Pine Falls Generation Station
Facility Up-grade
Interconnection Facility Study

Performed by:

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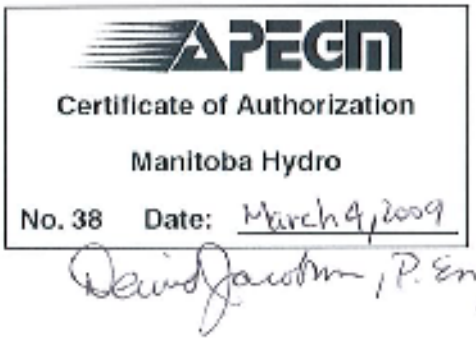
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Executive Summary

The objective of this study was to identify any possible system deficiencies and impacts attributed to a planned facility upgrade at Pine Falls Generation Station. For this study, two levels of generation increase were studied. The primary analysis was a proposed generation increase of 11.7 MW total (Pmax output from 89.6 MW to 101.3 MW). The estimated output increase would be to units 1 & 2 at 5.85 MW each. An alternative generation increase involving units 1-4 was also looked at as a sensitivity. Total output was increased 19.8 MW from 89.6 MW to 109.4 MW assuming an increase to units 1-4 of 4.95 MW each. The latest proposed in service date for units 1 & 2 is summer 2011 and for units 3 & 4 is summer 2013. At present there are two types of Interconnection Services available for Pine Falls GS. They are as follows;

1. Network Resource Interconnection Service (NRIS)
   Language within the Manitoba Hydro Open Access Interconnection Tariff (OAIT) states, "NRIS allows the Generator's Facility to be designated as a Network Resource, up to the facility's full output, on the same basis as existing Network Resources interconnected to Manitoba Hydro's System. NRIS in and of itself does not convey any right to deliver electricity to any specific customer or Point of Delivery." In order to be classified as NRIS status: Interconnection Facilities, Interconnection System Upgrades and Network upgrades must be satisfied. The Manitoba Hydro Transmission System Interconnections Generation Queue has allotted 14 MW for study purposes and accreditation. With option 2 upgrades of 19.8 MW (Units 1- 4), only 14 MW could be granted 'NRIS' status. The additional 5.8 MW would have to be placed back into the generation queue for evaluation.

2. Energy Resource Interconnection Service (ERIS)
   Language within the Manitoba Hydro Open Access Interconnection Tariff (OAIT) states, "ERIS allows the Generator to connect the facility to the system and be eligible to deliver the facility's output using existing firm or non-firm capacity of the Transmission System on an "as available" basis. ERIS does not in and of itself convey any right to deliver electricity to any specific customer or Point of Delivery." In order to be classified as ERIS status: Interconnection Facilities, Interconnection System Upgrades but not Network upgrades are satisfied. Again only 14 MW could be deemed as Energy Resource and the remainder would have to be placed back into the queue for evaluation.

This study also investigated the impact of varied export levels and generation output from Selkirk with the proposed Pine Falls facility upgrades on the system. Generally speaking, conditions of Selkirk Generation in service with high Winnipeg River Generation and high exports to Ontario introduced overloads within the Winnipeg River Transmission system. Refer to the Pine Falls IES for more detail.

Single Contingency Analysis, Stability Analysis and Short Circuit Analysis were investigated. Both stability analysis and short circuit analysis investigations demonstrated no impact due to the Pine Falls Facility upgrade. Single contingency analysis identified

'major transmission line' deficiencies. Minimum network facility upgrades incurred from the proposed Pine Falls upgrades are as follows. These minimum requirements are based on firm exports to Ontario (200 MW). It should be noted that irregardless of the upgrade option, the affected facilities remain the same. Costs for these upgrades are approximately $117 k, for option 1. Further enhancement costs of approximately $24 K would be required for combining options 1 & 2. There is a possibility of cost adjustment for the Transcona - WT 34 riser upgrades depending on time of the projects. The projects being; Pine Falls Units 1 & 2, Transcona New 230 kV - 66kV Station and Pine Falls Units 3 &4. The Transcona project has previously identified the deficiencies of the risers. Pine Falls Unit 1 & 2 upgrades would advance the replacement of the risers. Refer to appendix E for an estimate breakdown. A list of the affected equipment is as follows:

Station Work	**Upgrade**
Ridgeway – R23R (N/A)	Riser (pre-existing problem, not required for IFS, see section 3.2)
Transcona – WT34 (Network Upgrade)	Risers (during summer peak conditions)
Pine Falls - Hourly Unit Discharge (Inter-connection System Upgrade)	TSIR requirement
Pine Falls - Breaker CT upgrade (Inter-connection System Upgrade)	600 A CT's, in conjunction with breaker replacement project.
Pine Falls - Line Protection Issues (Inter-connection System Upgrades)	600 A CT's with new breakers

Of significant notability was the investigation into a stuck breaker scenario, based on the existing protection system. Independently, Rae Yang of System Planning supplied comments from her study of a Single Line to Ground fault @ 99% down PC4. It was discovered that the SLG fault would not clear and adjusting adjacent GP1 and PR2 protection would not isolate the fault. Rae recommends breaker fail protection, negative sequence generator protection and replacement of the existing relay protection to newer micro processor protection. An excerpt from her comments is as follows:

"At the moment, Pine Falls generators do not have negative sequence current protection and the criteria for negative sequence current at the generator after the fault is not exceeding 10% of the nominal current of the machine. If the single line to ground fault cannot be cleared, the unbalanced fault causes a negative sequence current component in the stator current. This current leads to a counter-rotating flux field in the machine and causes double frequency currents to flow in the rotor iron and slot wedges, resulting in local heating……the generators could be damaged if the fault is not cleared."

It is my general understanding that Generation Maintenance Engineering has a number of projects planned for Pine Falls including breaker replacements, low voltage breaker additions, generation controls and protection systems. In light of this, information was sent to 'Generation' for support in reference to the protection systems upgrades. Therefore, deficiencies found from the stuck breaker study are required to be rectified in conjunction with this project.

Further to the breaker replacement, Pine Falls will be required to have all existing 14 HV breakers replaced by 2014. These breakers have been mechanically failing and contain PCB's within the bushings. A sensitivity study was performed to explore alternate breaker numbers and some site modifications. That was; high side breaker reduction from 14 to 11 and co-termination of generators units 1-2, units 3-4 and units 5-6. Operationally and system stability wise either one-for-one high-side breaker replacement or breaker reduction and generation co-termination creates no issues.

With the increase in generation capacity, there are some concerns pertaining to current flow within the ring. The switchyard arrangement at Pine Falls is of two ring busses tied together through one section. The existing CT ratings of the breakers are 300 A. In both schemes, whenever one breaker was simulated out of service the rating of all the remaining breakers CT's were exceeded. The bus rating was not violated. It is recommended that the replacement breakers have CT's rated at 600 A. This could have an impact on the line protection relay scheme and new relay equipment maybe required.

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Appendices

1.0 Introduction

The purpose of this study was to evaluate the impacts attributed to a facility upgrade at Pine Falls Generation Station. The previous Interconnection Evaluation Study (IES) based existing Pine Falls maximum generation capability on a Northern MAPP operating guideline. After some consultation, it is felt that the IFS will use the URGE / accredited value (89.6 MW - 2007 value). Furthermore, revised generation output values will be utilized for the upgraded units. Refurbished generator parameters (impedance and inertia) will not be appreciably affected.

For this study, a proposed generation increase of 11.7 MW total was used (Plant Total P_{urge} output from 89.6 MW to 101.3 MW). This estimated output increase was applied to units 1 & 2 at 5.85 MW increase each. A sensitivity study with units 1 - 4 upgraded was also reviewed. The sensitivity study plant total output was 109.4 MW for a 19.8 MW total increase applied as a 4.95 MW increase to each of the four units. The latest proposed in service date (ISD) for units 1 & 2 is summer 2011 and summer 2013 for units 3 & 4.

The Manitoba Hydro Transmission System Interconnections Generation Queue has allotted 14 MW for study purposes and accreditation. This study has identified which facilities are needed for accreditation of either 'NRIS' or 'ERIS'.

1.1 Objectives

In order to evaluate the proposed facility upgrades at Pine Falls a number of different studies were required. Load Flow analysis included single contingencies and multi-element contingencies. Stability analysis simulated a number of disturbances on the system. Also, a short circuit analysis was performed to indicate any equipment violations due to increased fault contributions. Brief descriptions of each are as follows;

1.1.1 ACCC analysis

AC single contingency analysis was performed to identify any transmission limitations and voltage violation possibilities within the load flows following a single contingency outage. Common tower (two separate circuits sharing the same tower) contingency outages were also included. Screening parameters for ACCC analysis was set to 0.01 p.u. voltage change and 2% flow change.

1.1.2 Stability Analysis

This study utilized the existing NMORWG UIP package and updated models (provided by Rae Yang of System Planning). System transient response, including voltage, relay margin and local area damping were reviewed for the disturbances below:

3 –phase, 5-cycle, 110 kV fault at Pine Falls end of Pine Falls – Great Falls Line GP1
3 –phase, 5-cycle, 110 kV fault at Pine Falls end of Pine Falls – Parkdale Line PC3

3 –phase, 5-cycle, 110 kV fault at Pine Falls end of Pine Falls – Macarthur Falls Line PR2

3 –phase, 5-cycle, 110 kV fault at Pine Falls end of Pine Falls – Pine Falls Paper Co. Line PA1

SLG, 5-cycle, 110 kV fault at Pine Falls end of Pine Falls – Great Falls Line GP1

SLG, 5 + 15-cycle, 110 kV fault at Pine Falls end of Pine Falls - Parkdale Line PC4, simulates a stuck breaker disturbance

1.1.3 Fault Analysis

Short Circuit Analysis was required to indicate any impact of increased short circuit levels on local breakers with the increased output of Pine Fall. Three phase and single-line-to-ground fault levels were calculated with PSS/E.

2.0 Study Criteria

2.1 Operating Study Criteria

Standard MAPP Members Reliability Criteria and Study Procedures were applied, revised November 19, 2004.

No single contingency overloads (based on Rate C) were considered acceptable. Any single contingency loading above 100% Rate C was considered to require upgrades.

A short term transmission line conductor overload of up to 115% can be accepted for multiple contingency events (including common tower) on a case by case basis. Substation equipment overloads exceeding 100% capacity were considered to require upgrades.

2.2 Reference to MH Transmission System Interconnection Requirements

Section 3 of the TSIR document [1], “Generator Interconnection Requirements”, defines the requirements applicable for generators applying to connect to the 66 kV, 115 kV, 138 kV, 230 kV and 500 kV nominal voltage levels on the MH Interconnected Transmission System. Section 3 states that some of the requirements are to be defined/determined by the Interconnection Studies. Table A.1 (Refer to Appendix K) makes reference to only these requirements, and provides information for those requirements that were to be determined by Interconnection Studies.

3.0 Base Case Study Models

This study utilized the MRO 2006 Series PSS/E power flow models. Models representing years 2011 and 2016 were studied. Each study case contains five files, a base case file and a steady state files with incremental Pine Falls upgrades. All working

cases were modified to reflect known system changes. Listed below are the major changes;

- Set accredited generation (refer to Appendix J)
- Set Winnipeg River maximum generation (Varied from 597.9 - 617.7 MW)
  Base of 597.9 MW includes approved DRS increase of 8 MW due to upgrade of Great Falls units 3 (complete) and 4 (2010). Refer to Appendix G.
- Set Winnipeg River minimum generation (125 MW sum and 220 MW wtr)
- Set Great Falls accredited generation to 139.6 MW.
- Add Manigotagan Station and Great Falls South Station.
- Increase GS21, GS22, GP1, and SG12 rating.
- St. Leon Wind Generation in service
- System changes for new Transcona 230-66 kV Station **not** included.

In conjunction with the load flow and contingency analysis, a number of export scenarios were evaluated. For each case (summer off peak, summer peak and winter peak) Ontario export levels were varied from 0 MW - 200 MW with Selkirk G.S. on. A summer peak Ontario export level of 200 MW was also created for comparisons for a few contingency issues with Selkirk G.S. output set at 0 MW. Maximum power export to the US was 2175 MW (if possible) for summer and up to 1394 MW in winter.

Starting from a Pine Falls base rating of 89.6 MW, capability would increase to 95.45 and 101.3 MW for the proposed upgrade to units 1 & 2, respectively. Similarly, capability would increase to 94.55, 99.5, 104.45, and 109.4 MW for the proposed alternative upgrade to units 1 through 4, respectively. This is tabulated in Appendix H. To capture impacts at each stage of improvement, base power flows were therefore developed with five increasing levels of Pine Falls output: 89.6, 95.45, 101.3, 104.45, and 109.4 MW. A comprehensive listing of file names, generation, and export levels identified for study can be found in Appendix A (LF/ACCC File Names).

3.1 ACCC Analysis – Single Contingency

AC single contingency analysis was performed to identify any transmission limitations and voltage violations between base case and Pine Falls generation enhancements. Due to time constraints, only 'worst case' scenarios from Appendix A were investigated with transfer and generation levels at extremes. Intermediate levels (e.g. Selkirk at 1 unit) were not studied. Based on these parameters, there were no single contingency issues found.

3.2 ACCC Analysis – Single Contingency (Common Tower)

AC single contingency (multiple elements - common tower) analysis was performed to identify any transmission limitations and violations between base case and Pine Falls generation enhancements. The summer off peak cases produced one violation. Line

WT34 exceeded the riser limitation. A recommended action to rectify WT34 overload would be to upgrade Transcona risers to 721 A minimum summer rating. Though this is a pre-existing summer off-peak condition, it only becomes evident for summer peak conditions with increased Pine Falls output. An overview of the ACCC Screening Summary Summer Off-Peak can be found on Table 2. Complete ACCC Screening Summary Summer Off-peak results can be located in Appendix B.

ACCC Screening Summary
Single Contingency (Multiple Elements)
Summer Off Peak

Facility	Conductor Size (MCM)	Limit MVA	Contingency	PF2_so11b1 89.6 MW Overload (% Rate C)	PF2_so11b3 101.3 MW Overload (% Rate C)	PF2_so11b5 109.4 MW Overload (% Rate C)	PF2_so16b1 89.6 MW Overload (% Rate C)	PF2_so16b3 101.3 MW Overload (% Rate C)	PF2_so16b5 109.4 MW Overload (% Rate C)	Comment
WT34	336.4	120.6	ST5 ST6	107	109	111	110	113	114	Pre-existing O/L condition.

Table 2. ACCC Screening Summary, Single Contingency (Multiple Elements) - Summer Off Peak

The Summer Peak ACCC screening summary produced three line overload violations. Lines WT34, R23R and GP1 were in violation. Line GP1 risers should be upgraded to 93.2 MVA by fall 2008, as identified in P08242 (Great Falls GS 115kV Indoor Substation safety). Newly observed deficiency of the line and risers on R23R requires them to be upgraded. However, this is a pre-existing condition and is not required for this project to correct. This information will be forwarded to the appropriate section for investigation. A recommended action to rectify WT34 overload would be to upgrade Transcona risers to 721 A minimum summer rating. An overview of the ACCC Screening Summary Summer Peak can be found on Table 3. Complete ACCC Screening Summary Summer peak results can be located in Appendix C.

ACCC Screening Summary
Single Contingency (Multiple Elements)
Summer Peak

Facility	Conductor Size (MCM)	Limit MVA	Contingency	PF1_sp11b3 101.3 MW Overload (% Rate C)	PF1_sp11b5 109.4 MW Overload (% Rate C)	PF2_sp11b3 101.3 MW Overload (% Rate C)	PF2_sp11b5 109.4 MW Overload (% Rate C)	PF1_sp16b3 101.3 MW Overload (% Rate C)	PF1_sp16b5 109.4 MW Overload (% Rate C)	PF2_sp16b3 101.3 MW Overload (% Rate C)	PF2_sp16b5 109.4 MW Overload (% Rate C)	Comment
GP1	266.8	74.3	GS21	122	114	122	114	-	-	140	139	GP1 Riser to be upgraded 2008 (93.2 MVA)
	Revised 2008	93.2	GS22									
R23R	266.8	460.5	D36R D72V	-	-	110	112	114	114	110	110	Pre-existing O/L condition.
WT34	336.4	120.6	ST5 ST6	-	-	114	108	-	-	119	116	Upgrade Transc. Riser

Table 3. ACCC Screening Summary, Single Contingency (Multiple Elements) - Summer Peak

The Winter Peak ACCC screening summary produced no overload violations. However, there was a low bus voltage violation at MacGregor Station. The station 110 kV bus voltage dipped to 0.9 pu. The minimum allowable bus voltage in a post-contingency situation for this station is 0.94 pu (or 90% of nominal 115 kV). Information obtained from this report will be forwarded to the appropriate section. An overview of the ACCC Screening Summary Winter Peak can be found in Table 4. Note that the low voltage is a local issue, independent of Pine Falls generation addition or Manitoba - Ontario transfer level. Complete ACCC Screening Summary Winter peak results can be located in Appendix D.

ACCC Screening Summary
Single Contingency (Multiple Elements)
Winter Peak

Facility	Pre-C. min Limit (pu)	Post-C. min Limit (pu)	Contingency	MH/ON - 0 MW MH/ON - 200 MW Voltage Limit (pu)	Comment
MacGregor	0.99	0.94	CP17 RP16	0.9	Pre-existing

Table 4. ACCC Screening Summary, Single Contingency (Multiple Elements) - Winter Peak

3.3 ACCC Analysis – Conclusions

Single Contingency multiple elements – summer peak had the most impact on the system with 3 separate lines affected. The majority of the system deficiencies were within the Winnipeg River Transmission Line system. Although the 115 kV line WT34 risers at Transcona Station has a pre-existing summer off peak overload, the Pine falls upgrades exceed these equipment ratings during summer peak. Therefore, the risers on WT34 are required to be upgraded for this project. An estimate of $82 K is required for this work. An estimate breakdown of upgrade costs, conceptual SLD for work and a proposed schedule can be located in Appendix E.

4.0 Stability Analysis

Existing stability models from the NMORWG UIP package were utilized. It was an updated version of pkg2005, originally based on MRO 2004 series cases. Available year 2009 models were modified to attain desired summer off-peak conditions. Base case system intact models without Pine Falls upgrades and subsequently with Pine Falls upgrades were created. From these models, five different disturbances were monitored. There were 4 single contingency 3-phase, 5 cycle, 110 kV faults at Pine Falls end of transmission lines GP1, PC3, PR2 and PA1. A Single Line to Ground, 5 cycle, 110 kV fault at Pine Falls end of GP1 was performed. Additionally, a Single Line to Ground, 5 + 15 cycle, 110 kV fault at Pine Falls on PC4, this extended SLG fault was performed to simulate a stuck breaker scenario. In order to accommodate file changes required for this fault analysis, two cases were created. Case p7s utilized Pine Falls with an output of 101.3 MW (base upgrade scenario) and includes a proposed addition of breaker failure protection. Case p8s evaluated Pine Falls with an output of 109.4 MW (alternative upgrade scenario) and includes breaker failure protection. An evaluation of the existing protection system was performed with fault p9s. Interconnections and local area impacts of disturbances were investigated. Listed within Table 5 are the particulars of the cases used for the different disturbances monitored.

Pine Falls IFS - 2007

Stability Files

File Name	Type	Dorsey	Selkirk Output	PF Gen param based on MW Output	MHEX	MH / ON	Wpg River output
pf1-so09aa	Dyn	2948	0	89.6	2175	200	597.5
pfa-so09aa	Dyn	2938	0	101.3	2175	200	609.6
pfb-so09aa	Dyn	2930	0	109.4	2175	200	617.7
pf2-so09aa	Dyn	3350	0	89.6	2129	200	125
pfc-so09aa	Dyn	3350	0	101.3	2129	200	125
pfd-so09aa	Dyn	3350	0	109.4	2129	200	125

*Files derived from R. Yang 2005 Stab file: i00-so09aa.uzvV4W4
All files up-dated to 2011

Faults

p1z	3P, 5 cycle, 110 kV fault at Pine Falls on line GP1
p2z	3P, 5 cycle, 110 kV fault at Pine Falls on line PC3
p3z	3P, 5 cycle, 110 kV fault at Pine Falls on line PR2
p4z	3P, 5 cycle, 110 kV fault at Pine Falls on line PA1
p6s	SLG, 5 cycle, 110 kV fault at Pine Falls on GP1
p7s	SLG, 5 + 15 cycle, 110 kV fault at Pine Falls on PC4 (PF @101.3 MW)
p8s	SLG, 5 + 15 cycle, 110 kV fault at Pine Falls on PC4 (PF@ 109.4 MW)
p9s	SLG, 5 + 15 cycle, 110 kV fault at Pine Falls on PC4 (existing protection)

Table 5. Stability File Names and Fault Descriptions

4.1 Stability Disturbance Analysis Results

Complete tabular summaries of the summer off-peak results can be found in Appendix F.

4.1.1 Fault p1z observations

Interconnection power flow and stability was studied for summer off peak. Steady state flows produced no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced marginal changes. Transient voltages only varied 1-3% from base case and are well within acceptable limits. The out of step relay margins varied 2-20% from base case. The largest reduction in transient relay margins occurred for 115 kV line L20D with Pine Falls at maximum 109.4 MW generation, where it decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impact was observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 1.1 demonstrates an example of the post contingency results for fault p1z in relation to Power (MW) flow at various monitored locations. Figure 1.2 demonstrates an example of the post contingency results for fault p1z in relation to Voltage (PU) at various monitored locations.

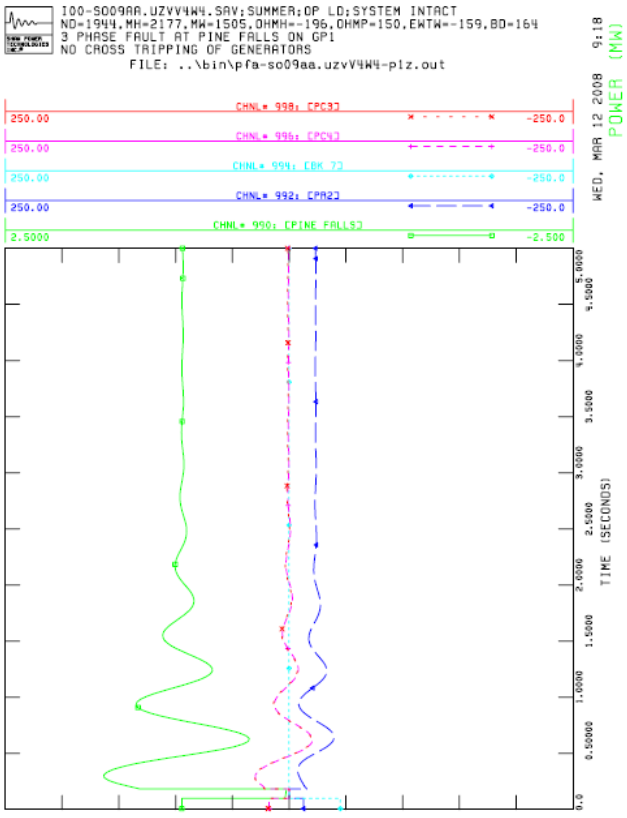


Figure 1.1. 3 Phase Fault at Pine Falls on GP1 (p1z Fault)
Power Flow (MW)

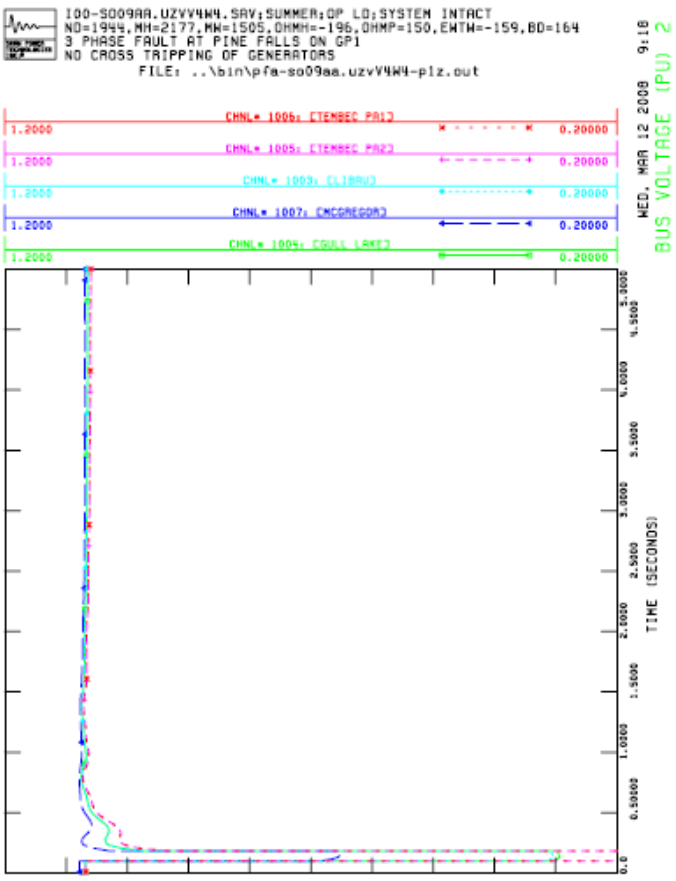


Figure 1.2. 3 Phase Fault at Pine Falls on GP1 (p1z Fault) Voltage (PU)

4.1.2 Fault p2z observations

Interconnection power flow and stability was studied for summer off peak. Steady state flows produced no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced marginal changes. Transient voltages are well within acceptable limits. The out of step relay margins varied 0-20% from base case. The largest reduction in relay margins occurred for L20D at Drayton during summer off peak, where it decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impact was observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 2 demonstrates an example of the post contingency results for fault p2z.

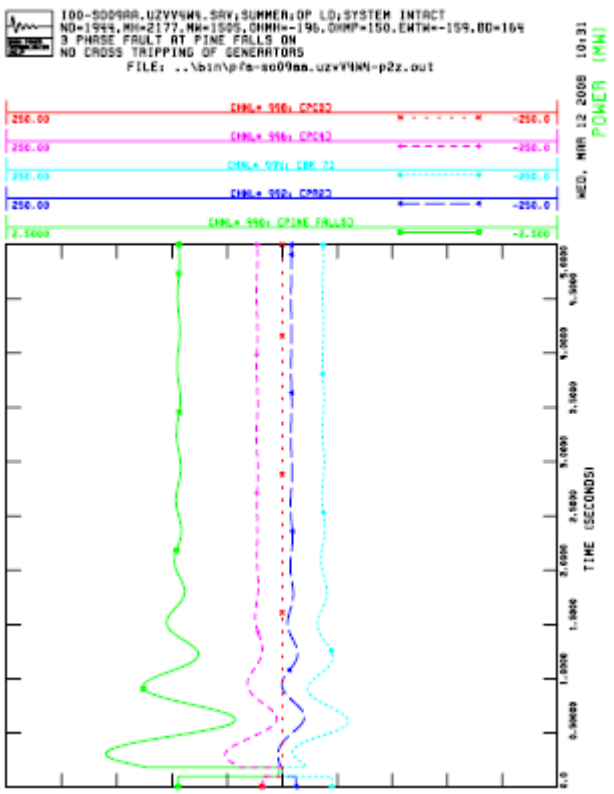


Figure 2. 3 Phase Fault at Pine Falls on PC3 (p2z Fault)

4.1.3 Fault p3z observations

Interconnection power flow and stability was studied for summer off peak. Steady state flows produced no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced marginal changes. Transient voltages are well within acceptable limits. The out of step relay margins varied 0-20% from base case. The largest reduction in relay margins occurred for Drayton 230 kV line L20D during summer off peak, where it decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impacts were observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 3 demonstrates an example of the post contingency results for fault p3z.

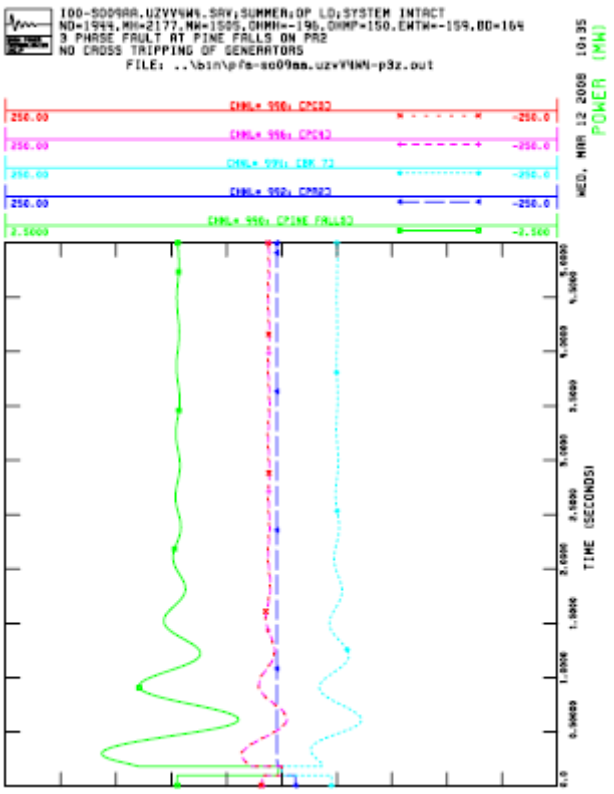


Figure 3. 3 Phase Fault at Pine Falls on PR2 (p3z Fault)

4.1.4 Fault p4z observations

Interconnection power flow and stability was studied for summer off peak. Steady state flows produced no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced marginal changes. Transient voltages are well within acceptable limits. The out of step relay margins varied 0-20% from base case. The largest reduction in relay margins occurred for Drayton 230 kV line (L20D) during summer off peak, decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impact was observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 4 demonstrates an example of the post contingency results for fault p4z.

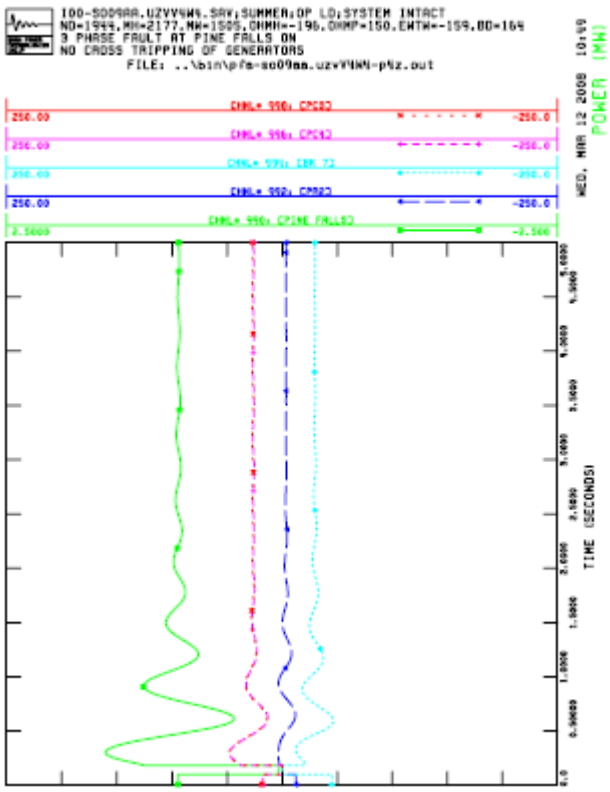


Figure 3. 3 Phase Fault at Pine Falls on PR2 (p4z Fault)

4.1.5 Fault p6s observations

Interconnection power flow and stability was studied for summer off peak. Steady state flows produced virtually no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced no changes. Transient voltages are well within acceptable limits. The out of step relay margins varied 0-20% from base case. The largest reduction in relay margins occurred for Drayton 230 kV line (L20D) during summer off peak, decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impact was observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 4 demonstrates an example of the post contingency results for fault p6s.

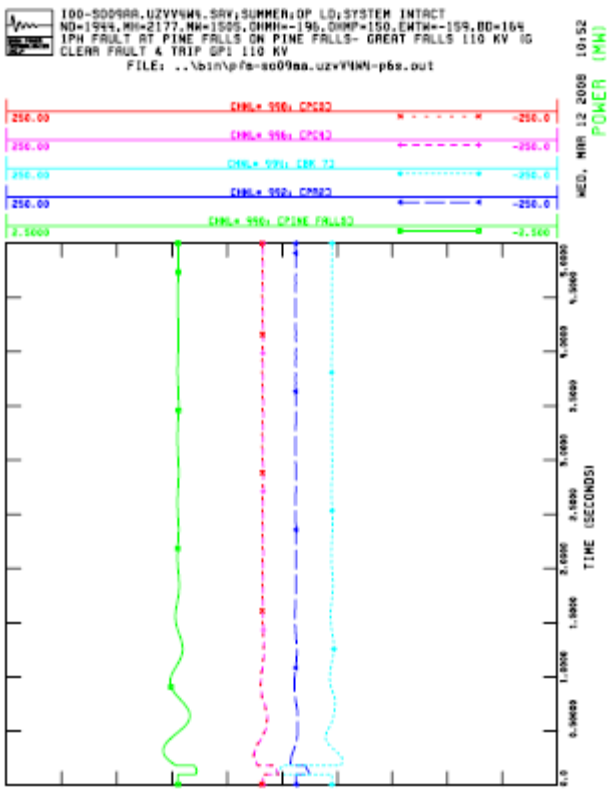


Figure 4. SLG Fault at Pine Falls on GP1 (p6s Fault)

4.1.6 Faults p7s and p8s observations

Interconnection power flow and stability was studied for summer off peak. These studies were performed with corrective actions completed. Ie: breaker fail protection at Pine Falls. Steady state flows produced virtually no impact due to the increased output of Pine Falls. Transient voltages and out of step relay margins portion of the stability study produced no changes. Transient voltages are well within acceptable limits. The out of step relay margins varied 0-13% from base case. The largest reduction in relay margins occurred for Drayton 230 kV line L20D during summer off peak, decreased from 681% to 661%. All relay margins were within acceptable limits.

Local area impact was observed to be very damped during recovery of the contingency. Results are acceptable for stability analysis. Figure 5 demonstrates an example of the post contingency results for fault p8s.

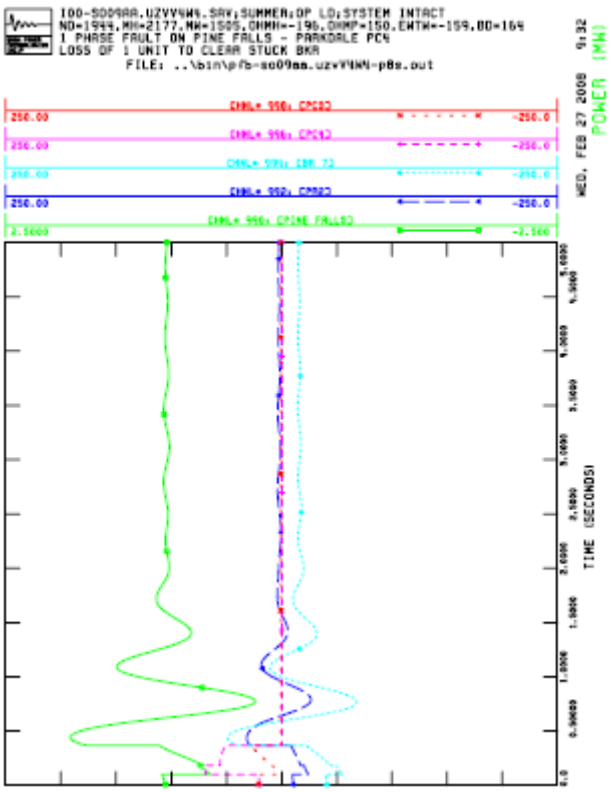


Figure 5. SLG Fault (5+15 cycles) at Pine Falls on PC4 (p8s Fault)

4.1.7 Fault p9s observations

Ray Yang of System Planning performed a stuck breaker relay study based on a Single Line to Ground fault @ 99% down PC4. It was discovered that the SLG fault would not clear and adjusting adjacent GP1 and PR2 protection would not isolate the fault. The existing protection system has been deemed inadequate and is required to be corrected in conjunction with this project. A copy of Rae's results can be located in Appendix I. Also, comments from Walter Marusenko (System Performance) can be reviewed here as well.

4.2 Stability Disturbance Analysis Conclusion

With the exception of the existing stuck breaker scenario, the proposed Pine Falls facility upgrades of up to 109.4 MW (total plant output) does not negatively affect system stability.

5.0 Short Circuit Analysis

A short circuit analysis was performed to indicate if there is any impact due to increased short circuit levels on local breakers with the proposed increased output of Pine Falls. Both three phase and single-line-to-ground fault levels were used. A report written by M.

Wonsiak regarding short circuit levels concluded that the fault level rise due to the facility improvements would not exceed the capabilities of the surrounding equipment. Furthermore, the maximum fault level on the 115 kV bus at Pine falls was under 82% of the breaker interrupting rating. Also, fault levels on the 66 kV portions of Pine Falls were only 15% of the breaker interrupting rating. In conclusion, the Pine Falls facility increase does not adversely affect any equipment in the surrounding area. A copy of Mr. Wonsiak's report can be located in Appendix J.

6.0 Breaker Replacement Sensitivity

Breaker replacement sensitivity was performed to indicate if there were any issues arising from two different High Voltage breaker replacement schemes. Option one was a direct replacement of the 14 BPOB oil filled breakers with new SF6 style breakers. Option two was a breaker reduction scheme with co-termination of generator units 1-2, units 3-4 and units 5-6. Refer to appendix L for SLD's of both options.

Newer PSS/E models were utilized to perform these studies as they included the explicit representation of the generators at Pine Falls. Both load flow studies and stability studies were performed.

6.1 Breaker Replacement Sensitivity - Load Flow

Load Flow studies looked at both existing and co-termination schemes for overloads and voltage concerns. Load flow analysis of voltage did not raise any issues. However, there were some concerns pertaining to current flow within the ring. The switchyard arrangement at Pine Falls is of two ring busses tied together through one section. The existing CT ratings of the breakers are 300 A. In both schemes, whenever one breaker was simulated out of service the rating of all the remaining breakers CT's were exceeded. The bus rating was not violated. It is recommended that the replacement breakers have CT's rated at 600 A. This could have an impact on the line protection relay scheme and new relay equipment maybe required.

6.2 Breaker Replacement Sensitivity - Stability

A number of stability cases were evaluated. These included a number of simulated fault situations on PC3, GP1, Pine Falls and dropping generation units at Pine Falls. Bus voltage, system frequency and rotor angles were scrutinized. In all cases the system was observed to be very well damped and stable.

A study case that simulated a fault on the Pine Falls HV bus was created. The intent of the study was to verify the system stability/response when comparing an existing breaker configuration to a co-termination configuration. Bus voltage, system frequency and units 4 and 6 rotor angles were captured. Figure 6 demonstrated the rotor angle response of units 4 and 6 when comparing 1 for 1 replacement to co-termination for a fault on Pine Falls bus. Note that wave forms are uniform and that they damp within 5 seconds. Figure 7 represented the bus voltage and frequency response at Pine Falls. Again, both

wave forms are uniform and that they damp within 5 seconds. These results demonstrate that co-termination of the Pine Falls units have little to no effect on Manitoba Hydro System Stability.

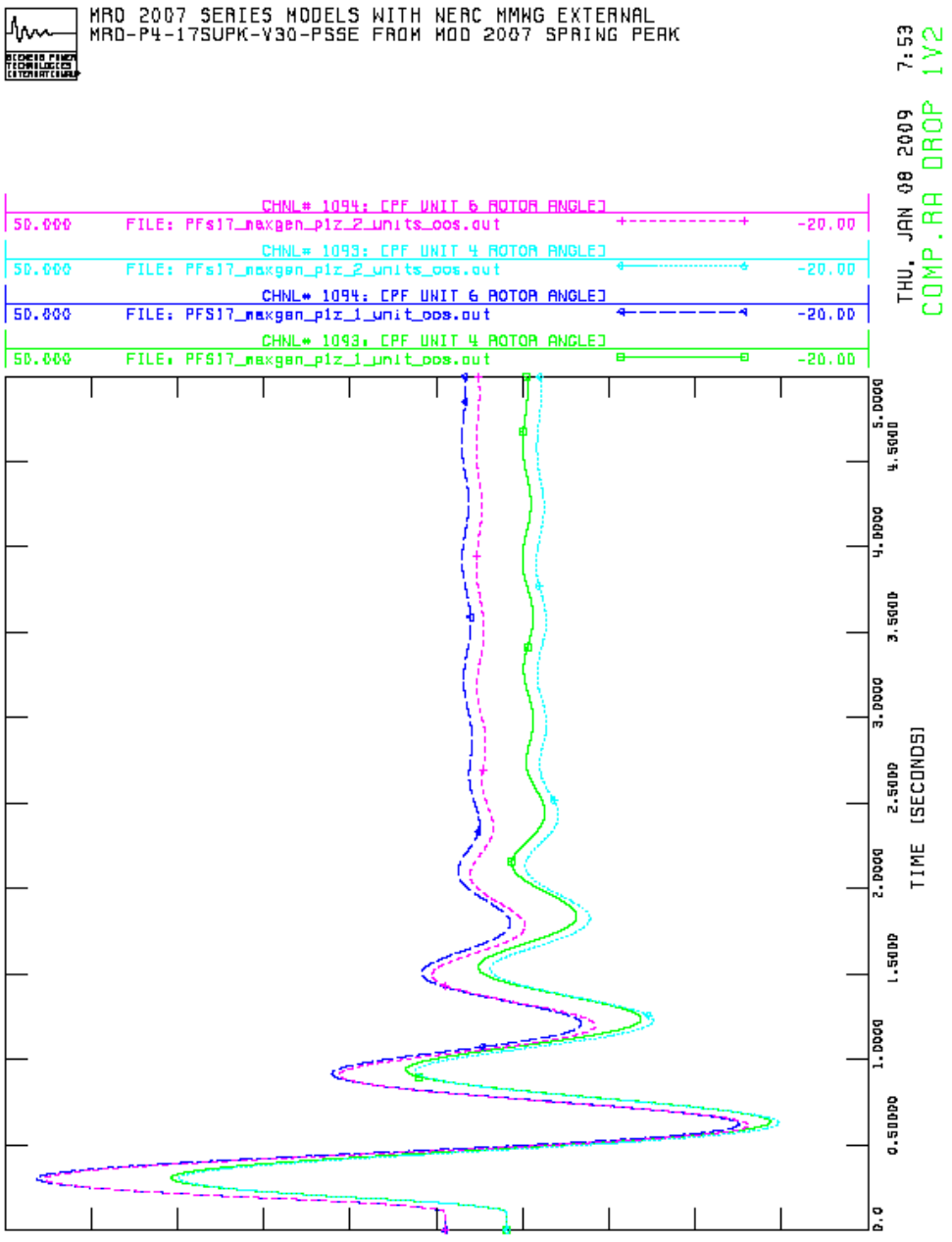


Figure 6. 3 Phase Fault at Pine Falls Compare Dropping Units 1 and 2 (Rotor Angles)

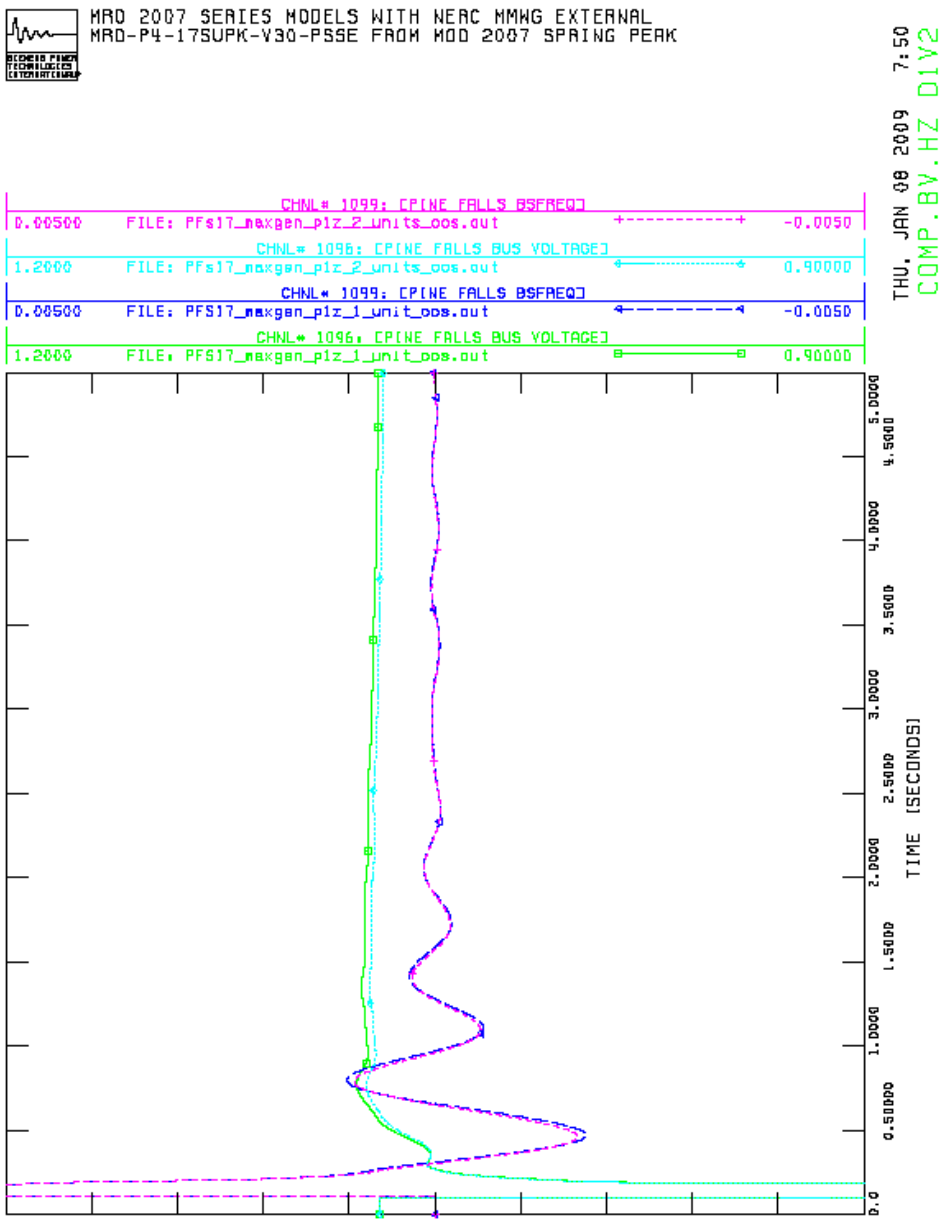


Figure7. 3 Phase Fault at Pine Falls Compare Dropping Units 1 and 2 (Bus Voltage, Hz)

7.0 Conclusions

The Manitoba Hydro Transmission System Interconnections Generation Queue has allotted 14 MW for study purposes and accreditation. Any additional generation would have to be placed back into the generation queue for evaluation. As a note, the proposed generator upper limits (14 MW plus extra 5.8 MW = 19.8 MW) indicated no other deficiencies during this study. With saying that, there are two types of Interconnection Services available for Pine Falls GS. They are as follows;

1. Network Resource Interconnection Service (NRIS)
   In order to be classified as NRIS status: Interconnection Facilities, Interconnection System Upgrades and Network upgrades must be completed. This pertains only for the generator upgrades to the 14 MW level. These items would be the following.

Station Work	**Upgrade**
Transcona – WT34 (Network Upgrade)	Risers (during summer peak conditions)
Pine Falls - Hourly Unit Discharge (Inter-connection System Upgrade)	TSIR requirement
Pine Falls - Breaker CT upgrade (Inter-connection System Upgrade)	600 A CT's, in conjunction with breaker replacement project.
Pine Falls - Line Protection Issues (Inter-connection System Upgrades)	600 A CT's with new breakers

The total cost for these upgrades depends on the generator option chosen. However, the costs vary from approximately $117 K to $141 K. A detailed breakdown of associated costs and options is available in appendix E.

2. Energy Resource Interconnection Service (ERIS)
   In order to be classified as ERIS status: Interconnection Facilities, Interconnection System Upgrades but not Network upgrades are completed. This pertains only for the generator upgrades to the 14 MW level. These items would be the following.

Station Work	**Upgrade**
Pine Falls - Hourly Unit Discharge (Inter-connection System Upgrade)	TSIR requirement
Pine Falls - Breaker CT upgrade (Inter-connection System Upgrade)	600 A CT's, in conjunction with breaker replacement project.

Pine Falls - Line Protection Issues (Inter-connection System Upgrades) — 600 A CT's with new breakers

The total cost for these upgrades depends on the generator option chosen. However, the costs vary from approximately $35 K to $59 K. A detailed breakdown of associated costs and options is available in appendix E.

There was an investigation into a stuck breaker scenario, based on the existing protection system. Independently, Rae Yang of System Planning supplied comments from her study of a Single Line to Ground fault @ 99% down PC4. It was discovered that the SLG fault would not clear and adjusting adjacent GP1 and PR2 protection would not isolate the fault. Rae recommends breaker fail protection, negative sequence generator protection and replacement of the existing relay protection to newer micro processor protection. An excerpt from her comments is as follows:

"At the moment, Pine Falls generators do not have negative sequence current protection and the criteria for negative sequence current at the generator after the fault is not exceeding 10% of the nominal current of the machine. If the single line to ground fault cannot be cleared, the unbalanced fault causes a negative sequence current component in the stator current. This current leads to a counter-rotating flux field in the machine and causes double frequency currents to flow in the rotor iron and slot wedges, resulting in local heating……the generators could be damaged if the fault is not cleared."

There are a number of projects planned for Pine Falls including breaker replacements, low voltage breaker additions, generation controls and protection systems. In light of this, information was sent to 'Generation' for support in reference to the protection systems upgrades. Therefore, deficiencies found from the stuck breaker study are required to be rectified in conjunction with this project.

Further to the breaker replacement, Pine Falls will be required to have all existing 14 HV breakers replaced by 2014. These breakers have been mechanically failing and contain PCB's within the bushings. A sensitivity study was performed to explore alternate breaker numbers and some site modifications. That was; high side breaker reduction from 14 to 11 and co-termination of generators units 1-2, units 3-4 and units 5-6. Operationally and system stability wise either one-for-one high-side breaker replacement or breaker reduction and generation co-termination creates no issues.

With the increase in generation capacity, there are some concerns pertaining to current flow within the ring. The switchyard arrangement at Pine Falls is of two ring busses tied together through one section. The existing CT ratings of the breakers are 300 A. In both schemes, whenever one breaker was simulated out of service the rating of all the remaining breakers CT's were exceeded. The bus rating was not violated. It is recommended that the replacement breakers have CT's rated at 600 A. This could have an impact on the line protection relay scheme and new relay equipment maybe required.

Appendices

Appendix A1

Pine Falls IFS - 2007

Summer 2011 Off Peak Files

Case		File Name	Type	Dorsey	Selkirk Output	Pine Falls	MHEX	MH / ON
	1	pf1-so11a1	**LF /ACCC**	2766	0	89.6	2175	199
		pf1-so11a2		2762	0	95.45	2176	199
Wpg River		pf1-so11a3	**LF /ACCC**	2756	0	101.3	2176	199
max gen		pf1-so11a4		2764	0	104.45	2174	199
(597.4 MW) +		pf1-so11a5	**LF /ACCC**	2748	0	109.4	2176	199
	2	pf2-so11a1	**LF /ACCC**	2572	0	89.6	2175	0
		pf2-so11a2		2566	0	95.45	2175	0
		pf2-so11a3	**LF /ACCC**	2560	0	101.3	2175	0
		pf2-so11a4		2558	0	104.45	2176	0
		pf2-so11a5	**LF /ACCC**	2552	0	109.4	2175	0
	3	pf3-so11a1		2694	72.5	89.6	2174	200
		pf3-so11a2		2688	72.5	95.45	2174	201
		pf3-so11a3		2684	72.5	101.3	2175	201
		pf3-so11a4		2682	72.5	104.45	2176	201
		pf3-so11a5		2678	72.5	109.4	2176	202
	4	pf4-so11a1		2500	72.5	89.6	2175	2
		pf4-so11a2		2496	72.5	95.45	2175	2
		pf4-so11a3		2490	72.5	101.3	2175	3
		pf4-so11a4		2486	72.5	104.45	2174	3
		pf4-so11a5		2482	72.5	109.4	2174	3
	5	pf5-so11a1	**LF /ACCC**	2622	145	89.6	2176	200
		pf5-so11a2		2618	145	95.45	2176	200
		pf5-so11a3	**LF /ACCC**	2612	145	101.3	2175	200
		pf5-so11a4		2610	145	104.45	2176	201
		pf5-so11a5	**LF /ACCC**	2606	145	109.4	2176	201
	6	pf6-so11a1		2428	145	89.6	2175	2
		pf6-so11a2		2426	145	95.45	2175	2
		pf6-so11a3		2418	145	101.3	2175	2
		pf6-so11a4		2416	145	104.45	2175	2
		pf6-so11a5		2412	145	109.4	2175	3

Pine Falls IFS - 2007

Summer 2016 Off Peak Files

Case		File Name	Type	Dorsey	Selkirk Output	Pine Falls	MHEX	MH / ON
	1	pf1-so16a1	**LF /ACCC**	2524	0	89.6	2176	200
		pf1-so16a2		2534	0	95.45	2174	199
Wpg River		pf1-so16a3	**LF /ACCC**	2530	0	101.3	2175	200
max gen		pf1-so16a4		2528	0	104.45	2176	200
(597.4 MW) +		pf1-so16a5	**LF /ACCC**	2522	0	109.4	2175	200
	2	pf2-so16a1	**LF /ACCC**	2344	0	89.6	2175	0
		pf2-so16a2			0	95.45		0
		pf2-so16a3	**LF /ACCC**	2334	0	101.3	2175	0
		pf2-so16a4		2332	0	104.45	2175	0
		pf2-so16a5	**LF /ACCC**	2326	0	109.4	2174	0
	3	pf3-so16a1		2468	72.5	89.6	2176	199
		pf3-so16a2		2462	72.5	95.45	2176	199
		pf3-so16a3		2456	72.5	101.3	2175	200
		pf3-so16a4		2454	72.5	104.45	2176	200
		pf3-so16a5		2448	72.5	109.4	2174	200
	4	pf4-so16a1		2272	72.5	89.6	2175	0
		pf4-so16a2		2266	72.5	95.45	2175	0
		pf4-so16a3		2262	72.5	101.3	2176	0
		pf4-so16a4		2258	72.5	104.45	2175	0
		pf4-so16a5		2254	72.5	109.4	2176	0
	5	pf5-so16a1	**LF /ACCC**	2394	145	89.6	2175	199
		pf5-so16a2		2388	145	95.45	2174	199
		pf5-so16a3	**LF /ACCC**	2384	145	101.3	2175	200
		pf5-so16a4		2380	145	104.45	2175	199
		pf5-so16a5	**LF /ACCC**	2376	145	109.4	2175	200
	6	pf6-so16a1		2200	145	89.6	2175	0
		pf6-so16a2		2194	145	95.45	2175	0
		pf6-so16a3		2188	145	101.3	2174	0
		pf6-so16a4		2188	145	104.45	2176	0
		pf6-so16a5		2182	145	109.4	2176	0

Appendix A2

Pine Falls IFS - 2007
Summer 2011 Peak Files

Case		File Name	Type	Dorsey	Selkirk Output	Pine Falls	NDEX	MH / ON
	1	pf1-sp11b1	**LF /ACCC**	3350	0	89.6	1811	199
		pf1-sp11b2		3350	0	95.45	1816	199
Wpg River		pf1-sp11b3	**LF /ACCC**	3350	0	101.3	1820	200
max gen		pf1-sp11b4		3350	0	104.45	1825	200
(597.4 MW) +		pf1-sp11b5	**LF /ACCC**	3350	0	109.4	1828	200
	2	pf2-sp11b1	**LF /ACCC**	3350	0	89.6	2006	0
		pf2-sp11b2		3350	0	95.45	2010	0
		pf2-sp11b3	**LF /ACCC**	3350	0	101.3	2015	0
		pf2-sp11b4		3350	0	104.45	2019	0
		pf2-sp11b5	**LF /ACCC**	3350	0	109.4	2023	0
	3	pf3-sp11b1		3350	72.5	89.6	1884	199
		pf3-sp11b2		3350	72.5	95.45	1889	200
		pf3-sp11b3		3350	72.5	101.3	1893	200
		pf3-sp11b4		3350	72.5	104.45	1897	200
		pf3-sp11b5		3350	72.5	109.4	1901	200
	4	pf4-sp11b1		3350	72.5	89.6	2078	0
		pf4-sp11b2		3350	72.5	95.45	2083	0
		pf4-sp11b3		3350	72.5	101.3	2087	1
		pf4-sp11b4		3350	72.5	104.45	2091	0
		pf4-sp11b5		3350	72.5	109.4	2094	1
	5	pf5-sp11b1	**LF /ACCC**	3350	145	89.6	1955	200
		pf5-sp11b2		3350	145	95.45	1960	200
		pf5-sp11b3	**LF /ACCC**	3350	145	101.3	1964	200
		pf5-sp11b4		3350	145	104.45	1968	200
		pf5-sp11b5	**LF /ACCC**	3350	145	109.4	1972	200
	6	pf6-sp11b1		3350	145	89.6	2148	0
		pf6-sp11b2		3350	145	95.45	2153	0
		pf6-sp11b3		3350	145	101.3	2157	1
		pf6-sp11b4		3350	145	104.45	2161	0
		pf6-sp11b5		3350	145	109.4	2164	1

Pine Falls IFS - 2007
Summer 2016 Peak Files

Case		File Name	Type	Dorsey	Selkirk Output	Pine Falls	NDEX	MH / ON
	1	pf1-sp16b1	**LF /ACCC**	3350	0	89.6	2079	197
		pf1-sp16b2		3350	0	95.45	2083	198
Wpg River		pf1-sp16b3	**LF /ACCC**	3350	0	101.3	2089	199
max gen		pf1-sp16b4		3350	0	104.45	2091	199
(597.4 MW) +		pf1-sp16b5	**LF /ACCC**	3350	0	109.4	2096	199
	2	pf2-sp16b1	**LF /ACCC**	3254	0	89.6	2174	0
		pf2-sp16b2		3250	0	95.45	2176	0
		pf2-sp16b3	**LF /ACCC**	3244	0	101.3	2175	1
		pf2-sp16b4		3242	0	104.45	2175	1
		pf2-sp16b5	**LF /ACCC**	3236	0	109.4	2174	1
	3	pf3-sp16b1		3350	72.5	89.6	2149	199
		pf3-sp16b2		3350	72.5	95.45	2154	199
		pf3-sp16b3		3350	72.5	101.3	2159	200
		pf3-sp16b4		3350	72.5	104.45	2162	200
		pf3-sp16b5		3350	72.5	109.4	2166	200
	4	pf4-sp16b1		3180	72.5	89.6	2175	-1
		pf4-sp16b2		3174	72.5	95.45	2175	0
		pf4-sp16b3		3170	72.5	101.3	2176	0
		pf4-sp16b4		3166	72.5	104.45	2175	0
		pf4-sp16b5		3162	72.5	109.4	2175	1
	5	pf5-sp16b1	**LF /ACCC**	3304	145	89.6	2175	198
		pf5-sp16b2		3298	145	95.45	2176	198
		pf5-sp16b3	**LF /ACCC**	3292	145	101.3	2175	198
		pf5-sp16b4		3288	145	104.45	2174	198
		pf5-sp16b5	**LF /ACCC**	3284	145	109.4	2175	199
	6	pf6-sp16b1		3108	145	89.6	2175	-1
		pf6-sp16b2		3102	145	95.45	2175	0
		pf6-sp16b3		3096	145	101.3	2174	0
		pf6-sp16b4		3094	145	104.45	2175	1
		pf6-sp16b5		3090	145	109.4	2175	1

Appendix A3

Pine Falls IFS - 2007

Winter 2011, 2016 Peak Files

Case		File Name	Type	Dorsey	Selkirk Output	Pine Falls	NDEX	MH / ON
	1	pf1-wp11c1	**LF /ACCC**	3350	0	89.6	395	197
		pf1-wp11c2		3350	0	95.45	395	197
Wpg River		pf1-wp11c3	**LF /ACCC**	3350	0	101.3	395	197
max gen		pf1-wp11c4		3350	0	104.45	395	197
(220 MW)		pf1-wp11c5	**LF /ACCC**	3350	0	109.4	395	197
	2	pf2-wp11c1	**LF /ACCC**	3350	0	89.6	612	0
		pf2-wp11c2		3350	0	95.45	612	0
		pf2-wp11c3	**LF /ACCC**	3350	0	101.3	612	0
		pf2-wp11c4		3350	0	104.45	612	0
		pf2-wp11c5	**LF /ACCC**	3350	0	109.4	612	0

Appendix B1

Pine Falls IFS

PF1-so11 SUMMARY
Selkirk 0 MW, ON 199 MW, US 2175 MW

Monitored Element					Contingency	Rating MVA	so11a1 Base Flow	so11a3 Flow	so11a5 Flow	Comments
67564 DORSEY 2	500.00	67598 DORSY2M4	230.00	1	165 DSY BK51	1200	1505.57	1507.47	1507.36	DC reduction
67564 DORSEY 2	500.00	67566 DORSEYM4	230.00	1	166 DSY BK52	1200	1499.1	1500.83	1500.73	DC reduction
67503 DORSEY 4	230.00	67598 DORSY2M4	230.00	1	165 DSY BK51	1200	1505.57	1507.47	1507.36	DC reduction
67503 DORSEY 4	230.00	67566 DORSEYM4	230.00	1	166 DSY BK52	1200	1499.1	1500.83	1500.72	DC reduction
67556 WHTSL1 4	220.00	67751 WHSL1PH7	110.00	1	30 K22W	144	167.98	169.06	169.05	adjust phase shifters
67589 WHTSL2 4	220.00	67705 WHSL2PH7	110.00	1	29 K21W	144	167.5	169.04	169.03	adjust phase shifters
67706 WHITESH7	110.00	67751 WHSL1PH7	110.00	1	30 K22W	144	162.45	163.37	163.35	adjust phase shifters
67705 WHSL2PH7	110.00	67706 WHITESH7	110.00	1	29 K21W	144	162.39	163.35	163.34	adjust phase shifters
67554 SLAVEFL7	110.00	67620 SCOTLDB7	110.00	1	158 WH	110.1	137.5	137.47	137.47	Wpg Cntrl adjustments
67554 SLAVEFL7	110.00	67620 SCOTLDB7	110.00	2	157 WH	110.1	137.5	137.47	137.47	Wpg Cntrl adjustments
67516 RAVLAKE7	110.00	67562 RAVLAKE4	230.00	1	7 C28R	65.1	72.44	72.44	72.4	Close Mr11 tap

Appendix B2

Pine Falls IFS

PF1-so16 SUMMARY
Selkirk 0 MW, ON 200 MW, US 2175 MW

Monitored Element	Contingency	Rating MVA	so16a1 Base Flow	so16a3 Flow	so16a5 Flow	Comments
67556 WHTSL1 4 220.00 67751 WHSL1PH7 110.00 1	30 K22W	144	168.41	168.42	168.79	Adjust Phase shifters
67589 WHTSL2 4 220.00 67705 WHSL2PH7 110.00 1	29 K21W	144	168.39	168.4	168.77	Adjust Phase shifters
67706 WHITESH7 110.00 67751 WHSL1PH7 110.00 1	30 K22W	144	162.79	162.8	163.18	Adjust Phase shifters
67705 WHSL2PH7 110.00 67706 WHITESH7 110.00 1	29 K21W	144	162.77	162.78	163.16	Adjust Phase shifters
67516 RAVLAKE7 110.00 67562 RAVLAKE4 230.00 1	7 C28R	65.1	102.08	102.03	102	Close Mr11 tap
67516 RAVLAKE7 110.00 67717 MR11 T 7 110.00 1	7 C28R	81.2	98.48	98.43	469.75	Close Mr11 tap
67568 DC6 JCT4 230.00 67685 SCA-4-6G 18.200 1	24 G37C	480	467.59	471.66	469.75	DC Reduction
67567 DC5 JCT4 230.00 67684 SCE-1-3G 18.200 1	24 G37C	480	467.59	471.66		DC Reduction

Appendix B3

Pine Falls IFS

PF2-so11-SUMMARY
Selkirk 0 MW, ON 0 MW, US 2175 MW

Monitored Element					Contingency	Rating MVA	so11a1 89.6 MW Base Flow	so11a3 101.3 MW Flow	so11a5 109.4 MW Flow	Comments
67564 DORSEY 2	500.00	67598 DORSY2M4	230.00	1	165 DSY BK51	1200	1500.46	1499.7	1499.67	DC Reduction
67564 DORSEY 2	500.00	67566 DORSEYM4	230.00	1	166 DSY BK52	1200		1497.01	1496.98	DC Reduction
67503 DORSEY 4	230.00	67598 DORSY2M4	230.00	1	165 DSY BK51	1200	1500.45	1499.7	1499.67	DC Reduction
67503 DORSEY 4	230.00	67566 DORSEYM4	230.00	1	166 DSY BK52	1200		1497.01	1496.97	DC Reduction
67554 SLAVEFL7	110.00	67620 SCOTLDB7	110.00	1	158 WH	110.1	137.58	137.57	137.57	Wpg Cntrl adjustments
67554 SLAVEFL7	110.00	67620 SCOTLDB7	110.00	2	157 WH	110.1	137.58	137.57	137.57	Wpg Cntrl adjustments
67536 GREATFL7	110.00	67762 PF-BK7 7	110.00	1	MH-022	74.3	91.13	89.27	87.43	Rating Change, '08 OK
67516 RAVLAKE7	110.00	67562 RAVLAKE4	230.00	1	7 C28R	65.1	72	71.95	71.91	close MR11 tap
67540 TRANSCO7	110.00	67706 WHITESH7	110.00	1	ST5 ST6	115.6	128.82	131.87	133.97	Pre-existing O/L condition

Appendix B4

Pine Falls IFS

PF2-so16-Summary
Selkirk 0 MW, ON 0 MW, US 2175 MW

Monitored Element					Contingency	Rating MVA	so16a1 Base Flow	so16a3 Flow	so16a5 Flow	Comments
67516 RAVLAKE7	110.00	67562 RAVLAKE4	230.00	1	7 C28R	65.1	101.71	101.68	101.65	Close MR11 Tap
67516 RAVLAKE7	110.00	67717 MR11 T 7	110.00	1	7 C28R	81.2	98.11	98.07	98.04	Close MR11 Tap
67536 GREATFL7	110.00	67762 PF-BK7 7	110.00	1	MH-022	74.3	93.94	91.16		Rating change OK!
67540 TRANSCO7	110.00	67706 WHITESH7	110.00	1	ST5 ST6	115.6	132.91	135.81	137.82	Pre-existing O/L condition

Appendix C1

Pine Falls IFS

PF1_SP11_SUMMARY
Selkirk 0 MW, ON 200 MW, US 1811 - 1828 MW

Monitored Element	Contingency	Rating MVA	sp11a1 89.6 MW Base Flow	sp11a3 101.3 MW Flow	sp11a5 109.4 MW Flow	comments
67530 ROSSER 4 230.00 67560 RIDGEWY4 230.00 1	D36R D72V	460.5	569.42	567.83	566.6	Existing condition
67564 DORSEY 2 500.00 67598 DORSY2M4 230.00 1	165 DSY BK51	1200	1261.12	1268.18	1277.59	DC Reduction
67564 DORSEY 2 500.00 67566 DORSEYM4 230.00 1	166 DSY BK52	1200	1257.74	1264.84	1270.43	DC Reduction
67503 DORSEY 4 230.00 67559 LAVEREN4 230.00 3	MH-004	503.5	545.67	544.96	544.4	DC Reduction
67556 WHTSL1 4 220.00 67751 WHSL1PH7 110.00 1	30 K22W	144	168.03	169.06	169.01	Adjust phase shifters
67589 WHTSL2 4 220.00 67705 WHSL2PH7 110.00 1	29 K21W	144	168.01	169.04	168.99	Adjust phase shifters
67572 RADSNDC6 138.00 67573 KETTLDC6 138.00 1	178 RAD BK42	1294.3	1304.71	1304.68	1304.53	Northern AC adjustment
67706 WHITESH7 110.00 67751 WHSL1PH7 110.00 1	30 K22W	144	162.62	163.6	163.55	Adjust phase shifters
67705 WHSL2PH7 110.00 67706 WHITESH7 110.00 1	29 K21W	144	162.6	163.59	163.54	Adjust phase shifters
67554 SLAVEFL7 110.00 67620 SCOTLDB7 110.00 1	158 WH	110.1	137.44	137.44	137.44	Wpg Cntrl adjustments
67554 SLAVEFL7 110.00 67620 SCOTLDB7 110.00 2	157 WH	110.1	137.44	137.44	137.44	Wpg Cntrl adjustments
67568 DC6 JCT4 230.00 67685 SCA-4-6G 18.200 1	166 DSY BK52	480	480	480	480	DC Reduction
67567 DC5 JCT4 230.00 67684 SCE-1-3G 18.200 1	166 DSY BK52	480	480	480	480	DC Reduction
67532 MC PHIL7 110.00 67757 MCPHL-P7 110.00 2	125 SB14	80	84.66	84.68	84.68	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 1	125 SB14	80	84.5	84.51	84.51	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 2	125 SB14	80	84.5	84.51	84.51	Wpg Cntrl adjustments
67503 DORSEY 4 230.00 67598 DORSY2M4 230.00 1	165 DSY BK51	1200			1257.83	DC Reduction
67503 DORSEY 4 230.00 67566 DORSEYM4 230.00 1	166 DSY BK52	1200			1257.02	DC Reduction
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 3	196 TRAN BK1	36			36.08	At Limit

Appendix C2

Pine Falls IFS

PF1_SP16_SUMMARY
Selkirk 0 MW, ON 200 MW, US 1811 - 1828 MW

Monitored Element	Facility	Contingency	Rating MVA	sp16a1 89.6 MW Base Flow	Percent Loading	sp16a3 101.3 MW Flow	sp16a5 109.4 MW Flow	Comments
67516 RAVLAKE7 110.00 67562 RAVLAKE4 230.00 1		7 C28R	65.1	93.02	142.89	93.08	93.1	Close MR11 Tap
67503 DORSEY 4 230.00 67559 LAVEREN4 230.00 3		MH-004	503.5	638.55	125.22	638.58	638.6	DC Reduction
67536 GREATFL7 110.00 67695 GTFNET5G 11.000 1		MH-023	120	141.08	117.57	140.94	140.86	Rating Change OK
67541 STVITAL7 110.00 67620 SCOTLDB7 110.00 1		100 HS5	110.1	126	115.6	125.94	125.9	Wpg Cntrl adjustments
67556 WHTSL1 4 220.00 67751 WHSL1PH7 110.00 1		30 K22W	144	165	114.58	166.23	166.72	Adjust Phase Shifters
67589 WHTSL2 4 220.00 67705 WHSL2PH7 110.00 1		29 K21W	144	164.98	114.57	166.21	166.71	Adjust Phase Shifters
67719 HIGHLND7 110.00 67720 BRANE 7 110.00 1		71 BD52	70.3	81.19	113.79	81.19	81.19	Base Case O/L: ignore
67530 ROSSER 4 230.00 67560 RIDGEWY4 230.00 1	R23R	D36R D72V	460.5	524.33	113.43	525.13	525.21	Exisitng Condition
67706 WHITESH7 110.00 67751 WHSL1PH7 110.00 1		30 K22W	144	163.29	113.4	164.68	165.24	Adjust Phase Shifters
67705 WHSL2PH7 110.00 67706 WHITESH7 110.00 1		29 K21W	144	163.29	113.39	164.68	165.24	Adjust Phase Shifters
67620 SCOTLDB7 110.00 67778 HRWYH337 110.00 1		MH-037	110.1	119.19	111.67	119.15	119.12	Adjust Phase Shifters
67527 LAVEREN7 110.00 67778 HRWYH337 110.00 1		MH-037	110.1	119.6	111.65	119.56	119.54	Wpg Cntrl adjustments
67513 OVERFLO4 230.00 67515 RALL 4 230.00 1		25 G8P	226.3	234.21	107.98	234.19	234.18	AC cross trip
67510 GR.RPDS4 230.00 67702 WILRIVR4 230.00 1		20 F27P	226.3	241.64	103.67	241.63	241.62	AC cross trip
67516 RAVLAKE7 110.00 67717 MR11 T 7 110.00 1		7 C28R	81.2	86.38	103.59	86.43	86.45	Close MR11 Tap
67536 GREATFL7 110.00 67762 PF-BK7 7 110.00 1	GP1	GS21 GS22	74.3	81.95	103.45			GP1 Riser to be fixed 2008 (93.2 MVA) / (OK)

Appendix C3

Pine Falls IFS

PF2_SP11_SUMMARY
Selkirk 0 MW, ON 0 MW, US 1811 - 1828 MW

Monitored Element	Contingency	Rating MVA	sp11b1 89.6 MW Base Flow	sp11b3 101.3 MW Flow	sp11b5 109.4 MW Flow	Comments
67541 STVITAL7 110.00 67620 SCOTLDB7 110.00 1	100 HS5	110.1		123.94		Wpg Cntrl adjustments
67532 MC PHIL7 110.00 67757 MCPHL-P7 110.00 1	125 SB14	80	84.32	80.43	84.3	Wpg Cntrl adjustments
67532 MC PHIL7 110.00 67757 MCPHL-P7 110.00 2	125 SB14	80	84.32	80.43	84.3	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 1	125 SB14	80	84.15	80.3	84.13	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 2	125 SB14	80	84.15	80.3	84.13	Wpg Cntrl adjustments
67527 LAVEREN7 110.00 67778 HRWYH337 110.00 1	MH-037	110.1		115.54		Wpg Cntrl adjustments
67620 SCOTLDB7 110.00 67778 HRWYH337 110.00 1	MH-037	110.1		115.7		Wpg Cntrl adjustments
67568 DC6 JCT4 230.00 67685 SCA-4-6G 18.200 1	18 D72V	480		480		DC reduction
67510 GR.RPDS4 230.00 67702 WILRIVR4 230.00 1	20 F27P	226.3		241.47		AC Cross trip
67510 GR.RPDS4 230.00 67511 ASHERN 4 230.00 2	21 G1A	349		346.52		AC Cross trip
67510 GR.RPDS4 230.00 67511 ASHERN 4 230.00 1	22 G2A	349		346.52		AC Cross trip
67513 OVERFLO4 230.00 67515 RALL 4 230.00 1	25 G8P	226.3		233.99		AC Cross trip
67557 LETELER4 230.00 66752 DRAYTON4 230.00 1	25A G82R	419.5		450.95		DC reduction
67567 DC5 JCT4 230.00 67684 SCE-1-3G 18.200 1	51 S53G	480		480		DC reduction
67567 DC5 JCT4 230.00 67684 SCE-1-3G 18.200 1	MH-028	470	480		480	DC reduction
67557 LETELER4 230.00 67559 LAVEREN4 230.00 1	52 S60L	419.5		416.6		DC reduction
67523 GLENBOR4 230.00 67524 CORNWLS4 230.00 1	55 Y51L	279.9		286.65		DC reduction
67516 RAVLAKE7 110.00 67562 RAVLAKE4 230.00 1	7 C28R	65.1		93.16		Close MR11
67516 RAVLAKE7 110.00 67717 MR11 T 7 110.00 1	7 C28R	81.2		86.5		Close MR11
67503 DORSEY 4 230.00 67598 DORSY2M4 230.00 1	165 DSY BK51	1200	1379.2		1391	DC reduction
67564 DORSEY 2 500.00 67598 DORSY2M4 230.00 1	165 DSY BK51	1200	1407.57		1420.37	DC reduction
67503 DORSEY 4 230.00 67566 DORSEYM4 230.00 1	166 DSY BK52	1200		1391.1	1396	DC reduction
67564 DORSEY 2 500.00 67566 DORSEYM4 230.00 1	166 DSY BK52	1200			1420.37	DC reduction
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 2	196 TRAN BK1	40	48.41	44.28	48.74	LD Transfer
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 3	196 TRAN BK1	36	41.43	37.89	41.71	LD Transfer
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 4	196 TRAN BK1	36	40.31	36.86	40.58	LD Transfer
67568 DC6 JCT4 230.00 67685 SCA-4-6G 18.200 1	MH-004	480	480		480	DC reduction
67530 ROSSER 4 230.00 67560 RIDGEWY4 230.00 1	D36R D72V	460.5	520.75	507.96	518	Pre-existing O/L Condition
67536 GREATFL7 110.00 67762 PF-BK7 7 110.00 1	GS21 GS22	74.3	89.18	91	84.99	GP1 Riser to be fixed 2008 (93.2 MVA)
67536 GREATFL7 110.00 67695 GTFNET5G 11.000 1	MH-024	120		141.08		Rating Change, ok!
67540 TRANSCO7 110.00 67706 WHITESH7 110.00 1	ST5 ST6	115.6		137.45	129.98	Upgrade WT34 Riser

Appendix C4

Pine Falls IFS

PF2_SP16_SUMMARY
Selkirk 0 MW, ON 0 MW, US 2079 - 2096 MW

Monitored Element	Contingency	Rating MVA	sp16a1 89.6 MW Base Flow	sp16a3 101.3 MW Flow	sp16a5 109.4 MW Flow	Comments
67541 STVITAL7 110.00 67620 SCOTLDB7 110.00 1	100 HS5	110.1	126.57	123.93	125.05	Wpg Cntrl adjustments
67532 MC PHIL7 110.00 67757 MCPHL-P7 110.00 1	125 SB14	80	81.24	80.7	80.43	Wpg Cntrl adjustments
67532 MC PHIL7 110.00 67757 MCPHL-P7 110.00 2	125 SB14	80	81.24	80.7	80.43	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 1	125 SB14	80	81.1	80.57	80.31	Wpg Cntrl adjustments
67757 MCPHL-P7 110.00 67550 MC.PHIL8 63.500 2	125 SB14	80	81.1	80.57	80.31	Wpg Cntrl adjustments
67529 ROSSER 7 110.00 67725 INKSTER7 110.00 1	155 YX48	186.7		150.71	189.13	At limit
67510 GR.RPDS4 230.00 67702 WILRIVR4 230.00 1	20 F27P	226.3	241.46	624	241.47	AC Cross Trip
67510 GR.RPDS4 230.00 67511 ASHERN 4 230.00 2	21 G1A	349	346.51	346.72	346.53	AC Cross Trip
67510 GR.RPDS4 230.00 67511 ASHERN 4 230.00 1	22 G2A	349	346.51	346.72	346.53	AC Cross Trip
67513 OVERFLO4 230.00 67515 RALL 4 230.00 1	25 G8P	226.3	233.99	234.1	233.99	AC Cross Trip
67557 LETELER4 230.00 66752 DRAYTON4 230.00 1	25A G82R	419.5	450.86	450.9	450.89	DC Reduction
67567 DC5 JCT4 230.00 67684 SCE-1-3G 18.200 1	31 L20D	480	480	480	480	DC Reduction
67568 DC6 JCT4 230.00 67685 SCA-4-6G 18.200 1	50 R7B	480	480	480	480	DC Reduction
67557 LETELER4 230.00 67559 LAVEREN4 230.00 1	52 S60L	419.5	416.1	416.02	416.13	DC Reduction
67516 RAVLAKE7 110.00 67562 RAVLAKE4 230.00 1	7 C28R	65.1	93.18	93.16	93.12	Close MR11 tap
67516 RAVLAKE7 110.00 67717 MR11 T 7 110.00 1	7 C28R	81.2	86.53	86.5	86.47	Close MR11 tap
67719 HIGHLND7 110.00 67730 FORTIER7 110.00 1	71 BD52	70.3	70.95	70.95	70.95	At limit
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 2	196 TRAN BK1	40	43.99	45.67	44.36	Ld Transfers
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 3	196 TRAN BK1	36	37.64	39.08	37.96	Ld Transfers
67540 TRANSCO7 110.00 67547 TRANSCO8 63.500 4	196 TRAN BK1	36	36.63	38.03	36.94	Ld Transfers
67503 DORSEY 4 230.00 67559 LAVEREN4 230.00 3	MH-004	503.5	625.58	624	624.25	DC Reduction
67530 ROSSER 4 230.00 67560 RIDGEWY4 230.00 1	D36R	460.5	508.21	507	506.97	Existing Condition
67536 GREATFL7 110.00 67762 PF-BK7 7 110.00 1	D72V GS21 GS22	74.3	106.64	103.86	103.32	GP1 Riser to be fixed 2008
67536 GREATFL7 110.00 67695 GTFNET5G 11.000 1	MH-024	120	141.08	140.76	141.02	Rating Change, OK!
67540 TRANSCO7 110.00 67706 WHITESH7 110.00 1	ST5 ST6	115.6	136	143.63	139.45	Pre-existing O/L condition
67620 SCOTLDB7 110.00 67778 HRWYH337 110.00 1	MH-037	110.1	118.1	117.82	115.14	Wpg Cntrl adjustments
67527 LAVEREN7 110.00 67778 HRWYH337 110.00 1	MH-037	110.1	118.52	118.23	115.52	Wpg Cntrl adjustments

Appendix D1

ACCC Screening Summary
Single Contingency (Multiple Elements)
Winter Peak

Facility	Pre-C. min Limit (pu)	Post-C. min Limit (pu)	Contingency	pf1-wp11/16c1 MH/ON -200 MW Voltage Limit (pu)	pf1-wp11/16c3 MH/ON -200 MW Voltage Limit (pu)	pf1-wp11/16c5 MH/ON - 200 MW Voltage Limit (pu)	pf2-wp11/16c1 MH/ON - 0 MW Voltage Limit (pu)	pf2-wp11/16c3 MH/ON - 0 MW Voltage Limit (pu)	pf2-wp11/16c5 MH/ON - 0 MW Voltage Limit (pu)	Comment
MacGregor	0.99	0.94	CP17 RP16	0.898	0.898	0.898	0.898	0.898	0.898	Pre-existing Condition

APPENDIX E

Pine Falls Generation Upgrades

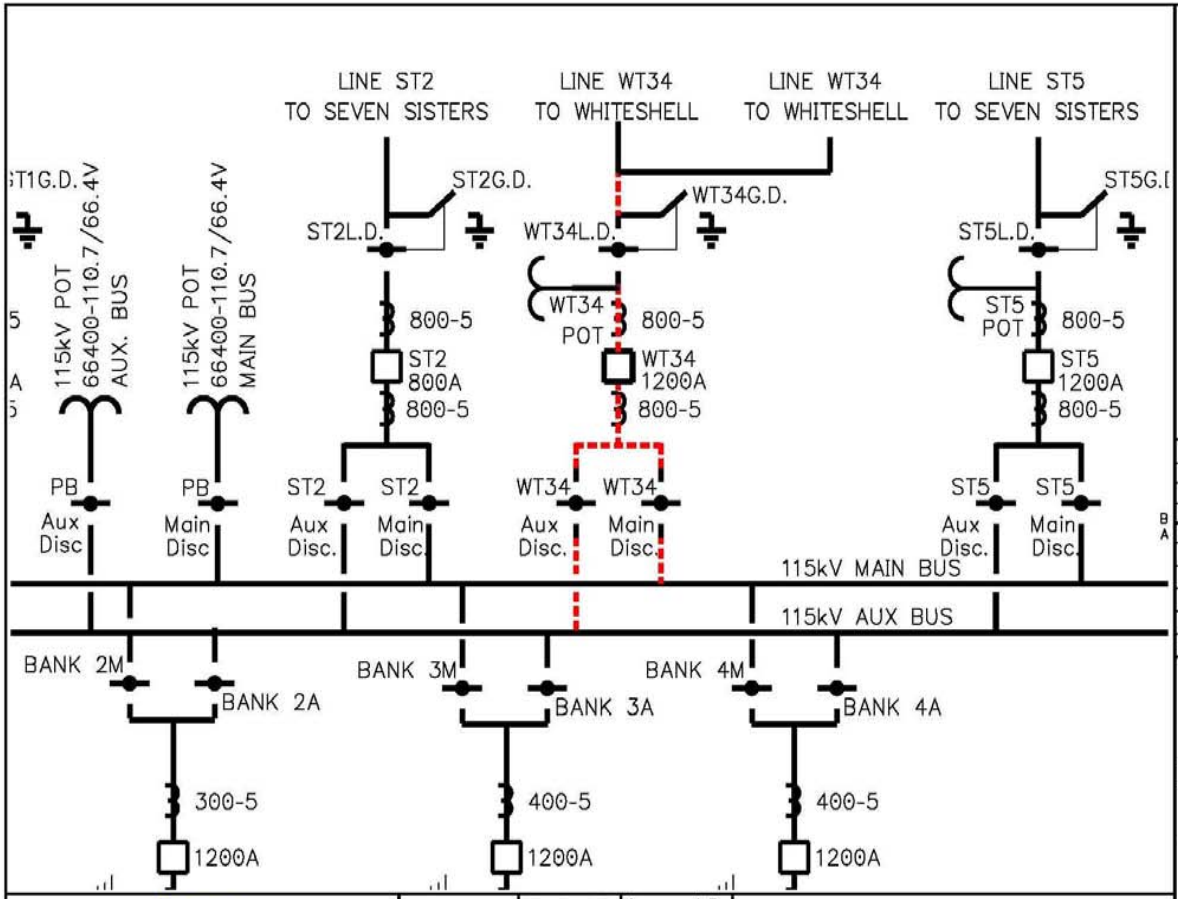
Required Facility Upgrades

Estimated Station Design Costs:

			Network Resource		Energy Resource	
			Units 1 & 2	*Units 1 - 4*	*Units 1 & 2*	*Units 1 - 4*
Pine Falls GS Work Required: (Inter-connection System Upgrade)						
Units 1 & 2	Hourly Unit Discharge					
	Design Costs	$ 22,446				
	Materials and Drafting	$ 3,443				
	Telecontrol (Great Falls and Dovercourt)	$ 9,061				
			$ 34,950	$ 34,950	$ 34,950	$ 34,950
Units 3 & 4	Hourly Unit Discharge					
	Design Costs	$ 11,223				
	Materials and Drafting	$ 3,443				
	Telecontrol (Great Falls and Dovercourt)	$ 9,061				
				$ 23,727		$ 23,727
Station Work Required: (Network Upgrade)						
	WT34 Riser Upgrade Transcona (1377 Amps)					
	Structure, Equip & Grounding	$ 37,094				
	SEG(Drafting)	$ 9,443				
	Suburban O/H Construction	$ 31,960				
	Apparatus Mtce Wpg. North	$ 3,034				
	Commissioning	$ 774				
			$ 82,304	$ 82,304		
Pine Falls Breaker CT's (Inter-connection System Upgrade)						
	New breakers with 600 A bushing CT's existing project P:14174	$ N/A				
Pine Falls Line Protection Issues (Inter-connection System Upgrade)						
	W/ breaker replacement / breaker Fail Study existing project P:14174	$ N/A				
	TOTAL FACILITY COSTS:		$ 117,254	$ 140,981	$ 34,950	$ 58,677

Estimated: Oct 6, 2006

FILE: TRANSCONA-PF-STUDY



REMARKS:
WITH FUTURE PROJECTS IN MIND, LINE WT34 TERMINATION RISER UPGRADE TO MINIMUM 1377 Amps SUMMER. (721 Amps REQUIRED FOR PINE FALLS IFS)

	Checked By: Date:	Approved By: Date:
Sys. Planning	G E 2008 02 12	
Dist. Planning		
Stn. Design		
A.M.D.		
Trans. Sys. Ops.		

CONCEPTUAL
STATION SINGLE LINE DIAGRAM
SYSTEM PLANNING DEPARTMENT
Prepared by: G E *Date:* 2008 02 12

TRANSCONA TERMINAL
WT34 TERMINATION UPGRADE

DESIGN REQUIREMENTS
SITE: New ☐ Expansion ☐
STRUCTURE: Wood ☐ Steel ☐ Switchgear ☐
BUILDING: Exist ☐ New ☐ Expansion ☐
COMMUNICATIONS: RTU ☐ Phone ☐ Data ☐ Telem ☐ Single Route ☐ Dual Route ☐ Protection ☐ Other ____
PROTECTION: Prot'n ☐
CONTROL REQUIREMENTS: Local ☐ RTU/SEA ☐
METERING: Revenue ☐ Operating ☐

PLANNING

kV	BUS AMPACITY	
		AMPS
		AMPS

	SHORT CIRCUIT kA			
	AT I.S.D.		HORIZON	
kV	3Ø	SLG	3Ø	SLG

LEGEND:
Existing
Proposed
Future
Salvaged

REVISIONS

No.	△	△	△
Date YYYY MM			
S.D. A B C			
S.P.			
D.P.			
A.M.D.			
T.S.D.			

I.M. #: NA
W.B.S.#: NA
NETWORK #: NA
REQUIRED BY: 2010_04

1-STN#-FA-04420-0001-0001-00

APPENDIX F1

POWER FLOW AND STABILITY SUMMARY

P1Z

Case No.	1	2	3		4	5	6
Case Name	pf1-so09aa.uzvV4W4-p1z	pfa-so09aa.uzvV4W4-p1z	pfb-so09aa.uzvV4W4-p1z		pf2-so09aa.uzvV4W4-p1z	pfc-so09aa.uzvV4W4-p1z	pfd-so09aa.uzvV4W4-p1z
Disturbance	p1z	p1z	p1z		p1z	p1z	p1z
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:41	MAR 12 2008 9:14	FEB 20 2008 14:24		MAR 12 2008 12:11	FEB 21 2008 8:23	FEB 21 2008 8:44
Comments	3P. 5 cycle F @ PF GP1	3P. 5 cycle F @ PF GP1	3P. 5 cycle F @ PF GP1		3P. 5 cycle F @ PF GP1	3P. 5 cycle F @ PF GP1	3P. 5 cycle F @ PF GP1
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	486 / 61		973 / 121	973 / 121	973 / 121
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	275 / 477		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	748 / 1193	1504 / 2399		373 / 595	373 / 595	373 / 595
D602F / F601C	120 / 109	841 / 764	851 / 771		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	-158 / -195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey BP1 / BP2	- 6 / 43	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	- 121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Steady State Vltgs	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Dorsey 500/Dorsey 230							
Roseau 500/Forbes 500	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Chisago 500/EauClaire 345	1.059 / 1.02	1.059 / 1.02	1.058 / 1.02		1.059 / 1.02	1.059 / 1.02	1.059 / 1.02
Int Falls 115/Badoura 115	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Drayton 230/Groton 345	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
SS OS Relay Margins	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.01 / 0.997	1.01 / 0.997	1.01 / 0.997
D602F at Forbes/Dorsey							
32R at Rugby/L20D at Drayton	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
R50M/F3M	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
B10T	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
Min/MaxTransientVltg	340%	339%	337%		336%	336%	336%
Arrowhd 230							
Boise 115	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dorsey 230	0.95 | 1.03	0.95 | 1.03	0.95 | 1.03		0.95 | 1.02	0.95 | 1.02	0.95 | 1.02
Forbes 230	0.94 | 1.08	0.94 | 1.08	0.94 | 1.08		0.93 | 1.07	0.93 | 1.07	0.93 | 1.07
Riverton 230	1.00 | 1.03	1.00 | 1.03	1.00 | 1.03		0.99 | 1.03	0.99 | 1.03	0.99 | 1.03
Coal Creek 230	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03		1.01 | 1.03	1.01 | 1.03	1.01 | 1.03
Dickinson 345	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Drayton 230	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Groton 345	0.97 | 1.04	0.97 | 1.04	0.97 | 1.04		0.94 | 1.02	0.94 | 1.02	0.94 | 1.02
Tioga 230	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Wahpeton 115	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Watertown 345	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05		1.03 | 1.05	1.03 | 1.05	1.03 | 1.05
Dynamic Voltage Warnings	1.02 | 1.02	1.02 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133		/ 0.133	/ 0.133	/ 0.133
Forbes DC Red (DCAR)	463%	463%	460%		490%	490%	490%
K22W (max +dP @ t, d-ang)	93.0@(0.15000,-3.1)	93.5@(0.15000,-3.2)	94.2@(0.15833,-3.2)		105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)
K22W (max -dP @ t, d-ang)	0.0@(0.00833,0.0)	0.0@(0.00833,0.0)	0.0@(0.00000,0.0)		0.2@(0.10000,0.0)	0.1@(0.10000,0.0)	0.1@(0.10000,0.0)
K22W (max d-ang @ t, dP)	-6.2@(0.84166,9.2)	-6.2@(0.84166,9.6)	-6.4@(0.87500,11.3)		-3.7@(2.24999,8.1)	-3.7@(2.24166,8.2)	-3.7@(2.24166,8.3)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M / F3M	975% / 328%	972% / 327%	949% / 326%		993% / 329%	993% / 329%	993% / 329%
B10T	340%	339%	337%		325%	325%	326%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p1z	pfa-so09aa.uzvV4W4-p1z	pfb-so09aa.uzvV4W4-p1z		pf2-so09aa.uzvV4W4-p1z	pfc-so09aa.uzvV4W4-p1z	pfd-so09aa.uzvV4W4-p1z
Disturbance	p1z	p1z	p1z		p1z	p1z	p1z
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping							

APPENDIX F2

POWER FLOW AND STABILITY SUMMARY

P2Z

Case No.	1	2	3	4	5	6	7
Case Name	pf1-so09aa.uzvV4W4-p2z	pfa-so09aa.uzvV4W4-p2z	pfb-so09aa.uzvV4W4-p2z		pf2-so09aa.uzvV4W4-p2z	pfc-so09aa.uzvV4W4-p2z	pfd-so09aa.uzvV4W4-p2z
Disturbance	p2z	p2z	p2z		p2z	p2z	p2z
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:44	MAR 12 2008 10:28	FEB 20 2008 14:28		MAR 12 2008 12:17	FEB 21 2008 8:28	FEB 21 2008 8:48
Comments	3P. 5 cycle F @ PF PC3	3P. 5 cycle F @ PF PC3	3P. 5 cycle F @ PF PC3		3P. 5 cycle F @ PF PC3	3P. 5 cycle F @ PF PC3	3P. 5 cycle F @ PF PC3
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	1944 / 244		1946 / 242	1946 / 242	1946 / 242
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	550 / 954		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	1496 / 2386	1504 / 2399		1492 / 2380	1492 / 2380	1492 / 2380
D602F / F601C	1680 / 1526	1682 / 1528	1702 / 1542		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	-158 / -195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey bipole / CU bipole	-150 / 1075	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	-121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Arrowhd-Wstn/ RCDC	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Steady State Vltgs							
Dorsey 500/Dorsey 230	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Roseau 500/Forbes 500	1.059 / 1.020	1.059 / 1.020	1.058 / 1.020		1.059 / 1.020	1.059 / 1.020	1.059 / 1.020
Chisago 500/EauClaire 345	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Int Falls 115/Badoura 115	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
Drayton 230/Groton 345	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.010 / 0.997	1.010 / 0.997	1.010 / 0.997
SS OS Relay Margins							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M/F3M	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
B10T	340%	339%	337%		336%	336%	336%
Min/MaxTransientVltg							
Arrowhd 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Boise 115	0.95 | 1.02	0.95 | 1.02	0.95 | 1.02		0.95 | 1.02	0.95 | 1.02	0.95 | 1.02
Dorsey 230	0.94 | 1.08	0.94 | 1.08	0.94 | 1.07		0.93 | 1.07	0.93 | 1.07	0.93 | 1.07
Forbes 230	1.00 | 1.03	1.00 | 1.03	1.00 | 1.03		0.99 | 1.03	0.99 | 1.03	0.99 | 1.03
Riverton 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Dickinson 345	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Drayton 230	0.97 | 1.04	0.97 | 1.04	0.97 | 1.04		0.94 | 1.02	0.94 | 1.02	0.94 | 1.02
Groton 345	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Tioga 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dynamic Voltage Warnings							
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133		/ 0.133	/ 0.133	/ 0.133
Forbes DC Red (DCAR)	484%	484%	482%		497%	496%	496%
K22W (max +dP @ t, d-ang)	93.0@(0.15000,-3.1)	93.5@(0.15000,-3.2)	94.2@(0.15833,-3.2)		105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)
K22W (max -dP @ t, d-ang)	18.2@(0.30833,1.3)	18.1@(0.30833,1.3)	18.7@(1.10000,-0.1)		4.9@(0.55833,-0.2)	5.0@(0.55833,-0.2)	5.1@(0.55833,-0.2)
K22W (max d-ang @ t, dP)	-3.2@(0.10833,90.7)	-3.2@(0.10833,91.1)	-3.3@(0.10833,91.6)		-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	284% / 411%	283% / 409%	275% / 397%		289% / 419%	289% / 419%	289% / 419%
32R at Rugby/L20D at Drayton	999% / 662%	999% / 660%	999% / 642%		999% / 663%	999% / 663%	999% / 663%
R50M / F3M	937% / 315%	933% / 314%	906% / 312%		981% / 328%	981% / 327%	981% / 327%
B10T	321%	320%	318%		316%	316%	316%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p2z	pfa-so09aa.uzvV4W4-p2z	pfb-so09aa.uzvV4W4-p2z		pf2-so09aa.uzvV4W4-p2z	pfc-so09aa.uzvV4W4-p2z	pfd-so09aa.uzvV4W4-p2z
Disturbance	p2z	p2z	p2z		p2z	p2z	p2z
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(9T)		(1T)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(

APPENDIX F3

POWER FLOW AND STABILITY SUMMARY

P3Z

Case No.	1	2	3	4	5	6	7
Case Name	pf1-so09aa.uzvV4W4-p3z	pfa-so09aa.uzvV4W4-p3z	pfb-so09aa.uzvV4W4-p3z		pf2-so09aa.uzvV4W4-p3z	pfc-so09aa.uzvV4W4-p3z	pfd-so09aa.uzvV4W4-p3z
Disturbance	p3z	p3z	p3z		p3z	p3z	p3z
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:47	MAR 12 2008 10:32	FEB 20 2008 14:33		MAR 12 2008 12:21	FEB 21 2008 8:36	FEB 21 2008 8:52
Comments	3P. 5 cycle F @ PF PR2	3P. 5 cycle F @ PF PR2	3P. 5 cycle F @ PF PR2		3P. 5 cycle F @ PF PR2	3P. 5 cycle F @ PF PR2	3P. 5 cycle F @ PF PR2
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	1944 / 244		1946 / 242	1946 / 242	1946 / 242
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	550 / 954		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	1496 / 2386	1504 / 2399		1492 / 2380	1492 / 2380	1492 / 2380
D602F / F601C	1680 / 1526	1682 / 1528	1702 / 1542		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	158 / 195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey bipole / CU bipole	-150 / 1075	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	-121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Arrowhd-Wstn/ RCDC	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Steady State Vltgs							
Dorsey 500/Dorsey 230	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Roseau 500/Forbes 500	1.059 / 1.020	1.059 / 1.020	1.058 / 1.020		1.059 / 1.020	1.059 / 1.020	1.059 / 1.020
Chisago 500/EauClaire 345	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Int Falls 115/Badoura 115	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
Drayton 230/Groton 345	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.010 / 0.997	1.010 / 0.997	1.010 / 0.997
SS OS Relay Margins							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M/F3M	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
B10T	340%	339%	337%		336%	336%	336%
Min/MaxTransientVltg							
Arrowhd 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Boise 115	0.95 | 1.03	0.95 | 1.03	0.95 | 1.03		0.95 | 1.02	0.95 | 1.02	0.95 | 1.02
Dorsey 230	0.94 | 1.08	0.94 | 1.08	0.94 | 1.08		0.93 | 1.07	0.93 | 1.07	0.93 | 1.07
Forbes 230	1.00 | 1.03	1.00 | 1.03	1.00 | 1.03		0.99 | 1.03	0.99 | 1.03	0.99 | 1.03
Riverton 230	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Dickinson 345	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Drayton 230	0.97 | 1.04	0.97 | 1.04	0.97 | 1.04		0.94 | 1.02	0.94 | 1.02	0.94 | 1.02
Groton 345	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Tioga 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.03 | 1.05	1.03 | 1.05	1.03 | 1.05		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dynamic Voltage Warnings							
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133		/ 0.133	/ 0.133	/ 0.133
Forbes DC Red (DCAR)	476%	476%	472%		496%	496%	496%
K22W (max +dP @ t, d-ang)	93.0@(0.15000,-3.1)	93.5@(0.15000,-3.2)	94.2@(0.15833,-3.2)		105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)
K22W (max -dP @ t, d-ang)	3.7@(1.03333,-3.0)	3.9@(1.03333,-3.0)	4.9@(1.09166,-3.0)		7.3@(0.55833,-0.3)	7.5@(0.55833,-0.3)	7.5@(0.55833,-0.3)
K22W (max d-ang @ t, dP)	-3.5@(0.85000,5.7)	-3.5@(0.85000,6.1)	-3.7@(0.89166,7.7)		-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	293% / 425%	292% / 423%	284% / 410%		291% / 421%	291% / 421%	291% / 421%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 668%	999% / 668%	999% / 668%
R50M / F3M	956% / 328%	951% / 327%	922% / 326%		986% / 327%	986% / 327%	986% / 327%
B10T	335%	333%	330%		314%	312%	298%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p3z	pfa-so09aa.uzvV4W4-p3z	pfb-so09aa.uzvV4W4-p3z		pf2-so09aa.uzvV4W4-p3z	pfc-so09aa.uzvV4W4-p3z	pfd-so09aa.uzvV4W4-p3z
Disturbance	p3z	p3z	p3z		p3z	p3z	p3z
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping	)(3T)(4T)(5T)(6T)(7T)(8T)(1	)(3T)(4T)(5T)(6T)(7T)(8T)(1	)(3T)(4T)(5T)(6T)(7T)(8T)(9T)		(1T)(3T)(4T)(5T)(6T)(7T)(8T)(1	)(3T)(4T)(5T)(6T)(7T)(8T)(1	)(3T)(4T)(5T)(6T)(7T)(8T)(

APPENDIX F4

POWER FLOW AND STABILITY SUMMARY

P4Z

Case No.	1	2	3	4	5	6	7
Case Name	pf1-so09aa.uzvV4W4-p4z	pfa-so09aa.uzvV4W4-p4z	pfb-so09aa.uzvV4W4-p4z		pf2-so09aa.uzvV4W4-p4z	pfc-so09aa.uzvV4W4-p4z	pfd-so09aa.uzvV4W4-p4z
Disturbance	p4z	p4z	p4z		p4z	p4z	p4z
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:50	MAR 12 2008 10:36	FEB 20 2008 14:45		MAR 12 2008 12:26	FEB 21 2008 8:40	FEB 21 2008 8:57
Comments	3P. 5 cycle F @ PF PA1	3P. 5 cycle F @ PF PA1	3P. 5 cycle F @ PF PA1		3P. 5 cycle F @ PF PA1	3P. 5 cycle F @ PF PA1	3P. 5 cycle F @ PF PA1
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	1944 / 244		1946 / 242	1946 / 242	1946 / 242
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	550 / 954		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	1496 / 2386	1504 / 2399		1492 / 2380	1492 / 2380	1492 / 2380
D602F / F601C	1680 / 1526	1682 / 1528	1702 / 1542		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	-158 / -195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey bipole / CU bipole	-150 / 1075	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	-121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Arrowhd-Wstn/ RCDC	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Steady State Vltgs							
Dorsey 500/Dorsey 230	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Roseau 500/Forbes 500	1.059 / 1.020	1.059 / 1.020	1.058 / 1.020		1.059 / 1.020	1.059 / 1.020	1.059 / 1.020
Chisago 500/EauClaire 345	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Int Falls 115/Badoura 115	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
Drayton 230/Groton 345	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.010 / 0.997	1.010 / 0.997	1.010 / 0.997
SS OS Relay Margins							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M/F3M	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
B10T	340%	339%	337%		336%	336%	336%
Min/MaxTransientVltg							
Arrowhd 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Boise 115	0.95 | 1.02	0.95 | 1.02	0.95 | 1.02		0.95 | 1.02	0.95 | 1.02	0.95 | 1.02
Dorsey 230	0.94 | 1.08	0.94 | 1.08	0.94 | 1.07		0.93 | 1.07	0.93 | 1.07	0.93 | 1.07
Forbes 230	1.00 | 1.03	1.00 | 1.03	1.00 | 1.03		0.99 | 1.03	0.99 | 1.03	0.99 | 1.03
Riverton 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Dickinson 345	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Drayton 230	0.97 | 1.04	0.97 | 1.04	0.97 | 1.04		0.94 | 1.02	0.94 | 1.02	0.94 | 1.02
Groton 345	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Tioga 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dynamic Voltage Warnings							
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold	/ 0.133	/ 0.133	/ 0.133		/ 0.133	/ 0.133	/ 0.133
Forbes DC Red (DCAR)	483%	483%	480%		494%	494%	494%
K22W (max +dP @ t, d-ang)	93.0@(0.15000,-3.1)	93.5@(0.15000,-3.2)	94.2@(0.15833,-3.2)		105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)	105.1@(0.18333,-3.6)
K22W (max -dP @ t, d-ang)	20.5@(0.31667,1.5)	20.5@(0.31667,1.5)	19.7@(0.33333,1.5)		14.7@(0.54166,1.4)	14.9@(0.54166,1.4)	15.0@(0.54166,1.4)
K22W (max d-ang @ t, dP)	-3.2@(0.10833,90.7)	-3.2@(0.10833,91.1)	-3.3@(0.10833,91.6)		-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)	-3.6@(0.18333,105.1)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	279% / 403%	278% / 401%	270% / 389%		280% / 405%	280% / 405%	280% / 405%
32R at Rugby/L20D at Drayton	999% / 642%	999% / 640%	999% / 623%		999% / 642%	999% / 642%	999% / 643%
R50M / F3M	918% / 310%	914% / 309%	888% / 308%		964% / 310%	964% / 311%	964% / 311%
B10T	312%	310%	308%		307%	307%	307%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p4z	pfa-so09aa.uzvV4W4-p4z	pfb-so09aa.uzvV4W4-p4z		pf2-so09aa.uzvV4W4-p4z	pfc-so09aa.uzvV4W4-p4z	pfd-so09aa.uzvV4W4-p4z
Disturbance	p4z	p4z	p4z		p4z	p4z	p4z
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(9T		(1T)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(	)(3T)(4T)(5T)(6T)(7T)(8T)(

APPENDIX F5

POWER FLOW AND STABILITY SUMMARY

P6S

Case No.	1	2	3		4	5	6
Case Name	pf1-so09aa.uzvV4W4-p6s	pfa-so09aa.uzvV4W4-p6s	pfb-so09aa.uzvV4W4-p6s		pf2-so09aa.uzvV4W4-p6s	pfc-so09aa.uzvV4W4-p6s	pfd-so09aa.uzvV4W4-p6s
Disturbance	p6s	p6s	p6s		p6s	p6s	p6s
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:54	FEB 22 2008 8:03	FEB 22 2008 8:08		MAR 12 2008 12:31	FEB 22 2008 8:13	FEB 22 2008 8:23
Comments	SLG. 5 cycle F @ PF GP1	SLG. 5 cycle F @ PF GP1	SLG. 5 cycle F @ PF GP1		SLG. 5 cycle F @ PF GP1	SLG. 5 cycle F @ PF GP1	SLG. 5 cycle F @ PF GP1
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	1944 / 244		1946 / 242	1946 / 242	1946 / 242
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	550 / 954		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	1496 / 2386	1504 / 2399		1492 / 2380	1492 / 2380	1492 / 2380
D602F / F601C	1680 / 1526	1682 / 1528	1702 / 1542		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	-158 / -195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey bipole / CU bipole	-150 / 1075	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	-121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Arrowhd-Wstn/ RCDC	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Steady State Vltgs							
Dorsey 500/Dorsey 230	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Roseau 500/Forbes 500	1.059 / 1.020	1.059 / 1.020	1.058 / 1.020		1.059 / 1.020	1.059 / 1.020	1.059 / 1.020
Chisago 500/EauClaire 345	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Int Falls 115/Badoura 115	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
Drayton 230/Groton 345	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.010 / 0.997	1.010 / 0.997	1.010 / 0.997
SS OS Relay Margins							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M/F3M	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
B10T	340%	339%	337%		336%	336%	336%
Min/MaxTransientVltg							
Arrowhd 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Boise 115	0.99 | 1.02	0.99 | 1.02	0.99 | 1.02		0.98 | 1.02	0.98 | 1.02	0.98 | 1.02
Dorsey 230	1.00 | 1.07	1.00 | 1.07	1.00 | 1.07		0.99 | 1.08	0.99 | 1.08	0.99 | 1.08
Forbes 230	1.01 | 1.03	1.01 | 1.03	1.01 | 1.03		1.01 | 1.03	1.01 | 1.03	1.01 | 1.03
Riverton 230	1.02 | 1.02	1.02 | 1.02	1.02 | 1.02		1.02 | 1.02	1.02 | 1.02	1.02 | 1.02
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Dickinson 345	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Drayton 230	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04		0.98 | 1.02	0.98 | 1.02	0.98 | 1.02
Groton 345	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Tioga 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.04 | 1.05	1.04 | 1.05	1.04 | 1.04		1.04 | 1.04	1.04 | 1.04	1.04 | 1.04
Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dynamic Voltage Warnings							
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold							
Forbes DC Red (DCAR)	496%	496%	495%		496%	496%	496%
K22W (max +dP @ t, d-ang)	40.8@(0.13333,-1.1)	40.9@(0.13333,-1.1)	40.5@(0.13333,-1.1)		47.9@(0.15000,-1.3)	47.8@(0.15000,-1.3)	47.7@(0.15000,-1.3)
K22W (max -dP @ t, d-ang)	10.3@(0.26667,0.8)	10.3@(0.26667,0.8)	9.9@(0.26667,0.8)		9.6@(0.25833,0.7)	9.5@(0.25833,0.7)	9.5@(0.25833,0.7)
K22W (max d-ang @ t, dP)	-1.2@(0.10833,39.5)	-1.2@(0.10833,39.7)	-1.2@(0.10833,39.4)		-1.3@(0.12500,46.8)	-1.3@(0.12500,46.8)	-1.3@(0.12500,46.6)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	291% / 421%	290% / 420%	282% / 408%		290% / 421%	290% / 421%	290% / 421%
32R at Rugby/L20D at Drayton	999% / 668%	999% / 666%	999% / 649%		999% / 668%	999% / 668%	999% / 668%
R50M / F3M	955% / 322%	952% / 322%	928% / 320%		993% / 326%	993% / 326%	993% / 326%
B10T	320%	316%	315%		315%	315%	315%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p6s	pfa-so09aa.uzvV4W4-p6s	pfb-so09aa.uzvV4W4-p6s		pf2-so09aa.uzvV4W4-p6s	pfc-so09aa.uzvV4W4-p6s	pfd-so09aa.uzvV4W4-p6s
Disturbance	p6s	p6s	p6s		p6s	p6s	p6s
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping	(3T)(4T)(5T)(6T)(7T)(8T)(	(3T)(4T)(5T)(6T)(7T)(8T)(	(3T)(4T)(5T)(6T)(7T)(8T)(9T)		(1T)(3T)(4T)(5T)(6T)(7T)(8T)(	(3T)(4T)(5T)(6T)(7T)(8T)(	(3T)(4T)(5T)(6T)(7T)(8T)(

APPENDIX F6

POWER FLOW AND STABILITY SUMMARY

P7S SLG, 5 + 15 CYCLE, 110 kV fault at Pine Falls on PC4 (PF @ 101.3 MW), **P8S** SLG, 5 + 15 CYCLE, 110 kV fault at Pine Falls on PC4 (PF @ 109.4 MW)

Case No.	1	2	3	4	5	6	7
Case Name	pf1-so09aa.uzvV4W4-p7s	pfa-so09aa.uzvV4W4-p7s	pfb-so09aa.uzvV4W4-p8s		pf2-so09aa.uzvV4W4-p8s	pfc-so09aa.uzvV4W4-p7s	pfd-so09aa.uzvV4W4-p8s
Disturbance	p7s	p7s	p8s		p8s	p7s	p8s
Prior Outage	None	None	None		None	None	None
Date/Time	MAR 12 2008 8:57	MAR 12 2008 10:55	FEB 27 2008 9:29		MAR 13 2008 7:42	FEB 26 2008 10:50	FEB 27 2008 9:34
Comments	SLG. 5 + 15 cycle F @ PF PC	SLG. 5 + 15 cycle F @ PF PC	SLG. 5 + 15 cycle F @ PF PC4		SLG. 5 + 15 cycle F @ PF PC	SLG. 5 + 15 cycle F @ PF PC	SLG. 5 + 15 cycle F @ PF PC4
Dorsey (MW)	2984	2938	2930		3350	3350	3350
Selkirk Output (MW)	0	0	0		0	0	0
Pine Falls Output (MW)	89.6	101.3	109.4		89.6	101.3	109.4
MHEX	2175	2175	2175		2129	2129	2129
MH / ON	200	200	200		200	200	200
Wpg River Output (MW)	597.9	609.6	617.7		125	125	125
Steady State Flows							
NDEX / EAST BIAS	1945 / 244	1945 / 244	1944 / 244		1946 / 242	1946 / 242	1946 / 242
MHEX / L20D	2141 / 288	2144 / 288	2175 / 293		2128 / 279	2128 / 279	2128 / 279
ECL-ARP / PRI-BYN	547 / 948	547 / 949	550 / 954		545 / 946	545 / 946	545 / 946
MWSI / MNEX	1495 / 2384	1496 / 2386	1504 / 2399		1492 / 2380	1492 / 2380	1492 / 2380
D602F / F601C	1680 / 1526	1682 / 1528	1702 / 1542		1681 / 1523	1681 / 1523	1681 / 1523
B10T / MH>SPC	163 / 60	164 / 61	164 / 61		164 / 61	164 / 61	164 / 61
OH E-W / OH>MH	-158 / -195	-158 / -195	-159 / -197		-160 / -196	-160 / -196	-160 / -196
R50M / OH>MP	139 / 150	139 / 150	141 / 150		136 / 150	136 / 150	136 / 150
G82R	33	33	37		31	31	31
Dorsey bipole / CU bipole	-150 / 1075	-150 / 1075	-150 / 1075		-150 / 1074	-149 / 1074	-150 / 1074
Dorsey Reserve / Wtrtn SVC	770 / 89	767 / 89	731 / 93		365 / 87	365 / 87	365 / 87
Forbes SVC / MSC	-121 / 600	-118 / 600	-95 / 600		-125 / 600	-125 / 600	-125 / 600
Arrowhd-Wstn/ RCDC	/ 0	/ 0	/ 0		/ 0	/ 0	/ 0
Steady State Vltgs							
Dorsey 500/Dorsey 230	1.032 / 1.045	1.032 / 1.045	1.031 / 1.045		1.032 / 1.045	1.032 / 1.045	1.032 / 1.045
Roseau 500/Forbes 500	1.059 / 1.020	1.059 / 1.020	1.058 / 1.020		1.059 / 1.020	1.059 / 1.020	1.059 / 1.020
Chisago 500/EauClaire 345	1.015 / 1.018	1.015 / 1.018	1.014 / 1.017		1.015 / 1.019	1.015 / 1.019	1.015 / 1.019
Int Falls 115/Badoura 115	1.016 / 1.029	1.016 / 1.029	1.015 / 1.029		1.016 / 1.028	1.016 / 1.028	1.016 / 1.028
Drayton 230/Groton 345	1.031 / 0.997	1.031 / 0.997	1.029 / 0.996		1.010 / 0.997	1.010 / 0.997	1.010 / 0.997
SS OS Relay Margins							
D602F at Forbes/Dorsey	295% / 429%	294% / 428%	288% / 417%		295% / 429%	295% / 429%	295% / 429%
32R at Rugby/L20D at Drayton	999% / 681%	999% / 679%	999% / 661%		999% / 681%	999% / 681%	999% / 681%
R50M/F3M	975% / 328%	972% / 327%	949% / 326%		999% / 329%	999% / 329%	999% / 329%
B10T	340%	339%	337%		336%	336%	336%
Min/MaxTransientVltg							
Arrowhd 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Boise 115	0.99 | 1.03	0.99 | 1.03	0.99 | 1.03		0.98 | 1.01	0.98 | 1.02	0.98 | 1.02
Dorsey 230	1.00 | 1.07	1.00 | 1.07	1.00 | 1.07		0.99 | 1.05	0.99 | 1.08	0.99 | 1.08
Forbes 230	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.03	1.01 | 1.03
Riverton 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.02	1.02 | 1.02	1.02 | 1.02
Coal Creek 230	1.03 | 1.04	1.03 | 1.04	1.03 | 1.04		1.03 | 1.04	1.03 | 1.04	1.03 | 1.04
Dickinson 345	1.00 | 1.01	1.00 | 1.01	1.00 | 1.01		1.00 | 1.01	1.00 | 1.01	1.00 | 1.01
Drayton 230	1.00 | 1.04	1.00 | 1.04	1.00 | 1.04		0.98 | 1.01	0.98 | 1.02	0.98 | 1.02
Groton 345	0.99 | 1.00	0.99 | 1.00	0.99 | 1.00		0.99 | 1.00	0.99 | 1.00	0.99 | 1.00
Tioga 230	1.02 | 1.03	1.02 | 1.03	1.02 | 1.03		1.02 | 1.03	1.02 | 1.03	1.02 | 1.03
Wahpeton 115	1.04 | 1.05	1.04 | 1.05	1.04 | 1.05		1.04 | 1.04	1.04 | 1.04	1.04 | 1.04
Watertown 345	1.01 | 1.02	1.01 | 1.02	1.01 | 1.02		1.01 | 1.02	1.01 | 1.02	1.01 | 1.02
Dynamic Voltage Warnings							
	none	none	none		none	none	none
Worst Case Angle Damping							
Dorsey SUVP / UdHold							
Forbes DC Red (DCAR)	474%	474%	469%		493%	486%	484%
K22W (max +dP @ t, d-ang)	35.9@(0.13333,-1.0)	36.1@(0.13333,-1.0)	36.0@(0.13333,-1.0)		42.3@(0.18333,-0.9)	42.2@(0.18333,-0.9)	42.1@(0.18333,-0.9)
K22W (max -dP @ t, d-ang)	25.7@(1.15000,-0.6)	26.4@(1.15833,-0.5)	31.3@(1.20833,-0.7)		0.2@(0.10000,0.0)	12.2@(0.40833,1.1)	9.3@(0.40833,0.9)
K22W (max d-ang @ t, dP)	2.9@(0.50833,-20.0)	2.9@(0.51666,-19.6)	3.3@(0.55833,-19.6)		-4.5@(2.74165,27.8)	-1.6@(2.34999,-1.5)	-2.4@(2.46666,0.0)
OS Rel Trip / Marg							
MH - OH							
D602F at Forbes/Dorsey	281% / 408%	280% / 405%	275% / 398%		280% / 404%	280% / 406%	280% / 406%
32R at Rugby/L20D at Drayton	999% / 657%	999% / 653%	999% / 639%		999% / 652%	999% / 652%	999% / 652%
R50M / F3M	931% / 310%	928% / 309%	917% / 302%		929% / 329%	930% / 328%	931% / 329%
B10T	316%	315%	315%		300%	312%	311%
FSCAPS (SS/Unav/Final)							
Balta 230	(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)		(0 | 0 | 0)	(0 | 0 | 0)	(0 | 0 | 0)
Eau Cl 345 / Park Lk 115	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)		(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)	(3 | 3 | 3) / (0 | 0 | 0)
Prairie 115 / Ramsey 230	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)
Roseau 230 / Running 230	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)		(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)	(0 | 0 | 0) / (2 | 2 | 2)
Shey 115 / Split Rock 115	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)		(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)	(1 | 1 | 1) / (0 | 0 | 0)

Case	pf1-so09aa.uzvV4W4-p7s	pfa-so09aa.uzvV4W4-p7s	pfb-so09aa.uzvV4W4-p8s		pf2-so09aa.uzvV4W4-p8s	pfc-so09aa.uzvV4W4-p7s	pfd-so09aa.uzvV4W4-p8s
Disturbance	p7s	p7s	p8s		p8s	p7s	p8s
System Response	OK	OK	OK		OK	OK	OK
70% or 120% Violations							
ORWG Criteria Violations							
Line Tripping	T)(3T)(4T)(5T)(6T)(7T)(8T)(9T	T)(3T)(4T)(5T)(6T)(7T)(8T)(9T	T)(3T)(4T)(5T)(6T)(7T)(8T)(9T)		(1T)(3T)(4T)(5T)(6T)(7T)(8T)(9T	T)(3T)(4T)(5T)(6T)(7T)(8T)(9T	T)(3T)(4T)(5T)(6T)(7T)(8T)(9T

APPENDIX G

Generation Profiles

	SevSis	McA	GrFalls	PineF	Pointe	Slave	Total WRG	
Units	1	1	1	1	7	3		
Max gen	29.13	7.00	23.40	14.18	33.14	25.18		
Gen	28.0	7.0	23.0	14.0	33.0	20.0	**125.0**	Sum Min
Units	2	3	2	2	10	3		
Max gen	57.84	20.90	44.30	28.36	46.58	25.18		
Gen	57.0	20.0	44.0	28.0	46.0	25.0	**220.0**	Wtr Min
Units	6.0	8.0	6.0	6.0	16.0	8.0		
Max gen	165.40	56.50	135.20	89.60	78.80	68.00	**593.5**	Max ('07)
Gen	165.40	56.50	135.20	89.60	78.80	68.00		
Units	6.0	8.0	6.0	6.0	16.0	8.0		
Max gen	165.40	56.50	139.60	89.60	78.80	68.00	**597.9**	Max ('10)
Gen	165.40	56.50	139.60	89.60	78.80	68.00		
Units	6.0	8.0	6.0	6.0	16.0	8.0		
Max gen	165.40	56.50	139.60	101.30	78.80	68.00	**609.6**	Max
Gen	165.40	56.50	139.60	89.60	78.80	68.00		Unit 1 & 2
Units	6.0	8.0	6.0	6.0	16.0	8.0		
Max gen	165.40	56.50	139.60	109.40	78.80	68.00	**617.7**	Max
Gen	165.40	56.50	139.60	89.60	78.80	68.00		Units 1-4

APPENDIX H

Pine Falls Proposed Generation Upgrades

Unit	Existing Output	Unit 1 Upgrade	Unit 2 Upgrade	Units 1-3 Upgrade	Units 1-4 Upgrade
1	14.18	20.03	20.03	19.13	19.13
2	14.18	14.18	20.03	19.13	19.13
3	14.08	14.08	14.08	19.03	19.03
4	13.78	13.78	13.78	13.78	18.73
5	16.54	16.54	16.54	16.54	16.54
6	16.84	16.84	16.84	16.84	16.84
Total	89.60	95.45	101.30	104.45	109.40

APPENDIX I

Single line to ground fault at 99% down PC4

1. TIME = 0 SLG Fault occurs on PC4

Thevenin Impedance at Fault Thevenin Impedance (ohm) Positive 1.07362+j4.0929 **Negative** 1.17489+j4.24039 **Zero** 0.98261+j6.33856

2.Parkdale end PC4 opens at: **0.05 sec**

Thevenin Impedance at Fault
Thevenin Impedance (ohm) Positive
13.4081+j47.1806 **Negative**
13.6768+j47.6785 **Zero**
18.0312+j80.7736

3. Parkdale PC3 opens at: **0.3593 second**

ASPEN gives: **no other relay will see the fault, and the SLG is not cleared. Adjusting relay setting on lines GP1 or PR2 cannot isolate the fault**

nominal current of Pine Falls generators = 15.5MVA/(13.8kV*sqrt(3)) = **648.4**7 A

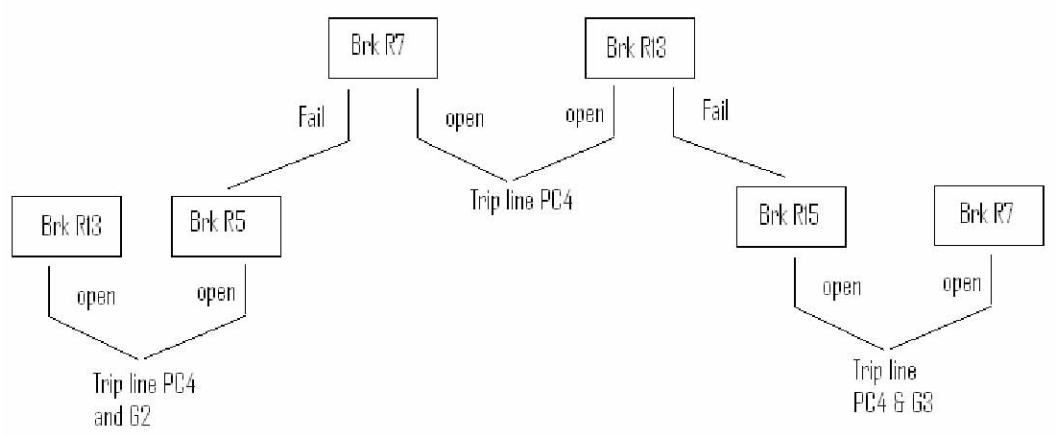
negative sequence component of the current at generators = 73@-62A

At the moment, pine fall generators do not have negative sequence current protection, and the criteria for negative sequence current at the generator after the fault is not exceeding 10% of the nominal current of the machine. If the single line to ground fault cannot be cleared, the unbalanced fault causes a negative sequence current component in the stator current. This current leads to a counter-rotating flux field in the machine and causes double frequency currents to flow in the rotor iron and slot wedges, resulting in local heating.

10% of 648.47A = 65.85A
Therefore, the negative sequence component of the current of 73@-62A is higher than the criteria of 65.85A, and the generators could be damaged if the fault is not cleared.

Recommendations:

1 Install breaker fail protection for line PC4 at Pine Falls station with the following logic:
2 Install negative sequence current protection on all 6 Pine Falls generators.
3 Replace the existing relay at the station with new microprocessor relays. The relays at the station are very old (installed around 1952) and the protection schemes are not adequate. The new microprocessor relays would have all the components required, such as breaker fail and negative sequence protections.



Single line to ground fault at 99% down PC4

1. TIME = 0 SLG Fault occurs on PC4

ASPEN gives:
Equipment
Parkdale end of PC4 opens in 0.00 seconds on Ground instantaneous (51N) Parkdale end of PC3 opens in 1.26 seconds Pine Falls end of PC3 operates by 51N in 1.59 seconds

Equipment	**Travel in Per Unit**
Parkdale end PC3	0.0397
Pine Falls end PC3	0.0314

Calculation: Parkdale PC3 travel = 0.050/1.26sec
Pine Falls PC3 travel = 0.05/1.59sec

Clearing Times and Thevenin Impedance: Parkdale end PC4 opens at: **0.05 sec**

Calculation: TIME = 0.050 seconds (relay + breaker time at Parkdale end PC4)

Thevenin Impedance at Fault

Thevenin Impedance (ohm) Positive 1.07362+j4.0929 **Negative** 1.17489+j4.24039 **Zero** 0.98261+j6.33856

2. Open Parkdale end of PC4

ASPEN gives:

Equipment Relay Operating Time (sec)
Parkdale PC3 0.43 Pine Falls
PC3 0.45

Calculation: Parkdale PC3 time to travel 1.00 per unit = (1.00 per unit – 0.0397 per unit)* 0.43 sec= **0.25929 sec**
Equipment Travel in Per Unit Detailed Calculation:
Pine Falls PC3 0.7187 Time = 0.0314+(0.25929+0.05)/0.45 sec

Clearing Times and Impedance at Fault

Parkdale PC3 opens at: 0.3593 second
Calculation: TIME = 0.050 (previous time) + 0.2593 (relay time) + 0.050 seconds (breaker time)

Thevenin Impedance at Fault

Thevenin Impedance (ohm)
Positive 13.4081+j47.1806
Negative 13.6768+j47.6785
Zero 18.0312+j80.7736

3. Open Parkdale PC3 ASPEN gives: no other relay will see the fault, and the SLG is not cleared. Adjusting relay setting on lines

nominal current of Pine Falls generators = 15.5MVA/(13.8kV*sqrt(3)) = **648.47 A**

negative sequence component of the current at generators = 73@-62A

At the moment, pine fall generators do not have negative sequence current protection, and the criteria for negative sequence current at the generator after the fault is not exceeding 10% of the nominal current of the machine. If the single line to ground

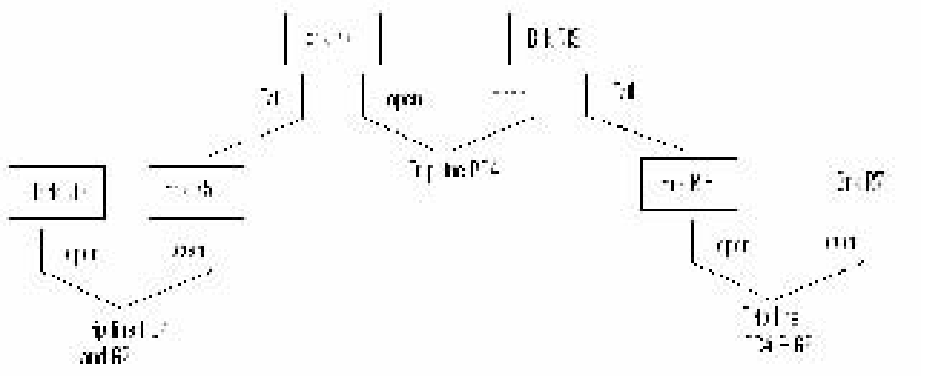
fault cannot be cleared, the unbalanced fault causes a negative sequence current component in the stator current. This current leads to a counter-rotating flux field in the machine and causes double frequency currents to flow in the rotor iron and slot wedges, resulting in local heating.

10% of 648.47A = 65.85A

Therefore, the negative sequence component of the current of 73@-62A is higher than the criteria of 65.85A, and the generators could be damaged if the fault is not cleared.

Recommendations:

1 Install breaker fail protection for line PC4 at Pine Falls station with the following logic:
2 Install negative sequence current protection on all 6 Pine Falls generators.
3 Replace the existing relay at the station with new microprocessor relays. The relays at the station are very old (installed around 1952) and the protection schemes are not adequate. The new microprocessor relays would have all the components required, such as breaker fail and negative sequence protections.



Single line to ground fault at 99% down GP1

1. TIME = 0 SLG Fault occurs on GP1

ASPEN gives:
Great Falls end of GP1 opens in 0.00 seconds on Ground instantaneous (51N)
McArthur end of PR2 operates by 51N in 1.96 seconds

Equipment Travel in Per Unit
McArthur PR2 0.0255102

Calculation: McArthur PR2 travel = 0.050 seconds/1.96sec = 0.0255 pu

Clearing Times and Thevenin Impedance:

Great Falls GP1 opens at: 0.05 sec
Calculation: TIME = 0.050 seconds (relay + breaker time at McArthur end of PR2)

Thevenin Impedance at Fault
Thevenin Impedance (ohm)
Positive 1.845+j6.87481
Negative 1.92638+j7.07524
Zero 0.41369+j5.32899

2. Open Great Falls end of GP1

ASPEN gives:
Equipment Relay Operating Time (sec)
McArthur PR2 0.39 Pine Falls PR2 0.45
Pine Falls PA1 11.46 Pine Falls PA2 12.22

McArthur PR2 time to travel 1.00 per unit = (1.00 per unit – 0.0255 per unit)* 0.39 sec= **0.3801 sec**

Equipmeent Travel in Per Unit Detailed Calculation:
Pine Falls PR2 0.9558 Pine Falls PR2 = (0.3801+0.05)/0.45 Pine Falls PA1 0.0375 Pine Falls PA1 = (0.3801+0.05)/11.46 Pine Falls PA2 0.0352 Pine Falls PA2 = (0.3801+0.05)/12.22

Clearing Times and Impedance at Fault
McArthur PR2 opens at: 0.4801 second

Calculation: TIME = 0.050 (previous time) + 0.3801 (relay time) + 0.050 seconds (breaker time)=0.4801 sec

Thevenin Impedance at Fault
Thevenin Impedance (ohm)
Positive 6.5164+j19.388
Negative 6.92236+j20.1276
Zero 6.37774+j26.5768

3. Open McArthur end PR2 [take PR2 out of service (o/s)]

ASPEN gives:
Equipment Relay Operating Time (sec)

Pine Falls G1 4.88 Pine Falls G3 4.92 Pine Falls G2 5.06 Pine Falls G5 5.38 Pine Falls G4 5.49 Pine Falls G6 5.64 Pine Falls PA1 6.00 Pine Falls PA2 6.33 Pine Falls PC3 6.77

Pine Falls G1 open time = 4.88 seconds + 0.050 seconds breaker time = **4.93 sec**

Equipment Travel in Per Unit Detailed Calculations:

Pine Falls G3 travel = 4.93 seconds per unit = 1.00 per unit Pine Falls G3 1.0020 4.92 seconds Pine Falls G2 0.9743 Pine Falls G2 travel = 4.93 seconds per unit = 0.9743 per unit Pine Falls G5 0.9164 5.06 seconds Pine Falls G4 0.8980 Pine Falls G6 0.8741 Pine Falls G5 travel = 4.93 seconds per unit = 0.9164 per unit Pine Falls PA1 0.8217 5.38 seconds
Calculation: TIME = 0.4801 (previous time) + 4.88 (relay time) + 0.050 seconds breaker time =5.4101 sec **Pine Falls G3 opens at: 5.410051**

Pine Falls PA2 0.7788 0.7282 Pine Falls G4 travel = 4.93 seconds per unit = 0.8980 per unit 5.49 seconds
Pine Falls PC3

Pine Falls G6 travel = 4.93 seconds per unit = 0.8741 per unit 5.64 seconds

Pine Falls PA1 travel = 4.93 seconds per unit = 0.8217 per unit 6.00 seconds

Pine Falls PA2 travel = 4.93 seconds per unit = 0.7788 per unit 6.33 seconds

Pine Falls PC3 travel = 4.93/6.77

Clearing Times and Impedance at Fault

Pine Falls G1 opens at: **5.410051**

Thevenin Impedance at Fault

Thevenin Impedance (ohm)

Positive 7.54481+j24.0168
Negative 8.17128+j25.1488
Zero 7.16749+j37.9565

4. Open Pine Falls G1 & G3 ASPEN gives:
Equipment Relay Operating Time (sec)

Pine Falls G2 3.26 Pine Falls G5 3.44 Pine Falls G4 3.5 Pine Falls G6 3.59 Pine Falls PA1 4.32 Pine Falls PA2 4.52 Pine Falls PC3 4.28

Pine Falls G2 time to travel 1.00 per unit = (1.00 per unit-0.9743pu) * 3.26 sec = **0.0837549 sec**

Equipment	**Travel in Per Unit**	**Detailed Calculations:**
Pine Falls G5	0.9552	Pine Falls G5 travel = 0.9164 per unit + (0.08376 seconds +0.050 seconds breaker time)
Pine Falls G4	0.9369	3.44 seconds
Pine Falls G6	0.9114	
Pine Falls PA1	0.8526	Pine Falls G4 travel = 0.8980 per unit + (0.08376 seconds +0.050 seconds breaker time)
Pine Falls PA2	0.8084	3.5 seconds
Pine Falls PC3	0.7595	Pine Falls G6 travel = 0.8741 per unit + (0.08376 seconds +0.050 seconds breaker time)
		3.59 seconds
		Pine Falls PA1 travel = 0.8217 per unit + (0.08376 seconds +0.050 seconds breakerime)
		4.32 seconds
		Pine Falls PA2 travel = 0.7788 per unit + (0.08376 seconds +0.050 seconds breakertime)
		4.52 seconds
		Pine Falls PC3 travel = 0.7282 + (0.08376+0.05)/4.28

Clearing Times and Impedance at Fault

Pine Falls G2 opens at: **5.543806 sec**

Calculation: TIME = 5.4101 (previous time) + 0.08376 (relay time) + 0.050 seconds breaker time

Thevenin Impedance at Fault

Thevenin Impedance (ohm)

Positive 8.56588+j25.7902
Negative 9.15963+j26.7188
Zero 7.24625+j39.8545

5. Open Pine Falls G2 ASPEN gives Equipment Relay Operating Time (sec)
Pine Falls G5 2.69 Pine Falls G4 2.74 Pine Falls G6 2.8 Pine
Falls PA1 3.65 Pine Falls PA2 3.8 Pine Falls PC3 3.33

Pine Falls G5 time to travel 1.00 per unit = (1.00 – 0.9552) * 2.69 seconds = **0.1204** sec **Equipment Travel in Per Unit Detailed Calculation:**
Pine Falls G4 0.9991 Pine Falls G4 travel = 0.9369 per unit + (0.1204 seconds +0.050 seconds breaker time) Pine Falls G6 0.9722 2.74 seconds Pine Falls PA1 0.8993 Pine Falls PA2 0.8533 Pine Falls G6 travel = 0.9114 per unit + (0.1204 seconds +0.050 seconds breaker time) Pine Falls PC3 0.8106 2.80 seconds
Pine Falls PA1 travel = 0.8526 per unit + (0.1204 seconds +0.050 seconds brker time)
3.65 seconds Pine Falls PA2 travel = 0.8084 per unit + (0.1204 seconds +0.050 seconds breakertime)
3.8 seconds
Pine Falls PC3 travel = 0.7595+(0.1204+0.05)/3.33
Clearing Times and Impedance at Fault Location Pine Falls G5 opens at: 5.7142 sec Calculation: TIME = 5.5438 (previous time) + 0.1204 (relay time) + 0.050 seconds breaker time =5.714 sec

Thevenin Impedance at Fault
Thevenin Impedance (ohm)
Positive 9.23184+j26.8229
Negative 9.77693+j27.6069
Zero 7.31504+j41.2294

6. Open Pine Falls G5:
ASPEN gives: Equipment **Relay Operating Time (sec)** Pine Falls G4 2.11 Pine Falls G6 2.16 Pine Falls PC3 2.56 Pine Falls PA1 3.1 Pine Falls PA2 3.21

Pine Falls G4 time to travel 1.00 per unit = (1.00 – 0.9983) * 2.11 seconds = **0.001961 sec**

Equipment Travel in Per Unit Detailed Calculations:
Pine Falls G6 0.9963 Pine Falls G6 travel = 0.9722 per unit + (0.001961 seconds +0.050 seconds breaker time)
Pine Falls PA1 0.9161 2.16 seconds
Pine Falls PA2 0.8695
Pine Falls PC3 0.8309 Pine Falls PA1 travel = 0.8993 per unit + (0.001961 seconds +0.050 seconds breakertime)
3.1 seconds Pine Falls PA2 travel = 0.8533 per unit + (0.001961 seconds +0.050 seconds breakertime)
3.21 seconds
= 0.8699 per unit Pine Falls PC3 travel = 0.8106+(0.003587+0.05)/2.56

Clearing Times and Impedance at Fault Location Pine Falls G4 opens at: 5.7662 sec Calculations: TIME = 5.7142 (previous time) + 0.001961 (relay time) + 0.050 seconds breaker time

Thevenin Impedance at Fault
Thevenin Impedance (ohm)
Positive 10.0351+j27.9664
Negative 10.4975+j28.5701
Zero 7.42167+j43.0552

7. Open Pine Falls G4
ASPEN gives:
Eqipment Relay Operating Time (sec)
Pine Falls G6 1.63 Pine Falls PC3 1.92 Pine
Falls PA1 2.62 Pine Fall PA2 2.7 Parkdale
PC3 5.9 Pine Falls PC4 9.35

Pine Falls G6 time to travel 1.00 per unit = (1.00 – 0.9970) * 1.63 seconds = **0.006053 sec**

Eqipment Travel in Per Unit Detailed Calculations:
Pine Falls PA1 travel = 0.9161 per unit + (0.006053 seconds +0.050 seconds breakertime) Pine Falls PA1 0.9375 2.62 seconds Pine Fall PA2 0.8902 Pine Falls PC3 0.8601 Pine Falls PA2 travel = 0.8695 per unit + (0.006053 seconds +0.050 seconds breakertime) Pine Falls PC4 0.0060 2.7 seconds Parkdale PC3 0.0095 = 0.8902 per unit
Pine Falls PC4 travel = 0.0 per unit + (0.006053 seconds +0.050 seconds breakertime)
9.35 seconds Pine

Falls PC3 travel = 0.8309+(0.006053+0.05)/1.92
Parkdale PC3 travel = (0.006053+0.05)/5.9

Clearing Times and Impedance at Fault Location Pine Falls G6 opens at: 5.8222 sec Calculations: TIME = 5.7662 (previous time) + 0.006053 (relay time) + 0.050 seconds breaker time

Thevenin Impedance at Fault

	Thevenin Impedance (ohm)
Positive	11.0201+j29.2385
Negative	11.3483+j29.6176
Zero	7.60298+j45.6469

8. Open Pine Falls G6
ASPEN gives:
Equipment Relay Operating Time (sec)
Pine Falls PC3 1.41 Pine Falls PA1 2.2 Pine Fall PA2 2.26 Parkdale PC4 3.74 Pine Falls PC4 5.76

Pine Falls PC3 time to travel 1.00 per unit = (1.00 – 0.8601) * 1.41 seconds = **0.1972 sec**

Equipment Travel in Perunit Pine Falls PA1 1.0498 **Detailed Calculation:** Pine Fall PA2 0.9996 Pine Falls PA2 time to travel 1.00 per unit = 0.8902 + (0.1972sec + 0.05 sec brk time)/2.26 sec Parkdale PC4 0.0661 Pine Falls PC4 0.0489 Parkdale PC4 travel = (0.1972 seconds +0.050 seconds breakertime)= 0.066096

3.74 seconds Pine Falls PC4 travel = 0.006+(0.1972+0.05)/5.76 = 0.048917 Pine Falls PA1 travel = 0.9375+(0.1972+0.05)/2.2 = 1.049864

Clearing Times and Impedance at Fault Location Pine Falls PC3 opens at: 6.0694 sec Calculation: TIME = 5.8220 (previous time) + 0.1972 (relay time) + 0.050 seconds breaker time **Pine Falls PA1 opens at: 6.0694 sec**

Thevenin Impedance at Fault

	Thevenin Impedance (ohm)
Positive	12.2401+j30.6535
Negative	12.3592+j30.756
Zero	7.94702+j49.5993

9. Open Pine Falls PC3 and PA1
ASPEN gives:
Equipment Breaker Operating Time (sec)
Parkdale PC4 ZP2 0.4 Pine Falls PC4 1.22 Pine Falls PA2 1.93

Parkdale PC4 time to travel 1.00 per unit = (1.00 – 0.0661) * 0.4 seconds = **0.3736 sec**

Eqipment Travel in Per Unit Detailed Calculations:
Pine Falls PC4 0.3961 Pine Falls PC4 travel = 0.0489+(0.3736+0.05)/1.22 0.396113 Pine Falls PA2 1.2191 Pine Falls PA2 travel =0.9996+ (0.3736+0.05)/1.93 1.219082

Clearing Times and Impedance at Fault Location Parkdale PC4 opens at: 6.4930 sec Calculation: TIME = 6.0694 (previous time) + 0.3736 (relay time) + 0.050 seconds breaker time **Pine Falls PA2 opens at: 6.4930 sec**

Thevenin Impedance at Fault

	Thevenin Impedance (ohm)
Positive	19.2599+j48.6443
Negative	19.3791+j48.7479
Zero	9.19142+j63.5297

0. Open Parkdale PC4 and Pine Falls PA2

Thevenin Impedance at Fault

Thevenin Impedance (ohm)

Positive 1.28799-j12539

Negative 1.28799-j12539

Zero 7.07546+j231.667

Evans, Glenn

From: Marusenko, Walter

Sent: Monday, December 17, 2007 1:57 PM

To: Borschawa, Earl **Cc:** Evans, Glenn; Lin, Ding; Neufeld, Maria; Aikens, Mark

Subject: Justification for new generator protection at Pine Falls Generating Station

Earl:
Glen Evans asked me to provide some justification for the replacement of Pine Falls generator protection. Issues with the existing Pine Falls
generator protection are as follows:

24 – V/Hz does not exist
The Volts per Hertz protection protects against overfluxing in the generator. A typical steady state maximum for generators is about 1.1 per unit.
This means that if the frequency is below 60Hz and the voltage is above 1.0 per unit if the ratio of voltage to frequency exceeds 1.1 per unit then the
machine may be damaged.

46 – negative sequence overcurrent does not exist
A typical steady state maximum for negative sequence current is 10% of the rating of the machine. Negative sequence is generated if you have a
stuck pole on a breaker where one phase is closed and the other two are open or one phase is opened and the other two phases are closed. The
consequences of too much negative sequence currents are overheating of the rotor.
Negative sequence can also be generated if you have a line to line fault on the 115kV system with a breaker failure that does not separate the
generation from the line to line fault. In general, there is no breaker failure protection on the 115kV transmission system breakers. This implies that
a line to line fault may not be seen by all other 115kV elements connected to the faulted line and the fault would not be cleared. In this case, the
machines may exceed their negative sequence capability and damage the machines. An example of this is a line to line fault on PR2 near the
McArthur end of PR2 with a breaker failure of Pine Falls PR2 115kV breaker. Our simulations indicate that PC3, PC4 and GP1 open at the ends
remote to Pine Falls. Lines PA1, PA2 and all generators do not clear the fault and this will leave the machines connected to an uncleared fault. The
generators see just over 600 amps of negative sequence current and the typical negative sequence rating of the generator is 10% or 65 amp on the
13.8kV voltage.

50BF – breaker failure does not exist on the generator 115kV breakers
Pine Falls does not have a 13.8kV generator breaker but uses the 115kV breakers as the generator breakers.

A low fault level inside the generator
would not be cleared with a 115kV generator breaker which has failed to open. The low level fault current inside the generator would have to
become catastrophic in order to be cleared by all attached elements. As an example, a 3 phase fault on the 13.8kV bus or on the high voltage side of
the machine winding would not be cleared by any other element if the 115kV generator breaker fails.
In addition, a stuck phase on the 115kV generator breaker would generate sufficient negative sequence to destroy the machine even if the negative
sequence overcurrent where to exist. An example of this type of event was the Great Falls unit 3 breaker failure of 2006 07 08 at 11:22 when low air
pressure on the Great Falls unit 3 115kV breaker caused one phase to close. The negative sequence current existed for about 6 ½
minutes before all other lines and generators were disconnected from the faulty breaker. The Great Falls unit 3 rotor was damaged. We can discuss these issues further is you wish.

APPENDIX J

D1910

MANITOBA HYDRO
INTEROFFICE MEMORANDUM

FROM	M. R. Wonsiak Transmission Planning Technical Officer System Planning Department 12-1146 Waverly St.	TO	Mr. G. Evans Interconnection & Grid Supply Planning Technical Officer System Planning Department 12-1146 Waverly St.

DATE 2008 05 27

FILE 5-9

SUBJECT **THE IMPACT OF INCREASED SHORT CIRCUIT FAULT LEVELS ON LOCAL CIRCUIT BREAKERS AFTER THE COMPLETION OF THE PINE FALLS GENERATOR UPGRADE PROJECT – SUPPLEMENT TO THE PINE FALLS IFS**

Summary

By modifying Pine Falls generation and unit transformers to accommodate both an 11.7 MW and a 19.8 MW upgrade, it was found that the additional capacity generated by either scenario will not raise fault levels in the surrounding area beyond the capabilities of any local area circuit breakers.

Study Model Description

The study model was based on the SPD 2008 Short Circuit Series, but includes the required generation and transformation necessary to accommodate both a 11.7 MW (13 MVA) and a 19.8 MW (22 MVA) increase.

In addition the following system conditions/modifications were included:

1. Winnipeg River Generation at maximum.
2. Selkirk G.S. in full operation.
3. St. Leon 99 MW wind farm completed.

Criteria Used In the Evaluation

Three phase and single-line-ground fault levels were calculated at Pine Falls as well as at 2 stations in close electrical proximity. The results were developed and evaluated under the following criteria:

1. "Flat Classical" analysis was used in all fault calculations. The base kV was then escalated and the fault levels adjusted to better reflect actual system voltages.
2. Station fault levels were directly compared to the lowest rated breaker(s) at a particular location, i.e. an individual breaker is required to interrupt the entire fault kA produced by a "close in" fault. No consideration was given for

breaker duty or individual equipment contribution. Appendix 1 contains a summary of circuit breaker data used in the study.

3. All busses in the major transmission system were analyzed in their "normal"[1] operating condition.
4. All busses in the sub-transmission system were analyzed in a "minimal networked"[2] operating condition.

Study Results

Base Case (No added Generation)

The evaluation of circuit breaker capabilities requires the development of a base set of fault levels that *do not* contain any added generation. This reference case was used to calculate the percent increase in fault levels associated with the generation increase.

11.7 MW (13MVA) Increase at Pine Falls

The additional 11.7 MW of Pine Falls generation, produces a maximum fault level increase of 2.2% at the Pine Falls 115 kV bus. The levels are however under 82% of the breaker interrupting rating. The increase at the 66 kV bus at Pine Falls is negligible with fault levels at only 15% of the interrupting rating.

A minimal fault level increase was observed at both Tembec Industries (formerly Pine Falls Paper) and the Great Falls Generating Station, and below the breaker interrupting rating. Table No. 1 is a summary of the resulting data.

19.8 MW (22MVA) Increase at Pine Falls

The additional 19.8 MW of Pine Falls generation, produces a maximum fault level increase of 4.1% at the Pine Falls 115 kV bus. The levels are however under 84% of the breaker interrupting rating. The increase at the 66 kV bus at Pine Falls is negligible with fault levels at only 15% of the interrupting rating.

A minimal fault level increase was observed at both Tembec Industries (formerly Pine Falls Paper) and the Great Falls Generating Station, and below the breaker interrupting rating. Table No. 2 is a summary of the resulting data.

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[1] This is the "normal operating" model of the 2005 Manitoba Hydro system; all N/O points in use during non-emergency operation are represented.

[2] "Minimal Networked" fault levels allow for a maximum of two switch closures thus linking as many as three supply stations. This differs from normal switching procedures in which only one closure linking a maximum of two supply stations is permitted. All other N/O points are consistent with normal operation

Table No. 1
Fault Levels and Percent Breaker Capability
After a 11.7 MW (13 MVA) Pine Falls Upgrade

Station	Base kV	SLG Fault (kA)	Increase (%)	3Phase Fault (kA)	Increase (%)	Lowest Breaker MSIR*	Breaker Capability (%)
Pine Falls 115 kV	118.0	10.6	2.1	9.9	2.2	13	81.5
Pine Falls 66 kV	68.0	1.4	Nil	2.9	Nil	19	15.3
Great Falls 115 kV	119.5	11.5	0.4	10.9	0.6	13	88.5
Tembec Industries	118.0	7.2	1.5	8.4	1.9	13	64.6

* MSIR – Maximum Symmetrical Interrupting Rating in kA.

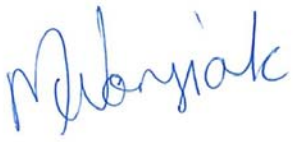
Table No. 2
Fault Levels and Percent Breaker Capability
After a 19.8 MW (22 MVA) Pine Falls Upgrade

Station	Base kV	SLG Fault (kA)	Increase (%)	3Phase Fault (kA)	Increase (%)	Lowest Breaker MSIR*	Breaker Capability (%)
Pine Falls 115 kV	118.0	10.8	4.1	10.1	4.1	13	83.2
Pine Falls 66 kV	68.0	1.4	Nil	2.9	Nil	19	15.3
Great Falls 115 kV	119.5	11.5	0.8	11.0	1.2	13	88.5
Tembec Industries	118.0	7.3	2.8	8.5	3.5	13	65.5

* MSIR – Maximum Symmetrical Interrupting Rating in kA.

If you require additional information feel free to contact Mike Wonsiak at 474-4455.

MRW/mrw/PineFalls_Upgrade_Breakers_IFS.doc



Appendix No.1
Circuit Breaker Data Used in the Study

Station	Location	Voltage	Manufacturer	Model	Serial#	Amps	MSIR*
Pine Falls G.S.	R1	115	Westinghouse	BQOB	1084253	800	13 kA
	R2	115	Westinghouse	BQOB	1084254	800	13 kA
	R3	115	Westinghouse	BQOB	1084255	800	13 kA
	R4	115	Westinghouse	BQOB	1084256	800	13 kA
	R5	115	Westinghouse	BQOB	1084257	800	13 kA
	R6	115	Westinghouse	BQOB	1084258	800	13 kA
	R7	115	Westinghouse	BQOB	1084259	800	13 kA
	R12	115	Westinghouse	BQOB	1084260	800	13 kA
	R13	115	Westinghouse	BQOB	1084261	800	13 kA
	R14	115	Westinghouse	BQOB	1084262	800	13 kA
	R15	115	Westinghouse	BQOB	1084263	800	13 kA
	R16	115	Westinghouse	BQOB	1084264	800	13 kA
	R17	115	Westinghouse	BQOB	1084265	800	13 kA
	R18	115	Westinghouse	BQOB	1084266	800	13 kA
	B9	66	CGE	FKP72.5	64710	1200	19 kA
	B10	66	CGE	FKP72.5	64711	1200	19 kA
	T910	66	ASEA	HPL72.5	7346281	2500	40 kA
Tembec Ind.	52LM	115	ABB	LTB145		3150	31.5 kA
	52PQ	115	ABB	LTB145		3150	31.5 kA
	52ST	115	ABB	LTB145		3150	31.5 kA
	52L1	115	Westinghouse	BQOB		800	13 kA
	52L2	115	Westinghouse	BQOB		800	13 kA
Great Falls G.S.	Bus Tie	115	BRBO	DCVF	354343	600	13 kA
	Gen1	115	BRBO	DCVF	354349	600	13 kA
	Gen2	115	BRBO	DCVF	354344	600	13 kA
	Gen3	115	BRBO	DCVF	354350	600	13 kA
	Gen4	115	BRBO	DCVF	354351	600	13 kA
	Gen5	115	BRBO	DCVF	354348	600	13 kA
	Gen6	115	BRBO	DCVF	354345	600	13 kA
	GP1	115	BRBO	DCVF	354346	600	13 kA
	GS21	115	BRBO	DCVF	354342	600	13 kA
	GS22	115	BRBO	DCVF	354347	600	13 kA
	GT1	115	BRBO	DCVF	354341	600	13 kA
	Mines	115	BRBO	DCVF	384099	600	13 kA

* MSIR – Maximum Symmetrical Interrupting Rating in kA.

APPENDIX K

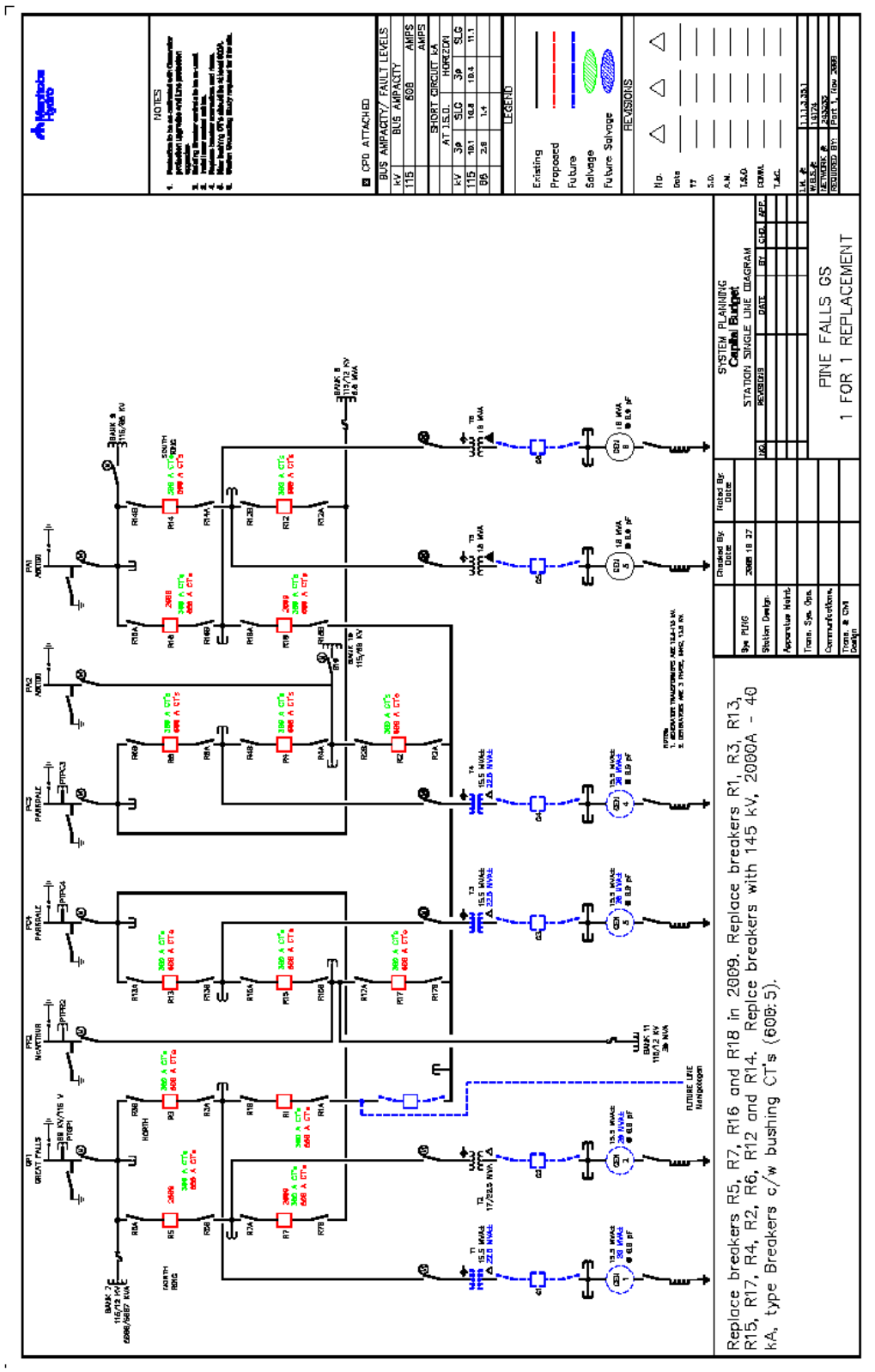
Reference to MH Transmission System Interconnection Requirements as Determined by Interconnection Studies

Section 3 of the TSIR document [1], "Generator Interconnection Requirements", defines the requirements applicable for generators applying to connect to the 66 kV, 115 kV, 138 kV, 230 kV and 500 kV nominal voltage levels on the MH Interconnected Transmission System. Section 3 states that some of the requirements are to be defined/determined by the Interconnection Studies. Table A.1 below makes reference to only these requirements, and provides information for those requirements that were to be determined by Interconnection Studies.

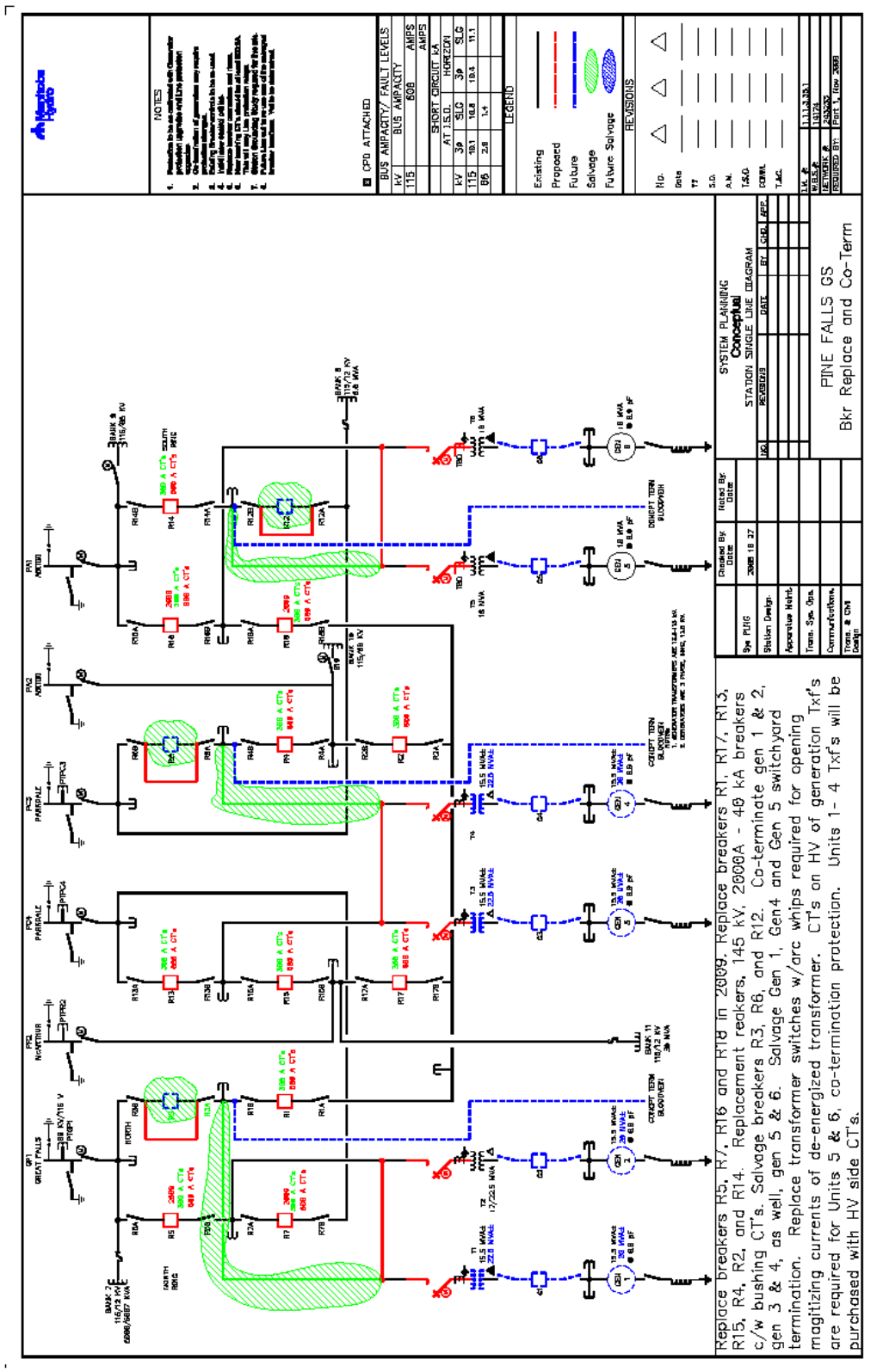
Table A.1. Interconnection Requirements to be determined by Interconnection Studies.

No.	**Item**	**Requirement**
3.1	Connection Location and Voltage Level	Pre-existing
3.3	Operating Procedures	No Change
3.4	Reactive Power Requirements	No Change
3.5	Dynamic Power Requirements	No Change
3.6	Voltage Variations	Hydro generator can meet specifications
3.7	Frequency Variations	Hydro generator can meet specifications
3.8	Inertia Constant (H)	The IFS demonstrated the ability of the generator unit to remain connected with damped recovery for typical fault-clearing times in Section 4.
3.9	Synchronous Generator Controls	
	3.9.2 Excitation System	Separate Winnipeg River Generation Study
	3.9.4 Automatic Voltage Regulator	Not Required
	3.9.6 Power System Stabilizer	Separate Winnipeg River Generation Study
	3.9.7 Automatic Generation Control	Separate Winnipeg River Generation Study
3.11	Special Protection System	Not Required
3.12	Black Start Capability	Not Required
3.14	Protective Equipment and Relaying System Requirements	Breaker fail protection and microprocessor Unit protection as in Section 4.
3.15	Communications	Existing system is adequate.
3.17	Supervisory Control and Data Acquisition (SCADA)	Details to be determined during design phase to co-ordinate with protection changes.
3.18	Disturbance Monitoring (Transient Fault recorder –TFR, Dynamic Swing Recorder – DSR)	Details to be determined (if required) during design phase to co-ordinate with protection changes.
3.20	Short Circuit Levels	Refer to IFS Section 5.0
3.21	Grounding	Ground grid studies should be completed during breaker replacement project.
3.27	Isolation	Safety ground switches should be identified with breaker replacement and/or new breaker installation.

APPENDIX L (1)


Replace breakers R5, R7, R16 and R18 in 2009. Replace breakers R1, R3, R13, R15, R17, R4, R2, R6, R12 and R14. Replce breakers with 145 kV, 2000A - 40 kA, type Breakers c/w bushing CTs (600:5).
PINE FALLS GS
1 FOR 1 REPLACEMENT
SYSTEM PLANNING
Capital Budget
STATION SINGLE LINE DIAGRAM
NOTES
LEGEND
Existing
Proposed
Future
Salvage
Future Salvage
REVISIONS

APPENDIX L (2)


PINE FALLS GS
Bkr Replace and Co-Term
SYSTEM PLANNING
Conceptual
STATION SINGLE LINE DIAGRAM
REVISIONS
LEGEND
Existing
Proposed
Future
Salvage
Future Salvage
NOTES
BUS AMPACITY/ FAULT LEVELS
BUS AMPACITY
SHORT CIRCUIT kA
AT 15/0.
Replace breakers R5, R7, R16 and R18 in 2009. Replace breakers R1, R17, R13, R15, R4, R2, and R14. Replacement reakers, 145 kV, 2000A - 40 kA breakers c/w bushing CT's. Salvage breakers R3, R6, and R12. Co-terminate gen 1 & 2, gen 3 & 4, as well, gen 5 & 6. Salvage Gen 1, Gen4 and Gen 5 switchyard termination. Replace transformer switches w/arc whips required for opening magitizing currents of de-energized transformer. CT's on HV of generation Txf's are required for Units 5 & 6, co-termination protection. Units 1- 4 Txf's will be purchased with HV side CT's.