Northern Umbrella Plan Phase 1 Projects
Impacts On U.P. Export Capability

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Purpose

This report contains the study results and recommendations regarding the U.P. export capability issues subsequent to the completion of Phase 1 of the Northern Umbrella Plan by 2009. The report describes the impact these projects will have on the Remedial Action Tripping Scheme (RATS) requirements at Presque Isle, and will include recommendations that address other system issues.

Study Methodology

A 2002 series, 2009 MMWG summer base case was used to create all base cases used in this study. Three starting base cases were created: 2009 summer peak, 2009 light-load case with Ludington cycle, and 2009 light-load case without Ludington cycle. For each of these starting base cases, different transfer level base cases were created to study a spectrum of system conditions.

All study cases included Presque Isle units #1 and #2 off-line, and the other Presque Isle units (#3-#9) on-line at full output (total net output = 555 MW). All Northern Umbrella Plan Phase 1 projects were modeled in the study cases. All other non-related projects in northern Wisconsin and the U.P. scheduled to be in-service by 2009 were also modeled in the cases.

For each base case, various contingencies were modeled to identify the required generation tripping (if any) at Presque Isle to avoid post-contingency system overloads and/or system instability. For each contingency, mine motor load shedding was applied where appropriate.

Study Results

The Northern Umbrella Plan Phase 1 projects, which are shown on diagram A1 in Appendix A, include:

1) Rebuild the Plains-Amberg-Crivitz-Stiles 138 kV lines, rebuild the Amberg-White Rapids 138 kV line, convert the White Rapids-Menominee 69 kV line to 138 kV, and add a new Menominee-West Marinette 138 kV line.
2) Rebuild the existing Indian Lake-Hiawatha 69 kV to double-circuit 138 kV, retaining a single 69 kV line.
3) Rebuild the Morgan-Falls-Pioneer-Stiles 138 kV lines.
4) Rebuild the Morgan-White Clay 138 kV line.
5) Add a second 250 MVA, 345/138 kV transformer at Plains.
6) Add a new 345/138 kV substation at Werner West with a 500 MVA 345/138 kV transformer.
7) Add a new Cranberry-Conover 138 kV line, convert the Conover-Iron River-Plains 69 kV to 138 kV, and add a new 138/69 kV transformer at Conover and Iron River.
8) Add a new Morgan-Werner West 345 kV line plus a Clintonville-Werner West 138 kV line.

Expected 2009 System

The results from the studies for the expected 2009 system are summarized in Table 1 below. The stability study results show that the addition of the Northern Umbrella Plan projects will greatly improve system stability at Presque Isle, resulting in a large reduction in required generation tripping within RATS.

Table 1: Required Generation Tripping At Presque Isle, Existing 2004 System And After Northern Umbrella Plan Phase 1.

					Required Generation Tripping		
Case	Load Level, Cycle	PI Export	Mine Load	Fault Contingency	2004 Existing	NUP Stability	NUP Thermal
S433	Peak, No Cycle	433	0	Presque Isle-Dead River 138	310	116	201
				Dead River-Plains 345	166	0	201
				Plains-Morgan 345	63	0	0
				Empire-Forsyth 138	166	0	0
				Presque Isle-Perch Lake 138	166	0	0
LL460	Light-Load, Cycle	460	42.3	Presque Isle-Dead River 138	310	143	289
				Dead River-Plains 345	199	58	289
				Plains-Morgan 345	95	0	0
				Empire-Forsyth 138	199	0	0
				Presque Isle-Perch Lake 138	199	0	0
LL460A	Light-Load, No Cycle	460	47.1	Presque Isle-Dead River 138	310	143	231
				Dead River-Plains 345	202	58	231
				Plains-Morgan 345	98	0	0
				Empire-Forsyth 138	202	0	0
				Presque Isle-Perch Lake 138	202	0	0

The only fault contingencies that need to remain within RATS for stability reasons are faults on the Presque Isle-Dead River 138 kV and Dead River-Plains 345 kV lines. In addition, the maximum generation tripped for either of these outages will be reduced to 143 MW (from 310 MW) for the 138 kV outage, and reduced to 58 MW (from ~200 MW) for the 345 kV outage.

The power flow study results also show that only the Presque Isle-Dead River 138 kV and the Dead River-Plains 345 kV contingencies will still require generation tripping subsequent to the completion of the Phase 1 projects. However, transmission uprates will be required to avoid thermal overloads for either of the other 138 kV contingencies:

- The Presque Isle-Dead River 138 kV line (KK481) should have its summer emergency rating raised to at least 424 MVA (existing Summer Emergency [SE] rating = 288 MVA, conductor SE rating = 531 MVA) to avoid the tripping of generation for specific 138 kV outages (i.e. Empire-Forsyth 138 kV and Presque Isle-Perch Lake 138 kV) that would not require generation tripping due to stability. This uprate would include substation upgrades at Presque Isle only. (This uprate is assumed completed in the study, otherwise thermal overloads for the Empire-Forsyth & Presque Isle-Perch Lake contingencies would have been observed.)

In addition, transmission upgrades or additions will be required in the Eastern U.P. to avoid a reduction in the export capability from the Presque Isle area:

- During maximum export from the Presque Isle area along with high west-to-east U.P. flows (due to the Ludington cycle), the outage of the Hiawatha-Straits 138 kV line will result in large overloads of the Straits 138/69 kV transformer and both Straits-Pine River 69 kV lines. The studies show that without system upgrades/additions the U.P. export level would need to be reduced to 199 MW (from 460 MW) to avoid overloading the 69 kV system in this area. It is required, therefore, that transmission upgrades in this area be completed by 2009/2010. There are two primary alternatives to address these issues: 1) uprate the existing Pine River-Straits 69

kV lines to at least 50 MVA and add a second 138/69 kV transformer at Straits, or 2) rebuild and convert the Hiawatha-Pine River-Straits 69 kV to 138 kV. Either alternative will suffice.

Finally, additional system upgrades should be performed on the Empire-Forsyth 138 kV line to reduce the amount of generation tripping required for thermal reasons to the amount of tripping required for stability reasons:

- The Empire-Forsyth 138 kV line (Forsyth) should have its summer emergency rating raised to at least 242 MVA (existing SE rating = 172 MVA, conductor SE rating = 202 MVA) to reduce the required generation tripping for the Presque Isle-Dead River outage to the same level needed for stability reasons. Although raising the Forsyth circuit SE rating to 322 MVA would totally eliminate post-contingency overloads with no generation tripped at Presque Isle, some generation must be tripped for stability reasons and the 242 MVA rating would avoid overloads at that tripping level. This rating increase would include substation upgrades at both Empire and Forsyth as well as an uprate of the transmission line.

Other Transmission Projects

Four additional transmission projects were studied to assess their impact on system performance in this area subsequent to the completion of the Northern Umbrella Plan Phase 1 projects. These studies were performed to determine their effect on required generation tripping at Presque Isle for either thermal or stability reasons. The conceptual projects studied, which are shown on diagram A2 in Appendix A, include:

1) Project A – Construct a new Presque Isle-Forsyth 138 kV line, rebuild the existing Forsyth-Munising 138 kV line, convert the existing Munising-Blaney Park 69 kV line to 138 kV and add a 138 kV switching station at Blaney Park.
2) Project B – Rebuild the Presque Isle-Perch Lake-Nordic-Plains 138 kV lines to double-circuit 138 kV, with the new 138 kV line stretching from Presque Isle to Perch Lake to Plains, bypassing Nordic substation.
3) Both Project A and Project B above.
4) Project C – Rebuild the Presque Isle-Perch Lake-Nordic-Plains 138 kV line to double-circuit 345/138 kV, with a second Presque Isle-Dead River 138 kV line and a new Dead River-Plains 345 kV line.

Note that for each of the project(s) studied, it as assumed that the uprates of the Presque Isle-Dead River 345 kV (to 424 MVA SE) and Empire-Forsyth 138 kV (to 242 MVA) lines were completed, and these uprates are reflected in the lower generation tripping requirements for the NUP Phase 1 (thermal reasons). In addition, the overloads observed in the eastern U.P. (Hiawatha/Straits 138/69 kV) mentioned above were ignored, and must be addressed as discussed earlier.

As expected, each of these projects provided additional system performance benefits from both a thermal and stability perspective. The results are shown in Table 2 below. The results show that all projects provide significant benefits from both a thermal and stability perspective, with Project C or both Projects A and B eliminating the need for RATS for these contingencies.

Table 2: Required Generation Tripping At Presque Isle, Expected 2009 System After Northern Umbrella Plan Phase 1, Plus Additional Projects.

Project(s)	Case	Load Level, Cycle	PI Export	Mine Load	Fault Contingency	Stability	Thermal
NUP Phase 1	S433	Peak, No Cycle	433	0	Presque Isle-Dead River 138 Dead River-Plains 345	116 0	116 116
	LL460	Light-Load, Cycle	460	42.3	Presque Isle-Dead River 138 Dead River-Plains 345	143 58	143 143
	LL460A	Light-Load, No Cycle	460	47.1	Presque Isle-Dead River 138 Dead River-Plains 345	143 58	116 116
Project A	S437	Peak, No Cycle	433	0	Presque Isle-Dead River 138 Dead River-Plains 345	58 0	0 0
	LL460	Light-Load, Cycle	460	49.3	Presque Isle-Dead River 138 Dead River-Plains 345	58 0	58 58
	LL460A	Light-Load, No Cycle	460	51.7	Presque Isle-Dead River 138 Dead River-Plains 345	58 0	58 58
Project B	S437	Peak, No Cycle	433	0	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
	LL460	Light-Load, Cycle	460	45.8	Presque Isle-Dead River 138 Dead River-Plains 345	58 0	58 58
	LL460A	Light-Load, No Cycle	460	51.5	Presque Isle-Dead River 138 Dead River-Plains 345	58 0	0 0
Projects A + B	S440	Peak, No Cycle	433	0	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
	LL460	Light-Load, Cycle	460	52.0	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
	LL460A	Light-Load, No Cycle	460	54.9	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
Project C	S439	Peak, No Cycle	433	0	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
	LL460	Light-Load, Cycle	460	48.6	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0
	LL460A	Light-Load, No Cycle	460	54.1	Presque Isle-Dead River 138 Dead River-Plains 345	0 0	0 0

* Note that the Thermal requirements for NUP Phase 1 were reduced due to the assumed uprate of the Empire-Forsyth 138 kV line.

Summary

The study results presented in this report show that significant performance benefits would be realized upon completion of the Northern Umbrella Plan Phase 1 Projects. The required generation tripping due to stability or thermal reasons will be limited in exposure to only the Presque Isle-Dead River 138 kV and Dead River-Plains 345 kV lines, assuming the following thermal uprates are performed:

1) Uprate the Dead River-Plains 138 kV line to at least 424 MVA, which will require substation upgrades at Presque Isle.
2) Uprate the Empire-Forsyth 138 kV line to at least 242 MVA, which will require substation upgrades at Empire and Forsyth as well as the transmission line.
3) Address overloads in the eastern U.P., which may reduce the allowable export from Presque Isle. The initial conceptual "fixes" could be either: 1) uprate the existing Pine River-Straits 69

kV lines to at least 50 MVA and add a second 138/69 kV transformer at Straits, or 2) rebuild and convert the Hiawatha-Pine River-Straits 69 kV to 138 kV. Either alternative will suffice.

The "additional" transmission projects associated with this study are conceptual only. However, the study results show that significant system performance benefits can be obtained with the completion of any of these projects. Future analyses, including planning, design, and economic, will continue to be performed to determine if any of these projects should be implemented.

APPENDIX A

TRANSMISSION DIAGRAMS

Figure A1 – U.P./Northern Wisconsin Transmission System, Includes NUP Phase 1 Projects.

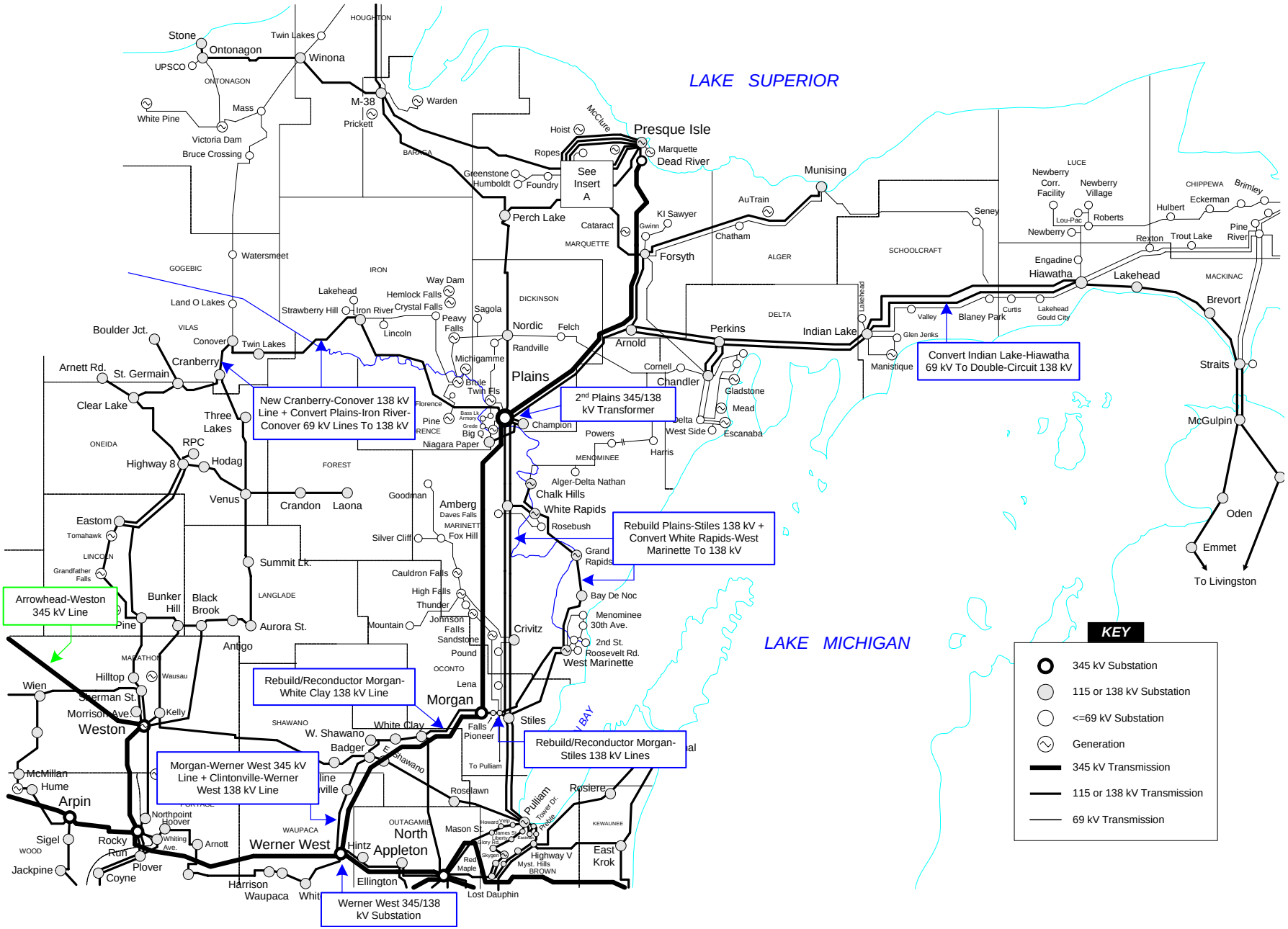
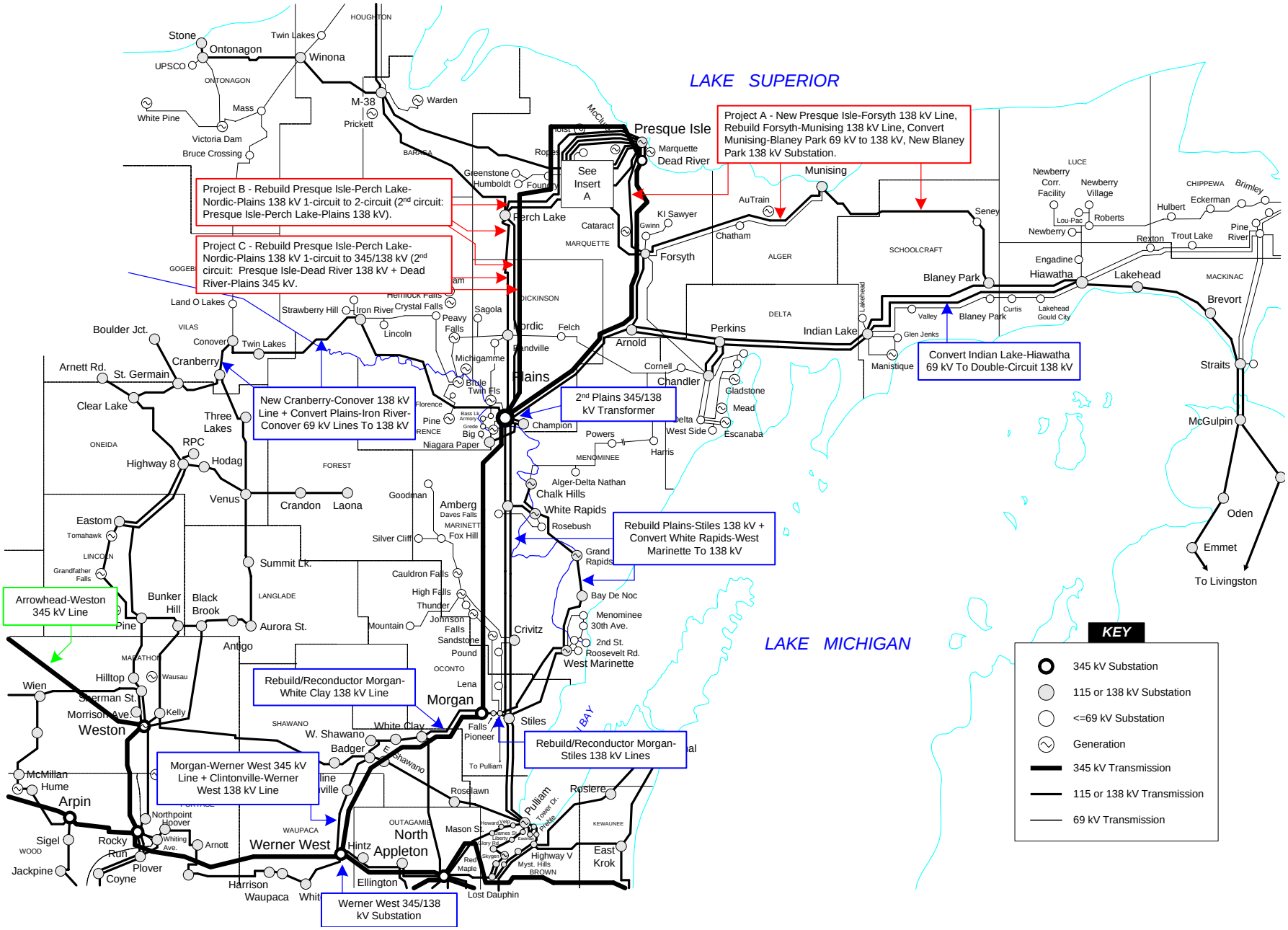


Figure A2 – U.P./Northern Wisconsin Transmission System. Includes NUP Phase 1 Projects. Additional Transmission Projects Studied.



APPENDIX B

STUDY TABLES

Stability Study Results, 2009 Cases, With & Without Transmission Alternatives, **Required Presque Isle Generation Tripping.**

Contingency	Case	Original System	W/Trans. A	W/Trans. B	W/Trans. A+B	W/Trans. C
PRI-DRV	S_147	A = 58 MW	None	None	None	None
	S_433	C = 116 MW	A = 58 MW	None	None	None
	LL_215	C = 116 MW	None	None	None	None
	LL_460	D = 143 MW	A = 58 MW	A = 58 MW	None	None
	LLA_220	C = 116 MW	None	None	None	None
	LLA_460	D = 143 MW	A = 58 MW	A = 58 MW	None	None
DRV-PLA	S_147	None				
	S_433	None				
	LL_215	None				
	LL_460	A = 58 MW	None	None	None	None
	LLA_220	None				
	LLA_460	A = 58 MW	None	None	None	None
PLA-MGN	S_147	None				
	S_433	None				
	LL_215	None				
	LL_460	None				
	LLA_220	None				
	LLA_460	None				
PRI-PLK	S_147	None				
	S_433	None				
	LL_215	None				
	LL_460	None				
	LLA_220	None				
	LLA_460	None				
EMP-FSY	S_147	None				
	S_433	None				
	LL_215	None				
	LL_460	None				
	LLA_220	None				
	LLA_460	None				

Notes: The Transmission Alternatives are: Trans A – New Presque Isle-Forsyth 138 kV line, rebuild Forsyth-Munising 138 kV line, convert Munising-Blaney Park 69 kV to 138 kV; Trans B – Rebuild Presque Isle-Perch Lake-Nordic-Plains 138 kV line to double-circuit 138 kV with the second 138 kV line tapping at Plains; Trans C – Rebuild Presque Isle-Perch Lake-Nordic-Plains 138 kV to double circuit 345/138 kV with a Presque Isle-Dead River 138 kV #2 and a new 345 kV from Dead River to Plains on this route.

All cases include Presque Isle units #1-#7 on-line and at full output (555 MW total), and units #1 and #2 off-line. These cases also include all Northern Umbrella Plan projects completed as well as the double-circuit Indian Lake-Hiawatha 138 kV lines.

The case titles listed in the Case column include both the load level and Flow North value. For example, Case S147 represents a 147 MW Flow North value, while Case LL460 includes a Flow North value of 460 MW. Case titles with an S prefix represent a summer peak case, case titles with an LL prefix represent a light-load case with Ludington cycle, and case titles with an LLA prefix are light load cases without the Ludington cycle.

Mine motor loads in cases: The smaller export cases (S147, LL215, etc.) include 300 MW of mine motor load modeled at Empire and Tilden. The larger export cases (S433, LLA460) are created with all or most mine load off-line.

Cases for Trans A: S149, S437, LL219, LL460, LLA221, LLA460.
Cases for Trans B: S149, S437, LL217, LL460, LLA221, LLA460.
Cases for Trans A+B: S150, S440, LL221, LL460, LLA223, LLA460.
Cases for Trans C: S149, S439, LL217, LL460, LLA222, LLA460.

Faults: PRI-DRV – 3-phase fault at Presque Isle on Presque Isle Dead River 138 kV line, cleared in 5/5 cycles.
DRV-PLA – 3-phase fault at Dead River on Dead River-Plains 345 kV line, cleared in 4/4 cycles.
PLA-MGN – 3-phase fault at Plains on Plains-Morgan 345 kV line, cleared in 4/4 cycles.
PRI-PLK – 3-phase fault at Presque Isle on Presque Isle-Perch Lake 138 kV line, cleared in 5/5 cycles.
EMP-FSY – 3-phase fault at Empire on Empire-Forsyth 138 kV line, cleared in 5/5 cycles.
Note that for all fault simulations, mine motors are tripped off-line if their terminal voltage dips below 0.70 per unit for 2.5 cycles or more (via MISHED user model).

Stability Study Results, 2009 Original Cases.

Contingency	Case	Mine Load Tripped	PI Generation Tripping Required For 1st Swing Stability
PRI-DRV	S_147	300.0	A = 58 MW
	S_433	-----	C = 116 MW
	LL_215	300.0	C = 116 MW
	LL_460	42.3	D = 143 MW
	LL_499	-----	E = 173 MW
	LLA_220	300.0	C = 116 MW
	LLA_460	47.1	D = 143 MW
	LLA_504	-----	E = 173 MW
DRV-PLA	S_147	262.7	None
	S_433	-----	None
	LL_215	262.7	None
	LL_460	42.3	A = 58 MW
	LL_499	-----	A = 58 MW
	LLA_220	262.7	None
	LLA_460	47.1	A = 58 MW
	LLA_504	-----	A = 58 MW
PLA-MGN	S_147	0	None
	S_433	0	None
	LL_215	0	None
	LL_460	0	None
	LL_499	0	None
	LLA_220	0	None
	LLA_460	0	None
	LLA_504	0	None
PRI-PLK	S_147	300.0	None
	S_433	-----	None
	LL_215	300.0	None
	LL_460	42.3	None
	LL_499	-----	None
	LLA_220	300.0	None
	LLA_460	47.1	None
	LLA_504	-----	None
EMP-FSY	S_147	300.0	None
	S_433	-----	None
	LL_215	300.0	None
	LL_460	42.3	None
	LL_499	-----	None
	LLA_220	300.0	None
	LLA_460	47.1	None
	LLA_504	-----	None

Stability Study Results, Required PIPP Generation Tripping, 2009 Original Cases, Plus:

Alternative A – Presque Isle-Forsyth-Munising-Blaney Park 138 kV.

Contingency	Case	Mine Load Tripped	With Original System	With Alternative A
PRI-DRV	S_149	300.0	A = 58 MW	None
	S_437	-----	C = 116 MW	A = 58 MW
	LL_219	300.0	C = 116 MW	None
	LL_460	49.3	D = 143 MW	A = 58 MW
	LL_510	-----	E = 173 MW	B = 85 MW
	LLA_221	300.0	C = 116 MW	None
	LLA_460	51.7	D = 143 MW	A = 58 MW
	LLA_508	-----	E = 173 MW	B = 85 MW
DRV-PLA	LL_460	49.3	A = 58 MW	None
	LL_510	-----	A = 58 MW	None
	LLA_460	51.7	A = 58 MW	None
	LLA_508	-----	A = 58 MW	None

Alternative B – Presque Isle-Perch Lake-Plains 138 kV.

Contingency	Case	Mine Load Tripped	With Original System	With Alternative B
PRI-DRV	S_149	300.0	A = 58 MW	None
	S_437	-----	C = 116 MW	None
	LL_217	300.0	C = 116 MW	None
	LL_460	45.8	D = 143 MW	A = 58 MW
	LL_503	-----	E = 173 MW	A = 58 MW
	LLA_221	300.0	C = 116 MW	None
	LLA_460	51.5	D = 143 MW	A = 58 MW
	LLA_509	-----	E = 173 MW	B = 85 MW
DRV-PLA	LL_460	45.8	A = 58 MW	None
	LL_503	-----	A = 58 MW	None
	LLA_460	51.5	A = 58 MW	None
	LLA_509	-----	A = 58 MW	None

Alternatives A + B – Presque Isle-Forsyth-Munising-Blaney Park 138 kV + Presque Isle-Perch Lake-Plains 138 kV.

Contingency	Case	Mine Load Tripped	With Original System	With Alternatives A+B
PRI-DRV	S_150	300.0	A = 58 MW	None
	S_440	-----	C = 116 MW	None
	LL_221	300.0	C = 116 MW	None
	LL_460	52.0	D = 143 MW	None
	LL_509	-----	E = 173 MW	None
	LLA_223	300.0	C = 116 MW	None
	LLA_460	54.9	D = 143 MW	None
	LLA_512	-----	E = 173 MW	None
DRV-PLA	LL_460	52.0	A = 58 MW	None
	LL_509	-----	A = 58 MW	None
	LLA_460	54.9	A = 58 MW	None
	LLA_508	-----	A = 58 MW	None

Alternative C – Presque Isle-Dead River 138 kV + Dead River-Plains 345 kV.

Contingency	Case	Mine Load Tripped	With Original System	With Alternative C
PRI-DRV	S_149	300.0	A = 58 MW	None
	S_439	-----	C = 116 MW	None
	LL_217	300.0	C = 116 MW	None
	LL_460	48.6	D = 143 MW	None
	LL_506	-----	E = 173 MW	None
	LLA_222	300.0	C = 116 MW	None
	LLA_460	54.1	D = 143 MW	None
	LLA_511	-----	E = 173 MW	None
DRV-PLA	LL_460	48.6	A = 58 MW	None
	LL_506	-----	A = 58 MW	None
	LLA_460	54.1	A = 58 MW	None
	LLA_511	-----	A = 58 MW	None

Presque Isle Generation + Generation Tripping Levels:

Presque Isle generation in all cases:

- **G1 – off-line**
- **G2 – off-line**
- **G3 – 58 MW**
- **G4 – 58 MW**
- **G5 – 88 MW**
- **G6 – 90 MW**
- **G7 – 85 MW**
- **G8 – 88 MW**
- **G9 – 88 MW**

Generation Tripping Levels:

- **Level A – 58 MW (G3)**
- **Level B – 85 MW (G7)**
- **Level C – 116 MW (G3, G4)**
- **Level D – 143 MW (G3, G7)**
- **Level E – 173 MW (G7, G9)**

Thermal Study Results, 2009 Cases.

Case	Contingency [1]	Mine Load Shed	RATS Gen. Tripped	Low Voltages / Overloads
S433	Presque Isle-Dead River 138 kV	-----	None	Empire-Forsyth 138 = 272.2 / 172.0 / 158.2%
	(or Dead River-Plains 345 kV)			Presque Isle-Perch Lake 138 = 184.2 / 161.0 / 114.4%
				Perch Lake-Nordic 138 = 171.6 / 161.0 / 106.6%
			A = 58 MW	Empire-Forsyth 138 = 239.7 / 172.0 / 139.4%
				Presque Isle-Perch Lake 138 = 162.7 / 161.0 / 101.1%
			B = 85 MW	Empire-Forsyth 138 = 225.5 / 172.0 / 131.1%
			C = 116 MW	Empire-Forsyth 138 = 208.7 / 172.0 / 121.3%
			D = 143 MW	Empire-Forsyth 138 = 194.3 / 172.0 / 139.4%
			E = 173 MW	Empire-Forsyth 138 = 178.3 / 172.0 / 139.4%
			F = 201 MW	None
LL460	Presque Isle-Dead River 138 kV	42.3	None	Empire-Forsyth 138 = 321.9 / 172.0 / 187.1%
	(or Dead River-Plains 345 kV)			Forsyth-Arnold 138 = 290.8 / 242.0 / 120.2%
				Perch Lake-Nordic 138 = 190.5 / 161.0 / 118.3%
				Presque Isle-Perch Lake 138 = 188.6 / 161.0 / 117.1%
			A = 58 MW	Empire-Forsyth 138 = 288.0 / 172.0 / 167.4%
				Forsyth-Arnold 138 = 260.1 / 242.0 / 107.5%
				Presque Isle-Perch Lake 138 = 165.8 / 161.0 / 103.0%
				Perch Lake-Nordic 138 = 164.4 / 161.0 / 102.1%
			B = 85 MW	Empire-Forsyth 138 = 272.4 / 172.0 / 158.4%
				Forsyth-Arnold 138 = 245.9 / 242.0 / 101.6%
			C = 116 MW	Empire-Forsyth 138 = 256.1 / 172.0 / 148.9%
			D = 143 MW	Empire-Forsyth 138 = 241.1 / 172.0 / 140.2%
			E = 173 MW	Empire-Forsyth 138 = 224.2 / 172.0 / 130.4%
			F = 201 MW	Empire-Forsyth 138 = 209.8 / 172.0 / 122.0%
			G = 231 MW	Empire-Forsyth 138 = 194.4 / 172.0 / 113.1%
			H = 261 MW	Empire-Forsyth 138 = 178.3 / 172.0 / 103.6%
			I = 289 MW	None
	Hiawatha-Straits 138 kV [2]	0	None	Straits 138/69 = 94.9 / 77.0 / 123.2%
				Pine River-Straits 69 #1 = 46.9 / 39.0 / 120.4%
				Pine River-Straits 69 #2 = 41.6 / 35.0 / 118.8%
LLA460	Presque Isle-Dead River 138 kV	47.1	None	Empire-Forsyth 138 = 298.3 / 172.0 / 173.4%
	(or Dead River-Plains 345 kV)			Perch Lake-Nordic 138 = 206.0 / 161.0 / 127.9%
				Presque Isle-Perch Lake 138 = 201.7 / 161.0 / 125.3%
				Forsyth-Arnold 138 = 270.6 / 242.0 / 111.8%
			A = 58 MW	Empire-Forsyth 138 = 264.9 / 172.0 / 154.0%
				Perch Lake-Nordic 138 = 181.1 / 161.0 / 112.5%
				Presque Isle-Perch Lake 138 = 179.9 / 161.0 / 111.7%
			B = 85 MW	Empire-Forsyth 138 = 249.7 / 172.0 / 145.2%
				Presque Isle-Perch Lake 138 = 170.0 / 161.0 / 105.6%
				Perch Lake-Nordic 138 = 169.7 / 161.0 / 105.4%
			C = 116 MW	Empire-Forsyth 138 = 233.1 / 172.0 / 135.5%
			D = 143 MW	Empire-Forsyth 138 = 218.0 / 172.0 / 126.8%
			E = 173 MW	Empire-Forsyth 138 = 201.4 / 172.0 / 117.1%
			F = 201 MW	Empire-Forsyth 138 = 186.9 / 172.0 / 108.6%
			G = 231 MW	None

1 Overload of Presque Isle-Dead River 138 kV line observed for outage of either Empire-Forsyth 138 kV line or Presque Isle-Perch Lake 138 kV line. Overload eliminated with uprate of Presque Isle-Dead River 138 kV line (substation upgrades at Presque Isle) to 424 MVA.

2 Overload of Straits area 69 kV facilities due to Hiawatha-Straits 138 kV outage eliminated with U.P. import value reduced to 199 MW.

Thermal Study Results, 2009 Cases, With Transmission Alternative A (Presque Isle-Forsyth-Munising-Blaney Park 138 kV).

Case	Contingency [1]	Mine Load Shed	RATS Gen. Tripped	Low Voltages / Overloads
S437	Presque Isle-Dead River 138 kV	-----	None	None
	(or Dead River-Plains 345 kV)			
LL460	Presque Isle-Dead River 138 kV	49.3	None	Hiawatha-Straits 138 = 189.8 / 177.0 / 107.2%
	(or Dead River-Plains 345 kV)			Forsyth-Arnold 138 = 248.0 / 242.0 / 102.5%
			A = 58 MW	Hiawatha-Straits 138 = 180.8 / 177.0 / 102.2%
			B = 85 MW	None
	Hiawatha-Straits 138 kV	0	None	Straits 138/69 = 104.3 / 77.0 / 135.5%
				Pine River-Straits 69 #1 = 51.9 / 39.0 / 133.2%
LLA460	Presque Isle-Dead River 138 kV	51.7	None	Forsyth-Arnold 138 = 250.2 / 242.0 / 103.4%
	(or Dead River-Plains 345 kV)		A = 58 MW	None

1 Overload of Presque Isle-Dead River 138 kV line observed for outage of either Empire-Forsyth 138 kV line or Presque Isle-Perch Lake 138 kV line. Overload eliminated with uprate of Presque Isle-Dead River 138 kV line (substation upgrades at Presque Isle) to 328 MVA.

Thermal Study Results, 2009 Cases, With Transmission Alternative B (Presque Isle-Perch Lake-Nordic-Plains 138 kV).

Case	Contingency [1]	Mine Load Shed	RATS Gen. Tripped	Low Voltages / Overloads
S437	Presque Isle-Dead River 138 kV	-----	None	Empire-Forsyth 138 = 201.6 / 172.0 / 117.2%
	(or Dead River-Plains 345 kV)		A = 58 MW	Empire-Forsyth 138 = 179.1 / 172.0 / 104.1%
			B = 85 MW	None
LL460	Presque Isle-Dead River 138 kV	45.8	None	Empire-Forsyth 138 = 245.7 / 172.0 / 142.8%
	(or Dead River-Plains 345 kV)		A = 58 MW	Empire-Forsyth 138 = 222.9 / 172.0 / 129.6%
			B = 85 MW	Empire-Forsyth 138 = 212.5 / 172.0 / 123.5%
			C = 116 MW	Empire-Forsyth 138 = 200.9 / 172.0 / 116.8%
			D = 143 MW	Empire-Forsyth 138 = 189.8 / 172.0 / 110.3%
			E = 173 MW	Empire-Forsyth 138 = 177.4 / 172.0 / 103.1%
			F = 201 MW	None
	Hiawatha-Straits 138 kV	0	None	Straits 138/69 = 94.4 / 77.0 / 122.6%
				Pine River-Straits 69 #1 = 46.7 / 39.0 / 119.8%
LLA460	Presque Isle-Dead River 138 kV	51.5	None	Empire-Forsyth 138 = 215.9 / 172.0 / 125.5%
	(or Dead River-Plains 345 kV)		A = 58 MW	Empire-Forsyth 138 = 193.2 / 172.0 / 112.3%
			B = 85 MW	Empire-Forsyth 138 = 182.5 / 172.0 / 106.1%
			C = 116 MW	None

1 Overload of Presque Isle-Dead River 138 kV line observed for outage of either Empire-Forsyth 138 kV line or Presque Isle-Perch Lake 138 kV line. Overload eliminated with uprate of Presque Isle-Dead River 138 kV line (substation upgrades at Presque Isle) to 358 MVA.

Thermal Study Results, 2009 Cases, With Transmission Alternatives A & B.

Case	Contingency [1]	Mine Load Shed	RATS Gen. Tripped	Low Voltages / Overloads
S440	Presque Isle-Dead River 138 kV	-----	None	None
	(or Dead River-Plains 345 kV)			
LL460	Presque Isle-Dead River 138 kV	52.0	None	Hiawatha-Straits 138 = 182.4 / 177.0 / 103.0%
	(or Dead River-Plains 345 kV)		A = 58 MW	None
	Hiawatha-Straits 138 kV	0	None	Straits 138/69 = 103.6 / 77.0 / 134.5%
				Pine River-Straits 69 #1 = 51.6 / 39.0 / 132.2%
LLA460	Presque Isle-Dead River 138 kV	54.9	None	None
	(or Dead River-Plains 345 kV)			

Thermal Study Results, 2009 Cases, With Transmission Alternative C (Presque Isle-Plains 345/138 kV Via Perch Lake).

Case	Contingency [1]	Mine Load Shed	RATS Gen. Tripped	Low Voltages / Overloads
S439	Presque Isle-Dead River 138 kV	-----	None	None
	(or Dead River-Plains 345 kV)			
LL460	Presque Isle-Dead River 138 kV	48.6	None	None
	(or Dead River-Plains 345 kV)			
	Hiawatha-Straits 138 kV	0	None	Straits 138/69 = 93.5 / 77.0 / 121.5%
				Pine River-Straits 69 #1 = 46.3 / 39.0 / 118.7%
LLA460	Presque Isle-Dead River 138 kV	54.1	None	None
	(or Dead River-Plains 345 kV)			