Report R20-10 DRAFT

MHEB Group TSR System Impact Study Transmission Options W.1 and W.2

Prepared for

Midwest ISO

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Revision History

Date	Description
3/3/2010	Issued as draft to study group
4/19/2010	General revisions to power flow and stability analysis based on study group comments; *Conclusions* and *Comparison of Options 1, W.1 and W.2* added to Executive Summary; *Additional Observations* added to Section 3.

Contents

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Executive Summary

A System Impact Study (SIS) for several requests for long term firm transmission service was posted on the Midwest ISO OASIS Studies Page in July of 2009[1]. The active requests are shown in Table E-1 and Table E-2. The South bound requests seek to reserve 1100 MW of transmission service from Manitoba Hydro to various sinks in the United States. The North bound requests seek to reserve 1100 MW of transmission service from various sources in the United State to Manitoba Hydro.

Table E-1: MH-US South bound Requests

Oasis Ref No	Service Type	Start Time	Stop Time	POR	POD	Requested Capacity	Queue Date	Study Number
76703536	Network	Nov-2014	Nov-2024	MHEB-MISO	GRE	200	12/7/2006	A388
76703671	Network	Jun-2017	Jun-2027	MHEB-MISO	WPS	500	6/12/2007	A380
76703672	Network	Jun-2017	Jun-2037	MHEB-MISO	MP	250	7/6/2007	A383
76703686	Network	Jun-2017	Jun-2027	MHEB-MISO	NSP	50	4/17/2008	A416
76703687	Network	Jun-2017	Jun-2027	MHEB-MISO	WEC	100	4/17/2008	A417
					Total (MW)	1100		

Table E-2: US-MH North bound Requests

Oasis Ref No	Service Type	Start time	Stop Time	POR	POD	Requested Capacity	Queue Date	Study Number
76537582	Network	Jun-2009	Jun-2027	WPS	MHEB	500	06/13/07	A380
76544699	Network	Jun-2009	Jun-2037	MP	MHEB	250	07/06/07	A383
76637089	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637091	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637257	P-to-P	Jun-2009	Jun-2027	WEC	MHEB	50	04/17/08	A414
76637259	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
76637260	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
					Total (MW)	1100		

[1] *MHEB Group TSR System Impact Study*; Siemens PTI Report R164-08, (July 17, 2009)

Two sets of network upgrades were developed and analyzed in the July SIS. One set of upgrades, Option 1, includes a 500 kV line from Dorsey to Bison to Helena. The other set of upgrades, Option 3, includes a 500 kV line from Dorsey to King.

A group of Transmission Owners has proposed a third option, the Comprehensive Option, which includes the following facilities.

- 500 kV line from Dorsey-Bison-Brookings Co-Split Rock
- Double circuit the Fargo-St. Cloud 345 kV CapX Group 1 project
- Double circuit the Brookings County-Hampton Corners 345 kV CapX Group 1 project
- Corridor project - Double circuit 345 kV MN Valley-Panther-Blue Lake

This report summarizes an analysis of two sets of facilities from the Comprehensive Plan.

- Option W.1: New Dorsey-Bison 500 kV line and double circuit the Fargo-St. Cloud 345 kV CapX Group 1 project
- Option W.2: New Dorsey-Bison-Brookings County 500 kV line

Proposed Transmission Options

Transmission upgrade options W.1 and W.2 are summarized in Table E-3 along with their cost estimates. The cost estimates are for the new transmission lines only and are based on $/mile costs taken from the JCSP 2008 Interim Stakeholder Meeting Introduction Presentation[2] and adjusted down from 2024 dollars to 2018 dollars using a 3% escalation factor. The costs for series compensation, transformers, line terminations and other required substation equipment are not included in this preliminary estimate. These costs will be further developed and refined in the Facilities study.

Table E-3: Proposed Transmission Options

Option No.	Project	Cost in 2018[1]
W.1	Dorsey – Bison 50% series compensated 500 kV line (230 miles) Double circuit the proposed CapX Group 1 345 kV line Bison – Alexandria Switching Station – Waite Park – Monticello Two 500/345 kV, 1200 MVA transformers at Bison (1500 MVA emergency)	$773.6 M
W.2	Dorsey – Bison 50% series compensated 500 kV line (230 miles) Bison – Brookings Co. 50% series compensated 500 kV line (180 miles) One 500/345 kV, 1200 MVA transformer at Bison Two 500/345 kV, 1200 MVA transformers at Brookings Co.	$987.2 M

Note 1: Cost estimates are for transmission lines only

[2] http://www.midwestmarket.org/publish/Document/81d7e_11b6e66e758_-795e0a48324a/Interim%20Presentation.pdf?action=download&_property=Attachment

Outage of the Dorsey-Bison 500 kV line associated with upgrade Option W.1 and Option W.2 is modeled with HVDC reduction in the south flow cases, along with existing 500 kV and 230 kV triggers to the Manitoba Hydro HVDC power order reduction scheme.

Power Flow Analysis

Benchmark power flow models representing 2017 Summer Peak and Winter Peak system conditions were created without the requested transmission service. TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options. The summer peak case was used to evaluate south bound TSRs and the winter peak case was used to evaluate north bound TSRs.

In the summer peak case, the total system losses within the study area increase by 248 MW with Option W.1, and increase by 263 MW with Option W.2; Option W.1 is 15 MW more efficient than Option W.2. In the winter peak case, losses increase by 26 MW with Option W.1 and decrease by 31 MW with Option W.2.

A nonlinear (ac) contingency analysis was performed and the combined impact of the transmission upgrades and the 1100 MW aggregate study TSRs were evaluated by comparing flows and voltages in the benchmark and study cases. Linear (dc) analysis was used to calculate distribution factors for each TSR and the distribution factors were used to identify the incremental impact of adding each TSR sequentially in queue date order.

South Flow Constraints

Facilities that are constraints to one or more south flow TSRs are summarized in Table E-4. Constraints to individual TSRs are described below the table.

Table E-4: South Flow Constraints

Monitored Element	Owner	Rating (MVA)	Mitigation Required	Option W.1	Option W.2
Saratoga-Petenwell 138 kV line	ATC	72.2	Reconductor 22.7 mi of the line	X	X
East Krok-Kewaunee 138 kV line	ATC	272.6	Replacing substation equipment at E. Krok	X	X

A388 (200 MW MHEB-MISO to GRE)

A388 is a request for 200 MW of network transmission service from MHEB-MISO to GRE. No constraints were identified for A388 for either of the transmission upgrade options.

A380 (500 MW MHEB-MISO to WPS)

A380 is a request for 500 MW of network transmission service from MHEB-MISO to WPS. A380 constraints are summarized in Table E-6.

Table E-6: A380 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option W.1	Option W.2
A380	Saratoga-Petenwell 138 kV line	72.2	134.7%	133.9%
	East Krok-Kewaunee 138 kV line	272.6	100.9%	101.1%

Note: Blank cell indicates facility is not significantly affected

A383 (250 MW MHEB-MISO to MP)

A383 is a request for 250 MW of network transmission service from MHEB-MISO to MP. No constraints were identified for A383 for either of the transmission upgrade options.

A416 (50 MW MHEB-MISO to NSP)

A416 is a request for 50 MW of network transmission service from MHEB-MISO to NSP. No constraints were identified for A416 for either of the transmission upgrade options.

A417 (100 MW MHEB-MISO to WEC)

A417 is a request for 100 MW of network transmission service from MHEB-MISO to WEC. A417 constraints are summarized in Table E-7.

Table E-7: A417 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option W.1	Option W.2
A417	Saratoga-Petenwell 138 kV line	72.2	140.6%	139.8%

Note: Blank cell indicates facility is not significantly affected

North Flow Constraints

With respect to north flow TSRs, no thermal constraints were identified for either of the transmission upgrade options.

Shunt Reactors

A steady-state analysis has been performed to size shunt reactors for the new 500 kV transmission facilities to limit voltage rise when one of the 500 kV lines is open ended. The shunt reactors listed in Table E-8 will be connected to the line terminals to limit voltage during open circuit conditions. These reactors were modeled in the off-peak stability case used for stability analysis.

Table E-8: Proposed Line Connected Shunt Reactors

Line	End	Option W.1	Option W.2
Dorsey-Bison	Dorsey	150 MVAR	150 MVAR
	Bison	150 MVAR	150 MVAR
Bison-Brookings Co	Bison		80 MVAR
	Brookings Co		80 MVAR

Stability Analysis

A transient stability analysis was performed for a summer off-peak, high transfer scenario. TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options. Interface loading was not reset in the study cases and the resulting interface flows are summarized in Table E-9. Power flow summaries and diagrams for each study case are in Appendix D.

Table E-9: Interface Loading

Interface	Benchmark	Study Option W.1	Study Option W.2
MHEX Dorsey-Bison Total	2178 MW - 2178 MW	2167 MW 1107 MW 3274 MW	2066 MW 1209 MW 3276 MW
MWEX Rochester-LaCrosse	1506 MW 247 MW	1653 MW 291 MW	1627 MW 286 MW

Flow on the Riel-Forbes 500 kV line is 28 MW higher in the Option W.1 study case than in the benchmark case. Flow on the Rosseau series capacitors in the study case is 1977 A, which is 99% of the 2000 A continuous rating, and will exceed the continuous rating of the series capacitors if the voltage at Rosseau is decreased by 0.01 per unit. This indicates that series compensation on the Dorsey-Bison line may need to be higher than 50%.

The disturbances listed in Table 3-6 were simulated in the stability analysis; it was assumed that outage of the new Dorsey-Bison 500 kV line associated with upgrade Option W.1 or Option W.3 triggers reduction of the power order on Manitoba Hydro's HVDC lines (HVDC reduction).

Option W.1

Significant results for Option W.1 are shown in Table E-10. All simulations are stable. Bus voltages and rotor damping do not violate transient-period criteria.

With Option W.1, the out-of-step relay at Forbes on the Riel-Forbes 500 kV line (M602F) violates the minimum transient-period relay margin during the simulation of a single-line-to-ground fault at the Dorsey 500 kV bus with delayed clearing (*he0* and *hl0*). The margin is 41% during the backup clearing time, which means that the violation is independent of the facility disconnected to clear the fault. Out-of-step relay settings will be adjusted when the new 500 kV line goes into service; mitigation will be required if the relay settings can not be adjusted to address this violation.

The Forbes SVS exceeds the 110 Mvar continuous rating after simulating simultaneous faults on each circuit of the Bison-Alexandria SS 345 kV tower line (*w13*). The proposed solution is 300 Mvar of additional dynamic (fast-switched capacitors) reactive support at Forbes.

Table E-10: Option W.1 Stability Results

ID	Description	M602F Relay Margin	Forbes SVS Output at 10 sec
he0	SLG fault at Dorsey 500 on Bison line with breaker failure; trip 500-230 kV xfmr; line outage triggers HVDC reduction	41%	
hl0	SLG fault at Dorsey 500 on Bison line with breaker failure, trip Dorsey-Riel; line outage triggers HVDC reduction	41%	
w13	Simultaneous faults at Bison 345 on both Alexandria SS circuits		312 Mvar

Note: Blank cell indicates that results do not violate criteria

Option W.2

Significant results for Option W.2 are shown in Table E-11. All simulations are stable. Bus voltages and rotor damping do not violate transient-period criteria.

The Forbes SVS exceeds the 110 Mvar continuous rating after simulating the outage of the Bison-Brookings Co 500 kV line (*w23* or *w63*). The proposed mitigation is HVDC reduction for loss of the Bison-Brookings Co 500 kV line.

The out-of-step relay at Forbes on the Riel-Forbes 500 kV line (M602F) does not violate the minimum transient-period relay margin during the simulation of a single-line-to-ground fault at the Dorsey 500 kV bus with delayed clearing (*he0* and *hl0*) with Option W.2; the 55% margin is above the 50% margin limit.

Table E-11: Option W.2 Results

ID	Description	M602F Relay Margin	Forbes SVS Output at 10 sec
he0	SLG fault at Dorsey 500 on Bison line with breaker failure; trip 500-230 kV xfmr; line outage triggers HVDC reduction	55%	
hl0	SLG fault at Dorsey 500 on Bison line with breaker failure, trip Dorsey-Riel; line outage triggers HVDC reduction	55%	
w23	3PH fault at Brookings Co 500 on Bison line		193 Mvar
w63	3PH fault at Bison 500 on Brookings Co line		190 Mvar

Note: Blank cell indicates that results do not violate criteria

Conclusions

System impact study results demonstrate a need for the system upgrades listed in Table E-12 and Table E-13.

Flow on the Rosseau series capacitors in the study case is 1977 A, which is 99% of the 2000 A continuous rating, and will exceed the continuous rating of the series capacitors if the voltage at Rosseau is decreased by 0.01 per unit. This indicates that series compensation on the Dorsey-Bison line may need to be higher than 50%.

Table E-12: Option W.1 System Upgrades

Item	Driver/Need	Cost Estimate ($1,000)
Facilities required to enable transmission service		
Transmission Facilities - Dorsey-Bison 500 kV line (230 miles); 50% series compensation - Double circuit the proposed CapX Group 1 345 kV line Bison-Alexandria Switching Station-Waite Park-Monticello (175 miles) - Two 500-345 kV, 1200 MVA transformers at Bison (1500 MVA emergency rating)	Enable new transmission service	$773,600
Constraint Mitigation		
- Reconductor 22.7 mi of the Saratoga - Petenwell 138 kV line	Enable new transmission service	$2,927
- Replace substation equipment at East Krok on East Krok - Kewaunee 138 kV line	Enable new transmission service	$1,000
- 300 Mvar capacitor at Forbes	Mitigate Forbes SVS overload	$16,000
Facilities identified through evaluation of open circuit conditions		
Shunt reactors connected to line terminals - 150 Mvar at Dorsey on Dorsey-Bison 500 kV line - 150 Mvar at Bison on Dorsey-Bison 500 kV line	Limit voltage rise on 500 kV line during open circuit conditions.	TBD

Table E-13: Option W.2 System Upgrades

Item	Driver/Need	Cost Estimate ($1,000)
Facilities required to enable transmission service		
Transmission Facilities - Dorsey-Bison 500 kV line (230 miles); 50% series compensation - Bison-Brookings Co 500 kV line (180 miles); 50% series compensation - One 500-345 kV, 1200 MVA transformer at Bison (1500 MVA emergency rating) - Two 500-345 kV, 1200 MVA transformers at Brookings Co (1500 MVA emergency rating)	Enable new transmission service	$987,200
Constraint Mitigation - Reconductor 22.7 mi of the Saratoga - Petenwell 138 kV line - Replace substation equipment at East Krok on East Krok - Kewaunee 138 kV line - HVDC reduction for loss of Bison-Brookins Co 500 kV line	 Enable new transmission service Enable new transmission service Mitigate Forbes SVS overload	 $2,927 $1,000 $1,000
Facilities identified through evaluation of open circuit conditions		
Shunt reactors connected to line terminals - 150 Mvar at Dorsey on Dorsey-Bison 500 kV line - 150 Mvar at Bison on Dorsey-Bison 500 kV line - 80 Mvar at Bison on Bison-Brookings Co 500 kV line - 80 Mvar at Brookings Co on Bison-Brookings Co 500 kV line	Limit voltage rise on 500 kV line during open circuit conditions.	TBD

Further Study

The next step in the study process is for the transmission customers to decide whether to proceed to a Facility Study with Option W.1 or Option W.2. The Facility Study will specify in more detail the schedule and cost to design, procure and construct the system upgrades identified in this SIS report.

Consistent with the analyses performed for Option 1, the additional items listed below should be studied for the option(s) evaluated in the Facilities Study.

- Reactive power requirements for low transfer condition.
- Transfer capability for prior-outage of the existing MH-US 500 kV tie-line.
- Condenser reserves for high transfer condition and low transfer condition.

Comparison of Options 1, W.1 and W.2

SIS results for Options 1, W.1 and W.2 are compared in Tables E-14 through E-26.

Table E-14: Ratings Required to Mitigate Thermal Constraints

Monitored Element	Mitigation Required	Option 1	Option W.1	Option W.2
Saratoga-Petenwell 138 kV line	Reconductor 22.7 mi of the line	109 MVA [1]	107 MVA [1]	107 MVA [1]
East Krok-Kewaunee 138 kV line	Replacing substation equipment at E. Krok	290 MVA [1]	289 MVA [1]	290 MVA [1]
Stanton – Coal Creek 230 kV (FG: SONCCTCOCSON)	Replace terminal equipment at Stanton and Coal Creek	505 MVA		

Note 1: Required rating includes 5% TRM per ATC Planning Criteria

Table E-15: Stability Constraints

Monitored Element	Mitigation Required	Option 1	Option W.1	Option W.2
Riel-Forbes OOS relay margin	None, assuming relay settings can be adjusted to address violation	69% [1]	41%	55% [1]
Forbes SVS steady state output	Mitigate Option 1 and W.2 using HVDC reduction for outage of south 500 kV line. Mitigate Option W.1 using 300 Mvar of additional dynamic reactive support at Forbes	290 Mvar	312 Mvar	193 Mvar

Note 1: Margins for Options 1 and W.2 are not constraints and are shown for comparison

Table E-16: Comparison of Options 1, W.1 and W.2

	Option 1	Option W.1	Option W.2
Estimated Cost ($1,000)			
New Transmission	$1,242,400	$773,600	$987,200
Constraint Mitigation	$5,427	$19,927	$4,927
Facilities identified through evaluation of open circuit conditions	TBD	TBD	TBD
Facilities identified through evaluation of operating scenarios	TBD	TBD	TBD
Total	**$1,247,827 + TBD**	**$793,527 + TBD**	**$992,127 + TBD**
Flows on MH-US Tie Lines in SUOP Stability Case			
Flow on Dorsey-Bison 500 kV	1320 MW	1108 MW	1212 MW
Flow on Riel-Forbes 500 kV	1631 MW	1806 MW	1739 MW
Balance D-B / R-F	45% / 55%	38% / 62%	41% / 59%
Flow on 230 kV ties	325 MW	362 MW	327 MW
Incremental Losses (combined impact of transmission option and 1100 MW transfer)			
Summer Peak	254 MW	248 MW	263 MW
Winter Peak	3 MW	26 MW	-31 MW

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Section
1

Transmission Upgrade Options

The W.1 and W.2 transmission upgrade options are summarized in Table 1-1. System diagrams for the benchmark and study cases are included in Appendix A, along with impedance data for each option. Substation diagrams document assumption made when stability disturbances were defined and do not necessarily reflect actual or proposed substation layouts.

Table 1-2 shows the balance of flow on the new and existing 500 kV lines with 50% compensation. Flow on the Riel-Forbes 500 kV line is 28 MW higher in the Option W.1 study case than in the benchmark case. Flow on the Rosseau series capacitors in the study case is 1977 A, which is 99% of the 2000 A continuous rating, and will exceed the continuous rating of the series capacitors if the voltage at Rosseau is decreased by 0.01 per unit. This indicates that series compensation on the Dorsey-Bison line may need to be higher than 50%.

Table 1-1: Transmission Upgrade Options

Option No.	Project
W.1	Dorsey-Bison 50% series compensated 500 kV line (230 miles) Double circuit the proposed CapX Group 1 345 kV line Bison-Alexandria Switching Station-Waite Park-Monticello Two 500/345 kV, 1200 MVA transformers at Bison
W.2	Dorsey-Bison 50% series compensated 500 kV line (230 miles) Bison-Brookings County 50% series compensated 500 kV line (180 miles) One 500/345 kV, 1200 MVA transformer at Bison Two 500/345 kV, 1200 MVA transformers at Brookings County

Table 1-2: Flow on New and Existing 500 kV Lines (50% Compensation)

Case	Option W.1			Option W.2		
	Dorsey-Bison	Riel-Forbes	Balance D-B/R-F	Dorsey-Bison	Riel-Forbes	Balance D-B/R-F
Summer Peak Thermal MHEX = 2950 MW (South)	1013 MW	1568 MW	39% / 61%	1015 MW	1576 MW	40% / 60%
Winter Peak Thermal MHEX = 1800 MW (North)	-703 MW	-777 MW	48% / 52%	-862 MW	-648 MW	57% / 43%
Off-Peak Stability MHEX = 3275 MW (South)	1107 MW	1805 MW	38% / 62%	1209 MW	1740 MW	41% / 59%

Section
2

Steady-State Analysis

2.1 Methodology

Benchmark power flow models representing 2017 Summer Peak and Winter Peak system conditions were created without the requested transmission service. TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options. A nonlinear (AC) contingency analysis was performed and the combined impacts of the transmission upgrade options and the 1100 MW aggregated study TSRs were evaluated by comparing flows and voltages in the benchmark and study cases.

Linear (DC) analysis was used to calculate distribution factors for each TSR and the distribution factors were used to identify the incremental impact of adding each TSR sequentially in queue date order.

2.2 Computer Programs

Analysis was performed using PSS®E version 30.3.3 and PSS®MUST version 8.3.2.

2.3 Model Development

2.3.1 Benchmark Cases

Summer peak and winter peak power flow cases were used to benchmark steady-state system performance; these benchmark cases do not include the study TSRs or associated transmission upgrades.

The benchmark power flow cases from the July SIS have been updated based on feedback provided by the study group. One significant update to both the summer peak and winter peak cases is the addition of the proposed Bison substation west of Fargo. The Bison substation is a CapX Group 1 project, and is the western terminal of the proposed Fargo-St Cloud 345 kV line. The Bison substation includes 345 kV and 230 kV buses and two new 345-230 kV transformers. The Bison substation will connect to Maple River at 345 kV and at 230 kV as shown in Figure 2-1.

In the winter peak case, flow on Boundary Dam-Tioga was reduced to 0 MW from 165 MW north bound since there is not 165 MW of confirmed firm service into Saskatchewan, and generation at Coal Creek (550 MW net) and Stanton (178 MW net) was dispatched at typical output levels.

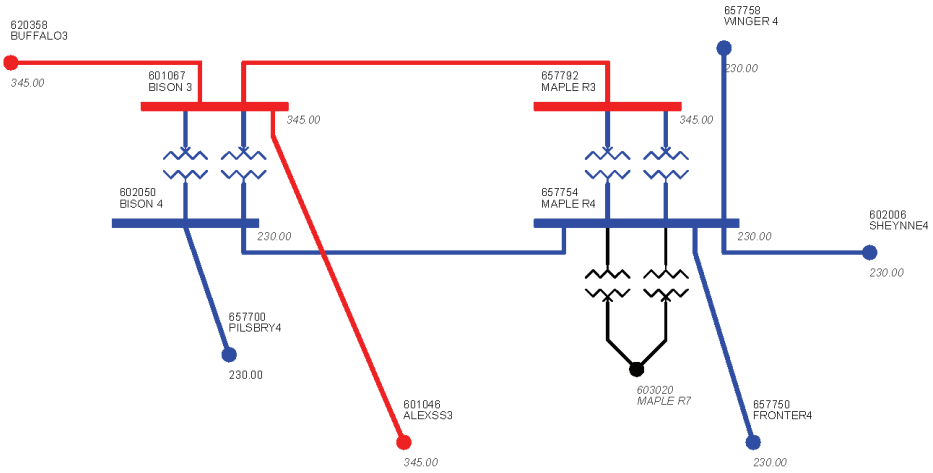


Figure 2-1: Bison Substation

As described in the July SIS report, the benchmark cases include transmission projects from MTEP 08 Appendices A and B, existing US to MH firm transmission service commitments, prior-queued transmission service requests (confirmed and study status) and MISO network resource generation. Projects in MTEP 08 Appendix B have not yet been studied through the MTEP cost-allocation process. If any of the projects in MTEP 08 Appendix B do not get developed, as per the identified need (in MTEP), the study TSRs would be reevaluated to determine if they are potentially responsible for the cost of those projects or appropriate alternatives.

Appendix A has diagrams for the summer peak and winter peak thermal cases. Flow on MHEX is 1845 MW (south) in the summer peak benchmark case, and 696 MW (north) in the winter peak benchmark case.

2.3.2 Study Cases

TSR study cases were created by taking the benchmark cases and modeling the requested transmission service along with one of the transmission upgrade options. South bound requests were studied using the summer peak case, and north bound requests were studied using the winter peak case.

2.3.2.1 Source and Sinks for South Bound TSRs

The source for south bound requests is the Dorsey inverter station, and the 1100 MW aggregate study TSRs were sourced by increasing the injection of the existing HVDC bipoles at Dorsey from 1740 MW in the benchmark case to 2848 MW in the study case. The study TSRs were sunk at the generators shown in Table 2-1.

Table 2-1: MH to US TSR Sinks

Bus #	Generator Name	MW
Masked		

2.3.2.2 Sources and Sink for North Bound TSRs

The sink for north bound requests is the Dorsey inverter station, and the 1100 MW aggregate study TSRs were sunk by decreasing the injection of the existing HVDC bipoles at Dorsey from 1950 MW in the benchmark case to 850 MW in the study case. The study TSRs were sourced at the generators shown in Table 2-2.

Table 2-2: US to MH TSR Sources.

Bus #	Generator Name	MW
	Masked	

2.3.2.3 Transmission Upgrade Options

The W.1 and W.2 transmission upgrade options are described in Section 1. For the steady state analyses no shunt reactors were included to compensate for the capacitive generation on the new 500 kV lines. Both options will require shunt reactors on the 500 kV line to control voltages when the line is open-ended and during light loading conditions.

2.4 Contingency Criteria

A variety of system conditions were considered for the steady-state analysis.

- NERC Category A with system intact (no contingencies)
- NERC Category B contingencies
  - Outage of single element 100 kV or higher (B.2 and B.3) associated with single contingency event in the following areas: ATCLLC (WEC, ALTE, WPS, MGE, UPPC), DPC, GRE, ITC Midwest, MH, MP, OTP, SMMPA, WAPA, XEL
  - Outage of multiple-elements 100 kV or higher (B.2 and B.3) associated with single contingency event in the Dakotas, Manitoba, Minnesota, Wisconsin

Existing 500 kV and 230 kV triggers to the Manitoba Hydro HVDC power order reduction scheme were simulated in the contingency analysis. Outage of the Dorsey-Bison 500 kV line associated with upgrade Option W.1 and Option W.2 is modeled with HVDC reduction in the South flow cases; no reduction was modeled for outage of Bison-Brookings County 500 kV line in Option W.2.

For all contingency and post-disturbance analyses, the power flow cases are solved with transformer tap adjustment and switched shunt adjustment enabled, area interchange adjustment and phase shifter adjustment disable, and dc tap adjustment enabled.

2.5 Monitored Facilities

Monitored facilities and associated thermal and voltage limits are shown in Table 2-3.

Table 2-3: Monitored Facilities and Limits

Owner/ Area	Monitored Facilities	Thermal Limits [1]		Voltage Limits	
		Pre-Disturbance	Post-Disturbance	Pre-Disturbance	Post-Disturbance
ATC LLC	69 kV and above	95% of Rate A	95% of Rate B	1.05/0.95	1.10/0.90
BEPC	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
DPC	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
GRE	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.92/0.90 [2]
ITCMW	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
MDU	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
MEC	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90

Owner/ Area	Monitored Facilities	Thermal Limits [1]		Voltage Limits	
		Pre-Disturbance	Post-Disturbance	Pre-Disturbance	Post-Disturbance
MH	69 kV and above	100% of Rate A	100% of Rate B	1.15/1.10/1.05/ 0.99/0.95 [3]	1.15/1.10/0.94/ 0.90 [3]
MP	69 kV and above	100% of Rate A	100% of Rate B	1.05/1.00	1.05/0.95
MPC	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
MRES	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
NWPS	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
OTP	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
RPU	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
SMMPA	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
SPC	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
WAPA	69 kV and above	100% of Rate A	100% of Rate A	1.05/0.95	1.10/0.90
XEL	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90

Note 1: PSS®E Rate A or Rate B
Note 2: 0.92 limit applies to load serving buses
Note 3: Limits dependent on nominal bus voltage

2.6 Reliability Margins

Flowgate ratings for out-year analysis are based on facility ratings and do not consider capacity benefit margin (CBM) or transmission reliability margin (TRM). All other system elements were monitored as shown in Table 2-3.

2.7 Performance Criteria

A branch or flowgate is considered a significantly affected facility if both of the following conditions are met for the transmission service under study:

1) the facility is loaded above its applicable normal or emergency rating in the study case, and
2) the power transfer distribution factor (PTDF) is greater than 5% or the outage transfer distribution factor (OTDF) is greater than 3% for the overloaded facility.

Distribution factors for each TSR are calculated using linear (dc) analysis.

A voltage impact is considered significant if both of the following conditions are met for the transmission service under study:

1) the bus voltage is outside of applicable normal or emergency limits in the study case, and
2) the impact of the requested service on bus voltage is greater than 0.01 per unit.

2.8 Network Analysis Results for South Bound TSRs

South bound TSRs were evaluated using the summer peak power flow cases.

2.8.1 Impact on System Losses for South Bound TSRs

The combined impact of the transmission upgrades and the aggregate TSRs (1100 MW) on system losses is shown in Appendix B, Table B-1. The change in system losses within the study area is tabulated for each upgrade option. The total system losses within the study area increase by 248 MW with Option W.1, and increase by 263 MW with Option W.2; Option W.1 is 15 MW more efficient than Option W.2.

2.8.2 Transmission Service Impacts for South Bound TSRs

Table B-2 in Appendix B shows the combined impact of the transmission upgrades and the aggregate south bound TSRs (1100 MW) on facilities impacted by one or more TSR. A thermal impact is considered significant if the facility loading exceeds the limit shown in Table 2-3 and the distribution factor exceeds the threshold given in Section 2.7. There are no significant voltage impacts attributable to any TSR.

2.8.2.1 A388 (200 MW MHEB-MISO to GRE) Impact

A388 is a request for 200 MW of network transmission service from MEHB-MISO to GRE. Request A388 has a significant thermal impact on the facilities shown in Table 2-4.

With upgrade option W.1, the Broadland 345/230 kV transformer and the Broadland-Huron 230 kV line are significantly affected facilities but are not constraints since loading does not exceed emergency ratings.

No significantly affected facilities were identified for transmission upgrade option W.2.

2.8.2.2 A380 (500 MW MHEB-MISO to WPS) Impact

A380 is a request for 500 MW of network transmission service from MHEB-MISO to WPS. Request A380 has a significant thermal impact on the facilities shown in Table 2-5.

With respect to A380, two significantly affected facilities are common to both transmission upgrade options: the Saratoga-Petenwell 138 kV line and the East Krok-Kewaunee 138 kV line. Both facilities are constraints with either option.

With upgrade option W.1, the Broadland 345/230 kV transformer and the Broadland-Huron 230 kV line are additional significantly affected facilities, but are not constraints since loading does not exceed emergency ratings.

2.8.2.3 A383 (250 MW MHEB-MISO to MP) Impact

A383 is a request for 250 MW of network transmission service from MHEB-MISO to MP. With respect to request A388, no significantly affected facilities were identified for transmission upgrade option W.1 or W.2.

2.8.2.4 A416 (50 MW MHEB-MISO to NSP) Impact

A416 is a request for 50 MW of network transmission service from MHEB-MISO to NSP. With respect to request A416, no significantly affected facilities were identified for transmission upgrade option W.1 or W.2.

2.8.2.5 A417 (100 MW MHEB-MISO to WEC) Impact

A417 is a request for 100 MW of network transmission service from MHEB-MISO to WEC. Request A417 has a significant thermal impact on the facilities shown in Table 2-8.

With respect to A417, one significantly affected facility is common to both transmission upgrade options: the Saratoga-Petenwell 138 kV line. This facility is a constraint with either option.

With upgrade option W.1, the Broadland 345/230 kV transformer and the Broadland-Huron 230 kV line are additional significantly affected facilities, but are not constraints since loading does not exceed emergency ratings.

Table 2-4: A388 Thermal Violations (200 MW MHEB-MISO to GRE)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
652514 HURON 4 230 659205 BRDLAND4 230 1	WAPA	N (E)	400 (480)	98.2% (81.8%)	100.2% (83.5%)	4.0%	FTTHOMP3 345 - LELANDO3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	99.9% (83.3%)	101.9% (84.9%)	4.0%	FTTHOMP3 345 - LELANDO3 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-5: A380 Thermal Violations (500 MW MHEB-MISO to WPS)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
652514 HURON 4 230 659205 BRDLAND4 230 1	WAPA	N (E)	400 (480)	100.2% (83.5%)	104.4% (87.0%)	3.4%	FTTHOMP3 345 - LELANDO3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	101.9% (84.9%)	106.1% (88.4%)	3.4%	FTTHOMP3 345 - LELANDO3 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	96.4%	134.7%	5.5%	ATC-ZN1-2 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	91.3%	128.4%	5.4%	ATC-ARP-OG2 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	88.6%	125.3%	5.3%	ATC-ARP-OG1 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	94.3%	116.4%	3.2%	ARP 345 345 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	92.7%	115.2%	3.3%	SGL 138 138 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	85.8%	108.5%	3.3%	NET 69 69.0 - BIG POND 69.0 1
699619 EAST KRK 138 699620 KEWAUNEE 138 1	ATC	E	272.6	87.6%	100.9%	7.3%	N APP 1 345 - KEWAUNEE 345 1

Table 2-5 (continued): A380 Thermal Violations (500 MW MHEB-MISO to WPS)

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	95.5%	133.9%	5.5%	ATC-ZN1-2 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	91.7%	128.8%	5.6%	ATC-ARP-OG2 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	87.9%	124.7%	5.3%	ATC-ARP-OG1 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	85.5%	108.5%	3.3%	ARP 345 345 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	85.5%	108.5%	3.3%	SGL 138 138 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	85.5%	108.5%	3.3%	NET 69 69.0 - BIG POND 69.0 1
699619 EAST KRK 138 699620 KEWAUNEE 138 1	ATC	E	272.6	87.7%	101.1%	7.3%	N APP 1 345 - KEWAUNEE 345 1

Table 2-6: A383 Thermal Violations (250 MW MHEB-MISO to MP)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-7: A416 Thermal Violations (50 MW MHEB-MISO to NSP)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-8: A417 Thermal Violations (100 MW MHEB-MISO to WEC)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
652514 HURON 4 230 659205 BRDLAND4 230 1	WAPA	N (E)	400 (480)	105.8% (88.2%)	106.7% (88.9%)	3.7%	FTTHOMP3 345 - LELANDO3 345 1
652514 HURON 4 230 659205 BRDLAND4 230 1	WAPA	N (E)	400 (480)	102.1% (85.1%)	102.9% (85.8%)	3.2%	LELANDO3 345 - GROTON 3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	107.4% (89.5%)	108.4% (90.3%)	3.7%	FTTHOMP3 345 - LELANDO3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	103.7% (86.4%)	104.5% (87.1%)	3.2%	LELANDO3 345 - GROTON 3 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	135.7%	140.6%	3.5%	ATC-ZN1-2 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	129.4%	134.1%	3.3%	ATC-ARP-OG2 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	126.3%	130.9%	3.3%	ATC-ARP-OG1 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1

Table 2-8 (continued): A417 Thermal Violations (100 MW MHEB-MISO to WEC)

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	134.9%	139.8%	3.5%	ATC-ZN1-2 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	129.9%	134.5%	3.4%	ATC-ARP-OG2 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	125.6%	130.2%	3.3%	ATC-ARP-OG1 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1

2.9 Network Analysis Results for North Bound TSRs

North bound TSRs were evaluated using the winter peak power flow cases.

2.9.1 Impact on System Losses for North Bound TSRs

The combined impact of the transmission upgrades and the aggregate TSRs (1100 MW) on system losses is shown in Appendix C, Table C-1. The change in system losses within the study area is tabulated for each upgrade option. The total system losses within the study area increase by 26 MW with Option W.1 and decrease by 31 MW with Option W.2.

2.9.2 Transmission Service Impacts for North Bound TSRs

Table C-2 in Appendix C shows the combined impact of the transmission upgrades and the aggregate north bound TSRs (1100 MW) on facilities impacted by one or more TSR. A thermal impact is considered significant if the facility loading exceeds the limit shown in Table 2-3 and the distribution factor exceeds the threshold given in Section 2.7. There are no significant voltage impacts attributable to any TSR.

2.9.2.1 A380 (500 MW from WPS to MHEB-MISO)

A380 is a request for 500 MW of network transmission service from WPS to MHEB-MISO. Request A380 has a significant thermal impact on the facilities shown in Table 2-9.

With upgrade Option 1, the Antelope Valley-Charlie Creek 345 kV line and Leland Olds 345/230 kV transformer #2 are significantly affected; the line and transformer are not constraints since loading does not exceed emergency ratings.

No significantly affected facilities were identified for transmission upgrade option W.2.

2.9.2.2 A383 (250 MW from MP to MHEB-MISO)

A383 is a request for 250 MW of network transmission service from MP to MHEB-MISO. Request A383 has a significant thermal impact on the facilities shown in Table 2-10.

With upgrade Option 1, the Leland Olds 345/230 kV transformer #2 is significantly affected but is not a constraint since loading does not exceed the emergency rating.

No significantly affected facilities were identified for transmission upgrade option W.2.

2.9.2.3 A415 (100+100 MW from GRE to MHEB-MISO)

A415 consists of two 100 MW requests for a total 200 MW of point-to-point transmission service from GRE to MHEB-MISO. Request A415 has a significant thermal impact on the facilities shown in Table 2-11 and Table 2-12.

With upgrade Option 1, the Antelope Valley-Charlie Creek 345 kV line and Leland Olds 345/230 kV transformer #2 are significantly affected; the line and transformer are not constraints since loading does not exceed emergency ratings.

No significantly affected facilities were identified for transmission upgrade option W.2.

2.9.2.4 A414 (50 MW from WEC to MHEB-MISO)

A414 is a request for 50 MW of point-to-point transmission service from WEC to MHEB-MISO. Request A414 has a significant thermal impact on the facilities shown in Table 2-13.

With upgrade Option 1, the Rugby 230-115 kV transformer, Antelope Valley-Charlie Creek 345 kV line, Leland Olds 345/230 kV transformer #1 and Leland Olds 345/230 kV transformer #2 are significantly affected; these facilities are not constraints since loading does not exceed emergency ratings.

No significantly affected facilities were identified for transmission upgrade option W.2.

2.9.2.5 A413 (50+50 MW from ALTE to MHEB-MISO)

A413 consists of two 50 MW requests for a total 100 MW of point-to-point transmission service from ALTE to MHEB-MISO. Request A413 has a significant thermal impact on the facilities shown in Table 2-14 and Table 2-15.

With upgrade Option 1, the Rugby 230-115 kV transformer, Antelope Valley-Charlie Creek 345 kV line, Leland Olds 345/230 kV transformer #1 and Leland Olds 345/230 kV transformer #2 are significantly affected; these facilities are not constraints since loading does not exceed emergency ratings.

No significantly affected facilities were identified for transmission upgrade option W.2.

Table 2-9: A380 Thermal Constraints (500 MW WPS to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	98.8% (89.8%)	102.2% (92.9%)	3.68%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	106.4% (76.0%)	111.7% (83.9%)	5.31%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	110.3% (78.8%)	117.5% (83.9%)	7.19%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-10: A383 Thermal Constraints (250 MW MP to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	117.5% (83.9%)	119.3% (85.2%)	3.44%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-11: A415 (1st of 2) Thermal Constraints (100 MW GRE to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	103.0% (93.6%)	103.7% (94.2%)	3.73%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	113.0% (80.7%)	114.0% (81.4%)	5.31%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	119.3% (85.2%)	120.7% (86.2%)	7.14%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-12: A415 (2nd of 2) Thermal Constraints (100 MW GRE to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620185 RUGBY Y 230 620379 RUGBY 4 230 1	WAPA	N (E)	125 (156)	100.0% (80.0%)	103.0% (83.4%)	3.79%	GRE-BALTA 4 230 - RUGBY 4 230 1
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	103.7% (94.2%)	104.4% (94.9%)	3.73%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	114.0% (81.4%)	115.1% (82.2%)	5.31%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	120.7% (86.2%)	122.1% (87.2%)	7.14%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-13: A414 Thermal Constraints (50 MW from WEC to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620185 RUGBY Y 230 620379 RUGBY 4 230 1	WAPA	N (E)	125 (156)	103.0% (83.4%)	104.6% (83.7%)	3.86%	GRE-BALTA 4 230 - RUGBY 4 230 1
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	104.4% (94.9%)	104.8% (95.2%)	3.96%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	121.3% (97.2%)	121.9% (97.7%)	3.02%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	115.1% (82.2%)	115.7% (82.6%)	5.73%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	122.1% (87.2%)	122.9% (87.8%)	7.77%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-14: A413 (1st of 2) Thermal Constraints (50 MW from ALTE to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620185 RUGBY Y 230 620379 RUGBY 4 230 1	WAPA	N (E)	125 (156.3)	104.6% (83.7%)	106.1% (84.9%)	3.89%	GRE-BALTA 4 230 - RUGBY 4 230 1
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	104.8% (95.2%)	105.2% (95.6%)	4.02%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	121.9% (97.7%)	122.6% (98.2%)	3.07%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	115.7% (82.6%)	116.2% (83.0%)	5.82%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	122.9% (87.8%)	123.7% (88.4%)	7.90%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Table 2-15: A413 (2nd of 2) Thermal Constraints (50 MW from ALTE to MHEB-MISO)

Option W.1

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620185 RUGBY Y 230 620379 RUGBY 4 230 1	WAPA	N (E)	125 (156)	106.1% (84.9%)	107.7% (86.1%)	3.89%	GRE-BALTA 4 230 - RUGBY 4 230 1
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	105.2% (95.6%)	105.5% (95.9%)	4.02%	LELND2T-XFMR-SPS LELANDO3 345 - LELND2TY 345 1 LELANDO3 345 - LELND1TY 345 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	122.6% (98.2%)	123.2% (98.7%)	3.07%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	99.5%% (0.8%)	100.3% (80.4%)	4.06%	B2_XEL_FORBES-ROSEAU500.0 FORBES 2 500 - ROSEAUS2 500 1 ROSEAUN2 500 - ROSEAUS2 500 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (300)	99.5% (82.9%)	100.3% (83.6%)	4.06%	R602F ROSEAUN2 500 - RIEL 2 500 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	116.2% (83.0%)	116.8% (83.4%)	5.82%	ANTELOP3 345 - CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	123.7% (88.4%)	124.5% (88.9%)	7.90%	LELANDO3 345 - LELND1TY 345 1

Option W.2

Monitored Branches	Owner	Rating N/E	Rating MVA	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
No significantly affected facilities							

Section
3

Transient Stability Analysis

Stability analyses have been performed to evaluate transient stability performance with the Manitoba Hydro TSRs and corresponding transmission upgrade options.

3.1 Stability Study Package

Stability analyses are performed using the UIP study package that was updated by the NMORWG in January 2009.

3.2 Model Development

The power flow cases utilized in the stability analyses are listed in Table 3-1.

Table 3-1: Power Flow Cases

Case Description	Case ID	CapX Projects	Study TSRs and Associated Transmission Upgrades
Benchmark Case	mbb-so15aa	Group 1 Projects	-
TSR Study Case with Option W.1	w1b-so15aa	Group 1 Projects	1100 MW with Upgrade Option W.1
TSR Study Case with Option W.2	w2b-so15aa	Group 1 Projects	1100 MW with Upgrade Option W.2

3.2.1 Benchmark Case

A summer off-peak power flow case was used to benchmark transient stability performance; the benchmark case does not include the study TSRs or associated transmission upgrades.

The benchmark power flow case from the July SIS has been updated based on feedback provided by the study group. The most significant change is the addition of the proposed Bison substation west of Fargo.

As described in the July SIS report, the benchmark case was developed from the 2015 summer off-peak case ("urg-so15aa.sav") in the UIP package, and includes transmission projects from MTEP 08 Appendices A and B, MISO network resource generation, MH bipole 3 and associated facilities at Riel.

The power flow summary for the benchmark case is in Appendix D.

3.2.2 Study Cases

TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options.

Power flow summaries and substation topology assumptions for each study case are in Appendix D. Power flow diagrams are in Appendix A.

The Arrowhead phase shifting transformer has been used to regulate flow in both study cases so that study results are consistent with those from the July SIS. The transformer angle is 8° in the W.1 study case and 6° in the W.2 study case.

3.2.2.1 Source and Sinks for TSRs

The TSR source is the Dorsey inverter station and the 1100 MW aggregate study TSRs were sourced by increasing the injection of the existing HVDC bipoles at Dorsey from 2114 MW in the benchmark case to 3214 MW in the study case. The study TSRs were sunk at the generators show in Table 3-2.

Table 3-2: MH to US TSR Sinks

Generator Bus	MW
Masked	

3.2.2.2 Transmission Upgrade Options

The W.1 and W.2 transmission upgrade options are described in Section 1.

Outage of the Dorsey-Bison 500 kV line associated with upgrade Option W.1 and Option W.2 is modeled with HVDC reduction; no reduction was modeled for outage of Bison-Brookings County 500 kV line in Option W.2.

Shunt reactors were modeled to limit voltage rise when an end of one of the 500 kV lines is open as described in Section 3.2.3.

3.2.3 Shunt Reactors

Shunt reactor sizes for the 500 kV transmission facilities in Option W.1 and W.2 were determined based on the following assumptions:

1) The series capacitor in the open line is completely bypassed.
2) All 500-345 kV transformers are in service.
3) Voltage at the sending end of line is 1.05 per unit.
4) Steady-state voltage at the open end of line should not exceed 1.10 per unit.

Table 3-3 shows the calculated reactor sizes; the proposed reactor sizes were adjusted based on the simulation results described below.

Table 3-3: Shunt Reactor Sizes

Line	End	Calculated	Proposed
Dorsey-Bison	Dorsey	135 MVAR	150 MVAR
	Bison	135 MVAR	150 MVAR
Bison-Brookings County	Bison	65 MVAR	80 MVAR
	Brookings County	65 MVAR	80 MVAR

The Option W.1 transmission facilities were modeled in the benchmark power flow cases (without the TSRs) using the reactor sizes from the column in Table 3-3 labeled "Proposed". Each end of the Dorsey-Bison line was opened and voltage at the open end was recorded in Table 3-4. These calculations assume that the series capacitor in the open line is completely bypassed.

Table 3-4: Option W.1 Voltages for Open Circuit Conditions

Line	Open End	Summer Peak Thermal MHEX = 1850 MW (South)		Winter Peak Thermal MHEX = 700 MW (North)		Off-Peak Stability MHEX = 2175 MW (South)	
		Dorsey 500 kV	Bison 500 kV	Dorsey 500 kV	Bison 500 kV	Dorsey 500 kV	Bison 500 kV
Dorsey - Bison	Dorsey	1.094 [1]	1.054	1.099 [1]	1.059	1.095 [1]	1.054
	Bison	1.046	1.086 [1]	1.047	1.088 [1]	1.044	1.084 [1]

Note 1: Voltage at open end of line, not at substation

The Option W.2 transmission facilities were modeled in the benchmark power flow cases (without the TSRs) using the reactors sizes from the column in Table 3-3 labeled "Proposed". Each end of the Dorsey-Bison line was opened and voltage at the open end was recorded in Table 3-5. These calculations assume that the series capacitor in the open line is completely bypassed.

Table 3-5: Option W.2 Voltages for Open Circuit Conditions

Line	Open End	Summer Peak Thermal MHEX = 1850 MW (South)			Winter Peak Thermal MHEX = 700 MW (North)			Off-Peak Stability MHEX = 2175 MW (South)		
		Dorsey 500 kV	Bison 500 kV	Brkngs Co 500 kV	Dorsey 500 kV	Bison 500 kV	Brkngs Co 500 kV	Dorsey 500 kV	Bison 500 kV	Brkngs Co 500 kV
Dorsey - Bison	Dorsey [2]	1.092 [1]	1.052	1.034	1.096 [1]	1.055	1.045	1.097 [1]	1.056	1.042
	Bison	1.047	1.088 [1]		1.047	1.088 [1]		1.044	1.084 [1]	
Bison-Brookings Co	Bison		1.068 [1]	1.032		1.086 [1]	1.050		1.083 [1]	1.047
	Brkngs Co [3]	1.042	1.053	1.090 [1]	1.046	1.061	1.098 [1]	1.045	1.054	1.091 [1]

Notes
1. Voltage at open end of line, not at substation
2. Values assume south line (Bison-Brookings Co) is in service
3. Values assume north line (Dorsey-Bison) is in service

3.3 Contingency Criteria

The disturbances listed in Table 3-6 were simulated in the stability analysis. Disturbances defined in the MAPP standard library were simulated using the switching sequence from the library. New switching sequence files were developed for disturbances not defined in the library; admittances used to simulate single-line-ground faults in new switching sequences were estimated assuming that the impedance in the positive, negative and zero sequences at the fault point are equal.

Table 3-6: Stability Disturbances

#	Benchmark: mbb	TSR Study Option W.1: w1b	TSR Study Option W.2: w2b	Description
1	ag1	ag1	ag1	4 cycle SLG fault at Leland Olds 345 kV on Leland Olds-Ft Thompson line; breaker 2692 fails; clear at 11 cycles by tripping faulted line
2	ag3	ag3	ag3	4 cycle 3PH fault at Leland Olds 345 kV, trip Leland Olds-Ft Thompson line
3	cts [1]	cts [1]	cts [1]	4 cycle SLG fault at Chisago 345 kV on TR10, breaker 9P20 fails, clear at 16 cycles by tripping Chisago-Forbes; cross-trip Forbes-Riel and trigger HVDC reduction
4	ei2	ei2	ei2	CU DC permanent bipole fault with tripping of both Coal Creek units

#	Benchmark: mbb	TSR Study Option W.1: w1b	TSR Study Option W.2: w2b	Description
5	em3	em3	em3	5 cycle 3PH fault at Letellier 230, clear by tripping Letellier-Drayton line; trigger HVDC reduction
6	eq1	eq1	eq1	SLG fault with breaker failure at Coal Creek on CU DC pole 1 with cross-trip of Coal Creek unit #2
7	fds	fds	fds	5 cycle 3PH fault at Square Butte 230 kV, clear by tripping Square Butte-Stanton line
8	mc3	mc3	mc3	5 cycle 3PH fault at Richer 230 kV, clear by tripping Richer-Roseau line; trigger HVDC reduction
9	md3	md3	md3	5 cycle 3PH fault at Glenboro 230 kV, clear by tripping Glenboro-Rugby line
10	mis	mis	mis	Bipole 2 block in the Manitoba Hydro System, Cross trip Manitoba Ontario Ties @ t=0.35s; trigger HVDC reduction
11	mjs	mjs	mjs	4 cycle SLG fault at Chisago 345 kV on Chisago-Kohlman Lake line, breaker fails at Chisago, clear by tripping Chisago 500-345 kV xfmr
12	mkd	mkd	mkd	4 cycle 3 phase fault at Chisago 345 kV, clear the Chisago-King line
13	mks	mks	mks	4.5 cycle SLG fault at Chisago 345 kV on Chisago-King line, King breaker fails, clear at 15 cycles by tripping Chisago 500-345 kV xfmr
14	nad [1]	nad [1]	nad [1]	4 cycle 3PH fault at Forbes 500 kV on M602F; trigger HVDC reduction
15	nmz [1]	nmz [1]	nmz [1]	4 cycle 3PH fault at Chisago 500 kV on F601C, xtrip M602F, 100% reduction, leave SVS on MP system
16	pas [1]	pas [1]	pas [1]	5 cycle SLG fault at Forbes 500 kV on M602F, Forbes breaker fails, Forbes breakers operate at 16 cycles, clear at 17 cycles; trigger HVDC reduction
17	pc0	pc0	pc0	4.5 cycle SLG fault at King 345 kV on King-Eau Claire line, King breaker fails, clear at 16 cycles by tripping King-Chisago
18	pcs	pcs	pcs	4.5 cycle SLG fault at King 345 kV on King-Eau Claire line, King breaker fails, clear at 16 cycles by tripping King-Chisago, cross trip Eau Claire-Arpin
19	pct	pct	pct	Trip of King-Eau Claire-Arpin without a fault
20	pzs [2]	pzs [2]	pzs [2]	4.5 cycle SLG fault Prairie Island 345 kV on Prairie Island-N Rochester, 8H9 fails, clear at 16 cycles by tripping Prairie Island xfmr #10
21	pzt [2]	pzt [2]	pzt [2]	Trip of Prairie Island-N Rochester without a fault
22	ya3	ya3	ya3	4 cycle 3 phase fault at Arrowhead 345 kV on Stone Lake line, trip the Arrowhead-Gardner park 345 kV line
23	yas	yas	yas	4 cycle SLG fault at Arrowhead 230 kV on Arrowhead-Stone Lake circuit, AHD brkr stk, clear at 17 cycles by tripping AHD-SLK bus section
24	yb3	yb3	yb3	4 cycle 3PH fault at Arrowhead 345 kV, trip the Arrowhead-Stone Lake line
25	h13	h13	h13	5 cycle 3PH fault at Dorsey, trip Dorsey-Riel 500 kV line #1

#	Benchmark: mbb	TSR Study Option W.1: w1b	TSR Study Option W.2: w2b	Description
26	h23	h23	h23	5 cycle 3PH fault at Dorsey, trip Dorsey 500/230 kV transformer #1; trigger HVDC reduction
27		h7d	h7d	5 cycle 3PH fault at Dorsey 500 kV, trip the Dorsey-Bison 500 kV line; trigger HVDC reduction
28		he0	he0	5 cycle SLG fault at Dorsey 500 kV on Dorsey-Bison line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey 500-230 kV xfmr, line outage triggers HVDC reduction; block SUVC
29		hl0	hl0	5 cycle SLG fault at Dorsey 500 kV on Dorsey-Bison line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey-Riel 500 kV line #2; line outage triggers HVDC reduction; block SUVC
30	h33	h33	h33	5 cycle 3PH fault at Riel, trip Riel-Forbes 500 kV line; trigger HVDC reduction
31	h43	h43	h43	5 cycle 3PH fault at Riel, trip Riel 500/230 kV transformer
32		h83	h83	5 cycle 3PH fault at Bison 500 kV, trip the Bison 500/345 kV transformer
33		hmd	hmd	5 cycle 3PH fault at Bison 500 kV, trip the Dorsey-Bison line; trigger HVDC reduction
34			w63	5 cycle 3PH fault at Bison 500 kV, trip the Bison-Brookings Co 500 kV line
35		ho0	ho0	5 cycle SLG fault at Bison 500 kV on 500-345 kV xfmr, 500 kV breaker fails, clear at 16 cycles by tripping Dorsey-Bison; line outage triggers HVDC reduction
36	h93	h93	h93	5 cycle 3PH fault at Bison 345 kV, trip Bison-Alexandria SS 345 kV line
37	hks	hks	hks	5 cycle SLG fault at Bison 345 on Alexandria SS line, Bison breaker fails, clear at 16 cycles by tripping Bison 345-230 kV xfmr
38	o2s	o2s	o2s	5 cycle SLG fault at Helena 345 kV on Lake Marion line, Helena breaker fails, clear at 16 cycles by tripping Helena-Franklin
39	o3s	o3s	o3s	5 cycle SLG fault at Bison 345 kV on Alexandria line, Bison breaker fails, clear at 16 cycles by tripping Bison-Jamestown
40	o4s	o4s	o4s	5 cycle SLG fault at Bison 345 kV on Maple River line, Bison breaker fails, clear at 16 cycles by tripping Bison 345-230 kV xfmr
41		w13		Simultaneous 5 cycle faults at Bison 345 kV on both circuits of the Alexandria SS line (assumes circuits are on same towers).
42			w23	5 cycle 3PH fault at Brookings Co 500 kV, trip the Brookings Co-Bison 500 kV line
43			w33	5 cycle 3PH fault at Brookings Co 500 kV, trip Brookings Co 500-345 kV xfmr
44			w43	5 cycle 3PH fault at Brookings Co 345 kV, trip Brookings Co-Lyon Co line
45			w53	5 cycle 3PH fault at Brookings Co 345 kV, trip Brookings Co-White line

#	Benchmark: mbb	TSR Study Option W.1: w1b	TSR Study Option W.2: w2b	Description
46			w2s	5 cycle SLG fault at Brookings Co 345 kV on Lyon Co line, Brookings Co breaker fails, clear at 16 cycles by tripping Brookings Co 500-230 kV transformer
47			w3s	5 cycle SLG fault at Brookings Co 345 kV on Lyon Co line, Brookings Co breaker fails, clear at 16 cycles by tripping Brookings Co-White line
48	mcs	mcs	mcs	4.5 cycle SLG fault at Sherburne Co. 345 kV on Coon Creek line with 8M40 stuck, clear at 12 cycles by tripping Bunker Lake and Bunker Lake TR1
49	mes	mes	mes	4 cycle SLG fault at Monticello 345 kV on Waite Park line with 8N8 stuck, clear at 14 cycles by tripping Elm Creek line
50	mfs	mfs	mfs	4 cycle SLG fault at Monticello 345 kV on Sherburne Co. line with 8N8 stuck; clear at 14 cycles by tripping Monticello Generator

Note 1: Switching sequence updated to account for Riel
Note 2: Switching sequence updated to account for N. Rochester

3.4 Performance Criteria

Simulation results were evaluated using the criteria in the MAPP Members Reliability Criteria and Study Procedures Manual. Transient voltages must be within the MAPP default limits of 0.70-1.20 per unit with the exception of a few specific buses, areas or companies that have different requirements. All machine rotor angle oscillations must be positively damped with a minimum damping factor of 5% for disturbances with a fault or 10% for line trips without a fault.

3.5 Results for Option W.1

Tables summarizing the performance of upgrade Option W.1 are in Appendix D.4; significant results are shown in Table 3-7. All simulations are stable. Bus voltages and rotor damping do not violate transient-period criteria.

The out-of-step relay at Forbes on the Riel-Forbes 500 kV line (M602F) violates the minimum transient-period relay margin during the simulation of a single-line-to-ground fault at the Dorsey 500 kV bus with delayed clearing (*he0* and *hl0*). The margin is 41% during backup clearing time as shown in Figure 3-1, which means that the violation is independent of the facility disconnected to clear the fault. Out-of-step relay settings will be adjusted when the new 500 kV line goes into service; mitigation will be required if the relay settings can not be adjusted to address this violation.

The Forbes SVS exceeds the 110 Mvar continuous rating after simulating simultaneous faults on each circuit of the Bison-Alexandria SS 345 kV tower line (*w13*). A potential solution is 300 Mvar of additional dynamic (fast-switched capacitors) reactive support at Forbes.

Table 3-7: Option W.1 Results

ID	Description	M602F Relay Margin	Forbes SVS Output at 10 sec
he0	SLG fault at Dorsey 500 on Bison line with breaker failure; trip 500-230 kV xfmr; line outage triggers HVDC reduction	41%	
hl0	SLG fault at Dorsey 500 on Bison line with breaker failure, trip Dorsey-Riel; line outage triggers HVDC reduction	41%	
w13	Simultaneous faults at Bison 345 on both Alexandria SS circuits		312 Mvar

Note: Blank cell indicates that results do not violate criteria

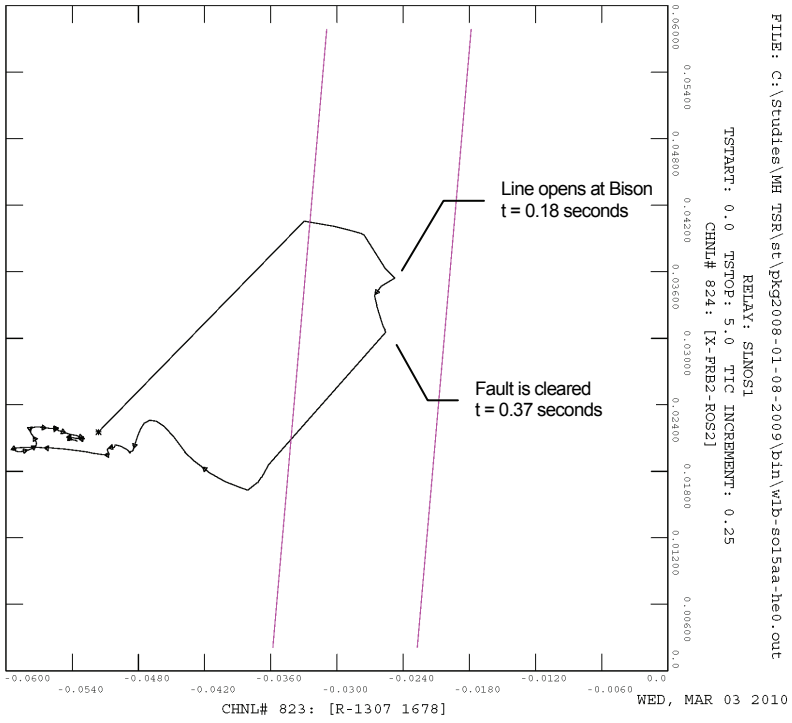


Figure 3-1: M602F Apparent Impedance at Forbes for SLG Fault at Dorsey with Delayed Clearing (*he0*)

3.6 Results for Option W.2

Tables summarizing the performance of upgrade Option W.2 are in Appendix D.4; significant results are shown in Table 3-8. All simulations are stable. Bus voltages and rotor damping do not violate transient-period criteria.

The Forbes SVS exceeds the 110 Mvar continuous rating after simulating the outage of the Bison-Brookings Co 500 kV line (*w23* or *w63*). Potential solutions include HVDC reduction for loss of the 500 kV line or 300 Mvar of additional dynamic (fast-switched capacitors) reactive support at Forbes.

The out-of-step relay at Forbes on the Riel-Forbes 500 kV line (M602F) does not violate the minimum transient-period relay margin during the simulation of a single-line-to-ground fault at the Dorsey 500 kV bus with delayed clearing (*he0* and *hl0*) with Option W.2; the 55% margin is above the 50% margin limit.

Table 3-8: Option W.2 Results

ID	Description	M602F Relay Margin	Forbes SVS Output at 10 sec
he0	SLG fault at Dorsey 500 on Bison line with breaker failure; trip 500-230 kV xfmr; line outage triggers HVDC reduction	55%	
hl0	SLG fault at Dorsey 500 on Bison line with breaker failure, trip Dorsey-Riel; line outage triggers HVDC reduction	55%	
w23	3PH fault at Brookings Co 500 on Bison line		193 Mvar
w63	3PH fault at Bison 500 on Brookings Co line		190 Mvar

Note: Blank cell indicates that results do not violate criteria

3.7 Additional Observations

In general, transient voltages in the Option W.1 and Option W.2 study cases are within 0.03 per unit of transient voltages for the same disturbance in the benchmark case. The difference in the number of fast switched capacitors used at Prairie, Running, Roseau or Sheyenne is typically less than two. Exceptions do not necessarily violate any criteria (all criteria violations are described in Sections 3.5 and 3.6), but might be beneficial in selecting one option over another; some of the exceptions are described below. It has been noted that the fast-switched capacitor summary produced by the UIP package (Table D-1) does not always show the correct number of capacitors; Table D-2 shows the correct number and facilitates comparison of the results or the benchmark and study cases.

Following a single line-to-ground fault at Chisago on TR10 with delayed clearing (*cts*) the benchmark case has a 1% relay margin on B10T, the Jamestown transient voltage is 0.71 per unit, and 7 capacitors are used at Prairie. Both Options W.1 and W.2 improve system performance of this fault. The B10T relay margin increases from 1% to more than 50%, the

transient voltage at Jamestown increases from 0.71 per unit to 0.80 per unit, and only 5 capacitors are used at Prairie.

Options W.1 and W.2 improve system performance for faults on the existing 500 kV line (*h33, nad, nmz, pas*). Fewer capacitors are used at Prarie, Sheyenne, and Running; and the B10T relay margin increases from 49% to more than 114% in *nmz*.

The TSRs decrease the Arrowhead transient voltage for disturbances that open King-Eau Claire-Arpin (*pc0, pct, pcs*); the Arrohead transient voltage for a single line-to-ground fault at King on the Eau Claire line with delayed clearing (*pcs*) is 0.92 per unit in the benchmark case, 0.86 per unit with Option W.1 and 0.88 per unit with Option W.2. These voltages do not violate transient voltage criteria.

Appendix

A

Transmission Upgrade Options

A.1 Model Data for Network Upgrade Options W.1 and W.2

A.1.1 Option W.1

```
DATA FOR BUS 601060 [BISON       500.00] RESIDING IN AREA  620

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601057 MIDCOMP-N   500.00  1   0.00113  0.01890  1.68300  1  F  1732.0 1905.0    0.0
 601062 MIDCOMP-S   500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0    0.0

 X------- TO BUS --------X        XFRMER    S W M C C      SPECIFIED
   BUS# X-- NAME --X BASKV CKT X-- NAME --X T 1 T Z M   R 1-2    X 1-2  SBAS1-2
601067 BISON 3     345.00  1  BISON500/345 1 F F 1 1  0.00005  0.00470  100.0
601067 BISON 3     345.00  2  BISON500/345 1 F F 1 1  0.00005  0.00470  100.0

 X------- TO BUS --------X     C
   BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  ANGLE  WINDV2  NOMV2  RATEA  RATEB  RATEC
601067 BISON 3     345.00  1  1 1.00000 0.0000    0.0 1.00000 0.0000 1200.0 1200.0    0.0
601067 BISON 3     345.00  2  1 1.00000 0.0000    0.0 1.00000 0.0000 1200.0 1200.0    0.0

 X------- TO BUS --------X     W C
   BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
601067 BISON 3     345.00  1  F 1  0 1.10000 0.90000 1.10000 0.90000   33
601067 BISON 3     345.00  2  F 1  0 1.10000 0.90000 1.10000 0.90000   33


 DATA FOR BUS 601061 [MIDCOMP-N   500.00] RESIDING IN AREA  620

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601062 MIDCOMP-S   500.00  1   0.00000 -0.02415  0.00000  1  F  1732.0 1905.0    0.0
 601062 MIDCOMP-S   500.00  2   0.00000  0.00010  0.00000  0  T     0.0    0.0    0.0
 667500 DORSEY 2    500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0    0.0


 DATA FOR BUS 601062 [MIDCOMP-S   500.00] RESIDING IN AREA  620

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601060 BISON       500.00  1   0.00145  0.02415  2.15000  1  F  1732.0 1905.0    0.0
 601061 MIDCOMP-N   500.00  1   0.00000 -0.02415  0.00000  1  T  1732.0 1905.0    0.0
 601061 MIDCOMP-N   500.00  2   0.00000  0.00010  0.00000  0  F     0.0    0.0    0.0
```

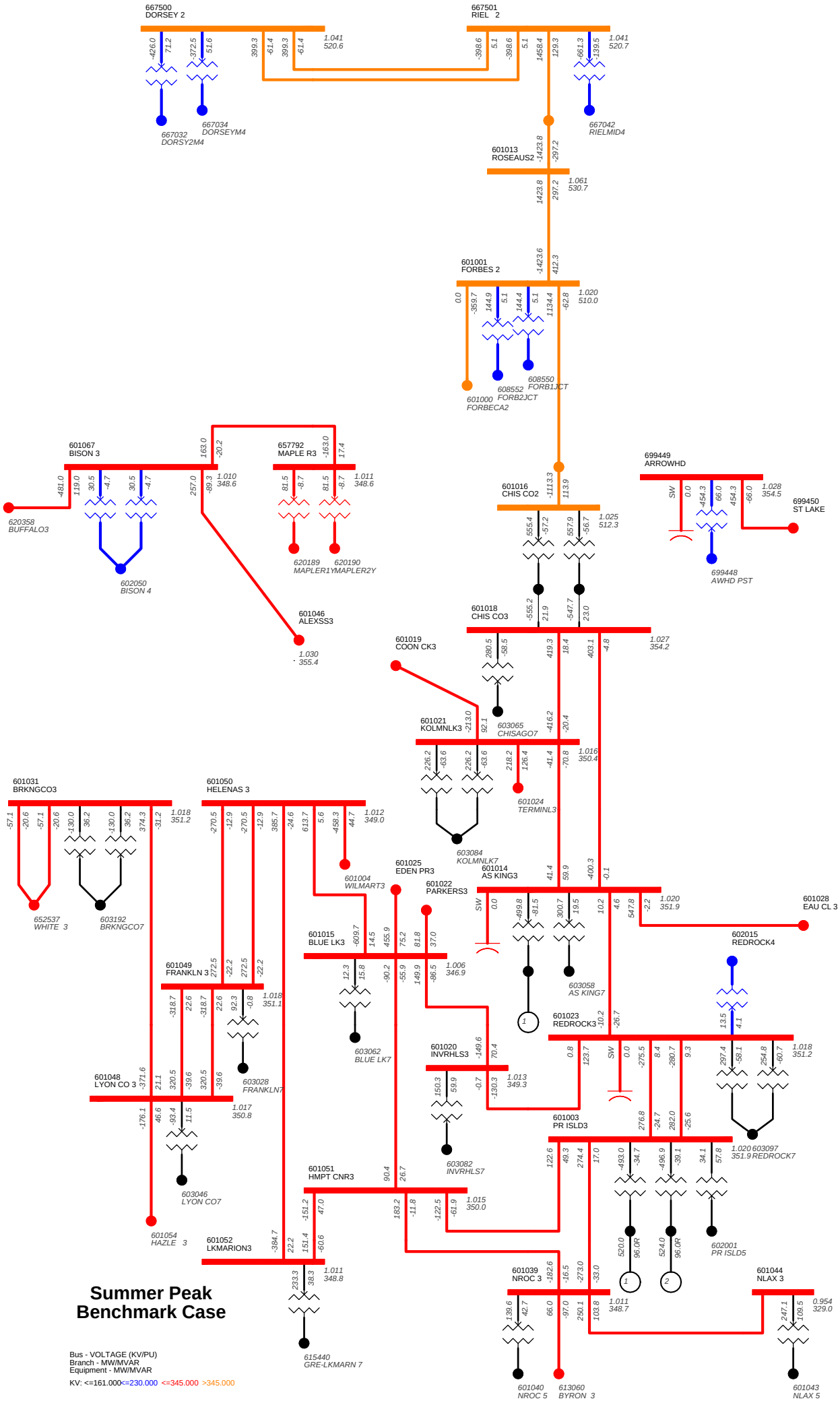
```
DATA FOR BUS 601010 [MNTCELO3    345.00] RESIDING IN AREA  600:

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601047 WAITEPK3    345.00  2   0.00128  0.01406  0.23994  1  T  2085.0 2293.0 2085.0


 DATA FOR BUS 601046 [ALEXSS3     345.00] RESIDING IN AREA  600:

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601047 WAITEPK3    345.00  2   0.00297  0.03251  0.55470  1  T  2085.0 2293.0 2085.0
 601067 BISON 3     345.00  2   0.00510  0.05584  0.95288  1  T  2085.0 2293.0 2085.0


 DATA FOR BUS 601047 [WAITEPK3    345.00] RESIDING IN AREA  600:

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601010 MNTCELO3    345.00  2   0.00128  0.01406  0.23994  1  F  2085.0 2293.0 2085.0
 601046 ALEXSS3     345.00  2   0.00297  0.03251  0.55470  1  F  2085.0 2293.0 2085.0


 DATA FOR BUS 601067 [BISON 3     345.00] RESIDING IN AREA  620:

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601046 ALEXSS3     345.00  2   0.00510  0.05584  0.95288  1  F  2085.0 2293.0 2085.0
```

A.1.2 Option W.2

```
DATA FOR BUS 601057 [MIDCOMP-N   500.00] RESIDING IN AREA  600

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601059 MIDCOMP-S   500.00  1   0.00000 -0.01890  0.00000  1  T  1732.0 1905.0    0.0
 601059 MIDCOMP-S   500.00  2   0.00000  0.00010  0.00000  0  F     0.0    0.0    0.0
 601060 BISON       500.00  1   0.00113  0.01890  1.68300  1  T  1732.0 1905.0    0.0


 DATA FOR BUS 601058 [BRKNGCO2    500.00] RESIDING IN AREA  600

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601059 MIDCOMP-S   500.00  1   0.00113  0.01890  1.68300  1  T  1732.0 1905.0    0.0

 X------- TO BUS --------X        XFRMER    S W M C C      SPECIFIED
   BUS# X-- NAME --X BASKV CKT X-- NAME --X T 1 T Z M   R 1-2    X 1-2  SBAS1-2
 601031 BRKNGCO3    345.00  1  BRKNGCO-TR1  1 F F 1 1  0.00005  0.00470  100.0
 601031 BRKNGCO3    345.00  2  BRKNGCO-TR2  1 F F 1 1  0.00005  0.00470  100.0

 X------- TO BUS --------X     C
   BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  ANGLE  WINDV2  NOMV2  RATEA  RATEB  RATEC
 601031 BRKNGCO3    345.00  1  1 1.00000 0.0000    0.0 1.00000 0.0000 1200.0 1200.0    0.0
 601031 BRKNGCO3    345.00  2  1 1.00000 0.0000    0.0 1.00000 0.0000 1200.0 1200.0    0.0

 X------- TO BUS --------X     W C
   BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
 601031 BRKNGCO3    345.00  1  F 1  0 1.10000 0.90000 1.10000 0.90000   33
 601031 BRKNGCO3    345.00  2  F 1  0 1.10000 0.90000 1.10000 0.90000   33


 DATA FOR BUS 601059 [MIDCOMP-S   500.00] RESIDING IN AREA  600

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601057 MIDCOMP-N   500.00  1   0.00000 -0.01890  0.00000  1  F  1732.0 1905.0    0.0
 601057 MIDCOMP-N   500.00  2   0.00000  0.00010  0.00000  0  T     0.0    0.0    0.0
 601058 BRKNGCO2    500.00  1   0.00113  0.01890  1.68300  1  F  1732.0 1905.0    0.0


 DATA FOR BUS 601060 [BISON       500.00] RESIDING IN AREA  620

 CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
  1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

 X------- TO BUS --------X
   BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
 601057 MIDCOMP-N   500.00  1   0.00113  0.01890  1.68300  1  F  1732.0 1905.0    0.0
 601062 MIDCOMP-S   500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0    0.0

 X------- TO BUS --------X        XFRMER    S W M C C      SPECIFIED
   BUS# X-- NAME --X BASKV CKT X-- NAME --X T 1 T Z M   R 1-2    X 1-2  SBAS1-2
 601067 BISON 3     345.00  1  BISON500/345 1 F F 1 1  0.00005  0.00470  100.0

 X------- TO BUS --------X     C
   BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  ANGLE  WINDV2  NOMV2  RATEA  RATEB  RATEC
 601067 BISON 3     345.00  1  1 1.00000 0.0000    0.0 1.00000 0.0000 1200.0 1200.0    0.0
```

```
X------- TO BUS --------X     W C
  BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
601067 BISON 3     345.00  1  F 1  0 1.10000 0.90000 1.10000 0.90000   33


DATA FOR BUS 601061 [MIDCOMP-N   500.00] RESIDING IN AREA  620

CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
 1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

X------- TO BUS --------X
  BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
601062 MIDCOMP-S   500.00  1   0.00000 -0.02415  0.00000  1  F  1732.0 1905.0    0.0
601062 MIDCOMP-S   500.00  2   0.00000  0.00010  0.00000  0  T     0.0    0.0    0.0
667500 DORSEY 2    500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0    0.0


DATA FOR BUS 601062 [MIDCOMP-S   500.00] RESIDING IN AREA  620

CODE PLOAD   QLOAD     I - L O A D     Y - L O A D G-SHUNT B-SHUNT
 1     0.0     0.0     0.0     0.0     0.0     0.0     0.0     0.0

X------- TO BUS --------X
  BUS# X-- NAME --X BASKV CKT   LINE R   LINE X CHARGING ST MET RATE-A RATE-B RATE-C
601060 BISON       500.00  1   0.00145  0.02415  2.15000  1  F  1732.0 1905.0    0.0
601061 MIDCOMP-N   500.00  1   0.00000 -0.02415  0.00000  1  T  1732.0 1905.0    0.0
601061 MIDCOMP-N   500.00  2   0.00000  0.00010  0.00000  0  F     0.0    0.0    0.0
```

A.2 Summer Peak Power Flow Diagrams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RIEL 2
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DORSY2M4
667034
DORSEYM4
667042
RIELMID4
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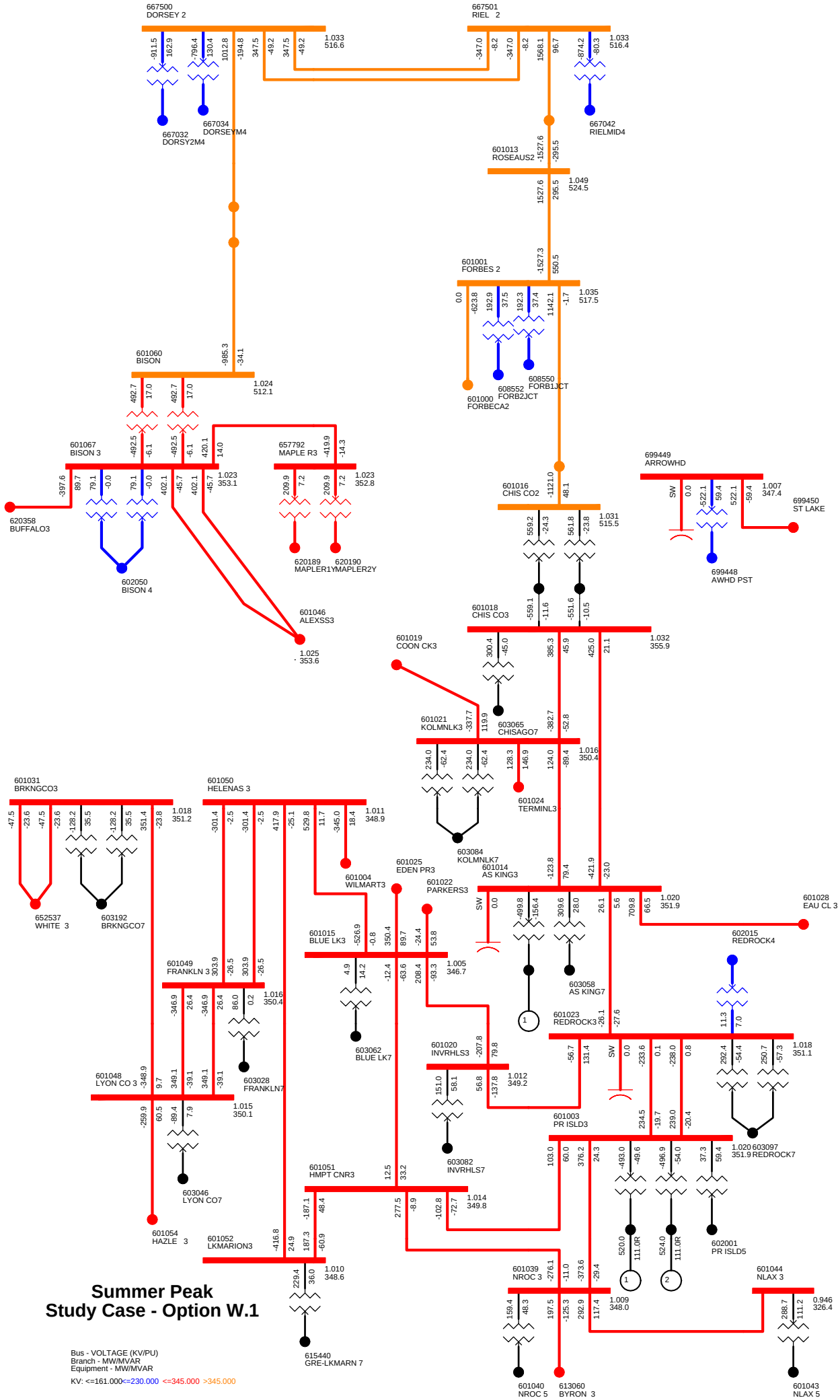
ROSEAUS2
601001
FORBES 2
601000
FORBECA2
608552
FORB2JCT
608550
FORB1JCT
601067
BISON 3
620358
BUFFALO3
602050
BISON 4
657792
MAPLE R3
620189
MAPLER1Y
620190
MAPLER2Y
601046
ALEXSS3
601016
CHIS CO2
699449
ARROWHD
699450
ST LAKE
699448
AWHD PST
601018
CHIS CO3
601019
COON CK3
603065
CHISAGO7
601021
KOLMNLK3
601024
TERMINL3
603084
KOLMNLK7
601031
BRKNGCO3
652537
WHITE 3
603192
BRKNGCO7
601050
HELENAS 3
601004
WILMART3
601025
EDEN PR3
601022
PARKERS3
601014
AS KING3
601028
EAU CL 3
602015
REDROCK4
603058
AS KING7
601015
BLUE LK3
603062
BLUE LK7
601049
FRANKLN 3
603028
FRANKLN7
601023
REDROCK3
601020
INVRHLS3
603082
INVRHLS7
601048
LYON CO 3
603046
LYON CO7
601054
HAZLE 3
601003
PR ISLD3
603097
REDROCK7
602001
PR ISLD5
601051
HMPT CNR3
601052
LKMARION3
615440
GRE-LKMARN 7
601039
NROC 3
601040
NROC 5
613060
BYRON 3
601044
NLAX 3
601043
NLAX 5
Summer Peak
Benchmark Case
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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601000
FORBECA2
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FORB2JCT
608550
FORB1JCT
601060
BISON
601067
BISON 3
620358
BUFFALO3
602050
BISON 4
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MAPLE R3
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MAPLER1Y
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MAPLER2Y
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ALEXSS3
601016
CHIS CO2
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ARROWHD
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ST LAKE
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AWHD PST
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COON CK3
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WHITE 3
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BRKNGCO7
601050
HELENAS 3
601004
WILMART3
601025
EDEN PR3
601014
AS KING3
601022
PARKERS3
603058
AS KING7
601028
EAU CL 3
602015
REDROCK4
601015
BLUE LK3
603062
BLUE LK7
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FRANKLN 3
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FRANKLN7
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LYON CO 3
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LYON CO7
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HAZLE 3
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INVRHLS3
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INVRHLS7
601023
REDROCK3
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PR ISLD3
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REDROCK7
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HMPT CNR3
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LKMARION3
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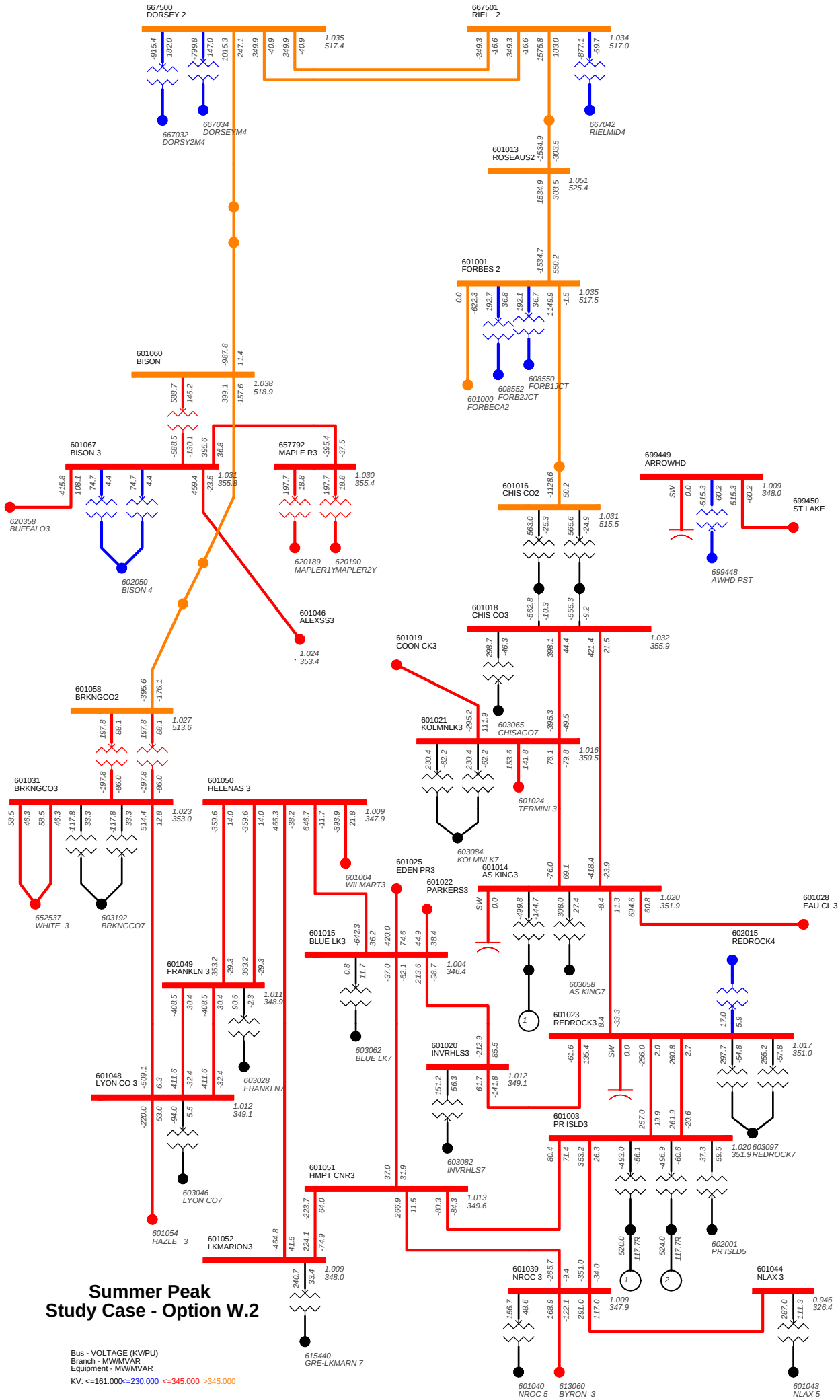
GRE-LKMARN 7
602001
PR ISLD5
601039
NROC 3
601040
NROC 5
613060
BYRON 3
601044
NLAX 3
601043
NLAX 5
Summer Peak
Study Case - Option W.1
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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601001
FORBES 2
601000
FORBECA2
608552
FORB2JCT
608550
FORB1JCT
601060
BISON
601067
BISON 3
620358
BUFFALO3
602050
BISON 4
657792
MAPLE R3
620189
MAPLER1Y
620190
MAPLER2Y
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ALEXSS3
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CHIS CO2
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ARROWHD
699450
ST LAKE
699448
AWHD PST
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CHIS CO3
601019
COON CK3
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CHISAGO7
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TERMINL3
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KOLMNLK7
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BRKNGCO3
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WHITE 3
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BRKNGCO7
601050
HELENAS 3
601004
WILMART3
601025
EDEN PR3
601022
PARKERS3
601014
AS KING3
603058
AS KING7
601028
EAU CL 3
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REDROCK4
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BLUE LK3
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BLUE LK7
601049
FRANKLN 3
603028
FRANKLN7
601048
LYON CO 3
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LYON CO7
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HAZLE 3
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INVRHLS3
603082
INVRHLS7
601023
REDROCK3
601003
PR ISLD3
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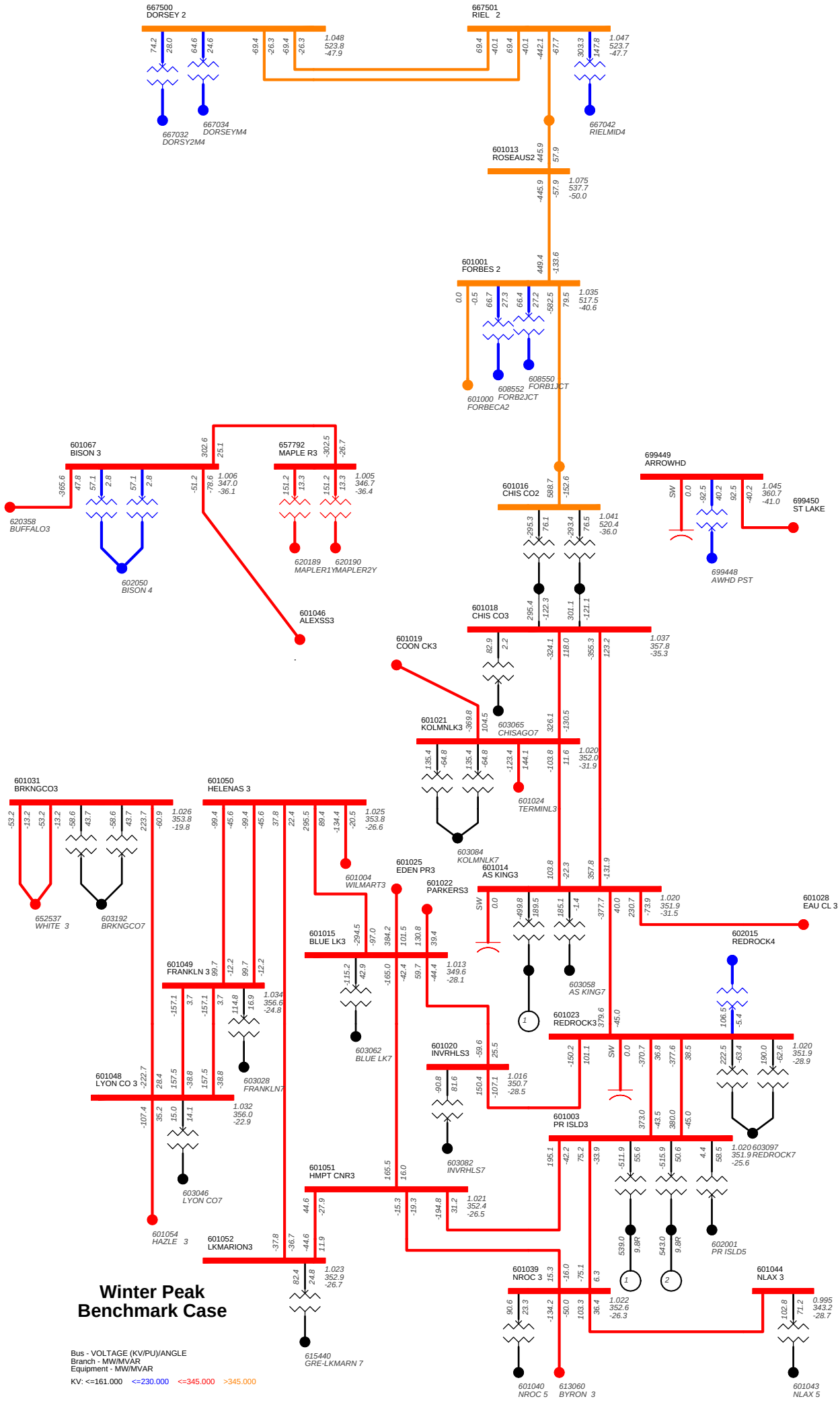
REDROCK7
602001
PR ISLD5
601051
HMPT CNR3
601052
LKMARION3
615440
GRE-LKMARN 7
601039
NROC 3
601040
NROC 5
613060
BYRON 3
601044
NLAX 3
601043
NLAX 5
Summer Peak
Study Case - Option W.2
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

A.3 Winter Peak Power Flow Diagrams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FORBES 2
601000
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608550
FORB1JCT
601067
BISON 3
620358
BUFFALO3
602050
BISON 4
601046
ALEXSS3
657792
MAPLE R3
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MAPLER1Y
620190
MAPLER2Y
601016
CHIS CO2
699449
ARROWHD
699450
ST LAKE
699448
AWHD PST
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CHIS CO3
601019
COON CK3
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CHISAGO7
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KOLMNLK3
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TERMINL3
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KOLMNLK7
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BRKNGCO3
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WHITE 3
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BRKNGCO7
601050
HELENAS 3
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WILMART3
601025
EDEN PR3
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AS KING3
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PARKERS3
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AS KING7
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EAU CL 3
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REDROCK4
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BLUE LK3
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BLUE LK7
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FRANKLN 3
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FRANKLN7
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LYON CO 3
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LYON CO7
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HAZLE 3
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INVRHLS7
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PR ISLD3
603097
REDROCK7
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PR ISLD5
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HMPT CNR3
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LKMARION3
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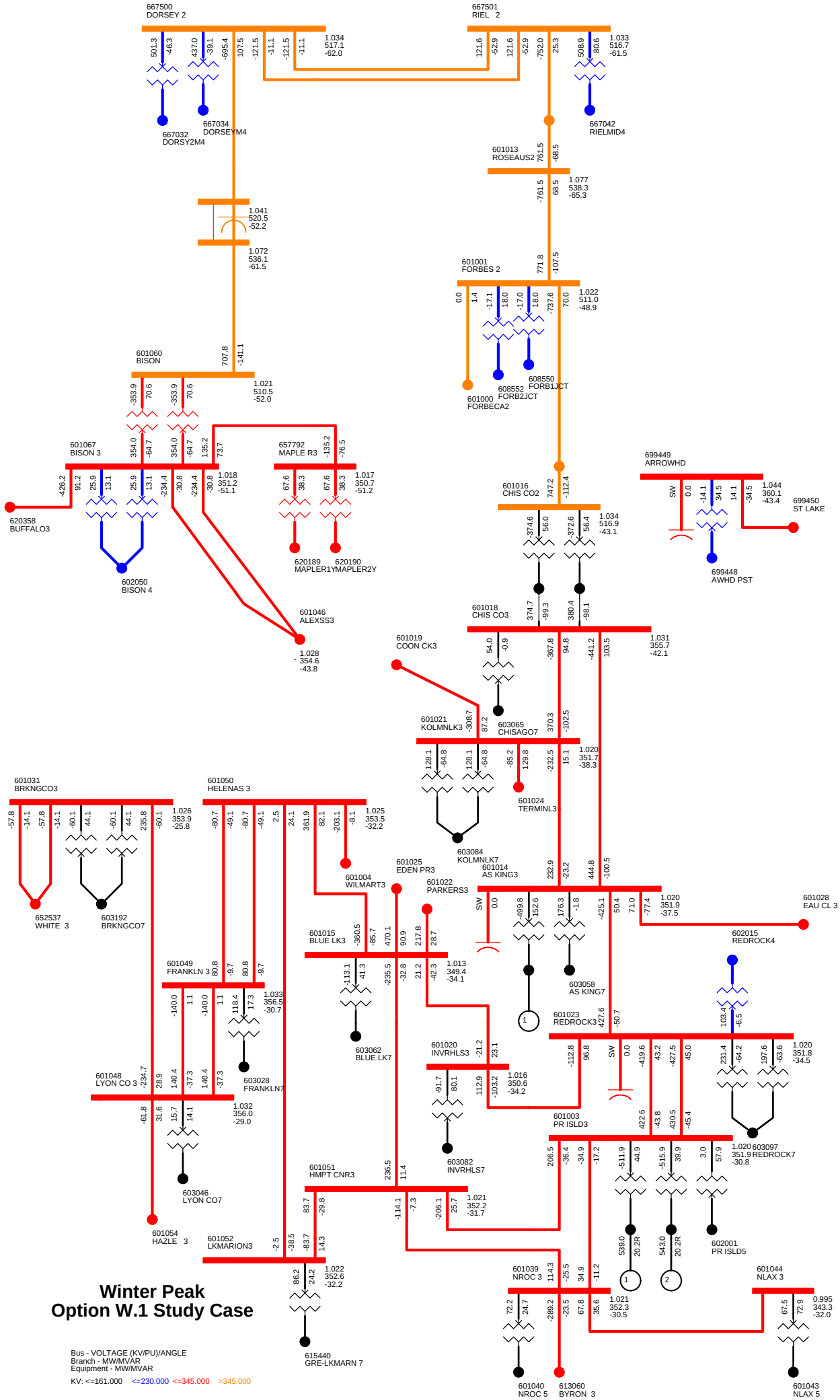
GRE-LKMARN 7
601039
NROC 3
601040
NROC 5
613060
BYRON 3
601044
NLAX 3
601043
NLAX 5
Winter Peak
Benchmark Case
Bus - VOLTAGE (KV/PU)/ANGLE
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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FORBECA2
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FORB2JCT
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FORB1JCT
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BISON
601067
BISON 3
620358
BUFFALO3
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BISON 4
657792
MAPLE R3
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MAPLER1Y
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MAPLER2Y
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ALEXSS3
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REDROCK4
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FRANKLN 3
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FRANKLN7
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LYON CO7
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HAZLE 3
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BLUE LK3
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REDROCK7
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HMPT CNR3
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NROC 5
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BYRON 3
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NLAX 3
601043
NLAX 5
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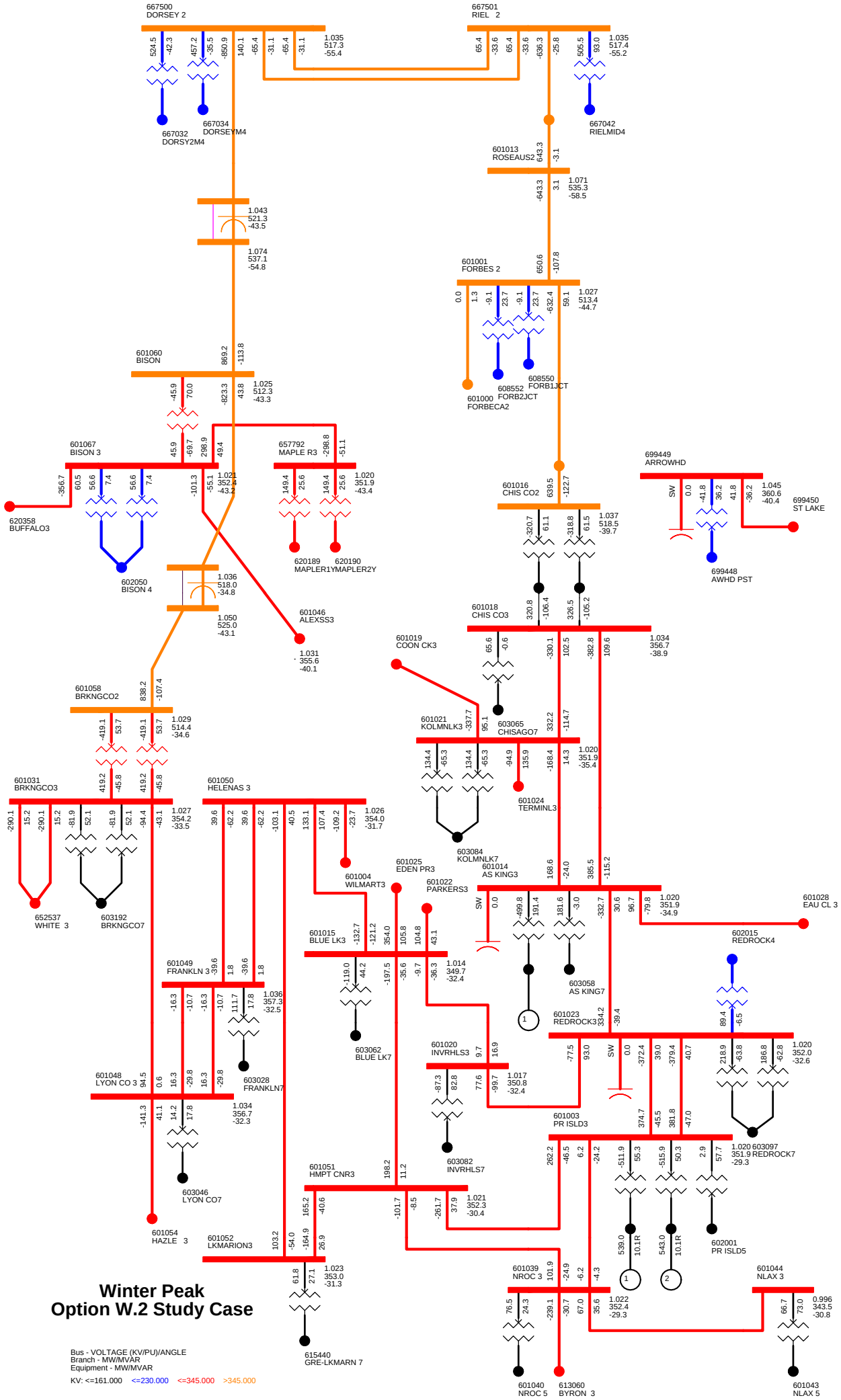
1.033 516.7 -61.5
1.041 520.5 -52.2
1.072 536.1 -61.5
1.077 538.3 -65.3
1.022 511.0 -48.9
1.021 510.5 -52.0
1.018 351.2 -51.1
1.017 350.7 -51.2
1.028 354.6 -43.8
1.034 516.9 -43.1
1.044 360.1 -43.4
1.031 355.7 -42.1
1.020 351.7 -38.3
1.026 353.9 -25.8
1.025 353.5 -32.2
1.033 356.5 -30.7
1.032 356.0 -29.0
1.013 349.4 -34.1
1.016 350.6 -34.2
1.020 351.9 -30.8
1.021 352.2 -31.7
1.022 352.6 -32.2
1.021 352.3 -30.5
0.995 343.3 -32.0
1.020 351.8 -34.5
1.020 351.9 -37.5
Winter Peak
Option W.1 Study Case
Bus - VOLTAGE (KV/PU)/ANGLE
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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601001
FORBES 2
601000
FORBECA2
608552
FORB2JCT
608550
FORB1JCT
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BISON
601067
BISON 3
620358
BUFFALO3
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BISON 4
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MAPLE R3
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620190
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CHIS CO2
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ARROWHD
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ST LAKE
699448
AWHD PST
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COON CK3
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BRKNGCO2
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BRKNGCO7
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HELENAS 3
601004
WILMART3
601025
EDEN PR3
601022
PARKERS3
601014
AS KING3
603058
AS KING7
601028
EAU CL 3
602015
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601023
REDROCK3
601015
BLUE LK3
603062
BLUE LK7
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FRANKLN 3
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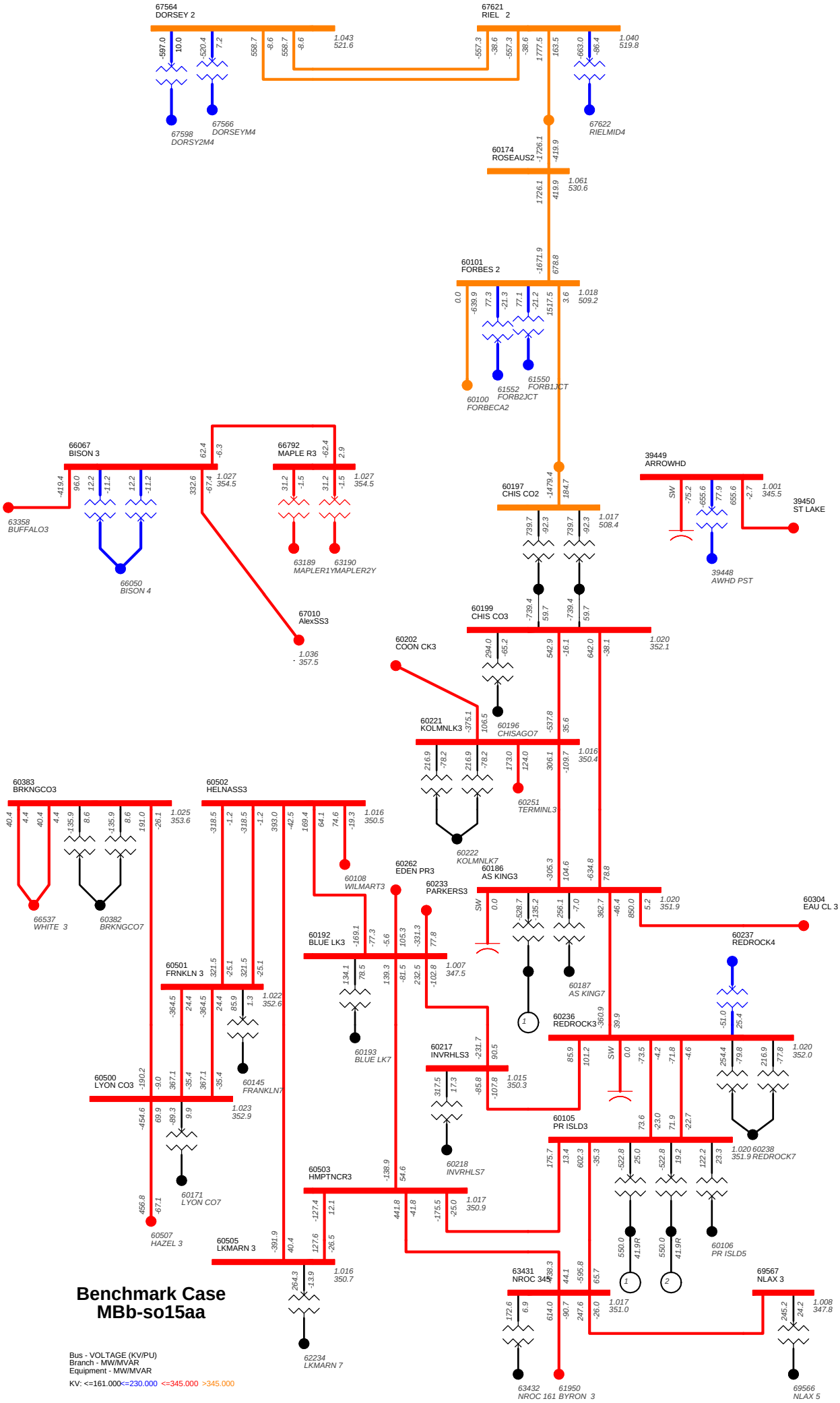
FRANKLN7
601048
LYON CO 3
603046
LYON CO7
601054
HAZLE 3
601020
INVRHLS3
603082
INVRHLS7
601003
PR ISLD3
603097
REDROCK7
602001
PR ISLD5
601051
HMPT CNR3
601052
LKMARION3
615440
GRE-LKMARN 7
601039
NROC 3
601040
NROC 5
613060
BYRON 3
601044
NLAX 3
601043
NLAX 5
Winter Peak
Option W.2 Study Case
Bus - VOLTAGE (KV/PU)/ANGLE
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

A.4 Off Peak Power Flow Diagrams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67622
RIELMID4
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ROSEAUS2
1.061
530.6
60101
FORBES 2
1.018
509.2
60100
FORBECA2
61552
FORB2JCT
61550
FORB1JCT
66067
BISON 3
66792
MAPLE R3
1.027
354.5
1.027
354.5
63358
BUFFALO3
66050
BISON 4
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MAPLER1Y
63190
MAPLER2Y
67010
AlexSS3
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357.5
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ARROWHD
1.001
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ST LAKE
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CHIS CO3
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352.1
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COON CK3
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CHISAGO7
60221
KOLMNLK3
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350.4
60251
TERMINL3
60222
KOLMNLK7
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BRKNGCO3
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353.6
66537
WHITE 3
60382
BRKNGCO7
60502
HELNASS3
1.016
350.5
60108
WILMART3
60262
EDEN PR3
60186
AS KING3
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PARKERS3
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60304
EAU CL 3
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AS KING7
60237
REDROCK4
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BLUE LK3
1.007
347.5
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BLUE LK7
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FRNKLN 3
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352.6
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FRANKLN7
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REDROCK3
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1.015
350.3
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INVRHLS7
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PR ISLD3
1.020
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REDROCK7
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LYON CO3
1.023
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LYON CO7
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HAZEL 3
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HMPTNCR3
1.017
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LKMARN 3
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62234
LKMARN 7
60106
PR ISLD5
63431
NROC 345
1.017
351.0
69567
NLAX 3
1.008
347.8
63432
NROC 161
61950
BYRON 3
69566
NLAX 5
Benchmark Case
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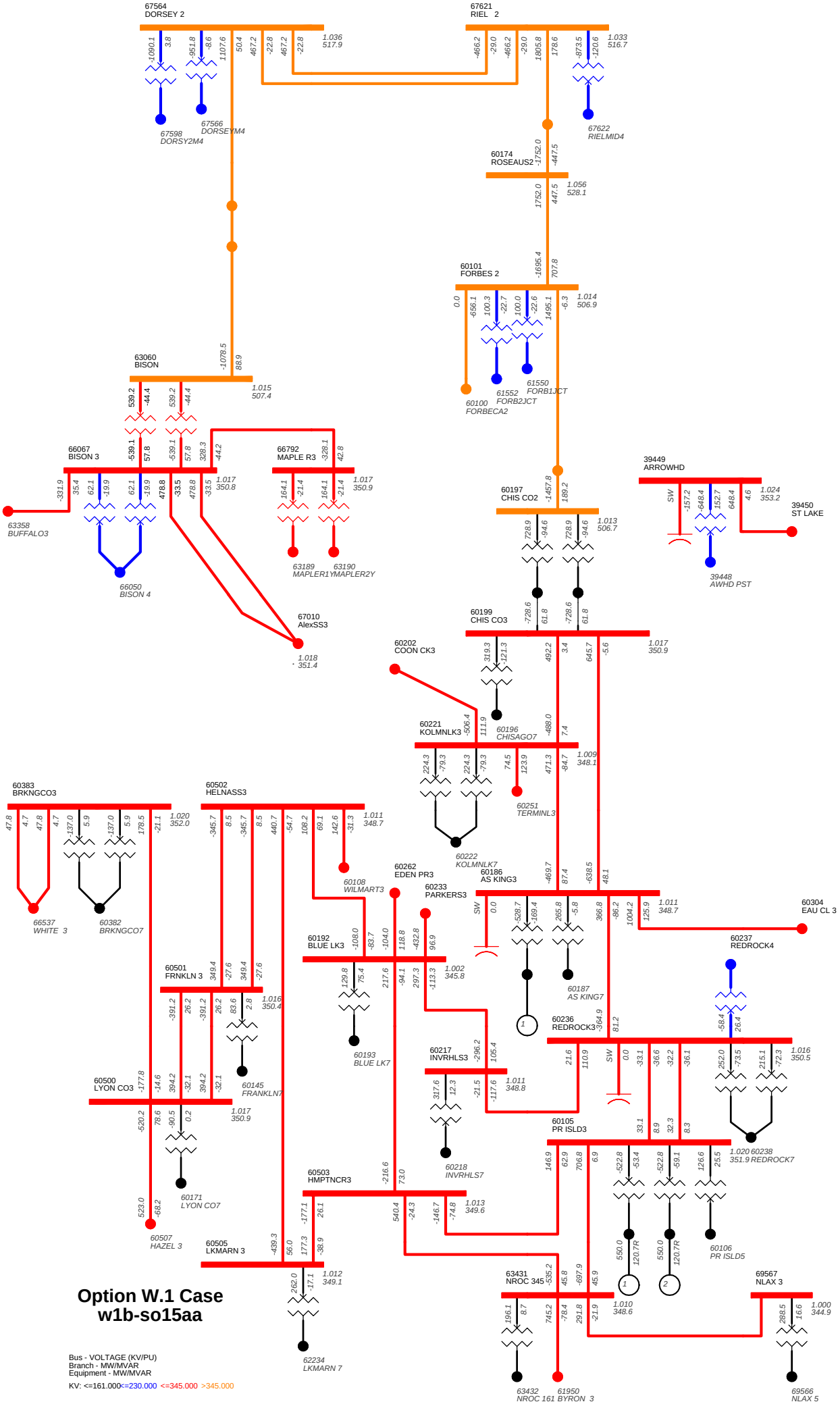
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000<=230.000 <=345.000 >345.000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FORBES 2
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FORB2JCT
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BISON
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BISON 3
66792
MAPLE R3
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BUFFALO3
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BISON 4
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MAPLER2Y
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AlexSS3
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CHIS CO2
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ARROWHD
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ST LAKE
39448
AWHD PST
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COON CK3
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BRKNGCO3
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WILMART3
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EDEN PR3
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LKMARN 3
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LKMARN 7
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NROC 345
63432
NROC 161
61950
BYRON 3
69567
NLAX 3
69566
NLAX 5
Option W.1 Case
w1b-so15aa
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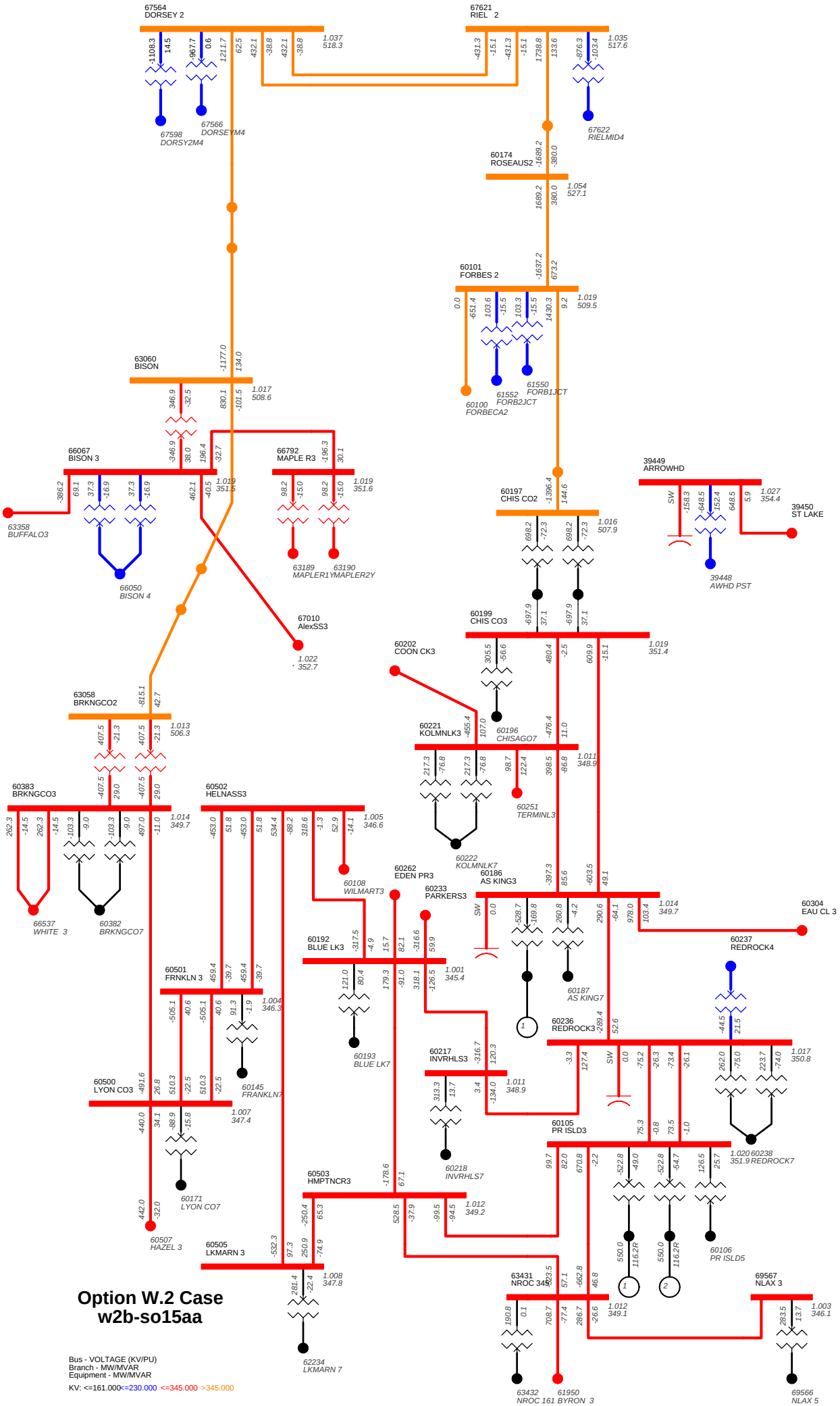
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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517.6
67598
DORSY2M4
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67622
RIELMID4
60174
ROSEAUS2
1.054
527.1
60101
FORBES 2
1.019
509.5
60100
FORBECA2
61552
FORB2JCT
61550
FORB1JCT
63060
BISON
1.017
508.6
66067
BISON 3
66792
MAPLE R3
1.019
351.5
1.019
351.6
63358
BUFFALO3
66050
BISON 4
63189
MAPLER1Y
63190
MAPLER2Y
60197
CHIS CO2
1.016
507.9
39449
ARROWHD
1.027
354.4
39450
ST LAKE
39448
AWHD PST
67010
AlexSS3
1.022
352.7
60199
CHIS CO3
1.019
351.4
60202
COON CK3
60196
CHISAGO7
63058
BRKNGCO2
1.013
506.3
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KOLMNLK3
1.011
348.9
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TERMINL3
60222
KOLMNLK7
60383
BRKNGCO3
1.014
349.7
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WHITE 3
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BRKNGCO7
60502
HELNASS3
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60108
WILMART3
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EDEN PR3
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AS KING3
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EAU CL 3
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PARKERS3
60187
AS KING7
60237
REDROCK4
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BLUE LK3
1.001
345.4
60193
BLUE LK7
60501
FRNKLN 3
1.004
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FRANKLN7
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INVRHLS7
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LYON CO7
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PR ISLD3
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60503
HMPTNCR3
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HAZEL 3
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LKMARN 3
1.008
347.8
60106
PR ISLD5
63431
NROC 345
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NLAX 3
1.003
346.1
62234
LKMARN 7
63432
NROC 161
61950
BYRON 3
69566
NLAX 5
Option W.2 Case
w2b-so15aa
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

Appendix

B

Summer Peak Network Analysis Results

Table B-1: Summer Peak Network Loss Analysis Results

Area	Benchmark Case Losses	W.1 Study Case		W.2 Study Case	
		Losses	Difference	Losses	Difference
295 WEC	158.7 MW 2663.3 Mvar	163.0 MW 2709.4 Mvar	4.3 MW 46.1 Mvar	162.9 MW 2707.2 Mvar	4.2 MW 43.9 Mvar
600 XEL	412.4 MW 4282.4 Mvar	464.5 MW 4816.3 Mvar	52.1 MW 533.9 Mvar	476.1 MW 4914.2 Mvar	63.7 MW 631.8 Mvar
608 MP	105.1 MW 1340.5 Mvar	109.9 MW 1392.8 Mvar	4.8 MW 52.3 Mvar	110.8 MW 1398.2 Mvar	5.7 MW 57.7 Mvar
613 SMMPA	1.6 MW 16.8 Mvar	2.0 MW 20.8 Mvar	0.4 MW 4.0 Mvar	2.0 MW 20.4 Mvar	0.4 MW 3.6 Mvar
615 GRE	95.0 MW 1839.2 Mvar	96.6 MW 1831.0 Mvar	1.6 MW -8.2 Mvar	97.2 MW 1830.5 Mvar	2.2 MW -8.7 Mvar
620 OTP	114.8 MW 1189.9 Mvar	115.6 MW 1168.9 Mvar	0.8 MW -21.0 Mvar	119.2 MW 1190.0 Mvar	4.4 MW 0.1 Mvar
627 ALTW	99.4 MW 1026.3 Mvar	101.3 MW 1029.8 Mvar	1.9 MW 3.5 Mvar	102.9 MW 1038.7 Mvar	3.5 MW 12.4 Mvar
635 MEC	115.1 MW 1319.1 Mvar	118.0 MW 1335.8 Mvar	2.9 MW 16.7 Mvar	119.7 MW 1347.9 Mvar	4.6 MW 28.8 Mvar
652 WAPA	223.9 MW 2552.0 Mvar	236.8 MW 2696.3 Mvar	12.9 MW 144.3 Mvar	239.5 MW 2704.3 Mvar	15.6 MW 152.3 Mvar
667 MH	335.8 MW 5214.4 Mvar	431.5 MW 7081.8 Mvar	95.7 MW 1867.4 Mvar	431.2 MW 7080.0 Mvar	95.4 MW 1865.6 Mvar
680 DPC	76.1 MW 443.2 Mvar	83.5 MW 488.4 Mvar	7.4 MW 45.2 Mvar	84.3 MW 490.7 Mvar	8.2 MW 47.5 Mvar
694 ALTE	118.3 MW 1123.2 Mvar	128.4 MW 1194.3 Mvar	10.1 MW 71.1 Mvar	128.5 MW 1195.9 Mvar	10.2 MW 72.7 Mvar
696 WPS	77.2 MW 808.3 Mvar	91.4 MW 911.6 Mvar	14.2 MW 103.3 Mvar	90.7 MW 901.5 Mvar	13.5 MW 93.2 Mvar
697 MGE	14.0 MW 215.5 Mvar	13.9 MW 214.6 Mvar	-0.1 MW -0.9 Mvar	13.9 MW 214.7 Mvar	-0.1 MW -0.8 Mvar
698 UPPC	8.0 MW 27.9 Mvar	7.9 MW 28.0 Mvar	-0.1 MW 0.1 Mvar	7.9 MW 28.0 Mvar	-0.1 MW 0.1 Mvar
Network Upgrade Facilities		39 MW 382.9 Mvar	39.0 MW 382.9 Mvar	31.2 MW 289.5 Mvar	31.2 MW 289.5 Mvar
Totals	1955.4 MW 24062.0 Mvar	2203.3 MW 27302.7 Mvar	247.9 MW 3240.7 Mvar	2218.0 MW 27351.7 Mvar	262.6 MW 3289.7 Mvar

Table B-2: Combined Impact of TSRs and Transmission Upgrade Options on SUPK Case
Thermal Violations, Significantly Affected Facilities

Monitored Element	Owner	Rating N/E	Rating MVA	Benchmark Loading (%)	W1 Study Case Loading (%)	W1 Study Case DF (%)	W2 Study Case Loading (%)	W2 Study Case DF (%)	Contingency
652514 HURON 4 230 659205 BRDLAND4 230 1	BEPC	N (E)	400 (480)	98.1% (81.8%)	106.7% (88.9%)	3.1%			FTTHOMP3 345 - LELANDO3 345 1
652514 HURON 4 230 659205 BRDLAND4 230 1	BEPC	N (E)	400 (480)	95.2% (79.3%)	102.9% (85.8%)	2.8%			LELANDO3 345 - GROTON 3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	99.5% (82.9%)	108.4% (90.3%)	3.2%			FTTHOMP3 345 - LELANDO3 345 1
659120 BRDLAND3 345 659204 BRDLNDTY 345 1	BEPC	N (E)	400 (480)	96.5% (80.4%)	104.5% (87.1%)	2.9%			LELANDO3 345 - GROTON 3 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	97.4%	140.6%	2.8%	139.8%	2.8%	ATC-ZN1-2 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	91.7%	134.1%	2.8%	134.5%	2.8%	ATC-ARP-OG2 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	88.9%	130.9%	2.8%	130.2%	2.7%	ATC-ARP-OG1 AS KING3 345 - EAU CL 3 345 1 EAU CL 3 345 - ARP 345 345 1 COC 69 69.0 - TIMBERWOLF 69.0 1 MAUSTON 69.0 - HLT 69 69.0 1 LUBLIN 69.0 - LAKEHEAD 69.0 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	93.4%	119.9%	1.7%	120.1%	1.8%	ARP 345 345 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	92.7%	118.8%	1.7%	118.8%	1.7%	SGL 138 138 - ARP 138 138 1
699240 SAR 138 138 699808 PETENWEL 138 1	ATC	E	72.2	84.9%	112.2%	1.8%	112.3%	1.8%	NET 69 69.0 - BIG POND 69.0 1
699619 EAST KRK 138 699620 KEWAUNEE 138 1	ATC	E	272.6	87.6%	100.6%	3.2%	100.8%	3.3%	N APP 1 345 - KEWAUNEE 345 1

Notes

1. Satatoga-Petenwell 138 kV line loading exceeds 72.2 MVA for several disturbances; worst 6 overloads are listed
2. Loading is compared against Normal (N) and/or Emergency (E) rating

Appendix

C

Winter Peak Network Analysis Results

Table C-1: Winter Peak Network Loss Analysis Results

Area	Benchmark Case Losses	W.1 Study Case		W.2 Study Case	
		Losses	Difference	Losses	Difference
295 WEC	139.3 MW 2276.5 Mvar	137.4 MW 2237.2 Mvar	-1.9 MW -39.3 Mvar	137.2 MW 2235.3 Mvar	-2.1 MW -41.2 Mvar
600 XEL	252.2 MW 2563.3 Mvar	268 MW 2710.3 Mvar	15.8 MW 147.0 Mvar	244.2 MW 2539.9 Mvar	-8.0 MW -23.4 Mvar
608 MP	95.6 MW 1327.2 Mvar	106.7 MW 1414.2 Mvar	11.1 MW 87.0 Mvar	103.9 MW 1397.8 Mvar	8.3 MW 70.6 Mvar
613 SMMPA	1.1 MW 11.1 Mvar	1.0 MW 9.7 Mvar	-0.1 MW -1.4 Mvar	1.0 MW 9.7 Mvar	-0.1 MW -1.4 Mvar
615 GRE	106 MW 1801.5 Mvar	106.3 MW 1812.3 Mvar	0.3 MW 10.8 Mvar	103.4 MW 1798.4 Mvar	-2.6 MW -3.1 Mvar
620 OTP	125.7 MW 1064.1 Mvar	145.7 MW 1206.7 Mvar	20.0 MW 142.6 Mvar	126.6 MW 1073.1 Mvar	0.9 MW 9.0 Mvar
627 ALTW	82.1 MW 911.7 Mvar	87.8 MW 947.6 Mvar	5.7 MW 35.9 Mvar	87.9 MW 945.9 Mvar	5.8 MW 34.2 Mvar
635 MEC	107.5 MW 1268.5 Mvar	109.9 MW 1290.7 Mvar	2.4 MW 22.2 Mvar	111 MW 1297 Mvar	3.5 MW 28.5 Mvar
652 WAPA	264.1 MW 2575.4 Mvar	280.3 MW 2680.8 Mvar	16.2 MW 105.4 Mvar	261.8 MW 2586 Mvar	-2.3 MW 10.6 Mvar
667 MH	208.8 MW 3641.3 Mvar	151.8 MW 2190.5 Mvar	-57.0 MW -1450.8 Mvar	153 MW 2203.1 Mvar	-55.8 MW -1438.2 Mvar
680 DPC	61.6 MW 335.8 Mvar	61.0 MW 330.6 Mvar	-0.6 MW -5.2 Mvar	58.6 MW 321.7 Mvar	-3.0 MW -14.1 Mvar
694 ALTE	103.9 MW 1016.8 Mvar	99.9 MW 986.2 Mvar	-4.0 MW -30.6 Mvar	99 MW 979.8 Mvar	-4.9 MW -37.0 Mvar
696 WPS	64.8 MW 610.5 Mvar	61.1 MW 633.8 Mvar	-3.7 MW 23.3 Mvar	60.4 MW 627.9 Mvar	-4.4 MW 17.4 Mvar
697 MGE	9.9 MW 143.1 Mvar	10.1 MW 144.4 Mvar	0.2 MW 1.3 Mvar	10.1 MW 144.6 Mvar	0.2 MW 1.5 Mvar
698 UPPC	9.1 MW 29.8 Mvar	9.1 MW 29.6 Mvar	0.0 MW -0.2 Mvar	9.1 MW 29.6 Mvar	0.0 MW -0.2 Mvar
Network Upgrade Facilities		21.6 MW 242.6 Mvar	21.6 MW 242.6 Mvar	34.0 MW 342.8 Mvar	34.0 MW 342.8 Mvar
Totals	1631.7 MW 19576.6 Mvar	1657.7 MW 18867.2 Mvar	26.0 MW -709.4 Mvar	1601.2 MW 18532.6 Mvar	-30.5 MW -1044.0 Mvar

Table C-2: Combined Impact of TSRs and Transmission Upgrade Options on WIPK Case
Thermal Violations, Significantly Affected Facilities

Monitored Element	Owner	Rating N/E	Rating MVA	Benchmark Loading (%)	W1 Study Case Loading (%)	W1 Study Case DF (%)	W2 Study Case Loading (%)	W2 Study Case DF (%)	Contingency
620185 RUGBY Y 230 620379 RUGBY 4 230 1	WAPA	N (E)	125 (156.3)	96.7% (77.6%)	107.7% (86.1%)	1.2%			GRE-BALTA 4 230 - RUGBY 4 230 1
659101 ANTELOP3 345 659183 CHAR.CK3 345 1	BEPC	N (E)	538 (592)	99.0% (90.0%)	105.5% (95.9%)	3.2%			LELND2T-XFMR-SPS LELAND03 345 - LELND2TY 345 1 LELAND03 345 - LELND1TY 345 1
659105 LELAND03 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	111.9% (89.7%)	123.2% (98.7%)	2.6%			ANTELOP3 345 - CHAR.CK3 345 1
659105 LELAND03 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	87.7% (70.3%)	100.3% (80.4%)	2.9%			B2_XEL_FORBES-ROSEAU500.0 FORBES 2 500 - ROSEAUS2 500 1 ROSEAUN2 500 - ROSEAUS2 500 1
659105 LELAND03 345 659201 LELND1TY 345 1	BEPC	N (E)	250 (312)	87.7% (70.3%)	100.3% (80.4%)	2.9%			R602F ROSEAUN2 500 - RIEL 2 500 1
659105 LELAND03 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	106.1% (75.8%)	116.8% (83.4%)	4.9%			ANTELOP3 345 - CHAR.CK3 345 1
659105 LELAND03 345 659202 LELND2TY 345 1	BEPC	N (E)	500 (700)	109.4% (78.1%)	124.5% (88.9%)	6.8%			LELAND03 345 - LELND1TY 345 1

Notes

1. Loading is compared against Normal (N) and/or Emergency (E) rating

Appendix

D

Transient Stability Results

D.1 Benchmark Case

P O W E R F L O W S U M M A R Y

NDEX:	2264 MW	ECL-ARP:	660 MW
MHEX:	2178 MW	NROC-BYN:	614 MW
MWEX:	1506 MW	AHD-SLK:	656 MW
KING-ECL:	849 MW	SLK-GPK:	464 MW
COOPER S:	1104 MW	WNE-WKS:	539 MW
FTCAL S:	648 MW	GGS:	1611 MW
GRIS-LNC:	663 MW	QC WEST:	148 MW
BISON-ALEX:	332 MW	WIL-BOWS:	-101 MW
NROC-NLAX:	247 MW		

LOAD LEVELS AS PERCENT OF 2015 SUMMER PEAK:

NORTH DAKOTA	(ZONE 90,990)	2904.1 MW,	78.3%	OF	3710.2 MW
NSP	(AREA 600)	8075.1 MW,	67.9%	OF	11889.2 MW
MAN HYDRO	(AREA 667)	2348.2 MW,	76.3%	OF	3076.0 MW

Load/Losses	MW / MW
Manitoba	2348/ 221
Ont. total	22150/ 478
NW	915/ 37
Sask.	2150/ 82
MP	2341/ 145
NSP	8075/ 480
N. Dakota	2904/ 281
Manitoba	481 MVARS
Ont. total	13082 MVARS
NW	489 MVARS
Sask.	502 MVARS
MP	669 MVARS
NSP	1714 MVARS
N. Dakota	756 MVARS
ATC	10812/ 318
ATC	3159 MVARS

Generation	MW
MH total gross	4941
Wpg River	568
7 Sisters	170
OH total gross	21884
northwest	717
SPC total gross	2406
MP total gross	2859
ND Cfd AC gross	3149
net	2978
NSP East gross	1942
net	1810
West gross	3057
net	2895
Total net	6167
WAPA SD Hydro	1497
Pleasant Valley	110
LGS/Trimont	109
SW MN Wind	1008
N DAK WIND	252
Swing Bus	754

Export	MW
ATC West Import	1404
ATC SW Import	613
ATC SE Import	-1630
East Bias	148
SPC>WAPA (B10T)	166
MH>SPC (3-230)	62
MH>SPC (FALLS)	0
OH>MH @Kenora	-195
OH>MP @Ft Fran	151
OH E>W @Wawa	191
OH>East USA	0
F601C @Forbes	1517
D602F @Riel	1777
L20D @Letell	287
R50M @Richer	138
G82R @Glenboro	-25

Tfmrs	MVA/ Load
Wshell #1 7-7	105/ 73%
Wshell #2 7-7	105/ 73%
Drayton#1 4-7	49/ 35%
Drayton#2 4-7	63/ 33%
Dorsey #1 2-4	521/ 43%
Dorsey #2 2-4	598/ 49%
Forbes 2-4	79/ 11%
Stone Lk 3-5	179/ 53%

Ph Shifters	Deg/ MW
Stinson	27/ 27
Boundary Dam	3/ 167
Whiteshell	98/ 199
Int Falls	121/ 150
St. Lawrence	16/ 0
Arrowhead	0/ 656

DC Lines	MW
CU (1,2)	1104
SQ BU (3,4)	455
MH Bipole 1	992
MH Bipole 2	1121
MH (BP1+BP2)	2114
Miles City E>W	-150
RCDC (15)	0
Stegall (10)	0

Dorsey SC's		I/S	MVAR	Qmax/ Qmin
MIL 7-9G	17.0	2	64	600/ -330
SCE 1-3G	18.2	3	52	480/ -240
SCA 4-6G	18.2	3	52	480/ -240
Total			168	1560/ -810
Margin			1392	

SVC's	MVAR	Qmax/ Qmin
Forbes	500	17 400/ -450
Fargo	13.2	4 20/ -135
Watertown	20.0	15 125/ -86

Series Caps	Num In Serv
Roseau	500 2 of 2
Chisago	500 1 of 1

Caps/Reactors	MVAR	Caps/Reactors	MVAR	Caps/Reactors	MVAR
Balta (FS) 230	0	Arrowhead 230	160	Chisago T 9 34.5	60
Drayton 115	20	Blackberry 230	47	Chisago T 10 34.5	60
Drayton 13.8	0	Minntac 115	45	Forbes 230	70
Eau Claire(FS) 161	356	Riverton 230	47	Forbes 500	600
Kohlman Lake 115	240	Roseau Co.(FS) 230	0		0
Parkers Lk(FS) 115	0	Running (FS) 230	30	Fargo 115	27
Prairie (FS) 115	40	Running react 230	0	Watertown 20	20
Ramsey (FS) 230	0	Shannon 230	72	Watertown 230	0
Red Rock 115	240		0		0
Rugby 13.8	-25	Glenboro 230	0	Arrowhead 345	75
Split Rock(FS) 115	80	Laverendrye 110	98	Stone Lake 345	0
Sheyenne (FS) 115	40	Richer react 230	0	Stone Lk Reac 345	0
Wilton/Bemidji 115	20	St Vital 110	98	Stone Lake 161	0
	0		0	Grdnr Pk Reac 345	0
	0		0	Grdnr Pk Caps 115	0
	0		0	Arpin Caps 138	52
	0		0	Council Creek 138	16

Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	1.009	Arrowhead 230	1.000	Whiteshell 110	118.9
Alexandria 115	1.037	Badoura 115	1.037	Kenora 220	246.6
Audubon 115	1.047	Blackberry 230	1.035	Dryden 220	250.8
Bemidji 115	1.032	Boise Cascade 13.8	1.051	Fort Frances 220	244.5
Byron 345	1.019	Boise Cascade 115	1.020	Mackenzie 220	253.7
Chisago Co. 345	1.020	ETCO 115	1.007	Lakehead 220	246.2
Chisago Co. 500	1.017	Forbes 230	1.022	Marathon 220	253.0
Drayton 230	1.026	Forbes 500	1.018	Wawa 220	254.8
Eau Claire 345	1.026	Hubbard 115	1.031	Mississagi 220	250.7
WEST FARIBAULT 115	1.030	Intl Falls 115	1.020	Fort Frances 118	118.8
LaPorte 115	1.027	Minntac 115	1.015	Lakehead 118	122.8
Maple River 230	1.028	Moranville 230	1.027	Birch 118	120.2
Marshall Tap 115	1.021	Riverton 230	1.029	Marathon 118	123.3
Owatonna 161	1.005	Running 230	1.028		0.000
Prairie 115	1.033	Shannon 230	1.029	Arrowhead 345	1.001
Prairie 230	1.027	Stinson MN 115	1.011	Stone Lake 345	1.000
Ramsey 230	1.004	Jamestown 345	1.004	Stone Lake 161	1.009
Roseau County 230	1.026	Groton 345	1.021	Gardner Park 345	1.035
Roseau County 500	1.061	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.030	Watertown 345	1.028	Arpin 345	1.020
Thief R Falls 115	1.030		0.000	Eau Claire 161	1.034
Tioga 230	1.033	Dorsey 230	1.045	Council Creek 161	0.972
Wahpeton 230	1.022	Dorsey 500	1.043	Hydro Lane 161	1.009
Winger 115	1.049		0.000	Wien 115	1.027
	0.000		0.000		0.000
	0.000		0.000		0.000
	0.000		0.000		0.000

Steady State Relay Margins (measured from inner blinder)

Relay Location	Manuf/Type	PSS Model	South	North	Em North
1) B10T-Tioga (South)	GE OST	SLLP	336%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	690%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	413%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	246%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	319%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	-54%	N/A	N/A
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	686%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	979%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A

D.2 Option W.1 Study Case

```
                    P O W E R   F L O W   S U M M A R Y
-------------------------------------------------------------------------------
               NDEX:      2670 MW         ECL-ARP:   805 MW
               MHEX:      2167 MW         NROC-BYN:  745 MW
               MWEX:      1653 MW         AHD-SLK:   649 MW
               KING-ECL:  1004 MW         SLK-GPK:   506 MW
               COOPER S:  1128 MW         WNE-WKS:   546 MW
               FTCAL S:    677 MW         GGS:      1623 MW
               GRIS-LNC:   690 MW         QC WEST:    73 MW
               BISN-ALEX:  956 MW         WIL-BOWS:  -33 MW
               NROC-NLAX:  291 MW         DRSY-BISN 1107 MW
               New MHEX:  3274 MW

          LOAD LEVELS AS PERCENT OF 2015 SUMMER PEAK:
          NORTH DAKOTA (ZONE 90,990) 2904.1 MW,  78.3% OF  3710.2 MW
          NSP             (AREA 600) 8075.1 MW,  67.9% OF  11889.2 MW
          MAN HYDRO       (AREA 667) 2348.2 MW,  76.3% OF  3076.0 MW

Load/Losses    MW  / MW       Generation         MW       Export            MW
------------ ------ -----     --------------- ------     --------------- ------
Manitoba      2348/ 329        MH total gross    6144     ATC West Import   1654
Ont. total   22150/ 478           Wpg River       568     ATC SW Import      713
     NW        915/  36           7 Sisters       170     ATC SE Import    -1385
Sask.         2150/  82        OH total gross   21884     East Bias          244
MP            2341/ 150           northwest        717     SPC>WAPA (B10T)    165
NSP           8075/ 584        SPC total gross   2406     MH>SPC  (3-230)     60
N. Dakota     2904/ 287        MP total gross    2609     MH>SPC  (FALLS)      0
Manitoba       481 MVARS       ND Cfd AC gross   3149     OH>MH  @Kenora    -196
Ont. total   13082 MVARS                net      2978     OH>MP  @Ft Fran    150
     NW        489 MVARS       NSP East gross    1942     OH E>W @Wawa       190
Sask.          502 MVARS                net      1810     OH>East USA          0
MP             669 MVARS           West gross    3057     F601C  @Forbes    1495
NSP           1714 MVARS                net      2895     D602F  @Riel      1805
N. Dakota      756 MVARS           Total net     6117     L20D   @Letell     253
ATC           10812/ 327       WAPA SD Hydro     1497     R50M   @Richer     148
ATC            3159 MVARS      Pleasant Valley      0     G82R   @Glenboro   -40
                               LGS/Trimont          19
                               SW MN Wind         1008
                               N DAK WIND          252
                               Swing Bus           995


Tfmrs          MVA/ Load     Ph Shifters  Deg/  MW      DC Lines          MW
-------------- ---- -----     ------------ --- -----     --------------- ------
Wshell #1 7-7  105/  73%     Stinson       33/   30     CU (1,2)          1104
Wshell #2 7-7  105/  73%     Boundary Dam   4/  165     SQ BU (3,4)        455
Drayton#1 4-7   46/  32%     Whiteshell   104/  199     MH Bipole 1       1507
Drayton#2 4-7   58/  31%     Int Falls    126/  150     MH Bipole 2       1705
Dorsey #1 2-4  953/  79%     St. Lawrence  16/    0     MH (BP1+BP2)      3213
Dorsey #2 2-4 1092/  91%     Arrowhead      8/  649     Miles City E>W    -150
Forbes    2-4  102/  15%                               RCDC (15)            0
Stone Lk  3-5  133/  39%                               Stegall (10)         0

Dorsey SC's       I/S  MVAR  Qmax/ Qmin    SVC's              MVAR  Qmax/ Qmin
----------------- --- -----  ---- -----    ----------------- -----  ---- -----
MIL 7-9G     17.0  2    368   600/ -330    Forbes          500    39   400/ -450
SCE 1-3G     18.2  3    301   480/ -240    Fargo         13.2    -9    20/ -135
SCA 4-6G     18.2  3    301   480/ -240    Watertown     20.0   -15   125/  -86
                         -----  ---- -----
       Total              971  1560/ -810    Series Caps       Num In Serv
       Margin             589               ----------------- -----------
                                            Roseau         500   2 of 2
                                            Chisago        500   1 of 1
```

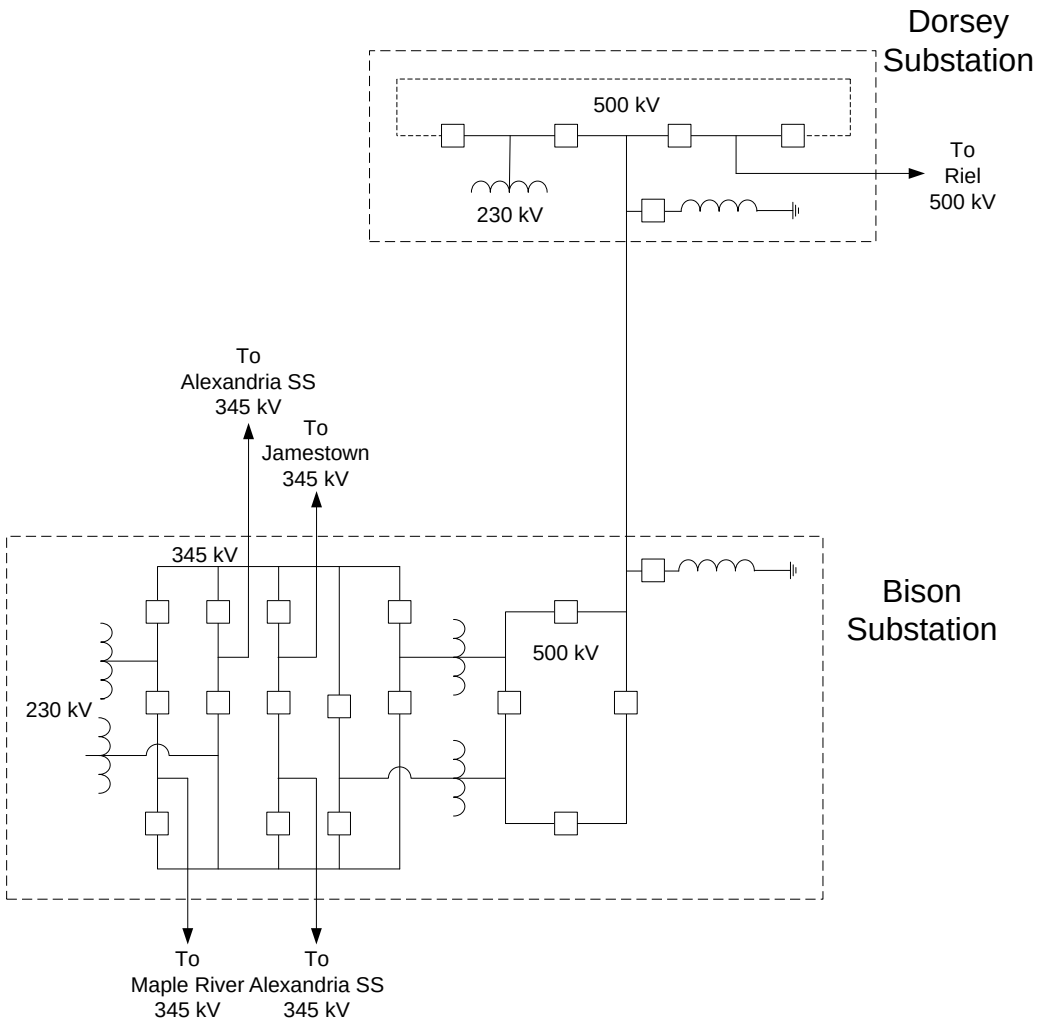
Caps/Reactors	MVAR	Caps/Reactors	MVAR	Caps/Reactors	MVAR
Balta (FS) 230	0	Arrowhead 230	160	Chisago T 9 34.5	60
Drayton 115	20	Blackberry 230	47	Chisago T 10 34.5	60
Drayton 13.8	0	Minntac 115	45	Forbes 230	70
Eau Claire(FS) 161	356	Riverton 230	47	Forbes 500	600
Kohlman Lake 115	240	Roseau Co.(FS) 230	0		0
Parkers Lk(FS) 115	0	Running (FS) 230	30	Fargo 115	54
Prairie (FS) 115	40	Running react 230	0	Watertown 20	20
Ramsey (FS) 230	0	Shannon 230	72	Watertown 230	76
Red Rock 115	240		0		0
Rugby 13.8	-25	Glenboro 230	0	Arrowhead 345	150
Split Rock(FS) 115	80	Laverendrye 110	98	Stone Lake 345	0
Sheyenne (FS) 115	40	Richer react 230	0	Stone Lk Reac 345	0
Wilton/Bemidji 115	20	St Vital 110	98	Stone Lake 161	40
	0		0	Grdnr Pk Reac 345	0
	0		0	Grdnr Pk Caps 115	0
	0		0	Arpin Caps 138	52
	0		0	Council Creek 138	16

Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	1.000	Arrowhead 230	0.999	Whiteshell 110	118.9
Alexandria 115	1.024	Badoura 115	1.030	Kenora 220	246.3
Audubon 115	1.040	Blackberry 230	1.035	Dryden 220	250.5
Bemidji 115	1.028	Boise Cascade 13.8	1.046	Fort Frances 220	243.7
Byron 345	1.011	Boise Cascade 115	1.015	Mackenzie 220	253.4
Chisago Co. 345	1.017	ETCO 115	1.001	Lakehead 220	246.2
Chisago Co. 500	1.013	Forbes 230	1.018	Marathon 220	253.0
Drayton 230	1.033	Forbes 500	1.014	Wawa 220	254.8
Eau Claire 345	0.988	Hubbard 115	1.024	Mississagi 220	250.7
WEST FARIBAULT 115	1.025	Intl Falls 115	1.016	Fort Frances 118	118.3
LaPorte 115	1.022	Minntac 115	1.010	Lakehead 118	122.8
Maple River 230	1.021	Moranville 230	1.019	Birch 118	120.2
Marshall Tap 115	1.017	Riverton 230	1.025	Marathon 118	123.3
Owatonna 161	1.000	Running 230	1.021		0.000
Prairie 115	1.038	Shannon 230	1.025	Arrowhead 345	1.024
Prairie 230	1.032	Stinson MN 115	1.008	Stone Lake 345	1.018
Ramsey 230	1.008	Jamestown 345	1.010	Stone Lake 161	1.029
Roseau County 230	1.019	Groton 345	1.012	Gardner Park 345	1.035
Roseau County 500	1.056	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.025	Watertown 345	1.025	Arpin 345	1.000
Thief R Falls 115	1.034		0.000	Eau Claire 161	1.025
Tioga 230	1.033	Dorsey 230	1.045	Council Creek 161	0.971
Wahpeton 230	1.016	Dorsey 500	1.036	Hydro Lane 161	0.999
Winger 115	1.049		0.000	Wien 115	1.035
	0.000		0.000		0.000
	0.000		0.000		0.000
	0.000		0.000		0.000

Steady State Relay Margins (measured from inner blinder)

Relay Location	Manuf/Type	PSS Model	South	North	Em North
1) B10T-Tioga (South)	GE OST	SLLP	341%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	700%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	392%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	233%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	316%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	N/A	1073%	
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	822%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	875%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A

Option W.1
System Topology Assumptions



Note: This diagram documents assumptions made when disturbances were defined and does not necessarily reflect actual or proposed substation layouts.

D.3 Option W.2 Study Case

```
                    P O W E R   F L O W   S U M M A R Y
-------------------------------------------------------------------------------
               NDEX:      2438 MW         ECL-ARP:   787 MW
               MHEX:      2066 MW         NROC-BYN:  708 MW
               MWEX:      1627 MW         AHD-SLK:   649 MW
               KING-ECL:   977 MW         SLK-GPK:   500 MW
               COOPER S:  1149 MW         WNE-WKS:   550 MW
               FTCAL S:    706 MW         GGS:      1623 MW
               GRIS-LNC:   692 MW         QC WEST:    60 MW
               BISON-ALEX: 461 MW         WIL-BOWS:  -39 MW
               NROC-NLAX:  286 MW         DRSY-BISN:1209 MW
               BISN-BRCO:  828 MW         New MHEX: 3276 MW

          LOAD LEVELS AS PERCENT OF 2015 SUMMER PEAK:
          NORTH DAKOTA (ZONE 90,990) 2904.1 MW,  78.3% OF  3710.2 MW
          NSP             (AREA 600) 8075.1 MW,  67.9% OF  11889.2 MW
          MAN HYDRO       (AREA 667) 2348.2 MW,  76.3% OF  3076.0 MW

Load/Losses   MW  / MW       Generation        MW       Export            MW
----------- ------ -----     --------------- ------     --------------- ------
Manitoba      2348/ 328       MH total gross    6144     ATC West Import   1625
Ont. total   22150/ 478          Wpg River       568     ATC SW Import      722
     NW        915/  36          7 Sisters       170     ATC SE Import    -1370
Sask.         2150/  82       OH total gross   21884     East Bias          244
MP            2341/ 149          northwest        717     SPC>WAPA (B10T)    165
NSP           8075/ 570       SPC total gross   2406     MH>SPC  (3-230)     60
N. Dakota     2904/ 279       MP total gross    2609     MH>SPC  (FALLS)      0
Manitoba       481 MVARS      ND Cfd AC gross   3149     OH>MH  @Kenora    -196
Ont. total   13082 MVARS               net      2978     OH>MP  @Ft Fran    150
     NW        489 MVARS      NSP East gross    1942     OH E>W @Wawa       190
Sask.          502 MVARS               net      1810     OH>East USA          0
MP             669 MVARS           West gross    3057     F601C  @Forbes    1431
NSP           1714 MVARS               net      2895     D602F  @Riel      1740
N. Dakota      756 MVARS           Total net     6117     L20D   @Letell     240
ATC           10812/ 324       WAPA SD Hydro     1497     R50M   @Richer     143
ATC            3159 MVARS      Pleasant Valley      0     G82R   @Glenboro   -57
                               LGS/Trimont          19
                               SW MN Wind         1008
                               N DAK WIND          252
                               Swing Bus           988


Tfmrs           MVA/ Load      Ph Shifters  Deg/  MW      DC Lines          MW
------------- ---- -----      ------------ --- -----     --------------- ------
Wshell #1 7-7  105/  73%      Stinson       30/   30     CU (1,2)          1104
Wshell #2 7-7  105/  73%      Boundary Dam   9/  165     SQ BU (3,4)        455
Drayton#1 4-7   44/  31%      Whiteshell   100/  199     MH Bipole 1       1508
Drayton#2 4-7   56/  30%      Int Falls    121/  150     MH Bipole 2       1706
Dorsey #1 2-4  969/  80%      St. Lawrence  16/    0     MH (BP1+BP2)      3214
Dorsey #2 2-4 1110/  92%      Arrowhead      6/  649     Miles City E>W    -150
Forbes    2-4  104/  15%                                RCDC (15)            0
Stone Lk  3-5  139/  41%                                Stegall (10)         0

Dorsey SC's       I/S  MVAR  Qmax/ Qmin    SVC's              MVAR  Qmax/ Qmin
---------------- --- -----  ---- -----    ---------------- -----  ---- -----
MIL 7-9G     17.0  2    366   600/ -330    Forbes          500    28   400/ -450
SCE 1-3G     18.2  3    299   480/ -240    Fargo          13.2    -5    20/ -135
SCA 4-6G     18.2  3    299   480/ -240    Watertown      20.0    43   125/  -86
                         -----  ---- -----
       Total              965  1560/ -810    Series Caps       Num In Serv
       Margin             595                ---------------- -----------
                                             Roseau        500   2 of 2
                                             Chisago       500   1 of 1
```

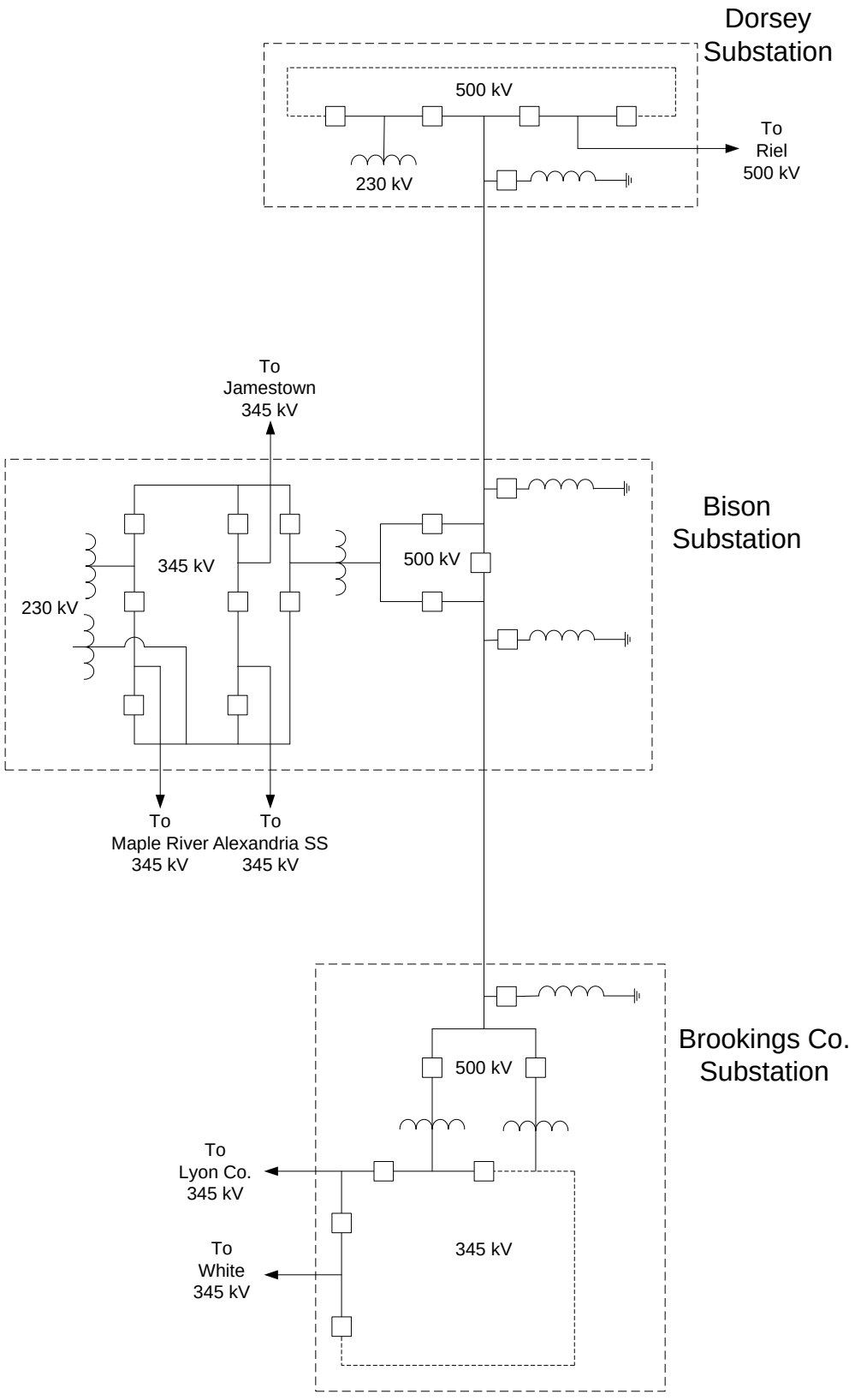
Caps/Reactors	MVAR	Caps/Reactors	MVAR	Caps/Reactors	MVAR
Balta (FS) 230	0	Arrowhead 230	160	Chisago T 9 34.5	60
Drayton 115	20	Blackberry 230	47	Chisago T 10 34.5	60
Drayton 13.8	0	Minntac 115	45	Forbes 230	70
Eau Claire(FS) 161	356	Riverton 230	47	Forbes 500	600
Kohlman Lake 115	240	Roseau Co.(FS) 230	0		0
Parkers Lk(FS) 115	0	Running (FS) 230	30	Fargo 115	54
Prairie (FS) 115	40	Running react 230	0	Watertown 20	20
Ramsey (FS) 230	0	Shannon 230	72	Watertown 230	0
Red Rock 115	240		0		0
Rugby 13.8	-25	Glenboro 230	0	Arrowhead 345	150
Split Rock(FS) 115	80	Laverendrye 110	98	Stone Lake 345	0
Sheyenne (FS) 115	40	Richer react 230	0	Stone Lk Reac 345	0
Wilton/Bemidji 115	20	St Vital 110	98	Stone Lake 161	40
	0		0	Grdnr Pk Reac 345	0
	0		0	Grdnr Pk Caps 115	0
	0		0	Arpin Caps 138	52
	0		0	Council Creek 138	16

Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	1.002	Arrowhead 230	1.002	Whiteshell 110	118.9
Alexandria 115	1.025	Badoura 115	1.030	Kenora 220	246.5
Audubon 115	1.039	Blackberry 230	1.035	Dryden 220	250.7
Bemidji 115	1.027	Boise Cascade 13.8	1.050	Fort Frances 220	244.3
Byron 345	1.012	Boise Cascade 115	1.018	Mackenzie 220	253.6
Chisago Co. 345	1.018	ETCO 115	1.004	Lakehead 220	246.2
Chisago Co. 500	1.016	Forbes 230	1.021	Marathon 220	253.1
Drayton 230	1.032	Forbes 500	1.019	Wawa 220	254.8
Eau Claire 345	0.996	Hubbard 115	1.024	Mississagi 220	250.7
WEST FARIBAULT 115	1.022	Intl Falls 115	1.019	Fort Frances 118	118.7
LaPorte 115	1.021	Minntac 115	1.013	Lakehead 118	122.8
Maple River 230	1.020	Moranville 230	1.023	Birch 118	120.2
Marshall Tap 115	1.011	Riverton 230	1.025	Marathon 118	123.3
Owatonna 161	0.998	Running 230	1.025		0.000
Prairie 115	1.035	Shannon 230	1.027	Arrowhead 345	1.027
Prairie 230	1.029	Stinson MN 115	1.012	Stone Lake 345	1.020
Ramsey 230	1.004	Jamestown 345	1.001	Stone Lake 161	1.031
Roseau County 230	1.023	Groton 345	1.024	Gardner Park 345	1.035
Roseau County 500	1.054	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.024	Watertown 345	1.025	Arpin 345	1.004
Thief R Falls 115	1.032		0.000	Eau Claire 161	1.026
Tioga 230	1.033	Dorsey 230	1.045	Council Creek 161	0.969
Wahpeton 230	1.015	Dorsey 500	1.036	Hydro Lane 161	1.000
Winger 115	1.047		0.000	Wien 115	1.033
	0.000		0.000		0.000
	0.000		0.000		0.000
	0.000		0.000		0.000

Steady State Relay Margins (measured from inner blinder)

Relay Location	Manuf/Type	PSS Model	South	North	Em North
1) B10T-Tioga (South)	GE OST	SLLP	340%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	700%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	425%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	253%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	319%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	N/A	1264%	
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	878%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	923%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A

Option W.2
System Topology Assumptions



Note: This diagram documents assumptions made when disturbances were defined and does not necessarily reflect actual or proposed substation layouts.

D.4 Stability Analysis Summary Tables

Table D-1: Stability Analysis Results

1	**Case No.**	1	1	1	2	2	2
2	**Case Name**	MBb-so15aa-ag1	w1b-so15aa-ag1	w2b-so15aa-ag1	MBb-so15aa-ag3	w1b-so15aa-ag3	w2b-so15aa-ag3
3	**Disturbance**	ag1	ag1	ag1	ag3	ag3	ag3
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 10:45	FEB 17 2010 14:15	FEB 17 2010 12:49	MAR 01 2010 10:47	FEB 17 2010 14:17	FEB 17 2010 12:51
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.97 | 1.02	0.97 | 1.00	0.98 | 1.01	0.97 | 1.02	0.97 | 1.00	0.98 | 1.01
35	Boise 115	1.00 | 1.03	1.00 | 1.02	1.01 | 1.03	1.00 | 1.03	1.00 | 1.02	1.00 | 1.02
36	Dorsey 230	1.04 | 1.05	1.03 | 1.05	1.04 | 1.05	1.04 | 1.05	1.03 | 1.05	1.03 | 1.05
37	Forbes 230	1.01 | 1.03	1.01 | 1.02	1.01 | 1.03	1.01 | 1.03	1.01 | 1.02	1.01 | 1.03
38	Riverton 230	1.01 | 1.04	1.00 | 1.03	1.00 | 1.03	1.00 | 1.04	1.00 | 1.03	1.00 | 1.03
39	Coal Creek 230	0.97 | 1.11	0.97 | 1.10	0.97 | 1.11	0.97 | 1.11	0.97 | 1.10	0.97 | 1.11
40	Jamestown 345	0.93 | 1.05	0.95 | 1.03	0.94 | 1.03	0.92 | 1.05	0.95 | 1.03	0.94 | 1.03
41	Drayton 230	1.01 | 1.05	1.01 | 1.05	1.02 | 1.06	1.00 | 1.05	1.01 | 1.04	1.00 | 1.04
42	Groton 345	0.92 | 1.04	0.91 | 1.03	0.93 | 1.05	0.92 | 1.04	0.91 | 1.03	0.93 | 1.04
43	Minong 161	0.98 | 1.04	0.99 | 1.03	1.00 | 1.04	0.98 | 1.04	0.99 | 1.03	1.00 | 1.03
44	Wahpeton 115	1.00 | 1.06	0.99 | 1.04	0.99 | 1.04	0.99 | 1.07	0.99 | 1.04	0.99 | 1.04
45	Watertown 345	0.98 | 1.04	0.98 | 1.03	0.98 | 1.03	0.98 | 1.04	0.98 | 1.03	0.98 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	451%	471%	471%	445%	463%	470%
57	K22W (max +dP @ t, d-ang)	13.2@(2.39166,0.8)	8.0@(2.31666,2.9)	11.6@(2.32499,1.6)	16.8@(2.35832,-0.4)	9.0@(2.29166,2.7)	13.2@(2.29166,1.1)
58	K22W (max -dP @ t, d-ang)	17.6@(0.78333,4.6)	22.6@(1.72500,1.5)	18.7@(1.74166,0.2)	19.1@(0.73333,5.4)	23.1@(1.68333,1.8)	18.9@(0.69166,4.8)
59	K22W (max d-ang @ t, dP)	6.7@(1.03333,-6.8)	7.3@(1.00000,-6.9)	6.3@(1.00000,-5.6)	7.5@(0.97500,-8.8)	8.3@(0.95833,-8.6)	7.1@(0.95000,-7.1)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	203% / 340%	199% / 334%	222% / 372%	199% / 334%	197% / 330%	219% / 367%
63	G82R at Rugby/L20D at Draytor	999% / 585%	999% / 743%	999% / 783%	999% / 571%	999% / 739%	999% / 792%
64	R50M / F3M	844% / 275%	761% / 279%	822% / 281%	833% / 272%	753% / 278%	813% / 279%
65	B10T	203%	214%	216%	190%	212%	214%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 2 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 2 | 2)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 3 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-ag1	w1b-so15aa-ag1	w2b-so15aa-ag1	MBb-so15aa-ag3	w1b-so15aa-ag3	w2b-so15aa-ag3
Disturbance	ag1	ag1	ag1	ag3	ag3	ag3
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	3	3	3	4	4	4
2	**Case Name**	MBb-so15aa-cts	w1b-so15aa-cts	w2b-so15aa-cts	MBb-so15aa-ei2	w1b-so15aa-ei2	w2b-so15aa-ei2
3	**Disturbance**	cts	cts	cts	ei2	ei2	ei2
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 10:49	FEB 17 2010 14:19	FEB 17 2010 12:53	MAR 01 2010 10:51	FEB 17 2010 14:21	FEB 17 2010 12:56
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.91 | 1.08	0.89 | 1.07	0.90 | 1.07	0.97 | 1.03	0.97 | 1.04	0.97 | 1.04
35	Boise 115	0.94 | 1.03	0.98 | 1.03	0.97 | 1.03	0.99 | 1.01	0.99 | 1.01	0.99 | 1.01
36	Dorsey 230	1.05 | 1.14	1.05 | 1.14	1.05 | 1.13	1.04 | 1.05	1.03 | 1.05	1.03 | 1.05
37	Forbes 230	0.95 | 1.06	0.94 | 1.06	0.94 | 1.05	0.99 | 1.03	0.98 | 1.03	0.99 | 1.03
38	Riverton 230	0.89 | 1.07	0.90 | 1.08	0.90 | 1.07	0.97 | 1.05	0.97 | 1.05	0.97 | 1.04
39	Coal Creek 230	0.88 | 1.09	0.89 | 1.09	0.89 | 1.08	1.02 | 1.11	1.02 | 1.10	1.02 | 1.10
40	Jamestown 345	0.71 | 1.06	0.81 | 1.07	0.80 | 1.06	0.85 | 1.06	0.89 | 1.04	0.89 | 1.04
41	Drayton 230	0.94 | 1.09	0.96 | 1.09	0.96 | 1.08	0.98 | 1.06	0.99 | 1.06	0.99 | 1.07
42	Groton 345	0.79 | 1.07	0.80 | 1.07	0.83 | 1.07	0.92 | 1.06	0.92 | 1.05	0.93 | 1.06
43	Minong 161	0.97 | 1.10	0.97 | 1.12	0.98 | 1.11	0.99 | 1.05	1.01 | 1.08	1.02 | 1.07
44	Wahpeton 115	0.84 | 1.08	0.88 | 1.09	0.88 | 1.08	0.95 | 1.08	0.96 | 1.06	0.95 | 1.06
45	Watertown 345	0.87 | 1.06	0.88 | 1.07	0.87 | 1.06	0.97 | 1.05	0.97 | 1.05	0.96 | 1.05
46	**Dynamic Voltage Warnings**						
47					none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	507%	507%	507%	507%	507%	507%
57	K22W (max +dP @ t, d-ang)	119.1@(2.44999,-55.5)	131.7@(2.41666,-55.1)	115.4@(2.41666,-50.1)	66.4@(2.40832,-29.5)	76.5@(2.33332,-31.8)	72.2@(2.34999,-30.4)
58	K22W (max -dP @ t, d-ang)	72.8@(0.45000,10.6)	63.9@(0.42500,8.9)	56.5@(0.42500,8.2)	1.7@(0.42500,0.0)	3.3@(0.46666,0.2)	2.9@(0.46666,0.1)
59	K22W (max d-ang @ t, dP)	-55.9@(2.55832,115.7)	-56.7@(2.63332,114.5)	-51.8@(2.65832,99.4)	-32.2@(4.99995,30.8)	-33.0@(2.62499,63.2)	-32.3@(4.99995,30.1)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	0.36667 sec / 0.36667 sec	0.36667 sec / 0.36667 sec	0.36667 sec / 0.36667 sec	178% / 299%	162% / 271%	175% / 294%
63	G82R at Rugby/L20D at Draytor	999% / 258%	999% / 582%	999% / 630%	999% / 509%	999% / 679%	999% / 723%
64	R50M / F3M	365% / 160%	490% / 183%	505% / 184%	827% / 220%	717% / 222%	755% / 224%
65	B10T	1%	52%	67%	108%	121%	125%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 2 | 0)	(0 | 2 | 0)	(0 | 2 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 1) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 7 | 1) / (0 | 2 | 2)	(1 | 5 | 1) / (0 | 2 | 1)	(1 | 5 | 1) / (0 | 2 | 2)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 0) / (1 | 3 | 1)	(0 | 0 | 0) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 5 | 2) / (1 | 2 | 2)	(1 | 5 | 1) / (1 | 2 | 2)	(1 | 5 | 3) / (1 | 2 | 2)	(1 | 4 | 3) / (1 | 1 | 1)	(1 | 4 | 4) / (1 | 1 | 1)	(1 | 4 | 4) / (1 | 1 | 1)

Case	MBb-so15aa-cts	w1b-so15aa-cts	w2b-so15aa-cts	MBb-so15aa-ei2	w1b-so15aa-ei2	w2b-so15aa-ei2
Disturbance	cts	cts	cts	ei2	ei2	ei2
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping	(5T)(6T)8	(5T)(6T)	(5T)(6T)			

Table D-1: Stability Analysis Results

1	**Case No.**	5	5	5	6	6	6
2	**Case Name**	MBb-so15aa-em3	w1b-so15aa-em3	w2b-so15aa-em3	MBb-so15aa-eq1	w1b-so15aa-eq1	w2b-so15aa-eq1
3	**Disturbance**	em3	em3	em3	eq1	eq1	eq1
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 10:53	FEB 17 2010 14:23	FEB 17 2010 12:58	MAR 01 2010 10:55	FEB 17 2010 14:25	FEB 17 2010 13:00
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01	0.98 | 1.02	0.98 | 1.03	0.98 | 1.03
35	Boise 115	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02	1.00 | 1.02	1.00 | 1.02	1.00 | 1.02
36	Dorsey 230	1.03 | 1.05	1.03 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
37	Forbes 230	1.02 | 1.03	1.02 | 1.02	1.02 | 1.03	1.01 | 1.03	1.00 | 1.03	1.00 | 1.03
38	Riverton 230	1.03 | 1.04	1.03 | 1.03	1.03 | 1.03	1.00 | 1.06	0.99 | 1.05	0.99 | 1.04
39	Coal Creek 230	1.03 | 1.05	1.03 | 1.05	1.03 | 1.04	0.99 | 1.16	1.00 | 1.16	0.99 | 1.16
40	Jamestown 345	1.00 | 1.01	1.00 | 1.02	1.00 | 1.01	0.88 | 1.08	0.91 | 1.06	0.90 | 1.05
41	Drayton 230	1.02 | 1.03	1.03 | 1.03	1.02 | 1.03	1.02 | 1.07	1.03 | 1.07	1.02 | 1.07
42	Groton 345	1.02 | 1.03	1.01 | 1.02	1.02 | 1.03	0.95 | 1.06	0.94 | 1.05	0.95 | 1.06
43	Minong 161	1.01 | 1.02	1.02 | 1.04	1.03 | 1.04	1.00 | 1.04	1.01 | 1.06	1.02 | 1.06
44	Wahpeton 115	1.04 | 1.04	1.03 | 1.04	1.03 | 1.04	0.98 | 1.08	0.98 | 1.06	0.98 | 1.06
45	Watertown 345	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	0.99 | 1.05	0.99 | 1.05	0.98 | 1.05
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133			
56	Forbes DC Red (DCAR)	507%	498%	497%	507%	507%	507%
57	K22W (max +dP @ t, d-ang)	30.4@(0.11667,-0.4)	31.7@(0.13333,-0.3)	31.1@(0.13333,-0.4)	46.3@(2.30833,-18.6)	54.3@(2.25833,-20.7)	52.1@(2.27499,-19.7)
58	K22W (max -dP @ t, d-ang)	28.9@(0.26667,2.6)	21.4@(0.26667,1.9)	20.3@(0.26667,1.8)	2.5@(0.29167,0.1)	4.5@(0.30833,0.3)	3.4@(0.30833,0.1)
59	K22W (max d-ang @ t, dP)	-9.3@(2.44166,13.2)	-9.3@(2.44166,15.2)	-8.3@(2.43332,13.3)	-18.9@(2.53332,39.6)	-21.7@(2.53332,41.2)	-20.8@(2.55832,38.3)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	207% / 348%	208% / 349%	230% / 386%	203% / 341%	185% / 311%	202% / 339%
63	G82R at Rugby/L20D at Draytor	999% / 0.18333 sec	999% / 0.18333 sec	999% / 0.18333 sec	45% / 532%	56% / 669%	64% / 702%
64	R50M / F3M	814% / 284%	769% / 286%	823% / 292%	880% / 247%	768% / 245%	810% / 248%
65	B10T	243%	274%	258%	124%	137%	140%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 0)	(0 | 1 | 0)	(0 | 1 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 4 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)

Case	MBb-so15aa-em3	w1b-so15aa-em3	w2b-so15aa-em3	MBb-so15aa-eq1	w1b-so15aa-eq1	w2b-so15aa-eq1
Disturbance	em3	em3	em3	eq1	eq1	eq1
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping	(3T)	(3T)	(3T)			

Table D-1: Stability Analysis Results

1	**Case No.**	7	7	7	8	8	8
2	**Case Name**	MBb-so15aa-fds	w1b-so15aa-fds	w2b-so15aa-fds	MBb-so15aa-mc3	w1b-so15aa-mc3	w2b-so15aa-mc3
3	**Disturbance**	fds	fds	fds	mc3	mc3	mc3
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 10:57	FEB 17 2010 14:27	FEB 17 2010 13:02	MAR 01 2010 10:59	FEB 17 2010 14:29	FEB 17 2010 13:04
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.96 | 1.01	0.96 | 1.01	0.96 | 1.02	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
35	Boise 115	1.01 | 1.03	1.00 | 1.02	1.01 | 1.02	1.00 | 1.02	1.00 | 1.01	1.00 | 1.01
36	Dorsey 230	1.04 | 1.05	1.04 | 1.06	1.04 | 1.06	1.03 | 1.05	1.03 | 1.05	1.04 | 1.05
37	Forbes 230	1.01 | 1.03	1.00 | 1.03	1.00 | 1.03	1.02 | 1.03	1.02 | 1.02	1.02 | 1.03
38	Riverton 230	1.00 | 1.05	0.99 | 1.04	0.99 | 1.04	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
39	Coal Creek 230	0.97 | 1.12	0.98 | 1.12	0.98 | 1.12	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
40	Jamestown 345	0.84 | 1.08	0.87 | 1.05	0.86 | 1.05	1.00 | 1.00	1.00 | 1.01	1.00 | 1.00
41	Drayton 230	1.00 | 1.06	1.00 | 1.06	1.00 | 1.06	1.02 | 1.03	1.02 | 1.04	1.02 | 1.03
42	Groton 345	0.95 | 1.06	0.95 | 1.04	0.96 | 1.06	1.02 | 1.02	1.01 | 1.01	1.02 | 1.03
43	Minong 161	0.98 | 1.02	0.99 | 1.03	0.99 | 1.04	1.01 | 1.02	1.03 | 1.03	1.03 | 1.04
44	Wahpeton 115	0.97 | 1.08	0.97 | 1.05	0.97 | 1.06	1.04 | 1.04	1.03 | 1.03	1.03 | 1.03
45	Watertown 345	0.99 | 1.05	0.99 | 1.04	0.98 | 1.04	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold		/ 0.150	/ 0.166	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	457%	444%	445%	493%	492%	492%
57	K22W (max +dP @ t, d-ang)	13.1@(2.40832,-1.5)	13.1@(2.34999,-1.5)	15.4@(2.34999,-2.0)	28.4@(0.11667,0.3)	27.7@(0.12500,0.4)	27.4@(0.12500,0.4)
58	K22W (max -dP @ t, d-ang)	12.6@(0.73333,2.4)	16.5@(0.55833,2.0)	16.4@(0.57500,2.0)	22.9@(1.03333,-4.6)	24.0@(0.98333,-4.6)	23.9@(0.96666,-4.4)
59	K22W (max d-ang @ t, dP)	4.5@(1.01666,-4.0)	4.2@(0.91666,-2.8)	4.5@(0.94166,-3.1)	-6.8@(2.29166,-13.7)	-7.4@(2.30833,-13.7)	-7.1@(2.29166,-14.2)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	216% / 363%	191% / 321%	211% / 353%	224% / 377%	215% / 362%	236% / 397%
63	G82R at Rugby/L20D at Draytor	999% / 585%	999% / 751%	999% / 799%	999% / 626%	999% / 768%	999% / 821%
64	R50M / F3M	868% / 281%	739% / 282%	785% / 285%	980% / 205%	876% / 198%	925% / 203%
65	B10T	184%	201%	199%	317%	324%	239%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 3 | 1) / (0 | 2 | 2)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 2 | 2)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 4 | 2) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	MBb-so15aa-fds	w1b-so15aa-fds	w2b-so15aa-fds	MBb-so15aa-mc3	w1b-so15aa-mc3	w2b-so15aa-mc3
Disturbance	fds	fds	fds	mc3	mc3	mc3
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

Case No.	9	9	9	10	10	10
Case Name	MBb-so15aa-md3	w1b-so15aa-md3	w2b-so15aa-md3	MBb-so15aa-mis	w1b-so15aa-mis	w2b-so15aa-mis
Disturbance	md3	md3	md3	mis	mis	mis
Prior Outage	None	None	None	None	None	None
Date/Time	MAR 01 2010 11:01	FEB 17 2010 14:31	FEB 17 2010 13:06	MAR 01 2010 11:03	FEB 17 2010 14:33	FEB 17 2010 13:07
Comments	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
Steady State Flows						
NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
G82R	-25	-40	-58	-25	-40	-58
Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
RCDC	0	0	0	0	0	0
Steady State Vltgs						
Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
SS OS Relay Margins						
D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
B10T	337%	343%	343%	337%	343%	343%
Min/MaxTransientVltg						
Arrowhd 230	1.00 | 1.00	1.00 | 1.00	1.00 | 1.00	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Boise 115	1.02 | 1.02	1.01 | 1.02	1.02 | 1.02	1.04 | 1.06	1.04 | 1.06	1.04 | 1.06
Dorsey 230	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
Forbes 230	1.02 | 1.02	1.02 | 1.02	1.02 | 1.02	1.02 | 1.03	1.02 | 1.02	1.02 | 1.02
Riverton 230	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Jamestown 345	1.00 | 1.00	1.00 | 1.01	1.00 | 1.00	1.00 | 1.00	1.01 | 1.01	1.00 | 1.00
Drayton 230	1.02 | 1.03	1.03 | 1.04	1.03 | 1.04	1.02 | 1.03	1.03 | 1.04	1.03 | 1.04
Groton 345	1.02 | 1.02	1.01 | 1.01	1.02 | 1.02	1.02 | 1.02	1.01 | 1.01	1.02 | 1.03
Minong 161	1.01 | 1.01	1.02 | 1.02	1.02 | 1.03	1.01 | 1.02	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.04 | 1.04	1.03 | 1.03	1.03 | 1.03	1.04 | 1.04	1.03 | 1.03	1.03 | 1.03
Watertown 345	1.03 | 1.03	1.02 | 1.02	1.02 | 1.03	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
Dynamic Voltage Warnings						
	none	none	none	none	none	none
Worst Case Angle Damping						
Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133			
Forbes DC Red (DCAR)	495%	497%	497%	482%	485%	487%
K22W (max +dP @ t, d-ang)	20.5@(0.11667,-0.4)	20.9@(0.12500,-0.4)	20.5@(0.12500,-0.4)	195.8@(0.35000,-11.9)	196.1@(0.35000,-11.9)	196.1@(0.35000,-11.9)
K22W (max -dP @ t, d-ang)	12.8@(0.24167,0.8)	10.5@(0.24167,0.6)	9.7@(0.24167,0.5)	0.0@(0.35000,0.0)	0.0@(0.35000,0.0)	0.0@(0.35000,0.0)
K22W (max d-ang @ t, dP)	0.8@(0.26667,-11.7)	0.6@(0.25833,-10.1)	-0.7@(3.45831,2.2)	-43.4@(0.96666,195.8)	-44.1@(0.96666,196.1)	-43.5@(0.96666,196.1)
OS Rel Trip / Marg						
MH - OH				0.35000 sec	0.35000 sec	0.35000 sec
D602F at Forbes/Dorsey	241% / 404%	231% / 387%	254% / 425%	234% / 393%	225% / 377%	245% / 410%
G82R at Rugby/L20D at Draytor	999% / 674%	999% / 823%	999% / 881%	999% / 652%	999% / 791%	999% / 844%
R50M / F3M	955% / 314%	861% / 311%	916% / 316%	615% / 319%	555% / 316%	581% / 320%
B10T	100%	328%	333%	329%	333%	332%
FSCAPS (SS/Unav/Final)						
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	MBb-so15aa-md3	w1b-so15aa-md3	w2b-so15aa-md3	MBb-so15aa-mis	w1b-so15aa-mis	w2b-so15aa-mis
Disturbance	md3	md3	md3	mis	mis	mis
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping				(1T)	(1T)	(1T)

Table D-1: Stability Analysis Results

1	**Case No.**	11	11	11	12	12	12
2	**Case Name**	MBb-so15aa-mjs	w1b-so15aa-mjs	w2b-so15aa-mjs	MBb-so15aa-mkd	w1b-so15aa-mkd	w2b-so15aa-mkd
3	**Disturbance**	mjs	mjs	mjs	mkd	mkd	mkd
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:05	FEB 17 2010 14:35	FEB 17 2010 13:09	MAR 01 2010 11:07	FEB 17 2010 14:37	FEB 17 2010 13:11
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.99 | 1.02	0.95 | 0.99	0.96 | 1.00	0.94 | 1.01	0.91 | 0.99	0.92 | 1.00
35	Boise 115	1.01 | 1.02	1.01 | 1.02	1.02 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03
36	Dorsey 230	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
37	Forbes 230	1.02 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.00 | 1.02	1.01 | 1.03
38	Riverton 230	1.00 | 1.03	0.99 | 1.02	1.00 | 1.03	0.97 | 1.03	0.97 | 1.02	0.97 | 1.02
39	Coal Creek 230	0.97 | 1.07	0.97 | 1.07	0.98 | 1.07	0.97 | 1.07	0.97 | 1.07	0.97 | 1.07
40	Jamestown 345	0.92 | 1.02	0.95 | 1.02	0.94 | 1.01	0.92 | 1.03	0.95 | 1.02	0.94 | 1.01
41	Drayton 230	1.00 | 1.03	1.01 | 1.04	1.01 | 1.04	0.99 | 1.04	1.01 | 1.04	1.01 | 1.04
42	Groton 345	0.98 | 1.03	0.97 | 1.02	0.98 | 1.03	0.97 | 1.03	0.96 | 1.02	0.97 | 1.03
43	Minong 161	1.01 | 1.04	0.98 | 1.02	0.99 | 1.02	0.96 | 1.03	0.95 | 1.04	0.94 | 1.04
44	Wahpeton 115	0.99 | 1.05	1.00 | 1.04	1.00 | 1.04	0.98 | 1.05	0.99 | 1.03	0.99 | 1.03
45	Watertown 345	1.00 | 1.03	1.00 | 1.03	0.99 | 1.03	1.00 | 1.03	0.99 | 1.03	0.99 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold				/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	443%	434%	445%	319%	295%	306%
57	K22W (max +dP @ t, d-ang)	2.1@(2.28333,1.4)	3.0@(3.31664,1.9)	2.9@(3.38331,1.6)	6.7@(0.10833,1.5)	7.9@(3.29998,2.0)	8.0@(0.10833,1.5)
58	K22W (max -dP @ t, d-ang)	21.9@(0.35833,3.5)	21.5@(0.35833,3.6)	19.2@(0.35833,3.2)	32.8@(1.21666,13.0)	33.4@(1.20833,14.4)	29.4@(1.17500,13.5)
59	K22W (max d-ang @ t, dP)	6.6@(0.77500,-7.0)	7.5@(0.87500,-9.4)	6.8@(0.95000,-12.5)	16.2@(0.84166,-19.1)	16.4@(0.87500,-19.9)	15.0@(0.88333,-19.2)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	229% / 390%	217% / 378%	239% / 416%	230% / 385%	234% / 392%	254% / 426%
63	G82R at Rugby/L20D at Draytor	999% / 579%	999% / 742%	999% / 797%	999% / 491%	999% / 675%	999% / 733%
64	R50M / F3M	870% / 315%	795% / 316%	848% / 320%	785% / 319%	761% / 316%	818% / 320%
65	B10T	211%	221%	241%	152%	184%	196%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 2 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-mjs	w1b-so15aa-mjs	w2b-so15aa-mjs	MBb-so15aa-mkd	w1b-so15aa-mkd	w2b-so15aa-mkd
Disturbance	mjs	mjs	mjs	mkd	mkd	mkd
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	13	13	13	14	14	14
2	**Case Name**	MBb-so15aa-mks	w1b-so15aa-mks	w2b-so15aa-mks	MBb-so15aa-nad	w1b-so15aa-nad	w2b-so15aa-nad
3	**Disturbance**	mks	mks	mks	nad	nad	nad
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:09	FEB 17 2010 14:38	FEB 17 2010 13:13	MAR 01 2010 11:11	FEB 17 2010 14:40	FEB 17 2010 13:15
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.96 | 1.02	0.93 | 1.00	0.95 | 1.01	1.00 | 1.06	0.99 | 1.06	0.99 | 1.05
35	Boise 115	1.01 | 1.03	1.02 | 1.04	1.02 | 1.04	0.91 | 1.03	0.95 | 1.01	0.96 | 1.02
36	Dorsey 230	1.04 | 1.06	1.04 | 1.06	1.04 | 1.06	1.04 | 1.07	1.04 | 1.08	1.04 | 1.08
37	Forbes 230	1.02 | 1.04	1.01 | 1.03	1.02 | 1.04	1.01 | 1.03	1.00 | 1.03	1.01 | 1.03
38	Riverton 230	0.99 | 1.04	0.98 | 1.03	0.99 | 1.03	0.99 | 1.05	0.98 | 1.05	0.98 | 1.04
39	Coal Creek 230	0.97 | 1.08	0.97 | 1.08	0.97 | 1.08	0.99 | 1.07	0.98 | 1.07	0.99 | 1.07
40	Jamestown 345	0.92 | 1.03	0.95 | 1.02	0.94 | 1.02	0.93 | 1.02	0.95 | 1.03	0.95 | 1.02
41	Drayton 230	1.00 | 1.06	1.01 | 1.04	1.01 | 1.04	0.96 | 1.07	1.00 | 1.06	1.00 | 1.05
42	Groton 345	0.97 | 1.03	0.95 | 1.02	0.97 | 1.04	0.98 | 1.04	0.97 | 1.04	0.99 | 1.04
43	Minong 161	0.98 | 1.04	0.96 | 1.04	0.98 | 1.05	1.02 | 1.07	1.02 | 1.09	1.03 | 1.09
44	Wahpeton 115	0.99 | 1.06	0.99 | 1.04	0.99 | 1.04	0.98 | 1.05	0.98 | 1.05	0.99 | 1.04
45	Watertown 345	1.00 | 1.04	0.99 | 1.03	0.99 | 1.03	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold				/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	370%	362%	381%	507%	507%	507%
57	K22W (max +dP @ t, d-ang)	8.2@(2.27499,0.2)	8.8@(3.24164,-0.5)	8.3@(3.26664,-1.2)	104.4@(2.03333,-45.2)	100.1@(2.05000,-47.4)	87.9@(2.05000,-44.0)
58	K22W (max -dP @ t, d-ang)	34.6@(0.37500,6.3)	35.4@(0.39166,6.9)	31.5@(0.39166,6.2)	89.4@(0.26667,9.8)	69.8@(0.25000,7.6)	64.4@(0.25000,7.0)
59	K22W (max d-ang @ t, dP)	11.2@(0.74166,-8.2)	12.2@(0.80000,-14.4)	10.7@(0.80000,-14.0)	-52.0@(4.99995,35.9)	-54.2@(4.99995,41.5)	-51.7@(4.99995,36.2)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	212% / 365%	203% / 363%	226% / 401%	0.16667 sec / 0.16667 sec	0.16667 sec / 0.16667 sec	0.16667 sec / 0.16667 sec
63	G82R at Rugby/L20D at Draytor	999% / 553%	999% / 713%	999% / 766%	999% / 339%	999% / 560%	999% / 605%
64	R50M / F3M	811% / 309%	754% / 311%	809% / 310%	364% / 117%	417% / 152%	466% / 156%
65	B10T	178%	198%	202%	101%	166%	178%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 4 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 2 | 0) / (1 | 5 | 3)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 3 | 3)
71	Shey 115 / Split Rock 115	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-mks	w1b-so15aa-mks	w2b-so15aa-mks	MBb-so15aa-nad	w1b-so15aa-nad	w2b-so15aa-nad
Disturbance	mks	mks	mks	nad	nad	nad
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping				(5T)(6T)	(5T)(6T)	(5T)(6T)

Table D-1: Stability Analysis Results

1	**Case No.**	15	15	15	16	16	16
2	**Case Name**	MBb-so15aa-nmz	w1b-so15aa-nmz	w2b-so15aa-nmz	MBb-so15aa-pas	w1b-so15aa-pas	w2b-so15aa-pas
3	**Disturbance**	nmz	nmz	nmz	pas	pas	pas
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:13	FEB 17 2010 14:43	FEB 17 2010 13:17	MAR 01 2010 11:15	FEB 17 2010 14:45	FEB 17 2010 13:19
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.92 | 1.07	0.92 | 1.05	0.93 | 1.05	1.01 | 1.05	0.98 | 1.06	0.98 | 1.06
35	Boise 115	0.95 | 1.03	0.96 | 1.02	0.97 | 1.03	0.97 | 1.02	0.98 | 1.02	0.98 | 1.02
36	Dorsey 230	1.05 | 1.07	1.05 | 1.08	1.05 | 1.08	1.05 | 1.07	1.05 | 1.08	1.05 | 1.08
37	Forbes 230	1.00 | 1.04	0.99 | 1.03	1.00 | 1.04	1.00 | 1.05	0.98 | 1.04	0.98 | 1.04
38	Riverton 230	0.94 | 1.05	0.94 | 1.06	0.95 | 1.05	1.00 | 1.05	0.98 | 1.05	0.99 | 1.04
39	Coal Creek 230	0.95 | 1.07	0.95 | 1.07	0.96 | 1.07	0.99 | 1.07	0.98 | 1.07	0.99 | 1.07
40	Jamestown 345	0.85 | 1.04	0.90 | 1.05	0.90 | 1.04	0.93 | 1.01	0.96 | 1.03	0.96 | 1.02
41	Drayton 230	0.96 | 1.07	0.99 | 1.08	0.99 | 1.08	0.97 | 1.06	1.00 | 1.06	1.01 | 1.06
42	Groton 345	0.92 | 1.05	0.91 | 1.05	0.93 | 1.06	0.97 | 1.04	0.97 | 1.03	0.98 | 1.04
43	Minong 161	0.96 | 1.09	0.97 | 1.09	0.98 | 1.09	1.03 | 1.09	1.02 | 1.10	1.02 | 1.09
44	Wahpeton 115	0.93 | 1.07	0.95 | 1.07	0.95 | 1.06	0.98 | 1.05	0.98 | 1.05	0.99 | 1.04
45	Watertown 345	0.96 | 1.05	0.96 | 1.05	0.95 | 1.05	1.00 | 1.04	1.00 | 1.04	0.99 | 1.04
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.150	/ 0.150	/ 0.150
56	Forbes DC Red (DCAR)	507%	507%	507%	507%	507%	506%
57	K22W (max +dP @ t, d-ang)	103.5@(2.17499,-46.4)	113.0@(2.19999,-49.1)	98.5@(2.20833,-45.1)	88.0@(2.13333,-42.9)	100.5@(2.09166,-46.0)	86.3@(2.06666,-41.6)
58	K22W (max -dP @ t, d-ang)	66.1@(0.25000,6.6)	56.0@(0.23333,5.3)	51.2@(0.22500,4.7)	61.3@(0.27500,5.6)	49.4@(0.25833,4.4)	44.8@(0.25833,3.9)
59	K22W (max d-ang @ t, dP)	-48.0@(2.43332,87.9)	-51.7@(2.50832,94.6)	-47.7@(4.99995,42.3)	-48.0@(4.99995,39.1)	-50.8@(4.99995,47.8)	-47.9@(4.99995,41.7)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	0.18333 sec / 0.18333 sec	0.18333 sec / 0.18333 sec	0.18333 sec / 0.18333 sec	0.38333 sec / 0.18333 sec	0.38333 sec / 0.18333 sec	0.38333 sec / 0.18333 sec
63	G82R at Rugby/L20D at Draytor	999% / 346%	999% / 661%	999% / 709%	999% / 404%	999% / 621%	999% / 666%
64	R50M / F3M	429% / 152%	549% / 180%	569% / 186%	455% / 169%	480% / 183%	527% / 185%
65	B10T	59%	114%	128%	119%	185%	201%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 1 | 0)	(0 | 1 | 0)	(0 | 1 | 1)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 2 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 0) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 2 | 2)
71	Shey 115 / Split Rock 115	(1 | 5 | 3) / (1 | 2 | 2)	(1 | 4 | 3) / (1 | 2 | 2)	(1 | 4 | 3) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	MBb-so15aa-nmz	w1b-so15aa-nmz	w2b-so15aa-nmz	MBb-so15aa-pas	w1b-so15aa-pas	w2b-so15aa-pas
Disturbance	nmz	nmz	nmz	pas	pas	pas
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping	(5T)(6T)	(5T)(6T)	(5T)(6T)	(5T)(6T)	(5T)(6T)	(5T)(6T)

Table D-1: Stability Analysis Results

1	**Case No.**	17	17	17	18	18	18
2	**Case Name**	MBb-so15aa-pc0	w1b-so15aa-pc0	w2b-so15aa-pc0	MBb-so15aa-pcs	w1b-so15aa-pcs	w2b-so15aa-pcs
3	**Disturbance**	pc0	pc0	pc0	pcs	pcs	pcs
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:17	FEB 17 2010 14:47	FEB 17 2010 13:21	MAR 01 2010 11:19	FEB 17 2010 14:49	FEB 17 2010 13:23
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.92 | 0.99	0.87 | 0.96	0.88 | 0.97	0.91 | 0.98	0.86 | 0.95	0.88 | 0.96
35	Boise 115	1.01 | 1.04	1.01 | 1.03	1.01 | 1.04	1.01 | 1.04	1.01 | 1.03	1.01 | 1.04
36	Dorsey 230	1.04 | 1.05	1.04 | 1.06	1.04 | 1.05	1.04 | 1.05	1.04 | 1.06	1.04 | 1.05
37	Forbes 230	1.01 | 1.04	1.00 | 1.03	1.00 | 1.03	1.01 | 1.04	1.00 | 1.03	1.00 | 1.04
38	Riverton 230	1.02 | 1.04	1.01 | 1.03	1.02 | 1.03	1.02 | 1.04	1.01 | 1.03	1.01 | 1.03
39	Coal Creek 230	0.98 | 1.08	0.98 | 1.08	0.99 | 1.08	0.98 | 1.08	0.98 | 1.07	0.99 | 1.08
40	Jamestown 345	0.96 | 1.03	0.99 | 1.03	0.97 | 1.02	0.96 | 1.03	0.98 | 1.02	0.97 | 1.01
41	Drayton 230	1.02 | 1.05	1.02 | 1.05	1.03 | 1.05	1.01 | 1.04	1.02 | 1.05	1.02 | 1.05
42	Groton 345	0.99 | 1.03	0.99 | 1.02	1.00 | 1.03	0.99 | 1.03	0.98 | 1.01	1.00 | 1.03
43	Minong 161	0.91 | 1.00	0.85 | 0.98	0.87 | 0.99	0.90 | 0.99	0.84 | 0.97	0.86 | 0.98
44	Wahpeton 115	1.02 | 1.05	1.02 | 1.04	1.02 | 1.04	1.02 | 1.05	1.02 | 1.04	1.02 | 1.04
45	Watertown 345	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	256%	215%	238%	250%	187%	218%
57	K22W (max +dP @ t, d-ang)	2.3@(3.34164,2.9)	1.3@(0.10000,0.5)	1.8@(3.37498,4.3)	1.2@(0.10000,0.4)	1.3@(0.10000,0.5)	1.6@(0.10000,0.4)
58	K22W (max -dP @ t, d-ang)	33.4@(1.57500,11.0)	49.2@(1.59166,18.7)	43.6@(1.60000,15.6)	39.4@(1.58333,13.1)	54.0@(1.61666,20.9)	47.4@(1.60833,17.4)
59	K22W (max d-ang @ t, dP)	16.9@(0.99166,-26.2)	20.9@(1.08333,-35.8)	19.6@(1.04166,-30.0)	18.9@(1.00833,-28.8)	22.6@(1.10833,-38.8)	20.8@(1.05833,-31.5)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	213% / 356%	219% / 367%	240% / 400%	221% / 369%	234% / 392%	254% / 425%
63	G82R at Rugby/L20D at Draytor	999% / 587%	999% / 742%	999% / 789%	999% / 555%	999% / 724%	999% / 773%
64	R50M / F3M	795% / 319%	736% / 316%	784% / 320%	785% / 319%	744% / 316%	791% / 320%
65	B10T	198%	225%	221%	185%	219%	218%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-pc0	w1b-so15aa-pc0	w2b-so15aa-pc0	MBb-so15aa-pcs	w1b-so15aa-pcs	w2b-so15aa-pcs
Disturbance	pc0	pc0	pc0	pcs	pcs	pcs
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	19	19	19	20	20	20
2	**Case Name**	MBb-so15aa-pct	w1b-so15aa-pct	w2b-so15aa-pct	MBb-so15aa-pzs	w1b-so15aa-pzs	w2b-so15aa-pzs
3	**Disturbance**	pct	pct	pct	pzs	pzs	pzs
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:21	FEB 17 2010 14:51	FEB 17 2010 13:25	MAR 01 2010 11:23	FEB 17 2010 14:53	FEB 17 2010 13:27
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.95 | 0.98	0.90 | 0.95	0.91 | 0.95	0.99 | 1.04	0.96 | 1.02	0.97 | 1.02
35	Boise 115	1.02 | 1.03	1.01 | 1.02	1.02 | 1.03	1.00 | 1.04	1.00 | 1.03	1.01 | 1.04
36	Dorsey 230	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.06	1.03 | 1.07	1.03 | 1.07
37	Forbes 230	1.01 | 1.02	1.00 | 1.01	1.01 | 1.02	1.02 | 1.05	1.01 | 1.04	1.01 | 1.05
38	Riverton 230	1.03 | 1.03	1.01 | 1.03	1.01 | 1.03	1.02 | 1.05	1.01 | 1.04	1.02 | 1.04
39	Coal Creek 230	1.02 | 1.04	1.02 | 1.05	1.02 | 1.05	0.98 | 1.08	0.98 | 1.07	0.98 | 1.08
40	Jamestown 345	1.00 | 1.02	1.01 | 1.03	1.00 | 1.02	0.96 | 1.03	0.98 | 1.03	0.97 | 1.02
41	Drayton 230	1.02 | 1.03	1.03 | 1.04	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04	1.02 | 1.05
42	Groton 345	1.01 | 1.03	1.00 | 1.02	1.01 | 1.03	0.99 | 1.04	0.98 | 1.03	1.00 | 1.04
43	Minong 161	0.94 | 0.98	0.89 | 0.96	0.91 | 0.97	0.99 | 1.05	0.97 | 1.06	0.98 | 1.06
44	Wahpeton 115	1.04 | 1.05	1.02 | 1.04	1.02 | 1.04	1.02 | 1.06	1.02 | 1.04	1.02 | 1.05
45	Watertown 345	1.02 | 1.03	1.01 | 1.03	1.02 | 1.03	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	330%	260%	281%	315%	319%	322%
57	K22W (max +dP @ t, d-ang)	0.0@(0.10000,0.0)	0.0@(0.10000,0.0)	0.0@(0.10000,0.0)	26.3@(2.40832,-5.6)	22.1@(3.29164,-4.7)	22.3@(2.39166,-3.4)
58	K22W (max -dP @ t, d-ang)	28.4@(2.05833,11.6)	45.5@(2.20833,19.3)	40.4@(2.20833,17.3)	26.2@(0.61666,9.2)	33.1@(0.59166,10.8)	30.4@(0.59166,10.2)
59	K22W (max d-ang @ t, dP)	11.6@(1.91666,-28.1)	19.6@(2.40832,-44.5)	17.4@(2.34999,-39.9)	13.4@(0.91666,-15.3)	16.2@(0.90833,-15.6)	15.1@(0.90833,-14.7)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	245% / 411%	231% / 388%	254% / 426%	195% / 326%	192% / 321%	213% / 355%
63	G82R at Rugby/L20D at Draytor	999% / 648%	999% / 780%	999% / 840%	999% / 566%	999% / 709%	999% / 763%
64	R50M / F3M	897% / 319%	786% / 316%	846% / 320%	782% / 281%	707% / 285%	759% / 288%
65	B10T	289%	295%	300%	159%	173%	177%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)

Case	MBb-so15aa-pct	w1b-so15aa-pct	w2b-so15aa-pct	MBb-so15aa-pzs	w1b-so15aa-pzs	w2b-so15aa-pzs
Disturbance	pct	pct	pct	pzs	pzs	pzs
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	21	21	21	22	22	22
2	**Case Name**	MBb-so15aa-pzt	w1b-so15aa-pzt	w2b-so15aa-pzt	MBb-so15aa-ya3	w1b-so15aa-ya3	w2b-so15aa-ya3
3	**Disturbance**	pzt	pzt	pzt	ya3	ya3	ya3
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:25	FEB 17 2010 14:55	FEB 17 2010 13:29	MAR 01 2010 11:27	FEB 17 2010 14:56	FEB 17 2010 13:31
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.99 | 1.00	0.99 | 1.00	1.00 | 1.00	1.02 | 1.02	1.00 | 1.01	1.01 | 1.02
35	Boise 115	1.02 | 1.02	1.02 | 1.02	1.02 | 1.02	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04
36	Dorsey 230	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
37	Forbes 230	1.02 | 1.02	1.02 | 1.02	1.02 | 1.02	1.02 | 1.03	1.01 | 1.02	1.01 | 1.03
38	Riverton 230	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	1.02 | 1.02	1.01 | 1.02	1.01 | 1.02
39	Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04
40	Jamestown 345	1.00 | 1.01	1.01 | 1.01	1.00 | 1.01	1.00 | 1.02	1.00 | 1.02	0.99 | 1.01
41	Drayton 230	1.02 | 1.03	1.03 | 1.04	1.03 | 1.03	1.02 | 1.03	1.03 | 1.04	1.03 | 1.04
42	Groton 345	1.02 | 1.02	1.01 | 1.01	1.02 | 1.03	1.01 | 1.02	1.00 | 1.01	1.01 | 1.03
43	Minong 161	1.00 | 1.00	1.01 | 1.02	1.02 | 1.02	0.98 | 0.99	0.98 | 1.01	0.99 | 1.01
44	Wahpeton 115	1.04 | 1.04	1.03 | 1.03	1.03 | 1.03	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04
45	Watertown 345	1.03 | 1.03	1.02 | 1.02	1.02 | 1.03	1.02 | 1.02	1.01 | 1.02	1.01 | 1.02
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	473%	462%	467%	371%	318%	335%
57	K22W (max +dP @ t, d-ang)	0.0@(0.10000,0.0)	0.0@(0.10000,0.0)	0.0@(0.10000,0.0)	4.0@(0.11667,0.7)	4.0@(0.11667,0.7)	4.3@(0.11667,0.7)
58	K22W (max -dP @ t, d-ang)	5.6@(1.61666,2.3)	7.9@(2.09166,3.4)	6.6@(2.10833,2.9)	27.9@(1.63333,12.3)	35.1@(1.69166,16.6)	31.1@(1.66666,14.9)
59	K22W (max d-ang @ t, dP)	2.4@(2.09999,-5.4)	3.4@(2.26666,-7.5)	2.9@(2.24166,-6.4)	12.6@(1.89166,-24.9)	17.3@(2.01666,-32.2)	15.5@(1.97500,-28.1)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	244% / 411%	234% / 392%	254% / 426%
63	G82R at Rugby/L20D at Draytor	999% / 678%	999% / 813%	999% / 871%	999% / 620%	999% / 769%	999% / 829%
64	R50M / F3M	968% / 319%	862% / 316%	915% / 320%	980% / 319%	876% / 316%	925% / 320%
65	B10T	325%	329%	331%	266%	276%	283%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	MBb-so15aa-pzt	w1b-so15aa-pzt	w2b-so15aa-pzt	MBb-so15aa-ya3	w1b-so15aa-ya3	w2b-so15aa-ya3
Disturbance	pzt	pzt	pzt	ya3	ya3	ya3
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	23	23	23	24	24	24
2	**Case Name**	MBb-so15aa-yas	w1b-so15aa-yas	w2b-so15aa-yas	MBb-so15aa-yb3	w1b-so15aa-yb3	w2b-so15aa-yb3
3	**Disturbance**	yas	yas	yas	yb3	yb3	yb3
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:29	FEB 17 2010 14:58	FEB 17 2010 13:33	MAR 01 2010 11:31	FEB 17 2010 15:00	FEB 17 2010 13:35
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.97 | 1.00	0.94 | 0.97	0.94 | 0.98	1.03 | 1.04	1.01 | 1.04	1.01 | 1.04
35	Boise 115	1.02 | 1.04	1.02 | 1.03	1.02 | 1.04	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
36	Dorsey 230	1.04 | 1.06	1.04 | 1.07	1.04 | 1.07	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
37	Forbes 230	1.01 | 1.03	1.00 | 1.02	1.01 | 1.03	1.02 | 1.03	1.01 | 1.02	1.02 | 1.03
38	Riverton 230	1.01 | 1.03	1.00 | 1.02	1.00 | 1.02	1.02 | 1.03	1.02 | 1.02	1.02 | 1.02
39	Coal Creek 230	1.00 | 1.05	0.99 | 1.05	1.00 | 1.05	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04
40	Jamestown 345	0.99 | 1.02	1.00 | 1.02	0.99 | 1.01	1.00 | 1.01	1.00 | 1.02	1.00 | 1.01
41	Drayton 230	1.02 | 1.04	1.03 | 1.04	1.03 | 1.04	1.02 | 1.03	1.03 | 1.04	1.03 | 1.04
42	Groton 345	1.01 | 1.02	1.00 | 1.01	1.01 | 1.03	1.01 | 1.02	1.00 | 1.01	1.02 | 1.03
43	Minong 161	0.97 | 1.01	0.95 | 1.02	0.96 | 1.03	0.98 | 1.01	0.97 | 1.00	0.97 | 1.00
44	Wahpeton 115	1.03 | 1.04	1.02 | 1.03	1.02 | 1.04	1.03 | 1.04	1.02 | 1.03	1.03 | 1.03
45	Watertown 345	1.02 | 1.03	1.01 | 1.02	1.02 | 1.02	1.02 | 1.03	1.02 | 1.02	1.02 | 1.02
46	**Dynamic Voltage Warnings**						
47		none			none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	424%	384%	399%	405%	374%	384%
57	K22W (max +dP @ t, d-ang)	2.4@(0.11667,0.3)	2.7@(0.11667,0.4)	2.8@(0.11667,0.4)	2.6@(0.10833,0.4)	2.6@(0.10833,0.5)	2.8@(0.11667,0.5)
58	K22W (max -dP @ t, d-ang)	23.8@(1.60000,9.6)	30.4@(1.63333,13.4)	26.4@(1.65000,11.9)	20.6@(1.59166,8.6)	25.6@(1.64166,11.7)	22.6@(1.61666,10.5)
59	K22W (max d-ang @ t, dP)	10.3@(1.03333,-14.5)	13.9@(1.92500,-26.5)	12.2@(1.90000,-23.2)	8.9@(1.85000,-18.0)	12.2@(1.95000,-23.0)	10.9@(1.90833,-20.1)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	240% / 403%	234% / 392%	254% / 426%	245% / 412%	234% / 392%	254% / 426%
63	G82R at Rugby/L20D at Draytor	999% / 630%	999% / 774%	999% / 836%	999% / 636%	999% / 781%	999% / 842%
64	R50M / F3M	965% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
65	B10T	269%	283%	288%	206%	290%	296%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	MBb-so15aa-yas	w1b-so15aa-yas	w2b-so15aa-yas	MBb-so15aa-yb3	w1b-so15aa-yb3	w2b-so15aa-yb3
Disturbance	yas	yas	yas	yb3	yb3	yb3
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	25	25	25	26	26	26
2	**Case Name**	MBb-so15aa-h13	w1b-so15aa-h13	w2b-so15aa-h13	MBb-so15aa-h23	w1b-so15aa-h23	w2b-so15aa-h23
3	**Disturbance**	h13	h13	h13	h23	h23	h23
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:32	FEB 17 2010 15:02	FEB 17 2010 13:37	MAR 01 2010 11:34	FEB 17 2010 15:04	FEB 17 2010 13:39
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.99 | 1.01	0.99 | 1.02	0.99 | 1.02	1.02 | 1.04	1.01 | 1.05	1.01 | 1.05
35	Boise 115	1.01 | 1.02	1.00 | 1.02	1.00 | 1.02	1.02 | 1.03	1.00 | 1.03	1.01 | 1.03
36	Dorsey 230	1.03 | 1.05	1.00 | 1.05	1.01 | 1.05	1.04 | 1.06	1.03 | 1.07	1.03 | 1.06
37	Forbes 230	1.01 | 1.03	1.01 | 1.02	1.01 | 1.03	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04
38	Riverton 230	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	1.04 | 1.05	1.04 | 1.05	1.03 | 1.05
39	Coal Creek 230	1.03 | 1.05	1.02 | 1.07	1.02 | 1.06	1.03 | 1.05	1.03 | 1.06	1.02 | 1.06
40	Jamestown 345	0.99 | 1.01	0.98 | 1.02	0.98 | 1.01	0.99 | 1.02	0.99 | 1.04	0.98 | 1.03
41	Drayton 230	1.02 | 1.03	1.01 | 1.04	1.01 | 1.04	1.04 | 1.06	1.03 | 1.06	1.03 | 1.06
42	Groton 345	1.01 | 1.03	1.00 | 1.03	1.01 | 1.04	1.01 | 1.04	1.00 | 1.04	1.01 | 1.05
43	Minong 161	1.00 | 1.02	1.01 | 1.04	1.01 | 1.04	1.03 | 1.05	1.04 | 1.08	1.04 | 1.08
44	Wahpeton 115	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04	1.03 | 1.05	1.04 | 1.06	1.03 | 1.05
45	Watertown 345	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03	1.03 | 1.04	1.02 | 1.04	1.03 | 1.05
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	475%	459%	472%	477%	463%	463%
57	K22W (max +dP @ t, d-ang)	105.2@(0.15833,-2.4)	102.8@(0.15000,-2.2)	102.3@(0.15000,-2.1)	114.8@(1.32500,-31.4)	106.1@(1.27500,-30.9)	102.3@(0.15000,-2.1)
58	K22W (max -dP @ t, d-ang)	18.8@(0.84166,-4.3)	20.8@(2.96665,5.1)	18.1@(2.94165,3.8)	0.0@(-0.01667,0.0)	0.0@(0.01667,0.0)	0.0@(0.02500,0.0)
59	K22W (max d-ang @ t, dP)	-6.2@(0.64166,2.9)	-8.2@(0.65833,0.1)	-7.3@(0.65000,0.5)	-38.8@(4.99995,67.7)	-37.0@(4.99995,56.1)	-34.8@(4.99995,51.1)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	232% / 389%	222% / 371%	241% / 405%	246% / 413%	234% / 392%	254% / 426%
63	G82R at Rugby/L20D at Draytor	999% / 618%	999% / 762%	999% / 807%	999% / 687%	999% / 823%	999% / 881%
64	R50M / F3M	894% / 264%	786% / 253%	831% / 261%	980% / 245%	876% / 235%	925% / 245%
65	B10T	282%	286%	277%	315%	283%	271%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-h13	w1b-so15aa-h13	w2b-so15aa-h13	MBb-so15aa-h23	w1b-so15aa-h23	w2b-so15aa-h23
Disturbance	h13	h13	h13	h23	h23	h23
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	27	27	28	28	29	29
2	**Case Name**	w1b-so15aa-h7d	w2b-so15aa-h7d	w1b-so15aa-he0	w2b-so15aa-he0	w1b-so15aa-hl0	w2b-so15aa-hl0
3	**Disturbance**	h7d	h7d	he0	he0	hl0	hl0
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	FEB 17 2010 15:06	FEB 17 2010 13:41	FEB 17 2010 15:08	FEB 17 2010 13:43	FEB 17 2010 15:10	FEB 17 2010 13:45
6	**Comments**	Option W.1	Option W.2	Option W.1	Option W.2	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2670 / 243	2438 / 244	2670 / 243	2438 / 244	2670 / 243	2438 / 244
10	MHEX / L20D	2167 / 253	2064 / 239	2167 / 253	2064 / 239	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	805 / 32	787 / 24	805 / 32	787 / 24	805 / 32	787 / 24
12	MWEX / AHD-SLK	1653 / 648	1627 / 648	1653 / 648	1627 / 648	1653 / 648	1627 / 648
13	D602F / F601C	1805 / 1495	1738 / 1430	1805 / 1495	1738 / 1430	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	165 / 60	165 / 60	165 / 60	165 / 60	165 / 60	165 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196
16	R50M / OH>MP	148 / 150	143 / 150	148 / 150	143 / 150	148 / 150	143 / 150
17	G82R	-40	-58	-40	-58	-40	-58
18	Dorsey bipole / CU bipole	3213 / 1104	3214 / 1103	3213 / 1104	3214 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	589 / -15	604 / 35	589 / -15	604 / 35	589 / -15	604 / 35
20	Forbes SVC / MSC	39 / 600	28 / 600	39 / 600	28 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.036 / 1.045	1.037 / 1.045	1.036 / 1.045	1.037 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.025 / 1.014	1.025 / 1.019	1.025 / 1.014	1.025 / 1.019	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.013 / 0.988	1.016 / 0.996	1.013 / 0.988	1.016 / 0.996	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.016 / 1.030	1.019 / 1.031	1.016 / 1.030	1.019 / 1.031	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.033 / 1.012	1.033 / 1.025	1.033 / 1.012	1.033 / 1.025	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	234% / 392%	254% / 426%	234% / 392%	254% / 426%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 823%	999% / 881%	999% / 823%	999% / 881%	999% / 823%	999% / 881%
31	R50M/F3M	876% / 316%	925% / 320%	876% / 316%	925% / 320%	876% / 316%	925% / 320%
32	B10T	343%	343%	343%	343%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	1.01 | 1.05	1.01 | 1.04	1.01 | 1.05	1.01 | 1.05	1.00 | 1.05	1.01 | 1.05
35	Boise 115	0.99 | 1.02	1.00 | 1.02	1.00 | 1.03	1.01 | 1.03	1.00 | 1.03	1.01 | 1.03
36	Dorsey 230	1.03 | 1.07	1.03 | 1.07	1.03 | 1.14	1.03 | 1.15	1.03 | 1.14	1.03 | 1.16
37	Forbes 230	1.01 | 1.03	1.01 | 1.03	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04
38	Riverton 230	1.03 | 1.05	1.03 | 1.05	1.04 | 1.06	1.03 | 1.05	1.04 | 1.06	1.03 | 1.05
39	Coal Creek 230	1.03 | 1.06	1.02 | 1.06	1.03 | 1.07	1.03 | 1.06	1.03 | 1.07	1.03 | 1.06
40	Jamestown 345	0.96 | 1.02	0.96 | 1.03	0.98 | 1.03	0.98 | 1.02	0.98 | 1.03	0.98 | 1.02
41	Drayton 230	1.01 | 1.04	1.01 | 1.05	1.03 | 1.08	1.04 | 1.10	1.03 | 1.08	1.04 | 1.10
42	Groton 345	1.00 | 1.05	1.00 | 1.06	1.00 | 1.05	1.01 | 1.05	1.00 | 1.05	1.01 | 1.05
43	Minong 161	1.04 | 1.08	1.04 | 1.08	1.03 | 1.08	1.03 | 1.08	1.03 | 1.08	1.03 | 1.08
44	Wahpeton 115	1.03 | 1.06	1.03 | 1.06	1.04 | 1.07	1.04 | 1.06	1.04 | 1.07	1.04 | 1.06
45	Watertown 345	1.02 | 1.05	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	507%	502%	375%	384%	375%	384%
57	K22W (max +dP @ t, d-ang)	102.8@(0.15000,-2.2)	102.3@(0.15000,-2.1)	88.4@(1.55833,-31.8)	87.3@(1.54166,-31.2)	89.3@(1.55833,-32.0)	88.2@(1.54166,-31.4)
58	K22W (max -dP @ t, d-ang)	3.9@(0.25000,0.2)	7.6@(0.25000,0.4)	61.3@(0.40833,7.4)	64.7@(0.40833,7.5)	61.6@(0.40833,7.5)	65.0@(0.40833,7.5)
59	K22W (max d-ang @ t, dP)	-38.4@(4.99995,44.2)	-40.3@(4.99995,45.4)	-37.7@(4.99995,38.7)	-38.9@(4.99995,38.9)	-37.9@(4.99995,39.1)	-39.1@(4.99995,39.3)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	200% / 337%	218% / 367%	41% / 57%	55% / 80%	41% / 57%	55% / 80%
63	G82R at Rugby/L20D at Draytor	999% / 562%	999% / 600%	999% / 297%	999% / 342%	999% / 297%	999% / 342%
64	R50M / F3M	815% / 220%	880% / 224%	418% / 198%	463% / 212%	418% / 198%	463% / 212%
65	B10T	167%	155%	118%	119%	119%	121%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 1 | 0) / (1 | 2 | 2)	(0 | 1 | 0) / (1 | 2 | 2)	(0 | 1 | 0) / (1 | 2 | 2)	(0 | 1 | 0) / (1 | 2 | 2)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)

Case	w1b-so15aa-h7d	w2b-so15aa-h7d	w1b-so15aa-he0	w2b-so15aa-he0	w1b-so15aa-hl0	w2b-so15aa-hl0
Disturbance	h7d	h7d	he0	he0	hl0	hl0
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping			5		5	

Table D-1: Stability Analysis Results

1	**Case No.**	30	30	30	31	31	31
2	**Case Name**	MBb-so15aa-h33	w1b-so15aa-h33	w2b-so15aa-h33	MBb-so15aa-h43	w1b-so15aa-h43	w2b-so15aa-h43
3	**Disturbance**	h33	h33	h33	h43	h43	h43
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	MAR 01 2010 11:36	FEB 17 2010 15:12	FEB 17 2010 13:47	MAR 01 2010 11:39	FEB 17 2010 15:15	FEB 17 2010 13:49
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	1.03 | 1.08	1.03 | 1.08	1.03 | 1.08	0.99 | 1.01	0.99 | 1.01	0.99 | 1.02
35	Boise 115	0.91 | 1.02	0.93 | 1.02	0.94 | 1.02	1.01 | 1.02	0.99 | 1.01	1.00 | 1.01
36	Dorsey 230	1.05 | 1.07	1.05 | 1.08	1.05 | 1.08	1.02 | 1.04	1.00 | 1.04	1.00 | 1.04
37	Forbes 230	1.05 | 1.08	1.05 | 1.08	1.04 | 1.07	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
38	Riverton 230	1.02 | 1.06	1.01 | 1.05	1.01 | 1.05	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
39	Coal Creek 230	1.01 | 1.08	1.01 | 1.08	1.01 | 1.07	1.03 | 1.05	1.02 | 1.06	1.02 | 1.06
40	Jamestown 345	0.93 | 1.02	0.96 | 1.03	0.96 | 1.02	0.99 | 1.01	0.98 | 1.01	0.98 | 1.01
41	Drayton 230	0.97 | 1.06	1.00 | 1.05	1.01 | 1.05	1.01 | 1.02	1.01 | 1.03	1.01 | 1.03
42	Groton 345	0.98 | 1.04	0.98 | 1.03	0.99 | 1.04	1.01 | 1.03	1.00 | 1.03	1.01 | 1.04
43	Minong 161	1.04 | 1.08	1.05 | 1.10	1.05 | 1.11	1.00 | 1.02	1.01 | 1.04	1.01 | 1.04
44	Wahpeton 115	0.98 | 1.05	1.00 | 1.05	1.00 | 1.04	1.03 | 1.04	1.02 | 1.03	1.02 | 1.03
45	Watertown 345	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	507%	507%	507%	485%	477%	487%
57	K22W (max +dP @ t, d-ang)	98.5@(0.15000,-2.0)	96.5@(1.90000,-51.0)	94.9@(0.15000,-1.7)	98.5@(0.15000,-2.0)	95.3@(0.15000,-1.7)	94.9@(0.15000,-1.7)
58	K22W (max -dP @ t, d-ang)	44.2@(0.27500,2.9)	25.5@(0.25000,1.2)	24.0@(0.24167,1.1)	24.5@(2.19999,5.1)	33.7@(2.94998,8.5)	31.3@(2.92498,7.2)
59	K22W (max d-ang @ t, dP)	-55.1@(4.99995,39.7)	-59.0@(4.99995,45.8)	-56.1@(4.99995,40.6)	6.1@(2.58332,-14.2)	8.8@(2.72499,-27.9)	7.3@(2.74998,-27.3)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	0.18333 sec / 0.18333 sec	0.18333 sec / 0.18333 sec	0.18333 sec / 0.18333 sec	239% / 399%	222% / 370%	244% / 407%
63	G82R at Rugby/L20D at Draytor	999% / 405%	999% / 689%	999% / 727%	999% / 566%	999% / 645%	999% / 679%
64	R50M / F3M	359% / 117%	432% / 145%	448% / 147%	790% / 263%	644% / 251%	681% / 259%
65	B10T	150%	235%	206%	275%	265%	256%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 3 | 2)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	MBb-so15aa-h33	w1b-so15aa-h33	w2b-so15aa-h33	MBb-so15aa-h43	w1b-so15aa-h43	w2b-so15aa-h43
Disturbance	h33	h33	h33	h43	h43	h43
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping	(5T)(6T)	(5T)(6T)	(5T)(6T)			

Table D-1: Stability Analysis Results

1	**Case No.**	32	32	33	33	34
2	**Case Name**	w1b-so15aa-h83	w2b-so15aa-h83	w1b-so15aa-hmd	w2b-so15aa-hmd	w2b-so15aa-w63
3	**Disturbance**	h83	h83	hmd	hmd	w63
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	FEB 17 2010 15:16	FEB 17 2010 13:52	FEB 17 2010 15:18	FEB 17 2010 13:54	MAR 01 2010 12:18
6	**Comments**	Option W.1	Option W.2	Option W.1	Option W.2	Option W.2
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2670 / 243	2438 / 244	2670 / 243	2438 / 244	2438 / 244
10	MHEX / L20D	2167 / 253	2064 / 239	2167 / 253	2064 / 239	2064 / 239
11	ECL-ARP / PRI-BYN	805 / 32	787 / 24	805 / 32	787 / 24	787 / 24
12	MWEX / AHD-SLK	1653 / 648	1627 / 648	1653 / 648	1627 / 648	1627 / 648
13	D602F / F601C	1805 / 1495	1738 / 1430	1805 / 1495	1738 / 1430	1738 / 1430
14	B10T / MH>SPC	165 / 60	165 / 60	165 / 60	165 / 60	165 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196
16	R50M / OH>MP	148 / 150	143 / 150	148 / 150	143 / 150	143 / 150
17	G82R	-40	-58	-40	-58	-58
18	Dorsey bipole / CU bipole	3213 / 1104	3214 / 1103	3213 / 1104	3214 / 1103	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	589 / -15	604 / 35	589 / -15	604 / 35	604 / 35
20	Forbes SVC / MSC	39 / 600	28 / 600	39 / 600	28 / 600	28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.036 / 1.045	1.037 / 1.045	1.036 / 1.045	1.037 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.025 / 1.014	1.025 / 1.019	1.025 / 1.014	1.025 / 1.019	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.013 / 0.988	1.016 / 0.996	1.013 / 0.988	1.016 / 0.996	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.016 / 1.030	1.019 / 1.031	1.016 / 1.030	1.019 / 1.031	1.019 / 1.031
27	Drayton 230/Groton 345	1.033 / 1.012	1.033 / 1.025	1.033 / 1.012	1.033 / 1.025	1.033 / 1.025
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	234% / 392%	254% / 426%	234% / 392%	254% / 426%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 823%	999% / 881%	999% / 823%	999% / 881%	999% / 881%
31	R50M/F3M	876% / 316%	925% / 320%	876% / 316%	925% / 320%	925% / 320%
32	B10T	343%	343%	343%	343%	343%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.97 | 1.00	0.97 | 1.01	0.98 | 1.04	0.98 | 1.05	0.94 | 1.00
35	Boise 115	1.01 | 1.02	1.01 | 1.02	0.99 | 1.02	0.99 | 1.02	1.00 | 1.02
36	Dorsey 230	1.03 | 1.05	1.03 | 1.05	1.03 | 1.07	1.04 | 1.07	1.03 | 1.05
37	Forbes 230	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.04	1.00 | 1.02
38	Riverton 230	1.01 | 1.03	1.01 | 1.04	1.02 | 1.05	1.01 | 1.05	0.99 | 1.02
39	Coal Creek 230	0.99 | 1.07	0.99 | 1.08	1.00 | 1.08	0.99 | 1.08	0.98 | 1.06
40	Jamestown 345	0.98 | 1.03	0.95 | 1.03	0.95 | 1.03	0.94 | 1.03	0.97 | 1.02
41	Drayton 230	1.02 | 1.04	1.02 | 1.04	1.01 | 1.05	1.02 | 1.07	1.01 | 1.04
42	Groton 345	0.99 | 1.02	1.00 | 1.04	0.99 | 1.05	0.99 | 1.06	0.96 | 1.01
43	Minong 161	0.99 | 1.03	0.99 | 1.03	1.01 | 1.08	1.00 | 1.08	0.96 | 1.04
44	Wahpeton 115	1.01 | 1.04	1.01 | 1.05	1.02 | 1.06	1.02 | 1.07	1.00 | 1.03
45	Watertown 345	1.01 | 1.03	1.01 | 1.03	1.02 | 1.05	1.02 | 1.06	0.99 | 1.03
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping					
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	451%	454%	507%	502%	447%
57	K22W (max +dP @ t, d-ang)	30.0@(0.11667,0.4)	28.9@(0.11667,0.5)	88.5@(2.05833,-33.3)	95.0@(2.08333,-35.4)	28.9@(0.11667,0.5)
58	K22W (max -dP @ t, d-ang)	34.4@(0.28333,4.8)	39.1@(0.29167,5.5)	55.6@(0.27500,6.1)	60.5@(0.27500,6.7)	47.2@(0.30000,6.6)
59	K22W (max d-ang @ t, dP)	6.7@(0.55000,-2.3)	8.7@(0.62500,-4.8)	-36.2@(4.99995,42.3)	-38.2@(4.99995,42.7)	14.9@(0.83333,-19.8)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	185% / 311%	195% / 327%	148% / 251%	164% / 279%	166% / 277%
63	G82R at Rugby/L20D at Draytor	999% / 695%	999% / 642%	999% / 449%	999% / 494%	999% / 711%
64	R50M / F3M	703% / 301%	715% / 289%	613% / 222%	645% / 225%	660% / 295%
65	B10T	252%	202%	133%	110%	182%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 2 | 2) / (0 | 0 | 0)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)

Case	w1b-so15aa-h83	w2b-so15aa-h83	w1b-so15aa-hmd	w2b-so15aa-hmd	w2b-so15aa-w63
Disturbance	h83	h83	hmd	hmd	w63
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table D-1: Stability Analysis Results

1	**Case No.**	35	35	36	36	36
2	**Case Name**	w1b-so15aa-ho0	w2b-so15aa-ho0	mbb-so15aa-h93	w1b-so15aa-h93	w2b-so15aa-h93
3	**Disturbance**	ho0	ho0	h93	h93	h93
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	FEB 17 2010 15:20	FEB 17 2010 13:56	APR 08 2010 11:49	FEB 17 2010 15:22	FEB 17 2010 13:58
6	**Comments**	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	1.00 | 1.05	1.00 | 1.05	0.98 | 1.01	0.96 | 1.01	0.96 | 1.01
35	Boise 115	0.99 | 1.04	0.99 | 1.04	1.01 | 1.03	1.00 | 1.02	1.00 | 1.02
36	Dorsey 230	1.04 | 1.16	1.04 | 1.16	1.04 | 1.05	1.03 | 1.05	1.03 | 1.05
37	Forbes 230	1.01 | 1.05	1.01 | 1.05	1.02 | 1.03	1.01 | 1.02	1.01 | 1.03
38	Riverton 230	1.04 | 1.06	1.04 | 1.05	1.01 | 1.03	1.00 | 1.02	0.99 | 1.02
39	Coal Creek 230	1.01 | 1.08	1.01 | 1.07	1.00 | 1.06	0.98 | 1.07	0.99 | 1.07
40	Jamestown 345	0.98 | 1.03	1.00 | 1.04	0.99 | 1.03	0.97 | 1.02	0.97 | 1.02
41	Drayton 230	1.03 | 1.11	1.03 | 1.11	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04
42	Groton 345	1.00 | 1.05	1.00 | 1.05	1.00 | 1.02	0.98 | 1.02	0.99 | 1.03
43	Minong 161	1.02 | 1.08	1.01 | 1.08	0.98 | 1.02	0.98 | 1.05	0.98 | 1.05
44	Wahpeton 115	1.05 | 1.07	1.04 | 1.06	1.02 | 1.04	1.00 | 1.03	1.00 | 1.03
45	Watertown 345	1.02 | 1.05	1.02 | 1.05	1.01 | 1.03	1.01 | 1.02	1.00 | 1.03
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping					
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133		/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	465%	483%	472%	463%	471%
57	K22W (max +dP @ t, d-ang)	88.7@(2.14999,-34.1)	87.3@(2.18333,-33.3)	5.5@(2.25833,-0.1)	28.0@(0.11667,0.5)	23.8@(0.11667,0.5)
58	K22W (max -dP @ t, d-ang)	42.8@(0.39166,4.8)	43.0@(0.40833,4.9)	9.9@(0.23333,1.0)	37.4@(0.29167,5.3)	35.9@(0.28333,4.9)
59	K22W (max d-ang @ t, dP)	-36.1@(4.99995,43.6)	-36.3@(4.99995,41.8)	4.8@(0.85000,-6.3)	8.4@(0.60833,-4.3)	8.9@(0.68333,-6.4)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	170% / 288%	189% / 321%	215% / 361%	178% / 299%	194% / 325%
63	G82R at Rugby/L20D at Draytor	999% / 518%	999% / 616%	999% / 687%	999% / 723%	999% / 799%
64	R50M / F3M	682% / 220%	734% / 225%	883% / 301%	686% / 293%	743% / 290%
65	B10T	139%	137%	279%	300%	232%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 2) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 3 | 2) / (1 | 1 | 1)	(1 | 3 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)

Case	w1b-so15aa-ho0	w2b-so15aa-ho0	mbb-so15aa-h93	w1b-so15aa-h93	w2b-so15aa-h93
Disturbance	ho0	ho0	h93	h93	h93
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table D-1: Stability Analysis Results

1	**Case No.**	37	37	37	38	38	38
2	**Case Name**	mbb-so15aa-hks	w1b-so15aa-hks	w2b-so15aa-hks	mbb-so15aa-o2s	w1b-so15aa-o2s	w2b-so15aa-o2s
3	**Disturbance**	hks	hks	hks	o2s	o2s	o2s
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	APR 08 2010 11:54	FEB 17 2010 15:24	FEB 17 2010 14:00	APR 08 2010 11:20	FEB 18 2010 8:28	FEB 18 2010 8:30
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	1.00 | 1.03	0.99 | 1.01	0.99 | 1.01	1.00 | 1.03	0.97 | 1.00	0.98 | 1.00
35	Boise 115	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03
36	Dorsey 230	1.04 | 1.06	1.03 | 1.12	1.03 | 1.10	1.04 | 1.05	1.04 | 1.06	1.04 | 1.06
37	Forbes 230	1.02 | 1.04	1.01 | 1.05	1.02 | 1.05	1.02 | 1.04	1.01 | 1.03	1.01 | 1.04
38	Riverton 230	1.03 | 1.05	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04	1.02 | 1.03	1.02 | 1.03
39	Coal Creek 230	0.99 | 1.10	1.01 | 1.08	1.00 | 1.08	1.00 | 1.05	1.00 | 1.05	1.00 | 1.05
40	Jamestown 345	0.97 | 1.05	1.00 | 1.04	1.00 | 1.03	1.00 | 1.01	1.00 | 1.02	1.00 | 1.01
41	Drayton 230	1.02 | 1.09	1.03 | 1.13	1.03 | 1.12	1.02 | 1.04	1.03 | 1.04	1.03 | 1.04
42	Groton 345	1.00 | 1.04	1.00 | 1.03	1.02 | 1.04	1.02 | 1.03	1.01 | 1.02	1.02 | 1.03
43	Minong 161	1.00 | 1.03	1.01 | 1.03	1.01 | 1.04	1.01 | 1.05	0.99 | 1.03	0.99 | 1.03
44	Wahpeton 115	1.03 | 1.07	1.03 | 1.06	1.03 | 1.06	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
45	Watertown 345	1.02 | 1.04	1.02 | 1.03	1.02 | 1.04	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
46	**Dynamic Voltage Warnings**						
47		none		none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold		/ 0.133	/ 0.133			
56	Forbes DC Red (DCAR)	395%	427%	431%	422%	436%	441%
57	K22W (max +dP @ t, d-ang)	12.8@(2.25833,-2.2)	9.6@(0.11667,0.2)	12.6@(2.15833,-2.1)	13.4@(2.34166,-2.9)	10.2@(3.24164,-1.8)	7.9@(3.25831,-1.3)
58	K22W (max -dP @ t, d-ang)	10.9@(0.39166,1.8)	31.0@(0.38333,3.8)	26.1@(0.38333,3.3)	12.3@(0.58333,4.6)	17.2@(0.36667,2.8)	18.8@(0.36667,3.0)
59	K22W (max d-ang @ t, dP)	4.0@(0.83333,-5.1)	3.8@(0.38333,-30.7)	3.4@(0.61666,1.5)	6.5@(0.86666,-7.1)	8.1@(0.86666,-7.2)	8.5@(0.86666,-8.3)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	218% / 367%	183% / 304%	211% / 352%	215% / 360%	208% / 349%	222% / 371%
63	G82R at Rugby/L20D at Draytor	999% / 531%	999% / 618%	999% / 681%	999% / 643%	999% / 779%	999% / 832%
64	R50M / F3M	887% / 291%	730% / 305%	799% / 302%	864% / 294%	780% / 298%	812% / 301%
65	B10T	225%	254%	244%	247%	194%	257%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 1 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)

Case	mbb-so15aa-hks	w1b-so15aa-hks	w2b-so15aa-hks	mbb-so15aa-o2s	w1b-so15aa-o2s	w2b-so15aa-o2s
Disturbance	hks	hks	hks	o2s	o2s	o2s
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	39	39	39	40	40	40
2	**Case Name**	mbb-so15aa-o3s	w1b-so15aa-o3s	w2b-so15aa-o3s	mbb-so15aa-o4s	w1b-so15aa-o4s	w2b-so15aa-o4s
3	**Disturbance**	o3s	o3s	o3s	o4s	o4s	o4s
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	APR 08 2010 11:23	FEB 17 2010 15:28	FEB 17 2010 14:04	APR 08 2010 11:26	FEB 17 2010 15:31	FEB 17 2010 15:36
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.98 | 1.00	0.99 | 1.00	0.99 | 1.00	0.99 | 1.01	0.99 | 1.01	1.00 | 1.01
35	Boise 115	1.01 | 1.02	1.00 | 1.02	1.01 | 1.02	1.01 | 1.03	1.01 | 1.02	1.01 | 1.02
36	Dorsey 230	1.04 | 1.05	1.02 | 1.07	1.03 | 1.06	1.04 | 1.05	1.02 | 1.07	1.03 | 1.07
37	Forbes 230	1.02 | 1.02	1.01 | 1.03	1.02 | 1.03	1.02 | 1.03	1.01 | 1.03	1.02 | 1.03
38	Riverton 230	1.02 | 1.03	1.02 | 1.03	1.01 | 1.02	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
39	Coal Creek 230	1.00 | 1.05	1.01 | 1.04	1.01 | 1.04	1.00 | 1.08	1.02 | 1.06	1.01 | 1.06
40	Jamestown 345	1.03 | 1.07	1.04 | 1.06	1.04 | 1.06	0.99 | 1.04	1.00 | 1.03	0.99 | 1.02
41	Drayton 230	1.03 | 1.08	1.03 | 1.08	1.04 | 1.07	1.02 | 1.08	1.03 | 1.07	1.04 | 1.07
42	Groton 345	0.99 | 1.01	0.99 | 1.00	1.00 | 1.01	1.01 | 1.03	1.00 | 1.02	1.02 | 1.04
43	Minong 161	0.99 | 1.01	1.01 | 1.03	1.01 | 1.03	0.99 | 1.02	1.01 | 1.03	1.02 | 1.03
44	Wahpeton 115	1.02 | 1.05	1.02 | 1.03	1.02 | 1.03	1.03 | 1.06	1.04 | 1.05	1.04 | 1.05
45	Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold		/ 0.133	/ 0.150		/ 0.133	/ 0.150
56	Forbes DC Red (DCAR)	488%	488%	496%	444%	460%	457%
57	K22W (max +dP @ t, d-ang)	1.5@(0.10833,0.1)	8.2@(0.11667,0.1)	6.4@(0.11667,0.1)	7.6@(2.22499,-1.0)	8.2@(0.11667,0.1)	8.3@(2.14166,-1.5)
58	K22W (max -dP @ t, d-ang)	6.6@(1.00000,2.2)	24.3@(0.35000,2.7)	21.6@(0.35000,2.5)	6.8@(0.35833,1.1)	24.8@(0.35000,2.6)	20.3@(0.35000,2.3)
59	K22W (max d-ang @ t, dP)	2.2@(0.97500,-6.6)	2.8@(0.33333,-17.7)	2.5@(0.38333,-17.3)	2.6@(0.81666,-3.1)	2.6@(0.37500,-21.8)	2.5@(0.59166,0.3)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	216% / 363%	183% / 306%	205% / 343%	229% / 385%	192% / 321%	220% / 367%
63	G82R at Rugby/L20D at Draytor	999% / 611%	999% / 680%	999% / 746%	999% / 628%	999% / 652%	999% / 733%
64	R50M / F3M	885% / 298%	738% / 297%	792% / 298%	923% / 301%	754% / 305%	824% / 306%
65	B10T	337%	343%	343%	258%	268%	270%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 3) / (0 | 1 | 1)	(1 | 4 | 3) / (0 | 1 | 1)	(1 | 4 | 3) / (0 | 1 | 1)	(1 | 4 | 1) / (0 | 1 | 1)	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 3 | 2) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 3 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 1 | 1)

Case	mbb-so15aa-o3s	w1b-so15aa-o3s	w2b-so15aa-o3s	mbb-so15aa-o4s	w1b-so15aa-o4s	w2b-so15aa-o4s
Disturbance	o3s	o3s	o3s	o4s	o4s	o4s
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	41	42	43	44	45	46
2	**Case Name**	w1b-so15aa-w13	w2b-so15aa-w23	w2b-so15aa-w33	w2b-so15aa-w43	w2b-so15aa-w53	w2b-so15aa-w2s
3	**Disturbance**	w13	w23	w33	w43	w53	w2s
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	FEB 17 2010 15:34	FEB 17 2010 15:47	FEB 17 2010 15:38	FEB 17 2010 15:49	FEB 17 2010 15:53	FEB 17 2010 15:55
6	**Comments**	Option W.1	Option W.2	Option W.2	Option W.2	Option W.2	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2670 / 243	2438 / 244	2438 / 244	2438 / 244	2438 / 244	2438 / 244
10	MHEX / L20D	2167 / 253	2064 / 239	2064 / 239	2064 / 239	2064 / 239	2064 / 239
11	ECL-ARP / PRI-BYN	805 / 32	787 / 24	787 / 24	787 / 24	787 / 24	787 / 24
12	MWEX / AHD-SLK	1653 / 648	1627 / 648	1627 / 648	1627 / 648	1627 / 648	1627 / 648
13	D602F / F601C	1805 / 1495	1738 / 1430	1738 / 1430	1738 / 1430	1738 / 1430	1738 / 1430
14	B10T / MH>SPC	165 / 60	165 / 60	165 / 60	165 / 60	165 / 60	165 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196
16	R50M / OH>MP	148 / 150	143 / 150	143 / 150	143 / 150	143 / 150	143 / 150
17	G82R	-40	-58	-58	-58	-58	-58
18	Dorsey bipole / CU bipole	3213 / 1104	3214 / 1103	3214 / 1103	3214 / 1103	3214 / 1103	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	589 / -15	604 / 35	604 / 35	604 / 35	604 / 35	604 / 35
20	Forbes SVC / MSC	39 / 600	28 / 600	28 / 600	28 / 600	28 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.036 / 1.045	1.037 / 1.045	1.037 / 1.045	1.037 / 1.045	1.037 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.025 / 1.014	1.025 / 1.019	1.025 / 1.019	1.025 / 1.019	1.025 / 1.019	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.013 / 0.988	1.016 / 0.996	1.016 / 0.996	1.016 / 0.996	1.016 / 0.996	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.016 / 1.030	1.019 / 1.031	1.019 / 1.031	1.019 / 1.031	1.019 / 1.031	1.019 / 1.031
27	Drayton 230/Groton 345	1.033 / 1.012	1.033 / 1.025	1.033 / 1.025	1.033 / 1.025	1.033 / 1.025	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	234% / 392%	254% / 426%	254% / 426%	254% / 426%	254% / 426%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 823%	999% / 881%	999% / 881%	999% / 881%	999% / 881%	999% / 881%
31	R50M/F3M	876% / 316%	925% / 320%	925% / 320%	925% / 320%	925% / 320%	925% / 320%
32	B10T	343%	343%	343%	343%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.93 | 1.00	0.95 | 1.00	0.97 | 1.02	0.96 | 1.02	0.96 | 1.02	0.99 | 1.00
35	Boise 115	0.99 | 1.00	1.00 | 1.02	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	1.01 | 1.02
36	Dorsey 230	1.02 | 1.05	1.03 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.06
37	Forbes 230	0.98 | 1.01	1.01 | 1.02	1.02 | 1.03	1.01 | 1.03	1.02 | 1.04	1.02 | 1.03
38	Riverton 230	0.97 | 1.00	0.99 | 1.02	1.01 | 1.03	1.00 | 1.03	1.00 | 1.03	1.02 | 1.03
39	Coal Creek 230	0.98 | 1.06	0.99 | 1.06	0.99 | 1.06	0.99 | 1.06	0.99 | 1.06	1.01 | 1.05
40	Jamestown 345	0.99 | 1.03	0.98 | 1.02	0.98 | 1.01	0.97 | 1.01	0.97 | 1.01	1.00 | 1.02
41	Drayton 230	1.01 | 1.03	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04	1.03 | 1.04
42	Groton 345	0.97 | 1.00	0.96 | 1.01	0.99 | 1.04	0.99 | 1.04	0.99 | 1.04	1.02 | 1.04
43	Minong 161	0.97 | 1.04	0.97 | 1.04	0.98 | 1.06	0.98 | 1.06	0.98 | 1.06	1.01 | 1.03
44	Wahpeton 115	0.98 | 1.01	1.00 | 1.03	1.01 | 1.04	1.00 | 1.04	1.01 | 1.04	1.03 | 1.04
45	Watertown 345	1.00 | 1.01	0.98 | 1.02	1.00 | 1.03	1.00 | 1.03	0.99 | 1.03	1.02 | 1.03
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133	
56	Forbes DC Red (DCAR)	507%	444%	424%	434%	414%	491%
57	K22W (max +dP @ t, d-ang)	28.0@(0.11667,0.5)	12.5@(0.11667,0.6)	13.2@(3.24164,-3.2)	12.8@(3.24998,-3.0)	15.3@(3.24998,-3.7)	6.5@(2.19166,-1.0)
58	K22W (max -dP @ t, d-ang)	45.9@(0.29167,6.2)	39.0@(1.60833,10.3)	28.8@(0.26667,3.6)	30.6@(0.26667,3.8)	29.1@(0.26667,3.7)	17.8@(0.35000,2.1)
59	K22W (max d-ang @ t, dP)	13.0@(0.72500,-13.2)	16.3@(0.90000,-24.3)	8.7@(0.82500,-11.0)	10.4@(0.85000,-14.5)	9.6@(0.84166,-12.6)	3.5@(0.69166,-3.2)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	130% / 217%	164% / 275%	217% / 364%	204% / 341%	216% / 361%	224% / 375%
63	G82R at Rugby/L20D at Draytor	999% / 723%	999% / 710%	999% / 791%	999% / 785%	999% / 787%	999% / 832%
64	R50M / F3M	590% / 276%	659% / 293%	796% / 291%	763% / 286%	790% / 288%	839% / 303%
65	B10T	217%	178%	233%	228%	228%	271%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 2 | 2)

Case	w1b-so15aa-w13	w2b-so15aa-w23	w2b-so15aa-w33	w2b-so15aa-w43	w2b-so15aa-w53	w2b-so15aa-w2s
Disturbance	w13	w23	w33	w43	w53	w2s
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-1: Stability Analysis Results

1	**Case No.**	47	48	48	48
2	**Case Name**	w2b-so15aa-w3s	mbb-so15aa-mcs	w1b-so15aa-mcs	w2b-so15aa-mcs
3	**Disturbance**	w3s	mcs	mcs	mcs
4	**Prior Outage**	None	None	None	None
5	**Date/Time**	FEB 17 2010 15:57	APR 06 2010 9:46	MAR 08 2010 15:55	MAR 08 2010 16:02
6	**Comments**	Option W.2	Benchmark	Option W.1	Option W.2
7					
8	**Steady State Flows**				
9	NDEX / EAST BIAS	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0
22	**Steady State Vltgs**				
23	Dorsey 500/Dorsey 230	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**				
29	D602F at Forbes/Dorsey	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	343%	337%	343%	343%
33	**Min/MaxTransientVltg**				
34	Arrowhd 230	0.99 | 1.01	0.96 | 1.03	0.91 | 1.02	0.93 | 1.02
35	Boise 115	1.01 | 1.02	1.00 | 1.04	1.00 | 1.03	1.00 | 1.03
36	Dorsey 230	1.04 | 1.06	1.04 | 1.05	1.03 | 1.05	1.03 | 1.05
37	Forbes 230	1.02 | 1.03	1.01 | 1.04	0.99 | 1.02	1.01 | 1.03
38	Riverton 230	1.02 | 1.03	1.00 | 1.05	0.98 | 1.04	0.99 | 1.04
39	Coal Creek 230	1.01 | 1.05	0.96 | 1.08	0.95 | 1.07	0.95 | 1.07
40	Jamestown 345	1.00 | 1.02	0.95 | 1.04	0.96 | 1.03	0.95 | 1.03
41	Drayton 230	1.03 | 1.04	1.02 | 1.05	1.02 | 1.05	1.02 | 1.05
42	Groton 345	1.02 | 1.04	0.97 | 1.04	0.96 | 1.03	0.98 | 1.04
43	Minong 161	1.01 | 1.03	0.97 | 1.06	0.93 | 1.07	0.95 | 1.07
44	Wahpeton 115	1.03 | 1.04	1.01 | 1.07	1.00 | 1.05	1.00 | 1.05
45	Watertown 345	1.02 | 1.03	1.00 | 1.04	0.99 | 1.04	0.99 | 1.04
46	**Dynamic Voltage Warnings**				
47		none	none	none	none
48					
49					
50					
51					
52					
53					
54	Worst Case Angle Damping				
55	Dorsey SUVP / UdHold				
56	Forbes DC Red (DCAR)	490%	347%	354%	349%
57	K22W (max +dP @ t, d-ang)	7.1@(2.19166,-1.2)	29.9@(2.41666,-7.0)	29.4@(3.29998,-6.6)	25.5@(3.31664,-6.0)
58	K22W (max -dP @ t, d-ang)	17.6@(0.35000,2.1)	26.4@(0.55000,9.8)	37.7@(0.56666,13.6)	32.5@(0.57500,12.1)
59	K22W (max d-ang @ t, dP)	3.4@(0.68333,-2.9)	14.9@(0.90833,-18.6)	19.8@(0.91666,-22.5)	17.5@(0.91666,-20.4)
60	**OS Rel Trip / Marg**				
61	MH - OH				
62	D602F at Forbes/Dorsey	224% / 375%	182% / 304%	170% / 284%	194% / 323%
63	G82R at Rugby/L20D at Draytor	999% / 832%	999% / 569%	999% / 699%	999% / 756%
64	R50M / F3M	839% / 302%	759% / 278%	666% / 275%	729% / 280%
65	B10T	273%	148%	153%	165%
66	**FSCAPS (SS/Unav/Final)**				
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)

Case	w2b-so15aa-w3s	mbb-so15aa-mcs	w1b-so15aa-mcs	w2b-so15aa-mcs
Disturbance	w3s	mcs	mcs	mcs
System Response	OK	OK	OK	OK
70% or 120% Violations				
ORWG Criteria Violations				
Line Tripping				

Table D-1: Stability Analysis Results

1	**Case No.**	49	49	49	50	50	50
2	**Case Name**	mbb-so15aa-mes	w1b-so15aa-mes	w2b-so15aa-mes	mbb-so15aa-mfs	w1b-so15aa-mfs	w2b-so15aa-mfs
3	**Disturbance**	mes	mes	mes	mfs	mfs	mfs
4	**Prior Outage**	None	None	None	None	None	None
5	**Date/Time**	APR 08 2010 14:00	APR 12 2010 9:14	APR 12 2010 9:20	APR 08 2010 14:02	APR 12 2010 9:17	APR 12 2010 9:22
6	**Comments**	Benchmark	Option W.1	Option W.2	Benchmark	Option W.1	Option W.2
7							
8	**Steady State Flows**						
9	NDEX / EAST BIAS	2264 / 148	2670 / 243	2438 / 244	2264 / 148	2670 / 243	2438 / 244
10	MHEX / L20D	2178 / 287	2167 / 253	2064 / 239	2178 / 287	2167 / 253	2064 / 239
11	ECL-ARP / PRI-BYN	660 / 74	805 / 32	787 / 24	660 / 74	805 / 32	787 / 24
12	MWEX / AHD-SLK	1506 / 655	1653 / 648	1627 / 648	1506 / 655	1653 / 648	1627 / 648
13	D602F / F601C	1777 / 1517	1805 / 1495	1738 / 1430	1777 / 1517	1805 / 1495	1738 / 1430
14	B10T / MH>SPC	166 / 62	165 / 60	165 / 60	166 / 62	165 / 60	165 / 60
15	OH E-W / OH>MH	191 / -195	190 / -196	190 / -196	191 / -195	190 / -196	190 / -196
16	R50M / OH>MP	138 / 151	148 / 150	143 / 150	138 / 151	148 / 150	143 / 150
17	G82R	-25	-40	-58	-25	-40	-58
18	Dorsey bipole / CU bipole	2114 / 1103	3213 / 1104	3214 / 1103	2114 / 1103	3213 / 1104	3214 / 1103
19	Dorsey Reserve / Wtrtn SVC	1392 / 15	589 / -15	604 / 35	1392 / 15	589 / -15	604 / 35
20	Forbes SVC / MSC	17 / 600	39 / 600	28 / 600	17 / 600	39 / 600	28 / 600
21	RCDC	0	0	0	0	0	0
22	**Steady State Vltgs**						
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045	1.043 / 1.045	1.036 / 1.045	1.037 / 1.045
24	Roseau 500/Forbes 500	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019	1.030 / 1.018	1.025 / 1.014	1.025 / 1.019
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996	1.017 / 1.026	1.013 / 0.988	1.016 / 0.996
26	Int Falls 115/Badoura 115	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031	1.020 / 1.037	1.016 / 1.030	1.019 / 1.031
27	Drayton 230/Groton 345	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025	1.026 / 1.021	1.033 / 1.012	1.033 / 1.025
28	**SS OS Relay Margins**						
29	D602F at Forbes/Dorsey	246% / 413%	234% / 392%	254% / 426%	246% / 413%	234% / 392%	254% / 426%
30	G82R at Rugby/L20D at Draytor	999% / 687%	999% / 823%	999% / 881%	999% / 687%	999% / 823%	999% / 881%
31	R50M/F3M	980% / 319%	876% / 316%	925% / 320%	980% / 319%	876% / 316%	925% / 320%
32	B10T	337%	343%	343%	337%	343%	343%
33	**Min/MaxTransientVltg**						
34	Arrowhd 230	0.96 | 1.03	0.92 | 1.02	0.94 | 1.02	0.98 | 1.05	0.94 | 1.03	0.96 | 1.04
35	Boise 115	1.00 | 1.04	1.00 | 1.03	1.00 | 1.04	0.99 | 1.04	0.99 | 1.02	1.00 | 1.03
36	Dorsey 230	1.03 | 1.06	1.03 | 1.07	1.03 | 1.07	1.03 | 1.05	1.03 | 1.06	1.03 | 1.06
37	Forbes 230	1.01 | 1.04	1.00 | 1.02	1.01 | 1.03	1.01 | 1.04	1.01 | 1.03	1.01 | 1.03
38	Riverton 230	1.01 | 1.05	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04	0.99 | 1.04	1.00 | 1.03
39	Coal Creek 230	1.00 | 1.08	0.99 | 1.07	0.99 | 1.08	1.00 | 1.07	1.00 | 1.07	1.00 | 1.07
40	Jamestown 345	1.01 | 1.04	1.01 | 1.03	0.99 | 1.02	0.98 | 1.01	0.98 | 1.01	0.98 | 1.01
41	Drayton 230	1.02 | 1.05	1.03 | 1.05	1.02 | 1.05	1.02 | 1.05	1.02 | 1.05	1.02 | 1.04
42	Groton 345	1.00 | 1.03	0.99 | 1.02	1.01 | 1.03	1.00 | 1.03	0.99 | 1.03	1.00 | 1.04
43	Minong 161	0.96 | 1.06	0.93 | 1.07	0.95 | 1.07	0.99 | 1.07	0.96 | 1.08	0.98 | 1.08
44	Wahpeton 115	1.04 | 1.06	1.03 | 1.05	1.02 | 1.05	1.02 | 1.05	1.01 | 1.04	1.01 | 1.04
45	Watertown 345	1.01 | 1.03	1.00 | 1.03	1.01 | 1.03	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04
46	**Dynamic Voltage Warnings**						
47		none	none	none	none	none	none
48							
49							
50							
51							
52							
53							
54	Worst Case Angle Damping						
55	Dorsey SUVP / UdHold						
56	Forbes DC Red (DCAR)	308%	323%	308%	439%	446%	440%
57	K22W (max +dP @ t, d-ang)	27.0@(2.42499,-6.0)	27.7@(3.30831,-6.2)	24.5@(3.34164,-5.9)	58.8@(2.31666,-20.7)	60.8@(2.31666,-20.5)	55.5@(2.34166,-19.3)
58	K22W (max -dP @ t, d-ang)	28.6@(0.63333,11.3)	38.9@(0.37500,6.6)	31.5@(0.60833,12.1)	20.3@(0.40000,4.5)	34.6@(0.35833,5.7)	26.8@(0.36667,4.8)
59	K22W (max d-ang @ t, dP)	15.9@(0.92500,-17.1)	19.8@(0.91666,-20.7)	17.4@(0.92500,-17.9)	-22.7@(2.65832,44.3)	-24.0@(2.69999,45.7)	-22.3@(2.74998,41.7)
60	**OS Rel Trip / Marg**						
61	MH - OH						
62	D602F at Forbes/Dorsey	186% / 311%	175% / 293%	198% / 331%	177% / 297%	175% / 293%	194% / 324%
63	G82R at Rugby/L20D at Draytor	999% / 585%	999% / 721%	999% / 773%	999% / 541%	999% / 688%	999% / 751%
64	R50M / F3M	760% / 278%	665% / 278%	732% / 282%	748% / 238%	680% / 235%	732% / 239%
65	B10T	168%	169%	182%	148%	159%	168%
66	**FSCAPS (SS/Unav/Final)**						
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 8 | 2) / (0 | 1 | 1)	(1 | 8 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 2 | 2)

Case	mbb-so15aa-mes	w1b-so15aa-mes	w2b-so15aa-mes	mbb-so15aa-mfs	w1b-so15aa-mfs	w2b-so15aa-mfs
Disturbance	mes	mes	mes	mfs	mfs	mfs
System Response	OK	OK	OK	OK	OK	OK
70% or 120% Violations						
ORWG Criteria Violations						
Line Tripping						

Table D-2: Fast Switched Capacitor Summary [1]

Notes
1. Top row is benchmark case summary; middle row is Option W.1; bottom row is Option W.2
2. Explanation of summary
   - First number: number of capacitors on in the power flow case (SS)
   - Second number: maximum number of capacitors on during the simulation
   - Third number: capacitors on at the end of the simulation (FINAL).

	Disturbance		Prarie	Running	Sheyenne	Roseau	Ramsey	Parkers Lake	Eau Claire	Split Rock	Balta
1	ag1	4 cycle SLG fault at Leland Olds 345 kV on Leland Olds-Ft Thompson line; breaker 2692 fails; clear at 11 cycles by tripping faulted line	(1|2|1) (1|1|1) (1|2|2)	(1|1|1) (1|1|1) (1|1|1)	(1|2|2) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
2	ag3	4 cycle 3PH fault at Leland Olds 345 kV, trip Leland Olds-Ft Thompson line	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|3|2) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|2|2) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|2|2) (1|1|1) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
3	cts	4 cycle SLG fault at Chisago 345 kV on TR10, breaker 9P20 fails, clear at 16 cycles by tripping Chisago-Forbes; cross-trip Forbes-Riel and trigger HVDC reduction	(1|7|1) (1|5|1) (1|5|1)	(1|3|1) (1|3|2) (1|2|2)	(1|5|2) (1|5|1) (1|5|3)	(0|1|0) (0|0|0) (0|0|0)	(0|2|2) (0|2|1) (0|2|2)	(0|0|0) (0|0|0) (0|0|0)	(4|4|2) (4|4|1) (4|4|2)	(1|2|2) (1|2|2) (1|2|2)	(0|2|0) (0|2|0) (0|2|0)
4	ei2	CU DC permanent bipole fault with tripping of both Coal Creek units	(1|3|1) (1|3|1) (1|3|1)	(1|1|1) (1|1|1) (1|1|1)	(1|4|3) (1|4|4) (1|4|4)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|3) (4|4|3) (4|4|3)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
5	em3	5 cycle 3PH fault at Letellier 230, clear by tripping Letellier-Drayton line; trigger HVDC reduction	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
6	eq1	SLG fault with breaker failure at Coal Creek on CU DC pole 1 with cross-trip of Coal Creek unit #2	(1|3|1) (1|3|1) (1|3|1)	(1|1|1) (1|1|1) (1|1|1)	(1|4|2) (1|3|3) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|1|0) (0|1|0) (0|1|0)
7	fds	5 cycle 3PH fault at Square Butte 230 kV, clear by tripping Square Butte-Stanton line	(1|2|1) (1|2|1) (1|2|1)	(1|1|1) (1|1|1) (1|1|1)	(1|4|2) (1|2|2) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|2|2) (0|1|1) (0|2|2)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
8	mc3	5 cycle 3PH fault at Richer 230 kV, clear by tripping Richer-Roseau line; trigger HVDC reduction	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
9	md3	5 cycle 3PH fault at Glenboro 230 kV, clear by tripping Glenboro-Rugby line	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
10	mis	Bipole 2 block in the Manitoba Hydro System, Cross trip Manitoba Ontario Ties @ t=0.35s; trigger HVDC reduction	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
11	mjs	4 cycle SLG fault at Chisago 345 kV on Chisago-Kohlman Lake line, breaker fails at Chisago, clear by tripping Chisago 500-345 kV xfmr	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|2|2) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
12	mkd	4 cycle 3 phase fault at Chisago 345 kV, clear the Chisago-King line	(1|2|2) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|3|3) (1|2|2) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|2|2) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
13	mks	4.5 cycle SLG fault at Chisago 345 kV on Chisago-King line, King breaker fails, clear at 15 cycles by tripping Chisago 500-345 kV xfmr	(1|3|2) (1|1|1) (1|1|1)	(1|1|1) (1|2|2) (1|2|2)	(1|3|3) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)

Table D-2: Fast Switched Capacitor Summary [1]

Notes
1. Top row is benchmark case summary; middle row is Option W.1; bottom row is Option W.2
2. Explanation of summary
   - First number: number of capacitors on in the power flow case (SS)
   - Second number: maximum number of capacitors on during the simulation
   - Third number: capacitors on at the end of the simulation (FINAL).

	Disturbance		Prarie	Running	Sheyenne	Roseau	Ramsey	Parkers Lake	Eau Claire	Split Rock	Balta
14	nad	4 cycle 3PH fault at Forbes 500 kV on M602F; trigger HVDC reduction	(1|3|2)	(1|5|3)	(1|3|3)	(0|2|0)	(0|1|1)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|3|3)	(1|2|2)	(0|1|1)	(0|1|1)	(0|0|0)	(4|4|2)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|3|3)	(1|1|1)	(0|1|1)	(0|1|1)	(0|0|0)	(4|4|3)	(1|2|2)	(0|0|0)
15	nmz	4 cycle 3PH fault at Chisago 500 kV on F601C, xtrip M602F, 100% reduction, leave SVC on MP system	(1|4|1)	(1|3|2)	(1|5|3)	(0|1|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|2|2)	(0|1|0)
			(1|2|1)	(1|2|2)	(1|4|3)	(0|0|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|2|2)	(0|1|0)
			(1|2|1)	(1|2|2)	(1|4|3)	(0|0|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|2|2)	(0|1|1)
16	pas	5 cycle SLG fault at Forbes 500 kV on M602F, Forbes breaker fails, Forbes breakers operate at 16 cycles, clear at 17 cycles; trigger HVDC reduction	(1|2|2)	(1|3|2)	(1|3|3)	(0|0|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|2|2)	(1|2|2)	(0|0|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|2|2)	(1|1|1)	(0|0|0)	(0|1|1)	(0|0|0)	(4|4|2)	(1|1|1)	(0|0|0)
17	pc0	4.5 cycle SLG fault at King 345 kV on King-Eau Claire line, King breaker fails, clear at 16 cycles by tripping King-Chisago	(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|0|0)	(0|3|3)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|3)	(1|2|2)	(0|0|0)
18	pcs	4.5 cycle SLG fault at King 345 kV on King-Eau Claire line, King breaker fails, clear at 16 cycles by tripping King-Chisago, cross trip Eau Claire-Arpin	(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|0|0)	(0|3|3)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|4)	(1|2|2)	(0|0|0)
19	pct	Trip of King-Eau Claire-Arpin without a fault	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
20	pzs	4.5 cycle SLG fault Prairie Island 345 kV on Prairie Island-N Rochester, 8H9 fails, clear at 16 cycles by tripping Prairie Island xfmr #10	(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|4)	(1|2|2)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|3|3)	(4|4|4)	(1|2|2)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|2|2)	(0|0|0)	(0|1|1)	(0|3|3)	(4|4|4)	(1|2|2)	(0|0|0)
21	pzt	Trip of Prairie Island-N Rochester without a fault	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
22	ya3	4 cycle 3 phase fault at Arrowhead 230 kV, clear the Arrowhead-Gardner park 345 kV line	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
23	yas	4 cycle SLG fault at Arrowhead 345 on AHD-GDP ckt #1, AHD brkr stk, clear at 17 cycles by tripping AHD-GDP bus section	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
24	yb3	4 cycle 3PH fault at Arrowhead 345 kV, trip the Arrowhead-Stone Lake line	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
25	h13	5 cycle 3PH fault at Dorsey, trip Dorsey-Riel 500 kV line #1	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|4)	(1|2|2)	(0|0|0)
26	h23	5 cycle 3PH fault at Dorsey, trip Dorsey 500/230 kV transformer #1; trigger HVDC reduction	(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|1|1)	(0|0|0)
			(1|1|1)	(1|1|1)	(1|1|1)	(0|0|0)	(0|0|0)	(0|0|0)	(4|4|3)	(1|2|2)	(0|0|0)

Table D-2: Fast Switched Capacitor Summary [1]

Notes
1. Top row is benchmark case summary; middle row is Option W.1; bottom row is Option W.2
2. Explanation of summary
   - First number: number of capacitors on in the power flow case (SS)
   - Second number: maximum number of capacitors on during the simulation
   - Third number: capacitors on at the end of the simulation (FINAL).

	Disturbance		Prarie	Running	Sheyenne	Roseau	Ramsey	Parkers Lake	Eau Claire	Split Rock	Balta
27	h7d	5 cycle 3PH fault at Dorsey 500 kV, trip the Dorsey-Bison 500 kV line; trigger HVDC reduction	Not Run (1|1|1) (1|1|1)	Not Run (1|1|1) (1|1|1)	Not Run (1|1|1) (1|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (0|0|0) (0|0|0)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|3) (4|4|3)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)
28	he0	5 cycle SLG fault at Dorsey 500 kV on Dorsey-Bison line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey 500-230 kV xfmr, line outage triggers HVDC reduction; block SUVC	Not Run (1|5|1) (1|5|1)	Not Run (1|2|2) (1|2|2)	Not Run (1|2|2) (1|1|1)	Not Run (0|1|0) (0|1|0)	Not Run (0|1|1) (0|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|3) (4|4|3)	Not Run (1|1|1) (1|1|1)	Not Run (0|1|1) (0|1|1)
29	hl0	5 cycle SLG fault at Dorsey 500 kV on Dorsey-Bison line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey-Riel 500 kV line #2; line outage triggers HVDC reduction; block SUVC	Not Run (1|5|1) (1|5|1)	Not Run (1|2|2) (1|2|2)	Not Run (1|2|2) (1|1|1)	Not Run (0|1|0) (0|1|0)	Not Run (0|1|1) (0|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|3) (4|4|3)	Not Run (1|1|1) (1|1|1)	Not Run (0|1|1) (0|1|1)
30	h33	5 cycle 3PH fault at Riel, trip Riel-Forbes 500 kV line; trigger HVDC reduction	(1|3|2) (1|1|1) (1|1|1)	(1|3|2) (1|3|3) (1|3|3)	(1|3|3) (1|1|1) (1|1|1)	(0|2|1) (0|1|1) (0|1|1)	(0|1|1) (0|0|0) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|2) (4|4|2) (4|4|2)	(1|1|1) (1|1|1) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
31	h43	5 cycle 3PH fault at Riel, trip Riel 500/230 kV transformer	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
32	h83	5 cycle 3PH fault at Bison 500 kV, trip the Bison 500/345 kV transformer	Not Run (1|1|1) (1|1|1)	Not Run (1|1|1) (1|1|1)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)	Not Run (0|0|0) (0|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|4) (4|4|4)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)
33	hmd	5 cycle 3PH fault at Bison 500 kV, trip the Dorsey-Bison line; trigger HVDC reduction	Not Run (1|2|2) (1|2|1)	Not Run (1|1|1) (1|1|1)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)	Not Run (0|0|0) (0|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|3) (4|4|3)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)
34	w63	5 cycle 3PH fault at Bison 500 kV, trip the Bison-Brookings Co 500 kV line	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
35	ho0	5 cycle SLG fault at Bison 500 kV on 500-345 kV xfmr, 500 kV breaker fails, clear at 16 cycles by tripping Dorsey-Bison; line outage triggers HVDC reduction	Not Run (1|4|2) (1|3|1)	Not Run (1|1|1) (1|1|1)	Not Run (1|3|2) (1|3|2)	Not Run (0|0|0) (0|0|0)	Not Run (0|1|1) (0|1|1)	Not Run (0|0|0) (0|0|0)	Not Run (4|4|3) (4|4|3)	Not Run (1|1|1) (1|2|2)	Not Run (0|0|0) (0|0|0)
36	h93	5 cycle 3PH fault at Bison 345 kV, trip Bison-Alexandria SS 345 kV line	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
37	hks	5 cycle SLG fault at Bison 345 on Alexandria SS line, Bison breaker fails, clear at 16 cycles by tripping Bison 345-230 kV xfmr	(1|5|1) (1|5|1) (1|5|1)	(1|1|1) (1|1|1) (1|1|1)	(1|2|2) (1|3|3) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|2|2)	(0|1|0) (0|0|0) (0|0|0)
38	o2s	5 cycle SLG fault at Helena 345 kV on Lake Marion line, Helena breaker fails, clear at 16 cycles by tripping Helena-Franklin	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|2|2) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)

Table D-2: Fast Switched Capacitor Summary [1]

Notes
1. Top row is benchmark case summary; middle row is Option W.1; bottom row is Option W.2
2. Explanation of summary
   - First number: number of capacitors on in the power flow case (SS)
   - Second number: maximum number of capacitors on during the simulation
   - Third number: capacitors on at the end of the simulation (FINAL).

	Disturbance		Prarie	Running	Sheyenne	Roseau	Ramsey	Parkers Lake	Eau Claire	Split Rock	Balta
39	o3s	5 cycle SLG fault at Bison 345 kV on Alexandria line, Bison breaker fails, clear at 16 cycles by tripping Bison-Jamestown	(1|5|3) (1|4|3) (1|4|3)	(1|1|1) (1|1|1) (1|1|1)	(1|3|2) (1|3|3) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
40	o4s	5 cycle SLG fault at Bison 345 kV on Maple River line, Bison breaker fails, clear at 16 cycles by tripping Bison 345-230 kV xfmr	(1|4|1) (1|3|2) (1|3|2)	(1|1|1) (1|1|1) (1|1|1)	(1|3|2) (1|3|3) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|0|0) (0|0|0) (0|0|0)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|1|1) (1|1|1)	(0|0|0) (0|0|0) (0|0|0)
41	w13	Simultaneous 5 cycle faults at Bison 345 kV on both circuits of the Alexandria SS line (assumes circuits are on same towers).	Not Run (1|1|1) Not Run	Not Run (1|1|1) Not Run	Not Run (1|1|1) Not Run	Not Run (0|0|0) Not Run	Not Run (0|0|0) Not Run	Not Run (0|0|0) Not Run	Not Run (4|4|4) Not Run	Not Run (1|1|1) Not Run	Not Run (0|0|0) Not Run
42	w23	5 cycle 3PH fault at Brookings Co 500 kV, trip the Brookings Co-Bison 500 kV line	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
43	w33	5 cycle 3PH fault at Brookings Co 500 kV, trip Brookings Co 500-345 kV xfmr	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
44	w43	5 cycle 3PH fault at Brookings Co 345 kV, trip Brookings Co-Lyon Co line	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
45	w53	5 cycle 3PH fault at Brookings Co 345 kV, trip Brookings Co-White line	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
46	w2s	5 cycle SLG fault at Brookings Co 345 kV on Lyon Co line, Brookings Co breaker fails, clear at 16 cycles by tripping Brookings Co 500-230 kV transformer	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|3|3)	Not Run Not Run (0|0|0)	Not Run Not Run (0|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
47	w3s	5 cycle SLG fault at Brookings Co 345 kV on Lyon Co line, Brookings Co breaker fails, clear at 16 cycles by tripping Brookings Co-White line	Not Run Not Run (1|1|1)	Not Run Not Run (1|1|1)	Not Run Not Run (1|3|3)	Not Run Not Run (0|0|0)	Not Run Not Run (0|1|1)	Not Run Not Run (0|0|0)	Not Run Not Run (4|4|4)	Not Run Not Run (1|2|2)	Not Run Not Run (0|0|0)
48	mcs	4.5 cycle SLG fault at Sherburne Co. 345 kV on Coon Creek line with 8M40 stuck, clear at 12 cycles by tripping Bunker Lake and Bunker Lake TR1	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|3|3) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|3|3) (0|3|3) (0|3|3)	(4|4|4) (4|4|4) (4|4|4)	(1|2|2) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
49	mes	4 cycle SLG fault at Monticello 345 kV on Waite Park line with 8N8 stuck, clear at 14 cycles by tripping Elm Creek line	(1|1|1) (1|1|1) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|3|3) (1|3|3) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|3|3) (0|3|3) (0|3|3)	(4|4|4) (4|4|4) (4|4|4)	(1|1|1) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)
50	mfs	4 cycle SLG fault at Monticello 345 kV on Sherburne Co. line with 8N8 stuck; clear at 14 cycles by tripping Monticello Generator	(1|2|2) (1|2|2) (1|1|1)	(1|1|1) (1|1|1) (1|1|1)	(1|3|3) (1|3|3) (1|3|3)	(0|0|0) (0|0|0) (0|0|0)	(0|1|1) (0|1|1) (0|1|1)	(0|3|3) (0|3|3) (0|3|3)	(4|4|4) (4|4|3) (4|4|4)	(1|1|1) (1|2|2) (1|2|2)	(0|0|0) (0|0|0) (0|0|0)