Report R164-08

MHEB Group TSR System Impact Study Out-Year Analysis; US to MH Requests

Prepared for

Midwest ISO

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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 steady-state power flow analysis performed to evaluate the requests for transmission service shown in Table E-1. These requests seek to reserve 1100 MW of transmission service from various sources in the US to Manitoba Hydro. The out-year analysis was performed for a 2019 winter peak scenario.

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
76537582	Network	Jun-2009	Jun-2027	WPS	MHEB	500	06/13/07	A380
76544699	Network	Jun-2009	Jun-2037	MP	MHEB	250	07/06/07	A383
76637089	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637091	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637257	P-to-P	Jun-2009	Jun-2027	WEC	MHEB	50	04/17/08	A414
76637259	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
76637260	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
					Total (MW)	1100		

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) and Xcel Energy (XEL).

Transmission Upgrade Options and Impacts

The objective of this study is to develop a transmission plan to accommodate the requested transmission service. Three network upgrade options are being evaluated:

1) Dorsey-Maple River-Helena 500 kV line
2) Dorsey-Maple River-Arrowhead 500 kV line with Arrowhead-Chisago-King 345 kV line
3) Dorsey-King 500 kV line

All three transmission upgrades include a 345 kV line from North LaCrosse to West Middleton.

Each transmission upgrade option was added to a winter peak benchmark case without the study TSRs in order to identify transmission impacts. The highest post-contingency loading in each case was compared with the highest post-contingency loading in the benchmark case. Impacts to the facilities shown in Table E-2 are significant in that these facilities do not overload before adding the transmission upgrades. No facility is significantly impacted by upgrade option 3. All facilities except for the Tioga-Boundary Dam 230 kV line are impacted by upgrade options 1 and/or 2 but are not further impacted by the requested transmission service. The post-contingency loading of the Tioga-Boundary Dam 230 kV line does not exceed its emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

Table E-2: Impacts of Transmission Upgrade Options

Constraint	Owner	Rating (MVA)	Highest Post-Contingency Loading [1]			
			Benchmark	Benchmark with Option 1	Benchmark with Option 2	Benchmark with Option 3
Maple River 345/230 kV transformer #1, #2	OTP	420	92.1	111.2	102.3	
Solway – Wilton Tap 115 kV line	OTP	106.3	98.3	103.0	103.2	
Tioga – Boundary Dam 230 kV line	BEPC	200	93.4	106.7	102.8	
Jamestown – Ladish 115 kV line	OTP	158.8	99.0		101.0	
Souris – Velva Tap 115 kV line	XEL	80	99.3	101.8		
WST CLD 115/69 kV transformer	GRE	46.7	99.7	102.3		

Note 1: Blank cell indicates facility is not significantly impacted

Transmission Service Impacts

TSR study cases were created by modeling the requested transmission service in the winter peak benchmark case along with one of the three transmission upgrade options. A nonlinear (ac) contingency analysis was performed on the benchmark and study cases and the incremental impact of the requested transmission service was evaluated by comparing flows and voltages without and with the service. Linear (dc) analysis was used to calculate distribution factors and estimate element loading for each TSR.

Facilities on which one or more TSR have a significant thermal impact are shown in Table E-3. A thermal impact is considered significant if the facility loading exceeds the applicable limit and the impact has a PTDF greater than 5% or an OTDF greater than 3%.

Table E-3: Significantly Impacted Facilities

Monitored Element	Owner	Rating (MVA)	Option 1 Study Case	Option 2 Study Case	Option 3 Study Case	Contingency
Flowgate 3532:ELNHNZNAPRRN	MISO	163	X	X	X	OTDF Flowgate
Flowgate 3766:DUNHAZARNHAZ	MISO	37	X			OTDF Flowgate
Flowgate 6174:SONCCTCOCSON	MISO	430	X	X	X	OTDF Flowgate
Flowgate 6189:ADARCRBYRPVV	MISO	103	X	X	X	OTDF Flowgate
Rugby – Rugby CPC 115 kV line	WAPA /BEPC	144.4	X	X	X	C: Rugby – Balta 230 kV line
Leland Olds 345/230kV transformer #1	BEPC	250		X		Multiple Contingencies: C: R602F 500kV line C: F601C 500kV line
Leland Olds 345/230kV transformer #2	BEPC	500	X	X	X	Multiple Contingencies: C: Leland Olds 345/230kV transformer #1 C: Antelope – Charlie Creek 345kV line C: Center2G GSU C: Center DC – Square Butte 230 kV line C: Coal Creek 41G GSU C: Coal Creek 42G GSU C: Leland Olds 41G GSU
Leland Olds 345/230kV transformer #2	BEPC	500		X		Multiple Contingencies: C: Charlie Creek 345/230 kV transformer C: Center1G GSU C: Coyote1G GSU C: Any segment of Oahe – Sullybt – Whitlock – Glenham 230 kV line C: Any segment of Charlie Creek – Watford – Williston 230 kV line
Coon Creek – Kolman Lake 345 kV Line	NSP	717			X	C: Coon Creek – Terminal 345 kV line C: Coon Creek – Terminal 345 kV line and Terminal 345/115 kV transformer
Cass Lake – Nary 115 kV line	OTP/ MPC	105.6	X	X		C: Wilton – Cass Lake 230 kV line
Mud Lake – Brainerd 115 kV line	MP	132		X		C: Riverton – Mud Lake 230 kV line
Moorhead – Morris 230 kV line	WAPA	239		X		C: Bigston - Brownsv 230 kV line
Tioga – Boundary Dam 230 kV line	BEPC	120	X			C: Maple River – Dorsey 500 kV line

A380 (500 MW WPS to MHEB-MISO)

A380 is a request for 500 MW of network transmission service from WPS to MHEB-MISO. A380 constraints are summarized in Table E-4.

Table E-4: A380 Flow-Based Analysis Constraints

Study	Constraint	Rating (MVA)	Significant Thermal Impacts - Highest Loading[1]		
			Option 1	Option 2	Option 3
A380	Flowgate 6174:SONCCTCOCSON	430	112.5%	114.0%	115.8%
	Coon Creek – Kolman Lake 345 kV line	717			100.1%
	Rugby – Rugby CPC 115kV line	144.4			101.2%

Note 1: Blank cell indicates facility is not significantly impacted

A383 (250 MW MP to MHEB-MISO)

A383 is a request for 250 MW of network transmission service from MP to MHEB-MISO. A383 constraints are summarized in Table E-5.

Table E-5: A383 Flow-Based Analysis Constraints

Study	Constraint	Rating (MVA)	Significant Thermal Impacts - Highest Loading[1]		
			Option 1	Option 2	Option 3
A383	Flowgate 6174:SONCCTCOCSON	430			117.8
	Cass Lake – Nary 115 kV line	105.6	100.9%	102.3%	
	Rugby – Rugby CPC 115kV line	144.4		101.8%	107.9%
	Coon Creek – Kolman Lake 345 kV line	717			102.9%

Note 1: Blank cell indicates facility is not significantly impacted

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

A415 consists of two 100 MW requests for point-to-point transmission service from GRE to MHEB-MISO. A415 constraints are summarized in Table E-6.

Table E-6: A415 Flow-Based Analysis Constraints

Study	Constraint	Rating (MVA)	Significant Thermal Impacts - Highest Loading[1]		
			Option 1	Option 2	Option 3
A415	Flowgate 6174:SONCCTCOCSON	430	114.8% (a) 115.6% (b)	116.4% (a) 117.3% (b)	118.9% (a) 120.1% (b)
	Rugby – Rugby CPC 115kV line	144.4	100.6% (a) 103.1% (b)	104.5% (a) 107.1% (b)	111.2% (a) 114.5% (b)
	Mud Lake – Brainerd 115 kV line	132		100.9% (a) 103.5% (b)	
	Coon Creek – Kolman Lake 345 kV line	717			106.0% (a) 109.1% (b)

Notes:
1: Blank cell indicates facility is not significantly impacted
(a): For 100 MW transmission service (b): For 200 MW transmission service

A414 (50 MW WEC to MHEB-MISO)

A414 is a request for 50 MW of point-to-point transmission service from WEC to MHEB-MISO. A414 constraints are summarized in Table E-7.

Table E-7: A414 Flow-Based Analysis Constraints

Study	Constraint	Rating (MVA)	Significant Thermal Impacts - Highest Loading[1]		
			Option 1	Option 2	Option 3
A414	Flowgate 6174:SONCCTCOCSON	430	116.0%	117.8%	120.6%
	Rugby – Rugby CPC 115kV line	144.4	104.4%	108.5%	116.2%
	Flowgate 6189:ADARCRBYRPVV	103	105.2%	102.8%	106.4%
	Flowgate 3532:ELNHNZNAPRRN	163		102.8%	102.5%
	Coon Creek – Kolman Lake 345 kV line	717			109.8%

Note 1: Blank cell indicates facility is not significantly impacted

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

A383 consists of two 50 MW requests for point-to-point transmission service from ALTE to MHEB-MISO. A383 constraints are summarized in Table E-8.

Table E-8: A383 Flow-Based Analysis Constraints

Study	Constraint	Rating (MVA)	Significant Thermal Impacts - Highest Loading[1]		
			Option 1	Option 2	Option 3
A413	Flowgate 3532:ELNHNZNAPRRN	163		105.8% (a) 108.9% (b)	105.4% (a) 108.4% (b)
	Flowgate 6174:SONCCTCOCSON	430	116.5% (a) 116.9% (b)	118.2% (a) 118.7% (b)	121.2% (a) 121.8% (b)
	Flowgate 6189:ADARCRBYRPVV	103	106.9% (a) 108.5% (b)	104.4% (a) 106.0% (b)	108.1% (a) 109.9% (b)
	Coon Creek – Kolman Lake 345 kV line	717			110.5% (a) 111.2% (b)
	Rugby – Rugby CPC 115kV line	144.4	105.6% (a) 106.9% (b)	109.8% (a) 111.2% (b)	117.8% (a) 119.5% (b)

Notes:
1: Blank cell indicates facility is not significantly impacted
(a): For 100 MW transmission service (b): For 200 MW transmission service

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Section

1

Steady-State Analysis

1.1 Methodology

A benchmark power flow model representing 2019 winter peak system conditions was created without the requested transmission service. TSR study cases were created by modeling the requested transmission service in the benchmark case along with one of three transmission upgrade options. A nonlinear (ac) contingency analysis was performed on the benchmark and study cases and the incremental impact of the requested transmission service was evaluated by comparing flows and voltages without and with the service.

Linear (dc) analysis was used to calculate distribution factors for each TSR. These distribution factors and the results of the nonlinear contingency analysis were used to calculate the loading on impacted facilities before and after each TSR.

1.2 Computer Programs

Analysis was performed using PSS®E version 30.3 and PSS®MUST version 8.3.2.

1.3 Model Development

1.3.1 Winter Peak Benchmark Case

A winter peak benchmark case without the study TSRs and associated transmission upgrades was developed. The source was a 2019 Winter Peak case from the MRO 2008 model series. The Winter Peak benchmark case was developed by adding MTEP08 projects, all existing US to MH firm transmission service commitments, prior-queued transmission service requests (confirmed and study status) not already included in the MRO case, MISO network resource generation and miscellaneous updates and corrections as described in the following sections.

The benchmark power flow case was solved with transformer tap adjustment enabled, switched shunt adjustment enabled, area interchange enabled (ties only), phase shifter adjustment enabled and dc tap adjustment enabled.

1.3.1.1 Midwest ISO Transmission Expansion Plan 2008 (MTEP) Projects

Table A-1 in Appendix A shows the MTEP08 projects that were added to the winter peak benchmark case using response files provided by Midwest ISO.

1.3.1.2 Existing US to MH Firm Transmission Service

The winter peak benchmark case includes all existing firm transmission service commitments on the MHEX_N interface, as listed in Table 1-1 below.

Table 1-1: Existing Firm Transmission Service on MHEX_N Interface

TSR Ref#	POR	POD	Capacity (MW)	Start Time	End Time	Service
76703716	NSP	MH	500	5/1/2009	5/1/2019	YEARLY FIRM PTP
76703479	OTP	MH	50	11/1/2008	1/1/2036	YEARLY FIRM PTP
76703476	NSP	MH	200	11/1/2008	5/1/2019	YEARLY FIRM PTP
76703474	NSP	MH	200	11/1/2008	11/1/2016	YEARLY FIRM PTP
76703244	GRE	MH	67	11/1/2008	5/1/2015	YEARLY FIRM PTP
Total			1017 MW			

The resulting MHEX_N interface flow in the winter peak benchmark case is 699 MW.

1.3.1.3 Prior-Queued WAPA TSRs

The following proposed generating facilities have TSRs under study on the WAPA OASIS and were added to the winter peak benchmark case.

- Culbertson Project GI-0708 + GI-0614a (120+10 MW)

Groton Unit 1 and Unit 2 are dispatched at 120 MW each.

1.3.1.4 Prior-Queued Midwest ISO TSRs

Table 1-2 shows prior-queued Midwest ISO TSRs and confirmed requests that were added to the winter peak benchmark case using sources and sinks provided by Midwest ISO.

Table 1-2: Midwest ISO TSRs Added to the WiPk Case

OASIS	OASIS #	STUDY	POR	POD	CAPACITY REQUESTED (MW)	START	STOP
MISO	Multiple	A054, A101, A183, A234 and A237	NSP	NSP	52	8/1/2002	8/1/2028
MISO	75836490	A194	NSP	NSP	100	12/1/2008	12/1/2025
MISO	76434677	A316	OTP	OTP	50	2/1/2010	11/1/2028
MISO	76509135	A356	GRE	NSP	100	10/1/2008	1/1/2034
MISO	76517411		GRE	OTP	94	4/1/2007	1/1/2036
MISO	76517414		GRE	OTP	30	4/1/2007	11/20/2027
MISO	76517415		GRE	MP	275	4/1/2007	3/2/2010
MISO	76526766	A374	OTP	OTP	49	11/1/2008	11/1/2028
MISO	76541075	A204	MP	MP	25	2/1/2008	2/1/2009
MISO	76541076	A204	MP	MP	25	2/1/2011	2/1/2012
MISO	76561178	A390	SMP	NSP	45	11/1/2007	11/1/2037
MISO	76668811	A373	MP	MP	100	7/1/2010	8/1/2015
MISO	76668831	A373	NSP	MP	100	7/1/2010	8/1/2015
MISO	76668843	A381	GRE	MP	200	7/1/2011	8/1/2016
MISO	76668850	A393	OTP	MP	100	7/1/2010	8/1/2015

1.3.1.5 Midwest ISO Network Resource Generation

The NR generating facilities listed in Table 1-3 were added to the winter peak benchmark case.

Table 1-3: Midwest ISO NR Generation Added to the WiPk 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
G691	39006-02	16-Oct-06	XEL	Vernon, WI	Westby - Cashton tap 69 kV line	50	10
G930	39426-03	10-Dec-07	XEL	Sherburne, MN	Sherco Substation	120	120

1.3.1.6 Miscellaneous Updates and Corrections

Table 1-4 shows other miscellaneous model updates.

Table 1-4: Miscellaneous Updates and Corrections

Area	Description
ITCM	Redispatched Alliant Energy generation so that area slack bus is within limits
MEC	Redispatched MidAmerican generation so that area slack bus is within limits
MH	Added Dorsey – Riel 500 kV circuit #2
MP	Purge extra Blackberry-Wilton 230 kV line
OTP	Added TSRs 76517414 and 76517411 from GRE to OTP so that OTP area slack bus is within limits
SMMPA/XEL	Shifted 220 MW from SMMPA generation in XEL control area to Austin so that SMMPA area slack bus is within limits
WAPA	Purged superfluous zero-impedance branches: - Max-ND Prairie Wind 115-34.5 kV transformer - Ft Thomson-Leland Olds 345 kV line - Whitlock-Glenham 230 kV line
WAPA	Letcher-Wessington correction
WAPA	Purge Storla-Broadland 230 kV line
WAPA	Set Miles City dc tie at 150 MW east to west Set Boundary Dam at 165 MW south to north
WAPA	Remove Selby generator and associated topology changes to make WiPk model topology consistent with SuPk model. Selby 540 MW output compensated by dispatching BEPC and MDU peakers.
WAPA	Redispatched WAPA generation so that area slack bus is within limits.
XEL	Increased generator MW limits at Prairie Island and Monticello (A201)
XEL	Removed Chanarambie 115/34.5 kV #4 transformer
XEL	Change the control area of Tatanka Wind to XEL (600)
XEL	Lena Tap correction
XEL	Colville generator updates

1.3.2 Winter Peak Study Cases

Three winter peak TSR study cases were created by modeling the requested transmission service in the benchmark case along with one of three transmission upgrade options. Losses for each TSR study case are summarized in Appendix B.

1.3.2.1 Transmission Upgrade Options

The transmission upgrade options proposed by the ad hoc study group are summarized in Table 1-5. Diagrams depicting the proposed upgrades are included in Appendix B.

Table 1-5: Transmission Upgrade Options

Project	1	2	3
Dorsey – Maple River 50% series compensated 500 kV line terminated via 500/345 kV transformer at Maple River. HVDC reduction for loss of the line or transformer.	X	X	
North LaCrosse – West Middleton 345 kV Line	X	X	X
Maple River – Helena 50% series compensated 500 kV line terminated via 500/345 kV transformer at Helena. HVDC reduction for loss of the line or transformer.	X		
Arrowhead – Chisago – King 345 kV line		X	
Maple River – Arrowhead 50% series compensated 500 kV line terminated via 500/345 kV transformer at Arrowhead. HVDC reduction for loss of the line or transformer.		X	
Dorsey – King 50% series compensated 500 kV line terminated via 500/345 kV transformer at King. HVDC reduction for loss of the line or transformer.			X

The cost estimates shown in Table 1-6 are based on $/mile costs taken from the JCSP 2008 Interim Stakeholder Meeting Introduction Presentation and adjusted down from 2024 dollars to 2018 dollars using a 3% escalation factor.

Table 1-6: Cost Estimates

Option	Cost in 2018
Option 1	$1,434,401,161
Option 2	$1,697,371,217
Option 3	$1,354,944,842

1.3.2.2 Source and Sinks for Study TSRs

The TSR sink is the Dorsey inverter station and the 1100 MW aggregate study TSRs were sunk by decreasing the injection of the existing two dc bipoles at Dorsey from 1950 MW in the benchmark case to 850 MW in the study case. The study TSRs were sourced at the generators shown in Table 1-7.

Table 1-7: US to MH TSR Sources

Bus #	Generator Name	MW
Removed		

1.4 Contingency Criteria

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

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

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

1.5 Monitored Facilities

Monitored facilities and associated thermal and voltage limits are shown in Table 1-8.

Table 1-8: Monitored Facilities and Limits

Owner/ Area	Monitored Facilities	Thermal Limits [1]		Voltage Limits
		Pre-Disturbance	Post-Disturbance	
ATC LLC	69 kV and above	95% of Rate A	95% of Rate B	1.10/0.90
BEPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
DPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
GRE	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.92/0.90 [2]
ITCMW	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
MDU	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
MEC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
MH	69 kV and above	100% of Rate A	100% of Rate B	1.15/1.10/0.94/0.90 [3]
MP	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95
MPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
MRES	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
NWPS	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
OTP	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
RPU	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
SMMPA	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
SPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
WAPA	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
XEL	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90

Note 1: PSSE Rate A, Rate B or Rate C
Note 2: 0.92 limit applies to load serving buses
Note 3: Limits dependent on nominal bus voltage

1.6 Reliability Margins

Capacity benefit margin (CBM) and transmission reliability margin (TRM) are accounted for in the flowgate definitions. All other system elements were monitored as shown in Table 1-8.

1.7 Performance Criteria

A branch or flowgate is considered a significantly impacted facility if both of the following conditions are met:

1) the branch is loaded above its applicable normal or emergency rating for the post-change case, and
2) the power transfer distribution factor (PTDF) is greater than 5% or the outage transfer distribution factor (OTDF) is greater than 3%.

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

A voltage impact is considered significant if both of the following conditions are met:

1) the bus voltage is outside of applicable normal or emergency limits for the post-disturbance case,
2) the impact of the service on bus voltage is greater than 0.01 per unit.

1.8 Network Analysis Results

1.8.1 Transmission Upgrade Impacts

Each transmission upgrade option was added to the winter peak benchmark case without the study TSRs in order to identify transmission impacts. The highest post-contingency loading in each case was compared with the highest post-contingency loading in the benchmark case; differences exceeding 2% of the monitored element rating are shown in Appendix C, Table C-1.

Impacts to the following facilities are significant in that these facilities do not overload before adding the transmission upgrades. No facility is significantly impacted by upgrade option 3.

- Maple River 345/230 kV transformer #1, #2
- Solway – Wilton Tap 115 kV line
- Jamestown – Ladish 115 kV line
- Souris – Velva Tap 115 kV line
- WST CLD 115/69 kV transformer
- Tioga – Boundary Dam 230 kV line

All facilities except for the Tioga-Boundary Dam 230 kV line are impacted by upgrade options 1 and/or 2 but are not further impacted by the requested transmission service. The post-contingency loading of the Tioga-Boundary Dam 230 kV line does not exceed its emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

1.8.2 Transmission Service Impacts

Facilities on which one or more TSR have a significant thermal impact are shown in Appendix C, Table C-2. A thermal impact is considered significant if the facility loading exceeds the limit shown in Table 1-8 and the impact has a PTDF greater than 5% or an OTDF greater than 3%. There are no significant voltage impacts attributable to any TSR.

1.8.2.1 A380 (500 MW WPS to MHEB-MISO)

A380 is a request for 500 MW of network transmission service from WPS to MHEB-MISO. Request A380 has a significant impact on multiple facilities as shown in Table 1-9.

Two of the significantly impacted facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2 and the Stanton-Coal Creek Tap flowgate (#6174). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The Stanton-Coal Creek Tap flowgate is a constraint with any of the upgrade options. There are no additional significantly impacted facilities for upgrade option 2.

The Tioga-Boundary Dam 230 kV line is a significantly impacted facility with upgrade option 1; Tioga-Boundary Dam is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

The Coon Creek-Kolman Lake 345 kV line and Rugby-Rugby CPC 115kV line are constraints for upgrade option 3.

1.8.2.2 A383 (250 MW MP to MHEB-MISO)

A383 is a request for 250 MW of network transmission service from MP to MHEB-MISO. Request A383 has a significant impact on multiple facilities as shown in Table 1-10.

The Cass Lake-Nary 115 kV line is a constraint with either upgrade option 1 or option 2. The Rugby-Ruby CPC 115 kV line is a constraint with either upgrade option 2 or option 3. Additionally, with upgrade option 3, a significant thermal impact is also seen on the Coon Creek-Kolman Lake 345 kV line, the Tioga-Boundary Dam 230 kV line and the Stanton-Coal Creek Tap flowgate (#6174). Tioga-Boundary Dam is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

1.8.2.3 A415 (100+100 MW GRE to MHEB-MISO)

A415 consists of two 100 MW requests for total 200 MW of point-to-point transmission service from GRE to MHEB-MISO. Request A415 has a significant thermal impact on the facilities shown in Table 1-11 and Table 1-12.

Three of the significantly impacted facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line and the Stanton-Coal Creek Tap flowgate (#6174). The Leland Olds transformer is not a

constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other facilities are constraints with any of the options.

The Tioga-Boundary Dam 230 kV line is a significantly impacted facility for upgrade option 1; Tioga-Boundary Dam is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

The Mud Lake-Brainerd 115kV line and Leland Olds transformer #1 are significantly impacted facilities with upgrade option 2. Mud Lake-Brainerd is a constraint; the Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's emergency rating. The Coon Creek-Kolman Lake 345 kV line is a constraint for upgrade option 3.

1.8.2.4 A414 (50 MW WEC to MHEB-MISO)

A414 is a request for 50 MW of point-to-point transmission service from WEC to MHEB-MISO. Request A414 has a significant thermal impact on the facilities shown in Table 1-13.

Four of the significantly impacted facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line, the Stanton-Coal Creek Tap flowgate (#6174) and the Adams-Rochester flowgate (#6189). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other facilities are constraints with any of the options.

The Tioga-Boundary Dam 230 kV line is a significantly impacted facility with upgrade option 1; Tioga-Boundary Dam is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

The Ellington-Hintz flowgate (#3532) is a constraint with either upgrade option 2 or option 3. The Coon Creek-Kolman Lake 345 kV line is a constraint for upgrade option 3.

1.8.2.5 A413 (50+50 MW ALTE to MHEB-MISO)

A413 consists of two 50 MW requests for total 100 MW of point-to-point transmission service from ALTE to MHEB-MISO. Request A417 has a significant thermal impact on the facilities shown in Table 1-14 and Table 1-15.

Five of the significantly impacted facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line, the Stanton-Coal Creek Tap flowgate (#6174), the Adams-Rochester flowgate (#6189) and the Ellington-Hintz flowgate (#3532). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other facilities are constraints with any of the options.

The Tioga-Boundary Dam 230 kV line is a significantly impacted facility with upgrade option 1; Tioga-Boundary Dam is not a constraint because the post-contingency loading does not

exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce flow to within normal limits.

The Leland Olds 345/230 kV transformer #1 and the Moorehead-Morris 230 kV line are significantly impacted facilities with upgrade option 2; the Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's emergency rating.

The Coon Creek-Kolman Lake 345 kV line is a constraint for upgrade option 3.

Table 1-9: A380 Thermal Constraints (500 MW WPS to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	108.4	112.5	3.6	C:Contingency of FlowGate 6174
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	117.1	122.4	5.3	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	113.8	117.8	3.9	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	98.3	102.0	3.6	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	98.3	102.0	3.6	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200.0	106.4	113.7	3.0	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed facilities emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	97.1	101.3	4.2	C:Contingency of FlowGate 6174
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	122.7	128.8	6.2	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	118.1	122.7	4.6	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.5	106.7	4.2	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.5	106.7	4.2	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	98.5	102.7	4.2	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	98.5	102.7	4.2	C:CENTRDC-SQBUTTE-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-9 (continued): A380 Thermal Constraints (500 MW WPS to MHEB-MISO)

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	110.4	115.8	4.7	C:Contingency of FlowGate 6174
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	94.6	100.1	7.8	C:COON_CK-TERMINL-345
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	85.2	101.2	4.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	119.6	124.4	4.9	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	115.7	119.3	3.6	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	104.2	3.3	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	104.2	3.3	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	96.9	100.2	3.3	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	96.9	100.2	3.3	C:CENTRDC-SQBUTTE-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-10: A383 Thermal Constraints (250 MW MP to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620247 CASS LK7 115 657710 NARY 7 115 1	OTP/ MPC	105.6	88.6	100.9	10.3	C:WILTON-CASSLK-230

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620247 CASS LK7 115 657710 NARY 7 115 1	OTP/ MPC	105.6	91.8	102.3	4.5	C:WILTON-CASSLK-230
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	96.7	101.8	3.0	C:GRE-BALTA-RUGBY-230

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	115.8	117.8	3.4	C:Contingency of FlowGate 6174
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	100.1	102.9	8.2	C:COON_CK-TERMINL-345
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	98.5	101.4	8.3	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	101.2	107.9	3.9	C:GRE-BALTA-RUGBY-230
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200.0	114.1	118.3	3.4	C:R602F

Note 1: Post-contingency loading does not exceed the facility's emergency rating

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

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	113.9	114.8	3.6	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	98.2	100.6	3.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	123.6	124.6	5.0	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	118.7	119.4	3.7	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.8	103.5	3.4	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.8	103.5	3.4	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200.0	116.7	118.3	3.1	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	115.5	116.4	3.9	C:Contingency of FlowGate 6174
608651 MUDLAKE7 115 608652 BRAINRD7 115 1	MP	132.0	98.3	100.9	3.4	C:RIVERTN-MUDLAKE-230
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	101.8	104.5	3.8	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	101.0	102.2	3.2	C:R602F
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	130.1	131.3	6.2	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	123.6	124.6	4.6	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	107.6	108.4	4.3	C:GRE-COAL41G-GSU

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	107.6	108.5	4.3	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.6	104.4	4.3	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.6	104.4	4.3	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.2	103.0	4.3	C:LELAN41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.1	100.9	4.3	C:SINGLE-046 Open 657791 CENTER 3 345 661016 COYOTE 3 345 1 Open 661015 COYOTE1G 24.0 661016 COYOTE 3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.9	100.7	4.3	C:COYOTE1G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	117.8	118.9	4.8	C:Contingency of FlowGate 6174
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	101.4	104.6	22.5	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	102.9	106.0	22.1	C:COON_CK-TERMINL-345
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	107.9	111.2	4.8	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	125.3	126.2	4.6	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	119.9	120.6	3.4	C:ANTELOP-CHAR.CK-345

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.7	105.4	3.2	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.7	105.4	3.2	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	101.4	3.2	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	101.4	3.2	C:CENTRDC-SQBUTTE-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-12: A415 (2nd of 2) Thermal Constraints (100 MW GRE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	114.8	115.6	3.6	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	100.6	103.1	3.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	124.6	125.6	5.0	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	119.4	120.2	3.7	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.5	104.2	3.4	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.5	104.2	3.4	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.5	100.2	3.4	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.5	100.2	3.4	C:CENTRDC-SQBUTTE-230
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200.0	118.3	119.8	3.1	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	116.4	117.3	3.9	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	104.5	107.1	3.8	C:GRE-BALTA-RUGBY-230
608651 MUDLAKE7 115 608652 BRAINRD7 115 1	MP	132.0	100.9	103.5	3.4	C:RIVERTN-MUDLAKE-230
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	102.2	103.5	3.2	C:R602F
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	131.3	132.6	6.2	C:LELND1T-XFMR

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	124.6	125.5	4.6	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	108.4	109.3	4.3	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	108.5	109.3	4.3	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.4	105.3	4.3	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.4	105.3	4.3	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.0	103.9	4.3	C:LELAN41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.9	101.8	4.3	C:SINGLE-046 Open 657791 CENTER 3 345 661016 COYOTE 3 345 1 Open 661015 COYOTE1G 24.0 661016 COYOTE 3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.7	101.6	4.3	C:COYOTE1G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	118.9	120.1	4.8	C:Contingency of FlowGate 6174
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	104.6	107.7	22.5	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	106.0	109.1	22.1	C:COON_CK-TERMINL-345
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	111.2	114.5	4.8	C:GRE-BALTA-RUGBY-230

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	126.2	127.1	4.6	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	120.6	121.3	3.4	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	105.4	106.0	3.2	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	105.4	106.0	3.2	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	101.4	102.1	3.2	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	101.4	102.1	3.2	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	99.7	100.3	3.2	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-13: A414 Thermal Constraints (50 MW WEC to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	115.6	116.0	3.7	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	103.7	105.2	3.2	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	103.1	104.4	3.7	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	125.6	126.2	5.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	120.2	120.6	4.2	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.2	104.6	3.9	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.2	104.6	3.9	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.2	100.6	3.9	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.2	100.6	3.9	C:CENTRDC-SQBUTTE-230
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200.0	119.8	120.6	3.0	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	99.0	102.8	12.5	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	117.3	117.8	4.0	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	101.4	102.8	3.1	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/	144.4	107.1	108.5	3.9	C:GRE-BALTA-RUGBY-230

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
	BEPC					
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	132.6	133.3	6.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	125.5	126.0	5.0	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	109.3	109.8	4.6	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	109.3	109.7	4.6	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	105.3	105.7	4.6	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	105.3	105.7	4.6	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	103.9	104.3	4.6	C:LELAN41G-GSU
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	103.5	104.2	3.3	C:R602F
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	102.3	103.0	3.1	C:F601C
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	101.6	102.0	4.6	C:COYOTE1G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.9	100.3	4.7	C:CHAR.CK-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.8	100.3	4.7	C:WATFORD-CHAR.CK-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	101.8	102.3	4.7	C:SINGLE-046 Open 657791 CENTER 3 345 661016 COYOTE 3 345 1 Open 661015 COYOTE1G 24.0 661016 COYOTE 3 345 1

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	98.7	102.5	12.2	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	120.1	120.6	4.9	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	104.8	106.4	3.3	C:Contingency of FlowGate 6189
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	107.7	108.4	10.0	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	109.1	109.8	9.7	C:COON_CK-TERMINL-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	127.1	127.7	5.3	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	121.3	121.7	3.9	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.0	106.4	3.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.0	106.4	3.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.1	102.4	3.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.1	102.4	3.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.3	100.7	3.7	C:LELAN41G-GSU
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	114.5	116.2	4.8	C:GRE-BALTA-RUGBY-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

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

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	430.0	116.0	116.5	3.8	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	105.2	106.9	3.4	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	104.4	105.6	3.7	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	126.2	126.8	5.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	120.6	121.0	4.3	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.6	101.0	4.0	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.6	101.0	4.0	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.6	105.0	4.0	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.6	105.0	4.0	C:CENTRDC-SQBUTTE-230
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200.0	120.6	121.3	3.0	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	105.8	105.8	9.9	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	118.2	118.2	4.0	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	104.4	104.4	3.3	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	109.8	109.8	3.9	C:GRE-BALTA-RUGBY-230

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	104.8	104.8	3.4	C:R602F
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	103.6	103.6	3.1	C:F601C
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	134.0	134.0	6.9	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	126.5	126.5	5.1	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	110.2	110.2	4.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	110.2	110.2	4.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.2	106.2	4.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.2	106.2	4.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.8	104.8	4.7	C:LELAN41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.7	102.7	4.7	C:SINGLE-046 Open 657791 CENTER 3 345 661016 COYOTE 3 345 1 Open 661015 COYOTE1G 24.0 661016 COYOTE 3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.5	102.5	4.7	C:COYOTE1G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	100.8	4.8	C:CHAR.CK-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	100.8	4.8	C:WATFORD-CHAR.CK-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.2	100.2	5.3	C:OAHE-SULLYBT-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	102.5	105.4	9.6	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	120.6	121.2	4.9	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	106.4	108.1	3.6	C:Contingency of FlowGate 6189
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	108.4	109.1	10.6	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	109.8	110.5	10.2	C:COON_CK-TERMINL-345
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	116.2	117.8	4.8	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	127.7	128.2	5.4	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	121.7	122.1	4.0	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.4	106.7	3.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.4	106.7	3.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.4	102.8	3.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.4	102.8	3.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.7	101.0	3.7	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-15: A413 (2nd of 2) Thermal Constraints (50 MW ALTE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	99.6	102.4	9.1	C:Contingency of FlowGate 3532
3766:DUNHAZARNHAZ	MISO	37.0	95.5	100.6	3.8	C:Contingency of FlowGate 3766
6174:SONCCTCOCSON	MISO	430.0	116.5	116.9	3.8	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	106.9	108.5	3.4	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	105.6	106.9	3.7	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	126.8	127.4	5.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	121.0	121.4	4.3	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	105.0	105.4	4.0	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	105.0	105.4	4.0	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	101.0	101.4	4.0	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	101.0	101.4	4.0	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.8	100.2	4.0	C:LELAN41G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200.0	121.3	122.1	3.0	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 2

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	105.8	108.9	9.9	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	118.2	118.7	4.0	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	104.4	106.0	3.3	C:Contingency of FlowGate 6189
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	109.8	111.2	3.9	C:GRE-BALTA-RUGBY-230
652553 MOORHED4 230 652554 MORRIS 4 230 1	WAPA	239.0	99.5	100.3	4.1	C:BIGSTON-BROWNSV-230
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	104.8	105.5	3.4	C:R602F
659105 LELANDO3 345 659201 LELND1TY 345 1 [1]	BEPC	250.0	103.6	104.2	3.1	C:F601C
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	134.0	134.6	6.9	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	126.5	127.0	5.1	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	110.2	110.7	4.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	110.2	110.7	4.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.2	106.7	4.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.2	106.7	4.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	104.8	105.3	4.7	C:LELAN41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.7	103.2	4.7	C:SINGLE-046
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.5	103.0	4.7	C:COYOTE1G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	101.3	4.8	C:WATFORD-CHAR.CK-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.8	101.3	4.8	C:CHAR.CK-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.4	101.1	5.3	C:WHITLOK-GLENHAM-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.3	100.8	4.8	C:WATFORD-WILISTN-230

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	100.2	100.7	5.3	C:OAHE-SULLYBT-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.1	100.6	4.7	C:CENTER1G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	99.8	100.3	5.3	C:SULLYBT-WHITLOK-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	105.4	108.4	9.6	C:Contingency of FlowGate 3532
6174:SONCCTCOCSON	MISO	430.0	121.2	121.8	4.9	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	108.1	109.9	3.6	C:Contingency of FlowGate 6189
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	109.1	109.9	10.6	C:B_XEL_COON_CK-TERMINL
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	110.5	111.2	10.2	C:COON_CK-TERMINL-345
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	117.8	119.5	4.8	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	128.2	128.8	5.4	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	122.1	122.5	4.0	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.7	107.1	3.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	106.7	107.1	3.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.8	103.2	3.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	102.8	103.2	3.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500.0	101.0	101.4	3.7	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

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Appendix

A

MTEP08 Projects

Table A-1 shows the MTEP08 projects that were added to the 2017 Winter Peak benchmark case using response files provided by Midwest ISO.

Table A-1: MTEP08 Projects added to the Winter Peak Case

Transmission Owner	PrjID	Project Name
ITCM	1288	Replace Hazleton 345/161 kV transformer #1 with 335 MVA unit
ITCM	1341	Replace two Hazleton 161/69 kV transformers
ITCM	1473	Mason City Armor - Emery North 69 kV line
ITCM	1522	6th Street - Beverly
ITCM	1619	Grnd Mnd 161-69kV 2nd Xfmr & 161kV loop
ITCM	1641	OGS 50 MVAR Cap Bank
ITCM	1739	Arnold-Vinton-Dysart-Washburn 161kV Reconductor
ITCM	1755	Washington-Hills 69kV Rebuild
ITCM	1756	Dyersville-Peoasta 69kV Rebuild
ITCM	1758	Beaver Channel-2nd Ave 69kV
ITCM	1772	North Centerville 7 MVAR Cap bank
GRE	1361	Badoura - Birch Lake 115 lines
MP	277	Badoura Project: Pine River - Pequot Lakes 115 kV line
MP/GRE	1021	Embarass to Tower 115 kV Line
MP/GRE	1022	Badoura-Long Lake 115 kV line
OTP	973	Big Stone II Generation Project
SMP	1367	Lake City load serving upgrades
SMP	4588	SMP-GRANDMEADOW-WF
XEL	675	Rebuild Westgate to Scott County 69 kV to 115 kV
XEL	1285	Build 18 miles 115 kV line from Glencoe - West Waconia
XEL	1457	G287, 37642-03. Upgrades for G287
XEL	1549	Eau Claire - Hydro Lane 161 kV Conversion
XEL	1953	St. Cloud - Sauk River 115 kV line upgrade

Transmission Owner	PrjID	Project Name
XEL	1954	Cherry Creek - Split Rock 115 kV line saperation
XEL	1956	Blue Lake - Wilmarth 345 kV line capacity upgrade
XEL	1957	New 161/69 kV Sub SW of Eau Claire where Alma – Elk Mound 161 kV intersects Shawtown – Naples 69 kV line. Rebuild 69 kV London/Madison to new substation. New 69 kV from new substation - DPC Union Sub. New 69 kV to DPC Brunswick Sub
XEL	1958	Stone Lake-Edgewater 161 kV line. A new radial 161 kV line and substation in Sawyer County, Wisconsin
XEL	1959	Yankee Doodle interconnection
XEL	1960	Traverse - St. Peter upgrade
XEL	1961	Lake Emily Capacitor bank
XEL	2109	G609
XEL		G037
XEL/GRE	1380	Scott County - West Waconia 115

Appendix

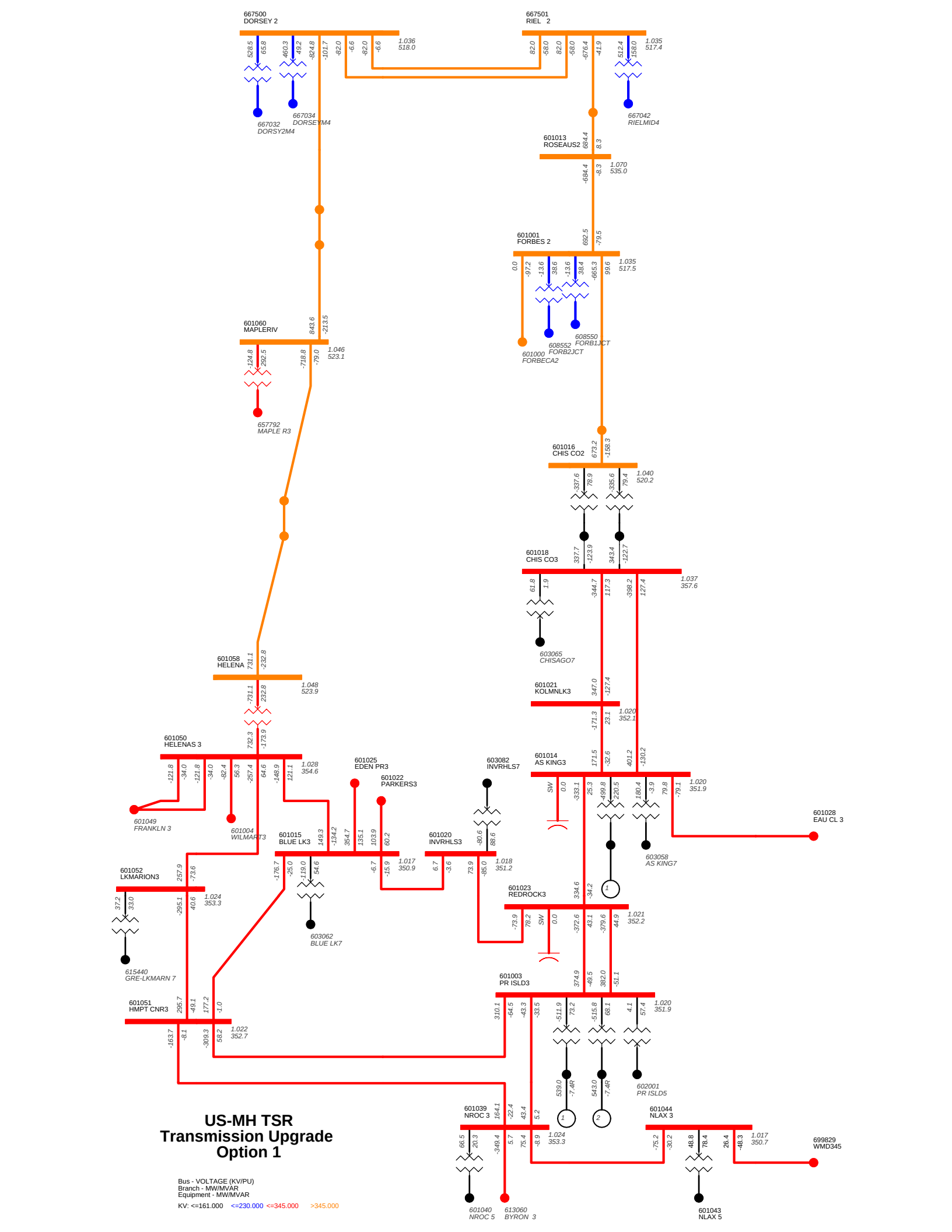
B

Loss Analysis of Transmission Upgrade Options

Table B-1: Loss Analysis Results

Area	Benchmark Case Losses	Option 1 Study Case		Option 2 Study Case		Option 3 Study Case	
		Losses	Difference	Losses	Difference	Losses	Difference
295 WEC	140.9 MW 2289.3 MVAR	137.4 MW 2236.9 MVAR	-3.5 MW -52.4 MVAR	137.7 MW 2239.4 MVAR	-3.2 MW -49.9 MVAR	137.6 MW 2238.7 MVAR	-3.3 MW -50.6 MVAR
600 XEL	262.4 MW 2650.7 MVAR	259.9 MW 2664.6 MVAR	-2.5 MW 13.9 MVAR	279.4 MW 2821.8 MVAR	17.0 MW 171.1 MVAR	276.5 MW 2793.7 MVAR	14.1 MW 143.0 MVAR
608 MP	97.8 MW 1290.7 MVAR	104.9 MW 1404.2 MVAR	7.1 MW 113.5 MVAR	106.4 MW 1405.7 MVAR	8.6 MW 115.0 MVAR	106.1 MW 1418.9 MVAR	8.3 MW 128.2 MVAR
613 SMMPA	1.2 MW 10.9 MVAR	1.0 MW 9.4 MVAR	-0.2 MW -1.5 MVAR	1.1 MW 10.1 MVAR	-0.1 MW -0.8 MVAR	1.1 MW 10.0 MVAR	-0.1 MW -0.9 MVAR
615 GRE	100.7 MW 1757.9 MVAR	102.6 MW 1790.3 MVAR	1.9 MW 32.4 MVAR	105.1 MW 1802.2 MVAR	4.4 MW 44.3 MVAR	104.7 MW 1806.5 MVAR	4.0 MW 48.6 MVAR
620 OTP	110.3 MW 922.5 MVAR	126.8 MW 1060.4 MVAR	16.5 MW 137.9 MVAR	135.4 MW 1117.5 MVAR	25.1 MW 195.0 MVAR	132.6 MW 1095.0 MVAR	22.3 MW 172.5 MVAR
627 ALTW	87.2 MW 942.3 MVAR	89.3 MW 954.4 MVAR	2.1 MW 12.1 MVAR	88.1 MW 947.0 MVAR	0.9 MW 4.7 MVAR	88.5 MW 950.5 MVAR	1.3 MW 8.2 MVAR
635 MEC	111 MW 1297.1 MVAR	111.8 MW 1307.1 MVAR	0.8 MW 10.0 MVAR	111.0 MW 1299.2 MVAR	0.0 MW 2.1 MVAR	111.3 MW 1302.8 MVAR	0.3 MW 5.7 MVAR
652 WAPA	271.8 MW 2681.1 MVAR	276.5 MW 2694.6 MVAR	4.7 MW 13.5 MVAR	286.6 MW 2765.3 MVAR	14.8 MW 84.2 MVAR	281.1 MW 2720.1 MVAR	9.3 MW 39.0 MVAR
667 MH	215.8 MW 3666.3 MVAR	154.7 MW 2262.7 MVAR	-61.1 MW -1403.6 MVAR	154.4 MW 2266.4 MVAR	-61.4 MW -1399.9 MVAR	153.8 MW 2271.3 MVAR	-62.0 MW -1395.0 MVAR
680 DPC	63.9 MW 342.7 MVAR	60.4 MW 327.7 MVAR	-3.5 MW -15.0 MVAR	63.1 MW 338.4 MVAR	-0.8 MW -4.3 MVAR	62.5 MW 336.6 MVAR	-1.4 MW -6.1 MVAR

Area	Benchmark Case Losses	Option 1 Study Case		Option 2 Study Case		Option 3 Study Case	
		Losses	Difference	Losses	Difference	Losses	Difference
694 ALTE	104.5 MW 1024.8 MVAR	99.2 MW 980.7 MVAR	-5.3 MW -44.1 MVAR	100.1 MW 986.1 MVAR	-4.4 MW -38.7 MVAR	100.1 MW 986.3 MVAR	-4.4 MW -38.5 MVAR
696 WPS	65.5 MW 615.3 MVAR	60.9 MW 631.9 MVAR	-4.6 MW 16.6 MVAR	62.1 MW 647.5 MVAR	-3.4 MW 32.2 MVAR	61.5 MW 636.5 MVAR	-4.0 MW 21.2 MVAR
697 MGE	10 MW 143.9 MVAR	9.9 MW 142.4 MVAR	-0.1 MW -1.5 MVAR	9.8 MW 141.6 MVAR	-0.2 MW -2.3 MVAR	9.9 MW 142.0 MVAR	-0.1 MW -1.9 MVAR
698 UPPC	9.1 MW 29.9 MVAR	9.1 MW 29.6 MVAR	0.0 MW -0.3 MVAR	9.1 MW 29.7 MVAR	0.0 MW -0.2 MVAR	9.1 MW 29.7 MVAR	0.0 MW -0.2 MVAR
Network Upgrade Facilities	0 MW 0 MVAR	32.5 MW 339.1 MVAR	32.5 MW 339.1 MVAR	22.9 MW 252.3 MVAR	22.9 MW 252.3 MVAR	29.8 MW 395.9 MVAR	29.8 MW 395.9 MVAR
TOTALS	1651.9 MW 19665.2 MVAR	2283.7 MW 28569.8 MVAR	345.5 MW 4703.2 MVAR	2271.5 MW 28561.7 MVAR	333.3 MW 4695.1 MVAR	2270.3 MW 28657.5 MVAR	332.1 MW 4790.9 MVAR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CHIS CO3
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CHISAGO7
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HELENA
601021
KOLMNLK3
601050
HELENAS 3
601049
FRANKLN 3
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EDEN PR3
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NROC 5
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NLAX 5
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WMD345
US-MH TSR
Transmission Upgrade
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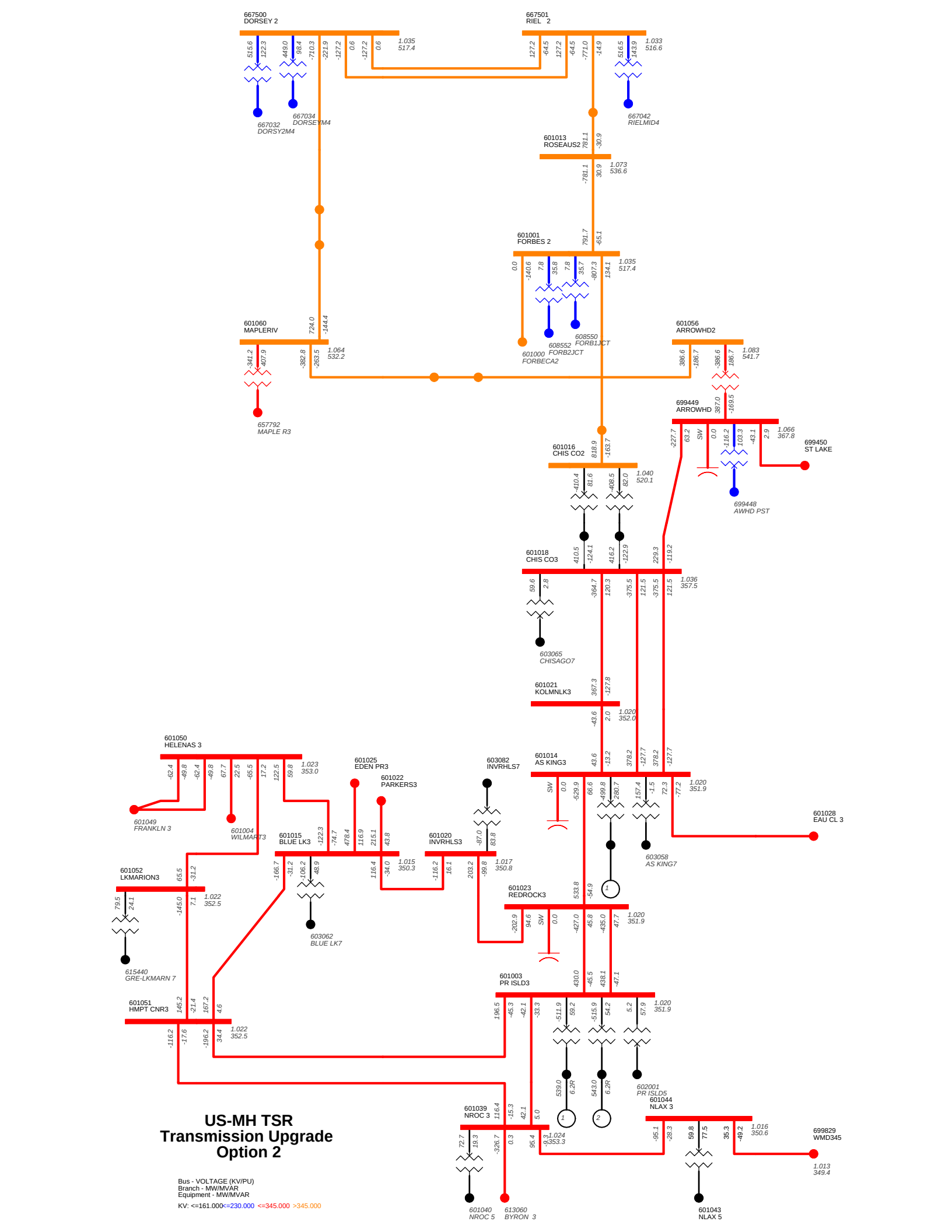
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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BYRON 3
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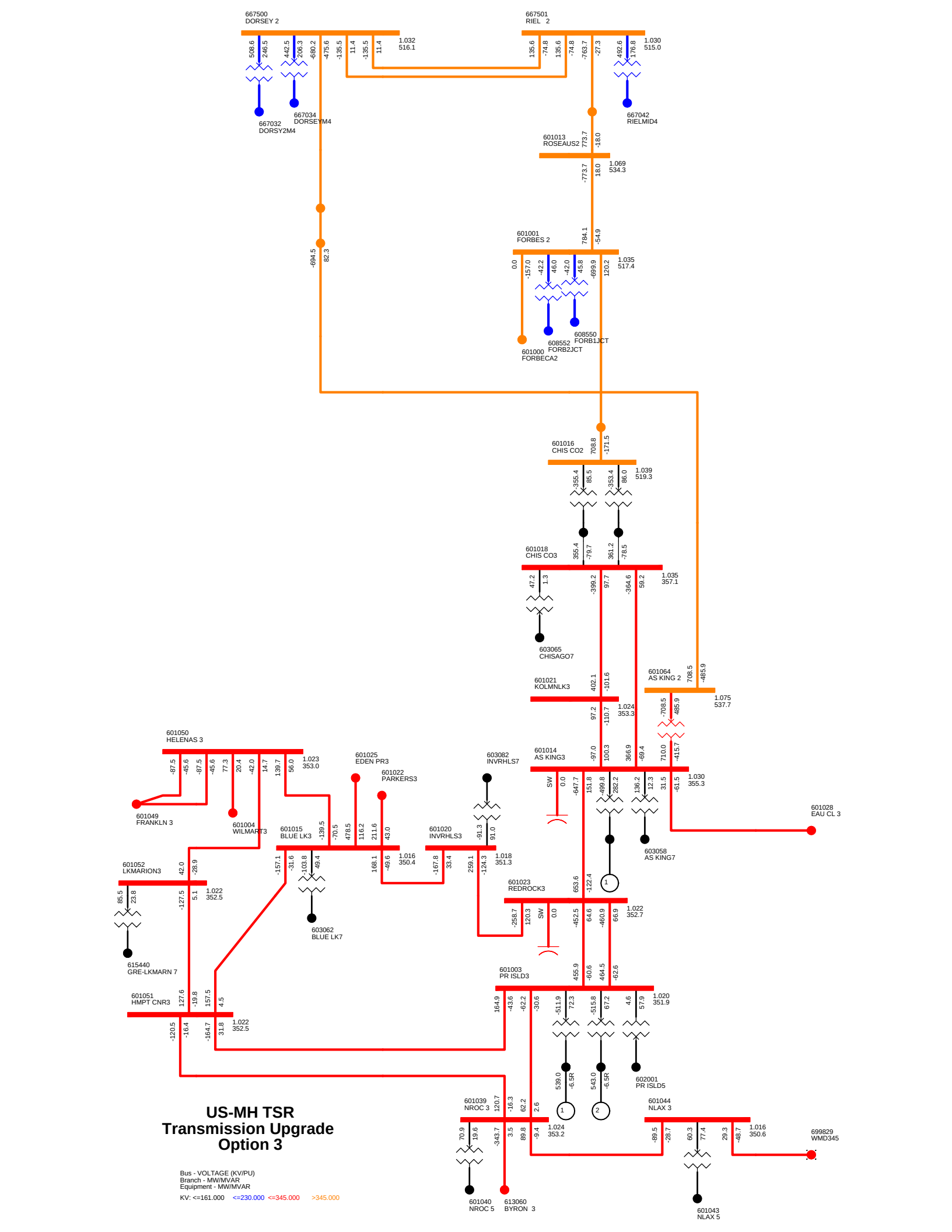
NLAX 5
699829
WMD345
US-MH TSR
Transmission Upgrade
Option 2
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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BYRON 3
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601043
NLAX 5
699829
WMD345
603058
AS KING7
601028
EAU CL 3
US-MH TSR
Transmission Upgrade
Option 3
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

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Appendix

C

Network Analysis Results

Table C-1: Impact of Transmission Upgrade Options on SUPK Benchmark Case
Impacts Exceeding 2% of Monitored Element Rating

** From bus **	** To bus **	CKT	Rating (MVA)	Benchmark Case Loading (%)	Benchmark Case with Option 1 Loading (%)	Benchmark Case with Option 2 Loading (%)	Benchmark Case with Option 3 Loading (%)
6186:GENLACGENCOU			260	114.2	119.9	120.3	120.8
603022 SOURIS 7 115	605634 VELVA TAP 115	1	80	99.3	101.8		
603152 T-CRNRS7 115	605028 T CORNE8 69.0	1	71.9	103.1	105.1	105.2	105.2
615518 GRE-4CORNRS869.0	B$0192 115/69 1.00	1	28	101.5		105.3	
615561 GRE-WST CLD869.0	B$0194 115/69 1.00	1	46.7	99.7	102.3		
620189 MAPLER1Y 345	657792 MAPLE R3 345	1	420	92.1	111.2	102.3	
620190 MAPLER2Y 345	657792 MAPLE R3 345	1	420	92.1	111.2	102.3	
620199 JAMSTN1Y 345	620269 JAMSTWN7 115	1	140	102.4	105.5	106.1	
620200 JAMSTN2Y 345	620269 JAMSTWN7 115	1	140	102.4	105.5	106.1	
620245 WILTON 7 115	620281 WILT TAP 115	1	106.3	95.0	100.0	100.1	
620281 WILT TAP 115	620285 SOLWAY 7 115	1	106.3	98.3	103.0	103.2	
620269 JAMSTWN7 115	620270 LADISH 7 115	1	158.8	99.0		101.0	
620269 JAMSTWN7 115	620275 NJAMES 7 115	1	106.3	137.6	143.0	144.0	
620272 JAMESPK7 115	620273 JAMETAP7 115	1	106.3	168.8	172.2	173.0	
620273 JAMETAP7 115	620275 NJAMES 7 115	1	106.3	149.1	153.7	154.6	
630341 IAFINDP8 69.0	631029 IAFINDP7 115	1	31.3	148.6	152.7	152.7	
652421 WILISTN7 115	661012 CLBRTSN7 115	1	80	200.5	202.6		
661084 TIOGA4 4 230	672603 BDV 4 230	1	200	93.4	106.7	102.8	
681523 GENOA 5 161	681531 LAC TAP5 161	1	279	112.4	118.5	118.8	119.0

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

** From bus ** ** To bus ** CKT	Owner	Rating (MVA)	Benchmark Case Loading (%)	Option 1 Study Case Loading (%)	Option 1 Study Case DF (%)	Option 2 Study Case Loading (%)	Option 2 Study Case DF (%)	Option 3 Study Case Loading (%)	Option 3 Study Case DF (%)	Contingency
3532:ELNHNZNAPRRN	MISO	163.0	80.5	101.8	3.15	109.4	4.28	108.3	4.13	C:Contingency of FlowGate 3532
3766:DUNHAZARNHAZ	MISO	37.0	42.4	101.9	2.00					C:Contingency of FlowGate 3766
6174:SONCCTCOCSON	MISO	430.0	114.6	117.6	1.15	119.5	1.93	122.8	3.19	C:Contingency of FlowGate 6174
6189:ADARCRBYRPVV	MISO	103.0	81.6	109.0	2.57	106.2	2.31	110.1	2.67	C:Contingency of FlowGate 6189
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	88.2					113.4	16.43	C:B_XEL_COON_CK-TERMINL Open 601019 COON CK3 345 601024 TERMINL3 345 1 Open 601024 TERMINL3 345 605585 TERMID1Y 110 10 Open 603110 TERMINL7 115 605585 TERMID1Y 110 10 Open 605516 TERTER19 34.5 605585 TERMID1Y 110 10
601019 COON CK3 345 601021 KOLMNLK3 345 1	XEL	717.0	90.1					114.6	15.97	C:601019 COON CK3 345 601024 TERMINL3 345 1
608651 MUDLAKE7 115 608652 BRAINRD7 115 1	MP	132.0	99.5			107.2	0.92			C:608612 RIVERTN4 230 608617 MUDLAKE4 230 1
620247 CASS LK7 115 657710 NARY 7 115 1	OTP/MPC	105.6	86.7	103.2	1.58	105.4	1.80			C:620345 WILTON 4 230 620447 CASS LK4 230 1
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/BEPC	144.4	98.1	107.4	1.22	111.5	1.76	119.4	2.80	C:615903 GRE-BALTA 4 230 620379 RUGBY 4 230 1
652553 MOORHED4 230 652554 MORRIS 4 230 1	WAPA	239.0	84.1			102.5	4.00			C:620314 BIGSTON4 230 620325 BROWNSV4 230 1
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	250.0	96.3			105.0	1.98			C:F601C
659105 LELANDO3 345 659201 LELND1TY 345 1	BEPC	250.0	98.2			106.3	1.84			C:R602F
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	118.4	122.3	1.77	128.3	4.50	123.4	2.27	C:659101 ANTELOP3 345 659183 CHAR.CK3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	92.0			100.6	3.91			C:657749 CENTER1G 22.0 657751 CENTER 4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	99.4	101.9	1.14	107.6	3.73	103.9	2.05	C:608601 CENTRDC4 230 657748 CENTER2G 20.0 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	99.4	101.9	1.14	107.6	3.73	103.9	2.05	C:608601 CENTRDC4 230 657756 SQBUTTE4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	93.2			102.3	4.14			C:659183 CHAR.CK3 345 659302 CHAR.CK4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	95.8			103.9	3.68			C:661015 COYOTE1G 24.0 661016 COYOTE 3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	103.5	105.9	1.09	111.7	3.73	108.0	2.05	C:615001 GRE-COAL 41G22.0 615600 GRE-COAL CR4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	103.5	106.0	1.14	111.7	3.73	108.0	2.05	C:615002 GRE-COAL 42G22.0 615600 GRE-COAL CR4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	97.5	100.9	1.55	106.3	4.00	102.2	2.14	C:659106 LELANDO4 230 659110 LELAN41G 22.0 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	123.0	128.4	2.45	136.2	6.00	129.8	3.09	C:659105 LELANDO3 345 659201 LELND1TY 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	91.8			101.9	4.59			C:652519 OAHE 4 230 652521 SULLYBT4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	95.9			104.1	3.73			C:SINGLE-046 Open 657791 CENTER 3 345 661016 COYOTE 3 345 1 Open 661015 COYOTE1G 24.0 661016 COYOTE 3 345 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	91.4			101.5	4.59			C:652521 SULLYBT4 230 652527 WHITLOK4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	93.1			102.3	4.18			C:652216 WATFORD4 230 659302 CHAR.CK4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	91.6			100.8	4.18			C:652216 WATFORD4 230 652400 WILISTN4 230 1
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500.0	91.0			101.1	4.59			C:652527 WHITLOK4 230 661038 GLENHAM4 230 1
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200.0	93.4	124.8	5.71					C: 601060 MAPLERIV 500 601062 MIDCOMP-S 500 1
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200.0	136.3					122.9	-2.44	C:R602F