Projected Flow South (Wisconsin-U.P. Transfer) Limits, 2006-2009/2014

American Transmission Company, LLC

Stephen D. Feak, P.E.
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Introduction

This report contains the study results of load flow analyses performed to identify the projected Wisconsin-Upper Michigan (U.P.) transfer capability, also called the Flow South limits, in the years 2006 through 2009 and the year 2014. Numerous transmission projects are expected to be completed by 2009 in the northern portion of the ATC system, and these projects will have a significant impact on the transfer capability into the U.P. from Wisconsin. The 2014 analyses were performed to identify any significant reduction in import capability by 2014. This study will identify the expected increases in Flow South capability in 2006-2009 and the projected Flow South limits for 2014.

Included in this report are the following sections: Introduction, Executive Summary, Study Methodology, Study Results, and Conclusions. In addition, Appendix A contains system diagrams of the expected northern ATC system in 2006 and 2007-2009, while Appendix B contains tabulated results of all studies.

Executive Summary

The study results in this report show that the Flow South limits will increase between 2006 and 2009 to a value over 500 MW by 2009. As expected, the Flow South limits increase each year due to the various projects completed. However, the largest increase by far will occur in 2009 upon completion of the Morgan-Werner West 345 kV line. The expected Flow South limits for each year are shown below in Table 1.

Table 1: Flow South Limits Yearly Summary.

Study Year	Flow South Limit (MW)	(MW) Change	Limiter / Contingency	Presque Isle Gen. (MW)	# PI Units
2006	279	-----	Pulliam-Stiles 138 kV / Pulliam-Stiles 138 kV (#1/#2)	268	4
2007	295	+ 16	Pulliam-Stiles 138 kV / Pulliam-Stiles 138 kV (#1/#2)	253	3
2008	326	+ 31	Pulliam-Stiles 138 kV / Pulliam-Stiles 138 kV (#1/#2)	264	4
2009	527	+ 201	U.P. Voltage / Dead River-Plains 345 kV	90	2
2014	521	- 6	U.P. Voltage / Plains-Morgan 345 kV	169	2

For each study year except 2014, the Flow South limit occurred in the shoulder peak case without Ludington cycle. In 2014, the Flow South limit occurred in the summer peak case.

The expected Flow South limit for 2014 is 521 MW, during summer peak conditions, a reduction of 6 MW from 2009. It should be noted that the 2014 TYA case used for the 2014 studies includes virtually no significant transmission projects added between 2010 and 2014 in ATC's northern zones, and the Flow South reduction is likely due to load growth.

The studies show that the addition of the second Plains 345/138 kV transformer in 2008 and either the uprate of the existing Morgan-Falls 138 kV line or the completion of the Morgan-Stiles double-circuit 138 kV corridor by 2009 are essential to avoid a drastic reduction in Flow South limits subsequent to the completion of the Northern Umbrella Plan. The values in Table 1, and Tables 3 and 4 later in this report and all tables in Appendix B, are based on the inclusion of the second Plains transformer in 2008 and the completion of the Morgan-Stiles double-circuit 138 kV corridor in 2009.

All study results are based upon modeling of specific levels of West Marinette and Pulliam generation in the yearly peak and shoulder peak cases (described in Study Assumptions below). Changes in generation output levels at these plants may have an impact on transfer capability. The results in this report, however, present transfer capabilities for typical peak and shoulder peak conditions.

Study Methodology

The methodology used for this study is very consistent with earlier Flow South studies. The intent of these studies was to determine the maximum Flow South value, for various years and load conditions, where first-contingency overloads or low voltages did not occur. Due to the numerous projects expected to be completed in ATC's northern zones by 2009, study cases for each year from 2006 through 2009 were used in the studies. In addition, three study cases were created for each year: one summer peak case and two shoulder peak (off-peak) cases.

The initial cases used to develop all study models were the ATC 2006, 2010, and 2014 Ten Year Assessment (TYA) All Projects summer peak study cases. The 2006 and 2007 peak and shoulder peak models used in this study were derived from the 2006 TYA case. The 2008 and 2009 peak and shoulder peak models were derived from the 2010 TYA case. The 2014 peak and shoulder peak models were derived directly from the 2014 TYA case.

The 2006 and 2010 TYA base case loads in planning zones 1, 2, and 4 (ATC's northern zones) were used to identify the expected 2007, 2008, and 2009 individual loads in these planning zones. The 2007 peak case in this study was identical to the 2006 peak case except for the increase in loads to reflect 2007 expected load conditions as well as the addition of models for transmission projects expected to be in service in 2007. Similarly, the 2008 and 2009 summer peak models were derived from the 2010 TYA case with the appropriate decrease in loads as well as the removal of projects expected in 2009 (2008 case) and 2010 (2008 and 2009 cases).

Table 2 below lists the projects included in the study models and the in-service year. These projects are also shown in the two figures in Appendix A.

One difficult aspect of this study was determining which study year to model the future transmission projects in. If a project is scheduled for completion in Fall 2008, it really wouldn't be available during 2008 summer peak conditions, but would be available for a portion of the 2008 shoulder peak conditions (fall and winter off-peak). If this project was not inserted in the studies until the 2009 models, then the 2009 peak cases would be accurate but the late 2008 shoulder peak cases would not have this project in the model. It was decided to go ahead and model the projects in the study years that they are scheduled for completion, and the audience of this report should recognize this methodology and adjust their reviews accordingly.

The shoulder peak cases in this study included modeling of 75% of peak loads within ATC. These reductions were accompanied by turning off or reducing the most expensive units within ATC: peaking units first, then other less expensive units. The loads in of Northern Illinois (75%), METC in Lower Michigan (85%) and XCel (90%) were also modified to create the shoulder peak cases.

Two shoulder peak cases were created for each year: without Ludington cycle and with Ludington cycle. The Ludington cycle is a nearly daily phenomenon that occurs within the northern ATC system where large imports into Lower Michigan are partially supplied by the transmission tie between ATC and Lower Michigan at ATC's Straits substation in the U.P. During this cycle, the generating units at the Ludington pumped storage plant in Lower Michigan transform from generating units during the day to large loads (motors) during pumping at night. The tie from the U.P. to Lower Michigan is a parallel path which causes the flows from west to east in the U.P. to increase dramatically during this cycle. This parallel flow can have a significant impact on transmission performance, so it is imperative that this scenario be included in the study models.

The shoulder peak cases with Ludington cycle included modeling of the Ludington units in full motor mode as well as some additional units reduced or turned off to import a large quantity of power. This power was replaced with imports from Illinois and Minnesota, which is consistent with earlier Flow South studies. The intent was to create a shoulder peak cycle case where the west to east flow at Indian Lake substation (in the central U.P.) was 80 MW in the 2006 case. The cycle dispatch was kept very similar for the 2007 through 2009 cases and the 2014 case to be able to observe how the cycle flow will increase as additional northern ATC projects are completed due to the lowering of the parallel path through the U.P. to Lower Michigan.

In the Study Results section, shoulder peak cases without the Ludington cycle will be referred to as shoulder peak without cycle. Similarly shoulder peak cases with the Ludington cycle will be referred to as shoulder peak with cycle.

The power flows in the northern ATC system are significantly impacted by the generation dispatch at Pulliam and West Marinette. To be consistent from year to year and be able to more easily quantify the benefits that various transmission projects have on transfer capability, the total generation output at Pulliam and West Marinette were kept the same from year to year, with the shoulder peak outputs less than the summer peak outputs at these plants. It is obvious that modifying the generation at Pulliam and West Marinette will have an impact on the Flow South limits, but the values used in these studies are very reasonable for the peak and shoulder peak conditions.

Flow South is defined as the sum (in MW) of the flows on the following transmission lines:

- Morgan to Plains 345 kV measured at Morgan.
- Stiles to Amberg 138 kV measured at Stiles.
- Stiles to Crivitz 138 kV measured at Stiles.
- Ingalls to Holmes 138 kV measured at Ingalls.
- Cranberry to Conover 115 kV measured at Cranberry (after Cranberry-Conover 115 kV is completed).

This study also includes a U.P. Import value, which is calculated for each Flow South limit. This U.P. import value basically calculates the total import into the U.P. from both Wisconsin and Lower Michigan. U.P. Import is defined as the sum (in MW) on the following transmission lines:

- Morgan to Plains 345 kV measured at Morgan.
- Amberg to Plains 138 kV #1 and #2 measured at Amberg.
- McGulpin (METC) to Straits 138 kV #1 and #3 measured at McGulpin.
- Cranberry to Conover 115 kV measured at Cranberry (after Cranberry-Conover 115 kV is completed).

The model assumptions used in this study, which include some of what was discussed above, are:

- For all cases, all three capacitor banks (58 MVAR total) were on-line at Plains, and one reactor was on-line and fixed at 25 MVAR at Morgan, Plains, and Dead River. The special protection scheme to trip the reactors at Plains and Morgan was not modeled in these studies.
- Flow South values were adjusted by modifying Presque Isle generation, with the slack machine at Pleasant Prairie increasing or decreasing to accommodate the changes at Presque Isle.
- West Marinette generation in all studies: peak cases = 180 MW, shoulder peak cases = 75 MW.
- Pulliam generation in all studies: peak cases = 429 MW, shoulder peak cases = 305 MW.

Study Results

The study results are shown in the tables in Appendix B, and are summarized in Tables 3 and 4 below.

2006

The 2006 studies were performed using 2006 study cases derived from the 2006 TYA All Projects case. The 2006 summer peak case included slight changes from the original case, including some of the study assumptions for reactive compensation in the U.P. (reactors, capacitor banks), generation at Pulliam and West Marinette, etc. The shoulder peak cases were derived from this new 2006 peak case as described earlier.

Table 2: Significant Northern Projects Added To Study Cases By Year.

Study Case Year	Year Project In Service	Planning Zone(s)	Project Description
2006	2005	4	Morgan-Stiles 138 kV rebuild
2006	2005	4	Morgan-White Clay 138 kV uprate
2006	2006	1	Uprate Weston-Kelly 115 kV line
2006	2006	2	Indian Lake-Hiawatha 2-ckt 138 kV, initially operated as 1-ckt 69 kV
2006	2006	2	Rebuild Nordic-Randville 69 kV
2006	2006	4	Werner West 345/138 kV substation
2006	2006	4	Install series reactor at Highway V on Highway V-Preble 138 kV line
2006	2006	1&2	Capacitor bank additions at Summit Lk 115 kV & Lincoln, Munising, and K.I. Sawyer 69 kV
2006	2006	2&4	Stiles-Amberg-Plains 138 kV rebuild + Amberg-West Marinette rebuild/conversion to 138 kV
2007	2007	1	Install 2x16.3 MVAR cap banks @ Wautoma 138 kV
2007	2007	1	Rebuild Weston-Sherman St. + new Gardner Park-Hilltop 138 kV
2007	2007	2	Relocate Cedar substation (North Lake)
2007	2007	2	Install 2x8.16 MVAR cap banks @ Ontonagon 138 kV
2007	2007	4	String Ellinwood-Sunset Pt. 138 kV line
2007	2007	4	Install 2x16.3 MVAR cap banks @ Canal 69 kV
2007	2007	4	Uprate N. Appleton-Lawn Rd.-White Clay 138 kV line
2007	2007	1&2	Cranberry-Conover 115 kV line + Conover 138/115 kV transformer
2008	2008	1	Uprate Kelly-Whitcomb 115 kV line to 300° F
2008	2008	1	Arrowhead-Stone Lake-Gardner Park 345 kV line
2008	2008	1	Uprate Highway 8-Clear Lake 115 kV line
2008	2008	2	Rebuild/Uprate Atlantic-Osceola 69 kV lines #1 & #2
2008	2008	2	Install 2nd Plains 345/138 kV transformer
2008	2008	2	Conover-Iron Grove 138 kV conversion + Iron Grove 138/69 transformer
2008	2008	4	Install 138/69 kV transformer at Menominee
2008	2008	4	Rebuild Crivitz-High Falls 2-ckt 69 kV
2009	2009	1	Gardner Park-Central Wisconsin 345 kV line + CWIS substation
2009	2009	2	Indian Lake-Hiawatha double-circuit 138 kV
2009	2009	2	Install 1x5.4 MVAR capacitor bank at MTU 69 kV
2009	2009	2	Install 1x5.4 MVAR capacitor bank at Roberts 69 kV
2009	2009	2	Iron Grove-Plains 138 kV conversion
2009	2009	4	Morgan-Stiles 2nd 138 kV circuit
2009	2009	4	Morgan-Werner West 345 kV line
2009	2009	4	Clintonville-Werner West 138 kV line

Table 3: Flow South Limits By Study Case.

Study Case	Flow South Limit (MW) [2]	U.P. Import (MW) [3]	Limiter	Contingency	Presque Isle Gen. (MW)	# PI Units
2006 Summer Peak	302	361	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	314	4
2006 Shoulder Peak, No Cycle	279	324	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	268	4
2006 Shoulder Peak, Full Cycle	287	257	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	337	4
2007 Summer Peak	308	370	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	311	4
2007 Shoulder Peak, No Cycle	295	341	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	253	3
2007 Shoulder Peak, Full Cycle	309	280	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	321	4
2008 Summer Peak [1]	348	383	Gardner Park-Blackbrook 115 kV	Maine-Pine 115 kV	314	4
2008 Shoulder Peak, No Cycle [1]	326	355	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	264	4
2008 Shoulder Peak, Full Cycle [1]	341	297	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	354	5
2009 Summer Peak [1]	555	591	U.P. Voltage	Dead River-Plains 345 kV	118	2
2009 Shoulder Peak, No Cycle [1]	527	558	U.P. Voltage	Dead River-Plains 345 kV	90	2
2009 Shoulder Peak, Full Cycle [1]	554	465	Plains-Arnold 138 kV	Dead River-Plains 345 kV	204	3
2014 Summer Peak	521	572	U.P. Voltage	Plains-Morgan 345 kV	169	2
2014 Shoulder Peak, No Cycle	532	569	Empire-Forsyth 138 kV	Dead River-Plains 345 kV	94	2
2014 Shoulder Peak, Full Cycle	567	482	Plains-Arnold 138 kV	Dead River-Plains 345 kV	200	3

1) Includes uprate of Q-95, Highway 8-Clear Lake 115 kV line, to 120 MVA (replace CT) by 2008. Includes 2nd Morgan-Stiles 138 kV circuit in the 2009 and 2014 study cases only.
2) Flow South is defined as the sum (in MW) of the flows on the following transmission lines: Morgan-Plains 345 kV at Morgan, Stiles-Amberg 138 kV at Stiles, Stiles-Crivitz 138 kV at Stiles, Ingalls-Holmes 138 kV at Ingalls. For those study cases which include the Cranberry-Conover 115 kV line, Flow South also includes the flows on the Cranberry-Conover 115 kV line at Cranberry.
3) U.P. Import is defined as the sum of the flows on: Morgan-Plains 345 kV at Morgan, Amberg -Plains 138 kV (both circuits) at Amberg, Cranberry-Conover 115 kV at Cranberry, McGulpin-Straits 138 kV (both circuits) at McGulpin. The U.P. Import values in the tables represent the U.P. Import level at the Flow South limit listed.

Table 4: Flow South Limits Yearly Summary.

Study Year	Limiting Study Case	Flow South Limit (MW)	(MW) Change	Limiter	Contingency	Presque Isle Gen. (MW)	# PI Units
2006	Shoulder Peak, No Cycle	279	-----	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	268	4
2007	Shoulder Peak, No Cycle	295	+ 16	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	253	3
2008	Shoulder Peak, No Cycle	326	+ 31	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	264	4
2009	Shoulder Peak, No Cycle	527	+ 201	U.P. Voltage	Dead River-Plains 345 kV	90	2
2014	Summer Peak	521	- 6	U.P. Voltage	Plains-Morgan 345 kV	169	2

Table 3 shows that in 2006, the Flow South limits for summer peak, shoulder peak without cycle, and shoulder peak with cycle are 302, 279, and 287 MW, respectively. The limiting elements for all three cases were the Pulliam-Stiles 138 kV lines (outage of one line overloads the other line). The lowest of the three limits is 279 MW, which occurs at shoulder peak without cycle.

Table 3 also lists the U.P. Import value associated with these Flow South limits. The largest U.P. import value in 2006 is during 2006 summer peak conditions, which includes large flows from Lower Michigan to the U.P. Conversely, the lowest U.P. import value is during shoulder peak with cycle, when the large flows to Lower Michigan reduce or nearly reverse the flow at Straits. All study years show similar results, with the largest U.P. Import during summer peak, and the lowest during shoulder peak with cycle.

It should be noted that by 2006 the Highway V-Preble 138 kV reactor project should be completed. This project includes the addition of a 5-ohm 138 kV series reactor on this line to increase the total impedance of this path and reduce its loading. Earlier studies had shown that this line was likely to be a significant limiter for south-to-north transfers. Power flow analyses as part of this study show that without this reactor, the Flow South limits for 2006 would be between 31 and 46 MW less than those for 2006 in Table 3, depending on the study case. In addition, other projects that are expected to have a direct and significant impact on Flow South capability include: Morgan-Stiles 138 kV rebuild, Morgan-White Clay 138 kV uprate, Indian Lake-Hiawatha 69 kV line, and the Stiles-Amberg-Plains/Amberg-West Marinette project.

2007

The 2007 summer peak case used in these studies used the 2006 summer peak case as its basis, but included load modeling for 2007 expected load levels as well as including projects expected to be in service in 2007. The shoulder peak cases were then derived from this new 2007 peak case.

The Flow South limits for 2007 are 308, 295, and 309 MW, an increase of 6, 16, and 22 MW. The limiting elements for all three cases were again the Pulliam-Stiles 138 kV lines. The lowest expected Flow South limit is 295 MW, at shoulder peak without cycle, an increase of 16 MW from 2006.

The only 2007 project that is expected to have a direct impact on Flow South capability is the Cranberry-Conover 115 kV line (plus Conover 138/115 kV transformer). This project is the first stage (of three stages) of the Cranberry-Conover-Plains Project.

2008

The 2008 studies were performed using a 2010 study case derived from the 2010 TYA All Projects case. The 2010 summer peak case included slight changes from the original 2010 case using the same assumptions as in creating the 2006 summer peak case. The 2008 summer peak case used in these studies then used this new 2010 summer peak case, but included modeling the expected loads in 2008 as well as removing projects expected to be in service in 2009 and 2010. The shoulder peak cases were then derived from this new 2008 peak case.

The expected Flow South limits for 2008 are 348, 326, and 341 MW, an increase of 40, 31, and 32 MW from 2007. The limiting element for the 2008 summer peak case was the Gardner Park-Blackbrook 115 kV line, while the limiters for the 2008 shoulder peak cases were the Pulliam-Stiles 138 kV lines. The lowest limit is 326 MW, at shoulder peak without cycle, which is an increase of 31 MW from 2006.

The transmission project with the largest impact on the performance of the northern ATC system is likely the second stage of the Cranberry-Conover-Plains project, which is the conversion of the Conover to Iron River 69 kV line to 138 kV. This project, along with the addition of Weston 4 generation in 2008, results in more power imported to the U.P. from the Rhinelander area, which in turn reduces the flow on the Pulliam-Stiles 138 kV lines. The 2008 study cases also include an uprate of the Highway 8-Clear Lake 115 kV line (Q-95), which is needed due to higher loadings in this portion of the system.

2009

The 2009 studies were performed using the derived 2010 peak case described in the 2008 section. The 2009 summer peak case used in these studies modified this 2010 summer peak case by modeling the expected loads for 2009 as well as removing projects expected to be in service in 2010. The shoulder peak cases were then derived from this new 2009 peak case.

One significant modeling change was used for the 2009 and 2014 study cases due to the large U.P. import capabilities starting in 2009: for any Presque Isle generation dispatch scenario with less than three units (two or one unit) on-line, 40 MVAR of capacitor banks were added in the study cases at the Presque Isle 138 kV bus to avoid voltage collapse in the U.P. Turning off generating units at Presque Isle not only increases import and therefore lowers system voltages due to voltage drops on the transmission system, it also removes rotating reactive power sources in this area which significantly degrades the voltage profile in the U.P. The large 90 MW units at Presque Isle can deliver approximately 40 MVAR each to the system grid. Therefore, with only two units on-line, the three large units off-line represent the loss of 120 MVAR of reactive capability to the system (not counting the smaller units 1-4).

This study took the liberty of replacing a portion of that lost reactive compensation due to the fact that ATC would likely take action in that direction should any units be retired. If an extreme event occurred where Presque Isle lost seven of the existing nine units in 2009, the Flow South limits would need to be reduced by about 50 MW to ensure system stability.

The study results for 2009 show a dramatic increase in the capability of moving power to the U.P. The expected Flow South limits for 2009 are 555, 527, and 554 MW, an increase of 207, 201, and 213 MW. The lowest limit is again for shoulder peak without cycle at 527 MW, an increase of 201 MW. The Flow South limiters for 2008 are the Plains-Arnold 138 kV line for the cycle shoulder case, and post-contingency voltages in the U.P. for the other cases.

There are several major transmission projects expected to be in service in 2009 which will have a large impact on U.P. import capability. The most significant of these is the Morgan-Werner West 345 kV line (and Clintonville-Werner West 138 kV line). This project provides a strong 345 kV parallel path west of the Green Bay area to the northern system, greatly relieving the 138 kV system. Although other projects in 2009 will add to the reliability of the system, the 200+ MW increase in transfer capability is primarily due to the Morgan-Werner West 345 kV line.

2014

The 2014 studies were performed using a case derived from the 2014 TYA All Projects case. The shoulder peak cases were then derived from this new 2014 peak case. It should be noted that the 2014 case does not include any significant northern projects that differ from the 2009 case due to the fact that nearly all the significant projects in this area are to be completed by 2009.

The results for 2014 show that the expected Flow South limits are 521, 532, and 567 MW. The summer peak capability was reduced to 521 MW. This reduction is likely due to increased load growth to 2014. Although this value is less than 2009, it is still in excess of 500 MW showing that the expected projects in service by 2009 will continue to provide a robust system through 2014.

Morgan-Stiles 138 kV circuit

One significant transmission project was added to the 2009 study cases that is not listed in the Ten Year Assessment – the Morgan to Stiles 2nd 138 kV circuit. The rebuild of the Morgan-Stiles 138 kV corridor in 2005 included double-circuit construction, with this corridor originally operated as one circuit with two conductors per phase. The intent was to have the capability for a future second circuit that was shown to be needed by future planning studies.

Additional analyses were performed using only single-circuit Morgan-Falls-Pioneer-Stiles 138 kV. The Summer Emergency ratings from the original 2006 case included 292.7 MVA for Morgan-Falls and 382 MVA for Falls-Pioneer-Stiles. Using these ratings, the analyses show that the Flow South limits in 2009 would be reduced by over 200 MW during the shoulder peak with cycle case and over 150 MW for the shoulder peak without cycle case.

One additional study was performed with the 2009 models modified to reflect a proposed uprate of the existing and rebuilt Morgan-Falls 138 kV line, specifically to a 403 MVA Summer Emergency rating. This MVA rating is of the overhead conductors of this circuit, with the proposed uprate project including the removal of all substation limiters at Morgan and Falls substations to increase the rating to the 403 MVA rating. The study showed a marked improvement compared to the existing 292.7 MVA rating. The 2009 studies showed no limitation on any portion of the Morgan-Stiles 138 kV corridor in the summer peak and shoulder peak without cycle cases. However, in the 2009 shoulder peak with cycle case, loading on the Falls-Pioneer 138 kV line resulted in limiting Flow South to 510 MW, a decrease from 554 MW from the 2009 shoulder peak with cycle case and with two Morgan-Stiles 138 kV circuit. This 510 MW limit would be the lowest limit among the three 2009 cases, even lower than the 524 MW limit for the shoulder peak without cycle case.

Therefore, if the uprate of the Morgan-Falls 138 kV line to 403 MVA is completed, the overall 2009 Flow South limit would be reduced from 527 MW with the double-circuit Morgan-Stiles corridor (shoulder peak without cycle case, limiter = U.P. post-contingency voltage) to 510 MW (shoulder peak with cycle case, limiter = Morgan-Falls 138 kV line loading).

From these studies it is imperative that the existing 292.7 MVA Summer Emergency rating of the Morgan-Falls 138 kV line be addressed. To do nothing would result in a dramatic reduction in transfer capability to the U.P. on a first-contingency basis, and likely a big reduction in reliability and operating flexibility during maintenance outages in this area. Certainly the proposed uprate to 403 MVA of this line is needed at a minimum to ensure capturing the vast majority of the benefits from the entire Northern Umbrella Plan. ATC will do an internal evaluation in the future to decide whether or not the double-circuit operation of the Morgan-Stiles 138 kV corridor is warranted from a reliability and economic perspective. The summarized results in this report, however, will continue to list the results using the double-circuit Morgan-Stiles 138 kV corridor model.

The reduction of 17 MW of transfer capability is a small percentage of the expected 500+ MW 2009 transfer capabilities. However, the cost of creating a double-circuit Morgan-Stiles 138 kV corridor, adding terminals at Morgan and Stiles, is not very significant compared to the overall cost of construction in this area, and 17 MW of transfer capability is not insignificant. In addition, it may be found that the second 138 kV circuit may be desired to avoid potential reliability issues during extended forced or maintenance outages in this area. Future studies and discussion will dictate the course of action ATC will take.

Indian Lake Flow During Cycle

The west-to-east power flows at the Indian Lake substation are increased significantly during the Ludington cycle. As mentioned earlier, the starting 2006 shoulder peak case, with the Ludington cycle, included power transfers to increase the flows at Indian Lake to approximately 80 MW, although this value changes as Flow South is modified. The 80 MW is a flow level actually experienced occasionally at Indian Lake, and represents a value toward the high end of observed flows.

In 2009, when the Morgan-Werner West 345 kV line and the double-circuit Indian Lake-Hiawatha 138 kV lines are in service, the shoulder peak case with the Ludington cycle showed a west-to-east flow at Indian Lake of over 160 MW. The projects in service by 2009 result in a large decrease in the equivalent impedance of the parallel transmission path from the U.P. to Lower Michigan, allowing larger flows in this direction. However, the stronger transmission system due to these projects can accommodate these larger flows.

Plains 2nd 345/138 kV Transformer

An analysis was performed to determine the impact on U.P. Import capability without the addition of the second 345/138 kV transformer at Plains Substation in 2008. Part of the planning process includes periodic reevaluation of the benefits that specific projects may provide. This analysis was performed to show that with the significant amount of capital invested in the Northern Umbrella Plan to provide a very reliable and robust system by 2009, U.P. import capability would be greatly reduced with the elimination of this project and its relatively modest cost.

The 2008 study cases were modified to remove the 2nd Plains 345/138 kV transformer, and the Flow South studies for these modified cases performed. The results showed that although the single existing Plains 345/138 kV transformer did not become an import limiter, the removal of this element did lower the Flow South limits by 6 MW, 1 MW, and 1 MW (summer peak, shoulder peak without cycle, shoulder peak with cycle). Perhaps more importantly, for the shoulder peak case with cycle, loading on the Iron Grove (Iron River) 138/69 kV transformer increased significantly under contingency, with this transformer moving to within 1 MW of the Flow South limit. This would mean that although the Pulliam-Stiles 138 kV lines are the limits in this study, a change in generation dispatch at West Marinette that would reduce the Pulliam-Stiles loading will likely not relieve the Iron Grove transformer loading and may limit transfer capability.

The 2009 study cases were also modified to determine the impact on Flow South capability in 2009 without the 2nd Plains 345/138 kV transformer. While the 2008 studies show that the elimination of the 2nd Plains transformer had a small impact on the Flow South limits, the 2009 studies show a significant reduction in U.P. Import capability without this project. Table 5 below shows a comparison of Flow South capability for each of the three 2009 study cases with and without the 2nd Plains transformer. The results show that Flow South will be reduced by over 100 MW without the Plains transformer.

Table 5: Comparison of 2009 Flow South Limits, With And Without 2nd Plains 345/138 kV Transformer.

2009 Case	Flow South Limit (MW)	Limiter	Contingency
Summer Peak			
Without Plains 345/138 kV #2	419	Plains 345/138 kV #1	Dead River-Plains 345 kV
With Plains 345/138 kV #2	555	U.P. Voltage	Dead River-Plains 345 kV
Shoulder Peak Without Cycle			
Without Plains 345/138 kV #2	409	Plains 345/138 kV #1	Dead River-Plains 345 kV
With Plains 345/138 kV #2	527	U.P. Voltage	Dead River-Plains 345 kV
Shoulder Peak With Cycle			
Without Plains 345/138 kV #2	405	Plains 345/138 kV #1	Dead River-Plains 345 kV
With Plains 345/138 kV #2	554	U.P. Voltage	Dead River-Plains 345 kV

Conclusions

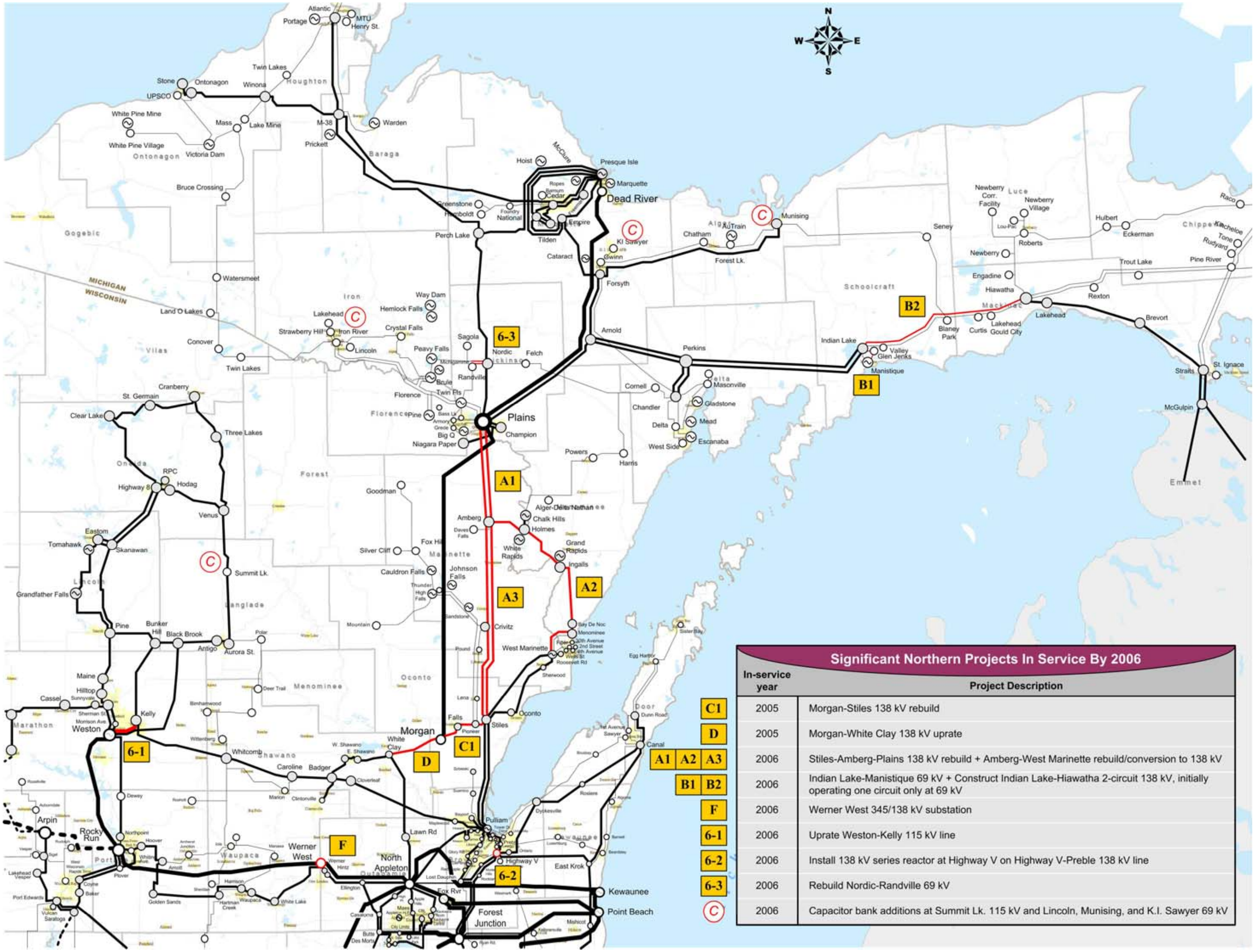
The study results in this report show that the Wisconsin-U.P. transfer capability (Flow South limits) will increase between 2006 and 2009 to a value over 500 MW by 2009. These results are very consistent with earlier studies. These results in *this* study, however, show the expected limits in each of these years as various transmission projects are completed. As expected, the Flow South limits increase each year due to the various projects completed. However, the largest increase by far will occur in 2009 upon completion of the Morgan-Werner West 345 kV line. The Flow South capability is expected to continue above 500 MW through 2014.

The studies show that the addition of the second Plains 345/138 kV transformer in 2008 and either the uprate of the existing Morgan-Falls 138 kV line or the completion of the Morgan-Stiles double-circuit 138 kV corridor by 2009 are essential to avoid a drastic reduction in Flow South limits subsequent to the completion of the Northern Umbrella Plan.

The results of this study are the expected transfer capabilities based on the current expected in service dates of the projects as well as the study cases used in these analyses. ATC will continue to periodically review these values as various projects are completed, as in-service dates of future projects are adjusted, and as study cases are created to more accurately reflect expected load conditions in the future.

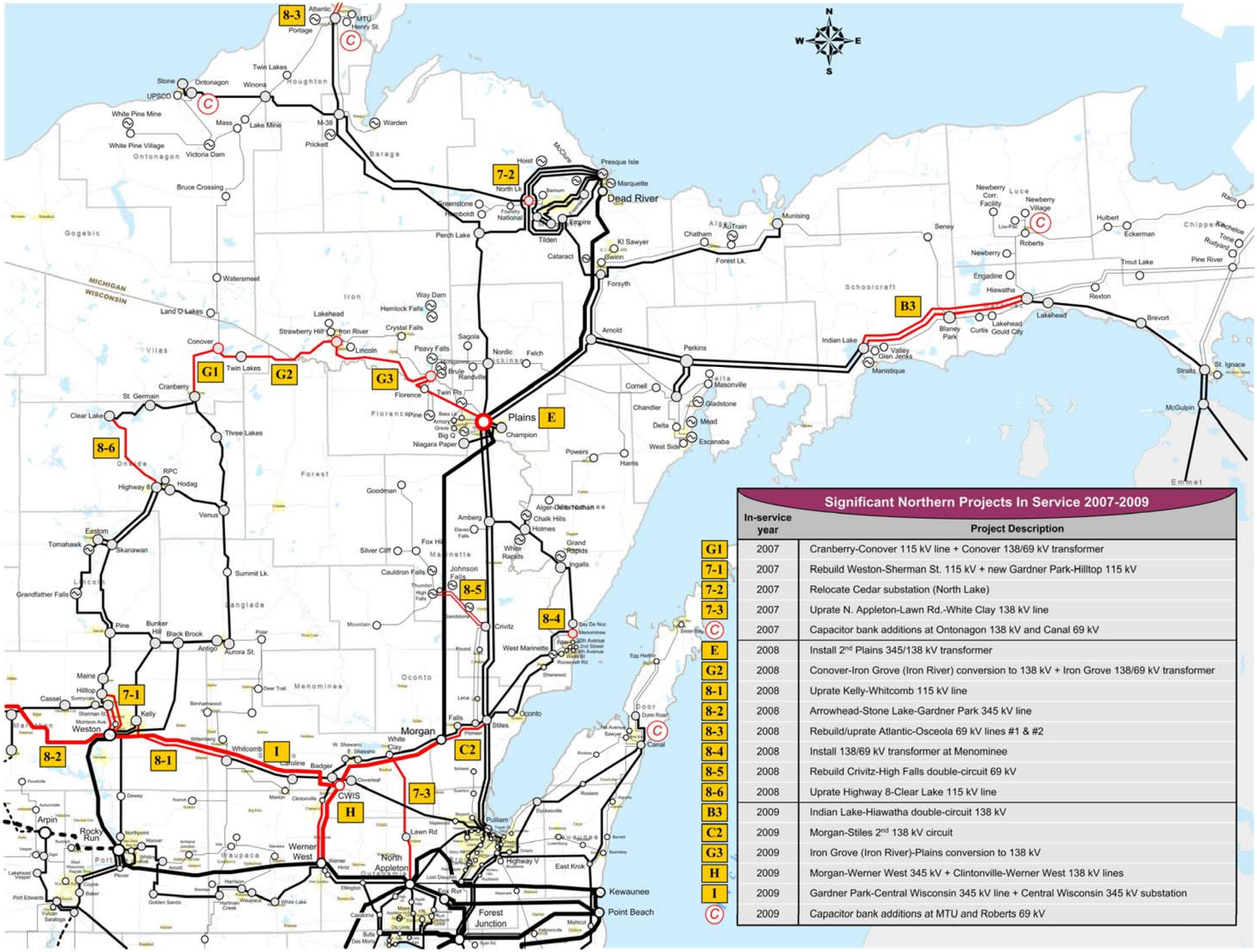
APPENDIX A

2006 and 2007-2009 Northern ATC System Transmission Diagrams



Significant Northern Projects In Service By 2006

	In-service year	Project Description
C1	2005	Morgan-Stiles 138 kV rebuild
D	2005	Morgan-White Clay 138 kV uprate
A1 A2 A3	2006	Stiles-Amberg-Plains 138 kV rebuild + Amberg-West Marinette rebuild/conversion to 138 kV
B1 B2	2006	Indian Lake-Manistique 69 kV + Construct Indian Lake-Hiawatha 2-circuit 138 kV, initially operating one circuit only at 69 kV
F	2006	Werner West 345/138 kV substation
6-1	2006	Uprate Weston-Kelly 115 kV line
6-2	2006	Install 138 kV series reactor at Highway V on Highway V-Preble 138 kV line
6-3	2006	Rebuild Nordic-Randville 69 kV
C	2006	Capacitor bank additions at Summit Lk. 115 kV and Lincoln, Munising, and K.I. Sawyer 69 kV



In-service year	Project Description
G1 2007	Cranberry-Conover 115 kV line + Conover 138/69 kV transformer
7-1 2007	Rebuild Weston-Sherman St. 115 kV + new Gardner Park-Hilltop 115 kV
7-2 2007	Relocate Cedar substation (North Lake)
7-3 2007	Uprate N. Appleton-Lawn Rd.-White Clay 138 kV line
C 2007	Capacitor bank additions at Ontonagon 138 kV and Canal 69 kV
E 2008	Install 2nd Plains 345/138 kV transformer
G2 2008	Conover-Iron Grove (Iron River) conversion to 138 kV + Iron Grove 138/69 kV transformer
8-1 2008	Uprate Kelly-Whitcomb 115 kV line
8-2 2008	Arrowhead-Stone Lake-Gardner Park 345 kV line
8-3 2008	Rebuild/uprate Atlantic-Osceola 69 kV lines #1 & #2
8-4 2008	Install 138/69 kV transformer at Menominee
8-5 2008	Rebuild Crivitz-High Falls double-circuit 69 kV
8-6 2008	Uprate Highway 8-Clear Lake 115 kV line
B3 2009	Indian Lake-Hiawatha double-circuit 138 kV
C2 2009	Morgan-Stiles 2nd 138 kV circuit
G3 2009	Iron Grove (Iron River)-Plains conversion to 138 kV
H 2009	Morgan-Werner West 345 kV + Clintonville-Werner West 138 kV lines
I 2009	Gardner Park-Central Wisconsin 345 kV line + Central Wisconsin 345 kV substation
C 2009	Capacitor bank additions at MTU and Roberts 69 kV

Significant Northern Projects In Service 2007-2009

APPENDIX B

Tabulated Study Results

Table B1a: Flow South Limits, 2006 Summer Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
302	361	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	314	4
373	444	U.P. Voltage	Plains-Morgan 345 kV	234	3
382	455	U.P. Voltage	Dead River-Plains 345 kV	224	3

1) For all study cases, all three cap banks (58 MVAR total) were on-line at Plains, and one 25 MVAR reactor was on-line and fixed at Morgan, Plains, and Dead River. The special protection scheme to trip the reactors at Plains and Morgan was not modeled in the studies.
2) Flow South is defined as the sum (in MW) of the flows on the following transmission lines: Morgan-Plains 345 kV at Morgan, Stiles-Amberg 138 kV at Stiles, Stiles-Crivitz 138 kV at Stiles, Ingalls-Holmes 138 kV at Ingalls. For those study cases which include the Cranberry-Conover 115 kV line, Flow South also includes the flows on the Cranberry-Conover 115 kV line at Cranberry.
3) U.P. Import is defined as the sum of the flows on: Morgan-Plains 345 kV at Morgan, Amberg -Plains 138 kV (both circuits) at Amberg, Cranberry-Conover 115 kV at Cranberry, McGulpin-Straits 138 kV (both circuits) at McGulpin. The U.P. Import values in the tables represent the U.P. Import level at the Flow South limit listed.
4) Generation dispatch for all cases (Summer Peak/Shoulder Peak): West Marinette = 180/75 MW, Pulliam = 429/305 MW.
5) Flow South was adjusted by modifying Presque Isle generation, with the area slack machine at Pleasant Prairie increasing or decreasing to accommodate the changes.

Table B1b: Flow South Limits, 2006 Shoulder Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
279	324	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	268	4
348	404	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	191	3
351	408	White Clay-Morgan 138 kV	None	187	3
354	411	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	184	3
366	426	U.P. Voltage	Plains-Morgan 345 kV	170	3
366	426	U.P. Voltage	Dead River-Plains 345 kV	170	3

Table B1c: Flow South Limits, 2006 Shoulder Peak Case With Ludington Cycle.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
287	257	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	337	4
339	317	White Clay-Morgan 138 kV	None	279	4
342	320	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	276	4
354	334	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	262	4
397	384	Highway V-Preble 138 kV	Lost Dauphin-Red Maple 138 kV	212	3
402	390	N. Appleton-Lawn Rd. 138 kV	Pulliam-Stiles 138 kV (#1/#2)	207	3
413	403	U.P. Voltage	Plains-Morgan 345 kV	194	3
434	428	U.P. Voltage	Dead River-Plains 345 kV	170	3

Table B2a: Flow South Limits, 2007 Summer Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
308	370	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	311	4
393	468	Conover 138/69 kV	Plains-Morgan 345 kV	216	3
394	469	U.P. Voltage	Plains-Morgan 345 kV	215	3
400	476	U.P. Voltage	Dead River-Plains 345 kV	208	3

Table B2b: Flow South Limits, 2007 Shoulder Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
295	341	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	253	3
348	402	Conover 138/69 kV	Plains-Morgan 345 kV	194	3
351	406	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	191	3
368	425	White Clay-Morgan 138 kV	None	172	3
370	428	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	170	3
371	429	U.P. Voltage	Dead River-Plains 345 kV	169	3
382	442	U.P. Voltage	Plains-Morgan 345 kV	158	2

Table B2c: Flow South Limits, 2007 Shoulder Peak Case With Ludington Cycle.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
309	280	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	321	4
328	302	Conover 138/69 kV	Plains-Morgan 345 kV	299	4
356	334	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	266	4
360	339	White Clay-Morgan 138 kV	None	262	4
369	349	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	252	3
391	374	Conover 138/69 kV	None	226	3
398	382	Mass-Lake Mine 69 kV	Victoria-Rockland Jct. Tap #1	219	3
402	387	Lake Mine-Winona 69 kV	Victoria-Rockland Jct. Tap #1	214	3
417	404	Highway V-Preble 138 kV	Lost Dauphin-Red Maple 138 kV	198	3
439	429	Preble-Tower Dr. 138 kV	Lost Dauphin-Red Maple 138 kV	173	3
441	432	U.P. Voltage	Plains-Morgan 345 kV	171	3
441	432	U.P. Voltage	Dead River-Plains 345 kV	171	3

Table B2d: 2007 Projects Added To 2006 Study Cases To Create 2007 Study Cases.

Zone	Project Description	Zone	Project Description
1	Install 2x16.3 MVAR cap banks @ Wautoma 138 kV	4	String Ellinwood-Sunset Pt. 138 kV line
1	Rebuild Weston-Sherman St. + new Gardner Park-Hilltop 138 kV	4	Install 2x16.3 MVAR cap banks @ Canal 69 kV
2	Relocate Cedar substation (North Lake)	4	Uprate N. Appleton-Lawn Rd.-White Clay 138 kV line
2	Install 2x8.16 MVAR cap banks @ Ontonagon 138 kV	1&2	Cranberry-Conover 115 kV line + Conover 138/115 kV xfmr

Table B3a: Flow South Limits, 2008 Summer Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
348	383	Gardner Park-Blackbrook 115 kV	Maine-Pine 115 kV	314	4
349	385	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	313	4
382	422	Maine-Hilltop 115 kV	Gardner Park-Kelly 115 kV	276	4
431	479	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	222	3
435	484	White Clay-Morgan 138 kV	None	217	3
435	484	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	217	3
457	509	Iron Grove 138/69 kV	Plains-Morgan 345 kV	193	3
460	513	U.P. Voltage	Plains-Morgan 345 kV	190	3
463	517	U.P. Voltage	Dead River-Plains 345 kV	186	3

Table B3b: Flow South Limits, 2008 Shoulder Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
326	355	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	264	4
357	391	White Clay-Morgan 138 kV	None	250	3
371	407	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	234	3
377	414	Iron Grove 138/69 kV	Plains-Morgan 345 kV	227	3
380	417	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	224	3
419	463	Highway V-Preble 138 kV	Lost Dauphin-Red Maple 138 kV	181	3
429	474	U.P. Voltage	Dead River-Plains 345 kV	170	3
429	474	U.P. Voltage	Plains-Morgan 345 kV	170	3

Table B3c: Flow South Limits, 2008 Shoulder Peak Case With Ludington Cycle.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
341	297	Pulliam-Stiles 138 kV (#1/#2)	Pulliam-Stiles 138 kV (#1/#2)	354	5
352	309	White Clay-Morgan 138 kV	None	341	5
354	312	Iron Grove 138/69 kV	Rocky Run-Werner West 345 kV	339	4
374	334	White Clay-Morgan 138 kV	Pulliam-Stiles 138 kV (#1/#2)	316	4
386	348	Caroline-Bell Plaine 115 kV	Rocky Run-Werner West 345 kV	302	4
388	351	N. Appleton-Mason St. 138 kV	N. Appleton-Lawn Rd. 138 kV	300	4
419	386	Bell Plaine-Badger 115 kV	Rocky Run-Werner West 345 kV	265	4
437	407	Iron Grove 138/69 kV	None	245	3
448	419	Highway V-Preble 138 kV	Lost Dauphin-Red Maple 138 kV	233	3
470	444	Venus-Three Lakes 115 kV	Highway 8-Clear Lake 115 kV	208	3
473	448	Preble-Tower Drive 138 kV	Lost Dauphin-Red Maple 138 kV	205	3
482	457	U.P. Voltage	Plains-Morgan 345 kV	196	3
485	461	U.P. Voltage	Dead River-Plains 345 kV	192	3

Table B3d: 2008 Projects Included In 2008 Study Cases.

Zone	Project Description	Zone	Project Description
1	Uprate Kelly-Whitcomb 115 kV line to 300˚ F	2	Conover-Iron Grove 138 kV conversion + Iron Grove 138/69 xfmr
1	Arrowhead-Stone Lake-Gardner Park 345 kV line	4	Install 138/69 kV transformer at Menominee
2	Rebuild/Uprate Atlantic-Osceola 69 kV lines #1 & #2	4	Rebuild Crivitz-High Falls 2-ckt 69 kV
2	Install 2nd Plains 345/138 kV transformer		

Table B4a: Flow South Limits, 2009 Summer Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
555	591	U.P. Voltage	Dead River-Plains 345 kV	118	2
564	601	U.P. Voltage	Plains-Morgan 345 kV	108	2

1) For the 2009 study cases, a 4x10.8 MVAR capacitor bank was added at the Presque Isle 138 kV bus if less than three Presque Isle units were on-line.

Table B4b: Flow South Limits, 2009 Shoulder Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
527	558	U.P. Voltage	Dead River-Plains 345 kV	90	2
532	564	U.P. Voltage	Plains-Morgan 345 kV	84	1

Table B4c: Flow South Limits, 2009 Shoulder Peak Case With Ludington Cycle.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
554	465	Plains-Arnold 138 kV	Dead River-Plains 345 kV	204	3
591	507	Presque Isle-Dead River 138 kV	Plains-Arnold 138 kV	162	2
609	527	U.P. Voltage	Dead River-Plains 345 kV	142	2
629	550	U.P. Voltage	Plains-Morgan 345 kV	120	2

Table B4d: 2009 Projects Included In 2009 Study Cases.

Zone	Project Description	Zone	Project Description
1	Gardner Park-Central Wisconsin 345 kV line + CWIS substation	2	Iron Grove-Plains 138 kV conversion
2	Indian Lake-Hiawatha double-circuit 138 kV	4	Morgan-Stiles 2nd 138 kV circuit
2	Install 1x5.4 MVAR capacitor bank at MTU 69 kV	4	Morgan-Werner West 345 kV line
2	Install 1x5.4 MVAR capacitor bank at Roberts 69 kV	4	Clintonville-Werner West 138 kV line

Table B5a: Flow South Limits, 2014 Summer Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
521	572	U.P. Voltage	Plains-Morgan 345 kV	169	2
544	599	U.P. Voltage	Dead River-Plains 345 kV	144	2

1) For the 2014 study cases, a 4x10.8 MVAR capacitor bank was added at the Presque Isle 138 kV bus if less than three Presque Isle units were on-line.

Table B5b: Flow South Limits, 2014 Shoulder Peak Case.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
532	569	Empire-Forsyth 138 kV	Dead River-Plains 345 kV	94	2
533	571	U.P. Voltage	Dead River-Plains 345 kV	92	2
540	579	U.P. Voltage	Plains-Morgan 345 kV	85	2

Table B5c: Flow South Limits, 2014 Shoulder Peak Case With Ludington Cycle.

Flow South Limit (MW)	U.P. Import (MW)	Limiter	Contingency	Presque Isle Generation (MW)	# PI Units
567	482	Plains-Arnold 138 kV	Dead River-Plains 345 kV	200	3
600	518	Presque Isle-Dead River 138 kV	Plains-Arnold 138 kV	164	2
609	528	U.P. Voltage	Dead River-Plains 345 kV	154	2
616	537	U.P. Voltage	Plains-Morgan 345 kV	146	2