Appendix C NDEX Wind Injection

Case File - C:\MP-MH-EHV\Work\Bison-Zion\Bison-Zion-PF\MH_SUPK_B_W1AssND.sav
Sub File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP_MH_EHV.sub
Mon File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP-MH.mon
Con File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP_MH_EHV-W1A.con
Exc File -

Transfer From: NDEX-Load
Transfer To: EAST_MISO
Transfer Level: 2000 MW
Transfer Goal: 2000 MW
System Intact DF 5.%
Contingency DF 5.%

Tue, 29 Jan 2013 13:52:34

MW*DF as % of Line Rating Cutoff: 9999.%

Transfer MW	Limiting Facility	Outage	DF%	Remedy	$M
-3560	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601061 DBCOMPN 500 667500 DORSEY 2 500 1	10.7	DC Runback	0
-3490	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601060 BISON 500 601062 DBCOMPS 500 1	10.7	DC Runback	0
-3490	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601061 DBCOMPN 500 601062 DBCOMPS 500 1	10.7	DC Runback	0
-235	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	20.5	DC Runback	0
185	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601046 ALEXSS3 345 601047 QUARRY3 345 1 Open 601046 ALEXSS3 345 601047 QUARRY3 345 2	21.1	DC Runback	0
355	Quarry-St. Cloud 115 kV at 100% of 239 MVA (1200 amps) Owner(s): XCEL ~9 Miles	Open 601010 MNTCELO3 345 601047 QUARRY3 345 1 Open 601010 MNTCELO3 345 601047 QUARRY3 345 2	6.1	DC Runback	0
430	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	System Intact	15.1	Construct Bison-Brookings 345 kV line (to get 545.1 MW transfer) $270M	$270.00M
495	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	7.3	Upgrade To 672 MVA	$8.00M
510	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	7.3	Upgrade to 1479 Amps (795 ACSS)	$4.80M
590	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601046 ALEXSS3 345 601047 QUARRY3 345 1 Open 601046 ALEXSS3 345 601047 QUARRY3 345 2	18.2		
700	Quarry-St. Cloud 115 kV at 100% of 239 MVA (1200 amps) Owner(s): XCEL ~9 Miles	Open 601010 MNTCELO3 345 601047 QUARRY3 345 1 Open 601010 MNTCELO3 345 601047 QUARRY3 345 2	5.2	DC Runback	0
705	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	System Intact	13.7	Roseau Series Cap 2000 A Limit	
710	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	6.7		
855	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	Open Arpin-Rocky run 345 kV	6.0	Upgrade To 550 MVA	$7.50M
870	Broadland 345/230 kV tx at 100% of 400 MVA Owner(s): 659	System Intact	5.3		
880	Broadland 345/230 kV tx at 100% of 400 MVA Owner(s): 659	System Intact	5.3		
885	Huron-Broadland 230 kV at 100% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	System Intact	5.3		
930	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	6.2		
960	Coon Creek-Kohlman Lake 345 kV at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~15 Miles	Open Coon Creek-Terminal 345 kV	6.9	Upgrade (Terminal Equipment)	$.50M
1095	Sigel-Arpin 138 kV at 100% of 287 MVA (1201 amps) Owner(s): 691 5.23 Miles	Open Arpin-Rocky run 345 kV	5.1	Upgrade to 1394 Amps (795 ACSS)	$7.85M
1120	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.0	Upgrade to 774 Amps (336 ACSS)	$151.32M
1165	Quarry-St. Cloud 115 kV at 100% of 239 MVA (1200 amps) Owner(s): XCEL ~9 Miles	Open 601010 MNTCELO3 345 601047 QUARRY3 345 1 Open 601010 MNTCELO3 345 601047 QUARRY3 345 2 Change bus 667033 DORSEYS4 230 load by 486.5 MW dispatch	5.2	Upgrade to 1704 Amps (954 ACSS)	$9.09M
1165	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open Ridgeway-Richer 230 kV	14.2		
1195	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open Shannon-Running 230 kV	14.2		
1235	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	Open 601046 ALEXSS3 345 601047 QUARRY3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open Alexandria 345/115 kV Tx	15.2	Roseau Series Cap 2000 A Limit	

1305	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Owner(s): 659 ~198 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.9	Upgrade to 1200 Amp (Terminal Equipment)	$1.00M
1435	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.6	Upgrade to 622 Amps (266 ACSS)	$57.35M
1560	Quarry 345/115 kV Tx at 115% of 448 MVA Owner(s): XCEL	Open 601010 MNTCELO3 345 601047 QUARRY3 345 1 Open 601010 MNTCELO3 345 601047 QUARRY3 345 2	7.7	DC Runback	0
1595	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 652529 WATERTN3 345 659160 GROTON 3 345 1	5.8		
1605	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 652529 WATERTN3 345 659160 GROTON 3 345 1	5.8		
1635	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Antelope Valley-Broadland 345 kV	5.4		
1635	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Broadland 345/230 kV tx	5.4		
1635	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Broadland 345/230 kV tx	5.4		
1635	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Huron-Broadland 230 kV	5.4		
1635	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open Buffalo-Jamestown 345 kV	5.7		
1635	Coon Creek-Kohlman Lake 345 kV at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~15 Miles	Open Coon Creek-Terminal 345 kV 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	6.9		
1650	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open T-Corners-Wien 115 kV Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV	12.9	Upgrade to (2-795 ACSS)	$159.04M
1650	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open Buffalo-Jamestown 345 kV	5.7		
1655	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Owner(s): 659 ~198 Miles	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	6.2		
1660	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Eau Claire-Arpin 345 kV Open T-Corners-Wien 115 kV Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV	12.9		
1675	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open 699706 WIEN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV Open 680242 LUBLIN 69.0 680505 LAKEHEAD 69.0 1	12.7		
1675	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open 699706 WIEN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV Open 680242 LUBLIN 69.0 680505 LAKEHEAD 69.0 1	12.7		
1700	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Eau Claire-Arpin 345 kV Open 699706 WIEN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV Open 680242 LUBLIN 69.0 680505 LAKEHEAD 69.0 1	12.7		
1780	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open Jamestown-Center 345 kV	5.6		
1795	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open Jamestown-Center 345 kV	5.6		
1805	Whitlock-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~39 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.6	Upgrade to 690 Amps (336 ACSS)	$60.84M
1875	Sully Buttes-Whitlock 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~22 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.9	Upgrade to 681 Amps (336 ACSS)	$34.32M
1955	Oahe-Sully Buttes 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~20 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.2	Upgrade to 670 Amps (336 ACSS)	$31.20M
1995	Chisago County 500/345/34.5 kV Tx #10 at 115% of 1203 MVA Owner(s): XCEL	Open Chisago County 500/345/34.5 kV Tx #9	14.1	Upgrade To Beyond Single Tx	$25.00M
1995	Chisago County 500/345/34.5 kV Tx #9 at 115% of 1203 MVA Owner(s): XCEL	Open Chisago County 500/345/34.5 kV Tx #10	14.1	Upgrade To Beyond Single Tx	$25.00M

Case File - C:\MP-MH-EHV\Work\Bison-Zion\Bison-Zion-PF\MH_SUPK_B_Y1BssND.sav
Sub File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP_MH_EHV.sub
Mon File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP-MH.mon
Con File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP_MH_EHV-Y1B.con
Exc File - C:\MP-MH-EHV\Work\Bison-Zion\MUST-Input\MP-MH-Exclude.exc

Transfer From: NDEX-Load
Transfer To: EAST_MISO
Transfer Level: 2000 MW
Transfer Goal: 2000 MW
System Intact DF 5.%
Contingency DF 5.%

Tue, 29 Jan 2013 15:06:09

MW*DF as % of Line Rating Cutoff: 9999.%

Transfer MW	Limiting Facility	Outage	DF%	Remedy	$M
665	Chisago County 500/345/34.5 kV Tx #10 at 115% of 1203 MVA Owner(s): XCEL	Open Chisago County 500/345/34.5 kV Tx #9	12.0	Upgrade To Beyond Single Tx	$25.00M
665	Chisago County 500/345/34.5 kV Tx #9 at 115% of 1203 MVA Owner(s): XCEL	Open Chisago County 500/345/34.5 kV Tx #10	12.0	Upgrade To Beyond Single Tx	$25.00M
685	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	7.6	Upgrade To 672 MVA	$8.00M
695	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	7.6	Upgrade to 1453 Amps (795 ACSS)	$4.80M
890	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	7.0		
905	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	7.0		
915	Broadland 345/230 kV tx at 100% of 400 MVA Owner(s): 659	System Intact	5.8		
930	Huron-Broadland 230 kV at 100% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	System Intact	5.8		
1060	Blackberry-Boswell 230 2 at 110% of 399 MVA (1002 amps) Owner(s): MP ~18 Miles	Open Blackberry-Boswell 230 1	5.8	Upgrade to 1235 Amps (636 ACSS)	$28.62M
1185	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.6	Upgrade to 777 Amps (336 ACSS)	$151.32M
1230	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	Open Arpin-Rocky run 345 kV	5.6	Upgrade To 448 MVA	$6.00M
1295	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Owner(s): 659 ~198 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	7.6	Upgrade to 1200 Amp (Terminal Equipment)	$1.00M
1465	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	5.9	Upgrade to 622 Amps (266 ACSS)	$57.35M
1495	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open 652529 WATERTN3 345 659160 GROTON 3 345 1	6.5		
1505	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open 652529 WATERTN3 345 659160 GROTON 3 345 1	6.5		
1555	Antelope Valley-Broadland 345 kV at 110% of 478 MVA (800 amps) Owner(s): 659 ~198 Miles	Open 659105 LELANDO3 345 659160 GROTON 3 345 1	7.0		
1630	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open Antelope Valley-Broadland 345 kV	5.1		
1630	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open Broadland 345/230 kV tx	5.1		
1630	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open Broadland 345/230 kV tx	5.1		
1635	Bismarck-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~97 Miles	Open Huron-Broadland 230 kV	5.1		
1650	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Antelope Valley-Broadland 345 kV	5.7		
1650	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Broadland 345/230 kV tx	5.7		
1650	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Broadland 345/230 kV tx	5.7		
1650	652470 BISON 4 230 661047 HETINGR4 230 1 at 100% of 216.1 MVA (542 amps) Owner(s): WAPA ~37 Miles	Open Huron-Broadland 230 kV	5.7		
1680	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open Buffalo-Jamestown 345 kV	6.0		
1690	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open Buffalo-Jamestown 345 kV	6.0		

1770	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open T-Corners-Wien 115 kV Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV	12.7	Upgrade to (2-795 ACSS)	$159.04M
1775	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Eau Claire-Arpin 345 kV Open T-Corners-Wien 115 kV Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV	12.7		
1780	Broadland 345/230 kV tx at 120% of 400 MVA Owner(s): 659	Open Bismarck-Glenham 230 kV	6.4		
1790	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open AS King-Eau Claire 345 kV Open Eau Claire-Arpin 345 kV Open 699706 WIEN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV Open 680242 LUBLIN 69.0 680505 LAKEHEAD 69.0 1	12.5		
1790	Huron-Broadland 230 kV at 120% of 400 MVA (1004 amps) Owner(s): WAPA ~3 Miles	Open Bismarck-Glenham 230 kV	6.4		
1790	Whitlock-Glenham 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~39 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.2	Upgrade to 695 Amps (336 ACSS)	$60.84M
1810	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Eau Claire-Arpin 345 kV Open 699706 WIEN 115 699710 STRATFRD 115 1 Open Council Creek-Timberwolf 69 kV Open Mauston-Hilltop 69 kV Open 680242 LUBLIN 69.0 680505 LAKEHEAD 69.0 1	12.5		
1850	Sully Buttes-Whitlock 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~22 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.5	Upgrade to 687 Amps (336 ACSS)	$34.32M
1855	Electric Jct-Nelson 345 kV at 100% of 1234 MVA (2065 amps) Owner(s): N/A ~56 Miles	Open Arrowhead-Stone Lake 345 kV	12.2		
1925	Garrison-Jamestown 230 kV at 110% of 318 MVA (798 amps) Owner(s): WAPA ~138 Miles	Open 652441 GARRISN4 230 659284 HILKEN 4 230 1 Open Garrison-Leland Olds 230 kV	5.1	Upgrade to 888 Amps (477 ACSS)	$175.26M
1925	Oahe-Sully Buttes 230 kV at 110% of 240 MVA (602 amps) Owner(s): WAPA ~20 Miles	Open 652506 FTTHOMP3 345 659105 LELANDO3 345 1	6.8	Upgrade to 676 Amps (336 ACSS)	$31.20M

Appendix D Costs

The costs used in this study are based on engineering judgment. Costs used in various studies were updated based on feedback of actual construction costs from various sources. The costs used are in 2012 dollars.

The cost used for line rebuilds and reconductor is shown below.

kV	$M/mile
0	0.2
41.6	0.4
69	0.75
115	0.75
138	0.8
161	1
230	1.3
345	2.8
500	4
765	5

The cost used for transformer replacement is shown below.

MVA	$M
0	1.2
70	1.4
112	1.6
187	2
224	4
336	6
448	7.5
550	8
672	9
800	20
1203	25
9999	30

The build out cost for the Fargo and Iron Range Options are shown below:

West Option	Units	Cost $M	Total	East Option	Units	Cost $M	Total
W1A				**Y1A**			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	8	16	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			942.6	Total			1206.1
W1AP				**Y1AP**			
W1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	1	10	10	Y1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	1	10	10
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	8	16	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			952.6	Total			1216.1
W1B				**Y1B**			
W1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2			0	Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2			0
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	8	16	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
				Blackberry 345/230 kV TX	1	6	6
			0				
Total			841	Total			1104.5
W1C				**Y1C**			
W1 with MVP not already in case added			0	Y1 with MVP not already in case added			0
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1 & #2	2	8	16	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203.2	0.5	101.6
Total			942.6	Total			1206.1
W2A				**Y2A**			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	8	8	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594	Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594
Brooking County 500/345 kV Tx #1 & #2	2	8	16	Brooking County 500/345 kV Tx #1 & #2	2	8	16

Total			1443	Total			1714.5
W2B				**Y2B**			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	8	8	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Brookings County345 kV line	180	1.5	270	Bison-Brookings County 345 kV line	180	1.5	270
Total			1103	Total			1374.5
W6A				**Y6A**			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	8	8	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594	Bison-Brookings County 500 kV line 50% series compensated	180	3.3	594
Brooking County 500/345 kV Tx #1 & #2	2	8	16	Brooking County 500/345 kV Tx #1 & #2	2	8	16
Brooking County-Split Rock 500 kV line	60	3	180	Brooking County-Split Rock 500 kV line	60	3	180
Split Rock 500/345 kV TX #1 & #2	2	8	16	Split Rock 500/345 kV TX #1 & #2	2	8	16
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5
Corridor Txs	2	3	6	Corridor Txs	2	3	6
Brookings County-Lyon County 345 kV line #2	50	0.5	25	Brookings County-Lyon County 345 kV line #2	50	0.5	25
Helena-Lake Marion-Hampton Corner 345 kV line #2	198	0.5	99	Helena-Lake Marion-Hampton Corner 345 kV line #2	198	0.5	99
Total			2148	Total			2419.5
W6B				**Y6B**			
Dorsey-Bison 500 kV line 50% series compensated	250	3.3	825	Dorsey-Blackberry 500 kV line 50% series compensated	275	3.3	907.5
Bison 500/345 kv Tx #1	1	8	8	Blackberry 500/345 kV Tx #1 & #2	2	8	16
			0	Blackberry-Arrowhead 345 kv lines #1 & #2	70	2.5	175
			0	Blackberry 345/230 kV TX	1	6	6
Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5	Bison-Alexandria-Quarry-Monticello 345 kV line #2	203	0.5	101.5
Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5	Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	111	2.5	277.5
Corridor Txs	2	3	6	Corridor Txs	2	3	6
Brookings County-Lyon County 345 kV line #2	57	0.5	28.5	Brookings County-Lyon County 345 kV line #2	57	0.5	28.5
Helena-Lake Marion-Hampton Corner 345 kV line #2	80	0.5	40	Helena-Lake Marion-Hampton Corner 345 kV line #2	80	0.5	40
Total			1286.5	Total			1558

Appendix E Iron Range Option With Fargo Tap Sensitivity

E.1 Summary

The scenario of a tap on the Winnipeg-Iron Range line going to Fargo was added to the eastern configuration and studied.

E.1.1 Fargo Injection

The most limiting first contingency incremental transfer for the Fargo wind injection is shown in Table E.1-1.

Table E.1-1 Worst Case Limiters Fargo Wind Injection

Option	MW	Limiting Facility	Outage	Case
West	-240	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line	W1B1
East	670	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line Maple River 345/230 kV tx 2 Maple River 345/230 kV tx 1	Y1B1
East with Fargo Tap	-340	Stone Lake 345/161 kV Tx	Stone Lake-Gardner Park 345 kV line	T1B1

Eastern 500 kV Line with Fargo Tap

The Eastern 500 kV with Fargo Tap provides a path that balances the 500 kV lines from Manitoba better than without the Fargo Tap. The tap line provides a path parallel to the CapX Fargo-Twin Cities to get wind injection out of the Red River Valley. Higher levels of wind injection can be reached before additional transmission lines are required. Being the power has a more direct connection to the Arrowhead area, the Roseau capacitors and Stone Lake transformers need upgrading, which is not required without the Fargo Tap line.

E.1.2 Fargo/Brookings County Injection

The most limiting first contingency incremental transfer for the Fargo/Brookings wind injection is shown in Table E.1-2.

Table E.1-2 Worst Case Limiters Fargo/Brookings Wind Injection

Option	MW	Limiting Facility	Outage	Case
West	-530	Bison-Maple River 230 kV line	Bison-Maple River 345 kV line	W1B2
East	1130	Split Rock-White 345 kV line	Brookings Co-Lyon Co 345 kV line	Y1B2
East with Fargo Tap	1125	Split Rock-White 345 kV line	Brookings Co-Lyon Co 345 kV line	T1B2

Eastern 500 kV Line with Fargo Tap

The Eastern Line with Fargo Tap provides for more wind injection with less transmission improvements then the western line but slightly less than the eastern line without the tap. The benefit of the eastern line with the Fargo tap is it ties the Red River Valley into the eastern side of Minnesota for wind injection while providing Manitoba power to the Red River Valley when needed.

E.2 Study Options

For the purpose of this study, there were three main transmission options: the west (Bison) or east (Blackberry) 500 kV lines coming out of Dorsey and the east (Blackberry) 500 kV line with a 345 kV line from Fargo tapping the Dorsey to Blackberry 500 kV line. The cases studied are listed in Table E.2-1 Study Options. With the wind injection at the Bison 345 kV bus or at the Bison and Brooking County 345 kV buses.

Table E.2-1 Study Options

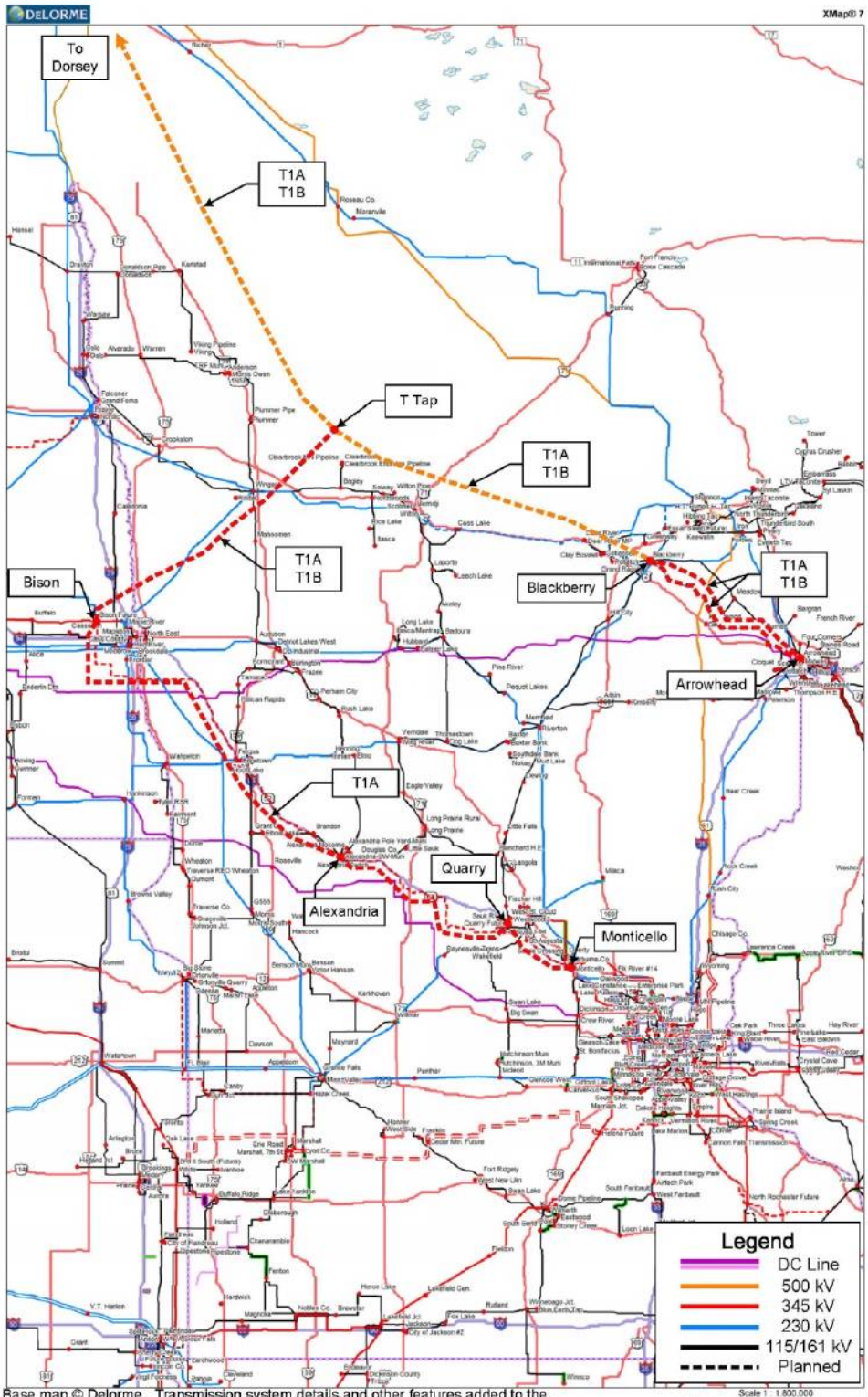
Fargo Option	Iron Range Option	Iron Range with Fargo Tap Option
W1A	**Y1A**	**T1A**
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2 T Tap-Bison 345 kv lines #1 & #2 T Tap 345/230 kV TX
W1AP	**Y1AP**	
W1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	Y1 with phase shirt transformer (PST) on Glenboro-Harvey 230 kV line at Glenboro	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2	
W1B	**Y1B**	**T1B**
W1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2	Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2	Y1 without Bison-Alexandria-Quarry-Monticello 345 kV line #2 + T Tap
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX T Tap-Bison 345 kv lines #1 & #2 T Tap 345/230 kV TX
W1C	**Y1C**	
W1 with MVP not already in case added	Y1 with MVP not already in case added	
Dorsey-Bison 500 kV line 50% series compensated	Dorsey-Blackberry 500 kV line 50% series compensated	

Bison 500/345 kv Tx #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2	Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2	
W2A	**Y2A**	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2	
W2B	**Y2B**	**T2B**
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Brookings County345 kV line	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 345 kV line	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 345 kV line T Tap-Bison 345 kv lines #1 & #2 T Tap 345/230 kV TX
W6A	**Y6A**	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2 Brooking County-Split Rock 500 kV line Split Rock 500/345 kV TX #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2 Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Brookings County 500 kV line 50% series compensated Brooking County 500/345 kV Tx #1 & #2 Brooking County-Split Rock 500 kV line Split Rock 500/345 kV TX #1 & #2 Bison-Alexandria-Quarry-Monticello 345 kV line #2 Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2	

Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	
W6B	**Y6B**	
Dorsey-Bison 500 kV line 50% series compensated Bison 500/345 kv Tx #1 Bison-Alexandria-Quarry-Monticello 345 kV line #2 Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2 Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	Dorsey-Blackberry 500 kV line 50% series compensated Blackberry 500/345 kV Tx #1 & #2 Blackberry-Arrowhead 345 kv lines #1 & #2 Blackberry 345/230 kV TX Bison-Alexandria-Quarry-Monticello 345 kV line #2 Hazel Creek-Panther-McLeod-Blue Lake 345 kV line #1 & #2 Corridor Txs Brookings County-Lyon County 345 kV line #2 Helena-Lake Marion-Hampton Corner 345 kV line #2	

Maps showing the options studied are included in FigureE.2-2 and Figure E.2-3.

Figure E.2-2 T1A and T1B Map



Base map © Delorme. Transmission system details and other features added to the base map © 2012 Excel Engineering, Inc. Minneapolis, Minnesota. All rights reserved

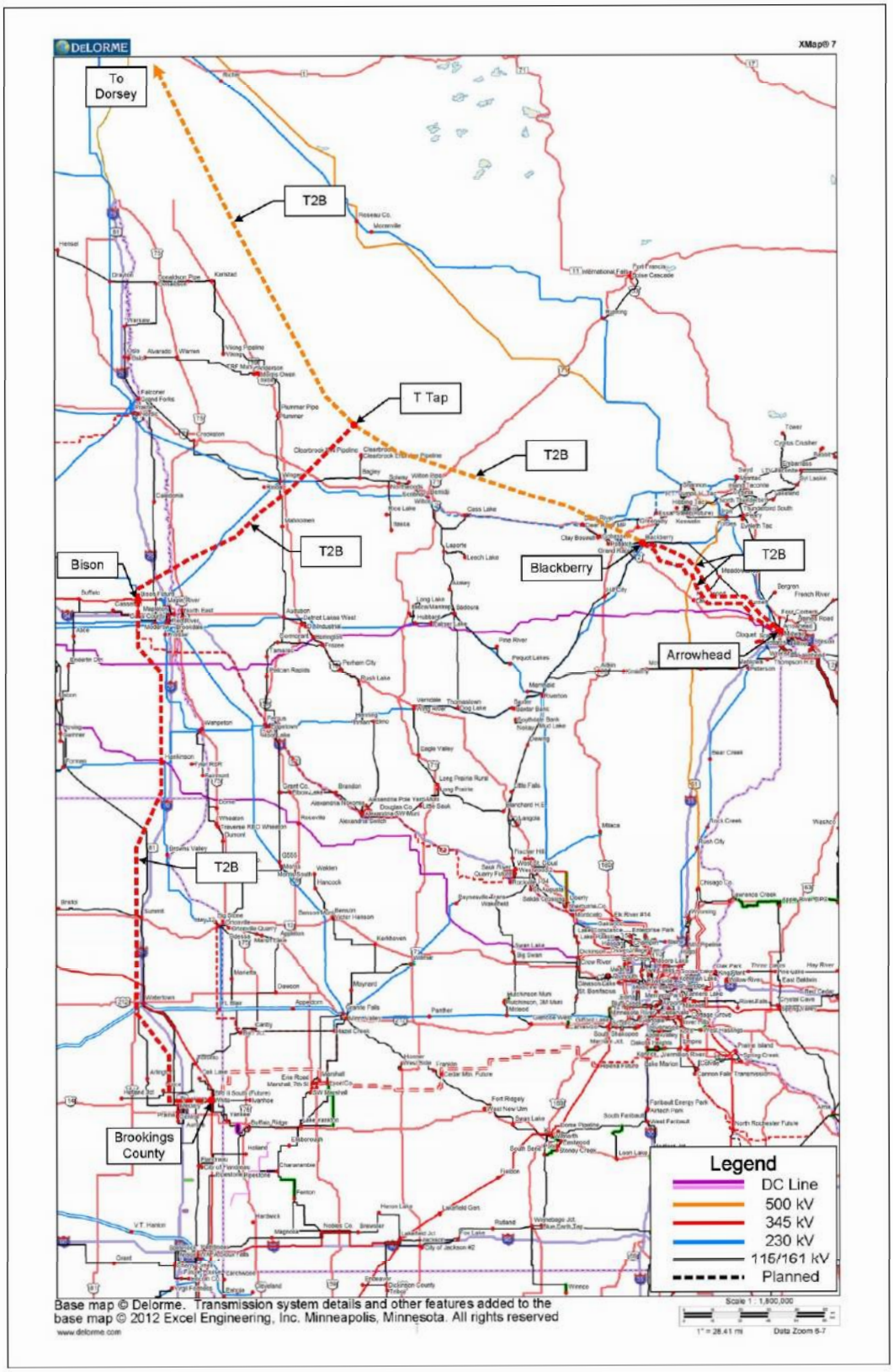
www.delorme.com

Scale 1 : 1,800,000

1" = 28.41 mi

Data Zoom 6-7

Figure E.2-3 T2B Map



E.3 Results

All comparisons were done using incremental costs. When a phase shifter was added to the Harvey-Glenboro 230 kV line, it made minimal differences in the overall results. The phase shifter was too far west of the injected areas to have a major effect on the study area.

E3.1 Fargo Wind Injection Results

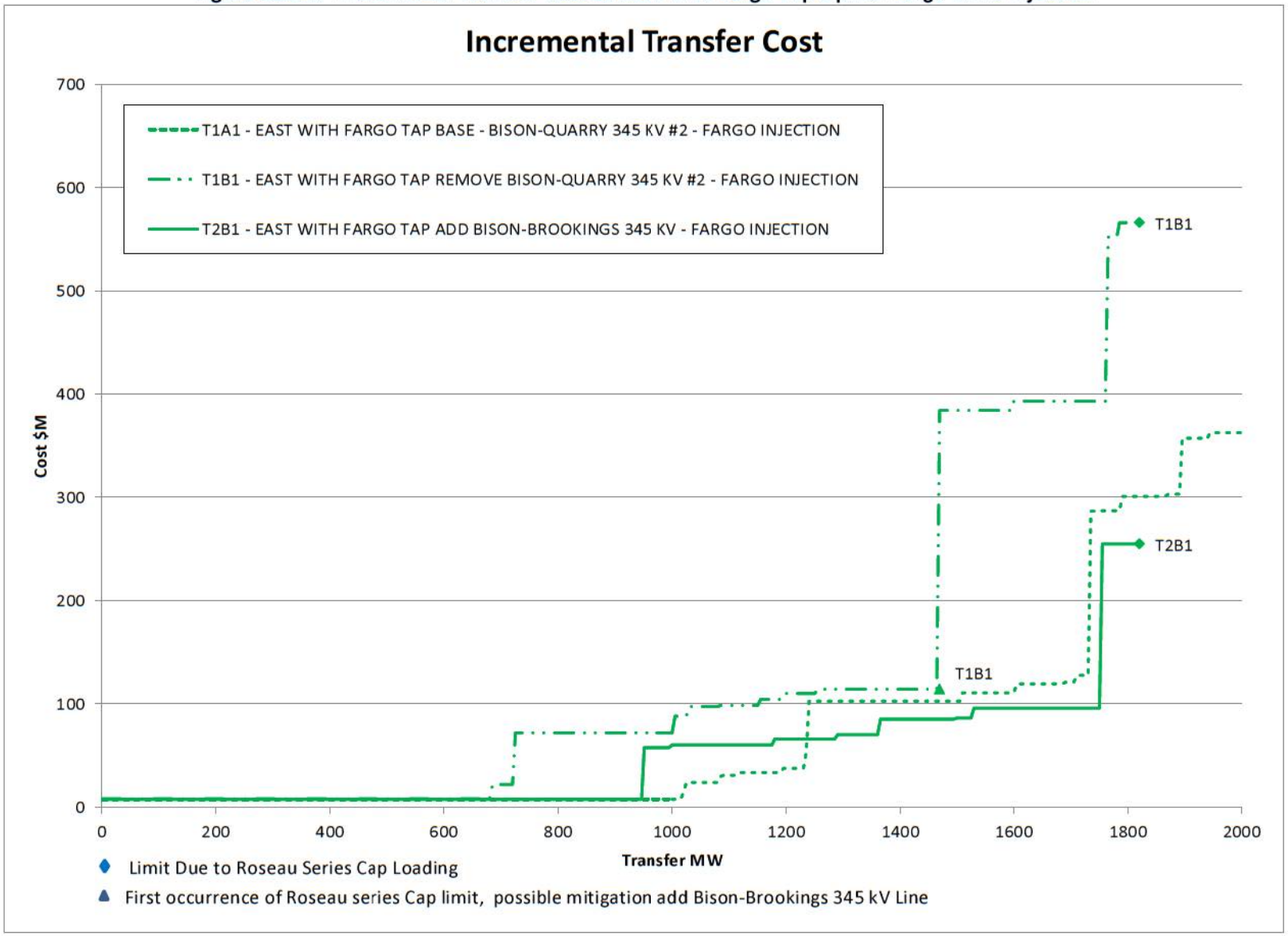
Eastern Option with Fargo Tap Fargo Wind Injection

The eastern option with the Fargo tap scenarios all have a 500 kV line from Dorsey to the Blackberry with 50% series compensation with the line tapped (T-Tap) south of the series compensation, a double circuit 345 kV line from T-Tap to Bison, a double circuit 345 kV line from the Blackberry to Arrowhead, two 500/345 kV transformers at Blackberry, one 345/230 kV transformer at Blackberry, and one 500/345 kV transformers at T-Tap. Only three scenarios were evaluated for this option, T1A, T1B, and T2B. With these scenarios, the Manitoba power and the wind injection are entering the 345 kV system at totally different points but are tied together. Most of the same upgrades due to CapX line outage are still required but at higher wind injection. Some occur after the 2000 MW cutoff. The Roseau capacitors overload for two of the three scenarios and the Stone Lake 345/161 kV transformer overloads for all of the three scenarios. The best performing scenario was the T1A which can go to the 2000 MW transfer level without the Roseau series capacitors system intact overloads. The Roseau series capacitors system intact overloads occur at higher transfer levels than the Fargo option.

The Bison-Maple River 345 kV, Bison-Maple River 230 kV, Maple River-Sheyenne 230 kV, Fargo-Moorhead 230 kV, Maple River-Frontier 230 kV, and Sheyenne-Audubon 230 kV lines and the Maple River 345/230 kV transformers overload for the loss of Bison-Alexandria 345 kV line are over 1000 MW wind injections when there is not an additional outlet for the wind injection out of the Fargo area. These lines still overload for some other scenarios but at higher wind injection levels. When the loss is the Alexandria-Quarry 345 kV, line the 115 kV system in the Alexandria area in addition to the Fargo area 230 kV system overloads. For T1A scenario, it occurs before the Fargo area overloads, -150. For a loss of the Quarry-Monticello 345 kV line, the 115 kV system in the St. Cloud area, Alexandria, and Fargo 230 and 115 kV system overloads. The overload output for all scenarios ran is in Appendix E.

The scenario with the lowest incremental cost is T2B but it only allows a transfer of 1820 MW. The second lowest incremental cost is T1A which is the Fargo Tap option and it is able to transfer 2000 MW. A chart showing the incremental cost is in Figure E3.1-1 . The scenario with the highest incremental cost is T1B.

Figure E3.1-1 Incremental Transfer Cost Eastern with Fargo Tap Option Fargo Wind Injection



Comparison of Options Fargo Wind Injection

The least incremental cost scenario is Y2A, eastern option with 500 kV line Bison-Brookings County. The 500 kV line only goes from Bison to Brookings County with transformers required at both ends. It provides to two independent outlets from Fargo for the wind injection. The east option with only 345 kV line instead is ranked fourth. The eastern option with the tap overloads the east transmission more. The second least cost incremental is Y2B which includes Stone Lake and Chisago Country #1 and #2 transformers upgrades. T2B is not the least cost option, but it provides for three independent outlets for wind injection from Bison and provides for a tie to North Dakota for the Manitoba generation, but it only has a 1820 MW transfer capability. A table showing the incremental cost is in Table E3.1-1.

The most costly incremental is Y1A, there are no additional independent outlets for the wind injections and upgrades to the 115 and 230 kV system are extensive. The Fargo options are not capable of getting the 2000 MW transfer. The chart comparing the wind injection options is shown in Figure E3.1-2. In order to compare easier the following charts have the data separated into individual options with both the Fargo wind injection and the Fargo/Brookings wind injection Figure E.3.1-3 to Figure E3.1-5 .

The eastern option has the first limiters occurring at higher wind injection than the other two options. For the eastern option with the Fargo Tap Stone Lake 345/161 kV transformer is a negative number for the Fargo wind injection. For the western option the first limiter is the Roseau capacitor banks. See Table E3.1-6 for the complete list of first limiters.

The eastern options have fewer system intact overloads than the western options. Also they occur at higher wind injection levels. The eastern options with the Fargo tap have even few system intact overloads than without the tap. A table showing the system intact overloads is in Table E3.1-7.

Table E3.1-1 Cost Comparison Fargo Wind Injection

	FARGO 500 MW	IRON RANGE 500 MW	IRON RANGE w/T Tap 500 MW	FARGO 1000 MW	IRON RANGE 1000 MW	IRON RANGE w/T Tap 1000 MW	FARGO 1500 MW	IRON RANGE 1500 MW	IRON RANGE w/T Tap 1500 MW	FARGO 2000 MW	IRON RANGE 2000 MW	IRON RANGE w/T Tap 2000 MW
1A Base Bison-Quarry #2	*(273 @ 490 MW)*	0	8	NA	42.5	8	NA	176	103	N/A	604	363
1A 60% 60% Series Comp new 500 kV	294	N/A	N/A	*(294 @ 670 MW)*	NA	N/A	NA	NA	N/A	N/A	N/A	N/A
1AP Add Glenboro Phase Shifter	284	0	N/A	*(284 @ 680 MW)*	48	N/A	NA	177	N/A	N/A	604	N/A
1B Remove Bison-Quarry #2	*(285 @ 50 MW)*	0	8	N/A	43	72	NA	304	384	N/A	558	*(565 @ 1820 MW)*
1B 60% 60% Series Comp new 500 kV	N/A	0	N/A	N/A	91	N/A	NA	360	N/A	N/A	614	N/A
1C Add All MVP	294	0	N/A	*(294 @ 630 MW)*	41	N/A	N/A	169	N/A	N/A	251	N/A
2A Add Bison-Brookings 500 kV with SC	(0 @ 375 MW)	0	N/A	*N/A*	0	N/A	N/A	9	N/A	N/A	193	N/A
2B Add Bison-Brookings 345 kV	*(0 @ 0MW)*	0	8	N/A	14	60	N/A	50	86	N/A	280	*(255 @ 1820 MW)*
6A Add Corridor Project Add Bison-Split Rock 500 kV with SC	0	0	N/A	8	0	N/A	*(15 @ 1355 MW)*	6	N/A	N/A	190	N/A
6B Add Corridor Project	287	0	N/A	*(287 @ 580 MW)*	36	N/A	N/A	180	N/A	N/A	615	N/A

Figure E3.1-2 Incremental Transfer Cost Fargo Wind Injection

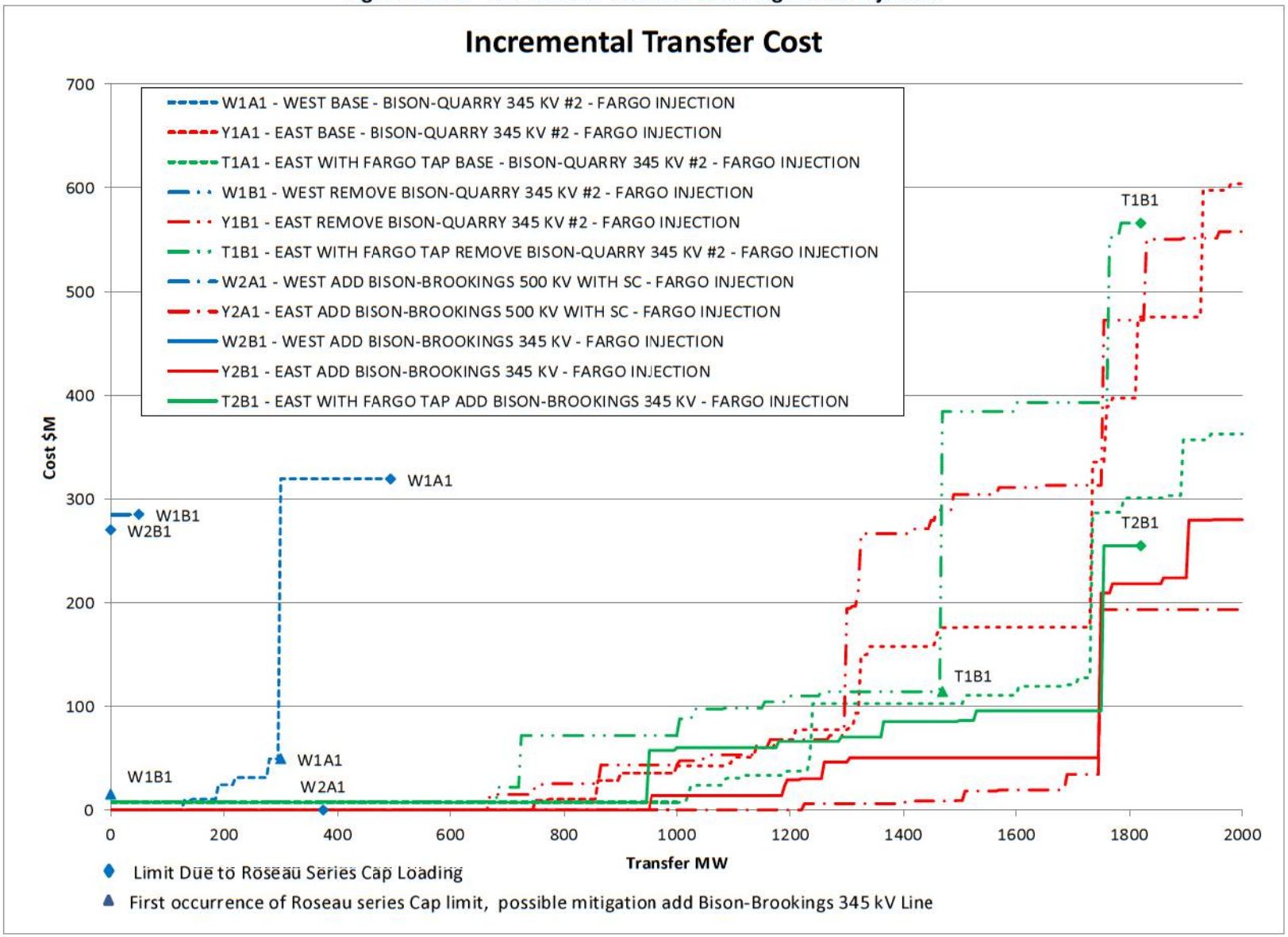


Figure E3.1-3 1A Base (Bison-Quarry 345 kV #2)

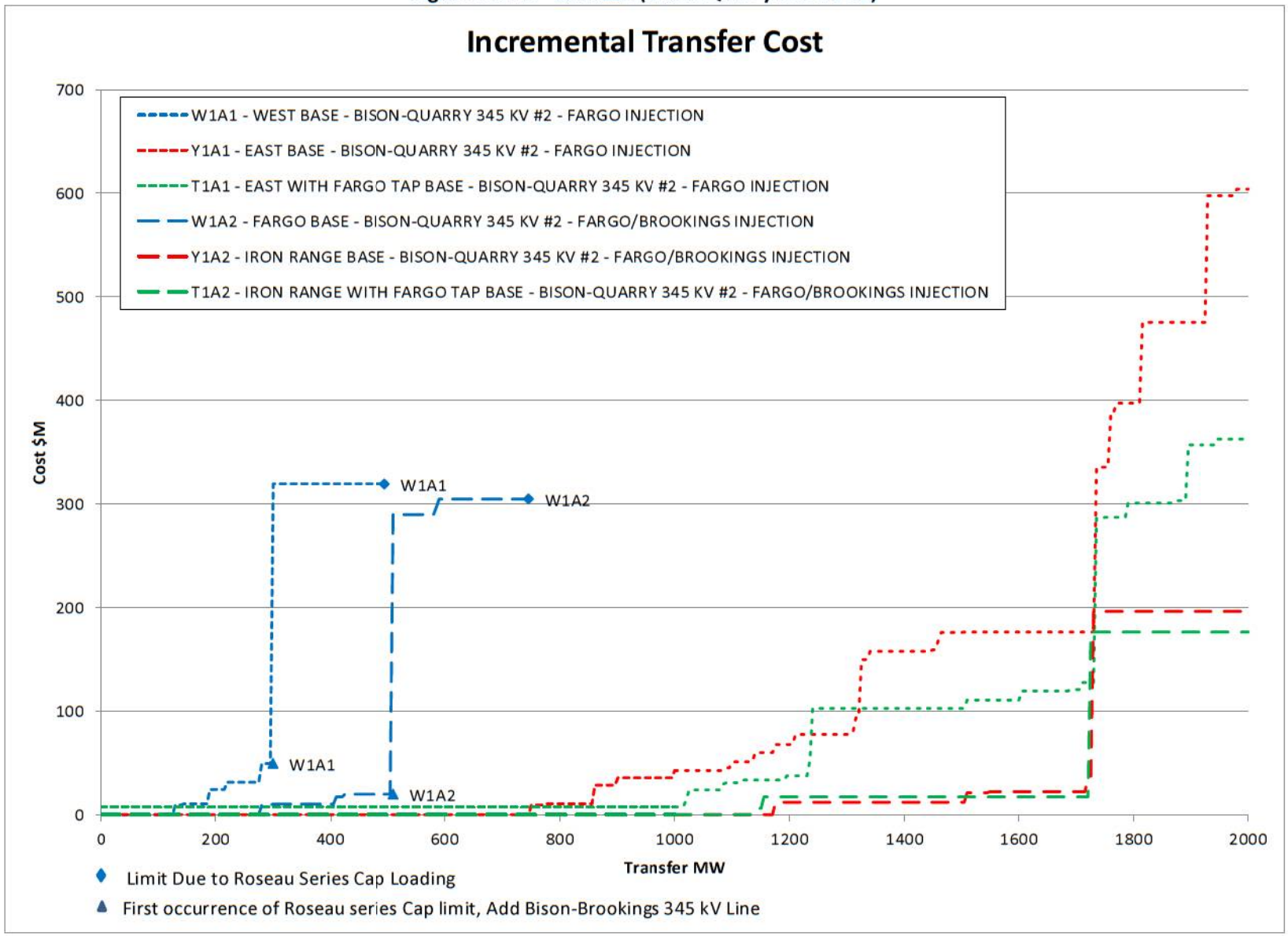


Figure E3.1-4 1B Remove Bison-Quarry 345 kV #2

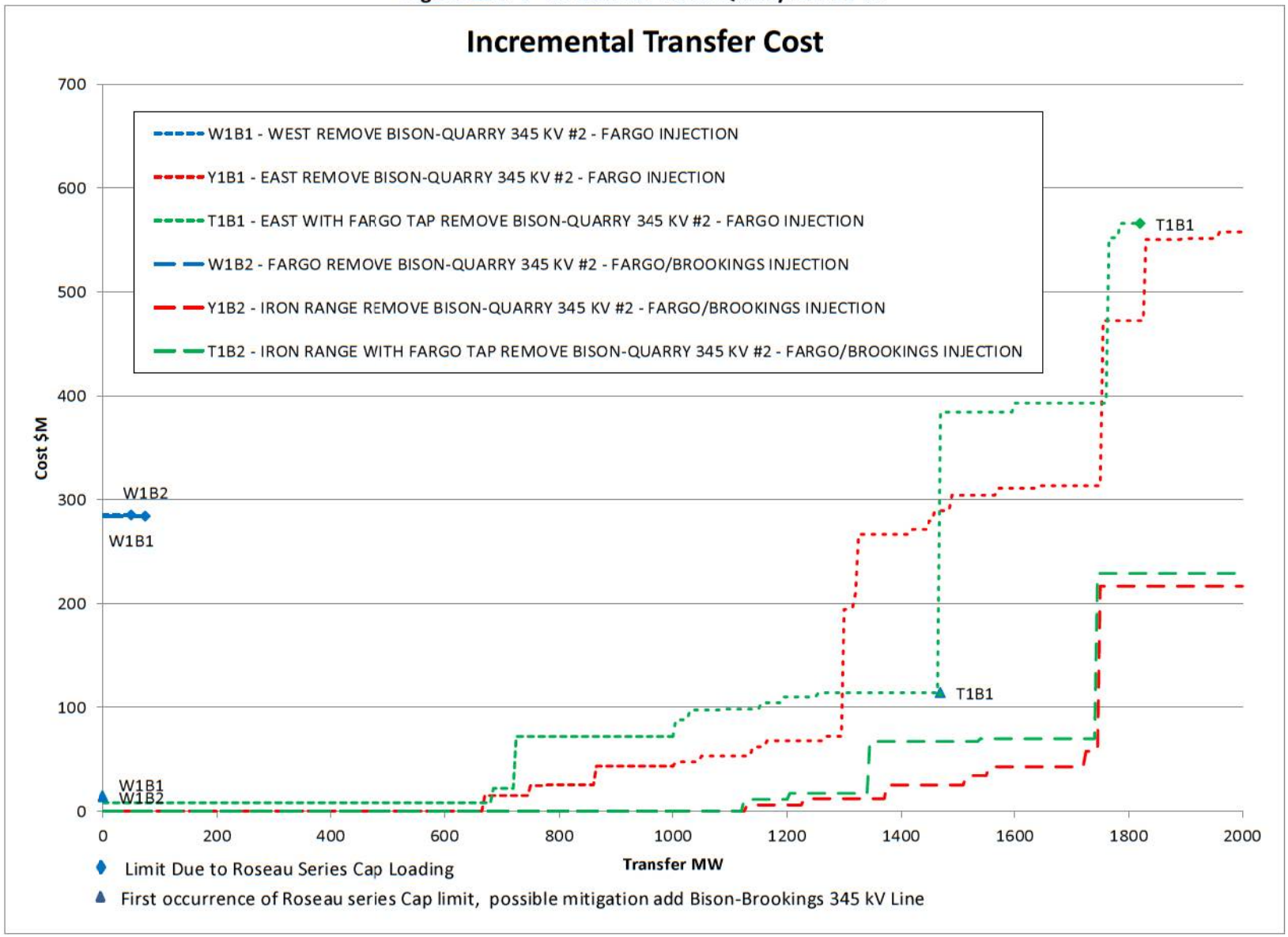


Figure E3.1-5 2B Add Bison-Brookings 345 kV

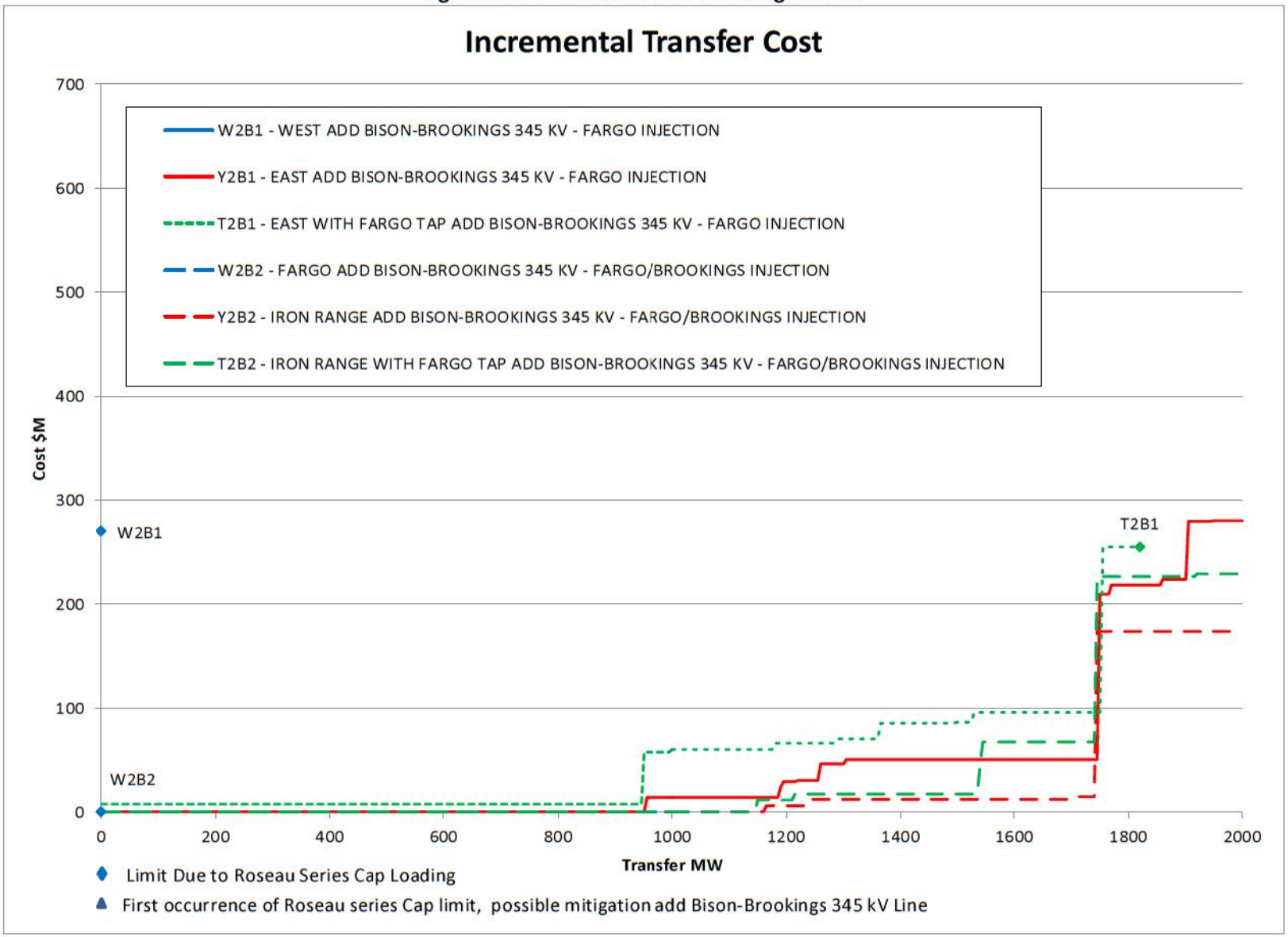


Table E3.1-6 First Limiters For All Options

Fargo Option				Iron Range Option				Iron Range with Fargo Tap Option			
Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage
W1A	Fargo - Base - Bison-Quarry 345 kV #2			Y1A	Iron Range - Base - Bison-Quarry 345 kV #2			T1A	Iron Range with Fargo Tap - Base - Bison-Quarry 345 kV #2		
W1A1	Fargo Wind Injection			Y1A1	Fargo Wind Injection			T1A1	Fargo Wind Injection		
190	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.0	Open Bison-Maple River 345 kV	750	Sheyenne-Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	-205	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	5.5	Open Stone Lake-Gardner Park 345 kV
W1A2	Fargo/Brookings Wind Injection			Y1A2	Fargo/Brookings Wind Injection			T1A2	Fargo/Brookings Wind Injection		
-255	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	19.0	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2	1175	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	28.6	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1	1145	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	5.6	Open Arpin-Rocky run 345 kV
W1A60	Fargo - Base - Bison-Quarry 345 kV #2, use 60% series compensation on new 500 kV line										
W1A160	Fargo Wind Injection										
105	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	22.3	Open Bison-Maple River 345 kV								
W1A260	Fargo/Brookings Wind Injection										
	DID NOT RUN										
W1AP	Fargo - Add Glenboro Phase Shifter			Y1AP	Iron Range - Add Glenboro Phase Shifter			T1AP	Iron Range with Fargo Tap - Add Glenboro Phase Shifter		
W1AP1	Fargo Wind Injection			Y1AP1	Fargo Wind Injection			T1AP1	Fargo Wind Injection		
280	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.0	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	745	Sheyenne-Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2		DID NOT RUN		

Fargo Option				Iron Range Option				Iron Range with Fargo Tap Option			
Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage
W1AP2	Fargo/Brookings Wind Injection			Y1AP2	Fargo/Brookings Wind Injection			T1AP2	Fargo/Brookings Wind Injection		
635	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	10.2	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	1160	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	28.6	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1		DID NOT RUN		
W1B	Fargo - Remove Bison-Quarry 345 kV #2			Y1B	Iron Range - Remove Bison-Quarry 345 kV #2			T1B	Iron Range with Fargo Tap - Remove Bison-Quarry 345 kV #2		
W1B1	Fargo Wind Injection			Y1B1	Fargo Wind Injection			T1B1	Fargo Wind Injection		
-240	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	27.6	Open Bison-Maple River 345 kV	670	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	42.6	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	-340	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	6.1	Open Stone Lake-Gardner Park 345 kV
W1B2	Fargo/Brookings Wind Injection			Y1B2	Fargo/Brookings Wind Injection			T1B2	Fargo/Brookings Wind Injection		
-530	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	12.6	Open Bison-Maple River 345 kV	1130	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	29.1	Open Brookings Co - Lyon Co 345 kV	1125	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	28.4	Open Brookings Co - Lyon Co 345 kV
				Y1B60	Iron Range - Remove Bison-Quarry 345 kV #2, use 60% series compensation on new 500 kV line						
				Y1B160	Fargo Wind Injection						
				670	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	42.6	Open Bison-Maple River 345 kV				
				Y1B260	Fargo/Brookings Wind Injection						

Fargo Option				Iron Range Option				Iron Range with Fargo Tap Option			
Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage
					DID NOT RUN						
W1C	Fargo - Add All MVP			Y1C	Iron Range - Add All MVP			T1C	Iron Range with Fargo Tap - Add All MVP		
W1C1	Fargo Wind Injection			Y1C1	Fargo Wind Injection			T1C1	Fargo Wind Injection		
125	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.5	Open Bison-Maple River 345 kV	775	Sheyenne-Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.0	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2		DID NOT RUN		
W1C2	Fargo/Brookings Wind Injection			Y1C2	Fargo/Brookings Wind Injection			T1C2	Fargo/Brookings Wind Injection		
	DID NOT RUN				DID NOT RUN				DID NOT RUN		
W2A	Fargo - Add Bison-Brookings 500 kV with SC			Y2A	Iron Range - Add Bison-Brookings 500 kV with SC			T2A	Iron Range with Fargo Tap - Add Bison-Brookings 500 kV with SC		
W2A1	Fargo Wind Injection			Y2A1	Fargo Wind Injection			T2A1	Fargo Wind Injection		
375	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	16.6	System Intact	1225	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	5.7	Open Arpin-Rocky run 345 kV		DID NOT RUN		
W2A2	Fargo/Brookings Wind Injection			Y2A2	Fargo/Brookings Wind Injection			T2A2	Fargo/Brookings Wind Injection		
465	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.4	System Intact	1190	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	31.3	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1		DID NOT RUN		
W2B	Fargo - Add Bison-Brookings 345 kV			Y2B	Iron Range - Add Bison-Brookings 345 kV			T2B	Iron Range with Fargo Tap - Add Bison-Brookings 345 kV		
W2B1	Fargo Wind Injection			Y2B1	Fargo Wind Injection			T2B1	Fargo Wind Injection		
-1145	Roseau N-Roseau S Series Caps 500 kV at 110% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	6.7	Open Bison 500/345 kV Tx #1 Change bus 667033 DORSEYS4 230 load by 454.5 MW dispatch	955	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	31.2	Open Bison-Maple River 345 kV Open Maple River 345/230 kV tx 2 Open Maple River 345/230 kV tx 1	-315	602017 ST LAKE5 161 699450 ST LAKE 345 1 at 125% of 336 MVA Owner(s): N/A	5.4	Open Stone Lake-Gardner Park 345 kV
W2B2	Fargo/Brookings Wind Injection			Y2B2	Fargo/Brookings Wind Injection			T2B2	Fargo/Brookings Wind Injection		

Fargo Option				Iron Range Option				Iron Range with Fargo Tap Option			
Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage	Transfer MW	Limiting Facility	DF%	Outage
-30	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	14.2	System Intact	1165	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~60 Miles	30.3	Open 601031 BRKNGCO3 345 601048 LYON CO 3 345 1	1150	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	28.5	Open Brookings Co - Lyon Co 345 kV
W6A	**Fargo - Add Corridor Project and Bison-Split Rock 500 kV with SC**			**Y6A**	**Iron Range - Add Corridor Project and Bison-Split Rock 500 kV with SC**			**T6A**	**Iron Range with Fargo Tap - Add Corridor Project and Bison-Split Rock 500 kV with SC**		
W6A1	**Fargo Wind Injection**			**Y6A1**	**Fargo Wind Injection**			**T6A1**	**Fargo Wind Injection**		
760	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	6.0	Open Arpin-Rocky run 345 kV	1115	Arpin 345/138 kV Tx at 113% of 336 MVA Owner(s): 691	5.7	Open Arpin-Rocky run 345 kV		**DID NOT RUN**		
W6A2	**Fargo/Brookings Wind Injection**			**Y6A2**	**Fargo/Brookings Wind Injection**			**T6A2**	**Fargo/Brookings Wind Injection**		
	DID NOT RUN				**DID NOT RUN**				**DID NOT RUN**		
W6B	**Fargo - Add Corridor Project**			**Y6B**	**Iron Range - Add Corridor Project**			**T6B**	**Iron Range with Fargo Tap - Add Corridor Project**		
W6B1	**Fargo Wind Injection**			**Y6B1**	**Fargo Wind Injection**			**T6B1**	**Fargo Wind Injection**		
165	Bison-Maple River 230 kV at 100% of 520 MVA (1305 amps) Owner(s): MPC 10.37 Miles	23.2	Open Bison-Maple River 345 kV	745	Sheyenne-Maple River 230 at 110% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	38.5	Open 601046 ALEXSS3 345 601067 BISON 3 345 1 Open 601046 ALEXSS3 345 601067 BISON 3 345 2		**DID NOT RUN**		
W6B2	**Fargo/Brookings Wind Injection**			**Y6B2**	**Fargo/Brookings Wind Injection**			**T6B2**	**Fargo/Brookings Wind Injection**		
	DID NOT RUN				**DID NOT RUN**				**DID NOT RUN**		

Table E3.1-7 System Intact Overloads for All Options

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
W1A	**Fargo - Base - Bison-Quarry 345 kV #2**		**Y1A**	**Iron Range - Base - Bison-Quarry 345 kV #2**		**T1A**	**Iron Range with Fargo Tap - Base - Bison-Quarry 345 kV #2**	
W1A1	**Fargo Wind Injection**		**Y1A1**	**Fargo Wind Injection**		**T1A1**	**Fargo Wind Injection**	
300	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.8	1785	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		**NONE**	
490	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.8	1785	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1495	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.2	1870	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.6			
1500	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.2	1940	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			
1700	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.9						
1755	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.4						
W1A2	**Fargo/Brookings Wind Injection**		**Y1A2**	**Fargo/Brookings Wind Injection**		**T1A2**	**Fargo/Brookings Wind Injection**	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
510	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.8		NONE			NONE	
740	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	12.4						
1970	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	22.9						
W1A160	**60% Series Comp New 500 kV Line**							
W1A160	**FargoWind Injection**							
440	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	22.8		DID NOT RUN			DID NOT RUN	
670	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	19.7						
1425	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.0						
1430	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.0						

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
1645	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.6						
1695	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.0						
W1A260	**Fargo/Brookings Wind Injection**							
	DID NOT RUN							
W1AP	**Fargo - Add Glenboro Phase Shifter**		**Y1AP**	**Iron Range - Add Glenboro Phase Shifter**		**T1AP**	**Iron Range with Fargo Tap - Add Glenboro Phase Shifter**	
W1AP1	**Fargo Wind Injection**		**Y1AP1**	**Fargo Wind Injection**		**T1AP1**	**Fargo Wind Injection**	
460	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.8	1790	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		**DID NOT RUN**	
680	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.8	1790	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1600	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.2	1890	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.5			
1600	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.2	1945	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
1830	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	12.9						
1860	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.4						
W1AP2	**Fargo/Brookings Wind Injection**		**Y1AP2**	**Fargo/Brookings Wind Injection**		**T1AP2**	**Fargo/Brookings Wind Injection**	
785	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.8		**NONE**			**DID NOT RUN**	
1030	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	12.4						
1980	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	22.9						
W1B	**Fargo - Remove Bison-Quarry 345 kV #2**		**Y1B**	**Iron Range - Remove Bison-Quarry 345 kV #2**		**T1B**	**Iron Range with Fargo Tap - Remove Bison-Quarry 345 kV #2**	
W1B1	**Fargo Wind Injection**		**Y1B1**	**Fargo Wind Injection**		**T1B1**	**Fargo Wind Injection**	
-135	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	26.2	1265	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	19.6	1470	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	12.9
50	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps)	22.0	1265	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	19.6	1475	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	12.9

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
	Owner(s): XCEL after Bison-Brookings 345 kV added							
930	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10.6	1340	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	26.8	1480	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	12.9
930	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10.6	1385	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	39.1	1580	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	18.1
1130	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	14.9	1740	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	13.0	1665	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	25.8
1155	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	21.3	1745	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	13.0			
1785	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	7.6						
1810	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	7.6						
W1B2	**Fargo/Brookings Wind Injection**		**Y1B2**	**Fargo/Brookings Wind Injection**		**T1B2**	**Fargo/Brookings Wind Injection**	
-235	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	15.2						

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
75	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	14.4						
1755	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	5.6						
1755	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	5.6						
1855	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	23.4		**NONE**			**NONE**	
			Y1B60	**60% Series Comp New 500 kV Line**				
			Y1B160	**Fargo Wind Injection**				
			1265	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	19.6			
			1265	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	19.6			
			1340	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	26.8			
			1385	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	39.1			
			1750	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	13.0			

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
			1750	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	13.0			
			Y1B260	**Fargo/Brookings Wind Injection**				
				DID NOT RUN				
W1C	**Fargo - Add All MVP**		**Y1C**	**Iron Range - Add All MVP**			**Iron Range with Fargo Tap - Add All MVP**	
W1C1	**Fargo Wind Injection**		**Y1C1**	**Fargo Wind Injection**		**T1C1**	**Fargo Wind Injection**	
425	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.3	1735	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.9		**DID NOT RUN**	
630	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.4	1735	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.9			
1390	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.4	1870	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.5			
1390	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.4	1885	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.8			
1645	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.8						
1650	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL	13.0						

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
	~7 Miles							
W1C2	**Fargo/Brookings Wind Injection**		**Y1C2**	**Fargo/Brookings Wind Injection**		**T1C2**	**Fargo/Brookings Wind Injection**	
	DID NOT RUN			**DID NOT RUN**			**DID NOT RUN**	
W2A	**Fargo - Add Bison-Brookings 500 kV with SC**		**Y2A**	**Iron Range - Add Bison-Brookings 500 kV with SC**		**T2A**	**Iron Range with Fargo Tap - Add Bison-Brookings 500 kV with SC**	
W2A1	**Fargo Wind Injection**		**Y2A1**	**Fargo Wind Injection**		**T2A1**	**Fargo Wind Injection**	
375	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	16.6		**NONE**			**DID NOT RUN**	
1605	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	8.6						
1605	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	8.6						
1860	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	11.9						
1885	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	17.1						
1945	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	19.2						
W2A2	**Fargo/Brookings Wind Injection**		**Y2A2**	**Fargo/Brookings Wind Injection**		**T2A2**	**Fargo/Brookings Wind Injection**	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	**Limiting Facility**	**DF %**	**Transfer MW**	**Limiting Facility**	**DF %**	**Transfer MW**	**Limiting Facility**	**DF %**
465	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.4	1990	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	25.6		**DID NOT RUN**	
1550	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	24.0						
W2B	**Fargo - Add Bison-Brookings 345 kV**		**Y2B**	**Iron Range - Add Bison-Brookings 345 kV**		**T2B**	**Iron Range with Fargo Tap - Add Bison-Brookings 345 kV**	
W2B1	**Fargo Wind Injection**		**Y2B1**	**Fargo Wind Injection**		**T2B1**	**Fargo Wind Injection**	
-20	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.6	1675	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	14.9	1820	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	10.8
965	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10.8	1680	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	14.9	1945	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	10.3
965	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10.8	1785	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	20.4	1945	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	10.3
1160	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	15.0	1840	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	29.8			
1185	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	21.5						
1800	Frontier-Maple River 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~11 Miles	7.6						

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
1825	Wahpeton-Frontier 230 kV at 100% of 265 MVA (665 amps) Owner(s): MPC ~44 Miles	7.6						
W2B2	**Fargo/Brookings Wind Injection**		**Y2B2**	**Fargo/Brookings Wind Injection**		**T2B2**	**Fargo/Brookings Wind Injection**	
-30	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	14.2		**NONE**			**NONE**	
1815	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	5.7						
1820	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	5.7						
1870	Split Rock-White 345 kV line 1 at 100% of 717 MVA (1200 amps) Owner(s): XCEL ~4 Miles	23.4						
W6A	**Fargo - Add Corridor Project and Bison-Split Rock 500 kV with SC**		**Y6A**	**Iron Range - Add Corridor Project and Bison-Split Rock 500 kV with SC**		**T6A**	**Iron Range with Fargo Tap - Add Corridor Project and Bison-Split Rock 500 kV with SC**	
W6A1	**Fargo Wind Injection**		**Y6A1**	**Fargo Wind Injection**		**T6A1**	**Fargo Wind Injection**	
1355	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	13.0		**NONE**			**DID NOT RUN**	
W6A2	**Fargo/Brookings Wind Injection**		**Y6A2**	**Fargo/Brookings Wind Injection**		**T6A2**	**Fargo/Brookings Wind Injection**	
	DID NOT RUN			**DID NOT RUN**			**DID NOT RUN**	
W6B	**Fargo - Add Corridor Project**		**Y6B**	**Iron Range - Add Corridor Project**		**T6B**	**Iron Range with Fargo Tap - Add Corridor Project**	
W6B1	**Fargo Wind Injection**		**Y6B1**	**Fargo Wind Injection**		**T6B1**	**Fargo Wind Injection**	

Fargo Option			Iron Range Option			T Tap Option		
Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %	Transfer MW	Limiting Facility	DF %
315	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL Zero Miles	21.4	1750	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	15.7		DID NOT RUN	
580	Roseau N-Roseau S Series Caps 500 kV at 100% of 1732 MVA (2000 amps) Owner(s): XCEL after Bison-Brookings 345 kV added	18.2	1750	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	15.7			
1525	Maple River 345/230 kV tx 1 at 100% of 336 MVA Owner(s): OTP	9.3	1825	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	21.6			
1525	Maple River 345/230 kV tx 2 at 100% of 336 MVA Owner(s): OTP	9.3	1900	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~10 Miles	31.4			
1705	Sheyenne-Maple River 230 at 100% of 459 MVA (1152 amps) Owner(s): XCEL ~7 Miles	13.1						
1780	Bison-Maple River 345 kV at 100% of 720 MVA (1205 amps) Owner(s): MPC ~3 Miles	18.6						
W6B2	**Fargo/Brookings Wind Injection**		**Y6B2**	**Fargo/Brookings Wind Injection**		**T6B2**	**Fargo/Brookings Wind Injection**	
	DID NOT RUN			**DID NOT RUN**			**DID NOT RUN**	

E3.2 Fargo and Brookings Wind Injection Results

The Fargo/Brookings wind injection did not have as many cases that were ran as for the Fargo only wind injection. The wind injection is split 50/50 between Fargo and Brookings Co sites. The same amount of maximum power of 2000MW was used.

Eastern Option with Fargo Tap Fargo/Brookings Wind Injection

The eastern Fargo tap scenarios all have a 500 kV line from Dorsey to the Blackberry with 50% series compensation with the line tapped (T-Tap) south of the series compensation, a double circuit 345 kV line from T-Tap to Bison, a double circuit 345 kV line from the Blackberry to Arrowhead, two 500/345 kV transformers at Blackberry, one 345/230 kV transformer at Blackberry, and one 500/345 kV transformers at T-Tap. Only three scenarios were run for this option: T1A, T1B, and T2B. With these scenarios the Manitoba power and the Fargo wind injection are entering the 345 kV system at totally different points but are tied together. Being one half the wind injection is at Brookings Co, only the Bison-Maple River 230 kV line upgrade due to CapX line outages still required. The Chisago 500/345 kV transformer #1 and #2 upgrades are required for loss of the other transformer except for T1A which has the double circuit CapX Fargo-Twin Cities. The Roseau capacitors or the Stone Lake 345/161 kV transformer do not overload with only half the wind being injected at Fargo. The best performing scenario was the T1A; it provides for an independent outlet from Bison but does not tie the Bison and Brookings Co. wind injection areas together directly.

The scenario with the lowest incremental cost is T1A (Fargo Tap option with CapX Fargo-Twin Cites 345 kV double circuit line). The other two scenarios are the same cost. A chart showing the incremental cost is in Figure E3.2-1 . The scenario with the highest incremental cost is T1A.

Figure E3.2-1 Incremental Transfer Cost Eastern with Fargo Tap Option Fargo/Brookings Wind Injection

Comparison of Options Fargo/Brookings Wind Injection

The least incremental cost scenario is Y2A, eastern option with 500 kV line Bison-Brookings County. The 500 kV line only goes from Bison to Brookings County with transformers required at both ends. It provides to two independent outlets from Fargo for the wind injection. The eastern option with a 345 kV line is a very close second. The eastern option with the tap T1A ties the Manitoba power and both wind injection sites together, overloading the Split Rock-White 345 kV line requiring an upgrade. T1A also includes Stone Lake and Chisago Country #1 and #2 transformers upgrades. A chart showing the incremental cost is in Figure E3.2-3 . A table with the incremental costs is shown in Table E3.2-2 .

The most costly incremental is W1A, there are no additional independent outlets for the wind injections and upgrades to the 230 kV system in the Red River Valley.

The eastern option has the first limiters occurring at higher wind injection than the other two options. For the eastern option with and without the tap the Split Rock-White 345 kV line is usually the first limiter. For the western option the Roseau capacitor bank is the first limiter. See Table E3.1-6 for the complete list of first limiters.

The eastern option only had one system intact overload, Y2A, Split Rock-White 345 kV line at 1990 MW. The eastern option with the Fargo tap had none. The western option had the Roseau capacitor bank and Split Rock-White 345 kV line for some of the scenarios. A table showing the system intact overloads is in TableE3.1-7 .

Table E3.2-2 Cost Comparison Fargo/Brookings Wind Injection

	FARGO 500 MW	IRON RANGE 500 MW	IRON RANGE w/ T Tap 500 MW	FARGO 1000 MW	IRON RANGE 1000 MW	IRON RANGE w/ T Tap 1000 MW	FARGO 1500 MW	IRON RANGE 1500 MW	IRON RANGE w/ T Tap 1500 MW	FARGO 2000 MW	IRON RANGE 2000 MW	IRON RANGE w/ T Tap 2000 MW
1A :Base Bison-Quarry #2	3	0	0	*(273 @ 740 MW)*	0	0	N/A	12	17	N/A	196	176
1AP Add Glenboro Phase Shifter	0	0	N/A	*292*	0	N/A	*(292 @ 1030 MW)*	26	N/A	N/A	209	N/A
1B Remove Bison-Quarry #2	*(284 @ 75 MW)*	0	0	N/A	0	0	N/A	25	67	N/A	217	229
2A Add Bison-Brookings 500 kV with SC	*(0 @ 465 MW)*	0	N/A	N/A	0	N/A	N/A	12	N/A	N/A	171	N/A
2B Add Bison-Brookings 345 kV	*(0 @ 0 MW)*	0	0	N/A	0	0	N/A	12	17	N/A	174	229

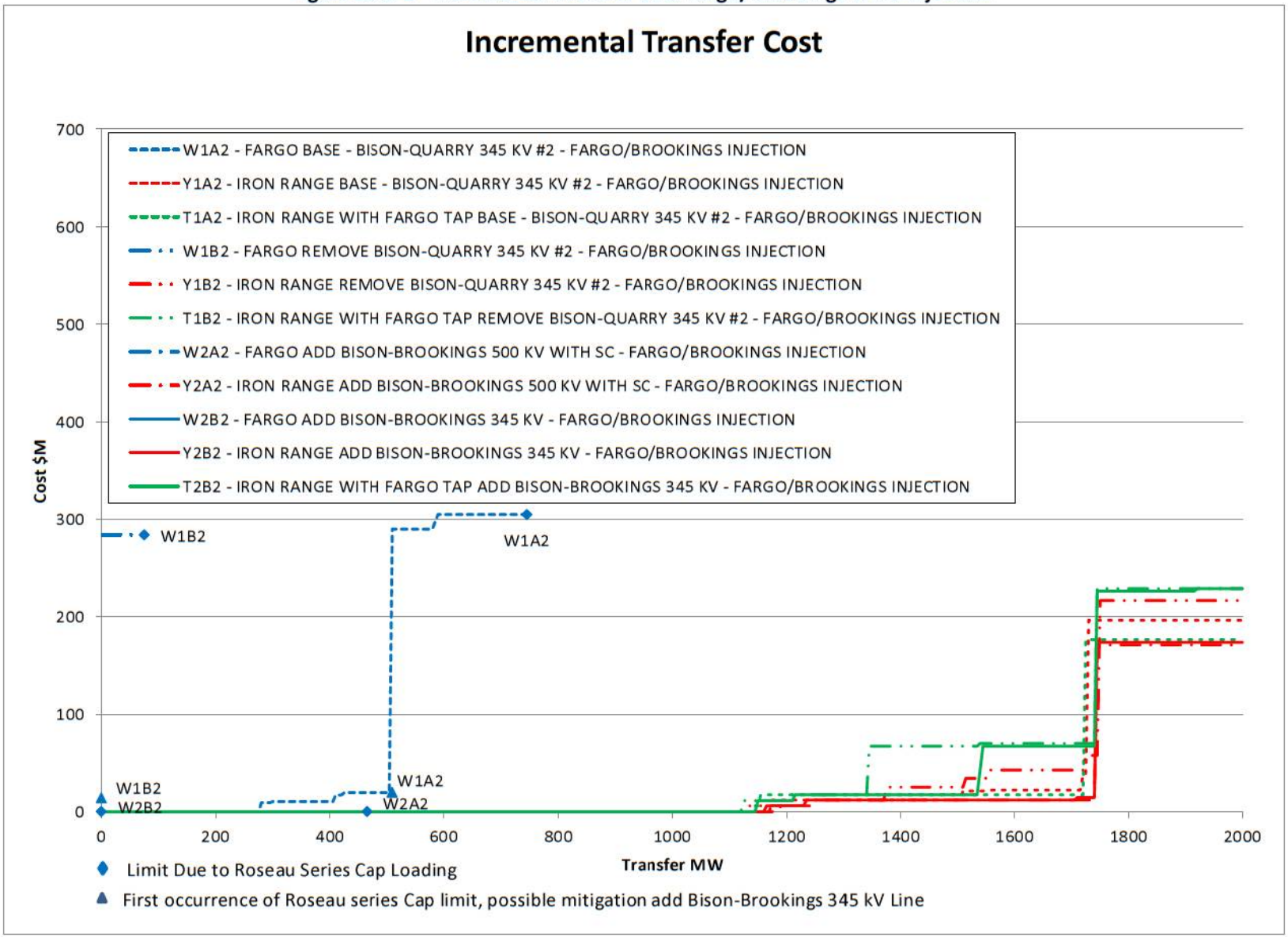



Figure E3.2-3 Incremental Transfer Cost Fargo/Brookings Wind Injection