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# **Kelsey Generator Re-Runnering Interconnection Evaluation Study**

*Performed by:*

*Manitoba Hydro*  
System Planning Department

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## Executive Summary

An Interconnection Evaluation Study (IES) has been performed to determine the impact a proposed capacity increase of up to 80 MW at the Kelsey G.S. (Township 81, Range 6 EPM) has on the reliability of the Manitoba Hydro network. The IES is based on the assumption that the proposed generation capacity increase will be designated as a Manitoba Hydro (MH) network resource under the Open Access Transmission Tariff (OATT). As a Network Resource, the impacts of scheduling to MH generation and Network Load were evaluated. MH's Network Load and generation are located entirely within the Province of Manitoba. Therefore, the new generation will not require the need to increase transfer levels on the Manitoba to Ontario, Saskatchewan or U.S. boundaries.

Although this IES Report contains transmission study results, based on directions from the Interconnection Customer that MH make certain assumptions for the purposes of this IES regarding type of transmission service that will be reserved by the Interconnection Customer, the Interconnection Customer is nevertheless obligated to reserve Transmission Service through the appropriate procedures under the MHO ATT.

The IES determined the impact that the additional generation has on the existing MH transmission system by means of steady-state post disturbance power flow analysis, stability analysis, short circuit analysis and voltage quality analysis.

There are no short circuit concerns for the additional Kelsey generation. Voltage flicker and voltage quality are not a concern.

Several thermal overloads and stability issues are identified that require continuing use of generator cross-tripping at Kelsey and Grand Rapids. The additional Kelsey generation impacts lines G8P, KT1 and KT2 without Wuskwatim and its associated transmission and additionally line F27P with Wuskwatim. Continued use of generator crosstripping is required at Kelsey to prevent thermal overloads on these lines. Continued use of crosstripping one unit at Grand Rapids is required to prevent thermal overloads on G1A, G2A and G31V.

Interconnection System Upgrades are required in the Kelsey 138 and 230 kV stations and Ponton station. Riser replacement and bus reconductoring are required at Kelsey and in addition, modified circuit breaker control logic is required at Ponton. The estimated cost of these facilities is \$510,000. A more detailed assessment of the cost estimates will be performed in the Interconnection Facilities study.

Network Upgrades are required for firm Network Transmission Integration Service (NITS). A 125-km 230-kV transmission line and associated terminating facilities are required between Dauphin and Neepawa to alleviate thermal overloading and voltage collapse issues. The line is estimated to cost \$33 million with potentially one-half the cost benefiting load serving. Without this new line, the MH transmission system can only accommodate 20 MW of additional output from Kelsey when Wuskwatim is in-service.

The addition or advancement of other Network Upgrades may be required depending on the timing of the unit upgrades for Kelsey and the in-service date of the nearby generator, Wuskwatim. For firm NITS of the entire Kelsey upgrade, the Birchtree SVC and Birchtree-Wuskwatim-Herblet Lake transmission lines are required to be in-service (\$57.9 million). Without these facilities, the existing network can only accommodate up to approximately 50 MW at Kelsey.

The option may be available to reserve Secondary Service or Non-Firm Point-Point Transmission service if Network Upgrades are not installed. A portion of Kelsey would be declared as a non-designated generating resource.

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## **1.0 Introduction**

### **1.1 Background Information**

This report documents the results of an Interconnection Evaluation Study for the proposed addition of 60 to 80 MW at the existing Kelsey Generating Station (G.S.) in northern Manitoba near the town of Thompson. The additional capacity will result following replacement of the existing hydraulic turbines, step-up transformers and exciters. The exact capacity expansion will depend on the final turbine design chosen. The proposed in-service dates for the Kelsey expansion project begins in November 2005 after the first unit is upgraded and ends in 2012 assuming one unit is upgraded per year.

The Generator and energy purchaser have requested the 80 MW hydro addition to the plant be considered a Manitoba Hydro Network Resource. As a network resource, the impacts of scheduling to all generation and load within Manitoba were evaluated. Any necessary Network Upgrades are separately identified. No transmission service is being granted by this study. The Generator must apply separately for Transmission Service according to the provisions of the Open Access Transmission Tariff.

Interconnection System Upgrades are the minimum necessary transmission upgrades required to interconnect the generator with the MH system in order to meet reliability criteria. A re-dispatch to the nearest MH generator is used as a test for Interconnection System Upgrades. For Kelsey, the nearest MH network resource is Grand Rapids.

Interconnection System and Network Upgrades are highly dependent on higher positioned generators in the Manitoba Hydro generator interconnection queue. In particular, the Wuskwatim 200 MW generator and associated transmission facilities have a large impact. This IES considers the necessary transmission facilities required for Kelsey both with and without Wuskwatim facilities in-service.

### **1.2 Objectives**

The Interconnection Evaluation Study objectives are to determine:

- Facilities required to electrically connect additional Kelsey generator capacity to the MH electrical system
- Adequacy of reactive power facilities
- System reliability limitations (i.e. equipment overloads, voltage violations) and associated mitigation options
- Short circuit impacts (e.g. circuit breaker replacement)
- Planning level cost estimates of transmission facilities

If the customer chooses to proceed, the Interconnection Facilities Study phase will:

- Determine a good faith cost estimate of all the interconnection facilities
- Determine a good faith construction schedule estimate

- Perform detailed ring bus/outlet lines evaluation with breaker fail and prior outage scenarios
- Determine need and settings for the Birchtree SVC power system stabilizer
- Determine any impacts of implementing the as-built PSS/E model for the Ponton SVC. Generic models were used in the IES.
- Determine sensitivity to higher queued generation and load sensitivity in Brandon and northern Manitoba.
- Determine impacts of breaker failure and prior outages.
- Perform constrained interface analysis.
- Satisfy any requirements of the Regional Transmission Organization

## 2.0 Generator Models

### 2.1 MH Generator Connection Standards

Please refer to the Manitoba Hydro TSIR [1] document for a detailed description of the MH Generator Connection standards.

### 2.2 Kelsey Re-running

The Kelsey rerunning project will potentially increase the rating of each generator unit to 50 MVA at 0.9 power factor for a total plant output of 315 MW. Please refer to email correspondence provided in Appendix B for more technical details.

The existing PSS/E model for the Kelsey G.S. was adjusted to reflect the new MVA rating. The loadflow model for the Kelsey G.S. represents one equivalent generator behind an equivalent step-up transformer. It was modified to allow a maximum power output of 315 MW, a reactive power supply range from 153 to -153 MVar and the total MVA base of the machine model was increased to 350 MVA.

The PSS/E stability models corresponding to the Kelsey G.S. include GENSAL, IEESGO, SCRX and PSS2A. The data for each model is summarized in Tables 1-4. Please refer to the PSS/E Operation Manual and PSS/E Application Manual for more information regarding the stability models.

GENSAL is a generator model used to represent salient pole machines at the subtransient level.

Table 1: Kelsey Generator “GENSAL” dynamics data.

Parameter	Value
Zsource	0.18 pu = X''d
Mbase	350.0
T'do (sec.)	3.600
T''do (sec)	0.050
T''qo (sec)	0.076
H (MW-sec./MVA)	4.10
D (damping)	0.00
Xd (pu)	0.9150
Xq (pu)	0.5411
X'd (pu)	0.2440
X''d=X''q (pu)	0.18
Xl (pu)	0.1333
E1	1.0
S(E1)	0.16
E2	1.2
S(E2)	0.52

IEESGO is a general purpose turbine governor model.

Table 2: Kelsey Generator “IEESGO” dynamics data.

Parameter	Value
T1 (sec)	0.44
T2 (sec)	6.710
T3 (sec)	74.40
T4 (sec)	0.0
T5 (sec)	0.63
T6 (sec)	0.0
K1	24.4
K2	3.00
K3	0.0
Pmax	0.9
Pmin	0.0

SCRX is an excitation system model used to represent a bus fed or solid fed static exciter.

Table 3: Kelsey Re-runner Generator “SCRX” dynamics data.

Parameter	Value
TA/TB	1.0
TB (sec)	0.10
K	117.0
TE (sec)	0.025
Emin (pu on EFD base)	-5.0
Emax (pu on EFD base)	6.0
Cswitch	0.0
rc/rfd	10.0

The NERC/MAPP Planning Standards, to which MH is contractually obligated to comply with, and Manitoba Hydro TSIR [1] require all generators greater than 70 MVA to be equipped with a Power System Stabilizer (PSS). The Kelsey units will at most be 50 MVA, however previous studies [22] have determined that high speed exciters (SCRX) and power system stabilizers are required at Kelsey in order for damping criteria to be met. The PSS model data is given in Table 4. PSS2A is a supplementary stabilizer model used to represent an IEEE dual-input stabilizer.

Table 4: Kelsey Re-runner Generator “PSS2A” dynamics data.

<b>Parameter</b>	<b>Value</b>
Tw1 (sec)	10.0
Tw2 (sec)	10.0
T6 (sec)	0.0
Tw3 (sec)	10.0
Tw4 (sec)	0.0
T7 (sec)	10.0
KS2	1.219
KS3	1.0
T8 (sec)	0.5
T9 (sec)	0.1
KS1	30.0
T1 (sec)	0.3
T2 (sec)	0.025
T3 (sec)	0.12
T4 (sec)	0.025
Vstmax	0.05
Vstmin	-0.05

### **3.0 Steady-State AC Power Flow Analysis**

#### **3.1 Introduction**

Steady state power flow analysis was performed to examine the system impacts of the proposed generation at Kelsey with and without Wuskwatim generation and its associated transmission facilities.

The analysis was performed using the Powertech Voltage Security Assessment Tool (VSAT) which is similar to PTI's AC contingency calculation (ACCC) and DC Power Flow analysis (TLTG) activities of PSS/E, but with several enhancements [23].

The following disturbances were considered for the steady state analysis:

- Single element outages in the MH system for all transmission lines and transformers 110 kV and above. Interconnection tie lines with neighboring utilities are included.
- Common tower outages in the MH system.
- Breaker fail outages approximately two busses back from Kelsey G.S. (i.e. at Wuskwatim, Birchtree, Herblet Lake, Ralls Island, Cliff Lake, Ponton 230 kV, Thompson MLR 138 kV and 230 kV, Kelsey 230 kV stations).

Contingency analysis was conducted on the summer peak (supk) and winter peak (wipk) models for the year 2008, updated to reflect the MH facility additions planned to be in-service by the end of 2012. The steady state analysis investigated sensitivity to SaskPower import and export levels of 200 MW, Brandon generation between 0 and 500 MW, as well as sensitivity to the location to which the new generation will be scheduled. The objective of this analysis is to assess the impact of the proposed generation on post contingency transmission line and transformer loadings and bus voltages.

#### **3.2 Study Criteria and Procedures**

Steady state AC power flow analysis (VSAT) monitors voltage and branch loading. Study criteria for both voltage and branch loading were set to match the limits specified in the *MAPP Member's Reliability Criteria & Study Procedures Manual (May 20, 2004)* and the MH TSIR document [1]. Transmission line and transformer loadings were compared with 100% of the PSS/E Rate C (30 minute emergency rating) following a contingency and 100% of Rate A (Continuous normal rating) for system intact conditions as a general study criteria. Bus voltages were monitored for voltages above 110% or below 90 % of the rated voltage following a contingency. Bus voltages were monitored for voltages above 105% or below 95% for system intact conditions.

Facility impacts that are created by the proposed generation additions are monitored. Impacts within the following bounds are considered acceptable:

- Contingency line or transformer overloads not exceeding 100% of Rate C
- Contingency voltage limits within 90 % and 110 % of rated voltage

The above parameters are used as screening parameters to minimize the output included in the VSAT summary report.

The MAPP Design Review Subcommittee (DRS) currently employs a 2% power transfer distribution factor (PTDF) threshold for MAPP member studies, while MISO employs a 3% threshold for MISO system impact studies. The PTDF is defined as the ratio of the change in power flow measured on an individual facility to the total change in scheduled transfer. The DRS is working with MISO to address the discrepancies especially with respect to MISO member impacts on MAPP facilities. The DRS is also evaluating a change in criteria to account for impacts based on a facility rating PTDF. For ACCC analysis, a 2% PTDF will be used to screen the output, however the 3% MISO criteria will be used for MH facilities. Unfortunately, VSAT presently does not employ this type of screening method and all overloads were initially reported, which made results difficult to analyze. The pre-existing overloads that were not impacted by Kelsey were manually screened and the relevant contingencies were set to “don’t run” in the VSAT contingency section. Powertech has indicated this will be fixed in the next version of VSAT.

The Voltage Security Assessment Tool (VSAT) is used to estimate import or export limits between a defined source and sink. The activity identifies a study system in which generation is increased and an opposing system in which generation is decreased (or load is increased). For this study, the source system or Point of Receipt (POR) is defined as Kelsey. The opposing system or Point of Delivery (POD) is defined as various combinations of Manitoba load or combinations of Manitoba generation, including Dorsey HVdc and Grand Rapids generation.

### **3.3 Power Flow Model**

The base cases were derived from the 2003 series of MAPP load flow summer peak and winter peak models representing the year 2008. The models were then updated to reflect the year 2012 changes, which included the Wuskwatim generation and transmission facilities.

The specific powerflow cases used to determine Interconnection System or Network Upgrades are summarized in Table 5. For VSAT analysis, the generation is integrated into the network by re-dispatching power from the Dorsey HVdc converters. This corresponds to reducing generation in the Northern ac collector system (i.e. Kettle, Longspruce, and Limestone) connected to Dorsey through HVdc transmission lines.

The powerflow analysis was performed at maximum nameplate generation levels for the northern ac generators during the INCO summer shut-down period (minimum load of 30 MW) and when INCO is at a normal summer and winter peak level of 140 MW.

Table 5: Power Flow Base Case Description

LF #	Yr/ld	Kelsey	Wusk-watim	Jenpeg	Grand Rapids	INCO load	P19W Flow	MH-US	MH-OH	MH-SP	MH Gen	MH DC
d00	08supk	235	n/a	168	480	30	154s	2172	204	109	5568	3348
d01	08supk	235	n/a	168	480	140	44s	2104	204	85	5568	3348
e00	08supk	235	200	168	480	30	97s	2175	204	105	5720	3310
e01	08supk	235	200	168	480	140	49s	2074	204	103	5704	3296
d01	08wipk	235	n/a	168	480	140	33n	988	199	99	5281	3350
e01	08wipk	235	200	168	480	140	11s	991	199	102	5295	3198

The Northern AC generation levels were set to maximum nameplate output (Jenpeg 168 MW, Grand Rapids 480 MW) and INCO load was set to minimum (30 MW). For all cases, reactors in the northern area were switched off as necessary to keep the steady state voltage to reasonable values. Grand Rapids steady state bus voltage was maintained near 1.03 pu.

The generation level in the summer peak cases were adjusted to the maximum accredited level less 55 MW to meet Manitoba’s regulating reserve requirements. MH is delivering firm and non-firm power sales on the tie lines as well as the MAPP reserve obligation.

Table 6 summarizes the output from each generator in the maximum generation case.

Table 6: Maximum Accredited Capability of MH Generation

Generation Plant	Accredited Value (MW)	PSS/E summer peak (MW)
Limestone	1348.7	1336.0
Long Spruce	1030.6	1025.0
Kettle	1233.1	1197
Jenpeg	168	168
Kelsey	237.6	235 to 315 max
Grand Rapids	480.0	480.0
Pine Falls	89.6	89.6 + 6
McArthur Falls	56.5	56.5
Great Falls	131.6	131.6
Seven Sisters	165.4	165.4
Slave Falls	68.0	68.0
Pointe du Bois	78.8	78.8
Brandon	386.5	386.5 to 500
Selkirk	145	145.0 + 18
St Leon	25	25
Total	5644.4	5589.8

The Generator has submitted three valid Interconnection Requests for Kelsey (33 MW, 27 MW and 17 MW). For the first 60 MW, the following generation has higher queue positions:

- Wuskwatim – 200 MW
- Gull – 620 MW

- Great Falls – 4 MW
- Pine Falls – 6 MW
- Selkirk – 18 MW
- Brandon – 122 MW
- St Leon – 99 MW
- Elie – 99 MW
- Conawapa – 1250 MW
- Lena – 99 MW
- Pembina Hills – 99 MW

The sensitivity to Wuskwatim generation is critical and is tested in this study. Gull and Conawapa are planned to be connected to a new Ontario tie and were not included in this study as there will be no impacts. Great Falls, Pine Falls and Selkirk additions were modeled. No generation was assumed connected at Elie, Lena and Pembina Hills. Only 25 MW was modeled at St. Leon. The assumption is that low southern generation will result in worst case overloads for Kelsey. Sensitivity to Brandon generation between 0 and 500 MW will be a sufficient initial test for sensitivity to higher queued generation in southern Manitoba. Sensitivity to other southern generation dispatch patterns will be tested in the Interconnection Facility Study (IFS).

For the next 17 MW (which was studied as 20 MW to provide additional margin), the following generation has higher queue positions:

- Pointe du Bois – 130 MW
- Waskada – 50 MW
- Alexander – 50 MW
- Letellier – 100 MW

Pointe du Bois and the other southern generator connections were not included in this IES. Sensitivity to these generator additions will be tested in the IFS and potential impacts will be addressed.

Up to two of the twelve Kettle generating units can be transferred from the HVdc system to the northern ac system to supply firm load today in the winter. After the Wuskwatim transmission is added, Kettle units are no longer required to be connected to the northern ac system for this load serving purpose. If there are HVdc contingencies, up to two Kettle units may still be connected on a non-firm basis. Because Kettle units are not considered firm, they were not included in this IES.

### **3.4 Results of Steady State Powerflow Analysis**

Tables 7-10 summarize the worst-case overloads as determined by VSAT analysis. These overloads are separated into categories for those that exist prior to the Wuskwatim generation and transmission being online and those that occur after the generation and transmission is online. For a more comprehensive overload summary see Appendix C, where the overloads are also separated into system intact - single, common tower and breaker fail contingencies.

The results presented in this section are based on the latest information in the MH Equipment Ratings web database (i.e. last update June 9, 2004). As well, System Performance has initiated the replacement of restrictive line end equipment on lines A3R, A4D and A6V. These upgrades will be in-service by the end of 2005 and the ratings of these three lines will be increased to 1200 A minimum [23].

VSAT tested two other generation sinks aside from Manitoba Load, including, Grand Rapids generation and Dorsey HVDC. The only notable difference between the sink locations is that scheduling to Grand Rapids generation eliminates most overloads south of Grand Rapids. The remaining sinks produce comparable results to those listed in Tables 7-10. Breaker fail contingencies were tested on the Manitoba Load sink only.

### 3.4.1 N-1 contingencies - System Intact – Base cases

Table 7 summarizes the overloaded lines for single and common tower contingencies. Overloads are indicated by the checkmark symbol.

Table 7 Summary of Thermal Overloads<sup>1</sup>

Limiting Facility	Contingency	Overload issues (supk)					
		Kelsey Re-Runner (MW)			Kelsey Re-Runner (MW) & Wuskwatim		
		60	70	80	60	70	80
A3R	A4D						
A4D	A3R						
A3R	G1 or 2A						
G31V	G1 or 2A						
G1A	G2A						
G2A	G1A						
MR11	Various						
G8P	H59C	√	√	√			
G8P	P58C		√	√			
G8P	P18H	√	√	√			
G8P	F27P					√	√
G8P	H75P					√	√
F27P	G8P						√
Stability	G8P	√	√	√			
KT1	K24W			√			√
KT2	K24W			√			√
KK35/Bank10	KT1/KT2	√	√	√	√	√	√

All thermal overloads that exist following a contingency with system intact are mitigated by either existing generator cross-trip schemes (Kelsey and Grand Rapids) or 30 minute transformer overload ratings.

### 3.4.2 N-2 Contingencies - System Intact – Base cases

The only common tower contingency that is impacted by the Kelsey re-running project is the double circuit loss of line KT1/KT2. At 60 MW additional output from Kelsey, Kelsey Bank 10 station equipment (buswork, risers & connectors) exceed the 250 MVA rating. The Kelsey bank 10 is rated for 285 MVA, which is sufficient. However, the 138 kV and 230 kV station equipment associated with the Bank needs to be upgraded to 1200 and 1000 amps respectively.

Breaker fail contingencies with system intact are mitigated by either existing generator cross-trip schemes (Kelsey and Grand Rapids) or 30 minute transformer overload ratings as well.

<sup>1</sup> Existing overloads that are not impacted by the additional northern ac generation are not included in this table. These overloads and planned fixes have been discussed in Reliability Studies Working Group reports and in the MAPP 10-year transmission plan.

No overload issues are present in the winter (wipk) peak cases.

### 3.4.3 Sensitivity to Saskatchewan Import/Export

The overloads are quite sensitive to variations in MH>SP export levels; lower export to SaskPower increases the overloads as it increases flows in the MH transmission system south of Grand Rapids, 0 MW export being the worst. Import from SaskPower (SP) create the highest overloads and are aggravated even more when Brandon generation is off, which would most likely be the case in the summer due to high costs of running the thermal and combustion plants. The overloads in Table 7 are based on an MH>SP export level of 105 MW. This is the value in the majority of the PSS/E base cases.

Loop flow through Saskatchewan is observed as new generation increases flows to Saskatchewan on line P52E and increases flows to Manitoba on line R7B. However, these lines still remain within their thermal ratings for system intact and single contingency outages.

MH-SP export/import levels of 200 MW were tested. For export conditions, generation at QE and Quarry was decreased and for import conditions, generation at QE, EB Cambell and Boundary Dam had to be increased to obtain the proper transfers. No additional overloads were reported with these transfers for 200 MW export.

Various contingencies in the south central and western part of Manitoba (see Appendix C) affect flows through SP and also cause overloading of MR11 bank and eventual overcurrent trip of MR11 bank, which further magnifies loop flows through Saskatchewan, however, no R7B - Rate C violations occur for these contingencies. Voltage collapse in Manitoba does occur if the Kelsey increase exceeds 20 MW.

The overloads in Table 8 are based on an SP>MH import level of 200 MW. Import from Saskatchewan will need to be curtailed as generation is added at Wuskwatim and Kelsey.

Table 8 Summary of Thermal Overloads SP>MH 200 MW

Limiting Facility	Contingency	Overload issues (supk)					
		Kelsey Re-Runner (MW)			Kelsey Re-Runner (MW) & Wuskwatim		
		60	70	80	60	70	80
A3R	A4D				√	√	√
A4D	A3R				√	√	√
A3R	G1 or 2A				√	√	√
G31V	G1 or 2A				√	√	√
G1A	G2A						
G2A	G1A						
MR11	Various	√	√	√	√	√	√
G8P	H59C	√	√	√			
G8P	P58C		√	√			
G8P	P18H	√	√	√			
G8P	F27P				√	√	√

G8P	H75P				√	√	√
F27P	G8P				√	√	√
Stability	G8P	√	√	√			
KT1	K24W			√			
KT2	K24W			√			
KK35/Bank10	KT1/KT2	√	√	√	√	√	√

### 3.4.4 Sensitivity to Brandon Generation 0 – 500 MW

The overloads related to MR11 are quite sensitive to the output of the Brandon Generating Station; the lower the generation the higher the overload on MR11. The overloads in Table 9 are based on a firm MH>SP export level of 105 MW. With Brandon at 500 MW output, no issues exist.

Table 9 Summary of Thermal Overloads Brandon 0 MW

Limiting Facility	Contingency	Overload issues (supk)					
		Kelsey Re-Runner (MW)			Kelsey Re-Runner (MW) & Wuskwatim		
		60	70	80	60	70	80
A3R	A4D						
A4D	A3R						
A3R	G1 or 2A						
G31V	G1 or 2A						
G1A	G2A						
G2A	G1A						
MR11	Various				√	√	√
G8P	H59C	√	√	√			
G8P	P58C						
G8P	P18H						
G8P	F27P						
G8P	H75P					√	√
F27P	G8P						√
Stability	G8P	√	√	√			
KT1	K24W			√			
KT2	K24W			√			
KK35/Bank10	KT1/KT2	√	√	√	√	√	√

The overloads identified in Table 10 are based on a MH>SP export level of 0 MW. This scenario would be the most limiting for the Kelsey re-running increase. As stated with the high SP>MH import, voltage collapse occurs with the anticipated re-runner values. The MR11 overcurrent trip intensifies the voltage collapse and as well, new overloads in the Brandon area occur, 110 kV lines CB1 and CB42 for loss of line CB3.

Table 10 Summary of Thermal Overloads MH>SP 0 MW & Brandon 0 MW

Limiting Facility	Contingency	Overload issues (supk)					
		Kelsey Re-Runner (MW)			Kelsey Re-Runner (MW) & Wuskwatim		
		60	70	80	60	70	80
A3R	A4D						
A4D	A3R				√	√	√
A3R	G1 or 2A						
G31V	G1 or 2A						
G1A	G2A						
G2A	G1A						
MR11	Various	√	√	√	√	√	√
G8P	H59C						
G8P	P58C						
G8P	P18H						
G8P	F27P						
G8P	H75P					√	√
F27P	G8P						√
Stability	G8P						
KT1	K24W			√			
KT2	K24W			√			
KK35/Bank10	KT1/KT2	√	√	√	√	√	√

### 3.5 Interconnection System & Network Upgrades

There are pre-existing operating guides and protection systems that are sufficient to mitigate the majority of overloads. The following sections discuss the transmission facilities that are required to address reliability limitations that result from the addition of capacity at Kelsey.

#### 3.5.1 G1A/G2A/G31V

There is a Grand Rapids Unit 3 cross-trip scheme that is normally armed to trip Grand Rapids unit 3 if all four units are on-line and if outlet lines G1A, G2A or G31V trip. If this scheme were not armed, lines G1A and G2A would need to be rated for 917 Amps and line end equipment replacement would be required. However, as long as this scheme is armed, these lines only need to be rated for 766 Amps, which is below the existing re-rated riser value of 876 Amps.

Similarly, G31V would require upgrades if the cross-trip scheme were not armed. G31V only overloads for prior outages of G1A or G2A, therefore it is more economic to continue using the existing cross-trip scheme then upgrading this line.

The Grand Rapids cross trip scheme cannot be expanded beyond the present one unit because of stability concerns [23].

### 3.5.2 MR11

Following the loss of line A3R, A4D, B69R, B70H, C28R, and many other western area contingencies, line MR11 (from Raven Lake to MR11 tap) overloads for certain system conditions. An overcurrent relay on Raven Lake 230-110 kV Bank 3 is currently set to trip the bank to protect MR11. System Performance has plans to install two new overcurrent relays on MR11, one at Raven Lake end and the other at Brandon end [23]. Each relay would trip its own line end to protect against overloads on its section, and would also provide backup clearing should the other relay fail to operate. As long as this overcurrent protection is in place, no MR11 equipment upgrades are required.

Tripping line MR11 on overcurrent does increase flows on lines A3R, A4D, G1A, G2A, C28R and R7B, however these flows are still within the line thermal ratings assuming no import from Saskatchewan. The exception is 110 kV lines CB1 and CB42 when no Brandon generation is on. This exception is discussed further in the next section. Another exception is tripping of C28R/MR11, R7B/MR11 or A3R/MR11, which leads to voltage collapse.

To circumvent the high overloading and voltage collapse issues, two new 230 kV line options were tested. The first was a line from Grand Rapids to Silver (estimated cost \$100 million) which would parallel the existing A3R/G1A lines. This option did not alleviate any of the MR11 issues reported in this report. The second option was a new 230 kV line from Dauphin Vermillion station to the new Neepawa 230 kV station (estimated cost \$33 million). All overloads associated with MR11 were either eliminated or substantially reduced. Furthermore, loop flows through Saskatchewan are reduced by approximately 20 MW (refer to Appendix D for summary of loop flows with and without the new line). Another benefit of the Dauphin-Neepawa line is losses in Manitoba are reduced by approximately 6-7 MW. Table 11 provides a summary of system loss calculations. The potential benefits for the loss reduction is \$6 million assuming \$1000/kW.

This new 230 kV line would off-load MR11 and therefore implementing equipment upgrades on MR11 at the present time is unnecessary. A planning level estimate of the necessary MR11 upgrades is approximately \$1 million assuming 55 km of 110 kV line are re-sagged and risers and bus sections are upgraded.

**Table 11 - MH Loss comparison**

LOSSES											
EXISTING SYSTEM											
Kelsey O/P				235				315			
AREA	MW	MVAR		MW	MVAR						
667 MH	371.9	6298.6		394.2	6496.7						
672 SPC	103.3	987.6		106.2	1005.9						
EXISTING SYSTEM WITH NEW LINE FROM DAUPHIN TO NEEPAWA											
Kelsey O/P				235				315			
AREA	MW	MVAR		MW	MVAR						
667 MH	366.2	6255.9		387.3	6444.8						
672 SPC	102.2	978.4		104.8	994.6						
		DELTA		DELTA		DELTA					
DELTA MW	%	MVAR	%	MW	%	MVAR	%				
-5.8	1.5	-42.7	0.7	-6.9	1.7	-51.9	0.8				
-1.1	1.1	-9.2	0.9	-1.4	1.3	-11.3	1.19				

### 3.5.3 CB1 and CB42

Riser ratings on these lines are going to be increased to 176 MVA[22], which is equivalent to the Bank ratings associated with these lines. However, this will not alleviate overloads that occurred in this study with the MR11 overcurrent trip. A minimum 185 MVA rating is required. If the new line from Dauphin to Neepawa is not added a new Cornwallis 115-230 kV transformer would have to be purchased to mitigate this problem. A planning level cost estimate for a new 115-230 kV step-up transformer is \$8 million. Alternatively, the two 176 MVA transformers could be replaced with 250 MVA units for a similar price. During this investigation it was found that a proposed increase at the Nexen plant of 80 MW is possible in the next couple of years. This was not represented in the models and therefore would most likely cause even higher overloads on these lines. The sensitivity to Brandon load changes will be investigated further in the IFS study.

### 3.5.4 KT1 and KT2

For the loss of line K24W, lines KT1 and KT2 become slightly overloaded at the maximum (315 MW) Kelsey re-running only. A 600/5 amp current transformer is limiting this and could be set to the higher tap ratio (800/5) to mitigate this problem.

### 3.5.5 Kelsey Bank 10/ KK35

The common tower contingency of KT1 and KT2 or loss of the Kelsey bank causes overloading of the Kelsey 138 kV bus. The 138 kV main buses require upgrades in bays that include Unit 3, KS37 and KK35. The bus needs to be upgraded to 1200 amps minimum. Also the station equipment on the 230-kV side of Bank 10 needs to be

upgraded to 1000 amps minimum to accommodate the worst contingency. In this case, the worst contingency includes the scenario where Kettle units are connected on AC duty.

### **3.5.6 G8P**

The thermal limits of 230 kV line G8P can be exceeded by several single contingencies in stressed cases (i.e import from SP or 0 export) as the new northern ac generation is added at Kelsey. Today, for loss of P18H, a temporary cross-trip signal trips Kelsey units to protect G8P. In 2005, a fully redundant Special Protection System (SPS) will be installed at Ponton that will include an overcurrent relay for protecting line G8P for loss of H59C or P58C. The SPS will cross-trip an appropriate number of Kelsey units if G8P becomes overloaded. The overcurrent relay is preferred to adding additional status detection for remote lines.

## **3.6 Summary of Steady-State Post-Disturbance Analysis**

The existing generator cross-trip scheme at Grand Rapids is adequate to mitigate thermal overloads on G1A, G2A and G31V for single and multiple contingencies given an intact system, all normal firm MH-SP transfers and Brandon at any output level between 0 and 500 MW.

The existing generator cross-trip scheme at Kelsey is adequate to protect for thermal overloads on G8P, KT1, KT2 and F27P.

Upgrades to the 138 kV and 230 kV station buswork at Kelsey are necessary to accommodate the additional output from Kelsey. Three 138 kV bays require upgrades to 1200 A and the 230 kV station at Kelsey must be upgraded to 1000 A. The IFS will analyze the station bus loading requirements in more detail.

The additional Kelsey generation requires additional Network Upgrades to mitigate thermal and voltage stability limitations in southern Manitoba. More than 20 line outages in southern Manitoba cause overloading of line MR11 with Wuskwatim and Kelsey generation on line. Overcurrent-tripping of MR11 leads to additional equipment overloads or voltage collapse at various levels of transfer increase from Kelsey. A new line between Dauphin and Neepawa is required to eliminate this reliability limitation. Benefits of the new line from Dauphin to Neepawa include avoiding the need to upgrade MR11 (\$1 million), loss reduction in Manitoba (\$6 million), avoiding the need for additional transformation at Brandon (\$8 million), improvement in non-firm import capability from Saskatchewan and loss reduction in Saskatchewan. Potentially one-half the cost of this \$33 million dollar Network Upgrade provides load serving reliability benefits. The appropriate share of the cost of the Network Upgrades the Eligible Customer must pay will be determined after the Transmission Service Request has been received.

## **4.0 Short Circuit Analysis**

### **4.1 Kelsey Re-Runnering**

The effects of Kelsey re-runnering on nearby fault current levels were studied. The existing 138 kV circuit breakers at the Kelsey G.S. as well as in the surrounding area remain within fault current interrupting capabilities. These breakers will not require replacement or refurbishment at this time.

Please refer to MH Interoffice Memo by M. R. Wonsiak, “The Kelsey Generating Station Re-runnering/Rewinding Project – Effects on Fault Current Interrupting Capability of the Existing 138 kV Circuit Breakers in the Surrounding Area”, file 5-9 and 4-4, August 15, 2003.

## **5.0 Voltage Quality Analysis**

There are no voltage quality concerns with hydro generation.

## **6.0 Stability Analysis**

### **6.1 Introduction**

Transient stability involves major disturbances such as sudden loss of generation, line-switching operations, faults or sudden load changes. Following a disturbance, synchronous machine frequencies undergo transient deviations from synchronous frequency and machine power angles change. The objective of a transient stability study is to determine whether or not the machines will return to synchronous frequency at a new steady-state power angle. Changes in power flows and bus voltages are also a concern. Stability analysis is performed using the Powertech Transient Stability Security Assessment Tool (TSAT) software to monitor bus voltages, rotor angles, relay margins, power flows and other system variables during critical disturbances.

Transient stability is investigated on the 2008 model updated as previously stated in section 3.3. The summer peak cases also include low and high INCO loading. Cases with and without Wuskwatim generation and its associated facilities are compared.

The three-phase normal-clearing faults and single line-to-ground stuck breaker faults under system intact conditions are tested for all summer peak and winter peak cases.

## 6.2 TSAT Program

### 6.2.1 Introduction

TSAT is a dynamic assessment software tool developed by Powertech Labs Incorporated and Nanjing Automation Research Institute. It is capable of running detailed time-domain simulations and processing large power system models. TSAT primarily deals with two dynamic security problems: transient (angle) stability and voltage stability. For the purpose of this study, the following two modules are utilized:

- A time-domain simulation engine for detailed analysis of the critical contingencies.
- A security computation module to determine the following security indices:
  - Transient stability index (a value of greater than zero percent indicates stability)
  - Damping index
  - Voltage drop/rise duration index

The advantage of the security computation module is that stability limits are determined automatically instead of by a trial-and-error method as in conventional programs (ie. PSS/E)

### 6.2.2 Damping Index

The damping index is used to determine the degree of small signal stability for a contingency. In TSAT, it is computed using Prony analysis by decomposing a time-domain signal into a number of modes. Each mode is characterized by frequency, damping ratio, and amplitude in the signal. The modes must satisfy the following conditions in order for the damping index to be calculated:

- be within a specified frequency range (0.2-2 Hz)
- have sufficiently large amplitudes (> 1 degree)

The damping index is calculated by averaging the damping ratio of the dominant mode from the three worst rotor angle oscillations (Kelsey, Jenpeg, Grand Rapids).

According to the MH TSIR [1], for disturbances within Manitoba, a power oscillation damping ratio which exceeds 0.05 is acceptable, between 0.03 and 0.05 is marginal and below 0.03 requires mitigation. A damping index of 5% is used as a TSAT security criterion. The system is planned such that the dominant mode has a damping ratio greater than 0.05. This ensures that secondary modes have a damping ratio greater than 0.03.

Simulations are run for 15 seconds with the last 10 seconds used for damping analysis.

The damping index is calculated by averaging the damping ratio of the dominant mode from the three worst rotor angle oscillations (Kelsey, Jenpeg, Grand Rapids)

The damping index will be looked at in detail in the Kelsey Re-runnering Interconnection Facility Study. Fine tuning is expected to be necessary for all power system stabilizers.

### 6.2.3 Transient Stability Index

The transient stability index indicates the degree of the stability for the given system condition and contingency. It is computed using a direct stability analysis method (i.e. Extended Equal Area Criterion) integrated with the time-domain simulation method. As illustrated in Figure 1, the time-domain trajectory of the system is mapped to a fictitious single machine to infinite bus system. This system can be used to compute the equivalent system kinetic energy decreasing and increasing areas,  $A_{dec}$  and  $A_{inc}$ . The transient stability index is defined using these normalized areas and is computed for each power swing.

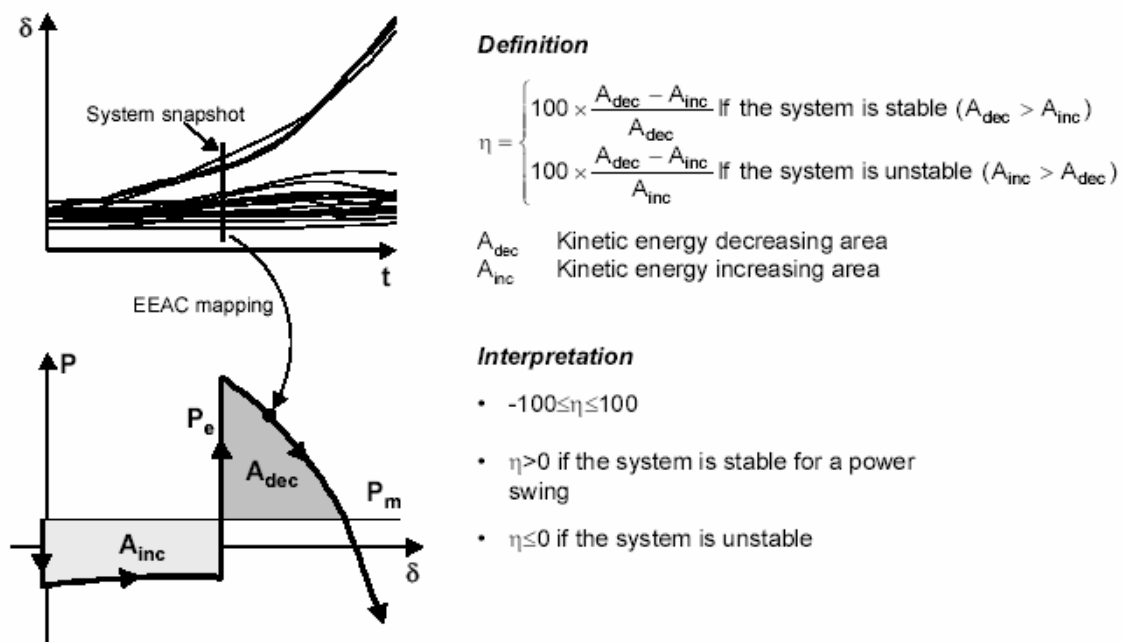


Figure 1 - TSAT Definition of the Transient Stability Index

A stability index greater than 5 is considered acceptable. The typical index for a small load change is approximately 20. Therefore, 25% of 20 is chosen arbitrarily as a stability margin. If the stability index is negative the system is unstable.

### 6.2.4 Analysis Modes

There are two analysis modes in TSAT for each computation scenario: Basecase analysis and transaction analysis.

#### **6.2.4.1 Basecase Analysis**

It is used to assess transient security for all critical contingencies at one system operating condition. It provides the following security indices:

- Transient stability index
- Damping index
- Voltage drop/rise duration indices
- Frequency drop/rise duration indices
- Relay margin indices

The transient stability index and voltage drop/rise duration indices are used as security criteria for this Interconnection Evaluation Study. Frequency drop/rise indices are tested manually for cases where P19W is tripped.

#### **6.2.4.2 Transaction Analysis**

Transaction analysis is used to determine the stability limit of a given power transaction under all critical contingencies. The stability limit obtained for a given power transaction must satisfy the following conditions:

- The system is secure at this power transfer limit for all critical contingencies subject to all specified security indices.
- The system will become insecure if the power transfer limit is increased by an amount equal to the specified power transfer threshold.

The transaction analysis is used for all the summer and winter cases to search for the power transfer limit for this study.

### **6.3 Study Criteria and Disturbance Definition**

MAPP has specific voltage criteria for buses during system disturbances. This criterion ensures that power system performance is within NERC guidelines. The default transient voltage criterion within MAPP requires that voltages do not swing below 0.70 per unit or above 1.20 per unit voltage after a disturbance clears. Specific buses defined in the *MAPP Member's Reliability Criteria & Study Procedures Manual (May 20, 2004)* have voltage limits outside of those defined by the MAPP default criteria. Bus voltages within Manitoba are allowed to increase above 1.30 pu for a duration no longer than 200 milliseconds. Such overvoltages result following temporary or permanent blocking of the HVdc system at Dorsey. The criteria for under/overvoltages and damping used in the Kelsey IES are shown in Table 12. The INCO 138 kV bus voltage has a more stringent transient undervoltage criterion to prevent loss of induction motor load. The voltage is permitted to drop below 0.85 pu for at most 10 cycles.

Table 12 - Transient Stability Criteria for Kelsey IES Study Cases

LF No.	Yr/Id	Kelsey Generation (MW)	Wuskwatim Generation (MW)	INCO Loading (MW)	Transient Overvoltage criteria (pu)	Overvolt. Threshold (second)	Transient Undervoltage criteria (pu) Inco/Other	Undervolt. Threshold (second) Inco/other
d00	08supk	235	n/a	30	1.2	1.0	0.7/0.7	0/0
d01	08supk	235	n/a	140	1.2	1.0	0.85/0.7	0.16/0
d01	08wipk	235	n/a	140	1.2	1.0	0.85/0.7	0.16/0
e00	08supk	235	200	30	1.2	1.0	0.7/0.7	0/0
e01	08supk	235	200	140	1.2	1.0	0.85/0.7	0.16/0
e01	08wipk	235	200	140	1.2	1.0	0.85/0.7	0.16/0

In general the MH transmission system is designed such that no firm load is shed or accredited firm generation is tripped for any single contingency (NERC Category B disturbance). A special protection system (e.g. Northern AC generator cross-trip scheme) may be used if the alternative transmission upgrade cannot be justified on an economic basis.

NERC has defined planning standards of transmission system contingency conditions for assessing system adequacy and security. Category B (single Component) and category C (multiple components) disturbances are used to analyze the stability of the system with the additional generation at Kelsey station. Table 13 summarizes the disturbance definitions, stations and lines used in the Kelsey Interconnection Evaluation Study (IES).

Table 13 - Disturbances Tested for the Kelsey IES Study

Disturbances	Description	Stations	Lines & Equipments
NERC Category B (Single Component)	3-Phase Normal Clearing Faults with System Intact	Kelsey, Ponton, Herblet Lake, Mystery Lake, Ashern, and Grand Rapids	K24W, G8P, Ponton SVC, Birchtree SVC, H59C, P18H, P19W, A4D, A3R, G1A, MLR Xfmr Bank 9, MLR Xfmr Bank 8, KN36, R26K, KT1, KT2, Kelsey Xfmr Bank 10, Wuskwatim-H75P, H73/74W, H75P
NERC Category C (Multiple Components)	Single Line to Ground Stuck Breaker Faults with System Intact	Cliff Lake, Birchtree, Herblet Lake, Ponton, Mystery Lake, Ralls Island, Wuskwatim, Thompson MLR 138kV and 230kV, Kelsey 230kV	Depends on breaker that fails!

#### 6.4 Single Contingencies

The maximum desired incremental power transfer from the Kelsey generating station is 80 MW. Transaction analysis is performed to search for the stability limit of each critical contingency. The NERC category B disturbances with single component outages are tested for system stability using the voltage criteria listed in Table 12. Three phase bus faults are applied at Kelsey, Ponton, Herblet Lake, Mystery Lake, Ashern, and Grand Rapids. The study is done for all summer and winter peak cases.

Without the new Wuskwatim generation and transmission facilities in service, all the contingencies at winter peak loading are secure at the maximum transfer increase of 80 MW.

Table 14 summarizes the critical summer peak contingency results for the case without Wuskwatim and associated transmission facilities. The Kelsey generator cross-trip scheme is able to eliminate stability violations for a number of disturbances. However, Kelsey cross trips are not sufficient for loss of lines G8P, P19W or Ponton SVC. Solutions to these reliability limitations are discussed later in the report.

Table 14 - Critical Single Contingencies Stability Results Without Wuskwatim Generation and Transmission Facilities (Kelsey Cross-trips)

LF #	Yr/Id	Contingency Description	INCO Loading (MW)	Without Cross Trip		With Kelsey Cross Trip		
				Transfer Level (MW)	Transient Stability Index (%)	No. of Kelsey Units	Transfer Level (MW)	Transient Stability Index (%)
d00	08supk	3P Fault K24W at Ponton	30	60	12.92	1	80	12.81
d00	08supk	3P Fault G8P at Ponton	30	0	-92.25	4	50.85	8.92
d00	08supk	3P Fault Ponton SVC	30	0	-93.7	3	0	-95.1
d00	08supk	3P Fault P18H at Ponton	30	35	8.12	2	80	11.45
d00	08supk	3P Fault P19W at MLR	30	0	-68.78	2	0	-68.54
d01	08supk	3P Fault G8P at Ponton	140	30	13.58	3	80	11.44
d01	08supk	3P Fault Ponton SVC	140	0	-94.15	4	0	-95.52
d01	08supk	3P Fault P19W at MLR	140	15	22.98	2	80	22.23

The new Wuskwatim generation and transmission facilities provide extra support to the northern system with the addition of new transmission and reactive support. Only one Kelsey unit is required to cross trip for loss of line G8P to reach the maximum transfer limit. All other contingencies are secure and there is no need to cross-trip Kelsey generation. The Wuskwatim transmission eliminates the need for Kelsey over-frequency tripping in the event of losing line P19W given an intact system. The TSAT transient stability results are presented in Appendix E.

## 6.5 Breaker Fail

Transaction analysis is performed to search for the stability limit of the NERC category C disturbances with multiple component outages. For this study, the single line-to-ground faults with breaker failure are analyzed using the voltage criteria listed in Table 12. The disturbances (i.e. refer to Table 13) are tested for all the summer and winter peak cases.

The stability results for the critical breaker failure contingencies, with and without the Kelsey generation cross trip scheme, are shown in Table 15. Without Wuskwatim

generation and transmission facilities, one Kelsey generator unit is required to trip for simultaneous loss of lines G8P and J30P at Ponton station. Two Kelsey units are required to cross trip for loss of lines P18H and Ponton SVC at Kelsey to reach the maximum power transfer level. For the contingencies involving the outage of line P19W, the Northern Islanding over-frequency scheme is used to trip the correct amount of generation. The present scheme limits the amount of generation tripped to four units, which is insufficient to permit a transfer level increase of 80 MW at Kelsey. Overfrequency tripping is discussed further later in the report.

Table 15 - Stability Results for Critical Breaker Fail Contingencies without Wuskwatim Generation and Transmission Facilities at INCO loading of 30MW

LF #	Yr/Id	Contingency Description	INCO Loading (MW)	Prior to Cross Trip		Post Cross Trip		
				Transfer Level (MW)	Transient Stability Index (%)	No. of Kelsey Units	Transfer Level	Transient Stability Index (%)
d00	08supk	SLG G8P at Ponton-Brk 1 Fail (loss G8P & P19W)	30	0	-66.74	4	45	18.55
d00	08supk	SLG P19W at Ponton-Brk 1 Fail (loss P19W & G8P)	30	0	-67.42	4	45	21.79
d00	08supk	SLG P19W at Ponton-Brk 2 Fail (loss P19W & PSVC)	30	0	-93.7	4	45	22.14
d00	08supk	SLG G8P at Ponton-Brk 4 Fail (loss G8P & J30P)	30	30	18.33	1	80	13.24
d00	08supk	SLG P18H at Ponton-Brk 6 Fail (loss P18H & PSVC)	30	51.13	11.38	2	80	15.99
d00	08supk	SLG B77W at MLR-Brk R2 Fail(loss K24W & P19W)	30	0	-64.87	4	45	21.89
d00	08supk	SLG P19W at MLR-Brk R2 Fail(loss K24W & P19W)	30	0	-67.38	4	45	21.84

The Kelsey cross trip results for high INCO loading is shown in Table 16. Once INCO loading reaches 140 MW, the existing overfrequency cross-trip logic is able to select the correct number of units, which permits stability criteria to be met at a transfer level increase of 80 MW.

**Table 16 - Stability Results for Critical Breaker Fail Contingencies without Wuskwatim Generation and Transmission Facilities at INCO loading of 140MW**

LF #	Yr/Id	Contingency Description	INCO Loading (MW)	Prior to Cross Trip		Post Cross Trip		
				Transfer Level (MW)	Transient Stability Index (%)	No. of Kelsey Units	Transfer Level	Transient Stability Index (%)
d01	08supk	SLG G8P at Ponton-Brk 1 Fail (loss G8P & P19W)	140	15	23.02	3	80	22.34
d01	08supk	SLG P19W at Ponton-Brk 1 Fail (loss G8P & P19W)	140	15	22.93	3	80	22.18
d01	08supk	SLG P19W at Ponton-Brk 2 Fail (loss P19W & PSVC)	140	15	22.94	2	80	22.77
d01	08supk	SLG K24W at MLR-Brk R2 Fail(loss K24W & P19W)	140	15	23.03	2	80	22.90
d01	08supk	SLG P19W at MLR-Brk R2 Fail(loss K24W & P19W)	140	15	23.01	2	80	22.85

The stability results for the critical breaker failure contingencies with Wuskwatim facilities in-service are shown in Table 17. At low INCO loading, loss of lines P58C and P52E requires cross trip of 1 Kelsey unit to reach the maximum transfer level. Based on the power flow results given in Section 3.0, loss of these two lines did not result in overloading of line G8P. This discrepancy will be investigated further in the Interconnection facilities Study. All other breaker failures occurring with intact system are transiently stable at the maximum desired transfer level and do not require Kelsey unit cross-trips.

**Table 17 - Stability Results for Critical Breaker Fail Contingencies with Wuskwatim Generation and Transmission Facilities**

LF #	Yr/Id	Contingency Description	INCO Loading (MW)	Prior to Cross Trip		Post Cross Trip		
				Transfer Level (MW)	Transient Stability Index (%)	No. of Kelsey Units	Transfer Level	Transient Stability Index (%)
e00	08supk	SLG P58C at Ponton-Brk 10 Fail (loss of P58C & P52E)	30	60	14.49	1	80	16.95
e00	08supk	SLG P52E at Ponton-Brk 10 Fail (loss of P52E & P58C)	30	60	14.55	1	80	16.84

## 6.6 Mitigation of G8P Disturbance

Only a 50 MW transfer level increase at Kelsey is possible in order for stability criteria to be met following a G8P disturbance, even if 4 Kelsey units are cross-tripped. There are two options available to realize an 80 MW transfer level increase:

- Install a Static Var Compensator (SVC) at Birchtree
- Connect Kelsey units onto the HVdc collector system

### 6.6.1 Birchtree SVC

The impact of a Static Var Compensator (SVC) at Birchtree is examined for a summer peak case with low INCO loading and without Wuskwatim generation and transmission facilities. The results are presented in Table 18. The full 80 MW transfer level is realized but 4 Kelsey units must be cross-tripped in order to maintain stability.

Table 18 - Impact of Birchtree SVC on G8P Disturbance

Contingency Description	INCO Loading (MW)	Kelsey Cross Trips (Units)	Birchtree SVC Offline		Birchtree SVC Online	
			Transfer Level (MW)	Transient Stability Index (%)	Transfer Level	Transient Stability Index (%)
3P Fault G8P at Ponton	30	0	0	-92.25	0	-92.25
		2	16.12	11.57	35	10.5
		3	36.52	10.37	60	8.37
		4	50	8.92	80	6.87

### 6.6.2 Kelsey Units on HVdc

If the Birchtree SVC is not installed, the existing north-south ac system does not have adequate capacity to be able to transmit all of the potential generation at Kelsey on a firm basis. It is possible to connect three to four Kelsey units (100-130 MW) onto the HVdc system today assuming the HVdc transmission system is intact and the collector system generation is not near maximum.

Connecting Kelsey units on the existing HVdc system on a long term firm basis is not feasible. Additional circuit breaker operations are required to change the connections between the ac and dc systems, which will require more frequent circuit breaker maintenance intervals. The existing HVdc transmission system does not have sufficient spare capacity to accommodate all of the generation from the collector system to meet a 500 MW spare valve group criteria. In other words, emergency energy is required for nearly every forced valve group outage. There is insufficient reactive support at Radisson to accommodate Kelsey plus existing firm accredited collector system generation. In addition, the reliability of the northern ac system is diminished as outages are required to accommodate the network reconfiguration. Kelsey units on DC are connected to R26K, which requires a K24W outage.

Connecting Kelsey units onto the HVdc collector system on a non-firm basis until Wuskwatim and its associated transmission are in-service is an option. Two rerunners

units (90 MW) could likely be accommodated on the HVdc system 80% of the time assuming loading on the bipoles is 3000 MW or less.

## 6.7 Mitigation of Ponton SVC Disturbance

In the case of losing Ponton SVC, the maximum transfer level can only be reached if lines J30P and P18H (coincidentally) are tripped and two units of Kelsey generation are cross tripped.

The Birchtree SVC would provide permit a transfer level increase of 35 MW without requiring the cross-trip of J30P as mentioned above. Table 19 summarizes the stability results.

Table 19 - Mitigating Loss of Ponton SVC

Contingency Description	INCO Loading (MW)	Kelsey Cross Trips (Units)	Birchtree SVC Offline		Birchtree SVC Online	
			Transfer Level (MW)	Transient Stability Index (%)	Transfer Level	Transient Stability Index (%)
3P Fault Ponton SVC	30	0	0	-93.7	35	9.09
		3	0	-95.1	35	9.14

## 6.8 Mitigation of P19W Disturbance

The Kelsey over-frequency tripping scheme is used to limit the northern AC system frequency rise in the case of losing line P19W, which forms an islanded northern ac system. The over-frequency relay is set to trip at 62 Hz on selected Kelsey units. The existing scheme is modeled to trip maximum of four Kelsey units. Results presented earlier indicated a maximum transfer level of 45 MW could be accommodated for cases without Wuskwatim facilities in-service. There are several options available to permit the maximum 80 MW transfer level:

- Increase the number of cross-tripped units to five
- Limit the flow on P19W to 190 MW and transfer Kelsey units to the HVdc collector system
- Construct a line parallel to P19W

### 6.8.1 Increasing Number of Units Tripped on Overfrequency

For cases without Wuskwatim facilities in service, the generator over-frequency tripping scheme model is used for contingencies involving loss of line P19W. At INCO loading of 30MW, up to five Kelsey units are tripped at maximum power transfer level.

Table 20 - Stability Results for Over-frequency (O/F) Trip of Kelsey Generation Units at P19W Loading of 220MW

LF #	Yr/Id	Contingency Description	INCO Loading (MW)	Prior to O/F Trip		Post O/F Trip		
				Transfer Level (MW)	Transient Stability Index (%)	No. of Kelsey Units	Transfer Level (MW)	Transient Stability Index (%)
d00	08supk	SLG Fault G8P at Ponton-Brk 1 Fail (loss of G8P & P19W)	30	0	-66.74	5	80	18.48
d00	08supk	SLG Fault P19W at Ponton-Brk 1 Fail (loss of G8P & P19W)	30	0	-67.42	5	80	21.75
d00	08supk	SLG Fault P19W at Ponton-Brk 2 Fail(loss of P19W & Ponton SVC)	30	0	-67.42	5	80	21.75
d00	08supk	SLG Fault B77W at MLR-Brk R2 Fail(loss of K24W & P19W)	30	0	-64.87	5	80	20.93
d00	08supk	SLG Fault P19W at MLR-Brk R2 Fail(loss of P19W & K24W)	30	0	-67.38	5	80	21.82
d00	08supk	3P Fault P19W at MLR	30	0	-68.78	5	80	20.71

### 6.8.2 Limit P19W flow & Put Kelsey Units on HVdc

To use the existing scheme of tripping up to four Kelsey units, the loading on P19W has to be limited to a maximum of 190 MW. At least one Kelsey unit could be transferred to the HVdc collector system to limit loading on P19W. Presently this would be required for up to two months in the summer. The duration will increase as Northern load is forecast to decrease over the next decade.

### 6.8.3 Construct New Line in Parallel with P19W

A new line in parallel with P19W will eliminate the potential for islanding except under prior outage scenarios. In addition, a new line will improve the stability index for several critical disturbances. A line from Birchtree to Wuskwatim is planned to be constructed in 2005/06. This line could be extended to Herblet to complete a parallel path to P19W. A planning level cost estimate of this 137 km line is \$32.9 million. This line is planned to be in-service in the fall of 2009 to accommodate first power at Wuskwatim in the spring of 2010. Delays in Wuskwatim will delay the construction of this line.

## 6.9 Summary of Stability Analysis

The stability investigation has demonstrated that transient voltage criteria and stability can be met during system intact conditions for all NERC category B and C disturbances at the maximum desired Kelsey transfer level of 80 MW if Wuskwatim generation and

transmission facilities are in-service, including the cross-trip scheme. The new Wuskwatim generation and transmission facilities greatly improve the stability of the northern ac system. For example, only one Kelsey unit is required to cross-trip for loss of line G8P to reach the maximum transfer limit. All other contingencies are secure, and there is no need to cross trip Kelsey generation. The over-frequency Kelsey tripping scheme is not required once Wuskwatim facilities are put into service.

The following additional Kelsey unit cross-trips are required before Wuskwatim generation and transmission is in service in order to accommodate the higher Kelsey transfer level:

- Cross tripping of one Kelsey unit is required for loss of K24W.
- Cross tripping two Kelsey units is required for loss of P18H.
- Cross tripping four Kelsey units for loss of G8P.
- Cross tripping of one Kelsey unit for breaker failure loss of G8P/J30P.
- Cross tripping two Kelsey units for loss of P18H/PSVC.
- Cross tripping up to four Kelsey units for breaker fail contingencies involving loss of P19W/G8P, P19W/PSVC, P19W/K24W. The exact number is determined by the over-frequency Kelsey tripping scheme.

Before Wuskwatim generation and transmission facilities are in service, under high transfer conditions, there are three main disturbances that cause stability criteria violations: loss of the Ponton SVC, loss of the Grand Rapids to Ponton line (G8P) and loss of the Thompson to Ponton line (P19W).

Loss of the Ponton SVC can be mitigated by modifying the local circuit breaker logic within the Ponton station. If the Ponton SVC trips during high transfer conditions, the local breakers associated with J30P are also tripped at the same time as the cross-trip to Kelsey. Coincidentally line P18H is disconnected too, because of the bus configuration at Ponton (located between SVC and line J30P breakers).

For loss of G8P, there are two options available to meet minimum transient voltage criteria at the maximum desired 80 MW Kelsey increase level. For firm network service, the Birchtree SVC is required to be connected if the Kelsey increase exceeds 50 MW. It may also be possible to request secondary service or non-firm point-point transmission service when above 50 MW and either be curtailed under the worst system conditions or be permitted to connect to the HVdc collector system assuming that this system is able to accommodate the connection when required. Once Wuskwatim is constructed and its associated transmission, this restriction is eliminated.

The existing Kelsey overfrequency tripping scheme is limited to four Kelsey units, which permits an increase in transfer level at Kelsey of 45 MW. Preliminary study results indicate that increasing the number of units tripped to five should be sufficient to meet under/overfrequency criteria. This needs to be further investigated in the Interconnection Facilities Study to ensure that there is sufficient reactive power available to completely control voltages in the island. Two alternatives to increased overfrequency tripping exist. The first alternative is to limit flow on P19W to approximately 190 MW and to transfer

Kelsey units to the HVdc collector system if sufficient capacity is available. The other alternative, which will ensure firm network delivery, is to construct a new transmission line between Birchtree and Herblet Lake. The current plans for Wuskwatim indicate that this transmission line will be in-service in the fall of 2009. Assuming that the fifth unit at Kelsey is upgraded and put in-service in the fall of 2009 (i.e. 55 MW increase), this timing lines up perfectly with the transmission line addition.

## 7.0 Transmission Facility Costs

The transmission facility costs to connect the additional Kelsey generation are calculated for planning purposes. Typical unit costs for equipment are used. A more detailed good faith cost estimate will be developed if the study proceeds to the Interconnection Facility Study phase.

### 7.1 Interconnection System and Network Upgrades

Please refer to the following Manitoba Hydro Interoffice Memos from file 4-4A by D. Jacobson, “Kelsey Capacity Expansion Transmission Options – Cost Estimates”, April 21, 2002, and “Kelsey Rerunning Transmission Cost Estimate”, July 5, 2002 and to email correspondence in Appendix B for information regarding the Interconnection System Upgrades cost estimate to connect the additional Kelsey generation. Table 21 below provides a summary of all Interconnection System Upgrades. The transmission lines and Birchtree SVC are considered Network Upgrades.

Table 21 - Summary of Issues and Mitigation for Kelsey Re-Running.

Criteria Violation	Contingencies	Mitigation	Cost (\$million)
unstable	Ponton SVC	Require J30P cross-trip	0.2
G8P	H59C, P18H, P58C	Overcurrent relay cross-trips up to 3 Kelsey units	0
Bank 8&9	K24W	After 40 MW increase must enable Kelsey cross-trip or <u>allow 30 minute Overload</u>	0
INCO transient voltage	K24W	After 60 MW increase must <u>enable cross-trip</u> or install Birchtree SVC	0
KT1 & 2	K24W	Change CT setting 800:5 on KT1 and KT2 at 70 MW increase	0
Kelsey Bank10	KT1+KT2	Requires Kelsey cross-trip after 50 MW increase, upgrade Bank 10 from 250 to 285 MVA and upgrade 230 kV bus to 1000 A	0.16
138 kV station bus	Kelsey Bank 10 or KT1/KT2	Kelsey GS – Replace six main 750 MCM horizontal Conductors with 2-500 MCM in three bay (1200 A)	0.15
INCO transient voltage	G8P+xtrip 3 Kelsey	3 unit cross-trip: Requires Birchtree SVC for a 35 MW increase then o.k. until 60 MW or 4 unit cross-trip: Requires Birchtree SVC for a 50 MW increase then o.k. until 80 MW or Kelsey units on HVdc duty	0-25
Under/over frequency; limit loss to 4 Kelsey units	P19W	Requires 137 km Birchtree-Herblet Lake line (60 MW increase) or 5 unit Kelsey cross-trip or Kelsey units on DC	0-32.9
MR11 & voltage collapse	C28R, A3R, R7B, B69R, B70H, A4D	Requires 125 km Dauphin-Neepawa 230 kV line	32.9
<b>Total: Interconnection System Upgrades</b>			<b>0.51</b>
<b>Total: Network Upgrades</b>			<b>32.9-90.8</b>

## 7.2 Project Timing

The Kelsey 230 kV bus is required to be able to carry the full output from Kelsey (350 MVA) with an open ring. Therefore, the risers are to be upgraded to 1000 A. Existing 991 A disconnect switches are adequate (395 MVA rating). Upgrades are required when the Kelsey expansion exceeds the existing 701 A (279 MVA) 230 kV riser rating. Therefore the upgrades are required by fall of 2006. In order to minimize outage costs, the 138 kV upgrades need to be constructed at the same time.

The Neepawa to Dauphin line is estimated to be needed for firm Network Integration Transmission service by the spring of 2011. The timing of this line will be further investigated in the IFS.

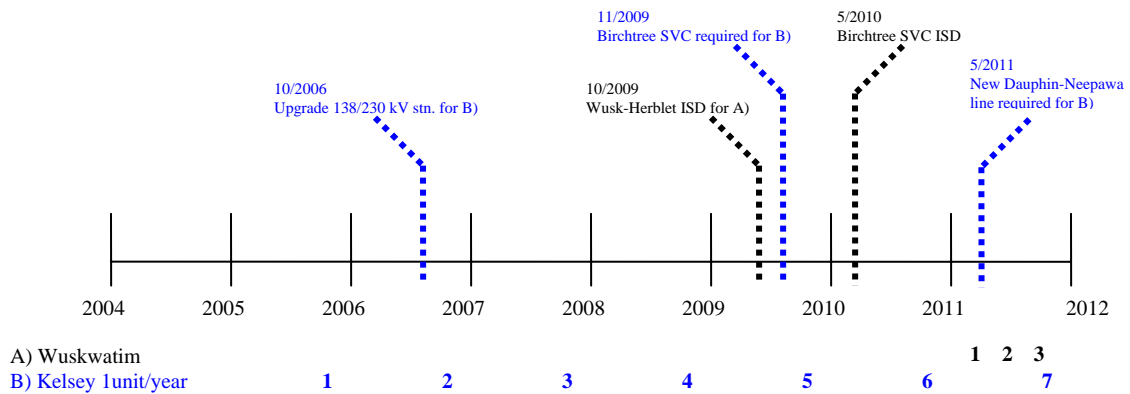


Figure 2 - Timeline Scenarios for Kelsey Rerunning and Wuskwatim.

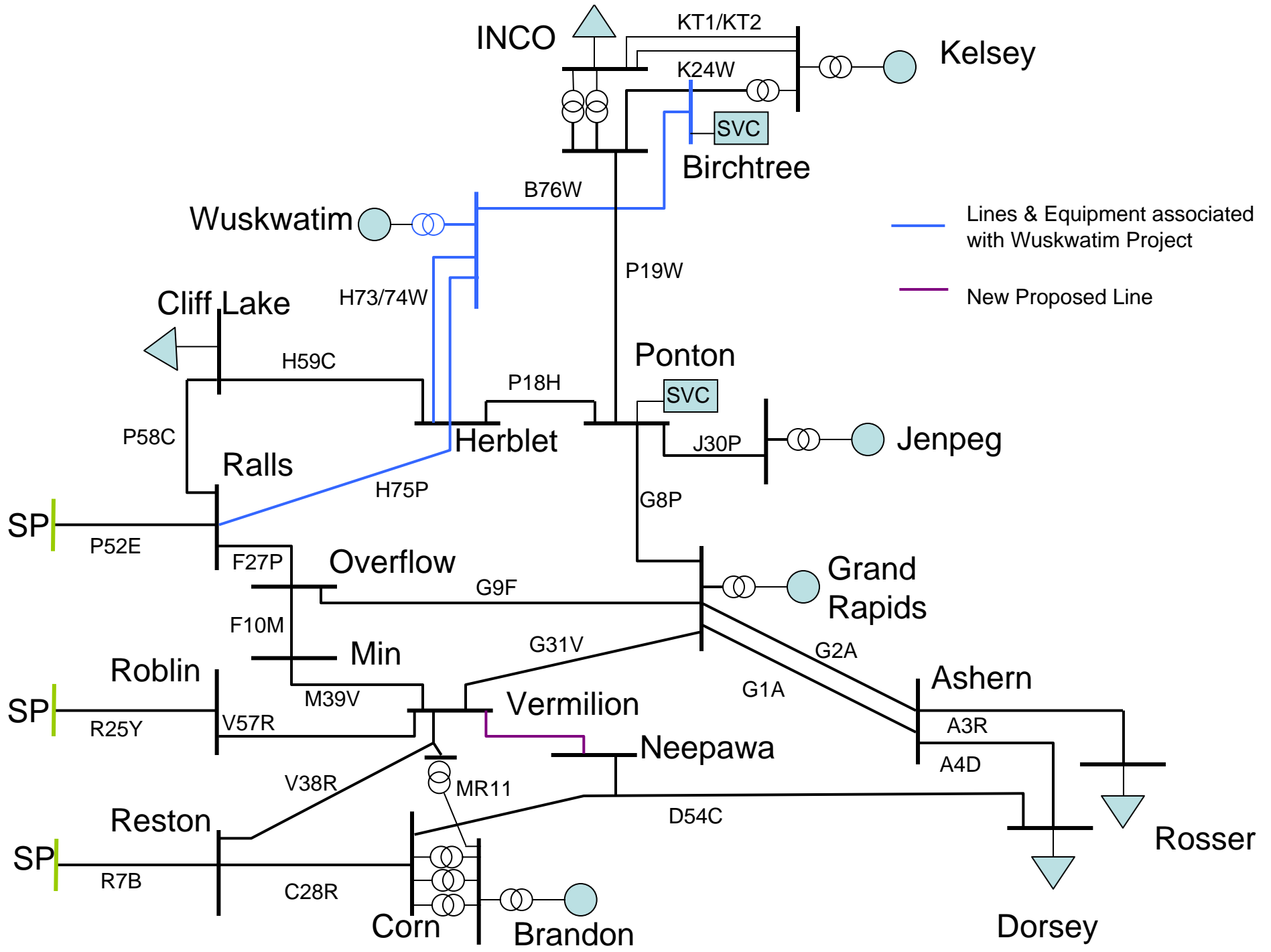
## 8.0 References

- [1] MH Document, "Transmission System Interconnection Upgrades".
- [2] "Wuskwatim Generating Station – Requirements for Generators and Controls", by Brian Archer, SPD Report 02/7, March 25, 2003.
- [3] "The Kelsey Generating Station Re-running/Rewinding Project – Effects on Fault Current Interrupting Capability of the Existing 138 kV Circuit Breakers in the Surrounding Area", by M. R. Wonsiak, file 5-9 and 4-4, August 15, 2003.
- [4] "Functional Specification for the New Northern Cross Trip Scheme", by David Jacobson, file 6-3, June 27, 2003.
- [5] "Wuskwatim Generator Power Factor Requirement", by David Diakiw, file 4-4, January 7, 2003.
- [6] "Update on the Northern AC/Wuskwatim Requirements", by David Diakiw, file 4-4A, April 30, 2002.
- [7] "Temporary Facility Additions to Allow a Transfer Limit Increase for P19W & Power Flow South of Ponton", by David Jacobson, file 6-3, March 28, 2002.
- [8] "Northern AC Assessment to Accommodate Kelsey Rerunning", by David Diakiw, TM 01/9, September 24, 2001.
- [9] "Dynamic Performance Evaluations of Notigi and Wuskwatim Transmission Options", by W. Zhang, SPD Report 01/16, December 20, 2001.
- [10] "Impact of Kelsey Re-running on Birchtree SVC / Ponton SVC", by David Diakiw. (Memo currently in Draft form.)
- [11] "Kelsey Exciter Replacement – Static Exciter and Stabilizer Considerations", by B.A. Archer, TM 00/6, file 7-3, October 13, 2000.
- [12] "Kelsey Capacity Expansion Transmission Options – Cost Estimates", by D. Jacobson, file 4-4A, April 21, 2002.
- [13] "Kelsey Rerunning Transmission Cost Estimate", by David Jacobson, file 4-4A, July 5, 2002.
- [14] Capital Project Justification for "Transmission Requirements for the Wuskwatim Generating Station", by David Jacobson, May 28, 2003.
- [15] "Short Term Overload Capability of the Dorsey 500 kV Station Wavetraps", by R. Brandt, file 5-15, March 12, 2003.
- [16] "Wuskwatim Generator Power Factor Requirement", by David Diakiw, file 4-4, January 7, 2003.
- [17] SPD00/16: Wuskwatim Generating Station Construction Power Supply Options, W. Zhang, October 20, 2000.
- [18] Memo W. Zhang to R.W. Mazur dated 2000 08 01: Wuskwatim Transmission Switching Station AC Station Service Supply Options.
- [19] Memo W. Zhang to R.W. Mazur dated 2001 02 13: Wuskwatim/Notigi Transmission Options – Cost Estimates.
- [20] SPD 01/16: Dynamic Performance Evaluations of Notigi and Wuskwatim Transmission Options Vol I & II (Appendices), W. Zhang.
- [21] Memo from R. Brandt to D. Jacobson dated 2003 08 25: Herblet Lake – Ralls Island Transmission Line Justification.
- [22] Memo from Amanda Cloney to Kerry Johnson dated 2003 08 26: Riser Ratings on Lines CB1 and CB42 from Cornwallis to Brandon GS.

- [23] Wuskwatim Interconnection Facility Studies Report, November 12, 2004.
- [24] Powertechs-DSA PowerTools™ <http://www.dsapowertools.com/>
- [25] “Kelsey Rerunning Project: Transmission Availability”, by D. Jacobson, File 7-3D, Feb 2, 2005.

## **Appendix A**

### **Single Line Diagram**



## **Appendix B**

### **Email Correspondence: Kelsey Rerunning Project**

**From:** Turner, Hal  
**Sent:** Monday, June 28, 2004 4:00 PM  
**To:** Jacobson, David  
**Cc:** Helm, Mike; Carriere, Dee-Dee  
**Subject:** Kelsey Rerunning Project Runner Power Output

File 111-41100  
File 111-57000

Dave,

To recap our phone conversation today. During Alstom's developmental model testing it became apparent that the replacement runners for Kelsey are capable of producing more power than Alstom tendered. Alstom has presented us with three options for the runner output:

- i) 57,930 Hp, 90.05% eff. - equates to 47 MVA at 0.9 PF, 60 MW increase in plant output,
- ii) 60,200 Hp, 90.05 % eff. - equates to 48.6 MVA at 0.9 PF, 70 MW increase in plant output,
- iii) 60920 Hp, 90.5% eff. - equates to 49.2 MVA at 0.9 PF, We are using 50 MVA for the new stator winding and transformers, 79 MW (based on 50 MVA) increase in plant output.

Please include the three options above in the Interconnection Facilities Study.

Alstom will be continuing testing of the model through out the summer. We are targeting early October for making a decision regarding which runner output option is most economical for Manitoba Hydro. The Interconnection Facilities Study is required for our analysis. Please advise if you can complete the study by the end of September.

If you have any questions please give me a call.

Thanks

Hal

Hal Turner, P. Eng.  
Project Engineer  
Power Projects Department  
Engineering Services Division  
Voice:(204) 474-3722  
Fax: (204) 474-4657

From: Schmidt, John  
Sent: Wednesday, July 30, 2003 4:42 PM  
To: Jacobson, David  
Cc: Helm, Mike; ee\_file; See-Toh, Eric  
Subject: Kelsey G.S. Rewound Generator subtransient reactance

Hi David

The present plan is to rewind all 7 Kelsey generators as they are re-runnered. Please see reactance data below from GE. I hope this is all the generator data you need to complete the fault study portion of the facility connection study for Kelsey re-runnering. The reactance values below are for the generator rewind to 46.85MVA 0.9pf.

We expect to attain near this MVA based on the revised turbine horsepower:  $57930\text{hp} * 0.746\text{kW/hp} = 43.216\text{MW}$  ( $43.216\text{MW} * 97.2\%$  generator efficiency) /  $0.9\text{pf} = 46.7\text{MVA}$

Thanks  
John  
Sap 236240 file 00111-42100

-----Original Message-----

From: haresh.ramchandani@ps.ge.com  
[<mailto:haresh.ramchandani@ps.ge.com>]  
Sent: Thursday, July 17, 2003 10:37 AM  
To: jdschmidt@hydro.mb.ca  
Subject: RE: Kelsey G.S. Generator subtransient reactance

John,

Here is the response that I got from our Generator Engineering .

The calculated values for the Reactances would be as follows for the Kelsey #5 : case-2.

Values in pu	Unsaturated value	Saturated value
xd	1.13	0.97
x'd	0.32	0.26
x''d	0.22	0.18

Regards & have a good day.

Haresh Ramchandani  
Account Manager , Canada  
GE HYDRO  
795 George V , Lachine (P.Q.)  
H8S - 4K8  
Canada.  
Telephone : 514-485-4069 Dialcom : 238-4069  
Fax : 514-485-4231 Dialcom 238-4231  
From: Schmidt, John [<mailto:jdschmidt@hydro.mb.ca>]  
Sent: July 11, 2003 5:33 PM  
To: Ramchandani, Haresh (PS, Hydro)  
Cc: ee\_file; Helm, Mike

Subject: Kelsey G.S. Generator subtransient reactance

Hi Haresh

The fault interrupt capability of the Kelsey G.S. 138kV breakers is near their limit. Our System Planning dept would like to determine, ahead of time, the effect of Unit 5 rewind on fault contribution. We would like to model the upgraded Unit 5 in a fault study (and possibly all 7 units). Could you please provide an estimate of the  $X_d$ ,  $X_d'$ ,  $X_d''$  of Unit 5 based on the stator rewind proposed in Case 2 of the GE "Generator Unit 5 Uprate Study". Please base the estimate using the proposed stator coil copper cross section (26% more copper than existing winding) that is described in Case 2 of the GE "Generator Unit 5 Uprate Study".

Thanks

John

Sap 236240 file 00111-42100

J.D. Schmidt

Elect Eng Dept

Engineering Services Div

1100 Waverley

ph: 474-3699 fax: 474-4682

## **Appendix C**

### **VSAT Results: Steady State AC Powerflow**

d00 = Low INCO and NO Wuskwatim generation or transmission  
d01 = High INCO and NO Wuskwatim generation or transmission

e00 = Low INCO and 200 MW of Wuskwatim generation plus transmission  
e01 = High INCO and 200 MW of Wuskwatim generation plus transmission

Maximum accredited generation  
Jenpeg = 168 MW  
Grand Rapids = 480 MW  
Brandon = 376 MW  
NO Kettle on AC

MH > SP  
105 MW

**Base case conditions unless otherwise specified !**

SINGLE CONTINGENCIES			KELSEY OUTPUT (MW) & % Rate C overload						60 MW	70 MW	80 MW	Comments	
Case	Contingency	Facility	235	245	255	265	275	285	295	305	315		
d00-no wusk xmission  No Wuskwatim 105 Export to Sask Power INCO = 30 MW  K24W =	G8P	STABILITY	Voltage Collapse										x-trip Kelsey - NOTE: 2 Units
	H59C	G8P	X	102.9	106	109	112.1	115	118	121	124	Overcurrent relay G8P x-trip Kelsey	
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	X	101	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	X	102	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5
	P18H	G8P	105.9	109	112	115.1	118.2	121.2	124.2	127.3	130.2	x-trip Kelsey	
P58C	G8P	X	X	X	X	X	X	X	102.5	105.4	Overcurrent relay G8P x-trip Kelsey		
d01-no wusk xmission  K24W =	K24B	KT1	X	X	X	X	X	X	X	X	100.3	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA	
	B77W	KT2	X	X	X	X	X	X	X	X	100.2	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5	
e00-200 wusk Wuskwatim ON at 200 MW o/p 105 Export to Sask Power INCO = 30 MW	G8P	F27P	X	X	X	X	X	X	X	102.1	104.5	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA	
	H75P	G8P	X	X	X	X	X	X	X	101.1	103	Overcurrent relay G8P x-trip Kelsey	
	F27P	G8P	X	X	X	X	X	X	X	X	100.8	Overcurrent relay G8P x-trip Kelsey	
e01-200 wusk	NONE	NONE											
d01-wipk-no wusk	NONE	NONE											
e01-wipk-200-wusk	NONE	NONE											
d00-no wusk sp200exp No Wuskwatim 200 Export to Sask Power INCO = 30 MW  K24W =	G8P	STABILITY	Voltage Collapse										x-trip Kelsey
	H59C	G8P	X	102.9	106	109	112.1	115.1	118.1	121.1	124	Overcurrent relay G8P x-trip Kelsey	
	P18H	G8P	105.9	109	112	115.1	118.2	121.2	124.2	127.3	130.3	x-trip Kelsey	
	P58C	G8P	X	X	X	X	X	X	X	102.5	105.4	Overcurrent relay G8P x-trip Kelsey	
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	X	102	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
KT2		X	X	X	X	X	X	X	X	X	102.6	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5	
e00-200 wusk sp200exp Wuskwatim ON at 200 MW o/p 200 Export to Sask Power INCO = 30 MW	H75P	G8P	X	X	X	X	X	X	X	X	100.5	Overcurrent relay G8P x-trip Kelsey	

COMMON TOWER			KELSEY OUTPUT (MW) & % Rate C overload						60 MW	70 MW	80 MW	Comments
Case	Contingency	Facility	235	245	255	265	275	285	295	305	315	
d00-no wusk xmission	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	103.4	107.6	112	250 MVA Rated in model (Bank is rated 285 MVA in Station database)
		KK35										600 CT limit?? Actual 800/5 amps NOTE: various station equipment related to 138 kV Line KK35 need to be upgraded to 1200 Amps
d01-no wusk xmission	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	103.3	107.4	111.6	minimum & 230 kV Kelsey terminal needs to be upgraded to 1000 amps minimum
		KK35										
e00-200 wusk	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	100.2	103.9	107.9	
		KK35										
e01-200 wusk	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	100.2	103.8	107.8	
		KK35										
d01-wipk-no wusk	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	X	X	101.8	
		KK35										
e01-wipk-200-wusk	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	X	X	100.2	
		KK35										
d00-no wusk sp200exp	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	103.3	107.4	111.6	
		KK35										
e00-200 wusk sp200exp	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	100.2	103.9	107.5	
		KK35										
d00-no wusk sp200imp	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	103.4	107.6	112	
		KK35										
e00-200 wusk sp200imp	KT1/KT2	Kelsey Bk10	X	X	X	X	X	X	100.2	103.9	107.5	
		KK35										

NOTE: Similar results for Brandon 0 and 500 MW cases both d and e

Case	Contingency	Facility	KELSEY OUTPUT (MW) & % Rate C overload					60 MW	70 MW	80 MW	Comments		
			235	245	255	265	275	285	295	305		315	
d00-no wusk sp200imp  No Wuskwatim 200 Import from Sask Power INCO = 30 MW	A3R	MR11 Bank	101.3	102.2	102.9	103.8	104.6	105.5	106.3	107.1	108	Overcurrent relay trip to protect MR11 Note: Could add to G.R. x-trip?	
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X		
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	101.8	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA	
		KT2	X	X	X	X	X	X	X	X	102.6	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5	
	C28R	MR11 Bank	119.5	120.9	122.4	123.4	124.8	125.8	127.3	128.3	129.7	Overcurrent relay trip to protect MR11	
	with MR11 trip	MR11	108.9	109.8	110.8	111.8	112.7	113.7	114.6	115.6	116.6	Xfmr Rating 110 MVA actual !! = 138%	
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	G8P	STABILITY	Voltage Collapse										x-trip Kelsey
	H59C	G8P	X	102.9	106	109	112	115.1	118.1	121.1	124	Overcurrent relay G8P x-trip Kelsey	
	P18H	G8P	105.9	109	112	115.1	118.2	121.2	124.2	127.4	130.8	x-trip Kelsey	
P58C	G8P	X	X	X	X	X	X	X	102.5	105.4	Overcurrent relay G8P x-trip Kelsey		
d01-no wusk sp200imp  No Wuskwatim 200 Import from Sask Power INCO = 140 MW	A3R	MR11 Bank	X	X	X	X	X	X	X	100.1	100.4	Overcurrent relay trip to protect MR11	
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
	C28R	MR11 Bank	114.4	115.8	117.1	118.9	120.2	122	123.8	125.1	126.8	Overcurrent relay trip to protect MR11	
	with MR11 trip	MR11	104	105.4	106.7	108	109.3	110.6	111.8	113.1	114.4		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	G8P	STABILITY	Voltage Collapse										x-trip Kelsey
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	100.7	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA	
		KT2	X	X	X	X	X	X	X	X	100.7	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5	
	e00-200 wusk sp200imp  Wuskwatim ON at 200 MW o/p 200 Import from Sask Power INCO = 30 MW	A3R	A4D	104.7	106.3	107.9	109.7	111.6	113.8	116.4	Voltage Collapse		Overcurrent relay trip to protect MR11
		with MR11 trip	MR11 Bank	127	128.3	129.6	131.1	132.6	134.3	136.3	Voltage Collapse		New line from Dauphin to Neepawa required !!!
		MR11	116.8	118.6	120.4	122.3	124.4	126.7	129.4	Voltage Collapse		New line from Dauphin to Neepawa required !!!	
A4D		A3R	112.2	113.8	115.3	116.9	118.6	120.4	122.3	124.5	126.8	Could add to G.R. x-trip?	
with MR11 trip		MR11 Bank	112.9	113.8	114.8	115.9	116.9	118.1	119.4	120.8	122.4	Overcurrent relay trip to protect MR11	
		MR11	101.9	103.1	104.6	106.1	107.7	109.4	111.2	113.3	115.6		
A3R		C28R	124.8	127.1	129.7	132.2	135.9	Voltage Collapse				New line from Dauphin to Neepawa required !!!	
with MR11 trip		A3R	104.8	106.5	108.5	110.7	113.4	Voltage Collapse				New line from Dauphin to Neepawa required !!!	
A6V		MR11 Bank	104.9	105.7	106.5	107.3	108.2	109	109.9	110.8	111.7	Overcurrent relay trip to protect MR11	
with MR11 trip		MR11	X	X	X	X	X	X	X	X	100.5	non-issue	
B69R		MR11 Bank	117.3	118.2	119.1	120.1	121	121.9	122.8	123.8	124.2	Overcurrent relay trip to protect MR11	
with MR11 trip		MR11	103.6	104.5	105.5	106.4	107.4	108.4	109.6	110.9	112.1	non-issue	
B70H		MR11 Bank	113.8	114.7	115.6	116.5	117.4	118.3	119.2	120	120.9	Overcurrent relay trip to protect MR11	
with MR11 trip		MR11	X	100.7	101.7	102.6	103.5	104.5	105.6	106.8	108		
C28R		MR11 Bank	159.1	160.4	161.9	163.3	164.8	166.4	167.9	169.5	171.2	Overcurrent relay trip to protect MR11	
with MR11 trip		MR11	142.4	143.9	145.4	147	148.6	150.2	151.9	153.6	155.4		
F27P		G8P	115	117.1	119.1	121.1	123.1	125	127	128.9	131	Overcurrent relay G8P x-trip Kelsey	
		B1W (SP)	X	X	X	X	100.1	101	101.9	102.8	103.7	????	
G1A/2A		A3R	105.2	106.6	108	109.5	111	112.5	114.2	115.9	117.6	Could add to G.R. x-trip?	
G31V		G1A/2A	X	X	X	X	X	X	100.4	101.9	103.6	x-trip Grand Rapids I Unit	
G8P	F27P	126	127.6	130	132.4	134.8	137.1	139.4	141.7	144.2	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA		
H75P	G8P	X	X	100.3	102.3	104.3	106.4	108.7	110.8	113.1	Overcurrent relay G8P x-trip Kelsey		
BRANDON UNIT5	MR11 Bank	100.3	100.9	101.5	102.1	102.8	103.4	104	104.6	105.2	Overcurrent relay trip to protect MR11		
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue		
e00-200 sp200impD-N New Line Dauphin to Neepawa 230 kV Estimated cost \$33 million	F27P	G8P	115.5	117.5	119.6	121.7	123.7	125.8	127.9	129.8	131.8	Overcurrent relay G8P x-trip Kelsey	
	G1A/2A	G2A	X	X	X	100.3	101.5	102.8	104.1	105.4	106.7	x-trip Grand Rapids I Unit	
	G8P	F27P	127.7	129.3	131.8	134.3	136.7	139.3	141.8	144.4	147	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA	
	H75P	G8P	X	X	X	101.8	103.8	105.7	107.7	109.8	111.8	Overcurrent relay G8P x-trip Kelsey	
	e00-200 sp200impA-S New Line Ashern to Silver 230 kV Estimated cost \$100 million Wuskwatim ON at 200 MW o/p 200 Import from Sask Power INCO = 30 MW	F27P		-Does not alleviate MR11 issues!!									
G1A/2A													
G8P													
H75P													
K24B													
e01-200 wusk sp200imp  Wuskwatim ON at 200 MW o/p 200 Import from Sask Power INCO = 140 MW	A3R	A4D	X	X	X	X	X	X	X	100.2	101.3	Could add to G.R. x-trip?	
	with MR11 trip	MR11 Bank	117.9	119.1	120.2	121.4	122.6	123.8	124.9	126.1	127.3	Overcurrent relay trip to protect MR11	
		MR11	105.6	106.9	108.1	109.4	110.6	111.9	113.1	114.4	115.7		
	A4D	A4D	100.9	102.1	103.3	104.5	105.7	106.9	108.1	109.5	111.5	New line from Dauphin to Neepawa required !!!	
	with MR11 trip	C28R	103.2	104.3	105.4	106.5	107.5	108.6	109.7	110.9	112.7	New line from Dauphin to Neepawa required !!!	
	A4D	A3R	X	100.7	101.7	102.8	103.9	105	106.2	107.2	108.3	Could add to G.R. x-trip?	
	with MR11 trip	MR11 Bank	103.7	104.7	105.7	106.7	107.7	108.7	109.6	110.6	111.6	Overcurrent relay trip to protect MR11	
		MR11	X	X	X	X	X	X	X	X	X		
	A3R	A3R	106.8	108	109.2	110.4	111.6	112.8	114	115.3	116.5	New line from Dauphin to Neepawa required !!!	
	A6V	MR11 Bank	X	X	X	X	X	X	100.6	101.5	102.4	Overcurrent relay trip to protect MR11	
	with MR11 trip	MR11	X	X	X	X	X	X	X	X	X	non-issue	
	B69R	MR11 Bank	104.7	105.7	106.7	107.7	108.6	109.5	110.9	112.3	113.7	Overcurrent relay trip to protect MR11	
	with MR11 trip	MR11	X	X	X	X	X	X	X	X	X	non-issue	
	B70H	MR11 Bank	101.2	102.2	103.5	104.4	105.3	106.2	107.2	108.1	109.4	Overcurrent relay trip to protect MR11	
	with MR11 trip	MR11	X	X	X	X	X	X	X	X	X	non-issue	
C28R	MR11 Bank	156.3	157.8	159.4	160.9	162.4	164	165.6	167.1	168.6	Overcurrent relay trip to protect MR11		
with MR11 trip	MR11	139.4	140.9	142.3	143.8	145.3	146.8	148.3	149.7	151.2			
F27P	G8P	X	X	X	X	X	X	X	X	X	non-issue		
G8P	F27P	X	100.7	103	105.3	107.6	109.8	112.2	114.5	116.8	Overcurrent relay G8P x-trip Kelsey		
	G8P	X	100.7	103	105.3	107.6	109.8	112.2	114.5	116.8	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA		

Case	Contingency	Facility	KELSEY OUTPUT (MW) & % Rate C overload								Comments	
			235	245	255	265	275	285	295	305		315
d00-no wusk sp 0imp-exp bdn 0  No Wuskwatim 0 Import from Sask Power INCO = 30 MW Brandon Generation = 0 MW	A3R	MR11 Bank	101.4	102.3	103.6	105.2	106.6	108.2	109	110.1	111.1	Could add to G.R. x-trip?
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	B69R	MR11 Bank	107	107.9	108.8	109.8	110.7	112.1	113.4	114.3	115.7	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	X	X	X	X	X	X	100.6	101.5	102.5	non-issue
	B70H	MR11 Bank	104.1	104.9	105.9	106.8	107.7	108.6	109.4	110.7	111.6	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	C28R	MR11 Bank	121.8	122.9	124.3	125.6	127	128.3	130.1	131.4	133.2	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	108.7	109.8	111.1	112.4	113.9	115.2	116.5	117.9	119.1	Xfmr Rating 110 MVA actual !! = 138%
e00-200 wusk sp 0imp-exp  Wuskwatim ON at 200 MW o/p 0 Import/export from Sask Power INCO = 30 MW Brandon Generation = 389 MW	A3R	MR11 Bank	102.1	103.3	104.3	105.3	106.3	107.3	108.3	109.3	110.3	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	X	X	X	X	X	X	X	X	X	non-issue
	A4D	A4D	X	X	X	X	X	X	X	X	100.8	30 minute Overload allowed
	with MR11 trip	A3R	X	X	X	X	X	X	X	X	100.1	30 minute Overload allowed
	B69R	MR11 Bank	X	X	X	101.1	102.5	103.8	104.7	106.1	107.3	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	X	X	X	X	X	X	X	X	X	non-issue
	B70H	MR11 Bank	X	X	X	X	X	X	100.6	101.8	102.6	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	C28R	MR11 Bank	116.9	118.2	120	121.8	123.6	124.9	126.7	128.5	129.8	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	105.3	106.7	108	109.3	110.5	111.8	113.1	114.4	115.8	non-issue
	G8P	F27P	103	105.4	107.7	109.2	111.6	114	116.5	118.9	121.4	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA
	H75P	G8P	X	X	X	X	X	100.7	102.6	104.6	106.6	Overcurrent relay G8P x-trip Kelsey
F27P	G8P	X	X	101.8	103.9	105.9	107.9	110	112	114.1	Overcurrent relay G8P x-trip Kelsey	
e00-200 wusk sp0imp-exp-bdn 0  Wuskwatim ON at 200 MW o/p 0 Import/export from Sask Power INCO = 30 MW Brandon Generation = 0 MW	Base Case	MR11 Bank	X	X	100.2	100.9	101.5	102	102.6	103.1	103.7	
	A3R	MR11 Bank	126.1	127.2	128.3	129.3	130.4	131.5	132.6	133.7	134.7	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	113.8	114.8	116.1	117.1	118.3	119.5	120.6	121.8	122.8	
	A4D	MR11 Bank	113.7	114.6	115.5	116.5	117.3	118.2	119.1	120	120.9	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	100.9	102.1	103	104	104.9	105.7	106.6	107.7	108.7	
	B69R	MR11 Bank	131.5	132.5	133.5	134.3	135.2	136.2	137.1	138.1	139.1	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	116.2	117.1	118	118.8	119.9	120.8	121.9	122.7	123.7	non-issue
	B70H	MR11 Bank	128.3	129.1	130	130.9	131.9	132.8	133.6	134.6	135.4	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	112.6	113.4	114.3	115.3	116.3	117.2	118.2	119.1	120	non-issue
	CB1	MR11 Bank	103.1	103.6	104.3	105	105.7	106.3	107.1	107.8	108.4	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	CB3	MR11 Bank	106.7	107.3	107.9	108.7	109.4	110	110.9	111.3	111.9	Overcurrent relay trip to protect MR11
	with MR11 trip	CB1	109	109.2	109.6	110	110.4	110.5	111	111.3	111.5	TRANSFORMER IS LIMITING ELEMENT 176 MVA
	CB42	MR11 Bank	103.1	103.6	104.2	105	105.7	106.3	107.1	107.8	108.3	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	Corn BK1	MR11 Bank	103	103.7	104.3	105	105.7	106.4	107.1	107.8	108.3	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	Corn BK2	MR11 Bank	103.1	103.6	104.2	105	105.7	106.4	107.1	107.7	108.3	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	Corn BK3	MR11 Bank	106.9	107.2	107.9	108.7	109.4	110.1	110.9	111.3	111.9	Overcurrent relay trip to protect MR11
	with MR11 trip	CB1	109	109.2	109.6	110	110.4	110.5	111	111.3	111.5	TRANSFORMER IS LIMITING ELEMENT 176 MVA
	C28R	MR11 Bank	159.5	160.8	162.2	163.6	164.9	166.3	167.3	168.7	170	Overcurrent relay trip to protect MR11
	with MR11 trip	MR11	141.4	142.6	144	145.3	146.5	147.9	149	150.3	151.6	
	D12C	MR11 Bank	104.6	105.3	106	106.8	107.5	108.1	108.8	109.5	110	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	D14S	MR11 Bank	102.7	103.5	104.2	104.9	105.4	106	106.7	107.4	108	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue
	F27P	G8P	X	X	X	101.6	103.7	105.7	107.8	109.8	111.8	Overcurrent relay G8P x-trip Kelsey
	G8P	F27P	100.4	102	104.3	106.6	109	111.4	113.8	116.3	118.8	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA
	R7B (SP)	MR11 Bank	101.3	102	102.7	103.3	104.1	104.9	105.6	106.3	107.3	Overcurrent relay trip to protect MR11
	with MR11 trip	?	X	X	X	X	X	X	X	X	X	Raven Lake Reactor of 30 MVAR turned OFF! NEW LINE REQUIRED Dauphin to Neepawa 230 kV
	R25Y	MR11 Bank	101.3	102.1	102.8	103.4	104	104.6	105.3	105.9	106.5	Overcurrent relay trip to protect MR11
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
R29H	MR11 Bank	106.3	106.9	107.7	108.4	109	109.7	110.5	111.3	112	Overcurrent relay trip to protect MR11	
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
S53G	MR11 Bank	100.4	100.8	101.5	102.2	102.8	103.4	104.2	104.8	105.3	Overcurrent relay trip to protect MR11	
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
V57R	MR11 Bank	101.4	102.1	102.8	103.3	104	104.6	105.3	105.9	106.6	Overcurrent relay trip to protect MR11	
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
Y51L	MR11 Bank	103.4	104	104.7	105.4	106.1	106.7	107.3	108.1	108.7	Overcurrent relay trip to protect MR11	
with MR11 trip	NONE	X	X	X	X	X	X	X	X	X	non-issue	
e00-200 wusk sp0imp bdn0 D-N New Line Dauphin to Neepawa 230 kV Estimated cost \$33 million	C28R	MR11 Bank	102.5	103.3	103.8	104.6	105.4	106.5	107.2	108.5	109.7	Overcurrent relay trip to protect MR11
	with MR11 trip	NONE	X	X	X	X	X	X	X	X	non-issue	
	F27P	G8P	X	X	100.1	102.1	104.2	106.2	108.3	110.3	112.3	Overcurrent relay G8P x-trip Kelsey
	G8P	F27P	101.9	103.5	105.8	108.2	110.6	113	115.5	117.9	120.4	x-trip kelsey
H75P	G8P	X	X	X	X	X	X	101.4	103.4	105.4	Overcurrent relay G8P x-trip Kelsey	

			KELSEY OUTPUT (MW) & % Rate C overload						60 MW	70 MW	80 MW		
Case	Contingency	Facility	235	245	255	265	275	285	295	305	315	Comments	
d00-no wusk bdn 0  No Wuskwatim Brandon generation = 0 MW INCO = 30 MW	H59C	G8P	X	102.9	106	109	112.1	115.1	118.1	121.1	124	Overcurrent relay G8P x-trip Kelsey	
	G8P	STABILITY	Voltage Collapse										x-trip Kelsey
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	101.4	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA	
		KT2	X	X	X	X	X	X	X	X	102.2	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)	
	P18H	G8P	105.9	109	112	115.1	118.2	121.2	124.2	127.3	130.3	x-trip Kelsey	
d00-no wusk bdn500  No Wuskwatim Brandon generation = 500 MW INCO = 30 MW	P58C	G8P	X	X	X	X	X	X	X	102.5	105.4	Overcurrent relay G8P x-trip Kelsey	
	G8P	STABILITY	Voltage Collapse										x-trip Kelsey
	H59C	G8P	X	102.9	106	109	112	115.1	118.1	121.1	124	Overcurrent relay G8P x-trip Kelsey	
	K24B & B77W	KT1	X	X	X	X	X	X	X	X	101.4	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA	
		KT2	X	X	X	X	X	X	X	X	102.3	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)	
e00-200 wusk bdn 0  Wuskwatim ON at 200 MW o/p Brandon generation = 0 MW INCO = 30 MW	P18H	G8P	105.9	109	112	115.1	118.2	121.2	124.2	127.3	130.3	x-trip Kelsey	
	P58C	G8P	X	X	X	X	X	X	X	102.5	105.4	Overcurrent relay G8P x-trip Kelsey	
	A3R	MR11 Bank	108	108.9	109.7	110.6	111.4	112.3	113.1	114	114.8	Overcurrent relay trip to protect MR11	
		MR11	X	X	X	X	X	100.1	100.9	101.9	102.8		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	A4D	MR11 Bank	X	X	100.3	101.1	101.8	102.5	103.2	104	104.8	Overcurrent relay trip to protect MR11	
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	B69R	MR11 Bank	120.7	122	123.4	124.2	125.1	126	126.8	127.6	128.5	Overcurrent relay trip to protect MR11	
		MR11	106.4	107.2	108	108.9	109.7	110.6	111.6	112.4	113.3		
	B70H	MR11 Bank	116.2	117.4	118.7	120	121.3	122.5	123.3	124.1	125	Overcurrent relay trip to protect MR11	
		MR11	102.9	103.7	104.5	105.3	106	106.9	107.8	108.7	109.4		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	CB3	MR11 Bank	X	X	X	X	X	X	100.2	100.8	101.5	Overcurrent relay trip to protect MR11	
		CB42	X	X	X	X	X	X	113.1	113.4	113.8	Transformer is limiting element 176 MVA	
		CB1 Xfmr	X	X	X	X	X	X	X	X	100	Station riser and buswork is limiting element 723 Amps Conductor = 965 amps	
e00-200 wusk-bdn500 Wuskwatim ON at 200 MW o/p Brandon generation = 500 MW INCO = 30 MW	C28R	MR11 Bank	121.2	122.2	123.7	124.7	126.1	127.6	128.6	130	131.5	Overcurrent relay trip to protect MR11	
		MR11	106.6	107.6	108.5	109.6	110.5	111.5	112.4	113.4	114.2		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	G8P	F27P	X	X	X	X	X	X	X	X	101.5	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA	
	H75P	G8P	X	X	X	X	X	X	X	100.2	102.2	Overcurrent relay G8P x-trip Kelsey	
e00-200 wusk bdn 0 New Line Dauphin to Neepawa Estimated cost \$33 million	R29H	MR11 Bank	X	X	X	X	X	X	100.4	101.1	101.7	Overcurrent relay trip to protect MR11	
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
e00-200 wusk bdn 0 New Line Ashern to Silver Estimated cost \$100 million	G8P	F27P	X	X	X	X	X	X	100.6	103	105.4	x-trip Kelsey Line conductor 712 amps 75deg C	
	H75P	G8P	X	X	X	X	X	X	X	101.3	103.3	Overcurrent relay G8P x-trip Kelsey	
e00-200 wusk bdn 0 New Line Ashern to Silver Estimated cost \$100 million	H75P	G8P	X	X	X	X	X	X	X	100.2	102.2	Overcurrent relay G8P x-trip Kelsey	
	H75P	G8P	X	X	X	X	X	X	X	100.4	102.4	Overcurrent relay G8P x-trip Kelsey	
	B69R	MR11 Bank	116.4	117.7	119	120.2	121	122.3	123.1	123.9	124.7	Overcurrent relay trip to protect MR11	
		MR11	102.8	103.6	104.3	105.1	105.9	106.8	107.6	108.5	109.3		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
	B70H	MR11 Bank	112	113.2	114.4	115.6	116.8	117.6	118.8	119.6	120.8	Overcurrent relay trip to protect MR11	
		MR11	X	100	100.8	101.6	102.4	103.3	104.1	104.8	105.6		
		NONE	X	X	X	X	X	X	X	X	X	non-issue	
C28R	MR11 Bank	116.2	119	119	119.9	121.3	122.2	123.6	124.5	125.9	Overcurrent relay trip to protect MR11		
	MR11	102.3	103.2	104.2	105.2	106.1	107	107.9	108.8	109.7			
	NONE	X	X	X	X	X	X	X	X	X	non-issue		
	G1A	G2A	X	X	X	X	X	X	100.7	101.7	102.6	x-trip 1 unit Grand Rapids GS	

BREAKER FAIL			KELSEY OUTPUT (MW) & % Rate C overload						60 MW	70 MW	80 MW	
Case	Contingency	Facility	235	245	255	265	275	285	295	305	315	Comments
d00-no wusk xmission	P18HSVC	G8P	109.3	113.4	117.5	121.8	126.4	131.3	Voltage Collapse			lack of SVC need x-trip to Kelsey or Birchtree SVC??
d01-no wusk xmission	K24WR26K	KT1	X	X	X	X	X	X	X	X	100.8	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	100.9	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
	R26KBK10	KT1	X	X	X	X	X	X	X	X	101.3	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	101.3	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
e00-200 wusk	F27PH75P	G8P	X	X	100.6	102.9	105.1	107.3	109.5	111.7	113.9	Overcurrent relay G8P x-trip
	K24BB77W	KT1	X	X	X	X	X	X	X	X	100.9	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	101.7	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
	B76WB77W	KT1	X	X	X	X	X	X	X	X	101.1	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	101.8	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
	H75PH73W	G8P	X	X	X	X	X	X	100.1	102	104	Overcurrent relay G8P x-trip
e01-200 wusk	P18HH75P	G8P	X	X	X	X	X	X	100.2	102.1	104	Overcurrent relay G8P x-trip
	G8PP19W	F27P	X	X	X	X	X	X	X	102.1	104.4	x-trip kelsey
	K24BB77W	KT1	X	X	X	X	X	X	X	X	100	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	100.1	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
d01-wipk-no wusk	B76WB77W	KT1	X	X	X	X	X	X	X	X	100.2	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	100.3	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
e01-wipk-200-wusk	NONE	NONE										
d00-no wusk sp200exp												did not do yet
e00-200 wusk sp200exp	F27PH75P	G8P	121.6	123.8	126.1	128.3	130.6	132.9	135.3	137.4	141.4	Overcurrent relay G8P x-trip
	G8PP19W	F27P	126.1	127.7	130.1	132.5	134.8	137.1	139.4	141.7	144.1	x-trip kelsey Line conductor 712 amps 75 deg C -> 100 deg C = 965 amps or 384 MVA
	H75PH73W	G8P	X	X	101.1	103.1	105.2	107.4	109.5	111.9	114.9	Overcurrent relay G8P x-trip
	P18HH75P	G8P	X	X	X	X	103.3	105.5	107.7	110	112.4	Overcurrent relay G8P x-trip
	K24BB77W	KT1	X	X	X	X	X	X	X	X	100.9	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
		KT2	X	X	X	X	X	X	X	X	101.7	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)
	B76WB77W	KT1	X	X	X	X	X	X	X	X	101.1	x-trip Kelsey for K24W - Line conductor 605 amps 75deg C -> 100 deg C = 818 amps or 196 MVA
	KT2	X	X	X	X	X	X	X	X	101.8	Present line conductor rating = 605 amps 75deg C. Station equipment (current transformer ratio tap needs too be changed to 800/5)	
H74WH59C	G8P	X	X	X	X	X	X	X	100.8	102.6	Overcurrent relay G8P x-trip	

## **Appendix D**

### **Loop Flows Through SaskPower**

**LOOP FLOW THROUGH SaskPower:**

<b>EXISTING SYSTEM</b>		
<b>e00-200 wusk-sp0imp-bdn0.sav Kelsey = 235 MW</b>		
TO AREA 672 SPC		
X-----FROM-----X X-----TO-----X	CKT	MW MVAR
67514* ROBLIN 4 230 68615	YORKTON4 230 1	76.5 -27.8
67515* RALL 4 230 68630	EBCAMPB4 230 1	59 -13
67525* RESTON 4 230 68613	AUBURNT4 230 1	-136.7 9.7
67604* BORDER7 110 68560	ISLAND 7 110 1	-27.6 -0.4
67604* BORDER7 110 68560	ISLAND 7 110 2	-27.6 -0.4
<b>TOTAL FROM AREA 667 TO AREA 672</b>		<b>-56.5 -31.9</b>

<b>EXISTING SYSTEM WITH NEW LINE FROM DAUPHIN TO NEEPAWA</b>		
<b>e00-200 wusk-sp0imp-bdn0-dn-line.sav Kelsey = 235 MW</b>		
TO AREA 672 SPC		
X-----FROM-----X X-----TO-----X	CKT	MW MVAR
67514* ROBLIN 4 230 68615	YORKTON4 230 1	62 -25.3
67515* RALL 4 230 68630	EBCAMPB4 230 1	55 -13.8
67525* RESTON 4 230 68613	AUBURNT4 230 1	-119.4 10.1
67604* BORDER7 110 68560	ISLAND 7 110 1	-27.6 -0.6
67604* BORDER7 110 68560	ISLAND 7 110 2	-27.6 -0.6
<b>TOTAL FROM AREA 667 TO AREA 672</b>		<b>-57.7 -30.2</b>

**Reduces loop flows through SaskPower by 19 MW**

<b>EXISTING SYSTEM</b>		
<b>e00-200 wusk-sp0imp-bdn0.sav Kelsey = 315 MW</b>		
TO AREA 672 SPC		
X-----FROM-----X X-----TO-----X	CKT	MW MVAR
67514* ROBLIN 4 230 68615	YORKTON4 230 1	74.9 -30.2
67515* RALL 4 230 68630	EBCAMPB4 230 1	72.6 -20.1
67525* RESTON 4 230 68613	AUBURNT4 230 1	-145.7 8.8
67604* BORDER7 110 68560	ISLAND 7 110 1	-27.6 -2.2
67604* BORDER7 110 68560	ISLAND 7 110 2	-27.6 -2.2
<b>TOTAL FROM AREA 667 TO AREA 672</b>		<b>-53.4 -45.8</b>

<b>EXISTING SYSTEM WITH NEW LINE FROM DAUPHIN TO NEEPAWA</b>		
<b>e00-200 wusk-sp0imp-bdn0-dn-line.sav Kelsey = 315 MW</b>		
TO AREA 672 SPC		
X-----FROM-----X X-----TO-----X	CKT	MW MVAR
67514* ROBLIN 4 230 68615	YORKTON4 230 1	59.1 -27.1
67515* RALL 4 230 68630	EBCAMPB4 230 1	68.2 -21
67525* RESTON 4 230 68613	AUBURNT4 230 1	-126.9 9.1
67604* BORDER7 110 68560	ISLAND 7 110 1	-27.6 -2.4
67604* BORDER7 110 68560	ISLAND 7 110 2	-27.6 -2.4
<b>TOTAL FROM AREA 667 TO AREA 672</b>		<b>-54.9 -43.8</b>

**Reduces loop flows through SaskPower by 18.8 MW**

# **Appendix E**

## **Stability Results Transaction Analysis**

Note: Transaction Analysis results provide a 5 MW margin.  
(i.e. for 80 MW transfer of 75 MW is shown for maximum)

Case: d00-no wusk xmission-TSAT-2.SAV  
SUMMER PEAK

INCO = 30 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

Grand Rapids = 480 MW

Brandon = 386 MW

No Wuskwatim Generation or Transmission



New Kelsey Exciter & Stabilizer, Without Damping Criteria

Case d00-no wusk xmission-TSAT.SAV

Northern Islanding occurs - Kelsey Overfrequency trip scheme required See next page for results!

Cont. No.	Transfer At The Last	Monitored Interface	Transient	Voltage Duration Index		Contingency Description
	Secure Level (MW)	Flow (MW)	Stability Index	Drop (sec)	Rise (sec)	
1	75	161.97	21.76	0.000	0.000	Steady state
2	75	161.97	16.34	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)
3	75	161.97	16.37	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R2 fail (Remove P58C & BK2, BK3)
4	75	161.97	11.88	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R3 fail (Remove H59C & BK2, BK3)
5	75	161.97	11.87	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)
6	75	161.97	16.96	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)
7	75	161.97	17.31	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)
8	75	161.97	13.07	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)
9	75	161.97	12.46	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 7 fail (Remove H59C)
10	0	0	-66.74	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)
11	0	0	-67.42	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)
12	0	0				SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)
13	75	161.97	17.4	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)
14	75	161.97	21.96	0.000	0.000	SLG on Line J30P at Ponton - Brk 3 fail (Remove J30P & P18H)
15	30	149.22	18.33	0.000	0.000	SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P)
16	75	161.65	13.24			SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P) & Xtrip 1 Klsy Unit
17	75	161.65	14.61			SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P) & Xtrip 2 Klsy Unit
18	75	161.65	15.12			SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P) & Xtrip 3 Klsy Unit
19	75	161.65	15.4			SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P) & Xtrip 4 Klsy Unit
20	75	161.97	21.96	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)
21	51.13	154.98	11.38	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)
22	75	161.65	15.99	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC) & xtrip 2 Kelsey
23	0	0	-64.87	0.000	0.000	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
24	0	0	-67.38	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
25	75	161.97	15.64	0.000	0.000	SLG on Line P58C at Ralls Island - Brk 9 fail (Remove P58C & BK1, BK2)
26	75	161.97	13.84	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E)
27	75	161.97	21.88	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)
28	75	161.97	19.57	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)
29	75	161.97	13.99	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C)
30	75	161.97	20.52	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)
31	75	161.97	20.29	0.000	0.000	SLG on Line TW40 at Mystery Lake - Brk B80 fail (Remove WL43 & TW40)
32	75	161.97	21.44	0.000	0.000	SLG on Line WB45 at Mystery Lake - Brk WB45 fail (Remove BK9 & WB45)
33	75	161.97	16.59	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)
34	75	161.65	20.36	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 1 Klsy Unit
35	75	161.65	20.64	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 2 Klsy Units
36	75	161.65	20.72	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 3 Klsy Units
37	75	161.65	20.76	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 4 Klsy Units
38	75	161.65	16.59	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K)
39	75	161.65	20.36	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 1 Klsy Unit
40	75	161.65	20.64	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 2 Klsy Units
41	75	161.65	20.72	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 3 Klsy Units
42	75	161.65	20.76	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 4 Klsy Units
43	75	161.65	16.05	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)
44	75	161.65	18.47	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 1 Klsy Unit
45	75	161.65	18.81	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 2 Klsy Units
46	75	161.65	18.93	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 3 Klsy Units
47	75	161.65	18.99	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 4 Klsy Units
48	75	161.65	16.05	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)
49	75	161.65	18.47	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 1 Klsy Unit
50	75	161.65	18.81	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 2 Klsy Units
51	75	161.65	18.93	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 3 Klsy Units
52	75	161.65	18.99	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 4 Klsy Units
53	20	146.31	19.72	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2
54	60	157.78	12.92	0.000	0.000	3 PHASE FAULT K24W at Kelsey Bus
55	75	161.65	12.81	0.000	0.000	3 PHASE FAULT K24W at Kelsey & Xtrip 1 Kelsey Unit
56	75	161.65	13.84	0.000	0.000	3 PHASE FAULT K24W at Kelsey & Xtrip 2 Kelsey Units
57	75	161.65	16.32	0.000	0.000	REMOVE Line K24W
58	0	0	-92.25	0.110	0.000	3 Phase Fault at Ponton - Remove Line G8P
59	0	0	-92.25	0.090	0.000	3 Phase Fault at Ponton - Remove Line G8P & BSVC
60	0	0	-90.95	0.080	0.070	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.
61	16.12	144.85	11.57	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.
62	35	150.7	10.5	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey & BSVC
63	36.52	150.65	10.37	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 3 unit Kelsey Gen.
64	60	157.9	8.37	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 3 unit Kelsey & BSVC
65	50.85	154.98	8.92	0.000	0.200	3 Phase fault at Ponton - Remove line G8P & Xtrip 4 unit Kelsey Gen.
66	75	161.91	6.87	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 4 unit Kelsey & BSVC
67	15	140.41	13	0.100	0.000	REMOVE LINE G8P
68	0	0	-93.7	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC
69	35	150.7	9.09	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC & BSVC
70	0	0	-93.86	0.366	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC Xtrip 1 unit Kelsey Gen.
71	0	0	-94.93	0.366	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC Xtrip 2 unit Kelsey Gen.
72	75	161.65	15.41	0.000	0.260	3 Phase fault at Ponton SVC bus - Remove Ponton SVC & trip J30P(Jenpeg) + P18H + 2 Kelsey
73	0	0	-95.1	0.306	0.040	3 Phase fault at Ponton SVC bus - Remove Ponton SVC Xtrip 3 unit Kelsey Gen.
74	35	150.7	9.14	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC Xtrip 3 Kelsey & BSVC.
75	75	161.65	21.52	0.000	0.000	Trip Ponton SVC
76	75	161.97	10.36	0.000	0.000	3 Phase fault at Herblet - Remove line H59C
77	75	161.97	14.19	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen
78	75	161.97	11.58	0.000	0.000	REMOVE LINE H59C
79	35	150.65	8.12	0.000	0.000	3 Phase fault at Ponton - Remove line P18H
80	60	157.8	8.92	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 1 unit Kelsey Gen.
81	75	162.16	9.44	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 1Kelsey & BSVC.
82	75	161.97	11.45	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.
83	75	161.97	13.06	0.000	0.000	REMOVE LINE P18H
84	0	0	-68.78	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W
85	0	0	-66.99	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen
86	0	0	-64.09	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen
87	0	0	-68.54	0.000	0.000	Remove P19W
88	75	161.97	15.7	0.000	0.000	3 Phase fault at Ashern - Remove line A4D
89	75	161.97	17.05	0.000	0.000	3 Phase fault at Ashern - Remove line A4D & Xtrip 1 unit Gr. Rapids Gen.
90	75	161.97	19.26	0.000	0.000	3 Phase fault at Ashern - Remove line A4D & Xtrip 2 unit Gr. Rapids Gen.
91	75	161.97	20.49	0.000	0.000	REMOVE LINE A4D
92	75	161.97	15.21	0.000	0.000	3 Phase fault at Ashern - Remove line A3R
93	75	161.97	16.59	0.000	0.000	3 Phase fault at Ashern - Remove line A3R & Xtrip 1 unit Gr. Rapids Gen.
94	75	161.97	19.16	0.000	0.000	3 Phase fault at Ashern - Remove line A3R & Xtrip 2 unit Gr. Rapids Gen.
95	75	161.97	19.05	0.000	0.000	REMOVE LINE A3R
96	75	161.97	9.53	0.100	0.000	3 Phase fault at Gr. Rapids - Remove line G1A
97	75	161.97	11.38	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A & Xtrip 1 unit Gr. Rapids Gen.
98	75	161.97	18.03	0.000	0.000	REMOVE LINE G1A
99	75	161.97	14.09	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9
100	75	161.97	14.94	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
101	75	161.97	15.44	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 2 Kelsey Units
102	75	161.97	15.76	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units
103	75	161.97	15.98	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units
104	75	161.97	21.97	0.000	0.000	REMOVE TRANSFORMER BANK 9
105	75	161.97	14	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8
106	75	161.97	14.88	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
107	75	161.97	15.4	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 2 Kelsey Units
108	75	161.97	15.72	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units
109	75	161.97	15.95	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units
110	75	161.97	21.87	0.000	0.000	REMOVE TRANSFORMER BANK 8
111	75	161.97	13.3	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus
112	75	161.97	13.25	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit
113	75	161.97	13.89	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
114	75	161.97	13.89	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
115	75	161.97	14.31	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units
116	75	161.97	14.6	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units
117	75	161.97	21.46	0.000	0.000	REMOVE LINE KN36
118	75	161.97	15.21	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey
119	75	161.97	15.89	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit
120	75	161.97	16.27	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units
121	75	161.97	16.51	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units
122	75	161.97	16.67	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units
123	75	161.97	22.14	0.000	0.000	REMOVE LINE R26K
124	75	161.97	12.6	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus
125	75	161.97	13.48	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus & Xtrip 1 Kelsey Unit
126	75	161.97	13.47	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units
127	75	161.97	13.97	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units
128	75	161.97	14.32	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units
129	75	161.97	21.18	0.000	0.000	REMOVE LINE KT1
130	75	161.97	12.6	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey
131	75	161.97	12.67	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 1 Kelsey Unit
132	75	161.97	13.47	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 2 Kelsey Units
133	75	161.97	13.97	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 3 Kelsey Units
134	75	161.97	14.32	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 4 Kelsey Units
135	75	161.97	21.18	0.000	0.000	REMOVE LINE KT2
136	75	161.97	12.62	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10
137	75	161.65	13.74	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10 & Xtrip 1 Klsy Unit
138	75	161.65	14.64	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER

**Results for Over-frequency Relay Trip of 5 Kelsey Units**

Case: d00-no wusk xmission-TSAT-3.SAV

**P19W = 220 MW**

Cont. No.	Transient Stability Index	Voltage Duration Index		Status	Contingency Description
		Drop (sec)	Rise (sec)		
1	18.48	0.000	0.000	Secure	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W) & Trip 5 Kelsey Units
2	21.75	0.000	0.080	Secure	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P) & Trip 5 Kelsey Units
3	21.75	0.000	0.080	Secure	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC) & Trip 5 Kelsey Units
4	20.93	0.000	0.070	Secure	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 5 Kelsey Units
5	21.82	0.000	0.070	Secure	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 5 Kelsey Units
6	20.71	0.000	0.110	Secure	3 Phase fault at Mystery Lake - Remove Line P19W & Trip 5 Kelsey Units

**Results for Over-frequency Relay Trip of 4 Kelsey Units**

Case: d00-no wusk xmission-TSAT-6.SAV

**P19W = 190MW**

Cont. No.	Transient Stability Index	Voltage Duration Index		Status	Contingency Description
		Drop (sec)	Rise (sec)		
1	22.86	0.000	0.000	Secure	Steady state
2	20.32	0.000	0.030	Secure	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W) & Trip 4 Klsy Units
3	22.03	0.000	0.030	Secure	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P) & Trip 4 Klsy Units
4	21.98	0.000	0.030	Secure	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC) & Trip 4 Klsy Units
5	22.17	0.000	0.050	Secure	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 4 Klsy Units
6	22.12	0.000	0.000	Secure	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 4 Klsy Units
7	22.07	0.000	0.090	Secure	3 Phase fault at Mystery Lake - Remove Line P19W & Trip 4 Klsy Units

**Over-frequency Kelsey Tripping Results**

Case: d01-no wusk xmission-TSAT-3.SAV

**P19W = low MW**

Cont. No.	Transient Stability Index	Voltage Duration Index		Status	Contingency Description
		Drop (sec)	Rise (sec)		
1	-52.06	0.000	0.020	Insecure	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W) & Trip 1 Klsy Unit
2	22.73	0.000	0.020	Secure	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W) & Trip 2 Klsy Units
3	-53.9	0.000	0.000	Insecure	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P) & Trip 1 Klsy Unit
4	22.58	0.000	0.000	Secure	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P) & Trip 2 Klsy Units
5	-53.93	0.000	0.000	Insecure	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC) & Trip 1 Klsy Unit
6	22.56	0.000	0.000	Secure	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC) & Trip 2 Klsy Units
7	-50.13	0.000	0.000	Insecure	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 1 Klsy Unit
8	22.72	0.000	0.000	Secure	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 2 Klsy Units
9	-52.1	0.000	0.000	Insecure	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 1 Klsy Unit
10	22.68	0.000	0.000	Secure	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W) & Trip 2 Klsy Units
11	-55.68	0.000	0.000	Insecure	3 Phase fault at Mystery Lake - Remove Line P19W & Trip 1 Klsy Unit
12	22.65	0.000	0.000	Secure	3 Phase fault at Mystery Lake - Remove Line P19W & Trip 2 Klsy Units

Case: d01-no wusk xmission-TSAT.SAV  
SUMMER PEAK

INCO = 140 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

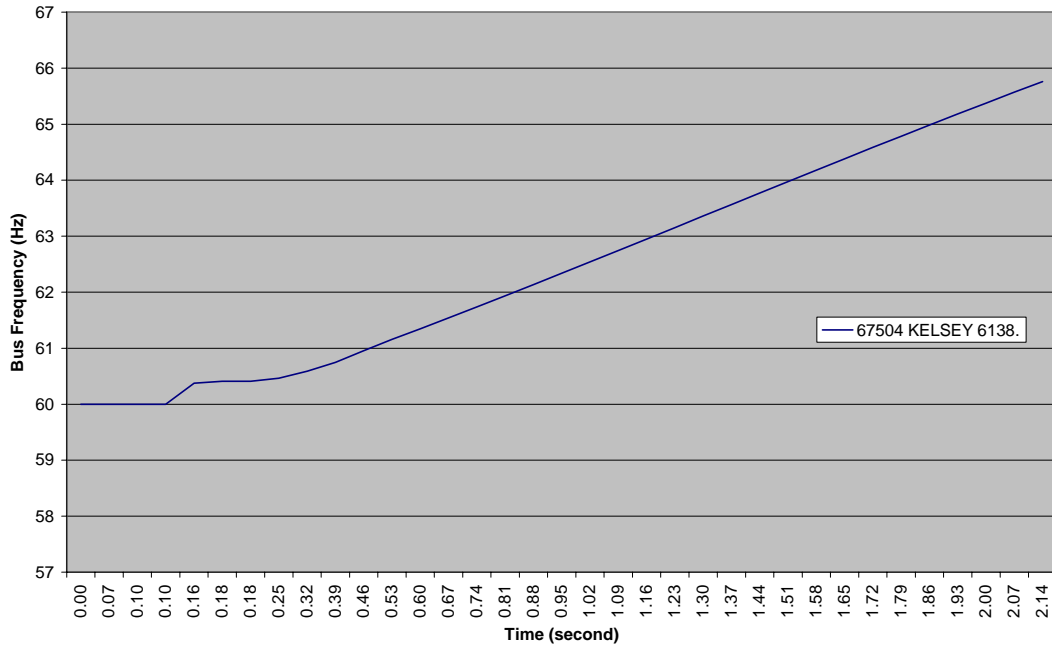
Grand Rapids = 480 MW

Brandon = 386 MW

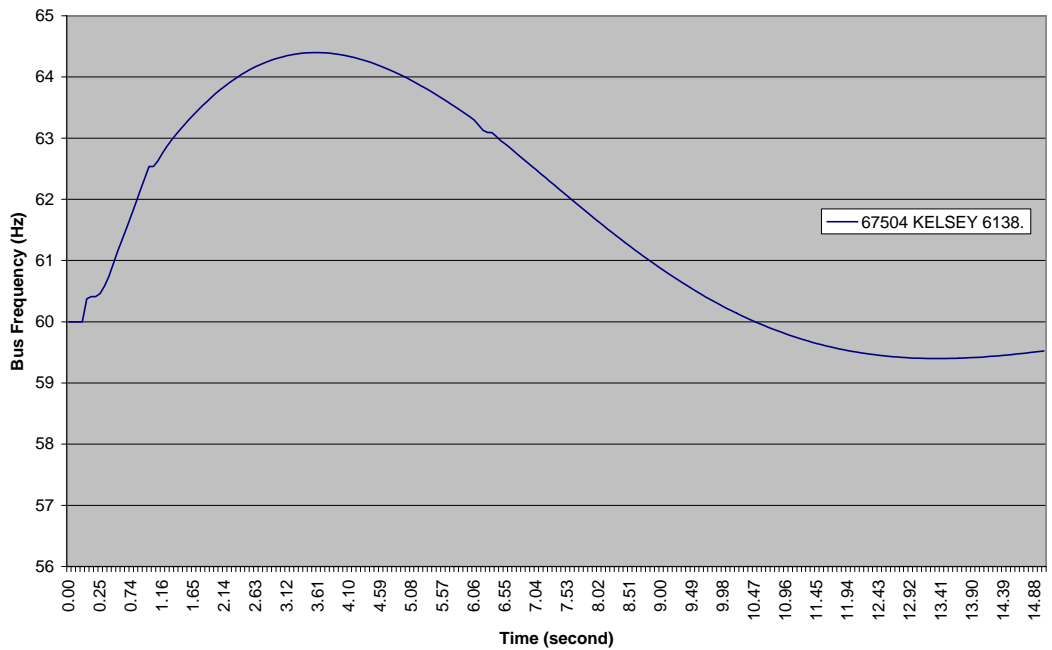
No Wuskwatim Generation or Transmission

# Bus Voltage Plots

**Kelsey Bus Frequency for 3 Phase Fault on Line P19W, Without Over-frequency Generator Tripping**



**Kelsey Bus Frequency for 3 Phase Fault on Lien P19W, With Over-frequency Generator Tripping**



Case d01-no wusk xmission-TSAT.SAV

Cont. No.	Transfer At The Last	Monitored Interface	Transient	Voltage Duration Index		Contingency Description
	Secure Level (MW)	Flow (MW)	Stability Index	Drop (sec)	Rise (sec)	
1	75	127.63	23.05	0.000	0.000	Steady state
2	75	127.63	23.08	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)
3	75	127.63	23.08	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R2 fail (Remove P58C & BK2, BK3)
4	75	127.63	21.73	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R3 fail (Remove H59C & BK2, BK3)
5	75	127.63	21.73	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)
6	75	127.63	22.45	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)
7	75	127.63	22.54	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)
8	75	127.63	20.56	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)
9	75	127.63	21.95	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 7 fail (Remove H59C)
10	15	109.59	23.02	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)
11	60	123.2	22.53	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W), Xtrip 1 Klsy Unit
12	75	127.63	22.34	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W), xtrip 2 Klsy Units
13	15	109.59	22.93	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)
14	60	123.2	22.4	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P), Xtrip 1 Klsy Unit
15	75	127.63	22.18	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P), Xtrip 2 Klsy Units
16	15	109.59	22.94	0.000	0.000	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)
17	75	127.63	22.08	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)
18	75	127.63	22.02	0.000	0.000	SLG on Line J30P at Ponton - Brk 3 fail (Remove J30P & P18H)
19	75	127.63	22.03	0.000	0.000	SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P)
20	75	127.63	21.93	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)
21	75	127.63	19.16	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)
22	15	109.59	23.03	0.000	0.000	SLG on Line K24W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
23	15	109.59	23.01	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
24	75	127.63	23.08	0.000	0.000	SLG on Line P58C at Ralls Island - Brk 9 fail(Remove P58C & BK1, BK2)
25	75	127.63	22.18	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail(Remove P58C & P52E)
26	75	127.63	23.08	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)
27	75	127.63	23.08	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)
28	75	127.63	22.5	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail(Remove P52E & P58C)
29	75	127.63	23.06	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)
30	75	127.63	23.08	0.000	0.000	SLG on Line TW40 at Mystery Lake - Brk B80 fail (Remove WL43 & TW40)
31	75	127.63	23.07	0.000	0.000	SLG on Line WB45 at Mystery Lake - Brk WB45 fail (Remove BK9 & WB45)
32	75	127.63	22.55	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)
33	75	127.63	22.55	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K)
34	75	127.63	21.68	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)
35	75	127.63	21.68	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)
36	75	127.95	19.92	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2
37	75	127.63	16.64	0.000	0.000	3 PHASE FAULT K24W at Kelsey Bus
38	75	127.63	18.28	0.000	0.000	3 PHASE FAULT K24W at Kelsey & Xtrip 1 Kelsey Unit
39	75	127.63	22.45	0.000	0.000	REMOVE Line K24W
40	30	114.18	13.58	0.100	0.000	3 Phase Fault at Ponton - Remove Line G8P
41	45	118.71	12.94	0.010	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.
42	45	118.71	12.94	0.020	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.
43	75	127.63	11.44	0.000	0.150	3 Phase fault at Ponton - Remove line G8P & Xtrip 3 unit Kelsey Gen.
44	75	127.63	16.42	0.000	0.000	REMOVE LINE G8P
45	75	127.63	23.08	0.000	0.000	Trip Ponton SVC
46	0	0	-94.15	0.420	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC
47	75	127.63	20.95	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC & trip J30P(Jenpeg) + P18H + 2 Kelsey
48	0	0	-95.52	0.236	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC, xtrip 4 klsy units
49	75	127.63	18.31	0.000	0.000	3 Phase fault at Herblet - Remove line H59C
50	75	127.63	18.31	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen
51	75	127.63	18.31	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 2 unit Kelsey Gen
52	75	127.63	21.3	0.000	0.000	REMOVE LINE H59C
53	75	127.63	11.58	0.150	0.000	3 Phase fault at Ponton - Remove line P18H
54	75	127.63	11.58	0.096	0.000	3 Phase fault at Ponton - Remove P18H & Xtrip 1 unit Kelsey Gen.
55	75	127.63	12.65	0.100	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.
56	75	127.63	20.34	0.000	0.000	REMOVE LINE P18H
57	15	109.59	22.98	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W
58	50	120.22	22.56	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen
59	75	127.63	22.23	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen
60						Remove P19W
61	75	127.63	23.02	0.000	0.000	3 Phase fault at Ashern - Remove line A4D
62	75	127.63	21.88	0.000	0.000	3 Phase fault at Ashern - Remove A4D & Xtrip 1 unit Gr. Rapids Gen.
63	75	127.63	19.78	0.000	0.000	3 Phase fault at Ashern - Remove line A4D & Xtrip 2 unit Gr. Rapids Gen.
64	75	127.63	23.08	0.000	0.000	REMOVE LINE A4D
65	75	127.63	22.47	0.000	0.000	3 Phase fault at Ashern - Remove line A3R
66	75	127.63	22.2	0.000	0.000	3 Phase fault at Ashern - Remove A3R & Xtrip 1 unit Gr. Rapids Gen.
67	75	127.63	21.37	0.000	0.000	3 Phase fault at Ashern - Remove line A3R & Xtrip 2 unit Gr. Rapids Gen.
68	75	127.63	23.08	0.000	0.000	REMOVE LINE A3R
69	75	127.63	18.47	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A
70	75	127.63	19.12	0.000	0.000	3 Phase fault at Gr. Rapids - Remove G1A & Xtrip 1 unit Gr. Rapids Gen.
71	75	127.63	19.12	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A & Xtrip 2 unit Gr. Rapid
72	75	127.63	23.07	0.000	0.000	REMOVE LINE G1A
73	75	127.63	19.89	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9
74	75	127.63	20.2	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
75	75	127.63	20.4	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 2 Kelsey Units
76	75	127.63	20.54	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units
77	75	127.63	20.65	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units
78	75	127.63	23.07	0.000	0.000	REMOVE TRANSFORMER BANK 9
79	75	127.63	19.83	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8
80	75	127.63	20.15	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
81	75	127.63	20.37	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 2 Kelsey Units
82	75	127.63	20.52	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units
83	75	127.63	20.62	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units
84	75	127.63	23.08	0.000	0.000	REMOVE TRANSFORMER BANK 8
85	75	127.63	18.13	0.030	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus
86	75	127.63	18.52	0.028	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit
87	75	127.63	18.79	0.028	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
88	75	127.63	18.99	0.028	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units
89	75	127.63	19.15	0.028	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units
90	75	127.63	23.07	0.000	0.000	REMOVE LINE KN36
91	75	127.95	21.08	0.010	0.000	3 PHASE FAULT LINE R26K at Kelsey
92	75	127.63	20.67	0.009	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit
93	75	127.63	20.85	0.009	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units
94	75	127.63	20.97	0.009	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units
95	75	127.63	21.07	0.009	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units
96	75	127.63	23.08	0.000	0.000	REMOVE LINE R26K
97	75	127.63	17.27	0.140	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus
98	75	127.63	17.8	0.090	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 1 Kelsey Unit
99	75	127.63	18.19	0.060	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units
100	75	127.63	18.47	0.047	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units
101	75	127.63	18.68	0.047	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units
102	75	127.63	23.08	0.000	0.000	REMOVE LINE KT1
103	75	127.63	17.27	0.140	0.000	3 PHASE FAULT LINE KT2 at Kelsey
104	75	127.63	17.81	0.090	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 1 Kelsey Unit
105	75	127.63	18.19	0.060	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 2 Kelsey Units
106	75	127.63	18.47	0.047	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 3 Kelsey Units
107	75	127.63	18.68	0.047	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 4 Kelsey Units
108	75	127.63	23.08	0.000	0.000	REMOVE LINE KT2
109	75	127.63	18.42	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10
110	75	127.63	19.35	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10 & Xtrip 1 Klsy unit
111	75	127.63	19.88	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10 & Xtrip 2 Klsy Units

Case: e00-200 wusk-TSAT.sav  
SUMMER PEAK

INCO = 30 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

Grand Rapids = 480 MW

Brandon = 386 MW

Wuskwatim Generation = 200 MW  
Transmission in-service

New Kelsey Exciter & Stabilizer, Without Damping Criteria

Case e00-200 wusk-TSAT.sav

Cont. No.	Transfer At The Last Secure Level (MW)	Monitored Interface Flow (MW)	Transient Stability Index	Voltage Duration Index		Contingency Description
				Drop (sec)	Rise (sec)	
1	75	145.93	21.15	0.000	0.000	Steady state
2	75	145.93	20.12	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)
3	75	145.93	20.12	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R2 fail (Remove P58C & BK2, BK3)
4	75	145.93	19.73	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R3 fail (Remove H59C & BK2, BK3)
5	75	145.93	19.74	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)
6	75	145.93	18.73	0.000	0.000	SLG on Line B76W at Birchtree - Brk 5 fail (Remove B76W & BSVC)
7	75	145.93	13.97	0.000	0.000	SLG on Line B76W at Birchtree - Brk 6 fail (Remove B76W & B77W)
8	75	145.93	13.55	0.000	0.000	SLG on Line B77W at Birchtree - Brk 6 fail (Remove B77W & B76W)
9	75	145.93	13.55	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)
10	75	145.93	13.82	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)
11	75	145.93	17.07	0.000	0.000	SLG on Line K24B at Birchtree - Brk 8 fail (Remove K24B & BSVC)
12	75	145.93	18.34	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 1 fail (Remove H75P & P18H)
13	75	145.93	17.96	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 1 fail (Remove P18H & H75P)
14	75	145.93	20.83	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)
15	75	145.93	19.62	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 3 fail (Remove H73W & BK1)
16	75	145.93	16.24	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 5 fail (Remove H73W & H75P)
17	75	145.93	16.17	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 5 fail (Remove H73W & H75P)
18	75	145.93	19.62	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 6 fail (Remove H73W & BK2)
19	75	145.93	19.9	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 7 fail (Remove H59C)
20	75	145.93	18.51	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 8 fail (Remove H59C & H74W)
21	75	145.93	18.58	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 8 fail (Remove H59C & H74W)
22	75	145.93	10.71	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)
23	75	145.93	11.15	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)
24	75	145.93	19.05	0.000	0.000	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)
25	75	145.93	20.58	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)
26	75	145.93	20.55	0.000	0.000	SLG on Line J30P at Ponton - Brk 3 fail (Remove J30P & P18H)
27	75	145.93	18.6	0.000	0.000	SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P)
28	75	145.93	20.48	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)
29	75	145.93	21.46	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)
30	75	145.93	17.11	0.000	0.000	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
31	75	145.93	16.93	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
32	75	145.93	19.82	0.000	0.000	SLG on Line P58C at Ralls Island - Brk 9 fail (Remove P58C & BK1, BK2)
33	60	143.09	14.49	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E)
34	75	145.11	16.95	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E) & Xtrip 1 Kisy Unit
35	75	145.11	18.76	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E) & Xtrip 2 Kisy Units
36	75	145.93	18.08	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 7 fail (Remove H75P & F27P)
37	75	145.93	18.25	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 8 fail (Remove H75P & BK1, BK2)
38	75	145.93	19.72	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)
39	75	145.93	17.61	0.000	0.000	SLG on Line F27P at Ralls Island - Brk 7 fail (Remove H75P & F27P)
40	75	145.93	15.97	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)
41	60	143.09	14.55	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C)
42	75	145.11	16.84	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C) & Xtrip 1 Kisy Unit
43	75	145.11	17.94	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C) & Xtrip 2 Kisy Units
44	75	145.93	18.84	0.000	0.000	SLG on Line B76W at Wusk - Brk 17 fail (Remove B76W)
45	75	145.93	20.2	0.000	0.000	SLG on Line H74W at Wusk - Brk 20 fail (Remove H74W)
46	75	145.93	20.8	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)
47	75	145.93	20.63	0.000	0.000	SLG on Line TW40 at Mystery Lake - Brk B80 fail (Remove WL43 & TW40)
48	75	145.93	21.08	0.000	0.000	SLG on Line WB45 at Mystery Lake - Brk WB45 fail (Remove BK9 & WB45)
49	75	145.11	16.85	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)
50	75	145.11	19.48	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 1 Kisy Unit
51	75	145.11	16.85	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K)
52	75	145.11	19.48	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 1 Kisy Unit
53	75	145.11	16.72	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)
54	75	145.11	18.04	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 1 Kisy Unit
55	75	145.11	16.72	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)
56	75	145.11	18.04	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 1 Kisy Unit
57	75	145.93	17.37	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2
58	75	145.11	12.9	0.000	0.000	3 Phase Fault at Birchtree - Remove line B76W
59	75	145.11	13.83	0.000	0.000	3 Phase fault at Birchtree - Remove B76W & Xtrip 1 unit Kelsey Gen.
60	75	145.11	14.45	0.000	0.000	3 Phase fault at Birchtree - Remove B76W & Xtrip 2 unit Kelsey Gen.
61	75	145.11	18.18	0.000	0.000	Remove line B76W
62	75	145.93	16.02	0.000	0.000	3 PHASE FAULT B77W
63	75	145.93	16.24	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 1 unit Kelsey Gen.
64	75	145.93	16.39	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 2 unit Kelsey Gen.
65	75	145.93	21.64	0.000	0.000	Remove Line B77W
66	75	145.93	11.68	0.080	0.000	3 PHASE FAULT K24B
67	60	143.93	7.55	0.000	0.000	3 Phase Fault at Ponton - Remove Line G8P
68	75	145.93	8.4	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.
69	75	145.93	8.4	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.
70	75	145.93	11.6	0.000	0.000	REMOVE LINE G8P
71	75	145.93	21.62	0.000	0.000	Trip Birchtree SVC
72	75	145.93	21.52	0.000	0.000	Trip Ponton SVC
73	75	145.93	15.43	0.000	0.000	3 Phase fault at Birchtree SVC Bus - Remove Birchtree SVC
74	75	145.93	7.57	0.080	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC
75	75	145.93	13.56	0.000	0.000	3 Phase fault at Herblet - Remove line H59C
76	75	145.93	13.57	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen
77	75	145.93	13.57	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 2 unit Kelsey Gen
78	75	145.93	19.53	0.000	0.000	REMOVE LINE H59C
79	75	145.93	14.02	0.000	0.000	3 Phase fault at Wuskwatim - Remove Line H73W
80	75	145.93	14.83	0.000	0.000	3 Phase fault at Wusk - Remove Line H73W & Xtrip 1 unit Kelsey Gen.
81	75	145.93	15.37	0.000	0.000	3 Phase fault at Wusk - Remove line H73W & Xtrip 2 unit Kelsey Gen.
82	75	145.93	20.2	0.000	0.000	Remove Line H73W
83	75	145.93	12.8	0.000	0.000	3 Phase fault at Herblet - Remove Line H75P
84	75	145.93	12.8	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 1 unit Kelsey Gen.
85	75	145.93	13.46	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 2 unit Kelsey Gen.
86	75	145.93	17.71	0.000	0.000	Remove Line H75P
87	75	145.93	8.39	0.000	0.000	3 Phase fault at Ponton - Remove line P18H
88	75	145.93	8.4	0.000	0.000	3 Phase fault at Ponton - Remove P18H & Xtrip 1 unit Kelsey Gen.
89	75	145.93	9.07	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.
90	75	145.93	21.4	0.000	0.000	REMOVE LINE P18H
91	75	145.93	13.82	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W
92	75	145.93	14.58	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen
93	75	145.93	15.07	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen
94	75	145.93	18.86	0.000	0.000	Remove P19W
95	75	145.93	15.95	0.000	0.000	3 Phase fault at Ashern - Remove line A4D
96	75	145.93	17	0.000	0.000	3 Phase fault at Ashern - Remove A4D & Xtrip 1 unit Gr. Rapids Gen.
97	60	143.09	19.67	0.000	0.000	3 Phase fault at Ashern - Remove line A4D & Xtrip 2 unit Gr. Rapids Gen.
98	75	145.93	19.36	0.000	0.000	REMOVE LINE A4D
99	75	145.93	15.04	0.000	0.000	3 Phase fault at Ashern - Remove line A3R
100	75	145.93	16.38	0.000	0.000	3 Phase fault at Ashern - Remove A3R & Xtrip 1 unit Gr. Rapids Gen.
101	75	145.93	19.24	0.000	0.000	3 Phase fault at Ashern - Remove line A3R & Xtrip 2 unit Gr. Rapids Gen.
102	75	145.93	17.46	0.000	0.000	REMOVE LINE A3R
103	75	145.93	11.62	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A
104	75	145.93	13.57	0.000	0.000	3 Phase fault at Gr. Rapids - Remove G1A & Xtrip 1 unit Gr. Rapids Gen.
105	75	145.93	14.86	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A & Xtrip 2 unit Gr. Rapid
106	75	145.93	16.93	0.000	0.000	REMOVE LINE G1A
107	75	145.93	15.93	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9
108	75	145.93	16.17	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
109	75	145.93	16.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 2 Kelsey Units
110	75	145.93	16.45	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units
111	75	145.93	16.53	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units
112	75	145.93	21.44	0.000	0.000	REMOVE TRANSFORMER BANK 9
113	75	145.93	15.92	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8
114	75	145.93	16.17	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
115	75	145.93	16.34	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 2 Kelsey Units
116	75	145.93	16.46	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units
117	75	145.93	16.54	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units
118	75	145.93	21.41	0.000	0.000	REMOVE TRANSFORMER BANK 8
119	75	145.93	16.15	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus
120	75	145.93	16.2	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit
121	75	145.93	16.23	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
122	75	145.93	16.23	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units
123	75	145.93	16.27	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units
124	75	145.93	16.29	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 5 Kelsey Units
125	75	145.93	21.1	0.000	0.000	REMOVE LINE KN36
126	75	145.93	17.93	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey
127	75	145.93	17.95	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit
128	75	145.93	17.98	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units
129	75	145.93	17.99	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units
130	75	145.93	18.01	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units
131	75	145.93	21.64	0.000	0.000	REMOVE LINE R26K
132	75	145.93	15.73	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus
133	75	145.93	15.82	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus & Xtrip 1 Kelsey Unit
134	75	145.93	15.88	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units
135	75	145.93	15.93	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units
136	75	145.93	15.98	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units
137	75	145.93	20.8	0.000	0.000	REMOVE LINE KT1
138	75	145.93	15.73	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey
139	75	145.93	15.82	0.000	0.	

Case: e01-200 wusk-TSAT.sav  
SUMMER PEAK

INCO = 140 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

Grand Rapids = 480 MW

Brandon = 386 MW

Wuskwatim Generation = 200 MW  
Transmission in-service

New Kelsey Exciter & Stabilizer, Without Damping Criteria

Case e01-200 wusk-TSAT.sav

Cont. No.	Transfer At The Last	Monitored Interface	Transient	Voltage Duration Index		Contingency Description
	Secure Level (MW)	Flow (MW)	Stability Index	Drop (sec)	Rise (sec)	
1	75	123.77	23.63	0.000	0.000	Steady state
2	75	123.77	23.64	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)
3	75	123.77	23.64	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R2 fail (Remove P58C & BK2, BK3)
4	75	123.77	23.64	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R3 fail (Remove H59C & BK2, BK3)
5	75	123.77	23.64	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)
6	75	123.77	23.64	0.000	0.000	SLG on Line B76W at Birchtree - Brk 5 fail (Remove B76W & BSVC)
7	75	123.77	20.89	0.000	0.000	SLG on Line B76W at Birchtree - Brk 6 fail (Remove B76W & B77W)
8	75	123.77	20.64	0.000	0.000	SLG on Line B77W at Birchtree - Brk 6 fail (Remove B77W & B76W)
9	75	123.77	20.63	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)
10	75	123.77	20.65	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)
11	75	123.77	21.56	0.000	0.000	SLG on Line K24B at Birchtree - Brk 8 fail (Remove K24B & BSVC)
12	75	123.77	22.94	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 1 fail (Remove H75P & P18H)
13	75	123.77	22.84	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 1 fail (Remove P18H & H75P)
14	75	123.77	23.64	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)
15	75	123.77	23.64	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 3 fail (Remove H73W & BK1)
16	75	123.77	21.35	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 5 fail (Remove H73W & H75P)
17	75	123.77	21.31	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 5 fail (Remove H73W & H75P)
18	75	123.77	23.64	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 6 fail (Remove H73W & BK2)
19	75	123.77	23.64	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 7 fail (Remove H59C)
20	75	123.77	23.33	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 8 fail (Remove H59C & H74W)
21	75	123.77	23.47	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 8 fail (Remove H59C & H74W)
22	75	123.77	18.39	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)
23	75	123.77	18.91	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)
24	75	123.77	23.63	0.000	0.000	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)
25	75	123.77	22.6	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)
26	75	123.77	22.57	0.000	0.000	SLG on Line J30P at Ponton - Brk 3 fail (Remove J30P & P18H)
27	75	123.77	22.63	0.000	0.000	SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P)
28	75	123.77	22.53	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)
29	75	123.77	23.64	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)
30	75	123.77	23.63	0.000	0.000	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
31	75	123.77	23.64	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
32	75	123.77	23.64	0.000	0.000	SLG on Line P58C at Ralls Island - Brk 9 fail (Remove P58C & BK1, BK2)
33	75	123.77	20.52	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E)
34	75	123.77	22.87	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 7 fail (Remove H75P & F27P)
35	75	123.77	22.95	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 8 fail (Remove H75P & BK1, BK2)
36	75	123.77	23.41	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)
37	75	123.77	22.42	0.000	0.000	SLG on Line F27P at Ralls Island - Brk 7 fail (Remove H75P & F27P)
38	75	123.77	22.09	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)
39	75	123.77	20.65	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C)
40	75	123.77	23.64	0.000	0.000	SLG on Line B76W at Wusk - Brk 17 fail (Remove B76W)
41	75	123.77	23.64	0.000	0.000	SLG on Line H74W at Wusk - Brk 20 fail (Remove H74W)
42	75	123.77	23.64	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)
43	75	123.77	23.64	0.000	0.000	SLG on Line TW40 at Mystery Lake - Brk B80 fail (Remove WL43 & TW40)
44	75	123.77	23.64	0.000	0.000	SLG on Line WB45 at Mystery Lake - Brk WB45 fail (Remove BK9 & WB45)
45	75	122.94	21.25	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)
46	75	122.94	22.74	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 1 Klsy Unit
47	75	122.94	21.25	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K)
48	75	122.94	22.74	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 1 Klsy Unit
49	75	122.94	21.11	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)
50	75	122.94	22.38	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 1 Klsy Unit
51	75	122.94	21.11	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)
52	75	122.94	22.38	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 1 Klsy Unit
53	75	123.77	21.31	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2
54	75	123.77	19.79	0.000	0.000	3 PHASE FAULT B77W
55	75	123.77	20.03	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 1 unit Kelsey Gen.
56	75	123.77	20.19	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 2 unit Kelsey Gen.
57	75	123.77	23.64	0.000	0.000	Remove Line B77W
58	75	122.94	15.64	0.000	0.000	3 PHASE FAULT K24B
59	75	123.77	11.03	0.000	0.000	3 Phase Fault at Ponton - Remove Line G8P
60	75	123.77	11.04	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.
61	75	123.77	11.04	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.
62	75	123.77	18.77	0.000	0.000	REMOVE LINE G8P
63	75	123.77	23.64	0.000	0.000	Trip Birchtree SVC
64	75	123.77	23.64	0.000	0.000	Trip Ponton SVC
65	75	123.77	19.24	0.000	0.000	3 Phase fault at Birchtree SVC Bus - Remove Birchtree SVC
66	75	123.77	10.12	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC
67	75	122.94	9.68	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC, xtrip 1 klsy unit
68	75	122.94	9.68	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC, xtrip 2 klsy units
69	75	122.94	9.68	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC, xtrip 3 klsy units
70	75	123.77	16.62	0.000	0.000	3 Phase fault at Herblet - Remove line H59C
71	75	123.77	16.63	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen
72	75	123.77	16.63	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 2 unit Kelsey Gen
73	75	123.77	23.64	0.000	0.000	REMOVE LINE H59C
74	75	123.77	18.4	0.000	0.000	3 Phase fault at Wuskwatim - Remove Line H73W
75	75	123.77	19.17	0.000	0.000	3 Phase fault at Wusk - Remove Line H73W & Xtrip 1 unit Kelsey Gen.
76	75	123.77	19.65	0.000	0.000	3 Phase fault at Wusk - Remove line H73W & Xtrip 2 unit Kelsey Gen.
77	75	123.77	23.64	0.000	0.000	Remove Line H73W
78	75	123.77	16.41	0.000	0.000	3 Phase fault at Herblet - Remove Line H75P
79	75	123.77	16.41	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 1 unit Kelsey Gen.
80	75	123.77	16.41	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 2 unit Kelsey Gen.
81	75	123.77	22.51	0.000	0.000	Remove Line H75P
82	75	123.77	10.92	0.150	0.000	3 Phase fault at Ponton - Remove line P18H
83	75	123.77	10.93	0.154	0.000	3 Phase fault at Ponton - Remove P18H & Xtrip 1 unit Kelsey Gen.
84	75	123.77	11.33	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.
85	75	123.77	23.64	0.000	0.000	REMOVE LINE P18H
86	75	123.77	18.1	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W
87	75	123.77	18.71	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen
88	75	123.77	19.15	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen
89	75	123.77	23.64	0.000	0.000	Remove P19W
90	75	123.77	21.05	0.000	0.000	3 Phase fault at Ashern - Remove line A4D
91	75	123.77	22.31	0.137	0.000	3 Phase fault at Ashern - Remove A4D & Xtrip 1 unit Gr. Rapids Gen.
92	75	123.77	21.96	0.000	0.000	3 Phase fault at Ashern - Remove line A4D & Xtrip 2 unit Gr. Rapids Gen.
93	75	123.77	23.64	0.000	0.000	REMOVE LINE A4D
94	75	123.77	20.16	0.000	0.000	3 Phase fault at Ashern - Remove line A3R
95	75	123.77	21.61	0.069	0.000	3 Phase fault at Ashern - Remove A3R & Xtrip 1 unit Gr. Rapids Gen.
96	75	123.77	22.1	0.000	0.000	3 Phase fault at Ashern - Remove line A3R & Xtrip 2 unit Gr. Rapids Gen.
97	75	123.77	22.35	0.000	0.000	REMOVE LINE A3R
98	75	123.77	17.24	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A
99	75	123.77	19.47	0.000	0.000	3 Phase fault at Gr. Rapids - Remove G1A & Xtrip 1 unit Gr. Rapids Gen.
100	75	123.77	20.02	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A & Xtrip 2 unit Gr. Rapid
101	75	123.77	21.99	0.000	0.000	REMOVE LINE G1A
102	75	123.77	19.76	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9
103	75	123.77	20.02	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
104	75	123.77	20.19	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 2 Kelsey Units
105	75	123.77	20.32	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units
106	75	123.77	20.4	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units
107	75	123.77	23.64	0.000	0.000	REMOVE TRANSFORMER BANK 9
108	75	123.77	19.75	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8
109	75	123.77	20.01	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
110	75	123.77	20.19	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 2 Kelsey Units
111	75	123.77	20.32	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units
112	75	123.77	20.4	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units
113	75	123.77	23.64	0.000	0.000	REMOVE TRANSFORMER BANK 8
114	75	123.77	19.74	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus
115	75	123.77	19.82	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit
116	75	123.77	19.87	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
117	75	123.77	19.9	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units
118	75	123.77	19.94	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units
119	75	123.77	23.64	0.000	0.000	REMOVE LINE KN36
120	75	123.77	21.67	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey
121	75	123.77	21.72	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit
122	75	123.77	21.75	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units
123	75	123.77	21.78	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units
124	75	123.77	21.8	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units
125	75	123.77	23.64	0.000	0.000	REMOVE LINE R26K
126	75	123.77	19.21	0.010	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus
127	75	123.77	19.33	0.009	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus & Xtrip 1 Kelsey Unit
128	75	123.77	19.42	0.009	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units
129	75	123.77	19.49	0.009	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units
130	75	123.77	19.54	0.009	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units
131	75	123.77	23.64	0.000	0.000	REMOVE LINE KT1
132	75	123.77	19.21	0.010	0.000	3 PHASE FAULT LINE KT2 at Kelsey
133	75	123.77	19.33	0.009	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 1 Kelsey Unit
134	75	123.77	19.42	0.009	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 2 Kelsey Units
135	75	123.77	19.49	0.009	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 3 Kelsey Units
136	75	123.77	19.54	0.009	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 4 Kelsey Units
137	75	123.77	23.64	0.000	0.000	REMOVE LINE KT2
138	75	123.77	19.54	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10
139	75	122.94	19.94	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10 & Xtrip 1 Klsy unit
140	75	122.				

Case: d01-wipk-no wusk xmission-TSAT.SAV  
WINTER PEAK

INCO = 140 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

Grand Rapids = 480 MW

Brandon = 386 MW

No Wuskwatim Generation or Transmission

New Kelsey Exciter & Stabilizer , Without Damping Criteria

Case d01-wipk-no wusk xmission-TSAT.SAV

Northern Islanding occurs - Kelsey Overfrequency trip scheme required

Cont. No.	Transfer At The Last	Monitored Interface	Transient	Voltage Duration Index		Contingency Description
	Secure Level (MW)	Flow (MW)	Stability Index	Drop (sec)	Rise (sec)	
1	75	131.19	22.94	0.000	0.000	Steady state
2	75	131.08	23.28	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)
3	75	131.08	23.28	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)
4	75	131.08	8.56	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)
5	75	131.08	17.34	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)
6	75	131.08	18.11	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)
7	75	131.19	23.28	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)
8	75	131.19	23.07	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)
9	75	131.08	23.28	0.000	0.000	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)
10	75	131.08	23.28	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)
11	75	131.07	23.28	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)
12	75	131.08	23.07	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)
13	75	131.08	17.34	0.000	0.000	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
14	75	131.08	23.28	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)
15	75	131.08	23.28	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)
16	75	131.08	23.28	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)
17	75	131.08	23.28	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)
18	75	131.07	17.3	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)
19	75	131.07	17.31	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)
20	75	131.07	17.31	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)
21	75	131.17	17.18	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2
22	75	131.08	23.28	0.000	0.000	3 PHASE FAULT K24W
23	75	131.08	23.28	0.000	0.000	3 Phase Fault at Birchtree - Remove K24W & Xtrip 1 unit Kelsey Gen.
24	75	131.08	17.68	0.000	0.000	3 Phase Fault at Birchtree - Remove K24W & Xtrip 2 unit Kelsey Gen.
25	75	131.08	17.29	0.000	0.000	Remove Line K24W
26	75	131.08	17.39	0.070	0.000	3 Phase Fault at Ponton - Remove Line G8P
27	75	131.08	23.28	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.
28	75	131.08	17.26	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.
29	75	131.19	23.28	0.000	0.000	REMOVE LINE G8P
30	75	131.08	17.3	0.000	0.000	Trip Ponton SVC
31	75	131.19	23.28	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC, xtrip 1 klsy unit
32	75	131.08	16.87	0.000	0.000	3 Phase fault at Herblet - Remove line H59C
33	75	131.08	17.78	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen
34	75	131.08	17.82	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 2 unit Kelsey Gen
35	75	131.08	8.56	0.000	0.000	REMOVE LINE H59C
36	75	131.08	23.28	0.000	0.000	3 Phase fault at Ponton - Remove line P18H
37	75	131.08	15.84	0.000	0.000	3 Phase fault at Ponton - Remove P18H & Xtrip 1 unit Kelsey Gen.
38	75	131.08	23.28	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.
39	75	131.17	23.49	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W
40	75	131.08	23.07	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen
41	75	131.08	17.28	0.009	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen
42	75	131.08	16.7	0.000	0.000	Remove P19W
43	75	131.15	23.63	0.000	0.000	3 Phase fault at Ashern - Remove line A4D
44	75	131.15	23.63	0.000	0.000	3 Phase fault at Ashern - Remove line A3R
45	75	131.08	23.28	0.000	0.000	REMOVE LINE A3R
46	75	131.15	23.42	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A
47	75	131.15	23.63	0.000	0.000	REMOVE LINE G1A
48	75	131.17	17.92	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9
49	75	131.07	23.28	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
50	75	131.07	22.28	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit
51	75	131.08	17.53	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units
52	75	131.08	16.95	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units
53	75	131.08	17.3	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8
54	75	131.07	23.28	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
55	75	131.07	21.28	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit
56	75	131.08	17.53	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units
57	75	131.08	17.45	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units
58	75	131.08	17.3	0.000	0.000	REMOVE TRANSFORMER BANK 8
59	75	131.08	17.27	0.030	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus
60	75	131.08	17.42	0.037	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit
61	75	131.08	17.48	0.037	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
62	75	131.08	17.48	0.037	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units
63	75	131.08	17.45	0.037	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units
64	75	131.08	17.76	0.037	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units
65	75	131.08	17.42	0.000	0.000	REMOVE LINE KN36
66	75	131.17	17.97	0.020	0.000	3 PHASE FAULT LINE R26K at Kelsey
67	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit
68	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units
69	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units
70	75	131.08	23.07	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units
71	75	131.08	23.28	0.000	0.000	REMOVE LINE R26K
72	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus
73	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus & Xtrip 1 Kelsey Unit
74	75	131.08	17.41	0.047	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units
75	75	131.08	23.07	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units
76	75	131.08	17.37	0.047	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units
77	75	131.17	17.59	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey
78	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 1 Kelsey Unit
79	75	131.08	17.41	0.047	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 2 Kelsey Units
80	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 3 Kelsey Units
81	75	131.08	23.28	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 4 Kelsey Units
82	75	131.08	23.28	0.000	0.000	REMOVE LINE KT2
83	75	131.07	23.28	0.000	0.000	3 PHASE FAULT Kelsey TRANSFORMER BANK 10 & Xtrip 1 Klsy unit

Case: e01-wipk-200-wusk-TSAT.SAV  
WINTER PEAK

INCO = 140 MW

Kelsey = 235 MW to 315 MW

Jenpeg = 168 MW

Grand Rapids = 480 MW

Brandon = 386 MW

Wuskwatim Generation = 200 MW  
Transmission in-service

New Kelsey Exciter & Stabilizer, Without Damping Criteria

Case e01-wipk-200-wusk-TSAT.SAV

Cont. No.	Transfer At The Last Secure Level (MW)	Monitored Interface Flow (MW)	Transient		Voltage Duration Index		Contingency Description
			Stability Index	Drop (sec)	Rise (sec)		
1	75	136.97	23.03	0.000	0.000	Steady state	
2	75	136.97	23.33	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R1 fail (Remove P58C & BK1)	
3	75	136.97	23.33	0.000	0.000	SLG on Line P58C at Cliff Lake - Brk R2 fail (Remove P58C & BK2, BK3)	
4	75	136.97	17.45	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R3 fail (Remove H59C & BK2, BK3)	
5	75	136.97	23.33	0.000	0.000	SLG on Line H59C at Cliff Lake - Brk R6 fail (Remove H59C & BK1)	
6	75	136.97	23.33	0.000	0.000	SLG on Line B76W at Birchtree - Brk 5 fail (Remove B76W & BSVC)	
7	75	136.97	23.33	0.000	0.000	SLG on Line B76W at Birchtree - Brk 6 fail (Remove B76W & B77W)	
8	75	136.97	17.39	0.000	0.000	SLG on Line B77W at Birchtree - Brk 6 fail (Remove B77W & B76W)	
9	75	136.97	23.33	0.000	0.000	SLG on Line B77W at Birchtree - Brk 7 fail (Remove B77W & K24B)	
10	75	136.97	23.33	0.000	0.000	SLG on Line K24B at Birchtree - Brk 7 fail (Remove K24B & B77W)	
11	75	136.97	23.33	0.000	0.000	SLG on Line K24B at Birchtree - Brk 8 fail (Remove K24B & BSVC)	
12	75	136.97	23.33	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 1 fail (Remove H75P & P18H)	
13	75	136.97	23.33	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 1 fail (Remove P18H & H75P)	
14	75	136.97	17.46	0.000	0.000	SLG on Line P18H at Herblet Lake - Brk 2 fail (Remove P18H & BK1)	
15	75	136.97	23.33	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 3 fail (Remove H73W & BK1)	
16	75	136.97	17.49	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 5 fail (Remove H73W & H75P)	
17	75	136.97	23.33	0.000	0.000	SLG on Line H75P at Herblet Lake - Brk 5 fail (Remove H73W & H75P)	
18	75	136.97	23.33	0.000	0.000	SLG on Line H73W at Herblet Lake - Brk 6 fail (Remove H73W & BK2)	
19	75	136.97	23.33	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 7 fail (Remove H59C)	
20	75	136.97	17.55	0.000	0.000	SLG on Line H59C at Herblet Lake - Brk 8 fail (Remove H59C & H74W)	
21	75	136.97	23.33	0.000	0.000	SLG on Line H74W at Herblet Lake - Brk 8 fail (Remove H59C & H74W)	
22	75	136.97	17.36	0.000	0.000	SLG on Line G8P at Ponton - Brk 1 fail (Remove G8P & P19W)	
23	75	136.97	17.35	0.000	0.000	SLG on Line P19W at Ponton - Brk 1 fail (Remove P19W & G8P)	
24	75	136.97	23.33	0.000	0.000	SLG on Line P19W at Ponton - Brk 2 fail (Remove P19W & PSVC)	
25	75	136.97	17.47	0.000	0.000	SLG on Line P18H at Ponton - Brk 3 fail (Remove P18H & J30P)	
26	75	136.97	23.33	0.000	0.000	SLG on Line J30P at Ponton - Brk 3 fail (Remove J30P & P18H)	
27	75	136.97	23.33	0.000	0.000	SLG on Line G8P at Ponton - Brk 4 fail (Remove G8P & J30P)	
28	75	136.97	23.33	0.000	0.000	SLG on Line J30P at Ponton - Brk 4 fail (Remove J30P & G8P)	
29	75	136.97	23.33	0.000	0.000	SLG on Line P18H at Ponton - Brk 6 fail (Remove P18H & PSVC)	
30	75	136.97	17.4	0.000	0.000	SLG on Line B77W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)	
31	75	136.97	23.33	0.000	0.000	SLG on Line P19W at Mystery Lake - Brk R2 fail (Remove K24W & P19W)	
32	75	136.97	17.53	0.000	0.000	SLG on Line P58C at Ralls Island - Brk 9 fail (Remove P58C & BK1, BK2)	
33	75	136.97	23.33	0.000	0.000	SLG on Line P58C @ Ralls Island - Brk 10 fail (Remove P58C & P52E)	
34	75	136.97	23.33	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 7 fail (Remove H75P & F27P)	
35	75	136.97	23.33	0.000	0.000	SLG on Line H75P at Ralls Island - Brk 8 fail (Remove H75P & BK1, BK2)	
36	75	136.97	23.33	0.000	0.000	SLG fault on line F27P at Ralls Island - Brk 4 fail (Remove F27P & BK3)	
37	75	136.97	23.33	0.000	0.000	SLG on Line F27P at Ralls Island - Brk 7 fail (Remove H75P & F27P)	
38	75	136.97	23.33	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 5 fail (Remove P52E & BK3)	
39	75	136.97	18.55	0.000	0.000	SLG on Line P52E at Ralls Island - Brk 10 fail (Remove P52E & P58C)	
40	75	136.97	23.33	0.000	0.000	SLG on Line B76W at Wusk - Brk 17 fail (Remove B76W)	
41	75	136.97	17.42	0.000	0.000	SLG on Line H74W at Wusk - Brk 20 fail (Remove H74W)	
42	75	136.97	23.33	0.000	0.000	SLG on Line WL43 at Mystery Lake - Brk WL43 fail (Remove WL43 & TW40)	
43	75	136.97	17.52	0.000	0.000	SLG on Line TW40 at Mystery Lake - Brk B90 fail (Remove WL43 & TW40)	
44	75	136.97	23.33	0.000	0.000	SLG on Line WB45 at Mystery Lake - Brk WB45 fail (Remove BK9 & WB45)	
45	75	136.96	23.06	0.000	0.000	Steady state	
46	75	136.96	23.33	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K)	
47	75	136.96	17.4	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 1 Kisy Unit	
48	75	136.96	17.33	0.000	0.000	SLG on Line R26K at Kelsey - Brk R1 fail (Trip BK10 & R26K), Xtrip 2 Kisy Units	
49	75	136.96	17.41	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K)	
50	75	136.96	23.33	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 1 Kisy Unit	
51	75	136.96	23.33	0.000	0.000	SLG on Line R26K at Kelsey - Brk R2 fail (Trip BK10 & R26K), Xtrip 2 Kisy Units	
52	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10)	
53	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 1 Kisy Unit	
54	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R1 fail (Trip K24B & BK10), Xtrip 2 Kisy Units	
55	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B)	
56	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 1 Kisy Unit	
57	75	136.96	23.33	0.000	0.000	SLG on Line K24B at Kelsey - Brk R3 fail (Trip BK10 & K24B), Xtrip 2 Kisy Units	
58	75	136.97	17.68	0.000	0.000	SLG on Line KT2 at Kelsey - Loss lines KT1 & KT2	
59	75	136.96	23.33	0.000	0.000	3 Phase Fault at Birchtree - Remove line B76W	
60	75	136.96	23.33	0.000	0.000	3 Phase fault at Birchtree - Remove B76W & Xtrip 1 unit Kelsey Gen.	
61	75	136.96	23.33	0.000	0.000	3 Phase fault at Birchtree - Remove B76W & Xtrip 2 unit Kelsey Gen.	
62	75	136.96	23.33	0.000	0.000	Remove line B76W	
63	75	136.97	23.33	0.000	0.000	3 PHASE FAULT B77W	
64	75	136.97	23.33	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 1 unit Kelsey Gen.	
65	75	136.97	17.41	0.000	0.000	3 Phase Fault at Birchtree - Remove B77W & Xtrip 2 unit Kelsey Gen.	
66	75	136.97	17.4	0.000	0.000	Remove Line B77W	
67	75	136.97	16.6	0.000	0.000	3 Phase Fault at Ponton - Remove Line G8P	
68	75	136.96	23.33	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 1 unit Kelsey Gen.	
69	75	136.96	16.61	0.000	0.000	3 Phase fault at Ponton - Remove line G8P & Xtrip 2 unit Kelsey Gen.	
70	75	136.97	17.24	0.000	0.000	REMOVE LINE G8P	
71	75	136.97	17.4	0.000	0.000	Trip Birchtree SVC	
72	75	136.97	17.4	0.000	0.000	Trip Ponton SVC	
73	75	136.97	17.46	0.000	0.000	3 Phase fault at Birchtree SVC Bus - Remove Birchtree SVC	
74	75	136.97	23.33	0.000	0.000	3 Phase fault at Ponton SVC bus - Remove Ponton SVC	
75	75	136.97	23.33	0.000	0.000	3 Phase fault at Herblet - Remove line H59C	
76	75	136.96	23.33	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 1 unit Kelsey Gen	
77	75	136.96	23.33	0.000	0.000	3 Phase fault at Herblet - Remove line H59C & Xtrip 2 unit Kelsey Gen	
78	75	136.97	17.53	0.000	0.000	REMOVE LINE H59C	
79	75	136.97	23.33	0.000	0.000	3 Phase fault at Wuskwatim - Remove Line H73W	
80	75	136.97	23.33	0.000	0.000	3 Phase fault at Wusk - Remove Line H73W & Xtrip 1 unit Kelsey Gen.	
81	75	136.97	23.33	0.000	0.000	3 Phase fault at Wusk - Remove line H73W & Xtrip 2 unit Kelsey Gen.	
82	75	136.97	23.33	0.000	0.000	Remove Line H73W	
83	75	136.97	17.63	0.000	0.000	3 Phase fault at Herblet - Remove Line H75P	
84	75	136.97	17.54	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 1 unit Kelsey Gen.	
85	75	136.97	17.42	0.000	0.000	3 Phase fault at Herblet - Remove line H75P & Xtrip 2 unit Kelsey Gen.	
86	75	136.97	23.33	0.000	0.000	Remove Line H75P	
87	75	136.97	16.58	0.000	0.000	3 Phase fault at Ponton - Remove line P18H	
88	75	136.97	23.33	0.000	0.000	3 Phase fault at Ponton - Remove P18H & Xtrip 1 unit Kelsey Gen.	
89	75	136.97	23.33	0.000	0.000	3 Phase fault at Ponton - Remove line P18H & Xtrip 2 unit Kelsey Gen.	
90	75	136.97	23.33	0.000	0.000	REMOVE LINE P18H	
91	75	136.97	23.33	0.000	0.000	3 Phase fault at Mystery Lake - Remove Line P19W	
92	75	136.97	23.33	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 1 unit Kelsey Gen	
93	75	136.97	23.33	0.000	0.000	3 Phase fault at MLR - Remove line P19W & Xtrip 2 unit Kelsey Gen	
94	75	136.97	23.33	0.000	0.000	Remove P19W	
95	75	137.75	19.23	0.000	0.000	3 Phase fault at Ashern - Remove line A4D	
96	75	136.97	23.33	0.000	0.000	REMOVE LINE A4D	
97	75	137.75	23.67	0.000	0.000	3 Phase fault at Ashern - Remove line A3R	
98	75	136.97	23.33	0.000	0.000	REMOVE LINE A3R	
99	75	137.7	23.64	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A	
100	75	137.75	23.67	0.000	0.000	3 Phase fault at Gr. Rapids - Remove G1A & Xtrip 1 unit Gr. Rapids Gen.	
101	75	137.7	9.47	0.000	0.000	3 Phase fault at Gr. Rapids - Remove line G1A & Xtrip 2 unit Gr. Rapid	
102	75	136.97	18.04	0.000	0.000	REMOVE LINE G1A	
103	75	136.97	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9	
104	75	136.96	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 1 Kelsey Unit	
105	75	136.96	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 2 Kelsey Units	
106	75	136.97	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 3 Kelsey Units	
107	75	136.97	17.46	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 9 & Xtrip 4 Kelsey Units	
108	75	136.97	17.4	0.000	0.000	REMOVE TRANSFORMER BANK 9	
109	75	136.97	17.38	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8	
110	75	136.96	17.44	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 1 Kelsey Unit	
111	75	136.96	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 2 Kelsey Units	
112	75	136.97	17.43	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 3 Kelsey Units	
113	75	136.97	23.33	0.000	0.000	3 PHASE FAULT MYSTERY LAKE TRANSFORMER BANK 8 & Xtrip 4 Kelsey Units	
114	75	136.97	23.33	0.000	0.000	REMOVE TRANSFORMER BANK 8	
115	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey Bus	
116	75	136.96	17.42	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 1 Kelsey Unit	
117	75	136.96	17.34	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units	
118	75	136.97	17.32	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 2 Kelsey Units	
119	75	136.97	17.34	0.009	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 3 Kelsey Units	
120	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KN36 at Kelsey & Xtrip 4 Kelsey Units	
121	75	136.97	17.44	0.000	0.000	REMOVE LINE KN36	
122	75	137.76	23.76	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey	
123	75	136.96	23.33	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 1 Kelsey Unit	
124	75	136.96	23.33	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 2 Kelsey Units	
125	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 3 Kelsey Units	
126	75	136.97	17.38	0.000	0.000	3 PHASE FAULT LINE R26K at Kelsey & Xtrip 4 Kelsey Units	
127	75	136.97	17.4	0.000	0.000	REMOVE LINE R26K	
128	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus	
129	75	136.96	23.33	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey Bus & Xtrip 1 Kelsey Unit	
130	75	136.96	17.36	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 2 Kelsey Units	
131	75	136.97	17.35	0.009	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 3 Kelsey Units	
132	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KT1 at Kelsey & Xtrip 4 Kelsey Units	
133	75	136.97	23.33	0.000	0.000	REMOVE LINE KT1	
134	75	136.97	17.46	0.010	0.000	3 PHASE FAULT LINE KT2 at Kelsey	
135	75	136.96	23.33	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 1 Kelsey Unit	
136	75	136.96	23.33	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 2 Kelsey Units	
137	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 3 Kelsey Units	
138	75	136.97	23.33	0.000	0.000	3 PHASE FAULT LINE KT2 at Kelsey & Xtrip 4 Kelsey Units	
139	75	136.97	23.33	0.000	0.000	REMOVE	