Report R164-08

MHEB Group TSR System Impact Study
Stability Analysis
MH to US Requests

Prepared for

Midwest ISO

Submitted by:
Douglas R. Brown
Lengcheng Huang
Harinderpal Singh

Revised July 17, 2009

Siemens PTI Project P/21-113318

Siemens Energy, Inc.
Siemens Power Technologies International
400 State Street • P.O. Box 1058
Schenectady, New York 12301-1058 US
Tel: 518-395-5000 • Fax: 518-346-2777
www.usa.siemens.com/PTI

SIEMENS

Revision History

Date	Description
4/28/09	Original
6/18/09	General revision including addition of Option 3 and analysis of both options without SPS
7/17/2009	Incorporated study group comments

Contents

Legal Notice

This document was prepared by Siemens Energy, Inc., Siemens Power Technologies International (Siemens PTI), solely for the benefit of Midwest ISO. Neither Siemens PTI, nor parent corporation or its or their affiliates, nor Midwest ISO, nor any person acting in their behalf (a) makes any warranty, expressed or implied, with respect to the use of any information or methods disclosed in this document; or (b) assumes any liability with respect to the use of any information or methods disclosed in this document.

Any recipient of this document, by their acceptance or use of this document, releases Siemens PTI, its parent corporation and its and their affiliates, and Midwest ISO from any liability for direct, indirect, consequential or special loss or damage whether arising in contract, warranty, express or implied, tort or otherwise, and irrespective of fault, negligence, and strict liability.

This page intentionally left blank.

Executive Summary

Several requests for long term firm transmission service have been made under the Midwest ISO's Open Access Transmission and Energy Markets Tariff. This report presents the results of a transient stability analysis performed on a summer off-peak scenario to evaluate the requests for transmission service shown in Table E-1. These requests seek to reserve 1130 MW of transmission service from Manitoba Hydro to various sinks in the US.

Table E-1: MHEB Group TSR MH to US 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
76703535	Network	Apr-2008	Apr-2013	MHEB-MISO	NSP	30	1/26/2007	A351
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)	1130		

This study was performed by Siemens PTI under the direction of Midwest ISO and an Ad Hoc Study Group consisting of American Transmission Company (ATC LLC), Basin Electric Power Cooperative (BEPC), Dairyland Power Cooperative (DPC), Great River Energy (GRE), Manitoba Hydro (MHEB), Minnesota Power (MP), Minnkota Power Cooperative (MPC), Otter Tail Power (OTP), Western Area Power Administration (WAPA) and Xcel Energy (XEL).

Transient stability analyses have been performed using a model representing off-peak system conditions after Manitoba Hydro's third HVDC bipole goes into service. The analyses were performed using a UIP study package that was updated by the NMORWG in January 2009.

Transmission Upgrade Options

The transmission upgrade options proposed by the ad hoc study group are summarized in Table E-2. The cost estimates are for the new 500 kV transmission lines only and are based on $/mile costs taken from the JCSP 2008 Interim Stakeholder Meeting Introduction Presentation[1] 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 during the Facilities study.

System diagrams depicting the proposed upgrade options are included in Appendix B.

Table E-2: Transmission Upgrade Options

Option No.	Project	Cost in 2018[1]
1	Dorsey – Maple River 50% series compensated 500 kV line with one 500/345 kV, 1200 MVA transformer at Maple River. Maple River – Helena 50% series compensated 500 kV line terminated with two 500/345 kV, 1200 MVA transformers at Helena.	$1.035 B
3	Dorsey – King 50% series compensated 500 kV line terminated via two 500/345 kV, 1200 MVA transformers at King.	$955 M

Note 1: Cost estimates are for transmission lines only

The transmission upgrade options evaluated in this study do not include shunt reactors to compensate for capacitive generation on the new 500 kV lines. Both Option 1 and Option 3 will require shunt reactors on the 500 kV line to control voltage when the line is open-ended. In Option 3, steady-state voltage is around 1.2 per unit at the series capacitor on the Dorsey-King 500 kV line and the series capacitors will need to be designed accordingly.

Pre-Benchmark Case

A pre-benchmark case without CapX projects, study TSRs or associated transmission upgrades was developed from the 2015 summer off-peak case in the UIP package. The pre-benchmark case includes future transmission upgrades from MTEP Appendices A and B (excluding CapX projects) and Manitoba Hydro system updates including the Riel station and bipole 3. 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. Loading of the MHEX, MWEX and NDEX interfaces was adjusted in the pre-benchmark case as shown in Table E-3. A power flow summary and diagram for the pre-benchmark case is in Appendix B. Simulated disturbances are described in Table 1-8; all of the disturbances simulated using the pre-benchmark case result in acceptable system performance.

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

Benchmark Case

A benchmark case without study TSRs or associated transmission upgrades was developed by adding the CapX 2020 Group 1 projects to the pre-benchmark case. Interface loading was not adjusted after adding the CapX projects and the resulting interface flows are summarized in Table E-3. A power flow summary and diagram for the benchmark case is in Appendix B. Simulated disturbances are described in Table 1-8; all of the disturbances simulated using the benchmark case result in acceptable system performance.

TSR 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. Interface loading was not reset in the study cases and the resulting interface flows are summarized in Table E-3. Power flow summaries and diagrams for each study case are in Appendix B.

Table E-3: Interface Loading

Interface	Pre-Benchmark	Benchmark	Study Option 1	Study Option 3
MHEX	2174 MW	2176 MW	1849 MW	1949 MW
Dorsey-Maple River	-	-	1459 MW	-
Dorsey-King	-	-	-	1361 MW
Total	2174 MW	2176 MW	3309 MW	3311 MW
MWEX	1519 MW	1497 MW	1645 MW	1724 MW
Rochester-LaCrosse	-	247 MW	308 MW	292 MW
NDEX	2451 MW	2271 MW	2287 MW	2300 MW

Simulated disturbances are described in Table 1-8; it was initially assumed that outage of new 500 kV facilities associated with upgrade Option 1 or Option 3 do not trigger reduction of the power order on Manitoba Hydro's HVDC lines (HVDC reduction). Simulation results for the disturbances listed in Table E-4 and Table E-5 indicate unacceptable transmission system performance as explained ahead. These disturbances involve outage of one of four facilities:

- Dorsey-Maple River 500 kV line in Option 1 without directly triggering HVDC reduction,
- Maple River-Helena 500 kV line in Option 1
- Dorsey-King 500 kV line in Option 3 without directly triggering HVDC reduction, or
- King-Eau Claire 345 kV line in Option 3.

In both options, several of the disturbances cause the relay on the Manitoba-Ontario tie or the Forbes DC reduction relay (DCAR) to operate. These relays are intended to operate for severe disturbances that could lead to voltage collapse and are not intended to operate for category B or category C disturbances. In Option 3, faults at King with delayed clearing that result in outage of the King-Eau Claire 345 kV line cause a transient voltage violation at the Minong 161 kV bus. Additional analyses were performed to address these violations.

Table E-4: Option 1 Simulation Results

ID	Description	MH-OH Relay Trip *	DCAR Relay Trip *	Transient Voltage Violations	M602F Relay Margin	Notes
h79	3PH fault at Dorsey 500 on Maple River line	X	-	-	52%	
h53	3PH fault at Helena 500 on Maple River line	-	-	-	154%	Forbes SVC exceeds continuous rating
hm9	3PH fault at Maple River 500 on Dorsey line	X	X	-	44%	M602F margin violation
hec	SLG fault at Dorsey 500 on Maple River line with breaker failure; trip 500-230 kV xfmr; xfmr outage triggers DC reduction	-	-	-	21%	M602F margin violation
hlc	SLG fault at Dorsey 500 on Maple River line, with breaker failure, trip Dorsey-Riel	X	-	-	21%	M602F margin violation
hoc	SLG fault at Maple River 500 on 500-345 kV xfmr with brkr failure, trip Maple River-Dorsey	X	X	-	52%	

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes.

Table E-5: Option 3 Simulation Results

ID	Description	MH-OH Relay Trip *	DCAR Relay Trip *	Transient Voltage Violations	M602F Relay Margin	Notes
pc0	SLG fault at King 345 on Eau Claire line with breaker failure; trip Chisago line			X		Minong voltage = 0.80
pcs	SLG fault at King 345 on Eau Claire line with breaker failure; trip Chisago line; cross trip Eau Claire-Arpin			X		Minong voltage = 0.80
hc9	3PH fault at Dorsey 500 on King line	X	X		45%	M602F margin violation
hfs	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey 500-230 kV xfmr; xfmr outage triggers DC reduction				11%	M602F margin violation
hna	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey-Riel #2	X	X		11%	M602F margin violation
hd9	3PH fault at King 500 on Dorsey line	X	X	X	38%	M602F margin violation, MP voltage violations
his	SLG fault at King 345 on 500-345 kV xfmr with breaker failure; trip Eau Claire line			X		Minong voltage = 0.81

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes.

Minong Voltage Violations

In Option 3, disturbances his, pc0 and pcs cause a transient voltage violation at the Minong 161 kV bus. A second 75 MVAR shunt capacitor at the Stone Lake 345 kV bus increases the minimum transient voltage to 0.82 per unit and eliminates the violation. In disturbances pc0 and pcs the voltage violation occurs approximately 0.52 seconds after the fault is applied at King. The existing capacitor at the Stone Lake 345 kV bus is modeled with a 15-cycle insertion time; if the capacitors are switched sequentially, the insertion time for each capacitor needs to be less than 12 cycles so that both capacitors are on before the violation occurs.

Outage of Dorsey-Maple River or Dorsey-King

In both options, several of the simulated disturbances cause the relay on the Manitoba-Ontario tie or the DCAR DC reduction relay at Forbes to operate. Simulations were repeated with the relays blocked to determine what happens if the settings of the relays could be changed so that the relays do not operate for the Dorsey-Maple River or Dorsey-King outage.

After blocking the MH-OH and/or DCAR relays with Option 1, the out-of-step relays on the Riel-Forbes 500 kV line (M602F) violate the minimum transient-period relay margin. With Option 3, three-phase faults on the Dorsey-King 500 kV line cause stability problems with an electrical center in northern Minnesota around Forbes. Voltage oscillations are poorly damped with either option because the Forbes SVC is at its capacitive limit following the disturbance and is not able to provide damping.

Two options were evaluated to address these violations:

- Additional reactive support at Forbes
- HVDC Reduction

Additional Reactive Support

Critical disturbances were repeated with additional dynamic reactive support added at the Forbes 500 kV bus. With Option 1, the analysis indicates that tripping Dorsey-Maple River without a corresponding HVDC reduction requires the installation of more than 400 MVAr of additional dynamic (fast-switched capacitors) reactive support at Forbes; a total of approximately 600 MVAR is required to reduce the Forbes SVC output below the 110 MVAr continuous rating within 10 seconds. With Option 3, the analysis indicates that tripping Dorsey-King without a corresponding reduction to the HVDC power order requires the installation of more than 600 MVAr of additional dynamic (fast-switched capacitors) reactive support at Forbes; approximately 900 MVAR are required to reduce the Forbes SVC output below the continuous rating within 10 seconds.

Simulation results indicate that overcurrent relays will initiate a bypass of the Roseau series capacitors during the post-disturbance swing with Option 3, which triggers the existing HVDC reduction scheme. Either option requires additional analysis of protection on the Monitoba-Ontario ties, M602F line and Roseau series capacitors to make sure the system is secure during the power swing and voltage dip that occurs following trip of Dorsey-Maple River in Option 1 or Dorsey-King in Option 3.

HVDC Reduction

Critical disturbances were repeated with the existing HVDC reduction scheme triggered by outage of the new Dorsey-Maple River 500 kV tie line in Option 1 and by outage of the new Dorsey-King 500 kV tie line in Option 3. Reduction is assumed equal to 100% of the pre-disturbance flow on the line. There are no criteria violations with either Option 1 or with Option 3. Depending on the final design of the transmission upgrades, the required amount of reduction may be less than 100%.

Reduction amounts for the new and existing triggers are lower in the Option 1 and Option 3 study cases than in the benchmark case because flows on the existing Manitoba-US ties lines are lower in the study cases as shown in Table E-6.

Table E-6: MH-US Tie Line Loading

Tie Line	Pre-Benchmark	Benchmark	Study Option 1	Study Option 3
M602F @ Riel	1855 MW	1777 MW	1545 MW	1583 MW
Dorsey-Maple River	-	-	1459 MW	-
Dorsey-King	-	-	-	1361 MW
L20D @ Letellier	238 MW	287 MW	236 MW	268 MW
R50M @Richer	142 MW	139 MW	128 MW	134 MW
G82R @Glenboro	-62 MW	-28 MW	-61 MW	-36 MW

Outage of Maple River-Helena

When simulating outage of the Maple River-Helena 500 kV line with Option 1, the output of the Forbes SVC exceeds the continuous rating at the end of the simulation. Either option described above for outage of Dorsey-Maple River or Dorsey-King will address this issue; additional reactive support at Forbes or a cross-trip of Dorsey-Maple River combined with HVDC reduction.

Constraint Mitigation Costs

Estimated costs for resolving each of the TSR stability constraints are summarized in Table E-7. The costs are good faith estimates and will be further developed and refined in the Facility Study.

Table E-7: Mitigation Costs for Stability Constraints

Mitigation	Option 1	Option 3
Fast-switched capacitors at Forbes 500 kV (400-600 MVAr)	$20,000,000	$32,000,000
or		
New trigger to existing HVDC power order reduction scheme	$3,000,000	$3,000,000
Additional switched capacitor at Stone Lake with insertion time less than 12 cycles	-	$930,000
Total	$20,000,000	$32,930,000

Section

1

Transient Stability Analysis

Stability analyses have been performed to evaluate transient stability performance with the Manitoba Hydro TSRs and corresponding transmission upgrade options. Analyses were also performed on two cases without the TSRs or associated transmission upgrades to benchmark the 2015 summer off-peak case from the UIP study package.

1.1 Stability Study Package

Midwest ISO provided a UIP study package that was updated by the NMORWG in January 2009. Manitoba Hydro provided updates required to incorporate the Riel Station Reliability Project and Bipole 3.

1.2 Power Flow Cases

The power flow cases utilized in the stability analysis are listed in Table 1-1. The cases were developed from the 2015 summer off-peak case ("urg-so15aa.sav") in the UIP package. Case development is summarized in the following sections; additional details are provided in Appendix A.

Loading of the MHEX, MWEX and NDEX interfaces was reset in the pre-benchmark case and allowed to float in the benchmark and study cases.

Table 1-1: Power Flow Cases

Case Description	Case ID	CapX Projects	Study TSRs and Associated Transmission Upgrades
Pre-Benchmark Case	moa-so15aa	-	-
Benchmark Case	mba-so15aa	Group 1 Projects	-
TSR Study Case with Option 1	m1a-so15aa	Group 1 Projects	1130 MW with Upgrade Option 1
TSR Study Case with Option 3	m3a-so15aa	Group 1 Projects	1130 MW with Upgrade Option 3

1.2.1 Pre-Benchmark Case "moa-so15aa"

A pre-benchmark case without CapX projects, study TSRs or associated transmission upgrades was developed from the 2015 summer off-peak case in the UIP package as follows:

1) Apply response file provided by ATC to update model
2) Add Big Stone II (generator and 230 kV outlet)
3) Add MTEP projects excluding CapX 2020 Group 1 projects
4) Apply miscellaneous updates and corrections
5) Add NR generating facilities
6) Reduce load in North Dakota to approximately 80% of summer peak and reduce generation west of NDEX by a corresponding amount
7) Turn on generation in the GRE and XEL control areas that will be used to sink A388 and A416
8) Manitoba Hydro system updates including the addition of Bipole 3. HVDC loading adjusted to maintain export level and prepare to source TSRs at Dorsey in the TSR study cases.
9) Dispatch wind generation in southwest Minnesota at 1083 MW; sink using Xcel Energy generation in the Twin Cities.
10) Apply iplan program setexports.ipl to adjust NDEX, MHEX and MWEX to their simultaneous maximum capability. MHEX = 2175 MW, MWEX = 1525 MW, NDEX=2450 MW

The power flow summary for the pre-benchmark case is in Appendix B.1.

1.2.1.1 Big Stone II

Big Stone II is dispatched at 600 MW (net) and is modeled in the pre-benchmark case with the 230 kV outlet facilities:

- Big Stone-Johnson Jct–Morris 230 kV line
- Big Stone-Canby-Granite Falls 230 kV line
- Johnson Jct 230-115 kV transformer
- Canby 230-115 kV transformer

1.2.1.2 Midwest ISO Transmission Expansion Plan 2008 (MTEP08) Projects

Table 1-2 shows the MTEP08 projects that were added to the pre-benchmark case using response files provided by Midwest ISO. 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.

Table 1-2: MTEP Projects Added to the Stability Case

Transmission Owner	MTEP Project ID	Project Name	MTEP Appendix
ITCM	1289	Marshalltown - Toledo - Belle Plaine - Stoney Point 115 kV line rebuild	A
ITCM	1618	Hrn Lk-Lkfld 161kV Ckt 1 Rbld	A
ITCM	1753	Winnebago Jct south 161/69kV	A
ITCM	1761	Readlyn-Tripoli 69kV Rebuild	A
ITCM	1739	Arnold-Vinton-Dysart-Washburn 161kV Reconductor	A
ITCM	1619	Grnd Mnd 161-69kV 2nd Xfmr & 161kV loop	A
ITCM	1342	Lewis Fields 161 kV substation which taps the SwampFX - Coggon 115 kV line	A
ITCM	1287	Replace Salem 345/161 kV transformer with 448 MVA unit	A
ATC LLC	339	Lake Mills Transmission-Distribution interconnection	A
ATC LLC	1553	Hiawatha 138kV Capacitor Bank	A
XEL	1368	Three Lakes 115/69 kV substation	A
XEL	1373	Ft. Ridgeley - Searles Jct 115 new line and Searles Jct - New Ulm 69 Reconductor	A
XEL	1457	G287, 37642-03. Upgrades for G287	A
XEL	1489	Woodbury - Tanners Lake upgrade	A
XEL/GRE	1545	Mankato 115 kV loop	A
XEL	1548	La Crosse Area Capacitor banks	A
XEL	1548	La Crosse Area Capacitor banks	A
XEL	1549	Eau Claire - Hydro Lane 161 kV Conversion	A
XEL	1959	Yankee Doodle interconnection	A
ITCM	1758	Beaver Channel-2nd Ave 69kV	A
ITCM	1288	Replace Hazleton 345/161 kV transformer #1 with 335 MVA unit	A
ITCM	1755	Washington-Hills 69kV Rebuild	A
ITCM	1345	Replace the limiting facility of CTs and conductor inside the substations for Quad Cities-Rock Creek-Salem 345 kV line	A
ITCM	1340	Hazleton - Salem 345 kV line with a 2nd Salem 345/161 kV 448 MVA transformer.	A
ITCM	1289	Marshalltown - Toledo - Belle Plaine - Stoney Point 115 kV line rebuild	A
MP/GRE	1021	Embarass to Tower 115 kV Line	A

Transmission Owner	MTEP Project ID	Project Name	MTEP Appendix
MP/GRE	1022	Badoura-Long Lake 115 kV line	A
GRE	1361	Badoura - Birch Lake 115 lines	A
GRE	599	Crooked Lake - Enterprise Park 115 kV line	A
ITCM	1341	Replace two Hazleton 161/69 kV transformers	A
ITCM	1473	Mason City Armor - Emery North 69 kV line	A
ITCM	1522	6th Street - Beverly	A
ITCM	1618	Hrn Lk-Lkfld 161kV Ckt 1 Rbld	A
ITCM	1641	OGS 50 MVAR Cap Bank	A
ITCM	1739	Arnold-Vinton-Dysart-Washburn 161kV Reconductor	A
ITCM	1753	Winnebago Jct south 161/69kV	A
ITCM	1756	Dyersville-Peoasta 69kV Rebuild	A
MP	1482	Pepin Lake 115/34.5 - Transformer 115/34.5 kV 39 MVA	A
GRE/OTP	1033	Silver Lake 230/41.6 kV transformer	A
OTP/MPC	971	Winger 230/115 kV Transformer Upgrade	A
OTP/MPC	2091	Cass Lake 115/69/41.6 kV sub	A
OTP	2092	South Cascade 115 kV Addition	A
SMP	1367	Lake City load serving upgrades	A
XEL	1371	Black Dog - Wilson 115 kV #2 Reconductor	A
XEL	1455	G238, 37642-02, Increase of generating capacity at Riverside Generating Plant	A
XEL	1487	Somerset - Stanton 69 kV line 84 MVA	A
XEL	1953	St. Cloud - Sauk River 115 kV line upgrade	A
XEL	1954	Cherry Creek - Split Rock 115 kV line saperation	A
XEL	1960	Traverse - St. Peter upgrade	A
XEL	1961	Lake Emily Capacitor bank	A
XEL	552	Ironwood 92/34.5 kV transformer #2	A
XEL	56	Chisago - Apple River	A
XEL	675	Rebuild Westgate to Scott County 69 kV to 115 kV	A
XEL	1958	Stone Lake-Edgewater 161 kV line. A new radial 161 kV line and substation in Sawyer County, Wisconsin	A
GRE	2569	Shoal Lake (Lawrence Lake) 115 kV line for new load	C
MP	2761	Pollymet load	C
MP	277	Badoura Project: Pine River - Pequot Lakes 115 kV line	A
ATC LLC	1463	Twin_Creeks-G384	N/A
ITCM	1645	Leon-1645_69kV_7MVAR	N/A
ITCM	1772	N_Cntrville_69kV-1772_7MVA	N/A
WAPA, BEPC	Correction	Su2009+-SplitWess	N/A
GRE	Network	KRMRLK(53801)	N/A

Transmission Owner	MTEP Project ID	Project Name	MTEP Appendix
XEL	1380	WWACONIA-SCOTT	N/A

N/A – These projects have been withdrawn and no longer appear in MTEP Appendix A/B.

1.2.1.3 Miscellaneous Updates and Corrections

Table 1-3 shows miscellaneous model updates and corrections.

Table 1-3: Miscellaneous Updates and Corrections

Area	Description
ATC	ATC footprint updates
GRE	MISO-PROJECT-KRMRLK(53801)
GRE	MISO-PROJECT-LWRNCTP(20138)
MP	MISO-Dunka-Load
MP	MISO-PROJECT-LL-BAD-PINE-PEQ
MP	Add MN Steel load and transmission
MP	GNET Unit 3 at Cloquet (bus 61668)
OTP	Put Buffalo-CSLTNET 115 kV line in service
OTP	Put Running 230/69 kV xfmr 1 in service
OTP	Put Moranville 230/115 kV xfmr 1 in service
OTP	Purge Center-Harvey-Prairie 345 kV line, Center 345-230 kV xfmr #2 and Harvey 345-230 kV xfmr
XEL	GNET Unit 1 at Chandler (bus 62710)

1.2.1.4 Midwest ISO Network Resource Generation

The NR generating facilities listed in Table 1-4 were added to the pre-benchmark case.

Table 1-4: Midwest ISO NR Generation Added to the Stability Case

MISO Project Number	MISO Queue Number	MISO Queue Date	Control Area	County	Point of Interconnection	Max Output (MW)	Dispatch (MW)
G519	38491-01	19-May-05	MP	Itasca, MN	Blackberry 230/115kV Substation	600	600
G618	38818-02	4/11/2006	OTP	Yellow Medicine, MN	Burr Jct to Toronto 115 kV line located 5 miles from Camby	138	27.6
G904	39388-01	11/2/2007	Xcel	Rolette, ND	Rugby-Glenboro 230kV	150	30
G930	39426-03	10-Dec-07	XEL	Sherburne, MN	Sherco Substation	120	120

1.2.1.5 North Dakota Load

Load in North Dakota was reduced by 540 MW to bring it down to approximately 80% of summer peak (to simulate summer off-peak conditions). Generation west of NDEX was reduced by a corresponding amount:

- North Dakota coal field generation units dispatched above their limits specified in the case were reduced to their respective limits (90 MW reduction)
- Big Stone Unit 1 reduced to its limit specified in the case (20 MW reduction)
- Wind generation in eastern North Dakota turned off at Ashtabula, Edgley and Langdon (430 MW reduction)

1.2.1.6 Manitoba Hydro (MH) System Updates

The following transmission and generating facilities were added to the pre-benchmark case to update the MH system representation and to ensure adequate generation reserves are available for sourcing the study TSRs:

- Bipole 3 and associated facilities at Riel
- Dorsey-Riel 500 kV circuit #2
- Dorsey-Portage 230 kV 2nd line
- Laverendrye-St Vital 230 kV line
- Letellier-St Vital 230 kV line
- Keeyask generating plant (7 x 90 MW)
- Conawapa generating plant (10 x 130 MW)

1.2.2 Benchmark Case "mba-so15aa"

A benchmark case without study TSRs or associated transmission upgrades was developed from the pre-benchmark case described in Section 1 as follows:

1) Add Big Stone 345 kV outlet facilities
2) Add CapX 2020 Group 1 projects

Interface loading was not reset in the benchmark case. The power flow summary for the benchmark case is in Appendix B.2.

1.2.2.1 Big Stone 345 kV Outlet Facilities

Big Stone II is modeled in the benchmark case with 345 kV outlet facilities:

- Big Stone - Johnson Jct-Morris 230 kV line
- Big Stone 345- 230 kV transformers
- Big Stone-Canby 345 line
- Canby 345-115 kV xfmr
- Canby-Hazel Run 345 line
- 2 Hazel Run 345/230 kV xfmrs
- Hazel Run 230/115 kV xfmr
- Hazel Run-Granite Falls 230 kV line
- Hazel Run-Minn Valley 230 kV line
- Johnson Jct 230-115 kV transformer

1.2.2.2 CapX 2020 Group 1 Projects

Table 1-5 shows the CapX 2020 Group 1 projects that were added to the benchmark case using response files provided by Midwest ISO.

Table 1-5: CapX 2020 Group 1 Projects Added to the Benchmark Case

PrjID	TO	Project Name
279	MPC, XEL, OTP, MP	CapX Bemidji-Grand Rapids 230 kV Line
286	GRE, XEL, OTP, MP, MRES	CapX Fargo, ND - St Cloud/Monticello, MN area 345 kV project
1024	XEL, DPC, RPU, SMP, WPPI	CapX SE Twin Cities - Rochester, MN - LaCrosse, WI 345 kV project
1203	XEL, GRE	CapX Brookings, SD - SE Twin Cities 345 kV project

1.2.3 TSR 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.

1) Increase loading on the MH HVDC system (Bipole 1-3) including generation adjustments at Kettle, Long Spruce, Limestone, Keeyask, and Conawapa plants.
2) Adjust US generation to sink study TSRs
3) Add transmission upgrade option

Power flow summaries and diagrams for each study case are in Appendix B.

1.2.3.1 Source and Sinks for Study TSRs

The TSR source is the Dorsey inverter station and the 1130 MW aggregate study TSRs were sourced by increasing the injection from bipoles 1 and 2 from approximately 1700 MW in the benchmark case to 3245 MW in the study case and reducing the injection from bipole 3 from 1540 MW to 1130 MW. The study TSRs were sunk using the generators shown in Table 1-6.

Table 1-6: MH to US TSR Sinks

Generator Bus	MW
REMOVED	

Generator Bus	MW

1.2.3.2 Transmission Upgrade Options

The transmission upgrade options proposed by the ad hoc study group are summarized in Table 1-7. Impedance data and substation configuration assumptions are documented in Appendix A.4. Substation diagrams document assumption made when disturbances were defined and do not necessarily reflect actual or proposed substation layouts.

Table 1-7: Transmission Upgrade Options

1	3	Project
X		Dorsey – Maple River 50% series compensated 500 kV line terminated via 500/345 kV transformer at Maple River.
X		Maple River – Helena 50% series compensated 500 kV line terminated via 500/345 kV transformers at Helena.
	X	Dorsey – King 50% series compensated 500 kV line terminated via 500/345 kV transformer at King.

The transmission upgrade options evaluated in this study do not include shunt reactors to compensate for capacitive generation on the new 500 kV lines. Both Option 1 and Option 3 will require shunt reactors on the 500 kV line to control voltage when the line is open-ended. In Option 3, steady-state voltage is around 1.2 per unit at the series capacitor on the Dorsey-King 500 kV line and the series capacitors will need to be designed accordingly.

```
OPTION 3 BUSES WITH VOLTAGE GREATER THAN 1.1000:

   BUS#  X-- NAME --X  BASKV   V(PU)   V(KV)
 63061  MIDCOMP-N    500.00  1.1822  591.08
 63062  MIDCOMP-S    500.00  1.1360  568.00
```

1.3 Contingency Criteria

The stability simulations performed as part of this study considered the contingencies listed in Table 1-8. Disturbances defined in the MAPP standard library were simulated using the switching sequence from the library; disturbances affected by the Riel substation were updated based on input provided by Manitoba Hydro. New switching sequence files were developed for disturbances not defined in the library (ID beginning with an "h"); admittances used to simulate single-line-to-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 1-8: Simulated Stability Disturbances

Pre-Benchmark moa	Benchmark mba	TSR Study Option 1 m1a	TSR Study Option 3 m3a	Description
ag1	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
ag3	ag3	ag3	ag3	4 cycle 3PH fault at Leland Olds 345 kV, trip Leland Olds-Ft Thompson line
		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
ei2	ei2	ei2	ei2	CU DC permanent bipole fault with tripping of both Coal Creek units
		em3	em3	5 cycle 3PH fault at Letellier 230, clear by tripping Letellier-Drayton line; trigger HVDC reduction
eq1	eq1	eq1	eq1	SLG fault with breaker failure at Coal Creek on CU DC pole 1 with cross-trip of Coal Creek unit #2
fds	fds	fds	fds	5 cycle 3PH fault at Square Butte 230 kV, clear by tripping Square Butte-Stanton line
		mc3	mc3	5 cycle 3PH fault at Richer 230 kV, clear by tripping Richer-Roseau line; trigger HVDC reduction
		md3	md3	5 cycle 3PH fault at Glenboro 230 kV, clear by tripping Glenboro-Rugby line
		mis	mis	Bipole 2 block in the Manitoba Hydro System, Cross trip Manitoba Ontario Ties @ t=0.35s; trigger HVDC reduction
		mjs	mjs	4 cycle SLG fault at Chisago 345 kV on Chisago-Kohlman Lake line, breaker

Pre-Benchmark moa	Benchmark mba	TSR Study Option 1 m1a	TSR Study Option 3 m3a	Description
				fails at Chisago, clear by tripping Chisago 500-345 kV xfmr
		mkd	mkd	4 cycle 3 phase fault at Chisago 345 kV, clear the Chisago-King line
		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
nad [1]	nad [1]	nad [1]	nad [1]	4 cycle 3PH fault at Forbes 500 kV on M602F; trigger HVDC reduction
nmz [1]	nmz [1]	nmz [1]	nmz [1]	4 cycle 3PH fault at Chisago 500 kV on F601C, xtrip M602F, 100% reduction, leave SVC on MP system
pas [1]	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
		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
pcs	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
pct	pct	pct	pct	Trip of King-Eau Claire-Arpin without a fault
pys	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
pyt	pzt [2]	pzt [2]	pzt [2]	Trip of Prairie Island-N Rochester without a fault
		ya3	ya3	4 cycle 3 phase fault at Arrowhead 230 kV, clear the Arrowhead-Gardner park 345 kV line
		yas	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
		yb3	yb3	4 cycle 3PH fault at Arrowhead 345 kV, trip the Arrowhead-Stone Lake line
		h13	h13	5 cycle 3PH fault at Dorsey, trip Dorsey-Riel 500 kV line #1
		h23	h23	5 cycle 3PH fault at Dorsey, trip Dorsey 500/230 kV transformer #1; trigger HVDC reduction
		h79		5 cycle 3PH fault at Dorsey 500 kV, trip the Dorsey-Maple River 500 kV line
			hc9	5 cycle 3PH fault at Dorsey 500 kV, trip Dorsey-King 500 kV line
		hec		5 cycle SLG fault at Dorsey 500 kV on Dorsey-Maple River line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey 500-230 kV xfmr, trigger HVDC reduction; block SUVC
			hfs	5 cycle SLG fault at Dorsey 500 kV on Dorsey-King line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey 500-230 kV xfmr, trigger HVDC reduction; block SUVC
		hlc		5 cycle SLG fault at Dorsey 500 kV on Dorsey-Maple River line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey-Riel 500 kV line #2; block SUVC

Pre-Benchmark moa	Benchmark mba	TSR Study Option 1 m1a	TSR Study Option 3 m3a	Description
			hna	5 cycle SLG fault at Dorsey 500 kV on Dorsey-King line, Dorsey breaker fails, clear at 16 cycles by tripping Dorsey-Riel 500 kV line #2; block SUVC
		h33	h33	5 cycle 3PH fault at Riel, trip Riel-Forbes 500 kV line; trigger HVDC reduction
		h43	h43	5 cycle 3PH fault at Riel, trip Riel 500/230 kV transformer
		h53		5 cycle 3PH fault at Helena 500 kV, trip the Helena-Maple River 500 kV line
		h63		5 cycle 3PH fault at Helena 345 kV, trip the Helena-Blue Lake 345 kV line
		he3		5 cycle 3PH fault at Helena 345 kV, trip the Helena-Lake Marion 345 kV line
		hgs		5 cycle SLG fault at Helena 345 kV on 500-345 kV xfmr, 345 kV breaker fails, clear at 16 cycles by tripping Helena-Blue Lake
		hjs		5 cycle SLG fault at Helena 345 kV on Helena-Blue Lake line, Helena breaker fails, clear at 16 cycles by tripping Helena-Wilmarth
		h83		5 cycle 3PH fault at Maple River 500 kV, trip the Maple River 500/345 kV transformer
		hm9		5 cycle 3PH fault at Maple River 500 kV, trip the Dorsey-Maple River line
		hoc		5 cycle SLG fault at Maple River 500 kV on 500-345 kV xfmr, 500 kV breaker fails, clear at 16 cycles by tripping Dorsey-Maple River
		h93		5 cycle 3PH fault at Maple River 345 kV, trip Maple River-Alexandria SS 345 kV line
		hhs		5 cycle SLG fault at Maple River 345 kV on 500-345 kV xfmr, 345 kV breaker fails, clear at 16 cycles by tripping Maple River-Alexandria SS
		hks		5 cycle SLG fault at Maple River 345 on Alexandria SS line, Maple River breaker fails, clear at 16 cycles by tripping Maple River 345-230 kV xfmr
			hd9	5 cycle 3PH fault at King 500 kV, trip Dorsey-King line
			his	5 cycle SLG fault at King 345 on 500-345 kV transformer, 345 kV breaker fails, clear at 16 cycles by tripping King-Eau Claire line

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

The disturbances listed in Table 1-8 assume that outage of new 500 kV facilities associated with upgrade Option 1 or Option 3 do not trigger HVDC reduction. Existing triggers to the HVDC reduction scheme were simulated and reduction amounts are summarized in Table 1-9. When an exporting tie line is lost the HVDC power order is reduced by the pre-contingent flow on the tie line. Reduction amounts in the study cases are lower than in the benchmark case because flow is reduced on the existing Manitoba-US ties lines in the Option 1 and Option 3 study cases.

Table 1-9: HVDC Reduction

ID	Description	Reduction	Pre-Benchmark moa	Benchmark mba	TSR Study Option 1 m1a	TSR Study Option 3 m3a
cts	SLG fault at Chisago 345 with breaker failure	100% M602F	1856 MW	1777 MW	1545 MW	1583 MW
em3	3PH fault at Letellier 230 on L20D	100% L20D	239 MW	288 MW	236 MW	268 MW
h23	3PH fault at Dorsey 500 on 500-230 xfmr	50% M602F	928 MW	888 MW	772 MW	791 MW
h33	3PH fault at Riel 500 on M602F	100% M602F	1856 MW	1777 MW	1545 MW	1583 MW
hec	SLG fault at Dorsey 500 with breaker failure; xfmr outage triggers HVDC reduction	50% M602F			772 MW	
hfs	SLG fault at Dorsey 500 with breaker failure; xfmr outage triggers HVDC reduction	50% M602F				791 MW
mc3	3PH fault at Richer 230 on R50M	100% R50M	142 MW	140 MW	129 MW	134 MW
mis	Bipole 2 block , cross trip MH-OH ties	100% (K21W+K22W)	200 MW	200 MW	199 MW	199 MW
nad	3PH fault at Forbes 500 on M602F	100% M602F	1856 MW	1777 MW	1545 MW	1583 MW
nmz	3PH fault at Chisago 500 on F601C	100% M602F	1856 MW	1777 MW	1545 MW	1583 MW
pas	SLG fault at Forbes 500 with breaker failure	100% M602F	1856 MW	1777 MW	1545 MW	1583 MW

1.4 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.

1.5 Results for Benchmark Cases

Transient stability simulation results for the pre-benchmark and benchmark cases are summarized in Appendix C. All of the simulated disturbances result in acceptable system performance.

1.6 Results for Option 1 Study Case

Transient stability simulation results for the TSR study cases are summarized in Appendix C.

1.6.1 Option 1 Results

Significant results are summarized in Table 1-10. These disturbances involve outage of the Dorsey-Maple River 500 kV line without directly triggering HVDC reduction or outage of the Maple River-Helena 500 kV line.

Several of the disturbances cause the relay on the Manitoba-Ontario tie or the DCAR DC reduction relay at Forbes to operate. These relays are intended to operate for severe disturbances that could lead to voltage collapse and are not intended to operate for category B or category C disturbances. The analysis summarized in Section 1.6.2 was performed to document system response if the settings of the Manitoba-Ontario relay and DCAR relay could be changed so that neither relay operates for the Dorsey-Maple River outage.

Table 1-10: Option 1 Simulation Results

ID	Description	MH-OH Relay Trip *	DCAR Relay Trip *	Transient Voltage Violations	M602F Relay Margin	DCAR Relay Margin	Notes
h79	3PH fault at Dorsey 500 on Maple River line	X	-	-	52%	39%	
h53	3PH fault at Helena 500 on Maple River line	-	-	-	154%	347%	Forbes SVC exceeds continuous rating
hm9	3PH fault at Maple River 500 on Dorsey line	X	X	-	44%	<0%	M602F margin violation
hec	SLG fault at Dorsey 500 on Maple River line with breaker failure; trip 500-230 kV xfmr; xfmr outage triggers HVDC reduction	-	-	-	21%	170%	M602F margin violation - minimum margin occurs during backup clearing.
hlc	SLG fault at Dorsey 500 on Maple River line, with breaker failure, trip Dorsey-Riel	X	-	-	21%	55%	M602F margin violation - minimum margin occurs during backup clearing.
hoc	SLG fault at Maple River 500 on 500-345 kV xfmr with breaker failure, trip Maple River-Dorsey	X	X	-	52%	<0%	

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes.

Neither the Manitoba-Ontario relay nor the DCAR relay operate in disturbance *hec* but the out-of-step relay on M602F violates the 50% minimum relay margin criterion. This disturbance is a fault at Dorsey on the Maple River line with delayed clearing. The margin violation occurs during the backup clearing time, which means that the violation is independent of the facility disconnected to clear the fault.

1.6.2 Option 1 Results with Relays Blocked

Disturbances *h79*, *hm9*, *hlc* and *hoc* were repeated with the Manitoba-Ontario, DCAR and M602F relays blocked as indicated in Table 1-11 to document system response if the settings of the relays could be changed so that the relays do not operate for the Dorsey-Maple River outage.

Results are summarized in Table 1-11. There are no transient voltage violations. The M602F relay margin violation in *hls* (originally *hlc*) occurs during backup clearing time as shown in Figure 1-1. M602F relay margin violations in *h73* (originally *h79*), *hm3* (originally *hm9*) and *hoa* (originally *hoc*) occur when voltage dips at Forbes following fault clearing. The voltage oscillation shown in Figure 1-3 is typical of all four disturbances; the Forbes SVC is at its capacitive limit and is not able to provide damping.

Table 1-11: Option 1 Results with Relays Blocked

ID	Description	MH-OH Blocked	DCAR Blocked	M602F OOS Blocked	Transient Voltage Violations	M602F Relay Margin	Forbes SVC Reaches Dynamic Limit	Notes
h73	3PH fault at Dorsey 500 on Maple River line	X	X	-	-	48%	X	M602F margin violation
hm3	3PH fault at Maple River 500 on Dorsey line	X	X	-	-	37%	X	M602F margin violation
hls	SLG fault at Dorsey 500 on Maple River line, with breaker failure, trip Dorsey-Riel	X	-	-	-	21%	X	Minimum relay margin occurs during backup clearing.
hoa	SLG fault at Maple River 500 on 500-345 kV xfmr with breaker failure, trip Maple River-Dorsey	X	X	X	-	<0%	X	M602F margin is around 10% on first swing; <0% for second swing

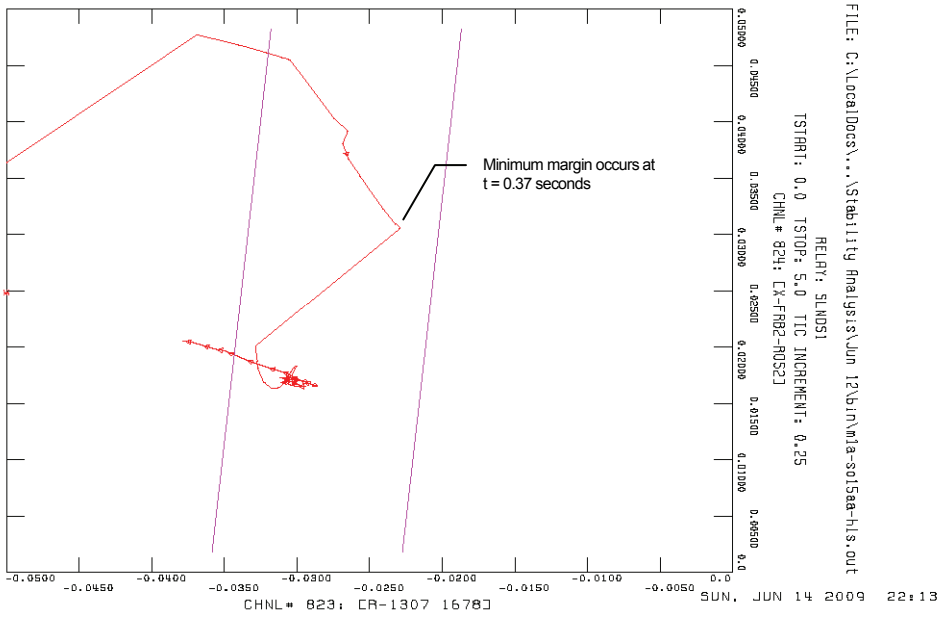


Figure 1-1: M602F Apparent Impedance at Forbes for SLG Fault at Dorsey with Delayed Clearing (*hls*)

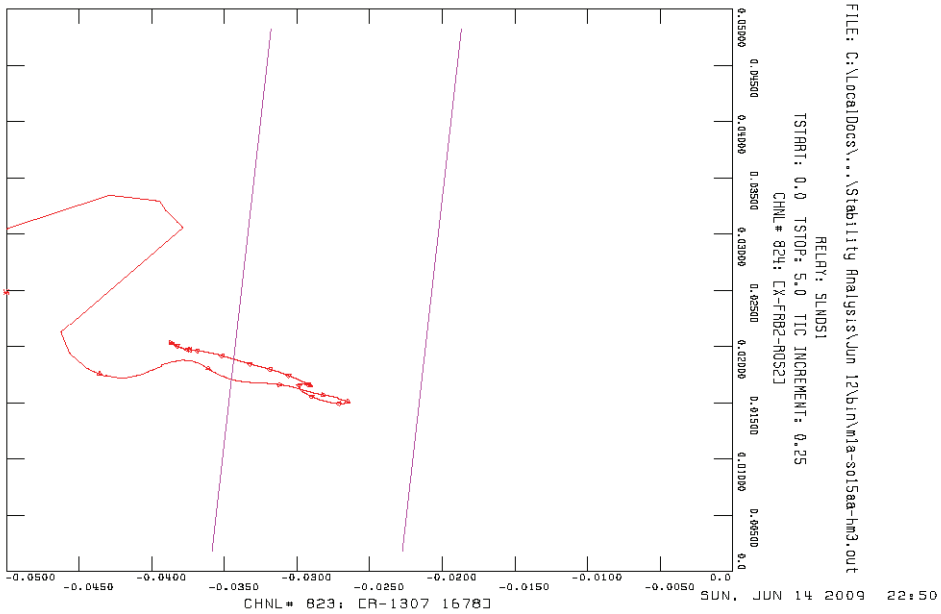


Figure 1-2: M602F Apparent Impedance at Forbes for 3PH fault at Maple River (*hm3*)

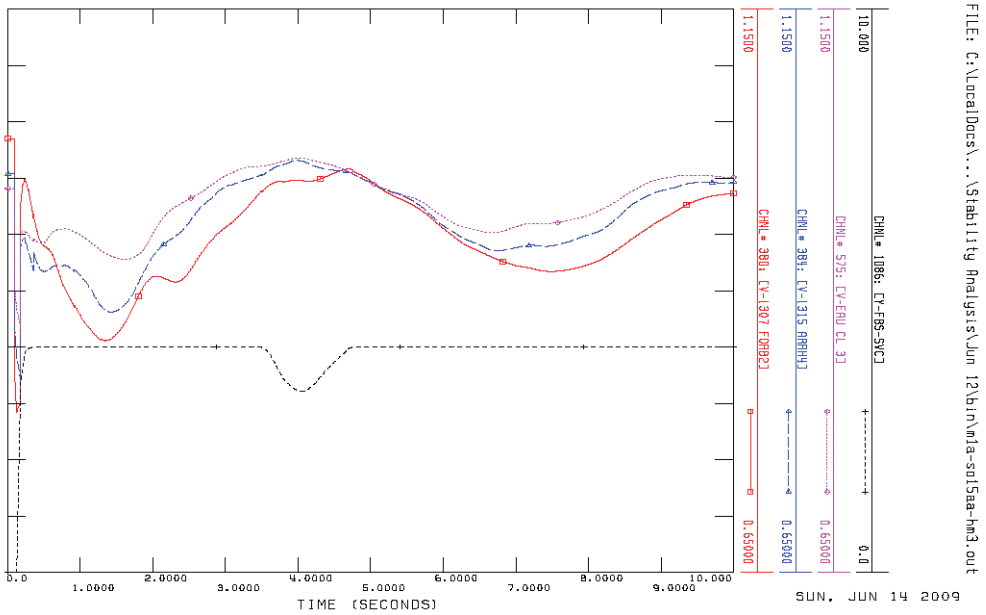


Figure 1-3: Bus Voltage and Forbes SVC Admittance for 3PH fault at Maple River (*hm3*)

1.6.3 Option 1 Results with Additional Reactive Support

Disturbances *h79*, *hm9*, *hlc* and *hoc* were repeated with additional reactive support added at the Forbes 500 kV bus. Results with an additional 400 MVAr of reactive support are summarized in Table 1-12. There are two 300 MVAr mechanically switched capacitors at Forbes; additional reactive support was simulated by switching a 400 MVAr capacitor 5 cycles after the fault is applied.

Table 1-12: Option 1 Results with Additional 400 MVAr Shunt at Forbes

ID	Description	MH-OH Blocked	DCAR Blocked	Transient Voltage Violations	M602F Relay Margin	Forbes SVC Reaches Dynamic Limit	Notes
h7z	3PH fault at Dorsey 500 on Maple River line	-	-	-	79%	X	
hmz	3PH fault at Maple River 500 on Dorsey line	X	-	-	58%	X	
hlz	SLG fault at Dorsey 500 on Maple River line, with breaker failure, trip Dorsey-Riel	X	-	-	15%	X	Minimum relay margin occurs during backup clearing.
hoz	SLG fault at Maple River 500 on 500-345 kV xfmr with breaker failure, trip Maple River-Dorsey	X	-	-	61%	X	

The Manitoba-Ontario relay does not operate in disturbance *h7z* (originally *h79*) but had to be blocked for the other disturbances. The M602F relay margin only violates criteria for *hlz* (originally *hlc*).

Figure 1-4 shows that additional reactive support reduces the magnitude of the voltage oscillations. However, in each simulation the Forbes SVC still hits the 400 MVAr dynamic limit for more than one second and exceeds the 110 MVAr steady-state limit at ten seconds.

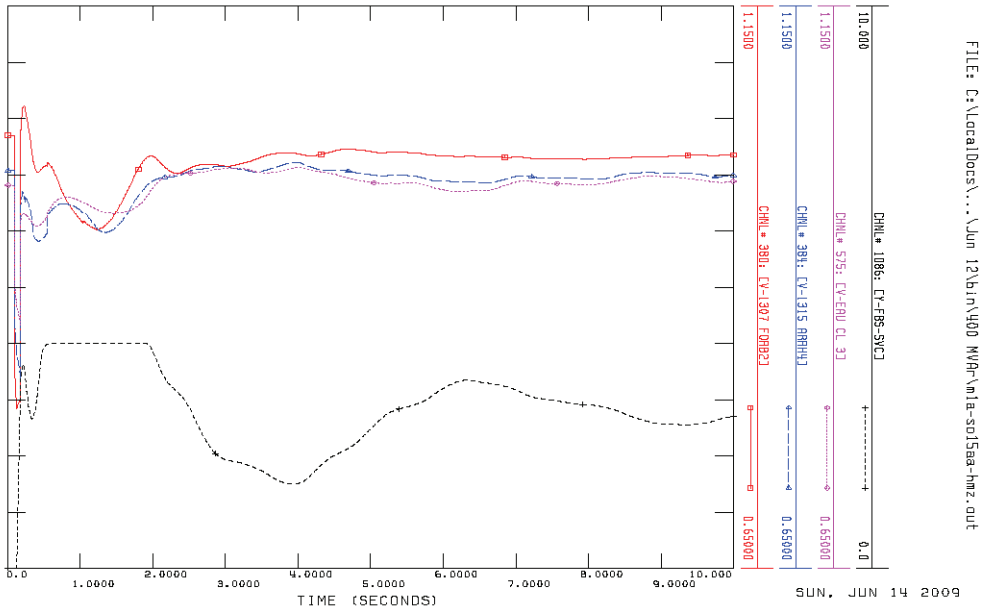


Figure 1-4: Bus Voltage and Forbes SVC Admittance with Additional Reactive Support for 3PH fault at Maple River (*hmz*)

Simulation results with an additional 600 MVAr of support at Forbes are similar to results for 400 MVAr except that the relay on the Manitoba-Ontario tie does not operate for any of the disturbances. SVC admittance and the 500 kV bus voltage at Forbes is shown in Figure 1-5 for the base Option 1 study case and the study case with additional 400 MVAr and 600 MVAr support. The SVC output should be less than or equal to the 110 MVAr continuous rating at the end of the simulation, which will require approximately 600 MVAr of support.

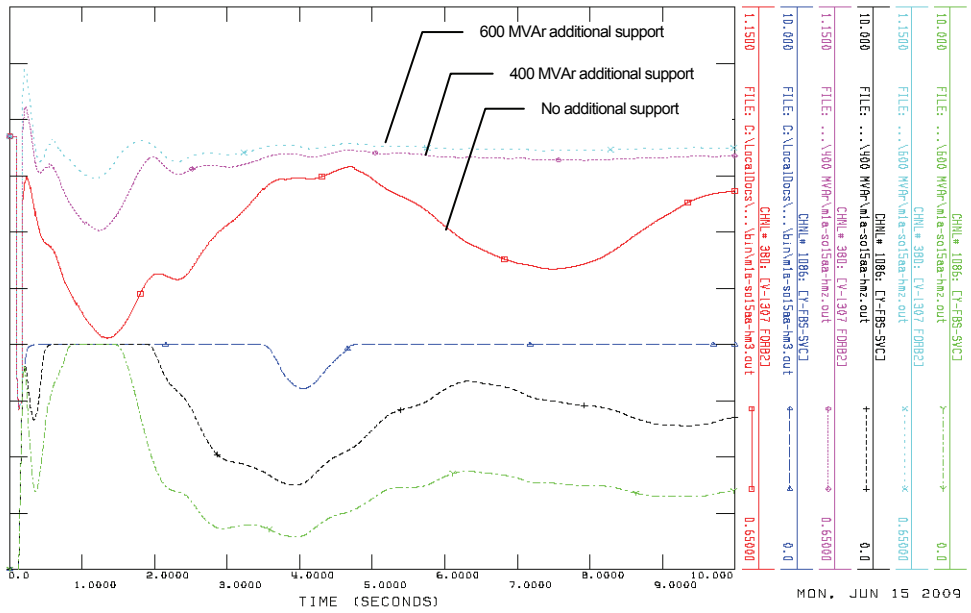


Figure 1-5: Forbes 500 kV Voltage and Forbes SVC Admittance for 3PH fault at Maple River (*hmz*)

Current through the Roseau series capacitors on M602F is shown in Figure 1-6 for the disturbances listed in Table 1-12. The series capacitors have inverse-time overcurrent relays that initiate a bypass of the series capacitors, which triggers the existing HVDC reduction scheme. The relay setting corresponds to operation in 1 second for a 3000 A current through the capacitors and operation in 5 seconds for a current of 2800 A. The current shown in Figure 1-6 should not trip the relays since the current does not exceed 2800 A for 5 seconds. Since much of the series capacitor's overload capability will have been used, it may be necessary to reduce the current to 2000 A in less than 30 minutes. Additional studies should be performed to confirm that the M602F series capacitors have adequate overload capability if outage of the new Dorsey-Maple River 500 kV line is not used to trigger HVDC reduction.

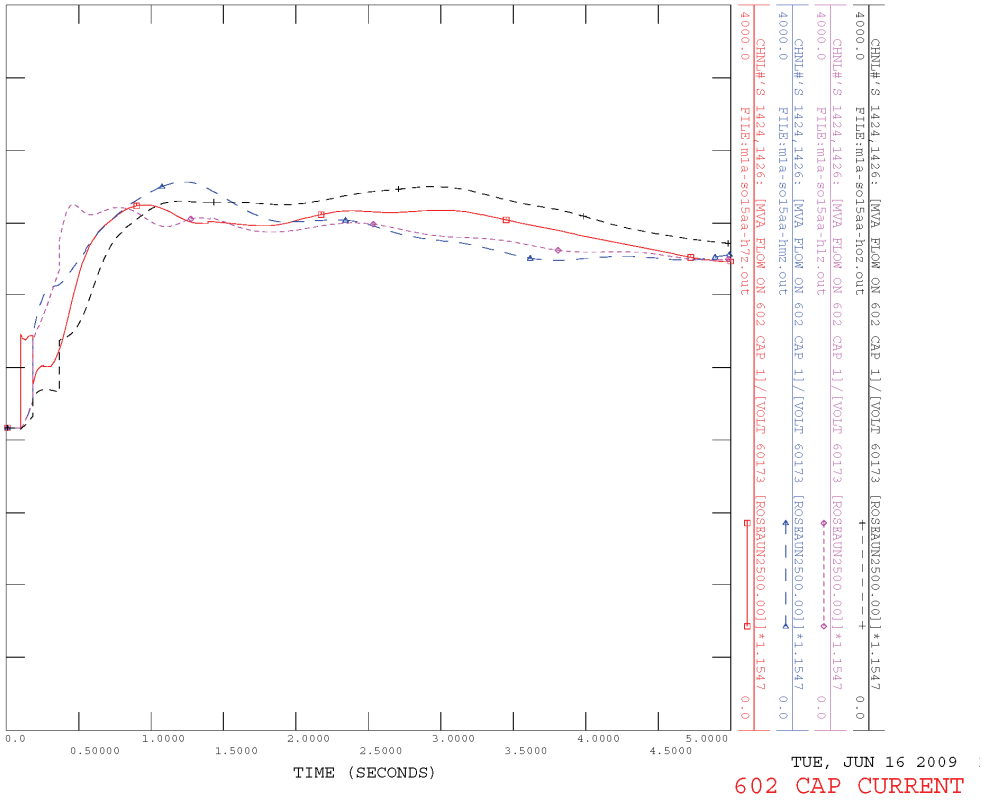


Figure 1-6: M602F Series Capacitor Current for Faults on Dorsey-Maple River 500 kV Line

The analysis summarized in this section indicates that tripping Dorsey-Maple River without a corresponding reduction to the HVDC power order requires the installation of more than 400 MVAr of additional dynamic (fast-switched capacitors) reactive support at Forbes and analysis of protection on the Monitoba-Ontario ties and M602F line to make sure the system is secure during the resulting power swing.

1.6.4 Option 1 Results with DC Reduction

Disturbances h79, hm9, hec, hlc and hoc were repeated with outage of the new Dorsey-Maple River 500 kV line used to trigger HVDC reduction. Reduction is assumed equal to 100% of the pre-disturbance flow on Dorsey-Maple River.

There are no criteria violations with a 100% reduction as shown in Table 1-13. The power order reduction increases the M602F relay margin for all disturbances, including the single-line-to-ground faults at Dorsey with delayed clearing, *he0* (originally *hec*) and *hl0* (originally *hlc*).

Table 1-13: Option 1 Results with DC Reduction

ID	Description	MH-OH Relay Trip*	DCAR Relay Trip*	Transient Voltage Violations	M602F Relay Margin	DCAR Relay Margin	Notes
h7d	3PH fault at Dorsey 500 on Maple River line	-	-	-	262%	507%	
hmd	3PH fault at Maple River 500 on Dorsey line	-	-	-	200%	507%	
he0	SLG fault at Dorsey 500 on Maple River line with breaker failure; trip 500-230 kV xfmr; xfmr outage triggers HVDC reduction	-	-	-	76%	445%	
hl0	SLG fault at Dorsey 500 on Maple River line, with breaker failure, trip Dorsey-Riel	-	-	-	76%	445%	
ho0	SLG fault at Maple River 500 on 500-345 kV xfmr with breaker failure, trip Maple River-Dorsey	-	-	-	220%	507%	

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes.

The HVDC reduction resulting from the M602F or Dorsey-Maple River triggers in the study case are lower than the reduction that occurs for the M602F trigger in the benchmark case as shown in Table 1-14. Depending on the final design of the Option 1 transmission upgrade, the required amount of reduction may be less than 100%.

Table 1-14: DC Power Order Reduction

Trigger	Benchmark Case	Option 1 Study Case
M602F	100% = 1749 MW	100% = 1545 MW
Dorsey-Maple River		100% = 1460 MW

1.7 Results for Option 3 Study Case

Transient stability simulation results for the TSR study cases are summarized in Appendix C.

1.7.1 Option 3 Results

Significant results are summarized in Table 1-15. These disturbances involve outage of one of two facilities:

- the Dorsey-King 500 kV line without directly triggering HVDC reduction, or
- the King-Eau Claire 345 kV line.

Table 1-15: Option 3 Simulation Results

ID	Description	MH-OH Relay Trip*	DCAR Relay Trip*	Transient Voltage Violations	M602F Relay Margin	DCAR Relay Margin	Notes
pc0	SLG fault at King 345 on Eau Claire line with breaker failure; trip Chisago line			X			Minong voltage = 0.80
pcs	SLG fault at King 345 on Eau Claire line with breaker failure; trip Chisago line; cross trip Eau Claire-Arpin			X			Minong voltage = 0.80
hc9	3PH fault at Dorsey 500 on King line	X	X		45%	<0%	M602F margin violation
hfs	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey 500-230 kV xfmr; xfmr outage triggers HVDC reduction				11%	143%	M602F margin violation - minimum margin occurs during backup clearing.
hna	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey-Riel #2	X	X		11%	<0%	M602F margin violation - minimum margin occurs during backup clearing.
hd9	3PH fault at King 500 on Dorsey line	X	X	X	38%	<0%	M602F margin violation, MP voltage violations
his	SLG fault at King 345 on 500-345 kV xfmr with breaker failure; trip Eau Claire line			X			Minong voltage = 0.81

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes.

Outage of King-Eau Claire in disturbances *his*, *pc0* and *pcs* cause a transient voltage violation at the Minong 161 kV bus. This constraint is analyzed in Section 1.7.2.

Disturbances *hc9*, *hna* and *hd9* cause the relay on the Manitoba-Ontario tie and the DCAR DC reduction relay at Forbes to operate. These relays are intended to operate for severe disturbances that could lead to voltage collapse and are not intended to operate for category B or category C disturbances. The analysis summarized in Section 1.7.3 was performed to determine what happens if the settings of the Manitoba-Ontario relay and DCAR relay could be changed so that neither relay operates for the Dorsey-King outage.

Neither the Manitoba-Ontario relay nor the DCAR relay operate in disturbance hfs but the out-of-step relay on M602F violates the 50% minimum relay margin criterion. This disturbance is a fault at Dorsey on the King line with delayed clearing. The margin violation occurs during the backup clearing time, which means that the violation is independent of the facility disconnected to clear the fault.

1.7.2 Minong Voltage Violation

As shown in Figure 1-7, disturbances *his*, *pc0* and *pcs* cause a transient voltage violation at the Minong 161 kV bus. A second 75 MVAR shunt capacitor at the Stone Lake 345 kV bus increases the minimum transient voltage to 0.82 per unit and eliminates the violation. In disturbances *pc0* and *pcs* the voltage violation occurs approximately 0.52 seconds after the fault is applied at King. The existing capacitor at the Stone Lake 345 kV bus is modeled with a 15-cycle insertion time; if the capacitors are switched sequentially, the insertion time for each capacitor needs to be less than 12 cycles so that both capacitors are on before the violation occurs. Table 1-16 shows a comparison of the minimum transient voltage at Arrowhead and Minong in the benchmark and study cases.

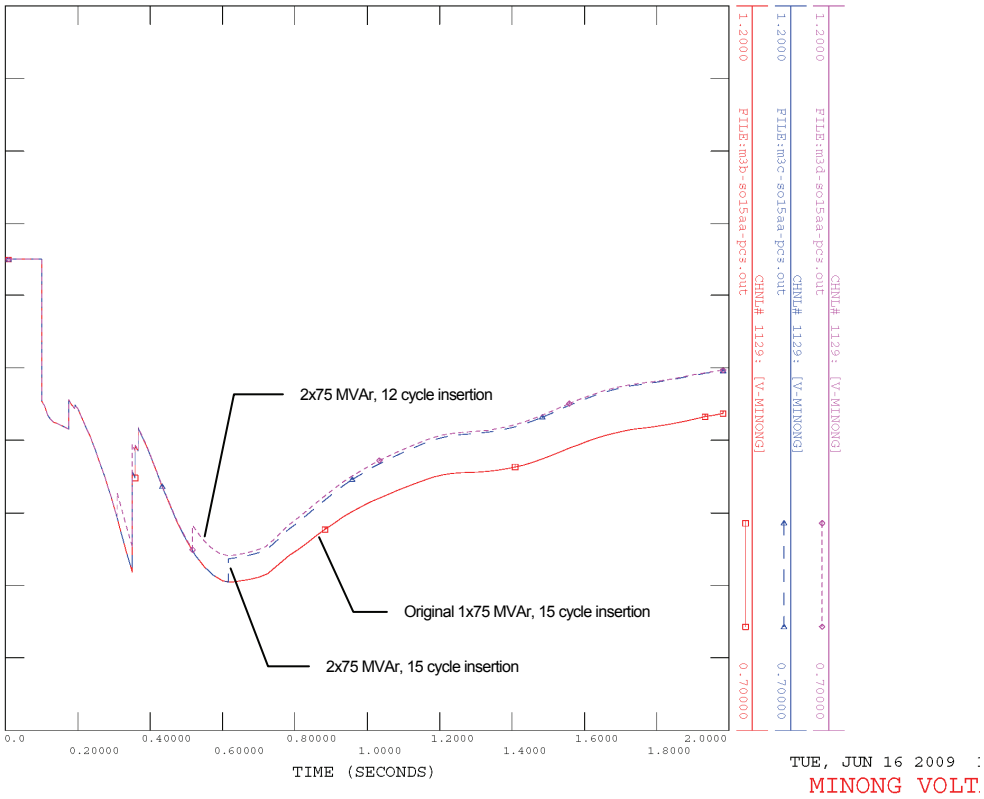


Figure 1-7: Minong Bus Voltage for SLG Fault at King with Delayed Clearing (pcs)

Table 1-16: Minimum Transient Voltage for Disturbance PCS

Case	MWEX/Rochester-LaCrosse	Minong 161 kV	Arrowhead 230 kV
Pre-Benchmark moa-so15aa	1519 MW/0 MW	0.86 per unit	0.88 per unit
Benchmark mba-so15aa	1497 MW/247 MW	0.88 per unit	0.90 per unit
Option 1 study case m1a-so15aa	1641 MW/309 MW	0.83 per unit	0.87 per unit
Option 3 study case - m3a-so15aa - with 2x75 MVAr cap at Stone Lake	1722 MW/292 MW	0.80 per unit 0.82 per unit	0.84 per unit 0.82 per unit

1.7.3 Option 3 Results with Relays Blocked

Disturbances *hc9*, *hna* and *hd9* were repeated with the Manitoba-Ontario, DCAR and M602F relays blocked as indicated in Table 1-17 to determine what happens if the settings of the relays could be changed so that the relays do not operate for the Dorsey-King outage.

Results are summarized in Table 1-17. Three-phase faults on the Dorsey-King 500 kV line cause stability problems as shown in Figure 1-8.

Table 1-17: Option 3 Results with Relays Blocked

ID	Description	MH-OH Blocked	DCAR Blocked	M602F OOS Blocked	Transient Voltage Violations	M602F Relay Margin	Forbes SVC Reaches Dynamic Limit	Notes
hc3	3PH fault at Dorsey 500 on King line	X	X	X	X	<0%	X	Loss of synchronism if relays are blocked
hns	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey-Riel #2	X	X	X	X	<0%	X	M602F margin violation, MP voltage violations
hd3	3PH fault at King 500 on Dorsey line	X	X	X	X	<0%	X	Transient voltage instability if relays are blocked

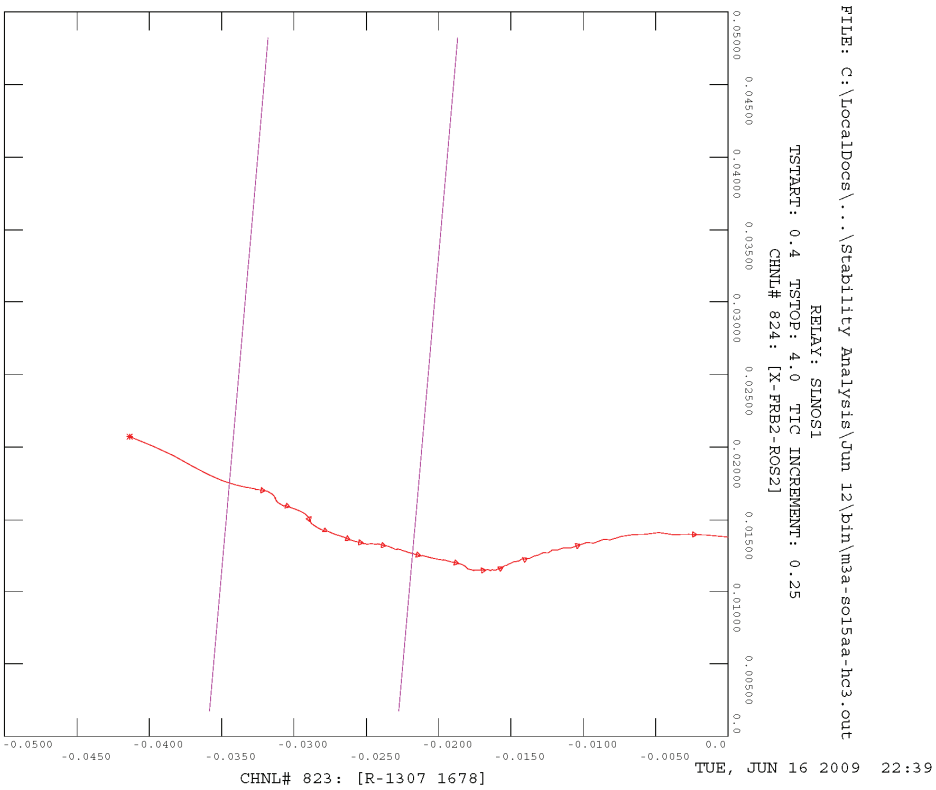


Figure 1-8: M602F Apparent Impedance at Forbes for 3PH Fault at Dorsey (*hc3*)

1.7.4 Option 3 Results with Additional Reactive Support

Disturbances *hc9*, *hna* and *hd9* were repeated with additional reactive support at the Forbes 500 kV bus. Results with an additional 400 MVAr of reactive support are summarized in Table 1-18. Additional reactive support was simulated by switching a 400 MVAr capacitor 5 cycles after the fault is applied, resulting in a total of 600+400=1000 MVAr of shunt capacitors in addition to the SVC.

Figure 1-9 shows that with an additional 400 MVAr of reactive support at Forbes, there are still severe voltage dips and the Forbes SVC remains at its 400 MVAr dynamic limit for most of the simulation. The magnitude of the voltage oscillation is significantly smaller with 600 MVAr of additional support as shown in Figure 1-10. The SVC output should be less than or equal to the 110 MVAr continuous rating at the end of the simulation, which will require approximately 900 MVAr of support.

Table 1-18: Option 3 Results with Additional 400 MVAr Shunt at Forbes

ID	Description	MH-OH Blocked	DCAR Blocked	M602F OOS Blocked	Transient Voltage Violations	M602F Relay Margin	Forbes SVC Reaches Dynamic Limit	Notes
hcz	3PH fault at Dorsey 500 on King line	X	-	-	-	31%	X	M602F margin violation
hnz	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey-Riel #2	X	X	X	-	<0%	X	M602F blocked for simulation
hdz	3PH fault at King 500 on Dorsey line	X	-	X	-	<0%	X	M602F blocked for simulation

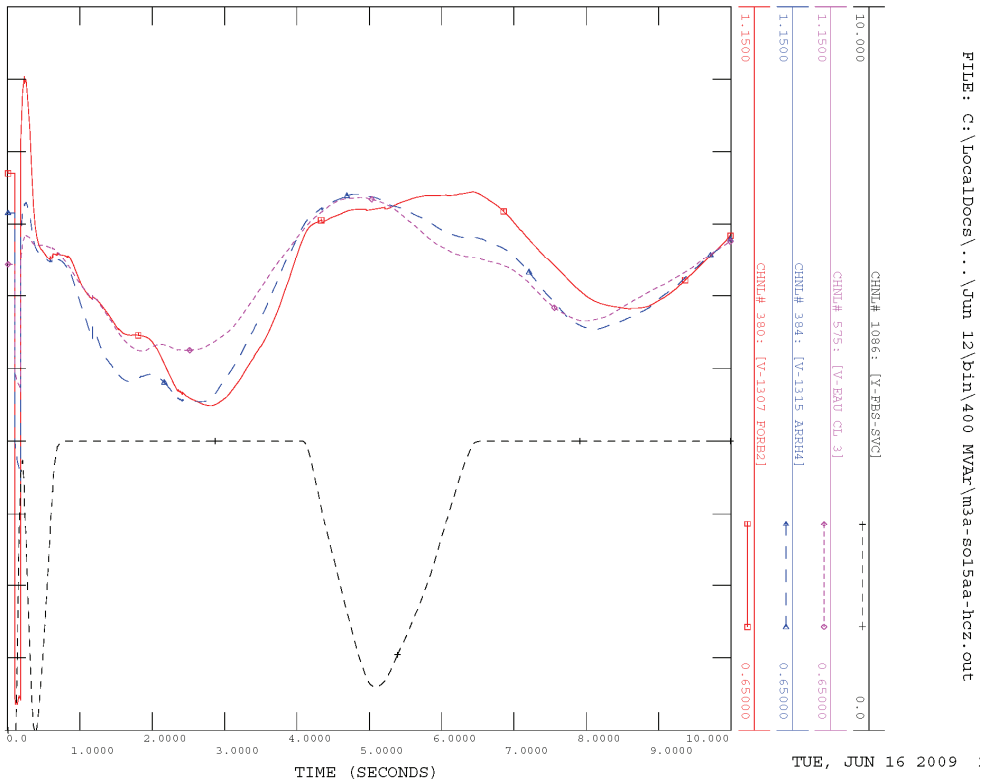


Figure 1-9: Bus Voltage and Forbes SVC Admittance with Additional Reactive Support for 3PH fault at Dorsey (*hcz*)

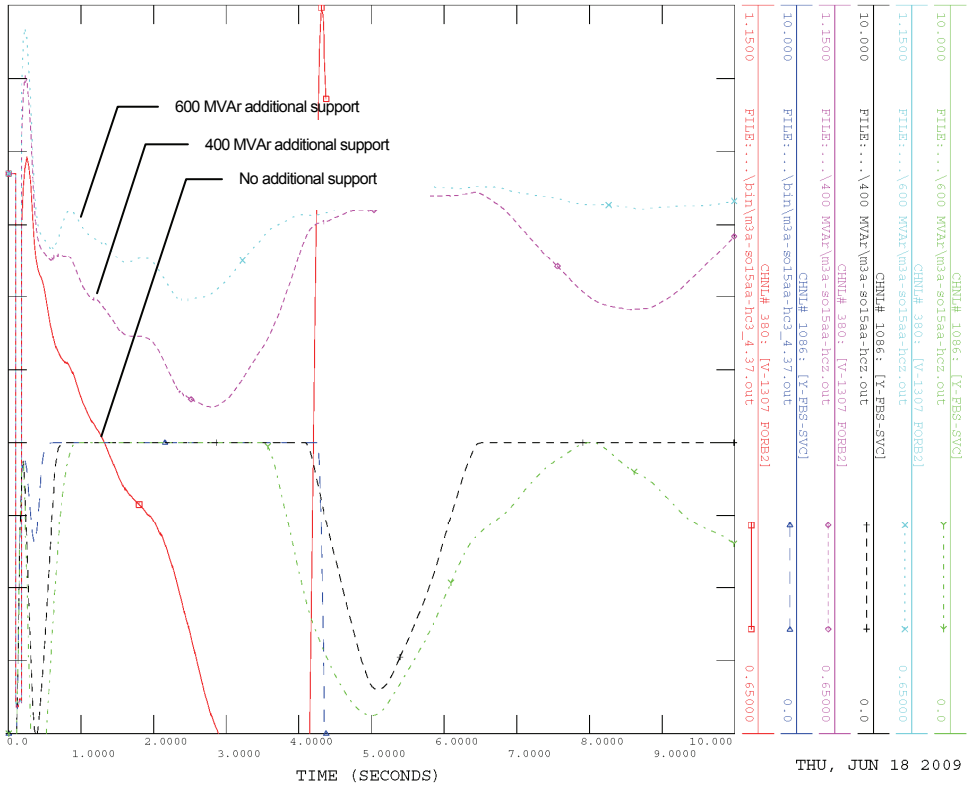


Figure 1-10: Forbes 500 kV Voltage and Forbes SVC Admittance for 3PH fault at Dorsey (*hcz*)

Current through the Roseau series capacitors on M602F is shown in Figure 1-11 for the disturbances listed in Table 1-17. The series capacitors have inverse-time overcurrent relays that initiate a bypass of the series capacitors, which triggers the existing HVDC reduction scheme. The relay setting corresponds to operation in 1 second for a 3000 A current through the capacitors and operation in 5 seconds for a current of 2800 A. The current shown in Figure 1-11 will trip the relays since the current exceeds 3000 A for more than 1 second. Additional mitigation will be required if the relay settings can not be adjusted and the new Dorsey-Maple River 500 kV line is not used to trigger HVDC reduction.

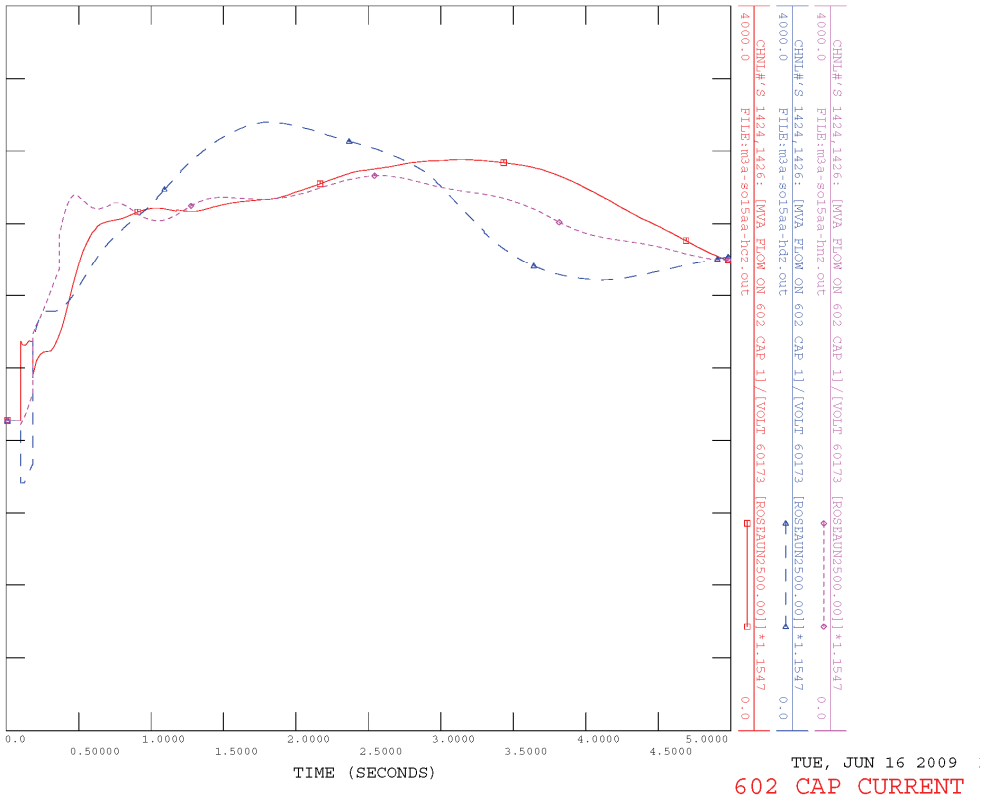


Figure 1-11: M602F Series Capacitor Current for Faults on Dorsey-King 500 kV Line

1.7.5 Option 3 Results with DC Reduction

Disturbances *hc9*, *hfs*, *hna* and *hd9* were repeated with outage of the new Dorsey-King 500 kV line used to trigger reduction of the power order on Manitoba Hydro's HVDC lines. Reduction is assumed equal to 100% of the pre-disturbance flow on Dorsey-King.

There are no criteria violations with a 100% reduction as shown in Table 1-19. The power order reduction increases the M602F relay margin for all disturbances, including the single-line-to-ground faults at Dorsey with delayed clearing, *hf0* (originally *hfs*) and *hn0* (originally *hna*).

Table 1-19: Option 3 Results with DC Reduction

ID	Description	MH-OH Relay Trip*	DCAR Relay Trip*	Transient Voltage Violations	M602F Relay Margin	DCAR Relay Margin	Notes
hcd	3PH fault at Dorsey 500 on King line	-	-	-	233%	507%	
hf0	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey 500-230 kV xfmr; xfmr outage triggers HVDC reduction	-	-	-	60%	409%	
hn0	SLG fault at Dorsey 500 on King line with breaker failure; trip Dorsey-Riel #2	-	-	-	60%	409%	
hdd	3PH fault at King 500 on Dorsey line	-	-	-	185%	507%	

* MH-OH relay is DPDARE relay. DCAR is delta current admittance relay at Forbes

The power order reduction resulting from the M602F or Dorsey-Maple River triggers in the study case are lower than the reduction that occurs for the M602F trigger in the benchmark case as shown in Table 1-20. Depending on the final design of the Option 3 transmission upgrade, the required amount of reduction may be less than 100%.

Table 1-20: DC Power Order Reduction

Trigger	Benchmark Case	Option 3 Study Case
M602F	100% = 1749 MW	100% = 1583 MW
Dorsey-King		100% = 1362 MW

Appendix

A

Stability Power Flow Model Development

A.1 Pre-Benchmark Case

1.1 Apply Response file provided by ATC to update model

```
2015SUOP_ATC_20090304_v29.idv
```

1.2 Add Big Stone II (generator and 230 kV outlet)

```
i-addBGSGrntFlls230.idv (added here but removed by later response file)
i-addBGSMrrs230.idv
purge_Ortonville230.idv
BSPII_BSP_JHNSJCT_MORRIS_1272.idv
BSPII_BSP_CANBY_GFLS_1272BNDL.idv
i-addBGSII.idv
```

1.3 Add MTEP near-term projects

```
ALTW_1289_Marshalltown-Toledo_115V.idv
ALTW_1618_Heron Lake-Lakefield_161kV.idv
altw_1753_Winnebago Jct_161-69_kV_75_MVA_TRFs1&2.idv
altw_1761_Tripoli-Readlyn_69_kV_Rebuild.idv
ALTW_Arnold-Washburn_1739-161kV_Upgrade.idv
ITCM_Grand_Mound-1619_161kV-CONVERTED_v2.idv
altw_hiawatha-Lws_Flds-1342_161-115kV.idv
altw_salem-1287_345-161kV_448_MVA.idv
ATC_(339)_Jefferson-Stonybrook_138_kV_and_Uprates.idv
ATC_(1553)_Hiawatha_Cap_1x16_3.idv
GRE-PROJECT-TOWER(1021)(for mp).idv
xel-1368-1369-1370-NEWRICHMOND.idv
xel-1373-NEWULM-TS.idv
xel-1457-BRIGO_.idv
xel-1489-WOODBURY-TANNERSLAKE.idv
xel-1545-MANKATO_115KV_LOOP_v2.idv
xel-1548-LACROSSE.idv
xel-1548-mONROECO_CAPBANK.idv
xel-1549-EAUCLAIRE_v2.idv
XEL-1959-YANKEEDOODLE-PILOTKNOB_v2.idv
```

1.4 Add MTEP out-year projects excluding CapX

```
ALTW_1758_Beaver_Channel-2nd_AVE_69_kV_Rebuild-CONVERTED.idv
ALTW_Hazelton-1288_345-161kV_335_MVA-CONVERTED.idv
ALTW_Hills-Washington-1755_69kV_Rbld-CONVERTED.idv
ALTW_Leon-1645_69kV_7MVAR-CONVERTED.idv
ALTW_N_Cntrville_69kV-1772_7MVAR-CONVERTED.idv
ALTW_Quad-RkCrk-Salem-1345_Terminals-CONVERTED.idv
ALTW_Salem-Lore-Hazelton-1340_345kV-CONVERTED.idv
ALTW_Toledo-Belle-1289_Plaine_Stoney_Pt-CONVERTED.idv
GRE-1021-EMBARRASS-TOWER115-CONVERTED.idv
GRE-1022-BADOURA-LONGLAKE115-CONVERTED.idv
GRE-1361-BADOURA-BIRCHLAKE115_BL115_69-CONVERTED.idv
GRE-PROJECT-599-ENTPPK_CRKDLK(20152)-CONVERTED.idv
ITCM_1341_Hazleton_161-69_kV_75_MVA_bothTRFs-CONVERTED.idv
ITCM_1473_Mason_City_Emery-Armour_69kV-CONVERTED_v2.idv
ITCM_1522_6th-Beverly_161kV-CONVERTED.idv
ITCM_1618_Heron Lake-Lakefield_161kV-CONVERTED.idv
ITCM_1641_Ottumwa_161kV_50MVAR-CONVERTED.idv
ITCM_1739_Arnold-Washburn_161kV_Upgrade-CONVERTED.idv
ITCM_1753_Winnebago Jct_161-69_kV_75_MVA_TRF-CONVERTED.idv
ITCM_1756_Dyersville-Seippel_Rd_69kV2-CONVERTED.idv
MP-MISO-PROJECT-1482-Pepin-Lk-r2-CONVERTED.idv
OTP-1033-SLVRLK-CONVERTED.idv
OTP-971-WINGERXFMR-20080613 [08-09-16 09_34]-CONVERTED.idv
OTP-MTEPA-2091-CASSLKXFMR-CONVERTED.idv
OTP-MTEPA-2092-SOCASCADE-CONVERTED.idv
SMP-MISO-LAKECITY-1367-AREA [08-10-18 16_21]-CONVERTED.idv
xel-1371-BLACKDOG-WILSON2-UPGRADE_v30-CONVERTED.idv
xel-1455-MERP-RIVERSIDE_v30-CONVERTED.idv
XEL-1487-SOMMERSET-CONVERTED.idv
XEL-1953-SAUKRIVER-STCLOUD-CONVERTED.idv
XEL-1954-WSIOUXFALLS-PATHFINDER-CONVERTED.idv
XEL-1960-TRAVERSE-STPETER-CONVERTED.idv
XEL-1961_LAKEEMILY_CAP-CONVERTED.idv
XEL-552-IRONWOOD_2ND_TR-CONVERTED.idv
XEL-56-CHISAGO-STCROIXFLS [08-10-31 18_27]-CONVERTED_v2.idv
XEL-675-SCOTTCO-WESTGATE-CONVERTED.idv
XEL-PROJECT-1380-WWACONIA-SCOTTCO-115KV-CONVERTED.idv
XEL-PROJECT-1958-StoneLake-Couderay-CONVERTED.idv
```

1.5 Apply miscellaneous updates and corrections

```
GRE-MISO-PROJECT-KRMRLK(53801)-CONVERTED.idv
GRE-MISO-PROJECT-LWRNCTP(20138)-CONVERTED.idv
MP-MISO-Dunka-Load-CONVERTED.idv
MP-MISO-PROJECT-LL-BAD-PINE-PEQ-CONVERTED.idv
add-essar-mn-detail-r1.idv

The following facilities were placed in service:
      - CSLTNET-Buffalo 115 kV line
      - Running 230-69 kV xfmr
      - Moranville 230/115 kV xfmr

The following facilities were purged
      - Center-Harvey-Prairie 345 kV line
      - Center 345/230 kV xfmr #2
      - Harvey 345/230 kV xfmr
```

```
Activity GNET used to replace generators with negative MVA load at the
following buses:
      - Cloquet 115 kV (61668)
      - Chandler 69 kV (bus 62710)
```

1.6 Add NR generating facilities

```
G519 Mesaba.idv
G618_5d.idv
G904_5d.idv
G930_A422_A423_5d.idv
```

1.7 Reduce generation in North Dakota by 540 MW so that North Dakota load is approximately 80% of summer peak. Generating units in the Dakotas dispatched above Pmax (given in power flow case) were reduced to Pmax and wind generation in eastern ND was turned off at Ashtabula, Edgley and Langdon.

1.8 Turn on generation in the GRE and XEL control areas that will be used to sink A388 and A416; scale load in the TVA control area by corresponding amount.

1.9 Manitoba Hyro system updates including the addition of Bipole 3. HVDC loading adjusted to maintain export level and prepare to source TSRs at Dorsey in the study cases. Bipole 1 = 797 MW, Bipole 2 = 903 MW, Bipole 3 = 1540 MW.

```
1-add transcona stuff-2004series.idv
2-Riel 230-500 buses 2004-series.idv
3-riel-sum-08s-2004series.idv
4-BP3_and_Conawapa.idv
5-Gull.idv
Bipole 3 changes.idv
Dorsey--Riel-Ckt2-500kV.idv
```

1.10 Dispatch wind generation in southwest Minnesota at 1083 MW; sink using Xcel Energy generation in the Twin Cities.

```
SW-MN-WIND3.idv
```

1.11 Apply setexports.ipl to adjust NDEX, MHEX and MWEX to their simultaneous maximum capability. NDEX=2450 MW, MHEX = 2175 MW, MWEX - 1525 MW

1.12 Scale load in the TVA control area to make up for load and generation changes

A.2 Benchmark Case

2.1 Add CapX 2020 Group 1 Projects

```
i-1-SWMINN_TC_345additionB_dpk'.idv
i-2-MapleRiver-AlexSS-WaitePark-Monticello_add.idv
i-3-alex-cloud-V29.idv
i-4-Bos230Wil_GIMod.idv
i-5-almx-no-bvd.idv
```

2.2 Add Big Stone 345 kV outlet facilities

```
XEL-1457-HAZEL.idv
MODIFY BIGSTONII.idv
```

A.3 TSR Study Case

3.1 Increase loading on MH bipole 1 and 2 from 1700 MW to 2830 MW and make corresponding change to MH generation schedule at Conawapa and Keeyask

3.2 Adjust generation to sink study TSR

3.3 Add transmission upgrades

3.3.1 Option 1

```
MHEB_Case\upgrades\Dorsey--MapleRiver-midcomp-500kV.idv
MHEB_Case\upgrades\MapleRiver--Helena-midcomp-500kV.idv
```

3.3.2 Option 3

```
MHEB_Case\upgrades\ Dorsey--King-500kV.idv
```

A.4 Model Data for Network Upgrade Option 1 and 3

A.4.1 Option 1

```
DATA FOR BUS  63057 [MIDCOMP-    500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63058 HELENA      500.00  1   0.00126  0.02100  1.87000  1  F  1732.0 1905.0 2361.0
  63059 MIDCOMP-    500.00  1   0.00000 -0.02099  0.00000  1  T  1732.0 1905.0 1732.0


 DATA FOR BUS  63058 [HELENA      500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63057 MIDCOMP-    500.00  1   0.00126  0.02100  1.87000  1  T  1732.0 1905.0 2361.0

 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
  60502 HELNASS3    345.00  1  HLENA500     1 F F 1 1  0.00006  0.00470  100.0
  60502 HELNASS3    345.00  2  HLENA500     1 F F 1 1  0.00006  0.00470  100.0

 X------- TO BUS --------X     C
   BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  WINDV2  NOMV2  RATEA  RATEB  RATEC
  60502 HELNASS3    345.00  1  1 1.00000 0.0000 1.00000 0.0000 1203.0 1203.0 1563.9
  60502 HELNASS3    345.00  2  1 1.00000 0.0000 1.00000 0.0000 1203.0 1203.0 1563.9

 X------- TO BUS --------X     W C
   BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
  60502 HELNASS3    345.00  1  F 1  0 1.10000 0.90000 1.10000 0.90000   33
  60502 HELNASS3    345.00  2  F 1  0 1.10000 0.90000 1.10000 0.90000   33


 DATA FOR BUS  63059 [MIDCOMP-    500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63057 MIDCOMP-    500.00  1   0.00000 -0.02099  0.00000  1  F  1732.0 1905.0 1732.0
  63060 MAPLERIV    500.00  1   0.00126  0.02100  1.87000  1  T  1732.0 1905.0 2361.0


 DATA FOR BUS  63060 [MAPLERIV    500.00] RESIDING IN AREA  620, ZONE    1, OWNER  657:

 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
  63059 MIDCOMP-    500.00  1   0.00126  0.02100  1.87000  1  F  1732.0 1905.0 2361.0
  63062 MIDCOMP-    500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0 2361.0

 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
  66792 MAPLE R3    345.00  1  MPLRV500     1 F F 1 1  0.00006  0.00470  100.0
```

```
X------- TO BUS --------X     C
  BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  WINDV2  NOMV2  RATEA  RATEB  RATEC
 66792 MAPLE R3    345.00  1  1 1.00000 0.0000 1.00000 0.0000 1203.0 1203.0 1563.9

X------- TO BUS --------X     W C
  BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
 66792 MAPLE R3    345.00  1  F 1  0 1.10000 0.90000 1.10000 0.90000   33


DATA FOR BUS  63061 [MIDCOMP-    500.00] RESIDING IN AREA  620, ZONE    1, OWNER  657:

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
 63062 MIDCOMP-    500.00  1   0.00000 -0.02414  0.00000  1  F  1732.0 1905.0 1732.0
 67564 DORSEY 2    500.00  1   0.00145  0.02415  2.15000  1  T  1732.0 1905.0 2361.0


DATA FOR BUS  63062 [MIDCOMP-    500.00] RESIDING IN AREA  620, ZONE    1, OWNER  657:

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
 63060 MAPLERIV    500.00  1   0.00145  0.02415  2.15000  1  F  1732.0 1905.0 2361.0
 63061 MIDCOMP-    500.00  1   0.00000 -0.02414  0.00000  1  T  1732.0 1905.0 1732.0
```

A.4.2 Option 3

```
DATA FOR BUS  63061 [MIDCOMP-    500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63062 MIDCOMP-    500.00  1   0.00000 -0.05349  0.00000  1  F  1732.0 1905.0 1732.0
  67564 DORSEY 2    500.00  1   0.00300  0.05350  5.00000  1  T  1732.0 1905.0 2361.0


 DATA FOR BUS  63062 [MIDCOMP-    500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63061 MIDCOMP-    500.00  1   0.00000 -0.05349  0.00000  1  T  1732.0 1905.0 1732.0
  63064 AS KING     500.00  1   0.00300  0.05350  5.00000  1  F  1732.0 1905.0 2361.0


 DATA FOR BUS  63064 [AS KING     500.00] RESIDING IN AREA  600, ZONE  601, OWNER  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
  63062 MIDCOMP-    500.00  1   0.00300  0.05350  5.00000  1  T  1732.0 1905.0 2361.0

 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
  60186 AS KING3    345.00  1  KING500/     1 T F 1 1  0.00006  0.00470  100.0
  60186 AS KING3    345.00  2  KING500/     1 F F 1 1  0.00006  0.00470  100.0

 X------- TO BUS --------X     C
   BUS# X-- NAME --X BASKV CKT W  WINDV1  NOMV1  WINDV2  NOMV2  RATEA  RATEB  RATEC
  60186 AS KING3    345.00  1  1 1.00000 0.0000 1.00000 0.0000 1203.0 1203.0 1563.9
  60186 AS KING3    345.00  2  1 1.00000 0.0000    0.0 1.00000 0.0000 1203.0 1203.0

 X------- TO BUS --------X     W C
   BUS# X-- NAME --X BASKV CKT 1 W CN   RMAX    RMIN    VMAX    VMIN  NTPS
  60186 AS KING3    345.00  1  T 1  0 1.10000 0.90000 1.10000 0.90000   33
  60186 AS KING3    345.00  2  F 1  0 1.10000 0.90000 1.10000 0.90000   33
```

This page intentionally left blank.

Appendix

B

Power Flow Summaries

B.1 Pre-Benchmark Case without CapX, MH TSRs or Transmission Upgrade Options

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

NDEX:	2451 MW	ECL-ARP:	626 MW
MHEX:	2174 MW	PRI-BYN:	702 MW
MWEX:	1519 MW	AHD-SLK:	638 MW
KING-ECL:	880 MW	SLK-GPK:	444 MW
COOPER S:	1116 MW	WNE-WKS:	545 MW
FTCAL S:	669 MW	GGS:	1623 MW
GRIS-LNC:	696 MW	QC WEST:	130 MW
MAP R-ALEX:	0 MW	WIL-BOWS:	0 MW
NROC-NLAX:	0 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)	8085.1 MW,	68.0% 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/ 242	MH total gross	4960	ATC West Import	1306
Ont. total	22150/ 478	Wpg River	568	ATC SW Import	642
NW	915/ 36	7 Sisters	170	ATC SE Import	-1577
Sask.	2150/ 82	OH total gross	21884	East Bias	286
MP	2341/ 174	northwest	717	SPC>WAPA (B10T)	167
NSP	8085/ 537	SPC total gross	2406	MH>SPC (3-230)	62
N. Dakota	2904/ 294	MP total gross	2859	MH>SPC (FALLS)	0
Manitoba	481 MVARS	ND Cfd AC gross	3149	OH>MH @Kenora	-197
Ont. total	13082 MVARS	net	2978	OH>MP @Ft Fran	149
NW	489 MVARS	NSP East gross	1942	OH E>W @Wawa	187
Sask.	502 MVARS	net	1810	OH>East USA	0
MP	669 MVARS	West gross	3057	F601C @Forbes	1678
NSP	1710 MVARS	net	2895	D602F @Riel	1855
N. Dakota	756 MVARS	Total net	6177	L20D @Letell	238
ATC	10812/ 306	WAPA SD Hydro	1497	R50M @Richer	142
ATC	3159 MVARS	Pleasant Valley	110	G82R @Glenboro	-62
		LGS/Trimont	109		
		SW MN Wind	1084		
		N DAK WIND	252		
		Swing Bus	869		

Tfmrs	MVA/ Load	Ph Shifters	Deg/ MW	DC Lines	MW
Wshell #1 7-7	105/ 73%	Stinson	30/ 31	CU (1,2)	1103
Wshell #2 7-7	105/ 73%	Boundary Dam	9/ 167	SQ BU (3,4)	455
Drayton#1 4-7	44/ 31%	Whiteshell	99/ 201	MH Bipole 1	797
Drayton#2 4-7	56/ 30%	Int Falls	120/ 149	MH Bipole 2	903
Dorsey #1 2-4	484/ 40%	St. Lawrence	16/ 0	MH (BP1+BP2)	1700
Dorsey #2 2-4	564/ 47%	Arrowhead	4/ 639	Miles City E>W	-150
Forbes 2-4	43/ 6%			RCDC (15)	0
Stone Lk 3-5	182/ 54%			Stegall (10)	0

Dorsey SC's	I/S	MVAR	Qmax/ Qmin
MIL 7-9G	17.0 2	-105	600/ -330
SCE 1-3G	18.2 3	-86	480/ -240
SCA 4-6G	18.2 3	-86	480/ -240
Total		-277	1560/ -810
Margin		1837	

SVC's	MVAR	Qmax/ Qmin
Forbes	500 40	400/ -450
Fargo	13.2 9	20/ -135
Watertown	20.0 -11	125/ -86

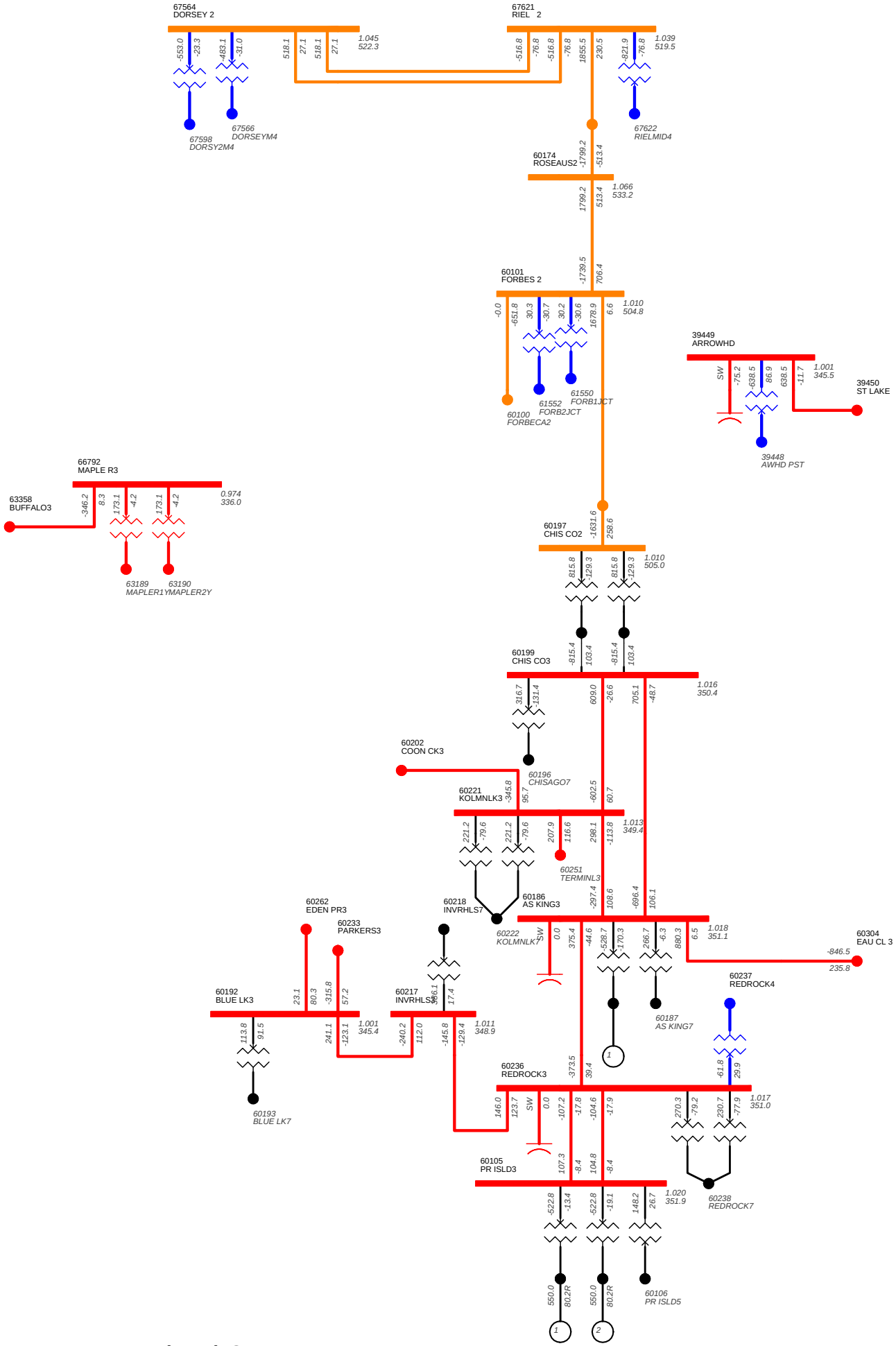
Series Caps	Num In Serv
Roseau	500 2 of 2
Chisago	500 1 of 1

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	76
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	0.997	Whiteshell 110	118.9
Alexandria 115	1.017	Badoura 115	1.022	Kenora 220	246.6
Audubon 115	1.034	Blackberry 230	1.035	Dryden 220	250.8
Bemidji 115	1.010	Boise Cascade 13.8	1.051	Fort Frances 220	244.5
Byron 345	1.017	Boise Cascade 115	1.019	Mackenzie 220	253.7
Chisago Co. 345	1.016	ETCO 115	1.002	Lakehead 220	246.3
Chisago Co. 500	1.010	Forbes 230	1.015	Marathon 220	253.2
Drayton 230	1.031	Forbes 500	1.010	Wawa 220	254.9
Eau Claire 345	1.027	Hubbard 115	1.016	Mississagi 220	250.7
WEST FARIBAULT 115	1.016	Intl Falls 115	1.020	Fort Frances 118	118.8
LaPorte 115	1.008	Minntac 115	1.011	Lakehead 118	122.8
Maple River 230	1.027	Moranville 230	1.024	Birch 118	120.2
Marshall Tap 115	1.025	Riverton 230	1.014	Marathon 118	123.4
Owatonna 161	0.996	Running 230	1.025		0.000
Prairie 115	1.032	Shannon 230	1.026	Arrowhead 345	1.001
Prairie 230	1.026	Stinson MN 115	1.008	Stone Lake 345	1.003
Ramsey 230	1.003	Jamestown 345	0.979	Stone Lake 161	1.011
Roseau County 230	1.024	Groton 345	1.019	Gardner Park 345	1.035
Roseau County 500	1.066	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.028	Watertown 345	1.025	Arpin 345	1.023
Thief R Falls 115	1.027		0.000	Eau Claire 161	1.037
Tioga 230	1.033	Dorsey 230	1.045	Council Creek 161	0.972
Wahpeton 230	1.013	Dorsey 500	1.045	Hydro Lane 161	1.012
Winger 115	1.040		0.000	Wien 115	1.030
	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	333%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	686%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	375%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	222%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	323%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	N/A	1221%	
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	880%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	939%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A



Pre-Benchmark Case

Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR

KV: <=161.000<=230.000 <=345.000 >345.000

B.2 Benchmark Case without MH TSRs or Transmission Upgrade Options

```
                    P O W E R   F L O W   S U M M A R Y
--------------------------------------------------------------------------------
               NDEX:      2271 MW         ECL-ARP:  661 MW
               MHEX:      2176 MW         PRI-BYN:   74 MW
               MWEX:      1497 MW         AHD-SLK:  645 MW
               KING-ECL:   850 MW         SLK-GPK:  459 MW
               COOPER S:  1104 MW         WNE-WKS:  538 MW
               FTCAL S:    647 MW         GGS:     1611 MW
               GRIS-LNC:   663 MW         QC WEST:  148 MW
               MAP R-ALEX: 318 MW         WIL-BOWS:-102 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       Generation        MW       Export            MW
----------- ------ -----     --------------- ------     --------------- ------
Manitoba      2348/ 244      MH total gross    4960     ATC West Import   1399
Ont. total   22150/ 478         Wpg River       568     ATC SW Import      614
     NW        915/  36         7 Sisters       170     ATC SE Import    -1628
Sask.         2150/  82      OH total gross   21884     East Bias          149
MP            2341/ 145         northwest       717     SPC>WAPA (B10T)    164
NSP           8075/ 480      SPC total gross   2406     MH>SPC  (3-230)     60
N. Dakota     2904/ 282      MP total gross    2859     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    151
     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    1521
NSP           1714 MVARS              net       2895     D602F  @Riel      1777
N. Dakota      756 MVARS          Total net     6167     L20D   @Letell     287
ATC           10812/ 317      WAPA SD Hydro     1497     R50M   @Richer     139
ATC            3159 MVARS     Pleasant Valley    110     G82R   @Glenboro   -28
                              LGS/Trimont        109
                              SW MN Wind        1084
                              N DAK WIND         252
                              Swing Bus          758


Tfmrs          MVA/ Load      Ph Shifters  Deg/  MW      DC Lines          MW
-------------- ---- -----     ------------ --- -----     --------------- ------
Wshell #1 7-7  105/  73%      Stinson       27/   30     CU (1,2)          1104
Wshell #2 7-7  105/  73%      Boundary Dam   3/  164     SQ BU (3,4)        455
Drayton#1 4-7   49/  35%      Whiteshell    98/  199     MH Bipole 1        797
Drayton#2 4-7   63/  33%      Int Falls    121/  150     MH Bipole 2        903
Dorsey #1 2-4  464/  38%      St. Lawrence  16/    0     MH (BP1+BP2)      1700
Dorsey #2 2-4  548/  45%      Arrowhead      1/  646     Miles City E>W    -150
Forbes    2-4   78/  11%                                 RCDC (15)            0
Stone Lk  3-5  174/  51%                                 Stegall (10)         0

Dorsey SC's       I/S  MVAR  Qmax/ Qmin    SVC's              MVAR  Qmax/ Qmin
----------------- --- -----  ---- -----    ----------------- -----  ---- -----
MIL 7-9G     17.0  2   -132   600/ -330    Forbes        500    17   400/ -450
SCE 1-3G     18.2  3   -108   480/ -240    Fargo        13.2   -23    20/ -135
SCA 4-6G     18.2  3   -108   480/ -240    Watertown    20.0    15   125/  -86
                        ----  ---- -----
       Total            -349  1560/ -810   Series Caps       Num In Serv
       Margin           1909               ----------------- -----------
                                           Roseau        500   2 of 2
                                           Chisago       500   1 of 1
```

Caps/Reactors		MVAR
Balta	(FS) 230	0
Drayton	115	20
Drayton	13.8	0
Eau Claire	(FS) 161	356
Kohlman Lake	115	240
Parkers Lk	(FS) 115	0
Prairie	(FS) 115	40
Ramsey	(FS) 230	0
Red Rock	115	240
Rugby	13.8	-25
Split Rock	(FS) 115	80
Sheyenne	(FS) 115	40
Wilton/Bemidji	115	20
		0
		0
		0
		0

Caps/Reactors		MVAR
Arrowhead	230	160
Blackberry	230	47
Minntac	115	45
Riverton	230	47
Roseau Co.	(FS) 230	0
Running	(FS) 230	30
Running react	230	0
Shannon	230	72
		0
Glenboro	230	0
Laverendrye	110	98
Richer react	230	0
St Vital	110	98
		0
		0
		0
		0

Caps/Reactors		MVAR
Chisago T 9	34.5	60
Chisago T 10	34.5	60
Forbes	230	70
Forbes	500	600
		0
Fargo	115	27
Watertown	20	20
Watertown	230	0
		0
Arrowhead	345	75
Stone Lake	345	0
Stone Lk Reac	345	0
Stone Lake	161	0
Grdnr Pk Reac	345	0
Grdnr Pk Caps	115	0
Arpin Caps	138	52
Council Creek	138	16

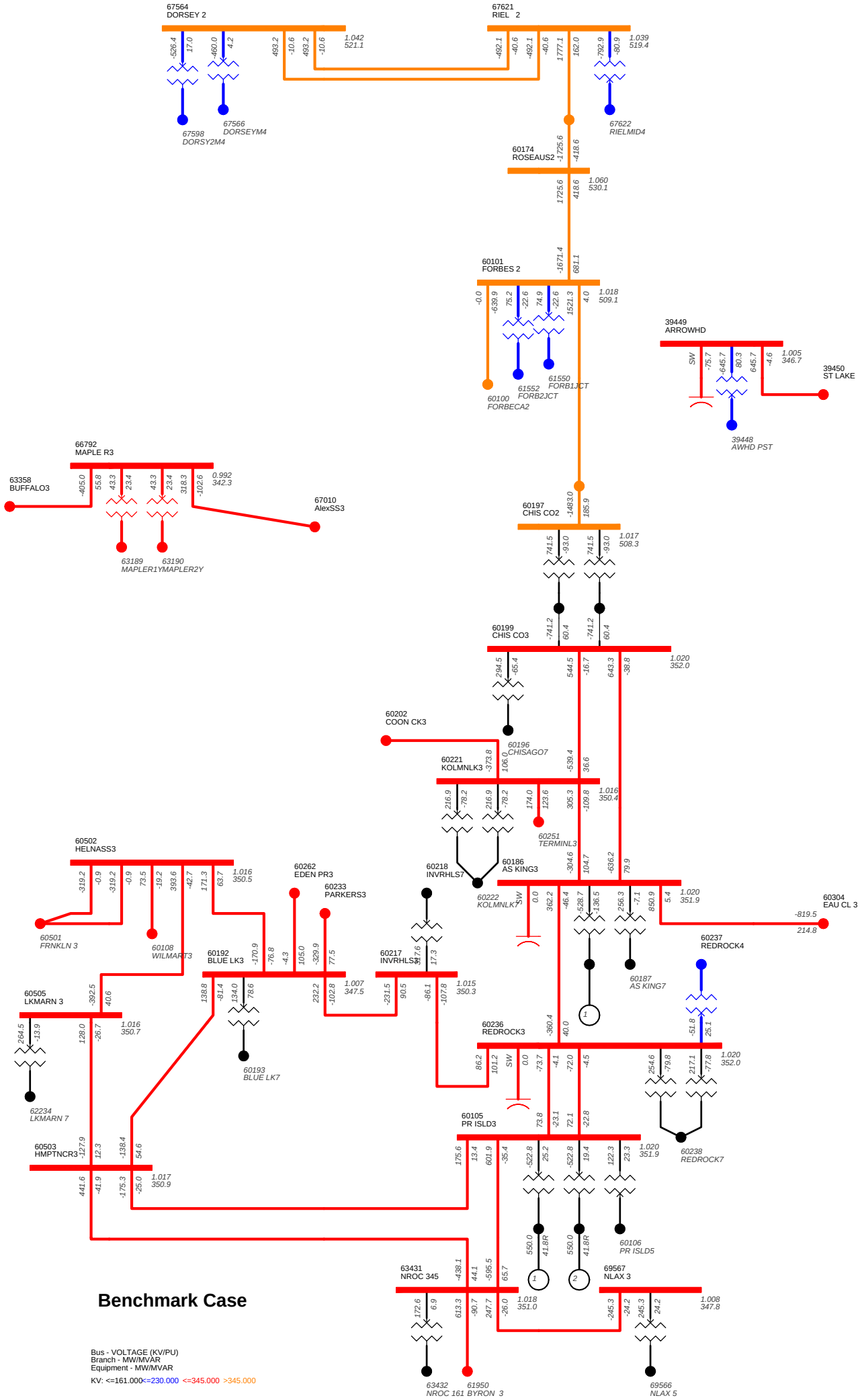
Bus Voltages		V,pu
Adams	345	1.009
Alexandria	115	1.028
Audubon	115	1.050
Bemidji	115	1.036
Byron	345	1.019
Chisago Co.	345	1.020
Chisago Co.	500	1.017
Drayton	230	1.028
Eau Claire	345	1.026
WEST FARIBAULT	115	1.030
LaPorte	115	1.030
Maple River	230	1.041
Marshall Tap	115	1.021
Owatonna	161	1.005
Prairie	115	1.037
Prairie	230	1.030
Ramsey	230	1.006
Roseau County	230	1.026
Roseau County	500	1.060
Sheyenne	230	1.039
Thief R Falls	115	1.035
Tioga	230	1.034
Wahpeton	230	1.027
Winger	115	1.055
		0.000
		0.000
		0.000

Bus Voltages		V,pu
Arrowhead	230	1.002
Badoura	115	1.039
Blackberry	230	1.035
Boise Cascade	13.8	1.051
Boise Cascade	115	1.020
ETCO	115	1.007
Forbes	230	1.022
Forbes	500	1.018
Hubbard	115	1.034
Intl Falls	115	1.020
Minntac	115	1.015
Moranville	230	1.026
Riverton	230	1.030
Running	230	1.027
Shannon	230	1.029
Stinson MN	115	1.013
Jamestown	345	0.982
Groton	345	1.021
Watertown	230	1.030
Watertown	345	1.028
		0.000
Dorsey	230	1.045
Dorsey	500	1.042
		0.000
		0.000
		0.000
		0.000

Bus Voltages		V,kV
Whiteshell	110	118.9
Kenora	220	246.6
Dryden	220	250.8
Fort Frances	220	244.5
Mackenzie	220	253.7
Lakehead	220	246.2
Marathon	220	253.0
Wawa	220	254.8
Mississagi	220	250.7
Fort Frances	118	118.8
Lakehead	118	122.8
Birch	118	120.2
Marathon	118	123.3
		0.000
Arrowhead	345	1.005
Stone Lake	345	1.004
Stone Lake	161	1.011
Gardner Park	345	1.035
Weston	115	1.035
Arpin	345	1.020
Eau Claire	161	1.034
Council Creek	161	0.972
Hydro Lane	161	1.009
Wien	115	1.027
		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	343%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	704%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	412%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	245%	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	100%	N/A	N/A
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	688%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	964%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A


67564
DORSEY 2
67621
RIEL 2
1.042
521.1
1.039
519.4
67598
DORSY2M4
67566
DORSEYM4
67622
RIELMID4
60174
ROSEAUS2
1.060
530.1
60101
FORBES 2
1.018
509.1
60100
FORBECA2
61552
FORB2JCT
61550
FORB1JCT
39449
ARROWHD
1.005
346.7
39450
ST LAKE
39448
AWHD PST
66792
MAPLE R3
0.992
342.3
63358
BUFFALO3
67010
AlexSS3
63189
MAPLER1Y
63190
MAPLER2Y
60197
CHIS CO2
1.017
508.3
60199
CHIS CO3
1.020
352.0
60202
COON CK3
60196
CHISAGO7
60221
KOLMNLK3
1.016
350.4
60251
TERMINL3
60218
INVRHLS7
60186
AS KING3
60222
KOLMNLK7
1.020
351.9
60304
EAU CL 3
60502
HELNASS3
1.016
350.5
60501
FRNKLN 3
60108
WILMART3
60262
EDEN PR3
60233
PARKERS3
60192
BLUE LK3
60217
INVRHLS3
1.007
347.5
1.015
350.3
60237
REDROCK4
60187
AS KING7
60505
LKMARN 3
1.016
350.7
62234
LKMARN 7
60193
BLUE LK7
60236
REDROCK3
1.020
352.0
60238
REDROCK7
60105
PR ISLD3
1.020
351.9
60503
HMPTNCR3
1.017
350.9
60106
PR ISLD5
63431
NROC 345
1.018
351.0
69567
NLAX 3
1.008
347.8
63432
NROC 161
61950
BYRON 3
69566
NLAX 5
Benchmark Case
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000<=230.000 <=345.000 >345.000

B.3 Study Case with MH TSRs and Transmission Upgrade Option 1

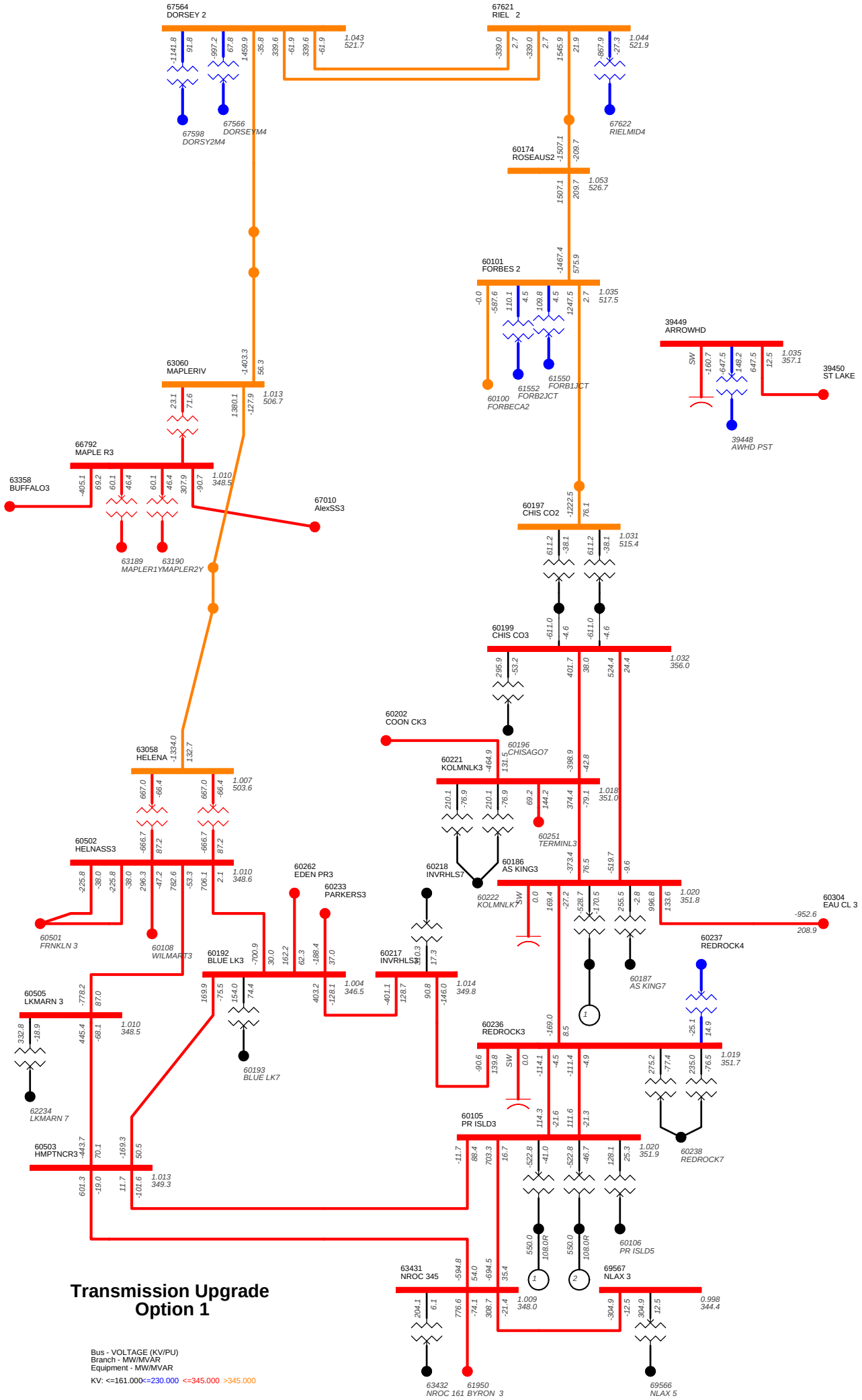
```
                    P O W E R   F L O W   S U M M A R Y
--------------------------------------------------------------------------------
               NDEX:      2287 MW         ECL-ARP:  810 MW
               MHEX:      1849 MW         PRI-BYN:   27 MW
               MWEX:      1645 MW         AHD-SLK:  647 MW
               KING-ECL:   996 MW         SLK-GPK:  506 MW
               COOPER S:  1144 MW         WNE-WKS:  546 MW
               FTCAL S:    698 MW         GGS:     1615 MW
               GRIS-LNC:   671 MW         QC WEST:   66 MW
               MAP R-ALEX: 307 MW         WIL-BOWS: -69 MW
               NROC-NLAX:  308 MW         DOR-MAPR:1459 MW
               MAPR-HELN: 1380 MW         New MHEX:3309 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/ 330       MH total gross    6179     ATC West Import   1667
Ont. total   22150/ 478          Wpg River       568     ATC SW Import      711
     NW        915/  36          7 Sisters       170     ATC SE Import    -1394
Sask.         2150/  82       OH total gross   21884     East Bias          186
MP            2341/ 134          northwest       717     SPC>WAPA (B10T)    163
NSP           8075/ 524       SPC total gross   2406     MH>SPC  (3-230)     59
N. Dakota     2904/ 275       MP total gross    2609     MH>SPC  (FALLS)      0
Manitoba       481 MVARS      ND Cfd AC gross   3149     OH>MH  @Kenora    -195
Ont. total   13082 MVARS            net         2978     OH>MP  @Ft Fran    151
     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      3027     F601C  @Forbes    1247
NSP           1714 MVARS            net         2865     D602F  @Riel      1545
N. Dakota      756 MVARS          Total net       6087     L20D   @Letell     236
ATC           10812/ 328       WAPA SD Hydro     1497     R50M   @Richer     128
ATC            3159 MVARS      Pleasant Valley      0     G82R   @Glenboro   -61
                               LGS/Trimont         19
                               SW MN Wind        1084
                               N DAK WIND         252
                               Swing Bus          931


Tfmrs           MVA/ Load     Ph Shifters  Deg/  MW      DC Lines          MW
------------- ---- -----     ------------ --- -----     --------------- ------
Wshell #1 7-7  105/  73%     Stinson       29/   26     CU (1,2)          1104
Wshell #2 7-7  105/  73%     Boundary Dam   9/  164     SQ BU (3,4)        455
Drayton#1 4-7   43/  31%     Whiteshell    95/  199     MH Bipole 1       1521
Drayton#2 4-7   55/  29%     Int Falls    119/  150     MH Bipole 2       1723
Dorsey #1 2-4  999/  83%     St. Lawrence  16/    0     MH (BP1+BP2)      3245
Dorsey #2 2-4 1150/  95%     Arrowhead      6/  648     Miles City E>W    -150
Forbes    2-4  109/  16%                               RCDC (15)            0
Stone Lk  3-5  132/  39%                               Stegall (10)         0

Dorsey SC's       I/S  MVAR  Qmax/ Qmin    SVC's              MVAR  Qmax/ Qmin
---------------- --- -----  ---- -----    ---------------- -----  ---- -----
MIL 7-9G     17.0  2    320   600/ -330    Forbes            500   -55   400/ -450
SCE 1-3G     18.2  3    261   480/ -240    Fargo            13.2   -28    20/ -135
SCA 4-6G     18.2  3    261   480/ -240    Watertown        20.0    28   125/  -86
                          -----  ---- -----
       Total              843  1560/ -810    Series Caps       Num In Serv
       Margin             717                ---------------- -----------
                                             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	0
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

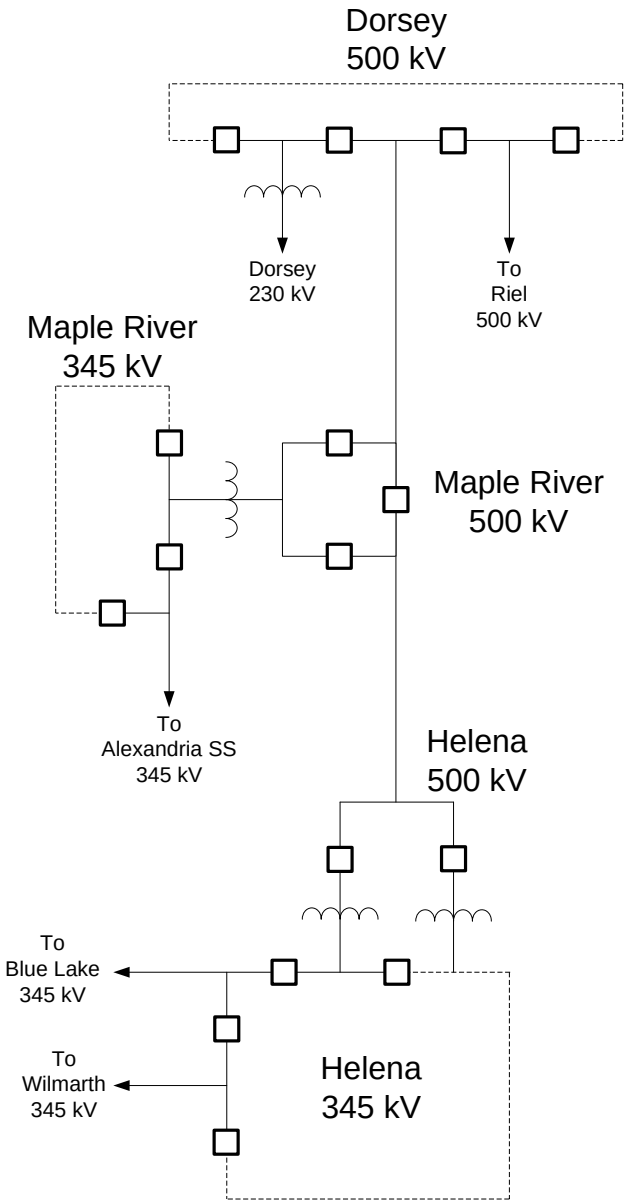
Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	0.997	Arrowhead 230	1.011	Whiteshell 110	118.9
Alexandria 115	1.036	Badoura 115	1.046	Kenora 220	246.7
Audubon 115	1.059	Blackberry 230	1.035	Dryden 220	250.9
Bemidji 115	1.043	Boise Cascade 13.8	1.053	Fort Frances 220	244.8
Byron 345	1.009	Boise Cascade 115	1.022	Mackenzie 220	253.8
Chisago Co. 345	1.032	ETCO 115	1.015	Lakehead 220	246.3
Chisago Co. 500	1.031	Forbes 230	1.034	Marathon 220	253.1
Drayton 230	1.041	Forbes 500	1.035	Wawa 220	254.8
Eau Claire 345	0.991	Hubbard 115	1.041	Mississagi 220	250.7
WEST FARIBAULT 115	1.025	Intl Falls 115	1.022	Fort Frances 118	119.0
LaPorte 115	1.037	Minntac 115	1.023	Lakehead 118	122.8
Maple River 230	1.055	Moranville 230	1.034	Birch 118	120.2
Marshall Tap 115	1.023	Riverton 230	1.035	Marathon 118	123.3
Owatonna 161	1.000	Running 230	1.036		0.000
Prairie 115	1.047	Shannon 230	1.034	Arrowhead 345	1.035
Prairie 230	1.040	Stinson MN 115	1.020	Stone Lake 345	1.025
Ramsey 230	1.010	Jamestown 345	0.994	Stone Lake 161	1.035
Roseau County 230	1.034	Groton 345	1.024	Gardner Park 345	1.035
Roseau County 500	1.053	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.050	Watertown 345	1.029	Arpin 345	1.001
Thief R Falls 115	1.047		0.000	Eau Claire 161	1.032
Tioga 230	1.033	Dorsey 230	1.045	Council Creek 161	0.971
Wahpeton 230	1.034	Dorsey 500	1.043	Hydro Lane 161	1.005
Winger 115	1.065		0.000	Wien 115	1.034
	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	345%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	708%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	542%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	324%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	321%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	N/A	1247%	
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	911%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	1093%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A


67564
DORSEY 2
1.043
521.7
67598
DORSY2M4
67566
DORSEYM4
67621
RIEL 2
1.044
521.9
67622
RIELMID4
60174
ROSEAUS2
1.053
526.7
60101
FORBES 2
1.035
517.5
60100
FORBECA2
61552
FORB2JCT
61550
FORB1JCT
39449
ARROWHD
1.035
357.1
39450
ST LAKE
39448
AWHD PST
63060
MAPLERIV
1.013
506.7
66792
MAPLE R3
1.010
348.5
63358
BUFFALO3
67010
AlexSS3
63189
MAPLER1Y
63190
MAPLER2Y
60197
CHIS CO2
1.031
515.4
60199
CHIS CO3
1.032
356.0
60202
COON CK3
60196
CHISAGO7
63058
HELENA
1.007
503.6
60221
KOLMNLK3
1.018
351.0
60251
TERMINL3
60502
HELNASS3
1.010
348.6
60262
EDEN PR3
60233
PARKERS3
60218
INVRHLS7
60186
AS KING3
1.020
351.8
60222
KOLMNLK7
60304
EAU CL 3
60501
FRNKLN 3
60108
WILMART3
60192
BLUE LK3
1.004
346.5
60217
INVRHLS3
1.014
349.8
60237
REDROCK4
60187
AS KING7
60505
LKMARN 3
1.010
348.5
60193
BLUE LK7
60236
REDROCK3
1.019
351.7
62234
LKMARN 7
60105
PR ISLD3
60503
HMPTNCR3
1.013
349.3
1.020
351.9
60238
REDROCK7
60106
PR ISLD5
63431
NROC 345
1.009
348.0
69567
NLAX 3
0.998
344.4
63432
NROC 161
61950
BYRON 3
69566
NLAX 5
Transmission Upgrade
Option 1
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

Option 1
System Topology Assumptions



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

B.4 Study Case with MH TSRs and Transmission Upgrade Option 3

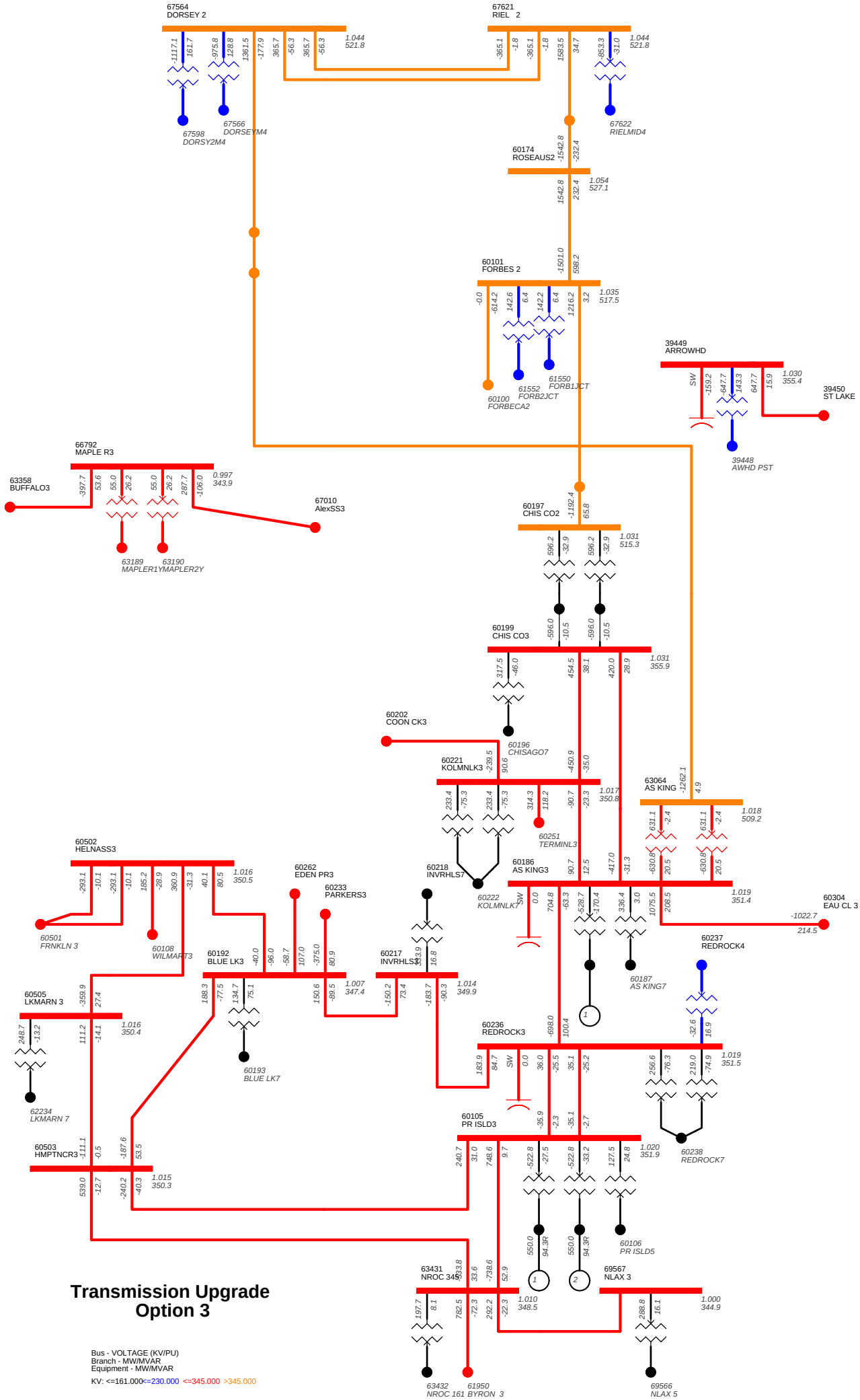
```
                    P O W E R   F L O W   S U M M A R Y
--------------------------------------------------------------------------------
               NDEX:      2300 MW         ECL-ARP:  839 MW
               MHEX:      1949 MW         PRI-BYN:   35 MW
               MWEX:      1724 MW         AHD-SLK:  647 MW
               KING-ECL:  1075 MW         SLK-GPK:  514 MW
               COOPER S:  1128 MW         WNE-WKS:  543 MW
               FTCAL S:    677 MW         GGS:     1615 MW
               GRIS-LNC:   673 MW         QC WEST:   79 MW
               MAP R-ALEX: 287 MW         WIL-BOWS: -87 MW
               NROC-NLAX:  292 MW         DOR-ASK: 1361 MW
               New MHEX:3311 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/ 332       MH total gross    6179     ATC West Import   1702
Ont. total   22150/ 478          Wpg River       568     ATC SW Import      700
     NW        915/  36          7 Sisters       170     ATC SE Import    -1412
Sask.         2150/  82       OH total gross   21884     East Bias          156
MP            2341/ 136          northwest       717     SPC>WAPA (B10T)    161
NSP           8075/ 592       SPC total gross   2406     MH>SPC  (3-230)     57
N. Dakota     2904/ 277       MP total gross    2609     MH>SPC  (FALLS)      0
Manitoba       481 MVARS      ND Cfd AC gross   3149     OH>MH  @Kenora    -194
Ont. total   13082 MVARS            net         2978     OH>MP  @Ft Fran    149
     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      3027     F601C  @Forbes    1216
NSP           1714 MVARS            net         2865     D602F  @Riel      1583
N. Dakota      756 MVARS          Total net       6087     L20D   @Letell     268
ATC           10812/ 332       WAPA SD Hydro     1497     R50M   @Richer     134
ATC            3159 MVARS      Pleasant Valley      0     G82R   @Glenboro   -36
                               LGS/Trimont         19
                               SW MN Wind        1084
                               N DAK WIND         252
                               Swing Bus          935


Tfmrs           MVA/ Load     Ph Shifters  Deg/  MW      DC Lines          MW
------------- ---- -----     ------------ --- -----     --------------- ------
Wshell #1 7-7  104/  72%     Stinson       30/   29     CU (1,2)          1103
Wshell #2 7-7  104/  72%     Boundary Dam   4/  162     SQ BU (3,4)        455
Drayton#1 4-7   47/  33%     Whiteshell   100/  198     MH Bipole 1       1522
Drayton#2 4-7   60/  32%     Int Falls    122/  149     MH Bipole 2       1723
Dorsey #1 2-4  982/  81%     St. Lawrence  16/    0     MH (BP1+BP2)      3245
Dorsey #2 2-4 1136/  94%     Arrowhead      7/  648     Miles City E>W    -150
Forbes    2-4  142/  21%                               RCDC (15)            0
Stone Lk  3-5  123/  36%                               Stegall (10)         0

Dorsey SC's       I/S  MVAR  Qmax/ Qmin    SVC's              MVAR  Qmax/ Qmin
---------------- --- -----  ---- -----    ---------------- -----  ---- -----
MIL 7-9G     17.0  2    269   600/ -330    Forbes            500   -28   400/ -450
SCE 1-3G     18.2  3    220   480/ -240    Fargo            13.2    -7    20/ -135
SCA 4-6G     18.2  3    220   480/ -240    Watertown        20.0     9   125/  -86
                          -----  ---- -----
       Total              710  1560/ -810    Series Caps       Num In Serv
       Margin             850                ---------------- -----------
                                             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	0
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

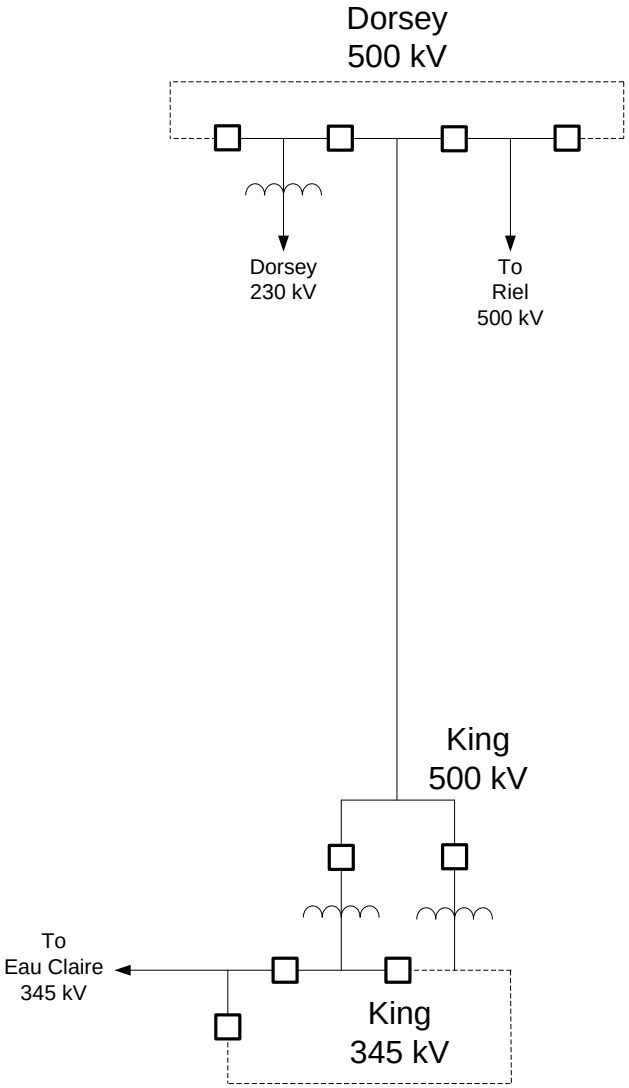
Bus Voltages	V,pu	Bus Voltages	V,pu	Bus Voltages	V,kV
Adams 345	0.998	Arrowhead 230	1.008	Whiteshell 110	118.9
Alexandria 115	1.033	Badoura 115	1.043	Kenora 220	246.7
Audubon 115	1.054	Blackberry 230	1.035	Dryden 220	250.9
Bemidji 115	1.039	Boise Cascade 13.8	1.052	Fort Frances 220	244.6
Byron 345	1.010	Boise Cascade 115	1.020	Mackenzie 220	253.8
Chisago Co. 345	1.031	ETCO 115	1.013	Lakehead 220	246.2
Chisago Co. 500	1.031	Forbes 230	1.034	Marathon 220	253.1
Drayton 230	1.034	Forbes 500	1.035	Wawa 220	254.8
Eau Claire 345	0.972	Hubbard 115	1.038	Mississagi 220	250.7
WEST FARIBAULT 115	1.028	Intl Falls 115	1.021	Fort Frances 118	118.9
LaPorte 115	1.034	Minntac 115	1.021	Lakehead 118	122.8
Maple River 230	1.045	Moranville 230	1.031	Birch 118	120.2
Marshall Tap 115	1.022	Riverton 230	1.033	Marathon 118	123.3
Owatonna 161	1.002	Running 230	1.034		0.000
Prairie 115	1.041	Shannon 230	1.033	Arrowhead 345	1.030
Prairie 230	1.035	Stinson MN 115	1.016	Stone Lake 345	1.019
Ramsey 230	1.008	Jamestown 345	0.986	Stone Lake 161	1.029
Roseau County 230	1.031	Groton 345	1.022	Gardner Park 345	1.031
Roseau County 500	1.054	Watertown 230	1.030	Weston 115	1.035
Sheyenne 230	1.042	Watertown 345	1.028	Arpin 345	0.988
Thief R Falls 115	1.040		0.000	Eau Claire 161	1.029
Tioga 230	1.034	Dorsey 230	1.045	Council Creek 161	0.968
Wahpeton 230	1.030	Dorsey 500	1.044	Hydro Lane 161	1.001
Winger 115	1.059		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	352%	N/A	N/A
2) -Tioga (North)	GE OST	SLLP	721%	N/A	N/A
3) -Tioga (Em North)	GE OST	SLLP		N/A	N/A
4) D602F-RIEL	ATP ???	SLINOS	520%	N/A	N/A
5) -Forbes (Normal)	ATP ???	SLINOS	311%	N/A	N/A
6) -Forbes (Em Nrth)	APT S-PRO	SLINOS		N/A	N/A
8) F3M-Intl Falls	APT S-PRO	SLINOS	323%	N/A	N/A
9) G82R-Rugby	APT	SLINOS	N/A	878%	
10) L20D-Drayton (Normal)	APT, ASEA	SLINOS	763%	N/A	N/A
11) -Drayton (Em Nrth)	ASEA RXZF2	SLINOS		N/A	N/A
12) R50M-Moranville (Norm)	APT, West	SLINOS	1028%	N/A	N/A
13) -Moranville (Em N)	ASEA RXZF2	SLINOS		N/A	N/A


67564
DORSEY 2
67621
RIEL 2
1.044
521.8
1.044
521.8
67598
DORSY2M4
67566
DORSEYM4
67622
RIELMID4
60174
ROSEAUS2
1.054
527.1
60101
FORBES 2
1.035
517.5
60100
FORBECA2
61552
FORB2JCT
61550
FORB1JCT
39449
ARROWHD
1.030
355.4
39450
ST LAKE
39448
AWHD PST
66792
MAPLE R3
0.997
343.9
63358
BUFFALO3
67010
AlexSS3
63189
MAPLER1Y
63190
MAPLER2Y
60197
CHIS CO2
1.031
515.3
60199
CHIS CO3
1.031
355.9
60202
COON CK3
60196
CHISAGO7
60221
KOLMNLK3
1.017
350.8
63064
AS KING
1.018
509.2
60251
TERMINL3
60218
INVRHLS7
60222
KOLMNLK7
60186
AS KING3
1.019
351.4
60304
EAU CL 3
60502
HELNASS3
1.016
350.5
60501
FRNKLN 3
60108
WILMART3
60262
EDEN PR3
60233
PARKERS3
60192
BLUE LK3
1.007
347.4
60217
INVRHLS3
1.014
349.9
60237
REDROCK4
60187
AS KING7
60505
LKMARN 3
1.016
350.4
62234
LKMARN 7
60193
BLUE LK7
60236
REDROCK3
1.019
351.5
60238
REDROCK7
60105
PR ISLD3
1.020
351.9
60503
HMPTNCR3
1.015
350.3
60106
PR ISLD5
63431
NROC 345
1.010
348.5
69567
NLAX 3
1.000
344.9
63432
NROC 161
61950
BYRON 3
69566
NLAX 5
Transmission Upgrade
Option 3
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

Option 3
System Topology Assumptions



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

This page intentionally left blank.

Appendix

C

Transient Stability Summary Tables

Table C-1: Pre-Benchmark Case

1	**Case No.**	1	2	3	4	5
2	**Case Name**	M0a-so15aa-ag1	M0a-so15aa-ag3	M0a-so15aa-ei2	M0a-so15aa-eq1	M0a-so15aa-fds
3	**Disturbance**	ag1	ag3	ei2	eq1	fds
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 20 2009 16:37	MAY 20 2009 16:40	MAY 20 2009 16:43	MAY 20 2009 16:46	MAY 20 2009 16:49
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2451 / 286	2451 / 286	2451 / 286	2451 / 286	2451 / 286
10	MHEX / L20D	2174 / 238	2174 / 238	2174 / 238	2174 / 238	2174 / 238
11	ECL-ARP / PRI-BYN	626 / 702	626 / 702	626 / 702	626 / 702	626 / 702
12	MWEX / AHD-SLK	1519 / 638	1519 / 638	1519 / 638	1519 / 638	1519 / 638
13	D602F / F601C	1855 / 1678	1855 / 1678	1855 / 1678	1855 / 1678	1855 / 1678
14	B10T / MH>SPC	167 / 62	167 / 62	167 / 62	167 / 62	167 / 62
15	OH E-W / OH>MH	187 / -197	187 / -197	187 / -197	187 / -197	187 / -197
16	R50M / OH>MP	142 / 149	142 / 149	142 / 149	142 / 149	142 / 149
17	G82R	-62	-62	-62	-62	-62
18	Dorsey bipole / CU bipole	1700 / 1103	1700 / 1103	1700 / 1103	1700 / 1103	1700 / 1103
19	Dorsey Reserve / Wtrtn SVC	1837 / -11	1837 / -11	1837 / -11	1837 / -11	1837 / -11
20	Forbes SVC / MSC	40 / 600	40 / 600	40 / 600	40 / 600	40 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045
24	Roseau 500/Forbes 500	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010
25	Chisago 500/EauClaire 345	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027
26	Int Falls 115/Badoura 115	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022
27	Drayton 230/Groton 345	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	223% / 375%	223% / 375%	223% / 375%	223% / 375%	223% / 375%
30	G82R at Rugby/L20D at Drayton	999% / 881%	999% / 881%	999% / 881%	999% / 881%	999% / 881%
31	R50M/F3M	939% / 324%	939% / 324%	939% / 324%	939% / 324%	939% / 324%
32	B10T	335%	335%	335%	335%	335%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.97 | 1.00	0.97 | 1.02	0.95 | 1.04	0.97 | 1.02	0.96 | 1.01
35	Boise 115	1.00 | 1.03	1.00 | 1.03	0.99 | 1.01	1.00 | 1.02	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
37	Forbes 230	1.01 | 1.02	1.01 | 1.02	0.97 | 1.03	0.99 | 1.02	1.00 | 1.02
38	Riverton 230	0.99 | 1.03	0.98 | 1.03	0.93 | 1.03	0.97 | 1.04	0.97 | 1.04
39	Coal Creek 230	0.97 | 1.11	0.97 | 1.11	1.01 | 1.10	1.00 | 1.16	0.96 | 1.13
40	Jamestown 345	0.91 | 1.03	0.89 | 1.03	0.85 | 1.03	0.87 | 1.04	0.81 | 1.06
41	Drayton 230	1.01 | 1.06	1.00 | 1.07	0.98 | 1.07	1.02 | 1.08	1.00 | 1.08
42	Groton 345	0.91 | 1.04	0.91 | 1.04	0.91 | 1.07	0.94 | 1.06	0.95 | 1.06
43	Minong 161	0.98 | 1.02	0.98 | 1.03	0.99 | 1.06	1.00 | 1.04	0.98 | 1.02
44	Wahpeton 115	0.98 | 1.06	0.97 | 1.06	0.92 | 1.07	0.96 | 1.07	0.95 | 1.08
45	Watertown 345	0.98 | 1.03	0.98 | 1.04	0.95 | 1.06	0.98 | 1.05	0.98 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 79.41%	KING 3 / 75.81%	SHERC3 / 23.73%	KING 3 / 22.95%	MNTCE3 / 63.22%
55	Dorsey SUVP / UdHold					
56	Forbes DC Red (DCAR)	470%	452%	507%	507%	451%
57	K22W (max +dP @ t, d-ang)	10.5@(2.40832,2.3)	16.1@(2.37499,0.2)	66.6@(2.41666,-31.7)	45.9@(2.34166,-19.2)	13.8@(2.46666,-1.0)
58	K22W (max -dP @ t, d-ang)	19.1@(1.80833,0.1)	20.1@(0.72500,5.3)	3.1@(0.45000,0.2)	2.6@(0.30833,0.1)	13.6@(0.74166,2.3)
59	K22W (max d-ang @ t, dP)	7.1@(1.05000,-6.5)	7.8@(0.99166,-8.1)	-51.8@(10.00821,39.0)	-29.2@(10.00821,22.2)	4.8@(1.05000,-3.8)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	183% / 308%	178% / 299%	142% / 239%	171% / 288%	191% / 322%
63	G82R at Rugby/L20D at Drayton	999% / 725%	999% / 706%	999% / 616%	65% / 636%	999% / 700%
64	R50M / F3M	806% / 281%	789% / 274%	747% / 219%	810% / 253%	816% / 287%
65	B10T	198%	183%	105%	129%	172%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 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 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 2 | 2)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 4 | 1) / (0 | 1 | 1)	(1 | 2 | 1) / (0 | 2 | 2)
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 | 4 | 2) / (1 | 2 | 2)	(1 | 4 | 2) / (1 | 1 | 1)	(1 | 5 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	M0a-so15aa-ag1	M0a-so15aa-ag3	M0a-so15aa-ei2	M0a-so15aa-eq1	M0a-so15aa-fds
Disturbance	ag1	ag3	ei2	eq1	fds
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table C-1: Pre-Benchmark Case

	Case No.	6	7	8	9	10
2	**Case Name**	M0a-so15aa-nad	M0a-so15aa-nmz	M0a-so15aa-pas	M0a-so15aa-pcs	M0a-so15aa-pct
3	**Disturbance**	nad	nmz	pas	pcs	pct
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 20 2009 16:52	MAY 20 2009 16:56	MAY 20 2009 16:59	MAY 20 2009 16:33	MAY 20 2009 17:02
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2451 / 286	2451 / 286	2451 / 286	2451 / 286	2451 / 286
10	MHEX / L20D	2174 / 238	2174 / 238	2174 / 238	2174 / 238	2174 / 238
11	ECL-ARP / PRI-BYN	626 / 702	626 / 702	626 / 702	626 / 702	626 / 702
12	MWEX / AHD-SLK	1519 / 638	1519 / 638	1519 / 638	1519 / 638	1519 / 638
13	D602F / F601C	1855 / 1678	1855 / 1678	1855 / 1678	1855 / 1678	1855 / 1678
14	B10T / MH>SPC	167 / 62	167 / 62	167 / 62	167 / 62	167 / 62
15	OH E-W / OH>MH	187 / -197	187 / -197	187 / -197	187 / -197	187 / -197
16	R50M / OH>MP	142 / 149	142 / 149	142 / 149	142 / 149	142 / 149
17	G82R	-62	-62	-62	-62	-62
18	Dorsey bipole / CU bipole	1700 / 1103	1700 / 1103	1700 / 1103	1700 / 1103	1700 / 1103
19	Dorsey Reserve / Wtrtn SVC	1837 / -11	1837 / -11	1837 / -11	1837 / -11	1837 / -11
20	Forbes SVC / MSC	40 / 600	40 / 600	40 / 600	40 / 600	40 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045	1.045 / 1.045
24	Roseau 500/Forbes 500	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010	1.028 / 1.010
25	Chisago 500/EauClaire 345	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027	1.010 / 1.027
26	Int Falls 115/Badoura 115	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022	1.020 / 1.022
27	Drayton 230/Groton 345	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019	1.031 / 1.019
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	223% / 375%	223% / 375%	223% / 375%	223% / 375%	223% / 375%
30	G82R at Rugby/L20D at Drayton	999% / 881%	999% / 881%	999% / 881%	999% / 881%	999% / 881%
31	R50M/F3M	939% / 324%	939% / 324%	939% / 324%	939% / 324%	939% / 324%
32	B10T	335%	335%	335%	335%	335%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.99 | 1.05	0.89 | 1.08	1.00 | 1.06	0.88 | 0.98	0.94 | 0.98
35	Boise 115	0.89 | 1.03	0.94 | 1.04	0.96 | 1.03	1.01 | 1.04	1.02 | 1.03
36	Dorsey 230	1.05 | 1.08	1.06 | 1.09	1.06 | 1.09	1.04 | 1.07	1.04 | 1.05
37	Forbes 230	1.00 | 1.03	0.99 | 1.03	0.99 | 1.05	1.00 | 1.04	1.01 | 1.02
38	Riverton 230	0.96 | 1.03	0.89 | 1.03	0.95 | 1.02	0.99 | 1.03	1.01 | 1.02
39	Coal Creek 230	0.99 | 1.08	0.94 | 1.08	0.99 | 1.09	0.97 | 1.08	1.02 | 1.04
40	Jamestown 345	0.91 | 1.01	0.85 | 1.01	0.91 | 0.99	0.93 | 1.00	0.98 | 0.99
41	Drayton 230	0.98 | 1.07	0.98 | 1.09	0.99 | 1.07	1.02 | 1.04	1.03 | 1.04
42	Groton 345	0.97 | 1.04	0.91 | 1.06	0.97 | 1.03	0.98 | 1.03	1.01 | 1.03
43	Minong 161	1.02 | 1.07	0.94 | 1.11	1.03 | 1.08	0.86 | 0.99	0.94 | 0.99
44	Wahpeton 115	0.95 | 1.05	0.91 | 1.06	0.95 | 1.04	1.01 | 1.04	1.03 | 1.04
45	Watertown 345	0.99 | 1.04	0.94 | 1.05	0.99 | 1.03	1.00 | 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	KING 3 / 35.26%	KING 3 / 28.68%	KING 3 / 41.73%	SHERC3 / 73.95%	SHERC3 / 59.37%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.150		
56	Forbes DC Red (DCAR)	507%	507%	507%	165%	299%
57	K22W (max +dP @ t, d-ang)	92.6@(2.06666,-46.5)	127.7@(2.17499,-55.9)	80.3@(2.08333,-40.9)	4.6@(3.45831,4.1)	0.0@(0.10000,0.0)
58	K22W (max -dP @ t, d-ang)	94.8@(0.27500,10.6)	69.7@(0.24167,6.6)	66.0@(0.27500,5.9)	54.0@(1.65000,17.9)	29.4@(2.14999,12.4)
59	K22W (max d-ang @ t, dP)	-80.6@(10.00821,41.1)	-87.0@(10.00821,68.5)	-76.3@(10.00821,45.1)	25.7@(1.06666,-40.1)	12.5@(2.00833,-29.2)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	0.16667 sec / 0.16667 sec	0.18333 sec / 0.18333 sec	0.38333 sec / 0.18333 sec	189% / 317%	223% / 375%
63	G82R at Rugby/L20D at Drayton	999% / 427%	999% / 555%	999% / 516%	999% / 667%	999% / 805%
64	R50M / F3M	274% / 96%	433% / 149%	413% / 171%	698% / 324%	864% / 324%
65	B10T	121%	94%	141%	160%	283%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 1 | 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 | 3) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 8 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 5 | 3)	(0 | 1 | 0) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 5 | 4) / (1 | 1 | 1)	(1 | 5 | 4) / (1 | 2 | 2)	(1 | 4 | 4) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	M0a-so15aa-nad	M0a-so15aa-nmz	M0a-so15aa-pas	M0a-so15aa-pcs	M0a-so15aa-pct
Disturbance	nad	nmz	pas	pcs	pct
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(5T)(6T)	(5T)(6T)	(5T)(6T)		

Table C-1: Pre-Benchmark Case

1	**Case No.**	11	12
2	**Case Name**	M0a-so15aa-pys	M0a-so15aa-pyt
3	**Disturbance**	pys	pyt
4	**Prior Outage**	None	None
5	**Date/Time**	MAY 20 2009 17:05	MAY 20 2009 17:08
6	**Comments**		
7			
8	**Steady State Flows**		
9	NDEX / EAST BIAS	2451 / 286	2451 / 286
10	MHEX / L20D	2174 / 238	2174 / 238
11	ECL-ARP / PRI-BYN	626 / 702	626 / 702
12	MWEX / AHD-SLK	1519 / 638	1519 / 638
13	D602F / F601C	1855 / 1678	1855 / 1678
14	B10T / MH>SPC	167 / 62	167 / 62
15	OH E-W / OH>MH	187 / -197	187 / -197
16	R50M / OH>MP	142 / 149	142 / 149
17	G82R	-62	-62
18	Dorsey bipole / CU bipole	1700 / 1103	1700 / 1103
19	Dorsey Reserve / Wtrtn SVC	1837 / -11	1837 / -11
20	Forbes SVC / MSC	40 / 600	40 / 600
21	RCDC	0	0
22	**Steady State Vltgs**		
23	Dorsey 500/Dorsey 230	1.045 / 1.045	1.045 / 1.045
24	Roseau 500/Forbes 500	1.028 / 1.010	1.028 / 1.010
25	Chisago 500/EauClaire 345	1.010 / 1.027	1.010 / 1.027
26	Int Falls 115/Badoura 115	1.020 / 1.022	1.020 / 1.022
27	Drayton 230/Groton 345	1.031 / 1.019	1.031 / 1.019
28	**SS OS Relay Margins**		
29	D602F at Forbes/Dorsey	223% / 375%	223% / 375%
30	G82R at Rugby/L20D at Drayton	999% / 881%	999% / 881%
31	R50M/F3M	939% / 324%	939% / 324%
32	B10T	335%	335%
33	**Min/MaxTransientVltg**		
34	Arrowhd 230	0.98 | 1.02	0.97 | 1.00
35	Boise 115	1.01 | 1.04	1.02 | 1.03
36	Dorsey 230	1.04 | 1.06	1.04 | 1.05
37	Forbes 230	1.00 | 1.05	1.01 | 1.02
38	Riverton 230	1.00 | 1.03	1.01 | 1.03
39	Coal Creek 230	0.98 | 1.08	1.02 | 1.04
40	Jamestown 345	0.94 | 1.00	0.98 | 0.99
41	Drayton 230	1.02 | 1.05	1.03 | 1.04
42	Groton 345	0.99 | 1.03	1.01 | 1.02
43	Minong 161	0.97 | 1.04	0.98 | 1.01
44	Wahpeton 115	1.01 | 1.04	1.03 | 1.04
45	Watertown 345	1.00 | 1.03	1.02 | 1.02
46	**Dynamic Voltage Warnings**		
47		none	none
48			
49			
50			
51			
52			
53			
54	Worst Case Angle Damping	SHERC3 / 77.66%	SHERC3 / 59.13%
55	Dorsey SUVP / UdHold		
56	Forbes DC Red (DCAR)	219%	361%
57	K22W (max +dP @ t, d-ang)	10.1@(3.44997,0.6)	0.0@(0.10000,0.0)
58	K22W (max -dP @ t, d-ang)	35.6@(1.62500,9.0)	19.9@(1.69166,7.7)
59	K22W (max d-ang @ t, dP)	18.9@(1.02500,-23.3)	8.1@(2.17499,-18.0)
60	**OS Rel Trip / Marg**		
61	MH - OH		
62	D602F at Forbes/Dorsey	185% / 309%	223% / 375%
63	G82R at Rugby/L20D at Drayton	999% / 708%	999% / 815%
64	R50M / F3M	741% / 309%	911% / 324%
65	B10T	171%	283%
66	**FSCAPS (SS/Unav/Final)**		
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 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)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A

Case	M0a-so15aa-pys	M0a-so15aa-pyt
Disturbance	pys	pyt
System Response	OK	OK
70% or 120% Violations		
ORWG Criteria Violations		
Line Tripping		

Table C-2: Benchmark Case

1	**Case No.**	1	2	3	4	5
2	**Case Name**	Mba-so15aa-ag1	Mba-so15aa-ag3	Mba-so15aa-ei2	Mba-so15aa-eq1	Mba-so15aa-fds
3	**Disturbance**	ag1	ag3	ei2	eq1	fds
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 26 2009 16:52	MAY 26 2009 16:54	MAY 26 2009 16:57	MAY 26 2009 17:00	MAY 26 2009 17:03
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2271 / 149	2271 / 149	2271 / 149	2271 / 149	2271 / 149
10	MHEX / L20D	2176 / 287	2176 / 287	2176 / 287	2176 / 287	2176 / 287
11	ECL-ARP / PRI-BYN	661 / 74	661 / 74	661 / 74	661 / 74	661 / 74
12	MWEX / AHD-SLK	1497 / 645	1497 / 645	1497 / 645	1497 / 645	1497 / 645
13	D602F / F601C	1777 / 1521	1777 / 1521	1777 / 1521	1777 / 1521	1777 / 1521
14	B10T / MH>SPC	164 / 60	164 / 60	164 / 60	164 / 60	164 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196
16	R50M / OH>MP	139 / 151	139 / 151	139 / 151	139 / 151	139 / 151
17	G82R	-28	-28	-28	-28	-28
18	Dorsey bipole / CU bipole	1700 / 1104	1700 / 1104	1700 / 1104	1700 / 1104	1700 / 1104
19	Dorsey Reserve / Wtrtn SVC	1909 / 15	1909 / 15	1909 / 15	1909 / 15	1909 / 15
20	Forbes SVC / MSC	17 / 600	17 / 600	17 / 600	17 / 600	17 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045
24	Roseau 500/Forbes 500	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026
26	Int Falls 115/Badoura 115	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039
27	Drayton 230/Groton 345	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	246% / 413%	246% / 413%	246% / 413%	246% / 413%	246% / 413%
30	G82R at Rugby/L20D at Drayton	999% / 689%	999% / 689%	999% / 689%	999% / 689%	999% / 689%
31	R50M/F3M	965% / 319%	965% / 319%	965% / 319%	965% / 319%	965% / 319%
32	B10T	345%	345%	345%	345%	345%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.98 | 1.01	0.98 | 1.02	0.97 | 1.04	0.98 | 1.03	0.96 | 1.02
35	Boise 115	1.00 | 1.03	1.00 | 1.03	0.99 | 1.01	1.00 | 1.02	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
37	Forbes 230	1.01 | 1.03	1.01 | 1.03	0.99 | 1.03	1.01 | 1.03	1.01 | 1.03
38	Riverton 230	1.01 | 1.04	1.00 | 1.04	0.97 | 1.05	1.00 | 1.05	0.99 | 1.05
39	Coal Creek 230	0.97 | 1.11	0.97 | 1.11	1.02 | 1.11	0.99 | 1.16	0.97 | 1.12
40	Jamestown 345	0.91 | 1.02	0.90 | 1.02	0.84 | 1.04	0.86 | 1.05	0.81 | 1.05
41	Drayton 230	1.01 | 1.05	1.00 | 1.04	0.98 | 1.06	1.02 | 1.07	1.00 | 1.06
42	Groton 345	0.92 | 1.04	0.92 | 1.04	0.93 | 1.06	0.95 | 1.06	0.95 | 1.06
43	Minong 161	0.98 | 1.02	0.98 | 1.04	1.00 | 1.05	1.00 | 1.04	0.98 | 1.02
44	Wahpeton 115	1.00 | 1.07	0.99 | 1.06	0.95 | 1.08	0.98 | 1.08	0.97 | 1.08
45	Watertown 345	0.98 | 1.04	0.99 | 1.04	0.97 | 1.05	0.99 | 1.05	0.99 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 77.44%	KING 3 / 74.30%	SHERC3 / 28.74%	KING 3 / 27.99%	MNTCE3 / 75.67%
55	Dorsey SUVP / UdHold					
56	Forbes DC Red (DCAR)	460%	452%	507%	507%	457%
57	K22W (max +dP @ t, d-ang)	10.5@(2.39166,2.0)	14.9@(2.35832,0.2)	65.5@(2.39999,-29.2)	45.4@(2.30833,-18.2)	12.5@(2.41666,-1.2)
58	K22W (max -dP @ t, d-ang)	18.2@(1.80000,0.3)	19.3@(0.74166,5.4)	1.6@(0.38333,0.1)	2.4@(0.29167,0.1)	12.8@(0.75833,2.6)
59	K22W (max d-ang @ t, dP)	6.8@(1.05000,-6.3)	7.7@(0.99166,-8.6)	-49.3@(10.00821,37.2)	-28.4@(10.00821,21.2)	4.6@(1.02500,-4.2)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	204% / 343%	199% / 334%	177% / 299%	202% / 340%	216% / 363%
63	G82R at Rugby/L20D at Drayton	999% / 590%	999% / 580%	999% / 511%	47% / 537%	999% / 588%
64	R50M / F3M	839% / 279%	820% / 274%	815% / 220%	868% / 248%	855% / 282%
65	B10T	211%	204%	111%	130%	190%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 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 | 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 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 1 | 1)	(1 | 3 | 1) / (0 | 2 | 2)
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 | 1 | 1) / (1 | 2 | 2)	(1 | 4 | 1) / (1 | 1 | 1)	(1 | 3 | 1) / (1 | 1 | 1)	(1 | 3 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	Mba-so15aa-ag1	Mba-so15aa-ag3	Mba-so15aa-ei2	Mba-so15aa-eq1	Mba-so15aa-fds
Disturbance	ag1	ag3	ei2	eq1	fds
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table C-2: Benchmark Case

	Case No.	6	7	8	9	10
2	**Case Name**	Mba-so15aa-nad	Mba-so15aa-nmz	Mba-so15aa-pas	Mba-so15aa-pcs	Mba-so15aa-pct
3	**Disturbance**	nad	nmz	pas	pcs	pct
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 26 2009 17:06	MAY 26 2009 17:10	MAY 26 2009 17:13	MAY 26 2009 17:16	MAY 26 2009 17:19
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2271 / 149	2271 / 149	2271 / 149	2271 / 149	2271 / 149
10	MHEX / L20D	2176 / 287	2176 / 287	2176 / 287	2176 / 287	2176 / 287
11	ECL-ARP / PRI-BYN	661 / 74	661 / 74	661 / 74	661 / 74	661 / 74
12	MWEX / AHD-SLK	1497 / 645	1497 / 645	1497 / 645	1497 / 645	1497 / 645
13	D602F / F601C	1777 / 1521	1777 / 1521	1777 / 1521	1777 / 1521	1777 / 1521
14	B10T / MH>SPC	164 / 60	164 / 60	164 / 60	164 / 60	164 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196	190 / -196	190 / -196	190 / -196
16	R50M / OH>MP	139 / 151	139 / 151	139 / 151	139 / 151	139 / 151
17	G82R	-28	-28	-28	-28	-28
18	Dorsey bipole / CU bipole	1700 / 1104	1700 / 1104	1700 / 1104	1700 / 1104	1700 / 1104
19	Dorsey Reserve / Wtrtn SVC	1909 / 15	1909 / 15	1909 / 15	1909 / 15	1909 / 15
20	Forbes SVC / MSC	17 / 600	17 / 600	17 / 600	17 / 600	17 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045	1.042 / 1.045
24	Roseau 500/Forbes 500	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018	1.039 / 1.018
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026	1.017 / 1.026
26	Int Falls 115/Badoura 115	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039	1.020 / 1.039
27	Drayton 230/Groton 345	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021	1.028 / 1.021
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	246% / 413%	246% / 413%	246% / 413%	246% / 413%	246% / 413%
30	G82R at Rugby/L20D at Drayton	999% / 689%	999% / 689%	999% / 689%	999% / 689%	999% / 689%
31	R50M/F3M	965% / 319%	965% / 319%	965% / 319%	965% / 319%	965% / 319%
32	B10T	345%	345%	345%	345%	345%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	1.00 | 1.06	0.93 | 1.07	1.00 | 1.07	0.90 | 0.99	0.95 | 0.98
35	Boise 115	0.91 | 1.03	0.96 | 1.03	0.97 | 1.02	1.01 | 1.04	1.02 | 1.03
36	Dorsey 230	1.05 | 1.08	1.06 | 1.09	1.05 | 1.09	1.04 | 1.07	1.04 | 1.05
37	Forbes 230	1.01 | 1.03	1.00 | 1.04	1.00 | 1.05	1.01 | 1.05	1.02 | 1.02
38	Riverton 230	1.00 | 1.05	0.94 | 1.06	1.00 | 1.05	1.01 | 1.04	1.03 | 1.03
39	Coal Creek 230	0.99 | 1.07	0.95 | 1.07	0.99 | 1.07	0.97 | 1.08	1.02 | 1.04
40	Jamestown 345	0.91 | 0.99	0.83 | 1.01	0.91 | 0.99	0.94 | 1.01	0.98 | 1.00
41	Drayton 230	0.96 | 1.07	0.97 | 1.09	0.98 | 1.07	1.01 | 1.04	1.02 | 1.04
42	Groton 345	0.97 | 1.04	0.92 | 1.06	0.97 | 1.03	0.99 | 1.04	1.01 | 1.03
43	Minong 161	1.02 | 1.07	0.96 | 1.09	1.03 | 1.08	0.88 | 1.00	0.94 | 0.99
44	Wahpeton 115	0.99 | 1.06	0.94 | 1.07	0.99 | 1.06	1.03 | 1.06	1.04 | 1.05
45	Watertown 345	1.00 | 1.04	0.96 | 1.05	1.00 | 1.04	1.01 | 1.04	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	KING 3 / 34.85%	KING 3 / 30.66%	KING 3 / 39.55%	SHERC3 / 73.39%	SHERC3 / 61.92%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.150		
56	Forbes DC Red (DCAR)	507%	507%	507%	215%	330%
57	K22W (max +dP @ t, d-ang)	103.9@(2.04166,-45.6)	126.9@(2.12499,-54.8)	89.4@(2.08333,-42.6)	4.8@(3.36664,2.7)	0.0@(0.10000,0.0)
58	K22W (max -dP @ t, d-ang)	90.8@(0.27500,10.2)	65.7@(0.24167,6.2)	61.9@(0.27500,5.6)	45.1@(1.60000,14.9)	28.1@(2.05000,11.5)
59	K22W (max d-ang @ t, dP)	-76.5@(10.00821,41.9)	-83.3@(10.00821,67.0)	-72.6@(10.00821,44.7)	23.3@(1.02500,-34.4)	11.5@(1.91666,-27.9)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	0.16667 sec / 0.16667 sec	0.18333 sec / 0.18333 sec	0.38333 sec / 0.18333 sec	205% / 344%	245% / 410%
63	G82R at Rugby/L20D at Drayton	999% / 338%	999% / 440%	999% / 410%	999% / 527%	999% / 650%
64	R50M / F3M	366% / 119%	532% / 166%	448% / 175%	726% / 319%	884% / 319%
65	B10T	108%	86%	128%	157%	295%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 1 | 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 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 3) / (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 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 0) / (1 | 5 | 3)	(0 | 0 | 0) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 3 | 2)	(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 | 4 | 2) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	Mba-so15aa-nad	Mba-so15aa-nmz	Mba-so15aa-pas	Mba-so15aa-pcs	Mba-so15aa-pct
Disturbance	nad	nmz	pas	pcs	pct
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(5T)(6T)	(5T)(6T)	(5T)(6T)		

Table C-2: Benchmark Case

1	**Case No.**	11	12
2	**Case Name**	Mba-so15aa-pzs	Mba-so15aa-pzt
3	**Disturbance**	pzs	pzt
4	**Prior Outage**	None	None
5	**Date/Time**	MAY 26 2009 17:22	MAY 26 2009 17:25
6	**Comments**		
7			
8	**Steady State Flows**		
9	NDEX / EAST BIAS	2271 / 149	2271 / 149
10	MHEX / L20D	2176 / 287	2176 / 287
11	ECL-ARP / PRI-BYN	661 / 74	661 / 74
12	MWEX / AHD-SLK	1497 / 645	1497 / 645
13	D602F / F601C	1777 / 1521	1777 / 1521
14	B10T / MH>SPC	164 / 60	164 / 60
15	OH E-W / OH>MH	190 / -196	190 / -196
16	R50M / OH>MP	139 / 151	139 / 151
17	G82R	-28	-28
18	Dorsey bipole / CU bipole	1700 / 1104	1700 / 1104
19	Dorsey Reserve / Wtrtn SVC	1909 / 15	1909 / 15
20	Forbes SVC / MSC	17 / 600	17 / 600
21	RCDC	0	0
22	**Steady State Vltgs**		
23	Dorsey 500/Dorsey 230	1.042 / 1.045	1.042 / 1.045
24	Roseau 500/Forbes 500	1.039 / 1.018	1.039 / 1.018
25	Chisago 500/EauClaire 345	1.017 / 1.026	1.017 / 1.026
26	Int Falls 115/Badoura 115	1.020 / 1.039	1.020 / 1.039
27	Drayton 230/Groton 345	1.028 / 1.021	1.028 / 1.021
28	**SS OS Relay Margins**		
29	D602F at Forbes/Dorsey	246% / 413%	246% / 413%
30	G82R at Rugby/L20D at Drayton	999% / 689%	999% / 689%
31	R50M/F3M	965% / 319%	965% / 319%
32	B10T	345%	345%
33	**Min/MaxTransientVltg**		
34	Arrowhd 230	0.99 | 1.04	1.00 | 1.00
35	Boise 115	1.00 | 1.04	1.02 | 1.02
36	Dorsey 230	1.04 | 1.06	1.04 | 1.05
37	Forbes 230	1.02 | 1.05	1.02 | 1.02
38	Riverton 230	1.02 | 1.05	1.03 | 1.03
39	Coal Creek 230	0.98 | 1.08	1.03 | 1.04
40	Jamestown 345	0.94 | 1.01	0.98 | 0.99
41	Drayton 230	1.02 | 1.04	1.03 | 1.03
42	Groton 345	0.99 | 1.04	1.02 | 1.02
43	Minong 161	1.00 | 1.05	1.00 | 1.01
44	Wahpeton 115	1.02 | 1.06	1.04 | 1.04
45	Watertown 345	1.01 | 1.04	1.03 | 1.03
46	**Dynamic Voltage Warnings**		
47		none	none
48			
49			
50			
51			
52			
53			
54	Worst Case Angle Damping	KING 3 / 75.27%	SHERC3 / 48.44%
55	Dorsey SUVP / UdHold		
56	Forbes DC Red (DCAR)	317%	473%
57	K22W (max +dP @ t, d-ang)	25.3@(2.41666,-5.3)	0.0@(0.10000,0.0)
58	K22W (max -dP @ t, d-ang)	25.9@(0.61666,9.1)	5.6@(1.61666,2.3)
59	K22W (max d-ang @ t, dP)	13.3@(0.92500,-15.2)	2.4@(2.09999,-5.4)
60	**OS Rel Trip / Marg**		
61	MH - OH		
62	D602F at Forbes/Dorsey	196% / 327%	246% / 413%
63	G82R at Rugby/L20D at Drayton	999% / 572%	999% / 680%
64	R50M / F3M	772% / 282%	953% / 319%
65	B10T	165%	332%
66	**FSCAPS (SS/Unav/Final)**		
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 1 | 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)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A

Case	Mba-so15aa-pzs	Mba-so15aa-pzt
Disturbance	pzs	pzt
System Response	OK	OK
70% or 120% Violations		
ORWG Criteria Violations		
Line Tripping		

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	1	2	3	4	5
	Case Name	m1a-so15aa-ag1	m1a-so15aa-ag3	m1a-so15aa-cts	m1a-so15aa-ei2	m1a-so15aa-em3
	Disturbance	ag1	ag3	cts	ei2	em3
	Prior Outage	None	None	None	None	None
	Date/Time	MAY 28 2009 11:35	MAY 28 2009 11:38	JUN 03 2009 17:43	MAY 28 2009 11:45	MAY 28 2009 11:48
	Comments					
	Steady State Flows					
	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
	G82R	-61	-61	-61	-61	-61
	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
	RCDC	0	0	0	0	0
	Steady State Vltgs					
	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
	SS OS Relay Margins					
	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
	B10T	347%	347%	347%	347%	347%
	Min/MaxTransientVltg					
	Arrowhd 230	0.98 | 1.01	0.98 | 1.01	0.92 | 1.07	0.98 | 1.04	1.00 | 1.01
	Boise 115	1.01 | 1.03	1.01 | 1.03	0.98 | 1.02	1.00 | 1.02	1.02 | 1.02
	Dorsey 230	1.03 | 1.05	1.03 | 1.05	1.04 | 1.12	1.04 | 1.05	1.03 | 1.05
	Forbes 230	1.02 | 1.04	1.02 | 1.04	0.96 | 1.05	1.01 | 1.04	1.03 | 1.04
	Riverton 230	1.01 | 1.04	1.01 | 1.04	0.94 | 1.07	0.99 | 1.05	1.04 | 1.04
	Coal Creek 230	0.97 | 1.10	0.97 | 1.10	0.89 | 1.07	1.02 | 1.10	1.03 | 1.05
	Jamestown 345	0.93 | 1.02	0.93 | 1.02	0.79 | 1.04	0.87 | 1.02	0.99 | 1.00
	Drayton 230	1.02 | 1.05	1.01 | 1.05	0.97 | 1.08	1.00 | 1.06	1.04 | 1.04
	Groton 345	0.93 | 1.05	0.93 | 1.04	0.87 | 1.06	0.94 | 1.06	1.02 | 1.03
	Minong 161	1.00 | 1.03	1.00 | 1.03	0.98 | 1.10	1.02 | 1.07	1.03 | 1.04
	Wahpeton 115	1.01 | 1.06	1.01 | 1.06	0.92 | 1.08	0.98 | 1.07	1.05 | 1.05
	Watertown 345	0.99 | 1.04	0.99 | 1.04	0.92 | 1.05	0.98 | 1.05	1.03 | 1.03
	Dynamic Voltage Warnings					
		none	none		none	none
	Worst Case Angle Damping	KING 3 / 74.83%	KING 3 / 75.32%	KING 3 / 39.02%	SHERC3 / 31.81%	KING 3 / 36.68%
	Dorsey SUVP / UdHold					/ 0.133
	Forbes DC Red (DCAR)	475%	473%	507%	505%	494%
	K22W (max +dP @ t, d-ang)	10.7@(2.31666,2.2)	13.0@(2.28333,1.3)	103.9@(2.39166,-43.6)	70.4@(2.35832,-30.2)	31.4@(0.13333,-0.3)
	K22W (max -dP @ t, d-ang)	20.0@(1.74166,0.6)	18.9@(0.69166,4.8)	46.5@(0.42500,7.0)	0.0@(0.03333,0.0)	20.4@(0.26667,1.8)
	K22W (max d-ang @ t, dP)	6.5@(1.00000,-5.8)	7.0@(0.95000,-6.7)	-63.5@(10.00821,45.6)	-49.9@(10.00821,38.5)	-11.8@(10.00821,10.6)
	OS Rel Trip / Marg					
	MH - OH					
	D602F at Forbes/Dorsey	285% / 477%	283% / 473%	0.36667 sec / 0.36667 sec	242% / 405%	296% / 496%
	G82R at Rugby/L20D at Drayton	999% / 820%	999% / 814%	999% / 683%	999% / 757%	999% / 0.18333 sec
	R50M / F3M	971% / 285%	965% / 282%	678% / 195%	928% / 226%	978% / 293%
	B10T	218%	215%	80%	139%	282%
	FSCAPS (SS/Unav/Final)					
	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 2 | 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 | 2) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 2 | 2)	(1 | 1 | 1) / (0 | 1 | 1)	(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)
	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 5 | 0) / (1 | 2 | 2)	(1 | 2 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
	Damping Performance	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-ag1	m1a-so15aa-ag3	m1a-so15aa-cts	m1a-so15aa-ei2	m1a-so15aa-em3
Disturbance	ag1	ag3	cts	ei2	em3
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping			(5T)(6T)		(3T)

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	6	7	8	9	10
2	**Case Name**	m1a-so15aa-eq1	m1a-so15aa-fds	m1a-so15aa-mc3	m1a-so15aa-md3	m1a-so15aa-mis
3	**Disturbance**	eq1	fds	mc3	md3	mis
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 11:51	MAY 28 2009 11:54	MAY 28 2009 11:57	MAY 28 2009 12:00	MAY 28 2009 12:03
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.98 | 1.03	0.96 | 1.02	1.01 | 1.01	1.00 | 1.00	1.00 | 1.01
35	Boise 115	1.00 | 1.02	1.01 | 1.03	1.01 | 1.02	1.02 | 1.02	1.04 | 1.06
36	Dorsey 230	1.04 | 1.05	1.04 | 1.06	1.03 | 1.05	1.03 | 1.05	1.04 | 1.05
37	Forbes 230	1.02 | 1.04	1.02 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
38	Riverton 230	1.01 | 1.05	1.00 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
39	Coal Creek 230	0.99 | 1.16	0.98 | 1.12	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
40	Jamestown 345	0.88 | 1.04	0.85 | 1.04	0.99 | 1.00	0.99 | 0.99	0.99 | 1.00
41	Drayton 230	1.02 | 1.07	1.01 | 1.06	1.03 | 1.04	1.03 | 1.04	1.04 | 1.04
42	Groton 345	0.96 | 1.06	0.96 | 1.05	1.02 | 1.03	1.02 | 1.02	1.02 | 1.03
43	Minong 161	1.02 | 1.06	0.99 | 1.04	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03
44	Wahpeton 115	1.00 | 1.07	0.99 | 1.07	1.05 | 1.05	1.05 | 1.05	1.05 | 1.05
45	Watertown 345	0.99 | 1.05	0.99 | 1.04	1.03 | 1.03	1.03 | 1.03	1.03 | 1.03
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 31.98%	STANT4 / 77.36%	KING 3 / 34.25%	ANTEL3 / 77.90%	SHERC3 / 20.13%
55	Dorsey SUVP / UdHold		/ 0.166	/ 0.133	/ 0.133	
56	Forbes DC Red (DCAR)	487%	446%	491%	498%	485%
57	K22W (max +dP @ t, d-ang)	48.0@(2.27499,-18.2)	12.3@(2.34999,-1.0)	28.2@(0.12500,0.4)	20.6@(0.12500,-0.4)	196.0@(0.35000,-11.9)
58	K22W (max -dP @ t, d-ang)	1.7@(0.30000,-0.1)	16.1@(0.58333,1.9)	22.0@(0.95833,-4.0)	10.2@(0.24167,0.5)	0.0@(0.35000,0.0)
59	K22W (max d-ang @ t, dP)	-27.8@(10.00821,20.7)	4.8@(0.96666,-3.2)	-8.2@(10.00821,-12.6)	-0.7@(3.44997,2.2)	-43.2@(0.96666,196.0)
60	**OS Rel Trip / Marg**					
61	MH - OH					0.35000 sec
62	D602F at Forbes/Dorsey	270% / 451%	274% / 459%	305% / 512%	325% / 542%	313% / 523%
63	G82R at Rugby/L20D at Drayton	66% / 743%	999% / 825%	999% / 859%	999% / 912%	999% / 874%
64	R50M / F3M	978% / 253%	934% / 289%	999% / 214%	999% / 318%	674% / 322%
65	B10T	149%	209%	102%	338%	318%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 1 | 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 | 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 | 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 | 1 | 0) / (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)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-eq1	m1a-so15aa-fds	m1a-so15aa-mc3	m1a-so15aa-md3	m1a-so15aa-mis
Disturbance	eq1	fds	mc3	md3	mis
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					(1T)

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	11	12	13	14	15
2	**Case Name**	m1a-so15aa-mjs	m1a-so15aa-mkd	m1a-so15aa-mks	m1a-so15aa-nad	m1a-so15aa-nmz
3	**Disturbance**	mjs	mkd	mks	nad	nmz
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 12:06	MAY 28 2009 12:09	MAY 28 2009 12:12	MAY 28 2009 12:15	JUN 03 2009 17:47
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.98 | 1.00	0.93 | 1.01	0.98 | 1.02	0.99 | 1.05	0.95 | 1.05
35	Boise 115	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03	0.97 | 1.01	0.98 | 1.02
36	Dorsey 230	1.04 | 1.06	1.04 | 1.05	1.04 | 1.07	1.04 | 1.07	1.04 | 1.07
37	Forbes 230	1.03 | 1.05	1.03 | 1.04	1.03 | 1.05	1.02 | 1.04	1.01 | 1.04
38	Riverton 230	1.02 | 1.04	0.99 | 1.03	1.01 | 1.04	1.00 | 1.05	0.97 | 1.06
39	Coal Creek 230	0.98 | 1.07	0.98 | 1.07	0.97 | 1.08	1.00 | 1.06	0.96 | 1.06
40	Jamestown 345	0.93 | 1.00	0.93 | 1.00	0.92 | 1.01	0.95 | 1.01	0.89 | 1.02
41	Drayton 230	1.02 | 1.05	1.01 | 1.04	1.02 | 1.05	1.01 | 1.06	1.00 | 1.07
42	Groton 345	0.99 | 1.03	0.98 | 1.03	0.98 | 1.03	1.00 | 1.04	0.95 | 1.05
43	Minong 161	1.00 | 1.02	0.95 | 1.04	0.99 | 1.04	1.02 | 1.08	0.99 | 1.08
44	Wahpeton 115	1.02 | 1.05	1.01 | 1.05	1.02 | 1.06	1.01 | 1.06	0.98 | 1.07
45	Watertown 345	1.01 | 1.03	1.00 | 1.03	1.00 | 1.03	1.01 | 1.04	0.98 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	SHERC3 / 75.93%	KING 3 / 79.65%	KING 3 / 81.07%	KING 3 / 38.58%	KING 3 / 34.64%
55	Dorsey SUVP / UdHold		/ 0.133		/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	454%	317%	391%	507%	507%
57	K22W (max +dP @ t, d-ang)	3.3@(0.11667,0.3)	11.8@(0.10833,1.4)	8.7@(3.27498,0.0)	83.6@(2.04166,-39.3)	89.9@(2.19166,-39.9)
58	K22W (max -dP @ t, d-ang)	17.6@(0.35833,2.8)	27.3@(0.22500,3.5)	29.6@(0.37500,5.4)	58.2@(0.25000,6.6)	45.3@(0.22500,4.4)
59	K22W (max d-ang @ t, dP)	5.7@(0.96666,-11.5)	13.3@(0.85000,-14.8)	9.9@(0.81666,-10.6)	-67.7@(10.00821,43.8)	-63.9@(10.00821,47.2)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	310% / 529%	325% / 543%	293% / 515%	0.16667 sec / 0.16667 sec	0.18333 sec / 0.18333 sec
63	G82R at Rugby/L20D at Drayton	999% / 836%	999% / 771%	999% / 805%	999% / 653%	999% / 757%
64	R50M / F3M	999% / 322%	970% / 322%	965% / 314%	593% / 167%	722% / 202%
65	B10T	251%	205%	215%	193%	146%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 1)
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 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (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 | 1 | 1) / (0 | 0 | 0)	(1 | 2 | 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 | 2 | 2)	(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 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 0) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-mjs	m1a-so15aa-mkd	m1a-so15aa-mks	m1a-so15aa-nad	m1a-so15aa-nmz
Disturbance	mjs	mkd	mks	nad	nmz
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping				(5T)(6T)	(5T)(6T)

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	16	17	18	19	20
2	**Case Name**	m1a-so15aa-pas	m1a-so15aa-pc0	m1a-so15aa-pcs	m1a-so15aa-pct	m1a-so15aa-pzs
3	**Disturbance**	pas	pc0	pcs	pct	pzs
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 12:22	MAY 28 2009 12:25	MAY 28 2009 12:28	MAY 28 2009 12:31	MAY 28 2009 12:34
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.99 | 1.05	0.87 | 0.99	0.87 | 0.97	0.92 | 0.96	0.98 | 1.03
35	Boise 115	0.99 | 1.02	1.01 | 1.04	1.02 | 1.05	1.02 | 1.03	1.01 | 1.04
36	Dorsey 230	1.05 | 1.07	1.03 | 1.08	1.03 | 1.09	1.04 | 1.05	1.03 | 1.08
37	Forbes 230	0.99 | 1.04	1.02 | 1.05	1.01 | 1.06	1.02 | 1.03	1.03 | 1.07
38	Riverton 230	1.00 | 1.05	1.01 | 1.04	1.02 | 1.04	1.02 | 1.04	1.03 | 1.05
39	Coal Creek 230	0.99 | 1.06	0.97 | 1.07	0.98 | 1.08	1.02 | 1.05	0.98 | 1.08
40	Jamestown 345	0.95 | 1.00	0.95 | 1.01	0.96 | 1.01	0.99 | 1.01	0.96 | 1.02
41	Drayton 230	1.02 | 1.06	1.03 | 1.05	1.03 | 1.06	1.04 | 1.05	1.03 | 1.06
42	Groton 345	1.00 | 1.04	0.99 | 1.03	1.00 | 1.03	1.01 | 1.03	1.00 | 1.04
43	Minong 161	1.03 | 1.09	0.83 | 1.00	0.83 | 0.98	0.90 | 0.96	0.98 | 1.05
44	Wahpeton 115	1.02 | 1.06	1.03 | 1.06	1.04 | 1.06	1.04 | 1.06	1.04 | 1.07
45	Watertown 345	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04	1.02 | 1.03	1.01 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 40.05%	SHERC3 / 69.93%	KING 3 / 57.49%	SHERC3 / 49.49%	SHERC3 / 77.75%
55	Dorsey SUVP / UdHold	/ 0.150				
56	Forbes DC Red (DCAR)	439%	222%	200%	299%	330%
57	K22W (max +dP @ t, d-ang)	80.6@(2.04166,-38.0)	15.7@(3.36664,0.8)	6.4@(3.38331,4.6)	0.0@(0.10000,0.0)	21.7@(2.38332,-3.2)
58	K22W (max -dP @ t, d-ang)	39.8@(0.25833,3.6)	51.5@(1.56666,18.5)	56.1@(1.58333,21.0)	43.0@(2.19999,18.4)	33.4@(0.39166,5.4)
59	K22W (max d-ang @ t, dP)	-64.9@(10.00821,46.4)	25.1@(1.02500,-34.1)	25.5@(1.05833,-36.9)	18.5@(2.34166,-42.5)	14.8@(0.88333,-14.1)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	0.38333 sec / 0.18333 sec	296% / 492%	309% / 514%	325% / 543%	275% / 458%
63	G82R at Rugby/L20D at Drayton	999% / 712%	999% / 758%	999% / 774%	999% / 860%	999% / 790%
64	R50M / F3M	654% / 197%	858% / 309%	878% / 322%	982% / 322%	893% / 290%
65	B10T	216%	178%	194%	76%	180%
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 | 2) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 0 | 0)	(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 | 0 | 0)	(1 | 1 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 0 | 0) / (1 | 2 | 2)	(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 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 2 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-pas	m1a-so15aa-pc0	m1a-so15aa-pcs	m1a-so15aa-pct	m1a-so15aa-pzs
Disturbance	pas	pc0	pcs	pct	pzs
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(5T)(6T)				

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	21	22	23	24	25
2	**Case Name**	m1a-so15aa-pzt	m1a-so15aa-ya3	m1a-so15aa-yas	m1a-so15aa-yb3	m1a-so15aa-h13
3	**Disturbance**	pzt	ya3	yas	yb3	h13
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 12:37	MAY 28 2009 12:40	MAY 28 2009 12:43	MAY 28 2009 12:45	MAY 28 2009 13:35
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	1.00 | 1.00	1.02 | 1.02	0.96 | 0.99	1.03 | 1.04	0.99 | 1.02
35	Boise 115	1.02 | 1.02	1.03 | 1.04	1.02 | 1.04	1.03 | 1.04	1.01 | 1.02
36	Dorsey 230	1.04 | 1.05	1.04 | 1.05	1.04 | 1.07	1.04 | 1.05	1.01 | 1.05
37	Forbes 230	1.03 | 1.03	1.03 | 1.04	1.02 | 1.05	1.03 | 1.04	1.03 | 1.04
38	Riverton 230	1.03 | 1.04	1.02 | 1.03	1.02 | 1.03	1.03 | 1.03	1.03 | 1.04
39	Coal Creek 230	1.03 | 1.04	1.02 | 1.04	1.00 | 1.05	1.02 | 1.04	1.02 | 1.07
40	Jamestown 345	0.99 | 1.00	0.98 | 1.00	0.98 | 1.01	0.99 | 1.00	0.97 | 1.01
41	Drayton 230	1.04 | 1.04	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.02 | 1.05
42	Groton 345	1.02 | 1.02	1.01 | 1.02	1.01 | 1.02	1.02 | 1.02	1.01 | 1.04
43	Minong 161	1.02 | 1.02	0.98 | 1.00	0.97 | 1.02	0.99 | 1.02	1.01 | 1.05
44	Wahpeton 115	1.05 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.06
45	Watertown 345	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03	1.03 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	SHERC3 / 41.73%	SHERC3 / 31.58%	SHERC3 / 32.36%	KING 3 / 42.52%	MNTCE3 / 60.62%
55	Dorsey SUVP / UdHold					/ 0.133
56	Forbes DC Red (DCAR)	470%	343%	406%	393%	468%
57	K22W (max +dP @ t, d-ang)	0.0@(0.10000,0.0)	5.0@(0.11667,0.7)	3.1@(0.11667,0.3)	3.3@(0.11667,0.5)	102.8@(0.15000,-2.0)
58	K22W (max -dP @ t, d-ang)	7.6@(2.05833,3.3)	31.6@(1.66666,15.1)	25.4@(1.60833,11.1)	21.3@(1.59166,9.8)	18.5@(2.93332,4.1)
59	K22W (max d-ang @ t, dP)	3.3@(2.22499,-7.3)	15.8@(1.98333,-28.7)	11.7@(1.94166,-20.5)	10.1@(1.88333,-18.9)	-7.1@(0.65833,-0.1)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	310% / 518%
63	G82R at Rugby/L20D at Drayton	999% / 899%	999% / 852%	999% / 863%	999% / 869%	999% / 839%
64	R50M / F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	987% / 265%
65	B10T	333%	284%	291%	299%	279%
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 | 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)
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 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-pzt	m1a-so15aa-ya3	m1a-so15aa-yas	m1a-so15aa-yb3	m1a-so15aa-h13
Disturbance	pzt	ya3	yas	yb3	h13
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table C-3: TSR Study Case with Upgrade Option 1

1	**Case No.**	26	27	28	29	30
2	**Case Name**	m1a-so15aa-h23	m1a-so15aa-h33	m1a-so15aa-h43	m1a-so15aa-h53	m1a-so15aa-h63
3	**Disturbance**	h23	h33	h43	h53	h63
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 13:38	MAY 28 2009 13:41	MAY 28 2009 13:44	MAY 28 2009 13:47	MAY 28 2009 13:50
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	1.01 | 1.05	1.03 | 1.07	0.99 | 1.02	0.91 | 1.01	0.95 | 1.03
35	Boise 115	1.01 | 1.03	0.96 | 1.01	1.00 | 1.02	0.99 | 1.01	1.01 | 1.03
36	Dorsey 230	1.02 | 1.06	1.04 | 1.07	1.00 | 1.04	1.03 | 1.05	1.03 | 1.05
37	Forbes 230	1.03 | 1.05	1.05 | 1.07	1.02 | 1.04	0.98 | 1.02	1.02 | 1.04
38	Riverton 230	1.04 | 1.05	1.03 | 1.06	1.03 | 1.04	0.98 | 1.02	1.01 | 1.04
39	Coal Creek 230	1.03 | 1.06	1.01 | 1.07	1.02 | 1.06	1.00 | 1.06	1.00 | 1.06
40	Jamestown 345	0.98 | 1.02	0.96 | 1.01	0.97 | 1.00	0.98 | 1.01	0.97 | 1.01
41	Drayton 230	1.04 | 1.06	1.02 | 1.06	1.02 | 1.04	1.02 | 1.04	1.03 | 1.05
42	Groton 345	1.01 | 1.05	1.00 | 1.04	1.01 | 1.04	0.95 | 1.00	1.00 | 1.04
43	Minong 161	1.03 | 1.08	1.04 | 1.10	1.01 | 1.05	0.93 | 1.04	0.95 | 1.06
44	Wahpeton 115	1.05 | 1.07	1.03 | 1.06	1.04 | 1.06	1.01 | 1.04	1.03 | 1.06
45	Watertown 345	1.03 | 1.05	1.02 | 1.04	1.02 | 1.04	0.98 | 1.02	1.01 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 22.27%	KING 3 / 32.55%	MNTCE3 / 62.97%	KING 3 / 69.91%	SHERC3 / 77.85%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	459%	507%	478%	347%	364%
57	K22W (max +dP @ t, d-ang)	102.8@(0.15000,-2.0)	96.4@(0.15000,-1.7)	96.4@(0.15000,-1.7)	10.2@(0.11667,1.2)	24.8@(3.23331,-5.3)
58	K22W (max -dP @ t, d-ang)	0.0@(0.03333,0.0)	17.0@(0.25000,0.7)	31.3@(2.92498,7.3)	75.7@(1.33333,28.8)	42.9@(0.28333,6.4)
59	K22W (max d-ang @ t, dP)	-41.2@(10.00821,45.7)	-71.0@(10.00821,44.2)	7.5@(2.74998,-27.1)	29.9@(1.06666,-63.6)	18.2@(0.85000,-22.1)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	325% / 543%	0.18333 sec / 0.18333 sec	318% / 528%	154% / 257%	243% / 405%
63	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 793%	999% / 710%	999% / 692%	999% / 789%
64	R50M / F3M	999% / 247%	605% / 165%	804% / 263%	616% / 278%	821% / 279%
65	B10T	276%	223%	263%	148%	190%
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 | 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 | 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 | 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 | 1 | 0) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-h23	m1a-so15aa-h33	m1a-so15aa-h43	m1a-so15aa-h53	m1a-so15aa-h63
Disturbance	h23	h33	h43	h53	h63
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping		(5T)(6T)			

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	31	32	33	34	35
2	**Case Name**	m1a-so15aa-h79	m1a-so15aa-h83	m1a-so15aa-h93	m1a-so15aa-he3	m1a-so15aa-hec
3	**Disturbance**	h79	h83	h93	he3	hec
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 12 2009 14:53	MAY 28 2009 13:57	MAY 28 2009 14:00	MAY 28 2009 13:32	JUN 11 2009 11:07
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1247	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-55 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.91 | 1.01	0.99 | 1.02	0.98 | 1.02	0.95 | 1.03	0.97 | 1.04
35	Boise 115	0.96 | 1.07	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03	0.97 | 1.03
36	Dorsey 230	1.00 | 1.04	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05	1.02 | 1.10
37	Forbes 230	0.93 | 1.01	1.03 | 1.05	1.03 | 1.04	1.02 | 1.04	0.97 | 1.03
38	Riverton 230	0.99 | 1.03	1.02 | 1.04	1.01 | 1.04	1.01 | 1.04	1.00 | 1.04
39	Coal Creek 230	1.00 | 1.05	1.00 | 1.08	1.00 | 1.07	1.00 | 1.06	1.00 | 1.07
40	Jamestown 345	0.92 | 0.97	0.96 | 1.01	0.96 | 1.01	0.97 | 1.01	0.92 | 0.99
41	Drayton 230	0.93 | 1.00	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05	1.00 | 1.05
42	Groton 345	0.99 | 1.03	1.00 | 1.03	1.00 | 1.03	1.00 | 1.04	1.00 | 1.04
43	Minong 161	0.95 | 1.05	1.00 | 1.05	1.00 | 1.05	0.95 | 1.06	1.01 | 1.07
44	Wahpeton 115	1.01 | 1.04	1.03 | 1.06	1.03 | 1.05	1.03 | 1.06	1.02 | 1.06
45	Watertown 345	1.01 | 1.04	1.02 | 1.04	1.02 | 1.03	1.01 | 1.04	1.02 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	MNTCE3 / 59.36%	KING 3 / 76.62%	KING 3 / 78.49%	SHERC3 / 77.79%	KING 3 / 11.51%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	39%	417%	439%	360%	170%
57	K22W (max +dP @ t, d-ang)	196.0@(1.63333,6.4)	29.5@(0.11667,0.7)	24.5@(0.11667,0.7)	23.2@(3.23331,-4.5)	47.2@(0.13333,-0.6)
58	K22W (max -dP @ t, d-ang)	102.7@(1.63333,25.7)	38.6@(0.28333,5.6)	36.9@(0.28333,5.2)	43.3@(0.28333,6.5)	105.4@(0.44166,15.1)
59	K22W (max d-ang @ t, dP)	-35.6@(2.24166,196.0)	8.4@(0.60000,-1.5)	9.0@(0.65833,-5.2)	18.8@(0.85833,-23.2)	-28.7@(10.00821,-1.0)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.63333 sec				
62	D602F at Forbes/Dorsey	52% / 85%	270% / 452%	265% / 442%	246% / 410%	21% / 22%
63	G82R at Rugby/L20D at Drayton	999% / 194%	999% / 786%	999% / 827%	999% / 789%	999% / 219%
64	R50M / F3M	201% / 213%	889% / 299%	899% / 297%	825% / 284%	333% / 197%
65	B10T	66%	241%	238%	189%	75%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 1)
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 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 4) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 5 | 3) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 2 | 2) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 1 | 1) / (1 | 2 | 2)
71	Shey 115 / Split Rock 115	(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 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-h79	m1a-so15aa-h83	m1a-so15aa-h93	m1a-so15aa-he3	m1a-so15aa-hec
Disturbance	h79	h83	h93	he3	hec
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(1T)				56

Table C-3: TSR Study Case with Upgrade Option 1

	Case No.	36	37	38	39	40
2	**Case Name**	m1a-so15aa-hhs	m1a-so15aa-hgs	m1a-so15aa-hjs	m1a-so15aa-hks	m1a-so15aa-hlc
3	**Disturbance**	hhs	hgs	hjs	hks	hlc
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 13:23	MAY 28 2009 14:06	MAY 28 2009 13:26	MAY 28 2009 13:29	JUN 12 2009 16:13
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642	1641 / 642	1641 / 642	1645 / 647
13	D602F / F601C	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1247
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29	717 / 29	717 / 29	717 / 28
20	Forbes SVC / MSC	-45 / 600	-45 / 600	-45 / 600	-45 / 600	-55 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.046
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%	999% / 322%	999% / 322%	999% / 321%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.99 | 1.01	0.97 | 1.03	0.96 | 1.03	0.99 | 1.01	0.90 | 1.00
35	Boise 115	1.01 | 1.03	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04	0.95 | 1.08
36	Dorsey 230	1.04 | 1.06	1.03 | 1.09	1.03 | 1.10	1.02 | 1.11	0.98 | 1.06
37	Forbes 230	1.03 | 1.05	1.02 | 1.06	1.02 | 1.06	1.03 | 1.06	0.91 | 1.00
38	Riverton 230	1.03 | 1.05	1.02 | 1.04	1.02 | 1.04	1.03 | 1.05	0.99 | 1.03
39	Coal Creek 230	1.00 | 1.07	1.01 | 1.07	1.01 | 1.07	1.00 | 1.07	1.00 | 1.05
40	Jamestown 345	0.98 | 1.03	0.98 | 1.01	0.98 | 1.02	0.98 | 1.02	0.92 | 0.97
41	Drayton 230	1.04 | 1.11	1.04 | 1.09	1.03 | 1.09	1.03 | 1.12	0.93 | 1.00
42	Groton 345	1.01 | 1.03	1.01 | 1.04	1.00 | 1.04	1.01 | 1.03	0.99 | 1.02
43	Minong 161	1.01 | 1.03	0.97 | 1.06	0.96 | 1.06	1.01 | 1.03	0.95 | 1.04
44	Wahpeton 115	1.03 | 1.07	1.05 | 1.06	1.04 | 1.06	1.03 | 1.07	1.01 | 1.04
45	Watertown 345	1.02 | 1.03	1.02 | 1.04	1.01 | 1.04	1.02 | 1.03	1.01 | 1.03
46	**Dynamic Voltage Warnings**					
47			none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 78.09%	SHERC3 / 79.83%	SHERC3 / 77.10%	SHERC3 / 81.95%	SHERC3 / 60.24%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.150	/ 0.141	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	461%	365%	357%	456%	55%
57	K22W (max +dP @ t, d-ang)	8.0@(0.11667,0.2)	20.4@(3.26664,-4.7)	17.9@(3.30831,-3.5)	8.0@(0.11667,0.2)	196.0@(1.21666,3.8)
58	K22W (max -dP @ t, d-ang)	13.3@(0.23333,1.3)	42.6@(0.39166,6.8)	49.1@(0.39166,7.7)	32.5@(0.38333,4.1)	116.5@(1.21666,23.9)
59	K22W (max d-ang @ t, dP)	4.1@(0.84166,-6.4)	15.4@(0.85000,-15.0)	17.6@(0.90000,-20.6)	5.0@(0.65833,-2.6)	-38.7@(1.79166,196.0)
60	**OS Rel Trip / Marg**					
61	MH - OH					1.21666 sec
62	D602F at Forbes/Dorsey	291% / 487%	246% / 410%	240% / 401%	257% / 428%	21% / 23%
63	G82R at Rugby/L20D at Drayton	999% / 632%	999% / 808%	999% / 785%	999% / 740%	999% / 175%
64	R50M / F3M	999% / 302%	836% / 278%	821% / 281%	911% / 306%	180% / 204%
65	B10T	265%	193%	180%	244%	47%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 1)
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)
69	Prairie 115 / Ramsey 230	(1 | 5 | 1) / (0 | 1 | 1)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 4 | 1) / (0 | 1 | 1)	(1 |11 | 5) / (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 | 2 | 2) / (1 | 4 | 2)
71	Shey 115 / Split Rock 115	(1 | 3 | 3) / (1 | 1 | 1)	(1 | 3 | 2) / (1 | 2 | 2)	(1 | 3 | 2) / (1 | 2 | 2)	(1 | 3 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-hhs	m1a-so15aa-hgs	m1a-so15aa-hjs	m1a-so15aa-hks	m1a-so15aa-hlc
Disturbance	hhs	hgs	hjs	hks	hlc
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					(1T)56

Table C-3: TSR Study Case with Upgrade Option 1

1	**Case No.**	41	42
2	**Case Name**	m1a-so15aa-hm9	m1a-so15aa-hoc
3	**Disturbance**	hm9	hoc
4	**Prior Outage**	None	None
5	**Date/Time**	JUN 12 2009 14:56	JUN 12 2009 15:02
6	**Comments**		
7			
8	**Steady State Flows**		
9	NDEX / EAST BIAS	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1645 / 647
13	D602F / F601C	1545 / 1247	1545 / 1247
14	B10T / MH>SPC	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151
17	G82R	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 28
20	Forbes SVC / MSC	-55 / 600	-55 / 600
21	RCDC	0	0
22	**Steady State Vltgs**		
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.046
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**		
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 321%
32	B10T	347%	347%
33	**Min/MaxTransientVltg**		
34	Arrowhd 230	0.91 | 1.05	0.86 | 1.03
35	Boise 115	0.96 | 1.09	0.96 | 1.08
36	Dorsey 230	1.01 | 1.06	1.01 | 1.14
37	Forbes 230	0.90 | 1.03	0.89 | 1.04
38	Riverton 230	0.98 | 1.05	0.97 | 1.04
39	Coal Creek 230	0.98 | 1.07	0.99 | 1.06
40	Jamestown 345	0.89 | 0.99	0.94 | 0.98
41	Drayton 230	0.91 | 1.04	0.94 | 1.08
42	Groton 345	0.98 | 1.04	0.96 | 1.02
43	Minong 161	0.94 | 1.09	0.92 | 1.08
44	Wahpeton 115	1.00 | 1.06	1.00 | 1.05
45	Watertown 345	1.01 | 1.04	0.99 | 1.03
46	**Dynamic Voltage Warnings**		
47		none	none
48			
49			
50			
51			
52			
53			
54	Worst Case Angle Damping	KING 3 / 38.95%	KING 3 / 53.41%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-37%	-33%
57	K22W (max +dP @ t, d-ang)	196.0@(1.20000,12.9)	196.0@(1.46666,14.9)
58	K22W (max -dP @ t, d-ang)	113.8@(1.16666,33.4)	115.3@(1.46666,35.0)
59	K22W (max d-ang @ t, dP)	-59.3@(10.00821,196.0)	-53.9@(9.24989,196.0)
60	**OS Rel Trip / Marg**		
61	MH - OH	1.20000 sec	1.46666 sec
62	D602F at Forbes/Dorsey	44% / 72%	52% / 87%
63	G82R at Rugby/L20D at Drayton	999% / 170%	999% / 242%
64	R50M / F3M	331% / 238%	313% / 237%
65	B10T	35%	78%
66	**FSCAPS (SS/Unav/Final)**		
67	Balta 230	(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)
69	Prairie 115 / Ramsey 230	(1 | 5 | 3) / (0 | 2 | 2)	(1 | 4 | 3) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 1) / (1 | 4 | 1)	(0 | 2 | 1) / (1 | 3 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A

Case	m1a-so15aa-hm9	m1a-so15aa-hoc
Disturbance	hm9	hoc
System Response	OK	OK
70% or 120% Violations		
ORWG Criteria Violations		
Line Tripping	2(1T)5	2(1T)

Table C-4: TSR Study Case with Upgrade Option 3

	Case No.	1	2	3	4	5
	Case Name	m3a-so15aa-ag1	m3a-so15aa-ag3	m3a-so15aa-cts	m3a-so15aa-ei2	m3a-so15aa-em3
	Disturbance	ag1	ag3	cts	ei2	em3
	Prior Outage	None	None	None	None	None
	Date/Time	MAY 28 2009 16:12	MAY 28 2009 16:15	JUN 03 2009 17:52	MAY 28 2009 16:22	MAY 28 2009 16:25
	Comments					
	Steady State Flows					
	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	842 / 35	842 / 35
	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1722 / 643	1722 / 643
	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218
	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
	G82R	-36	-36	-36	-36	-36
	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-21 / 600	-21 / 600
	RCDC	0	0	0	0	0
	Steady State Vltgs					
	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035
	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974
	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044
	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
	SS OS Relay Margins					
	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	999% / 324%
	B10T	354%	354%	354%	354%	354%
	Min/MaxTransientVltg					
	Arrowhd 230	0.98 | 1.01	0.97 | 1.01	0.92 | 1.08	0.98 | 1.04	1.00 | 1.01
	Boise 115	1.01 | 1.03	1.01 | 1.03	0.98 | 1.02	0.99 | 1.02	1.01 | 1.02
	Dorsey 230	1.03 | 1.05	1.03 | 1.05	1.04 | 1.12	1.03 | 1.05	1.03 | 1.05
	Forbes 230	1.02 | 1.04	1.02 | 1.04	0.95 | 1.05	1.01 | 1.04	1.03 | 1.04
	Riverton 230	1.01 | 1.04	1.01 | 1.04	0.93 | 1.07	0.98 | 1.05	1.04 | 1.04
	Coal Creek 230	0.97 | 1.11	0.97 | 1.11	0.89 | 1.08	1.02 | 1.10	1.03 | 1.05
	Jamestown 345	0.91 | 1.02	0.91 | 1.02	0.75 | 1.04	0.84 | 1.03	0.98 | 0.99
	Drayton 230	1.01 | 1.05	1.01 | 1.05	0.97 | 1.09	0.99 | 1.07	1.03 | 1.04
	Groton 345	0.92 | 1.04	0.92 | 1.04	0.85 | 1.07	0.93 | 1.06	1.02 | 1.03
	Minong 161	0.99 | 1.03	0.99 | 1.03	0.97 | 1.11	1.02 | 1.07	1.02 | 1.04
	Wahpeton 115	1.00 | 1.07	1.00 | 1.06	0.90 | 1.08	0.96 | 1.08	1.05 | 1.05
	Watertown 345	0.98 | 1.04	0.99 | 1.04	0.91 | 1.06	0.98 | 1.05	1.03 | 1.03
	Dynamic Voltage Warnings					
		none	none	63061 [MIDCOMP] 1.25	63061 [MIDCOMP] 1.21	none
	Worst Case Angle Damping	KING 3 / 76.34%	KING 3 / 77.38%	KING 3 / 38.08%	SHERC3 / 32.02%	KING 3 / 31.51%
	Dorsey SUVP / UdHold			/ 0.141		/ 0.133
	Forbes DC Red (DCAR)	463%	461%	507%	507%	497%
	K22W (max +dP @ t, d-ang)	10.6@(2.37499,2.3)	13.3@(2.34166,1.3)	106.7@(2.41666,-48.5)	71.0@(2.43332,-31.0)	32.0@(0.13333,-0.3)
	K22W (max -dP @ t, d-ang)	20.7@(1.78333,0.9)	19.6@(0.74166,5.7)	49.8@(0.41666,7.5)	0.0@(0.02500,0.0)	24.0@(0.26667,2.1)
	K22W (max d-ang @ t, dP)	7.3@(1.05000,-6.6)	8.0@(0.99166,-8.2)	-66.8@(10.00821,52.2)	-50.5@(10.00821,39.8)	-13.3@(10.00821,11.5)
	OS Rel Trip / Marg					
	MH - OH					
	D602F at Forbes/Dorsey	265% / 443%	262% / 438%	0.36667 sec / 0.36667 sec	246% / 412%	275% / 462%
	G82R at Rugby/L20D at Drayton	999% / 663%	999% / 654%	999% / 497%	999% / 590%	999% / 0.18333 sec
	R50M / F3M	902% / 284%	892% / 281%	616% / 179%	915% / 220%	891% / 288%
	B10T	217%	214%	66%	126%	265%
	FSCAPS (SS/Unav/Final)					
	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 2 | 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 | 2) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)
	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 6 | 1) / (0 | 2 | 2)	(1 | 3 | 1) / (0 | 1 | 1)	(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)
	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 5 | 0) / (1 | 2 | 2)	(1 | 3 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
	Damping Performance	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-ag1	m3a-so15aa-ag3	m3a-so15aa-cts	m3a-so15aa-ei2	m3a-so15aa-em3
Disturbance	ag1	ag3	cts	ei2	em3
System Response	OK	OK	OK	OK	OK
70% or 120% Violations			M	M	
ORWG Criteria Violations					
Line Tripping			(5T)(6T)		(3T)

Table C-4: TSR Study Case with Upgrade Option 3

1	**Case No.**	6	7	8	9	10
2	**Case Name**	m3a-so15aa-eq1	m3a-so15aa-fds	m3a-so15aa-mc3	m3a-so15aa-md3	m3a-so15aa-mis
3	**Disturbance**	eq1	fds	mc3	md3	mis
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 16:28	MAY 28 2009 16:31	MAY 28 2009 16:34	MAY 28 2009 16:37	MAY 28 2009 16:40
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	842 / 35	842 / 35
12	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1722 / 643	1722 / 643
13	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-21 / 600	-21 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974
26	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	999% / 324%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.98 | 1.03	0.96 | 1.01	1.00 | 1.01	1.00 | 1.00	1.00 | 1.01
35	Boise 115	1.00 | 1.02	1.01 | 1.03	1.00 | 1.02	1.02 | 1.02	1.04 | 1.06
36	Dorsey 230	1.04 | 1.05	1.03 | 1.06	1.03 | 1.05	1.03 | 1.05	1.04 | 1.05
37	Forbes 230	1.02 | 1.04	1.02 | 1.04	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
38	Riverton 230	1.00 | 1.06	1.00 | 1.05	1.03 | 1.04	1.03 | 1.03	1.03 | 1.04
39	Coal Creek 230	0.99 | 1.16	0.97 | 1.12	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
40	Jamestown 345	0.86 | 1.05	0.82 | 1.05	0.98 | 0.99	0.98 | 0.99	0.98 | 0.99
41	Drayton 230	1.02 | 1.08	1.01 | 1.05	1.02 | 1.04	1.03 | 1.04	1.03 | 1.04
42	Groton 345	0.95 | 1.06	0.96 | 1.06	1.02 | 1.02	1.02 | 1.02	1.02 | 1.02
43	Minong 161	1.02 | 1.06	0.99 | 1.03	1.02 | 1.03	1.02 | 1.02	1.02 | 1.03
44	Wahpeton 115	0.99 | 1.08	0.98 | 1.08	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05
45	Watertown 345	0.99 | 1.05	0.99 | 1.05	1.03 | 1.03	1.03 | 1.03	1.03 | 1.03
46	**Dynamic Voltage Warnings**					
47		63061 [MIDCOMP] 1.21	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 31.04%	MNTCE3 / 77.69%	KING 3 / 27.80%	ANTEL3 / 80.81%	KING 3 / 18.28%
55	Dorsey SUVP / UdHold			/ 0.133	/ 0.133	
56	Forbes DC Red (DCAR)	484%	450%	491%	497%	483%
57	K22W (max +dP @ t, d-ang)	50.5@(2.31666,-20.0)	10.7@(2.39999,-0.5)	28.9@(0.12500,0.4)	21.3@(0.12500,-0.4)	194.9@(0.35000,-11.8)
58	K22W (max -dP @ t, d-ang)	0.8@(0.29167,-0.1)	13.4@(0.77500,3.1)	22.3@(0.98333,-4.4)	11.7@(0.24167,0.7)	0.0@(0.35000,0.0)
59	K22W (max d-ang @ t, dP)	-29.9@(10.00821,22.8)	5.0@(1.02500,-4.2)	-8.8@(10.00821,-12.5)	-0.7@(3.49164,2.1)	-43.2@(0.96666,194.9)
60	**OS Rel Trip / Marg**					
61	MH - OH					0.35000 sec
62	D602F at Forbes/Dorsey	269% / 450%	276% / 462%	291% / 488%	309% / 514%	300% / 501%
63	G82R at Rugby/L20D at Drayton	54% / 607%	999% / 659%	999% / 707%	999% / 764%	999% / 729%
64	R50M / F3M	956% / 249%	913% / 289%	999% / 211%	999% / 319%	644% / 324%
65	B10T	140%	106%	336%	337%	347%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 1 | 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)
69	Prairie 115 / Ramsey 230	(1 | 3 | 1) / (0 | 1 | 1)	(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 | 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 | 1) / (1 | 1 | 1)	(1 | 2 | 0) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-eq1	m3a-so15aa-fds	m3a-so15aa-mc3	m3a-so15aa-md3	m3a-so15aa-mis
Disturbance	eq1	fds	mc3	md3	mis
System Response	OK	OK	OK	OK	OK
70% or 120% Violations	M				
ORWG Criteria Violations					
Line Tripping					(1T)

Table C-4: TSR Study Case with Upgrade Option 3

	Case No.	11	12	13	14	15
2	**Case Name**	m3a-so15aa-mjs	m3a-so15aa-mkd	m3a-so15aa-mks	m3a-so15aa-nad	m3a-so15aa-nmz
3	**Disturbance**	mjs	mkd	mks	nad	nmz
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 16:43	MAY 28 2009 16:45	MAY 28 2009 16:48	MAY 28 2009 16:51	JUN 03 2009 17:55
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	842 / 35	842 / 35
12	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1722 / 643	1722 / 643
13	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-21 / 600	-21 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974
26	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	999% / 324%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.97 | 1.00	0.92 | 1.01	0.96 | 1.02	0.99 | 1.06	0.95 | 1.06
35	Boise 115	1.02 | 1.03	1.02 | 1.03	1.01 | 1.03	0.97 | 1.01	0.97 | 1.02
36	Dorsey 230	1.03 | 1.06	1.03 | 1.05	1.03 | 1.07	1.04 | 1.07	1.04 | 1.08
37	Forbes 230	1.03 | 1.05	1.03 | 1.04	1.03 | 1.05	1.02 | 1.04	1.01 | 1.04
38	Riverton 230	1.01 | 1.04	0.99 | 1.04	1.00 | 1.04	1.00 | 1.05	0.97 | 1.06
39	Coal Creek 230	0.98 | 1.07	0.97 | 1.07	0.97 | 1.08	1.00 | 1.06	0.97 | 1.07
40	Jamestown 345	0.92 | 1.00	0.91 | 1.00	0.91 | 1.01	0.94 | 0.99	0.87 | 1.01
41	Drayton 230	1.01 | 1.04	1.01 | 1.04	1.02 | 1.05	1.00 | 1.05	0.99 | 1.07
42	Groton 345	0.98 | 1.03	0.98 | 1.03	0.97 | 1.03	1.00 | 1.04	0.95 | 1.05
43	Minong 161	0.99 | 1.02	0.94 | 1.04	0.98 | 1.04	1.02 | 1.08	0.99 | 1.10
44	Wahpeton 115	1.01 | 1.05	1.00 | 1.05	1.00 | 1.06	1.01 | 1.05	0.97 | 1.07
45	Watertown 345	1.01 | 1.03	1.00 | 1.03	1.00 | 1.03	1.01 | 1.04	0.98 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	63061 [MIDCOMP] 1.22	63061 [MIDCOMP] 1.23
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	SHERC3 / 75.25%	KING 3 / 79.27%	KING 3 / 77.71%	KING 3 / 40.44%	KING 3 / 37.49%
55	Dorsey SUVP / UdHold		/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	447%	320%	396%	507%	507%
57	K22W (max +dP @ t, d-ang)	4.1@(0.11667,0.3)	13.2@(0.10833,1.6)	10.1@(3.34164,-0.9)	94.3@(2.01666,-41.9)	98.5@(2.12499,-44.3)
58	K22W (max -dP @ t, d-ang)	21.7@(0.35000,3.3)	32.3@(0.24167,4.7)	32.0@(0.36667,5.7)	66.3@(0.25833,7.6)	51.8@(0.23333,5.3)
59	K22W (max d-ang @ t, dP)	6.6@(1.06666,-17.6)	13.4@(0.89166,-21.6)	9.7@(0.81666,-9.9)	-69.7@(10.00821,49.2)	-68.7@(10.00821,54.4)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	291% / 504%	311% / 517%	268% / 478%	0.16667 sec / 0.16667 sec	0.18333 sec / 0.18333 sec
63	G82R at Rugby/L20D at Drayton	999% / 673%	999% / 623%	999% / 660%	999% / 481%	999% / 599%
64	R50M / F3M	924% / 324%	889% / 324%	893% / 311%	517% / 167%	659% / 193%
65	B10T	247%	201%	214%	192%	137%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 1 | 1)
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 | 2) / (0 | 0 | 0)	(4 | 4 | 2) / (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 | 1 | 1) / (0 | 0 | 0)	(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 | 2 | 2)	(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 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 3 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-mjs	m3a-so15aa-mkd	m3a-so15aa-mks	m3a-so15aa-nad	m3a-so15aa-nmz
Disturbance	mjs	mkd	mks	nad	nmz
System Response	OK	OK	OK	OK	OK
70% or 120% Violations				M	M
ORWG Criteria Violations					
Line Tripping				(5T)(6T)	(5T)(6T)

Table C-4: TSR Study Case with Upgrade Option 3

1	**Case No.**	16	17	18	19	20
2	**Case Name**	m3a-so15aa-pas	m3a-so15aa-pc0	m3a-so15aa-pcs	m3a-so15aa-pct	m3a-so15aa-pzs
3	**Disturbance**	pas	pc0	pcs	pct	pzs
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 16:58	MAY 28 2009 17:01	MAY 28 2009 17:04	MAY 28 2009 17:08	MAY 28 2009 14:09
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	842 / 35	842 / 35
12	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1722 / 643	1722 / 643
13	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-21 / 600	-21 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974
26	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	999% / 324%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.99 | 1.06	0.84 | 0.99	0.84 | 0.97	0.89 | 0.95	0.97 | 1.02
35	Boise 115	0.99 | 1.02	1.01 | 1.04	1.01 | 1.04	1.02 | 1.03	1.01 | 1.04
36	Dorsey 230	1.04 | 1.07	1.03 | 1.09	1.04 | 1.10	1.04 | 1.05	1.03 | 1.08
37	Forbes 230	0.99 | 1.05	1.01 | 1.03	1.01 | 1.04	1.01 | 1.03	1.03 | 1.07
38	Riverton 230	1.01 | 1.05	1.00 | 1.05	1.01 | 1.04	1.02 | 1.04	1.02 | 1.05
39	Coal Creek 230	0.99 | 1.06	0.96 | 1.07	0.97 | 1.08	1.02 | 1.04	0.98 | 1.07
40	Jamestown 345	0.94 | 0.99	0.93 | 1.01	0.93 | 1.01	0.98 | 1.00	0.94 | 1.01
41	Drayton 230	1.00 | 1.05	1.03 | 1.07	1.02 | 1.07	1.03 | 1.04	1.02 | 1.05
42	Groton 345	1.00 | 1.04	0.98 | 1.03	0.99 | 1.03	1.01 | 1.03	0.99 | 1.04
43	Minong 161	1.03 | 1.10	(0.62)0.80 | 1.00	(0.62)0.80 | 0.98	0.87 | 0.95	0.97 | 1.05
44	Wahpeton 115	1.01 | 1.05	1.02 | 1.06	1.02 | 1.06	1.04 | 1.05	1.03 | 1.06
45	Watertown 345	1.01 | 1.04	1.00 | 1.04	1.01 | 1.04	1.02 | 1.03	1.01 | 1.04
46	**Dynamic Voltage Warnings**					
47		63061 [MIDCOMP] 1.22	61631 [MINONG 5] 0.80	61631 [MINONG 5] 0.80	none	none
48			63061 [MIDCOMP] 1.21	63061 [MIDCOMP] 1.23		
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 40.22%	SHERC3 / 64.73%	KING 3 / 52.48%	SHERC3 / 39.91%	SHERC3 / 75.47%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133		
56	Forbes DC Red (DCAR)	464%	226%	204%	275%	337%
57	K22W (max +dP @ t, d-ang)	94.8@(2.02500,-42.7)	17.0@(3.43331,-0.5)	5.0@(3.47497,4.3)	0.0@(0.10000,0.0)	21.0@(3.30831,-4.5)
58	K22W (max -dP @ t, d-ang)	45.7@(0.25833,4.1)	58.7@(0.38333,9.6)	64.0@(1.70000,24.7)	52.9@(2.24999,22.8)	33.2@(0.38333,5.2)
59	K22W (max d-ang @ t, dP)	-69.5@(10.00821,53.4)	28.0@(1.11666,-55.0)	28.3@(1.16666,-58.4)	22.9@(2.37499,-52.7)	15.8@(0.92500,-17.4)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	0.38333 sec / 0.18333 sec	247% / 411%	259% / 433%	295% / 494%	255% / 425%
63	G82R at Rugby/L20D at Drayton	999% / 539%	999% / 585%	999% / 603%	999% / 675%	999% / 636%
64	R50M / F3M	585% / 190%	746% / 299%	767% / 315%	878% / 324%	818% / 292%
65	B10T	214%	171%	189%	287%	117%
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 | 2) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 2 | 1) / (0 | 1 | 1)	(1 | 2 | 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 | 2 | 2)	(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 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-pas	m3a-so15aa-pc0	m3a-so15aa-pcs	m3a-so15aa-pct	m3a-so15aa-pzs
Disturbance	pas	pc0	pcs	pct	pzs
System Response	OK	OK	OK	OK	OK
70% or 120% Violations	M	MM	MM		
ORWG Criteria Violations		7	7		
Line Tripping	(5T)(6T)				

Table C-4: TSR Study Case with Upgrade Option 3

	Case No.	21	22	23	24	25
2	**Case Name**	m3a-so15aa-pzt	m3a-so15aa-ya3	m3a-so15aa-yas	m3a-so15aa-yb3	m3a-so15aa-h13
3	**Disturbance**	pzt	ya3	yas	yb3	h13
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 14:13	MAY 28 2009 14:15	MAY 28 2009 14:18	MAY 28 2009 14:21	MAY 28 2009 14:24
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	842 / 35	842 / 35
12	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1722 / 643	1722 / 643
13	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218	1582 / 1218
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-21 / 600	-21 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974
26	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	999% / 324%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.99 | 1.00	1.01 | 1.02	0.96 | 0.98	1.02 | 1.03	0.99 | 1.02
35	Boise 115	1.02 | 1.02	1.03 | 1.04	1.02 | 1.04	1.02 | 1.04	1.00 | 1.02
36	Dorsey 230	1.04 | 1.05	1.04 | 1.05	1.04 | 1.07	1.04 | 1.05	0.99 | 1.06
37	Forbes 230	1.03 | 1.03	1.03 | 1.04	1.02 | 1.05	1.03 | 1.04	1.02 | 1.04
38	Riverton 230	1.03 | 1.03	1.02 | 1.03	1.01 | 1.03	1.03 | 1.03	1.03 | 1.04
39	Coal Creek 230	1.03 | 1.04	1.02 | 1.04	1.00 | 1.05	1.02 | 1.04	1.02 | 1.06
40	Jamestown 345	0.99 | 0.99	0.98 | 1.00	0.97 | 1.00	0.98 | 1.00	0.96 | 1.00
41	Drayton 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.05	1.03 | 1.04	1.01 | 1.04
42	Groton 345	1.02 | 1.02	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02	1.01 | 1.04
43	Minong 161	1.01 | 1.02	0.97 | 1.00	0.96 | 1.02	0.98 | 1.01	1.01 | 1.04
44	Wahpeton 115	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05	1.03 | 1.05
45	Watertown 345	1.03 | 1.03	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03	1.02 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	SHERC3 / 38.47%	SHERC3 / 26.10%	SHERC3 / 34.90%	KING 3 / 36.29%	SHERC3 / 60.40%
55	Dorsey SUVP / UdHold					/ 0.133
56	Forbes DC Red (DCAR)	466%	330%	399%	384%	462%
57	K22W (max +dP @ t, d-ang)	0.0@(0.10000,0.0)	4.8@(0.11667,0.7)	3.0@(0.11667,0.4)	3.1@(0.11667,0.6)	102.7@(0.15000,-2.1)
58	K22W (max -dP @ t, d-ang)	9.1@(2.05000,3.8)	36.7@(1.69166,17.1)	29.3@(1.64166,12.5)	24.8@(1.60833,11.0)	23.6@(2.96665,5.2)
59	K22W (max d-ang @ t, dP)	3.8@(2.23333,-8.7)	18.0@(2.04166,-33.8)	12.9@(1.91666,-24.8)	11.5@(1.93333,-22.0)	-9.2@(0.64166,3.3)
60	**OS Rel Trip / Marg**					
61	MH - OH					
62	D602F at Forbes/Dorsey	309% / 517%	312% / 521%	311% / 519%	312% / 521%	294% / 490%
63	G82R at Rugby/L20D at Drayton	999% / 743%	999% / 682%	999% / 697%	999% / 706%	999% / 679%
64	R50M / F3M	999% / 324%	999% / 324%	999% / 324%	999% / 324%	924% / 261%
65	B10T	193%	277%	284%	295%	294%
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 | 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)
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 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-pzt	m3a-so15aa-ya3	m3a-so15aa-yas	m3a-so15aa-yb3	m3a-so15aa-h13
Disturbance	pzt	ya3	yas	yb3	h13
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping					

Table C-4: TSR Study Case with Upgrade Option 3

	Case No.	26	27	28	29	30
2	**Case Name**	m3a-so15aa-h23	m3a-so15aa-h33	m3a-so15aa-h43	m3a-so15aa-hc9	m3a-so15aa-hd9
3	**Disturbance**	h23	h33	h43	hc9	hd9
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	MAY 28 2009 14:27	MAY 28 2009 14:31	MAY 28 2009 14:34	JUN 15 2009 9:15	JUN 15 2009 9:18
6	**Comments**					
7						
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	842 / 35	842 / 35	842 / 35	839 / 35	839 / 35
12	MWEX / AHD-SLK	1722 / 643	1722 / 643	1722 / 643	1724 / 647	1724 / 647
13	D602F / F601C	1582 / 1218	1582 / 1218	1582 / 1218	1583 / 1216	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1103	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-21 / 600	-21 / 600	-21 / 600	-28 / 600	-28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.043 / 1.035	1.043 / 1.035	1.043 / 1.035	1.042 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.974	1.031 / 0.974	1.031 / 0.974	1.031 / 0.972	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.044	1.021 / 1.044	1.021 / 1.044	1.021 / 1.043	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 324%	999% / 324%	999% / 324%	999% / 323%	999% / 323%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	1.02 | 1.05	1.03 | 1.08	0.99 | 1.02	0.83 | 1.04	(0.77)0.77 | 1.07
35	Boise 115	1.01 | 1.03	0.96 | 1.00	1.00 | 1.02	0.96 | 1.08	0.96 | 1.11
36	Dorsey 230	1.02 | 1.07	1.04 | 1.07	0.99 | 1.04	1.00 | 1.07	1.01 | 1.06
37	Forbes 230	1.03 | 1.05	1.05 | 1.08	1.02 | 1.04	0.87 | 1.03	0.84 | 1.04
38	Riverton 230	1.03 | 1.05	1.03 | 1.06	1.02 | 1.04	0.95 | 1.04	0.91 | 1.07
39	Coal Creek 230	1.03 | 1.06	1.02 | 1.07	1.02 | 1.05	1.00 | 1.07	0.97 | 1.08
40	Jamestown 345	0.96 | 1.00	0.93 | 1.00	0.96 | 1.00	0.93 | 0.99	0.90 | 1.02
41	Drayton 230	1.03 | 1.06	1.01 | 1.05	1.01 | 1.03	0.93 | 1.05	0.94 | 1.06
42	Groton 345	1.01 | 1.04	1.00 | 1.04	1.01 | 1.03	0.96 | 1.03	0.93 | 1.06
43	Minong 161	1.03 | 1.08	1.04 | 1.10	1.01 | 1.04	0.89 | 1.08	0.82 | 1.11
44	Wahpeton 115	1.03 | 1.06	1.01 | 1.06	1.03 | 1.05	0.99 | 1.05	0.96 | 1.08
45	Watertown 345	1.02 | 1.04	1.02 | 1.04	1.02 | 1.04	0.98 | 1.04	0.96 | 1.06
46	**Dynamic Voltage Warnings**					
47		63061 [MIDCOMP] 1.24	63061 [MIDCOMP] 1.23	none	none	61615 [ARROWHD4] 0.80
48						61614 [98L TAP4] 0.80
49						61616 [HILLTOP4] 0.80
50						61686 [15TH AV7] 0.80
51						61672 [HILLTOP7] 0.81
52						61667 [POTLTCH7] 0.81
53						668 [CLOQUET7] 0.81 +m
54	Worst Case Angle Damping	KING 3 / -1.56%	KING 3 / 30.58%	SHERC3 / 60.85%	KING 3 / 59.95%	SHERC3 / 69.03%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	442%	507%	473%	-71%	-123%
57	K22W (max +dP @ t, d-ang)	102.7@(0.15000,-2.1)	97.2@(0.15000,-1.8)	97.2@(0.15000,-1.8)	195.0@(1.47500,14.2)	195.0@(1.22500,24.9)
58	K22W (max -dP @ t, d-ang)	0.0@(0.02500,0.0)	15.9@(0.24167,0.5)	35.1@(2.95832,8.1)	115.5@(1.47500,34.1)	110.8@(1.22500,44.5)
59	K22W (max d-ang @ t, dP)	-43.8@(10.00821,52.2)	-73.5@(10.00821,52.8)	8.6@(2.68332,-24.5)	-56.6@(9.29989,195.0)	-60.9@(3.27498,195.0)
60	**OS Rel Trip / Marg**					
61	MH - OH				1.47500 sec	1.22500 sec
62	D602F at Forbes/Dorsey	312% / 521%	0.18333 sec / 0.18333 sec	302% / 502%	45% / 75%	38% / 61%
63	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 710%	999% / 592%	999% / 229%	999% / 257%
64	R50M / F3M	999% / 240%	607% / 161%	765% / 259%	313% / 241%	149% / 268%
65	B10T	347%	255%	262%	121%	56%
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 | 2) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 2 | 2)
69	Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 5 | 2) / (0 | 1 | 1)	(1 | 5 | 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 | 2 | 1) / (1 | 3 | 1)	(0 | 2 | 1) / (1 | 4 | 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 | 5 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-h23	m3a-so15aa-h33	m3a-so15aa-h43	m3a-so15aa-hc9	m3a-so15aa-hd9
Disturbance	h23	h33	h43	hc9	hd9
System Response	OK	OK	OK	OK	OK
70% or 120% Violations	M	M			A9H1HPC
ORWG Criteria Violations					3
Line Tripping		(5T)(6T)		2(1T)5	2(1T)5

Table C-4: TSR Study Case with Upgrade Option 3

1	**Case No.**	31	32	33
2	**Case Name**	m3a-so15aa-hfs	m3a-so15aa-his	m3a-so15aa-hna
3	**Disturbance**	hfs	his	hna
4	**Prior Outage**	None	None	None
5	**Date/Time**	JUN 15 2009 9:21	MAY 28 2009 14:46	JUN 15 2009 10:16
6	**Comments**			
7				
8	**Steady State Flows**			
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	839 / 35	842 / 35	839 / 35
12	MWEX / AHD-SLK	1724 / 647	1722 / 643	1724 / 647
13	D602F / F601C	1583 / 1216	1582 / 1218	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1103	3245 / 1104	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-28 / 600	-21 / 600	-28 / 600
21	RCDC	0	0	0
22	**Steady State Vltgs**			
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.042 / 1.035	1.043 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.972	1.031 / 0.974	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.043	1.021 / 1.044	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**			
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 323%	999% / 324%	999% / 323%
32	B10T	354%	354%	354%
33	**Min/MaxTransientVltg**			
34	Arrowhd 230	0.92 | 1.03	0.85 | 0.99	0.84 | 1.04
35	Boise 115	0.95 | 1.04	1.01 | 1.05	0.94 | 1.08
36	Dorsey 230	1.02 | 1.08	1.03 | 1.12	0.99 | 1.07
37	Forbes 230	0.92 | 1.03	1.01 | 1.05	0.87 | 1.03
38	Riverton 230	0.97 | 1.04	1.01 | 1.05	0.96 | 1.05
39	Coal Creek 230	0.98 | 1.07	1.01 | 1.05	0.97 | 1.07
40	Jamestown 345	0.93 | 1.00	0.98 | 1.01	0.92 | 0.99
41	Drayton 230	1.00 | 1.06	1.02 | 1.08	0.95 | 1.05
42	Groton 345	0.98 | 1.03	1.00 | 1.03	0.96 | 1.03
43	Minong 161	0.96 | 1.08	(0.73)0.81 | 1.00	0.89 | 1.08
44	Wahpeton 115	1.00 | 1.05	1.04 | 1.06	0.99 | 1.06
45	Watertown 345	1.00 | 1.03	1.01 | 1.04	0.99 | 1.04
46	**Dynamic Voltage Warnings**			
47		none	61631 [MINONG 5] 0.81	none
48			63061 [MIDCOMP-] 1.21	
49				
50				
51				
52				
53				
54	Worst Case Angle Damping	KING 3 / 31.63%	ANTEL3 / 61.16%	KING 3 / 52.36%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	143%	226%	-123%
57	K22W (max +dP @ t, d-ang)	50.5@(0.13333,-0.7)	13.6@(3.44997,1.5)	195.0@(1.15000,12.1)
58	K22W (max -dP @ t, d-ang)	103.2@(0.45000,16.1)	67.5@(1.64166,27.8)	125.5@(1.15000,32.7)
59	K22W (max d-ang @ t, dP)	-26.2@(10.00821,-1.2)	30.2@(1.18333,-63.5)	-59.4@(10.00821,195.0)
60	**OS Rel Trip / Marg**			
61	MH - OH			1.15000 sec
62	D602F at Forbes/Dorsey	11% / 7%	252% / 421%	11% / 7%
63	G82R at Rugby/L20D at Drayton	999% / 223%	999% / 600%	999% / 208%
64	R50M / F3M	303% / 196%	754% / 302%	264% / 196%
65	B10T	118%	180%	81%
66	**FSCAPS (SS/Unav/Final)**			
67	Balta 230	(0 | 1 | 1)	(0 | 0 | 0)	(0 | 1 | 1)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 3 | 3)
69	Prairie 115 / Ramsey 230	(1 | 5 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 1 | 1)	(1 | 5 | 2) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 1) / (1 | 3 | 2)	(0 | 0 | 0) / (1 | 1 | 1)	(0 | 2 | 1) / (1 | 4 | 1)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A

Case	m3a-so15aa-hfs	m3a-so15aa-his	m3a-so15aa-hna
Disturbance	hfs	his	hna
System Response	OK	OK	OK
70% or 120% Violations		MM	
ORWG Criteria Violations		7	
Line Tripping	56		2(1T)56

Table C-5: Mitigation of Constraints for TSR Study Case with Upgrade Option 1

1	**Case No.**	1	2	3	4	5
2	**Case Name**	m1a-so15aa-h79	m1a-so15aa-h73	m1a-so15aa-h7z	m1a-so15aa-h7z	m1a-so15aa-h7d
3	**Disturbance**	h79	h73	h7z	h7z	h7d
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 12 2009 14:53	JUN 11 2009 10:54	JUN 11 2009 11:39	JUN 11 2009 12:33	JUN 11 2009 11:17
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR			
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1247	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-55 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.91 | 1.01	0.90 | 1.02	0.95 | 1.01	0.97 | 1.01	1.01 | 1.05
35	Boise 115	0.96 | 1.07	0.96 | 1.02	0.96 | 1.01	0.96 | 1.01	1.00 | 1.02
36	Dorsey 230	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04	1.04 | 1.07
37	Forbes 230	0.93 | 1.01	0.91 | 1.01	0.99 | 1.02	1.00 | 1.03	1.02 | 1.05
38	Riverton 230	0.99 | 1.03	0.98 | 1.04	1.01 | 1.03	1.01 | 1.03	1.03 | 1.05
39	Coal Creek 230	1.00 | 1.05	1.00 | 1.05	1.01 | 1.05	1.01 | 1.05	1.01 | 1.06
40	Jamestown 345	0.92 | 0.97	0.92 | 0.97	0.92 | 0.97	0.93 | 0.97	0.93 | 1.00
41	Drayton 230	0.93 | 1.00	0.92 | 1.02	0.94 | 1.00	0.94 | 0.98	1.02 | 1.05
42	Groton 345	0.99 | 1.03	0.99 | 1.03	1.00 | 1.03	1.00 | 1.03	1.00 | 1.05
43	Minong 161	0.95 | 1.05	0.94 | 1.05	0.98 | 1.04	0.99 | 1.04	1.03 | 1.08
44	Wahpeton 115	1.01 | 1.04	1.01 | 1.05	1.02 | 1.04	1.02 | 1.04	1.03 | 1.06
45	Watertown 345	1.01 | 1.04	1.01 | 1.04	1.02 | 1.04	1.02 | 1.04	1.02 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	MNTCE3 / 59.36%	MNTCE3 / 12.60%	MNTCE3 / 59.27%	SHERC3 / 67.90%	KING 3 / 34.35%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	39%	-66%	507%	507%	507%
57	K22W (max +dP @ t, d-ang)	196.0@(1.63333,6.4)	102.8@(0.15000,-2.0)	102.9@(0.15000,-2.0)	102.9@(0.15000,-2.0)	102.8@(0.15000,-2.0)
58	K22W (max -dP @ t, d-ang)	102.7@(1.63333,25.7)	117.0@(2.89165,36.2)	93.3@(2.88332,23.5)	88.7@(2.89998,20.3)	11.5@(0.25000,0.9)
59	K22W (max d-ang @ t, dP)	-35.6@(2.24166,196.0)	37.2@(2.53332,-108.1)	25.1@(2.40832,-81.9)	22.1@(2.36666,-75.7)	-66.4@(10.00821,55.9)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.63333 sec				
62	D602F at Forbes/Dorsey	52% / 85%	48% / 78%	79% / 129%	81% / 133%	262% / 441%
63	G82R at Rugby/L20D at Drayton	999% / 194%	999% / 180%	999% / 221%	999% / 227%	999% / 640%
64	R50M / F3M	201% / 213%	381% / 213%	478% / 206%	480% / 205%	999% / 212%
65	B10T	66%	60%	78%	80%	164%
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 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 4) / (0 | 1 | 1)	(1 | 5 | 4) / (0 | 1 | 1)	(1 | 3 | 3) / (0 | 1 | 1)	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 2) / (1 | 3 | 2)	(0 | 2 | 1) / (1 | 3 | 3)	(0 | 2 | 2) / (1 | 2 | 2)	(0 | 2 | 2) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(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 | 1 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-h79	m1a-so15aa-h73	m1a-so15aa-h7z	m1a-so15aa-h7z	m1a-so15aa-h7d
Disturbance	h79	h73	h7z	h7z	h7d
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(1T)	25			

Table C-5: Mitigation of Constraints for TSR Study Case with Upgrade Option 1

1	**Case No.**	6	7
2	**Case Name**	m1a-so15aa-hec	m1a-so15aa-he0
3	**Disturbance**	hec	he0
4	**Prior Outage**	None	None
5	**Date/Time**	JUN 11 2009 11:07	JUN 11 2009 11:33
6	**Comments**		Trigger DC Reduction
7			
8	**Steady State Flows**		
9	NDEX / EAST BIAS	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27
12	MWEX / AHD-SLK	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151
17	G82R	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 29	717 / 29
20	Forbes SVC / MSC	-45 / 600	-45 / 600
21	RCDC	0	0
22	**Steady State Vltgs**		
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**		
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%
31	R50M/F3M	999% / 322%	999% / 322%
32	B10T	347%	347%
33	**Min/MaxTransientVltg**		
34	Arrowhd 230	0.97 | 1.04	1.01 | 1.05
35	Boise 115	0.97 | 1.03	1.00 | 1.04
36	Dorsey 230	1.02 | 1.10	1.03 | 1.17
37	Forbes 230	0.97 | 1.03	1.03 | 1.06
38	Riverton 230	1.00 | 1.04	1.04 | 1.05
39	Coal Creek 230	1.00 | 1.07	1.03 | 1.06
40	Jamestown 345	0.92 | 0.99	0.95 | 1.00
41	Drayton 230	1.00 | 1.05	1.04 | 1.11
42	Groton 345	1.00 | 1.04	1.01 | 1.05
43	Minong 161	1.01 | 1.07	1.03 | 1.08
44	Wahpeton 115	1.02 | 1.06	1.04 | 1.06
45	Watertown 345	1.02 | 1.04	1.03 | 1.05
46	**Dynamic Voltage Warnings**		
47		none	none
48			
49			
50			
51			
52			
53			
54	Worst Case Angle Damping	KING 3 / 11.51%	KING 3 / 31.51%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	170%	445%
57	K22W (max +dP @ t, d-ang)	47.2@(0.13333,-0.6)	101.1@(1.53333,-34.6)
58	K22W (max -dP @ t, d-ang)	105.4@(0.44166,15.1)	66.3@(0.40000,7.6)
59	K22W (max d-ang @ t, dP)	-28.7@(10.00821,-1.0)	-65.1@(10.00821,54.9)
60	**OS Rel Trip / Marg**		
61	MH - OH		
62	D602F at Forbes/Dorsey	21% / 22%	76% / 113%
63	G82R at Rugby/L20D at Drayton	999% / 219%	999% / 360%
64	R50M / F3M	333% / 197%	544% / 200%
65	B10T	75%	131%
66	**FSCAPS (SS/Unav/Final)**		
67	Balta 230	(0 | 1 | 1)	(0 | 1 | 1)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 3) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 1) / (1 | 2 | 2)	(0 | 1 | 0) / (1 | 2 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A

Case	m1a-so15aa-hec	m1a-so15aa-he0
Disturbance	hec	he0
System Response	OK	OK
70% or 120% Violations		
ORWG Criteria Violations		
Line Tripping	56	

Table C-5: Mitigation of Constraints for TSR Study Case with Upgrade Option 1

1	**Case No.**	8	9	11	12	10
2	**Case Name**	m1a-so15aa-hlc	m1a-so15aa-hls	m1a-so15aa-hlz	m1a-so15aa-hlz	m1a-so15aa-hl0
3	**Disturbance**	hlc	hls	hlz	hlz	hl0
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 12 2009 16:13	JUN 11 2009 11:01	JUN 11 2009 11:45	JUN 11 2009 12:39	JUN 11 2009 11:24
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7				Block MH-OH		
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1247	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-55 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.90 | 1.00	0.90 | 1.01	0.95 | 1.01	0.97 | 1.00	1.01 | 1.05
35	Boise 115	0.95 | 1.08	0.95 | 1.03	0.95 | 1.02	0.96 | 1.01	1.00 | 1.04
36	Dorsey 230	0.98 | 1.06	0.98 | 1.06	0.98 | 1.07	0.99 | 1.08	1.03 | 1.17
37	Forbes 230	0.91 | 1.00	0.92 | 1.01	0.99 | 1.02	1.00 | 1.04	1.03 | 1.06
38	Riverton 230	0.99 | 1.03	0.99 | 1.04	1.01 | 1.03	1.02 | 1.03	1.04 | 1.05
39	Coal Creek 230	1.00 | 1.05	1.00 | 1.05	1.01 | 1.05	1.02 | 1.05	1.03 | 1.06
40	Jamestown 345	0.92 | 0.97	0.92 | 0.97	0.93 | 0.97	0.94 | 0.98	0.95 | 1.00
41	Drayton 230	0.93 | 1.00	0.94 | 1.01	0.95 | 1.01	0.96 | 1.01	1.04 | 1.11
42	Groton 345	0.99 | 1.02	0.99 | 1.02	1.00 | 1.02	1.00 | 1.03	1.01 | 1.05
43	Minong 161	0.95 | 1.04	0.95 | 1.04	0.98 | 1.04	1.00 | 1.03	1.03 | 1.08
44	Wahpeton 115	1.01 | 1.04	1.01 | 1.05	1.02 | 1.05	1.03 | 1.05	1.04 | 1.06
45	Watertown 345	1.01 | 1.03	1.01 | 1.03	1.02 | 1.03	1.02 | 1.03	1.03 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	SHERC3 / 60.24%	MNTCE3 / 21.99%	SHERC3 / 74.04%	SHERC3 / 73.98%	KING 3 / 31.58%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	55%	84%	507%	507%	445%
57	K22W (max +dP @ t, d-ang)	196.0@(1.21666,3.8)	47.2@(0.13333,-0.6)	47.2@(0.13333,-0.6)	47.2@(0.13333,-0.6)	102.0@(1.53333,-34.8)
58	K22W (max -dP @ t, d-ang)	116.5@(1.21666,23.9)	120.1@(1.29166,24.0)	102.3@(1.27500,16.0)	99.5@(0.44166,13.7)	66.6@(0.40000,7.6)
59	K22W (max d-ang @ t, dP)	-38.7@(1.79166,196.0)	33.2@(2.05833,-97.6)	21.1@(1.88333,-75.5)	19.0@(0.70833,-37.1)	-65.2@(10.00821,55.2)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.21666 sec				
62	D602F at Forbes/Dorsey	21% / 23%	21% / 22%	15% / 13%	12% / 7%	76% / 113%
63	G82R at Rugby/L20D at Drayton	999% / 175%	999% / 186%	999% / 213%	999% / 222%	999% / 360%
64	R50M / F3M	180% / 204%	333% / 202%	339% / 198%	343% / 197%	544% / 200%
65	B10T	47%	45%	52%	55%	132%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)
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 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 |11 | 5) / (0 | 1 | 1)	(1 |11 | 5) / (0 | 1 | 1)	(1 | 5 | 5) / (0 | 1 | 1)	(1 | 5 | 5) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 2 | 2) / (1 | 4 | 2)	(0 | 1 | 1) / (1 | 4 | 3)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 2 | 2)	(0 | 1 | 0) / (1 | 2 | 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)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-hlc	m1a-so15aa-hls	m1a-so15aa-hlz	m1a-so15aa-hlz	m1a-so15aa-hl0
Disturbance	hlc	hls	hlz	hlz	hl0
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	(1T)56	56	56	56	

Table C-5: Mitigation of Constraints for TSR Study Case with Upgrade Option 1

1	**Case No.**	13	14	16	17	15
2	**Case Name**	m1a-so15aa-hoc	m1a-so15aa-hoa	m1a-so15aa-hoz	m1a-so15aa-hoz	m1a-so15aa-ho0
3	**Disturbance**	hoc	hoa	hoz	hoz	ho0
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 12 2009 15:02	JUN 11 2009 11:11	JUN 11 2009 11:48	JUN 11 2009 12:42	JUN 11 2009 11:27
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR	Block MH-OH		
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1247	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-55 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.86 | 1.03	0.82 | 1.01	0.91 | 1.00	0.95 | 1.00	0.99 | 1.04
35	Boise 115	0.96 | 1.08	0.95 | 1.04	0.96 | 1.04	0.97 | 1.04	1.00 | 1.05
36	Dorsey 230	1.01 | 1.14	1.00 | 1.14	1.01 | 1.14	1.01 | 1.14	1.04 | 1.18
37	Forbes 230	0.89 | 1.04	0.82 | 1.04	0.95 | 1.06	0.99 | 1.07	1.02 | 1.06
38	Riverton 230	0.97 | 1.04	0.95 | 1.03	0.98 | 1.03	0.99 | 1.04	1.01 | 1.04
39	Coal Creek 230	0.99 | 1.06	0.99 | 1.06	1.00 | 1.04	1.01 | 1.04	1.02 | 1.05
40	Jamestown 345	0.94 | 0.98	0.92 | 0.98	0.94 | 0.98	0.95 | 0.98	0.95 | 0.98
41	Drayton 230	0.94 | 1.08	0.91 | 1.08	0.95 | 1.08	0.96 | 1.08	1.02 | 1.10
42	Groton 345	0.96 | 1.02	0.95 | 1.01	0.97 | 1.01	0.98 | 1.01	1.00 | 1.03
43	Minong 161	0.92 | 1.08	0.87 | 1.04	0.95 | 1.03	0.98 | 1.02	1.01 | 1.08
44	Wahpeton 115	1.00 | 1.05	0.98 | 1.04	1.01 | 1.05	1.02 | 1.05	1.02 | 1.05
45	Watertown 345	0.99 | 1.03	0.98 | 1.02	1.00 | 1.02	1.00 | 1.02	1.02 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	61564 [FORB4JCT] 0.80	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 53.41%	ANTEL3 / -23.74%	SHERC3 / 29.59%	SHERC3 / 52.00%	KING 3 / 39.12%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-33%	-432%	427%	507%	507%
57	K22W (max +dP @ t, d-ang)	196.0@(1.46666,14.9)	10.3@(0.11667,0.2)	10.3@(0.11667,0.2)	10.3@(0.11667,0.2)	85.7@(2.17499,-34.1)
58	K22W (max -dP @ t, d-ang)	115.3@(1.46666,35.0)	142.3@(2.94165,49.8)	105.2@(1.65000,28.7)	95.8@(1.63333,24.8)	54.3@(0.40833,6.3)
59	K22W (max d-ang @ t, dP)	-53.9@(9.24989,196.0)	52.8@(9.09989,-134.7)	34.6@(2.26666,-94.4)	28.5@(2.18333,-81.5)	-59.5@(10.00821,48.4)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.46666 sec				
62	D602F at Forbes/Dorsey	52% / 87%	0% / -3%	61% / 99%	76% / 124%	220% / 374%
63	G82R at Rugby/L20D at Drayton	999% / 242%	999% / 158%	999% / 275%	999% / 290%	999% / 646%
64	R50M / F3M	313% / 237%	269% / 237%	411% / 229%	459% / 227%	810% / 216%
65	B10T	78%	45%	84%	87%	199%
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 | 4) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 4 | 3) / (0 | 1 | 1)	(1 | 8 | 6) / (0 | 1 | 1)	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 3 | 2) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 3 | 1)	(0 | 2 | 2) / (1 | 6 | 4)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 2 | 2)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (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)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-hoc	m1a-so15aa-hoa	m1a-so15aa-hoz	m1a-so15aa-hoz	m1a-so15aa-ho0
Disturbance	hoc	hoa	hoz	hoz	ho0
System Response	OK	OK	OK	OK	OK
70% or 120% Violations		F			
ORWG Criteria Violations					
Line Tripping	2(1T)	2(5T)6			

Table C-5: Mitigation of Constraints for TSR Study Case with Upgrade Option 1

1	**Case No.**	18	19	20	21	22
2	**Case Name**	m1a-so15aa-hm9	m1a-so15aa-hm3	m1a-so15aa-hmz	m1a-so15aa-hmz	m1a-so15aa-hmd
3	**Disturbance**	hm9	hm3	hmz	hmz	hmd
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 12 2009 14:56	JUN 11 2009 10:57	JUN 11 2009 11:42	JUN 11 2009 12:36	JUN 11 2009 11:21
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR	Block MH-OH		
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2287 / 186	2287 / 186	2287 / 186	2287 / 186	2287 / 186
10	MHEX / L20D	1849 / 236	1849 / 236	1849 / 236	1849 / 236	1849 / 236
11	ECL-ARP / PRI-BYN	810 / 27	810 / 27	810 / 27	810 / 27	810 / 27
12	MWEX / AHD-SLK	1645 / 647	1641 / 642	1641 / 642	1641 / 642	1641 / 642
13	D602F / F601C	1545 / 1247	1545 / 1249	1545 / 1249	1545 / 1249	1545 / 1249
14	B10T / MH>SPC	163 / 59	163 / 59	163 / 59	163 / 59	163 / 59
15	OH E-W / OH>MH	190 / -195	190 / -195	190 / -195	190 / -195	190 / -195
16	R50M / OH>MP	128 / 151	128 / 151	128 / 151	128 / 151	128 / 151
17	G82R	-61	-61	-61	-61	-61
18	Dorsey bipole / CU bipole	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104	3245 / 1104
19	Dorsey Reserve / Wtrtn SVC	717 / 28	717 / 29	717 / 29	717 / 29	717 / 29
20	Forbes SVC / MSC	-55 / 600	-45 / 600	-45 / 600	-45 / 600	-45 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045	1.043 / 1.045
24	Roseau 500/Forbes 500	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035	1.050 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991	1.031 / 0.991
26	Int Falls 115/Badoura 115	1.022 / 1.046	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045	1.022 / 1.045
27	Drayton 230/Groton 345	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024	1.041 / 1.024
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	325% / 543%	325% / 543%	325% / 543%	325% / 543%	325% / 543%
30	G82R at Rugby/L20D at Drayton	999% / 912%	999% / 912%	999% / 912%	999% / 912%	999% / 912%
31	R50M/F3M	999% / 321%	999% / 322%	999% / 322%	999% / 322%	999% / 322%
32	B10T	347%	347%	347%	347%	347%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.91 | 1.05	0.88 | 1.02	0.94 | 1.01	0.95 | 1.01	0.98 | 1.05
35	Boise 115	0.96 | 1.09	0.96 | 1.03	0.96 | 1.02	0.97 | 1.02	0.99 | 1.02
36	Dorsey 230	1.01 | 1.06	1.01 | 1.04	1.01 | 1.04	1.01 | 1.04	1.04 | 1.07
37	Forbes 230	0.90 | 1.03	0.89 | 1.01	0.96 | 1.02	1.00 | 1.03	1.02 | 1.05
38	Riverton 230	0.98 | 1.05	0.98 | 1.04	0.99 | 1.03	1.00 | 1.03	1.01 | 1.06
39	Coal Creek 230	0.98 | 1.07	0.98 | 1.07	0.98 | 1.07	0.98 | 1.07	0.99 | 1.08
40	Jamestown 345	0.89 | 0.99	0.89 | 0.98	0.90 | 0.98	0.90 | 0.98	0.91 | 1.01
41	Drayton 230	0.91 | 1.04	0.91 | 1.02	0.93 | 1.01	0.93 | 0.99	1.01 | 1.07
42	Groton 345	0.98 | 1.04	0.97 | 1.03	0.98 | 1.03	0.99 | 1.03	0.99 | 1.05
43	Minong 161	0.94 | 1.09	0.93 | 1.05	0.97 | 1.04	0.97 | 1.04	1.00 | 1.08
44	Wahpeton 115	1.00 | 1.06	1.00 | 1.05	1.01 | 1.05	1.01 | 1.05	1.02 | 1.07
45	Watertown 345	1.01 | 1.04	1.00 | 1.04	1.01 | 1.03	1.01 | 1.03	1.02 | 1.05
46	**Dynamic Voltage Warnings**					
47		none	none	none	none	none
48						
49						
50						
51						
52						
53						
54	Worst Case Angle Damping	KING 3 / 38.95%	MNTCE3 / 35.38%	SHERC3 / 62.81%	KING 3 / 68.13%	KING 3 / 39.96%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-37%	-111%	507%	507%	507%
57	K22W (max +dP @ t, d-ang)	196.0@(1.20000,12.9)	29.5@(0.11667,0.7)	29.5@(0.11667,0.7)	29.5@(0.11667,0.7)	105.1@(2.06666,-39.8)
58	K22W (max -dP @ t, d-ang)	113.8@(1.16666,33.4)	121.4@(1.35833,34.1)	102.9@(1.30000,25.7)	95.0@(1.28333,22.3)	67.5@(0.27500,7.6)
59	K22W (max d-ang @ t, dP)	-59.3@(10.00821,196.0)	37.1@(1.86666,-111.7)	28.5@(0.84166,-46.7)	26.9@(0.80833,-41.8)	-64.8@(10.00821,55.6)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.20000 sec				
62	D602F at Forbes/Dorsey	44% / 72%	37% / 60%	58% / 94%	65% / 106%	200% / 341%
63	G82R at Rugby/L20D at Drayton	999% / 170%	999% / 159%	999% / 196%	999% / 214%	999% / 489%
64	R50M / F3M	331% / 238%	345% / 236%	384% / 226%	404% / 225%	732% / 210%
65	B10T	35%	35%	41%	44%	115%
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 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 3) / (0 | 2 | 2)	(1 | 5 | 4) / (0 | 2 | 2)	(1 | 4 | 4) / (0 | 2 | 2)	(1 | 3 | 3) / (0 | 2 | 2)	(1 | 2 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 1 | 1) / (1 | 4 | 1)	(0 | 2 | 1) / (1 | 4 | 3)	(0 | 2 | 2) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 2) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)	(1 | 2 | 0) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m1a-so15aa-hm9	m1a-so15aa-hm3	m1a-so15aa-hmz	m1a-so15aa-hmz	m1a-so15aa-hmd
Disturbance	hm9	hm3	hmz	hmz	hmd
System Response	OK	OK	OK	OK	OK
70% or 120% Violations					
ORWG Criteria Violations					
Line Tripping	2(1T)5	25			

Table C-6: Mitigation of Constraints for TSR Study Case with Upgrade Option 3

1	**Case No.**	1	2	3	4	5
2	**Case Name**	m3a-so15aa-hc9	m3a-so15aa-hc3	m3a-so15aa-hcz	m3a-so15aa-hcz	m3a-so15aa-hcd
3	**Disturbance**	hc9	hc3	hcz	hcz	hcd
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 15 2009 9:15	JUN 15 2009 10:59	JUN 15 2009 11:31	JUN 15 2009 12:52	JUN 15 2009 11:11
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR	Block MH-OH	Block MH-OH	
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	839 / 35	839 / 35	839 / 35	839 / 35	839 / 35
12	MWEX / AHD-SLK	1724 / 647	1724 / 647	1724 / 647	1724 / 647	1724 / 647
13	D602F / F601C	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-28 / 600	-28 / 600	-28 / 600	-28 / 600	-28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 323%	999% / 323%	999% / 323%	999% / 323%	999% / 323%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.83 | 1.04	(4.02)0.71 | 1.15	0.88 | 1.02	0.92 | 1.01	1.00 | 1.04
35	Boise 115	0.96 | 1.08	(5.69)0.25 | 0.98	0.97 | 1.03	0.97 | 1.03	1.00 | 1.02
36	Dorsey 230	1.00 | 1.07	(5.41)0.29 | 1.15	1.00 | 1.04	0.99 | 1.04	1.03 | 1.06
37	Forbes 230	0.87 | 1.03	(4.04)0.50 | 1.13	0.90 | 1.02	0.96 | 1.03	1.01 | 1.04
38	Riverton 230	0.95 | 1.04	0.77 | 1.18(5.72)	0.97 | 1.03	0.99 | 1.03	1.00 | 1.04
39	Coal Creek 230	1.00 | 1.07	0.83 | 1.22(5.72)	1.00 | 1.06	1.00 | 1.05	1.01 | 1.06
40	Jamestown 345	0.93 | 0.99	(4.55)0.30 | 1.22(5.72)	0.93 | 0.98	0.94 | 0.98	0.94 | 0.99
41	Drayton 230	0.93 | 1.05	(4.11)0.23 | 1.32(5.74)	0.93 | 1.03	0.94 | 1.01	1.01 | 1.05
42	Groton 345	0.96 | 1.03	(4.65)0.60 | 1.21(5.72)	0.96 | 1.01	0.97 | 1.01	0.99 | 1.03
43	Minong 161	0.89 | 1.08	(2.92)0.81 | 1.17	0.92 | 1.06	0.96 | 1.05	1.03 | 1.07
44	Wahpeton 115	0.99 | 1.05	(4.65)0.64 | 1.25(5.72)	1.00 | 1.05	1.01 | 1.04	1.01 | 1.05
45	Watertown 345	0.98 | 1.04	0.79 | 1.17	0.99 | 1.03	1.00 | 1.02	1.01 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	61615 [ARROWHD4] 0.80	none	none	none
48			61616 [HILLTOP4] 0.81			
49			61614 [98L TAP4] 0.81			
50			61686 [15TH AV7] 0.81			
51			61672 [HILLTOP7] 0.81			
52			61673 [ARROWHD7] 0.81			
53			687 [MIDWAY 7] 0.81 +mc			
54	Worst Case Angle Damping	KING 3 / 59.95%	STANT4 / -162.82%	MNTCE3 / 18.76%	SHERC3 / 36.95%	KING 3 / 28.81%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-71%	-1969%	91%	507%	507%
57	K22W (max +dP @ t, d-ang)	195.0@(1.47500,14.2)	492.4@(7.51658,3508.8)	102.7@(0.15000,-2.1)	102.7@(0.15000,-2.1)	102.7@(0.15000,-2.1)
58	K22W (max -dP @ t, d-ang)	115.5@(1.47500,34.1)	165.9@(2.91665,66.2)	129.7@(2.91665,41.7)	110.7@(2.89165,32.4)	7.1@(0.25000,0.7)
59	K22W (max d-ang @ t, dP)	-56.6@(9.29989,195.0)	4649.2@(9.68321,112.9)	42.5@(2.59165,-118.6)	34.6@(2.47499,-99.6)	-58.2@(10.00821,47.9)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.47500 sec				
62	D602F at Forbes/Dorsey	45% / 75%	-254% / -395%	31% / 50%	54% / 88%	233% / 392%
63	G82R at Rugby/L20D at Drayton	999% / 229%	-124% / -431%	999% / 212%	999% / 256%	999% / 746%
64	R50M / F3M	313% / 241%	-758% / -190%	346% / 230%	392% / 226%	950% / 217%
65	B10T	121%	4.08330 sec	83%	105%	264%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 3 | 1)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 3) / (0 | 0 | 0)	(4 | 4 | 0) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 2) / (0 | 1 | 1)	(1 | 0 | 0) / (0 | 2 | 0)	(1 | 5 | 4) / (0 | 1 | 1)	(1 | 4 | 3) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 3 | 1)	(0 | 2 | 2) / (1 | 6 | 6)	(0 | 2 | 1) / (1 | 4 | 3)	(0 | 2 | 2) / (1 | 3 | 3)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 5 | 0) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-hc9	m3a-so15aa-hc3	m3a-so15aa-hcz	m3a-so15aa-hcz	m3a-so15aa-hcd
Disturbance	hc9	hc3	hcz	hcz	hcd
System Response	OK	OK	OK	OK	OK
70% or 120% Violations		AH91HAM			
ORWG Criteria Violations		1235678BC			
Line Tripping	2(1T)5	234567(8T)9	5		

Table C-6: Mitigation of Constraints for TSR Study Case with Upgrade Option 3

1	**Case No.**	6	7	8	9	10
2	**Case Name**	m3a-so15aa-hd9	m3a-so15aa-hd3	m3a-so15aa-hdz	m3a-so15aa-hdz	m3a-so15aa-hdd
3	**Disturbance**	hd9	hd3	hdz	hdz	hdd
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 15 2009 9:18	JUN 15 2009 11:03	JUN 15 2009 11:34	JUN 15 2009 12:55	JUN 15 2009 11:14
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR	Block MH-OH	Block MH-OH	
8	**Steady State Flows**			Block DCAR		
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	839 / 35	839 / 35	839 / 35	839 / 35	839 / 35
12	MWEX / AHD-SLK	1724 / 647	1724 / 647	1724 / 647	1724 / 647	1724 / 647
13	D602F / F601C	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-28 / 600	-28 / 600	-28 / 600	-28 / 600	-28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 323%	999% / 323%	999% / 323%	999% / 323%	999% / 323%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	(0.77)0.77 | 1.07	(2.20)0.32 | 0.84	0.82 | 1.04	0.88 | 1.02	0.90 | 1.05
35	Boise 115	0.96 | 1.11	(2.20)0.66 | 0.98	0.95 | 1.04	0.96 | 1.03	0.99 | 1.02
36	Dorsey 230	1.01 | 1.06	0.93 | 1.03	1.00 | 1.05	1.01 | 1.04	1.04 | 1.07
37	Forbes 230	0.84 | 1.04	(2.20)0.25 | 0.91	0.83 | 1.03	0.90 | 1.03	0.98 | 1.04
38	Riverton 230	0.91 | 1.07	(2.20)0.58 | 0.94	0.94 | 1.05	0.95 | 1.04	0.97 | 1.04
39	Coal Creek 230	0.97 | 1.08	0.94 | 1.01	0.96 | 1.07	0.98 | 1.07	0.99 | 1.06
40	Jamestown 345	0.90 | 1.02	(2.20)0.55 | 0.93	0.91 | 1.00	0.92 | 0.99	0.93 | 0.99
41	Drayton 230	0.94 | 1.06	(2.20)0.63 | 0.97	0.89 | 1.03	0.91 | 1.03	1.01 | 1.05
42	Groton 345	0.93 | 1.06	(2.20)0.56 | 0.98	0.94 | 1.02	0.96 | 1.02	0.98 | 1.04
43	Minong 161	0.82 | 1.11	(2.20)0.53 | 0.88	0.88 | 1.08	0.92 | 1.07	0.93 | 1.09
44	Wahpeton 115	0.96 | 1.08	(2.20)0.62 | 0.99	0.98 | 1.07	0.98 | 1.06	1.00 | 1.05
45	Watertown 345	0.96 | 1.06	(2.20)0.66 | 0.99	0.98 | 1.04	0.98 | 1.03	1.00 | 1.04
46	**Dynamic Voltage Warnings**					
47		61615 [ARROWHD4] 0.80	61615 [ARROWHD4] 0.80	61564 [FORB4JCT] 0.80	none	none
48		61614 [98L TAP4] 0.80	61614 [98L TAP4] 0.80			
49		61616 [HILLTOP4] 0.80	61616 [HILLTOP4] 0.80			
50		61686 [15TH AV7] 0.80	61686 [15TH AV7] 0.80			
51		61672 [HILLTOP7] 0.81	61672 [HILLTOP7] 0.81			
52		61667 [POTLTCH7] 0.81	61667 [POTLTCH7] 0.81			
53		668 [CLOQUET7] 0.81 +m	668 [CLOQUET7] 0.81 +m			
54	Worst Case Angle Damping	SHERC3 / 69.03%	STANT4 / -162.82%	STANT4 / 54.93%	SHERC3 / 68.12%	KING 3 / 62.39%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-123%	-5806%	-325%	222%	507%
57	K22W (max +dP @ t, d-ang)	195.0@(1.22500,24.9)	10.6@(0.11667,1.9)	10.6@(0.11667,1.9)	10.6@(0.11667,1.9)	94.8@(2.12499,-34.7)
58	K22W (max -dP @ t, d-ang)	110.8@(1.22500,44.5)	172.4@(1.80833,88.6)	146.9@(1.80000,54.2)	127.9@(1.37500,43.1)	74.0@(0.27500,9.7)
59	K22W (max d-ang @ t, dP)	-60.9@(3.27498,195.0)	106.9@(2.08333,-157.7)	54.2@(1.79166,-146.9)	44.0@(1.61666,-126.5)	-55.9@(10.00821,46.9)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.22500 sec				
62	D602F at Forbes/Dorsey	38% / 61%	-116% / -203%	-4% / -11%	19% / 29%	185% / 310%
63	G82R at Rugby/L20D at Drayton	999% / 257%	157% / 34%	999% / 144%	999% / 185%	999% / 542%
64	R50M / F3M	149% / 268%	1% / 323%	260% / 222%	313% / 228%	725% / 210%
65	B10T	56%	40%	41%	47%	140%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 0 | 0)	(0 | 2 | 2)	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 2) / (0 | 2 | 2)	(4 | 4 | 4) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 2) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 2) / (0 | 1 | 1)	(1 |12 |12) / (0 | 2 | 2)	(1 | 8 | 3) / (0 | 2 | 2)	(1 | 6 | 3) / (0 | 1 | 1)	(1 | 1 | 1) / (0 | 0 | 0)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 4 | 1)	(0 | 2 | 2) / (1 | 6 | 6)	(0 | 2 | 1) / (1 | 6 | 3)	(0 | 2 | 1) / (1 | 4 | 3)	(0 | 0 | 0) / (1 | 1 | 1)
71	Shey 115 / Split Rock 115	(1 | 5 | 1) / (1 | 2 | 2)	(1 | 5 | 5) / (1 | 2 | 2)	(1 | 4 | 3) / (1 | 2 | 2)	(1 | 3 | 3) / (1 | 2 | 2)	(1 | 1 | 1) / (1 | 2 | 2)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-hd9	m3a-so15aa-hd3	m3a-so15aa-hdz	m3a-so15aa-hdz	m3a-so15aa-hdd
Disturbance	hd9	hd3	hdz	hdz	hdd
System Response	OK	OK	OK	OK	OK
70% or 120% Violations	A9H1HPC	A9H1HPC	F		
ORWG Criteria Violations	3	2345678ABC			
Line Tripping	2(1T)5	2567	256	56	

Table C-6: Mitigation of Constraints for TSR Study Case with Upgrade Option 3

1	**Case No.**	11	12
2	**Case Name**	m3a-so15aa-hfs	m3a-so15aa-hf0
3	**Disturbance**	hfs	hf0
4	**Prior Outage**	None	None
5	**Date/Time**	JUN 15 2009 9:21	JUN 15 2009 11:20
6	**Comments**		Trigger DC Reduction
7			
8	**Steady State Flows**		
9	NDEX / EAST BIAS	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	839 / 35	839 / 35
12	MWEX / AHD-SLK	1724 / 647	1724 / 647
13	D602F / F601C	1583 / 1216	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149
17	G82R	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1103	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9
20	Forbes SVC / MSC	-28 / 600	-28 / 600
21	RCDC	0	0
22	**Steady State Vltgs**		
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.042 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.972	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.043	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**		
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%
31	R50M/F3M	999% / 323%	999% / 323%
32	B10T	354%	354%
33	**Min/MaxTransientVltg**		
34	Arrowhd 230	0.92 | 1.03	0.99 | 1.04
35	Boise 115	0.95 | 1.04	1.01 | 1.03
36	Dorsey 230	1.02 | 1.08	1.03 | 1.14
37	Forbes 230	0.92 | 1.03	1.02 | 1.04
38	Riverton 230	0.97 | 1.04	1.01 | 1.04
39	Coal Creek 230	0.98 | 1.07	1.00 | 1.06
40	Jamestown 345	0.93 | 1.00	0.95 | 0.99
41	Drayton 230	1.00 | 1.06	1.04 | 1.10
42	Groton 345	0.98 | 1.03	1.00 | 1.04
43	Minong 161	0.96 | 1.08	1.01 | 1.07
44	Wahpeton 115	1.00 | 1.05	1.02 | 1.05
45	Watertown 345	1.00 | 1.03	1.01 | 1.04
46	**Dynamic Voltage Warnings**		
47		none	none
48			
49			
50			
51			
52			
53			
54	Worst Case Angle Damping	KING 3 / 31.63%	KING 3 / 23.81%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	143%	409%
57	K22W (max +dP @ t, d-ang)	50.5@(0.13333,-0.7)	82.8@(1.55833,-28.1)
58	K22W (max -dP @ t, d-ang)	103.2@(0.45000,16.1)	66.0@(0.40833,8.3)
59	K22W (max d-ang @ t, dP)	-26.2@(10.00821,-1.2)	-58.0@(10.00821,45.3)
60	**OS Rel Trip / Marg**		
61	MH - OH		
62	D602F at Forbes/Dorsey	11% / 7%	60% / 88%
63	G82R at Rugby/L20D at Drayton	999% / 223%	999% / 359%
64	R50M / F3M	303% / 196%	487% / 206%
65	B10T	118%	188%
66	**FSCAPS (SS/Unav/Final)**		
67	Balta 230	(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)
69	Prairie 115 / Ramsey 230	(1 | 5 | 2) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 1 | 1) / (1 | 3 | 2)	(0 | 1 | 0) / (1 | 2 | 2)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A

Case	m3a-so15aa-hfs	m3a-so15aa-hf0
Disturbance	hfs	hf0
System Response	OK	OK
70% or 120% Violations		
ORWG Criteria Violations		
Line Tripping	56	

Table C-6: Mitigation of Constraints for TSR Study Case with Upgrade Option 3

1	**Case No.**	13	14	15	16	17
2	**Case Name**	m3a-so15aa-hna	m3a-so15aa-hns	m3a-so15aa-hnz	m3a-so15aa-hnz	m3a-so15aa-hn0
3	**Disturbance**	hna	hns	hnz	hnz	hn0
4	**Prior Outage**	None	None	None	None	None
5	**Date/Time**	JUN 15 2009 10:16	JUN 15 2009 11:04	JUN 15 2009 11:37	JUN 15 2009 12:58	JUN 15 2009 11:17
6	**Comments**		Block MH-OH	Forbes 400 MVAr Cap	Forbes 600 MVAr Cap	Trigger DC Reduction
7			Block DCAR	Block MH-OH	Block MH-OH	
8	**Steady State Flows**					
9	NDEX / EAST BIAS	2300 / 156	2300 / 156	2300 / 156	2300 / 156	2300 / 156
10	MHEX / L20D	1949 / 268	1949 / 268	1949 / 268	1949 / 268	1949 / 268
11	ECL-ARP / PRI-BYN	839 / 35	839 / 35	839 / 35	839 / 35	839 / 35
12	MWEX / AHD-SLK	1724 / 647	1724 / 647	1724 / 647	1724 / 647	1724 / 647
13	D602F / F601C	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216	1583 / 1216
14	B10T / MH>SPC	161 / 57	161 / 57	161 / 57	161 / 57	161 / 57
15	OH E-W / OH>MH	190 / -194	190 / -194	190 / -194	190 / -194	190 / -194
16	R50M / OH>MP	134 / 149	134 / 149	134 / 149	134 / 149	134 / 149
17	G82R	-36	-36	-36	-36	-36
18	Dorsey bipole / CU bipole	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103	3245 / 1103
19	Dorsey Reserve / Wtrtn SVC	850 / 9	850 / 9	850 / 9	850 / 9	850 / 9
20	Forbes SVC / MSC	-28 / 600	-28 / 600	-28 / 600	-28 / 600	-28 / 600
21	RCDC	0	0	0	0	0
22	**Steady State Vltgs**					
23	Dorsey 500/Dorsey 230	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045	1.044 / 1.045
24	Roseau 500/Forbes 500	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035	1.042 / 1.035
25	Chisago 500/EauClaire 345	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972	1.031 / 0.972
26	Int Falls 115/Badoura 115	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043	1.021 / 1.043
27	Drayton 230/Groton 345	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022	1.034 / 1.022
28	**SS OS Relay Margins**					
29	D602F at Forbes/Dorsey	312% / 521%	312% / 521%	312% / 521%	312% / 521%	312% / 521%
30	G82R at Rugby/L20D at Drayton	999% / 764%	999% / 764%	999% / 764%	999% / 764%	999% / 764%
31	R50M/F3M	999% / 323%	999% / 323%	999% / 323%	999% / 323%	999% / 323%
32	B10T	354%	354%	354%	354%	354%
33	**Min/MaxTransientVltg**					
34	Arrowhd 230	0.84 | 1.04	(2.74)0.76 | 1.03	0.90 | 1.01	0.94 | 1.00	0.98 | 1.04
35	Boise 115	0.94 | 1.08	0.90 | 1.05	0.95 | 1.02	0.96 | 1.01	1.01 | 1.03
36	Dorsey 230	0.99 | 1.07	0.99 | 1.05	0.99 | 1.05	0.99 | 1.05	1.03 | 1.14
37	Forbes 230	0.87 | 1.03	(2.77)0.73 | 1.01	0.93 | 1.02	0.98 | 1.02	1.01 | 1.04
38	Riverton 230	0.96 | 1.05	0.92 | 1.05	0.98 | 1.03	0.99 | 1.02	1.01 | 1.04
39	Coal Creek 230	0.97 | 1.07	0.97 | 1.08	0.99 | 1.05	0.99 | 1.05	1.00 | 1.06
40	Jamestown 345	0.92 | 0.99	0.89 | 0.99	0.94 | 0.99	0.94 | 0.99	0.95 | 0.99
41	Drayton 230	0.95 | 1.05	0.86 | 1.03	0.96 | 1.02	0.97 | 1.02	1.04 | 1.10
42	Groton 345	0.96 | 1.03	0.92 | 1.02	0.97 | 1.01	0.98 | 1.01	1.00 | 1.04
43	Minong 161	0.89 | 1.08	0.84 | 1.08	0.94 | 1.05	0.98 | 1.04	1.01 | 1.07
44	Wahpeton 115	0.99 | 1.06	0.96 | 1.06	1.00 | 1.04	1.01 | 1.04	1.02 | 1.05
45	Watertown 345	0.99 | 1.04	0.97 | 1.03	1.00 | 1.02	1.01 | 1.02	1.01 | 1.04
46	**Dynamic Voltage Warnings**					
47		none	61615 [ARROWHD4] 0.80	none	none	none
48			61616 [HILLTOP4] 0.80			
49			61614 [98L TAP4] 0.81			
50			61686 [15TH AV7] 0.81			
51			61672 [HILLTOP7] 0.81			
52			61673 [ARROWHD7] 0.81			
53			687 [MIDWAY 7] 0.81 +mo			
54	Worst Case Angle Damping	KING 3 / 52.36%	ANTEL3 / -19.50%	SHERC3 / 32.51%	SHERC3 / 54.40%	KING 3 / 23.87%
55	Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133	/ 0.133	/ 0.133
56	Forbes DC Red (DCAR)	-123%	-1062%	351%	507%	409%
57	K22W (max +dP @ t, d-ang)	195.0@(1.15000,12.1)	50.5@(0.13333,-0.7)	50.5@(0.13333,-0.7)	50.5@(0.13333,-0.7)	83.6@(1.55833,-28.3)
58	K22W (max -dP @ t, d-ang)	125.5@(1.15000,32.7)	160.6@(2.79165,58.5)	117.2@(1.27500,25.9)	108.1@(1.25833,21.1)	66.3@(0.40833,8.3)
59	K22W (max d-ang @ t, dP)	-59.4@(10.00821,195.0)	59.4@(8.89989,-142.4)	35.7@(2.05833,-101.9)	27.8@(1.89166,-90.2)	-58.2@(10.00821,45.7)
60	**OS Rel Trip / Marg**					
61	MH - OH	1.15000 sec				
62	D602F at Forbes/Dorsey	11% / 7%	-36% / -66%	5% / -3%	3% / -8%	60% / 88%
63	G82R at Rugby/L20D at Drayton	999% / 208%	160% / 88%	999% / 228%	999% / 231%	999% / 359%
64	R50M / F3M	264% / 196%	164% / 196%	307% / 196%	309% / 195%	487% / 206%
65	B10T	81%	28%	84%	88%	189%
66	**FSCAPS (SS/Unav/Final)**					
67	Balta 230	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)	(0 | 1 | 1)
68	Eau Cl 345 / Park Lk 115	(4 | 4 | 2) / (0 | 3 | 3)	(4 | 4 | 3) / (0 | 3 | 3)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 4) / (0 | 0 | 0)	(4 | 4 | 3) / (0 | 0 | 0)
69	Prairie 115 / Ramsey 230	(1 | 5 | 2) / (0 | 1 | 1)	(1 |12 | 6) / (0 | 2 | 2)	(1 | 5 | 4) / (0 | 1 | 1)	(1 | 5 | 4) / (0 | 1 | 1)	(1 | 5 | 1) / (0 | 1 | 1)
70	Roseau 230 / Running 230	(0 | 2 | 1) / (1 | 4 | 1)	(0 | 2 | 1) / (1 | 6 | 3)	(0 | 2 | 2) / (1 | 3 | 3)	(0 | 1 | 1) / (1 | 3 | 3)	(0 | 1 | 0) / (1 | 2 | 2)
71	Shey 115 / Split Rock 115	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 5 | 4) / (1 | 1 | 1)	(1 | 2 | 2) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)	(1 | 1 | 1) / (1 | 1 | 1)
72	**Damping Performance**	N/A	N/A	N/A	N/A	N/A

Case	m3a-so15aa-hna	m3a-so15aa-hns	m3a-so15aa-hnz	m3a-so15aa-hnz	m3a-so15aa-hn0
Disturbance	hna	hns	hnz	hnz	hn0
System Response	OK	OK	OK	OK	OK
70% or 120% Violations		AH91HAM			
ORWG Criteria Violations		23			
Line Tripping	2(1T)56	256	56	56	