of the transformer with a higher capacity transformer. The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

+100/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of

RCG2 is required. Four N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
WYD-OSG	LKO-HGH	RCG7	Not solved
LNG-LKO	WHL-SRC	RCG7	Four 69 bus voltages (0.869) Nine 69 lines (158.5) Two 230/69 xfmrs (150.9%)
	YWC XFMR	RCG7	SPB-LKO 69 line (110.6% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (127.3% - 100 MVA)
SRC-WHL	LNG-LKO	RCG7	Four 69 bus voltages (0.890) Nine 69 lines (159.6%) Two 230/69 xfmrs (151.0%)
HGH-LKO	WYD-OSG	RCG7	Not solved

The addition of the 100 MVAR SVC improves the system performance when compared to the base case, but there are still numerous voltage issues. The transformer thermal overload can be mitigated by replacement of the transformer with a higher capacity transformer. The 69 kV line overloads can be mitigated by increasing the line ratings through either reconstruction or analyzing existing construction and clearances.

+150/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no must-run generation is required. Three N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	WHL-SRC	RCG7	Four 69 bus voltages (0.895) Nine 69 lines (158.5) Two 230/69 xfmrs (150.9%)
	YWC XFMR	RCG7	SPB-LKO 69 line (110.6% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (127.3% - 100 MVA)
SRC-WHL	LNG-LKO	RCG7	Four 69 bus voltages (0.890) Nine 69 lines (159.6%) Two 230/69 xfmrs (151.0%)
HGH-LKO	WYD-OSG	RCG7	Not solved

The addition of the 150 MVAR SVC improves the system performance when compared to the base case, but there are still numerous voltage issues. The transformer thermal

overload can be mitigated by replacement of the transformer with a higher capacity transformer. The 69 kV line overloads can be mitigated by increasing the line ratings through line reconstruction or analyzing existing construction and clearances.

9.1.3. 2020 STUDY YEAR

Based upon the near-term need for voltage support in the Rapid City area, an SVC will likely be installed prior to any 230 kV line additions. The 2020 study year simulation results which only included an SVC showed only a marginal improvement from the base case performance. Therefore, the 2020 study year results will focus on combinations of SVC size with potential 230 kV line additions.

BASE CASE

System intact conditions do not meet criteria with maximum must-run generation on-line due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG5 is required for system intact conditions. Nine N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
WYD-HGH	HGH-DFK	RCG7	Four 69 bus voltages (0.856)
WYD-OSG	WHL-SGL	RCG7	Not Solved
	LKO-HGH	RCG7	Not solved
LNG-LKO	YWC XFMR	RCG7	HLV-SPB 69 line (108.3% - 43 MVA) SPB-LKO 69 line (122.4% - 43 MVA) LKO 230/69 xfmr (130.0% - 100 MVA)
	LKO XFMR	RCG7	Multiple 69 bus voltages on the BLC line YWC 230/69 xfmr (144.3% - 100 MVA)
	WHL-SRC	RCG7	Not solved
SRC-WHL	LNG-LKO	RCG7	Not solved
	LKO-HGH	RCG7	Not solved
	YWC XFMR	RCG7	SPB-LKO 69 line (103.9% - 43 MVA)
	LKO XFMR	RCG7	Multiple 69 bus voltages on the BLC line YWC 230/69 xfmr (125.3% - 100 MVA)
OSG-WHL	WYD-OSG	RCG7	Four 69 bus voltages in the OSG area (0.896)
	LNG-LKO	RCG7	Not solved
SGL-WHL	WYD-OSG	RCG7	Not solved
	LKO-HGH	RCG7	Not solved

YWC-OSG	LKO-HGH	RCG7	Not solved
	LKO XFMR	RCG7	Ten 69 bus voltages in the northern Black Hills and on the BLC line (0.874)
HGH-LKO	WYD-OSG	RCG7	Not solved
	WHL-SGL	RCG7	Not solved
	WHL-SRC	RCG7	Not solved
	OSG-YWC	RCG7	Not solved
	LKO-YWC	RCG7	Three 230 bus voltages (0.873) Four 69 bus voltages on the BLC line (0.890)

As can be seen from the results table above, the current system network cannot support the projected 2020 load. These results confirm the need to add reactive support as well as an additional transmission path into the Black Hills load area.

TEK-OSG-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG3 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. One N-1-1 condition does not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (101.4% - 43 MVA)

The 69 kV line overload can be mitigated by increasing the line rating through line reconstruction.

TEK-OSG 230
YWC-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. One N-1-1 condition does not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
HGH-LKO	OSG-YWC	RCG7	Nine 69 bus voltages on the BLC line and in the Sturgis area (0.877)

The N-1-1 voltage violations occur on the radial Sundance Hill-Belle Creek 69 kV line and the radial Yellow Creek-Sturgis area 69 kV line. While these 230 kV line additions vastly improve the load serving ability of the transmission system, the violations noted above require additional voltage support on the 69 kV system. Closing the normally open 69 kV lines for this prior outage degrades system performance.

TEK-OSG-BFR-LNG 230
±50 MVAR SVC

System intact conditions require no Rapid City must-run generation. The two most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG6	SPB-LKO 69 line (102.2% - 43 MVA)
HGH-LKO	OSG-YWC	RCG5	STG area 69 bus voltages (0.884)

The Lange-Lookout 230 line prior outage must-run generation requirement reduces to RCG2 if the Spearfish BEC-Lookout 69 line rating is increased. If the Lange-Lookout 230 line prior outage restrictions are corrected, the Hughes-Lookout 230 line prior outage then requires the highest must-run generation levels.

TEK-OSG 230
YWC-BF-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG3 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. The two most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
YWC-OSG	LKO-HGH	RCG7	Not solved
HGH-LKO	OSG-YWC	RCG7	Not solved

The simplest solution to these N-1-1 combinations is additional reactive support.

TEK-OSG-LNG 230
+100/-50 MVAR SVC

System intact conditions require a generation level of RCG2. One N-1-1 condition does not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (101.5% - 43 MVA)

If Spearfish BEC-Lookout 69 line rating is increased the must-run generation requirement would be RCG2 for system intact and all prior outage conditions.

TEK-OSG 230
YWC-LNG 230
+100/-50 MVAR SVC

System intact conditions require a generation level of RCG2. The two most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
YWC-OSG	LKO-HGH	RCG6	Not solved
LKO-HGH	YWC-OSG	RCG6	Not solved

The simplest solution to reduce the must-run requirements of these N-1-1 combinations is to install additional reactive support.

TEK-OSG-BF-LNG 230
+100/-50 MVAR SVC

System intact conditions do not require any must-run generation. The most limiting prior outage is shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SFB-LKO 69 line (104.0%)

If the Spearfish BEC-Lookout 69 line rating is increased the must-run generation requirement would be RCG0 for system intact and eight prior outage conditions. The Wyodak-Osage, Yellow Creek-Osage, Hughes-Lookout and Osage-Ben French 230 line prior outages would require a must-run generation level of RCG2. The prior outage RCG2 must-run generation requirements are removed with the addition of additional reactive support.

TEK-OSG 230
YWC-BF-LNG 230
+100/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no must-run generation is required. The two most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
YWC-OSG	LKO-HGH	RCG5	Not solved
LKO-HGH	YWC-OSG	RCG6	Not solved

Installing additional reactive support will reduce the required must-run generation for these N-1-1 conditions.

TEK-OSG-LNG 230
+150/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no system intact must-run generation is required. One N-1-1 condition does not meet criteria with maximum Rapid City generation on-line. The most limiting prior outage is shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (101.5% - 43 MVA)

Increasing the rating of the Spearfish BEC-Lookout 69 line reduces the Lange-Lookout 230 prior outage must-run generation requirements to RCG2. The next limiter becomes the Hillsview-Spearfish BEC 69 line and Lookout 230/69 transformer thermal limits. Fixing these thermal limits results in five N-1-1 combinations requiring a must-run generation level of RCG2. The Lange-South Rapid, Yellow Creek-Osage, Hughes-Lookout, Yellow Creek-Lookout and Osage-Lange 230 prior outages all show minor voltage violations for the next worst contingency.

TEK-OSG 230
YWC-LNG 230
+150/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no system intact must-run generation is required. The three most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG5	SPB-LKO 69 line (100.1% - 43 MVA)
YWC-OSG	LKO-HGH	RCG4	Not solved

HGH-LKO	YWC-OSG	RCG4	Not solved

Increasing the rating of the Spearfish BEC-Lookout 69 line eliminates the Lange-Lookout 230 prior outage must-run generation requirements. Installing additional reactive capability reduces the must-run generation requirements for the Yellow Creek-Osage and Hughes-Lookout prior outages.

TEK-OSG-BF-LNG 230
+150/-50 MVAR SVC

No must-run generation is required for system intact conditions.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (100.2% - 43 MVA)

Increasing the rating of the Spearfish BEC-Lookout 69 line eliminates the Lange-Lookout 230 prior outage must-run generation requirements. Resolving this criteria violation removes any must-run generation requirements for all prior outage conditions.

TEK-OSG 230
YWC-BF-LNG 230
+150/-50 MVAR SVC

No must-run generation is required for system intact conditions. The four most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG2	SPB-LKO 69 line (101.3% - 43 MVA)
SRC-WHL	OSG-YWC	RCG2	Not solved
YWC-OSG	LKO-HGH	RCG4	Not solved
HGH-LKO	YWC-OSG	RCG4	Not solved

Increasing the rating of the Spearfish BEC-Lookout 69 line eliminates the Lange-Lookout 230 prior outage must-run generation requirements.

9.1.4. 2025 STUDY YEAR

BASE CASE

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of

RCG4 is required. Six N-1-1 scenarios did not meet criteria with maximum Rapid City generation on-line.

TEK-OSG-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG3 is required. Four N-1-1 conditions do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (107.2% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (125.7% - 100 MVA)
YWC-OSG	LKO XFMR	RCG7	Six 69 bus voltages on or near the BLC line (0.883)
HGH-LKO	OSG-YWC	RCG7	STG 69 (0.882) & WTW (0.890)
YWC-LKO	LKO XFMR	RCG7	Six 69 bus voltages on or near the BLC line (0.882)

Increasing the rating on the Spearfish BEC-Lookout 69 line and Yellow Creek 230/69 transformer would reduce the required must-run generation level to RCG6. The Yellow Creek-Osage and Yellow Creek-Lookout 230 line prior outage must-run generation levels can be reduced by adding reactive resources on the 69 kV system in the Lookout area. The Hughes-Lookout 230 prior outage must-run generation requirements can be reduced by adding reactive resources on the 230 kV system in the Rapid City area.

TEK-OSG 230
YWC-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG3 is required. Six N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (100.3% - 43 MVA)
	LKO XFMR	RCG7	Two 69 bus voltages at STG (0.895)
SRC-WHL	LKO XFMR	RCG7	Four 69 bus voltage on the BLC line and STB bus (0.891)

YWC-OSG	LKO-HGH	RCG7	Not solved
	LKO XFMR	RCG7	Ten 69 bus voltages around Spearfish and on the BLC line (0.871)
HGH-LKO	OSG-YWC	RCG7	Not solved
YWC-LKO	LKO XFMR	RCG7	Two 69 bus voltages on the BLC line (0.896)

The N-1-1 voltage violations which occur on the radial Sundance Hill-Belle Creek 69 kV line can be corrected with either reactive support on that line or in the Sundance Hill area.

TEK-OSG-BFR-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, system intact conditions require no Rapid City must-run generation. Four N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (103.7% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (121.5% - 100 MVA)
YWC-OSG	LKO XFMR	RCG7	Five 69 bus voltages on BLC line (0.886)
HGH-LKO	OSG-YWC	RCG7	STG 69 bus voltage (0.895)
YWC-LKO	LKO XFMR	RCG7	Five 69 bus voltages on BLC line (0.885)

The Lange-Lookout 230 line prior outage must-run generation requirement can be reduced by increasing the BEC-Lookout 69 line and Yellow Creek 230/69 transformer ratings. The Lookout 230/69 transformer contingency violations can be mitigated by the addition of reactive support to the 69 kV system around Lookout.

TEK-OSG 230
YWC-BF-LNG 230
±50 MVAR SVC

System intact conditions require a must-run generation level of RCG4 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. Four N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation

SRC-WHL	LKO XFMR	RCG7	Two 69 bus voltages on BLC line (0.896)
YWC-OSG	LKO-HGH	RCG7	Not solved
	LKO XFMR	RCG7	Six 69 bus voltages on BLC line (0.880)
HGH-LKO	OSG-YWC	RCG7	Not solved
YWC-LKO	LKO XFMR	RCG7	Three 69 bus voltages on BLC line (0.894)

The Yellow Creek-Osage and Hughes-Lookout prior outage violations can be mitigated by adding reactive support to the 230 kV system, preferably in the Rapid City or Lookout areas. However, the reactive support would be most effective if it were dynamic or automatically controlled. The Lookout 230/69 kV transformer contingency violations can be mitigated by adding reactive support to the 69 kV system in the Lookout area.

TEK-OSG-LNG 230
+100/-50 MVAR SVC

System intact conditions require a generation level of RCG2. Three N-1-1 condition does not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (107.1% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (124.8% - 100 MVA)
YWC-OSG	LKO XFMR	RCG7	Four 69 bus voltages on BLC line (0.892)
YWC-LKO	LKO XFMR	RCG7	Six 69 bus voltages on BLC line (0.882)

If the Spearfish BEC-Lookout 69 kV line and Yellow Creek 230/69 kV transformer ratings are increased, the must-run generation requirement could be reduced for the Lange-Lookout 230 kV prior outage.

TEK-OSG 230
YWC-LNG 230
+100/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG3 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, a must-run generation level of RCG2 is required. One N-1-1 scenario did not meet criteria with maximum Rapid City generation on-line. Two N-1-1 scenarios required a must-run generation level of RCG7.

Prior Outage	Limiting Contingency	Gen Level	Violation

LNG-LKO	YWC XFMR	RCG7	SFB-LKO 69 line (100.2% - 43 MVA)
YWC-OSG	LKO-HGH	RCG6	Not solved
HGH-LKO	YWC-OSG	RCG6	Not solved

If the Spearfish BEC-Lookout 69 kV line rating is increased the must-run generation requirement could be reduced for the Lange-Lookout 230 kV prior outage. The next worst contingency would be the loss of the Lookout 230/69 kV transformer. This contingency results in four voltage violations on the Belle Creek 69 kV line at RCG3. The Yellow Creek-Osage and Hughes-Lookout 230 kV line prior outage must-run generation requirements can be reduced by adding reactive support on the 230 kV system in the Rapid City area.

TEK-OSG-BF-LNG 230
+100/-50 MVAR SVC

System intact conditions do not require any must-run generation. Three N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (103.7% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (120.9% - 100 MVA)
YWC-OSG	LKO XFMR	RCG7	Four 69 bus voltages on BLC line (0.892)
YWC-LKO	LKO XFMR	RCG7	Five 69 bus voltages on BLC line (0.885)

If the Spearfish BEC-Lookout 69 kV line and Yellow Creek 230/69 kV transformer ratings are increased, the must-run generation requirement would be reduced to RCG3. There then becomes a voltage limitation on the Belle Creek 69 kV line. Adding reactive support on the 69 kV system in the Lookout area would reduce the must-run generation requirement for prior outages with the Lookout 230/69 kV transformer contingency causing the limitation.

TEK-OSG 230
YWC-BF-LNG 230
+100/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. Ignoring breaker-fail contingencies, no must-run generation is required. The three most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation

LNG-LKO	YWC XFMR	RCG5	SPB-LKO 69 line (100% - 43 MVA)
YWC-OSG	LKO-HGH	RCG5	Not solved
LKO-HGH	YWC-OSG	RCG6	Not solved

If the Spearfish BEC-Lookout 69 kV line and Yellow Creek 230/69 kV transformer ratings are increased, the must-run generation requirement would be reduced to RCG3. Installing additional reactive support will further reduce the required must-run generation for these N-1-1 conditions.

TEK-OSG-LNG 230
+150/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2 due to breaker-fail contingencies. This is primarily due to inadequate 230/69 transformation capacity in Rapid City. Ignoring breaker-fail contingencies, no system intact must-run generation is required. Three N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (107.1% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (124.8% - 100 MVA) Two 69 bus voltages on BLC line (0.898)
YWC-OSG	LKO XFMR	RCG7	Four 69 bus voltages on BLC line (0.892)
YWC-LKO	LKO XFMR	RCG7	Six 69 bus voltages on BLC line (0.882)

Adding reactive support to the 69 kV system in the Lookout area reduces the must-run generation requirements of all of the prior outages noted above. Other less severe prior outages would also benefit from the added reactive support around Lookout. An increase to the Spearfish BEC-Lookout 69 kV line and Yellow Creek 230/69 kV transformer ratings would be needed to reduce the required must-run generation for the Lange-Lookout 230 kV line prior outage.

TEK-OSG 230
YWC-LNG 230
+150/-50 MVAR SVC

System intact conditions require a must-run generation level of RCG2. This must-run generation requirement is primarily due to inadequate 230/69 transformation capacity in Rapid City. One N-1-1 scenario did not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation

LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (100.2% - 43 MVA)

Increasing the rating of the Spearfish BEC-Lookout 69 kV line reduces the Lange-Lookout 230 kV prior outage must-run generation requirements. This system improvement along with additional reactive support would further reduce the required must-run generation levels for many of the 230 kV line prior outages.

TEK-OSG-BF-LNG 230
+150/-50 MVAR SVC

No must-run generation is required for system intact conditions. Three N-1-1 scenarios do not meet criteria with maximum Rapid City generation on-line.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG7	SPB-LKO 69 line (103.7% - 43 MVA)
	LKO XFMR	RCG7	YWC 230/69 xfmr (120.9% - 100 MVA)
YWC-OSG	LKO XFMR	RCG7	Four 69 bus voltages on BLC line (0.892)
YWC-LKO	LKO XFMR	RCG7	Five 69 bus voltages on BLC line (0.885)

Increasing the Spearfish BEC-Lookout 69 kV line and Yellow Creek 230/69 kV transformer rating, and adding reactive support on the 69 kV system around Lookout reduces or eliminates the required must-run generation for many of the 230 kV line prior outages.

TEK-OSG 230
YWC-BF-LNG 230
+150/-50 MVAR SVC

No must-run generation is required for system intact conditions. The four most limiting prior outages are shown below.

Prior Outage	Limiting Contingency	Gen Level	Violation
LNG-LKO	YWC XFMR	RCG4	SPB-LKO 69 line (101.4% - 43 MVA)
SRC-WHL	YWC XFMR	RCG2	SPB-LKO 69 line (100.0% - 43 MVA)
YWC-OSG	LKO-HGH	RCG5	WHL-SRC 230 line (100.8% - 332 MVA)
HGH-LKO	YWC-OSG	RCG5	WHL-SRC 230 line (107.5% - 332 MVA)

Increasing the rating of the Spearfish BEC-Lookout 69 kV line and the Westhill-South Rapid 230 kV line would reduce the required must-run generation levels for the prior outages noted above.

9.2. EXTREME CONTINGENCIES

A number of Category D Extreme Contingencies as defined in Table 1 of NERC Reliability Standard TPL-004-0 were simulated. The extreme contingencies were the loss of the 230 kV substations at Wyodak, Hughes, Lookout, Lange, South Rapid, Westhill, Osage and Yellow Creek. These substations and the lines associated with them make up our bulk 230 kV transmission system.

2010 STUDY YEAR

The base case showed that most severe extreme contingencies were the loss of the Wyodak, Lange and South Rapid 230 kV substations. Each of these contingencies caused extremely low voltages, primarily in the Black Hills and Rapid City areas. Adding an SVC at the Lange 230 kV bus removes the Wyodak and South Rapid 230 kV substation post-contingent violations. As would be expected, the Lange 230 kV substation contingency continues to result in extremely low voltages in the Black Hills and Rapid City areas.

2015 STUDY YEAR

The base case showed the same performance for the contingencies noted in the 2010 study year, but included post-contingent low voltages for additional 230 kV substation contingencies. Only the Yellow Creek 230 kV substation contingency did not result in any voltage violations. The addition of an SVC at Lange produced the same results as in the 2010 study year. With the SVC, only the Lange 230 kV substation contingency shows post-contingent voltage violations, which is to be expected.

2020 STUDY YEAR

The base case showed similar results to the 2015 study year simulations. The system additions that were simulated include various sizes of SVC and the four transmission lines outlined earlier in this report. Either the Tekla-Osage-Ben French-Lange or Tekla-Osage and Yellow Creek-Ben French-Lange 230 kV lines eliminate the violations caused by the simulated extreme contingencies.

2025 STUDY YEAR

The base case showed similar results to the 2020 study year simulations. Again, the same system additions were simulated for 2025 as were simulated for the 2020 study year. Again the Tekla-Osage-Ben French-Lange or Tekla-Osage and Yellow Creek-Ben French-Lange 230 kV line additions showed the best system performance for these contingencies.

10. CONCLUSIONS

This study has shown that system additions will be required in the future to accommodate anticipated load growth and future generating station retirements. In all of the study years, the must-run generation requirements for system intact conditions increase from the requirements today. As expected, subsequent study years showed that the must-run generation requirements continue to increase. Additionally, numerous 230 kV transmission line N-1-1 conditions do not meet criteria with all Rapid City generation on-line in the 2010 study year. The study results also indicate that the out year problems become worse, with more 230 kV transmission line prior outage conditions failing to meet criteria, even with Rapid City generation at maximum levels.

The results indicate that reactive support installed on the 230 kV system around Rapid City, preferably at the Lange substation, mitigates the voltage violations in 2010. The size of the SVC is ultimately dependent on the acceptable level of must-run generation for system intact and prior outage conditions. If the goal is to minimize or eliminate must-run generation requirements, a 100 to 150 MVAR SVC should be installed. If the goal is simply to meet criteria under system intact and prior outage conditions, a 50 MVAR SVC would be acceptable. It is recommended that a 50 or 100 MVAR SVC be installed with plans for the future addition of switched capacitors which could be controlled by the SVC. The additional switched capacitors would likely be needed prior to 2015 or as studies indicate based on updated load forecasts. The addition of a larger SVC also improved the system response to many extreme 230 kV substation contingencies when compared to the base case results for both the 2010 and 2015 study years.

A number of aged, low capacity 69 kV lines also need to be rebuilt to allow for increased power flow into the Rapid City load center. Ideally, these modifications should be implemented prior to 2010. To meet performance criteria in the 2015 timeframe additional 69 kV lines may need to be improved to increase their rating, and additional or increased transformation in the northern Black Hills may be needed. As the load changes on the Sundance Hill-Belle Creek 69 kV line, power factor correction capacitors or 69 kV capacitors may need to be installed should voltage issues present themselves.

In the 2020 timeframe an additional 230 kV line will be needed to serve the Rapid City and Black Hills area load. Assuming that the upgrades referred to previously are implemented, it is recommended that the Tekla-Osage-Ben French-Lange 230 kV line be built. This project would also include a new Ben French 230 kV substation with a 150 MVA 230/69 kV transformer, to be tied into the existing Ben French 69 kV substation. Additionally, the existing triple-circuit 69 kV line connecting the Ben French 69 kV substation to the Lange substation should be rebuilt to 230 kV with a single-circuit 69 kV under build. These transmission additions, coupled with an earlier SVC installation and previously discussed sub-transmission upgrades, would allow for no must-run generation requirements for system intact and most prior outage conditions. The Tekla-Osage-Ben French-Lange 230 kV line also has the added benefit of almost eliminating any violations due to extreme 230 kV substation contingencies in the 2025 study year, and entirely eliminating violation in the 2020 study year. The loss of the

Lange 230 kV substation resulted in low voltages in the Rapid City area, but increasing the size of the SVC would eliminate these violations.

APPENDIX A

MONITORED BUSES

ANT MINE230.
BUFFALO 230.
CARR DRA230.
DAVEJOHN230.
DAVEJOHN115.
DAVEJOHN69.0
DECKER 230.
GOOSE CK230.
SHERIDAN230.
SHERIDAN35.0
WYODAK 230.
WYOMONT 230.
YELLOWCK230.
GLENRCKN115.
GLENRCKS115.
WESTHILL230.
LAR.RIVR230.
LAR.RIVR345.
OSAGE 230.
LANGE 230.
REFNRYTP115.
RENO 230.
SIDNEY 115.
SIDNEY 230.
SIDNEYDC230.
LOOKOUT 230.
STEGALDC230.
STEGALL 115.
STEGALL 230.
YELLOWBR115.
YELLOWBR230.
38TH ST 69.0
4THST TP69.0
ANGOSTUR69.0
ARGYLE 69.0
BENFRNCH69.0
BIG BEN 69.0
CAMBELL 69.0
CEMETERY69.0
CLINTON 69.0
CUSTER 69.0
DENVERST69.0
DUMONT 69.0
EDGEMONT69.0
HILLCITY69.0
HILLSVW 69.0
WESTHILL69.0
JWL CAVE69.0
KIRK 69.0
LINGLETP115.
LYMANTP 115.
MERILLAT69.0
MCFT PR69.0
NSS1 69.0
OSAGE 69.0
PACTOLA 69.0
PLSNTVLY69.0
PLUMA 69.0
POPE&TAL69.0
PRINGLE 69.0
LANGE 69.0
RICHMHIL69.0
5TH ST 69.0
SALT CRK69.0
SPFSHBEC69.0
SPFSHCIT69.0
LOOKOUT 69.0
STURG_CI69.0
SUNDHILL69.0
TEKLA 230.
TROJAN 69.0
WESTBLVD69.0
WTRPLANT69.0
WHTEWOOD69.0
WNDYFLAT69.0
WYODAK 69.0
YELOWCRK230.
YELOWCRK69.0
ANAMOSA 69.0
4TH ST 69.0
EASTNRTH69.0
HUGHES 230.
HUGHES 69.0
DUTONBAS115.
ERVAYBAS115.
GARCANPP4.20
GARCANPP12.5
NAHNEJEN115.
NSS2 69.0
PILOT BU69.0
CORLETT 115.
JACKLOPE115.
KIMBALLC115.
LIMESTON115.
MEDBOWHS115.
MEDBOWTP115.
WARMSPGS115.
EMIGRANT115.
WAGNHNDS115.
FTSANDER115.
GUERNRRL115.
WARRENLM115.
BUFFBLPP69.0
CENTRYRD69.0
HARRSBRG115.
CROWCRK 115.
GRANBY 138.
BUFBASIN69.0
HDOME 69.0
CMTDUM 69.0
CAMBELL 115.
MALL 69.0
NLOOP TP69.0
LANGE TP69.0
ROBINSDL69.0
ROBNS TP69.0
5THST TP69.0
SWEST TP69.0
RADIO_DR69.0
44TH ST 69.0
BFRNCH2669.0
CMNTPLNT69.0
CROSS ST69.0
AMCOLOID69.0
BELLECRK69.0
COLONY 69.0
BUTTEPMP69.0
MTNVIEW 69.0
NEWCASTL69.0
MEETSETP115.
STURGIS 69.0
WY REFIN69.0
88 OIL 69.0
S.CRK TP69.0
PLUMA TP69.0
SPRUCEGL69.0
OSAG CTY69.0
BENTON 69.0
UPTON_C 69.0
GILLETTE69.0
PEDMNT 69.0
SW_TAP1 69.0
SW_TAP2 69.0
RCSOUTH1230.
RCSOUTH269.0
ADON PR69.0
RCDC W 230.
STURGBEC69.0
HARTZOG 230.
BARBERCK230.
DRYFORK 230.
ARVADA 230.
DRYFRK1 13.8
DRYFRK2 13.8
DECKER 230.
WYOMONT 230.
BENFRCH 230.

APPENDIX B

MONITORED BRANCHES

DAVEJOHN-DAVEJOHN- 1
DAVEJOHN-DAVEJOHN- 1
SHERIDAN-SHERIDAN- 1
SHERIDAN-SHERIDAN- 2
WYODAK-WYODAK- 1
WYODAK-WYODAK- 2
YELOWTLP-YELOWTLP- 1
WESTHILL-WESTHILL- 1
LAR.RIVR-LAR.RIVR- 1
OSAGE-OSAGE- 1
LANGE-LANGE- 1
LANGE-LANGE- 2
SIDNEY-SIDNEY- 1
SIDNEY-SIDNEYDC- 1
LOOKOUT-LOOKOUT- 1
STEGALL-STEGALL- 1
STEGALL-STEGALL- 2
YELLOWBR-YELLOWBR- 1
CAMBELL-CAMBELL- 1
CAMBELL-CAMBELL- 2
YELOWCRK-YELOWCRK- 1
HUGHES-HUGHES- 1
RCSOUTH1-RCSOUTH2- 1
BLGS PHA-YELOWTLP- 1
RMRK PHA-YELOWTLP- 1
CROS PHA-YELLOWBR- 1
ANT MINE-YELLOWCK- 1
ANT MINE-TEKLA- 1
ATLANTIC-ROCKSPGS- 1
ATLANTIC-WYOPO- 1
BADWATER-SPENCE- 1
BADWATER-THERMOPL- 1
BAIROIL-WHISKEYP- 1
BAR-X-PLATTE- 1
BAR-X-PT ROCKS- 1
BLUE RIM-BRDGR PP- 1
BLUE RIM-S. TRONA- 1
BRDGR PP-FIREHOLE- 1
BRIDGER-MUSTANG- 1
BRIDGER-PT ROCKS- 1
BRIDGER-ROCKSPGS- 1
BUFFALO-CARR DRA- 1
BUFFALO-KAYCEE- 1
BUFFALO-SHERIDAN- 1
CARR DRA-WYODAK- 1
CASPERPP-DAVEJOHN- 1
CASPERPP-MIDWEST- 1
CASPERPP-RIVERTON- 1
CASPERPP-CASPERLM- 1
CASPERPP-REFNRYTP- 1
DAVEJO&1-DAVEJOHN- 1
DAVEJO&1-SPENCE- 1
DAVEJOHN-DIFICULT- 1
DAVEJOHN-YELLOWCK- 1
DAVEJOHN-LAR.RIVR- 1
DAVEJOHN-STEGALL- 1
DAVEJOHN-GLENRCKN- 1
DAVEJOHN-GLENRCKS- 1
DECKER-GOOSE CK- 1
DECKER-WYOMONT- 1
DIFICULT-MINERS- 1
FIREHOLE-LITTLEMT- 1
FIREHOLE-ROCKSPGS- 1
FLAMGORG-LITTLEMT- 1
FRANNIE-GARLAND- 1
FRANNIE-YELOWTLP- 1
FT CREEK-MINERS- 1
GARLAND-OREBASIN- 1
GOOSE CK-SHERIDAN- 1
GOOSE CK-YELOWTLP- 1
GRASS CK-OREBASIN- 1
GRASS CK-THERMOPL- 1
GREATDIV-MUSTANG- 1
KAYCEE-MIDWEST- 1
MINERS-PLATTE- 1
MONUM PS-NAUGHTON- 1
MONUM PS-OPAL TAP- 1
MUSTANG-SPENCE- 1
PALISADE-RAVEN- 1
PALISADE-ROCKSPGS- 1
PLATTE-WHISKEYP- 1
PT ROCKS-ROCKSPGS- 1
RIVERTON-THERMOPL- 1
RIVERTON-WYOPO- 1

THERPACE-WORLAND- 1
THERPACE-THERMOPL- 1
THERPACE-THERMOPL- 2
WORLAND-WORLANTP- 1
WYODAK-OSAGE- 1
WYODAK-RENO- 1
WYODAK-HUGHES- 1
YELOWTLP-YELLOWBR- 1
ALCOVA-CASPERLM- 1
ALCOVA-CASPERLM- 2
ALCOVA-FREMONT- 1
ALCOVA-MIRACLEM- 1
ALCOVA-MIRACLEM- 2
ALCOVA-RADERVIL- 1
ARCHER-CHEYENNE- 1
ARCHER-MYERS TP- 1
ARCHER-PINEBLUF- 1
ARCHER-SKYLINE- 1
ARCHER-CROWCRK- 1
ARCHER-AULT- 1
ARCHER-STEGALL- 1
ARCHER-HAYDEN- 1
AULT-LAR.RIVR- 1
BASIN-GREYBULL- 1
BASIN-WORLANTP- 1
BGEORGE-GLENDLTP- 1
BGEORGE-LOVELL- 1
BGEORGE-MEETSETP- 1
BOYSEN-COPPERMT- 1
BOYSEN-THERMOPL- 1
BOYSEN-HARRSBRG- 1
BRIDGEPT-MCGREW- 1
BRIDGEPT-GREENWOD- 1
BUFFBILL-HEART MT- 1
BUFFBILL-N. CODY- 1
BUFFBILL-BUFFBLPP- 1
BUSHNELL-BUSHNLTP- 1
BUSHNLTP-KIMBALL- 1
BUSHNLTP-PINEBLUF- 1
CARTERMT-THERMOPL- 1
CARTERMT-MEETSETP- 1
CASPERLM-GLENRCKN- 1
CHEYENNE-HAPPYJCK- 1
CHEYENNE-LARAMIE- 1
CHEYENNE-CROWCRK- 1
CHEYENNE-PONNEQUI- 1
COPPERMT-RADERVIL- 1
DALTON-SIDNEY- 1
DALTON-GREENWOD- 1
GARLAND-LOVELL- 1
GARLAND-POWELLTP- 1
GEMCTYTP-HAPPYJCK- 1
GEMCTYTP-OASISTAP- 1
GEMCTYTP-SPRINGCK- 1
GERING-MCGREW- 1
GERING-STEGALL- 1
GERING-EMIGRANT- 1
GLENDLTP-HEART MT- 1
GLENDO-GLENRCKN- 1
GLENDO-GUERNTAP- 1
GLENDO-PODOLAK- 1
GLENDO-LINGLETP- 1
GLENDO-WAGNHNDS- 1
GLENRCKS-REFNRYTP- 1
GLENRCKS-WAGNHNDS- 1
GREYBULL-LOVELL- 1
GREYBULL-NAHNEJEN- 1
GUERNTAP-STEGALL- 1
GUERNTAP-LIMESTON- 1
GUERNTAP-GUERNRRL- 1
HAPPYJCK-CORLETT- 1
HDOME-JIMRDYTP- 1
HEART MT-N. CODY- 1
WESTHILL-OSAGE- 1
WESTHILL-STEGALL- 1
WESTHILL-RCSOUTH1- 1
JACINTO-KIMBALL- 1
JACINTO-SIDNEY- 1
JIMREADY-JIMRDYTP- 1
KIMBALL-KIMBALLC- 1
KORTES-KORTESTP- 1
KORTES-MIRACLEM- 1
KORTESTP-MIRACLEM- 1
KORTESTP-SEMINOE- 1
LAGRANGE-ROUNDTOP- 1
LAGRANGE-STEGALL- 1
LAR.RIVR-STEGALL- 1
LAR.RIVR-STORY- 1
LARAMIE-MEDBOWTP- 1
LINGLE-LINGLETP- 1

LOVELL-YELLOWBR- 1
LOVELL-YELLOWBR- 2
LYMAN-TORRNGTN- 1
LYMAN-LYMANTP- 1
MAY-OASISTAP- 1
MED BOW-MEDBOWTP- 1
MIRACLEM-OASISTAP- 1
MIRACLEM-SEMINOTP- 1
MIRACLEM-MEDBOWTP- 1
MYERS-MYERS TP- 1
MYERS TP-POLE CK- 1
N. CODY-RALSTON- 1
N.YUMA-SIDNEY- 1
OSAGE-YELOWCRK- 1
PEETZ-SIDNEY- 1
PILOT BU-WINDRIVT- 1
PILOT BU-HARRSBRG- 1
POLE CK-QUALLS- 1
POLE CK-ROUNDTOP- 1
POWELLTP-RALSTON- 1
RADERVIL-ERVAYBAS- 1
LANGE-LOOKOUT- 1
LANGE-RCSOUTH1- 1
RENO-TEKLA- 1
RIVERTON-WINDRIVT- 1
ROUNDTOP-SENTINEL- 1
SEMINOE-SEMINOTP- 1
SEMINOTP-SINCLAIR- 1
SIDNEY-STEGALL- 1
SINCLAIR-TROWBRDG- 1
SKYLINE-WARRENLM- 1
LOOKOUT-YELOWCRK- 1
LOOKOUT-HUGHES- 1
SPRINGCK-FTSANDER- 1
STEGALDC-STEGALL- 1
STEGALL-LYMANTP- 1
STEGALL-EMIGRANT- 1
TCAPS-THERMOPL- 1
TCAPS-JIMRDYTP- 1
THERMOPL-WORLANTP- 1
WILDCAT-EMIGRANT- 1
WINDRIVR-WINDRIVT- 1
WINDYGAP-GRANBY- 1
38TH ST-CEMETERY- 1
38TH ST-WTRPLANT- 1
4THST TP-WESTBLVD- 1
4THST TP-ANAMOSA- 1
4THST TP-4TH ST- 1
4THST TP-EASTNRTH- 1
ANGOSTUR-EDGEMONT- 1
ANGOSTUR-WESTHILL- 1
ARGYLE-EDGEMONT- 1
ARGYLE-PRINGLE- 1
BENFRNCH-BIG BEN- 1
BENFRNCH-PLSNTVLY- 1
BENFRNCH-LANGE- 2
BENFRNCH-LANGE- 3
BENFRNCH-WTRPLANT- 1
BENFRNCH-BFRNCH26- 1
BENFRNCH-CMNTPLNT- 1
BENFRNCH-CROSS ST- 1
BIG BEN-PACTOLA- 1
CAMBELL-DENVERST- 1
CAMBELL-CENTRYRD- 1
CAMBELL-ROBNS TP- 1
CEMETERY-5THST TP- 1
CLINTON-PACTOLA- 1
CUSTER-WESTHILL- 1
CUSTER-JWL CAVE- 1
CUSTER-PRINGLE- 1
DENVERST-EASTNRTH- 1
DUMONT-YELOWCRK- 1
HILLCITY-PACTOLA- 1
HILLSVW-POPE&TAL- 1
HILLSVW-SPFSHBEC- 1
KIRK-YELOWCRK- 1
KIRK-YELOWCRK- 2
LINGLETP-LYMANTP- 1
MERILLAT-ROBNS TP- 1
MERILLAT-SW_TAP2- 1
MCFT PR-HUGHES- 1
NSS1-WYODAK- 1
NSS1-NSS2- 1
NSS1-GILLETTE- 1
OSAGE-88 OIL- 1
OSAGE-OSAG CTY- 1
PLSNTVLY-44TH ST- 1
PLUMA-YELOWCRK- 1
PLUMA-SPRUCEGL- 1
POPE&TAL-SPFSHCIT- 1
LANGE-NLOOP TP- 1
LANGE-PEDMNT- 1

RICHMHIL-TROJAN- 1
5TH ST-ROBINSDL- 1
5TH ST-5THST TP- 1
SALT CRK-S.CRK TP- 1
SPFSHBEC-LOOKOUT- 1
LOOKOUT-SUNDHILL- 1
LOOKOUT-SUNDHILL- 2
LOOKOUT-MTNVIEW- 1
STURG_CI-WHTEWOOD- 1
SUNDHILL-AMCOLOID- 1
SUNDHILL-STURGBEC- 1
TROJAN-YELOWCRK- 1
WESTBLVD-LANGE TP- 1
WHTEWOOD-STURGBEC- 1
WNDYFLAT-PLUMA TP- 1
WYODAK-NSS2- 1
YELOWCRK-PLUMA TP- 1
HUGHES-ADON PR- 1
BBILL1-2-SHOSHONE- 1
DUTONBAS-ERVAYBAS- 1
GARCANPP-RALSTON- 1
CORLETT-WARRENLM- 1
JACKLOPE-WARMSPGS- 1
MEDBOWHS-MEDBOWTP- 1
WARMSPGS-WAGNHNDS- 1
BBILL3-4-SPIRTMTN- 1
CENTRYRD-MALL- 1
BUFBASIN-CMTDUM- 1
HDOME-CMTDUM- 1
MALL-NLOOP TP- 1
5THST TP-SWEST TP- 1
SWEST TP-RCSOUTH2- 1
RADIO_DR-44TH ST- 1
RADIO_DR-SW_TAP1- 1
AMCOLOID-COLONY- 1
BELLECRK-BUTTEPMP- 1
COLONY-BUTTEPMP- 1
NEWCASTL-WY REFIN- 1
STURGIS-PEDMNT- 1
WY REFIN-S.CRK TP- 1
88 OIL-S.CRK TP- 1
OSAG CTY-BENTON- 1
BENTON-UPTON_C- 1
SW_TAP1-RCSOUTH2- 1
SW_TAP2-RCSOUTH2- 1
RCSOUTH1-RCDC W- 1
CARR DRAW-BARBCK- 1
BARBCK-HARTZOG- 1
HARTZOG-TEKLA- 1
HUGHES-DRYFORK- 1
DRYFORK-DRYFORK- 1
KIRK-MTNVIEW- 1
RICHMHIL-SPFSHCIT- 1
WNDYFLAT-PACTOLA- 1
HILLCITY-CUSTER- 1
STURG_CI-STURGIS- 1
WYODAK-HUGHES- 1
TEKLA-OSAGE- 1
OSAGE-LANGE- 1
YELOWCRK-LANGE- 1
BENFRCH-LANGE- 1
YELOWCRK-BENFRCH- 1
OSAGE-BENFRCH- 1

APPENDIX C

SIMULATED CONTINGENCIES

CARRDRAW-WYODAK- 1	BR.FAIL WHL 2361
CARRDRAW-BBCRK- 1	BR.FAIL WHL 2364
WYODAK-OSAGE- 1	BR.FAIL WHL 2353
WYODAK-RENO- 1	BR.FAIL WHL 2351
WYODAK-HUGHES- 1	BR.FAIL SRC 23317
WESTHILL-OSAGE- 1	BR.FAIL SRC 23313
WESTHILL-STEGALL- 1	BR.FAIL SRC 23309
WESTHILL-RCSOUTH1- 1	BR.FAIL SRC 23305
OSAGE-YELOWCRK- 1	BR.FAIL LNG 23103/2392
LANGE-LOOKOUT- 1	BR.FAIL LNG 2396/2399
LANGE-RCSOUTH1- 1	BR.FAIL LKO 2378
RENO-TEKLA- 1	BR.FAIL LKO 2375
HARTZOG-TEKLA- 1	BR.FAIL LKO 2381
LOOKOUT-YELOWCRK- 1	BR.FAIL LKO 2372
LOOKOUT-HUGHES- 1	BR.FAIL HGH 23HB2
HUGHES-DRYFORK-1	BR.FAIL HGH 23HB3
ARVADA-DRYFORK-1	BR.FAIL HGH 23HB1
TEKLA-OSAGE-1	BR.FAIL WYD 1H328
OSAGE-LANGE-1	BR.FAIL WYD 1H330
YELOWCRK-LANGE-1	BR.FAIL WYD 1H368
SUNDHILL-LOOKOUT-1	BR.FAIL WYD 1H326
YELOWCRK-BENFRCH-1	BR.FAIL WYD 1H334
OSAGE-BENFRCH-1	BR.FAIL WYD 1H370
BENFRCH-LANGE-1	BR.FAIL WYD 1H332
LANGE 230KV XFMR#1	BR.FAIL WYD 1H346
SOUTH_RC 230KV XFMR	BR.FAIL WYD 1H768
WESTHILL 230KV XFMR	BR.FAIL OSG 23215
YELLOWCREEK 230KV XFMR	BR.FAIL OSG 23203
LOOKOUT 230KV XFMR	BR.FAIL OSG 23207
BEN FRENCH 230KV XFMR	BR.FAIL OSG 23211
WYODAK UNIT	BR.FAIL YWC 2301
BEN FRENCH UNIT	BR.FAIL YWC 2310
WYD 230 BUS	BR.FAIL YWC 2307
SRC 230 BUS	
WHL 230 BUS	
LKO 230 BUS	
LNG 230 BUS	
OSG 230 BUS	
HGH 230 BUS	
YWC 230 BUS	

APPENDIX D

SUBSTATION ABBREVIATIONS

Sub Name	Code	Sub Name	Code	Sub Name	Code
38th Street	38S	Gilette	GIL	Robbinsdale	RBD
44th Street	44S	Hughes	HGH	Robbinsdale Tap	RBT
4th Street	4ST	Hill City	HLC	Rapid City CT #1	RC1
4th Street Tap	4TP	Hillsview	HLV	Rapid City CT #2	RC2
5th Street	5ST	Hartzog	HTZ	Rapid City CT #3	RC3
5th Street Tap	5TP	Kirk	KRK	Rapid City CT #4	RC4
88 Oil	88O	Lange CT	LCT	South RC	SRC
AM Colloid	AMC	Lange Tap	LGT	RC DC West	RDC
Angostura	ANG	Lookout	LKO	Richmond Hill	RHL
Anamosa	ANM	Lange	LNG	Reno	RNO
Antelope Mine	ANT	Mall	MAL	Salt Creek	SCK
Argyle	ARG	Merillat	MER	Salt Creek Tap	SCT
Ben French 26 kV	B26	Moorcroft	MFT	Sundance Hill	SDH
Ben French Diesel	BFD	Mountain View	MTV	Stegall	SGL
Ben French	BFR	Neil Simpson CT #1	NC1	Spearfish BEC	SPB
Ben French Steam	BFS	Neil Simpson CT #2	NC2	Spearfish City	SPF
Big Ben	BGB	Newcastle Tap	NCT	Spruce Gulch	SPG
Belle Creek	BLC	Neil Simpson #1 Gen	NG1	Salt Creek Tap #2	ST2
Barber Creek	BRB	Neil Simpson #2 Gen	NG2	Sturgis BEC	STB
Bentonites	BTN	North Loop Tap	NLT	Sturgis City	STC
Butte Pump	BTP	Neil Simpson #1	NS1	Sturgis	STG
Buffalo	BUF	Neil Simpson #2	NS2	Tekla	TEK
Carr Draw	CDW	Newcastle	NWC	Trojan	TRJ
Cement Plant	CEM	Osage #1 Gen	OG1	Upton City	UPT
Clinton	CLN	Osage #2 Gen	OG2	Upton Tap	UTP
Cambell	CMB	Osage #3 Gen	OG3	Windy Flats	WFL
Cemetary	CMT	Osage City	OSC	Wygen	WG1
Colony	COL	Osage	OSG	Westhill	WHL
Century Road	CRD	Pactola	PAC	Whitewood	WHT
Cross Street	CRS	Piedmont	PED	Water Plant	WPT
Custer	CUS	Pluma	PLM	Wyo Refinery	WRF
Dave Johnson	DJN	Pluma Tap	PLT	West Boulevard	WST
Dumont	DMT	Pleasant Valley	PLV	Wyodak	WYD
Denver Street	DNV	Pope & Talbot	PPT	Yellow Creek	YWC
Edgemont	EDG	Pringle	PRG	Yellowcake	YWK
East North Street	ENS	Radio Drive	RAD		